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Understanding Wetlands and Irrigation in the Little Snake River Basin, Wyoming

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by

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Abstract

The Little Snake River Basin (LSRB) is a highly managed basin in South-central Wyoming located within the Colorado River watershed which is facing severe water shortages. As a result, there is increased pressure on water resource managers and agricultural producers to adopt water efficiency practices in the basin that could negatively affect the wetland resource. However, studies have begun to quantify the importance of irrigation for recharging groundwater, maintaining late season instream flows, and maintaining and creating wetlands that provide valuable wildlife habitat and ecosystem services.

In the LSRB there are 11,636 acres of wetlands; 56% of which overlap with irrigation. Conversion to more efficient irrigation could reduce water availability to an estimated 6,500 wetland acres. The high proportion of wetlands that overlap with flood irrigation in the LSRB suggest high vulnerability to wetland loss in the future if producers convert to more efficient irrigation. Associated ecological benefits and ecosystems services could also be diminished resulting in economic losses in the basin. Conservation strategies aimed at protecting wetlands and wildlife habitat may fall short of their intended purpose if water quantity and timing associate with current water management practices are also not retained.

The objectives of this report are to: 1) summarize information about wetland resources and land use practices in the LSRB; 2) discuss results from a wetland assessment conducted by the Wyoming Natural Diversity Database which identified major wetland types, condition, and potential indicators of disturbance in the LSRB; 3) investigate the economic impact of water management changes to irrigated wetlands in the LSRB, and 4) present trends on the public perception of irrigation in the LSRB.

ACKNOWLEDGEMENTS

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The framework for this study was informed by the State Wildlife Wetlands Conservation Strategy (Wyoming Joint Ventures Steering Committee 2010), the State Wildlife Action Plan (Wyoming Game and Fish Department 2010), and members of the Wyoming Bird Conservation Habitat Partnership (WBCHP).

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1.0 INTRODUCTION

1.1 Wetlands and Irrigation

Prior to European settlement, wetlands covered approximately 3.2% of Wyoming and were predominantly associated with riparian floodplains, glaciated mountain regions, and playa lakebeds (Dahl 1980). By the mid-1980s, hydrologic modifications associated with irrigation infrastructure such as dams, diversions, and levees had altered the timing, amount, and dispersion of water, reducing wetlands by 38%. The number and area of natural wetlands continue to decline, and recent studies identify wetlands as one of the habitat types most vulnerable to impacts of future development and climate change in Wyoming (Copeland et al. 2010, Pocewicz et al. 2014).

Hydrologic modifications associated with irrigation have also enhanced water availability to existing wetlands and have created new wetland area in many arid river basins in Wyoming. In fact, previous wetland assessment studies in Wyoming estimated that 10-46% of the current wetlands sampled were supported or created by irrigation (Tibbets et al. 2015; Tibbets et al. 2016a, 2016b). Wetlands receive irrigation water through seepage from canals and ponds, tailwater from irrigated fields, and through interactions with shallow aquifers which receive groundwater recharge from irrigated fields (Sueltenfuss 2012).

Wetlands, both natural and created by irrigation, are critically important parts of the arid landscape. In the Intermountain West, more than 140 bird species, 30 mammal species, 36 amphibians, and 30 reptiles are either dependent on or associated with wetlands (Gammonley 2004). More than one-third of species listed as threatened or endangered in the United States live solely in wetlands and almost half use wetlands at some point in their lives (U.S. Environmental Protection Agency 1995).

Wetlands in Wyoming only occupy 1.5% of the total land area, but support a disproportionately high number of plant and wildlife species (Knight et al. 2014). Approximately 90% of the wildlife species use wetland and riparian habitats daily or seasonally during their life cycle, and about 70% of Wyoming bird species are wetland or riparian obligates (Nicholoff 2003).

In Wyoming, 44% of wetlands occur on private lands (Copeland et al. 2010b). Much of these wetland resources are associated with irrigated hay meadows and rangelands occurring in historic river floodplains and lowlands. Many studies have begun to quantify the importance of irrigation-influenced wetlands for migrating birds and other wildlife (Chester and Robson 2013, Moulton et al. 2013, Patla 2015, Donnelly et al. 2016). Irrigated landscapes often support foraging habitat for migrating and breeding waterbirds (Peck and Lovvorn 2001, Intermountain West Joint Venture 2013) and provide late summer brood rearing habitat for sage grouse (Donnelly et al. 2016). This means the future success of wildlife habitat conservation for wetland-dependent species is inextricably tied to private lands and current agricultural practices.

In addition to wildlife habitat, there is increased recognition of the ecosystem services provided by irrigation-influenced wetlands for pesticide de-contamination, reduction of nitrogen transport from agricultural catchments, and the support of biodiversity (Strand and Weisner 2013, Tanner et al. 2013, Tournebize et al. 2013).

1.2 Threats to Water Management

The Colorado River supplies irrigation water to nearly 5.5 million acres of land and to the municipal use of more than 40 million people (Bureau of Reclamation 2012). Climate change simulations indicate a 6% to 20% reduction in average stream flow (Ray et al. 2008) which is particularly problematic as water demands continue to grow. The population in Colorado alone is projected to nearly double by 2050, resulting in an estimated increase in water demand of between 600,000 and 1 million acre-feet/year (CWCB 2010). Water supply managers anticipate addressing supply and demand conflicts through reusing and conserving water, new water supply development, and the reallocation of water from agriculture to urban uses (Smith 2010).

Agriculture is one of the main water users in the west. In Wyoming, irrigated agriculture accounts for 87% of total water use and up to 91% of surface water withdrawals (Boughton et al. 2006). For most of Wyoming's history surface water irrigation application was done in the form of "flood irrigation". Flood irrigation is the practice of diverting water from nearby streams to apply to fields through ditches and canals at specific intervals to spread water out downslope (Carter et al. 2017). Flood irrigation is often considered an "inefficient" agricultural practice because water is applied at a rate greater than what crops can utilize (Fernald et al. 2010). The remaining water is lost to evaporation (Peck et al. 2004), recharges alluvial aquifers (Kendy and Bredehoeft 2006), is returned to rivers as overland flow or shallow groundwater discharge (Fernald and Guldan 2006), can enhance water availability to adjacent wetlands (Sueltenfuss 2012), or can create new wetlands (Kendy 2006).

The definition of irrigation efficiency is the ratio of the net volume of water consumed by a crop to the volume of water applied. (Burt et al. 1997). No irrigation methods are 100% efficient. Water is lost to seepage, runoff, and evaporation before it can be consumptively used by a crop. More efficient irrigation practices include lining earthen ditches with concrete to reduce seepage and switching from flood irrigation to gated pipe or sprinkler systems. For perspective, irrigation efficiencies for flood irrigation range from 45 to 60%, while efficiencies for sprinkler irrigation range from 60 to 80% (Wolters and Berisavljevic 1991, Zalidis et al. 1997).

Water shortages are predicted in the Colorado River Basin due to climate change, drought, and increased population (Cook et al. 2004; Hansen et al. 2002). These shortages will put pressure on agricultural producers in Wyoming to utilize more efficient irrigation methods so that there is more water available for downstream water users. The term "efficiency" suggests that increasing irrigation efficiency will result in more available fresh water in the watershed (Willardson et al. 1994), however increased efficiency means that water is applied in such a way that it is more

fully consumed by a crop so that there is less water lost to the system. In some instances, increased efficiency has actually increased water use in a watershed (Ward and Pulido-Velazquez 2008).

Shifting to efficient irrigation practices can have negative impacts on existing wetlands, especially those created or supported by "inefficient" irrigation practices. Studies have shown that increased efficiency can decrease water availability to adjacent wetlands which can reduce wetland area (Sueltenfuss 2012, Smith 2010) and shift plant species composition to more upland species (Venn et al. 2004). Policies intended to increase water use efficiencies could jeopardize the ecological benefits associated with flood irrigation (Goldstein et al. 2011).

It is important to consider the tradeoffs for different water management scenarios when evaluating changes to current irrigation practices. Policies aimed at increasing water availability for downstream users can result in negative ecological and socio-economic impacts locally. Conservation and restoration strategies aimed at protecting wetland acreage will fall short of their intended purpose without an understanding of the role between irrigation and wetland condition, function, and value in highly managed landscapes. In light of these threats, and general lack of information about the current status of wetlands in Wyoming, a description of wetland resources and an evaluation of wetland condition are urgently needed to better inform conservation and management priorities.

1.3 Project Background

The Little Snake River Basin (LSRB) is a highly managed basin in South-central Wyoming located within the Colorado River watershed. There is increased pressure on water resource managers and agricultural producers in the basin to adopt water efficiency practices in an effort to reduce water consumption so that more water is available for downstream users. There is an urgent need to understand baseline wetland conditions as it relates to current water management practices in the LSRB because changes in water management could drastically change the types and distribution of wetland acres which provide critical ecosystems services and wildlife habitat in the basin.

The Wyoming Natural Diversity Database (WYNDD), in collaboration with the Wyoming chapter of The Nature Conservancy (TNC), completed a landscape profile and ecological assessment of wetlands within the LSRB between 2016 – 2018. The objectives of this capstone are to: 1) summarize information about wetland resources and land use practices from the landscape profile of the LSRB; 2) discuss results from the wetland assessment completed by WYNDD which identified major wetland types, condition, and potential indicators of disturbance in the LSRB; 3) investigate the economic impact of water management changes to irrigated wetlands in the LSRB, and 4) present trends on the public perception of irrigation in the LSRB.

2.0 STUDY AREA

The LSRB covers 267,098 acres in extreme south-central Wyoming (Figure 1). The study area includes the Little Snake River floodplain and its main tributaries of Cow Creek, Wild Cow Creek, Big Sandstone Creek, and Little Savery Creek. Water from the LSRB flows into the Yampa River, then into the Green River, a major tributary of the Colorado River.

2.1 Land Use

Land uses in the LSRB are predominantly agriculture-based. This includes sheep and cattle grazing, small scale farming, and cultivated hay crops (WBHCP 2014). Approximately 5% (13,374 acres) of the total basin area is irrigated (Section 4.1.3, Table 4). Over 80% of irrigated lands in the study area (10,907 acres) are located along the Little Snake River floodplain where flood irrigation is used for hay production and cattle grazing (WBHCP 2014).

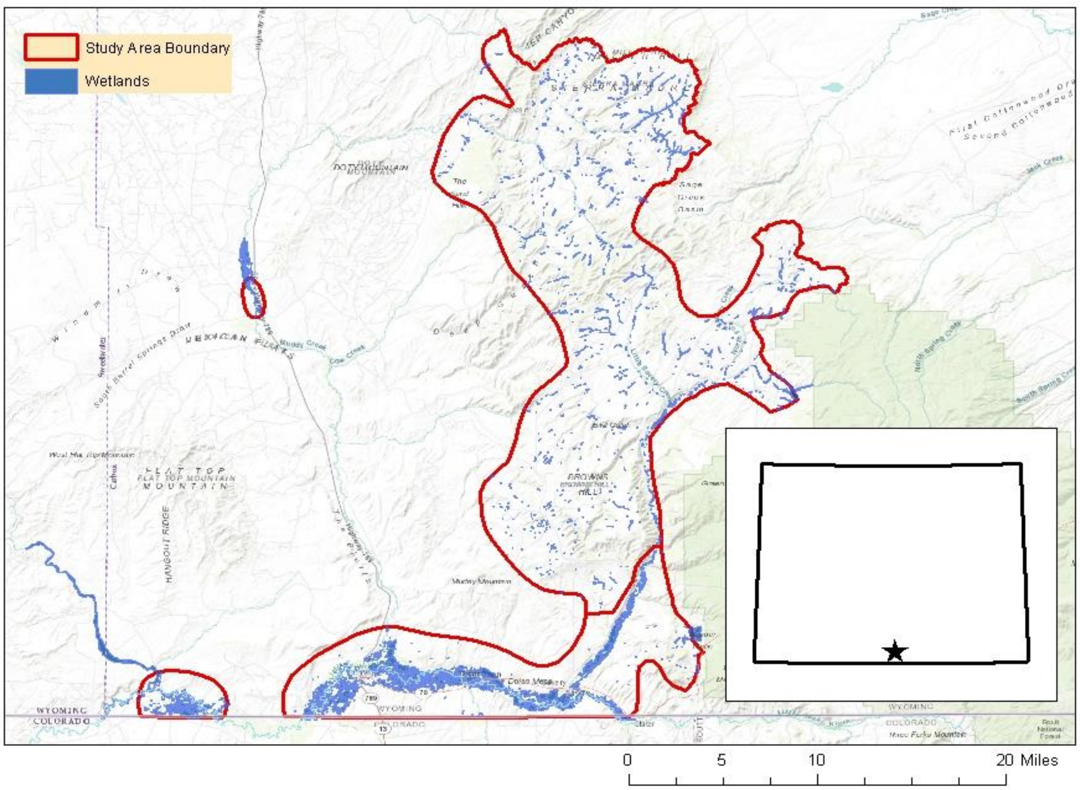

Figure 1. The Little Snake River Basin study area

2.2 Topography

The LSRB is located along the west side of the Sierra Madre and ranges from 6,079 (1853m) to 9,350 ft (2580m) in elevation. The area includes a wide diversity of habitats, from aspen glades, mixed mountain shrubs and sagebrush steppe at higher elevations, to riparian galleries of cottonwood and willow intermixed with herbaceous wetlands at lower elevations (Copeland et

al. 2010a). The dominant ecological system is Inter-Mountain Basin Montane Sagebrush Steppe (Comer et al. 2003).

2.3 Hydrology

Historically, wetlands in the LSRB consisted of seeps, springs, oxbows and other wetlands associated with the riparian corridor, and to a lesser extent with temporary and seasonal playas fed mainly by precipitation (WBHCP 2014). Stream flow in the Little Snake River is generally driven by snowpack that accumulates in the mountains and is stored in the High Savery Reservoir during spring runoff for release during the irrigation season. Annual stream flow is naturally highly variable and difficult to predict and is influenced by the High Savery Dam (22,433 acre-foot capacity) and multiple irrigation projects along the Little Snake River (WBHCP 2014).

Water is diverted from the Little Snake River and its tributaries into delivery ditches and canals that convey it by gravity to irrigated fields. The application of irrigation water over time can augment or enlarge historical wetlands or create new wetlands by altering natural hydrology, soil characteristics (e.g., color, redox features, and salt content), and vegetation (U.S. Army Corps of Engineers 2008). Wetlands associated with irrigation in the LSRB include margins of storage reservoirs, seeps along canals and ditches, natural or constructed basins to capture return flows from flood irrigated fields and pastures or overlap with flood irrigation. Irrigation also augments stream flow by contributing late season flows to streams which were historically dry by midsummer, allowing associated wetlands to retain water longer in the season (WBHCP 2014). Overall, these alterations to the hydrology in the LSRB have likely both removed and created wetland area in the basin.

3.0 METHODS

Recent studies of wetlands in the Intermountain West, including Wyoming, (Lemly and Gilligan 2012, Newlon et al. 2013, Tibbets et al. 2015, 2016a, 2016b) have utilized landscape profiles and rapid assessment methods (RAMs), such as the Ecological Integrity Assessment method (EIA) (Lemly and Gilligan 2012), to draw conclusions regarding the condition of wetland resources in a given geographical area. Landscape profiles primarily use digital spatial information to quantify the distribution of resources, such as wetland types or area, and to develop conservation goals at a landscape scale (Gwin et al. 1999). RAMs assess the condition of wetlands based on field surveys that measure abiotic and biotic indicators of ecological function and indicators of disturbance that have the potential to negatively affect wetlands. Together, landscape profiles and RAMs are used to establish baseline wetland profiles that include ecological condition, assessment of cumulative impacts, and information useful to prioritize protection and restoration efforts (Gwin et al. 1999).

3.1 Landscape Profile

A landscape profile for the LSRB was created using digital wetland mapping data compiled from the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) and additional data layers describing irrigated lands and land ownership within the LSRB study area. The landscape profile describes wetlands within the study area based on codes and modifiers defined by Cowardin et al. (1979) by the following attributes: wetland class; hydrologic regime; extent of wetlands modified/irrigated (Wyoming Wildlife Consultants 2007); and land management/ownership (Bureau of Land Management 2010).

3.2 Wetland Condition Assessment

Below is a summary of methods from the wetland condition assessment completed by WYNDD between 2016 – 2018. For more detailed information about the projects survey design, target population, methods description and data analysis please see the methods section taken from Washkoviak et al. (2018) in Appendix A. Datasheets used for field sampling can be found in Appendix C.

3.2.1 Target Population and Sample Frame

The target population defines wetlands to be characterized in the LSRB. The wetland target population consisted of the six classes of Palustrine wetlands that were used in the landscape profile (see Table 1). The target population is digitally represented by the NWI polygon dataset (U.S. Fish and Wildlife Service 1984) but it contains a degree of detail that makes it very difficult to use without grouping NWI codes into wetland subgroups. The sample frame was simplified (See Appendix A, Table 1) by grouping the NWI Cowardin et al (1979) codes into three target subgroups: 1) Wet meadow; 2) Emergent Marsh; and 3) Riverine Shrubland. Wetland subgroups were crosswalked to the Ecological Systems classification (Comer et al. 2003, Appendix B) and the Hydro Geomorphic (HGM) Classification (Brinson 1993, Adamus 2004) because these are the dominant systems used regionally for identifying wetland types in the field, and provide a valuable system for defining landscape units by biotic (e.g., plant community) and abiotic (e.g., geologic, hydrologic, elevation) criteria (Lemly and Gillian 2012, Newlon et al. 2013).

Seventy five sites divided across the three wetland subgroups were randomly selected from the sample frame using a Generalized Random Tessellation Stratified (GRTS) survey design for a finite resource (Stevens et al. 2004, Stevens and Jensen 2007). GRTS sampling was performed using R package spsurvey (Olsen and Kincaid 2009, R Development Core Team 2014). After potential sample sites were randomly selected, and prior to field sampling, a desktop site evaluation was performed to determine if the sites were sampleable. Permission was sought to access sampleable sites.

3.2.2 Assessment Methods

Wetlands were assessed using the rapid Ecological Integrity Assessment (EIA) framework (Lemly and Gilligan 2013) with added intensive protocols for floristic quality assessments, soil characterization, macro invertebrate assessments, and water quality measurements. The EIA framework provides a rapid, repeatable, scientifically-defensible evaluation of the ecological condition of a wetland. Field indicators or metrics were evaluated at each wetland based on narrative ratings of four attributes: Landscape Context, Hydrologic Condition, Physicochemical Condition, and Biotic Condition. The field metrics were assumed to represent a visible quality of a wetland ecosystem's complex ecological structure and function. Metric scores for each of the four attributes were combined into an overall EIA score that can be used to describe wetlands in relation to a reference condition.

Hydrologic condition was evaluated using the Landscape Hydrology Metric (LHM) (Tibbets et al 2015) which assesses alteration to a wetland' s hydrologic regime. Separate disturbance indicator metrics that identify the presence of anthropogenic disturbance associated with degradation of wetland ecosystems were recorded.

3.3 Economic Assessment

Wetlands in agricultural landscapes, both natural and created, provide ecosystem services including wildlife habitat, water filtration and supply, stream flow control, nutrient cycling, recreational opportunities, and carbon sequestration (Smith 2010, Brander et al. 2013). Ecosystem services are valued by estimating the cost of replacing the service with man-made infrastructure or defining the maximum amount a person would pay to continue to have access to a given natural resource (Loomis and Richardson 2007, Brander et al. 2013).

The economic value of wetlands in the LSRB was assessed using a benefit transfer model of economic valuation. A benefit transfer model refers to transferring available information from studies completed in another location to the context of the study location (Loomis 1992). For this study, the economic value for wetlands in the LSRB was calculated from a meta-analysis by Brander et al. 2013. This analysis valued three ecosystem services provided by wetlands in agricultural landscapes based on global economic value averages: flood control, water supply, and nutrient cycling.

The benefit transfer model was used to ascertain the ecosystem services value for all wetland acres in the LSRB assuming that they provided all ecosystem services equally. The valuation of wetland acres was refined by using additional wetland mapping within the LSRB floodplain completed by St. Mary's University of Minnesota in 2018 (GeoSpatial Services Saint Mary's University of Minnesota 2018). As part of the new mapping, wetland polygons in the LSRB floodplain were attributed with the Landscape, Landform, Waterbody, Water flow path (LLWW) classification developed by USFWS (Tiner 2003) which was combined with Cowardin et al. (1979) to estimate the ecosystem service potential of each wetland polygon.

Studies have shown that wetland area decreases when producers switch to more efficient irrigation systems (Smith 2010, Sueltenfuss 2012), however, it is difficult to precisely estimate the impact on individual wetlands. A study completed in an adjacent Colorado watershed by Smith (2010) estimated a 26% to 48% loss of irrigation dependent wetland acres if producers switched to more efficient irrigation methods. This estimated percent loss was applied to wetlands in the LSRB floodplain.

3.4 Human Dimensions

In Oct 2017, the Inter-mountain West Joint Venture and Little Snake Conservation District hosted a landowner meeting to investigate the human dimensions of conserving working wet meadow habitat in sage steppe landscapes. The objectives of the workshop were to: 1) Understand the financial, social, and natural factors landowners consider when deciding to continue or discontinue flood irrigation; and 2) Understand the financial, social, and natural factors landowners recognize from being involved in flood irrigation (Dayer et al. *in progress*.). Approximately 20 landowners and 15 – 20 state, federal, and NGO conservation professionals attended. The workshop consisted of presentations and panels by landowners including a presentation by myself on results from the WYNDD wetland assessment conducted in 2016, discussions between landowners and conservation professionals, and informal conversations. A summary of major trends identified at this meeting from my notes is found in Section 5.7.

4.0 LANDSCAPE PROFILE OF THE LITTLE SNAKE RIVER BASIN

4.1 Wetland Resource Description

According to mapping from the National Wetland Inventory (U.S. Fish and Wildlife Service 1984), wetland area comprises 11,636 acres, or 4% of the total land area of the LSRB study area (Table 1). This estimate excludes 1,879 acres of mapped non-wetland features such as deep lakes, river channels, and excavated wetlands.

4.1.1 Wetland Class

Palustrine freshwater emergent wetlands are the most common wetland class in the basin, totaling 9,526 acres and representing 82% of the wetland area (Table 1). Palustrine freshwater emergent wetlands include irrigated hayfields, wet meadows, and emergent vegetation zones around more permanent water features such as rivers and ponds. Palustrine forested wetlands are the second most common wetland class and cover 1,498 acres or 12% of the wetland area. Many forested wetlands are associated with cotton wood galleries and are located along the main stem of the Little Snake River. Palustrine scrub/shrub wetlands account for 265 acres, and palustrine freshwater ponds, mainly shallow ponds, account for 316 acres. Two additional classes of palustrine wetlands, unconsolidated bottom and unconsolidated shore, comprise the remaining 3% of wetland area.

Table 1. Surface area of wetlands based on NWI classifications in the LSRB.

NWI Wetland Class	Cowardin Code	Wetland Acres	% of Wetland Area
Palustrine Freshwater Emergent	PEM	9,526	81.86%
Palustrine Unconsolidated Bottom & Palustrine Unconsolidated Shore	PUB /PUS	31	0.27%
Palustrine Scrub/Shrub	PSS	265	2.28%
Palustrine Freshwater Pond	PAB	317	2.72%
Palustrine Forested	PFO	1,498	12.87%-
Total		**11,636**	

4.1.2 Hydrologic Regime

A hydrologic regime represents the amount, timing, and duration of water present in wetlands during the year (Cowardin et al. 1979). Seasonally and temporarily flooded wetlands are the two most common hydrologic regimes in the LSRB, representing 74% and 18% of the wetland area respectively (Figure 2). Seasonally flooded wetlands hold surface water for extended periods during the growing season but are dry by the end of the growing season in most years (Cowardin et al. 1979). Temporarily flooded wetlands hold surface water for relatively shorter periods during the growing season. They include wetlands with hydrology dependent on alluvial groundwater and seasonal flooding along the Little Snake River and its tributaries. These hydrologic regimes represent most freshwater emergent marshes, forested wetlands, shrub wetlands and wetlands with unconsolidated bottom/shores (Table 2). Semi-permanently flooded wetlands account for 7% of the wetlands area, and all of them are as freshwater ponds. Intermittently exposed wetlands constitute only 1% of the wetlands area (Figure 3) and are mapped as freshwater ponds or riverine wetlands (Table 2). Less than 1% of the wetlands are saturated (Figure 2), and they are freshwater emergent marshes or forested wetlands (Table 2). No wetlands within the LSRB are permanently flooded.

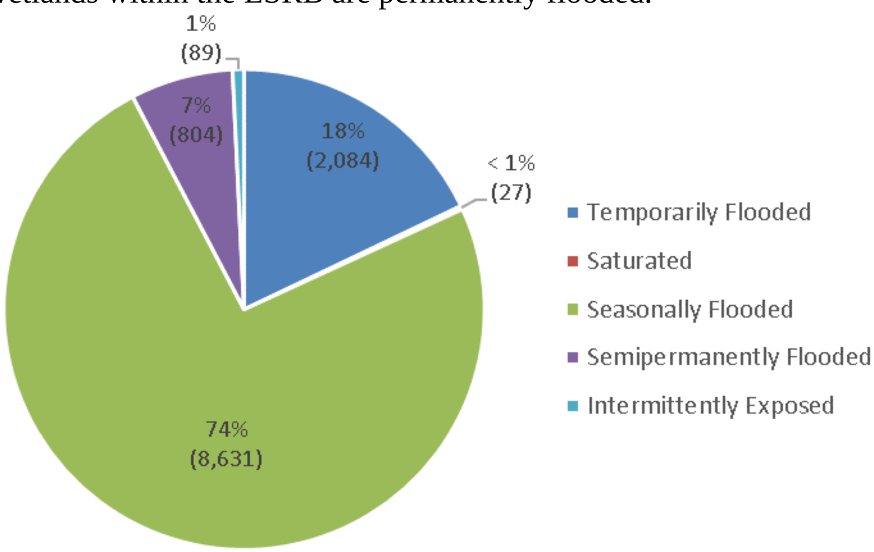

Figure 2. Surface area (acres) of wetlands classified according to NWI hydrologic regime in the LSRB.

Table 2. Percent of wetlands with a specific hydrologic regime in the LSRB.

Hydrologic regime		NWI Wetland Type					
		Palustrine Freshwater Emergent	**Palustrine Scrub/Shrub**	**Freshwater Pond**	**Palustrine Forested**	**Riverine**	**Palustrine Unconsolidated Bottom/Shore**
A	Temporarily Flooded	8%	16%	-	83%	-	36%
B	Saturated	<1%	-	-	<1%	-	-
C	Seasonally Flooded	85%	84%	-	17%	72%	64%
F	Semi-permanently Flooded	6%	-	73%	-	-	-
G	Intermittently Exposed	-	-	27%	-	28%	-

4.1.3 Special modifiers describing wetlands

NWI mapping includes modifier codes that identify man-made and natural alterations. Only 2% of the wetlands mapped in the LSRB have been assigned modifiers (Table 3). Modifications by beavers were identified in only 68 wetland acres. Beaver eradication has occurred throughout the basin leading to channel destabilization and down-cutting of tributaries in the basin (WBHCP 2014). At the time of study, beavers were present at wetlands in the northern portion of the LSRB. Approximately 2% of wetlands (176 acres) were impounded or diked, many in intermittent drainages to retain water for livestock use. Excavated wetlands represent less than 1% (18 acres) of wetland acres and were excluded from the sample frame because most were associated are gravel pits or water treatment facilities.

NWI does not include irrigation as a wetland modifier, however data from Wyoming Wildlife Consultants (2007) identified 13,374 acres of irrigated lands in the LSRB representing 5% of the total basin area. It is important to note that 6509 wetland acres (56%) are also mapped as irrigated acres. The most common wetland type overlapping with irrigation is freshwater emergent wetlands – 6,188 acres (65%) (Table 4). Many of these wetlands are associated with irrigation infrastructure or were created as retention ponds to provide water for livestock and wildlife.

Table 3. Area of wetland in acres classified according to NWI modifiers in the LSRB.

NWI Wetland Class	No Modifier		Beaver		Excavated		Impounded/diked	
	Acres	% of wetland type	Acres	% of wetland type	Acres	% of wetland type	Acres	% of wetland type
Freshwater Emergent Wetland	9506	99.9%	-	-	-	-	20	<1%
Freshwater Pond	103	31%	68	21%	13	4%	145	44%
Forested Wetland	1498	100%	-	-	-	-	-	
Scrub/Shrub Wetland	265	100%	-	-	-	-	-	-
Unconsolidated Bottom/Shore	19	53%	-	-	5	14%	11	31%
Total	**11,391**	**98%**	**68**	**1%**	**18**	**<1%**	**176**	**2%**

Table 4. Areas of irrigated wetlands in acres based on NWI classifications in the LSRB.

NWI Wetland Class	Irrigated	
	Acres	% of wetland type
Freshwater Emergent Wetland	6188	65%
Freshwater Pond	42	13%
Forested Wetland	190	13%
Scrub/Shrub Wetland	89	34%
Unconsolidated Bottom/Shore	0	0%
Total	**6,509**	**56%**

4.2 Land Ownership/Management

Land ownership in the LSRB study area is predominantly private, representing 48% of the basin, (127,033 acres) and 84% (9,849 acres) of wetland acres (Figures 3 & 4, Table 5). Lands managed by the Bureau of Land Management (BLM), State of Wyoming, and the Bureau of Reclamation comprise 38% (101,339 acres), 14% (38,079 acres), and <1% (647 acres) of the area, respectively. The Wyoming Game and Fish Commission (WGFC), in cooperation with the BLM and private landowners, manages the 37,848 acre Red-Rim Grizzly Wildlife Habitat Management Area for the co-existence of wildlife and livestock (Figure 3).

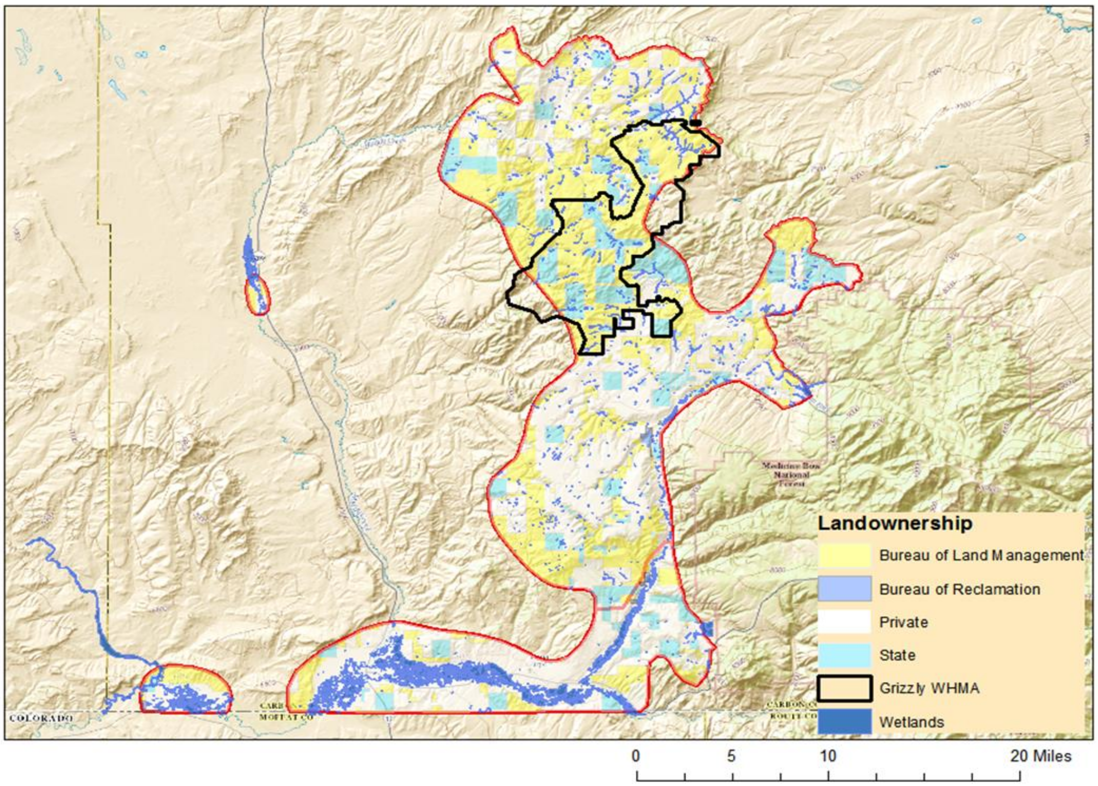

Figure 3. Spatial distribution of land ownership/management and wetlands within the LSRB study area.

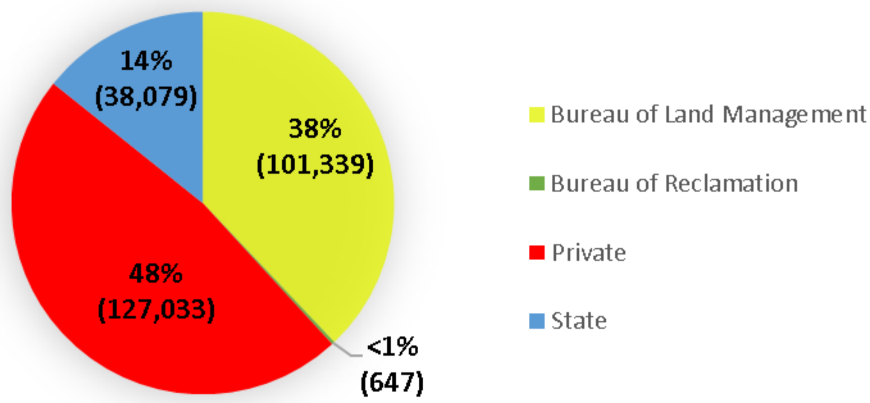

Figure 4. Description of land ownership/management (acres) of the study area in the LSRB

Table 5. Land ownership/management of wetlands by area in the LSRB

Landowner/ Manager	Wetlands in LSRB		
	Acres	% of Basin Area	% Wetland Acres
Bureau of Land Management	1,010	0.38%	8.68%
Private	9,849	3.69%	84.64%
State	771	0.29%	6.62%
Total	11,636	4.36%	-

5.0 WETLAND CONDITION ASSESSMENT RESULTS

5.1 Characteristics of Sampled Wetlands

Seventy wetlands, including 3 reference sites, were sampled in 2016. Permission was obtained to sample 31% of the sites selected in the random survey design. Thirty-nine (56%) sampled wetlands were on private lands, 15 (23%) on State lands, and 16 (21%) on lands administered by the BLM (Figure 5). The percentage of the sampled points on private lands (56%) was less than the percentage of the potential randomly selected points on private lands (70%) revealing a bias in sampling toward public-land sites.

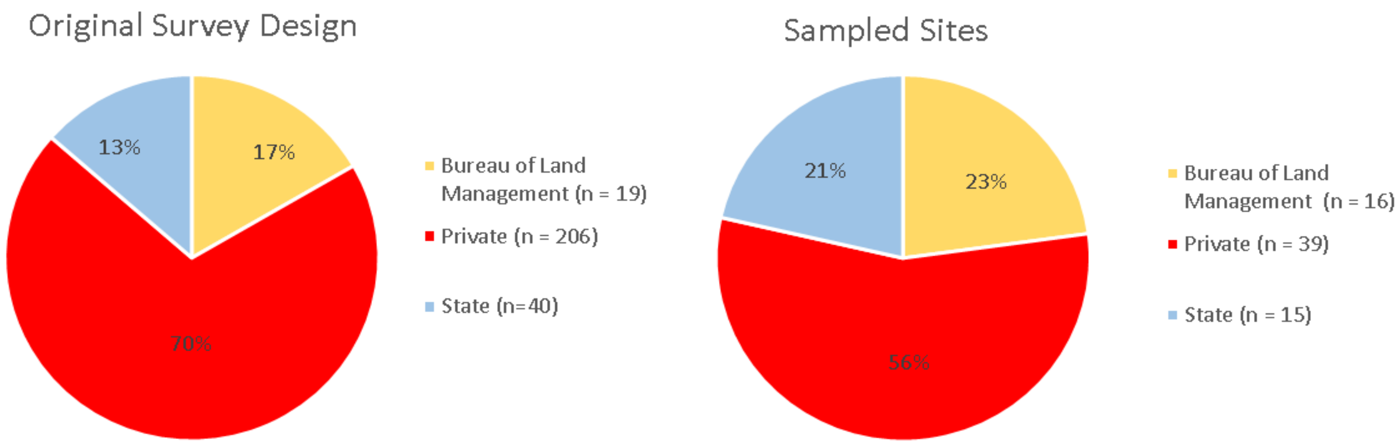

Figure 5. Percentage of points selected in the original survey design versus sites sampled by landowner/manager

5.1.1 Characteristics of Sampled Wetland Subgroups

A field key developed for wetlands in Wyoming was used to classify each sampled wetland into one of the of the three target wetland subgroup according to an ecological system (Appendix B). After completion of the field survey, the general characteristics of each target wetland subgroup were summarized. The descriptions below include specific observations made during field sampling in the LSRB combined with more general information from the ecological system key.

Riverine Shrubland

Riverine shrublands are typically distributed along the Little Snake River and its tributaries within the LSRB. Riverine shrublands are dominated by a shrub overstory of *Salix* sp., *Ribes* sp. and *Pentaphylloides floribunda* with a mesic to hydric meadow understory vegetation of native and non-native grasses and forbs such as *Poa pratensis*, *Phleum pretense, Carex utriculata*, *Juncus balticus*, *Mentha arvensis, and Cirsium arvense.* Many are associated with historical floodplains and receive water from overbank flooding and alluvial aquifers. Some riverine shrubland complexes higher in the basin are associated with peat soil layers, likely relics of historic beaver activity in the basin (Knight et al. 2014).

Figure 6. Riverine shrubland wetlands in the LSRB.

Freshwater Emergent Marsh

Freshwater marshes and ponds include riverine oxbows, created ponds receiving irrigation inputs, and some areas along the shorelines of major reservoirs within the basin. Marshes characteristically have central areas that are frequently flooded and surrounded by increasingly drier zones. The central area is dominated by hydrophytic species such as *Eleocharis palustris, Polygonum amphibium,* and *Hippuris vulgaris*. Dominant species in the surrounding dryer zones include *Hordeum jubatum, Phalaris arundinacea, Juncus balticus, Alopecurus arundinaceus,* and *Cirsium arvense.*

Figure 7. Freshwater emergent marsh wetlands in the LSRB.

Wet meadows

Wet meadows are wetlands dominated by native and non-native herbaceous vegetation, often within floodplains with a high-water table and/or artificial overland flow (irrigation). These sites typically lack prolonged standing water. Graminoids typically comprise the greatest canopy cover. Common native species in the LSRB include *Juncus balticus, Carex nebrascensis, Achillea millefolium,* and *Deschampsia cespitosa*. Non-native hay grasses such as *Poa* spp., *Alopecurus* sp, *Phleum pretense,* and *Agrostis stolonifera* are often abundant within wet meadows. Standing water less than 0.1 ha in size can exist within wet meadows and may sustain emergent marsh vegetation but it is not the dominant ecological system.

Figure 8. Wet meadow wetlands in the LSRB.

5.2 Characterization of Wetland Vegetation

5.2.1 Species Diversity of Wetland Vegetation

Plant surveys identified 273 taxa of vascular plants at the 70 wetlands sampled. Thirty-seven were identified only to genus and two more only to family. Two species were unidentifiable because diagnostic floristic parts required for species identification were absent at the time of sampling. The remaining 232 taxa were identified to the species and subspecies level and represent 8% of Wyoming's flora (Dorn 2001).

The two most common plant species found at wetlands sampled in the LSRB were native. Nebraska Sedge (*Carex nebrascensis*) and Baltic Rush (*Juncus balticus*) were found at 76% and 73% of sites respectively (Table 11 & 12). Many non-native species are commonly planted lawn and pasture grasses such as Kentucky Blue Grass (*Poa pratensis*), Common Timothy (*Phleum pratense*), Spreading Bent (*Agrostis stolonifera*), Creeping Meadow Foxtail (*Alopecurus arundinaceus*), Dandelion (*Taraxacum officinale*), and White Clover (*Trifolium repens*). Canada thistle (*Cirsium arvense*), a state designated noxious weed, was found at 36% of sites.

Table 6. Ten most common plant species documented at sampled wetland in the LSRB.

Species	% of Sites	Wetland Status	Nativity	WY C Value	Common Name
Carex nebrascensis	76%	OBL	Native	4	Nebraska Sedge
Juncus balticus	73%	FACW	Native	3	Baltic Rush
Poa pratensis	71%	FAC	Exotic	0	Kentucky Blue Grass
Taraxacum officinale	69%	FACU	Exotic	0	Common Dandelion
Trifolium repens	53%	FACU	Exotic	0	White Clover
Phleum pratense	53%	FACU	Exotic	0	Common Timothy
Cirsium arvense	50%	FACU	Exotic	0	Canadian Thistle
Achillea millefolium	49%	FACU	Native	4	Common Yarrow
Mentha arvensis	49%	FACW	Native	4	American Wild Mint
Deschampsia cespitosa	49%	FACW	Native	5	Tufted Hair Grass
Potentilla anserina	47%	OBL	Native	4	Common Silverweed

Table 7. Frequencies of native and non-native species encountered at the sites sampled in the LSRB.

Native		Non-Native	
Species	**% of Sites**	**Species**	**% of Sites**
Carex nebrascensis	76%	*Poa pratensis*	71%
Juncus balticus	73%	*Taraxacum officinale*	69%
Deschampsia cespitosa	49%	*Trifolium repens*	53%
Mentha arvensis	49%	*Phleum pratense*	53%
Achillea millefolium	49%	*Cirsium arvense*	36%
Potentilla anserina	47%	*Agrostis stolonifera*	47%
Equisetum laevigatum	46%	*Alopecurus arundinaceus*	40%
Carex utriculata	43%	*Plantago major*	16%
Cirsium scariosum	40%	*Bromus inermis*	16%
Epilobium ciliatum	39%	*Lactuca serriola*	10%

5.3 Wetland Condition Assessment

5.3.1 Ecological Integrity Assessment of Sampled Wetlands

Ecological integrity assessment (EIA) scores from the 70 sampled wetlands ranged from 1.97 to 4.63 out of a possible range of 1.0 - 5.0. We established four wetland condition categories based on values defined in Appendix D:

- A (4.5 - 5.0) = At or near reference condition (no or little human impact)
- B (3.5 - < 4.5) = Level of disturbance indicates slight departure from reference condition
- C (2.5 - < 3.5) = Level of disturbance indicates moderate deviation from reference condition
- D (< 2.5) = Level of disturbance indicates severe deviation from reference condition

Seven percent of the 70 study sites in the LSRB were ranked "A," 60% were ranked "B," 24% were ranked "C," and 9% were ranked "D" (Fig. 9). All three target wetland subgroups were dominated by B-ranked wetlands. Riverine shrublands had the highest proportion of A-ranked sites and no D-ranked sites, indicating overall lower disturbance relative to other wetland types. Wet meadows and emergent marshes scored a C or below for 30% and 50% of sites, respectively.

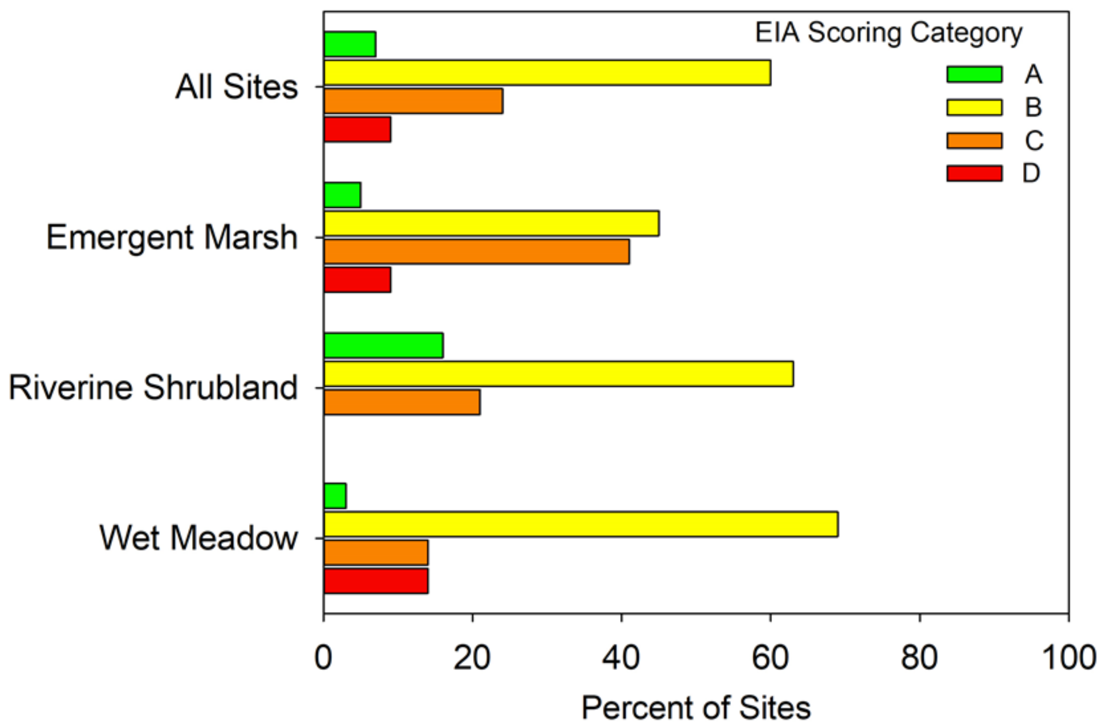

Figure 9. Sixty-seven percent of the wetlands in the LSRB received an EIA score of B or above. EIA scores were lowest for emergent marshes, indicating 50% of these wetlands surveyed received a C or below, indicating moderate to significant departure from reference

5.3.2 Landscape Hydrology Metric

The Landscape Hydrology Metric (LHM) is an assessment of alteration to hydrologic regime of sampled wetlands. LHM incorporates landscape-level data identifying alterations to hydroperiod and water source, along with field data characterizing wetland soils. LHM categories (historical, hybrid, supported, created) are defined in Appendix A, Table 3.

Fifty-three percent of the wetlands sampled in the LSRB were historical and 26% were considered hybrid, while 10% were considered supported and 11% created. (Figure 10). Wet meadows had both the highest percentage of historical sites (65%) as well has the highest percentage of sites created by hydrological alterations (17%).

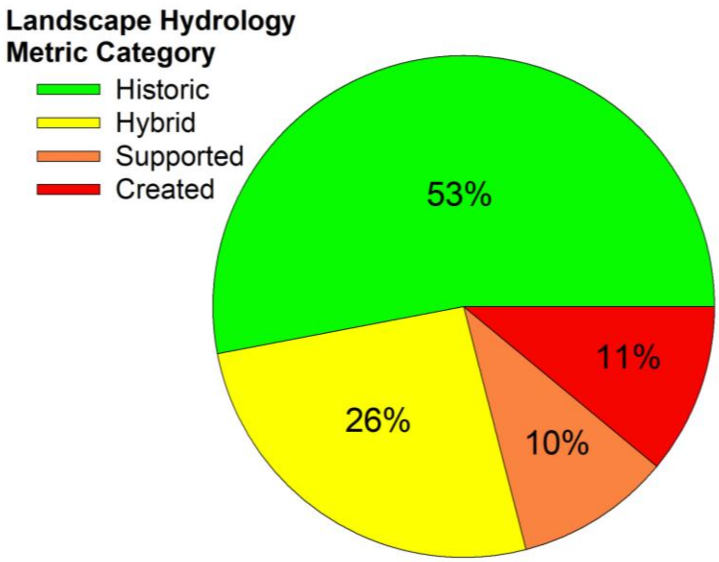

Figure 10. Proportion of total wetland sites based on categories for the Landscape Hydrology Metric.

5.3.3 Indicators of disturbance

Potential indicators of disturbance include natural phenomena or human caused land management impacts that have the ability to stress a wetland or reduce its ecological condition. These indicators can be used to identify the most prevalent impacts affecting wetland health in a given area and can help land mangers change and address disturbances that are under their control. Indicators of disturbance were recorded within a 500-meter wide buffer around the wetland and within the wetland boundary. These indicators were later grouped into categories based on disturbance type. A full list is available in Appendix E.

The most common potential indicators of disturbance in the LSRB are listed in Figure 11. Almost all (97%) of sites sampled had non-native species present. Roads were record within 500 meters of 60 (86%) sites. Roads lead to fragmentation and can change the lateral movement of water by both blocking and diverting flow. Lightly used 2-tracts or farm roads and gravel roads

were the most common type of road. Soil degradation from livestock and wild horses occurred at 27 (69%) sites. Light to moderate grazing by livestock or native ungulates was present at 41 (57%) sites. Only 5 wetlands (< 1%) were being impacted by heavy grazing (plants grazed less than 3 inches). Irrigation infrastructure, including ditches, berms, and head gates that change the flow of water, was the third most common stressor impacting 33 (47%) sites. In Wyoming irrigation infrastructure can both create and degrade wetlands.

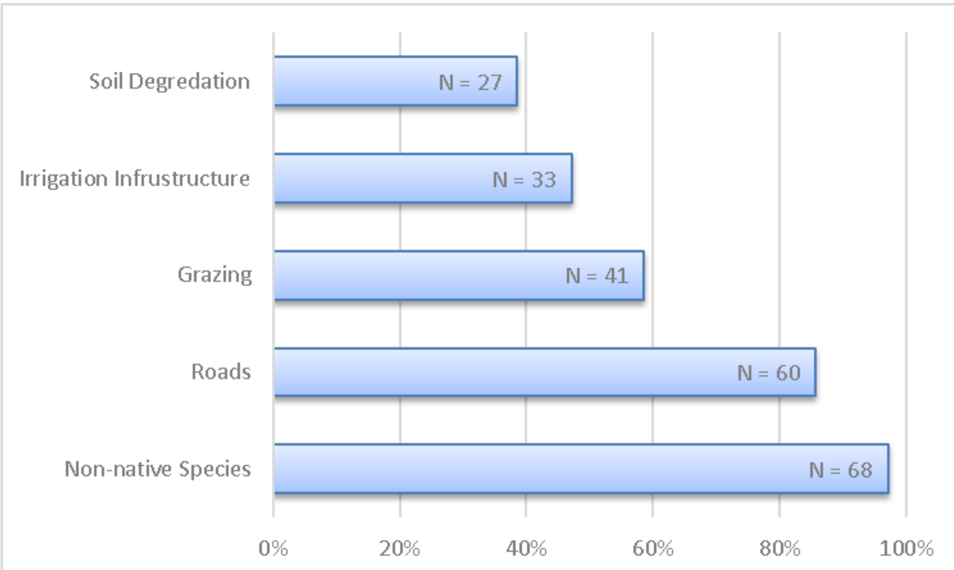

Figure 11. Potential indicators of disturbance observed across all wetlands in the Little Snake River Basin.

5.4 Spatial Distribution of Wetland Condition and Disturbance

Patterns of landownership/management, land uses, wetland types, and potential indicators of disturbance are not equally distributed across the LSRB but were concentrated in specific areas. This is important to consider when making conservation, protection, and restoration decisions.

The northern portion of the study area (Figure 12), referred to herein as the Upper Basin, had more publicly owned lands, wetlands with higher overall condition, and lower potential indicators of disturbance. This area consists of upland sagebrush slopes with intermittent drainages that contain wet meadows, willow shrubland wetland, and some beaver-influenced emergent marsh complexes. Cattle grazing is the dominant land use in this area. There is little irrigation and most hydrologic alterations occur in the form of bermed ponds developed in ephemeral drainages to provide water for livestock and wildlife use.

The southern portion of the study area (Figure 12), referred to herein as the Floodplain, lies within the floodplain of the Little Snake River and the lower reaches of Savery Creek. Here the landscape is a mosaic of riparian cottonwood and willow galleries, irrigated pastures and

hayfields, and some residential development. Wetlands are associated with the river channel and irrigated areas, and include irrigated wet meadows, riverine oxbows, willow shrublands, and emergent marshes dominated by rushes and cattails. Wetlands in the Floodplain had increased exposure to potential disturbances and hydrological modifications which resulted in lower overall condition.

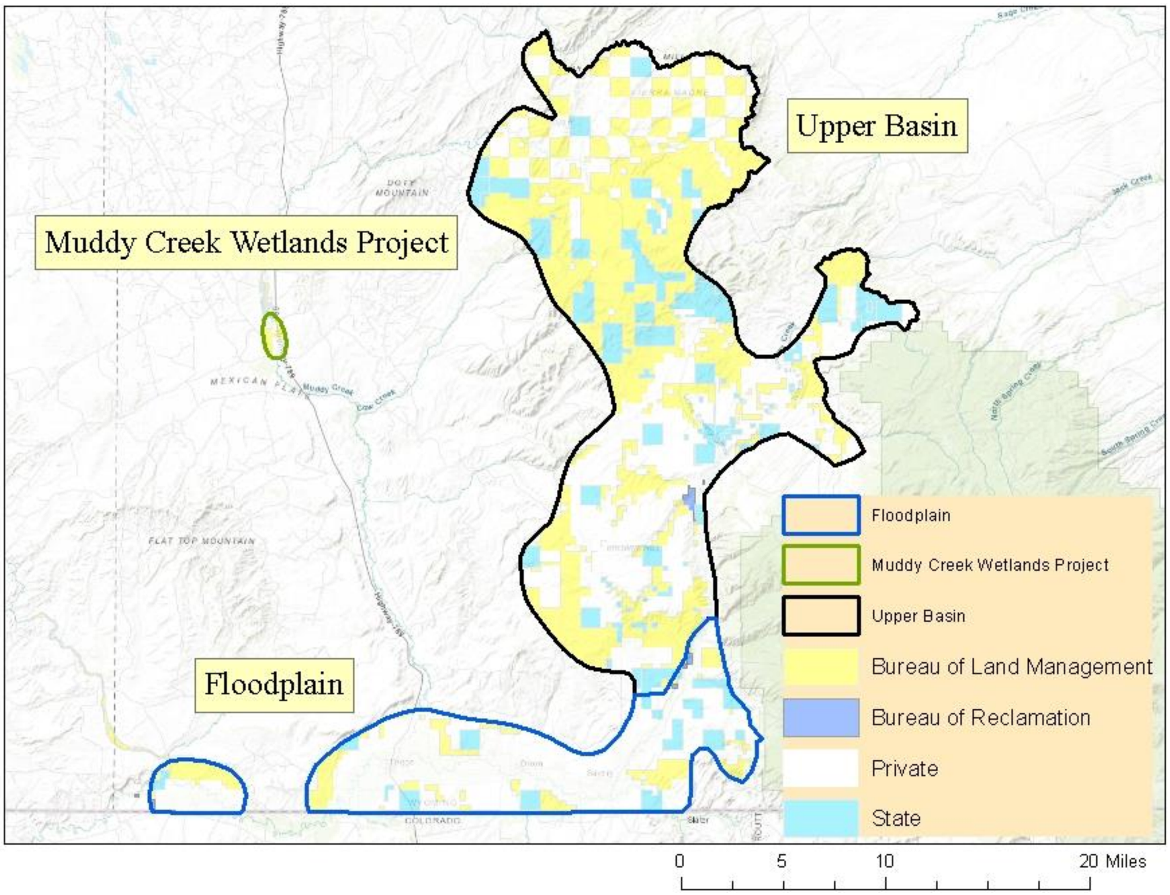

Figure 12. Focal areas within the LSRB showing landownership/management

5.4.1 Ecological Condition

Ecological condition scores are influenced by alterations to natural hydrology, natural plant community composition and/or the impacts from surrounding land use. All A-ranked wetlands and most (88%) B-ranked wetlands were located in the Upper Basin. In contrast, 71% of C-ranked wetlands and all D-ranked wetlands (n = 6) were sampled in the Floodplain.

5.4.2 Indicators of Disturbance

Main indicators of disturbances in the floodplain were typically associated with agriculture and development. Specifically, hay production was observed at 96% of the sampled wetlands, run-off from agricultural practices (observed or inferred) at 87%, irrigation infrastructure at 87%, and residential development at 43%. Indicators of disturbance in the Upper Basin were associated

with grazing (at 76% of wetlands) and soil degradation by native ungulates and livestock (at 42% of wetlands). Roads and the presence of non-native species were observed near or within almost all sites sampled in both focal areas.

5.4.3 Hydrologic Alteration

Hydrology is the primary driver of the establishment and maintenance of wetlands, affecting the ecological processes that sustain ecosystem function (Maltby and Barker 2009). Therefore, the presence of hydrological alterations (such as irrigation infrastructure) alters the timing and quantity of water available within the basin, directly or indirectly affecting the quantity and type of wetlands present.

Flood irrigation for hay production alters the hydrology of wetlands in the LSRB (WBHCP 2014). Five percent of the entire LSRB (13,374 acre) is mapped as irrigated lands however most of these acres (95%) occur in the Floodplain. Seventy-two percent (5863 acres) of wetland acres in the Floodplain overlap with irrigation (Figure 13). Field observations identified that more wetlands were receiving water from irrigation runoff and seepage from irrigation infrastructure than are currently mapped in available data layers.

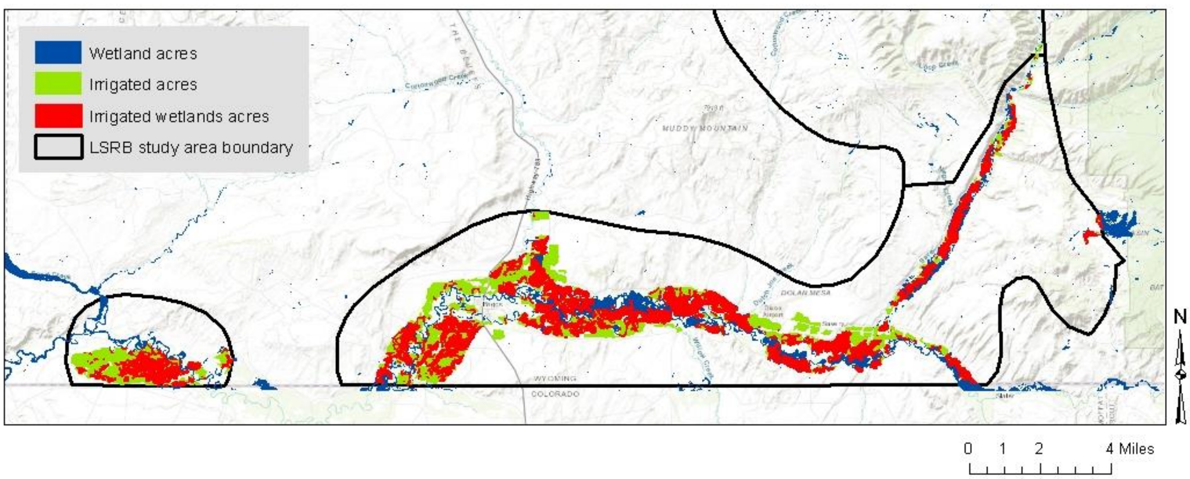

Figure 13. Spatial distribution of wetland acres, irrigated acres, and wetlands acres overlapping with irrigated acres in the Floodplain focal area.

Sampled wetlands identified similar patterns of hydrologic impacts from irrigation. Only one sampled wetland was classified as historical based on the LHM analysis, meaning the wetland appeared to have natural water sources without human alteration. All other sampled wetlands in the Floodplain (96%) were affected by hydrological alterations related to irrigation infrastructure. Thirty percent of wetlands received water both from natural sources and from irrigation (supported wetlands) and 26% lacked natural water sources and appear to depend entirely on water from adjacent irrigated infrastructure (created wetlands). Wetlands supported or created by irrigation infrastructure can be highly vulnerable to changes management practices when water is scare (Peck et al. 2004).

5.5 Understanding the Threat

According to the Upper Little Snake River wetland plan (WBHCP 2014), flood irrigation is used on most irrigated lands in the basin. Pressure to change current water management practices is identified as a moderate threat to wetlands in the LSRB (WBCHP 2014). Water shortages in the Colorado River Basin due to climate alteration and predicted drought (Cook et al. 2004) and increased population (Hansen et al. 2002) are putting pressure on Wyoming agricultural producers, including those in the LSRB, to alter current irrigation practices.

The number and location of wetlands in the LSRB that overlap with irrigation and irrigation infrastructure suggests high vulnerability to wetland loss in the future from conversion to more efficient irrigation systems (Copeland et al. 2010a, Pocewicz et al. 2014). Approximately 56% of wetland acres in the LSRB overlap with irrigation; conversion to more efficient irrigation could potentially affect an estimated 6,500 acres of wetlands in the basin and the wildlife habitat and ecosystem services they provide. Conservation strategies aimed at protecting lands designated as wetlands may fall short of their intended purpose if water quantity and timing crucial to wetland function are also not retained (Downard and Endter-Wada 2013).

6.0 ECONOMICS OF IRRIGATED WETLANDS IN THE LSRB

According to Brander et al. (2013), the global mean value for ecosystem services of wetlands in agricultural landscapes is $6,923 ha/year in flood control, $3,389 ha/year in water supply, and $5,788 ha/year in nutrient cycling, resulting in a total of $16,100 in services per ha/year. There are 11,636 acres (4,709 ha) of wetlands in the LSRB which could be providing over $75.8 million in ecosystem services per year. This number is misleading since not all wetlands perform all ecosystems services equally, however it is useful to understand the maximum potential value of ecosystem services wetlands provide in the basin.

We can use the potential functional assessment completed by St. Mary's University of Minnesota in 2018 (GeoSpatial Services Saint Mary's University of Minnesota 2018) to refine economic value estimates of ecosystem services defined by Brander et al. (2013) in the LSRB Floodplain. According to the new functional assessment data, approximately 2,107 wetland acres (853 ha) provide bank and shoreline stabilization which can reduce flooding valued at $5.9 million, 2,630 acres (1,064 ha) provide surface water detention for water supply valued at $3.6 million, and 4,870 acres (1,970 ha) provide nutrient cycling valued at $11.4 million, combining to provide almost $21 million in ecosystem services per year.

If we assume shifting to more efficient irrigation practices could result in a 26% - 48% reduction in wetland area (Smith 2010), the LSRB could see a $2.9 million to $5.5 million loss in ecosystem services provided by irrigation-dependent wetland acres per year.

It is important to note that changes in water management would not affect all wetlands equally. Studies have shown that the closer a wetland is to irrigation, the greater the impact it has on

wetland size (Smith 2010). It is unlikely that all wetland acres would be lost if producers switched to more efficient irrigation methods. However, more efficient irrigation would result in less available water to adjacent wetlands (Smith 2010, Sueltenfuss 2012). Less water availability changes a wetland's hydrologic regime, potentially changing its wetland type and the associated ecosystem services that the wetland provides.

There are additional costs associated with changes in irrigation practices besides a loss in potential ecosystem services. In Wyoming, the average value of irrigated cropland is $2,170 per acre, the average value of non-irrigated cropland is $760 per acre, and pasture is valued at $510 per acre (NASS 2017). Using these numbers, the current value of irrigated cropland in the LSRB is $29,021,580. If producers change their agricultural practices from irrigated cropland to non-irrigated pasture, there could be large reductions in property value in the basin. For example, a 5% conversion of irrigated cropland to non-irrigated pasture land would result in $1,110,042 in lost property value.

7.0 HUMAN DIMENSIONS OF FLOOD IRRIGATION IN THE LSRB

Based on my notes from the 2017 Inter-mountain West Joint Venture landowner workshop, landowners expressed the following views about flood irrigation in the LSRB:

- Many landowners flood irrigate because they already have the infrastructure in place and have first water rights. If they applied water more efficiently, they fear they would have a hard time utilizing their full water right allotment and could potentially loose it under Wyoming's current water laws. This pushes landowners to be less efficient with their water for fear of losing their water right.
- Landowners feel that they must flood irrigate to capture the seasonal availability of water. Most of the water in the basin occurs in the spring during snowmelt. Flood irrigation captures the spring snowmelt and disperse it across their fields where it slowly moves downslope across the landscape filling up wetlands and oxbows in the floodplain which increases water availability to adjacent fields later in the season. Landowners believe they would need to build storage reservoirs that could provide a more stable water source to utilize more efficient irrigation systems. This solution is less desirable because it would incur additional infrastructure and maintenance costs, additional permitting requirements, and potentially require additional water rights.
- For many landowners, flood irrigation is central to their identify and their ranching lifestyle. Flood irrigation provides a time to get away for it all and think. Many also like the challenge and reward of moving water across the landscape.
- Many ranchers express a belief that wildlife and livestock can coexist and that agricultural activity on the landscape can foster ecosystem services such as wildlife habitat potential, stream flow maintenance, and ground water recharge.

- Many landowners feel pressure from the government, from conservation organizations, and the public to switch irrigation practices. They feel like the public doesn't understand the ecological values flood irrigation supports and only sees their practices as wasteful. They want conservation organizations to educate the public to help them understand the values and services flood irrigation maintains.
- One of the main reasons landowners shift to more efficient irrigation is because these methods often reduce labor costs and time. This is not a strong incentive in the LSRB because there is a surplus of cheap labor available from herders who are hired to tend large flocks of sheep and help with irrigation in the basin.
- Landowners currently use more efficient irrigation methods in areas where flood irrigation is not effective. Many use center pivot and sprinkler systems on relatively flat and treeless uplands. Flood irrigation is more efficient in the flood plain where the landscape is too complex because of cottonwood galleries, willow stands, and uneven topography to build center pivot.

In summary, landowners in the LSRB flood irrigate because they have the historical water rights and infrastructure in place to do so. Many feel it's the best method to capture available water and fully utilize their water right. Irrigating is a way of life that creates a sense of place and an attachment to the land. Landowners feel pressure from the government, conservation organizations, and the public to switch irrigation practices because they are viewed as wasteful. However, landowners believe that their practices are actually beneficial to the ecosystem.

8.0 CONCLUSION

Downstream water shortages and increasing demand are placing pressure on producers in the LSRB to evaluate their irrigation practices. Landowners are reluctant to change because flood irrigating is central to their ranching lifestyle, however they feel pressure from society to switch to more efficient practices. Studies have begun to quantify the importance of irrigation-influenced landscapes for recharging groundwater, maintaining late season instream flows, and creating wetlands that provide valuable wildlife habitat and ecosystem services (Hart and Lovvorn 2000, Kendy and Bredehoeft 2006, Chester and Robson 2013, Moulton et al. 2013, Patla 2015, Donnelly et al. 2016). Many wetlands in the LSRB overlap with flood irrigation, suggesting high vulnerability to wetland loss in the future if producers do convert to more efficient irrigation. Associated ecological benefits and ecosystems services could be diminished, resulting in economic losses in the basin.

Policies aimed at increasing water availability for downstream users can result in negative ecological and socio-economic impacts locally. Conservation and restoration strategies aimed at protecting wetland acreage will fall short of their intended purpose without considering the relationship between current irrigation practices and wetland condition, function, and value.

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Appendix A: Wetland Condition Assessment Methods taken from Washkoviak et al. (2018)

Ecological Integrity Assessment Framework

The overarching goal of the Ecological Integrity Assessment (EIA) framework is to provide a rapid and repeatable evaluation of the ecological condition of a wetland. EIA methods were developed by NatureServe to assess the condition of wetlands across North America (Faber-Langendoen et al. 2011) and have more recently been refined by several regional wetland programs to specifically address wetland ecological condition in the Intermountain West (Rocchio 2007, Lemly and Gilligan 2012, Vance et al. 2012). We assessed condition of randomly selected wetlands in the LSRB based on EIA methods developed in Colorado by Lemly et al. (2012, 2013).

Descriptive metrics were used in the field to evaluate four attributes at each wetland: Landscape Context, Hydrologic Condition, Physicochemical Condition, and Biotic Condition. Separate disturbance indicator metrics that identify the severity of anthropogenic disturbance associated with degradation of wetland ecosystems were recorded. Metric scores for each of the four attributes were combined into an overall EIA score that can be used to describe wetlands in relation to a reference condition.

Hydrologic condition was evaluated using the Landscape Hydrology Metric (LHM) (Tibbets et al 2015) which assesses alteration to a wetland' s hydrologic regime. We incorporated additional intensive assessment protocols from Colorado's EIA framework (Lemly and Gilligan 2012) including a floristic quality assessments, soil characterization, and water quality incorporated.

Survey Design and Evaluation of Sample Sites

The following sections describe the survey design and process for selection of random sample sites. The steps in the survey design, were defining the target population, specifying the sample frame, choosing the sample size, and specifying the selection criteria. These methods are based on the EPA's National Aquatic Resource Survey program (Stevens & Olsen 2004; Detenbeck et al. 2005).

Wetland Definitions for Target Population

The target population is the set of wetlands that we want to characterize in the LSRB. Our wetland target population consisted of the six classes of Palustrine wetlands that we used in the landscape profile. Palustrine wetlands can be situated shoreward of lakes or river channels, on floodplains, in locations isolated from water bodies, in depressions, or on slopes. The target population included all palustrine wetlands within the LSRB study area and excluded non-wetland features such as deepwater lakes (Lacustrine system) and stream channel bottoms

(Riverine system) (Table 6). We also set a minimum size threshold of at 0.1 hectare and a minimum width of 10 m.

Sample Frame and Classification

The sample frame is a digital representation of the target population. The digital NWI polygon dataset (U.S. Fish and Wildlife Service 1984) is a complete representation of the target population, but it contains a degree of detail that makes it very difficult to use without grouping NWI codes into wetland subgroups. We simplified the sample frame by grouping the NWI Cowardin et al (1979) codes into three target groups: 1) Wet meadow; 2) Emergent Marsh; and 3) Riverine Shrubland. We the crosswalk each target wetland subgroup to the Ecological Systems classification (Comer et al. 2003, Appendix B). Classification by Ecological Systems is the dominant system used regionally for identifying wetland types in the field and provides a valuable system for defining landscape units by biotic (e.g., plant community) and abiotic (e.g., geologic, hydrologic, elevation) criteria (Lemly and Gillian 2012, Newlon et al. 2013). NWI codes were also crosswalk to Hydrogeomorphic (HGM) Classification (Brinson 1993, Adamus 2004) (Table 1).

Table 1. Target wetland subgroups classified by Cowardin, Hydrogeomorphic (HGM), and Ecological Systems used in the LSRB.

Targeted Wetland Subgroups	NWI Codes	HGM	NWI Codes	Ecological System
Wet Meadows	PEMB, PEMA, PEMC	Slope, Depression	PEMB, PEMA, PEMC	Rocky Mountain Alpine-Montane Wet Meadow, Irrigated Wet Meadow (not an official Ecological System)
Emergent Marsh	PEMFh, PUSCh, PUSC, PABG, PUSAh, PEMCh, PUSC, PABGh, PABF, PABGh, PEMF, PEMAh	Depression, Riverine	PEMFh, PUSCh, PUSC, PABG, PUSAh, PEMCh, PUSC, PABGh, PABF, PABGh, PEMF, PEMAh	Western North American Emergent Marsh
Riverine Shrubland	PABFb, PSSB, PABGb, PSSA, PSSC, PFOA	Riverine	PABFb, PSSB, PABGb, PSSA, PSSC, PFOA	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

Sample Size and Selection Criteria for Site Evaluation

The target sample size was 75 sites selected from the sample frame, divide across the three target wetland subgroups. Sample sites were randomly selected from the sample frame using a Generalized Random Tessellation Stratified (GRTS) survey design for a finite resource (Stevens

et al. 2004, Stevens and Jensen 2007). GRTS sampling was performed using R package spsurvey (Olsen and Kincaid 2009, R Development Core Team 2014).

After potential sample sites were randomly selected, and prior to field sampling, a desktop site evaluation was performed to determine: 1) whether a wetland was likely present, based on examination of aerial imagery (USDA Farm Service Agency 2009); and 2) land ownership/management status (private, state, federal). Permission was then sought to access sample sites.

Potential sample sites that met one of the following conditions were withdrawn from potential sample sites *before* field sampling:

1. Wetland type: the wetland at the site appeared to not belong to the target wetland group that the site was chosen to represent.
2. Size: the wetland area did not meet the minimum 0.1-hectare area threshold or 10-meter width threshold required for sampling
3. Minimum distance: the wetland was within 500 meters of another sample location of the same target subgroup.
4. Permission denied: permission to access the site was denied by the landowner.

Sites that remained after the initial review were visited and were evaluated by field crews before assessment. Sites that met one of the following conditions were withdrawn from the sample frame before field assessment:

5. Wetland type: the wetland did not belong to the target wetland group that the site was chosen to represent. The field crew used a key to ecological systems (Appendix B) for this evaluation
6. Access issues: permission was granted by landowner, but the point could not be safely accessed at the time of sampling. Sites were rejected if they were more than 2 miles from the vehicle for efficiency and safety of the field crew.
7. Depth: the wetland exceeded the maximum depth threshold of 1 meter and the assessment area could not be repositioned to a location that met our size criterion.
8. Hayed before sampling: all of the vegetation was cropped from the site prior to sampling, so that plant identification was not possible.
9. Not a wetland: the sample location did not meet our operational definition of a wetland (Washkoviak et al. 2018, Appendix B) or no wetland was present due to mapping error

If a site was withdrawn from the set of potential sample sites, it was replaced with the next site from the sequential list generated by the GRTS site selection.

In addition to the random survey sites, we identified 3 to 4 reference wetlands from each target wetland subgroup that represented "least disturbed" condition based on professional judgment of regional wildlife managers or the field crew. We used the definition provided by Stoddard et al.

(2006) for least disturbed condition: "in the best available physical, chemical and biological habitat conditions given today's state of the landscape".

Field Methods

Field methods were based on EIA protocols developed by Lemly et al. (2013). In addition, we collected data on soils and vegetation to supplement the EIA protocol. These assessments required a half a day or less to complete at each site. Detailed field data forms are included in Appendix C and our field manual is available upon request.

Wetland Assessment Area (AA)

The field crew applied the EPA's National Wetland Condition Assessment (U.S. Environmental Protection Agency 2016) methodology for establishing an assessment area (AA) at each wetland site. When possible a standard 40 m radius circular AA was established. If the site configuration did not accommodate a circular AA of this size, the crew adjusted the AA to a rectangular or irregular shape of at least 1000 m^2 (0.1 ha) and 10 m wide. The AA boundary was marked with flagging to aid with data collection. A 500-m buffer was established from the perimeter of each AA. Standard descriptions of each wetland included: UTM coordinates, wetland classification, presence or signs of wildlife, and photos of the buffer and AA.

Ecological Integrity Assessment of Wetland Sites

After the AA was established, each wetland was assessed based on the EIA manual and field forms (see Appendix C) adapted from Lemly et al. (2013). The principal attributes and metrics that were measured in this study are summarized in Table 2.

Table 2. EIA attributes and metrics used for wetland assessments in the LSRB.

Attributes	Indicators and Metrics
Landscape Context	• Landscape Fragmentation • Buffer Extent • Buffer Width • Buffer Condition
Hydrologic Condition*	• Water Source • Hydrologic Connectivity • Alteration of Hydroperiod
Physicochemical Condition	• Water Quality • Algal Growth • Substrate/soil Disturbance
Biological Condition	• Relative Cover of Native Plant Species • Absolute Cover of Noxious Weeds

	• Absolute Cover of Aggressive Native Species • Mean C • Structural Complexity

*Field data were collected for the EIA hydrology metrics using the Colorado EIA method, however, we used Landscape Hydrologic Metric in place of the Colorado EIA method for scoring wetland condition.

Landscape Hydrology Metric (LHM)

Hydrology is broadly characterized as the movement, distribution, timing, and quality of water across the landscape. Hydrology is the primary driver of the processes that establish and maintain wetlands, including ecological, physical, and chemical processes that sustain ecosystem functions and associated services and values to people (Mitsch and Gossilink 2000). Therefore, it is important to identify alterations to the natural hydrologic regime that may detrimentally affect the structure and function of a wetland. Identifying alterations to natural wetland hydrology can be a challenge because significant alterations such as major dams or ditches may not be evident during a single site visit or are located outside the 500m buffer surrounding the AA. In addition, it can be difficult to identify a wetland's water source when the wetland is supported or created by hydrologic alterations, such as leaky dams or canals.

We used the Landscape Hydrology Metric (LHM) (Tibbets et al. 2015), instead of the hydrology component of the Colorado EIA method (Lemly et al. 2013), to calculate the hydrologic condition metrics. LHM incorporates landscape-level data identifying alterations to hydroperiod and water source, along with field data characterizing wetland soils. LHM relies on descriptive criteria from submetrics to assign a rank from 5 to 0 (Table 3). Historic wetlands (score = 5) were defined in this study as wetlands without evidence of hydrologic alteration, whereas created wetlands (score = 0) are dependent on hydrologic alteration.

Table 3. Landscape Hydrology Metric scoring criteria.

Hydrologic Category	LHM Score	Landscape Hydrology Metric Criteria
Historical Wetland	5	No alterations to hydrology identified, natural water source or no observed natural water source but histic soil layer present.
Hybrid Wetland in landscape with site-level hydrologic alterations	4	Site-level hydrologic alteration, natural water source identified or no observed natural water source but histic soil layer present.
Hybrid Wetland in landscape with basin-wide hydrologic alterations	3	Basin-wide hydrologic alteration (major dam present) and direct hydrologic connectivity to natural water source observed. No histic soil layer observed.

Supported Wetland with natural water source	2	Basin-wide hydrologic alteration (major dam present), landscape position is in depression with natural water source potential, however, dominant water source is unclear due to presence of large canals. No histic soil layer observed.
Supported Wetland- Irrigation Dependent Depression	1	Hydrologic alteration identified, landscape position is in depression. Irrigation is likely dominant water source. No histic soil layer observed.
Created Wetland - Irrigation Dependent	0	Hydrologic alteration identified, no natural water source identified. Irrigation is exclusive water source. No histic soil layer observed.

Vegetation Assessments

We used a plotless sample design to collect vegetation data using methods described in Lemly et al. (2012). Species searches were limited to no more than 1 hour at each site. Vascular plant species were identified using Dorn (2001) and regional keys including Johnston (2001), Skinner (2010), and Culver and Lemly (2013). Species names were taken from the WYNDD database. Unknown plant specimens were pressed in the field and saved for later identification. The percent cover of each species, including that of unidentified specimens, was estimated over the entire AA.

Soils

We dug 1 to 2 soil pits within each AA. The first soil pit was placed in a representative location close to the AA center excluding those areas covered completely by water. An additional pit was dug if there was a high degree of variability within the site. We recorded GPS waypoints at each soil pit and then marked the location on a map. Pits were dug to a depth of 40 cm (about one shovel length) when possible. The core was removed and laid next to the pit, ensuring all horizons were intact and in order. We recorded the following information from each horizon: 1) color (based on a Munsell Soil Color Chart (2013)) of the matrix and any redoximorphic concentrations (mottles and oxidized root channels) and depletions; 2) soil texture; and 3) any other specifics about the concentration of roots, the presence of gravel or cobble, or other unusual soil features. Hydric soil indicators were identified based on guidance from the Interim Regional Supplement to the U.S. Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (2008) and the National Resources Conservation Service (NRCS) Field Indicators of Hydric Soils in the United States (Vasilas et al. 2010).

Surface Water Characterization

We estimated percent cover and interspersion (patch complexity) of open water within the AA. The water depth range and average were recorded within the AA.

Data Analysis

Data Management

All field data were entered into relational databases that were developed using Microsoft Access and/or ArcGIS 10.3 platforms. Data were then proofed to correct any errors prior to analysis. The data are stored at the Wyoming Natural Diversity Database.

Ecological Integrity Assessment

To be effective tools, ecological assessment metrics should provide information about the integrity of major ecological attributes in relation to a gradient of disturbance or stressors. We evaluated performance of each EIA metric based on methods used to refine stream and wetland condition indices (Stoddard et al. 2008, Deller et al. 2010, Faber-Langendoen et al. 2011). Evaluation of EIA methods and scoring was a vital step to ensure the EIA methods we selected were relevant and effective for assessing wetland condition in Wyoming. The applicable range of each metric was determined by examining histograms depicting ranges and distributions of scores. We evaluated metric redundancy by calculating Spearman's rank correlation coefficients among all metrics. None of the metrics within an attribute category were found to be highly correlated (as determined by a coefficient value of $r > 0.8$).

We calculated EIA scores and thresholds based on EIA methods used in Colorado (Lemly and Gillian 2012). Refer to Appendix D for a detailed description of scoring formulas and thresholds with ranks ranging from A-D. Ideally, wetlands that are ranked "A" are those in minimally disturbed condition (MDC), representing the best approximation of "naturalness" or a high degree of "biological integrity" on the landscape (Stoddard et al. 2006). However, reference wetland condition in the LSRB was defined as least disturbed condition (LDC), meaning "in the best available physical, chemical and biological habitat conditions given today's state of the landscape" (Stoddard et al. 2006). Because LDC can differ from MDC, the biological integrity of our A-ranked sites may not reflect the sites' fullest potential for biological integrity.

We created a cumulative distribution function (CDF) plot to display EIA scores estimated for wetlands across the entire sample frame in the LSRB. CDF plots use scores from the random sample to create a probability plot for the entire basin. CDF plots are useful to estimate the cumulative proportion of the resource (wetlands) estimated to have at least a certain EIA score (Whittier et al. 2002). EIA rank thresholds were superimposed on the CDF plot to facilitate interpretation of the cumulative number of wetlands within each rank. Cumulative distribution functions were calculated using R software package version 3.3.3 (R Development Core Team 2014) available from the spsurvey library.

Floristic Quality Assessment (FQA)

Floristic Quality Assessment (FQA) uses plant community composition as an indicator of ecological condition. The FQA method assesses the degree of human caused disturbance based on the proportion of "conservative" plants present. "Coefficients of conservatism" (C-values)

are the foundation of FQA. C values range from 0 to 10 and represent an estimated probability that a plant is likely to occur in a landscape relatively unaltered from conditions that existed before European settlement (Swink and Wilhelm 1979, 1994). A C-value of 10 is assigned to plant species having low tolerance for habitat degradation and are restricted to relatively unaltered areas, whereas a 0 is assigned to plant species with a wide tolerance to human disturbance (Rocchio 2007). Species with low C values may be found in relatively unaltered areas, but they also grow in altered areas. Once C-values have been assigned for a given region or area, they can then be used to calculate a number of FQA indices such as the average C-value of a site (Mean C) and the Floristic Quality Assessment Index (FQAI) (Swink and Wilhelm 1979, 1994). C-values were developed for Wyoming in 2017 and have been incorporated into data analysis (Washkoviak et al. 2017)

We calculated Mean C, total species richness, and the numbers of native and non-native species from the species lists compiled at each wetland site. Mean C for the site calculated by summing the C-values of the plant species found at each site, and then dividing by the number of species.

In in conjunction with this study, the Nature Conservancy in Wyoming, in collaboration with St. Mary's University of Minnesota, is developing the WyoWet Decision Support Tool. St. Mary's University is updating NWI mapping for 8 USGS Quads along the Little Snake River and the Muddy Creek Wetlands Project which will result in more accurate wetland boundaries. Wetland polygons are being attributed with the Landscape, Landform, Waterbody, Water flow path (LLWW) classification developed by USFWS (Tiner 2003) which can be combined with Cowardin et al. (1979) to estimate functional potential for all wetlands and riparian areas in the LSRB (GeoSpatial Services Saint Mary's University of Minnesota 2018).

WyoWet allows users to view wetland polygons and interact with associated data that: describes the wetlands biological and hydrologic functional potential; ranks its vulnerability to disturbances; displays hydrologic alterations to the landscape; and displays adjacent landownership/management patterns. WyoWet will give land managers the tools to prioritize restoration, conservation, and protection efforts based on site specific data in the LSRB. The updated mapping and WyoWet tool will be available in 2019.

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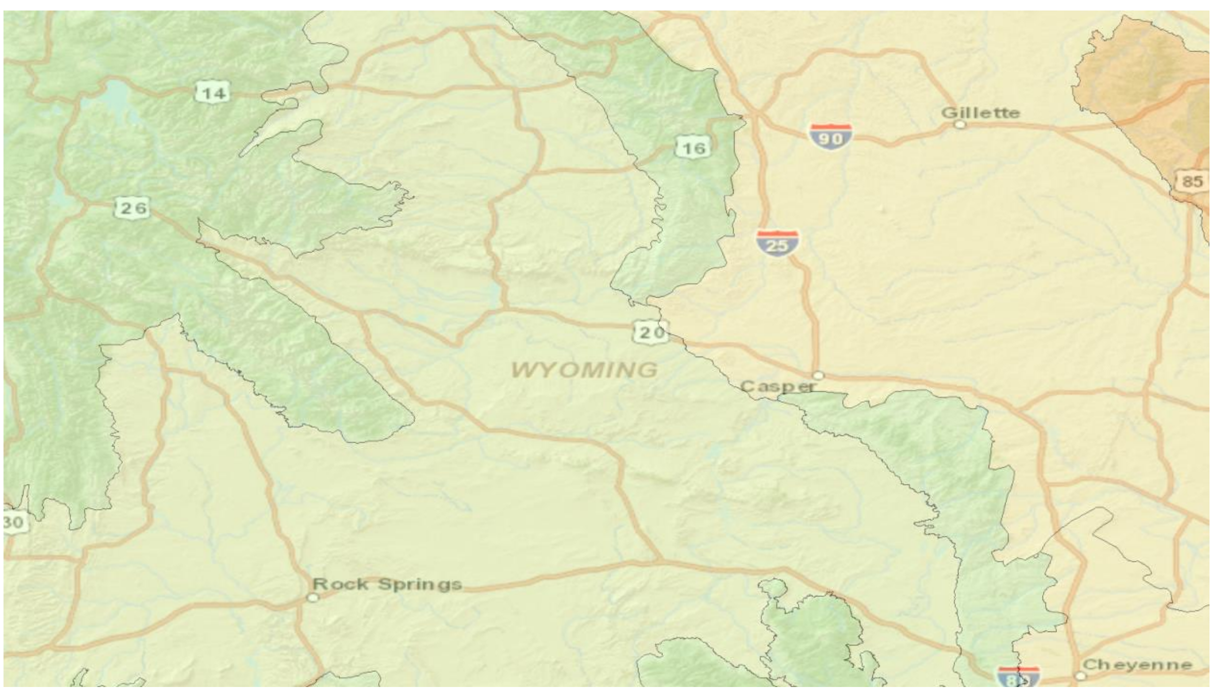
Appendix B: Field Key to Wetland and Riparian Ecological Systems of Wyoming
Last Updated April 7, 2015

1b. Wetlands and riparian areas of the Western Great Plains. *[If on the edge of the foothills, try both Key A and Key B]* .... **KEY A**: **WETLANDS AND RIPARIAN AREAS OF THE WESTERN GREAT PLAINS**

1b. Wetland and riparian areas west of the Great Plains **2**

2a. Wetlands and riparian areas with alkaline or saline soils within the inter-mountains basins of the Rocky Mountains (Upper Green River basin, Wind River basin, etc.) *[If the site does not match any of the descriptions within Key B, try Key C as well. Wetlands and riparian areas of the Rocky Mountains transition into the inter-mountain basins.]*... ....**KEY B: WETLANDS AND RIPARIAN AREAS OF THE INTER-MOUNTAIN BASINS**

2b. Wetlands and riparian areas of the Rocky Mountains, including the Snowy Mountains, the Wind Rivers, the Absorakas and the Bighorns.. ....**KEY C: WETLANDS AND RIPARIAN AREAS OF THE ROCKY MOUNTAINS**



Ecological Systems of Wyoming

- Black Hills
- Inter-mountain Basins
- Rocky Mountains
- Western Great Plains

KEY A: WETLANDS AND RIPARIAN AREAS OF THE WESTERN GREAT PLAINS

1a. Low stature shrublands dominated by species such as *Sarcobatus vermiculatus, Atriplex* spp., *Ericameria nauseosa*, *Artemisia sp.* Vegetation may be sparse and soils may be saline. Sites may be located on the edge alkali depressions, or in flats or washes not typically associated with river and stream floodplains. *[These systems were originally described for the Inter-Mountain Basins, but may extend to the plains.]* **2**

1b. Wetland is not a low stature shrub-dominated saline wash or flat. **3**

2a. Shrublands with sparse (<20%) vegetation cover, located on flats or in temporarily or intermittently flooded drainages, or on the edge of playas and alkali depressions. They are typically dominated by *Sarcobatus vermiculatus* and *Atriplex* spp. with inclusions of *Sporobolus airoides, Pascopyrum smithii, Distichlis spicata, Puccinellia nuttalliana,* and *Eleocharis palustris* herbaceous vegetation ………………………………………………………………………………………….**Inter-Mountain Basins Greasewood Flat**

2b. Sites with > 20% total vegetation cover and restricted to temporarily or intermittently flooded drainages with a variety of sparse or patchy vegetation including *Sarcobatus vermiculatus*, *Ericameria nauseosa*, *Artemisia sp., Grayia spinosa*, *Distichlis spicata*, and *Sporobolus airoides.* .... …….**Inter-Mountain Basins Wash**

3a. Sites located within the floodplain or immediate riparian zone of a river or stream. Vegetation may be entirely herbaceous or may contain tall stature woody species, such as *Populus* spp. or *Salix* spp. Water levels variable. Woody vegetation that occurs along reservoir edges can also be included here.... **4**

3b. Herbaceous wetlands of the Western Great Plains that are isolated or partially isolated from floodplains and riparian zones, often depressional with or without an outlet. **8**

4a. Herbaceous wetlands within the floodplain with standing water at or above the surface throughout the growing season, except in drought years. Water levels are often high at some point during the growing season, but managed systems may be drawn down at any point depending on water management regimes. Vegetation typically dominated by species of *Typha, Scirpus, Schoenoplectus*, *Carex*, *Eleocharis*, *Juncus*, and floating genera such as *Potamogeton*, *Sagittaria*, and *Ceratophyllum*. The hydrology may be entirely managed. Water may be brackish or not. Soils are highly variable. This system includes natural warm water sloughs and other natural floodplain marshes as well as a variety of managed wetlands on the floodplain (e.g., recharge ponds, moist soil units, shallow gravel pits, etc.)……… .... **Western North American Emergent Marsh**

4b. Not as above. Wetland and riparian vegetation that typically lacks extensive standing water. Vegetation may be herbaceous or woody. Management regimes variable.. **5**

5a. Large herbaceous wetlands within the floodplain associated with a high water table that is controlled by artificial overland flow (irrigation). Sites typically lack prolonged standing water. Vegetation is dominated by native or non-native herbaceous species; graminoids have the greatest canopy cover. Species composition may be dominated by non-native hay grasses such as *Poa spp., Alopecurus sp, Phleum pretense, and* Bromus inermis spp. inermis. There can be patches of emergent marsh vegetation and standing water less than 0.1 ha in size; these are not the predominant vegetation. .... **Irrigated Wet Meadow (not an official Ecological System)**

5b. Predominantly natural vegetation (though may be weedy and altered) within the floodplain or immediate riparian zone of a river or stream, dominated by either woody or herbaceous species. Not obviously controlled by irrigation. **6**

6a. Riparian woodlands and shrublands of the Rocky Mountain foothills on the very western margins of the Great Plains. Woodlands are dominated by *Populus* spp. (mainly *Populus angustifolia*,). Common native shrub species include *Salix* spp., *Alnus incana*, *Betula occidentalis, Cornus sericea*, and *Crataegus* spp. Sites are most often associated with a stream channel, including ephemeral, intermittent, or perennial streams (Riverine HGM Class). This system can occur on slopes, lakeshores, or around ponds, where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water, and may experience overland flow but no channel formation (Slope, Flat, Lacustrine, or Depressional HGM Classes). It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplain swales and irrigation ditches. .... **Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

6b. Riparian woodlands, shrublands and meadows of Wyoming's Western Great Plains. Common native trees are *Populus deltoides*, *Salix amygdaloides, Acer negundo, Fraxinus* pennsylvanica., and *Ulmus* americana. Common native shrubs include *Salix* spp., Rosa spp, and Symphoricarpos spp. Common non-native trees and shrubs are *Tamarix* spp. and *Elaeagnus angustifolia.* **7**

7a. Riparian woodlands, shrublands, and meadows along medium and small rivers and streams. Sites have less floodplain development and flashier hydrology than the next, and all streamflow may drawdown completely for some portion of the year. Water sources include snowmelt runoff (more common in Wyoming), groundwater (prairie streams), and summer rainfall. Dominant species include *Populus deltoides, Salix* spp., *Fraxinus pennsylvanica, Pascopyrum smithii, Panicum sp., Carex* spp., *Tamarix* spp., *Elaeagnus angustifolia,* and other non-native grasses and forbs…….W**estern Great Plains Riparian**

7b. Woodlands, shrublands, and meadows along large rivers (the North Platte and its larger tributaries) with extensive floodplain development and periodic flooding that is more associated with snowmelt and seasonal dynamics in the mountains than with local precipitation events. Hydroperiod alterations from major dams and reservoirs alter historic flooding patterns. Dominant communities within this system range from floodplain forests to wet meadow patches, to gravel/sand flats dominated by early successional herbs and annuals; however, they are <u>linked by underlying soils and the flooding regime</u>. Dominant species include *Populus deltoides* and *Salix* spp., *Panicum sp.* and *Carex* spp. *Tamarix* spp., *Elaeagnus angustifolia,* and non-native grasses.…………………………….**Western Great Plains Floodplain**

8a. Natural shallow depressional wetlands in the Western Great Plains with an impermeable soil layer, such as dense hardpan clay that causes periodic ponding after heavy rains. Sites generally have closed contour topography and are surrounded by upland vegetation. Hydrology is typically tied to precipitation and runoff but lacks a groundwater connection; however some of these sites are receiving increased water from irrigation seepage. Ponding is often ephemeral and sites may be dry throughout the entire growing season during dry years. Species composition depends on soil salinity, may fluctuate depending on seasonal moisture availability, and many persistent species may be upland species. *[The wetlands within this group are collectively referred to* ***playas or playa lakes****. Ecological systems listed below separate playas based on the level of salinity and total cover of vegetation.]* **9**

8b. Herbaceous wetlands in the Western Great Plains not associated with hardpan clay soils. Sites may or may not be depressional and may or may not be natural. **10**

9a. Shallow depressional wetlands with less saline soils than the next. Dominant species are typically not salt-tolerant. Sites may have obvious vegetation zonation of tied to water levels, with the most hydrophytic species occurring in the wetland center where ponding lasts the longest. Common native species include *Pascopyrum smithii, Iva axillaris, , Eleocharis* spp., *Oenothera canescens, Plantago* spp., *Polygonum* spp., *Conyza canadensis* ,and *Phyla cuneifolia.* Non-native species are very common in these sites, including *Salsola australis, Bassia sieversiana, Verbena bracteata,* and Polygonum aviculare. Sites have often been affected by agriculture and heavy grazing. Many have been dug out or “pitted” to increase water retention and to tap shallow groundwater...**Western Great Plains Closed Depression Wetland**

9b. Shallow depressional herbaceous wetlands with saline soils. Salt encrustations can occur on the surface. Species are typically salt-tolerant, including *Distichlis spicata*, *Puccinellia nuttalliana, Salicornia rubra, Schoenoplectus maritimus, Schoenoplectus americanus, Suaeda calceoliformis, Spartina* spp., *Triglochin maritima,* and occasional shrubs such as *Sarcobatus vermiculatus .[This system resembles the Inter-Mountain Basins Alkaline Closed Depression but occur in the Great Plains ecoregion. Note: Low stature shrub-dominant wetlands key in the flats and wash systems above.]*.. ....**Western Great Plains Saline Depression Wetland**

10a. Herbaceous wetlands with standing water at or above the surface throughout the growing season, except in drought years. Water levels are often high at some point during the growing season, but managed systems may be drawn down at any point depending on water management regimes. Vegetation typically dominated by species of *Typha, Scirpus, Schoenoplectus*, *Carex*, *Eleocharis*, *Juncus*, and floating genera such as *Potamogeton*, *Sagittaria*, and *Ceratophyllum*. The isolated expression of this system can occur around ponds, as fringes around lakes, and at any impoundment of water, including irrigation run-off. The hydrology may be entirely managed or artificial. Water may be brackish or not. Soils are highly variable... **Western North American Emergent Marsh**

10b. Herbaceous wetlands associated with a high water table that is controlled by artificial overland flow (irrigation) or artificial groundwater seepage (including from leaky irrigation ditches). Sites typically lack prolonged standing water. Vegetation is dominated by native or non-native herbaceous species; graminoids have the greatest canopy cover. s. Patches of emergent marsh vegetation and standing water are less than 0.1 ha in size and not the predominant vegetation... ....**Irrigated Wet Meadow (not an official Ecological System)**

KEY B: WETLANDS AND RIPARIAN AREAS OF THE INTER-MOUNTAIN BASINS

1a. Depressional, herbaceous wetlands occurring within dune fields of the inter-mountain basins (e.g. Great Divide basin)..**Inter-Mountain Basins Interdunal Swale Wetland**

1b. Wetlands not associated with dune fields **2**

2a. Depressional wetlands. Soils are typically alkaline to saline clay with hardpans. Salt encrustation typically visible on the soil surface or along the water edge. Water levels various. Cover of vegetation variable, can be extremely sparse (<10% cover) or moderate to high (30–60% cover). Typically herbaceous dominated, but may contain salt-tolerant shrubs on the margins... **3**

2b. Non-depressional wetlands on flats or in washes, with alkaline to saline soils. Cover of vegetation variable, can be extremely sparse (<10% cover) or moderate to high (30–60% cover). Typically shrub dominated. Most common species are *Sarcobatus vermiculatus* and *Atriplex* spp.................................... **4**

3a. Depressional, alkaline wetlands that are seasonally to semi-permanently flooded, usually retaining water into the growing season and drying completely only in drought years. Many are associated with irrigation seepage, springs, or located in large basins with internal drainage. Seasonal drying exposes mudflats colonized by annual wetland vegetation. This system can occur in alkaline basins and swales and along the drawdown zones of lakes and ponds. They generally have thick unvegetated salt crusts over clay soils surrounded by zones of vegetation transitioning to the uplands. In these zones vegetation cover is generally >10% and species are typically salt-tolerant such as *Distichlis spicata*, *Puccinellia* spp., *Leymus* sp., *Schoenoplectus maritimus, Schoenoplectus americanus, Triglochin maritima,* and *Salicornia* spp*.*...**Inter-Mountain Basins Alkaline Closed Depression**

3b. Barren and sparsely vegetated playas (generally <10% plant cover. Could be more if annuals or upland vegetation are encroaching). Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water generally comes from precipitation and is prevented from percolating through the soil by an impermeable soil sub horizon and is left to evaporate. Soil salinity varies with soil moisture and greatly affects species composition. Characteristic species may include *Sarcobatus vermiculatus, Distichlis spicata,* and/or *Atriplex* spp. .... **Inter-Mountain Basins Playa**

4a. Shrublands with >10% total vegetation cover, located on flats. Vegetation dominated by *Sarcobatus vermiculatus* and *Atriplex* spp. with inclusions of *Artemisia tridentata ssp. Tridentate, Sporobolus airoides, Pascopyrum smithii, Distichlis spicata, Puccinellia nuttalliana,* and.herbaceous vegetation. .... **Inter-Mountain Basins Greasewood Flat**

4b. Sites with < 10% total vegetation cover and restricted to temporarily or intermittently flooded drainages with a variety of sparse or patchy vegetation including *Sarcobatus vermiculatus*, *Ericameria nauseosa*, *Artemisia cana*, *Artemisia tridentata*, *Distichlis spicata*, and *Sporobolus airoides.* .... **Inter-Mountain Basins Wash**

KEY C: WETLANDS AND RIPARIAN AREAS OF THE ROCKY MOUNTAINS

1a. Wetland defined by groundwater inflows and organic soil (peat) accumulation of at least 40 cm in the upper 80 cm. Vegetation can be woody or herbaceous. If the wetland occurs within a mosaic of non-peat forming wetland or riparian systems, then the patch must be at least 0.1 hectare (0.25 acre). If the wetland occurs as an isolated patch surrounded by upland, then there is no minimum size criterion. .... **Rocky Mountain Subalpine-Montane Fen**

1b. Wetland does not have at least 40 cm of organic soil (peat) accumulation or occupies an area less than 0.1 hectares (0.25 acres) within a mosaic of other non-peat forming wetland or riparian systems ... 2

2a. Total woody canopy cover generally 25% or more within the overall wetland/riparian area. Any purely herbaceous patches are less than 0.5 hectare and occur within a matrix of woody vegetation. *[Note: Relictual woody vegetation such as standing dead trees and shrubs are included here.] 3*

2b. Total woody canopy cover generally less than 25% within the overall wetland/riparian area. Any woody vegetation patches are less than 0.5 hectare and occur within a matrix of herbaceous wetland vegetation 5

3a. Riparian woodlands and shrublands of the foothill and lower montane zones on the Rocky Mountains. Woodlands are dominated by *Populus* spp. (*Populus angustifolia*, or the hybrid *P. acuminate*. At higher elevations Picea engelmannii, Abies lasiocarpa, Pseudotsuga menziesii, and Pinus ponderosa can be found. Common native shrub species include *Salix* spp., *Alnus incana*, *Betula occidentalis, Cornus sericea*, and *Crataegus* spp. Sites are most often associated with a stream channel, including ephemeral, intermittent, or perennial streams (Riverine HGM Class). This system can occur on slopes, lakeshores, or around ponds, where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water, and may experience overland flow but no channel formation (Slope, Flat, Lacustrine, or Depressional HGM Classes). It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplain swales and irrigation ditches. (this system is also found in the inter-mountain basin ecoregion).. ....
……………………………………..**Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

3b. Riparian woodlands and shrublands of the montane or subalpine zone 4

4a. Montane or subalpine riparian woodlands (canopy dominated by trees). This system occurs as a narrow streamside forest lining small, confined low- to mid-order streams. Common tree species include *Abies lasiocarpa*, *Picea engelmannii*, ,and *Populus tremuloides* (The overstory consists of Picea engelmannii, often with some Abies lasiocarpa and Populus tremuloides. These riparian areas generally occur at elevations where the uplands support upper montane and subalpine forests -- Pinus contorta, Picea engelmannii, Abies lasiocarpa. The common riparian trees in this type -- Picea engelmannii, Abies lasiocarpa, Populus tremuloides -- also grow in riparian zones in the lower montane, but there they are joined by Populus angustifolia, sometimes Populus acuminata, Populus balsamifera (mostly in NW Wyoming), Picea pungens (NW Wyoming : Snake River drainage, and the Wind River around Dubois), Pseudotsuga menziesii, Pinus ponderosa (eastern half of WY). Then, with decreasing elevation, the conifer drop out, Populus acuminata increases, and Populus deltoides becomes a major species.) ....
.... **Rocky Mountain Subalpine-Montane Riparian Woodland**

4b. Montane or subalpine shrub wetlands (canopy dominated by shrubs with sparse or no tree cover). This system is most often associated with streams (Riverine HGM Class), occurring as either a narrow band of shrubs lining streambanks of steep V-shaped canyons (straight, with boulder and cobble substrate)*or* as a wide, extensive shrub stand on alluvial terraces in low-gradient valley bottoms (more sinuous, with finer-textured substrates. Sometimes referred to as a *shrub carr*). Beaver activity is common within the wider occurrences. In addition, this system can occur around the edges of fens, lakes, seeps, and springs on slopes away from valley bottoms. This system can also occur within a mosaic of multiple shrub- and herb-dominated communities within snowmelt-fed basins. In all cases, vegetation is dominated by species of *Salix*, *Alnus*, or *Betula* but their composition varies depending on stream gradient. Alnus incana is a dominant or co-dominant along high-gradient streams; Betula occidentalis often co-dominates. Willows are present, as is Cornus sericea, but rarely dominate. In contrast, along the lower-gradient streams in wide valleys, the willows dominate; Betula and Cornus often are present but secondary to the willows; Alnus usually is a minor component. . ...
....**Rocky Mountain Subalpine-Montane Riparian Shrubland**

5a. Herbaceous wetlands with water present throughout all or most of the year. Water is at or above the surface throughout the growing season, except in drought years. This system can occur around ponds, as fringes around lakes, and along slow-moving streams and rivers. The vegetation is dominated by common emergent and floating leaved plants, including species of *Scirpus*, *Schoenoplectus*, *Typha*, *Juncus*, *Carex*, *Potamogeton*, *Polygonum*, and *Nuphar*..
.... **Western North American Emergent Marsh**

5b. Herbaceous wetlands that typically lack extensive standing water. Patches of emergent marsh vegetation and standing water are less than 0.1 ha in size and not the predominant vegetation............. **7**

6a. Herbaceous wetlands associated with a high water table or overland flow, but typically lack standing water. Sites with *no channel formation* are typically associated with snowmelt or groundwater and not subjected to high disturbance events such as flooding (Slope HGM Class). Sites *associated with a stream channel* are more tightly connected to overbank flooding from the stream channel than with snowmelt and groundwater discharge. Vegetation is dominated by herbaceous species; typically graminoids have the highest canopy cover including *Carex* spp., *Calamagrostis* spp., and *Deschampsia caespitosa*.............
.... **Rocky Mountain Alpine-Montane Wet Meadow**

6b. Large herbaceous wetlands associated with a high water table that is controlled by artificial overland flow (irrigation). Sites typically lack prolonged standing water, but may have standing water early in the season if water levels are very high. Vegetation is dominated by native or non-native herbaceous species; graminoids have the highest canopy cover ....
. ...**Irrigated Wet Meadow (not an official Ecological System)**

Appendix C. Little Snake Basin Wetland Assessment Field Form

LOCATION AND GENERAL INFORMATION

Point Code __________ Date: __________________________Surveyors:____

Access Comments (note permit requirement or difficulties accessing the site):

GPS COORDINATES OF TARGET POINT AND ASSESSMENT AREA

Dimensions of AA:

____40 m radius circle

____Rectangle

____Freeform, describe and take a GPS Track

Elevation (m):

Target Wetland: ___ Yes ___ No / Type:
if no what is new target type:

Relation to AA: ___Centered ___Included ___Outside

AA-Center WP #: __________ LAT: ______________________ LONG: __________________________ Error (+/-): ______________
(Circle AAs Only)

AA-Track Track Name: ____ Area: ____

PHOTOS OF ASSESSMENT AREA (Taken at the center point looking out in the cardinal directions for standard 40 m radius circle AA's or from four points on edge of AA looking in for freeform AA's

AA-1 WP/Photo #: __________ Aspect: _____________ LAT: ______________________ LONG: __________________________

AA-2 WP/Photo #: __________ Aspect: _____________ LAT: ______________________ LONG: __________________________

AA-3 WP/Photo #: __________ Aspect: _____________ LAT: ______________________ LONG: __________________________

AA-4 WP/Photo #: __________ Aspect: _____________ LAT: ______________________ LONG: __________________________

Additional AA Photos and Comments:

(Note range of photo numbers and explain particular photos of interest)

ENVIRONMENTAL DESCRIPTION AND CLASSIFICATION OF ASSESSMENT AREA

Non-target Inclusions:

% AA with > 1m standing water: ______________

% AA with Non-target inclusions: _________________

Non-target description:

Wetland origin (if known):

____ Natural feature with minimal alteration

____ Natural feature, but altered or augmented by modification

____ Non-natural feature created by passive or active management

____ Unknown

Ecological System: (see manual for key and rules on inclusions and pick the *best match*) Fidelity: High Med Low

ENVIRONMENTAL DESCRIPTION AND CLASSIFICATION OF ASSESSMENT AREA (continued)

Cowardin Classification (pick *one each that best represents AA*)	HGM Class (pick *only one that best represents AA*)
Fidelity: High Med Low (see manual and pick *one each* of System, Class, Water Regime, and optional Modifier for dominant type)	Fidelity: High Med Low ____Riverine* ____Lacustrine Fringe ____Depressional ____ Slope ____ Flats ____ Irrigated (choose additional class) **Specific classification and metrics apply to the Riverine HGM Class*

AA REPRESENTATIVENESS

Is AA the entire wetland? ___ Yes ___ No If no, is AA representative of larger wetland? ___ Yes ___ No
Provide comments:

Wildlife Observation – record any wildlife observations from site. List species of and type of observation

Species:	# individuals	Nests	Visible	Vocal	Tracks	Scat

Wildlife Comments:

ASSESSMENT AREA DRAWING AND COMMENTS
Add north arrow and approx. scale bar. Document **Community types and abiotic zones** (particularly open water), inflows and outflows, and indicate direction of drainage. Include sketch of soil pit placement. If appropriate, add a **cross-sectional diagram** and indicate slope of side.
ASSESSMENT AREA SETTING AND SURROUNDING LANDSCAPE DESCRIPTION
Overall site description and details on site hydrology, soil, and vegetation. Include general landscape setting, dominant plants in buffer, and information on any target wetland types occurring with AA.

AA GROUND COVER AND VERTICAL STRATA	
Cover Classes 1: trace **2:** <1% **3:** 1–<2% **4:** 2–<5% **5:** 5–<10% **6:** 10–<25% **7:** 25–<50% **8:** 50–<75% **9:** 75–<95% **10:** >95% (Unless otherwise noted)	
Cover of standing water of any depth, vegetated or not:	
Cover of running water of any depth, vegetated or not:	
Cover of open water (plant canopy cover < 10%)	
Cover of water with emergent vegetation:	
Cover of water with floating or submerged vegetation:	
Cover of exposed bare ground* – soil / sand / sediment	
Cover of exposed bare ground* – gravel / cobble (~2–250 mm)	
Cover of exposed bare ground* – bedrock / rock / boulder (>250 mm)	
Cover salt crust (all cover, including over vegetation or litter cover)	
Cover of litter (all cover, including under water or vegetation)	
Depth of litter (cm) – average of four non-trampled locations where litter occurs Depth 1 _____ cm Depth 2 _____ cm Depth 3 _____ cm Depth 4 _____ cm Ave depth:	
Predominant litter type (C = coniferous, E = broadleaf evergreen, D = deciduous, S = sod/thatch, F = forb)	
Cover of standing dead trees (>5 cm diameter at breast height)	
Cover of standing dead shrubs or small trees (<5 cm diameter at breast height)	
Cover of downed coarse woody debris (fallen trees, rotting logs, >5 cm diameter)	
Cover of downed fine woody debris (<5 cm diameter)	
Cover bryophytes (all cover, including under water, vegetation or litter cover)	
Cover lichens (all cover, including under water, vegetation or litter cover)	
Cover algae (all cover, including under water, vegetation or litter cover)	

Height Classes 1:<0.5 m 2: 0.5–1m 3: 1–2 m 4: 2–5 m 5: 5–10 m 6: 10–15 m 7: 15–20 m 8: 20–35 m 9: 35–50 m 10:>50 m			
Vertical Vegetation Strata(live or very recently dead)	**Cover / Height →**	**C**	**H**
(T1)	Dominant canopy trees (>5 m and > 30% cover)		
(T2)	Sub-canopy trees (> 5m but < dominant canopy height) or trees with sparse cover		
(S1)	Canopy layer 2–5 m includes both Tall shrubs or older tree saplings		
	Older tree saplings 2–5 m		
	Tall shrubs 2–5 m		
(S2)	Canopy layer 0.5 – 2 includes both Short shrubs or young tree saplings (0.5–2 m)		
	Young tree saplings 0.5–2 m		
	Short shrubs 0.5–2 m		
(S3)	Dwarf shrubs or tree seedlings (<0.5 m; included short *Vaccinium* spp., etc.)		
	Tree seedlings <0.5 m		
	Dwarf shrubs <0.5 m (included short *Vaccinium* spp., etc.)		
(HT)	Herbaceous total		
(H1)	Graminoids (grass and grass-like plants)		
(H2)	Forbs (all non-graminoids)		
(H3)	Ferns and fern allies		
(AQ)	Submergent or floating aquatics		

Point Code_____________

Vegetation Species List

Walk through the AA and identify as many plant species as possible beginning with the most dominant species first. Spend *no more* than 1 hour compiling the species list. Once the species list is compiled. Estimate absolute cover for each species.

Scientific Name or Pseudonym	**% Cover**	**Coll #**	**Photos**

Walk through the AA and identify as many plant species as possible beginning with the most dominant species first. Spend *no more* than 1 hour compiling the species list. Once the species list is compiled. Estimate absolute cover for each species.

Scientific Name or Pseudonym	**% Cover**	**Coll #**	**Photos**

SOIL PROFILE DESCRIPTION – SOIL PIT ☐ **Representative Pit?**

GPS Waypoint ___________ Lat: ___ ___ ___ ___ ___ ___Long: ___ ___ ___ ___ ___ ___ ___

Temp_________ pH ________ EC _______ TDS ________ Salinity ________

Settling Time: ___________ Depth to saturated soil (cm): ____________Depth to free water (cm): _____________ ☐ Not observed, if so: ☐Pit is filling slowly OR ☐Pit appears dry

Depth (cm)	Matrix Color (moist)	Dominant Redox Features Color (moist)	%	Secondary Redox Features Color (moist)	%	Texture	% Roots	% Gravel	Remarks

Hydric Soil Indicators: See field manual for descriptions and check all that apply to pit.

____Histosol (A1)
____Histic Epipedon (A2/A3)
____Mucky Mineral (S1/F1)
____Hydrogen Sulfide Odor (A4)
____Gleyed Matrix (S4/F2)
____Depleted Matrix (A11/A12/F3)
____Redox Concentrations (S5/F6/F8)
____Redox Depletions (S6/F7)
___ Surface Salt Crusts
___ Translocated Salts

Comments:

SOIL PROFILE DESCRIPTION – SOIL PIT 2 ☐ **Representative Pit?**

GPS Waypoint ___________ Lat: ___ ___ ___ ___ ___ ___Long: ___ ___ ___ ___ ___ ___

Temp_________ pH ________ EC _______ TDS ________ Salinity ________

Settling Time: ___________ Depth to saturated soil (cm): ____________Depth to free water (cm): _____________ ☐ Not observed, if so: ☐Pit is filling slowly OR ☐Pit appears dry

Depth (cm)	Matrix Color (moist)	Dominant Redox Features Color (moist)	%	Secondary Redox Features Color (moist)	%	Texture	% Roots	% Gravel	Remarks

Hydric Soil Indicators: See field manual for descriptions and check all that apply to pit.

____Histosol (A1)
____Histic Epipedon (A2/A3)
____Mucky Mineral (S1/F1)
____Hydrogen Sulfide Odor (A4)
____Gleyed Matrix (S4/F2)
____Depleted Matrix (A11/A12/F3)
____Redox Concentrations (S5/F6/F8)
____Redox Depletions (S6/F7)
___ Surface Salt Crusts
___Translocated Salts

Comments:

Point Code__________________

SOIL PROFILE DESCRIPTION – SOIL PIT 3 ☐ **Representative Pit**

GPS Waypoint ___________ Lat: ___ ___ ___ ___ ___ ___Long: ___ ___ ___ ___ ___ ___ ___ | Temp_________ pH ________ EC _______ TDS ________ Salinity ________

Settling Time: ___________ Depth to saturated soil (cm): ____________Depth to free water (cm): _____________ ☐ Not observed, if so: ☐Pit is filling slowly OR ☐Pit appears dry

Depth (cm)	Matrix Color (moist)	Dominant Redox Features Color (moist)	%	Secondary Redox Features Color (moist)	%	Texture	% Roots	% Gravel	Remarks
_______	______________	______________	________	_____________	________	_____________________	_________	_________	_______________________________
_______	______________	______________	________	_____________	________	_____________________	_________	_________	_______________________________
_______	______________	______________	________	_____________	________	_____________________	_________	_________	_______________________________
_______	______________	______________	________	_____________	________	_____________________	_________	_________	_______________________________
_______	______________	______________	________	_____________	________	_____________________	_________	_________	_______________________________

Hydric Soil Indicators: See field manual for descriptions and check all that apply to pit.

____Histosol (A1) ____Gleyed Matrix (S4/F2) ___ Surface Salt Crusts
____HisticEpipedon (A2/A3) ____Depleted Matrix (A11/A12/F3) ___Translocated Salts
____Mucky Mineral (S1/F1) ____Redox Concentrations (S5/F6/F8)
____Hydrogen Sulfide Odor (A4) ____Redox Depletions (S6/F7)

Comments:

WATER QUALITY

Site 1: GPS Waypoint ______________ Lat: Long: **Standing OR Flowing**

Temp_____________ pH _____________ EC _____________ TDS __________________ Salinity __________________

Site 2: GPS Waypoint ______________ Lat: Long: **Standing OR Flowing**

Temp_____________ pH _____________ EC _____________ TDS __________________ Salinity __________________

Water quality measurement comments:

*Be sure to mark down any soils and water chemistry units

Macro Invertebrate sample taken: | Macro invertebrate comments:

Point Code____________

LEVEL 2 ECOLOGICAL INTEGRITY ASSESSMENT

1. *LANDSCAPE CONTEXT METRICS – Check the applicable box.*

1a. PERCENT NATURAL LAND COVER

Select the statement that best describes the **percent of natural land cover** within 100, 200 and 500 m envelopes surrounding the AA. To determine, identify any patches of natural land cover within the 100, 200 and 500 m envelopes and estimate their total percent of the envelopes. See definitions in the field manual of natural land cover types. Natural land cover patches *do not* need to be contiguous with the AA.	Distance from AA:	***100m***	***200 m***	***500 m***
	Intact: Landscape contains 90–100% natural land cover.			
	Variegated: Landscape contains 60–90% natural land cover.			
	Fragmented: Landscape contains 20–60% natural land cover.			
	Relictual: Landscape contains <20% natural land cover.			

1b. LANDSCAPE FRAGMENTATION

Select the statement that best describes the **landscape fragmentation** with in a 500 m envelope surrounding the AA. To determine, identify the largest unfragmented block *that includes the AA* within the 500 m envelope and estimate its percent of the total envelope. Well-traveled dirt roads and major canals count as fragmentation, but hiking trails, hayfields, fences and small ditches can be included in unfragmented blocks (see definitions).	Intact: AA embedded in >90–100% unfragmented, natural landscape.	
	Variegated: AA embedded in >60–90% unfragmented, natural landscape.	
	Fragmented: AA embedded in >20–60% unfragmented, natural landscape.	
	Relictual: AA embedded in ≤20% unfragmented, natural landscape.	

1b. RIPARIAN CORRIDOR CONTINUITY*(RIVERINE WETLANDS ONLY)*

For riverine wetlands, select the statement that best describes the **riparian corridor continuity** within 500 m upstream and downstream of the AA. To determine, identify any non-buffer patches (see definitions) within the potential riparian corridor (natural geomorphic floodplain) both upstream and downstream of the AA. Estimate the percentage of the riparian corridor they occupy. *For AAs on one side of a very large river channel (~20 m width),* only consider the riparian corridor on that side of the channel.	Intact: >95–100% natural habitat within the riparian corridor both upstream and downstream.	
	Variegated: >80–95% natural within the riparian corridor both upstream and downstream.	
	Fragmented: >50–80% natural habitat within the riparian corridor both upstream and downstream.	
	Relictual: ≤50% natural habitat within the riparian corridor both upstream and downstream.	

Landscape fragmentation and riparian corridor continuity comments:

1c. BUFFER EXTENT

Select the statement that best describes the **extent of buffer land cover** surrounding the AA. To determine, estimate the percent of the AA surrounded by buffer land covers (see definitions). Each segment must be ≥ 5 m wide and extend along ≥ 10 m of the AA perimeter.	Buffer land covers surround >100% of the AA.	
	Buffer land covers surround >75–<100% of the AA.	
	Buffer land covers surround >50–75% of the AA.	
	Buffer land covers surround >25–50% of the AA.	
	Buffer land covers surround ≤25% of the AA.	

1d. BUFFER WIDTH

Select the statement that best describes the **buffer width**. To determine, estimate width (up to 200 m from AA) along eight lines radiating out from the AA at the cardinal and ordinal directions (N, NE, E, SE, S, SW, W, NW).

1: ____________	5: ____________	Average buffer width is >200 m	
2: ____________	6: ____________	Average buffer width is >100–200 m	
3: ____________	7: ____________	Average buffer width is >50–100 m	
4: ____________	8: ____________	Average buffer width is >25–50 m	
Average width: ________________________		Average buffer width is ≤25 m OR no buffer exists	

1e. BUFFER CONDITION

Select the statement that best describes the **buffer condition**. Select one statement per column. Only consider <u>the actual buffer</u> measured in metrics 1c and 1d. Use the Landscape Stressor list below to help inform your buffer condition decision

Abundant (≥95%) relative cover native vegetation and little or no (<5%) cover of non-native plants.		Intact soils, little or no trash or refuse, and no evidence of human visitation. Light grazing can be present.	
Substantial (≥75–95%) relative cover of native vegetation and low (5–25%) cover of non-native plants.		Intact or moderately disrupted soils, moderate or lesser amounts of trash, light grazing to moderate grazing OR minor intensity of human visitation or recreation	
Moderate (≥50–75%) relative cover of native vegetation.		Moderate or extensive soil disruption, moderate or greater amounts of trash, moderate to heavy grazing OR moderate intensity of human use.	
Low (<50%) relative cover of native vegetation OR no buffer exists.		Barren ground and highly compacted or otherwise disrupted soils, moderate or greater amounts of trash, moderate or greater intensity of human use, very heavy grazing OR no buffer exists.	

Buffer comments:

LANDSCAPE STRESSORS

Using the table below, identify all **landscape stressor / land uses within a 200 and 500 m envelope** of the AA. Stressors can overlap (e.g., Grazing and moderate recreation can both be counted in the same portion of the envelope). Rank the top 3 stressors effecting the wetland within the 200m and 500m buffers.

Landscape stressor/ land use categories	*200m*		*500m*	
	Present	*Rank*	*Present*	*Rank*
Paved roads, parking lots, railroad tracks				
Unpaved roads (e.g., driveway, tractor trail, 4-wheel drive roads)				
Domestic or commercially developed buildings				
Trash or refuse				
Gravel pit operation, open pit mining, strip mining				
Mining (other than gravel, open pit, and strip mining), abandoned mines				
Resource extraction (oil and gas wells and surrounding footprint)				
Agriculture – tilled crop production				
Agriculture – permanent crop (hay pasture, vineyard, orchard, tree plantation)				
Recent old fields and other lands dominated by non-native species (weeds or hay fields)				
Intensively managed golf courses, sports fields, urban parks, expansive lawns				
Vegetation conversion (chaining, cabling, rotochopping, or clear-cutting of woody veg)				
Heavy grazing: (> 2/3 of herbaceous plants have been grazed) by livestock or native ungulate				
Moderate Grazing: (at least 1/3 to 2/3 of herbaceous plants have been grazed) by livestock or native ungulate				
Light Grazing: (< 1/3 of herbaceous plants have been grazed) by livestock or native ungulates				
Heavy browse (> 2/3 of woody plants have been browsed by livestock or native ungulates)				
Moderate browse (at least 1/3 to 2/3 of woody plants have been browsed by livestock or native ungulates)				
Light browse (< 1/3 of woody plants have been browsed by livestock or native ungulates)				
Heavy recreation or human visitation (ATV use / camping / popular fishing spot, etc.)				
Moderate recreation or human visitation (high-use trail)				
Light recreation or human visitation (low-use trail)				
Logging or tree removal with 50-75% of trees				
Selective logging or tree removal with <50% of trees				
Evidence of recent fire (<5years old, still very apparent on vegetation, little regrowth)				
Dam sites and flood disturbed shorelines around water storage reservoirs				
Beetle-killed conifers				
Irrigation ditches, berms, dams, head gates that change how water moves				
Non-native species				
Other:				

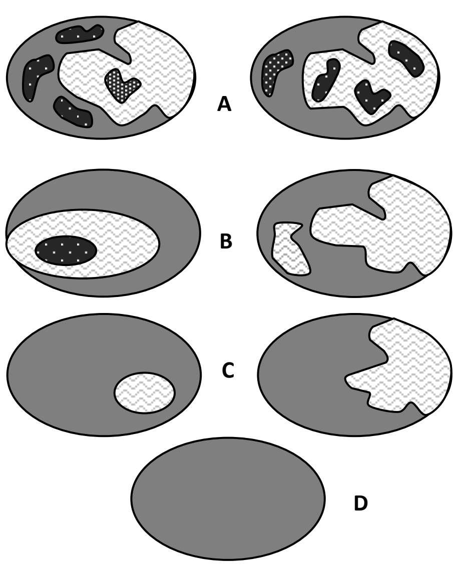
Landscape Stressor Comments:

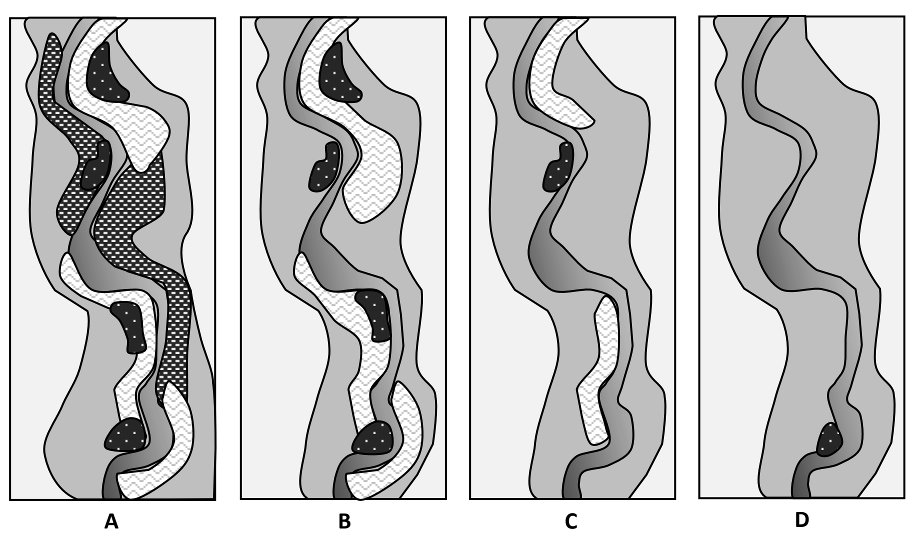
2. VEGETATION CONDITION METRICS – Check the applicable box.

VEGETATION COMPOSITION
Vegetation compositions and structure, woody regeneration and liter metrics will be calculated out of the field based on the species list and cover values. To aid data interpretation, provide comments on composition and **list noxious species identified in field.**

2e. REGENERATION OF NATIVE WOODY SPECIES- Select the statement that best describes the **regeneration of native woody species** within the AA.	
Woody species are naturally uncommon or absent.	**N/A**
All age classes of desirable (native) woody riparian species present.	
Age classes restricted to mature individuals and young sprouts. Middle age groups absent.	
Stand comprised of mainly mature species OR mainly evenly aged young sprouts that choke out other vegetation.	
Woody species predominantly consist of decadent or dying individuals OR woody layer is dominated by Russian olive and/or Salt Cedar	
Regeneration comments and photo #'s:	

2h. HORIZONTAL INTERSPERSION OF BIOTIC AND ABIOTIC ZONES		
Refer to diagrams below and select the statement that best describes the **horizontal interspersion of biotic and abiotic zones** within the AA. Rules for defining zones are in the field manual. Include zones of open water when evaluating interspersion.	High degree of horizontal interspersion: AA characterized by a very complex array of nested or interspersed zones with no single dominant zone.	
	Moderate degree of horizontal interspersion: AA characterized by a moderate array of nested or interspersed zones with no single dominant zone.	
	Low degree of horizontal interspersion: AA characterized by a simple array of nested or interspersed zones. One zone may dominate others.	
	No horizontal interspersion: AA characterized by one dominant zone.	





2k. VEGETATION STRESSORS WITHN THE AA		
Using the table below, mark all vegetation stressor within the AA. Stressors can overlap (e.g., light grazing can occur along with moderate recreation). Rank the top 3 effecting the wetland.		
Vegetation stressor categories	*Present*	*Rank*
Unpaved Roads (e.g., driveway, tractor trail, 4-wheel drive roads)		
Vegetation conversion (chaining, cabling, rotochopping, clearcut)		
Logging or tree removal with 50-75% of trees >50 cm dbh removed		
Selective logging or tree removal with <50% of trees >50 cm dbh removed		
Heavy grazing: (> 2/3 of herbaceous plants have been grazed) by livestock or native ungulate		
Moderate Grazing: (at least 1/3 to 2/3 of herbaceous plants have been grazed) by livestock or native ungulate		
Light Grazing: (< 1/3 of herbaceous plants have been grazed) by livestock or native ungulates		
Heavy browse (> 2/3 of woody plants have been browsed) by livestock or native ungulates		
Moderate browse (at least 1/3 to 2/3 of woody plants have been browsed) by livestock or native ungulates		
Light browse (< 1/3 of woody plants have been browsed) by livestock or native ungulates		
Intense recreation or human visitation (ATV use / camping / popular fishing spot, etc.)		
Moderate recreation or human visitation (high-use trail)		
Light recreation or human visitation (low-use trail)		
Recent old fields and other lands dominated by *non-native* species (weeds or hay)		
Haying of *native* grassland (*not* dominated by non-native hay grasses)		
Beetle-killed conifers		
Non-native Species		
Litter is extensive and limits new growth (thick cattails litter)		
Other:		
Vegetation stressor comments and photo #'s:		

3. HYDROLOGY METRICS – Check the applicable box.

3a. Water source and Hydrologic stressors within the drainage basin

Check off all *major* water sources in the table to the right. If the dominant water source is evident, mark it with a star (*).

_____ Overbank flooding	_____ Irrigation via direct application
_____ Alluvial aquifer	_____ Irrigation via seepage
_____ Groundwater discharge	_____ Irrigation via tail water run-off
_____ Natural surface flow	_____ Urban run-off / culverts
_____ Precipitation	_____ Pipes (directly feeding wetland)
_____ Snowmelt	_____ Other:

In the table below, estimate the scope of each **hydrology stressor within the AA and within the 500 m envelope of the AA**. If known hydrologic alterations occur further than 500 m from the AA and are positioned in a way that have an effect on the sites hydrology record the stressors scope in the proper location and please explain in comments below. ***Scope rating: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.***

Hydrology stressor categories	***Within AA***	***Upstream / Upslope***	***Downstream / Downslope***
Ditches < 1 feet deep are present			
Ditches 1 foot to 3 feet deep are present			
Ditches > 3 feet deep are present			
Diversion structures < 1 foot tall are present			

Diversion structures 1 foot to 3 feet tall are present			
Diversion structures > 3 feet tall are present			
Major irrigation canal			
Spring box diverting water from wetland			
Berms present that impede forward or lateral movement of water			
Weir or drop structure that impounds water and controls energy of flow			
Impoundment / stock pond			
Large dam / reservoir			
Dirt or gravel road that alters forward or lateral movement of water			
2-lane road crosses that alters forward or lateral movement of water			
4-lane road crosses that alters forward or lateral movement of water			
Culvert too small to accommodate base flow			
Culvert appears large enough to accommodate base flow but not flood flows			
Culvert appears large enough to accommodate base flow and flood flows			
Pugging by livestock, native ungulates, or wild horses that alters water movement in the site			
Dug pits for holding water			
Fill that has been added to site			
Surrounding land cover / vegetation that interrupts surface flow			
Observed or potential agricultural runoff			
Developed or irrigated lands occupy drainage basin.			
Other:			
Other			

Hydrologic stressor and water source comments:

Hydrologic landscape and management context. Check all that apply checklist	
Wetland appears to be still connected to its natural water source, natural flows appear to be unaltered.	
Wetland appears to naturally lack water at times.	
Land use in the local watershed is primarily open space or low-density development	
Local watershed includes little or no irrigated land.	
Wetland is in a location that appears to have supported a wetland before development in the immediate drainage basin	
Filling and drawdown of the wetland appear to be unmanaged	
Filling & drawdown are managed to mimic natural timing and amount	
Filling & drawdown are managed with no regard to natural timing and amount	
Xeric vegetation is encroaching into the wetland	
Natural wet-season or dry season inflows to the wetland have been eliminated by impoundment or diversion.	
Wetland exists in intermittent drainage basin that has been bermed or dugout to hold water for livestock use or irrigation storage	
Wetland appears to be largely or entirely supported by anthropogenic inputs such as: direct irrigation, runoff from irrigated fields, seepage from irrigation canals or ditches, urban stormwater runoff, direct pumping, or landscape modification for water storage	

Wetland landscape and management context comments:

4a. WATER SOURCES / INPUTS

Select the statement below that best describes the water sources feeding the AA during the growing season. Use the water source, hydrologic stressor and wetland landscape and management context tables to inform your answers

Water sources are precipitation, groundwater, natural runoff, or natural flow from an adjacent freshwater body. The system may naturally lack water at times, such as in the growing season. There is no indication of direct artificial water sources, either point sources or non-point sources. Land use in the local watershed is primarily open space or low density, passive use with little irrigation.	
Water sources are mostly natural, but also include occasional or small amounts of inflow from anthropogenic sources. Indications of anthropogenic sources include developed land or irrigated agriculture that comprises < 20% of the immediate drainage basin, the presence of a few small storm drains or scattered homes with septic system. No large point sources control the overall hydrology.	
Water sources are moderately impacted by anthropogenic sources, but are still a mix of natural and non-natural sources. Indications of moderate contribution from anthropogenic sources include developed land or irrigated agriculture that comprises 20–60% of the immediate drainage basin or the presence of a many small storm drains or a few large ones. The key factor to consider is whether the wetland is located in a landscape position that supported a wetland before development and whether the wetland is still connected to its natural water source (e.g., modified ponds on a floodplain that are still connected to alluvial aquifers, natural stream channels that now receive substantial irrigation return flows).	
Water sources are primarily from anthropogenic sources (e.g., urban runoff, direct irrigation, pumped water, artificially impounded water, or another artificial hydrology). Indications of substantial artificial hydrology include developed or irrigated agricultural land that comprises > 60% of the immediate drainage basin of the AA, or the presence of major drainage point source discharges that obviously control the hydrology of the AA. The key factor to consider is whether the wetland is located in a landscape position that likely never supported a wetland prior to human development. The reason the wetland exists is because of direct irrigation, irrigation seepage, irrigation return flows, urban storm water runoff, direct pumping, or landscape modifications for water storage.	
Natural sources have been **eliminated** based on the following indicators: impoundment of all wet season inflows, diversions of all dry-season inflows, predominance of xeric vegetation, etc. The wetland is in steady decline and may not be a wetland in the near future.	

Water Source/ inputs comments:

4b. HYDROPERIOD

Select the statement below that best describes the **hydroperiod** within the AA (extent and duration of inundation and/or saturation). **Use the water source, hydrologic stressor and wetland landscape and management context tables to determine the overall condition of the hydroperiod.** For some wetlands, this may mean that water is being channelized or diverted away from the wetland. For others, water may be concentrated or increased.

Hydroperiod is characterized by natural patterns of filling or inundation and drying or drawdowns. There are no major hydrologic stressors that impact the natural hydroperiod.	
Hydroperiod filling or inundation patterns deviate slightly from natural conditions due to presence of stressors such as: small ditches or diversions; berms or roads at/near grade; minor pugging by livestock; or minor flow additions. Outlets may be slightly constricted. Playas are not significantly pitted or dissected. *If hydrology is artificially controlled,* the management regime closely mimics a natural analogue (it is very unusual for a purely artificial wetland to be rated in this category).	
Hydroperiod filling or inundation and drying patterns deviate moderately from natural conditions due to presence of stressors such as: ditches or diversions 1–3 ft. deep; two lane roads; culverts adequate for base stream flow but not flood flow; moderate pugging by livestock that could channelize or divert water; shallow pits within playas; or moderate flow additions. Outlets may be moderately constricted, but flow is still possible. *If hydrology is artificially controlled,* the management regime approaches a natural analogue. Site may be passively managed, meaning that the hydroperiod is still connected to and influenced by natural high flows timed with seasonal water levels.	

Hydroperiod filling or inundation and drawdown of the AA deviate substantially from natural conditions from high intensity alterations such as: a 4-lane highway; large dikes impounding water; diversions > 3ft. deep that withdraw a significant portion of flow, deep pits in playas; large amounts of fill; significant artificial groundwater pumping; or heavy flow additions. Outlets may be significantly constricted, blocking most flow. *If hydrology is artificially controlled,* the site is actively managed and not connected to any natural season fluctuations, but the hydroperiod supports natural functioning of the wetland.	
Hydroperiod is dramatically different from natural. Upstream diversions severely stress the wetland. Riverine wetlands may run dry during critical times. *If hydrology is artificially controlled,* hydroperiod does not mimic natural seasonality. Site is actively managed for filling or drawing down without regard for natural wetland functioning.	

4c. HYDROLOGIC CONNECTIVITY

Select the statement below that best describes the degree to which **hydrology within the AA is connected to the larger landscape** throughout the year, but particularly at times of high water. **Use the water source, hydrologic stressor and wetland landscape and management context tables to determine the overall condition of hydrologic connectivity.** Consider the effect of impoundments, entrenchment, or other obstructions to connectivity that occur within the surrounding landscape, if those impoundments clearly impact the AA.

General criteria	***Riverine variant***	***Playa variant***	
Nothing obstructs lateral or vertical movement of surface or ground waterIf wetland depends on perched water table then impermeable soil layer (fragipan or duripan) is intact. Rising water in the site has unrestricted access to adjacent upland, without levees, excessively high banks, artificial barriers, or other obstructions to the lateral movement of flood flows.	Completely connected to floodplain (backwater sloughs and channels). No geomorphic modifications have been made to contemporary floodplain. Channel is not entrenched.	Surrounding land cover / vegetation does not interrupt surface flow. No artificial channels feed water to playa.	
Constructed levees or road grades limit the amount of adjacent transition zone or the lateral movement of floodwaters for <50% of the AA boundary. Restrictions may be intermittent along the margins of the AA, or they may occur only along one bank or shore.	Minimally disconnected from floodplain. Up to 25% of stream banks are affected by constructed levees or road grades and/or channel is somewhat entrenched.	Surrounding land cover / vegetation does not interrupt surface flow. Artificial channels may feed minor amounts of water to playa.	
Constructed features such as levees or road grades border 50–90% of the boundary of the AA. Flood flows may overtop the obstructions, but drainage out of the AA is probably obstructed.	Dikes, tide gates, or elevated culverts affect 25-75% of stream banks. Channel may be moderately entrenched and disconnected from the floodplain except in large floods.	Surrounding land cover / vegetation may interrupt surface flow. Artificial channels may feed moderate amounts of excess water to playa.	
Constructed features such as levees or roadbeds border >90% of the boundary of the AA.	Channel is severely entrenched and entirely disconnected from the floodplain.	Surrounding land cover / vegetation may dramatically restrict surface flow. Artificial channels may feed significant amounts of excess water to playa.	

Hydroperiod and hydrologic connectivity comments:

4. PHYSIOCHEMICAL METRICS – Check the applicable box.

3a. WATER QUALITY - SURFACE WATER TURBIDITY / POLLUTANTS

Select the statement that best describes the **turbidity or evidence or pollutants** in surface water within the AA.

No open water in AA	
No visual evidence of degraded water quality. No visual evidence of turbidity or other pollutants.	
Some negative water quality indicators are present, but limited to small and localized areas within the wetland. Water is slightly cloudy, but there is no obvious source of sedimentation or other pollutants.	
Water is cloudy or has unnatural oil sheen, but the bottom is still visible. Sources of water quality degradation are apparent (identify in comments below). *Note: If the sheen breaks apart when you run your finger through it, it is a natural bacterial process and not water pollution. Riverine wetlands can be turbid if flood waters are high*	
Water is milky and/or muddy or has unnatural oil sheen. The bottom is difficult to see. There are obvious sources of water quality degradation (identify in comments below). *Note: If the sheen breaks apart when you run your finger through it, it is a natural bacterial process and not water pollution. Riverine wetlands can be turbid if flood waters are high*	

Surface water turbidity / pollutants comments and photo #'s:

3b. WATER QUALITY - ALGAL GROWTH

Select the statement that best describes **algal growth** within surface water in the AA.

No open water in AA or evidence of open water.	
Water is clear with minimal algal growth.	
Algal growth is limited to small and localized areas of the wetland. Water may have a greenish tint or cloudiness.	
Algal growth occurs in moderate to large patches throughout the AA. Water may have a moderate greenish tint or sheen. Sources of water quality degradation are apparent (identify in comments below).	
Algal mats are extensive, blocking light to the bottom. Water may have a strong greenish tint and the bottom is difficult to see. There are obvious sources of water quality degradation (identify in comments below).	

Algal growth comments and photo #'s:

Algal growth may be natural and not necessarily indicative of poor water quality. If algal growth appears natural, describe and record % of total algae that is due to natural processes.

3c. SUBSTRATE / SOIL DISTURBANCE

Select the statement below that best describes disturbance to the substrate or soil within the AA. For playas, the most significant substrate disturbance is sedimentation or unnaturally filling, which prevents the system's ability to pond after heavy rains. For other wetland types, disturbances may lead to bare or exposed soil and may increase ponding or channelization where it is not normally. For any wetland type, consider the disturbance relative to what is expected for the system.

No soil disturbance within AA. Little bare soil OR bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails OR soil is naturally bare (e.g., playas). No pugging, soil compaction, or sedimentation.	
Less than 10% of the AA affected by some amount of bare soil, pugging, compaction, or sedimentation present due to human causes. The depth of disturbance is limited to 1 – 2 inches and does not show evidence of altering hydrology or vegetation growth at the site	
10 –25% of the AA has bare soil areas due to human causes are common. There may be pugging due to livestock resulting in several inches of soil disturbance. Sedimentation may be filling the wetland. Damage is obvious, but not excessive.	
25-50% of the AA has bare soil areas due to human causes are common. ORVs or other machinery may have left some shallow ruts < 3 inches deep or livestock pugging and/or trails are widespread. Unnatural hummocks created by livestock, wild horses, or native ungulates present, especially when the site lacks hummock forming vegetation. These hummocks typically have sheer edges with exposed soil. Compaction and disturbance change water moment in the site and affect vegetation growth. Sedimentation may have severely impacted the hydrology.	
Greater than 50% off the AA has bare soil areas that substantially degrade the site and have led to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, Unnatural hummocks created by livestock, wild horses, or native ungulates present, especially when the site lacks hummock forming vegetation. These hummocks typically have sheer edges with exposed soil. Sedimentation has dried the wetland.	

Substrate / soil comments and photo #'s:

3d. PHYSIOCHEMICAL STRESSORS WITHIN THE AA

Using the table below, estimate the independent scope of each physiochemical stressor within the AA. Independent scopes can overlap (e.g., soil compaction can occur with trash or refuse). ***Scope rating: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.***

Physiochemical stressor categories	*Scope*
Erosion	
Sedimentation	
Current plowing or disking	
Historic plowing or disking (evident by abrupt A horizon boundary at plow depth)	
Substrate removal (excavation)	
Filling or dumping of sediment	
Trash or refuse dumping	
Compaction and soil disturbance by livestock, wild horses, or native ungulates < 3 inches deep	
Compaction and soil disturbance by livestock, wild horses, or native ungulates > 3 inches deep	
Unnatural hummocks created by livestock, wild horses, or native ungulates. These typically have sheer edges with exposed soil. Site lacks hummock forming vegetation	

Compaction and soil disturbance by human use (trails, ORV use, camping) < 3 inches deep	
Compaction and soil disturbance by human use (trails, ORV use, camping) > 3 inches deep	
Mining activities, current or historic	
Obvious point source of water pollutants (discharge from waste water plants, factories)	
Agricultural runoff (drain tiles, excess irrigation)	
Direct application of agricultural chemicals	
Discharge or runoff from feedlots	
Obvious excess salinity (dead or stressed plants, salt encrustations)	
Other:	
Physiochemical stressor comments:	

AREM Long Form

Please evaluate the wetland or riparian habitat within the **200 meter** buffer when answering the below questions. Do not consider upland habitat except for questions 16 – 21. For each numbered item, check only one response unless noted otherwise. Then proceed to the next question unless noted otherwise. Parenthetical names are the names of fields in the supporting software database (WHRBASE). If a field name is lacking, the information is not used directly.

Note: 1 Acre = .5 hectares

1. Season: Migratory__________ Breeding__________Winter__________
2. LOCATION. Is the area part of, or is it within 0.5 mile of, a major* river or lake?
   ** river channel wider than 100 ft, or lake larger than 40 acres*
   ____ Yes (field BigWater) ____ No
3. SURFACE WATER. During this season, does the area contain at least 0.1 acre* of surface water, either obscured by vegetation or not?
   ** See Figure B-1 for guidance in estimating acreage categories.*
   ____ Yes (field AnyWater). Go to next question.
   ____ No. **Skip to question #5.**
4. OPEN WATER. During this season, how much open* water is present in the area?
   ** water deeper than 2 inches and mostly lacking vegetation (except submerged plants).*
   ____ > 20 acres and it is mostly wider than 500 ft (field OpenBig)
   ____ < 1 acre, or, >1 acre but mostly narrower than 3 ft (field OpenSmall)
   ____ Other conditions (field OpenOther)
5. SPECIFIC AQUATIC CONDITIONS
   Check all that apply during this season:
   ____ > 0.1 acre of the surface water is still, i.e., usually flows at less than 1 ft/s (field StillWater)
   ____ The evaluated area can be assumed to contain fish (field Fish)
   ____ The evaluated area can be assumed to contain frogs, salamanders, and/or crayfish (field Amphibs)
   ____ Water transparency in the deepest part of the area is (or would be, if depth is shallow) sufficient to see an object 10 inches below the surface, and the area is not known to have problems with metal contamination (field Clear)
   ____ The evaluated area is highly enriched by direct fertilizer applications, water from nearby feedlots, or other sources (field Enriched)
   ____ Most of the normally-flooded part of the area goes dry at least one year in five, or, is subject to flooding from a river at least as often (field Drawdown)
6. BARE SOIL. Is there at least 0.1 acre of mud*, alkali flat, gravel/sand bar, recently tilled soil, and/or heavily grazed open (grassy, non-shrubby) areas during this season?
   ** includes soil that is continually saturated up to the surface, or which was previously covered by water but has become exposed to the air during this period*
   ____ Yes (field Bare). Go to next question.
   ____ No. **Skip to question #7.**
7. LARGE MUDFLAT. Does the area at this season contain mud that has all these features?:
   - At least 1 acre in size
   - Maximum dimension is greater than 100 ft
   - Salt crust or salt stains are not apparent
   - Not recessed within a wash or canal whose depth (relative to surrounding landscape) is greater than half its width.

   ____ Yes (field MudBig) ____ No

8. TREES. Are there at least 3 trees*:
   ** woody plants taller than 20 ft.*
   ____ in the evaluation area? (field TreeIn).
   ____ within 1000 ft of the evaluation area? (field TreeNear). **Go to #8.**
   ____ neither of the above. **Skip to #11.**
9. TREE COVER. Check one or more responses below that describe the maximum cumulative acreage of various conditions of tree cover in the evaluation area. Also include areas within 300 ft:
   ____ >1 acre, dense*, and wide** (field ForestDens)
   ____ >1 acre and open; or, dense but narrow (field ForestOpen)
   ____ 0.1-1 acre, dense* (field WoodDens)
   ____ 0.1-1 acre, open (field WoodOpen)
   ____ <0.1 acre
   ** Dense= the tree canopy, viewed from the ground during midsummer, appears at least 50% closed, as averaged across an area that is at least as large as the acreage specified.*
   *** Wide= the wooded area is wider than 300 ft (average).*
10. BIG TREES. Are there at least three trees whose trunk diameter 20 ft above the ground is >12 inches?
    ____ Yes (field TreesBig) ____ No
11. SNAGS. Are there at least three snags, or trees with dead limbs with diameter >5 inches?
    ____ Yes (field Snags) ____ No
12. SHRUBS. Is there at least 0.1 acre of shrubs*:
    ** woody plants 2-20 ft in height.*
    ____ in the evaluation area? (field ShrubIn).
    ____ within 1000 ft of the wetland (including the wetland itself)? (field ShrubNear). **Go to #12.**
    ____ Neither of the above. **Skip to #13.**
13. SHRUB SPECIES AND DENSITY. Check one or more responses below that describe the maximum cumulative extent of various types and conditions of shrub cover in the evaluation area. Also include areas within 300 ft.
    Willow:
    ____ >1 acre, dense*, and wide** (field WwMuchDens)
    ____ >1 acre and open; or, dense but narrow (field WwMuchOpen)
    ____ 0.1-1 acre, dense* (field WwSomeDens)
    ____ 0.1-1 acre, open (field WwSomeOpen)
    ____ <0.1 acre; or larger area but height mostly <4 ft and openly spaced

    Greasewood or other tall desert shrubs:
    ____ >1 acre, dense*, and wide** (field GrMuchDens)
    ____ >1 acre and open; or, dense but narrow (field GrMuchOpen)
    ____ 0.1-1 acre, dense* (field GrSomeDens)
    ____ 0.1-1 acre, open (field GrSomeOpen)
    ____ <0.1 acre

    Russian olive, sumac, buffaloberry, wild rose, or others with fleshy fruit:
    ____ >1 acre, dense*, and wide** (field FrMuchDens)
    ____ >1 acre, open; or, dense but narrow (field FrMuchOpen)
    ____ 0.1-1 acre, dense (field FrSomeDens)
    ____ 0.1-1 acre, open (field FrSomeOpen)
    ____ <0.1 acre; or larger area but height mostly <4 ft

Tamarisk (salt cedar):
____ >1 acre, dense*, and wide** (field TmMuchDens)
____ >1 acre, open; or, dense but narrow (field TmMuchOpen)
____ 0.1-1 acre, dense (field TmSomeDens)
____ 0.1-1 acre, open (field TmSomeOpen)
____ <0.1 acre; or larger area but height mostly <4 ft

** Dense= the shrub canopy, as viewed from a height of 100 ft during midsummer, appears to be >50% closed, as averaged across an area that is at least as large as the acreage specified.*
*** Wide= the shrub area is wider than 300 ft (average).*

14. HERBACEOUS VEGETATION. Is there at least 0.1 acre of herbaceous vegetation*:
** Nonwoody plants such as cattail, bulrush, sedges, grasses, and forbs.*
____ in the evaluation area? (field HerbIn).
____ within 1000 ft? (field HerbNear). **Go to #14.**
____ Neither of the above. **Skip to #15.**

15. HERBACEOUS SPECIES. Check one or more responses below that describe the maximum cumulative extent of various types and conditions of shrub cover in the evaluation area. Also include areas within 300 ft.

Robust emergents (e.g., cattail, phragmites)
____ >1 acre, dense*, and wide** (field RbMuchDens)
____ >1 acre, open; or dense but narrow (field RbMuchOpen)
____ 0.1-1 acre, dense (field RbSomeDens)
____ 0.1-1 acre, open (field RbSomeOpen)

Other wet** emergents (e.g., bulrush, sedge)
____ >1 acre, dense*, wide**, and tall*** (field WEMuchDens)
____ >1 acre, tall, open; or dense but narrow (field WEMuchOpen)
____ >1 acre, dense or open, and short (field WEMuchShrt)
____ 0.1-1 acre, tall, dense (field WESomeDens)
____ 0.1-1 acre, tall, open; or dense but narrow (field WESomeOpen)
____ 0.1-1 acre, dense or open, and short (field WESomeShrt)

Drier emergents (e.g., saltgrass, other grasses
____ >1 acre, dense*, wide**, and tall*** (field DEMuchDens)
____ >1 acre, tall, open; or dense but narrow (field DEMuchOpen)
____ >1 acre, dense or open, and short (field DEMuchShrt)
____ 0.1-1 acre, tall, dense (field DESomeDens)
____ 0.1-1 acre, tall, open; or dense but narrow (field DESomeOpen)
____ 0.1-1 acre, dense or open, and short (field DESomeShrt)

Broad-leaved Forbs (e.g., milkweed, thistle, alfalfa)
____ >1 acre (field ForbMuch)
____ 0.1-1 acre (field ForbSome)

Aquatic plants (e.g., watercress, sago pondweed, duckweed)
____ >10 acres (field AqMuch)
____ 0.1-10 acres (field AqSome)

** Dense= plants are so close together that the duff layer or soil beneath the plants is mostly obscured by foliage, when looking down from just above the plant tops.*
*** Wet= water is visible at or above the soil surface during most of the growing season.*
**** Wide= the shrub area is wider than 300 ft (average).*
***** Tall= taller than 1 ft.*

16. SURROUNDING LAND COVER (includes wetland and upland habitat). Check one:
    Within 0.5 mi of the wetland, >60% of the land cover is:
    ____ Pasture, alfalfa, grain crops, row crops, other wetlands, grass lawns, and/or weed fields (field SurAgwet)
    ____ Desert shrubs (e.g., sagebrush, shadscale, rabbitbrush)(field SurDesrt)
    ____ Pinyon-juniper (field SurPJ)
    ____ Oak scrub (e.g., Gambel oak, serviceberry, skunkbrush)(field SurOak)
    ____ Other, or none of the above comprise >60%
17. LOCAL LAND COVER (includes wetland and upland habitat). Check one:
    Within 3 mi of the wetland, > 60% of the land cover is:
    ____ Pasture, alfalfa, grain crops, row crops, other wetlands, grass lawns, and/or weed fields (field LocAgWet)
    ____ Desert shrubs (e.g., sagebrush, shadscale, rabbitbrush)(field LocDesrt)
    ____ Pinyon-juniper (field LocPJ)
    ____ Oak scrub (e.g., Gambel oak, serviceberry, skunkbrush)(field LocOak)
    ____ Other, or none of the above comprise >60%
18. VISUAL SECLUSION
    Check only one:
    ____ Both of the following:
    (a) wetland is seldom visited by people on foot or boat (less than once weekly), (b) there are no paved roads within 600 ft, or if there are, wetland is not visible from the roads (field SeclusionH).
    ____ Either (a) or (b) above (field SeclusionM).
    ____ Other condition.
19. PREDATION POTENTIAL
    Check only one. The evaluation area:
    ____ is linear*, adjoins a heavily-traveled road (usual maximum of >1 car/minute), and/or is in a high-density housing area (>1 house/5 acres) (field PredHPot)
    ____ adjoins a less-traveled road, and/or is in an area with sparser housing density but is closer than 1000 ft to a normally-occupied building (field PredMPot)
    ____ Other condition.
    ** at least 90% of the area being evaluated is within 25 ft of a canal, road, railroad tracks, or other artificially linear feature.*
20. GRAZED, BURNED, MOWED. Is the area mowed, burned, or grazed intensively (i.e., with clearly visible effects on vegetation) during this season?
    ____ Yes (field GrazBurnMo)
    ____ No
21. NESTING LOCATIONS
    Check all that apply:
    ____ Semi-open structures (bridges, barns) suitable for nesting swallows are present within 300 ft (field SwallNest)
    ____ Platforms suitable for nesting geese are present in the wetland or along its perimeter (field GooseNest)
    ____ Vertical, mostly bare dirt banks at least 5 ft high are present within 0.5 mi., of potential use to nesting kingfishers, barn owls, and swallows (field Banks

APPENDIX D. Scoring formulas for Ecological Integrity Assessment wetland condition scores.

Table D.1. EIA ranks and definitions adapted from (Lemly and Gilligan 2013).

Rank	***Condition Category***	***Interpretation***
A	**Excellent / Reference Condition (No or Minimal Human Impact)**	Wetland functions within the bounds of natural disturbance regimes. The surrounding landscape contains natural habitats that are essentially unfragmented with little to no stressors; vegetation structure and composition are within the natural range of variation, nonnative species are essentially absent, and a comprehensive set of key species are present; soil properties and hydrological functions are intact. Management should focus on preservation and protection.
B	**Good / Slight Deviation from Reference**	Wetland predominantly functions within the bounds of natural disturbance regimes. The surrounding landscape contains largely natural habitats that are minimally fragmented with few stressors; vegetation structure and composition deviate slightly from the natural range of variation, nonnative species and noxious weeds are present in minor amounts, and most key species are present; soils properties and hydrology are only slightly altered. Management should focus on the prevention of further alteration.
C	**Fair / Moderate Deviation from Reference**	Wetland has a number of unfavorable characteristics. The surrounding landscape is moderately fragmented with several stressors; the vegetation structure and composition is somewhat outside the natural range of variation, nonnative species and noxious weeds may have a sizeable presence or moderately negative impacts, and many key species are absent; soil properties and hydrology are altered. Management would be needed to maintain or restore certain ecological attributes.
D	**Poor / Significant Deviation from Reference**	Wetland has severely altered characteristics. The surrounding landscape contains little natural habitat and is very fragmented; the vegetation structure and composition are well beyond their natural range of variation, nonnative species and noxious weeds exert a strong negative impact, and most key species are absent; soil properties and hydrology are severely altered. There may be little long term conservation value without restoration, and such restoration may be difficult or uncertain.

Table D.2. EIA methods for scoring.

1. The score for each EIA submetric was calculated using the equations below.

    Landscape Context Score:
    (Landscape Fragmentation * 0.4) + ([(Buffer Width * Buffer Extent)$^{1/2}$ * ((Buffer Condition + Buffer Natural Cover)/2)]$^{1/2}$ * 0.6)

    Biotic Condition Score:
    (Relative Cover Native Plant Sp. * 0.2) + (Absolute Cover Noxious Weeds * 0.2) + (Mean C * 0.4) + (Horizontal Interspersion * 0.2)

    Hydrologic Condition Score:
    Landscape Hydrology Metric score

    Physicochemical Condition Score:
    (Surface Water Quality * 0.25) + (Algal Growth * 0.25) + (Substrate/Soil Disturbance * 0.5)
    If no standing water was present, score = Substrate/Soil Disturbance.

2. EIA score was calculated using submetric scores:
    EIA Score:
    (Landscape Context * 0.2) + (Biotic Condition * 0.4) + (Hydrologic Condition * 0.3) + (Physicochemical Condition * 0.1)

3. Score to rank conversion:

    A = 4.5 – 5.0
    B = 3.5 – <4.5
    C = 2.5 - <3.5
    D = 1.0 - <2.5

Appendix E: Indicators of Disturbance Categories

Category	Stressor Type	Landscape	Hydrology	Physiochemistry	Vegetation
Agriculture	Agriculture – permanent crop (hay pasture, vineyard, orchard, tree plantation)	x			
	Agriculture – tilled crop production	x			
	Current plowing or disking			x	
	Haying of native grassland (not dominated by non-native hay grasses)				x
	Recent old fields and other fallow lands dominated by non-native species (weeds or hay)	x			x
Browse	Heavy browse (at least 2/3 of woody plants have been browsed) by livestock or native ungulates	x			x
	Moderate browse (at least 1/3 to 2/3 of woody plants have been browsed) by livestock or native ungulates	x			x
	Light browse (< 1/3 of woody plants have been browsed) by livestock or native ungulates	x			x
Development	Domestic or commercially developed buildings	x			
Filling	Filling or dumping of sediment		x	x	
	Sedimentation			x	
Grazing	Heavy grazing: (> 2/3 of herbaceous plants have been grazed) by livestock or native ungulate	x			x
	Moderate Grazing: (at least 1/3 to 2/3 of herbaceous plants have been grazed) by livestock or native ungulate	x			x
	Light Grazing: (< 1/3 of herbaceous plants have been grazed) by livestock or native ungulates	x			x

Category	Stressor Type	Landscape	Hydrology	Physiochemistry	Vegetation
Invasive Species	Invasive Species	x			x
Irrigation Infrastructure	Ditches < x feet deep are present		x		
	Ditches > 3 feet deep are present		x		
	Ditches x foot to 3 feet deep are present		x		
	Diversion structures < x foot tall are present		x		
	Diversion structures > 3 feet tall are present		x		
	Diversion structures x foot to 3 feet tall are present		x		
	Irrigation ditches, berms, head gates that change how water moves	x			
	Spring box diverting water from wetland		x		
	Weir or drop structure that impounds water and controls energy of flow		x		
Natural	Beetle-killed conifers	x			x
	Evidence of recent fire (<5 years old, still very apparent on vegetation, little regrowth)	x			x
Pollution	Agricultural runoff (drain tiles, excess irrigation)			x	
	Direct application of agricultural chemicals			x	
	Discharge or runoff from feedlots			x	
	Observed or potential agricultural runoff		x		
	Obvious point source of water pollutants (discharge from waste water plants, factories)			x	
	Trash or refuse dumping	x		x	

Category	Stressor Type	Landscape	Hydrology	Physiochemistry	Vegetation
Recreation	Intense recreation or human visitation (ATV use / camping / popular fishing spot, etc.)	x			x
	Intensively managed golf courses, sports fields, urban parks, expansive lawns	x			
	Moderate recreation or human visitation (high-use trail)	x			x
	Light recreation or human visitation (low-use trail)	x			x
Resource Extraction	Gravel pit operation, open pit mining, strip mining	x			
	Logging or tree removal with 50-75% of trees >50 cm dbh removed	x			
	Mining (other than gravel, open pit, and strip mining), abandoned mines	x			
	Resource extraction (oil and gas wells and surrounding footprint)	x			
Roads	2-tract or lightly used farm road that coauses fragmentation or alters the lateral movement of water	x	x		x
	2-lane road crosses that alters forward or lateral movement of water		x		
	4-lane road crosses that alters forward or lateral movement of water		x		
	Culvert appears large enough to accommodate base flow and flood flows		x		
	Culvert appears large enough to accommodate base flow but not flood flows		x		
	Culvert too small to accommodate base flow		x		
	Paved roads, parking lots, railroad tracks	x			

Category	Stressor Type	Landscape	Hydrology	Physiochemistry	Vegetation
Soil Degradation	Compaction and soil disturbance by human use (trails, ORV use, camping) < 3 inches deep			x	
	Compaction and soil disturbance by human use (trails, ORV use, camping) > 3 inches deep			x	
	Compaction and soil disturbance by livestock, wild horses, or native ungulates < 3 inches deep			x	
	Compaction and soil disturbance by livestock, wild horses, or native ungulates > 3 inches deep			x	
	Erosion			x	
	Historic plowing or disking (evident by abrupt A horizon boundary at plow depth)			x	
	Mining activities, current or historic			x	
	Obvious excess salinity (dead or stressed plants, salt encrustations)			x	
	Pugging by livestock, native ungulates, or wild horses that alters water movement in the site		x	x	
	Substrate removal (excavation)			x	
Veg Conversion	Litter is extensive and limits new growth (thick cattails litter)				x
	Logging or tree removal with 50-75% of trees >50 cm dbh removed				x
	Selective logging or tree removal with <50% of trees >50 cm dbh removed	x			x
	Surrounding land cover / vegetation that interrupts surface flow		x		
	Vegetation conversion (chaining, cabling, rotochopping, clear-cut)	x			x
Water Development	Berms present that impede forward or lateral movement of water		x		
	Dam sites and flood disturbed shorelines around water storage reservoirs	x			
	Dug pits for holding water		x		
	Impoundment / stock pond		x		
	Large dam / reservoir		x		
	Major irrigation canal		x		