Evaluation of Environmental Flow Management Alternatives for the Bear River Migratory Bird Refuge

Project Progress Report

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1 Introduction

This project entails an analysis of different management alternatives for achieving the target deliveries of the Bear River Migratory Bird Refuge. The supply of water is imperative when addressing wetland issues because water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (US DOI, 2004), which directly affects the habitat of priority bird species. For this reason, this report investigates additional management alternatives to improve summer deliveries to more closely meet the water demand in these months. Each alternative will be evaluated based on the metric of water deliveries to the refuge. The evaluation of the proposed management alternatives will be carried out using the existing Water Evaluation and Planning (WEAP) model for the Lower Bear River system.

How evaluated? what criteria are used?

2 Institutional Review

The Bear River Migratory Bird Refuge (BRMBR) is a sanctuary for native bird species managed by the U.S. Fish and Wildlife Services. The Refuge was established in 1928 and to this day operates under a singular conservation mission to "administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (US DOI, 2004). The BRMBR is approximately 74,000 acres and is located directly upstream of the 112,000 acre Bear River delta (see figure 1 in the appendix). Within the BRMBR, 29,259 acres are managed as freshwater wildlife habitat (US DOI, 2004). This area takes the form of many land use types that are designed to benefit a diversity of wetland plants and migratory bird species that depend on them. In conjunction with the non-watered lands, the refuge provides feeding, breeding, and resting habitat for more than 260 bird species (Downard, 2010).

Most of this section is a hydrologic not institutional review.

The BRMBR area is situated near the Bear River delta of the Great Salt Lake. The Bear River Basin, located in northern Utah, southeast Idaho, and southwest Wyoming encompasses an area of 4.8 million acres (US DOI, 2004). With 500 miles of flow from its origin in the Uintah Mountains to the Great Salt Lake, the Bear River is noted for being the longest flowing river in the western hemisphere that doesn't reach the ocean. Of the water supplied to the Bear River, 60% comes from the Bear River Mountain Range in the form of spring snowmelt. The region is in the rain shadow of the Cascade and Sierra Mountain Ranges resulting in a semiarid climate that on average provides 12.5 inches of precipitation to the refuge annually. Therefore, each years winter snowpack is crucial for recharging the Bear River and maintaining flows throughout the dry summer months.

2.1 Objectives of the BRMBR

The objectives specific to the BRMBR relate to the management or manipulation of target water levels of wetland units to foster desired species occupation with primary attention to the needs of priority bird species. This includes the maintenance, recovery and enhancement of plant and wildlife values. However, problems exist within the wetlands that need to be addressed to meet the objectives of the Refuge. These challenges, among acquiring target environmental flows, include the revival of pre-flood (1983-1988) populations of nesting waterfowl species, control of noxious and invasive species abundance (post-flood), and reduction of pest fish species (carp) that occupy some wetland units.

Not all objectives of the refuge can be met on an annual basis. The maintenance, recovery, and enhancement of plant and wildlife within the refuge are dependent on water availability; primarily form the Bear River, which may be unobtainable in drier years. Due to the variability in annual flows to the BRMBR, managers have developed an adaptive management strategy that prioritizes certain species and wetland units when shortages occur. The goal of this strategy is also to formulate future policies based on what is learned from effects of previous management efforts and protect the resilience of the ecosystems.

2.2 BRMBR Water Demands

this means what?

The BRMBR uses water to manage species diversity and success. Wetlands within the refuge are managed by a series of dikes and canals that impound and transport the water to individual wetland units. In total, the BRMBR has 26 units divided by 96 miles of dikes (Downard, 2010). This allows the BRMBR managers to control the depth of water for individual units, which creates a variety of wetland habitats to accommodate priority bird species needs. In order to maintain good water quality in the units managers seasonally drain them in a process called drawdown. This is a beneficial practice that helps mitigate the spread of diseases (i.e. avian botulism) and restores a more natural hydroperiod in wetlands (Downard, 2010). A constraint to this, however, is the seasonal timing of the drawdown, which may disrupt the benefits of this practice depending on how quickly near future water deliveries can recharge these units.

The water needs of wetlands in the Bear River Basin were originally determined by modeling done by the Utah Division of Water Rights, which calculated the amount needed to manage salinity and water loss. Improvements to the model were made by the USFWS in the 1990s, which took into account water depths for different habitat types, salinity, losses from evapotranspiration and seepage, and volumes needed for flushing (UT DWR, 2009). The volumes deemed necessary by the model are included in **Error! Reference source not found.** of the appendix.

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2.2.1 Wetland marshes

The wetland marshes, comprised of 29,259 acres, account for the refuge's largest water needs. These units make up differing soil development and types of plants and animal communities that are directly related to the depth of water. The different wetland types at the BRMBR are deep and shallow submergent, and deep, mid-depth, and shallow emergent. Deep submergent marshes take up 2,500 acres and are filled with 18-36 inches of water at any given time. The shallow submergent marshes cover 8,700 acres and are filled with 4-18 inches of water. The emergent make up 2,800 acres, 6,600 acres, and 8,659 acres of marshes with water depths of 12-24 inches, 8-12 inches, and 2-8 inches respectively.

Summarize in a table. Ditto for subsequent sub-sections.

2.2.2 Saltair Mudflats

Another major water need on the refuge comes from the saltair mudflats, which encompass 38,064 acres. This land use consists of strongly saline soils and is nearly barren of vegetation. The two forms of mudflats at the BRMBR are vegetated (31,213 acres) and unvegetated (6,852 acres). Water needs are negligible for the unvegetated area as it only receives small amounts of sheet water from snowmelt or heavy rainfall events. However, management of the vegetated mudflats requires the area to be inundated with up to 2 inches of surface water during seasonal high river flows or heavy precipitation.

2.2.3 Additional Water and Land Uses

While wetlands require the largest quantity of water among the land use types, the BRMBR also has water needs for managing 374 acres of wet meadow, consisting of sedges and rushes, and 45.5 acres of riparian habitat along the stream bank of the Bear River channel. The BRMBR also manages less water dependent areas such as semi-desert alkali knolls (522 acres), alkali bottoms (973 acres) and salt meadows (2,625 acres). Alkali knolls are scattered throughout the landscape of the mudflat habitat as abrupt mounds consisting of forbs, grasses, shrubs, and bare ground. Alkali bottoms consist of similar vegetation while its low-lying characteristic provides nesting for waterfowl species. The salt meadows are more heavily vegetated communities that consist of sedges, rushes and saltgrasses. Lastly, the 96 miles of dikes account for 791 acres within the refuge. While dikes have a major role in the impoundment of water with units they also provide a vegetation community, which is dominated by forbs.

2.3 BRMBR Management Strategies and Constraints

Each year the BRMBR develops a Habitat Management Plan that describes how the water will be managed within the wetland units. The decisions are based on the anticipated water supply, which is provided by the annual Natural Resources Conservation Service (NRCS) water supply outlook. The NRCS supplies extensive data in regards to winter snowpack water equivalent, soil moisture, precipitation, and reservoir storage in respect to historical minimums, maximums, and averages. Staff biologists at the BRMBR also use bird survey data with previous water and vegetation management strategies, in what is called adaptive management, to determine the best strategies. The BRMBR has constructed general management goals that the refuge continually seeks reach. However, the successes of most management goals are dependent on seasonal deliveries.

2.3.1 Wetlands

A major concern in the wetland units is the salinity of the water and soil. Freshwater is essential for maintaining species diversity, germination, growth, and production of aquatic plants. The BRMBR manages salinity levels by flushing units with equal inflow and outflow volumes, maintaining water levels to offset evapotranspiration losses, or entire unit drawdowns, which allows salt to wick from the soil and be washed away from the surface upon the net re-flooding cycle. Other goals within the wetland units include the management of water clarity, control of aquatic vegetation community composition, control of aquatic invertebrate abundance and diversity, and the maintenance of structures and levees. While not all these goals are dependent on water, most the challenges associated with reaching these goals are due to seasonal availabilities of water.

Constraints

An all too often issue with this strategy is the timing and amount of water from the Bear River. While spring flows often exceed the delivery targets of the refuge, summer flows tend to be too low to maintain desirable pool elevations on constructed units because of higher net evaporation and a reduction in river flows due to upstream irrigation demands. (US DOI, 2004). Furthermore, the refuge may need to take advantage of high river flows, regardless of the clarity, to meet other management priorities.

What is the constraint (limitation) here?

2.3.2 Saltair Mudflat

The mudflat units are difficult to manage as they are mainly influenced by spring runoff and precipitation events. Thus, often no management action is taken unless river flows are exceptionally high. In which case, habitat can be improved by drawdown of an impounded unit and re-flooding.

Constraints

As with the constraints of wetland units, the timing and amount of water is key to the management decisions taken for mudflat areas. This includes the possibility of being unable to re-fill a unit due to lack of water or a poor clarity of water upon refill (US DOI, 2004).

2.3.3 Additional Water and Land Uses

Additional regions that are water dependent include the wet meadows and the semi-wet streambanks. The BRMBR manages the wet meadows by maintaining water supply and conducting prescribed grazing. The major goal of the semi-wet streambanks is to obtain rich native plant communities.

Constraints

The major constrains associated with the wet meadows is again the timing and amount of water. Semi-wet streambanks face a slightly different problem, which is the prevalence of invasive tamarisk plants. These plants pose an exceptionally higher demand on water than native vegetation and grow in dense thickets with root structures reaching 50 to 100 feet deep. Therefore, tamarisk plants may be considered a constraint on water availability.

3 Current Water Challenges

Forecasting the water availability to the BRMBR occurs on an annual basis. Managers at the BRMBR look at current NRCS snow survey data for the Bear River Basin each season to estimate water supply and timing. However, the quantity and timing of water delivered to the BRMBR can still be uncertain each year. Therefore, the refuge uses adaptive management approaches to prioritize wetland units so that it maximizes migratory bird habitat and puts the water rights of the BRMBR to the most critical and beneficial use.

How is this different than the constraints described in the prior section?

The currently held water rights for the BRMBR were obtained from the "Keeping Wetlands Wet" graduate thesis by Downard. A table including the water source and quantity of these rights, along with the priority date and beneficial use designation is included in the appendix. It is worthy of note that 93% of the flow right in cubic feet per second (cfs) comes from the Bear River. Therefore, improving flows from the Bear River will be the objective of this evaluation.

The BRMBR's primary water right is of 1,000 cfs from the Bear River (UT DWRe, 2010). However, since many user groups in the region made claims to water prior to 1928, the BRMBR is referred to as a junior appropriator, and thus is subject to having their water rights cut off first when shortages occur. In essence, even though the BRMBR has a legal right to 1,000 cfs of water, there is no guarantee water will always be available. Therefore, water security is of great interest for the refuge.

The security of water to the refuge can depend on proposed or available infrastructure and planning for future demands and forecasted availabilities. The implementation structural or non-structural applications can be used to maintain or increase the security of water but comes as a monetary cost to the refuge or as a social cost of conflict among other water user groups. The socially beneficial but most difficult to achieve outcome is an agreement that enhances each user groups water security. Historically, storage and delivery facilities have been implemented to increase water security and reach a beneficial outcome. However, with regional changes in water demands posed by growing populations and subsequent transitions of agricultural lands to developed urban land, it is important the BRMBR managers effectively optimize their infrastructure and planning procedures to ensure water security for the refuge in the future. Therefore, management alternative must be considered now, before shortages have a detrimental impact on the BRMBR.

Very general, vague. More of an Intro statement.

Means what here? What is being maximized or minimized? Using what decisions & under what constraints?

The BRMBR already faces very unreliable flows with its primary source delivering far lower quantities than the refuge needs during the peak irrigation season, which occurs in the late summer months. The supply of water is imperative when addressing wetland issues because water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (US DOI, 2004), which directly affects the habitat of the priority bird species. Thus, there is a need to investigate additional management alternatives to improve summer deliveries to more closely meet the water demand in these months.

4 Quantitative Metrics for Evaluating Alternatives

There are many variables of concern in management of ideal summer habitat for the priority species, including water volumes, water quality (salinity and stagnation), vegetation, invertebrates, and invasive species management. However, most of these parameters depend on water quantity, meaning that successful management of the many important habitat variables is greatly enhanced when there is no shortage of available water. Additionally, water quantity is much easier to quantify than the other quality and habitat parameters, and will be easily integrated into the WEAP model. Therefore, our evaluation will focus on water volume, specifically in achieving deliveries equal to or greater than the summer water delivery targets. This can be done at various time steps, including annual, monthly, and potentially even weekly or daily basis because of the proximity of the USGS "Bear River Near Corinne" stream gage station just upstream on the Bear River before the diversion to the refuge (USGS, 2016). The ability of various alternative structural and non-structural management strategies to meet these targets will be determined using a couple of the following quantitative metrics: reliability, resilience,

Why? Explain.

What are the targets? How determined?

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vulnerability, shortage cost (in terms of habitat value), and firm yield (Loucks, 2005). The use of a "wetland performance metric" which quantifies habitat health as a function of water deliveries using the SWAMPS model, will be considered (Rosenberg).

Explain more. How will the metrics be calculated?

5 Proposed Structural and Non-Structural Management Alternatives

There are many structural and non-structural alternative management strategies that could be employed to improve summer deliveries. An explanation of our top three is given below, along with a discussion as to why they are the preferred alternatives.

5.1 Structural Alternatives

5.1.1 Purchasing storage rights to a proposed upstream reservoir

There have been numerous proposals by the Utah Division of Water Resources (UDWR) to develop storage capacity on the Bear River. The Bear River Development Act, passed by the Utah State Legislature in 1991, gives four development approaches to increasing the available supply of the Bear River, one of which is building a new reservoir in the Bear River Basin. The plan estimates that there are currently 250,000 acre-feet of Bear River water that remains to be developed, and of this nearly 190,000 acre-feet will require new storage. The plan also states that the BRMBR has expressed interest in enlarging Hyrum Reservoir in the southern part of Cache Valley (Bear River Plan, 2004). Enlarging Hyrum Reservoir, as well as assessing storage in other proposed reservoir locations, will be modeled as the primary structural management alternative.

How much storage rights? where?

5.1.2 Aquifer storage and recovery

Aquifer storage and recovery (ASR) has been proposed by the UDWR as a means of meeting future water demands in the Bear River Basin. ASR uses surplus water in wet periods to recharge groundwater aquifers (artificial recharge), which can then be pumped in dry periods when surface flows are low (USGS Aquifer Storage and Recovery). The feasibility of employing this method is site specific and must take into account numerous legal and hydrogeological considerations. Use of this method for improving water deliveries to the BRMBR may be a viable and promising option, but the practicality of it will require further investigation.

How modeled/implemented in WEAP?

5.1.3 Onsite storage of spring excess flows

The refuge typically has more delivery rights in the spring than it needs to meet its target flows. The current water right from the Bear River is 1,000 cfs (61,488 acre-feet/month) but only in the month of May does its demand come close to meeting that volume. A table of the monthly demands is included in the **Error! Reference source not found.** in the appendix. As calculated from the table, if the BRMBR were able to divert the entirety of their 1,000 cfs right, they would divert a total of 737,856 ac-ft/year. However, their monthly demands only add up to 431,541 ac-ft/year, a difference of 306,315 ac-ft. If even a portion of this could be stored onsite in raised basins it could work towards decreasing the summer shortage. The feasibility of this management approach will be assessed.

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How Assessed? Where would the basins be located? How operated? Is this alt. really even plausible?

5.2 Non-Structural Alternatives

Non-structural alternatives to meeting the water delivery targets can be a cost and socio-economically beneficial alternative to structural options. One such viable alternative is explained below. The acquisition of additional water rights was deemed a non-feasible solution for this evaluation, due to past conflicts (and associated distrust), that arose when the refuge once sought to acquire more water via a federal reserved water right claim (Downard, 2014).

How deemed non-feasible? Explain

5.2.1 Agricultural Easements

One of the primary sources of the water that is delivered to the BRMBR in the summer months actually comes from return flows from irrigation. As agricultural land is transitioned to municipal development the water demand shifts from summer irrigation to year-round household and commercial use, smoothing out the return flow/discharge hydrograph and decreasing summer return flows. This important fact links the success of the summer flows to the refuge to agriculture, creating incentive for BRMBR managers to "communicate with other users about their water use plans and the refuge's needs during this critical season" (Downard, 2014). Creating support for the continued role of agriculture in the region, whether via social support networks or creating economically lucrative agricultural easements for farmers, could be both a short and long term means of ensuring some, albeit maybe small, quantity of summer flows. For this evaluation, we will consider modelling the impact of agricultural easements, and their role in maintaining summer irrigation return flows.

How to model in WEAP?

6 Findings to Date and Future Steps

6.1 Major Findings to Date

The BRMBR and its water needs have a plethora of documentation available, from doctoral dissertations to River Basin planning documents. Due to the combination of being a junior water right holder, its location in the watershed, and the complexity of habitat that it contains, it has had many challenges in meeting water delivery targets deemed necessary for successful summer habitat. It has therefore proved to be an interesting subject for our evaluation. We have mostly collected the pertinent background information and formal documentation to conduct our evaluation. This report contains a summary of what we have found and learned thus far.

6.2 Continuation of this Work

The next step for our group will be to narrow-in on defining exactly how we will measure the quantitative metrics used in our evaluation. Details regarding how we will go about data collection, reasonable assumptions we will need to make, clearly defining our performance metrics, and the practicality of our suggested management strategies will need to be refined. We will also need to assess how well the aforementioned metrics will integrate into the WEAP model. Then, we will narrow our selection to one to three proposed structural and/or non-structural alternatives and begin to integrate them into the WEAP model. As we proceed we will continually update this progress report with our improvements and findings, as well as receive peer-reviewed feedback on our report. The final product of our efforts will be a professional grade paper which explains critical

Yes. Good observations of what is needed.

issues and challenges faced by a river basin stakeholder, explains the creation of performance metrics to evaluate its current operation, and then proposes a few structural and non-structural alternatives to improve its operation and analyzes the alternatives with the said metrics. Hopefully, this report will serve as a useful document to the stakeholder, the BRMBR, as well as be an educational resource for students involved in river basin/watershed planning and management.

References

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What model is referred to here?

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Appendix

Map of the BRMBR

Figure 1. Online screen shot of the BRMBR depicting the management units. Taken from the Utah Division of Water Rights website.

Not very informative or easy to read. Where is the Refuge located?

Water Rights, Source, and Allocated Flow of the BRMBR.
Bear River Water Rights are in Bold.

Primary Right Holder	Water Right number	Source	Allocated Flow	Point of Diversion
Paul W. and Mary V. Nelson J.T.	29-3172	Stauffer-Packer Spring	1.04 cfs	SURFACE
John Robert Reese Trustee	29-951	Perry Spring Stream	1.0 cfs	SURFACE
USA Fish &Wildlife Services	29-1919	Unnamed Stream	2.4 cfs	SURFACE
USA Fish and Wildlife Services	29-973	Unnamed Stream	2.4 cfs	SURFACE
Grace G. White Trust and LeRoy Clark White Family Trust	29-936	Dan Walker Spring	3.06 cfs	SURFACE
Grace G. White Trust and LeRoy Clark White Family Trust	29-937	Perry Spring Stream	0.56 cfs	SURFACE
USA Fish & Wildlife Service	29-3061	Underground Water Drain (open)	0.002 cfs	POINT TO POINT
USA Fish and Wildlife Service	29-2622	Unnamed Spring Stream	0.015 cfs	POINT TO POINT
USA Fish and Wildlife Service	29-1697	Unnamed Spring Stream	1.0 cfs	SURFACE
Grace G. White Trust and LeRoy Clark White Family Trust	29-3060	Unnamed Spring	1.0 cfs	SURFACE
USA Fish and Wildlife Service	29-1915	Underground Water Drain	1.5 cfs	UNDERGROUND
USA Fish and Wildlife	29-1916	Underground Water Drain	2.0 cfs	UNDERGROUND
USA Fish and Wildlife Service	29-1914	Underground Water Drain	3.0 cfs	UNDERGROUND
USA Fish & Wildlife Services	29-1450	East Slough	7.37 cfs	SURFACE
USA Fish & Wildlife Service	29-3484	Black Slough	45.0 cfs	SURFACE
USA Fish and Wildlife Service	29-768	Underground Water Drain	1.59 cfs	UNDERGROUND
USA Fish and Wildlife Service	29-769	Underground Water Drain	1.114 cfs	UNDERGROUND
USA Fish & Wildlife Service	**29-3485**	**Bear River**	**15.9 cfs**	**SURFACE**
USA Fish & Wildlife Service	**29-3698**	**Bear River**	**2000.0 acre-feet**	**SURFACE**
USA Fish & Wildlife Service	29-3157	Unnamed Stream	0.002 cfs	SURFACE
USA Fish & Wildlife Service	29-770	Underground Water Well	0.01 cfs	UNDERGROUND
USA Fish & Wildlife Service	29-980	Surface Drains	0.5 cfs	SURFACE
USA Fish & Wildlife Service	**29-1014**	**Bear River**	**1000.0 cfs**	**SURFACE**
USA Fish & Wildlife Service	29-1165	Underground Water Well	0.011 cfs	UNDERGROUND
USA Fish & Wildlife Service	29-1330	Underground Water Well	0.134 cfs	UNDERGROUND

USA Fish and Wildlife Service	29-3668	Salt Creek	2468.1267 acre-feet	SURFACE
USA Fish & Wildlife Service	29-3825	Stauffer-Packer Spring	1.04 cfs OR 4.0 acre-feet	SURFACE
USA Fish & Wildlife Service	29-3824	Underground Water Drain	1.0 cfs OR 40.0 acre-feet	SURFACE
USA Fish and Wildlife Service	29-1637	Surface Water	132.88 acre-feet	SURFACE

Table 1. Water Rights of the BRMBR

Note: Data gathered from the Utah Division of Water Rights (2009) online database. Water right numbers for the BRMBR were obtained from Downard, 2010. Water right listed where USA Fish USA Fish & Wildlife Service are not primary water right holders indicate shared water right use with USA Fish & Wildlife Service being a secondary or tertiary water user on that right.

What is the purpose of this column?

Monthly Water Targets of the BRMBR and Historical Bear River Discharges

Month	Water Right Number			Total Flow (ac-ft)	50 Year Average Monthly Flow (ac-ft)
	29-3485	29-3698	29-1014		
Jan			5938	5938	1671.51
Feb			8202	8202	1689.51
Mar			61380	61380	2235.08
Apr			59400	59400	2676.63
May	975.94	750	60077	61802.94	2715.99
Jun	472.23	250	35120	35842.23	2135.43
Jul			56978	56978	668.21
Aug			40868	40868	546.57
Sep	472.23	200	59400	60072.23	827.98
Oct	975.94	400	27424	28799.94	1249.28
Nov	944.46	400	8987	10331.46	1494.15
Dec			1997	1997	1561.80

"Average" is difficult to interpret. Instead show as reliability?

I doubt these digits are significant

Table 2. Water Needs of the BRMBR and Historical Bear River Discharges

Note: Data gathered from the Utah Division of Water Rights (2009) online database. Water right numbers for the BRMBR were obtained from Downard, 2010.

Is this the sum of the prior 3 columns? "Flow" implies something else.