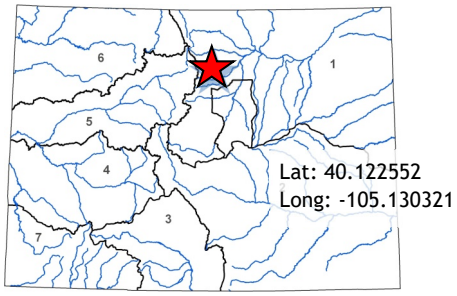
COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Water Plan Grant Application

Jack's Solar Garden, LLC
Jack's Solar Garden Agrivoltaic Study
March 2021 Board Meeting



LOCATION	
County/Counties:	Boulder
Drainage Basin:	South Platte

DETAILS	
Total Project Cost:	$2,288,235
Water Plan Grant Request:	$99,675
Recommended Amount:	$99,675
Other CWCB Funding:	$0
Other Funding Amount:	$456,560
Applicant Match:	$1,732,000
Project Type(s): Construction, Study	
Project Category(Categories): Agricultural	
Measurable Result: Agricultural efficiency, renewable energy development, outreach	

Jack's Solar Garden (JSG) is a first of its kind commercial- and research-centric agrivoltaic system (the colocation of agriculture with solar panels) - not just in Colorado, but also the largest of its kind in the entire United States. JSG is a family-owned social enterprise dedicating land to academic researchers to study the environmental and socio-economic benefits of agrivoltaics on the Front Range. Project research partners include the National Renewable Energy Laboratory, Colorado State University, and the University of Arizona. The research will measure the variations in microclimates (e.g., temperature, light intensity, humidity, soil moisture, soil heat flux) underneath and around the solar array.

Researchers will study growing over 30 different types of vegetables, wildflower seed mixes, and prairie grasses to determine what vegetation grows best and requires less water due to the expected improvement in soil moisture retention. This information will be made public and benefit local governments and farmers interested in improving their economic standing by incorporating solar energy on their lands while continuing to keep their soils productive. JSG is also collaborating with Sprout City Farms, a nonprofit farming organization based in Denver, to farm most of the land under the solar array. They will be learning the practical means for engaging in an agrivoltaic system, training young farmers in agrivoltaic techniques, and growing food to sell or donate to the local community. Colorado Water Plan funds will support the installation of the irrigation system necessary to implement the research project.

This project furthers several Colorado Water Plan critical action goals relating to agriculture, including encouraging agriculture efficiency and resiliency while promoting agricultural productivity. The project also supports collaboration, bringing a diverse group of stakeholders together to leverage public dollars. By supporting research into agrivoltaic systems, the project will also help further Colorado's recent commitments to reduce greenhouse gas pollution and mitigate climate change while providing important co-benefits such as conserving water, improving soil health, and enhancing a producer's bottom line through the leasing of land for renewable energy development.

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Water Plan Grant Application

Instructions

To receive funding for a Water Plan Grant, applicant must demonstrate how the project, activity, or process (collectively referred to as "project") funded by the CWCB will help meet the measurable objectives and critical actions in the Water Plan. Grant guidelines are available on the CWCB website.

If you have questions, please contact CWCB at (303) 866-3441 or email the following staff to assist you with applications in the following areas:

Water Storage Projects	Matthew.Stearns@state.co.us
Conservation, Land Use Planning	Kevin.Reidy@state.co.us
Engagement & Innovation Activities	Ben.Wade@state.co.us
Agricultural Projects	Alexander.Funk@state.co.us
Environmental & Recreation Projects	Chris.Sturm@state.co.us

FINAL SUBMISSION: Submit all application materials in one email to *waterplan.grants@state.co.us* in the original file formats [Application (word); Statement of Work (word); Budget/Schedule (excel)]. Please do not combine documents. In the subject line, please include the funding category and name of the project.

Water Project Summary

Name of Applicant	Jack's Solar Garden, LLC
Name of Water Project	Jack's Solar Garden – Agrivoltaics Research

CWP Grant Request Amount	$99,675
Other Funding Sources National Science Foundation via the University of Arizona	$75,000.00 (confirmed)
Other Funding Sources National Renewable Energy Laboratory	$35,000 (confirmed)
Other Funding Sources Colorado State University	$94,560 (confirmed)
Other Funding Sources Golson Family Fund via Sprout City Farms	$43,200.00 (confirmed)
Other Funding Sources Sprout City Farms	$208,800 (pending)
Applicant Funding Contribution	$1,732,000 (confirmed)
Total Project Cost	**$2,288,235**

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Applicant & Grantee Information	
Name of Grantee(s)	Jack's Solar Garden, LLC
Mailing Address	8102 North 95th St, Longmont, CO 80504
FEIN	83-3045419
Organization Contact	Byron Kominek
Position/Title	Owner & Manager
Email	byron@jackssolargarden.com
Phone	970-344-8066
Grant Management Contact	Byron Kominek
Position/Title	Owner & Manager
Email	byron@jackssolargarden.com
Phone	970-3448066
Name of Applicant (if different than grantee)	
Mailing Address	
Position/Title	
Email	
Phone	

Description of Grantee/Applicant
Provide a brief description of the grantee's organization (100 words or less).
Jack's Solar Garden, LLC - a family-owned enterprise in Boulder County - built a 1.2MW solar to power over 300 homes and study agrivoltaics. We are partnering with the National Renewable Energy Laboratory, Colorado State University, and the University of Arizona to study growing crops, wildflowers, and pasture and prairie grasses underneath and around our solar array. A CO nonprofit organization, Sprout City Farms, will conduct the farming at our solar array and train young farmers in agrivoltaics, and we have created a nonprofit to educate K-12 kids. We will be a national model for the water-saving potential of agrivoltaics.

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Type of Eligible Entity (check one)	
	Public (Government): Municipalities, enterprises, counties, and State of Colorado agencies. Federal agencies are encouraged to work with local entities. Federal agencies are eligible, but only if they can make a compelling case for why a local partner cannot be the grant recipient.
	Public (Districts): Authorities, Title 32/special districts (conservancy, conservation, and irrigation districts), and water activity enterprises.
X	**Private Incorporated:** Mutual ditch companies, homeowners associations, corporations.
	Private Individuals, Partnerships, and Sole Proprietors: Private parties may be eligible for funding.
	Non-governmental organizations (NGO): Organization that is not part of the government and is non-profit in nature.
	Covered Entity: As defined in Section 37-60-126 Colorado Revised Statutes.

Type of Water Project (check all that apply)	
X	Study
X	Construction
	Identified Projects and Processes (IPP)
	Other

Category of Water Project (check the primary category that applies and include relevant tasks)		
	Water Storage - Projects that facilitate the development of additional storage, artificial aquifer recharge, and dredging existing reservoirs to restore the reservoirs' full decreed capacity and Multi-beneficial projects and those projects identified in basin implementation plans to address the water supply and demand gap.. *Applicable Exhibit A Task(s):*	
	Conservation and Land Use Planning - Activities and projects that implement long-term strategies for conservation, land use, and drought planning. *Applicable Exhibit A Task(s):*	
	Engagement & Innovation - Activities and projects that support water education, outreach, and innovation efforts. Please fill out the Supplemental Application on the website. *Applicable Exhibit A Task(s):*	
X	Agricultural - Projects that provide technical assistance and improve agricultural efficiency. *Applicable Exhibit A Task(s):*	
	Environmental & Recreation - Projects that promote watershed health, environmental health, and recreation. *Applicable Exhibit A Task(s):*	
	Other	Explain:

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Location of Water Project	
Please provide the general county and coordinates of the proposed project below in **decimal degrees**. The Applicant shall also provide, in Exhibit C, a site map if applicable.	
County/Counties	Boulder County
Latitude	40.122552
Longitude	-105.130321

Water Project Overview
Please provide a summary of the proposed water project (200 words or less). Include a description of the project and what the CWP Grant funding will be used for specifically (e.g., studies, permitting process, construction). Provide a description of the water supply source to be utilized or the water body affected by the project, where applicable. Include details such as acres under irrigation, types of crops irrigated, number of residential and commercial taps, length of ditch improvements, length of pipe installed, and area of habitat improvements, where applicable. If this project addresses multiple purposes or spans multiple basins, please explain. The Applicant shall also provide, in Exhibit A, a detailed Statement of Work, Budget, Other Funding Sources/Amounts and Schedule.
Jack's Solar Garden (JSG) will be a model for agrivoltaics water savings. We built a 1.2 MW solar array – the largest agrivoltaics research site in the US – for researchers across CO (Colorado State University and the National Renewable Energy Laboratory) and beyond (University of Arizona) to study the long-term benefits of co-locating crops and beneficial vegetation with our solar array. Sprout City Farms will farm the land at JSG. JSG still needs an irrigation system within our solar array to allow for crop production and research of ~30 vegetables (e.g., peppers, tomatoes) along with wildflower seed mixes and prairie grasses. The Boulder & Left Hand Ditch Company delivers water via a lateral ditch through which we will receive Big Thompson water shares in future years. The planned irrigation system includes a ditch turnout, a retention pond, a pump, a chemigation system, and a series of pipes and valves delivering water to 15+ miles of drip tape on 5 acres of land. The retention pond requires a grading permit from Boulder County. Environmental sensors for wind, rain, water flow, temperature, and soil moisture are being installed. The project is in the South Platte River Basin.

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Measurable Results		
To catalog measurable results achieved with the CWP Grant funds, please provide any of the following values as applicable:		
	New Storage Created (acre-feet)	
	New Annual Water Supplies Developed or Conserved (acre-feet), Consumptive or Nonconsumptive	
	Existing Storage Preserved or Enhanced (acre-feet)	
	Length of Stream Restored or Protected (linear feet)	
X (acre-feet/year)	Efficiency Savings (indicate acre-feet/year OR dollars/year)	
	Area of Restored or Preserved Habitat (acres)	
	Quantity of Water Shared through Alternative Transfer Mechanisms	
	Number of Coloradans Impacted by Incorporating Water-Saving Actions into Land Use Planning	
	Number of Coloradans Impacted by Engagement Activity	
	Other	Explain:

Water Project Justification
Provide a description of how this water project supports the goals of Colorado's Water Plan, the most recent Statewide Water Supply Initiative, and the applicable Roundtable Basin Implementation Plan and Education Action Plan. The Applicant is required to reference specific needs, goals, themes, or Identified Projects and Processes (IPPs), including citations (e.g. document, chapters, sections, or page numbers). The proposed water project shall be evaluated based upon how well the proposal conforms to Colorado's Water Plan Framework for State of Colorado Support for a Water Project (CWP, Section 9.4, pp. 9-43 to 9-44;)
Within the Colorado Water Plan, the Critical Action Plan sets out the goals and actions needed for the Agriculture on page 10-10. The goals of *Maintain Agricultural Viability* and *Support Agricultural Conservation and Efficiency* line up with Jack's Solar Garden's (JSG) project. Through the study of agrivoltaics on the Front Range, we will create documented proof as to how rural economies can benefit from the incorporation of solar arrays on their land while maintaining or possibly enhancing Colorado's agricultural productivity by monitoring water savings and microclimates created by a solar array built over farmland. Our project is intent on studying the likely conservation of water for crop growth under solar arrays, which will assist in agricultural resiliency with a warming climate. Within the South Platte Basin Implementation Plan, as stated on page 1-26, the Basin's first theme for action is Agriculture with the goal to: *fully recognize the importance of agriculture to Colorado's future well-being, and support continued success and develop new voluntary measures to sustain irrigated agriculture*. The 1st Measurable Outcome to this end is: *support strategies that reduce traditional permanent dry-up of irrigated acreage through implementation of other solutions including conservation, reuse, successful implementation of local IPPs, successful implementation of ATMs, and development of new Colorado River supplies*. This project speaks to the need for additional strategies to reduce the permanent dry-up of irrigated acreage through conservation. Agrivoltaics is a means to reduce evaporation from soils due to the partial shade provided by solar panels, thereby maintaining more moisture in the ground for plants to access. This ability to retain more moisture in soils may even

help farm fields that have dried up begin retaining more moisture so that dryland crops could become more viable. Further, the economic benefits a solar installation can provide to a farmer could help them retain water shares and improve water-efficient irrigation systems on their land. Jack's Solar Garden (JSG) also supports the 4th Measurable Outcome: *develop local tools and political/community support for tools to sustain irrigated farmland*. JSG and our research partners will publicly share research analyses about the water savings, the microclimates, and resulting crop yields due to agrivoltaics. Further, JSG will map out farms across the South Platte River Basin looking at electricity utility and county land use regulations and overlaying proximity to three-phase electricity lines that an agrivoltaics solar array could tap in to. This would be information shared with local policymakers and interested farmers.

The South Platte Basin Implementation Plan also shares on page 1-29 that the Statewide Long-term Goal to Meet Colorado's Agricultural Needs include: *1) ensuring that irrigated agriculture remains a viable statewide economic driver and supports food security, jobs, and rural communities and protects private property rights; 2) meeting agricultural water demands through IPPs and other multipurpose projects, and 3) implementing efficiency and conservation measures to reduce agricultural water shortages.* JSG's study of irrigating lands underneath our solar array can create an economic driver for farmers who want to keep their soils agriculturally productive while also benefiting from the sale of solar electricity – a means for a farmer to harvest the sun twice. Agrivoltaics creates jobs and provides food security by keeping more moisture in the soil which will be vital as our climate continues to warm. Agrivoltaics as displayed at JSG will demonstrate a means to more efficiently utilize agricultural water.

Also, in the South Platte Basin Implementation Plan is Table 2-6 on page 2-14 that expresses how warming temperatures can increase loss of water from plants and soils and increase overall water demand while extending the growing season. JSG's agrivoltaics project is intended to decrease soil moisture loss through shading the soil with solar panels thereby retaining more moisture in the soils during these extended growing seasons. The University of Arizona has shown under solar panels that they can increase the growing season by a few weeks in the spring and a few weeks in the fall already.

The Statewide Water Education Action Plan states in Outcome #9 on page 16 that *where relevant, local and state policies, regulations, and practices demonstrate a consideration of impacts on sustainable water resources*. The research collected by JSG will be publicly available and local and state policymakers will be invited to our solar array to learn about the benefits of agrivoltaics. JSG has created a spinoff nonprofit organization called The Colorado Agrivoltaic Learning Center that will use our research findings to improve its educational curriculum for K-12 and community members.

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Related Studies

Please provide a list of any related studies, including if the water project is complementary to or assists in the implementation of other CWCB programs.

Greg Barron-Gafford of the University of Arizona published the study: Agrivoltaics Provide Mutual Benefits Across the Food-Energy-Water Nexus in Drylands in Nature Sustainability in 2019 (https://www.nature.com/articles/s41893-019-0364-5). This work highlights the increased moisture content in soils underneath solar panels vs. soils in the open. This work shows that agrivoltaics can improve the water use efficiency in agriculture and thereby reduce the amount of water needed for crop growth.

Jordan Macknick of the National Renewable Energy Laboratory leads the InSPIRE project, a national research effort funded by the Department of Energy (https://openei.org/wiki/InSPIRE). The InSPIRE project has 25 field research sites located across the country examining different aspects of agrivoltaics. Recently, Macknick published a study evaluating the impacts of utility-scale solar projects on soil conditions and soil moisture: Choi et al., 2020: Effects of Revegetation on Soil Physical and Chemical Properties in Solar Photovoltaic Infrastructure: https://www.frontiersin.org/articles/10.3389/fenvs.2020.00140/full. Other ongoing work in the InSPIRE project is examining soil moisture patterns and runoff at solar sites that have pollinator habitat as groundcover; JSG provides a unique opportunity to examine irrigation impacts for crop production, pasture grasses, and native vegetation, all in one location.

Previous CWCB Grants, Loans or Other Funding

List all previous or current CWCB grants (including WSRF) awarded to both the Applicant and Grantee. Include: 1) Applicant name; 2) Water activity name; 3) Approving RT(s); 4) CWCB board meeting date; 5) Contract number or purchase order; 6) Percentage of other CWCB funding for your overall project.

N/A

Taxpayer Bill of Rights

The Taxpayer Bill of Rights (TABOR) may limit the amount of grant money an entity can receive. Please describe any relevant TABOR issues that may affect your application.

Jack's Solar Garden knows of no relevant TABOR issues that would impact our application.

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Submittal Checklist	
X	I acknowledge the Grantee will be able to contract with CWCB using the Standard Contract.
Exhibit A	
X	Statement of Work(1)
X	Budget & Schedule(1)
X	Engineer's statement of probable cost (projects over $100,000)
X	Letters of Matching and/or Pending 3rd Party Commitments(1)
Exhibit C	
X	Map (if applicable)(1)
X	Photos/Drawings/Reports
X	Letters of Support (Optional)
X	Certificate of Insurance (General, Auto, & Workers' Comp.) (2)
X	Certificate of Good Standing with Colorado Secretary of State(2)
X	W-9(2)
	Independent Contractor Form(2) (If applicant is individual, not company/organization)
Engagement & Innovation Grant Applicants ONLY	
	Engagement & Innovation Supplemental Application(1)

(1) Required with application.
(2) Required for contracting. While optional at the time of this application, submission can expedite contracting upon CWCB Board approval.

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Colorado Water Conservation Board
Water Plan Grant - Exhibit A

Statement Of Work	
Date:	**11/22/2020**
Name of Grantee:	**Jack's Solar Garden, LLC**
Name of Water Project:	**Jack's Solar Garden**
Funding Sources:	**SECURED: Jack's Solar Garden, LLC / National Science Foundation / National Renewable Energy Laboratory / Golson Family Fund** **PENDING: Xcel Energy's Renewable Energy Trust / Department of Energy / CWCB / Irrigation Innovation Consortium**

Water Project Overview:

Jack's Solar Garden (JSG) is a first of its kind commercial- and research-centric agrivoltaic system (the co-location of agriculture with solar panels) - not just in Colorado, but also in the US. JSG is a family-owned social enterprise dedicating land to academic researchers to study the benefits of agrivoltaics on the Front Range. Our research partners include: the National Renewable Energy Laboratory, Colorado State University, and the University of Arizona. These researchers will measure the variations in microclimates (e.g., temperature, light intensity, humidity, soil moisture, soil heat flux) underneath and around our solar array, especially as the array was designed with 2/3 of the panels elevated at 6ft and the other 1/3 elevated to 8ft to answer questions about optimal agrivoltaic design in CO. Researchers will study growing over 30 different types of vegetables, wildflower seed mixes, and prairie grasses to determine what vegetation grows best and requires less water due to the expected improvement in soil moisture retention. This information will be made public and would benefit local governments and farmers interested in improving their economic standing by incorporating solar energy on their lands while continuing to keep their soils productive.

JSG has also partnered with Sprout City Farms, a nonprofit farming organization based in Denver, to farm the majority of the land under our 1.2 MW solar array. They will be learning the practical means for engaging in an agrivoltaic system, training young farmers in agrivoltaic techniques, and growing food to sell or donate into the local community. They will be planting crops in drip tape irrigated bed rows (three bed rows in between rows of solar panels) to learn what positioning within the solar array different crops do best as shade and soil moisture content will be variable.

As a national model for agrivoltaics, JSG wants to identify other farms within the South Platte River Basin that could benefit from incorporating solar on their land. This entails learning about County regulations for developing solar on farmlands, restrictions or opportunities offered by local utilities, and pin-pointing electricity substations to see what farms are close enough to them to make their interconnection costs low enough to keep the project economically viable. Together, this support from the CWCB would enable the irrigation system that supports this agrivoltaics research, training, and education.

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Project Objectives:

1) Jack's Solar Garden responsibility: Secure financing and build Jack's Solar Garden's 1.2 MW solar array – financing secured throughout 2020 through sales and a bank loan and construction commenced in June 2020 and was completed in October 2020.
   a) This objective enables all other objectives to occur.
2) Jack's Solar Garden responsibility: Secure financing and install a water-efficient drip irrigation system to deliver water throughout the solar array for purposes of growing crops and other vegetation for research and food production objectives – to be done March-May 2021
   a) Enable the irrigation system to have variable settings to allow researchers to adjust water delivery for purposes of studying how plants react to water stresses in an agrivoltaic setting.
   b) Enable water-efficient delivery to bed rows of crops for farmers.
3) Sprout City Farms responsibility: Establish agrivoltaic farm management practices to cultivate crops underneath and around solar panels
   a) Assess the needs to keep farmers and the solar panels safe during agricultural activities
   b) Implement a standard operating procedure for farm hands to plant, maintain, and harvest crops underneath and around solar panels.
   c) Train young farmers in agrivoltaic farm management practices and benefits in order to create a new farming vocation
4) Researchers responsibilities: Study the microclimates created by different heights of solar panels and the impacts of planting crops underneath and around solar panels both on the growth of vegetation and on the electricity production of the solar array.
   a) Install soil moisture, temperature, humidity, light intensity, and soil heat flux sensors to study the solar array's microclimates.
   b) Monitor water flow delivery to crops and measure the differences in productivity of crops at various locations under the solar array as well as outside the solar array to learn what crops did the best and what crops required less water to grow.
   c) Analyze collected data and publish articles based on analyses.
5) Jack's Solar Garden responsibility: Identify farmlands in the South Platte River Basin that could benefit from installing an agrivoltaic system on the land.
   a) Collate information from various County land use regulations as to where solar arrays are allowed.
   b) Collect information from local utilities as to means by which solar arrays can be interconnected to their electricity grids.
   c) Pinpoint utility substations and map out farmlands around these substations to determine the radius around which farms would have an economically viable interconnection cost.
   d) Create a map of farmlands with proximity of utility substations and are within government and utility jurisdictions that would enable agrivoltaics systems to be constructed.

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Tasks
Task 1 –Solar Array Engineering, Procurement, and Construction
Description of Task:
Jack's Solar Garden signed an Engineering, Procurement, and Construction contract with Namaste Solar in February of 2020 to build the 1.24488 MW community solar garden on our family's farmland. The design of the solar array was done by AZTEC Engineering Group in 2019. Namaste Solar began procuring modules and racking infrastructure in March/April of 2020. In June of this year, equipment was delivered to Jack's Solar Garden for installation. Construction lasted from June to October 2020. On October 30th, Jack's Solar Garden was energized and began producing power being delivered into Xcel Energy's electricity grid.
Method/Procedure:
This was a contractual arrangement in which Namaste Solar built our solar array.
Deliverable:
The turn-key installation of a 1.2 MW community solar garden designed to enable agrivoltaics while minimizing impact on our soils during construction.

Tasks
Task 2 – Irrigation System Engineering, Procurement, and Construction
Description of Task:
A licensed Colorado professional engineer certified in irrigation design will design, procure, and manage the construction of Jack's Solar Garden's irrigation system. The irrigation system will consist of a clay lined retention pond with a 184,500 gallon capacity with a variable frequency drive pump delivering ditch water to at least 4 acres of land through approximately 20 miles of drip tape laid over 3ft wide planting beds. Each bed row will have valves able to control water flow and fertilizer delivery through an installed chemigation system to enable researchers to test variable water delivery to crops over time. Layflat mainlines will be used as the main arteries of water flow on-site. Pressure regulators, air vents, controllers, regulating valves, flow meters, and polyethylene manifolds will be used throughout the site. The professional engineer will oversee the excavation and layout of the retention pond, delivery of materials to site, the connection of all system components, system training for Jack's Solar Garden and partners, and the system start-up, flushing, and pressure testing. A grading permit will be sought from Boulder County as the retention pond is planned to be deeper than 24". The professional engineer will also oversee the installation, start-up, and testing of a primary weather station (rain, temperature, humidity, wind), soil moisture and temperature sensors, and water pressure sensors on-site.

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Tasks
Method/Procedure:
Jack's Solar Garden, LLC has an on-going relationship with Loveland Environmental Resource Development Corp. (LERDC) who has previously designed a low-volume irrigation system for our 3,000 perennial pollinator habitat and who has provided free consultations on the design of this proposed irrigation system. LERDC is owned and operated by a CO professional engineer that is a certified irrigation designer, certified landscape irrigation auditor, and technical service provider, and a class C licensed contractor. LERDC has worked with Jack's Solar Garden, our researchers at the National Renewable Energy Laboratory and University of Arizona, and our agriculture partner, Sprout City Farms, to design this irrigation system to meet their various needs for water delivery flexibility. Upon notification of being awarded this grant, LERDC will be contracted to procure the requisite materials and begin excavation work for the retention pond. Once materials arrive on-site, LERDC will assemble and test the irrigation system. LERDC will provide training for Jack's Solar Garden and partners on operating the installed irrigation system.
Deliverable:
In the end, Jack's Solar Garden will have the irrigation infrastructure needed to supply water to our agrivoltaics research project that researchers from the National Renewable Energy Laboratory, Colorado State University, and the University of Arizona can measure the water savings of growing crops underneath solar panels.

Tasks
Task 3 – Planting Crops, Managing Land, and Harvesting Crops in Agrivoltaic System
Description of Task:
Sprout City Farms will establish agrivoltaic farm management practices to cultivate crops underneath and around solar panels in Spring 2020. They will assess the needs to keep farmers and the solar panels safe during agricultural activities. They will implement a standard operating procedure for farm workers to plant, maintain, and harvest crops underneath and around solar panels. They will train young farmers in agrivoltaic farm management practices and benefits in order to create a new farming vocation. These activities are envisioned to be carried out year after year for at least three years.

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Tasks
Method/Procedure:
Sprout City Farms will work with Jack's Solar Garden and the National Renewable Energy Laboratory to establish their standard operating procedures to begin managing the soils at Jack's Solar Garden. Sprout City Farms has years of experience farming and training young farmers in agricultural techniques. They will conduct trainings for these young farmers in bed row preparation, crop planting, weed management, and harvesting of crops.
Deliverable:
Sprout City Farms will derive lessons learned from years of work at Jack's Solar Garden on how best they discovered to work within an agrivoltaic system. They will learn about the changes in their expectations for water usage and crop growth depending on the location of cropping within the solar array. To start, 70% of crops will be sold through Sprout City Farms existing distribution network, and the remaining 30% of crops will be donated through community food bank programs. Sprout City Farms will also create a standard operating procedure for how they will cultivate crops underneath and around the solar panels and update the document during the initial years.

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Tasks
Task 4 – Monitoring and Analyzing Water Savings from Agrivoltaics
Description of Task:
Researchers from the National Renewable Energy Laboratory, Colorado State University, and the University of Arizona will monitor and analyze the delivery of water to various crops and vegetation underneath Jack's Solar Garden's solar array to determine the capacity for agrivoltaics to serve as a water-smart farming practice. While the potential benefits for agrivoltaics include lower PV costs through lower land acquisition and development costs, broader adoption will hinge on how the arrays can be optimized to allow for efficient crop production. In contrast to conventional utility scale arrays designed to maximum yearly PV generation with south-facing panels tilted at the site latitude, an agrivoltaic system is designed to allow for more crop illumination in the morning and more shading in the afternoon, which reduces plant temperature stress and reduced water use (because of less direct sunlight hitting the ground). We will investigate cropping choices, including cultivar and irrigation, their levels of performance, ability to attract and support pollinators, and their feedbacks to the PV array in terms of their capacity to PV cooling.
Method/Procedure:
To determine the impact of an agrivoltaics installation on growing conditions, we will measure soil moisture, air temperature, and relative humidity. To capture the effects of this modified environment on crop production, we will also measure water consumption, plant stress, rates of photosynthesis and transpiration, and growth and production on a minimum of ten crop types per season. We will also monitor pollinator, pest, and bird presence using high definition wildlife cameras to measure the ability of an agrivoltaics design to attract pollinators. Instrumentation to support these activities in one section of JSG has been purchased by University of Arizona collaborators, and installation will be completed by March 2021. All data will be captured by an automated datalogger and stored to the web. At the end of each harvest, crops will be weighed to determine pounds of production per unit water delivery. We will then calculate the water savings provided by the microclimate of the solar array by comparing food production, irrigation delivered, and water residency time across our research areas.
Deliverable:
Collectively, these findings will help us determine optimal placement of different crop varieties with respect to growing under shade from the solar panels. All findings will be shared through social media, academic articles (noting CWCB support), signs on site for our visitors to see, and on our website. These findings will also enable researchers to extrapolate out how much water savings in acre-feet per season a farmer would have on an acre of a specific crop underneath a solar array of Jack's Solar Garden's layout.

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Budget and Schedule

This Statement of Work shall be accompanied by a combined Budget and Schedule that reflects the Tasks identified in the Statement of Work and shall be submitted to CWCB in excel format.

Reporting Requirements

Progress Reports: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of issuance of a purchase order, or the execution of a contract. The progress report shall describe the status of the tasks identified in the statement of work, including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Report: At completion of the project, the applicant shall provide the CWCB a Final Report on the applicant's letterhead that:

- Summarizes the project and how the project was completed.
- Describes any obstacles encountered, and how these obstacles were overcome.
- Confirms that all matching commitments have been fulfilled.
- Includes photographs, summaries of meetings and engineering reports/designs.

The CWCB will pay out the last 10% of the budget when the Final Report is completed to the satisfaction of CWCB staff. Once the Final Report has been accepted, and final payment has been issued, the purchase order or grant will be closed without any further payment.

Payment

Payment will be made based on actual expenditures and must include invoices for all work completed. The request for payment must include a description of the work accomplished by task, an estimate of the percent completion for individual tasks and the entire Project in relation to the percentage of budget spent, identification of any major issues, and proposed or implemented corrective actions.

Costs incurred prior to the effective date of this contract are not reimbursable. The last 10% of the entire grant will be paid out when the final deliverable has been received. All products, data and information developed as a result of this contract must be provided to CWCB in hard copy and electronic format as part of the project documentation.

Performance Measures

Performance measures for this contract shall include the following:
(a) Performance standards and evaluation: Grantee will produce detailed deliverables for each task as specified. Grantee shall maintain receipts for all project expenses and documentation of the minimum in-kind contributions (if applicable) per the budget in Exhibit B. Per Water Plan Grant Guidelines, the CWCB will pay out the last 10% of the budget when the Final Report is completed to the satisfaction of CWCB staff. Once the Final Report has been accepted, and final payment has been issued, the purchase order or grant will be closed without any further payment.
(b) Accountability: Per Water Plan Grant Guidelines full documentation of project progress must be submitted with each invoice for reimbursement. Grantee must confirm that all grant conditions have been complied with on each invoice. In addition, per Water Plan Grant Guidelines, Progress Reports must be submitted at least once every 6 months. A Final Report must be submitted and approved before final project

Performance Measures
payment. (c) Monitoring Requirements: Grantee is responsible for ongoing monitoring of project progress per Exhibit A. Progress shall be detailed in each invoice and in each Progress Report, as detailed above. Additional inspections or field consultations will be arranged as may be necessary. (d) Noncompliance Resolution: Payment will be withheld if grantee is not current on all grant conditions. Flagrant disregard for grant conditions will result in a stop work order and cancellation of the Grant Agreement.

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Conservation Board

Water Plan Grant - Exhibit B
Budget and Schedule

Prepared Date: 11/30/2020

Name of Applicant: Jack's Solar Garden, LLC

Name of Water Project: Jack's Solar Garden - Agrivoltaic Research

Project Start Date: 03/01/2021

Project End Date: 12/01/2023

Task No.	Task Description	Task Start Date	Task End Date	Grant Funding Request	Match Funding	Total
1	Solar Array Engineering, Procurement, and Construction	3/1/2021	6/1/2021	$0	$1,732,000	$1,732,000
2	Irrigation System Engineering, Procurement, Construction	3/1/2021	8/1/2021	$99,675	$0	$99,675
3	Planting, Managing, & Harvesting Crops in Agrivoltaic System (3yrs)	1/1/2021	12/1/2023	$0	$252,000	$252,000
4	Monitoring and Analyzing Water Savings from Agrivoltaics (3yrs)	10/16/2020	12/1/2023	$0	$204,560	$204,560
			Total	$99,675	$2,188,560	$2,288,235

LERDC Project Estimate

Jack Solar Garden Under Array Irrigation System

October 16, 2020, Expires November 16, 2020

Irrigation System: Layout as per previous written communications to LERDC……..……$47,700.00

System Description:

Concrete ditch turn out with; gate and over flow. Reservoir with; native clay liner, riprap fill-way, concrete sump & self-cleaning intake screen. VFD Pump with; pressure relief, combination air valve & by-pass. Auto-flushing (PD, Timed and Manual) media filter with; restricting valve, pilot filter, site tube and sustaining valve. Chemigation system with; venturi, isolation valves, chem tank, flow meter and regulating valve. Above ground layflat mainlines with; fittings, pressure relief, continuous acting air vents and end flush valves. Automatic block valves with; pressure regulator, air vent, DC controller. In-field: PE manifolds, drip tape laterals, and fittings.

Installation of above items including:

Design, specifications and project management by a licensed Colorado professional engineer certified in irrigation design. Deliverables; materials list, product specifications, construction plans with details, as-built plans. Delivery of product to job site, Excavation, shaping and compaction for turn-out, reservoir and sump. One pass roto-till of bed areas, Sub-surface injection of tape and bed shaping. Connection of all system components. System; Start-up, flush, pressure test and testing. And operator training.

Basic Data System …….$14,200.00

Basic Data System Description:

Primary flow meter. Primary weather station with; precipitation, temperature, humidity, solar radiation, wind sensors. Three soil moisture sensors per zone. One soil temperature sensor per zone. One pressure sensor per zone (records valve on/off times). Relay of referenced data to farm office PC or cloud. (Required dedicated Farm office PC not included). And web based; dash board and reports available to stake-holders. (Farm office WiFi required but not included) One-year software and cloud service fees included. On-going Additional annual fees not included and estimated at $1200 to $1500 per year.

Installation of above items including:

Design, specifications and project management by a licensed Colorado professional engineer certified in irrigation design. Deliverables; materials list, product specifications, construction plans with details, as-built plans. Delivery of product to job site, Connection of all system components. System; Start-up, testing and operator training.

Advanced Data System……..$34,500.00

Basic Data System Description:

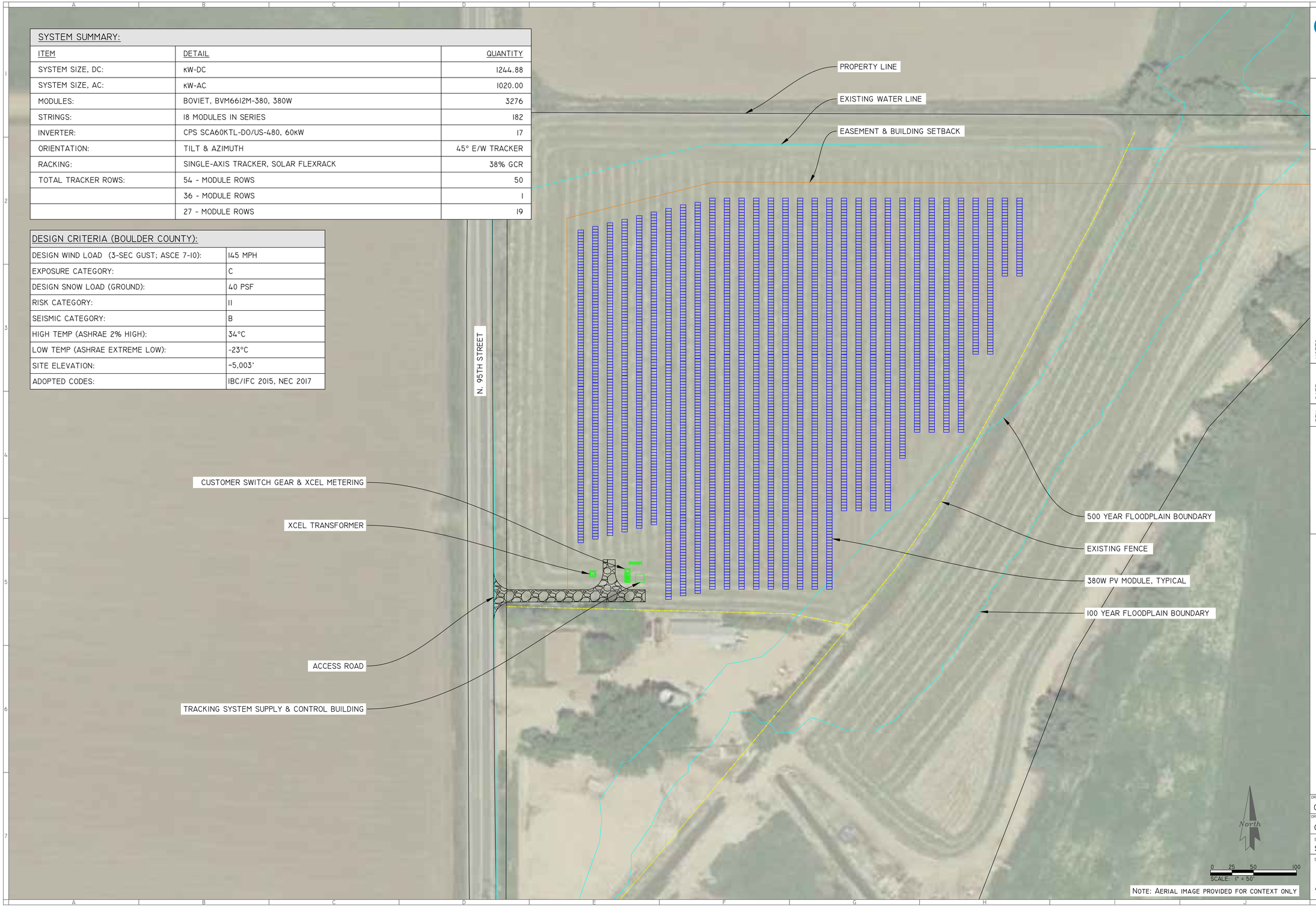
Primary flow meter and one flow meter per block valve. Two weather station (One in solar array area one outside solar array area) with; precipitation, temperature, humidity, solar radiation, wind sensors. Three soil moisture sensors per block valve. One soil temperature sensor per block valve. One pressure sensor per block valve (records valve on/off times). Relay of referenced data to farm office PC or cloud. (Required dedicated Farm office PC not included). And web based; dash board and reports available to stake-holders. (Farm office WiFi required but not included) One-year software and cloud service fees included. On-going Additional annual fees not included and estimated at $1200 to $1500 per year.

Installation of above items including:

Design, specifications and project management by a licensed Colorado professional engineer certified in irrigation design. Deliverables; materials list, product specifications, construction plans with details, as-built plans. Delivery of product to job site, Connection of all system components. System; Start-up, testing and operator training.

SYSTEM SUMMARY:		
ITEM	DETAIL	QUANTITY
SYSTEM SIZE, DC:	kW-DC	1244.88
SYSTEM SIZE, AC:	kW-AC	1020.00
MODULES:	BOVIET, BVM6612M-380, 380W	3276
STRINGS:	18 MODULES IN SERIES	182
INVERTER:	CPS SCA60KTL-DO/US-480, 60kW	17
ORIENTATION:	TILT & AZIMUTH	45° E/W TRACKER
RACKING:	SINGLE-AXIS TRACKER, SOLAR FLEXRACK	38% GCR
TOTAL TRACKER ROWS:	54 - MODULE ROWS	50
	36 - MODULE ROWS	1
	27 - MODULE ROWS	19

DESIGN CRITERIA (BOULDER COUNTY):	
DESIGN WIND LOAD (3-SEC GUST; ASCE 7-10):	145 MPH
EXPOSURE CATEGORY:	C
DESIGN SNOW LOAD (GROUND):	40 PSF
RISK CATEGORY:	II
SEISMIC CATEGORY:	B
HIGH TEMP (ASHRAE 2% HIGH):	34°C
LOW TEMP (ASHRAE EXTREME LOW):	-23°C
SITE ELEVATION:	~5,003'
ADOPTED CODES:	IBC/IFC 2015, NEC 2017



NOTE: AERIAL IMAGE PROVIDED FOR CONTEXT ONLY

namasté SOLAR
6707 Winchester Cir, Boulder, CO 80301
888 Federal Blvd, Denver, CO 80204
www.NamasteSolar.com • 303.447.0300

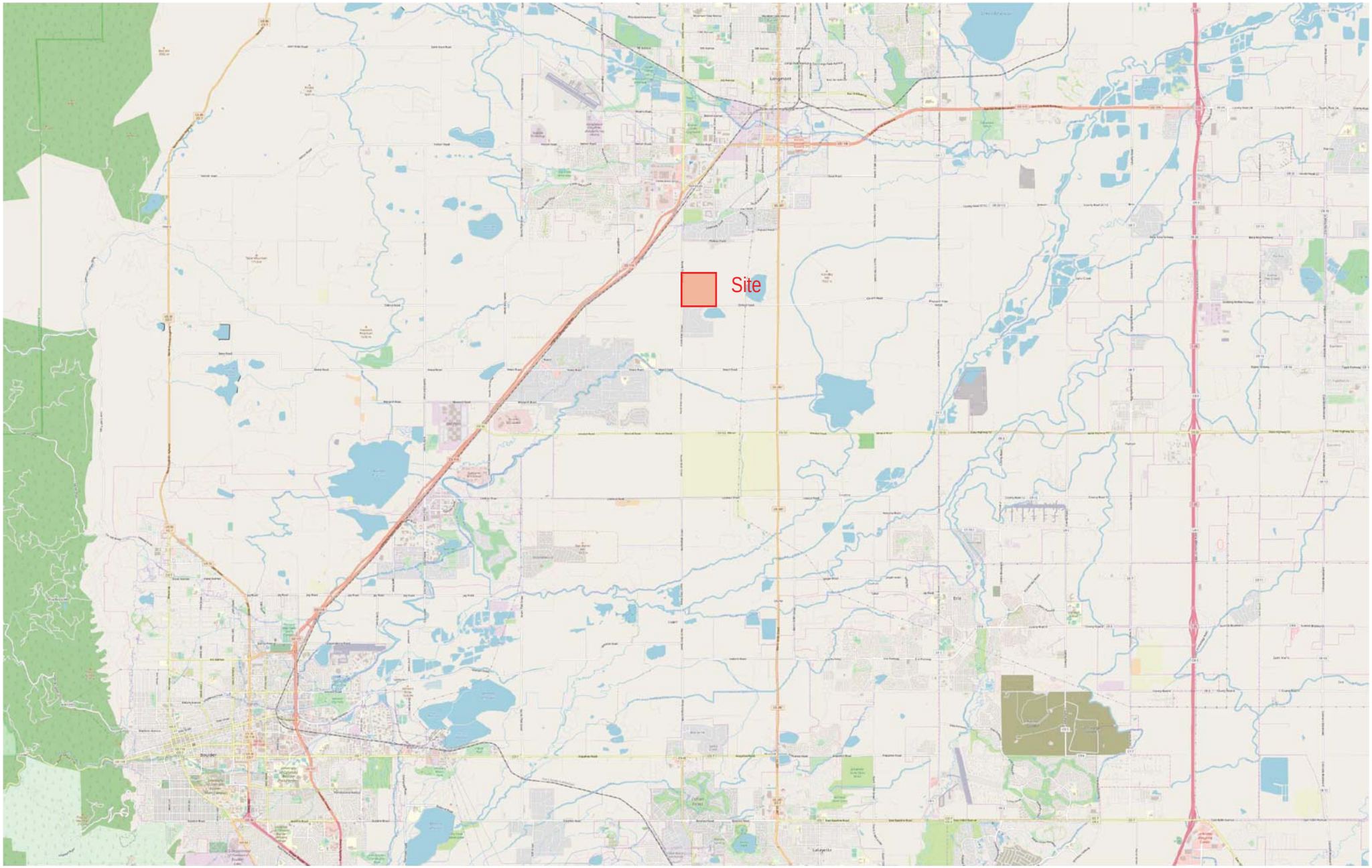
REV.	DATE	NOTES
---	2019/12/12	PRELIMINARY

NOT FOR CONSTRUCTION

CLIENT: JACK'S SOLAR GARDEN
PROJECT: JACK'S SOLAR GARDEN
DESCRIPTION: SINGLE AXIS TRACKER PV SYSTEM
SITE ADDRESS: 8102 NORTH 95TH STREET LONGMONT CO, 80504

DRAWING SET ISSUE: 0.0
DRAWN BY: CEM
REVIEWED BY: SKM
SHEET TITLE: SITE PLAN
SHEET NUMBER: A101

LOCATION MAP



November 5, 2020

Attn: Meg Caley
Sprout City Farms Inc
PO Box 7536
Denver, CO 80207

IMPACTASSETS
INVEST WITH MEANING

Dear Sir or Madam,

We are pleased to enclose a check in the amount of $43,200.00 to your organization from The Golson Family Fund, an ImpactAssets Donor Advised Fund account, administered by ImpactAssets.

Grant Amount:	$43,200.00
Acknowledgement Name:	Emery Golson and Miles Golson
Acknowledgement Address:	4795 Jay Rd Boulder, CO 80301
Recommended Grant Purpose:	Other: Jack's Solar Garden Farm Infrastructure!

Your acceptance of this check confirms that there has been no change in your tax status as a 501(c)(3) public charity. In addition, acceptance certifies that neither the donor nor any affiliates of the donor have received any goods or services, and this donation will not be treated as payment for any financial or other obligation.

Please contact us at 855.482.2946 or ClientService@impactassets.org if you have any questions regarding this donation.

Best wishes in your endeavors.

Sincerely,
The ImpactAssets Team

November 30, 2020

To the Colorado Water Conservation Board:

I am writing in support of Jack's Solar Garden's agrivoltaics proposal requesting irrigation system installation support from the Colorado Water Conservation Board. Jack's Solar Garden, operated by Byron Kominek, has installed a 1.2 MW solar array in Boulder County that will be a great site for novel agrivoltaics research. The irrigation system requested will support research activities by the National Renewable Energy Laboratory, Colorado State University, and the University of Arizona. They intend to study the ability of prairie grass, wildflower seed mixes, and various vegetables to grow underneath and around this solar array. The idea is that the solar array provides shade to the land, dampening temperature swings, protecting crops from damaging hail and winds, and reduces evapotranspiration which will keep more moisture in the soils.

Sprout City Farms intends to work with Jack's Solar Garden to cultivate vegetables under 3 out of the 5 acres of solar panels in conjunction with their proposal to the Colorado Water Conservation Board. We will work in collaboration with the researchers on-site, especially Greg Barron-Gafford from the University of Arizona, on cultivating vegetables for measurement purposes but also for distribution into the local community. We plan to learn how best to cultivate crops underneath and around solar panels, and then train young farmers in agrivoltaic techniques so that they can ply their trade at other solar arrays. The benefit of reducing evapotranspiration by solar panels shading the ground may prove beneficial in reducing the amount of drip irrigation we need to deliver to crops over the course of the season. We don't yet know which crops will do best, or by how much irrigation water will be saved, but we intend to find out!

Sprout City Farms is an urban agricultural nonprofit, partnering with Jack's Solar Garden to cultivate the land underneath the solar panels and distribute the produce grown within the local Longmont community. Farmer training programs are an important component of our work. We will provide incubator farm plots for beginning farmers to test their business plans and ideas, along with an in-depth farmer training curriculum.

Sincerely,

Meg Caley
Executive Director
Sprout City Farms
meg@sproutcityfarms.org
720-319-8126

Loveland Environmental Resource Development Corp.
2000 S. CR 29, Loveland, CO 80537
(720) 936-3575 http://LERDC.co Jmchugh1958@Hotmail.com

Letter of Support

To: Colorado Conservation Board **Date:** November 20, 2020
RE: Jack's Solar Garden, 8102 N. 95th Str., Longmont, CO 80537
www.JacksSolarGarden.com

I started working with Byron Kominek of Jack's Solar Garden (JSG) in November of 2018, on behalf of the Boulder Valley/ Longmont Conservation Districts and the Colorado Natural Resource Conservation Service. I found the project to be of worth while interest for water and energy conservation. And for the research and development of symbiotic crops and agricultural business model for solar farms.

Solar farms provide beneficial "clean-green" energy to our communities. Building them on agricultural land is more cost-effective then building them on suburban or urban land. However, conversion of agricultural lands to solar farming has often been problematic due to the loss of needed beneficial agricultural production and the degradation of traditional crops causing increases in: dust, noxious weeds, non-beneficial insects and rodents. Solar farms can form islands that harbor unwanted and problematic vectors, thus having negative impact on the surrounding areas. Developing a profitable cropping and business model that maintains needed beneficial agricultural production and manages undesirable vectors would be beneficial to all communities.

JSG is attempting to do this. In 2020, Loveland Environmental Resource Development Corp (LERDC) contracted with JSG to provide irrigation engineering and consulting services for the irrigation of the pollinator/wind break area on the North-West edge of the project site. LERDC more recently has done engineering and submitted estimates to JSG for the design and installation of the micro irrigation system under the solar arrays and the associated water, supply, storage, automation, data collection, chemigation, filtration and pumping systems. If JSG is successful in gaining the needed funding and contracts LERDC to do so, LERDC will complete: a detailed design, materials list, specification, construction plan and install the systems noted.

LERDC was incorporated in Colorado, in 2007 and is good standing with the Colorado Secretary of State office. I am thepresident / co-owner of LERDC. I am a: licensed professional engineer by the State of Colorado (PE), Certified Irrigation Designer (CID) by the Irrigation Association (IA), Registered Technical Service Provider (TSP) with the USDA NRCS (TSP), and have a Bachelor's of Science in Agricultural and Irrigation Engineering from Utah State University with a minor in Natural Resource Conservation. I am a member of ASABE, IA and AWWA and have served on the IA Board of Directors, ASABE Chair Micro-Irrigation Sub-committee, NRCS State Technical Committee and ISO standards committee. With over 35 years' experience in this field I have worked for large multi-national producers, small local producers, Rain Bird Agri-Product and other Industry leaders.

It is my professional opinion the referenced project is a project of merit that will not only benefit the local community but will be of benefit to the agricultural industry, energy industry and the world community.

John McHugh; PE, CID, TSP
John McHugh
President / owner
Loveland Environmental Resource Development Corp.

SOIL AND CROP SCIENCES
COLORADO STATE UNIVERSITY

Department of Soil and Crop Sciences
1170 Campus Delivery
Fort Collins, Colorado 80523-1170
Phone: (970) 491-1320
Email: meagan.schipanski@colostate.edu

November 26, 2020

To the Colorado Water Conservation Board,

I am excited to give my strong support to Jack's Solar Garden's agrivoltaics proposal for irrigation system installation support from the Colorado Water Conservation Board. Jack's Solar Garden, operated by Byron Kominek, has installed a 1.2 MW solar array in Boulder County that creates a unique opportunity for agrivoltaics research. The irrigation system installation will support collaborative research between Colorado State University, the University of Arizona, and the National Renewable Energy Laboratory to investigate a broad range of potential land uses under solar arrays. These systems offer a potential win-win for improving irrigation water use efficiency while producing both food and renewable energy. The shading patterns underneath solar arrays have the potential to dampen temperature swings, protect crops from hail and damaging winds, and reduce evapotranspiration rates.

As one of the Colorado State University research partners, I am excited about the potential research and outreach avenues this project will provide. I am an Associate Professor in the Department of Soil and Crop Sciences and a member of the leadership team for the Interdisciplinary Training, Education and Research in Food-Energy-Water Systems (InTERFEWS) graduate training program at CSU. Through the InTERFEWS program, I am the faculty advisor for a PhD student who is conducting research focused on understanding the land use and ecosystem service implications of solar array installations across the Front Range. The irrigation system requested will support these research activities.

Through this research, we are hoping to identify land management practices, including planting mixtures and supplemental water treatments, that optimize multiple desirable outcomes such as increasing net climate change mitigation of solar systems and enhancing pollinator habitats. We are investigating the levels of irrigation required to establish different planting mixtures and the net effect of limited irrigation on overall system water use efficiency. Researchers from the National Renewable Energy Laboratory and the University of Arizona are also conducting experiments at Jack's Solar Garden that focus on agricultural crops and pasture, and through the harmonization of our projects we expect to be able to learn much more together than we could separately.

We are excited to be involved with Jack's Solar Garden as it represents a prototype for agrivoltaic systems that has great potential for replication across the region. The outcomes from this research will be useful to other companies and land and resource managers for regional planning efforts and the development of site management plans for new solar array installations. Jack's Solar Garden has already

established itself as an education resource to the community and it will continue to train and inform current land managers, the next generation of farmers, and the broader public. We look forward to contributing to outreach activities at the site and through the development of online learning resoures.

My research group's involvement in the research at Jack's Solar Garden is supported through multiple funding sources. Christopher Toy, the PhD student leading the research outlined above, is supported by the NSF-funded InTERFEWS program that has provided 2-years of graduate research assistantship funding which represents a contribution of $79,560. In addition, my research group will contribute existing weather monitoring equipment and soil sampling equipment and the procurement of new soil moisture sensors at a total contribution of approximately $5000 of in-kind materials and $10,000 for new sensors, materials, and analysis costs.

Sincerely,

Meagan Schipanski
Associate Professor