SolSpec
AERIAL ANALYTICS

Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

Re: Transmittal Letter for SolSpec, Inc. Project Titled "*DEVELOPMENT & AUTOMATION OF AERIAL ANALYTICS TOOLS FOR REMOTELY MEASURING RECLAMATION SUCCESS & LANDSLIDE SUSCEPTIBILITY IN NORTH DAKOTA"*

Dear Ms. Fine:

SolSpec, Inc. (SolSpec) is pleased to propose the development, validation, and automation of aerial analytics tools to support North Dakota's oil and gas industry in achieving safety and stewardship goals through innovation. The project seeks to empower operators and agencies with the best available technology and information needed to improve efficiencies, reduce costs, and ensure the safety and sustainability of oil and gas operations in North Dakota.

Enclosed please find the grant application titled "Development and Automation of Aerial Analytics Tools for Remotely Measuring Reclamation Success and Landslide Susceptibility in North Dakota". SolSpec is a Denver-based software company that specializes in the processing and analysis of geospatial data for commercial applications in oil and gas, natural resources, infrastructure, and other major land-use activities.

This transmittal letter represents a commitment by SolSpec to complete the project described in the enclosed proposal. If you have any questions, please contact me directly at (970) 541-8636.

Respectfully,

Katherine Kraft

Katherine Kraft
Director of Public Policy & Government Affairs
SolSpec, Inc.

Enclosures

Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title:

Development & Automation of Aerial Analytics Tools for Remotely Measuring Reclamation Success & Landslide Susceptibility in North Dakota

Applicant:

SolSpec, Inc.

Principal Investigators:

Nathan Casler & John Norman, SolSpec, Inc.

Date of Application:

June 1, 2019

Amount of Request:

$252,385.00

Total Amount of Proposed Project:

$504,770.00

Duration of Project:

16 Months

Point of Contact (POC):

Katherine Kraft, SolSpec, Inc.

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970.541.8636

POC E-Mail Address:

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ABSTRACT

Objective: If remote sensing technologies are to perform to the optimal benefit of North Dakota's oil and gas industry, big data collected in the field must be transformed into decision tools at the desktop. The transformation process that turns remotely sensed data into actionable intelligence requires efficient, scalable, and statistically robust methods and infrastructure. These needs form the basis of the project proposed herein. This project seeks to develop, validate, and automate aerial analytics tools that empower operators and agencies with the best available technology and information needed to improve efficiencies, reduce costs, and ensure the safety and sustainability of oil and gas operations in North Dakota. To fulfill this goal, the project holds three objectives:

- *Reclamation.* Build upon the findings of OGRC Project G-037-73 (2016) to develop and validate efficient, proven, and scalable metrics for remotely measuring the success of well site reclamation.
- *Landslides.* Build upon proven models for assessing geologic hazards to pipelines in the Marcellus Shale region to develop and validate landslide susceptibility and threat models specific to the Bakken Shale region of North Dakota.
- *Automation.* Automate the above aerial analytics tools within a secure, open source, web-based platform in which oil and gas operators and agencies can easily upload, manage, process, analyze, visualize, and download aerially-derived information and reports for use in decision making.

Expected Results:

- *Reclamation.* We predict that the reclamation assessment model developed will be validated as a useful tool for determining reclamation success. This will inform efficient resource allocation, prioritization of site inspections, and bond release within North Dakota's well site reclamation program.
- *Landslides.* We anticipate that the Bakken-specific landslide susceptibility and threat models will be validated as useful tools for forecasting pipeline vulnerability to mass soil movement. This will enable operators to efficiently prioritize resource allocation, monitoring, and mitigation efforts to proactively manage risk where it is needed most.
- *Automation.* We expect the automation of the reclamation and landslide models to provide a feasible and scalable method for analyzing large quantities of aerial data per OGRC Project G-43-01 Final Report recommendations.

Duration: September 2019 to December 2020 (16 months)

Total Project Cost:

Participants:

SolSpec, Inc.

- Principal Investigators: Nathan Casler and John Norman

Whiting Oil and Gas Corporation

ONEOK, Inc. *(contingent upon final approval)*

ISight RPV Services

Duraroot

PROJECT DESCRIPTION

Objectives:

North Dakota leadership strives to position the state as an incubator for oil and gas safety and reclamation technologies that protect public and environmental health while promoting industry vitality. In 2017, North Dakota Governor Doug Burgum issued a zero-spill challenge to the state's pipeline industry to be achieved through innovation, rather than regulation. A year later, Director of Mineral Resources Lynn Helms underscored the North Dakota Industrial Commission's (NDIC) commitment to advancing the adoption of aerial imagery collection for improving well site reclamation program efficiencies (see Appendix A). Remote sensing technology is key to executing these goals. However, as a recent Oil and Gas Research Council (OGRC) study concluded:

> *"Huge amounts of data can be collected, but those data require appropriate analysis. To make analysis of large quantities of data economical, automated data processing and analysis must be employed."* (OGRC Project G-43-01 Final Report, pg. 18, Appendix B)

If remote sensing technologies are to perform to the optimal benefit of North Dakota's oil and gas industry, big data collected in the field must be transformed into decision tools at the desktop. The transformation process that turns remotely sensed data into actionable intelligence requires efficient, scalable, and statistically robust methods and infrastructure. These needs form the basis of the project proposed herein.

In response to the state and industry goals described above, this project, titled *DEVELOPMENT AND AUTOMATION OF AERIAL ANALYTICS TOOLS FOR REMOTELY MEASURING RECLAMATION SUCCESS AND LANDSLIDE SUSCEPTIBILITY IN NORTH DAKOTA,* seeks to develop, validate, and automate aerial analytics tools that empower operators and agencies with the best available technology and information needed to improve efficiencies, reduce costs, and ensure the safety and sustainability of oil and gas operations in North Dakota. To fulfill this goal, the project holds three objectives:

1. *Reclamation.* Build upon the findings of OGRC Project G-037-73 (2016) to develop and validate efficient, proven, and scalable metrics for remotely measuring the success of well site reclamation.
2. *Landslides.* Build upon proven models for assessing geologic hazards to pipelines in the Marcellus Shale region to develop and validate landslide susceptibility and threat models specific to the Bakken Shale region of North Dakota.[1]
3. *Automation.* Automate the above aerial analytics tools within a secure, open source, web-based platform in which oil and gas operators and agencies can easily upload, manage, process, analyze, visualize, and download aerially-derived information and reports for use in decision making.

[1] The portion of this project dedicated to developing Bakken-specific models for forecasting and prioritizing landslide threats is contingent upon the anticipated partnership of ONEOK, Inc. (ONEOK). Full approval of ONEOK's participation in this project is currently under consideration by company leadership. This contingency applies to all activities related to landslide tool development, validation, and automation within the proposal.

Alignment with OGRC Priorities:
This project aligns with the following NDIC and OGRC priorities:

Generate information and knowledge that will have the highest probability of bringing new oil and gas companies and industry investment to North Dakota.

a. Improving efficiencies in the reclamation and bond release program will be attractive to upstream oil and gas companies.
b. Increasing available tools for proactive pipeline risk reduction enhances operational certainty, which will be attractive to midstream oil and gas companies.
c. This project contributes to the successful implementation of the "innovation instead of regulation" market-based model for attaining safety and stewardship objectives, which is attractive to all aspects of the oil and gas industry, as well as other business sectors.

Maximize the market potential for oil, natural gas, and the associated byproducts.

a. A more efficient reclamation inspection process will support faster bond release, thus freeing industry funds for reallocation toward new exploration and production activity.
b. Identifying and managing landslide threats to pipeline integrity reduces the probability of a pipeline failure and subsequent shut-in that could damage market potential.

Improve the overall suitability of the oil and gas energy industry in North Dakota through the development of new environmental practices that will help to reduce the footprint of oil and gas activities.

a. Aerial data collection is a non-invasive inspection technique that minimizes the impacts of human and vehicle disturbance on and near the reclaimed well site.
b. The efficient clearance of well sites from the reclamation inspection schedule and release of bonds will better incentivize reclamation activities.
c. A statistical measurement of reclamation success will provide a trusted, objective, impartial means of assessing environmental conditions and informing management decisions.
d. The modeling of landslide susceptibility and threat will empower pipeline operators to proactively monitor and mitigate risks that, if unmanaged, could compromise pipeline integrity and thus environmental quality.

Develop baseline information that will lead to other projects, processes, ideas, and activities.

a. As developments in technology and regulations make beyond visual line-of-sight (BVLOS) unmanned aerial vehicle (UAV) flights feasible, so will rise the demand for efficiently transforming big data into actionable intelligence. This project will inform and stimulate further research and development of statistically robust and automated tools for processing and analyzing aerial imagery, thus driving additional business opportunities and technology innovation and adoption in North Dakota.

Additionally, this research project addresses intentions set forth by Director of Mineral Resources Lynn Helms in a 2018 memorandum (Appendix A) that commits NDIC support to the following:

Research designed to achieve the realities of an operational capability based on OGRC Project G-037-73, which demonstrated the use of enhanced imagery to evaluate site reclamation status:

a. *Data management: what is the optimum data storage architecture?*
b. *Image processing: how do we derive actionable, decision support data from gross data?*
c. *Imagery display: what is the imagery provided to the manager for decision making?*

Methodology:

Project-wide Aerial Data Collection. Aerial imagery for both the reclamation and landslide portions of the project will be acquired by ISight RPV Services (ISight), a Grand Forks-based UAV services provider. ISight will collect imagery using the V2 UAV manufactured by Hybrid Project, a USA manufacturer. The V2 is specialized for endurance flight and BVLOS operations. A 100-megapixel camera mounted on the V2 will capture four band imagery including red, green, blue, and near infrared at a resolution of three-to-five centimeters.

Reclamation. The development of the remote reclamation analysis tool will involve a two-tiered process. First, SolSpec will apply a preliminary assessment of reclamation success to rank the population (n= approximately 2,175) of well sites operated by Whiting Oil and Gas Corporation (Whiting), a project partner, in the state of North Dakota. The preliminary assessment will draw data inputs from publicly available sources, including the NDIC for well site locations and the National Agricultural Imagery Program (NAIP) red, green, blue, and near infrared imagery. SolSpec will compute a Normalized Difference Vegetation Index (NDVI) based on 0.6-meter NAIP imagery (USDA, 2018) and then perform k-statistic and cumulative frequency distribution calculations to measure the statistical difference in spectral reflectance between well pad sites and their adjacent areas within a buffer and radius zone (appropriate distances to be determined). A minimal difference between on- and off-pad spectral reflectance would indicate a continuity in ground cover and a higher level of well pad reclamation success. Conversely, a large difference in spectral reflectance between the well pad and adjacent area would imply a discontinuity in ground cover and a lower level of reclamation success. Thus, the preliminary assessment method should enable operators and agencies to quickly and cost-effectively deduce reclamation success across a large population and/or landscape in order to prioritize resource allocation toward inspection of the sites showing the highest readiness for reclamation inspection.

Though the NAIP dataset provides a relatively recent assessment of spectral reflectance, it fails to account for reclamation advances that have occurred since the imagery collect, which can span up to 5 years. Aerial data collection during the second tier of the remote reclamation analysis method will enable a more current assessment of reclamation stage at a finer, sub-decimeter resolution than capable with NAIP imagery. Whiting has selected 52 reclaimed and near-reclaimed well pad sites (exact locations to be determined) for inclusion in the second-tier reclamation study, none of which have been inspected for bond release. ISight will capture aerial imagery of these sites using the V2 UAV and upload the data to SolSpec's secure, web-based platform for aerial data management, processing, analytics, and visualization. SolSpec will then employ photogrammetric methods to generate a digital surface model (DSM) based on the imagery's spectral attributes. The spectral data will be organized into a triangular greenness index (TGI) representing leaf chlorophyll content, while the structural data will be organized

by relative vegetation height derived from the DSM. Finally, SolSpec will calculate a similarity index based on how similar the TGI and vegetation structure cumulative distribution functions are between on pad sites and adjacent off pad sites (appropriate buffer and radius to be determined). Like the preliminary assessment, more similar scores between on- and off-pad samples will indicate a closer relationship between the well site and background vegetative conditions.

Validation of the remote reclamation analysis tool will occur at the following three levels:

1. The preliminary assessment model outputs will be compared against the aerial inspection outputs to determine the effectiveness of the preliminary assessment method in detecting reclamation success. (It should be noted that this preliminary assessment method is based on the best available NAIP data, which may vary across time and location).
2. The aerial inspection model outputs will be compared against ground truthed data collected by Duraroot Environmental Consulting (Duraroot), a project partner, to determine the accuracy of the model in comparing on-pad vegetative conditions to background conditions. Duraroot will visit a random subset of the study pads (n=26 or 50%) to measure species composition, vegetation structure, and health for on- and off-pad plots, as well as assess overall pad reclamation success.
3. SolSpec will seek collaboration with the NDIC for a final tier of tool validation. Contingent upon the NDIC's willingness and resources, an NDIC reclamation specialist will visit at least 25% (n=13) of well sites to inspect for reclamation success for bond release. The reclamation index results will be compared against the NDIC's and Duraroot's reclamation success ratings to evaluate the effectiveness of the reclamation index's ability to determine reclamation success.

Landslides. The development of the landslide susceptibility and threat models will include an iterative process of model development and validation. First, SolSpec will acquire the most recent publicly available datasets for LiDAR (2-meter resolution, 2019) and historical landslides (1:24,000 scale) developed by the North Dakota Geological Survey (NGDS). A random subset of the historical landslide datasets will be used as training data to develop a predictive algorithm for landslide occurrence using an unsupervised classification method. The rest of the historical landslide dataset will be withheld as validation data to test the algorithm's predictive accuracy. The model will be trained on compound terrain-related variables such as well as soil chemical and physical properties derived from the USDA-NRCS Soil Survey Geographic Database (SSURGO). The soil properties considered in the analysis will include but are not limited to bulk density, angle of internal friction, total soil depth, saturated hydrologic connectivity, and liquid limit. The modeling process will entail the generation of many instances, with each iteration adjusting the model parameters and covariate preferences to derive the best performing landslide prediction model. The final model will be subjected to a 10-fold cross validation process to reduce overfitting and develop a manageable decision tree that can be implemented in a Geographic Information System (GIS). This process will identify the combination of terrain and soil variables and their properties yielding the highest prediction rate for landslide occurrence in western North Dakota.

Once the final landslide susceptibility model is developed, it will be incorporated into SolSpec's Right-of-Way Health Assessment (ROWHA) model to assess landslide threat to pipeline integrity to

approximately 100 miles of pipeline ROW operated by ONEOK, Inc. (ONEOK) in western North Dakota (exact pipelines and distances yet to be determined). The ROWHA model will assess hillslope stability and landslide threat to pipeline integrity for 3-meter segments along a given pipeline's centerline. This information is then aggregated into management zones by averaging threats using a sliding mile analysis. The results from the sliding mile analysis are ranked into percentiles to target high threat zones.

The landslide susceptibility model will undergo a second tier of validation through ground truthing of the model's predictions for the ONEOK ROW. Duraroot's geotechnical engineering staff and soil scientists will perform assessments of geotechnical and soil stability at randomly selected pipeline segments (10%) along and adjacent to the pipeline ROW. The landslide susceptibility model outcomes will be compared against the geotechnical determinations to test the model's predictive effectiveness. Any false positive and false negative outputs will be identified, and that information will be incorporated into the model for continuous improvement.

Automation. Upon the development of preliminary reclamation and landslide forecasting models, but prior to field validation, the model components will be automated within the SolSpec platform. This will include the automation of the following model steps: data aggregation, dissemination, derivative generation, and model validation. The model validation will provide a significance value based on the initial training data. Field validation of the models will provide an opportunity to test the robustness of the models in comparison to on-site observations. This information will be used to further train and improve the model.

Anticipated Results:

Reclamation. We predict that the coarser preliminary assessment model of the well pads and the refined aerial inspection model of selected well pads will be validated as a useful tool for determining reclamation success. This will inform efficient resource allocation, prioritization of site inspections, and bond release within North Dakota's well site reclamation program, thereby supporting NDIC intentions (see Appendix A).

Landslides. We anticipate that the Bakken-specific landslide susceptibility and threat models will be validated as useful tools for forecasting pipeline vulnerability as a result of mass soil movement. This will enable operators to efficiently prioritize resource allocation, monitoring, and mitigation efforts. The tools will equip operators to proactively manage risk caused by earth movement, which is required by American Society of Mechanical Engineers (ASME) B31.8S (2016, pg. 3-5) for gas pipelines and American Petroleum Institute (API) RP-1160 (2013, pg. 11-14) for hazardous liquid pipelines.

Automation. We expect the automation of the reclamation and landslide models to provide a feasible, economical, and scalable avenue for analyzing large quantities of aerial data per OGRC Project G-43-01 recommendations (see Appendix B).

Facilities:

Aerial data collection and validation will take place on 52 well pad sites operated by Whiting and approximately 100 miles of pipeline operated by ONEOK, all located within western North Dakota. Data

will be uploaded to, managed, processed, analyzed, and visualized at SolSpec's headquarter office location in Denver, CO.

Resources:
The primary resources deployed to this project will be SolSpec's personnel and computer hardware; ISight's personnel, V2 UAV, and equipment; and Duraroot's, Whiting's, and ONEOK's personnel, vehicle, and field equipment supporting ground truthing and data collection.

Techniques to Be Used, Their Availability and Capability:
Photogrammetry is a measuring technique for triangulating among photographs of a point of interest taken from at least two different locations to mathematically extract 3-dimensional (3D) coordinates of the point of interest. Developments in digital camera chips with high megapixel levels and improvements in software have enabled the production of high-accuracy 3D coordinates through photogrammetric techniques.

Environmental and Economic Impacts while Project is Underway:
One of the benefits of non-invasive remote sensing technologies is the minimal impact that aerial data collection poses to the environment. On-ground visits to sites to validate the models developed in this research will pose some minor, temporary environmental disturbance as a result in-situ soil or vegetation classification within the bounds of traditionally accepted environmental inspection protocols. There are no foreseeable adverse economic impacts while the project is underway.

Ultimate Technological and Economic Impacts:
This research project will produce tools for improving both technological and economic efficiencies among North Dakota's oil and gas industry and its agency collaborators.

Why the Project is Needed:
Reclamation. Prior OGRC research (Project G-037-73, 2016) validated the feasibility of image collection as a means of determining reclamation success. However, existing methods for remotely analyzing ground cover data, including those used in the OGRC study, are scale-limited and technologically cumbersome, impeding the widespread adoption of aerial imagery technology in reclamation monitoring. In order for remote sensing technologies to bring efficiencies to the reclamation inspection and bond release process, well pad operators and regulatory agencies need access to efficient, scalable, and statistically robust methods of remotely analyzing reclamation success.

Landslides. The badlands and buttes of western North Dakota are susceptible to landslides and subsidence, which can compromise the integrity of pipelines in the area. Traditional methods of ocular inspection for earth movement along a pipeline ROW can be inefficient, unsafe for personnel, and subject to human error. Additionally, they often limit operators to reactive measures. Pipeline operators currently lack access to proven aerial analytics methods that enable fast, safe, scalable, and statistically robust remote measurement of landslide susceptibility and threats. Aerial imagery is not enough to solve this problem. According to OGRC Project G-43-01 Final Report (pg. 21), "what pipeline operators require is actionable intelligence from this data – a red flag to indicate a problem or a green flag to indicate situation normal."

Automation. Aerial imagery collection provides operators with an overwhelming amount of raw data, sometimes requiring the employment of specialized teams of analysts to process and interpret the data into meaningful information. In order for the analysis of aerial imagery to be cost-effective and scalable—both precursors to adoption throughout the oil and gas industry—data management, processing, and analysis must be automated.

STANDARDS OF SUCCESS

Measurable deliverables and success reporting

Success will be achieved when the reclamation and landslide tools are statistically validated at an acceptable level of accuracy and automated to enable efficient, scalable data processing and analysis by operators and agencies.

Core deliverables include:

1. Interim reports to NDIC highlighting ongoing research activities and results;
2. Final report summarizing research achievements, challenges, conclusions, and recommendations;
3. Statistically validated, automated model for remote assessment of well site reclamation success;
4. Statistically validated, automated model for remote assessment of landslide susceptibility along pipeline ROWs; and
5. Statistically validated, automated model for remote assessment of landslide threats to pipelines.

Value to North Dakota and public and private utilization of results

North Dakota's oil and gas industry, agencies, and public will derive benefit from the results of this research.

1. Industry will gain awareness of and access to affordable, statistically sound, best available technology developed for and tested in the Bakken.
    a. This project will provide upstream operators access to a quantitative method for proactively monitoring reclamation progress, developing reports for NDIC, and proving readiness for bond release.
    b. Midstream operators will have access to a forecasting tool for determining where landslide threats to the pipeline are highest along a ROW, enabling the efficient allocation of resources toward proactive monitoring and mitigation where it is needed most to maintain pipeline integrity.
2. Industry use of the aerial analytics tools produced in this project will translate to increased efficiencies within oil and gas regulatory agencies.
    a. The NDIC well site reclamation program will have the option of receiving a model-derived statistical comparison of on-site vegetation to background conditions using publicly available NAIP data and/or more current aerial imagery, thus streamlining the inspection process.

   b. Where the landslide susceptibility and risk models are used to inform decisions, the North Dakota Pipeline Authority, environmental, and emergency response agencies can be more confident that the pipeline is not at risk of mass earth movements.
3. Industry use of the aerial analytics tools developed in this project will translate into benefits for the public and the environment.
   a. As stated by Director of Mineral Resources Lynn Helms (Appendix A, pg. 1), "the public, which has a stake both in the protection and restoration of the landscape, also seeks a consistent and sustainable reclamation program to help support an active oil and gas industry." This project's aim is to produce tools that support a more consistent and sustainable reclamation program.
   b. Proactive measures by operators to identify, monitor, and mitigate landslide threats to pipeline integrity directly contribute to the protection of public safety and environmental quality, thus supporting a more sustainable oil and gas industry.

Commercial Use

Remote sensing technology has dramatically changed the way that many sectors, including energy, agriculture, mining, infrastructure, and government, do business. As developments in technology and regulations make BVLOS UAV flights possible, so will rise the demand for efficiently transforming mountains of data into actionable intelligence to guide decisions. This project will produce technological advances that make big data meaningful for the oil and gas industry. Results will inform and inspire further development of statistically robust and automated tools for processing and analyzing aerial imagery, thus stimulating innovation and business opportunities in a much-needed space. Additionally, the aerial analytics tools derived from this project will increase use of remote sensing technologies in the state, thereby fortifying the UAV industry.

How the project will enhance the education, research, development and marketing of North Dakota's oil and natural gas resources;

North Dakota's vision for its oil and gas industry is to achieve safety and stewardship through innovation, rather than regulation. This research aims to prove the effectiveness and efficiency of market-based approaches in creating a sustainable and thriving oil and gas industry. The project will demonstrate that market-based safety and stewardship tools can be affordable, trusted, and produce net gains for upstream and midstream operators by quickening bond release and reducing risk.

How it will preserve existing jobs and create new ones

Successful execution of this project will fortify the remote sensing industry in the state – from UAV imagery collection to processing to analytics. It will encourage the certification and employment of more FAA 107-licensed pilots among oil and gas personnel, agency inspectors, and third-party service providers. It will also stimulate and drive further technological innovations and applications among North Dakota's public, private, and academic sectors for turning big data into actionable intelligence.

BACKGROUND/QUALIFICIATIONS

SolSpec, Inc.

SolSpec is a Denver-based software company that specializes in the processing and analysis of geospatial data. With a principal focus on the scalability and automation of Manned and Unmanned Aerial Systems (UAS) data, SolSpec productizes analytics for commercial applications in natural resources, infrastructure, and other major land-use industries. Having mapped and analyzed more than 1.2 million acres, SolSpec's product and prediction models have become increasingly accurate, reliable, and user-friendly.

John Norman, MS, Principal Spatial Scientist, SolSpec (Principal Investigator)
https://www.researchgate.net/profile/John_Norman6
John Norman specializes in remote sensing, ecology, and spatial statistical analysis. His interdisciplinary expertise in soil, water, and vegetation combined with his tenure as a research scientist have made him proficient at the predictive modeling of terrestrial and hydrological systems.

Nathan Casler, MS, Lead Spatial Developer, SolSpec (Principal Investigator)
https://www.researchgate.net/profile/Nathan_Casler
Nathan Casler specializes in geospatial programming, distributed database design, and High Performance Computing (HPC). His technical literacy in both spatial statistical analysis and distributed databases make him exceptional at building HPC workflows for performant large-scale analysis.

Bryan Crowe, Chief Operating Officer, SolSpec
Bryan Crowe's experience includes tenure at MarkWest Energy Partners as a regional manager with overall responsibility for pipeline operations in five states (~12% of the nation's gas) in the Appalachian region. In addition to his operational responsibilities at SolSpec, Crowe serves as the lead technical and regulatory subject matter expert for a myriad of pipeline integrity and safety issues including API and PHMSA Recommended Practices.

ISight RPV Services

Grand Forks-based ISight provides Remotely Piloted Vehicle operations to customers including energy and engineering firms, agricultural producers, DOD contractors, NASA and the North Dakota and Nevada FAA UAS Test Sites. As part of its ongoing work, ISight has inspected over 175 miles of oil pipeline utilizing drones. ISight conducted and successfully completed work with the OGRC in the completion of a project entitled "UAS Aerial Observation to Support Oil & Gas Pipeline Construction Restoration Efforts". ISight and the Unmanned Applications Institute, in collaboration with ONEOK, Barr Engineering and the Public Service Commission, provided high fidelity/clarity images for use in developing signature images of potential problem areas in the creation of an image library for ONEOK's use in restoration activities (focused on the Bear Creek Pipeline, McKenzie County), reducing costs and increasing pipeline construction environmental restoration.

Tommy Kenville, Chief Executive Officer, ISight RPV Services
Tommy Kenville has over 25 years in aviation-related experience, including 15 years at the University of North Dakota Aerospace Foundation and founding the Unmanned Applications Institute (the first institute for research, testing and consulting in the emerging UAV industry in North Dakota, founded in 2010) prior to merging with ISight in 2016.

Whiting Oil and Gas Corporation
As a company, Whiting has reclaimed nearly 100 facilities in the past three years in North Dakota alone. Whiting's Regulatory, Permitting, and Environmental Departments have worked closely with the NDIC and United States Forest Service (USFS) to successfully fulfill requirements for proper site reclamation.

Mark Keyes, Environmental Compliance Supervisor, Whiting
Mark Keyes has 6 years of experience working and supervising Whiting's environmental compliance in the Williston and DJ Basins of North Dakota and Colorado. In 2016, Mark and Whiting teamed with SolSpec and the Colorado Oil and Gas Conservation Commission on a pilot study for using remote sensing to evaluate reclamation success. Mark and his counterparts at Whiting continue to use remotely sensed data and the SolSpec Platform for the inventory, maintenance planning, and execution of reclamation activities.

ONEOK, Inc.
ONEOK's operations in the Williston Basin consist of approximately 6,900 miles of gathering lines and nine processing plants capable of carrying 615 million cubic feet per day of product to market.

Todd Kelvington, Environmental Manager, ONEOK
Todd Kelvington has spent the past 4 years working as manager of both the GIS and Environmental teams at ONEOK. Todd is considered a thought leader of UAS applications in the oil and gas industry and throughout his tenure at ONEOK has sponsored the development of numerous UAS initiatives.

Duraroot Environmental Consulting
With decades of experience in the energy and environmental industries, Duraroot provides consulting services for soil, plant, and water sciences. Specifically, Duraroot provides site-specific reclamation and monitoring plans for large pipeline and E&P facilities. Since 2014, Duraroot has sampled over 50,000 acres of soil and vegetation on oil and gas facilities.

Aaron DeJoia MS CPSS, Environmental Soil Scientist/Agronomist and Director, Duraroot
Aaron DeJoia is a North Dakota Professional Soil Classifier and board-certified Professional Soil Scientist and Agronomist with 18 years of experience providing support in permitting, operations, reclamation, remediation, and expert witness testimony to clients in the oil and gas sectors.

MANAGEMENT

Management of this research project will be led by SolSpec and include time and milestones tracking, budgetary reporting, fund accounting, and contract services. SolSpec employs the Agile Method for project management that is common in software development. Agile uses incremental, iterative work sequences known as “sprints” to assist collaborative teams in responding to the unpredictability of constructing software. The project objectives will be broken into smaller tasks that will be incorporated into sprints with built-in twice-monthly evaluation points.

TIMETABLE

Key Milestones	Month	Year
Planning/Preparation		
OGRC research proposal submitted	June	2019
Letters of support provided by partners	June	2019
MSAs signed among project partners	June	2019
OGRC grant awarded	Aug	2019
Model Development		
Reclamation assessment index development	Sept-April	2019-2020
Landslide susceptibility model development	Sept-April	2019-2020
Model Automation		
Reclamation assessment index automation	Sept-April	2019-2020
Landslide susceptibility model automation	Sept-April	2019-2020
Field Data Acquisition		
Reclamation field data collection: Whiting well sites	June-July	2020
Landslide susceptibility field data collection: ONEOK pipeline	June-July	2020
Model Validation		
Reclamation assessment index validation	Aug-Sept	2020
Landslide susceptibility model validation	Aug-Sept	2020
Model Refinement		
Reclamation assessment index validation	Oct-Nov	2020
Landslide susceptibility model validation	Oct-Nov	2020
Reports		
Interim Report 1	Dec	2019
Interim Report 2	March	2020
Interim Report 3	June	2020
Interim Report 4	Sept	2020
Final Report	Dec	2020
Briefings to NDIC/OGRC	On demand	

BUDGET

Project Associated Expense	NDIC's Share	Applicant's Share (In-Kind)	Partner's Share (In-Kind)
Initial development of reclamation index & landslide model	$15,875.00	$31,750.00	
Initial automation of reclamation index & landslide model	$18,750.00	$37,500.00	
Aerial data acquisition for reclamation index: $800 per well site * 52 well sites	$41,600.00		$41,920.00
Aerial data acquisition for landslide model: $750 per pipeline miles * 100 pipeline miles	$75,000.00		$16,080.00
Processing of aerial imagery	$9,23.00	$9,235.00	
Ground truthing of landslide model: Sampling design and execution on 100 miles of pipeline	$30,00.00	$10,000.00	$10,000.00
Ground truthing of the reclamation index: 26 well pad sites	$18,000.00	$7,000.00	$5,000.00
Final Validation & refinement of reclamation index & landslide model	$29,280.00	$69,250.00	
Project Management and Reporting	$14,650.00	$14,650.00	
Total Contributions:	**$252,385.00**	**$179,385.00**	**$73,000.00**

The above expenses will be necessary to carry out the objectives and activities outline in this research proposal. If less funding is available than that requested, the project will need to be reduced in scope.

CONFIDENTIAL INFORMATION

There is no confidential information contained within this document.

PATENTS/RIGHTS TO TECHNICAL DATA

SolSpec is a Licensed Software provider. "Licensed Software" includes SolSpec's confidential and proprietary SolSpec Viewer™ cloud-based software, algorithms, programs, and tools designed to analyze, manipulate and process data into reports in a usable and presentable manner that is valuable to users, including, without limitation, any applicable API(s) and any and all updates and upgrades

STATUS OF ONGOING PROJECTS (IF ANY)

SolSpec has not received prior funding from the OGRC grant program.

Appendix A. Memorandum from Director of Mineral Resources Lynn Helms establishing NDIC intent to gain efficiencies and improve procedures concerning the well site reclamation program.

Oil and Gas Division

Lynn D. Helms - Director Bruce E. Hicks - Assistant Director

Department of Mineral Resources

Lynn D. Helms - Director

North Dakota Industrial Commission

www.oilgas.nd.gov

To: North Dakota Oil and Gas Industry

Fr: Lynn Helms
North Dakota Industrial Commission (NDIC)

RE: NDIC Intent to gain efficiencies and improve procedures concerning the well site reclamation program

Background

NDIC has recently pursued the application of new technologies to our procedures for reviewing and approving reclamation of plugged and abandoned drill sites. Current site clearance procedures can be cumbersome and inefficient. Site review scheduling delays and lack of standardization in the evaluation process can result in final site clearance and bond release being delayed unnecessarily. The public, which has a stake both in the protection and restoration of the landscape, also seeks a consistent and sustainable reclamation program to help support an active oil and gas industry.

The Oil and Gas Research Council (OGRC), NDIC, and Hess engaged in imagery collection research (OGRP project G-037-73, 2016) of reclaimed well sites. As a result of that research, NDIC is now confident that image collection is a viable method of determining reclamation success.

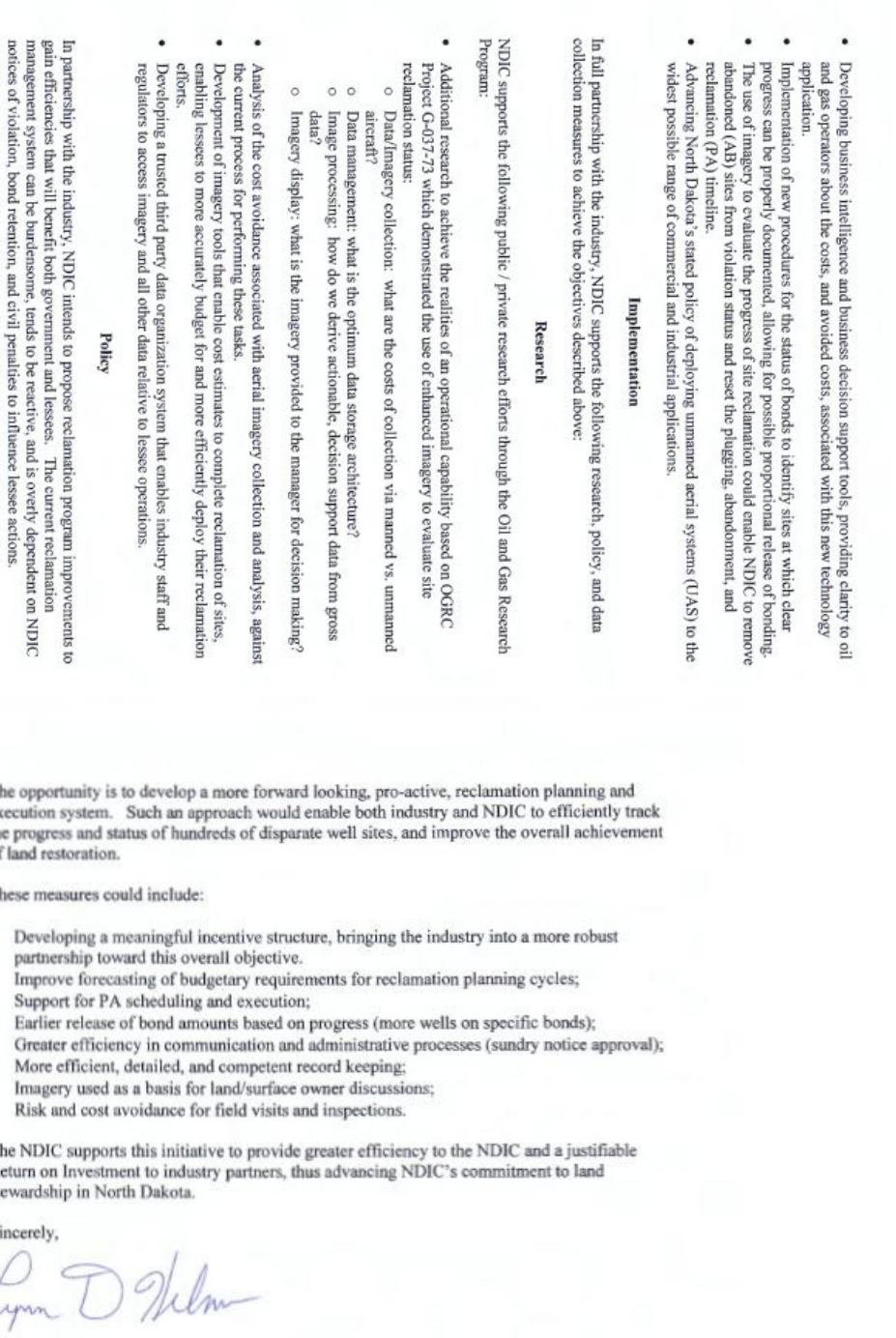
Objectives

This memorandum commits the NDIC to continue working with trusted program developers, and industry partners to apply a range of new imagery technologies, and new administrative tools to the process of certifying successful site reclamation thus eliminating the backlog of sites at which reclamation is believed to have occurred, but NDIC has not yet been able to inspect. NDIC is also considering proportional bond release for partial reclamation as an incentive for oil and gas operators to diligently pursue their reclamation obligations.

In general, this initiative includes the following objectives:

- Increasing reliance on the use of modern aerial imagery to support NDIC decisions to clear, or partially clear, plugged well sites from the reclamation schedule.
- Developing technology applications that are trusted by both the industry and the regulatory agencies.
- Establishing third party independent organizations to collect and analyze imagery and data to the satisfaction of public and private organizations.

600 E Boulevard Ave - Dept 405, Bismarck, North Dakota 58505-0840 Phone (701)328-8020 Fax (701)328-8022



- Developing business intelligence and business decision support tools, providing clarity to oil and gas operators about the costs, and avoided costs, associated with this new technology application.
- Implementation of new procedures for the status of bonds to identify sites at which clear progress can be properly documented, allowing for possible proportional release of bonding.
- The use of imagery to evaluate the progress of site reclamation could enable NDIC to remove abandoned (AB) sites from violation status and reset the plugging, abandonment, and reclamation (PA) timeline.
- Advancing North Dakota's stated policy of deploying unmanned aerial systems (UAS) to the widest possible range of commercial and industrial applications.

Implementation

In full partnership with the industry, NDIC supports the following research, policy, and data collection measures to achieve the objectives described above:

Research

NDIC supports the following public / private research efforts through the Oil and Gas Research Program:

- Additional research to achieve the realities of an operational capability based on OGRC Project G-037-73 which demonstrated the use of enhanced imagery to evaluate site reclamation status:
  - Data/Imagery collection: what are the costs of collection via manned vs. unmanned aircraft?
  - Data management: what is the optimum data storage architecture?
  - Image processing: how do we derive actionable, decision support data from gross data?
  - Imagery display: what is the imagery provided to the manager for decision making?
- Analysis of the cost avoidance associated with aerial imagery collection and analysis, against the current process for performing these tasks.
- Development of imagery tools that enable cost estimates to complete reclamation of sites, enabling lessees to more accurately budget for and more efficiently deploy their reclamation efforts.
- Developing a trusted third party data organization system that enables industry staff and regulators to access imagery and all other data relative to lessee operations.

Policy

In partnership with the industry, NDIC intends to propose reclamation program improvements to gain efficiencies that will benefit both government and lessees. The current reclamation management system can be burdensome, tends to be reactive, and is overly dependent on NDIC notices of violation, bond retention, and civil penalties to influence lessee actions.

The opportunity is to develop a more forward looking, pro-active, reclamation planning and execution system. Such an approach would enable both industry and NDIC to efficiently track the progress and status of hundreds of disparate well sites, and improve the overall achievement of land restoration.

These measures could include:

- Developing a meaningful incentive structure, bringing the industry into a more robust partnership toward this overall objective.
- Improve forecasting of budgetary requirements for reclamation planning cycles;
- Support for PA scheduling and execution;
- Earlier release of bond amounts based on progress (more wells on specific bonds);
- Greater efficiency in communication and administrative processes (sundry notice approval);
- More efficient, detailed, and competent record keeping;
- Imagery used as a basis for land/surface owner discussions;
- Risk and cost avoidance for field visits and inspections.

The NDIC supports this initiative to provide greater efficiency to the NDIC and a justifiable Return on Investment to industry partners, thus advancing NDIC's commitment to land stewardship in North Dakota.

Sincerely,

Lynn D Helms

Appendix B. Excerpt from OGRC Project G-43-01 Final Report (pg. 18) "Liquids Gathering Pipelines: Survey of Emerging Technologies and Applications of Risk Assessment to Increase Pipeline Integrity".

IV. PREREQUISITES FOR PROLIFERATION OF DRONE EMPLOYMENT IN PIPELINE MONITORING

KEY TAKEAWAYS:

- Although drones are frequently discussed as a promising tool for pipelines, certain prerequisites must underlie their fruitful application:
  - Drones are merely platforms for scientific sensors. Focus must be placed on collection of insightful data via these sensors.
  - Huge amounts of data can be collected, but those data require appropriate analysis. To make analysis of large quantities of data economic, automated data processing and analysis must be employed.
  - Drones will only be economical for application to large-area gathering pipeline systems if rules for BVLOS flight operations are enacted.
  - Automated flight operations (takeoff, flight path, data collection, landing, data uploading) will greatly enhance the economics of drone application.

SolSpec
AERIAL ANALYTICS

AFFIDAVIT OF TAX LIABILITY

State of Colorado
County of Jefferson

I, the undersigned, do hereby affirm the following:

1. I am authorized on behalf of the company SolSpec, Inc. (SolSpec) to submit this affidavit of tax liability; and

2. SolSpec does not have any outstanding tax liabilities owed to the state of North Dakota or any of its political subdivisions.

Name and Position: Tobias Kraft - CEO

Signature:

Date: 5-31-2019

Notary: Denise Rodarte 5.31.19

DENISE RODARTE
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19924000410
My Commission Expires February 18, 2022

SolSpec
AERIAL ANALYTICS

Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

Re: Transmittal Letter for SolSpec, Inc. Project Titled "*DEVELOPMENT & AUTOMATION OF AERIAL ANALYTICS TOOLS FOR REMOTELY MEASURING RECLAMATION SUCCESS & LANDSLIDE SUSCEPTIBILITY IN NORTH DAKOTA"*

Dear Ms. Fine:

SolSpec, Inc. (SolSpec) is pleased to propose the development, validation, and automation of aerial analytics tools to support North Dakota's oil and gas industry in achieving safety and stewardship goals through innovation. The project seeks to empower operators and agencies with the best available technology and information needed to improve efficiencies, reduce costs, and ensure the safety and sustainability of oil and gas operations in North Dakota.

Enclosed please find the grant application titled "Development and Automation of Aerial Analytics Tools for Remotely Measuring Reclamation Success and Landslide Susceptibility in North Dakota". SolSpec is a Denver-based software company that specializes in the processing and analysis of geospatial data for commercial applications in oil and gas, natural resources, infrastructure, and other major land-use activities.

This transmittal letter represents a commitment by SolSpec to complete the project described in the enclosed proposal. If you have any questions, please contact me directly at (970) 541-8636.

Respectfully,

Katherine Kraft

Katherine Kraft
Director of Public Policy & Government Affairs
SolSpec, Inc.

Enclosures

Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title:

Development & Automation of Aerial Analytics Tools for Remotely Measuring Reclamation Success & Landslide Susceptibility in North Dakota

Applicant:

SolSpec, Inc.

Principal Investigators:

Nathan Casler & John Norman, SolSpec, Inc.

Date of Application:

June 1, 2019

Amount of Request:

$252,385.00

Total Amount of Proposed Project:

$504,770.00

Duration of Project:

16 Months

Point of Contact (POC):

Katherine Kraft, SolSpec, Inc.

POC Telephone:

970.541.8636

POC E-Mail Address:

kkraft@solspec.io

TABLE OF CONTENTS

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ABSTRACT

Objective: If remote sensing technologies are to perform to the optimal benefit of North Dakota's oil and gas industry, big data collected in the field must be transformed into decision tools at the desktop. The transformation process that turns remotely sensed data into actionable intelligence requires efficient, scalable, and statistically robust methods and infrastructure. These needs form the basis of the project proposed herein. This project seeks to develop, validate, and automate aerial analytics tools that empower operators and agencies with the best available technology and information needed to improve efficiencies, reduce costs, and ensure the safety and sustainability of oil and gas operations in North Dakota. To fulfill this goal, the project holds three objectives:

- *Reclamation.* Build upon the findings of OGRC Project G-037-73 (2016) to develop and validate efficient, proven, and scalable metrics for remotely measuring the success of well site reclamation.
- *Landslides.* Build upon proven models for assessing geologic hazards to pipelines in the Marcellus Shale region to develop and validate landslide susceptibility and threat models specific to the Bakken Shale region of North Dakota.
- *Automation.* Automate the above aerial analytics tools within a secure, open source, web-based platform in which oil and gas operators and agencies can easily upload, manage, process, analyze, visualize, and download aerially-derived information and reports for use in decision making.

Expected Results:

- *Reclamation.* We predict that the reclamation assessment model developed will be validated as a useful tool for determining reclamation success. This will inform efficient resource allocation, prioritization of site inspections, and bond release within North Dakota's well site reclamation program.
- *Landslides.* We anticipate that the Bakken-specific landslide susceptibility and threat models will be validated as useful tools for forecasting pipeline vulnerability to mass soil movement. This will enable operators to efficiently prioritize resource allocation, monitoring, and mitigation efforts to proactively manage risk where it is needed most.
- *Automation.* We expect the automation of the reclamation and landslide models to provide a feasible and scalable method for analyzing large quantities of aerial data per OGRC Project G-43-01 Final Report recommendations.

Duration: September 2019 to December 2020 (16 months)

Total Project Cost:

Participants:

SolSpec, Inc.

- Principal Investigators: Nathan Casler and John Norman

Whiting Oil and Gas Corporation

ONEOK, Inc. *(contingent upon final approval)*

ISight RPV Services

Duraroot

PROJECT DESCRIPTION

Objectives:

North Dakota leadership strives to position the state as an incubator for oil and gas safety and reclamation technologies that protect public and environmental health while promoting industry vitality. In 2017, North Dakota Governor Doug Burgum issued a zero-spill challenge to the state's pipeline industry to be achieved through innovation, rather than regulation. A year later, Director of Mineral Resources Lynn Helms underscored the North Dakota Industrial Commission's (NDIC) commitment to advancing the adoption of aerial imagery collection for improving well site reclamation program efficiencies (see Appendix A). Remote sensing technology is key to executing these goals. However, as a recent Oil and Gas Research Council (OGRC) study concluded:

> *"Huge amounts of data can be collected, but those data require appropriate analysis. To make analysis of large quantities of data economical, automated data processing and analysis must be employed."* (OGRC Project G-43-01 Final Report, pg. 18, Appendix B)

If remote sensing technologies are to perform to the optimal benefit of North Dakota's oil and gas industry, big data collected in the field must be transformed into decision tools at the desktop. The transformation process that turns remotely sensed data into actionable intelligence requires efficient, scalable, and statistically robust methods and infrastructure. These needs form the basis of the project proposed herein.

In response to the state and industry goals described above, this project, titled *DEVELOPMENT AND AUTOMATION OF AERIAL ANALYTICS TOOLS FOR REMOTELY MEASURING RECLAMATION SUCCESS AND LANDSLIDE SUSCEPTIBILITY IN NORTH DAKOTA,* seeks to develop, validate, and automate aerial analytics tools that empower operators and agencies with the best available technology and information needed to improve efficiencies, reduce costs, and ensure the safety and sustainability of oil and gas operations in North Dakota. To fulfill this goal, the project holds three objectives:

1. *Reclamation.* Build upon the findings of OGRC Project G-037-73 (2016) to develop and validate efficient, proven, and scalable metrics for remotely measuring the success of well site reclamation.
2. *Landslides.* Build upon proven models for assessing geologic hazards to pipelines in the Marcellus Shale region to develop and validate landslide susceptibility and threat models specific to the Bakken Shale region of North Dakota.[1]
3. *Automation.* Automate the above aerial analytics tools within a secure, open source, web-based platform in which oil and gas operators and agencies can easily upload, manage, process, analyze, visualize, and download aerially-derived information and reports for use in decision making.

[1] The portion of this project dedicated to developing Bakken-specific models for forecasting and prioritizing landslide threats is contingent upon the anticipated partnership of ONEOK, Inc. (ONEOK). Full approval of ONEOK's participation in this project is currently under consideration by company leadership. This contingency applies to all activities related to landslide tool development, validation, and automation within the proposal.

Alignment with OGRC Priorities:
This project aligns with the following NDIC and OGRC priorities:

Generate information and knowledge that will have the highest probability of bringing new oil and gas companies and industry investment to North Dakota.

a. Improving efficiencies in the reclamation and bond release program will be attractive to upstream oil and gas companies.
b. Increasing available tools for proactive pipeline risk reduction enhances operational certainty, which will be attractive to midstream oil and gas companies.
c. This project contributes to the successful implementation of the "innovation instead of regulation" market-based model for attaining safety and stewardship objectives, which is attractive to all aspects of the oil and gas industry, as well as other business sectors.

Maximize the market potential for oil, natural gas, and the associated byproducts.

a. A more efficient reclamation inspection process will support faster bond release, thus freeing industry funds for reallocation toward new exploration and production activity.
b. Identifying and managing landslide threats to pipeline integrity reduces the probability of a pipeline failure and subsequent shut-in that could damage market potential.

Improve the overall suitability of the oil and gas energy industry in North Dakota through the development of new environmental practices that will help to reduce the footprint of oil and gas activities.

a. Aerial data collection is a non-invasive inspection technique that minimizes the impacts of human and vehicle disturbance on and near the reclaimed well site.
b. The efficient clearance of well sites from the reclamation inspection schedule and release of bonds will better incentivize reclamation activities.
c. A statistical measurement of reclamation success will provide a trusted, objective, impartial means of assessing environmental conditions and informing management decisions.
d. The modeling of landslide susceptibility and threat will empower pipeline operators to proactively monitor and mitigate risks that, if unmanaged, could compromise pipeline integrity and thus environmental quality.

Develop baseline information that will lead to other projects, processes, ideas, and activities.

a. As developments in technology and regulations make beyond visual line-of-sight (BVLOS) unmanned aerial vehicle (UAV) flights feasible, so will rise the demand for efficiently transforming big data into actionable intelligence. This project will inform and stimulate further research and development of statistically robust and automated tools for processing and analyzing aerial imagery, thus driving additional business opportunities and technology innovation and adoption in North Dakota.

Additionally, this research project addresses intentions set forth by Director of Mineral Resources Lynn Helms in a 2018 memorandum (Appendix A) that commits NDIC support to the following:

Research designed to achieve the realities of an operational capability based on OGRC Project G-037-73, which demonstrated the use of enhanced imagery to evaluate site reclamation status:

a. *Data management: what is the optimum data storage architecture?*
b. *Image processing: how do we derive actionable, decision support data from gross data?*
c. *Imagery display: what is the imagery provided to the manager for decision making?*

Methodology:

Project-wide Aerial Data Collection. Aerial imagery for both the reclamation and landslide portions of the project will be acquired by ISight RPV Services (ISight), a Grand Forks-based UAV services provider. ISight will collect imagery using the V2 UAV manufactured by Hybrid Project, a USA manufacturer. The V2 is specialized for endurance flight and BVLOS operations. A 100-megapixel camera mounted on the V2 will capture four band imagery including red, green, blue, and near infrared at a resolution of three-to-five centimeters.

Reclamation. The development of the remote reclamation analysis tool will involve a two-tiered process. First, SolSpec will apply a preliminary assessment of reclamation success to rank the population (n= approximately 2,175) of well sites operated by Whiting Oil and Gas Corporation (Whiting), a project partner, in the state of North Dakota. The preliminary assessment will draw data inputs from publicly available sources, including the NDIC for well site locations and the National Agricultural Imagery Program (NAIP) red, green, blue, and near infrared imagery. SolSpec will compute a Normalized Difference Vegetation Index (NDVI) based on 0.6-meter NAIP imagery (USDA, 2018) and then perform k-statistic and cumulative frequency distribution calculations to measure the statistical difference in spectral reflectance between well pad sites and their adjacent areas within a buffer and radius zone (appropriate distances to be determined). A minimal difference between on- and off-pad spectral reflectance would indicate a continuity in ground cover and a higher level of well pad reclamation success. Conversely, a large difference in spectral reflectance between the well pad and adjacent area would imply a discontinuity in ground cover and a lower level of reclamation success. Thus, the preliminary assessment method should enable operators and agencies to quickly and cost-effectively deduce reclamation success across a large population and/or landscape in order to prioritize resource allocation toward inspection of the sites showing the highest readiness for reclamation inspection.

Though the NAIP dataset provides a relatively recent assessment of spectral reflectance, it fails to account for reclamation advances that have occurred since the imagery collect, which can span up to 5 years. Aerial data collection during the second tier of the remote reclamation analysis method will enable a more current assessment of reclamation stage at a finer, sub-decimeter resolution than capable with NAIP imagery. Whiting has selected 52 reclaimed and near-reclaimed well pad sites (exact locations to be determined) for inclusion in the second-tier reclamation study, none of which have been inspected for bond release. ISight will capture aerial imagery of these sites using the V2 UAV and upload the data to SolSpec's secure, web-based platform for aerial data management, processing, analytics, and visualization. SolSpec will then employ photogrammetric methods to generate a digital surface model (DSM) based on the imagery's spectral attributes. The spectral data will be organized into a triangular greenness index (TGI) representing leaf chlorophyll content, while the structural data will be organized

by relative vegetation height derived from the DSM. Finally, SolSpec will calculate a similarity index based on how similar the TGI and vegetation structure cumulative distribution functions are between on pad sites and adjacent off pad sites (appropriate buffer and radius to be determined). Like the preliminary assessment, more similar scores between on- and off-pad samples will indicate a closer relationship between the well site and background vegetative conditions.

Validation of the remote reclamation analysis tool will occur at the following three levels:

1. The preliminary assessment model outputs will be compared against the aerial inspection outputs to determine the effectiveness of the preliminary assessment method in detecting reclamation success. (It should be noted that this preliminary assessment method is based on the best available NAIP data, which may vary across time and location).
2. The aerial inspection model outputs will be compared against ground truthed data collected by Duraroot Environmental Consulting (Duraroot), a project partner, to determine the accuracy of the model in comparing on-pad vegetative conditions to background conditions. Duraroot will visit a random subset of the study pads (n=26 or 50%) to measure species composition, vegetation structure, and health for on- and off-pad plots, as well as assess overall pad reclamation success.
3. SolSpec will seek collaboration with the NDIC for a final tier of tool validation. Contingent upon the NDIC's willingness and resources, an NDIC reclamation specialist will visit at least 25% (n=13) of well sites to inspect for reclamation success for bond release. The reclamation index results will be compared against the NDIC's and Duraroot's reclamation success ratings to evaluate the effectiveness of the reclamation index's ability to determine reclamation success.

Landslides. The development of the landslide susceptibility and threat models will include an iterative process of model development and validation. First, SolSpec will acquire the most recent publicly available datasets for LiDAR (2-meter resolution, 2019) and historical landslides (1:24,000 scale) developed by the North Dakota Geological Survey (NGDS). A random subset of the historical landslide datasets will be used as training data to develop a predictive algorithm for landslide occurrence using an unsupervised classification method. The rest of the historical landslide dataset will be withheld as validation data to test the algorithm's predictive accuracy. The model will be trained on compound terrain-related variables such as well as soil chemical and physical properties derived from the USDA-NRCS Soil Survey Geographic Database (SSURGO). The soil properties considered in the analysis will include but are not limited to bulk density, angle of internal friction, total soil depth, saturated hydrologic connectivity, and liquid limit. The modeling process will entail the generation of many instances, with each iteration adjusting the model parameters and covariate preferences to derive the best performing landslide prediction model. The final model will be subjected to a 10-fold cross validation process to reduce overfitting and develop a manageable decision tree that can be implemented in a Geographic Information System (GIS). This process will identify the combination of terrain and soil variables and their properties yielding the highest prediction rate for landslide occurrence in western North Dakota.

Once the final landslide susceptibility model is developed, it will be incorporated into SolSpec's Right-of-Way Health Assessment (ROWHA) model to assess landslide threat to pipeline integrity to

approximately 100 miles of pipeline ROW operated by ONEOK, Inc. (ONEOK) in western North Dakota (exact pipelines and distances yet to be determined). The ROWHA model will assess hillslope stability and landslide threat to pipeline integrity for 3-meter segments along a given pipeline's centerline. This information is then aggregated into management zones by averaging threats using a sliding mile analysis. The results from the sliding mile analysis are ranked into percentiles to target high threat zones.

The landslide susceptibility model will undergo a second tier of validation through ground truthing of the model's predictions for the ONEOK ROW. Duraroot's geotechnical engineering staff and soil scientists will perform assessments of geotechnical and soil stability at randomly selected pipeline segments (10%) along and adjacent to the pipeline ROW. The landslide susceptibility model outcomes will be compared against the geotechnical determinations to test the model's predictive effectiveness. Any false positive and false negative outputs will be identified, and that information will be incorporated into the model for continuous improvement.

Automation. Upon the development of preliminary reclamation and landslide forecasting models, but prior to field validation, the model components will be automated within the SolSpec platform. This will include the automation of the following model steps: data aggregation, dissemination, derivative generation, and model validation. The model validation will provide a significance value based on the initial training data. Field validation of the models will provide an opportunity to test the robustness of the models in comparison to on-site observations. This information will be used to further train and improve the model.

Anticipated Results:

Reclamation. We predict that the coarser preliminary assessment model of the well pads and the refined aerial inspection model of selected well pads will be validated as a useful tool for determining reclamation success. This will inform efficient resource allocation, prioritization of site inspections, and bond release within North Dakota's well site reclamation program, thereby supporting NDIC intentions (see Appendix A).

Landslides. We anticipate that the Bakken-specific landslide susceptibility and threat models will be validated as useful tools for forecasting pipeline vulnerability as a result of mass soil movement. This will enable operators to efficiently prioritize resource allocation, monitoring, and mitigation efforts. The tools will equip operators to proactively manage risk caused by earth movement, which is required by American Society of Mechanical Engineers (ASME) B31.8S (2016, pg. 3-5) for gas pipelines and American Petroleum Institute (API) RP-1160 (2013, pg. 11-14) for hazardous liquid pipelines.

Automation. We expect the automation of the reclamation and landslide models to provide a feasible, economical, and scalable avenue for analyzing large quantities of aerial data per OGRC Project G-43-01 recommendations (see Appendix B).

Facilities:

Aerial data collection and validation will take place on 52 well pad sites operated by Whiting and approximately 100 miles of pipeline operated by ONEOK, all located within western North Dakota. Data

will be uploaded to, managed, processed, analyzed, and visualized at SolSpec's headquarter office location in Denver, CO.

Resources:
The primary resources deployed to this project will be SolSpec's personnel and computer hardware; ISight's personnel, V2 UAV, and equipment; and Duraroot's, Whiting's, and ONEOK's personnel, vehicle, and field equipment supporting ground truthing and data collection.

Techniques to Be Used, Their Availability and Capability:
Photogrammetry is a measuring technique for triangulating among photographs of a point of interest taken from at least two different locations to mathematically extract 3-dimensional (3D) coordinates of the point of interest. Developments in digital camera chips with high megapixel levels and improvements in software have enabled the production of high-accuracy 3D coordinates through photogrammetric techniques.

Environmental and Economic Impacts while Project is Underway:
One of the benefits of non-invasive remote sensing technologies is the minimal impact that aerial data collection poses to the environment. On-ground visits to sites to validate the models developed in this research will pose some minor, temporary environmental disturbance as a result in-situ soil or vegetation classification within the bounds of traditionally accepted environmental inspection protocols. There are no foreseeable adverse economic impacts while the project is underway.

Ultimate Technological and Economic Impacts:
This research project will produce tools for improving both technological and economic efficiencies among North Dakota's oil and gas industry and its agency collaborators.

Why the Project is Needed:
Reclamation. Prior OGRC research (Project G-037-73, 2016) validated the feasibility of image collection as a means of determining reclamation success. However, existing methods for remotely analyzing ground cover data, including those used in the OGRC study, are scale-limited and technologically cumbersome, impeding the widespread adoption of aerial imagery technology in reclamation monitoring. In order for remote sensing technologies to bring efficiencies to the reclamation inspection and bond release process, well pad operators and regulatory agencies need access to efficient, scalable, and statistically robust methods of remotely analyzing reclamation success.

Landslides. The badlands and buttes of western North Dakota are susceptible to landslides and subsidence, which can compromise the integrity of pipelines in the area. Traditional methods of ocular inspection for earth movement along a pipeline ROW can be inefficient, unsafe for personnel, and subject to human error. Additionally, they often limit operators to reactive measures. Pipeline operators currently lack access to proven aerial analytics methods that enable fast, safe, scalable, and statistically robust remote measurement of landslide susceptibility and threats. Aerial imagery is not enough to solve this problem. According to OGRC Project G-43-01 Final Report (pg. 21), "what pipeline operators require is actionable intelligence from this data – a red flag to indicate a problem or a green flag to indicate situation normal."

Automation. Aerial imagery collection provides operators with an overwhelming amount of raw data, sometimes requiring the employment of specialized teams of analysts to process and interpret the data into meaningful information. In order for the analysis of aerial imagery to be cost-effective and scalable—both precursors to adoption throughout the oil and gas industry—data management, processing, and analysis must be automated.

STANDARDS OF SUCCESS

Measurable deliverables and success reporting

Success will be achieved when the reclamation and landslide tools are statistically validated at an acceptable level of accuracy and automated to enable efficient, scalable data processing and analysis by operators and agencies.

Core deliverables include:

1. Interim reports to NDIC highlighting ongoing research activities and results;
2. Final report summarizing research achievements, challenges, conclusions, and recommendations;
3. Statistically validated, automated model for remote assessment of well site reclamation success;
4. Statistically validated, automated model for remote assessment of landslide susceptibility along pipeline ROWs; and
5. Statistically validated, automated model for remote assessment of landslide threats to pipelines.

Value to North Dakota and public and private utilization of results

North Dakota's oil and gas industry, agencies, and public will derive benefit from the results of this research.

1. Industry will gain awareness of and access to affordable, statistically sound, best available technology developed for and tested in the Bakken.
    a. This project will provide upstream operators access to a quantitative method for proactively monitoring reclamation progress, developing reports for NDIC, and proving readiness for bond release.
    b. Midstream operators will have access to a forecasting tool for determining where landslide threats to the pipeline are highest along a ROW, enabling the efficient allocation of resources toward proactive monitoring and mitigation where it is needed most to maintain pipeline integrity.
2. Industry use of the aerial analytics tools produced in this project will translate to increased efficiencies within oil and gas regulatory agencies.
    a. The NDIC well site reclamation program will have the option of receiving a model-derived statistical comparison of on-site vegetation to background conditions using publicly available NAIP data and/or more current aerial imagery, thus streamlining the inspection process.

   b. Where the landslide susceptibility and risk models are used to inform decisions, the North Dakota Pipeline Authority, environmental, and emergency response agencies can be more confident that the pipeline is not at risk of mass earth movements.
3. Industry use of the aerial analytics tools developed in this project will translate into benefits for the public and the environment.
   a. As stated by Director of Mineral Resources Lynn Helms (Appendix A, pg. 1), "the public, which has a stake both in the protection and restoration of the landscape, also seeks a consistent and sustainable reclamation program to help support an active oil and gas industry." This project's aim is to produce tools that support a more consistent and sustainable reclamation program.
   b. Proactive measures by operators to identify, monitor, and mitigate landslide threats to pipeline integrity directly contribute to the protection of public safety and environmental quality, thus supporting a more sustainable oil and gas industry.

Commercial Use

Remote sensing technology has dramatically changed the way that many sectors, including energy, agriculture, mining, infrastructure, and government, do business. As developments in technology and regulations make BVLOS UAV flights possible, so will rise the demand for efficiently transforming mountains of data into actionable intelligence to guide decisions. This project will produce technological advances that make big data meaningful for the oil and gas industry. Results will inform and inspire further development of statistically robust and automated tools for processing and analyzing aerial imagery, thus stimulating innovation and business opportunities in a much-needed space. Additionally, the aerial analytics tools derived from this project will increase use of remote sensing technologies in the state, thereby fortifying the UAV industry.

How the project will enhance the education, research, development and marketing of North Dakota's oil and natural gas resources;

North Dakota's vision for its oil and gas industry is to achieve safety and stewardship through innovation, rather than regulation. This research aims to prove the effectiveness and efficiency of market-based approaches in creating a sustainable and thriving oil and gas industry. The project will demonstrate that market-based safety and stewardship tools can be affordable, trusted, and produce net gains for upstream and midstream operators by quickening bond release and reducing risk.

How it will preserve existing jobs and create new ones

Successful execution of this project will fortify the remote sensing industry in the state – from UAV imagery collection to processing to analytics. It will encourage the certification and employment of more FAA 107-licensed pilots among oil and gas personnel, agency inspectors, and third-party service providers. It will also stimulate and drive further technological innovations and applications among North Dakota's public, private, and academic sectors for turning big data into actionable intelligence.

BACKGROUND/QUALIFICIATIONS

SolSpec, Inc.

SolSpec is a Denver-based software company that specializes in the processing and analysis of geospatial data. With a principal focus on the scalability and automation of Manned and Unmanned Aerial Systems (UAS) data, SolSpec productizes analytics for commercial applications in natural resources, infrastructure, and other major land-use industries. Having mapped and analyzed more than 1.2 million acres, SolSpec's product and prediction models have become increasingly accurate, reliable, and user-friendly.

John Norman, MS, Principal Spatial Scientist, SolSpec (Principal Investigator)
https://www.researchgate.net/profile/John_Norman6
John Norman specializes in remote sensing, ecology, and spatial statistical analysis. His interdisciplinary expertise in soil, water, and vegetation combined with his tenure as a research scientist have made him proficient at the predictive modeling of terrestrial and hydrological systems.

Nathan Casler, MS, Lead Spatial Developer, SolSpec (Principal Investigator)
https://www.researchgate.net/profile/Nathan_Casler
Nathan Casler specializes in geospatial programming, distributed database design, and High Performance Computing (HPC). His technical literacy in both spatial statistical analysis and distributed databases make him exceptional at building HPC workflows for performant large-scale analysis.

Bryan Crowe, Chief Operating Officer, SolSpec
Bryan Crowe's experience includes tenure at MarkWest Energy Partners as a regional manager with overall responsibility for pipeline operations in five states (~12% of the nation's gas) in the Appalachian region. In addition to his operational responsibilities at SolSpec, Crowe serves as the lead technical and regulatory subject matter expert for a myriad of pipeline integrity and safety issues including API and PHMSA Recommended Practices.

ISight RPV Services

Grand Forks-based ISight provides Remotely Piloted Vehicle operations to customers including energy and engineering firms, agricultural producers, DOD contractors, NASA and the North Dakota and Nevada FAA UAS Test Sites. As part of its ongoing work, ISight has inspected over 175 miles of oil pipeline utilizing drones. ISight conducted and successfully completed work with the OGRC in the completion of a project entitled "UAS Aerial Observation to Support Oil & Gas Pipeline Construction Restoration Efforts". ISight and the Unmanned Applications Institute, in collaboration with ONEOK, Barr Engineering and the Public Service Commission, provided high fidelity/clarity images for use in developing signature images of potential problem areas in the creation of an image library for ONEOK's use in restoration activities (focused on the Bear Creek Pipeline, McKenzie County), reducing costs and increasing pipeline construction environmental restoration.

Tommy Kenville, Chief Executive Officer, ISight RPV Services
Tommy Kenville has over 25 years in aviation-related experience, including 15 years at the University of North Dakota Aerospace Foundation and founding the Unmanned Applications Institute (the first institute for research, testing and consulting in the emerging UAV industry in North Dakota, founded in 2010) prior to merging with ISight in 2016.

Whiting Oil and Gas Corporation
As a company, Whiting has reclaimed nearly 100 facilities in the past three years in North Dakota alone. Whiting's Regulatory, Permitting, and Environmental Departments have worked closely with the NDIC and United States Forest Service (USFS) to successfully fulfill requirements for proper site reclamation.

Mark Keyes, Environmental Compliance Supervisor, Whiting
Mark Keyes has 6 years of experience working and supervising Whiting's environmental compliance in the Williston and DJ Basins of North Dakota and Colorado. In 2016, Mark and Whiting teamed with SolSpec and the Colorado Oil and Gas Conservation Commission on a pilot study for using remote sensing to evaluate reclamation success. Mark and his counterparts at Whiting continue to use remotely sensed data and the SolSpec Platform for the inventory, maintenance planning, and execution of reclamation activities.

ONEOK, Inc.
ONEOK's operations in the Williston Basin consist of approximately 6,900 miles of gathering lines and nine processing plants capable of carrying 615 million cubic feet per day of product to market.

Todd Kelvington, Environmental Manager, ONEOK
Todd Kelvington has spent the past 4 years working as manager of both the GIS and Environmental teams at ONEOK. Todd is considered a thought leader of UAS applications in the oil and gas industry and throughout his tenure at ONEOK has sponsored the development of numerous UAS initiatives.

Duraroot Environmental Consulting
With decades of experience in the energy and environmental industries, Duraroot provides consulting services for soil, plant, and water sciences. Specifically, Duraroot provides site-specific reclamation and monitoring plans for large pipeline and E&P facilities. Since 2014, Duraroot has sampled over 50,000 acres of soil and vegetation on oil and gas facilities.

Aaron DeJoia MS CPSS, Environmental Soil Scientist/Agronomist and Director, Duraroot
Aaron DeJoia is a North Dakota Professional Soil Classifier and board-certified Professional Soil Scientist and Agronomist with 18 years of experience providing support in permitting, operations, reclamation, remediation, and expert witness testimony to clients in the oil and gas sectors.

MANAGEMENT

Management of this research project will be led by SolSpec and include time and milestones tracking, budgetary reporting, fund accounting, and contract services. SolSpec employs the Agile Method for project management that is common in software development. Agile uses incremental, iterative work sequences known as “sprints” to assist collaborative teams in responding to the unpredictability of constructing software. The project objectives will be broken into smaller tasks that will be incorporated into sprints with built-in twice-monthly evaluation points.

TIMETABLE

Key Milestones	Month	Year
Planning/Preparation		
OGRC research proposal submitted	June	2019
Letters of support provided by partners	June	2019
MSAs signed among project partners	June	2019
OGRC grant awarded	Aug	2019
Model Development		
Reclamation assessment index development	Sept-April	2019-2020
Landslide susceptibility model development	Sept-April	2019-2020
Model Automation		
Reclamation assessment index automation	Sept-April	2019-2020
Landslide susceptibility model automation	Sept-April	2019-2020
Field Data Acquisition		
Reclamation field data collection: Whiting well sites	June-July	2020
Landslide susceptibility field data collection: ONEOK pipeline	June-July	2020
Model Validation		
Reclamation assessment index validation	Aug-Sept	2020
Landslide susceptibility model validation	Aug-Sept	2020
Model Refinement		
Reclamation assessment index validation	Oct-Nov	2020
Landslide susceptibility model validation	Oct-Nov	2020
Reports		
Interim Report 1	Dec	2019
Interim Report 2	March	2020
Interim Report 3	June	2020
Interim Report 4	Sept	2020
Final Report	Dec	2020
Briefings to NDIC/OGRC	On demand	

BUDGET

Project Associated Expense	NDIC's Share	Applicant's Share (In-Kind)	Partner's Share (In-Kind)
Initial development of reclamation index & landslide model	$15,875.00	$31,750.00	
Initial automation of reclamation index & landslide model	$18,750.00	$37,500.00	
Aerial data acquisition for reclamation index: $800 per well site * 52 well sites	$41,600.00		$41,920.00
Aerial data acquisition for landslide model: $750 per pipeline miles * 100 pipeline miles	$75,000.00		$16,080.00
Processing of aerial imagery	$9,23.00	$9,235.00	
Ground truthing of landslide model: Sampling design and execution on 100 miles of pipeline	$30,00.00	$10,000.00	$10,000.00
Ground truthing of the reclamation index: 26 well pad sites	$18,000.00	$7,000.00	$5,000.00
Final Validation & refinement of reclamation index & landslide model	$29,280.00	$69,250.00	
Project Management and Reporting	$14,650.00	$14,650.00	
Total Contributions:	**$252,385.00**	**$179,385.00**	**$73,000.00**

The above expenses will be necessary to carry out the objectives and activities outline in this research proposal. If less funding is available than that requested, the project will need to be reduced in scope.

CONFIDENTIAL INFORMATION

There is no confidential information contained within this document.

PATENTS/RIGHTS TO TECHNICAL DATA

SolSpec is a Licensed Software provider. "Licensed Software" includes SolSpec's confidential and proprietary SolSpec Viewer™ cloud-based software, algorithms, programs, and tools designed to analyze, manipulate and process data into reports in a usable and presentable manner that is valuable to users, including, without limitation, any applicable API(s) and any and all updates and upgrades

STATUS OF ONGOING PROJECTS (IF ANY)

SolSpec has not received prior funding from the OGRC grant program.

Appendix A. Memorandum from Director of Mineral Resources Lynn Helms establishing NDIC intent to gain efficiencies and improve procedures concerning the well site reclamation program.

Oil and Gas Division

Lynn D. Helms - Director Bruce E. Hicks - Assistant Director

Department of Mineral Resources

Lynn D. Helms - Director

North Dakota Industrial Commission

www.oilgas.nd.gov

To: North Dakota Oil and Gas Industry

Fr: Lynn Helms
North Dakota Industrial Commission (NDIC)

RE: NDIC Intent to gain efficiencies and improve procedures concerning the well site reclamation program

Background

NDIC has recently pursued the application of new technologies to our procedures for reviewing and approving reclamation of plugged and abandoned drill sites. Current site clearance procedures can be cumbersome and inefficient. Site review scheduling delays and lack of standardization in the evaluation process can result in final site clearance and bond release being delayed unnecessarily. The public, which has a stake both in the protection and restoration of the landscape, also seeks a consistent and sustainable reclamation program to help support an active oil and gas industry.

The Oil and Gas Research Council (OGRC), NDIC, and Hess engaged in imagery collection research (OGRP project G-037-73, 2016) of reclaimed well sites. As a result of that research, NDIC is now confident that image collection is a viable method of determining reclamation success.

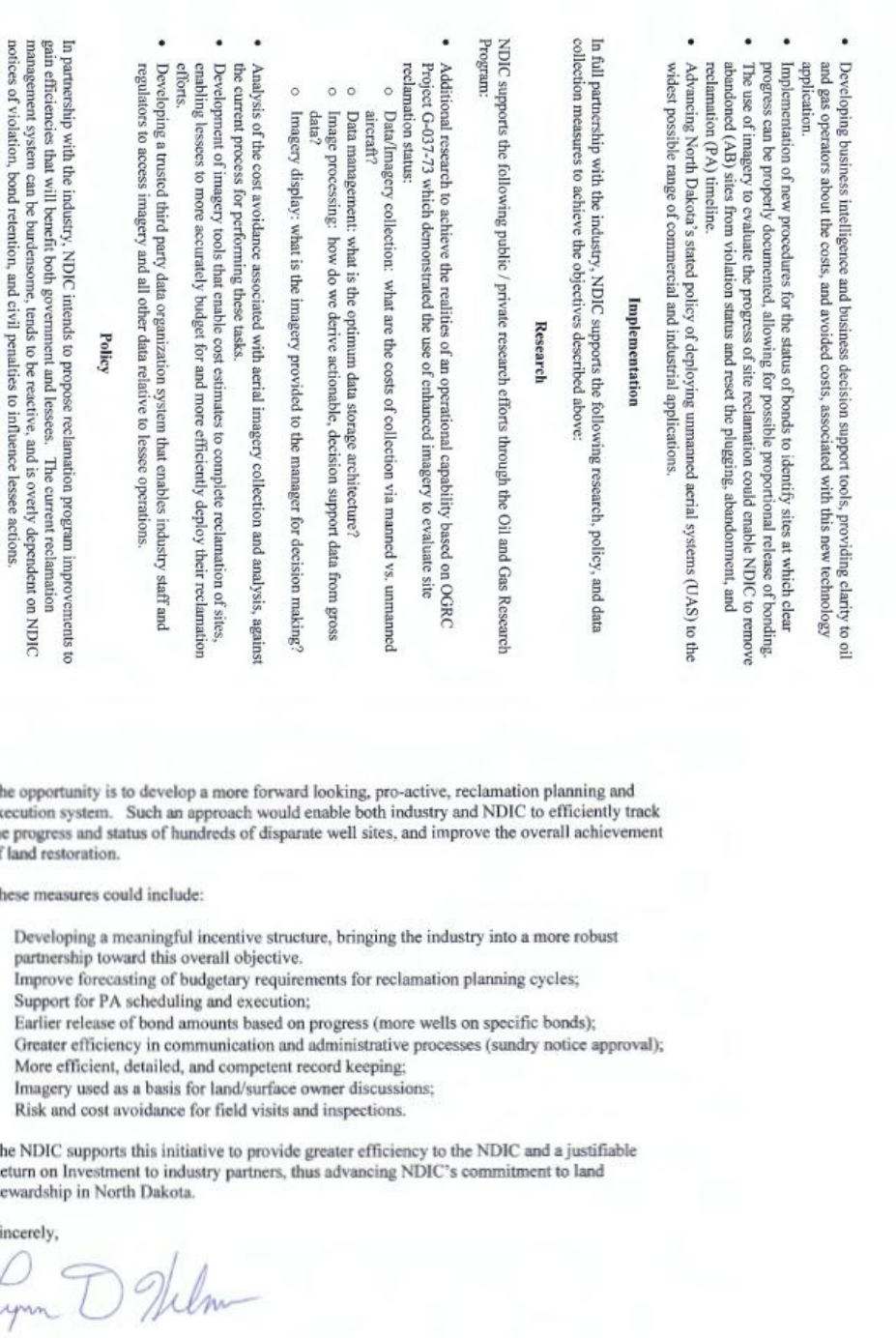
Objectives

This memorandum commits the NDIC to continue working with trusted program developers, and industry partners to apply a range of new imagery technologies, and new administrative tools to the process of certifying successful site reclamation thus eliminating the backlog of sites at which reclamation is believed to have occurred, but NDIC has not yet been able to inspect. NDIC is also considering proportional bond release for partial reclamation as an incentive for oil and gas operators to diligently pursue their reclamation obligations.

In general, this initiative includes the following objectives:

- Increasing reliance on the use of modern aerial imagery to support NDIC decisions to clear, or partially clear, plugged well sites from the reclamation schedule.
- Developing technology applications that are trusted by both the industry and the regulatory agencies.
- Establishing third party independent organizations to collect and analyze imagery and data to the satisfaction of public and private organizations.

600 E Boulevard Ave - Dept 405, Bismarck, North Dakota 58505-0840 Phone (701)328-8020 Fax (701)328-8022



- Developing business intelligence and business decision support tools, providing clarity to oil and gas operators about the costs, and avoided costs, associated with this new technology application.
- Implementation of new procedures for the status of bonds to identify sites at which clear progress can be properly documented, allowing for possible proportional release of bonding.
- The use of imagery to evaluate the progress of site reclamation could enable NDIC to remove abandoned (AB) sites from violation status and reset the plugging, abandonment, and reclamation (PA) timeline.
- Advancing North Dakota's stated policy of deploying unmanned aerial systems (UAS) to the widest possible range of commercial and industrial applications.

Implementation

In full partnership with the industry, NDIC supports the following research, policy, and data collection measures to achieve the objectives described above:

Research

NDIC supports the following public / private research efforts through the Oil and Gas Research Program:

- Additional research to achieve the realities of an operational capability based on OGRC Project G-037-73 which demonstrated the use of enhanced imagery to evaluate site reclamation status:
  - Data/Imagery collection: what are the costs of collection via manned vs. unmanned aircraft?
  - Data management: what is the optimum data storage architecture?
  - Image processing: how do we derive actionable, decision support data from gross data?
  - Imagery display: what is the imagery provided to the manager for decision making?
- Analysis of the cost avoidance associated with aerial imagery collection and analysis, against the current process for performing these tasks.
- Development of imagery tools that enable cost estimates to complete reclamation of sites, enabling lessees to more accurately budget for and more efficiently deploy their reclamation efforts.
- Developing a trusted third party data organization system that enables industry staff and regulators to access imagery and all other data relative to lessee operations.

Policy

In partnership with the industry, NDIC intends to propose reclamation program improvements to gain efficiencies that will benefit both government and lessees. The current reclamation management system can be burdensome, tends to be reactive, and is overly dependent on NDIC notices of violation, bond retention, and civil penalties to influence lessee actions.

The opportunity is to develop a more forward looking, pro-active, reclamation planning and execution system. Such an approach would enable both industry and NDIC to efficiently track the progress and status of hundreds of disparate well sites, and improve the overall achievement of land restoration.

These measures could include:

- Developing a meaningful incentive structure, bringing the industry into a more robust partnership toward this overall objective.
- Improve forecasting of budgetary requirements for reclamation planning cycles;
- Support for PA scheduling and execution;
- Earlier release of bond amounts based on progress (more wells on specific bonds);
- Greater efficiency in communication and administrative processes (sundry notice approval);
- More efficient, detailed, and competent record keeping;
- Imagery used as a basis for land/surface owner discussions;
- Risk and cost avoidance for field visits and inspections.

The NDIC supports this initiative to provide greater efficiency to the NDIC and a justifiable Return on Investment to industry partners, thus advancing NDIC's commitment to land stewardship in North Dakota.

Sincerely,

Lynn D Helms

Appendix B. Excerpt from OGRC Project G-43-01 Final Report (pg. 18) "Liquids Gathering Pipelines: Survey of Emerging Technologies and Applications of Risk Assessment to Increase Pipeline Integrity".

IV. PREREQUISITES FOR PROLIFERATION OF DRONE EMPLOYMENT IN PIPELINE MONITORING

KEY TAKEAWAYS:

- Although drones are frequently discussed as a promising tool for pipelines, certain prerequisites must underlie their fruitful application:
  - Drones are merely platforms for scientific sensors. Focus must be placed on collection of insightful data via these sensors.
  - Huge amounts of data can be collected, but those data require appropriate analysis. To make analysis of large quantities of data economic, automated data processing and analysis must be employed.
  - Drones will only be economical for application to large-area gathering pipeline systems if rules for BVLOS flight operations are enacted.
  - Automated flight operations (takeoff, flight path, data collection, landing, data uploading) will greatly enhance the economics of drone application.

SolSpec
AERIAL ANALYTICS

AFFIDAVIT OF TAX LIABILITY

State of Colorado
County of Jefferson

I, the undersigned, do hereby affirm the following:

1. I am authorized on behalf of the company SolSpec, Inc. (SolSpec) to submit this affidavit of tax liability; and

2. SolSpec does not have any outstanding tax liabilities owed to the state of North Dakota or any of its political subdivisions.

Name and Position: Tobias Kraft - CEO

Signature:

Date: 5-31-2019

Notary: Denise Rodarte 5.31.19

DENISE RODARTE
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19924000410
My Commission Expires February 18, 2022