2023 319 Application Form - General and Focus Watershed

General Information

Project Name: Stone Creek Treatment Wetland Design

Sponsor Name: Beaverhead Conservation District

Registered with the Secretary of State? Y

Registered with SAM? Y

UEI #: GLG7WFUXLD83

Does your organization have liability insurance? Y

Primary Contact: Zach Owen	Signatory: Byron Martinell
Title: Watershed Coordinator - Beaverhead CD	Title: Board Chair - Beaverhead CD
Address: 420 Barrett St	Address: 420 Barrett St
City: Dillon State: MT Zip Code: 59725	City: Dillon State: MT Zip Code: 59725
Phone Number: 406.683.3802	Phone Number: 406.683.3802
Email Address: beaverheadwatershed@gmail.com	Email Address: beaverheadcd@gmail.com
Signature: Zach Owen Digitally signed by Zach Owen Date: 2022.09.29 14:42:37 -06'00'	Signature: Byron Martinell Digitally signed by Byron Martinell Date: 2022.09.29 14:42:14 -06'00'

Technical and Administrative Qualifications

The Beaverhead Conservation District (BCD) has administered over a dozen DNRC grants including through the Renewable Resource Grant and Loan, Reclamation and Development Grant, Watershed Management Grant, and Conservation District programs, for well over $500,000. The BCD just completed a 5-year cooperative agreement with the BLM with funding just under $500,000. The BCD has managed dozens of projects concurrently with multiple funding sources and complex report requirements. The Beaverhead Watershed Committee (BWC) is a subcommittee of the BCD focused on improving and repairing the environment across the Beaverhead Watershed. As a diverse group of volunteers and stakeholders from many different organizations, the BWC has coordinated a citizen-based approach that maintains public awareness and implements improvements in the Beaverhead Watershed. Since its formation in 2001, the BWC has completed a dozen of successful projects related to water quality and quantity, fencing and grazing, weed management, and public outreach.

Budget Summary: **Fields outlined in __black__ on this page will auto-populate from other sections of the application form. Fields outlined in __red__ on this page will not auto-populate. You must manually input the information for fields outlined in __red__.*

	319 Funding Request	Non-Federal Match	Other Funding	Total Cost
Education and Outreach Project	$ 0	$ 10,000	$ 0	$ 10,000
Administration	$ 5,700	$ 0	$ 0	$ 5,700
Project 1 Name	Stone Creek Treatment Wetland Design			
Project Planning	$ 51,000	$ 19,600	$ 0	$ 70,600
Landowner Agreements	$ 0	$ 4,080	$ 0	$ 4,080
Project Implementation	$ 0	$ 0	$ 0	$ 0
Project Effectiveness Monitoring	$ 0	$ 4,320	$ 0	$ 4,320
Total	$ 51,000	$ 28,000	$ 0	$ 79,000
Project 2 Name				
Project Planning				$ 0
Landowner Agreements				$ 0
Project Implementation Project				$ 0
Effectiveness Monitoring				$ 0
Total	$ 0	$ 0	$ 0	$ 0
Project 3 Name				
Project Planning				$ 0
Landowner Agreements				$ 0
Project Implementation Project				$ 0
Effectiveness Monitoring				$ 0
Total	$ 0	$ 0	$ 0	$ 0
Project 4 Name				
Project Planning				$ 0
Landowner Agreements				$ 0
Project Implementation Project				$ 0
Effectiveness Monitoring				$ 0
Total	$ 0	$ 0	$ 0	$ 0
Grand Total	$ 56,700	$ 38,000	$ 0	$ 94,700

Education and Outreach

Developing good projects often requires a considerable amount of time and effort up front to build relationships and trust with individual landowners and stakeholder groups. It also requires adequate training for project sponsor staff (e.g., technical training, project management, public procurement, technical writing, etc).To promote the development of future projects, DEQ is encouraging project sponsors to use up to $5,000 in 319 funding for education and outreach to develop and capitalize on critical relationships and to improve organizational capacity. DEQ also encourages applicants to incorporate on-the-ground projects into education and outreach efforts through on-site demonstrations and project tours. 319 funding may not be used to pay for food and beverages, or for honorariums and gifts.

Activity (method of delivery)	1. Education and Outreach - Conduct a minimum of one workshop to inform people of the importance of natural and constructed wetlands for protecting and improving water quality and wildlife habitat. Conduct at least one tour of the pilot project/proposed larger wetland site.
Target Audience	General public, students, contractors, landowners, local producers.
Goals	Spread awareness of the current water quality issues in the watershed, nutrient loading impacts, and demonstrate how vital both natural and constructed wetlands are to preserving and improving water quality and wildlife habitat. Encourage local landowners and producers to take on similar projects if they have similar impairments along their land.
Effectiveness Evaluation	Measured mostly by attendance to workshops. We can also survey attendants for feedback after workshops and tours. One-on-one conversations from locals expressing interest in doing similar projects.

Activity (method of delivery)	2. Newsletter/Website/Pamphlets- Use current website and newsletter to highlight project, water quality issues, and the projects impact on them. A pamphlet may be designed and distributed with similar information. We put out a newsletter at least quarterly, and would dedicate a minimum of two newsletters per year to this project.
Target Audience	General public, students, contractors, landowners and producers.
Goals	Spread awareness of natural and constructed wetlands ability to improve water quality impairments in the watershed. Encourage other landowners to considered constructed wetlands (or restoration of natural wetlands) as a method of correcting water quality impairments.
Effectiveness Evaluation	Web traffic, newsletter recipients, pamphlets distributed, one-on-one conversations with managers and landowners.

Activity (method of delivery)	
Target Audience	
Goals	
Effectiveness Evaluation	

319 Funding Request	Non-Federal Match	Other Funding*	Total
	$ 10,000		$ 10,000

Match Source DNRC HB-223 Grant ____ Secured ☐

Match Source ____ Secured ☐

Match Source ____ Secured ☐

**Use this space to record any funding that will be used to support creation of the task deliverables, but will not be reported as match. The purpose of this information is to give application reviewers a clearer understanding of the total amount of funding required to complete a task.*

Project Administration

Project administration includes book keeping, invoicing, interim/annual/final report preparation, office supplies, rent, communications, etc. 319 funding applied to this task must not exceed 10% of the total amount of 319 funding requested, or $12,000, **whichever is lower**. Like all other tasks, payment is by reimbursement for actual expenses incurred.

319 Funding Request	Non-Federal Match	Other Funding*	Total Cost
$ 5,700	$ 0		$ 5,700

Match Source ______________________ Secured ☐

Match Source ______________________ Secured ☐

**Use this space to record any funding that will be used to support creation of the task deliverables, but will not be reported as match. The purpose of this information is to give application reviewers a clearer understanding of the total amount of funding required to complete a task.*

Project 1

Project Form

A separate Project Form ***(including providing separate attachments)*** must be submitted for each project included in your application. Use the following examples to help determine when to lump and when to split projects. For additional assistance, contact Mark Ockey at mockey@mt.gov or 406-444-5351.

Splitting Examples (fill out multiple Project Forms)

- Stream restoration work occurring on two separate streams, on parcels owned by two separate individuals
- Two projects with significantly different sets of project partners
- Two projects that address substantially different pollution sources (e.g., one project moves a corral off of a streambank, and another removes mine tailings, with both projects being on the same property)

Lumping Examples

- Contiguous stream restoration work spanning multiple land parcels
- 3 projects that address similar sources of pollution on a single land parcel (e.g., moving a corral off a stream, implementing a grazing management plan, and relocating a manure storage facility out of the floodplain, all on the same ranch)

Project 1 Name

Stone Creek Treatment Wetland Design

Project 1 - Problem Description

Select the watershed restoration plan (WRP) that your project will help implement.

Beaverhead - Beaverhead Watershed Committee

Y — Letter of support from author entity attached? *(If no, explain why below.)*

Waterbody name from the 2020 List of Impaired Waters	Lower Stone Creek
Probable causes of impairment to be addressed	Primary: Total Nitrogen and Nitrate/Nitrite as N Secondary: Metals (Al, Fe, Cu) and Phosphorus
Waterbody name from the 2020 List of Impaired Waters	
Probable causes of impairment to be addressed	
Name of healthy waterbody to be protected	
Description of identified threat to non-impairment status	
Name of healthy waterbody to be protected	
Description of identified threat to non-impairment status	

Detailed Problem Description

Provide a detailed description of the nonpoint source pollution problem you are attempting to address. Be sure to include the following:

- Identify the primary types of pollution
- Identify the primary sources of the pollution
- Identify the root causes of the pollution
- Describe any previous work done to address the problem (who, what, where, when)
- Describe the impacts of the problem (who, what, where)

Lower Stone Creek is a tributary to the Carlton Slough, which ultimately flows into the Beaverhead River. Lower Stone Creek flows through cropland for approximately 6.5 miles before reaching the Staudaher Bishop Ditch. The project map provides an overview of both sections of Stone Creek. Approximately half the landcover is cropland with large-scale pivot agriculture applications near the lower portion. Most of Lower Stone Creek's flow is sourced from groundwater return flows originating from irrigation-induced groundwater recharge associated with the East Bench Irrigation District. Elevated concentrations of nitrates and nitrates were originally found in Stone Creek in 2003. Nutrient and metals pollutant impairments were identified based on subsequent sampling more recently outlined in the 2018 Integrated Report. Sediment TMDLs were established for Lower Stone Creek in July of 2012. A TMDL for metals was established for Lower Stone Creek in September of 2020. Nutrient TMDLS are currently awaiting development based on listings and data in the 2018 Integrated Report. Lower Stone Creek has the following pollutants listed as causes of impairment in the 2020 List of Impaired Waters: Total Nitrogen, Nitrate + Nitrite as N, Total Phosphorus, Aluminum, Iron, and Copper.

Arsenic, Chlorophyll-a, and sedimentation/siltation were previously delisted as impairment causes. The source of the nitrates and nitrates in Lower Stone Creek are not specifically defined but is likely the result of nitrate-based fertilizer applied to crops in the watershed, ultimately entering the creek via a complex groundwater return flow system. Elevated temperatures occurring during the late-summer months combined with elevated nitrate and nitrite concentrations lead to excessive algae growth, impacting fish and aquatic life downstream. The primary source of metals in Lower Stone Creek subwatershed is linked to the Upper Stone Creek subwatershed. A total of 31 abandoned mines are present in the Upper Stone Creek Watershed along with mining operations associated with three hardrock permits. All exceedances of water quality targets were observed during a sampling event conducted in April of 2017.

Following the discovery of elevated Nitrate and Nitrite concentrations in 2003, KirK Engineering & Natural Resources, CDM, and the Beaverhead Conservation District implemented a pilot scale test program of a constructed Free Water Surface (FWS) wetland in 2005 to evaluate a conceptual design and method that reduces the Nitrate and Nitrite concentrations in Stone Creek. During the spring and summer of 2005, a pilot scale FWS treatment wetland was designed, installed, and tested. The program demonstrated that the system was capable of significantly reducing nitrate and ammonia concentrations with an added benefit of a slight reduction in Phosphorus. Following implementation of the test program, it was decided that a full-scale 6-acre FWS wetland be designed, constructed, and implemented to reduce nitrate concentrations within Lower Stone Creek. Even though metals were not considered during the design or implementation of the pilot program, a properly designed and constructed treatment wetland can significantly reduce the metal concentrations listed as impairment for Lower Stone Creek. This application outlines the proposed project to design a full-scale FWS treatment wetland to prepare for the construction and implementation of the system.

Project 1 - Solution Description

Provide a detailed description of the solution you are proposing to implement to address the nonpoint source pollution problem described in the previous section. Be sure to include the following:

- Describe the range of options available for solving the problem, including a no-action alternative
- Describe the practices you intend to design and/or implement to solve the problem (what, where, when, how much or how many)
- Explain why the chosen alternative is the best alternative
- Describe any pre-project planning that has already taken place (e.g., design work, permitting consultation, Endangered Species Act consultation, wetland delineations, landowner agreements, community outreach)
- Describe the anticipated maintenance needs (what, where, who, how long)

The proposed project (phase I) is intended to expand on previous findings supported by the pilot project completed in 2005 by designing a full-scale FWS treatment wetland. The long-term goal (phase II) is to construct and implement the designed system in a subsequent project. The best route for a successful FWS wetlands project utilizes scaling of the pilot study along with careful planning, data collection, and additional design analysis to achieve the desired pollutant reduction targets. Further investigations into local climate, hydraulic loading, substrate composition, modeling, and water chemistry needs to be completed as part of the design of the proposed full-scale treatment wetland in order to optimize pollutant removal efficiencies and provide added benefits, such as treating metals. The water chemistry and flow may have changed since 2005 due to a variety of factors such as changes in land-use, agricultural management, irrigation methods, mining operations, and climate. Rather than leading directly into a design-build project from the findings of the pilot study, this application and portion of the project focuses solely on the design of the proposed FWS treatment wetland prior to pursuing funding for construction and implementation.

FWS wetlands are demonstrated to be an efficient way to remove excess nutrients from cropland runoff and are the nearly exclusive choice for the treatment of agricultural runoff because of their ability to deal with changing flows and water levels. FWS wetlands are simpler to construct and maintain, making them useful as a long-term treatment option, particularly in remote area. FWS systems can provide significant ancillary benefits such as recreational opportunities and wildlife habitat, along with treatment of metals. Engineered FWS treatment wetlands consist of both of a nature-based solution combined with an engineered solution and thereby are considered a passive form of treatment by closely mimicking natural wetlands and taking advantage of natural processes. Constructed FWS wetlands capitalize on my intrinsic physical, chemical, and biological processes that operate both simultaneously and sequentially to improve the quality of incoming water. The relative importance of a process varies significantly, depending on the pollutant being treated, speciation of the pollutant, operational design (residence time), environmental conditions (temperature), type and density of macrophytes, physiochemical water parameters, and substrate characteristics. Therefore, proper site-specific data collection, design, construction, operation, maintenance, and monitoring must be implemented to ensure that reduction targets are met.

The proposed project consists of the following tasks or phases conducted in order as follows:

- Coordination with existing landowner to secure long-term site access
- Site selection
- Topographical survey and on-site soils evaluation
- Flow measurement and background pollutant sampling
- Preliminary design (sizing, hydraulic calculations and modelling, and development of preliminary design plans)
- Final design and permitting
- Preparation of the technical report and Operation and Maintenance plan (O&M)
- Preparation of bid documents and bid advertisement and selection.

While not listed, procurement of additional funds will need to occur before implementing the construction phase of the project. These funds will most likely be in the form of additional 319 funding coupled with a FWP Future Fisheries Grant and possible contributions or in-kind volunteering through partnerships.

*See "Solution Description Additional Text" document for remaining information.

Project 1 - Goals and Effectiveness Evaluation

List the specific, measurable nonpoint source goals for your project.

The goals and effectiveness of the project can be estimated and later quantified after implementation. The following provides an estimation of the benefits along with the benefits gained from public education and outreach. The purpose of this phase is to determine the best location, placement and methods for the wetland, and design the wetland.

1. Reduce nitrate loading into the Beaverhead river by approximately 4,800 pounds per year as reported in the pilot study. Additional background sampling scheduled for the project along with revised loading and treatment estimates may result in a different removal rate once the design is complete. The actual reduction will be quantified as part of implementation of the project.

2. Reduction of additional pollutants such as metals, phosphorus, and sediment. The proposed treatment wetland's design will be optimized for Nitrate removal, however FWS wetlands will reduce concentrations and loading of metals, phosphorus, and sediment by similar mechanisms as for nitrates, such as sedimentation, adsorption, precipitation, and biological uptake.

3. Increased wetland habitat for wildlife.

4. Educational benefits of showing and promoting the project will lead to other nutrient reduction projects and FWS wetlands.

Explain how you will determine whether the you have met the goals described above. Identify any data you intend to collect, calculations you'll make, or methods you intend to use.

1 & 2. Ongoing influent and effluent concentration sampling, in conjunction with continuous flow monitoring, will allow for the calculation of pollutant reduction rates and the mass of pollutants exiting the system on an annual basis. Careful planning and use of proper sampling and analytical techniques will be used to ensure representative removal, concentration, and mass loading values. Continuous sampling and monitoring will be instrumental in optimizing treatment performance since rarely are CTWs operated without hydraulic adjustments (water level, residence time, etc.).

3. The total area of the proposed system constructed will determine the amount and quality of habitat produced for plant and wildlife species. Plant species will be carefully curated and selected to optimize treatment, but macrophytes selected will be species native to the surrounding region. In addition to the water quality sampling described above, wildlife population surveys may be implemented to measure the effectiveness of the system to provide habitat for crucial wildlife populations.

4. Use of surveys, public outreach, and meetings to quantify the feedback from stakeholders, farmers, rancher, and interested citizens.

Project 1 - Location

	Latitude		Longitude	
Upstream End	Latitude	45.32150°	Longitude	-112.52070°
Downstream End	Latitude	45.32193	Longitude	-112.52560
Centerpoint	Latitude	45.32174	Longitude	-112.52449°
Upstream End	Latitude		Longitude	
Downstream End	Latitude		Longitude	
Centerpoint	Latitude		Longitude	
Upstream End	Latitude		Longitude	
Downstream End	Latitude		Longitude	
Centerpoint	Latitude		Longitude	

List the 12-digit Hydrologic Unit Code(s) (HUCs) in which the project area is located: MT41B002_131

☑ **Detailed Project site map(s)** Attach a map or set of maps showing the location and size of proposed activity. The map scale must be between 1:1,000 and 1:12,500. The map(s) must have an aerial photo background (e.g., USDA NAIP photography, Google Earth imagery, etc.). The map(s) must show the latitude, longitude, site name, and landowner for the activity site. The map(s) should also identify waterbodies affected by the pollution that the activity is designed to address.

Other Attachments - *(These documents are not required, but may be submitted to provide more specific details about a project or to demonstrate adequate planning and preparation; please, however, be respectful of the amount of time it will take an application reviewer to find relevant information within a document and use excerpts where appropriate; do not attach WRPs, TMDLs or other large-scale planning documents)*

- ☑ Conceptual Design Technical Memo and Pilot Scale Treatment Results Beaverhead County Nitrate Treatment Wetlands
- ☑ Solution Description Additional Text
- ☐
- ☐
- ☐

Project 1 - Partners

Identify each of the project partners and describe their contribution to the project. Include landowners, land managers, project designers, funders, and your own organization. Indicate whether each partner, other than your organization, has provided a letter of support. (*Note: each landowner must provide a letter of support.*)

Landowner	Contributions to Project	Letter of Support Attached?
Carl Malesich	Site access and long-term lease for future project site.	☑
		☐
		☐
		☐

Project Partner	Contributions to Project	Letter of Support Attached?
Montana Department of Fish, Wildlife, and Parks (FWP)	Public outreach and education and potential funding (Future Implementation). FWP Biologist supports this project but was unable to get us a letter of support by deadline.	☐
Montana Trout Unlimited	Public outreach and education and potential funding (Future Implementation).	☑
Beaverhead Watershed Committee	Public outreach and education	☑
		☐
		☐

Project 1 - Budget

Use the space below to outline your project budget.

Project Planning This includes costs for surveying, engineering, permitting, procurement, construction oversight, and overall coordination of the proposed project. This does not include things like reporting, book keeping, communications, office space, or utilities, which are all covered in the Project Administration budget.

319 Funding Request	Non-Federal Match	Other Funding*	Total Cost
$ 51,000	$ 19,600		$ 70,600

Match Source	Watershed Planning Grant	Secured	☐
Match Source	Renewable Resource Planning Grant	Secured	☐
Match Source		Secured	☐
Match Source		Secured	☐

**Use this space to record any funding that will be used to support creation of the task deliverables, but will not be reported as match. The purpose of this information is to give application reviewers a clearer understanding of the total amount of funding required to complete a task.*

Landowner Agreements This includes costs for developing and managing landowner agreements. The landowner agreement(s) must verify that Contractor and DEQ staff may access the project site, at reasonable times and with prior notification, for the purposes of project planning, implementation, and post-implementation monitoring. The agreement(s) must ensure appropriate operation and maintenance of all structures, vegetation, and management measures for the life of the project. If grazing will be allowed within the project area, the agreement(s) must include a sustainable management plan for livestock grazing, designed to protect and enhance riparian function.

319 Funding Request	Non-Federal Match	Other Funding*	Total Cost
	$ 4,080		$ 4,080

Match Source	Watershed Planning Grant	Secured	☐
Match Source		Secured	☐
Match Source		Secured	☐
Match Source		Secured	☐

**Use this space to record any funding that will be used to support creation of the task deliverables, but will not be reported as match. The purpose of this information is to give application reviewers a clearer understanding of the total amount of funding required to complete a task.*

Project Implementation This includes costs for all materials, labor, equipment, and as-built surveys associated with implementing the plans developed under the Project Planning task. If you are requesting funding for design only, leave this task blank.

319 Funding Request	Non-Federal Match	Other Funding*	Total Cost
			$ 0

Match Source ______________________ Secured ☐

Match Source ______________________ Secured ☐

Match Source ______________________ Secured ☐

Match Source ______________________ Secured ☐

**Use this space to record any funding that will be used to support creation of the task deliverables, but will not be reported as match. The purpose of this information is to give application reviewers a clearer understanding of the total amount of funding required to complete a task.*

Project Effectiveness Monitoring This includes costs for developing and implementing a reasonable method or set of methods for evaluating and reporting on the effectiveness of the project in achieving NPS pollution goals. It includes preparation and implementation of a monitoring plan, and preparation of a monitoring report. If the project goals include reducing sediment, nitrogen and/or phosphorus, this task will also include calculation of annual load reduction estimates. Photo-point monitoring is also a standard requirement for this task. If you are requesting funding for design only, you may either leave this task blank or request funding for plan development and pre-project monitoring.

319 Funding Request	Non-Federal Match	Other Funding*	Total Cost
	$ 4,320		$ 4,320

Match Source Renewable Resource Planning Grant Secured ☐

Match Source ______________________ Secured ☐

Match Source ______________________ Secured ☐

Match Source ______________________ Secured ☐

**Use this space to record any funding that will be used to support creation of the task deliverables, but will not be reported as match. The purpose of this information is to give application reviewers a clearer understanding of the total amount of funding required to complete a task.*

Project 1 - Project Timeline

Task Description	3Q 2023	4Q 2023	1Q 2024	2Q 2024	3Q 2024	4Q 2024	1Q 2025	2Q 2025	3Q 2025	4Q 2025	1Q 2026	2Q 2026
Education and Outreach	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Preliminary Landowner Coordination	✓	✓										
Site Selection	✓	✓										
Topographical Survey		✓										
Procurement of Landowner Agreements, Easements, Leases, etc.		✓	✓									
Flow Measurement and Background Pollutant Sampling	✓	✓										
Preliminary Design - Sizing, Hydraulic Calculations and Modelling, Preliminary Design Plans.			✓	✓	✓							
Final Design Plans					✓	✓						
Technical Report						✓						
O&M Plan						✓						
Project Manual (Bid Documents)							✓					
Bid Advertisement								✓				
Selection								✓				
Award Notice								✓				
Notice to Proceed									✓			

Project 1 - Bigger Picture Benefits

Environmental Justice

Explain how your project incorporates disadvantaged community populations and priorities, Tribal and community leader engagement, or socioeconomic barriers in the context of equal protection and access to a healthy environment.

Access to clean, safe, abundant, and affordable water is a fundamental human right essential for a healthy population, environment, and economy. This normally is considered for drinking water, but this principle also applies to recreational access and availability as well. Montanans from all walks of life and socioeconomic backgrounds deserve to benefit from the recreational possibilities provided by the Beaverhead River and tributaries within the watershed. The most intensive recreation use within the Watershed is fishing, and trout populations are heavily dependent on water quality. The proposed constructed treatment wetland will provide an environmental benefit by reducing the nutrient load into the Beaverhead River. Currently, water quality is linked to fishery issues in the Beaverhead River and this project improves water quality providing one step forward for watershed fishery restoration work. This project benefits the local fish population and ultimately provide a continued benefit for all Montanans, regardless of their socioeconomic status.

Climate Change/Resilience

How will your project improve climate change resilience for communities, native plants, wildlife, or ecosystems?

Montana is expected to experience increased temperatures and severe drought by receiving precipitation in the form of rain rather than much needed snow to maintain water storage in the form of winter snowpack. Increased temperatures and lowered flow rates within surface water bodies due to climate change in combination with elevated nitrates and nitrites can result in excessive algae growth, which can harm fish and other aquatic life. Stone Creek is currently a valuable spawning and refuge trout habitat for the Beaverhead River. Increased frequency and severity of algal blooms may compromise this habitat in the future. The proposed treatment wetland is estimated to remove approximately 4,800 pounds of nitrates per year, thereby reducing a major component of algae blooms and reducing potential impacts to fish and other aquatic life. Additional reductions in metals concentrations will also assist in reducing potential impacts to fish and other aquatic life. Climate changes in combination with other stressors may further exacerbate the loss of existing natural wetlands. Wetlands loss can also lead to reduced habitat for fish and wildlife and worsen existing shifts in species ranges. The introduction of the proposed wetland will provide approximately 6 acres of free water surface wetland habitat for wildlife.

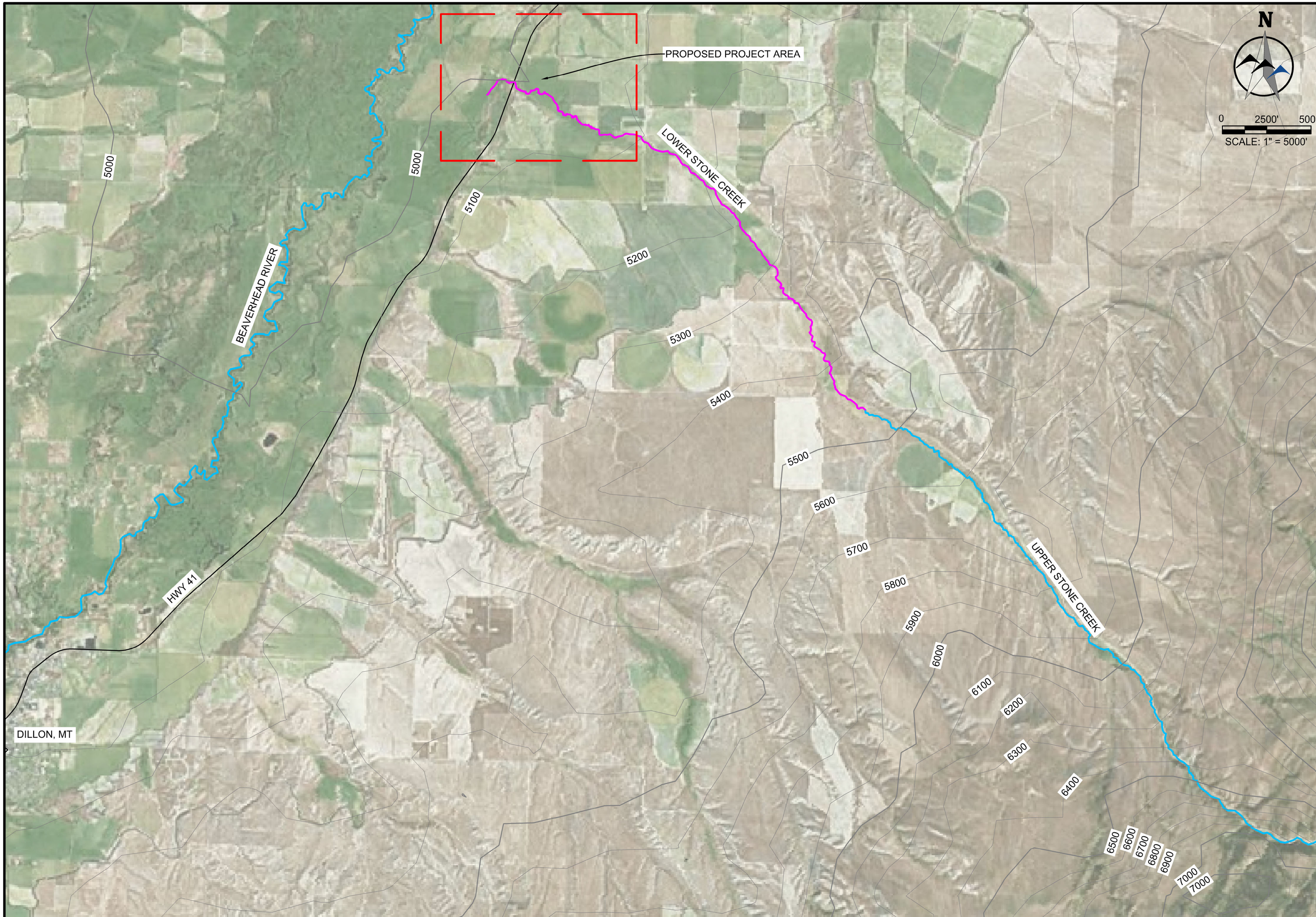
Impacts to Downstream Human, Plant and Animal Communities

What sort of an impact will your project have on downstream human, plant or animal communities?

Wetlands, especially in areas of intense agricultural production, play an important role in maintaining and improving water quality while preserving and providing habitat for plant and animal communities. The downstream water quality benefits ultimately improve by removing nutrients, metals, and sediment before reaching downstream surface water bodies, thereby improving conditions for animal and plant communities, particularly spawning habitat for trout populations in the case of the Beaverhead River. Communities that utilize surface water as their primary source of drinking water, such as the City of Helena, will benefit from water quality improvements. In the case of areas downstream of the proposed treatment wetland where Stone Creek or downstream irrigation ditches that are losing water via groundwater echarge, the water quality improvements benefit downstream communities and locals that utilize groundwater as their primary source of drinking water and stock water for cattle. Additionally, the deep areas of the proposed FWS wetland could potentially provide habitat for fish and recreational opportunities such as kayaking and fishing.

Map

K:\Helena\BEAVERHEAD CD\2022328 Stone Creek Nutrient Pond\05CAD\Sheets\2022328-PLAN.dwg 11X17 LANDSCAPE 9/13/2022 6:54:49 PM



NO.	REVISION	BY	DATE

PROJECT NO. 2022-328

PREPARED BY
WWC ENGINEERING
7600 SHEDHORN DRIVE, SUITE 7
BOZEMAN, MT 59718
(406) 624-3910
www.wwcengineering.com

BEAVERHEAD CONSERVATION DISTRICT
STONE CREEK TREATMENT WETLAND
OVERVIEW MAP
BEAVERHEAD COUNTY, STATE

DESIGNED BY: *PJH*
DRAWN BY: *PJH*
CHECKED BY: *SP*
DATE: *09/12/2022*

SHEET
1

Letters

of

Support

BEAVERHEAD
WATERSHED COMMITTEE
420 Barrett St. Dillon, MT 59725
406.683.3802
zach@beaverheadwatershed.org

Mark Ockey | *Water Quality Specialist*
Water Quality Planning Bureau
Montana Department of Environmental Quality

Mark,

The Beaverhead Watershed Committee is part of, and works closely with the Beaverhead Conservation District. We support the application for funding to design and construct a nutrient reduction wetland on Stone Creek. We previously completed a pilot project to test the effectiveness of a wetland on nutrient levels in Stone Creek. That project was a success, and a full-scale project was recommended years ago. We're excited to see this finally move forward.

Thank you for your time and consideration,

Sincerely,

Zach Owen

BWC Watershed Coordinator

406-461-1846

Malesich Ranch Company, Stone Creek Ranches, Carl Malesich

9575A MT Highway 41

Dillon, MT 59725

October 3, 2022

Dear Mark Ockey,

The Malesich family supports the 319 grant proposal to reduce nutrients in Stone Creek. We have owned this property for forty years and the property next to it for more than 100 years. We have tried to be good stewards of the land during that time and are always looking for ways to help improve it.

We support the efforts to improve the watershed in all aspects, including erosion, temperature, and nutrients.

Thank you for your consideration

Sincerely

Carl Malesich

Carl Malesich

Landowner (1 of 3 brothers)

MONTANA TROUT UNLIMITED

October 6, 2022

Montana Trout Unlimited
PO Box 7186
Missoula, MT. 59827

Mark Ockey, Water Quality Specialist
Water Quality Planning Bureau
Montana Department of Environmental Quality

RE: Support for Beaverhead Conservation District's Montana DEQ-319 Proposal

To whom it may concern,

Montana Trout Unlimited (MTU) supports the Beaverhead Conservation District's Montana DEQ-319 Proposal to address non-point source pollution on Stone Creek. Stone Creek is an important tributary in the middle Beaverhead drainage. It provides thermal refugia for wild trout on a section of the Beaverhead River that is chronically dewatered and suffers from elevated water temperatures.

The goal of BCD's project is to construct a nutrient reduction wetland. A pilot project was conducted with promising results. A full-scale project will primarily address Total Nitrogen and Nitrate/Nitrites, with secondary benefits expected to reduce metals (Al, Fe, Cu) and Phosphorus. These impairments are a direct result of a Talc mine in the headwaters of Stone Creek. The BCD has successfully completed several projects on Stone Creek that have shown measurable reduction in non-point source pollution.

MTU's mission is to conserve, protect, and restore Montana's world class fisheries and their watersheds. This project aligns with our mission.

Please contact me with any questions you may have about our support.

Chris Edgington
Jefferson Watershed Project Manager
Montana Trout Unlimited
chris@montanatu.org

Beaverhead Conservation District
420 Barrett St, Dillon, MT 59725
406.683.3802 beaverheadcd@gmail.com

September 29, 2022

Mark Ockey
Water Quality Planning Bureau
Montana Department of Environmental Quality

Dear Mark Ockey,

Beaverhead Conservation District supports this 319 grant proposal to construct a nutrient reduction wetland on Stone Creek. We previously sponsored a pilot project for a small test wetland, and everyone involved felt it worked well and was worth a larger project.

Sincerely,

Jess Fields

Jess Fields, Administrator
Beaverhead Conservation District

Supplemental Attachment 1

Solution Description Additional Text

Solution Description continued

The initial steps of the project, and probably the most critical, will be coordination with the landowner to finalize access and a long-term lease for the system. The landowner previously involved in the pilot study, Carl Malesich, was instrumental by donating his time, money, support, and land to complete the project. Mr. Malesich is a great steward of the land and water for Montana and is committed to the success of this project and has agreed to locate the project on his land pending funding approval. Preliminary estimates provided in the pilot study state that 7 acres would be required for leasing to ensure sufficient space is available, not only for the wetland cells but also berms and structures. Ongoing conversations with Mr. Malesich regarding access will be completed in the context of whether the site is open to the public for recreation. Educational use of the site is considered a required element for the project to go forward. Site selection will also be a significant task coinciding with landowner coordination since a multitude of factors must be considered that will impact operation and treatment performance of the wetland, such as soil type, topography, and access. The general area considered for site selection is illustrated in Figure 1. During these initial steps prior to design, updated flow, concentration, and temperature sampling and measurement should occur to provide an update to the background conditions. Since the system will be sized and designed based on these inputs, gathering representative data is crucial for the success of the project. In addition to the sampling conducted as part of the initial pilot study, water quality sampling data collected from 2003 to 2017 is available on the National Water Quality Monitoring Council's Water Quality Portal.

The most important phase of the project is the preliminary design, which will entail FWS wetland sizing, hydraulic design, modelling, and preparation of preliminary design plans. Selection and implementation of sizing methods are essential to the performance and treatment efficacy of the system. Sizing will incorporate water quality, hydraulic, and climate data collected and incorporate other factors such as land availability, topography, elevation, and construction costs. Several methods for sizing are available, such as hydraulic sizing, Wetland to Watershed Area Ratio (WWAR), kinetics, and empirical performance relationships. The preliminary design phase of the project will consider the most appropriate sizing methods to use when designing the system. The hydraulic design of the system will be based on a variety of factors, such as size, flow rate variability, and the desired residence time and treatment targets. The design will be an iterative process in combination of hydraulic and possibly kinetic modelling to simulate system hydraulic and/or treatment performance before settling on a final design. The final design plans and specifications will be drafted, along with a technical report outlining the assumptions, data, and design methodology.

An O&M plan will be developed during the final design phase to outline operation and maintenance of the system. The O&M plan will also outline monitoring requirements, which is important in providing insight in how the wetland is functioning and allow for adjustment to be made to optimize treatment performance. Water quality sampling and flow monitoring of both the inlet and outlet sides of the system will be necessary to assess operation and performance. Operation and maintenance of the system is a continuous effort for the life of the system, requiring seasonal hydraulic adjustments, sediment removal, and plant harvesting and replanting. Since most of the pollutants removed from the incoming water will be stored in the sediment, periodic sediment removal and disposal is required. As a general rule, FTW systems are designed with sufficient capacity for a 10-year removal frequency. The sediment will be organic rich and useful for off-site placement on agricultural fields away from waterways.

Permitting for the system will be completed during the final design phase of the project and will most likely consist of a 310 permit through the BCD. The remaining steps of the project will be to prepare the bid documents, advertise the project, and conduct the contractor selection process before selecting and issuing a notice to proceed. Throughout the initial and design phases of the project, the engineer and BCD will pursue funding sources for the construction phase of the project and ensure that funding is committed prior to proceeding into the bidding phase of the design project. Water rights are retained and owned by the landowner, and they will be linked to the current irrigation water right already used on the property for crop production. Very little water will be lost from evapotranspiration but will be estimated by producing a complete water balance during the preliminary design period before the FWS wetlands are constructed. The appropriate changes (if any) will be completed to support the project using the landowner's water right and essentially the FWS wetlands are part of the existing beneficial use on the associated land.

Supplemental Attachment 2

DRAFT Conceptual Design Technical Memorandum And Pilot Scale Treatment Results

DRAFT Conceptual Design Technical Memorandum
And Pilot Scale Treatment Results
Beaverhead County
Nitrate Treatment Wetlands

1.0 Introduction

KirK Environmental and its team member CDM have been working with the Beaverhead Conservation District to evaluate methods to reduce the concentration of nutrients in Stone Creek, a valuable spawning and refuge trout habitat for the Beaverhead River. EPA/DEQ TMDL programs have shown that nutrients are a water quality concern for the Beaverhead River, and Stone Creek is a cool water refuge and spawning area for the Beaverhead Rivers great trout fishery. Stone Creek has been shown to have Nitrate concentrations as high as 7mg/l. This has caused significant nusicence vegetation such as water-crest and algae. A pilot scale test program was implemented in 2005 to evaluate a method to help reduce the concentrations of nutrients in Stone Creek, and was completed in partnership with Mr. Carl Malesich, who through this program is proving to be a great steward of the land and water for Montana by donating his time, money and support to evaluate the potential to enhance stream water quality for Montana.

2.0 Wetland Treatment Systems and Nitrogen Removal Processes

2.1 Types of Constructed Wetlands

Treatment wetlands remove nitrite mainly through the biologically mediated denitrification reaction in which bacteria use organic carbon to convert nitrate (NO_3^-) or nitrite (NO_2^-) into nitrogen gas (N_2), which is volatilized to the atmosphere. Other products of the reaction include carbon dioxide gas (CO_2) and increased bacterial biomass (proteins are created from carbon, oxygen, hydrogen and nitrogen). The reaction occurs under anaerobic (generally oxygen free) conditions.

Constructed wetland treatment systems are of two types; Free Water Systems (FWS) and Vegetated Submerged Beds (VSB). FWS wetlands resemble natural wetlands in that the water flow is on the surface and is relatively shallow; 1-2 feet for emergent plant zones (zones where plants are only partially submerged) and ~5 feet for submergent plant zones (zones where plants are completely submerged). In FWS wetlands the treatment occurs within the shallow wetland soils (substrate) and the overlying episediment layer, which consists of plant litter. VBS wetlands are constructed using porous materials mixed with the treatment media in such a way that the water flows in the subsurface. Usually the water is introduced at the bottom of a pond containing a mixture of gravel and composted manure, after passing through the media in an upflow fashion, the water is collected near the top of the pond and discharged. A VBS type system was originally envisioned for the proposed application, but was eliminated from further consideration due to the following:

- VBS systems are subject to plugging
- VBS wetlands are more expensive to build and to maintain than FWS wetlands
- FWS wetlands are able to handle higher flow rates than VBS systems
- FWS wetlands can remove ammonia and TKN, unlike VBS wetlands
- FWS wetlands are self-sustaining (the carbon source is created by plants) whereas in VBS wetlands the carbon source must be added
- System life for a VBS is approximately 5 years, compared to >20 years for a properly maintained FWS wetland

2.2 Nitrogen Treatment in FWS Wetlands and Required Residence Time based upon a Literature Search

As mentioned previously, the main nitrate treatment process in constructed wetlands is denitrification by bacteria within the sediment and episediment layers of the FWS. The systems are generally self sustaining because the organic matter required for the bacteria to perform the denitrification reaction are provided by the litter (leaves, stems, stalks, etc.) shed by the plants. In addition, significant litter is accumulated at the end of the growing season when the plants die. Therefore, the establishment of a healthy plant community is the key to the success of an FWS constructed wetland.

Another process which occur in FWS wetlands which only a minor contribution to nitrate removal is direct uptake by plants, algae and blue-green algae (actually a bacteria and not an algae as the name implies). In general, plant uptake represents only temporary storage, because after the plants die in the fall the nitrogen is returned to the wetlands as the plant material decays. Similarly, algae return any nitrogen they remove after death and decomposition. Unless the plants or algae are periodically harvested the net nitrate removal by uptake is essentially zero.

Adsorption of nitrate/nitrite onto plant surfaces and wetland sediments has been shown to be very minor and typically only temporary in nature. Generally, the adsorption sites are quickly filled, at which point the process stops unless influent nitrate/nitrite concentrations increase (conversely a decrease in nitrate/nitrite concentration would result in desorption).

Studies have shown that the nitrate/nitrite within the overlying water column must diffuse into the episediment or sediment layer where conditions are anaerobic (reducing) in order for denitrification to occur. Thus it is important to have sufficient residence time to allow the diffusion to take place. In many systems, especially ones in which the plant communities are not fully established, the supply of organic carbon is the limiting factor in the rate of denitrification. Often, addition of an external source of carbon such as methanol, ethanol or leachate from hay or straw can greatly increase the denitrification rate. In the absence of an external carbon source, FWS wetlands are sized according to the residence time required for diffusion and carbon production to occur (via breakdown of plant matter by fungi and bacteria).

Residence Time Requirements and Nitrate Reduction (Denitrification) Rates

The rate of denitrification has been strongly and positively correlated to temperature, rate of organic carbon production or introduction and residence time.

The denitrifying bacteria are more active at higher temperatures than at lower temperatures. Thus, systems tend to work better in warmer climates and at warmer times of the year. However, the temperature dependence does not preclude the use of constructed wetlands in northern climates, as numerous successful FWS systems (mostly for wastewater treatment) are located in northern climates.

The residence time, as previously mentioned, relates to the carbon supply rate and the diffusion rate and is a key design parameter. Some investigators have suggested that hydraulic loading rate (HLR), which is the volume of flow introduced per unit of wetland area, is a more accurate predictor of denitrification rate than residence time. Residence time can be increased at a given flow rate (a constant HLR) by raising the water level in the wetland, which increases the volume of water. However, because the increased water levels also increase the diffusion distance between the additional water volume and the episediment and sediment layers, such an increase in residence time is not very beneficial.

The rate of nitrate reduction is generally expressed as the mass of nitrate/nitrate removed (as mg N) per square meter of wetland area per day (mg N/m^2/d). Given this value, the decrease in nitrate/nitrate concentration can be calculated for a given wetland area and flow rate. Similarly, the wetland cells can be sized given the required nitrogen removal and influent flow rate. The denitrification rates reported in the literature vary widely both seasonally and from site to site, as shown in Table 1 below.

Average Denitrification Rate (mg N/m^2/d)	**Summer Denitrification Rate (mg N/m^2/d)**	**Source**
261 (bulrush vegetation)	≤1100	Bachand and Horne, 2000b
565 (cattail vegetation)	1500-2000	Bachand and Horne, 2000b
835 (mixed vegetation)	Not reported	Bachand and Horne, 2000b
522	≤1071	Reilly et al., 2000
1000-1500	2800	Bachand and Horne, 2000a

Given an average denitrification rate of 500 mg N/m^2/d a flow rate of 1300 gpm (1,872,000 gallons/day), an influent nitrate/nitrite concentration of 7 mg-N/L, and a required nitrate/nitrite discharge concentration of 1 mg-N/L results in a wetland area of approximately 21 acres. However, if the cell efficiency can be increased to 1000 mg N/m^2/d then the wetland area requirement is halved (10.5 acres). Note that these calculations refer only to planted wetland area not including berming, influent and effluent controls, access roads and other infrastructure. A factor of 1.2 to 1.4 is typically used to adjust the land requirements for infrastructure, with smaller systems at the upper end of the range (1.4). Therefore, an FWS with 21 acres of wetland (a small wetland) would require about 29 acres (21 acres * 1.4 = 29.4 acres) of land.

Treatment of Ammonia and Total Kjeldahl Nitrogen (TKN)

In order to denitrify reduced forms of nitrogen such as ammonia and TKN (includes ammonia and organic forms of nitrogen), which are more reduced than nitrogen gas (N_2), they must first be oxidized to forms more oxidized than N_2 (i.e. nitrate/nitrite) in order to be denitrified in a wetland. The process is referred to as *nitrification*. Wetlands that treat wastewater often include aeration ponds or open water bodies containing submergent plants to oxidize the ammonia and TKN prior to denitrification in the shallow wetlands. The submerged plants used in the open water bodies in wetlands produce oxygen via photosynthesis which obviates the need for active aeration.

Algae

Algae can accumulate in open water bodies and in stagnant areas of constructed wetlands. Algae, when present in large quantities, are referred to as a *bloom*, which is generally an undesirable condition as algae tend to block sunlight needed for submergent plants to survive.

A distinction should be made between *green algae* which are plants and *blue green algae* or *cyanobacteria* which are photosynthetic bacteria. Cyanobacteria can occur in constructed wetlands if provided enough residence time to reproduce and can be of particular concern at high concentrations. Some species of cyanobacteria produce toxins that in high concentrations can be fatal to livestock that consume the water. Cyanobacteria are possible within any nutrient rich water and can not be ruled out in the proposed wetlands. However, the current irrigation system including backwaters does not appear to have a cyanobacteria problem and there is no reason to expect a cyanobacteria bloom in the proposed constructed wetlands.

Figure 1 – Dammed up area used for a pump inlet at the site showing several types of green algae.

Both green algae and cyanobacteria can be controlled by designing the wetlands in such a way as to minimize stagnant areas. Carefully controlled gradient tolerances will limit the formation of backwaters, while control on the residence time within open water bodies will flush out cyanobacteria and algae before they have a chance to bloom. Most sources suggest open water residence times of no more than 2 days, although one day is generally preferred. Algae can also be controlled by the use of floating plants (i.e. duckweed, lilies, etc.) and shade provided by tall emergent plants, which can block sunlight to open water bodies and prevent photosynthesis within the algae.

3.0 Site Water Quality and Flow

As part of the Pilot testing, we evaluated flow rates and nutrient concentrations in Stone Creek. Previous estimates have shown flow rates in the 2 to 5 CFS range and Nitrate concentrations from 2 to 7 mg/l. High concentrations of Nitrates and other nutrients are causing nescience algae and water-crest growth in Stone Creek, as well as a significant load of Nitrates to the Beaverhead River. At 5 CFS and 7 mg/l Nitrate concentrations, the load of Nitrates to the Beaverhead can be as much as 4800 pounds per year.

4.0 Conceptual Design

4.1 Configuration

Many treatment wetlands are comprised entirely of shallow water zones with stands of emergent vegetation. When the nitrogen load is predominantly as nitrate/nitrite, denitrification can occur without prior nitrification (i.e. oxidation of ammonia and TKN into nitrate/nitrite). Therefore, an oxic zone consisting of open water areas with submergent vegetation was deemed unnecessary and a waste of space. However, there are many advantages to incorporating open water bodies into a treatment wetland design, including the following:

- Nitrate or TKN present in the influent can be converted to nitrate/nitrite prior to denitrification in the shallow water zone.
- Water can be remixed and homogenized in the open water zones before going into the next shallow water zone, providing more uniform treatment.
- The open water can be stocked with mosquitofish (*gambusia*), which feed on mosquito larvae (FWP should be consulted prior to the introduction of any non-native wildlife)
- Open waters support a more diverse wildlife community and provide a more dynamic ecosystem
- Some evidence suggests that open waters actually enhance nitrate treatment, although the reasons are not clear.

In a full-scale system, the open water bodies could be incorporated between cells to distribute flow evenly, as well as providing the added benefits outlined above. Therefore, the pilot system incorporated an open water wetland which incorporates submergent and floating plant species to promote oxygenation and limit algal growth. The influent water should flow from the control structure into the open water portion of the wetland, followed by the shallow portion containing the emergent plants.

4.2 Plants

Plants have been shown to be a very important aspect for creating successful treatment wetlands. Wetland plants can be introduced in one of three ways:

- Grow from seed (or existing wetland sediments containing seeds)
- Plant shoots or adults
- Allow volunteer plants to establish themselves naturally

Growing plants from seed is very inexpensive, but often requires skill and an in depth knowledge of each particular species to provide the proper conditions for germination. In addition, the time required to establish the plant communities is longer than when planting shoots or adult plants. When shoots or adults are planted in early spring, significant vegetative density can be achieved by late in the growing season of the first year. However, the plant communities and distributions that equilibrate by the end of the second growing season are very often not the same as specified in the initial design. Some plant species out compete others, while the seeds of volunteer species can be blown in from adjacent areas or washed in from upstream and produce unintended results. In fact, a wetland can be established without any planting or seeding at all, but it requires at least one additional growing season for this to occur. The wetland would be likely to contain the same plant communities as are currently found along the irrigation ditches, such as cattails, watercress, green algae, and possibly smartweed (see Figure 1).

Figure 2 – Site drainage ditch showing volunteer cattail, suspected smartweed (in center and right foreground with white flowers) and several types of green algae.

Naturally established wetlands are generally better adapted to the local conditions and are therefore healthier than those with introduced plant (and bacterial) communities. However, due to time constraints wetlands are rarely established naturally. In fact, once equilibrium is reached (after 2-3 years) a naturally established and an artificially established wetland may be very similar in appearance and function. Therefore, for the current pilot investigation the plant communities will be established using shoots purchased from a local nursery which specializes in aquatic plants. Planting density should be one shoot for every 2-3 square feet of wetland area. Planting in rows should be avoided, or if unavoidable, the rows should be perpendicular to the flow direction to minimize channeling. Other general planting guidelines are presented in section 5 (Construction Procedure). Specific requirements for different species (such as planting depth, water depth, sun requirements, etc.) will be provided by the supplier. Some nurseries may offer planting services and provide support during the crucial period when the plants become acclimated to their new environment. Such services, if available, should be taken advantage of, as this is the stage where most implementation failures take place.

Plants for use in nitrate treatment wetlands are chosen based on the following criteria:

- Ability to tolerate partially or fully submerged conditions
- Hardiness
- Ability to grow and propagate quickly, but not so much that it crowds out all other species.
- High litter rate
- Low fiber content (litter breaks down into useable organics quickly)
- Perennial (die off in late fall and grow back in the same place in the spring)
- Must not be an invasive nuisance species that could spread to natural wetlands or nearby agricultural fields
- Can be purchased locally
- Value to wildlife
- Native species are preferred but not required

Ability to Tolerate Partially or Fully Submerged Conditions

By definition, wetland plants live in fully or partially submerged conditions for at least a part of their life cycle. Unlike most natural wetlands, which tend to dry out periodically, constructed wetlands are flooded and maintained at a constant level for most if not all of the year. Therefore, wetland plants that require periodic dry conditions will not survive in a constructed wetland for very long. The plants should also be selected for the intended water level for various areas of the wetland. Wetland plants tend to have a very specific preference for water level. Differences of just a few inches in water level can favor one emergent plant species over another. One of the main reasons for the failure of introduced plant species is poor management of water levels and planting species in areas of the wetland which provide inappropriate water levels.

Hardiness

The hardiness of wetland plants is very important to the success of a constructed wetland, because often ideal growing conditions for all plants can not be guaranteed in all areas. Species that can survive changes in water level, for instance cattails, are preferred over plants that die in response to the first stress on the system.

Ability to Grow and Propagate Quickly

The bacteria that perform denitrification require organic carbon in order to grow and function. In FWS wetlands the source of the organic carbon used by the bacteria is the debris (litter) shed by wetland plants. Therefore, the faster the plant growth, the faster the buildup of litter to form the crucial episediment layer above the substrate.

High Litter Rate

Plants that tend to shed leaves, stocks and other debris quickly (have a high litter rate) will contribute to the episediment layer faster than plants that are less productive. The result is a thicker episediment layer and higher denitrification rates.

Low Fiber Content

In order for bacteria to use the organic carbon within the episediment layer, the material must first be broken down by other types of bacteria and fungi into forms of organic carbon which the denitrifying bacteria can use. Wetland plants with high fiber content (cellulose, hemicellulose, and lignin) take longer to break down into useable organic carbon than species with low fiber content. For example, cattail is a woody plant and has relatively high fiber content, and consequently approximately one year is required for cattail litter to be converted into a useable form. The litter of lower fiber wetland species such as arrow arum (Peltandra virginica), yellow pond lily (Nuphar luteum), wild rice (Zizania aquatica) pickerel weed (Pontederia cordata), arrowhead (Sagittaria latifolia) and bur marigold (Bidens laevis) decompose by approximately 70-80% over only a 60 day period.

Perennial

Perennial plants, which grow back each spring, are favorable over annuals which must be replanted each year.

Non-invasive/Non-nuisance Species

Unfortunately, many of the favorable properties listed above, such as fast growing and hardiness, are exhibited by plant species with such aggressive reproduction that they can crowd out other species. Wind-borne seeds can also spread to nearby agricultural fields or natural wetlands. Therefore, plants which are considered nuisance or noxious weeds will be avoided, as their introduction would be unwise and would likely violate federal, state and county laws.

Value to Wildlife

Although not intended as a wildlife habitat, constructed wetlands can be very beneficial to wildlife communities. Some evidence even indicates that wetlands with more balanced ecosystems have superior treatment efficiency compared to systems which are built without considering wildlife habitat. Therefore, where practicable, plant species that provide benefits to wildlife should be utilized.

Can be Purchased Locally

Due to practical considerations (transportation costs, plant health during shipping, etc.), plants will be purchased from local nurseries.

Native Species

While not a strict requirement for treatment wetlands, the use of native plant species have some very significant advantages over non-native species. Native plants (especially those that grow naturally within a 50 to 100 mile radius) have a better survival rate and grow better on local conditions than many non-native species. In addition, the use of native species avoids the risk of introducing a nuisance species and is generally more favorable to regulatory agencies, environmental groups and the general public.

Monoculture vs. Mixed Stand Vegetation

Wetlands consisting of a single plant species (a monoculture) have been used in many wetlands in the past, but have met with mixed results. In general, monocultures are more susceptible to insect infestations and blight than mixed stands as well as limiting the biodiversity of the ecosystem by limiting the types of wildlife habitat.

Buchand and Horne (2000) tested three vegetation types in side by side pilot tests; a monoculture of bulrush (*Scirpus spp*.), a monoculture of cattail (Typha spp.) and a mixed stand containing bulrush, smartweed (*Polygonum lapathifolium*) barnyard grass (Echinochloa *crusgalli*), duckweed (Lemna spp.) and cattail. The mixed stand performed far better than the monocultures, with double the nitrate removal rate of cattails alone and triple the rate of the bulrush monoculture (see Table 1). One reason for the superior performance of the mixed stand was due to the varying fiber contents and associated breakdown rates of the various plants used. The mixed stand provided both long term and short term carbon sources, which provided a more constant and reliable carbon source for the denitrifying bacteria than the did the monocultures. In addition, the mixed stand provided a more balanced ecosystem which likely contributed to favorable bacteriological conditions and resultant denitrification.

Plants Used in Existing Constructed Wetlands

Plants which have been used in existing constructed wetlands (both for wastewater and agricultural runoff) are listed in Table 2.

Table 2
Plants Used in Constructed Wetlands[1]

Name	Maximum Water Depth	Notes
Emergent (for shallow areas of the wetland		
Arrow arum (*Peltandra virginica*)	12 inches	Full sun to partial shade. High wildlife value. Foliage and rootstocks are not eaten by muskrats. Slow grower. pH 5.0-6.5. Low fiber content.
Arrowhead/duck potato *(Saggitaria Latifolia)*	12 inches	Aggressive colonizer. Mallards and muskrats can rapidly consume tubers. Loses much water through transpirtation
Common three-square bulrush *(Scirpus pungens)*	6 inches	Fast colonizer. Can tolerate periods of dryness. High metal removal. High waterflow and songbird value.
Softstem bulrush *(Scirpus validus)*	12 inches	Aggressive colonizer. Full sun. High pollutant removal. Provides food and cover for many species of birds. pH 6.5-8.5.
Blue flag iris *(Iris versicolor)*	3-6 inches	Attractive flowers. Can tolerate partial shade but requires full sun to flower. Prefers acidic soil. Tolerant of high nutrient levels.
Broad-leaved cattail *(Typha latifolia)*	12-18 inches	Aggressive. Tubers eaten by muskrat and beaver. High pollutant treatment, pH: 3.0-8.5.
Narrow-leaved cattail *(Typha angustifolio)*	12 inches	Aggressive. Tubers eaten by muskrat and beaver. Tolerates brackish water. pH: 3.7-8.5.
Reed canary grass *(Phalaris arundinocea)*	6 inches	Grows on exposed areas and in shallow water. Good ground cover for berms.
Lizard's tail (*Saururus cernuus)*	6 inches	Rapid grower. Shade tolerant. Low wildlife value except for wood ducks.
Pickerelweed *(Pontedaria cordata*)	12 inches	Full sun to partial shade. Moderate wildlife value. Nectar for butterflies. pH: 6.0-8.0.
Common reed *(Phragmites australis)*	3 inches	Highly invasive; considered a pest species in many states. Poor wildlife value. pH: 3.7-8.0.
Soft rush (Juncus effuses)	3 inches	Tolerates wet or dry conditions. Food for birds. Often grows in tussocks or hummocks.
Spikerush (*Eleocharis palustris)*	3 inches	Tolerates partial shade.

Sedges *(Carex* spp.)	3 inches	Many wetland and several upland species. High wildlife value for waterfowl and songbirds.
Spatterdock *(Nuphar luteum)*	5 ft. 2 ft minimum	Tolerant of fluctuating water levels. Moderate food value for wildlife, high cover value. Tolerates acidic water (to pH 5.0)
Sweet flag *(Acorus calamus)*	3 inches	Produces distinctive flowers. Not a rapid colonizer. Tolerates acidic conditions. Tolerant of dry periods and partial shade. Low wildlife value.
Wild rice *(Zizania aquatica)*	12 inches	Requires full sun. High wildlife value (seeds, plant parts, and rootstocks are food for birds). Eaten by muskrats. Annual, nonpersistent. Does not reproduce vegetatively.

1. Table adapted from USDA/NRCS/EPA, 1993

The decision on which plants to use should be arrived at through consultation with local nurseries, regulatory agencies (MDA, DEQ, USDA, etc.) and in compliance with the Beaverhead County Noxious Weed Management Plan.

4.3 Pilot Cell Sizing and Flow

The KirK team completed a data review and based upon the review, it was determined that a typical wetland could remove approximately 500mg of N per square meter of wetland area. There for, to treat an influent of 15 gpm at 5mg/l of N to 0 mg/l N, an area of 8800 square feet would be required. For the full treatment area available, the preliminary loading analysis suggests that we could treat about 1.5 cfs.
Given the constraints of a pilot scale budget as it relates to the costs of plants and liner, the KirK team selected an area of 20 feet by 40 feet for a pilot scale test. Flow rates were limited to less than 10 gpm in the pilot scale wetland.

Attachment 1 to this memorandum are figures showing the design of the pilot scale wetlands, Attachment 2 shows before, during and after photo's of the project.

4.4 Aspect Ratio (AR)

The aspect ratio is the length to width ratio (L:W) of the wetland. In general, a high AR is preferred to provide the maximum contact between the water to be treated and the wetland episediment and shallow sediment layers. However, as the AR increases, riling can be problematic and the total length of the berms increases, which increases costs. A reasonable compromise on AR which has been reached over the years is in the range of 3:1 to 5:1. In order to reduce costs and avoid importing soil from off-site, the cuts and fills should be balanced, which can be achieved by adjusting the aspect ratio (or by lowering or raising the grade). Contact time can be maintained by use of baffles within the wetland to direct the flow in a serpentine fashion. Arrangement of hay or straw bales into rows has been used successfully in FWS systems in the past. In addition to providing a physical barrier to direct surface flow, the hay or straw bales will also add a source of organic carbon which will be needed to provide denitrification, especially initially when the plant communities are becoming established and the episediment layer is being produced.

4.5 Topographical Orientation

The long dimension of the cell was placed parallel to topographical contours in order to minimize the amount of grading required to build the system. However, given the generally flat topography of the pilot site, the orientation of the system was less critical and was determined based on other practical considerations, such as accessibility and potential incorporation of the pilot cell into a future full-scale system.

4.6 Berms

Berms were constructed with slopes no greater than 3:1. The freeboard was at least 2 feet above the designed water level. Berms were constructed the soil which is fine enough to compact into a stable and impervious structure. Berm integrity was a critical component of the system, as the berms are used to contain the water within the wetland. Plant and tree roots can also affect the stability of the berms; therefore, only shallow rooting plants were used to vegetate berm surfaces. In a full scale system, should erosion of the berms into the wetland become a problem, rip rap can be applied near the waters edge.

4.7 Liner

Given that there are no current WQB-7 exceedances within the water to be treated, discharge to groundwater would not result in groundwater contamination. However, loss of significant water through the bottom of the wetland would reduce the quantity of water discharged and could also make it difficult to maintain the optimal water levels for successful plant growth. Usually, a hydraulic conductivity of less than or equal to 10^{-6} cm/s is desired to minimize infiltration. Sometimes native soils with a clay content of at least 15% can be compacted to provide a sufficiently low hydraulic conductivity. Native soils at the subgrade level having clay contents of less than 15% would likely require amendment with bentonite or some other imported clay prior to compacting. Alternatively, a plastic membrane liner (such as HDPE) or GCL liner could be used. For the pilot scale test, it was decided to line the wetland area but also to use the area down stream of the wetland area to evaluate percolation for the full-scale system. This was accomplished by creating a ditch and pond area and observing the rate of seepage.

4.8 Soil Substrate

An ideal soil for the wetland substrate would be a loam having a pH of between 6.5 and 8.5, a cation exchange capacity of greater than 15 meq/100g, and sufficient organic material to provide carbon to the plants and to create reducing conditions in the subsurface. Sandy soils may require amendments such as hay or compost in order to provide the conditions necessary for plant growth and propagation. Soils will be collected during the pilot test and straw will be added to the pilot wetland area.

4.9 Inlet and Outlet Control Structures

Inlet and outlet control structures should provide adequate flexibility to adjust wetland water levels to perform complete cell draining (for planting and maintenance) and for fine changes in water levels to be made. In addition, the system should be amenable to flow and head measurement both at the inlet and outlet. Accurate flow and head measurement is important for determining the water balance and head drop for the wetland.

Inlet Structures

At the pilot-scale a single inlet control structure is all that is needed. However, for a full-scale system multiple inlet structures spaced every 15 to 30 feet would be required to provide even flow distribution to the wetland. Alternatively, equal distribution can be achieved by Teeing the inlet pipe into a section of perforated PVC pipe or a PVC pipe fitted with multiple swiveling tees which is installed into a gravel bed placed directly against the berm. The disadvantage to this type of system is that back pressure can build up and flow is more difficult to measure. In addition, because the inlet is buried it is difficult to observe obstructions in the inlet and to take corrective actions if problems occur. Another type of inlet is a simple open discharge pipe. While the system is exposed and easy to maintain, flow control would have to be performed with a valve, which would likely require constant adjustment. One of the most popular and versatile inlet control structures is the V-notch weir. The system is relatively simple to build and install, is above ground to facilitate maintenance, and flow measurements can easily be made by placing graduations on the notch for different flow rates. Flow rates can be adjusted by raising or lowering the weir plate.

Outlet Structures

Weirs are often used for outlet control structures as well. However, because flow control is not performed at the outlet and flow measurements are required less often on the outlet (for water balance and head drop analyses) than on the inlet, a very simple adjustable riser type outlet can be employed. First, a perforated PVC pipe is placed within a gravel bed built against the berm on the outlet end of the wetland. The outlet discharge pipe (effluent collection pipe) is then Teed into the perforated PVC pipe and extended horizontally into the berm. The effluent collection pipe should be placed at or near the bottom of the wetland to allow for complete draining, so it may be necessary to excavate slightly deeper at the effluent end (against the berm) to accommodate the perforated PVC pipe bedding. An adjustable riser is simply a wye extending vertically from the discharge pipe to the desired water level in the wetland. The riser would extend through the berm and daylight on the outside slope of the berm. A valve is installed on the outlet pipe (after daylighting at the base of the outside of the berm beyond the wye), which when closed, will force the water into the riser. Water levels can be adjusted be removing small sections of the riser pipe to lower the level of the outlet or adding sections to raise the level. Flows can be measured using the bucket and stopwatch method. The entire wetland can be drained simply by opening the valve within the outlet pipe, which allows the effluent to bypass the riser.

The attached figures show a riser pipe outlet configuration for the pilot wetlands that allowed steady maintenance of the level of water in the wetlands by adjusting the riser height and inflow. The wetlands can also be drained by removing all of the riser pipe.

Bypass/Valving

The wetlands should receive a constant flow, regardless of the flow rates within the ditch. When wetlands receive flows far in excess of design standards plant litter is often washed away, riling can occur, and plants can be uprooted or significantly damaged. Therefore, a valving system was needed to prevent storm flows from disrupting the system.

The team utilized a check structure and gate valve in the influent line to help maintain the flow into the system.

4.10 Wildlife

While the constructed wetland is not specifically designed for use by wildlife, a full scale design would likely be utilized by a wide range of wildlife species, including protozoans, insects, mollusks, fish, amphibians, reptiles, birds and mammals. The wetland plants, especially if the communities are diverse, and water bodies provide habitat, food shelter/cover and nesting areas for a wide range of species. As mentioned previously, mosquitoes can be a nuisance, especially if the wetlands contain stagnant backwaters. Other potential pests include burrowing mammals. Muskrat and beaver in large populations can decimate wetland plants, especially cattails and bulrushes, which they use for food. Wetland plant diversity can help maintain organic carbon and in extreme cases the animals can be trapped and relocated to thin out populations.

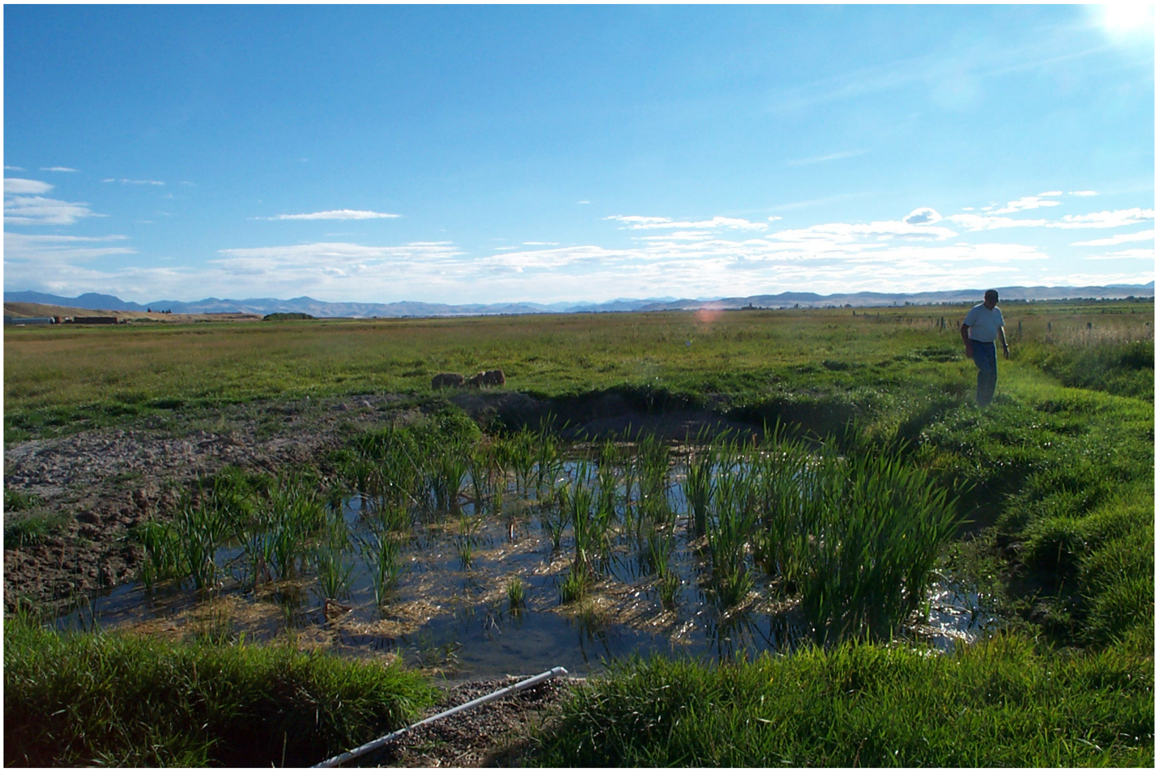
5.0 Pilot Test Results and Full Scale Design

During the Spring and Summer of 2005, KirK and CDM completed a conceptual design and with significant support from Mr. Carl Malesich, Nick Hoyrup and the Beaverhead Conservation District, installed and tested a pilot scale wetlands water treatment system. Attachment 1 to this report shows the plans prepared for the system, Attachment 2 shows the system photos both during and after construction, and Attachment 3 shows the laboratory analytical results and the results from in-field testing.

The system constructed was 800 square feet (74.3 Square Meters) and included a lined bottom, a new check structure, and a valved inlet which utilized well screen for the intake to the treatment cell. Well screen was used so that neither fish, fish fry nor reds would be siphoned into the treatment cell. After the newly constructed cell was installed, it was flooded and allowed to settle so that the wetland species could be planted into the cell. Rather than purchase immature wetlands plant species, small plots of already established plants were harvested from Mr. Malesich's property and utilized for the treatment cell. Plant species utilized included rushes, sedges, and cat-tails, and were placed at a rate of one plant per square foot. On-going monitoring was conducted with field test kits and one round of laboratory confirmation samples were obtained at the site.

In-field testing showed that the system was effective in removal of Nitrates; however, it is believed that the laboratory results are more accurate for estimation of treatment efficiency.

Laboratory results from the site showed at a flow rate of 5 gallons per minute, over the pilot treatment area, Nitrate concentrations were reduced from 3.96 mg/l to 2.20 mg/l. Ammonia was reduced from 0.52 to 0.37 mg/l and Phosphorus showed a slight reduction from 0.09 to 0.08 mg/l. Field tests showed that the water in Stone Creek has significant concentrations of Nitrates as provided in Attachment 3.



Given the reductions shown in the field, the calculated Nitrate removal from the wetland pilot system was 645.5 mg of N/square meter/day. This reduction is consistent with the values shown in the literature of 500 to 1000 mg of N/square meter/day.

After constructing the pilot scale system, it was apparent by completing a visual analysis of the soil in the excavated area, and observing the ponding of water in the unlined area that the soils are fine grained and contain a significant amount of clay. Although a detailed sieve analysis and compaction test would be suggested for a final design, it is expected that the soil offers a low enough permeability that a liner would not be required for a full-scale system.

5.1 Prediction of Nitrate Removal with a Full-Scale System.

If a full-scale system was funded and installed, the treatment area available is 29,280 square meters. Assuming that the pilot scale results could be achieved with a full-scale system, the area provided could remove 12,585 pounds of Nitrate per year. This is significantly more than the 4800 pounds of N discharged by Spring Creek to the Beaverhead River, providing very good evidence that a passive treatment wetlands system would have a strong positive effect on the water quality of Spring Creek and the Beaverhead River. However, a final design would have to be prepared to provide a more detailed removal estimate.

5.2 Summary of Design Recommendations

A summary of the design recommendations are provided in Table 3 below, assuming the system is funded for full-scale construction. Attachment 4 is a plan view design drawing showing the placement and slope and approximate location of structures required for the full-scale system.

Table 3
Nitrogen Full-Scale Treatment Wetlands
Summary of Design Recommendations

Design Element	**Recommendations**
Type	Free Water Surface (FWS)
Configuration	Shallow wetlands with open water bodies
Plants	Hardy, fast growing, non-nuisance perennials which have low fiber content and provide wildlife habitat. Native species are preferred but are not mandatory. Plant communities should be mixed and planned to coincide with preferred water levels for each species. Vegetation should be hand planted as shoots at a density of 1 plant every 1-3 square feet. Avoid planting in rows, or plant in rows perpendicular to the flow direction.
Sizing and flow	261,000ft^2 at a flow rate of approximately 2 to 4 CFS.
Aspect Ratio	3:1 minimum with hay or straw bale baffles
Topographical Orientation	The long axis should be parallel to topographical contours. However, given that the proposed site is quite flat the topographical orientation is probably not important.
Berms	≤2:1 but 3:1 ratio preferred. ≤2 ft of freeboard. Constructed of materials of fine enough grain size to be compacted into a stable structure. Internal rock layer to prevent burrowing. Seed slopes with shallow rooting grasses.
Grade	Grade parallel to the flow direction <1%. Perpendicular to flow the grade should be level with a tolerance of 0.1 ft. between low areas and high areas. The grade levels should be adjusted to balance the cut and fill soil volumes.
Liner	Compacted clay subgrade
Inlet/Outlet /Bypass Structures	Check structure, well screen intake and gate valve to control flow.
Wildlife	The wetland should be made wildlife friendly where practicable, including deep and shallow water habitats and a diverse habitat rich plant community. Mosquitofish should be introduced to control mosquitoes if needed and supported by FWP.

5. 3 Proposed Full-Scale Wetland Construction Procedure

1. Funding sources should be evaluated and a proposed agreement should be prepared with the existing landowner.
2. Grant Applications should be prepared and submitted.
3. If funding is secured, a detailed design basis report and design plans and specifications should be prepared.
4. The project should be bid per the requirements of the funding source.
5. The general sequence of construction activities should be as follows:

- The general area where the system is to be installed should be mowed to remove the tall grass and provide organic material for the wetland.
- The excavation limits should be staked based on the design drawings.
- The topsoil should be stripped and stockpiled for use as substrate.
- The wetlands and pond should be excavated, using the removed soil to construct berms around the excavation (gravel should be added to the berms as appropriate).
- The bottom of the excavation should be brought to the approximate grade (to balance cut and fill volumes)
- Clay should be tilled in to the subgrade soils (if necessary)
- The excavation should be brought to final grade and compacted.
- The inlet and outlet structures should be constructed and the berms restored.
- The topsoil should be mixed with the organic (to form the substrate) and placed in the bottom of the excavation to a depth of at least 6 inches. The substrate should be disked or harrowed to break up the clumps. Compaction of the substrate should be minimized.
- Low areas should be filled and high areas raked by hand to fine tune the grade to specified tolerances (0.1 foot).
- Hay or straw bales should be arranged in rows to form the baffles.
- Water should be added and allowed to sit stagnant for 2-3 days to allow settling.
- The cell should be completely drained and allowed to partially dry (to the point where the soil is moist but not saturated with water)
- The berms should be seeded with appropriate shallow root grass species or sodded to minimize weed growth and erosion.
- Planting of shoots (usually by hand using board paths to minimize compaction of the substrate)
- The plants should be watered but not flooded until 2-3 inches of new growth appears.
- The wetlands can then be flooded to a level which allows the tops of the plants to remain above the water surface (for emergent plants). As the plants grow, the water level can be slowly increased until the design level is reached (by adjusting the outlet riser).

6. The project should be monitored and maintained to optimize efficiency and to provide training to the land owner for long-term use.

6.0 Cost Estimate

The following Table provides a Cost Estimate for the Design and Final Construction of the Wetlands Treatment System:

Activity	Cost/unit	# of Units	Total Cost
Planning	Lump Sum		$5,000
Design/Oversight/Plans	Lump Sum		$30,000
Bidding	Lump Sum		$2500
Plants	$0.50	130,000	$65,000
Planting/Transplanting	Labor Only	1000	$12,500
Seeding	Lump Sum	6 acres	$2500
earthwork	$1.00 CY	29,000	$29,000
Inlet/Outlet Structures	$5,000	2	$10,000
Sub-Total			$163,825
Maintenance/Monitoring	5% of cost		$8,191
Total Cost			$172,016

Note: Match costs would include Long-term Lease with owner access restrictions at a rate of $5,000 per acre or, $35,000. Cost assumes ½ of 6 acres would be planted at a rate of 1 plant per square foot, 1 acre would be needed for berming and structures but 7 would be leased, and remaining planting would be done by transplant and seeding. Cost is preliminary estimate only and does not include contractor bids.

6.0 References

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