

November 17, 2023

Jane Lazorchak, Director of the Global Warming Solutions Act
Agency of Natural Resources
103 South Main Street, 1 South
Commissioner's Office
Waterbury, VT 05671-0401

RE: Measuring and Assessing Progress of Vermont's Climate Action Plan

Dear Ms. Lazorchak,

Please accept our formal response to the Vermont Agency of Natural Resources' (the Agency) request for technical support services to help develop a tool to measure and assess indicators of progress related to reducing greenhouse gas (GHG) emissions and increasing resilience. Team Cadmus has the understanding and expertise to provide the Agency and the Vermont Climate Council (VCC) with practical guidance to use data and metrics to inform a tool that will support effective climate policymaking. We will apply proven approaches and methodologies with our unique understanding of the Agency's culture, resources, and objectives to provide the required technical support.

- **The Cadmus Group, LLC (Cadmus)** is a consulting firm with +1,000 consultants worldwide. Our team brings expertise in decarbonization, adaptation and resilience, equity, data analytics, economic modeling and policy analysis, inventorying GHG emissions, setting science-based targets, and designing data platforms and reporting tools. Cadmus helped the Agency develop the Vermont Climate Action Plan (the Plan) Pathways Study and Analysis, and proposes the same team the Agency has come to see as trusted partners. We have expertise in Vermont-specific data to track key metrics, fill data gaps, and form a Data Governance Team to support this next phase.
- **Energy Futures Group (EFG)**, partnered with Prime Cadmus to develop the Pathways Study and the Massachusetts' Decarbonization Roadmap Study. Based in Hinesburg, Vermont, EFG partners with Vermont Agencies and stakeholders including members of the VCC and its subcommittees, providers of electric, gas and fuel and efficiency services in the state, the Agency, and the Department of Public Service.
- **Dr. Gillian Galford, Dr. Heather Darby, Dr. Eric Roy, and Dr. Josh Faulkner, University of Vermont** are experts in Vermont's natural and working lands and the opportunities for Vermont to integrate these important resources into its carbon accounting.

As Prime, Cadmus will apply proven project management and data governance approach to seamlessly integrate our team's efforts and help the Agency achieve the ambitious goals of the Global Warming Solutions Act (GWSA) within nine months. Team Cadmus appreciates your consideration.

Sincerely,



Christina Becker-Birck
Vice President, Government Sector
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Measuring and Assessing Progress of Vermont's Climate Action Plan

November 17, 2023

Prepared for:

Vermont Agency of Natural Resources

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Action Office

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Summary and Team Qualifications

The Agency requires a team that understands its data, programs, and objectives; brings best practices in data collection and analytics, program evaluation and social sciences; and understands the stakeholders who manage and implement successful climate policies and programs. The Agency needs a partner that has supported similar projects, and can apply their understanding of Vermont's unique requirements as defined in the GWSA, the guidance provided by the VCC, and the Plan. The Agency requires this expertise to help track emissions and policy progress. Team Cadmus collaborated with the Agency to support the Plan's policy pathways analysis and will apply this unique experience and our expertise of having supported climate planning and data reporting initiatives across New England and globally. We will apply our technical expertise and Vermont-centric understanding to provide detailed analysis, relevant context setting and program review, and actionable program and tool design. We are familiar with the Agency's existing data sets, GHG inventories, and state policies and implementation pathways, and have a proven and replicable approach (**Figure 1**) that will allow us to begin work on day one with no transition time, to help the Agency develop a policy-decision support tool that is sustainable, open, and accessible. We have used this approach to support similar work for Massachusetts, New York, and New Jersey to develop informative climate actions, and analyze GHG reduction pathways, policies, and programs and track their results. In addition, we have the resources to provide the framework for a tool that will facilitate public education, and help the state and its partners make effective climate policies. Team Cadmus will help catalyze complete and consistent tracking across multiple initiatives and include measures and indicators of technical impacts as well as equity of access, and participation and impacts. Team Cadmus will provide the Agency with:

Technical Expertise and Practical Policymaking Expertise

Team Cadmus has more than 20 years of experience supporting state agencies and local governments in climate policy design and implementation. We will build off Vermont's program and planning work to collaboratively determine which metrics and indicators to track, form a Data Governance Team, determine data availability and sources, and advise on how to fill data gaps for the selected metrics. Our analysis help the Agency develop the right tool to monitor and evaluate progress on key strategies and initiatives that will drive down emissions in line with the GWSA. Our holistic understanding of the Plan, GWSA, and Vermont uniquely positions our team to complete this phase and help the Agency transition to Phase 2. Our team includes former government employees; subject matter experts (SMEs) who inform state policy and program design for renewable thermal, resilience, adaptation, equity and energy; and analysts who support solar, clean transportation, renewable thermal and energy efficiency policies. We have supported data-driven climate and energy strategies, including creating models and conducting analyses for the Massachusetts Decarbonization Roadmap, developed the [Massachusetts Clean Energy and Climate Plan Metric Tracking](#), and helped Southern California Edison develop a [detailed dashboard](#) and data tracking tool as a part of the third-party program impact evaluation for one of the largest electric vehicle incentive programs in the country. We will combine this technical and policy expertise to translate technical information, and policymaking political, regulatory, and technical dynamics to help the Agency make data-driven decisions about how to select and sequence data and track progress to achieve its climate goals.

Comprehensive Modeling and Analytical Approaches

With over 75 data scientists, IT solution and data modelers, and data analytics professionals, our SMEs have supported technical analysis across GHG inventories, carbon budgeting, LEAP modeling, resilience and adaptation planning, energy efficiency and electric vehicle program measurement and verification, and economic impact analysis. They will apply this expertise to recommend and implement technically

and financially feasible approaches that are consistent with current standards and best practices. We develop models to analyze and support policy design in an open and accessible manner. Our tools flexibly adapt to changes and create the analytical structure to sustain policy coordination to help the state meet its climate targets. We will apply our expertise in creating these tools to implement Phase 1 so that it informs Phase 2—the development of a tool that meets the GWSA requirements—and provides the Agency and stakeholders with the insights to inform effective policies, programs, and education in an open and sustainable way. For example, in Massachusetts we created a [clean energy and climate plan metric tracking system](#) to collect, analyze and report on key clean energy and climate planning metrics; developed visualizations from these metrics to be included in the written Clean Energy and Climate Plan for 2025/2030 and on an interactive website; and supported the layout and design 2025/2030 Clean Energy and Climate Plan.

Equity-Focused Approach

Team Cadmus is committed to integrating equity in climate planning, process, and outcomes. In addition to designing an inclusive engagement process that involves underserved communities, our approach to analyze, measure, and report data goes beyond the technical to include equity impacts. Our proven approach includes inclusive planning processes, design strategies, and implementation steps to deliver equitable outcomes. For example, we worked with municipalities across the United States to develop the Urban Sustainability Director’s Network [Guidebook on Equitable Clean Energy Program Design for Local Governments](#) and will apply this knowledge to integrate equity.

Team Cadmus will customize our national and regional experience developing logic models and data governance to meet Vermont’s unique needs including agriculture, commercial, and industrial, and diverse community dynamics. We will apply our Vermont roots to help the Agency integrate Vermont’s unique circumstances to deliver results that the Green Mountain State needs. **Table 1** presents our business organization, company size, and resources.

Table 1: Business, Organization, Company Size, and Resources

Form of Business Organization	Delaware Limited Liability Company
Company Size	1,000+ employees globally
Resources	Eight staff and a team of 10 individuals from two subcontractors dedicated to this project plus an additional 10 SMEs to support as needed

The Cadmus Group LLC (Cadmus) is a sustainability consultancy with more than 1,000 consultants globally who provide expertise in market-based climate program development, economic and public health analysis, resilience and adaptation, and stakeholder engagement who have supported similar efforts for utilities and policy makers across the country and including Massachusetts, Maine, Pennsylvania, Vermont, Wisconsin, Oregon, Hawaii, New York, New Jersey, and Rhode Island. We will apply our proven approach, technical expertise, understanding of analytical tools, and facilitation, and our experience on similar projects to help Vermont navigate challenges (e.g., addressing the challenges that natural and working lands comprise 94% of the state, larger use of high-efficiency wood pellets for heating) and identify opportunities (i.e., get to 100% renewable electricity supply and facilitate a just transition) inherent to implementing climate programs. We have conducted over 100 GHG inventories for government and corporate clients, and will apply this GHG expertise in best practices, approaches, protocols and tracking tools to help the Agency and the VCC craft and assess a program that meets the unique needs of decarbonizing Vermont. Our team uses GHG inventories to inform and drive practical decisions to reduce GHG impacts for our clients.

Relevant Current or Past State Projects

Team Cadmus' project work in Vermont includes seven projects for the Vermont Department of Public Service and Renewable Energy Vermont. We supported the Vermont Pathways Analysis Report 2.0, the Heat Pump Evaluation, the Commercial Building Market Study and Code Review, the Efficiency Vermont Continuous Energy Improvement Pilot, the Evaluation of Efficiency Vermont's Annual Savings Claim, the Behavioral Savings Pilot Evaluation (Residential HER and Commercial CEI), the Energy Efficiency Potential Study, and Standard Offer Regulation Development.

We have provided details on these projects and other relevant projects in **Table 6**.

Energy Futures Group (EFG) is based in Hinesburg, Vermont, and well known to key Vermont Agencies and stakeholders including the VCC and its subcommittees, providers of electric, gas and fuel and efficiency services in the state, the Agency, and the Department of Public Service.

In 2021, EFG, under subcontract with Cadmus, led major portions of the Pathways Analysis Report for Vermont, including reviewing the State's GHG inventory and methods, reviewing and recommending the social cost of carbon and its application to the Plan, and developing and analyzing mitigation scenarios.

EFG will lead the Vermont Thermal Sector Analysis, and build on the LEAP modeling to estimate the net costs and benefits of policy approaches to meet GWSA requirements for thermal energy use in the residential, commercial, and industrial sectors. We will apply our experience having supported this work to integrate the analyses, data, scenarios, key drivers, activities, and metrics to progress the Plan.

EFG's recent work involves efficiency program portfolios and policies in the fifteen highest-ranking states on the ACEEE State Energy Efficiency Scorecard, and in Ontario, Nova Scotia, and British Columbia.

EFG's expertise includes reviewing the development and implementation of evaluation plans to measure progress in the efficiency industry. We advocate for, and help define, the frameworks and performance metrics for gas and electric energy efficiency initiatives in Connecticut, California, Illinois, Maryland, New York, Ontario, Rhode Island, and Vermont. For this project EFG will lead the development of the logic model. In this capacity we will gather information on the programs and activities impacting progress on the Plan, catalogue existing and planned activities, identify the planned outputs and outcomes, and link outcomes to long-term impacts.

University of Vermont (UVM) Gund Institute for Environment offers expertise in climate change research, communication and outreach related to agriculture, forests and land use and GHG emissions specific to Vermont. Gillian Galford, PhD, a Research Associate Professor in the Rubenstein School of Environment and Natural Resources, will serve as the lead for a team of researchers supporting this project. Dr. Galford studies land-cover and land-use change and its impacts, particularly on GHG emissions. She works across scales, from plot level studies on farms to regional analyses through remote sensing and ecosystems modeling, and leads the Vermont Climate Assessment. Dr. Galford and her colleagues will help the team identify gaps in proposed metrics, and define inputs in agricultural impacts on water, soil, farms.

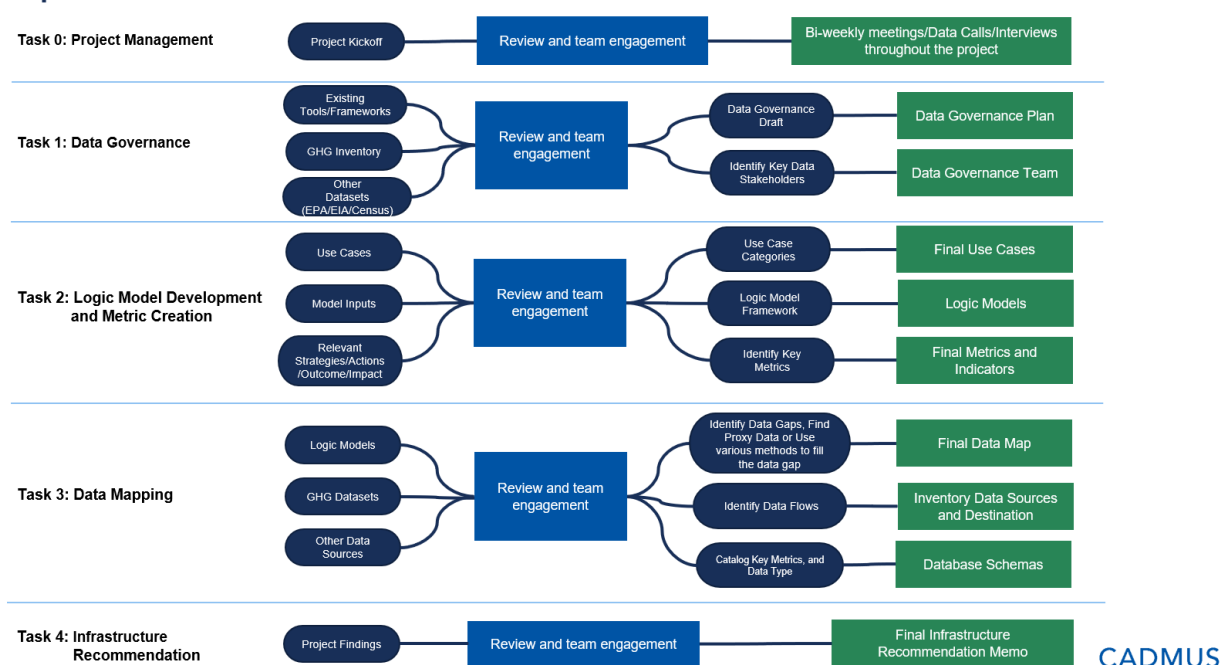
The Gund Institute brings scholars and leaders together to accelerate research, uncover solutions and tackle the world's most pressing environmental issues. The Institute connects the University of Vermont with the world to accelerate research and bring scholars and decision-makers together, to focus on environmental issues at the interface of climate solutions, health and well-being, sustainable agriculture, and resilient communities. They catalyze promising transdisciplinary research at the university, and amplify results and findings from research.

Technical Approach

Our Project Manager (PM), Ryan Bodanyi, PMP leads our team and is the Agency's primary point of contact. He will oversee the implementation of all tasks as shown in **Figure 1**. To deliver this Phase efficiently, we will involve representatives from the team (e.g., Cadmus, EFG, the University of Vermont, the Agency, and key stakeholders) throughout the process to review relevant inputs and products. This collaborative approach is critical to meet the timeline and comprehensively capture all data required, thereby setting the Agency up for success in Phase 2. Our deliverables are shown in green.

Figure 1: Team Cadmus' Implementation Overview to Measure and Assess the Progress of Vermont's CAP

Implementation Overview



Task 0. Project Management

Upon contract award, Team Cadmus will conduct a 1-hour virtual kickoff meeting to introduce relevant staff, roles and responsibilities, project scope and objectives, our proposed plan including schedule and deliverable timeline, and communication strategies between the Agency and the project team. During this meeting we will discuss the process management expectations and receive feedback on the proposed communication strategy, timelines, and deliverables.

Based on the discussion during the kickoff meeting, the project team will provide a project initiation work plan

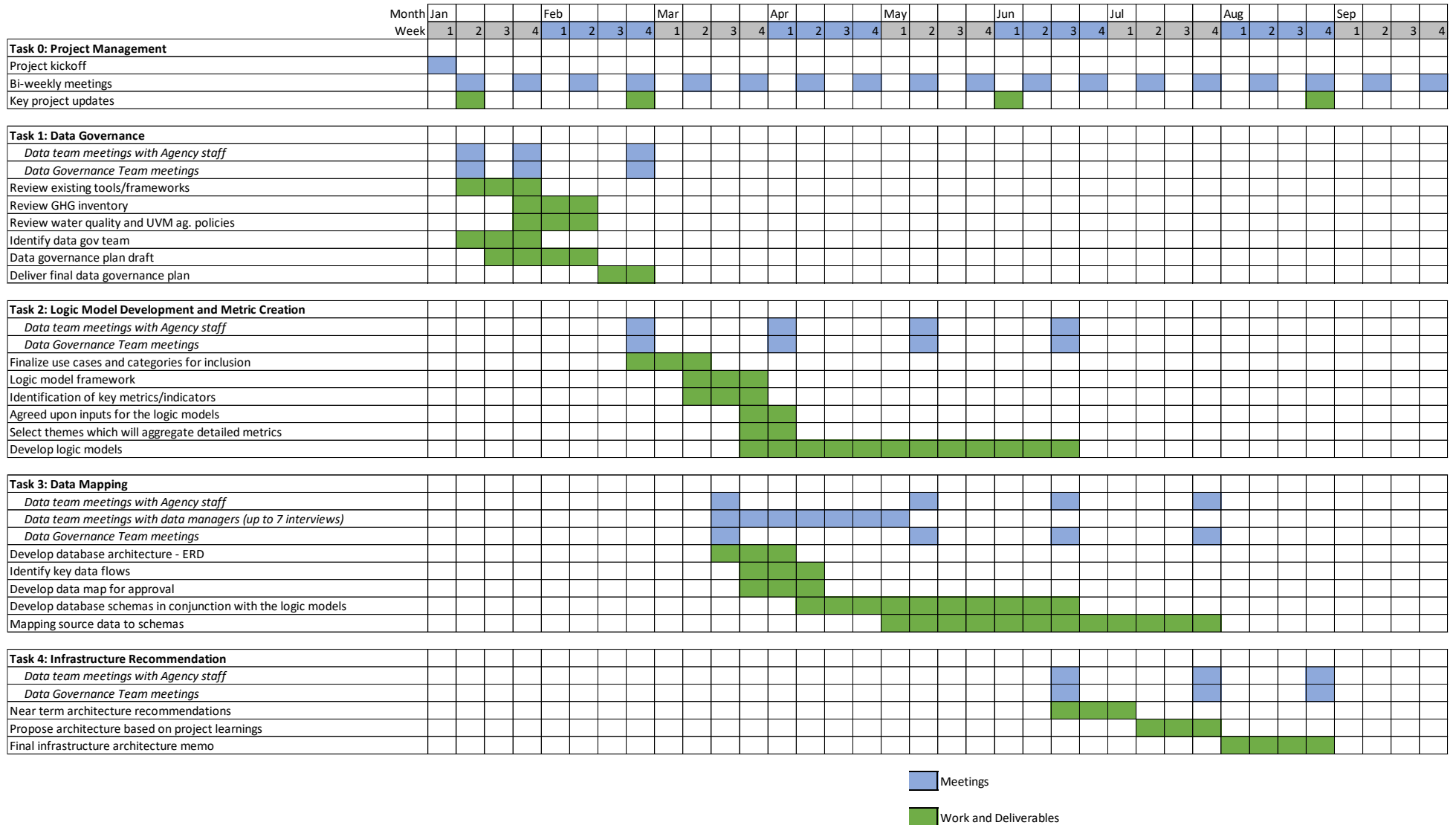
Deliverables

- Project kickoff meeting within two weeks after signing of contract
- Project initiation workplan within two weeks after signing of contract
- Ongoing project management tasks, including bi-weekly meetings and presentations through the project duration

for the review of the CAO Director. As per the review and agreed upon by the CAO Director and the PM, the work plan will be modified accordingly. We will conduct 30-minute bi-weekly check-in meetings with the CAO Director; these meetings will include leads from EFG and the University of Vermont, and other staff as relevant. The PM will communicate the meeting agenda to the attendees in advance of the meeting. In the bi-weekly check-in meetings, we will discuss the project's progress, review interim deliverables, tasks underway, and key decision points, and adjust the timelines if necessary. In addition, we will create a SharePoint site to provide all relevant documentation and status reports. The site will be accessible to the CAO Director, other CAO staff as needed, and our project team. The SharePoint site will function as a management dashboard where CAO can access project deliverables and check the status of project activities. The project team maintains active communication channels across the Team Cadmus, and the PM invoices the state for completed deliverables.

Figure 2 presents our proposed timeline of activities and milestones to complete Phase 1 within nine months.

Figure 2: Project Timeline



Team Cadmus will implement a modified Agile program management approach to meet the goals and requirements of the Agency and will adapt this as needed based, on the Agency’s feedback. **Table 2** presents a high-level overview of our project management approach.

Table 2: Management Approach

Step	Description
Project Monitoring	Cadmus will hold regular meetings via conference call with the Agency to discuss project progress, interim task findings, and proposed next steps. We will organize meetings and provide an agenda one day before the meeting to efficiently use meeting time. We will share updates on program progress and achievements weekly using a live tracker that the Agency staff can access in real time.
Cost Management	Cadmus has rigorous accounting policies, procedures, and tools in place to track project budgets and expenditures. We will provide the Agency with regular reports on budget status and progress and share monthly status reports to give the Agency insight into the budget, our progress toward project deliverables, and successes and challenges.
Project Management	Cadmus’ PM will hold frequent meetings with the team to align efforts, identify best practices, and implement lessons learned. We will develop detailed plans with tasks and timelines that clearly define processes and procedures; and will establish a communication cadence to provide stakeholders with advance notice of changes, hold team members accountable for deliverables, and identify and correct issues in real time.
Continuous Improvement	We will implement a continuous improvement process to identify challenges and opportunities in real time and course correct to optimize efficiency. Our continuous improvement process helps us address unforeseen changes or challenges. We will mitigate risk through comprehensive planning, and our supportive culture encourages our team to communicate, call out challenges, ask for help, and proactively recommend solutions.

Task 1.0 Data Governance

Team Cadmus understands that tracking data to assess the State’s progress on GHG mitigation, resilience, and adaptation efforts is an ongoing effort that will take decades and requires formal data management guidelines. As a result, Vermont needs a Data Governance Plan (DGP) – and a Data Governance Team to implement it.

To inform DGP development, we will review the Agency’s existing data-related assets, including three to five data-related tools, data frameworks, and the GHG inventory. During this review we will identify relevant data metrics, and how they may be aggregated to associated themes.

We will review the University of Vermont’s water quality data and agricultural policies in the Plan and identify cross-cutting relationships with GHG mitigation, appropriate metrics, and relevant data. We also anticipate reviewing other states’ GHG inventories and their data sources, the US Environmental Protection Agency’s (EPA) inventory tool, and the Energy Information Administration’s State Energy Data and Census. We will use this review to help identify and inform the amount of data the Tool will store, and to develop the DGP framework.

Deliverables

- Review of three to five relevant existing tools and/or data frameworks, GHG inventory, water quality, and UVM Extension data processes and associated recommendations
- Three Data Governance Team scoping meetings with the Agency that may include the S&D Subcommittee
- Three meetings with the Data Governance Team to develop the DGP
- DGP draft and final

Data Governance Plan Framework

Team Cadmus will build a DGP using a framework which consists of data policies, standards, and procedures. The DGP will include how the Agency will oversee and manage a rich set of data/metrics, and describe the actions taken and progress made to achieve GHG reductions aligned to the GWSA. The DGP will accommodate future data needs and coordinate relevant data and reporting across private and public entities. The DGP framework is summarized in **Table 3**.

Table 3: DGP Framework

Framework Component	Activity	Examples
Policies	Interview Agency staff to identify existing data policies and incorporate them into the DGP to create a comprehensive plan.	• Data creation and acquisition • Data storage and retention • Data security and protection • Data integrity and quality • Open and accessible data
Standards	Develop data standards to provide guidelines for existing and new data. Use existing IT standards and develop new standards for data gaps.	• Key data should have associated metadata • Key data should be unique • Key data should have associated data types and lengths • Key data should be cataloged
Procedures	Develop clear data procedures to define how data is handled through the Agency. Understand how the Agency works with data and incorporate these workflows into the procedures.	• Assigning data ownership and access • Using data to develop software • User guidelines on how to store, secure, and share data • How to resolve data conflicts • How to audit and review data for quality

The project team will prepare a draft DGP and provide it to the CAO Director for review. We will incorporate changes and feedback and submit the final DGP. Team Cadmus has developed data governance policies for multiple organizations to conform with ISO 27001 standards.

Data Governance Team. Team Cadmus will work with the CAO Director to identify a Data Governance Team. We will identify SMEs who understand the Tool's data, those with insight into IT policies, and those with availability, understanding, and skills for the following key project roles:

- Data Director – Provides overall team leadership and oversees the DGP
- Data Steward – Oversees Agency datasets and key SMEs
- Data Owner – Responsible for data quality, security, and appropriate use
- Data Quality Manager – Responsible for the quality of all Agency datasets
- Representatives for IT and business departments

Team Cadmus will collaborate with the Data Governance Team throughout the project to guide and refine the DGP so that it meets the Agency's needs.

Task 2.0 Logic Model Development and Metric Creation

Team Cadmus will apply our previous work with large-scale climate strategies and experience working with the VCC to capture informative metrics, effectively leverage them in a logic model suited to the identified use cases, and communicate the Agency's progress toward the Plan's goals and objectives. Our SMEs will work with the VCC to identify relevant indicators to build a coherent overarching framework. We will apply our expertise and unique understanding to create the foundation for a Tool that can help Agency stakeholders understand how these complex and diverse activities contribute to the Agency's goals.

Deliverables

- Within two months of the kickoff meeting Team Cadmus will provide a summary of framework use cases and categories, logic models, including identified metrics, indicators, and data needs.
- We will hold up to four meetings with Agency staff which may also include the Data Governance Team or S&D Subcommittee.

We will develop a final logic model in conjunction with relevant stakeholders and collaborate with the Agency to identify a structure that adequately reflects connections and cross-cutting relationships and is flexible enough to accommodate additional activities and outcomes. The example logic model below in **Figure 3** is a possible solution, modeled after the W.K. Kellogg Foundation "Logic Model Development Guide" (2004) and adapted for the needs of the Tool. The Tool would trace the pathway from inputs and resources to activities and enabling actions; to outputs and strategies; to cross-cutting outcomes; and finally to the impacts outlined in the Plan. A model such as this can be used to present metrics in an understandable and visually engaging interface.

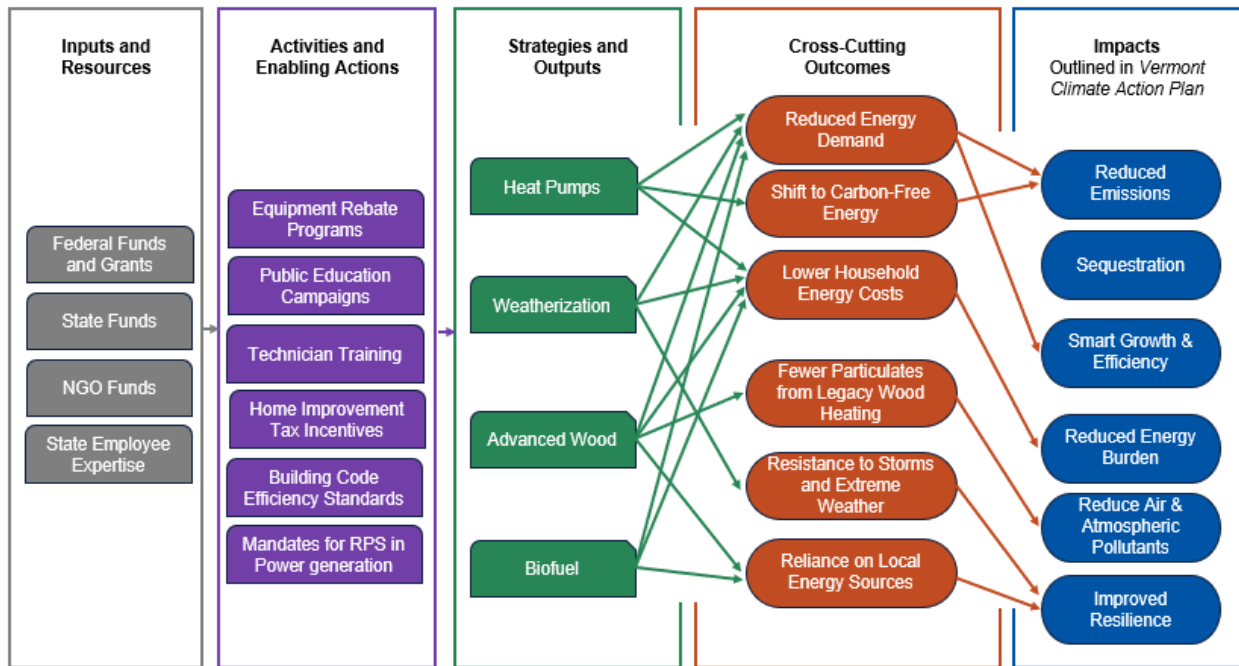
Figure 3: Logic Model Components



We will apply our expertise in climate change mitigation, resilience, adaptation and equity in designing the logic models with input from the S&D Subcommittee. We helped develop the Vermont Pathways Analysis in 2021 and the Vermont Thermal Sector study in 2022, and will apply this foundational understanding of these interconnected elements of the Plan. We will work with the VCC to identify use cases, define themes or focus areas, and engage relevant stakeholders in each area to build out the logic model. To that end, we will leverage existing relationships from past work supporting climate change mitigation, stakeholder engagement, and energy efficiency throughout Vermont for electric and gas utilities, Efficiency Vermont, Energy Action Network, community action agencies, and fuel dealers.

As the Agency has noted, the Tool might track over a hundred indicators. The logic model will characterize the relationships between them, and use these relationships to better understand larger processes. For example, **Figure 4** depicts a number of relationships for the home heating focus area. Each strategy and output may have one or more cross-cutting outcome, such as weatherization reducing energy demand, lowering household energy costs, and improving resistance to storms and extreme weather. These outcomes, in turn, lead to impacts.

Figure 4: Example Logic Model for Home Heating Focus Area



For Task 2, we will work with the Agency to identify key metrics and indicators that demonstrate Vermont's progress. For example, the following might be metrics used to characterize home heating strategies and outputs.

Strategy and Output 1: Heat pump adoption

- Metric: number of heat pumps installed (space heating)
- Metric: sales of FO heating, sales of natural gas, and sales of propane
- Metric: number of heat pump water heaters installed

Strategy and Output 2: Weatherized homes

- Metric: increase in number of weatherized homes

Strategy and Output 3: Advanced wood heat

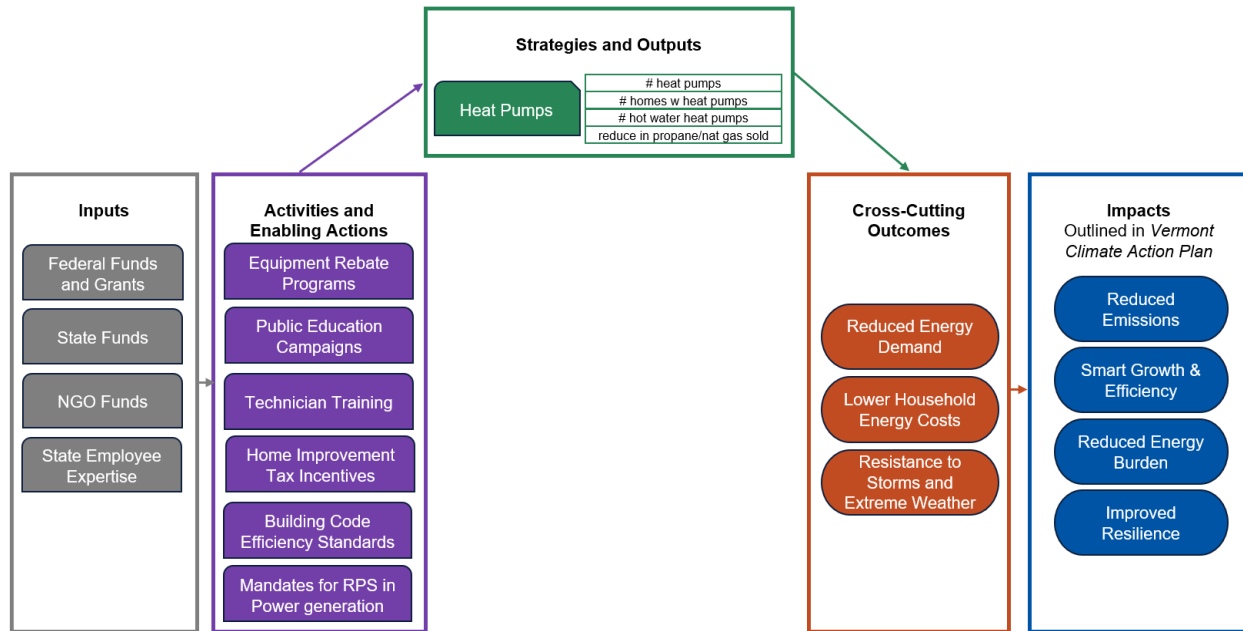
- Metric: number homes with wood heating

Strategy and Output 4: Adoption of homes with biofuels

- Metric: number homes with biofuels heating, blending % of biofuels

When navigating the logic model, users can focus on one strategy, view the metrics for that strategy, and see the inputs and enabling actions, resulting outcomes, and final impacts. **Figure 5** shows how the heat pump strategy could be examined in detail using metrics on the strategy and the connected components traced through the logic model.

Figure 5: Example Detailed View into One Home Heating Output/Strategy



Team Cadmus will complete a logic model for all sectors. For example, **Table 4** lists potential strategies, cross-cutting outcomes, and impacts from the transportation sector. Because the Tool will use a consistent logic model and store metrics in a consistent data structure, outputs from diverse sectors and programs can be analyzed holistically to comprehensively understand their cross-cutting nature.

Table 4: Sample Transportation Strategies, Outcomes, and Impacts

Transportation Strategies and Outputs	Transportation Cross-Cutting Outcomes	Transportation-Related Impacts
Public Transportation	Reduced Energy Demand	Reduced Emissions
Smart Growth Walkable Communities	Shift to Carbon-Free Energy	Smart Growth and Efficiency
Electric Vehicles and Accessible Chargers	Walkable Communities	Reduced Energy Burden on Rural and Marginalized Communities
Hydrogen Vehicles	Lower Commuter Financial Burden	Reduce Air and Atmospheric Pollutants
Biofuel Vehicles	Improved Local Air Quality	
Electrifying Public Fleet		

After the Data Governance Team has been formed, we will meet with them as soon as possible, preferably within one week. During this meeting we will confirm goals and objectives to monitor and assess. We will get input for the logic model from the S&D Subcommittee and the Data Governance Team. We will work with the Data Governance Team and Agency staff to finalize the relevant use cases and identify the focus areas, indicators, and metrics for inclusion.

To create the logic model Team Cadmus will:

1. Determine use cases and key focus areas.
2. Identify relevant actions related to reducing GHG emissions.
3. Select indicators and metrics for each step in the logic flow, covering all sectors and focus areas. Indicators may be quantitative (e.g., deployment of 170,000 electric vehicles) or qualitative (e.g., increase the knowledge of weatherization workforce). Team Cadmus may apply engineering calculations to quantify strategies and outputs where necessary and appropriate.
4. Inventory data needs, based on selected indicators and metrics.
5. Depict the connections from each activity and enabling action to specific strategies and outputs and the connections from strategies to specific cross-cutting outcomes.
6. Describe the connection from outcomes to long-term impacts. Review against the use cases from step 1 to ensure that all goals and focus areas are investigated.

Indicator selection will inform Task 3, where we will identify metric source data for the indicators and identify data gaps.

Task 3.0 Data Mapping

Team Cadmus understands that a critical deliverable for this phase is a comprehensive data map that illustrates the data flow from source to destination, data relationships, and dependencies between different datasets. Data mapping is a core part of preparing data for the Tool.

Our data mapping approach includes developing a visual diagram for each major data flow and how it is mapped to a destination. This could include a line chart showing a dataset of energy generation and how each fuel type maps to multiple categories, including impacts on emissions, equity, and resilience. Additionally, we will create a text-based catalog that lists all source and destination mappings.

While we create the source and destination flows, we may identify gaps (e.g., gaps in fuel types for residential, commercial, or industrial for geographic areas). For these instances we will recommend how to find relevant data from other datasets available outside of the State's GHG inventory, and document each metric, data type, and other characteristics. We recommend, based on previous experience with data mapping, that the source data destination be translated into a database schema. This level of granularity removes ambiguity about the data quantity and scope that will need to be presented in a user interface to help the Tool software developers. **Figure 6** presents a sample data map and database.

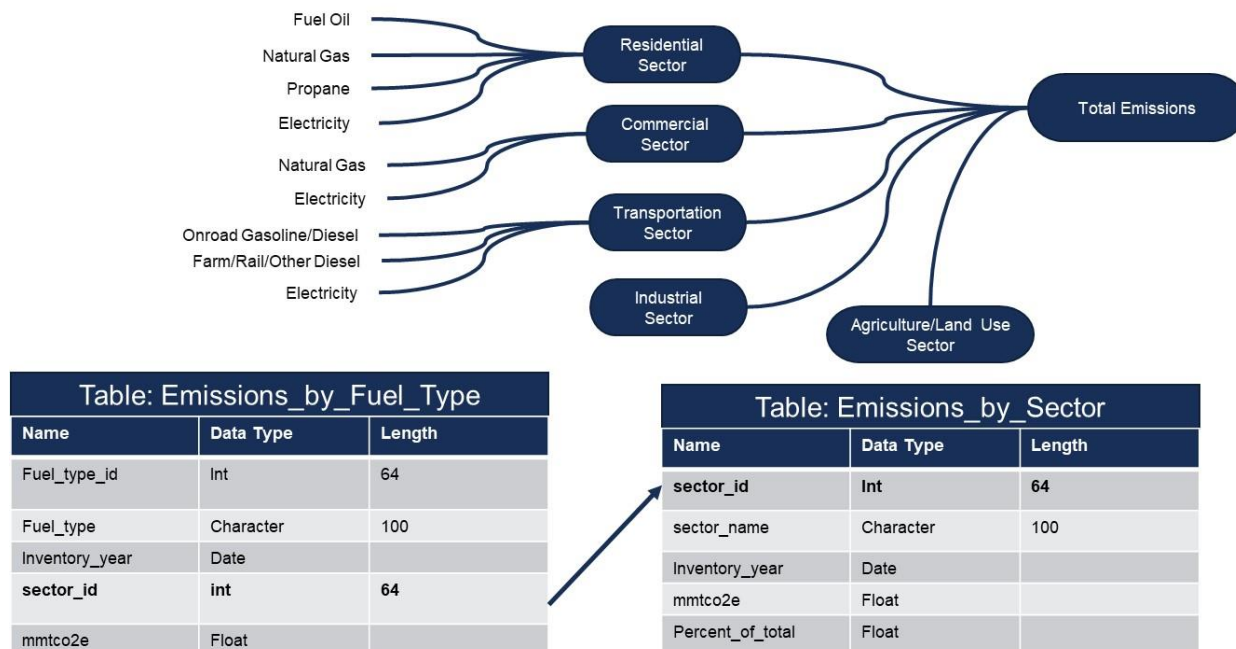
Deliverables

- Four working sessions with Agency staff, which may also include the Data Governance Team
- Seven data manager interviews
- Data map with logic model, metrics and indicators, data source, and data characteristics for Vermont's GWSA-related efforts

Data Mapping Expertise

Team Cadmus helped the California Public Utilities Commission (CPUC) create a data map for their statewide electric vehicle evaluation. In this capacity we helped CPUC answer how electric vehicle adoption impacts California's environment, people, and economy.

Figure 6: Data Map and Database Example



During Task 3 Team Cadmus will host working sessions with the Data Governance Team and interview internal and external Agency stakeholders. We will help the team reach consensus so that all desired data is represented, and also discuss the frequency of updates from data sources, based on the amount of data and availability of the source systems (if the source is outside of the Agency’s control).

Cadmus will work with the Data Governance Team to document the details of how and when data will get from source systems to the target Tool. For example:

- System A is accessible by an API and data may be gathered at any time
- System B is owned by the IT department and data can be transferred every 24 hours
- System C is external to the Agency and will only produce data via an offline manual batch request

Relational Data

Team Cadmus recommends maximizing data organization into a structure where different datasets can relate to each other. As shown in **Figure 6** different datasets may be joined by a unique identifier “sector_id”. By using a unique identifier data may be stored in a more flexible way and which allows for new relationships to be established. This flexibility makes it possible for Tool users to see data organized by all fuel types across inventory sectors.

Team Cadmus will deliver the data map and associated documentation described above to the CAO Director for review and approval at a subsequent working session.

Task 4.0 Infrastructure Recommendation

Based on our experience working on the Plan and other similar projects, we understand that the infrastructure for the Tool must be a complete solution that allows the Agency to manage data related to climate actions. This data should be presented via engaging graphs and reports that informs the public on achieving GWSA commitments. All data should be open and presented in a way that allows access to third parties for independent analyses.

Deliverables

Within nine months of kickoff meeting deliver draft and final Phase 4 memo to Agency staff, presentations to Data Governance Team and to S&D Subcommittee

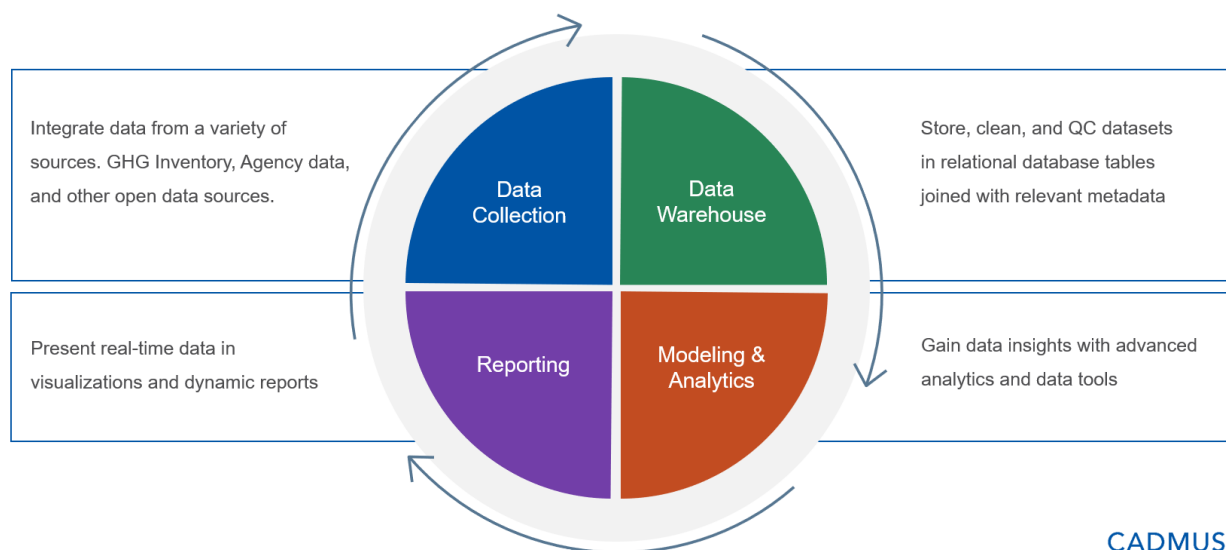
To recommend the best infrastructure options for the Agency, Cadmus will work with the Agency staff to better understand the existing IT infrastructure and policies. Based on interviews with the Data Governance Team, IT staff, and other technology SMEs, Cadmus will deliver a specific infrastructure recommendation.

Team Cadmus has built multiple web-based platforms for commercial and government clients that achieve goals that are similar to those identified by the Agency. These web-based platforms follow a common industry standard architecture shown in **Figure 7**. The diagram represents a sample of this architecture which has four functional areas. Each area moves data from initial collection to the final step of presenting it in visual charts, graphs, and reports.

Figure 7: Infrastructure Overview

Infrastructure Overview

Diagram of a common data-driven web application



This infrastructure will support automated intake and cleansing of diverse data; custom security and compliance workflows for storage; a flexible analytics engine that can integrate analytical processes to

enrich data; and custom reporting templates and data visualizations to help the Agency make informed data-driven decisions. A brief description of each of these functional areas follows.

Data Collection. This functional area ingests data from multiple sources. Automated data “pipelines” are created to move source data and place it into the *Data Warehouse*. Cadmus will work with the Data Governance Team to determine how often data will be collected from the source systems.

Data Warehouse. This functional area is where data is stored in a structured format, each data metric has a specific data type and an associated set of metadata that describes what the metric represents. Cadmus recommends that the source of the data is also stored in this set of metadata. This is where relational data, shown in **Figure 6**, is stored and organized in a logical way which supports the *Reporting* functional area. In addition, a well-built data warehouse will support sustainable data management (priority outcome #2) to accommodate adding new data in the future.

Modeling and Analytics. This functional area uses custom and open-source data modeling programs that provide deeper data-driven insights for *Reporting*. Our data scientists apply data logic within this functional area to improve quality, accessibility, and data usability to improve decision-making.

Reporting. This functional area presents dynamic, real-time data in user-friendly formats. We know that one of the Agency’s priority outcomes is to provide open and accessible data. We will do this by ensuring that data in the reporting functional area can be easily exported in open data formats such as comma separated values (csv) files.

The reporting functional area will allow the Agency to produce custom reports and self-service dashboards with compelling charts and graphs (priority outcome #5) that tell a visual story of trends, comparisons, or correlate findings over time. Users can generate outputs in most the relevant format – either for further analysis or to visualize and better understand data. Users can also generate reports in custom templates or view results dynamically in a suite of dashboards and visualization tools.

Cadmus Project Team

Team Cadmus’ core staff is shown in **Figure 8**. PM Ryan Bodanyi expertise includes data fluency and an extensive background in climate action and project management; he will answer to and be supported by our Project Director, Chad Laurent, with additional support from Senior Advisor Jim Sprague. We have included resumes for these personnel at the end of the document.

Figure 8: Cadmus Organization Chart

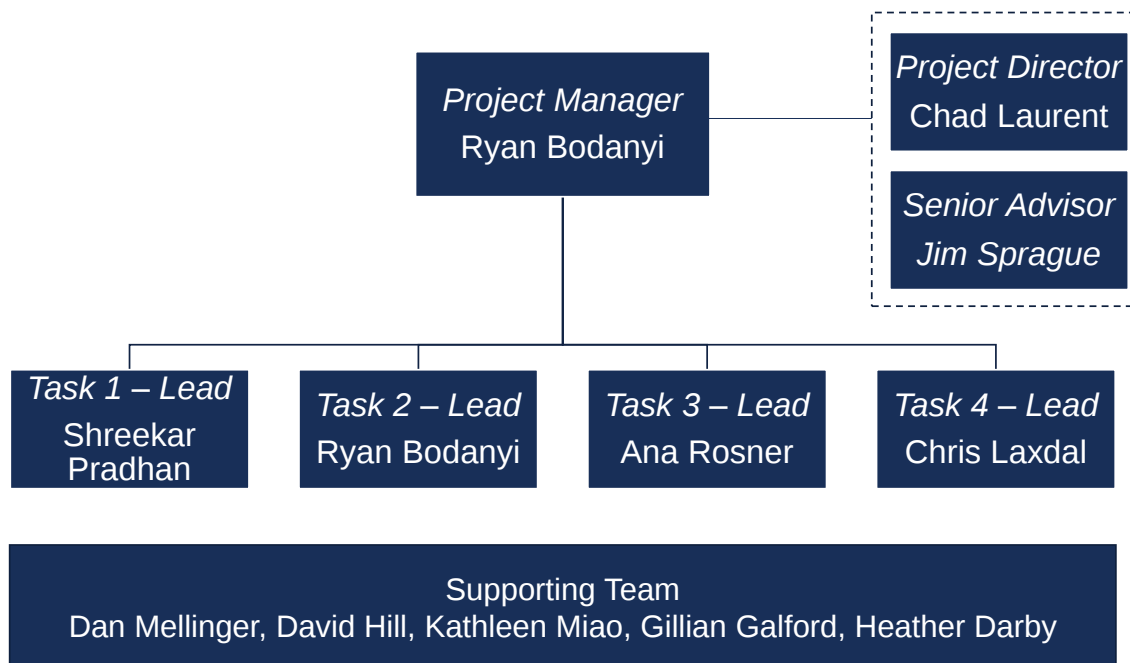


Table 5 presents our team, including roles, and relevant experience. Our proposed staff have the capacity and availability to meet the Agency’s timeline. In addition to our proposed staff our team can draw on SMEs from across the firm who have expertise in decarbonization and modeling, environmental and economic modeling and policy analysis, inventorying GHG emissions, setting science-based targets, and designing LEAP inputs as needed.

Table 5: Team Qualifications

Name/Role	Experience Summary and Relevant Projects
<i>Cadmus</i>	
Ryan Bodanyi, PhD, PMP Project Manager Task 2 Lead	Ryan has more than 20 years of environmental experience, and brings a unique combination of data fluency, project management expertise, and familiarity with climate action. The former comes from his quantitative PhD, focused on what local governments are doing to mitigate their GHG emissions, and why. That expertise was honed at the Center for Sustainable Energy (CSE), where he oversaw data collection, management, visualization, and analysis across five statewide rebate programs for electric vehicles, disbursing \$200 million/year. He earned his certification in project management (PMP) in 2017, and since then has overseen nearly two dozen projects at CSE, CivicWell, and Cadmus. His work is climate-focused, including resiliency (helping water utilities adapt to climate change), mitigation (helping New York develop its cap-and-invest program), and equity (tailoring EV incentive programs to better serve disadvantaged communities). He started his career as an organizer, building climate and environmental justice campaigns for the National Wildlife Federation, Clean Water Action, and the Clean Air Task Force which required expertise in logic models, stakeholder engagement, and process improvement. Relevant projects. New York Cap-and-Invest (for NYSERDA and DEC); CREAT (for the US EPA); Community Choice Aggregation (for Calpine); the California Climate and Energy

	Collaborative (for BayREN, SoCalREN, and 3C-REN); Clean Vehicle Rebate Program Evaluation (for CARB).
Shreekar Pradhan, PhD Task 1 Lead	Shreekar is an energy and environmental economist with 12 years of experience in the economics of energy and environmental policies. He specializes in the economic analysis of energy and climate policies. He has developed energy system models used in energy system planning analysis that are technology-rich and bottom-up. Shreekar has worked in large-scale data analysis in the distributive computing platform. He is experienced working in Azure Data Factory, SQL, and Databricks, and skilled in scenario-based policy analysis using energy system models to integrate assessment models, computable general equilibrium models, and dynamic stochastic general equilibrium models. Relevant projects. New York State Energy Research and Development Authority (NYSERDA): Building Efficiency and Electrification Model (BEEM) Upgrade, Southern California Edison: Standard Review Projects, Public Service Electric & Gas Company (PSE&G): Clean Energy Future Evaluation, Montgomery County Public School: MCPS GHG Emissions and Reduction Strategies, NYSEDA: Decarbonization Guidebook, Metropolitan Washington Council of Governments: GHG Inventory, Mass Audubon: Net Zero Strategy, University of Virginia: Negative Emissions Strategies in Meeting Virginia Carbon Neutrality Goal 2050, University of Virginia: China's Carbon Neutrality Goal 2060, University of Virginia: Economic Effects of Virginia's Net-Zero Carbon Neutrality Goal 2050, The Trustees for Conservations: GHG Inventory, Vermont Agency of Natural Resources: Vermont Marginal Abatement Cost Curve, City of Walnut Creek, CA: Cost-Benefit Analysis of Climate Mitigation Strategies, and Enbridge: Greening of Grid in Enbridge Regions.
Ana Rosner Task 3 Lead	Ana has 11 years of experience in data analytics, environmental modelling, climate change adaptation, cloud computing, and data visualization in federal, commercial electric, NGO, and local government sectors. She has worked extensively with large datasets, constructing automated data processing methods, developing data QA plans, and training teams on best practices for analytics and documentation. With a background in environmental and statistical modelling, she is adept at translating scientific research into actionable information and developing dashboards for decision-support. Relevant projects. U.S. EPA Creating Resilient Water Utilities, Northwest Energy Efficiency Alliance Commercial Building Stock Assessment (CBSA), USAID Climate Profiles, and US Army Corps of Engineers Climate Change Vulnerability Assessment Tool (VA Tool), US Cybersecurity and Infrastructure Security Agency Exercise Analytics, Climate-Ready DC.
Jim Sprague Senior Advisor Data Mapping and Data Governance, Logic Model	Jim has 20 years of technology and business experience in the government and commercial sectors across several business functions and technology markets (including enterprise software and hardware, professional services, and sales and engineering leadership). He has domain expertise in public cloud computing (AWS and Azure), data analytics, business intelligence, big data technologies, and software development. Jim supported 15+ data-driven projects for the electrical utility industry and is a SME in scaling computing resources to meet the industries increasing data demands. He is results-driven and has exceptional business and communication skills and a proven history of building and directing high-performance teams and managing technical change. Relevant projects. NYSEDA building efficiency and electrification model (BEEM) - architecture guidance, U.S. Department of Energy (DOE) and Bonneville Power Authority - technical lead, California Standard Review Projects EV evaluation – platform development and guidance, NOAA scientific journal search engine – development lead.

Chris Laxdal Task 4 Lead	Chris has 15 years of professional IT experience. He is a lead data architect, senior extract-transform-load (ETL) developer and data warehouse implementer who excels in data analysis and management; designing, developing, and implementing data warehousing solutions, systems integration, data conversion, data warehouse design, report, dashboard and query development, troubleshooting and issue resolution, and communicating with technical and nontechnical staff. He has extensive experience designing and implementing high-performance database and reporting solutions for customers with large datasets and a high volume of transactions. Relevant projects. New York State Energy Research and Development Authority (NYSERDA) Code to Zero Initiative – data architect, data modeling, integration development; NYSERDA Building Efficiency and Electrification Model (BEEM) – data architecture, data modeling, technical resource; E4 the Future – Residential ccASHP Building Electrification Study – data architecture, data modeling; PPL EMV PhaseIV – integration development, technical resource; EmPOWER EMV Res EE – integration development, technical resource.
Chad Laurent, Esq., PMP Project Director	Chad is a Sustainability and Clean Energy Principal with the Cadmus Group LLC and former Vice President and General Counsel at Meister Consultants Group. Chad specializes in clean energy law and policy, decarbonization strategies, stakeholder engagement, and clean energy project development. He is a nationally recognized expert in clean energy market development and soft cost reduction strategies. He frequently works with local governments across the country to develop and implement decarbonization, net zero, and 100% clean energy strategies. He has managed large technical assistance programs on behalf of state and federal agencies for over a decade. He has over 15 years of experience supporting dozens of municipalities with solar procurement including multi-megawatt-scale projects. His expertise includes procurement, financing, zoning, solar access and rights laws, permitting, planning, and renewable energy as an economic development tool. In addition, Chad has worked with over 30 public-sector clients providing regulatory, technical, and program assistance for energy efficiency and renewable energy development. He manages Cadmus’ role in multiple Department of Energy programs including the SolSmart Designation program, the Solar in Your Community Challenge, and Fleets 4 the Future. He was the lead author for the Pathways to 100 and Pathways to EV reports and has managed multi-year, multimillion-dollar programs at the federal and state levels. Relevant projects. Net Zero Project Management Office and Implementation Support, Massachusetts Port Authority (Massport), Rhode Island Carbon Pricing Study, Rhode Island Office of Energy Resources, SolSmart Designation Program, U.S. Department of Energy (DOE), and Massachusetts Executive Office of Energy and Environmental Affairs: Massachusetts Decarbonization Study.
<i>Subcontractor EFG</i>	
David G. Hill, PhD Support for Data Mapping, Data Governance, Metric Creation	David has more than 25 years of expertise in sustainable energy program design and evaluation, and renewable energy policy. He worked for VEIC for 22 of those as Director of Distributed Resources and a VEIC Policy Fellow. David has been the principal investigator and led analysis teams for multi-year stakeholder-informed studies on solar market and decarbonization pathways and scenarios. For Phase 1 David will participate and present at stakeholder, and client meetings and apply his expertise having led the analytic scenario modeling for clean energy transition and climate action plans, including using scenario planning and reporting tools, including multi-scenario, sensitivity, long-range, and economy-wide scopes of work. Relevant projects. Massachusetts Executive Office of Environmental Affairs (EOEA), U.S. Department of Energy Sun Shot Initiative, Pennsylvania Department of Environmental Protection, Vermont Department of Public Service, Burlington Climate Alliance.

Dan Mellinger
Logic Model Lead

Dan has 24 years of experience specializing in the design, planning and administration of energy efficiency programs, with an emphasis on commercial and industrial sectors. He provides technical consultative services on efficient technology capabilities, market analysis, technology adoption, energy savings potential, industry standards, training, and financing. He is experienced in the policy and regulation of demand-side management goal setting, budgets, annual reporting, and performance incentives. Dan has consulted on hundreds of commercial efficiency projects across many jurisdictions nationwide and has designed and administered industry-leading commercial lighting programs.

Relevant projects. Vermont Agency of Natural Resources, Vermont Demand Resources Plan. General Services Administration (GSA), DesignLights Consortium (DLC). Rhode Island Energy Efficiency & Resource Management Council.

Chris Neme, EFG Founding Partner,
Senior Advisor and Editor

Chris has over 25 years expertise helping clients in more than 30 states, six Canadian provinces, and several European countries with energy efficiency, demand response, strategic electrification and other distributed energy resource market assessments, programs and policies. He will provide expert review and input on all reports. Chris has filed expert witness testimony on these issues in more than 60 dockets before energy regulators in 13 states and provinces, and before several state legislatures. Chris also authored or co-authored reports and papers on clean energy policies and programs, including the 2017 National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources (NSPM for EE), the 2020 National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources (NSPM for DERs), and several reports on non-wires alternatives. Chris currently serves as a co-chair for the Energy Action Network Clean Heat Standard working group. Chris led an analysis of the costs and emission reductions possible from a number of different program options for decarbonizing Vermont buildings which was ultimately presented to the Vermont state legislature by Regulatory Assistance Project in February 2019.

Relevant projects. Vermont Energy Action Network working group co-leader, E4theFuture – National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources, Plan for meeting Green Mountain Power RPS Tier 3 obligations and development of Tier 3 savings assumptions, Review of Green Mountain Power's electricity forecast and the development of alternative 10-year forecasts of sales, energy efficiency, demand response, integrated resource planning, strategic electrification, distribution system planning, non-wires solutions and other related clean energy policies and programs support for Natural Resources Defense Council – Midwest Office.

Kathleen Miao, Logic model
development, Support for Data
Mapping, Data Governance, Metric
Creation

Kathleen has four years of experience as a Project Coordinator where she provides data analysis and project management. She works with climate models and large datasets to help clients make actionable decisions. She also supports projects that focus on deep energy reduction, decarbonization, electrification of existing buildings, and movement towards a carbon-free future.

Relevant projects. Natural Resource Defense Council (NRDC), Southern Environmental Law Center (SELC), Department of Energy (DOE), Northeast Energy Efficiency Partnerships (NEEP), and Massachusetts Clean Energy Center (MassCEC).

University of Vermont

Gillian Galford, PhD

Gillian is a Research Associate Professor in the Rubenstein School of Environment and Natural Resources, and a Fellow of the Gund Institute for Environment at the University of Vermont. She studies land-cover and land-use change and its impacts, particularly on GHG emissions. She works across scales, from plot level studies on farms to regional analyses through remote sensing and ecosystems modeling. Gillian leads the Vermont Climate Assessment. Her colleagues represent universities in the United States, Brazil

	and Cuba, NGOs (e.g., Imflora, Ceres, and IFPRI), international research organizations (e.g., CCAFS and IPAM) and government institutions (e.g., USAID and Vermont agencies). Gillian maintains active research projects funded by NASA, NSF, USDA and private foundations. Relevant projects. Vermont Climate Assessment, PI G. Galford; vtclimate.org, 2014, 2020-2021, PI C. Adair, Co-I G. Galford. The state of carbon in Northeast forests: Creating an Integrated Soil Carbon (iSoC) inventory to explore and understand what drives variation in soil carbon across scales and with management, USDA Forest Service McIntire-Stennis, PI L. Chase et al., Co-PI G. Galford. The Farm-Community Nexus: Metrics for Socioeconomic and Ecosystems Sustainability of Agritourism and Direct Farm Sales in Vermont, USDA ARS, PI Wollenberg, Co-PI G. Galford. 01/01/15-06/30/2017. “Reducing and accounting for agriculture-driven GHG emissions in USAID’s agriculture related work” U.S. Agency for International Development, PI E. Davidson et al., Co-I G. Galford. Disrupted Nitrogen Cycles in the Brazilian Amazon, NSF Division of Environmental Biology (Ecosystems).
Eric Roy, PhD	Eric is an Assistant Professor of Environmental Sciences focusing on Ecological Design within the Rubenstein School of Environment and Natural Resources. He leads the Nutrient Cycling & Ecological Design Lab at the University of Vermont, working at the interface of ecology and engineering, and focusing on water, food systems, and resource management. A common thread of his research is nutrient cycling. His group quantifies the forms, biogeochemical transformations, and fluxes of essential nutrients for life on Earth, to clarify important processes that underpin ecosystem function; identify opportunities for beneficial intervention, and; design systems that achieve nutrient management objectives. This includes analyzing soils, sediments, plants, water, and organic residuals in engineered, urban, and agricultural ecosystems. He also works with material flow analysis, modeling, and GIS to study nutrient dynamics at larger spatial scales. In this capacity he engages with organics recycling businesses, farmers, pioneers in resource recovery from human waste, and fellow academics from diverse disciplines. Relevant Projects. The Nature Conservancy Vermont: Net GHG mitigation in Vermont wetlands and floodplains. 2022-2023. Lake Champlain Basin Conservation Effects Assessment Project (CEAP): Evaluation of innovative and stacked conservation practices at the field-scale. USDA NRCS.2020-2023. Mapping and Building Sustainability Partners for Global Impact. Amazon. 2023.
Heather Darby, PhD	Heather has more than 26 years of relevant project experience. She is currently an agronomic and soils specialist for the University of Vermont Extension. Her expertise includes delivering science-based information to the farming community, sustainable agriculture and promoting environmental stewardship of the land. In addition, she implements applied research and outreach programs in the areas of fuel, soil, forage, and grain production systems throughout the Northeast. Her outreach programs deliver on-farm education in soil health, nutrient management, organic grain and forage production, and pest management. Her research focuses on traditional and niche crop trials, weed management strategies, and sustainable cropping systems development. Relevant Projects. Nutrient Cycling in Organic Field Crops in Canada and the United States. Resilient Soils for Resilient Farms: An Integrative Approach to Assess, Promote, and Value Soil Health for Small- and Medium-Size Farms. Evaluating Winter Barley Cultivar Using Data Envelopment Analysis Models.
Joshua Faulkner, PhD	Josh has more than 13 years of relevant experience. He is currently the Interim Director, the University of Vermont Extension Center for Sustainable Agriculture, a Faculty Fellow at the Gund Institute for Environment, the Director of UVM’s Agricultural and Environmental Testing Laboratory, and a Research Associate Professor, University of Vermont Extension. His expertise includes climate change impacts and adaptation in Northeastern agricultural systems; treatment of agricultural wastewater and best

	management practices for control of nonpoint source pollution; field scale hydrology and water management in agricultural landscapes, fate and transport of nutrients in soil and water biological and environmental engineering; soil and water concentration; agricultural and biological engineering; soil and water concentration, and biological systems engineering, land and water resources. Relevant Projects. Expanding Weather Data Availability for Watershed Modeling: Integrating High-Density GHCN Data with Missing Data Estimation Techniques. Enhancing Watershed Model Calibration in Low-Data Environments: A Multi-Basin Calibration Approach.
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Current and Past Projects

Team Cadmus has supported seven projects in the state of Vermont. **Table 6** presents our work in Vermont along with relevant project work for other states. We will apply this expertise and understanding to support the Agency in this next phase.

Table 6: Current and Past Projects

Project	Relevance
<i>Vermont-Specific Projects</i>	
Vermont Pathways Analysis Report <i>Vermont Agency of Natural Resources, pathway analysis, GHG reduction targets 2021–2022</i>	<i>Understanding of the climate planning at the state level, strategies, actions, sub-actions, pathway analysis, GHG reduction targets</i> Cadmus, in partnership with Energy Futures Group and the University of Vermont, worked with the Agency and the VCC to assess Vermont’s GHG inventory, develop a carbon budget, research a social cost of carbon, and analyze pathways for Vermont to achieve at least an 80% reduction in GHG emissions by 2050 and a 26% reduction from 2005 by 2025 and 40% from 1990 by 2030. We recommended how to align Vermont’s emissions inventory with the GWSA objectives and GHG emissions requirements. To do this we reviewed Vermont’s current emissions inventory and data sources (e.g., methodology, data inputs, emissions factors and global warming potential values, and best-practices for sector-based and consumption-based inventories). We reviewed how other states in the region approached carbon budgeting, to assess best practices on methodology and data sets, and the developed a carbon budget (stocks and fluxes) including opportunities to collaborate on strategies. The team adapted FAO’s EX-ACT tool as the framework for Vermont’s Carbon Budget and used IPCC emissions methodologies to account for GHG emissions impacts of activities in the Agricultural, Forestry, and other Land Use sectors. We also analyzed and built on completed Pathways to align them with GWSA targets and other state work. We recommended amendments to and the integration of the Cost of Carbon analysis into the state’s LEAP modeling, conducted economic analysis including a marginal abatement cost curve, and IMPLAN modeling to inform prioritization of Pathways to achieve GWSA targets. The team created a searchable database in Excel that identifies Vermont’s available mechanisms to reduce emissions in each sector, and the existing rules and regulations, codes and standards, programs, subsidies and incentives, and financing that are in use to reduce emissions. This supports strategy development, and is used by the State and the VCC as they design and implement state and local policies, programs, and initiatives. With this baseline, the team assessed opportunities recommended by the VCC to implement the strategies analyzed in Task 3 and develop pathways to achieve the GWSA reduction requirements for 2025, 2030, and 2050. During development of the Plan, the team developed a tracking and reporting tool that allows the State to track and report on important metrics going forward to verify that they are on track to meet the GWSA requirement.

Heat Pump Evaluation Vermont Department of Public Service (PSD), 2016–2017	<i>Understanding of key metrics/indicators, inputs for logic models, and themes to aggregate detailed measures.</i> Cadmus evaluated cold-climate heat pump (ccHP) systems operating in Vermont to understand the extent to which the state should promote ccHP efficiency measures. Cadmus conducted 65 site visits, analyzed AMI data, and surveyed 135 Vermont homeowners who received a rebate for the purchase and installation of a program-qualifying ccHP. Cadmus metered ccHPs and other heating systems for two heating seasons and one cooling season, recorded heating fuel consumption, analyzed utility interval meter data, and collected qualitative data to understand homeowner perspectives. We examined heating and cooling energy use and information collected through homeowner surveys and site visits, and assessed homeowners’ motivation to install ccHPs, their ccHP equipment use, the home’s alternative or baseline equipment options, and occurrences of fuel switching and load building.
Commercial Building Market Study and Code Review Vermont PSD, 2015–2017	<i>Understanding of key metrics/indicators, inputs for logic models, and themes to aggregate detailed measures.</i> Cadmus performed a stock assessment of new and existing commercial buildings in Vermont, and examined all energy-related characteristics of business facilities, including building shell, lighting, HVAC equipment, plug loads, and process equipment. We characterized the energy use of business facilities for Vermont as a whole and within the jurisdictions of Efficiency Vermont, Burlington Electric Department, and Vermont Gas Systems. Staff visited over 250 buildings to examine building attributes and record data on Cadmus’ custom tablet-based software data collection tool that resided on iPads. The software also allowed field technicians to examine the code compliance of the new buildings. Cadmus designed the study to allow for direct comparison with the previous stock assessment of commercial buildings. We also conducted 32 in-depth telephone interviews with market actors, including electrical distributors (i.e., lighting suppliers), lighting professionals (e.g., designers, specifiers, and architects), building decision makers (e.g., owners, property managers, and operators), and HVAC designers, distributors, and installers.
Efficiency Vermont Continuous Energy Improvement (CEI) Pilot Vermont PSD, 2015	<i>Understanding of key inputs for logic models, and themes to aggregate detailed measures.</i> The Vermont PSD contracted with Cadmus to evaluate Efficiency Vermont’s CEI Pilot to help participants achieve lasting energy consumption reductions and increase customer engagement. The pilot launched in 2013 and included two cohorts of industrial and large commercial facilities. CEI incorporates energy management practices into regular business operations integrate waste reduction and energy consumption into the workplace culture. Cadmus conducted impact and process evaluations. We used the normalized metered energy consumption (NMEC) approach to develop baseline consumption models and estimated energy savings from CEI for individual participant facilities. We also interviewed stakeholders and pilot participants, assessed participant satisfaction and how participants implemented specific energy management elements. Cadmus calculated the pilot’s cost-effectiveness for a range of CEI measure life assumptions and determined that the pilot was cost-effective for a measure life greater than three years.
Evaluation of Efficiency Vermont’s Annual Savings Claim Vermont PSD, 2014–2019	<i>Understanding of key inputs for logic models, and themes to aggregate detailed measures.</i> Vermont PSD evaluates Vermont utilities’ energy efficiency programs including Efficiency Vermont. Cadmus conducted the annual verification of the energy, coincident peak, and total resource benefits savings claimed by Efficiency Vermont for its portfolio of commercial, industrial, and residential demand side management programs portfolio. In this capacity we assessed fuel-switching measures involving thermal energy

	and process fuels, provided realization rates at program, sector, and portfolio levels for each savings component, and verified the application of evaluated realization rates. Cadmus selected and evaluated four stratified random samples of projects to evaluate claimed savings for commercial and industrial custom projects to analyze and report on budgets. We requested detailed project files for each sampled project (e.g., metering or energy management system data, invoices, post-installation inspection reports, and project documentation) and created an evaluation report for each project that summarized the project, documented issues with claimed savings calculations or documentation, and summarized evaluated savings. For commercial prescriptive and residential upstream program categories we reviewed databases and compared reported savings against savings calculated using the Vermont Technical Resource Manual. For the Residential New Construction Program, we verified that inputs to REM/Rate modeling software yield results consistent with reported savings.
Energy Efficiency Potential Study Vermont PSD, 2010–2017	<i>Understanding of key inputs for logic models, and themes to aggregate detailed measures.</i> Cadmus was a subcontractor to GDS Associates. In this capacity, we assessed electric and natural gas energy efficiency potential in the commercial and industrial sectors for Vermont’s three energy efficiency utilities. Estimates of energy efficiency potential informed the utilities’ energy efficiency plan by setting savings targets and identified acquisition costs. Cadmus also researched demand response programs and developed a demand response catalog. We used a bottom-up energy efficiency potential model to forecast savings in the commercial sector and a top-down approach for the industrial sector. This involved disaggregating each sector into market segments and vintages, characterizing baseline details, developing a baseline end-use forecast, researching the savings and costs for energy efficiency measures, and forecasting energy efficiency potential using the baseline forecast and measure savings estimates. Cadmus and GDS Associates delivered forecasts of realistic achievable potential and maximum achievable potential for each utility. Two of the energy efficiency utilities, Burlington Electric and Vermont Gas, relied on Cadmus to inform their energy efficiency plans. This involved delivering energy saving targets and acquisition costs. Cadmus and GDS Associates provided ongoing support through each utilities’ filing process by estimating conservation potential for different program scenarios.
Standard Offer Regulation Development Renewable Energy Vermont (REV), 2009–2010	<i>Understanding of key inputs for logic models, and themes to aggregate detailed measures.</i> In 2009, the Vermont Public Service Board opened Dockets 7523 and 7533 to investigate the development of standard offer prices for qualifying renewable generation under the Sustainably Priced Energy Enterprise Development (SPEED) program. Cadmus supported REV’s participation in the SPEED regulatory proceedings. Standard offer rates for 50 MW of new renewable energy capacity were set in January, 2010. Cadmus prepared and delivered written and oral testimony regarding setting rates for photovoltaic, wind energy, landfill gas, biomass, farm biogas, and small hydropower systems, and developed a rate setting model that was adopted by the state for setting the standard offer rates for each of the target technologies.
Other Relevant Project Work	
Clean Energy and Climate Plan Metric Tracking Services Massachusetts Executive Office of Energy and Environmental Affairs (EEA), 2021–2022	<i>Understanding of key metrics/indicators, experience in developing climate metric tracking systems and designing a reporting system for policy action use cases.</i> Cadmus developed the Clean Energy and Climate Plan Metric Tracking System for Massachusetts EEA and developed visualizations from these metrics on interactive websites. This work was in continuation of our previous project that supported the development of Commonwealth’s 2025/2030 Clean Energy and Climate Plan (CECP). Cadmus collected, analyzed, and reported on several key clean energy and climate

	planning metrics those required by Massachusetts climate legislation and supporting metrics that provided additional insight on Massachusetts’ progress toward meeting statutory GHG limits. The metric tracking system helped EEA collect, clean, manage, analyze, and report data from public and agency data sources, including the U.S. Census Bureau, Energy Information Administration, Massachusetts Registry of Motor Vehicles, Massachusetts Department of Environmental Protection, Massachusetts Clean Energy Center, and Massachusetts Department of Energy Resources. Deliverables included a metric tracking system, data catalogues, technical documentations, data collection, and supporting analysis to create key metrics to meet EEA’s internal reporting deadlines, a suite of visualizations, graphs, and charts of the metrics, report layout and design of 2025/2030 CECP.
Greenhouse Gas Inventory Updates <i>Metropolitan Washington Council of Governments (MWWOG), 2022</i>	<i>Understanding of key inputs for logic models, GHG inventory at the regional level, data sources and mapping.</i> Cadmus helped MWWOG develop the regional and 24 MWWOG members’ individual GHG inventories. This work built off of the MWWOG GHG inventory business as usual updates and training sessions. We supported MWWOG GHG inventory business-as-usual projections; emissions scenario development; methodology improvements; comprehensive data collection and review; sectoral trend analysis; and modeling, projection, and tracked GHG mitigation metrics, fuel consumption, fuel intensities, and emissions over time. Cadmus also helped MWWOG develop updated GHG inventory projections and emissions reduction scenarios for four sectors of MWWOG inventories, including non-utility fuel in the residential and commercial sectors, agriculture, commuter rail, and hydrofluorocarbons (HFCs). We reviewed existing methodology and revised the method based on a comprehensive review of the datasets from ACS, RECS, CBCES, Res Stock, and Com Stock to help MWWOG update the methodology that accounts for non-utility fuel consumption. Since much of the non-utility fuel consumption was not readily available in the MWWOG region, we also examined the fuel consumption pattern in nearby regions. To do this we reviewed datasets available from the energy benchmarking initiatives in Washington DC, Montgomery County, and New York and Pennsylvania. Further, we explored modeling tools like SLOPE, CURB, NEMS, and GCAM to identify if these could provide fuel consumption that could be downscaled to the MWWOG region. Based on our review, we recommended revising the methodology to account for the non-utility fuel consumption in residential households and ensure the methodology was simple, tractable, and consistent with the currently available datasets and also future datasets. We recommended not revising the current methodology for the commercial sector, due to the lack of relevant data. Based on our recommendation, we revised the previous GHG inventories along with tracking these updated inventories in the ClearPath tool. We also supported MWWOG in tracking mitigation measures metrics for the 2030 Climate Action Plan, which focused on updating MWWOG’s Green Building Database. We collected data from third-party certified/rated green buildings—LEED, ENERGY STAR, EC, PHIUS, and LFI for calendar years 2019, 2020, and 2021.
Transportation Electrification Priority Review Project (PRP) and Standard Review Project (SRP) Evaluations <i>Southern California Edison, San Diego Gas & Electric, Pacific Gas & Electric, PacifiCorp, Bear Valley Electric Service, and Liberty Utilities, 2018–present</i>	<i>Understanding of key metrics/indicators, experience in large scale data collection, visualization, tracking systems and designing a reporting system.</i> Southern California Edison, San Diego Gas & Electric, Pacific Gas & Electric, PacifiCorp, Bear Valley Electric Service, and Liberty Utilities sought an experienced EM&V contractor to evaluate the \$780M+ portfolio of transportation electrification investments in the PRPs and SRPs to determine the effects of utility programs and their impact on disadvantaged communities. To meet these requirements, Cadmus created a standard evaluation plan, which we applied across multiple programs; guided utility program managers through the data collection, analysis and M&V process; verified data results reported across the programs; conducted additional research, analysis across the projects and overarching programs, including surveys, site visits, in-depth interviews, Delphi panels, and performed grid, economic, and emission modeling. The

	team summarized key findings and lessons learned in a comprehensive evaluation report to determine if the programs met the objectives of Senate Bill 350. This included a discussion of whether projects achieved their potential to scale and a webinar on lessons learned to the utilities and relevant stakeholders.
Greenhouse Gas Emissions and Reduction Strategies Montgomery County Public Schools (MCPS), 2022–2023	<i>Understanding of the climate planning, actions, sub actions, GHG inventory, GHG reduction targets.</i> MCPS, the 14th largest school system in the nation, adopted a transformative sustainability policy to reduce GHG emissions by 80% by 2027 and 100% by 2035. This groundbreaking plan centers environmental sustainability across all aspects of MCPS, from energy use to climate change education. Cadmus developed a GHG analysis and modeled mitigation scenarios on behalf of MCPS. We created MCPS’ GHG-emission profile using 2005 to 2022 utilities billing data. The GHG inventory and emission reduction opportunities describe MCPS’ progress to achieve its GHG reduction targets and offers a strategic pathway forward to ensure they are met. Cadmus prepared a spreadsheet tool that tracks MCPS’ GHG emissions in the future years and estimates GHG reductions by several GHG mitigating activities and strategies such as electrifying building end-uses in the school building, zero emissions school fleets and staff vehicles, renewable energy generation and offset purchase. Cadmus prepared the final report that included the current state of GHG emissions, GHG analysis, GHG reduction targets, “What If” GHG mitigation scenarios through year 2035 to achieve MCPS’ GHG reduction targets and future recommendations.
Net Zero Greenhouse Gas Emissions Roadmap and Project Management Office Implementation Massachusetts Port Authority (Massport), 2021–present	<i>Understanding of developing Climate Plan at the state level, Sectoral Detail Strategies, Project Management and working with a large group of stakeholders.</i> Cadmus was awarded a multi-year project to help implement Massport’s aggressive goal to achieve net zero by 2031. This team is led by Project Management Advisors who are setting up and staffing a project management office within Massport. Our team provides clean energy and electrification technical support and works on-site to implement the Net Zero Plan including procurement, change management, education, financial analysis, electrification strategies, energy efficiency initiatives, and partnerships. In this capacity Cadmus has assessed options for alternative fuels (i.e., hydrogen), identified and tracked federal and state funding for decarbonization efforts, created educational and training resources, and provided on-call analysis and expertise related to energy markets, electrification, offsets, and other interventions that involve a shift away from fossil fuel reliance. Additionally, Cadmus has developed a zero-emission energy strategy, analyzed the financials, timelines, and procurement pathways for priority solar sites that Massport should consider; examined how Massport’s Net Zero Program aligns and fits into the Commonwealth of Massachusetts’ climate goals; and facilitated partnerships between utilities, state and local entities, and Massport.
Climate Adaptation and Resilience Plan for Fairfax County Fairfax County, Virginia, 2020–2022	<i>Understanding of key inputs for logic models, cross-cutting issues and themes to aggregate detailed measures.</i> Cadmus supported Fairfax County to develop a Climate Adaptation and Resilience Plan. The major project tasks included initiating the project; convening and facilitating staff and stakeholder groups; supporting a community-wide climate vulnerability and risk assessment; developing of climate adaptation and resilience strategies and an implementation roadmap; and developing a final report and outreach materials. Cadmus is currently conducting a climate vulnerability and risk assessment that leverages the best available data on vulnerability and risk, engages a diverse set of stakeholders to build shared understanding of those risks, and identifies and prioritizes action in line with community needs and values. The work included a climate vulnerability and risk assessment supporting a project Planning Team, Steering Committee, Infrastructure Advisory Group and Community Advisory Group Community. In addition we implemented surveys and facilitated community meetings; identified and prioritized climate adaptation strategies; and developed a Climate Adaptation and Resilience Implementation Roadmap. The final roadmap won an award for excellence in

	sustainability from the American Planning Association Sustainable Communities Division (APA SCD). https://www.fairfaxcounty.gov/environment-energy-coordination/resilient-fairfax; https://www.apascd.com/awards
Multi-Family Housing Analysis New York State Energy Research and Development Authority (NYSERDA), 2021–present	<i>Understanding of key inputs for logic models, and themes to aggregate detailed measures.</i> Cadmus is conducting the first statewide multifamily baseline study in New York, which has included site visits to 435 multifamily buildings and surveys of building representatives for 1,369 multifamily buildings. The study examines all energy-related characteristics of New York’s multifamily building stock, including building envelope, HVAC systems and controls, lighting, appliances, and other end uses. Collected data also include electric service and panel capacity and other attributes that support the determination of electrification potential. Field inspectors captured data with Cadmus’ tablet-based data collection tool. The study developed a comprehensive database of multifamily buildings in New York. An image analysis component will catalog key exterior attributes of all known multifamily buildings in the state by using machine learning techniques to analyze high-quality aerial photographs.
Vulnerability Assessment (VA) Tool US Army Corps of Engineers (USACE), 2012–2017	<i>Understanding of data collection, analysis, combining several data to create metrics and development of reporting tools.</i> The VA Tool is a decision-support methodology developed by Cadmus for the USACE Institute for Water Resources. The VA Tool helps assess the relative vulnerability of the USACE mission, programs, and projects to extreme and gradual climate change events. The VA Tool aggregates data to produce meaningful and informative indices of vulnerability to climate change of USACE’s eight water resources management areas (e.g., water supply, flood risk, emergency response, navigation, hydropower, and ecosystems). Cadmus evaluated more than 600 national-scale hydrological, ecological, and socioeconomic indicators, many of which assess the vulnerability of water resources to project future increases or decreases in precipitation and temperature, and prepared data for 27 chosen indicators. Source data included current assessments, projections based on climate models, and projections of population and land use change. The tool provides vulnerability scores for each management area for 204 watersheds across the United States and allows users to examine the indicators that contribute to the vulnerability of each of those watersheds. The tool is a screening-level assessment and provides USACE managers with an easy to access view of vulnerability in their districts, which they can use to conduct detailed analyses to help select appropriate adaptation options. The easy-to-use interface is built using Tableau and Oracle APEX technology.
US EPA Office of Water Recovery Potential Screening Tool United States Environmental Protection Agency, 2007–2023	<i>Understanding of data collection, screening tools, and development of metrics and indices for different use cases.</i> Since 2007, Cadmus has provided spatial data analysis support to US EPA for state and basin-wide evaluations of priority watersheds for restoration and protection using the Recovery Potential Screening (RPS) framework. RPS provides a systematic approach for comparing watersheds and predicting how well they may respond to restoration or protection efforts, using a set of indicators that describe ecological conditions, stressor magnitude, and social factors in each watershed. Cadmus has supported RPS use by calculating over 200 indicators for every HUC-12 watershed in the contiguous United States using dozens of national geospatial datasets. Cadmus implemented efficient data processing methods using Python and R programming languages so that indicator values could be readily updated as calculation methods were refined and updated source data were released. Cadmus also led the development of an RPS scoring tool that allows managers to select appropriate indicators for evaluating a recovery potential topic, automatically calculate recovery potential index scores, and display results as tabular rankings, bubble plots, and mapping visualizations. The results of the

screening provide water resource managers with tools to make data-driven decisions to prioritize watershed restoration and protection actions.

References

Richard Benjamin, Program Manager-SERT
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Montgomery County Public Schools (MCPS)
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Team Resumes

Ryan Bodanyi, PhD, PMP, Senior Associate, Cadmus

Ryan has more than 20 years of environmental experience, and brings a unique combination of data fluency, project management expertise, and familiarity with climate action. The former comes from his quantitative PhD, focused on what local governments are doing to mitigate their GHG emissions, and why. That expertise was honed at the Center for Sustainable Energy (CSE), where he oversaw data collection, management, visualization, and analysis across five statewide rebate programs for electric vehicles, disbursing \$200 million/year. He earned his certification in project management (PMP) in 2017, and since then has overseen nearly two dozen projects at CSE, CivicWell, and Cadmus. At all three, his work has been climate-focused, ranging from resiliency (helping water utilities adapt to climate change) to mitigation (helping New York develop its cap-and-invest program) to equity (tailoring EV incentive programs to better serve disadvantaged communities). He started his career as an organizer, building climate and environmental justice campaigns for the National Wildlife Federation, Clean Water Action, and the Clean Air Task Force which required expertise in logic models, stakeholder engagement, and process improvement.

Education and Certifications

PhD and MS Public Policy and Management, University of Washington

BA, Environmental Public Policy, University of Michigan

Project Management Professional (PMP) Certification

Relevant Experience

- **Senior Associate, Cadmus, Ann Arbor, MI (2022–Present).** Supports public sector clients with climate action strategy, data analytics, and stakeholder engagement.
 - **Project Manager for New York’s Cap-And-Invest Regulatory Development. *New York State Energy Research Development Authority (NYSERDA) and New York State Department of Environmental Conservation (DEC)*.** Manages Cadmus’ efforts to support NYSERDA and DEC in soliciting and interpreting public comment and stakeholder feedback regarding New York’s development of an economy-wide cap-and-invest program. Project responsibilities include research, event planning and facilitation, and coding technical comment submissions.
 - **Facilitator for the CREAT Project. *US Environmental Protection Agency (EPA)*.** Leads water utilities through detailed assessments of their infrastructure, climate vulnerabilities, and potential adaptation options, using the EPA’s CREAT (Climate Resilience Evaluation and Awareness) Tool.
- **Senior Project Manager, CivicWell, Ann Arbor, MI (2021–2022).** Provided task and financial management for five statewide projects; organized an effort to have the California Air Resources Board (CARB) conduct GHG inventories for local governments; submitted comments on CARB’s Scoping Plan Update.
- **Senior Specialist, Center for Sustainable Energy, San Diego, CA (2017–2021).** Responsible for data collection, management, and visualization across five statewide rebate programs for electric vehicles. Designed and conducted program/market evaluations, customer segmentation, and GHG inventories to quantify the impact that rebate programs have on consumer behavior, the vehicle market, and the environment. Provided guidance, oversight, and quality control for 12 cross-functional staff and one direct report.

Technical Skills

Data Analysis: SPSS / Stata, Data Management: SQL / Salesforce, Data Visualization: Tableau, Survey Design: Qualtrics / SurveyGizmo, Qualitative Analysis: ATLAS.ti, Planning: Logic Models / Power Mapping, Communication: Facilitation / Stakeholder Engagement, Program Evaluation / Process Improvement, Cost-Benefit Analysis, Project Management (PMP)

Shreekar Pradhan, PhD, Senior Specialist, Cadmus

Shreekar Pradhan is an energy and environmental economist with more than 12 years of experience in the economics of energy and environmental policies. Dr. Pradhan specializes in the economic analysis of energy and climate policies. He has worked in developing energy system models used in energy system planning analysis that are technology-rich bottom-up. He has worked in large-scale data transformation in the distributive computing platform. He has significant experience working in Azure Data Factory, SQL, and Databricks. He is skilled in scenario-based policy analysis using different economic modeling tools such as energy system models to integrated assessment models and computable general equilibrium models to dynamic stochastic general equilibrium models.

Education and Certifications

PhD, Economics, University of Tennessee

MS, Agricultural Economics, University of Tennessee

MS, Renewable Energy Engineering, Tribhuvan University

BE, Mechanical Engineering, Tribhuvan University

Relevant Experience

- **New York State Energy Research and Development Authority (NYSERDA): Building Efficiency and Electrification Model (BEEM) Upgrade (2023–present).** Supporting the upgrade of the Excel-based BEEM tool to a cloud-based distributive computing platform.
- **Southern California Edison: Standard Review Projects (2022–present).** Managing large-scale automated metered infrastructure data from utilities in the cloud-based distributive computing environment.
- **Public Service Electric & Gas Company (PSE&G): Clean Energy Future Evaluation (2022–Present).** Managing large-scale program data from in the cloud-based distributive computing environment.
- **Montgomery County Public School: MCPS GHG Emissions and Reduction Strategies (2022–2023).** Estimated MCPS’s GHG inventories (2005–2022), projected baseline emissions up to 2035, analyzed GHG emissions developed GHG reduction targets and ‘what-if’ scenarios to achieve the GHG reduction targets.
- **NYSERDA: Decarbonization Guidebook (2023).** Developed a guidebook useful for local governments in New York in preparing GHG inventories from local government operations.
- **Metropolitan Washington Council of Governments: GHG Inventory (2022).** Refined the methodology to estimate the residential and commercial sector Fuel Oil and LPG/Propane use in the 24 MWCOG jurisdictions. Conducted comprehensive review of the surveys available from Census, energy consumption metrics from ACS, USEPA, RECS, CBECS, Building Benchmarking Initiatives, NREL SEDS, ResStock, ComStock, US GHG Inventory Emissions and Sinks, and eGRID. Updated the GHG inventories of the 24 MWCOG jurisdictions.
- **Mass Audubon: Net Zero Strategy (2022–2023).** Estimated Mass Audubon’s GHG inventory including Scope 3 emissions in year 2022, projected baseline emissions up to 2050, and analyzed net-zero strategies up to 2050.
- **University of Virginia: Negative Emissions Strategies in Meeting Virginia Carbon Neutrality Goal 2050.** Modeled the Virginia net-zero carbon neutrality goal 2050 in the Global Change Analysis Model (GCAM), a global integrated assessment model with the representation of 50+ U.S. states. Modeled Virginia’s renewable energy policy standards and phasing out of coal power plants in the GCAM model. Analyzed and quantified the negative emissions requirements to meet the carbon neutrality goal in Virginia by 2050. Examined the least-cost technology landscape in achieving the carbon neutrality goal in Virginia.

- **University of Virginia: China's Carbon Neutrality Goal 2060.** Investigated the role of China's ambitious carbon neutrality goal 2060 in meeting the global climate mitigation efforts in the GCAM model. Analyzed the role of different negative emissions technologies, especially direct air capture, in meeting carbon neutrality target.
- **University of Virginia: Economic Effects of Virginia's Net-Zero Carbon Neutrality Goal 2050.** Investigated how Virginia's carbon neutrality goal 2050 would impact Virginia's employment and productivity. Soft-linked the GCAM-US model to the REMI Pi+ model to quantify the carbon neutrality goal's impact to Virginia's economy.
- **The Trustees for Conservations: GHG Inventory (2022).** Estimated the Trustees' GHG inventory and GHG mitigation potential. Reviewed previous GHG inventories, improved the data collection/estimation procedures and estimation methodology, and prepared the GHG inventory including the Scope 3 emissions from sources such as waste, employee commute, and property visitations.
- **Vermont Agency of Natural Resources: Vermont Marginal Abatement Cost Curve (2022).** Supported reviewing the LEAP results to develop marginal abatement cost curves of several measures in Vermont's Global Warming Solutions Act.
- **City of Walnut Creek, CA: Cost-Benefit Analysis of Climate Mitigation Strategies (2022).** Supported Walnut Creek in estimating the Walnut Creek's climate mitigation strategies' costs and benefits to households, businesses, and the city.
- **Enbridge: Greening of Grid in Enbridge Regions (2022).** Forecasted grid emissions in the Enbridge regions; used different methods to forecast renewable energy penetration and state-level electricity demand up to year 2050 and conducted greening of grid analysis in the Enbridge regions in different scenarios including the Biden Administration's Carbon Neutral Electricity by 2035.

Ana Rosner, Lead Data Scientist, Cadmus

Ana Rosner has 10 years' experience in statistical and environmental modeling, Geographic Information Systems (GIS), data visualization, big data analytics, and vulnerability and risk assessment. She has worked extensively with large datasets, constructing automated data processing methods, developing data QA plans, and creating maps and data visualizations. Her GIS work uses datasets including hydrological, climatological, land use, transportation, infrastructure, building stock, and demographic information. She has led analyses using multiple database platforms and scripting languages to process large datasets, such as natural hazards, water quality sampling, climate projections, real estate sales, and commercial and residential structures. Ms. Rosner leads the development of several interactive web mapping applications and other JavaScript-based web apps with data and map components.

Education and Certifications

MS, Environmental and Water Resources Engineering, Tufts University, 2012

BA, Anthropology, Johns Hopkins University, 2005

Relevant Experience

- **Northwest Energy Efficiency Alliance Commercial Building Stock Assessment (CBSA).** Led the Virtual Catalog task of a broad inventory of commercial building stock across a four-state region in the Northwest U.S. The Virtual Catalog survey involved leveraging multiple, high-quality data sources including Google Places and a privately assembled tax parcel-based dataset. Data on hundreds of thousands of commercial locations were collected and compared in an automated process written in the R programming language, and then manually reviewed to assess total square footage across census blocks. This data was used to design a statistically representative sample of blocks for on-site physical surveys. Ms. Rosner created multiple interactive mapping applications for this task using ArcGIS Online, RShiny, and Google Maps API: an interface for Cadmus staff to perform the manual review, an interactive map for the client to review and explore the Virtual Catalog data, and an interactive map for Cadmus staff to manage the logistics of scheduling in-person surveys of selected sample locations.
- **Ontario Independent Electricity System Operator Home Assistance Program (HAP).** Conducted the geospatial analysis of Program Participation Gap Analysis for the study. Presented a geospatial analysis of past HAP participation and the demographic traits of the areas of low and high HAP participant saturation. Using ArcGIS, she assessed participation gaps by Demographic information from Statistics Canada included income, housing cost, housing construction, and Aboriginal descent characteristics.
- **US Army Corps of Engineers Climate Change Vulnerability Assessment Tool (VA Tool).** Part of the development team who analyzed GIS and timeseries data and developed interactive dashboards and maps that are core components of the VA Tool. This multi-objective climate change adaptation prioritization tool synthesizes uses 27 indicators developed from numerous data sources to evaluate potential impacts relating to flood risk, navigation, water and hydropower infrastructure, and ecology. Indicators were calculated using ArcGIS and R, and web-based maps and dashboards were built using Tableau and Oracle databases.

Jim Sprague, Director of Analytics, Cadmus

Jim Sprague has over 20 years of technology and business experience in the government and commercial sectors across several business functions and technology markets (including enterprise software and hardware, professional services, and sales and engineering leadership). He has experience developing a large-scale IP network architecture for a global ISP, data warehouse and integrated reporting solutions, and enterprise-wide big data workflows. Jim has domain expertise in public cloud computing (AWS and Azure), data analytics, business intelligence, big data technologies, and software development. He is a results-driven consultant with exceptional business and communication skills and a proven history of building and directing high-performance teams and managing technical change.

Education and Certifications

MBA, University of Maryland

Relevant Experience

As the Director of Analytics at Cadmus, Jim provides thought leadership around advanced analytics trends and modern software development practices. He supports the strategic goal to modernize the analytics development environment, ensuring that all Cadmus staff have access to people, processes, and tools to provide the best deliverables to our clients.

Jim has led multiple efforts at Cadmus to deploy advanced analytics platforms for large-scale data analytics. He has produced several web-based application frameworks for client-facing projects and is leading the effort to integrate Cadmus' content management platform with energy- and climate-centric datasets for client use.

Technical Skills

Jim is experienced with several tools and technologies:

- Cloud platforms: AWS, Azure, Salesforce.com, and Google G-Suite
- Analytics software: R, Spark (Databricks), and Python
- Data science: Supervised and unsupervised learning models, ARIMA models, and data pipelines
- Open-source technologies: Hadoop, Elastic, and Apache Spark
- Programming languages: Python, JavaScript, PHP, T-SQL, and PL/SQL
- Web technologies: REST, API development, JSON, XML, HTML5, and CSS
- Traditional DBMS: Oracle, MS SQL Server, and MySQL
- ETL tools: Azure Data Factory, ODI, SSIS, and custom-developed RESTful interfaces

Professional Memberships and Associations

Association of Energy Services Professionals (AESP)

Cisco Certified Internetwork Expert (CCIE)

Christopher Laxdal, Lead Data Architect, Cadmus

Christopher Laxdal has over 15 years of professional IT experience. He is a senior extract transform and load (ETL) developer and data warehouse architect who excels in data analysis and designing, developing, and implementing data warehousing solutions, including data conversions, data warehouse design, report, dashboard and query development, troubleshooting and issue resolution, and communicating with technical and nontechnical staff.

Education and Certifications

MS, Telecommunication, Saint Mary's University of Minnesota

BA, Asian Studies, St. Olaf College

Relevant Experience

Data Conversion and Integration

- **Data Conversion and Integration (2020–present).** Creates and supports databases, tables, views, and other tools that improve analysis workflow and enable analysts to produce interactive data solutions. Delivers reliable, consistent, and scalable ETL solutions. Sources include government websites, internal Excel analyses, publicly available downloads (such as XML, JSON, and CSV), and other sources.
- **Various Building Electrification Projects (2020–present).** Develops Access-based proof of concept applications to organically identify application requirements. Develops tools and methodologies for capturing, importing, integrating, and storing new and existing data from internal, external, and archival sources.

Data Warehouse Implementation

- **Data Modeling and Warehouse Design (2020–present).** Design and implement database models and objects to support analysis and storage of data from a variety of internal and external data sources. Develops and implements Azure-based data models to provide long-term storage and accessibility for analysts and customers. Implemented solutions for project ranging in size from thousands to hundreds of millions of data rows.
- **Dashboard and Presentation Development (2020–present).** Develops and implements Power BI dashboards and reports to provide analysts and customers with graphical insights into the data.

Technical Skills

Chris is proficient with data modeling, SQL Server, IBM iSeries (AS/400, iServer, and System i), SQL (including ANSI SQL, PL-SQL, T-SQL, tables, queries, views, stored procedures, and functions), Python, C#, technical documentation, and data analysis.

Publications and Presentations

2005. "Turbo-Charge EnterpriseOne Batch Performance Using Subsystems." Presentation at Quest Collaborate Conference and Oracle OpenWorld.

2006. "Minimizing Data Platform Migration Pain." Presentation at Oracle OpenWorld.

Chad H. Laurent, Esq., PMP, Principal, Cadmus

As Cadmus' Senior Advisor for Clean Energy, Policy, Sustainability and Resilience, Chad Laurent is a nationally recognized expert in zero-emission technology energy market development strategies, working with corporate, university, non-profit, and municipal clients to achieve climate and GHG emission reduction goals. He has managed and overseen dozens of policy and technical assessments and analysis projects in the United States and internationally. He has more than 20 years of experience supporting dozens of clients with renewable energy procurement including multi-megawatt-scale projects, and has managed multi-year, multimillion-dollar programs at the federal and state levels. His expertise includes procurement, financing, zoning, permitting, planning, and zero-emission energy as an economic development tool.

Education and Certifications

Juris Doctor, Suffolk University Law School, Boston, 2009

BS, Natural Resource Ecology and Management, University of Michigan, Ann Arbor, 2001

BS, Environmental Policy and Behavior, University of Michigan, Ann Arbor, 2001

Project Management Professional (PMP) Certification

Bar Admission, Massachusetts Bar

Relevant Experience

- **Net Zero Project Management Office and Implementation Support, Massachusetts Port Authority (Massport) (2022–present).** Leads Cadmus' multi-year project to support implementation of the Massachusetts Port Authority's (Massport) aggressive goal to achieve net zero by 2031. He is part of the core management team that has set up and staffs a project management office within Massport and provides clean energy and electrification technical support. Cadmus works within the organization to implement all phases of the Net Zero plan from procurement, to change management, education, financial analysis, electrification strategies, energy efficiency initiatives, and partnerships. Cadmus has developed a zero-emission energy strategy, analyzed the financials, timelines, and procurement pathways, examined how Massport's Net Zero program aligns with Massachusetts' climate goals, and facilitated partnerships between utilities, state and local entities, and the port authority.
- **Rhode Island Carbon Pricing Study, Rhode Island Office of Energy Resources (2019–2022).** Project director for an analysis of the impact of various state and regional scale carbon pricing policies. The study is evaluating the impacts of carbon pricing on fossil fuel usage, and the impacts of varied use of revenue strategies including dividend, electrification, and efficiency programs.
- **SolSmart Designation Program, U.S. Department of Energy (DOE) (2015–present).** Works with a national team to develop and implement SolSmart, which energizes local solar markets and advances soft cost reductions by recognizing community efforts to reduce solar energy supply and siting costs. Delivers solar technical assistance to municipalities including policy and impact analyses, workshops, presentations, fact sheets, and policy best practices. Led development of designation criteria by facilitating a Criteria Advisory Committee of key stakeholders. Provides technical assistance for participating communities around a wide range of solar policy questions, including permitting and inspection processes, and solar market development.
- **Massachusetts Executive Office of Energy and Environmental Affairs: Massachusetts Decarbonization Study (2019–2020).** Served as one of five consultants that conducted analysis and stakeholder engagement in support of the development of two major strategy and modeling documents: the *Massachusetts 2050 Decarbonization Roadmap* and the *2030 Clean Energy and Climate Plan*. Supported the commonwealth's short- and long-term planning process to identify cost-effective and equitable strategies to ensure that Massachusetts achieves net-zero emissions by 2050. Policy support included developing screening criteria, policy review, and policy analysis.

David G. Hill, Principal Investigator, EFG

David is known nationally for his advancement of sustainable energy program design and evaluation, and renewable energy policy. He has been the principal investigator and led analysis teams for multi-year stakeholder informed studies on solar market and decarbonization pathways and scenarios.

David provides expert testimony and regulatory support; participates in national, and state boards; leads policy committees and conferences; provides comprehensive studies of the economic, technical, and achievable potentials for sustainable energy programming; and supports program budget planning and implementation. He has led or significantly contributed to the design and development of efficiency and renewable energy programs with annual budgets of \$100M+ for initiatives in New Jersey, Washington DC, New York, Vermont, Arizona, and Maryland.

Experience

Energy Futures Group, Managing Consultant, 2020–present

Vermont Energy Investment Corporation (VEIC)

- Director, Distributed Energy Resources, Policy Fellow, 2014–2020
- Managing Consultant and Deputy Director Planning and Evaluation, 2008–2014
- Senior Consultant and Consultant, 1998–2008

Tellus Institute and the Boston Center of the Stockholm Environment Institute

- Research Associate, 1993–1998

Education

PhD, University of Pennsylvania, Energy Management and Policy Planning, 1993

MA, University of Pennsylvania, Appropriate Technology and International Development, 1989

BA, Middlebury College, Geography and Political Science, 1981

Select Projects (from more than 100)

- **Vermont Agency of Natural Resources, (2023–present)**. Senior advisor to team analyzing policy and regulatory options for emissions reductions from Vermont’s residential, commercial, and industrial building sectors. In partnership with Stockholm Environment Institute and Cadmus Group, incorporating LEAP scenario modeling and complementary models to assess program and administrative costs, customer economics, and rate impacts for electricity, gas and delivered fuels.
- **General Services Administration, (2023–present)**. Team leader for EFG on team primed by Cadmus Group assisting the GSA analyze and facilitate strategies for all Federal Government Agencies to procure carbon free electricity by 2030. EFG task area involves mapping results from NREL’s Cambium model to Federal agencies and facilities, and assessment of trends on Carbon Free Electricity procurement options by state and electric balancing authority region.
- **Delaware Department of Natural Resources, (2022)**. Lead analysis for a team of EFG and NV5/Optimal Energy, providing baseline scenario modeling for an update to Delaware’s Comprehensive Energy Plan using the Low Emissions Analysis Platform LEAP model.
- **Conservation Law Foundation, (2021–2022)**. Appearance before the Rhode Island Energy Facilities Siting Board in support of Expert Witness testimony of EFG colleague Gabrielle Stebbins, relating to request for declaratory order for expansion of a propane facility in Providence RI.
- **Vermont Agency of Natural Resources, (2021–2022)**. Co-leader of team of EFG and Cadmus Group, serving as technical consultants to the Vermont Climate Council. Used Low Emissions Analysis Platform (LEAP) model to inform Pathways Analysis report on scenarios for meeting Global Warming Solutions Act requirements.
- **Environmental Defense Fund and Citizens Utility Board, (2021)**. Expert testimony on two proposed gas company pilots in Nicor gas general rate case. Illinois Commerce Commission, Docket 21-0098.

- **Citizens Utility Board and NRDC, (2021).** Expert testimony submitted to Illinois Commerce Commission on renewable natural gas pilot proposed by Nicor gas. Docket 20-0722.
- **Clean Energy New Hampshire, (2020).** Expert testimony in support of joint utilities Triennial Energy Efficiency Plan. New Hampshire Public Utilities Commission, Docket DE 2—092,
- **Southern Alliance for Clean Energy, (2020).** Expert testimony on energy efficiency in Dominion Energy South Carolina’s 2020 Integrated Resource Plan. Public Service Commission adopted recommendations for revisions and strengthening of DSM resource in the plan.
- **Massachusetts Executive Office of Energy and Environmental Affairs, (2019–2020).** Under subcontract with Cadmus, Inc. Led scenario modeling team investigating the building sector decarbonization strategies for Massachusetts Decarbonization Roadmap.
- **U.S. Department of Energy, (2014–2017).** Principal Investigator for a three-year SunShot Initiative Solar Market Pathways study, investigating the technical, regulatory, and business model implications of getting 20 percent of Vermont’s total electric supply from solar by 2025.
- **Sun Shares, (2015–2019).** Created and launched, and responsible for management and business development of, a community solar business subsidiary to provide “Easy and Affordable Solar for Employers and their Employees.”
- **Maryland Office of Peoples Counsel, (2011–2020).** Expert witness and senior advisor for review and design of EmPOWER Maryland portfolio. Includes strategies for coordination with grid modernization and cost recovery, amortization, and utility incentives.
- **Washington, D.C., Department of Energy and Environment, (2017–2019).** Led design and launch of the DC Sustainable Energy Utility’s Solar for All Initiative. Supports single family and community solar installations directly benefitting income qualified households.
- **Pennsylvania Department of Environmental Protection, (2016–2019).** Led scenario analysis and modeling for Pennsylvania’s Solar Future. Stakeholder presentations at six workshops on total energy sector modeling for meeting 10% of Pennsylvania’s electric needs from solar by 2030.

Dan Mellinger, PE Principal, EFG

Dan specializes in the design, planning and administration of energy efficiency programs, with an emphasis on commercial and industrial sectors. He provides technical consultative services on efficient technology capabilities, market analysis, technology adoption, energy savings potential, industry standards, training, and financing. He is experienced in the policy and regulation of demand-side management goal setting, budgets, annual reporting, and performance incentives. Dan has consulted on hundreds of commercial efficiency projects across many jurisdictions nationwide and has designed and administered industry-leading commercial lighting programs. He received his degree in Electrical Engineering from Michigan State University, is a licensed Professional Engineer, is a Certified Energy Manager, and is Lighting Certified.

Experience

Principal, Energy Futures Group, Hinesburg, VT, 2020–present

Senior Consultant, Energy Futures Group, Hinesburg, VT, 2017-2019

Senior Strategic Planner, VEIC, Burlington, VT, 2016–2017

Efficiency Vermont Commercial Lighting Lead, VEIC, Burlington, VT, 2009–2016

Efficiency Vermont Business Energy Consultant, VEIC, Burlington, VT, 2005–2009

Semiconductor Manufacturing Engineer, IBM, Essex Junction, VT, 1999–2005

Education

BS, Electrical Engineering, Michigan State University, 1999

Certifications

Professional Engineer (PE) – State of Vermont

Lighting Certified (LC) – National Council on Qualifications for the Lighting Professions

Certified Energy Manager (CEM) – Association of Energy Engineers

Leadership and Management Professional Certificate – University of Vermont

Select Projects

- **General Services Administration (GSA), (2023)** Provide technical support and assistance in developing strategies to achieve 100% carbon free electricity for all federal government agencies by 2030. Develop a forecast model using agency consumption data mapped against multiple scenarios of NREL's Cambium 2022 data model by state and balancing authority. **(2023)**
- **Vermont Agency of Natural Resources, (2021)** Developed a data tracking framework and recommendations as technical consultants to the Vermont Climate Council. **(2021)**
- **DesignLights Consortium (DLC), (2018–present).** Conduct research for and provide technical assistance on the evolution of the technical requirements for the Solid-State Lighting (SSL) and Networked Lighting Control (NLC) programs. Incorporate LED product requirements that support the integration of networked lighting controls. **(2018–present)**
- **Citizens Action Coalition (Indiana), (2018–present).** Critically review and deliver testimony on market potential study findings, action plans, and multi-year DSM plans for each of the Indiana investor-owned utilities. Delivered and defended testimony quantifying the potential for higher levels of energy efficiency as an alternative resource to a proposed 850 MW natural gas plant. **(2018–present)**
- **California Alternative Energy and Advanced Transportation Financing Authority, (2017–present).** Provide technical assistance on the design and implementation of commercial and residential energy efficiency financing programs. Calculate and report program energy savings estimates to the program administrators and regulators. **(2017 to present)**
- **Rhode Island Energy Efficiency & Resource Management Council, (2018–present).** Provide technical consultative insights on commercial and industrial energy-saving measures. Advise on new

technologies, programs, and models for accelerating innovation in achieving aggressive energy savings.

- **Connecticut Energy Efficiency Board, (2018–present).** Provide technical consultative insights on commercial and industrial energy-saving programs and measures. Lead technical consultant to the Research, Development and Demonstration (RD&D) team.
- **Natural Resources Defense Council (Michigan, Illinois, Colorado), (2017–present).** Provide technical consultative insights on commercial and industrial energy-saving programs and measures. Critically review multi-year demand side management (DSM) plans filed by Michigan and Colorado utilities. Deliver and defend regulatory testimony on energy waste reduction (EWR) plans for Consumers Energy and DTE in Michigan.
- **Independent Electricity System Operator (IESO) Ontario, (2022).** Perform a jurisdictional scan of commercial lighting programs across the U.S. and Canada. Develop program design recommendations for networked lighting controls and lighting design. (2022)
- **EfficiencyOne (Nova Scotia), (2021).** Provide program design consultation and recommendations for the Business, Non-Profit, and Institutional (BNI) market within the 2023-2023 DSM Plan.
- **Northwest Energy Efficiency Alliance (NEEA), (2019–2020).** Senior advisor on the market assessment of Luminaire Level Lighting Controls. Perform secondary data analysis, energy code review, and in-depth interviews of relevant market actors.
- **Alliance to Save Energy, (2019).** Conducted research and published a report on lifetime savings potential, peak demand savings potential, and cost effectiveness of commercial LED and networked lighting controls. (2019)
- **DLC.** Developed an analysis and published product adoption and energy savings forecasts for commercial and industrial LED lighting and networked lighting controls. (2018)
- **Vermont Demand Resources Plan, (2016–2017).** Developed a 20-year forecast of efficiency potential from commercial and residential lighting for the Vermont Demand Resources Plan (DRP).

Chris Neme, Principal, EFG

Chris specializes in analysis of markets for energy efficiency, demand response, renewable energy and strategic electrification measures, and the design and evaluation of programs and policies to promote them. During his 25+ years in the industry, he has worked for energy regulators, utilities, government agencies and advocacy organizations in 30+ states, seven Canadian provinces and several European countries. He has filed expert witness testimony in ~70 cases before regulatory commissions in 13 different jurisdictions; he has also testified before several state legislatures. Chris has authored numerous reports on clean energy policies and programs, including the National Standard Practice Manual for Benefit Cost Analysis of Distributed Energy Resources (2020), The Clean Heat Standard whitepaper for Vermont, and several reports on electric non-wires and gas non-pipe alternatives.

Experience

Principal, Energy Futures Group, Hinesburg, VT, 2010–present

Director of Planning & Evaluation, Vermont Energy Investment Corp., Burlington, VT, 1999–2010

Senior Analyst, Vermont Energy Investment Corp., Burlington, VT, 1993–1999

Energy Consultant, Lawrence Berkeley National Laboratory, Gaborone, Botswana, 1992–1993

Senior Policy Analyst, Center for Clean Air Policy, Washington, DC, 1986–1991

Education

MPP, University of Michigan, 1986

BA, Political Science, University of Michigan, 1985

Selected Projects

- **Natural Resources Defense Council (Illinois, Michigan and Ohio), (2010–present).** Critically review and draft regulatory testimony on efficiency, demand response, electrification, distribution system investment and integrated resource plans filed by IL, MI and OH utilities. Represent NRDC in regular stakeholder-utility engagement processes. Represent NRDC in collaborative development of non-wires solution pilots. Support development of clean energy legislation.
- **Green Energy Coalition (Ontario), (1993–present).** Represent coalition of environmental groups in regulatory proceedings, utility negotiations and stakeholder meetings on DSM policies, utility proposed DSM Plans, integrated resource planning and rules governing non-pipe alternatives and regulatory policy implications of future decarbonization pathways.
- **E4TheFuture, (2016–present).** Co-authored National Standard Practice Manual Benefit Cost-Analysis of Distributed Energy Resources (2020) and NSPM for efficiency (2017). Presents the NSPM to audiences across the U.S. and Canada; helps assess how to use it to refine current practices.
- **Vermont Agency of Natural Resources, (2021–present).** Support for analysis of pathways for achieving the state's GHG emission reduction requirements, particularly thermal sector emission reduction measures, cost-effectiveness analyses and marginal abatement cost curve development.
- **Public Interest Organizations (Illinois), (2023).** Analysis of the customer economics of electrification in Peoples Gas' Chicago service territory. Filed expert witness testimony on analysis results on behalf of Environmental Defense Fund and other advocacy organizations in Peoples Gas rate case. **(2023)**
- **Connecticut Energy Efficiency Board, (2019–present).** Part of team providing on-going review and input on utility efficiency program planning and related policy issues. Lead role in providing input on New England Avoided Energy Supply Cost study and cost-effectiveness screening policy issues.
- **Ontario Energy Board, (2015–present)** . Serve on provincial gas DSM Evaluation Advisory Committee overseeing assessments of utilities' annual gas savings claims. Also serve on Gas IRP Committee, providing input on non-pipe alternatives, including cost-effectiveness analyses. Previously served on advisory committees on efficiency potential and carbon price forecast studies.

- **Energy Action Network (Vermont), (2020–present).** Co-authored white paper on a “Clean Heat Standard” for reducing thermal sector GHG emissions. Co-lead working group that developed the policy proposal. Testified before Vermont House Energy and Technology Committee on the concept. (2020-present)
- **New Jersey Board of Public Utilities, (2015–2020).** Served on management team responsible for statewide delivery of New Jersey Clean Energy Programs. Led strategic planning; support regulatory filings, cost-effectiveness analysis & evaluation work. (2015 to 2020).
- **Regulatory Assistance Project-U.S., (2010–2020).** Lead author on strategic reports on program options for decarbonizing Vermont buildings, achieving 30% electricity savings in 10 years, using efficiency to defer T&D system investments, and bidding efficiency into capacity markets. (2010 to 2020)
- **Green Mountain Power (Vermont), (2016–2018).** Supported GMP’s first compliance plan for Vermont RPS Tier 3 requirement to reduce customers’ direct consumption of fossil fuels. Also developed 10-year forecast of sales that could result from three different levels of policy/program promotion of residential electric space heating, electric water heating and electric vehicles. (2016 to 2018)
- **Regulatory Assistance Project – Europe, (2009–2018).** Provided support on efficiency policies in the UK and Germany. Reviewed draft EU policies on Energy Savings Obligations and EM&V protocols. Drafted policy briefs on efficiency feed-in-tariffs and roadmap for residential retrofits.
- **Toronto Atmospheric Fund, (2017).** Helped draft an assessment of efficiency potential from retrofitting of cold climate heat pumps into electrically heated multi-family buildings.
- **Northeast Energy Efficiency Partnerships, (2009–2015).** Helped manage Regional EM&V forum project estimating savings for emerging technologies, including field study of cold climate heat pumps. Led assessment of best practices on use of efficiency to defer T&D investment.
- **Vermont Public Interest Research Group, (2014–2015).** Filed regulatory testimony comparing economic and CO2 impacts of switching from oil/propane heat to natural gas vs. electric heat pumps.
- **Efficiency Vermont, (2000–2010).** Served on Senior Management Team. Supported initial project start-up. Oversaw residential planning, input to regulators on evaluation, input to regional EM&V forum, and bidding efficiency into New England’s Forward Capacity Market (FCM).

Kathleen Miao, Project Coordinator, EFG

Kathleen is a Project Coordinator at Energy Futures Group where she provides data analysis, project management, client relations, and team support. She works with climate models and large datasets to help clients make actionable decisions. She also supports projects that focus on deep energy reduction, decarbonization, electrification of existing buildings, and movement towards a carbon-free future. She has a knowledge of urban environmental issues, environmental policy, and environmental justice. Her professional experience includes conducting project management work with New York City's Mayor's Office of Operations as an Urban Fellow/Policy Analyst.

Experience

Project Coordinator, Energy Futures Group, Hinesburg, VT, 2022–Present

Energy Efficiency Intern, Energy Futures Group, Hinesburg, VT, 2021–2021

Urban Fellow/Policy Analyst, NYC Mayor's Office of Operations' Project and Performance Management Team, New York, NY, 2020–2021

Enumerator, U.S. Census Bureau, New York, NY, 2020–2020

Office of Environmental Justice Intern, Environmental Protection Agency, Washington, DC, 2019–2019

Intern, OCA National – Asian Pacific American Advocates, Washington, DC, 2019–2019

Education

BA, Franklin & Marshall College, Environmental Studies (major) & Art History (minor), 2020

Select Projects

- **Natural Resource Defense Council (NRDC), (2023–present).** Compiling research to support ten states to develop methods to implement Inflation Reduction Act (IRA) funds, such as providing a literature review of IRA resources and creating factsheets about each state's energy networks.
- **Southern Environmental Law Center (SELC), (2023).** Conducting research and data analysis to narrow where to implement a low-income electrification pilot in Virginia.
- **Delaware Department of Natural Resources and Environmental Control (DNREC), (2021–present).** Supporting consulting team with data gathering, analysis, and inputs into the LEAP (Low Emissions Analysis Platform) model for updating the Delaware Energy Plan Update.
- **Department of Energy (DOE), (2022–2023).** Researching and compiling references to create training modules for a comprehensive residential building retrofit certificate program. **(2022–2023)**
- **Groton School, (2022–present).** Compiling and analyzing 15+ years of energy data for 110 buildings in transitioning from a spreadsheet tool to EPA's ENERGY STAR Portfolio Manager for tracking energy use and prioritizing energy saving projects. **(2022–present)**
- **Northeast Energy Efficiency Partnerships (NEEP), (2021–2023).** Coordinating Zero Energy Now (ZEN) program, a comprehensive carbon reduction program including weatherization, heat pump, and solar PV by recruiting customers and coordinating with contractors and a technical director for 40+ projects.
- **Massachusetts Clean Energy Center (MassCEC), (2021–2023).** Gathering and analyzing energy data for 49 customers in Solar Access Program that includes heat pumps and solar PV for homeowners to compute energy savings and heat pump performance.

Gillian Galford, Research Associate Professor, University of Vermont (UVM)

Professional Preparation

Washington University in St. Louis (cum laude) BA 05/2003 Earth & Planetary Sciences; Environmental Studies

Brown University PhD 05/2010 Geological Sciences

Appointments and Positions

Research Associate Professor, University of Vermont Graduate Faculty, Complex Systems and Data Science Program, UVM, 2019–present

Director of Geospatial Technologies, UVM, 2017–present

Graduate Faculty, Food Systems Program, UVM

Fellow, Gund Institute for Environment, UVM, 2012–present

Sustainability Fellow, UVM

Research Assistant Professor, UVM, 2012–2019

Postdoctoral Fellow, Woods Hole Research Center, 2011–2012

Fellow, The Earth Institute, Columbia University, 2010–2011

Publications Most Related to Project

**Denotes a student at the time of research, ^ denotes a postdoctoral researcher*

- Q. Ren*, B. Panikkar, G.L. Galford (2022). Vermont Environmental Disparity Index and Risks. Environmental Justice. DOI: 10.3389/fhumd.2022.886545
- M. Zeraatpisheh^, G.L. Galford, A. White, A. Noel, H. Darby, E.C. Adair. Soil organic stock prediction using multi-spatial resolutions of environmental variables: How well does the prediction match local references? (2023). Catena. <https://doi.org/10.1016/j.catena.2023.107197>
- E. Kinnebrew*, D.A. Neher, T.H. Ricketts, K.F. Wallin, H. Darby, S.E. Ziegler, S.A. Alger, G.L. Galford (2022). Cultivated milkweed hosts high diversity of above and belowground soil arthropods. Agriculture, Ecosystems and Environment. <https://doi.org/10.1016/j.agee.2021.107749>
- A.M. Huddell*, G.L. Galford, D.N.L. Menge, K.L. Tully, C.A. Palm, C. Neill, M.N. Macedo, J.E. Hickman (2020). Environmentally-important impacts of intensive nitrogen use in tropical agroecosystems. Global Change Biology. DOI: 10.1111/gcb.14951
- G.L. Galford, O. Peña*, A.K. Sullivan*, J. Nash^, N. Gurwick, G. Pirolli, M. Richards, J. White, E. Wollenberg (2020). Agricultural development addresses food loss and waste while reducing greenhouse gas emissions. Science of the Total Environment. DOI: 10.1016/j.scitotenv.2019.134318
- A. Adams*, J. Pontius, G.L. Galford, D. Gudex-Cross* (2020). Simulating forest cover change in the northeastern U.S.: Decreasing forest area and increasing fragmentation. Landscape Ecology. <https://doi.org/10.1007/s10980-019-00896-7>
- D. Thom^, M. Golivets^, L. Edling*, G. Meigs^, J. Gourevitch*, L.J. Sonter, G.L. Galford, W.S. Keeton (2019). Climate sensitivity of carbon, timber, and species richness in the boreal-temperate ecotone co-varies with forest development. Global Change Biology 25: 2446-2458. <https://doi.org/10.1111/gcb.14656>
- C. Ramirez-Reyes^, K. Brauman, G.L. Galford, B. Chapin-Kramer, S.B. Adamo, G.R.H. Allington, C. Anderson, K. Bagstad, M.T. Coe, A.F. Cord, L.E. Dee, M. Jain, V.G. Kowal, F. Muller-Karger, P. Potapov, J. Qiu, J. Rieb, L.H. Samberg, N. Singh, R. Sharp, S. Szeto (2019). Improving Integration of Earth Observations into Ecosystem Service Models.
- K.J. Jankowski^, C. Neill, E.A. Davidson, M.N. Macedo, C. Costa Jr^, G.L. Galford, L. Maracahipes*, P. Lefebvre, D. Nunes, C.E.P. Cerri, R.M. McHorney, C. O'Connell*, M.T. Coe (2018). Fate of nitrogen fertilizer in intensive soybean-maize tropical cropland in Mato Grosso, Brazil. Scientific Reports. DOI: 10.1038/s41598-018-31175-1.

- U. Grever, J. Nash[^], N. Gurwick, L. Bockel, G.L. Galford, M. Richards, C. Costa Junior[^], J. White, G. Pirolli, E. Wollenberg (2018). Analyzing the greenhouse gas impact of smallholder development actions across a global food security program. *Environmental Research Letters* <https://doi.org/10.1088/1748-9326/aab0b0>
- A.B. Adams*, J. Pontius, G.L. Galford, S.C. Merrill, D. Gudex-Cross* (2018). Modeling carbon storage across a heterogeneous mixed temperate forest: the influence of forest type specificity on regionalscale carbon storage estimates. *Landscape Ecology*. <https://doi.org/10.1007/s10980-018-0625-0>
- A. Zia, A. Bomblies, A.W. Schroth, C. Koliba, P.D.F. Isles, Y. Tsai[^], I.N. Mohammed, G. Bucini[^], P.J. Clemins, S. Turnbull, M. Rodgers, A. Hamed, B. Beckage, J. Winter, C. Adair, G.L. Galford, D. Rizzo, J. Van Houten (2016). Coupled impacts of climate and land use change across a river-lake continuum: insights from an integrated assessment model of Lake Champlain's Missisquoi Basin, 2000-2040. *Environmental Research Letters* 11(11). <https://doi.org/10.1088/1748-9326/11/11/114026/>
- K. Bryan Watson*, T.H. Ricketts, G. Galford, S. Polasky, J. O'Neil-Dunne (2016). Avoided flood damages on the Otter Creek, VT: Impacts of intact wetland complexes. *Ecological Economics* 130, 16-24. <https://doi.org/10.1016/j.ecolecon.2016.05.015>
- G.L. Galford, J.M. Melillo, D.W. Kicklighter, J.F. Mustard, T.W. Cronin, C.E.P. Cerri, C.C. Cerri (2011). Carbon emissions and uptake from 105 years of land-cover and land-use change at the agricultural frontier of the Brazilian Amazon. *Ecological Applications* 21(3):750-763. <https://doi.org/10.1890/09-1957.1>
- G.L. Galford, J.M. Melillo, D.W. Kicklighter, T.W. Cronin, C.E.P. Cerri, J.F. Mustard, C.C. Cerri (2010). Estimating greenhouse gas emissions from land-cover and land-use change: Future scenarios of deforestation and agricultural management. *Proceedings of the National Academy of Science* 107:19649-19654. <https://doi.org/10.1073/pnas.1000780107>
- G.L. Galford, J.M. Melillo, J.F. Mustard, C.E.P. Cerri, C.C. Cerri (2010). The Amazon frontier of land-use change: croplands and consequences for greenhouse gas emissions. *Earth Interactions* 14:14. <https://doi.org/10.1175/2010EI327.1>

Other Activities

- **Principal Investigator, USDA ARS Food Systems Research Center, "Sustainability Starts with Soil" (2023–2026).** Lead team of social and natural scientists to understand environmental, human, social, production and economic dimensions of sustainability in small to medium farms in NE USA.
- **Institutional Principal Investigator, NASA CONVEI Consortium (2023–2028).** Evaluation of Earth Observation data use and values by decision makers. Serve on advisory group and coordinate researchers at UVM.
- **Principal Investigator, NASA Land Cover and Land Use Change, "Socioeconomic and environmental dynamics of land cover and land use change in the Cerrado frontier" (2023–2026).** Created international, interdisciplinary team to develop remote sensing methods for cropland change and spatial analysis of correlations to socioeconomic factors.
- **Principal Investigator and Director, Private Donations, Vermont Climate Assessment "Climate Science Support for Local Decision Making" (2014–present).** Developed co-design and co-production of climate change information on local impacts, adaptation and mitigation in VT's key socioeconomic sectors (e.g., agriculture, tourism, forestry). Communication and outreach to policy makers, land managers, state agencies and NGOs.
- **Co-Investigator, (2019–2024).** USDA McEntire Stennis, "The State of Carbon in Northeast Forests—creating an Integrated Soil Carbon (iSoC) inventory to explore and understand what drives variation in soil carbon across scales and with management".

Eric D. Roy, Professional Engineer, University of Vermont

Education

BS, Mechanical Engineering Old Dominion University, 2006

MS, Agricultural & Biological Engineering Ohio State University Food, 2008

PhD, Louisiana State University Oceanography & Coastal Sciences, 2013

Post-Doc, Biogeochemistry Brown University, 2014–2015

Licensure

Professional Engineer (Vermont) – Agricultural & Biological Engineering

Recent Appointments

- Associate Professor with tenure, Rubenstein School of Environment & Natural Resources (Primary Appointment) and Dept. of Civil & Environmental Engineering (Secondary Appointment), University of Vermont, Burlington, VT, 2022–present)
- Assistant Professor of Environmental Sciences, Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT. (Secondary appointment in the Department of Civil & Environmental Engineering since 2020), 2016–2022
- Fellow, Gund Institute for Environment, University of Vermont, Burlington, VT, 2018–present
- Voss Postdoctoral Fellow, Institute at Brown for Environment and Society, Brown University, Providence, RI, 2014–2015
- Environmental Scientist, Comite Resources, Inc., Baton Rouge, LA, 2014

Most Relevant Research Grants and Gifts at UVM (out of ~35 awards totaling over \$5M since 2016)

- 2023 Niles, M.T. (PI), E.D. Roy (Co-PI), G. Galford (Co-PI), & A. Glavas (Co-PI). Mapping and Building Sustainability Partners for Global Impact. Amazon. \$109,890.
- 2022–2024 Scarborough, M. (PI), and E.D. Roy (Co-PI). Agricultural digesters as biorefining hubs: food waste co-digestion focused on farmers. US EPA. \$199,941.
- 2022–2023 Roy, E.D. (PI), R. Diehl, K. Underwood. Net greenhouse gas mitigation in Vermont wetlands and floodplains: An initial assessment. The Nature Conservancy Vermont. \$32,768.
- 2022–2024 Schroth, A. (UVM PI), E.D. Roy (UVM Co-PI), J. Faulkner (UVM Co-PI), et al. Development of a Comprehensive Binational Phosphorus Mass Balance Analysis Toolkit for the Missisquoi Bay. Subaward from Stone Environment. Primary funding source: Lake Champlain Basin Program. \$106,642.
- 2021–2022 Roy, E.D. (PI). Sustainable Materials Management Graduate Fellowship. Casella Waste Systems, Inc. \$100,000.
- 2021–2022 Faulkner, J. (PI), and E.D. Roy (Co-PI). Third Party Evaluation of Agricultural Nutrient Management Technologies @ Vermont Natural Ag Products, Middlebury, Vermont. Newtrient, LLC. \$44,495.
- 2023 Faulkner, J. (PI), and E.D. Roy (Co-PI). Design, demonstration and evaluation of an innovative mobile phosphorus removal system for Vermont CEAP and priority HABSaffected watersheds. USDA NRCS. \$38,289.
- 2021–2026 Faulkner, J. (PI), E.D. Roy (Co-PI), C. Adair, and K. Workman. U.S. Dairy Net Zero Initiative: Improving Dairy On-Farm Sustainability through Improved Soil Health and Manure Management. FFAR. \$846,915 (UVM portion of larger multi-institution proposal).
- 2020–2023 Faulkner, J. (PI) and E.D. Roy (Co-I). Lake Champlain Basin Conservation Effects Assessment Project (CEAP): Evaluation of innovative and stacked conservation practices at the field-scale. USDA NRCS. \$815,000.

- 2019 Faulkner, J. (PI), and E.D. Roy (Co-PI). Performance Evaluation of Phosphorus Removal Technology. Newtrient LLC. \$35,342.
- 2019-2020 Roy, E.D. (PI), M.T. Niles (PI), D.A. Neher (PI). Casella Sustainable Materials Management Research Fund for the Recycling, Organics and Resources (ROAR) research group. Casella Waste Systems, Inc. \$70,000.
- 2019 Roy, E.D. (PI), D. Neher, J. Faulkner, and D. Rizzo. Recovery of phosphorus from digested dairy manure. Vermont Phosphorus Innovation Challenge, VT Office of the Governor. \$26,447.
- 2018-2021 Darby, H. (PI), and E.D. Roy (Co-PI). Agronomy and Conservation Practice Assistance Services in Lake Carmi. Vermont Agency of Natural Resources. \$200,000.
- 2018-2020 Roy, E.D. (PI), C. Koliba. Resource recovery and reuse to support phosphorus management and sustainable development goals in Sri Lanka. REACH Award, UVM Office of the Vice President for Research, \$29,999.
- 2018-2020 Niles, M.T. (Co-PI), and E.D. Roy (Co-PI). Identifying nitrogen hotspots in the United States to improve nitrogen management through farmer incentive programs. Catalyst Award, Gund Institute of Environment, University of Vermont. \$35,973.

Selected Publications (out of ~40 total publications)

- Bondeson, F.A., J.W. Faulkner, & E.D. Roy. 2023. Performance of a compost aeration and heat recovery system at a commercial composting facility. *Journal of Ecological Engineering Design*. In Press.
- Porterfield, K.K., M.J. Scarborough, & E.D. Roy. 2023. Resource recovery tradeoffs: Biogas potential and microplastic content of mechanically depackaged food wastes. *ACS Sustainable Chemistry & Engineering* 11(28): 10422-10429.
- Wiegman, A.R.H., G.H. Meyers, I.C. Augustin, M.L. Kubow, M.J. Fein-Cole, V.L. Perillo, D.S. Ross, W.B. Bowden, R.M. Diehl, K.L. Underwood, & E.D. Roy. 2022. Potential for soil legacy phosphorus release from restored riparian wetlands within an agricultural landscape. *Biogeochemistry* 161: 137-156.
- Roy, E.D., & C.E. Horner. 2021. Carbon sequestration in agricultural soils. In Galford, G.L., Faulkner, J. et al. (Eds), *The Vermont Climate Assessment 2021*. Burlington, Vermont: Gund Institute for Environment at the University of Vermont.
- Roy, E.D., C.R. Hammond Wagner, & M.T. Niles. 2021. Hot spots of opportunity for improved cropland nitrogen management across the United States. *Environmental Research Letters* 16: 035004.
- Roy, E.D., M. Esham, N. Jayathilake, M. Otoo, C. Koliba, I. Wijethunga, & M.J. Fein-Cole. 2021. Compost quality and markets are pivotal for sustainability in circular food-nutrient systems: A case study of Sri Lanka. *Frontiers in Sustainable Food Systems* 5: 748391.
- Porterfield, K.K., & E.D. Roy. 2021. Lake Carmi Watershed Phosphorus Study - Final Report. Submitted to the VT Department of Environmental Conservation.
- Conrad, Z., N. Tichenor Blackstone, & E.D. Roy. 2020. Healthy diets can create environmental trade-offs, depending on how diet quality is measured. *Nutrition Journal* 19: 117.
- Porterfield, K.K., J. Faulkner, & E.D. Roy. 2020. Nutrient recovery from anaerobically digested dairy manure using dissolved air flotation (DAF). *ACS Sustainable Chemistry & Engineering* 8(4): 1964-1970.
- Hammond Wagner, C., J. Gourevitch, J., K. Horner, E. Kinnebrew, B. Maden, E. Rechhia, A. White, A. Wiegman, T. Ricketts, and E.D. Roy. 2019. "Payment for Ecosystem Services for Vermont." Issue Paper 19-01. Burlington, VT: Gund Institute for Environment.
- Hammond Wagner, C.R., M.T. Niles, & E.D. Roy. 2019. U.S. county-level agricultural crop production typology. *BMC Research Notes* 12: 552.

- Wiegman, A., J.W. Day, C.F. D'Elia, J.S. Rutherford, J.T. Morris, E.D. Roy, R.R. Lane, D.E. Dismukes, & B.F. Snyder. 2018. Modeling impacts of sea-level rise, oil price, and management strategy on the costs of sustaining Mississippi delta marshes with hydraulic dredging. *Science of the Total Environment* 618: 1547-1559.
- Roy, E.D., P.D. Richards, L.A. Martinelli, L. Della Coletta, S.R. Machado Lins, F. Ferraz Vazquez, E. Willig, S. Spera, L.K. VanWey, & S. Porder. 2016. The phosphorus cost of agricultural intensification in the tropics. *Nature Plants* 2: 16043.

Heather Darby, Professor of Extension, University of Vermont

As an agronomic and soils Specialist for the University of Vermont her my responsibilities include delivering science-based information to the farming community. Practical experiences complemented by her education focus on sustainable agriculture and promoting environmental stewardship of the land. She is involved with implementing many applied research and outreach programs in fuel, soil, forage, and grain production systems throughout the Northeast. Outreach programs have focused on delivering on-farm education in the areas of soil health, nutrient management, organic grain and forage production, and pest management. Research has focused on traditional and niche crop trials, weed management strategies, and sustainable cropping systems development.

Institution and Location

BS, Plant Biology, University of New Hampshire

MS, Agronomy, University of Wisconsin-Madison

PhD, Horticulture, Oregon State University-Corvallis

Book Chapters (peer-reviewed)

- Fike J.H., Darby H., Johnson B.L., Smart L., Williams D.W. 2020. Industrial Hemp in the USA: A Brief Synopsis. In: Crini G., Lichtfouse E. (eds) Sustainable Agriculture Reviews 42. Sustainable Agriculture Reviews, vol 42. Springer, Cham. https://doi.org/10.1007/978-3-030-41384-2_3.

Journal Publications (peer-reviewed)

- White, A., Darby, H., Ruhl, L., & Sands, B. (2023). Long term influence of alternative corn cropping practices and corn-hay rotations on soil health, yields and forage quality. *Frontiers in Environmental Science*.
- Deborah A. Neher, Jeanne M. Harris, Catherine E. Horner, Matthew J. Scarborough, Appala Raju Badireddy, Joshua W. Faulkner, Alissa C. White, Heather M. Darby, Joshua C. Farley, and Eric J. Bishopvon Wettberg. (2022). Resilient Soils for Resilient Farms: An Integrative Approach to Assess, Promote, and Value Soil Health for Small- and Medium-Size Farms. *Phytobiomes Journal* 2022 6:3, 201-206
- Kinnebrew, Eva, Neher, Deborah, A., Ricketts, Taylor, Wallin, Kimberley, Darby, Heather, Ziegler, Sara Alger, Samantha, Galford, Gillian. 2022. Cultivated milkweed hosts high diversity of surface-active and soil-dwelling arthropods in a New England case study. *Agriculture, Ecosystems & Environment*. 325. 107749. <https://doi.org/10.1016/j.agee.2021.107749>.
- Siller, A., Hashemi, M., Wise, C.; Smychkovich, A., and Darby, H. 2021. Date of Planting and Nitrogen Management for Winter Malt Barley Production in the Northeast, USA. *Agronomy* 11(4), 797; <https://doi.org/10.3390/agronomy11040797>.
- Siller, A., Darby, H., Smychkovich, A., and Hashemi, M. 2021. Winter Malting Barley Growth, Yield, and Quality following Leguminous Cover Crops in the Northeast United States. *Nitrogen*, 2(4), 415-427; <https://doi.org/10.3390/nitrogen2040028>.
- Marques, E.; Darby, H.; Kraft, J. Benefits and Limitations of Non-Transgenic Micronutrient Biofortification Approaches. *Agronomy* 2021, 11(3), 464; <https://doi.org/10.3390/agronomy11030464>.
- Marques Edward, Darby, Heather, and Kraft, Jana. 2021. Omega-3 Fatty Acid Fortification of Flax Through Nutri-Priming. *Frontiers in Nutrition*. 8, 492; DOI=10.3389/fnut.2021.715287
- Carr, P. M., M. A. Cavigelli, H. Darby, K. Delate, J. O. Eberly, G. G. Gramig, J. R. Heckman, E. B. Mallory, J. R. Reeve, E. M. Silva, D. H. Suchoff, and A. L. Woodley. 2019. Green and animal manure use in organic field crop systems. *Agronomy Journal*. 2020 00: 1– 27. <https://doi.org/10.1002/agj2.20082>

- Carr, P. M., M. A. Cavigelli, H. Darby, K. Delate, J. O. Eberly, G. G. Gramig, J. R. Heckman, E. B. Mallory, J. R. Reeve, E. M. Silva, D. H. Suchoff, and A. L. Woodley. 2019. Nutrient Cycling in Organic Field Crops in Canada and the United States. *Agron. J.* 111:2769-2785. doi:10.2134/agronj2019.04.0275
- McCollough, M., Gallandt, E., Darby, H., & Molloy, T. 2020. Band-Sowing with Hoeing in Organic Grains: I. Comparisons with Alternative Weed Management Practices in Spring Barley. *Weed Science*, 1-33. doi:10.1017/wsc.2019.64
- Hashemi, M., O. Zandvakili, F. Etemadi, H. Darby and R. Shureshjani. 2019. Evaluating Winter Barley Cultivar Using Data Envelopment Analysis Models. *Journal of Agricultural Science*. 11(6), <https://doi.org/10.5539/>.

Joshua W. Faulkner, PhD, University of Vermont

Education

PhD, Biological & Environmental Engineering, Soil and Water Concentration Cornell University, 2009

MS, Agricultural & Biological Engineering, Soil and Water Concentration, Cornell University, 2005

BS, Biological Systems Engineering, Land and Water Resources Option, Virginia Tech, 2003

Appointments

Interim Director, UVM Extension Center for Sustainable Agriculture, 2022–present

Faculty Fellow, Gund Institute for Environment, 2021–present

Director, UVM Agricultural and Environmental Testing Laboratory, 2020–present

Research Associate Professor, University of Vermont Extension, 2023–present

Research Assistant Professor, University of Vermont Extension, 2018–2023

Adjunct Assistant Professor, University of Vermont, Department of Civil and Environmental Engineering, 2018–2023

Farming and Climate Change Program Coordinator, University of Vermont Extension Center for Sustainable Agriculture, 2013–present

Adjunct Assistant Professor, University of Vermont, Department of Plant and Soil Science, 2009–2013

Extension Assistant Professor and Agricultural Engineering Specialist, West Virginia University, Agriculture and Natural Resources Extension Unit, 2009–2013

Regular Graduate Faculty Member, West Virginia University, Davis College of Agriculture, Natural Resources & Design, 2010–2013

Areas of Expertise

- Climate change impacts and adaptation in Northeastern agricultural systems
- Treatment of agricultural wastewater and best management practices for control of nonpoint source pollution
- Field scale hydrology and water management in agricultural landscapes
- Fate and transport of nutrients in soil and water

Publications (peer-reviewed)

- Garna, R.K., Fuka, D.R., Faulkner, J.W., Collick, A.S., Easton, Z.M. Accepted. Employing Higher Density Lower Reliability Weather Data from the Global Historical Climatology Network (GHCN) Monitors to Generate Serially Complete Weather Data for Watershed Modelling. *Hydrological Processes*. **In Press**
- Garna, R.K., Fuka, D.R., Faulkner, J.W., Collick, A.S., Easton, Z.M. 2023. Watershed Model Parameter Estimation in Low Data Environments. *Journal of Hydrology: Regional Studies*. 45. <https://doi.org/10.1016/j.ejrh.2022.101306>
- Sarazen, J., S. Hurley, and J.W. Faulkner. 2023. Nitrogen and Phosphorus Removal in a Bioretention Cell Experiment Receiving Agricultural Runoff from a Dairy Farm Production Area During Third and Fourth Years of Operation. *Journal of Environmental Quality*. 52:149-160.
- Williams, M., Welikhe, P., Bos, J., King, K., Akland, M., Augustine, D., Baffaut, C., Beck, E.G., Bierer, A., Bosch, D., Boughton, E., Brandani, C., Brooks, E., Buda, A., Cavigelli, M., Faulkner, J., Feyereisen, G., Fortuna, A., Gamble, J., Hanrahan, B., Hussain, M.Z., Kohmann, M., Kovar, J., Lee, B., Leytem, A., Liebig, M., Line, D., Macrae, M., Moorman, T., Moriasi, D., Nelson, N., Ortega-Pieck, A., Osmond, D., Pisani, O., Ragosta, J., Reba, M., Saha, A., Sanchez, J., Silveira, M., Smith, D., Spiegel, S., Swain, H., Unrine, J., Webb, P., White, K., Wilson, H., Yasarer, L. 2022. P-FLUX: A phosphorus budget dataset spanning diverse agricultural production systems in the U.S. and Canada. *Journal of Environmental Quality*. 51:451-461. <http://dx.doi.org/10.1002/jeq2.20351>

- Neher DA, Harris JM, Horner CE, Scarborough MJ, Badireddy AR, Faulkner JW, White AC, Darby HM, Farley JC, and Bishop-von Wettberg EJ. 2022. Resilient Soils for Resilient Farms: An Integrative Approach to Assess, Promote and Value Soil Health for Small- and Medium-Size Farms. *Phytobiomes*. <https://doi.org/10.1094/PBIOMES-10-21-0060-P>
- White, A.C., Faulkner, J.W., Conner, D.S., Mendez, V.E., and M.T. Niles. 2022. “How can you put a price on the environment?” Farmer perspectives on stewardship and payment for ecosystem services. *J. of Soil and Water Conservation*. 77(2). doi: <https://doi.org/10.2489/jswc.2022.00041>
- Ruggiero R, Ross D, Faulkner JW. 2022. Tile Drainage Flow Partitioning and Phosphorus Export in Vermont USA. *Agriculture*. 12(2):167. <https://doi.org/10.3390/agriculture12020167>
- White, A.; Faulkner, J.W.; Conner, D.; Barbieri, L.; Adair, E.C.; Niles, M.T.; Mendez, V.E.; Twombly, C.R. 2021. Measuring the Supply of Ecosystem Services from Alternative Soil and Nutrient Management Practices: A Transdisciplinary, Field-Scale Approach. *Sustainability*, 13, 10303. <https://www.mdpi.com/2071-1050/13/18/10303>
- Twombly, C.R., J.W. Faulkner, Z.M. Easton, and A.S. Collick. 2021. Identification of Phosphorus Index improvements through model comparisons across topographic regions in a small agricultural watershed in Vermont, U.S. *Soil Science Society of America Journal*. <https://doi.org/10.1002/saj2.20254>
- Ament, M.R., S.E. Hurley, M. Voorhees, E. Perkins, Y. Yuan, J.W. Faulkner, and E.D. Roy. 2021. Balancing Hydraulic Control and Phosphorus Removal in Bioretention Media Amended with Drinking Water Treatment Residuals. *Environmental Science & Technology Water*.

CERTIFICATE OF COMPLIANCE

For a bid to be considered valid, this form must be completed in its entirety, executed by a duly authorized representative of the bidder, and submitted as part of the response to the proposal.

- A. **NON COLLUSION:** Bidder hereby certifies that the prices quoted have been arrived at without collusion and that no prior information concerning these prices has been received from or given to a competitive company. If there is sufficient evidence to warrant investigation of the bid/contract process by the Office of the Attorney General, bidder understands that this paragraph might be used as a basis for litigation.
- B. **CONTRACT TERMS:** Bidder hereby acknowledges that is has read, understands and agrees to the terms of this RFP, including Attachment C: Standard State Contract Provisions, and any other contract attachments included with this RFP.
- C. **WORKER CLASSIFICATION COMPLIANCE REQUIREMENT:** In accordance with Section 32 of The Vermont Recovery and Reinvestment Act of 2009 (Act No. 54), the following provisions and requirements apply to Bidder when the amount of its bid exceeds \$250,000.00.

Self-Reporting. Bidder hereby self-reports the following information relating to past violations, convictions, suspensions, and any other information related to past performance relative to coding and classification of workers, that occurred in the previous 12 months.

Summary of Detailed Information	Date of Notification	Outcome
None.		

Subcontractor Reporting. Bidder hereby acknowledges and agrees that if it is a successful bidder, prior to execution of any contract resulting from this RFP, Bidder will provide to the State a list of all proposed subcontractors and subcontractors' subcontractors, together with the identity of those subcontractors' workers compensation insurance providers, and additional required or requested information, as applicable, in accordance with Section 32 of The Vermont Recovery and Reinvestment Act of 2009 (Act No. 54), and Bidder will provide any update of such list to the State as additional subcontractors are hired. Bidder further acknowledges and agrees that the failure to submit subcontractor reporting in accordance with Section 32 of The Vermont Recovery and Reinvestment Act of 2009 (Act No. 54) will constitute non-compliance and may result in cancellation of contract and/or restriction from bidding on future state contracts.

D. Executive Order 05 – 16: Climate Change Considerations in State Procurements Certification

Bidder certifies to the following (Bidder may attach any desired explanation or substantiation. Please also note that Bidder may be asked to provide documentation for any applicable claims):

1. Bidder owns, leases or utilizes, for business purposes, space that has received:

- ☒ Energy Star® Certification
- ☒ LEED®, Green Globes®, or Living Buildings ChallengeSM Certification
- ☐ Other internationally recognized building certification:

2. Bidder has received incentives or rebates from an Energy Efficiency Utility or Energy Efficiency Program in the last five years for energy efficient improvements made at bidder's place of business. Please explain:

Utility-paid for lighting retrofit in our Boston office.

3. Please Check all that apply:

- ☒ Bidder can claim on-site renewable power or anaerobic-digester power ("cow-power"). Or bidder consumes renewable electricity through voluntary purchase or offset, provided no such claimed power can be double-claimed by another party.
- ☐ Bidder uses renewable biomass or bio-fuel for the purposes of thermal (heat) energy at its place of business.
- ☐ Bidder's heating system has modern, high-efficiency units (boilers, furnaces, stoves, etc.), having reduced emissions of particulate matter and other air pollutants.
- ☒ Bidder tracks its energy consumption and harmful greenhouse gas emissions. What tool is used to do this? An internal GHG inventory tool for the annual review and verified through a 3rd party.
- ☒ Bidder promotes the use of plug-in electric vehicles by providing electric vehicle charging, electric fleet vehicles, preferred parking, designated parking, purchase or lease incentives, etc..
- ☒ Bidder offers employees an option for a fossil fuel divestment retirement account.
- ☒ Bidder offers products or services that reduce waste, conserve water, or promote energy efficiency and conservation. Please explain:

We provide services that help our clients reduce GHG emissions, be resilient and adapt to the impacts of climate change,

including development of strategies and implementation of policies and strategies; Design and evaluate energy efficiency programs; Develop sustainable transportation plans; Support high performance buildings.

4. Please list any additional practices that promote clean energy and take action to address climate change:

Purchase renewable energy credits to offset 100% of electric usage; Move Boulder office to a LEED Gold facility with solar PV generation; Conduct a climate scenario analysis; Incorporate climate risks and opportunities into Cadmus' risk register based on its ISO 9001:2015 QMS; Have a Science-Based emission reduction target and report annually to CDP; Recycle; Offer bike and public transit subsidy programs.

E. Executive Order 02 – 22: Solidarity with the Ukrainian People

- ☒ By checking this box, Bidder certifies that none of the goods, products, or materials offered in response to this solicitation are Russian-sourced goods or produced by Russian entities. If Bidder is unable to check the box, it shall indicate in the table below which of the applicable offerings are Russian-sourced goods and/or which are produced by Russian entities. An additional column is provided for any note or comment that you may have.

Provided Equipment or Product	Note or Comment

Bidder Name: The Cadmus Group LLC Contact Name: Chad Laurent, Principal

Address: 410 Totten Pond Road, Suite 400 Fax Number: 617-673-7001

Waltham, MA 02451-2004 Telephone: 617-209-1986

E-Mail: chad.laurent@cadmusgroup.com

By:  Name: Jing Hoffmann, Deputy Director of Contracts
Signature of Bidder (or Representative) (Type or Print)

END OF CERTIFICATE OF COMPLIANCE

PRICE SCHEDULE

A. Fixed Price Deliverables:

Deliverable Description	Fixed Price
Task 0: Project Management	\$30,775.00
Task 1: Data Governance	\$55,590.00
Task 2: Logic Model Development and Metric Creation	\$85,680.00
Task 3: Data Mapping	\$63,068.00
Task 4: Infrastructure Recommendation	\$34,800.00
Total Project Cost	\$269,913.00

B. Hourly Labor Rate:

Service Category/Title of Positions	Hourly Rates
Sr. Managing Consultant	\$305.00
Principal II	\$275.00
Principal I	\$255.00
Sr. Associate III	\$225.00
Sr. Associate II	\$205.00
Sr. Associate I	\$185.00
Associate III	\$165.00
Associate II	\$155.00
Associate I	\$145.00
Sr. Analyst II	\$135.00
Sr. Analyst I	\$125.00
Analyst III	\$115.00
Analyst II	\$105.00
Analyst I	\$95.00
Research Analyst	\$85.00

C. This contract can be extended up to one (1) additional 24-month period with mutual agreement between both parties at a rate not to exceed 3%.

Name of Bidder: The Cadmus Group LLC

Signature of Bidder: 
Jing Hoffmann, Deputy Director of Contracts

Date: November 17, 2023