TETRA TECH

May 18, 2022

Mr. Cody Flammond
Engineering Inspector
City of Bozeman
P.O. Box 1230
Bozeman, Montana 59771-1230

RE: Final 2019-2021 Remediation System Evaluation Report
Bozeman Landfill, Bozeman, Montana

Dear Mr. Flammond:

We have conducted an evaluation of the operation of the Landfill Gas Extraction System and Remediation System at the former Story Mill Landfill in Bozeman, Montana. This work was conducted per our 2020 and 2021 Task Orders for *Groundwater and Perimeter Methane Monitoring Assessment of System Performance and Effectiveness*. This report includes review of the operation of the various systems comprising of the expanded remediation system. Groundwater quality data and remediation system operating data through December 2021, are evaluated in regard to what effect the remediation systems are having on groundwater quality and landfill gas migration.

This report is a continuation of the DEQ requirements to implement remedial measures and show they are effectively addressing the impacts to groundwater and landfill gas migration. This report also includes recommendations for changes to the remediation systems to improve performance, reduce costs, and improve groundwater quality.

Sincerely,

Larry Cawlfield
Project Manager

Enclosure: Final 2019-2021 Remediation System Evaluation, dated May 18, 2022, (2 hard copies, 1 electronic copy on USB drive).

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FINAL - 2019-2021 REMEDIATION SYSTEM EVALUATION,
BOZEMAN LANDFILL
BOZEMAN, MONTANA

#114-710326G
May 18, 2022

PRESENTED TO

City of Bozeman
Mr. Cody Flammond
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The objective of this Remediation System Evaluation Report is to review the operation and effectiveness of the remediation system at the City of Bozeman's Landfill (Bozeman Landfill; also known as Story Mill Landfill) on Story Mill Road (**Figure 1**). This report format has been abbreviated from previous System Evaluation Reports (SER) submitted in March 2018 (Tetra Tech, 2018) and March 2020 (Tetra Tech, 2020), by removing most of the background information on project history, site geology, and previous investigations and referring the reader to the earlier reports for details. This report presents groundwater data and remediation system data through December 2021.

This landfill has also been referred to as the Story Mill Landfill in other documents. The upgrades to the Landfill Gas Extraction System (LFGES) and the new remediation system, installed in 2016 (Soil Vapor Extraction and Air Injection (SVE/AI) system), were required as the result of a June 6, 2014, Montana Department of Environmental Quality (DEQ) letter requiring the City of Bozeman (City) to initiate a Corrective Measures Assessment (CMA) of offsite groundwater impacts downgradient of the landfill. DEQ rules (ARM 17.50.1308) require the owner or operator of a facility, which has detected an exceedance of groundwater protection standards, to initiate an assessment of corrective measures and submit to the DEQ a report describing an assessment of corrective measures. A Revised CMA was completed in September 2014 (Tetra Tech, 2014). This report is designed to show compliance with the monitoring requirements of DEQ's solid waste rules relative to CMAs, and progress towards meeting closure requirements.

A summary of background information on the landfill is presented in **Section 2.0**. More detailed information on its history, environmental setting, previous investigations, and previous remediation activities are presented in the previous System Evaluation Reports. Methods for current data evaluation and monitoring activities are summarized in **Section 3.0** below. Details on previous methods used can be found in Section 3 of previous SERs. An analysis of the collected data, relative to evaluation of the effectiveness of the LFGES and SVE/AI system, are presented in **Section 4.0**. Summary and Conclusions are presented in **Section 5.0**. Recommendations for future actions are included in **Section 6.0** and references cited are listed in **Section 7.0**. Most tables, and all figures, are presented at the end of the document. In some cases, only the last six years of data are presented; historic data (dated back to 1995), can be found in previous SER's. No appendices are presented. Lab reports, field reports, and data validation reports are available upon request to Tetra Tech.

The new LFGES and SVE/AI remediation systems began operation on August 9, 2016, and have continuously operated since that time. Monitoring and maintenance of these systems have been conducted on a routine basis to ensure continuous operation. Groundwater monitoring activities, at selected wells, have been conducted on a semi-annual basis since 1995 and on a quarterly basis from August 2016 through December 2021. Groundwater monitoring and preparation of this report have been conducted in accordance with 2020/2021 Task Order for Groundwater and Perimeter Methane Monitoring Assessment of System Performance and Effectiveness (Tetra Tech 2020a). This report updates, through December 2021, the findings presented in *Final 2018/2019 Remedial System Evaluation Report, Bozeman Landfill*, dated March 2020.

This report includes the results of an evaluation that focused on volatile organic compounds (VOCs) in groundwater in the southeast corner of the landfill, which was a recommendation from the *Final 2018-2019 Remediation System Evaluation* report. Additional reports summarizing ongoing site-wide groundwater monitoring events are prepared as part of the semi-annual groundwater monitoring requirements of DEQ's Solid Waste Program for the Bozeman Landfill.

2.0 BACKGROUND INFORMATION

Detailed discussion of the Bozeman Landfill (the Site) and its history of operation and environmental investigations are presented in Section 2 of previous SERs. This includes discussion of the location of the landfill, land use/ownership, environmental setting, history, previous investigations, and current operations.

In summary, the Bozeman Landfill is located between Story Mill Road and McIlhattan Road on the western flanks of the Bridger Mountains (**Figure 1**). The Site is located in Section 30 of Township 1 South, Range 6 East in Gallatin County. The Site consists of two historic closed landfill cells and some active operations (e.g., composting, recycling, and hazardous material collection). One of the closed cells is an unlined cell and the other is a lined cell. Both cells accepted Class II, III, and IV wastes, which were solid, non-hazardous, household, industrial, commercial, municipal, construction and demolition-related wastes. Waste and recyclables are currently accepted in containers located at the Bozeman Convenience Site at the southeast corner of the landfill property. These containers are transported offsite to the Gallatin County Landfill at Logan, Montana where waste is off-loaded.

Groundwater monitoring activities have been conducted on a quarterly basis since the current LFGES and SVE/AI remediation system began operation in 2016.

3.0 METHODS

This section summarizes methods used to conduct monitoring of groundwater, site soil gasses, and the Site remedial system operations.

3.1 GROUNDWATER MONITORING

The groundwater sampling events following startup of the current remediation systems occurred in August 2016 (baseline), with quarterly sampling events occurring since that time. The summer and winter groundwater sampling events include a larger parameters list and greater number of wells than the spring and fall events because they are the compliance monitoring events required by DEQ. The spring and fall events are conducted to provide more data from selected wells that reflect changes in water quality resulting from operation of the remediation systems and are limited to a few VOCs. This report presents data from 2014 to present. Groundwater quality data from the second half of 2019 through December of 2021 is presented for the first time. Also, data for wells MW-28 and MW-29, installed in 2021, is presented for the first time.

Groundwater monitoring activities included the measurement of water levels, field parameters, and purging and sampling of existing monitoring wells. The routine semi-annual monitoring events (summer and winter of each year) include wells LF-2, LF-3, MW-4, MW-5, MW-6, MW-6B, MW-7A, MW-7B, MW-8A, MW-8B, MW-8C, MW-9A, MW-9B, MW-10, MW-11, MW-12, MW-13, MW-14, MW-15, MW-17, MW-18, MW-19, MW-20, MW-21, MW-22, MW-23, MW-24, MW-25, MW-26, MW-27, MW-28, and MW-29 (**Figure 2**). Spring and fall monitoring included wells LF-2, LF-3, MW-12, MW-17, MW-18, MW-20, MW-28, and MW-29 (**Figure 2**).

Sampling methodologies follow typical DEQ requirements as outlined in Section 3 of previous SERs. Although 58 parameters are analyzed during the summer and winter events, only four parameters are presented in the following discussion, charts, and figures. These constituents are tetrachloroethene (PCE), trichloroethene (TCE), methylene chloride (MECL) and vinyl chloride (VC) since these parameters have historically been the compounds that most frequently exceed Montana Groundwater Protection Standards (GPS) and will likely be the parameters used for future site closure decisions. Analytic results for all 58 constituents are included in the annual groundwater monitoring reports.

Water levels were measured from each well sampled using an electric well probe. Other field parameters including temperature, pH, specific conductivity, dissolved oxygen (DO, measured in milligrams per liter), and oxidation reduction potential (ORP, measured in millivolts) were also measured. Water samples were collected from each monitoring well, or monitoring site, in accordance with the Groundwater Monitoring Sampling and Analysis Plan (Tetra Tech, 2015) for the Site. Samples collected from the sites were analyzed for volatile organic compounds (VOCs), in accordance with EPA Method 8260B MSV Low Level.

Pace Analytical Services, Inc. (Pace), in Minneapolis, Minnesota, was contracted to furnish the sample containers, trip blanks, and conduct the analysis of water samples. Upon Pace's receipt of samples from each monitoring event, the trip blank was analyzed for VOCs (in accordance with EPA Method 8260B MSV Low Level). Data quality has been evaluated by completing data validation reports, which compare data quality to the objectives in the *Groundwater Monitoring Sampling and Analysis Plan* (Tetra Tech 2015). Where appropriate, these reports modify data in the project database and identify areas where field methods were not followed. No data was removed from the database as a result of the data validation process; however, several qualifications of individual data points were made. Data validation reports are available from Tetra Tech upon request.

3.2 METHANE MONITORING

Methane monitoring at the Site consists of monthly field measurements of methane, carbon dioxide, oxygen, nitrogen, and static well pressure at eight locations along the site perimeter. Two of the locations (BLG-1 and BLG-2) are on the upslope eastern property boundary while one (BLG-6) is along the western boundary and the remaining five (BLG-3, BLG-4, BLG-4New, BLG-5, and BLG-10) are along the southern boundary (**Figure 3**).

3.3 REMEDIAL OPERATIONS SYSTEMS MONITORING

The current remedial system started operation in August 2016. The system consists of three subsystems:

1) A network of wells under vacuum to remove gases from the waste prism (landfill gas extraction (LFGES)).
2) A network of wells to extract soil vapor (SVE) from downgradient of the waste prisms.
3) A network of air injection (AI) wells to volatize groundwater contaminants into soil vapor for capture by the SVE system.

At the heart of the remedial system is an automated flare station primarily consisting of suction blowers, an air compressor for air injection, and a flare for disposal of volatized contaminants. Combined, this system provides a barrier to the migration of LFG into an adjacent residential neighborhood and removes VOCs from groundwater and the vadose zone.

3.3.1 LFGES and SVE System Monitoring

The LFGES extracts landfill gas (LFG) from 25 wells labeled GW-1 through GW-26 (except for LFG well GW-20 that was closed in 2008). The locations of the LFG extraction wells are shown on **Figure 3**.

The Soil Vapor Extraction (SVE) subsystem consists of 16 SVE wells along the south landfill property boundary. Locations of the SVE wells are shown on **Figure 4**.

Monitoring in individual LFG extraction wells (GW- wells) and at the system flare is conducted to support optimizing landfill gas collection. These measurements include gas flow rates, operational vacuums for the system (and individual LFG wells), and select gas concentrations (oxygen, nitrogen, methane, etc.).

Monitoring of the SVE wells is conducted using the Envision® gas analyzer, which is capable of measuring airflow, percent oxygen, percent nitrogen, percent methane, and other field parameters. This monitoring is conducted to support analysis of system operations. The objective is to ensure adequate extraction of soil gas from across the SVE well treatment zone, including VOCs mobilized by the air injection system.

Monitoring at the flare station tracks operation of the individual subsystems as individual processes. Measurement of operation parameters at this location provides information on the condition of blowers and compressor, LFGES and SVE gas flows, and overall physical qualities of the LFG and SVE gas streams. Many of these parameters are tracked in real time by a Supervisory Control and Data Acquisition (SCADA) system.

3.3.2 Air Injection System Monitoring

Air injection (AI) into groundwater and the vadose zone along the south boundary of the landfill is part of the remediation system (**Figure 4**). Nine AI wells became operational in 2016, along with the LFG/SVE system. The AI system injects atmospheric air into seven wells, screened below the level of groundwater, and two wells (AI-5 and AI-6 shallow) that are screened above groundwater. The system is intended to 1) provide additional oxygen to the groundwater and soil vadose zone to enhance beneficial microbial activity; and 2) volatilize VOC's present in groundwater to the overlying vadose zone for capture by the SVE system.

Two types of AI well monitoring are conducted. The most frequent is the monitoring of compressed air temperature, barometric pressure, and air pressure at select plumbing distribution locations. This allows calculation of the volume of air flow into each well. The second type of AI well monitoring is at each well-head, where the condition of each AI wells' air-tight cap and 2-inch ball valve is inspected. Site visits are also conducted at the flare to ensure that the air compressor operates within specifications and that recommended maintenance of the compressor is conducted.

3.4 LEACHATE / CONDENSATE COLLECTION

Operation of the LFGES results in the accumulation of condensate along the walls of the LFG collector piping and in the LFGES wells. Operation of 17 leachate/condensate collection pumps in select LFGES wells produces leachate that is discharged into leachate drainage pipelines. These leachate pipelines then gravity drain to a 4,000-gallon underground storage tank (UST). Condensate that forms along the LFG collector piping also gravity-drains to the 4,000-gallon UST. The leachate/condensate collection pumps and associated plumbing were installed during construction of the current system and became operational in 2016. The UST is located near the southwest corner of the Unlined Cell (**Figure 3**).

The volume of condensate and leachate accumulating in the UST is monitored using a water level meter lowered into the UST. Fluid level data allows for the calculation of accumulation rates and estimation of when the fluid in the UST needs to be pumped. A City-owned truck and tank is used to pump out the UST and transport the fluid to the municipal sanitary sewer. The City of Bozeman has approved the design and construction of a direct connection from the leachate UST to the City sewer, thereby eliminating the need for pumping the UST. Construction of the direct discharge line is anticipated for 2023.

The fluid in the UST is sampled quarterly, laboratory analyzed, and reported to the Bozeman Water Reclamation Facility (WRF), in accordance with an Industrial User Permit. In accordance with the permit, laboratory analysis is completed for specific VOCs, metals, and inorganic constituents. Reporting is completed on a semi-annual basis for the purpose of maintaining compliance and approval to discharge the fluid to the City sanitary sewer.

An evaluation of leachate distribution in the unlined cell (Technical Memorandum, Tetra Tech, 2021) identified that leachate accumulation and pumping volumes from LFG extraction wells (GW wells) was greatest in the center to southwest portion of the landfill.

4.0 DATA PRESENTATION AND ANALYSIS

Remediation system monitoring data and groundwater data collected at the Bozeman Landfill are summarized and discussed in this section. Data is only presented for period 2014 to present; hence, focus is on evaluating the effects of the remediation system on groundwater VOC concentrations. Two additional wells (MW-28 and MW-29) were installed in 2021. Data from these wells are included in this report. The LFGES and SVE/AI system performance data is also presented and analyzed.

4.1 GROUNDWATER ELEVATIONS

Groundwater elevation data has been collected on a quarterly and semi-annual basis from wells across the Site since the early 1990s. Groundwater flow beneath the unlined cell is to the southwest, which then turns more westerly once offsite (**Figures 5A through 5F**). Depth to groundwater ranges from approximately 117 feet bgs at the eastern margin of the Site (MW-5), to approximately 20-feet bgs at the western margin of the Site (MW-4) at McIlhattan Road.

Long-term rises and declines in groundwater elevations are evident with a typical high to low cycle of every six to eight years (sometimes shorter). The magnitude of elevation change between high and low periods is approximately 3 feet. Fluctuations of up to 10 feet have occurred in the upgradient well MW-5. These groundwater elevation changes appear to be related to precipitation cycles for the Bozeman area (based upon data from a weather station near Montana State University campus), with an apparent two-year lag between changes in precipitation and the resultant change in groundwater levels beneath the landfill site. Previous SERs have identified that a relationship exists between changes in groundwater elevations and changes in VOC concentrations in groundwater, which is discussed further in **Section 4.2**.

4.2 VOCS IN GROUNDWATER

One of the objectives of the expanded remediation system was to decrease the concentration of VOCs in groundwater. The effect of the remediation systems on the change in concentrations of four selected VOCs (PCE, TCE, MECL, and VC) over time is presented in this section. This report focuses on concentrations in the southeast corner of the landfill since that is the one remaining area where offsite exceedances of regulatory standards occur. Concentrations of these VOCs from the six wells in the southeast corner of the Site (MW-17, MW-18, MW-20, MW-24, MW-28, and MW-29) are presented in **Table 1**. The Montana Human Health Standard (HHS) for PCE, TCE and MECL is 5 µg/L and there is a Montana health advisory for vinyl chloride of 0.2 µg/L. The USEPA National Primary Drinking Water Regulations (NPDWR) Maximum Contaminant Level (MCL) for vinyl chloride is 2.0 µg/L.

PCE, TCE, and VC have historically exceeded regulatory standards in several monitoring wells across the Site and recently MECL exceeded standards in MW-17 during 2018 through 2020 (**Figures 6** and **7** and **Table 1**).

Concentrations of VOCs in groundwater have declined significantly across the Site since the first LFGES was installed in 1996. However, concentrations in MW-17 (Site southeast corner) have shown variability in VOCs, hence, the reason the area near this well is the focus of this report (**Figure 8**). MW-17 exhibited slight increases in concentrations of TCE in 2018-2019 but has gradually decreased since June 2019. Concentrations of TCE have remained below the 5 µg/L regulatory standard since December 2015. PCE concentrations in MW-17 were relatively stable and slightly below regulatory standards in 2016 through 2018. Beginning in 2019, concentrations of PCE more than doubled exceeding the 5 µg/L regulatory standard. For the period of June 2020 through 2021, PCE concentrations have consistently declined but remain above the regulatory standard. Beginning in 2018, MECL concentrations also drastically increased to just over 14 µg/L in early 2019. MECL concentrations exceeded the regulatory standard of 5 µg/L for the period of mid-2018 to mid-2020. Since that time concentrations have decreased to approximately 2 µg/L throughout 2021.

Figures 8 through **10** present data from MW-18, MW-20, MW-24, MW-28, and MW-29 in the landfill's southeast corner. MW-18 (**Figure 8**) reported variable concentrations of VC, with concentrations remaining below the EPA regulatory standard of 2.0 µg/L since December 2020, while concentrations of MECL, PCE, and TCE have remained at or below the method detection limit since 2015. MW-20 (**Figure 9**) continues to exhibit a relatively consistent decline in the concentration of PCE from August 2014 through December 2021. PCE concentrations have remained below the 5 µg/L regulatory standard in MW-20 throughout 2021. Concentrations of MECL, TCE, and VC in MW-20 have been at or below the method detection limit and regulatory standards since MW-20 was installed in 2014 (**Table 1**). PCE has been the only VOC reported in MW-24 (**Figure 9**). Concentrations have remained below regulatory standards with a general decline since late 2018. In 2021, wells MW-28 and MW-29 were installed and monitored. MW-28 was below method detection limits for MECL, PCE, TCE, and VC during 2021. Well MW-29 however; exhibited PCE concentrations of approximately 20 µg/L exceeding the 5 µg/L regulatory standard. Concentrations of TCE were approximately 4 µg/L, slightly below the regulatory standard, while MECL and VC were below method detection limits (**Figure 10**).

Well LF-3, which is an offsite monitoring well southwest of the landfill, continued its trend of declining PCE concentrations (**Figure 11**). PCE and all other VOCs have remained below regulatory standards in LF-3 since December 2014.

The concentrations of MECL, PCE, TCE, and VC in groundwater have fluctuated since startup of the remediation system in 2016. As presented in previous SERs, there appears to be a connection between fluctuating water levels and VC concentrations in well MW-12 immediately downgradient of the unlined waste cell (Tetra Tech 2018). Some short term, or small-scale, VOC variability shown on **Figures 6** through **11**, may be the result of changing groundwater elevations, however, the significant decline of VOC concentrations in well MW-17 and MW-20 does not appear associated with groundwater levels (**Figures 8 and 9**).

Wells with VOCs that exceeded the GPS or Montana Human Health Standard (HHS) between late 2019 and December 2021 include the following:

- Well MW-17 had concentrations of PCE above the 5.0 µg/L regulatory standards but is declining rapidly since late 2020.
- Well MW-17 had concentrations of MECL above 5.0 µg/L from December 2019 until June 2020; however, concentrations dropped to 2.8 µg/L by March 2021 and continued to decline to approximately 1.5 by December 2021.
- Well MW-18 had VC concentrations at or above 2.0 µg/L for most of 2020; however, concentrations declined to below 2.0 µg/L for all of 2021.
- Well MW-20 had concentrations of PCE above 5.0 µg/L from late 2019 to late-2020 and below 5.0 µg/L for all of 2021.
- Well MW-29 (installed 2021) exhibited the highest concentrations of PCE at approximately 20 µg/L for all samples in 2021.

No TCE concentrations in groundwater wells in the southeast corner of the landfill exceeded the regulatory standard of 5.0 µg/L from late 2019 through March 2021.

4.3 LANDFILL GAS EXTRACTION SYSTEM

The expanded LFGES system has been operational since August 2016. The upgrades included a new enclosed flare with improved instrumentation, along with ten new LFG extraction wells. Six of these LFG wells were completed in new locations on the Unlined Closed Cell. The other four new LFG wells replaced four existing LFG wells that had impairments resulting in decreased LFG collection.

The collection of LFG from the Unlined Closed Cell has remained relatively stable since 2017. Operational parameters for the upgraded LFGES are summarized in **Table 2**. This summary presents information relative to system operation run time efficiency, average gas flow, and methane collection from startup in August 2016 to December 2021. The LFGES maintained an operational run time efficiency of 98 percent between August 28, 2019 and August 19, 2020, and 97 percent from August 20, 2020 to December 19, 2021. In the 2 to 3 percent remainder of time, the flare was down for scheduled maintenance, such as lubrication of bearings, alignment of drive shafts, changing of air filters, maintenance of the compressor, and lubrication of the blowers. An occasional system initiated shut down was experienced, typically caused by inclement weather. In addition, there were repairs to the flare and leachate drain pipeline that resulted in the flare being down.

During August 2019 through August 2020, the LFGES removed an average of 173 cubic feet per minute (CFM) of LFG with an average methane content of 35 percent (**Table 2**); whereas 220 CFM with 33 percent methane was removed during August 2020 through December 2021. The calculated methane removal from the Unlined Closed Cell was 3,582 pounds per day (2019-2020), which is 3.5 percent higher than the previous year. During 2020 through 2021, the calculated methane removal from the Unlined Closed Cell was 4,332 pounds per day, which is 21 percent higher than 2019 – 2020. In the August 2019 to August 2020 period, the LFGES well field was under an average of -24 inWC vacuum which increased to -27 inWC in 2020 to 2021. The system vacuum and rate of LFG extraction continues to increase over previous years of operation. Prior to 2021, flare emissions were periodically measured to calculate VOC destruction efficiency in compliance with Montana Air Permit #2951-05. These results were consistently calculated to be 99.996 percent destructive. In 2021, emissions destruction efficiency testing methods were replaced with nonmethane organic compounds (NMOC) testing. This testing method identified 12 parts per million per volume wet (ppmvw) of NMOCs which was well below the 20 ppmvw flare emissions concentration allowed under the site permit (Bison, 2021).

Table 3 summarizes the LFGES field monitoring data (flow, methane, carbon dioxide, etc.) since the August 2016 startup with averages calculated for the most recent project year. **Figure 12** graphically presents the LFGES field parameters since startup of the new system.

Analysis of LFGES operational parameters from June 2019 through December 2021, indicates that concentrations of methane and carbon dioxide were generally consistent with past data. Methane concentrations ranged between 30 to 40 percent, which is slightly higher than carbon dioxide concentrations with two exceptions. During December 2020, methane concentrations exceeded 50 percent and beginning in August 2021 methane concentration has remained below 30 percent which is also below carbon dioxide concentrations. Oxygen concentrations were generally less than 1 percent; however, several spikes up to as high as 3.4 percent were observed. Several of these seem to be related to system adjustments or data collected right after a system restart. Nitrogen concentrations were typically 30 to 40 percent prior to September 2020. Since September 2020, nitrogen concentrations have exhibited periods of more than 45 percent and dropped to 12.5 percent for one event in December 2020. Over the period of record, higher nitrogen concentration routinely occurs in the months of September, October, and November. This is interpreted to be the result of a decrease in soil moisture during the summer (a seasonal dry time of the year) that allows for a small increase of atmospheric air intrusion into the waste. However, this air intrusion is minimal, since less than one percent oxygen is measured in the individual LFGES wells or at the flare.

Since system startup, there have been gradual increases in the vacuum applied to the LFGES. As of December 2021, the average annual vacuum was 176 percent greater than in 2016. This has resulted in a 38 percent increase in the flow rate from approximately 155 Standard Cubic Feet per Minute (SCFM) in in 2016 to about 215 SCFM in 2021 (**Figure 12**).

4.4 SOIL VAPOR EXTRATION SYSTEM

The SVE system has been operational since August 2016. The system consists of 16 wells along the south property boundary of the landfill (**Figure 4**). This system was designed to provide a barrier to the migration of LFG into an adjacent residential neighborhood and to remove VOCs from groundwater.

The SVE system has had an operational run time efficiency of 97 percent (same as the LFGES) during 2021. **Table 4** summarizes the SVE system monitoring data measured at the flare since start up and **Figure 13** presents field data graphically. From August 28, 2019, through August 19, 2020, the SVE well field was under an average of -38 inWC vacuum with soil gas removed at an average rate of 252 CFM. For the 2021 calendar year, the SVE well field was under an average of -39 inWC vacuum with soil gas removed at an average rate of 263 CFM. The rate of extracted gas has increased, without system adjustment, from an average of 173 CFM at the end of 2017, to over 280 CFM in October through December 2021 (**Figure 13**). The reason for this over 60 percent increase in average soil gas removal is likely the result of the soils affected by the system continuing to dry out, thereby opening more pathways for air to move through the subsurface. During the period 2017 through 2021 the methane and carbon dioxide in the extracted soil gas have decreased while the oxygen and nitrogen content in the extracted soil gas have increased (**Figure 13).** During cold winter periods, concentrations of oxygen have shown slight increases and inlet temperatures have decreased at some wells, indicating fresh air is being pulled into the SVE system. This may be a result of soil drying mentioned above or may be influence from the air injection system. Neither is a preferred condition, since the SVE system is intended to pull air out of the soil column, particularly at depth near groundwater, to effect maximum removal of VOCs.

A testing plan was developed in 2021 to evaluate potential influx of fresh air into the SVE system as a possible cause for the increased SVE system flow rates. At the time of this writing, the investigation is ongoing.

4.5 AIR INJECTION SYSTEM PERFOMANCE

During the period of analysis of this report, nine AI wells were operational. The operational run time efficiency of the AI system is similar to the SVE system at approximately 97 percent during 2021. Air is delivered to the subsurface under pressures ranging between 93 and 125 pounds per square inch (psi).

There were twelve compressed air flow monitoring events between August 2019 and December 2021. These indicated that compressed air flowed through the AI wells at a rate between 249 and 444 CFM. Air flow has been calculated for each AI well and summed for each monitoring event in **Table 5**. The air flow into each AI well on September 29, 2020, is summarized in **Table 6** to provide a typical example of air flows during 2019 through 2021. Gate valves are fitted on each of the AI compressed air lines and adjustment of these between open and closed is difficult. All gate valves are in a position of being minimally open.

Table 5

Total Air Flow Through Air Injection Wells

Monitoring Date	All AI- Wells Open?	Total Air Flow (CFM)	Comments
12/14/2016	Yes	128.6	
11-12/2017			Well heads repaired to stop leakage
1/18/2017	Yes	91.9	
3/9/2017	Yes	129.2	Compressor service on 3/2/17
5/16/2017	Yes	261.6	Reset valves after AI well maintenance
8/11/2017	Yes	272.5	
1/16/2018	Yes	293.6	
3/8/2018	Yes	350.2	
7/12/2018	Yes	285.0	
11/15/2018	Yes	318.0	
4/1/2019	Yes	320.5	
6/6/2019	Yes	291.8	Reset valves after SVE ROI Testing
8/26/2019	Yes	296.4	
12/19/2019	Yes	327.7	
2/19/2020	Yes	288.8	
4/6/2020	Yes	301.9	
9/29/2020	Yes	280.9	
1/21/21	Yes	278.5	

Monitoring Date	All AI- Wells Open?	Total Air Flow (CFM)	Comments
4/28/21	Yes	309.1	
5/19/21	Yes	286.3	
6/17/21	Yes	443.8	
7/8/21	Yes	255.5	
9/15/21	Yes	248.8	
10/5/21	Yes	263.5	
11/3/21	Yes	291.8	

Table 6
Air Flow Through Injection Wells on September 29, 2020

Air Injection Well	Monitoring Date	Calculated Flow (cfm)
AI-1	9/29/2020	31.7
AI-2	9/29/2020	35.3
AI-3	9/29/2020	33.9
AI-4	9/29/2020	31.2
AI-5	9/29/2020	24.2
AI-5deep	9/29/2020	33.7
AI-6shallow	9/29/2020	29.1
AI-6mid	9/29/2020	31.0
AI-6deep	9/29/2020	30.9
Total Air Flow (CFM)		280.9

4.6 CONDENSATE AND LEACHATE COLLECTION SYSTEM

Condensate and leachate are produced during operation of the LFGES and 17 leachate collection pumps. The collection system gravity drains to a 4,000-gallon underground storage tank. The operational run time efficiency of the condensate and leachate collection system (i.e., leachate collection pump operation) is similar to the LFGES at approximately 97 percent.

The liquid level at the UST is monitored through the year so that pumping events can be scheduled. Monthly sampling of the UST and analysis for metals, inorganic constituents, and VOCs indicate that for the 2019-2021 period, water quality was within regulatory standards to comply with USEPA and City of Bozeman industrial user discharge regulations. The sampling and analysis of samples and submittal of the semi-annual monitoring reports is separate from this report. The formation of a precipitate (also referred to as scaling) has occurred in the lower portion of the 2-inch diameter HDPE, leachate drain pipeline (LDL). This scaling is removed by periodic scouring via a flexible, high water pressure jetting device that accesses the LDL via several clean out pipes that were installed in 2019.

4.7 POSSIBLE SOURCES OF ELEVATED VOCS IN SOUTHEAST CORNER OF LANDFILL

Based on recommendations from the November 2019 SER (Tetra Tech 2019), an evaluation of potential sources of VOCs in the southeast corner of the landfill was conducted. This included evaluating leachate distribution, refuse thickness, and LFG well spacing in the southeast corner of the landfill. Leachate production from GW wells and observed leachate thicknesses in GW wells were mapped. Waste and groundwater can be within a few feet of each other in the center and southwestern corner of the landfill, while in the southeast corner there is up to 70 feet of separation. Leachate does not appear to be present to a large extent in the southeastern corner of the landfill.

Waste thickness data was compiled, and it was determined that, although there are areas of the landfill with 50 feet or more of waste, the southeast corner of the landfill has thicknesses of 20 feet to 40 feet, which are believed to be sufficient to generate LFG that could affect groundwater quality. The boundary of waste extends very close to the eastern and southern property boundaries (**Figure 4**).

The LFGES was expanded in 2016 to increase the capture of LFG by installing six new wells. No radius of influence was estimated for the LFG wells since it is difficult to do in the heterogenous refuse. Along the south boundary of the landfill, LFG wells are spaced approximately 200 feet apart; and based on the low levels of methane measured in methane monitoring wells along the south boundary of the landfill, this LFG well spacing appears to be functioning as designed. Hence, the LFG wells appear to have a radius of influence of at least 100 feet; however, it is not clear how much larger the ROI may be. Based on evaluation of the typical radius of influence created by the LFG wells (100 feet), the distance between LFG wells GW-19 and GW-26 (**Figure 4**), and the edge of refuse in the southeast corner of the landfill, there appears to be approximately 50,000 square feet (or 38,000 cubic yards) of refuse in the southeast corner of the landfill where LFG may not be effectively captured by the LFGES. LFG extraction well GW-20 was formerly located in this area; however, it was removed in 2009 to make room for the Convenience Site scale house.

Concentrations of PCE and MECL in well MW-17 and PCE in well MW-29 groundwater are higher than most other wells at the landfill, which raises questions about the source of these VOCs since groundwater in this area is about 70 feet below the closest waste. In addition, groundwater flow direction near wells MW-17 and MW-29 indicates only a small corner of refuse is upgradient of MW-17 and cross gradient of MW-29, while wells MW-12 and MW-18 are downgradient of the large central core of the landfill where refuse is 50 to 100 feet thick. At this time, two possible mechanisms of elevated VOCs in groundwater near MW-17 and MW-29 in the southeast corner have been conceptualized.

First, as discussed in our Evaluation of Southeast Corner of Landfill Technical Memorandum (Tetra Tech, 2021), it is possible that landfill gas is flowing out of the refuse into the subsurface. Since soil gas migration is controlled by air pressures in the subsurface (which varies daily based on atmospheric pressure) and gas pressure created by the refuse, soil gas can flow in any direction. This means landfill gas leaving the refuse can flow uphill, opposite of groundwater flow directions. If this is occurring, the lack of a nearby extraction well could be allowing LFG to migrate offsite along the eastern boundary of the landfill (since there is no SVE system along the east boundary). Since January 2014, methane has not been observed in monitoring wells along the east boundary, except for two monthly monitoring events (July 2014 and February 2021 – LFGES inoperable for extended period). However, methane monitoring does not monitor for volatized PCE or MECL. Low levels of these VOCs in soil gas can be problematic and these could occur along the east boundary without methane exceeding DEQ standards. Offsite migration of landfill gas to the east could interact with upgradient groundwater, which, in turn, would cause VOCs to enter groundwater upgradient of the landfill and subsequently migrate southwesterly back onto the landfill property impacting water quality at well MW-17.

Alternatively, over the period of 2016 to present, the vacuum and flow rates of the remediation system have consistently increased rather than decreased. This, combined with the rapid rise and fall of select VOCs (MECL, PCE, and TCE) in well MW-17 at the southeast corner of the site, suggest a transient source(s) rather than an ongoing process. A transient source(s) could be something as simple as a localized release of compounds from a container(s) within waste near the southeast corner. The constituents of PCE and MECL are considered relatively dense resulting in a tendency for downward migration with advection and dispersion likely occurring during migration. During 2021, well MW-29 exhibited the highest concentrations of PCE (twice that of MW-17) and a relative lack of degradation products such as TCE or VC. Considering the oxygenated environment documented by groundwater field measurements, this suggests well MW-29 maybe relatively close to a point source influenced to some extent by plume dispersion. Downgradient well MW-17 exhibited much lower PCE concentrations along with a higher percentage of degradation product TCE relative to PCE indicating aerobic decay from PCE to TCE. The presence of a 70-foot vadose zone combined with groundwater field measurements indicate an oxygen rich environment suitable for aerobic reactions to occur is present between refuse and MW-17 and further supports well MW-29 being closer to the source.

5.0 SUMMARY AND CONCLUSIONS

The following summary and conclusions of the data and analysis presented in this report are provided below:

- Since 2014, there have been dramatic decreases in VOC concentrations in groundwater across the site.
- Wells MW-17, MW-18, MW-20, MW-24, MW-28, and MW-29 are in the southeast corner of the Site. During late 2018, concentrations of PCE and MECL in MW-17 rose rapidly. Since June 2020, concentrations of MECL have been below the GPS. PCE continues a gradual decline and was just above the GPS in December 2021. As of December 2020, concentrations of VC in MW-18 and PCE in MW-20 have also been below their respective GPS. Concentrations of PCE exceeding the GPS were identified in newly installed well MW-29 during 2021.
- Groundwater measurements indicate an oxygen rich environment suitable for aerobic reactions to occur in the southeast corner of the site. The absence of PCE degradation products in well MW-29 and the presence of degradation products in well MW-17 suggest beneficial microbial aerobic reactions are occurring and that MW-29 may be relatively close to a PCE point source.
- Expansion of the LFGES and installation of an enclosed flare has resulted in an increase in operational efficiency and greater rate of removal/destruction of LFG. There is an average of 33 to 35 percent methane in the LFG. Calculated methane removal from the Unlined Closed Cell during August 2020 through December 2021 is 4,332 pounds per day which is an increase of 21 percent over the previous year.
- Flare emissions remained well below the 20 ppmvw concentration allowed under the site permit during 2021.
- Gradual increase of air flow through the SVE and AI systems without adjustment is likely the result of the soils affected by the systems continuing to dry out, thereby opening more pathways for air to move through the subsurface.
- Decreases of methane and carbon dioxide concentrations paired with increases in oxygen and nitrogen concentrations within extracted soil gas of the SVE system may be an unintended result of improved communications between SVE and AI systems due to soil drying.
- Waste in the southeast corner of the landfill may have limited landfill gas capture due to the past removal of LFG well GW-20. Some of the refuse is up to 300 feet away from the closest extraction wells (GW-19 and GW-26).

6.0 RECOMMENDATIONS

In consideration of the summary and conclusions presented above, the following recommendations have been developed:

1. Continue to conduct quarterly groundwater monitoring events in March and September of each year, in wells LF-2, LF-3, MW-12, MW-17, MW-18, and MW-20, MW-24, and MW-29 to supplement the DEQ requirement of June and December monitoring. This will provide additional data to support analysis of the fluctuations in VOC concentrations in groundwater. This will also help future evaluations of the LFGES and SVE/AI remediation systems performance relative to groundwater remediation.
2. Continue operations of the LFGES/SVE/AI remediation system. Combined, this system provides an effective barrier to offsite migration of landfill soil gasses and groundwater contaminants.
3. Waste in the southeast corner of the landfill may have limited landfill gas capture due to the past removal of LFG well GW-20. Some of the waste is up to 300 feet away from the closest extraction wells (GW-19 and GW-26). The installation of one or two additional LFG wells should be considered.
4. Expansion of the SVE system, by installation of four additional wells at the southeast corner of the Site, is approved by the City. This would eliminate the potential for vapor migration offsite to the east and facilitate removal and or degradation of PCE and MECL detected in the area limiting offsite migration.
5. The City has approved the design and construction of a pipeline from the leachate and condensate UST to the City sewer. This would eliminate the need for pumping the UST, eliminate the risk of an overflow at the UST, and reduce operating costs of the LFGES by allowing maximum leachate pumping rates from LFGES wells. This pipeline was designed in 2021 with anticipated construction in fiscal year 2022/2023.
6. The ROI investigation in the 2019 SER (Tetra Tech, 2019) recommended that two new SVE wells with screened intervals from 40 to 70 feet bgs be installed near the location of SVE-15 and SVE-16. As a lower priority recommendation, these were not proposed to be completed during the last two years. These new wells should be designed to intersect the vadose zone below SVE-15 and SVE-16, which are only screened to approximately 25 feet bgs. We also recommend installation of a third new SVE well near SVE-14, with a screened interval from 35 to 50 feet bgs. SVE-14 is only screened to approximately 25 feet bgs. This new well would be designed to intersect the deeper vadose zone.
7. The 2019 SER (Tetra Tech, 2019) recommended an evaluation of the effectiveness of the landfill cover be conducted and recommendations developed. Site observations indicate several areas along the east and north edges of the cell exhibiting settlement and cracks within cover material up to 6 inches wide. The evaluation should evaluate the need for repairs to the current cover and/or construction of a thicker and lower permeability cover on some portions of the landfill. This relates to the reduction of leachate pumping from the LFGES wells. This recommendation was considered lower priority but should be maintained for future consideration.

7.0 REFERENCES

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Tetra Tech, 2018. Initial Remediation System Evaluation, Bozeman Landfill. Report submitted to City of Bozeman and Montana DEQ. March 9, 2018.

Tetra Tech, 2015. Groundwater Monitoring Sampling and Analysis Plan, for the Bozeman Landfill. Plan submitted to City of Bozeman and Montana DEQ. November 12.

Tetra Tech, 2014. Revised Corrective Measures Assessment. Submitted to City of Bozeman. September.

ONLINE REFERENCES

Bozeman Area Climate

https://www.usclimatedata.com/climate.php?location=USMT0040

USEPA National Primary Drinking Water Regulations

https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

FIGURES

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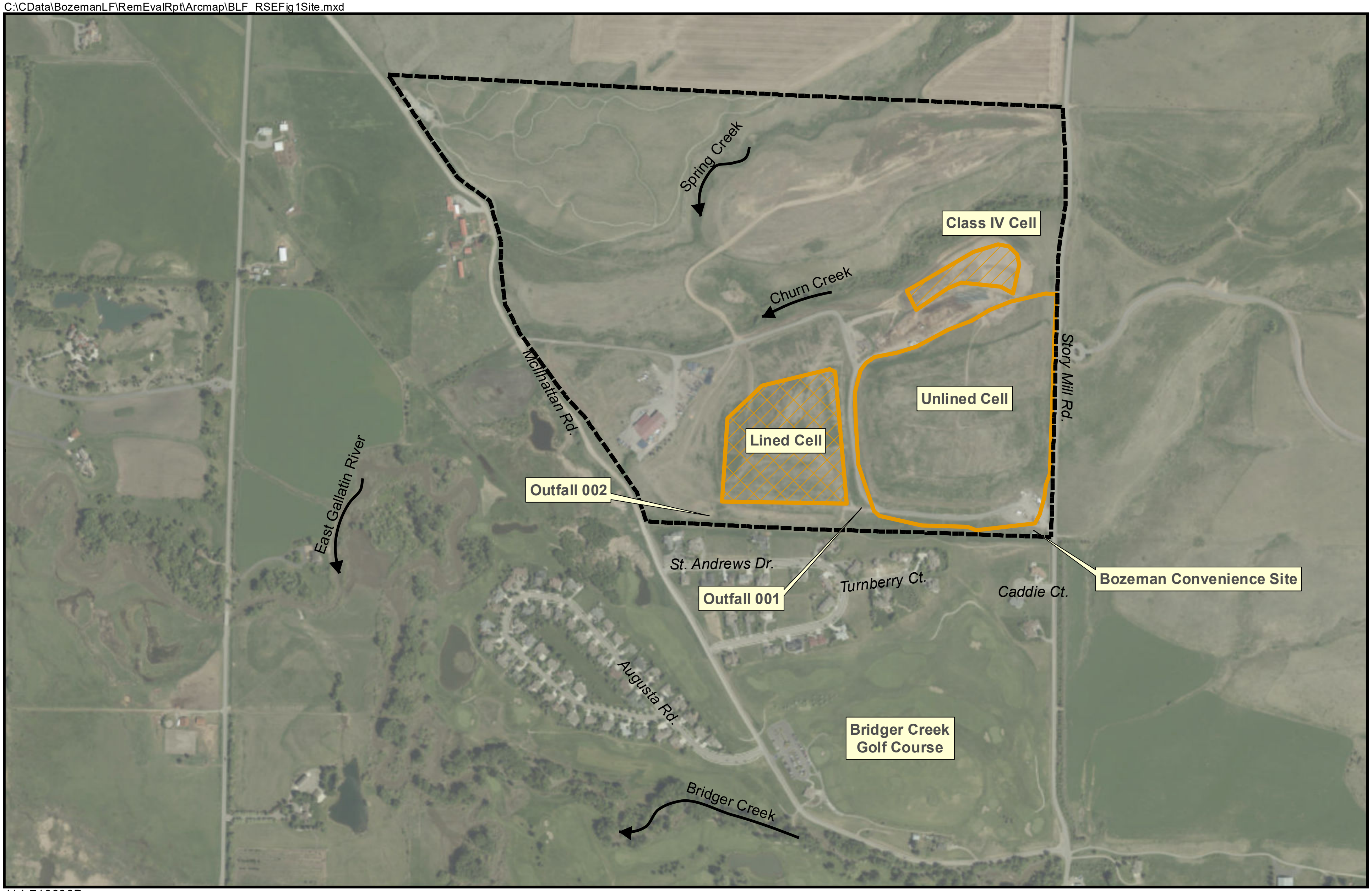

114-710336D
11/11/2019

N W E S
0 400 800
Feet
Datum: NAD83 StatePlane Montana

NOTE:
All station locations and landfill boundary are approximate

Landfill Property Boundary
Flow Direction
Class IV Cell
Lined Landfill
Unlined Landfill

Site Plan
Remediation System Evaluation
Bozeman Landfill
Bozeman, Montana
FIGURE 1

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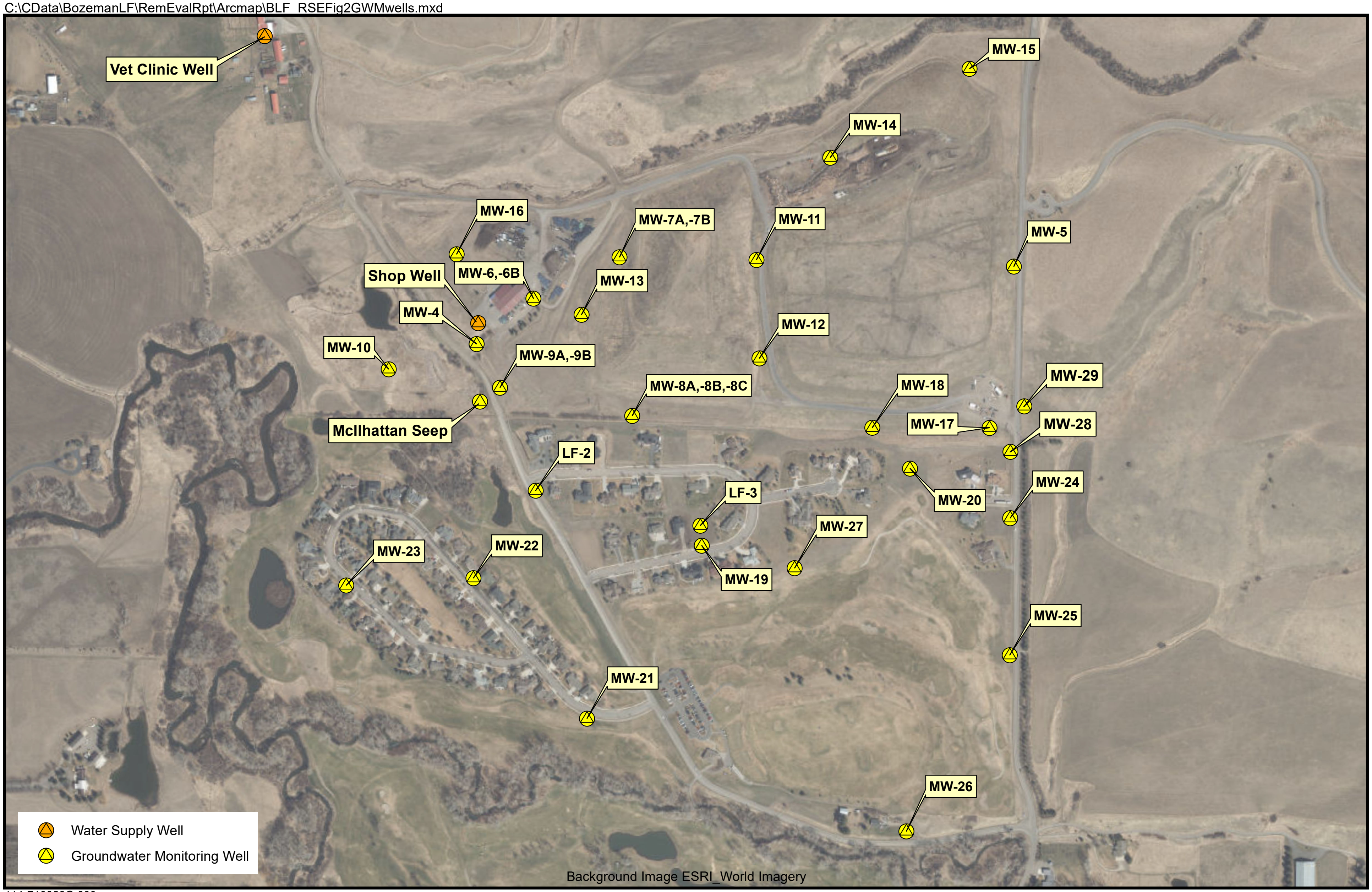

114-710326G.600
3/1/2022

N
W E
S
0 300 600
Feet
Datum: NAD83 StatePlane Montana

NOTE:
All locations are approximate.

Groundwater Monitoring Locations
Remediation System Evaluation
Bozeman Landfill
Bozeman, Montana
FIGURE 2

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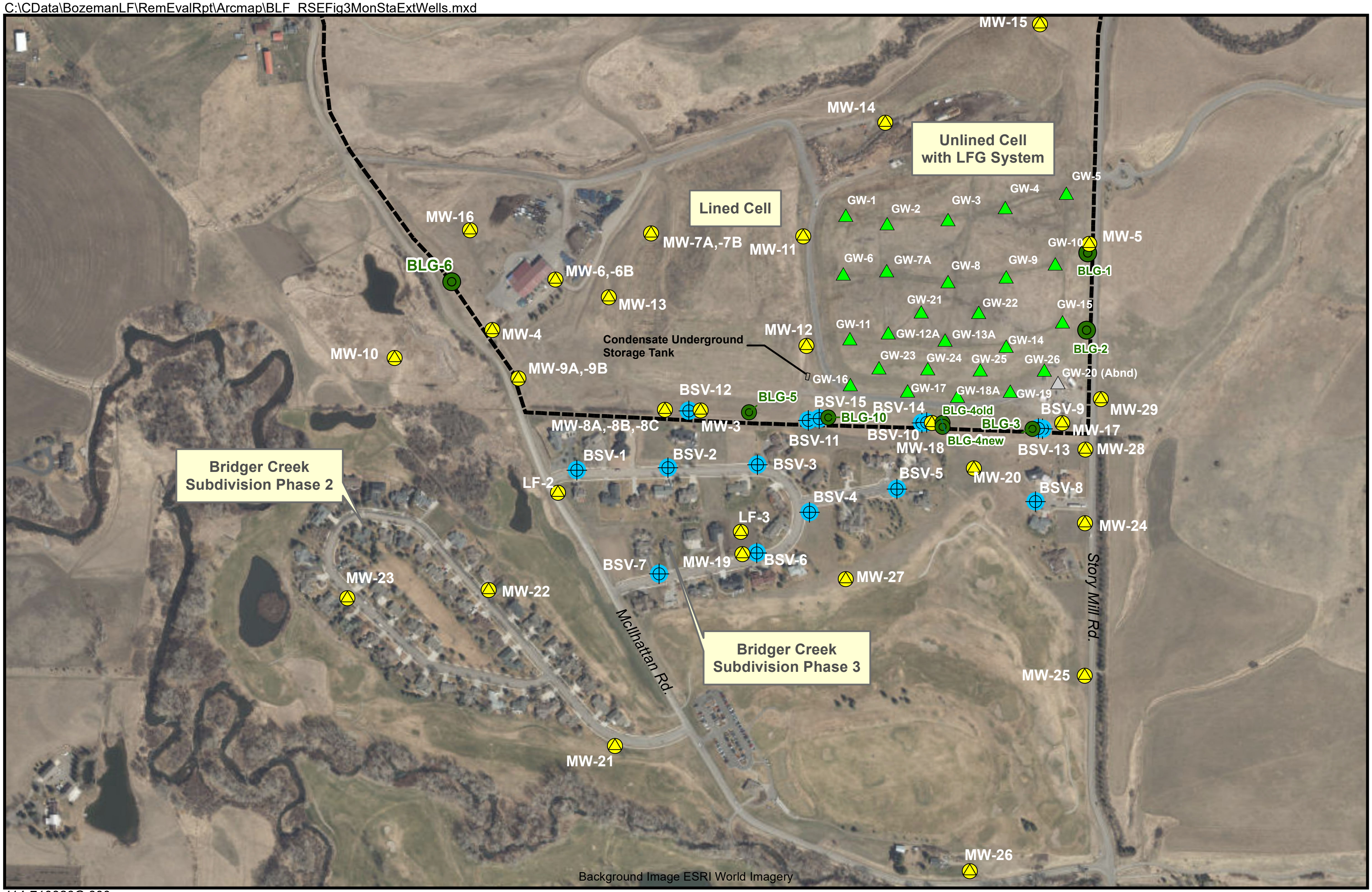

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N

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Feet
Datum: NAD83 State Plane Montana

- Soil Gas Probe
- Groundwater Monitoring Well
- Methane Monitoring Well
- Surface Water Monitoring Site
- Landfill Gas Extraction Well
- Landfill Gas Extraction Well (Abandoned)
- Landfill Property Boundary

Landfill Gas Extraction System and Monitoring Network
Remediation System Evaluation
Bozeman Landfill
Bozeman, Montana
FIGURE 3

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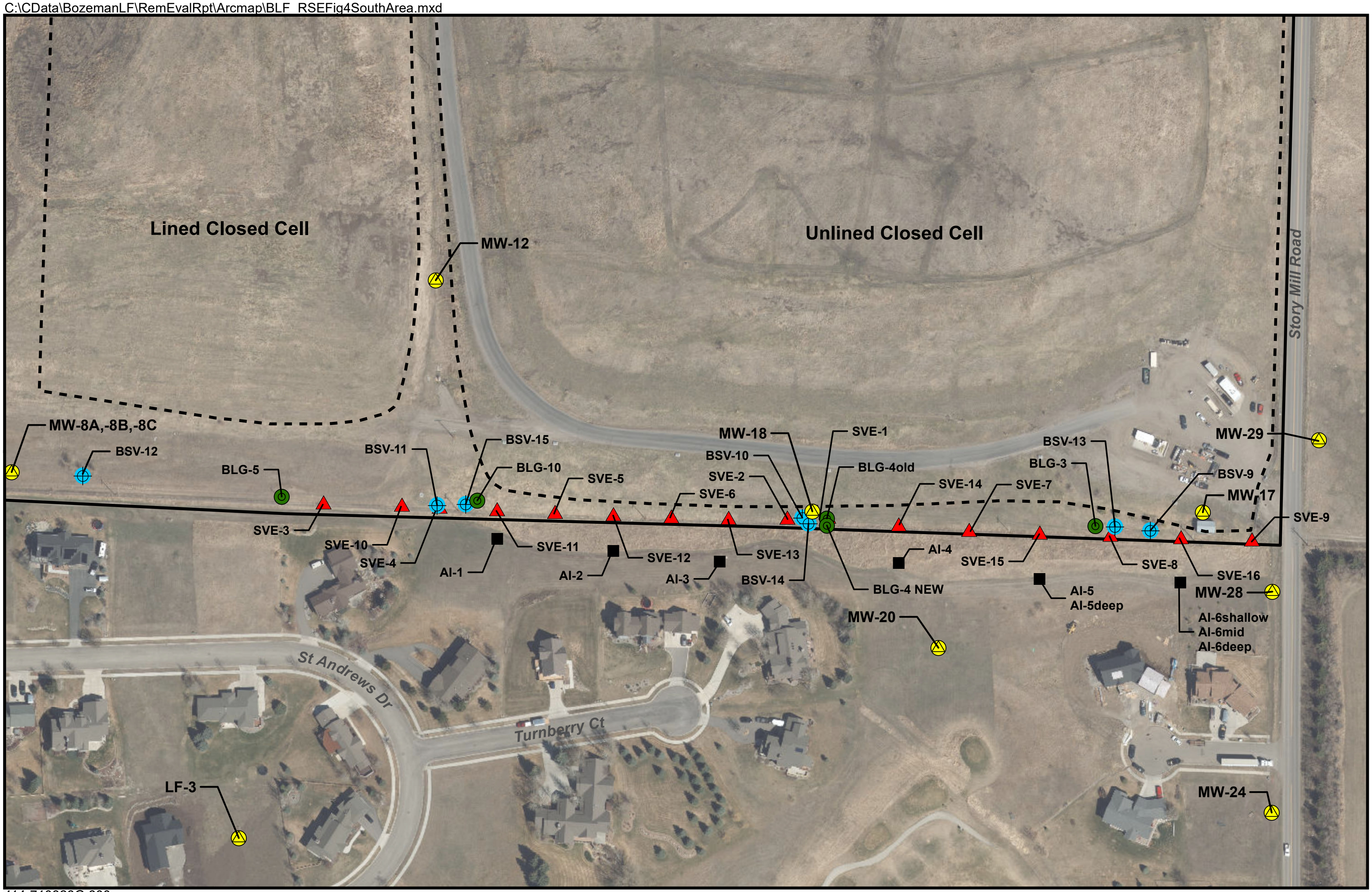

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3/9/2022

N

0 75 150
Feet
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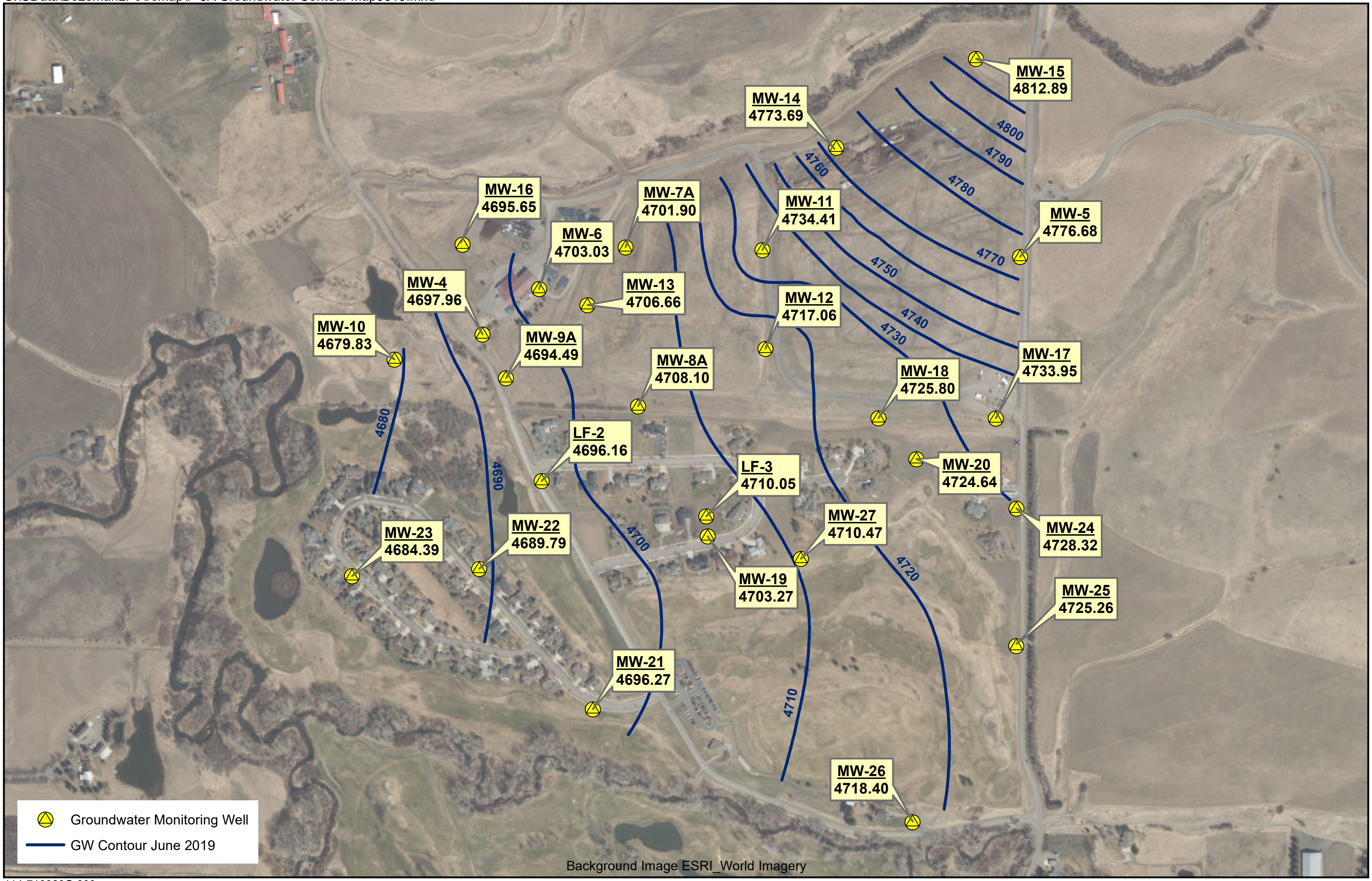
- - - Waste Boundary
— Landfill Boundary
■ Air Injection Well
Groundwater Monitoring Well
Methane Monitoring Well
Soil Gas Probe
▲ Soil Vapor Extraction Well (SVE)

Soil Vapor Extraction, Air Injection System Wells And Other Monitoring Wells Along The South Boundary
Remediation System Evaluation
Bozeman Landfill
Bozeman, Montana
FIGURE 4

C:\CData\BozemanLF\Arcmap\F-5A Groundwater Contour Map0619.mxd



114-710326G.600
3/3/2022

N
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Feet

NOTE:
All well locations are approximate.
Only those wells used for preparation of groundwater contour map are shown

Groundwater Contour Map
June 2019
Bozeman Landfill
Bozeman, Montana
FIGURE 5A

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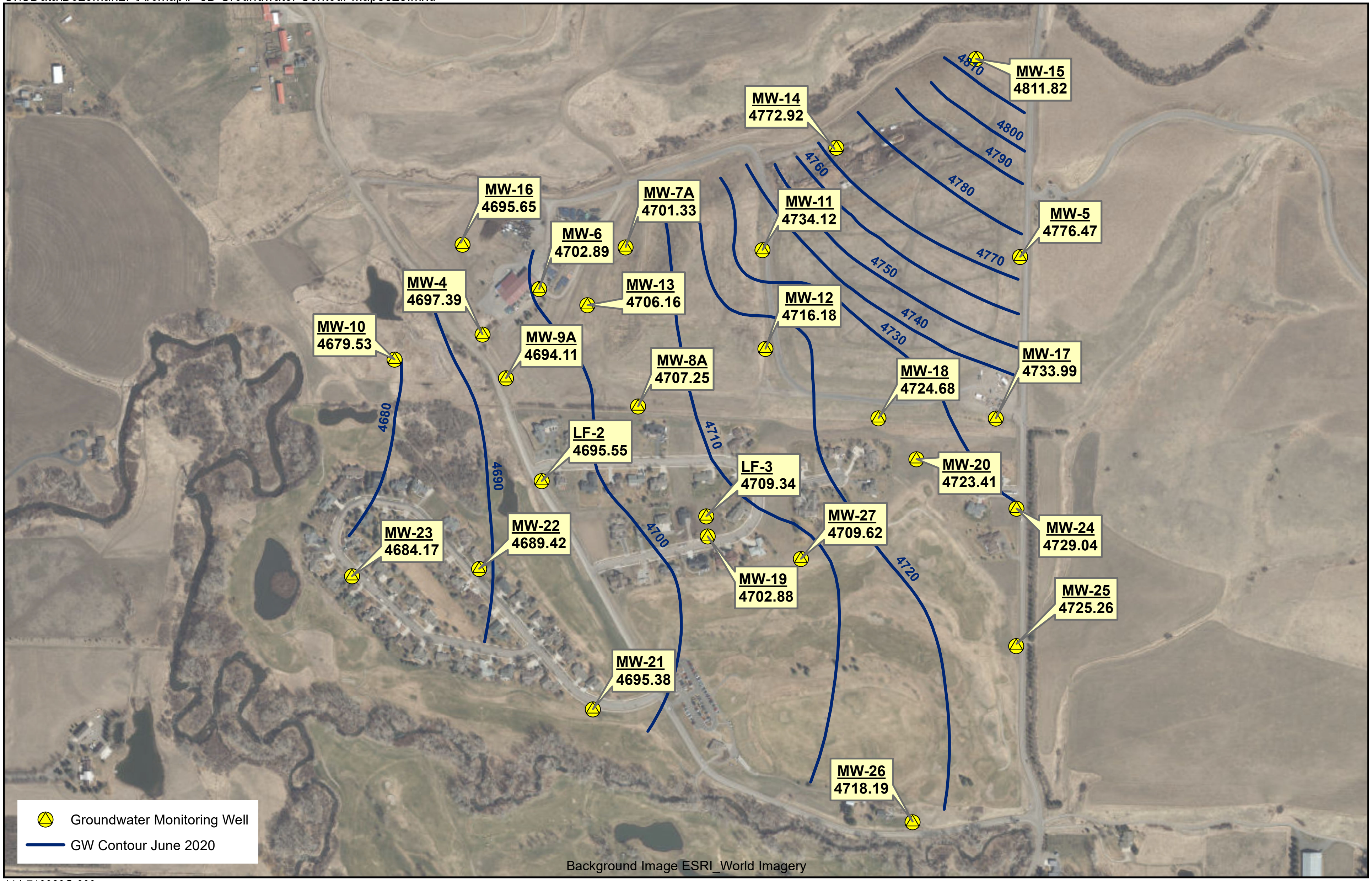

114-710326G.600
3/3/2022

N
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Feet

NOTE:
All well locations are approximate.
Only those wells used for preparation of groundwater contour map are shown

Groundwater Contour Map
June 2020
Bozeman Landfill
Bozeman, Montana
FIGURE 5B

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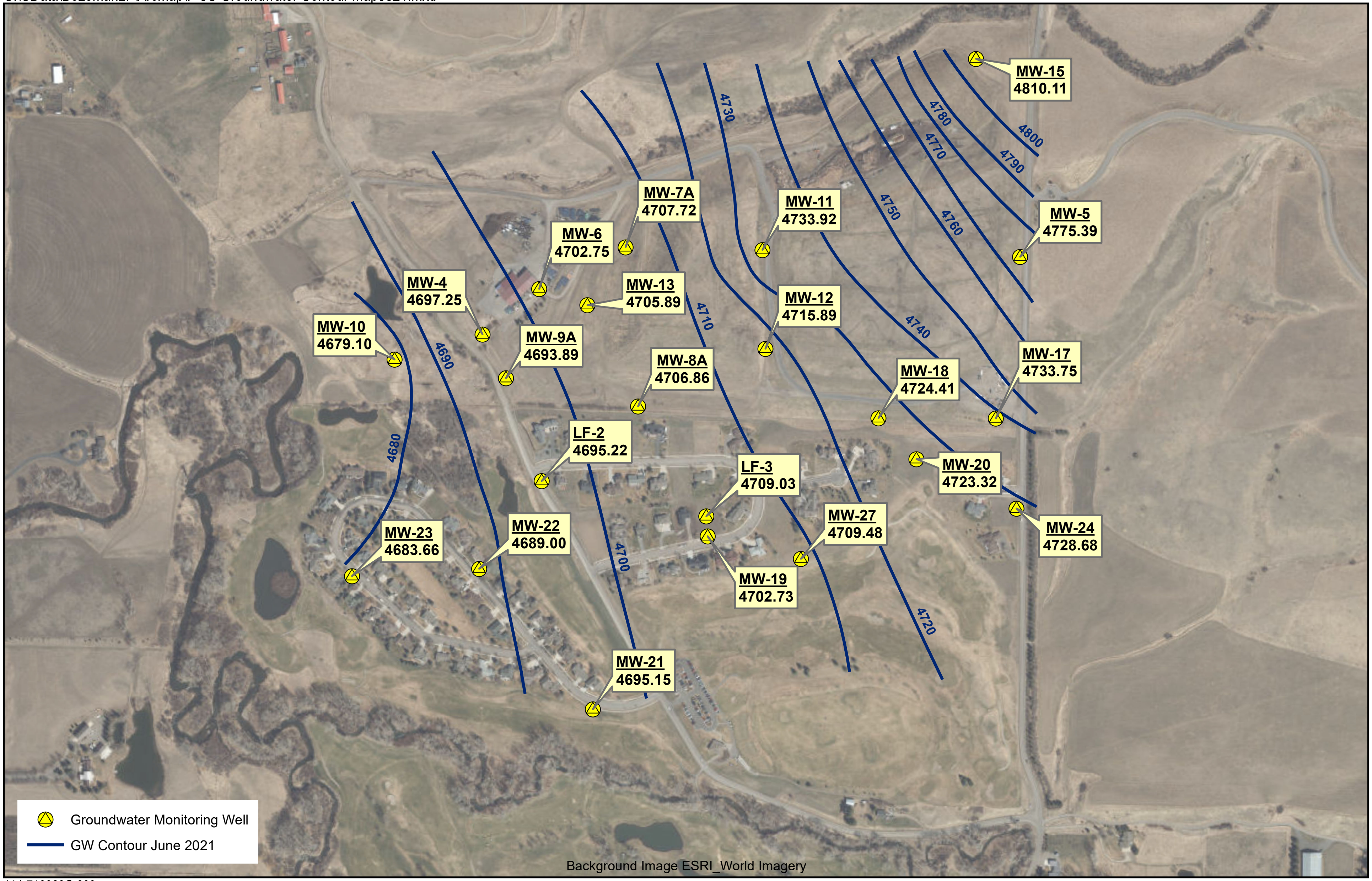

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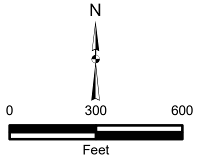
3/3/2022



NOTE:
All well locations are approximate.
Only those wells used for preparation of groundwater contour map are shown

Groundwater Contour Map
June 2021
Bozeman Landfill
Bozeman, Montana
FIGURE 5C

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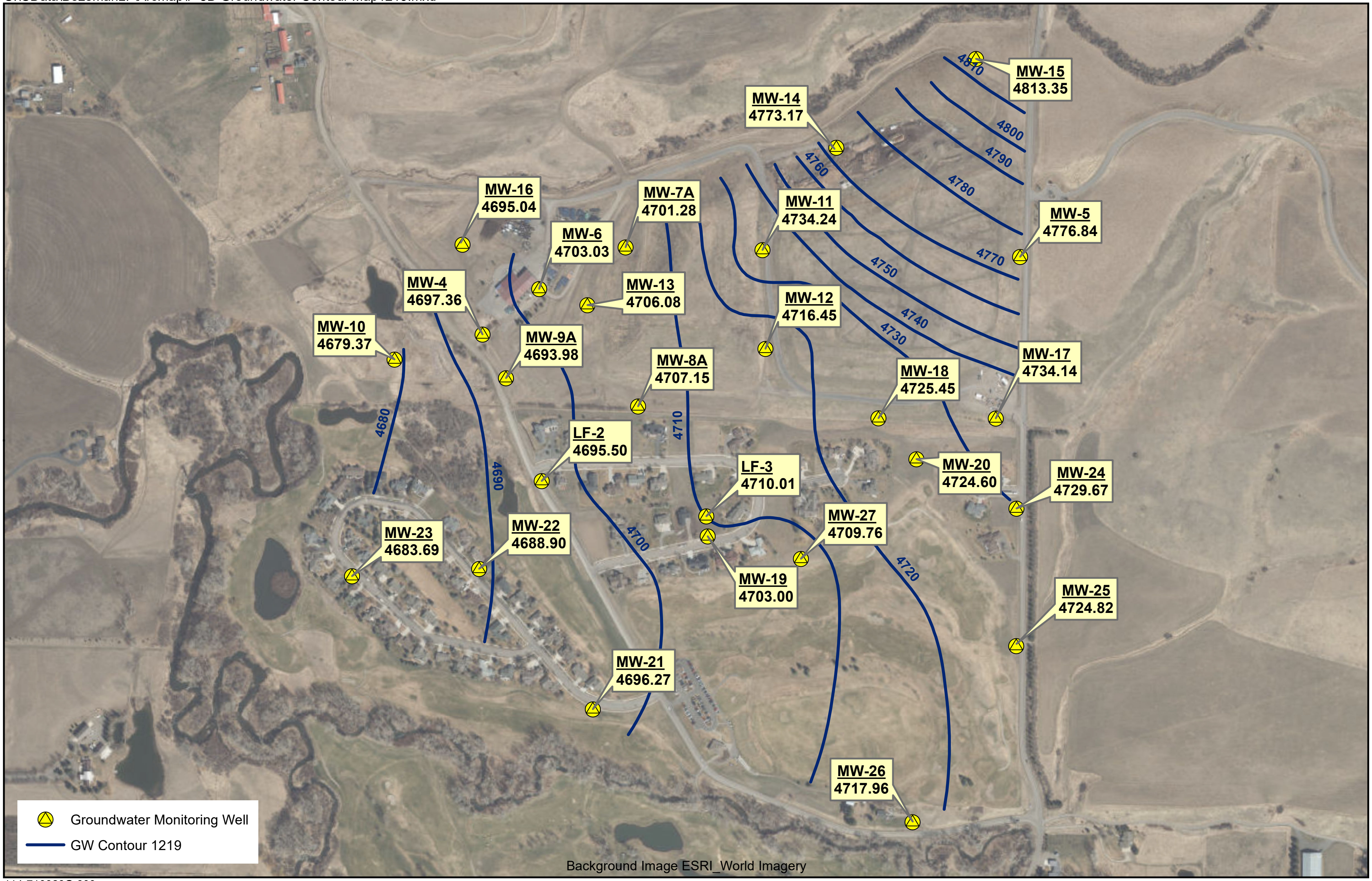

114-710326G.600
3/3/2022

N

0 300 600
Feet

NOTE:
All well locations are approximate.
Only those wells used for preparation of groundwater contour map are shown

Groundwater Contour Map
December 2019
Bozeman Landfill
Bozeman, Montana
FIGURE 5D

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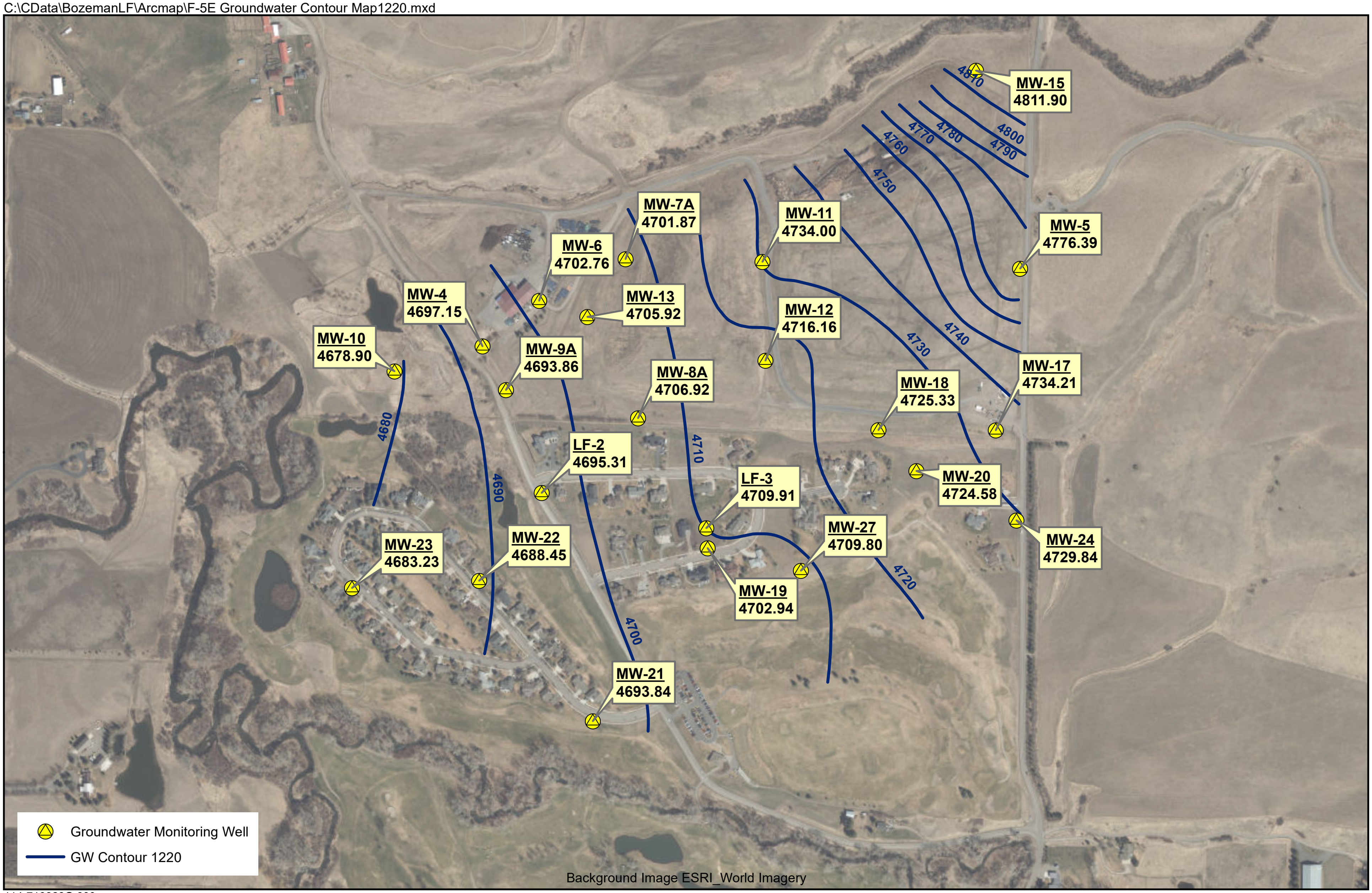

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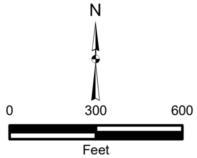
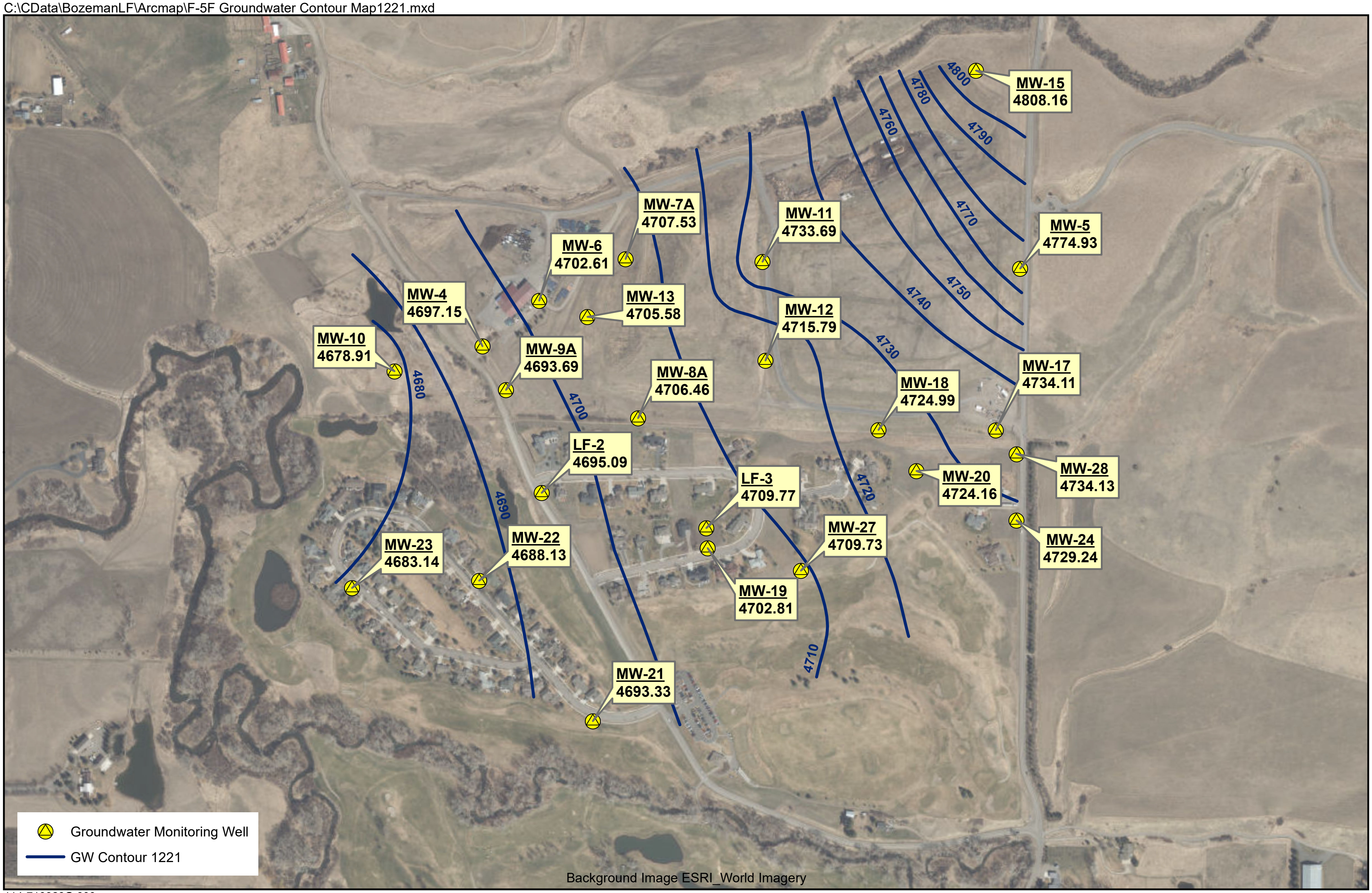
3/3/2022



NOTE:
All well locations are approximate.
Only those wells used for preparation of groundwater contour map are shown

Groundwater Contour Map
December 2020
Bozeman Landfill
Bozeman, Montana
FIGURE 5E

C:\CData\BozemanLF\Arcmap\F-5F Groundwater Contour Map1221.mxd



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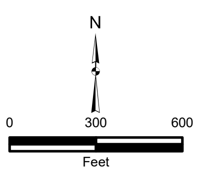

NOTE:
All well locations are approximate.
Only those wells used for preparation of groundwater contour map are shown

Groundwater Contour Map
December 2021
Bozeman Landfill
Bozeman, Montana
FIGURE 5F

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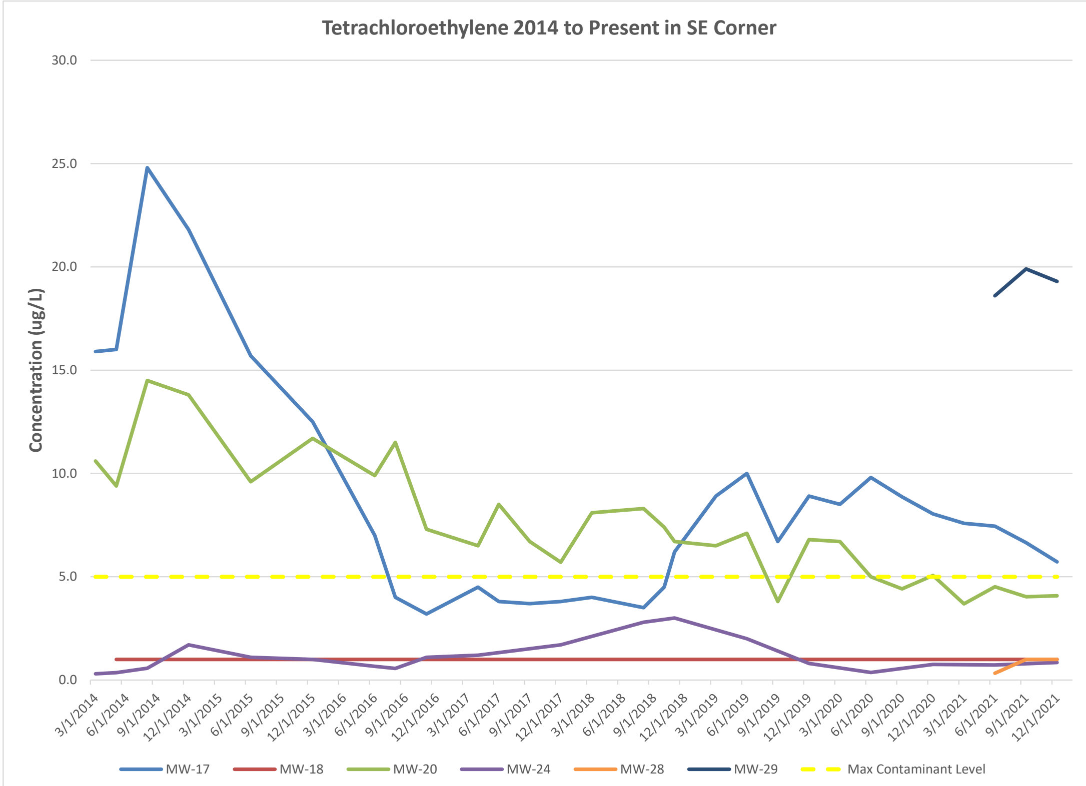

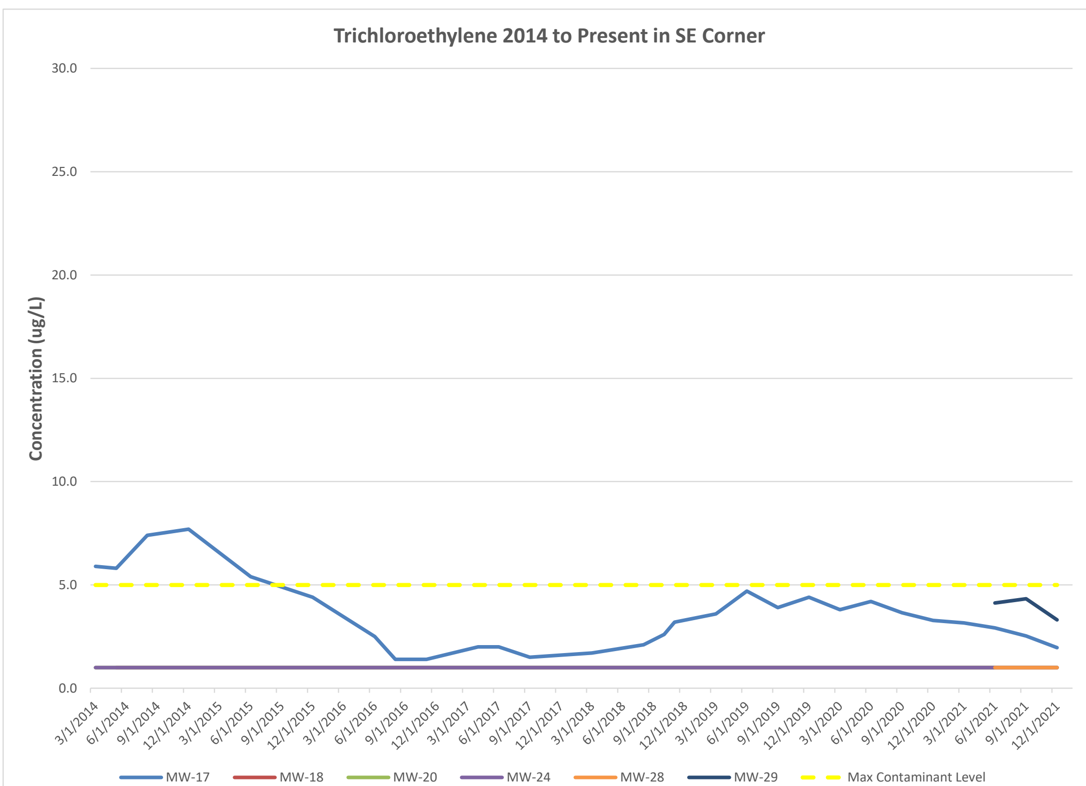

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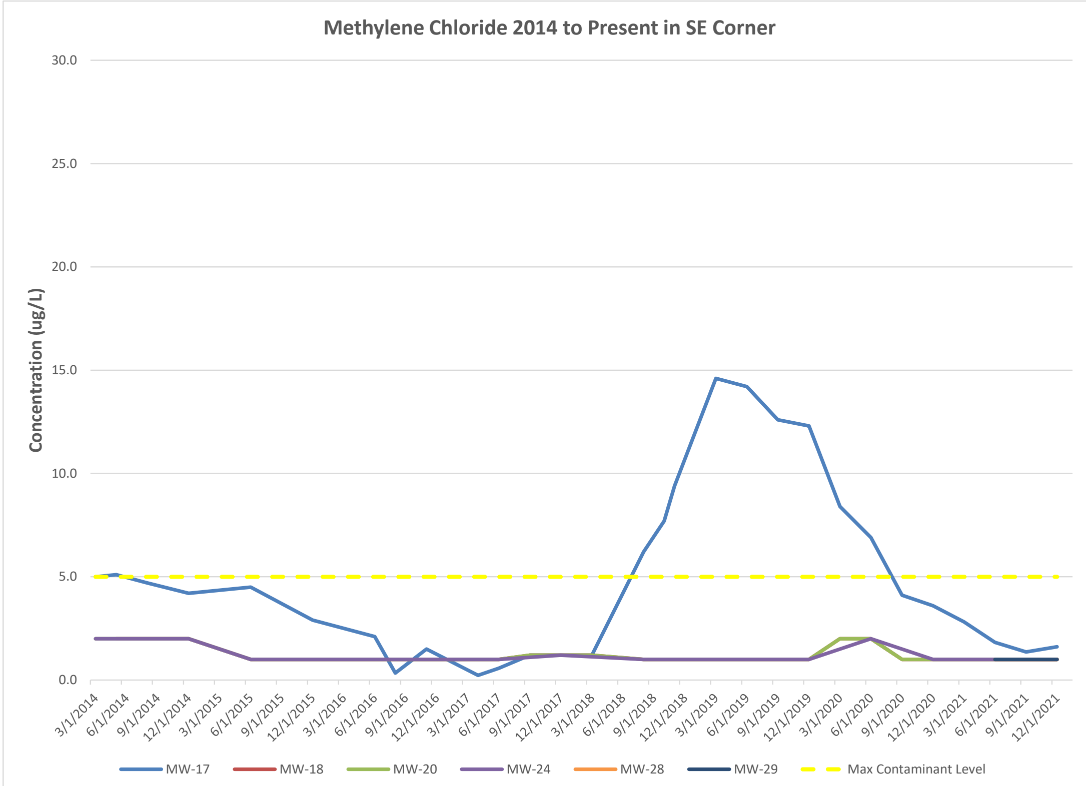
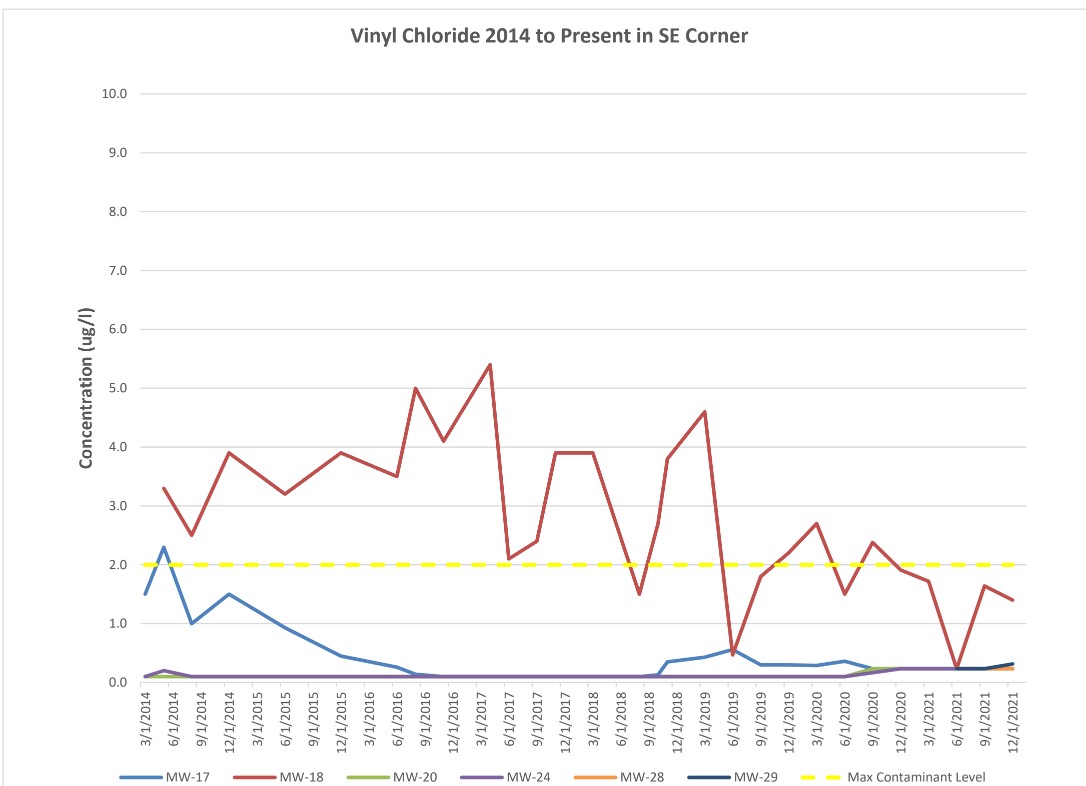
TCE and PCE versus Time
In Selected Wells
Bozeman Landfill
Bozeman, Montana
Figure 6





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3/2/2022

MECL and VC versus Time
In Selected Wells
Bozeman Landfill
Bozeman, Montana
Figure 7

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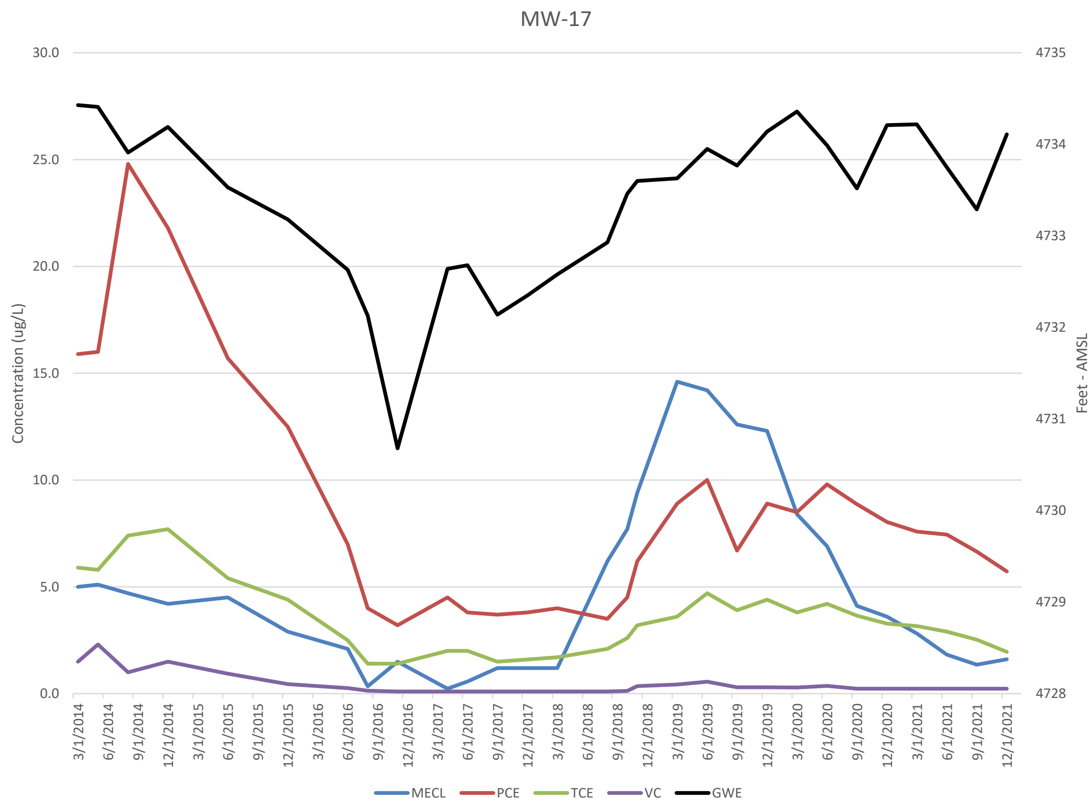

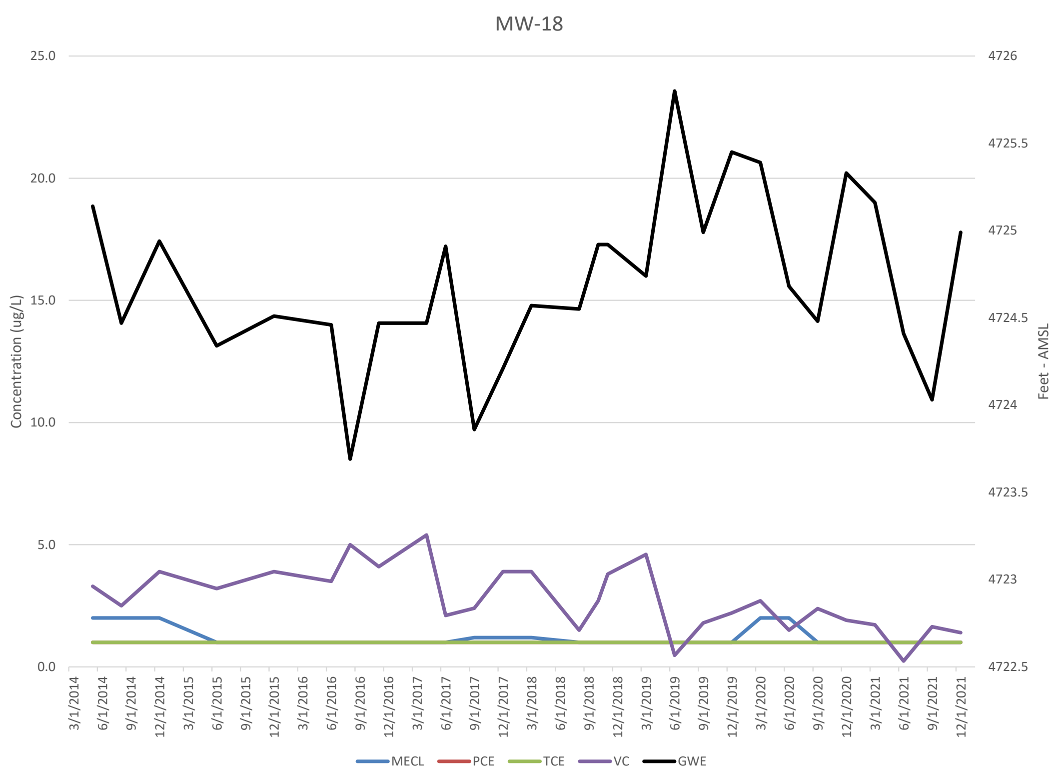

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3/11/2022

VOC's With GWE versus Time
In Selected Wells
Bozeman Landfill
Bozeman, Montana
Figure 8

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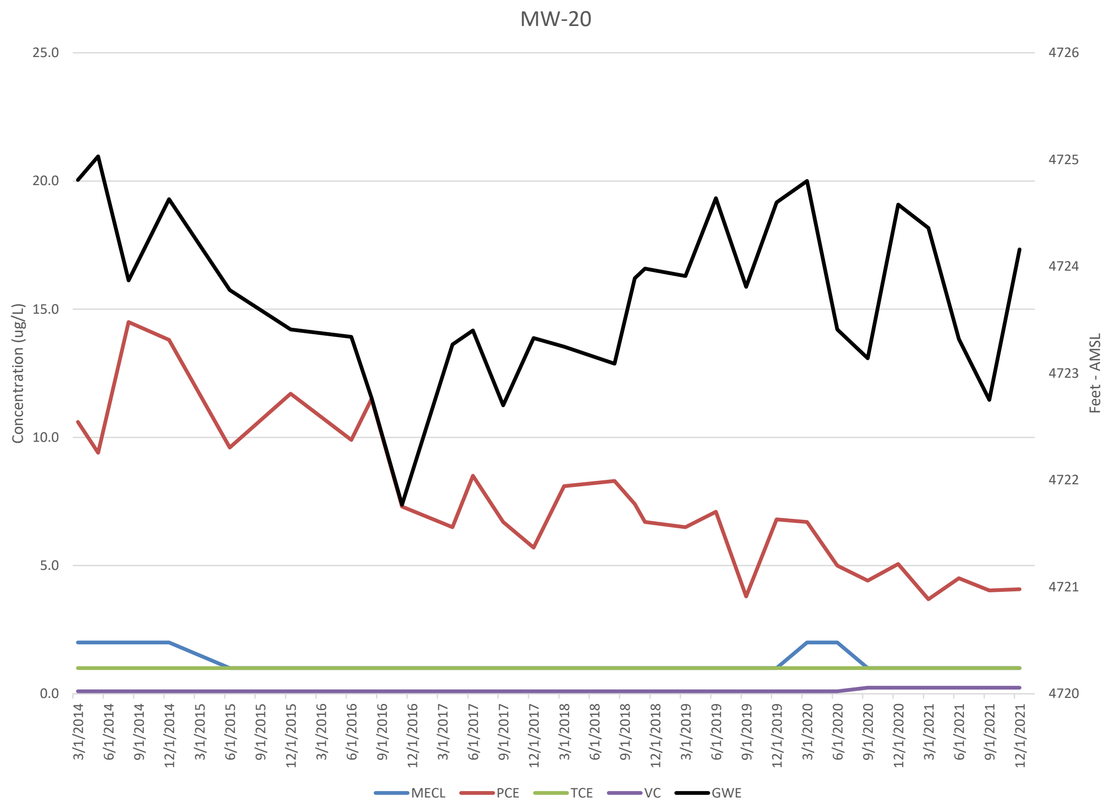

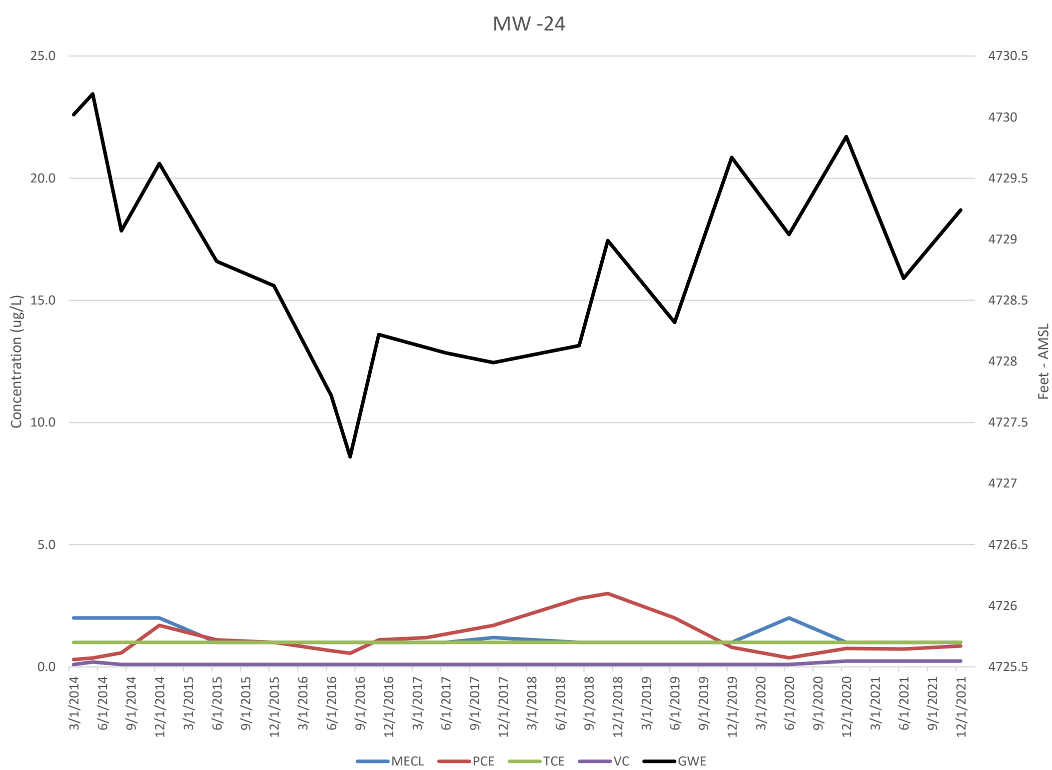

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VOC's With GWE versus Time
In Selected Wells
Bozeman Landfill
Bozeman, Montana
Figure 9

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3/3/2022

VOC's With GWE versus Time
In Selected Wells
Bozeman Landfill
Bozeman, Montana
Figure 10

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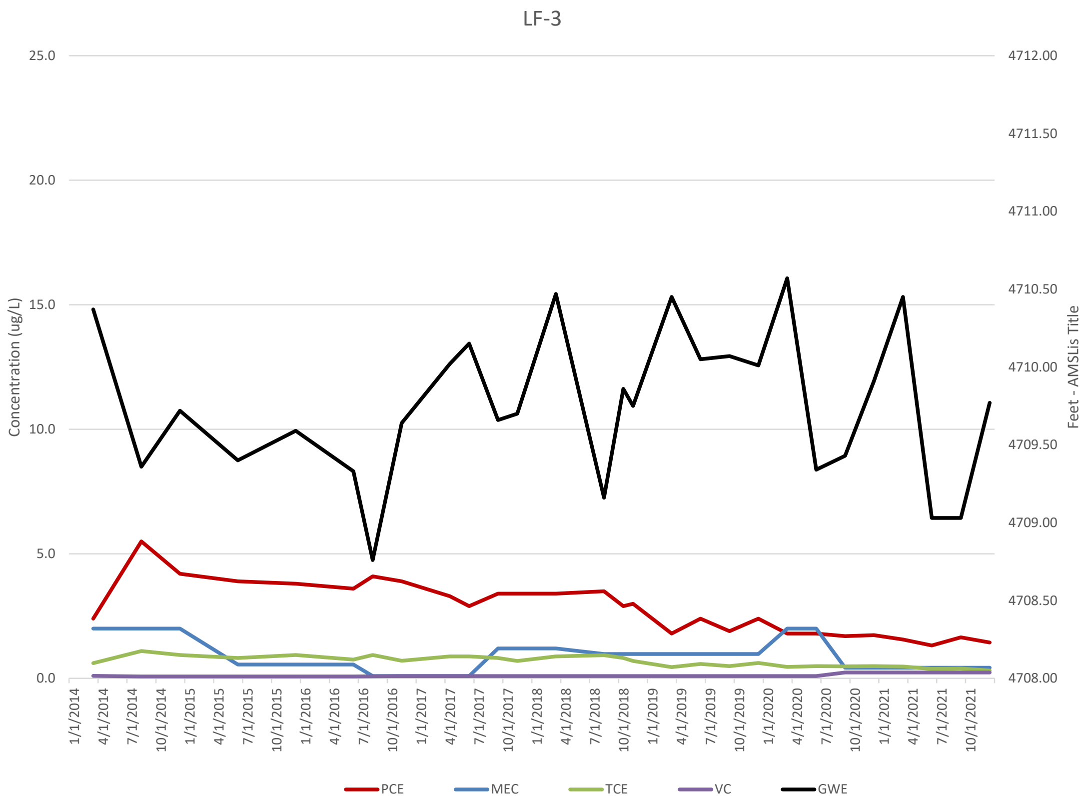

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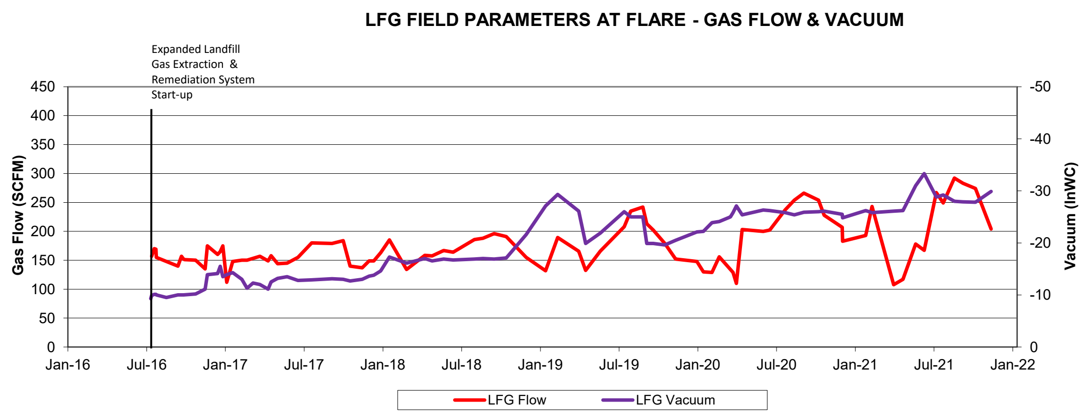
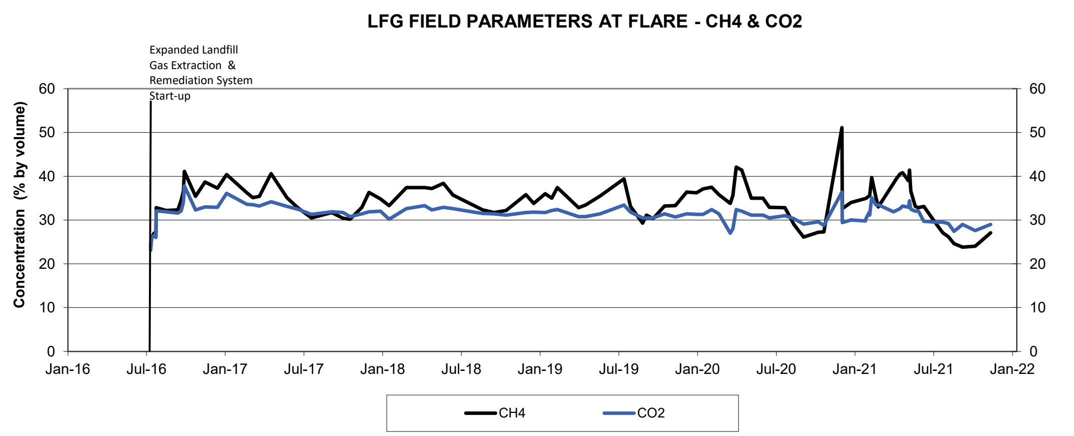
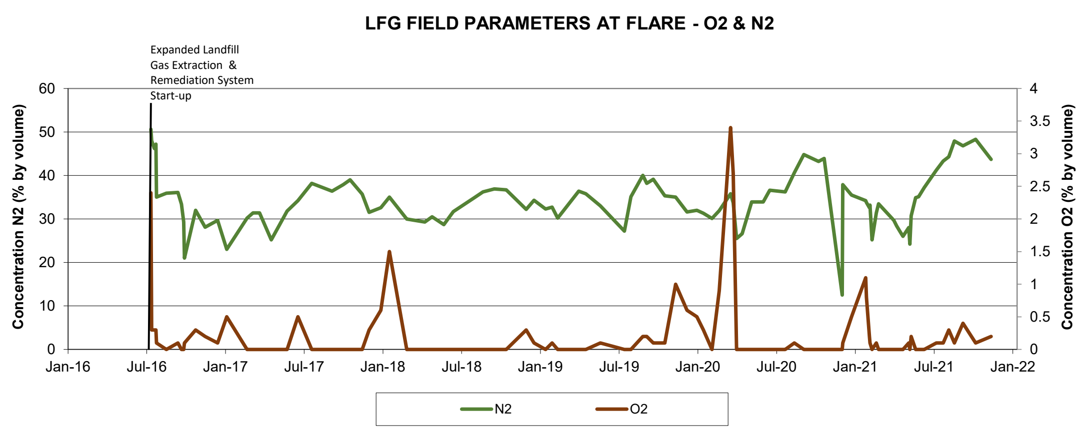
VOC's With GWE versus Time
In Selected Wells
Bozeman Landfill
Bozeman, Montana
Figure 11







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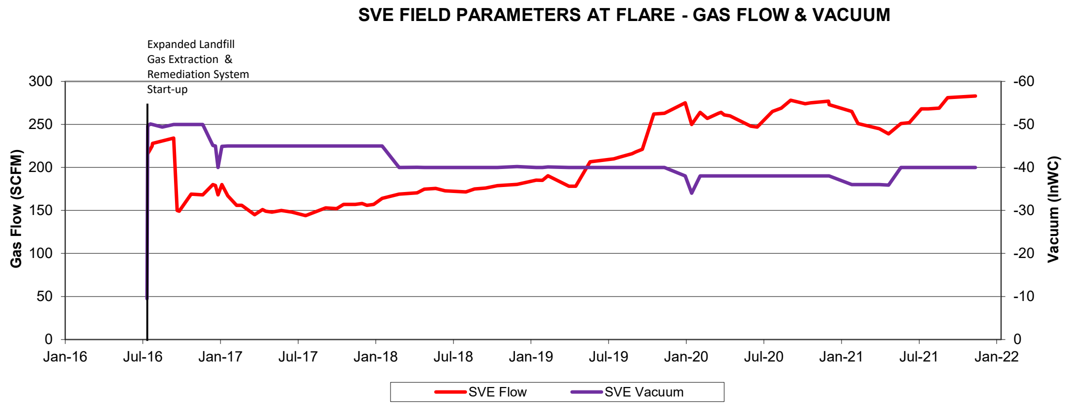
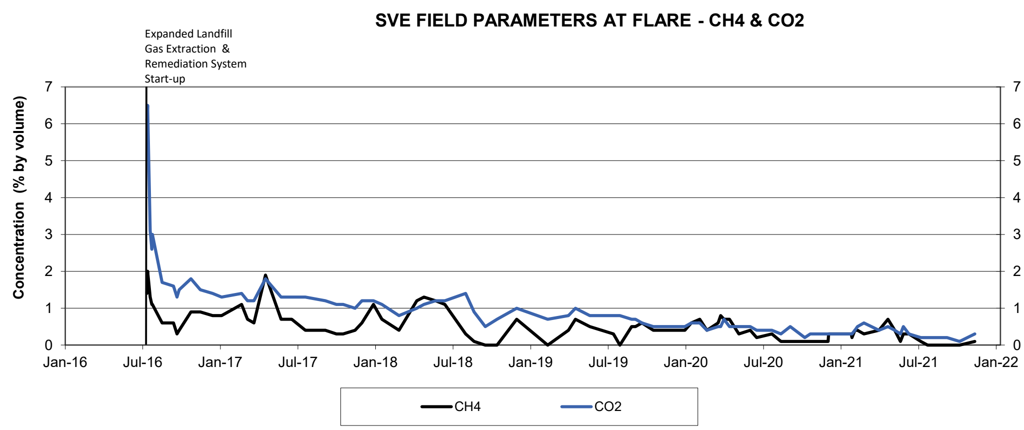
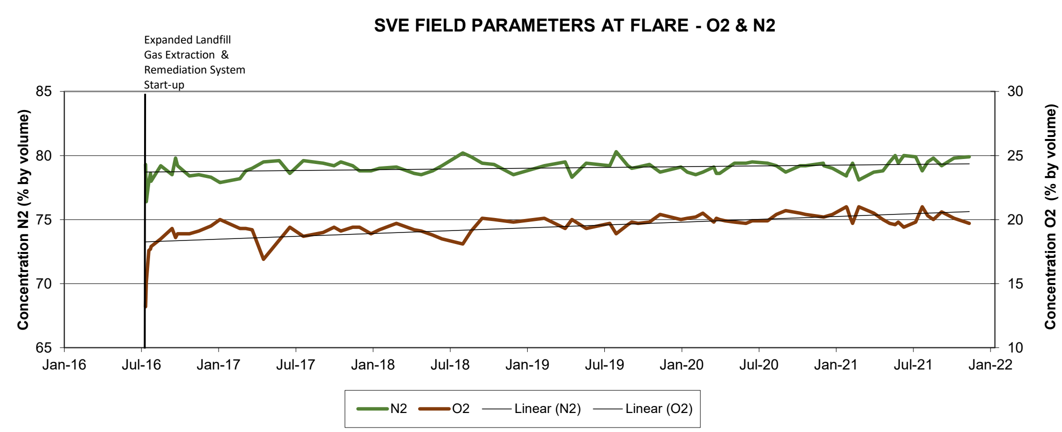
Landfill Gas Extraction
Field Parameters at Flare
Bozeman Landfill
Bozeman, Montana
Figure 12







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3/10/2022

Soil Vapor Extraction Field Parameters at Flare
Bozeman Landfill
Bozeman, Montana
Figure 13

TABLES

TABLE 1
Summary of Select Volatile Organic Compounds at Southeast Corner of Landfill
2014 to Present
Bozeman Landfill

Sampling Location	Sampling Date	Methylene chloride (µg/L)	Tetrachloro-ethene (µg/L)	Trichloro-ethene (µg/L)	Vinyl chloride (µg/L)
		LABORATORY PARAMETERS			
HHS		**30**	**5**	**5**	**2**
MW-17	3/25/2014	J 5	15.9	5.9	1.5
	5/1/2014	5.1	16	5.8	2.3
	8/19/2014	4.7	24.8	7.4	1
	12/9/2014	4.2	21.8	7.7	1.5
	6/17/2015	4.5	15.7	5.4	0.93
	12/2/2015	J 2.9	12.5	4.4	0.45
	6/14/2016	J 2.1	7	2.5	0.26
	8/25/2016	J 0.34	4	1.4	J 0.14
	11/30/2016	J 1.5	3.2	1.4	U 0.098
	4/18/2017	J 0.23	4.5	2	U 0.098
	6/14/2017	J 0.57	3.8	2	U 0.098
	9/20/2017	U 1.2	3.7	1.5	U 0.096
	12/4/2017	U 1.2	3.8	1.6	U 0.096
	3/27/2018	U 1.2	4	1.7	U 0.096
	8/21/2018	6.2	3.5	2.1	U 0.092
	10/16/2018	7.7	4.5	2.6	J 0.13
	11/28/2018	9.4	6.2	3.2	0.35
	3/27/2019	14.6	8.9	3.6	0.43
	6/13/2019	14.2	10	4.7	0.56
	9/23/2019	12.6	6.7	3.9	0.3
	12/2/2019	12.3	8.9	4.4	0.3
	3/23/2020	8.4	8.5	3.8	0.29
	6/23/2020	6.9	9.8	4.2	0.36
	9/21/2020	4.11	8.87	3.65	U 0.234
	12/1/2020	3.6	8.04	3.28	U 0.234
	3/19/2021	2.82	7.59	3.16	U 0.234
	6/22/2021	J 1.82	7.45	2.92	U 0.234
	9/14/2021	J 1.36	6.65	2.53	U 0.234
	12/14/2021	J 1.61	5.72	1.96	U 0.234
MW-18	5/2/2014	U 2	0.87	J 0.38	3.3
	8/20/2014	U 2	0.94	0.49	2.5
	12/9/2014	U 2	0.51	0.5	3.9
	6/16/2015	U 0.56	J 0.23	0.47	3.2
	12/2/2015	U 0.56	U 0.19	0.42	3.9
	6/14/2016	U 0.56	U 0.19	J 0.29	3.5
	8/25/2016	U 0.097	U 0.13	J 0.3	5
	11/30/2016	U 0.097	U 0.13	J 0.35	4.1
	4/18/2017	U 0.097	U 0.13	J 0.27	5.4

Notes: µg/L - micrograms per liter
HHS - Human Health Standard (EPA Maximum Contaminant Level or HHS in Circular DEQ-7, Montana Numeric WQ Stds, June 2019)
-- - Not collected/analyzed

U - Below Method Detection Limit
J - Estimated Concentration
[shaded box] - Value greater than the HHS

Vinyl Chloride concentration highlighted only if greater than 2 micrograms per liter (EPA Maximum Contaminant Level). Montana HHS is greater than 0.2 micrograms per liter (not highlighted).

TABLE 1
Summary of Select Volatile Organic Compounds at Southeast Corner of Landfill
2014 to Present
Bozeman Landfill

Sampling Location	Sampling Date	LABORATORY PARAMETERS: Methylene chloride (µg/L)	Tetrachloro-ethene (µg/L)	Trichloro-ethene (µg/L)	Vinyl chloride (µg/L)
HHS		**30**	**5**	**5**	**2**
MW-18	6/15/2017	U 0.097	U 0.13	J 0.3	2.1
	9/21/2017	U 1.2	U 0.16	J 0.32	2.4
	12/4/2017	U 1.2	U 0.16	J 0.29	3.9
	3/27/2018	U 1.2	U 0.16	J 0.25	3.9
	8/21/2018	U 0.98	U 0.17	U 0.15	1.5
	10/16/2018	U 0.98	U 0.17	J 0.29	2.7
	11/28/2018	U 0.98	U 0.17	J 0.32	3.8
	3/27/2019	U 0.98	U 0.17	J 0.27	4.6
	6/10/2019	U 0.98	U 0.17	U 0.15	0.47
	9/23/2019	U 0.98	U 0.17	U 0.15	1.8
	12/3/2019	U 0.98	U 0.17	U 0.15	2.2
	3/23/2020	U 2	U 0.093	U 0.11	2.7
	6/22/2020	U 2	U 0.093	J 0.24	1.5
	9/21/2020	U 0.43	U 0.3	J 0.218	2.38
	12/1/2020	U 0.43	U 0.3	U 0.19	1.91
	3/19/2021	U 0.43	U 0.3	U 0.19	1.72
	6/22/2021	U 0.43	U 0.3	U 0.19	U 0.234
	9/14/2021	U 0.43	U 0.3	U 0.19	1.64
	12/14/2021	U 0.43	U 0.3	U 0.19	1.4
MW-20	3/25/2014	U 2	10.6	J 0.34	U 0.1
	5/2/2014	U 2	9.4	J 0.33	U 0.2
	8/19/2014	U 2	14.5	0.76	U 0.082
	12/9/2014	U 2	13.8	0.91	U 0.082
	6/17/2015	U 0.56	9.6	0.55	U 0.081
	12/1/2015	U 0.56	11.7	0.7	U 0.081
	6/15/2016	U 0.56	9.9	0.66	U 0.081
	8/25/2016	U 0.097	11.5	0.55	U 0.084
	11/30/2016	U 0.097	7.3	J 0.39	U 0.098
	4/17/2017	U 0.097	6.5	J 0.4	U 0.098
	6/15/2017	U 0.097	8.5	0.47	U 0.098
	9/21/2017	U 1.2	6.7	J 0.39	U 0.096
	12/4/2017	U 1.2	5.7	J 0.22	U 0.096
	3/27/2018	U 1.2	8.1	J 0.39	U 0.096
	8/22/2018	U 0.98	8.3	J 0.34	U 0.092
	10/16/2018	U 0.98	7.4	0.41	U 0.092
	11/27/2018	U 0.98	6.7	J 0.32	U 0.092
	3/27/2019	U 0.98	6.5	J 0.22	U 0.092
	6/13/2019	U 0.98	7.1	J 0.27	U 0.092

Notes: µg/L - micrograms per liter
HHS - Human Health Standard (EPA Maximum Contaminant Level or HHS in Circular DEQ-7, Montana Numeric WQ Stds, June 2019)
-- - Not collected/analyzed

U - Below Method Detection Limit
J - Estimated Concentration
(shaded) - Value greater than the HHS

Vinyl Chloride concentration highlighted only if greater than 2 micrograms per liter (EPA Maximum Contaminant Level). Montana HHS is greater than 0.2 micrograms per liter (not highlighted).

TABLE 1
Summary of Select Volatile Organic Compounds at Southeast Corner of Landfill
2014 to Present
Bozeman Landfill

Sampling Location	Sampling Date	Methylene chloride (µg/L)	Tetrachloro-ethene (µg/L)	Trichloro-ethene (µg/L)	Vinyl chloride (µg/L)
		LABORATORY PARAMETERS			
HHS		**30**	**5**	**5**	**2**
MW-20	9/23/2019	U 0.98	3.8	U 0.15	U 0.092
	12/3/2019	U 0.98	6.8	J 0.16	U 0.092
	3/23/2020	U 2	6.7	J 0.17	U 0.098
	6/23/2020	U 2	5	J 0.2	U 0.098
	9/22/2020	U 0.43	4.41	JL0 0.208	U 0.234
	12/1/2020	U 0.43	5.06	J 0.267	U 0.234
	3/19/2021	U 0.43	3.69	J 0.245	U 0.234
	6/22/2021	U 0.43	4.51	U 0.19	U 0.234
	9/14/2021	U 0.43	4.03	U 0.19	U 0.234
	12/14/2021	U 0.43	4.08	U 0.19	U 0.234
MW-24	3/25/2014	U 2	J 0.3	U 0.13	U 0.1
	5/2/2014	U 2	J 0.36	U 0.084	U 0.2
	8/21/2014	U 2	0.57	U 0.084	U 0.082
	12/8/2014	U 2	1.7	U 0.084	U 0.082
	6/18/2015	U 0.56	1.1	U 0.14	U 0.081
	12/1/2015	U 0.56	1	U 0.14	U 0.081
	6/16/2016	U 0.56	0.66	U 0.14	U 0.081
	8/25/2016	U 0.097	0.56	U 0.051	U 0.084
	11/28/2016	U 0.097	1.1	U 0.044	U 0.098
	6/15/2017	U 0.097	1.2	U 0.044	U 0.098
	11/28/2017	U 1.2	1.7	U 0.18	U 0.096
	8/22/2018	U 0.98	2.8	U 0.15	U 0.092
	11/27/2018	U 0.98	3	U 0.15	U 0.092
	6/13/2019	U 0.98	2	U 0.15	U 0.092
	12/3/2019	U 0.98	0.8	U 0.15	U 0.092
	6/23/2020	U 2	J 0.37	U 0.11	U 0.098
	12/2/2020	U 0.43	0.755	U 0.19	U 0.234
	6/22/2021	U 0.43	0.726	U 0.19	U 0.234
	12/14/2021	U 0.43	0.852	U 0.19	U 0.234
MW-28	6/15/2021	U 0.43	J 0.333	U 0.19	U 0.234
	6/22/2021	U 0.43	U 0.3	U 0.19	U 0.234
	12/14/2021	U 0.43	U 0.3	U 0.19	U 0.234
MW-29	6/15/2021	U 0.43	18.6	4.12	U 0.234
	6/22/2021	U 0.43	19.9	4.33	U 0.234
	12/15/2021	U 0.43	19.3	3.31	J 0.314

Notes: µg/L - micrograms per liter
HHS - Human Health Standard (EPA Maximum Contaminant Level or HHS in Circular DEQ-7, Montana Numeric WQ Stds, June 2019)
-- - Not collected/analyzed

U - Below Method Detection Limit
J - Estimated Concentration
(shaded) - Value greater than the HHS

Vinyl Chloride concentration highlighted only if greater than 2 micrograms per liter (EPA Maximum Contaminant Level). Montana HHS is greater than 0.2 micrograms per liter (not highlighted).

TABLE 2
PERFORMANCE OF LANDFILL GAS EXTRACTION SYSTEM

	Number of LFG Extraction Wells	Destruction Efficiency	Average System Vacuum (inWC)	Average Gas Flow (SCFM)	Average Methane Content (% by volume)	Percent of Time Flare Operates (%)	Total Hours per Time Duration	Approximate SCF CH4 per Time Duration	Approximate Methane Collected (pounds/yr)	Approximate Methane Collected (pounds/day)	Approximate Methane Destroyed (pounds/yr)
New LFG Extraction System First Year Months (Aug 9, 2016 to August 9, 2017)	25	0.99996	-12	154	34	92	8,760	25,318,783	1,070,127 Note 1	2,932	1,070,084
Second Year (August 10, 2017 to August 29, 2018)	25	0.99996	-15	160	34	95	9,216	28,934,273	1,222,940 Note 1	3,185	1,222,891
Third Year (August 30, 2018 to August 27, 2019)	25	0.99996	-22	179	34	92	8,688	29,621,974	1,252,006 Note 1	3,459	1,251,956
Fourth Year (August 28, 2019 to August 19, 2020)	25	0.99996	-24	173	35	98	8,544	30,169,710	1,275,157 Note 1	3,582	1,275,106
Fifth Year (August 20, 2020 to December 9, 2021)	25	NM	-27	220	33	97	11,448	48,894,910	2,066,599 Note 1	4,332	NM

Notes : LFG: Landfill Gas inWC: Inches Water Column SCFM: Standard Cubic Feet per Minute %: Percent yr: Year NM: Not Measured

Operational Efficiency is the difference between actual time elapsed and the flare operation timer

Methane Content measured using an Envision® Gas Analyzer in the field

Mass calculated using the molar volume of 379.5 ft^3/lb-mole @ STP

TABLE 3
LANDFILL GAS FIELD MONITORING DATA
BOZEMAN LANDFILL
BOZEMAN, MONTANA

Date	Inlet Vacuum InWC	Inlet Temperature DegF	Low Flow SCFM	High Flow SCFM	LFG Flow SCFM	CH4 %	CO2 %	O2 %	N2 %	Comment
8/9/2016										New Flare Startup
8/10/2016	-9.30					24.0	23.1	2.4	50.6	
8/12/2016	-9.90				157	25.8	25.9	0.3	48.0	
8/18/2016	-10.10				170	27.0	26.5	0.3	46.2	
8/22/2016	-10.10				169	26.5	26.0	0.3	47.2	
8/23/2016	-10.00				155	32.8	32.1	0.1	35.0	
9/15/2016	-9.52					32.2	31.9	0.0	35.9	
10/12/2016	-10.00				140	32.3	31.6	0.1	36.1	
10/20/2016	-10.00				157	34.5	32.1	0.0	33.4	
10/25/2016	-10.00				152	36.6	34.1	0.0	29.3	
10/27/2016		62			151	41.1	37.8	0.1	21.0	
11/22/2016	-10.20	50	89	164	150	35.4	32.3	0.3	32.0	LFG vac setpt incr to 11.9 inWC
12/14/2016	-11.10	43	75	149	135	38.7	33.0	0.2	28.1	
12/19/2016	-13.90	43			175					LFG vac set pt incr to 14 inWC
1/12/2017	-14.10	44	155	172	160	37.3	32.9	0.1	29.7	
1/18/2017	-15.50	42			165					
1/24/2017	-13.50	41			175					Bison conducts Emissions test
2/2/2017	-13.90	39			112	40.4	36.1	0.5	23.0	
2/16/2017	-14.30	40			148					
3/9/2017	-13.00	41	117	179	150					
3/21/2017	-11.30	44	139	189	150	36.2	33.6	0.0	30.2	
4/4/2017	-12.28					35.1	33.5	0.0	31.4	
4/19/2017						35.4	33.2	0.0	31.4	
4/20/2017	-12.00	48	116	190	157					
5/9/2017	-11.10	50			149					
5/16/2017	-12.50	54			158	40.6	34.2	0.0	25.2	
5/31/2017	-13.20	57	124	182	144					
6/22/2017	-13.50	61	118	180	145	35.1	33.1	0.0	31.8	
7/17/2017	-12.80	67	136	188	155	32.8	32.5	0.5	34.2	
8/18/2017	-12.90	70	180	180	180	30.5	31.3	0.0	38.2	Long dry spell (+4 weeks)
10/4/2017	-13.10	58			179	31.7	31.9	0.0	36.4	
10/30/2017	-13.00	55			184	30.4	31.7	0.0	37.9	
11/15/2017	-12.70	45	97	173	140	30.2	30.8	0.0	39.0	
12/13/2017	-13.00	44	74	167	137	32.9	31.4	0.0	35.7	
12/29/2017	-13.60	42			149	36.3	31.9	0.3	31.5	1.5 ft snowpack, cold
1/9/2018	-13.80	42			149					
1/25/2018	-14.60	42			163	34.8	32.0	0.6	32.6	
2/14/2018	-17.30	40			185.1	33.3	30.2	1.5	35.0	GW well couplers leaking
3/26/2018	-16.10	41			134	37.4	32.6	0.0	30.0	
5/7/2018	-17.02	50			158.5	37.4	33.3	0.0	29.3	
5/24/2018	-16.53	54			157.4	37.2	32.3	0.0	30.5	
6/20/2018	-16.90	60			166.8	38.4	32.9	0.0	28.7	
7/12/2018	-16.70	65			164	35.7	32.6	0.0	31.7	
8/30/2018	-16.90	64			185.9	33.3	31.8	0.0	34.9	
9/19/2018	-17.00	62			188	32.3	31.5	0	36.2	
10/15/2018	-16.90	57			196	31.7	31.4	0	36.9	PID - 1.7 ppm
11/12/2018	-17.10	50			191	32.2	31.1	0.0	36.7	
12/28/2018	-21.60	41			155	35.8	31.7	0.3	32.2	Incr vacuum for cold wx op
1/15/2019						33.8	31.8	0.1	34.3	
2/11/2019	-27.10	39			132	36.0	31.7	0.0	32.3	
2/26/2019		37				35.0	32.2	0.1	32.7	
3/11/2019	-29.30	40			189.4	37.4	32.4	0.0	30.2	
4/29/2019	-26.10	43			165.5	32.8	30.8	0.0	36.4	
5/15/2019	-19.90	49			132.5	33.4	30.8	0.0	35.8	
6/18/2019	-21.90	57			166	35.5	31.4	0.1	33.0	
8/12/2019	-26	64	185	227	208	39.4	33.4	0.0	27.2	25 inWC set point
8/27/2019	-25	66			235	33.1	31.8	0.0	35.1	
9/24/2019	-25	61			242	29.3	30.5	0.2	40.0	
10/3/2019	-19.9	59			213	31.1	30.5	0.2	38.2	
10/18/2019	-19.9	53			202	30.3	30.5	0.1	39.1	

TABLE 3
LANDFILL GAS FIELD MONITORING DATA
BOZEMAN LANDFILL
BOZEMAN, MONTANA

Date	Inlet Vacuum InWC	Inlet Temperature DegF	Low Flow SCFM	High Flow SCFM	LFG Flow SCFM	CH4 %	CO2 %	O2 %	N2 %	Comment
11/14/2019	-19.6	48	143	218	179	33.2	31.4	0.1	35.3	
12/9/2019	-20.5	44	89	213	152	33.3	30.7	1.0	35.0	
1/4/2020						36.4	31.4	0.6	31.6	
1/27/2020	-22.1	40	101	188	148	36.2	31.3	0.5	32.0	
2/11/2020	-22.2	39	115	147	130	37.1	31.3	0.3	31.3	
3/2/2020	-23.9	39	108	153	129	37.5	32.4	0.0	30.1	
3/19/2020	-24.1	39	112	193	156	35.8	31.4	0.9	31.9	
4/14/2020	-25	42	114	162	134	33.8	27.0	3.4	35.8	Following adjustment of LFG wells
4/20/2020	-25.8	45	110	153	129	35.6	28.0	2.7	33.7	
4/28/2020	-27.1	47	98	128	110	42.1	32.4	0.0	25.5	
5/11/2020	-25.4	48	147	226	203	41.4	32.0	0.0	26.6	
6/2/2020						35.0	31.1	0.0	33.9	
6/29/2020	-26.3	56	145	241	200	35.0	31.1	0.0	33.9	
7/14/2020	-26.2	61	145	241	202	32.9	30.5	0.0	36.6	
8/19/2020	-25.8	65	203	259	237	32.8	31.0	0.0	36.2	
9/9/2020	-25.4	63	236	261	254	29.0	30.3	0.1	40.6	
10/1/2020	-25.9	61	265	268	266	26.1	29.1	0.0	44.8	
11/4/2020	-26.0	59	250	256	254	27.2	29.6	0.0	43.2	
11/17/2020	-26.1	50	206	253	228	27.3	28.8	0.0	43.9	
12/29/2020	-25.5	42			207	51.1	36.4	0.0	12.5	At startup
12/30/2020	-24.8	42	142	237	183	32.6	29.4	0.1	37.9	Running
1/20/2021						34.0	30.0	0.5	35.5	
2/22/2021	-26.2	40	141	218	193	34.9	29.8	1.1	34.2	Prior to increasing flow from GW-19 and 26
2/23/2021						35.0	30.4	0.8	33.8	After increasing flow from 19 and 26
3/2/2021						35.5	31.7	0.2	32.6	
3/4/2021						35.6	31.1	0.1	33.2	
3/8/2021	-25.8	43	201	278	243	39.7	35.1	0	25.2	
3/18/2021						35.1	33.4	0.1	31.4	After increasing flow from 19 and 26 to 40%
3/23/2021						33.0	33.5	0	33.5	
4/28/2021	-26.1	46	91	136	107.7	38.4	31.9	0	29.7	After increasing flow from 19 and 26 to 80%
5/4/2021						39.4	32.2	0	28.4	
5/13/2021						40.5	32.6	0	26.9	
5/19/2021	-26.2	52			117	40.8	33.2	0	26	
6/1/2021						39	32.9	0.1	28	
6/4/2021						41.4	34.4	0	24.2	
6/7/2021						36.6	32.5	0.2	30.7	
6/17/2021	-31.0	59			178	33.1	32	0	34.9	
6/24/2021						32.8	32.1	0	35.1	
7/7/2021	-33.3	65			167	33.1	29.7	0	37.2	
8/4/2021	-28.8	65			267	29.2	29.5	0.1	41.2	
8/20/2021	-29.2	63			249	27.1	29.5	0.1	43.3	
9/2/2021						26.2	29.2	0.3	44.3	
9/15/2021	-28.0	64			292	24.6	27.4	0.1	47.9	
10/5/2021	-27.9	57			283	23.8	29	0.4	46.8	
11/3/2021	-27.8	54			274	24.0	27.6	0.1	48.3	
12/9/2021	-29.9	48			204	27.1	29	0.2	43.7	
Minimum	-33.3	37.0	74.0	128.0	107.7	23.8	23.1	0.0	12.5	
Maximum	-9.3	70.0	265.0	278.0	292.0	51.1	37.8	3.4	50.6	
Median	-17.2	49.5	130.0	188.5	165.3	34.7	31.7	0.0	33.9	
Average	-19.2	50.8	140.2	199.1	176.2	34.1	31.4	0.2	34.3	
Average 8/20/20 to 12/9/21	-27.4	54.1	191.5	238.4	220.4	33.3	31.1	0.1	35.4	

Notes : InWC : Inches water column
DegF : Degrees Fahrenheit
SCFM : Standard temperature and pressure cubic feet per minute
% : Percent by Volume

TABLE 4
SOIL VAPOR EXTRACTION FIELD MONITORING DATA
BOZEMAN LANDFILL
BOZEMAN, MONTANA

Date	Inlet Vacuum InWC	Inlet Temperature DegF	SVE Flow SCFM	CH4 %	CO2 %	O2 %	N2 %	Comment
8/9/2016								New Flare Startup
8/10/2016	-9.50			1.4	6.1	13.2	79.3	
8/12/2016	-49.64		216	2.0	6.5	15.1	76.4	
8/18/2016	-50.10		221	1.3	3.1	17.6	78.0	
8/22/2016			225	1.1	2.6	17.7	78.6	
8/23/2016	-50.00		228	1.1	3.0	17.9	78.0	
9/15/2016	-49.38			0.6	1.7	18.5	79.2	
10/12/2016	-50.00		234	0.6	1.6	19.3	78.5	
10/20/2016	-50.00		150	0.3	1.3	18.6	79.8	
10/25/2016	-50.00		149	0.4	1.5	18.9	79.2	
10/27/2016								
11/22/2016	-50.00		169	0.9	1.8	18.9	78.4	
12/14/2016				0.9	1.5	19.1	78.5	
12/19/2016	-50.00	43	168					
1/12/2017	-45.10	45.1	180	0.8	1.4	19.5	78.3	
1/18/2017	-45.00	44	179					
1/24/2017	-40.00	42	168					SVE vac setpt decr to 40 inWC
2/2/2017	-44.90	39	180	0.8	1.3	20.0	77.9	
2/16/2017	-45.00	45	167					
3/9/2017	-45.00	45	156					
3/21/2017	-45.00	49	156	1.1	1.4	19.3	78.2	
4/4/2017				0.7	1.2	19.3	78.8	
4/19/2017				0.6	1.2	19.2	79.0	
4/20/2017	-45.00	57	145					
5/9/2017	-45.00	56	151					
5/16/2017	-45.00	60	149	1.9	1.8	16.9	79.5	
5/31/2017	-45.00	68	148					
6/22/2017	-45.00	69	150	0.7	1.3	18.4	79.6	
7/17/2017	-45.00	74	148	0.7	1.3	19.4	78.6	
8/18/2017	-45.00	78	144	0.4	1.3	18.7	79.6	
10/4/2017	-45.00	58	153	0.4	1.2	19.0	79.4	
10/30/2017	-45.00	55	152	0.3	1.1	19.4	79.2	
11/15/2017	-45.00	45	157	0.3	1.1	19.1	79.5	
12/13/2017	-45.00	46	157	0.4	1.0	19.4	79.2	
12/29/2017	-45.00	42	158	0.6	1.2	19.4	78.8	
1/9/2018	-45.00	45	156					
1/25/2018	-45.00	47	157	1.1	1.2	18.9	78.8	
2/14/2018	-45.00	41	164	0.7	1.1	19.2	79	
3/26/2018	-40.00	46	169	0.4	0.8	19.7	79.1	
5/7/2018	-40.01	56	170	1.2	1.0	19.2	78.6	
5/24/2018	-40.00	61	175	1.3	1.1	19.1	78.5	PID - 0.9 ppm
6/20/2018	-40.00	67	176	1.2	1.2	18.8	78.8	
7/12/2018	-40.00	72	173	1.1	1.2	18.5	79.2	PID - 0.3 ppm
8/30/2018	-40.00	67	172	0.3	1.4	18.1	80.2	
9/19/2018	-40.00	62	175	0.1	0.9	19.1	79.9	

TABLE 4
SOIL VAPOR EXTRACTION FIELD MONITORING DATA
BOZEMAN LANDFILL
BOZEMAN, MONTANA

Date	Inlet Vacuum InWC	Inlet Temperature DegF	SVE Flow SCFM	CH4 %	CO2 %	O2 %	N2 %	Comment
10/15/018	-40.00	57	176	0.0	0.5	20.1	79.4	PID - 0.7 ppm
11/12/2018	-40.00	50	179	0.0	0.7	20.0	79.3	
12/18/2018	-40.20	41	180	0.7	1.0	19.8	78.5	
1/15/2019								
2/11/2019	-40.00	38	185					
2/26/2019	-40.00	37	185					
3/11/2019	-40.10	45	190.3	0.0	0.7	20.1	79.2	
4/29/2019	-40.00	43	178.2	0.4	0.8	19.3	79.5	
5/15/2019	-40.00	55	178.2	0.7	1.0	20.0	78.3	
6/18/2019	-40.00	61	206.5	0.5	0.8	19.3	79.4	
8/12/2019	-40.00	68	210	0.3	0.8	19.7	79.2	
8/27/2019	-40.00	69	212	0.0	0.8	18.9	80.3	
9/24/2019	-40.00	66	216	0.5	0.7	19.6	79.2	
10/3/2019	-40.00	63	218	0.5	0.7	19.8	79.0	
10/18/2019	-40.00	56	221	0.6	0.6	19.7	79.1	
11/14/2019	-40.00	51	262	0.4	0.5	19.8	79.3	
12/9/2019	-40.00	46	263	0.4	0.5	20.4	78.7	
1/4/2020								
1/27/2020	-38.0	43	275	0.4	0.5	20.0	79.1	
2/11/2020	-34.0	41	250	0.6	0.6	20.1	78.7	
3/2/2020	-38.0	43	264	0.7	0.6	20.2	78.5	
3/19/2020	-38.0	41	257	0.4	0.4	20.5	78.7	
4/14/2020	-38.0	44	263	0.6	0.5	19.8	79.1	
4/20/2020	-38.0	45	264	0.8	0.5	20.1	78.6	
4/28/2020	-38.0	38	261	0.7	0.7	20.0	78.6	
5/11/2020	-38.0	50	260	0.7	0.5	19.9	78.9	
6/2/2020				0.3	0.5	19.8	79.4	
6/29/2020	-38.0	55	248	0.4	0.5	19.7	79.4	
7/14/2020	-38.0	68	247	0.2	0.4	19.9	79.5	
8/19/2020	-38.0	70	265	0.3	0.4	19.9	79.4	
9/9/2020	-38.0	65	269	0.1	0.3	20.4	79.2	
10/1/2020	-38.0	66	278	0.1	0.5	20.7	78.7	
11/4/2020	-38.0	59	274	0.1	0.2	20.5	79.2	
11/17/2020	-38.0	55	275	0.1	0.3	20.4	79.2	
12/29/2020	-38.0	44	277	0.1	0.3	20.2	79.4	
12/30/2020	-38.0	46	273	0.3	0.3	20.2	79.2	
1/20/2021				0.3	0.3	20.4	79.0	
2/22/2021	-36.0	46	265	0.3	0.3	21.0	78.4	
2/23/2021				0.2	0.3	20.9	78.6	
3/2/2021				0.4	0.4	20.2	79.0	
3/4/2021								
3/8/2021	-36.0	43	251	0.4	0.5	19.7	79.4	
3/18/2021								
3/23/2021				0.3	0.6	21	78.1	
4/28/2021	-36.0	51	245	0.4	0.4	20.5	78.7	

TABLE 4
SOIL VAPOR EXTRACTION FIELD MONITORING DATA
BOZEMAN LANDFILL
BOZEMAN, MONTANA

Date	Inlet Vacuum InWC	Inlet Temperature DegF	SVE Flow SCFM	CH4 %	CO2 %	O2 %	N2 %	Comment
5/4/2021								
5/13/2021								
5/19/2021	-35.9	85	239	0.7	0.5	20	78.8	
6/1/2021								
6/4/2021				0.4	0.4	19.7	79.5	
6/7/2021								
6/17/2021	-40.0	67	251	0.1	0.3	19.6	80	
6/24/2021				0.3	0.5	19.8	79.4	
7/7/2021	-40.0	74	252	0.3	0.3	19.4	80	
8/4/2021	-40.0	70	268	0.1	0.2	19.8	79.9	
8/20/2021	-40.0	63	268	0.0	0.2	21.0	78.8	
9/2/2021				0.0	0.2	20.3	79.5	
9/15/2021	-40.0	72	269	0.0	0.2	20	79.8	
10/5/2021	-40.0	59	281	0.0	0.2	20.6	79.2	
11/3/2021	-40.0	55	282	0.0	0.1	20.1	79.8	
12/9/2021	-40.0	47	283	0.1	0.3	19.7	79.9	
Minimum	-50.1	37.0	144.0	0.0	0.1	13.2	76.4	
Maximum	-9.5	85.0	283.0	2.0	6.5	21.0	80.3	
Median	-40.0	55.0	206.5	0.4	0.7	19.7	79.2	
Average	-41.3	54.3	209.1	0.5	1.0	19.5	79.0	
Average 8/20/20 to 12/9/21	-38.7	61.0	262.8	0.2	0.3	20.2	79.3	

Notes :
InWC : Inches water column
DegF : Degrees Fahrenheit
SCFM : Standard temperature and pressure cubic feet per minute
% : Percent by Volume