PHASE II EVALUATION
OF
MANAGED RECHARGE
ON THE ESRP
DEVELOPMENT OF RECHARGE FACILITIES

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INTRODUCTION

The report entitled _Feasibility of Large-Scale Managed Recharge of the Eastern Snake River Plain Aquifer System_ (1999) (feasibility report) was the first stage of an expected multi-stage managed recharge evaluation and design process, as such the feasibility report did not adequately explore the many detailed complexities of managed recharge. Further evaluation is showing that estimates of recharge potential documented in the feasibility report are in all probability high for many identified sites particularly those on the western end of the ESRP. A successful recharge program will depend upon a reliable source of water and development of sites that have a known and reliable recharge capacity. This evaluation will outline an appropriate strategy for developing recharge sites with the adequate recharge capacity to provide surety for the long-term success of a recharge program.

RECHARGE CAPACITY

Estimated Recharge Capacity of Proposed Recharge Sites

The feasibility report provided a number of estimates about the capacity of recharge sites across the ESRP. The report provides no mention of how site capacities were determined, but it is suspected that most of the reported recharge rates are high. In most cases, the authors of the feasibility report relied on an average infiltration rate of 6 inches/hour. In some cases, recharge capacity appears to be based on the belief that cracks and crevices in basalt would provide the needed capacity for recharge operations. We believe that estimated recharge capacity should not be based infiltration rates or a reliance on cracks and crevices in the basalt but instead should initially be evaluated using soil permeability (saturated hydraulic conductivity). Recharge rates based upon soil permeability may also be high given the physical and biological impacts to soils during recharge activities. Our experience with the Sugar Loaf site provides a useful example. According to the feasibility study, the Sugar Loaf site had an estimated recharge capacity of 40 cubic feet per second (cfs). However experience has shown that the actual capacity is only 5 – 10 cfs. One large sinkhole at the site did not take the desired amount of water even after extensive excavation. If recharge capacity is estimated using permeability data from the soil survey (Ames 1998)), the capacity for the Sugar Loaf site is calculated at just 11 cfs (Table 1).

Table 3: Soil map units for the Sugar Loaf recharge site and calculated recharge capacity.

Soil Symbol and Map Unit	Major Map Unit Components	Acres	Depth (In)	Clay (Pct)	Permeability (In/hr)	Minimum Ave Permeability (In/hr)	Calculated Recharge (cfs)
107	Banbury	5	0-5	10-15	0.6-2.0	1.3	7
			5-15	25-33	0.6-2.0		
Rock Outcrop-Banbury-Paulville, 2 to 6 percent slope	Paulville	3	0-8	15-22	0.6-2.0	0.4	1
			8-31	24-31	0.2-0.6		
			31-47	16-24	0.6-2.0		
			47-60	10-15	0.6-2.0		
	Rock Outcrop	7	-	-	-		
	Inclusions	2	-	-	2.0-6.0	1.3	3
Total		**17.0**					**11**

Soils at many identified recharge sites contain high amounts of clay, which is expected to limit, recharge capacity. For example, the feasibility report estimated the recharge capacity of the Milepost 31 recharge site at 1500 cfs. In the summer of 2003, a small-scale soils investigation was conducted by the Department with assistance from the Natural Resources Conservation Service (Leah Juarros, personal communication). The soils investigation and data from the soil survey indicated a high percentage of clay within the soil profile. Textural analysis from soil samples taken at the site indicates approximately 30% clay (textured as a clay loam) at a depth of 24 inches. Based on that information and permeability rates (using a minimum average) from the soil survey (Ames 1998), the calculated capacity of the site is 210 cfs (Table 2). If recharge rates are

Table 2: Soil map units for the Milepost 31 recharge site and calculated recharge capacity.

Soil Symbol and Map Unit	Major Map Unit Components	Acres	Depth (In)	Clay (Pct)	Permeability (In/hr)	Minimum Ave Permeability (In/hr)	Calculated Recharge (cfs)
91 Power-McCain, 1 to 4 percent slope	Power	50.0	0-14	18-22	0.6-2.0	0.4	20
			14-28	24-35	0.2-0.6		
			28-72	15-20	0.6-2.0		
	McCain	30.0	0-6	15-22	0.6-2.0	0.4	12
			6-16	18-30	0.2-0.6		
			16-23	10-18	0.6-2.0		
	Inclusions	20.0			0.6-2.0	1.3	26
107 Rock Outcrop-Banbury-Paulville, 2 to 6 percent slope	Banbury	70	0-5	10-15	0.6-2.0	1.3	92
			5-15	25-33	0.6-2.0		
	Paulville	35.0	0-8	15-22	0.6-2.0	0.4	14
			8-31	24-31	0.2-0.6		
			31-47	16-24	0.6-2.0		
			47-60	10-15	0.6-2.0		
	Rock Outcrop	93.0	-	-	-		
	Inclusions	35.0	-	-	-	1.3	46
Total		**333.0**					**210**

based on the minimum permeability rate, the recharge capacity for Milepost 31 drops to 150 cfs. At the K Canal site, the feasibility report estimated the capacity at 500 cfs, but calculations based on permeability data from the soil survey (Ames 1998) show the recharge rate at just over 40 cfs (Table 3).

Table 3: Soil map units for the K Canal Recharge site and calculated recharge capacity.

Soil Symbol and Map Unit	Major Map Unit Components	Acres	Depth (In)	Clay (Pct)	Permeability (In/hr)	Minimum Ave Permeability (In/hr)	Calculated Recharge (cfs)
15 Banbury-Rock Outcrop, 2 to 4 percent slope	Banbury	19.0	0-4	10-15	0.6-2.0	1.3	25
			4-12	25-33	0.6-2.0		
	Rock Outcrop	12.1	-	-	-		
	Inclusions	3.4	-	-	0.6-2.0	1.3	4
92 Power-Owinza Rock Outcrop, 1 to 8 percent slope	Power	7.5	0-8	18-22	0.6-2.0	0.4	3
			8-20	24-35	0.2-0.6		
			20-60	15-20	0.6-2.0		
	Owinza	5.8	0-4	20-26	0.2-0.6	0.03	0
			4-10	45-55	0.0-0.06		
			10-16	35-45	0.06-0.20		
			16-23	28-32	0.2-0.6		
			23-63	15-25	0.2-2.0		
	Rock Outcrop	3.3	-	-	-		
107 Rock Outcrop-Banbury-Paulville, 2 to 6 percent slope	Banbury	7.7	0-5	10-15	0.6-2.0	0.4	3
			5-15	25-33	0.6-2.0		
	Paulville	3.8	0-8	15-22	0.6-2.0	0.4	2
			8-31	24-31	0.2-0.6		
			31-47	16-24	0.6-2.0		
			47-60	10-15	0.6-2.0		
	Rock Outcrop	10.2	-	-	-		
	Inclusions	3.8	-	-	-	1.3	5
Total		**76.6**					**42**

Impacts to Recharge Capacity

Soils in recharge basins should be permeable to facilitate recharge activities. Desirable soils for recharge sites should be sand-gravel mixes, sand, or loamy sands (ACSE 2001). Soils in most of the recharge sites identified in the feasibility report contain silt loam, silty clay loam or clay loam (Unified Classification CL or ML) (Ames 1998). These soils have low saturated hydrologic conductivity rates and are not favorable for recharge activities.

Soil clogging is considered one of the primary problems during the operation of surface recharge systems (ASCE 2001). After recharge operations begin, changes within the top few inches of soils will be the primary factor affecting infiltration capacity of the recharge site (State of California 1978, Bouwer 1998) The new calculated recharge estimates for Milepost 31 and K Canal may still be optimistic, and actual recharge rates would probably be much less. Permeability reported in USDA soil surveys is based partially on soil texture and soil structure, which determine porosity and pore connectivity within the soil profile. When soils are continuously flooded, structure of the soil may be compressed resulting in a decrease of porosity and soil permeability. Soil erosion can also occur within the soil profile where by small clay particles move downward through the soil column filling pores and reducing porosity and permeability (State of California1978).

Porosity can also be reduced as flooded soils reach low redox potential and the break down of organic material slows. The build up of organic matter clogs soils pores resulting in a decrease of infiltration. The growth of anaerobic bacteria and their secretion of biofilms in these reduced conditions can also reduce infiltration by filling pore space on the soil surface (Mattison 2002, Seki 1998). The loss of soil porosity and resulting decrease in permeability would further reduce recharge capacity. Algal growth can be another important factor in clogging of recharge basins. The long hydraulic residence time in basins like Milepost 31 are conducive to the growth of algae and algal mats that can reduce recharge capacity.

The depth of water (25 to 30 feet) at the Milepost 31 site also has the potential to reduce recharge rates. While the additional head may help move water through the soil profile, it can also compress restrictive layers, reducing porosity and infiltration rates (Bouwer and Rice 1989). Most constructed recharge sites are less than one meter depth. Given its topography and low permeability soils, the site at Milepost 31 may be better suited for the storage of water than for recharge.

Subsurface geology can also have a dramatic impact to recharge capabilities. Geophysical logs of monitoring wells at the Milepost 31 site indicate massive basalt with "minimal open/or interconnected joints, fractures, and/or vesicularity" (Squires 2000). The upper most 100 feet appears to be the most massive basalts. At the K Canal and Sugar Loaf sites the upper 100 feet of the volcanic section "appear to be moderately fractured and jointed" (Squires 2001). Recharge at K Canal and Sugar Loaf are more probably than at Milepost 31 but further study is probably required to fully evaluate the impacts of subsurface geology on recharge capacity.

Maintenance Requirements

Maintenance of recharge basins will be required after recharge operations begin (ASCE 2001, State of California, 1978). Scarifying or deep ripping of the soil surface will be necessary to maintain permeability. In some instances, it may be necessary to remove algal mats and biofilms that form on the surface of the recharge basins. After several years of operation, it may also be necessary to remove a layer of soil from the infiltration basin to remove organic matter and fine material that can decrease recharge capacity. While the feasibility report does mention maintenance of recharge basins, the use of natural basins complicates the required maintenance because access may be limited or prevented by local topography.

In addition to problems associated with recharge capacity, most of the perennial vegetations will be eliminated by flooding and replaced with annual weed species. The control of weeds is of the utmost importance. Invasive weeds are currently one of the largest ecological threats to rangelands in the western US. The State of Idaho Noxious Weed Law (IC Title 22, Chapter 24) requires the control of Noxious Weeds on private, state and federal property.

PROPOSED ACTION

Constructed Facilities

Given the uncertainty for recharge capacity in natural basins, a prudent course of action is to design and construct engineered recharge facilities. The design and site selection of these facilities should also consider required maintenance. A review of recharge projects across the United States reveals that while some recharge is done through natural streambeds, most recharge is accomplished through constructed infiltration ponds (Figure 1) or injection wells. Recharge facilities are constructed to meet capacity requirements and provide filtration of potential water quality contaminants. These facilities are also constructed to allow for required maintenance to sustain infiltration rates and to control unwanted vegetation. Realistic rates for infiltration in a constructed facility range from two to four feet/day. A facility with a required capacity of 100 cfs and an infiltration rate of three feet/day would need to be 66 acres in size.

Based on the problems associated with "natural basins" discussed previously, and experience with the Sugar Loaf site, we should not rely on natural basins as our mechanism of recharge. Instead, we should design and construct recharge facilities with known recharge capacities. Each site should be designed and constructed to specific standards and recharge requirements. This will require analysis and design at each recharge facility and will undoubtedly increase the capitol cost associated with recharge.

However, the long-term benefits will far outweigh the short-term design and construction expenses. A well-designed and constructed facility would provide surety for recharge rates and allow for more orderly maintenance of the sites. This approach also would provide for additional flexibility in the placement of recharge sites particularly along the Milner-Gooding and North Side canals.

Figure 1: Recharge operations at a constructed facility in Arizona.

Construction of recharge facilities on the ESRP would require removal of over burden to expose bedrock at each site. These constructed facilities would then be back filled with appropriate size material to filter water and provide for a designed infiltration rate. This approach may also require the fracturing of bedrock formations to remove barriers for water entering into subsurface strata, or installation of injection wells. Injection wells, while expensive, may prove to be the best alternative for insuring recharge, particularly if subsurface geology is massive basalts that may mound water under the recharge facility. The layering of backfill into the site would not impede water infiltration but would provide for filtration of water at the surface. The design and construction of these facilities has the potential to decrease the required area for recharge basins (increase recharge/unit area) reducing potential environmental impacts and other related concerns.

The protection of ground water quality is a major concern when recharge is allowed to occur through cracks, crevices and sink holes with little or no surface filtration of potential contaminants. These designed and constructed facilities would reduce or eliminate many potential contaminants from the water column before reaching ground water. This should also reduce monitoring cost by providing a known medium for filtration of potential contaminants.

Costs of Recharge Facility Development

The feasibility report cited the costs for the development of some recharge sites on the ESRP. Those included costs for diversion and turn out structures but did not include costs for the actual development of the recharge site. The recommendations made in this report are likely to substantially increase the cost for recharge site development. However, given the cost for transporting water and site management, the cost for site development are not prohibitive if amortized over 30 years. Based on data from Arizona, a constructed recharge facility with a capacity of 100 cfs would likely cost 4 – 5 million dollars. Table 4 shows the cost/acre-foot amortized over a 30-year period of time.

Table 4: Estimated cost and 30 year amortized cost for the construction and operation of a recharge facility with a 100 cfs capacity supporting an annual recharge of approximately 30,000 acre-feet.

Construction Cost	Deliver Cost of 30,000 acre/year @ $3/acre-foot	Estiamted Annual O&M	Total Expenditures after 30 years*	Total Water Recharge After 30 Years (Acre-feet)	30 Year Amortized Cost/acre-foot
$4,000,000	$90,000	$20,000	$7,179,185	900,000	$7.98

*30 year costs include a 1%/year increase for the deliver cost and 3%/year increase for estimtated O&M.

Conclusions

The implementation of a recharge program for the purposes of mitigation will require a system with a high degree of functional reliability. The use of natural basins, as outlined in the feasibility report, may not provide the degree of reliability required. Additionally, natural basins may not allow for the required maintenance to sustain that reliability and provide aquifer protection. Our limited experience to date has shown that relying on natural basins has been less than successful and we should at a minimum consider large-scale testing before moving forward on any project. The design and construction of managed recharge facilities, while initially expensive, will provide long-term benefits not found with the use of natural basins.

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