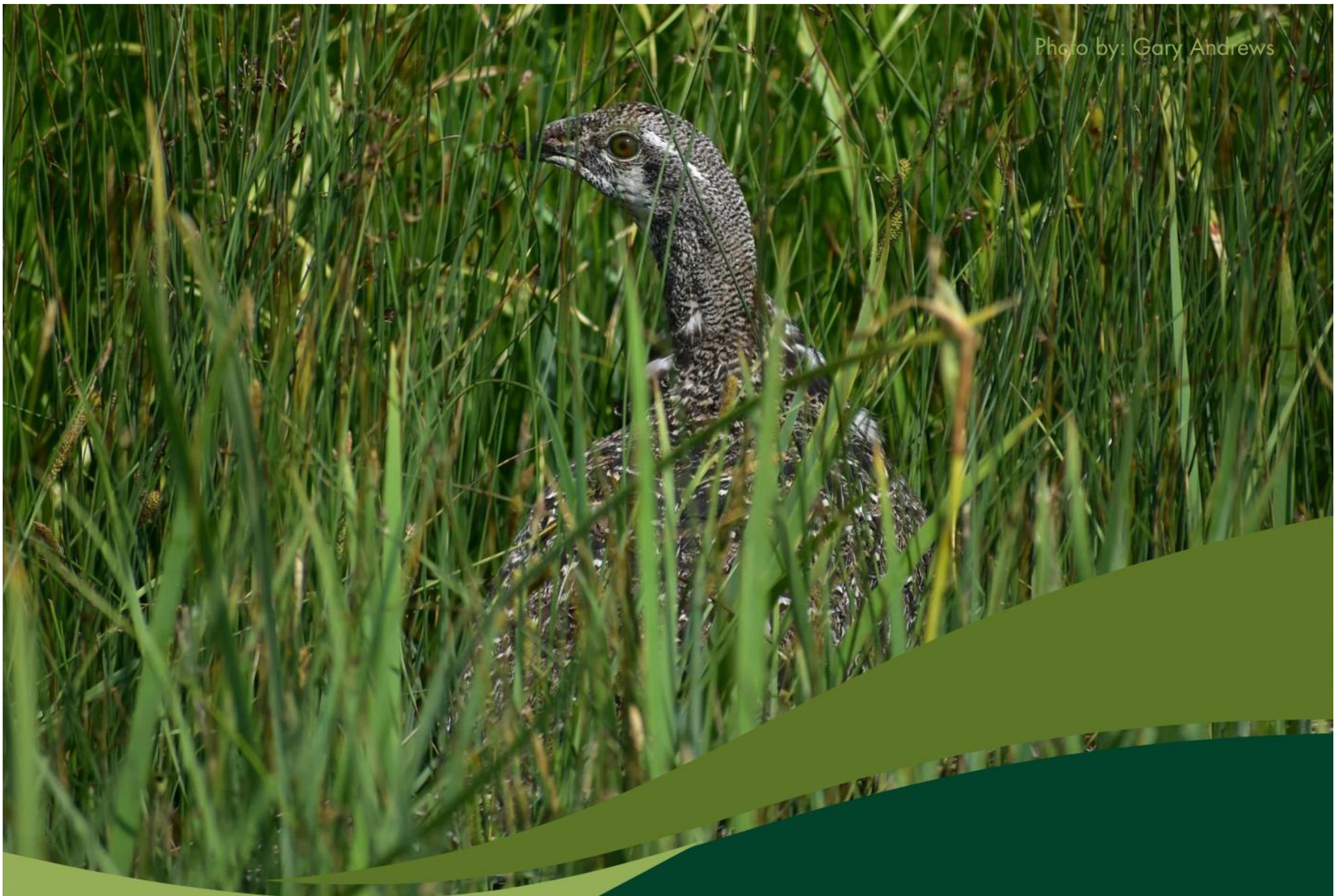

Restoring Riparian Function to Support Greater Sage-Grouse Brood Habitat in Grasslands National Park

A DESMAN 2026 Project Proposal for Low-Tech Riparian Restoration and Monitoring

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Introduction

Grassland ecosystems, particularly sagebrush steppe landscapes, support a wide range of species that depend on spatially limited but highly productive wet meadow habitats (Johnson & Jones, 1977; Krueper, 1995). The Greater Sage-Grouse relies on these mesic areas during brood-rearing to access forbs and invertebrates critical for chick survival (Peterson, 1970). However, populations have declined substantially across North America, with the Canadian range reduced by approximately 90% (Aldridge, 2000), leaving only small populations in areas such as Grasslands National Park. While multiple threats contribute to this decline, increasing evidence suggests that degradation of wet meadow systems, particularly through channel incision and altered hydrology, may limit the availability of suitable brood-rearing habitat (Aldridge & Brigham, 2001). Despite growing interest in low-tech restoration approaches to address these issues, there is limited empirical evidence of their effectiveness in Canadian systems. This project aims to evaluate whether such restoration techniques can improve wet meadow conditions and enhance habitat suitability for Greater Sage-Grouse (Figure 1).

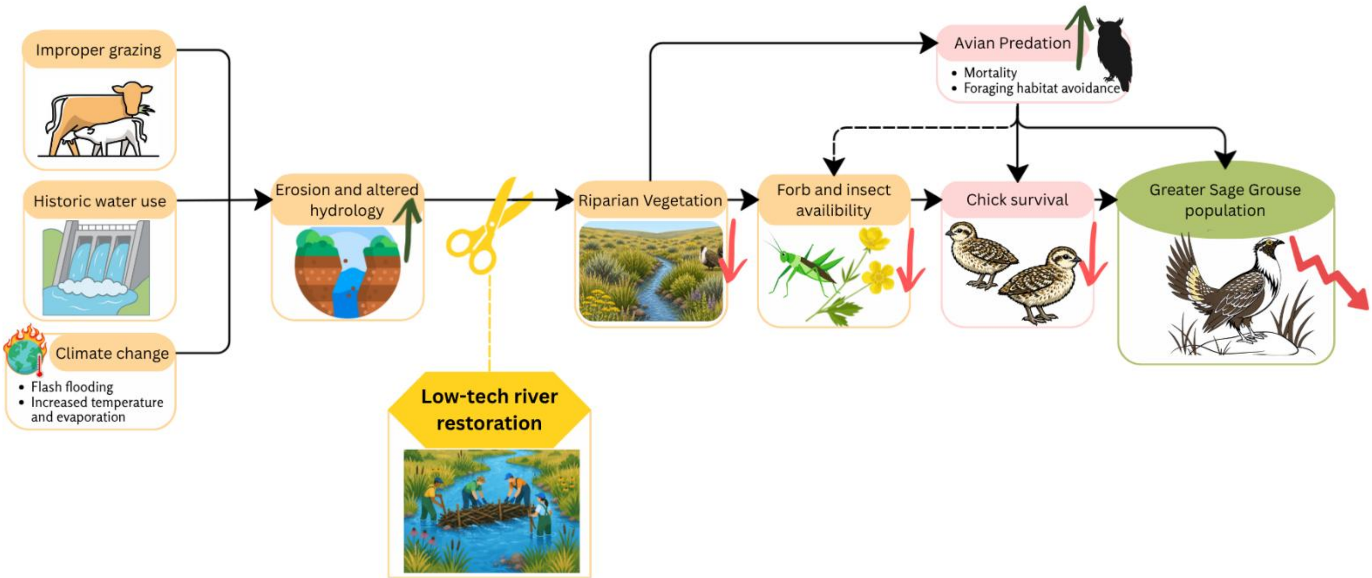

Figure 1: Conceptual model of wet meadow degradation and restoration pathways influencing Greater Sage-Grouse populations. Drivers of riparian degradation (e.g., improper grazing, historical water use, and climate change) contribute to channel incision and altered hydrology, resulting in reduced riparian vegetation condition *(Conover & Roberts, 2016; Krueper, 1995)*. Low-tech restoration approaches, including beaver dam analogues (BDAs) and Zeedyk structures, aim to restore hydrological function and improve vegetation condition. Improved vegetation supports increased forb and invertebrate availability, enhancing chick survival and ultimately contributing to population persistence (Donnelly et al., 2016; Drut et al., 1994; Peterson, 1970; Remington et al., 2021). Avian predators act as an additional pressure on chick survival and may indirectly interact with habitat condition *(Dinkins et al., 2012, 2014, 2016; Mabray & Conover, 2015)*.

Background

Current Problem: Decline of Wet Meadow Habitat and Sage-Grouse Populations

The decline of Greater Sage-Grouse populations has been attributed to a combination of factors, including overhunting, disease, predation, and habitat loss (Braun, 1998; Connelly et al., 2004; Schroeder et al., 2004). However, increasing evidence highlights the importance of mesic habitats, particularly wet meadows, as a limiting factor for brood survival and recruitment (Aldridge, 2000; Aldridge & Brigham, 2002; Robinson, 2007; Smith, 2009) (Figure 2).

Sage-grouse chicks rely heavily on forbs and associated invertebrates for nutrition, with forbs comprising up to 78% of their diet by volume (Peterson, 1970). Broods typically move from upland sagebrush nesting areas to more mesic environments as the season progresses (Autenrieth, 1981; Dunn & Braun, 1986). These wet meadow systems provide high-quality forage, often requiring 20–40% forb cover, yet only approximately 12% forb cover is available in parts of the Canadian range (Aldridge & Brigham, 2002). This mismatch between habitat requirements and availability may contribute to reduced chick survival and low recruitment.

Figure 2: Greater Sage-Grouse life stages and brood-rearing behaviour. Adult (bottom right), chicks (top right) and juvenile (left) individuals are shown using riparian habitats, including foraging near water sources. Chicks rely on mesic environments for access to forbs and invertebrates, highlighting the importance of wet meadow habitats for survival during early life stages.

Wet meadows are disproportionately important within arid landscapes, supporting approximately 80% of animal species and over 50% of breeding birds despite occupying a small fraction of the land area (Johnson & Jones, 1977; Krueper, 1995). However, these systems have been extensively altered by historical land use practices, with up to 95% of riparian habitats modified or lost in some regions (Krueper, 1995) (Figure 3). In prairie systems, many wet meadows have been converted to pasture or agricultural land, further reducing habitat quality (Conover & Roberts, 2016).

Figure 3: Comparison of riparian condition. Conceptual diagrams (top) illustrate differences in hydrological connectivity between intact and incised systems. The left image shows a healthy wet meadow with intact hydrological connectivity and mesic vegetation across the floodplain. The right image shows a degraded, incised channel within the Frenchman River in Grasslands National Park, where channelization and lateral cutting have disconnected the stream from its floodplain, reducing water table access and limiting mesic vegetation.

A major driver of wet meadow degradation is channel incision, often caused by historical water management and land use (Krueper, 1995). Incised channels disconnect streams from their floodplains, lowering groundwater tables and reducing soil moisture availability (B. Zeedyk & Clothier, 2014)(Figure 3). This leads to a shift from mesic, forb-rich communities to drier, grass-dominated or invasive plant communities (W. D. Zeedyk, 2003), reducing habitat suitability for sage-grouse broods. Additional pressures, such as climate change, are expected to exacerbate these effects through increased drought frequency, altered precipitation patterns, and greater variability in hydrological regimes (Joyce et al., 2016). These relationships are summarized conceptually in Figure 1.

Although predation, particularly by avian predators such as ravens, also influences sage-grouse survival, habitat degradation can indirectly increase predation risk by forcing birds into suboptimal or clustered habitats(Conover, 2007; Dinkins et al., 2012).

Potential Solutions: Low-Tech Restoration Approaches

Restoration of wet meadow hydrology has been identified as a key strategy for improving sage-grouse habitat and population resilience (Remington et al., 2021). Low-tech process-based restoration techniques, such as beaver dam analogues (BDAs) and Zeedyk structures (Figure 4), aim to slow water flow, reconnect floodplains, and raise local water tables using natural materials.

Figure 4: Examples of low-tech, process-based restoration techniques. Images show (bottom) installation of a post-assisted structure or beaver dam analogue (BDA), (top right) weaving of a demonstration BDA, and (top left) construction of a rock Zeedyk-style structure. These structures are installed manually using locally sourced materials, reflecting their low cost, scalability, and ability to mimic natural hydrological processes.

These approaches are increasingly promoted because they are cost-effective, scalable, and mimic natural hydrological processes compared to traditional engineering-based restoration methods. By increasing water retention and soil moisture, these techniques can promote the recovery of wetland vegetation, including forbs critical to sage-grouse chicks.

Evidence from the Gunnison Basin demonstrates the potential effectiveness of these methods (Figure 4). A study on Gunnison Sage-Grouse habitat found that low-tech restoration structures increased wetland plant cover by an average of 40% within 5 years and improved forb and grass abundance in the majority of treated areas, even during drought conditions (Rondeau et al., 2024).

These findings suggest that similar approaches could be beneficial in other semi-arid sagebrush systems.

Figure 5: Before and after restoration photos from a media luna (Top) and Log structure (Bottom). Before-and-after photographs showing vegetation and channel responses to low-tech restoration structures. The upper panel illustrates increased wetland vegetation associated with a media luna structure, while the lower panel shows sediment accumulation and reduced channel incision following installation of log-based structures. Photos were taken at comparable times of year to highlight changes over time. (Rondeau et al., 2024)

However, despite widespread implementation and support from land managers, there remains a lack of peer-reviewed studies evaluating these techniques in Canadian contexts, particularly within sage-grouse range. This limits the ability of conservation practitioners to make evidence-based management decisions.

Project Relevance and Knowledge Gap

Given the critical role of wet meadows in sage-grouse ecology and the ongoing degradation of these systems, there is a clear need to evaluate effective restoration strategies. While low-tech approaches show promise, their outcomes in northern sagebrush ecosystems remain poorly understood.

This project aims to address this gap by investigating whether low-tech restoration techniques can improve wet meadow hydrology and vegetation composition, particularly forb availability, within sage-grouse habitat in Grasslands National Park. By linking hydrological restoration to ecological responses relevant to brood-rearing habitat, this study will provide valuable insights to inform conservation and management of Greater Sage-Grouse in Canada.

Overall Goal

To evaluate the effectiveness of low-tech river restoration techniques in improving wet meadow habitat quality for Greater Sage-Grouse in Grasslands National Park.

Specific Objectives

- **Quantify changes in riparian vegetation composition following restoration**, with a focus on percent cover of forbs, grasses, and bare ground in treated versus control sites over time.
- **Evaluate whether low-tech restoration increases the availability of sage-grouse preferred forbs,** by comparing forb cover and species composition before and after restoration using a BACI design.
- **Assess changes in vegetation structure relevant to brood-rearing habitat**, including vegetation height and visual obstruction, between restored and unrestored areas.
- **Determine whether restoration sites show greater improvement in habitat suitability indicators compared to control sites**, using statistical comparisons of vegetation and habitat metrics.

Methodology

Site considerations

The Frenchman River is a precipitation- and snowmelt-driven prairie system draining a watershed of approximately 5,500 km², with low annual precipitation (~300–350 mm/year) characteristic of semi-arid grasslands (Parks Canada, 2023; U.S. Geological Survey, 2007). Flow in the river is highly variable and further influenced by upstream water management, including the Val Marie Reservoir, which was constructed for irrigation and contributes to fluctuating downstream water levels (Environment and Climate Change Canada, 2024) (Figure 6). In addition to hydrological alteration, the surrounding landscape has a long history of livestock grazing, including leased cattle grazing within Grasslands National Park. Grazing pressure can influence vegetation composition and bank stability, interacting with hydrological processes to affect wet meadow condition. Ongoing management efforts, including the reintroduction of plains bison, aim to restore more natural disturbance regimes within the system.

Site Selection

Potential restoration sites will be identified using existing geospatial data provided by Parks Canada, including river, sage-grouse habitat suitability models, and lek locations. Sites will be prioritized based on proximity to nesting habitat, degree of channel incision, and accessibility.

Ground-truthing will be conducted to assess site conditions and determine the most appropriate restoration approach (e.g. beaver dam analogues or Zeedyk-style structures) based on hydrological and geomorphological characteristics.

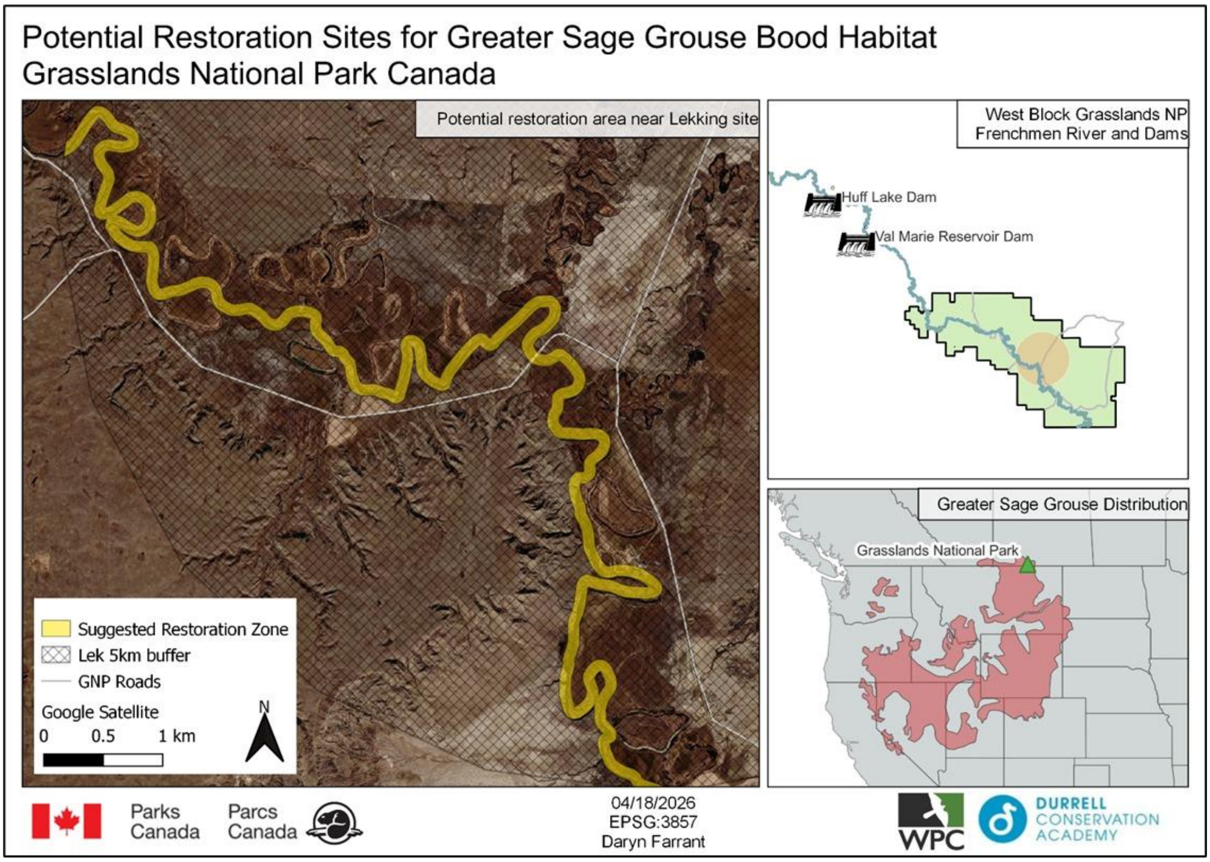

Figure 6: Map of the study area in Grasslands National Park. The bottom right panel shows the park in relation to the current distribution of Greater Sage-Grouse *(BirdLife International & Handbook of the Birds of the World, 2025)*, highlighting its position at the northern edge of the species' range. The top right panel shows dams and reservoirs influencing flow in the Frenchman River, with a 5 km buffer around an active lek highlighted in orange; regulated water releases have historically contributed to rapid downstream fluctuations in water levels. The left panel shows satellite imagery of the study area, with potential restoration sites along the river highlighted in yellow.

Study Design and Monitoring

Methods are adapted from previous restoration monitoring studies (Rondeau et al., 2024).

A **Before–After–Control–Impact (BACI)** design will be used to evaluate restoration effectiveness. At each site, permanent transects will be established in both treated and untreated (control) areas.

Vegetation monitoring will be conducted annually during peak growing season (June–August) using a combination of methods adapted to available equipment:

- **Line-point intercept (meter tape):** to estimate percent cover of plant functional groups (forbs, grasses, shrubs, bare ground)
- **Daubenmire frames:** to assess species composition and percent cover within quadrats
- **Robel pole:** to measure vegetation structure and visual obstruction

Transects will extend across the riparian zone (upland edge to upland edge) and will be permanently marked to allow repeated annual sampling. Photo monitoring will also be conducted to provide visual comparisons over time.

Data Analysis

Vegetation responses will be analysed using R (RStudio), focusing on changes in cover, composition, and structure over time.

- Changes in vegetation metrics (e.g. forb cover, vegetation height) will be assessed using **linear models** comparing pre- and post-restoration conditions
- Differences between treated and control sites will be evaluated using **t-tests or mixed-effects models**, depending on data structure
- Trends in sage-grouse habitat indicators (e.g. preferred forb availability) will be analysed to assess ecological relevance

Table 1: Key vegetation and habitat variables *measured to assess restoration effectiveness and implications for Greater Sage-Grouse habitat.*

Variable	**Method**	**Relevance**
Total vegetation cover (%)	Line-point intercept	Overall vegetation response
Forb cover (%)	Line-point intercept / Daubenmire	Key food resource for chicks
Grass cover (%)	Line-point intercept	Competition / habitat structure
Bare ground (%)	Line-point intercept	Indicator of degradation
Species composition	Daubenmire frames	Community change
Vegetation height / structure	Robel pole	Cover from predators
Grazing level	High, medium, low	Grazing dynamics
Photo monitoring	Fixed-point photos	Visual change over time

Project Schedule

Table 2: Gantt chart showing the overall schedule of activities and tasks

	Year 0				Year 1			Years 2-4	Year 5	
Task	**Mar–May**	**Jun–Aug**	**Sep–Nov**	**Dec–Feb**	**Mar–May**	**Jun–Aug**	**Sep–Nov**	**August**	**August**	**Fall/Winter**
Budgeting & funding										
Permits										
Site selection (GIS + field checks)										
Monitoring protocol development										
Material acquisition										
Field logistics planning										
Baseline / initial vegetation survey										
Restoration installation										
Annual vegetation monitoring										
Data analysis										
Reporting & write-up										
Data sharing / outputs										

Expected Outputs

- **A technical report** evaluating the effectiveness of low-tech restoration techniques on wet meadow vegetation and habitat indicators for Greater Sage-Grouse
- **A geospatial dataset and GIS maps** showing restoration sites and changes in vegetation condition over time
- **A vegetation monitoring dataset** (BACI design) suitable for long-term use by Parks Canada
- **Management recommendations** for implementing low-tech restoration techniques in sage-grouse habitat
- A **peer-reviewed publication** or internal conservation report

Expected Outcomes

- **Improved understanding** of the effectiveness of low-tech restoration techniques in Canadian prairie systems
- **Evidence-based guidance** to support future restoration and habitat management decisions in Grasslands National Park
- **Potential improvement in brood-rearing habitat quality**, through increased availability of forbs and suitable vegetation structure
- **Contribution to the long-term conservation and recovery of Greater Sage-Grouse in Canada**

Resources Required

Table 3: Budget estimates and justification of resources required for the project, including staffing, field, and materials. All costs are in Canadian Dollars.

	Price per unit	# of units	Cost	Justification	Source/Example
Planning					
Project planning	$37.70/hour	7.5 * 15 days	$4,242	EG03 salary average: 73,600/year. An estimated 3 weeks of GIS and project planning.	EG Rates of Pay Government of Canada
Permitting	$41.50/hour	20 hours	$830	EG04 salary average: 80,960/year ≈ $41.50/hour. Estimated 2–3 days for permit preparation and coordination	EG Rates of Pay Government of Canada
Restoration costs					
Labour	$34.30/hour	7.5 hrs *3 days	$3,087	EG02 salary average: 66,900/year. Small crew 4 ppl*3 days for installation of low-tech structures and material gathering.	Rates of Pay, Government of Canada
Materials			$1,000	Estimated cost of materials for low-tech restoration structures (e.g., BDAs). ~35–40 wooden posts ($4.86 each) installed at ~0.5 m spacing across a ~3 m channel width. Additional costs include wire/twine and minor equipment (e.g., post driver). Natural materials sourced on-site; includes contingency.	Home Depot Canada - Pressure treated wooden posts Home Depot Canada - Hand Post driver
Transport	$0.68/km	500km	$340	Estimated travel to remote sites using standard Canadian mileage rates; distance varies by site and access.	
Monitoring Costs					
Staffing	$34.30/hour	7.5 hours * 3 days	$6,174	EG02 salary average $34.30/hour * 3 days per year * 2 persons = 1,544$/year * 4 years	EG Rates of Pay Government of Canada
Equipment	$0	$0	$200	Equipment already owned by Grasslands National Park; budget reflects minor maintenance and replacement costs.	
Transport	$0.68/km	500km*4years	$1,360	Annual travel to monitoring sites; cost varies depending on access and field logistics.	
Reporting					
Data analysis and write-up	$37.70/hour	7.5 * 15 days	$4,242	EG03 salary average: = 73,600/year.	EG Rates of Pay Government of Canada
5% contingency fund			$1,100	Contingency for unexpected or underestimated costs (5%* $21,475)	
Total			**$22,575**		

Risks/Assumptions

Table 4: Description of potential assumptions and risks of this project, along with the likelihood of them occurring and possible mitigation and response options.

Assumption/Risk	Likelihood	Mitigation/Response
Risk that permits for installation of the restoration structure won't be approved by the field season	*Medium* -Permitting can be a lengthy process and subject to delay and prioritization	Start permitting process as soon as possible to avoid delays. If necessary, delay installation until the following year
Assumption that suitable restoration sites can be identified using available spatial data	*Medium* – Existing data may be coarse or outdated	Combine GIS analysis with ground-truthing to refine site selection and ensure suitability
Risk that selected sites are too highly incised for restoration structures to be effective	*Medium–High* – Some areas may exceed the functional limits of low-tech restoration	Select a range of sites with varying levels of incision and acknowledge limitations in interpretation of results
Risk of extreme weather events (e.g. drought, flooding) affecting restoration success or monitoring	*Medium* – Climate variability is high in prairie systems	Incorporate multi-year monitoring, and control sites to account for variability and document weather conditions during analysis
Risk that restoration structures fail or are damaged (e.g. high flow events)	Low	Use appropriate site selection and installation techniques; monitor structures regularly and repair if necessary
Assumption that vegetation response can be detected within the monitoring timeframe (3–5 years)	*Medium* – Ecological responses can be slow in semi-arid environments	Frame results as early indicators of change and recommend longer-term monitoring where possible
Risk of logistical constraints during field season (e.g. staffing, time limitations)	*Medium* – Field season is short and resource-intensive	Prioritise key measurements and ensure efficient field protocols are in place
Assumption that control sites are comparable to treatment sites	*Medium* – Environmental variability may influence results	Select control sites within the same drainage systems and account for variation in statistical analysis
Risk that grazing pressure influences vegetation independently of restoration	*Medium-high*	Record grazing intensity during surveys and consider as a variable in analysis
Risk that sage-grouse use of restored areas cannot be directly measured	*High* – Species detection is limited	Use vegetation and habitat metrics (e.g. forb availability) as proxies for habitat suitability

References

Aldridge, C. L. (2000). *Reproduction and habitat use by sage grouse (Centrocercus urophasianus) in a northern fringe population.* Faculty of Graduate Studies and Research, University of Regina.

Aldridge, C. L., & Brigham, R. M. (2001). Nesting and reproductive activities of greater sage-grouse in a declining northern fringe population. *The Condor*, *103*(3), 537–543.

Aldridge, C. L., & Brigham, R. M. (2002). Sage-grouse nesting and brood habitat use in southern Canada. *The Journal of Wildlife Management*, 433–444.

Autenrieth, R. E. (1981). *Sage grouse management in Idaho* (Number 9). Idaho Department of Fish & Game.

BirdLife International, & Handbook of the Birds of the World. (2025). *Bird species distribution maps of the world*. http://datazone.birdlife.org/species/requestdis

Braun, C. E. (1998). Sage grouse declines in western North America: what are the problems. *Proceedings of the Western Association of State Fish and Wildlife Agencies*, *78*.

Connelly, J. W., Knick, S. T., Schroeder, M. A., & Stiver, S. J. (2004). Conservation assessment of greater sage-grouse and sagebrush habitats. *All US Government Documents (Utah Regional Depository)*, 73.

Conover, M. R. (2007). *Predator-prey dynamics: the role of olfaction*. CRC Press.

Conover, M. R., & Roberts, A. J. (2016). Declining populations of greater sage-grouse: where and why. *Human-Wildlife Interactions*, *10*(2), 217–229.

Dinkins, J. B., Conover, M. R., Kirol, C. P., & Beck, J. L. (2012). Greater sage-grouse (Centrocercus urophasianus) select nest sites and brood sites away from avian predators. *The Auk*, *129*(4), 600–610.

Dinkins, J. B., Conover, M. R., Kirol, C. P., Beck, J. L., & Frey, S. N. (2014). Greater Sage-Grouse (Centrocercus urophasianus) select habitat based on avian predators, landscape composition, and anthropogenic features. *The Condor: Ornithological Applications*, *116*(4), 629–642.

Dinkins, J. B., Conover, M. R., Kirol, C. P., Beck, J. L., & Frey, S. N. (2016). Effects of common raven and coyote removal and temporal variation in climate on greater sage-grouse nesting success. *Biological Conservation*, *202*, 50–58.

Donnelly, J. P., Naugle, D. E., Hagen, C. A., & Maestas, J. D. (2016). Public lands and private waters: scarce mesic resources structure land tenure and sage-grouse distributions. *Ecosphere*, *7*(1), e01208.

Drut, M. S., Crawford, J. A., & Gregg, M. A. (1994). Brood habitat use by sage grouse in Oregon. *The Great Basin Naturalist*, 170–176.

Dunn, P. O., & Braun, C. E. (1986). Summer habitat use by adult female and juvenile sage grouse. *The Journal of Wildlife Management*, 228–235.

Environment and Climate Change Canada. (2024, April 3). *Val Marie Reservoir Migratory Bird Sanctuary*. https://www.canada.ca/en/environment-climate-change/services/migratory-bird-sanctuaries/locations/val-marie-reservoir.html

Johnson, R. R., & Jones, D. A. (1977). *Importance, Preservation, and Management of Riparian Habitat: A Symposium, Tucson, Arizona, July 9, 1977* (Vol. 43). Rocky Mountain Forest and Range Experiment Station, Forest Service, US ….

Joyce, C. B., Simpson, M., & Casanova, M. (2016). Future wet grasslands: ecological implications of climate change. *Ecosystem Health and Sustainability*, *2*(9), e01240.

Krueper, D. J. (1995). *Conservation priorities in naturally fragmented and human-altered riparian habitats of the arid west*. US Bureau of Land Management.

Mabray, S. T., & Conover, M. R. (2015). Microhabitat selection by greater sage-grouse hens during brood rearing. *Human-Wildlife Interactions*, *9*(2), 219–228.

Parks Canada. (2023). *Grasslands National Park – Weather*. https://parks.canada.ca/pn-np/sk/grasslands/visit/meteo-weather

Peterson, J. G. (1970). The food habits and summer distribution of juvenile sage grouse in central Montana. *The Journal of Wildlife Management*, 147–155.

Remington, T. E., Deibert, P. A., Hanser, S. E., Davis, D. M., Robb, L. A., & Welty, J. L. (2021). *Sagebrush conservation strategy—Challenges to sagebrush conservation*. US Geological Survey.

Robinson, J. D. (2007). *Ecology of two geographically distinct greater sage-grouse populations inhabiting Utah's West Desert*. Utah State University.

Rondeau, R. J., Austin, G., Miller, R. S., Parker, S., Breibart, A., Conner, S., Neely, E., Seward, N. W., Vasquez, M. G., & Zeedyk, W. D. (2024). Restoration of wet meadows to enhance Gunnison sage-grouse habitat and drought resilience in arid rangelands. *Restoration Ecology*, *32*(2). https://doi.org/10.1111/rec.14039

Schroeder, M. A., Aldridge, C. L., Apa, A. D., Bohne, J. R., Braun, C. E., Bunnell, S. D., Connelly, J. W., Deibert, P. A., Gardner, S. C., & Hilliard, M. A. (2004). Distribution of sage-grouse in North America. *The Condor*, *106*(2), 363–376.

Smith, L. S. (2009). *Greater sage-grouse and energy development in northeastern Utah: implications for management*. Utah State University.

U.S. Geological Survey. (2007). *Water-resources data for the United States, Water Year 2006: Frenchman River Basin*. https://pubs.usgs.gov/of/2007/1346/sds/06164000.2006.pdf

Zeedyk, B., & Clothier, V. (2014). *Let the water do the work: induced meandering, an evolving method for restoring*. Chelsea Green Publishing.

Zeedyk, W. D. (2003). *An introduction to induced meandering: a method for restoring stability to incised stream channels*. Quivira Coalition.