KANSAS SKY
ENERGY CENTER

March 21, 2024

VIA E-MAIL ONLY
Board of County Commissioners
Douglas County, Kansas
c/o Sarah Plinsky, County Administrator
1100 Massachusetts Street
Lawrence, Kansas 66044
splinsky@douglascountyks.org

*Re: Free State Solar Project, LLC d/b/a Kansas Sky Energy Center (the "**Applicant**")*
*159-megawatt Commercial/Utility Scale Solar Energy Conversion System (the "**Project**")*
*CUP-23-00312 (the "**Application**")*

Dear Commissioners:

The Applicant requests your consideration of the supplemental materials included with this letter. These materials contain additional Project information, augment the materials previously provided, and reflect the collaborative efforts of the Applicant and the County administration. The following is a summary of each component of the supplemental materials.

Project Location

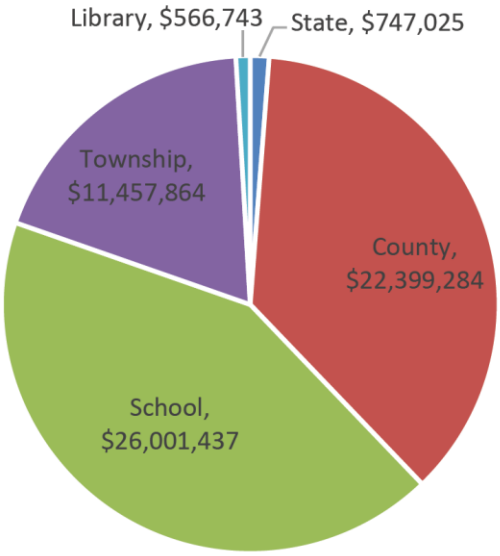
The Douglas County Alternative Site Analysis enclosed as Supplemental Exhibit 1.A. evaluates the entire County in search of potential alternate sites for the Project. Of the twelve (12) sites that could potentially host a utility scale solar project, the Project is the only site that both meets all land use requirements and has a financially feasible interconnection point located in close proximity.

Economic Impact

Supplemental Exhibit 2.A. is an Economic Impact Analysis of the Project (the "**Economic Study**") prepared by Strategic Economic Research, LLC. As detailed in the Economic Study, the Project's total State and local impacts, such as job creation, earnings, economic activity, taxes paid and other economic outputs, both direct and indirect, are in excess of **$269 million**. Of that, the Project's estimated new tax revenue directly to Douglas County and other local taxing jurisdictions during the 25-year term of the CUP is **$61,172,353**. *See* Economic Study, pg. 23. Figure 1 from the Economic Study, on the following page, illustrates the tax benefit to each of the local taxing jurisdictions.

By way of contrast, if the land were to remain agricultural, the estimated taxes paid during the same period would be less than $1,000,000.

Figure 1 – Total Property Taxes Paid by the Kansas Sky Energy Center



The Project provides other economic, public and environmental benefits, including but not limited to groundwater monitoring, water well testing, soil testing, road repair and maintenance as set forth in a future Road Maintenance Agreement, a decommissioning bond, a revegetation bond, vegetative screening, additional fencing for wildlife corridors, post construction bird mortality studies, and third-party consultant reviews and inspections. As discussed in greater detail below, the Project will also support various agrivoltaics programs.

Revised Conditions

The revised conditions to the Application are set forth on Supplemental Exhibit 4.B, and the Applicant believes that a verbatim set of conditions are included in the Staff report. These revised conditions reflect the discussion by the Planning Commission, as further evaluated and considered by the Applicant and the County administration. The Applicant and the Staff are aligned and in agreement with respect to the proposed conditions.

Limits on Construction Activity. In response to Planning Commission commentary suggesting that all types of construction activity should be limited (as opposed to daylight hours, seven days a week), the revised Condition 2.c. limits construction activity to 6 a.m. to 7 p.m., Monday through *Friday*, and limits pile driving activities to 7 a.m. and 5 p.m., Monday through Friday. The condition provides the limited ability to work on certain Saturdays, if the Project schedule is impacted by ongoing weather delays, subject to approval by the Zoning and Codes Director or the County Commission. The condition also includes an exception that permits construction activity to occur during the daylight hours of Saturday and Sunday, if the sound generated is below 60 decibels measured at the property line or 500 feet from any residence. Not only do the conditions impose limits upon the hours of construction activity, the Applicant is also interested in discussing good neighbor agreements with all property owners that are affected by the construction of the Project. These agreements would create opportunity for the owners to request specific types of screening and other accommodations, and could also include certain monetary compensation.

Grant Township Fire Protection. The Planning Commission considered a proposed condition requiring the Project to pay any increase to Grant Township in fire protection services resulting from the Project. The Project will not affect Grant Township's rates for fire protection services under its current agreement with Lawrence-Douglas County Fire and Medical. Moreover, the Economic Study demonstrates a significant increase to Grant Township's tax base, which adequately compensates Grant Township for any future increase to fire protection services charged by Lawrence-Douglas County Fire and Medical. Furthermore, Condition 2.u. obligates the operator of the Project to provide, update and/or replace any specialty response equipment required to adequately manage "Extraordinary Events," as more specifically discussed in the Condition. The Applicant and the Staff agree that the above-described Grant Township condition need not be included in the Application.

Vegetation Bond. The Staff requested that the Project operator provide a vegetation bond to ensure revegetation of the Project site after completion (*see* Condition 2.dd). The vegetation bond amount reflects an amount that reasonably approximates the cost to revegetate the Project.

Agrivoltaics

A revised condition related to agrivoltaics (*see* Condition 2.t.) reflects the County administration's observation that various agrivoltaic uses may have different impacts on storm water drainage and runoff and requires careful analysis for proposed changes in groundcover. The revised agrivoltaics conditions have no cap or restrictions to the potential expansion of agrivoltaics uses on the Project. Supplemental Exhibit 3.A. contains an updated memorandum concerning potential agrivoltaic activities. The Applicant has secured approvals and permissions from all applicable landowners to enable agrivoltaic uses on site. *See* Supplemental Exhibit 3.B. (Project leases have been amended to explicitly allow for agrivoltaics). Furthermore, Evergy has executed a Memorandum of Understanding (the "**MOU**") with The Nature Conservancy ("**TNC**"), as set forth in Supplemental Exhibit 3.C. As set forth in the MOU, TNC would administer agrivoltaic activities within the Project. In addition, the Applicant has committed to creating an Agrivoltaics Fund in the amount of **$100,000** to directly support research and development of agrivoltaic practices at the Project. TNC will establish an advisory board comprised of representatives of key stakeholder groups to evaluate projects and create metrics for agrivoltaics projects (e.g., grazing, vegetables, seed crops, research, etc.). The Applicant, Evergy, and TNC believe this approach is the most effective way to enable collaboration with multiple community partners in an equitable manner to advance intersecting goals including ecology, habitat, research, diverse and beginning farmer training, local food, specialty crops.

Stormwater

The Applicant and Evergy are committed to designing, constructing and operating the Project in a manner that reduces stormwater runoff from current levels. Revised Condition 1.d. requires approval of the Board of County Commissioners of the final stormwater management study prior to issuance of the CUP permit by the Douglas County Planning and Zoning Department. The Project must be and therefore will be designed in a manner that improves the stormwater runoff conditions in the area.

Environmental Impacts

Burns & McDonnell ("**B&M**") prepared a white paper, *The Potential for Introduction of Zinc into the Soil and Water Environment from Hot-Dip Galvanized Supports Used in Solar Panels*, dated March 13, 2024, attached as Supplemental Exhibit 5.A. B&M reviewed available reports, studies and other analyses to evaluate whether galvanized steel structures are reasonably expected to cause zinc to accumulate at concentrations above Kansas Department of Health & Environment and US Environmental Protection Agency standards. The white paper concludes that zinc accumulations in soil, groundwater, and surface water are unlikely to exceed regulatory thresholds as a result of the Project. In addition, the Applicant has agreed to conduct ground water

monitoring per the Groundwater Monitoring Plan prepared by Burns & McDonnell, dated March 14, 2024, as set forth in Supplemental Exhibit 5.B.

Conclusion

The Applicant requests your unanimous approval of the Application based on the contents of the original materials considered by the Planning Commission and the Supplemental Materials provided with this letter. The Project meets or exceeds the requirements of the Douglas County Solar Regulations and advances the County's goals with respect to reducing carbon emissions and increasing renewable energy production. The Project's benefits, protections and safeguards are too numerous to conveniently summarize. The economic benefits to local taxing jurisdictions are monumental. As the Application materials state, the Project will upon completion produce clean renewable energy, reduce stormwater runoff, generate minimal traffic, with interim agrivoltaics uses administered by a third party. Upon reclamation, the rejuvenated land can return to agricultural use. Please vote unanimously to approve the Application, subject to the mutually acceptable conditions as proposed.

FREE STATE SOLAR PROJECT, LLC

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By: _____
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Name: Emily Truebner

Title: Authorized Person

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By: _____
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Name: Rod Northway

Title: Authorized Agent

KANSAS SKY
ENERGY CENTER

CUP APPLICATION: SUPPLEMENTAL MATERIALS
TABLE OF CONTENTS

KANSAS SKY
ENERGY CENTER

PROJECT SITING AND ALTERNATE LOCATIONS MEMORANDUM

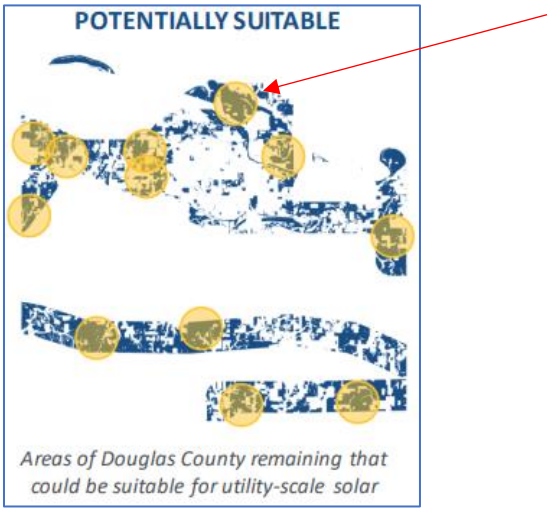
The Applicant evaluated all potential sites in Douglas County, and determined that the Project location, as proposed, is the only feasible site in the County. This Memorandum describes the methodology and rationale that the Applicant utilized in reaching this determination.

The first step in the analysis involved considering the entire County and eliminating obvious areas where a solar project is infeasible.

- The Applicant eliminated from consideration all residential tax parcels and parcels under 20 acres, resulting in a remainder of potential sites depicted in blue, below.

Excludes Residential Tax Parcels and Parcels Under 20 Acres

- The Applicant then eliminated those portions of the County that include FEMA Zone A, Zone AE, AE Floodway, and Zone AH, areas having slope greater than eight percent (8%), areas of significant tree cover, areas located in designated conservation areas, and areas that are more than one (1) mile from the existing transmission grid. As a result, the below map depicts all those portions in Douglas County that could potentially be utilized for a solar project – a total of twelve (12) areas, with the Project location identified by the red arrow. *See also* **Appendix 1**.



Areas of Douglas County remaining that could be suitable for utility-scale solar

Comparing the Project site with the other eleven (11) potential sites, the Project site ranked the best in all critical non-economic metrics, such as size, floodplain area (zero percent), tree cover area (zero percent), and average slope (1.9%).

The potential project sites labeled as “Lawrence 2” and “Lawrence 3” are likely infeasible due to their proximity to the City of Lawrence and its anticipated growth.

These sites and the “Berryton” site are also not recommended based on The Nature Conservancy “Site Renewables Right” tool due to known presence of threatened or endangered species (see **Appendix 2**).

The transmission lines near “BaldwinCitySW” and “BaldwinCitySE” are not suitable for utility-scale solar projects.

“Lawrence1”, “BaldwinCityNorth”, and “Eudora” all had a greater proportion of project area classified as prime farmland than Kansas Sky Energy Center.

Comparing the three remaining alternate sites (“Lecompton”, “Lecompton2”, and “Overbrook”) to the Project all three alternate sites had over 118 acres of trees, five times the average slope, greater residential density, and only 20% less prime farmland.

For the reasons listed above, the Kansas Sky Energy Center is best site for a utility-scale solar project. Even if one were to discard all these reasons, any viable utility-scale solar project must be able to inject the electricity generated at the site into the electric grid.

The Applicant conducted a detailed transmission injection analysis of each of the twelve (12) potential sites. *None of the other eleven (11) potential alternative sites presently have injection capacity, and only nine (9) could possibly obtain capacity but only after significant investment in additional infrastructure for network upgrades and connectivity.*

The proposed location of the Project is unique in Douglas County because it is the only site where existing injection capacity exists, by virtue of the adjacent Midland Junction 115kV substation. The nine other alternate sites that might possibly gain such capacity would require additional capital expenditures to upgrade the network, with an average cost of approximately $154,300,000 (in addition to the cost of the project itself). Allocation of these costs would be dependent on the number of interconnection requests attributed to each network upgrade but suffice to say network upgrades would be cost-prohibitive for alternative sites.

Finally, every solar project must have the cooperation and consent of the landowners. As evidenced in the application materials, the Applicant has obtained leases or options to enable the use of the Project location as a solar project.

In conclusion, the Project has:

1. The lowest residential density around the site
2. The least amount of grading required due to lowest average slope
3. No regulatory floodplain impacts
4. No removal of mature stands of trees required
5. No impacts to cultural resources
6. No native prairies
7. No known occurrences of the federally or state listed species
8. Comparable project area consisting of prime farmland relative to other sites.
9. Financially viable transmission network injection capacity available with no off-site additional high voltage transmission lines required to interconnect.

Consequently, the proposed location of the Project is best suited among all other potential sites from a land use and Code compliance perspective. The Project location is unique in Douglas County in that it has a financially feasible interconnection point located in close proximity to the Project with no need for long overhead generation interconnection tie lines.

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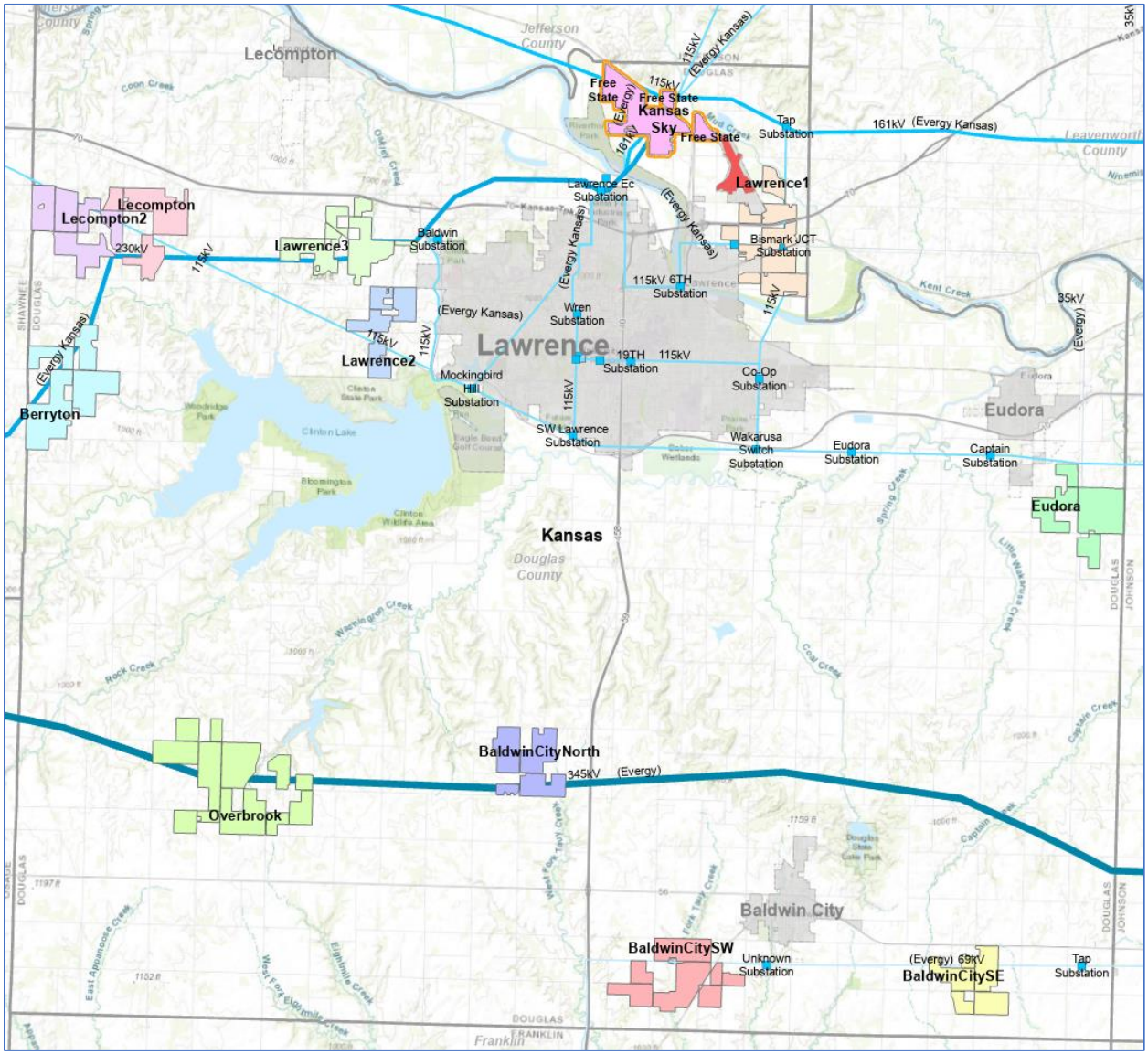
APPENDIX 1

OTHER POTENTIAL SITES



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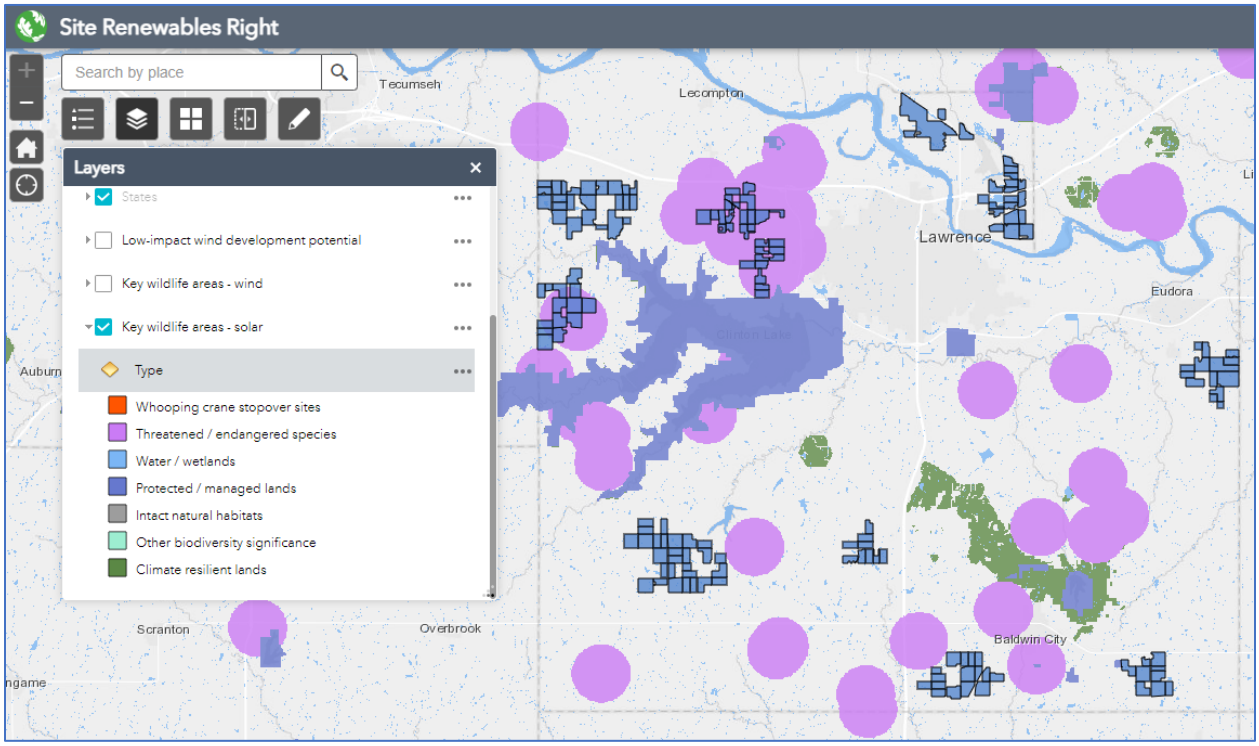
APPENDIX 2

The Nature Conservancy – Site Renewables Right



Strategic Economic Research, LLC

ECONOMIC IMPACT ANALYSIS OF THE KANSAS SKY ENERGY CENTER

March 2024

Dr. David G. Loomis,
Bryan Loomis, and
Chris Thankan

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About the Authors

Dr. David G. Loomis, PhD

Professor Emeritus of Economics, Illinois State University
Co-Founder of the Center for Renewable Energy
President of Strategic Economic Research, LLC

Dr. David G. Loomis is Professor Emeritus of Economics at Illinois State University and Co-Founder of the Center for Renewable Energy. He has over 20 years of experience in the renewable energy field. He has served as a consultant for 43 renewable energy development companies. He has testified on the economic impacts of energy projects before the Illinois Commerce Commission, Iowa Utilities Board, Missouri Public Service Commission, Illinois Senate Energy and Environment Committee, the Wisconsin Public Service Commission, Kentucky Public Service Commission, Ohio Public Siting Board, and numerous county boards. Dr. Loomis is a widely recognized expert and has been quoted in the Wall Street Journal, Forbes Magazine, Associated Press, and Chicago Tribune as well as appearing on CNN.

Dr. Loomis has published 40 peer-reviewed articles in leading energy policy and economics journals. He has raised and managed over $7 million in grants and contracts from government, corporate and foundation sources. He received the 2011 Department of Energy's Midwestern Regional Wind Advocacy Award and the 2006 Best Wind Working Group Award. Dr. Loomis received his Ph.D. in economics from Temple University in 1995.

Bryan Loomis, MBA

Vice President of Strategic Economic Research, LLC

Bryan Loomis has been conducting economic impact, property tax, and land use analyses at Strategic Economic Research since 2019. He has performed or overseen over 100 wind and solar analyses, and has also provided expert testimony for permitting hearings and open houses in many states, including Colorado, Kansas, Indiana, Illinois, and Iowa. He improved the property tax analysis methodology at SER by researching various state taxing laws and implementing depreciation, taxing jurisdiction millage rates, and other factors into the tax analysis tool. Before working with SER, Bryan ran a consulting agency, working with over 30 technology startups on growth and marketing. Bryan received his MBA from Belmont University in 2016.

Chris Thankan

Economic Analyst

Christopher Thankan assists with the production of the economic impact studies including sourcing, analyzing, and graphing government data. He also performs economic and property tax analysis for wind, solar, and transmission projects. Chris has a Bachelor of Science degree in Sustainable & Renewable Energy and minored in Economics.

Strategic Economic Research, LLC (SER) provides economic consulting for renewable energy projects across the U.S. We have produced over 250 economic impact reports in 32 states. Research Associates who performed work on this project include Ethan Loomis, Madison Schneider, Zoë Calio, Patrick Chen, Kathryn Keithley, Morgan Stong, Mandi Mitchell, Tim Roberts, Russell Piontek, Drew Kagel, Cedric Volkmer, Paige Afram, Clara Lewis, Rachel Swanson, and Ashley Thompson.

Table of Contents

Table of Contents - Figures

Table of Contents - Tables

I. Executive Summary

Savion is developing the Kansas Sky Energy Center in Douglas County, Kansas. The purpose of this report is to aid decision makers in evaluating the economic impact of this project on Douglas County and the State of Kansas. The basis of this analysis is to study the direct, indirect, and induced impacts on job creation, wages, and total economic output.

The Kansas Sky Energy Center is a 159-megawatt alternating current (MWac) utility-scale solar powered-electric generation facility that will utilize photovoltaic (PV) panels installed on a single-axis tracking system (the Project). The total Project represents an investment in excess of $234 million. The total development is anticipated to result in the following:

Economic Impact

Jobs – all numbers are full-time equivalents

- 240 new local jobs during construction for Douglas County
- 786 new local jobs during construction for the State of Kansas
- 21.5 new local long-term jobs for Douglas County
- 32.3 new local long-term jobs for the State of Kansas

Output

- Over $34.3 million in new local output during construction for Douglas County
- Over $136 million in new local output during construction for the State of Kansas
- Over $4.9 million in new local long-term output for Douglas County annually
- Over $8.9 million in new local long-term output for the State of Kansas annually

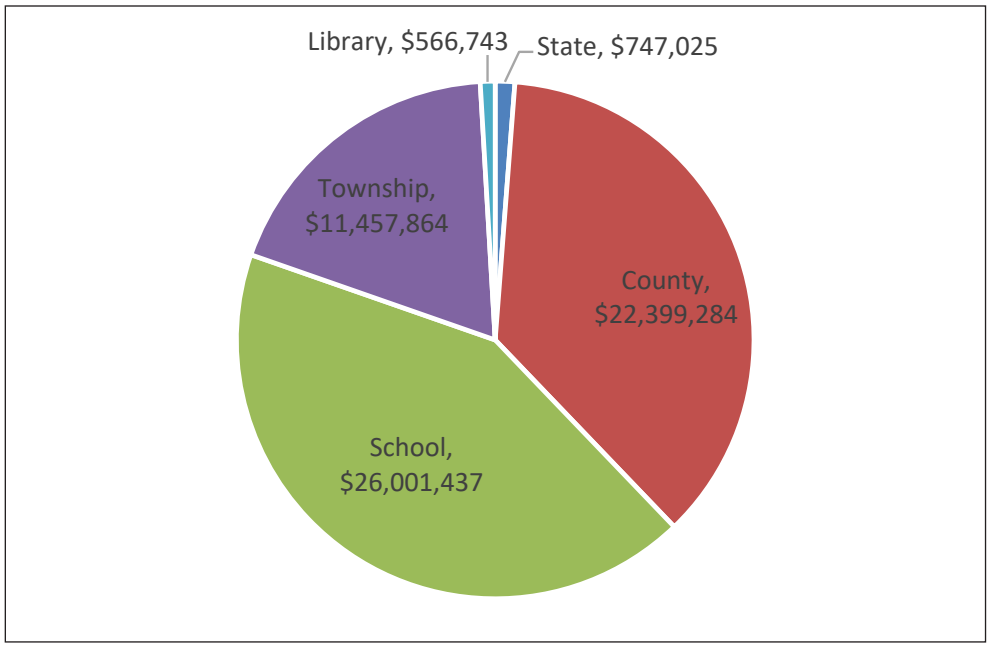
Earnings

- Over $14.8 million in new local earnings during construction for Douglas County
- Over $60.7 million in new local earnings during construction for the State of Kansas
- Over $1.0 million in new local long-term earnings for Douglas County annually
- Over $1.8 million in new local long-term earnings for the State of Kansas annually

Property Taxes

- Over $26.0 million in total school district revenue over the life of the Project
- Over $22.0 million in total county property taxes for Douglas County over the life of the Project
- Over $61.1 million in property taxes in total for all taxing districts over the life of the Project

Figure 1 – Total Property Taxes Paid by the Kansas Sky Energy Center



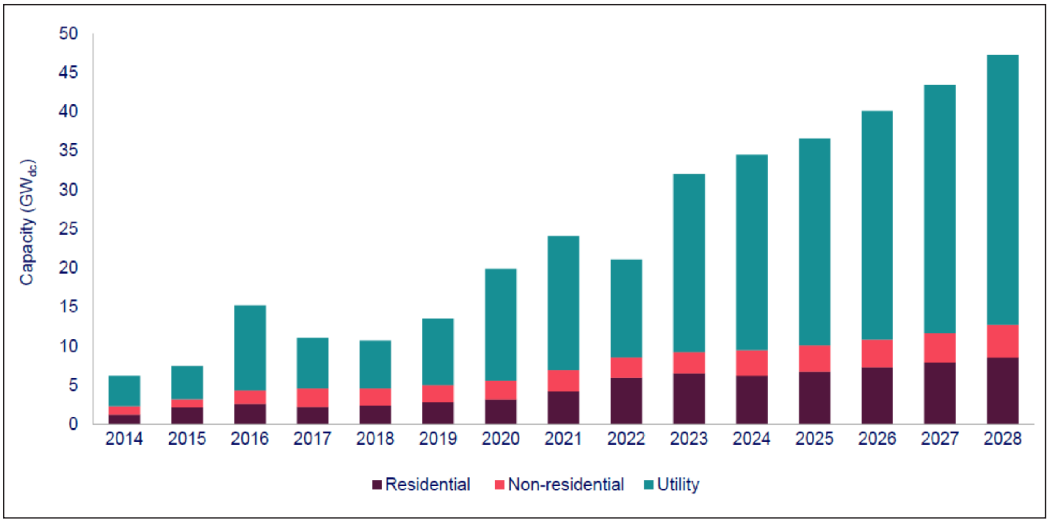
II. U.S. Solar PV Industry Growth and Economic Development

a. U.S. Solar PV Industry Growth

The U.S. solar industry is growing at a rapid but uneven pace. Solar energy systems are installed for onsite use, including residential, commercial and industrial properties, and utility-scale solar powered-electric generation facilities intended for wholesale distribution. The Kansas Sky Energy Center is a utility-scale solar PV project intended for wholesale markets through the transmission grid. From 2013 to 2018, the amount of electricity generated from solar had more than quadrupled, increasing 444% (SEIA, 2020). The industry has continued to add increasing numbers of PV systems to the grid. In the first half of 2021, the U.S. installed over 11,000 MW direct current (MWdc) of solar PV driven mostly by utility-scale PV which exceeds most of the annual installations in the last decade. Figure 2 shows the historical capacity additions as well as the forecasted additions into 2028. The primary driver of this overall sharp pace of growth is large price declines in solar equipment. According to Figure 3, utility-scale solar fixed tilt and single-axis tracking have decreased from an average of $6/watt in 2010 to slightly more than $1/watt in 2022. Solar PV also benefits from the Federal Investment Tax Credit (ITC) which provides a tax credit for residential and commercial properties.

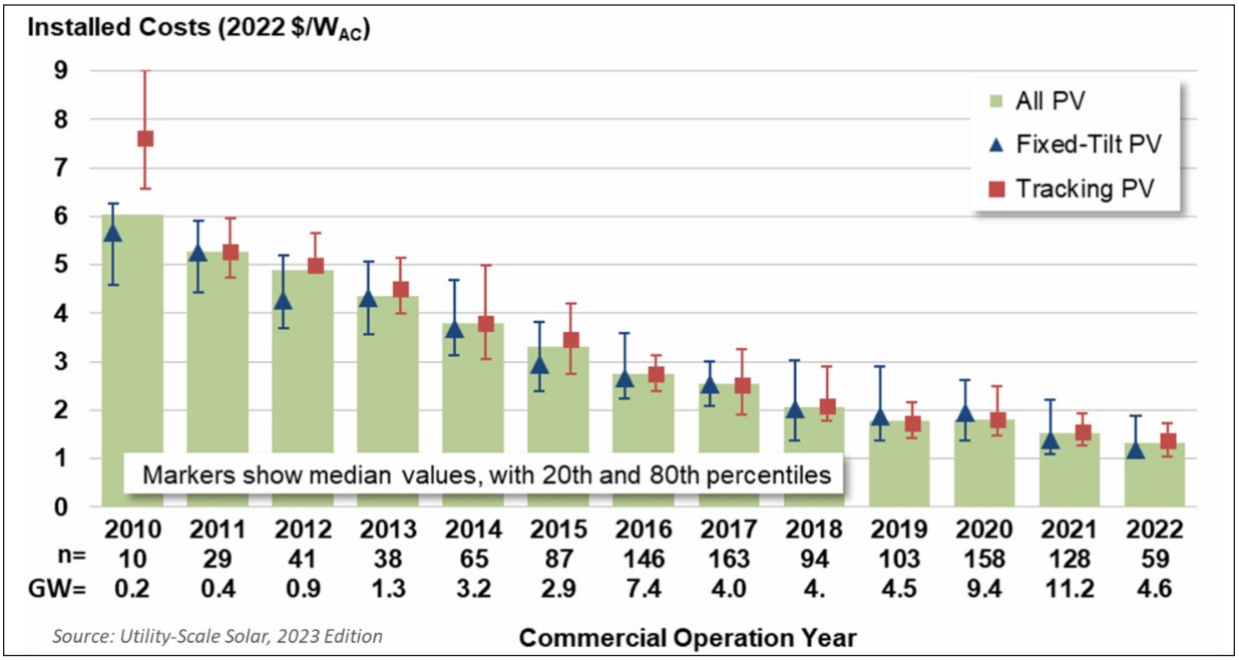
Utility-scale PV leads the installation growth in the U.S. Just under 12 GWdc of utility PV projects were completed in 2022. According to Figure 4, there are 90,300 MWdc of contracted utility-scale installations that have not been built yet.

Figure 2 – Annual U.S. Solar PV Installations, 2014 – 2028E



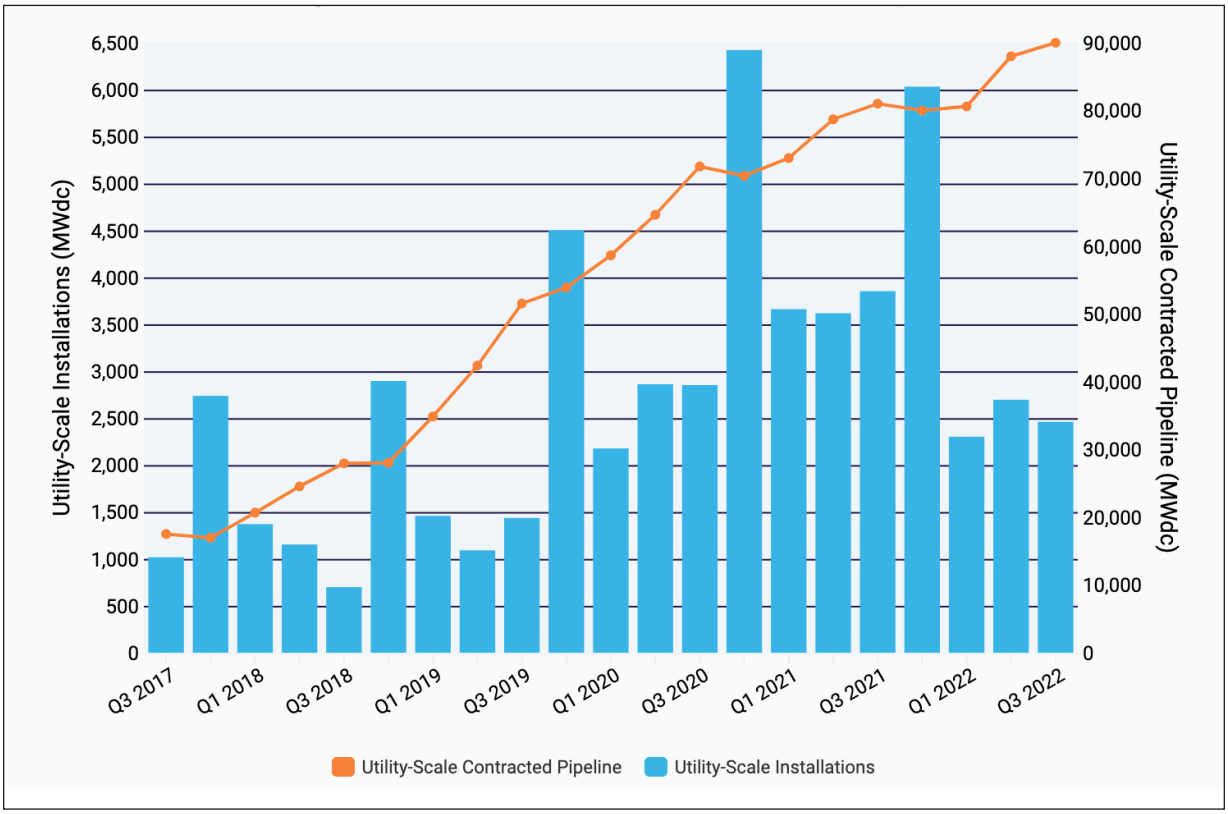
Source: Solar Energy Industries Association, Solar Market Insight Report Q3 2023

Figure 3 – Installed Costs of Utility-Scale Solar from 2010 to 2022 (adjusted for inflation)



Source: Lawrence Berkeley National Laboratory, Utility-Scale Solar, 2023 Edition

Figure 4 – U.S. Utility PV Installations vs. Contracted Pipeline



Source: Solar Energy Industries Association, Solar Market Insight Report Q4 2022

b. Kansas Solar PV Industry

According to SEIA, Kansas is ranked 46th in the U.S. in cumulative installations of solar PV. California, Texas, and Florida are the top 3 states for solar PV which may not be surprising because of the high solar irradiation that they receive. However, other states with similar solar irradiation to Kansas rank highly including New Jersey (8th), New York (9th), Virginia (10th), and Massachusetts (11th). In 2022, Kansas installed 17 MW of solar electric capacity bringing its cumulative capacity to 125 MW.

Kansas has great potential to expand its solar installations. Kansas has two utility-scale solar farms in operation: Johnson Corner Solar (20 MW) in Stanton County and City of Pratt Solar (6 MW) in Pratt County.[1] The 159 MW Kansas Sky Energy Center will be the largest installation in Kansas to date.

There are 47 solar companies in Kansas including 6 manufacturers, 23 installers/developers, and 18 others.[2] Figure 5 shows the locations of solar companies in Kansas as of the time of this report. Currently, there are 1,004 solar jobs in the State of Kansas according to SEIA.

Figure 6 shows the Kansas historical installed capacity by year according to the SEIA. Huge growth was seen in 2020 and is forecasted to continue to grow in 2023 and beyond. Over the next five years, solar in Kansas is projected to grow by 1,347 MW.

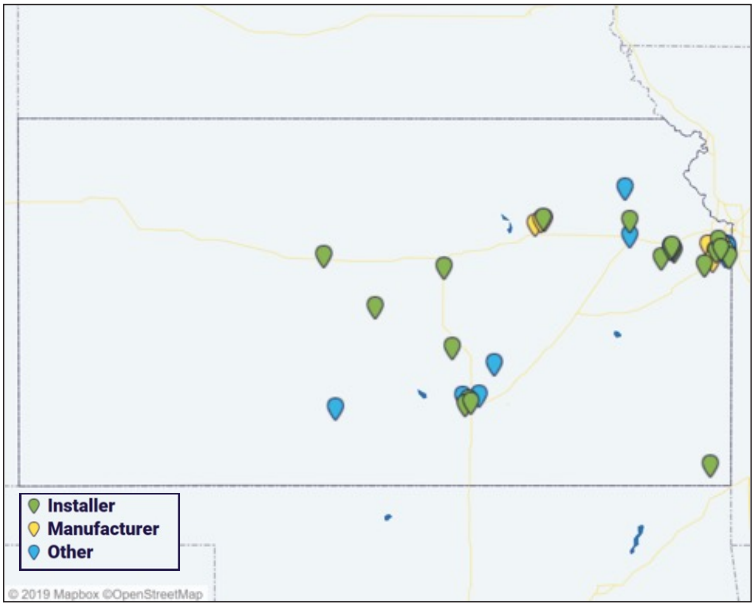
The Energy Information Administration (EIA) calculated the number of megawatt-hours generated from different energy sources in 2022. As shown in Figure 7, the greatest percentage of electricity generated in Kansas comes from wind with 47.1% followed by coal with 32.3% and nuclear energy with 14.4%. Approximately 0.1% of the total electricity power generated in Kansas came from solar thermal and solar PV in 2022.

The U.S. Department of Energy sponsors the U.S. Energy and Employment Report each year. Electric Power Generation covers all utility and non-utility employment across electric generating technologies, including fossil fuels, nuclear, and renewable technologies. It also includes employees engaged in facility construction, turbine and other generation equipment manufacturing, operations and maintenance, and wholesale parts distribution for all electric generation technologies. According to Figure 8, employment in Kansas in the solar energy industry (1,210) falls behind natural gas generation (4,474), wind electric generation (2,033), and coal generation (1,768).

[1] The megawatts listed in this paragraph are MWac. To convert to MWdc, multiply the MWac by 1.3 to get the approximate MWdc capacity.

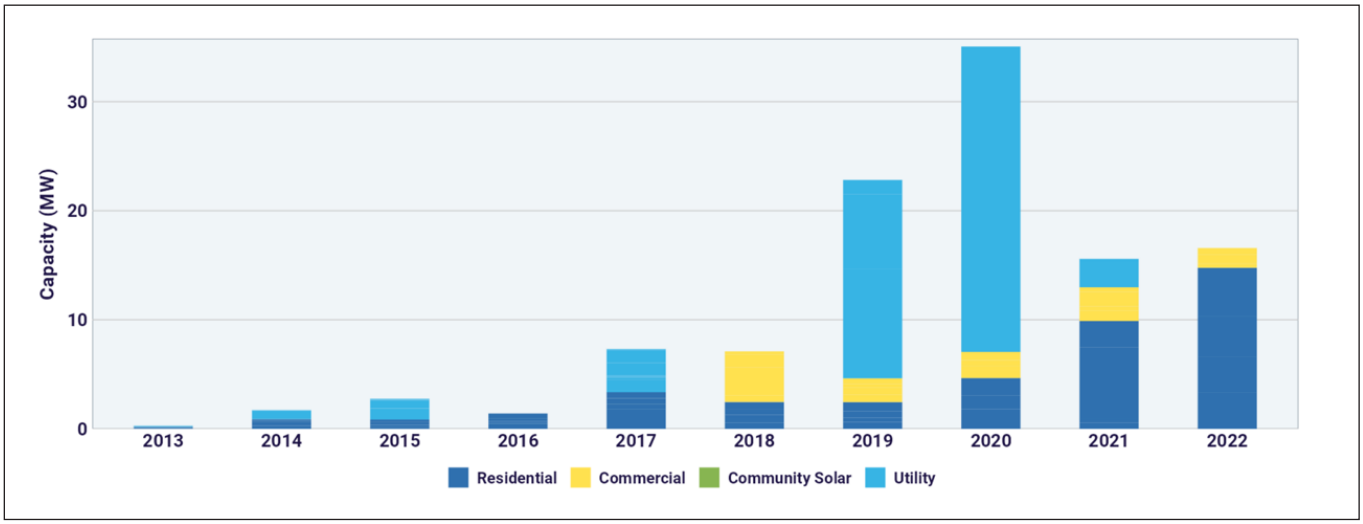
[2] "Other" includes Sales and Distribution, Project Management, and Engineering.

Figure 5 – Solar Company Locations in Kansas



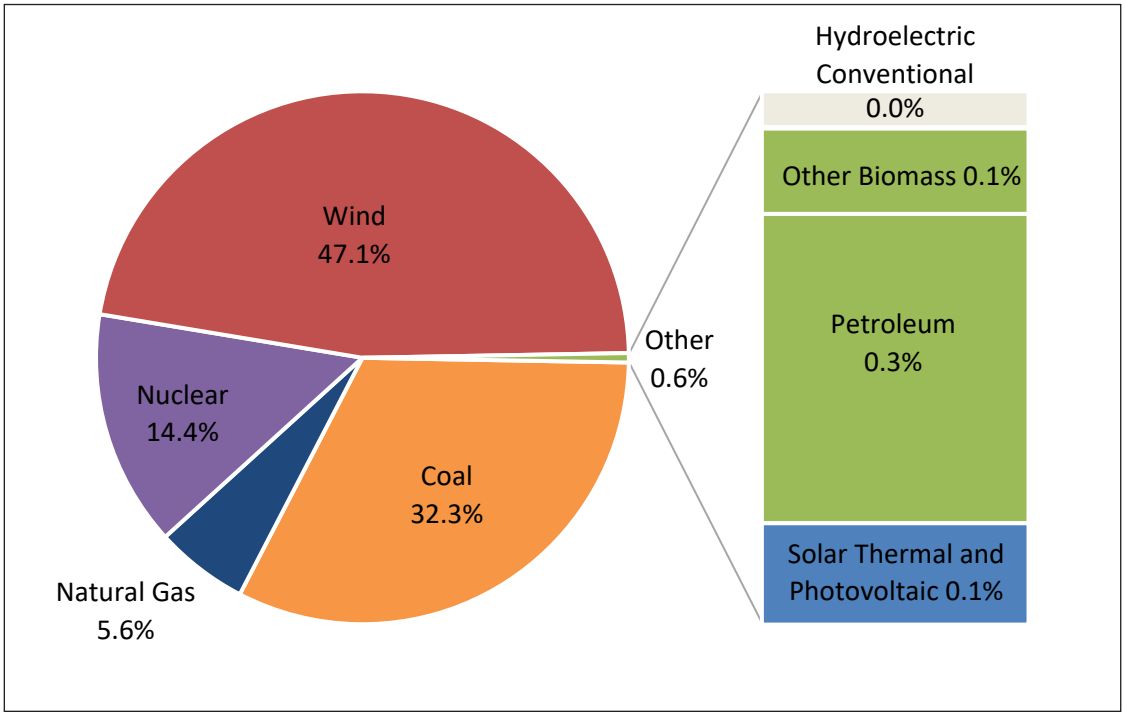
Source: Solar Energy Industries Association, Solar Spotlight: Kansas, Q2 2023

Figure 6 – Kansas Annual Solar Installations



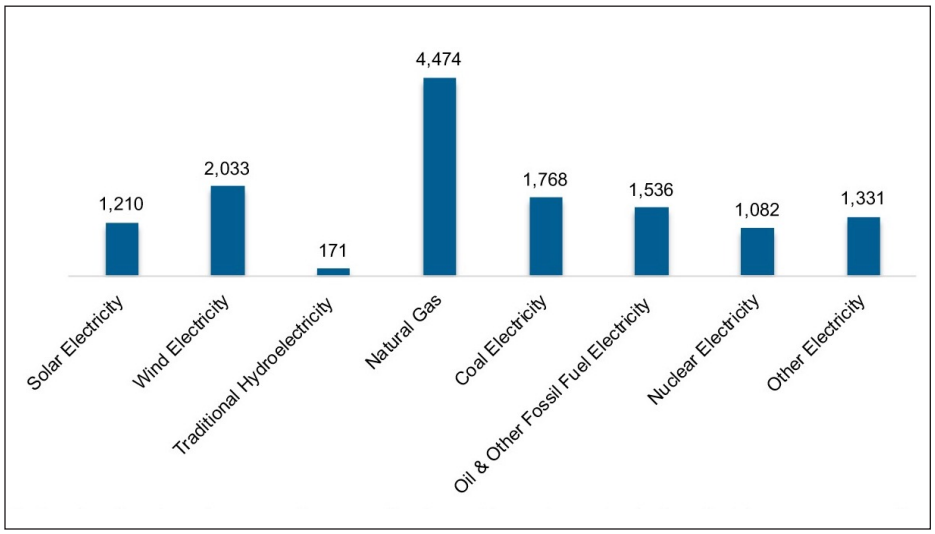
Source: Solar Energy Industries Association, Solar Spotlight: Kansas, Q2 2023

Figure 7 – Electric Generation by Fuel Type for Kansas in 2022



Source: U.S. Energy Information Association (EIA): Kansas, 2022

Figure 8 – Electric Generation Employment by Technology



Source: U.S. Energy and Employment Report 2023: Kansas

c. Economic Benefits of Utility-Scale Solar PV Energy

Utility-scale solar powered-electric generation facilities have numerous economic benefits. Solar PV installations create job opportunities in the local area during both the short-term construction phase and the long-term operational phase. In addition to the workers directly involved in the construction and maintenance of the solar energy project, numerous other jobs are supported through indirect supply chain purchases and the higher spending that is induced by these workers. Solar PV projects strengthen the local tax base and help improve county services, and local infrastructure, such as public roads.

Numerous studies have quantified the economic benefits of solar PV projects across the United States and have been published in peer-reviewed academic journals using the same methodology as this report. Some of these studies examine smaller-scale solar systems, and some examine utility-scale solar energy. Croucher (2012) uses NREL's Jobs and Economic Development Impacts ("JEDI") modeling methodology to find which state will receive the greatest economic impact from installing one hundred 2.5 kW residential systems. He shows that Pennsylvania ranked first supporting 28.98 jobs during installation and 0.20 jobs during operations. Illinois ranked second supporting 27.65 jobs during construction and 0.18 jobs during operations.

Jo et al. (2016) analyzes the financing options and economic impact of solar PV systems in Normal, IL and uses the JEDI model to determine the county and state economic impact. The study examines the effect of 100 residential retrofit fixed-mount crystalline-silicone systems having a nameplate capacity of 5kW. Eight JEDI models estimated the economic impacts using different input assumptions. They found that county employment impacts varied from 377 to 1,059 job-years during construction and 18.8 to 40.5 job-years during the operating years. Each job-year is a full-time equivalent job of 2,080 hours for a year.

More recently, Michaud et al. (2020) performed an analysis of the economic impact of utility-scale solar energy projects in the State of Ohio. They detail three scenarios: low (2.5 GW), moderate (5 GW) and high (7.5 GW). Using the JEDI model, they find that between 18,039 and 54,113 jobs would be supported during construction and between 207 and 618 jobs would be supported annually during operations. In addition, between $22.5 million and $67.5 million annually in tax revenues would come from these projects.

Loomis et al. (2016) estimates the economic impact for the State of Illinois if the state were to reach its maximum potential for solar PV. The study estimates the economic impact of three different scenarios for Illinois – building new solar installations of either 2,292 MW, 2,714 MW or 11,265 MW. The study assumes that 60% of the capacity is utility-scale solar, 30% of the capacity is commercial, and 10% of the capacity is residential. It was found that employment impacts vary from 26,753 to 131,779 job years during construction and from 1,223 to 6,010 job years during operating years.

Several other reports quantify the economic impact of solar energy. Bezdek (2006) estimates the economic impact for the State of Ohio and finds the potential for PV market in Ohio to be $25 million with 200 direct jobs and 460 total jobs. The Center for Competitive Florida (2009) estimates the impact if the state were to install 1,500 MW of solar and finds that 45,000 direct jobs and 50,000 indirect jobs could be created. The Solar Foundation (2013) uses the JEDI modeling methodology to show that Colorado's solar PV installation to date created 10,790 job-years. They also analyze what would happen if the state were to install 2,750 MW of solar PV from 2013 to 2030 and find that it would result in nearly 32,500 job years. Berkman et al. (2011) estimates the economic and fiscal impacts of the 550 MWac Desert Sunlight Solar Farm. The project creates approximately 440 construction jobs over a 26-month period, $15 million in new sales tax revenues, $12 million in new property revenues for Riverside County, CA, and $336 million in indirect benefits to local businesses in the county.

Finally, Jenniches (2018) performed a review of the literature assessing the regional economic impacts of renewable energy sources. After reviewing all of the different techniques for analyzing the economic impacts, he concludes "for assessment of current renewable energy developments, beyond employment in larger regions, IO [Input-Output] tables are the most suitable approach" (Jenniches, 2018, 48). Input-Output analysis is the basis for the methodology used in the economic impact analysis of this report.

III. Project Description and Location

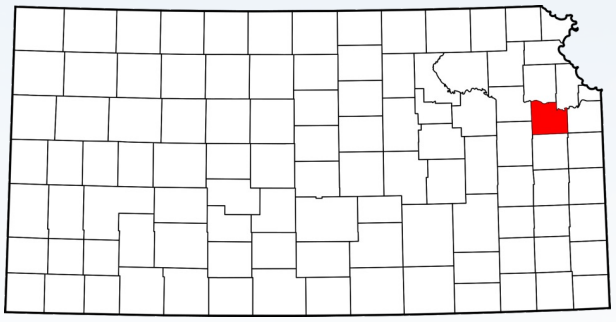
a. Kansas Sky Energy Center

Savion is developing the Kansas Sky Energy Center in Douglas County, Kansas. The Project consists of an estimated 159-megawatt alternative current (MWac) utility-scale solar powered-electric generation facility that will utilize photovoltaic (PV) panels installed on a single-axis tracking system. The total Project represents an investment in excess of $234 million.

b. Douglas County, Kansas

Douglas County is located in the eastern part of Kansas (see Figure 9). It has a total area of 475 square miles, and the U.S. Census estimates that the 2022 population was 119,964 with 53,771 housing units. The county has a population density of 260.5 (persons per square mile) compared to 34.9 for the State of Kansas (2020). Median household income in the county was $62,594 (U.S. Census Bureau, 2021).

Figure 9 – Location of Douglas County, Kansas



i. Economic and Demographic Statistics

As shown in Table 1, the largest industries in the county are "Administrative Government" followed by "Other Services (except Public Administration)," "Accommodation and Food Services," and "Professional, Scientific, and Technical Services." These data for Table 1 come from IMPLAN covering the year 2021 (the latest year available).

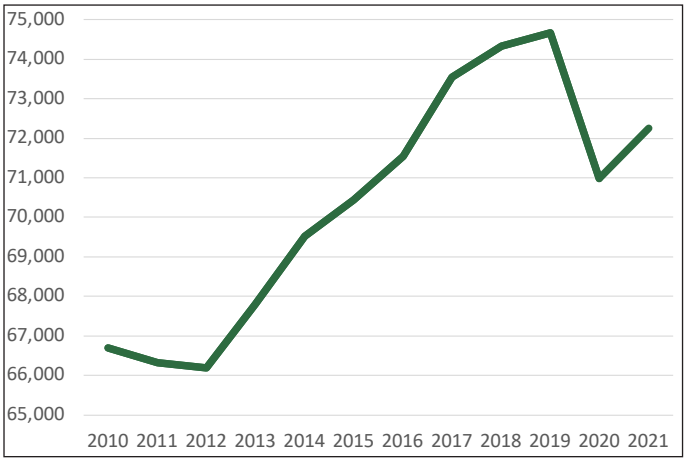
Table 1 provides the most recent snapshot of total employment but does not examine the historical trends within the county. Figure 10 shows employment from 2010 to 2021. Total employment in Douglas County was at its lowest at 66,193 in 2012 and its highest at 74,668 in 2019 (BEA, 2023).

Table 1 – Employment by Industry in Douglas County

Industry	Number	Percent
Administrative Government	16,516	20.2%
Other Services (except Public Administration)	16,169	19.8%
Accommodation and Food Services	7,270	8.9%
Professional, Scientific, and Technical Services	6,771	8.3%
Retail Trade	5,937	7.3%
Health Care and Social Assistance	5,077	6.2%
Manufacturing	4,690	5.7%
Real Estate and Rental and Leasing	3,327	4.1%
Construction	3,305	4.0%
Finance and Insurance	2,383	2.9%
Administrative and Support and Waste Management and Remediation Services	2,167	2.6%
Educational Services	1,620	2.0%
Transportation and Warehousing	1,424	1.7%
Arts, Entertainment, and Recreation	1,413	1.7%
Wholesale Trade	1,074	1.3%
Agriculture, Forestry, Fishing and Hunting	931	1.1%
Information	798	1.0%
Government Enterprises	348	0.4%
Management of Companies and Enterprises	241	0.3%
Mining, Quarrying, and Oil and Gas Extraction	230	0.3%
Utilities	157	0.2%

Source: Impact Analysis for Planning (IMPLAN), County Employment by Industry, 2021

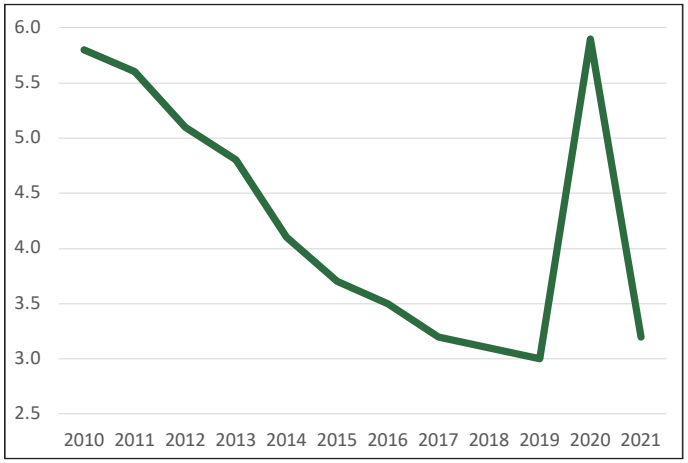
Figure 10 – Total Employment in Douglas County from 2010 to 2021



Source: Bureau of Economic Analysis, Regional Data, GDP and Personal Income, 2010-2021

The unemployment rate signifies the percentage of the labor force without employment in the county. Figure 11 shows the unemployment rates from 2010 to 2021. Unemployment in Douglas County was at its lowest at 3.0% in 2019 and at its highest at 5.9% in 2020 (FRED, 2023). The unemployment rate decreased to 3.2% by 2021.

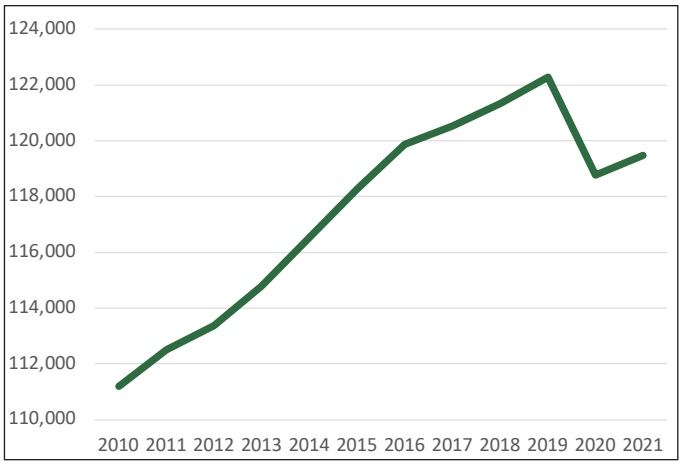
Figure 11 – Unemployment Rate in Douglas County from 2010 to 2021



Source: Federal Reserve Bank of St. Louis Economic Data, U.S. Census Bureau, Unemployment Rates, 2010-2021

The overall population in the county has increased steadily, as shown in Figure 12. Douglas County's population was at its lowest of 111,204 in 2010 and its highest of 122,269 in 2019, a gain of 11,065 people in nine years (FRED, 2023). The population has since decreased to 119,480 by 2021.

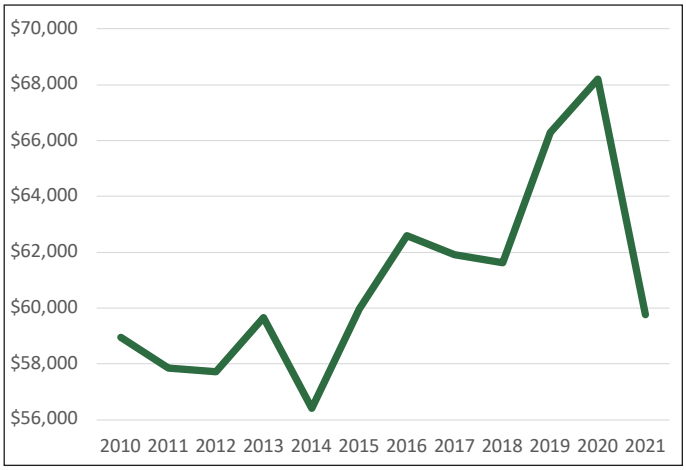
Figure 12 – Population in Douglas County from 2010 to 2021



Source: Federal Reserve Bank of St. Louis Economic Data, U.S. Census Bureau, Population Estimates, 2010-2021

Unlike to the population trend, household income has fluctuated significantly in the county. Figure 13 shows the real median household income in Douglas County from 2010 to 2021. Using the national Consumer Price Index (CPI), the nominal median household income for each year was adjusted to 2021 dollars. Household income was at its lowest at $56,414 in 2014 and its highest at $68,191 in 2020 (FRED, 2023).

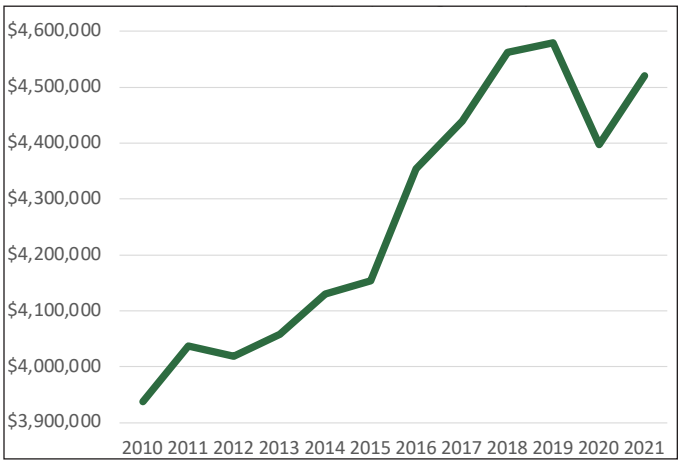
Figure 13 – Real Median Household Income in Douglas County from 2010 to 2021



Source: Federal Reserve Bank of St. Louis Economic Data, U.S. Census Bureau, Estimate of Median Household Income, 2010-2021

Real Gross Domestic Product (GDP) is a measure of the value of goods and services produced in an area and adjusted for inflation over time. The Real GDP for Douglas County has trended upward since hitting a low in 2010, as shown in Figure 14 (BEA, 2023).

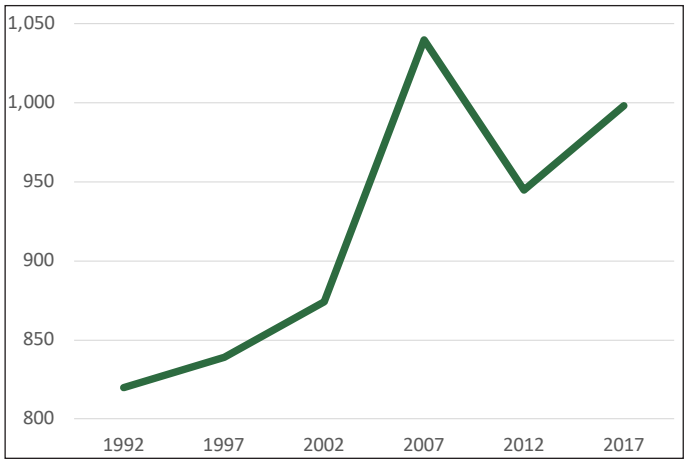
Figure 14 – Real Gross Domestic Product (GDP) in Douglas County from 2010 to 2021



Source: Bureau of Economic Analysis, Regional Data, GDP and Personal Income, 2010-2021

The farming industry has fluctuated in Douglas County. As shown in Figure 15, the number of farms hit a low of 820 in 1992 and a high of 1,040 in 2007.

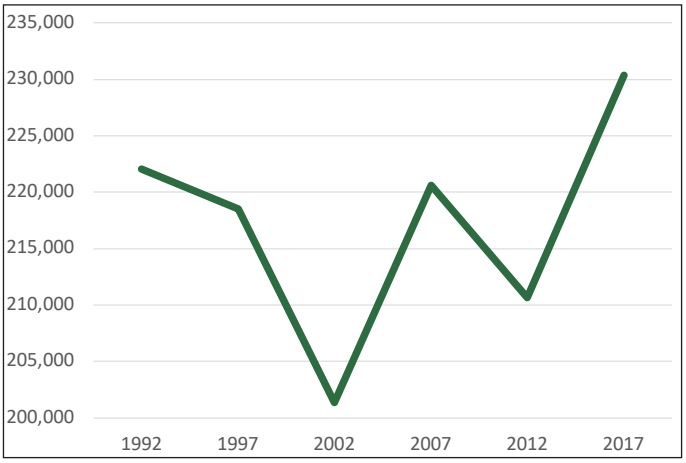
Figure 15 – Number of Farms in Douglas County from 1992 to 2017



Source: USDA National Agricultural Statistics Service, Census of Agriculture, 1992-2017

The amount of land in farms has fluctuated significantly as well. The county farmland hit a low of 201,358 acres in 2002 and a high of 230,364 acres in 2017, according to Figure 16.

Figure 16 – Land in Farms in Douglas County from 1992 to 2017



Source: USDA National Agricultural Statistics Service, Census of Agriculture, 1992-2017

ii. Agricultural Statistics

Kansas is ranked fifth among U.S. states in total value of agricultural products sold (Census, 2017). It is ranked fourth in the value of livestock and tenth in the value of crops (Census, 2017). In 2022, Kansas had 57,700 farms and 45.7 million acres in operation with the average farm being 792 acres (State Agricultural Overview, 2022). Kansas had 173 thousand cattle and produced 4.14 billion pounds of milk (State Agricultural Overview, 2022). In 2022, Kansas yields averaged 115 bushels per acre for corn with a total market value of $3.67 billion (State Agricultural Overview, 2022). Wheat yields averaged 37 bushels per acre with a total market value of $2.14 billion (State Agricultural Overview, 2022). The average net cash farm income per farm is $49,291 (Census, 2017).

In 2017, Douglas County had 998 farms covering 230,364 acres for an average farm size of 231 acres (Census, 2017). The total market value of products sold was $65.8 million, with 23% coming from livestock sales and 77% coming from crop sales (Census, 2017). The average net cash farm income of operations was $18,599 (Census, 2017).

Solar energy projects are compatible with agricultural land use by benefiting the land while solar farms are in operation. Some of these benefits include increased pollination, improved soil quality, and increased future production from soil fallowing.

Recent research has shown that pollinating insects can help soybean yields and improvement in pollinator habitats has been shown to boost soybean production (Garibaldi et. al. 2021; de O. Milfant, 2013). Walston, et. al. (2018) shows the potential for agricultural benefits from pollinator habitats in the United States. Using native plant species in the land around solar projects can improve pollinator habitats which leads to increased yields, and the partial shading caused by solar panels can be quite beneficial to pollinators (Graham, et. al. 2021). Additionally, BRE (2014) shows that utility-scale solar can increase biodiversity.

Solar energy projects built on agricultural lands will allow the soil to rest for around 30 years. The U.S. Department of Energy (2022) states that “land can be reverted back to agricultural uses at the end of the operational life for solar installations. A life of a solar installation is roughly 20-25 years and can provide a recovery period, increasing the value of that land for agriculture in the future. Giving soil rest can also maintain soil quality and contribute to the biodiversity of agricultural land. Planting crops such as legumes underneath the solar installation can increase nutrient levels in the soil."

Several studies have shown that leaving the soil fallow for an extended period of time increases the productivity of the land when it is returned to crop production. Cusimano et. al. (2014) found that the use of land fallowing can induce significant improvements to soil quality and crop production in California. Kozak and Pudelko (2021) studied abandoned land in Poland and showed that fallowed land could be restored to agricultural production.

IV. Economic Impact Methodology

The economic analysis of the solar PV project presented uses IMPLAN (IMpact analysis for PLANning). IMPLAN software and data are managed and updated by the Minnesota IMPLAN Group, Inc., using data collected at federal, state, and local levels. IMPLAN is a leading provider of economic development software that is widely used by economists and economic development professionals. More information about IMPLAN can be found at http:/implan.com.

IMPLAN is an input-output model that measures the spending patterns and location-specific economic structures that reflect expenditures supporting varying levels of employment, income, and output. That is, IMPLAN takes into account that the output of one industry can be used as an input for another. For example, when a PV system is installed, there are both soft costs consisting of permitting, installation and customer acquisition costs, and hardware costs, of which the PV module is the largest component. The purchase of a module not only increases demand for manufactured components and raw materials, but also supports labor to build and install a module. When a module is purchased from a manufacturing facility, the manufacturer uses some of that money to pay employees. The employees use a portion of their compensation to purchase goods and services within their community. Likewise, when a developer pays workers to install the systems, those workers spend money in the local economy that boosts economic activity and employment in other sectors. The goal of economic impact analysis is to quantify all of those reverberations throughout the local and state economy.

The IMPLAN model utilizes county-specific and state-specific industry multipliers in the analysis. This study analyzes the gross jobs that the new solar energy project development supports and does not analyze the potential loss of jobs due to declines in other forms of electric generation.

The total economic impact can be broken down into three distinct types: direct impacts, indirect impacts, and induced impacts. **Direct impacts** during the construction period refer to the changes that occur in the onsite construction industries in which the direct final demand (i.e., spending on construction labor and services) change is made. Onsite construction-related services include installation labor, engineering, design, and other professional services. Direct impacts during operating years refer to the final demand changes that occur in the onsite spending for the solar operations and maintenance workers.

The initial spending on the construction and operation of the solar PV installation will create a second layer of impacts, referred to as "supply chain impacts" or "indirect impacts." **Indirect impacts** during the construction period consist of changes in inter-industry purchases resulting from the direct final demand changes and include construction spending on materials and PV equipment, as well as other purchases of goods and offsite services. Utility-scale solar PV indirect impacts include PV modules, invertors, tracking systems, cabling, and foundations.

Induced impacts during construction refer to the changes that occur in household spending as household income increases or decreases as a result of the direct and indirect effects of final demand changes. Local spending by employees working directly or indirectly on the Project that receive their paychecks and then spend money in the community is included. The model includes additional local jobs and economic activity that are supported by the purchases of these goods and services.

The majority of the jobs during construction are construction workers but there are other occupations involved as well. In addition, during operations, there are other occupations involved besides solar technicians. A sample of those occupations, the education/training needed, and wages percentiles is contained in Table 8 in the Appendix. A larger description of those occupations, their work environment, and future job growth is found in Table 9 in the Appendix.

V. Economic Impact Results

The economic impact results were derived from detailed project cost estimates supplied by Savion. In addition, Savion also estimated the percentages of project materials and labor that will be coming from within Douglas County and the State of Kansas.

Two sets of models were produced to show the economic impact of the Kansas Sky Energy Center. The first set of models examines the construction costs and the second set of models examines the operating expenses. The first model uses the capital expenditures and the 2021 IMPLAN Douglas County dataset. The second model uses the 2021 IMPLAN dataset for the State of Kansas and the same project costs. The third model uses the operating expenditures and the 2021 IMPLAN Douglas County dataset. The fourth model uses the 2021 IMPLAN dataset for the State of Kansas and the same project costs. The latest dataset from IMPLAN and specific project cost data from the Kansas Sky Energy Center are used and SER translated the project costs into IMPLAN sectors.

Tables 2 to 4 show the output from these models. Table 2 lists the total employment impact from the Kansas Sky Energy Center for Douglas County and the State of Kansas. Table 3 shows the impact on total earnings and Table 4 contains the impact on total output.

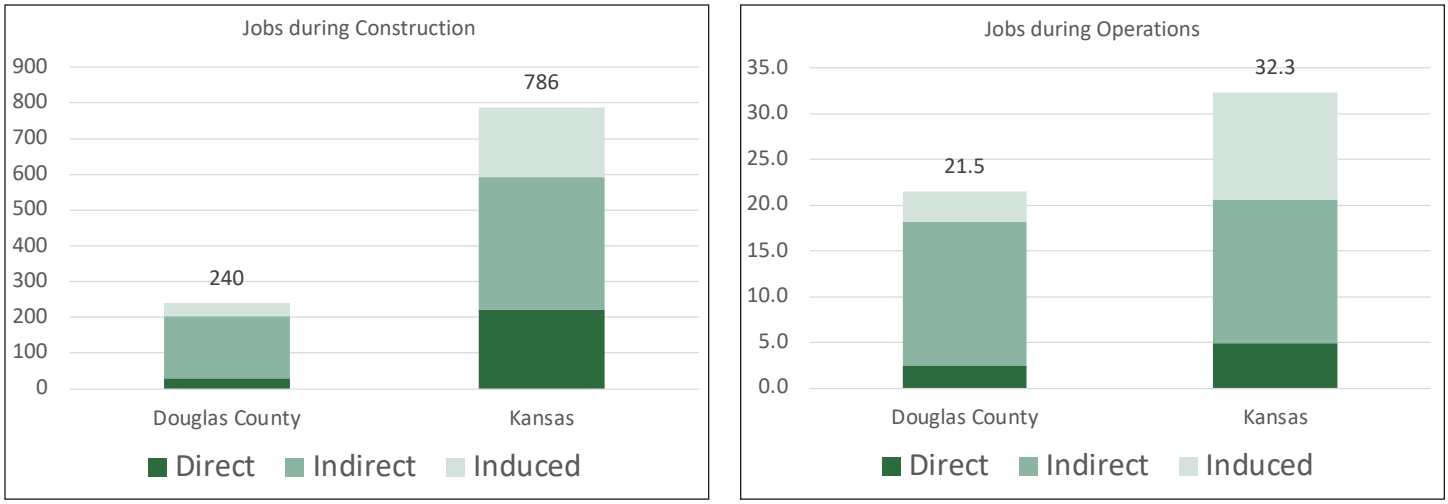
Table 2 – Total Employment Impact from the Kansas Sky Energy Center

	Douglas County Jobs	State of Kansas Jobs
Construction		
Direct Impacts	29	222
Indirect Impacts	174	370
Induced Impacts	37	194
Local Jobs during Construction	240	786
Operations (Annual/Ongoing)		
Onsite Direct Impacts	2.5	4.9
Indirect Impacts	15.7	15.7
Induced Impacts	3.3	11.7
Local Long-Term Jobs	21.5	32.3

The results from the IMPLAN model show significant employment impacts from the Kansas Sky Energy Center. Employment impacts can be broken down into several different components. Direct jobs created during the construction phase typically last anywhere from 12 to 18 months depending on the size of the project; however, the direct job numbers present in Table 2 from the IMPLAN model are based on a full time equivalent (FTE) basis for a year. In other words, 1 job = 1 FTE = 2,080 hours worked in a year. A part time or temporary job would constitute only a fraction of a job according to the model. For example, the IMPLAN model results show 29 new direct jobs during construction in Douglas County, though the construction of the solar center could involve closer to 58 workers working half-time for a year. Thus, due to the short-term nature of construction projects, IMPLAN often significantly understates the actual number of people hired to work on the project. It is important to keep this fact in mind when looking at the numbers or when reporting the numbers.

As shown in Table 2, new local jobs created or retained during construction total 240 for Douglas County and 786 for the State of Kansas. New local long-term jobs created from the Kansas Sky Energy Center total 21.5 for Douglas County and 32.3 for the State of Kansas.

Figure 17 – Total Employment Impact from the Kansas Sky Energy Center



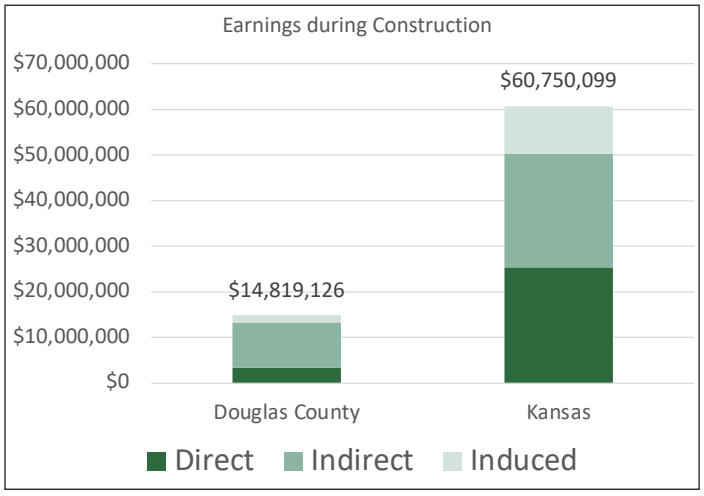
Direct jobs created during the operational phase last the life of the solar PV project, typically 20-30 years. Both direct construction jobs and operations and maintenance jobs require highly-skilled workers in the fields of construction, management, and engineering. For a list of occupations expected to be employed, their wages, benefits, total compensation, and hours worked, please see Tables 10 to 12 in the Appendix.

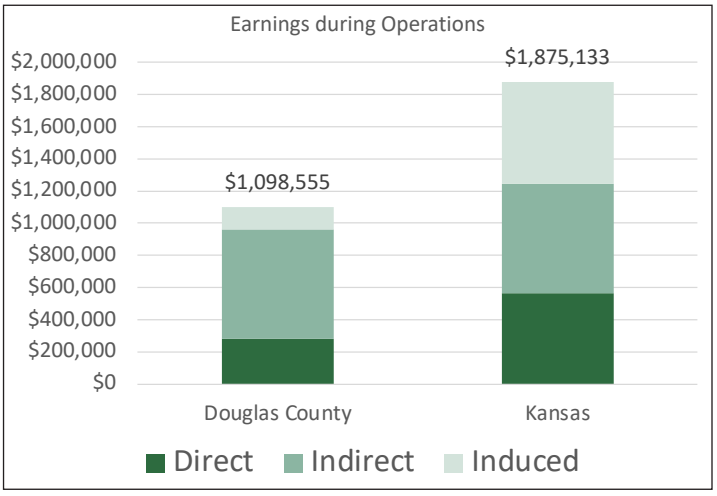
Accordingly, it is important to not just look at the number of jobs but also the earnings that they produce. Table 3 shows the earnings impacts from the Kansas Sky Energy Center, which are categorized by construction impacts and operations impacts. The new local earnings during construction totals over $14.8 million for Douglas County and over $60.7 million for the State of Kansas. The new local long-term earnings totals over $1.0 million for Douglas County and over $1.8 million for the State of Kansas.

Table 3 – Total Earnings Impact from the Kansas Sky Energy Center

	Douglas County	State of Kansas
Construction		
Direct Impacts	$3,299,065	$25,327,630
Indirect Impacts	$9,959,453	$24,846,135
Induced Impacts	$1,560,608	$10,576,334
Local Earnings during Construction	$14,819,126	$60,750,099
Operations (Annual/Ongoing)		
Onsite Direct Impacts	$283,076	$566,153
Indirect Impacts	$678,370	$678,369
Induced Impacts	$137,109	$630,611
Local Long-Term Earnings	$1,098,555	$1,875,133

Figure 18 – Total Earnings Impact from the Kansas Sky Energy Center



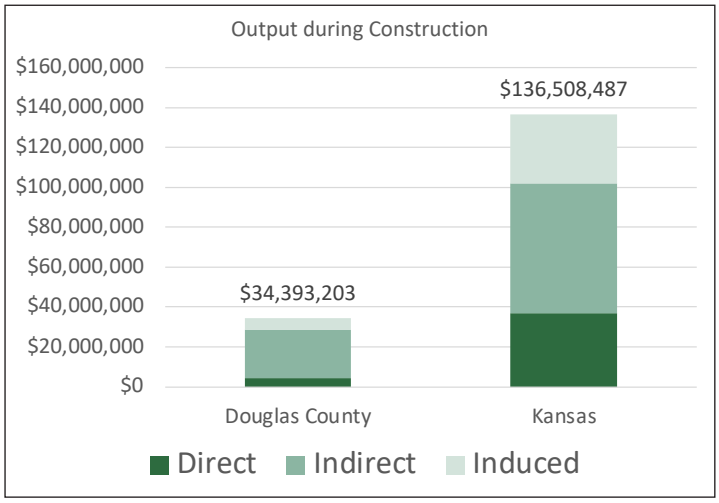


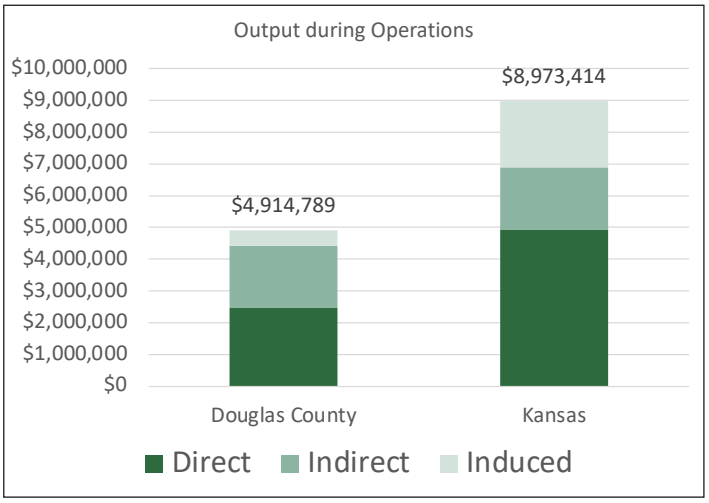
Output refers to economic activity or the value of production in the state or local economy. It is an equivalent measure to the Gross Domestic Product, which measures output on a national basis. According to Table 4, the new local output during construction totals over $34.3 million for Douglas County and over $136 million for the State of Kansas. The new local long-term output totals over $4.9 million for Douglas County and over $8.9 million for the State of Kansas.

Table 4 – Total Output Impact from the Kansas Sky Energy Center

	Douglas County	State of Kansas
Construction		
Direct Impacts	$4,462,327	$36,694,825
Indirect Impacts	$24,365,025	$65,141,239
Induced Impacts	$5,565,851	$34,672,423
Local Output during Construction	$34,393,203	$136,508,487
Operations (Annual/Ongoing)		
Onsite Direct Impacts	$2,469,957	$4,939,914
Indirect Impacts	$1,943,673	$1,943,673
Induced Impacts	$501,159	$2,089,827
Local Long-Term Output	$4,914,789	$8,973,414

Figure 19 – Total Output Impact from the Kansas Sky Energy Center





VI. Tax Revenue

As of 2016, renewable energy generators are exempt from property taxes for ten years per K.S.A. 79-257-79-258.3 After this 10-year exemption period, the project will pay property taxes to all the taxing jurisdictions. This exemption is determined by state law and not subject to the County's authority. For utility-owned projects, the evaluation of utility property is also determined at the state level. However, pursuant to Article 11, Section 1 of the Constitution of the State of Kansas, the appraised value of a project cannot be less than 20% of the "retail cost when new" if the project is in operation.

Tables 5 to 7 detail the tax implications of the Kansas Sky Energy Center. There are several important assumptions built into the analysis in these tables:

- The Project will be placed in service on January 1st, 2026.
- A 10-year exemption for the Project is assumed for personal property taxes.
- The analysis assumes that a PILOT is paid to the local jurisdictions according to their relative millage rates for the first 10 years of the project. This PILOT is equivalent to $200,000 for the first ten years, and escalates by 5% compounding for years 6-10.
- The Project is decommissioned in 25 years and pays no more taxes after that date.
- It is assumed that Evergy will own and operate the project. Therefore, estimates for the total taxes to be paid in years 11-25 were supplied by Evergy.
- It is assumed that the total tax numbers provided by Evergy will be apportioned to the jurisdictions according to their relative tax rates.
- All millage rates are assumed to stay constant at their 2022 rates during the entire life of the Project.
- The comprehensiveness and accuracy of the analysis below is dependent upon the assumptions listed above and used to calculate the property tax results. The analysis is to serve as a projection of property tax benefits to the local community and is not a guarantee of property tax revenue.
- If the inputs received from Savion and Evergy, the laws surrounding renewable energy taxation in Kansas, or the millage rates in Douglas County change in a material way after the completion of this report, this analysis may no longer accurately reflect the property taxes to be paid by the Kansas Sky Energy Center.
- No comprehensive tax payment was calculated, and these calculations are only to be used to illustrate the economic impact of the Project.

Figure 20 – Percentages of Property Taxes Paid to Taxing Jurisdictions

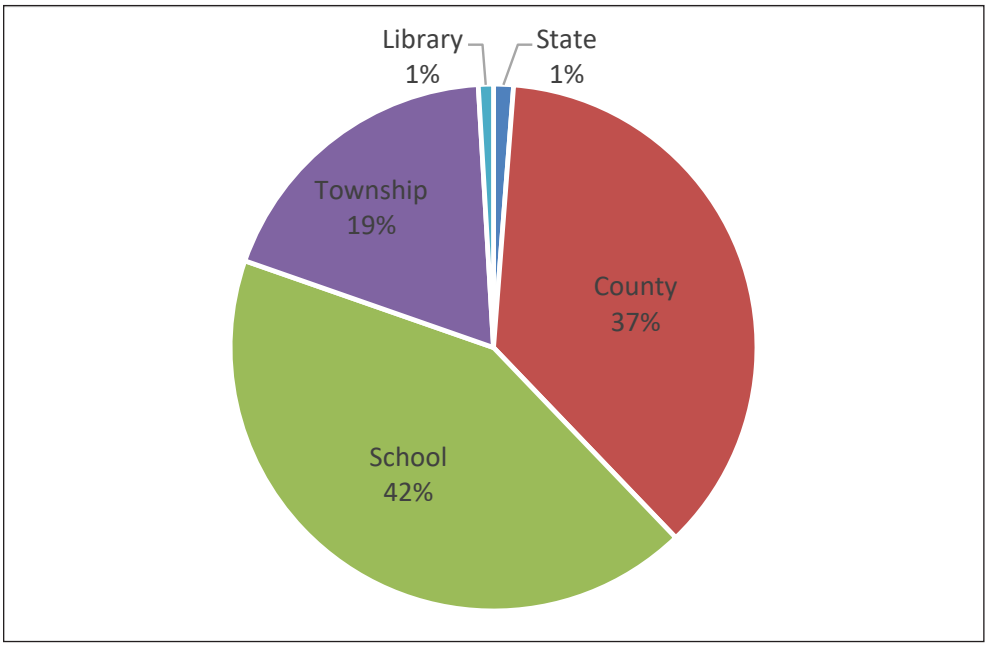


Table 5 – Total Property Taxes Paid by the Kansas Sky Energy Center

Year	Total Property Taxes
2026	$200,000
2027	$200,000
2028	$200,000
2029	$200,000
2030	$200,000
2031	$210,000
2032	$220,500
2033	$231,525
2034	$243,101
2035	$255,256
2036	$4,647,250
2037	$4,549,710
2038	$4,543,510
2039	$4,598,600
2040	$4,688,120
2041	$4,785,940
2042	$4,706,400
2043	$4,498,300
2044	$4,202,270
2045	$3,853,830
2046	$3,487,010
2047	$3,132,090
2048	$2,783,850
2049	$2,439,120
2050	$2,095,970
TOTAL	$61,172,353
AVG ANNUAL	$2,446,894

As shown in Table 5, a conservative estimate of the total property taxes paid by the Project starts out at $200 thousand in payments in lieu of taxes (PILOT) until 2030. The PILOT amount then increases annually until 2035. After the 10-year exemption on the personal property portion of the Project ends, taxes begin at over $4.6 million and decline steadily until 2050 due to depreciation. The expected total property taxes paid over the 25-year lifetime of the Project are over $61.1 million, and the average annual property taxes paid will be over $2.4 million.

Table 6 shows an estimate of the likely taxes paid to the following taxing bodies: Douglas County, State of Kansas, Douglas County Kaw Drainage, Grant Township, and Northeast Kansas Library.

According to Table 6, the total amounts paid over 25 years are over $22.0 million for Douglas County, over $747 thousand for the State of Kansas, over $382 thousand for Douglas County Kaw Drainage, over $11.4 million for Grant Township, and over $566 thousand for Northeast Kansas Library over the life of the Project.

Table 6 – Tax Revenue from the Kansas Sky Energy Center for the County and Other Taxing Bodies[3]

Year	Douglas County	State of Kansas	Douglas County Kaw Drainage	Grant Township	Northeast Kansas Library
2026	$71,983	$2,442	$1,250	$37,461	$1,853
2027	$71,983	$2,442	$1,250	$37,461	$1,853
2028	$71,983	$2,442	$1,250	$37,461	$1,853
2029	$71,983	$2,442	$1,250	$37,461	$1,853
2030	$71,983	$2,442	$1,250	$37,461	$1,853
2031	$75,582	$2,564	$1,313	$39,334	$1,946
2032	$79,361	$2,693	$1,379	$41,301	$2,043
2033	$83,329	$2,827	$1,448	$43,366	$2,145
2034	$87,496	$2,969	$1,520	$45,534	$2,252
2035	$91,870	$3,117	$1,596	$47,811	$2,365
2036	$1,672,612	$56,751	$29,057	$870,451	$43,055
2037	$1,637,506	$55,560	$28,447	$852,182	$42,152
2038	$1,635,274	$55,484	$28,408	$851,020	$42,094
2039	$1,655,102	$56,157	$28,752	$861,339	$42,605
2040	$1,687,322	$57,250	$29,312	$878,106	$43,434
2041	$1,722,529	$58,445	$29,924	$896,429	$44,340
2042	$1,693,901	$57,474	$29,426	$881,530	$43,603
2043	$1,619,003	$54,932	$28,125	$842,552	$41,675
2044	$1,512,457	$51,317	$26,274	$787,105	$38,933
2045	$1,387,049	$47,062	$24,096	$721,840	$35,705
2046	$1,255,025	$42,583	$21,802	$653,133	$32,306
2047	$1,127,284	$38,248	$19,583	$586,655	$29,018
2048	$1,001,948	$33,996	$17,406	$521,428	$25,791
2049	$877,874	$29,786	$15,250	$456,858	$22,598
2050	$754,370	$25,596	$13,105	$392,585	$19,419
TOTAL	$22,016,808	$747,025	$382,477	$11,457,864	$566,743
AVG ANNUAL	$880,672	$29,881	$15,299	$458,315	$22,670

[3] The assumed millage rates are 44.209 for Douglas County, 1.5 for the State of Kansas, 0.768 for Douglas County Kaw Drainage, 23.007 for Grant Township, and 1.138 for Northeast Kansas Library.

The largest taxing jurisdictions for property taxes are local school districts. However, the tax implications for school districts are more complicated than for other taxing bodies. School districts receive state aid based on the assessed value of the taxable property within its district. As assessed value increases, the state aid to the school district is decreased.

Although the exact amount of the reduction in state aid to the school districts is uncertain, local project tax revenue is superior to relying on state aid for the following reasons: (1) the solar project can't relocate – it is a permanent structure that will be within the school district's footprint for the life of the Project; (2) the school district can raise the tax rate and increase its revenues as needed; (3) the school district does not have to deal with the year-to-year uncertainty of state aid amounts; (4) the school district does not have to wait for months (or even into the next Fiscal Year!) for payment; (5) the Project does not increase the overall cost of education in the way that a new residential development would.

Table 7 shows the direct property tax revenue coming from the Project to the Lawrence Unified School District 497. This tax revenue uses the assumptions outlined earlier to calculate the other tax revenue and assumes that 100% of the project area is in the Lawrence USD 497. Over the 25-year life of the Project, the school district is expected to receive over $26.0 million in tax revenue.

Table 7 – Tax Revenue from the Kansas Sky Energy Center for the School District[4]

Year	USD 497 Bond & Interest	Lawrence USD 497	Lawrence USD 497 (SC)	Lawrence USD 497 (SG)
2026	$14,679	$24,767	$13,000	$32,565
2027	$14,679	$24,767	$13,000	$32,565
2028	$14,679	$24,767	$13,000	$32,565
2029	$14,679	$24,767	$13,000	$32,565
2030	$14,679	$24,767	$13,000	$32,565
2031	$15,413	$26,006	$13,650	$34,193
2032	$16,183	$27,306	$14,332	$35,903
2033	$16,992	$28,671	$15,049	$37,698
2034	$17,842	$30,105	$15,801	$39,583
2035	$18,734	$31,610	$16,591	$41,562
2036	$341,075	$575,496	$302,068	$756,684
2037	$333,917	$563,417	$295,728	$740,802
2038	$333,461	$562,649	$295,325	$739,793
2039	$337,505	$569,471	$298,906	$748,763
2040	$344,075	$580,557	$304,725	$763,339
2041	$351,254	$592,671	$311,083	$779,266
2042	$345,416	$582,821	$305,913	$766,315
2043	$330,143	$557,051	$292,387	$732,431
2044	$308,417	$520,392	$273,145	$684,230
2045	$282,844	$477,242	$250,496	$627,496
2046	$255,922	$431,817	$226,653	$567,769
2047	$229,873	$387,865	$203,584	$509,979
2048	$204,315	$344,740	$180,948	$453,278
2049	$179,014	$302,050	$158,541	$397,147
2050	$153,829	$259,556	$136,237	$341,274
TOTAL	$4,489,618	$7,575,328	$3,976,163	$9,960,328
AVG ANNUAL	$179,585	$303,013	$159,047	$398,413

[4] The assumed millage rates are 9.015 for Lawrence USD 497 Bond & Interest, 15.211 for Lawrence USD 497, 7.984 for Lawrence USD 497 (SC), and 20.0 for Lawrence USD 497 (SG).

VII. Appendix

Table 8 – Local and Statewide Compensation by Occupation

BLS Occupation Code	Job Type	Education/Training Required	Kansas 10th Percentile of Wages	Kansas 90th Percentile of Wages	Kansas Mean Wages	Lawrence, KS 10th Percentile of Wages	Lawrence, KS 90th Percentile of Wages	Lawrence, KS Mean Wages	US Fringe Benefits Median	Total Compensation Local mean wages plus US Fringe
	Jobs during Construction									
47-2231	Solar Photovoltaic Installers	High school diploma or equivalent	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	$27,394	#N/A
47-3013	Helpers – Electricians	High school diploma or equivalent	$23,680	$49,600	$35,140	#N/A	#N/A	#N/A	$27,394	#N/A
47-2111	Electricians	High school diploma or equivalent	$37,000	$89,400	$59,750	$36,270	$75,010	$53,040	$27,394	$80,434
47-2061	Construction Laborers	No formal educational credential	$28,020	$52,320	$39,400	$29,740	$47,410	$39,960	$27,394	$67,354
47-2073	Operating Engineers and Other Construction Equipment Operators	High school diploma or equivalent	$34,440	$71,360	$48,960	$38,800	$62,600	$55,200	$27,394	$82,594
47-1011	First-Line Supervisors of Construction Trades	High school diploma or equivalent	$46,840	$99,780	$71,040	$48,630	$101,260	$72,520	$27,394	$99,914
13-1082	Project Management Specialists and Business Operations Specialists		$49,580	$128,290	$90,240	$44,740	$112,320	$80,090	$27,394	$107,484
49-9071	Maintenance and Repair Workers, General (Operations)	High school diploma or equivalent	$27,790	$62,350	$42,910	$22,850	$62,800	$41,910	$27,394	$69,304
13-1111	Management Analysts	Bachelor's degree	$42,870	$124,220	$80,940	$40,040	$208,530	$116,390	$27,394	$143,784
11-1021	General and Operations Managers	Bachelor's degree	$43,960	$168,380	$98,580	$39,960	$159,610	$89,890	$27,394	$117,284
17-2071	Electrican Engineers		$64,390	$139,400	$98,630	$49,920	$131,420	$89,660	$27,394	$117,054
41-3091	Sales Representatives of Services		$30,380	$147,250	$76,130	$28,470	$150,870	$78,820	$27,394	$106,214
53-7062	Laborers and Freight, Stock and Material Movers	No formal educational credential	$27,980	$48,060	$37,970	$27,210	$47,050	$37,120	$27,394	$64,514
43-3031	Bookkeeping, Accounting and Auditing	Some college, no degree	$26,100	$56,950	$40,960	$26,000	$55,810	$41,020	$27,394	$68,414
	Jobs during Operations									
51-8013	Power Plant Operators	High school diploma or equivalent	$38,860	$124,740	$82,390	#N/A	#N/A	#N/A	$27,394	#N/A
37-3011	Landscaping and Grounds-keeping	No formal educational credential	$22,060	$44,700	$33,580	$22,940	$43,770	$33,040	$27,394	$60,434
51-1011	First-Line Supervisors of Production and Operating Workers	High school diploma or equivalent	$43,850	$99,610	$68,460	$44,130	$99,100	$68,760	$27,394	$96,154

Table 9 – Occupational Description and Future Outlook

Occupation Code	Occupation Title	Description	Work Environment	Current Employment	Job Growth, 2021-2031 (percent)
11-1021	General and Operations Managers	Plan, direct, or coordinate the operations of public or private sector organizations, overseeing multiple departments or locations. Duties and responsibilities include formulating policies, managing daily operations, and planning the use of materials and human resources, but are too diverse and general in nature to be classified in any one functional area of management or administration, such as personnel, purchasing, or administrative services. Usually manage through subordinate supervisors. Excludes First-Line Supervisors.	Top executives work in nearly every industry, for both small and large organizations. They often have irregular schedules, which may include working evenings and weekends. Travel is common, particularly for chief executives.	3,328,200	209,800 (7%)
13-1082	Project Management Specialists and Business Operations Specialists	Analyze and coordinate the schedule, timeline, procurement, staffing, and budget of a product or service on a per project basis. Lead and guide the work of technical staff. May serve as a point of contact for the client or customer. Excludes "Management Occupations" (11-0000), "Logisticians" (13-1081), "Meeting, Convention, and Event Planners" (13-1121), and "Production, Planning, and Expediting Clerks" (43-5061).	Project management specialists usually work in an office setting. Although project management specialists may collaborate on teams, some work independently. Project management specialists also may travel to their clients' places of business.	781,400	56,300 (7%)
13-1111	Management Analysts	Conduct organizational studies and evaluations, design systems and procedures, conduct work simplification and measurement studies, and prepare operations and procedures manuals to assist management in operating more efficiently and effectively. Includes program analysts and management consultants. Excludes "Computer Systems Analysts" (15-1211) and "Operations Research Analysts" (15-2031).	Management analysts may travel frequently to meet with clients. Some work more than 40 hours per week.	950,600	108,400 (11%)
17-2071	Electrican Engineers	Research, design, develop, test, or supervise the manufacturing and installation of electrical equipment, components, or systems for commercial, industrial, military, or scientific use. Excludes "Computer Hardware Engineers" (17-2061).	Electrical and electronics engineers work in industries including research and development, engineering services, manufacturing, telecommunications, and the federal government. Electrical and electronics engineers generally work indoors in offices. However, they may have to visit sites to observe a problem or a piece of complex equipment.	303,800	9,800 (3%)
37-3011	Landscaping and Groundskeeping	Landscape or maintain grounds of property using hand or power tools or equipment. Workers typically perform a variety of tasks, which may include any combination of the following: sod laying, mowing, trimming, planting, watering, fertilizing, digging, raking, sprinkler installation, and installation of mortarless segmental concrete masonry wall units. Excludes "Farmworkers and Laborers, Crop, Nursery, and Greenhouse" (45-2092).	Most grounds maintenance work is done outdoors in all weather conditions. Some work is seasonal, available mainly in the spring, summer, and fall. The work may be repetitive and physically demanding, requiring frequent bending, kneeling, lifting, or shoveling.	1,299,000	61,300 (5%)
41-3091	Sales Representatives of Services	Sell services to individuals or businesses. May describe options or resolve client problems. Excludes "Advertising Sales Agents" (41-3011), "Insurance Sales Agents" (41-3021), "Securities, Commodities, and Financial Services Sales Agents" (41-3031), "Travel Agents" (41-3041), "Sales Representatives, Wholesale and Manufacturing" (41-4010), and "Telemarketers" (41-9041).	Wholesale and manufacturing sales representatives work under pressure because their income and job security depend on the amount of merchandise they sell. Some sales representatives travel frequently.	1,597,600	63,300 (4%)
43-3031	Bookkeeping, Accounting and Auditing	Compute, classify, and record numerical data to keep financial records complete. Perform any combination of routine calculating, posting, and verifying duties to obtain primary financial data for use in maintaining accounting records. May also check the accuracy of figures, calculations, and postings pertaining to business transactions recorded by other workers. Excludes "Payroll and Timekeeping Clerks" (43-3051).	Most accountants and auditors work full time. Overtime hours are typical at certain periods of the year, such as for quarterly audits or during tax season.	1,449,800	81,800 (6%)
47-1011	First-Line Supervisors of Construction Trades	Directly supervise and coordinate activities of construction or extraction workers.	N/A	735,500	29,900 (4%)

Table 9 – Occupational Description and Future Outlook (Cont.)

47-2061	Construction Laborers	Perform tasks involving physical labor at construction sites. May operate hand and power tools of all types: air hammers, earth tampers, cement mixers, small mechanical hoists, surveying and measuring equipment, and a variety of other equipment and instruments. May clean and prepare sites, dig trenches, set braces to support the sides of excavations, erect scaffolding, and clean up rubble, debris, and other waste materials. May assist other craft workers. Construction laborers who primarily assist a particular craft worker are classified under "Helpers, Construction Trades" (47-3010). Excludes "Hazardous Materials Removal Workers" (47-4041).	Most construction laborers and helpers typically work full time and do physically demanding work. Some work at great heights or outdoors in all weather conditions. Construction laborers have one of the highest rates of injuries and illnesses of all occupations.	1,572,200	69,500 (4%)
47-2073	Operating Engineers and Other Construction Equipment Operators	Operate one or several types of power construction equipment, such as motor graders, bulldozers, scrapers, compressors, pumps, derricks, shovels, tractors, or front-end loaders to excavate, move, and grade earth, erect structures, or pour concrete or other hard surface pavement. May repair and maintain equipment in addition to other duties. Excludes "Extraction Workers" (47-5000) and "Crane and Tower Operators" (53-7021).	Construction equipment operators may work even in unpleasant weather. Most operators work full time, and some have irregular work schedules that include nights.	466,900	22,000 (5%)
47-2111	Electricians	Install, maintain, and repair electrical wiring, equipment, and fixtures. Ensure that work is in accordance with relevant codes. May install or service street lights, intercom systems, or electrical control systems. Excludes "Security and Fire Alarm Systems Installers" (49-2098).	Almost all electricians work full time. Work schedules may include evenings and weekends. Overtime is common.	711,200	50,200 (7%)
47-2231	Solar Photovoltaic Installers	Assemble, install, or maintain solar photovoltaic (PV) systems on roofs or other structures in compliance with site assessment and schematics. May include measuring, cutting, assembling, and bolting structural framing and solar modules. May perform minor electrical work such as current checks. Excludes solar PV electricians who are included in "Electricians" (47-2111) and solar thermal installers who are included in "Plumbers, Pipefitters, and Steamfitters" (47-2152).	Most solar panel installations are done outdoors, but PV installers sometimes work in attics and crawl spaces to connect panels to the electrical grid. Installers also must travel to jobsites.	17,100	4,600 (27%)
47-3013	Helpers – Electricians	Help electricians by performing duties requiring less skill. Duties include using, supplying, or holding materials or tools, and cleaning work area and equipment. Construction laborers who do not primarily assist electricians are classified under "Construction Laborers" (47-2061). Apprentice workers are classified with the appropriate skilled construction trade occupation (47-2011 through 47-2231).	Most construction laborers and helpers typically work full time and do physically demanding work. Some work at great heights or outdoors in all weather conditions. Construction laborers have one of the highest rates of injuries and illnesses of all occupations.	1,572,200	69,500 (4%)
49-9071	Maintenance and Repair Workers, General (Operations)	Perform work involving the skills of two or more maintenance or craft occupations to keep machines, mechanical equipment, or the structure of a building in repair. Duties may involve pipe fitting; HVAC maintenance; insulating; welding; machining; carpentry; repairing electrical or mechanical equipment; installing, aligning, and balancing new equipment; and repairing buildings, floors, or stairs. Excludes "Facilities Managers" (11-3013) and "Maintenance Workers, Machinery" (49-9043).	General maintenance and repair workers often carry out many different tasks in a single day. They could work at any number of indoor or outdoor locations. They may work inside a single building, such as a hotel or hospital, or be responsible for the maintenance of many buildings, such as those in an apartment complex or on a college campus.	1,539,100	76,300 (5%)
51-1011	First-Line Supervisors of Production and Operating Workers	Directly supervise and coordinate the activities of production and operating workers, such as inspectors, precision workers, machine setters and operators, assemblers, fabricators, and plant and system operators. Excludes team or work leaders.	N/A	646,800	12,200 (2%)
51-8013	Power Plant Operators	Control, operate, or maintain machinery to generate electric power. Includes auxiliary equipment operators. Excludes "Nuclear Power Reactor Operators" (51-8011).	Most power plant operators, distributors, and dispatchers work full time. Many work rotating 8- or 12-hour shifts.	43,700	(6,500) (-15%)
53-7062	Laborers and Freight, Stock and Material Movers	Manually move freight, stock, luggage, or other materials, or perform other general labor. Includes all manual laborers not elsewhere classified. Excludes "Construction Laborers" (47-2061) and "Helpers, Construction Trades" (47-3011 through 47-3019). Excludes "Material Moving Workers" (53-7011 through 53-7199) who use power equipment.	Most hand laborers and material movers work full time. Because materials are shipped around the clock, some workers, especially those in warehousing, work overnight shifts.	6,473,000	358,300 (6%)

Table 10 – Occupational Output from IMPLAN Construction Model, Direct Jobs, Employment Greater than 1.0

Occ Code	Occupation	Wage and Salary Employment	Wage and Salary Income	Supplements to Wages and Salaries	Employee Compensation	Hours Worked
47-2000	Construction Trades Workers	14.09	$1,208,610.01	$223,020.61	$1,431,630.62	26,516.92
47-1000	Supervisors of Construction and Extraction Workers	2.03	$239,241.21	$44,146.35	$283,387.56	4,339.12
49-9000	Other Installation, Maintenance, and Repair Occupations	1.92	$160,201.20	$29,561.37	$189,762.58	3,723.31
13-1000	Business Operations Specialists	1.37	$176,388.91	$32,548.43	$208,937.34	2,757.30
11-9000	Other Management Occupations	1.02	$171,934.25	$31,726.43	$203,660.68	2,194.24
43-9000	Other Office and Administrative Support Workers	1.01	$59,784.55	$11,031.84	$70,816.39	1,614.39

Table 11 – Occupational Output from IMPLAN Construction Model, Indirect Jobs, Employment Greater than 1.0

Occ Code	Occupation	Wage and Salary Employment	Wage and Salary Income	Supplements to Wages and Salaries	Employee Compensation	Hours Worked
37-3000	Grounds Maintenance Workers	19.67	$673,851.46	$106,157.37	$780,008.84	33,347.40
47-2000	Construction Trades Workers	13.31	$570,350.65	$103,686.04	$674,036.69	25,058.03
17-2000	Engineers	9.78	$925,532.24	$132,142.37	$1,057,674.61	19,890.75
13-1000	Business Operations Specialists	7.06	$533,122.38	$80,226.05	$613,348.44	14,052.34
17-3000	Drafters, Engineering Technicians, and Mapping Technicians	5.65	$312,854.56	$44,690.34	$357,544.90	10,934.64
11-1000	Top Executives	3.98	$434,677.32	$67,179.55	$501,856.86	8,880.28
15-1200	Computer Occupations	3.82	$345,442.67	$49,210.62	$394,653.30	7,552.95
17-1000	Architects, Surveyors, and Cartographers	3.70	$288,214.51	$41,090.84	$329,305.35	7,373.08
43-9000	Other Office and Administrative Support Workers	3.27	$108,237.11	$17,241.89	$125,478.99	5,270.59
11-9000	Other Management Occupations	3.15	$372,484.60	$56,490.31	$428,974.91	6,790.52
49-9000	Other Installation, Maintenance, and Repair Occupations	2.62	$118,047.54	$20,657.05	$138,704.60	5,094.73
37-1000	Supervisors of Building and Grounds Cleaning and Maintenance Workers	2.61	$125,838.44	$19,828.56	$145,666.99	5,442.12
43-6000	Secretaries and Administrative Assistants	2.51	$101,748.61	$15,650.40	$117,399.01	4,406.13
43-3000	Financial Clerks	2.29	$94,792.61	$14,961.51	$109,754.11	4,020.70
47-1000	Supervisors of Construction and Extraction Workers	2.02	$122,273.50	$21,855.56	$144,129.07	4,326.79
43-4000	Information and Record Clerks	2.00	$72,067.27	$11,452.99	$83,520.26	3,297.24
53-7000	Material Moving Workers	1.93	$59,692.61	$10,018.36	$69,710.97	3,165.76
13-2000	Financial Specialists	1.88	$132,466.79	$19,795.08	$152,261.87	3,709.66
41-3000	Sales Representatives, Services	1.85	$103,240.13	$16,280.06	$119,520.19	3,680.98
53-3000	Motor Vehicle Operators	1.70	$66,193.43	$12,233.38	$78,426.81	3,331.63
41-2000	Retail Sales Workers	1.48	$34,042.34	$5,885.20	$39,927.54	2,029.25
11-3000	Operations Specialties Managers	1.42	$176,449.47	$26,250.92	$202,700.39	2,989.68
47-4000	Other Construction and Related Workers	1.26	$75,074.30	$11,256.11	$86,330.41	2,399.90
51-9000	Other Production Occupations	1.24	$52,686.76	$8,055.34	$60,742.10	2,338.70
35-3000	Food and Beverage Serving Workers	1.13	$19,500.97	$2,799.44	$22,300.41	1,198.61

Table 12 – Occupational Output from IMPLAN Construction Model, Direct Jobs, Employment Greater than 1.0

Occ Code	Occupation	Wage and Salary Employment	Wage and Salary Income	Supplements to Wages and Salaries	Employee Compensation	Hours Worked
41-2000	Retail Sales Workers	3.13	$64,960.03	$12,174.88	$77,134.92	3,989.59
35-3000	Food and Beverage Serving Workers	3.04	$50,044.42	$7,343.68	$57,388.10	3,129.66
35-2000	Cooks and Food Preparation Workers	1.68	$33,916.71	$5,157.82	$39,074.52	2,196.99
31-1100	Home Health and Personal Care Aides; and Nursing Assistants, Orderlies, and Psychiatric Aides	1.56	$30,761.49	$6,496.71	$37,258.20	2,393.66
53-7000	Material Moving Workers	1.36	$38,455.28	$7,317.94	$45,773.22	2,037.76
29-1000	Healthcare Diagnosing or Treating Practitioners	1.03	$109,862.77	$21,745.95	$131,608.72	1,788.82

VIII. Glossary

Cc

Consumer Price Index (CPI)

An index of the changes in the cost of goods and services to a typical consumer, based on the costs of the same goods and services at a base period.

Dd

Direct impacts

During the construction period: the changes that occur in the onsite construction industries in which the direct final demand change is made.

During operating years: the final demand changes that occur in the onsite spending for the solar operations and maintenance workers.

Ff

Full-time equivalent (FTE)

A unit that indicates the workload of an employed person. One FTE is equivalent to one worker working 2,080 hours in a year. One half FTE is equivalent to a half-time worker or someone working 1,040 hours in a year.

Ii

IMPLAN (IMpact analysis for PLANning)

A business who is the leading provider of economic impact data and analytic applications. IMPLAN data is collected at the federal, state, and local levels and used to create state-specific and county-specific industry multipliers.

Indirect impacts

Impacts that occur in industries that make up the supply chain for that industry.

During the construction period: the changes in inter- industry purchases resulting from the direct final demand changes, including construction spending on materials and wind farm equipment and other purchases of good and offsite services.

During operating years: the changes in inter-industry purchases resulting from the direct final demand changes.

Induced impacts

The changes that occur in household spending as household income increases or decreases as a result of the direct and indirect effects of final demand changes.

Inflation

A persistent rise in the general level of prices related to an increase in the volume of money and resulting in the loss of value of currency. Inflation is typically measured by the CPI.

Mm

Median Household Income (MHI)

The income amount that divides a population into two equal groups, half having an income above that amount, and half having an income below that amount.

Millage rate

The tax rate, as for property, assessed in mills per dollar.

Multiplier

A factor of proportionality that measures how much a variable changes in response to a change in another variable.

MW

A unit of power, equal to one million watts or one thousand kilowatts.

MWac (megawatt alternating current)

The power capacity of a utility-scale solar PV system after its direct current output has been fed through an inverter to create an alternating current (AC). A solar system's rated MWac will always be lower than its rated MWdc due to inverter losses. AC is the form in which electric energy is delivered to businesses and residences and that consumers typically use when plugging electric appliances into a wall socket.

MWdc (megawatt direct current)

The power capacity of a utility-scale solar PV system before its direct current output has been fed through an inverter to create an alternating current. A solar system's rated MWdc will always be higher than its rated MWac.

Nn

National Renewable Energy Laboratory's (NREL) Jobs and Economic Development Impacts (JEDI) Model

An input-output model that measures the spending patterns and location-specific economic structures that reflect expenditures supporting varying levels of employment, income, and output.

Oo

Output

Economic output measures the value of goods and services produced in a given area. Gross Domestic Product is the economic output of the United States as a whole.

Pp

PV (photovoltaic) system

Solar modules, each comprising a number of solar cells, which generate electrical power.

Rr

Real Gross Domestic Product (GDP)

A measure of the value of goods and services produced in an area and adjusted for inflation over time.

Tt

Tax rate

The percentage (or millage) of the value of a property to be paid as a tax.

Total economic output

The quantity of goods or services produced in a given time period by a firm, industry, county, or country.

Uu

Utility-scale solar

Solar powered-electric generation facilities intended for wholesale distribution typically over 5MW in capacity.

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X. Curriculum Vitae (Abbreviated)

David G. Loomis
Strategic Economic Research, LLC
2705 Kolby Court
Bloomington, IL 61704
815-905-2750
dave@strategiceconomic.com

Education

Doctor of Philosophy, Economics, Temple University, Philadelphia, Pennsylvania, May 1995.

Bachelor of Arts, Mathematics and Honors Economics, Temple University, Magna Cum Laude, May 1985.

Experience

2011-present Strategic Economic Research, LLC
President

- Performed economic impact analyses on policy initiatives and energy projects such as wind energy, solar energy, natural gas plants and transmission lines at the county and state level.
- Provided expert testimony before state legislative bodies, state public utility commissions, and county boards.
- Wrote telecommunications policy impact report comparing Illinois to other Midwestern states.

1996-2023 Illinois State University, Normal, IL
Professor Emeritus – Department of Economics (2023 - present)
Full Professor – Department of Economics (2010-2023)
Associate Professor - Department of Economics (2002-2009)
Assistant Professor - Department of Economics (1996-2002)

- Taught Regulatory Economics, Telecommunications Economics and Public Policy, Industrial Organization and Pricing, Individual and Social Choice, Economics of Energy and Public Policy and a Graduate Seminar Course in Electricity, Natural Gas and Telecommunications Issues.
- Supervised as many as 5 graduate students in research projects each semester.
- Served on numerous departmental committees.

1997-2023 Institute for Regulatory Policy Studies, Normal, IL
Executive Director (2005-2023)
Co-Director (1997-2005)

- Grew contributing membership from 5 companies to 16 organizations.
- Doubled the number of workshop/training events annually.
- Supervised 2 Directors, Administrative Staff and internship program.
- Developed and implemented state-level workshops concerning regulatory issues related to the electric, natural gas, and telecommunications industries.

2006-2018 Illinois Wind Working Group, Normal, IL
Director

- Founded the organization and grew the organizing committee to over 200 key wind stakeholders
- Organized annual wind energy conference with over 400 attendees
- Organized strategic conferences to address critical wind energy issues
- Initiated monthly conference calls to stakeholders
- Devised organizational structure and bylaws

2007-2018 Center for Renewable Energy, Normal, IL
Director

- Created founding document approved by the Illinois State University Board of Trustees and Illinois Board of Higher Education.
- Secured over $150,000 in funding from private companies.
- Hired and supervised 4 professional staff members and supervised 3 faculty members as Associate Directors.
- Reviewed renewable energy manufacturing grant applications for Illinois Department of Commerce and Economic Opportunity for a $30 million program.
- Created technical "Due Diligence" documents for the Illinois Finance Authority loan program for wind farm projects in Illinois.
- Published 40 articles in leading journals such as AIMS Energy, Renewable Energy, National Renewable Energy Laboratory Technical Report, Electricity Journal, Energy Economics, Energy Policy, and many others
- Testified over 80 times in formal proceedings regarding wind, solar and transmission projects
- Raised over $7.7 million in grants
- Raised over $2.7 million in external funding

Bryan A. Loomis
Strategic Economic Research, LLC
Vice President

Education

Master of Business Administration (M.B.A.), Marketing and Healthcare, Belmont University, Nashville, Tennessee, 2017.

Experience

2019-present Strategic Economic Research, LLC, Bloomington, IL
Vice President
(2021-present)
Property Tax Analysis and Land Use Director
(2019-2021)

- Directed the property tax analysis by training other associates on the methodology and overseeing the process for over twenty states
- Improved the property tax analysis methodology by researching various state taxing laws and implementing depreciation, taxing jurisdiction millage rates, and other factors into the tax analysis tool
- Executed land use analyses by running Monte Carlo simulations of expected future profits from farming and comparing that to the solar lease
- Performed economic impact modeling using JEDI and IMPLAN tools
- Improved workflow processes by capturing all tasks associated with economic modeling and report-writing, and created automated templates in Asana workplace management software

2019-2021 Viral Healthcare Founders LLC, Nashville, TN
CEO and Founder

- Founded and directed marketing agency for healthcare startups
- Managed three employees
- Mentored and worked with over 30 startups to help them grow their businesses
- Grew an email list to more than 2,000 and LinkedIn following to 3,500
- Created a Slack community and grew to 450 members
- Created weekly video content for distribution on Slack, LinkedIn and Email

Christopher Thankan
Strategic Economic Research, LLC
Economic Analyst

Education

Bachelor of Science in Sustainable & Renewable Energy (B.S.), Minor in Economics, Illinois State University, Normal, IL, 2021

Experience

2021-present Strategic Economic Research, LLC, Bloomington, IL
Economic Analyst

- Create economic impact results on numerous renewable energy projects Feb 2021-Present
- Utilize IMPLAN multipliers along with NREL's JEDI model for analyses
- Review project cost Excel sheets
- Conduct property tax analysis for different US states
- Research taxation in states outside research portfolio
- Complete ad hoc research requests given by the president
- Hosted a webinar on how to run successful permitting hearings
- Research school funding and the impact of renewable energy on state aid to school districts
- Quality check coworkers JEDI models
- Started more accurate methodology for determining property taxes that became the main process used

by Dr. David G. Loomis,
Bryan Loomis, and Chris Thankan
Strategic Economic Research, LLC
strategiceconomic.com
815-905-2750

KANSAS SKY
ENERGY CENTER

KANSAS SKY ENERGY CENTER AGRIVOLTAICS MEMO

Agrivoltaics is a nascent, but growing industry and the successful implementation of any agrivoltaics program at a utility scale solar project will depend on several factors including, but not limited to access, investment, and multi-stakeholder support. The Applicant has taken several key and important steps to ensure a successful outcome for the Kansas Sky Energy Center (KSEC or 'Project') agrivoltaics program, some of which are summarized below.

Access:

Some of the KSEC landowner agreements did not previously allow for agrivoltaics, which could have limited the future expansion of agrivoltaics on site. Those agreements have since been amended to explicitly allow for agrivoltaics, effectively making the entire site 'agrivoltaic-ready' by ensuring access for agrivoltaics. The amended landowner agreements have been recorded with Douglas County and are included as Supplemental Exhibit 3.B.

Investment:

Savion, LLC (Savion), the owner and developer of KSEC, has made significant investment to advance agrivoltaics as part of a larger land use strategy for its portfolio of solar projects. To that end, Savion has staff dedicated to agrivoltaics and has partnered with the Department of Energy to conduct agrivoltaics research and development.

Savion explores agrivoltaics opportunities for all its projects. For the KSEC, a Vegetation Management Plan and Grazing Management Plan were prepared and submitted with the Project's Conditional Use Permit Application (Exhibits L & H, respectively). These plans detail some of the agrivoltaics practices proposed for the site including native grasses, pollinator habitat and complementary sheep grazing. In addition to preparing these plans, Savion has conducted significant outreach to understand the community's needs and gauge interest for potential agrivoltaic partnerships.

Evergy, Inc. (Evergy), the proposed long-term owner and operator of KSEC, was an early supporter of the monarch butterfly Candidate Conservation Agreement with Assurances (CCAA). This CCAA is a formal agreement between the U.S. Fish and Wildlife Service and non-federal property owners, like Evergy, to voluntarily commit to enhance, restore or maintain habitat to benefit the monarch butterfly with the goal that listing this species as endangered or threatened will become unnecessary. By enrolling in this CCAA, Evergy has committed to conserving over 20,000 acres of monarch butterfly habitat on our rights-of-way and company-owned land throughout Kansas and Missouri.

In 2022 Evergy dedicated more than $1.1 million in community contributions toward sustainability and conservation efforts, nature-based carbon sequestration and heat island mitigation. Through its Green Team, Evergy has conducted 64 projects dedicating 2,846 hours in volunteerism. They collected 500 tires and tons of trash from Kansas River, and planted more than 2,000 trees. Since 1989, our volunteer, employee-driven Green Team has completed thousands of projects restoring hundreds of acres of wetlands, thousands of acres of prairie and planting more than 30,000 trees. Partnering with agencies, non-profits, and schools, we protect, preserve, and educate.

Evergy is committed to bringing that same spirit of conservation forward for the KSEC. In addition to enrolling applicable Project acres into the CCAA, Evergy will create a grant opportunity for agrivoltaics research and development on the KSEC site. The grant would be awarded to up to three applicants who successfully demonstrate that their proposal 1.) seeks to identify scalable solutions for agrivoltaics; 2.) includes an analysis on the impact to the surrounding area and solar facility; and 3.) involves collaboration with community partners.

The KSEC agrivoltaics program has the potential become a case-study for how to implement agrivoltaics at a utility scale; and to help ensure a successful outcome, Savion and Evergy are committed to setting up an **Agrivoltaics Fund** in the amount of **$100,000** to directly support agrivoltaic research and development at the KSEC.

Multi-Stakeholder Support:

To understand how agrivoltaics can benefit the local community and be implemented effectively, the Savion and Evergy have collaborated with a diverse group of stakeholders including local agricultural producers, businesses, university researchers, K-12 instructors, county staff and non-profit organizations. In all these stakeholder groups, there exists keen interest in participating in the KSEC agrivoltaics program. The Nature Conservancy is among those with expressed interest.

Over the past several months the Savion, Evergy and The Nature Conservancy have worked collaboratively to foster an opportunity in which The Nature Conservancy would partner with Evergy and community stakeholders to implement the KSEC agrivoltaics program. Commitment to this partnership is demonstrated by Supplemental Exhibit 3.C., Memorandum of Understanding between The Nature Conservancy and Evergy.

Given that agrivoltaics is in its infancy and the KSEC is still under development, many of the details surrounding the KSEC agrivoltaics program are yet to be known. However, Savion and Evergy have laid the foundation for a successful outcome, by ensuring access, providing investment, and identifying key partners to stand up the KSEC agrivoltaics program.

The KSEC agrivoltaics program will include practices such as native vegetation, pollinator habitat, grazing and specialty crop farming that will benefit local agricultural producers and the broader community. The partnership between The Nature Conservancy and Evergy will elevate opportunities and resources available for the KSEC agrivoltaics program while identifying replicable and scalable solutions to some of the challenges currently facing those at the confluence of agriculture and utility-scale renewable energy.

Douglas County Register of Deeds
BK: 1227 PG: 79 - 86 Receipt #:583866
Rec Fees: $140.00
Pages Recorded: 8 Record Date: 3/14/2024 9:27 AM
Cashier Initials : wt Authorized By Kent Brown

RECORDING REQUESTED BY:
Clifton Nix

WHEN RECORDED MAIL TO:
Free State Solar Project, LLC
c/o Savion, LLC
422 Admiral Boulevard
Kansas City, MO 64106

SPACE DIRECTLY ABOVE RESERVED FOR RECORDER'S USE

Amendment to Memorandum of Option and

Solar Energy Lease

See Attached.

Reason for re-recording: Solely intended to rectify an omission by adding the missing date to the designated space in sub-section A, page 1 of the Amendment to Memorandum of Option and Solar Energy Lease recorded in Book 1226, Page 5616 in the Douglas County Register of Deeds.

REGISTER OF DEEDS
DOUGLAS COUNTY
KANSAS

Douglas County Register of Deeds
BK: 1226 PG: 5616 - 5622 Receipt #:583827
Rec Fees: $123.00
Pages Recorded: 7 Record Date: 3/12/2024 2:46 PM
Cashier Initials : tg Authorized By Kent Brown

PREPARED BY AND
WHEN RECORDED RETURN TO:

Free State Solar Project, LLC
c/o Savion, LLC
422 Admiral Boulevard
Kansas City, Missouri 64106
Attn: Aaron Lipscomb

AMENDMENT TO MEMORANDUM OF OPTION AND SOLAR ENERGY LEASE

THIS AMENDMENT TO MEMORANDUM OF OPTION AND SOLAR ENERGY LEASE (this "***Amendment to Memorandum***") is dated effective as of the date of execution hereby by the final party to sign this Amendment to Memorandum (for all other purposes the "***Effective Date***" shall be March 3, 2022) by and between the Strong Family Irrevocable Trust Agreement dated December 19, 2023 ("***Lessor***"), whose address is 18975 Clare Rd., Gardner, Kansas 66030, and Free State Solar Project, LLC, a Delaware limited liability company ("***Lessee***"), whose address is 422 Admiral Boulevard, Kansas City, Missouri 64106, (Lessor and Lessee together, the "***Parties***," and each a "***Party***") with reference to the following recitals:

A. the Evelyn M. Strong Trust dated March 11, 2008, as amended (the "***Original Lessor***"), and Lessee entered into that certain unrecorded Option and Solar Energy Lease dated March 3, 2022, notice of which is imparted by that certain Memorandum of Option and Solar Energy Lease dated March 3, 2022 and recorded in the official public records of Douglas County, Kansas on March 9, 2022 in Book 1209 at Page 637 (the "***Memorandum***"), as amended by that certain unrecorded Amendment to Option and Solar Energy Lease dated March 11th, 2024 (collectively, the "***Lease***"), pursuant to which Lessor agreed to lease to Lessee, and Lessee agreed to lease from Lessor, upon certain terms and conditions provided therein, certain real property as legally described on Exhibit "A" attached hereto (the "***Property***").

B. Pursuant to certain conveyances of record in Douglas County, Kansas, by Original Lessor and subsequently by an entity affiliated with Lessor, Lessor is the successor in interest to the Property.

C. The Parties have executed and acknowledged this Amendment to Memorandum and are recording the same for the purpose of amending the Memorandum and providing

constructive notice of the Lease and Lessee's rights thereunder. Capitalized terms used and not defined herein shall have the same meaning as given in the Lease.

NOW, THEREFORE, for and in consideration of the promises, covenants and agreements of the Parties contained in the Lease and herein, and for other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the Parties hereby agree as follows:

1. Section 1.4. Section 1.4 of the Memorandum is hereby deleted in its entirety and replaced with the following Section 1.4:

> "1.4 During the Extended Term, removing, trimming, pruning, topping, clearing or otherwise controlling the growth of any tree, shrub, plant or other vegetation; dismantling, demolishing, and removing any improvement, Structure (as defined in the Lease), embankment, impediment, berm, wall, fence, engineering works, or other object, on or that intrudes (or upon further growth or maturity could intrude) into the Property that could obstruct, interfere with or impair the Solar Energy System or the use of the Property intended by Lessee hereunder; provided, however, that the overall drainage of the Property remain materially unaffected and in compliance with any Stormwater Pollution Prevention Plan required in connection with the Solar Operations, if any portion of the Property is utilized for agricultural purposes, and provided further that, Lessee's removal of any such improvements or Structures having salvage value (as reasonably determined by Lessee) shall be coordinated with Lessor, and if so elected by Lessor in writing within ten (10) days after written notice from Lessee that any such improvement or Structure must be removed, Lessor shall have a fifteen (15) day period to remove any such improvement or Structure at Lessor's expense. In the event Lessor fails to respond in writing to Lessee within such ten (10) day period, or Lessor elects not to remove or fails to remove any such improvements or Structures within such fifteen (15) day period, Lessee may remove and dispose of such improvements or Structures at Lessee's expense, and Lessee shall have no liability to Lessor relating to the removal and disposal thereof. In addition to the foregoing rights listed in this Section 1.4, Lessee shall have the right during the Extended Term to conduct and/or perform (or engage third parties to conduct and/or perform) agrivoltaic activities as an alternative to traditional methods of maintenance with respect to the Extended Term Property;"

2. Section 9. Section 9 of the Memorandum is hereby deleted in its entirety and replaced with the following Section 9:

> "9. In accordance with K.S.A. § 58-2272, the Lease contains (i) a description of the real property subject to the easement and a description of the real property benefitting from the solar lease or easement; (ii) a description of the vertical and horizontal angles, expressed in degrees, and distances from the site of the solar power system in which an obstruction to the solar system is prohibited or limited; (iii) the terms or conditions under which the lease or easement is granted or may be terminated; (iv) and the provisions necessary or desirable to execute the instrument."

[REST OF PAGE LEFT BLANK; SIGNATURES ON SEPARATE SHEETS]

IN WITNESS WHEREOF, Lessee has executed and delivered this Amendment to Memorandum as of March 11th, 2024.

LESSEE: FREE STATE SOLAR PROJECT, LLC,
a Delaware limited liability company

By: _____

Name: Aaron Lipscomb

Title: Authorized Person

STATE OF Missouri)
) ss.
COUNTY OF Jackson)

Be it remembered that on this 11th day of March, 2024, before me, the undersigned, a Notary Public in and for the County and State aforesaid, came Aaron Lipscomb, to me personally known, who being by me duly sworn did say that he is an Authorized Person of Free State Solar Project, LLC, a Delaware limited liability company, and that the within instrument was signed and sealed on behalf of said Free State Solar Project, LLC by authority thereof, and acknowledged said instrument to be the free act and deed of said limited liability company for the purposes therein expressed.

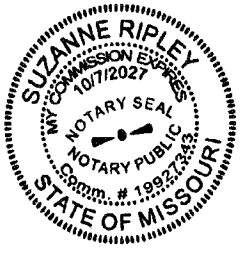
IN WITNESS WHEREOF, I have hereunto set my hand and affixed my Notarial Seal in the date herein last above written.

My Commission Expires:

10/07/2027
[SEAL]

Suzanne Ripley
Notary Public in and for said County and State

Print Name: Suzanne Ripley



LESSEE: FREE STATE SOLAR PROJECT, LLC,
a Delaware limited liability company

By: _____

Name: Rod Northway

Title: Authorized Person

STATE OF Missouri)
) ss.
COUNTY OF Jackson)

Be it remembered that on this 11th day of March, 2024, before me, the undersigned, a Notary Public in and for the County and State aforesaid, came Rod Northway, to me personally known, who being by me duly sworn did say that he/she is Authorized Person of Free State Solar Project, LLC, a Delaware limited liability company, and that the within instrument was signed and sealed on behalf of said Free State Solar Project, LLC by authority thereof, and acknowledged said instrument to be the free act and deed of said limited liability company for the purposes therein expressed.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my Notarial Seal in the date herein last above written.

My Commission Expires:

10/07/2027

[SEAL]

_____
Notary Public in and for said County and State

Print Name: Suzanne Ripley

SUZANNE RIPLEY
NOTARY SEAL
NOTARY PUBLIC
STATE OF MISSOURI
COMMISSION EXPIRES 10/7/2027
Comm. # 19927343

IN WITNESS WHEREOF, Lessor has executed and delivered this Amendment to Memorandum as of March 11, 2024.

LESSOR:

STRONG FAMILY IRREVOCABLE TRUST
DATED DECEMBER 19, 2023

Evelyn M. Strong

Evelyn M. Strong, Trustee

STATE OF Kansas)
) ss.
COUNTY OF Johnson)

BE IT REMEMBERED, that on this 11th day of March, 2024, before me, the undersigned, a Notary Public in and for the County and State aforesaid, came Evelyn M. Strong, to me personally known, who being by me duly sworn did say that she is the Trustee of the Strong Family Irrevocable Trust dated December 19, 2023, and that the within instrument was signed and sealed on behalf of said Trust, by authority thereof, and acknowledged said instrument to be the free act and deed of said Trust for the purposes therein expressed.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year LAST above written.

My Commission Expires: 3-1-2025

[SEAL] Michelle E Winfield Notary Public State of Kansas My Appt Expires 3-1-2025

Michelle E. Winfield

Notary Public in and for said County and State

Print Name: Michelle E. Winfield

EXHIBIT "A"

DESCRIPTION OF THE PROPERTY

THE FOLLOWING REAL PROPERTY LOCATED IN THE COUNTY OF DOUGLAS, STATE OF KANSAS:

TRACT I:
The North Half of the Northeast Quarter of Section 12, Township 12 South, Range 19 East of the 6th P.M., EXCEPT 3 2/3 acres in the Northeast corner deeded to School District 62 in Douglas County, Kansas, and less any portion thereof lying within the Railroad right of way.

Tax ID: 061-12-0-00-00-003.00

TRACT II:
The North 96 acres of the Northwest Quarter of Section 12, Township 12 South, Range 19 East of the 6th P.M., in Douglas County, Kansas.

Tax ID: 061-12-0-00-00-003.00

TRACT III:
A parcel of land located in the East Half (E 1/2) of Section 12, Township 12 South, Range 19 East of the 6th P.M., Douglas County, Kansas, more particularly described as follows:

Beginning at the Southwest corner of the Southeast Quarter (SE 1/4); thence North 00°04'13" West a distance of 2,644.51 feet, said point being the Northwest corner of the Southeast Quarter (SE 1/4); thence North 00°02'19" West a distance of 1,324.06 feet, said point being the Northwest corner of the South Half (S 1/2), of the Northeast Quarter (NE 1/4); thence South 89°46'40" East a distance of 2,676.07 feet, said point being the Northeast corner of the South Half (S 1/2) of the Northeast Quarter (NE 1/4); thence South 00°00'24" West a distance of959.90 feet, said point being on the East line of the South Half (S 1/2) of the Northeast Quarter (NE 1/4); thence North 89°44'18" West a distance of 440.00 feet; thence South 00°00'24" West a distance of 297.00 feet; thence South 89°44'18" East a distance of 440.00 feet, said point being on the East line of the South Half (S 1/2) of the Northeast Quarter (NE 1/4); thence South 00°00'24" West a distance of 69.00 feet, said point being the Northeast corner of the Southeast Quarter (SE 1/4); thence South 00°00'0011 East a distance of 682.00 feet, said point being on the East line of the Southeast Quarter (SE 1/4); thence South 90°00'00" West a distance of 352.63 feet; thence South 00°00'00" East a distance of 420.00 feet; thence North 90°00'00" East a distance of 352.63 feet, said point being on the East line of the Southeast Quarter (SE 1/4); thence South 00°00'00" East a distance of 256.75 feet, said point being on the East line of the Southeast Quarter (SE 1/4); thence South 90°00'00" West a distance of247.50 feet; thence South 00°00'00" East a distance of 243.08 feet; thence North 90°00'00" East a distance of 247.50 feet, said point being on the East line of the Southeast Quarter (SE 1/4); thence South 00°00'00" East a distance of 160.41 feet, said point being on the East line of the Southeast Quarter (SE 1/4); thence North 89°44'40" West a distance of 1,336.25 feet; thence South 00°02'10" East a distance of 881.35 feet, said point being on the South line of the Southeast Quarter (SE 1/4); thence North 89°46'15" West a distance of 1,336.09 feet, to the Point of Beginning, containing 208.83 Acres more or less, subject to public road right-of-way and easements of record.

Tax ID: 061-12-0-00-00-012.01

TRACT IV:
The South One-Third of the East One-Half of the Southeast Quarter of Section 12, Township 12 South, Range 19 East of the 6th Principal Meridian, in Douglas County, Kansas, LESS a tract of land located in the Southeast Quarter of Section 12, Township 12 South, Range 19 East, of the 6th P.M., Douglas County, Kansas, more particularly described as follows:

Beginning at the Southeast corner of Section 12; thence North 90°00'00" West a distance of 467.00 feet, said point being on the South line of the Southeast Quarter; thence North 0°13'27" West a distance of 467.00 feet; thence South 90°00'00" East a distance of 467.00 feet, said point being on the East line of the Southeast Quarter; thence South 0°13'27" East a distance of 467.00 feet to the point of beginning.

Tax ID: 061-12-0-00-00-009.00-0

TRACT V (a/k/a the "VanMeter Property"):
The East Half of the Southeast Quarter of Section 1, Township 12 South, Range 19 East of the 6th Principal Meridian, lying North of the right of way of the Union Pacific Railroad, in Douglas County, Kansas, LESS THE FOLLOWING DESCRIBED TRACT:

Beginning at the Northeast corner of the Southeast Quarter of said Section 1, thence North 89°49'24" West along the North line of the Southeast Quarter of said Section 1, 1331.55 feet; to the Northwest corner of the East One-Half of the Southeast Quarter of said Section 1; thence South 00°01 '57" West along the West line of the East One-Half of the Southeast Quarter of said Section 1, 654.15 feet; thence South 90°00'00" East 1333.37 feet to the East line of the Southeast Quarter of said Section 1; thence North 00°07'44" West along the East line of the Southeast quarter of said Section 1 to the point of beginning.

Tax ID: 061-01-0-00-00-012.00

REGISTER OF DEEDS
DOUGLAS COUNTY
KANSAS

Douglas County Register of Deeds
BK: 1227 PG: 1 - 8 Receipt #:583858
Rec Fees: $140.00
Pages Recorded: 8 Record Date: 3/14/2024 8:10 AM
Cashier Initials : eb Authorized By Kent Brown

RECORDING REQUESTED BY:

Clifton Nix

WHEN RECORDED MAIL TO:

Free State Solar Project, LLC
c/o Savion, LLC
422 Admiral Boulevard
Kansas City, MO 64106

SPACE DIRECTLY ABOVE RESERVED FOR RECORDER'S USE

Amendment to Memorandum of Option and Solar Energy Lease

See Attached.

Reason for re-recording: Solely intended to rectify an omission by adding the missing date to the designated space in sub-section A, page 1 of the memorandum.

PREPARED BY AND
WHEN RECORDED RETURN TO:

Free State Solar Project, LLC
c/o Savion, LLC
422 Admiral Boulevard
Kansas City, Missouri 64106
Attn: Aaron Lipscomb

AMENDMENT TO MEMORANDUM OF OPTION AND SOLAR ENERGY LEASE

THIS AMENDMENT TO MEMORANDUM OF OPTION AND SOLAR ENERGY LEASE (this "***Amendment to Memorandum***") is dated effective as of the date of execution hereby by the final party to sign this Amendment to Memorandum (for all other purposes the "***Effective Date***" shall be March 3, 2022) by and between the Strong Family Irrevocable Trust Agreement dated December 19, 2023 ("***Lessor***"), whose address is 18975 Clare Rd., Gardner, Kansas 66030, and Free State Solar Project, LLC, a Delaware limited liability company ("***Lessee***"), whose address is 422 Admiral Boulevard, Kansas City, Missouri 64106, (Lessor and Lessee together, the "***Parties***," and each a "***Party***") with reference to the following recitals:

A. the Daniel E. Strong Trust dated March 11, 2008, as amended (the "***Original Lessor***"), and Lessee entered into that certain unrecorded Option and Solar Energy Lease dated March 3, 2022, notice of which is imparted by that certain Memorandum of Option and Solar Energy Lease dated March 3, 2022 and recorded in the official public records of Douglas County, Kansas on March 9, 2022 in Book 1209 at Page 700, and recorded in the official public records of Jefferson County, Kansas on August 25, 2022 as Instrument Number 2022R2568 (the "***Memorandum***"), as amended by that certain unrecorded Amendment to Option and Solar Energy Lease dated March 11th, 2024 (collectively, the "***Lease***"), pursuant to which Lessor agreed to lease to Lessee, and Lessee agreed to lease from Lessor, upon certain terms and conditions provided therein, certain real property as legally described on Exhibit "A" attached hereto (the "***Property***").

B. Pursuant to certain conveyances of record in Douglas County and Jefferson County, State of Kansas, by Original Lessor, Lessor is the successor in interest to the Property.

C. The Parties have executed and acknowledged this Amendment to Memorandum and are recording the same for the purpose of amending the Memorandum and providing

constructive notice of the Lease and Lessee's rights thereunder. Capitalized terms used and not defined herein shall have the same meaning as given in the Lease.

NOW, THEREFORE, for and in consideration of the promises, covenants and agreements of the Parties contained in the Lease and herein, and for other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the Parties hereby agree as follows:

1. Section 1.4. Section 1.4 of the Memorandum is hereby deleted in its entirety and replaced with the following Section 1.4:

> "1.4 During the Extended Term, removing, trimming, pruning, topping, clearing or otherwise controlling the growth of any tree, shrub, plant or other vegetation; dismantling, demolishing, and removing any improvement, Structure (as defined in the Lease), embankment, impediment, berm, wall, fence, engineering works, or other object, on or that intrudes (or upon further growth or maturity could intrude) into the Property that could obstruct, interfere with or impair the Solar Energy System or the use of the Property intended by Lessee hereunder; provided, however, that the overall drainage of the Property remain materially unaffected and in compliance with any Stormwater Pollution Prevention Plan required in connection with the Solar Operations, if any portion of the Property is utilized for agricultural purposes, and provided further that, Lessee's removal of any such improvements or Structures having salvage value (as reasonably determined by Lessee) shall be coordinated with Lessor, and if so elected by Lessor in writing within ten (10) days after written notice from Lessee that any such improvement or Structure must be removed, Lessor shall have a fifteen (15) day period to remove any such improvement or Structure at Lessor's expense. In the event Lessor fails to respond in writing to Lessee within such ten (10) day period, or Lessor elects not to remove or fails to remove any such improvements or Structures within such fifteen (15) day period, Lessee may remove and dispose of such improvements or Structures at Lessee's expense, and Lessee shall have no liability to Lessor relating to the removal and disposal thereof. In addition to the foregoing rights listed in this Section 1.4, Lessee shall have the right during the Extended Term to conduct and/or perform (or engage third parties to conduct and/or perform) agrivoltaic activities as an alternative to traditional methods of maintenance with respect to the Extended Term Property;"

2. Section 9. Section 9 of the Memorandum is hereby deleted in its entirety and replaced with the following Section 9:

> "9. In accordance with K.S.A. § 58-2272, the Lease contains (i) a description of the real property subject to the easement and a description of the real property benefitting from the solar lease or easement; (ii) a description of the vertical and horizontal angles, expressed in degrees, and distances from the site of the solar power system in which an obstruction to the solar system is prohibited or limited; (iii) the terms or conditions under which the lease or easement is granted or may be terminated; (iv) and the provisions necessary or desirable to execute the instrument."

[REST OF PAGE LEFT BLANK; SIGNATURES ON SEPARATE SHEETS]

IN WITNESS WHEREOF, Lessee has executed and delivered this Amendment to Memorandum as of March 11th, 2024.

LESSEE: FREE STATE SOLAR PROJECT, LLC,
a Delaware limited liability company

By: _____

Name: Aaron Lipscomb

Title: Authorized Person

STATE OF Missouri)
) ss.
COUNTY OF Jackson)

Be it remembered that on this 11th day of March, 2024, before me, the undersigned, a Notary Public in and for the County and State aforesaid, came Aaron Lipscomb, to me personally known, who being by me duly sworn did say that he is an Authorized Person of Free State Solar Project, LLC, a Delaware limited liability company, and that the within instrument was signed and sealed on behalf of said Free State Solar Project, LLC by authority thereof, and acknowledged said instrument to be the free act and deed of said limited liability company for the purposes therein expressed.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my Notarial Seal in the date herein last above written.

My Commission Expires:

10/07/2027
[SEAL]

_____
Notary Public in and for said County and State

Print Name: Suzanne Ripley

SUZANNE RIPLEY
NOTARY SEAL
NOTARY PUBLIC
STATE OF MISSOURI
MY COMMISSION EXPIRES 10/7/2027
Comm. # 19927343

LESSEE: FREE STATE SOLAR PROJECT, LLC,
a Delaware limited liability company

By: _____

Name: Rod Northway

Title: Authorized Person

STATE OF Missouri)
) ss.
COUNTY OF Jackson)

Be it remembered that on this 11th day of March, 2024, before me, the undersigned, a Notary Public in and for the County and State aforesaid, came Rod Northway, to me personally known, who being by me duly sworn did say that he/she is Authorized Person of Free State Solar Project, LLC, a Delaware limited liability company, and that the within instrument was signed and sealed on behalf of said Free State Solar Project, LLC by authority thereof, and acknowledged said instrument to be the free act and deed of said limited liability company for the purposes therein expressed.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my Notarial Seal in the date herein last above written.

My Commission Expires:

10/07/2027

[SEAL]

_____
Notary Public in and for said County and State

Print Name: Suzanne Ripley

SUZANNE RIPLEY
NOTARY SEAL
NOTARY PUBLIC
STATE OF MISSOURI
COMMISSION EXPIRES
10/7/2027
Comm. # 19927343

IN WITNESS WHEREOF, Lessor has executed and delivered this Amendment to Memorandum as of March 11, 2024.

LESSOR:

STRONG FAMILY IRREVOCABLE TRUST
DATED DECEMBER 19, 2023

Evelyn M. Strong
Evelyn M. Strong, Trustee

STATE OF Kansas)
) ss.
COUNTY OF Johnson)

BE IT REMEMBERED, that on this 11th day of March, 2024, before me, the undersigned, a Notary Public in and for the County and State aforesaid, came Evelyn M. Strong, to me personally known, who being by me duly sworn did say that she is the Trustee of the Strong Family Irrevocable Trust dated December 19, 2023, and that the within instrument was signed and sealed on behalf of said Trust, by authority thereof, and acknowledged said instrument to be the free act and deed of said Trust for the purposes therein expressed.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year LAST above written.

My Commission Expires: 3-1-2025

Michelle E. Winfield
Notary Public in and for said County and State

[SEAL] Michelle E Winfield
Notary Public State of Kansas
My Appt Expires 3-1-2025

Print Name: Michelle E. Winfield

EXHIBIT "A"

DESCRIPTION OF THE PROPERTY

THE FOLLOWING REAL PROPERTY LOCATED IN THE COUNTY OF DOUGLAS, STATE OF KANSAS:

Tract 1: The West Half of the Southwest Quarter of Section 1 and the West Half of the East Half of the Southwest Quarter of Section 1 lying South of the right of way of the Union Pacific Railroad, also all of the West Half of the Northwest Quarter of Section 1 lying South of the right of way of the Union Pacific Railroad, all in Township 12 South, Range 19 East of the 6th P.M., Except that portion thereof conveyed by the Deed recorded in Deed Book 109, Page 379, in Douglas County, Kansas.
Tax ID: 061-01-0-00-00-008.00-0

Tract 2: The South 64 acres of the Northwest Quarter and the North 18.64 acres of the Southwest Quarter of Section 12, Township 12 South, Range 19 East of the Sixth Principal Meridian, in Douglas County, Kansas; Except that portion conveyed by Deed recorded in the Douglas County, Kansas Register of Deeds in Deed Book 705, Page 54.
Tax ID: 061-12-0-00-00-004.00-0

Tract 3: Beginning at the Southwest corner of the Northwest 1/4 of Section 7, Township 12 South, Range 20 East of the 6th P.M., Douglas County, Kansas; thence North 2°08'48" West, along the West line of said Northwest Quarter, 2028.97 feet, to the South right of way of the Union Pacific Railroad Co.; thence South 55°48'46" East, along said right of way, 673.52 feet; thence North 34°11'14" East along said right of way 25.0 feet; thence South 55°48'46" East, along said right of way, 710.52 feet; thence along said right of way on a curve to the right with a radius of 2815.26 feet, a distance of 1591.83 feet to the South line of said Northwest Quarter; thence South 88°20'11" West, along said South line 2085.32 feet to the point of beginning.
Tax ID: 073-07-0-00-00-009.00-0

Tracts 4 & 5: The middle or center one-third, being the North Half of the South Two-thirds of the West Half of the Southeast Quarter of Section 2, Township 12 South, Range 19 East of the 6th P.M., in Douglas County, Kansas; AND The North 76 rods of Lot 3; the South 4 rods of Lot 3, and all of Lot 4, in the Southwest Quarter of Section 2, Township 12 South, Range 19 East of the 6th P.M., in Douglas County, Kansas;

AND

Part of the Southwest Quarter of Section 2, Township 12 South, Range 19 East of the 6th P.M., in Douglas County, Kansas, described as Beginning at a point on the East and West center line of said Section 2, a distance of 920.5 feet East of the West line of said Section 2; thence South 0°30" East, 933 feet; thence South 25° East, 360 feet to a point 76 rods South of the East and West center line of Section 2; thence East parallel to the East and West center line of Section 2, a distance of 450 feet; thence South ALTA Commitment (6/17/06) 1° East, 506 feet; thence East parallel to the East and West center line of Section 2, a distance of 450 feet to a point 53 1/3 rods (880 feet) North of the South line of Section 2; thence North 1° West, 490 feet; thence North 24°30" West, 365 feet; thence North 0°30" West, 55 feet to a point 53 1/3 rods (880 feet) South of the East and West center line of Section 2; thence West parallel to the East and West center line of Section 2, a distance of 450 feet; thence North 0°30" West 53 1/3 rods (880 feet) to a point on the East and West center line of Section 2; thence West on the East and West center line of

Section 2, a distance of 450 feet to the point of beginning, as described in Deed Book 132 Page 109. Except that portion thereof taken by Condemnation proceedings in District Court of Douglas County, Kansas, in Case No. 24333 and Case No 24437.
Tax ID: Tract 4: 061-02-0-00-00-006.00-0 ; Tract 5: 061-02-0-00-00-009.00-0

Tract 6: The East Half of the Southeast Quarter of Section 2, Township 12 South, Range 19 East of the 6th Principal Meridian, Douglas County, Kansas.
Tax ID: 061-02-0-00-00-011.00-0

AND

THE FOLLOWING REAL PROPERTY LOCATED IN THE COUNTY OF JEFFERSON, STATE OF KANSAS:

Tract 1: Part of the Southwest fractional 1/4 of Section 30, Township 11 South, Range 19 East of the 6th P.M., Jefferson County, Kansas, described as follows: Beginning at a point on the South line of the Southwest fractional 1/4 of said Section 30, which is 20 chains West of the Southeast corner of said quarter section; thence running West 19.21 chains to the West line of said Section 30; thence North 20.50 chains; thence East at right angles to the West line of said section, 19.21 chains; thence South 20.50 chains to the place of beginning.
Tax ID: 044-229-30-0-00-00-007.00-0

Tract 2: The South 9 acres of the North 15 acres of the Northwest 1/4 of the Northeast 1/4 of Section 36, Township 11 South, Range 18 East of the 6th P.M. in Jefferson County, Kansas; AND The North 6 acres of the Northwest 1/4 of the Northeast 1/4 of Section 36, Township 11 South, Range 18 East of the 6th P.M. in Jefferson County, Kansas.
Tax ID: 044-237-36-0-00-00-003.00-0

Tract 3: All that part of the West 1/2 of the Southwest 1/4 of Section 25, Township 11 South, Range 18 East of the 6th P.M. in Jefferson County, Kansas, lying East of Survey 20, Kaw Half Breed Indian Lands, and known as Lot 1; AND a tract described as follows: Beginning at the Southeast corner of said Lot 1; thence North 160 rods to the North line of the Southwest 1/4 of Section 25; thence East 149.5 rods; thence South 160 rods to the South line of Section 25; thence West 149.5 rods to the place of beginning. Except a parcel of land located in the South Half of Section 25, Township 11 South, Range 18 East of the 6th P.M., Jefferson County, Kansas, described as follows: Commencing at the South quarter corner of said Section 25; thence North 90°00'00" West, assumed bearing, along the South line of said Section 25, a distance of 288.95 feet for the Point of Beginning; thence continuing North 90°00'00" West along the South line 425.00 feet; thence North 00°00'00" East, 513.00 feet; thence North 90°00'00" East parallel with said South line, 425.00 feet; thence South 00°00'00" East, 513.00 feet to the point of beginning.
Tax ID: 044-237-25-0-00-00-014.01-0

Memorandum of Understanding between
The Nature Conservancy
and Evergy

This Memorandum of Understanding ("MOU") is entered into this 18th of March, 2024, between Evergy Kansas Central, Inc. ("Partner"), an investor-owned utility, established under the laws of Kansas with its principal place of business at 818 South Kansas Avenue, Topeka, Kansas 66612, USA, and The Nature Conservancy ("TNC"), a Kansas, USA, non-profit corporation with its principal place of business at 4920 Bob Billings Parkway, Lawrence, Kansas 66049, USA.

Partner's mission includes an objective on producing, transmitting and delivering reliable, affordable, and sustainable energy for the benefit of our customers and stakeholders. TNC's mission is to conserve the lands and waters on which all life depends. The parties wish to work together for the promotion of agrivoltaics as part of the responsible and scalable renewable energy deployment in Kansas.

1. **OBJECTIVES.** The objective of this MOU is to document a potential mutual collaboration, with the purpose of demonstrating TNC's intent in assisting the implementation of an agrivoltaics project at Kansas Sky Energy Center (KSEC) located in Douglas County, KS with the aim of increasing and promoting knowledge of successful agrivoltaics practices. The goals and responsibilities of TNC described herein are conditioned on and subject to (a) issuance of a conditional use permit to Partner from Douglas County Board of Commissioners and (b) subsequent TNC formal corporate approval of the engagement following TNC's Principles of Corporate Engagement; (c) agreement on terms of a definitive contract outlining specific responsibilities, terms and conditions ("Definitive Agreement").

2. **GOALS AND CONTROL MEASURES.**

PRIMARY GOALS

a) Through agrivoltaics research and demonstration, TNC will develop replicable and scalable resources supporting the clean energy transition with responsible land use.
b) Outcomes associated with the primary goal include:
    1) Measurable and replicable results for both agricultural producers and utility-scale solar project operators.
    2) Agricultural production research that would provide techniques, inputs, and yields for various types of agriculture, including those most likely to be applied in areas of future renewable deployment.
    3) Develop research that would demonstrate access controls, lease and legal agreements (on owned and leased acreage), engineering modifications, and payment rates suitable for profitable but responsible agrivoltaic sites at KSEC.

AUXILIARY GOALS

a) Support the deployment of the KSEC as a valuable clean energy asset to the region and enhance the regenerative food systems of Douglas County, KS.
b) Ensuring that the agrivoltaics operations do not interfere with the successful operation of the KSEC.
c) Ensuring that local markets, producers, and communities are benefited and utilized throughout the execution.

CONTROL MEASURES

a) An advisory group comprising of stakeholders representing at least the county, the Partner, TNC, local agriculture, industry experts, and researchers would be established to approve and oversee the project's strategic direction.
b) Given the size proposed for this agrivoltaic project, there would be no predetermined set minimum or maximum acres. Rather, acreage would be incorporated into the project as called for by the implementation plan and with consideration to the uncharted nature of agrivoltaics on leased land as a research area.
c) The primary and auxiliary goals would serve as the guidelines for the selection of agriculture methods and practitioners for the project. Given the lack of existing field studies of this size, these decisions should remain otherwise free from external pressure to ensure reliable and usable results.

3. **WORKFLOW TIMELINE.** Following Douglas County Board of County Commissioners Conditional Use Permit approval TNC and Partner shall begin negotiations on a mutually acceptable the Definitive Agreement and, upon execution of the Definitive Agreement, begin development of an implementation plan in Q3 of 2024.

4. **RESPONSIBILITIES OF THE PARTIES.** This section sets forth the parties' intentions with respect to the expected activities under the Definitive Agreement. Each party's responsibilities shall be fulfilled within the bounds of its available resources, budget, and procedures, as determined in the Definitive Agreement.

a) TNC will be responsible for:

(1) making its personnel available for the implementation of actions for which TNC is responsible, as set forth in the implementation plan;
(2) presenting a strategic agenda, programs, and projects, aiming at identifying joint agendas and possibilities for cooperation with the Partner; and
(3) providing equipment, infrastructure, human resources, and services necessary for the execution of the proposed actions, as specified in the implementation plan.
(4) providing reporting requirements which shall align with the CONDITIONS OF APPROVAL AND CONDITIONS AND RESTRICTIONS OF USE of the Conditional Use Permit

b) Partner will be responsible for:

(1) Contributing to the development of the implementation plan together with TNC and other possible partners and participants;

(2) providing technical support, logistics, and infrastructure necessary for full implementation of the proposed activities, established in the respective agreed-upon implementation plan; and

(3) providing equipment, infrastructure, human resources, and services necessary for the execution of the proposed actions, as specified in the implementation plan.

5. PRINCIPAL CONTACTS. The principal contact for each party will be:

For Partner:
Jason Humphrey
Vice President Development
818 South Kansas Avenue, Topeka, Kansas 66612
785-575-8132
Jason.Humphrey@Evergy.com

For TNC:
Ben Postlethwait
State Director, Kansas
PO Box 4345, Topeka, Kansas 66604
785-233-4400
Ben.postlethwait@tnc.org

Each party may change its principal contact at any time by written notice to the other party.

6. TERM. This MOU will begin upon signature by both parties and will remain in effect until the earlier of (a) denial of a Conditional Use Permit from Douglas County Board of Commissioners, (b) execution by the parties of the Definitive Agreement or (c) November 15, 2024, unless sooner terminated as provided herein. Any extension of the term must be in writing and signed by the parties.

7. TRANSFER OF FUNDS. This MOU does not obligate either party to provide financial support of any sort. As a tax exempt charity, TNC must receive fair value for services provided to private companies. Such compensation shall be determined and incorporated into the Definitive Agreement.

8. TERMINATION. Either party may terminate this MOU by giving thirty (30) days written notice to the other party.

9. INTELLECTUAL PROPERTY.

a) Title and use of intellectual property shall be determined and described in the Definitive Agreement. This MOU gives no rights any intellectual property of either party, including the names and logos of the parties, which may not be used for any purpose without the prior express written permission of the owners. Notwithstanding the foregoing, Partner may indicate to the Douglas County Board of Commissioners of TNC's intent to perform the services described herein, subject to County and TNC formal approval.

10. POLITICAL CAMPAIGN INTERVENTION PROHIBITION. The parties agree not to directly or indirectly participate or intervene in any political campaign on behalf of or in opposition to any Candidate for public office or any political party in any election, at any level of government, anywhere in the world. This means that any activity that could help or hurt the chances for election of any Candidate, group of Candidates, or any political party is prohibited. A "Candidate" is any individual who offers him/herself, or is proposed by others, as a contestant for an elective public office.

11. CONFIDENTIALITY. During the course of the performance of this MOU, the parties may have access to materials, data, strategies, systems, or other information relating to the other party and its programs which is intended for internal use only. Any such information shall not be used, published, or divulged to any individual or corporation, in any manner or for whatever purpose, except through the party's previous written permission, which may be withheld by the respective party at its sole discretion.

12. OTHER PARTNERS. This MOU does not preclude the parties from establishing similar agreements or contracts with other individuals, entities, agencies, and public or private organizations. The parties recognize the importance of continuing to cooperate and work with other partners in programs of mutual interest and to be able to, by means of a written document signed by both parties, invite other partners to participate in the activities implemented under this MOU.

13. [Reserved].

14. NO JOINT VENTURE. The parties agree that they are not entering into a legal partnership, joint venture or other such business arrangement, nor is the purpose of the parties to enter into a commercial undertaking for monetary gain. Neither party will refer to or treat the arrangements under this MOU as a legal partnership or take any action inconsistent with such intention.

15. DISPUTE RESOLUTION. The parties hereby agree that, in the event of any dispute relating to this MOU, they shall first seek to resolve the dispute through informal discussions. If a dispute cannot be resolved informally within sixty (60) consecutive working days, the parties agree to terminate this MOU.

16. LIABILITY. Each party shall be solely responsible and liable for the actions or omissions of its own employees, agents, and representatives involved with the activities contemplated under this MOU, including any related damages, losses and claims to or by third parties. Nothing herein shall be construed as creating joint or several liability between the parties.

17. ASSIGNMENT. Neither party may assign or transfer its rights and obligations under this MOU without the prior written consent of the other party.

18. COMPLIANCE WITH LAWS. The parties will observe all applicable laws and regulations during the execution of the work implemented under the provisions of this MOU.

19. AMENDMENTS. This MOU, including any material modification to Section 2, may only be modified by a written amendment signed by both parties.

IN WITNESS WHEREOF, the parties have executed this Memorandum of Understanding, effective as of the last date written below.

FOR Evergy Kansas Central, Inc.

DocuSigned by:
Jason Humphrey
0D22279D46074DA...

Jason Humphrey
Vice President Development

3/18/2024

Date

FOR THE NATURE CONSERVANCY

DocuSigned by:
Ben Postlethwait
5AA5636CAD5049A...

Ben Postlethwait
State Director, Kansas

3/18/2024

Date

BURNS McDONNELL

FREE STATE SOLAR PROJECT, LLC

ENVIRONMENTAL SOUND STUDY

KANSAS SKY ENERGY CENTER

PROJECT NO. 147658

REVISION 0

FEBRUARY 2024

CONTENTS

TABLES

List of Abbreviations

Abbreviation	Term/Phrase/Name
CadnaA	Computer Aided Noise Abatement
dB	Decibels
dBA	A-weighted decibels
Developer	Free State Solar Project, LLC
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
Hz	Hertz
HVAC	Heating ventilation and air conditioning
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization of Standardization
L_{eq}	Equivalent sound level
MW	Megawatt
MVA	Megavolt-ampere
NEMA	National Electrical Manufacturers Association
Project	Kansas Sky Energy Center
PV	Photovoltaic
PWL	Sound power level
SPL	Sound pressure level

1.0 Executive Summary

Burns & McDonnell conducted an environmental sound study for the Kansas Sky Energy Center located in Douglas County, Kansas (Project). The Project is being developed by Free State Solar Project, LLC (Developer), who plans to install a new 159-megawatt (MW) solar energy plant consisting of multiple arrays of photovoltaic (PV) panels, inverters, transformers, switchgear, and associated equipment.

The objectives of this sound study were to:

- Identify state and local sound level regulations that are applicable to the Project
- Develop a model to estimate Project-generated sound levels in the surrounding community
- Establish whether the Project will meet the identified noise requirements

There are no State of Kansas sound level limits applicable to the Project. However, there are local sound level limits for Douglas County specific to utility scale solar energy conversion systems. Douglas County limits the Project to 60 A-weighted decibels (dBA) at the property lines. Modeling results show that the Project as designed is predicted to meet the Douglas County sound level limits along the Project property lines. The following sections discuss the sound study methodology and modeling results in further detail.

2.0 Acoustical Terminology

The terms “noise level” and “sound level” are often used to describe two different sound characteristics: sound power and sound pressure. Every source that produces sound has a sound power level (PWL). The PWL is the acoustical energy emitted by a sound source and is an absolute number that is not affected by the surrounding environment. The acoustical energy produced by a source propagates through media as pressure fluctuations. These pressure fluctuations, also called sound pressure levels (SPL), are what human ears hear and microphones measure.

Sound is physically characterized by amplitude and frequency. The amplitude of sound is measured in decibels (dB) as the logarithmic ratio of a sound pressure to a reference sound pressure (20 micropascals). The reference sound pressure corresponds to the typical threshold of human hearing. To the average listener, a 3-dB change in a continuous broadband sound is generally considered “just barely perceptible”; a 5-dB change is generally considered “clearly noticeable”; and a 10-dB change is generally considered a doubling (or halving, if the sound is decreasing) of the apparent loudness.

Sound waves can occur at many different wavelengths, also known as the frequency. Frequency is measured in hertz (Hz) and is the number of wave cycles per second that occur. The typical human ear can hear frequencies ranging from approximately 20 to 20,000 Hz. Normally, the human ear is most sensitive to sounds in the middle frequencies (1,000 to 8,000 Hz) and is less sensitive to sounds in the lower and higher frequencies. As such, the A-weighting scale was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighting scale emphasizes sounds in the middle frequencies and de-emphasizes sounds in the low and high frequencies. Any sound level to which the A-weighting scale has been applied is expressed in A-weighted decibels, or dBA. The C-weighting scale (dBC) is commonly used for sources with a low-frequency component that would be de-emphasized by the A-weighted scale. For reference, the A-weighted sound pressure level and subjective loudness associated with some common sound sources are listed in Table 2-1.

Sound in the environment is constantly fluctuating, as when a car drives by, a dog barks, or a plane passes overhead. Therefore, sound metrics have been developed to quantify fluctuating environmental sound levels. These metrics include the exceedance sound level. The exceedance sound level is the sound level exceeded during “x” percent of the sampling period and is also referred to as a statistical sound level. Common exceedance sound level values are the 10-, 50-,90-percentile exceedance sound levels, denoted by L_{10}, L_{50}, and L_{90}. The equivalent-continuous sound level (L_{eq}) is the arithmetic average of the varying sound over a given time period and is the most common metric used to describe sound.

Table 2-1: Typical Sound Pressure Levels Associated with Common Sound Sources

Sound Pressure Level (dBA)	Subjective Evaluation	Environment
140	Deafening	Jet aircraft at 75 feet
130	Threshold of pain	Jet aircraft during takeoff at a distance of 300 feet
120	Threshold of feeling	Elevated train
110	Very loud	Jet flyover at 1,000 feet
100		Motorcycle at 25 feet
90	Moderately loud	Propeller plane flyover at 1,000 feet
80		Diesel truck (40 mph) at 50 feet
70	Loud	B-757 cabin during flight
60	Moderate	Air-conditioner condenser at 15 feet
50	Quiet	Private Office
40		Farm field with light breeze, birdcalls
30	Very quiet	Quiet residential neighborhood
20		Rustling leaves
10	Just audible	--
0	Threshold of hearing	--

Sources:
(1) Adapted from *Architectural Acoustics*, *M. David Egan, 1988*
(2) *Architectural Graphic Standards*, Ramsey and Sleeper, 1994

3.0 Applicable Regulations

Burns & McDonnell reviewed Federal, State, and local level ordinance documentation to determine the noise requirements applicable to the Project. The Project is located in Douglas County, Kansas. The following sections include regulatory noise information that was found as part of the review and indication on its applicability to the Project.

3.1 Federal

The Noise Control Act of 1972 mandated a national policy "to promote an environment for all Americans free from noise that jeopardizes their health or welfare, to establish a means for effective coordination of federal research activities in noise control, to authorize the establishment of federal noise emission standards for products distributed in commerce, and to provide information to the public respecting the noise emission and noise reduction characteristics of such products." As required by the Act, the Environmental Protection Agency ("EPA") published *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety* in 1974. EPA phased out the Office of Noise Abatement and Control in 1982, transferring the primary responsibility of regulating noise to state and local governments. The Noise Control Act can be used as guidance, but is not an enforceable regulation. As a result, there are no applicable Federal sound level limits.

3.2 State of Kansas

The State of Kansas does not have state-wide noise limits applicable to this Project.

3.3 Douglas County, Kansas

The Douglas County Code of Ordinances, Chapter 12, Section 306-49.05(n)[1] limits noise from Commercial/Utility Scale Solar Energy Conversion System. The Code states, "the operational noise generated from the solar installation equipment, including inverters, battery energy storage systems, components, and associated ancillary equipment shall not exceed a noise level of 60 dBA as measured the property line or 500 feet from an existing residence." The design goal for the Project is to meet 60 dBA at all Project property lines that abut non-participating landowner properties.

[1] https://www.douglascountyks.org/sites/default/files/media/depts/administration/pdf/chapter-12-zoning-and-land-use-regulations.pdf (last accessed 6/13/2023).

4.0 Predictive Noise Modeling

The Project consists of noise emitting equipment in the form of inverters and transformers. To estimate future Project sound levels, the sound sources were input into a predictive model and sound levels generated by the Project were projected out to the property lines and surrounding community.

4.1 Methodology

Predictive noise modeling was performed using the industry-accepted sound modeling software CadnaA, version 2023. The software is a scaled, three-dimensional program, which considers air absorption, terrain, ground absorption, and reflections and shielding for each piece of noise-emitting equipment, and then predicts sound pressure levels at discrete locations and over a gridded area based on input source sound levels. The model calculates sound propagation based on International Organization for Standardization (ISO) 9613-2:1996, General Method of Calculation. ISO 9613-2 assesses the sound level propagation based on the octave band center-frequency range from 31.5 to 8,000 Hz.

The ISO standard considers sound propagation and directivity. The sound-modeling software calculates omnidirectional, downwind sound propagation using worst-case directivity factors, in tandem with user-specified directivities and propagation properties. Empirical studies accepted within the industry have demonstrated that modeling may over-predict sound levels in certain directions, and as a result, modeling results generally are considered a conservative measure of the Project's actual sound level.

The modeled atmospheric conditions were assumed to be calm, and the temperature and relative humidity were left at the program's default values. Reflections and shielding were considered for sound waves encountering physical structures. The area surrounding the Project has mild elevation changes, which scatter and absorb the sound waves. Thus, terrain was included to account for surface effects such as ground absorption. Farm fields are generally considered soft, absorptive ground, and would have a high ground absorption factor. To be conservative, only half the available absorption was considered, and the model's ground absorption factor was set to 0.5 for the Project and surrounding areas. The sound modeling parameters used in the model are outlined in Table 4-1.

Table 4-1: Sound Modeling Parameters

Model Input	Parameter Value
Ground Absorption	0.5
Number of Reflections	2
Foliage	None
Receptor Height	5 feet above grade
Terrain	USGS topographic land data
Temperature	50 °F
Humidity	70%

4.2 Project Equipment

Project transformers and inverters are the major sound sources associated with the Project. The Project transformers sound levels were derived from the use of historical transformer data and the National Electrical Manufacturers Association ("NEMA") *TR 1-2013: Transformers, Step Voltage Regulators and Reactors*. It is anticipated that transformers for this Project can be specified to a maximum 2nd stage of cooling average sound pressure level of 75 dBA. This sound pressure level, according to Institute of Electrical and Electronics Engineers ("IEEE") Standard C57.12.90, is an average of measurements along the equipment envelope, 6 feet from the cooling fans and 1 foot from the tank. Specific vendor data may demonstrate a transformer of the same specification that is considerably quieter (i.e., this analysis provides conservative modeling predictions).

The power conversion skids consist of the inverter, medium voltage transformer, and other associated equipment. The power conversion skids (SMA Sunny Central) were provided with acoustic test data. The average sound level measured on the sides of the unit is 67 dBA at 10 meters, as provided in the equipment specifications sheet. The modeled sound levels for the noise emitting equipment included in the Project are listed below in Table 4-2.

Table 4-2: Project Equipment Sound Levels

Source	Number of Sources	Sound Pressure Level per Source	Sound Level per Source[a]
PV Power Conversion Skid	41	67 dBA at 10 meters	98 dBA
Substation Transformer	2	75 dBA per NEMA	95 dBA

* dBA – A-weighted decibels, NEMA – National Electrical Manufacturers Association

(a) Sound power levels are estimated based on the sound pressure level and dimensions of the unit.

4.3 Sound Modeling Results

Project sound levels were modeled to show the noise propagation in the surrounding community from the Project. Transformers and power conversion skids were modeled based on general arrangement drawings provided by the Developer. As modeled, the Project includes 41 PV power conversion skids and two (2) substation transformers. The Project layout is depicted in Figure A-1 of Appendix A.

The maximum Project sound levels occur during solar inverters full load. A graphical representation of the model layout and sound level contours generated by the Project during the loudest operating scenario (i.e., all sources operating at maximum sound levels) is provided in Figure A-2 of Appendix A. The contours are shown in 5-dB sound level increments and represent the Project-generated sound levels only (i.e., no existing ambient sound levels). The maximum Project-generated sound level at the Project property line is below 60 dBA. Sound levels are predicted to be significantly less at property line locations farther from the Project sound sources. As can be seen in Figure A-2, the majority of Project property lines around the PV portion of the Project have sound level impacts below 45 dBA, which is significantly below the design goal of 60 dBA.

During nighttime hours, when the sun is no longer shining and the Project is not generating power, Project sound levels from the PV portion of the Project would be less than those shown in the figures in Appendix A. The substation transformers would remain energized during

nighttime hours, but sound levels would generally be less than those emitted during peak power generation.

5.0 Construction Noise

Project construction will generate noise that may periodically be audible offsite. Construction of the proposed Project is expected to involve limited site clearing and solar panel erection, which each use various types of construction equipment. Although construction will intermittently generate the types and levels of sound common at large construction sites, it will not feature many of the most significant sound-generating activities common during construction of other facilities. The Project will not involve extensive excavation or other earth-moving work or, with the exception of the Substation, construction of large foundations. A solar plant only involves the installation of the mounting posts for the panel racks. Driving the mounting posts is essentially a small-scale pile driving operation that produces a repetitive, metallic pounding noise, may be audible offsite. The primary sources of construction noise will be associated with heavy-duty equipment operation.

Although numerous piles will be driven, they likely will be only driven to a shallow depth and the activity will be relatively brief at any particular location. This activity is short-lived and would proceed fairly quickly, only occurring for a period of days or a couple weeks at any one location. Blasting is not expected and any rock-breaking activities using conventional construction equipment are expected to be limited. In any event, such activities would be very limited in any particular location and of limited duration.

Pile-driving will be avoided during early and late hours and will involve smaller machines that repeatedly “tap” galvanized steel I-beams through about 10 feet of soil and earth. These are not the large pile drivers associated with major construction projects such as bridges and high-rise buildings that “drive” or “pound” large pilings, typically made of iron, deeply through earth and rock. The erection of structures and components will require almost exclusively standard construction vehicles and hand tools.

Noise levels resulting from construction equipment are dependent on several factors, including the number and type of equipment operating, the level of operation, and the distance between sources and receptors. The impacts that various construction-related activities might have will vary considerably based on the proximity to the Project boundary. Construction noise levels associated with the Project could be greater than ambient conditions for some receptors close to the Project.

During a typical day, equipment would not be operated continuously at peak levels. While the average noise levels would represent a noticeable temporary increase over the ambient noise levels near the construction sites, the noise would attenuate with increasing distance, fading into ambient noise background levels at greater distances from the loudest equipment. Generic sound data ranges are available for various types of equipment at certain distances. Table 5-1 lists generic activities and their minimum and maximum instantaneous sound levels at 50 feet as provided in the Federal Highway Administration (FHWA), Highway Construction Noise handbook and the Federal Transit Administration (FTA), Transit Noise and Vibration Impact Assessment Manual. It should be noted that the FHWA and FTA describe noise from large pile drivers that are significantly louder than the smaller pile drivers used for this Project. The Project pile drivers are expected to operate at or below the provided minimum noise level at 50 feet, for pile drivers provided in the table.

Table 5-1: Range of Typical Construction Equipment Noise Levels

Generic Construction Equipment	Minimum / Maximum Noise at 50 feet (dBA)	Average Noise at 500 feet (dBA)[a]
Backhoes	74 / 92	63
Concrete Mixers	76 / 88	62
Cranes (movable)	70 / 94	62
Front Loaders	77 / 96	67
Graders	72 / 91	62
Pile Driver[b]	96 / 101	79
Scrapers	76 / 95	66
Trucks	83 / 96	70

Source: Values taken from FHWA Highway Construction Noise handbook and the Federal Transit Administration, Transit Noise and Vibration Impact Assessment Manual, 2006
(a) Average of the minimum and maximum sound levels projected out to 500 feet.
(b) Pile driver sound levels provided are associated with larger pile drivers than those typically used in solar panel erection.

Sound levels are expected to be lower in areas where activities are occurring at distances greater than 50 feet from the construction zone. The types of equipment listed in the table above may be used at various times and for various periods of time. Typically, construction equipment has a usage factor ranging between 15 and 50 percent of the day, according to the FHWA roadway construction noise handbook. However, the actual amount of use for each type of equipment would vary day to day.

5.1 Construction Noise Mitigation

Noise from construction equipment will be temporary during construction of the Project. The construction contractor selected is expected to implement, where appropriate, construction methods that limit construction noise levels to the extent practicable. Construction is anticipated to occur during typical work hours. There may be times that work needs to be accomplished in part outside of typical working hours. Such work generally consists of activities that must occur continuously once begun (e.g., a concrete pour or transformer oil filling).

Additionally, most construction activities will not occur simultaneously at any location. Construction noise will mostly be audible near the construction activities. Construction noise mitigation measures that could be implemented include the following actions:

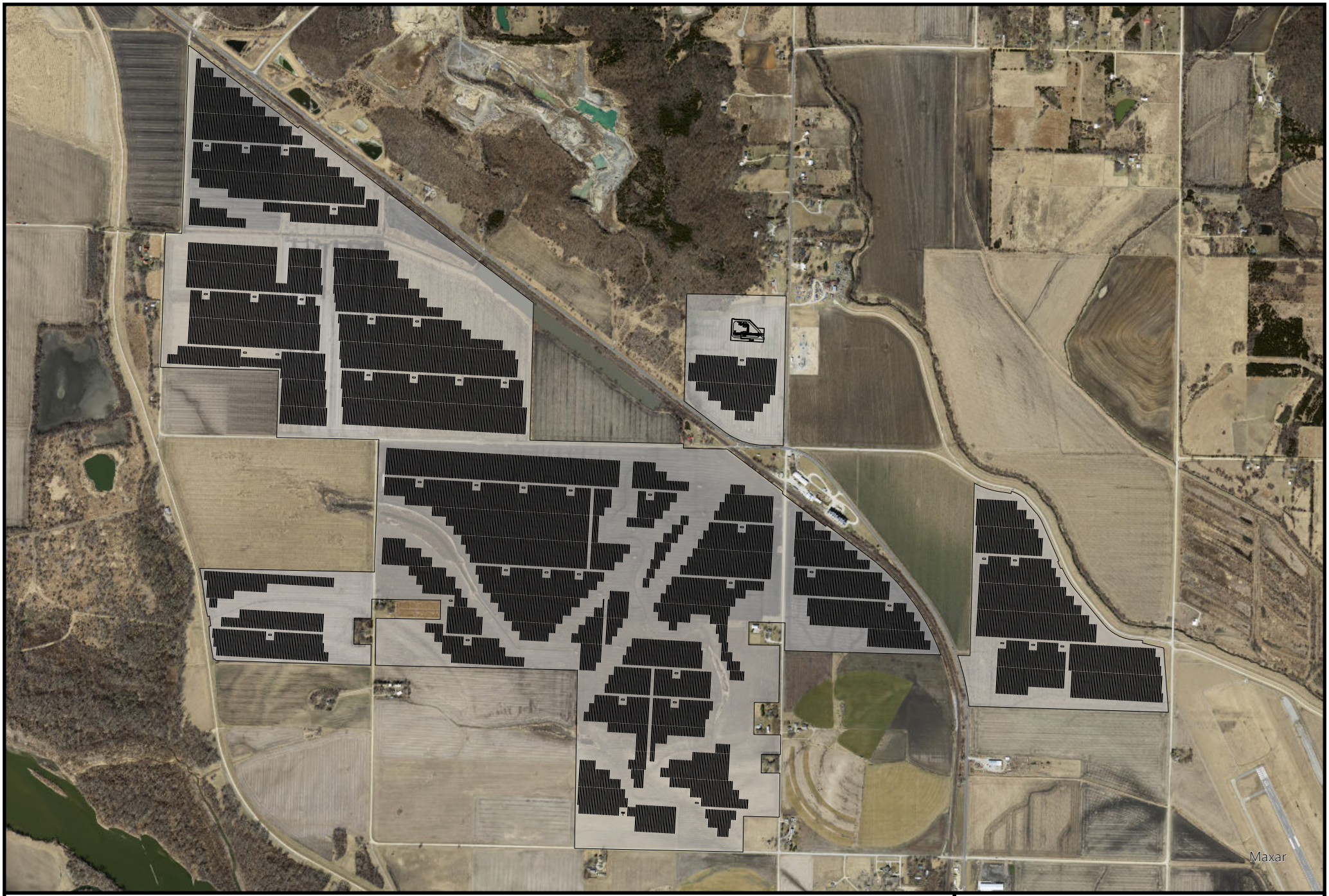
1. Limit construction activities to daytime hours;
2. Maintain construction-related vehicles in proper working condition;
3. Utilize construction equipment with proper mufflers;
4. Turn off idling equipment when not in use; and
5. Work with the local community to advise residents of those periods when sustained construction activity is expected to take place in proximity to their homes.

The construction phase of a solar energy facility is fairly short and the activities that generate any significant noise are few. Due to the temporary nature of the construction activities, and best practices with regards to controlling construction noise in the directions of noise sensitive areas, no adverse impacts with respect to construction noise are anticipated.

6.0 Conclusions

Burns & McDonnell conducted an environmental sound study of the Kansas Sky Energy Center proposed to be located in Douglas County, Kansas. The Project will consist of multiple arrays of PV panels, power conversion skids, transformers, and associated equipment. The proposed Project sound levels were modeled using industry-accepted sound modeling software to predict future sound levels at the property lines and in the surrounding community. Project transformers and power conversion skids are expected to be the significant sound-emitting sources associated with the Project. Sources were modeled based on Developer-provided general arrangement drawings. Modeling results show that the Project sound levels are predicted to meet the Douglas County sound level limits for solar energy conversion systems of 60 dBA along the Project property lines.

APPENDIX A – FIGURES



LEGEND

Project Area

Project Layout

REFERENCE

0 0.2 0.4

MILES

0 0.25 0.5

KILOMETERS

N

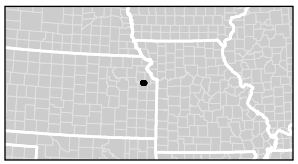


Figure A-1
Project Layout

LOCATION:	Douglas County, KS
CLIENT:	Free State Solar Project, LLC
PROJ. NO.:	147658
CREATED:	07/26/2023

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Path: Z:\Clients\ENS\Savion\LLC\147658_FreeStateStudies\Modeling\Noise\GIS\Savion Free State Figures\Savion Free State Figures.aprx • Coordinate System: • Units:

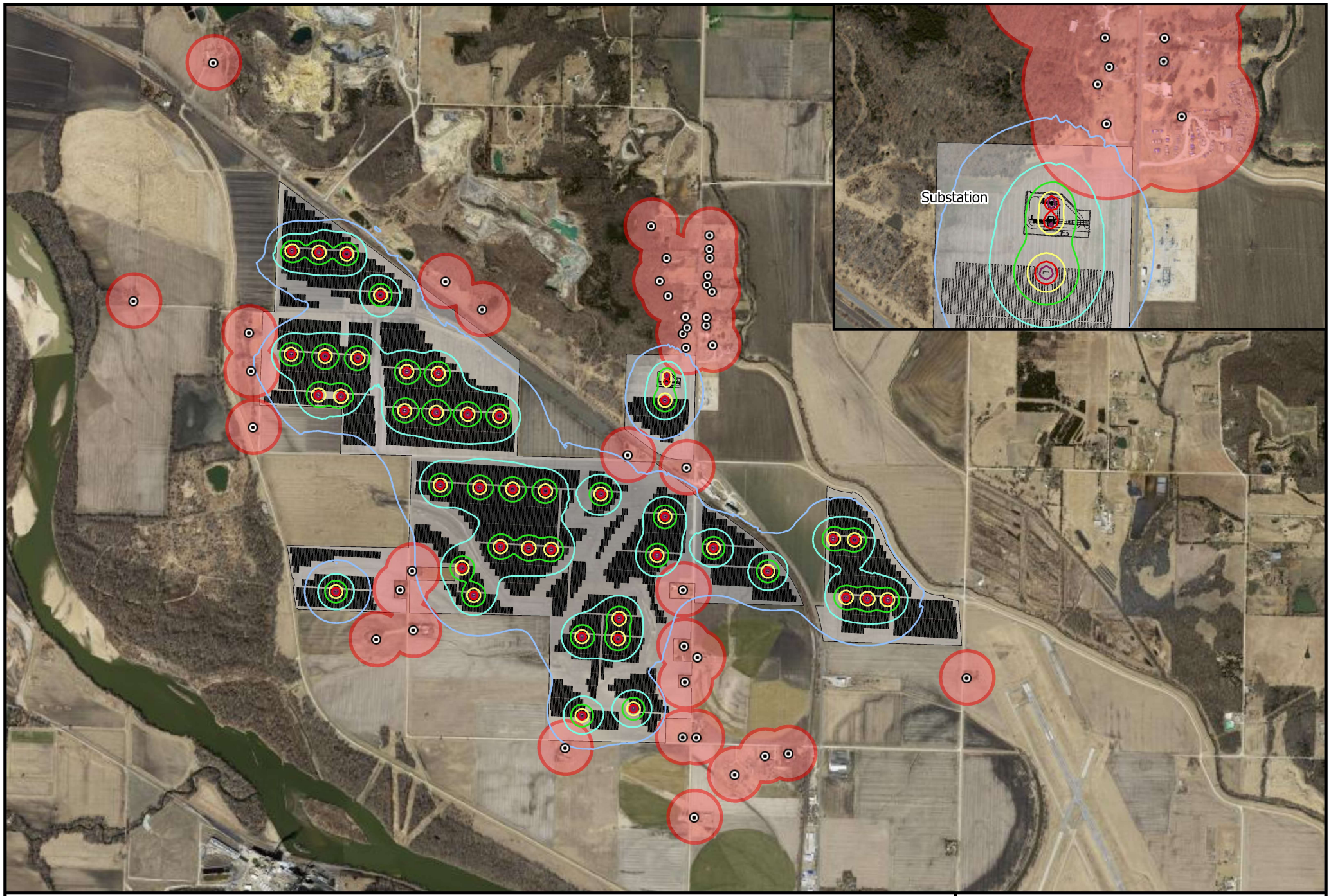

Figure A-2
Sound Level Contours

LOCATION:	Douglas County, KS
CLIENT:	Free State Solar Project, LLC
PROJ. NO.:	147658
CREATED:	08/09/2023

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Memorandum
City of Lawrence/Douglas County
Planning & Development Services

TO: **Douglas County Board of County Commissioners**

FROM: **Mary Miller, Planner**

Date: **March 27, 2024**

RE: **CUP-23-00312; Conditional Use Permit application for Commercial/Utility Scale Solar Energy Conversion System**

Attachments:
Attachment A: Protest Petition Certification

Planning Commission Vote and Protest Petition
The Planning Commission considered the conditional use permit referenced above at their December 18, 2023 meeting. The Commission's vote was tied and did not achieve the majority required to recommend approval or denial of the application. Per Section 12-307-2.05(c) of the Zoning Regulations, if the Planning Commission fails to make a recommendation on a conditional use, the Planning Commission shall be deemed to have made a recommendation of denial. A protest petition provided for this item was determined by the County Clerk to be a valid petition; therefore, a unanimous vote of the Board of County Commissioners is required for approval.

Revised Conditions
Following the Planning Commission meeting, staff and the applicant met several times to discuss the recommended conditions listed in the staff report. As a result of these discussions, the conditions being provided to the Board of County Commission have been revised from those in the staff report. These changes were necessary primarily due to the complicated nature of the review and the scale of the proposed facility. In staff's opinion, the revised conditions provide greater clarity and specificity.

This memo provides the revised conditions that were discussed by the Planning Commission at their December 18th meeting, along with staff comments.

The revised conditions that have been developed by staff in coordination with the applicant are also included with this memo. Each revised condition is followed by staff's comment on the reason for the revision.

REVISED CONDITIONS DISCUSSED BY THE PLANNING COMMISSION

New language is noted in **bold** and deleted language is shown as ~~struckthrough.~~
Staff comments follow in red.

Condition 1.c.

The Decommissioning, and Reclamation Plan shall be revised to note the piles will be installed to a depth of 6 feet and that they will be completely removed by being pulled up when decommissioned.

Staff Comment: The Planning Commission felt that the galvanized piers should not remain following decommissioning. The applicant noted they would drive them approximately 6 feet deep and would remove them by pulling them out. This condition places a limit of 6 feet on the depth of the piers and requires that they be removed completely when the facility is decommissioned.
(This condition is in the revised conditions in the agenda packet, but has been revised slightly to remove the information on the depth of the piles as that wouldn't be part of the decommissioning.)

Condition 2.c.

Limit on construction activity: ~~Construction activities shall occur during daytime hours.~~

i. ~~The driving of the steel piles shall occur only between the hours of 8AM and 8PM, Monday through Friday.~~ **All construction activity and traffic shall occur only between the hours of 7 AM and 6 PM, Monday through Saturday.**

ii. Any solid waste produced by construction activities shall be disposed of in accordance with Douglas County's Chapter 10: Solid Waste Management Code.

Staff Comment: The Planning Commission felt more limited hours were appropriate for the construction activities than staff had recommended.
(This condition was further revised in the revised conditions in the agenda packet.)

Condition 2.e.

If the solar panels create hazardous or unreasonable glare not adequately contemplated by the Solar Glare Hazard Analysis, additional glare reducing measures, as described in Section 12-306-49.05.f ~~may~~ **shall** be implemented to limit glare.

Staff Comment: The Planning Commission indicated that the glare reducing measures should be a requirement and changed the wording from 'may' to 'shall'.
(This condition is in the revised conditions in the agenda packet.)

Condition 2.n.

The sound level generated by the facility shall not exceed 60 dBA (decibels) at the property line **or 500 feet from an existing residence**

(building permit plans have been submitted or the residence is on-site at time of conditional use permit approval.)

Staff Comment: The Planning Commission corrected an omission with this condition. This language was provided in the regulations.
(This condition is in the revised conditions in the agenda packet.)

Condition 2.v.iii.

The operator shall reimburse Grant Township for any increase in the cost of the contract with the Lawrence-Douglas County Fire Department that results from fire protection activities due to this facility.

Staff Comment: In staff's opinion, this would not be a condition of the conditional use permit, but should be worked out between the Township, the County, and the fire department.
(This condition is not included in the revised conditions in the agenda packet.)

Condition 2.z.

v. Bond Requirement. **The applicant shall post a bond, with the Douglas County Clerk, establish an escrow account, or provide such other financial security deemed acceptable by the County, in an amount equal to the estimated decommissioning costs, to ensure proper decommission and reclamation of the site.**

i. **The County shall contract with an independent third party for estimated decommissioning and reclamation costs, at the applicant's expense.**

Staff Comment: The full language from the regulations was added to the condition for clarity.
(This condition is in the revised conditions in the agenda packet.)

Condition 2.aa.
Ground water analysis

i. **An optional water analysis of active wells within one-quarter mile of the site area shall be offered by the operator prior to the installation of the equipment. The offer shall be made to all owners of property within ¼ mile of the site area by certified mail, at least one-month prior to the installation.**

ii. **A copy of the certified letter and a list of property owners notified shall be provided to the Planning office along with a list of all property owners who requested the testing and the results of that testing. This must occur prior to the installation of the facility.**

iii. **The test shall analyze the water in the nearby wells for substances such as lead and cadmium, as determined with the conditional use permit, and shall include a pesticide panel.**

iv. **The results of ground water testing shall be provided to the Director of zoning and Codes and sent by certified mail to the landowner.**

Staff Comment: The Planning Commission corrected an omission with this condition. This language was provided in the regulations.
(This condition is in the revised conditions in the agenda packet.)

Condition 2.bb.
Groundwater monitoring

i. Groundwater monitoring for zinc levels shall occur pre-construction and with construction.

Staff Comment: The Planning Commission suggested this condition based on another item which was on the agenda. Zinc pollution from solar energy conversion systems has not been determined to be an issue and groundwater monitoring is not currently required.

(Groundwater monitoring is not required by the Zoning Regulations. This condition is not in the revised conditions in the agenda packet.)

PROPOSED REVISIONS TO CONDITIONS
New language is noted in **bold** and deleted language is shown as ~~struckthrough.~~
Staff comments follow each revision, in red.

1. The applicant shall provide revised plans with the following changes:
   a. The Proposed Conditions Site Plan shall be revised with the following changes:
      i. Setbacks for each parcel shall be noted and labeled on each parcel, as shown and noted in the graphic included in Section i of Appendix A, Code Review, of this report.
      ii. Off-street parking spaces shown for the operation and maintenance building shall be dimensioned with a note that the parking area and access drive shall be paved.
      iii. The location of all exterior lighting shall be shown. If the lights face roadways or developed residential properties, angled lighting fixtures may not be used; the light fixtures would need to be installed perpendicular to the pole to avoid off-site glare.
      iv. The landscape option for each adjacent residential buffer shall be noted on the plan.
      v. The approved construction route map shall be included in the plan.

      The construction traffic route map shall show the interior access drives in blue, to avoid confusion with the restricted routes which are shown in red.

   Staff Comment: This revision clarifies that the construction route map must be approved and included as part of the plan. The technical change in the second paragraph was relocated and is not new language.

      vi. The Decommissioning, and Reclamation Plan shall be revised to note the following:

         1. The piles shall be completely removed by being pulled up when decommissioned.

   Staff Comment: This revision was discussed by the Planning Commission. It is intended to ensure that galvanized metal piles will not remain when the project has been decommissioned.

         2. A new road maintenance agreement, including the route map, shall be executed by the Operator and the applicable governing bodies prior to the commencement of decommissioning.

   Staff Comment: This condition is based on the fact that road conditions in the area could be quite different when the project is decommissioned and

the original road maintenance agreement and route map may no longer be appropriate.

vii. The Plan shall list the approved Conditions and Restrictions of Use.

b. The Operator shall execute a road maintenance agreement with the governing bodies of Douglas County and Grant Township prior to the issuance of the CUP permit.

i. The agreement shall contain the approved construction route map.

ii. The agreement shall identify the timing and amount of payments to be made by the Operator to the township or county for increased road maintenance costs resulting from the construction of the project.

iii. The agreement shall identify the designated construction routes to be used for access to the project, the anticipated costs to improve those roadways to support construction access, and the anticipated costs to maintain those roadways during each year of CUP construction.

iv. The agreement shall identify penalties to be assessed if the designated construction routes are not followed.

Staff Comment: This revision provides additional clarity to the requirements of the road maintenance agreement which will be developed after the Board of County Commissioners act on the conditional use permit.

c. **The Operator shall enter into a contract with the Board of County Commissioners to finance any required third-party reviews or inspections required by these conditions.**

Staff Comment: One change with these updated revisions is the addition of several possibilities for third-party reviews. This condition is intended to ensure that the Operator is responsible for financing any required third-party reviews.

d. **The Operator shall obtain Board of County Commissioners approval of a final stormwater management study prior to issuance of the CUP permit. The County engineer will review the study and forward approval recommendations to the Board. The stormwater study for the Project must include calculations and plan documents in sufficient detail to identify:**

i. Stormwater conveyance – the location and required capacity of ditches, channels and culverts carrying concentrated flow from each project area, through the project, and to points of discharge;

ii. Stormwater detention – the location and design of each detention basin proposed to control rates of runoff to predeveloped conditions; and

iii. Analysis of public roadway culverts – at all points of discharge crossing public roadways, provide a review of existing capacity and a preliminary design for necessary replacements.

Staff Comment: The stormwater study will be completed following the County Commission's approval of the conditional use. This condition provides clear expectations for the study, which will be helpful both in the preparation and review of the study.

e. The Operator shall revise the Vegetation Management and Agrivoltaic Plan to outline the various potential phases of agrivoltaics and provide more detailed information on the agrivoltaic activities being proposed.

i. The plan will be provided to the Board of County Commissioners with a staff recommendation for action.

Staff Comment: This change will result in more detailed goals for the agrivoltaic activities.

f. The specific plantings for each landscaped buffer shall be determined with the following process:

i. The applicant shall notify the owners of residences that are adjacent to the project (identified on the plan) through certified mail of the landscape options and the buffer area location. The applicant shall provide Planning with a list of the adjacent property owners, proof of mailing of notification, and property owner's response.

ii. If a response is received within 30 days of the date of mailing, the selected buffer landscaping shall be noted on the plan for that residence. If no response is received within 30 days of the date of mailing, the applicant may select the landscape option for this area based on availability of plants.

2. The following Conditions and Restrictions of Use shall apply to the use:

a. The approval of the Kansas Sky Commercial/Utility Scale Solar Energy Conversion System (CSECS) shall be valid for 25 years from the date of the Board of County Commissioner's approval. Continuation of the use beyond that date will require the submittal and approval of a new conditional use permit.

b. Construction traffic **shall travel only on the approved routes and intersections shown on the approved construction route map. Construction traffic shall not travel on roads identified as restricted routes or intersections.** ~~in the vicinity of the project shall comply with the approved route shown on the construction traffic route map and shall not travel on public roads marked as 'Restricted Route', except that in case of emergency, all public roads shall be available~~.

Staff Comment: Revised for clarity. No change in meaning.

i. The term 'construction traffic' refers to all traffic generated as a result of the construction activity. This includes personnel,

employees, workers and contractors as well as material hauling, deliveries, and heavy equipment, **but excludes traffic occurring in the event of or due to an emergency involving life, health or safety.**

~~ii. Any deviation from the approved route made necessary by an emergency shall be reported to the Director of Zoning and Codes at the earliest opportunity.~~

Staff Comment: This change excludes emergency traffic from the term 'construction traffic' and removes the need to report any emergency traffic to the Zoning and Codes Director.

c. Limit on construction activity: ~~Construction activities shall occur during daytime hours.~~

~~iii. The driving of the steel piles shall occur only between the hours of 8AM and 8PM, Monday through Friday.~~

i. Pile driving shall occur only between the hours of 7 AM and 5 PM, Monday through Friday, with the following exception: If the Project schedule is impacted by ongoing weather delays, the applicant may submit a written request to allow pile driving operations on a limited number of Saturdays during the hours of 8 AM to 5 PM.

1. The request must be made to the Zoning and Codes Director at least five days prior to the requested Saturday operation. The Director may administratively approve the request for up to four Saturdays. A request for additional Saturdays must be reviewed and approved by the Board of County Commissioners.

Staff Comment: Pile driving is the loudest construction activity and a more restrictive time limit is proposed for the benefit of residents in the area. Saturday operations are possible when required by weather delays. Up to 4 Saturdays may be approved by the Zoning and Codes Director, any more would require the approval of the County Commission.

ii. Except as provided in iii, below, all other construction activity, including staging and traffic, shall occur only between the hours of 6 AM and 7 PM, Monday through Friday, with the following exception: If the Project schedule is impacted by ongoing weather delays, the applicant may submit a written request to allow all other construction activity on a limited number of Saturdays during the hours of 8am to 5pm.

1. The request must be made to the Zoning and Codes Director at least five days prior to the requested Saturday operation. The Director may administratively approve the request for up to four Saturdays. A request for additional Saturdays must be

reviewed and approved by the Board of County Commissioners.

Staff Comment: Standard construction, other than pile driving, would be quieter and less impactful; therefore, a longer timeframe is proposed. Standard construction would be limited to weekdays except when necessary for weather delays.

iii. Notwithstanding subsection ii., above, construction activity on Saturdays and Sundays is permitted during daylight hours if the sound generated by such construction activity is below 60dB measured at the property line or 500 feet from any residence, which sound measurements shall be conducted per industry standards ANSI 12.9 Part 3 and S12.18 for measuring outdoor sound pressure levels and measured over a period of not less than 10 minutes using an ANSI S1.4 Type 1 or Type 2 sound level meter calibrated within the last 12 months.

1. Light vehicular traffic, excluding heavy equipment, to and from the site is permitted and not considered for purposes of measuring the sound maximum in subsection iii.

Staff Comment: Many construction activities associated with a solar energy conversion system are low impact. (This could include seeding, electrical wiring, and other similar activities, as well as construction that would be located away from residences.) Light vehicular traffic and any construction activity that would not exceed the noise limit set for the overall facility when completed (60dB measured at the property line or 500 feet from any residence) is considered low impact. Allowing the low impact construction activities to occur on the weekends would shorten the overall timeframe needed for construction.

iv. Any solid waste produced by construction activities shall be disposed of in accordance with Douglas County's Chapter 10: Solid Waste Management Code.

~~d. Road Maintenance Agreement: Prior to the issuance of building permits, the applicant or operator shall enter into a Road Maintenance Agreement with Douglas County, Kansas and Grant Township. The Agreement shall require the operator to be financially responsible for upgrades to the roads within the approved construction route and for any maintenance or repairs needed due to damage caused by the construction traffic for the project, per the road maintenance agreement as determined by the County Engineer and Township Trustee.~~

Staff Comment: This condition was moved to Section 1 and revised.

d. If the solar panels create hazardous or unreasonable glare not adequately contemplated by the Solar Glare Hazard Analysis, additional glare reducing measures, as described in Section 12-306-49.05.f ~~may~~ **shall** be implemented to limit glare.

Staff Comment: This change was suggested by the Planning Commission and makes additional glare reducing measures mandatory rather than optional.

e. The Operator shall conduct bird mortality surveys for the first two years of operation using measures outlined in the guidance document "Mortality Monitoring Design for Utility-Scale Solar Power Facilities" prepared by the US Geological Survey and US Fish and Wildlife Service and conduct insect surveys for the first two years of operation. The survey results shall be provided to the KS Department of Wildlife and Parks and the US Fish and Wildlife Service and to the Zoning and Codes Office.

f. If the potential bat-roost tree is to be removed, removal shall not occur in June or July.

g. A maximum of 5% of the site area may be graded.

   i. If more than 5% of the site area is proposed to be graded, the operator shall seek a modification from the Board of County Commissioners. A modification is required prior to grading of more than 5% of the site area.

   ii. Fine grading, which would be required for reclamation or seeding, is not included in this limitation. This type of grading does not create significant topographic change but smooths the disturbed areas, so they are suitable for planting.

h. Height. Solar panels shall not exceed 15 feet in height when oriented at maximum tilt.

   i. The Board of County Commissioners may approve a modification to allow panels of greater height, if found to be necessary to accommodate slopes without grading or to accommodate agrivoltaics, provided the height of the solar panels do not negatively impact nearby land uses or the character of the area.

Staff Comment: This standard is provided in the Zoning Regulations and was added to these conditions for clarity.

i. Concentrating Solar Thermal Devices are prohibited.

j. Pesticides. Any pesticides (both insecticides and herbicides) shall be applied only by a pesticide applicator certified by the Kansas Department of Agriculture.

   i. The Zoning and Codes Office shall be provided with the name and contact information of the certified applicator prior to the application of any pesticides.

k. Signage. Emergency contact information shall be posted at the site. Perimeter signage required at a minimum of 500-foot spacings.

l. Lighting. If any changes to the approved exterior lighting are proposed, a lighting plan shall be provided to the Planning Office for approval prior to installation.

m. The sound level generated by the facility shall not exceed 60 dBA (decibels) at the property line **or 500 feet from an existing residence (building permit plans have been submitted or the residence is on-site at time of conditional use permit approval.)**

Staff Comment: The Planning Commission noted this condition was not complete. This has been corrected with the wording from the Zoning Regulations.

i. The Operator shall contract with a qualified professional, approved by the Zoning and Codes Director, at the Operator's expense, to measure the noise levels at the closest impacted residences after construction is completed. The measurements shall be taken within one month of the release of the Certificate of Completion to verify the noise impact meets the project noise level threshold.

Staff Comment: This condition notes when the original sound testing of the facility to determine compliance with the noise level shall occur and provides for the testing to be done by a qualified professional.

n. All electrical interconnection and distribution lines within the site shall be located underground, unless the Board of County Commissioners approves a modification from this requirement. If a modification is approved, it shall be noted on the plan with the approval date.

o. Liability Insurance. The operator shall provide general liability insurance, showing general liability insurance coverage for the lifespan of the project encompassing installation and operation through decommissioning. Evidence shall be provided annually to the Director of Zoning and Codes in the form of a certificate of insurance.

p. The facility shall comply with all applicable local, state, and federal regulatory standards including, but not limited to, the Endangered Species Act, Clean Water Act, the International Building Code, National Fire Protection Association 855 Standards, and the National Electric Code, as amended.

q. Transfer of Operator. If the Operator listed on the approved conditional use permit plans to sell or otherwise transfer their responsibilities to an entity not listed on the conditional use permit, the listed Operator shall notify the Zoning and Codes Director of this proposed change. Furthermore, the new Operator shall notify the Board of County Commissioners and the Zoning and Codes Director in writing, acknowledging their acceptance of responsibility and intent to comply with all conditions listed in the approved conditional use permit.

i. The Board of County Commissioners may approve the transfer of operator if they find the proposed Operator has demonstrated their ability to strictly conform to all applicable performance standards detailed in these Regulations as well as applicable Local, State, and Federal laws or regulations.

r. Extraordinary Event. Within 3 days of an extraordinary event, as defined in the Zoning Regulations, the Operator shall provide written notice of the event to the Zoning and Codes Director, noting the cause and the degree of damage associated with the event.

i. Within 30 days of the event, the Operator shall provide the Zoning and Codes Director with a mitigation plan noting the steps they will take to mitigate any negative impacts. Additional mitigation steps may be required by the Zoning and Codes Office.

ii. If the additional mitigation steps required by the Zoning and Codes Office are unacceptable to the Operator, the Operator may appeal to the Board of County Commissioners.

Staff Comment: While the Zoning and Codes Office and the Operator would work together on the mitigation, this provides an appeal if the Operator disagrees with the required mitigation.

iii. Nothing in this subsection (i) shall limit the right of the Operator to perform routine or necessary repairs or make in kind replacements.

Staff Comment: Added at the applicant's request for clarity.

s. Reviews. The solar facility shall be reviewed for compliance with the standards of the conditional use permit 1 year after release of Certificate of Occupancy and every 5 years thereafter through the life of the conditional use permit. These reviews may be conducted by a third-party firm, selected by the Director of Zoning and Codes, and financed by the Operator.

i. If a third-party review is utilized and the selected firm or the cost of the review is unacceptable to the operator, the operator may submit a request to the Board of County Commissioners for an alternate third-party ~~or an in-house, staff~~ review.

t. **Twelve to twenty-four months from the release of the Certificate of Completion, and** with the first five-year review, and in each five-year review thereafter, the operator shall provide a detailed agrivoltaic report listing the agrivoltaic area and the type of agrivoltaic activities achieved. Each report shall demonstrate a measurable shift to vegetation management by grazing and shall incorporate other activities such as research and/or specialty crops.

Staff Comment: Requiring an early report on agrivoltaic activities would provide the Commission with a progress update in the early stages and is expected to result in a more robust and successful agrivoltaics program.

i. The intent is for the agrivoltaic activity to increase **and/or diversify** each five-year period unless the operator provides evidence that the increase was not feasible or possible.

Staff Comment: An increase in the agrivoltaic program was originally seen as an increase in area but, with this revision, could also be achieved with an increase in diversity.

ii. The Zoning and Codes Director will evaluate the agrivoltaic report and provide a summary to the Board of County Commissioners noting the progress, identifying any challenges, and setting goals for the next five-year period that have been coordinated with the Operator.

iii. A third party may be used for this evaluation, at the Operator's expense. If a third-party review is utilized and the selected firm or the cost of the review is unacceptable to the Operator, the Operator may submit a request to the Board of County Commissioners for an alternate third-party review.

Staff Comment: This condition, used in several locations, provides for a third-party review for several of the reviews required with this conditional use permit.

iv. If the area utilized for row crops increases within the 5-year period or is proposed with the new 5-year plan, a revised drainage study shall be provided by the Operator. The study will determine if additional stormwater detention is needed to manage the additional stormwater flow.

This study will be placed on the Board of County Commissioners' agenda for consideration and action, with the County Engineer's recommendation.

If additional detention is required and the necessary grading would increase the total grading to more than the permitted 5% of the total site area, a modification can be requested from the Board of County Commissioners.

Staff Comment: The impact of agrivoltaics on stormwater management was not considered with the original conditions. The drainage study considers the property planted in cover crop, but the addition of row crops could result in greater runoff than anticipated in the drainage study. This condition would require a new drainage study if the area utilized for row crops increases and allows for additional detention to be added to the site if necessary to accommodate the row crops.

u. Safety. The Operator shall update the Emergency Services and Fire Safety Plan annually in collaboration with Emergency Management, and provide new copies to the system owner, the applicable fire district, emergency response agencies, Douglas County Emergency Management, and the Zoning and Codes Office.

i. Any specialty response equipment required to adequately manage Extraordinary Events will be provided, updated, and/or replaced by the operator, as needed and at the operator's expense.

ii. Annual Emergency and Extraordinary Event response training shall be provided for all emergency response stakeholders on the plan, site, equipment, and processes required to assure their safety and effective management during an event.

v. No topsoil shall be removed from the site, except as permitted by Section 12-306-49.05.h. After rough grading, topsoil shall be redistributed uniformly on the surface of areas to be vegetated.

w. Soil Testing. Soil tests shall be taken in an approved location before construction begins, when construction is complete, prior to renewing a conditional use permit, prior to beginning decommissioning and reclamation, and following decommissioning/reclamation of the site to evaluate the soil health and/or contamination and develop a remediation program, if needed

x. The soil sampling plan shall include 1). Total carbon (organic and inorganic), 2). Phospholipid fatty acid (PFLA) for soil health, and 3). Heavy metals such as lead and cadmium.

   i. The samples shall be taken in compliance with the measures identified in Section 12-306-49.06(d)(17).

   ii. **The sampling and testing shall be conducted by a third-party agency at the Operator's expense.**

   iii. The Zoning and Codes Director and the Operator shall coordinate the selection of the consultants performing the soil tests.

   iv. If a third-party review is utilized and the selected firm or the cost of the review is unacceptable to the Operator, the Operator may submit a request to the Board of County Commissioners for an alternate third-party review.

Staff Comment: In this case the third-party review is not optional, but it includes the same provisions for the selection and the County Commission option for an alternate third party.

y. Decommissioning/Reclamation. The operator shall notify the Zoning and Codes Director when decommissioning and reclamation phases begin and when decommissioning and reclamation is completed.

   i. A third-party inspector shall be utilized for the review of the decommissioning and reclamation to ensure the approved plans are being followed, at the Operator's expense.

   ii. If a third-party review is utilized and the selected firm or the cost of the review is unacceptable to the Operator, the Operator may submit a request to the Board of County Commissioners for an alternate third-party review.

Staff Comment: Third-party review condition.

   iii. The Operator shall execute a Road Maintenance Agreement with the applicable governing bodies, regarding the approved route and any necessary road improvement and maintenance measures, to be financed by the Operator.

Staff Comment: This condition accounts for the possibility that the roads in the area may be of different condition/quality when the Project is decommissioned and reclaimed.

z. Bond Requirement. The applicant shall post a bond, with the Douglas County Clerk, establish an escrow account, or provide such other financial security deemed acceptable by the County, in an amount equal to the estimated decommissioning costs, to ensure proper decommission and reclamation of the site.

i. The County shall contract with an independent third party for estimated decommissioning and reclamation costs, at the applicant's expense. **If the selected firm or the cost of the review is unacceptable to the Operator, the Operator may submit a request to the Board of County Commissioners for an alternate third-party review.**

Staff Comment: Third-party review condition.

ii. The bond, or other financial security, shall be **approved by the County Commission and** posted prior to the commencement of the use in an amount equal to the estimated decommissioning costs, to ensure proper decommissioning and reclamation of the site. The bond, or other financial security, shall include a mechanism for adjustment over the life of the project.

Staff Comment: The regulations do not require the County Commission to approve the bond and it typically falls to the Zoning and Codes Director to approve bonds. Given the scale of this project, it would be more appropriate to have staff provide a recommendation and the final decision be made by the Board of County Commissioners.

iii. The bond, or other financial security, shall be adjusted for inflation annually.

iv. The Solar Facility owner or operator shall engage a qualified individual, **approved by the Zoning and Codes Director,** to recalculate the estimated cost of decommissioning at an interval of every five years, and every year for the final five years of the conditional use permit. If the recalculated estimated cost of decommissioning exceeds the previous estimated cost of decommissioning, then the owner or operator shall adjust their financial security to meet the new cost estimate. If the recalculated estimated cost of decommissioning is less than the previous estimated cost of decommissioning, then the County may approve reducing the amount of the security to the recalculated estimate of decommissioning cost.

Staff Comment: This change would allow the Zoning and Codes Director to have input into selecting the individual who will recalculate the decommissioning costs.

aa**. Ground water analysis**

i. An optional water analysis of active wells within one-quarter mile of the site area shall be offered by the operator prior to the installation of the equipment. The offer shall be made to all

owners of property within ¼ mile of the site area by certified mail, at least one-month prior to the installation.

ii. **A copy of the certified letter and a list of property owners notified shall be provided to the Planning office along with a list of all property owners who requested the testing and the results of that testing. This must occur prior to the installation of the facility.**

iii. **The test shall analyze the water in the nearby wells for substances such as lead and cadmium, as determined with the conditional use permit, and shall include a pesticide panel.**

iv. **The results of ground water testing shall be provided to the Director of zoning and Codes and sent by certified mail to the landowner.**

Staff Comment: This condition had been omitted from the staff report. The added language is provided in the Zoning Regulations standards.

v. **The Zoning and Codes Director may contract with a third-party agency to conduct the tests and review the findings of the groundwater analysis, at the Operator's expense.**

1. **The Zoning and Codes Director and the Operator shall coordinate the selection of the third-party agency performing the water samples and tests.**

2. **If the selected firm or the cost of the review is unacceptable to the Operator, the Operator may submit a request to the Board of County Commissioners for an alternate third-party review.**

Staff Comment: Third-party review condition.

bb. **The Operator shall contract with a special inspector and/or Plan Reviewer, approved by the Zoning and Codes Director, for construction plan review and all required construction inspections, and code enforcement complaints during the construction period, as determined by the Zoning and Codes Director, at the Operator's expense.**

i. **If the selected firm or the cost of the review is unacceptable to the Operator, the Operator may submit a request to the Board of County Commissioners for an alternate third-party review.**

Staff Comment: This condition places the responsibility for review, inspection, and enforcement during construction with a third party, as these operations are beyond the scope of the Zoning and Codes office.

cc. **The laydown yard shall be reclaimed and vegetated as shown on the vegetation plan within 6 months of completion of construction of the Project.**

Staff Comment: This condition corrects an earlier oversight. The laydown yard will be used only during the construction phase; therefore, reclamation would occur earlier than the overall Project.

dd. The Operator/applicant shall file a vegetation bond in the amount of $1,100 per acre, for each acre within the limit of disturbance as shown on the approved final Proposed Conditions Site Plan, with the Douglas County Clerk's Office prior to the issuance of the building permit.

i. The vegetation bond shall be released by the Zoning and Codes Director when soil disturbing activities are complete and final stabilization of all disturbed areas has been achieved using the following criteria used by the Kansas Department of Health and Environment (KDHE) for the closure of the National Pollutant Discharge Elimination System (NPDES) permit:

1. perennial vegetation, roads, Project facilities, pavement, buildings, or structures cover all areas which have been disturbed.

2. Vegetation must have a density of at least 70 percent compared to a typical undisturbed condition at or near the site.

Staff Comment: A vegetation bond will provide assurance that the site will be vegetated as shown on the vegetation plan.

ee. In the event that the Zoning and Codes Director reasonably determines that the Operator is conducting construction activities that are inconsistent with the approved Environmental Sound Study, and that such activities have caused, or are causing, significant adverse impacts on area residents with respect to construction noise, the Zoning and Codes Director shall work with the Operator to determine appropriate mitigation measures.

i. The Operator may appeal the mitigation measures to the Board of County Commissioners.

Staff Comment: The low-impact construction activities permitted on Saturdays and Sundays have a 60dB limit. This condition provides a mitigation requirement if this limit is exceeded.

SUMMARY

While there were some compromises in the development of these revised conditions, in staff's opinion the revisions provide greater clarity and specificity that will assist in the review of plans or in the enforcement of requirements.

March 13, 2024

Ashton Martin
Senior Permitting & Environmental Manager
Savion, LLC
422 Admiral Blvd.
Kansas City, MO 64106

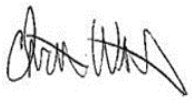
Potential for Introduction of Zinc into the Soil and Water Environment from Hot-Dip Galvanized Supports Used in Solar Panel Arrays

Dear Mr. Martin:

Burns & McDonnell is submitting this white paper to present a summary of findings from available peer reviewed literature regarding the potential for introduction of zinc into the environment from hot-dip galvanized steel structures like the support piers used in solar panel arrays. This white paper has been prepared in response to an August 9, 2023 request from the Douglas County Planning Department and in response to a landowner's request to consider initiating Text Amendment TA-23-00240 to the Zoning and Land Use Regulations for the Unincorporated Territory of Douglas County, Kansas. The text amendment requests inclusion of additional standards to monitor for and remediate groundwater pollution resulting from the proposed solar development.

If you have any questions concerning this white paper, please contact me via phone or email at cfwisniewski@burnsmcd.com.

Sincerely,



Christa Wisniewski
Project Manager
(816) 652-2970

Attachments:

Table of Contents
White Paper - Potential for Introduction of Zinc into the Soil and Water Environment from Hot-Dip Galvanized Supports Used in Solar Panel Arrays

Table of Contents

Potential for Introduction of Zinc into the Soil and Water Environment from Hot-Dip Galvanized Supports Used in Solar Panel Arrays

Report Index

Potential for Introduction of Zinc into the Soil and Water Environment from Hot-Dip Galvanized Supports Used in Solar Panel Arrays

Introduction

Approximately 50 percent of the zinc produced worldwide is used as a coating to resist corrosion on other metals, in particular steel and iron (American Galvanizers Association, 2011). Zinc coating is a sacrificial protection for metals as the zinc coating is preferentially corroded delaying corrosion of the metal beneath. This white paper presents a summary of findings from available peer reviewed literature regarding the potential for introduction of zinc into the environment from hot-dip galvanized steel structures like the support piers used in solar panel arrays. This white paper has been prepared in response to an August 9, 2023 request from the Douglas County Planning Department and in response to a landowner's request to consider initiating Text Amendment TA-23-00240 to the Zoning and Land Use Regulations for the Unincorporated Territory of Douglas County, Kansas. The text amendment requests inclusion of additional standards to monitor for and remediate groundwater pollution resulting from the proposed solar development.

Zinc in the Environment

According to the U. S. Department of Health and Human Services' Toxicological Profile for Zinc (August 2005), zinc is one of the most common elements/metals in the earth's surface. It can be found in the air, soil, and water and is present in all foods. Zinc is ubiquitous in the environment, constituting 20-200 ppm (by weight) of the earth's crust. Zinc can be found naturally in soils across the United States at concentrations ranging from less than (<)5 to 2,900 milligrams per kilogram (mg/kg) with a mean concentration of 60 mg/kg. Background concentrations in surface waters are typically <0.05 milligrams per liter (mg/L); however, can be as high as 50 mg/L (U. S. Department of Health and Human Services, 2005). Zinc is released into the environment in a variety of ways, both naturally by the weathering zinc-containing minerals, and anthropogenically from practices including steel production, coal burning, burning of wastes, mining, and smelting of zinc, lead, and cadmium ores.

Natural releases of zinc from the earth's crust to the environment from weathering processes can be significant (U. S. Department of Health and Human Services, 2005). Approximately six million tons of zinc naturally circulates throughout the environment each year, and anthropogenic emissions of zinc to the atmosphere resulting from industry, urban waste streams, agriculture, corrosion, and tire wear are estimated to be approximately 62,000 tons worldwide (American Galvanizers Association, 2013).

Galvanization Process

Steel and iron are commonly coated with zinc to prevent rust and corrosion through the process of galvanization. Hot-dip galvanizing is the factory-controlled process of immersing steel or iron into a bath of molten zinc, where the zinc reacts with the iron in steel to form a series of zinc iron

intermetallic alloy layers (American Galvanizers Association, 2013). This zinc coating resists steel corrosion and provides protection to the steel for many decades in most environments. During galvanization, a metallurgical reaction takes place as the coating grows perpendicular to all surfaces, creating a coating that is uniform and tightly bonded to the steel. The tightly bonded layers have a bond strength of approximately 3,600 pounds per square inch (psi), making the layers of the coating abrasion resistant and difficult to damage and wear (American Galvanizers Association, 2013).

Corrosive Environments

Corrosion is the deterioration of a metal through exposure to a reactive environment (Dosvig, 1995) and is the primary mechanism which causes metal structures to weather and release elemental metals to the environment. Zinc lost by sacrificial protection when exposed to a corrosive environment enters the environment creating a source for zinc to soil and/or surface water (Jones and Burgess, 1984). According to multiple sources in the available literature, highly corrosive environments are typically a result of acid rain, acidic soils, marine environments, and/or exposure to marine splash. The California Department of Transportation (DOT) Corrosion Branch defines a corrosive soil and/or water environment as one that includes:

- chloride concentration of 500 part per million (ppm) or greater;
- sulfate concentration of 1,500 ppm or greater; and/or
- pH is 5.5 or less.

The California DOT Corrosion Branch considers a soil, surface water, and or aquatic water environment to be non-corrosive if they do not meet the above requirements.

The modern design of buried steel structures is typically based on key parameters of the soil that influence corrosivity; however, direct connection between any one soil parameter and a quantitative corrosion relationship has not been proven to exist (Dosvig, 1995). Parameters most commonly used to evaluate corrosion potential are resistivity, pH, presence of aggressive soluble salt (chlorides and sulfates), moisture content, aeration, and temperature (Dosvig, 1995). A typical design life for a galvanized structure in the United States ranges from 50 to 75 years (California DOT, 2021).

Corrosivity As It Relates to The Potential Solar Panel Array Area

The Acid Rain Program was established under Title IV of the Clean Air Act, first enacted in 1970 (U.S. Environmental Protection Agency [USEPA], 2023). The Acid Rain Program requires major emission reductions of sulfur dioxide and nitrogen oxides, primary precursors of acid rain. Since its inception, the Acid Rain Program has achieved significant emission reductions and has been instrumental in reducing acid rain levels in the United States (USEPA, 2023). The National Atmospheric Deposition Program's National Trends Network provides long term records of precipitation chemistry across the United States. According to the annual gradient maps, the

precipitation-weighted mean concentrations for the potential solar panel array area for chloride, sulfate, and pH are:

- chloride concentration of 0.1 mg/L (mg/L is equivalent to ppm);
- sulfate concentration of 0.7 mg/L; and
- pH concentration of 6.2.

Therefore, precipitation events in the potential solar panel array area are unlikely to produce rain that would produce a corrosive environment.

The H-pile piers that are planned for the Kansas Sky Energy Center project will be installed to depths ranging from approximately 5-10 feet below the ground surface (bgs). In 2022, Kleinfelder, Inc. (Kleinfelder) performed 20 geotechnical borings as part of the *Preliminary Geotechnical Engineering Study, Free State Solar Project, Douglas County, Kansas* (Geotechnical Study), dated September 1, 2022, prepared by Kleinfelder. The Geotechnical Study characterizes subsurface conditions such as: geotechnical conditions, depth to groundwater, and soil chemistry. During geotechnical boring activities performed in the potential solar panel array area in 2022, groundwater was observed at 13 of the 20 boring locations at depths ranging from 6 to 26 feet bgs, with an average depth of approximately 16 feet bgs (Kleinfelder, 2022). Of the 20 geotechnical borings, there were only two locations in which groundwater was observed shallower than 10 feet bgs. Therefore, it is anticipated that few of the piers may be installed below the top of the water table while the majority of others will likely not be exposed to groundwater at all or will only come into contact with groundwater periodically during periods when the water table may become elevated. According to data included in the Geotechnical Study and literature review, the soil and groundwater in Douglas County potential solar panel array area do not meet the criteria for a corrosive environment listed in the above section. The Geotechnical Study summarizes soil chemistry data for the potential solar panel array area as the following:

- water soluble chloride concentrations ranging from 26.6 to 60.7 mg/kg (mg/kg is equivalent to ppm);
- water soluble sulfate concentrations ranging from 34.5 to 131.3 mg/kg; and
- pH concentrations ranging from 6.7 to 8.2
- Soil in Douglas County in the potential solar panel array area is not acidic with pH in the soil ranging from 6.7 to 8.2 (Kleinfelder, 2022) whereas the pH of groundwater in Douglas County is expected to range from approximately 7.0 to 7.3 (Terracon, 2019). The available surface water pH data from the Kansas River at Topeka and Desoto, Kansas stations (stations most closely located to Douglas County) is 8.8 and 8.4, respectively (U.S. Geological Survey [USGS], 2023). Because these values are outside of the ranges established by the California DOT, it is apparent that corrosive environment unlikely exists; therefore, reducing the potential that zinc will leach from the galvanized steel used in the proposed project.

A comparison of soil and water chemistry data available for the potential solar panel array area to corrosive environments as defined by the California DOT is summarized in the following table:

Project Specific Soil and Groundwater Data Compared to Corrosive Environment Criteria			
	California DOT	**Kansas Sky Energy Center**	
	Corrosive Environment Criteria	EPA Acid Rain Program (Precipitation weighted mean concentrations)	Soil Chemistry Data
Water Soluble Chloride Concentration	500 ppm	0.1 mg/L*	26.6 – 60.7 mg/kg**
Sulfate Concentration	1,500 ppm	0.7 mg/L*	34.5 – 131.3 mg/kg**
pH Concentration	5.5	6.2	6.7 – 8.2
*mg/L is equivalent to ppm. **mg/kg is equivalent to ppm.			

Soil and groundwater data available indicates non-corrosive environments are present for the potential solar panel array area as compared to highly corrosive environments typically a result of acid rain, acidic soils, marine environments, and/or exposure to marine splash as discussed in the previous section on corrosive environments.

Zinc in the Soil Environment

Point sources of zinc to soils resulting from the corrosion of hot-dip galvanized steel (bridges, guiderails, light poles, and sign structures) have been the focus of several studies described in the literature reviewed when preparing this white paper. Exposure of galvanized steel to air and the natural wet and dry cycles of weather events oxidizes the coating and slowly over time (often 75 years or more), the zinc can make its way into the soil (American Galvanizers Association, 2013). Neutral and elevated soil pH limits the mobilization of zinc in soil. Under these conditions, the majority of the zinc released to the environment is bound to the soil and therefore does not dissolve in water and is not bioavailable (Smolders and Degryse, 2002). Lower pH values and higher hydrolytic acidity values of soils have been associated with increased mobility of Zinc in groundwater (Niesiobedzka, 2023). Due to processes such as atmospheric deposition, zinc is often present in soils and grasses in the United States. It has

also been documented that approximately 22,000 tons of zinc is used in fertilizers each year resulting in additional sources of zinc to the environment (U. S. Department of Health and Human Services, 2005).

A review of available literature identified a number of studies that evaluated the potential for zinc to accumulate in soil near large, galvanized steel structures such as transmission line support structures. While a study was not identified which evaluated the potential for zinc to leach from solar panel array supports, the results of the following studies are considered relevant and if anything, give a more conservative evaluation of the potential for zinc to be released to the environment from galvanized steel due to the size of the structures evaluated and/or the environment that the structures were exposed to. As presented in the following studies, the presence of these structures did not result in the presence of zinc at concentrations above the Kansas Department of Health and Environment (KDHE) Risk-Based Standard for Kansas (RSK) residential soil pathway scenario value for zinc of 23,500 micrograms per gram (µg/g) or the USEPA's Regional Screening Level (RSL) for residential soil of 23,000 µg/g.

Study: Hot-Dip Galvanized Steel's Contribution to Zinc Levels in the Soil Environment (American Galvanizers Association, 2013)

A study in the American Galvanizers Association publication Hot-Dip Galvanized Steel's Contribution to Zinc Levels in the Soil Environment discusses zinc concentrations in soil as a result of weathering corrosion of zinc coatings on exposed transmission towers (American Galvanizers Association, 2013). In this study soil samples were collected in the vicinity of eight towers of variable ages (see table below) to evaluate the potential for Zinc to accumulate in soil near the towers. Two or three towers were evaluated in each of three environments 1. Arid (<25 centimeters [cm] annual rainfall), 2. Moist (25-100 cm rainfall), and 3. Marine splash (salt spray). Soil samples were collected at depths of 0-5 and 5-30 cm bgs at a control point; the base of each tower; and locations 3 meters (m), 6 m, and 9 m away from each tower. The soil sampling results are summarized in the following table from the referenced article:

	Age of Towers (years)	Sample Depth (cm)	Location				
			Base (µg/g)	3m (µg/g)	6m (µg/g)	9m (µg/g)	Control (µg/g)
ZONE 1	1	0-5 5-30	56 52	42 37	44 36	45 38	41 42
	19	0-5 5-30	452 90	66 35	62 37	59 35	45 31
	28	0-5 5-30	115 75	107 46	81 47	72 45	46 37
ZONE 2	1	0-5 5-30	12 21	13 22	9 16	10 19	9 21
	14	0-5 5-30	559 786	71 33	53 37	62 30	51 32
	24	0-5 5-30	903 256	114 76	92 113	81 55	73 95
ZONE 3	2	0-5 5-30	135 80	104 45	69 27	63 30	68 31
	26	0-5 5-30	481 460	288 86	124 74	123 93	99 45

Note. Table summarizes concentration of zinc in soil samples near electrical transmission towers. Table from American Galvanizers Association publication Hot-Dip Galvanized Steel's Contribution to Zinc Levels in the Soil Environment.

Conclusions from this study indicate the highest zinc concentrations in soil are located at the base of each tower and zinc concentrations decrease with distance from the base of each tower. With the exception of the 19-year-old tower in Zone 1, the older towers in each zone have higher concentrations of zinc in the soil samples collected at the base of each tower. Zinc concentrations generally decreased to near background concentrations within 6 to 9 m from the base of each tower and this study indicates minimal vertical movement of zinc in the soil. All zinc concentrations from soil samples summarized in the above table are well below the KDHE RSK residential soil pathway scenario value for zinc of 23,500 µg/g and the USEPA's RSL for residential soil of 23,000 µg/g. This suggests that these towers and similar galvanized steel structures are unlikely to result in soil contamination of zinc at concentrations above regulatory criteria established by USEPA and KDHE.

Zinc concentrations in soil samples collected near transmission towers in Zone 3 are likely elevated due to the corrosive environments that are typical of marine splash. Therefore, the results for Zone 3 represent a worse-case scenario than what is typical of Douglas County, Kansas. Furthermore, the towers investigated in this study provided a larger surface area of galvanized steel exposed to the elements than is typical of a solar panel array where smaller H-piles are used. While the samples from Zone 3 included elevated levels of zinc in soil as compared to the other zones investigated, even these concentrations were well below KDHE RSK value for zinc in soil of 23,500 µg/g and the USEPA RSL of 23,000 µg/g.

Study: Zinc and Cadmium in Soils and Plants Near Electrical Transmission (Hydro) Towers (Jones and Burgess, 1984)

In a similar study including an electrical transmission tower on a drumlin in a highly industrialized area in Canada, atmospheric pollution results in increased corrosion of protective zinc coating from transmission towers in the area in only five to ten years (Jones and Burgess, 1984). Soil samples were collected from the base of the tower and locations 1, 2, 5, 10, 25, and 50 m from the tower from a depth of 0-10 cm bgs. Corrosion of the galvanized transmission tower led to increases in concentrations of zinc in soils beneath and adjacent to the tower. As seen in the previous study, zinc concentrations in soil decrease with distance from the tower and most of the zinc lost by corrosion from the drumlin tower appears to be concentrated in the upper 10 cm of the soil profile. The following data summarizes the zinc concentrations in soil samples collected from locations starting at the base of the tower and increasing distance from the tower:

- Zinc = 11,480 ± 2,966 µg/g for soil touching the tower concrete base
- Zinc = 10,431 ± 7,511 µg/g for soil 1 m from the tower concrete base
- Zinc = 869 ± 339 µg/g for soil 2 m from the tower concrete base
- Zinc = 362 ± 240 µg/g for soil 5 m from the tower concrete base
- Zinc = 160 ± 38 µg/g for soil 10 m from the tower concrete base
- Zinc = 70 ± 4 µg/g for soil 25 m from the tower concrete base
- Zinc = 54 ± 16 µg/g for soil 50 m from the tower concrete base

The study attributed increased zinc corrosion of the transmission tower to the acidity of precipitation resulting from the area being highly industrialized. Therefore, this study likely represents a more corrosive environment than is typical of Douglas County. Additionally, transmission towers from this study are larger and have more surface area exposed to direct precipitation compared to partially shielded, smaller solar panel array support piers. Although, this study identified higher concentrations of zinc than the Jones and Burgess study, none of the zinc concentrations exceeded the KDHE RSK value for zinc in residential soil of 23,500 µg/g or the USEPA RSL of 23,000 µg/g.

Study: The Effects of Zinc contamination From Electricity Pylons – Evolution in a Replicated Situation (Al-Hiyaly et al., 1988)

The Al-Hiyaly et al. study evaluated zinc concentrations in soil near transmission pylons in North Wales. A total of 399 soil samples were collected from a depth of 0-5 cm bgs in a 20 by 20 m grid containing the four legs supporting the pylon. Total zinc concentrations in soil samples collected during this study ranged from 1,250 ± 200 to 6,500 ± 4,000 µg/g beneath the pylons and generally decreased with distance from the pylons. This study concluded that the pattern of zinc distribution under the pylons is dependent upon the pattern of precipitation drips and runoff from the structures and affected by prevailing wind direction and ground surface slope (Al-Hiyaly et al., 1988).

Once again, none of the zinc concentrations identified in this study exceeded the KDHE RSK value for zinc in soil of 23,500 µg/g or the USEPA RSL of 23,000 µg/g. Furthermore, the size of the structure investigated in this study is again larger than the H-pile supports that are planned for the solar farm.

Zinc in Surface Water

Zinc enters the surface water as a result of both natural and anthropogenic activities. Zinc is emitted to the air both naturally due to windborne soil particles, volcanic emissions, and forest fires and anthropogenically from dust and fumes from mining, zinc production facilities, processing of zinc-bearing raw materials, brass works, coal and fuel combustion, refuse incineration, agricultural fertilization, and iron and steel production. Fine zinc dust particles settle over land and surface water with rain and snow aiding in the removal of zinc from the air. Most of the zinc in lakes or rivers remains sorbed to sediments or suspended solids and settles to the bottom of the water body resulting in the enrichment of zinc in suspended and bed sediments. In aerobic waters, zinc is separated into sediments through sorption onto hydrous iron and manganese oxides, clay minerals, and organic material. The efficiency of these materials in removing zinc from solution depends on factors including the concentration of these materials, pH, redox potential (Eh), salinity, nature and concentration of complexing ligands, cation exchange capacity, and concentration of zinc (U. S. Department of Health and Human Services, 2005). Zinc tends to be adsorbed and transported by suspended solids in unpolluted waters; however, increases in the acidity of water may increase the level of dissolved zinc in water (U. S. Department of Health and Human Services, 2005).

As presented in Toxicological Profile for Zinc (U. S. Department of Health and Human Services, 2005), the weathering of naturally occurring minerals releases zinc to water while the erosion of soil particles containing natural traces of zinc results in the largest input of zinc to surface water (45,400 metric tons/year). This source of low levels of zinc is widely dispersed and unlikely to increase aquatic concentrations significantly.

Smaller but more concentrated sources of zinc in water include urban runoff, mine drainage, and municipal and industrial effluents. The total releases to surface water from urban runoff and inactive mines account for approximately 5,250 and 4,060 metric tons/year, respectively (U. S. Department of Health and Human Services, 2005).

A review of available literature identified a number of studies that evaluated the potential for zinc to enter surface water as a result of galvanized steel structures such as bridge structures. As presented in the following studies, the presence of these structures did not result in the presence of zinc at concentrations above the KDHE RSK residential groundwater scenario value for zinc of 4,670 micrograms per liter (µg/L).

Study: Loading estimates of Lead, Copper, Cadmium, and Zinc in Urban Runoff From Specific Sources (Davis et al, 2000)

One study on urban stormwater runoff looked at a variety of roof and siding materials as point sources for the addition of zinc to the surface water environment. Just prior to a rain event, a plastic bag sampling device was placed at the effluent point of a roof downspout (Davis et al., 2001). Approximately 500-1,000 milliliters of the initial rain flush were collected in the first few minutes of a rain event. A water sample collected from direct runoff from a galvanized metal roof exit point resulted in the highest zinc concentration in this study of 7,600 µg/L. This value exceeds the KDHE RSK value for zinc in groundwater of 4,670 µg/L; however, it should be noted, these results do not directly apply to the solar arrays due to the large size and surface area of galvanized metal roofing compared to H-pile piers for solar arrays. Furthermore, this study is a point source result, and these concentrations are not transferable to the solar array project application, where regional runoff would occur, and this study does not account for any dilution as regional runoff enters nearby surface water.

Study: Roofing Materials' Contributions to Storm-Water Runoff Pollution (Clark et al., 2008)

Another study on roofing materials contributions to storm water runoff consisted of a laboratory leaching study simulating the exposure of materials to acidic environmental conditions and a pilot-scale field study collecting runoff water samples during storm events. The results from the laboratory leaching study were used to identify if zinc exists in the material and if over time zinc might be released to the environment. The laboratory leaching results indicated that galvanized metal roofing contributed to the greatest concentrations of zinc with a concentration of 16,500 mg/kg (Clark et al., 2008). Even though the metals' results in this study indicated significant potential exists for metals to be leached from these materials as they degrade, the zinc concentration from degradation of the galvanized metal roof material was below the KDHE RSK value for zinc of 23,500 mg/kg and the USEPA RSL of 23,000 mg/kg.

Zinc concentrations in runoff water samples collected during the pilot-scale runoff test ranged from 5 to 30 mg/L (Clark et al., 2008), exceeding the KDHE RSK value for zinc of 4.67 mg/L and the USEPA secondary maximum contaminant level (SMCL) of 5 mg/L. Again, these concentrations are a result from direct runoff from a large surface area of galvanized metal roofing during a storm event and may not be representative of the solar array project (Clark et al., 2008).

Study: Hot-Dip Galvanized Steel's Contribution to Zinc Levels in the Water Environment (American Galvanizers Association, 2013)

Six studies in the American Galvanizers Association publication Hot-Dip Galvanized Steel's Contribution to Zinc Levels in the Water Environment discuss contributions of zinc to surface water due to the weathering of galvanized steel used to construct five bridges and one dock (American Galvanizers Association, 2013). In these studies, the addition of zinc to surface water

was modeled using a conservative assumption that all of the zinc on each structure is transmitted to the water over 40 storm events resulting in increases to surface water concentrations. Flow rates during these storm events are often 5-10 times the average flow rate of the surface water environments; however, for these studies, flow rates were conservatively estimated to be two times the average flow rate. These assumptions were used to model changes in zinc concentrations in the receiving water body to evaluate the potential effects of these structures on the environment. The data pertaining to each study is summarized below:

- Study #1: Grey Road Bridge (84 feet long by 40 feet wide) – surface water concentrations of zinc increased by approximately 12 parts per billion (ppb) during each storm event.
- Study #2: Warmington Bridge (126 feet long by 40 feet wide) – surface water concentrations of zinc increased by approximately 14 ppb of zinc is added to the river during each storm event.
- Study #3: Blough Avenue Bridge (237 feet long by 40 feet wide) – surface water concentrations of zinc increased by approximately 5 ppb of zinc is added to the canal during each storm event.
- Study #4: SR3023 Bridge (300 feet long by 40 feet wide) – surface water concentrations of zinc increased by approximately 41 ppb of zinc is added to the river during each storm event.
- Study #5: Commercial Dock – surface water concentrations of zinc increased by approximately 0.0001 ppb of zinc is added to the river during each storm event.
- Study #6: Wes Smith Bridge (220 feet long by 40 feet wide) – surface water concentrations of zinc increased by approximately 5.4 ppb of zinc is added to the river during each storm event.

While the results of this study are not directly transferable to the project given the size of the structures evaluated and the site-specific hydrological dynamics of the receiving water bodies, this study does present a line of evidence that galvanized steel structures, even when very large, are unlikely to result in surface water contamination of zinc at concentrations above the KDHE RSK residential groundwater scenario value for zinc in groundwater of 4,670 ppb.

Review of the available literature did not return any studies that specifically evaluated the effects of galvanized steel structures on groundwater concentrations of zinc. However, the studies discussed above indicate minimal vertical movement of zinc in the soil. Once released from the structures, zinc is expected to be relatively immobile in non-corrosive soil environments as the zinc tends to remain sorbed to the soil matrix and therefore does not dissolve in water (Smolders and Degryse, 2002). Therefore, regional impacts to groundwater as a result of galvanized steel structures is unlikely.

Conclusions and Limitations

This white paper presents the results of a literature review performed to evaluate the potential for galvanized steel structures to result in the addition of zinc to the environment at concentrations above KDHE and USEPA standards. With the exception of the Geotechnical Study, the conclusions and opinions drawn from the available literature are not based on site-specific information or data and may require additional assessment or evaluation to be confirmed. Reuse of this deliverable for purposes other than those identified herein are at the sole risk of those reusing this deliverable unless approved in writing by Burns & McDonnell.

The studies and evaluations summarized in this white paper demonstrated a limited potential for galvanized steel structures to result in environmental contamination of zinc. While one study observed elevated concentrations of zinc in surface water runoff from a galvanized steel roof, the samples that were collected in this study were directly from a down-spout at the start of a rain event. Therefore, they were greatly conservative and do not represent the average concentration of runoff throughout the rain event. These results are also not representative of conditions at the proposed solar project given the size of the structure and the manner in which runoff was captured and directed to a single downspout.

The literature reviewed suggests that zinc that is introduced to the environment is fairly immobile under non-corrosive conditions. Once released from galvanized coatings, zinc is expected to be relatively immobile in non-corrosive soil environments as the zinc tends to remain sorbed to the soil matrix and therefore does not dissolve in water indicating minimal vertical movement of zinc in the soil. Conclusions from literature reviewed indicate the highest zinc concentrations in soil are located at the base of zinc coated structures and zinc concentrations decrease with distance from the base of each tower, generally decreasing to near background concentrations in less than 10 m from the base of structures. Data available for the project site indicates non-corrosive environments are present which will limit the mobility of zinc that may leach from galvanized steel. If released to the environment, available literature suggests that zinc is unlikely to accumulate at concentrations above risk-based standards developed by KDHE and USEPA to be protective of human health and the environment. Furthermore, literature suggests that without the presence of corrosive environment it is unlikely that the zinc will become dissolved and enter groundwater at concentrations that would drive local groundwater contamination. Therefore, the risk for zinc concentrations in soil, groundwater, and surface water to be above regulatory thresholds as a result of the proposed KSEC is considered to be unlikely.

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FREE STATE SOLAR PROJECT, LLC

GROUNDWATER MONITORING PLAN

KANSAS SKY ENERGY CENTER (KSEC)

DOUGLAS COUNTY, KANSAS

PROJECT NO. 147658

REVISION 0

MARCH 14, 2024

CONTENTS

FIGURES

List of Abbreviations

Abbreviation	Term/Phrase/Name
bgs	below ground surface
BOW	Bureau of Water
CSECS	Commercial/Utility Scale Solar Energy Conversion System
CUP	Conditional Use Permit
EPA	U. S. Environmental Protection Agency
Free State	Free State Solar Project, LLC
Geotechnical Report	*Preliminary Geotechnical Engineering Study, Free State Solar Project, Douglas County, Kansas*
HSA	hollow-stem auger
K.A.R.	Kansas Administrative Regulations
KCC	Kansas Corporation Commission
KDHE	Kansas Department of Health and Environment
KGS	Kansas Geological Survey
Kleinfelder	Kleinfelder, Inc.
MS/MSD	Matrix spike/matrix spike duplicate
MSL	mean sea level
MW	Megawatt
NRCS	United States Department of Agriculture, National Resource Conservation Service
NTU	nephelometric turbidity unit
Plan	Groundwater Monitoring Plan
PPE	Personal Protective Equipment
Project	Kansas Sky Energy Center Project
Project Area	Project Development Area
PV	photovoltaic
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
Region	fenced PV array area(s)
ROW	right-of-way
SOP	Standard Operating Procedure
SVOC	semi-volatile organic compound

USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USGS	United States Geological Survey
VOC	volatile organic compound
WWC-5	Water Well Completion Record form
WWC-5P	Water Well Plugging Record form

1.0 Introduction

1.1 Overview

Free State Solar Project, LLC (Free State), is proposing to construct a new utility scale photovoltaic (PV) solar generation facility in Douglas County, Kansas. The Kansas Sky Energy Center (Project) would have a nameplate capacity of 159 Megawatts (MW)ac. The Project is located approximately 1 mile north of Lawrence, Kansas. The Project parcels are illustrated on Figures 1 and 2. The Project location was selected by Free State based on the area's strong solar resource, land use, and proximity to existing transmission infrastructure. The Project would include solar array blocks containing PV panels attached to a single-axis tracking system mounted to steel piles. The PV panels will track the sun during the day. Direct current electricity from the PV panels will be routed underground through collection wiring to Power Conversion Units located throughout the PV array areas. Each PV array area will be enclosed by a fence line with gated access at the road entrances. One or more fenced PV array areas (Regions) are illustrated on Figure 2. Constructed access roads to each PV Region will be gravel and approximately 16 feet wide. Pending regulatory approval by the Kansas Corporation Commission (KCC) and Douglas County, construction of the Project is anticipated to begin in 2025 and be completed in 2026.

This Groundwater Monitoring Plan (Plan) has been prepared as a supplemental component of the application submittal for the Conditional Use Permit (CUP) for a Commercial/Utility Scale Solar Energy Conversion System (CSECS).

1.1.1 Area Description

The total Project study area that encompasses all PV Regions is approximately 1,105 acres (Figure 2). The total area for all the PV Regions is approximately 604 acres. For the purpose of this Plan, Project Development Area (Project Area) will refer to only areas within the primary PV Regions (631 acres) of the Project.

Land use within the Project Area is primarily cultivated crops (95%), with interspersed pasture/hay, deciduous forest, wetlands, and developed areas (Figure 2). Much of the Project Area is comprised mostly of agricultural row crops including corn and soybeans.

1.1.2 Array Spacing/PV Panels

The typical minimum leading-edge height between the PV panels and the ground is approximately 18 inches. Post-to-post spacing between rows is approximately 21 feet. Final spacing within and between the arrays will be determined once equipment selection is finalized and the detailed engineering plan is complete. The installation of low-growing plant species and performance of vegetation management practices within the PV Regions will be conducted to minimize vegetation touching or shading the PV panels.

1.2 Groundwater Monitoring Purpose and Objectives

This Plan outlines the methods and procedures to install monitoring wells and perform groundwater monitoring within the Project Area. The Plan is designed to monitor and document the potential presence of Resource Conservation and Recovery Act (RCRA) 8

metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver), herbicides, and pesticides in the uppermost groundwater at the following project phases:

- Before construction begins (representative of regional background)
- Prior to review completed 1 year after Certificate of Completion
- Annually for the following four years
- After project completion and decommission

Additional to the monitoring above, volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) will be monitored in the uppermost groundwater at the following project phases:

- Before construction begins (representative of regional background)
- After project completion and decommission

This Plan was prepared alongside several other project plans relating to land and water management in the Project Area, including those addressing soil health, vegetation management, erosion and sediment control, stormwater management, perimeter landscaping, and decommissioning. This Plan may be updated as needed based on changing conditions, new methods, and/or Project needs. Standard Operating Procedures (SOPs) for activities that are anticipated for installing monitoring wells and performing groundwater sampling are included in Appendix A. Prior to the start of work activities, the contractor installing monitoring wells or collecting groundwater samples shall review and evaluate the procedures included in this Plan and the SOPs to determine if any modifications are necessary to promote the safe and proper implementation of work activities given site conditions at that time.

2.0 Site Description

2.1 Geology

The Project Area and surrounding areas consists of primarily agricultural fields and few residential and/or developed areas. The topography is generally flat sloping from the north to the southeast.

The *Preliminary Geotechnical Engineering Study, Free State Solar Project, Douglas County, Kansas* (Geotechnical Report), dated September 1, 2022 and prepared by Kleinfelder, Inc. (Kleinfelder) reported the bedrock and surficial geology encountered within the Project Area. The surficial deposit formation consists of alluvium and Newman terrace deposits. The United States Department of Agriculture, National Resource Conservation Service (NRCS) soil surveys indicate that surface soils for Project Area is generally silty loam, and silty clay loam from Quaternary-aged Pleistocene series.

Boring logs included in the Geotechnical Report indicate unconsolidated subsurface soils within the Project Area consist of six inches of topsoil over medium stiff, reddish-brown to dark brown, moist, lean, and fat clay with various amounts of sand and gravel. Underlying the clay is a wet yellowish brown to light brown sand, medium- to coarse-grained, poorly graded, and of medium density. The uppermost alluvial clay-rich zone thins to the south toward the Kansas River with thicknesses ranging between approximately 35 feet to the north to 7 feet to the south. At one boring location, highly weathered grayish-brown to brown shale (Pennsylvanian-aged) was encountered beneath the lean and fat clay layer at approximately 36 feet below ground surface (bgs).

2.2 Groundwater and Surface Water

As reported in the Geotechnical Report, groundwater was observed at 13 of the 20 boring locations at depths ranging from 6 to 26 feet bgs, with an average depth of approximately 16 feet bgs. Groundwater flow direction at Project Area is not known; however, groundwater is assumed to generally flow south-southeast following Project Area topography and the general flow direction of the Kansas River and Mud Creek. The Kansas River and Mud Creek generally bound the Project Area to the south and east, respectively (see Figures 1 and 2).

3.0 Plan Methods and Procedures

3.1 Health and Safety

A site-specific health and safety program will be prepared and implemented by the contractor performing monitoring well installation and groundwater sampling activities. The health and safety program will meet Free State health and safety requirements and present procedures and protocols required to safely guide field activities, identify and describe hazards, outline required personnel protection equipment (PPE), and present contingency plans for site personnel to follow.

3.2 Permitting and Access

According to the United States Army Corps of Engineers (USACE) National Levee Database, the monitoring well installations will be within a leveed area. Depending on the final monitoring well locations, well installation activities may be performed within the USACE critical levee area of the Lawrence Levee Unit (3605000045). The critical levee area is generally the area from 300 feet riverward to 500 feet landward from the centerline of the levee and requires approval from the local levee sponsor (City of Lawrence) and the USACE prior to work activities within the critical levee area. Included in the critical levee area is the levee right-of-way (ROW) which is defined as the area within 10 feet of either side of the levee toe and requires a USACE 408 Permit prior to work activities within the levee ROW. Attempts shall be made to avoid installing monitoring wells within the levee ROW. If any monitoring wells are located within the critical levee area, a request for work activities within the critical levee area will be submitted to the City of Lawerence (levee sponsor for the Lawrence Levee Unit) and the USACE for review/approval prior to initiating field activities.

The City of Lawrence and Douglas County shall be contacted as to whether other work permits will be required prior to the start of any intrusive field activities. If necessary, work permits/licenses will be obtained from the City or County.

Pending the final monitoring well locations, some wells may be on private property or City/County ROW and require access agreements and access coordination for monitoring well installation and groundwater sampling activities. Access agreements and/or access coordination for work activities on private property or City/County ROW will be managed by Free State.

If any permits or access agreements cannot be obtained for a proposed monitoring well location, potential areas to relocate will be evaluated and discussed with Free State, County/City, KCC and the Kansas Department of Health and Environment (KDHE) while also taking into consideration the final design of the PV Regions and associated infrastructure.

3.3 Utility Clearance

Prior to the start of any intrusive field activities, final monitoring well locations will be marked in the field. Utility locates (Kansas One-Call) and/or private utility locating services will be performed prior to any intrusive field activities. Depending on the presence of underground or overhead utilities, it may be necessary to offset proposed well locations. Monitoring well

offsets will be done with the approval of the Free State project manager while also taking into consideration the final design of the PV Regions and associated infrastructure. Procedures for utility clearance are outlined in *SOP 501 Utility Clearance*, included in Appendix A.

3.4 Monitoring Well Installation

Up to 14 new monitoring wells will be installed by hollow-stem auger (HSA) drilling methods. Based on the investigation results of the Geotechnical Report, the depths of monitoring well installation are anticipated to be up approximately 35 feet bgs. Depths may be adjusted in the field by the field site manager based on borehole logging observations made during drilling activities and gauging of existing monitoring wells and piezometers at the Project Area. Monitoring well drilling and installation activities will be completed by a Kansas-licensed driller in accordance with Kansas rules and regulations. Proposed new monitoring well locations are illustrated on Figure 3. Final monitoring well locations may need to be adjusted and will be dependent on access, presence of utilities, and the final design of the PV Regions and associated infrastructure.

Prior to HSA drilling activities, locations for each monitoring well will be continuously sampled utilizing direct-push drilling techniques and logged using the Unified Soil Classification System (USCS) in accordance with *SOP 521 Field Classification and Description of Soil and Bedrock*, located in Appendix A. When logging, a field geologist will document principle and minor soil constituents, an estimate of moisture content, relative plasticity, and other visible features and color will be defined using the Munsell Color System. Evaluation of direct-push logging results and encountered depth to groundwater will be used to determine where to place the screened interval for each of the new monitoring wells. Temporary piezometers may be installed inside the direct-push borehole by a Kansas-licensed driller to evaluate occurrence of groundwater prior to installing permanent monitoring wells. Monitoring well screened intervals will be placed just below the water table. After the direct-push logging is completed, the direct-push soil boring will be abandoned in accordance with KDHE Kansas Administrative Regulations (K.A.R.) 28-30-7 *Plugging of Abandoned Wells, Cased and Uncased Test Holes* and the new monitoring well location will be offset slightly to drill the new monitoring well borehole using HSA. Procedures for advancement and abandonment of boreholes are outlined in *SOP 554 – Advancement and Abandonment of Boreholes* (Appendix A). If temporary piezometers are installed, these will be abandoned in accordance with K.A.R. 28-30.

Upon the completion of each HSA soil boring, a monitoring well will be installed in the resulting borehole through the HSAs in accordance with KDHE K.A.R. 28-30-6 *Construction Regulations For All Water Wells Not Included Under K.A.R 28-30-5*. Well materials will consist of 2-inch diameter schedule 40 polyvinyl chloride (PVC) riser with the lower 10 feet consisting of 0.010-inch machine slotted PVC screen. The bottom of the well screen will be equipped with a threaded end cap. The screen will be within the unconsolidated sediments at estimated depths between approximately 20 to 35 feet bgs (below the top of the water table). A filter pack of 12/20 sand will be added to the annulus around each newly installed monitoring well from the borehole total depth to approximately three feet above the top of the screened interval. A 3-foot thick bentonite seal will be installed from the top of the filter pack using bentonite pellets hydrated in one-foot lifts. An annular seal will be installed from the top of the bentonite seal to approximately three-foot bgs using high-solids bentonite grout slurry. Each newly installed monitoring well will be completed with a stick-up protective

casing and a 2-foot by 2-foot square concrete pad approximately six inches in thickness, with the well centered within the pad. The concrete pad will be sloped outward from the well to provide a means for water to flow off the well pad and two one-quarter inch weep holes will be drilled into opposite sides of the steel protective casing, approximately one-half inch above the concrete pad. Two protective bollard posts will be placed on two opposite sides of each newly installed monitoring well pad to provide protection against potential damage from lawn maintenance activities. The bollards will not be located within or in contact with the concrete well pad and consist of 3-inch diameter steel pipes that are 5-foot in length, extending 3-feet above ground surface and 2-feet bgs. A water-tight well cap will be installed in the top of the PVC well casing and a minimum clearance of one inch will be maintained between the top of the PVC well casing and the protective casing to provide secure unobstructive closure of the lid. A minimum clearance of 2 inches will be maintained between the outer steel protective casing and the inner PVC well casing and silica sand will be used to fill the open area between the outer protective casing and the inner well casing.

Well development will be conducted after a period of at least 24 hours after the installation of the well and shall involve removal of at least the amount of any water added during drilling and installation activities plus five times the saturated well volume. The saturated well volume is considered, for development purposes, the volume of standing water within the well casing, and the volume of water within the filter pack with an assumed porosity of 30%. The water within each well will be surged and/or agitated within the screened interval to affect development of the filter pack and any formation skin along the borehole wall by pumping rapidly and intermittently at various depths within the screened interval using a downhole submersible pump, a surge block or bailer, and/or air-lift pumping. The field site manager will monitor the groundwater quality field parameters during development activities for stabilization of temperature (± 10%), pH (± 0.1 pH units), specific conductance (± 10%), and turbidity (< 5 of nephelometric turbidity units [NTUs]). Field notes of the data collected during the development of each well will be recorded in the field logbook. Procedures for field documentation are outlined in *SOP 701 Field Documentation*, included in Appendix A.

After the completion of the newly installed monitoring wells, KDHE Bureau of Water (BOW) Kansas Geological Survey (KGS) Water Well Completion Records (WWC-5) will be completed and filed by the driller with the KGS. Monitoring wells will be installed and developed in accordance with *SOP 551 Installation and Development of Monitoring Wells and Piezometers*, located in Appendix A. Copies of the WWC-5 forms will be provided to KDHE and included in the appendices of a final monitoring well installation report. Pertinent information collected during the field activities will be documented in the field logbook and/or field forms in accordance with *SOP 701 Field Documentation* (Appendix A).

Following the monitoring well installations the locations of the newly installed monitoring wells will be surveyed by a Kansas-Licensed Surveyor. Both Kansas state plane coordinates, accurate to 0.05 feet, and latitude and longitude coordinates will be provided for each of the newly installed monitoring well locations. The surveyor will establish the elevation of ground surface and top of PVC well casing at each of the newly installed monitoring wells within a minimum 0.01 vertical feet relative to established United States Geological Survey (USGS) mean sea level (MSL) benchmark.

3.5 Well Integrity Inspection

Each monitoring well will be inspected prior to the start of groundwater sampling events during the collection of water level measurements (refer to Section 3.7). Items to be inspected will include condition of the well pad (no evidence of cracking, undermining, or heaving from frost), well protective cover (damaged or excessively corroded), well padlock, and bumper posts (if any); presence of excessive vegetation; presence of erosional features or the indication of ponding of water near the well; condition of the PVC well casing and well cap, and condition of well label. The integrity of the dedicated HydraSleeve™ tether assembly will be inspected during the sampling event. Monitoring well screen occlusion will be evaluated during total well depth gauging. The results of the well inspection will be documented in the field logbook or field sampling forms. If a maintenance item is noted that could compromise the integrity of the groundwater sample, then a sample will not be collected until well maintenance has been conducted.

3.6 Well Maintenance

Well maintenance items noted in the field during the well integrity inspection (Section 3.5) or identified by Free State will be corrected prior to the next sampling event by Free State. Well maintenance items such as painting, labeling, erosion control, and vegetation management may be conducted on a yearly basis if the deficiency will not affect the groundwater sampling. Major repairs or alteration of a monitoring well (if necessary) will be corrected prior to the next sampling event and may require a Kansas certified well driller depending on the repair/alternation needed. No monitoring well modifications shall be conducted without prior approval by the Free State and the KDHE shall be notified prior to modifications of each monitoring well. A record of monitoring well repairs will be maintained by Free State. If significant modifications are made that affect the height of the well casing above ground, re-surveying of the top of well PVC casing shall be performed.

3.7 Groundwater Sampling

Groundwater sampling events will be conducted to monitor and document the potential presence of RCRA 8 metals, herbicides, and pesticides in the upper most groundwater at the following frequency:

- Before construction begins (representative of regional background)
- Prior to review completed 1 year after Certificate of Completion
- Annually for the following four years
- After project completion and decommission

Additional to the monitoring above, VOCs and SVOCs will be monitored in the uppermost groundwater at the following project phases:

- Before construction begins (representative of regional background)
- After project completion and decommission

Initial groundwater sampling will consist of five sampling events, four quarterly groundwater sampling events will be performed before construction begins to establish seasonal baseline/background groundwater quality conditions and a fifth sampling event following construction of the PV Regions. Additional groundwater sampling events prior to

construction and upon completion of construction may be evaluated based on review of the groundwater results.

The frequency of subsequent groundwater sampling during the active operation of the PV array system will be determined after the submittal/approval of CUP application and based on review of the initial groundwater sampling results and discussions with KDHE and Douglas County.

One groundwater sampling event will be performed prior to each renewal period of the CUP and prior to the beginning decommissioning and reclamation activities. The frequency of subsequent groundwater sampling following completion of decommissioning and reclamation activities will be determined based on review of groundwater sampling results and discussions with KDHE and Douglas County.

During each event groundwater samples will be collected from the 14 monitoring well locations illustrated on Figure 3 using HydraSleeves™. Procedures for collection of groundwater samples using HydraSleeves™ are outlined in *SOP 206 – Collection of Groundwater Sampling Using HydraSleeves™* (Appendix A). Water level and total well depth measurements will be collected prior to deploying HydraSleeve™ sampling devices during each event. Procedures for fluid level and total depth measurements are outlined in *SOP 511 Fluid Level and Total Depth Measurements*, included in Appendix A. HydraSleeves™ will be hung from the well caps using tethers so that the HydraSleeves™ are suspended approximately 1-foot above the total depth of the well. HydraSleeves™ tethers will be constructed to fit each monitoring well in accordance with the wells measured total depth. The HydraSleeves™ will be retrieved at least 12 hours following their deployment and groundwater samples will be collected using laboratory-supplied sample containers. Pertinent information related to the groundwater sampling will be recorded in the field logbook and/or on field forms. The groundwater samples will be submitted to an off-site Kansas-certified laboratory for analysis of RCRA 8 metals by United States Environmental Agency (EPA) Method 6010D, VOCs by EPA Method 8260, SVOCs by EPA Method 8270, pesticides by EPA Method 8081, and herbicides by EPA Method 8151 under standard turnaround time. Duplicate groundwater samples will be collected at a rate of 5% or one per day and one matrix spike / matrix spike duplicate (MS/MSD) sample will be collected per sampling event. The wells from which the duplicate and MS/MSD samples are collected will be documented. Field notes will be recorded in the field logbook and include field site groundwater sampling activities and pertinent information. Procedures for field documentation are outlined in *SOP 701 Field Documentation* (Appendix A).

3.8 Sample Handling and Analysis

Analytical methods and sample storage procedures for soil samples are outlined below. Additional information regarding sample packaging and shipping is outlined in *SOP 592 Sample Packaging and Shipping*, included in Appendix A.

Sample Media	Analyses/Method	Container/Storage	Preservation	Holding Time
Groundwater	RCRA 8 metals – 6010D	250 mL plastic bottle / cooled to 4°C	Nitric Acid	6 months

Groundwater	VOC – 8260	3 - 40 ml glass VOA cooled to 4°C	HCl	14 days
Groundwater	SVOC – 8270	4 - 40 ml glass VOA cooled to 4°C	None	7 days
Groundwater	Pesticides – 8081	4 - 40 ml glass VOA cooled to 4°C	None	7 days
Groundwater	Herbicides – 8151	250 mL glass bottle / cooled to 4°C	None	7 days

The noted analytical method and sample container(s) are for typical method requirements. These may vary slightly by laboratory and by method updates and/or laboratory sample volume preferences.

3.9 Sampling Equipment Decontamination

During monitoring well installation activities non-disposable and other non-dedicated equipment will be decontaminated according to the procedures in *SOP 504 Decontamination* included in Appendix A. Prior to drilling and between boring locations, direct-push and HSA drilling equipment will be decontaminated with high-pressure steam within a decontamination pad constructed in the staging area determined by the Free State project manager.

Clean nitrile gloves will be worn when collecting and handling groundwater samples and changed between sampling locations to minimize potential for cross contamination between sampling points. All reusable sampling equipment will be decontaminated between each sample collection using non-phosphate detergent solution (e.g. - Liquinox®), potable water rinse, and drying by use of disposable paper towels or air drying. Sample collection equipment and PPE generated during the sampling event will be disposed of as municipal solid waste.

3.10 Monitoring Well Redevelopment

If a monitoring well screen becomes 20 percent occluded or greater based on a wells total depth measurement during sampling activities, the monitoring well will be redeveloped. Well development will involve removal of fine sediments from within the well by the same methods as discussed previously in Section 3.7. The field site manager will monitor the groundwater quality field parameters during redevelopment activities for stabilization of temperature (± 10%), pH (± 0.1 pH units), specific conductance (± 10%), and turbidity (< 5 of NTUs).

3.11 Monitoring Well Abandonment

When monitoring wells are no longer required following decommission/reclamation of the Project site, existing monitoring wells installed in the Project Area will be abandoned in accordance with *SOP 553 Abandonment of Monitoring Wells and Piezometers*, located in Appendix A. Abandonment activities of monitoring wells will be completed by a

Kansas-licensed driller in accordance with K.A.R. 28-30-7 *Plugging of Abandoned Wells, Cased and Uncased Test Holes*. Abandonment activities will include the following:

- Measure the water level and total well depth.
- Any equipment/devices in the well will be documented and removed.
- Each casing will be cut off a minimum of three feet bgs and removed.
- Each well will be plugged from bottom to top using volumes of grout equaling at least the inside volume of the well.
- Any groundwater displaced upward inside the well casings during the plugging operation shall be removed and containerized before additional plugging materials are added.
- From three feet below ground level to ground level, the plugged well shall be covered over with compacted surface silts or clays.

The protective casings and concrete well pads will be removed and disposed of by the driller as municipal waste and the ground surface will be restored in the area of the abandoned well with soil to a level that matches current site conditions. Photographs will be taken prior to, during, and after well abandonment activities at each well. After the abandonment activities are complete, KDHE BOW Water Well Plugging Record forms (WWC-5P) will be completed and filed by the driller with the KGS. Pertinent information related to the monitoring well abandonment activities will be recorded in the field logbook. Copies of the WWC-5P forms will be provided to KDHE and included in the appendices of a final well abandonment report.

3.12 Investigative Derived Waste

IDW soil generated during monitoring well installation will be thin spread on the ground surface in the vicinity of the monitoring well which the soil was generated. IDW water generated during monitoring well installation, development, groundwater sampling activities, and/or abandonment will be discharged to the ground surface away from drainage ways the vicinity of the monitoring well which the groundwater is generated.

Disposable sampling materials and used PPE will be placed in plastic bags and disposed as municipal solid waste.

4.0 Quality Assurance/Quality Control

The Quality Assurance/Quality Control section of this Plan presents the objectives and specific quality assurance (QA) and quality control (QC) activities designed to achieve data quality goals. QA/QC samples and procedures will be implemented to achieve acquisition of valid data. QA/QC sampling protocol and procedures are presented below.

A Kansas-certified laboratory will perform analytical testing. Laboratory analytical testing for groundwater samples will be in accordance with EPA methodologies when applicable. The laboratory will be responsible for all chemical sample analyses, data validation, and data verification. Groundwater samples will be analyzed for cadmium, lead, and zinc by EPA Method 6010D under standard turn-around time. Duplicate samples will be collected at a frequency of 5% or one per sampling event and one MS/MSD sample will be collected per sampling event.

Precision is expressed in terms of standard deviation or relative percent difference and is assessed by evaluating duplicate sample results. Laboratory method blanks and calibration standards will be used to determine calibration stability and analytical method accuracy of the laboratory analysis. Field duplicates will be collected to evaluate the overall precision of field sampling, field screening methods, and laboratory analytical methods.

Accuracy is expressed in terms of percent recovery and measures the degree of agreement between a measurement and its true value. Laboratory accuracy is assessed by evaluating spike sample recoveries (i.e., surrogate and matrix spike samples) and blank results (i.e., laboratory and MS/MSD).

Analytical laboratory data obtained during the course of this project will be validated for completeness and accuracy by the contractor performing the groundwater sampling activities through an internal data validation process in accordance with EPA National Functional Guidelines.

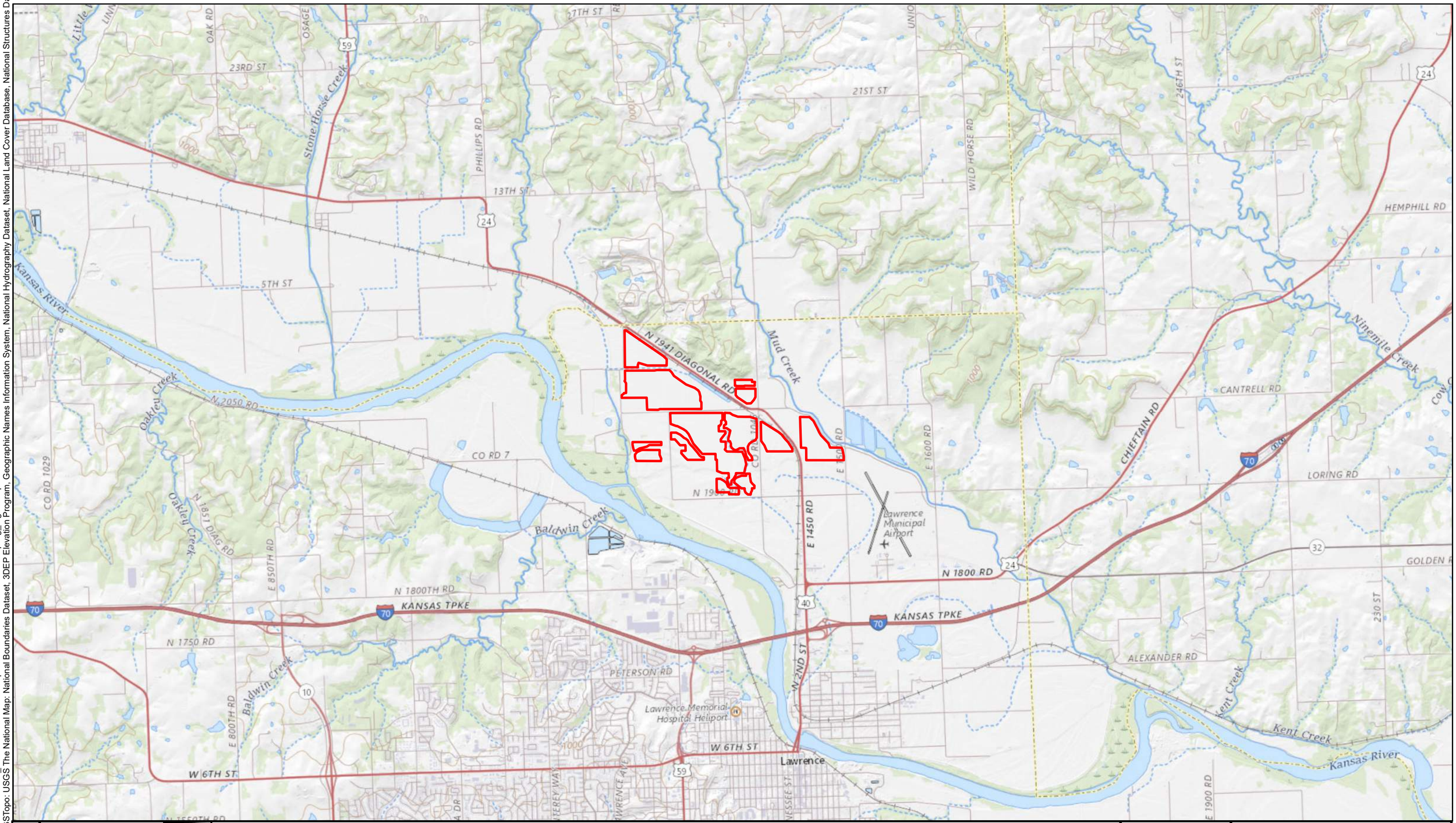
5.0 Reporting

Upon completion of newly installed monitoring wells, a Monitoring Well Installation Report will be submitted to Free State, KDHE, and Douglas County. The letter report will include a summary of the completed field activities, well development records, survey report, field photographs, well construction details, and copies of drill logs and WWC-5 records.

Upon completion of each groundwater sampling event, a Groundwater Sampling Report will be submitted to Free State, KDHE, and Douglas County. The letter report will include a summary of the completed field activities, compilation of laboratory analytical data, evaluation of results to previous sampling events, discussion of trends, site figures, and appendices that will include a copy of field log notes, laboratory analytical reports, and field photographs.

Upon completion of monitoring well abandonments, a Monitoring Well Abandonment Report will be submitted to Free State, KDHE, and Douglas County. The letter report will include a summary of the completed field activities; field photographs; and copies of drill logs, WWC-5 forms, and WWC-5P records.

Figures



Proposed Project Fence Boundary

NORTH

1 0.5 0 1

Miles

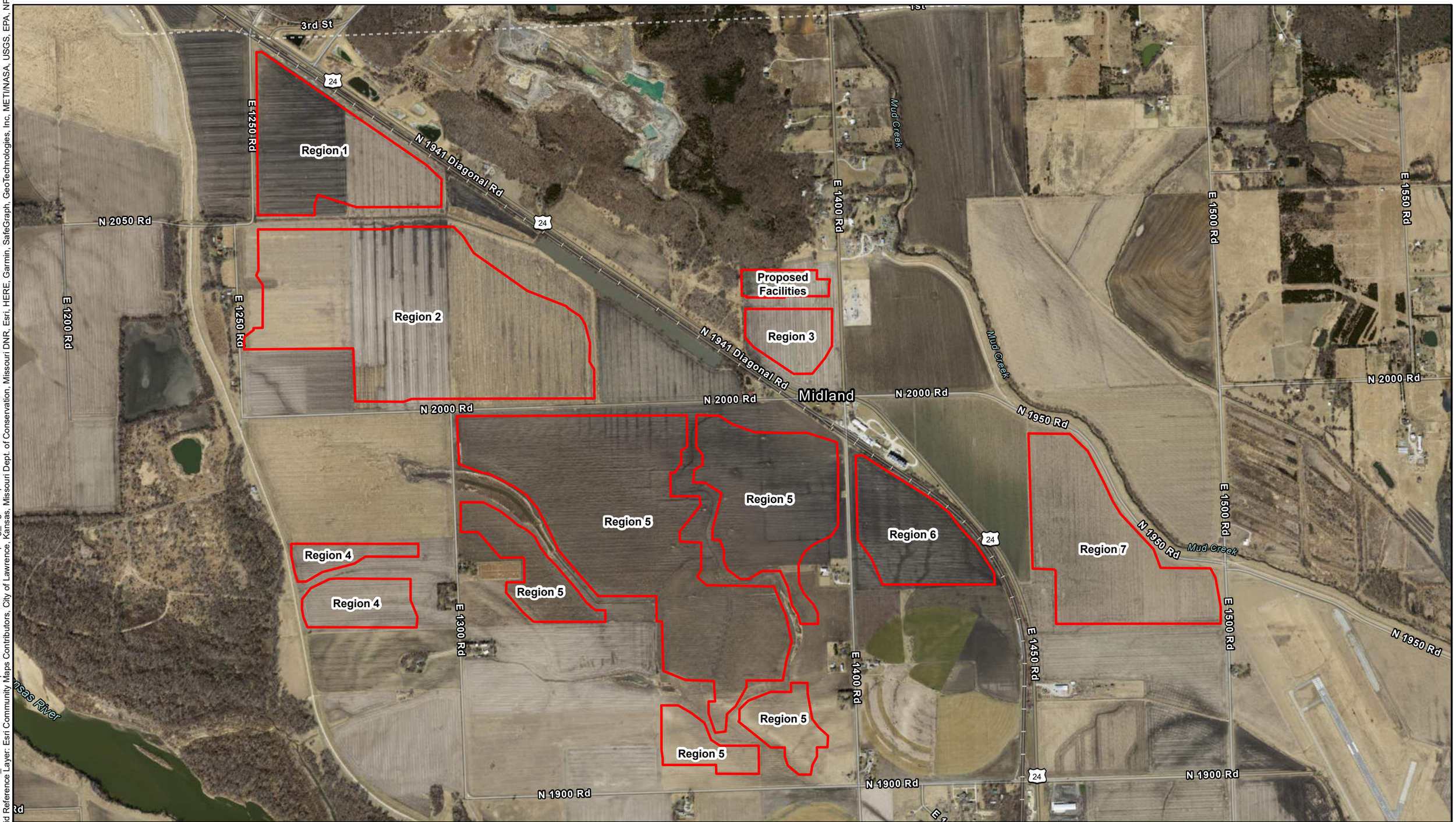
BURNS McDONNELL

Figure 1
Project Location Map
Kansas Sky Energy Center
Free State Solar Project, LLC
Douglas County, Kansas

Issued: 6/7/2023

Source: ESRI and Burns & McDonnell

Path: Z:\Clients\ENS\SavionLLC\147658_FreeState\Studies\Geospatial\DataFiles\ArcDocs\SoilSampling_Figures.aprx cfwisniewski 6/7/2023
Service Layer Credits: USGSTopo: USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset



Proposed Project Fence Boundary

NORTH

1,200 600 0 1,200

Scale in Feet

BURNS McDONNELL

Figure 2
Site Vicinity Map
Kansas Sky Energy Center
Free State Solar Project, LLC
Douglas County, Kansas

Issued: 6/7/2023

Source: ESRI and Burns & McDonnell

Path: Z:\Clients\ENS\SavionLLC\147658_FreeState\Studies\Geospatial\DataFiles\ArcDocs\SoilSampling_Figures.aprx cfwisniewski 6/7/2023
Service Layer Credits: Hybrid Reference Layer: Esri Community Maps Contributors, City of Lawrence, Kansas, Missouri Dept. of Conservation, Missouri DNR, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, U

Region 1
Region 2
Region 3
Region 4
Region 5
Region 6
Region 7
Proposed Facilities
Midland
N 2050 Rd
N 2000 Rd
N 1900 Rd
N 1950 Rd
E 1200 Rd
E 1300 Rd
E 1400 Rd
E 1450 Rd
E 1500 Rd
E 1550 Rd
N 1941 Diagonal Rd
Mud Creek
24

Proposed Project Fence Boundary
Proposed Monitoring Well Location Within Project Area
Proposed Monitoring Well Location Within County Road Right of Way

NORTH
1,200 600 0 1,200
Scale in Feet

BURNS McDONNELL

Figure 3
Proposed Monitoring Well Location
Kansas Sky Energy Center
Free State Solar Project, LLC
Douglas County, Kansas

Issued: 3/11/2024

Source: ESRI and Burns & McDonnell

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Service Layer Credits: Dark Gray Base: Esri Community Maps Contributors, Douglas County Kansas GIS, Missouri Dept. of Conservation, Missouri DNR, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NA

APPENDIX A – STANDARD OPERATING PROCEDURES

SOP 206 – Collection of Groundwater Sampling Using HydraSleeves™

SOP 501 – Utility Clearance

SOP 504 – Decontamination

SOP 511 – Fluid Levels and Total Depth Measurements

SOP 521 – Field Classification and Description of Soil and Bedrock

SOP 551 – Installation and Development of Monitoring Wells and Piezometers

SOP 553 – Abandonment of Monitoring Wells and Piezometers

SOP 554 – Advancement and Abandonment of Boreholes

SOP 592 – Sample Packing and Shipping

SOP 701 – Field Documentation

SOP 206
Collection of Groundwater Sampling Using HydraSleeves™

Revision 01
04/06/2018

Approved by:

Lewis Turner, PG, Staff Geologist, Environmental Services Division	02/16/2018 Date
Ben Clement, R.G., Senior Geologist, Environmental Services Division	04/02/2018 Date
John Hesemann, PE, Remediation Technical Service Area Leader, Environmental Services Division	04/06/2018 Date

Biennial Review:

Revision/Review	Date	Responsible Party	Description of Change
Revision	2/16/2018	Lewis Turner	Minor grammar and clarification. Added deployment and sampling form.

TABLE OF CONTENTS

Page No.

1.0 PURPOSE AND APPLICABILITY

The purpose of *Standard Operating Procedure (SOP) 206 Collection of Groundwater Sampling Using HydraSleeves™* is to establish a uniform procedure for the collection of groundwater samples using the HydraSleeve sampler. This SOP covers the *process* for the collection of groundwater samples; sample rationale and scope including locations, depths, required sample amounts, sample preservatives, etc. are detailed in the Project-Specific Work Plan(s). *SOP 206 Collection of Groundwater Sampling Using HydraSleeves™* has been prepared in accordance with the *Guidance for the Preparing of Standard Operating Procedures* (USEPA, and the Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) *Policy Manual* (Burns & McDonnell, 2018).

2.0 SUMMARY OF METHOD

The HydraSleeve is a no-purge grab sampling device that collects a "core" of groundwater from within the screened interval of a monitoring well with little disturbance and minimal drawdown of the water column. Prior to collection, the HydraSleeve is placed within the screened interval of the monitoring well, and the well is allowed to re-equilibrate over a period of time. The HydraSleeve is then retrieved at a rate of greater than one foot per second forcing the one-way check valve open and water to fill the sampler. When the HydraSleeve is full, the one-way check valve seals preventing mixing of extraneous fluid from the well during retrieval. The field sampler then inserts a discharge tube into the side of the HydraSleeve, and a groundwater sample is dispensed into the sample container(s). After groundwater samples and parameters have been collected, the used HydraSleeve sampler is discarded. The tether, clips, and weights can be dedicated to a monitoring well and reused for multiple rounds of groundwater sampling.

3.0 DEFINITIONS

- **Equilibration time** - The time it takes for conditions in the water column to restabilize after vertical mixing occurs.

- **HydraSleeve™** – A disposable one-time use sampling device used to collect a representative sample without purging the well. Standard HydraSleeves for deployment in 2-inch wells, range in length from 30 to 38 inches with maximum sample volumes of 600 milliliters (mL) to 1,300 mL. Additional products are available for use in 1-inch to 4-inch monitoring wells with sampler lengths of up to 8 feet and sample volumes up to 4,400 mL.

- **Project-Specific Accident Prevention Plan/Site Safety and Health Plan** (Project-Specific APP/SSHP) – A plan or plans that address occupational safety and health hazards associated with site operations.

- **Project-Specific Work Plan** – The plan that details the rationale, scope, and techniques to be used at the Site to achieve the project objectives. Project-Specific Work Plans can include work plans, field sampling plans, quality assurance project plans, technical memorandums, and other documentation of proposed work.

4.0 HEALTH AND SAFETY

Field activities as detailed in this SOP will be performed in accordance with applicable safety related documents/requirements which may include but are not limited to: Project-Specific APP/SSHP, the Burns & McDonnell *Safety and Health Program* (Burns & McDonnell, 2017), and site / client-specific requirements. Personal protective equipment (PPE) including safety glasses and gloves should be worn as appropriate and as detailed in the Project-Specific APP/SSHP. PPE requirements should be assessed daily and on a per task basis.

5.0 CAUTIONS

As the HydraSleeve is a single use sampler, the needed sample volume should be calculated and the appropriate sized sampler used. Because of the limited sample volume, quality control (QC) samples for multiple parameters may be collected from different wells (i.e. for a set of parameters, a volatile organic compound (VOC) sample duplicate may be collected at one well and the metals duplicate from another well).

During deployment, field personnel should not pull the HydraSleeve upward. If the HydraSleeve is pulled upward at a rate greater than 0.5 feet/second at any time prior to re-equilibration, the top check valve may open causing water to enter the HydraSleeve prematurely.

To ensure that the HydraSleeve opens properly, the sampler should be sized correctly for the diameter of the monitoring well to be sampled.

To collect the sample at the correct interval, the HydraSleeve must move upward at an approximate rate of one foot per second or faster for water to pass through the check valve into the sample sleeve. If upon retrieval the sleeve appears to not have filled fully, this may be indicative that the check valve did not fully open and the collected water may not be from the screened interval.

Field personnel should decant and discard the small volume of water trapped in the HydraSleeve above the check valve by turning the sleeve over.

The length of the tether should not be changed unless specified in the Project-Specific Work Plan. If zip ties are present, field personnel should completely remove zip ties after sample retrieval and prior to reattaching a new HydraSleeve.

6.0 PERSONNEL QUALIFICATIONS

Burns & McDonnell personnel conducting on-site environmental activities will have completed the 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) course and annual 8-hour HAZWOPER refresher courses. At a minimum, one person on site will be certified in first aid and cardiopulmonary resuscitation (CPR) and, if multiple people are on site, at least one person will have completed the 8-hour HAZWOPER Supervisor Training course. If Burns & McDonnell subcontractors are on site then, at a minimum, one Burns & McDonnell person will have completed the OSHA 30-hour Construction Industry Outreach Training.

7.0 EQUIPMENT AND SUPPLIES

Equipment to be used during HydraSleeve sampling typically includes:

- HydraSleeve, sized per the Project-Specific Work Plan
- Tether rope, spring clip, and weights
- Elevated hook to hang sampler on during decanting (recommended for one-person sampling)
- Zip ties
- Garbage bags
- Knife or scissors
- Buckets and lids
- Personal protective equipment (PPE) and safety equipment per the Project-Specific APP/SSHP
- Sample containers and sample preservatives per the Project-Specific Work Plan

Equipment to be used for water or product level measurements, well headspace measurements, water quality measurements, decontamination, sample labeling, packing and shipping can be found in the SOPs for those activities.

Prior to the start of field activities, the Field Site Manager and/or the Project Manager should determine that 1) necessary permits and right of entries have been obtained; 2) the Project-Specific APP/SSHP has been reviewed by Burns & McDonnell personnel participating in the work and subcontractors who will be on site; 3) appropriate PPE has been obtained for Burns & McDonnell personnel and will be available on site; 4) equipment and meters are available, in working order, and complete with needed components; 5) applicable safety data sheets are on site and available to the field team; and 6) sample containers provided by the laboratory are the correct size and type, are preserved, if required, per the Project-Specific Work Plan, and are sufficient in number for the planned field activities.

8.0 PROCEDURES

This SOP covers the most commonly used procedure for sampling groundwater using HydraSleeves. Alternative deployment methods including multiple sleeve deployment and deployment in wells with limited water columns are detailed in the HydraSleeve Manual (GeoInsight, 2016) attached to this SOP. An example of a HydraSleeve deployment and sampling form is also attached to this SOP. HydraSleeve groundwater sampling will be conducted according to the following procedures:

8.1 Assembling the HydraSleeve

1. Remove the HydraSleeve from the packaging, unfold, and hold it by the top.

2. Crimp the top of the HydraSleeve outward by folding the hard polyethylene reinforcing strips at the holes.

3. Attach the spring clip to the holes to ensure the top will remain open until the sampler is retrieved. Place a zip tie through the eye of the spring clip and one of the holes on the HydraSleeve as a disconnect fail-safe.

4. For a first-time deployment, measure a length of tether to place the HydraSleeve at the required depth as detailed in the Project-Specific Work Plan or unpackage the custom-length premade tether.

5. Attach the tether to the spring clip by tying a knot in the tether.

6. Align the two holes at the bottom of the HydraSleeve together and slide the weight clips through the holes.

7. Attach the appropriate stainless-steel weight to the bottom of the weight clip to ensure that the HydraSleeve will descend to the required depth or bottom of the well.

8.2 Deploying the HydraSleeve

1. For above grade completions, unlock the casing protector and remove the well cap. For flush mount completions, open the well vault and unlock and remove the well cap.

2. If required, measure a headspace reading from the top of the well per *SOP 513 Field and Headspace Screening Using a Photoionization Detector*.

3. Measure the depth to water, any light non-aqueous phase liquids or dense non-aqueous phase liquid and total well depth to within 0.01 feet relative to the measuring point at the top of the well casing (TOC) per *SOP 511 Fluid Level and Total Depth Measurements*. If sediment has occluded more than 10 percent of the screen, the well should be redeveloped prior to placement of the Hydrasleeve. Record the measurements and any observations on the field parameter form and/or in the field logbook.

4. Using the tether, slowly lower the HydraSleeve to the required depth or bottom of the well in the water column. Ensure the HydraSleeve is not pulled upward during its descent. If the HydraSleeve is pulled upward at a rate greater than 0.5 ft/second at any time prior to retrieval, the top check valve may open causing water to enter the HydraSleeve prematurely.

5. Secure the tether at the top of the well by attaching it to the bottom or top of the well cap.

6. Allow the water column to re-equilibrate after installation. The required equilibration time will be specified in the Project-Specific Work Plan**.**

For wells with a limited water column, the HydraSleeve can be deployed with an optional top weight and a bottom weight. The optional weight attaches to the top and outside of the HydraSleeve and is held in place by the spring clip. The weight collapses the HydraSleeve to a short (6”-9”) length, allowing the HydraSleeve to be filled in a smaller water column.

8.3 HydraSleeve Sample Collection

8.3.1 Retrieval

1. For above grade completions, unlock the casing protector and remove the well cap. For flush mount completions, open the well vault and unlock and remove the well cap.

2. Hold the tether while removing the well cap. Secure the tether at the top of the well while maintaining tension on the tether (but without pulling the tether upwards).

3. If required, measure a headspace reading from the top of the well per *SOP 513 Field and Headspace Screening Using a Photoionization Detector*.

4. Measure the depth to water to within 0.01 feet relative to the measuring point at the top of the well casing (TOC) per *SOP 511 Fluid Level and Total Depth Measurements*. Record the measurements and any observations on the field parameter form and/or in the field logbook.

5. In one smooth motion, pull the tether up at a rate of approximately 1 foot per second (or faster). The upward motion will open the check valve and allow the HydraSleeve to fill. Once the HydraSleeve is full, the top check valve will close, preventing the loss of sample and entry of water from the interval above the well screen.

6. Decant and discard the small volume of water trapped on the HydraSleeve above the check valve by turning the sleeve over.

An alternate retrieval method involves cycling the sampler up and down within the sample interval. *Verify* in the Project-Specific Work Plan that this method is acceptable for the project. Pull the tether up at a rate of one foot per second (or faster) for a short distance (typically 1 to 3 feet) then allow the sampler to fall back down to the resting position. Repeat this cycle until the sampler is full, and then retrieve as normal.

8.3.2 Sample Collection

1. Remove the discharge tube from its sleeve.

2. Hang or hold the HydraSleeve at the check valve over a bucket.

3. Puncture the HydraSleeve just below the check valve with the pointed end of the discharge tube. As the water level in the sampler falls, extract and then reinsert the discharge tube below the water level to continue filling sample containers.

4. Discharge water directly from the HydraSleeve into the sample containers. Fill the appropriate sample containers with groundwater, label the containers, and place immediately in a cooler with ice. In general, sample containers will be filled in the order of most volatile to least volatile constituents to

be analyzed. Specific sample order, sample containers, and sample preservatives will be detailed in the Project-Specific Work Plan.

5. Enter the appropriate information on the chain of custody (COC) form and field logbook/groundwater sampling form in accordance with *SOP 701 Field Documentation*.

6. If field indicator measurements are required, measurements can be taken from water within the HydraSleeve that is not used for collecting a sample per *SOP 514 Field Measurements of Dissolved Oxygen, Oxygen Reduction Potential, pH, Specific Conductivity, Temperature, and Turbidity in Aqueous Samples.*

7. With the HydraSleeve removed from the well, measure the total well depth to within 0.01 feet relative to the TOC per *SOP 511 Fluid Level and Total Depth Measurements*. Record the depth on the field sample collection form and in the field logbook.

8. If required by the Project-Specific Work Plan, after sampling, deploy a new HydraSleeve using the dedicated tether and weight assigned to the monitoring well per the procedures for assembly and deployment described in Sections 8.1 and 8.2 of this SOP.

9. Pack the samples for shipping as specified in the Project-Specific Work Plan and *SOP 592 Sample Packaging and Shipping*.

10. Decontaminate non-disposable sampling equipment between locations as specified in *SOP 504 Decontamination*.

11. Manage excess groundwater as specified in the Project-Specific Work Plan and *SOP 601 Investigative Derived Waste Storage, Sampling, and Disposal*.

An example of a HydraSleeve sampling form is attached to this SOP.

9.0 DATA AND RECORDS MANAGEMENT

Environmental field activities will be documented as detailed in *SOP 701 Field Documentation*. Field documentation will be completed as activities are conducted and will be relayed to the Field Site Manager or Project Manager at a minimum weekly or on a more frequent basis if so stated in the Project-Specific Work Plan. The location, depth, and time of collection for each groundwater sample will be documented

in the field logbook and/or groundwater sampling form. Unique sample numbers will be assigned to each groundwater sample collected.

10.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to the start of any field activity, Burns & McDonnell personnel will have read and understood the Project-Specific Work Plan as well as this SOP. Field personnel will be trained for a minimum of 40 hours prior to their working independently on environmental field activities.

Quality control (QC) samples will be collected in the field to aid in the determination of the validity of the analytical results. The type, number, and location of QC samples to be collected will be detailed in the Project-Specific Work Plan. Typical field QC samples for groundwater samples include:

- Field duplicates
- Matrix spike/matrix spike duplicates (MS/MSDs)
- Trip blanks
- Temperature blanks

10.1 Field Duplicate Samples

Field duplicate samples will be obtained at the same time and analyzed for the same set of parameters as the investigative sample they are intended to replicate. Field duplicate samples are used to assess precision, including variability associated with both the laboratory analysis and the sample collection process. Field duplicate water sample containers will be filled immediately following the filling of the original sample containers for each analyte. The original and duplicate samples will be placed in separate, but identical containers and preserved in the same manner. Both the original and the duplicate will be sent to the primary laboratory or on-site laboratory, as applicable, and analyzed for the same analytical parameters. Field samples will be identified with unique sample identification numbers. Field duplicates will be numbered so to be blind to the laboratory. Sample locations where field duplicate samples are collected will be documented in the field logbook. Field duplicates are typically taken on 10 percent of the original samples collected.

10.2 MS/MSDs

MS/MSDs will be analyzed for the same constituents as the primary sample. MS/MSD samples provide information on matrix interference encountered during extraction, digestion, and analysis (i.e., suppression or enhancement of instrument signals). MS samples are principally used to evaluate accuracy

by measuring recovery of the spiked compounds. When the MS sample is used together with an associated MSD sample, information is obtained on analytical precision. Groundwater samples will be collected in triplicate at certain locations also unless previous arrangements have been made with the analytical laboratory regarding sample volume requirements. Groundwater MS/MSD samples for VOC analyses will always be collected in triplicate. The samples will be identified as the original, MS, and MSD and will be collected in the same manner as duplicate samples. The COC will be completed to notify the laboratory that a MS/MSD should be completed in addition to the original sample.

MS/MSDs are typically taken on 5 percent of the original samples collected; however, some projects may require a site-specific MS/MSD for each batch analyzed at the laboratory. For analytical methods with short holding times (i.e., less than 7 days), it may be necessary to collect MS/MSDs at a frequency greater than 5 percent. The analytical laboratory should be consulted regarding their MS/MSD batching needs when requesting sample analysis for short holding time methods.

10.3 Trip Blanks

Trip blanks are analyte-free water, shipped from and returned unopened to the laboratory in the same shipping containers for VOCs including methane, ethane, and ethylene; and, at times, gasoline hydrocarbons. The blanks are prepared at the laboratory, sent to the project location, carried with the sampling team(s) during sampling, and shipped to the laboratory for analysis with the environmental samples.

Trip blank samples are commonly collected and analyzed at a rate of one per sample cooler containing samples for volatile analyses or the gasoline fraction of petroleum hydrocarbons. The number or rate of trip blanks to be collected and the specific analyses to be conducted for the trip blanks will be provided in the Project-Specific Work Plan.

10.4 Temperature Blanks

Temperature blanks consist of small containers filled with water that are included in each cooler. The temperature of each blank will be measured by laboratory personnel upon arrival at the laboratory to determine if method-specific preservative requirements (i.e., $\leq 4^{o}C$) were met. Temperature blanks are often prepared by the laboratory and included with the sample container order shipment to Burns & McDonnell.

11.0 REFERENCES

Burns & McDonnell Engineering, Co, Inc. (Burns & McDonnell), 2018. *Policy Manual*,

- Chapter 8, Employee Safety & Health, April 2017.
- Chapter 10, Quality Control Manual, January 2017.

GeoInsight, Inc, 2016. *Standard Operating Procedure: Sampling Ground Water with a HydraSleeve*. Las Cruces, NM

United States Environmental Protection Agency (USEPA), 2007. *Guidance for Preparing Standard Operating Procedures*. EPA/600/B-07/001. April

12.0 ATTACHMENTS

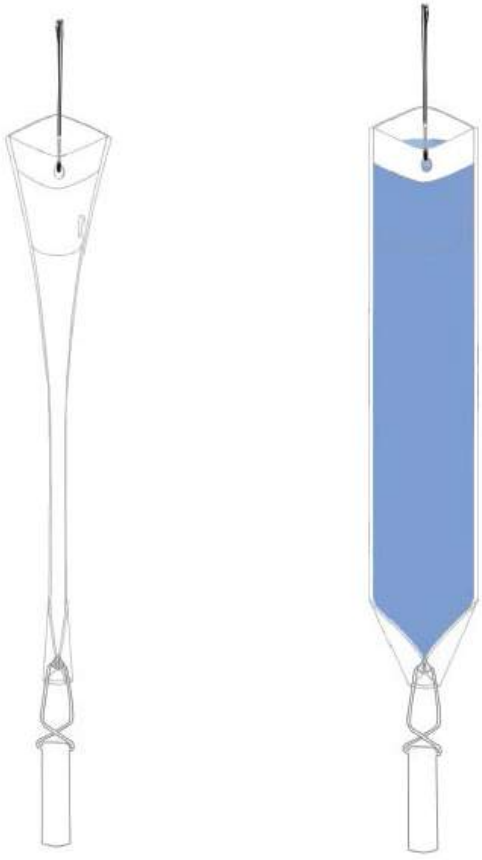
- *Standard Operating Procedure: Sampling Ground Water with a HydraSleeve* (GeoInsight, Inc., 2016) – Note that all pages of the manual have been attached and that page numbering is incorrect.
- HydraSleeve™ Deployment and Sampling Form

ATTACHMENTS

HYDRASleeve™

Simple by Design US Patent No. 6,481,300; No. 6,837,120 others pending

Standard Operating Procedure: Sampling Groundwater with a HydraSleeve



This guide should be used in addition to field manuals and instructions appropriate to the chosen sampling device (i.e., HydraSleeve, SpeedBag or Super/Skinny Sleeve and W3 HybridSleeve).

Find the appropriate field manual and instructions on the HydraSleeve website at http://www.hydrasleeve.com.

For more information about the HydraSleeve, or if you have questions, contact:
GeoInsight, P.O. Box 1266, Mesilla Park, NM 88047
800-996-2225, info@hydrasleeve.com.

Table of Contents

Introduction

The HydraSleeve is classified as a no-purge (passive) grab sampling device, meaning that it is used to collect groundwater samples directly from the screened interval of a well without having to purge the well prior to sample collection. When it is used as described in this Standard Operating Procedure (SOP), the HydraSleeve causes no drawdown in the well (until the sample is withdrawn from the water column) and only minimal disturbance of the water column, because it has a very thin cross section and it displaces very little water (<100 ml) during deployment in the well. The HydraSleeve collects a sample from within the screen only. It excludes water from any other part of the water column in the well through the use of a self-sealing check valve at the top of the sampler. It is a single-use (disposable) sampler that is not intended for reuse, so there are no decontamination requirements for the sampler itself.

The use of no-purge sampling as a means of collecting representative groundwater samples depends on the natural movement of groundwater (under ambient hydraulic head) from the formation adjacent to the well screen through the screen. Robin and Gillham (1987) demonstrated the existence of a dynamic equilibrium between the water in a formation and the water in a well screen installed in that formation, which results in formation-quality water being available in the well screen for sampling at all times. No-purge sampling devices like the HydraSleeve collect this formation-quality water as the sample, under undisturbed (non-pumping) natural flow conditions. Samples collected in this manner generally provide more conservative (i.e., higher concentration) values than samples collected using well-volume purging, and values equivalent to samples collected using low-flow purging and sampling (Parsons, 2005).

Applications of the HydraSleeve

The HydraSleeve can be used to collect representative samples of groundwater for all analytes (volatile organic compounds [VOCs], semi-volatile organic compounds [SVOCs], common metals, trace metals, major cations and anions, dissolved gases, total dissolved solids, radionuclides, pesticides, PCBs, explosive compounds, and all other analytical parameters). Designs are available to collect samples from wells from 1" inside diameter and larger. The HydraSleeve can collect samples from wells of any yield, but it is especially well-suited to collecting samples from low-yield wells, where other sampling methods can't be used reliably because their use results in dewatering of the well screen and alteration of sample chemistry (McAlary and Barker, 1987).

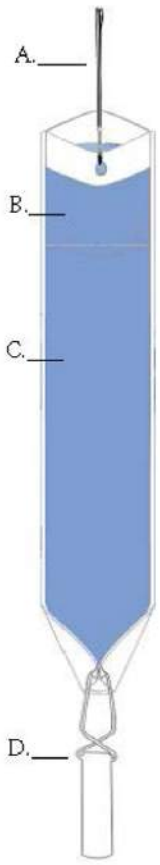
The HydraSleeve can collect samples from wells of any depth, and it can be used for single-event sampling or long-term groundwater monitoring programs. Because of its thin cross section and flexible construction, it can be used in narrow, constricted or damaged wells where rigid sampling devices may not fit. Using multiple HydraSleeves deployed in series along a single suspension line or tether, it is also possible to conduct in-well vertical profiling in wells in which contaminant concentrations are thought to be stratified.

As with all groundwater sampling devices, HydraSleeves should not be used to collect groundwater samples from wells in which separate (non-aqueous) phase hydrocarbons (i.e., gasoline, diesel fuel or jet fuel) are present because of the possibility of incorporating some of the separate-phase hydrocarbon into the sample.

Description of the HydraSleeve

The basic HydraSleeve (Figure 1) consists of the following components*:

- A suspension line or tether (A.), attached to the spring clip or directly to the top of the sleeve to deploy the device into and recover the device from the well. Tethers with depth indicators marked in 1-foot intervals are available from the manufacturer.
- A long, flexible, 4-mil thick lay-flat polyethylene sample sleeve (C.) sealed at the bottom (this is the sample chamber), which comes in different sizes, as discussed below with a self-sealing reed-type flexible polyethylene check valve built into the top of the sleeve (B.) to prevent water from entering or exiting the sampler except during sample acquisition.
- A reusable stainless-steel weight with clip (D.), which is attached to the bottom of the sleeve to carry it down the well to its intended depth in the water column. Bottom weights available from the manufacturer are 0.75" OD and are available in a variety of sizes. An optional top weight may be attached to the top of the HydraSleeve to carry it to depth and to compress it at the bottom of the well (not shown in Figure 1);
- A discharge tube that is used to puncture the HydraSleeve after it is recovered from the well so the sample can be decanted into sample bottles (not shown).
- Just above the self-sealing check valve at the top of the sleeve are two holes which provide attachment points for the spring clip and/or suspension line or tether. At the bottom of the sample sleeve are two holes which provide attachment points for the weight clip and weight.



*Other configurations such as top weighted assemblies, Super/SkinnySleeves, Speedbags, and W3 Hybrids are available.

Note: The sample sleeve and the discharge tube are designed for one-time use and are disposable. The spring clip, weight and weight clip may be reused after thorough cleaning. Suspension cord is generally disposed after one use although, if it is dedicated to the well, it may be reused at the discretion of the sampling personnel.

Selecting the HydraSleeve Size to Meet Site-Specific Sampling Objectives

It is important to understand that each HydraSleeve is able to collect a finite volume of sample because, after the HydraSleeve is deployed, you only get one chance to collect an undisturbed sample. Thus, the volume of sample required to meet your site-specific sampling and analytical requirements will dictate the size of HydraSleeve you need to meet these requirements.

Table 1. Dimensions and Volumes of HydraSleeve Models.

Diameter	Volume	Length	Lay-Flat Width	Filled Dia.
2-Inch HydraSleeves				
Standard 600 mls HydraSleeve	~600mls	30"	2.5"	1.4"
Standard 1-liter HydraSleeve	~1 Liter	38"	3"	1.9"
Super/SkinnySleeve 1-liter	~1 Liter	38"	2.5"	1.5"*
Super/SkinnySleeve 1.5-liter	~1.5 Liters	52"	2.5"	1.5"*
Super/SkinnySleeve 2-liter	*~2Liters*	*66"*	*2.5"*	*1.5"**
4-Inch HydraSleeves				
Standard 2.5 liter	~2 Liters	38"	4"	2.7"

* outside diameter on the Heavy Duty Universal Super/SkinnySleeves is 1.5" however when using with schedule 40 hardware the O.D. of the assembly will be 1.9"

It's also recommended that you size the diameter of the HydraSleeve according to the diameter of the well (i.e. use 2-inch HydraSleeves in 2-inch wells). Using smaller sleeves in larger diameter wells (i.e. 2-inch HydraSleeves in 4-inch wells) will result in a longer fill rate and will require special retrieval instructions (explained later).

The volume of sample collected by the HydraSleeve varies with the diameter and length of the HydraSleeve. Dimensions and volumes of available HydraSleeve models are detailed in Table 1.

HydraSleeves can be custom-fabricated by GeoInsight in varying diameters and lengths to meet specific volume requirements. HydraSleeves can also be deployed in series (i.e., multiple HydraSleeves attached to one tether) to collect additional sample to meet specific volume requirements, as described below.

If you have questions regarding the availability of sufficient volume of sample to satisfy laboratory requirements for analysis, it is recommended that you contact the laboratory to discuss the minimum volumes needed for each suite of analytes. Laboratories often require only 10% to 25% of the volume they specify to complete analysis for specific suites of analytes, so they can often work with much smaller sample volumes that can easily be supplied using a HydraSleeve.

HydraSleeve Deployment

Information Required Before Deploying a HydraSleeve

Before installing a HydraSleeve in any well, you will need to know the following:

- The inside diameter of the well
- The length of the well screen
- The water level in the well
- The position of the well screen in the well
- The total depth of the well

The inside diameter of the well is used to determine the appropriate HydraSleeve diameter for use in the well. The other information is used to determine the proper placement of the HydraSleeve in the well to collect a representative sample from the screen (see HydraSleeve Placement, below), and to determine the appropriate length of tether to attach to the HydraSleeve to deploy it at the appropriate position in the well.

Most of this information (with the exception of the water level) should be available from the well log; if not, it will have to be collected by some other means. The inside diameter of the well can be measured at the top of the well casing, and the total depth of the well can be measured by sounding the bottom of the well with a weighted tape. The position and length of the well screen may have to be determined using a down-hole camera if a well log is not available. The water level in the well can be measured using any commonly available water-level gauge.

HydraSleeve Placement

The HydraSleeve is designed to collect a sample directly from the well screen. It fills by pulling it up through the screen a distance equivalent to the length of the sampler when correctly sized to the well diameter. This upward motion causes the top check valve to open, which allows the device to fill. To optimize sample recovery, it is recommended that the HydraSleeve be placed in the well so that the bottom weight rests on the bottom of the well and the top of the HydraSleeve is as close to the bottom of the well screen as possible. This should allow the sampler to fill before the top of the device reaches the top of the screen as it is pulled up through the water column, and ensure that only water from the screen is collected as the sample. In short-screen wells, or wells with a short water column, it may be necessary to use a top-weight on the HydraSleeve to compress it in the bottom of the well so that, when it is recovered, it has room to fill before it reaches the top of the screen.

Example

2" ID PVC well, 50' total depth, 10' screen at the bottom of the well, with water level above the screen (the entire screen contains water).

Correct Placement (figure 2): Using a standard HydraSleeve for a 2" well (2.5" flat width/1.5" filled OD x 30" long, 600 ml volume), deploy the sampler so the weight (a 5 oz., 2.5" long weight with a 2" long clip) rests at the bottom of the well. The top of the sleeve is thus set at ~34" above the bottom of the well. When the sampler is recovered, it will be pulled upward approximately 30" before it is filled; therefore, it is full (and the top check valve closes) at approximately 64" (5.3 feet) above the bottom of the well, which is well before the sampler reaches the top of the screen. In this example, only water from the screen is collected as a sample.

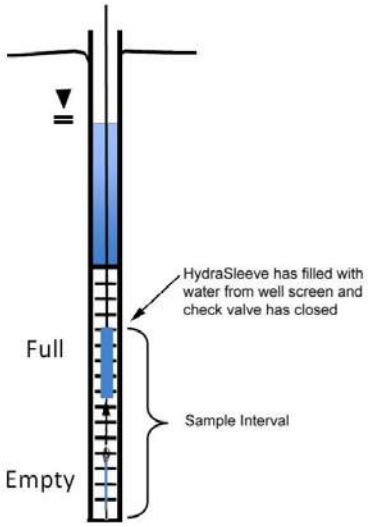


Figure 2. Correct Placement of HydraSleeve.

Incorrect Placement (figure 3): If the well screen in this example was only 5' long, and the HydraSleeve was placed as above, it would not fill before the top of the device reached the top of the well screen, so the sample would include water from above the screen, which may not have the same chemistry.

The solution? Deploy the HydraSleeve with a top weight, so that it is collapsed to within 6" of the bottom of the well. When the HydraSleeve is recovered, it will fill within 36" (3 feet) from the bottom of the well, or 2-feet before the sampler reaches the top of the screen, so it collects only water from the screen as the sample.

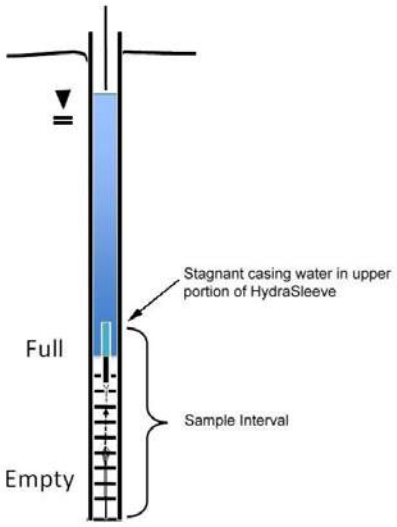


Figure 3. Incorrect placement of HydraSleeve.

This example illustrates one of many types of HydraSleeve placements. More complex placements are discussed in a later section.

NOTE: Using smaller diameter HydraSleeves (2-inch) in larger diameter wells (4-inch) causes a slower fill rate. Special retrieval methods are necessary if this is your set up (shown later in this document).

Procedures for Sampling with the HydraSleeve

Collecting a groundwater sample with a HydraSleeve is usually a simple one-person operation.

Note: Before deploying the HydraSleeve in the well, collect the depth-to-water measurement that you will use to determine the preferred position of the HydraSleeve in the well. This measurement may also be used with measurements from other wells to create a groundwater contour map. If necessary, also measure the depth to the bottom of the well to verify actual well depth to confirm your decision on placement of the HydraSleeve in the water column.

Measure the correct amount of tether needed to suspend the HydraSleeve in the well so that the weight will rest on the bottom of the well (or at your preferred position in the well). Make sure to account for the need to leave a few feet of tether at the top of the well to allow recovery of the sleeve.

Note: Always wear sterile gloves when handling and discharging the HydraSleeve.

I. Assembling the Basic HydraSleeve*

1. Remove the HydraSleeve from its packaging, unfold it, and hold it by its top.
2. Crimp the top of the HydraSleeve by folding the hard polyethylene reinforcing strips at the holes.
3. Attach the spring clip to the holes to ensure that the top will remain open until the sampler is retrieved.
4. Attach the tether to the spring clip by tying a knot in the tether.

Note: Alternatively, if spring clips are not being utilized, attach the tether to one (NOT both) of the holes at the top of the Hydrasleeve by tying a knot in the tether.

5. Fold the flaps with the two holes at the bottom of the HydraSleeve together to align the holes and slide the weight clip through the holes.
6. Attach a weight to the bottom of the weight clip to ensure that the HydraSleeve will descend to the bottom of the well.

*See Super/SkinnySleeve assembly manual and HydraSleeve Field Manual for other assembly instructions.

II. Deploying the HydraSleeve

1. Using the tether, carefully lower the HydraSleeve to the bottom of the well, or to your preferred depth in the water column

   During installation, hydrostatic pressure in the water column will keep the self-sealing check valve at the top of the HydraSleeve closed, and ensure that it retains its flat, empty profile for an indefinite period prior to recovery.

Note: Make sure that it is not pulled upward at any time during its descent. If the HydraSleeve is pulled upward at a rate greater than 0.5'/second at any time prior to recovery, the top check valve will open and water will enter the HydraSleeve prematurely.

2. Secure the tether at the top of the well by placing the well cap on the top of the well casing and over the tether.

Note: Alternatively, you can tie the tether to a hook on the bottom of the well cap (you will need to leave a few inches of slack in the line to avoid pulling the sampler up as the cap is removed at the next sampling event).

III. Equilibrating the Well

The equilibration time is the time it takes for conditions in the water column (primarily flow dynamics and contaminant distribution) to restabilize after vertical mixing occurs (caused by installation of a sampling device in the well).

- Situation: The HydraSleeve is deployed for the first time or for only one time in a well

  The basic HydraSleeve is very thin in cross section and displaces very little water (<100 ml) during deployment so, unlike most other sampling devices, it does not disturb the water column to the point at which long equilibration times are necessary to ensure recovery of a representative sample.

  In some cases, like when useing the SpeedBags, the HydraSleeve can be recovered immediately (with no equilibration time) or within a few hours. In regulatory jurisdictions that impose specific requirements for equilibration times prior to recovery of no-purge sampling devices, these requirements should be followed.

  NOTE: If using top weights additional equilibration time is needed to allow the top weight time to compress the HydraSleeve into the bottom of the well.

- Situation: The HydraSleeve is being deployed for recovery during a future sampling event.

  In periodic (i.e., quarterly, semi-annual, or annual) sampling programs, the sampler for the current sampling event can be recovered and a new sampler (for the next sampling event) deployed immediately thereafter, so the new sampler remains in the well until the next sampling event.

Thus, a long equilibration time is ensured and, at the next sampling event, the sampler can be recovered immediately. This means that separate mobilizations, to deploy and then to recover the sampler, are not required. HydraSleeves can be left in a well for an indefinite period of time without concern.

IV. HydraSleeve Recovery and Sample Collection

1. Hold on to the tether while removing the well cap.
2. Secure the tether at the top of the well while maintaining tension on the tether (but without pulling the tether upwards)
3. Measure the water level in the well.
4. Use one of the following 3 retrieval methods. In all 3 scenarios, when the HydraSleeve is full, the top check valve will close. You should begin to feel the weight of the HydraSleeve on the tether and it will begin to displace water. The closed check valve prevents loss of sample and entry of water from zones above the well screen as the HydraSleeve is recovered.

   a. In one smooth motion, pull the tether up 30"-60" (the length of the sampler) at a rate of about 1 foot per second (or faster). The motion will open the top check valve and allow the HydraSleeve to fill (it should fill in about 1:1 ratio or the length of the HydraSleeve if the sleeve is sized to fit the well). This is analogous to coring the water column in the well from the bottom up.

   b. There are times it is recommended that the HydraSleeve be oscillated in the screen zone to ensure it is full before leaving the screen area. Pull up 1-3 feet, let the sleeve assembly drop back down and repeat 3-5 times before pulling the sleeve to the surface. The collection zone will be the oscillation zone. ***When in doubt use this retrieval method.***

   c. SpeedBags require check valve activation and oscillation during recovery: When retrieving the SpeedBag, pull up hard 1-2 feet to open the check valve; let the assembly drop back down to the starting point; REPEAT THIS PROCESS 4 TIMES; and then quickly recover the SpeedBag through the well sceen to the surface.

5. Continue pulling the tether upward until the HydraSleeve is at the top of the well.
6. Discard the small volume of water trapped in the Hydrasleeve above the check valve by pinching it off at the top under the stiffeners (above the check valve).

v. Sample Discharge

NOTE: Sample collection should be done immediately after the HydraSleeve has been brought to the surface to preserve sample integrity.

Be sure you have discarded the water sitting above the check valve – see step #6 above.

1. Remove the discharge tube from its sleeve.
2. Hold the HydraSleeve at the check valve
3. Puncture the HydraSleeve at least 3-4 inches below the reinforcement strips with the pointed end of the discharge tube. NOTE: For some contaminants (VOC's/sinkers) the best location for discharge is the middle to bottom of the sampler. This would be representative of the deeper portion of the well screen.
4. Discharge water from the HydraSleeve into your sample containers. Control the discharge from the HydraSleeve by either raising the bottom of the sleeve, by squeezing it like a tube of toothpaste, or both.
5. Continue filling sample containers until all are full.

Measurement of Field Indicator Parameters

Field indicator parameter measurement is generally done during well purging and sampling to confirm when parameters are stable and sampling can begin. Because no-purge sampling does not require purging, field indicator parameter measurement is not necessary for the purpose of confirming when purging is complete.

If field indicator parameter measurement is required to meet a specific non-purging regulatory requirement, it can be done by taking measurements from water within a HydraSleeve that is not used for collecting a sample to submit for laboratory analysis (i.e., a second HydraSleeve installed in conjunction with the primary sample collection HydraSleeve [see Multiple Sampler Deployment below]).

Alternate Deployment Strategies

Deployment in Wells with Limited Water Columns

For wells in which only a limited water column needs to be sampled, the HydraSleeve can be deployed with an optional top weight in addition to a bottom weight. The top weight will collapse the HydraSleeve to a very short (approximately 6" to 24") length, depending on the length and volume of the sampler. This allows the HydraSleeve to fill in a water column only 3' to 10' in height (again) depending on the sampler size. Note the SuperSleeves accomplish the same thing but provide greater sample volume at a lower per sample cost.

Multiple Sampler Deployment

Multiple sampler deployment in a single well screen can accomplish two purposes:

1. It can collect additional sample volume to satisfy site or laboratory-specific sample volume requirements.
2. It can be used to collect samples from multiple intervals in the screen to allow identification of possible contaminant stratification.

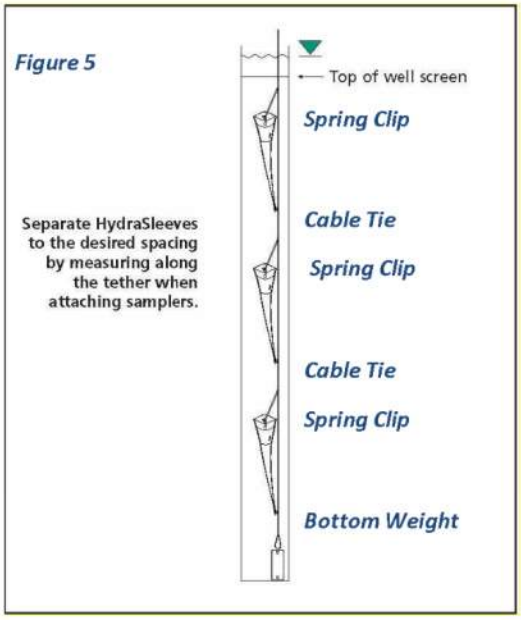


Figure 5. Multiple HydraSleeve deployment

If there is a need for only 2 samplers, they can be installed as follows. The first sampler can be attached to the tether as described above, a second attached to the bottom of the first using your desired length of tether between the two and the weight attached to the bottom of the second sampler (figure 6). This method can only be used with 2 samplers; 3 or more HydraSleeves in tandem need to be attached as described above.

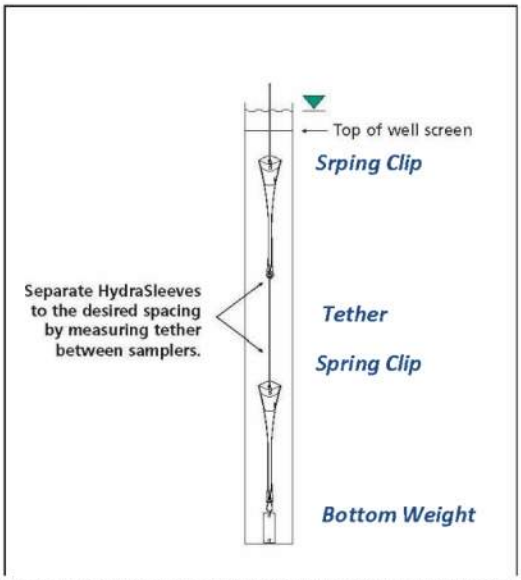


Figure 6. Alternative method for deploying multiple HydraSleeves.

In either case, when attaching multiple HydraSleeves in series, more weight will be required to hold the samplers in place in the well than would be required with a single sampler. Recovery of multiple samplers and collection of samples is done in the same manner as for single sampler deployments.

Post-Sampling Activities

The recovered HydraSleeve and the sample discharge tubing should be disposed as per the solid waste management plan for the site. To prepare for the next sampling event, a new HydraSleeve can be deployed in the well (as described previously) and left in the well until the next sampling event, at which time it can be recovered.

The weight and weight clip can be reused on this sampler after they have been thoroughly cleaned as per the site equipment decontamination plan. The tether may be dedicated to the well and reused or discarded at the discretion of sampling personnel.

References

McAlary, T. A. and J. F. Barker, 1987, Volatilization Losses of Organics During groundwater Sampling From Low-Permeability Materials, groundwater Monitoring Review, Vol. 7, No. 4, pp. 63-68

Parsons, 2005, Results Report for the Demonstration of No-Purge groundwater Sampling Devices at Former McClellan Air Force Base, California; Contract F44650-99-D-0005, Delivery Order DKO1, U.S. Army Corps of Engineers (Omaha District), U.S. Air Force Center for Environmental Excellence, and U.S. Air Force Real Property Agency

Robin, M. J. L. and R. W. Gillham, 1987, Field Evaluation of Well Purging Procedures, groundwater Monitoring Review, Vol. 7, No. 4, pp. 85-93

Example HydraSleeve Deployment and Sampling Forms

HydraSleeve™ Deployment and Sampling Form

Project Number:	**Well Number:**
Project Name:	**Site Name:**

Deployment

Field Team Members:		**Date:**			
	Weather:	Temp	Precip	Wind	Other

Well Construction Information (ft from TOC):

- Constructed Total Depth: _____
- Diameter of Well (in): _____
- Historic Depth to Water: _____
- Depth to Top of Screen: _____
- Depth to Bottom of Screen: _____

Field Measurements:

- PID Reading at Well Head: _____ ppm
- Measured Total Depth: _____ ft from TOC
- Depth to Water: _____ ft from TOC
- Depth to Top of HydraSleeve™: _____ ft from TOC
- Ft of Water Above HydraSleeve™: _____ ft

HydraSleeve™ Information:

- HydraSleeve™ Manufacturer: _____
- HydraSleeve™ Type: _____
- HydraSleeve™ Part#: _____
- Number of HydraSleeves™ Set: _____

Comments:

Sample Collection

Field Team Members:		**Date:**			
	Weather:	Temp	Precip	Wind	Other

Comments:

Field Measurements:

- PID Reading at Well Head: _____ ppm
- Measured Total Depth: _____ ft from TOC
- Depth to Water: _____ ft from TOC
- Depth to Top of HydraSleeve™: _____ ft from TOC
- Ft of Water Above HydraSleeve™: _____ ft

Sample ID: **Sample Date & Time:**

Analysis	Method	Sample Container(s)	Preser-vative	Collected (Y/N)	Comments

QA/QC Samples

Sample ID:	QA/QC Type	Comments

SOP 501
Utility Clearance

Revision 01
04/06/2018

Approved by:

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Environmental Division

04/02/2018
Date

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04/02/2018
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Biennial Review:

Revision/Review	Date	Responsible Party	Description of Change
Revision 01	04/06/2018	Hildebrandt, Martha	Minor grammar and reference updates.

TABLE OF CONTENTS

Page No.

1.0 PURPOSE AND APPLICABILITY

The purpose of *Standard Operating Procedure (SOP) 501 Utility Clearance* is to establish a uniform procedure for field personnel to use for utility clearance prior to intrusive work at an environmental site. This SOP covers the ***process*** for the utility clearance; specifics of the utility clearance including property ownership and potential utilities are detailed in the Project-Specific Work Plan and the Project-Specific Accident Prevention Plan/Site Safety and Health Plan (Project-Specific APP/SSHP). *SOP 501 Utility Clearance* has been prepared in accordance with the *Guidance for the Preparing of Standard Operating Procedures* (USEPA, 2007) and the Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) *Policy Manual* (Burns & McDonnell, 2017).

2.0 SUMMARY OF METHOD

Prior to any field work involving intrusive activities, utility clearance will be required. Subcontractor or Burns & McDonnell personnel will locate utilities with the aid of state-mandated utility location services, private utility location services, as-built drawings, client personnel, and/or individual property owners. Typically, utility locates are the responsibility of the subcontractor conducting the intrusive activities; however, in some cases, such as hand augering, the intrusive activities are being conducted by Burns & McDonnell, in which case, Burns & McDonnell is responsible for the utility clearance prior to the start of the intrusive activities.

3.0 DEFINITIONS

- **Project-Specific Accident Prevention Plan/Site Safety and Health Plan** (Project-Specific APP/SSHP) – A plan or plans that address occupational safety and health hazards associated with site operations.
- **Project-Specific Work Plan** – The plan that details the rationale, scope, and techniques to be used at the site to achieve the project objectives. Project-Specific Work Plans can include work plans, field sampling plans, quality assurance project plans, technical memorandums, and other documentation of proposed work.

4.0 SAFETY AND HEALTH

Utility clearance is required prior to conducting any intrusive activity at a site. Hitting a utility can result in property destruction, injury, or even death. Work may be stopped at ***any*** time by ***any*** team personnel due to utility concerns. At some locations, client requirements will include additional precautions for utility clearance such as using an air knife, hydro vacuum, and/or soil vacuum.

Field activities as detailed in this SOP will be performed in accordance with applicable safety related documents/requirements which may include but are not limited to: Project-Specific APP/SSHP, the Burns & McDonnell *Safety and Health Program* (Burns & McDonnell 2017), and site / client-specific requirements. Personal protective equipment (PPE) should be worn as appropriate and as detailed in the Project-Specific APP/SSHP. PPE requirements should be assessed daily and on a per task basis.

5.0 CAUTIONS

See Section 4.0

6.0 PERSONNEL QUALIFICATIONS

Burns & McDonnell personnel conducting on-site environmental activities will have completed the 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) course and annual 8-hour HAZWOPER refresher courses. At a minimum, one person on site will be certified in first aid and cardiopulmonary resuscitation (CPR) and, if multiple people are on site, at least one person will have completed the 8-hour HAZWOPER Supervisor Training course. If Burns & McDonnell subcontractors are on site then, at a minimum, one Burns & McDonnell person will have completed the OSHA 30-hour Construction Industry Outreach Training.

7.0 EQUIPMENT AND SUPPLIES

Equipment and supplies are the responsibility of the subcontractor or utility location service.

8.0 PROCEDURES

Utility clearance activities start during the project planning process. Information on the location of utilities should be requested from the client and locations and potential locations of utilities should be avoided when planning sample locations. A minimum of two full business days' notification is required for most state one-calls prior to commencing intrusive activities. Utility clearance activities, including the ticket number, request date and end date, utilities notified, and the names and companies of persons granting utility clearance will be documented on the ticket and in the field logbook. If a subcontractor is performing the utility clearance, a copy of the utility clearance ticket will be requested for documentation purposes. The Field Site Manager should track the effective date of the utility clearance and check that the utility clearance has been renewed prior to the ticket expiring.

Specific utility clearance procedures will be detailed in the Project-Specific Work Plan and the Project-Specific APP/SSHP. At a minimum, drilling rigs/equipment will be positioned such that they are no closer than the lesser of the height of the mast/tallest part of the equipment or 20 feet of overhead lines with voltages 0-50 kV; for other voltages refer to 29 CFR 1926.550 (a) (15) and 29 CFR 1910.333 (i) (1). Other vehicles will remain a minimum lateral distance of 30 feet from overhead utilities to reduce the possibility of arcing. Intrusive activities will be no closer than 10 feet from buried utilities. Specific procedures for any activities that are closer than 10 feet will be detailed in the Project-Specific Work Plan and in the Project-Specific APP/SSHP.

Due to the presence of underground or overhead utilities, it may be necessary to offset boring locations. This will be done with the approval of the Field Site Manager and documented in the field logbook. Notification of the relocation of boring locations due to utility or other interference will be reported to the Project Manager by the Field Site Manager immediately.

9.0 DATA AND RECORDS MANAGEMENT

A copy of the utility clearance ticket number will be kept in the project file and notes regarding utility location activities will be maintained in the field logbook as described in *SOP 701 Field Documentation*. Field documentation will be completed as activities are conducted and will be relayed to the Field Site Manager or Project Manager at a minimum weekly or on a more frequent basis if so stated in the Project-Specific Work Plan. The client will be notified if data collected in the field screening indicates unmarked or unknown underground lines are present so that they can update their records.

10.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to the start of any field activity, Burns & McDonnell personnel will have read and understood the Project-Specific Work Plan as well as this SOP. Field personnel will be trained for a minimum of 40 hours prior to their working solo on environmental field activities.

11.0 REFERENCES

Burns & McDonnell Engineering, Co, Inc. (Burns & McDonnell), 2018. *Policy Manual*,

- Chapter 8, Employee Safety & Health, April 2017.
- Chapter 10, Quality Control Manual, January 2017.

United States Environmental Protection Agency (USEPA), 2007. *Guidance for Preparing Standard Operating Procedures*. EPA/600/B-07/001. April

12.0 ATTACHMENTS

None.

SOP 504
Decontamination

Revision 01
04/06/2018

Approved by:

04/03/2018

Martha Hildebrandt, PG, Associate Geologist,
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Date

04/04/2018

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04/06/2018

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TABLE OF CONTENTS

Page No.

1.0 PURPOSE AND APPLICABILITY

The purpose of *Standard Operating Procedure (SOP) 504 Decontamination* is to establish a uniform procedure for field personnel in the decontamination of environmental equipment. Proper equipment decontamination is essential in ensuring the quality and integrity of samples collected during a given sampling event. This SOP covers the *process* for the equipment decontamination; specifics of decontamination including decontamination fluids and rinses, location of decontamination places and pad, and extra washes and rinses to be used are detailed in the Project-Specific Work Plans. *SOP 504 Decontamination* has been prepared in accordance with the *Guidance for the Preparing of Standard Operating Procedures* (USEPA, 2007) and the Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) *Policy Manual* (Burns & McDonnell, 2018).

2.0 SUMMARY OF METHOD

Decontamination is the process of removing contamination from equipment prior and post sampling. Removing contaminants from equipment minimizes the likelihood of sample cross contamination, reduces transfer of contaminants to clean areas, and prevents the mixing of incompatible substances. Decontamination typically includes both physical (scrubbing) and chemical (soap and acid or solvent rinses). It is important that decontamination is performed using materials and equipment that can effectively remove anticipated contaminants of concern while not damaging the equipment. After decontamination, equipment should be handled only by personnel wearing clean gloves and moved out of the decontamination area to prevent re-contamination.

3.0 DEFINITIONS

- **Distilled Water** - Water that has had many of its impurities removed through distillation. Distillation involves boiling the water and then condensing the steam into a clean container.

- **Laboratory Grade Detergent** – A detergent formulated specifically for use in laboratories to be clean rinsing and phosphate free. Standard brands include Alconox® and Liquinox®.

- **Potable Water** - Treated municipal water or well water used and approved for drinking.

- **Project-Specific Accident Prevention Plan/Site Safety and Health Plan** (Project-Specific APP/SSHP) – A plan or plans that address occupational safety and health hazards associated with site operations.

- **Project-Specific Work Plan** – The plan that details the rationale, scope, and techniques to be used at the Site to achieve the project objectives. Project-Specific Work Plans can include work plans, field sampling plans, quality assurance project plans, technical memorandums, and other documentation of proposed work.

4.0 SAFETY AND HEALTH

Field activities as detailed in this SOP will be performed in accordance with applicable safety related documents/requirements which may include but are not limited to: Site Safety and Health Plans, the Burns & McDonnell *Safety and Health Program* (Burns & McDonnell, 2017), and site / client-specific requirements. Personal protective equipment (PPE) including safety glasses and gloves should be worn as appropriate and as detailed in the Project-Specific APP/SSHP. PPE requirements should be assessed daily and on a per task basis. Rinses such as acids and solvents should be handled with care during transportation to and from the site and stored properly while on site. A Safety Data Sheet should be on site for all chemical rinses.

5.0 CAUTIONS

High concentrations of contaminants or the requirement of very low detection levels may require decontamination procedures that are more stringent than that described in this SOP. This should be considered during work plan development but also recognized if encountered in the field.

Prior to field mobilization, the expected types of contamination should be evaluated to determine if the field cleaning and decontamination activities will generate rinsates and other wastewaters that might be considered Resource Conservation and Recovery Act (RCRA) hazardous waste thus require special handling and disposal procedures.

Care should be taken to remove all visible potential contamination from sample equipment to prevent cross contamination which could result in false positive analytical results.

6.0 PERSONNEL QUALIFICATIONS

Burns & McDonnell personnel conducting on-site environmental activities will have completed the 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) course and annual 8-hour HAZWOPER refresher courses. At a minimum, one person on site will be certified in first aid and cardiopulmonary resuscitation (CPR) and, if multiple people are on site, at least one person will have completed the 8-hour HAZWOPER Supervisor

Training course. If Burns & McDonnell subcontractors are on site then, at a minimum, one Burns & McDonnell person will have completed the OSHA 30-hour Construction Industry Outreach Training course.

7.0 EQUIPMENT AND SUPPLIES

Typical decontamination equipment and supplies include the following items:

- Potable water
- Distilled water
- Non-phosphate laboratory-grade detergent
- Wash bottles
- Buckets
- Scrub brushes
- Plastic sheeting
- Garbage bags
- PPE and safety equipment per the Project-Specific APP/SSHP

Additional rinsates including methanol, isopropyl, and hexane, may be required dependent upon the chemicals of concern.

Prior to the start of field activities, the Field Site Manager and/or the Project Manager should determine that 1) necessary permits, and right of entries have been obtained; 2) the Project-Specific APP/SSHP has been reviewed by Burns & McDonnell personnel participating in the work and subcontractors who will be on site; 3) appropriate PPE has been obtained for Burns & McDonnell personnel and will be available on site; 4) equipment and meters are available, in working order, and complete with needed components; and 5) applicable safety data sheets are on site and available to the field team.

8.0 PROCEDURES

8.1 Decontamination of Non-Dedicated Bladder Pumps

Non-dedicated bladder pumps will be decontaminated according to the following procedure:

1. Leave or attach approximately 4 feet of air supply and water discharge tubing to the pump. Place the pump inside a solid/blank 5-foot section of 2-inch inside diameter polyvinyl chloride (PVC) pipe that has one end capped.

2. Attach the air supply tube to the controller, which is attached to the compressed air source, and direct the discharge tube back into the PVC pipe to recirculate the wash water. Fill the PVC pipe with distilled or potable water, adding approximately one-half teaspoon of non-phosphate, laboratory-grade detergent.

3. Turn on the pump and circulate the wash water for approximately one minute.

4. Direct the discharge into a bucket and pump the detergent water from the PVC pipe.

5. Pump 3 to 5 liters of distilled water through the pump, adding water to the pipe as needed, to rinse the detergent from the pump.

6. Retain decontamination fluids per *SOP 601 Investigative Derived Waste Storage, Sampling, and Disposal*.

8.2 Decontamination of Other Sample-Contacting Equipment

Non-disposable and other non-dedicated equipment which contacts the sample will be decontaminated prior to the collection of each sample and at the close of each day. This equipment includes, but is not limited to, sampling knives and spoons, mixing bowls, split-sampling barrels, direct-push shoes and subs, and reusable containers.

Sampling equipment will be decontaminated according to the following procedure:

1. Fill a nonmetallic wash tub or bucket to a depth of approximately 6 inches with potable water. Mix a detergent solution in the tub. The solution shall consist of approximately 1 tablespoon of non-phosphate laboratory-grade detergent (e.g. Liquinox) per gallon of water.

2. Scrub sampling equipment with a stiff-bristled brush and detergent solution to physically remove visible gross contamination.

3. Transfer the equipment to another wash tub partially filled with distilled water and rinse.

4. Rinse the sampling equipment again with fresh distilled water.

5. Place the equipment on clean plastic and allow it to air dry.

6. Store the equipment covered with plastic or aluminum foil upon the completion of decontamination.

7. Retain decontamination fluids per *SOP 601 Investigative Derived Waste Storage, Sampling, and Disposal*.

8.3 Decontamination of Meters and Probes

Meter probes, water level indicator and oil/water interface probe, will be decontaminated prior to use at each sample location and at the close of each day. Water indicator probes and tapes will be decontaminated per the following procedure.

1. As the tape is being reeled onto the instrument, the tape will be wiped with paper towels that have been sprayed or dampened with a detergent solution. The solution shall consist of approximately 1 tablespoon of non-phosphate laboratory-grade detergent (e.g. Liquinox) per gallon of water.

2. Decontaminate the probe portion of the instrument by spraying with the detergent solution then rinsing with water. If sediment is present on the probe, then ensure the sediment is removed by the cleaning followed by a distilled water rinse.

If nonaqueous phase liquids are encountered or if the measured media is severely impacted, then decontaminate water level indicators and oil/water interface probes by:

1. Fill a nonmetallic wash tub or bucket to a depth of about 6 inches with potable water. Mix a detergent solution in the tub. The solution shall consist of approximately 1 tablespoon of non-phosphate laboratory-grade detergent (e.g. Liquinox) per gallon of water.

2. Clean the portions of the meters and probes that had contact with site media with the detergent solution.

3. Rinse the portions of the meters and probes with distilled water.

4. Place the equipment on clean plastic and allow it to air dry.

5. Store the equipment in the provided case or covered with plastic or aluminum foil.

6. Retain decontamination fluids per *SOP 601 Investigative Derived Waste Storage, Sampling, and Disposal*.

Instruments such as pH meters, conductivity meters, and other instruments that do not come into contact with the material that will be collected for analysis may be decontaminated by thoroughly rinsing the instrument probes.

8.4 Decontamination of Non-Sample-Contacting Equipment

Down-hole sampling tools such as drill string, augers, and direct-push rods, as well as drill rigs and direct-push trucks/vans, will be decontaminated prior to the start of work on site, between each borehole, and prior to leaving the site. Decontamination of subcontractor-owned equipment is typically the responsibility of the subcontractor. Decontamination should be according to the following procedure:

1. Construct a three-sided decontamination pad using planks as a frame and plastic sheeting as the bottom. The pad should be constructed on a slight slope with the open side facing uphill.

2. Back the drill rig or direct-push rig into the decontamination pad or place equipment in a rack off the ground inside the pad.

3. Use pressurized, potable water to completely remove visible soil and contamination from surfaces. Include the inside of drill string, augers, and direct-push rods. If necessary, use a stiff-bristled brush to remove soil and contamination. Dependent upon the contaminant present, the Project-Specific Work Plan may require the use of hot, pressurized water with laboratory grade detergent. The use of a detergent wash will require a rinse with potable water.

4. Place the equipment on clean plastic and allow to air dry.

5. Store equipment and cover with plastic after decontamination.

6. Retain decontamination fluids as described in *SOP 601 Investigative Derived Waste Storage, Sampling, and Disposal*.

9.0 DATA AND RECORDS MANAGEMENT

A documentation of field activities will be maintained in the field logbook as described in *SOP 701 Field Documentation*. Field documentation will be completed as activities are conducted and will be relayed to the Field Site Manager or Project Manager at a minimum weekly or on a more frequent basis if so stated in the Project-Specific Work Plan.

10.0 QUALITY ASSURANCE/QUALITY CONTROL

Equipment rinstate blanks (ERBs) are often collected from non-disposable, sample-contacting equipment to determine if cross contamination is occurring. Procedures for the collection of ERBs can be found in the SOPs for the specific sampling method.

Prior to the start of any field activity, Burns & McDonnell personnel will have read and understood the Project-Specific Plans as well as this SOP. Field personnel will be trained for a minimum of 40 hours prior to their working solo on environmental field activities.

11.0 REFERENCES

Burns & McDonnell Engineering, Co, Inc. (Burns & McDonnell), 2018. *Policy Manual*,

- Chapter 8, Employee Safety & Health, April 2017.
- Chapter 10, Quality Control Manual, January 2017.

United States Environmental Protection Agency (USEPA), 2007. *Guidance for Preparing Standard Operating Procedures*. EPA/600/B-07/001. April

12.0 ATTACHMENTS

None.

SOP 511
Fluid Level and Total Depth Measurements

Revision 01
04/06/2018

Approved by:

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04/02/2018
Date

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04/02/2018
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04/06/2018
Date

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Revision/Review	Date	Responsible Party	Description of Change
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TABLE OF CONTENTS

Page No.

1.0 PURPOSE AND APPLICABILITY

The purpose of *Standard Operating Procedure (SOP) 511 Fluid Level and Total Depth Measurements* is to establish a uniform procedure for the collection of fluid levels of water, light non-aqueous phase liquids (LNAPLs), and dense non-aqueous phase liquid (DNAPLs); and the measurement of the total depth in borings, monitoring wells, piezometers, tanks, excavations, and other containers that may hold fluids. This SOP covers the *process* for the measurements of fluid levels and total depths: sample rationale and scope including locations, depths, number of measurements, etc. are detailed in the Project-Specific Work Plan. *SOP 511 Fluid Level and Total Depth Measurements* has been prepared in accordance with the *Guidance for the Preparing of Standard Operating Procedures* (USEPA, 2007) and the Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) *Policy Manual* (Burns & McDonnell, 2018).

2.0 SUMMARY OF METHOD

Fluid levels and total depths measurements are collected to characterize the conditions, hydrogeology, and contaminants presence at a site. Fluid levels and total depth will be measured as specified in the Project-Specific Work Plans but are typically measured in boreholes during drilling and well installation and prior to collection of groundwater samples from piezometers, monitoring wells, and boreholes; but can also be measured in tanks, excavations, and other containers that may hold fluids. Electronic water level meters will be typically used; however, electronic oil/water interface probes should be used at locations where LNAPL or DNAPL is potentially present. In monitoring wells with watertight caps, the cap will be removed and fluid level measurements repeated at regular intervals until the readings stabilize. If required by the Project-Specific Work Plan, as the well cap is removed or the protective cover lid opened, a photoionization detector (PID) will be used to measure the organic vapor content at the well head.

3.0 DEFINITIONS

- **Dense non-aqueous phase liquid (DNAPL)** - Single or multicomponent liquids that are denser than water and relatively insoluble in water.

- **Light non-aqueous phase liquid (LNAPL)** - Single or multicomponent liquids that are less dense than water and relatively insoluble in water.

- **Project-Specific Accident Prevention Plan/Site Safety and Health Plan** (Project-Specific APP/SSHP) – A plan or plans that address occupational safety and health hazards associated with site operations.

- **Project-Specific Work Plan** – The plan that details the rationale, scope, and techniques to be used at the site to achieve the project objectives. Project-Specific Work Plans can include work plans, field sampling plans, quality assurance project plans, technical memorandums, and other documentation of proposed work.

4.0 SAFETY AND HEALTH

Field activities as detailed in this SOP will be performed in accordance with applicable safety related documents/requirements which may include but are not limited to: Project-Specific APP/SSHP, the Burns & McDonnell *Safety and Health Program* (Burns & McDonnell, 2017), and site / client-specific requirements. Personal protective equipment (PPE) including safety glasses and gloves should be worn as appropriate and as detailed in the Project-Specific APP/SSHP. PPE requirements should be assessed daily and on a per task basis.

5.0 CAUTIONS

Groundwater elevations in a network of wells which monitor a specific site must be measured within a period of time short enough to avoid temporal variations in groundwater flow which could preclude accurate determination of groundwater flow rate and direction (typically < 24 hours). Where possible, comparison to prior fluid levels and total depths should be made before the field personnel leaves the location or site. If there is significant difference between the current and previous measurement, the field personnel should repeat the measurement to determine if the current measurement is correct.

When water tight caps are used, an extended period of time after removal of the well caps and prior to planned fluid level measurements may be necessary to allow fluid levels to stabilize. In this case, the procedure and length of time will be dependent upon site-specific well conditions, approval from Project Manager, and weather conditions. In no case, should the well be open to allow precipitation and/or surface runoff (flush-mount completions) to enter the well.

For monitoring wells, fluid levels and total depths should be measured to the reference mark on the top of the riser pipe. If no notch or mark is present on the casing, measurements should be made to the north side of the casing and a notation entered into the field logbook and/or the water level form. For boreholes, the

fluid levels and the total depths should be measured to the north side of the borehole relative to the ground surface. Care should be taken to note within the field logbook, water level form, or groundwater sampling form, the reference point for field measurements (i.e., top of casing, top of well pad, ground surface).

6.0 PERSONNEL QUALIFICATIONS

Burns & McDonnell personnel conducting on-site environmental activities will have completed the 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) course and annual 8-hour HAZWOPER refresher courses. At a minimum, one person on site will be certified in first aid and cardiopulmonary resuscitation (CPR) and, if multiple people are on site, at least one person will have completed the 8-hour HAZWOPER Supervisor Training course. If Burns & McDonnell subcontractors are on site then, at a minimum, one Burns & McDonnell person will have completed the OSHA 30-hour Construction Industry Outreach Training course.

7.0 EQUIPMENT AND SUPPLIES

Equipment to be used during fluid level or total depth measurements may include:

- Electronic water level meter or electronic oil/water interface probe
- Steel tape
- Personal protective equipment (PPE) per the Project-Specific APP/SSHP

Equipment to be used for decontamination and documentation can be found in the SOPs for those activities. Prior to the start of field activities, the Field Site Manager and/or the Project Manager should determine that 1) necessary permits, right of entries, and utilities clearances have been obtained; 2) the Project-Specific APP/SSHP has been reviewed by Burns & McDonnell personnel participating in the work and subcontractors who will be on site; 3) appropriate PPE has been obtained for Burns & McDonnell personnel and will be available on site; 4) equipment and meters are available, in working order, and complete with needed components; and 5) applicable safety data sheets are on site and available to the field team.

8.0 PROCEDURES

The following procedure will be used to measure fluid levels using an electronic water level indicator or electronic oil/water interface probe:

1. Prior to measuring the water level in the first well or borehole of the day, decontaminate the cable and probe per *SOP 504 Decontamination*. Wipe the cable with paper towels as it is rewound onto the reel.

2. Remove the cap from the monitoring well. If specified in the Project-Specific Work Plan, record a PID measurement.

3. Turn on the meter and push the instrument test button to check the batteries.

4. Lower the probe into the monitoring well or borehole by gently releasing the cable from the hand-held reel until the indicator light or audible signal responds.

5. Move the cable up and down to determine the top of the fluid. Note the exact length of cable extended from the tip of the sensor to the reference point. Record the cable length to the nearest 0.01 foot, the monitoring well or borehole number, and the time and date of the measurement. If the monitoring well cap was watertight, repeat the measurement after a short interval of time to see if the water level is static.

6. If using an electronic oil/water interface probe, determine if LNAPLs or DNAPLs are present by slowly lowering the cable into the monitoring well or boring until the bottom is reached while watching to see if the instrument responds to an immiscible fluid/water interface. If the instrument indicates that an interface exists, repeat Step 5 to determine the depth for each interface. Wind the cable back onto the reel. If measurable immiscible fluid is not present, but the instrument probe shows visible evidence, document this.

7. Measure the total depth by gently lowering the steel tape to the bottom of the monitoring well or boring until the cable is slack. Reel in the slack cable. Move the cable up and down to determine well total depth and note the length of cable extended from the tip of the tape to the reference point. Record the cable length to the nearest 0.01 foot, the monitoring well identification, and the time and date of the measurement. This measurement will be compared with previous measurements to determine if sediment has deposited at the bottom of the well. Dependent upon the water level meter, the distance between the end of the probe and the probe sensor may need to be added to the total well depth measurement.

8. Decontaminate the tape, probe, and cable prior to measuring the next boring or monitoring well or prior to storing as specified in *SOP 504 Decontamination of Sampling Equipment*.

9. Enter the appropriate information on the field logbook, water level form, or groundwater sampling form in accordance with *SOP 701 Field Documentation.*

For wells with dedicated pumps, total well depths will be measured immediately following the sampling activities to prevent the sampling technician from surging the wells prior to sampling when removing the dedicated pumps. Another option for measuring total well depths to avoid removing pumps from the wells may be using a steel tape measure that can slide down the side of the well past the pump.

Fluid levels collected from tanks, excavations, and other liquid containers should be measured per the general protocol detailed above. Care should be taken to keep the tape perpendicular to the fluid surface; however, if due to safety considerations, this is not possible, then the constraints on the measurement should be detailed in the field logbook.

9.0 DATA AND RECORDS MANAGEMENT

Fluid levels and total depth measurements should be recorded in the field logbook or on a field data form. An Observed Water Level form is attached to this SOP. Environmental field activities will be documented as detailed in *SOP 701 Field Documentation*. Field documentation will be completed as activities are conducted and will be relayed to the Field Site Manager or Project Manager at a minimum weekly or on a more frequent basis if so stated in the Project-Specific Work Plan.

10.0 QUALITY ASSURANCE/QUALITY CONTROL

Where possible measurements should be compared to prior measurements. If a large difference is noted from the previous measurement, the water level or total depth will be re-measured. A lesser total depth in monitoring wells or piezometers is an indication that either sediment may have accumulated in the monitoring well or an obstruction is present, and should be reported to the FSM. Prior to the start of any field activity, Burns & McDonnell personnel will have read and understood the Project-Specific Work Plan as well as this SOP. Field personnel will be trained for a minimum of 40 hours prior to their working solo on environmental field activities.

11.0 REFERENCES

Burns & McDonnell Engineering, Co, Inc. (Burns & McDonnell), 2018. *Policy Manual*,

- Chapter 8, Employee Safety & Health, March 2017.
- Chapter 10, Quality Control Manual, January 2017.

United States Environmental Protection Agency (USEPA), 2007. *Guidance for Preparing Standard Operating Procedures*. EPA/600/B-07/001. April

12.0 ATTACHMENTS

Observed Water Level Form

Attachment

Observed Water Level Form

Project Name:	Project Number:		Well Number:
Facility Name:		Ground Surface Elevation (GS):	feet amsl
Location: N E		Top of Pipe Elevation (TOP):	feet amsl
		Reference Point Elevation (RP):	feet amsl
Date Drilling Began:		Total Depth of Boring:	feet from GS
Date Drilling Completed:		Total Depth of Well:	feet from TOP
Drilling Type:		Depth to Top of Screen:	feet from TOP
Date Well Installed:		Length of Casing Screened:	feet

Remarks:

Date	Time	By Whom	Depth to Water*	Water Elevation	Total Depth*	Remarks**
			from		from	
			from		from	
			from		from	
			from		from	
			from		from	
			from		from	
			from		from	
			from		from	
			from		from	
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			from		from	
			from		from	

* Depth noted from Ground Surface (GS), Top of Pipe (TOP), or Reference Point (RP)

** e.g. Added or removed water, began pumping, took samples

SOP 521
Field Classification and Description of Soil and Bedrock

Revision 01
04/06/2018

Approved by:

04/02/2018

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Environmental Services Division

Date

04/02/2018

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Date

04/06/2018

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TABLE OF CONTENTS

Page No.

1.0 PURPOSE AND APPLICABILITY

The purpose of *Standard Operating Procedure (SOP) 521 Field Classification and Description of Soil and Bedrock* is to establish a uniform procedure for the description and classification of soil and bedrock during sampling and site characterization, for documenting excavations and borings, and for the preparation of bedrock core for storage at environmental sites. This SOP covers the *process* for the soil and bedrock characterization; rationale and scope including locations, depths, number of measurements, etc. are detailed in the Project-Specific Work Plan. *SOP 521 Field Classification and Description of Soil and Bedrock* has been prepared in accordance with the *Guidance for the Preparing of Standard Operating Procedures* (USEPA, 2007) and the Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) *Policy Manual* (Burns & McDonnell, 2018).

2.0 SUMMARY OF METHOD

Field classification of soil and bedrock consists of characterizing soil and bedrock samples and cuttings by standard methods resulting in consistent descriptions of the subsurface materials. Soils are classified by the Unified Soil Classification System (ASTM, 2011) for both major and minor components. Soil should also be described for color, moisture, plasticity, size, grading, consistency/density and depositional type, as appropriate (see attachment TS-GT-3-1). Bedrock should be classified by rock type then described by color, hardness, texture, weathering, and other significant features. Soil and bedrock samples will be logged by an experienced on-site geologist, geotechnical engineer, or other trained scientist or engineer. Soil and bedrock logging will be documented as appropriate in boring logs, excavation logs, and field logbooks.

3.0 DEFINITIONS

- **Drilling Log -** Burns & McDonnell Forms WCI-OP3-1/3-2, WCD-2-1/2-2; MRK Forms 55/55-2 (United States Army Corps of Engineers [USACE] projects); or other forms as specified in the Project-Specific Work Plan used to document soil and bedrock descriptions and classifications.

- **Drill Rig –** Mechanically driven equipment used to advance a borehole for the collection of soil or bedrock samples for geologic or geotechnical characterization or chemical analysis.

- **Project-Specific Accident Prevention Plan/Site Safety and Health Plan** (Project-Specific APP/SSHP) – A plan or plans that address occupational safety and health hazards associated with site operations.

- **Project-Specific Work Plan** – The plan that details the rationale, scope, and techniques to be used at the site to achieve the project objectives. Project-Specific Work Plans can include work plans, field sampling plans, quality assurance project plans, technical memorandums, and other documentation of proposed work.

4.0 SAFETY AND HEALTH

Field activities as detailed in this SOP will be performed in accordance with applicable safety related documents/requirements which may include but are not limited to: Project-Specific APP/SSHP, the Burns & McDonnell *Safety and Health Program* (Burns & McDonnell, 2017), and site / client-specific requirements. For any intrusive activities, *SOP 501 Utility Clearance* should be followed. Potential health and safety issues with drill rigs include mechanical and hydraulic systems that result in loud repetitive noises and the potential for physical injury. Personal protective equipment (PPE) including hard hats, safety glasses, steel toed boots, and hearing protection should be worn as appropriate and as detailed in the Project-Specific APP/SSHP. PPE requirements should be assessed daily and on a per task basis.

5.0 CAUTIONS

Because field identification of soil is a learned skill, results may vary due to experience, weather conditions, and type of sampling. Soil and bedrock should be logged in a clear and concise manner. The logger should take care to follow the same order for descriptions throughout the logging process with the main constituent of the soil or rock as the first word of the description. Ensure that the color chart being used is appropriate for the media logged and that both the color name and color notation are included. Note, where possible, when fractures or partings are caused by drilling and are not naturally occurring. The logger should take care that the material being logged is native material and not slough from an upper portion of the boring. Note where soil or rock core has not been recovered. If the logger is unsure where in the interval the recovered portion should be assigned, this also should be documented on the log. Document on the log if the soil or bedrock was characterized based upon cuttings. Photos of soil or bedrock cores should include a scale and labeling of date, boring, and interval.

6.0 PERSONNEL QUALIFICATIONS

Burns & McDonnell personnel conducting on-site environmental activities will have completed the 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) course and annual 8-hour HAZWOPER refresher courses. At a minimum, one person on site will be certified in first aid and cardiopulmonary resuscitation (CPR) and, if

multiple people are on site, at least one person will have completed the 8-hour HAZWOPER Supervisor Training course. If Burns & McDonnell subcontractors are on site then, at a minimum, one Burns & McDonnell person will have completed the OSHA 30-hour Construction Industry Outreach Training.

7.0 EQUIPMENT AND SUPPLIES

Equipment to be used during soil and bedrock logging typically includes:

- Munsell color chart (soil or rock, as appropriate)
- Boring logs including
  - WCD-2-1/2-2 – Burns & McDonnell forms for environmental borings
  - WCI-OP3-1/3-2 - Burns & McDonnell forms for geotechnical borings
  - MRK Forms 55/55-2 - USACE forms typically used on Department of Defense Sites
- Folding ruler (engineer scale) or tape measure (engineer scale)
- Utility knife
- Indelible marking pen
- Hand lens
- Camera
- Paper towels
- Plastic sheeting
- Hand sprayer or wash bottle
- Dilute hydrochloric acid solution (10%)
- Aluminum foil and/or plastic wrap
- Rock Hammer
- Chisel
- Handsaw
- Core boxes
- Wooden blocks or spacers
- Laths, stakes, and or flags
- Drilling or excavation forms/field logbooks
- PPE and safety equipment per the Project-Specific APP/SSHP

Equipment to be used for decontamination and documentation can be found in the SOPs for those activities.

Prior to the start of field activities, the Field Site Manager and/or the Project Manager should determine that 1) necessary permits, right of entries, and utilities clearances have been obtained; 2) the Project-Specific APP/SSHP has been reviewed by Burns & McDonnell personnel participating in the work and subcontractors who will be on site; 3) appropriate PPE has been obtained for Burns & McDonnell personnel and will be available on site; 4) sample equipment and meters are available, in working order, and complete with needed components; 5) core boxes or storage containers are the correct size and type; and are sufficient in number for the planned field activities; and 6) applicable safety data sheets are on site and available to the field team.

8.0 PROCEDURES

8.1 Borehole Logging

The procedures and requirements listed below will be followed for borehole logging in the field. Where a specific location on a form is noted and the forms differ, the first description will be for Burns & McDonnell's WCD-2-1/2-2 or WCI-OP3-1/3-2 forms and the second for USACE's MRK 55/55-2 forms. MRK 55/55-2 forms should meet the requirements put forth in the USACE guidance document entitled *Engineering and Design - Monitor Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites,* EM 1110-1-4000 (USACE, 1998).

1. Boreholes will be logged at the drilling site as the holes are drilled. A geologic log should be prepared for each borehole in the field by a qualified geologist, scientist, or engineer; however, a single geologic log maybe prepared for nested wells that are located in close proximity to each other, if so directed by the Project-Specific Work Plan. The logs will be hand printed, neatly and legibly, using an appropriate scale and will be based upon the unconsolidated and consolidated material samples and cuttings collected.
2. The drilling logs must be filled out as completely as possible where appropriate and as the applicable data are available. The information in the header of the first page of the borehole log including the size and type of sampler or coring bit and barrel will be completed for each borehole. "NA" will be written on the forms for entries that are not applicable (e.g., "NA" is written in the *Bedrock Footage/Depth to Bedrock* section if bedrock is not encountered in the borehole).
3. The scale of the log shall be 1 inch equals 1 foot unless otherwise noted in the Project-Specific Work Plan.

4. Stratigraphic or lithologic changes encountered within the boring will be shown in the *Description* column as a solid line. Gradational changes in stratigraphy and lithology will be shown as a dashed line in the *Description* column.

5. The bottom of the borehole will be represented on the form as a solid double line with the notation "Bottom of Hole." Note in the *Description* column if the bottom of the borehole was at drill rig refusal or at top of bedrock.

6. Results of air monitoring will be reported in the *PID/Field Screening Results* column. Any evidence of contamination will be noted in the *Remarks* column including color, odor, or staining.

7. During the course of drilling, water levels and times of measurement should be taken as often as possible and noted in the *Remarks* column. The absence of water following drilling of the borehole shall also be indicated in the *Remarks* column. The depth to water will be recorded in the *Remarks* column and also *Box 15* on the MRK forms including the time when the first water zone is encountered. Depth to water measurements will be recorded in *Remarks* column and also *Boxes 16 and 17* on the MRK forms after the completion of drilling and again after additional time has elapsed and groundwater has reached static conditions.

8. As the borehole is advanced, the depth of the borehole will be periodically measured with a weighted tape to the nearest 0.1 foot and recorded in the *Remarks* Column. The weighted tape will be constructed of materials that will not introduce contaminants into the borehole and will be decontaminated between boreholes. Borehole depths and time of measurement should be taken as often as practical and recorded on the drilling log. Significant times to record depth include the beginning and end of each day, the time prior to equipment placement in the borehole, and when any equipment is removed from the borehole.

9. The total length of the core or soil sample (recovery) will be measured with a tape measure or folding ruler to the nearest 0.1 foot and recorded in *Recovery/Column E*. Intervals of bedrock or soil cores including both intact and lost intervals will also be recorded in *Recovery/Column E*.

10. Record a visual description of bedrock core in the *Classification* column, include lithology, jointing, fractures, vugs, fossiliferous zones, etc.

11. If required by the Project-Specific Work Plan, the rock quality designation (RQD) should be calculated per *ASTM D6032 - 08 Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core* (ASTM, 2008) and recorded in either the *Field Strength* column (WCI-OP3-1/3-2) or the *Remarks* column (WCD-2-1/2-2 and MRK 55/55-2).

12. Changes in type of sampler or coring bit and barrel sizes should be noted in the *Remarks* column at the depth the change occurred.
13. The source of the water used for coring or monitoring well installation will be recorded in the *Remarks* column.
14. Drill fluid volume, loss or gain, brand, and product name will be recorded in the remarks section in the *Remarks* column.
15. If compressed air is used during the drilling process, the type of air filter will be recorded in the *Remarks* column.
16. The depth and type of any temporary casing used during the well installation procedure will be recorded in the *Remarks* column.
17. Depth intervals of borehole instability that are encountered during drilling will be recorded in the *Remarks* column.
18. Difficulties during drilling (e.g., changes in drilling speed, rates, downhole torque, or drill rig chatter) and any special sampling problems also will be noted in the *Remarks* column, including descriptions of problem resolutions.
19. The depth interval over which samples are collected for chemical analysis will be noted and recorded in the *Sample Designation/Analytical Sample No.* column.
20. A description (i.e. boring number) will be provided for the boring at the top of each page.
21. If monitoring wells or piezometers are installed, a detailed installation diagram should be included as either on the last page of the boring log, a construction diagram form, or within the field logbook per *SOP 551 Installation and Development of Monitoring Wells and Piezometers.*
22. Each boring log will be legibly signed by the preparer after proofreading the log for completeness.

Monitoring well/piezometer installation procedures are detailed in *SOP 551 Installation and Development of Monitoring Wells and Piezometers*. Abandonment procedures are detailed in *SOP 553 Abandonment of Monitoring Wells and Piezometers*, and *SOP 554 Advancement and Abandonment* of *Boreholes* Decontamination procedures are in *SOP 504 Decontamination.* Additional documentation procedures are in *SOP 701 Field Documentation*.

8.2 Excavation Logging

Excavations for site characterization and sample collection should be documented into the field logbook or onto a Project-Specific form. Log the excavation per the following procedures

1. Include the date, start and completion times of the excavation, type of excavation equipment used, and name of the excavator operator.
2. Note any debris or non-native materials removed from the excavation. Include a description and amount of non-native material.
3. Measure and record the length, width, and depth of the excavation. If the excavation is irregular in shape, include a plan map in your logbook with sufficient measurements to draw the excavation to scale at a later date. Include a north arrow.
4. If the excavation is a trench, draw one of the side of the trench in the log book. Include sufficient measurements to draw the trench side to scale at a later date. Classify the soil and bedrock per Sections 8.3 and 8.4 below. Include the direction the observer is looking (i.e. looking northeast.)
5. If the excavation is not a trench, repeat Step 4 for each side of the excavation. Information on the bottom of the excavation should be included on the plan view.
6. If groundwater is present within the excavation, note the depth to groundwater and, if known, where the groundwater is entering the excavation.
7. Record results of headspace air monitoring and any evidence of contamination including color, odor, or staining.
8. Document date, time, and method of backfilling the excavation. Include the material and amount of material used to backfill the excavation.

8.3 Characterization of Soils (Unconsolidated Material)

Unconsolidated material will be logged using the Unified Soil Classification System (ASTM, 2011). Items in this section are recorded in *Description* column of the Burns & McDonnell forms or in *Column C* of the MRK forms.

- The primary and secondary constituents of the soil (ie, clay, silt, sand, gravel, etc.) will be logged. The primary constituent will be the first word of the description and will have all letters capitalized.

- Secondary constituents will be preceded by an estimation of amount in either percentages or descriptive (trace – >0 to 10%, some – 11% to 35%, with – 36% to 50%, and – 50%)
- The standardized color of the unconsolidated material will be logged using the Munsell Soil Color Chart.
- The moisture content, in relative terms (i.e., dry, moist, wet/saturated), will be noted. If the sample is saturated (i.e., encountered groundwater), the groundwater level will be recorded to the nearest 0.1 foot as noted above.
- The angularity, grain size, and grading of soil classified as coarse will be logged.
- The consistency of materials classified as fine (e.g., ML or CH) and the density of materials classified as coarse (e.g., SW or GM) will be noted.
- Bedding characteristics, evidence of bioturbation, root holes, and fractures will be noted and logged.
- When known, the depositional type (i.e., alluvium, residual, till) will be noted.

8.4 Characterization of Rock (Consolidated Material)

Items in this section are recorded in *Description* column of the Burns & McDonnell forms or in *Column C* of the MRK forms.

- The primary rock type (i.e., limestone, sandstone, shale) will be logged. The primary constituent will be the first word of the description and will have all letters capitalized. The primary consistent will be followed by secondary constituent, if present (i.e. SHALE, sandy).
- The formation name, if known, will be logged.
- The relative hardness of the consolidated material will be measured and logged.
- The texture and grain angularity of the consolidated material will be examined with a hand lens, and the results of the field analysis will be logged.
- The standardized color of the consolidated material will be logged using a Munsell Rock Color Chart.
- The consolidated material will be inspected for apparent weathering. The results of the inspection will be logged.
- The moisture content, in relative terms (i.e., dry, moist, wet/saturated), will be noted. If the sample is saturated (i.e., encountered groundwater), the groundwater level will be recorded to the nearest 0.1 foot as noted above.

- Evidence of bedding, bedding planes, fractures, and joints will be noted and logged. The approximate angle of the dip of bedding, fracture, and joint planes will be noted.
- Other significant features (e.g., fossils, crystals, pits, solution cavities) will be noted.
- The reaction of the consolidated material to hydrochloric acid, if any, will be recorded.

8.5 Preparation of Bedrock Core for Storage

Upon completion of characterization of each core run, bedrock core should be placed into core boxes for long term storage.

1. Rinse the core with water to remove drilling fluids and grit from the drilling process.
2. Place the core in a core box. Core should be placed so that the top of the core is the upper left core when looking at the box in landscape and the bottom is in the lower right corner.
3. If the core is fragile, wrap in aluminum or plastic wrap. Label the wrap surrounding the core. If the core is fragmented and cannot be wrapped, simply place it in the correct interval of the core box.
4. Record the top and bottom depth, position of core loss or no recovery zones (if known), and identification of fractures on the boring log. Fractures caused by the coring process of from breakage to fit the core into the box, should be differentiated from fractures interpreted as in-situ.
5. Label the top and end of the core boxes. Record the borehole number, depth interval of the core, and other appropriate information. Wooden blocks may be used as spacers inside core boxes to mark the ends of core runs and positions of core loss or no recovery zones. Label the wooden blocks with the depth intervals they represent.
6. Photograph the core prior to sealing the box. The photograph should be of high-enough resolution to see details on the core. Ensure that a scale and notations on the boring, interval represented, project number, and date are clearly visible in the photograph.

9.0 DATA AND RECORDS MANAGEMENT

Soil and bedrock characterizations are typically documented in boring logs or field logbooks. Boring logs may vary dependent on the client or the type of boring being done. On environmental projects, soil and bedrock classifications and descriptions are typically documented on Burns & McDonnell's WCD-2-1/2-2 forms and for geotechnical projects on WCD-2-1/2-2 forms. Soil and bedrock boreholes for US Army Corps of Engineers projects are typically documented on MRK 55/55-2 forms. Excavations are typically documented within the field logbooks but maybe documented on borehole or excavation forms.

Surface soil characterization is documented in the field logbooks. Environmental field activities will be documented as detailed in *SOP 701 Field Documentation.*

10.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to the start of any field activity, Burns & McDonnell personnel will have read and understood the Project-Specific Work Plan as well as this SOP. Field personnel will be trained for a minimum of 40 hours prior to their working solo on environmental field activities. Field documentation will be completed as activities are conducted and will be relayed to the Field Site Manager or Project Manager at a minimum weekly or on a more frequent basis if so stated in the Project-Specific Plans.

11.0 REFERENCES

ASTM, *D6032-08, Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core*, ASTM International, West Conshohocken, PA, 2008, www.astm.org

ASTM, *D2487-11, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*, ASTM International, West Conshohocken, PA, 2011, www.astm.org

Burns & McDonnell Engineering, Co, Inc. (Burns & McDonnell), 2018. *Policy Manual*,

- Chapter 8, Employee Safety & Health, April 2017.
- Chapter 10, Quality Control Manual, January 2017.

United States Army Corps of Engineers (USACE), 1998. *Engineering and Design - Monitor Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites,* EM 1110 1 4000, November 1, 1998.

United States Environmental Protection Agency (USEPA), 2007. *Guidance for Preparing Standard Operating Procedures*. EPA/600/B-07/001. April

12.0 ATTACHMENTS

The following forms are included with this SOP:

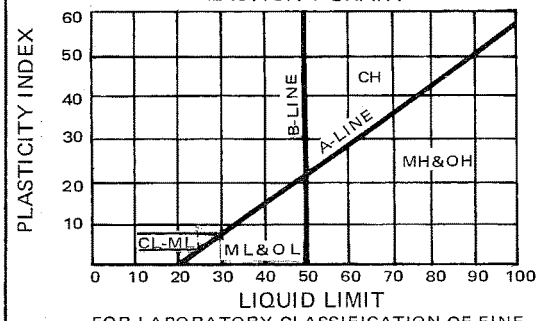
- Burns & McDonnell's TS-GT-3-1 form
- Burns & McDonnell's WCD-2-1/2-2 forms
- Burns & McDonnell's WCI-OP3-1/3-2 forms
- US Army Corps of Engineers' MRK Forms 55/55-2.

Attachments

Unified Soil Classification System

MAJOR DIVISIONS			LETTER SYMBOL	DESCRIPTION
COARSE-GRAINED SOILS MORE THAN 50% LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS LITTLE OR NO FINES	GW	WELL-GRADED GRAVEL, GRAVEL-SAND MIXTURE
			GP	POORLY-GRADED GRAVEL, GRAVEL-SAND MIXTURE
		GRAVELS WITH FINES APPRECIABLE FINES	GM	SILTY GRAVEL, GRAVEL-SAND-SILT MIXTURE
			GC	CLAYEY-GRAVEL, GRAVEL-SAND-CLAY MIXTURE
	SAND AND SANDY SOILS	CLEAN SANDS LITTLE OR NO FINES	SW	WELL-GRADED SAND, GRAVELLY SAND
			SP	POORLY-GRADED SAND, GRAVELLY SAND
		SANDS WITH FINES APPRECIABLE FINES	SM	SILTY SAND, SAND-SILT MIXTURE
			SC	CLAYEY SAND, SAND-CLAY MIXTURE
FINE-GRAINED SOILS MORE THAN 50% SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	SILT, CLAYEY SILT, SILTY OR CLAYEY VERY FINE SAND, SLIGHT PLASTICITY
			CL	CLAY, SANDY CLAY, SILTY CLAY, LOW TO MEDIUM PLASTICITY
			OL	ORGANIC SILTS OR SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT MORE THAN 50	MH	SILT, FINE SANDY OR SILTY SOIL WITH HIGH PLASTICITY
			CH	CLAY, HIGH PLASTICITY
			OH	ORGANIC CLAY OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOIL

PLASTICITY CHART



FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

RELATIVE PARTICLE SIZE	
BOULDER	LARGER THAN 12"
COBBLE	3" TO 12"
GRAVEL COARSE	3/4" TO 3"
FINE	4.76MM TO 3/4"
SAND COARSE	2MM TO 4.76MM
MEDIUM	0.42MM TO 2MM
FINE	0.074MM TO 0.42MM
SILTS AND CLAY	SMALLER THAN 0.074MM

RELATIVE PLASTICITY	
NONPLASTIC	CANNOT ROLL INTO BALL
TRACE PLASTICITY	BARELY ROLL INTO BALL
MEDIUM PLASTIC	CAN BE ROLLED INTO BALL
HIGHLY PLASTIC	NO RUPTURE BY KNEADING

RELATIVE COMPOSITION	
TRACE	0-10%
SOME	11-35%
AND/WITH	36-50%

RELATIVE MOISTURE	
DRY	POWDERY
DAMP	BELOW PLASTIC LIMIT
MOIST	PL TO LL RANGE
WET	ABOVE LIQUID LIMIT

DENSITY	N-VALUE
VERY LOOSE	0-4
LOOSE	5-10
MEDIUM	11-30
DENSE	31-50
VERY DENSE	>50

RELATIVE CONSISTENCY	
VERY SOFT	< 1/4 TSF
SOFT	1/4-1/2 TSF
MEDIUM	1/2-1 TSF
STIFF	1-2 TSF
VERY STIFF	2-4 TSF
HARD	> 4 TSF

N-VALUE (BLOW COUNT) IS THE STANDARD PENETRATION RESISTANCE BASED ON THE TOTAL NUMBER OF BLOWS, USING A 140-LB HAMMER WITH 30-INCH FREE FALL, REQUIRED TO DRIVE A SPLIT-SPOON THE LAST TWO OF THREE 6-INCH DRIVE INCREMENTS. (EXAMPLE: 4/7/9, N = 7+9=16)

072478 Burns & McDonnell Engineers-Architects-Consultants *Form TS-GT-3-1*

Drilling Log

Project Name	Project Number	Boring Number
Ground Elevation	Location	Page
Air Monitoring Equipment		Total Footage

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes

Drilling Company	Driller(s)
Drilling Rig	Type of Sampler
Date / To	Field Observer(s)

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-2-1

Drilling Log Continuation

	Boring Number
Project Name	Page
Project Number	Date

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels

BZ=Breathing Zone BH=Bore Hole S=Sample

Burns & McDonnell SINCE 1898

051601 Form WCD-KC-2-2

Drilling Log

Project Name						Boring Number	
Project No.						Page 1 of	
Ground Elevation		Location				Total Footage	
Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. Of Samples	No. Core Boxes	Depth to Water	Date Measured
Drilling Co.				Driller (s)			
Drilling Rig.				Type of Penetration Test			
Date	To			Field Observer (s)			

Depth	Description	Class.	Blow Count	Field Strength	Recov.		Sample or Box No.	Remarks
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								

Burns & McDonnell SINCE 1898

01/11/1994

Form WCI-OP3-1

Drilling Log, continued

						Boring No.		
Project Name						Page of		
Project No.						Date		
Depth	Description	Class.	Blow Count	Field Strength	Recov.		Sample or Box No.	Remarks

Burns & McDonnell SINCE 1898

01/11/1994

Form WCI-OP3-2

HTW DRILLING LOG

		HOLE NO.
1. COMPANY NAME	2. DRILLING SUBCONTRACTOR	SHEET 1 OF SHEETS
3. PROJECT	4. LOCATION	
5. NAME OF DRILLER	6. MANUFACTURER'S DESIGNATION OF DRILL	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8. HOLE LOCATION	
	9. SURFACE ELEVATION	
	10. DATE STARTED / 11. DATE COMPLETED	
12. OVERBURDEN THICKNESS	15. DEPTH GROUNDWATER ENCOUNTERED	
13. DEPTH DRILLED INTO ROCK	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14. TOTAL DEPTH OF HOLE	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h

PROJECT | HOLE NO.

MRK FORM JUN 89 55

HTW DRILLING LOG

HOLE NO.

PROJECT | INSPECTOR | SHEET 1 OF SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h

PROJECT | HOLE NO.

051601
Form MRK-55-2

SOP 551
Installation and Development of Monitoring Wells and Piezometers

Revision 01
04/06/2018

Approved by:

04/02/2018

Martha Hildebrandt, PG, Associate Geologist,
Environmental Services Division

Date

04/02/2018

Jeffrey Binder, PG, Associate Geologist,
Environmental Services Division

Date

04/06/2018

John Hesemann, PE,
Remediation Technical Service Area Leader
Environmental Services Division

Date

Biennial Review:

Revision/Review	Date	Responsible Party	Description of Change
Revision 01	04/02/2018	Hildebrandt, Martha	Minor grammar and updated references.

TABLE OF CONTENTS

Page No.

1.0 PURPOSE AND APPLICABILITY

The purpose of *Standard Operating Procedure (SOP) 551 Installation and Development of Monitoring Wells and Piezometers* is to establish a uniform procedure for the installation and development of monitoring wells and piezometers using traditional-style drill rigs. This SOP covers the *process* for the installation and development of monitoring wells and piezometers; rationale and scope including locations, depths, drilling methods, development criteria, etc. are detailed in the Project-Specific Work Plan. As Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) does not self-perform well installation but instead subcontracts drilling services, this SOP is for the oversight and direction of the drilling subcontractor with Burns & McDonnell personnel responsible for geologic logging, field measurements, and well development activities. The installation and development of monitoring wells and piezometers is regulated in most states. It is the responsibility of both the Project Manager and the on-site field personnel to ascertain that state regulations are met, that the driller is properly licensed for work in that state, and that required paperwork is completed by the responsible person (typically the driller) and submitted to the proper state agency. *SOP 551 Installation and Development of Monitoring Wells and Piezometers* has been prepared in accordance with the *Guidance for the Preparing of Standard Operating Procedures* (USEPA, 2007) and the Burns & McDonnell *Policy Manual* (Burns & McDonnell, 2018).

2.0 SUMMARY OF METHOD

Monitoring wells and piezometers are installed at project sites to monitor hydrogeologic and contaminant parameters. Monitoring wells and piezometers are typically constructed in the same manner but are intended for different uses: monitoring wells are for the monitoring of groundwater quality while piezometers are for monitoring hydrogeologic parameters such as water levels. Throughout this SOP, the term “monitoring well” is interchangeable with “piezometer.”

Monitoring well installation includes advancing a borehole into the unconsolidated and/or consolidated materials that underlie a site, building a monitoring well within the borehole, and developing the monitoring well. Various drilling methods including hollow-stem augers, solid-stem augers, air rotary, rotary wash, sonic, cable tool, and other methods can be used to advance the borehole. The specific drilling method should be chosen based upon the site geology, desired depth, desired borehole diameter, logging and testing requirements, and potential site contaminants and should be specified in the Project-Specific Work Plan. If soil or bedrock is to be sampled, logged, or tested, the Project-Specific Work Plan should reference the appropriate SOP.

Upon completion of the borehole and any required sampling, testing, and/or logging, the monitoring well is installed. Monitoring wells should be installed per the specific construction details included in the Project-Specific Work Plan including location, approximate depth, diameter, weight and material of riser and screen, screen slot size, length of screen, and placement of the screen in relationship to the groundwater table. Monitoring wells are typically completed with either flush mount or above grade completions dependent upon the site and the client's requirements.

Monitoring wells are developed after installation to remove the any soil or rock fines that are left within the filter pack and well during installation and to improve the conductivity between the well and the formation. Well development is typically conducted by gently surging the screened interval then purging groundwater in cycles until the monitoring well meets the development criteria set forth in the Project-Specific Work Plan. The monitoring well is then allowed to stabilize prior to the collection of hydrogeologic measurements or samples.

3.0 DEFINITIONS

For this SOP the following definitions will apply:

- **Annular Space** - The space between two cylindrical objects one of which surrounds the other for example the space between the well casing and the borehole.
- **Bentonite** - Any type of commercial sodium bentonitic clay used in the construction or plugging of wells.
- **Bentonite Cement Grout** - A cement grout generally containing one 94 pound bag of Portland cement mixed with 7 gallons of clean water and 2 pounds of bentonite.
- **Borehole** - Any hole drilled into the subsurface for the purpose of identifying lithology, collecting soil samples, and/or installing groundwater wells.
- **Casing/Riser** - An impervious durable pipe placed in a well to keep the well from caving and help seal the well from the surface and upper sources of water and contaminants. Typically composed of polyvinyl chloride (PVC) but can also be composed of steel or stainless steel.
- **Cuttings** - Pieces of fill, soil, or rock displaced from the borehole during drilling or development.
- **Filter Pack** - Granular filter material (sand, gravel, etc.) placed in the annular space between the well screen and the borehole to increase the effective diameter of the well and prevent fine-grained material from entering the well.

- **Grout** - The material placed between the borehole wall and the casing to keep surface water out of the well and to restrict movement of water in the annular space between the borehole and the riser. Materials commonly used include bentonite and bentonite cement.
- **Monitoring Well** - A well that provides for the collection of representative groundwater samples, the detection and collection of representative light and dense non-aqueous phase organic liquids, and the measurement of fluid levels.
- **Piezometer** - A well that provides for the measurement of fluid levels and other hydrogeologic properties.
- **Project-Specific Accident Prevention Plan/Site Safety and Health Plan** (Project-Specific APP/SSHP) – A plan or plans that address occupational safety and health hazards associated with site operations.
- **Project-Specific Work Plan** - The plan that details the rationale, scope, and techniques to be used at the site to achieve the project objectives. Project-Specific Work Plans can include work plans, field sampling plans, quality assurance project plans, technical memorandums, and other documentation of proposed work.
- **Tremie** - A tubular device or pipe used to place grout, bentonite, or filter pack in the annular space.
- **Well Screen** - A commercially available, factory-perforated, wire wound, continuous wrap, or slotted casing segment used in a well to maximize the entry of water from the producing zone and to minimize the entrance of sand.

4.0 SAFETY AND HEALTH

Field activities as detailed in this SOP will be performed in accordance with applicable safety related documents/requirements which may include but are not limited to: Project-Specific APP/SSHP, the Burns & McDonnell *Safety and Health Program* (Burns & McDonnell, 2017), and site/client-specific requirements. For any intrusive activities, *SOP 501 Utility Clearance* should be followed. Potential health and safety issues with drill rigs include mechanical and hydraulic systems that result in loud repetitive noises and the potential for physical injury. Personal protective equipment (PPE) including hard hats, safety glasses, steel toed boots, and hearing protection should be worn as appropriate and as detailed in the Project-Specific APP/SSHP. PPE requirements should be assessed daily and on a per task basis.

5.0 CAUTIONS

Installation of a monitoring well or piezometer is a complex procedure that has the potential to result in non-optimum results due to a variety of circumstances that may occur due to natural conditions or due to

inattention to detail in the field. Since long term monitoring occurs at many sites, most monitoring wells should be built to meet an expected life span of 20+ years. Cautions have been included in the procedures below; however not all situations that may arise can be covered in an SOP or the Project-Specific Work Plan. The on-site personnel should be aware of situations that may result in a compromised well, correct them as they arise, and stay in communication with their Project Manager and regulator as needed.

6.0 PERSONNEL QUALIFICATIONS

Burns & McDonnell personnel conducting on-site environmental activities will have completed the 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) course and annual 8-hour HAZWOPER refresher courses. At a minimum, one person on site will be certified in first aid and cardiopulmonary resuscitation (CPR) and, if multiple people are on site, at least one person will have completed the 8-hour HAZWOPER Supervisor Training course. If Burns & McDonnell subcontractors are on site then, at a minimum, one Burns & McDonnell person will have completed the OSHA 30-hour Construction Industry Outreach Training.

7.0 EQUIPMENT AND SUPPLIES

Equipment used during the oversight and direction of monitoring well installation and development may include the following:

- Indelible marking pen
- Locks keyed to other site monitoring wells
- Fiberglass or steel tape with weight
- Field logbook and appropriate field forms
- PPE and safety equipment per the Project-Specific APP/SSHP

Equipment to be used for the collection of fluid levels, logging of soil and bedrock, water quality measurements, decontamination, and documentation can be found in the SOPs for those activities.

Prior to the start of field activities, the Field Site Manager and/or the Project Manager should determine that 1) necessary permits, right of entries, and utilities clearances have been obtained; 2) the Project-Specific APP/SSHP has been reviewed by Burns & McDonnell personnel participating in the work and subcontractors who will be on site; 3) appropriate PPE has been obtained for Burns & McDonnell personnel and will be available on site; and 4) equipment and meters are available, in working order, and

complete with needed components; and 5) applicable safety data sheets are on site and available to the field team.

8.0 PROCEDURES

Each monitoring well installed and developed during field investigations will be constructed according to the requirements and procedures below and the appropriate state regulations. Clients may have additional requirements or requests for monitoring wells to meet safety and aesthetic requirements. Additionally monitoring wells placed at sites overseen by the United States Army Corps of Engineers (USACE) should meet the USACE guidance document entitled *Engineering and Design - Monitor Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites,* EM 1110 1 4000 (USACE, 1998).

8.1 Monitoring Well Construction Requirements

The following installation and construction requirements will be used:

- Riser and screen will be packaged in containers that bear the manufacturer's markings.

- Monitoring well/piezometer screen and riser pipe will be flush-threaded. The joints will be constructed so as to form a watertight seal. Screen bottoms will be sealed with a flush-threaded cap or slip-on cap secured with stainless-steel, self-tapping screws.

- Requirements for PVC riser and screen include:
  - Monitoring wells/piezometers will be constructed with National Sanitation Foundation (NSF) potable water grade, flush-threaded PVC riser and screen that conforms to American Society of Testing and Materials (ASTM)-D 1785 standards.

  - PVC riser and screen for 2-inch diameter monitoring wells will typically be schedule 40 for shallow wells but should be upgraded to schedule 80 for wells greater than 100 feet in depth. Riser and screen specifics will be included in the Project-Specific Work Plan.

  - No glues or solvents shall be used in the construction of PVC monitoring wells/piezometers.

- Specifications for steel or stainless steel riser and casings will be included in the Project-Specific Work Plan.

- Well screen shall be factory slotted and sized to be compatible with the filter pack and aquifer materials. Screen size will be specified in the Project-Specific Work Plan or will be determined by a geologist based upon the size and gradation of the material to be screened. Field slotted or cut screens will not be used.

- A minimum annulus of 2 inches will be maintained between the outside of the well casing and the borehole wall.

- Centralizers will be used to maintain concentricity and alignment of the well in the borehole. Centralizers will not be installed in the filter pack or bentonite seal. Centralizers will not be used on wells installed through hollow stem augers or in wells less than 30 feet deep.

- The filter pack will consist of clean, inert, non-carbonate, uniform sand. Filter pack size will be specified in the Project-Specific Work Plan or will be determined by a geologist based upon the size and gradation of the material to be screened.

- The annular seal shall consist of coarse-granular, chipped or pelletized bentonite; a high-solids bentonite grout slurry; or a bentonite cement grout. Grout will be mixed per the manufacturer's instructions and so to meet all state requirements. If bentonite pellets or chips are used, adequate time will be allowed for hydration (typically >4 hours) prior to installation of the of an upper annular seal or the surface seal.

- Monitoring wells will be completed either as an above-grade or a flush with grade well. In either case, the well will be completed in such a way so that there is enough room at the top of the well riser to the bottom of the protective cover to install a locking, protective cap on the riser.

- Monitoring well pads will consists of a concrete pad installed around the monitoring well/piezometer. The borehole will be enlarged so that the concrete pad will extend away from the well casing at the surface and taper down to the size of the borehole within 2 to 3 feet. The pad should be constructed so that the deeper portion is below the frost line for the project location. The top of the concrete pad will slope gently away from the protective cover, but be constructed nearly flush with the surrounding surface.

- Monitoring wells completed above grade will have a steel protective cover installed. The protective cover should be installed so that at least two feet of the casing is within the concrete

pad and such that the cover can open easily over the capped riser. A weep hole should be drilled into the protective cover approximately 1 inch above the top of the pad and the annular space between the protective cover and the riser should be filled with coarse sand or pea gravel.

- Monitoring wells completed as flush grade completion should use a watertight well cap for the well riser pipe in addition to a watertight road box to prevent surface water from entering the well. The well casing should extend approximately 3 inches above the sealant in the bottom of the well box. Flush-grade completion within traffic areas may require more substantive well boxes and concrete completions. The surface completion should provide positive drainage away from the well box to prevent ponding around the well. In traffic areas and sidewalks, this positive drainage slope away from the box should be minimized to prevent physical hazards. The surface seal around the box should be a minimum of 12 inches around the perimeter of the box.

- Guard posts will consist of 3-inch diameter steel posts or tee-bar driven steel posts placed around the concrete pad. These posts will be positioned one foot outside the pad and equally spaced and will be placed so to be protective of the well from vehicular traffic and other hazards. The posts will extend above the protective casing and 2 feet below ground surface. The protective casing and posts will be painted in high visibility colors in remote areas and brown in populated areas.

- At locations where a monitoring well/piezometer is needed but groundwater is not apparent during drilling, the borehole may be left open to determine if groundwater is seeping into the borehole. The borehole will be bermed and covered during this period to reduce the potential for entry of surface water runoff or contamination. After 24 hours (unless specified otherwise in the Project-Specific Work Plan), the on-site personnel will consult with the Project Manager to determine if the borehole should be advanced further or abandoned.

8.2 Borehole Advancement

Boreholes may be advanced by a variety of techniques including hollow or solid stem augers, air rotary, rotary wash, cable tool, sonic, dual-tube percussion, or other drilling techniques. The specific drilling method should be chosen based upon the site geology, desired depth, desired borehole diameter, logging and testing requirements, and potential site contaminants and should be specified in the Project-Specific Work Plan. If soil or bedrock is to be sampled, the Project-Specific Work Plan should include the rationale and scope for the sampling including the number of samples to be collect, depth, analytical parameters, and method of collection with the referenced SOPs. Soil and bedrock should be logged from

either the samples collected or from cuttings in accordance with *SOP 521 Soil and Bedrock Logging*. Other types of testing that may be required including packer tests and downhole geophysical logging should be specified in the Project-Specific Work Plan with the referenced SOPs.

Temporary casing may be required in some boreholes to maintain the stability of the borehole or to prevent contaminants from an upper zone to enter a lower zone. The need for temporary casing should be determined on a site-specific basis and detailed in the Project-Specific Work Plan.

For many boreholes, the initial borehole advanced for sample collection or logging purposes is insufficient in diameter for the installation of a monitoring well. In these cases the borehole is then reamed to the final desired diameter. Care should be taken during this step to remove as many cutting from the borehole as possible without damaging the integrity of the borehole side.

8.3 Monitoring Well Installation

Monitoring well installation specifics including screen size, length, and placement; filter pack size and placement, secondary filter pack use and placement, grout type, placement method and thickness; and well completion type will be detailed in the Project-Specific Work Plan. After installation of the riser, a locking sealed cap should be placed on the riser if the well is left unattended for any significant amount of time.

1. Inspect well materials to determine if they meet the project specifications and are clean and free of foreign matter prior to use. Wash screens and casings with laboratory grade detergent and potable water mixture then rinse with deionized water and allow to air dry. Store washed materials in clean plastic sheeting until installation. Washing is not necessary if well material is in the manufacturer's original packaging and the packaging is intact. Keep materials in the manufacturer's original packaging until time of use.

2. Assemble the screen and riser. Attach centralizers as needed. Measure the length of screen and riser components and placement of the centralizers. Record the information in the field logbook or on the appropriate field form. Calculate and note the approximate amount of filter pack that will be needed.

3. Lower well screen and casing into the borehole. Record to the nearest 0.1 foot the depth of the top and bottom of the well screen from the grade/ground surface. If the terrain is very uneven, drive a bolt or spike in the ground to serve as a reference until the well is completed.

4. With the casing string suspended near the bottom of the boring, pour the filter pack material slowly into the annular space to prevent bridging. For deep wells and wells where the screen is set significantly below the water table, the filter pack should be emplaced via a tremie pipe. Use of a tremie should be specified in the Project-Specific Work Plan in these cases. If installing through hollow stem augers or a temporary casing, slowly raise the augers or casing as the filter pack is emplaced. Use a fiberglass or steel tape with a weight attached to the end to determine the top of the filter pack. Measure the depth to the top of the filter pack to within 0.1 foot. Compare the estimated amount of filter pack needed to that used to determine if bridging has occurred.

5. Unless specified otherwise, swab the well screen with a surge block and remove water from the well. Allow the filter sand pack to settle and measure the depth to the top of the filter pack again. Add additional filter material, if necessary. If over one foot of filter pack is added, repeat the process. Filter packs should be emplaced to the level above the well screen detailed in the Project-Specific Work Plan. This is typically 3 to 5 feet above the top of the screen but can be less if the well is shallow or a secondary filter pack is to be installed. Record the brand and size of the filter pack, the amount emplaced, and the final depth to top of filter pack in the field logbook or on the appropriate field form.

6. If a secondary filter pack is required, install per the same process as that used for the primary filter pack. Record the brand and size of the secondary filter pack, the amount emplaced, and the final depth to top of the secondary filter pack in the field logbook or on the appropriate field form.

7. Install the grout seal from the top of the filter pack to approximately 3 feet below ground surface. The grout seal is typically either bentonite in chip, pellet, or slurry form or a bentonite cement. Bentonite cement grout should only be placed upon a bentonite layer or on a secondary filter pack. In no circumstances should cuttings be used as a seal. If installing through hollow stem augers or a temporary casing, slowly raise the augers or casing as the filter pack is emplaced. Take and record depth measurements on a frequent basis during the installation of the grout seal. Based upon the grout specified in the Project-Specific Work Plan install the grout by:

    a. Bentonite chips or pellets - Pour bentonite chips or pellets slowly down the annulus to prevent bridging. Measure the depth to the top of the bentonite seal to within 0.1 feet with the weighted tape. If the seal is above the water table, pour several gallons of potable water down the annulus to hydrate the bentonite seal for every foot of pellets or chips emplaced. If the

bentonite layer is being placed between the primary filter pack and a bentonite cement seal, then the bentonite seal should be a minimum of three feet in thickness and allowed to hydrate for a minimum of three to four hours.

b. Bentonite slurry – Calculate and mix the amount of bentonite slurry needed. Bentonite slurry should consist of a commercial bentonite powder approved for environmental use, mixed per the manufacturer's instructions. Bentonite slurry should be emplaced using a tremie pipe. The pipe should be placed so that the end is submerged within the grout and raised slowly as the grout is emplaced into the annular space.

c. Bentonite cement - Calculate and mix the amount of bentonite cement grout needed. The bentonite cement grout should consist of at least five pounds of bentonite powder per 94 pound sack of cement. A commercial grade bentonite powder approved for environmental use, should be mixed per the manufacturer's instructions. Bentonite cement grout should be emplaced using a tremie pipe. The pipe should be placed so that the end is submerged within the grout and raised slowly as the grout is emplaced into the annular space. It should be noted that bentonite cement grout will give off heat during the hydration and curing process. Care should be taken to ensure that the PVC riser is not compromised by the heat.

Record the brand and size (if using bentonite pellets or granular bentonite), the amount of grout emplaced, and the final depth to top of grout in the field logbook or on the appropriate field form.

8. Allow the grout to settle before installing the protective cover and concrete pad. If the top of grout falls below the depth needed for the pad installation (typically 3 feet below ground surface), then additional grout should be added. Note the amount of grout added and the final depth to top of grout in the field logbook or on the appropriate field form.

9. Prior to installing the protective cover and concrete pad, trim the rise stickup to approximately the final elevation needed. Measure and record the amount of riser removed. Cut a notch or place a mark on the top of the well casing as a reference point for top of casing (TOC) elevation and depth to water measurements and place a lockable sealable cap such as a J-plug on the riser.

10. Install the protective casing/flush mount cover, well pad, and protective bollards, as needed, per the specifications in Section 8.1. Ensure the protective cover is locked for above ground

completions or a lockable J-plug with lock is installed for flush mount completions. Document the installation in the field logbook or on the appropriate field form.

As the well or piezometer is installed, a construction diagram should be sketched. It is preferable to place the diagram on either a well construction diagram or on the final page of the boring log but it can also be documented in the field logbook. The field personnel should take care to record date and time of activities; materials used including brands, amounts, and size; depths and methods of placement; and other pertinent information.

8.4 Development of Monitoring Wells and Piezometers

Monitoring wells and piezometers will be developed to remove fine particles and sediment from the screen and filter pack. The method will consist of swabbing with a surge block or similar apparatus, followed by pumping and/or bailing. Swabbing consists of raising and lowering a surge block within the casing and screened interval. Caution should be exercised when swabbing within the screened interval so as not to damage the screen or the filter pack. Sediment and volume of water removed will be monitored and recorded regularly until development is complete. The development of a monitoring well should be initiated not sooner than 24 hours, nor longer than seven days after the final grouting of the monitoring well. For work performed for the USACE, the time before development begins should be more than 48 hours (USACE, 1994). Field measurements collected as part of well development should be recorded in either the field logbook or on a standardized well development form. Development will continue until the well or piezometer is properly developed based on attainment of the specified standard for turbidity units and stabilization of the pH, conductivity, and temperature. The required parameter standard criteria are detailed in the Project-Specific Work Plan.

The development sequence is as follows:

1. Record water level and total depth of the well. Calculate the volume of standing water.

2. Collect a water sample. If the water is fairly clear, measure and record pH, conductivity, temperature, and turbidity.

3. Gently swab the well with a surge block for 10 to 15 minutes, starting at the bottom and working upward in intervals.

4. Bail and/or pump the well to remove any sediment in the well. Record the amount of water and sediment removed. If required by the Project-Specific Work Plan, containerize the removed water and sediment per the protocol and SOP specified in the Plan.

5. Re-measure and record the water level and the total depth of the well.

6. Repeat Steps 2-5 until the water bailed or pumped meets the required turbidity standard set forth in the Project-Specific Work Plan; the pH, conductivity, and temperature stabilize to the criteria in the Project-Specific Work Plan (typically <10 percent variation between 3 or more readings taken one well volume apart); and no sediment is left within the well casing. At a minimum, three to five times the volume of any water introduced during drilling and installation shall be removed. Monitoring wells or piezometers that purge dry during development should be purged dry a minimum of three times. Once purged dry, the water level should be allowed to recover to at least 95 percent of the static water level prior to purging a second or third time.

If after a reasonable effort has been made, stabilization of the monitored groundwater parameters (pH, temperature, conductivity, and turbidity) cannot be achieved, the Field Site Manager will discuss the matter with the Project Manager. The Project Manager, with consultation of the client, will determine whether to end development, continue development, or change development methods. It is noted that it is usually possible to reach the stabilization criterion during development, but various conditions may cause ongoing turbidity problems.

After development is complete, the monitoring well should be allowed to stabilize prior to sampling. The stabilization period is dependent upon the production of the aquifer screened and the contaminant being sampled for. The minimum amount of time is 24 hours. Longer periods may be required by the USACE and other clients.

9.0 DATA AND RECORDS MANAGEMENT

All data will be documented on standardized boring logs, well completion forms, well development forms, field-data sheets, and/or site log books as specified in the Project Specific Work Plan and as detailed in *SOP 701 Field Documentation*. Photos of the well locations both prior to the well installation and upon completion of the well installation and photos of the final appearance of groundwater upon completion of development are a good field practice; care should be taken to be aware of any client restrictions on photographs. Field documentation will be completed as activities are conducted and will be

relayed to the Field Site Manager or Project Manager at a minimum weekly or on a more frequent basis if so stated in the Project-Specific Work Plan.

10.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to the start of any field activity, Burns & McDonnell personnel will have read and understood the Project-Specific Work Plan as well as this SOP. Field personnel will be trained for a minimum of 40 hours prior to their working solo on environmental field activities.

11.0 REFERENCES

Burns & McDonnell Engineering, Co, Inc. (Burns & McDonnell), 2018. *Policy Manual*,

- Chapter 8, Employee Safety & Health, April 2017.
- Chapter 10, Quality Control Manual, January 2017.

United States Army Corps of Engineers (USACE), 1998. *Engineering and Design - Monitor Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites,* EM 1110 1 4000, November 1, 1998.

United States Environmental Protection Agency (USEPA), 2007. *Guidance for Preparing Standard Operating Procedures*. EPA/600/B-07/001. April

12.0 ATTACHMENTS

- Example Monitoring Well Construction Diagram – Stick up
- Example Monitoring Well Construction Diagram – Flush Mount

Attachments

Monitoring Well Construction Diagram

Project Number:	**Well Number:**
Project Name:	**Site Name:**
Geologist:	Northing:
Drilling Company:	Easting:
Driller:	Survey Datum:

Drilling Method: _____
Borehole Diamter: _____

Elevations	
Top of Casing (TOC)	
Ground Surface (GS)	
Reference Point (RP)	

Dates	
Drilling Start	
Drilling Complete	
Installation Start	
Installation Complete	
Development Start	
Development Complete	

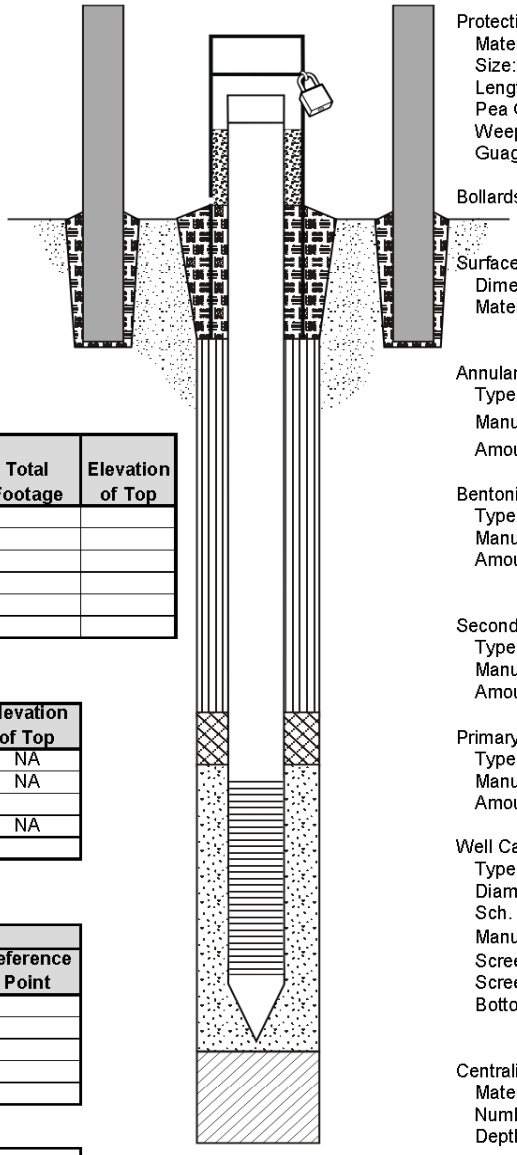
Annular Material Measurements	Depth to Top from GS	Total Footage	Elevation of Top
Annular Seal			
Bentonite Seal			
Secondary Filter Pack			
Filter Pack			
Backfill			
Bottom of Borehole			

(Use NA for Not Applicable)

Casing Materials Measurements	Total Footage	Elevation of Top
Total Riser Installed		NA
Total Riser Cutoff		NA
Screen		
Bottom Cap		NA
Total Depth from TOC		

Groundwater Levels		
Date & Time	Depth	Reference Point

Notes:



Cap Type: _____
Lock Keyed to: _____

Protective Cover:
- Material: _____
- Size: _____
- Length: _____
- Pea Gravel (Y/N): _____
- Weep Hole (Y/N): _____
- Guage Mark (Y/N): _____

Bollards (# and type): _____

Surface Pad:
- Dimensions: _____
- Material: _____

Annular Seal:
- Type & Size: _____
- Manufacturer: _____
- Amount Used: _____

Bentonite Seal:
- Type & Size: _____
- Manufacturer: _____
- Amount Used: _____

Secondary Filter Pack:
- Type & Size: _____
- Manufacturer: _____
- Amount Used: _____

Primary Filter Pack:
- Type & Size: _____
- Manufacturer: _____
- Amount Used: _____

Well Casing:
- Type: _____
- Diameter: _____
- Sch. or Weight: _____
- Manufacturer: _____
- Screen Type: _____
- Screen Slot Size: _____
- Bottom Cap Type: _____

Centralizers (Y/N): _____
- Material: _____
- Number: _____
- Depth(s): _____

Backfill Material:
- Type & Size: _____
- Manufacturer: _____
- Amount Used: _____

Monitoring Well Construction Diagram

Project Number:	**Well Number:**
Project Name:	**Site Name:**
Geologist:	Northing:
Drilling Company:	Easting:
Driller:	Survey Datum:

Drilling Method: _____
Borehole Diamter: _____

Elevations	
Top of Casing (TOC)	
Ground Surface (GS)	
Reference Point (RP)	

Dates	
Drilling Start	
Drilling Complete	
Installation Start	
Installation Complete	
Development Start	
Development Complete	

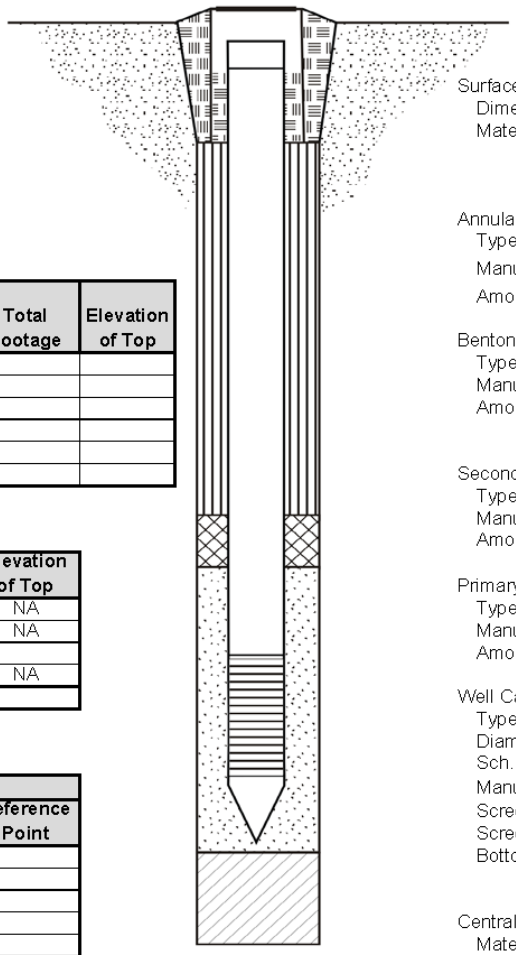
Annular Material Measurements	Depth to Top from GS	Total Footage	Elevation of Top
Annular Seal			
Bentonite Seal			
Secondary Filter Pack			
Filter Pack			
Backfill			
Bottom of Borehole			

(Use NA for Not Applicable)

Casing Materials Measurements	Total Footage	Elevation of Top
Total Riser Installed		NA
Total Riser Cutoff		NA
Screen		
Bottom Cap		NA
Total Depth from TOC		

Groundwater Levels		
Date & Time	Depth	Reference Point

Notes:



Cap Type: _____
Lock Keyed to: _____

Protective Cover:
- Material: _____
- Size: _____
- Length: _____
- Guage Mark (Y/N): _____

Surface Pad:
- Dimensions: _____
- Material: _____

Annular Seal:
- Type & Size: _____
- Manufacturer: _____
- Amount Used: _____

Bentonite Seal:
- Type & Size: _____
- Manufacturer: _____
- Amount Used: _____

Secondary Filter Pack:
- Type & Size: _____
- Manufacturer: _____
- Amount Used: _____

Primary Filter Pack:
- Type & Size: _____
- Manufacturer: _____
- Amount Used: _____

Well Casing:
- Type: _____
- Diameter: _____
- Sch. or Weight: _____
- Manufacturer: _____
- Screen Type: _____
- Screen Slot Size: _____
- Bottom Cap Type: _____

Centralizers (Y/N): _____
- Material: _____
- Number: _____
- Depth(s): _____

Backfill Material:
- Type & Size: _____
- Manufacturer: _____
- Amount Used: _____

SOP 553
Abandonment of Monitoring Wells and Piezometers

Revision 01
04/06/2018

Approved by:

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Environmental Services Division

04/02/2018
Date

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04/06/2018
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Biennial Review:

Revision/Review	Date	Responsible Party	Description of Change
Revision 01	04/02/2018	Hildebrandt, Martha	Minor grammar and updated references.

TABLE OF CONTENTS

Page No.

1.0 PURPOSE AND APPLICABILITY

The purpose of *Standard Operating Procedure (SOP) 553 Abandonment of Monitoring Wells and Piezometers* is to establish a uniform procedure for the removal and abandonment of monitoring wells and piezometers using traditional-style drill rigs. This SOP covers the *process* for the removal and abandonment of monitoring wells and piezometers; rationale and scope including locations and depths of wells to be abandoned, drilling methods, and final site restoration are detailed in the Project-Specific Work Plan. As Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) does not self-perform well abandonment but instead subcontracts drilling services, this SOP is for the oversight and direction of the drilling subcontractor with Burns & McDonnell personnel responsible for the direction and documentation.

The abandonment of monitoring wells and piezometers is regulated in most states. It is the responsibility of both the Project Manager and the on-site field personnel to confirm that state regulations are met, that the driller is properly licensed for work in that state, and that required paperwork is completed by the responsible person (typically the driller) and submitted to the proper state agency. *SOP 553 Abandonment of Monitoring Wells and Piezometers* has been prepared in accordance with the *Guidance for the Preparing of Standard Operating Procedures* (USEPA, 2007) and the Burns & McDonnell *Policy Manual* (Burns & McDonnell, 2018).

2.0 SUMMARY OF METHOD

(Monitoring wells and piezometers are typically constructed in the same manner but are intended for different uses: monitoring wells are for the monitoring of groundwater quality while piezometers are for monitoring hydrogeologic parameters such as water levels. Throughout this SOP, the term “monitoring well” is used interchangeably with “piezometer.”)

Monitoring wells and piezometers are installed at project sites to monitor hydrogeologic and contaminant parameters. When monitoring wells or piezometers are no longer needed for these services, they should be removed and/or plugged (i.e. abandoned). If not properly abandoned, monitoring wells and piezometers can provide pathways for contamination to enter the subsurface and potentially impact groundwater aquifers. Additionally, abandoned monitoring wells and piezometers have to the potential to become a physical hazard to both humans and animals.

Monitoring well abandonment consists of either removing a monitoring well and backfilling the borehole with a relatively impermeable substance; or backfilling the screen and casing with relatively-impermeable

fill. For either case, the surface expression of the well (either the flush mount cover or the above-grade cover and bollards) are removed and the site should be restored. The specific method of abandonment should be chosen based upon the monitoring well size, materials, and condition; depth of the well; hydrogeologic setting; potential site contaminants; and regulatory requirements. Specifics on methods to be used and the rationale for that method should be detailed in the Project-Specific Work Plan.

3.0 DEFINITIONS

- **Annular space** - The space between two cylindrical objects one of which surrounds the other for example the space between the well casing and the borehole.
- **Bentonite** - Any type of commercial sodium bentonite clay used in the construction or plugging of wells.
- **Bentonite cement grout** - A cement grout generally containing one 94 pound bag of Portland cement mixed with 7 gallons of clean water and 2 pounds of bentonite.
- **Borehole** - Any hole drilled into the subsurface for the purpose of identifying lithology, collecting soil samples, and/or installing groundwater wells.
- **Casing/riser** - An impervious durable pipe placed in a well to keep the well from caving and help seal the well from the surface and upper sources of water and contaminants. Typically composed of polyvinyl chloride (PVC) but can also be composed of steel or stainless steel.
- **Filter pack** - Granular filter material (sand, gravel, etc.) placed in the annular space between the well screen and the borehole to increase the effective diameter of the well and prevent fine-grained material from entering the well.
- **Grout** - The material placed between the borehole wall and the casing to keep surface water out of the well and to restrict movement of water in the annular space between the borehole and the riser. Materials commonly used include bentonite and bentonite cement.
- **Monitoring well** - A well that provides for the collection of representative groundwater samples, the detection and collection of representative light and dense non-aqueous phase organic liquids, and the measurement of fluid levels.
- **Piezometer** - A well that provides for the measurement of fluid levels and other hydrogeologic properties.
- **Project-Specific Accident Prevention Plan/Site Safety and Health Plan** (Project-Specific APP/SSHP) – A plan or plans that address occupational safety and health hazards associated with site operations.

- **Project-Specific Work Plan** - The plan that details the rationale, scope, and techniques to be used at the site to achieve the project objectives. Project-Specific Work Plans can include work plans, field sampling plans, quality assurance project plans, technical memorandums, and other documentation of proposed work.
- **Tremie** - A tubular device or pipe used to place grout, bentonite, or filter pack in the annular space.
- **Well screen** - A commercially available, factory-perforated, wire wound, continuous wrap, or slotted casing segment used in a well to maximize the entry of water from the producing zone and to minimize the entrance of sand.

4.0 SAFETY AND HEALTH

Field activities as detailed in this SOP will be performed in accordance with applicable safety related documents/requirements which may include but are not limited to: the Project-Specific APP/SSHP, the Burns & McDonnell *Safety and Health Program* (Burns & McDonnell, 2017), and site/client-specific requirements. For any intrusive activities, *SOP 501 Utility Clearance* should be followed. Potential health and safety issues with drill rigs include mechanical and hydraulic systems that result in loud repetitive noises and the potential for physical injury. Personal protective equipment (PPE) including hard hats, safety glasses, steel toed boots, and hearing protection should be worn as appropriate and as detailed in the Project-Specific APP/SSHP. PPE requirements should be assessed daily and on a per task basis.

5.0 CAUTIONS

Abandonment of a monitoring well or piezometer is a complex procedure that has the potential to result in non-optimum results due to a variety of circumstances that may occur due to unknown conditions present within the well (i.e. a broken screen), natural conditions, or other issues. Cautions have been included in the procedures below; however not all situations that may arise can be covered in an SOP or the Project-Specific Work Plan. The on-site personnel should be aware of situations that may result in a non-optimal outcome, correct them as they arise, and stay in communication with their Project Manager and regulator as needed.

6.0 PERSONNEL QUALIFICATIONS

Burns & McDonnell personnel conducting on-site environmental activities will have completed the 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) course and annual 8-hour HAZWOPER refresher courses. At a minimum, one person on site will be certified in first aid and cardiopulmonary resuscitation (CPR) and, if

multiple people are on site, at least one person will have completed the 8-hour HAZWOPER Supervisor Training course. If Burns & McDonnell subcontractors are on site then, at a minimum, one Burns & McDonnell person will have completed the OSHA 30-hour Construction Industry Outreach Training.

7.0 EQUIPMENT AND SUPPLIES

Equipment used during the oversight and direction of monitoring well abandonment may include the following:

- Fiberglass or steel tape with weight
- Field logbook and appropriate field forms
- PPE and safety equipment per the Project-Specific APP/SSHP

Equipment to be used for the collection of fluid levels, decontamination, documentation, and the disposal of IDW can be found in the SOPs for those activities.

Prior to the start of field activities, the Field Site Manager and/or the Project Manager should determine that 1) necessary permits, right of entries, and utilities clearances have been obtained; 2) the Project-Specific APP/SSHP has been reviewed by Burns & McDonnell personnel participating in the work and subcontractors who will be on site; 3) appropriate PPE has been obtained for Burns & McDonnell personnel and will be available on site; 4) applicable safety data sheets are on site and available to the field team; and 5) equipment and meters are available, in working order, and complete with needed components.

8.0 PROCEDURES

Monitoring well abandonment will be conducted in accordance to the requirements and procedures below and the appropriate state regulations. Clients may have additional requirements or requests to meet safety and aesthetic requirements. Additionally, abandonment of monitoring wells placed at sites overseen by the US Army Corps of Engineers should meet the USACE guidance document entitled *Engineering and Design - Monitor Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites,* EM 1110 1 4000 (USACE, 1998).

8.1 Inspection and Preparation

Remove any dedicated equipment such as pumps and sampling tethers from the monitoring well. For above ground installations, remove the protective casing. Collect a measurement of the depth to

groundwater per SOP For flush grade wells, remove the flush mount protective casing. The monitoring well pad may be removed at this time or at the time of site restoration.

8.2 Abandonment with Casing Removal

Removal of the well casing and screen is recommended for most environmental sites and should be done for any monitoring well where the condition of the seal between the casing and the borehole is potentially compromised. Removal of the well casing and screen is also recommended if there is the potential for the well to have been cased across multiple aquifers or if there is any potential for the well to serve as a pathway for contamination.

8.2.1 Removal of Casing by Pulling

For shallow monitoring wells, the casing and screen can often be removed by pulling or bumping the casing and screen with the drill rig. This method requires that the casing and screen be structurally sound or the casing will break during removal. If the borehole begins to collapse as the screen and riser is removed, grout should be emplaced as the screen and riser is removed.

8.2.2 Removal of Casing by Overdrilling

Overdrilling is a method for removing a casing and well materials from the borehole by using a large-diameter hollow stem auger to drill around the casing. Typically, the inside diameter of the auger is at least 2 inches larger than the well casing. The auger is advanced to the total depth of the well and then the casing is removed from the borehole either before or during the removal of the auger flights.

8.2.3 Removal of the Casing by Drilling Through the Well

In this case, the casing and well materials are destroyed and removed by drilling out the well using a solid stem auger or a rotary bit. The bit used should be larger than the original diameter of the borehole and should be advance to slightly beyond the original depth of the borehole. Care should be taken during drilling to ensure that the drill bit is centered on the former borehole. Cuttings can be difficult to removed using this method.

8.2.4 Backfilling of the Borehole

Boreholes should be backfilled with grout from the bottom of the borehole to within 3 feet of the ground surface. Grout that can be used for backfilling includes bentonite/cement grout, a high solids bentonite grout, or bentonite pellets or chips. The on-site person should check and document the materials used including brand name and amount, and, if using a slurry, that the grout was mixed per the manufacturer's

directions. Grout should be approved for environmental use. Frequent measurements of the level of the grout in the borehole should be made during emplacement to determine if bridging has occurred.

Borings backfilled with bentonite/cement slurry or bentonite grout should be backfilled from the bottom of the borehole to within 3 feet of the ground surface. If the borehole is greater than 50 feet or if the grout is being emplaced as the casing is removed then the slurry should be emplaced from the bottom upward, using a tremie pipe. The tremie pipe should be slowly raised as the slurry is emplaced, while keeping the end of the tremie pipe submerged below the surface of the slurry. If the boring is less than 50 feet then the backfill can be poured from the surface.

Bentonite pellets or chips may be emplaced through a tremie pipe or can be poured from the surface. Chips should not be poured through the surface through a large water column, as they will hydrate quickly and bridge resulting in voids in the grout. Chips placed above the water table should be hydrated every 1 foot during placement using potable water.

After 24 hours, the abandoned borehole should be checked for grout settlement. Additional grout should be emplaced into the borehole if the top of the grout is greater than 3 feet from the ground surface. If less than 15 lineal feet exists between the ground surface and the upper surface of the slurry, a tremie pipe is not required for emplacement of additional slurry.

8.3 Abandonment without Casing Removal

Monitoring wells can be sealed without casing removal when the construction details are known, the annular seal is intact, and the filter pack does not cross more than one ground water zone. Additionally, for some environmental sites or wells, casing removal may be difficult or unsafe and abandonment of the well without removal of the casing is warranted. The Project Manager should be aware of state regulations regarding this and, if needed, request the proper variances prior to the start of field activities. Dependent upon site/well conditions or state regulations, it may be appropriate to perforate the casing prior to emplacement of the backfill. Any procedures for casing perforation will be addressed in the Project-Specific Work Plans.

If the screen is across a highly permeable formation, then the monitoring well can be backfilled with clean, well rounded, silica sand from the bottom of the well to the top of the screen. Otherwise the backfill should consist of a grout consisting of a bentonite cement, bentonite slurry, or bentonite chips. The on-site person should check and document the materials used including brand name and amount, and,

if using a slurry, that the grout was mixed per the manufacturer's directions. Grout should be approved for environmental use.

Monitoring wells with a depth greater than 50 feet should add backfill material from the bottom upward using a tremie pipe. For these wells, slowly raise the tremie pipe as the sand or grout is emplaced, while keeping the end of the tremie pipe submerged below the surface of the sand. Wells less than 50 feet may emplace grout or sand by pouring from the surface. Backfill material will be placed to within 3 feet below ground surface. Bentonite pellets or chips may be emplaced through a tremie pipe or can be poured from the surface. Chips should not be poured through the surface through a large water column, as they will hydrate quickly and bridge resulting in voids in the grout. Chips placed above the water table should be hydrated every 1 foot during placement using potable water.

After 24 hours, the abandoned borehole should be checked for grout settlement. Additional grout should be emplaced into the borehole if the top of the grout is greater than 3 feet from the ground surface. If less than 15 lineal feet exists between the ground surface and the upper surface of the slurry, a tremie pipe is not required for emplacement of additional slurry.

8.4 Site Restoration

Upon completion of the well abandonment, the site should be restored so to match the original surrounding conditions. This is accomplished by backfilling the remaining borehole and any voids caused by the removal of the surface pad with clean, native material to the ground surface. The on-site personnel should check that the backfill is compacted as it is emplaced so to minimize later settlement. The area should then be restored as much as possible to match the original surrounding conditions. Patches in concrete or asphalt should match the original surface. Grassed areas should be sodded or seeded, per the client's request.

9.0 DATA AND RECORDS MANAGEMENT

All data will be documented on field-data sheets and/or site log books as specified in the Project-Specific Work Plan and as detailed in *SOP 701 Field Documentation*. There should be sufficient information documented to fully complete any required state forms. Photos of the well locations both prior to the well abandonment and upon completion of the site restoration are a good field practice; care should be taken to be aware of any client restrictions on photographs. Field documentation will be completed as activities are conducted and will be relayed to the Field Site Manager or Project Manager at a minimum weekly or on a more frequent basis if so stated in the Project-Specific Work Plan.

10.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to the start of any field activity, Burns & McDonnell personnel will have read and understood the Project-Specific Work Plans as well as this SOP. Field personnel will be trained for a minimum of 40 hours prior to their working solo on environmental field activities.

11.0 REFERENCES

Burns & McDonnell Engineering, Co, Inc. (Burns & McDonnell), 2018. *Policy Manual*,

- Chapter 8, Employee Safety & Health, April 2017.
- Chapter 10, Quality Control Manual, January.

United States Army Corps of Engineers (USACE), 1998. *Engineering and Design - Monitor Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites,* EM 1110 1 4000, November 1, 1998.

United States Environmental Protection Agency (USEPA), 2007. *Guidance for Preparing Standard Operating Procedures*. EPA/600/B-07/001. April

12.0 ATTACHMENTS

None.

SOP 554
Advancement and Abandonment of Boreholes

Revision 0
09/25/2018

Approved by:

9/25/2018

Martha Hildebrandt, PG, Associate Geologist,
Environmental Services Division

Date

9/25/2018

Chris Hoglund, PG, Senior Geologist
Environmental Services Division

Date

9/25/2018

John Hesemann, PE,
Remediation Technical Service Area Leader,
Environmental Services Division

Date

Annual Review:

Revision/Review	Date	Responsible Party	Description of Change

TABLE OF CONTENTS

Page No.

1.0 PURPOSE AND APPLICABILITY

The purpose of *Standard Operating Procedure (SOP) 554 Advancement and Abandonment of Boreholes* is to establish a uniform procedure for the advancement and abandonment of boreholes using direct push or traditional-style drill rigs. This SOP covers the *process* for the advancement and abandonment of boreholes; rationale and scope including locations and depths of boreholes, drilling methods, and final site restoration are detailed in the Project-Specific Work Plan. As Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) does not self-perform borehole advancement or abandonment but instead subcontracts drilling services, this SOP is for the oversight and direction of the drilling subcontractor with Burns & McDonnell personnel responsible for the direction and documentation.

The advancement and abandonment of boreholes is regulated in most states. It is the responsibility of both the Project Manager and the on-site field personnel to ensure that state regulations are met, that the driller is properly licensed for work in the state, and that required paperwork is completed by the responsible person (typically the driller) and submitted to the proper state agency. *SOP 554 Advancement and Abandonment of Boreholes* has been prepared in accordance with the *Guidance for the Preparing of Standard Operating Procedures* (USEPA, 2007) and the Burns & McDonnell *Policy Manual* (Burns & McDonnell, 2018).

2.0 SUMMARY OF METHOD

Boreholes are advanced at project sites to collect soil, materials, rock, product, and/or groundwater samples for geologic logging and/or environmental sampling and to measure geotechnical or hydrogeologic properties. When boreholes are no longer needed for these services, they should be abandoned (i.e. plugged). If not properly abandoned, boreholes can provide pathways for contamination to enter the subsurface and potentially impact groundwater aquifers. Additionally, abandoned boreholes have the potential to become a physical hazard to both humans and animals.

Borehole advancement can be accomplished by a variety of mechanical methods means such as augers or drill bits but can also be advanced using high frequency vibrations (sonic drilling) or static pressure and percussion (direct push). Soil, bedrock, and subsurface materials are brought to the surface as samples or cuttings by mechanical means (augers or samplers), or by using pressurized air, water, or a slurry of water and other materials such as bentonite. Some drilling methods such as direct push advance a small diameter rod into the subsurface by direct or percussive force resulting in no cuttings being brought to the surface.

Borehole abandonment consists of backfilling the borehole with a relatively impermeable substance and restoring the site. The specific method of abandonment should be chosen based upon the depth and diameter of the borehole; hydrogeologic setting; potential site contaminants; and regulatory requirements. Specifics on methods to be used and the rationale for that method should be detailed in the Project-Specific Work Plan.

3.0 DEFINITIONS

- **Bentonite** - Any type of commercial sodium bentonite clay used in the construction or plugging of wells.
- **Bentonite cement grout** - A cement grout generally containing one 94-pound bag of Portland cement mixed with 7 gallons of clean water and 2 pounds of bentonite.
- **Borehole** - Any hole drilled into the subsurface to identify lithology, collect soil samples, and/or install wells.
- **Grout** - The material placed in the borehole to keep surface water from entering the subsurface and to prevent movement of groundwater and/or contaminants from one aquifer or portion of an aquifer to another. Materials commonly used include bentonite and bentonite cement.
- **Project-Specific Accident Prevention Plan/Site Safety and Health Plan** (Project-Specific APP/SSHP) – A plan or plans that address occupational safety and health hazards associated with site operations.
- **Project-Specific Work Plan** - The plan that details the rationale, scope, and techniques to be used at the site to achieve the project objectives. Project-Specific Work Plans can include work plans, field sampling plans, quality assurance project plans, technical memorandums, and other documentation of proposed work.
- **Tremie** - A tubular device or pipe used to place grout, from bottom to top, in the borehole.

4.0 SAFETY AND HEALTH

Field activities as detailed in this SOP will be performed in accordance with applicable safety related documents/requirements which may include but are not limited to: the Project-Specific APP/SSHP, the Burns & McDonnell *Safety and Health Program* (Burns & McDonnell, 2017), and site/client-specific requirements. For any intrusive activities, *SOP 501 Utility Clearance* should be followed. Potential health and safety issues with drill rigs include mechanical and hydraulic systems that result in loud repetitive noises and the potential for physical injury. Personal protective equipment (PPE) including hard

hats, safety glasses, steel toed boots, and hearing protection should be worn as appropriate and as detailed in the Project-Specific APP/SSHP.

5.0 CAUTIONS

Advancement or abandonment of a borehole is a complex procedure that has the potential to result in non-optimum results due to a variety of circumstances that may occur because of unknown conditions present in the subsurface. Cautions have been included in the procedures below; however not all situations that may arise can be covered in an SOP or the Project-Specific Work Plan. The on-site personnel should be aware of situations that may result in a non-optimal outcome, correct them as they arise, and stay in communication with their Project Manager and regulator as needed.

Open boreholes can be both a physical danger to human and animals and a potential pathway for contaminants to enter the subsurface. Open boreholes should be flagged, and physical barriers/covers installed to prevent entry into the area. Additionally, the boreholes should be bermed to prevent precipitation, in the form of overland flow, from entering the borehole. Boreholes should be abandoned expeditiously after completion of data gathering. Note that some states have regulations on the length of time that boreholes are allowed to remain open.

While some states allow the use of permeable materials such as sand or gravel for select types of borehole abandonment; however, for environmental projects, usage of these materials in the abandonment of boreholes is not advisable. If these materials are to be used in borehole abandonment, the specific procedures and requirements should be detailed in the Project-Specific Work Plan and approval should be obtained from the regulators prior to the start of field work.

6.0 PERSONNEL QUALIFICATIONS

Burns & McDonnell personnel conducting on-site environmental activities will have completed the 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) course and annual 8-hour HAZWOPER refresher courses. At a minimum, one person on site will be certified in first aid and cardiopulmonary resuscitation (CPR) and, if multiple people are on site, at least one person will have completed the 8-hour HAZWOPER Supervisor Training course. If Burns & McDonnell subcontractors are on site then, at a minimum, one Burns & McDonnell person will have completed the OSHA 30-hour Construction Industry Outreach Training course.

7.0 EQUIPMENT AND SUPPLIES

Equipment used during the oversight and direction of borehole advancement and abandonment may include the following:

- Fiberglass or steel tape with weight
- Field logbook and appropriate field forms
- PPE and safety equipment per the Project-Specific APP/SSHP

Equipment to be used for the collection of fluid levels, the collection and logging of samples, decontamination, documentation, and the storage and disposal of IDW can be found in the SOPs for those activities.

Prior to the start of field activities, the Field Site Manager and/or the Project Manager should determine that 1) necessary permits, right of entries, and utilities clearances have been obtained; 2) the Project-Specific APP/SSHP has been reviewed by Burns & McDonnell personnel participating in the work and subcontractors who will be on site; 3) appropriate PPE has been obtained for Burns & McDonnell personnel and will be available on site; and 4) equipment and meters are available, in working order, and complete with needed components.

8.0 PROCEDURES

Borehole advancement and abandonment will be conducted in accordance to the requirements and procedures below and the appropriate state regulations. Clients may have additional requirements or requests to meet safety and aesthetic requirements.

8.1 Utility Clearance

Prior to the start of any intrusive activity, utility clearance should be completed in accordance with *SOP 501 Utility Clearance*.

8.2 Advancement of the Borehole

Boreholes may be advanced by a variety of techniques including hollow or solid stem augers, air rotary, rotary wash, cable tool, sonic, dual-tube percussion, direct push, or other drilling techniques. The specific drilling method should be chosen based upon the site geology, desired depth, desired borehole diameter, logging and testing requirements, and potential site contaminants and should be specified in the Project-Specific Work Plan. If soil or bedrock is to be sampled for analysis, the Project-Specific Work Plan

should include the rationale and scope for the sampling including the number of samples to be collect, depth, analytical parameters, and method of collection with the referenced SOPs. Soil and bedrock should be logged from either the samples collected or from cuttings in accordance with *SOP 521 Soil and Bedrock Logging*. Other types of testing that may be required, including packer tests, downhole geophysical logging, geotechnical testing, geotechnical sampling, or direct sensing/imaging tools. should be specified in the Project-Specific Work Plan with the referenced SOPs. Borehole depths and depths to groundwater should be measured when the drilling equipment is tripped from the borehole and upon reaching final depth. Cuttings and liquids should be handled in accordance with the Project-Specific Work Plan and in accordance with *SOP 601 Investigative Derived Waste, Storage, Sampling, and Disposal*.

8.3 Backfilling of the Borehole

All drilling equipment, testing devices, and obstructions should be removed from boreholes prior to backfilling to prevent bridging and result in a continuous seal. Hollow stem augers and surface casings may be removed as the borehole is backfilled. Boreholes should be backfilled with grout from the bottom of the borehole to within 3 feet of the ground surface. Grout that can be used for backfilling includes bentonite/cement grout, a high-solids bentonite grout, or bentonite pellets or chips. The type of grout used and the method of emplacement should meet state-specific regulations. The on-site person should check and document the materials used including brand name and amount, and, if using a slurry, that the grout was mixed per the manufacturer's directions. Grout should be approved for environmental use. Frequent measurements of the level of the grout in the borehole should be made during emplacement to determine if bridging has occurred.

Borings backfilled with bentonite/cement slurry or bentonite grout should be backfilled from the bottom of the borehole to within 3 feet of the ground surface. If the borehole is greater than 50 feet or if the grout is being emplaced as the casing is removed, then the slurry should be emplaced from the bottom upward, using a tremie pipe. The tremie pipe should be slowly raised as the slurry is emplaced, while keeping the end of the tremie pipe submerged below the surface of the slurry. If the boring is less than 50 feet, then the backfill can be poured from the surface as specified in the Project-Specific Work Plan.

Bentonite pellets or chips may be emplaced through a tremie pipe or can be poured from the surface. Chips should not be poured through the surface through a large water column, as they will hydrate quickly and bridge, resulting in voids in the grout. Chips placed above the water table should be hydrated every foot during placement using potable water. If needed, coated chips can be placed though a water

column, typically through either a tremie pipe or hollow stem augers. If this method is used, it will be detailed in the Project-Specific Work Plan.

After 24 hours, the abandoned borehole should be checked for grout settlement. Additional grout should be emplaced into the borehole if the top of the grout is greater than 3 feet from the ground surface. If less than 15 lineal feet exists between the ground surface and the upper surface of the slurry, a tremie pipe is not required for emplacement of additional slurry.

8.4 Site Restoration

Upon completion of the borehole abandonment, the site should be restored so to match the original surrounding conditions. This is accomplished by backfilling the remaining borehole and any voids caused by drilling activities with clean, native material to the ground surface. The on-site personnel should check that the backfill is compacted as it is emplaced so to minimize later settlement. The area should then be restored as much as possible to match the original surrounding conditions. Patches in concrete or asphalt should match the original surface. Grassed areas should be sodded or seeded, per the client's request.

9.0 DATA AND RECORDS MANAGEMENT

All data will be documented on field-data sheets and/or in site log books as specified in the Project-Specific Work Plan and as detailed in *SOP 701 Field Documentation*. There should be sufficient information documented to fully complete any required state forms. Photos of the borehole location both prior to the start of activities and upon completion of the site restoration are a good field practice; however, care should be taken to be aware of any client restrictions on photographs. Field documentation will be completed as activities are conducted and will be relayed to the Field Site Manager or Project Manager at a minimum weekly or on a more frequent basis if so stated in the Project-Specific Work Plan.

10.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to the start of any field activity, Burns & McDonnell personnel will have read and understood the Project-Specific Work Plans as well as this SOP. Field personnel will be trained for a minimum of 40 hours prior to their working solo on environmental field activities.

11.0 REFERENCES

Burns & McDonnell Engineering, Co, Inc. (Burns & McDonnell), 2018. *Policy Manual*,

- Chapter 8, Employee Safety & Health, April 2017.
- Chapter 10, Quality Control Manual, January 2017.

United States Environmental Protection Agency (USEPA), 2007. *Guidance for Preparing Standard Operating Procedures*. EPA/600/B-07/001. April

12.0 ATTACHMENTS

None.

SOP 592
Sample Packaging and Shipping

Revision 01
04/06/2018

Approved by:

04/03/2018

Martha Hildebrandt, PG, Associate Geologist,
Environmental Services Division — Date

02/22/2018

Justin Carter, PG, Senior Geologist,
Environmental Services Division — Date

04/06/2018

John Hesemann, PE,
Remediation Technical Service Area Leader
Environmental Services Division — Date

Biennial Review:

Revision/Review	Date	Responsible Party	Description of Change
Revision 01	02/22/2018	Carter, Justin	Minor grammar and updated references.

TABLE OF CONTENTS

Page No.

1.0 PURPOSE AND APPLICABILITY

The purpose of *Standard Operating Procedure (SOP) 592 Sample Packaging and Shipping* is to establish a uniform procedure for field personnel to use in the packaging and shipping of environmental samples for chemical and physical analysis. This SOP only applies to the packaging and shipping of limited quantity, low concentration environmental samples. This procedure does not apply to those samples considered hazardous materials, hazardous waste, mixed waste, radioactive waste, and/or dangerous goods. Requirements for packing and shipping those types of samples are specified in the U.S. Department of Transportation (DOT) 49 Code of Federal Regulation (CFR) 114-327 and the International Air Transport Association (IATA) procedures. This SOP covers the *process* for the packaging and shipping of environmental samples; specific of shippers and shipping dates are detailed in the Project-Specific Work Plan. *SOP 592 Sample Packaging and Shipping* has been prepared in accordance with the *Guidance for the Preparing of Standard Operating Procedures* (USEPA, 2007) and the Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) *Policy Manual* (Burns & McDonnell, 2018).

2.0 SUMMARY OF METHOD

Samples collected for laboratory analysis shall be packed and shipped in a way to maintain quality control and limit breakage of sample containers. Dependent upon the analyses, samples may require placement in coolers with an appropriate amount of ice to maintain an internal temperature of 4° Celsius (C) during shipping from the field to the lab. Chain-of-custody (COC) documentation will be included inside of the cooler.

Samples will be sent to the laboratory via overnight shipment (ie FedEx) or a laboratory courier. If sent via FedEx, a FedEx air bill will be completely filled out and the cooler(s) will be delivered directly to a FedEx agent or to an authorized agent for shipment. The shipment tracking number will be recorded in the field logbook. (For additional questions regarding shipping, contact FedEx at 1-800-463-3339.) If sent via laboratory courier, the courier will sign the COC upon receipt of the packed samples.

3.0 DEFINITIONS

- **Environmental Sample** - A limited quantity, low concentration sample that does not require DOT or IATA hazardous waste labeling as a hazardous waste or material.

- **Hazardous Material** - A substance or material in a quantity or form, which may pose an unreasonable risk to health, safety, and/or property when transported in commerce. Hazardous material is defined and regulated by DOT (49 CFR 173.2 and 172.101) and IATA (Section 4.2).

- **Hazardous Waste** - Any substance listed in 40 CFR Subpart D (260.30 et seq.) or otherwise characterized as ignitable, corrosive, reactive, or toxic as specified in Subpart C (261.20 et seq.) that would be subject to manifest and packaging requirements specified in 40 CFR 262. Hazardous waste is defined and regulated by the United States Environmental Protection Agency (USEPA).

- **Hazardous Waste Sample** - A medium or high concentration sample requiring, either DOT or IATA labeling as a hazardous waste or material.

- **Project-Specific Accident Prevention Plan/Site Safety and Health Plan** (Project-Specific APP/SSHP) – A plan or plans that address occupational safety and health hazards associated with site operations.

- **Project-Specific Work Plan** – The plan that details the rationale, scope, and techniques to be used at the Site to achieve the project objectives. Project-Specific Work Plans can include work plans, field sampling plans, quality assurance project plans, technical memorandums, and other documentation of proposed work.

- **Sample** - Physical evidence collected from a facility or the environment which is representative of conditions at the point and time at which the sample is collected.

4.0 SAFETY AND HEALTH

Field activities as detailed in this SOP will be performed in accordance with applicable safety related documents/requirements which may include but are not limited to: Project-Specific APP/SSHP, the Burns & McDonnell *Safety and Health Program* (Burns & McDonnell, 2017), and site / client-specific requirements. Care should be taken when handling sample bottles that have been prepared with preservatives such as acids or bases. Personal protective equipment (PPE) as listed in the Project-Specific APP/SSHP should be worn while handling and packing filled sample containers. PPE requirements should be assessed daily and on a per task basis.

5.0 CAUTIONS

Sample quality is dependent upon proper preservation including sample temperature. Care should be taken not to over or under dilute the preservative within pre-preserved sample containers. Care should be taken to ensure that sufficient ice is present in the coolers during sampling and that the ice is replenished prior to shipping. Samples that contain liquids (including the ice) should be double bagged so to prevent leakage during shipment.

6.0 PERSONNEL QUALIFICATIONS

Burns & McDonnell personnel conducting on-site environmental activities will have completed the 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) course and annual 8-hour HAZWOPER refresher courses. At a minimum, one person on site will be certified in first aid and cardiopulmonary resuscitation (CPR) and, if multiple people are on site, at least one person will have completed the 8-hour HAZWOPER Supervisor Training course. If Burns & McDonnell subcontractors are on site then, at a minimum, one Burns & McDonnell person will have completed the OSHA 30-hour Construction Industry Outreach Training course.

7.0 EQUIPMENT AND SUPPLIES

Equipment and supplies required when shipping and handling samples can include:

- Packing materials such as bubble wrap, plastic sealable bags, tape, etc.
- Contractor-grade plastic trash bags
- Ice
- Coolers
- Labeling supplies such as shipping labels, waterproof pens, etc.
- PPE and safety equipment per the Project-Specific APP/SSHP

Equipment to be used for decontamination and documentation can be found in the SOPs for those activities.

Prior to the start of field activities, the Field Site Manager and/or the Project Manager should determine that 1) the Project-Specific APP/SSHP has been reviewed by Burns & McDonnell personnel participating in the work and subcontractors who will be on site; 2) appropriate PPE has been obtained for Burns & McDonnell personnel and will be available on site; 3) equipment and supplies are available, in working

order, and complete with needed components; and 4) sample shipping containers provided by the laboratory are the correct size and type, and are sufficient in number for the planned field activities.

8.0 PROCEDURES

The sample packaging and shipping procedures to be used for the shipment of samples by an overnight carrier are based on USEPA specifications and Department of Transportation regulations (49 CFR Parts 172 and 173). Samples will be packed and shipped according to requirements for low hazard-level samples. The following procedure will be used to pack samples being shipped by overnight carrier:

1. At the time of sampling, wipe the outside of each sample container with a paper towel and place a label on each container. Each glass container will be wrapped with bubble wrap. Place each sample bottle in an individual, sealable plastic bag. Volatile organic compound (VOC) vials may be grouped within a bag by sample. Remove as much air as possible from the plastic bag prior to sealing. Complete the COC as detailed in *SOP 701 Field Documentation.*

2. Prior to shipping, arrange sample containers in groups by sample number.

3. Tape drains shut on shipping cooler, if present.

4. Place an absorbent pad in the bottom of the cooler, followed by a layer of bubble wrap.

5. Insert a contractor-grade (minimum of 2 mils thick) plastic trash bag into the cooler.

6. Place the sample containers inside the trash bag in an upright position so they do not touch. Place one temperature blank in each cooler.

7. Add ice (double packaged in sealable plastic bags).

8. Check the COC against the contents of the cooler. Sign the COC and indicate the time and date the cooler is sealed. Record the time in the field logbook.

9. If shipping via overnight carrier (i.e. FedEx):

    a. Separate the copies of the COCs. Seal the top form (original) in a large, sealable, plastic bag and tape them to the inside of the cooler lid.

    b. Complete shipping paperwork (if applicable). Include air bill number and name of carrier on the COC, and record the information in the field logbook.

c. Close the lid and latch the cooler. Tape the cooler shut on both ends, make several revolutions with the strapping tape. The strapping tape should cover the ends of the clear tape used to secure the shipping label but should not cover the label.

d. Affix signed custody seals over lid openings (opposite corners of the cooler). Cover the seals with clear, plastic tape.

e. Attach the FedEx air-bill to the top of the cooler. Use two strips of clear tape to securely fasten the shipping label to the cooler so that the label will not peel off even if the coolers are stacked during shipment. The clear tape should extend across the entire top of the cooler. Field samples will be shipped to the contracted laboratory(ies).

f. Enter the appropriate information including air-shipping number, and time and date relinquished to the shipper in the field logbook.

10. If shipping via a laboratory courier:

a. Have the courier sign the COC noting receipt of samples.

b. Separate the copies of the COCs. Seal the top form (original) in a large, sealable, plastic bag and tape to the inside of the cooler lid.

c. Close the lid and latch the cooler. Tape the cooler shut on both ends, make several revolutions with the strapping tape. The strapping tape should cover the ends of the clear tape used to secure the shipping label but should not cover the label.

d. Affix signed custody seals over lid openings (opposite corners of the cooler). Cover the seals with clear, plastic tape.

e. Enter the appropriate information including name of the courier, and time and date relinquished to the courier in the field.

9.0 DATA AND RECORDS MANAGEMENT

Shipping information including COC numbers, shipping numbers, and date and times should be entered into the field logbook as detailed in *SOP 701 Field Documentation*. Field documentation will be completed as activities are conducted and will be relayed to the Field Site Manager or Project Manager at a minimum weekly or on a more frequent basis if so stated in the Project-Specific Work Plan.

10.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to the start of any field activity, Burns & McDonnell personnel will have read and understood the Project-Specific Plans as well as this SOP. Field personnel will be trained for a minimum of 40 hours prior to their working solo on environmental field activities.

11.0 REFERENCES

Burns & McDonnell Engineering, Co, Inc. (Burns & McDonnell), 2015. *Policy Manual*,

- Chapter 8, Employee Safety & Health, April 2017.
- Chapter 10, Quality Control Manual, January 2017.

United States Environmental Protection Agency (USEPA), 2007. *Guidance for Preparing Standard Operating Procedures*. EPA/600/B-07/001. April

12.0 ATTACHMENTS

None.

SOP 701
Field Documentation

Revision 01
04/06/2018

Approved by:

04/03/2018

Martha Hildebrandt, PG, Associate Geologist,
Environmental Services Division

Date

04/02/2018

Ben Clement, R.G., Senior Geologist,
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Date

04/06/2018

John Hesemann, PE,
Remediation Technical Service Area Leader
Environmental Services Division

Date

Biennial Review:

Revision/Review	Date	Responsible Party	Description of Change
Revision 01	04/06/2018	Hildebrandt, Martha	Minor grammar and reference updates.

TABLE OF CONTENTS

Page No.

1.0 PURPOSE AND APPLICABILITY

The purpose of *Standard Operating Procedure (SOP) 701 Field Documentation* is to establish a uniform procedure for documentation of field activities on environmental sites. Soil and bedrock logging for excavations and borings is not included in this SOP but can be found in *SOP 521 Soil and Bedrock Logging*. This SOP covers the ***process*** for the field documentation; specific documentation requirements that may be required by the client, regulator, or specific processes are detailed in the Project-Specific Work Plan. *SOP 701 Field Documentation* has been prepared in accordance with the *Guidance for the Preparing of Standard Operating Procedures* (USEPA, 2007) and the Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) *Policy Manual* (Burns & McDonnell, 2017).

2.0 SUMMARY OF METHOD

Each sample, field measurement, and field activity will be properly documented to facilitate timely, correct, and complete analyses, and support actions concerning site work. The documentation system will provide a means to identify, track, and monitor individual samples from the point of collection through the final reporting of data and to record field activities that occurred. Field forms referenced in this SOP are attached.

3.0 DEFINITIONS

- **Field Forms** – Forms prepared for specific activities. Forms used in the field should either be Burns & McDonnell standard forms or be included in the Project-Specific Work Plans.

- **Field Logbook –** A bound logbook that is kept per team during environmental work. Whenever possible, logbooks should have pre-numbered pages and stitched bindings.

- **Project-Specific Accident Prevention Plan/Site Safety and Health Plan** (Project-Specific APP/SSHP) – A plan or plans that address occupational safety and health hazards associated with site operations.

- **Project-Specific Work Plan** – The plan that details the rationale, scope, and techniques to be used at the site to achieve the project objectives. Project-Specific Work Plans can include work plans, field sampling plans, quality assurance project plans, technical memorandums, and other documentation of proposed work.

4.0 SAFETY AND HEALTH

Field activities as detailed in this SOP will be performed in accordance with applicable safety related documents/requirements which may include but are not limited to: Project-Specific APP/SSHP, the Burns & McDonnell Safety and Health Program (Burns & McDonnell, 2017), and site / client-specific requirements. Personal protective equipment (PPE) should be worn as appropriate and as detailed in the Project-Specific APP/SSHP. PPE requirements should be assessed daily and on a per task basis.

5.0 CAUTIONS

Field documentation should be completed with indelible marking/ink pens preferably in blue or black. Hand entries should be printed and the author should ensure that the writing is legible and clear. Any errors made should be lined out so that the original writing is still visible, initialed, and dated. Field documentation should stay either with the field personnel on site or be kept within a secure location. Upon completion of the field activities, field documentation is kept with the project files. The Project Manager should ensure that photographs or videos are allowed prior to the start of field activities.

6.0 PERSONNEL QUALIFICATIONS

Burns & McDonnell personnel conducting on-site environmental activities will have completed the 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) course and annual 8-hour HAZWOPER refresher courses. At a minimum, one person on site will be certified in first aid and cardiopulmonary resuscitation (CPR) and, if multiple people are on site, at least one person will have completed the 8-hour HAZWOPER Supervisor Training course. If Burns & McDonnell subcontractors are on site then, at a minimum, one Burns & McDonnell person will have completed the OSHA 30-hour Construction Industry Outreach Training course.

7.0 EQUIPMENT AND SUPPLIES

Equipment to be used during field documentation may include:

- Field logbooks
- Field forms
- Labels and seals
- Indelible marking pen/ink pens, black or blue in color
- Digital cameras/recorders

- Personal protective equipment (PPE) and safety equipment per the Project-Specific APP/SSHP

Equipment to be used for sampling activities can be found in the SOPs for those activities.

8.0 PROCEDURES

Included below are procedures for completing field logbooks and specific forms and labels. Which forms and labels should be completed on a project is a function of the activities to be performed and the preferences of the client and regulator. Refer to the Project-Specific Work Plan for the specific project documentation that is to be completed.

Field documentation should be completed as the activities are being done. On a regular basis, typically not less than once a week, the field personnel should scan their field documentation for placement in the project file. At the completion of a field effort, the field personnel are responsible for ensuring that a complete scan of the documentation is in the files and that the originals have been given to the project manager for inclusion in the project files.

8.1 Corrections to Documentation

Original recorded data will be written with indelible, waterproof ink. Accountable serialized documents will not be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. Errors will be corrected by marking a line through the error, entering the correct information, and initialing and dating the correction. The erroneous information will not be obliterated. Any subsequent error discovered later on an accountable document will be corrected, initialed, and dated by the person who made the entry.

8.2 Field Logbook

Information pertinent to the investigation will be recorded in a bound logbook with consecutively-numbered, water-resistant pages. The field personnel responsible for the entries will sign and date each entry or page. Logbook entries will be made in waterproof, indelible ink. The time and date of each entry will be noted in the logbook.

General rules cannot specify the exact information that must be entered in a logbook for a particular site. However, the logbook should contain sufficient information so that field activities can be reconstructed without discussion with the original author. Logbooks will be kept in the field personnel's possession or a secure place during the investigation. Following the investigation, logbooks will become part of the

project file. The following list contains typical field logbook entries to be recorded on a daily basis, depending upon field activities being performed.

- Date
- Weather conditions
- Names of field personnel and site visitors including time on and off the site
- Documentation of daily safety meeting including topics and attendance
- Calibration record of field equipment
- Name and location of area of investigation
- Location of sample (may include a sketch)
- Type of sample (soil, groundwater, sediment, air, etc.)
- Time (military) of sample collection
- Sample identification number
- Interval and depth of sample
- Field screening results
- Sample collection procedure/equipment
- Sample description (color, odor, etc.)
- Field observations of sampling event
- Parameters requested for analyses
- Field measurements
- Quality assurance/quality control (QA/QC) sample information
- Equipment decontamination procedures
- Sample shipment information
- Number assigned to chain of custody (COC)
- Documentation of investigative derived waste (IDW) per *SOP 601 Investigative Derived Waste Storage, Sampling, and Disposal*
- Air monitoring results
- Level of PPE

8.3 Field Forms

Field forms can be specific forms for field measurements such as water level forms, sampling forms, forms associated with specific activities such as well development or in-situ testing, equipment calibration forms, or health and safety forms. Specific field forms to be used should be referenced in the Project-

Specific Work Plan or the Project-Specific APP/SSHP. In all cases, the forms should be completed in entirety. Items on the forms that do not apply should be filled with NA. Forms should be completed in waterproof, indelible ink. Time entries should be military.

8.4 Daily Quality Control Reports

Daily Quality Control Reports (DQCR) are used to transmit a summary of daily activities to the client or to the regulators. DQCRs are used on most Department of Defense projects. DQCRs can be used on state or private projects if the client or regulator requests a daily field summary. With DQCRs, field activities will be recorded daily by the Field Site Manager (FSM) to verify that procedures outlined in the Project-Specific Work Plans are implemented. DQCRs will be completed with the following information:

- **Site Information** - To accurately track field activities from one site location to another, site-specific information will be recorded on the DQCR form. Information such as site location, project number, area of investigation, date, time, crew numbers, names of crew members, and the name of the FSM will be recorded.

- **Weather Conditions** - General weather conditions such as air temperature, relative wind speed and direction, and relative humidity will be estimated daily and recorded on the DQCR forms. Any change in weather conditions encountered during the day will be recorded on the DQCR.

- **Subcontractors and Equipment** - The subcontractors performing work associated with the investigation at the site will be tracked by recording on the DQCR form the subcontractor's company name, crew size, and a list of the major equipment used during daily field activities.

- **Summary of Work Performed -** A brief description of the daily field activities performed at the site will be recorded on the DQCR form. For field measurements, the numerical value and units will be recorded on the DQCR form.

- **Instrument Calibration** - Instrumentation used for sampling and personal protection, and verification of instrument calibration during daily field activities will be recorded on the DQCR form. Additional instruments used will be written in the space provided. Further information on calibration procedures will be recorded on the calibration log for each instrument used during daily field activities.

- **Health and Safety Requirements** - The level of protection used during daily field activities and any other health and safety modifications will be recorded in the DQCR form. Modifications that may occur during field activities, including upgrading to higher levels of protection based on air-monitoring data and other chemical or physical hazards encountered at the site that were not previously known to exist, will also be recorded on the DQCR form.

- **Sample Numbers Collected Including QA/QC Samples** – A summary of the samples collected, including QA/QC samples and the relationship of the QA/QC samples to the original samples, will be recorded on the DQCR form under the "Summary of Work Performed" heading.

- **Deviations from the Approved Site-Specific Documents** - Any anticipated deviation in field activities that is not specified in the site-specific documents will be recorded on the DQCR form. The actual deviation will not be performed until a written request is submitted by the Project Manager to the client and approval, written or verbal, has been granted by the client.

- **Problems Encountered/Corrective Action Taken** - During daily field activities, any problems encountered and the corrective actions taken for each incident will be recorded on the DQCR form. For each problem encountered, the Project Manager will be notified and the date and time recorded of when notification was given.

- **Work Status for the Following Day** - A summary of field activities planned for the following day will be recorded on the DQCR form.

The FSM will verify completion by signing and dating the DQCR form. The DQCR form will be completed and forward to the Project Manager daily. The DQCRs and any attachments will be submitted to the client either daily or weekly as requested. Copies of the completed forms will be placed in the project file.

8.5 Chain-of-Custody Records

The COC will be employed as physical evidence of sample custody. Field personnel will initiate a COC with acquisition of the sample. Transferred possession of samples will be recorded on the COC by both the person relinquishing and the person receiving the samples by signing, dating, and noting the time the transfer of possession takes place. Samples are considered to be in a person's custody if they are within that person's line of sight, kept in a locked room or vehicle, or adequately sealed with custody seals.

A COC will be prepared for each cooler shipped or transported to the laboratory. All samples packed in the cooler will be recorded on the COC accompanying that cooler. A document control number consisting of the date and consecutive alphabetic suffix will be completed in the space provided on the COC. For example, if a shipment of samples is prepared on January 31, 2016 with two coolers, the document control numbers will be 01312016A for the COC(s) included with the first cooler and 01312016B for the COC(s) included with the second cooler.

The following information is to be included on the COC:

- Sample numbers
- Signature(s) of field personnel
- Date of collection
- Time (military) of collection
- Sample type (solid, etc.)
- Identification of sampling point (including depth)
- Number of containers
- Preservative used
- Parameters requested for analysis
- Signature of person(s) involved in the chain of possession
- Inclusive dates and times of possession
- Notations regarding the possible compromise of sample integrity
- Notation regarding sample temperature
- Document control number

After completing the COC, the original (white copy) will be enclosed in a plastic bag and secured to the inside of the cooler lid for the laboratory and the yellow copy will be placed in the project file.

8.6 Sample Labels

Each sample removed from a site and transferred to a laboratory for analysis will be identified with a sample label containing specific information regarding the sample. Each completed sample identification label will be securely fastened to the sample container. Complete sample labels will include the following information:

- Date

- Time (military) of sample collection
- Type of analyses requested
- Sample number
- Sample collection depth, if appropriate
- Location of sample collection
- Type of preservative
- Initials of sampler

8.7 Custody Seals

From the time the coolers are packed until they are opened in the laboratory, custody seals will be used to preserve the integrity of the cooler during shipment. Custody seals must be attached so that it is necessary to break the seals to open the cooler and should be initialized by the person applying the seal. The custody seals will be covered with clear tape. All samples shipped overnight to the laboratory will be shipped in coolers sealed on two opposite sides with custody seals. As long as the COCs are sealed inside the sample cooler and custody seals remain intact, commercial carriers and laboratory couriers are not required to sign the custody form.

8.8 Digital Cameras or Recorders

Sample points and field activities may be documented using cameras or recorders. Photographs and recordings may be used to document sample characteristics, sample collection activities, remediation activities, equipment used, and features of the site and surrounding areas. Photographs and recordings taken to document sampling points should include one or more reference points to facilitate relocating the sample location at a later date. Where appropriate, a scale should also be included in the photograph or recording. Date and time stamps should be turned on for all digital documentation. Photographs and recordings can be located using the built-in GPS unit on the camera or recorder, a handheld GPS, or a photograph location sketch drawn in the field logbook. The following information will be recorded in the field logbook for each photograph or recording:

- Date
- Time
- Photographer
- Name of building or area
- General direction faced and description of subject
- Sequential number of the photograph or recording

- Camera or recorder serial number

9.0 DATA AND RECORDS MANAGEMENT

9.1 Field Activities

Field documentation should be completed as the activities are being done. On a regular basis, typically not less than once a week, the field personnel should scan their field documentation for placement in the project file. At the completion of a field effort, the field personnel are responsible for ensuring that a complete scan of the documentation is in the files and that the originals have been given to the project manager for inclusion in the project files.

9.2 Filing System

A project file will be established to organize and maintain data throughout the life of the project. The field data file will include either hard or electronic copies of record documents generated in the field including but will not be limited to the following:

- Field logbooks
- Site planning documents and project-specific plans
- Contract specifications
- Subcontractor agreements/purchase orders
- Safety Data Sheets for chemicals used on the site
- Field instrument operating manuals
- List of important phone numbers
- Shipping forms
- Equipment calibration records
- Health and safety forms
- Applicable field forms
- Applicable laboratory forms

Field forms in hard format should be electronically scanned and placed in the electronic project files upon return to the office.

The project file in the office can also include, but is not limited to:

- Chemical laboratory data file including copies of the COCs, cooler receipt forms, requests for chemical analysis, and the laboratory results
- Physical laboratory data file including requests for physical analysis and the laboratory results
- Field data file including boring log originals, field logbooks, field transmittals, photographs, and field performance and system reviews
- Data record file including backup copies of the computerized data record system.
- Project correspondence including transmittal letters
- Project memoranda including minutes of meetings and progress reports
- QA/QC file including copies of the laboratory's QA/QC manual, the laboratory's QA/QC project plan, the laboratory's QA/QC internal audit, and performance and system QA reviews
- Report originals in pdf (portable document file) format
- Drawing and plan file including original report exhibits, original maps, and miscellaneous plans and drawings related to the field investigation

10.0 QUALITY ASSURANCE/QUALITY CONTROL

Prior to the start of any field activity, Burns & McDonnell personnel will have read and understood the Project-Specific Work Plan as well as this SOP. Field personnel will be trained for a minimum of 40 hours prior to their working solo on environmental field activities. Field documentation will be completed as activities are conducted and will be relayed to the FSM or Project Manager at a minimum weekly or on a more frequent basis if so stated in the Project-Specific Work Plan.

11.0 REFERENCES

Burns & McDonnell Engineering, Co, Inc. (Burns & McDonnell), 2018. *Policy Manual*,

- Chapter 8, Employee Safety & Health, April 2017.
- Chapter 10, Quality Control Manual, January 2017.

United States Environmental Protection Agency (USEPA), 2007. *Guidance for Preparing Standard Operating Procedures*. EPA/600/B-07/001. April

12.0 ATTACHMENTS

The following example forms are attached to this SOP:

- DQCR

- COC
- Sample label
- Custody seal

Project-specific forms should be included with the Project-Specific Work Plans.

Attachments

DAILY QUALITY CONTROL REPORT

Site: _____
Project No: _____
Date: _____
Crew No: _____
Crew Mem: _____

Weather (circle)

	Bright Sun	Clear	Overcast	Rain	T-storm	Snow
Temp:	to 32	32-50	50-70	70-85	85+	
Wind:	Still	Gusty	Moder.	High	**Direction: NW**	
Humidity:	Dry	Moder.	Humid			

Subcontractors and Equipment on Site: None

Health and Safety Levels: (circle)

D	Mod. D.	C	B	A

Summary of Health and Safety Activities: _____

Instrument Used: (circle)	**PID**	**pH**	**Cond.**	**Therm.**	**Turbidity**	**DO**	**ORP**	**Other**
Calibrated: (check)								

For actual calibration results, see field calibration forms.

Summary of Work Performed: _____

All Samples Were Collected According to Procedures Outlined in the Work Plan?
Yes _____ No _____

Problems Encountered/Corrective Action Taken: _____

Time Project Manager Contacted: _____

Tomorrow's Expectations: _____

Name: _____ Signature: _____

Burns & McDonnell SINCE 1898

Request for Chemical Analysis and Chain of Custody Record

Burns & McDonnell Engineering 9400 Ward Parkway Kansas City, Missouri 64114 Phone: (816) 333-9400 Fax: (816) 270-0575 Attention:	Laboratory: Address: City/State/Zip: Telephone:	Document Control No: Lab. Reference No. or Episode No.:

Project Number:

Client Name:

Sample Type Matrix

Analysis

Sample Number	Location	Material Sampled	Sample Collection Date	Air	Wipe	Bulk					Remarks (sq. ft, linear ft, volume)

Sampler *(signature)*:

Sampler *(signature)*:

Special Instructions:

Relinquished By *(signature)*:	Date/Time	Received By *(signature)*:	Date/Time	Ice Present in Container: Yes ☐ No ☐	Temperature Upon Receipt:
1.					
Relinquished By *(signature)*:	Date/Time	Received By *(signature)*:	Date/Time	Laboratory Comments:	
2.					

032703 Form WCD-KC-105

ROUTE TO		ANALYSIS
	Burns & McDonnell WCD 9400 Ward Parkway Kansas City, MO 64114 Phone: (816) 333-9400	

Sample Group: _____

Sample Point: _____

Sample Designator: _____

Sample Round: _____ Year: _____

Sample Depth From: _____ To: _____

Date Sampled: _____

Time Sampled: _____

Preservation: _____

_____

090705 Form WCD-97N

WCD-101

Burns & McDonnell ENV
9400 Ward Parkway
Kansas City, MO 64114-3319

Signature _____

Date _____


BURNS McDONNELL