EVALUATION OF ENVIRONMENTAL IMPACTS OF SPIRE STL PIPELINE

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1. EXECUTIVE SUMMARY

Trinity Consultants (Trinity) evaluated the various environmental impacts associated with the new STL Pipeline operated by Spire Missouri Inc. (Spire). This evaluation included a review of both internal assessments conducted by Spire as well as an independent review conducted by Trinity. The following conclusions were made about the operation of the STL Pipeline upon completion of the evaluation:

- The pipeline resulted in reduced emissions and environmental impacts from Spire's Underground Gas Storage Facility.
- The pipeline resulted in reduced emissions and environmental impacts from Spire's Propane Storage Facility.
- The pipeline decreased the use of less efficient fuel sources such as propane and those used during gas curtailment.
- The pipeline allows Spire to source gas that is extracted and transported with less emissions than its other existing gas sources.

Trinity's overall assessment is that the operation of the STL Pipeline allows Spire to maintain their current gas supply operations while decreasing both environmental impacts and the emissions of greenhouse gasses, criteria pollutants, and hazardous air pollutants.

2. INTRODUCTION AND PURPOSE

Spire engaged Trinity to conduct a validation of the data analysis that Spire performed regarding environmental impacts associated with Spire Missouri's decision to take service on the Spire STL Pipeline. The environmental impacts analysis primarily focused on three areas:

- Evaluating the change in emissions at Spire's Underground Gas Storage Facility due to the operation of the pipeline
- Comparing the environmental impact of vaporized propane usage to natural gas usage since additional propane will no longer be needed with the pipeline in service
- Comparing the environmental impact associated with past pipeline operations to the impact associated with using the new pipeline

In completing this evaluation, Trinity also researched other potential environmental impacts with the primary focus being on air quality-related issues. Trinity's findings for both the validation and the additional research are summarized in this report.

3. UNDERGROUND STORAGE FACILITY REDUCTIONS

The STL Pipeline receives gas at a higher pressure, utilizing less compression given the direct path from REX to Spire's city-gate, than the gas previously used for Spire's operations in this area. This allows Spire to reduce the use of equipment such as compressor engines at its underground gas storage facility. This section of the report evaluates the environmental impacts of reducing the use of this equipment due to the installation and operation of the STL Pipeline.

3.1 Emissions Reduction Evaluation

For this evaluation, Spire prepared an Excel spreadsheet named "NOx_GHG_Reductions for STL Changes to UGS (Lange)" that calculated the reduction of NO_X and GHG emissions at its underground storage facility due to the operation of the STL Pipeline. The pipeline came online in November 2019 and the calculations compared compressor engine and heater emissions from 2020 to average emissions from 2016 to 2018.

Trinity confirmed that all emissions calculations were completed correctly and used industry-accepted standards. For NO_X emissions, Spire utilized emissions factors from AP-42 Chapter 3.2 *Natural Gas-fired Reciprocating Engines* (08/2000), which is a widely accepted methodology whenever stack testing or manufacturer's data is not available. For GHG emissions, Spire utilized emission factors from Subpart C of EPA's GHG Mandatory Reporting Rule (40 CFR 98.30-98.38) for its evaluation. For the specific NO_X and GHG factors used, Trinity noticed that they were both approximately 1% different than the respective AP-42 and Subpart C values, and this was most likely due to how the values were either rounded or converted.

Trinity agrees that the reduction in engine operation is directly tied to the operation of the STL Pipeline, but it was not readily apparent how heater emissions are impacted. Trinity assumes that the operation of the heaters are driven more by ambient temperatures, and the operation of the STL Pipeline does not result in a lesser volume of gas needing to be heated. However, engine emissions account for 99% of the overall NOX emissions reductions and 76% of the overall GHG emissions reductions so there is still a significant reduction in these emissions due to the operation of the pipeline even when heater emissions are not considered.

3.2 Other Potential Environmental Benefits

Trinity conducted its own evaluation of the operations at the Underground Gas Storage facility to determine if there are any other changes in environmental-related impacts due to the operation of the pipeline. The following potential impacts were identified:

- Emissions of carbon monoxide (CO), particulate matter (PM), volatile organic compounds (VOC), and hazardous air pollutants (HAPs) also decreased by a similar percentage to that of NO_X and GHG due to the reduced operation of the engines
- NO_X, VOC, and methane are all precursors to ozone formation and their reduction will potentially have an impact on ozone concentrations in St. Louis county and St. Louis city, which are both currently classified as Marginal nonattainment for the National Ambient Air Quality Standard for ozone according to the most recent EPA Green Book data
- The reduction in engine fuel usage results in less natural gas being extracted, processed, and transported
- The reduction in engine operation reduces noise pollution levels

- The reduction in NO_X and PM emissions could have a potential impact on improving the visibility at the Mingo Wilderness Area, which is a Class I area (land classification scheme under the Prevention of Significant Deterioration (PSD) program) located approximately 180 km south of the facility, but the impact would most likely be negligible due to the quantity of emissions reductions and distance between the locations
- The reduction in NO_X and PM emissions could have a potential impact on improving the visibility in the immediate vicinity of the facility
- The reduction in all emissions could potentially reduce the acute and chronic impacts on nearby soil and vegetation

4. COMPARISON OF PROPANE VAPORIZATION & NATURAL GAS USAGE

The installation and operation of the STL Pipeline allowed Spire to discontinue the use of its liquid propane vaporization system that provided additional supply on an as-needed basis. This section of the report compares the environmental impacts of using the propane vaporization system as opposed to only using natural gas.

4.1 GHG Intensity Comparison

For this evaluation, Spire prepared an Excel spreadsheet named "Propane vs NG Emission Calculations" that compared the GHG intensities of using propane versus natural gas. It also calculated actual GHG emissions from the two most recent years where propane vaporization was needed (2014 and 2019) and compared these to what the emissions would have been if only natural gas were used. Propane vaporization requires the use of natural gas combustion to heat the liquified propane, and the emissions from this heating operation were also included in the evaluation.

Trinity confirmed that all emissions calculations were completed correctly and used industry-accepted standards. Spire utilized emission factors from Subpart C of EPA's GHG Mandatory Reporting Rule (40 CFR 98.30-98.38) for its evaluation. However, Trinity noted that the factors for CH_4 and N_2O taken from Subpart C are for "Petroleum Products", which includes propane, but these are general factors used for a variety of fuels and may not be the most representative of GHG emissions from propane combustion specifically. Therefore, Trinity also reviewed GHG emission factors from other commonly available sources such as EPA's *AP-42: Compilation of Air Emissions Factors* and API's *Compendium of GHG Emissions Methodologies for the Oil and Natural Gas Industry* (08/2009). Specifically for natural gas and propane combustion, Trinity reviewed emissions factors published in AP-42 Chapter 1.4 *Natural Gas Combustion* (07/1998) and Chapter 1.5 *Liquified Petroleum Gas Combustion* (07/2008). The API Compendium utilizes these AP-42 Chapters for its factors as well. Compared to Subpart C, the CO_2 factors were approximately the same (within 1%) for both natural gas and propane combustion, as was the CH_4 factor for natural gas combustion. The CH_4 AP-42 factor for propane was one-third of the Subpart C factor, and the N_2O AP-42 factors for both CH_4 and N_2O were an order of magnitude greater than the Subpart C factors. A summary of the combined factors using both approaches on a CO_2e basis is provided in the table below.

Using Subpart C factors, propane combustion results in 16.2% more GHG emissions than natural gas combustion on an equivalent Btu basis. Due to the additional natural gas combustion needed for propane vaporization, this operation results in 16.8% more GHG emissions than natural gas by itself. This equates to an additional 1,310 mt CO_2e being emitted per year when using propane vaporization (based on average of 2014 and 2019 usage). The GHG emissions increase from propane combustion are even greater when using AP-42 factors.

GHG Emissions Comparison for Propane vs. Natural Gas Usage

Source	Propane (kg CO_2e/ MMBtu)	Nat. Gas (kg CO_2e/ MMBtu)	Propane vs Nat. Gas Intensity	GHG Increase for Propane Use (%)	GHG Increase for Propane Use (mt/yr)
MRR Subpart C	61.71	53.11	16.2%	16.8%	1,310
AP-42 1.4 & 1.5	63.32	53.68	18.0%	18.6%	1,463

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4.2 Non-GHG Environmental Impacts

Trinity conducted its own evaluation of the propane vaporization process to determine if there are any other changes in environmental-related impacts compared to only using natural gas. The following potential impacts were identified:

- Less fuel usage from discontinuing the vaporization of propane means there are less emissions of CO, NO_X, PM, VOC, and HAPs
- The likelihood of fugitive VOC emissions leaks from piping components would potentially be reduced as additional piping segments will either be out-of-service or depressurized
- With additional equipment being out-of-service, there will be less emissions from routine maintenance and the potential for excess emission events will be reduced
- Similar to the discussion in Section 2, the reduction in emissions could have an impact on ambient ozone concentrations, visibility, and soil and vegetation

5. COMPARISON OF PAST AND CURRENT PIPELINE OPERATIONS

This section of the report evaluates the differences in environmental impacts between Spire's existing operations and Spire's operations without an operational STL Pipeline.

5.1 GHG Intensity for Onshore Production Basins

The installation and operation of the STL Pipeline allows Spire to access gas from the Appalachian Basin, which is one of the geological basins identified by EPA for its Mandatory Reporting Rule. Under this rule, emissions are reported on a basin-wide basis for both the Onshore Production and Gathering and Boosting sectors. Companies are only required to report emissions under this rule if their basin-wide annual GHG emissions exceed 25,000 metric tons of CO_2e. Spire prepared an Excel spreadsheet named "Source Carbon Intensity" that compares the GHG intensity of the Appalachian Basin to other significant basins reported under the MRR. The intensity values in this spreadsheet were taken from the Clean Air Task Force's *Benchmarking Methane and Other GHG Emissions* (6/2021) report, which utilizes GHG data published by EPA in their Envirofacts database.

Trinity reviewed and confirmed that the intensity values calculated by Spire are correct. The benchmarking data shows that the Appalachian Basin has the lowest GHG intensity of the twenty largest-producing basins, and that this intensity is 22% of the average intensity across all basins. This means that the CO_2e emissions per Btu of gas extracted from the Appalachian Basin are almost one-fifth of the emissions from a typical production basin. Therefore, the access to the Appalachian Basin via the STL Pipeline means that Spire is now able to use natural gas that was extracted using production methods with less GHG emissions than that of the natural gas that they were previously purchasing. Specifically, 7.6% of Spire's gas in 2019 was transported through pipelines that pulled gas from the Appalachian Basin. With the operation of the STL Pipeline, Spire is now pulling 55.1% of its gas from the Appalachian Basin.

5.2 Other Impacts from Current Pipeline Operations

Trinity conducted its own evaluation of the current pipeline operations to determine if there are any other changes in environmental-related impacts compared to the past pipeline operations. The following potential impacts were identified:

- Based on data published in EPA's Envirofacts database, Trinity determined that the Appalachian also has the lowest GHG intensity for the Gathering and Boosting Sector among the five largest-producing basins (specifically, the intensity is 43% of the average GHG intensity across all five basins)
- The newer infrastructure associated with the current STL Pipeline will potentially result in less fugitive leaks and reliability issues
- A greater distance to market could potentially increase the amount of emissions from pipeline leaks and support operations, but due to the complexity of the pipeline networks, and due to the limited scope of this assessment, Trinity was not able to determine the difference in the distances to market between existing operations and the STL Pipeline operations (In general, the distance to market for most existing operations (primarily from Oklahoma and Texas) is not significantly different than the distance to market for the STL Pipeline (primarily from Ohio and Pennsylvania))
- Unlike other existing pipelines that serve Spire Missouri, the newer infrastructure and design of the STL Pipeline allows Spire to source gas from the Appalachian Basin without the need for additional compression, which means there are less associated emissions from the transportation of the gas when compared to other pipeline pathways that would otherwise be used to source this gas

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- Current operations decrease the likelihood of gas curtailment, which would otherwise potentially result in customers switching to less efficient sources of heating
- Current operations receive more gas from states that have more stringent environmental regulations (i.e., Pennsylvania and Ohio) compared to existing operations (i.e., primarily Oklahoma) as summarized in the table below for typical minor sources

Air Quality Regulatory Comparison

State	Air Permit Threshold for VOC	Leak Monitoring Required?	Tank Control Required?	Loading Control Required?	Engine Testing Required?	Dehy Control Required?
Pennsylvania (GP-5A)	2.7 tpy	Quarterly	If VOC > 2.7 tpy	If VOC > 2.7 tpy	Quarterly for NO_X/CO/VOC	If VOC > 2.7 tpy
Ohio (GP 12.1)	10 lb/day	Quarterly	If VOC > 4.28 tpy	None	If > 500 hp	If VOC > 5 tpy
Oklahoma (GP-OGF)	40 tpy	None	None for Upstream	None for Upstream	Quarterly for NO_X/CO	None

APPENDIX A. SPIRE EVALUATIONS