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Colorado Water Conservation Board	
Water Supply Reserve Fund	
Exhibit A - Statement of Work	
Date:	**30 July 2018**
Water Activity Name:	**YAMPA RIVER LEAFY SPURGE PROJECT—Integrated Management & Predictive Modeling—Research Component**
Grant Recipient:	**Friends of the Yampa (FOTY)**
Funding Source:	**WSRF – Yampa-White-Green Basin Account**

Water Activity Overview: (Please provide brief description of the proposed water activity (no more than 200 words). Include a description of the overall water activity and specifically what the WSRF funding will be used for.

Leafy spurge is a Eurasian plant accidentally introduced to North America in the early 19th century. It aggressively invades riparian and upland plant communities, including agricultural lands. Millions of acres are affected in 29 states. Leafy spurge is listed among the top 25 invasive terrestrial species in a recent (2018) report by the Western Governors Association.

The Yampa River and its associated agricultural water delivery systems are spreading leafy spurge seeds downstream from a large infestation that has occupied floodplain areas between Hayden and Craig for several decades. Since the 2011 high water run-off season, an exponential increase in the leafy spurge population has been observed in riparian habitat along the Yampa River. Riparian habitat quality and agricultural productivity are actively being degraded downstream for 166 miles to the confluence with the Green River. Tributary streams are also affected (e.g., Little Snake River, Fortification Creek, and Milk Creek).

This project will provide information necessary for development of effective and sustainable management programs for riparian environments in the Yampa River Basin. It will support needed scientific work, engage local youth, and build on local knowledge and relationships as we strive to protect both agricultural and environmental water uses for our future.

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Objectives: (List the objectives of the project)

- Work with stakeholders and the University of Wyoming to develop a robust, publicly available spatial data set documenting the current distribution of leafy spurge in riparian habitat associated with the Yampa River, tributary streams, and irrigation water delivery systems in the Yampa Valley.
- Utilize remote sensing technology to direct and enhance monitoring and mapping efforts.
- Develop a susceptibility model to predict where new leafy spurge invasion is most likely in Moffat and Routt Counties.
- Quantify the current seed load produced by leafy spurge populations in 4 (possibly 5) specific riparian habitats along the Yampa River and associated tributaries.
- Study and evaluate best integrated management practices for reducing cover and seed production of leafy spurge in diverse riparian systems in the Yampa Valley.
- Develop a map of known and potential leafy spurge biological control sites in the Yampa Valley, and work with the Colorado Department of Agriculture to develop kid-friendly monitoring protocols in anticipation of a future adopt-a-spurge-bug-patch program for engagement of local 4-H clubs, school science classes, and other youth organizations, aimed at improving understanding and appreciation for the relationships between the river, associated riparian habitat, agricultural water delivery systems, and invasive weeds.

Tasks

Task 1 – Develop a watershed scale management framework for leafy spurge in the Yampa Valley through mapping and predictive modelling

Description of Task:

Management decisions in many weed invasions are often haphazard and based on incomplete or outdated location information. Haphazard management of an invasive species without regard for landscape distribution often results in less than optimal results. Reinvasion frequently occurs shortly after active management ends, negating any long-term benefit to the landscape. By utilizing spatial distribution data, best management practices (BMPs) can be developed and implemented to more effectively reduce the impact of current invasions and prevent or slow future spread at a landscape scale.
Knowledge of the spatial distribution of the current invasion can be used to identify which populations represent the greatest risk to the overall landscape. The Yampa River Leafy Spurge Project (YRLSP) advocates for managing leafy spurge in the Yampa Valley to prevent or reduce the spread and establishment of new populations and recognizes that having a map that clearly delineates current leafy spurge extent is critical to this mission. High quality and accessible spatial information will assist managers in determining which populations are highest in priority and acting as likely “source” populations that require immediate and aggressive management attention.

Remote sensing is one tool that can be used to direct scouting/monitoring efforts to be more effective and efficient. Vegetation reflects unique spectral signatures that can be detected from satellite or other remote

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methods. These unique signatures can possibly allow for differentiation, in some cases down to the species level. For example, the uniform yellow flower color of a leafy spurge invasion can be unique enough to differentiate it from surrounding vegetation. Maps can be developed using this technology to indicate the probability that an area is currently invaded by leafy spurge.

In addition facilitating short-term management decisions, spatial data can also help in developing invasion susceptibility models capable of predicting potential for future spread and invasion. These models utilize environmental conditions associated with known populations to predict where in the landscape we might expect future invasions to occur. These models identify environmentally similar areas and assign susceptibility ratings at a landscape scale, which enables land owners/managers to assess future risk and apply strategic management actions. A susceptibility model can be utilized to direct monitoring efforts in susceptible areas and to educate the public on the importance of timely and effective invasive plant management.

Task Schedule:

Development of Field Mapping Protocols:

1. YRLSP volunteers and Moffat/Routt counties are currently working on this and will continue through the duration of the project, mostly with volunteer labor.

Graduate Student Recruitment:

2. Upon notification of funding, with intended enrollment in January 2019.

Research Project/Student Activities:

3. Spring 2019
    a. Obtain satellite imagery
    b. Collect local reflectance signature data of leafy spurge in Yampa Valley
    c. Consolidate presence/absence data of Yampa Valley leafy spurge
    d. Begin modeling susceptibility utilizing proxy data
4. Summer 2019
    a. Begin modeling susceptibility utilizing local data
    b. Create remote detection map and remotely ground truth
5. Fall 2019
    a. Ground truth remote detection map
    b. Compete proxy susceptibility (future invasion) map
6. Winter 2019/Spring 2020
    a. Complete local susceptibility (current) map

Final Products

7. Spring 2021
    a. Master's Thesis
    b. Final Report to YWG BRT and CWCB

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Method/Procedure:
Current mapping efforts utilize MapItFast software (both counties use this platform). Spatial and tabular data will be stored in a format that is compatible with both EDDMaps (required by the State of Colorado Department of Agriculture) and ArcGIS (for availability to anyone). YRLSP volunteers and Moffat/Routt County are currently working out details of field mapping protocols. The BLM will utilize these protocols, as they are developed. Moffat County and YRLSP have agreed to store data and make it available. University of Wyoming will utilize mapping data to develop predictive models for future spread of leafy spurge. Although mapping efforts have begun, the current distribution of leafy spurge in the Yampa Valley is poorly known. This makes it difficult to predict where leafy spurge is likely to spread, although it is clear that water is a primary vector for seed dispersal. Remote sensing can be used to support current mapping and monitoring efforts. Current satellite imagery will be analyzed using proprietary machine learning algorithms to develop a leafy spurge presence probability map. This map will then be remotely ground-truthed with current extent mapping to identify how effective the model was at detecting known invasions. Then, field ground-truthing will be used on prospective undetected populations to identify how useful the map is overall. Utilizing the most up to date leafy spurge spatial extent based on on-going mapping efforts, a susceptibility model will be developed for the entirety of the Yampa River Watershed. Importantly, leafy spurge absence data (i.e., known areas where leafy spurge is not) will also be included in the model to create a more confident result. This current extent data will be inputted into a computational model along with abiotic factors (e.g., slope, elevation, aspect, average temperature) to build this susceptibility map. The product will be a heat map indicating areas that are most and least susceptible to invasion. The current known extent of leafy spurge in the Yampa Valley is indicative of a relatively young invasion. The current spatial extent does not represent what may happen if invasion begins to leave the river corridor, as examples from several Wyoming counties suggest. Thus, we intend to use a much more established invasion as proxy data to predict what a future invasion could look like in the Yampa Valley. Specific counties in Wyoming have leafy spurge invasions that have been established for a longer period of time and have spread beyond the riparian areas of the watershed and into high value agronomic land. These regions have similar elevations to the Yampa River watershed making them ideal surrogates. Another susceptibility model will be developed for the Yampa River watershed utilizing Wyoming data to show what an invasion could look like into the future if management actions are not taken.
Grantee Deliverable: (Describe the deliverable the grantee expects from this task)
1. Master's Thesis (University of Wyoming-Spring of 2021) 2. Spatial database that will be made publicly available 3. Future data needs and management direction are identified
CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the completion of this task)
1. Final Report to Y-W-G Roundtable and CWCB, including an executive summary, documenting results of the study and distribution of data to stakeholders.

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Task 2 – Identify best integrated management practices for reducing leafy spurge seed production in four (possibly 5) specific riparian habitat types in the Yampa Valley.
Description of Task:
Leafy spurge has been identified as one of the top problematic invasive species across the western US in a recent report by the Western Governors Association because of its ability to spread rapidly and adversely affect productivity of invaded lands, both for agriculture and wildlife. Leafy spurge can outcompete other vegetation, resulting in a monoculture, and leading in some cases to unusable land. It produces a milky compound making it undesirable and/or toxic to most wildlife and classes of livestock. Leafy spurge is a water-loving species that most often establishes first in low-lying riparian areas, where it aggressively displaces desirable native vegetation—valued resource identified in the YWG Basin Implementation Plan. Leafy spurge is an extremely difficult species to manage effectively and many of our standard herbicide management options have proven generally unsuccessful. Limited herbicide options exist for sensitive riparian habitat, and many of these options, when used alone, impose significant collateral damage on surrounding vegetation, while failing to adequately control leafy spurge. Repeated and/or widespread use of herbicides can pose a risk to water quality, as well. Biocontrol agents, although successful in ideal conditions, are inconsistent in their effectiveness and tend to work best in upland sites. Therefore, in many situations, the best solution is to inhibit the spread of leafy spurge in the first place. Although leafy spurge prefers moist soils, it is not restricted to riparian habitat and is capable of escaping the river corridor when populations reach threshold levels. Once established in cropland, eradication becomes increasingly difficult, with obvious negative impacts on the economic value of land associated with a particular water source. Lands bordering the Yampa River comprise some of the most productive agricultural land in the region, yet, this proximity to the river, which functions as an effective vector for seed dispersal, renders these lands highly vulnerable to leafy spurge invasion. A worst-case scenario of escape from riparian to upland habitat has occurred in some nearby Wyoming counties. Previously valuable arable land has been converted into unusable leafy spurge that cannot be eradicated. The Wyoming invasion has become so widespread that recent conversations have suggested abandoning management of lands invaded by leafy spurge. This worst-case scenario can (and should) be avoided in the Yampa Valley. Preventing the spread of leafy spurge to prime agricultural lands is critical to ensuring we protect both riparian habitat and agricultural land and the economic and environmental resource value they provide. Because eradication is nearly impossible for well-established invasions, reducing seed sources contributing to the spread of leafy spurge to new areas is the most responsible use of management resources. Our goal is to protect the river corridor, irrigated agricultural lands, and associated uplands. Leafy spurge utilizes projectile capsules that rupture and spray seed many feet away from the parent plant. Thus, seed produced by riparian populations of leafy spurge can disperse seed directly in to the water, allowing movement of the species downstream. Combined with periodic overbank flooding, which also entrains seed in to the river, this characteristic means of leafy spurge seed dispersal makes the Yampa River and its associated water distribution system a worrisome vector for new infestations downstream—both to new riparian habitats and to irrigated agricultural lands.

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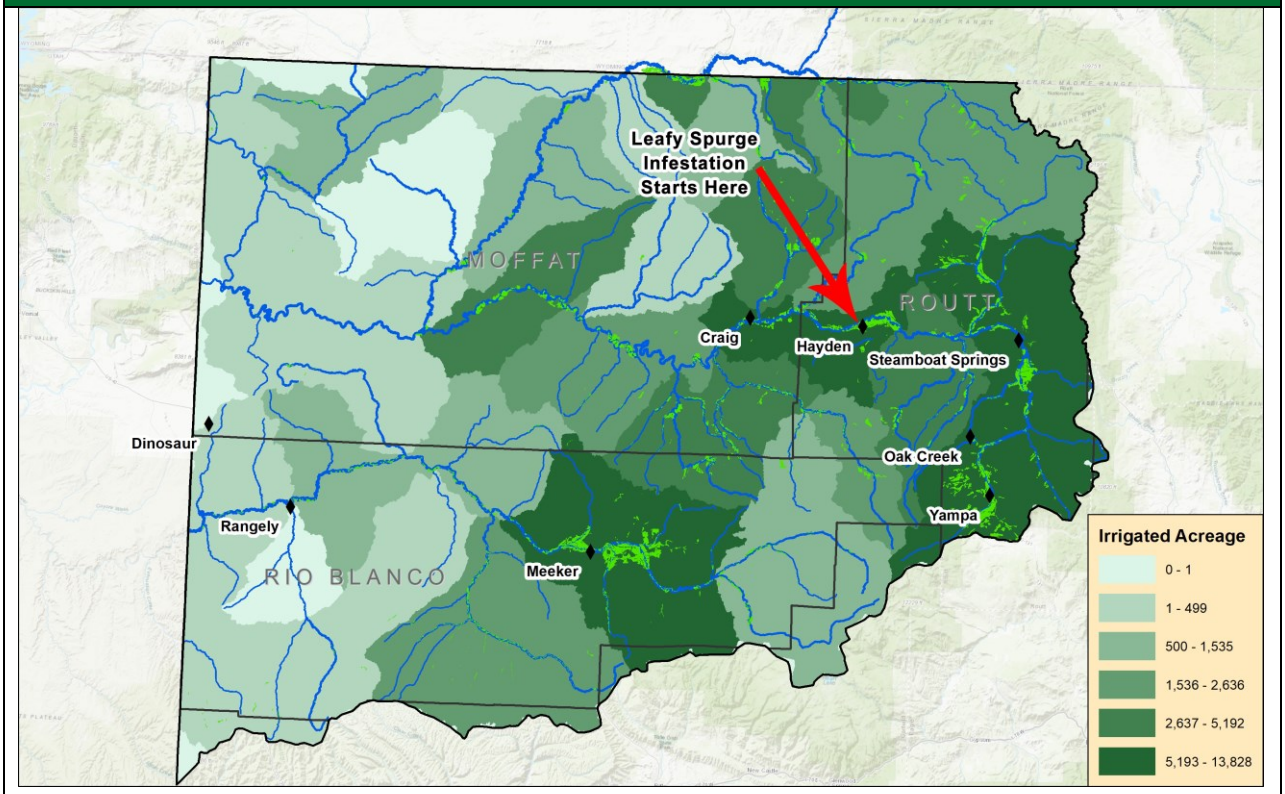

Figure 1: Irrigated acreage by sub-basin. Demand nodes are concentrated in the brightly-colored areas. The red arrow indicates the most upstream known leafy spurge infestation. New infestations have been documented from there downstream to beyond the confluence with the Green River, especially since the high-water event in 2011. (Source: 2010 irrigated acreage assessment and modeling information from the Colorado Decision Support System (CDSS))

Targeted grazing is one tool that may be effective for reducing seed load produced by existing leafy spurge infestations. Sheep and goats have unique digestive systems that can tolerate the toxins produced by leafy spurge. In fact, because leafy spurge is high-value forage, spurge-tolerant species like sheep and goat often display a preference for leafy spurge. Thus, carefully timed sheep and/or goat grazing may be a viable option for reducing seed production in areas that are compatible with this class of livestock. Much of the limited research looking at targeted grazing management practices was performed in the Northern Great Plains and is not necessarily directly translatable to the diverse landscape present in the Yampa Valley. This study will focus on local conditions and target riparian habitats where we have such limited options for herbicide use.

Four (possibly 5) specific riparian environments will be the focus for this work:

1. Riparian forest/woodland—seasonally flooded (Yampa River)
2. Riparian meadow—seasonally flooded (Yampa River)
3. Sparsely vegetated bars/beaches in active channel environments (Yampa River)
4. Tributary stream riparian habitat (possibly Fortification Creek or Fourmile Creek)
5. Optional (if time and resources are available) Irrigation ditch bank

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Task Schedule:

Graduate Student Recruitment:

1. Upon notification of funding, with intended enrollment in January 2019.

Research Project/Student Activities:

2. Spring 2019
    a. Identify Plot Locations
    b. Work with YRLSP volunteers/land owners to install necessary temporary fencing
    c. Begin early grazing treatments
3. Summer 2019
    a. Begin late grazing treatments
4. Fall 2019
    a. Apply herbicide treatments
    b. Collect biomass, biodiversity, and seed production data
    c. Begin analyzing data
5. Winter 2019
    a. Complete data analysis and identify best integrated management practices
    b. Produce extension publication on results
6. Spring 2020
    a. Collect biomass, biodiversity, and seed production for 1-year post-treatment analysis
    b. Integrate results in to previous conclusions, as appropriate

Final Products

7. Spring 2021
    a. Master's Thesis
    b. Final Report to YWG BRT and CWCB

Method/Procedure:

YRLSP partners will work with local stakeholders and the University of Wyoming (UWYO) to identify suitable sites to conduct the proposed field studies across the target habitat types. If a local livestock operator is interested in participating, the option exists to utilize local livestock. Otherwise, UWYO livestock will be used to accomplish the work.

To identify when targeted grazing will be most successful at 1) reducing leafy spurge density and seed production, and 2) retaining desirable species, two grazing timings will be utilized—early and late. Early grazing (approximately late April to early May depending on seasonality) is more likely to be injurious to the target plant but may not reduce seed production if leafy spurge is capable of still producing flowering structures after the grazing event. Late grazing (approximately August depending on seasonality) may be less likely to injure the target plant but may ensure seed production is more effectively limited. Post grazing data will be collected on these treatments to determine how effectively these timings reduce leafy spurge biomass and seed production.

Targeted grazing is not selective enough to adversely impact only the target species. The desirable resident plant community is also susceptible to injury from grazing. The goal of targeted grazing is to more greatly impact the target species when compared to the desirable community. If the inverse happens, then management is unsuccessful and may lead to further leafy spurge invasion. To monitor the effect of our timing treatments on the resident plant community, plant community biomass and diversity will also be collected to comparatively monitor the impact to the target and other species.

Preliminary results from another study examining integrated management of Dalmatian toadflax—another perennial large-statured forb invader—suggest the integration of herbicide and grazing can result in better control of the target species. Additionally, because leafy spurge infestations in the Yampa River corridor

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are currently primarily restricted to riparian areas, herbicide usage is a concern. Thus, the integration of grazing with reduced-rate herbicide applications could lead to greater reductions in seed production while also minimizing the herbicide applied. In this study, we will integrate low-dosage herbicide to reduce injury to surrounding vegetation and risk of leaching while still reducing leafy spurge seed production. Leafy spurge seed production, biomass, and cover will be monitored in response to the combined treatments to identify how effective our treatments are at reducing the spread and impact of leafy spurge.
Grantee Deliverable: (Describe the deliverable the grantee expects from this task)
1. Master's Thesis (University of Wyoming-Spring of 2021) 2. Extension publication recommending best integrated management practices for riparian settings 3. Future data needs and management direction are identified
CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the completion of this task)
1. Final Report to Y-W-G Roundtable and CWCB, including an executive summary, documenting results of the study and recommendations for future work.

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Tasks
Task 3 – Education and Outreach—Engage youth in the Yampa River Leafy Spurge Project, using biological control as a means to encourage learning, participation and productive involvement.
Description of Task:

Several species of flea beetles (*Aphthona* spp.) are available for use as biological control agents to manage leafy spurge. While it has been reported that previous releases of these insects in riparian areas have been unsuccessful in establishing viable populations, the Colorado Department of Agriculture (CDA) has had some success near Meeker in the past decade. It may be that we simply need to be more systematic and persistent in our efforts to establish viable flea beetle populations in the Yampa Valley. The first step toward revitalizing this effort is to produce a map of all known historical release sites in Moffat and Routt counties and to begin a systematic monitoring program. Labor is the limiting resource for accomplishment of this objective.

The YRLSP is interested in working with the Colorado Department of Agriculture to develop a simple, kid-friendly monitoring protocol that could be used to engage youth in "adopting" and monitoring specific biocontrol release sites. This approach would be appropriate for 4-H clubs, school science classes, and other youth organizations. The intent is to integrate river and riparian ecosystem health, irrigation water delivery systems, agricultural systems, leafy spurge biology (interesting seed dispersal mechanism), invasive species ecology and management, and community service and learning.

The Colorado Department of Agriculture has been approached and is interested in working with the Yampa River Leafy Spurge Project to establish viable biological control species for leafy spurge in the Yampa Valley. It may be that a combination of site characteristics must occur in close proximity to ensure successful establishment and long-term viability of biocontrol insect populations. Mapping, monitoring of historical release sites and consultation with experts in the next two years should help the YRLSP identify potential future release sites for biological control agents and determine whether viable biocontrol populations presently exist in the Yampa Valley.

The YRLSP is already making progress in some of these areas, but with a small amount of funding for printing, materials and supplies, we would like to begin the youth engagement component by running several "adopt-a-bug-site" monitoring pilot projects. If this model is well-received, then we would be positioned to expand the effort as funds (from other sources) become available.

Task Schedule:

Generate a map of known biological control release sites:

1. Winter 2018-Spring 2019
    a. Gather existing information from Moffat and Routt counties, CPW and CDA.
    b. Create comprehensive map and database in ArcGIS/Access.

Develop a simple, kid-friendly monitoring protocol:

2. Spring 2019
    a. Work with CDA and other interested stakeholders to develop a draft protocol
    b. Identify 2-4 interested youth organizations willing to test the protocol
3. Summer 2019
    a. Adopt and monitor
4. Fall 2019-Winter 2020
    a. Analyze results and modify protocol
    b. Seek additional funding sources and approach additional youth organizations

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5. Summer 2020 a. Adopt and monitor b. Use new information to identify additional release sites 6. Fall 2020 a. Analyze results b. Use results to identify best potential viable population areas Final Products 7. Spring 2021 a. Final Report to YWG BRT and CWCB
Method/Procedure:
Map and associated data will be gathered from identified sources by YRLSP volunteers and stored in ArcGIS/Access formats for best availability to interested partners/stakeholders. YRLSP volunteer(s) will work with CDA and other interested stakeholders to develop the draft monitoring protocol. Insects are available from the Colorado Department of Agriculture at no cost. Local 4-H clubs will be approached first to implement pilot "adopt-a-bug-site" monitoring protocols. YRLSP volunteer(s) will look for additional funding sources to grow and sustain the program.
Grantee Deliverable: (Describe the deliverable the grantee expects from this task)
1. A comprehensive release site map and associated shapefiles/data. 2. Youth engagement in helping to solve a problem that adversely affects our agricultural economy and our river and riparian resources.
CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the completion of this task)
Report to YWG Roundtable and CWCB, including an executive summary, documenting progress in developing biological control capability and youth involvement in grassroots management of leafy spurge in riparian and agricultural environments in the Yampa Valley.

Budget and Schedule
Exhibit B - 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. A separate excel formatted Budget is required for engineering costs to include rate and unit costs.

Reporting Requirements
Progress Reports: The grantee 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. The CWCB may withhold reimbursement until satisfactory progress reports have been submitted.

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Reporting Requirements

Final Report: At completion of the project, the grantee shall provide the CWCB a Final Report on the grantee'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.

Payments

Payment will be made based on actual expenditures, must include invoices for all work completed and must be on grantee's letterhead. 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.

The CWCB will pay the last 10% of the entire water activity 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 water activity and purchase order or contract will be closed without any further payment. Any entity that fails to complete a satisfactory Final Report and submit to CWCB within 90 days of the expiration of a purchase order or contract may be denied consideration for future funding of any type from CWCB.

Performance Requirements

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 Grant Guidelines, the CWCB will pay out the last 10% of the budget when the final deliverable is completed to the satisfaction of CWCB staff. Once the final deliverable has been accepted, and final payment has been issued, the purchase order or grant will be closed without any further payment.
(b) Accountability: Per the 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 the Grant Guidelines, Progress Reports must be submitted at least once every 6 months. A Final Report must be submitted and approved before final project 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.