TECHNICAL REPORT

3 August 2022	A Technical, Economic and Environmental Analysis of Beneficial Use of Stranded Associated Gas in Kazakhstan

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EXECUTIVE SUMMARY

The Global Methane Initiative is an international public-private partnership focused on reducing barriers to the recovery and use of methane as a clean energy source. U.S. Environmental Protection Agency (U.S. EPA) supports activities of GMI in all three sectors: biogas, coal mining, and oil and gas. This includes engagement with the oil and natural gas sector to identify and promote cost-effective technologies and practices to reduce methane emissions, including through conducting preferability studies.

Kazakhstan is among top fossil fuel producing countries, raking #9 in coal production, #13 in oil production, and #23 in natural gas production (IEA, 2022a). There are about 170 oil fields and 40 gas condensate fields in Kazakhstan, some of which are located offshore. The locations of oil and natural gas fields do not always overlap, and Kazakhstan's vast territory with limited natural gas infrastructure means that a lot of gas associated with production of crude oil ends up stranded with no access to the market.

This prefeasibility study, conducted in partnership and with data support from the Methane Center, investigates the possibility to monetize the stranded associated gas in the Mangystau oilfield by utilizing modular, small-scale processing technologies to produce marketable liquid hydrocarbon commodities such as methanol, syn-diesel, oil, or others.

Based on the information GMI received from the Methane Center in Kazakhstan, an opportunity exists to potentially conserve 200 to 250 million Nm^3 of stranded associated gas annually from the Mangystau oilfield located 160 miles southwest of Beyneu in southwest Kazakhstan. This gas comprises 64% to 66% methane, 4.3% to 4.7% N_2, 2.5% to 2.6% CO_2, with the balance being heavier-than-methane hydrocarbons and trace amounts of H_2S. This report provides a techno-economic and environmental analysis of selected mitigation options suited to the project circumstances.

The key challenges to capturing/using associated gas are as follows:

- No economic access to a gas gathering system or nearby natural gas market.
- Low pricing for electric power sold to the electric utility grid.
- Greater supply than needed for onsite natural gas fuel requirements.

This report considers two basic mitigation strategies:

- Recover condensable hydrocarbons from the associated gas, blend these into the produced oil, and use the residue gas to fulfil fuel gas requirements of the condensate recovery process.
- Implement a mini-gas-to-liquids (GTL) project (e.g., to produce marketable methanol, syn-diesel, etc.).

The first mitigation approach would utilize standard off-the-shelf technologies to extract liquids from the associated natural gas. Because the recovered liquids would be blended with the sales oil, the recovered liquids are valued at crude oil pricing. Two different liquids recovery technologies are evaluated, namely Joule-Thomson and propane refrigeration chiller systems. Chiller technologies recover condensable hydrocarbon streams through a combination of compressing the process gas to an optimum pressure and cooling the gas using to promote condensation. A Joule-Thompson chiller system uses expansion cooling from partial depressurization of compressed natural gas to achieve the required cooling. A propane refrigeration system uses propane refrigerant to achieve the required cooling. Water chiller systems were also initially considered; however, they proved to be uneconomic and therefore were excluded from further analysis.

The second mitigation approach involves the application of emerging small-scale (or mini) GTL technology. These technologies are generally based on the Fischer-Tropsch process and utilize proprietary catalysts. Because the technology is new, it qualifies for certain duty and tax waivers. The costing data for mini-GTL systems is referenced from recent publications by the World Bank's Global Gas Flaring Reduction (GGFR) partnership as well as from peer-reviewed scientific literature. Allowances have been made for systems that are only available in discrete modular size options, and those that are available in custom sizes within a specific size range. The mini-GTL technologies provided by three different vendors are considered: CompactGTL, Greyrock Ventures, LLC, and Emerging Fuels Technology. All three companies are reported to have successful pilot projects in progress. The latter two have already been in preliminary communications with the developers of the subject mitigation opportunity.

Background

According to the information GMI received from the Methane Center, associated gas production from the Mangystau oilfield in Kazakhstan is expected to increase from a current value of 200 million Nm^3 per annum up to 250 million Nm^3 per annum by 2024, plateau at this peak value for the period of 2024 to 2028, and then go through progressive decline thereafter a rate of 5% to 7% annually. A decline rate of 7% per annum is applied to be conservative.

In general, the associated gas is either flared or vented, which results in climate pollutant emissions of CO_2, CH_4 (including due to flaring inefficiencies), N_2O, and black carbon. Flaring is also a source of criteria air contaminant emissions such as volatile organic compounds (VOCs) (including some air toxics), oxides of nitrogen (NO_x), fine particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), and CO.

Flaring is typically assumed to have a destruction and removal efficiency of 98%. However, International Energy Agency (IEA) estimates that in 2020 the global average flaring efficiency was only about 92% (https://www.iea.org/reports/flaring-emissions). Hence, flaring can be a significant source of CH_4 which is a powerful short-lived climate pollutant. Additionally, Kort (2020) reports that approximately 5% of flares in recent surveys in the United States were determined to be unlit (i.e., due to flare system reliability issues).

Currently in Kazakhstan, associate gas venting statistics are not maintained nor legally stipulated (Nurbekov et al., 2014); therefore, it is difficult to estimate the percentage of associate gas that is vented or flared. However, as Calel et al. (2020) published in Proceedings of the National Academy of Sciences (PNAS), regulatory restrictions on flaring can inadvertently push oil producers toward greater venting. In addition, emissions data reported by IEA (2022b) for Kazakhstan implies that approximately equal amount of waste natural gas are vented (50.1%) versus flared (49.9%) (i.e., based on the reported amounts of methane emissions from venting and flaring and an assumed flaring destruction and removal efficiency of 92%).

Key Environmental and Economic Analysis Assumptions

All techno-economic and environmental assessments were performed using Clearstone's *CSimOnline,* a multi-featured tool for performing full life-cycle analyses of GHG emissions mitigation opportunities at oil and natural gas facilities. For each specified mitigation technology, *CSimOnline* determines the optimum design and operating conditions (e.g., equipment sizes, number of trains, key operating temperatures and pressures), capital costs and operating costs, environmental impacts (i.e., in terms of changes in atmospheric emissions), and overall economics. It also accounts for system efficiency changes with declining loads. The software comprises a process simulator, models of individual equipment packages, emissions estimation algorithms, artificial intelligence for performing a front-end engineering design, robust multi-parameter optimization algorithms, refined cost estimating algorithms, production decline models and a selection of economic analysis tools, all in a single integrated environment. The key outputs for a given emissions reduction application is the basic system design for each evaluated mitigation technology, an assessment of the emissions reductions achieved over the project life cycle, and the full life-cycle economics for each evaluated technology. CSimOnline has been used for major projects with the World Bank's Global Gas Flaring Reduction (GGFR) Partnership, Climate and Clean Air Coalition (CCAC), and Environment and Climate Change Canada (ECCC).

Throughout this report, emissions and potential emission reductions are reported in units of tonnes (t) per annum, while process activity levels, natural gas losses and methane losses are all expressed in cubic meters per day (m^3/d) or cubic meters per hour (m^3/h) (depending on the circumstances). The volumetric flowrates are referenced at standard conditions of 101.325 kPa and 15ºC. All reported GHG emissions include contributions due to CH_4, CO_2, and N_2O emissions. BC emissions are reported separately. The impact on emissions of selected criteria air contaminants (CACs) is considered, including volatile organic compounds (VOCs), SO_2, NO_x, CO, and particulate matter (PM).

All prices presented throughout this report are expressed in 2022 US dollars (USD).

Values of the key parameters applied in the economic analysis are summarized in Table i below.

Table i: Applied economic parameters.

Parameter	Value
Project Life	Lesser of asset life and project viability.
Life of New Equipment	10 years.
Discount Rate	10%
Annual Asset Depreciation Rate (Capital Cost Allowance)	10% of book value.
Life of New Equipment	10 years
Asset Salvage Value Determination	Straight-line depreciation of the aggregate equipment purchase price over 10 years.
Inflation Rate	3.0%
Royalty Rate	30%[4]
Tax Rate	20% for conventional technologies and 0% for the first 10 years for innovative technologies[1].
Import Duty	20% for existing technologies and 0% for innovative technologies[1].
Carbon Pricing[2,3]	\$1.10 USD/tonne CO_2E GHG (Scenario 1) \$1.10 USD/tonne CO_2E GHG+BC (Scenario 2) \$55 USD/tonne CO_2E GHG+BC (Scenario 3)
Production Decline Rate	As per site-specific production decline curve determined based on historical production data; otherwise, 8% of the previous year's production (default if no data available).

1 In accordance with the Sater Innovation Industrial Development program.
2 The price of \$1.10 USD/tonne of CO_2E is reported for Kazakhstan by International Carbon Action Partnership (ICAP) (2021) (https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=46)
3 The price of \$55 USD/tonne of CO_2E is the estimated social cost of carbon emissions.

4 The presented royalty rate is an approximate placeholder value. The actual effective royalty rate depends on various factors and may include contributions for the mineral production tax (5% to 18% for oil), excess profits tax (0 to 60%), rent tax on exports (0 to 32%), and customs duties on crude oil exports. The oil export customs duty is $40 USD per tonne.

The commodity prices used in the economic analyses are summarized in Table ii.

Table ii: Applied commodity prices.

Commodity	Value	Units of Measure
Natural Gas	3.10	USD/GJ
Ethane	60.26	USD/m^3 (Liquid)
LPG	0.14	USD/L (Liquid)
	90	USD/ton
Pentanes Plus (C_5+)	389.84	USD/m^3 (Liquid)
Hydrogen	2.00	USD/kg
	0.17	USD/m^3 (gas)
Electricity	0.039	USD/kW·h (Purchases)
	0.013	USD/kW·h (Sales)
Crude Oil	75	USD/bbl
	471.7	USD/m^3
	532.1	USD/ton
Diesel	600.0	USD/ton
	562.2	USD/m^3
Syn-Diesel	900.0	USD/ton
	756.8	USD/m^3
Syn-naphtha	600.0	USD/ton
	444.0	USD/m^3

The capital (CAPEX) and operating (OPEX) costs used in the prefeasibility assessments are estimated using the following information and the Class 4 and 5 methods (AACE RP No. 18R-97) described in Appendix II:

- Site-specific flaring rates verified through field measurements.
- Detailed laboratory analyses of the waste gas, oil and solvent (where applicable).
- Production accounting data provided by the site operator.
- Current commodity pricing.
- Current Class 4 and Class 5 pricing correlations for equipment and materials.
- Listings of the key equipment and materials required for each applicable mitigation strategy (e.g., piping, heat exchangers, vessels, engines, compressors).
- Rigorous sizing of these items.
- Standard marketplace equipment size ranges.
- Typical equipment turndown capabilities.
- Predicted changes in activity levels over the project life.

Prefeasibility Assessment

The results of the completed prefeasibility assessment show that mini-GTL and liquids extraction technologies are both viable options for waste gas recovery or utilization in the Mangystau oilfield application. Payback periods of less than 3 years are potentially achievable. While liquids extraction using propane refrigeration offers the best economics and is a well-proven off-the-shelf technology, this approach does not utilize the full economic potential of the opportunity. Rather, it results in a much smaller scale project and with reduced capital costs (3.7 million USD), but also reduced emissions reduction potential (i.e., only 0.21 to 0.23 Mt CO_2E depending on scenario).

Much better utilization, although at moderately reduced economics, may be achieved through use of mini-GTL technology. The capital cost for full utilization of the available waste gas would be 192 million USD and the resulting emissions reduction would be 3.2 to 11.5 Mt CO_2E over a 10-year project life. The size of the opportunity is such that multiple mini-GTL plants would be needed to fully utilize the available waste gas stream. This means that the project could be implemented in stages to manage risks, and that the plants could be progressively redeployed or sold as the production declines.

The detailed results of the assessment are presented in Appendix III.

Figure i below presents a graph depicting the temperature-pressure phase envelope for the waste gas. It shows the dew point temperature is less than about 38°C. Shallow-cut NGL extraction process are limited to temperatures of typically no less than -35°C.

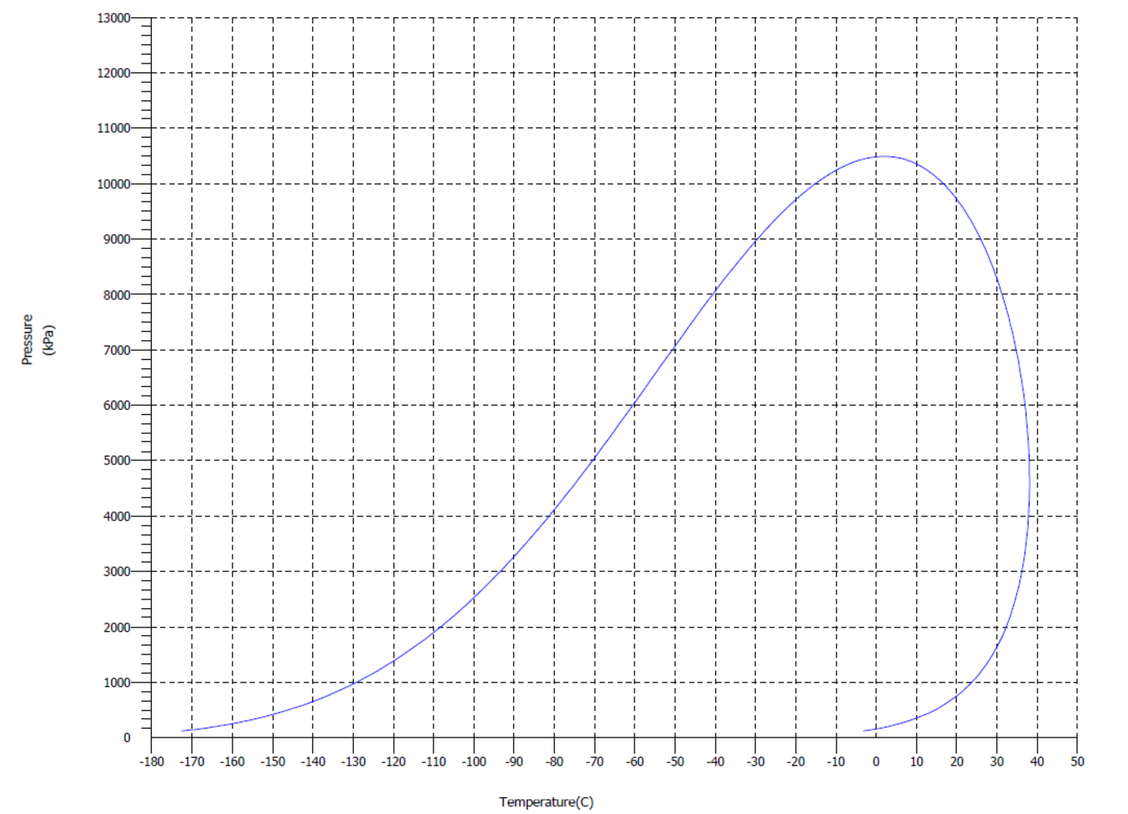

Figure i: Phase envelope for the associated gas.

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LIST OF ACRONYMS

AACE	-	Association for Advancement of Cost Engineering
BC	-	Black Carbon
BL	-	Baseline
CAC	-	Criteria Air Contaminant
CAPEX	-	Capital Expense
CAPP	-	Canadian Association of Petroleum Producers
CCAC	-	Climate and Clean Air Coalition
GHG	-	Greenhouse Gas (CO_2, CH_4, N_2O)
GTL	-	Gas to Liquids
GWP	-	Global Warming Potential
HHV	-	Higher Heating Value
IPCC	-	Intergovernmental Panel on Climate Change
IRR	-	Internal Rate of Return
LHV	-	Lower Heating Value
LNG	-	Liquefied Petroleum Gas
LPG	-	Liquefied Natural Gas
MJ	-	Megajoule
Ng	-	Nanogram
NGL	-	Natural Gas Liquid
NPV	-	Net Present Value
OPEX	-	Operating Expense
PM	-	Particulate Matter
$PM_{2.5}$	-	Particulate Matter ≤ 2.5 µm in Diameter
RISE	-	Research Institute of Safety and Environmental Technology
ROI	-	Return on Investment
SLCP	-	Short-lived Climate Pollutant
THC	-	Total Hydrocarbons
USD	-	US Dollars
VOC	-	Volatile Organic Compound

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1 INTRODUCTION

The Global Methane Initiative is an international public-private partnership focused on reducing barriers to the recovery and use of methane as a clean energy source. U.S. Environmental Protection Agency supports activities of GMI in all three sectors: biogas, coal mining, and oil and gas. This includes engagement with the oil and natural gas sector to identify and promote cost-effective technologies and practices to reduce methane emissions. GMI has 25 years of experience working with oil and natural gas companies to identify and quantify sources of methane emissions, and to identify technologies and practices that reduce these emissions cost effectively. Kazakhstan has been a member of GMI since 2008.

This report presents an assessment of a methane mitigation, as well as flaring reduction, opportunity at Mangystau oilfield located 160 miles southwest of Beyneu in southwest Kazakhstan. Included are a prefeasibility assessment of the range of practical mitigation options, and recommendations for an optimum solution.

The key benefits of mitigating associated petroleum include increased profits, improved overall energy efficiencies, conservation of a valuable non-renewable resource, reduced GHG emissions, reduced air pollution, avoided carbon emission fees and both national and international recognition. Moreover, both venting and flaring are sources of methane (CH_4) and black carbon (BC) emissions, which are both powerful climate forcers. Hence, related mitigation actions offer quick environmental payback.

Section 2 delineates the assessed mitigation opportunity and presents the results of the prefeasibility assessment of each viable mitigation technology evaluated. The conclusions and recommendations are presented in Section 3 and the references cited are presented in Section 4.

Details of the applied technical, economic and environmental analysis methods are presented in Appendices I to II. Details of the completed prefeasibility assessment and a copy of the detailed results are provided in Appendix III.

2 OPPORTUNITY DELINEATION

The proposed project would bring stranded associated gas from three main oil production facilities in the Mangystau oilfield to a central location where a suitable waste gas mitigation technology would be implemented.

Table 1 presents a summary of the economic analysis results for each of the assessed mitigation technologies based on a 10-year project life. Table 2 (A and B) summarizes the net reduction in short-lived climate pollutants (i.e., CH_4 and black carbon), greenhouse (GHG) gases, and selected criteria air contaminants (i.e., volatile organic compounds [VOCs], CO, NO_x, H_2S, SO_2, and particulate matter [PM]) over the 10-year project life for each of the assessed mitigation technologies. Two baseline scenarios are considered regarding the current disposition of waste associated gas (i.e., vented versus flared): (1) best case scenario, in which 98% of the gas is flared, and (2) low-flaring scenario, in which 50% of the associated gas is flared and the balance is vented.

Two basic categories of mitigation technologies are evaluated: (1) mini gas-to-liquids (GTL) Fischer Tropsch (FT) technologies that convert natural gas to diesel and other liquid fuels, and (2) liquids extraction technologies that recovery condensable hydrocarbons from the waste gas and use the residue gas to power the process. In Kazakhstan, mini-GTL systems are deemed to be innovative technologies and therefore qualify for a duty waiver and 10-year tax holiday. Liquids extraction technologies are deemed to be conventional technologies and do not qualify for these incentives.

The best internal rate of return (63.12%) and payback period (1.89 years) are achieved from liquids extraction using propane refrigeration. The economics are best where all compressor drivers are natural gas fueled engines. Slightly reduced economics result from using electric motors to drive all compressors with the electricity being purchased from the electric utility grid. The key disadvantage of a liquids extraction mitigation strategy is that it utilizes only a small portion of the waste gas economic potential.

The use of mini-GTL technology results in moderately reduced economics (i.e., 38.74% internal rate of return and 3.21-year payback period), but potentially full utilization of the waste gas. The other advantage of the use of mini-GTL technology is that the systems are generally supplied as modular plants and multiple plants would be required. This means the project could be implemented in stages to manage risks, and the plants can potentially be redeployed or sold as the production declines.

With the mini-GTL options, the produced product may be transported to market by tanker trucks. Since the final sales point is not currently known, the transportation costs have not been assessed.

Mini-GTL systems by three different technology vendors are evaluated, namely: CompactGTL (https://www.compactgtl.com), Emerging Fuels Technology (www.emergingfuels.com), and Greyrock (http://www.greyrock.com/). The pricing for the different systems was taken from mini-GTL technology bulletins published by the World Bank's Global Gas Flaring Reduction (GGFR) Partnership (2019 and 2020) and adjusted to 2022 dollars.

For the liquids-extraction mitigation options, the recovered liquids are blended with the sales oil in a managed manner that ensures acceptable sales oil vapour pressures. The specific liquids extraction technologies considered comprised: air coolers, water chillers, Joule Thomson plant, and propane refrigeration plant. In all four of these cases, the optimum operating temperatures and pressures were determined. Only the Joule Thomson and propane refrigeration options showed positive economics and therefore are included in Table 1 and Table 2.A/2.B.

With both classes of mitigation options, any surplus gas is flared due to lack of economic access to a gas gathering system or nearby market and the poor economics associated with producing electric power and selling it into the electrical utility grid.

Table 1: Summary of the economic analysis results for the assessed mitigation options based on a 10-year project life.

Control Technology			Capital Cost (USD)	Payback Period (y)	Net Present Value		Return on Investment		Internal Rate of Return (%)
Primary Category	Subcategory	Model			Before Tax (USD)	After Tax (USD)	Before Tax (%)	After Tax (%)	
Mini-GTL	CompactGTL	Compact	403,254,379	No Payback	-86.392.664	-86.392.664	-21.42	-21.42	5.43
	Emerging Fuels Technology	GS50	192,538,522	3.21	316,738,227	316,738,227	164.51	164.51	38.74
		GS100	192,538,522	3.21	316,738,227	316,738,227	164.51	164.51	38.74
		GS250	201,306,281	3.38	307,767,731	307,767,731	152.89	152.89	36.90
	Greyrock	M	210,394,887	3.59	294,060,762	294,060,762	139.77	139.77	34.81
		P	210,394,887	3.59	294,060,762	294,060,762	139.77	139.77	34.81
Liquids Extraction	Joule Thomson Plant	Electric Compressor Driver	7,725,836	7.85	3,897,350	1,780,431	50.45	23.05	14.58
		Natural Gas Fueled Compressor Driver	8,489,070	6.24	7,028,148	4,152,943	82.79	48.92	19.39
	Propane Refrigeration Plant	Electric Compressor Driver	3,691,462	2.02	14,368,414	10,855,688	389.23	294.08	59.35
		Natural Gas Fueled Compressor Driver	3,660,544	1.89	15,376,245	11,667,305	420.05	318.73	63.12

Table 2.A: Summary of the net reduction in short-lived climate pollutants, greenhouse gases and criteria air contaminant emission over the 10-year project life for each of the assessed mitigation technologies (assuming best case scenario: 98% flared).

Control Technology			CH_4 (kt)	CO_2 (kt)	N_2O (kt)	CO_2E (kt)	BC (kt)	VOC (t)	CO (t)	NO_x (t)	H_2S (t)	SO_2 (t)	PM (t)
Primary Category	**Subcategory**	**Model**											
Mini-GTL	CompactGTL	Compact	13.6	2,377.2	0.0	2,719.2	2.4	7,537.1	8,973.3	1,928.0	0.0	0.0	1,525.1
	Emerging Fuels Technology	GS50	16.0	2,793.9	0.0	3,195.9	2.4	8,858.4	10,546.4	2,266.0	0.0	0.0	1,792.4
		GS100	16.0	2,793.9	0.0	3,195.9	2.4	8,858.4	10,546.4	2,266.0	0.0	0.0	1,792.4
		GS250	16.0	2,793.9	0.0	3,195.9	2.4	8,858.4	10,546.4	2,266.0	0.0	0.0	1,792.4
	Greyrock	M	16.0	2,793.9	0.0	3,195.9	2.4	8,858.4	10,546.4	2,266.0	0.0	0.0	1,792.4
		P	16.0	2,793.9	0.0	3,195.9	2.4	8,858.4	10,546.4	2,266.0	0.0	0.0	1,792.4
Liquids Extraction	Joule Thomson Plant	Electric Compressor Driver	0.0	198.5	0.0	199.1	0.2	1,299.9	428.5	93.5	0.0	0.0	71.5
		Natural Gas Fueled Compressor Driver	0.4	198.5	0.0	208.2	0.2	1,484.7	686.9	150.2	0.0	0.0	114.2
	Propane Refrigeration Plant	Electric Compressor Driver	0.0	206.8	0.0	207.5	0.2	1,354.4	446.4	97.4	0.0	0.0	74.4
		Natural Gas Fueled Compressor Driver	0.1	206.8	0.0	209.6	0.2	1,398.6	508.2	110.9	0.0	0.0	84.7

Table 3.B: Summary of the net reduction in short-lived climate pollutants, greenhouse gases and criteria air contaminant emission over the 10-year project life for each of the assessed mitigation technologies (assuming 50% flared scenario).

Control Technology			CH_4 (kt)	CO_2 (kt)	N_2O (kt)	CO_2E (kt)	BC (kt)	VOC (t)	CO (t)	NO_x (t)	H_2S (t)	SO_2 (t)	PM (t)
Primary Category	**Subcategory**	**Model**											
Mini-GTL	CompactGTL	Compact	340	1,298.71	0.0	9,798.71	1.2	188,427.50	4,578.21	983.67	0	0	778.11
	Emerging Fuels Technology	GS50	400	1,525.30	0.0	11,525.30	1.2	221,460.00	5,380.82	1,156.12	0	0	914.49
		GS100	400	1,525.30	0.0	11,525.30	1.2	221,460.00	5,380.82	1,156.12	0	0	914.49
		GS250	400	1,525.30	0.0	11,525.30	1.2	221,460.00	5,380.82	1,156.12	0	0	914.49

Table 2.A: Summary of the net reduction in short-lived climate pollutants, greenhouse gases and criteria air contaminant emission over the 10-year project life for each of the assessed mitigation technologies (assuming best case scenario: 98% flared).														
Control Technology			**CH_4 (kt)**	**CO_2 (kt)**	**N_2O (kt)**	**CO_2E (kt)**	**BC (kt)**	**VOC (t)**	**CO (t)**	**NO_x (t)**	**H_2S (t)**	**SO_2 (t)**	**PM (t)**
Primary Category	**Subcategory**	**Model**											
	Greyrock	M	400	1,525.30	0.0	11,525.30	1.2	221,460.00	5,380.82	1,156.12	0	0	914.49
		P	400	1,525.30	0.0	11,525.30	1.2	221,460.00	5,380.82	1,156.12	0	0	914.49
Liquids Extraction	Joule Thomson Plant	Electric Compressor Driver	0	167.30	0	167.30	0.1	32,497.50	218.62	47.70	0	0	36.48
		Natural Gas Fueled Compressor Driver	10	136.47	0	386.47	0.1	37,117.50	350.46	76.63	0	0	58.27
	Propane Refrigeration Plant	Electric Compressor Driver	0	174.29	0	174.29	0.1	33,860.00	227.76	49.69	0	0	37.96
		Natural Gas Fueled Compressor Driver	2.5	166.63	0	229.13	0.1	34,965.00	259.29	56.58	0	0	43.21

3 CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

The key conclusions of this study are as follows:

1. Mini-GTL and liquids extraction technologies are both viable options for waste gas recovery or utilization in the subject Mangystau oilfield application, and with optimized designs they can achieve payback periods of less than 3 years.
2. Liquids extraction using propane refrigeration offers the best economics and is a well-proven off-the-shelf technology; however, this approach does not utilize the full economic potential of the opportunity. Rather, it results in a much smaller scale project and with reduced capital costs (3.7 million USD), but also reduced emissions reduction potential (i.e., only 0.21 to 0.23 Mt CO_2E).
3. Mini-GTL offers much better utilization of the recovered waste gas, but at moderately reduced economics. The capital cost for full utilization of the available waste gas would be 192 million USD and the resulting emissions reduction would be 3.2 to 11.5 Mt CO_2E over a 10-year project life. The size of the opportunity is such that multiple mini-GTL plants would be needed to fully utilize the available waste gas stream. This means that the project could be implemented in stages to manage risks, and that the plants could be progressively redeployed or sold as the production declines.

3.2 RECOMMENDATIONS

The results of this study are suitable for a comparative analysis of the assessed mitigation technologies. To support a final business decision, it is recommended that a more refined analysis be conducted of the most promising opportunities. This would involve the completion of a front-end engineering design study and obtaining vendor pricing for the key equipment and services needed to implement the project.

4 REFERENCES CITED

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5 APPENDIX I: ECONOMIC EVALUATION METHODOLOGY

A rigorous economic analysis is performed for each applicable control technology considered for a particular emissions reduction opportunity. The objective of the evaluation is to determine the practicability of each option and help determine the best choice for the given application. All economic values are given in US dollars (USD) unless otherwise stated.

Other factors, beyond feasibility, that may affect a final decision include, but are not limited to:

- Net environmental impacts of the project (i.e., both in terms of total GHG emissions and local air quality impacts).
- Impacts on the facility reliability and work-place safety.
- Benefits to the local economy.
- Site-specific constraints that may adversely affect the ability to implement the technology. These constraints could, for example, include excessive footprint requirement compared to the space available, inadequate capacity of the existing utilities to accommodate the incremental loads of the technology and excessive unaccounted for costs to upgrade the utility system, excessive distances and routing challenges to run the necessary piping and utility services required by the technology, lack of adequately skilled local labour pools to operate and maintain the technology, limited capital resources, etc.

The final ranking of opportunities and control options needs to consider the evaluation criteria of management, or the financiers being approached. Generally, energy conservation and environmental projects only proceed if they are driven by regulatory requirements. In the oil and natural gas industry, environmental or green projects do not, regardless of their profitability, compete effectively against traditional exploration and drilling projects that increase reserves and infrastructure projects that bring new production online. Increased reserves, increased revenues and overall profitability are the key parameters upon which the market evaluates energy companies. A company's socioeconomic and environmental performance is often only assessed on a qualitative basis and not given meaningful weighting in the evaluation of a project or in the incentive program for management and employees. One of the challenges is the cost of trying to quantify such parameters in an objective manner. Accordingly, it is expected that identified project opportunities will only proceed through access to green bonds and other non-traditional capital funds specifically dedicated for environmental and energy conservation projects. In these cases, not only is the return on investment a consideration, but so also is the amount of GHG emission reductions achieved and secondary benefits such as local air quality improvements, conservation of a non-renewable resource and socio-economic factors such as job creation and stimulation of the local economy.

The key outputs of the economic analysis are the cash commitments and revenues produced (or costs avoided) in each year of operation, the net present value of the project, the return on investment, and the payback period. The detailed results of each economic analysis completed are presented in the results section of the appendix, herein, relating to the specific waste gas recovery, emissions management or energy efficiency opportunity being considered.

The analysis is truncated at the end of the specified project life or at the point where the operating costs exceed the financial benefits being achieved. Details of the calculations performed, key assumptions and the applied level of rigor are delineated in the following subsections. All calculations are performed using *CSimOnline*.

The primary input information required for the economic analysis includes the following:

- Capital and operating costs.
- Relevant interest rates, discount rates and taxes (including emission taxes).
- Site-specific production decline over the life of the project.
- Energy demands and commodity pricing.
- Decommissioning costs and salvage values.

5.1 COST ESTIMATING

5.1.1 CAPITAL COSTS

The capital costs of a given, fully-installed and commissioned, control option are estimated using one of the following two approaches, depending on the circumstances and the time and resources available for the evaluation:

- Method 1: Determination on a per-unit throughput basis, according to the scale of the application and recent pricing for comparable sized and types of systems in Canada. The throughput requirements are determined based on the relevant measured and reported activity for the application (e.g., gas flow and oil production).
- Method 2: Determination based on a semi-detailed assessment of the major equipment, materials, labour, and services needed to design, procure, construct and commission the control measure, and recent or budgetary pricing obtained from vendors and service providers. The major equipment or process packages (e.g., compressors, line heaters, aerial coolers, refrigeration systems, etc.), as well as any piping systems or pipeline sections, are sized based on rigorous process simulations and sizing calculations performed using *CSimOnline*. A preliminary material take-off (e.g., instrumentation, valves, piping, pumps, vessels, heat exchangers, etc.), is developed based on typical piping and instrumentation

diagrams (P&ID) for the control measure and supplemental estimates by a senior cost estimator or engineer. Additional material needs (e.g., valves, piping, structural, steel, piles, cement), trades and services (e.g., welders, pipe fitters, laborers, etc.), onsite-supervision, engineering and drafting are estimated by a senior cost estimator or engineer based on experience and/or typical cost breakdowns from other similar projects.

Method 1 is classified as a Class 5 cost estimate based on the estimate classification system developed by American Associate of Cost Engineers (AACE) International and summarized in Table 4 below. The AACE suggested contingency for this estimate class is 50% and the results are deemed to be suitable for concept screening. The second approach is equivalent to a Class 4 or Class 3 estimate, depending on the quality and detail of the information available for the simulation and sizing calculations. The corresponding AACE suggested contingency for these estimates is 30% or 20%, respectively, and the results are deemed to be suitable for at least the study of feasibility and potentially even for budget authorization or control. The actual method applied can be determined by viewing the detailed economic analysis results for each case (i.e., which are located in the results section of the appendix dealing with the type of opportunity being considered such as vents and flares, compressors, steam systems, etc.).

Table 4: Estimate classification system as applied in engineering, procurement and construction for the process industries.

Estimate Class	Project Stage	Methodology	Expected Accuracy	Suggested Contingency
Class 5	Concept Screening	• Capacity Factored • Parametric Models • Judgement • Analogy	L: -20% to -50% H: +30% to +100%	50%
Class 4	Study of Feasibility	• Equipment Factored • Parametric Models	L: -15% to -30% H: +20% to +50%	30%
Class 3	Budget Authorization or Control	• Semi-Detailed Unit Costs with Assembly Level Line Items.	L: -10% to -20% H: +10% to +30%	20%
Class 2	Control or Bid/Tender	• Detailed Unit Costs with Forced Detailed Take-off	L: -5% to -15% H: +5% to +20%	15%
Class 1	Check Estimate or Bid/Tender	• Detailed Unit Costs with Detailed Take-off	L: -3% to -10% H: +3% to +15%	5%

Source: AACE RP No. 18R-97.

Normal practice is to express the capital costs on a before-tax basis and exclude overhead costs. In regulatory applications, it may also be required that contingency costs be excluded. Contingencies are not applied herein unless otherwise stated in the capital cost breakdown provided in the economic analysis results.

Capital costs may include the following major expense categories:

- Public consultation and regulatory approvals.
- Additional surface lease or right-of-way.
- Engineering, procurement and project-management services.
- Equipment and materials (including structural steel).
- Freight.
- Construction services.
- Installation of utility services (e.g., electric power, fuel gas, water, telecommunications, and roadways).
- Inspection and commissioning services.

Structural steel is required for aboveground piping systems, equipment bases, access platforms, stairs and handrails. Some structural work may be done at fabrication shops and then shipped to the site for reduced costs. Typical company specifications require all structural steel work to be sandblasted, primed and painted.

The construction services may be further disaggregated into the following subcategories:

- Labour: Labour hours are directly related to the quantities of materials. The relative efficiency of labour depends on the availability of skilled craftsmen and the relative site conditions. Weather conditions may also be important if significant outside work is planned. Remote sites or areas with infrequent workloads may have problems maintaining a reasonable number and selection of qualified crafts people. If adequate numbers of skilled people are not available locally, training is an option if the project is large enough; or else craftsmen can be imported from other locations. Subsistence and travel pay usually is required when importing crafts people.
- Excavation/Civil: Soil conditions and the required depth of any underground systems may have a significant impact on costs. Compaction is also more difficult to achieve in certain situations and this increases the hours needed for backfill operations. Other matters to consider are the presence of rock, high water tables, poor soil conditions requiring removal, availability of import fill, site access for equipment, degree of hand excavation or backfill required, and constraints on pile driving due to close proximity of sensitive operating equipment and buried piping.
- Concrete: Foundation costs can be substantial. If piling is required, then the cost of the concrete for pile caps is less than for a spread footing type foundation but the combined cost of piling and pile caps is usually higher. The depth of foundation needed to avoid frost lines (where applicable) is also a factor that can increase the amount of concrete required. Designing for earthquake zones increases the size of the foundations, rebar and anchor

bolts and can add 20 to 30 percent to concrete costs. Additionally, soil and environmental conditions which attack concrete may require special mixes of concrete costing more and special coating or treatment of rebar and anchor bolts. Pouring and curing of concrete may require expensive heating and hoarding if done during severe winter conditions.

Winterization requirements (where applicable) can drive up costs if heat tracing or additional shelters are required.

The applicability and relative contribution of each expense category to total costs depends on the type of control technology being considered and the specific application. The costs of any equipment (such as emergency flares) that would also be required in the absence of the proposed control technology are excluded from the assessed capital cost.

In assessing the capital costs for each technology, it is assumed, for simplicity, that the costs are incurred all in the first year. This may be true for low-capital-cost options, but for more capital-intensive options, the cost would normally be incurred in phases over several years to help minimize risks. In many applications, the total capital cost of a control technology is substantially greater than the direct costs of the basic uninstalled control device. For example, the uninstalled end control device (e.g., an incinerator) for a large-scale vapour collection and control application may represent less that 10 percent of the capital cost for the total installed system. Thus, it is important to account for all ancillary system, installation and other requirements needed to implement a safe, operable and reliable solution.

Where one control device may service a number of different sources at a site (such as a vapour collection and control system), only a single appropriately sized unit is priced.

5.1.2 R&D COSTS

Some emerging and embryonic control technologies may be assessed a research and development cost. For simplicity, where these costs occur it is assumed that they are all incurred in the first year; however, they would normally be incurred over a much longer period of time (e.g., 5 to 10 years).

5.1.3 OPERATING COSTS

The operating costs for a technology may include the following items (where applicable):

- Energy (fuel or electricity) consumption.
- Chemical consumption.
- Inspection, servicing and repairs (i.e., including parts, materials, and labour).
- Process operators and their associated overhead (i.e., including training, supervision and administration).

- Monitoring and third-party verification of emission reductions being achieved.
- Environmental reporting.
- Lease payments.
- Royalty payments.
- Insurance premiums.
- Other expenses (e.g., vehicles, subsistence, etc.) associated with operating and maintaining a control measure or device.

Currently, for most technologies, only energy and chemical consumption costs are assessed, which tend to be the dominant operating costs. The only exception is for technologies comprising the implementation of improved operating procedures and formal directed inspection and maintenance (DI&M) programs to manage fugitive losses of hydrocarbons or steam. The costs of improved operating procedures are assessed based on the increased labour and, possibly, training requirements, while any instrumentation or software needs would be assessed as a capital cost.

Operating cost estimates for DI&M programs are developed based on estimated component populations, per-component inspection costs, typical leak frequencies and per-component repair or replacement costs by type of component.

The amount and type of energy and chemical consumption required by a technology is determined based on the types of equipment or process units involved (e.g., pump, compressor, heater, boiler, refrigeration system, etc.), rigorous simulations of the process and modelling of the system losses (e.g., friction effects and heat losses). The typical efficiency of the devices involved is accounted for, and detailed engineering calculations are performed to estimate secondary energy demands such as the power requirements of fans.

Current commodity pricing for fuel, electricity and chemicals is applied to the assessed energy and chemical requirements where these commodities are purchased from third parties. Where electricity is produced on site, the costs are evaluated based on the cost of the fuel requirements by the power generator. Electricity purchased from the utility grid may include both an energy and a demand charge. The existence of demand changes may adversely affect the economics of simply reducing a facilities base load.

A direct commodity price of zero is applied to fuel gas in the following situations:

- The fuel gas is withdrawn from a waste stream.
- The fuel is extracted from the process, and there are no direct costs or penalties payable for doing so (e.g., royalties).
- The process gas is owned by others (e.g., the producer or shipper), but the facility operator is given a shrinkage allowance to account for fuel use and system losses (e.g., station and

unit blowdowns, compressor starts, fugitive equipment leaks, etc.), and there are no rewards to the facility operator for achieving better than the allowable shrinkage limit.

A non-zero price for fuel gas is only assigned where it is directly derived from a purchased energy input stream.

Fuel gas that is assigned a price of zero may have an indirect value, depending on the net impact its use has on a facility's product sales and purchased energy inputs This impact is assessed for a given control measure by performing detailed mass and energy balances for the before (baseline) and after cases.

If changes in the amount of fuel gas withdrawn from the process do not increase product sales or reduce purchased energy inputs (e.g., due to system bottlenecks), but help to reduce production at the wellhead, then the applied measure extends the life of the reservoir. This benefit is not fully realized until the economic end of the reservoir's life and, therefore, is assigned a zero value for simplification purposes.

5.1.4 REMOVAL COSTS

Removal costs are separate from installation costs and apply where a process unit must be removed and replaced by an alternative unit (e.g., removing gas-operated pumps and replacing them with electric-powered units).

5.1.5 DECOMMISSIONING COSTS AND SALVAGE VALUE

Currently, decommissioning costs are assumed to be negligible and the salvage value of a control technology at the end of the project life is assumed to be zero. This is likely a conservative position for projects that have a life expectancy of less than 10 years; especially, where the control technology can be installed as a skid-mounted solution that may be easily reused at other locations.

Where a salvage value is assessed, it is included as project revenue in the year the value would be realized. The salvage value is assessed as the reasonable market value of the equipment and not simply a depreciated value from a taxation perspective.

5.2 DETERMINATION OF COSTS AVOIDED AND REVENUES PRODUCED

Avoided or reduced costs are treated as a positive source of revenue for the purpose of the economic analysis. Avoided costs may result from energy efficiency and waste gas utilization measures that reduced purchased fuel or electric power consumption. They may also include avoided or reduced emission taxes, where applicable.

Positive revenue also results from increased product sales, either at the facility where the control measure is implemented, or at downstream facilities that may benefit from the measure (such as a gas processing plant or petroleum refinery). Products may include natural gas, ethane, liquefied petroleum gas (LPG) (i.e., propane and butane), condensate (e.g., pentanes and heavier hydrocarbons), crude oil, hydrogen, refined products (e.g., diesel, gasoline, naphtha, gas oil, synthetic crude oil, lubricants, and chemicals), and even electricity and low-pressure ((LP) or high-pressure (HP) steam.

Avoided product or commodity losses and increases in product sales achieved through capture and production of waste gas streams and reduced fuel withdrawals from the process are all classified as conserved product and assessed an economic value. The value of the product depends on the type of product and where in the system it is conserved, the quality of the conserved product, and the applicable regulatory and contract incentives. Generally, the value of natural gas decreases in moving upstream due to increasing treating, processing and transport requirements.

5.2.1 COMMODITY PRICING

The applied commodity pricing is given in the detailed economic analysis results of the control option being evaluated. These results are presented in the results section of the appendix dealing with the type of opportunity being considered (such as vents and flares, compressors, steam systems, etc.).

Natural gas is normally priced on a calorific basis (e.g., in $/GJ). If the natural gas contains non-methane hydrocarbons, then this increases the specific calorific value of the gas and, consequently, its price on a volumetric basis. If the natural gas is rich in condensable hydrocarbons, such as LPGs and Pentanes Plus, then much greater value may be realized for the gas by first processing it to extract these fractions and marketing them separately from the remaining residue gas (i.e., mostly methane and ethane). This increased value typically occurs regardless of whether the LPG and Pentanes Plus is extracted and marketed at the facility where the control measure is installed, or where the actual extraction and sale or benefit of the LPGs and Pentanes Plus occurs at a downstream facility such as a gas processing plant or petroleum refinery. Extracting and marketing the LPGs and Pentanes Plus separately can easily double the total value realized, even after accounting for processing costs.

In this report, the application of calorific pricing is deemed to give the lower economic value of natural gas. The higher economic value of the natural gas is determined by applying calorific pricing to the residue gas fraction and appropriate commodity pricing to the LPG, Pentanes Plus and other fractions. If the final disposition of the natural gas is simply use as fuel without any preprocessing to recovery of the LPG and Pentanes Plus fractions, then the lower pricing is applied to the natural gas. If the gas is pre-processed to recover the LPG and Pentanes Plus fractions before it is used or sold as fuel, then the higher natural gas pricing is applied, even if the processing occurs at a downstream facility (e.g., at a gas processing plant).

Overall, the actual value of avoided hydrocarbon losses is very site-specific and depends on many factors. Some important considerations are listed below:

- Cost to find, develop, produce, treat/upgrade/process/refine, and deliver the sales product,
- Parts of the system where emission reductions are achieved; for instance, gas conserved before processing is less valuable than gas conserved after processing.
- Impact of emission reductions on specific energy consumption, equipment life, workplace safety, operability, reliability and deliverability.
- Supply and Demand Constraints (Conserved gas may become reserve production that is not sold until the reservoir and market conditions change to the point where demand exceeds supplied; this time lag reduces the present value of such gas.)
- Market prices and current contract requirements.
- Government taxes and royalties.

5.2.1.1 DETERMINATION OF THE HIGHER ECONOMIC VALUE OF AN ENERGY STREAM

The higher economic value of an energy stream is assessed using the following relation:

$$V_{Higher} = (Q_{V_{CH4}} \cdot p_{CH4} + Q_{L_{LPG}} \cdot p_{LPG} + Q_{L_{C5+}} \cdot p_{C5+} + Q_{H2} \cdot p_{H2} + e \cdot p_e) \cdot g_c$$

Equation 1

Where,

V	=	value of a stream (USD/y)
p	=	commodity price (USD/unit of flow measure)
e	=	electric power consumption (kW·h)
g_c	=	constant of proportionality
	=	365 d/y

The subscripts CH_4, LPG, C_5+, H_2 and e denote methane, liquefied petroleum gas, Pentanes Plus, hydrogen and electricity, respectively, and the subscripts V and L denote vapour and liquid, respectively.

Equation 1 is applicable where the energy either has or will be fractionated into its different commodity constituents so that the full market value of these constituents can be realized.

5.2.1.2 DETERMINATION OF THE LOWER ECONOMIC VALUE OF AN ENERGY STREAM

The lower value of an energy stream occurs when the stream is simply used for fuel in a combustion source without first extracting any of the more valuable commodities present in the stream. In such cases, the value of the stream is assessed based on its calorific value and the pricing of natural gas expressed on a calorific basis.

$$V_{Lower} = Q_V \cdot p_{CH4}$$

Equation 2

5.2.2 DETERMINATION OF THE NET OPERATING COST

The net operating cost is determined by the following relation:

$$NOC = OC + OCS$$

Equation 3

Where,

NOC = Net operating costs (USD/y)

OC = Operating cost of the considered control technology (USD). For the purposes of these calculations, the operating cost is assumed to remain constant; however, these costs would tend to increase with time due to increasing maintenance needs as infrastructure ages and the accumulated effects of wear and tear need to be addressed.

OCS = Operating and maintenance savings from discontinued use of the replaced system (USD/y)

Typically, the incremental annual operating costs for a gas conservation project, including gas gathering and processing fees, may be assumed to be up to 10 per cent of the initial capital cost of installing the conservation facilities. If the gas contains 10 moles per kilomole (mol/kmol) hydrogen sulphide (H_2S) or more, the incremental annual operating costs for the project may be assumed to be up to 20 per cent of the capital cost to initially install the conservation facilities.

5.2.3 EMISSION TAXES AND TRADABLE PERMITS

Some jurisdictions impose taxes on emissions of certain pollutants; this is usually expressed in terms of USD per tonne of pollutant emitted. Examples of pollutant emissions that may be taxed include SO_2, NO_x, VOC and CO_2. Where CO_2 emissions are taxed, this is referred to as a carbon tax. If a Cap-and-Trade program exists, then emission reductions achieved below an operators allowance may be registered and marketed as emission reduction credits.

Reductions in the amount of emission tax paid, or the generation of marketable emission reduction credits (ERCs), as a result of applying emission control measures is treated as a source of revenues. If the control technology actually increases the emissions of a taxable pollutant, then this is treated as negative revenue (or an operating cost).

These revenues are assessed based on the rules or laws of the applicable jurisdiction.

5.3 PROJECT LIFE

The life of a given control option is dependent on the demands of the application as well as the remaining economic life of the associated facility and its source of production or feedstock. In the upstream sector, new conventional oil and gas developments typically are assessed based on a 20-year life expectancy, while unconventional oil and gas developments may have much short lives (e.g., heavy oil wells may only have 2 to 4 years of economic life through application of primary production techniques and an additional 4 to 6 years with subsequent application of enhanced recovery techniques). As the upstream industry ages, the quality of finds in a given sedimentary basin gradually declines leading to reduced life expectancies for new projects.

The life of downstream facilities, such as petroleum refineries and petrochemical plants, may be much longer (e.g., 40 to 60+ years).

5.4 FINANCIAL RATES

5.4.1 DISCOUNT RATE

The discount rate and opportunity cost of equity in the upstream petroleum industry is usually taken to be a value in the range of 6 to 12 percent, depending on the segment of the industry. Typically, the discount rate increases in moving upstream through the industry in accordance with increasing financial risks. The actual value applied herein is declared in the sections where it is used and is shown in the results of the completed economic evaluations.

Most oil and gas ventures are expected to yield better than bank interest to compensate for the added risk involved. Typically, a non-redeemable guaranteed interest certificate (GIC) yields a 3.900 to 4.450 percent rate of return for a 1-year term, and a 5.150 percent return for a 10-year GIC. In comparison, the prime interest rate might be 6.250 percent.

5.4.2 OTHER DISCOUNT RATES

In addition to the overall financial discount rate, further discount factors may be applied to the relevant cost and revenue accounts for each control option to account for the applicable taxes, tax shields and royalties.

5.4.3 INFLATION RATES

An average inflation rate may be assumed for the time series.

5.5 ECONOMIC ANALYSIS

5.5.1 NET PRESENT VALUE (NPV)

The net present value of an investment is assessed using the following relation:

$$NPV = -CC + SV_{RE} + \frac{SV_{CE}}{(1+i)^N} + \sum_{n=1}^{n=N} \frac{((V_{Losses} \cdot \eta - OC + OCS)}{(1+i)^n}$$

Equation 4

Where,

n	=	a variable indicating the number of years since the start of the project (y),
N	=	life expectancy of the project or life expectancy of the control technology, whichever is less (y).
i	=	discount rate (expressed as a fractional value).
V_{Losses}	=	value of avoidable product losses or energy consumption (USD/y). For the purposes of these calculations, the value of the product losses is assumed to remain constant with time but would actually tend to increase due to inflation and supply and demand considerations. Also, the costs of any required processing have not been considered in assessing the value of the product losses (these costs are assumed to be small).
η	=	Control efficiency of the considered control technology (dimensionless fractional value).
OC	=	Operating cost of the considered control technology (USD). For the

purposes of these calculations, the operating cost is assumed to remain constant; however, these would tend to increase with time due to inflation.

OCS	=	Operating and maintenance savings from discontinued use of the replaced System (USD/y)
CC	=	Capital cost of the considered control technology (USD).
SV_{RE}	=	Net salvage value of any equipment removed when the control technology is installed (USD).
SV_{CE}	=	Net salvage value of the control equipment at the end of the project life or at the end of the life of the control technology, whichever occurs first (USD).

5.5.2 RETURN ON INVESTMENT (ROI)

The return on investment (ROI) is determined using the following relation:
(1)

$$ROI = \frac{(V_{Losses} \cdot \eta - OC + OCS)}{CC - SV_{RE}} \cdot 100\%$$

Equation 5

Where,

V_{Losses}	=	Value of avoidable product losses or energy consumption (USD/y).
η	=	Efficiency of the selected control measure in reducing product losses and avoidable fuel consumption (fractional dimensionless value).
OC	=	Operating cost of the considered control technology (USD).
CC	=	Capital cost of the considered control technology (USD).

5.5.3 PAYBACK PERIOD

The payback period is determined using the following relation:

$$PP = \frac{CC - SV_{RE}}{V_{Losses} \cdot \eta - OC + OCS}$$

Equation 6

5.6 PRODUCTION DECLINE RATES

For projects at production facilities, it is appropriate to predict the change in inlet production with time and the corresponding impact on the control opportunity activity levels. Decreases in activity levels may adversely affect the operability, performance and economics of the control measure. Production decline rates are not directly applicable to midstream or downstream facilities.

A production decline curve analysis is derived from empirical observations of the production performance of oil and gas wells. Three types of decline have been observed historically: exponential, hyperbolic, and harmonic.

Decline curves represent production from the reservoir under "boundary dominated flow" conditions. This means that during the early life of a well, while it is still in "transient flow" and the reservoir boundaries have not been reached, decline curves should NOT be expected to be applicable. Typically, during transient flow, the decline rate is high, but it stabilizes once boundary dominated flow is reached. For most wells this happens within a few months of production. However, for low permeability wells (tight gas wells, in particular) transient flow conditions can last several years, and strictly speaking, should not be analyzed by decline curve methods until after they have reached stabilization.

The generalized relation used to predict production decline rates for oil and natural gas wells is:

$$\frac{dQ}{dt} = -DQ^{(b+1)}$$

Equation 7

Where,

D	=	Decline as a fraction of production rate.
Q	=	Production rate at time t.
b	=	Constant (dimensionless) that varies from 0 to 1.

Decline analysis is valid when the recovery mechanism and the operating conditions do not vary with time. Single-phase liquid production, high-pressure gas, tubing-restricted gas production, and poor waterflood performance lead to $b = 0$ (Fetkovich). Under solution gas drive, the lower the gas relative permeability, the smaller is the quantity of gas produced; hence the decline in reservoir pressure is slower, and accordingly the decline rate is lower (higher value of b). Simulation studies for a range of gas and oil relative permeability values have indicated $0.1 < b < 0.4$, with the average resulting in $b = 0.3$. Above the bubble point pressure, $b = 0$ (exponential decline), while below the bubble point b increases for solution gas drive. Typical gas wells have b in the range of 0.4 to 0.5. Conventional (light oil) reservoirs under edge water drive (effective water drive) seem to exhibit $b = 0.5$.

If there is a mechanism present that maintains reservoir pressure, the production rate would essentially remain constant (under constant producing pressure) and the decline would tend towards zero. Examples of such mechanisms could be gas or water injection, an active water drive, or gas-cap drive. Since the decline in reservoir pressure is small, the production driving force remains large, and the decline in the producing rate is correspondingly smaller. For such cases, there is no theoretical reason why the decline coefficient could not be greater than one. Much later in the life of these reservoirs, when the oil column thins, the production rate would decline exponentially, and hydrocarbon production is replaced by water.

Situations where values of b > 1 occur are as follows:

- The interpretation of the available production data is wrong.
- The data is still in transient flow and has not reached "boundary-dominated flow".
- Reservoir layering is occurring.
- Some fractured gas wells have values of b >1 (and sometimes as high as 3.5).

The exponential solution occurs when b = 0 and is given by the following relation:

$$Q(t) = Q_i e^{-D_i \cdot t}$$

Equation 8

Where

D_i	=	Initial decline.
Q_i	=	Initial production rate.
$Q(t)$	=	Production rate at time t.
t	=	Time.

For exponential decline the decline rate, D, is constant. If D varies, the decline is considered to be either hyperbolic or harmonic, in which case, an exponent "b" is incorporated into the equation of the decline curve, to account for the changing decline rate.

The hyperbolic solutions are given by the following relation:

$$Q(t) = Q_i(1 + bD_i t)^{-\frac{1}{b}}, \ for\ 0 < b \leq 1$$

Equation 9

Harmonic decline is a special case of hyperbolic decline, with b = 1, i.e., the decline rate, D, is proportional to q and the above equation simplifies to:

$$Q(t) = \frac{Q_i}{(1 + Dt)}$$

Equation 10

This means that the decline rate, *D,* goes to zero when Q approaches zero. This type of performance is expected when very effective recovery mechanisms such as gravity drainage are active. Another example of harmonic decline is the production of high viscosity oil driven by encroaching edge-water. Due to unfavorable mobility ratio, early water breakthrough occurs, and the bulk of the oil production will be obtained at high water cuts. If the total fluid rate is kept constant, then the increasing amount of water in the total fluid will cause the oil production to decline. This decline in oil rate may follow a harmonic decline.

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5.8 RESULTS

The results of each economic analysis performed, including all input information used in the analysis, are provided in the results section of the Appendix dealing with the given waste gas recovery, energy management or fugitive emissions management opportunity.

6 APPENDIX II: ECONOMIC ANALYSIS METHODOLOGY

The key economic indicators assessed for each technology comprise the following:

- **Capital Cost**: The money used to designed, procure, construct and commission the permanent fixed assets needed to implement a mitigation option.
- **Operating Costs**: The costs needed to operate and maintain a mitigation option once it is implemented.
- **Application Life Expectancy**: The economic life of the mitigation option.
- **Salvage Value**: Estimated resale value of the installed assets at the end of the mitigation project.
- **Payback Period**: The time required to recoup the capital costs.
- **Net Present Value**: The income generated by a mitigation measure minus all the costs and referenced in today's dollars.
- **Return on Investment**: The financial gain expressed as a percentage of the funds invested to generate that gain.
- **Internal Rate of Return**: A discount rate that makes the net present value of all cash flows (both positive and negative) from the mitigation project equal to zero.

All economic values are given in US dollars (USD) unless otherwise stated.

The key parameters used in evaluating the feasibility of a project are:

- **Discount Rate**: An interest rate used to convert a future income stream to its present value.
- **Inflation Rate**: The percentage change in the price index for a given period compared to that recorded in a previous year.
- **Depreciation Rate**: The percentage rate at which an asset is depreciated in any one of the methods for computing depreciation.
- **Royalty Rate**: A defined percentage of the gross revenue from a resource extraction operation, less certain contract-defined costs.
- **Tax Rate**: The percentage of tax paid on the net earnings of an operation.
- **Import Duty**: The percentage fee paid on equipment and materials imported for a project.
- **Emissions Fees**: A tax or fee applied per unit of emission for a target pollutant or pollutant category such as greenhouse gas emissions.
- **Commodity Prices**: The amount at which commodities produced by a particular emissions mitigation project sell, and the pricing of commodity purchases avoided by a project.

Other factors, beyond feasibility, that may affect a final decision include, but are not limited to:

- Net environmental impacts of the project (i.e., in terms of both total GHG emissions and local air quality).
- Impacts on the facility reliability and work-place safety.

- Benefits to the local economy.
- Site-specific constraints that may adversely affect the ability to implement the technology. These constraints could, for example, include excessive footprint requirement compared to the space available, inadequate capacity of the existing utilities to accommodate the incremental loads of the technology and excessive unaccounted for costs to upgrade the utility system, excessive distances and routing challenges to run the necessary piping and utility services required by the technology, lack of adequately skilled local labour pools to operate and maintain the technology, limited capital resources, etc.

The final ranking of opportunities and control options needs to consider the selection criteria of the facility owner and any financiers being approached for financing. Generally, energy conservation and environmental projects only proceed if they are driven by regulatory requirements. In the oil and natural gas industry, environmental or green projects do not, regardless of their profitability, compete effectively against traditional exploration and drilling projects that increase reserves and infrastructure projects that bring new production on line. Increased reserves, increased revenues and overall profitability are the key parameters upon which the market evaluates energy companies. A company's socioeconomic and environmental performance are often only assessed on a qualitative basis, and not given meaningful weighting in the evaluation of a project or in the incentive program for management and employees. One of the challenges is the cost of trying to quantify such parameters in an objective manner. Accordingly, it is expected that the identified project opportunities will only proceed through access to non-traditional capital funds specifically dedicated for environmental and energy conservation projects. In these cases, not only is the return on investment a consideration, but so also is the amount of GHG emission reductions achieved and secondary benefits such as local air quality improvements, conservation of a non-renewable resource and socio-economic factors such as job creation and stimulation of the local economy.

The key outputs of the economic analysis are the estimated cash commitments and revenues produced (or costs avoided) in each year of operation, the net present value of the project, the return on investment, and the payback period. The detailed results of each economic analysis completed are presented in the results section of this report for each targeted category of mitigation opportunities (e.g., flares, storage tanks, process vents, fuel gas management, etc.).

The analysis is truncated at the end of the specified project life or at the point where the operating costs exceed the financial benefits. Details of the calculations performed, key assumptions, and the applied level of rigor are delineated in the following subsections. All calculations are performed using *CSimOnline*, a proprietary software tool.

The primary input information required for the economic analysis includes the following:

- Capital and operating costs.

- Relevant interest rates, discount rates and taxes (including emission taxes).
- Site-specific production decline over the life of the project.
- Energy demands and commodity pricing.
- Decommissioning costs and salvage values.

6.1 COST ESTIMATING

6.1.1 CAPITAL COSTS

AACE Recommended Practice No. 17R-96 (Christensen et al., 2016) defines five classes of capital cost estimates. These classes are delineated in Table 4 and differ in accuracy and the required engineering details. Class 5 and 4 estimates are used for the purposes of pre-feasibility assessments and for screening the practicability of various technology options. Class 3 and 2 estimates are performed following completion of the front-end engineering design (FEED) when information on the key equipment and material requirements are known. The results of a Class 3 and 2 estimate are used for developing a refined business case for the preferred option or options, which is then used to obtain facility owner and investor approval to proceed with the implementation of a final solution (i.e., authority for expenditures). The next step is to conduct the full detailed design. A Class 1 estimate is conducted following the completion of the detailed design and prior to construction, or in some cases, may be prepared as a final go/no-go decision point in critical applications (e.g., applications offering marginal economics).

Here a Class 5 approach is applied to determine capital costs of common packaged units such as glycol dehydrators and gas sweetening units. A Class 4 approach is applied individual pieces of equipment and instrumentation identified on standard piping and instrumentation diagrams (P&ID). Clearstone maintains an inventory of over 200 P&ID standards for the different types of process units, packages and systems relevant to the mitigation of BC and GHG emissions.

Capital costs for pipelines are estimated based on the material, right-of-way and construction costs determined as a function of the length of the pipeline, size of piping and terrain conditions.

Ultimately, vendor pricing is obtained for the key components of the preferred solutions to advance these to a Class 3 capital cost estimate.

Normal practice is to express the capital costs on a before-tax basis and exclude overhead costs. In regulatory applications, it may also be required that contingency costs be excluded. Contingencies are not applied herein unless otherwise stated in the capital cost breakdown provided in the economic analysis results.

In assessing the capital costs for each technology, it is assumed, for simplicity, that the costs are all incurred in the first year. This may be true for low-capital-cost options, but for more capital-intensive options, the cost would normally be incurred in phases over several years to help minimize risks. In many applications, the total capital cost of a control technology is substantially greater than the direct costs of the basic uninstalled control device. For example, the uninstalled end control device (e.g., an incinerator) for a large-scale vapour collection and control application may represent less that 10 percent of the capital cost for the total installed system. Thus, it is important to account for all ancillary system, installation and other requirements needed to implement a safe, operable and reliable solution.

Capital costs may include the following major expense categories:

- Public consultation and regulatory approvals.
- Additional surface lease or right-of-way.
- Engineering, procurement and project-management services.
- Equipment and materials (including structural steel).
- Freight.
- Construction services.
- Installation of utility services (e.g., electric power, fuel gas, water, telecommunications, and roadways).
- Inspection and commissioning services.

Structural steel is required for aboveground piping systems, equipment bases, access platforms, stairs and handrails. Some structural work may be done at fabrication shops and then shipped to the site for reduced costs. Typical company specifications require all structural steel work to be sandblasted, primed and painted.

6.1.1.1 CLASS 4 AND 5 CAPITAL COST ESTIMATES

First, the purchase cost of each item is estimated using an adaptation of the method by Turton et al. (2018). Then a module cost is used to determine the total cost of each piece of equipment (including the associated materials and labor), by multiplying the purchased equipment cost evaluated at base conditions (i.e. carbon steel and ambient pressure) by a factor known as the bare module factor. Other factors, such as the material and pressure factors, are also used in this method to account for the effect of special construction materials and high operating pressures on the equipment cost. The total cost of the project is the sum of the module costs of all equipment. Lastly, the results are corrected with respect to time (month and year) to account for the effect of inflation on the determined costs; this is done using the Chemical Engineering Plant Index.

6.1.1.1.1 EQUIPMENT PURCHASE COST CORRELATION

The equipment purchase cost at base conditions is estimated using the following relation (Turton et al., 2018):

$$\log C^{\circ} = K_1 + K_2 \cdot \log A + K_3 (\log A)^2$$

Equation 11

Where,

C°	=	equipment purchase cost at standard conditions (atmospheric pressure and carbon steel is the equipment material) (USD).
A	=	equipment cost attribute.
K_1	=	Capital cost correlation parameter (see Table 6 for sample values).
K_2	=	Capital cost correlation parameter (see Table 6 for sample values).
K_3	=	Capital cost correlation parameter (see Table 6 for sample values).

Where appropriate, the parameters presented by Turton et al. (2018) have been updated based on more recent costs data from Clearstone's proprietary database of actual costs for equipment, instrumentation, materials and third-party services. Additionally, correlations for additional types and size ranges of equipment have been developed to allow full evaluation of all of the mitigation technologies considered.

6.1.1.1.2 TOTAL MODULE INSTALLED COST

The total module installed cost is estimated using the following relation:

$$C_M = \sum F_{BM} \cdot C^{\circ}$$

Equation 12

Where,

C_M	=	capital cost of the emissions mitigation technology (or module) to be implemented (USD).
F_{BM}	=	bare module factor, which accounts for variations in material and pressure, as well as for extra costs (installation and bulk material) to convert the equipment purchase cost to total capital cost (dimensionless).

The values of F_{BM} are determined using the following relation:

$$F_{BM} = B_1 + B_2 \cdot F_M \cdot F_P$$

Equation 13

Where,

B_1	=	parameter to obtain the bare module factor.
B_2	=	parameter to obtain the bare module factor.
F_M	=	material factor (dimensionless) (see Table 9).
F_P	=	pressure factor (dimensionless) (see Equation 14).

The values of F_P are determined using the following relation:

$$\log F_P = C_1 + C_2 * \log P + C_3 * (\log P)^2$$

Equation 14

C_1	=	parameter used to calculate the pressure factor (see Table 10).
C_2	=	parameter used to calculate the pressure factor (see Table 10).
C_3	=	parameter used to calculate the pressure factor (see Table 10).

The construction services may be further disaggregated into the following subcategories:

- Labour: Labour hours are directly related to the quantities of materials. The relative efficiency of labour depends on the availability of skilled craftsmen and the relative site conditions. Weather conditions may also be important if significant outside work is planned. Remote sites or areas with infrequent workloads may have problems maintaining a reasonable number and selection of qualified crafts people. If adequate numbers of skilled people are not available locally, training is an option if the project is large enough; or else craftsmen can be imported from other locations. Subsistence and travel pay usually is required when importing crafts people.
- Excavation/Civil: Soil conditions and the required depth of any underground systems may have a significant impact on costs. Compaction is also more difficult to achieve in certain situations and this increases the hours needed for backfill operations. Other matters to consider are the presence of rock, high water tables, poor soil conditions requiring removal, availability of import fill, site access for equipment, degree of hand excavation or backfill required, and constraints on pile driving due to proximity of sensitive operating equipment and buried piping.
- Concrete: Foundation costs can be substantial. If piling is required, then the cost of the concrete for pile caps is less than for a spread footing type foundation but the combined cost of piling and pile caps is usually higher. The depth of foundation needed to avoid frost lines (where applicable) is also a factor that can increase the amount of concrete required. Designing for earthquake zones increases the size of the foundations, rebar and anchor bolts and can add 20 to 30 percent to concrete costs. Additionally, soil and environmental conditions that attack concrete may require special mixes of concrete costing more and

special coating or treatment of rebar and anchor bolts. Pouring and curing of concrete may require expensive heating and hoarding if done during severe winter conditions.

Winterization requirements (where applicable) can drive up costs if heat tracing or additional shelters are required.

6.1.1.1.3 CORRECTIONS FROM A BASE YEAR

Corrections of costs from a base year are applied using the following relation:

$$C(y) = \left[C \cdot \frac{I_y}{I_{yb}} \right]$$

Equation 15

Where,

$C(y)$ = cost of an item in year y (USD)

I_y = composite index in year y (dimensionless)

I_{yb} = composite index in the base year for which a cost has been developed.

The Chemical Engineering Plant Composite Index (CEPCI) is used. It accounts for the cost of inflation on the Producer's Price Index (PPI) (Published by BLS) of the following individual items: equipment, buildings, construction labor, engineering and supervision. The Equipment Index includes indexes for heat exchangers, tanks, pumps, compressors, process machinery, pipes, valves and fittings, electrical equipment, process instruments and structural support. The CEPCI is based on price quotations from a statistically chosen sample of representative transactions obtained from a statistically chosen sample of representative producers in each of 600 or so industries. It includes 41 PPIs of important products for chemical plant construction obtained from the US Bureau of Labor statistics. The base year for this index is 1957.

6.1.1.1.4 CORRECTION FOR THE COUNTRY IN WHICH THE PROJECT WILL OCCUR

Location factors may be applied to convert costs from one country to another, since location affects the labour costs, governmental requirements, taxes, freight requirements and availability of services. However, these factors are influenced by currency exchange rates and vary greatly with time. Hence, all costs are first estimated in USD based on Canada/USA pricing. Equipment and materials costs are then adjusted to account for added duties and shipping costs where items would be imported.

Table 5: Estimate classification system as applied in engineering, procurement and construction for the process industries.				
Estimate Class	**Project Stage**	**Methodology**	**Expected Accuracy**	**Suggested Contingency**
Class 5	Concept Screening	• Capacity Factored • Parametric Models • Judgement • Analogy	L: -20% to -50% H: +30% to +100%	50%
Class 4	Study of Feasibility	• Equipment Factored • Parametric Models	L: -15% to -30% H: +20% to +50%	30%
Class 3	Budget Authorization or Control	• Semi-Detailed Unit Costs with Assembly Level Line Items.	L: -10% to -20% H: +10% to +30%	20%
Class 2	Control or Bid/Tender	• Detailed Unit Costs with Forced Detailed Take-off	L: -5% to -15% H: +5% to +20%	15%
Class 1	Check Estimate or Bid/Tender	• Detailed Unit Costs with Detailed Take-off	L: -3% to -10% H: +3% to +15%	5%

Source: AACE RP No. 18R-97.

Table 6: Sample purchase cost parameters.							
Equipment	**Description**	**K_1**	**K_2**	**K_3**	**Size Limits**	**Capacity Variable**	**Capacity Unit**
Compressors	Centrifugal, Axial & Reciprocating	2.2897	1.3604	-0.1027	450-3000	Fluid Power	kW
Compressors	Rotary	5.0355	-1.8002	0.8253	18-950	Fluid Power	kW
Drives	Gas Turbine	-21.7702	13.2175	-1.5279	7500-23000	Shaft Power	kW
Drives	Internal Combustion Reciprocating Engine	2.7635	0.8574	-0.0098	10-10000	Shaft Power	kW
Drives	Steam Turbine	2.6259	1.4398	-0.1776	70-7500	Shaft Power	kW
Drives	Electric-Explosion Proof	2.4604	1.4191	-0.1798	75-2600	Shaft Power	kW
Drives	Electric-Totally Enclosed	1.9560	1.7142	-0.2282	75-2600	Shaft Power	kW
Drives	Electric-Open/Drip-Proof	2.9508	1.0688	-0.1315	75-2600	Shaft Power	kW
Turbine	Axial - Gas	2.7051	1.4398	-0.1776	100-4000	Fluid Power	kW
Turbine	Radial Gas/Liquid Expander	2.2476	1.4965	-0.1618	100-1500	Fluid Power	kW
Pumps	Reciprocating	3.8696	0.3161	0.1220	0.1-200	Shaft Power	kW
Pumps	Positive Displacement (General)	3.4771	0.1350	0.1438	1-100	Shaft Power	kW
Pumps	Centrifugal	3.3892	0.0536	0.1538	1-300	Shaft Power	kW
Process Vessels	Horizontal	3.5565	0.3776	0.0905	0.1-628	Volume	m^3
Process Vessels	Vertical	3.4974	0.4485	0.1074	0.3-520	Volume	m^3

Table 6: Sample purchase cost parameters.							
Equipment	**Description**	**K_1**	**K_2**	**K_3**	**Size Limits**	**Capacity Variable**	**Capacity Unit**
Heat Exchangers	Shell & Tube (Floating Head)	4.8306	-0.8509	0.3187	10-1000	Area	m^2
Heat Exchangers	Shell & Tube (Fixed Tube)	4.3247	-0.3030	0.1634	10-1000	Area	m^2
Heat Exchangers	Shell & Tube (U-Tube)	4.1884	-0.2503	0.1974	10-1000	Area	m^2
Heat Exchangers	Air Cooler	4.0336	0.2341	0.0497	10-10000	Area	m^2
Heater	Molten Salt Heater	1.1979	1.4782	-0.0958	650 - 10,750	Duty	kW
Heater	Hot Water Heater	2.0829	0.9074	-0.0243	650 - 10,750	Duty	kW
Heater	Steam Boiler	6.9617	-1.4800	0.3161	1200-9400	Duty	kW

Source: Turton et al., 2018).

Table 7: Bare module factors for some equipment types.			
Equipment	**Subtype**	**Material of Construction**	**Bare Module Factor (F_{BM})**
Compressor	Reciprocating	Carbon Steel	3.3
Compressor	Reciprocating	Stainless Steel (Type 410)	7.0
Compressor	Reciprocating	Stainless Steel (Type 304)	7.0
Compressor	Reciprocating	Stainless Steel (Type 316)	7.0
Compressor	Reciprocating	Stainless Steel (Type 310)	7.0
Compressor	Reciprocating	Ni	13.9
Compressor	Rotary (vane, screw)	Carbon Steel	2.4
Compressor	Rotary (vane, screw)	Stainless Steel (Type 410)	5.0
Compressor	Rotary (vane, screw)	Stainless Steel (Type 304)	5.0
Compressor	Rotary (vane, screw)	Stainless Steel (Type 316)	5.0
Compressor	Rotary (vane, screw)	Stainless Steel (Type 310)	5.0
Compressor	Rotary (vane, screw)	Ni	9.8

Source: (Turton et al., 2018)

Table 8: B_1 and B_2 Parameters used to calculate the bare module factor for some equipment types.			
Equipment	**Subtype**	**B_1**	**B_2**
Heat Exchanger	Shell and Tube (Fixed Tube & U-Tube)	1.63	1.66
Heat Exchanger	Air Cooler	0.96	1.21
Pumps	Reciprocating	1.89	1.35
Pumps	Positive Displacement	1.89	1.35
Pumps	Centrifugal	1.89	1.35
Separator Vessels	Horizontal	1.49	1.52
Separator Vessels	Vertical	2.25	1.82

Source: (Turton et al., 2018)

Table 9: Material factors for different equipment and material options (e.g., CS: carbon steel and SS: stainless steel).			
Equipment	**Subtype**	**Material**	**Material Factor (F_M)**
Pump	Centrifugal	Cast Iron	1.0
Pump	Centrifugal	Carbon Steel	1.6
Pump	Centrifugal	Stainless Steel (Type 410)	2.3
Pump	Centrifugal	Stainless Steel (Type 304)	2.3
Pump	Centrifugal	Stainless Steel (Type 316)	2.3
Pump	Centrifugal	Stainless Steel (Type 310)	2.3
Pump	Centrifugal	Ni	4.4
Pump	Positive displacement (General)	Cast Iron	1.0
Pump	Positive displacement (General)	Carbon Steel	1.4
Pump	Positive displacement (General)	Stainless Steel (Type 410)	2.7
Pump	Positive displacement (General)	Stainless Steel (Type 304)	2.7
Pump	Positive displacement (General)	Stainless Steel (Type 316)	2.7
Pump	Positive displacement (General)	Stainless Steel (Type 310)	2.7
Pump	Positive displacement (General)	Cu	1.3
Pump	Positive displacement (General)	Ni	4.7
Pump	Positive displacement (General)	Ti	10.7
Pump	Positive displacement (Reciprocating)	Cast Iron	1.0
Pump	Positive displacement (Reciprocating)	Carbon Steel	1.5
Pump	Positive displacement (Reciprocating)	Stainless Steel (Type 410)	2.3
Pump	Positive displacement (Reciprocating)	Stainless Steel (Type 304)	2.3
Pump	Positive displacement (Reciprocating)	Stainless Steel (Type 316)	2.3
Pump	Positive displacement (Reciprocating)	Stainless Steel (Type 310)	2.3
Pump	Positive displacement (Reciprocating)	Cu	1.3
Pump	Positive displacement (Reciprocating)	Ni	3.9
Pump	Positive displacement (Reciprocating)	Ti	6.4
Shell and tube	Floating Head	CS-shell/CS-tube	1
Shell and tube	Floating Head	CS-shell/Cu-tube	1.3
Shell and tube	Floating Head	CS-shell/Ni-tube	N.A.
Shell and tube	Floating Head	CS-shell/SS(type 304)-tube	2.65
Shell and tube	Floating Head	CS-shell/Ti-tube	1.8
Shell and tube	Floating Head	SS(type 304)-shell/SS(type 304)-	4.6
Shell and tube	Floating Head	Cu-shell/Cu-tube	2.7
Shell and tube	Floating Head	Ni-shell/Ni-tube	1.7
Shell and tube	Floating Head	Ni-shell/Ni-tube	3.7
Shell and tube	Fixed Tube	CS-shell/CS-tube	11.4

Table 9: Material factors for different equipment and material options (e.g., CS: carbon steel and SS: stainless steel).			
Equipment	**Subtype**	**Material**	**Material Factor (F_M)**
Shell and tube	Fixed Tube	CS-shell/Cu-tube	1
Shell and tube	Fixed Tube	CS-shell/Ni-tube	1.3
Shell and tube	Fixed Tube	CS-shell/SS(type 304)-tube	N.A.
Shell and tube	Fixed Tube	CS-shell/Ti-tube	2.65
Shell and tube	Fixed Tube	SS(type 304)-shell/SS(type 304)-tube	1.8
Shell and tube	Fixed Tube	Cu-shell/Cu-tube	4.6
Shell and tube	Fixed Tube	Ni-shell/Ni-tube	2.7
Shell and tube	Fixed Tube	Ti-shell/Ti-tube	1.7
Shell and tube	U-Tube	CS-shell/CS-tube	3.7
Shell and tube	U-Tube	CS-shell/Cu-tube	11.4
Shell and tube	U-Tube	CS-shell/Ni-tube	1
Shell and tube	U-Tube	CS-shell/SS(type 304)-tube	1.3
Shell and tube	U-Tube	CS-shell/Ti-tube	N.A.
Shell and tube	U-Tube	SS(type 304)-shell/SS(type 304)-tube	2.65
Shell and tube	U-Tube	Cu-shell/Cu-tube	1.8
Shell and tube	U-Tube	Ni-shell/Ni-tube	4.6
Shell and tube	U-Tube	Ti-shell/Ti-tube	2.7
Aerial cooler	-	CS	1
Aerial cooler	-	SS (type 410)	2.9
Aerial cooler	-	SS (type 304)	2.9
Aerial cooler	-	SS (type 316)	2.9
Aerial cooler	-	SS (type 310)	2.9
Aerial cooler	-	Rubber-lined steel	N.A.
Aerial cooler	-	Al	1.4
Separator Vessels	-	CS	1.0
Separator Vessels	-	SS Clad	1.7
Separator Vessels	-	SS (type 410)	3.1
Separator Vessels	-	SS (type 304)	3.1
Separator Vessels	-	SS (type 316)	3.1
Separator Vessels	-	SS (type 310)	3.1
Separator Vessels	-	Ni Clad	3.6
Separator Vessels	-	Ni	7.1
Separator Vessels	-	Ti Clad	4.7
Separator Vessels	-	Ti	9.4

Source: (Turton et al., 2018)

Table 10: Pressure factors for process equipment.					
Equipment Type	**Equipment Description**	**C_1**	**C_2**	**C_3**	**Pressure Range (barg)**
Compressors	Centrifugal, Axial, Rotary, and Reciprocating	0	0	0	-
Drives	All	0	0	0	-
Heat Exchangers	Bayonet, Fixed Tube Sheet, Floating Head, Kettle Reboiler, and Y-Tube (both shell and tube)	0	0	0	P<5
		0.03881	-0.11272	0.08183	5<P<140
	Bayonet, Fixed Tube Sheet, Floating Head, Kettle Reboiler, and Y-Tube (tube only)	0	0	0	P,5
		-0.00164	-0.00627	0.0123	5<P<140
Heaters	Molten Salt and Hot Water	0	0	0	P<2
		-0.01633	0.056875	-0.00876	2<P<200
	Steam Boiler	0	0	0	P<20
		2.594072	-4.23476	1.722404	20<P<40
Pumps	Reciprocating	0	0	0	P<10
		-0.245382	0.259016	-0.01363	10<P<100
	Positive Displacement	0	0	0	P<10
		-0.245382	0.259016	-0.01363	10<P<100
	Centrifugal	0	0	0	P<10
		-0.3935	0.3957	-0.00226	10<P<100
Tanks	API	0	0	0	P<0.07
Turbines	Axial Gas Turbines	0	0	0	-
	Radial Gas/Liquid Expanders	0	0	0	-

Source: (Turton et al., 2018)

6.1.1.2 PIPELINE CAPITAL COST ESTIMATES

Pipeline capital costs are divided into the following basic categories:

- Pipe (based on size [OD and WT], and type [A106 or A333]) (USD/m).
- Pipe coating (based on pipe size [OD]) (USD/m)
- Fittings
- Pipeline Weights
- Construction (based on type of terrain [plain area, forest or swampy areas, remote]) (USD/m).
- Right-of-way
- Surveying and staking of the route.
- Engineering & Drafting
- Regulatory

These cost contributions are estimated individually using Equation 11 and then are summed to determine the total cost.

6.1.2 R&D COSTS

Some emerging and embryonic control technologies may be assessed a research and development cost. For simplicity, where these costs occur, it is assumed that they are all incurred in the first year; however, they would normally be incurred over a much longer period (e.g., 5 to 10 years).

6.1.3 OPERATING COSTS

The operating costs for a technology may include the following items (where applicable):

- Energy (fuel or electricity) consumption.
- Chemical and lube oil consumption.
- Maintenance (i.e., including parts, materials, and labour).
- Process operators and their associated overhead (i.e., including training, supervision and administration).
- Monitoring and third-party verification of emission reductions being achieved.
- Environmental reporting.
- Lease payments.
- Royalty payments.
- Insurance premiums.
- Other expenses (e.g., vehicles, subsistence, etc.) associated with operating and maintaining a control measure or device.

The amount and type of energy consumption required by a technology is determined based on the types of equipment or process units involved (e.g., pump, compressor, heater, boiler, refrigeration system, etc.), rigorous simulations of the process and modelling of the system losses (e.g., friction effects and heat losses). The typical efficiency of the devices involved is accounted for, and detailed engineering calculations are performed to estimate secondary energy demands such as the power requirements of fans.

Current commodity pricing for fuel, electricity and chemicals is applied to the assessed energy requirements where these commodities are purchased from third parties. Where electricity is produced on site, the costs are evaluated based on the cost of the fuel requirements by the installed power generator. Electricity purchased from the utility grid may include both an energy and a demand charge. The existence of demand changes may adversely affect the economics of simply reducing a facility's base load.

A direct commodity price of zero is applied to fuel gas in the following situations:

- The fuel gas is withdrawn from a waste stream.

- The fuel is extracted from the process, and there are no direct costs or penalties payable for doing so (e.g., royalties do not apply to these volumes).
- The process gas is owned by others (e.g., the producer or shipper), but the facility operator is given a shrinkage allowance to account for fuel use and system losses (e.g., station and unit blowdowns, compressor starts, fugitive equipment leaks, etc.), and there are no rewards to the facility operator for achieving better than the allowable shrinkage limit.

A non-zero price for fuel gas is only assigned where it is directly derived from a purchased energy input stream.

Fuel gas that is assigned a zero commodity price may have an indirect value, depending on the net impact its use has on a facility's product sales and purchased energy inputs. This impact is assessed for a given control measure by performing detailed mass and energy balances for the before (baseline) and after cases for each year of the project's life.

If changes in the amount of fuel gas withdrawn from the process do not increase product sales or reduce purchased energy inputs (e.g., due to system bottlenecks), but help to reduce production at the wellhead, then the applied measure extends the life of the reservoir. This benefit is not fully realized until the economic end of the reservoir's life and, therefore, is assigned a zero value for simplification purposes.

Chemical and lube oil consumption costs are assessed based on the type and size of equipment involved. Operating and maintenance costs are similarly estimated based on the size and type of equipment involved, and local labour rates. The data for lube oil and chemical consumption and operator and maintenance hours are estimated based on unpublished proprietary data for upstream and midstream facilities in Canada.

The costs of improved operating procedures are assessed based on the increased labour and possibly training requirements; while any instrumentation or software needs are assessed as a capital cost. An example of where an improved operating procedure may be is the implementation of a formal directed inspection and maintenance (DI&M) program to manage fugitive losses of hydrocarbons or steam from process systems.

Where applicable, operating cost estimates for DI&M programs are developed based on estimated component populations, per-component inspection costs, typical leak frequencies and per-component repair or replacement costs by type of component.

6.1.4 REMOVAL COSTS

Removal costs are separate from installation costs and apply where a process unit must be removed and replaced by an alternative unit (e.g., removing gas-operated pumps and replacing them with electric-powered units).

6.1.5 DECOMMISSIONING COSTS AND SALVAGE VALUE

Decommissioning costs at the end of a project are assumed negligible and the salvage value of an asset at the end of its useful life is assumed zero. If a project ends before the useful life of the asset is reached, then its salvage value is taken to be its estimated market value at that point in time rather than its depreciated book value.

A default asset life expectancy of 10 years is applied. This value is likely conservative where the control technology can be installed as a skid-mounted solution that may be easily reused at other locations.

The depreciated value of an asset is assessed using one of two user-selected methods: straight-line depreciation and the diminishing-balance method. These are delineated in the following subsections. The actual approach applied is declared in the detailed economic analysis results presented for each assessed mitigation technology.

Where a salvage value is assessed, it is included as project revenue in the year the value is realized.

6.1.5.1 STRAIGHT LINE DEPRECIATION FORMULA

The formula for annual depreciation using the straight-line method is as follows:

$$D = \frac{C - SV}{UL}$$

Equation 16

Where,

D	=	Annual depreciation (USD)
C	=	Initial cost of the asset (USD)
SV	=	Salvage value of the asset at the end of its useful life (USD) (e.g., as scrap metal).
UL	=	Expected useful life of the asset (years).

6.1.5.2 DIMINISHING BALANCE METHOD

With this method, a fixed percentage depreciation rate is charged in each accounting period to the net balance of the fixed asset. The net balance is the value of the asset that remains after deducting accumulated depreciation. The diminishing balance formula is:

$$D(t) = C \cdot (1 - r_D)^{t-1} \cdot r_D$$

Equation 17

Where,

$D(t)$ = depreciation in year t (USD).

r_D = fixed deprecation rate (%).

t = the number of years since the asset was purchased (years).

6.2 DETERMINATION OF COSTS AVOIDED AND REVENUES PRODUCED

Avoided or reduced costs are treated as a positive source of revenue for the purpose of the economic analysis. Avoided costs may result from energy-efficiency and waste-gas-utilization measures that reduce purchased fuel or electric power consumption. They may also include avoided or reduced emission taxes, where applicable.

Positive revenue also results from increased product sales, either at the facility where the control measure is implemented, or at downstream facilities that may benefit from the measure (such as a gas processing plant or petroleum refinery). Products may include natural gas, ethane, liquefied petroleum gas (LPG) (i.e., propane and butane), condensate (e.g., pentanes and heavier hydrocarbons), crude oil, hydrogen, refined products (e.g., diesel, gasoline, naphtha, gas oil, synthetic crude oil, lubricants, and chemicals), and even electricity and low-pressure ((LP) or high-pressure (HP) steam.

Avoided product or commodity losses and increases in product sales achieved through capture and production of waste gas streams and reduced fuel withdrawals from the process are all classified as conserved product and assessed an economic value. The value of the product depends on the type of product and where in the system it is conserved, the quality of the conserved product, and the applicable regulatory and contract incentives. Generally, the value of natural gas decreases in moving upstream due to increasing treating, processing and transport requirements.

6.2.1 COMMODITY PRICING

The applied commodity pricing is given in the detailed economic analysis results of the control option being evaluated. These results are presented in the results section of the appendix dealing with the type of opportunity being considered (such as vents and flares, compressors, steam systems, etc.).

Natural gas is normally priced on a calorific basis (e.g., in USD/GJ). If the natural gas contains non-methane hydrocarbons, then this increases the specific calorific value of the gas and, consequently, its price on a volumetric basis. If the natural gas is rich in condensable hydrocarbons, such as LPGs and Pentanes Plus (C_5+), then much greater value may be realized for the gas by first processing it to extract these fractions and then marketing them separately along with the remaining residue gas (i.e., mostly methane and ethane). This increased value typically occurs regardless of whether the LPG and Pentanes Plus is extracted and marketed at: (1) the facility where the control measure is installed, or (2) at a downstream facility such as a gas processing plant or petroleum refinery where such capabilities already exist. Extracting and marketing the LPGs and Pentanes Plus separately can easily double the total value realized, even after accounting for processing costs.

In this report, the application of calorific pricing is deemed to give the lower economic value of natural gas. The higher economic value of the natural gas is determined by applying calorific pricing to the residue gas fraction and appropriate commodity pricing to the LPG, Pentanes Plus and other distinct commodity fractions. If the final disposition of the natural gas is simply for use as fuel without any preprocessing to recovery of the LPG and Pentanes Plus fractions, then the lower pricing is applied to the natural gas. If the gas is pre-processed to recover the LPG and Pentanes Plus fractions before it is used or sold as fuel, then the higher natural gas pricing is applied, even if the processing occurs at a downstream facility (e.g., at a gas processing plant).

If condensate or Pentane Plus is blended into crude as a means of getting it to market, then it is assigned crude oil pricing rather than condensate pricing.

Overall, the actual value of avoided hydrocarbon losses is very site-specific and depends on many factors. Some important considerations are listed below:

- Cost to find, develop, produce, treat/upgrade/process/refine, and deliver the sales product,
- Parts of the system where emission reductions are achieved; for instance, gas conserved before processing is less valuable than gas conserved after processing.
- Impact of emission reductions on specific energy consumption, equipment life, workplace safety, operability, reliability and deliverability.
- Supply and Demand Constraints (conserved gas may become reserve production that is not sold until the reservoir and market conditions change to the point where demand exceeds supplied; this time lag reduces the present value of such gas.)
- Market prices and current contract requirements.
- Government taxes and royalties.

6.2.1.1 DETERMINATION OF THE HIGHER ECONOMIC VALUE OF AN ENERGY STREAM

The higher economic value of an energy stream is assessed using the following relation:

$$V_{Higher} = (Q_{V_{CH4}} \cdot p_{CH4} + Q_{L_{LPG}} \cdot p_{LPG} + Q_{L_{C5+}} \cdot p_{C5+} + Q_{H2} \cdot p_{H2} + e \cdot p_e) \cdot g_c$$

Equation 18

Where,

Q	=	commodity volumetric or mass flow rate.
V	=	value of a stream (USD/y)
p	=	commodity price (USD/unit of flow or mass measure)
e	=	electric power consumption (kW·h)
g_c	=	constant of proportionality
	=	365 d/y

The subscripts CH_4, LPG, C_5+, H_2 and e denote methane, liquefied petroleum gas, Pentanes Plus, hydrogen and electricity, respectively, and the subscripts V and L denote vapour and liquid, respectively.

Equation 1 is applicable where the energy either has or will be fractionated into its different commodity constituents so that the full market value of these constituents can be realized.

6.2.1.2 DETERMINATION OF THE LOWER ECONOMIC VALUE OF AN ENERGY STREAM

The lower value of an energy stream occurs when the stream is simply used for fuel in a combustion source without first extracting any of the more valuable commodities present in the stream. In such cases, the value of the stream is assessed based on its calorific value and the pricing of natural gas expressed on a calorific basis.

$$V_{Lower} = Q_V \cdot p_{CH4}$$

Equation 19

6.2.2 DETERMINATION OF THE NET OPERATING COST

The following relation determines the net operating cost:

$$NOC = OC + OCS$$

Equation 20

Where,

NOC = Net operating costs (USD/y)

OC = Operating cost of the considered control technology (USD). This cost is corrected for inflation, but otherwise is assumed constant with time. Actual values would tend to increase with time due to increasing maintenance needs as infrastructure ages and the accumulated effects of wear and tear need to be addressed.

OCS = Operating and maintenance savings from discontinued use of a replaced system (USD/y)

Typically, the incremental annual operating costs for a gas conservation project, including gas gathering and processing fees, may be assumed to be up to 10 per cent of the initial capital cost of installing the conservation facilities. If the gas contains 10 moles per kilomole (mol/kmol) hydrogen sulphide (H_2S) or more, then the incremental annual operating costs for the project may be assumed to be up to 20 per cent of the capital cost to initially install the conservation facilities.

6.2.3 EMISSION TAXES AND TRADABLE PERMITS

Some jurisdictions impose taxes on emissions of certain pollutants; this is usually expressed in terms of USD per tonne of pollutant emitted. Examples of pollutant emissions that may be taxed include SO_2, NO_x, VOC and CO_2 equivalent. Where CO_2 equivalent emissions are taxed, this is referred to as a carbon tax. If a Cap-and-Trade program exists, then emission reductions achieved below an operator's allowance may be registered and marketed as emission reduction credits.

Reductions in the amount of emission tax paid or the generation of marketable emission reduction credits (ERCs) from applying emission control measures are treated as sources of revenue. If the control technology actually increases the emissions of a taxable pollutant, then this is treated as negative revenue (or an operating cost).

These revenues are assessed based on the rules or laws of the applicable jurisdiction.

6.3 PROJECT LIFE

The life of a given control option depends on the demands of the application as well as the remaining economic life of the associated facility and its source of production or feedstock. In the upstream sector, new conventional oil and gas developments typically are assessed based on a 20-year life expectancy. Unconventional oil and gas developments may be assigned much short lives (e.g., heavy oil wells may only have 2 to 4 years of economic life through application of primary production techniques and an additional 4 to 6 years with subsequent application of enhanced recovery techniques). Additionally, as the upstream industry ages, the quality of finds in a given sedimentary basin gradually declines leading to reduced life expectancies for new projects.

The life of downstream facilities, such as petroleum refineries and petrochemical plants, may be much longer (e.g., 40 to 60+ years).

6.4 FINANCIAL RATES

6.4.1 DISCOUNT RATE

The discount rate and opportunity cost of equity in the upstream petroleum industry is usually taken to be a value in the range of 6 to 12 percent, depending on the segment of the industry. Typically, the discount rate increases in moving upstream through the industry in accordance with increasing financial risks. The actual value applied herein is declared in the sections where it is used and is shown in the results of the completed economic evaluations.

Most oil and gas ventures are expected to yield better than bank interest to compensate for the added risk involved.

6.4.2 OTHER DISCOUNT RATES

In addition to the overall financial discount rate, further discount factors may be applied to the relevant cost and revenue accounts for each control option to account for the applicable taxes, tax shields and royalties.

6.4.3 INFLATION RATES

An average inflation rate may be assumed for the assessed time series.

6.5 ECONOMIC ANALYSIS

6.5.1 NET PRESENT VALUE (NPV)

The net present value (NPV) is a time-based method used in evaluating investments, whereby the NPV of all cash outflows (such as the cost of the investment) and cash inflows (returns) is calculated using a given discount rate, usually the minimum required rate of return. An investment is acceptable if the NPV is positive. In capital budgeting, the discount rate used is called the hurdle rate and is usually equal to the incremental cost of capital.

The NPV of an investment may be assessed using the following relation:

$$NPV = \sum_{n=0}^{n=N} \frac{R_t}{(1+i)^n}$$

Equation 21

Where:

R_t	=	net cash inflow-outflows during a single period t
i	=	nominal discount rate or return that could be earned in alternative Investments
n	=	a variable indicating the number of years since the start of the project (y),
N	=	life expectancy of the project or life expectancy of the control technology, whichever is less (y).

If inflation is considered, then the discount rate is replaced with the nominal interest rate, which is determined using the following formula:

$$NPV = \sum_{n=1}^{n=N} \frac{R_t \cdot (1+k)^n}{(1+i)^n \cdot (1+k)^n}$$

Equation 22

$$i = (1+r)(1+k) - 1$$

Equation 23

Where,

i	=	the real discount rate, and
k	=	inflation rate.

If taxes and depreciation are considered, then the formula changes to:

$$NPV = \sum_{n=1}^{n=N} \frac{R_t \cdot (1-t_r) \cdot (D\&A) \cdot t_r \cdot (1+k)^n}{(1+i)^n \cdot (1+k)^n}$$

Equation 24

Where,

t_r	=	tax rate
$D\&A$	=	depreciation and amortization

6.5.2 RETURN ON INVESTMENT (ROI)

Return on investment (ROI) is a profitability measure that evaluates the performance of a business. ROI can be calculated in various ways. The most common method is Net Income as a percentage of Net Book Value (total assets minus intangible assets and liabilities). Other sources suggest factoring in the marginal tax rate for an after-tax ROI.

The return on investment (ROI) is determined here on both a before and after tax basis using the following relation:

$$ROI = \frac{Net\ Return\ on\ Investment}{Cost\ of\ Investment} \times 100\%$$

Equation 25

6.5.3 PAYBACK PERIOD

The payback period is determined using the following relation for the general case of an uneven cash flow:

$$Payback = Year\ Before\ Full\ Recovery + \frac{Unrecovered\ Amount\ at\ the\ Start\ of\ the\ Year}{Cash\ Flow\ During\ That\ Year}$$

Equation 26

6.5.4 INTERNAL RATE OF RETURN (IRR)

The internal rate of return (IRR) is used in capital budgeting to estimate the profitability of potential investments. It is the discount rate that makes the net present value of all cash flows from a project equal to the initial investment or market value of the portfolio. The formula for calculation of IRR is as follows:

$$0 = NPV = \sum_{n=0}^{n=N} \frac{R_t \cdot (1 - t_r) \cdot (D\&A) \cdot t_r}{(1 + IRR)^n}$$

Equation 27

Where:

IRR = the internal rate of return
N = the number of periods.

The term "internal" refers to the fact the calculation excludes external factors such as risk-free rate, inflation, the cost of capital, or various financial factors.

6.6 PRODUCTION DECLINE RATES

For projects at production facilities, it is appropriate to predict the change in inlet production with time and assess the corresponding impact on the opportunity activity levels. Decreases in activity levels may adversely affect the operability, performance and economics of the control measure. Production decline rates are not directly applicable to midstream or downstream facilities as they will tend to add production from new sources as contributions from existing sources decline.

Here three different models are considered for predicting production decline: zero decline, fixed rate of decline and generalized decline curves.

6.6.1 ZERO DECLINE

The zero decline model is applied to sources where the production activity levels are expected to remain relatively constant over the life of a project. This model will often apply to major oil terminals, gas processing plants, petroleum refineries and petrochemical facilities.

6.6.2 FIXED RATE OF DECLINE

The model for a fixed rate of decline is applied using the following relation:

$$Q(i) = Q(i-1) \cdot (1-D)$$

Equation 28

Where,

$Q(i)$	=	Production rate for year i.
$Q(i-1)$	=	Production rate for the previous year (i.e., year i-1).
D	=	Decline rate as a fraction of the production rate (dimensionless).

This model is used where production decline is expected, but insufficient information is available to develop a site-specific decline correlation. A default value of 0.08 is used for D in the absence of better information.

6.6.3 GENERALIZED DECLINE CURVES

A production decline curve may be derived from empirical observations of the production performance of oil and gas wells. Three types of decline have been observed historically: exponential, hyperbolic, and harmonic.

Decline curves represent production from the reservoir under "boundary dominated flow" conditions. This means that during the early life of a well, while it is still in "transient flow" and the reservoir boundaries have not been reached, decline curves should NOT be expected to be applicable. Typically, during transient flow, the decline rate is high, but it stabilizes once boundary dominated flow is reached. For most wells, this happens within a few months of production. However, for low permeability wells (tight gas wells, in particular) transient flow conditions can last several years, and strictly speaking, should not be analyzed by decline curve methods until after they have reached stabilization.

The generalized relation used to predict production decline rates for oil and natural gas wells is:

$$\frac{dQ}{dt} = -DQ^{(b+1)}$$

Equation 29

Where,

D	=	Decline as a fraction of production rate.
Q	=	Production rate at time t.
b	=	Constant (dimensionless) that varies from 0 to 1.

Decline analysis is valid when the recovery mechanism and the operating conditions do not vary with time. Single-phase liquid production, high-pressure gas, tubing-restricted gas production, and poor waterflood performance lead to $b = 0$ (Fetkovich). Under solution gas drive, the lower the gas relative permeability, the smaller is the quantity of gas produced; hence the decline in reservoir pressure is slower, and accordingly the decline rate is lower (higher value of b). Simulation studies for a range of gas and oil relative permeability values have indicated $0.1 < b < 0.4$, with the average resulting in $b = 0.3$. Above the bubble point pressure, $b = 0$ (exponential decline), while below the bubble point b increases for solution gas drive. Typical gas wells have b in the range of 0.4 to 0.5. Conventional (light oil) reservoirs under edge water drive (effective water drive) seem to exhibit $b = 0.5$.

If there is a mechanism present that maintains reservoir pressure, the production rate would essentially remain constant (under constant producing pressure) and the decline would tend towards zero. Examples of such mechanisms could be gas or water injection, an active water drive, or gas-cap drive. Since the decline in reservoir pressure is small, the production driving force remains large, and the decline in the producing rate is correspondingly smaller. For such cases, there is no theoretical reason why the decline coefficient could not be greater than one. Much later in the life of these reservoirs, when the oil column thins, the production rate would decline exponentially, and hydrocarbon production is replaced by water.

Situations where values of b > 1 occur are as follows:

- The interpretation of the available production data is wrong.
- The data is still in transient flow and has not reached “boundary-dominated flow”.

- Reservoir layering is occurring.
- Some fractured gas wells have values of b >1 (and sometimes as high as 3.5).

The exponential solution occurs when b = 0 and is given by the following relation:

$$Q(t) = Q_i e^{-D_i \cdot t}$$

Equation 30

Where

D_i	=	Initial decline.
Q_i	=	Initial production rate.
$Q(t)$	=	Production rate at time t.
t	=	Time.

For exponential decline the decline rate, D, is constant. If D varies, the decline is considered either hyperbolic or harmonic, in which case, an exponent "b" is incorporated into the equation of the decline curve, to account for the changing decline rate.

The following relation gives the hyperbolic solutions:

$$Q(t) = Q_i(1 + bD_i t)^{-\frac{1}{b}}, \ for\ 0 < b \leq 1$$

Equation 31

Harmonic decline is a special case of hyperbolic decline, with b = 1, i.e., the decline rate, *D*, is proportional to q and the above equation simplifies to:

$$Q(t) = \frac{Q_i}{(1 + Dt)}$$

Equation 32

This means that the decline rate, *D,* goes to zero when Q approaches zero. This type of performance is expected when very effective recovery mechanisms such as gravity drainage are active. Another example of harmonic decline is the production of high viscosity oil driven by encroaching edge-water. Due to unfavorable mobility ratio, early water breakthrough occurs, and the bulk of the oil production will be obtained at high water cuts. If the total fluid rate is kept constant, then the increasing amount of water in the total fluid will cause the oil production to decline. This decline in oil rate may follow a harmonic decline.

6.7 REFERENCES CITED

American Associate of Cost Engineers (AACE) International. 2011. 18R-97: Cost Estimate Classification System: As Applied in Engineering, Procurement, and Construction for the Process Industries.

Turton, R., Shaeiwitz, J. A., D. Bhattacharyya, and W.B. Whiting. 2018. *Analysis, Synthesis, and Design of Chemical Processes* (5th Edition). Upper Saddle River, NJ: Prentice Hall.

6.8 RESULTS

The results of each economic analysis performed, including all input information used in the analysis, are presented in *Appendix 6: Prefeasibility Assessment*. Where applicable, an updated assessment is provided for the preferred options in *Appendix 7: Recommended Mitigation Options*.

7 APPENDIX III: PREFEASIBILITY ASSESSMENT

This section presents the individual mitigation-strategy evaluation reports for the assessed mitigation options. Each report features an administrative title block and a mitigation-strategy notification block at the top of the first page for easy identification. The key information presented in each report includes the following:

- Site, operator and source identification (i.e., in an anonymized format for public copies of this report, and un-anonymized format for operator copies of this report).
- Identification of the mitigation strategy modeled.
- Key findings (economic impacts, pre-mitigation commodity losses, and total reductions of BC, GHG and CAC pollutants over the predicted project life).
- Listing of the key equipment additions and application input and output streams.
- Summary of the applied economic parameters (i.e., financial rates and commodity pricing).
- Project financials for each year of the project time series.
- Project financials for the last profitable year in the project time series after asset liquidation and final and tax adjustments and closing book entries.
- Avoided BC and GHG emissions for each year of the project time series.
- Avoided CAC emissions for each year of the project time series.
- Forecast site activity levels over the project time series.
- Applied emission factors for baseline and proposed mitigation equipment at the site.
- Itemized summary of the estimated capital costs of the key equipment and materials required for the simulated mitigation strategy.
- Itemized summary of the estimated installation costs of the key equipment and materials required for the simulated mitigation strategy.
- Itemized summary of the estimated operating costs in the first operating year of the mitigation project.

In the emission factor section of each report, the acronym BL is used as a Tag No. prefix to denote the emission factors applied to the given source for the baseline case (i.e., normal site conditions in the absence of any mitigation strategy).

7.1 MINI-GTL PLANTS

This section presents a process flow diagram (PFD) that depicts how the mini-GTL plant would be implemented, and a simulation flow diagram (SFD) showing how the mini-GTL process was modeled. Following these drawings are the individual techno-economic and environmental report and simulation report for the different mini-GTL technologies considered, namely:

- CompactGTL
- Emerging Fuels Technology (Models GS50, GS100 and GS250)
- Greyrock (Models M and P)

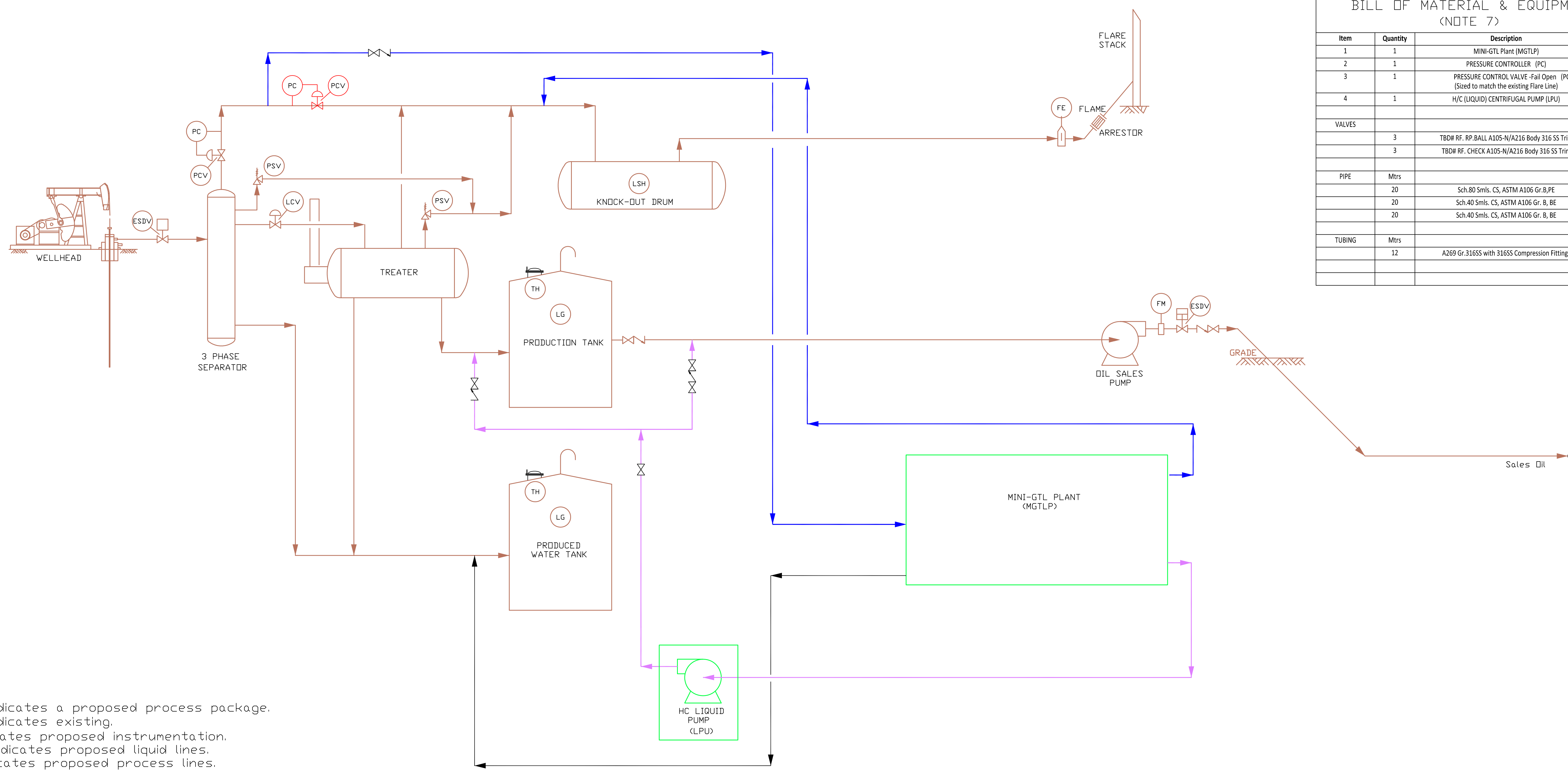
The stream numbers presented in the simulation reports match those used on the SFD.

7.2 LIQUIDS EXTRACTION BY JOULE THOMSON PLANT

This section presents a process flow diagram (PFD) that depicts how the Joule Thomson liquids extraction process would be implemented, and a simulation flow diagram (SFD) showing how the Joule Thomson liquids extraction process was modeled. Following these drawings are the individual techno-economic and environmental report and simulation report for two scenarios: (1) the compressors drivers are electric motors powered by the electric utility grid, and (2) the compressor drivers are natural gas fueled engines. The stream numbers presented in the simulation reports match those used on the SFD.

7.3 LIQUIDS EXTRACTION BY PROPANE REFRIGERATION

This section presents a process flow diagram (PFD) that depicts how the propane refrigeration liquids extraction process would be implemented, and a simulation flow diagram (SFD) showing how the process was modeled. Following these drawings are the individual techno-economic and environmental report and simulation report for two scenarios: (1) the compressors drivers are electric motors powered by the electric utility grid, and (2) the compressor drivers are natural gas fueled engines. The stream numbers presented in the simulation reports match those used on the SFD.



BILL OF MATERIAL & EQUIPMENT (NOTE 7)

Item	Quantity	Description	Size
1	1	MINI-GTL Plant (MGTLP)	TBD
2	1	PRESSURE CONTROLLER (PC)	TBD
3	1	PRESSURE CONTROL VALVE -Fail Open (PCV) (Sized to match the existing Flare Line)	TBD
4	1	H/C (LIQUID) CENTRIFUGAL PUMP (LPU)	TBD
VALVES			
	3	TBD# RF. RP.BALL A105-N/A216 Body 316 SS Trim	TBD
	3	TBD# RF. CHECK A105-N/A216 Body 316 SS Trim	TBD
PIPE	Mtrs		
	20	Sch.80 Smls. CS, ASTM A106 Gr.B,PE	TBD
	20	Sch.40 Smls. CS, ASTM A106 Gr. B, BE	TBD
	20	Sch.40 Smls. CS, ASTM A106 Gr. B, BE	TBD
TUBING	Mtrs		
	12	A269 Gr.316SS with 316SS Compression Fittings	1/2"

Notes:

1) Green indicates a proposed process package.
2) Brown indicates existing.
3) Red indicates proposed instrumentation.
4) Purple indicates proposed liquid lines.
5) Blue indicates proposed process lines.
6) Black indicates proposed utility lines & valves.
7) The presented Bill of Materials is intended to capture all of the major equipment components and materials, down to piping,valves, & instrumentation,required for the project. Contributions from structural steel and smaller items such as gaskets, studs,nuts,etc. shall be estimated separately.
8) Where a reciprocating engine generator or a gas turbine generator are chosen.
9) Where a Aerial condenser unit or Vessel condenser system are chosen.

Plot Date: YR MT DY 22-02-15 TIME 16:52

Major Equipment P&IDs		
Tag	Referenced Drawing	Number of Times Referenced
LPU	PID-15-Pum-Cen-000-500-1 (Pump)	1
GTL-Plant		1

REV	DATE	REVISION DESCRIPTION	BY
1.0	FEB 14/2022	PRELIMINARY	JMT

Discipline	Initials
Project Manager	D.P.
Process Engineer	
Checked By	
Designed By	PGS
Drawn By	JMT

ENGINEER'S STAMP

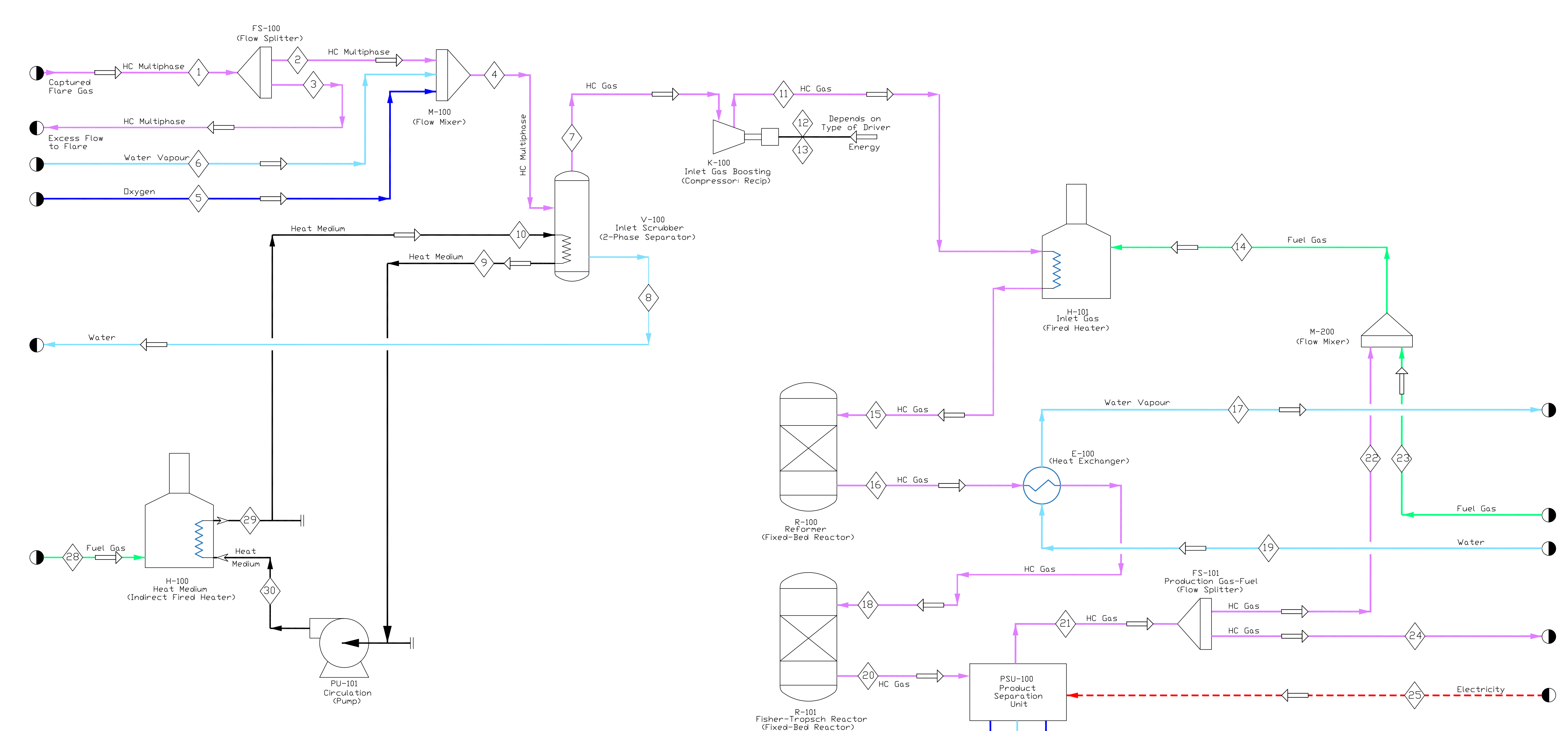
CLEARSTONE ENGINEERING
Calgary Canada

DRAWING TITLE

PROCESS FLOW DIAGRAM (PFD):
GENERIC OIL BATTERY
Associated Gas Liquids Extraction Scheme

PROJECT #.	SCALE:	CLIENT:	DRAWING IDENTIFICATION	REV
N/A	NTS	GENERAL	PFD-22-OB-OSP-AGV-038-1	1.2

Plot Date: YR MT DY 22-04-13 TIME 15:54



Notes:
1) Blue indicates process-gas/vapour.
2) Purple indicates hydrocarbon gas.
3) Green indicates natural gas.
4) Light blue indicates water.
5) Black indicates utility & equipment.
6) Dashed Red indicates electrical.

ITEM	REFERENCE FILES	REV	DATE	REVISION DESCRIPTION	BY	Discipline	Initials	ENGINEER'S STAMP
Excel File	SFD Stream Table Dwg 49-2B (Mini-GTL-Plant) (Shown on sheet 2)	0	APR 5/2022	GENERAL ISSUE	JT	Project Manager	D.P.	
		1	APR 13/2022	GENERAL REVISION	JT	Process-Engineer		
						Checked By	JMT	
						Designed By	P.S.	
						Drawn By	J.T.	

CLEARSTONE ENGINEERING
Calgary Canada

DRAWING TITLE

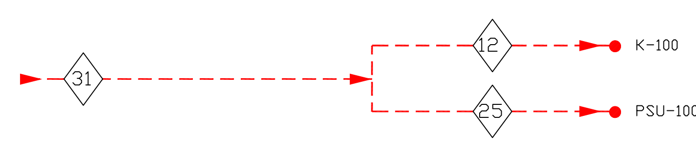
SIMULATION FLOWSHEET DIAGRAM (SFD):
KAZAKHSTAN OIL BATTERY (OPTION 9)

Mini-GTL Plant for Producing Naphtha and Diesel using Fischer-Tropsch Synthesis

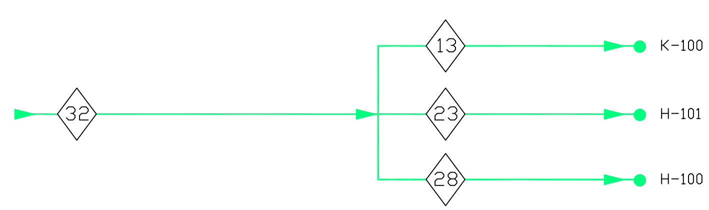
PROJECT #.	SCALE:	CLIENT:	DRAWING IDENTIFICATION	REV
N/A	NTS	GENERAL	SFD-22-OB-OSP-AGV-049-9A Sht.1 of 2	1

Plot Date: YR MT DY 22-04-13 TIME 15:56

ELECTRICAL DEMANDS



FUEL DEMANDS



Stream			Unit Operation (Stream Origin)		
ID No.	Fluid Type	Physical State	Tag No.	Service	Type
1	HC	Multiphase	----	Captured Flare Gas	Flare Gas Recovery Line
2	HC	Multiphase	FS-100	Gas to Process	Flow Splitter
3	HC	Multiphase	FS-100	Excess Flow to Flare	Flow Splitter
4	HC	Multiphase	M-100	Flow Mixer	Reformer Inlet Gas
5	Oxygen	Gas	M-100	Flow Mixer	Oxygen Plant
6	Water	Vapour	M-100	Flow Mixer	HP Steam Header
7	HC	Gas	V-100	Inlet Scrubber	2-Phase Separator
8	Water	Liquid	V-100	Inlet Scrubber	2-Phase Separator
9	Heat Medium	Liquid	V-100	Inlet Scrubber	2-Phase Separator
10	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
11	HC	Gas	K-100	Inlet Gas Boosting	Compressor: Recip.
12	Electricity	---	---	Electricity to K-100	Electric Utility System
13	Fuel Gas	Gas	---	Fuel Gas to K-100	Fuel Gas Header
14	Fuel Gas	Gas	M-200	Flow Mixer	Fuel Gas Header
15	HC	Gas	H-101	Fired Heater	Heater - Indirect Fired
16	HC	Gas	R-100	Reformer	Fixed-Bed Reactor
17	Water	Vapour	E-100	Heat Exchanger	HP Steam Header
18	HC	Gas	E-100	Heat Exchanger	Heat Recovery Unit
19	Water	Liquid	E-100	Heat Exchanger	Boiler Water Header
20	HC	Gas	R-101	Fischer-Tropsch Reactor	Fixed-Bed Reactor
21	HC	Gas	PSU-100	Product Separation	Crude Product Refining
22	HC	Gas	FS-101	Product Gas to Fuel H-101	Flow Splitter
23	Fuel Gas	Gas	---	Fuel Gas to H-101	Fuel Gas Header
24	HC	Gas	FS-101	Gas to Flare	Flow Splitter
25	Electricity	---	---	Electricity to GTL Plant	Electric Utility System
26	Naphtha	Liquid	PSU-100	Product Separation	Crude Product Refining
27	Diesel	Liquid	PSU-100	Product Separation	Crude Product Refining
28	Fuel Gas	Gas	---	Fuel Gas to H-100	Fuel Gas Header
29	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
30	Heat Medium	Liquid	PU-101	Circulation Pump	Pump - Centrifugal
33	Water	Liquid	PSU-100	Product Separation	Crude Product Refining

Notes:
1) Blue indicates process-gas/vapour.
2) Purple indicates hydrocarbon gas.
3) Green indicates natural gas.
4) Light blue indicates water.
5) Black indicates utility & equipment.
6) Dashed Red indicates electrical.

ITEM	REFERENCE FILES	REV	DATE	REVISION DESCRIPTION	BY
Excel File	SFD Stream Table Dwg 49-2b (Mini-GTL-Plant)	0	APR 5/2022	GENERAL ISSUE	JT
		1	APR 13/2020	GENERAL REVISION	JT

Discipline	Initials
Project Manager	D.P.
Process-Engineer	
Checked By	JMT
Designed By	P.S.
Drawn By	J.T.

ENGINEER'S STAMP

CLEARSTONE ENGINEERING
Calgary Canada

DRAWING TITLE

SIMULATION FLOWSHEET DIAGRAM (SFD):
KAZAKHSTAN OIL BATTERY (OPTION 9)
Mini-GTL Plant for Producing Naphtha and Diesel using Fischer-Tropsch Synthesis

PROJECT #.	SCALE:	CLIENT:	DRAWING IDENTIFICATION	REV
N/A	NTS	GENERAL	SFD-22-OB-OSP-AGV-049-9B Sht.2 of 2	1

REPORT: SOURCE MITIGATION ANALYSIS

Header Block

Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed

Time Series	**CEL Mitigation Code:**	OP-009-GSC	**End-Year**	**Asset Life:**	2032
	Start Year:	2022		**Viability:**	2032
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**		
	CEL Reference Code:	GTL	**Subcategory 2:**		
	Reference CEL Drawing No:	Unavailable	**Reference CEL Drawing Title:**	Unavailable	
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
	Optimization Objective Function:	Net Present Value Over Pay-Back Period Ratio	**Economic Scenario Name:**	None	

Optimization Search Space

Search Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.75**	0.60	1.20
Electric Generator Drive Type	**Reciprocating**	---	---
Number of Electric Generator Trains	**2.00**	1.00	10.00

Key Findings

Economic Impacts	**Capital Cost (USD):**	403,254,379	**Net Present Value (USD) (Before Tax):**	-86,392,664
	Project Life (Years):	10	**Net Present Value (USD) (After Tax):**	-86,392,664
	Asset Life Expectancy (Years):	10	**Return on Investment (%) (Before Tax):**	-21.42%
	Asset Salvage Value (USD):	0	**Return on Investment (%) (After Tax):**	-21.42%
	Payback Period (Years):	No Payback	**Internal Rate of Return (%):**	5.43%

Pre-Mitigation Commodity Losses	Value of Gas Losses (USD/y) Energy Basis	Value of Gas Losses (USD/y) Commodity Basis	Total Gas Loss (m^3/h)	Residue Gas (10^3 m^3/d)	Ethane (m^3/d liq)	LPG (m^3/d liq)	NGL (m^3/d)	Hydrogen (m^3/d)		
	0	30,154,630	30,104.0	512.8	439.8	311.8	32.0	0.0		

Lifetime GHG Emission Reductions	CH_4 (kilotonnes)	CO_2 (kilotonnes)	N_2O (kilotonnes)	CO_2E (kilotonnes)	Black Carbon (kilotonnes)
	13.6	2,377.2	0.0	2,719.2	2.4

Lifetime CAC Emission Reductions	VOC (tonnes)	CO (tonnes)	NO_x (tonnes)	H_2S (tonnes)	SO_2 (tonnes)	PM (tonnes)	PM_{10} (tonnes)	$PM_{2.5}$ (tonnes)		
	7,537.1	8,973.3	1,928.0	0.0	0.0	1,525.1	1,525.1	1,525.1		

Key Equipment Additions

Key Equipment or	Reference No.	Category	Subcategory 1	Subcategory 2 or Manufacturer Make And Model
	Mini_GTL_1_1	Mini-GTL Plant	Compact	
	VVN_1_1	Tank	API 650 - Fixed Roof	
	VVD_1_1	Tank	API 650 - Fixed Roof	

Applied Economic Parameters

Financial Rates	**Discount Rate (%):**	10.00	**Inflation Rate (%):**	3.00
	Depreciation Rate (%):	10.00	**Tax Rate (%)**	0.00
	Royalty Rate (%):	30.00	**Import Duty (%):**	0.00
	GHG Emission Fee (USD/Tonne):	$1.10	**CAC Emission Fee (USD/Tonne):**	0.00
Production Decline Model	**Model Type:**	Initial Linear Increase	**D (decline as a fraction of production):**	0.0000
			b (correlation constant):	Not Applicable

Commodity Prices	Natural Gas Purchases (USD/GJ)	Natural Gas Sales (USD/GJ)	Ethane (USD/m^3 Liq)	LPG (USD/L Liq)	NGL (USD/m^3 Liq)	Crude Oil (USD/m^3)	Hydrogen (USD/m^3)	Electricity Purchases (USD/kW·h)	Electricity Sales (USD/kW·h)	Diesel (USD/L Liq)	Naptha (USD / m3 Liq)
	$ -	$ -	$ 60.26	$ 0.14	$ 389.84	$ 471.70	$ 2.00	$ 0.04	$ -	$ 0.76	

REPORT: SOURCE MITIGATION ANALYSIS

	A	B	C	D	E	F	G	H	I	J	K	L
64	Financials (Time Series Results)											
65	Year	Gross Revenues	Costs		Asset Book Value	Salvage Value	Royalty Payment	Emission Fee	Net Revenues		Cumulative After Tax Earnings	
66			Capital	Operating					Before Tax	After Tax		
67		(Inflation Adjusted USD)							(Present Value USD)			
68	2022	86,630,791	403,254,379	6,603,014	362,928,941	161,931,247	8,843,398	-299,473	28,325,830	28,325,830	28,325,830	
69	2023	89,229,714		6,801,105	326,636,047	143,938,886	9,108,700	-299,473	30,848,337	30,848,337	59,174,167	
70	2024	91,906,606		7,005,138	293,972,442	125,946,526	9,381,961	-299,473	32,423,272	32,423,272	91,597,439	
71	2025	94,663,804		7,215,292	264,575,198	107,954,165	9,663,420	-299,473	33,254,095	33,254,095	124,851,534	
72	2026	97,503,718		7,431,751	238,117,678	89,961,804	9,953,323	-299,473	33,505,286	33,505,286	158,356,820	
73	2027	100,428,829		7,654,703	214,305,910	71,969,443	10,251,922	-299,473	33,309,555	33,309,555	191,666,375	
74	2028	103,441,694		7,884,345	192,875,319	53,977,082	10,559,480	-299,473	32,773,742	32,773,742	224,440,117	
75	2029	106,544,945		8,120,875	173,587,787	35,984,722	10,876,264	-299,473	31,983,628	31,983,628	256,423,745	
76	2030	109,741,294		8,364,501	156,229,009	17,992,361	11,202,552	-299,473	31,007,870	31,007,870	287,431,614	
77	2031	111,676,689		8,615,436	140,606,108	0	11,400,128	-295,878	29,430,101	29,430,101	316,861,715	
78	Last Profitable Year (After Asset Liquidation, Final Tax Adjustments and Closing Book Entries)											
79	2031	111,676,689	999	8,615,436	140,606,108	0	11,400,128	-295,878	29,430,101	29,430,101	316,861,715	
80												
81	Avoided GHG and BC Emissions (Time Series Results)											
82	Year	CH_4 (kt)	CO_2 (kt)	N_2O (kt)	CO_2E (kt)	Black Carbon (t)						
83	2022	1.4	238.0	0.0	272.2	250.0						
84	2023	1.4	238.0	0.0	272.2	250.0						
85	2024	1.4	238.0	0.0	272.2	250.0						
86	2025	1.4	238.0	0.0	272.2	250.0						
87	2026	1.4	238.0	0.0	272.2	250.0						
88	2027	1.4	238.0	0.0	272.2	250.0						
89	2028	1.4	238.0	0.0	272.2	250.0						
90	2029	1.4	238.0	0.0	272.2	229.9						
91	2030	1.4	238.0	0.0	272.2	211.5						
92	2031	1.3	235.1	0.0	269.0	194.6						
93												
94	Other Avoided Atmospheric Emissions (Time Series Results)											
95	Year	VOC (t)	CO (t)	NO_x (t)	H_2S (t)	SO_2 (t)	PM (t)	PM_{10} (t)	$PM_{2.5}$ (t)			
96	2022	0.8	0.9	0.2	0.0	0.0	152.7	152.7	152.7			
97	2023	0.8	0.9	0.2	0.0	0.0	152.7	152.7	152.7			
98	2024	0.8	0.9	0.2	0.0	0.0	152.7	152.7	152.7			
99	2025	0.8	0.9	0.2	0.0	0.0	152.7	152.7	152.7			
100	2026	0.8	0.9	0.2	0.0	0.0	152.7	152.7	152.7			
101	2027	0.8	0.9	0.2	0.0	0.0	152.7	152.7	152.7			
102	2028	0.8	0.9	0.2	0.0	0.0	152.7	152.7	152.7			
103	2029	0.8	0.9	0.2	0.0	0.0	152.7	152.7	152.7			
104	2030	0.8	0.9	0.2	0.0	0.0	152.7	152.7	152.7			
105	2031	0.7	0.9	0.2	0.0	0.0	150.9	150.9	150.9			
106												
107	Forecast Site Activity Data (Time Series Results - Part 1)											
108	Year	Production			Waste Gas Disposition			Incremental Energy Purchases				
109		Oil (10^3 m^3)	Gas (10^6 m^3)	Water (10^3 m^3)	Collected (10^6 m^3)	Conserved (10^6 m^3)	Flared (10^6 m^3)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)	
110	2022	960.72	263.71		263.71	92.91	170.80	0.00	0.00	0.00	114,155	
111	2023	960.72	263.71		263.71	92.91	170.80	0.00	0.00	0.00	114,155	
112	2024	960.72	263.71		263.71	92.91	170.80	0.00	0.00	0.00	114,155	
113	2025	960.72	263.71		263.71	92.91	170.80	0.00	0.00	0.00	114,155	
114	2026	960.72	263.71		263.71	92.91	170.80	0.00	0.00	0.00	114,155	
115	2027	960.72	263.71		263.71	92.91	170.80	0.00	0.00	0.00	114,155	
116	2028	960.72	263.71		263.71	92.91	170.80	0.00	0.00	0.00	114,155	
117	2029	883.87	242.62		242.61	92.91	149.70	0.00	0.00	0.00	114,155	
118	2030	813.16	223.21		223.20	92.91	130.29	0.00	0.00	0.00	114,155	
119	2031	748.10	205.35		205.35	91.80	113.55	0.00	0.00	0.00	112,786	
120												
121	Forecast Site Activity Data (Time Series Results - Part 2)											
122	Year	Incremental Product Sales					Incremental Utilization	Avoided Purchases				
123		Gas (10^6 m^3 Gas)	LPG (10^3 m^3 Liq)	NGL (10^3 m^3 Liq)	Oil (10^3 m^3)	Electricity (10^3 kW·h)	Fuel Gas (10^6 m^3 Gas)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)	
124	2022	0.00	0.00	0.00	0.00	0	32.02	0.00	66.39	42,451	0.00	
125	2023	0.00	0.00	0.00	0.00	0	32.02	0.00	66.39	42,451	0.00	
126	2024	0.00	0.00	0.00	0.00	0	32.02	0.00	66.39	42,451	0.00	
127	2025	0.00	0.00	0.00	0.00	0	32.02	0.00	66.39	42,451	0.00	
128	2026	0.00	0.00	0.00	0.00	0	32.02	0.00	66.39	42,451	0.00	
129	2027	0.00	0.00	0.00	0.00	0	32.02	0.00	66.39	42,451	0.00	
130	2028	0.00	0.00	0.00	0.00	0	32.02	0.00	66.39	42,451	0.00	
131	2029	0.00	0.00	0.00	0.00	0	32.02	0.00	66.39	42,451	0.00	
132	2030	0.00	0.00	0.00	0.00	0	32.02	0.00	66.39	42,451	0.00	

	A	B	C	D	E	F	G	H	I	J	K	L
133	2031	0.00	0.00	0.00	0.00	0	31.64	0.00	65.59	41,941	0.00	
134												
135	**Applied Emission Factors (EF) For Year One Emissions For Baseline (BL) and Simulated Equipment**											
136	**Source**			**Pollutant**	**EF (ng/J of Fuel)**	**Reference (Where Applicable) and Basis**						
137	**Category**	**Tag No.**	**DB EF Key**			**Basis**	**Author or Reporting Agency**		**Code**			
138	**Flares**	**BL FLARE_1**	**335**	**CH_4**	180.0	Calculated	US EPA		2018-U.S.EPAAP-42Table13.5-1			
139				**CO_2**	54,529.6	Calculated	NA					
140				**N_2O**	0.1	Referenced	WCI		2012-BCWCI.363(k)			
141				**BC**	19.7	Calculated	NA					
142				**VOC**	22.3	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
143				**CO**	133.0	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
144				**NO_x**	29.2	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-1			
145				**SO_2**	0.0	Calculated	NA					
146				**PM**	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
147				**PM_{10}**	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
148				**$PM_{2.5}$**	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
149	**Heaters and Boilers**	**Mini_GTL_1_1**	**7**	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
150				**CO_2**	83,629.7	Calculated	NA					
151				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
152				**BC**	0.6	Calculated	NA					
153				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
154				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
155				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
156				**SO_2**	0.0	Calculated	NA					
157				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
158				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
159				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
160	**Flares**	**FLARE_1**	**335**	**CH_4**	143.8	Calculated	US EPA		2018-U.S.EPAAP-42Table13.5-1			
161				**CO_2**	79,036.2	Calculated	NA					
162				**N_2O**	0.1	Referenced	WCI		2012-BCWCI.363(k)			
163				**BC**	0.0	Calculated	NA					
164				**VOC**	22.3	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
165				**CO**	133.0	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
166				**NO_x**	29.2	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-1			
167				**SO_2**	0.0	Calculated	NA					
168				**PM**	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
169				**PM_{10}**	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
170				**$PM_{2.5}$**	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
171												
172	**Capital Cost**											
173	**Equipment**	**Item**	**Category**	**Subcategory 1**	**Subcategory 2**	**Capacity or Rated Power Output**		**Price (USD)**	**FOB Point**	**Basis**		
174						**Value**	**Units of Measure**					
175		Mini_GTL_1_1	Mini-GTL Plant	Compact		541.87	10^3 m^3	179,531,142	NA	Predicted (Class 5)		
176		VVN_1_1	Tank	API 650 - Fixed Roof		1,497.97	m^3	217,751	NA	Predicted (Class 4)		
177		VVD_1_1	Tank	API 650 - Fixed Roof		957.80	m^3	174,715	NA	Predicted (Class 4)		
178		**E7**	**Engineering & Drafting**					21,703,581				
179		**Subtotal:**						201,627,189				
180	**Pipeline**	**Pipe Specifications**	**OD (mm)**			**Material:**			**Design P (kPa)**			
181			**WT (mm)**			**Length (km):**			**Coating:**			
182		**Item**	**Category**		**Material (USD)**	**Labour (USD)**		**Total (USD)**		**Basis**		
183		**PL1**	**Pipe**									
184		**PL2**	**Right-of-Way (ROW)**									
185		**PL3**	**ROW Land Survey**									
186		**PL4**	**Clearing**									
187		**PL5**	**Soil Stripping**									
188		**PL6**	**Timber Salvage**									
189		**PL7**	**Rock excavation**									
190		**PL8**	**Cathodic Protection**									
191		**PL9**	**Construction**									
192		**PL10**	**Engineering & Drafting**									
193		**PL11**	**Supervision**									
194		**PL12**	**Safety**									
195		**PL13**	**Reseeding ROW**									
196		**Subtotal:**										
197	**Materials & Services**	**Item**	**Category**		**Material (USD)**	**Labour (USD)**		**Total (USD)**		**Basis**		
198		**MS1**	**Equipment Setting**		0	24,825,610		24,825,610		Predicted		
199		**MS2**	**Foundations**		6,206,402	8,254,515		14,460,918		Predicted		
200		**MS3**	**Structural Steel**		6,206,402	3,103,201		9,309,604		Predicted		

	A	B	C	D	E	F	G	H	I	J	K	L
201		**MS4**	**Buildings**		3,723,841	3,723,841		7,447,683		Predicted		
202		**MS5**	**Insulation**		1,241,280	1,861,921		3,103,201		Predicted		
203		**MS6**	**Instruments**		7,447,683	2,979,073		10,426,756		Predicted		
204		**MS7**	**Electrical**		9,930,244	7,447,683		17,377,927		Predicted		
205		**MS8**	**Piping**		55,857,622	27,928,811		83,786,434		Predicted		
206		**MS9**	**Painting**		620,640	1,861,921		2,482,561		Predicted		
207		**MS10**	**Miscellaneous**		3,723,841	2,979,073		6,702,915		Predicted		
208		**MS11**	**Engineering & Drafting**		0	21,703,581		21,703,581		Predicted		
209		**MS12**	**Supervision**		Unavailable	0		0				
210		**MS13**	**Safety**		Unavailable	0		0				
211		**Subtotal:**						201,627,189				
212	**Summary**	**Total:**						403,254,379				
213		**Duties:**						0				
214		**Freight:**						Unavailable				
215		**Grand Total:**						403,254,379				
216	**Year 1 Operating Costs**											
217		**Operating**	**Hours Per Shift:**		Unknown	**Operator Hourly Labour Rate:**		$ 2.05				
218		**Labour**	**Shifts Per Day:**		Unknown	**Maintenance Hourly Labour Rate:**		$ 2.05				
219		**Item**	**Category**		**Material (USD**	**Labour (Hours)**	**Labour (USD)**	**Line Total (USD)**		**Basis**		
220	**Fixed**	**L1**	**Operating Labour**		0	1,080	2,214	2,214		Predicted		
221	**O&M Costs**	**L2**	**Maintenance Labour**		0	360	738	738		Predicted		
222		**L3**	**Direct Supervision**		0		399	399		Predicted		
223		**L4**	**Administration**		0		3,629,681	3,629,681		Predicted		
224		**L5**	**Unclassified Costs**					0		Predicted		
225		**Total Fixed O&M Costs:**						3,633,032		Predicted		
226	**Variable**	**SS1**	**Third-Party Services**					4,947		Predicted		
227	**O&M Costs**	**SS2**	**Parts & Consumables**					13,974		Predicted		
228		**SS3**	**Unclassified Costs**					2,951,062		Predicted		
229		**Total Variable O&M Costs:**						2,969,983		Predicted		
230	**Total O&M Costs**	**Total Fixed and Variable O&M Costs:**						6,603,014		Predicted		
231	**Purchased**	**PC1**	**Electricity**		4,452,054	0	0	4,452,054		Predicted		
232	**Commodities**	**PC2**	**Natural Gas**		0	0	0	0		Predicted		
233		**PC3**	**LPG**		0	0	0	0		Predicted		
234		**PC4**	**Diesel**		0	0	0	0		Predicted		
235	**Summary**	**Total:**						11,055,069				

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSC	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.75**	0.50	2.00

Proposed Equipment

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSC	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.75**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	1	2	3	4	5	6	7	8
- Fluid	HC	HC	HC	HC	HC	Not Known	HC	Not Known
- Physical State	Vapour	Vapour	Vapour	Vapour	Vapour	Unknown	Vapour	Unknown
- Temperature (°C)	40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Pressure (kPa)	800.0	800.0	800.0	800.0	800.0	---	800.0	---
- Total Molar Flowrate (kmole/h)	1,273.17	954.88	318.30	1,618.73	663.85	0.00	1,618.73	0.00
- Total Mass Flowrate (kg/h)	30176.9	22632.6	7544.4	43875.2	21242.6	0.0	43875.2	0.0
- Total Gas Volumetric Flowrate (Std m^3/h)	30104.0	22577.9	7526.1	38274.5	15696.7	---	38274.5	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	From Flare Line	FS-100	FS-100	M-100	Oxygen Plant	HP Steam Header	V-100	V-100
- Service:	---	Not Applicable	Not Applicable	Not Applicable	---	---	Inlet Scrubber	Inlet Scrubber

			1	2	3	4	5	6	7	8
- Type:			---	Flow Splitter	Flow Splitter	Mixer	---	---	2-Phase Separator	2-Phase Separator
Destination (Unit Operation):										
- Tag No.			FS-100	M-100	To Flare Line	V-100	M-100	M-100	K-100	Waste Water Header
- Service:			Not Applicable	Not Applicable	---	Inlet Scrubber	Not Applicable	Not Applicable	Inlet Gas Boosting	---
- Type:			Flow Splitter	Mixer	---	2-Phase Separator	Mixer	Mixer	Compressor: Recip.	---
Properties:			1	2	3	4	5	6	7	8
- Vapour Mole Fraction			1.000000	1.000000	1.000000	1.000000	1.000000	---	1.000000	---
- Liquid Mole Fraction			0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			23.702	23.702	23.702	27.105	31.999	---	27.105	---
- Mass Density (kg/m^3)			8.439	8.439	8.439	9.634	11.470	---	9.634	---
- Molar Density (kmole/m^3)			0.356	0.356	0.356	0.355	0.358	---	0.355	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			0.9669	0.9669	0.9669	0.9794	0.9925	---	0.9794	---
- Specific Heat Capacity (kJ/kmole·°C)			46.7971	46.7971	46.7971	39.4833	29.4594	---	39.4833	---
- Enthalpy (kJ/kmole)			-85,487	-85,487	-85,487	-50,404	60	---	-50,404	---
- Entropy (kJ/kmole·°C)			-202	-202	-202	-152	-95	---	-152	---
- Gross Heating Value (MJ/m^3)			48.3	48.3	48.3	28.5	0.0	---	28.5	---
- Net Heating Value (MJ/m^3)			43.3	43.3	43.3	25.6	0.0	---	25.6	---
- Sound Speed (m/s)			359.316	359.316	359.316	344.504	332.061	---	344.504	---
- Dew Point Temperature (°C)			40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Dew Point Pressure (°kPa)			896.4	896.4	896.4	896.4	896.4	---	896.4	---
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.033	0.033	0.033	0.033	0.030	---	0.033	---
- Viscosity (cp)			0.012	0.012	0.012	0.015	0.023	---	0.015	---
Composition (Mole Fraction):			1	2	3	4	5	6	7	8
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043380	0.043380	0.043380	0.025590	0.000001	---	0.025590	---
Oxygen	**O2**	**7782-44-7**	---	---	---	0.410107	0.999999	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
Carbon Dioxide	**CO2**	**124-38-9**	0.025205	0.025205	0.025205	0.014868	---	---	0.014868	---
Methane	**CH4**	**74-82-8**	0.641174	0.641174	0.641174	0.378224	---	---	0.378224	---
Ethane	**C2H6**	**74-84-0**	0.171376	0.171376	0.171376	0.101094	---	---	0.101094	---
Propane	**C3H8**	**74-98-6**	0.084805	0.084805	0.084805	0.050026	---	---	0.050026	---
i-Butane	**C4H10**	**75-28-5**	0.007275	0.007275	0.007275	0.004291	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	0.017510	0.017510	0.017510	0.010329	---	---	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	0.002545	0.002545	0.002545	0.001501	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	0.003010	0.003010	0.003010	0.001776	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	0.000100	0.000100	0.000100	0.000059	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	0.000175	0.000175	0.000175	0.000103	---	---	0.000103	---
Hexane	**C6H14**	**110-54-3**	0.000745	0.000745	0.000745	0.000439	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.000170	0.000170	0.000100	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	0.001975	0.001975	0.001975	0.001165	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.000190	0.000190	0.000112	---	---	0.000112	---

Toluene	**C7H8**	**108-88-3**	0.000165	0.000165	0.000165	0.000097	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.000040	0.000040	0.000024	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	0.000075	0.000075	0.000075	0.000044	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	0.000035	0.000035	0.000035	0.000021	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	0.000020	0.000020	0.000020	0.000012	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000015	0.000015	0.000009	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSC	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.75**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	9	10	11	12	13	14	15	16
- Fluid	Heat Medium	Heat Medium	HC	Electricity	Fuel Gas	HC	HC	HC
- Physical State	Liquid	Liquid	Vapour	Unknown	Gas	Vapour	Vapour	Vapour
- Temperature (°C)	120.00	120.00	192.34	---	39.90	39.90	1,050.00	1,050.00
- Pressure (kPa)	276.0	276.0	5,100.0	---	0.0	0.0	5,000.0	5,000.0
- Total Molar Flowrate (kmole/h)	0.00	0.00	1,618.73	---	0.00	112.81	1,618.73	3,608.57
- Total Mass Flowrate (kg/h)	0.0	0.0	43875.2	---	0.0	3031.7	43875.2	43874.7
- Total Gas Volumetric Flowrate (Std m^3/h)	---	---	38274.5	---	0.0	2667.4	38274.5	85324.0
- Total Liq Volumetric Flowrate (m^3/h)	0.0	0.0	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	3,170.011	---	---	---	---
Origin (Unit Operation):								
- Tag No.	V-100	H-100	K-100	Electric Utility System	Fuel Gas Header	M-200	H-101	R-100
- Service:	Inlet Scrubber	Boiler	Inlet Gas Boosting	---	---	Not Applicable	Heat Medium Heater	---

- Type:	2-Phase Separator	Heater	Compressor: Recip.	---	---	Mixer	Heater: Fired	---
Destination (Unit Operation):								
- Tag No.	PU-101	V-100	H-101	K-100	K-100	H-101	R-100	E-100
- Service:	Circulation	Inlet Scrubber	Heat Medium Heater	Inlet Gas Boosting	Inlet Gas Boosting	Heat Medium Heater	---	Boiler
- Type:	Pump	2-Phase Separator	Heater: Fired	Compressor: Recip.	Compressor: Recip.	Heater: Fired	---	Heat Exchanger: Shell and Tube
Properties:	9	10	11	12	13	14	15	16
- Vapour Mole Fraction	0.000000	0.000000	1.000000	---	1.000000	1.000000	1.000000	1.000000
- Liquid Mole Fraction	1.000000	1.000000	0.000000	---	0.000000	0.000000	0.000000	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	41.686	41.686	27.105	---	---	26.875	27.105	12.158
- Mass Density (kg/m^3)	1,025.000	1,025.000	36.987	---	---	0.996	12.411	5.584
- Molar Density (kmole/m^3)	---	---	1.365	---	---	0.037	0.458	0.459
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	---	0.9839	---	---	0.9986	1.0117	1.0086
- Specific Heat Capacity (kJ/kmole·°C)	135.4802	135.4802	48.4778	---	---	35.4385	77.7041	32.4041
- Enthalpy (kJ/kmole)	---	---	-44,103	---	---	-103,562	11,746	-12,049
- Entropy (kJ/kmole·°C)	---	---	-150	---	---	-59	-85	-25
- Gross Heating Value (MJ/m^3)	---	---	28.5	---	---	24.7	28.5	11.9
- Net Heating Value (MJ/m^3)	---	---	25.6	---	---	22.9	25.6	10.3
- Sound Speed (m/s)	---	---	418.851	---	---	355.689	682.497	1,113.676
- Dew Point Temperature (°C)	---	---	192.34	---	---	39.90	1,050.00	1,050.00
- Dew Point Pressure (°kPa)	---	---	5,196.4	---	---	96.4	5,096.4	5,096.4
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	---	0.057	---	---	0.032	0.194	0.201
- Viscosity (cp)	1.100	1.100	0.022	---	---	0.016	0.045	0.038

Composition (Mole Fraction):			9	10	11	12	13	14	15	16
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	---	---	---	---	0.000000	---	0.613921
Nitrogen	**N2**	**7727-37-9**	---	---	0.025590	---	0.062677	0.062677	0.025590	0.011479
Oxygen	**O2**	**7782-44-7**	---	---	0.410107	---	---	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.462700	0.462700	0.000000	---	0.000000	0.000000	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	0.014868	---	0.036417	0.036417	0.014868	0.006670
Carbon Monoxide	**CO**	**630-08-0**	---	---	---	---	0.553432	0.553432	---	0.367931
Methane	**CH4**	**74-82-8**	---	---	0.378224	---	0.249780	0.249780	0.378224	---
Ethane	**C2H6**	**74-84-0**	---	---	0.101094	---	0.044421	0.044421	0.101094	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	0.537300	0.537300	---	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	---	0.050026	---	0.030293	0.030293	0.050026	---
i-Butane	**C4H10**	**75-28-5**	---	---	0.004291	---	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	---	---	0.010329	---	0.022981	0.022981	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	---	---	0.001501	---	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	---	---	0.001776	---	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	---	---	0.000059	---	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	---	---	0.000103	---	---	---	0.000103	---

Hexane	**C6H14**	**110-54-3**	---	---	0.000439	---	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	0.000100	---	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	---	---	0.001165	---	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	0.000112	---	---	---	0.000112	---
Toluene	**C7H8**	**108-88-3**	---	---	0.000097	---	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	---	---	0.000003	---	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	---	---	0.000024	---	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	---	---	0.000044	---	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	---	---	0.000003	---	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	---	---	0.000021	---	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	---	---	0.000012	---	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	---	---	0.000009	---	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	---	---	0.000003	---	---	---	0.000003	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSC	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.75**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	17	18	19	20	21	22	23	24
- Fluid	Water	HC	Water	HC	HC	HC	Not Known	HC
- Physical State	Vapour	Vapour	Liquid	Vapour	Vapour	Vapour	Unknown	Vapour
- Temperature (°C)	226.32	240.00	14.40	240.00	39.90	39.90	---	39.90
- Pressure (kPa)	2,517.0	2,500.0	2,517.0	2,500.0	0.0	0.0	---	0.0
- Total Molar Flowrate (kmole/h)	1.83	3,608.57	1.83	1,684.68	660.89	112.81	0.00	548.08
- Total Mass Flowrate (kg/h)	32.9	43874.7	32.9	43874.7	17761.2	3031.7	0.0	14729.5
- Total Gas Volumetric Flowrate (Std m³/h)	43.2	85324.0	---	39834.0	15626.7	2667.4	---	12959.3
- Total Liq Volumetric Flowrate (m³/h)	---	---	0.0	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	E-100	E-100	Water Header	R-101	PSU-100	FS-101	Fuel Gas Header	FS-101
- Service:	Boiler	Boiler	---	---	---	Not Applicable	---	Not Applicable

- Type:	Heat Exchanger:	Heat Exchanger:	---	---	---	Flow Splitter	---	Flow Splitter
Destination (Unit Operation):								
- Tag No.	HP Steam Header	R-101	E-100	PSU-100	FS-101	M-200	M-200	Gas to Flare
- Service:	---	---	Boiler	---	Not Applicable	Not Applicable	Not Applicable	---
- Type:	---	---	Heat Exchanger: Shell and Tube	---	Flow Splitter	Mixer	Mixer	---
Properties:	17	18	19	20	21	22	23	24
- Vapour Mole Fraction	1.000000	1.000000	0.000000	1.000000	1.000000	1.000000	---	1.000000
- Liquid Mole Fraction	0.000000	0.000000	1.000000	0.000000	0.000000	0.000000	---	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	18.015	12.158	18.015	26.043	26.875	26.875	---	26.875
- Mass Density (kg/m^3)	13.071	7.321	1,000.364	16.505	0.996	0.996	---	0.996
- Molar Density (kmole/m^3)	0.726	0.602	55.529	0.634	0.037	0.037	---	0.037
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	1.0106	---	0.9602	0.9986	0.9986	---	0.9986
- Specific Heat Capacity (kJ/kmole·°C)	62.1935	29.5433	75.3123	52.2772	35.4385	35.4385	---	35.4385
- Enthalpy (kJ/kmole)	50,485	-37,028	1,134	-178,960	-103,562	-103,562	---	-103,562
- Entropy (kJ/kmole·°C)	112	-49	4	-126	-59	-59	---	-59
- Gross Heating Value (MJ/m^3)	0.0	11.9	0.0	20.4	24.7	24.7	---	24.7
- Net Heating Value (MJ/m^3)	0.0	10.3	0.0	18.8	22.9	22.9	---	22.9
- Sound Speed (m/s)	504.574	707.655	1,467.920	433.537	355.689	355.689	---	355.689
- Dew Point Temperature (°C)	226.32	240.00	240.00	240.00	39.90	39.90	---	39.90
- Dew Point Pressure (°kPa)	2,613.3	2,596.4	2,596.4	2,596.4	96.4	96.4	---	96.4
- Bubble Point Temperature (°C)	226.32	---	226.32	---	---	---	---	---
- Bubble Point Pressure (kPa)	1.6	---	1.6	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	0.045	0.100	0.589	0.065	0.032	0.032	---	0.032
- Viscosity (cp)	0.017	0.021	1.154	0.020	0.016	0.016	---	0.016

Composition (Mole Fraction):			17	18	19	20	21	22	23	24
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	0.613921	---	0.000000	0.000000	0.000000	---	0.000000
Nitrogen	**N2**	**7727-37-9**	---	0.011479	---	0.024588	0.062677	0.062677	---	0.062677
Water	**H2O**	**7732-18-5**	1.000000	0.000000	1.000000	0.570995	0.000000	0.000000	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	0.006670	---	0.014286	0.036417	0.036417	---	0.036417
Carbon Monoxide	**CO**	**630-08-0**	---	0.367931	---	0.217109	0.553432	0.553432	---	0.553432
Methane	**CH4**	**74-82-8**	---	---	---	0.097988	0.249780	0.249780	---	0.249780
Ethane	**C2H6**	**74-84-0**	---	---	---	0.017426	0.044421	0.044421	---	0.044421
Propane	**C3H8**	**74-98-6**	---	---	---	0.011884	0.030293	0.030293	---	0.030293
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.009015	0.022981	0.022981	---	0.022981
n-Pentane	**C5H12**	**109-66-0**	---	---	---	0.005002	---	---	---	---
Hexane	**C6H14**	**110-54-3**	---	---	---	0.004422	---	---	---	---
Heptane	**C7H16**	**142-82-5**	---	---	---	0.003905	---	---	---	---
Octane	**C8H18**	**111-65-9**	---	---	---	0.003445	---	---	---	---
Nonane	**C9H20**	**111-84-2**	---	---	---	0.003037	---	---	---	---
Decane	**C10H22**	**124-18-5**	---	---	---	0.002677	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	---	---	---	0.002359	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	---	---	---	0.002078	---	---	---	---

Tridecane	**C13H28**	**629-50-5**	---	---	---	0.001830	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	---	0.001612	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	---	0.001419	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	---	0.001250	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	---	0.001100	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	---	0.000969	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	---	0.000853	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	---	0.000751	---	---	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSC	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.75**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	25	26	27	28	29	30	31	32
- Fluid	Electricity	HC	HC	HC	Heat Medium	Heat Medium	Electricity	HC
- Physical State	Unknown	Liquid	Liquid	Vapour	Liquid	Liquid	Unknown	Vapour
- Temperature (°C)	---	39.90	39.90	40.00	120.00	120.00	---	40.00
- Pressure (kPa)	---	0.0	0.0	800.0	276.0	276.0	---	800.0
- Total Molar Flowrate (kmole/h)	---	45.36	16.48	0.00	0.00	0.00	---	0.00
- Total Mass Flowrate (kg/h)	---	5087.5	3696.5	0.0	0.0	0.0	---	0.0
- Total Gas Volumetric Flowrate (Sm^3/h)	---	---	---	0.0	---	---	---	0.0
- Total Liq Volumetric Flowrate (m^3/h)	---	7.6	4.8	---	0.0	0.0	---	---
- Energy Flowrate kW	9,861.410	---	---	---	---	---	19,722.819	---
Origin (Unit Operation):								
- Tag No.	Electric Utility System	PSU-100	PSU-100	Fuel Gas Header	H-100	PU-101	Electric Utility System	Fuel Gas Header
- Service:	---	---	---	---	Boiler	Circulation	---	---

			25	26	27	28	29	30	31	32
- Type:			---	---	---	---	Heater	Pump	---	---
Destination (Unit Operation):										
- Tag No.			PSU-100	Naphtha Storage	Diesel Storage	H-100	V-100	H-100	Mini-GTL Plant	Mini-GTL Plant
- Service:			---	---	---	Boiler	Inlet Scrubber	Boiler	---	---
- Type:			---	---	---	Heater	2-Phase Separator	Heater	---	---
Properties:			25	26	27	28	29	30	31	32
- Vapour Mole Fraction			---	0.000000	0.000000	1.000000	0.000000	0.000000	---	1.000000
- Liquid Mole Fraction			---	1.000000	1.000000	0.000000	1.000000	1.000000	---	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			---	112.161	224.249	23.702	41.686	41.686	---	23.702
- Mass Density (kg/m^3)			---	671.270	762.803	8.439	1,025.000	1,025.000	---	8.439
- Molar Density ($kmole/m^3$)			---	5.985	3.402	0.356	---	---	---	0.356
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	0.0063	0.0134	0.9669	---	---	---	0.9669
- Specific Heat Capacity (kJ/kmole·°C)			---	245.2118	472.3949	46.7971	135.4802	135.4802	---	46.7971
- Enthalpy (kJ/kmole)			---	-241,592	-437,240	-85,487	---	---	---	-85,487
- Entropy (kJ/kmole·°C)			---	-891	-1,701	-202	---	---	---	-202
- Gross Heating Value (MJ/m^3)			---	230.6	454.9	48.3	---	---	---	48.3
- Net Heating Value (MJ/m^3)			---	212.1	419.8	43.3	---	---	---	43.3
- Sound Speed (m/s)			---	969.621	1,355.431	359.316	---	---	---	359.316
- Dew Point Temperature (°C)			---	---	---	40.00	---	---	---	40.00
- Dew Point Pressure (°kPa)			---	---	---	896.4	---	---	---	896.4
- Bubble Point Temperature (°C)			---	39.90	39.90	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	96.4	96.4	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	338.5	338.5	---	---	---	---	---
- True Vapour Pressure (kPa)			---	96.4	96.4	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	0.110	0.076	0.033	---	---	---	0.033
- Viscosity (cp)			---	0.308	0.447	0.012	1.100	1.100	---	0.012
Composition (Mole Fraction):			25	26	27	28	29	30	31	32
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	---	0.043380	---	---	---	0.043380
Water	**H2O**	**7732-18-5**	---	0.000000	0.000000	0.000000	0.462700	0.462700	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	---	0.025205	---	---	---	0.025205
Methane	**CH4**	**74-82-8**	---	---	---	0.641174	---	---	---	0.641174
Ethane	**C2H6**	**74-84-0**	---	---	---	0.171376	---	---	---	0.171376
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	---	---	0.537300	0.537300	---	---
Propane	**C3H8**	**74-98-6**	---	---	---	0.084805	---	---	---	0.084805
i-Butane	**C4H10**	**75-28-5**	---	---	---	0.007275	---	---	---	0.007275
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.017510	---	---	---	0.017510
i-Pentane	**C5H12**	**78-78-4**	---	---	---	0.002545	---	---	---	0.002545
n-Pentane	**C5H12**	**109-66-0**	---	0.185773	---	0.003010	---	---	---	0.003010
Benzene	**C6H6**	**71-43-2**	---	---	---	0.000100	---	---	---	0.000100
Cyclohexane	**C6H12**	**110-82-7**	---	---	---	0.000175	---	---	---	0.000175
Hexane	**C6H14**	**110-54-3**	---	0.164245	---	0.000745	---	---	---	0.000745
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	---	0.000170	---	---	---	0.000170
Heptane	**C7H16**	**142-82-5**	---	0.145020	---	0.001975	---	---	---	0.001975
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	---	0.000190	---	---	---	0.000190

Toluene	**C7H8**	**108-88-3**	---	---	---	0.000165	---	---	---	0.000165
Ethylbenzene	**C8H10**	**100-41-4**	---	---	---	0.000005	---	---	---	0.000005
m-Xylene	**C8H10**	**108-38-3**	---	---	---	0.000040	---	---	---	0.000040
Octane	**C8H18**	**111-65-9**	---	0.127939	---	0.000075	---	---	---	0.000075
o-Xylene	**C8H10**	**95-47-6**	---	---	---	0.000005	---	---	---	0.000005
Nonane	**C9H20**	**111-84-2**	---	0.112808	---	0.000035	---	---	---	0.000035
Decane	**C10H22**	**124-18-5**	---	0.099427	---	0.000020	---	---	---	0.000020
Undecanes	**C11H24**	**1120-21-4**	---	0.087609	---	0.000015	---	---	---	0.000015
Dodecane	**C12H26**	**112-40-3**	---	0.077179	---	0.000005	---	---	---	0.000005
Tridecane	**C13H28**	**629-50-5**	---	---	0.187058	---	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	0.164740	---	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	0.145069	---	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	0.127737	---	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	0.112467	---	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	0.099017	---	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	0.087172	---	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	0.076740	---	---	---	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSC	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.75**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	33							
- Fluid	Water							
- Physical State	Liquid							
- Temperature (°C)	14.40							
- Pressure (kPa)	2,517.0							
- Total Molar Flowrate (kmole/h)	961.94							
- Total Mass Flowrate (kg/h)	17329.4							
- Total Gas Volumetric Flowrate (Std m^3/h)	---							
- Total Liq Volumetric Flowrate (m^3/h)	17.3							
- Energy Flowrate kW	---							
Origin (Unit Operation):								
- Tag No.	PSU-100							

- Service:			---						
- Type:			---						
Destination (Unit Operation):									
- Tag No.			Produced Water Header						
- Service:			---						
- Type:			---						
Properties:			33	0	0	0	0	0	0	0
- Vapour Mole Fraction			0.000000							
- Liquid Mole Fraction			1.000000							
- Solid Mole Fraction			---							
- Aqueous Mole Fraction			---							
- Molecular Weight			18.015							
- Mass Density (kg/m^3)			1,000.364							
- Molar Density ($kmole/m^3$)			55.529							
- API Gravity (°)			---							
- Compressibility Factor			---							
- Specific Heat Capacity (kJ/kmole·°C)			75.3123							
- Enthalpy (kJ/kmole)			1,134							
- Entropy (kJ/kmole·°C)			4							
- Gross Heating Value (MJ/m^3)			0.0							
- Net Heating Value (MJ/m^3)			0.0							
- Sound Speed (m/s)			1,467.920							
- Dew Point Temperature (°C)			240.00							
- Dew Point Pressure (°kPa)			2,596.4							
- Bubble Point Temperature (°C)			226.32							
- Bubble Point Pressure (kPa)			1.6							
- Reid Vapour Pressure (kPa)			---							
- True Vapour Pressure (kPa)			---							
- Thermal Conductivity (W/m·°C)			0.589							
- Viscosity (cp)			1.154							
Composition (Mole Fraction):			33	0	0	0	0	0	0	0
Name	**Formula**	**CAS No.**								
Water	**H2O**	**7732-18-5**	1.000000							

REPORT: SOURCE MITIGATION ANALYSIS

Header Block

Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed

Time Series	**CEL Mitigation Code:**	OP-009-GS50	**End-Year**	**Asset Life:**	2032
	Start Year:	2022		**Viability:**	2032
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**		
	CEL Reference Code:	GTL	**Subcategory 2:**		
	Reference CEL Drawing No:	Unavailable	**Reference CEL Drawing Title:**	Unavailable	
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
	Optimization Objective Function:	Net Present Value Over Pay-Back Period Ratio	**Economic Scenario Name:**	None	

Optimization Search Space

Search Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.60	1.20
Electric Generator Drive Type	**Reciprocating**	---	---
Number of Electric Generator Trains	**2.00**	1.00	10.00

Key Findings

Economic Impacts	**Capital Cost (USD):**	192,532,522	**Net Present Value (USD) (Before Tax):**	316,738,227
	Project Life (Years):	10	**Net Present Value (USD) (After Tax):**	316,738,227
	Asset Life Expectancy (Years):	10	**Return on Investment (%) (Before Tax):**	164.51%
	Asset Salvage Value (USD):	0	**Return on Investment (%) (After Tax):**	164.51%
	Payback Period (Years):	3.21	**Internal Rate of Return (%):**	38.74%

Pre-Mitigation Commodity Losses	**Value of Gas Losses (USD/y)**		**Total Gas Loss (m^3/h)**	**Residue Gas (10^3 m^3/d)**	**Ethane (m^3/d liq)**	**LPG (m^3/d liq)**	**NGL (m^3/d)**	**Hydrogen (m^3/d)**		
	Energy Basis	**Commodity Basis**								
	0	30,154,630	30,104.0	512.8	439.8	311.8	32.0	0.0		

Lifetime GHG Emission Reductions	**CH_4 (kilotonnes)**	**CO_2 (kilotonnes)**	**N_2O (kilotonnes)**	**CO_2E (kilotonnes)**	**Black Carbon (kilotonnes)**
	16.0	2,793.9	0.0	3,195.9	2.4

Lifetime CAC Emission Reductions	**VOC (tonnes)**	**CO (tonnes)**	**NO_x (tonnes)**	**H_2S (tonnes)**	**SO_2 (tonnes)**	**PM (tonnes)**	**PM_{10} (tonnes)**	**$PM_{2.5}$ (tonnes)**		
	8,858.4	10,546.4	2,266.0	0.0	0.0	1,792.4	1,792.4	1,792.4		

Key Equipment Additions

Key Equipment or	**Reference No.**	**Category**	**Subcategory 1**	**Subcategory 2 or Manufacturer Make And Model**
	Mini_GTL_1_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_2_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_3_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_4_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_5_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_6_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_7_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_8_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_9_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_10_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_11_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_12_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_13_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_14_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_15_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_16_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_17_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_18_1	Mini-GTL Plant	EFT FB 50	
	Mini_GTL_19_1	Mini-GTL Plant	EFT FB 50	

	A	B	C	D	E	F	G	H	I	J	K	L
66		Mini_GTL_20_1	Mini-GTL Plant			EFT FB 50						
67		Mini_GTL_21_1	Mini-GTL Plant			EFT FB 50						
68		Mini_GTL_22_1	Mini-GTL Plant			EFT FB 50						
69		Mini_GTL_23_1	Mini-GTL Plant			EFT FB 50						
70		Mini_GTL_24_1	Mini-GTL Plant			EFT FB 50						
71		Mini_GTL_25_1	Mini-GTL Plant			EFT FB 50						
72		Mini_GTL_26_1	Mini-GTL Plant			EFT FB 50						
73		Mini_GTL_27_1	Mini-GTL Plant			EFT FB 50						
74		Mini_GTL_28_1	Mini-GTL Plant			EFT FB 50						
75		Mini_GTL_29_1	Mini-GTL Plant			EFT FB 50						
76		Mini_GTL_30_1	Mini-GTL Plant			EFT FB 50						
77		Mini_GTL_31_1	Mini-GTL Plant			EFT FB 50						
78		Mini_GTL_32_1	Mini-GTL Plant			EFT FB 50						
79		Mini_GTL_33_1	Mini-GTL Plant			EFT FB 50						
80		Mini_GTL_34_1	Mini-GTL Plant			EFT FB 50						
81		Mini_GTL_35_1	Mini-GTL Plant			EFT FB 50						
82		Mini_GTL_36_1	Mini-GTL Plant			EFT FB 50						
83		Mini_GTL_37_1	Mini-GTL Plant			EFT FB 50						
84		Mini_GTL_38_1	Mini-GTL Plant			EFT FB 50						
85		Mini_GTL_39_1	Mini-GTL Plant			EFT FB 50						
86		Mini_GTL_40_1	Mini-GTL Plant			EFT FB 50						
87		Mini_GTL_41_1	Mini-GTL Plant			EFT FB 50						
88		Mini_GTL_42_1	Mini-GTL Plant			EFT FB 50						
89		Mini_GTL_43_1	Mini-GTL Plant			EFT FB 50						
90		VVN_1_1	Tank			API 650 - Fixed Roof						
91		VVD_1_1	Tank			API 650 - Fixed Roof						
92												
93						**Applied Economic Parameters**						
94	**Financial Rates**	**Discount Rate (%):**		10.00		**Inflation Rate (%):**					3.00	
95		**Depreciation Rate (%):**		10.00		**Tax Rate (%)**					0.00	
96		**Royalty Rate (%):**		30.00		**Import Duty (%):**					0.00	
97		**GHG Emission Fee (USD/Tonne):**		$1.10		**CAC Emission Fee (USD/Tonne):**					0.00	
98	**Production Decline Model**	**Model Type:**		Initial Linear Increase		**D (decline as a fraction of production):**					0.0000	
99						**b (correlation constant):**					Not Applicable	
100	**Commodity Prices**	**Natural Gas**		**Ethane**	**LPG**	**NGL**	**Crude Oil**	**Hydrogen**	**Electricity**		**Diesel**	**Naptha**
101		**Purchases (USD/GJ)**	**Sales (USD/GJ)**	**(USD/m^3 Liq)**	**(USD/L Liq)**	**(USD/m^3 Liq)**	**(USD/m^3)**	**(USD/m^3)**	**Purchases (USD/kW·h)**	**Sales (USD/kW·h)**	**(USD/L Liq)**	**(USD / m3 Liq)**
102		$ -	$ -	$ 60.26	$ 0.14	$ 389.84	$ 471.70	$ 2.00	$ 0.04	$ -	$ 0.76	
103												
104												
105												
106						**Financials (Time Series Results)**						
107	**Year**	**Gross Revenues**	**Costs**		**Asset Book Value**	**Salvage Value**	**Royalty Payment**	**Emission Fee**	**Net Revenues**		**Cumulative After Tax Earnings**	
108			**Capital**	**Operating**					**Before Tax**	**After Tax**		
109		**(Inflation Adjusted USD)**							**(Present Value USD)**			
110	2022	103,936,320	192,532,522	6,040,371	173,279,270	76,078,650	10,609,875	-359,293	62,174,650	62,174,650	62,174,650	
111	2023	107,054,410		6,221,582	155,951,343	67,625,467	10,928,171	-359,293	60,277,704	60,277,704	122,452,354	
112	2024	110,266,042		6,408,230	140,356,208	59,172,284	11,256,017	-359,293	58,126,187	58,126,187	180,578,541	
113	2025	113,574,023		6,600,476	126,320,588	50,719,100	11,593,697	-359,293	55,804,605	55,804,605	236,383,146	
114	2026	116,981,244		6,798,491	113,688,529	42,265,917	11,941,508	-359,293	53,379,662	53,379,662	289,762,808	
115	2027	120,490,681		7,002,445	102,319,676	33,812,733	12,299,753	-359,293	50,903,651	50,903,651	340,666,459	
116	2028	124,105,402		7,212,519	92,087,708	25,359,550	12,668,746	-359,293	48,417,219	48,417,219	389,083,678	
117	2029	125,599,679		7,428,894	82,878,937	16,906,367	12,821,293	-353,029	45,015,046	45,015,046	434,098,724	
118	2030	123,307,201		7,651,761	74,591,044	8,453,183	12,587,305	-336,491	40,338,780	40,338,780	474,437,503	
119	2031	117,358,010		7,881,314	67,131,939	0	11,980,054	-310,930	34,833,245	34,833,245	509,270,748	
120		**Last Profitable Year (After Asset Liquidation, Final Tax Adjustments and Closing Book Entries)**										
121	2031	117,358,010	999	7,881,314	67,131,939	0	11,980,054	-310,930	34,833,245	34,833,245	509,270,748	
122												
123						**Avoided GHG and BC Emissions (Time Series Results)**						
124	**Year**	**CH_4 (kt)**	**CO_2 (kt)**	**N_2O (kt)**	**CO_2E (kt)**	**Black Carbon (t)**						
125	2022	1.6	285.5	0.0	326.6	249.9						
126	2023	1.6	285.5	0.0	326.6	249.9						
127	2024	1.6	285.5	0.0	326.6	249.9						
128	2025	1.6	285.5	0.0	326.6	249.9						
129	2026	1.6	285.5	0.0	326.6	249.9						
130	2027	1.6	285.5	0.0	326.6	249.9						
131	2028	1.6	285.5	0.0	326.6	249.9						
132	2029	1.6	280.6	0.0	320.9	229.8						
133	2030	1.5	267.4	0.0	305.9	211.4						
134	2031	1.4	247.1	0.0	282.7	194.5						
135												
136						**Other Avoided Atmospheric Emissions (Time Series Results)**						

	A	B	C	D	E	F	G	H	I	J	K
137	Year	VOC (t)	CO (t)	NO_x (t)	H_2S (t)	SO_2 (t)	PM (t)	PM_{10} (t)	$PM_{2.5}$ (t)		
138	2022	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
139	2023	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
140	2024	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
141	2025	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
142	2026	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
143	2027	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
144	2028	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
145	2029	0.9	1.1	0.2	0.0	0.0	180.0	180.0	180.0		
146	2030	0.8	1.0	0.2	0.0	0.0	171.6	171.6	171.6		
147	2031	0.8	0.9	0.2	0.0	0.0	158.5	158.5	158.5		
148											
149	Forecast Site Activity Data (Time Series Results - Part 1)										
150	Year	Production			Waste Gas Disposition			Incremental Energy Purchases			
151		Oil (10^3 m^3)	Gas (10^6 m^3)	Water (10^3 m^3)	Collected (10^6 m^3)	Conserved (10^6 m^3)	Flared (10^6 m^3)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)
152	2022	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
153	2023	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
154	2024	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
155	2025	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
156	2026	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
157	2027	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
158	2028	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
159	2029	883.87	242.62		242.61	109.53	133.09	0.00	0.00	0.00	134,548
160	2030	813.16	223.21		223.20	104.40	118.81	0.00	0.00	0.00	128,251
161	2031	748.10	205.35		205.35	96.47	108.88	0.00	0.00	0.00	118,518
162											
163	Forecast Site Activity Data (Time Series Results - Part 2)										
164	Year	Incremental Product Sales					Incremental Utilization	Avoided Purchases			
165		Gas (10^6 m^3 Gas)	LPG (10^3 m^3 Liq)	NGL (10^3 m^3 Liq)	Oil (10^3 m^3)	Electricity (10^3 kW·h)	Fuel Gas (10^6 m^3 Gas)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)
166	2022	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
167	2023	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
168	2024	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
169	2025	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
170	2026	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
171	2027	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
172	2028	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
173	2029	0.00	0.00	0.00	0.00	0	37.75	0.00	78.26	50,043	0.00
174	2030	0.00	0.00	0.00	0.00	0	35.98	0.00	74.60	47,698	0.00
175	2031	0.00	0.00	0.00	0.00	0	33.25	0.00	68.93	44,075	0.00
176											
177	Applied Emission Factors (EF) For Year One Emissions For Baseline (BL) and Simulated Equipment										
178		Source		Pollutant	EF (ng/J of Fuel)	Reference (Where Applicable) and Basis					
179	Category	Tag No.	DB EF Key			Basis	Author or Reporting Agency	Code			
180	Flares	BL FLARE_1	335	CH_4	180.0	Calculated	US EPA	2018-U.S.EPAAP-42Table13.5-1			
181				CO_2	54,529.6	Calculated	NA				
182				N_2O	0.1	Referenced	WCI	2012-BCWCI.363(k)			
183				BC	19.7	Calculated	NA				
184				VOC	22.3	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2			
185				CO	133.0	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2			
186				NO_x	29.2	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-1			
187				SO_2	0.0	Calculated	NA				
188				PM	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas			
189				PM_{10}	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas			
190				$PM_{2.5}$	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas			
191	Heaters and Boilers	Mini_GTL_1_1	7	CH_4	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2			
192				CO_2	83,629.7	Calculated	NA				
193				N_2O	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2			
194				BC	0.6	Calculated	NA				
195				VOC	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2			
196				CO	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1			
197				NO_x	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1			
198				SO_2	0.0	Calculated	NA				
199				PM	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1			
200				PM_{10}	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1			
201				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1			
202	Heaters and Boilers	Mini_GTL_2_1	7	CH_4	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2			
203				CO_2	83,629.7	Calculated	NA				
204				N_2O	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2			
205				BC	0.6	Calculated	NA				
206				VOC	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2			

	A	B	C	D	E	F	G	H	I	J	K	L
207				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
208				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
209				SO_2	0.0	Calculated	NA					
210				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
211				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
212				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
213	Heaters and	Mini_GTL_3_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
214	Boilers			CO_2	83,629.7	Calculated	NA					
215				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
216				BC	0.6	Calculated	NA					
217				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
218				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
219				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
220				SO_2	0.0	Calculated	NA					
221				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
222				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
223				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
224	Heaters and	Mini_GTL_4_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
225	Boilers			CO_2	83,629.7	Calculated	NA					
226				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
227				BC	0.6	Calculated	NA					
228				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
229				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
230				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
231				SO_2	0.0	Calculated	NA					
232				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
233				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
234				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
235	Heaters and	Mini_GTL_5_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
236	Boilers			CO_2	83,629.7	Calculated	NA					
237				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
238				BC	0.6	Calculated	NA					
239				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
240				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
241				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
242				SO_2	0.0	Calculated	NA					
243				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
244				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
245				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
246	Heaters and	Mini_GTL_6_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
247	Boilers			CO_2	83,629.7	Calculated	NA					
248				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
249				BC	0.6	Calculated	NA					
250				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
251				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
252				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
253				SO_2	0.0	Calculated	NA					
254				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
255				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
256				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
257	Heaters and	Mini_GTL_7_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
258	Boilers			CO_2	83,629.7	Calculated	NA					
259				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
260				BC	0.6	Calculated	NA					
261				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
262				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
263				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
264				SO_2	0.0	Calculated	NA					
265				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
266				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
267				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
268	Heaters and	Mini_GTL_8_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
269	Boilers			CO_2	83,629.7	Calculated	NA					
270				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
271				BC	0.6	Calculated	NA					
272				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
273				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
274				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
275				SO_2	0.0	Calculated	NA					
276				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
277				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			

	A	B	C	D	E	F	G	H	I	J	K	L
278				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
279	Heaters and	Mini_GTL_9_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
280	Boilers			CO_2	83,629.7	Calculated	NA					
281				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
282				BC	0.6	Calculated	NA					
283				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
284				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
285				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
286				SO_2	0.0	Calculated	NA					
287				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
288				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
289				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
290	Heaters and	Mini_GTL_10_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
291	Boilers			CO_2	83,629.7	Calculated	NA					
292				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
293				BC	0.6	Calculated	NA					
294				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
295				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
296				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
297				SO_2	0.0	Calculated	NA					
298				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
299				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
300				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
301	Heaters and	Mini_GTL_11_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
302	Boilers			CO_2	83,629.7	Calculated	NA					
303				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
304				BC	0.6	Calculated	NA					
305				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
306				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
307				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
308				SO_2	0.0	Calculated	NA					
309				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
310				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
311				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
312	Heaters and	Mini_GTL_12_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
313	Boilers			CO_2	83,629.7	Calculated	NA					
314				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
315				BC	0.6	Calculated	NA					
316				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
317				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
318				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
319				SO_2	0.0	Calculated	NA					
320				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
321				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
322				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
323	Heaters and	Mini_GTL_13_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
324	Boilers			CO_2	83,629.7	Calculated	NA					
325				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
326				BC	0.6	Calculated	NA					
327				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
328				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
329				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
330				SO_2	0.0	Calculated	NA					
331				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
332				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
333				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
334	Heaters and	Mini_GTL_14_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
335	Boilers			CO_2	83,629.7	Calculated	NA					
336				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
337				BC	0.6	Calculated	NA					
338				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
339				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
340				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
341				SO_2	0.0	Calculated	NA					
342				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
343				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
344				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
345	Heaters and	Mini_GTL_15_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
346	Boilers			CO_2	83,629.7	Calculated	NA					
347				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			

	A	B	C	D	E	F	G	H	I	J	K	L
348				**BC**	0.6	Calculated	NA					
349				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
350				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
351				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
352				**SO_2**	0.0	Calculated	NA					
353				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
354				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
355				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
356	**Heaters and Boilers**	**Mini_GTL_16_**	**7**	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
357				**CO_2**	83,629.7	Calculated	NA					
358				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
359				**BC**	0.6	Calculated	NA					
360				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
361				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
362				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
363				**SO_2**	0.0	Calculated	NA					
364				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
365				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
366				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
367	**Heaters and Boilers**	**Mini_GTL_17_**	**7**	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
368				**CO_2**	83,629.7	Calculated	NA					
369				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
370				**BC**	0.6	Calculated	NA					
371				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
372				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
373				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
374				**SO_2**	0.0	Calculated	NA					
375				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
376				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
377				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
378	**Heaters and Boilers**	**Mini_GTL_18_**	**7**	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
379				**CO_2**	83,629.7	Calculated	NA					
380				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
381				**BC**	0.6	Calculated	NA					
382				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
383				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
384				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
385				**SO_2**	0.0	Calculated	NA					
386				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
387				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
388				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
389	**Heaters and Boilers**	**Mini_GTL_19_**	**7**	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
390				**CO_2**	83,629.7	Calculated	NA					
391				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
392				**BC**	0.6	Calculated	NA					
393				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
394				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
395				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
396				**SO_2**	0.0	Calculated	NA					
397				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
398				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
399				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
400	**Heaters and Boilers**	**Mini_GTL_20_**	**7**	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
401				**CO_2**	83,629.7	Calculated	NA					
402				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
403				**BC**	0.6	Calculated	NA					
404				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
405				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
406				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
407				**SO_2**	0.0	Calculated	NA					
408				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
409				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
410				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
411	**Heaters and Boilers**	**Mini_GTL_21_**	**7**	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
412				**CO_2**	83,629.7	Calculated	NA					
413				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
414				**BC**	0.6	Calculated	NA					
415				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
416				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
417				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
418				**SO_2**	0.0	Calculated	NA					

	A	B	C	D	E	F	G	H	I	J	K	L
419				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
420				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
421				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
422	Heaters and Boilers	Mini_GTL_22_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
423				CO_2	83,629.7	Calculated	NA					
424				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
425				BC	0.6	Calculated	NA					
426				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
427				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
428				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
429				SO_2	0.0	Calculated	NA					
430				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
431				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
432				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
433	Heaters and Boilers	Mini_GTL_23_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
434				CO_2	83,629.7	Calculated	NA					
435				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
436				BC	0.6	Calculated	NA					
437				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
438				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
439				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
440				SO_2	0.0	Calculated	NA					
441				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
442				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
443				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
444	Heaters and Boilers	Mini_GTL_24_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
445				CO_2	83,629.7	Calculated	NA					
446				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
447				BC	0.6	Calculated	NA					
448				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
449				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
450				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
451				SO_2	0.0	Calculated	NA					
452				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
453				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
454				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
455	Heaters and Boilers	Mini_GTL_25_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
456				CO_2	83,629.7	Calculated	NA					
457				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
458				BC	0.6	Calculated	NA					
459				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
460				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
461				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
462				SO_2	0.0	Calculated	NA					
463				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
464				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
465				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
466	Heaters and Boilers	Mini_GTL_26_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
467				CO_2	83,629.7	Calculated	NA					
468				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
469				BC	0.6	Calculated	NA					
470				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
471				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
472				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
473				SO_2	0.0	Calculated	NA					
474				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
475				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
476				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
477	Heaters and Boilers	Mini_GTL_27_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
478				CO_2	83,629.7	Calculated	NA					
479				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
480				BC	0.6	Calculated	NA					
481				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
482				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
483				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
484				SO_2	0.0	Calculated	NA					
485				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
486				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
487				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
488	Heaters and	Mini_GTL_28_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			

	A	B	C	D	E	F	G	H	I	J	K	L
489	Boilers			CO_2	83,629.7	Calculated	NA					
490				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
491				BC	0.6	Calculated	NA					
492				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
493				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
494				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
495				SO_2	0.0	Calculated	NA					
496				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
497				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
498				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
499	Heaters and	Mini_GTL_29_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
500	Boilers			CO_2	83,629.7	Calculated	NA					
501				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
502				BC	0.6	Calculated	NA					
503				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
504				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
505				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
506				SO_2	0.0	Calculated	NA					
507				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
508				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
509				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
510	Heaters and	Mini_GTL_30_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
511	Boilers			CO_2	83,629.7	Calculated	NA					
512				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
513				BC	0.6	Calculated	NA					
514				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
515				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
516				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
517				SO_2	0.0	Calculated	NA					
518				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
519				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
520				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
521	Heaters and	Mini_GTL_31_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
522	Boilers			CO_2	83,629.7	Calculated	NA					
523				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
524				BC	0.6	Calculated	NA					
525				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
526				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
527				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
528				SO_2	0.0	Calculated	NA					
529				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
530				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
531				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
532	Heaters and	Mini_GTL_32_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
533	Boilers			CO_2	83,629.7	Calculated	NA					
534				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
535				BC	0.6	Calculated	NA					
536				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
537				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
538				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
539				SO_2	0.0	Calculated	NA					
540				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
541				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
542				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
543	Heaters and	Mini_GTL_33_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
544	Boilers			CO_2	83,629.7	Calculated	NA					
545				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
546				BC	0.6	Calculated	NA					
547				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
548				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
549				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
550				SO_2	0.0	Calculated	NA					
551				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
552				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
553				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
554	Heaters and	Mini_GTL_34_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
555	Boilers			CO_2	83,629.7	Calculated	NA					
556				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
557				BC	0.6	Calculated	NA					
558				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
559				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			

	A	B	C	D	E	F	G	H	I	J	K	L
560				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
561				SO_2	0.0	Calculated	NA					
562				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
563				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
564				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
565	Heaters and Boilers	Mini_GTL_35_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
566				CO_2	83,629.7	Calculated	NA					
567				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
568				BC	0.6	Calculated	NA					
569				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
570				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
571				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
572				SO_2	0.0	Calculated	NA					
573				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
574				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
575				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
576	Heaters and Boilers	Mini_GTL_36_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
577				CO_2	83,629.7	Calculated	NA					
578				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
579				BC	0.6	Calculated	NA					
580				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
581				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
582				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
583				SO_2	0.0	Calculated	NA					
584				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
585				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
586				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
587	Heaters and Boilers	Mini_GTL_37_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
588				CO_2	83,629.7	Calculated	NA					
589				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
590				BC	0.6	Calculated	NA					
591				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
592				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
593				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
594				SO_2	0.0	Calculated	NA					
595				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
596				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
597				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
598	Heaters and Boilers	Mini_GTL_38_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
599				CO_2	83,629.7	Calculated	NA					
600				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
601				BC	0.6	Calculated	NA					
602				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
603				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
604				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
605				SO_2	0.0	Calculated	NA					
606				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
607				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
608				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
609	Heaters and Boilers	Mini_GTL_39_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
610				CO_2	83,629.7	Calculated	NA					
611				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
612				BC	0.6	Calculated	NA					
613				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
614				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
615				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
616				SO_2	0.0	Calculated	NA					
617				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
618				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
619				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
620	Heaters and Boilers	Mini_GTL_40_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
621				CO_2	83,629.7	Calculated	NA					
622				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
623				BC	0.6	Calculated	NA					
624				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
625				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
626				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
627				SO_2	0.0	Calculated	NA					
628				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
629				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			

	A	B	C	D	E	F	G	H	I	J	K	L
630				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
631	**Heaters and Boilers**	**Mini_GTL_41_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
632				CO_2	83,629.7	Calculated	NA					
633				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
634				BC	0.6	Calculated	NA					
635				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
636				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
637				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
638				SO_2	0.0	Calculated	NA					
639				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
640				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
641				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
642	**Heaters and Boilers**	**Mini_GTL_42_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
643				CO_2	83,629.7	Calculated	NA					
644				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
645				BC	0.6	Calculated	NA					
646				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
647				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
648				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
649				SO_2	0.0	Calculated	NA					
650				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
651				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
652				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
653	**Heaters and Boilers**	**Mini_GTL_43_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
654				CO_2	83,629.7	Calculated	NA					
655				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
656				BC	0.6	Calculated	NA					
657				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
658				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
659				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
660				SO_2	0.0	Calculated	NA					
661				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
662				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
663				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
664	**Flares**	**FLARE_1**	**335**	CH_4	137.0	Calculated	US EPA		2018-U.S.EPAAP-42Table13.5-1			
665				CO_2	83,629.7	Calculated	NA					
666				N_2O	0.1	Referenced	WCI		2012-BCWCI.363(k)			
667				BC	0.0	Calculated	NA					
668				VOC	22.3	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
669				CO	133.0	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
670				NO_x	29.2	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-1			
671				SO_2	0.0	Calculated	NA					
672				PM	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
673				PM_{10}	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
674				$PM_{2.5}$	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
675												

						Capital Cost						
676												
677	**Equipment**	**Item**	**Category**	**Subcategory 1**	**Subcategory 2**	**Capacity or Rated Power Output**		**Price (USD)**	**FOB Point**	**Basis**		
678						**Value**	**Units of Measure**					
679		Mini_GTL_1_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
680		Mini_GTL_2_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
681		Mini_GTL_3_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
682		Mini_GTL_4_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
683		Mini_GTL_5_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
684		Mini_GTL_6_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
685		Mini_GTL_7_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
686		Mini_GTL_8_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
687		Mini_GTL_9_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
688		Mini_GTL_10_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
689		Mini_GTL_11_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
690		Mini_GTL_12_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
691		Mini_GTL_13_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
692		Mini_GTL_14_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
693		Mini_GTL_15_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		

	A	B	C	D	E	F	G	H	I	J	K	L
694		Mini_GTL_16_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
695		Mini_GTL_17_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
696		Mini_GTL_18_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
697		Mini_GTL_19_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
698		Mini_GTL_20_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
699		Mini_GTL_21_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
700		Mini_GTL_22_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
701		Mini_GTL_23_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
702		Mini_GTL_24_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
703		Mini_GTL_25_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
704		Mini_GTL_26_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
705		Mini_GTL_27_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
706		Mini_GTL_28_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
707		Mini_GTL_29_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
708		Mini_GTL_30_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
709		Mini_GTL_31_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
710		Mini_GTL_32_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
711		Mini_GTL_33_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
712		Mini_GTL_34_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
713		Mini_GTL_35_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
714		Mini_GTL_36_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
715		Mini_GTL_37_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
716		Mini_GTL_38_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
717		Mini_GTL_39_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
718		Mini_GTL_40_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
719		Mini_GTL_41_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
720		Mini_GTL_42_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
721		Mini_GTL_43_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
722		VVN_1_1	Tank	API 650 - Fixed Roof		1,797.57	m^3	239,924	NA	Predicted (Class 4)		
723		VVD_1_1	Tank	API 650 - Fixed Roof		1,149.36	m^3	190,546	NA	Predicted (Class 4)		
724		**E7**	**Engineering & Drafting**					11,734,427				
725		**Subtotal:**						96,266,261				
726	**Pipeline**	**Pipe Specifications**	**OD (mm)**			**Material:**			**Design P (kPa)**			
727			**WT (mm)**			**Length (km):**			**Coating:**			
728		**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
729		**PL1**	**Pipe**									
730		**PL2**	**Right-of-Way (ROW)**									
731		**PL3**	**ROW Land Survey**									
732		**PL4**	**Clearing**									
733		**PL5**	**Soil Stripping**									
734		**PL6**	**Timber Salvage**									
735		**PL7**	**Rock excavation**									
736		**PL8**	**Cathodic Protection**									
737		**PL9**	**Construction**									

	A	B	C	D	E	F	G	H	I	J	K	L
738		**PL10**	**Engineering & Drafting**									
739		**PL11**	**Supervision**									
740		**PL12**	**Safety**									
741		**PL13**	**Reseeding ROW**									
742		**Subtotal:**										
743	**Materials & Services**	**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
744		**MS1**	**Equipment Setting**		0	11,663,585		11,663,585		Predicted		
745		**MS2**	**Foundations**		2,915,896	3,878,142		6,794,038		Predicted		
746		**MS3**	**Structural Steel**		2,915,896	1,457,948		4,373,844		Predicted		
747		**MS4**	**Buildings**		1,749,538	1,749,538		3,499,076		Predicted		
748		**MS5**	**Insulation**		583,179	874,769		1,457,948		Predicted		
749		**MS6**	**Instruments**		3,499,076	1,399,630		4,898,706		Predicted		
750		**MS7**	**Electrical**		4,665,434	3,499,076		8,164,510		Predicted		
751		**MS8**	**Piping**		26,243,067	13,121,533		39,364,600		Predicted		
752		**MS9**	**Painting**		291,590	874,769		1,166,359		Predicted		
753		**MS10**	**Miscellaneous**		1,749,538	1,399,630		3,149,168		Predicted		
754		**MS11**	**Engineering & Drafting**		0	11,734,427		11,734,427		Predicted		
755		**MS12**	**Supervision**		Unavailable	0		0				
756		**MS13**	**Safety**		Unavailable	0		0				
757		**Subtotal:**						96,266,261				
758	**Summary**	**Total:**						192,532,522				
759		**Duties:**						0				
760		**Freight:**						Unavailable				
761		**Grand Total:**						192,532,522				
762	**Year 1 Operating Costs**											
763		**Operating Labour**	**Hours Per Shift:**		Unknown	**Operator Hourly Labour Rate:**		$ 2.05				
764			**Shifts Per Day:**		Unknown	**Maintenance Hourly Labour Rate:**		$ 2.05				
765		**Item**	**Category**		**Material (USD**	**Labour (Hours)**	**Labour (USD)**	**Line Total (USD)**		**Basis**		
766	**Fixed O&M Costs**	**L1**	**Operating Labour**		0	31,320	64,206	64,206		Predicted		
767		**L2**	**Maintenance Labour**		0	10,440	21,402	21,402		Predicted		
768		**L3**	**Direct Supervision**		0		11,557	11,557		Predicted		
769		**L4**	**Administration**		0		1,744,157	1,744,157		Predicted		
770		**L5**	**Unclassified Costs**					0		Predicted		
771		**Total Fixed O&M Costs:**						1,841,322		Predicted		
772	**Variable O&M Costs**	**SS1**	**Third-Party Services**					160,765		Predicted		
773		**SS2**	**Parts & Consumables**					497,010		Predicted		
774		**SS3**	**Unclassified Costs**					3,541,274		Predicted		
775		**Total Variable O&M Costs:**						4,199,049		Predicted		
776	**Total O&M Costs**	**Total Fixed and Variable O&M Costs:**						6,040,371		Predicted		
777	**Purchased Commodities**	**PC1**	**Electricity**		5,340,406	0	0	5,340,406		Predicted		
778		**PC2**	**Natural Gas**		0	0	0	0		Predicted		
779		**PC3**	**LPG**		0	0	0	0		Predicted		
780		**PC4**	**Diesel**		0	0	0	0		Predicted		
781	**Summary**	**Total:**						11,380,777				

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS50	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Proposed Equipment

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS50	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	1	2	3	4	5	6	7	8
- Fluid	HC	HC	HC	HC	HC	Not Known	HC	Not Known
- Physical State	Vapour	Vapour	Vapour	Vapour	Vapour	Unknown	Vapour	Unknown
- Temperature (°C)	40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Pressure (kPa)	800.0	800.0	800.0	800.0	800.0	---	800.0	---
- Total Molar Flowrate (kmole/h)	1,273.17	1,145.61	127.56	1,942.07	796.46	0.00	1,942.07	0.00
- Total Mass Flowrate (kg/h)	30176.9	27153.5	3023.5	52639.3	25485.8	0.0	52639.3	0.0
- Total Gas Volumetric Flowrate (Std m³/h)	30104.0	27087.8	3016.2	45919.9	18832.1	---	45919.9	---
- Total Liq Volumetric Flowrate (m³/h)	---	---	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	From Flare Line	FS-100	FS-100	M-100	Oxygen Plant	HP Steam Header	V-100	V-100
- Service:	---	Not Applicable	Not Applicable	Not Applicable	---	---	Inlet Scrubber	Inlet Scrubber

	1	2	3	4	5	6	7	8
- Type:	---	Flow Splitter	Flow Splitter	Mixer	---	---	2-Phase Separator	2-Phase Separator
Destination (Unit Operation):								
- Tag No.	FS-100	M-100	To Flare Line	V-100	M-100	M-100	K-100	Waste Water Header
- Service:	Not Applicable	Not Applicable	---	Inlet Scrubber	Not Applicable	Not Applicable	Inlet Gas Boosting	---
- Type:	Flow Splitter	Mixer	---	2-Phase Separator	Mixer	Mixer	Compressor: Recip.	---
Properties:	1	2	3	4	5	6	7	8
- Vapour Mole Fraction	1.000000	1.000000	1.000000	1.000000	1.000000	---	1.000000	---
- Liquid Mole Fraction	0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	23.702	23.702	23.702	27.105	31.999	---	27.105	---
- Mass Density (kg/m^3)	8.439	8.439	8.439	9.634	11.470	---	9.634	---
- Molar Density (kmole/m^3)	0.356	0.356	0.356	0.355	0.358	---	0.355	---
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	0.9669	0.9669	0.9669	0.9794	0.9925	---	0.9794	---
- Specific Heat Capacity (kJ/kmole·°C)	46.7971	46.7971	46.7971	39.4833	29.4594	---	39.4833	---
- Enthalpy (kJ/kmole)	-85,487	-85,487	-85,487	-50,404	60	---	-50,404	---
- Entropy (kJ/kmole·°C)	-202	-202	-202	-152	-95	---	-152	---
- Gross Heating Value (MJ/m^3)	48.3	48.3	48.3	28.5	0.0	---	28.5	---
- Net Heating Value (MJ/m^3)	43.3	43.3	43.3	25.6	0.0	---	25.6	---
- Sound Speed (m/s)	359.316	359.316	359.316	344.504	332.061	---	344.504	---
- Dew Point Temperature (°C)	40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Dew Point Pressure (°kPa)	896.4	896.4	896.4	896.4	896.4	---	896.4	---
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	0.033	0.033	0.033	0.033	0.030	---	0.033	---
- Viscosity (cp)	0.012	0.012	0.012	0.015	0.023	---	0.015	---

Composition (Mole Fraction): Name	Formula	CAS No.	1	2	3	4	5	6	7	8
Nitrogen	N2	7727-37-9	0.043380	0.043380	0.043380	0.025590	0.000001	---	0.025590	---
Oxygen	O2	7782-44-7	---	---	---	0.410107	0.999999	---	0.410107	---
Water	H2O	7732-18-5	0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
Carbon Dioxide	CO2	124-38-9	0.025205	0.025205	0.025205	0.014868	---	---	0.014868	---
Methane	CH4	74-82-8	0.641174	0.641174	0.641174	0.378224	---	---	0.378224	---
Ethane	C2H6	74-84-0	0.171376	0.171376	0.171376	0.101094	---	---	0.101094	---
Propane	C3H8	74-98-6	0.084805	0.084805	0.084805	0.050026	---	---	0.050026	---
i-Butane	C4H10	75-28-5	0.007275	0.007275	0.007275	0.004291	---	---	0.004291	---
n-Butane	C4H10	106-97-8	0.017510	0.017510	0.017510	0.010329	---	---	0.010329	---
i-Pentane	C5H12	78-78-4	0.002545	0.002545	0.002545	0.001501	---	---	0.001501	---
n-Pentane	C5H12	109-66-0	0.003010	0.003010	0.003010	0.001776	---	---	0.001776	---
Benzene	C6H6	71-43-2	0.000100	0.000100	0.000100	0.000059	---	---	0.000059	---
Cyclohexane	C6H12	110-82-7	0.000175	0.000175	0.000175	0.000103	---	---	0.000103	---
Hexane	C6H14	110-54-3	0.000745	0.000745	0.000745	0.000439	---	---	0.000439	---
Methylcyclopentane	C6H12	96-37-7	0.000170	0.000170	0.000170	0.000100	---	---	0.000100	---
Heptane	C7H16	142-82-5	0.001975	0.001975	0.001975	0.001165	---	---	0.001165	---
Methylcyclohexane	C7H14	108-87-2	0.000190	0.000190	0.000190	0.000112	---	---	0.000112	---

Toluene	**C7H8**	**108-88-3**	0.000165	0.000165	0.000165	0.000097	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.000040	0.000040	0.000024	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	0.000075	0.000075	0.000075	0.000044	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	0.000035	0.000035	0.000035	0.000021	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	0.000020	0.000020	0.000020	0.000012	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000015	0.000015	0.000009	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS50	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	9	10	11	12	13	14	15	16
- Fluid	Heat Medium	Heat Medium	HC	Electricity	Fuel Gas	HC	HC	HC
- Physical State	Liquid	Liquid	Vapour	Unknown	Gas	Vapour	Vapour	Vapour
- Temperature (°C)	120.00	120.00	192.34	---	39.90	39.90	1,050.00	1,050.00
- Pressure (kPa)	276.0	276.0	5,100.0	---	0.0	0.0	5,000.0	5,000.0
- Total Molar Flowrate (kmole/h)	0.00	0.00	1,942.07	---	0.00	135.34	1,942.07	4,329.38
- Total Mass Flowrate (kg/h)	0.0	0.0	52639.3	---	0.0	3637.3	52639.3	52638.8
- Total Gas Volumetric Flowrate (Std m^3/h)	---	---	45919.9	---	0.0	3200.2	45919.9	102367.5
- Total Liq Volumetric Flowrate (m^3/h)	0.0	0.0	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	3,800.442	---	---	---	---
Origin (Unit Operation):								
- Tag No.	V-100	H-100	K-100	Electric Utility System	Fuel Gas Header	M-200	H-101	R-100
- Service:	Inlet Scrubber	Boiler	Inlet Gas Boosting	---	---	Not Applicable	Heat Medium Heater	---

- Type:	2-Phase Separator	Heater	Compressor: Recip.	---	---	Mixer	Heater: Fired	---
Destination (Unit Operation):								
- Tag No.	PU-101	V-100	H-101	K-100	K-100	H-101	R-100	E-100
- Service:	Circulation	Inlet Scrubber	Heat Medium Heater	Inlet Gas Boosting	Inlet Gas Boosting	Heat Medium Heater	---	Boiler
- Type:	Pump	2-Phase Separator	Heater: Fired	Compressor: Recip.	Compressor: Recip.	Heater: Fired	---	Heat Exchanger: Shell and Tube
Properties:	9	10	11	12	13	14	15	16
- Vapour Mole Fraction	0.000000	0.000000	1.000000	---	1.000000	1.000000	1.000000	1.000000
- Liquid Mole Fraction	1.000000	1.000000	0.000000	---	0.000000	0.000000	0.000000	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	41.686	41.686	27.105	---	---	26.875	27.105	12.158
- Mass Density (kg/m^3)	1,025.000	1,025.000	36.987	---	---	0.996	12.411	5.584
- Molar Density (kmole/m^3)	---	---	1.365	---	---	0.037	0.458	0.459
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	---	0.9839	---	---	0.9986	1.0117	1.0086
- Specific Heat Capacity (kJ/kmole·°C)	135.4802	135.4802	48.4778	---	---	35.4385	77.7041	32.4041
- Enthalpy (kJ/kmole)	---	---	-44,103	---	---	-103,562	11,746	-12,049
- Entropy (kJ/kmole·°C)	---	---	-150	---	---	-59	-85	-25
- Gross Heating Value (MJ/m^3)	---	---	28.5	---	---	24.7	28.5	11.9
- Net Heating Value (MJ/m^3)	---	---	25.6	---	---	22.9	25.6	10.3
- Sound Speed (m/s)	---	---	418.851	---	---	355.689	682.497	1,113.676
- Dew Point Temperature (°C)	---	---	192.34	---	---	39.90	1,050.00	1,050.00
- Dew Point Pressure (°kPa)	---	---	5,196.4	---	---	96.4	5,096.4	5,096.4
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	---	0.057	---	---	0.032	0.194	0.201
- Viscosity (cp)	1.100	1.100	0.022	---	---	0.016	0.045	0.038

Composition (Mole Fraction):			9	10	11	12	13	14	15	16
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	---	---	---	---	0.000000	---	0.613921
Nitrogen	**N2**	**7727-37-9**	---	---	0.025590	---	0.062677	0.062677	0.025590	0.011479
Oxygen	**O2**	**7782-44-7**	---	---	0.410107	---	---	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.462700	0.462700	0.000000	---	0.000000	0.000000	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	0.014868	---	0.036417	0.036417	0.014868	0.006670
Carbon Monoxide	**CO**	**630-08-0**	---	---	---	---	0.553432	0.553432	---	0.367931
Methane	**CH4**	**74-82-8**	---	---	0.378224	---	0.249780	0.249780	0.378224	---
Ethane	**C2H6**	**74-84-0**	---	---	0.101094	---	0.044421	0.044421	0.101094	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	0.537300	0.537300	---	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	---	0.050026	---	0.030293	0.030293	0.050026	---
i-Butane	**C4H10**	**75-28-5**	---	---	0.004291	---	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	---	---	0.010329	---	0.022981	0.022981	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	---	---	0.001501	---	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	---	---	0.001776	---	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	---	---	0.000059	---	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	---	---	0.000103	---	---	---	0.000103	---

Hexane	**C6H14**	**110-54-3**	---	---	0.000439	---	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	0.000100	---	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	---	---	0.001165	---	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	0.000112	---	---	---	0.000112	---
Toluene	**C7H8**	**108-88-3**	---	---	0.000097	---	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	---	---	0.000003	---	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	---	---	0.000024	---	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	---	---	0.000044	---	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	---	---	0.000003	---	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	---	---	0.000021	---	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	---	---	0.000012	---	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	---	---	0.000009	---	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	---	---	0.000003	---	---	---	0.000003	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS50	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	17	18	19	20	21	22	23	24
- Fluid	Water	HC	Water	HC	HC	HC	Not Known	HC
- Physical State	Vapour	Vapour	Liquid	Vapour	Vapour	Vapour	Unknown	Vapour
- Temperature (°C)	226.32	240.00	14.40	240.00	39.90	39.90	---	39.90
- Pressure (kPa)	2,517.0	2,500.0	2,517.0	2,500.0	0.0	0.0	---	0.0
- Total Molar Flowrate (kmole/h)	2.19	4,329.38	2.19	2,021.20	792.91	135.34	0.00	657.56
- Total Mass Flowrate (kg/h)	39.5	52638.8	39.5	52638.7	21309.0	3637.3	0.0	17671.7
- Total Gas Volumetric Flowrate (Std m³/h)	51.8	102367.5	---	47790.8	18748.2	3200.2	---	15548.0
- Total Liq Volumetric Flowrate (m³/h)	---	---	0.0	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	E-100	E-100	Water Header	R-101	PSU-100	FS-101	Fuel Gas Header	FS-101
- Service:	Boiler	Boiler	---	---	---	Not Applicable	---	Not Applicable

- Type:	Heat Exchanger:	Heat Exchanger:	---	---	---	Flow Splitter	---	Flow Splitter
Destination (Unit Operation):								
- Tag No.	HP Steam Header	R-101	E-100	PSU-100	FS-101	M-200	M-200	Gas to Flare
- Service:	---	---	Boiler	---	Not Applicable	Not Applicable	Not Applicable	---
- Type:	---	---	Heat Exchanger: Shell and Tube	---	Flow Splitter	Mixer	Mixer	---
Properties:	17	18	19	20	21	22	23	24
- Vapour Mole Fraction	1.000000	1.000000	0.000000	1.000000	1.000000	1.000000	---	1.000000
- Liquid Mole Fraction	0.000000	0.000000	1.000000	0.000000	0.000000	0.000000	---	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	18.015	12.158	18.015	26.043	26.875	26.875	---	26.875
- Mass Density (kg/m^3)	13.071	7.321	1,000.364	16.505	0.996	0.996	---	0.996
- Molar Density (kmole/m^3)	0.726	0.602	55.529	0.634	0.037	0.037	---	0.037
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	1.0106	---	0.9602	0.9986	0.9986	---	0.9986
- Specific Heat Capacity (kJ/kmole·°C)	62.1935	29.5433	75.3123	52.2772	35.4385	35.4385	---	35.4385
- Enthalpy (kJ/kmole)	50,485	-37,028	1,134	-178,960	-103,562	-103,562	---	-103,562
- Entropy (kJ/kmole·°C)	112	-49	4	-126	-59	-59	---	-59
- Gross Heating Value (MJ/m^3)	0.0	11.9	0.0	20.4	24.7	24.7	---	24.7
- Net Heating Value (MJ/m^3)	0.0	10.3	0.0	18.8	22.9	22.9	---	22.9
- Sound Speed (m/s)	504.574	707.655	1,467.920	433.537	355.689	355.689	---	355.689
- Dew Point Temperature (°C)	226.32	240.00	240.00	240.00	39.90	39.90	---	39.90
- Dew Point Pressure (°kPa)	2,613.3	2,596.4	2,596.4	2,596.4	96.4	96.4	---	96.4
- Bubble Point Temperature (°C)	226.32	---	226.32	---	---	---	---	---
- Bubble Point Pressure (kPa)	1.6	---	1.6	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	0.045	0.100	0.589	0.065	0.032	0.032	---	0.032
- Viscosity (cp)	0.017	0.021	1.154	0.020	0.016	0.016	---	0.016

Composition (Mole Fraction):			17	18	19	20	21	22	23	24
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	0.613921	---	0.000000	0.000000	0.000000	---	0.000000
Nitrogen	**N2**	**7727-37-9**	---	0.011479	---	0.024588	0.062677	0.062677	---	0.062677
Water	**H2O**	**7732-18-5**	1.000000	0.000000	1.000000	0.570995	0.000000	0.000000	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	0.006670	---	0.014286	0.036417	0.036417	---	0.036417
Carbon Monoxide	**CO**	**630-08-0**	---	0.367931	---	0.217109	0.553432	0.553432	---	0.553432
Methane	**CH4**	**74-82-8**	---	---	---	0.097988	0.249780	0.249780	---	0.249780
Ethane	**C2H6**	**74-84-0**	---	---	---	0.017426	0.044421	0.044421	---	0.044421
Propane	**C3H8**	**74-98-6**	---	---	---	0.011884	0.030293	0.030293	---	0.030293
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.009015	0.022981	0.022981	---	0.022981
n-Pentane	**C5H12**	**109-66-0**	---	---	---	0.005002	---	---	---	---
Hexane	**C6H14**	**110-54-3**	---	---	---	0.004422	---	---	---	---
Heptane	**C7H16**	**142-82-5**	---	---	---	0.003905	---	---	---	---
Octane	**C8H18**	**111-65-9**	---	---	---	0.003445	---	---	---	---
Nonane	**C9H20**	**111-84-2**	---	---	---	0.003037	---	---	---	---
Decane	**C10H22**	**124-18-5**	---	---	---	0.002677	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	---	---	---	0.002359	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	---	---	---	0.002078	---	---	---	---

Tridecane	**C13H28**	**629-50-5**	---	---	---	0.001830	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	---	0.001612	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	---	0.001419	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	---	0.001250	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	---	0.001100	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	---	0.000969	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	---	0.000853	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	---	0.000751	---	---	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS50	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	25	26	27	28	29	30	31	32
- Fluid	Electricity	HC	HC	HC	Heat Medium	Heat Medium	Electricity	HC
- Physical State	Unknown	Liquid	Liquid	Vapour	Liquid	Liquid	Unknown	Vapour
- Temperature (°C)	---	39.90	39.90	40.00	120.00	120.00	---	40.00
- Pressure (kPa)	---	0.0	0.0	800.0	276.0	276.0	---	800.0
- Total Molar Flowrate (kmole/h)	---	54.42	19.78	0.00	0.00	0.00	---	0.00
- Total Mass Flowrate (kg/h)	---	6103.8	4434.9	0.0	0.0	0.0	---	0.0
- Total Gas Volumetric Flowrate	---	---	---	0.0	---	---	---	0.0
- Total Liq Volumetric Flowrate (m^3/h)	---	9.1	5.8	---	0.0	0.0	---	---
- Energy Flowrate kW	11,831.235	---	---	---	---	---	23,662.470	---
Origin (Unit Operation):								
- Tag No.	Electric Utility System	PSU-100	PSU-100	Fuel Gas Header	H-100	PU-101	Electric Utility System	Fuel Gas Header
- Service:	---	---	---	---	Boiler	Circulation	---	---

- Type:	---	---	---	---	Heater	Pump	---	---
Destination (Unit Operation):								
- Tag No.	PSU-100	Naphtha Storage	Diesel Storage	H-100	V-100	H-100	Mini-GTL Plant	Mini-GTL Plant
- Service:	---	---	---	Boiler	Inlet Scrubber	Boiler	---	---
- Type:	---	---	---	Heater	2-Phase Separator	Heater	---	---
Properties:	25	26	27	28	29	30	31	32
- Vapour Mole Fraction	---	0.000000	0.000000	1.000000	0.000000	0.000000	---	1.000000
- Liquid Mole Fraction	---	1.000000	1.000000	0.000000	1.000000	1.000000	---	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	---	112.161	224.249	23.702	41.686	41.686	---	23.702
- Mass Density (kg/m^3)	---	671.270	762.803	8.439	1,025.000	1,025.000	---	8.439
- Molar Density ($kmole/m^3$)	---	5.985	3.402	0.356	---	---	---	0.356
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	0.0063	0.0134	0.9669	---	---	---	0.9669
- Specific Heat Capacity (kJ/kmole·°C)	---	245.2118	472.3949	46.7971	135.4802	135.4802	---	46.7971
- Enthalpy (kJ/kmole)	---	-241,592	-437,240	-85,487	---	---	---	-85,487
- Entropy (kJ/kmole·°C)	---	-891	-1,701	-202	---	---	---	-202
- Gross Heating Value (MJ/m^3)	---	230.6	454.9	48.3	---	---	---	48.3
- Net Heating Value (MJ/m^3)	---	212.1	419.8	43.3	---	---	---	43.3
- Sound Speed (m/s)	---	969.621	1,355.431	359.316	---	---	---	359.316
- Dew Point Temperature (°C)	---	---	---	40.00	---	---	---	40.00
- Dew Point Pressure (°kPa)	---	---	---	896.4	---	---	---	896.4
- Bubble Point Temperature (°C)	---	39.90	39.90	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	96.4	96.4	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	338.5	338.5	---	---	---	---	---
- True Vapour Pressure (kPa)	---	96.4	96.4	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	0.110	0.076	0.033	---	---	---	0.033
- Viscosity (cp)	---	0.308	0.447	0.012	1.100	1.100	---	0.012

Composition (Mole Fraction):			25	26	27	28	29	30	31	32
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	---	0.043380	---	---	---	0.043380
Water	**H2O**	**7732-18-5**	---	0.000000	0.000000	0.000000	0.462700	0.462700	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	---	0.025205	---	---	---	0.025205
Methane	**CH4**	**74-82-8**	---	---	---	0.641174	---	---	---	0.641174
Ethane	**C2H6**	**74-84-0**	---	---	---	0.171376	---	---	---	0.171376
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	---	---	0.537300	0.537300	---	---
Propane	**C3H8**	**74-98-6**	---	---	---	0.084805	---	---	---	0.084805
i-Butane	**C4H10**	**75-28-5**	---	---	---	0.007275	---	---	---	0.007275
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.017510	---	---	---	0.017510
i-Pentane	**C5H12**	**78-78-4**	---	---	---	0.002545	---	---	---	0.002545
n-Pentane	**C5H12**	**109-66-0**	---	0.185773	---	0.003010	---	---	---	0.003010
Benzene	**C6H6**	**71-43-2**	---	---	---	0.000100	---	---	---	0.000100
Cyclohexane	**C6H12**	**110-82-7**	---	---	---	0.000175	---	---	---	0.000175
Hexane	**C6H14**	**110-54-3**	---	0.164245	---	0.000745	---	---	---	0.000745
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	---	0.000170	---	---	---	0.000170
Heptane	**C7H16**	**142-82-5**	---	0.145020	---	0.001975	---	---	---	0.001975
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	---	0.000190	---	---	---	0.000190

Toluene	**C7H8**	**108-88-3**	---	---	---	0.000165	---	---	---	0.000165
Ethylbenzene	**C8H10**	**100-41-4**	---	---	---	0.000005	---	---	---	0.000005
m-Xylene	**C8H10**	**108-38-3**	---	---	---	0.000040	---	---	---	0.000040
Octane	**C8H18**	**111-65-9**	---	0.127939	---	0.000075	---	---	---	0.000075
o-Xylene	**C8H10**	**95-47-6**	---	---	---	0.000005	---	---	---	0.000005
Nonane	**C9H20**	**111-84-2**	---	0.112808	---	0.000035	---	---	---	0.000035
Decane	**C10H22**	**124-18-5**	---	0.099427	---	0.000020	---	---	---	0.000020
Undecanes	**C11H24**	**1120-21-4**	---	0.087609	---	0.000015	---	---	---	0.000015
Dodecane	**C12H26**	**112-40-3**	---	0.077179	---	0.000005	---	---	---	0.000005
Tridecane	**C13H28**	**629-50-5**	---	---	0.187058	---	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	0.164740	---	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	0.145069	---	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	0.127737	---	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	0.112467	---	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	0.099017	---	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	0.087172	---	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	0.076740	---	---	---	---	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS50	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	33							
- Fluid	Water							
- Physical State	Liquid							
- Temperature (°C)	14.40							
- Pressure (kPa)	2,517.0							
- Total Molar Flowrate (kmole/h)	1,154.09							
- Total Mass Flowrate (kg/h)	20791.0							
- Total Gas Volumetric Flowrate (Std m^3/h)	---							
- Total Liq Volumetric Flowrate (m^3/h)	20.8							
- Energy Flowrate kW	---							
Origin (Unit Operation):								
- Tag No.	PSU-100							

- Service:	---							
- Type:	---							
Destination (Unit Operation):								
- Tag No.	Produced Water Header							
- Service:	---							
- Type:	---							
Properties:	33	0	0	0	0	0	0	0
- Vapour Mole Fraction	0.000000							
- Liquid Mole Fraction	1.000000							
- Solid Mole Fraction	---							
- Aqueous Mole Fraction	---							
- Molecular Weight	18.015							
- Mass Density (kg/m^3)	1,000.364							
- Molar Density (kmole/m^3)	55.529							
- API Gravity (°)	---							
- Compressibility Factor	---							
- Specific Heat Capacity (kJ/kmole·°C)	75.3123							
- Enthalpy (kJ/kmole)	1,134							
- Entropy (kJ/kmole·°C)	4							
- Gross Heating Value (MJ/m^3)	0.0							
- Net Heating Value (MJ/m^3)	0.0							
- Sound Speed (m/s)	1,467.920							
- Dew Point Temperature (°C)	240.00							
- Dew Point Pressure (°kPa)	2,596.4							
- Bubble Point Temperature (°C)	226.32							
- Bubble Point Pressure (kPa)	1.6							
- Reid Vapour Pressure (kPa)	---							
- True Vapour Pressure (kPa)	---							
- Thermal Conductivity (W/m·°C)	0.589							
- Viscosity (cp)	1.154							
Composition (Mole Fraction):	33	0	0	0	0	0	0	0

Name	Formula	CAS No.									
Water	**H2O**	**7732-18-5**	1.000000								

Clearstone Engineering Ltd.
700, 900-6 Avenue SW, Calgary, AB, T2P 3K2

REPORT: SOURCE MITIGATION ANALYSIS

Header Block

2	**Client:**	TetraTech		**Operator:**	Tetra Tech
3	**Site:**	Mangghystau Oilfield		**Country:**	Kazakhstan
4	**Facility:**	**Category:**	Oil Field	**Subcategory 1:**	
5		**CEL Facility Code:**	OP-009	**Subcategory 2:**	
6	**Source:**	**Category:**	Flare	**Subcategory 1:**	Elevated
7		**CEL Equipment Code:**	OP-009-1	**Subcategory 2:**	Unassisted
8		**Tag No:**	TECH-FL-1	**Make:**	Unavailable
9		**Model:**	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed

12	**Time Series**	**CEL Mitigation Code:**	OP-009-GS100	**End-Year**	**Asset Life:**	2032
13		**Start Year:**	2022		**Viability:**	2032
14	**Mitigation Measure (Stage 1)**	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**		
15		**CEL Reference Code:**	GTL	**Subcategory 2:**		
16		**Reference CEL Drawing No:**	Unavailable	**Reference CEL Drawing Title:**	Unavailable	
17	**Mitigation Measure (Stage 2)**	**Category:**	None	**Subcategory 1:**		
18		**CEL Reference Code:**		**Subcategory 2:**		
19		**Reference CEL Drawing No:**		**Reference CEL Drawing Title:**		
20	**Mitigation Measure (Stage 3)**	**Category:**	None	**Subcategory 1:**		
21		**CEL Reference Code:**		**Subcategory 2:**		
22		**Reference CEL Drawing No:**		**Reference CEL Drawing Title:**		
23		**Optimization Objective Function:**	Net Present Value Over Pay-Back Period Ratio	**Economic Scenario Name:**	None	

Optimization Search Space

	Search Parameter	Value Chosen	Min Search Value	Max Search Value
27	Year-1 Peak Flow Rate Design Factor	**0.90**	0.60	1.20
28	Electric Generator Drive Type	**Reciprocating**	---	---
29	Number of Electric Generator Trains	**2.00**	1.00	10.00

Key Findings

32	**Economic Impacts**	**Capital Cost (USD):**	192,532,522	**Net Present Value (USD) (Before Tax):**	316,738,227
33		**Project Life (Years):**	10	**Net Present Value (USD) (After Tax):**	316,738,227
34		**Asset Life Expectancy (Years):**	10	**Return on Investment (%) (Before Tax):**	164.51%
35		**Asset Salvage Value (USD):**	0	**Return on Investment (%) (After Tax):**	164.51%
36		**Payback Period (Years):**	3.21	**Internal Rate of Return (%):**	38.74%

		Value of Gas Losses (USD/y)									
37–38	**Pre-Mitigation Commodity Losses**	**Energy Basis**	**Commodity Basis**	**Total Gas Loss (m^3/h)**	**Residue Gas (10^3 m^3/d)**	**Ethane (m^3/d liq)**	**LPG (m^3/d liq)**	**NGL (m^3/d)**	**Hydrogen (m^3/d)**		
39		0	30,154,630	30,104.0	512.8	439.8	311.8	32.0	0.0		
40	**Lifetime GHG Emission Reductions**	**CH_4 (kilotonnes)**	**CO_2 (kilotonnes)**	**N_2O (kilotonnes)**	**CO_2E (kilotonnes)**	**Black Carbon (kilotonnes)**					
41		16.0	2,793.9	0.0	3,195.9	2.4					
42	**Lifetime CAC Emission Reductions**	**VOC (tonnes)**	**CO (tonnes)**	**NO_x (tonnes)**	**H_2S (tonnes)**	**SO_2 (tonnes)**	**PM (tonnes)**	**PM_{10} (tonnes)**	**$PM_{2.5}$ (tonnes)**		
43		8,858.4	10,546.4	2,266.0	0.0	0.0	1,792.4	1,792.4	1,792.4		

Key Equipment Additions

		Reference No.	Category	Subcategory 1	Subcategory 2 or Manufacturer Make And Model
46	**Key Equipment or**				
47		Mini_GTL_1_1	Mini-GTL Plant	EFT FB 50	
48		Mini_GTL_2_1	Mini-GTL Plant	EFT FB 50	
49		Mini_GTL_3_1	Mini-GTL Plant	EFT FB 50	
50		Mini_GTL_4_1	Mini-GTL Plant	EFT FB 50	
51		Mini_GTL_5_1	Mini-GTL Plant	EFT FB 50	
52		Mini_GTL_6_1	Mini-GTL Plant	EFT FB 50	
53		Mini_GTL_7_1	Mini-GTL Plant	EFT FB 50	
54		Mini_GTL_8_1	Mini-GTL Plant	EFT FB 50	
55		Mini_GTL_9_1	Mini-GTL Plant	EFT FB 50	
56		Mini_GTL_10_1	Mini-GTL Plant	EFT FB 50	
57		Mini_GTL_11_1	Mini-GTL Plant	EFT FB 50	
58		Mini_GTL_12_1	Mini-GTL Plant	EFT FB 50	
59		Mini_GTL_13_1	Mini-GTL Plant	EFT FB 50	
60		Mini_GTL_14_1	Mini-GTL Plant	EFT FB 50	
61		Mini_GTL_15_1	Mini-GTL Plant	EFT FB 50	
62		Mini_GTL_16_1	Mini-GTL Plant	EFT FB 50	
63		Mini_GTL_17_1	Mini-GTL Plant	EFT FB 50	
64		Mini_GTL_18_1	Mini-GTL Plant	EFT FB 50	
65		Mini_GTL_19_1	Mini-GTL Plant	EFT FB 50	

	A	B	C	D	E	F	G	H	I	J	K	L
66		Mini_GTL_20_1	Mini-GTL Plant			EFT FB 50						
67		Mini_GTL_21_1	Mini-GTL Plant			EFT FB 50						
68		Mini_GTL_22_1	Mini-GTL Plant			EFT FB 50						
69		Mini_GTL_23_1	Mini-GTL Plant			EFT FB 50						
70		Mini_GTL_24_1	Mini-GTL Plant			EFT FB 50						
71		Mini_GTL_25_1	Mini-GTL Plant			EFT FB 50						
72		Mini_GTL_26_1	Mini-GTL Plant			EFT FB 50						
73		Mini_GTL_27_1	Mini-GTL Plant			EFT FB 50						
74		Mini_GTL_28_1	Mini-GTL Plant			EFT FB 50						
75		Mini_GTL_29_1	Mini-GTL Plant			EFT FB 50						
76		Mini_GTL_30_1	Mini-GTL Plant			EFT FB 50						
77		Mini_GTL_31_1	Mini-GTL Plant			EFT FB 50						
78		Mini_GTL_32_1	Mini-GTL Plant			EFT FB 50						
79		Mini_GTL_33_1	Mini-GTL Plant			EFT FB 50						
80		Mini_GTL_34_1	Mini-GTL Plant			EFT FB 50						
81		Mini_GTL_35_1	Mini-GTL Plant			EFT FB 50						
82		Mini_GTL_36_1	Mini-GTL Plant			EFT FB 50						
83		Mini_GTL_37_1	Mini-GTL Plant			EFT FB 50						
84		Mini_GTL_38_1	Mini-GTL Plant			EFT FB 50						
85		Mini_GTL_39_1	Mini-GTL Plant			EFT FB 50						
86		Mini_GTL_40_1	Mini-GTL Plant			EFT FB 50						
87		Mini_GTL_41_1	Mini-GTL Plant			EFT FB 50						
88		Mini_GTL_42_1	Mini-GTL Plant			EFT FB 50						
89		Mini_GTL_43_1	Mini-GTL Plant			EFT FB 50						
90		VVN_1_1	Tank			API 650 - Fixed Roof						
91		VVD_1_1	Tank			API 650 - Fixed Roof						
92												
93						**Applied Economic Parameters**						
94	**Financial Rates**	**Discount Rate (%):**		10.00		**Inflation Rate (%):**					3.00	
95		**Depreciation Rate (%):**		10.00		**Tax Rate (%)**					0.00	
96		**Royalty Rate (%):**		30.00		**Import Duty (%):**					0.00	
97		**GHG Emission Fee (USD/Tonne):**		$1.10		**CAC Emission Fee (USD/Tonne):**					0.00	
98	**Production Decline Model**	**Model Type:**		Initial Linear Increase		**D (decline as a fraction of production):**					0.0000	
99						**b (correlation constant):**					Not Applicable	
100	**Commodity Prices**	**Natural Gas**		**Ethane**	**LPG**	**NGL**	**Crude Oil**	**Hydrogen**	**Electricity**		**Diesel**	**Naptha**
101		**Purchases (USD/GJ)**	**Sales (USD/GJ)**	**(USD/m³ Liq)**	**(USD/L Liq)**	**(USD/m³ Liq)**	**(USD/m³)**	**(USD/m³)**	**Purchases (USD/kW·h)**	**Sales (USD/kW·h)**	**(USD/L Liq)**	**(USD / m3 Liq)**
102		$ -	$ -	$ 60.26	$ 0.14	$ 389.84	$ 471.70	$ 2.00	$ 0.04	$ -	$ 0.76	
103												
104												
105												
106						**Financials (Time Series Results)**						
107	**Year**	**Gross Revenues**	**Costs**		**Asset Book Value**	**Salvage Value**	**Royalty Payment**	**Emission Fee**	**Net Revenues**		**Cumulative After Tax Earnings**	
108			**Capital**	**Operating**					**Before Tax**	**After Tax**		
109		**(Inflation Adjusted USD)**							**(Present Value USD)**			
110	2022	103,936,320	192,532,522	6,040,371	173,279,270	76,078,650	10,609,875	-359,293	62,174,650	62,174,650	62,174,650	
111	2023	107,054,410		6,221,582	155,951,343	67,625,467	10,928,171	-359,293	60,277,704	60,277,704	122,452,354	
112	2024	110,266,042		6,408,230	140,356,208	59,172,284	11,256,017	-359,293	58,126,187	58,126,187	180,578,541	
113	2025	113,574,023		6,600,476	126,320,588	50,719,100	11,593,697	-359,293	55,804,605	55,804,605	236,383,146	
114	2026	116,981,244		6,798,491	113,688,529	42,265,917	11,941,508	-359,293	53,379,662	53,379,662	289,762,808	
115	2027	120,490,681		7,002,445	102,319,676	33,812,733	12,299,753	-359,293	50,903,651	50,903,651	340,666,459	
116	2028	124,105,402		7,212,519	92,087,708	25,359,550	12,668,746	-359,293	48,417,219	48,417,219	389,083,678	
117	2029	125,599,679		7,428,894	82,878,937	16,906,367	12,821,293	-353,029	45,015,046	45,015,046	434,098,724	
118	2030	123,307,201		7,651,761	74,591,044	8,453,183	12,587,305	-336,491	40,338,780	40,338,780	474,437,503	
119	2031	117,358,010		7,881,314	67,131,939	0	11,980,054	-310,930	34,833,245	34,833,245	509,270,748	
120		**Last Profitable Year (After Asset Liquidation, Final Tax Adjustments and Closing Book Entries)**										
121	2031	117,358,010	999	7,881,314	67,131,939	0	11,980,054	-310,930	34,833,245	34,833,245	509,270,748	
122												
123						**Avoided GHG and BC Emissions (Time Series Results)**						
124	**Year**	**CH_4 (kt)**	**CO_2 (kt)**	**N_2O (kt)**	**CO_2E (kt)**	**Black Carbon (t)**						
125	2022	1.6	285.5	0.0	326.6	249.9						
126	2023	1.6	285.5	0.0	326.6	249.9						
127	2024	1.6	285.5	0.0	326.6	249.9						
128	2025	1.6	285.5	0.0	326.6	249.9						
129	2026	1.6	285.5	0.0	326.6	249.9						
130	2027	1.6	285.5	0.0	326.6	249.9						
131	2028	1.6	285.5	0.0	326.6	249.9						
132	2029	1.6	280.6	0.0	320.9	229.8						
133	2030	1.5	267.4	0.0	305.9	211.4						
134	2031	1.4	247.1	0.0	282.7	194.5						
135												
136						**Other Avoided Atmospheric Emissions (Time Series Results)**						

Year	VOC (t)	CO (t)	NO_x (t)	H_2S (t)	SO_2 (t)	PM (t)	PM_{10} (t)	$PM_{2.5}$ (t)
2022	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
2023	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
2024	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
2025	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
2026	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
2027	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
2028	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
2029	0.9	1.1	0.2	0.0	0.0	180.0	180.0	180.0
2030	0.8	1.0	0.2	0.0	0.0	171.6	171.6	171.6
2031	0.8	0.9	0.2	0.0	0.0	158.5	158.5	158.5

Forecast Site Activity Data (Time Series Results - Part 1)

Year	Production			Waste Gas Disposition			Incremental Energy Purchases			
	Oil (10^3 m^3)	Gas (10^6 m^3)	Water (10^3 m^3)	Collected (10^6 m^3)	Conserved (10^6 m^3)	Flared (10^6 m^3)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)
2022	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
2023	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
2024	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
2025	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
2026	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
2027	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
2028	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
2029	883.87	242.62		242.61	109.53	133.09	0.00	0.00	0.00	134,548
2030	813.16	223.21		223.20	104.40	118.81	0.00	0.00	0.00	128,251
2031	748.10	205.35		205.35	96.47	108.88	0.00	0.00	0.00	118,518

Forecast Site Activity Data (Time Series Results - Part 2)

Year	Incremental Product Sales					Incremental Utilization	Avoided Purchases			
	Gas (10^6 m^3 Gas)	LPG (10^3 m^3 Liq)	NGL (10^3 m^3 Liq)	Oil (10^3 m^3)	Electricity (10^3 kW·h)	Fuel Gas (10^6 m^3 Gas)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)
2022	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
2023	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
2024	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
2025	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
2026	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
2027	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
2028	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00
2029	0.00	0.00	0.00	0.00	0	37.75	0.00	78.26	50,043	0.00
2030	0.00	0.00	0.00	0.00	0	35.98	0.00	74.60	47,698	0.00
2031	0.00	0.00	0.00	0.00	0	33.25	0.00	68.93	44,075	0.00

Applied Emission Factors (EF) For Year One Emissions For Baseline (BL) and Simulated Equipment

Source			Pollutant	EF (ng/J of Fuel)	Reference (Where Applicable) and Basis		
Category	Tag No.	DB EF Key			Basis	Author or Reporting Agency	Code
Flares	BL FLARE_1	335	CH_4	180.0	Calculated	US EPA	2018-U.S.EPAAP-42Table13.5-1
			CO_2	54,529.6	Calculated	NA	
			N_2O	0.1	Referenced	WCI	2012-BCWCI.363(k)
			BC	19.7	Calculated	NA	
			VOC	22.3	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
			CO	133.0	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
			NO_x	29.2	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-1
			SO_2	0.0	Calculated	NA	
			PM	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
			PM_{10}	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
			$PM_{2.5}$	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
Heaters and Boilers	Mini_GTL_1_1	7	CH_4	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
			CO_2	83,629.7	Calculated	NA	
			N_2O	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
			BC	0.6	Calculated	NA	
			VOC	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
			CO	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
			NO_x	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
			SO_2	0.0	Calculated	NA	
			PM	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
			PM_{10}	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
			$PM_{2.5}$	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
Heaters and Boilers	Mini_GTL_2_1	7	CH_4	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
			CO_2	83,629.7	Calculated	NA	
			N_2O	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
			BC	0.6	Calculated	NA	
			VOC	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2

	A	B	C	D	E	F	G	H	I	J	K	L
207				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
208				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
209				SO_2	0.0	Calculated	NA					
210				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
211				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
212				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
213	Heaters and	Mini_GTL_3_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
214	Boilers			CO_2	83,629.7	Calculated	NA					
215				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
216				BC	0.6	Calculated	NA					
217				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
218				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
219				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
220				SO_2	0.0	Calculated	NA					
221				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
222				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
223				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
224	Heaters and	Mini_GTL_4_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
225	Boilers			CO_2	83,629.7	Calculated	NA					
226				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
227				BC	0.6	Calculated	NA					
228				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
229				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
230				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
231				SO_2	0.0	Calculated	NA					
232				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
233				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
234				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
235	Heaters and	Mini_GTL_5_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
236	Boilers			CO_2	83,629.7	Calculated	NA					
237				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
238				BC	0.6	Calculated	NA					
239				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
240				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
241				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
242				SO_2	0.0	Calculated	NA					
243				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
244				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
245				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
246	Heaters and	Mini_GTL_6_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
247	Boilers			CO_2	83,629.7	Calculated	NA					
248				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
249				BC	0.6	Calculated	NA					
250				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
251				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
252				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
253				SO_2	0.0	Calculated	NA					
254				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
255				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
256				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
257	Heaters and	Mini_GTL_7_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
258	Boilers			CO_2	83,629.7	Calculated	NA					
259				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
260				BC	0.6	Calculated	NA					
261				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
262				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
263				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
264				SO_2	0.0	Calculated	NA					
265				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
266				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
267				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
268	Heaters and	Mini_GTL_8_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
269	Boilers			CO_2	83,629.7	Calculated	NA					
270				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
271				BC	0.6	Calculated	NA					
272				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
273				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
274				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
275				SO_2	0.0	Calculated	NA					
276				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
277				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			

	A	B	C	D	E	F	G	H	I	J	K	L
278				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
279	**Heaters and**	**Mini_GTL_9_1**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
280	**Boilers**			CO_2	83,629.7	Calculated	NA					
281				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
282				BC	0.6	Calculated	NA					
283				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
284				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
285				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
286				SO_2	0.0	Calculated	NA					
287				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
288				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
289				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
290	**Heaters and**	**Mini_GTL_10_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
291	**Boilers**			CO_2	83,629.7	Calculated	NA					
292				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
293				BC	0.6	Calculated	NA					
294				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
295				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
296				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
297				SO_2	0.0	Calculated	NA					
298				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
299				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
300				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
301	**Heaters and**	**Mini_GTL_11_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
302	**Boilers**			CO_2	83,629.7	Calculated	NA					
303				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
304				BC	0.6	Calculated	NA					
305				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
306				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
307				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
308				SO_2	0.0	Calculated	NA					
309				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
310				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
311				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
312	**Heaters and**	**Mini_GTL_12_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
313	**Boilers**			CO_2	83,629.7	Calculated	NA					
314				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
315				BC	0.6	Calculated	NA					
316				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
317				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
318				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
319				SO_2	0.0	Calculated	NA					
320				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
321				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
322				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
323	**Heaters and**	**Mini_GTL_13_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
324	**Boilers**			CO_2	83,629.7	Calculated	NA					
325				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
326				BC	0.6	Calculated	NA					
327				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
328				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
329				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
330				SO_2	0.0	Calculated	NA					
331				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
332				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
333				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
334	**Heaters and**	**Mini_GTL_14_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
335	**Boilers**			CO_2	83,629.7	Calculated	NA					
336				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
337				BC	0.6	Calculated	NA					
338				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
339				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
340				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
341				SO_2	0.0	Calculated	NA					
342				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
343				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
344				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
345	**Heaters and**	**Mini_GTL_15_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
346	**Boilers**			CO_2	83,629.7	Calculated	NA					
347				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			

	A	B	C	D	E	F	G	H	I	J	K	L
348				BC	0.6	Calculated	NA					
349				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
350				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
351				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
352				SO_2	0.0	Calculated	NA					
353				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
354				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
355				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
356	Heaters and	Mini_GTL_16_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
357	Boilers			CO_2	83,629.7	Calculated	NA					
358				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
359				BC	0.6	Calculated	NA					
360				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
361				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
362				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
363				SO_2	0.0	Calculated	NA					
364				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
365				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
366				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
367	Heaters and	Mini_GTL_17_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
368	Boilers			CO_2	83,629.7	Calculated	NA					
369				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
370				BC	0.6	Calculated	NA					
371				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
372				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
373				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
374				SO_2	0.0	Calculated	NA					
375				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
376				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
377				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
378	Heaters and	Mini_GTL_18_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
379	Boilers			CO_2	83,629.7	Calculated	NA					
380				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
381				BC	0.6	Calculated	NA					
382				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
383				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
384				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
385				SO_2	0.0	Calculated	NA					
386				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
387				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
388				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
389	Heaters and	Mini_GTL_19_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
390	Boilers			CO_2	83,629.7	Calculated	NA					
391				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
392				BC	0.6	Calculated	NA					
393				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
394				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
395				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
396				SO_2	0.0	Calculated	NA					
397				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
398				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
399				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
400	Heaters and	Mini_GTL_20_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
401	Boilers			CO_2	83,629.7	Calculated	NA					
402				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
403				BC	0.6	Calculated	NA					
404				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
405				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
406				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
407				SO_2	0.0	Calculated	NA					
408				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
409				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
410				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
411	Heaters and	Mini_GTL_21_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
412	Boilers			CO_2	83,629.7	Calculated	NA					
413				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
414				BC	0.6	Calculated	NA					
415				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
416				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
417				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
418				SO_2	0.0	Calculated	NA					

	A	B	C	D	E	F	G	H	I	J	K	L
419				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
420				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
421				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
422	**Heaters and**	**Mini_GTL_22_**	7	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
423	**Boilers**			**CO_2**	83,629.7	Calculated	NA					
424				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
425				**BC**	0.6	Calculated	NA					
426				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
427				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
428				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
429				**SO_2**	0.0	Calculated	NA					
430				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
431				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
432				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
433	**Heaters and**	**Mini_GTL_23_**	7	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
434	**Boilers**			**CO_2**	83,629.7	Calculated	NA					
435				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
436				**BC**	0.6	Calculated	NA					
437				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
438				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
439				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
440				**SO_2**	0.0	Calculated	NA					
441				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
442				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
443				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
444	**Heaters and**	**Mini_GTL_24_**	7	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
445	**Boilers**			**CO_2**	83,629.7	Calculated	NA					
446				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
447				**BC**	0.6	Calculated	NA					
448				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
449				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
450				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
451				**SO_2**	0.0	Calculated	NA					
452				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
453				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
454				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
455	**Heaters and**	**Mini_GTL_25_**	7	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
456	**Boilers**			**CO_2**	83,629.7	Calculated	NA					
457				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
458				**BC**	0.6	Calculated	NA					
459				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
460				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
461				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
462				**SO_2**	0.0	Calculated	NA					
463				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
464				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
465				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
466	**Heaters and**	**Mini_GTL_26_**	7	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
467	**Boilers**			**CO_2**	83,629.7	Calculated	NA					
468				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
469				**BC**	0.6	Calculated	NA					
470				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
471				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
472				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
473				**SO_2**	0.0	Calculated	NA					
474				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
475				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
476				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
477	**Heaters and**	**Mini_GTL_27_**	7	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
478	**Boilers**			**CO_2**	83,629.7	Calculated	NA					
479				**N_2O**	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
480				**BC**	0.6	Calculated	NA					
481				**VOC**	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
482				**CO**	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
483				**NO_x**	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
484				**SO_2**	0.0	Calculated	NA					
485				**PM**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
486				**PM_{10}**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
487				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
488	**Heaters and**	**Mini_GTL_28_**	7	**CH_4**	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			

	A	B	C	D	E	F	G	H	I	J	K	L
489	**Boilers**			CO_2	83,629.7	Calculated	NA					
490				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
491				BC	0.6	Calculated	NA					
492				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
493				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
494				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
495				SO_2	0.0	Calculated	NA					
496				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
497				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
498				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
499	**Heaters and**	**Mini_GTL_29_**	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
500	**Boilers**			CO_2	83,629.7	Calculated	NA					
501				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
502				BC	0.6	Calculated	NA					
503				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
504				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
505				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
506				SO_2	0.0	Calculated	NA					
507				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
508				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
509				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
510	**Heaters and**	**Mini_GTL_30_**	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
511	**Boilers**			CO_2	83,629.7	Calculated	NA					
512				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
513				BC	0.6	Calculated	NA					
514				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
515				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
516				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
517				SO_2	0.0	Calculated	NA					
518				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
519				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
520				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
521	**Heaters and**	**Mini_GTL_31_**	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
522	**Boilers**			CO_2	83,629.7	Calculated	NA					
523				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
524				BC	0.6	Calculated	NA					
525				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
526				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
527				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
528				SO_2	0.0	Calculated	NA					
529				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
530				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
531				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
532	**Heaters and**	**Mini_GTL_32_**	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
533	**Boilers**			CO_2	83,629.7	Calculated	NA					
534				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
535				BC	0.6	Calculated	NA					
536				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
537				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
538				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
539				SO_2	0.0	Calculated	NA					
540				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
541				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
542				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
543	**Heaters and**	**Mini_GTL_33_**	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
544	**Boilers**			CO_2	83,629.7	Calculated	NA					
545				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
546				BC	0.6	Calculated	NA					
547				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
548				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
549				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
550				SO_2	0.0	Calculated	NA					
551				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
552				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
553				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
554	**Heaters and**	**Mini_GTL_34_**	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
555	**Boilers**			CO_2	83,629.7	Calculated	NA					
556				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
557				BC	0.6	Calculated	NA					
558				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
559				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			

	A	B	C	D	E	F	G	H	I	J	K	L
560				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
561				SO_2	0.0	Calculated	NA					
562				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
563				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
564				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
565	Heaters and	Mini_GTL_35_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
566	Boilers			CO_2	83,629.7	Calculated	NA					
567				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
568				BC	0.6	Calculated	NA					
569				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
570				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
571				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
572				SO_2	0.0	Calculated	NA					
573				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
574				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
575				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
576	Heaters and	Mini_GTL_36_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
577	Boilers			CO_2	83,629.7	Calculated	NA					
578				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
579				BC	0.6	Calculated	NA					
580				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
581				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
582				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
583				SO_2	0.0	Calculated	NA					
584				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
585				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
586				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
587	Heaters and	Mini_GTL_37_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
588	Boilers			CO_2	83,629.7	Calculated	NA					
589				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
590				BC	0.6	Calculated	NA					
591				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
592				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
593				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
594				SO_2	0.0	Calculated	NA					
595				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
596				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
597				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
598	Heaters and	Mini_GTL_38_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
599	Boilers			CO_2	83,629.7	Calculated	NA					
600				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
601				BC	0.6	Calculated	NA					
602				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
603				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
604				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
605				SO_2	0.0	Calculated	NA					
606				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
607				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
608				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
609	Heaters and	Mini_GTL_39_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
610	Boilers			CO_2	83,629.7	Calculated	NA					
611				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
612				BC	0.6	Calculated	NA					
613				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
614				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
615				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
616				SO_2	0.0	Calculated	NA					
617				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
618				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
619				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
620	Heaters and	Mini_GTL_40_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
621	Boilers			CO_2	83,629.7	Calculated	NA					
622				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
623				BC	0.6	Calculated	NA					
624				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
625				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
626				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
627				SO_2	0.0	Calculated	NA					
628				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
629				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			

	A	B	C	D	E	F	G	H	I	J	K	L
630				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
631	**Heaters and Boilers**	**Mini_GTL_41_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
632				CO_2	83,629.7	Calculated	NA					
633				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
634				BC	0.6	Calculated	NA					
635				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
636				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
637				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
638				SO_2	0.0	Calculated	NA					
639				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
640				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
641				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
642	**Heaters and Boilers**	**Mini_GTL_42_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
643				CO_2	83,629.7	Calculated	NA					
644				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
645				BC	0.6	Calculated	NA					
646				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
647				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
648				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
649				SO_2	0.0	Calculated	NA					
650				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
651				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
652				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
653	**Heaters and Boilers**	**Mini_GTL_43_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
654				CO_2	83,629.7	Calculated	NA					
655				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
656				BC	0.6	Calculated	NA					
657				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
658				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
659				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
660				SO_2	0.0	Calculated	NA					
661				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
662				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
663				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
664	**Flares**	**FLARE_1**	**335**	CH_4	137.0	Calculated	US EPA		2018-U.S.EPAAP-42Table13.5-1			
665				CO_2	83,629.7	Calculated	NA					
666				N_2O	0.1	Referenced	WCI		2012-BCWCI.363(k)			
667				BC	0.0	Calculated	NA					
668				VOC	22.3	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
669				CO	133.0	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
670				NO_x	29.2	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-1			
671				SO_2	0.0	Calculated	NA					
672				PM	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
673				PM_{10}	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
674				$PM_{2.5}$	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
675												
676	**Capital Cost**											
677	**Equipment**	**Item**	**Category**	**Subcategory 1**	**Subcategory 2**	**Capacity or Rated Power Output**		**Price (USD)**	**FOB Point**	**Basis**		
678						**Value**	**Units of Measure**					
679		Mini_GTL_1_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
680		Mini_GTL_2_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
681		Mini_GTL_3_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
682		Mini_GTL_4_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
683		Mini_GTL_5_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
684		Mini_GTL_6_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
685		Mini_GTL_7_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
686		Mini_GTL_8_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
687		Mini_GTL_9_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
688		Mini_GTL_10_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
689		Mini_GTL_11_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
690		Mini_GTL_12_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
691		Mini_GTL_13_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
692		Mini_GTL_14_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		
693		Mini_GTL_15_1	Mini-GTL Plant	EFT FB 50		15.12	10^3 m^3	1,955,846	NA	Predicted (Class 5)		

	A	B	C	D	E	F	G	H	I	J	K	L
694		Mini_GTL_16_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
695		Mini_GTL_17_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
696		Mini_GTL_18_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
697		Mini_GTL_19_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
698		Mini_GTL_20_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
699		Mini_GTL_21_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
700		Mini_GTL_22_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
701		Mini_GTL_23_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
702		Mini_GTL_24_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
703		Mini_GTL_25_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
704		Mini_GTL_26_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
705		Mini_GTL_27_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
706		Mini_GTL_28_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
707		Mini_GTL_29_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
708		Mini_GTL_30_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
709		Mini_GTL_31_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
710		Mini_GTL_32_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
711		Mini_GTL_33_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
712		Mini_GTL_34_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
713		Mini_GTL_35_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
714		Mini_GTL_36_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
715		Mini_GTL_37_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
716		Mini_GTL_38_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
717		Mini_GTL_39_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
718		Mini_GTL_40_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
719		Mini_GTL_41_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
720		Mini_GTL_42_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
721		Mini_GTL_43_1	Mini-GTL Plant	EFT FB 50		15.12	$10^3\ m^3$	1,955,846	NA	Predicted (Class 5)		
722		VVN_1_1	Tank	API 650 - Fixed Roof		1,797.57	m^3	239,924	NA	Predicted (Class 4)		
723		VVD_1_1	Tank	API 650 - Fixed Roof		1,149.36	m^3	190,546	NA	Predicted (Class 4)		
724		**E7**	**Engineering & Drafting**					11,734,427				
725		**Subtotal:**						96,266,261				
726	**Pipeline**	**Pipe Specifications**	**OD (mm)**			**Material:**			**Design P (kPa)**			
727			**WT (mm)**			**Length (km):**			**Coating:**			
728		**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
729		**PL1**	**Pipe**									
730		**PL2**	**Right-of-Way (ROW)**									
731		**PL3**	**ROW Land Survey**									
732		**PL4**	**Clearing**									
733		**PL5**	**Soil Stripping**									
734		**PL6**	**Timber Salvage**									
735		**PL7**	**Rock excavation**									
736		**PL8**	**Cathodic Protection**									
737		**PL9**	**Construction**									

	A	B	C	D	E	F	G	H	I	J	K	L
738		**PL10**	**Engineering & Drafting**									
739		**PL11**	**Supervision**									
740		**PL12**	**Safety**									
741		**PL13**	**Reseeding ROW**									
742		**Subtotal:**										
743	**Materials &**	**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
744	**Services**	**MS1**	**Equipment Setting**		0	11,663,585		11,663,585		Predicted		
745		**MS2**	**Foundations**		2,915,896	3,878,142		6,794,038		Predicted		
746		**MS3**	**Structural Steel**		2,915,896	1,457,948		4,373,844		Predicted		
747		**MS4**	**Buildings**		1,749,538	1,749,538		3,499,076		Predicted		
748		**MS5**	**Insulation**		583,179	874,769		1,457,948		Predicted		
749		**MS6**	**Instruments**		3,499,076	1,399,630		4,898,706		Predicted		
750		**MS7**	**Electrical**		4,665,434	3,499,076		8,164,510		Predicted		
751		**MS8**	**Piping**		26,243,067	13,121,533		39,364,600		Predicted		
752		**MS9**	**Painting**		291,590	874,769		1,166,359		Predicted		
753		**MS10**	**Miscellaneous**		1,749,538	1,399,630		3,149,168		Predicted		
754		**MS11**	**Engineering & Drafting**		0	11,734,427		11,734,427		Predicted		
755		**MS12**	**Supervision**		Unavailable	0		0				
756		**MS13**	**Safety**		Unavailable	0		0				
757		**Subtotal:**						96,266,261				
758	**Summary**	**Total:**						192,532,522				
759		**Duties:**						0				
760		**Freight:**						Unavailable				
761		**Grand Total:**						192,532,522				
762	**Year 1 Operating Costs**											
763		**Operating**	**Hours Per Shift:**		Unknown	**Operator Hourly Labour Rate:**		$ 2.05				
764		**Labour**	**Shifts Per Day:**		Unknown	**Maintenance Hourly Labour Rate:**		$ 2.05				
765		**Item**	**Category**		**Material (USD**	**Labour (Hours)**	**Labour (USD)**	**Line Total (USD)**		**Basis**		
766	**Fixed**	**L1**	**Operating Labour**		0	31,320	64,206	64,206		Predicted		
767	**O&M Costs**	**L2**	**Maintenance Labour**		0	10,440	21,402	21,402		Predicted		
768		**L3**	**Direct Supervision**		0		11,557	11,557		Predicted		
769		**L4**	**Administration**		0		1,744,157	1,744,157		Predicted		
770		**L5**	**Unclassified Costs**					0		Predicted		
771		**Total Fixed O&M Costs:**						1,841,322		Predicted		
772	**Variable**	**SS1**	**Third-Party Services**					160,765		Predicted		
773	**O&M Costs**	**SS2**	**Parts & Consumables**					497,010		Predicted		
774		**SS3**	**Unclassified Costs**					3,541,274		Predicted		
775		**Total Variable O&M Costs:**						4,199,049		Predicted		
776	**Total O&M Costs**	**Total Fixed and Variable O&M Costs:**						6,040,371		Predicted		
777	**Purchased**	**PC1**	**Electricity**		5,340,406	0	0	5,340,406		Predicted		
778	**Commodities**	**PC2**	**Natural Gas**		0	0	0	0		Predicted		
779		**PC3**	**LPG**		0	0	0	0		Predicted		
780		**PC4**	**Diesel**		0	0	0	0		Predicted		
781	**Summary**	**Total:**						11,380,777				

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS100	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Proposed Equipment

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS100	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	1	2	3	4	5	6	7	8
- Fluid	HC	HC	HC	HC	HC	Not Known	HC	Not Known
- Physical State	Vapour	Vapour	Vapour	Vapour	Vapour	Unknown	Vapour	Unknown
- Temperature (°C)	40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Pressure (kPa)	800.0	800.0	800.0	800.0	800.0	---	800.0	---
- Total Molar Flowrate (kmole/h)	1,273.17	1,145.61	127.56	1,942.07	796.46	0.00	1,942.07	0.00
- Total Mass Flowrate (kg/h)	30176.9	27153.5	3023.5	52639.3	25485.8	0.0	52639.3	0.0
- Total Gas Volumetric Flowrate (Sm^3/h)	30104.0	27087.8	3016.2	45919.9	18832.1	---	45919.9	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	From Flare Line	FS-100	FS-100	M-100	Oxygen Plant	HP Steam Header	V-100	V-100
- Service:	---	Not Applicable	Not Applicable	Not Applicable	---	---	Inlet Scrubber	Inlet Scrubber

- Type:			---	Flow Splitter	Flow Splitter	Mixer	---	---	2-Phase Separator	2-Phase Separator
Destination (Unit Operation):										
- Tag No.			FS-100	M-100	To Flare Line	V-100	M-100	M-100	K-100	Waste Water Header
- Service:			Not Applicable	Not Applicable	---	Inlet Scrubber	Not Applicable	Not Applicable	Inlet Gas Boosting	---
- Type:			Flow Splitter	Mixer	---	2-Phase Separator	Mixer	Mixer	Compressor: Recip.	---
Properties:			1	2	3	4	5	6	7	8
- Vapour Mole Fraction			1.000000	1.000000	1.000000	1.000000	1.000000	---	1.000000	---
- Liquid Mole Fraction			0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			23.702	23.702	23.702	27.105	31.999	---	27.105	---
- Mass Density (kg/m^3)			8.439	8.439	8.439	9.634	11.470	---	9.634	---
- Molar Density (kmole/m^3)			0.356	0.356	0.356	0.355	0.358	---	0.355	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			0.9669	0.9669	0.9669	0.9794	0.9925	---	0.9794	---
- Specific Heat Capacity (kJ/kmole·°C)			46.7971	46.7971	46.7971	39.4833	29.4594	---	39.4833	---
- Enthalpy (kJ/kmole)			-85,487	-85,487	-85,487	-50,404	60	---	-50,404	---
- Entropy (kJ/kmole·°C)			-202	-202	-202	-152	-95	---	-152	---
- Gross Heating Value (MJ/m^3)			48.3	48.3	48.3	28.5	0.0	---	28.5	---
- Net Heating Value (MJ/m^3)			43.3	43.3	43.3	25.6	0.0	---	25.6	---
- Sound Speed (m/s)			359.316	359.316	359.316	344.504	332.061	---	344.504	---
- Dew Point Temperature (°C)			40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Dew Point Pressure (°kPa)			896.4	896.4	896.4	896.4	896.4	---	896.4	---
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.033	0.033	0.033	0.033	0.030	---	0.033	---
- Viscosity (cp)			0.012	0.012	0.012	0.015	0.023	---	0.015	---
Composition (Mole Fraction):			1	2	3	4	5	6	7	8
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043380	0.043380	0.043380	0.025590	0.000001	---	0.025590	---
Oxygen	**O2**	**7782-44-7**	---	---	---	0.410107	0.999999	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
Carbon Dioxide	**CO2**	**124-38-9**	0.025205	0.025205	0.025205	0.014868	---	---	0.014868	---
Methane	**CH4**	**74-82-8**	0.641174	0.641174	0.641174	0.378224	---	---	0.378224	---
Ethane	**C2H6**	**74-84-0**	0.171376	0.171376	0.171376	0.101094	---	---	0.101094	---
Propane	**C3H8**	**74-98-6**	0.084805	0.084805	0.084805	0.050026	---	---	0.050026	---
i-Butane	**C4H10**	**75-28-5**	0.007275	0.007275	0.007275	0.004291	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	0.017510	0.017510	0.017510	0.010329	---	---	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	0.002545	0.002545	0.002545	0.001501	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	0.003010	0.003010	0.003010	0.001776	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	0.000100	0.000100	0.000100	0.000059	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	0.000175	0.000175	0.000175	0.000103	---	---	0.000103	---
Hexane	**C6H14**	**110-54-3**	0.000745	0.000745	0.000745	0.000439	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.000170	0.000170	0.000100	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	0.001975	0.001975	0.001975	0.001165	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.000190	0.000190	0.000112	---	---	0.000112	---

Toluene	**C7H8**	**108-88-3**	0.000165	0.000165	0.000165	0.000097	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.000040	0.000040	0.000024	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	0.000075	0.000075	0.000075	0.000044	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	0.000035	0.000035	0.000035	0.000021	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	0.000020	0.000020	0.000020	0.000012	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000015	0.000015	0.000009	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS100	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	9	10	11	12	13	14	15	16
- Fluid	Heat Medium	Heat Medium	HC	Electricity	Fuel Gas	HC	HC	HC
- Physical State	Liquid	Liquid	Vapour	Unknown	Gas	Vapour	Vapour	Vapour
- Temperature (°C)	120.00	120.00	192.34	---	39.90	39.90	1,050.00	1,050.00
- Pressure (kPa)	276.0	276.0	5,100.0	---	0.0	0.0	5,000.0	5,000.0
- Total Molar Flowrate (kmole/h)	0.00	0.00	1,942.07	---	0.00	135.34	1,942.07	4,329.38
- Total Mass Flowrate (kg/h)	0.0	0.0	52639.3	---	0.0	3637.3	52639.3	52638.8
- Total Gas Volumetric Flowrate (Sm^3/h)	---	---	45919.9	---	0.0	3200.2	45919.9	102367.5
- Total Liq Volumetric Flowrate (m^3/h)	0.0	0.0	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	3,800.442	---	---	---	---
Origin (Unit Operation):								
- Tag No.	V-100	H-100	K-100	Electric Utility System	Fuel Gas Header	M-200	H-101	R-100
- Service:	Inlet Scrubber	Boiler	Inlet Gas Boosting	---	---	Not Applicable	Heat Medium Heater	---

- Type:			2-Phase Separator	Heater	Compressor: Recip.	---	---	Mixer	Heater: Fired	---
Destination (Unit Operation):										
- Tag No.			PU-101	V-100	H-101	K-100	K-100	H-101	R-100	E-100
- Service:			Circulation	Inlet Scrubber	Heat Medium Heater	Inlet Gas Boosting	Inlet Gas Boosting	Heat Medium Heater	---	Boiler
- Type:			Pump	2-Phase Separator	Heater: Fired	Compressor: Recip.	Compressor: Recip.	Heater: Fired	---	Heat Exchanger: Shell and Tube
Properties:			9	10	11	12	13	14	15	16
- Vapour Mole Fraction			0.000000	0.000000	1.000000	---	1.000000	1.000000	1.000000	1.000000
- Liquid Mole Fraction			1.000000	1.000000	0.000000	---	0.000000	0.000000	0.000000	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			41.686	41.686	27.105	---	---	26.875	27.105	12.158
- Mass Density (kg/m^3)			1,025.000	1,025.000	36.987	---	---	0.996	12.411	5.584
- Molar Density (kmole/m^3)			---	---	1.365	---	---	0.037	0.458	0.459
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	---	0.9839	---	---	0.9986	1.0117	1.0086
- Specific Heat Capacity (kJ/kmole·°C)			135.4802	135.4802	48.4778	---	---	35.4385	77.7041	32.4041
- Enthalpy (kJ/kmole)			---	---	-44,103	---	---	-103,562	11,746	-12,049
- Entropy (kJ/kmole·°C)			---	---	-150	---	---	-59	-85	-25
- Gross Heating Value (MJ/m^3)			---	---	28.5	---	---	24.7	28.5	11.9
- Net Heating Value (MJ/m^3)			---	---	25.6	---	---	22.9	25.6	10.3
- Sound Speed (m/s)			---	---	418.851	---	---	355.689	682.497	1,113.676
- Dew Point Temperature (°C)			---	---	192.34	---	---	39.90	1,050.00	1,050.00
- Dew Point Pressure (°kPa)			---	---	5,196.4	---	---	96.4	5,096.4	5,096.4
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	---	0.057	---	---	0.032	0.194	0.201
- Viscosity (cp)			1.100	1.100	0.022	---	---	0.016	0.045	0.038
Composition (Mole Fraction):			9	10	11	12	13	14	15	16
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	---	---	---	---	0.000000	---	0.613921
Nitrogen	**N2**	**7727-37-9**	---	---	0.025590	---	0.062677	0.062677	0.025590	0.011479
Oxygen	**O2**	**7782-44-7**	---	---	0.410107	---	---	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.462700	0.462700	0.000000	---	0.000000	0.000000	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	0.014868	---	0.036417	0.036417	0.014868	0.006670
Carbon Monoxide	**CO**	**630-08-0**	---	---	---	---	0.553432	0.553432	---	0.367931
Methane	**CH4**	**74-82-8**	---	---	0.378224	---	0.249780	0.249780	0.378224	---
Ethane	**C2H6**	**74-84-0**	---	---	0.101094	---	0.044421	0.044421	0.101094	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	0.537300	0.537300	---	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	---	0.050026	---	0.030293	0.030293	0.050026	---
i-Butane	**C4H10**	**75-28-5**	---	---	0.004291	---	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	---	---	0.010329	---	0.022981	0.022981	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	---	---	0.001501	---	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	---	---	0.001776	---	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	---	---	0.000059	---	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	---	---	0.000103	---	---	---	0.000103	---

Hexane	**C6H14**	**110-54-3**	---	---	0.000439	---	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	0.000100	---	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	---	---	0.001165	---	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	0.000112	---	---	---	0.000112	---
Toluene	**C7H8**	**108-88-3**	---	---	0.000097	---	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	---	---	0.000003	---	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	---	---	0.000024	---	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	---	---	0.000044	---	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	---	---	0.000003	---	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	---	---	0.000021	---	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	---	---	0.000012	---	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	---	---	0.000009	---	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	---	---	0.000003	---	---	---	0.000003	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS100	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	17	18	19	20	21	22	23	24
- Fluid	Water	HC	Water	HC	HC	HC	Not Known	HC
- Physical State	Vapour	Vapour	Liquid	Vapour	Vapour	Vapour	Unknown	Vapour
- Temperature (°C)	226.32	240.00	14.40	240.00	39.90	39.90	---	39.90
- Pressure (kPa)	2,517.0	2,500.0	2,517.0	2,500.0	0.0	0.0	---	0.0
- Total Molar Flowrate (kmole/h)	2.19	4,329.38	2.19	2,021.20	792.91	135.34	0.00	657.56
- Total Mass Flowrate (kg/h)	39.5	52638.8	39.5	52638.7	21309.0	3637.3	0.0	17671.7
- Total Gas Volumetric Flowrate (Std m^3/h)	51.8	102367.5	---	47790.8	18748.2	3200.2	---	15548.0
- Total Liq Volumetric Flowrate (m^3/h)	---	---	0.0	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	E-100	E-100	Water Header	R-101	PSU-100	FS-101	Fuel Gas Header	FS-101
- Service:	Boiler	Boiler	---	---	---	Not Applicable	---	Not Applicable

- Type:	Heat Exchanger:	Heat Exchanger:	---	---	---	Flow Splitter	---	Flow Splitter
Destination (Unit Operation):								
- Tag No.	HP Steam Header	R-101	E-100	PSU-100	FS-101	M-200	M-200	Gas to Flare
- Service:	---	---	Boiler	---	Not Applicable	Not Applicable	Not Applicable	---
- Type:	---	---	Heat Exchanger: Shell and Tube	---	Flow Splitter	Mixer	Mixer	---
Properties:	17	18	19	20	21	22	23	24
- Vapour Mole Fraction	1.000000	1.000000	0.000000	1.000000	1.000000	1.000000	---	1.000000
- Liquid Mole Fraction	0.000000	0.000000	1.000000	0.000000	0.000000	0.000000	---	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	18.015	12.158	18.015	26.043	26.875	26.875	---	26.875
- Mass Density (kg/m^3)	13.071	7.321	1,000.364	16.505	0.996	0.996	---	0.996
- Molar Density (kmole/m^3)	0.726	0.602	55.529	0.634	0.037	0.037	---	0.037
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	1.0106	---	0.9602	0.9986	0.9986	---	0.9986
- Specific Heat Capacity (kJ/kmole·°C)	62.1935	29.5433	75.3123	52.2772	35.4385	35.4385	---	35.4385
- Enthalpy (kJ/kmole)	50,485	-37,028	1,134	-178,960	-103,562	-103,562	---	-103,562
- Entropy (kJ/kmole·°C)	112	-49	4	-126	-59	-59	---	-59
- Gross Heating Value (MJ/m^3)	0.0	11.9	0.0	20.4	24.7	24.7	---	24.7
- Net Heating Value (MJ/m^3)	0.0	10.3	0.0	18.8	22.9	22.9	---	22.9
- Sound Speed (m/s)	504.574	707.655	1,467.920	433.537	355.689	355.689	---	355.689
- Dew Point Temperature (°C)	226.32	240.00	240.00	240.00	39.90	39.90	---	39.90
- Dew Point Pressure (°kPa)	2,613.3	2,596.4	2,596.4	2,596.4	96.4	96.4	---	96.4
- Bubble Point Temperature (°C)	226.32	---	226.32	---	---	---	---	---
- Bubble Point Pressure (kPa)	1.6	---	1.6	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	0.045	0.100	0.589	0.065	0.032	0.032	---	0.032
- Viscosity (cp)	0.017	0.021	1.154	0.020	0.016	0.016	---	0.016

Composition (Mole Fraction):			17	18	19	20	21	22	23	24
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	0.613921	---	0.000000	0.000000	0.000000	---	0.000000
Nitrogen	**N2**	**7727-37-9**	---	0.011479	---	0.024588	0.062677	0.062677	---	0.062677
Water	**H2O**	**7732-18-5**	1.000000	0.000000	1.000000	0.570995	0.000000	0.000000	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	0.006670	---	0.014286	0.036417	0.036417	---	0.036417
Carbon Monoxide	**CO**	**630-08-0**	---	0.367931	---	0.217109	0.553432	0.553432	---	0.553432
Methane	**CH4**	**74-82-8**	---	---	---	0.097988	0.249780	0.249780	---	0.249780
Ethane	**C2H6**	**74-84-0**	---	---	---	0.017426	0.044421	0.044421	---	0.044421
Propane	**C3H8**	**74-98-6**	---	---	---	0.011884	0.030293	0.030293	---	0.030293
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.009015	0.022981	0.022981	---	0.022981
n-Pentane	**C5H12**	**109-66-0**	---	---	---	0.005002	---	---	---	---
Hexane	**C6H14**	**110-54-3**	---	---	---	0.004422	---	---	---	---
Heptane	**C7H16**	**142-82-5**	---	---	---	0.003905	---	---	---	---
Octane	**C8H18**	**111-65-9**	---	---	---	0.003445	---	---	---	---
Nonane	**C9H20**	**111-84-2**	---	---	---	0.003037	---	---	---	---
Decane	**C10H22**	**124-18-5**	---	---	---	0.002677	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	---	---	---	0.002359	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	---	---	---	0.002078	---	---	---	---

Tridecane	**C13H28**	**629-50-5**	---	---	---	0.001830	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	---	0.001612	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	---	0.001419	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	---	0.001250	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	---	0.001100	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	---	0.000969	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	---	0.000853	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	---	0.000751	---	---	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS100	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	25	26	27	28	29	30	31	32
- Fluid	Electricity	HC	HC	HC	Heat Medium	Heat Medium	Electricity	HC
- Physical State	Unknown	Liquid	Liquid	Vapour	Liquid	Liquid	Unknown	Vapour
- Temperature (°C)	---	39.90	39.90	40.00	120.00	120.00	---	40.00
- Pressure (kPa)	---	0.0	0.0	800.0	276.0	276.0	---	800.0
- Total Molar Flowrate (kmole/h)	---	54.42	19.78	0.00	0.00	0.00	---	0.00
- Total Mass Flowrate (kg/h)	---	6103.8	4434.9	0.0	0.0	0.0	---	0.0
- Total Gas Volumetric Flowrate	---	---	---	0.0	---	---	---	0.0
- Total Liq Volumetric Flowrate (m^3/h)	---	9.1	5.8	---	0.0	0.0	---	---
- Energy Flowrate kW	11,831.235	---	---	---	---	---	23,662.470	---
Origin (Unit Operation):								
- Tag No.	Electric Utility System	PSU-100	PSU-100	Fuel Gas Header	H-100	PU-101	Electric Utility System	Fuel Gas Header
- Service:	---	---	---	---	Boiler	Circulation	---	---

	25	26	27	28	29	30	31	32
- Type:	---	---	---	---	Heater	Pump	---	---
Destination (Unit Operation):								
- Tag No.	PSU-100	Naphtha Storage	Diesel Storage	H-100	V-100	H-100	Mini-GTL Plant	Mini-GTL Plant
- Service:	---	---	---	Boiler	Inlet Scrubber	Boiler	---	---
- Type:	---	---	---	Heater	2-Phase Separator	Heater	---	---
Properties:	25	26	27	28	29	30	31	32
- Vapour Mole Fraction	---	0.000000	0.000000	1.000000	0.000000	0.000000	---	1.000000
- Liquid Mole Fraction	---	1.000000	1.000000	0.000000	1.000000	1.000000	---	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	---	112.161	224.249	23.702	41.686	41.686	---	23.702
- Mass Density (kg/m^3)	---	671.270	762.803	8.439	1,025.000	1,025.000	---	8.439
- Molar Density (kmole/m^3)	---	5.985	3.402	0.356	---	---	---	0.356
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	0.0063	0.0134	0.9669	---	---	---	0.9669
- Specific Heat Capacity (kJ/kmole·°C)	---	245.2118	472.3949	46.7971	135.4802	135.4802	---	46.7971
- Enthalpy (kJ/kmole)	---	-241,592	-437,240	-85,487	---	---	---	-85,487
- Entropy (kJ/kmole·°C)	---	-891	-1,701	-202	---	---	---	-202
- Gross Heating Value (MJ/m^3)	---	230.6	454.9	48.3	---	---	---	48.3
- Net Heating Value (MJ/m^3)	---	212.1	419.8	43.3	---	---	---	43.3
- Sound Speed (m/s)	---	969.621	1,355.431	359.316	---	---	---	359.316
- Dew Point Temperature (°C)	---	---	---	40.00	---	---	---	40.00
- Dew Point Pressure (°kPa)	---	---	---	896.4	---	---	---	896.4
- Bubble Point Temperature (°C)	---	39.90	39.90	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	96.4	96.4	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	338.5	338.5	---	---	---	---	---
- True Vapour Pressure (kPa)	---	96.4	96.4	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	0.110	0.076	0.033	---	---	---	0.033
- Viscosity (cp)	---	0.308	0.447	0.012	1.100	1.100	---	0.012

Composition (Mole Fraction):			25	26	27	28	29	30	31	32
Name	**Formula**	**CAS No.**								
Nitrogen	N2	7727-37-9	---	---	---	0.043380	---	---	---	0.043380
Water	H2O	7732-18-5	---	0.000000	0.000000	0.000000	0.462700	0.462700	---	0.000000
Carbon Dioxide	CO2	124-38-9	---	---	---	0.025205	---	---	---	0.025205
Methane	CH4	74-82-8	---	---	---	0.641174	---	---	---	0.641174
Ethane	C2H6	74-84-0	---	---	---	0.171376	---	---	---	0.171376
Ethylene Glycol	C2H6O2	107-21-1	---	---	---	---	0.537300	0.537300	---	---
Propane	C3H8	74-98-6	---	---	---	0.084805	---	---	---	0.084805
i-Butane	C4H10	75-28-5	---	---	---	0.007275	---	---	---	0.007275
n-Butane	C4H10	106-97-8	---	---	---	0.017510	---	---	---	0.017510
i-Pentane	C5H12	78-78-4	---	---	---	0.002545	---	---	---	0.002545
n-Pentane	C5H12	109-66-0	---	0.185773	---	0.003010	---	---	---	0.003010
Benzene	C6H6	71-43-2	---	---	---	0.000100	---	---	---	0.000100
Cyclohexane	C6H12	110-82-7	---	---	---	0.000175	---	---	---	0.000175
Hexane	C6H14	110-54-3	---	0.164245	---	0.000745	---	---	---	0.000745
Methylcyclopentane	C6H12	96-37-7	---	---	---	0.000170	---	---	---	0.000170
Heptane	C7H16	142-82-5	---	0.145020	---	0.001975	---	---	---	0.001975
Methylcyclohexane	C7H14	108-87-2	---	---	---	0.000190	---	---	---	0.000190

Toluene	**C7H8**	**108-88-3**	---	---	---	0.000165	---	---	---	0.000165
Ethylbenzene	**C8H10**	**100-41-4**	---	---	---	0.000005	---	---	---	0.000005
m-Xylene	**C8H10**	**108-38-3**	---	---	---	0.000040	---	---	---	0.000040
Octane	**C8H18**	**111-65-9**	---	0.127939	---	0.000075	---	---	---	0.000075
o-Xylene	**C8H10**	**95-47-6**	---	---	---	0.000005	---	---	---	0.000005
Nonane	**C9H20**	**111-84-2**	---	0.112808	---	0.000035	---	---	---	0.000035
Decane	**C10H22**	**124-18-5**	---	0.099427	---	0.000020	---	---	---	0.000020
Undecanes	**C11H24**	**1120-21-4**	---	0.087609	---	0.000015	---	---	---	0.000015
Dodecane	**C12H26**	**112-40-3**	---	0.077179	---	0.000005	---	---	---	0.000005
Tridecane	**C13H28**	**629-50-5**	---	---	0.187058	---	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	0.164740	---	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	0.145069	---	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	0.127737	---	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	0.112467	---	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	0.099017	---	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	0.087172	---	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	0.076740	---	---	---	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS100	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	33							
- Fluid	Water							
- Physical State	Liquid							
- Temperature (°C)	14.40							
- Pressure (kPa)	2,517.0							
- Total Molar Flowrate (kmole/h)	1,154.09							
- Total Mass Flowrate (kg/h)	20791.0							
- Total Gas Volumetric Flowrate (Std m^3/h)	---							
- Total Liq Volumetric Flowrate (m^3/h)	20.8							
- Energy Flowrate kW	---							
Origin (Unit Operation):								
- Tag No.	PSU-100							

- Service:	---							
- Type:	---							
Destination (Unit Operation):								
- Tag No.	Produced Water Header							
- Service:	---							
- Type:	---							
Properties:	33	0	0	0	0	0	0	0
- Vapour Mole Fraction	0.000000							
- Liquid Mole Fraction	1.000000							
- Solid Mole Fraction	---							
- Aqueous Mole Fraction	---							
- Molecular Weight	18.015							
- Mass Density (kg/m^3)	1,000.364							
- Molar Density (kmole/m^3)	55.529							
- API Gravity (°)	---							
- Compressibility Factor	---							
- Specific Heat Capacity (kJ/kmole·°C)	75.3123							
- Enthalpy (kJ/kmole)	1,134							
- Entropy (kJ/kmole·°C)	4							
- Gross Heating Value (MJ/m^3)	0.0							
- Net Heating Value (MJ/m^3)	0.0							
- Sound Speed (m/s)	1,467.920							
- Dew Point Temperature (°C)	240.00							
- Dew Point Pressure (°kPa)	2,596.4							
- Bubble Point Temperature (°C)	226.32							
- Bubble Point Pressure (kPa)	1.6							
- Reid Vapour Pressure (kPa)	---							
- True Vapour Pressure (kPa)	---							
- Thermal Conductivity (W/m·°C)	0.589							
- Viscosity (cp)	1.154							

Composition (Mole Fraction):			33	0	0	0	0	0	0	0
Name	**Formula**	**CAS No.**								
Water	**H2O**	**7732-18-5**	1.000000							

REPORT: SOURCE MITIGATION ANALYSIS

Row	A	B	C	D	E	F	G	H	I	J	K
	Header Block										
	Client:	TetraTech					**Operator:**		Tetra Tech		
	Site:	Mangghystau Oilfield					**Country:**		Kazakhstan		
4	**Facility:**	**Category:**		Oil Field			**Subcategory 1:**				
5		**CEL Facility Code:**		OP-009			**Subcategory 2:**				
6	**Source:**	**Category:**		Flare			**Subcategory 1:**		Elevated		
7		**CEL Equipment Code:**		OP-009-1			**Subcategory 2:**		Unassisted		
8		**Tag No:**		TECH-FL-1			**Make:**		Unavailable		
9		**Model:**		Unavailable			**Serial No:**		Unavailable		

Row	A	B	C	D	E	F	G	H	I
	Mitigation Measure Assessed								
12	**Time Series**	**CEL Mitigation Code:**		OP-009-GS250			**End-Year**	**Asset Life:**	2032
13		**Start Year:**		2022				**Viability:**	2032
14	**Mitigation Measure (Stage 1)**	**Category:**		Small-Scale Gas-to-Liquids Production			**Subcategory 1:**		
15		**CEL Reference Code:**		GTL			**Subcategory 2:**		
16		**Reference CEL Drawing No:**		Unavailable			**Reference CEL Drawing Title:**		Unavailable
17	**Mitigation Measure (Stage 2)**	**Category:**		None			**Subcategory 1:**		
18		**CEL Reference Code:**					**Subcategory 2:**		
19		**Reference CEL Drawing No:**					**Reference CEL Drawing Title:**		
20	**Mitigation Measure (Stage 3)**	**Category:**		None			**Subcategory 1:**		
21		**CEL Reference Code:**					**Subcategory 2:**		
22		**Reference CEL Drawing No:**					**Reference CEL Drawing Title:**		
		Optimization Objective Function:		Net Present Value Over Pay-Back Period Ratio			**Economic Scenario Name:**		None

Row	Search Parameter	Value Chosen	Min Search Value	Max Search Value
	Optimization Search Space			
26	**Search Parameter**	**Value Chosen**	**Min Search Value**	**Max Search Value**
27	**Year-1 Peak Flow Rate Design Factor**	**0.90**	0.60	1.20
28	**Electric Generator Drive Type**	**Reciprocating**	---	---
29	**Number of Electric Generator Trains**	**2.00**	1.00	10.00

Row	A	B	C	D	E	F	G	H	I	J	K
	Key Findings										
32	**Economic Impacts**	**Capital Cost (USD):**		201,306,281		**Net Present Value (USD) (Before Tax):**			307,767,731		
33		**Project Life (Years):**		10		**Net Present Value (USD) (After Tax):**			307,767,731		
34		**Asset Life Expectancy (Years):**		10		**Return on Investment (%) (Before Tax):**			152.89%		
35		**Asset Salvage Value (USD):**		0		**Return on Investment (%) (After Tax):**			152.89%		
36		**Payback Period (Years):**		3.38		**Internal Rate of Return (%):**			36.90%		
37	**Pre-Mitigation Commodity Losses**	**Value of Gas Losses (USD/y)**		**Total Gas Loss (m^3/h)**	**Residue Gas (10^3 m^3/d)**	**Ethane (m^3/d liq)**	**LPG (m^3/d liq)**	**NGL (m^3/d)**	**Hydrogen (m^3/d)**		
38		**Energy Basis**	**Commodity Basis**								
39		0	30,154,630	30,104.0	512.8	439.8	311.8	32.0	0.0		
40	**Lifetime GHG Emission Reductions**	**CH_4 (kilotonnes)**	**CO_2 (kilotonnes)**	**N_2O (kilotonnes)**	**CO_2E (kilotonnes)**	**Black Carbon (kilotonnes)**					
41		16.0	2,793.9	0.0	3,195.9	2.4					
42	**Lifetime CAC Emission Reductions**	**VOC (tonnes)**	**CO (tonnes)**	**NO_x (tonnes)**	**H_2S (tonnes)**	**SO_2 (tonnes)**	**PM (tonnes)**	**PM_{10} (tonnes)**	**$PM_{2.5}$ (tonnes)**		
43		8,858.4	10,546.4	2,266.0	0.0	0.0	1,792.4	1,792.4	1,792.4		
44											

		Reference No.	Category	Subcategory 1	Subcategory 2 or Manufacturer Make And Model
45	**Key Equipment Additions**				
46	**Key Equipment or**	**Reference No.**	**Category**	**Subcategory 1**	**Subcategory 2 or Manufacturer Make And Model**
47		Mini_GTL_1_1	Mini-GTL Plant	EFT FB 250	
48		Mini_GTL_2_1	Mini-GTL Plant	EFT FB 250	
49		Mini_GTL_3_1	Mini-GTL Plant	EFT FB 250	
50		Mini_GTL_4_1	Mini-GTL Plant	EFT FB 250	
51		Mini_GTL_5_1	Mini-GTL Plant	EFT FB 250	
52		Mini_GTL_6_1	Mini-GTL Plant	EFT FB 250	
53		Mini_GTL_7_1	Mini-GTL Plant	EFT FB 250	
54		Mini_GTL_8_1	Mini-GTL Plant	EFT FB 250	
55		Mini_GTL_9_1	Mini-GTL Plant	EFT FB 250	
56		VVN_1_1	Tank	API 650 - Fixed Roof	
57		VVD_1_1	Tank	API 650 - Fixed Roof	
58					

59	**Applied Economic Parameters**				
60	**Financial Rates**	**Discount Rate (%):**	10.00	**Inflation Rate (%):**	3.00
61		**Depreciation Rate (%):**	10.00	**Tax Rate (%)**	0.00
62		**Royalty Rate (%):**	30.00	**Import Duty (%):**	0.00
63		**GHG Emission Fee (USD/Tonne):**	$1.10	**CAC Emission Fee (USD/Tonne):**	0.00
64	**Production**	**Model Type:**	Initial Linear Increase	**D (decline as a fraction of production):**	0.0000

	A	B	C	D	E	F	G	H	I	J	K	L
65	**Decline Model**					**b (correlation constant):**					Not Applicable	
66	**Commodity Prices**	**Natural Gas**		**Ethane**	**LPG**	**NGL**	**Crude Oil**	**Hydrogen**	**Electricity**		**Diesel**	**Naptha**
67		**Purchases (USD/GJ)**	**Sales (USD/GJ)**	**(USD/m^3 Liq)**	**(USD/L Liq)**	**(USD/m^3 Liq)**	**(USD/m^3)**	**(USD/m^3)**	**Purchases (USD/kW·h)**	**Sales (USD/kW·h)**	**(USD/L Liq)**	**(USD / m3 Liq)**
68		$ -	$ -	$ 60.26	$ 0.14	$ 389.84	$ 471.70	$ 2.00	$ 0.04	$ -	$ 0.76	
69												
70												
71												
72	**Financials (Time Series Results)**											
73	**Year**	**Gross**	**Costs**		**Asset Book**	**Salvage Value**	**Royalty**	**Emission Fee**	**Net Revenues**		**Cumulative**	
74		**Revenues**	**Capital**	**Operating**	**Value**		**Payment**		**Before Tax**	**After Tax**	**After Tax Earnings**	
75		**(Inflation Adjusted USD)**							**(Present Value USD)**			
76	2022	103,936,320	201,306,281	5,517,340	181,175,653	79,599,173	10,609,875	-359,293	61,852,518	61,852,518	61,852,518	
77	2023	107,054,410		5,682,860	163,058,088	70,754,820	10,928,171	-359,293	60,070,336	60,070,336	121,922,854	
78	2024	110,266,042		5,853,346	146,752,279	61,910,468	11,256,017	-359,293	58,009,139	58,009,139	179,931,993	
79	2025	113,574,023		6,028,946	132,077,051	53,066,115	11,593,697	-359,293	55,758,107	55,758,107	235,690,100	
80	2026	116,981,244		6,209,815	118,869,346	44,221,763	11,941,508	-359,293	53,387,753	53,387,753	289,077,853	
81	2027	120,490,681		6,396,109	106,982,411	35,377,410	12,299,753	-359,293	50,953,468	50,953,468	340,031,321	
82	2028	124,105,402		6,587,992	96,284,170	26,533,058	12,668,746	-359,293	48,498,428	48,498,428	388,529,749	
83	2029	125,599,679		6,785,632	86,655,753	17,688,705	12,821,293	-353,029	45,119,364	45,119,364	433,649,113	
84	2030	123,307,201		6,989,201	77,990,178	8,844,353	12,587,305	-336,491	40,459,596	40,459,596	474,108,709	
85	2031	117,358,010		7,198,877	70,191,160	0	11,980,054	-310,930	34,965,303	34,965,303	509,074,012	
86	**Last Profitable Year (After Asset Liquidation, Final Tax Adjustments and Closing Book Entries)**											
87	2031	117,358,010	999	7,198,877	70,191,160	0	11,980,054	-310,930	34,965,303	34,965,303	509,074,012	
88												
89	**Avoided GHG and BC Emissions (Time Series Results)**											
90	**Year**	**CH_4 (kt)**	**CO_2 (kt)**	**N_2O (kt)**	**CO_2E (kt)**	**Black Carbon (t)**						
91	2022	1.6	285.5	0.0	326.6	249.9						
92	2023	1.6	285.5	0.0	326.6	249.9						
93	2024	1.6	285.5	0.0	326.6	249.9						
94	2025	1.6	285.5	0.0	326.6	249.9						
95	2026	1.6	285.5	0.0	326.6	249.9						
96	2027	1.6	285.5	0.0	326.6	249.9						
97	2028	1.6	285.5	0.0	326.6	249.9						
98	2029	1.6	280.6	0.0	320.9	229.8						
99	2030	1.5	267.4	0.0	305.9	211.4						
100	2031	1.4	247.1	0.0	282.7	194.5						
101												
102	**Other Avoided Atmospheric Emissions (Time Series Results)**											
103	**Year**	**VOC (t)**	**CO (t)**	**NO_x (t)**	**H_2S (t)**	**SO_2 (t)**	**PM (t)**	**PM_{10} (t)**	**$PM_{2.5}$ (t)**			
104	2022	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2			
105	2023	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2			
106	2024	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2			
107	2025	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2			
108	2026	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2			
109	2027	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2			
110	2028	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2			
111	2029	0.9	1.1	0.2	0.0	0.0	180.0	180.0	180.0			
112	2030	0.8	1.0	0.2	0.0	0.0	171.6	171.6	171.6			
113	2031	0.8	0.9	0.2	0.0	0.0	158.5	158.5	158.5			
114												
115	**Forecast Site Activity Data (Time Series Results - Part 1)**											
116	**Year**	**Production**			**Waste Gas Disposition**			**Incremental Energy Purchases**				
117		**Oil (10^3 m^3)**	**Gas (10^6 m^3)**	**Water (10^3 m^3)**	**Collected (10^6 m^3)**	**Conserved (10^6 m^3)**	**Flared (10^6 m^3)**	**Natural Gas (10^6 m^3)**	**Naphtha (10^3 m^3)**	**Diesel (m^3)**	**Electricity (10^3 kW·h)**	
118	2022	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933	
119	2023	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933	
120	2024	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933	
121	2025	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933	
122	2026	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933	
123	2027	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933	
124	2028	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933	
125	2029	883.87	242.62		242.61	109.53	133.09	0.00	0.00	0.00	134,548	
126	2030	813.16	223.21		223.20	104.40	118.81	0.00	0.00	0.00	128,251	
127	2031	748.10	205.35		205.35	96.47	108.88	0.00	0.00	0.00	118,518	
128												
129	**Forecast Site Activity Data (Time Series Results - Part 2)**											
130	**Year**	**Incremental Product Sales**					**Incremental Utilization**	**Avoided Purchases**				
131		**Gas (10^6 m^3 Gas)**	**LPG (10^3 m^3 Liq)**	**NGL (10^3 m^3 Liq)**	**Oil (10^3 m^3)**	**Electricity (10^3 kW·h)**	**Fuel Gas (10^6 m^3 Gas)**	**Natural Gas (10^6 m^3)**	**Naphtha (10^3 m^3)**	**Diesel (m^3)**	**Electricity (10^3 kW·h)**	

	A	B	C	D	E	F	G	H	I	J	K	L
132	2022	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
133	2023	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
134	2024	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
135	2025	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
136	2026	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
137	2027	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
138	2028	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
139	2029	0.00	0.00	0.00	0.00	0	37.75	0.00	78.26	50,043	0.00	
140	2030	0.00	0.00	0.00	0.00	0	35.98	0.00	74.60	47,698	0.00	
141	2031	0.00	0.00	0.00	0.00	0	33.25	0.00	68.93	44,075	0.00	
142												

143	Applied Emission Factors (EF) For Year One Emissions For Baseline (BL) and Simulated Equipment							
144	Source			Pollutant	EF (ng/J of Fuel)	Reference (Where Applicable) and Basis		
145	Category	Tag No.	DB EF Key			Basis	Author or Reporting Agency	Code
146	**Flares**	**BL FLARE_1**	**335**	**CH_4**	180.0	Calculated	US EPA	2018-U.S.EPAAP-42Table13.5-1
147				**CO_2**	54,529.6	Calculated	NA	
148				**N_2O**	0.1	Referenced	WCI	2012-BCWCI.363(k)
149				**BC**	19.7	Calculated	NA	
150				**VOC**	22.3	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
151				**CO**	133.0	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
152				**NO_x**	29.2	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-1
153				**SO_2**	0.0	Calculated	NA	
154				**PM**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
155				**PM_{10}**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
156				**$PM_{2.5}$**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
157	**Heaters and Boilers**	**Mini_GTL_1_1**	**7**	**CH_4**	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
158				**CO_2**	83,629.7	Calculated	NA	
159				**N_2O**	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
160				**BC**	0.6	Calculated	NA	
161				**VOC**	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
162				**CO**	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
163				**NO_x**	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
164				**SO_2**	0.0	Calculated	NA	
165				**PM**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
166				**PM_{10}**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
167				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
168	**Heaters and Boilers**	**Mini_GTL_2_1**	**7**	**CH_4**	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
169				**CO_2**	83,629.7	Calculated	NA	
170				**N_2O**	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
171				**BC**	0.6	Calculated	NA	
172				**VOC**	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
173				**CO**	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
174				**NO_x**	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
175				**SO_2**	0.0	Calculated	NA	
176				**PM**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
177				**PM_{10}**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
178				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
179	**Heaters and Boilers**	**Mini_GTL_3_1**	**7**	**CH_4**	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
180				**CO_2**	83,629.7	Calculated	NA	
181				**N_2O**	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
182				**BC**	0.6	Calculated	NA	
183				**VOC**	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
184				**CO**	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
185				**NO_x**	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
186				**SO_2**	0.0	Calculated	NA	
187				**PM**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
188				**PM_{10}**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
189				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
190	**Heaters and Boilers**	**Mini_GTL_4_1**	**7**	**CH_4**	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
191				**CO_2**	83,629.7	Calculated	NA	
192				**N_2O**	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
193				**BC**	0.6	Calculated	NA	
194				**VOC**	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
195				**CO**	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
196				**NO_x**	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
197				**SO_2**	0.0	Calculated	NA	
198				**PM**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
199				**PM_{10}**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
200				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
201	**Heaters and Boilers**	**Mini_GTL_5_1**	**7**	**CH_4**	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
202				**CO_2**	83,629.7	Calculated	NA	
203				**N_2O**	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2

	A	B	C	D	E	F	G	H	I	J	K	L
204				BC	0.6	Calculated	NA					
205				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
206				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
207				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
208				SO_2	0.0	Calculated	NA					
209				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
210				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
211				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
212	**Heaters and Boilers**	**Mini_GTL_6_1**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
213				CO_2	83,629.7	Calculated	NA					
214				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
215				BC	0.6	Calculated	NA					
216				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
217				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
218				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
219				SO_2	0.0	Calculated	NA					
220				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
221				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
222				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
223	**Heaters and Boilers**	**Mini_GTL_7_1**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
224				CO_2	83,629.7	Calculated	NA					
225				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
226				BC	0.6	Calculated	NA					
227				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
228				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
229				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
230				SO_2	0.0	Calculated	NA					
231				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
232				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
233				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
234	**Heaters and Boilers**	**Mini_GTL_8_1**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
235				CO_2	83,629.7	Calculated	NA					
236				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
237				BC	0.6	Calculated	NA					
238				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
239				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
240				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
241				SO_2	0.0	Calculated	NA					
242				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
243				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
244				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
245	**Heaters and Boilers**	**Mini_GTL_9_1**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
246				CO_2	83,629.7	Calculated	NA					
247				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
248				BC	0.6	Calculated	NA					
249				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
250				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
251				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
252				SO_2	0.0	Calculated	NA					
253				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
254				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
255				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
256	**Flares**	**FLARE_1**	**335**	CH_4	137.0	Calculated	US EPA		2018-U.S.EPAAP-42Table13.5-1			
257				CO_2	83,629.7	Calculated	NA					
258				N_2O	0.1	Referenced	WCI		2012-BCWCI.363(k)			
259				BC	0.0	Calculated	NA					
260				VOC	22.3	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
261				CO	133.0	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
262				NO_x	29.2	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-1			
263				SO_2	0.0	Calculated	NA					
264				PM	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
265				PM_{10}	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
266				$PM_{2.5}$	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
267												
268	Capital Cost											
269	Equipment	Item	Category	Subcategory 1	Subcategory 2	Capacity or Rated Power Output		Price (USD)	FOB Point	Basis		
270						Value	Units of Measure					
271		Mini_GTL_1_1	Mini-GTL Plant	EFT FB 250		72.25	10^3 m^3	9,779,228	NA	Predicted (Class 5)		
272		Mini_GTL_2_1	Mini-GTL Plant	EFT FB 250		72.25	10^3 m^3	9,779,228	NA	Predicted (Class 5)		
273		Mini_GTL_3_1	Mini-GTL Plant	EFT FB 250		72.25	10^3 m^3	9,779,228	NA	Predicted (Class 5)		

REPORT: SOURCE MITIGATION ANALYSIS

	A	B	C	D	E	F	G	H	I	J	K	L
274		Mini_GTL_4_1	Mini-GTL Plant	EFT FB 250		72.25	10^3 m³	9,779,228	NA	Predicted (Class 5)		
275		Mini_GTL_5_1	Mini-GTL Plant	EFT FB 250		72.25	10^3 m³	9,779,228	NA	Predicted (Class 5)		
276		Mini_GTL_6_1	Mini-GTL Plant	EFT FB 250		72.25	10^3 m³	9,779,228	NA	Predicted (Class 5)		
277		Mini_GTL_7_1	Mini-GTL Plant	EFT FB 250		72.25	10^3 m³	9,779,228	NA	Predicted (Class 5)		
278		Mini_GTL_8_1	Mini-GTL Plant	EFT FB 250		72.25	10^3 m³	9,779,228	NA	Predicted (Class 5)		
279		Mini_GTL_9_1	Mini-GTL Plant	EFT FB 250		72.25	10^3 m³	9,779,228	NA	Predicted (Class 5)		
280		VVN_1_1	Tank	API 650 - Fixed Roof		1,797.57	m³	239,924	NA	Predicted (Class 4)		
281		VVD_1_1	Tank	API 650 - Fixed Roof		1,149.36	m³	190,546	NA	Predicted (Class 4)		
282		**E7**	**Engineering & Drafting**					12,209,616				
283		**Subtotal:**						100,653,141				
284	**Pipeline**	**Pipe Specifications**	**OD (mm)**			**Material:**			**Design P (kPa)**			
285			**WT (mm)**			**Length (km):**			**Coating:**			
286		**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
287		**PL1**	**Pipe**									
288		**PL2**	**Right-of-Way (ROW)**									
289		**PL3**	**ROW Land Survey**									
290		**PL4**	**Clearing**									
291		**PL5**	**Soil Stripping**									
292		**PL6**	**Timber Salvage**									
293		**PL7**	**Rock excavation**									
294		**PL8**	**Cathodic Protection**									
295		**PL9**	**Construction**									
296		**PL10**	**Engineering & Drafting**									
297		**PL11**	**Supervision**									
298		**PL12**	**Safety**									
299		**PL13**	**Reseeding ROW**									
300		**Subtotal:**										
301	**Materials & Services**	**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
302		**MS1**	**Equipment Setting**		0	12,203,315		12,203,315		Predicted		
303		**MS2**	**Foundations**		3,050,829	4,057,602		7,108,431		Predicted		
304		**MS3**	**Structural Steel**		3,050,829	1,525,414		4,576,243		Predicted		
305		**MS4**	**Buildings**		1,830,497	1,830,497		3,660,994		Predicted		
306		**MS5**	**Insulation**		610,166	915,249		1,525,414		Predicted		
307		**MS6**	**Instruments**		3,660,994	1,464,398		5,125,392		Predicted		
308		**MS7**	**Electrical**		4,881,326	3,660,994		8,542,320		Predicted		
309		**MS8**	**Piping**		27,457,459	13,728,729		41,186,188		Predicted		
310		**MS9**	**Painting**		305,083	915,249		1,220,331		Predicted		
311		**MS10**	**Miscellaneous**		1,830,497	1,464,398		3,294,895		Predicted		
312		**MS11**	**Engineering & Drafting**		0	12,209,616		12,209,616		Predicted		
313		**MS12**	**Supervision**		Unavailable	0		0				
314		**MS13**	**Safety**		Unavailable	0		0				
315		**Subtotal:**						100,653,141				
316	**Summary**	**Total:**						201,306,281				
317		**Duties:**						0				
318		**Freight:**						Unavailable				
319		**Grand Total:**						201,306,281				
320	**Year 1 Operating Costs**											
321		**Operating Labour**	**Hours Per Shift:**		Unknown	**Operator Hourly Labour Rate:**		$ 2.05				
322			**Shifts Per Day:**		Unknown	**Maintenance Hourly Labour Rate:**		$ 2.05				
323		**Item**	**Category**		**Material (USD**	**Labour (Hours)**	**Labour (USD)**	**Line Total (USD)**		**Basis**		
324	**Fixed O&M Costs**	**L1**	**Operating Labour**		0	6,840	14,022	14,022		Predicted		
325		**L2**	**Maintenance Labour**		0	2,280	4,674	4,674		Predicted		
326		**L3**	**Direct Supervision**		0		2,524	2,524		Predicted		
327		**L4**	**Administration**		0		1,814,238	1,814,238		Predicted		
328		**L5**	**Unclassified Costs**					0		Predicted		
329		**Total Fixed O&M Costs:**						1,835,458		Predicted		
330	**Variable O&M Costs**	**SS1**	**Third-Party Services**					34,626		Predicted		
331		**SS2**	**Parts & Consumables**					105,981		Predicted		
332		**SS3**	**Unclassified Costs**					3,541,274		Predicted		
333		**Total Variable O&M Costs:**						3,681,881		Predicted		
334	**Total O&M Costs**	**Total Fixed and Variable O&M Costs:**						5,517,340		Predicted		
335	**Purchased Commodities**	**PC1**	**Electricity**		5,340,406	0	0	5,340,406		Predicted		
336		**PC2**	**Natural Gas**		0	0	0	0		Predicted		
337		**PC3**	**LPG**		0	0	0	0		Predicted		
338		**PC4**	**Diesel**		0	0	0	0		Predicted		
339	**Summary**	**Total:**						10,857,746				

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS250	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Proposed Equipment

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS250	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	1	2	3	4	5	6	7	8
- Fluid	HC	HC	HC	HC	HC	Not Known	HC	Not Known
- Physical State	Vapour	Vapour	Vapour	Vapour	Vapour	Unknown	Vapour	Unknown
- Temperature (°C)	40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Pressure (kPa)	800.0	800.0	800.0	800.0	800.0	---	800.0	---
- Total Molar Flowrate (kmole/h)	1,273.17	1,145.61	127.56	1,942.07	796.46	0.00	1,942.07	0.00
- Total Mass Flowrate (kg/h)	30176.9	27153.5	3023.5	52639.3	25485.8	0.0	52639.3	0.0
- Total Gas Volumetric Flowrate	30104.0	27087.8	3016.2	45919.9	18832.1	---	45919.9	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	From Flare Line	FS-100	FS-100	M-100	Oxygen Plant	HP Steam Header	V-100	V-100
- Service:	---	Not Applicable	Not Applicable	Not Applicable	---	---	Inlet Scrubber	Inlet Scrubber

- Type:	---	Flow Splitter	Flow Splitter	Mixer	---	---	2-Phase Separator	2-Phase Separator
Destination (Unit Operation):								
- Tag No.	FS-100	M-100	To Flare Line	V-100	M-100	M-100	K-100	Waste Water Header
- Service:	Not Applicable	Not Applicable	---	Inlet Scrubber	Not Applicable	Not Applicable	Inlet Gas Boosting	---
- Type:	Flow Splitter	Mixer	---	2-Phase Separator	Mixer	Mixer	Compressor: Recip.	---
Properties:	1	2	3	4	5	6	7	8
- Vapour Mole Fraction	1.000000	1.000000	1.000000	1.000000	1.000000	---	1.000000	---
- Liquid Mole Fraction	0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	23.702	23.702	23.702	27.105	31.999	---	27.105	---
- Mass Density (kg/m^3)	8.439	8.439	8.439	9.634	11.470	---	9.634	---
- Molar Density (kmole/m^3)	0.356	0.356	0.356	0.355	0.358	---	0.355	---
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	0.9669	0.9669	0.9669	0.9794	0.9925	---	0.9794	---
- Specific Heat Capacity (kJ/kmole·°C)	46.7971	46.7971	46.7971	39.4833	29.4594	---	39.4833	---
- Enthalpy (kJ/kmole)	-85,487	-85,487	-85,487	-50,404	60	---	-50,404	---
- Entropy (kJ/kmole·°C)	-202	-202	-202	-152	-95	---	-152	---
- Gross Heating Value (MJ/m^3)	48.3	48.3	48.3	28.5	0.0	---	28.5	---
- Net Heating Value (MJ/m^3)	43.3	43.3	43.3	25.6	0.0	---	25.6	---
- Sound Speed (m/s)	359.316	359.316	359.316	344.504	332.061	---	344.504	---
- Dew Point Temperature (°C)	40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Dew Point Pressure (°kPa)	896.4	896.4	896.4	896.4	896.4	---	896.4	---
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	0.033	0.033	0.033	0.033	0.030	---	0.033	---
- Viscosity (cp)	0.012	0.012	0.012	0.015	0.023	---	0.015	---

Composition (Mole Fraction):			1	2	3	4	5	6	7	8
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043380	0.043380	0.043380	0.025590	0.000001	---	0.025590	---
Oxygen	**O2**	**7782-44-7**	---	---	---	0.410107	0.999999	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
Carbon Dioxide	**CO2**	**124-38-9**	0.025205	0.025205	0.025205	0.014868	---	---	0.014868	---
Methane	**CH4**	**74-82-8**	0.641174	0.641174	0.641174	0.378224	---	---	0.378224	---
Ethane	**C2H6**	**74-84-0**	0.171376	0.171376	0.171376	0.101094	---	---	0.101094	---
Propane	**C3H8**	**74-98-6**	0.084805	0.084805	0.084805	0.050026	---	---	0.050026	---
i-Butane	**C4H10**	**75-28-5**	0.007275	0.007275	0.007275	0.004291	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	0.017510	0.017510	0.017510	0.010329	---	---	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	0.002545	0.002545	0.002545	0.001501	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	0.003010	0.003010	0.003010	0.001776	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	0.000100	0.000100	0.000100	0.000059	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	0.000175	0.000175	0.000175	0.000103	---	---	0.000103	---
Hexane	**C6H14**	**110-54-3**	0.000745	0.000745	0.000745	0.000439	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.000170	0.000170	0.000100	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	0.001975	0.001975	0.001975	0.001165	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.000190	0.000190	0.000112	---	---	0.000112	---

Toluene	**C7H8**	**108-88-3**	0.000165	0.000165	0.000165	0.000097	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.000040	0.000040	0.000024	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	0.000075	0.000075	0.000075	0.000044	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	0.000035	0.000035	0.000035	0.000021	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	0.000020	0.000020	0.000020	0.000012	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000015	0.000015	0.000009	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS250	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	9	10	11	12	13	14	15	16
- Fluid	Heat Medium	Heat Medium	HC	Electricity	Fuel Gas	HC	HC	HC
- Physical State	Liquid	Liquid	Vapour	Unknown	Gas	Vapour	Vapour	Vapour
- Temperature (°C)	120.00	120.00	192.34	---	39.90	39.90	1,050.00	1,050.00
- Pressure (kPa)	276.0	276.0	5,100.0	---	0.0	0.0	5,000.0	5,000.0
- Total Molar Flowrate (kmole/h)	0.00	0.00	1,942.07	---	0.00	135.34	1,942.07	4,329.38
- Total Mass Flowrate (kg/h)	0.0	0.0	52639.3	---	0.0	3637.3	52639.3	52638.8
- Total Gas Volumetric Flowrate (Std m^3/h)	---	---	45919.9	---	0.0	3200.2	45919.9	102367.5
- Total Liq Volumetric Flowrate (m^3/h)	0.0	0.0	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	3,800.442	---	---	---	---
Origin (Unit Operation):								
- Tag No.	V-100	H-100	K-100	Electric Utility System	Fuel Gas Header	M-200	H-101	R-100
- Service:	Inlet Scrubber	Boiler	Inlet Gas Boosting	---	---	Not Applicable	Heat Medium Heater	---

- Type:			2-Phase Separator	Heater	Compressor: Recip.	---	---	Mixer	Heater: Fired	---
Destination (Unit Operation):										
- Tag No.			PU-101	V-100	H-101	K-100	K-100	H-101	R-100	E-100
- Service:			Circulation	Inlet Scrubber	Heat Medium Heater	Inlet Gas Boosting	Inlet Gas Boosting	Heat Medium Heater	---	Boiler
- Type:			Pump	2-Phase Separator	Heater: Fired	Compressor: Recip.	Compressor: Recip.	Heater: Fired	---	Heat Exchanger: Shell and Tube
Properties:			9	10	11	12	13	14	15	16
- Vapour Mole Fraction			0.000000	0.000000	1.000000	---	1.000000	1.000000	1.000000	1.000000
- Liquid Mole Fraction			1.000000	1.000000	0.000000	---	0.000000	0.000000	0.000000	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			41.686	41.686	27.105	---	---	26.875	27.105	12.158
- Mass Density (kg/m^3)			1,025.000	1,025.000	36.987	---	---	0.996	12.411	5.584
- Molar Density (kmole/m^3)			---	---	1.365	---	---	0.037	0.458	0.459
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	---	0.9839	---	---	0.9986	1.0117	1.0086
- Specific Heat Capacity (kJ/kmole·°C)			135.4802	135.4802	48.4778	---	---	35.4385	77.7041	32.4041
- Enthalpy (kJ/kmole)			---	---	-44,103	---	---	-103,562	11,746	-12,049
- Entropy (kJ/kmole·°C)			---	---	-150	---	---	-59	-85	-25
- Gross Heating Value (MJ/m^3)			---	---	28.5	---	---	24.7	28.5	11.9
- Net Heating Value (MJ/m^3)			---	---	25.6	---	---	22.9	25.6	10.3
- Sound Speed (m/s)			---	---	418.851	---	---	355.689	682.497	1,113.676
- Dew Point Temperature (°C)			---	---	192.34	---	---	39.90	1,050.00	1,050.00
- Dew Point Pressure (°kPa)			---	---	5,196.4	---	---	96.4	5,096.4	5,096.4
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	---	0.057	---	---	0.032	0.194	0.201
- Viscosity (cp)			1.100	1.100	0.022	---	---	0.016	0.045	0.038
Composition (Mole Fraction):			9	10	11	12	13	14	15	16
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	---	---	---	---	0.000000	---	0.613921
Nitrogen	**N2**	**7727-37-9**	---	---	0.025590	---	0.062677	0.062677	0.025590	0.011479
Oxygen	**O2**	**7782-44-7**	---	---	0.410107	---	---	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.462700	0.462700	0.000000	---	0.000000	0.000000	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	0.014868	---	0.036417	0.036417	0.014868	0.006670
Carbon Monoxide	**CO**	**630-08-0**	---	---	---	---	0.553432	0.553432	---	0.367931
Methane	**CH4**	**74-82-8**	---	---	0.378224	---	0.249780	0.249780	0.378224	---
Ethane	**C2H6**	**74-84-0**	---	---	0.101094	---	0.044421	0.044421	0.101094	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	0.537300	0.537300	---	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	---	0.050026	---	0.030293	0.030293	0.050026	---
i-Butane	**C4H10**	**75-28-5**	---	---	0.004291	---	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	---	---	0.010329	---	0.022981	0.022981	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	---	---	0.001501	---	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	---	---	0.001776	---	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	---	---	0.000059	---	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	---	---	0.000103	---	---	---	0.000103	---

Hexane	**C6H14**	**110-54-3**	---	---	0.000439	---	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	0.000100	---	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	---	---	0.001165	---	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	0.000112	---	---	---	0.000112	---
Toluene	**C7H8**	**108-88-3**	---	---	0.000097	---	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	---	---	0.000003	---	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	---	---	0.000024	---	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	---	---	0.000044	---	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	---	---	0.000003	---	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	---	---	0.000021	---	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	---	---	0.000012	---	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	---	---	0.000009	---	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	---	---	0.000003	---	---	---	0.000003	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS250	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	17	18	19	20	21	22	23	24
- Fluid	Water	HC	Water	HC	HC	HC	Not Known	HC
- Physical State	Vapour	Vapour	Liquid	Vapour	Vapour	Vapour	Unknown	Vapour
- Temperature (°C)	226.32	240.00	14.40	240.00	39.90	39.90	---	39.90
- Pressure (kPa)	2,517.0	2,500.0	2,517.0	2,500.0	0.0	0.0	---	0.0
- Total Molar Flowrate (kmole/h)	2.19	4,329.38	2.19	2,021.20	792.91	135.34	0.00	657.56
- Total Mass Flowrate (kg/h)	39.5	52638.8	39.5	52638.7	21309.0	3637.3	0.0	17671.7
- Total Gas Volumetric Flowrate (Sm³/h)	51.8	102367.5	---	47790.8	18748.2	3200.2	---	15548.0
- Total Liq Volumetric Flowrate (m³/h)	---	---	0.0	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	E-100	E-100	Water Header	R-101	PSU-100	FS-101	Fuel Gas Header	FS-101
- Service:	Boiler	Boiler	---	---	---	Not Applicable	---	Not Applicable

- Type:			Heat Exchanger:	Heat Exchanger:	---	---	---	Flow Splitter	---	Flow Splitter
Destination (Unit Operation):										
- Tag No.			HP Steam Header	R-101	E-100	PSU-100	FS-101	M-200	M-200	Gas to Flare
- Service:			---	---	Boiler	---	Not Applicable	Not Applicable	Not Applicable	---
- Type:			---	---	Heat Exchanger: Shell and Tube	---	Flow Splitter	Mixer	Mixer	---
Properties:			17	18	19	20	21	22	23	24
- Vapour Mole Fraction			1.000000	1.000000	0.000000	1.000000	1.000000	1.000000	---	1.000000
- Liquid Mole Fraction			0.000000	0.000000	1.000000	0.000000	0.000000	0.000000	---	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			18.015	12.158	18.015	26.043	26.875	26.875	---	26.875
- Mass Density (kg/m^3)			13.071	7.321	1,000.364	16.505	0.996	0.996	---	0.996
- Molar Density (kmole/m^3)			0.726	0.602	55.529	0.634	0.037	0.037	---	0.037
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	1.0106	---	0.9602	0.9986	0.9986	---	0.9986
- Specific Heat Capacity (kJ/kmole·°C)			62.1935	29.5433	75.3123	52.2772	35.4385	35.4385	---	35.4385
- Enthalpy (kJ/kmole)			50,485	-37,028	1,134	-178,960	-103,562	-103,562	---	-103,562
- Entropy (kJ/kmole·°C)			112	-49	4	-126	-59	-59	---	-59
- Gross Heating Value (MJ/m^3)			0.0	11.9	0.0	20.4	24.7	24.7	---	24.7
- Net Heating Value (MJ/m^3)			0.0	10.3	0.0	18.8	22.9	22.9	---	22.9
- Sound Speed (m/s)			504.574	707.655	1,467.920	433.537	355.689	355.689	---	355.689
- Dew Point Temperature (°C)			226.32	240.00	240.00	240.00	39.90	39.90	---	39.90
- Dew Point Pressure (°kPa)			2,613.3	2,596.4	2,596.4	2,596.4	96.4	96.4	---	96.4
- Bubble Point Temperature (°C)			226.32	---	226.32	---	---	---	---	---
- Bubble Point Pressure (kPa)			1.6	---	1.6	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.045	0.100	0.589	0.065	0.032	0.032	---	0.032
- Viscosity (cp)			0.017	0.021	1.154	0.020	0.016	0.016	---	0.016
Composition (Mole Fraction):			17	18	19	20	21	22	23	24
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	0.613921	---	0.000000	0.000000	0.000000	---	0.000000
Nitrogen	**N2**	**7727-37-9**	---	0.011479	---	0.024588	0.062677	0.062677	---	0.062677
Water	**H2O**	**7732-18-5**	1.000000	0.000000	1.000000	0.570995	0.000000	0.000000	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	0.006670	---	0.014286	0.036417	0.036417	---	0.036417
Carbon Monoxide	**CO**	**630-08-0**	---	0.367931	---	0.217109	0.553432	0.553432	---	0.553432
Methane	**CH4**	**74-82-8**	---	---	---	0.097988	0.249780	0.249780	---	0.249780
Ethane	**C2H6**	**74-84-0**	---	---	---	0.017426	0.044421	0.044421	---	0.044421
Propane	**C3H8**	**74-98-6**	---	---	---	0.011884	0.030293	0.030293	---	0.030293
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.009015	0.022981	0.022981	---	0.022981
n-Pentane	**C5H12**	**109-66-0**	---	---	---	0.005002	---	---	---	---
Hexane	**C6H14**	**110-54-3**	---	---	---	0.004422	---	---	---	---
Heptane	**C7H16**	**142-82-5**	---	---	---	0.003905	---	---	---	---
Octane	**C8H18**	**111-65-9**	---	---	---	0.003445	---	---	---	---
Nonane	**C9H20**	**111-84-2**	---	---	---	0.003037	---	---	---	---
Decane	**C10H22**	**124-18-5**	---	---	---	0.002677	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	---	---	---	0.002359	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	---	---	---	0.002078	---	---	---	---

Tridecane	**C13H28**	**629-50-5**	---	---	---	0.001830	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	---	0.001612	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	---	0.001419	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	---	0.001250	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	---	0.001100	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	---	0.000969	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	---	0.000853	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	---	0.000751	---	---	---	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS250	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	25	26	27	28	29	30	31	32
- Fluid	Electricity	HC	HC	HC	Heat Medium	Heat Medium	Electricity	HC
- Physical State	Unknown	Liquid	Liquid	Vapour	Liquid	Liquid	Unknown	Vapour
- Temperature (°C)	---	39.90	39.90	40.00	120.00	120.00	---	40.00
- Pressure (kPa)	---	0.0	0.0	800.0	276.0	276.0	---	800.0
- Total Molar Flowrate (kmole/h)	---	54.42	19.78	0.00	0.00	0.00	---	0.00
- Total Mass Flowrate (kg/h)	---	6103.8	4434.9	0.0	0.0	0.0	---	0.0
- Total Gas Volumetric Flowrate (Sm³/h)	---	---	---	0.0	---	---	---	0.0
- Total Liq Volumetric Flowrate (m³/h)	---	9.1	5.8	---	0.0	0.0	---	---
- Energy Flowrate kW	11,831.235	---	---	---	---	---	23,662.470	---
Origin (Unit Operation):								
- Tag No.	Electric Utility System	PSU-100	PSU-100	Fuel Gas Header	H-100	PU-101	Electric Utility System	Fuel Gas Header
- Service:	---	---	---	---	Boiler	Circulation	---	---

- Type:			---	---	---	---	Heater	Pump	---	---
Destination (Unit Operation):										
- Tag No.			PSU-100	Naphtha Storage	Diesel Storage	H-100	V-100	H-100	Mini-GTL Plant	Mini-GTL Plant
- Service:			---	---	---	Boiler	Inlet Scrubber	Boiler	---	---
- Type:			---	---	---	Heater	2-Phase Separator	Heater	---	---
Properties:			25	26	27	28	29	30	31	32
- Vapour Mole Fraction			---	0.000000	0.000000	1.000000	0.000000	0.000000	---	1.000000
- Liquid Mole Fraction			---	1.000000	1.000000	0.000000	1.000000	1.000000	---	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			---	112.161	224.249	23.702	41.686	41.686	---	23.702
- Mass Density (kg/m^3)			---	671.270	762.803	8.439	1,025.000	1,025.000	---	8.439
- Molar Density (kmole/m^3)			---	5.985	3.402	0.356	---	---	---	0.356
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	0.0063	0.0134	0.9669	---	---	---	0.9669
- Specific Heat Capacity (kJ/kmole·°C)			---	245.2118	472.3949	46.7971	135.4802	135.4802	---	46.7971
- Enthalpy (kJ/kmole)			---	-241,592	-437,240	-85,487	---	---	---	-85,487
- Entropy (kJ/kmole·°C)			---	-891	-1,701	-202	---	---	---	-202
- Gross Heating Value (MJ/m^3)			---	230.6	454.9	48.3	---	---	---	48.3
- Net Heating Value (MJ/m^3)			---	212.1	419.8	43.3	---	---	---	43.3
- Sound Speed (m/s)			---	969.621	1,355.431	359.316	---	---	---	359.316
- Dew Point Temperature (°C)			---	---	---	40.00	---	---	---	40.00
- Dew Point Pressure (°kPa)			---	---	---	896.4	---	---	---	896.4
- Bubble Point Temperature (°C)			---	39.90	39.90	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	96.4	96.4	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	338.5	338.5	---	---	---	---	---
- True Vapour Pressure (kPa)			---	96.4	96.4	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	0.110	0.076	0.033	---	---	---	0.033
- Viscosity (cp)			---	0.308	0.447	0.012	1.100	1.100	---	0.012
Composition (Mole Fraction):			25	26	27	28	29	30	31	32
Name	Formula	CAS No.								
Nitrogen	N2	7727-37-9	---	---	---	0.043380	---	---	---	0.043380
Water	H2O	7732-18-5	---	0.000000	0.000000	0.000000	0.462700	0.462700	---	0.000000
Carbon Dioxide	CO2	124-38-9	---	---	---	0.025205	---	---	---	0.025205
Methane	CH4	74-82-8	---	---	---	0.641174	---	---	---	0.641174
Ethane	C2H6	74-84-0	---	---	---	0.171376	---	---	---	0.171376
Ethylene Glycol	C2H6O2	107-21-1	---	---	---	---	0.537300	0.537300	---	---
Propane	C3H8	74-98-6	---	---	---	0.084805	---	---	---	0.084805
i-Butane	C4H10	75-28-5	---	---	---	0.007275	---	---	---	0.007275
n-Butane	C4H10	106-97-8	---	---	---	0.017510	---	---	---	0.017510
i-Pentane	C5H12	78-78-4	---	---	---	0.002545	---	---	---	0.002545
n-Pentane	C5H12	109-66-0	---	0.185773	---	0.003010	---	---	---	0.003010
Benzene	C6H6	71-43-2	---	---	---	0.000100	---	---	---	0.000100
Cyclohexane	C6H12	110-82-7	---	---	---	0.000175	---	---	---	0.000175
Hexane	C6H14	110-54-3	---	0.164245	---	0.000745	---	---	---	0.000745
Methylcyclopentane	C6H12	96-37-7	---	---	---	0.000170	---	---	---	0.000170
Heptane	C7H16	142-82-5	---	0.145020	---	0.001975	---	---	---	0.001975
Methylcyclohexane	C7H14	108-87-2	---	---	---	0.000190	---	---	---	0.000190

Toluene	**C7H8**	**108-88-3**	---	---	---	0.000165	---	---	---	0.000165
Ethylbenzene	**C8H10**	**100-41-4**	---	---	---	0.000005	---	---	---	0.000005
m-Xylene	**C8H10**	**108-38-3**	---	---	---	0.000040	---	---	---	0.000040
Octane	**C8H18**	**111-65-9**	---	0.127939	---	0.000075	---	---	---	0.000075
o-Xylene	**C8H10**	**95-47-6**	---	---	---	0.000005	---	---	---	0.000005
Nonane	**C9H20**	**111-84-2**	---	0.112808	---	0.000035	---	---	---	0.000035
Decane	**C10H22**	**124-18-5**	---	0.099427	---	0.000020	---	---	---	0.000020
Undecanes	**C11H24**	**1120-21-4**	---	0.087609	---	0.000015	---	---	---	0.000015
Dodecane	**C12H26**	**112-40-3**	---	0.077179	---	0.000005	---	---	---	0.000005
Tridecane	**C13H28**	**629-50-5**	---	---	0.187058	---	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	0.164740	---	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	0.145069	---	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	0.127737	---	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	0.112467	---	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	0.099017	---	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	0.087172	---	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	0.076740	---	---	---	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GS250	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	33							
- Fluid	Water							
- Physical State	Liquid							
- Temperature (°C)	14.40							
- Pressure (kPa)	2,517.0							
- Total Molar Flowrate (kmole/h)	1,154.09							
- Total Mass Flowrate (kg/h)	20791.0							
- Total Gas Volumetric Flowrate (Std m^3/h)	---							
- Total Liq Volumetric Flowrate (m^3/h)	20.8							
- Energy Flowrate kW	---							
Origin (Unit Operation):								
- Tag No.	PSU-100							

- Service:			---							
- Type:			---							
Destination (Unit Operation):										
- Tag No.			Produced Water Header							
- Service:			---							
- Type:			---							
Properties:			33	0	0	0	0	0	0	0
- Vapour Mole Fraction			0.000000							
- Liquid Mole Fraction			1.000000							
- Solid Mole Fraction			---							
- Aqueous Mole Fraction			---							
- Molecular Weight			18.015							
- Mass Density (kg/m^3)			1,000.364							
- Molar Density (kmole/m^3)			55.529							
- API Gravity (°)			---							
- Compressibility Factor			---							
- Specific Heat Capacity (kJ/kmole·°C)			75.3123							
- Enthalpy (kJ/kmole)			1,134							
- Entropy (kJ/kmole·°C)			4							
- Gross Heating Value (MJ/m^3)			0.0							
- Net Heating Value (MJ/m^3)			0.0							
- Sound Speed (m/s)			1,467.920							
- Dew Point Temperature (°C)			240.00							
- Dew Point Pressure (°kPa)			2,596.4							
- Bubble Point Temperature (°C)			226.32							
- Bubble Point Pressure (kPa)			1.6							
- Reid Vapour Pressure (kPa)			---							
- True Vapour Pressure (kPa)			---							
- Thermal Conductivity (W/m·°C)			0.589							
- Viscosity (cp)			1.154							
Composition (Mole Fraction):			33	0	0	0	0	0	0	0
Name	**Formula**	**CAS No.**								
Water	**H2O**	**7732-18-5**	1.000000							

REPORT: SOURCE MITIGATION ANALYSIS

Header Block

Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed

Time Series	**CEL Mitigation Code:**	OP-009-GSM	**End-Year**	**Asset Life:**	2032
	Start Year:	2022		**Viability:**	2032
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**		
	CEL Reference Code:	GTL	**Subcategory 2:**		
	Reference CEL Drawing No:	Unavailable	**Reference CEL Drawing Title:**	Unavailable	
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
	Optimization Objective Function:	Net Present Value Over Pay-Back Period Ratio	**Economic Scenario Name:**	None	

Optimization Search Space

Search Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.60	1.20
Electric Generator Drive Type	**Reciprocating**	---	---
Number of Electric Generator Trains	**2.00**	1.00	10.00

Key Findings

Economic Impacts	**Capital Cost (USD):**	210,394,887	**Net Present Value (USD) (Before Tax):**	294,060,762
	Project Life (Years):	10	**Net Present Value (USD) (After Tax):**	294,060,762
	Asset Life Expectancy (Years):	10	**Return on Investment (%) (Before Tax):**	139.77%
	Asset Salvage Value (USD):	0	**Return on Investment (%) (After Tax):**	139.77%
	Payback Period (Years):	3.59	**Internal Rate of Return (%):**	34.81%

Pre-Mitigation Commodity Losses	**Value of Gas Losses (USD/y)**		**Total Gas Loss (m^3/h)**	**Residue Gas (10^3 m^3/d)**	**Ethane (m^3/d liq)**	**LPG (m^3/d liq)**	**NGL (m^3/d)**	**Hydrogen (m^3/d)**		
	Energy Basis	**Commodity Basis**								
	0	30,154,630	30,104.0	512.8	439.8	311.8	32.0	0.0		

Lifetime GHG Emission Reductions	**CH_4 (kilotonnes)**	**CO_2 (kilotonnes)**	**N_2O (kilotonnes)**	**CO_2E (kilotonnes)**	**Black Carbon (kilotonnes)**
	16.0	2,793.9	0.0	3,195.9	2.4

Lifetime CAC Emission Reductions	**VOC (tonnes)**	**CO (tonnes)**	**NO_x (tonnes)**	**H_2S (tonnes)**	**SO_2 (tonnes)**	**PM (tonnes)**	**PM_{10} (tonnes)**	**$PM_{2.5}$ (tonnes)**		
	8,858.4	10,546.4	2,266.0	0.0	0.0	1,792.4	1,792.4	1,792.4		

Key Equipment Additions

Key Equipment or	**Reference No.**	**Category**	**Subcategory 1**	**Subcategory 2 or Manufacturer Make And Model**
	Mini_GTL_1_1	Mini-GTL Plant	Greyrock M	
	Mini_GTL_2_1	Mini-GTL Plant	Greyrock M	
	Mini_GTL_3_1	Mini-GTL Plant	Greyrock M	
	Mini_GTL_4_1	Mini-GTL Plant	Greyrock M	
	Mini_GTL_5_1	Mini-GTL Plant	Greyrock M	
	Mini_GTL_6_1	Mini-GTL Plant	Greyrock M	
	Mini_GTL_7_1	Mini-GTL Plant	Greyrock M	
	Mini_GTL_8_1	Mini-GTL Plant	Greyrock M	
	Mini_GTL_9_1	Mini-GTL Plant	Greyrock M	
	Mini_GTL_10_1	Mini-GTL Plant	Greyrock M	
	VVN_1_1	Tank	API 650 - Fixed Roof	
	VVD_1_1	Tank	API 650 - Fixed Roof	

Applied Economic Parameters

Financial Rates	**Discount Rate (%):**	10.00	**Inflation Rate (%):**	3.00
	Depreciation Rate (%):	10.00	**Tax Rate (%)**	0.00
	Royalty Rate (%):	30.00	**Import Duty (%):**	0.00
	GHG Emission Fee (USD/Tonne):	$1.10	**CAC Emission Fee (USD/Tonne):**	0.00

REPORT: SOURCE MITIGATION ANALYSIS

	A	B	C	D	E	F	G	H	I	J	K	L
65	Production	Model Type:		Initial Linear Increase		D (decline as a fraction of production):					0.0000	
66	Decline Model					b (correlation constant):					Not Applicable	
67	Commodity	Natural Gas		Ethane	LPG	NGL	Crude Oil	Hydrogen	Electricity		Diesel	Naptha
68	Prices	Purchases (USD/GJ)	Sales (USD/GJ)	(USD/m^3 Liq)	(USD/L Liq)	(USD/m^3 Liq)	(USD/m^3)	(USD/m^3)	Purchases (USD/kW·h)	Sales (USD/kW·h)	(USD/L Liq)	(USD / m3 Liq)
69		$ -	$ -	$ 60.26	$ 0.14	$ 389.84	$ 471.70	$ 2.00	$ 0.04	$ -	$ 0.76	
70												
71												
72												

73	Financials (Time Series Results)										
74	Year	Gross	Costs		Asset Book	Salvage Value	Royalty	Emission Fee	Net Revenues		Cumulative
75		Revenues	Capital	Operating	Value		Payment		Before Tax	After Tax	After Tax Earnings
76		(Inflation Adjusted USD)							(Present Value USD)		
77	2022	103,936,320	210,394,887	5,616,843	189,355,398	83,250,975	10,609,875	-359,293	60,935,824	60,935,824	60,935,824
78	2023	107,054,410		5,785,348	170,419,858	74,000,867	10,928,171	-359,293	59,309,623	59,309,623	120,245,446
79	2024	110,266,042		5,958,909	153,377,872	64,750,759	11,256,017	-359,293	57,376,727	57,376,727	177,622,174
80	2025	113,574,023		6,137,676	138,040,085	55,500,650	11,593,697	-359,293	55,231,307	55,231,307	232,853,480
81	2026	116,981,244		6,321,806	124,236,077	46,250,542	11,941,508	-359,293	52,947,957	52,947,957	285,801,437
82	2027	120,490,681		6,511,460	111,812,469	37,000,433	12,299,753	-359,293	50,585,418	50,585,418	336,386,855
83	2028	124,105,402		6,706,804	100,631,222	27,750,325	12,668,746	-359,293	48,189,600	48,189,600	384,576,455
84	2029	125,599,679		6,908,008	90,568,100	18,500,217	12,821,293	-353,029	44,859,482	44,859,482	429,435,937
85	2030	123,307,201		7,115,249	81,511,290	9,250,108	12,587,305	-336,491	40,240,218	40,240,218	469,676,155
86	2031	117,358,010		7,328,706	73,360,161	0	11,980,054	-310,930	34,779,494	34,779,494	504,455,648
87	Last Profitable Year (After Asset Liquidation, Final Tax Adjustments and Closing Book Entries)										
88	2031	117,358,010	999	7,328,706	73,360,161	0	11,980,054	-310,930	34,779,494	34,779,494	504,455,648
89											

90	Avoided GHG and BC Emissions (Time Series Results)					
91	Year	CH_4 (kt)	CO_2 (kt)	N_2O (kt)	CO_2E (kt)	Black Carbon (t)
92	2022	1.6	285.5	0.0	326.6	249.9
93	2023	1.6	285.5	0.0	326.6	249.9
94	2024	1.6	285.5	0.0	326.6	249.9
95	2025	1.6	285.5	0.0	326.6	249.9
96	2026	1.6	285.5	0.0	326.6	249.9
97	2027	1.6	285.5	0.0	326.6	249.9
98	2028	1.6	285.5	0.0	326.6	249.9
99	2029	1.6	280.6	0.0	320.9	229.8
100	2030	1.5	267.4	0.0	305.9	211.4
101	2031	1.4	247.1	0.0	282.7	194.5
102						

103	Other Avoided Atmospheric Emissions (Time Series Results)								
104	Year	VOC (t)	CO (t)	NO_x (t)	H_2S (t)	SO_2 (t)	PM (t)	PM_{10} (t)	$PM_{2.5}$ (t)
105	2022	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
106	2023	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
107	2024	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
108	2025	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
109	2026	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
110	2027	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
111	2028	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2
112	2029	0.9	1.1	0.2	0.0	0.0	180.0	180.0	180.0
113	2030	0.8	1.0	0.2	0.0	0.0	171.6	171.6	171.6
114	2031	0.8	0.9	0.2	0.0	0.0	158.5	158.5	158.5
115									

116	Forecast Site Activity Data (Time Series Results - Part 1)									
117	Year	Production			Waste Gas Disposition			Incremental Energy Purchases			
118		Oil (10^3 m^3)	Gas (10^6 m^3)	Water (10^3 m^3)	Collected (10^6 m^3)	Conserved (10^6 m^3)	Flared (10^6 m^3)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)
119	2022	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
120	2023	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
121	2024	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
122	2025	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
123	2026	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
124	2027	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
125	2028	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
126	2029	883.87	242.62		242.61	109.53	133.09	0.00	0.00	0.00	134,548
127	2030	813.16	223.21		223.20	104.40	118.81	0.00	0.00	0.00	128,251
128	2031	748.10	205.35		205.35	96.47	108.88	0.00	0.00	0.00	118,518
129											

130	Forecast Site Activity Data (Time Series Results - Part 2)		
131	Year	Incremental Product Sales	Incremental Utilization	Avoided Purchases

	A	B	C	D	E	F	G	H	I	J	K	L
132		Gas (10^6 m^3 Gas)	LPG (10^3 m^3 Liq)	NGL (10^3 m^3 Liq)	Oil (10^3 m^3)	Electricity (10^3 kW·h)	Fuel Gas (10^6 m^3 Gas)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)	
133	2022	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
134	2023	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
135	2024	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
136	2025	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
137	2026	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
138	2027	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
139	2028	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
140	2029	0.00	0.00	0.00	0.00	0	37.75	0.00	78.26	50,043	0.00	
141	2030	0.00	0.00	0.00	0.00	0	35.98	0.00	74.60	47,698	0.00	
142	2031	0.00	0.00	0.00	0.00	0	33.25	0.00	68.93	44,075	0.00	
143												
144	Applied Emission Factors (EF) For Year One Emissions For Baseline (BL) and Simulated Equipment											
145	Source			Pollutant	EF (ng/J of Fuel)	Reference (Where Applicable) and Basis						
146	Category	Tag No.	DB EF Key			Basis	Author or Reporting Agency		Code			
147	Flares	BL FLARE_1	335	CH_4	180.0	Calculated	US EPA		2018-U.S.EPAAP-42Table13.5-1			
148				CO_2	54,529.6	Calculated	NA					
149				N_2O	0.1	Referenced	WCI		2012-BCWCI.363(k)			
150				BC	19.7	Calculated	NA					
151				VOC	22.3	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
152				CO	133.0	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
153				NO_x	29.2	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-1			
154				SO_2	0.0	Calculated	NA					
155				PM	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
156				PM_{10}	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
157				$PM_{2.5}$	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
158	Heaters and Boilers	Mini_GTL_1_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
159				CO_2	83,629.7	Calculated	NA					
160				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
161				BC	0.6	Calculated	NA					
162				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
163				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
164				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
165				SO_2	0.0	Calculated	NA					
166				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
167				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
168				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
169	Heaters and Boilers	Mini_GTL_2_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
170				CO_2	83,629.7	Calculated	NA					
171				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
172				BC	0.6	Calculated	NA					
173				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
174				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
175				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
176				SO_2	0.0	Calculated	NA					
177				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
178				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
179				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
180	Heaters and Boilers	Mini_GTL_3_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
181				CO_2	83,629.7	Calculated	NA					
182				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
183				BC	0.6	Calculated	NA					
184				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
185				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
186				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
187				SO_2	0.0	Calculated	NA					
188				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
189				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
190				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
191	Heaters and Boilers	Mini_GTL_4_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
192				CO_2	83,629.7	Calculated	NA					
193				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
194				BC	0.6	Calculated	NA					
195				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
196				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
197				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
198				SO_2	0.0	Calculated	NA					
199				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
200				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
201				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
202	Heaters and	Mini_GTL_5_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			

	A	B	C	D	E	F	G	H	I	J	K	L
203	Boilers			CO_2	83,629.7	Calculated	NA					
204				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
205				BC	0.6	Calculated	NA					
206				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
207				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
208				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
209				SO_2	0.0	Calculated	NA					
210				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
211				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
212				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
213	Heaters and	Mini_GTL_6_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
214	Boilers			CO_2	83,629.7	Calculated	NA					
215				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
216				BC	0.6	Calculated	NA					
217				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
218				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
219				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
220				SO_2	0.0	Calculated	NA					
221				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
222				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
223				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
224	Heaters and	Mini_GTL_7_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
225	Boilers			CO_2	83,629.7	Calculated	NA					
226				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
227				BC	0.6	Calculated	NA					
228				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
229				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
230				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
231				SO_2	0.0	Calculated	NA					
232				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
233				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
234				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
235	Heaters and	Mini_GTL_8_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
236	Boilers			CO_2	83,629.7	Calculated	NA					
237				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
238				BC	0.6	Calculated	NA					
239				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
240				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
241				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
242				SO_2	0.0	Calculated	NA					
243				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
244				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
245				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
246	Heaters and	Mini_GTL_9_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
247	Boilers			CO_2	83,629.7	Calculated	NA					
248				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
249				BC	0.6	Calculated	NA					
250				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
251				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
252				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
253				SO_2	0.0	Calculated	NA					
254				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
255				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
256				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
257	Heaters and	Mini_GTL_10_	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
258	Boilers			CO_2	83,629.7	Calculated	NA					
259				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
260				BC	0.6	Calculated	NA					
261				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
262				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
263				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
264				SO_2	0.0	Calculated	NA					
265				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
266				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
267				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
268	Flares	FLARE_1	335	CH_4	137.0	Calculated	US EPA		2018-U.S.EPAAP-42Table13.5-1			
269				CO_2	83,629.7	Calculated	NA					
270				N_2O	0.1	Referenced	WCI		2012-BCWCI.363(k)			
271				BC	0.0	Calculated	NA					
272				VOC	22.3	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
273				CO	133.0	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			

	A	B	C	D	E	F	G	H	I	J	K	L
274				NO_x	29.2	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-1			
275				SO_2	0.0	Calculated	NA					
276				PM	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
277				PM_{10}	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
278				$PM_{2.5}$	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
279												
280						**Capital Cost**						
281	**Equipment**	**Item**	**Category**	**Subcategory 1**	**Subcategory 2**	**Capacity or Rated Power Output**		**Price (USD)**	**FOB Point**	**Basis**		
282						**Value**	**Units of Measure**					
283		Mini_GTL_1_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
284		Mini_GTL_2_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
285		Mini_GTL_3_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
286		Mini_GTL_4_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
287		Mini_GTL_5_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
288		Mini_GTL_6_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
289		Mini_GTL_7_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
290		Mini_GTL_8_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
291		Mini_GTL_9_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
292		Mini_GTL_10_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
293		VVN_1_1	Tank	API 650 - Fixed Roof		1,797.57	m^3	239,924	NA	Predicted (Class 4)		
294		VVD_1_1	Tank	API 650 - Fixed Roof		1,149.36	m^3	190,546	NA	Predicted (Class 4)		
295		**E7**	**Engineering & Drafting**					12,696,360				
296		**Subtotal:**						105,197,443				
297	**Pipeline**	**Pipe Specifications**	**OD (mm)**			**Material:**			**Design P (kPa)**			
298			**WT (mm)**			**Length (km):**			**Coating:**			
299		**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
300		**PL1**	**Pipe**									
301		**PL2**	**Right-of-Way (ROW)**									
302		**PL3**	**ROW Land Survey**									
303		**PL4**	**Clearing**									
304		**PL5**	**Soil Stripping**									
305		**PL6**	**Timber Salvage**									
306		**PL7**	**Rock excavation**									
307		**PL8**	**Cathodic Protection**									
308		**PL9**	**Construction**									
309		**PL10**	**Engineering & Drafting**									
310		**PL11**	**Supervision**									
311		**PL12**	**Safety**									
312		**PL13**	**Reseeding ROW**									
313		**Subtotal:**										
314	**Materials & Services**	**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
315		**MS1**	**Equipment Setting**		0	12,763,171		12,763,171		Predicted		
316		**MS2**	**Foundations**		3,190,793	4,243,754		7,434,547		Predicted		
317		**MS3**	**Structural Steel**		3,190,793	1,595,396		4,786,189		Predicted		
318		**MS4**	**Buildings**		1,914,476	1,914,476		3,828,951		Predicted		
319		**MS5**	**Insulation**		638,159	957,238		1,595,396		Predicted		
320		**MS6**	**Instruments**		3,828,951	1,531,581		5,360,532		Predicted		
321		**MS7**	**Electrical**		5,105,268	3,828,951		8,934,220		Predicted		
322		**MS8**	**Piping**		28,717,135	14,358,568		43,075,703		Predicted		
323		**MS9**	**Painting**		319,079	957,238		1,276,317		Predicted		
324		**MS10**	**Miscellaneous**		1,914,476	1,531,581		3,446,056		Predicted		
325		**MS11**	**Engineering & Drafting**		0	12,696,360		12,696,360		Predicted		
326		**MS12**	**Supervision**		Unavailable	0		0				
327		**MS13**	**Safety**		Unavailable	0		0				
328		**Subtotal:**						105,197,443				
329	**Summary**	**Total:**						210,394,887				
330		**Duties:**						0				
331		**Freight:**						Unavailable				
332		**Grand Total:**						210,394,887				
333						**Year 1 Operating Costs**						
334		**Operating Labour**	**Hours Per Shift:**		Unknown	**Operator Hourly Labour Rate:**		$ 2.05				
335			**Shifts Per Day:**		Unknown	**Maintenance Hourly Labour Rate:**		$ 2.05				
336		**Item**	**Category**		**Material (USD**	**Labour (Hours)**	**Labour (USD)**	**Line Total (USD)**		**Basis**		
337	**Fixed O&M Costs**	**L1**	**Operating Labour**		0	7,560	15,498	15,498		Predicted		
338		**L2**	**Maintenance Labour**		0	2,520	5,166	5,166		Predicted		
339		**L3**	**Direct Supervision**		0		2,790	2,790		Predicted		
340		**L4**	**Administration**		0		1,896,297	1,896,297		Predicted		

	A	B	C	D	E	F	G	H	I	J	K	L
341		**L5**	**Unclassified Costs**					0		Predicted		
342		**Total Fixed O&M Costs:**						1,919,751		Predicted		
343	**Variable**	**SS1**	**Third-Party Services**					38,336		Predicted		
344	**O&M Costs**	**SS2**	**Parts & Consumables**					117,482		Predicted		
345		**SS3**	**Unclassified Costs**					3,541,274		Predicted		
346		**Total Variable O&M Costs:**						3,697,092		Predicted		
347	**Total O&M Costs**	**Total Fixed and Variable O&M Costs:**						5,616,843		Predicted		
348	**Purchased**	**PC1**	**Electricity**		5,340,406	0	0	5,340,406		Predicted		
349	**Commodities**	**PC2**	**Natural Gas**		0	0	0	0		Predicted		
350		**PC3**	**LPG**		0	0	0	0		Predicted		
351		**PC4**	**Diesel**		0	0	0	0		Predicted		
352	**Summary**	**Total:**						10,957,249				

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSM	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Proposed Equipment

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSM	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	1	2	3	4	5	6	7	8
- Fluid	HC	HC	HC	HC	HC	Not Known	HC	Not Known
- Physical State	Vapour	Vapour	Vapour	Vapour	Vapour	Unknown	Vapour	Unknown
- Temperature (°C)	40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Pressure (kPa)	800.0	800.0	800.0	800.0	800.0	---	800.0	---
- Total Molar Flowrate (kmole/h)	1,273.17	1,145.61	127.56	1,942.07	796.46	0.00	1,942.07	0.00
- Total Mass Flowrate (kg/h)	30176.9	27153.5	3023.5	52639.3	25485.8	0.0	52639.3	0.0
- Total Gas Volumetric Flowrate (Sm^3/h)	30104.0	27087.8	3016.2	45919.9	18832.1	---	45919.9	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	From Flare Line	FS-100	FS-100	M-100	Oxygen Plant	HP Steam Header	V-100	V-100
- Service:	---	Not Applicable	Not Applicable	Not Applicable	---	---	Inlet Scrubber	Inlet Scrubber

- Type:			---	Flow Splitter	Flow Splitter	Mixer	---	---	2-Phase Separator	2-Phase Separator
Destination (Unit Operation):										
- Tag No.			FS-100	M-100	To Flare Line	V-100	M-100	M-100	K-100	Waste Water Header
- Service:			Not Applicable	Not Applicable	---	Inlet Scrubber	Not Applicable	Not Applicable	Inlet Gas Boosting	---
- Type:			Flow Splitter	Mixer	---	2-Phase Separator	Mixer	Mixer	Compressor: Recip.	---
Properties:			1	2	3	4	5	6	7	8
- Vapour Mole Fraction			1.000000	1.000000	1.000000	1.000000	1.000000	---	1.000000	---
- Liquid Mole Fraction			0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			23.702	23.702	23.702	27.105	31.999	---	27.105	---
- Mass Density (kg/m^3)			8.439	8.439	8.439	9.634	11.470	---	9.634	---
- Molar Density (kmole/m^3)			0.356	0.356	0.356	0.355	0.358	---	0.355	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			0.9669	0.9669	0.9669	0.9794	0.9925	---	0.9794	---
- Specific Heat Capacity (kJ/kmole·°C)			46.7971	46.7971	46.7971	39.4833	29.4594	---	39.4833	---
- Enthalpy (kJ/kmole)			-85,487	-85,487	-85,487	-50,404	60	---	-50,404	---
- Entropy (kJ/kmole·°C)			-202	-202	-202	-152	-95	---	-152	---
- Gross Heating Value (MJ/m^3)			48.3	48.3	48.3	28.5	0.0	---	28.5	---
- Net Heating Value (MJ/m^3)			43.3	43.3	43.3	25.6	0.0	---	25.6	---
- Sound Speed (m/s)			359.316	359.316	359.316	344.504	332.061	---	344.504	---
- Dew Point Temperature (°C)			40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Dew Point Pressure (°kPa)			896.4	896.4	896.4	896.4	896.4	---	896.4	---
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.033	0.033	0.033	0.033	0.030	---	0.033	---
- Viscosity (cp)			0.012	0.012	0.012	0.015	0.023	---	0.015	---
Composition (Mole Fraction):			1	2	3	4	5	6	7	8
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043380	0.043380	0.043380	0.025590	0.000001	---	0.025590	---
Oxygen	**O2**	**7782-44-7**	---	---	---	0.410107	0.999999	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
Carbon Dioxide	**CO2**	**124-38-9**	0.025205	0.025205	0.025205	0.014868	---	---	0.014868	---
Methane	**CH4**	**74-82-8**	0.641174	0.641174	0.641174	0.378224	---	---	0.378224	---
Ethane	**C2H6**	**74-84-0**	0.171376	0.171376	0.171376	0.101094	---	---	0.101094	---
Propane	**C3H8**	**74-98-6**	0.084805	0.084805	0.084805	0.050026	---	---	0.050026	---
i-Butane	**C4H10**	**75-28-5**	0.007275	0.007275	0.007275	0.004291	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	0.017510	0.017510	0.017510	0.010329	---	---	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	0.002545	0.002545	0.002545	0.001501	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	0.003010	0.003010	0.003010	0.001776	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	0.000100	0.000100	0.000100	0.000059	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	0.000175	0.000175	0.000175	0.000103	---	---	0.000103	---
Hexane	**C6H14**	**110-54-3**	0.000745	0.000745	0.000745	0.000439	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.000170	0.000170	0.000100	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	0.001975	0.001975	0.001975	0.001165	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.000190	0.000190	0.000112	---	---	0.000112	---

Toluene	**C7H8**	**108-88-3**	0.000165	0.000165	0.000165	0.000097	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.000040	0.000040	0.000024	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	0.000075	0.000075	0.000075	0.000044	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	0.000035	0.000035	0.000035	0.000021	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	0.000020	0.000020	0.000020	0.000012	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000015	0.000015	0.000009	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSM	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	9	10	11	12	13	14	15	16
- Fluid	Heat Medium	Heat Medium	HC	Electricity	Fuel Gas	HC	HC	HC
- Physical State	Liquid	Liquid	Vapour	Unknown	Gas	Vapour	Vapour	Vapour
- Temperature (°C)	120.00	120.00	192.34	---	39.90	39.90	1,050.00	1,050.00
- Pressure (kPa)	276.0	276.0	5,100.0	---	0.0	0.0	5,000.0	5,000.0
- Total Molar Flowrate (kmole/h)	0.00	0.00	1,942.07	---	0.00	135.34	1,942.07	4,329.38
- Total Mass Flowrate (kg/h)	0.0	0.0	52639.3	---	0.0	3637.3	52639.3	52638.8
- Total Gas Volumetric Flowrate (Std m^3/h)	---	---	45919.9	---	0.0	3200.2	45919.9	102367.5
- Total Liq Volumetric Flowrate (m^3/h)	0.0	0.0	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	3,800.442	---	---	---	---
Origin (Unit Operation):								
- Tag No.	V-100	H-100	K-100	Electric Utility System	Fuel Gas Header	M-200	H-101	R-100
- Service:	Inlet Scrubber	Boiler	Inlet Gas Boosting	---	---	Not Applicable	Heat Medium Heater	---

- Type:	2-Phase Separator	Heater	Compressor: Recip.	---	---	Mixer	Heater: Fired	---
Destination (Unit Operation):								
- Tag No.	PU-101	V-100	H-101	K-100	K-100	H-101	R-100	E-100
- Service:	Circulation	Inlet Scrubber	Heat Medium Heater	Inlet Gas Boosting	Inlet Gas Boosting	Heat Medium Heater	---	Boiler
- Type:	Pump	2-Phase Separator	Heater: Fired	Compressor: Recip.	Compressor: Recip.	Heater: Fired	---	Heat Exchanger: Shell and Tube
Properties:	9	10	11	12	13	14	15	16
- Vapour Mole Fraction	0.000000	0.000000	1.000000	---	1.000000	1.000000	1.000000	1.000000
- Liquid Mole Fraction	1.000000	1.000000	0.000000	---	0.000000	0.000000	0.000000	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	41.686	41.686	27.105	---	---	26.875	27.105	12.158
- Mass Density (kg/m^3)	1,025.000	1,025.000	36.987	---	---	0.996	12.411	5.584
- Molar Density ($kmole/m^3$)	---	---	1.365	---	---	0.037	0.458	0.459
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	---	0.9839	---	---	0.9986	1.0117	1.0086
- Specific Heat Capacity (kJ/kmole·°C)	135.4802	135.4802	48.4778	---	---	35.4385	77.7041	32.4041
- Enthalpy (kJ/kmole)	---	---	-44,103	---	---	-103,562	11,746	-12,049
- Entropy (kJ/kmole·°C)	---	---	-150	---	---	-59	-85	-25
- Gross Heating Value (MJ/m^3)	---	---	28.5	---	---	24.7	28.5	11.9
- Net Heating Value (MJ/m^3)	---	---	25.6	---	---	22.9	25.6	10.3
- Sound Speed (m/s)	---	---	418.851	---	---	355.689	682.497	1,113.676
- Dew Point Temperature (°C)	---	---	192.34	---	---	39.90	1,050.00	1,050.00
- Dew Point Pressure (°kPa)	---	---	5,196.4	---	---	96.4	5,096.4	5,096.4
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	---	0.057	---	---	0.032	0.194	0.201
- Viscosity (cp)	1.100	1.100	0.022	---	---	0.016	0.045	0.038

Composition (Mole Fraction):			9	10	11	12	13	14	15	16
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	---	---	---	---	0.000000	---	0.613921
Nitrogen	**N2**	**7727-37-9**	---	---	0.025590	---	0.062677	0.062677	0.025590	0.011479
Oxygen	**O2**	**7782-44-7**	---	---	0.410107	---	---	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.462700	0.462700	0.000000	---	0.000000	0.000000	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	0.014868	---	0.036417	0.036417	0.014868	0.006670
Carbon Monoxide	**CO**	**630-08-0**	---	---	---	---	0.553432	0.553432	---	0.367931
Methane	**CH4**	**74-82-8**	---	---	0.378224	---	0.249780	0.249780	0.378224	---
Ethane	**C2H6**	**74-84-0**	---	---	0.101094	---	0.044421	0.044421	0.101094	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	0.537300	0.537300	---	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	---	0.050026	---	0.030293	0.030293	0.050026	---
i-Butane	**C4H10**	**75-28-5**	---	---	0.004291	---	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	---	---	0.010329	---	0.022981	0.022981	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	---	---	0.001501	---	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	---	---	0.001776	---	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	---	---	0.000059	---	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	---	---	0.000103	---	---	---	0.000103	---

Hexane	**C6H14**	**110-54-3**	---	---	0.000439	---	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	0.000100	---	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	---	---	0.001165	---	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	0.000112	---	---	---	0.000112	---
Toluene	**C7H8**	**108-88-3**	---	---	0.000097	---	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	---	---	0.000003	---	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	---	---	0.000024	---	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	---	---	0.000044	---	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	---	---	0.000003	---	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	---	---	0.000021	---	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	---	---	0.000012	---	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	---	---	0.000009	---	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	---	---	0.000003	---	---	---	0.000003	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSM	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	17	18	19	20	21	22	23	24
- Fluid	Water	HC	Water	HC	HC	HC	Not Known	HC
- Physical State	Vapour	Vapour	Liquid	Vapour	Vapour	Vapour	Unknown	Vapour
- Temperature (°C)	226.32	240.00	14.40	240.00	39.90	39.90	---	39.90
- Pressure (kPa)	2,517.0	2,500.0	2,517.0	2,500.0	0.0	0.0	---	0.0
- Total Molar Flowrate (kmole/h)	2.19	4,329.38	2.19	2,021.20	792.91	135.34	0.00	657.56
- Total Mass Flowrate (kg/h)	39.5	52638.8	39.5	52638.7	21309.0	3637.3	0.0	17671.7
- Total Gas Volumetric Flowrate (Std m³/h)	51.8	102367.5	---	47790.8	18748.2	3200.2	---	15548.0
- Total Liq Volumetric Flowrate (m³/h)	---	---	0.0	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	E-100	E-100	Water Header	R-101	PSU-100	FS-101	Fuel Gas Header	FS-101
- Service:	Boiler	Boiler	---	---	---	Not Applicable	---	Not Applicable

- Type:	Heat Exchanger:	Heat Exchanger:	---	---	---	Flow Splitter	---	Flow Splitter
Destination (Unit Operation):								
- Tag No.	HP Steam Header	R-101	E-100	PSU-100	FS-101	M-200	M-200	Gas to Flare
- Service:	---	---	Boiler	---	Not Applicable	Not Applicable	Not Applicable	---
- Type:	---	---	Heat Exchanger: Shell and Tube	---	Flow Splitter	Mixer	Mixer	---
Properties:	17	18	19	20	21	22	23	24
- Vapour Mole Fraction	1.000000	1.000000	0.000000	1.000000	1.000000	1.000000	---	1.000000
- Liquid Mole Fraction	0.000000	0.000000	1.000000	0.000000	0.000000	0.000000	---	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	18.015	12.158	18.015	26.043	26.875	26.875	---	26.875
- Mass Density (kg/m^3)	13.071	7.321	1,000.364	16.505	0.996	0.996	---	0.996
- Molar Density (kmole/m^3)	0.726	0.602	55.529	0.634	0.037	0.037	---	0.037
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	1.0106	---	0.9602	0.9986	0.9986	---	0.9986
- Specific Heat Capacity (kJ/kmole·°C)	62.1935	29.5433	75.3123	52.2772	35.4385	35.4385	---	35.4385
- Enthalpy (kJ/kmole)	50,485	-37,028	1,134	-178,960	-103,562	-103,562	---	-103,562
- Entropy (kJ/kmole·°C)	112	-49	4	-126	-59	-59	---	-59
- Gross Heating Value (MJ/m^3)	0.0	11.9	0.0	20.4	24.7	24.7	---	24.7
- Net Heating Value (MJ/m^3)	0.0	10.3	0.0	18.8	22.9	22.9	---	22.9
- Sound Speed (m/s)	504.574	707.655	1,467.920	433.537	355.689	355.689	---	355.689
- Dew Point Temperature (°C)	226.32	240.00	240.00	240.00	39.90	39.90	---	39.90
- Dew Point Pressure (°kPa)	2,613.3	2,596.4	2,596.4	2,596.4	96.4	96.4	---	96.4
- Bubble Point Temperature (°C)	226.32	---	226.32	---	---	---	---	---
- Bubble Point Pressure (kPa)	1.6	---	1.6	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	0.045	0.100	0.589	0.065	0.032	0.032	---	0.032
- Viscosity (cp)	0.017	0.021	1.154	0.020	0.016	0.016	---	0.016

Composition (Mole Fraction):			17	18	19	20	21	22	23	24
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	0.613921	---	0.000000	0.000000	0.000000	---	0.000000
Nitrogen	**N2**	**7727-37-9**	---	0.011479	---	0.024588	0.062677	0.062677	---	0.062677
Water	**H2O**	**7732-18-5**	1.000000	0.000000	1.000000	0.570995	0.000000	0.000000	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	0.006670	---	0.014286	0.036417	0.036417	---	0.036417
Carbon Monoxide	**CO**	**630-08-0**	---	0.367931	---	0.217109	0.553432	0.553432	---	0.553432
Methane	**CH4**	**74-82-8**	---	---	---	0.097988	0.249780	0.249780	---	0.249780
Ethane	**C2H6**	**74-84-0**	---	---	---	0.017426	0.044421	0.044421	---	0.044421
Propane	**C3H8**	**74-98-6**	---	---	---	0.011884	0.030293	0.030293	---	0.030293
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.009015	0.022981	0.022981	---	0.022981
n-Pentane	**C5H12**	**109-66-0**	---	---	---	0.005002	---	---	---	---
Hexane	**C6H14**	**110-54-3**	---	---	---	0.004422	---	---	---	---
Heptane	**C7H16**	**142-82-5**	---	---	---	0.003905	---	---	---	---
Octane	**C8H18**	**111-65-9**	---	---	---	0.003445	---	---	---	---
Nonane	**C9H20**	**111-84-2**	---	---	---	0.003037	---	---	---	---
Decane	**C10H22**	**124-18-5**	---	---	---	0.002677	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	---	---	---	0.002359	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	---	---	---	0.002078	---	---	---	---

Tridecane	**C13H28**	**629-50-5**	---	---	---	0.001830	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	---	0.001612	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	---	0.001419	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	---	0.001250	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	---	0.001100	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	---	0.000969	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	---	0.000853	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	---	0.000751	---	---	---	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSM	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	25	26	27	28	29	30	31	32
- Fluid	Electricity	HC	HC	HC	Heat Medium	Heat Medium	Electricity	HC
- Physical State	Unknown	Liquid	Liquid	Vapour	Liquid	Liquid	Unknown	Vapour
- Temperature (°C)	---	39.90	39.90	40.00	120.00	120.00	---	40.00
- Pressure (kPa)	---	0.0	0.0	800.0	276.0	276.0	---	800.0
- Total Molar Flowrate (kmole/h)	---	54.42	19.78	0.00	0.00	0.00	---	0.00
- Total Mass Flowrate (kg/h)	---	6103.8	4434.9	0.0	0.0	0.0	---	0.0
- Total Gas Volumetric Flowrate	---	---	---	0.0	---	---	---	0.0
- Total Liq Volumetric Flowrate (m^3/h)	---	9.1	5.8	---	0.0	0.0	---	---
- Energy Flowrate kW	11,831.235	---	---	---	---	---	23,662.470	---
Origin (Unit Operation):								
- Tag No.	Electric Utility System	PSU-100	PSU-100	Fuel Gas Header	H-100	PU-101	Electric Utility System	Fuel Gas Header
- Service:	---	---	---	---	Boiler	Circulation	---	---

- Type:			---	---	---	---	Heater	Pump	---	---
Destination (Unit Operation):										
- Tag No.			PSU-100	Naphtha Storage	Diesel Storage	H-100	V-100	H-100	Mini-GTL Plant	Mini-GTL Plant
- Service:			---	---	---	Boiler	Inlet Scrubber	Boiler	---	---
- Type:			---	---	---	Heater	2-Phase Separator	Heater	---	---
Properties:			25	26	27	28	29	30	31	32
- Vapour Mole Fraction			---	0.000000	0.000000	1.000000	0.000000	0.000000	---	1.000000
- Liquid Mole Fraction			---	1.000000	1.000000	0.000000	1.000000	1.000000	---	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			---	112.161	224.249	23.702	41.686	41.686	---	23.702
- Mass Density (kg/m^3)			---	671.270	762.803	8.439	1,025.000	1,025.000	---	8.439
- Molar Density (kmole/m^3)			---	5.985	3.402	0.356	---	---	---	0.356
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	0.0063	0.0134	0.9669	---	---	---	0.9669
- Specific Heat Capacity (kJ/kmole·°C)			---	245.2118	472.3949	46.7971	135.4802	135.4802	---	46.7971
- Enthalpy (kJ/kmole)			---	-241,592	-437,240	-85,487	---	---	---	-85,487
- Entropy (kJ/kmole·°C)			---	-891	-1,701	-202	---	---	---	-202
- Gross Heating Value (MJ/m^3)			---	230.6	454.9	48.3	---	---	---	48.3
- Net Heating Value (MJ/m^3)			---	212.1	419.8	43.3	---	---	---	43.3
- Sound Speed (m/s)			---	969.621	1,355.431	359.316	---	---	---	359.316
- Dew Point Temperature (°C)			---	---	---	40.00	---	---	---	40.00
- Dew Point Pressure (°kPa)			---	---	---	896.4	---	---	---	896.4
- Bubble Point Temperature (°C)			---	39.90	39.90	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	96.4	96.4	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	338.5	338.5	---	---	---	---	---
- True Vapour Pressure (kPa)			---	96.4	96.4	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	0.110	0.076	0.033	---	---	---	0.033
- Viscosity (cp)			---	0.308	0.447	0.012	1.100	1.100	---	0.012
Composition (Mole Fraction):			25	26	27	28	29	30	31	32
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	---	0.043380	---	---	---	0.043380
Water	**H2O**	**7732-18-5**	---	0.000000	0.000000	0.000000	0.462700	0.462700	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	---	0.025205	---	---	---	0.025205
Methane	**CH4**	**74-82-8**	---	---	---	0.641174	---	---	---	0.641174
Ethane	**C2H6**	**74-84-0**	---	---	---	0.171376	---	---	---	0.171376
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	---	---	0.537300	0.537300	---	---
Propane	**C3H8**	**74-98-6**	---	---	---	0.084805	---	---	---	0.084805
i-Butane	**C4H10**	**75-28-5**	---	---	---	0.007275	---	---	---	0.007275
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.017510	---	---	---	0.017510
i-Pentane	**C5H12**	**78-78-4**	---	---	---	0.002545	---	---	---	0.002545
n-Pentane	**C5H12**	**109-66-0**	---	0.185773	---	0.003010	---	---	---	0.003010
Benzene	**C6H6**	**71-43-2**	---	---	---	0.000100	---	---	---	0.000100
Cyclohexane	**C6H12**	**110-82-7**	---	---	---	0.000175	---	---	---	0.000175
Hexane	**C6H14**	**110-54-3**	---	0.164245	---	0.000745	---	---	---	0.000745
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	---	0.000170	---	---	---	0.000170
Heptane	**C7H16**	**142-82-5**	---	0.145020	---	0.001975	---	---	---	0.001975
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	---	0.000190	---	---	---	0.000190

Toluene	**C7H8**	**108-88-3**	---	---	---	0.000165	---	---	---	0.000165
Ethylbenzene	**C8H10**	**100-41-4**	---	---	---	0.000005	---	---	---	0.000005
m-Xylene	**C8H10**	**108-38-3**	---	---	---	0.000040	---	---	---	0.000040
Octane	**C8H18**	**111-65-9**	---	0.127939	---	0.000075	---	---	---	0.000075
o-Xylene	**C8H10**	**95-47-6**	---	---	---	0.000005	---	---	---	0.000005
Nonane	**C9H20**	**111-84-2**	---	0.112808	---	0.000035	---	---	---	0.000035
Decane	**C10H22**	**124-18-5**	---	0.099427	---	0.000020	---	---	---	0.000020
Undecanes	**C11H24**	**1120-21-4**	---	0.087609	---	0.000015	---	---	---	0.000015
Dodecane	**C12H26**	**112-40-3**	---	0.077179	---	0.000005	---	---	---	0.000005
Tridecane	**C13H28**	**629-50-5**	---	---	0.187058	---	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	0.164740	---	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	0.145069	---	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	0.127737	---	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	0.112467	---	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	0.099017	---	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	0.087172	---	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	0.076740	---	---	---	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSM	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	33							
- Fluid	Water							
- Physical State	Liquid							
- Temperature (°C)	14.40							
- Pressure (kPa)	2,517.0							
- Total Molar Flowrate (kmole/h)	1,154.09							
- Total Mass Flowrate (kg/h)	20791.0							
- Total Gas Volumetric Flowrate (Std m^3/h)	---							
- Total Liq Volumetric Flowrate (m^3/h)	20.8							
- Energy Flowrate kW	---							
Origin (Unit Operation):								
- Tag No.	PSU-100							

- Service:	---							
- Type:	---							
Destination (Unit Operation):								
- Tag No.	Produced Water Header							
- Service:	---							
- Type:	---							
Properties:	33	0	0	0	0	0	0	0
- Vapour Mole Fraction	0.000000							
- Liquid Mole Fraction	1.000000							
- Solid Mole Fraction	---							
- Aqueous Mole Fraction	---							
- Molecular Weight	18.015							
- Mass Density (kg/m^3)	1,000.364							
- Molar Density (kmole/m^3)	55.529							
- API Gravity (°)	---							
- Compressibility Factor	---							
- Specific Heat Capacity (kJ/kmole·°C)	75.3123							
- Enthalpy (kJ/kmole)	1,134							
- Entropy (kJ/kmole·°C)	4							
- Gross Heating Value (MJ/m^3)	0.0							
- Net Heating Value (MJ/m^3)	0.0							
- Sound Speed (m/s)	1,467.920							
- Dew Point Temperature (°C)	240.00							
- Dew Point Pressure (°kPa)	2,596.4							
- Bubble Point Temperature (°C)	226.32							
- Bubble Point Pressure (kPa)	1.6							
- Reid Vapour Pressure (kPa)	---							
- True Vapour Pressure (kPa)	---							
- Thermal Conductivity (W/m·°C)	0.589							
- Viscosity (cp)	1.154							

Composition (Mole Fraction):			33	0	0	0	0	0	0	0
Name	**Formula**	**CAS No.**								
Water	**H2O**	**7732-18-5**	1.000000							

REPORT: SOURCE MITIGATION ANALYSIS

6/16/2022

Row	A	B	C	D	E
	Header Block				
	Client:	TetraTech		**Operator:**	Tetra Tech
	Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
4	**Facility:**	**Category:**	Oil Field	**Subcategory 1:**	
5		**CEL Facility Code:**	OP-009	**Subcategory 2:**	
6	**Source:**	**Category:**	Flare	**Subcategory 1:**	Elevated
7		**CEL Equipment Code:**	OP-009-1	**Subcategory 2:**	Unassisted
8		**Tag No:**	TECH-FL-1	**Make:**	Unavailable
9		**Model:**	Unavailable	**Serial No:**	Unavailable

Row						
	Mitigation Measure Assessed					
12	**Time Series**	**CEL Mitigation Code:**	OP-009-GSP	**End-Year**	**Asset Life:**	2032
13		**Start Year:**	2022		**Viability:**	2032
14	**Mitigation Measure (Stage 1)**	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**		
15		**CEL Reference Code:**	GTL	**Subcategory 2:**		
16		**Reference CEL Drawing No:**	Unavailable	**Reference CEL Drawing Title:**		Unavailable
17	**Mitigation Measure (Stage 2)**	**Category:**	None	**Subcategory 1:**		
18		**CEL Reference Code:**		**Subcategory 2:**		
19		**Reference CEL Drawing No:**		**Reference CEL Drawing Title:**		
20	**Mitigation Measure (Stage 3)**	**Category:**	None	**Subcategory 1:**		
21		**CEL Reference Code:**		**Subcategory 2:**		
22		**Reference CEL Drawing No:**		**Reference CEL Drawing Title:**		
		Optimization Objective Function:	Net Present Value Over Pay-Back Period Ratio	**Economic Scenario Name:**		None

Row	Search Parameter	Value Chosen	Min Search Value	Max Search Value
	Optimization Search Space			
26	**Search Parameter**	**Value Chosen**	**Min Search Value**	**Max Search Value**
27	**Year-1 Peak Flow Rate Design Factor**	**0.90**	0.60	1.20
28	**Electric Generator Drive Type**	**Reciprocating**	---	---
29	**Number of Electric Generator Trains**	**2.00**	1.00	10.00

Row					
	Key Findings				
32	**Economic Impacts**	**Capital Cost (USD):**	210,394,887	**Net Present Value (USD) (Before Tax):**	294,060,762
33		**Project Life (Years):**	10	**Net Present Value (USD) (After Tax):**	294,060,762
34		**Asset Life Expectancy (Years):**	10	**Return on Investment (%) (Before Tax):**	139.77%
35		**Asset Salvage Value (USD):**	0	**Return on Investment (%) (After Tax):**	139.77%
36		**Payback Period (Years):**	3.59	**Internal Rate of Return (%):**	34.81%

Row	A	B	C	D	E	F	G	H	I	J	K
37	**Pre-Mitigation Commodity Losses**	**Value of Gas Losses (USD/y)**		**Total Gas Loss (m^3/h)**	**Residue Gas (10^3 m^3/d)**	**Ethane (m^3/d liq)**	**LPG (m^3/d liq)**	**NGL (m^3/d)**	**Hydrogen (m^3/d)**		
38		**Energy Basis**	**Commodity Basis**								
39		0	30,154,630	30,104.0	512.8	439.8	311.8	32.0	0.0		
40	**Lifetime GHG Emission Reductions**	**CH_4 (kilotonnes)**	**CO_2 (kilotonnes)**	**N_2O (kilotonnes)**	**CO_2E (kilotonnes)**	**Black Carbon (kilotonnes)**					
41		16.0	2,793.9	0.0	3,195.9	2.4					
42	**Lifetime CAC Emission Reductions**	**VOC (tonnes)**	**CO (tonnes)**	**NO_x (tonnes)**	**H_2S (tonnes)**	**SO_2 (tonnes)**	**PM (tonnes)**	**PM_{10} (tonnes)**	**$PM_{2.5}$ (tonnes)**		
43		8,858.4	10,546.4	2,266.0	0.0	0.0	1,792.4	1,792.4	1,792.4		

Row		Reference No.	Category	Subcategory 1	Subcategory 2 or Manufacturer Make And Model
45	**Key Equipment Additions**				
46	**Key Equipment or**	**Reference No.**	**Category**	**Subcategory 1**	**Subcategory 2 or Manufacturer Make And Model**
47		Mini_GTL_1_1	Mini-GTL Plant	Greyrock M	
48		Mini_GTL_2_1	Mini-GTL Plant	Greyrock M	
49		Mini_GTL_3_1	Mini-GTL Plant	Greyrock M	
50		Mini_GTL_4_1	Mini-GTL Plant	Greyrock M	
51		Mini_GTL_5_1	Mini-GTL Plant	Greyrock M	
52		Mini_GTL_6_1	Mini-GTL Plant	Greyrock M	
53		Mini_GTL_7_1	Mini-GTL Plant	Greyrock M	
54		Mini_GTL_8_1	Mini-GTL Plant	Greyrock M	
55		Mini_GTL_9_1	Mini-GTL Plant	Greyrock M	
56		Mini_GTL_10_1	Mini-GTL Plant	Greyrock M	
57		VVN_1_1	Tank	API 650 - Fixed Roof	
58		VVD_1_1	Tank	API 650 - Fixed Roof	

Row					
60	**Applied Economic Parameters**				
61	**Financial Rates**	**Discount Rate (%):**	10.00	**Inflation Rate (%):**	3.00
62		**Depreciation Rate (%):**	10.00	**Tax Rate (%)**	0.00
63		**Royalty Rate (%):**	30.00	**Import Duty (%):**	0.00
64		**GHG Emission Fee (USD/Tonne):**	$1.10	**CAC Emission Fee (USD/Tonne):**	0.00

REPORT: SOURCE MITIGATION ANALYSIS

	A	B	C	D	E	F	G	H	I	J	K	L
65	Production	Model Type:		Initial Linear Increase		D (decline as a fraction of production):					0.0000	
66	Decline Model					b (correlation constant):					Not Applicable	
67	Commodity Prices	Natural Gas		Ethane	LPG	NGL	Crude Oil	Hydrogen	Electricity		Diesel	Naptha
68		Purchases (USD/GJ)	Sales (USD/GJ)	(USD/m^3 Liq)	(USD/L Liq)	(USD/m^3 Liq)	(USD/m^3)	(USD/m^3)	Purchases (USD/kW·h)	Sales (USD/kW·h)	(USD/L Liq)	(USD / m3 Liq)
69		$ -	$ -	$ 60.26	$ 0.14	$ 389.84	$ 471.70	$ 2.00	$ 0.04	$ -	$ 0.76	
70												
71												
72												

	A	B	C	D	E	F	G	H	I	J	K
73	Financials (Time Series Results)										
74	Year	Gross Revenues	Costs		Asset Book Value	Salvage Value	Royalty Payment	Emission Fee	Net Revenues		Cumulative After Tax Earnings
75			Capital	Operating					Before Tax	After Tax	
76		(Inflation Adjusted USD)							(Present Value USD)		
77	2022	103,936,320	210,394,887	5,616,843	189,355,398	83,250,975	10,609,875	-359,293	60,935,824	60,935,824	60,935,824
78	2023	107,054,410		5,785,348	170,419,858	74,000,867	10,928,171	-359,293	59,309,623	59,309,623	120,245,446
79	2024	110,266,042		5,958,909	153,377,872	64,750,759	11,256,017	-359,293	57,376,727	57,376,727	177,622,174
80	2025	113,574,023		6,137,676	138,040,085	55,500,650	11,593,697	-359,293	55,231,307	55,231,307	232,853,480
81	2026	116,981,244		6,321,806	124,236,077	46,250,542	11,941,508	-359,293	52,947,957	52,947,957	285,801,437
82	2027	120,490,681		6,511,460	111,812,469	37,000,433	12,299,753	-359,293	50,585,418	50,585,418	336,386,855
83	2028	124,105,402		6,706,804	100,631,222	27,750,325	12,668,746	-359,293	48,189,600	48,189,600	384,576,455
84	2029	125,599,679		6,908,008	90,568,100	18,500,217	12,821,293	-353,029	44,859,482	44,859,482	429,435,937
85	2030	123,307,201		7,115,249	81,511,290	9,250,108	12,587,305	-336,491	40,240,218	40,240,218	469,676,155
86	2031	117,358,010		7,328,706	73,360,161	0	11,980,054	-310,930	34,779,494	34,779,494	504,455,648
87	Last Profitable Year (After Asset Liquidation, Final Tax Adjustments and Closing Book Entries)										
88	2031	117,358,010	999	7,328,706	73,360,161	0	11,980,054	-310,930	34,779,494	34,779,494	504,455,648
89											

	A	B	C	D	E	F	G	H	I	J	K
90	Avoided GHG and BC Emissions (Time Series Results)										
91	Year	CH_4 (kt)	CO_2 (kt)	N_2O (kt)	CO_2E (kt)	Black Carbon (t)					
92	2022	1.6	285.5	0.0	326.6	249.9					
93	2023	1.6	285.5	0.0	326.6	249.9					
94	2024	1.6	285.5	0.0	326.6	249.9					
95	2025	1.6	285.5	0.0	326.6	249.9					
96	2026	1.6	285.5	0.0	326.6	249.9					
97	2027	1.6	285.5	0.0	326.6	249.9					
98	2028	1.6	285.5	0.0	326.6	249.9					
99	2029	1.6	280.6	0.0	320.9	229.8					
100	2030	1.5	267.4	0.0	305.9	211.4					
101	2031	1.4	247.1	0.0	282.7	194.5					
102											

	A	B	C	D	E	F	G	H	I	J	K
103	Other Avoided Atmospheric Emissions (Time Series Results)										
104	Year	VOC (t)	CO (t)	NO_x (t)	H_2S (t)	SO_2 (t)	PM (t)	PM_{10} (t)	$PM_{2.5}$ (t)		
105	2022	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
106	2023	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
107	2024	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
108	2025	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
109	2026	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
110	2027	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
111	2028	0.9	1.1	0.2	0.0	0.0	183.2	183.2	183.2		
112	2029	0.9	1.1	0.2	0.0	0.0	180.0	180.0	180.0		
113	2030	0.8	1.0	0.2	0.0	0.0	171.6	171.6	171.6		
114	2031	0.8	0.9	0.2	0.0	0.0	158.5	158.5	158.5		
115											

	A	B	C	D	E	F	G	H	I	J	K
116	Forecast Site Activity Data (Time Series Results - Part 1)										
117	Year	Production			Waste Gas Disposition			Incremental Energy Purchases			
118		Oil (10^3 m^3)	Gas (10^6 m^3)	Water (10^3 m^3)	Collected (10^6 m^3)	Conserved (10^6 m^3)	Flared (10^6 m^3)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)
119	2022	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
120	2023	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
121	2024	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
122	2025	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
123	2026	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
124	2027	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
125	2028	960.72	263.71		263.71	111.47	152.24	0.00	0.00	0.00	136,933
126	2029	883.87	242.62		242.61	109.53	133.09	0.00	0.00	0.00	134,548
127	2030	813.16	223.21		223.20	104.40	118.81	0.00	0.00	0.00	128,251
128	2031	748.10	205.35		205.35	96.47	108.88	0.00	0.00	0.00	118,518
129											

	A	B	C	D	E	F	G	H	I	J	K
130	Forecast Site Activity Data (Time Series Results - Part 2)										
131	Year	Incremental Product Sales					Incremental Utilization	Avoided Purchases			

	A	B	C	D	E	F	G	H	I	J	K	L
132		Gas (10^6 m^3 Gas)	LPG (10^3 m^3 Liq)	NGL (10^3 m^3 Liq)	Oil (10^3 m^3)	Electricity (10^3 kW·h)	Fuel Gas (10^6 m^3 Gas)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)	
133	2022	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
134	2023	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
135	2024	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
136	2025	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
137	2026	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
138	2027	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
139	2028	0.00	0.00	0.00	0.00	0	38.42	0.00	79.65	50,931	0.00	
140	2029	0.00	0.00	0.00	0.00	0	37.75	0.00	78.26	50,043	0.00	
141	2030	0.00	0.00	0.00	0.00	0	35.98	0.00	74.60	47,698	0.00	
142	2031	0.00	0.00	0.00	0.00	0	33.25	0.00	68.93	44,075	0.00	
143												

144	**Applied Emission Factors (EF) For Year One Emissions For Baseline (BL) and Simulated Equipment**							
145	Source			Pollutant	EF (ng/J of Fuel)	Reference (Where Applicable) and Basis		
146	Category	Tag No.	DB EF Key			Basis	Author or Reporting Agency	Code
147	**Flares**	**BL FLARE_1**	**335**	CH_4	180.0	Calculated	US EPA	2018-U.S.EPAAP-42Table13.5-1
148				CO_2	54,529.6	Calculated	NA	
149				N_2O	0.1	Referenced	WCI	2012-BCWCI.363(k)
150				BC	19.7	Calculated	NA	
151				VOC	22.3	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
152				CO	133.0	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
153				NO_x	29.2	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-1
154				SO_2	0.0	Calculated	NA	
155				PM	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
156				PM_{10}	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
157				$PM_{2.5}$	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
158	**Heaters and Boilers**	**Mini_GTL_1_1**	**7**	CH_4	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
159				CO_2	83,629.7	Calculated	NA	
160				N_2O	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
161				BC	0.6	Calculated	NA	
162				VOC	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
163				CO	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
164				NO_x	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
165				SO_2	0.0	Calculated	NA	
166				PM	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
167				PM_{10}	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
168				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
169	**Heaters and Boilers**	**Mini_GTL_2_1**	**7**	CH_4	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
170				CO_2	83,629.7	Calculated	NA	
171				N_2O	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
172				BC	0.6	Calculated	NA	
173				VOC	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
174				CO	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
175				NO_x	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
176				SO_2	0.0	Calculated	NA	
177				PM	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
178				PM_{10}	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
179				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
180	**Heaters and Boilers**	**Mini_GTL_3_1**	**7**	CH_4	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
181				CO_2	83,629.7	Calculated	NA	
182				N_2O	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
183				BC	0.6	Calculated	NA	
184				VOC	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
185				CO	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
186				NO_x	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
187				SO_2	0.0	Calculated	NA	
188				PM	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
189				PM_{10}	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
190				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
191	**Heaters and Boilers**	**Mini_GTL_4_1**	**7**	CH_4	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
192				CO_2	83,629.7	Calculated	NA	
193				N_2O	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
194				BC	0.6	Calculated	NA	
195				VOC	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
196				CO	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
197				NO_x	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
198				SO_2	0.0	Calculated	NA	
199				PM	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
200				PM_{10}	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
201				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
202	**Heaters and**	**Mini_GTL_5_1**	**7**	CH_4	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2

	A	B	C	D	E	F	G	H	I	J	K	L
203	**Boilers**			CO_2	83,629.7	Calculated	NA					
204				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
205				BC	0.6	Calculated	NA					
206				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
207				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
208				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
209				SO_2	0.0	Calculated	NA					
210				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
211				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
212				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
213	**Heaters and**	**Mini_GTL_6_1**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
214	**Boilers**			CO_2	83,629.7	Calculated	NA					
215				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
216				BC	0.6	Calculated	NA					
217				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
218				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
219				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
220				SO_2	0.0	Calculated	NA					
221				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
222				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
223				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
224	**Heaters and**	**Mini_GTL_7_1**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
225	**Boilers**			CO_2	83,629.7	Calculated	NA					
226				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
227				BC	0.6	Calculated	NA					
228				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
229				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
230				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
231				SO_2	0.0	Calculated	NA					
232				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
233				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
234				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
235	**Heaters and**	**Mini_GTL_8_1**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
236	**Boilers**			CO_2	83,629.7	Calculated	NA					
237				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
238				BC	0.6	Calculated	NA					
239				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
240				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
241				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
242				SO_2	0.0	Calculated	NA					
243				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
244				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
245				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
246	**Heaters and**	**Mini_GTL_9_1**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
247	**Boilers**			CO_2	83,629.7	Calculated	NA					
248				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
249				BC	0.6	Calculated	NA					
250				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
251				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
252				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
253				SO_2	0.0	Calculated	NA					
254				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
255				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
256				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
257	**Heaters and**	**Mini_GTL_10_**	**7**	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
258	**Boilers**			CO_2	83,629.7	Calculated	NA					
259				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
260				BC	0.6	Calculated	NA					
261				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
262				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
263				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
264				SO_2	0.0	Calculated	NA					
265				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
266				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
267				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
268	**Flares**	**FLARE_1**	**335**	CH_4	137.0	Calculated	US EPA		2018-U.S.EPAAP-42Table13.5-1			
269				CO_2	83,629.7	Calculated	NA					
270				N_2O	0.1	Referenced	WCI		2012-BCWCI.363(k)			
271				BC	0.0	Calculated	NA					
272				VOC	22.3	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
273				CO	133.0	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			

	A	B	C	D	E	F	G	H	I	J	K	L
274				NO_x	29.2	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-1			
275				SO_2	0.0	Calculated	NA					
276				PM	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
277				PM_{10}	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
278				$PM_{2.5}$	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
279												
280	Capital Cost											
281	Equipment	Item	Category	Subcategory 1	Subcategory 2	Capacity or Rated Power Output		Price (USD)	FOB Point	Basis		
282						Value	Units of Measure					
283		Mini_GTL_1_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
284		Mini_GTL_2_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
285		Mini_GTL_3_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
286		Mini_GTL_4_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
287		Mini_GTL_5_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
288		Mini_GTL_6_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
289		Mini_GTL_7_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
290		Mini_GTL_8_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
291		Mini_GTL_9_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
292		Mini_GTL_10_1	Mini-GTL Plant	Greyrock M		65.02	10^3 m^3	9,207,061	NA	Predicted (Class 5)		
293		VVN_1_1	Tank	API 650 - Fixed Roof		1,797.57	m^3	239,924	NA	Predicted (Class 4)		
294		VVD_1_1	Tank	API 650 - Fixed Roof		1,149.36	m^3	190,546	NA	Predicted (Class 4)		
295		**E7**	**Engineering & Drafting**					12,696,360				
296		**Subtotal:**						105,197,443				
297	**Pipeline**	**Pipe Specifications**	**OD (mm)**			**Material:**			**Design P (kPa)**			
298			**WT (mm)**			**Length (km):**			**Coating:**			
299		Item	Category		Material (USD)	Labour (USD)		Total (USD)		Basis		
300		**PL1**	**Pipe**									
301		**PL2**	**Right-of-Way (ROW)**									
302		**PL3**	**ROW Land Survey**									
303		**PL4**	**Clearing**									
304		**PL5**	**Soil Stripping**									
305		**PL6**	**Timber Salvage**									
306		**PL7**	**Rock excavation**									
307		**PL8**	**Cathodic Protection**									
308		**PL9**	**Construction**									
309		**PL10**	**Engineering & Drafting**									
310		**PL11**	**Supervision**									
311		**PL12**	**Safety**									
312		**PL13**	**Reseeding ROW**									
313		**Subtotal:**										
314	**Materials & Services**	Item	Category		Material (USD)	Labour (USD)		Total (USD)		Basis		
315		**MS1**	**Equipment Setting**		0	12,763,171		12,763,171		Predicted		
316		**MS2**	**Foundations**		3,190,793	4,243,754		7,434,547		Predicted		
317		**MS3**	**Structural Steel**		3,190,793	1,595,396		4,786,189		Predicted		
318		**MS4**	**Buildings**		1,914,476	1,914,476		3,828,951		Predicted		
319		**MS5**	**Insulation**		638,159	957,238		1,595,396		Predicted		
320		**MS6**	**Instruments**		3,828,951	1,531,581		5,360,532		Predicted		
321		**MS7**	**Electrical**		5,105,268	3,828,951		8,934,220		Predicted		
322		**MS8**	**Piping**		28,717,135	14,358,568		43,075,703		Predicted		
323		**MS9**	**Painting**		319,079	957,238		1,276,317		Predicted		
324		**MS10**	**Miscellaneous**		1,914,476	1,531,581		3,446,056		Predicted		
325		**MS11**	**Engineering & Drafting**		0	12,696,360		12,696,360		Predicted		
326		**MS12**	**Supervision**		Unavailable	0		0				
327		**MS13**	**Safety**		Unavailable	0		0				
328		**Subtotal:**						105,197,443				
329	**Summary**	**Total:**						210,394,887				
330		**Duties:**						0				
331		**Freight:**						Unavailable				
332		**Grand Total:**						210,394,887				
333	Year 1 Operating Costs											
334		**Operating Labour**	**Hours Per Shift:**		Unknown	**Operator Hourly Labour Rate:**		$ 2.05				
335			**Shifts Per Day:**		Unknown	**Maintenance Hourly Labour Rate:**		$ 2.05				
336		Item	Category		Material (USD)	Labour (Hours)	Labour (USD)	Line Total (USD)		Basis		
337	**Fixed O&M Costs**	**L1**	**Operating Labour**		0	7,560	15,498	15,498		Predicted		
338		**L2**	**Maintenance Labour**		0	2,520	5,166	5,166		Predicted		
339		**L3**	**Direct Supervision**		0		2,790	2,790		Predicted		
340		**L4**	**Administration**		0		1,896,297	1,896,297		Predicted		

	A	B	C	D	E	F	G	H	I	J	K	L
341		L5	Unclassified Costs					0		Predicted		
342		Total Fixed O&M Costs:						1,919,751		Predicted		
343	Variable	SS1	Third-Party Services					38,336		Predicted		
344	O&M Costs	SS2	Parts & Consumables					117,482		Predicted		
345		SS3	Unclassified Costs					3,541,274		Predicted		
346		Total Variable O&M Costs:						3,697,092		Predicted		
347	Total O&M Costs	Total Fixed and Variable O&M Costs:						5,616,843		Predicted		
348	Purchased	PC1	Electricity		5,340,406	0	0	5,340,406		Predicted		
349	Commodities	PC2	Natural Gas		0	0	0	0		Predicted		
350		PC3	LPG		0	0	0	0		Predicted		
351		PC4	Diesel		0	0	0	0		Predicted		
352	Summary	Total:						10,957,249				

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSP	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Proposed Equipment

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSP	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	1	2	3	4	5	6	7	8
- Fluid	HC	HC	HC	HC	HC	Not Known	HC	Not Known
- Physical State	Vapour	Vapour	Vapour	Vapour	Vapour	Unknown	Vapour	Unknown
- Temperature (°C)	40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Pressure (kPa)	800.0	800.0	800.0	800.0	800.0	---	800.0	---
- Total Molar Flowrate (kmole/h)	1,273.17	1,145.61	127.56	1,942.07	796.46	0.00	1,942.07	0.00
- Total Mass Flowrate (kg/h)	30176.9	27153.5	3023.5	52639.3	25485.8	0.0	52639.3	0.0
- Total Gas Volumetric Flowrate (Sm³/h)	30104.0	27087.8	3016.2	45919.9	18832.1	---	45919.9	---
- Total Liq Volumetric Flowrate (m³/h)	---	---	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	From Flare Line	FS-100	FS-100	M-100	Oxygen Plant	HP Steam Header	V-100	V-100
- Service:	---	Not Applicable	Not Applicable	Not Applicable	---	---	Inlet Scrubber	Inlet Scrubber

REPORT: PROCESS SIMULATION RESULTS

- Type:			---	Flow Splitter	Flow Splitter	Mixer	---	---	2-Phase Separator	2-Phase Separator
Destination (Unit Operation):										
- Tag No.			FS-100	M-100	To Flare Line	V-100	M-100	M-100	K-100	Waste Water Header
- Service:			Not Applicable	Not Applicable	---	Inlet Scrubber	Not Applicable	Not Applicable	Inlet Gas Boosting	---
- Type:			Flow Splitter	Mixer	---	2-Phase Separator	Mixer	Mixer	Compressor: Recip.	---
Properties:			1	2	3	4	5	6	7	8
- Vapour Mole Fraction			1.000000	1.000000	1.000000	1.000000	1.000000	---	1.000000	---
- Liquid Mole Fraction			0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			23.702	23.702	23.702	27.105	31.999	---	27.105	---
- Mass Density (kg/m^3)			8.439	8.439	8.439	9.634	11.470	---	9.634	---
- Molar Density (kmole/m^3)			0.356	0.356	0.356	0.355	0.358	---	0.355	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			0.9669	0.9669	0.9669	0.9794	0.9925	---	0.9794	---
- Specific Heat Capacity (kJ/kmole·°C)			46.7971	46.7971	46.7971	39.4833	29.4594	---	39.4833	---
- Enthalpy (kJ/kmole)			-85,487	-85,487	-85,487	-50,404	60	---	-50,404	---
- Entropy (kJ/kmole·°C)			-202	-202	-202	-152	-95	---	-152	---
- Gross Heating Value (MJ/m^3)			48.3	48.3	48.3	28.5	0.0	---	28.5	---
- Net Heating Value (MJ/m^3)			43.3	43.3	43.3	25.6	0.0	---	25.6	---
- Sound Speed (m/s)			359.316	359.316	359.316	344.504	332.061	---	344.504	---
- Dew Point Temperature (°C)			40.00	40.00	40.00	36.53	29.90	---	36.53	---
- Dew Point Pressure (°kPa)			896.4	896.4	896.4	896.4	896.4	---	896.4	---
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.033	0.033	0.033	0.033	0.030	---	0.033	---
- Viscosity (cp)			0.012	0.012	0.012	0.015	0.023	---	0.015	---
Composition (Mole Fraction):			1	2	3	4	5	6	7	8
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043380	0.043380	0.043380	0.025590	0.000001	---	0.025590	---
Oxygen	**O2**	**7782-44-7**	---	---	---	0.410107	0.999999	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000	---
Carbon Dioxide	**CO2**	**124-38-9**	0.025205	0.025205	0.025205	0.014868	---	---	0.014868	---
Methane	**CH4**	**74-82-8**	0.641174	0.641174	0.641174	0.378224	---	---	0.378224	---
Ethane	**C2H6**	**74-84-0**	0.171376	0.171376	0.171376	0.101094	---	---	0.101094	---
Propane	**C3H8**	**74-98-6**	0.084805	0.084805	0.084805	0.050026	---	---	0.050026	---
i-Butane	**C4H10**	**75-28-5**	0.007275	0.007275	0.007275	0.004291	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	0.017510	0.017510	0.017510	0.010329	---	---	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	0.002545	0.002545	0.002545	0.001501	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	0.003010	0.003010	0.003010	0.001776	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	0.000100	0.000100	0.000100	0.000059	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	0.000175	0.000175	0.000175	0.000103	---	---	0.000103	---
Hexane	**C6H14**	**110-54-3**	0.000745	0.000745	0.000745	0.000439	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.000170	0.000170	0.000100	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	0.001975	0.001975	0.001975	0.001165	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.000190	0.000190	0.000112	---	---	0.000112	---

Toluene	**C7H8**	**108-88-3**	0.000165	0.000165	0.000165	0.000097	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.000040	0.000040	0.000024	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	0.000075	0.000075	0.000075	0.000044	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	0.000035	0.000035	0.000035	0.000021	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	0.000020	0.000020	0.000020	0.000012	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000015	0.000015	0.000009	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000005	0.000005	0.000003	---	---	0.000003	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSP	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	9	10	11	12	13	14	15	16
- Fluid	Heat Medium	Heat Medium	HC	Electricity	Fuel Gas	HC	HC	HC
- Physical State	Liquid	Liquid	Vapour	Unknown	Gas	Vapour	Vapour	Vapour
- Temperature (°C)	120.00	120.00	192.34	---	39.90	39.90	1,050.00	1,050.00
- Pressure (kPa)	276.0	276.0	5,100.0	---	0.0	0.0	5,000.0	5,000.0
- Total Molar Flowrate (kmole/h)	0.00	0.00	1,942.07	---	0.00	135.34	1,942.07	4,329.38
- Total Mass Flowrate (kg/h)	0.0	0.0	52639.3	---	0.0	3637.3	52639.3	52638.8
- Total Gas Volumetric Flowrate (Std m^3/h)	---	---	45919.9	---	0.0	3200.2	45919.9	102367.5
- Total Liq Volumetric Flowrate (m^3/h)	0.0	0.0	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	3,800.442	---	---	---	---
Origin (Unit Operation):								
- Tag No.	V-100	H-100	K-100	Electric Utility System	Fuel Gas Header	M-200	H-101	R-100
- Service:	Inlet Scrubber	Boiler	Inlet Gas Boosting	---	---	Not Applicable	Heat Medium Heater	---

- Type:	2-Phase Separator	Heater	Compressor: Recip.	---	---	Mixer	Heater: Fired	---
Destination (Unit Operation):								
- Tag No.	PU-101	V-100	H-101	K-100	K-100	H-101	R-100	E-100
- Service:	Circulation	Inlet Scrubber	Heat Medium Heater	Inlet Gas Boosting	Inlet Gas Boosting	Heat Medium Heater	---	Boiler
- Type:	Pump	2-Phase Separator	Heater: Fired	Compressor: Recip.	Compressor: Recip.	Heater: Fired	---	Heat Exchanger: Shell and Tube
Properties:	9	10	11	12	13	14	15	16
- Vapour Mole Fraction	0.000000	0.000000	1.000000	---	1.000000	1.000000	1.000000	1.000000
- Liquid Mole Fraction	1.000000	1.000000	0.000000	---	0.000000	0.000000	0.000000	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	41.686	41.686	27.105	---	---	26.875	27.105	12.158
- Mass Density (kg/m^3)	1,025.000	1,025.000	36.987	---	---	0.996	12.411	5.584
- Molar Density (kmole/m^3)	---	---	1.365	---	---	0.037	0.458	0.459
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	---	0.9839	---	---	0.9986	1.0117	1.0086
- Specific Heat Capacity (kJ/kmole·°C)	135.4802	135.4802	48.4778	---	---	35.4385	77.7041	32.4041
- Enthalpy (kJ/kmole)	---	---	-44,103	---	---	-103,562	11,746	-12,049
- Entropy (kJ/kmole·°C)	---	---	-150	---	---	-59	-85	-25
- Gross Heating Value (MJ/m^3)	---	---	28.5	---	---	24.7	28.5	11.9
- Net Heating Value (MJ/m^3)	---	---	25.6	---	---	22.9	25.6	10.3
- Sound Speed (m/s)	---	---	418.851	---	---	355.689	682.497	1,113.676
- Dew Point Temperature (°C)	---	---	192.34	---	---	39.90	1,050.00	1,050.00
- Dew Point Pressure (°kPa)	---	---	5,196.4	---	---	96.4	5,096.4	5,096.4
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	---	0.057	---	---	0.032	0.194	0.201
- Viscosity (cp)	1.100	1.100	0.022	---	---	0.016	0.045	0.038

Composition (Mole Fraction):			9	10	11	12	13	14	15	16
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	---	---	---	---	0.000000	---	0.613921
Nitrogen	**N2**	**7727-37-9**	---	---	0.025590	---	0.062677	0.062677	0.025590	0.011479
Oxygen	**O2**	**7782-44-7**	---	---	0.410107	---	---	---	0.410107	---
Water	**H2O**	**7732-18-5**	0.462700	0.462700	0.000000	---	0.000000	0.000000	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	0.014868	---	0.036417	0.036417	0.014868	0.006670
Carbon Monoxide	**CO**	**630-08-0**	---	---	---	---	0.553432	0.553432	---	0.367931
Methane	**CH4**	**74-82-8**	---	---	0.378224	---	0.249780	0.249780	0.378224	---
Ethane	**C2H6**	**74-84-0**	---	---	0.101094	---	0.044421	0.044421	0.101094	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	0.537300	0.537300	---	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	---	0.050026	---	0.030293	0.030293	0.050026	---
i-Butane	**C4H10**	**75-28-5**	---	---	0.004291	---	---	---	0.004291	---
n-Butane	**C4H10**	**106-97-8**	---	---	0.010329	---	0.022981	0.022981	0.010329	---
i-Pentane	**C5H12**	**78-78-4**	---	---	0.001501	---	---	---	0.001501	---
n-Pentane	**C5H12**	**109-66-0**	---	---	0.001776	---	---	---	0.001776	---
Benzene	**C6H6**	**71-43-2**	---	---	0.000059	---	---	---	0.000059	---
Cyclohexane	**C6H12**	**110-82-7**	---	---	0.000103	---	---	---	0.000103	---

Hexane	**C6H14**	**110-54-3**	---	---	0.000439	---	---	---	0.000439	---
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	0.000100	---	---	---	0.000100	---
Heptane	**C7H16**	**142-82-5**	---	---	0.001165	---	---	---	0.001165	---
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	0.000112	---	---	---	0.000112	---
Toluene	**C7H8**	**108-88-3**	---	---	0.000097	---	---	---	0.000097	---
Ethylbenzene	**C8H10**	**100-41-4**	---	---	0.000003	---	---	---	0.000003	---
m-Xylene	**C8H10**	**108-38-3**	---	---	0.000024	---	---	---	0.000024	---
Octane	**C8H18**	**111-65-9**	---	---	0.000044	---	---	---	0.000044	---
o-Xylene	**C8H10**	**95-47-6**	---	---	0.000003	---	---	---	0.000003	---
Nonane	**C9H20**	**111-84-2**	---	---	0.000021	---	---	---	0.000021	---
Decane	**C10H22**	**124-18-5**	---	---	0.000012	---	---	---	0.000012	---
Undecanes	**C11H24**	**1120-21-4**	---	---	0.000009	---	---	---	0.000009	---
Dodecane	**C12H26**	**112-40-3**	---	---	0.000003	---	---	---	0.000003	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSP	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	17	18	19	20	21	22	23	24
- Fluid	Water	HC	Water	HC	HC	HC	Not Known	HC
- Physical State	Vapour	Vapour	Liquid	Vapour	Vapour	Vapour	Unknown	Vapour
- Temperature (°C)	226.32	240.00	14.40	240.00	39.90	39.90	---	39.90
- Pressure (kPa)	2,517.0	2,500.0	2,517.0	2,500.0	0.0	0.0	---	0.0
- Total Molar Flowrate (kmole/h)	2.19	4,329.38	2.19	2,021.20	792.91	135.34	0.00	657.56
- Total Mass Flowrate (kg/h)	39.5	52638.8	39.5	52638.7	21309.0	3637.3	0.0	17671.7
- Total Gas Volumetric Flowrate (Sm³/h)	51.8	102367.5	---	47790.8	18748.2	3200.2	---	15548.0
- Total Liq Volumetric Flowrate (m³/h)	---	---	0.0	---	---	---	---	---
- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	E-100	E-100	Water Header	R-101	PSU-100	FS-101	Fuel Gas Header	FS-101
- Service:	Boiler	Boiler	---	---	---	Not Applicable	---	Not Applicable

- Type:			Heat Exchanger:	Heat Exchanger:	---	---	---	Flow Splitter	---	Flow Splitter
Destination (Unit Operation):										
- Tag No.			HP Steam Header	R-101	E-100	PSU-100	FS-101	M-200	M-200	Gas to Flare
- Service:			---	---	Boiler	---	Not Applicable	Not Applicable	Not Applicable	---
- Type:			---	---	Heat Exchanger: Shell and Tube	---	Flow Splitter	Mixer	Mixer	---
Properties:			17	18	19	20	21	22	23	24
- Vapour Mole Fraction			1.000000	1.000000	0.000000	1.000000	1.000000	1.000000	---	1.000000
- Liquid Mole Fraction			0.000000	0.000000	1.000000	0.000000	0.000000	0.000000	---	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			18.015	12.158	18.015	26.043	26.875	26.875	---	26.875
- Mass Density (kg/m^3)			13.071	7.321	1,000.364	16.505	0.996	0.996	---	0.996
- Molar Density (kmole/m^3)			0.726	0.602	55.529	0.634	0.037	0.037	---	0.037
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	1.0106	---	0.9602	0.9986	0.9986	---	0.9986
- Specific Heat Capacity (kJ/kmole·°C)			62.1935	29.5433	75.3123	52.2772	35.4385	35.4385	---	35.4385
- Enthalpy (kJ/kmole)			50,485	-37,028	1,134	-178,960	-103,562	-103,562	---	-103,562
- Entropy (kJ/kmole·°C)			112	-49	4	-126	-59	-59	---	-59
- Gross Heating Value (MJ/m^3)			0.0	11.9	0.0	20.4	24.7	24.7	---	24.7
- Net Heating Value (MJ/m^3)			0.0	10.3	0.0	18.8	22.9	22.9	---	22.9
- Sound Speed (m/s)			504.574	707.655	1,467.920	433.537	355.689	355.689	---	355.689
- Dew Point Temperature (°C)			226.32	240.00	240.00	240.00	39.90	39.90	---	39.90
- Dew Point Pressure (°kPa)			2,613.3	2,596.4	2,596.4	2,596.4	96.4	96.4	---	96.4
- Bubble Point Temperature (°C)			226.32	---	226.32	---	---	---	---	---
- Bubble Point Pressure (kPa)			1.6	---	1.6	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.045	0.100	0.589	0.065	0.032	0.032	---	0.032
- Viscosity (cp)			0.017	0.021	1.154	0.020	0.016	0.016	---	0.016
Composition (Mole Fraction):			17	18	19	20	21	22	23	24
Name	**Formula**	**CAS No.**								
Hydrogen	**H2**	**1333-74-0**	---	0.613921	---	0.000000	0.000000	0.000000	---	0.000000
Nitrogen	**N2**	**7727-37-9**	---	0.011479	---	0.024588	0.062677	0.062677	---	0.062677
Water	**H2O**	**7732-18-5**	1.000000	0.000000	1.000000	0.570995	0.000000	0.000000	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	0.006670	---	0.014286	0.036417	0.036417	---	0.036417
Carbon Monoxide	**CO**	**630-08-0**	---	0.367931	---	0.217109	0.553432	0.553432	---	0.553432
Methane	**CH4**	**74-82-8**	---	---	---	0.097988	0.249780	0.249780	---	0.249780
Ethane	**C2H6**	**74-84-0**	---	---	---	0.017426	0.044421	0.044421	---	0.044421
Propane	**C3H8**	**74-98-6**	---	---	---	0.011884	0.030293	0.030293	---	0.030293
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.009015	0.022981	0.022981	---	0.022981
n-Pentane	**C5H12**	**109-66-0**	---	---	---	0.005002	---	---	---	---
Hexane	**C6H14**	**110-54-3**	---	---	---	0.004422	---	---	---	---
Heptane	**C7H16**	**142-82-5**	---	---	---	0.003905	---	---	---	---
Octane	**C8H18**	**111-65-9**	---	---	---	0.003445	---	---	---	---
Nonane	**C9H20**	**111-84-2**	---	---	---	0.003037	---	---	---	---
Decane	**C10H22**	**124-18-5**	---	---	---	0.002677	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	---	---	---	0.002359	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	---	---	---	0.002078	---	---	---	---

Tridecane	**C13H28**	**629-50-5**	---	---	---	0.001830	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	---	0.001612	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	---	0.001419	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	---	0.001250	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	---	0.001100	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	---	0.000969	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	---	0.000853	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	---	0.000751	---	---	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSP	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	25	26	27	28	29	30	31	32
- Fluid	Electricity	HC	HC	HC	Heat Medium	Heat Medium	Electricity	HC
- Physical State	Unknown	Liquid	Liquid	Vapour	Liquid	Liquid	Unknown	Vapour
- Temperature (°C)	---	39.90	39.90	40.00	120.00	120.00	---	40.00
- Pressure (kPa)	---	0.0	0.0	800.0	276.0	276.0	---	800.0
- Total Molar Flowrate (kmole/h)	---	54.42	19.78	0.00	0.00	0.00	---	0.00
- Total Mass Flowrate (kg/h)	---	6103.8	4434.9	0.0	0.0	0.0	---	0.0
- Total Gas Volumetric Flowrate (Sm^3/h)	---	---	---	0.0	---	---	---	0.0
- Total Liq Volumetric Flowrate (m^3/h)	---	9.1	5.8	---	0.0	0.0	---	---
- Energy Flowrate kW	11,831.235	---	---	---	---	---	23,662.470	---
Origin (Unit Operation):								
- Tag No.	Electric Utility System	PSU-100	PSU-100	Fuel Gas Header	H-100	PU-101	Electric Utility System	Fuel Gas Header
- Service:	---	---	---	---	Boiler	Circulation	---	---

- Type:			---	---	---	---	Heater	Pump	---	---
Destination (Unit Operation):										
- Tag No.			PSU-100	Naphtha Storage	Diesel Storage	H-100	V-100	H-100	Mini-GTL Plant	Mini-GTL Plant
- Service:			---	---	---	Boiler	Inlet Scrubber	Boiler	---	---
- Type:			---	---	---	Heater	2-Phase Separator	Heater	---	---
Properties:			25	26	27	28	29	30	31	32
- Vapour Mole Fraction			---	0.000000	0.000000	1.000000	0.000000	0.000000	---	1.000000
- Liquid Mole Fraction			---	1.000000	1.000000	0.000000	1.000000	1.000000	---	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			---	112.161	224.249	23.702	41.686	41.686	---	23.702
- Mass Density (kg/m^3)			---	671.270	762.803	8.439	1,025.000	1,025.000	---	8.439
- Molar Density (kmole/m^3)			---	5.985	3.402	0.356	---	---	---	0.356
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	0.0063	0.0134	0.9669	---	---	---	0.9669
- Specific Heat Capacity (kJ/kmole·°C)			---	245.2118	472.3949	46.7971	135.4802	135.4802	---	46.7971
- Enthalpy (kJ/kmole)			---	-241,592	-437,240	-85,487	---	---	---	-85,487
- Entropy (kJ/kmole·°C)			---	-891	-1,701	-202	---	---	---	-202
- Gross Heating Value (MJ/m^3)			---	230.6	454.9	48.3	---	---	---	48.3
- Net Heating Value (MJ/m^3)			---	212.1	419.8	43.3	---	---	---	43.3
- Sound Speed (m/s)			---	969.621	1,355.431	359.316	---	---	---	359.316
- Dew Point Temperature (°C)			---	---	---	40.00	---	---	---	40.00
- Dew Point Pressure (°kPa)			---	---	---	896.4	---	---	---	896.4
- Bubble Point Temperature (°C)			---	39.90	39.90	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	96.4	96.4	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	338.5	338.5	---	---	---	---	---
- True Vapour Pressure (kPa)			---	96.4	96.4	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	0.110	0.076	0.033	---	---	---	0.033
- Viscosity (cp)			---	0.308	0.447	0.012	1.100	1.100	---	0.012
Composition (Mole Fraction):			25	26	27	28	29	30	31	32
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	---	0.043380	---	---	---	0.043380
Water	**H2O**	**7732-18-5**	---	0.000000	0.000000	0.000000	0.462700	0.462700	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	---	0.025205	---	---	---	0.025205
Methane	**CH4**	**74-82-8**	---	---	---	0.641174	---	---	---	0.641174
Ethane	**C2H6**	**74-84-0**	---	---	---	0.171376	---	---	---	0.171376
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	---	---	0.537300	0.537300	---	---
Propane	**C3H8**	**74-98-6**	---	---	---	0.084805	---	---	---	0.084805
i-Butane	**C4H10**	**75-28-5**	---	---	---	0.007275	---	---	---	0.007275
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.017510	---	---	---	0.017510
i-Pentane	**C5H12**	**78-78-4**	---	---	---	0.002545	---	---	---	0.002545
n-Pentane	**C5H12**	**109-66-0**	---	0.185773	---	0.003010	---	---	---	0.003010
Benzene	**C6H6**	**71-43-2**	---	---	---	0.000100	---	---	---	0.000100
Cyclohexane	**C6H12**	**110-82-7**	---	---	---	0.000175	---	---	---	0.000175
Hexane	**C6H14**	**110-54-3**	---	0.164245	---	0.000745	---	---	---	0.000745
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	---	0.000170	---	---	---	0.000170
Heptane	**C7H16**	**142-82-5**	---	0.145020	---	0.001975	---	---	---	0.001975
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	---	0.000190	---	---	---	0.000190

Toluene	**C7H8**	**108-88-3**	---	---	---	0.000165	---	---	---	0.000165
Ethylbenzene	**C8H10**	**100-41-4**	---	---	---	0.000005	---	---	---	0.000005
m-Xylene	**C8H10**	**108-38-3**	---	---	---	0.000040	---	---	---	0.000040
Octane	**C8H18**	**111-65-9**	---	0.127939	---	0.000075	---	---	---	0.000075
o-Xylene	**C8H10**	**95-47-6**	---	---	---	0.000005	---	---	---	0.000005
Nonane	**C9H20**	**111-84-2**	---	0.112808	---	0.000035	---	---	---	0.000035
Decane	**C10H22**	**124-18-5**	---	0.099427	---	0.000020	---	---	---	0.000020
Undecanes	**C11H24**	**1120-21-4**	---	0.087609	---	0.000015	---	---	---	0.000015
Dodecane	**C12H26**	**112-40-3**	---	0.077179	---	0.000005	---	---	---	0.000005
Tridecane	**C13H28**	**629-50-5**	---	---	0.187058	---	---	---	---	---
Tetradecane	**C14H30**	**629-59-4**	---	---	0.164740	---	---	---	---	---
Pentadecane	**C15H32**	**629-62-9**	---	---	0.145069	---	---	---	---	---
Cetane	**C16H34**	**544-76-3**	---	---	0.127737	---	---	---	---	---
Heptadecane	**C17H36**	**629-78-7**	---	---	0.112467	---	---	---	---	---
Octadecane	**C18H38**	**593-45-3**	---	---	0.099017	---	---	---	---	---
Nonadecane	**C19H40**	**629-92-5**	---	---	0.087172	---	---	---	---	---
Eicosane	**C20H42**	**112-95-8**	---	---	0.076740	---	---	---	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-GSP	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	Small-Scale Gas-to-Liquids Production	**Subcategory 1:**	
	CEL Reference Code:	GTL	**Subcategory 2:**	
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

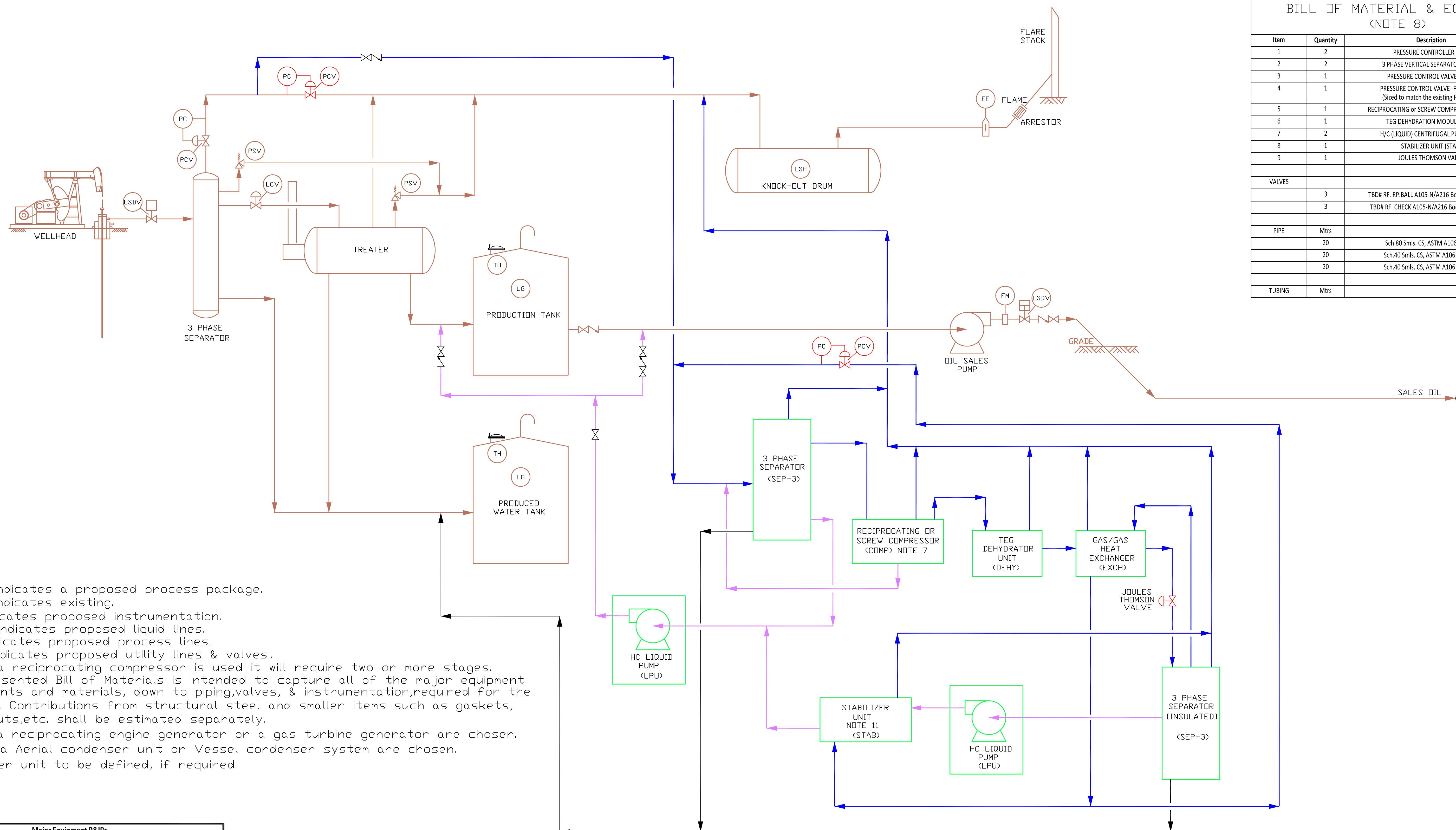
Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00

Simulation Flowsheet Drawing No:	SFD-22-OB-OSP-AGV-049-9							
Streams:	33							
- Fluid	Water							
- Physical State	Liquid							
- Temperature (°C)	14.40							
- Pressure (kPa)	2,517.0							
- Total Molar Flowrate (kmole/h)	1,154.09							
- Total Mass Flowrate (kg/h)	20791.0							
- Total Gas Volumetric Flowrate (Sm^3/h)	---							
- Total Liq Volumetric Flowrate (m^3/h)	20.8							
- Energy Flowrate kW	---							
Origin (Unit Operation):								
- Tag No.	PSU-100							

- Service:			---							
- Type:			---							
Destination (Unit Operation):										
- Tag No.			Produced Water Header							
- Service:			---							
- Type:			---							
Properties:			33	0	0	0	0	0	0	0
- Vapour Mole Fraction			0.000000							
- Liquid Mole Fraction			1.000000							
- Solid Mole Fraction			---							
- Aqueous Mole Fraction			---							
- Molecular Weight			18.015							
- Mass Density (kg/m^3)			1,000.364							
- Molar Density (kmole/m^3)			55.529							
- API Gravity (°)			---							
- Compressibility Factor			---							
- Specific Heat Capacity (kJ/kmole·°C)			75.3123							
- Enthalpy (kJ/kmole)			1,134							
- Entropy (kJ/kmole·°C)			4							
- Gross Heating Value (MJ/m^3)			0.0							
- Net Heating Value (MJ/m^3)			0.0							
- Sound Speed (m/s)			1,467.920							
- Dew Point Temperature (°C)			240.00							
- Dew Point Pressure (°kPa)			2,596.4							
- Bubble Point Temperature (°C)			226.32							
- Bubble Point Pressure (kPa)			1.6							
- Reid Vapour Pressure (kPa)			---							
- True Vapour Pressure (kPa)			---							
- Thermal Conductivity (W/m·°C)			0.589							
- Viscosity (cp)			1.154							
Composition (Mole Fraction):			33	0	0	0	0	0	0	0
Name	Formula	CAS No.								
Water	H2O	7732-18-5	1.000000							

7.2 LIQUIDS EXTRACTION BY JOULE THOMSON PLANT

This section presents a process flow diagram (PFD) that depicts how the Joule Thomson liquids extraction process would be implemented, and a simulation flow diagram (SFD) showing how the Joule Thomson liquids extraction process was modeled. Following these drawings are the individual techno-economic and environmental report and simulation report for two scenarios: (1) the compressors drivers are electric motors powered by the electric utility grid, and (2) the compressor drivers are natural gas fueled engines. The stream numbers presented in the simulation reports match those used on the SFD.



BILL OF MATERIAL & EQUIPMENT (NOTE 8)

Item	Quantity	Description	Size
1	2	PRESSURE CONTROLLER (PC)	
2	2	3 PHASE VERTICAL SEPARATOR (SEP-3)	TBD
3	1	PRESSURE CONTROL VALVE (PCV)	TBD
4	1	PRESSURE CONTROL VALVE -Fail Open (PCV) (Sized to match the existing Flare Line)	TBD
5	1	RECIPROCATING or SCREW COMPRESSOR (COMP)	TBD
6	1	TEG DEHYDRATION MODULE (TEG)	TBD
7	2	H/C (LIQUID) CENTRIFUGAL PUMP (LPU)	TBD
8	1	STABILIZER UNIT (STAB)	TBD
9	1	JOULES THOMSON VALVE	
VALVES			TBD
	3	TBD# RF. RP.BALL A105-N/A216 Body 316 SS Trim	TBD
	3	TBD# RF. CHECK A105-N/A216 Body 316 SS Trim	
PIPE	Mtrs		TBD
	20	Sch.80 Smls. CS, ASTM A106 Gr.B,PE	TBD
	20	Sch.40 Smls. CS, ASTM A106 Gr. B, BE	TBD
	20	Sch.40 Smls. CS, ASTM A106 Gr. B, BE	
TUBING	Mtrs		1/2"

Notes:

1) Green indicates a proposed process package.
2) Brown indicates existing.
3) Red indicates proposed instrumentation.
4) Purple indicates proposed liquid lines.
5) Blue indicates proposed process lines.
6) Black indicates proposed utility lines & valves..
7) Where a reciprocating compressor is used it will require two or more stages.
8) The presented Bill of Material is intended to capture all of the major equipment components and materials, down to piping,valves, & instrumentation,required for the project. Contributions from structural steel and smaller items such as gaskets, studs,nuts,etc. shall be estimated separately.
9) Where a reciprocating engine generator or a gas turbine generator are chosen.
10) Where a Aerial condenser unit or Vessel condenser system are chosen.
11) Stabilizer unit to be defined, if required.

Plot Date: YR MT DY 22-02-15 TIME 16:37

Major Equipment P&IDs

Tag	Referenced Drawing	Number of Times Referenced
LPU	PID-15-Pum-Cen-000-500-2 (Pump)	2
DEHY	PID-15-Deh-Gly-000-419-1 - (Dehy)	1
EXCH	PID-15-HE-TC-000-451-1 (Exchanger)	1
COMP	PID-15-Com-S-000-413-1 (Screw)	1
COMP	PID-15-Com-R-2S-408-1 (2-Stage Recip)	Note 7
COMP	PID-15-Com-R-3S-409-1 (3-Stage Recip)	Note 7
COMP	PID-15-Com-R-4S-410-1 (4-Stage Recip)	Note 7
EPG	PID-16-EPG-RE-NGC-420-1 (Reciprocating)	Note 9
EPG	PID-16-EPG-ETG-GC-529-1 (Gas Turbine)	Note 9
SEP-3	PID-15-Sep-3S-V-470-1 (Separator)	2
STAB	PID-18-Sta-Con-Hor-402-1 (Stabilizer)	Note 11
TEG	TEG DEHYDRATION MODULE (TEG)	1

REV	DATE	REVISION DESCRIPTION	BY
1	FEB 14/2022	PRELIMINARY	JMT

Discipline	Initials
Project Manager	D.P.
Process Engineer	
Checked By	
Designed By	PGS
Drawn By	JMT

ENGINEER'S STAMP

CLEARSTONE ENGINEERING
Calgary Canada

DRAWING TITLE

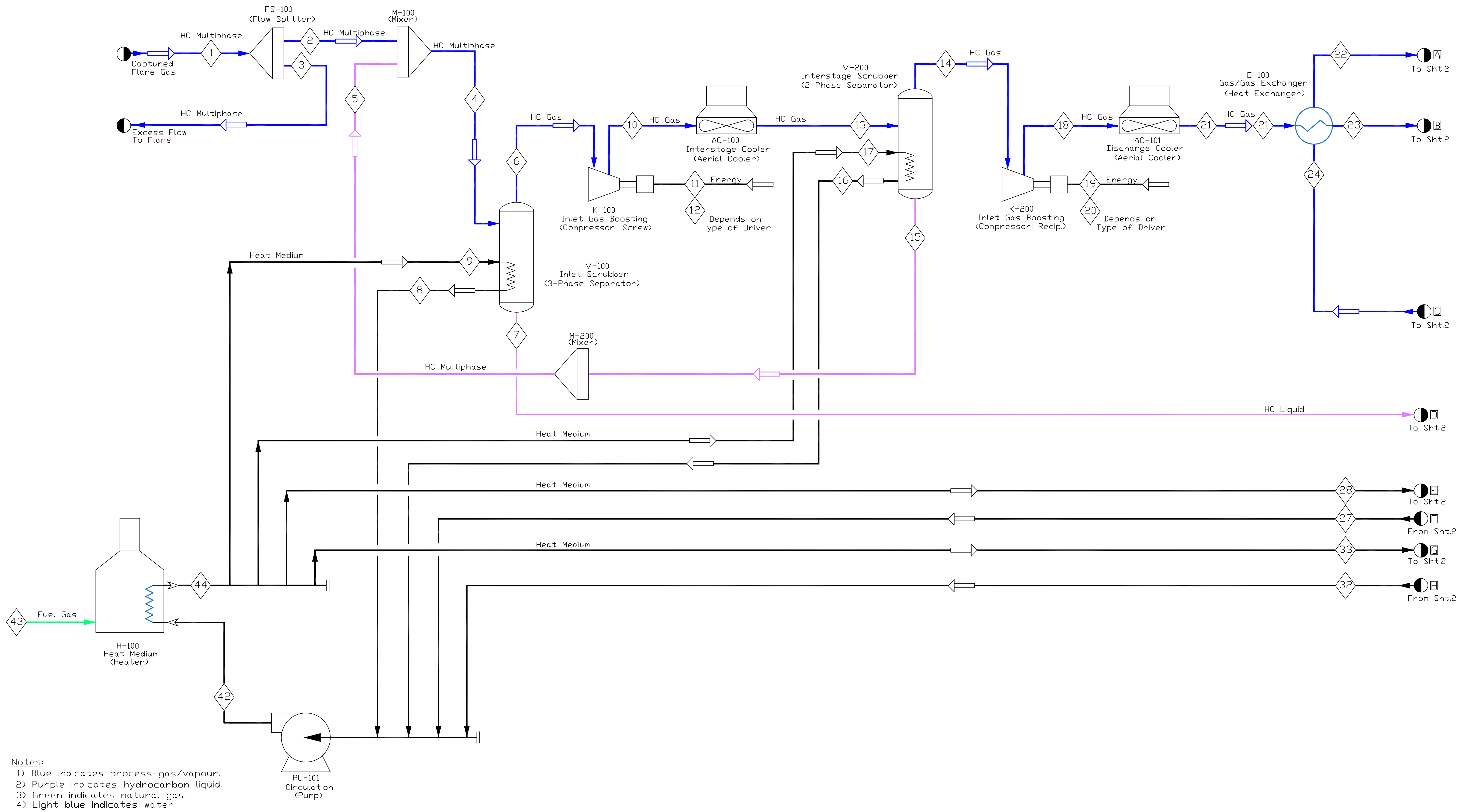
PROCESS FLOW DIAGRAM (PFD): GENERIC OIL BATTERY

Associated Gas - Joules Thomson Unit, Liquids Extraction Scheme

PROJECT #.	SCALE:	CLIENT:	DRAWING IDENTIFICATION	REV
N/A	NTS	GENERAL	PFD-22-OB-OSP-JTU-034-1	1.2

Plot Date: YR MT DY 20-07-01 TIME 14:00

Stream Detail Tables Site3 2St-Comp Option 4



Notes:
1) Blue indicates process-gas/vapour.
2) Purple indicates hydrocarbon liquid.
3) Green indicates natural gas.
4) Light blue indicates water.
5) Black indicates utility & equipment.
6) Dashed Red indicates electrical.

ITEM	REFERENCE FILES	REV	DATE	REVISION DESCRIPTION	BY	Discipline	Initials
Excel File	SFD Stream Table-Dwg (JT Plant) 2-Stage	1	JUN 8/2020	GENERAL ISSUE	JMT	Project Manager	D.P.
		2	JUL 01/2020	GENERAL REVISION	JMT	Process-Engineer	
						Checked By	D.P.
						Designed By	P.S.
						Drawn By	J.T.

ENGINEER'S STAMP

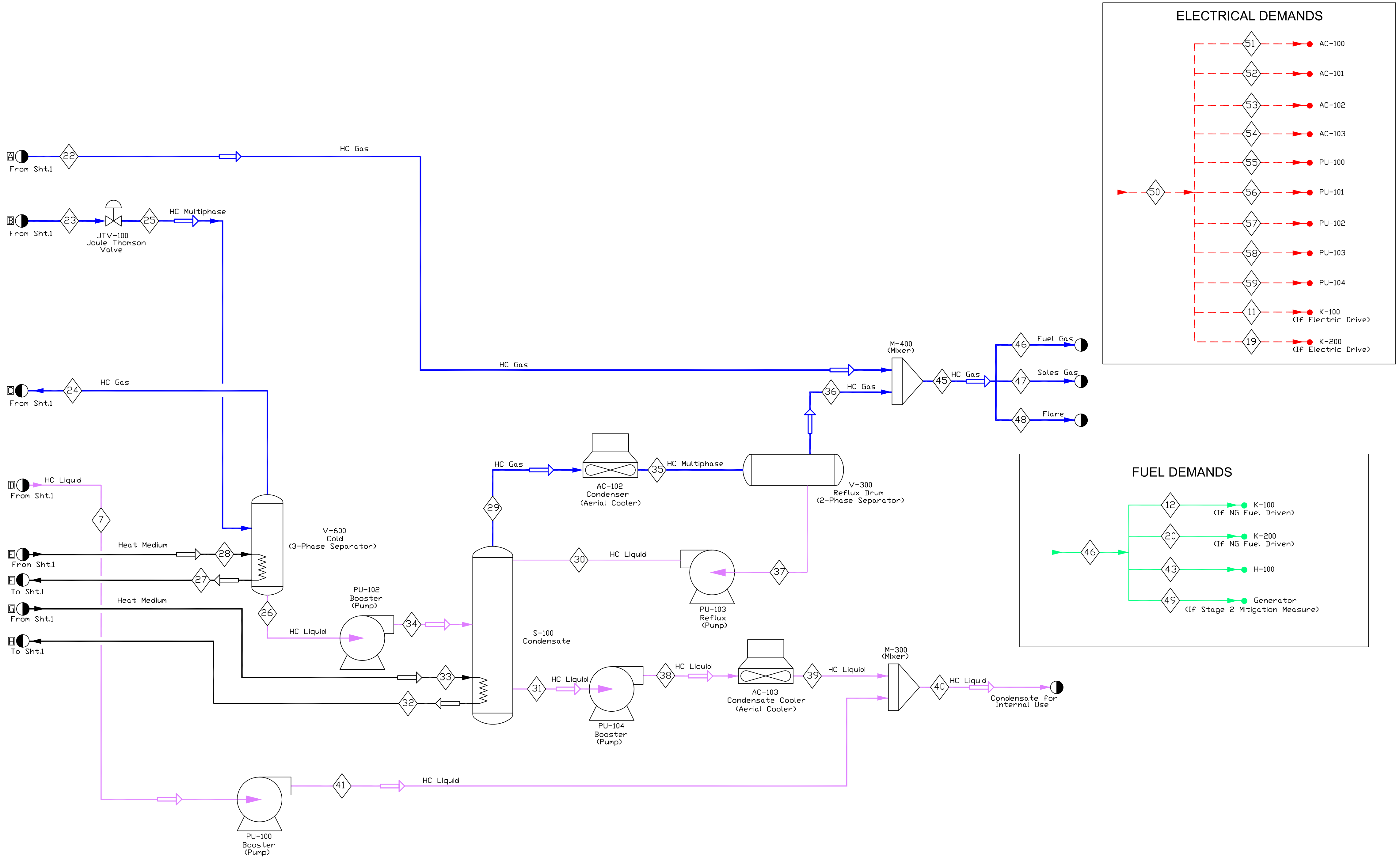
CLEARSTONE ENGINEERING
Calgary Canada

DRAWING TITLE

SIMULATION FLOWSHEET DIAGRAM (SFD):
SITE 3 OIL BATTERY (OPTION 4)
(2 STAGE COMPRESSION)
JT PLANT TECHNOLOGY
(With Electricity Generation)

PROJECT #.	SCALE:	CLIENT:	DRAWING IDENTIFICATION	REV
N/A	NTS	GENERAL	SFD-20-OB-OSP-AGV-049-4A Sht.1 of 2	2

Plot Date: YR MT DY 20-07-21 TIME 16:02 Stream Detail Tables Site3 2St-Comp Option 4



Notes:
1) Blue indicates process-gas/vapour.
2) Purple indicates hydrocarbon liquid.
3) Green indicates natural gas.
4) Light blue indicates water.
5) Black indicates utility & equipment.
6) Dashed Red indicates electrical.

Stream			Unit Operation (Stream Origin)		
ID No.	Fluid Type	Physical State	Tag No.	Service	Type
1	HC	Multiphase	----	Captured Flare Gas	Flare Gas Recovery Line
2	HC	Multiphase	FS-100	Gas to Process	Flow Splitter
3	HC	Multiphase	FS-100	Excess Gas to Flare	Flow Splitter
4	HC	Multiphase	M-100	Flow Mixer	Process Inlet
5	HC	Multiphase	M-200	Flow Mixer	Scrubber Liquids
6	HC	Gas	V-100	Inlet Scrubber	3-Phase Separator
7	HC	Liquid	V-100	Inlet Scrubber	3-Phase Separator
8	Heat Medium	Liquid	V-100	Inlet Scrubber	3-Phase Separator
9	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
10	HC	Gas	K-100	Inlet Gas Boosting	Compressor: Screw
11	Electricity	---	---	Electricity to K-100	Electric Utility System
12	Fuel Gas	Gas	---	Fuel Gas to K-100	Fuel Gas Header
13	HC	Multiphase	AC-100	Interstage Cooler	Aerial Cooler
14	HC	Gas	V-200	Interstage Scrubber	2-Phase Separator
15	HC	Liquid	V-200	Interstage Scrubber	2-Phase Separator
16	Heat Medium	Liquid	V-200	Inlet Scrubber	3-Phase Separator
17	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
18	HC	Gas	K-200	Inlet Gas Boosting	Compressor: Recip.
19	Electricity	---	---	Electricity to K-200	Electric Utility System
20	Fuel Gas	Gas	---	Fuel Gas to K-200	Fuel Gas Header
21	HC	Multiphase	AC-101	Interstage Cooler	Aerial Cooler
22	HC	Gas	E-100	Gas-Gas Exchanger	Heat Exchanger
23	HC	Multiphase	E-100	Gas-Gas Exchanger	Heat Exchanger
24	HC	Gas	V-600	Cold	3-Phase Separator
25	HC	Multiphase	JTV-100	Joule Thomson	Valve
26	HC	Liquid	V-600	Cold	3-Phase Separator
27	Heat Medium	Liquid	V-600	Inlet Scrubber	3-Phase Separator
28	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
29	HC	Gas	S-100	Condensate Stabilizer	Distillation Column
30	HC	Liquid	PU-102	Reflux Pump	Pump - Centrifugal
31	HC	Liquid	S-100	Condensate Stabilizer	Distillation Column
32	Heat Medium	Liquid	S-100	Condensate Stabilizer	Distillation Column
33	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
34	HC	Liquid	PU-102	Booster Pump	Pump - Centrifugal
35	HC	Multiphase	AC-102	Reflux Condenser	Aerial Cooler
36	HC	Gas	V-300	Reflux Drum	2-Phase Separator
37	HC	Liquid	V-300	Reflux Drum	2-Phase Separator
38	HC	Liquid	PU-103	Booster Pump	Pump - Centrifugal
39	HC	Liquid	AC-103	Condensate Cooler	Aerial Cooler
40	HC	Liquid	M-300	Flow Mixer	Produced HC Liquids
41	HC	Liquid	PU-100	Booster Pump	Pump - Centrifugal
42	Heat Medium	Liquid	PU-101	Circulation Pump	Pump - Centrifugal
43	Fuel Gas	Gas	---	Fuel to H-100	Fuel Gas Header
44	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
45	HC	Gas	M-400	Flow Mixer	Produced Residue Gas
46	HC	Gas	---	Produced Gas to Fuel	Produced Gas Header
47	HC	Gas	---	Produced Gas to Sales	Produced Gas Header
48	HC	Gas	---	Produced Gas to Flare	Produced Gas Header
49	HC	Gas	---	Fuel Gas to Generator	Fuel Gas Header
50	Electricity	---	---	Electricity for Site Use	Electric Utility System
51	Electricity	---	---	Electricity to AC-100	Electric Utility System
52	Electricity	---	---	Electricity to AC-101	Electric Utility System
53	Electricity	---	---	Electricity to AC-102	Electric Utility System
54	Electricity	---	---	Electricity to AC-103	Electric Utility System
55	Electricity	---	---	Electricity to PU-100	Electric Utility System
56	Electricity	---	---	Electricity to PU-101	Electric Utility System
57	Electricity	---	---	Electricity to PU-102	Electric Utility System
58	Electricity	---	---	Electricity to PU-103	Electric Utility System
59	Electricity	---	---	Electricity to PU-104	Electric Utility System

ITEM	REFERENCE FILES	REV	DATE	REVISION DESCRIPTION	BY	Discipline	Initials
1	SEE SHEET 1	1	JUN 27/2020	GENERAL ISSUE	JMT	Project Manager	D.P.
		2	JUL 01/2020	GENERAL REVISION	JMT	Process-Engineer	
						Checked By	D.P.
						Designed By	P.S.
						Drawn By	J.T.

ENGINEER'S STAMP

CLEARSTONE ENGINEERING
Calgary Canada

DRAWING TITLE

SIMULATION FLOWSHEET DIAGRAM (SFD):
SITE 3 OIL BATTERY (OPTION 4)
(2 STAGE COMPRESSION)
JT PLANT TECHNOLOGY
(With Electricity Generation)

PROJECT #.	SCALE:	CLIENT:	DRAWING IDENTIFICATION	REV
N/A	NTS	GENERAL	SFD-20-OB-OSP-AGV-049-4B Sht.2 of 2	2.2

REPORT: SOURCE MITIGATION ANALYSIS

Header Block

Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed

Time Series	**CEL Mitigation Code:**	OP-009-JT	**End-Year**	**Asset Life:**	2032
	Start Year:	2022		**Viability:**	2032
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**		Using a Joule-Thomson (JT) Plant and upstream electric-drive compression.
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**		NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL Drawing No:	Unavailable	**Reference CEL Drawing Title:**		Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
	Optimization Objective Function:	Net Present Value Over Pay-Back Period Ratio	**Economic Scenario Name:**		None

Optimization Search Space

Search Parameter	Value Chosen	Min Search Value	Max Search Value
JT Valve Pressure Drop (kPa)	3,945.00	2,845.00	4,445.00
Outlet Pressure (kPa)	100.00	100.00	600.00
Year-1 Peak Flow Rate Design Factor	0.90	0.60	1.20
Electric Generator Drive Type	Reciprocating	---	---
Number of Electric Generator Trains	2.00	1.00	10.00

Key Findings

Economic Impacts	**Capital Cost (USD):**	7,725,836	**Net Present Value (USD) (Before Tax):**	3,897,350
	Project Life (Years):	10	**Net Present Value (USD) (After Tax):**	1,780,431
	Asset Life Expectancy (Years):	10	**Return on Investment (%) (Before Tax):**	50.45%
	Asset Salvage Value (USD):	0	**Return on Investment (%) (After Tax):**	23.05%
	Payback Period (Years):	7.85	**Internal Rate of Return (%):**	14.58%

Pre-Mitigation Commodity Losses	Value of Gas Losses (USD/y) Energy Basis	Value of Gas Losses (USD/y) Commodity Basis	Total Gas Loss (m^3/h)	Residue Gas (10^3 m^3/d)	Ethane (m^3/d liq)	LPG (m^3/d liq)	NGL (m^3/d)	Hydrogen (m^3/d)		
	0	30,154,630	30,104.0	512.8	439.8	311.8	32.0	0.0		

Lifetime GHG Emission Reductions	CH_4 (kilotonnes)	CO_2 (kilotonnes)	N_2O (kilotonnes)	CO_2E (kilotonnes)	Black Carbon (kilotonnes)
	0.0	198.5	0.0	199.1	0.2

Lifetime CAC Emission Reductions	VOC (tonnes)	CO (tonnes)	NO_x (tonnes)	H_2S (tonnes)	SO_2 (tonnes)	PM (tonnes)	PM_{10} (tonnes)	$PM_{2.5}$ (tonnes)		
	1,299.9	428.5	93.5	0.0	0.0	71.5	71.5	71.5		

Key Equipment Additions

Key Equipment or	Reference No.	Category	Subcategory 1	Subcategory 2 or Manufacturer Make And Model
	DPH_1	Process Heater	Dow-therm	
	C_Recip_1_1	Compressor (Driver Excluded)	Reciprocating	
	EM_Recip_1_1	Driver	Electric Motor	Explosion Proof
	AC1_1	Heat Exchanger	Air Cooler	
	AC2_1	Heat Exchanger	Air Cooler	
	TPS1_1	Pressure Vessel	Separator	Vertical
	TPS2_1	Pressure Vessel	Separator	Vertical
	DHS1_1	Glycol Dehydrator	TEG	
	STB1_1	NGL Stabilizer		
	ST_AC_1_1	Heat Exchanger	Air Cooler	
	ST_AC_2_1	Heat Exchanger	Air Cooler	
	_FEED_PUMP_1	Pump (Package)	Centrifugal	Horizontal
	_BOT_PUMP_1	Pump (Package)	Centrifugal	Horizontal
	GG_SHT1_1	Heat Exchanger	Shell and Tube	Fixed Tube
	M_CIR_PUMP_1	Pump (Package)	Centrifugal	Horizontal
	PS1	Pipeline	Buried	

	A	B	C	D	E	F	G	H	I	J	K	L
66	Applied Economic Parameters											
67	**Financial Rates**	**Discount Rate (%):**			10.00	**Inflation Rate (%):**					3.00	
68		**Depreciation Rate (%):**			10.00	**Tax Rate (%)**					20.00	
69		**Royalty Rate (%):**			30.00	**Import Duty (%):**					20.00	
70		**GHG Emission Fee (USD/Tonne):**			$1.10	**CAC Emission Fee (USD/Tonne):**					0.00	
71	**Production Decline Model**	**Model Type:**		Initial Linear Increase		**D (decline as a fraction of production):**					0.0000	
72						**b (correlation constant):**					Not Applicable	
73	**Commodity Prices**	**Natural Gas**		**Ethane**	**LPG**	**NGL**	**Crude Oil**	**Hydrogen**	**Electricity**		**Diesel**	**Naptha**
74		**Purchases (USD/GJ)**	**Sales (USD/GJ)**	**(USD/m^3 Liq)**	**(USD/L Liq)**	**(USD/m^3 Liq)**	**(USD/m^3)**	**(USD/m^3)**	**Purchases (USD/kW·h)**	**Sales (USD/kW·h)**	**(USD/L Liq)**	**(USD / m3 Liq)**
75		$ -	$ -	$ 60.26	$ 0.14	$ 389.84	$ 471.70	$ 2.00	$ 0.04	$ -	$ 0.76	
76												
77												
78												

	A	B	C	D	E	F	G	H	I	J	K
79	Financials (Time Series Results)										
80	**Year**	**Gross Revenues**	**Costs**		**Asset Book Value**	**Salvage Value**	**Royalty Payment**	**Emission Fee**	**Net Revenues**		**Cumulative After Tax Earnings**
81			**Capital**	**Operating**					**Before Tax**	**After Tax**	
82		(Inflation Adjusted USD)							(Present Value USD)		
83	2022	3,647,225	7,725,836	167,334	6,953,252	2,412,171	1,286,932	-22,383	1,311,599	1,049,279	1,049,279
84	2023	3,756,642		172,354	6,257,927	2,144,152	1,325,540	-22,383	1,310,583	1,048,467	2,097,745
85	2024	3,869,341		177,525	5,632,134	1,876,133	1,365,307	-22,383	1,294,591	1,035,673	3,133,418
86	2025	3,985,422		182,851	5,068,921	1,608,114	1,406,266	-22,383	1,267,315	1,013,852	4,147,270
87	2026	4,104,984		188,336	4,562,029	1,340,095	1,448,454	-22,383	1,231,713	985,370	5,132,640
88	2027	4,228,134		193,986	4,105,826	1,072,076	1,491,907	-22,383	1,190,149	952,119	6,084,759
89	2028	4,354,978		199,806	3,695,243	804,057	1,536,665	-22,383	1,144,501	915,601	7,000,359
90	2029	4,407,301		205,800	3,325,719	536,038	1,555,168	-21,993	1,072,408	857,927	7,858,286
91	2030	4,326,523		211,974	2,993,147	268,019	1,526,786	-20,963	965,312	772,249	8,630,535
92	2031	4,117,225		218,333	2,693,832	0	1,453,129	-19,370	835,017	668,013	9,298,549
93	Last Profitable Year (After Asset Liquidation, Final Tax Adjustments and Closing Book Entries)										
94	2031	4,117,225	999	218,333	2,693,832	0	1,453,129	-19,370	835,017	875,731	9,506,266
95											

	A	B	C	D	E	F	G	H	I	J	K
96	Avoided GHG and BC Emissions (Time Series Results)										
97	**Year**	**CH_4 (kt)**	**CO_2 (kt)**	**N_2O (kt)**	**CO_2E (kt)**	**Black Carbon (t)**					
98	2022	0.0	20.3	0.0	20.3	18.4					
99	2023	0.0	20.3	0.0	20.3	18.4					
100	2024	0.0	20.3	0.0	20.3	18.4					
101	2025	0.0	20.3	0.0	20.3	18.4					
102	2026	0.0	20.3	0.0	20.3	18.4					
103	2027	0.0	20.3	0.0	20.3	18.4					
104	2028	0.0	20.3	0.0	20.3	18.4					
105	2029	0.0	19.9	0.0	20.0	18.1					
106	2030	0.0	19.0	0.0	19.1	17.3					
107	2031	0.0	17.6	0.0	17.6	16.0					
108											

	A	B	C	D	E	F	G	H	I	J	K
109	Other Avoided Atmospheric Emissions (Time Series Results)										
110	**Year**	**VOC (t)**	**CO (t)**	**NO_x (t)**	**H_2S (t)**	**SO_2 (t)**	**PM (t)**	**PM_{10} (t)**	**$PM_{2.5}$ (t)**		
111	2022	0.1	0.0	0.0	0.0	0.0	7.3	7.3	7.3		
112	2023	0.1	0.0	0.0	0.0	0.0	7.3	7.3	7.3		
113	2024	0.1	0.0	0.0	0.0	0.0	7.3	7.3	7.3		
114	2025	0.1	0.0	0.0	0.0	0.0	7.3	7.3	7.3		
115	2026	0.1	0.0	0.0	0.0	0.0	7.3	7.3	7.3		
116	2027	0.1	0.0	0.0	0.0	0.0	7.3	7.3	7.3		
117	2028	0.1	0.0	0.0	0.0	0.0	7.3	7.3	7.3		
118	2029	0.1	0.0	0.0	0.0	0.0	7.2	7.2	7.2		
119	2030	0.1	0.0	0.0	0.0	0.0	6.8	6.8	6.8		
120	2031	0.1	0.0	0.0	0.0	0.0	6.3	6.3	6.3		
121											

	A	B	C	D	E	F	G	H	I	J	K
122	Forecast Site Activity Data (Time Series Results - Part 1)										
123	**Year**	**Production**			**Waste Gas Disposition**			**Incremental Energy Purchases**			
124		**Oil (10^3 m^3)**	**Gas (10^6 m^3)**	**Water (10^3 m^3)**	**Collected (10^6 m^3)**	**Conserved (10^6 m^3)**	**Flared (10^6 m^3)**	**Natural Gas (10^6 m^3)**	**Naphtha (10^3 m^3)**	**Diesel (m^3)**	**Electricity (10^3 kW·h)**
125	2022	960.72	263.71		263.71	2.11	261.60	0.00	0.00	0.00	16,476
126	2023	960.72	263.71		263.71	2.11	261.60	0.00	0.00	0.00	16,476
127	2024	960.72	263.71		263.71	2.11	261.60	0.00	0.00	0.00	16,476
128	2025	960.72	263.71		263.71	2.11	261.60	0.00	0.00	0.00	16,476
129	2026	960.72	263.71		263.71	2.11	261.60	0.00	0.00	0.00	16,476
130	2027	960.72	263.71		263.71	2.11	261.60	0.00	0.00	0.00	16,476
131	2028	960.72	263.71		263.71	2.11	261.60	0.00	0.00	0.00	16,476
132	2029	883.87	242.62		242.61	2.08	240.54	0.00	0.00	0.00	16,191
133	2030	813.16	223.21		223.20	1.98	221.23	0.00	0.00	0.00	15,439
134	2031	748.10	205.35		205.35	1.83	203.52	0.00	0.00	0.00	14,278

	A	B	C	D	E	F	G	H	I	J	K	L
135												

136	Forecast Site Activity Data (Time Series Results - Part 2)										
137	Year	Incremental Product Sales					Incremental Utilization	Avoided Purchases			
138		Gas (10^6 m^3 Gas)	LPG (10^3 m^3 Liq)	NGL (10^3 m^3 Liq)	Oil (10^3 m^3)	Electricity (10^3 kW·h)	Fuel Gas (10^6 m^3 Gas)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)
139	2022	0.00	0.00	0.00	9.09	0	0.24	0.00	0.00	0	0.00
140	2023	0.00	0.00	0.00	9.09	0	0.24	0.00	0.00	0	0.00
141	2024	0.00	0.00	0.00	9.09	0	0.24	0.00	0.00	0	0.00
142	2025	0.00	0.00	0.00	9.09	0	0.24	0.00	0.00	0	0.00
143	2026	0.00	0.00	0.00	9.09	0	0.24	0.00	0.00	0	0.00
144	2027	0.00	0.00	0.00	9.09	0	0.24	0.00	0.00	0	0.00
145	2028	0.00	0.00	0.00	9.09	0	0.24	0.00	0.00	0	0.00
146	2029	0.00	0.00	0.00	8.94	0	0.24	0.00	0.00	0	0.00
147	2030	0.00	0.00	0.00	8.52	0	0.23	0.00	0.00	0	0.00
148	2031	0.00	0.00	0.00	7.87	0	0.21	0.00	0.00	0	0.00
149											

150	Applied Emission Factors (EF) For Year One Emissions For Baseline (BL) and Simulated Equipment							
151	Source			Pollutant	EF (ng/J of Fuel)	Reference (Where Applicable) and Basis		
152	Category	Tag No.	DB EF Key			Basis	Author or Reporting Agency	Code
153	**Flares**	**BL FLARE_1**	**335**	**CH_4**	180.0	Calculated	US EPA	2018-U.S.EPAAP-42Table13.5-1
154				**CO_2**	54,529.6	Calculated	NA	
155				**N_2O**	0.1	Referenced	WCI	2012-BCWCI.363(k)
156				**BC**	19.7	Calculated	NA	
157				**VOC**	22.3	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
158				**CO**	133.0	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
159				**NO_x**	29.2	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-1
160				**SO_2**	0.0	Calculated	NA	
161				**PM**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
162				**PM_{10}**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
163				**$PM_{2.5}$**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
164	**Heaters and Boilers**	**DPH_1**	**7**	**CH_4**	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
165				**CO_2**	54,279.2	Calculated	NA	
166				**N_2O**	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
167				**BC**	0.6	Calculated	NA	
168				**VOC**	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
169				**CO**	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
170				**NO_x**	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
171				**SO_2**	0.0	Calculated	NA	
172				**PM**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
173				**PM_{10}**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
174				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
175	**Flares**	**FLARE_1**	**335**	**CH_4**	185.2	Calculated	US EPA	2018-U.S.EPAAP-42Table13.5-1
176				**CO_2**	54,279.2	Calculated	NA	
177				**N_2O**	0.1	Referenced	WCI	2012-BCWCI.363(k)
178				**BC**	18.6	Calculated	NA	
179				**VOC**	22.3	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
180				**CO**	133.0	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
181				**NO_x**	29.2	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-1
182				**SO_2**	0.0	Calculated	NA	
183				**PM**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
184				**PM_{10}**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
185				**$PM_{2.5}$**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
186								

187	Capital Cost									
188	Equipment	Item	Category	Subcategory 1	Subcategory 2	Capacity or Rated Power Output		Price (USD)	FOB Point	Basis
189						Value	Units of Measure			
190		DPH_1	Process Heater	Dow-therm		289.59	kW	96,533	NA	Predicted (Class 5)
191		C_Recip_1_1	Compressor (Driver Excluded)	Reciprocating		1,417.13	kW	705,504	NA	Predicted (Class 4)
192		EM_Recip_1_1	Driver	Electric Motor	Explosion Proof	1,691.92	kW	288,015	NA	Predicted (Class 4)
193		AC1_1	Heat Exchanger	Air Cooler		10.00	m²	52,280	NA	Predicted (Class 4)
194		AC2_1	Heat Exchanger	Air Cooler		10.00	m²	55,240	NA	Predicted (Class 4)
195		TPS1_1	Pressure Vessel	Separator	Vertical	1.74	m³	34,768	NA	Predicted (Class 4)
196		TPS2_1	Pressure Vessel	Separator	Vertical	1.07	m³	45,619	NA	Predicted (Class 4)

	A	B	C	D	E	F	G	H	I	J	K	L
197		DHS1_1	Glycol Dehydrator	TEG		27,093.60	m^3/h	419,611	NA	Predicted (Class 5)		
198		STB1_1	NGL Stabilizer			2.71	m^3/h	763,962	NA	Predicted (Class 5)		
199		ST_AC_1_1	Heat Exchanger	Air Cooler		10.00	m^2	49,177	NA	Predicted (Class 4)		
200		ST_AC_2_1	Heat Exchanger	Air Cooler		10.00	m^2	49,177	NA	Predicted (Class 4)		
201		ST_FEED_PUMP_1_1	Pump (Package)	Centrifugal	Horizontal	1.49	kW	1,635	NA	Predicted (Class 4)		
202		ST_BOT_PUMP_1_1	Pump (Package)	Centrifugal	Horizontal	1.49	kW	1,635	NA	Predicted (Class 4)		
203		GG_SHT1_1	Heat Exchanger	Shell and Tube	Fixed Tube	160.74	m^2	91,874	NA	Predicted (Class 4)		
204		HM_CIR_PUMP_1_1	Pump (Package)	Centrifugal	Horizontal	3.37	kW	2,977	NA	Predicted (Class 4)		
205		PS1	Pipeline	Buried		0.10	km	22,184	NA	Predicted (Class 5)		
206		**E7**	**Engineering & Drafting**					415,921				
207		**Subtotal:**						3,096,111				
208	**Pipeline**	**Pipe Specifications**	**OD (mm)**			**Material:**			**Design P (kPa)**			
209			**WT (mm)**			**Length (km):**			**Coating:**			
210		**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
211		**PL1**	**Pipe**									
212		**PL2**	**Right-of-Way (ROW)**									
213		**PL3**	**ROW Land Survey**									
214		**PL4**	**Clearing**									
215		**PL5**	**Soil Stripping**									
216		**PL6**	**Timber Salvage**									
217		**PL7**	**Rock excavation**									
218		**PL8**	**Cathodic Protection**									
219		**PL9**	**Construction**									
220		**PL10**	**Engineering & Drafting**									
221		**PL11**	**Supervision**									
222		**PL12**	**Safety**									
223		**PL13**	**Reseeding ROW**									
224		**Subtotal:**										
225	**Materials & Services**	**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
226		**MS1**	**Equipment Setting**		0	508,570		508,570		Predicted		
227		**MS2**	**Foundations**		122,933	163,501		286,434		Predicted		
228		**MS3**	**Structural Steel**		121,529	60,765		182,294		Predicted		
229		**MS4**	**Buildings**		72,918	72,918		145,835		Predicted		
230		**MS5**	**Insulation**		24,940	37,410		62,349		Predicted		
231		**MS6**	**Instruments**		147,239	60,448		207,687		Predicted		
232		**MS7**	**Electrical**		193,949	144,131		338,080		Predicted		
233		**MS8**	**Piping**		1,086,743	543,372		1,630,115		Predicted		
234		**MS9**	**Painting**		12,153	36,459		48,612		Predicted		
235		**MS10**	**Miscellaneous**		74,321	59,457		133,779		Predicted		
236		**MS11**	**Engineering & Drafting**		0	549,932		549,932		Predicted		
237		**MS12**	**Supervision**		Unavailable	0		0				
238		**MS13**	**Safety**		Unavailable	0		0				
239		**Subtotal:**						4,093,686				
240	**Summary**	**Total:**						7,189,798				
241		**Duties:**						536,038				
242		**Freight:**						Unavailable				
243		**Grand Total:**						7,725,836				
244	**Year 1 Operating Costs**											
245		**Operating Labour**	**Hours Per Shift:**		Unknown	**Operator Hourly Labour Rate:**		$ 2.05				
246			**Shifts Per Day:**		Unknown	**Maintenance Hourly Labour Rate:**		$ 2.05				
247		**Item**	**Category**		**Material (USD**	**Labour (Hours)**	**Labour (USD)**	**Line Total (USD)**		**Basis**		
248	**Fixed O&M Costs**	**L1**	**Operating Labour**		0	4,680	9,594	9,594		Predicted		
249		**L2**	**Maintenance Labour**		0	2,160	4,428	4,428		Predicted		
250		**L3**	**Direct Supervision**		0		1,727	1,727		Predicted		
251		**L4**	**Administration**		0		71,231	71,231		Predicted		
252		**L5**	**Unclassified Costs**					0		Predicted		
253		**Total Fixed O&M Costs:**						86,980		Predicted		
254	**Variable O&M Costs**	**SS1**	**Third-Party Services**					29,061		Predicted		
255		**SS2**	**Parts & Consumables**					43,530		Predicted		
256		**SS3**	**Unclassified Costs**					0		Predicted		
257		**Total Variable O&M Costs:**						72,591		Predicted		
258	**Total O&M Costs**	**Total Fixed and Variable O&M Costs:**						159,571		Predicted		

	A	B	C	D	E	F	G	H	I	J	K	L
259	**Purchased**	**PC1**	**Electricity**		642,549	0	0	642,549		Predicted		
260	**Commodities**	**PC2**	**Natural Gas**		0	0	0	0		Predicted		
261		**PC3**	**LPG**		0	0	0	0		Predicted		
262		**PC4**	**Diesel**		0	0	0	0		Predicted		
263	**Summary**	**Total:**						802,120				

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JT	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Proposed Equipment

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JT	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	1	2	3	4	5	6	7	8
- Fluid	HC	HC	HC	HC	HC	HC	HC	Heat Medium
- Physical State	Vapour	Vapour	Vapour	Vapour	Liquid	Vapour	Liquid	Liquid
- Temperature (°C)	40.00	40.00	40.00	40.00	---	40.00	---	120.00
- Pressure (kPa)	800.0	800.0	800.0	800.0	---	800.0	---	276.0
- Total Molar Flowrate (kmole/h)	1,273.17	1,145.61	127.56	1,145.61	---	1,145.61	0.00	0.00
- Total Mass Flowrate (kg/h)	30176.9	27153.5	3023.5	27153.5	---	27153.5	0.0	0.0
- Total Gas Volumetric Flowrate (Std m^3/h)	30104.0	27087.8	3016.2	27087.8	---	27087.8	---	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	0.0

- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	From Flare Line	FS-100	FS-100	M-100	M-200	V-100	V-100	V-100
- Service:	---	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Inlet Scrubber	Inlet Scrubber	Inlet Scrubber
- Type:	---	Flow Splitter	Flow Splitter	Mixer	Mixer	3-Phase Separator	3-Phase Separator	3-Phase Separator
Destination (Unit Operation):								
- Tag No.	FS-100	M-100	To Flare Line	V-100	M-100	K-100	PU-100	PU-101
- Service:	Not Applicable	Not Applicable	---	Inlet Scrubber	Not Applicable	Inlet Gas Boosting	Booster	Circulation
- Type:	Flow Splitter	Mixer	---	3-Phase Separator	Mixer	Compressor: Recip.	Pump	Pump
Properties:	1	2	3	4	5	6	7	8
- Vapour Mole Fraction	1.000000	1.000000	1.000000	1.000000	0.000000	1.000000	0.000000	0.000000
- Liquid Mole Fraction	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	1.000000	1.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	23.702	23.702	23.702	23.702	---	23.702	---	41.686
- Mass Density (kg/m^3)	8.439	8.439	8.439	8.439	---	8.439	---	1,025.000
- Molar Density (kmole/m^3)	0.356	0.356	0.356	0.356	---	0.356	---	---
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	0.9669	0.9669	0.9669	0.9669	---	0.9669	---	---
- Specific Heat Capacity (kJ/kmole·°C)	46.7971	46.7971	46.7971	46.7971	---	46.7971	---	135.4802
- Enthalpy (kJ/kmole)	-85,487	-85,487	-85,487	-85,487	---	-85,487	---	---
- Entropy (kJ/kmole·°C)	-202	-202	-202	-202	---	-202	---	---
- Gross Heating Value (MJ/m^3)	48.3	48.3	48.3	48.3	---	48.3	---	---
- Net Heating Value (MJ/m^3)	43.3	43.3	43.3	43.3	---	43.3	---	---
- Sound Speed (m/s)	359.316	359.316	359.316	359.316	---	359.316	---	---
- Dew Point Temperature (°C)	40.00	40.00	40.00	40.00	---	40.00	---	---
- Dew Point Pressure (°kPa)	896.4	896.4	896.4	896.4	---	896.4	---	---
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	0.033	0.033	0.033	0.033	---	0.033	---	---
- Viscosity (cp)	0.012	0.012	0.012	0.012	---	0.012	---	1.100

Composition (Mole Fraction):			1	2	3	4	5	6	7	8
Name	**Formula**	**CAS No.**								
Nitrogen	N2	7727-37-9	0.043380	0.043380	0.043380	0.043380	---	0.043380	---	---
Water	H2O	7732-18-5	0.000000	0.000000	0.000000	0.000000	---	0.000000	---	0.462700
Carbon Dioxide	CO2	124-38-9	0.025205	0.025205	0.025205	0.025205	---	0.025205	---	---
Methane	CH4	74-82-8	0.641174	0.641174	0.641174	0.641174	---	0.641174	---	---
Ethane	C2H6	74-84-0	0.171376	0.171376	0.171376	0.171376	---	0.171376	---	---
Ethylene Glycol	C2H6O2	107-21-1	---	---	---	---	---	---	---	0.537300
Propane	C3H8	74-98-6	0.084805	0.084805	0.084805	0.084805	---	0.084805	---	---
i-Butane	C4H10	75-28-5	0.007275	0.007275	0.007275	0.007275	---	0.007275	---	---
n-Butane	C4H10	106-97-8	0.017510	0.017510	0.017510	0.017510	---	0.017510	---	---
i-Pentane	C5H12	78-78-4	0.002545	0.002545	0.002545	0.002545	---	0.002545	---	---
n-Pentane	C5H12	109-66-0	0.003010	0.003010	0.003010	0.003010	---	0.003010	---	---
Benzene	C6H6	71-43-2	0.000100	0.000100	0.000100	0.000100	---	0.000100	---	---
Cyclohexane	C6H12	110-82-7	0.000175	0.000175	0.000175	0.000175	---	0.000175	---	---

Hexane	**C6H14**	**110-54-3**	0.000745	0.000745	0.000745	0.000745	---	0.000745	---	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.000170	0.000170	0.000170	---	0.000170	---	---
Heptane	**C7H16**	**142-82-5**	0.001975	0.001975	0.001975	0.001975	---	0.001975	---	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.000190	0.000190	0.000190	---	0.000190	---	---
Toluene	**C7H8**	**108-88-3**	0.000165	0.000165	0.000165	0.000165	---	0.000165	---	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000005	0.000005	0.000005	---	0.000005	---	---
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.000040	0.000040	0.000040	---	0.000040	---	---
Octane	**C8H18**	**111-65-9**	0.000075	0.000075	0.000075	0.000075	---	0.000075	---	---
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000005	0.000005	0.000005	---	0.000005	---	---
Nonane	**C9H20**	**111-84-2**	0.000035	0.000035	0.000035	0.000035	---	0.000035	---	---
Decane	**C10H22**	**124-18-5**	0.000020	0.000020	0.000020	0.000020	---	0.000020	---	---
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000015	0.000015	0.000015	---	0.000015	---	---
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000005	0.000005	0.000005	---	0.000005	---	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JT	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	9	10	11	12	13	14	15	16
- Fluid	Heat Medium	HC	Electricity	Fuel Gas	HC	HC	HC	Heat Medium
- Physical State	Liquid	Vapour	Unknown	Gas	Vapour	Vapour	Liquid	Liquid
- Temperature (°C)	120.00	101.37	---	29.91	39.90	39.90	---	120.00
- Pressure (kPa)	276.0	2,008.9	---	200.0	1,898.9	1,898.9	---	276.0
- Total Molar Flowrate (kmole/h)	0.00	1,145.61	---	0.00	1,145.61	1,145.61	0.00	0.00
- Total Mass Flowrate (kg/h)	0.0	27153.5	---	0.0	27153.5	27153.5	0.0	0.0
- Total Gas Volumetric Flowrate (Sm^3/h)	---	27087.8	---	0.0	27087.8	27087.8	---	---
- Total Liq Volumetric Flowrate (m^3/h)	0.0	---	---	---	---	---	---	0.0

- Energy Flowrate kW	---	---	977.380	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	H-100	K-100	Electric Utility System	Fuel Gas Header	AC-100	V-200	V-200	V-200
- Service:	Boiler	Inlet Gas Boosting	---	---	Interstage Cooler	Interstage Scrubber	Interstage Scrubber	Interstage Scrubber
- Type:	Heater	Compressor: Recip.	---	---	Aerial Cooler	2-Phase Separator	2-Phase Separator	2-Phase Separator
Destination (Unit Operation):								
- Tag No.	V-100	AC-100	K-100	K-100	V-200	K-200	M-200	PU-101
- Service:	Inlet Scrubber	Interstage Cooler	Inlet Gas Boosting	Inlet Gas Boosting	Interstage Scrubber	Inlet Gas Boosting	Not Applicable	Circulation
- Type:	3-Phase Separator	Aerial Cooler	Compressor: Recip.	Compressor: Recip.	2-Phase Separator	Compressor: Recip.	Mixer	Pump
Properties:	9	10	11	12	13	14	15	16
- Vapour Mole Fraction	0.000000	1.000000	---	1.000000	1.000000	1.000000	0.000000	0.000000
- Liquid Mole Fraction	1.000000	0.000000	---	0.000000	0.000000	0.000000	1.000000	1.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	41.686	23.702	---	---	23.702	23.702	---	41.686
- Mass Density (kg/m^3)	1,025.000	16.719	---	---	19.608	19.608	---	1,025.000
- Molar Density (kmole/m^3)	---	0.705	---	---	0.827	0.827	---	---
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	0.9585	---	---	0.9266	0.9266	---	---
- Specific Heat Capacity (kJ/kmole·°C)	135.4802	52.3343	---	---	48.8357	48.8357	---	135.4802
- Enthalpy (kJ/kmole)	---	-82,762	---	---	-85,835	-85,835	---	---
- Entropy (kJ/kmole·°C)	---	-201	---	---	-209	-209	---	---
- Gross Heating Value (MJ/m^3)	---	48.3	---	---	48.3	48.3	---	---
- Net Heating Value (MJ/m^3)	---	43.3	---	---	43.3	43.3	---	---
- Sound Speed (m/s)	---	387.893	---	---	350.830	350.830	---	---
- Dew Point Temperature (°C)	---	101.37	---	---	39.90	39.90	---	---
- Dew Point Pressure (°kPa)	---	2,105.3	---	---	1,995.3	1,995.3	---	---
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	0.044	---	---	0.034	0.034	---	---
- Viscosity (cp)	1.100	0.015	---	---	0.012	0.012	---	1.100

Composition (Mole Fraction):			9	10	11	12	13	14	15	16
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	0.043380	---	0.044719	0.043380	0.043380	---	---
Water	**H2O**	**7732-18-5**	0.462700	0.000000	---	0.000000	0.000000	0.000000	---	0.462700
Carbon Dioxide	**CO2**	**124-38-9**	---	0.025205	---	0.025821	0.025205	0.025205	---	---
Methane	**CH4**	**74-82-8**	---	0.641174	---	0.660322	0.641174	0.641174	---	---
Ethane	**C2H6**	**74-84-0**	---	0.171376	---	0.173592	0.171376	0.171376	---	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	0.537300	---	---	---	---	---	---	0.537300
Propane	**C3H8**	**74-98-6**	---	0.084805	---	0.078546	0.084805	0.084805	---	---
i-Butane	**C4H10**	**75-28-5**	---	0.007275	---	0.005121	0.007275	0.007275	---	---
n-Butane	**C4H10**	**106-97-8**	---	0.017510	---	0.010445	0.017510	0.017510	---	---
i-Pentane	**C5H12**	**78-78-4**	---	0.002545	---	0.000703	0.002545	0.002545	---	---
n-Pentane	**C5H12**	**109-66-0**	---	0.003010	---	0.000673	0.003010	0.003010	---	---
Benzene	**C6H6**	**71-43-2**	---	0.000100	---	0.000001	0.000100	0.000100	---	---
Cyclohexane	**C6H12**	**110-82-7**	---	0.000175	---	0.000006	0.000175	0.000175	---	---
Hexane	**C6H14**	**110-54-3**	---	0.000745	---	0.000026	0.000745	0.000745	---	---

Methylcyclopentane	**C6H12**	**96-37-7**	---	0.000170	---	0.000007	0.000170	0.000170	---	---
Heptane	**C7H16**	**142-82-5**	---	0.001975	---	0.000016	0.001975	0.001975	---	---
Methylcyclohexane	**C7H14**	**108-87-2**	---	0.000190	---	0.000002	0.000190	0.000190	---	---
Toluene	**C7H8**	**108-88-3**	---	0.000165	---	0.000001	0.000165	0.000165	---	---
Ethylbenzene	**C8H10**	**100-41-4**	---	0.000005	---	0.000000	0.000005	0.000005	---	---
m-Xylene	**C8H10**	**108-38-3**	---	0.000040	---	0.000000	0.000040	0.000040	---	---
Octane	**C8H18**	**111-65-9**	---	0.000075	---	0.000000	0.000075	0.000075	---	---
o-Xylene	**C8H10**	**95-47-6**	---	0.000005	---	0.000000	0.000005	0.000005	---	---
Nonane	**C9H20**	**111-84-2**	---	0.000035	---	0.000000	0.000035	0.000035	---	---
Decane	**C10H22**	**124-18-5**	---	0.000020	---	0.000000	0.000020	0.000020	---	---
Undecanes	**C11H24**	**1120-21-4**	---	0.000015	---	0.000000	0.000015	0.000015	---	---
Dodecane	**C12H26**	**112-40-3**	---	0.000005	---	0.000000	0.000005	0.000005	---	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JT	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	17	18	19	20	21	22	23	24
- Fluid	Heat Medium	HC	Electricity	Fuel Gas	HC	HC	HC	HC
- Physical State	Liquid	Vapour	Unknown	Gas	Vapour	Vapour	Multiphase	Vapour
- Temperature (°C)	120.00	101.15	---	29.91	39.90	29.91	0.10	-43.24
- Pressure (kPa)	276.0	4,455.0	---	200.0	4,345.0	200.0	4,245.0	300.0
- Total Molar Flowrate (kmole/h)	0.00	1,145.61	---	0.00	1,145.61	1,111.00	1,145.61	1,111.00
- Total Mass Flowrate (kg/h)	0.0	27153.5	---	0.0	27153.5	25192.2	27153.5	25192.2
- Total Gas Volumetric Flowrate (Sm^3/h)	---	27087.8	---	0.0	27087.8	26269.5	---	26269.5
- Total Liq Volumetric Flowrate (m^3/h)	0.0	---	---	---	---	---	---	---

- Energy Flowrate kW	---	---	902.135	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	H-100	K-200	Electric Utility System	Fuel Gas Header	AC-101	E-100	E-100	V-600
- Service:	Boiler	Inlet Gas Boosting	---	---	Discharge Cooler	---	---	Cold
- Type:	Heater	Compressor: Recip.	---	---	Aerial Cooler	---	---	3-Phase Separator
Destination (Unit Operation):								
- Tag No.	V-200	AC-101	K-200	K-200	E-100	M-400	JTV-100	E-100
- Service:	Interstage Scrubber	Discharge Cooler	Inlet Gas Boosting	Inlet Gas Boosting	---	Not Applicable	Joule Thomson	---
- Type:	2-Phase Separator	Aerial Cooler	Compressor: Recip.	Compressor: Recip.	---	Mixer	Control Valve	---
Properties:	17	18	19	20	21	22	23	24
- Vapour Mole Fraction	0.000000	1.000000	---	1.000000	1.000000	1.000000	0.921455	1.000000
- Liquid Mole Fraction	1.000000	0.000000	---	0.000000	0.000000	0.000000	0.078545	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	41.686	23.702	---	---	23.702	22.675	23.702	22.675
- Mass Density (kg/m^3)	1,025.000	37.875	---	---	48.171	2.697	61.985	4.864
- Molar Density ($kmole/m^3$)	---	1.598	---	---	2.032	0.119	2.615	0.215
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	0.9152	---	---	0.8396	0.9889	---	0.9666
- Specific Heat Capacity (kJ/kmole·°C)	135.4802	55.3315	---	---	54.8976	43.5216	---	39.9140
- Enthalpy (kJ/kmole)	---	-83,322	---	---	-86,643	-84,597	-89,627	-87,674
- Entropy (kJ/kmole·°C)	---	-208	---	---	-218	-187	-228	-201
- Gross Heating Value (MJ/m^3)	---	48.3	---	---	48.3	46.1	48.3	46.1
- Net Heating Value (MJ/m^3)	---	43.3	---	---	43.3	41.3	43.3	41.3
- Sound Speed (m/s)	---	380.842	---	---	335.926	368.593	273.091	320.643
- Dew Point Temperature (°C)	---	101.15	---	---	39.90	29.91	---	-43.24
- Dew Point Pressure (°kPa)	---	4,551.4	---	---	4,441.4	296.4	---	396.4
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	0.045	---	---	0.036	0.032	0.033	0.022
- Viscosity (cp)	1.100	0.015	---	---	0.013	0.012	0.014	0.009

Composition (Mole Fraction):			17	18	19	20	21	22	23	24
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	0.043380	---	0.044719	0.043380	0.044719	0.043380	0.044719
Water	**H2O**	**7732-18-5**	0.462700	0.000000	---	0.000000	0.000000	0.000000	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	0.025205	---	0.025821	0.025205	0.025821	0.025205	0.025821
Methane	**CH4**	**74-82-8**	---	0.641174	---	0.660322	0.641174	0.660322	0.641174	0.660322
Ethane	**C2H6**	**74-84-0**	---	0.171376	---	0.173592	0.171376	0.173592	0.171376	0.173592
Ethylene Glycol	**C2H6O2**	**107-21-1**	0.537300	---	---	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	0.084805	---	0.078546	0.084805	0.078546	0.084805	0.078546
i-Butane	**C4H10**	**75-28-5**	---	0.007275	---	0.005121	0.007275	0.005121	0.007275	0.005121
n-Butane	**C4H10**	**106-97-8**	---	0.017510	---	0.010445	0.017510	0.010445	0.017510	0.010445
i-Pentane	**C5H12**	**78-78-4**	---	0.002545	---	0.000703	0.002545	0.000703	0.002545	0.000703
n-Pentane	**C5H12**	**109-66-0**	---	0.003010	---	0.000673	0.003010	0.000673	0.003010	0.000673
Benzene	**C6H6**	**71-43-2**	---	0.000100	---	0.000001	0.000100	0.000001	0.000100	0.000001
Cyclohexane	**C6H12**	**110-82-7**	---	0.000175	---	0.000006	0.000175	0.000006	0.000175	0.000006
Hexane	**C6H14**	**110-54-3**	---	0.000745	---	0.000026	0.000745	0.000026	0.000745	0.000026

Methylcyclopentane	**C6H12**	**96-37-7**	---	0.000170	---	0.000007	0.000170	0.000007	0.000170	0.000007
Heptane	**C7H16**	**142-82-5**	---	0.001975	---	0.000016	0.001975	0.000016	0.001975	0.000016
Methylcyclohexane	**C7H14**	**108-87-2**	---	0.000190	---	0.000002	0.000190	0.000002	0.000190	0.000002
Toluene	**C7H8**	**108-88-3**	---	0.000165	---	0.000001	0.000165	0.000001	0.000165	0.000001
Ethylbenzene	**C8H10**	**100-41-4**	---	0.000005	---	0.000000	0.000005	0.000000	0.000005	0.000000
m-Xylene	**C8H10**	**108-38-3**	---	0.000040	---	0.000000	0.000040	0.000000	0.000040	0.000000
Octane	**C8H18**	**111-65-9**	---	0.000075	---	0.000000	0.000075	0.000000	0.000075	0.000000
o-Xylene	**C8H10**	**95-47-6**	---	0.000005	---	0.000000	0.000005	0.000000	0.000005	0.000000
Nonane	**C9H20**	**111-84-2**	---	0.000035	---	0.000000	0.000035	0.000000	0.000035	0.000000
Decane	**C10H22**	**124-18-5**	---	0.000020	---	0.000000	0.000020	0.000000	0.000020	0.000000
Undecanes	**C11H24**	**1120-21-4**	---	0.000015	---	0.000000	0.000015	0.000000	0.000015	0.000000
Dodecane	**C12H26**	**112-40-3**	---	0.000005	---	0.000000	0.000005	0.000000	0.000005	0.000000

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JT	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	25	26	27	28	29	30	31	32
- Fluid	HC	HC	Heat Medium	Heat Medium	HC	HC	HC	Heat Medium
- Physical State	Multiphase	Liquid	Liquid	Liquid	Vapour	Liquid	Liquid	Liquid
- Temperature (°C)	-43.24	-43.24	120.00	120.00	105.00	---	105.00	115.00
- Pressure (kPa)	300.0	300.0	276.0	276.0	357.5	---	357.5	276.0
- Total Molar Flowrate (kmole/h)	1,145.61	34.61	0.00	0.00	25.58	---	9.03	1,538.68
- Total Mass Flowrate (kg/h)	27153.5	1961.2	0.0	0.0	1209.0	---	752.3	64141.7
- Total Gas Volumetric Flowrate	---	---	---	---	604.8	---	---	---
- Total Liq Volumetric Flowrate (m^3/h)	---	2.9	0.0	0.0	---	---	1.3	62.6

- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	JTV-100	V-600	V-600	H-100	S-100	PU-103	S-100	S-100
- Service:	Joule Thomson	Cold	Cold	Boiler	Condensate	Reflux	Condensate	Condensate
- Type:	Control Valve	3-Phase Separator	3-Phase Separator	Heater	Stabilizer: Distillation	Pump	Stabilizer: Distillation	Stabilizer: Distillation
Destination (Unit Operation):								
- Tag No.	V-600	PU-102	PU-101	V-600	AC-102	S-100	PU-104	PU-101
- Service:	Cold	Booster	Circulation	Cold	Overhead Condenser	Condensate	Booster	Circulation
- Type:	3-Phase Separator	Pump: Centrifugal	Pump	3-Phase Separator	Aerial Cooler	Stabilizer: Distillation Column	Pump	Pump
Properties:	25	26	27	28	29	30	31	32
- Vapour Mole Fraction	0.969788	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000	0.000000
- Liquid Mole Fraction	0.030212	1.000000	1.000000	1.000000	0.000000	1.000000	1.000000	1.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	23.702	56.665	41.686	41.686	47.264	---	83.289	41.686
- Mass Density (kg/m^3)	5.240	668.091	1,025.000	1,025.000	7.130	---	585.901	1,025.000
- Molar Density ($kmole/m^3$)	0.221	11.790	---	---	0.151	---	7.035	---
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	0.0176	---	---	0.9569	---	0.0354	---
- Specific Heat Capacity (kJ/kmole·°C)	---	112.3251	135.4802	135.4802	97.4893	---	217.5962	135.4802
- Enthalpy (kJ/kmole)	-89,627	-152,326	---	---	-106,264	---	-167,372	---
- Entropy (kJ/kmole·°C)	-211	-522	---	---	-350	---	-630	---
- Gross Heating Value (MJ/m^3)	48.3	118.7	---	---	100.1	---	171.5	---
- Net Heating Value (MJ/m^3)	43.3	108.6	---	---	91.2	---	157.7	---
- Sound Speed (m/s)	298.263	1,063.331	---	---	260.176	---	555.621	---
- Dew Point Temperature (°C)	---	---	---	---	105.00	---	---	---
- Dew Point Pressure (°kPa)	---	---	---	---	453.8	---	---	---
- Bubble Point Temperature (°C)	---	-43.24	---	---	---	---	105.00	---
- Bubble Point Pressure (kPa)	---	396.4	---	---	---	---	783.8	---
- Reid Vapour Pressure (kPa)	---	1,580.8	---	---	---	---	1,705.3	---
- True Vapour Pressure (kPa)	---	396.4	---	---	---	---	783.8	---
- Thermal Conductivity (W/m·°C)	0.022	0.155	---	---	0.031	---	0.093	---
- Viscosity (cp)	0.010	0.345	1.100	1.100	0.012	---	0.146	1.100

Composition (Mole Fraction):			25	26	27	28	29	30	31	32
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043380	0.000408	---	---	0.000552	---	---	---
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.462700	0.462700	0.000000	---	0.000000	0.462700
Carbon Dioxide	**CO2**	**124-38-9**	0.025205	0.005436	---	---	0.007356	---	---	---
Methane	**CH4**	**74-82-8**	0.641174	0.026515	---	---	0.035877	---	---	---
Ethane	**C2H6**	**74-84-0**	0.171376	0.100237	---	---	0.135631	---	---	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	0.537300	0.537300	---	---	---	0.537300
Propane	**C3H8**	**74-98-6**	0.084805	0.285732	---	---	0.386623	---	---	---
i-Butane	**C4H10**	**75-28-5**	0.007275	0.076415	---	---	0.103396	---	---	---
n-Butane	**C4H10**	**106-97-8**	0.017510	0.244302	---	---	0.330565	---	---	---
i-Pentane	**C5H12**	**78-78-4**	0.002545	0.061668	---	---	---	---	0.236315	---
n-Pentane	**C5H12**	**109-66-0**	0.003010	0.078032	---	---	---	---	0.299026	---
Benzene	**C6H6**	**71-43-2**	0.000100	0.003281	---	---	---	---	0.012573	---
Cyclohexane	**C6H12**	**110-82-7**	0.000175	0.005604	---	---	---	---	0.021475	---

Hexane	**C6H14**	**110-54-3**	0.000745	0.023840	---	---	---	---	0.091358	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.005396	---	---	---	---	0.020677	---
Heptane	**C7H16**	**142-82-5**	0.001975	0.064872	---	---	---	---	0.248595	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.006224	---	---	---	---	0.023849	---
Toluene	**C7H8**	**108-88-3**	0.000165	0.005425	---	---	---	---	0.020788	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000165	---	---	---	---	0.000633	---
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.001323	---	---	---	---	0.005068	---
Octane	**C8H18**	**111-65-9**	0.000075	0.002479	---	---	---	---	0.009498	---
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000165	---	---	---	---	0.000634	---
Nonane	**C9H20**	**111-84-2**	0.000035	0.001158	---	---	---	---	0.004438	---
Decane	**C10H22**	**124-18-5**	0.000020	0.000662	---	---	---	---	0.002537	---
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000496	---	---	---	---	0.001903	---
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000165	---	---	---	---	0.000634	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JT	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	33	34	35	36	37	38	39	40
- Fluid	Heat Medium	HC	HC	HC	HC	HC	HC	HC
- Physical State	Liquid	Liquid	Multiphase	Gas	Liquid	Liquid	Liquid	Liquid
- Temperature (°C)	120.00	-43.24	39.90	39.90	---	105.00	39.90	39.90
- Pressure (kPa)	276.0	357.5	257.5	257.5	---	657.5	557.5	557.5
- Total Molar Flowrate (kmole/h)	1,538.68	34.61	25.58	25.58	---	9.03	9.03	9.03
- Total Mass Flowrate (kg/h)	64141.7	1961.2	1209.0	1209.0	---	752.3	752.3	752.3
- Total Gas Volumetric Flowrate (Sm^3/h)	---	---	---	604.8	---	---	---	---
- Total Liq Volumetric Flowrate (m^3/h)	62.6	2.9	---	---	---	1.3	1.0	1.0

- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	H-100	PU-102	AC-102	V-300	V-300	PU-104	AC-103	M-300
- Service:	Boiler	Booster	Overhead Condenser	Reflux Drum	Reflux Drum	Booster	Bottoms Cooler	Not Applicable
- Type:	Heater	Pump: Centrifugal	Aerial Cooler	2-Phase Separator	2-Phase Separator	Pump	Aerial Cooler	Mixer
Destination (Unit Operation):								
- Tag No.	S-100	S-100	V-300	M-400	PU-103	AC-103	M-300	Condensate Internal Use
- Service:	Condensate	Condensate	Reflux Drum	Not Applicable	Reflux	Bottoms Cooler	Not Applicable	---
- Type:	Stabilizer: Distillation Column	Stabilizer: Distillation Column	2-Phase Separator	Mixer	Pump	Aerial Cooler	Mixer	---
Properties:	33	34	35	36	37	38	39	40
- Vapour Mole Fraction	0.000000	0.000000	---	1.000000	0.000000	0.000000	0.000000	0.000000
- Liquid Mole Fraction	1.000000	1.000000	---	0.000000	1.000000	1.000000	1.000000	1.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	41.686	56.665	---	---	---	83.289	---	---
- Mass Density (kg/m^3)	1,025.000	668.091	---	---	---	585.901	724.600	724.600
- Molar Density (kmole/m^3)	---	11.790	---	---	---	7.035	---	---
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	0.0176	---	---	---	0.0354	---	---
- Specific Heat Capacity (kJ/kmole·°C)	135.4802	112.3251	---	---	---	217.5962	---	---
- Enthalpy (kJ/kmole)	---	-152,326	---	---	---	-167,372	---	---
- Entropy (kJ/kmole·°C)	---	-522	---	---	---	-630	---	---
- Gross Heating Value (MJ/m^3)	---	118.7	---	100.1	---	171.5	---	---
- Net Heating Value (MJ/m^3)	---	108.6	---	91.2	---	157.7	---	---
- Sound Speed (m/s)	---	1,063.331	---	---	---	555.621	---	---
- Dew Point Temperature (°C)	---	---	---	---	---	---	---	---
- Dew Point Pressure (°kPa)	---	---	---	---	---	---	---	---
- Bubble Point Temperature (°C)	---	-43.24	---	---	---	105.00	---	---
- Bubble Point Pressure (kPa)	---	396.4	---	---	---	783.8	---	---
- Reid Vapour Pressure (kPa)	---	1,580.8	---	---	---	1,705.3	---	---
- True Vapour Pressure (kPa)	---	396.4	---	---	---	783.8	---	---
- Thermal Conductivity (W/m·°C)	---	0.155	---	---	---	0.093	---	---
- Viscosity (cp)	1.100	0.345	---	---	---	0.146	0.269	0.269

Composition (Mole Fraction):			33	34	35	36	37	38	39	40
Name	Formula	CAS No.								
Nitrogen	N2	7727-37-9	---	0.000408	0.000552	0.000552	---	---	---	---
Water	H2O	7732-18-5	0.462700	0.000000	0.000000	0.000000	---	0.000000	0.000000	0.000000
Carbon Dioxide	CO2	124-38-9	---	0.005436	0.007356	0.007356	---	---	---	---
Methane	CH4	74-82-8	---	0.026515	0.035877	0.035877	---	---	---	---
Ethane	C2H6	74-84-0	---	0.100237	0.135631	0.135631	---	---	---	---
Ethylene Glycol	C2H6O2	107-21-1	0.537300	---	---	---	---	---	---	---
Propane	C3H8	74-98-6	---	0.285732	0.386623	0.386623	---	---	---	---
i-Butane	C4H10	75-28-5	---	0.076415	0.103396	0.103396	---	---	---	---
n-Butane	C4H10	106-97-8	---	0.244302	0.330565	0.330565	---	---	---	---
i-Pentane	C5H12	78-78-4	---	0.061668	---	---	---	0.236315	0.236315	0.236315
n-Pentane	C5H12	109-66-0	---	0.078032	---	---	---	0.299026	0.299026	0.299026

Benzene	**C6H6**	**71-43-2**	---	0.003281	---	---	---	0.012573	0.012573	0.012573
Cyclohexane	**C6H12**	**110-82-7**	---	0.005604	---	---	---	0.021475	0.021475	0.021475
Hexane	**C6H14**	**110-54-3**	---	0.023840	---	---	---	0.091358	0.091358	0.091358
Methylcyclopentane	**C6H12**	**96-37-7**	---	0.005396	---	---	---	0.020677	0.020677	0.020677
Heptane	**C7H16**	**142-82-5**	---	0.064872	---	---	---	0.248595	0.248595	0.248595
Methylcyclohexane	**C7H14**	**108-87-2**	---	0.006224	---	---	---	0.023849	0.023849	0.023849
Toluene	**C7H8**	**108-88-3**	---	0.005425	---	---	---	0.020788	0.020788	0.020788
Ethylbenzene	**C8H10**	**100-41-4**	---	0.000165	---	---	---	0.000633	0.000633	0.000633
m-Xylene	**C8H10**	**108-38-3**	---	0.001323	---	---	---	0.005068	0.005068	0.005068
Octane	**C8H18**	**111-65-9**	---	0.002479	---	---	---	0.009498	0.009498	0.009498
o-Xylene	**C8H10**	**95-47-6**	---	0.000165	---	---	---	0.000634	0.000634	0.000634
Nonane	**C9H20**	**111-84-2**	---	0.001158	---	---	---	0.004438	0.004438	0.004438
Decane	**C10H22**	**124-18-5**	---	0.000662	---	---	---	0.002537	0.002537	0.002537
Undecanes	**C11H24**	**1120-21-4**	---	0.000496	---	---	---	0.001903	0.001903	0.001903
Dodecane	**C12H26**	**112-40-3**	---	0.000165	---	---	---	0.000634	0.000634	0.000634

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JT	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	41	42	43	44	45	46	47	48
- Fluid	HC	Heat Medium	Fuel Gas	Heat Medium	HC	Fuel Gas	HC	HC
- Physical State	Liquid	Liquid	Vapour	Liquid	Vapour	Gas	Vapour	Vapour
- Temperature (°C)	---	115.00	30.24	120.00	30.24	29.91	30.24	30.24
- Pressure (kPa)	---	276.0	200.0	276.0	200.0	200.0	200.0	200.0
- Total Molar Flowrate (kmole/h)	---	1,538.68	1.16	1,538.68	1,136.58	1.16	0.00	1,135.42
- Total Mass Flowrate (kg/h)	---	64141.7	27.0	64141.7	26401.2	27.0	0.0	26374.2
- Total Gas Volumetric Flowrate (Std m^3/h)	---	---	27.5	---	26874.3	27.5	0.0	26846.7
- Total Liq Volumetric Flowrate (m^3/h)	---	62.6	---	62.6	---	---	---	---

- Energy Flowrate kW			---	---	---	---	---	---	---	---
Origin (Unit Operation):										
- Tag No.			PU-100	PU-101	Fuel Gas Header	H-100	M-400	M-400	M-400	M-400
- Service:			Booster	Circulation	---	Boiler	Not Applicable	Not Applicable	Not Applicable	Not Applicable
- Type:			Pump	Pump	---	Heater	Mixer	Mixer	Mixer	Mixer
Destination (Unit Operation):										
- Tag No.			M-300	H-100	H-100	Heat-Medium Header	FUEL HEADER	Fuel Gas Header	Gas Gathering System	To Flare Line
- Service:			Not Applicable	Boiler	Boiler	---	---	---	---	---
- Type:			Mixer	Heater	Heater	---	---	---	---	---
Properties:			41	42	43	44	45	46	47	48
- Vapour Mole Fraction			0.000000	0.000000	1.000000	0.000000	1.000000	1.000000	1.000000	1.000000
- Liquid Mole Fraction			1.000000	1.000000	0.000000	1.000000	0.000000	0.000000	0.000000	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			---	41.686	23.229	41.686	23.229	---	23.229	23.229
- Mass Density (kg/m^3)			---	1,025.000	2.761	1,025.000	2.761	---	2.761	2.761
- Molar Density ($kmole/m^3$)			---	---	0.119	---	0.119	---	0.119	0.119
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	---	0.9884	---	0.9884	---	0.9884	0.9884
- Specific Heat Capacity (kJ/kmole·°C)			---	135.4802	44.4111	135.4802	44.4111	---	44.4111	44.4111
- Enthalpy (kJ/kmole)			---	---	-85,215	---	-85,215	---	-85,215	-85,215
- Entropy (kJ/kmole·°C)			---	---	-191	---	-191	---	-191	-191
- Gross Heating Value (MJ/m^3)			---	---	47.3	---	47.3	---	47.3	47.3
- Net Heating Value (MJ/m^3)			---	---	42.4	---	42.4	---	42.4	42.4
- Sound Speed (m/s)			---	---	363.350	---	363.350	---	363.350	363.350
- Dew Point Temperature (°C)			---	---	30.24	---	30.24	---	30.24	30.24
- Dew Point Pressure (°kPa)			---	---	296.4	---	296.4	---	296.4	296.4
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	---	0.032	---	0.032	---	0.032	0.032
- Viscosity (cp)			---	1.100	0.012	1.100	0.012	---	0.012	0.012
Composition (Mole Fraction):			41	42	43	44	45	46	47	48
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	0.043725	---	0.043725	0.044719	0.043725	0.043725
Water	**H2O**	**7732-18-5**	---	0.462700	0.000000	0.462700	0.000000	0.000000	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	0.025405	---	0.025405	0.025821	0.025405	0.025405
Methane	**CH4**	**74-82-8**	---	---	0.646269	---	0.646269	0.660322	0.646269	0.646269
Ethane	**C2H6**	**74-84-0**	---	---	0.172738	---	0.172738	0.173592	0.172738	0.172738
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	0.537300	---	0.537300	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	---	0.085479	---	0.085479	0.078546	0.085479	0.085479
i-Butane	**C4H10**	**75-28-5**	---	---	0.007333	---	0.007333	0.005121	0.007333	0.007333
n-Butane	**C4H10**	**106-97-8**	---	---	0.017649	---	0.017649	0.010445	0.017649	0.017649
i-Pentane	**C5H12**	**78-78-4**	---	---	0.000687	---	0.000687	0.000703	0.000687	0.000687
n-Pentane	**C5H12**	**109-66-0**	---	---	0.000658	---	0.000658	0.000673	0.000658	0.000658
Benzene	**C6H6**	**71-43-2**	---	---	0.000001	---	0.000001	0.000001	0.000001	0.000001
Cyclohexane	**C6H12**	**110-82-7**	---	---	0.000006	---	0.000006	0.000006	0.000006	0.000006

Hexane	**C6H14**	**110-54-3**	---	---	0.000025	---	0.000025	0.000026	0.000025	0.000025
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	0.000007	---	0.000007	0.000007	0.000007	0.000007
Heptane	**C7H16**	**142-82-5**	---	---	0.000015	---	0.000015	0.000016	0.000015	0.000015
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	0.000002	---	0.000002	0.000002	0.000002	0.000002
Toluene	**C7H8**	**108-88-3**	---	---	0.000001	---	0.000001	0.000001	0.000001	0.000001
Ethylbenzene	**C8H10**	**100-41-4**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
m-Xylene	**C8H10**	**108-38-3**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
Octane	**C8H18**	**111-65-9**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
o-Xylene	**C8H10**	**95-47-6**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
Nonane	**C9H20**	**111-84-2**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
Decane	**C10H22**	**124-18-5**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
Undecanes	**C11H24**	**1120-21-4**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
Dodecane	**C12H26**	**112-40-3**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JT	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	49	50	51	52	53	54	55	56
- Fluid	HC	Electricity	Electricity	Electricity	Electricity	Electricity	Electricity	Electricity
- Physical State	Vapour	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
- Temperature (°C)	30.24	---	---	---	---	---	---	---
- Pressure (kPa)	200.0	---	---	---	---	---	---	---
- Total Molar Flowrate (kmole/h)	0.00	---	---	---	---	---	---	---
- Total Mass Flowrate (kg/h)	0.0	---	---	---	---	---	---	---
- Total Gas Volumetric Flowrate (Std m^3/h)	0.0	---	---	---	---	---	---	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	---
- Energy Flowrate kW	---	1,883.871	0.220	0.205	0.006	0.005	0.000	3.744

Origin (Unit Operation):										
- Tag No.			M-400	Electric Utility System	Electric Utility System	Electric Utility System	Electric Utility	Electric Utility System	Electric Utility System	Electric Utility System
- Service:			Not Applicable	---	---	---	---	---	---	---
- Type:			Mixer	---	---	---	---	---	---	---
Destination (Unit Operation):										
- Tag No.			Fuel Gas Header		AC-100	AC-101	AC-102	AC-103	PU-100	PU-101
- Service:			---	---	Interstage Cooler	Discharge Cooler	Overhead Condenser	Bottoms Cooler	Booster	Circulation
- Type:			---	---	Aerial Cooler	Aerial Cooler	Aerial Cooler	Aerial Cooler	Pump	Pump
Properties:			49	50	51	52	53	54	55	56
- Vapour Mole Fraction			1.000000	---	---	---	---	---	---	---
- Liquid Mole Fraction			0.000000	---	---	---	---	---	---	---
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			23.229	---	---	---	---	---	---	---
- Mass Density (kg/m^3)			2.761	---	---	---	---	---	---	---
- Molar Density (kmole/m^3)			0.119	---	---	---	---	---	---	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			0.9884	---	---	---	---	---	---	---
- Specific Heat Capacity (kJ/kmole·°C)			44.4111	---	---	---	---	---	---	---
- Enthalpy (kJ/kmole)			-85,215	---	---	---	---	---	---	---
- Entropy (kJ/kmole·°C)			-191	---	---	---	---	---	---	---
- Gross Heating Value (MJ/m^3)			47.3	---	---	---	---	---	---	---
- Net Heating Value (MJ/m^3)			42.4	---	---	---	---	---	---	---
- Sound Speed (m/s)			363.350	---	---	---	---	---	---	---
- Dew Point Temperature (°C)			30.24	---	---	---	---	---	---	---
- Dew Point Pressure (°kPa)			296.4	---	---	---	---	---	---	---
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.032	---	---	---	---	---	---	---
- Viscosity (cp)			0.012	---	---	---	---	---	---	---
Composition (Mole Fraction):			49	50	51	52	53	54	55	56
Name	**Formula**	**CAS No.**								
Nitrogen	N2	7727-37-9	0.043725	---	---	---	---	---	---	---
Water	H2O	7732-18-5	0.000000	---	---	---	---	---	---	---
Carbon Dioxide	CO2	124-38-9	0.025405	---	---	---	---	---	---	---
Methane	CH4	74-82-8	0.646269	---	---	---	---	---	---	---
Ethane	C2H6	74-84-0	0.172738	---	---	---	---	---	---	---
Propane	C3H8	74-98-6	0.085479	---	---	---	---	---	---	---
i-Butane	C4H10	75-28-5	0.007333	---	---	---	---	---	---	---
n-Butane	C4H10	106-97-8	0.017649	---	---	---	---	---	---	---
i-Pentane	C5H12	78-78-4	0.000687	---	---	---	---	---	---	---
n-Pentane	C5H12	109-66-0	0.000658	---	---	---	---	---	---	---
Benzene	C6H6	71-43-2	0.000001	---	---	---	---	---	---	---
Cyclohexane	C6H12	110-82-7	0.000006	---	---	---	---	---	---	---
Hexane	C6H14	110-54-3	0.000025	---	---	---	---	---	---	---
Methylcyclopentane	C6H12	96-37-7	0.000007	---	---	---	---	---	---	---

Heptane	**C7H16**	**142-82-5**	0.000015	---	---	---	---	---	---	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000002	---	---	---	---	---	---	---
Toluene	**C7H8**	**108-88-3**	0.000001	---	---	---	---	---	---	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000000	---	---	---	---	---	---	---
m-Xylene	**C8H10**	**108-38-3**	0.000000	---	---	---	---	---	---	---
Octane	**C8H18**	**111-65-9**	0.000000	---	---	---	---	---	---	---
o-Xylene	**C8H10**	**95-47-6**	0.000000	---	---	---	---	---	---	---
Nonane	**C9H20**	**111-84-2**	0.000000	---	---	---	---	---	---	---
Decane	**C10H22**	**124-18-5**	0.000000	---	---	---	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	0.000000	---	---	---	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	0.000000	---	---	---	---	---	---	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JT	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	57	58	59					
- Fluid	Electricity	Electricity	Electricity					
- Physical State	Unknown	Unknown	Unknown					
- Temperature (°C)	---	---	---					
- Pressure (kPa)	---	---	---					
- Total Molar Flowrate (kmole/h)	---	---	---					
- Total Mass Flowrate (kg/h)	---	---	---					
- Total Gas Volumetric Flowrate	---	---	---					
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---					

- Energy Flowrate kW	0.028	0.000	0.148					
Origin (Unit Operation):								
- Tag No.	Electric Utility System	Electric Utility System	Electric Utility System					
- Service:	---	---	---					
- Type:	---	---	---					
Destination (Unit Operation):								
- Tag No.	PU-102	PU-103	PU-104					
- Service:	Booster	Reflux	Booster					
- Type:	Pump: Centrifugal	Pump	Pump					
Properties:	57	58	59	0	0	0	0	0
- Vapour Mole Fraction	---	---	---					
- Liquid Mole Fraction	---	---	---					
- Solid Mole Fraction	---	---	---					
- Aqueous Mole Fraction	---	---	---					
- Molecular Weight	---	---	---					
- Mass Density (kg/m^3)	---	---	---					
- Molar Density (kmole/m^3)	---	---	---					
- API Gravity (°)	---	---	---					
- Compressibility Factor	---	---	---					
- Specific Heat Capacity (kJ/kmole·°C)	---	---	---					
- Enthalpy (kJ/kmole)	---	---	---					
- Entropy (kJ/kmole·°C)	---	---	---					
- Gross Heating Value (MJ/m^3)	---	---	---					
- Net Heating Value (MJ/m^3)	---	---	---					
- Sound Speed (m/s)	---	---	---					
- Dew Point Temperature (°C)	---	---	---					
- Dew Point Pressure (°kPa)	---	---	---					
- Bubble Point Temperature (°C)	---	---	---					
- Bubble Point Pressure (kPa)	---	---	---					
- Reid Vapour Pressure (kPa)	---	---	---					
- True Vapour Pressure (kPa)	---	---	---					
- Thermal Conductivity (W/m·°C)	---	---	---					
- Viscosity (cp)	---	---	---					
Composition (Mole Fraction):	57	58	59	0	0	0	0	0
Name / **Formula** / **CAS No.**								

REPORT: SOURCE MITIGATION ANALYSIS

Header Block

Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed

Time Series	**CEL Mitigation Code:**	OP-009-JTN	**End-Year**	**Asset Life:**	2032
	Start Year:	2022		**Viability:**	2032
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**		Using a Joule-Thomson (JT) Plant and upstream electric-drive compression.
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**		NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL Drawing No:	Unavailable	**Reference CEL Drawing Title:**		Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
	Optimization Objective Function:	Net Present Value Over Pay-Back Period Ratio	**Economic Scenario Name:**		None

Optimization Search Space

Search Parameter	Value Chosen	Min Search Value	Max Search Value
JT Valve Pressure Drop (kPa)	**3,945.00**	2,845.00	4,445.00
Outlet Pressure (kPa)	**100.00**	100.00	600.00
Year-1 Peak Flow Rate Design Factor	**0.90**	0.60	1.20
Electric Generator Drive Type	**Reciprocating**	---	---
Number of Electric Generator Trains	**2.00**	1.00	10.00

Key Findings

Economic Impacts	**Capital Cost (USD):**	8,489,070	**Net Present Value (USD) (Before Tax):**	7,028,148
	Project Life (Years):	10	**Net Present Value (USD) (After Tax):**	4,152,943
	Asset Life Expectancy (Years):	10	**Return on Investment (%) (Before Tax):**	82.79%
	Asset Salvage Value (USD):	0	**Return on Investment (%) (After Tax):**	48.92%
	Payback Period (Years):	6.24	**Internal Rate of Return (%):**	19.39%

Pre-Mitigation Commodity Losses	**Value of Gas Losses (USD/y) Energy Basis**	**Value of Gas Losses (USD/y) Commodity Basis**	**Total Gas Loss (m^3/h)**	**Residue Gas (10^3 m^3/d)**	**Ethane (m^3/d liq)**	**LPG (m^3/d liq)**	**NGL (m^3/d)**	**Hydrogen (m^3/d)**		
	0	30,154,630	30,104.0	512.8	439.8	311.8	32.0	0.0		

Lifetime GHG Emission Reductions	**CH_4 (kilotonnes)**	**CO_2 (kilotonnes)**	**N_2O (kilotonnes)**	**CO_2E (kilotonnes)**	**Black Carbon (kilotonnes)**
	0.4	198.5	0.0	208.2	0.2

Lifetime CAC Emission Reductions	**VOC (tonnes)**	**CO (tonnes)**	**NO_x (tonnes)**	**H_2S (tonnes)**	**SO_2 (tonnes)**	**PM (tonnes)**	**PM_{10} (tonnes)**	**$PM_{2.5}$ (tonnes)**		
	1,484.7	686.9	150.2	0.0	0.0	114.2	114.2	114.2		

Key Equipment Additions

Key Equipment or	**Reference No.**	**Category**	**Subcategory 1**	**Subcategory 2 or Manufacturer Make And Model**
	DPH_1	Process Heater	Dow-therm	
	C_Recip_1_1	Compressor (Driver Excluded)	Reciprocating	
	RICE_Recip_1_1	Driver	Reciprocating	
	AC1_1	Heat Exchanger	Air Cooler	
	AC2_1	Heat Exchanger	Air Cooler	
	TPS1_1	Pressure Vessel	Separator	Vertical
	TPS2_1	Pressure Vessel	Separator	Vertical
	DHS1_1	Glycol Dehydrator	TEG	
	STB1_1	NGL Stabilizer		
	ST_AC_1_1	Heat Exchanger	Air Cooler	
	ST_AC_2_1	Heat Exchanger	Air Cooler	
	_FEED_PUMP_1	Pump (Package)	Centrifugal	Horizontal
	_BOT_PUMP_1	Pump (Package)	Centrifugal	Horizontal
	GG_SHT1_1	Heat Exchanger	Shell and Tube	Fixed Tube
	M_CIR_PUMP_1	Pump (Package)	Centrifugal	Horizontal
	PS1	Pipeline	Buried	

	A	B	C	D	E	F	G	H	I	J	K	L
66	**Applied Economic Parameters**											
67	**Financial Rates**	**Discount Rate (%):**		10.00		**Inflation Rate (%):**					3.00	
68		**Depreciation Rate (%):**		10.00		**Tax Rate (%)**					20.00	
69		**Royalty Rate (%):**		30.00		**Import Duty (%):**					20.00	
70		**GHG Emission Fee (USD/Tonne):**		$1.10		**CAC Emission Fee (USD/Tonne):**					0.00	
71	**Production Decline Model**	**Model Type:**		Initial Linear Increase		**D (decline as a fraction of production):**					0.0000	
72						**b (correlation constant):**					Not Applicable	
73	**Commodity Prices**	**Natural Gas**		**Ethane**	**LPG**	**NGL**	**Crude Oil**	**Hydrogen**	**Electricity**		**Diesel**	**Naptha**
74		**Purchases (USD/GJ)**	**Sales (USD/GJ)**	**(USD/m^3 Liq)**	**(USD/L Liq)**	**(USD/m^3 Liq)**	**(USD/m^3)**	**(USD/m^3)**	**Purchases (USD/kW·h)**	**Sales (USD/kW·h)**	**(USD/L Liq)**	**(USD / m3 Liq)**
75		$ -	$ -	$ 60.26	$ 0.14	$ 389.84	$ 471.70	$ 2.00	$ 0.04	$ -	$ 0.76	
76												
77												
78												

	A	B	C	D	E	F	G	H	I	J	K
79	**Financials (Time Series Results)**										
80	**Year**	**Gross Revenues**	**Costs**		**Asset Book Value**	**Salvage Value**	**Royalty Payment**	**Emission Fee**	**Net Revenues**		**Cumulative After Tax Earnings**
81			**Capital**	**Operating**					**Before Tax**	**After Tax**	
82		**(Inflation Adjusted USD)**							**(Present Value USD)**		
83	2022	4,289,343	8,489,070	186,337	7,640,163	2,626,317	1,286,932	-23,401	1,809,607	1,447,686	1,447,686
84	2023	4,418,023		191,927	6,876,146	2,334,504	1,325,540	-23,401	1,785,075	1,428,060	2,875,745
85	2024	4,550,564		197,685	6,188,532	2,042,691	1,365,307	-23,401	1,745,574	1,396,459	4,272,205
86	2025	4,687,081		203,615	5,569,679	1,750,878	1,406,266	-23,401	1,695,067	1,356,054	5,628,258
87	2026	4,827,693		209,724	5,012,711	1,459,065	1,448,454	-23,401	1,636,717	1,309,373	6,937,632
88	2027	4,972,524		216,015	4,511,440	1,167,252	1,491,907	-23,401	1,573,037	1,258,430	8,196,061
89	2028	5,121,700		222,496	4,060,296	875,439	1,536,665	-23,401	1,506,015	1,204,812	9,400,873
90	2029	5,183,376		229,171	3,654,266	583,626	1,555,168	-22,993	1,406,987	1,125,589	10,526,462
91	2030	5,088,763		236,046	3,288,840	291,813	1,526,786	-21,916	1,264,837	1,011,870	11,538,332
92	2031	4,843,227		243,127	2,959,956	0	1,453,129	-20,252	1,094,302	875,442	12,413,774
93	**Last Profitable Year (After Asset Liquidation, Final Tax Adjustments and Closing Book Entries)**										
94	2031	4,843,227	999	243,127	2,959,956	0	1,453,129	-20,252	1,094,302	1,103,680	12,642,012
95											

	A	B	C	D	E	F	G	H	I	J	K
96	**Avoided GHG and BC Emissions (Time Series Results)**										
97	**Year**	**CH_4 (kt)**	**CO_2 (kt)**	**N_2O (kt)**	**CO_2E (kt)**	**Black Carbon (t)**					
98	2022	0.0	20.3	0.0	21.3	22.1					
99	2023	0.0	20.3	0.0	21.3	22.1					
100	2024	0.0	20.3	0.0	21.3	22.1					
101	2025	0.0	20.3	0.0	21.3	22.1					
102	2026	0.0	20.3	0.0	21.3	22.1					
103	2027	0.0	20.3	0.0	21.3	22.1					
104	2028	0.0	20.3	0.0	21.3	22.1					
105	2029	0.0	19.9	0.0	20.9	21.8					
106	2030	0.0	19.0	0.0	19.9	20.7					
107	2031	0.0	17.6	0.0	18.4	19.2					
108											

	A	B	C	D	E	F	G	H	I	J	K
109	**Other Avoided Atmospheric Emissions (Time Series Results)**										
110	**Year**	**VOC (t)**	**CO (t)**	**NO_x (t)**	**H_2S (t)**	**SO_2 (t)**	**PM (t)**	**PM_{10} (t)**	**$PM_{2.5}$ (t)**		
111	2022	0.2	0.1	0.0	0.0	0.0	11.7	11.7	11.7		
112	2023	0.2	0.1	0.0	0.0	0.0	11.7	11.7	11.7		
113	2024	0.2	0.1	0.0	0.0	0.0	11.7	11.7	11.7		
114	2025	0.2	0.1	0.0	0.0	0.0	11.7	11.7	11.7		
115	2026	0.2	0.1	0.0	0.0	0.0	11.7	11.7	11.7		
116	2027	0.2	0.1	0.0	0.0	0.0	11.7	11.7	11.7		
117	2028	0.2	0.1	0.0	0.0	0.0	11.7	11.7	11.7		
118	2029	0.1	0.1	0.0	0.0	0.0	11.5	11.5	11.5		
119	2030	0.1	0.1	0.0	0.0	0.0	10.9	10.9	10.9		
120	2031	0.1	0.1	0.0	0.0	0.0	10.1	10.1	10.1		
121											

	A	B	C	D	E	F	G	H	I	J	K
122	**Forecast Site Activity Data (Time Series Results - Part 1)**										
123	**Year**	**Production**			**Waste Gas Disposition**			**Incremental Energy Purchases**			
124		**Oil (10^3 m^3)**	**Gas (10^6 m^3)**	**Water (10^3 m^3)**	**Collected (10^6 m^3)**	**Conserved (10^6 m^3)**	**Flared (10^6 m^3)**	**Natural Gas (10^6 m^3)**	**Naphtha (10^3 m^3)**	**Diesel (m^3)**	**Electricity (10^3 kW·h)**
125	2022	960.72	263.71		263.71	6.31	257.41	0.00	0.00	0.00	11
126	2023	960.72	263.71		263.71	6.31	257.41	0.00	0.00	0.00	11
127	2024	960.72	263.71		263.71	6.31	257.41	0.00	0.00	0.00	11
128	2025	960.72	263.71		263.71	6.31	257.41	0.00	0.00	0.00	11
129	2026	960.72	263.71		263.71	6.31	257.41	0.00	0.00	0.00	11
130	2027	960.72	263.71		263.71	6.31	257.41	0.00	0.00	0.00	11
131	2028	960.72	263.71		263.71	6.31	257.41	0.00	0.00	0.00	11
132	2029	883.87	242.62		242.61	6.20	236.42	0.00	0.00	0.00	11
133	2030	813.16	223.21		223.20	5.91	217.30	0.00	0.00	0.00	11
134	2031	748.10	205.35		205.35	5.46	199.89	0.00	0.00	0.00	11

	A	B	C	D	E	F	G	H	I	J	K
135											
136	**Forecast Site Activity Data (Time Series Results - Part 2)**										
137	**Year**	**Incremental Product Sales**					**Incremental Utilization**	**Avoided Purchases**			
138		**Gas (10^6 m^3 Gas)**	**LPG (10^3 m^3 Liq)**	**NGL (10^3 m^3 Liq)**	**Oil (10^3 m^3)**	**Electricity (10^3 kW·h)**	**Fuel Gas (10^6 m^3 Gas)**	**Natural Gas (10^6 m^3)**	**Naphtha (10^3 m^3)**	**Diesel (m^3)**	**Electricity (10^3 kW·h)**
139	2022	0.00	0.00	0.00	9.09	0	4.43	0.00	0.00	0	0.00
140	2023	0.00	0.00	0.00	9.09	0	4.43	0.00	0.00	0	0.00
141	2024	0.00	0.00	0.00	9.09	0	4.43	0.00	0.00	0	0.00
142	2025	0.00	0.00	0.00	9.09	0	4.43	0.00	0.00	0	0.00
143	2026	0.00	0.00	0.00	9.09	0	4.43	0.00	0.00	0	0.00
144	2027	0.00	0.00	0.00	9.09	0	4.43	0.00	0.00	0	0.00
145	2028	0.00	0.00	0.00	9.09	0	4.43	0.00	0.00	0	0.00
146	2029	0.00	0.00	0.00	8.94	0	4.36	0.00	0.00	0	0.00
147	2030	0.00	0.00	0.00	8.52	0	4.16	0.00	0.00	0	0.00
148	2031	0.00	0.00	0.00	7.87	0	3.84	0.00	0.00	0	0.00
149											

150	**Applied Emission Factors (EF) For Year One Emissions For Baseline (BL) and Simulated Equipment**							
151	**Source**			**Pollutant**	**EF (ng/J of Fuel)**	**Reference (Where Applicable) and Basis**		
152	**Category**	**Tag No.**	**DB EF Key**			**Basis**	**Author or Reporting Agency**	**Code**
153	**Flares**	**BL FLARE_1**	**335**	**CH_4**	180.0	Calculated	US EPA	2018-U.S.EPAAP-42Table13.5-1
154				**CO_2**	54,529.6	Calculated	NA	
155				**N_2O**	0.1	Referenced	WCI	2012-BCWCI.363(k)
156				**BC**	19.7	Calculated	NA	
157				**VOC**	22.3	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
158				**CO**	133.0	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
159				**NO_x**	29.2	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-1
160				**SO_2**	0.0	Calculated	NA	
161				**PM**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
162				**PM_{10}**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
163				**$PM_{2.5}$**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
164	**Heaters and Boilers**	**DPH_1**	**7**	**CH_4**	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
165				**CO_2**	54,279.2	Calculated	NA	
166				**N_2O**	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
167				**BC**	0.6	Calculated	NA	
168				**VOC**	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
169				**CO**	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
170				**NO_x**	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
171				**SO_2**	0.0	Calculated	NA	
172				**PM**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
173				**PM_{10}**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
174				**$PM_{2.5}$**	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
175	**Reciprocating Engines**	**RICE_Recip_1_**	**3**	**CO_2**	54,279.2	Calculated	NA	
176				**SO_2**	0.0	Calculated	NA	
177	**Flares**	**FLARE_1**	**335**	**CH_4**	185.2	Calculated	US EPA	2018-U.S.EPAAP-42Table13.5-1
178				**CO_2**	54,279.2	Calculated	NA	
179				**N_2O**	0.1	Referenced	WCI	2012-BCWCI.363(k)
180				**BC**	18.6	Calculated	NA	
181				**VOC**	22.3	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
182				**CO**	133.0	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
183				**NO_x**	29.2	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-1
184				**SO_2**	0.0	Calculated	NA	
185				**PM**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
186				**PM_{10}**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
187				**$PM_{2.5}$**	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
188								

189	**Capital Cost**									
190	**Equipment**	**Item**	**Category**	**Subcategory 1**	**Subcategory 2**	**Capacity or Rated Power Output**		**Price (USD)**	**FOB Point**	**Basis**
191						**Value**	**Units of Measure**			
192		DPH_1	Process Heater	Dow-therm		289.59	kW	96,533	NA	Predicted (Class 5)
193		C_Recip_1_1	Compressor (Driver Excluded)	Reciprocating		1,417.13	kW	705,504	NA	Predicted (Class 4)
194		RICE_Recip_1_1	Driver	Reciprocating		1,691.92	kW	525,954	NA	Predicted (Class 4)
195		AC1_1	Heat Exchanger	Air Cooler		10.00	m²	52,280	NA	Predicted (Class 4)
196		AC2_1	Heat Exchanger	Air Cooler		10.00	m²	55,240	NA	Predicted (Class 4)
197		TPS1_1	Pressure Vessel	Separator	Vertical	1.74	m³	34,768	NA	Predicted (Class 4)

	A	B	C	D	E	F	G	H	I	J	K	L
198		TPS2_1	Pressure Vessel	Separator	Vertical	1.07	m^3	45,619	NA	Predicted (Class 4)		
199		DHS1_1	Glycol Dehydrator	TEG		27,093.60	m^3/h	419,611	NA	Predicted (Class 5)		
200		STB1_1	NGL Stabilizer			2.71	m^3/h	763,962	NA	Predicted (Class 5)		
201		ST_AC_1_1	Heat Exchanger	Air Cooler		10.00	m^2	49,177	NA	Predicted (Class 4)		
202		ST_AC_2_1	Heat Exchanger	Air Cooler		10.00	m^2	49,177	NA	Predicted (Class 4)		
203		ST_FEED_PUMP_1_1	Pump (Package)	Centrifugal	Horizontal	1.49	kW	1,635	NA	Predicted (Class 4)		
204		ST_BOT_PUMP_1_1	Pump (Package)	Centrifugal	Horizontal	1.49	kW	1,635	NA	Predicted (Class 4)		
205		GG_SHT1_1	Heat Exchanger	Shell and Tube	Fixed Tube	160.74	m^2	91,874	NA	Predicted (Class 4)		
206		HM_CIR_PUMP_1_1	Pump (Package)	Centrifugal	Horizontal	3.37	kW	2,977	NA	Predicted (Class 4)		
207		PS1	Pipeline	Buried		0.10	km	22,184	NA	Predicted (Class 5)		
208		**E7**	**Engineering & Drafting**					452,659				
209		**Subtotal:**						3,370,789				
210	**Pipeline**	**Pipe**	**OD (mm)**			**Material:**			**Design P (kPa)**			
211		**Specifications**	**WT (mm)**			**Length (km):**			**Coating:**			
212		**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
213		**PL1**	**Pipe**									
214		**PL2**	**Right-of-Way (ROW)**									
215		**PL3**	**ROW Land Survey**									
216		**PL4**	**Clearing**									
217		**PL5**	**Soil Stripping**									
218		**PL6**	**Timber Salvage**									
219		**PL7**	**Rock excavation**									
220		**PL8**	**Cathodic Protection**									
221		**PL9**	**Construction**									
222		**PL10**	**Engineering & Drafting**									
223		**PL11**	**Supervision**									
224		**PL12**	**Safety**									
225		**PL13**	**Reseeding ROW**									
226		**Subtotal:**										
227	**Materials &**	**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
228	**Services**	**MS1**	**Equipment Setting**		0	572,249		572,249		Predicted		
229		**MS2**	**Foundations**		135,669	180,440		316,109		Predicted		
230		**MS3**	**Structural Steel**		134,265	67,133		201,398		Predicted		
231		**MS4**	**Buildings**		80,559	80,559		161,118		Predicted		
232		**MS5**	**Insulation**		27,487	41,230		68,717		Predicted		
233		**MS6**	**Instruments**		162,522	66,562		229,084		Predicted		
234		**MS7**	**Electrical**		214,326	159,414		373,740		Predicted		
235		**MS8**	**Piping**		1,201,365	600,683		1,802,048		Predicted		
236		**MS9**	**Painting**		13,427	40,280		53,706		Predicted		
237		**MS10**	**Miscellaneous**		81,963	65,570		147,533		Predicted		
238		**MS11**	**Engineering & Drafting**		0	608,953		608,953		Predicted		
239		**MS12**	**Supervision**		Unavailable	0		0				
240		**MS13**	**Safety**		Unavailable	0		0				
241		**Subtotal:**						4,534,655				
242	**Summary**	**Total:**						7,905,444				
243		**Duties:**						583,626				
244		**Freight:**						Unavailable				
245		**Grand Total:**						8,489,070				
246	**Year 1 Operating Costs**											
247		**Operating**	**Hours Per Shift:**		Unknown	**Operator Hourly Labour Rate:**		$ 2.05				
248		**Labour**	**Shifts Per Day:**		Unknown	**Maintenance Hourly Labour Rate:**		$ 2.05				
249		**Item**	**Category**		**Material (USD**	**Labour (Hours)**	**Labour (USD)**	**Line Total (USD)**		**Basis**		
250	**Fixed**	**L1**	**Operating Labour**		0	5,220	10,701	10,701		Predicted		
251	**O&M Costs**	**L2**	**Maintenance Labour**		0	2,520	5,166	5,166		Predicted		
252		**L3**	**Direct Supervision**		0		1,926	1,926		Predicted		
253		**L4**	**Administration**		0		78,296	78,296		Predicted		
254		**L5**	**Unclassified Costs**					0		Predicted		
255		**Total Fixed O&M Costs:**						96,089		Predicted		
256	**Variable**	**SS1**	**Third-Party Services**					32,153		Predicted		
257	**O&M Costs**	**SS2**	**Parts & Consumables**					50,332		Predicted		
258		**SS3**	**Unclassified Costs**					0		Predicted		
259		**Total Variable O&M Costs:**						82,485		Predicted		

	A	B	C	D	E	F	G	H	I	J	K	L
260	**Total O&M Costs**	**Total Fixed and Variable O&M Costs:**						178,573		Predicted		
261	**Purchased Commodities**	**PC1**	**Electricity**		432	0	0	432		Predicted		
262		**PC2**	**Natural Gas**		0	0	0	0		Predicted		
263		**PC3**	**LPG**		0	0	0	0		Predicted		
264		**PC4**	**Diesel**		0	0	0	0		Predicted		
265	**Summary**	**Total:**						179,005				

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JTN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Proposed Equipment

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JTN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	1	2	3	4	5	6	7	8
- Fluid	HC	HC	HC	HC	HC	HC	HC	Heat Medium
- Physical State	Vapour	Vapour	Vapour	Vapour	Liquid	Vapour	Liquid	Liquid
- Temperature (°C)	40.00	40.00	40.00	40.00	---	40.00	---	120.00
- Pressure (kPa)	800.0	800.0	800.0	800.0	---	800.0	---	276.0
- Total Molar Flowrate (kmole/h)	1,273.17	1,145.61	127.56	1,145.61	---	1,145.61	0.00	0.00
- Total Mass Flowrate (kg/h)	30176.9	27153.5	3023.5	27153.5	---	27153.5	0.0	0.0
- Total Gas Volumetric Flowrate (Std m^3/h)	30104.0	27087.8	3016.2	27087.8	---	27087.8	---	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	0.0

- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	From Flare Line	FS-100	FS-100	M-100	M-200	V-100	V-100	V-100
- Service:	---	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Inlet Scrubber	Inlet Scrubber	Inlet Scrubber
- Type:	---	Flow Splitter	Flow Splitter	Mixer	Mixer	3-Phase Separator	3-Phase Separator	3-Phase Separator
Destination (Unit Operation):								
- Tag No.	FS-100	M-100	To Flare Line	V-100	M-100	K-100	PU-100	PU-101
- Service:	Not Applicable	Not Applicable	---	Inlet Scrubber	Not Applicable	Inlet Gas Boosting	Booster	Circulation
- Type:	Flow Splitter	Mixer	---	3-Phase Separator	Mixer	Compressor: Recip.	Pump	Pump
Properties:	1	2	3	4	5	6	7	8
- Vapour Mole Fraction	1.000000	1.000000	1.000000	1.000000	0.000000	1.000000	0.000000	0.000000
- Liquid Mole Fraction	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	1.000000	1.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	23.702	23.702	23.702	23.702	---	23.702	---	41.686
- Mass Density (kg/m^3)	8.439	8.439	8.439	8.439	---	8.439	---	1,025.000
- Molar Density (kmole/m^3)	0.356	0.356	0.356	0.356	---	0.356	---	---
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	0.9669	0.9669	0.9669	0.9669	---	0.9669	---	---
- Specific Heat Capacity (kJ/kmole·°C)	46.7971	46.7971	46.7971	46.7971	---	46.7971	---	135.4802
- Enthalpy (kJ/kmole)	-85,487	-85,487	-85,487	-85,487	---	-85,487	---	---
- Entropy (kJ/kmole·°C)	-202	-202	-202	-202	---	-202	---	---
- Gross Heating Value (MJ/m^3)	48.3	48.3	48.3	48.3	---	48.3	---	---
- Net Heating Value (MJ/m^3)	43.3	43.3	43.3	43.3	---	43.3	---	---
- Sound Speed (m/s)	359.316	359.316	359.316	359.316	---	359.316	---	---
- Dew Point Temperature (°C)	40.00	40.00	40.00	40.00	---	40.00	---	---
- Dew Point Pressure (°kPa)	896.4	896.4	896.4	896.4	---	896.4	---	---
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	0.033	0.033	0.033	0.033	---	0.033	---	---
- Viscosity (cp)	0.012	0.012	0.012	0.012	---	0.012	---	1.100

Composition (Mole Fraction):			1	2	3	4	5	6	7	8
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043380	0.043380	0.043380	0.043380	---	0.043380	---	---
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.000000	0.000000	---	0.000000	---	0.462700
Carbon Dioxide	**CO2**	**124-38-9**	0.025205	0.025205	0.025205	0.025205	---	0.025205	---	---
Methane	**CH4**	**74-82-8**	0.641174	0.641174	0.641174	0.641174	---	0.641174	---	---
Ethane	**C2H6**	**74-84-0**	0.171376	0.171376	0.171376	0.171376	---	0.171376	---	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	---	---	---	---	---	0.537300
Propane	**C3H8**	**74-98-6**	0.084805	0.084805	0.084805	0.084805	---	0.084805	---	---
i-Butane	**C4H10**	**75-28-5**	0.007275	0.007275	0.007275	0.007275	---	0.007275	---	---
n-Butane	**C4H10**	**106-97-8**	0.017510	0.017510	0.017510	0.017510	---	0.017510	---	---
i-Pentane	**C5H12**	**78-78-4**	0.002545	0.002545	0.002545	0.002545	---	0.002545	---	---
n-Pentane	**C5H12**	**109-66-0**	0.003010	0.003010	0.003010	0.003010	---	0.003010	---	---
Benzene	**C6H6**	**71-43-2**	0.000100	0.000100	0.000100	0.000100	---	0.000100	---	---
Cyclohexane	**C6H12**	**110-82-7**	0.000175	0.000175	0.000175	0.000175	---	0.000175	---	---

Hexane	**C6H14**	**110-54-3**	0.000745	0.000745	0.000745	0.000745	---	0.000745	---	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.000170	0.000170	0.000170	---	0.000170	---	---
Heptane	**C7H16**	**142-82-5**	0.001975	0.001975	0.001975	0.001975	---	0.001975	---	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.000190	0.000190	0.000190	---	0.000190	---	---
Toluene	**C7H8**	**108-88-3**	0.000165	0.000165	0.000165	0.000165	---	0.000165	---	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000005	0.000005	0.000005	---	0.000005	---	---
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.000040	0.000040	0.000040	---	0.000040	---	---
Octane	**C8H18**	**111-65-9**	0.000075	0.000075	0.000075	0.000075	---	0.000075	---	---
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000005	0.000005	0.000005	---	0.000005	---	---
Nonane	**C9H20**	**111-84-2**	0.000035	0.000035	0.000035	0.000035	---	0.000035	---	---
Decane	**C10H22**	**124-18-5**	0.000020	0.000020	0.000020	0.000020	---	0.000020	---	---
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000015	0.000015	0.000015	---	0.000015	---	---
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000005	0.000005	0.000005	---	0.000005	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JTN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	9	10	11	12	13	14	15	16
- Fluid	Heat Medium	HC	Electricity	Fuel Gas	HC	HC	HC	Heat Medium
- Physical State	Liquid	Vapour	Unknown	Gas	Vapour	Vapour	Liquid	Liquid
- Temperature (°C)	120.00	101.37	---	29.91	39.90	39.90	---	120.00
- Pressure (kPa)	276.0	2,008.9	---	200.0	1,898.9	1,898.9	---	276.0
- Total Molar Flowrate (kmole/h)	0.00	1,145.61	---	10.53	1,145.61	1,145.61	0.00	0.00
- Total Mass Flowrate (kg/h)	0.0	27153.5	---	244.5	27153.5	27153.5	0.0	0.0
- Total Gas Volumetric Flowrate (Std m^3/h)	---	27087.8	---	248.9	27087.8	27087.8	---	---
- Total Liq Volumetric Flowrate (m^3/h)	0.0	---	---	---	---	---	---	0.0

- Energy Flowrate kW	---	---	0.000	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	H-100	K-100	Electric Utility System	Fuel Gas Header	AC-100	V-200	V-200	V-200
- Service:	Boiler	Inlet Gas Boosting	---	---	Interstage Cooler	Interstage Scrubber	Interstage Scrubber	Interstage Scrubber
- Type:	Heater	Compressor: Recip.	---	---	Aerial Cooler	2-Phase Separator	2-Phase Separator	2-Phase Separator
Destination (Unit Operation):								
- Tag No.	V-100	AC-100	K-100	K-100	V-200	K-200	M-200	PU-101
- Service:	Inlet Scrubber	Interstage Cooler	Inlet Gas Boosting	Inlet Gas Boosting	Interstage Scrubber	Inlet Gas Boosting	Not Applicable	Circulation
- Type:	3-Phase Separator	Aerial Cooler	Compressor: Recip.	Compressor: Recip.	2-Phase Separator	Compressor: Recip.	Mixer	Pump
Properties:	9	10	11	12	13	14	15	16
- Vapour Mole Fraction	0.000000	1.000000	---	1.000000	1.000000	1.000000	0.000000	0.000000
- Liquid Mole Fraction	1.000000	0.000000	---	0.000000	0.000000	0.000000	1.000000	1.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	41.686	23.702	---	---	23.702	23.702	---	41.686
- Mass Density (kg/m^3)	1,025.000	16.719	---	---	19.608	19.608	---	1,025.000
- Molar Density (kmole/m^3)	---	0.705	---	---	0.827	0.827	---	---
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	0.9585	---	---	0.9266	0.9266	---	---
- Specific Heat Capacity (kJ/kmole·°C)	135.4802	52.3343	---	---	48.8357	48.8357	---	135.4802
- Enthalpy (kJ/kmole)	---	-82,762	---	---	-85,835	-85,835	---	---
- Entropy (kJ/kmole·°C)	---	-201	---	---	-209	-209	---	---
- Gross Heating Value (MJ/m^3)	---	48.3	---	---	48.3	48.3	---	---
- Net Heating Value (MJ/m^3)	---	43.3	---	---	43.3	43.3	---	---
- Sound Speed (m/s)	---	387.893	---	---	350.830	350.830	---	---
- Dew Point Temperature (°C)	---	101.37	---	---	39.90	39.90	---	---
- Dew Point Pressure (°kPa)	---	2,105.3	---	---	1,995.3	1,995.3	---	---
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	0.044	---	---	0.034	0.034	---	---
- Viscosity (cp)	1.100	0.015	---	---	0.012	0.012	---	1.100

Composition (Mole Fraction):			9	10	11	12	13	14	15	16
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	0.043380	---	0.044719	0.043380	0.043380	---	---
Water	**H2O**	**7732-18-5**	0.462700	0.000000	---	0.000000	0.000000	0.000000	---	0.462700
Carbon Dioxide	**CO2**	**124-38-9**	---	0.025205	---	0.025821	0.025205	0.025205	---	---
Methane	**CH4**	**74-82-8**	---	0.641174	---	0.660322	0.641174	0.641174	---	---
Ethane	**C2H6**	**74-84-0**	---	0.171376	---	0.173592	0.171376	0.171376	---	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	0.537300	---	---	---	---	---	---	0.537300
Propane	**C3H8**	**74-98-6**	---	0.084805	---	0.078546	0.084805	0.084805	---	---
i-Butane	**C4H10**	**75-28-5**	---	0.007275	---	0.005121	0.007275	0.007275	---	---
n-Butane	**C4H10**	**106-97-8**	---	0.017510	---	0.010445	0.017510	0.017510	---	---
i-Pentane	**C5H12**	**78-78-4**	---	0.002545	---	0.000703	0.002545	0.002545	---	---
n-Pentane	**C5H12**	**109-66-0**	---	0.003010	---	0.000673	0.003010	0.003010	---	---
Benzene	**C6H6**	**71-43-2**	---	0.000100	---	0.000001	0.000100	0.000100	---	---
Cyclohexane	**C6H12**	**110-82-7**	---	0.000175	---	0.000006	0.000175	0.000175	---	---
Hexane	**C6H14**	**110-54-3**	---	0.000745	---	0.000026	0.000745	0.000745	---	---

Methylcyclopentane	**C6H12**	**96-37-7**	---	0.000170	---	0.000007	0.000170	0.000170	---	---
Heptane	**C7H16**	**142-82-5**	---	0.001975	---	0.000016	0.001975	0.001975	---	---
Methylcyclohexane	**C7H14**	**108-87-2**	---	0.000190	---	0.000002	0.000190	0.000190	---	---
Toluene	**C7H8**	**108-88-3**	---	0.000165	---	0.000001	0.000165	0.000165	---	---
Ethylbenzene	**C8H10**	**100-41-4**	---	0.000005	---	0.000000	0.000005	0.000005	---	---
m-Xylene	**C8H10**	**108-38-3**	---	0.000040	---	0.000000	0.000040	0.000040	---	---
Octane	**C8H18**	**111-65-9**	---	0.000075	---	0.000000	0.000075	0.000075	---	---
o-Xylene	**C8H10**	**95-47-6**	---	0.000005	---	0.000000	0.000005	0.000005	---	---
Nonane	**C9H20**	**111-84-2**	---	0.000035	---	0.000000	0.000035	0.000035	---	---
Decane	**C10H22**	**124-18-5**	---	0.000020	---	0.000000	0.000020	0.000020	---	---
Undecanes	**C11H24**	**1120-21-4**	---	0.000015	---	0.000000	0.000015	0.000015	---	---
Dodecane	**C12H26**	**112-40-3**	---	0.000005	---	0.000000	0.000005	0.000005	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JTN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	17	18	19	20	21	22	23	24
- Fluid	Heat Medium	HC	Electricity	Fuel Gas	HC	HC	HC	HC
- Physical State	Liquid	Vapour	Unknown	Gas	Vapour	Vapour	Multiphase	Vapour
- Temperature (°C)	120.00	101.15	---	29.91	39.90	29.91	0.10	-43.24
- Pressure (kPa)	276.0	4,455.0	---	200.0	4,345.0	200.0	4,245.0	300.0
- Total Molar Flowrate (kmole/h)	0.00	1,145.61	---	9.72	1,145.61	1,111.00	1,145.61	1,111.00
- Total Mass Flowrate (kg/h)	0.0	27153.5	---	225.7	27153.5	25192.2	27153.5	25192.2
- Total Gas Volumetric Flowrate (Std m^3/h)	---	27087.8	---	229.8	27087.8	26269.5	---	26269.5
- Total Liq Volumetric Flowrate (m^3/h)	0.0	---	---	---	---	---	---	---

			17	18	19	20	21	22	23	24
- Energy Flowrate kW			---	---	0.000	---	---	---	---	---
Origin (Unit Operation):										
- Tag No.			H-100	K-200	Electric Utility System	Fuel Gas Header	AC-101	E-100	E-100	V-600
- Service:			Boiler	Inlet Gas Boosting	---	---	Discharge Cooler	---	---	Cold
- Type:			Heater	Compressor: Recip.	---	---	Aerial Cooler	---	---	3-Phase Separator
Destination (Unit Operation):										
- Tag No.			V-200	AC-101	K-200	K-200	E-100	M-400	JTV-100	E-100
- Service:			Interstage Scrubber	Discharge Cooler	Inlet Gas Boosting	Inlet Gas Boosting	---	Not Applicable	Joule Thomson	---
- Type:			2-Phase Separator	Aerial Cooler	Compressor: Recip.	Compressor: Recip.	---	Mixer	Control Valve	---
Properties:			17	18	19	20	21	22	23	24
- Vapour Mole Fraction			0.000000	1.000000	---	1.000000	1.000000	1.000000	0.921455	1.000000
- Liquid Mole Fraction			1.000000	0.000000	---	0.000000	0.000000	0.000000	0.078545	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			41.686	23.702	---	---	23.702	22.675	23.702	22.675
- Mass Density (kg/m^3)			1,025.000	37.875	---	---	48.171	2.697	61.985	4.864
- Molar Density (kmole/m^3)			---	1.598	---	---	2.032	0.119	2.615	0.215
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	0.9152	---	---	0.8396	0.9889	---	0.9666
- Specific Heat Capacity (kJ/kmole·°C)			135.4802	55.3315	---	---	54.8976	43.5216	---	39.9140
- Enthalpy (kJ/kmole)			---	-83,322	---	---	-86,643	-84,597	-89,627	-87,674
- Entropy (kJ/kmole·°C)			---	-208	---	---	-218	-187	-228	-201
- Gross Heating Value (MJ/m^3)			---	48.3	---	---	48.3	46.1	48.3	46.1
- Net Heating Value (MJ/m^3)			---	43.3	---	---	43.3	41.3	43.3	41.3
- Sound Speed (m/s)			---	380.842	---	---	335.926	368.593	273.091	320.643
- Dew Point Temperature (°C)			---	101.15	---	---	39.90	29.91	---	-43.24
- Dew Point Pressure (°kPa)			---	4,551.4	---	---	4,441.4	296.4	---	396.4
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	0.045	---	---	0.036	0.032	0.033	0.022
- Viscosity (cp)			1.100	0.015	---	---	0.013	0.012	0.014	0.009
Composition (Mole Fraction):			17	18	19	20	21	22	23	24
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	0.043380	---	0.044719	0.043380	0.044719	0.043380	0.044719
Water	**H2O**	**7732-18-5**	0.462700	0.000000	---	0.000000	0.000000	0.000000	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	0.025205	---	0.025821	0.025205	0.025821	0.025205	0.025821
Methane	**CH4**	**74-82-8**	---	0.641174	---	0.660322	0.641174	0.660322	0.641174	0.660322
Ethane	**C2H6**	**74-84-0**	---	0.171376	---	0.173592	0.171376	0.173592	0.171376	0.173592
Ethylene Glycol	**C2H6O2**	**107-21-1**	0.537300	---	---	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	0.084805	---	0.078546	0.084805	0.078546	0.084805	0.078546
i-Butane	**C4H10**	**75-28-5**	---	0.007275	---	0.005121	0.007275	0.005121	0.007275	0.005121
n-Butane	**C4H10**	**106-97-8**	---	0.017510	---	0.010445	0.017510	0.010445	0.017510	0.010445
i-Pentane	**C5H12**	**78-78-4**	---	0.002545	---	0.000703	0.002545	0.000703	0.002545	0.000703
n-Pentane	**C5H12**	**109-66-0**	---	0.003010	---	0.000673	0.003010	0.000673	0.003010	0.000673
Benzene	**C6H6**	**71-43-2**	---	0.000100	---	0.000001	0.000100	0.000001	0.000100	0.000001
Cyclohexane	**C6H12**	**110-82-7**	---	0.000175	---	0.000006	0.000175	0.000006	0.000175	0.000006
Hexane	**C6H14**	**110-54-3**	---	0.000745	---	0.000026	0.000745	0.000026	0.000745	0.000026

Methylcyclopentane	**C6H12**	**96-37-7**	---	0.000170	---	0.000007	0.000170	0.000007	0.000170	0.000007
Heptane	**C7H16**	**142-82-5**	---	0.001975	---	0.000016	0.001975	0.000016	0.001975	0.000016
Methylcyclohexane	**C7H14**	**108-87-2**	---	0.000190	---	0.000002	0.000190	0.000002	0.000190	0.000002
Toluene	**C7H8**	**108-88-3**	---	0.000165	---	0.000001	0.000165	0.000001	0.000165	0.000001
Ethylbenzene	**C8H10**	**100-41-4**	---	0.000005	---	0.000000	0.000005	0.000000	0.000005	0.000000
m-Xylene	**C8H10**	**108-38-3**	---	0.000040	---	0.000000	0.000040	0.000000	0.000040	0.000000
Octane	**C8H18**	**111-65-9**	---	0.000075	---	0.000000	0.000075	0.000000	0.000075	0.000000
o-Xylene	**C8H10**	**95-47-6**	---	0.000005	---	0.000000	0.000005	0.000000	0.000005	0.000000
Nonane	**C9H20**	**111-84-2**	---	0.000035	---	0.000000	0.000035	0.000000	0.000035	0.000000
Decane	**C10H22**	**124-18-5**	---	0.000020	---	0.000000	0.000020	0.000000	0.000020	0.000000
Undecanes	**C11H24**	**1120-21-4**	---	0.000015	---	0.000000	0.000015	0.000000	0.000015	0.000000
Dodecane	**C12H26**	**112-40-3**	---	0.000005	---	0.000000	0.000005	0.000000	0.000005	0.000000

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JTN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	25	26	27	28	29	30	31	32
- Fluid	HC	HC	Heat Medium	Heat Medium	HC	HC	HC	Heat Medium
- Physical State	Multiphase	Liquid	Liquid	Liquid	Vapour	Liquid	Liquid	Liquid
- Temperature (°C)	-43.24	-43.24	120.00	120.00	105.00	---	105.00	115.00
- Pressure (kPa)	300.0	300.0	276.0	276.0	357.5	---	357.5	276.0
- Total Molar Flowrate (kmole/h)	1,145.61	34.61	0.00	0.00	25.58	---	9.03	1,538.68
- Total Mass Flowrate (kg/h)	27153.5	1961.2	0.0	0.0	1209.0	---	752.3	64141.7
- Total Gas Volumetric Flowrate	---	---	---	---	604.8	---	---	---
- Total Liq Volumetric Flowrate (m^3/h)	---	2.9	0.0	0.0	---	---	1.3	62.6

			25	26	27	28	29	30	31	32
- Energy Flowrate kW			---	---	---	---	---	---	---	---
Origin (Unit Operation):										
- Tag No.			JTV-100	V-600	V-600	H-100	S-100	PU-103	S-100	S-100
- Service:			Joule Thomson	Cold	Cold	Boiler	Condensate	Reflux	Condensate	Condensate
- Type:			Control Valve	3-Phase Separator	3-Phase Separator	Heater	Stabilizer: Distillation	Pump	Stabilizer: Distillation	Stabilizer: Distillation
Destination (Unit Operation):										
- Tag No.			V-600	PU-102	PU-101	V-600	AC-102	S-100	PU-104	PU-101
- Service:			Cold	Booster	Circulation	Cold	Overhead Condenser	Condensate	Booster	Circulation
- Type:			3-Phase Separator	Pump: Centrifugal	Pump	3-Phase Separator	Aerial Cooler	Stabilizer: Distillation Column	Pump	Pump
Properties:			25	26	27	28	29	30	31	32
- Vapour Mole Fraction			0.969788	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000	0.000000
- Liquid Mole Fraction			0.030212	1.000000	1.000000	1.000000	0.000000	1.000000	1.000000	1.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			23.702	56.665	41.686	41.686	47.264	---	83.289	41.686
- Mass Density (kg/m^3)			5.240	668.091	1,025.000	1,025.000	7.130	---	585.901	1,025.000
- Molar Density (kmole/m^3)			0.221	11.790	---	---	0.151	---	7.035	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	0.0176	---	---	0.9569	---	0.0354	---
- Specific Heat Capacity (kJ/kmole·°C)			---	112.3251	135.4802	135.4802	97.4893	---	217.5962	135.4802
- Enthalpy (kJ/kmole)			-89,627	-152,326	---	---	-106,264	---	-167,372	---
- Entropy (kJ/kmole·°C)			-211	-522	---	---	-350	---	-630	---
- Gross Heating Value (MJ/m^3)			48.3	118.7	---	---	100.1	---	171.5	---
- Net Heating Value (MJ/m^3)			43.3	108.6	---	---	91.2	---	157.7	---
- Sound Speed (m/s)			298.263	1,063.331	---	---	260.176	---	555.621	---
- Dew Point Temperature (°C)			---	---	---	---	105.00	---	---	---
- Dew Point Pressure (°kPa)			---	---	---	---	453.8	---	---	---
- Bubble Point Temperature (°C)			---	-43.24	---	---	---	---	105.00	---
- Bubble Point Pressure (kPa)			---	396.4	---	---	---	---	783.8	---
- Reid Vapour Pressure (kPa)			---	1,580.8	---	---	---	---	1,705.3	---
- True Vapour Pressure (kPa)			---	396.4	---	---	---	---	783.8	---
- Thermal Conductivity (W/m·°C)			0.022	0.155	---	---	0.031	---	0.093	---
- Viscosity (cp)			0.010	0.345	1.100	1.100	0.012	---	0.146	1.100
Composition (Mole Fraction):			25	26	27	28	29	30	31	32
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043380	0.000408	---	---	0.000552	---	---	---
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.462700	0.462700	0.000000	---	0.000000	0.462700
Carbon Dioxide	**CO2**	**124-38-9**	0.025205	0.005436	---	---	0.007356	---	---	---
Methane	**CH4**	**74-82-8**	0.641174	0.026515	---	---	0.035877	---	---	---
Ethane	**C2H6**	**74-84-0**	0.171376	0.100237	---	---	0.135631	---	---	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	0.537300	0.537300	---	---	---	0.537300
Propane	**C3H8**	**74-98-6**	0.084805	0.285732	---	---	0.386623	---	---	---
i-Butane	**C4H10**	**75-28-5**	0.007275	0.076415	---	---	0.103396	---	---	---
n-Butane	**C4H10**	**106-97-8**	0.017510	0.244302	---	---	0.330565	---	---	---
i-Pentane	**C5H12**	**78-78-4**	0.002545	0.061668	---	---	---	---	0.236315	---
n-Pentane	**C5H12**	**109-66-0**	0.003010	0.078032	---	---	---	---	0.299026	---
Benzene	**C6H6**	**71-43-2**	0.000100	0.003281	---	---	---	---	0.012573	---
Cyclohexane	**C6H12**	**110-82-7**	0.000175	0.005604	---	---	---	---	0.021475	---

Hexane	**C6H14**	**110-54-3**	0.000745	0.023840	---	---	---	---	0.091358	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.005396	---	---	---	---	0.020677	---
Heptane	**C7H16**	**142-82-5**	0.001975	0.064872	---	---	---	---	0.248595	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.006224	---	---	---	---	0.023849	---
Toluene	**C7H8**	**108-88-3**	0.000165	0.005425	---	---	---	---	0.020788	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000165	---	---	---	---	0.000633	---
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.001323	---	---	---	---	0.005068	---
Octane	**C8H18**	**111-65-9**	0.000075	0.002479	---	---	---	---	0.009498	---
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000165	---	---	---	---	0.000634	---
Nonane	**C9H20**	**111-84-2**	0.000035	0.001158	---	---	---	---	0.004438	---
Decane	**C10H22**	**124-18-5**	0.000020	0.000662	---	---	---	---	0.002537	---
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000496	---	---	---	---	0.001903	---
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000165	---	---	---	---	0.000634	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JTN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	33	34	35	36	37	38	39	40
- Fluid	Heat Medium	HC	HC	HC	HC	HC	HC	HC
- Physical State	Liquid	Liquid	Multiphase	Gas	Liquid	Liquid	Liquid	Liquid
- Temperature (°C)	120.00	-43.24	39.90	39.90	---	105.00	39.90	39.90
- Pressure (kPa)	276.0	357.5	257.5	257.5	---	657.5	557.5	557.5
- Total Molar Flowrate (kmole/h)	1,538.68	34.61	25.58	25.58	---	9.03	9.03	9.03
- Total Mass Flowrate (kg/h)	64141.7	1961.2	1209.0	1209.0	---	752.3	752.3	752.3
- Total Gas Volumetric Flowrate	---	---	---	604.8	---	---	---	---
- Total Liq Volumetric Flowrate (m^3/h)	62.6	2.9	---	---	---	1.3	1.0	1.0

- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	H-100	PU-102	AC-102	V-300	V-300	PU-104	AC-103	M-300
- Service:	Boiler	Booster	Overhead Condenser	Reflux Drum	Reflux Drum	Booster	Bottoms Cooler	Not Applicable
- Type:	Heater	Pump: Centrifugal	Aerial Cooler	2-Phase Separator	2-Phase Separator	Pump	Aerial Cooler	Mixer
Destination (Unit Operation):								
- Tag No.	S-100	S-100	V-300	M-400	PU-103	AC-103	M-300	Condensate Internal Use
- Service:	Condensate	Condensate	Reflux Drum	Not Applicable	Reflux	Bottoms Cooler	Not Applicable	---
- Type:	Stabilizer: Distillation Column	Stabilizer: Distillation Column	2-Phase Separator	Mixer	Pump	Aerial Cooler	Mixer	---
Properties:	33	34	35	36	37	38	39	40
- Vapour Mole Fraction	0.000000	0.000000	---	1.000000	0.000000	0.000000	0.000000	0.000000
- Liquid Mole Fraction	1.000000	1.000000	---	0.000000	1.000000	1.000000	1.000000	1.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	41.686	56.665	---	---	---	83.289	---	---
- Mass Density (kg/m^3)	1,025.000	668.091	---	---	---	585.901	724.600	724.600
- Molar Density (kmole/m^3)	---	11.790	---	---	---	7.035	---	---
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	0.0176	---	---	---	0.0354	---	---
- Specific Heat Capacity (kJ/kmole·°C)	135.4802	112.3251	---	---	---	217.5962	---	---
- Enthalpy (kJ/kmole)	---	-152,326	---	---	---	-167,372	---	---
- Entropy (kJ/kmole·°C)	---	-522	---	---	---	-630	---	---
- Gross Heating Value (MJ/m^3)	---	118.7	---	100.1	---	171.5	---	---
- Net Heating Value (MJ/m^3)	---	108.6	---	91.2	---	157.7	---	---
- Sound Speed (m/s)	---	1,063.331	---	---	---	555.621	---	---
- Dew Point Temperature (°C)	---	---	---	---	---	---	---	---
- Dew Point Pressure (°kPa)	---	---	---	---	---	---	---	---
- Bubble Point Temperature (°C)	---	-43.24	---	---	---	105.00	---	---
- Bubble Point Pressure (kPa)	---	396.4	---	---	---	783.8	---	---
- Reid Vapour Pressure (kPa)	---	1,580.8	---	---	---	1,705.3	---	---
- True Vapour Pressure (kPa)	---	396.4	---	---	---	783.8	---	---
- Thermal Conductivity (W/m·°C)	---	0.155	---	---	---	0.093	---	---
- Viscosity (cp)	1.100	0.345	---	---	---	0.146	0.269	0.269

Composition (Mole Fraction):			33	34	35	36	37	38	39	40
Name	**Formula**	**CAS No.**								
Nitrogen	N2	7727-37-9	---	0.000408	0.000552	0.000552	---	---	---	---
Water	H2O	7732-18-5	0.462700	0.000000	0.000000	0.000000	---	0.000000	0.000000	0.000000
Carbon Dioxide	CO2	124-38-9	---	0.005436	0.007356	0.007356	---	---	---	---
Methane	CH4	74-82-8	---	0.026515	0.035877	0.035877	---	---	---	---
Ethane	C2H6	74-84-0	---	0.100237	0.135631	0.135631	---	---	---	---
Ethylene Glycol	C2H6O2	107-21-1	0.537300	---	---	---	---	---	---	---
Propane	C3H8	74-98-6	---	0.285732	0.386623	0.386623	---	---	---	---
i-Butane	C4H10	75-28-5	---	0.076415	0.103396	0.103396	---	---	---	---
n-Butane	C4H10	106-97-8	---	0.244302	0.330565	0.330565	---	---	---	---
i-Pentane	C5H12	78-78-4	---	0.061668	---	---	---	0.236315	0.236315	0.236315
n-Pentane	C5H12	109-66-0	---	0.078032	---	---	---	0.299026	0.299026	0.299026

Benzene	**C6H6**	**71-43-2**	---	0.003281	---	---	---	0.012573	0.012573	0.012573
Cyclohexane	**C6H12**	**110-82-7**	---	0.005604	---	---	---	0.021475	0.021475	0.021475
Hexane	**C6H14**	**110-54-3**	---	0.023840	---	---	---	0.091358	0.091358	0.091358
Methylcyclopentane	**C6H12**	**96-37-7**	---	0.005396	---	---	---	0.020677	0.020677	0.020677
Heptane	**C7H16**	**142-82-5**	---	0.064872	---	---	---	0.248595	0.248595	0.248595
Methylcyclohexane	**C7H14**	**108-87-2**	---	0.006224	---	---	---	0.023849	0.023849	0.023849
Toluene	**C7H8**	**108-88-3**	---	0.005425	---	---	---	0.020788	0.020788	0.020788
Ethylbenzene	**C8H10**	**100-41-4**	---	0.000165	---	---	---	0.000633	0.000633	0.000633
m-Xylene	**C8H10**	**108-38-3**	---	0.001323	---	---	---	0.005068	0.005068	0.005068
Octane	**C8H18**	**111-65-9**	---	0.002479	---	---	---	0.009498	0.009498	0.009498
o-Xylene	**C8H10**	**95-47-6**	---	0.000165	---	---	---	0.000634	0.000634	0.000634
Nonane	**C9H20**	**111-84-2**	---	0.001158	---	---	---	0.004438	0.004438	0.004438
Decane	**C10H22**	**124-18-5**	---	0.000662	---	---	---	0.002537	0.002537	0.002537
Undecanes	**C11H24**	**1120-21-4**	---	0.000496	---	---	---	0.001903	0.001903	0.001903
Dodecane	**C12H26**	**112-40-3**	---	0.000165	---	---	---	0.000634	0.000634	0.000634

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JTN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	41	42	43	44	45	46	47	48
- Fluid	HC	Heat Medium	Fuel Gas	Heat Medium	HC	Fuel Gas	HC	HC
- Physical State	Liquid	Liquid	Vapour	Liquid	Vapour	Gas	Vapour	Vapour
- Temperature (°C)	---	115.00	30.24	120.00	30.24	29.91	30.24	30.24
- Pressure (kPa)	---	276.0	200.0	276.0	200.0	200.0	200.0	200.0
- Total Molar Flowrate (kmole/h)	---	1,538.68	1.16	1,538.68	1,136.58	21.41	0.00	1,115.17
- Total Mass Flowrate (kg/h)	---	64141.7	27.0	64141.7	26401.2	497.3	0.0	25903.9
- Total Gas Volumetric Flowrate (Std m^3/h)	---	---	27.5	---	26874.3	506.2	0.0	26368.0
- Total Liq Volumetric Flowrate (m^3/h)	---	62.6	---	62.6	---	---	---	---

- Energy Flowrate kW			---	---	---	---	---	---	---	---
Origin (Unit Operation):										
- Tag No.			PU-100	PU-101	Fuel Gas Header	H-100	M-400	M-400	M-400	M-400
- Service:			Booster	Circulation	---	Boiler	Not Applicable	Not Applicable	Not Applicable	Not Applicable
- Type:			Pump	Pump	---	Heater	Mixer	Mixer	Mixer	Mixer
Destination (Unit Operation):										
- Tag No.			M-300	H-100	H-100	Heat-Medium Header	FUEL HEADER	Fuel Gas Header	Gas Gathering System	To Flare Line
- Service:			Not Applicable	Boiler	Boiler	---	---	---	---	---
- Type:			Mixer	Heater	Heater	---	---	---	---	---
Properties:			41	42	43	44	45	46	47	48
- Vapour Mole Fraction			0.000000	0.000000	1.000000	0.000000	1.000000	1.000000	1.000000	1.000000
- Liquid Mole Fraction			1.000000	1.000000	0.000000	1.000000	0.000000	0.000000	0.000000	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			---	41.686	23.229	41.686	23.229	---	23.229	23.229
- Mass Density (kg/m^3)			---	1,025.000	2.761	1,025.000	2.761	---	2.761	2.761
- Molar Density ($kmole/m^3$)			---	---	0.119	---	0.119	---	0.119	0.119
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	---	0.9884	---	0.9884	---	0.9884	0.9884
- Specific Heat Capacity (kJ/kmole·°C)			---	135.4802	44.4111	135.4802	44.4111	---	44.4111	44.4111
- Enthalpy (kJ/kmole)			---	---	-85,215	---	-85,215	---	-85,215	-85,215
- Entropy (kJ/kmole·°C)			---	---	-191	---	-191	---	-191	-191
- Gross Heating Value (MJ/m^3)			---	---	47.3	---	47.3	---	47.3	47.3
- Net Heating Value (MJ/m^3)			---	---	42.4	---	42.4	---	42.4	42.4
- Sound Speed (m/s)			---	---	363.350	---	363.350	---	363.350	363.350
- Dew Point Temperature (°C)			---	---	30.24	---	30.24	---	30.24	30.24
- Dew Point Pressure (°kPa)			---	---	296.4	---	296.4	---	296.4	296.4
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	---	0.032	---	0.032	---	0.032	0.032
- Viscosity (cp)			---	1.100	0.012	1.100	0.012	---	0.012	0.012
Composition (Mole Fraction):			41	42	43	44	45	46	47	48
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	0.043725	---	0.043725	0.044719	0.043725	0.043725
Water	**H2O**	**7732-18-5**	---	0.462700	0.000000	0.462700	0.000000	0.000000	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	0.025405	---	0.025405	0.025821	0.025405	0.025405
Methane	**CH4**	**74-82-8**	---	---	0.646269	---	0.646269	0.660322	0.646269	0.646269
Ethane	**C2H6**	**74-84-0**	---	---	0.172738	---	0.172738	0.173592	0.172738	0.172738
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	0.537300	---	0.537300	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	---	0.085479	---	0.085479	0.078546	0.085479	0.085479
i-Butane	**C4H10**	**75-28-5**	---	---	0.007333	---	0.007333	0.005121	0.007333	0.007333
n-Butane	**C4H10**	**106-97-8**	---	---	0.017649	---	0.017649	0.010445	0.017649	0.017649
i-Pentane	**C5H12**	**78-78-4**	---	---	0.000687	---	0.000687	0.000703	0.000687	0.000687
n-Pentane	**C5H12**	**109-66-0**	---	---	0.000658	---	0.000658	0.000673	0.000658	0.000658
Benzene	**C6H6**	**71-43-2**	---	---	0.000001	---	0.000001	0.000001	0.000001	0.000001
Cyclohexane	**C6H12**	**110-82-7**	---	---	0.000006	---	0.000006	0.000006	0.000006	0.000006

Hexane	**C6H14**	**110-54-3**	---	---	0.000025	---	0.000025	0.000026	0.000025	0.000025
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	0.000007	---	0.000007	0.000007	0.000007	0.000007
Heptane	**C7H16**	**142-82-5**	---	---	0.000015	---	0.000015	0.000016	0.000015	0.000015
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	0.000002	---	0.000002	0.000002	0.000002	0.000002
Toluene	**C7H8**	**108-88-3**	---	---	0.000001	---	0.000001	0.000001	0.000001	0.000001
Ethylbenzene	**C8H10**	**100-41-4**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
m-Xylene	**C8H10**	**108-38-3**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
Octane	**C8H18**	**111-65-9**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
o-Xylene	**C8H10**	**95-47-6**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
Nonane	**C9H20**	**111-84-2**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
Decane	**C10H22**	**124-18-5**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
Undecanes	**C11H24**	**1120-21-4**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000
Dodecane	**C12H26**	**112-40-3**	---	---	0.000000	---	0.000000	0.000000	0.000000	0.000000

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JTN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4							
Streams:	49	50	51	52	53	54	55	56
- Fluid	HC	Electricity	Electricity	Electricity	Electricity	Electricity	Electricity	Electricity
- Physical State	Vapour	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
- Temperature (°C)	30.24	---	---	---	---	---	---	---
- Pressure (kPa)	200.0	---	---	---	---	---	---	---
- Total Molar Flowrate (kmole/h)	0.00	---	---	---	---	---	---	---
- Total Mass Flowrate (kg/h)	0.0	---	---	---	---	---	---	---
- Total Gas Volumetric Flowrate (Sm³/h)	0.0	---	---	---	---	---	---	---
- Total Liq Volumetric Flowrate (m³/h)	---	---	---	---	---	---	---	---
- Energy Flowrate kW	---	4.356	0.220	0.205	0.006	0.005	0.000	3.744

Origin (Unit Operation):										
- Tag No.			M-400	Electric Utility System	Electric Utility System	Electric Utility System	Electric Utility	Electric Utility System	Electric Utility System	Electric Utility System
- Service:			Not Applicable	---	---	---	---	---	---	---
- Type:			Mixer	---	---	---	---	---	---	---
Destination (Unit Operation):										
- Tag No.			Fuel Gas Header		AC-100	AC-101	AC-102	AC-103	PU-100	PU-101
- Service:			---	---	Interstage Cooler	Discharge Cooler	Overhead Condenser	Bottoms Cooler	Booster	Circulation
- Type:			---	---	Aerial Cooler	Aerial Cooler	Aerial Cooler	Aerial Cooler	Pump	Pump
Properties:			49	50	51	52	53	54	55	56
- Vapour Mole Fraction			1.000000	---	---	---	---	---	---	---
- Liquid Mole Fraction			0.000000	---	---	---	---	---	---	---
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			23.229	---	---	---	---	---	---	---
- Mass Density (kg/m^3)			2.761	---	---	---	---	---	---	---
- Molar Density (kmole/m^3)			0.119	---	---	---	---	---	---	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			0.9884	---	---	---	---	---	---	---
- Specific Heat Capacity (kJ/kmole·°C)			44.4111	---	---	---	---	---	---	---
- Enthalpy (kJ/kmole)			-85,215	---	---	---	---	---	---	---
- Entropy (kJ/kmole·°C)			-191	---	---	---	---	---	---	---
- Gross Heating Value (MJ/m^3)			47.3	---	---	---	---	---	---	---
- Net Heating Value (MJ/m^3)			42.4	---	---	---	---	---	---	---
- Sound Speed (m/s)			363.350	---	---	---	---	---	---	---
- Dew Point Temperature (°C)			30.24	---	---	---	---	---	---	---
- Dew Point Pressure (°kPa)			296.4	---	---	---	---	---	---	---
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.032	---	---	---	---	---	---	---
- Viscosity (cp)			0.012	---	---	---	---	---	---	---
Composition (Mole Fraction):			49	50	51	52	53	54	55	56
Name	**Formula**	**CAS No.**								
Nitrogen	N2	7727-37-9	0.043725	---	---	---	---	---	---	---
Water	H2O	7732-18-5	0.000000	---	---	---	---	---	---	---
Carbon Dioxide	CO2	124-38-9	0.025405	---	---	---	---	---	---	---
Methane	CH4	74-82-8	0.646269	---	---	---	---	---	---	---
Ethane	C2H6	74-84-0	0.172738	---	---	---	---	---	---	---
Propane	C3H8	74-98-6	0.085479	---	---	---	---	---	---	---
i-Butane	C4H10	75-28-5	0.007333	---	---	---	---	---	---	---
n-Butane	C4H10	106-97-8	0.017649	---	---	---	---	---	---	---
i-Pentane	C5H12	78-78-4	0.000687	---	---	---	---	---	---	---
n-Pentane	C5H12	109-66-0	0.000658	---	---	---	---	---	---	---
Benzene	C6H6	71-43-2	0.000001	---	---	---	---	---	---	---
Cyclohexane	C6H12	110-82-7	0.000006	---	---	---	---	---	---	---
Hexane	C6H14	110-54-3	0.000025	---	---	---	---	---	---	---
Methylcyclopentane	C6H12	96-37-7	0.000007	---	---	---	---	---	---	---

Heptane	**C7H16**	**142-82-5**	0.000015	---	---	---	---	---	---	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000002	---	---	---	---	---	---	---
Toluene	**C7H8**	**108-88-3**	0.000001	---	---	---	---	---	---	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000000	---	---	---	---	---	---	---
m-Xylene	**C8H10**	**108-38-3**	0.000000	---	---	---	---	---	---	---
Octane	**C8H18**	**111-65-9**	0.000000	---	---	---	---	---	---	---
o-Xylene	**C8H10**	**95-47-6**	0.000000	---	---	---	---	---	---	---
Nonane	**C9H20**	**111-84-2**	0.000000	---	---	---	---	---	---	---
Decane	**C10H22**	**124-18-5**	0.000000	---	---	---	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	0.000000	---	---	---	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	0.000000	---	---	---	---	---	---	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-JTN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a Joule-Thomson (JT) Plant and upstream electric-drive
	CEL Reference Code:	NGL-BSO-JT	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

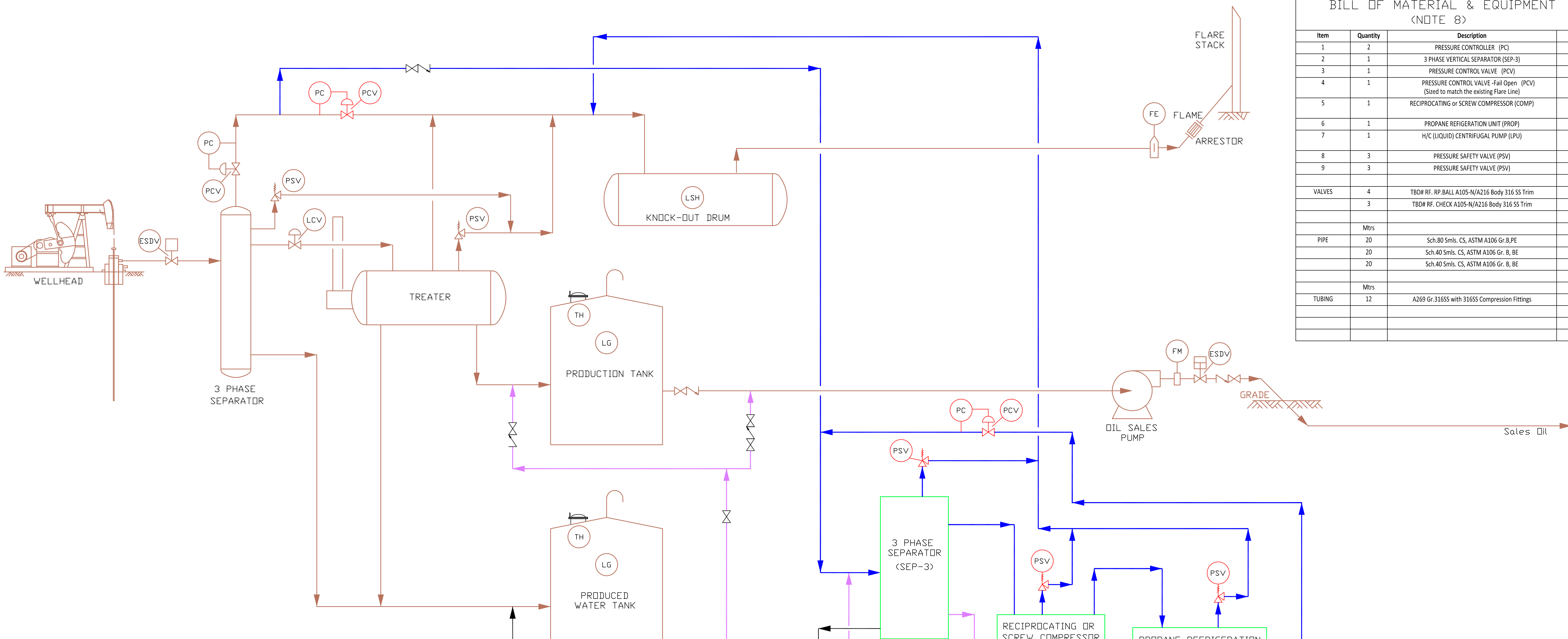
Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**0.90**	0.50	2.00
JT Valve Pressure Drop (kPa)	**3,945.00**	345.00	3,345.00
Outlet Pressure (kPa)	**100.00**	200.00	800.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-4								
Streams:	57	58	59						
- Fluid	Electricity	Electricity	Electricity						
- Physical State	Unknown	Unknown	Unknown						
- Temperature (°C)	---	---	---						
- Pressure (kPa)	---	---	---						
- Total Molar Flowrate (kmole/h)	---	---	---						
- Total Mass Flowrate (kg/h)	---	---	---						
- Total Gas Volumetric Flowrate (Sm³/h)	---	---	---						
- Total Liq Volumetric Flowrate (m³/h)	---	---	---						

- Energy Flowrate kW	0.028	0.000	0.148					
Origin (Unit Operation):								
- Tag No.	Electric Utility System	Electric Utility System	Electric Utility System					
- Service:	---	---	---					
- Type:	---	---	---					
Destination (Unit Operation):								
- Tag No.	PU-102	PU-103	PU-104					
- Service:	Booster	Reflux	Booster					
- Type:	Pump: Centrifugal	Pump	Pump					
Properties:	57	58	59	0	0	0	0	0
- Vapour Mole Fraction	---	---	---					
- Liquid Mole Fraction	---	---	---					
- Solid Mole Fraction	---	---	---					
- Aqueous Mole Fraction	---	---	---					
- Molecular Weight	---	---	---					
- Mass Density (kg/m^3)	---	---	---					
- Molar Density (kmole/m^3)	---	---	---					
- API Gravity (°)	---	---	---					
- Compressibility Factor	---	---	---					
- Specific Heat Capacity (kJ/kmole·°C)	---	---	---					
- Enthalpy (kJ/kmole)	---	---	---					
- Entropy (kJ/kmole·°C)	---	---	---					
- Gross Heating Value (MJ/m^3)	---	---	---					
- Net Heating Value (MJ/m^3)	---	---	---					
- Sound Speed (m/s)	---	---	---					
- Dew Point Temperature (°C)	---	---	---					
- Dew Point Pressure (°kPa)	---	---	---					
- Bubble Point Temperature (°C)	---	---	---					
- Bubble Point Pressure (kPa)	---	---	---					
- Reid Vapour Pressure (kPa)	---	---	---					
- True Vapour Pressure (kPa)	---	---	---					
- Thermal Conductivity (W/m·°C)	---	---	---					
- Viscosity (cp)	---	---	---					
Composition (Mole Fraction):	57	58	59	0	0	0	0	0
Name / **Formula** / **CAS No.**								

7.3 LIQUIDS EXTRACTION BY PROPANE REFRIGERATION

This section presents a process flow diagram (PFD) that depicts how the propane refrigeration liquids extraction process would be implemented, and a simulation flow diagram (SFD) showing how the process was modeled. Following these drawings are the individual techno-economic and environmental report and simulation report for two scenarios: (1) the compressors drivers are electric motors powered by the electric utility grid, and (2) the compressor drivers are natural gas fueled engines. The stream numbers presented in the simulation reports match those used on the SFD.



BILL OF MATERIAL & EQUIPMENT (NOTE 8)

Item	Quantity	Description	Size
1	2	PRESSURE CONTROLLER (PC)	TBD
2	1	3 PHASE VERTICAL SEPARATOR (SEP-3)	TBD
3	1	PRESSURE CONTROL VALVE (PCV)	TBD
4	1	PRESSURE CONTROL VALVE -Fail Open (PCV) (Sized to match the existing Flare Line)	TBD
5	1	RECIPROCATING or SCREW COMPRESSOR (COMP)	TBD
6	1	PROPANE REFRIGERATION UNIT (PROP)	TBD
7	1	H/C (LIQUID) CENTRIFUGAL PUMP (LPU)	TBD
8	3	PRESSURE SAFETY VALVE (PSV)	TBD
9	3	PRESSURE SAFETY VALVE (PSV)	TBD
			TBD
VALVES	4	TBD# RF. RP.BALL A105-N/A216 Body 316 SS Trim	TBD
	3	TBD# RF. CHECK A105-N/A216 Body 316 SS Trim	TBD
	Mtrs		
PIPE	20	Sch.80 Smls. CS, ASTM A106 Gr.B,PE	TBD
	20	Sch.40 Smls. CS, ASTM A106 Gr. B, BE	TBD
	20	Sch.40 Smls. CS, ASTM A106 Gr. B, BE	TBD
	Mtrs		
TUBING	12	A269 Gr.316SS with 316SS Compression Fittings	1/2"

Notes:

1) Green indicates a proposed process package.
2) Brown indicates existing.
3) Red indicates proposed instrumentation.
4) Purple indicates proposed liquid lines.
5) Blue indicates proposed process lines.
6) Black indicates proposed utility lines & valves.
7) Where a reciprocating compressor is used it will require two or more stages.
8) The presented Bill of Materials is intended to capture all of the major equipment components and materials, down to piping,valves, & instrumentation,required for the project. Contributions from structural steel and smaller items such as gaskets, studs,nuts,etc. shall be estimated separately.
9) Where a reciprocating engine generator or a gas turbine generator are chosen.

Plot Date: YR MT DY 22-02-15 TIME 16:48

Major Equipment P&IDs

Tag	Referenced Drawing	Number of Times Referenced
-	-	
LPU	PID-15-Pum-Cen-000-500-2 (Pump)	1
PROR	PID-19-NEP-PR-WMI-558-1 (Propane Refrig)	1
COMP	PID-15-Com-S-000-413-1 (Screw)	1
COMP	PID-15-Com-R-2S-408-1 (2-Stage Recip)	Note 7
COMP	PID-15-Com-R-3S-409-1 (3-Stage Recip)	Note 7
COMP	PID-15-Com-R-4S-410-1 (4-Stage Recip)	Note 7
EPG	PID-16-EPG-RE-NGC-420-1 (Reciprocating)	Note 9
EPG	PID-16-EPG-ETG-GC-529-1 (Gas Turbine)	Note 9
(Sep-3)	PID-15-Sep-3S-V-470-1 (Separator)	1

REV	DATE	REVISION DESCRIPTION	BY
1	FEB 14/2022	PRELIMINARY	JMT

Discipline	Initials
Project Manager	D.P.
Process Engineer	
Checked By	
Designed By	PGS
Drawn By	JMT

ENGINEER'S STAMP

CLEARSTONE ENGINEERING
Calgary Canada

DRAWING TITLE

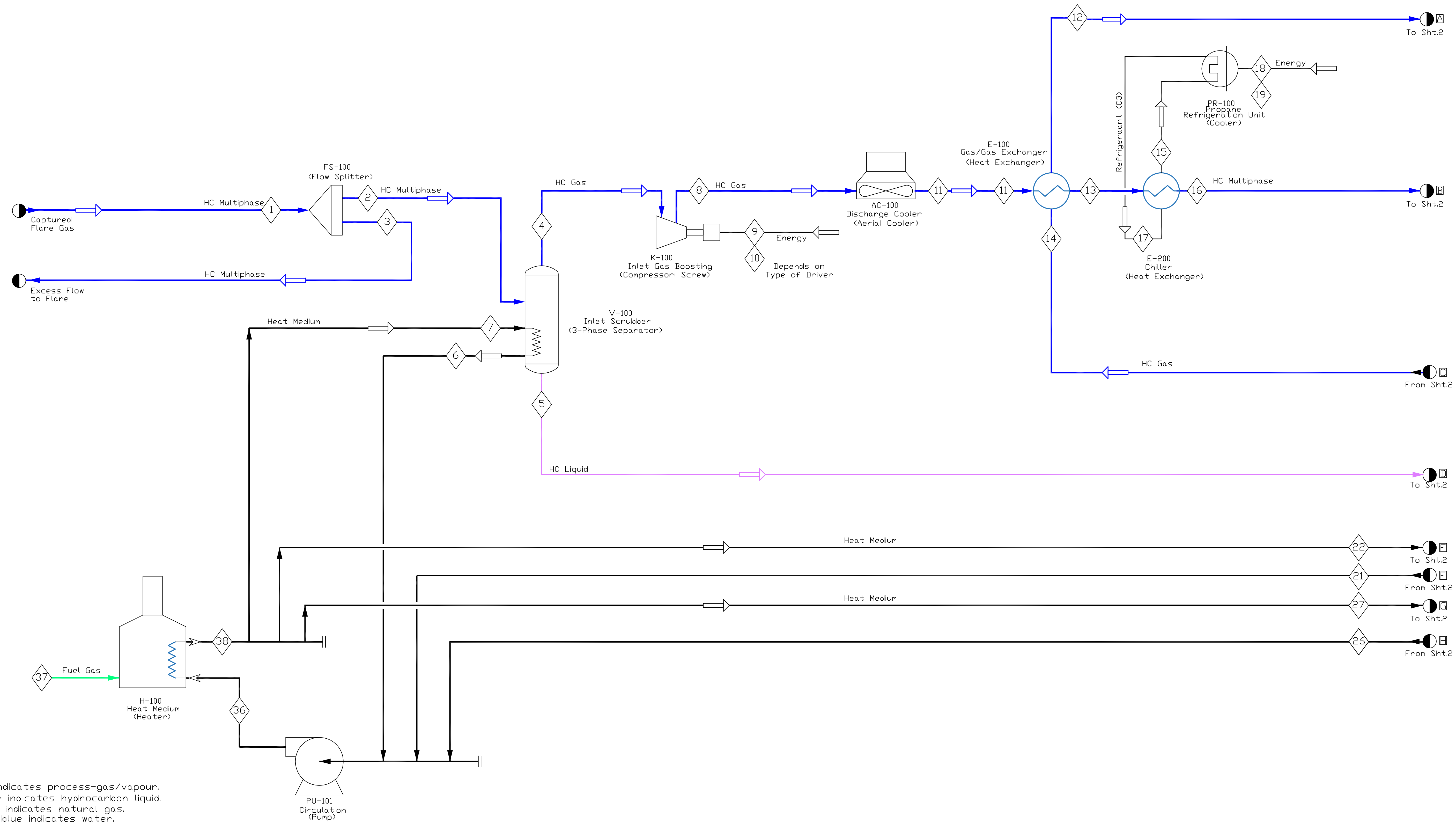
PROCESS FLOW DIAGRAM (PFD): GENERIC OIL BATTERY

Associated Gas-with Propane Refrigeration Liquids Extraction Scheme

PROJECT #.: N/A | SCALE: NTS | CLIENT: GENERAL | DRAWING IDENTIFICATION: PFD-22-OB-OSP-AGV-033-1 | REV: 1.2

Plot Date: YR MT DY 20-07-01 TIME 15:54

Steam Details Tables Site3 (Option 3)(C3 Chiller).v2



Notes:
1) Blue indicates process-gas/vapour.
2) Purple indicates hydrocarbon liquid.
3) Green indicates natural gas.
4) Light blue indicates water.
5) Black indicates utility & equipment.
6) Dashed Red indicates electrical.

ITEM	REFERENCE FILES	REV	DATE	REVISION DESCRIPTION	BY	Discipline	Initials
Excel File	SFD Stream Table - Dwg 49-6 (Propane Chiller) 1-Stage	1	JUN 10/2020	GENERAL ISSUE	JMT	Project Manager	D.P.
		2	JUN 29/2020	GENERAL REVISION	JMT	Process-Engineer	
		3	JUL 01/2020	GENERAL REVISION	JMT	Checked By	D.P.
						Designed By	P.S.
						Drawn By	J.T.

ENGINEER'S STAMP

CLEARSTONE ENGINEERING
Calgary Canada

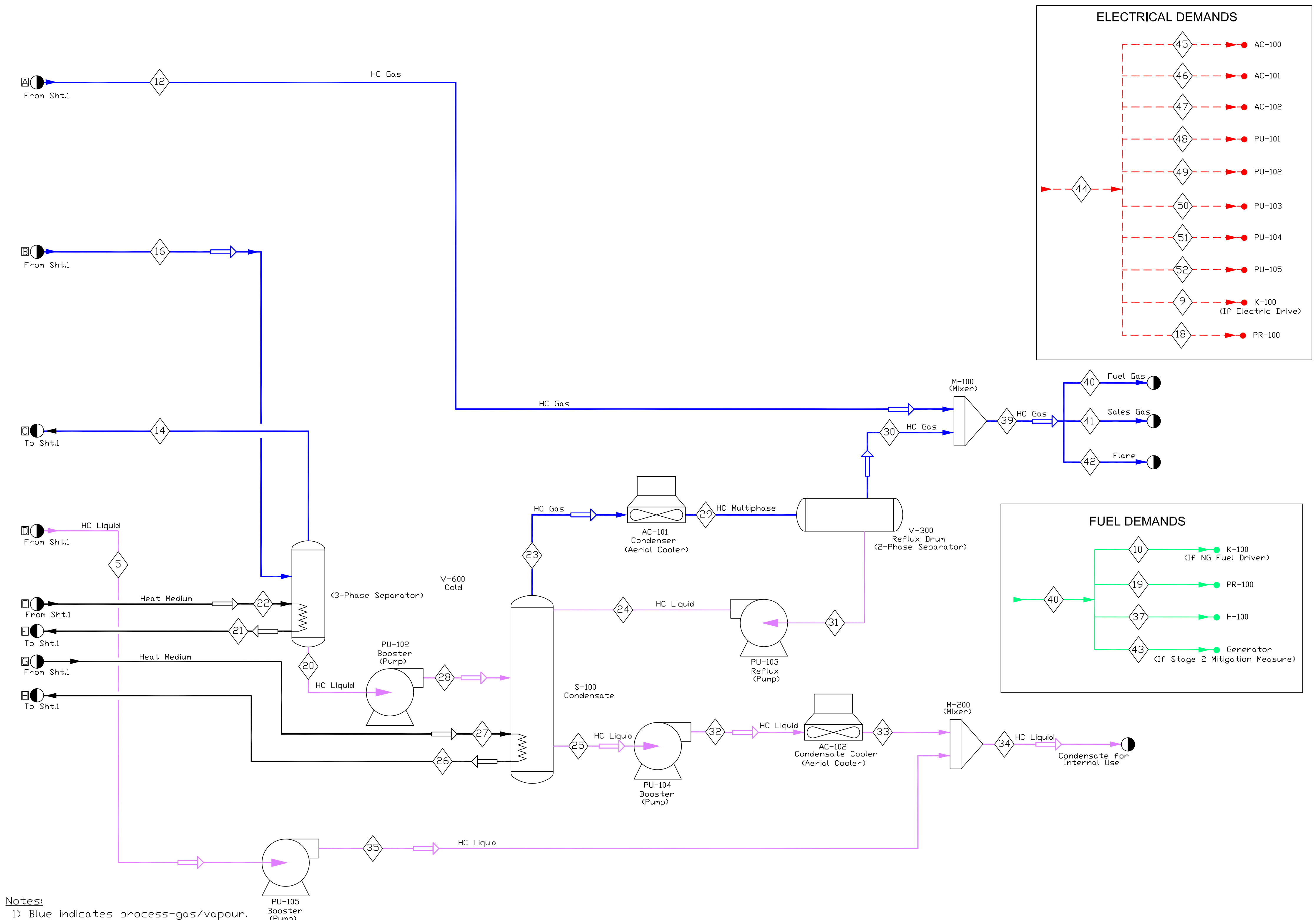
DRAWING TITLE

SIMULATION FLOWSHEET DIAGRAM (SFD):
SITE 3 STAGE BATTERY (OPTION 3)
(SINGLE STAGE COMPRESSION)
Propane Refrigeration Technology
With Electricity Generation

PROJECT #.	SCALE:	CLIENT:	DRAWING IDENTIFICATION	REV
N/A	NTS	GENERAL	SFD-20-OB-OSP-AGV-049-6A Sht.1 of 2	3

Plot Date: YR MT DY 20-07-13 TIME 10:01

Steam Details Tables Site3 (Option 3)(C3 Chiller).v2



Notes:
1) Blue indicates process-gas/vapour.
2) Purple indicates hydrocarbon liquid.
3) Green indicates natural gas.
4) Light blue indicates water.
5) Black indicates utility & equipment.
6) Dashed Red indicates electrical.

Stream			Unit Operation (Stream Origin)		
ID No.	Fluid Type	Physical State	Tag No.	Service	Type
1	HC	Multiphase	----	Captured Flare Gas	Flare Gas Recovery Line
2	HC	Multiphase	FS-100	Gas to Process	Flow Splitter
3	HC	Multiphase	FS-100	Excess Gas to Flare	Flow Splitter
4	HC	Gas	V-100	Inlet Scrubber	3-Phase Separator
5	HC	Liquid	V-100	Inlet Scrubber	3-Phase Separator
6	Heat Medium	Liquid	V-100	Inlet Scrubber	3-Phase Separator
7	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
8	HC	Gas	K-100	Inlet Gas Boosting	Compressor: Screw
9	Electricity	---	---	Electricity to K-100	Electric Utility System
10	Fuel Gas	Gas	---	Fuel Gas to K-100	Fuel Gas Header
11	HC	Multiphase	AC-100	Interstage Cooler	Aerial Cooler
12	HC	Gas	E-100	Gas-Gas Exchanger	Heat Exchanger
13	HC	Multiphase	E-100	Gas-Gas Exchanger	Heat Exchanger
14	HC	Gas	V-600	Cold	3-Phase Separator
15	Refrigerant (C3)	Liquid	E-200	Chiller	Heat Exchanger
16	HC	Multiphase	E-200	Chiller	Heat Exchanger
17	Refrigerant (C3)	Liquid	PR-100	Cooler	Propane Refrigerator
18	Electricity	---	PR-100	Electricity to PR-100	Electric Utility System
19	Fuel Gas	Gas	PR-100	Fuel Gas to PR-100	Fuel Gas Header
20	HC	Liquid	V-600	Cold	3-Phase Separator
21	Heat Medium	Liquid	V-600	Inlet Scrubber	3-Phase Separator
22	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
23	HC	Gas	S-100	Condensate Stabilizer	Distillation Column
24	HC	Liquid	PU-103	Reflux Pump	Pump - Centrifugal
25	HC	Liquid	S-100	Condensate Stabilizer	Distillation Column
26	Heat Medium	Liquid	S-100	Condensate Stabilizer	Distillation Column
27	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
28	HC	Liquid	PU-102	Booster Pump	Pump - Centrifugal
29	HC	Multiphase	AC-101	Reflux Condenser	Aerial Cooler
30	HC	Gas	V-300	Reflux Drum	2-Phase Separator
31	HC	Liquid	V-300	Reflux Drum	2-Phase Separator
32	HC	Liquid	PU-104	Booster Pump	Pump - Centrifugal
33	HC	Liquid	AC-102	Condensate Cooler	Aerial Cooler
34	HC	Liquid	M-200	Flow Mixer	Produced HC Liquids
35	HC	Liquid	PU-100	Booster Pump	Pump - Centrifugal
36	Heat Medium	Liquid	PU-101	Circulation Pump	Pump - Centrifugal
37	Fuel Gas	Gas	---	Fuel to H-100	Fuel Gas Header
38	Heat Medium	Liquid	H-100	Heat Medium Heater	Heater - Indirect Fired
39	HC	Gas	M-100	Flow Mixer	Produced Residue Gas
40	HC	Gas	---	Produced Gas to Fuel	Produced Gas Header
41	HC	Gas	---	Produced Gas to Sales	Produced Gas Header
42	HC	Gas	---	Produced Gas to Flare	Produced Gas Header
43	HC	Gas	---	Fuel Gas to Generator	Fuel Gas Header
44	Electricity	---	---	Electricity for Site Use	Electric Utility System
45	Electricity	---	---	Electricity to AC-100	Electric Utility System
46	Electricity	---	---	Electricity to AC-101	Electric Utility System
47	Electricity	---	---	Electricity to AC-102	Electric Utility System
48	Electricity	---	---	Electricity to PU-101	Electric Utility System
49	Electricity	---	---	Electricity to PU-102	Electric Utility System
50	Electricity	---	---	Electricity to PU-103	Electric Utility System
51	Electricity	---	---	Electricity to PU-104	Electric Utility System
52	Electricity	---	---	Electricity to PU-105	Electric Utility System

ITEM	REFERENCE FILES	REV	DATE	REVISION DESCRIPTION	BY	Discipline	Initials
1	SEE SHEET 1	1	JUN 27/2020	GENERAL ISSUE	JMT	Project Manager	D.P.
		2	JUN 29/2020	GENERAL REVISION	JMT	Process-Engineer	
		3	JUL 01/2020	GENERAL REVISION	JMT	Checked By	D.P.
						Designed By	P.S.
						Drawn By	J.T.

ENGINEER'S STAMP

CLEARSTONE ENGINEERING
Calgary Canada

DRAWING TITLE

SIMULATION FLOWSHEET DIAGRAM (SFD):
SITE 3 STAGE BATTERY (OPTION 3)
(SINGLE STAGE COMPRESSION)
Propane Refrigeration Technology
With Electricity Generation

PROJECT #.	SCALE:	CLIENT:	DRAWING IDENTIFICATION	REV
N/A	NTS	GENERAL	SFD-20-OB-OSP-AGV-049-6B Sht.2 of 2	3.1

REPORT: SOURCE MITIGATION ANALYSIS

Header Block

Row	A	B–C	D–F	G–H	I–K
2	**Client:**	TetraTech		**Operator:**	Tetra Tech
3	**Site:**	Mangghystau Oilfield		**Country:**	Kazakhstan
4	**Facility:**	**Category:**	Oil Field	**Subcategory 1:**	
5		**CEL Facility Code:**	OP-009	**Subcategory 2:**	
6	**Source:**	**Category:**	Flare	**Subcategory 1:**	Elevated
7		**CEL Equipment Code:**	OP-009-1	**Subcategory 2:**	Unassisted
8		**Tag No:**	TECH-FL-1	**Make:**	Unavailable
9		**Model:**	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed

12	**Time Series**	**CEL Mitigation Code:**	OP-009-PR	**End-Year**	**Asset Life:**	2032
13		**Start Year:**	2022		**Viability:**	2032
14	**Mitigation Measure (Stage 1)**	**Category:**	NGL Recovery	**Subcategory 1:**		Using a propane-refrigeration condenser (shallow cut) and upstream electric-drive
15		**CEL Reference Code:**	NGL-BSO-PR	**Subcategory 2:**		NGL blended into the sales oil without exceeding RVP limits.
16		**Reference CEL Drawing No:**	Unavailable	**Reference CEL Drawing Title:**		Unavailable
17	**Mitigation Measure (Stage 2)**	**Category:**	None	**Subcategory 1:**		
18		**CEL Reference Code:**		**Subcategory 2:**		
19		**Reference CEL Drawing No:**		**Reference CEL Drawing Title:**		
20	**Mitigation Measure (Stage 3)**	**Category:**	None	**Subcategory 1:**		
21		**CEL Reference Code:**		**Subcategory 2:**		
22		**Reference CEL Drawing No:**		**Reference CEL Drawing Title:**		
23		**Optimization Objective Function:**	Net Present Value Over Pay-Back Period Ratio	**Economic Scenario Name:**		None

Optimization Search Space

Row	Search Parameter	Value Chosen	Min Search Value	Max Search Value
27	**Final Cooling Temperature (°C)**	**-35.00**	-35.00	5.00
28	**Outlet Pressure (kPa)**	**300.00**	100.00	1,000.00
29	**Year-1 Peak Flow Rate Design Factor**	**1.00**	0.70	1.30
30	**Electric Generator Drive Type**	**Reciprocating**	---	---
31	**Number of Electric Generator Trains**	**2.00**	1.00	10.00

Key Findings

34	**Economic Impacts**	**Capital Cost (USD):**	3,691,462	**Net Present Value (USD) (Before Tax):**	14,368,414
35		**Project Life (Years):**	10	**Net Present Value (USD) (After Tax):**	10,855,688
36		**Asset Life Expectancy (Years):**	10	**Return on Investment (%) (Before Tax):**	389.23%
37		**Asset Salvage Value (USD):**	0	**Return on Investment (%) (After Tax):**	294.08%
38		**Payback Period (Years):**	2.02	**Internal Rate of Return (%):**	59.35%

Row	A	Value of Gas Losses (USD/y) Energy Basis	Value of Gas Losses (USD/y) Commodity Basis	Total Gas Loss (m^3/h)	Residue Gas (10^3 m^3/d)	Ethane (m^3/d liq)	LPG (m^3/d liq)	NGL (m^3/d)	Hydrogen (m^3/d)		
39–41	**Pre-Mitigation Commodity Losses**	0	30,154,630	30,104.0	512.8	439.8	311.8	32.0	0.0		

Row	A	CH_4 (kilotonnes)	CO_2 (kilotonnes)	N_2O (kilotonnes)	CO_2E (kilotonnes)	Black Carbon (kilotonnes)
42–43	**Lifetime GHG Emission Reductions**	0.0	206.8	0.0	207.5	0.2

Row	A	VOC (tonnes)	CO (tonnes)	NO_x (tonnes)	H_2S (tonnes)	SO_2 (tonnes)	PM (tonnes)	PM_{10} (tonnes)	$PM_{2.5}$ (tonnes)		
44–45	**Lifetime CAC Emission Reductions**	1,354.4	446.4	97.4	0.0	0.0	74.4	74.4	74.4		

Key Equipment Additions

Row	Key Equipment or	Reference No.	Category	Subcategory 1	Subcategory 2 or Manufacturer Make And Model
49		DPH_1	Process Heater	Dow-therm	
50		C_Recip_1_1	Compressor (Driver Excluded)	Reciprocating	
51		EM_Recip_1_1	Driver	Electric Motor	Explosion Proof
52		VFD_REC1_1	Variable Frequency Drive (VFD)		
53		AC1_1	Heat Exchanger	Air Cooler	
54		TPS1_1	Pressure Vessel	Separator	Vertical
55		NGLPR_1_1	NGL Recovery Unit	Refrigeration (Shallow-Cut) c/w Gylcol Injection a	Rich Gas (6 gpm C3+)
56		M_CIR_PUMP_1	Pump (Package)	Centrifugal	Horizontal
57		STB1_1	NGL Stabilizer		
58		ST_AC_1_1	Heat Exchanger	Air Cooler	
59		ST_AC_2_1	Heat Exchanger	Air Cooler	
60		T_BOT_PUMP_1	Pump (Package)	Centrifugal	Horizontal
61		PS1	Pipeline	Buried	

Applied Economic Parameters

64	**Financial Rates**	**Discount Rate (%):**	10.00	**Inflation Rate (%):**	3.00
65		**Depreciation Rate (%):**	10.00	**Tax Rate (%)**	20.00

	Royalty Rate (%):	30.00	Import Duty (%):	20.00
	GHG Emission Fee (USD/Tonne):	$1.10	CAC Emission Fee (USD/Tonne):	0.00
Production Decline Model	Model Type:	Initial Linear Increase	D (decline as a fraction of production):	0.0000
			b (correlation constant):	Not Applicable

Commodity Prices	Natural Gas		Ethane	LPG	NGL	Crude Oil	Hydrogen	Electricity		Diesel	Naptha
	Purchases (USD/GJ)	Sales (USD/GJ)	(USD/m^3 Liq)	(USD/L Liq)	(USD/m^3 Liq)	(USD/m^3)	(USD/m^3)	Purchases (USD/kW·h)	Sales (USD/kW·h)	(USD/L Liq)	(USD / m3 Liq)
	$ -	$ -	$ 60.26	$ 0.14	$ 389.84	$ 471.70	$ 2.00	$ 0.04	$ -	$ 0.76	

Financials (Time Series Results)

Year	Gross Revenues	Costs		Asset Book Value	Salvage Value	Royalty Payment	Emission Fee	Net Revenues		Cumulative After Tax Earnings
		Capital	Operating					Before Tax	After Tax	
	(Inflation Adjusted USD)							(Present Value USD)		
2022	4,390,455	3,691,462	102,260	3,322,316	1,268,776	1,364,402	-23,735	2,343,983	1,875,186	1,875,186
2023	4,522,168		105,328	2,990,084	1,127,801	1,405,334	-23,735	2,233,892	1,787,114	3,662,300
2024	4,657,833		108,488	2,691,076	986,826	1,447,494	-23,735	2,123,650	1,698,920	5,361,220
2025	4,797,568		111,742	2,421,968	845,851	1,490,918	-23,735	2,014,572	1,611,657	6,972,878
2026	4,941,495		115,095	2,179,771	704,876	1,535,646	-23,735	1,907,652	1,526,122	8,498,999
2027	5,089,740		118,548	1,961,794	563,901	1,581,715	-23,735	1,803,627	1,442,901	9,941,901
2028	5,242,433		122,104	1,765,615	422,925	1,629,167	-23,735	1,703,027	1,362,421	11,304,322
2029	5,101,356		125,767	1,589,053	281,950	1,585,341	-22,423	1,509,669	1,207,736	12,512,057
2030	4,838,539		129,540	1,430,148	140,975	1,503,688	-20,649	1,300,731	1,040,585	13,552,642
2031	4,584,927		133,426	1,287,133	0	1,424,894	-18,997	1,119,073	895,259	14,447,901
Last Profitable Year (After Asset Liquidation, Final Tax Adjustments and Closing Book Entries)										
2031	4,584,927	999	133,426	1,287,133	0	1,424,894	-18,997	1,119,073	994,508	14,547,150

Avoided GHG and BC Emissions (Time Series Results)

Year	CH_4 (kt)	CO_2 (kt)	N_2O (kt)	CO_2E (kt)	Black Carbon (t)
2022	0.0	21.5	0.0	21.6	19.4
2023	0.0	21.5	0.0	21.6	19.4
2024	0.0	21.5	0.0	21.6	19.4
2025	0.0	21.5	0.0	21.6	19.4
2026	0.0	21.5	0.0	21.6	19.4
2027	0.0	21.5	0.0	21.6	19.4
2028	0.0	21.5	0.0	21.6	19.4
2029	0.0	20.3	0.0	20.4	18.3
2030	0.0	18.7	0.0	18.8	16.9
2031	0.0	17.2	0.0	17.3	15.5

Other Avoided Atmospheric Emissions (Time Series Results)

Year	VOC (t)	CO (t)	NO_x (t)	H_2S (t)	SO_2 (t)	PM (t)	PM_{10} (t)	$PM_{2.5}$ (t)
2022	0.1	0.0	0.0	0.0	0.0	7.7	7.7	7.7
2023	0.1	0.0	0.0	0.0	0.0	7.7	7.7	7.7
2024	0.1	0.0	0.0	0.0	0.0	7.7	7.7	7.7
2025	0.1	0.0	0.0	0.0	0.0	7.7	7.7	7.7
2026	0.1	0.0	0.0	0.0	0.0	7.7	7.7	7.7
2027	0.1	0.0	0.0	0.0	0.0	7.7	7.7	7.7
2028	0.1	0.0	0.0	0.0	0.0	7.7	7.7	7.7
2029	0.1	0.0	0.0	0.0	0.0	7.3	7.3	7.3
2030	0.1	0.0	0.0	0.0	0.0	6.7	6.7	6.7
2031	0.1	0.0	0.0	0.0	0.0	6.2	6.2	6.2

Forecast Site Activity Data (Time Series Results - Part 1)

Year	Production			Waste Gas Disposition			Incremental Energy Purchases			
	Oil (10^3 m^3)	Gas (10^6 m^3)	Water (10^3 m^3)	Collected (10^6 m^3)	Conserved (10^6 m^3)	Flared (10^6 m^3)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)
2022	960.72	263.71		263.71	2.24	261.48	0.00	0.00	0.00	4,040
2023	960.72	263.71		263.71	2.24	261.48	0.00	0.00	0.00	4,040
2024	960.72	263.71		263.71	2.24	261.48	0.00	0.00	0.00	4,040
2025	960.72	263.71		263.71	2.24	261.48	0.00	0.00	0.00	4,040
2026	960.72	263.71		263.71	2.24	261.48	0.00	0.00	0.00	4,040
2027	960.72	263.71		263.71	2.24	261.48	0.00	0.00	0.00	4,040
2028	960.72	263.71		263.71	2.24	261.48	0.00	0.00	0.00	4,040
2029	883.87	242.62		242.61	2.11	240.50	0.00	0.00	0.00	3,818
2030	813.16	223.21		223.20	1.95	221.26	0.00	0.00	0.00	3,517
2031	748.10	205.35		205.35	1.79	203.56	0.00	0.00	0.00	3,237

Forecast Site Activity Data (Time Series Results - Part 2)

	A	B	C	D	E	F	G	H	I	J	K
134	Year	Incremental Product Sales					Incremental Utilization	Avoided Purchases			
135		Gas (10^6 m^3 Gas)	LPG (10^3 m^3 Liq)	NGL (10^3 m^3 Liq)	Oil (10^3 m^3)	Electricity (10^3 kW·h)	Fuel Gas (10^6 m^3 Gas)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)
136	2022	0.00	0.00	0.00	9.64	0	0.26	0.00	0.00	0	0.00
137	2023	0.00	0.00	0.00	9.64	0	0.26	0.00	0.00	0	0.00
138	2024	0.00	0.00	0.00	9.64	0	0.26	0.00	0.00	0	0.00
139	2025	0.00	0.00	0.00	9.64	0	0.26	0.00	0.00	0	0.00
140	2026	0.00	0.00	0.00	9.64	0	0.26	0.00	0.00	0	0.00
141	2027	0.00	0.00	0.00	9.64	0	0.26	0.00	0.00	0	0.00
142	2028	0.00	0.00	0.00	9.64	0	0.26	0.00	0.00	0	0.00
143	2029	0.00	0.00	0.00	9.11	0	0.24	0.00	0.00	0	0.00
144	2030	0.00	0.00	0.00	8.39	0	0.22	0.00	0.00	0	0.00
145	2031	0.00	0.00	0.00	7.72	0	0.21	0.00	0.00	0	0.00
146											

147	Applied Emission Factors (EF) For Year One Emissions For Baseline (BL) and Simulated Equipment							
148	Source			Pollutant	EF (ng/J of Fuel)	Reference (Where Applicable) and Basis		
149	Category	Tag No.	DB EF Key			Basis	Author or Reporting Agency	Code
150	**Flares**	**BL FLARE_1**	**335**	CH_4	180.0	Calculated	US EPA	2018-U.S.EPAAP-42Table13.5-1
151				CO_2	54,529.6	Calculated	NA	
152				N_2O	0.1	Referenced	WCI	2012-BCWCI.363(k)
153				BC	19.7	Calculated	NA	
154				VOC	22.3	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
155				CO	133.0	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
156				NO_x	29.2	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-1
157				SO_2	0.0	Calculated	NA	
158				PM	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
159				PM_{10}	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
160				$PM_{2.5}$	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
161	**Heaters and Boilers**	**DPH_1**	**7**	CH_4	1.0	Calculated	US EPA	1998-U.S.EPAAP-42Table1.4-2
162				CO_2	54,283.7	Calculated	NA	
163				N_2O	0.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
164				BC	0.6	Calculated	NA	
165				VOC	2.3	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-2
166				CO	35.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
167				NO_x	13.0	Referenced	US EPA	1998-U.S.EPAAP-42Table1.4-1
168				SO_2	0.0	Calculated	NA	
169				PM	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
170				PM_{10}	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
171				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and	2018-CEPEITable1
172	**Flares**	**FLARE_1**	**335**	CH_4	185.1	Calculated	US EPA	2018-U.S.EPAAP-42Table13.5-1
173				CO_2	54,283.7	Calculated	NA	
174				N_2O	0.1	Referenced	WCI	2012-BCWCI.363(k)
175				BC	18.6	Calculated	NA	
176				VOC	22.3	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
177				CO	133.0	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-2
178				NO_x	29.2	Referenced	US EPA	2018-U.S.EPAAP-42Table13.5-1
179				SO_2	0.0	Calculated	NA	
180				PM	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
181				PM_{10}	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
182				$PM_{2.5}$	22.0	Referenced	US EPA	1991-EPAFire6.22.Flaringlandfillgas
183								

184	Capital Cost									
185	Equipment	Item	Category	Subcategory 1	Subcategory 2	Capacity or Rated Power Output		Price (USD)	FOB Point	Basis
186						Value	Units of Measure			
187		DPH_1	Process Heater	Dow-therm		317.60	kW	104,126	NA	Predicted (Class 5)
188		C_Recip_1_1	Compressor (Driver Excluded)	Reciprocating		26.39	kW	27,103	NA	Predicted (Class 4)
189		EM_Recip_1_1	Driver	Electric Motor	Explosion Proof	34.36	kW	37,783	NA	Predicted (Class 4)
190		VFD_REC1_1	Variable Frequency Drive (VFD)			38.17	kW	8,206	NA	Predicted (Class 4)
191		AC1_1	Heat Exchanger	Air Cooler		10.00	m²	49,177	NA	Predicted (Class 4)
192		TPS1_1	Pressure Vessel	Separator	Vertical	1.94	m³	21,819	NA	Predicted (Class 4)

	A	B	C	D	E	F	G	H	I	J	K	L
193		NGLPR_1_1	NGL Recovery Unit	Refrigeration (Shallow-Cut) c/w Gylcol Injection and Stabilizer	Rich Gas (6 gpm C3+)	52.60	m^3/h	201,637	NA	Predicted (Class 5)		
194		HM_CIR_PUMP 1_1	Pump (Package)	Centrifugal	Horizontal	3.70	kW	3,198	NA	Predicted (Class 4)		
195		STB1_1	NGL Stabilizer			3.04	m^3/h	838,466	NA	Predicted (Class 5)		
196		ST_AC_1_1	Heat Exchanger	Air Cooler		10.00	m^2	49,177	NA	Predicted (Class 4)		
197		ST_AC_2_1	Heat Exchanger	Air Cooler		10.00	m^2	49,177	NA	Predicted (Class 4)		
198		ST_BOT_PUMP 1_1	Pump (Package)	Centrifugal	Horizontal	1.49	kW	1,635	NA	Predicted (Class 4)		
199		PS1	Pipeline	Buried		0.10	km	18,249	NA	Predicted (Class 5)		
200		**E7**	**Engineering & Drafting**					219,245				
201		**Subtotal:**						1,628,996				
202	**Pipeline**	**Pipe Specifications**	**OD (mm)**			**Material:**			**Design P (kPa)**			
203			**WT (mm)**			**Length (km):**			**Coating:**			
204		**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
205		**PL1**	**Pipe**									
206		**PL2**	**Right-of-Way (ROW)**									
207		**PL3**	**ROW Land Survey**									
208		**PL4**	**Clearing**									
209		**PL5**	**Soil Stripping**									
210		**PL6**	**Timber Salvage**									
211		**PL7**	**Rock excavation**									
212		**PL8**	**Cathodic Protection**									
213		**PL9**	**Construction**									
214		**PL10**	**Engineering & Drafting**									
215		**PL11**	**Supervision**									
216		**PL12**	**Safety**									
217		**PL13**	**Reseeding ROW**									
218		**Subtotal:**										
219	**Materials & Services**	**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
220		**MS1**	**Equipment Setting**		0	188,981		188,981		Predicted		
221		**MS2**	**Foundations**		54,137	72,002		126,138		Predicted		
222		**MS3**	**Structural Steel**		54,001	27,000		81,001		Predicted		
223		**MS4**	**Buildings**		32,400	32,400		64,801		Predicted		
224		**MS5**	**Insulation**		10,800	16,200		27,000		Predicted		
225		**MS6**	**Instruments**		64,937	25,975		90,911		Predicted		
226		**MS7**	**Electrical**		86,537	64,903		151,440		Predicted		
227		**MS8**	**Piping**		485,325	242,662		727,987		Predicted		
228		**MS9**	**Painting**		5,400	16,200		21,600		Predicted		
229		**MS10**	**Miscellaneous**		32,536	28,481		61,018		Predicted		
230		**MS11**	**Engineering & Drafting**		0	239,638		239,638		Predicted		
231		**MS12**	**Supervision**		Unavailable	0		0				
232		**MS13**	**Safety**		Unavailable	0		0				
233		**Subtotal:**						1,780,515				
234	**Summary**	**Total:**						3,409,512				
235		**Duties:**						281,950				
236		**Freight:**						Unavailable				
237		**Grand Total:**						3,691,462				
238						**Year 1 Operating Costs**						
239		**Operating Labour**	**Hours Per Shift:**	Unknown		**Operator Hourly Labour Rate:**		$ 2.05				
240			**Shifts Per Day:**	Unknown		**Maintenance Hourly Labour Rate:**		$ 2.05				
241		**Item**	**Category**		**Material (USD**	**Labour (Hours)**	**Labour (USD)**	**Line Total (USD)**		**Basis**		
242	**Fixed O&M Costs**	**L1**	**Operating Labour**		0	3,720	7,626	7,626		Predicted		
243		**L2**	**Maintenance Labour**		0	1,740	3,567	3,567		Predicted		
244		**L3**	**Direct Supervision**		0		1,373	1,373		Predicted		
245		**L4**	**Administration**		0		34,573	34,573		Predicted		
246		**L5**	**Unclassified Costs**					0		Predicted		
247		**Total Fixed O&M Costs:**						47,139		Predicted		
248	**Variable O&M Costs**	**SS1**	**Third-Party Services**					22,260		Predicted		
249		**SS2**	**Parts & Consumables**					29,432		Predicted		
250		**SS3**	**Unclassified Costs**					0		Predicted		
251		**Total Variable O&M Costs:**						51,692		Predicted		
252	**Total O&M Costs**	**Total Fixed and Variable O&M Costs:**						98,831		Predicted		

	A	B	C	D	E	F	G	H	I	J	K	L
253	**Purchased Commodities**	**PC1**	**Electricity**		157,550	0	0	157,550		Predicted		
254		**PC2**	**Natural Gas**		0	0	0	0		Predicted		
255		**PC3**	**LPG**		0	0	0	0		Predicted		
256		**PC4**	**Diesel**		0	0	0	0		Predicted		
257	**Summary**	**Total:**						256,381				

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PR	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Proposed Equipment

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PR	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	1	2	3	4	5	6	7	8
- Fluid	HC	HC	HC	HC	HC	Heat Medium	Heat Medium	HC
- Physical State	Vapour	Vapour	Vapour	Vapour	Liquid	Liquid	Liquid	Vapour
- Temperature (°C)	40.00	40.00	40.00	40.00	---	120.00	120.00	42.05
- Pressure (kPa)	800.0	800.0	800.0	800.0	---	276.0	276.0	826.9
- Total Molar Flowrate (kmole/h)	1,273.17	1,238.64	34.53	1,238.64	0.00	0.00	0.00	1,238.64
- Total Mass Flowrate (kg/h)	30176.9	29358.5	818.5	29358.5	0.0	0.0	0.0	29358.5
- Total Gas Volumetric Flowrate (Std m^3/h)	30104.0	29287.5	816.5	29287.5	---	---	---	29287.5
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	0.0	0.0	---

- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	From Flare Line	FS-100	FS-100	V-100	V-100	V-100	H-100	K-100
- Service:	---	Not Applicable	Not Applicable	Inlet Scrubber	Inlet Scrubber	Inlet Scrubber	Boiler	Inlet Gas Boosting
- Type:	---	Flow Splitter	Flow Splitter	3-Phase Separator	3-Phase Separator	3-Phase Separator	Heater	Compressor: Recip.
Destination (Unit Operation):								
- Tag No.	FS-100	V-100	To Flare Line	K-100	PU-105	PU-101	V-100	AC-100
- Service:	Not Applicable	Inlet Scrubber	---	Inlet Gas Boosting	Booster	Circulation	Inlet Scrubber	Discharge Cooler
- Type:	Flow Splitter	3-Phase Separator	---	Compressor: Recip.	Pump	Pump	3-Phase Separator	Aerial Cooler
Properties:	1	2	3	4	5	6	7	8
- Vapour Mole Fraction	1.000000	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000	1.000000
- Liquid Mole Fraction	0.000000	0.000000	0.000000	0.000000	1.000000	1.000000	1.000000	0.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	23.702	23.702	23.702	23.702	---	41.686	41.686	23.702
- Mass Density (kg/m^3)	8.439	8.439	8.439	8.439	---	1,025.000	1,025.000	8.638
- Molar Density (kmole/m^3)	0.356	0.356	0.356	0.356	---	---	---	0.364
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	0.9669	0.9669	0.9669	0.9669	---	---	---	0.9666
- Specific Heat Capacity (kJ/kmole·°C)	46.7971	46.7971	46.7971	46.7971	---	135.4802	135.4802	46.9687
- Enthalpy (kJ/kmole)	-85,487	-85,487	-85,487	-85,487	---	---	---	-85,399
- Entropy (kJ/kmole·°C)	-202	-202	-202	-202	---	---	---	-202
- Gross Heating Value (MJ/m^3)	48.3	48.3	48.3	48.3	---	---	---	48.3
- Net Heating Value (MJ/m^3)	43.3	43.3	43.3	43.3	---	---	---	43.3
- Sound Speed (m/s)	359.316	359.316	359.316	359.316	---	---	---	360.310
- Dew Point Temperature (°C)	40.00	40.00	40.00	40.00	---	---	---	42.05
- Dew Point Pressure (°kPa)	896.4	896.4	896.4	896.4	---	---	---	923.2
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	0.033	0.033	0.033	0.033	---	---	---	0.034
- Viscosity (cp)	0.012	0.012	0.012	0.012	---	1.100	1.100	0.012

Composition (Mole Fraction):			1	2	3	4	5	6	7	8
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043380	0.043380	0.043380	0.043380	---	---	---	0.043380
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.000000	0.000000	---	0.462700	0.462700	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	0.025205	0.025205	0.025205	0.025205	---	---	---	0.025205
Methane	**CH4**	**74-82-8**	0.641174	0.641174	0.641174	0.641174	---	---	---	0.641174
Ethane	**C2H6**	**74-84-0**	0.171376	0.171376	0.171376	0.171376	---	---	---	0.171376
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	---	---	---	0.537300	0.537300	---
Propane	**C3H8**	**74-98-6**	0.084805	0.084805	0.084805	0.084805	---	---	---	0.084805
i-Butane	**C4H10**	**75-28-5**	0.007275	0.007275	0.007275	0.007275	---	---	---	0.007275
n-Butane	**C4H10**	**106-97-8**	0.017510	0.017510	0.017510	0.017510	---	---	---	0.017510
i-Pentane	**C5H12**	**78-78-4**	0.002545	0.002545	0.002545	0.002545	---	---	---	0.002545
n-Pentane	**C5H12**	**109-66-0**	0.003010	0.003010	0.003010	0.003010	---	---	---	0.003010
Benzene	**C6H6**	**71-43-2**	0.000100	0.000100	0.000100	0.000100	---	---	---	0.000100
Cyclohexane	**C6H12**	**110-82-7**	0.000175	0.000175	0.000175	0.000175	---	---	---	0.000175

Hexane	**C6H14**	**110-54-3**	0.000745	0.000745	0.000745	0.000745	---	---	---	0.000745
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.000170	0.000170	0.000170	---	---	---	0.000170
Heptane	**C7H16**	**142-82-5**	0.001975	0.001975	0.001975	0.001975	---	---	---	0.001975
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.000190	0.000190	0.000190	---	---	---	0.000190
Toluene	**C7H8**	**108-88-3**	0.000165	0.000165	0.000165	0.000165	---	---	---	0.000165
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000005	0.000005	0.000005	---	---	---	0.000005
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.000040	0.000040	0.000040	---	---	---	0.000040
Octane	**C8H18**	**111-65-9**	0.000075	0.000075	0.000075	0.000075	---	---	---	0.000075
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000005	0.000005	0.000005	---	---	---	0.000005
Nonane	**C9H20**	**111-84-2**	0.000035	0.000035	0.000035	0.000035	---	---	---	0.000035
Decane	**C10H22**	**124-18-5**	0.000020	0.000020	0.000020	0.000020	---	---	---	0.000020
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000015	0.000015	0.000015	---	---	---	0.000015
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000005	0.000005	0.000005	---	---	---	0.000005

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PR	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	9	10	11	12	13	14	15	16
- Fluid	Electricity	Fuel Gas	HC	HC	HC	HC	Refrigerant (C_3)	HC
- Physical State	Unknown	Gas	Vapour	Vapour	Multiphase	Vapour	Vapour	Multiphase
- Temperature (°C)	---	29.90	39.90	29.90	-15.75	-35.00	-40.00	-35.00
- Pressure (kPa)	---	399.9	700.0	400.0	600.0	500.0	14.6	500.0
- Total Molar Flowrate (kmole/h)	---	0.00	1,238.64	1,199.95	1,238.64	1,199.95	80.68	1,238.64
- Total Mass Flowrate (kg/h)	---	0.0	29358.5	27214.6	29358.5	27214.6	7115.5	29358.5
- Total Gas Volumetric Flowrate	---	0.0	29287.5	28372.7	---	28372.7	1907.7	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	---

- Energy Flowrate kW	37.199	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	Electric Utility System	Fuel Gas Header	AC-100	E-100	E-100	V-600	E-200	E-200
- Service:	---	---	Discharge Cooler	Gas-Gas Exchanger	Gas-Gas Exchanger	Cold	Chiller	Chiller
- Type:	---	---	Aerial Cooler	Heat Exchanger:	Heat Exchanger:	3-Phase Separator	Head Exchanger	Head Exchanger
Destination (Unit Operation):								
- Tag No.	K-100	K-100	E-100	M-100	E-200	E-100	PR-100	V-600
- Service:	Inlet Gas Boosting	Inlet Gas Boosting	Gas-Gas Exchanger	Not Applicable	Chiller	Gas-Gas Exchanger	Chiller	Cold
- Type:	Compressor: Recip.	Compressor: Recip.	Heat Exchanger: Shell and Tube	Mixer	Head Exchanger	Heat Exchanger: Shell and Tube	Cooler	3-Phase Separator
Properties:	9	10	11	12	13	14	15	16
- Vapour Mole Fraction	---	1.000000	1.000000	1.000000	0.990882	1.000000	1.000000	0.968766
- Liquid Mole Fraction	---	0.000000	0.000000	0.000000	0.009118	0.000000	0.000000	0.031234
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	---	---	23.702	22.680	23.702	22.680	---	23.702
- Mass Density (kg/m^3)	---	---	7.472	4.552	8.149	7.159	13.255	7.716
- Molar Density (kmole/m^3)	---	---	0.315	0.201	0.344	0.316	---	0.326
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	---	0.9706	0.9815	---	0.9542	---	---
- Specific Heat Capacity (kJ/kmole·°C)	---	---	46.6222	43.8435	---	40.8558	---	---
- Enthalpy (kJ/kmole)	---	---	-85,461	-84,660	-88,150	-87,435	---	-89,370
- Entropy (kJ/kmole·°C)	---	---	-201	-192	-209	-203	---	-213
- Gross Heating Value (MJ/m^3)	---	---	48.3	46.1	48.3	46.1	---	48.3
- Net Heating Value (MJ/m^3)	---	---	43.3	41.3	43.3	41.3	---	43.3
- Sound Speed (m/s)	---	---	360.063	366.884	320.378	323.265	---	300.660
- Dew Point Temperature (°C)	---	---	39.90	29.90	---	-35.00	---	---
- Dew Point Pressure (°kPa)	---	---	796.4	496.4	---	596.4	---	---
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	---	0.033	0.032	0.025	0.023	---	0.023
- Viscosity (cp)	---	---	0.012	0.012	0.010	0.010	0.000	0.010

Composition (Mole Fraction):			9	10	11	12	13	14	15	16
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	0.044759	0.043380	0.044759	0.043380	0.044759	---	0.043380
Water	**H2O**	**7732-18-5**	---	0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	0.025808	0.025205	0.025808	0.025205	0.025808	---	0.025205
Methane	**CH4**	**74-82-8**	---	0.660679	0.641174	0.660679	0.641174	0.660679	---	0.641174
Ethane	**C2H6**	**74-84-0**	---	0.173186	0.171376	0.173186	0.171376	0.173186	---	0.171376
Propane	**C3H8**	**74-98-6**	---	0.078104	0.084805	0.078104	0.084805	0.078104	1.000000	0.084805
i-Butane	**C4H10**	**75-28-5**	---	0.005161	0.007275	0.005161	0.007275	0.005161	---	0.007275
n-Butane	**C4H10**	**106-97-8**	---	0.010691	0.017510	0.010691	0.017510	0.010691	---	0.017510
i-Pentane	**C5H12**	**78-78-4**	---	0.000775	0.002545	0.000775	0.002545	0.000775	---	0.002545
n-Pentane	**C5H12**	**109-66-0**	---	0.000759	0.003010	0.000759	0.003010	0.000759	---	0.003010
Benzene	**C6H6**	**71-43-2**	---	0.000001	0.000100	0.000001	0.000100	0.000001	---	0.000100
Cyclohexane	**C6H12**	**110-82-7**	---	0.000008	0.000175	0.000008	0.000175	0.000008	---	0.000175
Hexane	**C6H14**	**110-54-3**	---	0.000033	0.000745	0.000033	0.000745	0.000033	---	0.000745

Methylcyclopentane	**C6H12**	**96-37-7**	---	0.000009	0.000170	0.000009	0.000170	0.000009	---	0.000170
Heptane	**C7H16**	**142-82-5**	---	0.000023	0.001975	0.000023	0.001975	0.000023	---	0.001975
Methylcyclohexane	**C7H14**	**108-87-2**	---	0.000003	0.000190	0.000003	0.000190	0.000003	---	0.000190
Toluene	**C7H8**	**108-88-3**	---	0.000002	0.000165	0.000002	0.000165	0.000002	---	0.000165
Ethylbenzene	**C8H10**	**100-41-4**	---	0.000000	0.000005	0.000000	0.000005	0.000000	---	0.000005
m-Xylene	**C8H10**	**108-38-3**	---	0.000000	0.000040	0.000000	0.000040	0.000000	---	0.000040
Octane	**C8H18**	**111-65-9**	---	0.000000	0.000075	0.000000	0.000075	0.000000	---	0.000075
o-Xylene	**C8H10**	**95-47-6**	---	0.000000	0.000005	0.000000	0.000005	0.000000	---	0.000005
Nonane	**C9H20**	**111-84-2**	---	0.000000	0.000035	0.000000	0.000035	0.000000	---	0.000035
Decane	**C10H22**	**124-18-5**	---	0.000000	0.000020	0.000000	0.000020	0.000000	---	0.000020
Undecanes	**C11H24**	**1120-21-4**	---	0.000000	0.000015	0.000000	0.000015	0.000000	---	0.000015
Dodecane	**C12H26**	**112-40-3**	---	0.000000	0.000005	0.000000	0.000005	0.000000	---	0.000005

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PR	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	17	18	19	20	21	22	23	24
- Fluid	Refrigerant (C_3)	Electricity	Fuel Gas	HC	Heat Medium	Heat Medium	HC	HC
- Physical State	Liquid	Unknown	Gas	Liquid	Liquid	Liquid	Vapour	Liquid
- Temperature (°C)	-40.00	---	29.90	-35.00	120.00	120.00	105.00	---
- Pressure (kPa)	14.6	---	399.9	500.0	276.0	276.0	357.5	---
- Total Molar Flowrate (kmole/h)	80.68	---	0.00	38.69	0.00	0.00	29.14	---
- Total Mass Flowrate (kg/h)	7115.5	---	0.0	2143.9	0.0	0.0	1346.3	---
- Total Gas Volumetric Flowrate (Sm^3/h)	---	---	0.0	---	---	---	688.9	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	3.3	0.0	0.0	---	---

- Energy Flowrate kW	---	419.928	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	PR-100	Electric Utility System	Fuel Gas Header	V-600	V-600	H-100	S-100	PU-103
- Service:	Chiller	---	---	Cold	Cold	Boiler	Condensate	Reflux
- Type:	Cooler	---	---	3-Phase Separator	3-Phase Separator	Heater	Stabilizer: Distillation	Pump
Destination (Unit Operation):								
- Tag No.	E-200	PR-100	PR-100	PU-102	PU-101	V-600	AC-101	S-100
- Service:	Chiller	Chiller	Chiller	Booster	Circulation	Cold	Overhead Condenser	Condensate
- Type:	Head Exchanger	Cooler	Cooler	Pump: Centrifugal	Pump	3-Phase Separator	Aerial Cooler	Stabilizer: Distillation Column
Properties:	17	18	19	20	21	22	23	24
- Vapour Mole Fraction	0.000000	---	1.000000	0.000000	0.000000	0.000000	1.000000	0.000000
- Liquid Mole Fraction	1.000000	---	0.000000	1.000000	1.000000	1.000000	0.000000	1.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	---	---	---	55.414	41.686	41.686	46.210	---
- Mass Density (kg/m^3)	578.250	---	---	655.768	1,025.000	1,025.000	6.956	---
- Molar Density (kmole/m^3)	---	---	---	11.834	---	---	0.151	---
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	---	---	0.0255	---	---	0.9589	---
- Specific Heat Capacity (kJ/kmole·°C)	---	---	---	113.0690	135.4802	135.4802	95.2963	---
- Enthalpy (kJ/kmole)	---	---	---	-149,378	---	---	-105,264	---
- Entropy (kJ/kmole·°C)	---	---	---	-508	---	---	-342	---
- Gross Heating Value (MJ/m^3)	---	---	---	116.1	---	---	97.8	---
- Net Heating Value (MJ/m^3)	---	---	---	106.1	---	---	89.1	---
- Sound Speed (m/s)	---	---	---	995.581	---	---	263.924	---
- Dew Point Temperature (°C)	---	---	---	---	---	---	105.00	---
- Dew Point Pressure (°kPa)	---	---	---	---	---	---	453.8	---
- Bubble Point Temperature (°C)	---	---	---	-35.00	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	596.4	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	1,910.4	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	596.4	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	---	---	0.150	---	---	0.031	---
- Viscosity (cp)	---	---	---	0.299	1.100	1.100	0.012	---

Composition (Mole Fraction):			17	18	19	20	21	22	23	24
Name	**Formula**	**CAS No.**								
Nitrogen	**N_2**	**7727-37-9**	---	---	0.044759	0.000604	---	---	0.000802	---
Water	**H_2O**	**7732-18-5**	---	---	0.000000	0.000000	0.462700	0.462700	0.000000	---
Carbon Dioxide	**CO_2**	**124-38-9**	---	---	0.025808	0.006508	---	---	0.008642	---
Methane	**CH_4**	**74-82-8**	---	---	0.660679	0.036201	---	---	0.048070	---
Ethane	**C_2H_6**	**74-84-0**	---	---	0.173186	0.115250	---	---	0.153038	---
Ethylene Glycol	**$C_2H_6O_2$**	**107-21-1**	---	---	---	---	0.537300	0.537300	---	---
Propane	**C_3H_8**	**74-98-6**	1.000000	---	0.078104	0.292650	---	---	0.388604	---
i-Butane	**C_4H_{10}**	**75-28-5**	---	---	0.005161	0.072855	---	---	0.096742	---
n-Butane	**C_4H_{10}**	**106-97-8**	---	---	0.010691	0.229014	---	---	0.304102	---
i-Pentane	**C_5H_{12}**	**78-78-4**	---	---	0.000775	0.057443	---	---	---	---
n-Pentane	**C_5H_{12}**	**109-66-0**	---	---	0.000759	0.072823	---	---	---	---
Benzene	**C_6H_6**	**71-43-2**	---	---	0.000001	0.003161	---	---	---	---
Cyclohexane	**C_6H_{12}**	**110-82-7**	---	---	0.000008	0.005366	---	---	---	---

Hexane	**C6H14**	**110-54-3**	---	---	0.000033	0.022820	---	---	---	---
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	0.000009	0.005156	---	---	---	---
Heptane	**C7H16**	**142-82-5**	---	---	0.000023	0.062530	---	---	---	---
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	0.000003	0.005995	---	---	---	---
Toluene	**C7H8**	**108-88-3**	---	---	0.000002	0.005231	---	---	---	---
Ethylbenzene	**C8H10**	**100-41-4**	---	---	0.000000	0.000160	---	---	---	---
m-Xylene	**C8H10**	**108-38-3**	---	---	0.000000	0.001278	---	---	---	---
Octane	**C8H18**	**111-65-9**	---	---	0.000000	0.002395	---	---	---	---
o-Xylene	**C8H10**	**95-47-6**	---	---	0.000000	0.000160	---	---	---	---
Nonane	**C9H20**	**111-84-2**	---	---	0.000000	0.001120	---	---	---	---
Decane	**C10H22**	**124-18-5**	---	---	0.000000	0.000640	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	---	---	0.000000	0.000480	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	---	---	0.000000	0.000160	---	---	---	---

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PR	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	25	26	27	28	29	30	31	32
- Fluid	HC	Heat Medium	Heat Medium	HC	HC	HC	HC	HC
- Physical State	Liquid	Liquid	Liquid	Liquid	Multiphase	Gas	Liquid	Liquid
- Temperature (°C)	105.00	115.00	120.00	-35.00	39.90	39.90	---	105.00
- Pressure (kPa)	357.5	276.0	276.0	500.0	257.5	257.5	---	657.5
- Total Molar Flowrate (kmole/h)	9.55	1,642.07	1,642.07	38.69	29.14	29.14	---	9.55
- Total Mass Flowrate (kg/h)	797.5	68451.8	68451.8	2143.9	1346.3	1346.3	---	797.5
- Total Gas Volumetric Flowrate (Std m^3/h)	---	---	---	---	---	688.9	---	---
- Total Liq Volumetric Flowrate (m^3/h)	1.4	66.8	66.8	3.3	---	---	---	1.4

- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	S-100	S-100	H-100	PU-102	AC-101	V-300	V-300	PU-104
- Service:	Condensate	Condensate	Boiler	Booster	Overhead Condenser	Reflux Drum	Reflux Drum	Booster
- Type:	Stabilizer: Distillation	Stabilizer: Distillation	Heater	Pump: Centrifugal	Aerial Cooler	2-Phase Separator	2-Phase Separator	Pump
Destination (Unit Operation):								
- Tag No.	PU-104	PU-101	S-100	S-100	V-300	M-100	PU-103	AC-102
- Service:	Booster	Circulation	Condensate	Condensate	Reflux Drum	Not Applicable	Reflux	Bottoms Cooler
- Type:	Pump	Pump	Stabilizer: Distillation Column	Stabilizer: Distillation Column	2-Phase Separator	Mixer	Pump	Aerial Cooler
Properties:	25	26	27	28	29	30	31	32
- Vapour Mole Fraction	0.000000	0.000000	0.000000	0.000000	---	1.000000	0.000000	0.000000
- Liquid Mole Fraction	1.000000	1.000000	1.000000	1.000000	---	0.000000	1.000000	1.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	83.488	41.686	41.686	55.414	---	---	---	83.488
- Mass Density (kg/m^3)	586.612	1,025.000	1,025.000	655.768	---	---	---	586.612
- Molar Density (kmole/m^3)	7.026	---	---	11.834	---	---	---	7.026
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	0.0355	---	---	0.0255	---	---	---	0.0355
- Specific Heat Capacity (kJ/kmole·°C)	217.8930	135.4802	135.4802	113.0690	---	---	---	217.8930
- Enthalpy (kJ/kmole)	-167,475	---	---	-149,378	---	---	---	-167,475
- Entropy (kJ/kmole·°C)	-631	---	---	-508	---	---	---	-631
- Gross Heating Value (MJ/m^3)	171.9	---	---	116.1	---	97.8	---	171.9
- Net Heating Value (MJ/m^3)	158.0	---	---	106.1	---	89.1	---	158.0
- Sound Speed (m/s)	557.222	---	---	995.581	---	---	---	557.222
- Dew Point Temperature (°C)	---	---	---	---	---	---	---	---
- Dew Point Pressure (°kPa)	---	---	---	---	---	---	---	---
- Bubble Point Temperature (°C)	105.00	---	---	-35.00	---	---	---	105.00
- Bubble Point Pressure (kPa)	783.8	---	---	596.4	---	---	---	783.8
- Reid Vapour Pressure (kPa)	1,705.3	---	---	1,910.4	---	---	---	1,705.3
- True Vapour Pressure (kPa)	783.8	---	---	596.4	---	---	---	783.8
- Thermal Conductivity (W/m·°C)	0.093	---	---	0.150	---	---	---	0.093
- Viscosity (cp)	0.147	1.100	1.100	0.299	---	---	---	0.147

Composition (Mole Fraction):			25	26	27	28	29	30	31	32
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	---	0.000604	0.000802	0.000802	---	---
Water	**H2O**	**7732-18-5**	0.000000	0.462700	0.462700	0.000000	0.000000	0.000000	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	---	0.006508	0.008642	0.008642	---	---
Methane	**CH4**	**74-82-8**	---	---	---	0.036201	0.048070	0.048070	---	---
Ethane	**C2H6**	**74-84-0**	---	---	---	0.115250	0.153038	0.153038	---	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	0.537300	0.537300	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	---	---	0.292650	0.388604	0.388604	---	---
i-Butane	**C4H10**	**75-28-5**	---	---	---	0.072855	0.096742	0.096742	---	---
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.229014	0.304102	0.304102	---	---
i-Pentane	**C5H12**	**78-78-4**	0.232640	---	---	0.057443	---	---	---	0.232640
n-Pentane	**C5H12**	**109-66-0**	0.294927	---	---	0.072823	---	---	---	0.294927
Benzene	**C6H6**	**71-43-2**	0.012803	---	---	0.003161	---	---	---	0.012803
Cyclohexane	**C6H12**	**110-82-7**	0.021731	---	---	0.005366	---	---	---	0.021731

Hexane	**C6H14**	**110-54-3**	0.092418	---	---	0.022820	---	---	---	0.092418
Methylcyclopentane	**C6H12**	**96-37-7**	0.020882	---	---	0.005156	---	---	---	0.020882
Heptane	**C7H16**	**142-82-5**	0.253242	---	---	0.062530	---	---	---	0.253242
Methylcyclohexane	**C7H14**	**108-87-2**	0.024279	---	---	0.005995	---	---	---	0.024279
Toluene	**C7H8**	**108-88-3**	0.021185	---	---	0.005231	---	---	---	0.021185
Ethylbenzene	**C8H10**	**100-41-4**	0.000647	---	---	0.000160	---	---	---	0.000647
m-Xylene	**C8H10**	**108-38-3**	0.005178	---	---	0.001278	---	---	---	0.005178
Octane	**C8H18**	**111-65-9**	0.009700	---	---	0.002395	---	---	---	0.009700
o-Xylene	**C8H10**	**95-47-6**	0.000647	---	---	0.000160	---	---	---	0.000647
Nonane	**C9H20**	**111-84-2**	0.004536	---	---	0.001120	---	---	---	0.004536
Decane	**C10H22**	**124-18-5**	0.002593	---	---	0.000640	---	---	---	0.002593
Undecanes	**C11H24**	**1120-21-4**	0.001945	---	---	0.000480	---	---	---	0.001945
Dodecane	**C12H26**	**112-40-3**	0.000648	---	---	0.000160	---	---	---	0.000648

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PR	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	33	34	35	36	37	38	39	40
- Fluid	HC	HC	HC	Heat Medium	Fuel Gas	Heat Medium	HC	Fuel Gas
- Physical State	Liquid	Liquid	Liquid	Liquid	Vapour	Liquid	Vapour	Gas
- Temperature (°C)	39.90	39.90	---	115.00	29.36	120.00	29.36	29.90
- Pressure (kPa)	557.5	557.5	---	276.0	257.5	276.0	257.5	399.9
- Total Molar Flowrate (kmole/h)	9.55	9.55	---	1,642.07	1.24	1,642.07	1,229.09	1.24
- Total Mass Flowrate (kg/h)	797.5	797.5	---	68451.8	28.9	68451.8	28560.9	28.9
- Total Gas Volumetric Flowrate (Std m^3/h)	---	---	---	---	29.4	---	29061.6	29.4
- Total Liq Volumetric Flowrate (m^3/h)	1.1	1.1	---	66.8	---	66.8	---	---

- Energy Flowrate kW			---	---	---	---	---	---	---	---
Origin (Unit Operation):										
- Tag No.			AC-102	AC-102	PU-100	PU-101	Fuel Gas Header	H-100	M-100	M-100
- Service:			Bottoms Cooler	Bottoms Cooler	---	Circulation	---	Boiler	Not Applicable	Not Applicable
- Type:			Aerial Cooler	Aerial Cooler	---	Pump	---	Heater	Mixer	Mixer
Destination (Unit Operation):										
- Tag No.			M-200	Condensate Internal Use	M-200	H-100	H-100	Heat-Medium Header	Fuel Gas Header	Fuel Gas Header
- Service:			Not Applicable	---	Not Applicable	Boiler	Boiler	---	---	---
- Type:			Mixer	---	Mixer	Heater	Heater	---	---	---
Properties:			33	34	35	36	37	38	39	40
- Vapour Mole Fraction			0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	1.000000	1.000000
- Liquid Mole Fraction			1.000000	1.000000	1.000000	1.000000	0.000000	1.000000	0.000000	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			---	---	---	41.686	23.237	41.686	23.237	---
- Mass Density (kg/m^3)			724.600	724.600	---	1,025.000	3.315	1,025.000	3.315	---
- Molar Density (kmole/m^3)			---	---	---	---	0.143	---	0.143	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	---	---	---	0.9860	---	0.9860	---
- Specific Heat Capacity (kJ/kmole·°C)			---	---	---	135.4802	44.4607	135.4802	44.4607	---
- Enthalpy (kJ/kmole)			---	---	---	---	-85,284	---	-85,284	---
- Entropy (kJ/kmole·°C)			---	---	---	---	-192	---	-192	---
- Gross Heating Value (MJ/m^3)			---	---	---	---	47.4	---	47.4	---
- Net Heating Value (MJ/m^3)			---	---	---	---	42.4	---	42.4	---
- Sound Speed (m/s)			---	---	---	---	362.258	---	362.258	---
- Dew Point Temperature (°C)			---	---	---	---	29.36	---	29.36	---
- Dew Point Pressure (°kPa)			---	---	---	---	353.8	---	353.8	---
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	---	---	---	0.032	---	0.032	---
- Viscosity (cp)			0.270	0.270	---	1.100	0.012	1.100	0.012	---
Composition (Mole Fraction):			33	34	35	36	37	38	39	40
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	---	---	0.043717	---	0.043717	0.044759
Water	**H2O**	**7732-18-5**	0.000000	0.000000	---	0.462700	0.000000	0.462700	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	---	---	0.025401	---	0.025401	0.025808
Methane	**CH4**	**74-82-8**	---	---	---	---	0.646157	---	0.646157	0.660679
Ethane	**C2H6**	**74-84-0**	---	---	---	---	0.172708	---	0.172708	0.173186
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	---	0.537300	---	0.537300	---	---
Propane	**C3H8**	**74-98-6**	---	---	---	---	0.085464	---	0.085464	0.078104
i-Butane	**C4H10**	**75-28-5**	---	---	---	---	0.007332	---	0.007332	0.005161
n-Butane	**C4H10**	**106-97-8**	---	---	---	---	0.017646	---	0.017646	0.010691
i-Pentane	**C5H12**	**78-78-4**	0.232640	0.232640	---	---	0.000757	---	0.000757	0.000775
n-Pentane	**C5H12**	**109-66-0**	0.294927	0.294927	---	---	0.000741	---	0.000741	0.000759
Benzene	**C6H6**	**71-43-2**	0.012803	0.012803	---	---	0.000001	---	0.000001	0.000001
Cyclohexane	**C6H12**	**110-82-7**	0.021731	0.021731	---	---	0.000007	---	0.000007	0.000008

Hexane	**C6H14**	**110-54-3**	0.092418	0.092418	---	---	0.000032	---	0.000032	0.000033
Methylcyclopentane	**C6H12**	**96-37-7**	0.020882	0.020882	---	---	0.000009	---	0.000009	0.000009
Heptane	**C7H16**	**142-82-5**	0.253242	0.253242	---	---	0.000022	---	0.000022	0.000023
Methylcyclohexane	**C7H14**	**108-87-2**	0.024279	0.024279	---	---	0.000003	---	0.000003	0.000003
Toluene	**C7H8**	**108-88-3**	0.021185	0.021185	---	---	0.000002	---	0.000002	0.000002
Ethylbenzene	**C8H10**	**100-41-4**	0.000647	0.000647	---	---	0.000000	---	0.000000	0.000000
m-Xylene	**C8H10**	**108-38-3**	0.005178	0.005178	---	---	0.000000	---	0.000000	0.000000
Octane	**C8H18**	**111-65-9**	0.009700	0.009700	---	---	0.000000	---	0.000000	0.000000
o-Xylene	**C8H10**	**95-47-6**	0.000647	0.000647	---	---	0.000000	---	0.000000	0.000000
Nonane	**C9H20**	**111-84-2**	0.004536	0.004536	---	---	0.000000	---	0.000000	0.000000
Decane	**C10H22**	**124-18-5**	0.002593	0.002593	---	---	0.000000	---	0.000000	0.000000
Undecanes	**C11H24**	**1120-21-4**	0.001945	0.001945	---	---	0.000000	---	0.000000	0.000000
Dodecane	**C12H26**	**112-40-3**	0.000648	0.000648	---	---	0.000000	---	0.000000	0.000000

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PR	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	41	42	43	44	45	46	47	48
- Fluid	HC	HC	HC	Electricity	Electricity	Electricity	Electricity	Electricity
- Physical State	Vapour	Vapour	Vapour	Unknown	Unknown	Unknown	Unknown	Unknown
- Temperature (°C)	29.36	29.36	29.36	---	---	---	---	---
- Pressure (kPa)	257.5	257.5	257.5	---	---	---	---	---
- Total Molar Flowrate (kmole/h)	0.00	1,227.85	0.00	---	---	---	---	---
- Total Mass Flowrate (kg/h)	0.0	28532.1	0.0	---	---	---	---	---
- Total Gas Volumetric Flowrate (Std m^3/h)	0.0	29032.3	0.0	---	---	---	---	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	461.316	0.024	0.007	0.006	3.996

Origin (Unit Operation):										
- Tag No.			M-100	M-100	M-100	Electric Utility System	Electric Utility	Electric Utility System	Electric Utility System	Electric Utility System
- Service:			Not Applicable	Not Applicable	Not Applicable	---	---	---	---	---
- Type:			Mixer	Mixer	Mixer	---	---	---	---	---
Destination (Unit Operation):										
- Tag No.			Gas Gathering System	To Flare Line	Fuel Gas Header		AC-100	AC-101	AC-102	PU-101
- Service:			---	---	---	---	Discharge Cooler	Overhead Condenser	Bottoms Cooler	Circulation
- Type:			---	---	---	---	Aerial Cooler	Aerial Cooler	Aerial Cooler	Pump
Properties:			41	42	43	44	45	46	47	48
- Vapour Mole Fraction			1.000000	1.000000	1.000000	---	---	---	---	---
- Liquid Mole Fraction			0.000000	0.000000	0.000000	---	---	---	---	---
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			23.237	23.237	23.237	---	---	---	---	---
- Mass Density (kg/m^3)			3.315	3.315	3.315	---	---	---	---	---
- Molar Density ($kmole/m^3$)			0.143	0.143	0.143	---	---	---	---	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			0.9860	0.9860	0.9860	---	---	---	---	---
- Specific Heat Capacity (kJ/kmole·°C)			44.4607	44.4607	44.4607	---	---	---	---	---
- Enthalpy (kJ/kmole)			-85,284	-85,284	-85,284	---	---	---	---	---
- Entropy (kJ/kmole·°C)			-192	-192	-192	---	---	---	---	---
- Gross Heating Value (MJ/m^3)			47.4	47.4	47.4	---	---	---	---	---
- Net Heating Value (MJ/m^3)			42.4	42.4	42.4	---	---	---	---	---
- Sound Speed (m/s)			362.258	362.258	362.258	---	---	---	---	---
- Dew Point Temperature (°C)			29.36	29.36	29.36	---	---	---	---	---
- Dew Point Pressure (°kPa)			353.8	353.8	353.8	---	---	---	---	---
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.032	0.032	0.032	---	---	---	---	---
- Viscosity (cp)			0.012	0.012	0.012	---	---	---	---	---
Composition (Mole Fraction):			41	42	43	44	45	46	47	48
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043717	0.043717	0.043717	---	---	---	---	---
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.000000	---	---	---	---	---
Carbon Dioxide	**CO2**	**124-38-9**	0.025401	0.025401	0.025401	---	---	---	---	---
Methane	**CH4**	**74-82-8**	0.646157	0.646157	0.646157	---	---	---	---	---
Ethane	**C2H6**	**74-84-0**	0.172708	0.172708	0.172708	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	0.085464	0.085464	0.085464	---	---	---	---	---
i-Butane	**C4H10**	**75-28-5**	0.007332	0.007332	0.007332	---	---	---	---	---
n-Butane	**C4H10**	**106-97-8**	0.017646	0.017646	0.017646	---	---	---	---	---
i-Pentane	**C5H12**	**78-78-4**	0.000757	0.000757	0.000757	---	---	---	---	---
n-Pentane	**C5H12**	**109-66-0**	0.000741	0.000741	0.000741	---	---	---	---	---
Benzene	**C6H6**	**71-43-2**	0.000001	0.000001	0.000001	---	---	---	---	---
Cyclohexane	**C6H12**	**110-82-7**	0.000007	0.000007	0.000007	---	---	---	---	---
Hexane	**C6H14**	**110-54-3**	0.000032	0.000032	0.000032	---	---	---	---	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000009	0.000009	0.000009	---	---	---	---	---

Heptane	**C7H16**	**142-82-5**	0.000022	0.000022	0.000022	---	---	---	---	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000003	0.000003	0.000003	---	---	---	---	---
Toluene	**C7H8**	**108-88-3**	0.000002	0.000002	0.000002	---	---	---	---	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000000	0.000000	0.000000	---	---	---	---	---
m-Xylene	**C8H10**	**108-38-3**	0.000000	0.000000	0.000000	---	---	---	---	---
Octane	**C8H18**	**111-65-9**	0.000000	0.000000	0.000000	---	---	---	---	---
o-Xylene	**C8H10**	**95-47-6**	0.000000	0.000000	0.000000	---	---	---	---	---
Nonane	**C9H20**	**111-84-2**	0.000000	0.000000	0.000000	---	---	---	---	---
Decane	**C10H22**	**124-18-5**	0.000000	0.000000	0.000000	---	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	0.000000	0.000000	0.000000	---	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	0.000000	0.000000	0.000000	---	---	---	---	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PR	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	49	50	51	52				
- Fluid	Electricity	Electricity	Electricity	Electricity				
- Physical State	Unknown	Unknown	Unknown	Unknown				
- Temperature (°C)	---	---	---	---				
- Pressure (kPa)	---	---	---	---				
- Total Molar Flowrate (kmole/h)	---	---	---	---				
- Total Mass Flowrate (kg/h)	---	---	---	---				
- Total Gas Volumetric Flowrate	---	---	---	---				
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---				

- Energy Flowrate kW	0.000	0.000	0.157	0.000				
Origin (Unit Operation):								
- Tag No.	Electric Utility System	Electric Utility System	Electric Utility System	Electric Utility System				
- Service:	---	---	---	---				
- Type:	---	---	---	---				
Destination (Unit Operation):								
- Tag No.	PU-102	PU-103	PU-104	PU-105				
- Service:	Booster	Reflux	Booster	Booster				
- Type:	Pump: Centrifugal	Pump	Pump	Pump				
Properties:	49	50	51	52	0	0	0	0
- Vapour Mole Fraction	---	---	---	---				
- Liquid Mole Fraction	---	---	---	---				
- Solid Mole Fraction	---	---	---	---				
- Aqueous Mole Fraction	---	---	---	---				
- Molecular Weight	---	---	---	---				
- Mass Density (kg/m^3)	---	---	---	---				
- Molar Density (kmole/m^3)	---	---	---	---				
- API Gravity (°)	---	---	---	---				
- Compressibility Factor	---	---	---	---				
- Specific Heat Capacity (kJ/kmole·°C)	---	---	---	---				
- Enthalpy (kJ/kmole)	---	---	---	---				
- Entropy (kJ/kmole·°C)	---	---	---	---				
- Gross Heating Value (MJ/m^3)	---	---	---	---				
- Net Heating Value (MJ/m^3)	---	---	---	---				
- Sound Speed (m/s)	---	---	---	---				
- Dew Point Temperature (°C)	---	---	---	---				
- Dew Point Pressure (°kPa)	---	---	---	---				
- Bubble Point Temperature (°C)	---	---	---	---				
- Bubble Point Pressure (kPa)	---	---	---	---				
- Reid Vapour Pressure (kPa)	---	---	---	---				
- True Vapour Pressure (kPa)	---	---	---	---				
- Thermal Conductivity (W/m·°C)	---	---	---	---				
- Viscosity (cp)	---	---	---	---				
Composition (Mole Fraction):	49	50	51	52	0	0	0	0
Name / **Formula** / **CAS No.**								

REPORT: SOURCE MITIGATION ANALYSIS

Header Block

Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed

Time Series	**CEL Mitigation Code:**	OP-009-PRN	**End-Year**	**Asset Life:**	2032
	Start Year:	2022		**Viability:**	2032
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**		Using a propane-refrigeration condenser (shallow cut) and upstream electric-drive
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**		NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL Drawing No:	Unavailable	**Reference CEL Drawing Title:**		Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**		
	CEL Reference Code:		**Subcategory 2:**		
	Reference CEL Drawing No:		**Reference CEL Drawing Title:**		
	Optimization Objective Function:	Net Present Value Over Pay-Back Period Ratio	**Economic Scenario Name:**		None

Optimization Search Space

Search Parameter	Value Chosen	Min Search Value	Max Search Value
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00
Year-1 Peak Flow Rate Design Factor	**1.00**	0.70	1.30
Electric Generator Drive Type	**Reciprocating**	---	---
Number of Electric Generator Trains	**2.00**	1.00	10.00

Key Findings

Economic Impacts	**Capital Cost (USD):**	3,660,544	**Net Present Value (USD) (Before Tax):**	15,376,245
	Project Life (Years):	10	**Net Present Value (USD) (After Tax):**	11,667,305
	Asset Life Expectancy (Years):	10	**Return on Investment (%) (Before Tax):**	420.05%
	Asset Salvage Value (USD):	0	**Return on Investment (%) (After Tax):**	318.73%
	Payback Period (Years):	1.89	**Internal Rate of Return (%):**	63.12%

Pre-Mitigation Commodity Losses	Value of Gas Losses (USD/y) Energy Basis	Value of Gas Losses (USD/y) Commodity Basis	Total Gas Loss (m^3/h)	Residue Gas (10^3 m^3/d)	Ethane (m^3/d liq)	LPG (m^3/d liq)	NGL (m^3/d)	Hydrogen (m^3/d)		
	0	30,154,630	30,104.0	512.8	439.8	311.8	32.0	0.0		

Lifetime GHG Emission Reductions	CH_4 (kilotonnes)	CO_2 (kilotonnes)	N_2O (kilotonnes)	CO_2E (kilotonnes)	Black Carbon (kilotonnes)
	0.1	206.8	0.0	209.6	0.2

Lifetime CAC Emission Reductions	VOC (tonnes)	CO (tonnes)	NO_x (tonnes)	H_2S (tonnes)	SO_2 (tonnes)	PM (tonnes)	PM_{10} (tonnes)	$PM_{2.5}$ (tonnes)		
	1,398.6	508.2	110.9	0.0	0.0	84.7	84.7	84.7		

Key Equipment Additions

Key Equipment or	Reference No.	Category	Subcategory 1	Subcategory 2 or Manufacturer Make And Model
	DPH_1	Process Heater	Dow-therm	
	C_Recip_1_1	Compressor (Driver Excluded)	Reciprocating	
	RICE_Recip_1_1	Driver	Reciprocating	
	AC1_1	Heat Exchanger	Air Cooler	
	TPS1_1	Pressure Vessel	Separator	Vertical
	NGLPR_1_1	NGL Recovery Unit	Refrigeration (Shallow-Cut) c/w Gylcol Injection a	Rich Gas (6 gpm C3+)
	M_CIR_PUMP_1	Pump (Package)	Centrifugal	Horizontal
	STB1_1	NGL Stabilizer		
	ST_AC_1_1	Heat Exchanger	Air Cooler	
	ST_AC_2_1	Heat Exchanger	Air Cooler	
	T_BOT_PUMP_1	Pump (Package)	Centrifugal	Horizontal
	PS1	Pipeline	Buried	

Applied Economic Parameters

Financial Rates	**Discount Rate (%):**	10.00	**Inflation Rate (%):**	3.00
	Depreciation Rate (%):	10.00	**Tax Rate (%)**	20.00
	Royalty Rate (%):	30.00	**Import Duty (%):**	20.00

	A	B	C	D	E	F	G	H	I	J	K	L
66		**GHG Emission Fee (USD/Tonne):**			$1.10	**CAC Emission Fee (USD/Tonne):**					0.00	
67	**Production**	**Model Type:**		Initial Linear Increase		**D (decline as a fraction of production):**					0.0000	
68	**Decline Model**					**b (correlation constant):**					Not Applicable	
69	**Commodity Prices**	**Natural Gas**		**Ethane**	**LPG**	**NGL**	**Crude Oil**	**Hydrogen**	**Electricity**		**Diesel**	**Naptha**
70		**Purchases (USD/GJ)**	**Sales (USD/GJ)**	**(USD/m^3 Liq)**	**(USD/L Liq)**	**(USD/m^3 Liq)**	**(USD/m^3)**	**(USD/m^3)**	**Purchases (USD/kW·h)**	**Sales (USD/kW·h)**	**(USD/L Liq)**	**(USD / m3 Liq)**
71		$ -	$ -	$ 60.26	$ 0.14	$ 389.84	$ 471.70	$ 2.00	$ 0.04	$ -	$ 0.76	
72												
73												
74												
75	**Financials (Time Series Results)**											
76	**Year**	**Gross**	**Costs**		**Asset Book**	**Salvage Value**	**Royalty**	**Emission Fee**	**Net Revenues**		**Cumulative**	
77		**Revenues**	**Capital**	**Operating**	**Value**		**Payment**		**Before Tax**	**After Tax**	**After Tax Earnings**	
78		**(Inflation Adjusted USD)**							**(Present Value USD)**			
79	2022	4,546,627	3,660,544	114,115	3,294,490	1,247,486	1,364,402	-23,982	2,478,216	1,982,573	1,982,573	
80	2023	4,683,026		117,539	2,965,041	1,108,876	1,405,334	-23,982	2,359,245	1,887,396	3,869,969	
81	2024	4,823,517		121,065	2,668,537	970,267	1,447,494	-23,982	2,240,749	1,792,599	5,662,568	
82	2025	4,968,223		124,697	2,401,683	831,657	1,490,918	-23,982	2,123,991	1,699,193	7,361,761	
83	2026	5,117,269		128,438	2,161,515	693,048	1,535,646	-23,982	2,009,922	1,607,937	8,969,698	
84	2027	5,270,787		132,291	1,945,363	554,438	1,581,715	-23,982	1,899,235	1,519,388	10,489,087	
85	2028	5,428,911		136,260	1,750,827	415,829	1,629,167	-23,982	1,792,425	1,433,940	11,923,027	
86	2029	5,282,868		140,347	1,575,744	277,219	1,585,341	-22,657	1,588,343	1,270,675	13,193,702	
87	2030	5,010,774		144,558	1,418,170	138,610	1,503,688	-20,864	1,368,062	1,094,450	14,288,151	
88	2031	4,748,210		148,895	1,276,353	0	1,424,894	-19,195	1,176,600	941,280	15,229,432	
89	**Last Profitable Year (After Asset Liquidation, Final Tax Adjustments and Closing Book Entries)**											
90	2031	4,748,210	999	148,895	1,276,353	0	1,424,894	-19,195	1,176,600	1,039,698	15,327,849	
91												
92	**Avoided GHG and BC Emissions (Time Series Results)**											
93	**Year**	**CH_4 (kt)**	**CO_2 (kt)**	**N_2O (kt)**	**CO_2E (kt)**	**Black Carbon (t)**						
94	2022	0.0	21.5	0.0	21.8	20.3						
95	2023	0.0	21.5	0.0	21.8	20.3						
96	2024	0.0	21.5	0.0	21.8	20.3						
97	2025	0.0	21.5	0.0	21.8	20.3						
98	2026	0.0	21.5	0.0	21.8	20.3						
99	2027	0.0	21.5	0.0	21.8	20.3						
100	2028	0.0	21.5	0.0	21.8	20.3						
101	2029	0.0	20.3	0.0	20.6	19.2						
102	2030	0.0	18.7	0.0	19.0	17.7						
103	2031	0.0	17.2	0.0	17.5	16.2						
104												
105	**Other Avoided Atmospheric Emissions (Time Series Results)**											
106	**Year**	**VOC (t)**	**CO (t)**	**NO_x (t)**	**H_2S (t)**	**SO_2 (t)**	**PM (t)**	**PM_{10} (t)**	**$PM_{2.5}$ (t)**			
107	2022	0.1	0.1	0.0	0.0	0.0	8.8	8.8	8.8			
108	2023	0.1	0.1	0.0	0.0	0.0	8.8	8.8	8.8			
109	2024	0.1	0.1	0.0	0.0	0.0	8.8	8.8	8.8			
110	2025	0.1	0.1	0.0	0.0	0.0	8.8	8.8	8.8			
111	2026	0.1	0.1	0.0	0.0	0.0	8.8	8.8	8.8			
112	2027	0.1	0.1	0.0	0.0	0.0	8.8	8.8	8.8			
113	2028	0.1	0.1	0.0	0.0	0.0	8.8	8.8	8.8			
114	2029	0.1	0.0	0.0	0.0	0.0	8.3	8.3	8.3			
115	2030	0.1	0.0	0.0	0.0	0.0	7.7	7.7	7.7			
116	2031	0.1	0.0	0.0	0.0	0.0	7.1	7.1	7.1			
117												
118	**Forecast Site Activity Data (Time Series Results - Part 1)**											
119	**Year**	**Production**			**Waste Gas Disposition**			**Incremental Energy Purchases**				
120		**Oil (10^3 m^3)**	**Gas (10^6 m^3)**	**Water (10^3 m^3)**	**Collected (10^6 m^3)**	**Conserved (10^6 m^3)**	**Flared (10^6 m^3)**	**Natural Gas (10^6 m^3)**	**Naphtha (10^3 m^3)**	**Diesel (m^3)**	**Electricity (10^3 kW·h)**	
121	2022	960.72	263.71		263.71	3.26	260.46	0.00	0.00	0.00	35	
122	2023	960.72	263.71		263.71	3.26	260.46	0.00	0.00	0.00	35	
123	2024	960.72	263.71		263.71	3.26	260.46	0.00	0.00	0.00	35	
124	2025	960.72	263.71		263.71	3.26	260.46	0.00	0.00	0.00	35	
125	2026	960.72	263.71		263.71	3.26	260.46	0.00	0.00	0.00	35	
126	2027	960.72	263.71		263.71	3.26	260.46	0.00	0.00	0.00	35	
127	2028	960.72	263.71		263.71	3.26	260.46	0.00	0.00	0.00	35	
128	2029	883.87	242.62		242.61	3.08	239.54	0.00	0.00	0.00	33	
129	2030	813.16	223.21		223.20	2.83	220.37	0.00	0.00	0.00	31	
130	2031	748.10	205.35		205.35	2.61	202.74	0.00	0.00	0.00	28	
131												
132	**Forecast Site Activity Data (Time Series Results - Part 2)**											
133	**Year**	**Incremental Product Sales**					**Incremental Utilization**	**Avoided Purchases**				

	A	B	C	D	E	F	G	H	I	J	K	L
134		Gas (10^6 m^3 Gas)	LPG (10^3 m^3 Liq)	NGL (10^3 m^3 Liq)	Oil (10^3 m^3)	Electricity (10^3 kW·h)	Fuel Gas (10^6 m^3 Gas)	Natural Gas (10^6 m^3)	Naphtha (10^3 m^3)	Diesel (m^3)	Electricity (10^3 kW·h)	
135	2022	0.00	0.00	0.00	9.64	0	1.28	0.00	0.00	0	0.00	
136	2023	0.00	0.00	0.00	9.64	0	1.28	0.00	0.00	0	0.00	
137	2024	0.00	0.00	0.00	9.64	0	1.28	0.00	0.00	0	0.00	
138	2025	0.00	0.00	0.00	9.64	0	1.28	0.00	0.00	0	0.00	
139	2026	0.00	0.00	0.00	9.64	0	1.28	0.00	0.00	0	0.00	
140	2027	0.00	0.00	0.00	9.64	0	1.28	0.00	0.00	0	0.00	
141	2028	0.00	0.00	0.00	9.64	0	1.28	0.00	0.00	0	0.00	
142	2029	0.00	0.00	0.00	9.11	0	1.21	0.00	0.00	0	0.00	
143	2030	0.00	0.00	0.00	8.39	0	1.11	0.00	0.00	0	0.00	
144	2031	0.00	0.00	0.00	7.72	0	1.02	0.00	0.00	0	0.00	
145												
146	Applied Emission Factors (EF) For Year One Emissions For Baseline (BL) and Simulated Equipment											
147	Source			Pollutant	EF (ng/J of Fuel)	Reference (Where Applicable) and Basis						
148	Category	Tag No.	DB EF Key			Basis	Author or Reporting Agency		Code			
149	Flares	BL FLARE_1	335	CH_4	180.0	Calculated	US EPA		2018-U.S.EPAAP-42Table13.5-1			
150				CO_2	54,529.6	Calculated	NA					
151				N_2O	0.1	Referenced	WCI		2012-BCWCI.363(k)			
152				BC	19.7	Calculated	NA					
153				VOC	22.3	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
154				CO	133.0	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
155				NO_x	29.2	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-1			
156				SO_2	0.0	Calculated	NA					
157				PM	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
158				PM_{10}	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
159				$PM_{2.5}$	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
160	Heaters and Boilers	DPH_1	7	CH_4	1.0	Calculated	US EPA		1998-U.S.EPAAP-42Table1.4-2			
161				CO_2	54,283.7	Calculated	NA					
162				N_2O	0.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
163				BC	0.6	Calculated	NA					
164				VOC	2.3	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-2			
165				CO	35.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
166				NO_x	13.0	Referenced	US EPA		1998-U.S.EPAAP-42Table1.4-1			
167				SO_2	0.0	Calculated	NA					
168				PM	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
169				PM_{10}	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
170				$PM_{2.5}$	0.6	Referenced	Ramboll Environment and		2018-CEPEITable1			
171	Reciprocating Engines	RICE_Recip_1_	3	CO_2	54,283.7	Calculated	NA					
172				SO_2	0.0	Calculated	NA					
173	Reciprocating Engines	NGLPR_1_1	3	CO_2	54,283.7	Calculated	NA					
174				SO_2	0.0	Calculated	NA					
175	Flares	FLARE_1	335	CH_4	185.1	Calculated	US EPA		2018-U.S.EPAAP-42Table13.5-1			
176				CO_2	54,283.7	Calculated	NA					
177				N_2O	0.1	Referenced	WCI		2012-BCWCI.363(k)			
178				BC	18.6	Calculated	NA					
179				VOC	22.3	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
180				CO	133.0	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-2			
181				NO_x	29.2	Referenced	US EPA		2018-U.S.EPAAP-42Table13.5-1			
182				SO_2	0.0	Calculated	NA					
183				PM	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
184				PM_{10}	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
185				$PM_{2.5}$	22.0	Referenced	US EPA		1991-EPAFire6.22.Flaringlandfillgas			
186												
187	Capital Cost											
188	Equipment	Item	Category	Subcategory 1	Subcategory 2	Capacity or Rated Power Output		Price (USD)	FOB Point	Basis		
189						Value	Units of Measure					
190		DPH_1	Process Heater	Dow-therm		317.60	kW	104,126	NA	Predicted (Class 5)		
191		C_Recip_1_1	Compressor (Driver Excluded)	Reciprocating		26.39	kW	27,103	NA	Predicted (Class 4)		
192		RICE_Recip_1_1	Driver	Reciprocating		34.36	kW	22,332	NA	Predicted (Class 4)		
193		AC1_1	Heat Exchanger	Air Cooler		10.00	m²	49,177	NA	Predicted (Class 4)		
194		TPS1_1	Pressure Vessel	Separator	Vertical	1.94	m³	21,819	NA	Predicted (Class 4)		

	A	B	C	D	E	F	G	H	I	J	K	L
195		NGLPR_1_1	NGL Recovery Unit	Refrigeration (Shallow-Cut) c/w Gylcol Injection and Stabilizer	Rich Gas (6 gpm C3+)	52.60	m^3/h	201,637	NA	Predicted (Class 5)		
196		HM_CIR_PUMP_1_1	Pump (Package)	Centrifugal	Horizontal	3.70	kW	3,198	NA	Predicted (Class 4)		
197		STB1_1	NGL Stabilizer			3.04	m^3/h	838,466	NA	Predicted (Class 5)		
198		ST_AC_1_1	Heat Exchanger	Air Cooler		10.00	m^2	49,177	NA	Predicted (Class 4)		
199		ST_AC_2_1	Heat Exchanger	Air Cooler		10.00	m^2	49,177	NA	Predicted (Class 4)		
200		ST_BOT_PUMP_1_1	Pump (Package)	Centrifugal	Horizontal	1.49	kW	1,635	NA	Predicted (Class 4)		
201		PS1	Pipeline	Buried		0.10	km	18,249	NA	Predicted (Class 5)		
202		**E7**	**Engineering & Drafting**					215,569				
203		**Subtotal:**						1,601,664				
204	**Pipeline**	**Pipe Specifications**	**OD (mm)**			**Material:**			**Design P (kPa)**			
205			**WT (mm)**			**Length (km):**			**Coating:**			
206		**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
207		**PL1**	**Pipe**									
208		**PL2**	**Right-of-Way (ROW)**									
209		**PL3**	**ROW Land Survey**									
210		**PL4**	**Clearing**									
211		**PL5**	**Soil Stripping**									
212		**PL6**	**Timber Salvage**									
213		**PL7**	**Rock excavation**									
214		**PL8**	**Cathodic Protection**									
215		**PL9**	**Construction**									
216		**PL10**	**Engineering & Drafting**									
217		**PL11**	**Supervision**									
218		**PL12**	**Safety**									
219		**PL13**	**Reseeding ROW**									
220		**Subtotal:**										
221	**Materials & Services**	**Item**	**Category**		**Material (USD**	**Labour (USD)**		**Total (USD)**		**Basis**		
222		**MS1**	**Equipment Setting**		0	189,555		189,555		Predicted		
223		**MS2**	**Foundations**		54,251	72,154		126,406		Predicted		
224		**MS3**	**Structural Steel**		54,115	27,058		81,173		Predicted		
225		**MS4**	**Buildings**		32,469	32,469		64,938		Predicted		
226		**MS5**	**Insulation**		10,823	16,235		27,058		Predicted		
227		**MS6**	**Instruments**		65,074	26,030		91,104		Predicted		
228		**MS7**	**Electrical**		86,721	65,040		151,761		Predicted		
229		**MS8**	**Piping**		486,357	243,179		729,536		Predicted		
230		**MS9**	**Painting**		5,412	16,235		21,646		Predicted		
231		**MS10**	**Miscellaneous**		32,605	26,084		58,689		Predicted		
232		**MS11**	**Engineering & Drafting**		0	239,795		239,795		Predicted		
233		**MS12**	**Supervision**		Unavailable	0		0				
234		**MS13**	**Safety**		Unavailable	0		0				
235		**Subtotal:**						1,781,661				
236	**Summary**	**Total:**						3,383,325				
237		**Duties:**						277,219				
238		**Freight:**						Unavailable				
239		**Grand Total:**						3,660,544				
240	**Year 1 Operating Costs**											
241		**Operating Labour**	**Hours Per Shift:**		Unknown	**Operator Hourly Labour Rate:**		$ 2.05				
242			**Shifts Per Day:**		Unknown	**Maintenance Hourly Labour Rate:**		$ 2.05				
243		**Item**	**Category**		**Material (USD**	**Labour (Hours)**	**Labour (USD)**	**Line Total (USD)**		**Basis**		
244	**Fixed O&M Costs**	**L1**	**Operating Labour**		0	4,260	8,733	8,733		Predicted		
245		**L2**	**Maintenance Labour**		0	2,100	4,305	4,305		Predicted		
246		**L3**	**Direct Supervision**		0		1,572	1,572		Predicted		
247		**L4**	**Administration**		0		34,491	34,491		Predicted		
248		**L5**	**Unclassified Costs**					0		Predicted		
249		**Total Fixed O&M Costs:**						49,101		Predicted		
250	**Variable O&M Costs**	**SS1**	**Third-Party Services**					25,351		Predicted		
251		**SS2**	**Parts & Consumables**					36,234		Predicted		
252		**SS3**	**Unclassified Costs**					0		Predicted		
253		**Total Variable O&M Costs:**						61,585		Predicted		
254	**Total O&M Costs**	**Total Fixed and Variable O&M Costs:**						110,686		Predicted		

	A	B	C	D	E	F	G	H	I	J	K	L
255	**Purchased Commodities**	**PC1**	**Electricity**		1,378	0	0	1,378		Predicted		
256		**PC2**	**Natural Gas**		0	0	0	0		Predicted		
257		**PC3**	**LPG**		0	0	0	0		Predicted		
258		**PC4**	**Diesel**		0	0	0	0		Predicted		
259	**Summary**	**Total:**						112,063				

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PRN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Proposed Equipment

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PRN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	1	2	3	4	5	6	7	8
- Fluid	HC	HC	HC	HC	HC	Heat Medium	Heat Medium	HC
- Physical State	Vapour	Vapour	Vapour	Vapour	Liquid	Liquid	Liquid	Vapour
- Temperature (°C)	40.00	40.00	40.00	40.00	---	120.00	120.00	42.05
- Pressure (kPa)	800.0	800.0	800.0	800.0	---	276.0	276.0	826.9
- Total Molar Flowrate (kmole/h)	1,273.17	1,238.64	34.53	1,238.64	0.00	0.00	0.00	1,238.64
- Total Mass Flowrate (kg/h)	30176.9	29358.5	818.5	29358.5	0.0	0.0	0.0	29358.5
- Total Gas Volumetric Flowrate	30104.0	29287.5	816.5	29287.5	---	---	---	29287.5
- Total Liq Volumetric Flowrate	---	---	---	---	---	0.0	0.0	---

- Energy Flowrate kW			---	---	---	---	---	---	---	---
Origin (Unit Operation):										
- Tag No.			From Flare Line	FS-100	FS-100	V-100	V-100	V-100	H-100	K-100
- Service:			---	Not Applicable	Not Applicable	Inlet Scrubber	Inlet Scrubber	Inlet Scrubber	Boiler	Inlet Gas Boosting
- Type:			---	Flow Splitter	Flow Splitter	3-Phase Separator	3-Phase Separator	3-Phase Separator	Heater	Compressor: Recip.
Destination (Unit Operation):										
- Tag No.			FS-100	V-100	To Flare Line	K-100	PU-105	PU-101	V-100	AC-100
- Service:			Not Applicable	Inlet Scrubber	---	Inlet Gas Boosting	Booster	Circulation	Inlet Scrubber	Discharge Cooler
- Type:			Flow Splitter	3-Phase Separator	---	Compressor: Recip.	Pump	Pump	3-Phase Separator	Aerial Cooler
Properties:			1	2	3	4	5	6	7	8
- Vapour Mole Fraction			1.000000	1.000000	1.000000	1.000000	0.000000	0.000000	0.000000	1.000000
- Liquid Mole Fraction			0.000000	0.000000	0.000000	0.000000	1.000000	1.000000	1.000000	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			23.702	23.702	23.702	23.702	---	41.686	41.686	23.702
- Mass Density (kg/m^3)			8.439	8.439	8.439	8.439	---	1,025.000	1,025.000	8.638
- Molar Density (kmole/m^3)			0.356	0.356	0.356	0.356	---	---	---	0.364
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			0.9669	0.9669	0.9669	0.9669	---	---	---	0.9666
- Specific Heat Capacity (kJ/kmole·°C)			46.7971	46.7971	46.7971	46.7971	---	135.4802	135.4802	46.9687
- Enthalpy (kJ/kmole)			-85,487	-85,487	-85,487	-85,487	---	---	---	-85,399
- Entropy (kJ/kmole·°C)			-202	-202	-202	-202	---	---	---	-202
- Gross Heating Value (MJ/m^3)			48.3	48.3	48.3	48.3	---	---	---	48.3
- Net Heating Value (MJ/m^3)			43.3	43.3	43.3	43.3	---	---	---	43.3
- Sound Speed (m/s)			359.316	359.316	359.316	359.316	---	---	---	360.310
- Dew Point Temperature (°C)			40.00	40.00	40.00	40.00	---	---	---	42.05
- Dew Point Pressure (°kPa)			896.4	896.4	896.4	896.4	---	---	---	923.2
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.033	0.033	0.033	0.033	---	---	---	0.034
- Viscosity (cp)			0.012	0.012	0.012	0.012	---	1.100	1.100	0.012
Composition (Mole Fraction):			1	2	3	4	5	6	7	8
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043380	0.043380	0.043380	0.043380	---	---	---	0.043380
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.000000	0.000000	---	0.462700	0.462700	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	0.025205	0.025205	0.025205	0.025205	---	---	---	0.025205
Methane	**CH4**	**74-82-8**	0.641174	0.641174	0.641174	0.641174	---	---	---	0.641174
Ethane	**C2H6**	**74-84-0**	0.171376	0.171376	0.171376	0.171376	---	---	---	0.171376
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	---	---	---	0.537300	0.537300	---
Propane	**C3H8**	**74-98-6**	0.084805	0.084805	0.084805	0.084805	---	---	---	0.084805
i-Butane	**C4H10**	**75-28-5**	0.007275	0.007275	0.007275	0.007275	---	---	---	0.007275
n-Butane	**C4H10**	**106-97-8**	0.017510	0.017510	0.017510	0.017510	---	---	---	0.017510
i-Pentane	**C5H12**	**78-78-4**	0.002545	0.002545	0.002545	0.002545	---	---	---	0.002545
n-Pentane	**C5H12**	**109-66-0**	0.003010	0.003010	0.003010	0.003010	---	---	---	0.003010
Benzene	**C6H6**	**71-43-2**	0.000100	0.000100	0.000100	0.000100	---	---	---	0.000100
Cyclohexane	**C6H12**	**110-82-7**	0.000175	0.000175	0.000175	0.000175	---	---	---	0.000175

Hexane	**C6H14**	**110-54-3**	0.000745	0.000745	0.000745	0.000745	---	---	---	0.000745
Methylcyclopentane	**C6H12**	**96-37-7**	0.000170	0.000170	0.000170	0.000170	---	---	---	0.000170
Heptane	**C7H16**	**142-82-5**	0.001975	0.001975	0.001975	0.001975	---	---	---	0.001975
Methylcyclohexane	**C7H14**	**108-87-2**	0.000190	0.000190	0.000190	0.000190	---	---	---	0.000190
Toluene	**C7H8**	**108-88-3**	0.000165	0.000165	0.000165	0.000165	---	---	---	0.000165
Ethylbenzene	**C8H10**	**100-41-4**	0.000005	0.000005	0.000005	0.000005	---	---	---	0.000005
m-Xylene	**C8H10**	**108-38-3**	0.000040	0.000040	0.000040	0.000040	---	---	---	0.000040
Octane	**C8H18**	**111-65-9**	0.000075	0.000075	0.000075	0.000075	---	---	---	0.000075
o-Xylene	**C8H10**	**95-47-6**	0.000005	0.000005	0.000005	0.000005	---	---	---	0.000005
Nonane	**C9H20**	**111-84-2**	0.000035	0.000035	0.000035	0.000035	---	---	---	0.000035
Decane	**C10H22**	**124-18-5**	0.000020	0.000020	0.000020	0.000020	---	---	---	0.000020
Undecanes	**C11H24**	**1120-21-4**	0.000015	0.000015	0.000015	0.000015	---	---	---	0.000015
Dodecane	**C12H26**	**112-40-3**	0.000005	0.000005	0.000005	0.000005	---	---	---	0.000005

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PRN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen

Parameter	Value Chosen	Min Search Value	Max Search Value
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	9	10	11	12	13	14	15	16
- Fluid	Electricity	Fuel Gas	HC	HC	HC	HC	Refrigerant (C_3)	HC
- Physical State	Unknown	Gas	Vapour	Vapour	Multiphase	Vapour	Vapour	Multiphase
- Temperature (°C)	---	29.90	39.90	29.90	-15.75	-35.00	-40.00	-35.00
- Pressure (kPa)	---	399.9	700.0	400.0	600.0	500.0	14.6	500.0
- Total Molar Flowrate (kmole/h)	---	0.40	1,238.64	1,199.95	1,238.64	1,199.95	80.68	1,238.64
- Total Mass Flowrate (kg/h)	---	9.3	29358.5	27214.6	29358.5	27214.6	7115.5	29358.5
- Total Gas Volumetric Flowrate (Std m^3/h)	---	9.5	29287.5	28372.7	---	28372.7	1907.7	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	---

- Energy Flowrate kW	0.000	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	Electric Utility System	Fuel Gas Header	AC-100	E-100	E-100	V-600	E-200	E-200
- Service:	---	---	Discharge Cooler	Gas-Gas Exchanger	Gas-Gas Exchanger	Cold	Chiller	Chiller
- Type:	---	---	Aerial Cooler	Heat Exchanger:	Heat Exchanger:	3-Phase Separator	Head Exchanger	Head Exchanger
Destination (Unit Operation):								
- Tag No.	K-100	K-100	E-100	M-100	E-200	E-100	PR-100	V-600
- Service:	Inlet Gas Boosting	Inlet Gas Boosting	Gas-Gas Exchanger	Not Applicable	Chiller	Gas-Gas Exchanger	Chiller	Cold
- Type:	Compressor: Recip.	Compressor: Recip.	Heat Exchanger: Shell and Tube	Mixer	Head Exchanger	Heat Exchanger: Shell and Tube	Cooler	3-Phase Separator
Properties:	9	10	11	12	13	14	15	16
- Vapour Mole Fraction	---	1.000000	1.000000	1.000000	0.990882	1.000000	1.000000	0.968766
- Liquid Mole Fraction	---	0.000000	0.000000	0.000000	0.009118	0.000000	0.000000	0.031234
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	---	---	23.702	22.680	23.702	22.680	---	23.702
- Mass Density (kg/m^3)	---	---	7.472	4.552	8.149	7.159	13.255	7.716
- Molar Density (kmole/m^3)	---	---	0.315	0.201	0.344	0.316	---	0.326
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	---	---	0.9706	0.9815	---	0.9542	---	---
- Specific Heat Capacity (kJ/kmole·°C)	---	---	46.6222	43.8435	---	40.8558	---	---
- Enthalpy (kJ/kmole)	---	---	-85,461	-84,660	-88,150	-87,435	---	-89,370
- Entropy (kJ/kmole·°C)	---	---	-201	-192	-209	-203	---	-213
- Gross Heating Value (MJ/m^3)	---	---	48.3	46.1	48.3	46.1	---	48.3
- Net Heating Value (MJ/m^3)	---	---	43.3	41.3	43.3	41.3	---	43.3
- Sound Speed (m/s)	---	---	360.063	366.884	320.378	323.265	---	300.660
- Dew Point Temperature (°C)	---	---	39.90	29.90	---	-35.00	---	---
- Dew Point Pressure (°kPa)	---	---	796.4	496.4	---	596.4	---	---
- Bubble Point Temperature (°C)	---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)	---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)	---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)	---	---	0.033	0.032	0.025	0.023	---	0.023
- Viscosity (cp)	---	---	0.012	0.012	0.010	0.010	0.000	0.010

Composition (Mole Fraction):			9	10	11	12	13	14	15	16
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	0.044759	0.043380	0.044759	0.043380	0.044759	---	0.043380
Water	**H2O**	**7732-18-5**	---	0.000000	0.000000	0.000000	0.000000	0.000000	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	0.025808	0.025205	0.025808	0.025205	0.025808	---	0.025205
Methane	**CH4**	**74-82-8**	---	0.660679	0.641174	0.660679	0.641174	0.660679	---	0.641174
Ethane	**C2H6**	**74-84-0**	---	0.173186	0.171376	0.173186	0.171376	0.173186	---	0.171376
Propane	**C3H8**	**74-98-6**	---	0.078104	0.084805	0.078104	0.084805	0.078104	1.000000	0.084805
i-Butane	**C4H10**	**75-28-5**	---	0.005161	0.007275	0.005161	0.007275	0.005161	---	0.007275
n-Butane	**C4H10**	**106-97-8**	---	0.010691	0.017510	0.010691	0.017510	0.010691	---	0.017510
i-Pentane	**C5H12**	**78-78-4**	---	0.000775	0.002545	0.000775	0.002545	0.000775	---	0.002545
n-Pentane	**C5H12**	**109-66-0**	---	0.000759	0.003010	0.000759	0.003010	0.000759	---	0.003010
Benzene	**C6H6**	**71-43-2**	---	0.000001	0.000100	0.000001	0.000100	0.000001	---	0.000100
Cyclohexane	**C6H12**	**110-82-7**	---	0.000008	0.000175	0.000008	0.000175	0.000008	---	0.000175
Hexane	**C6H14**	**110-54-3**	---	0.000033	0.000745	0.000033	0.000745	0.000033	---	0.000745

Methylcyclopentane	**C6H12**	**96-37-7**	---	0.000009	0.000170	0.000009	0.000170	0.000009	---	0.000170
Heptane	**C7H16**	**142-82-5**	---	0.000023	0.001975	0.000023	0.001975	0.000023	---	0.001975
Methylcyclohexane	**C7H14**	**108-87-2**	---	0.000003	0.000190	0.000003	0.000190	0.000003	---	0.000190
Toluene	**C7H8**	**108-88-3**	---	0.000002	0.000165	0.000002	0.000165	0.000002	---	0.000165
Ethylbenzene	**C8H10**	**100-41-4**	---	0.000000	0.000005	0.000000	0.000005	0.000000	---	0.000005
m-Xylene	**C8H10**	**108-38-3**	---	0.000000	0.000040	0.000000	0.000040	0.000000	---	0.000040
Octane	**C8H18**	**111-65-9**	---	0.000000	0.000075	0.000000	0.000075	0.000000	---	0.000075
o-Xylene	**C8H10**	**95-47-6**	---	0.000000	0.000005	0.000000	0.000005	0.000000	---	0.000005
Nonane	**C9H20**	**111-84-2**	---	0.000000	0.000035	0.000000	0.000035	0.000000	---	0.000035
Decane	**C10H22**	**124-18-5**	---	0.000000	0.000020	0.000000	0.000020	0.000000	---	0.000020
Undecanes	**C11H24**	**1120-21-4**	---	0.000000	0.000015	0.000000	0.000015	0.000000	---	0.000015
Dodecane	**C12H26**	**112-40-3**	---	0.000000	0.000005	0.000000	0.000005	0.000000	---	0.000005

REPORT: PROCESS SIMULATION RESULTS

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PRN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	17	18	19	20	21	22	23	24
- Fluid	Refrigerant (C_3)	Electricity	Fuel Gas	HC	Heat Medium	Heat Medium	HC	HC
- Physical State	Liquid	Unknown	Gas	Liquid	Liquid	Liquid	Vapour	Liquid
- Temperature (°C)	-40.00	---	29.90	-35.00	120.00	120.00	105.00	---
- Pressure (kPa)	14.6	---	399.9	500.0	276.0	276.0	357.5	---
- Total Molar Flowrate (kmole/h)	80.68	---	4.52	38.69	0.00	0.00	29.14	---
- Total Mass Flowrate (kg/h)	7115.5	---	105.1	2143.9	0.0	0.0	1346.3	---
- Total Gas Volumetric Flowrate	---	---	106.9	---	---	---	688.9	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	3.3	0.0	0.0	---	---

- Energy Flowrate kW			---	0.000	---	---	---	---	---	---
Origin (Unit Operation):										
- Tag No.			PR-100	Electric Utility System	Fuel Gas Header	V-600	V-600	H-100	S-100	PU-103
- Service:			Chiller	---	---	Cold	Cold	Boiler	Condensate	Reflux
- Type:			Cooler	---	---	3-Phase Separator	3-Phase Separator	Heater	Stabilizer: Distillation	Pump
Destination (Unit Operation):										
- Tag No.			E-200	PR-100	PR-100	PU-102	PU-101	V-600	AC-101	S-100
- Service:			Chiller	Chiller	Chiller	Booster	Circulation	Cold	Overhead Condenser	Condensate
- Type:			Head Exchanger	Cooler	Cooler	Pump: Centrifugal	Pump	3-Phase Separator	Aerial Cooler	Stabilizer: Distillation Column
Properties:			17	18	19	20	21	22	23	24
- Vapour Mole Fraction			0.000000	---	1.000000	0.000000	0.000000	0.000000	1.000000	0.000000
- Liquid Mole Fraction			1.000000	---	0.000000	1.000000	1.000000	1.000000	0.000000	1.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			---	---	---	55.414	41.686	41.686	46.210	---
- Mass Density (kg/m^3)			578.250	---	---	655.768	1,025.000	1,025.000	6.956	---
- Molar Density (kmole/m^3)			---	---	---	11.834	---	---	0.151	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	---	---	0.0255	---	---	0.9589	---
- Specific Heat Capacity (kJ/kmole·°C)			---	---	---	113.0690	135.4802	135.4802	95.2963	---
- Enthalpy (kJ/kmole)			---	---	---	-149,378	---	---	-105,264	---
- Entropy (kJ/kmole·°C)			---	---	---	-508	---	---	-342	---
- Gross Heating Value (MJ/m^3)			---	---	---	116.1	---	---	97.8	---
- Net Heating Value (MJ/m^3)			---	---	---	106.1	---	---	89.1	---
- Sound Speed (m/s)			---	---	---	995.581	---	---	263.924	---
- Dew Point Temperature (°C)			---	---	---	---	---	---	105.00	---
- Dew Point Pressure (°kPa)			---	---	---	---	---	---	453.8	---
- Bubble Point Temperature (°C)			---	---	---	-35.00	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	596.4	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	1,910.4	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	596.4	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	---	---	0.150	---	---	0.031	---
- Viscosity (cp)			---	---	---	0.299	1.100	1.100	0.012	---
Composition (Mole Fraction):			17	18	19	20	21	22	23	24
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	0.044759	0.000604	---	---	0.000802	---
Water	**H2O**	**7732-18-5**	---	---	0.000000	0.000000	0.462700	0.462700	0.000000	---
Carbon Dioxide	**CO2**	**124-38-9**	---	---	0.025808	0.006508	---	---	0.008642	---
Methane	**CH4**	**74-82-8**	---	---	0.660679	0.036201	---	---	0.048070	---
Ethane	**C2H6**	**74-84-0**	---	---	0.173186	0.115250	---	---	0.153038	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	---	---	0.537300	0.537300	---	---
Propane	**C3H8**	**74-98-6**	1.000000	---	0.078104	0.292650	---	---	0.388604	---
i-Butane	**C4H10**	**75-28-5**	---	---	0.005161	0.072855	---	---	0.096742	---
n-Butane	**C4H10**	**106-97-8**	---	---	0.010691	0.229014	---	---	0.304102	---
i-Pentane	**C5H12**	**78-78-4**	---	---	0.000775	0.057443	---	---	---	---
n-Pentane	**C5H12**	**109-66-0**	---	---	0.000759	0.072823	---	---	---	---
Benzene	**C6H6**	**71-43-2**	---	---	0.000001	0.003161	---	---	---	---
Cyclohexane	**C6H12**	**110-82-7**	---	---	0.000008	0.005366	---	---	---	---

Hexane	**C6H14**	**110-54-3**	---	---	0.000033	0.022820	---	---	---	---
Methylcyclopentane	**C6H12**	**96-37-7**	---	---	0.000009	0.005156	---	---	---	---
Heptane	**C7H16**	**142-82-5**	---	---	0.000023	0.062530	---	---	---	---
Methylcyclohexane	**C7H14**	**108-87-2**	---	---	0.000003	0.005995	---	---	---	---
Toluene	**C7H8**	**108-88-3**	---	---	0.000002	0.005231	---	---	---	---
Ethylbenzene	**C8H10**	**100-41-4**	---	---	0.000000	0.000160	---	---	---	---
m-Xylene	**C8H10**	**108-38-3**	---	---	0.000000	0.001278	---	---	---	---
Octane	**C8H18**	**111-65-9**	---	---	0.000000	0.002395	---	---	---	---
o-Xylene	**C8H10**	**95-47-6**	---	---	0.000000	0.000160	---	---	---	---
Nonane	**C9H20**	**111-84-2**	---	---	0.000000	0.001120	---	---	---	---
Decane	**C10H22**	**124-18-5**	---	---	0.000000	0.000640	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	---	---	0.000000	0.000480	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	---	---	0.000000	0.000160	---	---	---	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PRN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	25	26	27	28	29	30	31	32
- Fluid	HC	Heat Medium	Heat Medium	HC	HC	HC	HC	HC
- Physical State	Liquid	Liquid	Liquid	Liquid	Multiphase	Gas	Liquid	Liquid
- Temperature (°C)	105.00	115.00	120.00	-35.00	39.90	39.90	---	105.00
- Pressure (kPa)	357.5	276.0	276.0	500.0	257.5	257.5	---	657.5
- Total Molar Flowrate (kmole/h)	9.55	1,642.07	1,642.07	38.69	29.14	29.14	---	9.55
- Total Mass Flowrate (kg/h)	797.5	68451.8	68451.8	2143.9	1346.3	1346.3	---	797.5
- Total Gas Volumetric Flowrate	---	---	---	---	---	688.9	---	---
- Total Liq Volumetric Flowrate (m^3/h)	1.4	66.8	66.8	3.3	---	---	---	1.4

- Energy Flowrate kW	---	---	---	---	---	---	---	---
Origin (Unit Operation):								
- Tag No.	S-100	S-100	H-100	PU-102	AC-101	V-300	V-300	PU-104
- Service:	Condensate	Condensate	Boiler	Booster	Overhead Condenser	Reflux Drum	Reflux Drum	Booster
- Type:	Stabilizer: Distillation	Stabilizer: Distillation	Heater	Pump: Centrifugal	Aerial Cooler	2-Phase Separator	2-Phase Separator	Pump
Destination (Unit Operation):								
- Tag No.	PU-104	PU-101	S-100	S-100	V-300	M-100	PU-103	AC-102
- Service:	Booster	Circulation	Condensate	Condensate	Reflux Drum	Not Applicable	Reflux	Bottoms Cooler
- Type:	Pump	Pump	Stabilizer: Distillation Column	Stabilizer: Distillation Column	2-Phase Separator	Mixer	Pump	Aerial Cooler
Properties:	25	26	27	28	29	30	31	32
- Vapour Mole Fraction	0.000000	0.000000	0.000000	0.000000	---	1.000000	0.000000	0.000000
- Liquid Mole Fraction	1.000000	1.000000	1.000000	1.000000	---	0.000000	1.000000	1.000000
- Solid Mole Fraction	---	---	---	---	---	---	---	---
- Aqueous Mole Fraction	---	---	---	---	---	---	---	---
- Molecular Weight	83.488	41.686	41.686	55.414	---	---	---	83.488
- Mass Density (kg/m^3)	586.612	1,025.000	1,025.000	655.768	---	---	---	586.612
- Molar Density (kmole/m^3)	7.026	---	---	11.834	---	---	---	7.026
- API Gravity (°)	---	---	---	---	---	---	---	---
- Compressibility Factor	0.0355	---	---	0.0255	---	---	---	0.0355
- Specific Heat Capacity (kJ/kmole·°C)	217.8930	135.4802	135.4802	113.0690	---	---	---	217.8930
- Enthalpy (kJ/kmole)	-167,475	---	---	-149,378	---	---	---	-167,475
- Entropy (kJ/kmole·°C)	-631	---	---	-508	---	---	---	-631
- Gross Heating Value (MJ/m^3)	171.9	---	---	116.1	---	97.8	---	171.9
- Net Heating Value (MJ/m^3)	158.0	---	---	106.1	---	89.1	---	158.0
- Sound Speed (m/s)	557.222	---	---	995.581	---	---	---	557.222
- Dew Point Temperature (°C)	---	---	---	---	---	---	---	---
- Dew Point Pressure (°kPa)	---	---	---	---	---	---	---	---
- Bubble Point Temperature (°C)	105.00	---	---	-35.00	---	---	---	105.00
- Bubble Point Pressure (kPa)	783.8	---	---	596.4	---	---	---	783.8
- Reid Vapour Pressure (kPa)	1,705.3	---	---	1,910.4	---	---	---	1,705.3
- True Vapour Pressure (kPa)	783.8	---	---	596.4	---	---	---	783.8
- Thermal Conductivity (W/m·°C)	0.093	---	---	0.150	---	---	---	0.093
- Viscosity (cp)	0.147	1.100	1.100	0.299	---	---	---	0.147

Composition (Mole Fraction):			25	26	27	28	29	30	31	32
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	---	0.000604	0.000802	0.000802	---	---
Water	**H2O**	**7732-18-5**	0.000000	0.462700	0.462700	0.000000	0.000000	0.000000	---	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	---	0.006508	0.008642	0.008642	---	---
Methane	**CH4**	**74-82-8**	---	---	---	0.036201	0.048070	0.048070	---	---
Ethane	**C2H6**	**74-84-0**	---	---	---	0.115250	0.153038	0.153038	---	---
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	0.537300	0.537300	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	---	---	---	0.292650	0.388604	0.388604	---	---
i-Butane	**C4H10**	**75-28-5**	---	---	---	0.072855	0.096742	0.096742	---	---
n-Butane	**C4H10**	**106-97-8**	---	---	---	0.229014	0.304102	0.304102	---	---
i-Pentane	**C5H12**	**78-78-4**	0.232640	---	---	0.057443	---	---	---	0.232640
n-Pentane	**C5H12**	**109-66-0**	0.294927	---	---	0.072823	---	---	---	0.294927
Benzene	**C6H6**	**71-43-2**	0.012803	---	---	0.003161	---	---	---	0.012803
Cyclohexane	**C6H12**	**110-82-7**	0.021731	---	---	0.005366	---	---	---	0.021731

Hexane	**C6H14**	**110-54-3**	0.092418	---	---	0.022820	---	---	---	0.092418
Methylcyclopentane	**C6H12**	**96-37-7**	0.020882	---	---	0.005156	---	---	---	0.020882
Heptane	**C7H16**	**142-82-5**	0.253242	---	---	0.062530	---	---	---	0.253242
Methylcyclohexane	**C7H14**	**108-87-2**	0.024279	---	---	0.005995	---	---	---	0.024279
Toluene	**C7H8**	**108-88-3**	0.021185	---	---	0.005231	---	---	---	0.021185
Ethylbenzene	**C8H10**	**100-41-4**	0.000647	---	---	0.000160	---	---	---	0.000647
m-Xylene	**C8H10**	**108-38-3**	0.005178	---	---	0.001278	---	---	---	0.005178
Octane	**C8H18**	**111-65-9**	0.009700	---	---	0.002395	---	---	---	0.009700
o-Xylene	**C8H10**	**95-47-6**	0.000647	---	---	0.000160	---	---	---	0.000647
Nonane	**C9H20**	**111-84-2**	0.004536	---	---	0.001120	---	---	---	0.004536
Decane	**C10H22**	**124-18-5**	0.002593	---	---	0.000640	---	---	---	0.002593
Undecanes	**C11H24**	**1120-21-4**	0.001945	---	---	0.000480	---	---	---	0.001945
Dodecane	**C12H26**	**112-40-3**	0.000648	---	---	0.000160	---	---	---	0.000648

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PRN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	33	34	35	36	37	38	39	40
- Fluid	HC	HC	HC	Heat Medium	Fuel Gas	Heat Medium	HC	Fuel Gas
- Physical State	Liquid	Liquid	Liquid	Liquid	Vapour	Liquid	Vapour	Gas
- Temperature (°C)	39.90	39.90	---	115.00	29.36	120.00	29.36	29.90
- Pressure (kPa)	557.5	557.5	---	276.0	257.5	276.0	257.5	399.9
- Total Molar Flowrate (kmole/h)	9.55	9.55	---	1,642.07	1.24	1,642.07	1,229.09	6.16
- Total Mass Flowrate (kg/h)	797.5	797.5	---	68451.8	28.9	68451.8	28560.9	143.2
- Total Gas Volumetric Flowrate	---	---	---	---	29.4	---	29061.6	145.7
- Total Liq Volumetric Flowrate (m^3/h)	1.1	1.1	---	66.8	---	66.8	---	---

- Energy Flowrate kW			---	---	---	---	---	---	---	---
Origin (Unit Operation):										
- Tag No.			AC-102	AC-102	PU-100	PU-101	Fuel Gas Header	H-100	M-100	M-100
- Service:			Bottoms Cooler	Bottoms Cooler	---	Circulation	---	Boiler	Not Applicable	Not Applicable
- Type:			Aerial Cooler	Aerial Cooler	---	Pump	---	Heater	Mixer	Mixer
Destination (Unit Operation):										
- Tag No.			M-200	Condensate Internal Use	M-200	H-100	H-100	Heat-Medium Header	Fuel Gas Header	Fuel Gas Header
- Service:			Not Applicable	---	Not Applicable	Boiler	Boiler	---	---	---
- Type:			Mixer	---	Mixer	Heater	Heater	---	---	---
Properties:			33	34	35	36	37	38	39	40
- Vapour Mole Fraction			0.000000	0.000000	0.000000	0.000000	1.000000	0.000000	1.000000	1.000000
- Liquid Mole Fraction			1.000000	1.000000	1.000000	1.000000	0.000000	1.000000	0.000000	0.000000
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			---	---	---	41.686	23.237	41.686	23.237	---
- Mass Density (kg/m^3)			724.600	724.600	---	1,025.000	3.315	1,025.000	3.315	---
- Molar Density (kmole/m^3)			---	---	---	---	0.143	---	0.143	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			---	---	---	---	0.9860	---	0.9860	---
- Specific Heat Capacity (kJ/kmole·°C)			---	---	---	135.4802	44.4607	135.4802	44.4607	---
- Enthalpy (kJ/kmole)			---	---	---	---	-85,284	---	-85,284	---
- Entropy (kJ/kmole·°C)			---	---	---	---	-192	---	-192	---
- Gross Heating Value (MJ/m^3)			---	---	---	---	47.4	---	47.4	---
- Net Heating Value (MJ/m^3)			---	---	---	---	42.4	---	42.4	---
- Sound Speed (m/s)			---	---	---	---	362.258	---	362.258	---
- Dew Point Temperature (°C)			---	---	---	---	29.36	---	29.36	---
- Dew Point Pressure (°kPa)			---	---	---	---	353.8	---	353.8	---
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			---	---	---	---	0.032	---	0.032	---
- Viscosity (cp)			0.270	0.270	---	1.100	0.012	1.100	0.012	---
Composition (Mole Fraction):			33	34	35	36	37	38	39	40
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	---	---	---	---	0.043717	---	0.043717	0.044759
Water	**H2O**	**7732-18-5**	0.000000	0.000000	---	0.462700	0.000000	0.462700	0.000000	0.000000
Carbon Dioxide	**CO2**	**124-38-9**	---	---	---	---	0.025401	---	0.025401	0.025808
Methane	**CH4**	**74-82-8**	---	---	---	---	0.646157	---	0.646157	0.660679
Ethane	**C2H6**	**74-84-0**	---	---	---	---	0.172708	---	0.172708	0.173186
Ethylene Glycol	**C2H6O2**	**107-21-1**	---	---	---	0.537300	---	0.537300	---	---
Propane	**C3H8**	**74-98-6**	---	---	---	---	0.085464	---	0.085464	0.078104
i-Butane	**C4H10**	**75-28-5**	---	---	---	---	0.007332	---	0.007332	0.005161
n-Butane	**C4H10**	**106-97-8**	---	---	---	---	0.017646	---	0.017646	0.010691
i-Pentane	**C5H12**	**78-78-4**	0.232640	0.232640	---	---	0.000757	---	0.000757	0.000775
n-Pentane	**C5H12**	**109-66-0**	0.294927	0.294927	---	---	0.000741	---	0.000741	0.000759
Benzene	**C6H6**	**71-43-2**	0.012803	0.012803	---	---	0.000001	---	0.000001	0.000001
Cyclohexane	**C6H12**	**110-82-7**	0.021731	0.021731	---	---	0.000007	---	0.000007	0.000008

Hexane	**C6H14**	**110-54-3**	0.092418	0.092418	---	---	0.000032	---	0.000032	0.000033
Methylcyclopentane	**C6H12**	**96-37-7**	0.020882	0.020882	---	---	0.000009	---	0.000009	0.000009
Heptane	**C7H16**	**142-82-5**	0.253242	0.253242	---	---	0.000022	---	0.000022	0.000023
Methylcyclohexane	**C7H14**	**108-87-2**	0.024279	0.024279	---	---	0.000003	---	0.000003	0.000003
Toluene	**C7H8**	**108-88-3**	0.021185	0.021185	---	---	0.000002	---	0.000002	0.000002
Ethylbenzene	**C8H10**	**100-41-4**	0.000647	0.000647	---	---	0.000000	---	0.000000	0.000000
m-Xylene	**C8H10**	**108-38-3**	0.005178	0.005178	---	---	0.000000	---	0.000000	0.000000
Octane	**C8H18**	**111-65-9**	0.009700	0.009700	---	---	0.000000	---	0.000000	0.000000
o-Xylene	**C8H10**	**95-47-6**	0.000647	0.000647	---	---	0.000000	---	0.000000	0.000000
Nonane	**C9H20**	**111-84-2**	0.004536	0.004536	---	---	0.000000	---	0.000000	0.000000
Decane	**C10H22**	**124-18-5**	0.002593	0.002593	---	---	0.000000	---	0.000000	0.000000
Undecanes	**C11H24**	**1120-21-4**	0.001945	0.001945	---	---	0.000000	---	0.000000	0.000000
Dodecane	**C12H26**	**112-40-3**	0.000648	0.000648	---	---	0.000000	---	0.000000	0.000000

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PRN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	41	42	43	44	45	46	47	48
- Fluid	HC	HC	HC	Electricity	Electricity	Electricity	Electricity	Electricity
- Physical State	Vapour	Vapour	Vapour	Unknown	Unknown	Unknown	Unknown	Unknown
- Temperature (°C)	29.36	29.36	29.36	---	---	---	---	---
- Pressure (kPa)	257.5	257.5	257.5	---	---	---	---	---
- Total Molar Flowrate (kmole/h)	0.00	1,222.93	0.00	---	---	---	---	---
- Total Mass Flowrate (kg/h)	0.0	28417.7	0.0	---	---	---	---	---
- Total Gas Volumetric Flowrate	0.0	28915.9	0.0	---	---	---	---	---
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---	---	---	---	---
- Energy Flowrate kW	---	---	---	4.189	0.024	0.007	0.006	3.996

Origin (Unit Operation):										
- Tag No.			M-100	M-100	M-100	Electric Utility System	Electric Utility	Electric Utility System	Electric Utility System	Electric Utility System
- Service:			Not Applicable	Not Applicable	Not Applicable	---	---	---	---	---
- Type:			Mixer	Mixer	Mixer	---	---	---	---	---
Destination (Unit Operation):										
- Tag No.			Gas Gathering System	To Flare Line	Fuel Gas Header		AC-100	AC-101	AC-102	PU-101
- Service:			---	---	---	---	Discharge Cooler	Overhead Condenser	Bottoms Cooler	Circulation
- Type:			---	---	---	---	Aerial Cooler	Aerial Cooler	Aerial Cooler	Pump
Properties:			41	42	43	44	45	46	47	48
- Vapour Mole Fraction			1.000000	1.000000	1.000000	---	---	---	---	---
- Liquid Mole Fraction			0.000000	0.000000	0.000000	---	---	---	---	---
- Solid Mole Fraction			---	---	---	---	---	---	---	---
- Aqueous Mole Fraction			---	---	---	---	---	---	---	---
- Molecular Weight			23.237	23.237	23.237	---	---	---	---	---
- Mass Density (kg/m^3)			3.315	3.315	3.315	---	---	---	---	---
- Molar Density (kmole/m^3)			0.143	0.143	0.143	---	---	---	---	---
- API Gravity (°)			---	---	---	---	---	---	---	---
- Compressibility Factor			0.9860	0.9860	0.9860	---	---	---	---	---
- Specific Heat Capacity (kJ/kmole·°C)			44.4607	44.4607	44.4607	---	---	---	---	---
- Enthalpy (kJ/kmole)			-85,284	-85,284	-85,284	---	---	---	---	---
- Entropy (kJ/kmole·°C)			-192	-192	-192	---	---	---	---	---
- Gross Heating Value (MJ/m^3)			47.4	47.4	47.4	---	---	---	---	---
- Net Heating Value (MJ/m^3)			42.4	42.4	42.4	---	---	---	---	---
- Sound Speed (m/s)			362.258	362.258	362.258	---	---	---	---	---
- Dew Point Temperature (°C)			29.36	29.36	29.36	---	---	---	---	---
- Dew Point Pressure (°kPa)			353.8	353.8	353.8	---	---	---	---	---
- Bubble Point Temperature (°C)			---	---	---	---	---	---	---	---
- Bubble Point Pressure (kPa)			---	---	---	---	---	---	---	---
- Reid Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- True Vapour Pressure (kPa)			---	---	---	---	---	---	---	---
- Thermal Conductivity (W/m·°C)			0.032	0.032	0.032	---	---	---	---	---
- Viscosity (cp)			0.012	0.012	0.012	---	---	---	---	---
Composition (Mole Fraction):			41	42	43	44	45	46	47	48
Name	**Formula**	**CAS No.**								
Nitrogen	**N2**	**7727-37-9**	0.043717	0.043717	0.043717	---	---	---	---	---
Water	**H2O**	**7732-18-5**	0.000000	0.000000	0.000000	---	---	---	---	---
Carbon Dioxide	**CO2**	**124-38-9**	0.025401	0.025401	0.025401	---	---	---	---	---
Methane	**CH4**	**74-82-8**	0.646157	0.646157	0.646157	---	---	---	---	---
Ethane	**C2H6**	**74-84-0**	0.172708	0.172708	0.172708	---	---	---	---	---
Propane	**C3H8**	**74-98-6**	0.085464	0.085464	0.085464	---	---	---	---	---
i-Butane	**C4H10**	**75-28-5**	0.007332	0.007332	0.007332	---	---	---	---	---
n-Butane	**C4H10**	**106-97-8**	0.017646	0.017646	0.017646	---	---	---	---	---
i-Pentane	**C5H12**	**78-78-4**	0.000757	0.000757	0.000757	---	---	---	---	---
n-Pentane	**C5H12**	**109-66-0**	0.000741	0.000741	0.000741	---	---	---	---	---
Benzene	**C6H6**	**71-43-2**	0.000001	0.000001	0.000001	---	---	---	---	---
Cyclohexane	**C6H12**	**110-82-7**	0.000007	0.000007	0.000007	---	---	---	---	---
Hexane	**C6H14**	**110-54-3**	0.000032	0.000032	0.000032	---	---	---	---	---
Methylcyclopentane	**C6H12**	**96-37-7**	0.000009	0.000009	0.000009	---	---	---	---	---

Heptane	**C7H16**	**142-82-5**	0.000022	0.000022	0.000022	---	---	---	---	---
Methylcyclohexane	**C7H14**	**108-87-2**	0.000003	0.000003	0.000003	---	---	---	---	---
Toluene	**C7H8**	**108-88-3**	0.000002	0.000002	0.000002	---	---	---	---	---
Ethylbenzene	**C8H10**	**100-41-4**	0.000000	0.000000	0.000000	---	---	---	---	---
m-Xylene	**C8H10**	**108-38-3**	0.000000	0.000000	0.000000	---	---	---	---	---
Octane	**C8H18**	**111-65-9**	0.000000	0.000000	0.000000	---	---	---	---	---
o-Xylene	**C8H10**	**95-47-6**	0.000000	0.000000	0.000000	---	---	---	---	---
Nonane	**C9H20**	**111-84-2**	0.000000	0.000000	0.000000	---	---	---	---	---
Decane	**C10H22**	**124-18-5**	0.000000	0.000000	0.000000	---	---	---	---	---
Undecanes	**C11H24**	**1120-21-4**	0.000000	0.000000	0.000000	---	---	---	---	---
Dodecane	**C12H26**	**112-40-3**	0.000000	0.000000	0.000000	---	---	---	---	---

Header Block				
Client:	TetraTech		**Operator:**	Tetra Tech
Site:	Mangghystau Oilfield		**Country:**	Kazakhstan
Facility:	**Category:**	Oil Field	**Subcategory 1:**	
	CEL Facility Code:	OP-009	**Subcategory 2:**	
Source:	**Category:**	Flare	**Subcategory 1:**	Elevated
	CEL Equipment Code:	OP-009-1	**Subcategory 2:**	Unassisted
	Tag No:	TECH-FL-1	**Make:**	Unavailable
	Model:	Unavailable	**Serial No:**	Unavailable

Mitigation Measure Assessed				
Administrative Information:	**CEL Mitigation Code:**	OP-009-PRN	**Reference Year:**	2022
Mitigation Measure (Stage 1)	**Category:**	NGL Recovery	**Subcategory 1:**	Using a propane-refrigeration condenser (shallow cut) and
	CEL Reference Code:	NGL-BSO-PR	**Subcategory 2:**	NGL blended into the sales oil without exceeding RVP limits.
	Reference CEL	Unavailable	**Reference CEL**	Unavailable
Mitigation Measure (Stage 2)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	
Mitigation Measure (Stage 3)	**Category:**	None	**Subcategory 1:**	
	CEL Reference Code:		**Subcategory 2:**	
	Reference CEL		**Reference CEL**	

Mitigation Measure Primary Design Factors Chosen			
Parameter	**Value Chosen**	**Min Search Value**	**Max Search Value**
Year-1 Peak Flow Rate Design Factor	**1.00**	0.50	2.00
Final Cooling Temperature (°C)	**-35.00**	-35.00	5.00
Outlet Pressure (kPa)	**300.00**	100.00	1,000.00

Simulation Flowsheet Drawing No:	SFD-20-OB-OSP-AGV-049-6							
Streams:	49	50	51	52				
- Fluid	Electricity	Electricity	Electricity	Electricity				
- Physical State	Unknown	Unknown	Unknown	Unknown				
- Temperature (°C)	---	---	---	---				
- Pressure (kPa)	---	---	---	---				
- Total Molar Flowrate (kmole/h)	---	---	---	---				
- Total Mass Flowrate (kg/h)	---	---	---	---				
- Total Gas Volumetric Flowrate	---	---	---	---				
- Total Liq Volumetric Flowrate (m^3/h)	---	---	---	---				

- Energy Flowrate kW	0.000	0.000	0.157	0.000				
Origin (Unit Operation):								
- Tag No.	Electric Utility System	Electric Utility System	Electric Utility System	Electric Utility System				
- Service:	---	---	---	---				
- Type:	---	---	---	---				
Destination (Unit Operation):								
- Tag No.	PU-102	PU-103	PU-104	PU-105				
- Service:	Booster	Reflux	Booster	Booster				
- Type:	Pump: Centrifugal	Pump	Pump	Pump				
Properties:	49	50	51	52	0	0	0	0
- Vapour Mole Fraction	---	---	---	---				
- Liquid Mole Fraction	---	---	---	---				
- Solid Mole Fraction	---	---	---	---				
- Aqueous Mole Fraction	---	---	---	---				
- Molecular Weight	---	---	---	---				
- Mass Density (kg/m^3)	---	---	---	---				
- Molar Density (kmole/m^3)	---	---	---	---				
- API Gravity (°)	---	---	---	---				
- Compressibility Factor	---	---	---	---				
- Specific Heat Capacity (kJ/kmole·°C)	---	---	---	---				
- Enthalpy (kJ/kmole)	---	---	---	---				
- Entropy (kJ/kmole·°C)	---	---	---	---				
- Gross Heating Value (MJ/m^3)	---	---	---	---				
- Net Heating Value (MJ/m^3)	---	---	---	---				
- Sound Speed (m/s)	---	---	---	---				
- Dew Point Temperature (°C)	---	---	---	---				
- Dew Point Pressure (°kPa)	---	---	---	---				
- Bubble Point Temperature (°C)	---	---	---	---				
- Bubble Point Pressure (kPa)	---	---	---	---				
- Reid Vapour Pressure (kPa)	---	---	---	---				
- True Vapour Pressure (kPa)	---	---	---	---				
- Thermal Conductivity (W/m·°C)	---	---	---	---				
- Viscosity (cp)	---	---	---	---				
Composition (Mole Fraction):	49	50	51	52	0	0	0	0
Name / **Formula** / **CAS No.**								