8. EAST CANYON CREEK IMPLEMENTATION PLAN

8.1 INTRODUCTION

The East Canyon Creek Implementation Plan outlines a strategy to achieve water quality endpoints identified in the TMDL analysis (Chapter 7) for DO and macrophytes. The implementation plan combines recommendations for reduced primary productivity (macrophytes and periphyton) and establishment of a protected base flow in East Canyon Creek during the critical summer period when DO concentrations are too low.

The plan also describes regulatory and voluntary measures needed to achieve pollutant reductions specified by the TMDL. A schedule of BMP implementation, measurements, and milestones will be defined in the implementation plan, but it is not static. The plan is a dynamic document open to changes as new information becomes available. This implementation plan is designed to be a flexible tool for restoring water quality in the East Canyon watershed.

Implementation will be accomplished through the cooperation and assistance of many agencies, organizations and individual stakeholders. The organizations involved include the East Canyon Creek Watershed Committee, the Natural Resources Conservation Service (NRCS), the Utah Association of Conservation Districts (UACD), Kamas Valley Conservation District, the Park City Municipal Corporation, Summit County, Morgan County, the Snyderville Basin Water Reclamation District, and Trout Unlimited, as well as individual landowners and managers located in the watershed.

The implementation proposal includes:

- a description of management actions recommended for implementation to achieve water quality endpoints defined in the TMDL,
- a schedule for implementation to achieve water quality endpoints in a timely manner,
- a follow-up plan for monitoring water quality to determine the effectiveness of the management actions, and
- identified measurable outcomes, which will be reviewed to assess the success of implementation and achievement of water quality endpoints.

8.2 STATEMENT OF NEED

The Federal Water Pollution Control Act (FWPCA) is the primary federal legislation that protects surface waters such as lakes and rivers. This legislation, originally enacted in 1948, was further expanded and enhanced in 1972; at this time it became known as the Clean Water Act (CWA). The main purpose of the CWA is the improvement and protection of water quality through restoration and maintenance of the physical, chemical, and biological integrity of the nation's waters. The CWA provides a statutory means to designate beneficial uses for waterbodies, establish criteria to protect those uses, and to evaluate and report on the health of the nation's waters.

Under Section 303(d) of the CWA, East Canyon Creek has been identified by the State of Utah as water quality–limited due to low DO associated with poor physical stream conditions that allow excessive inputs of light and heat from the sun. The State of Utah has designated the beneficial uses of the creek as domestic water use (1C), primary contact recreation (2A), secondary contact recreation (2B), cold water game fish and the associated food chain (3A), and agricultural water supply (4). The cold water game fish designated use (3A) was identified as impaired on the State of Utah 2006 303(d) list.

8.2.1 Summary of Endpoints

Two endpoints have been defined for East Canyon Creek: (1) total biomass for macrophytes and periphyton of 6.3 mg/cm^2 (measured as ash-free dry mass) and (2) a minimum (acute) DO of 4 mg/L. A reduction of algal growth and subsequent night time respiration reflected by an ash-free biomass of 6.3 mg/cm^2 was determined through observation and modeling as protective of the fisheries beneficial use, leading to support of the acute DO criteria. The recommended algal biomass was derived from modeled increases in DO with a 25% reduction in photosynthetic rates (P_{max}) and current total periphyton and macrophyte biomass in reaches with minimum DO concentrations less than 4.0 mg/L (see Chapter 7).

8.2.2 Description of Ecological Drivers

DO concentrations in water are influenced by water temperature, stream velocity, photosynthetic rate of algae and other aquatic plants, and oxygen demand from decomposing organic matter in the bottom sediments. As a result, solar radiation, air temperature, channel shape, water volume and flow, sediment and nutrient loads, riparian shading, and the amount of aquatic vegetation can all influence DO concentrations.

Stream shading reduces stream temperatures by blocking solar radiation and reducing air temperatures (Hill et al. 1995). Shade is created by riparian vegetation and by topographic features such as channel banks, ridges, and surrounding hills. Macrophyte and periphyton growth, respiration and decomposition contribute to diurnal fluctuations in DO and can be controlled by reducing light availability (EPA 2000b). Riparian vegetation can intercept over 95% of ambient light, resulting in reduced photosynthetically active radiation (PAR) levels that limit plant growth (Steinman 1992; Hill et al. 1995).

DO concentrations increase when stream velocity and turbulence bring more water into contact with air. Aeration of water generally corresponds to flow rate, with higher DO concentrations occurring during periods of high flow and lower DO concentrations occurring during periods of low flow. High water volume and increased flow also decreases the amount of heating and cooling and associated fluctuations in DO concentrations. Increased flow through a healthy riparian area also promotes the channel to deepen, further reducing the amount of photosynthetically available light. As a result, there is less light available to aquatic plants under higher flows and a reduction in DO fluctuations from night to day. Water diversions and decreased streamflow contribute to lower DO concentrations by decreasing water volume and depth, limiting aeration, increasing water temperatures, and decreasing scouring of algae, macrophytes, and sediments.

Following the 2003 upgrade at the ECWRF, HydroQual was retained by the Snyderville Basin Water Reclamation District (SBWRD) to model the linkages between diurnal oxygen fluctuations and other creek parameters including water quality and physical stream habitat characteristics (SBWRD 2008). The steady-state model DIURNAL was selected for its ability to address physical and biochemical reactions and to calculate diurnal DO fluctuations (SBWRD 2008). The scenarios addressed in the modeling include physical changes to the stream such as (1) increasing riparian canopy shading along the creek, (2) changing creek geometry (narrowing and deepening), and (3) modifying creek flow (SBWRD 2008).

The East Canyon Creek implementation plan is based on a 25% reduction in primary productivity and an increase in flow of 5 cfs over baseflow during the critical season of 2007, which were found to be sufficient to achieve the acute DO criteria of 4 mg/L during critical summer low-flow periods (SBWRD 2008). This level of biomass reduction and increased minimum flow recognizes the uncertainty inherent in modeling water quality in a creek affected by various climatic and anthropogenic factors. Following the establishment of a protected base flow and implementation of riparian plantings and bank stabilization, the creek will be reassessed iteratively as part of an adaptive management plan to evaluate water quality improvement.

8.3 PROJECT DESCRIPTION

8.3.1 PROJECT GOALS AND OBJECTIVES

The East Canyon Creek Implementation Plan has been developed to assist in defining the means and methods to achieve water quality endpoints in the watershed. The proposal includes the following:

- Implementation of stream shading (through stream plantings) and establishment of a protected base flow to attain DO and primary production endpoints
- Reduction of sediment load (a substrate for macrophyte growth) through bank stabilization
- Projected costs for implementation
- Funding mechanisms and a proposed schedule of implementation
- Reasonable assurance that the proposed measures are feasible
- Monitoring and progress reporting
- Requirements for Interagency and Stakeholder coordination and cooperation

8.3.2 DESCRIPTION OF IMPLEMENTATION MEASURES

Based on the observed water quality impairments, TMDL endpoints, and the environmental factors discussed above, three primary implementation measures are proposed for East Canyon Creek: increased shading, establishment of a protected base flow, and streambank stabilization. The first two implementation measures are derived from results of the DIURNAL model conducted by HydroQual in 2007 (SBWRD 2008). Bank stabilization will reduce sediment loads to the creek, and thereby reduce macrophyte growth. Bank stabilization will also facilitate narrowing of the stream channel, another recommendation from the DIURNAL model. Each of these measures is described in more detail below, along with a discussion of their benefits and limitations.

8.3.2.1 Shading

Plantings of native willows, cottonwood, and other woody riparian species adjacent to East Canyon Creek will provide additional shade to the creek, reducing light and heat inputs. Shading reduces the growth of macrophytes and algae by limiting photosynthesis, which increases the amount of DO in the creek at night and reduces the amount of fluctuation between daytime and nighttime DO concentrations. Shading also decreases water temperature, thereby increasing the stream's ability to retain oxygen in solution.

Shading via riparian plantings is a relatively inexpensive and effective method for reducing primary productivity in streams. Short reference reaches along East Canyon Creek with dense riparian canopies, (e.g., the Kimball Creek section studied by Baker et al. [2008] within SVAP Reach 25) exhibit relatively high levels of night-time DO. The SVAP inventory of East Canyon Creek (ECRFC 2002) showed that most reaches had less than 20% canopy cover, meaning that there is good potential for increasing shading along the creek. Riparian plantings are included in the following NRCS Conservation Practice Standard Methods and Codes:

- Channel bank vegetation (322)
- Riparian forest buffer (391)
- Stream habitat improvement and management (395)
- Streambank and shoreline protection (580)
- Riparian herbaceous cover (595)

Riparian plantings can be accomplished in sensitive areas without the need for heavy machinery. Other methods to increase riparian shading include pest management (595), irrigation systems and microirrigation (441). Vegetation commonly used in the area for riparian plantings includes several native willows, narrowleaf cottonwood, hawthorn, Woods' rose, and water birch.

A healthy riparian zone provides shade to its stream thereby reducing water temperature and evaporation (National Research Council 2002). Dense riparian vegetation does increase transpiration of water from leaf surfaces, but anecdotal evidence suggests that healthy riparian areas actually increase the duration of flows in intermittent creeks whereas denuded streams run dry more often (Gordon et al. 1992).

8.3.2.2 Establishing a Protected Base Flow

Increases to the "normal" summer flows of East Canyon Creek would help stabilize water temperature, decrease the width-to-depth ratio of the channel, and increase reaeration rates via increased stream velocity. All of these outcomes would also increase the nighttime (nocturnal) DO levels in the creek and reduce primary productivity through scouring of rooted macrophytes.

Establishing a protected base flow in East Canyon Creek could be achieved through enforcement of existing water rights and agreements (thereby reducing diversions) and through acquisition of in-stream water rights with early priority dates. Base flow restoration with an in-stream water right could also prevent future incidences of extremely low flow if the in-stream right had a sufficiently senior priority date, or was from a new water source that superseded existing rights.

Establishing a protected base flow, more than any other implementation measure, would address the lack of water in East Canyon Creek during the critical summer months. If provided in sufficient quantity during critical summer periods, augmented flows would likely prevent impairments associated with low DO almost immediately. The DIURNAL model assessed the effectiveness of increased flows as an implementation measure under two scenarios: (1) the addition of 5 cfs and (2) the addition of 10 cfs to the conditions which the model was calibrated (SBWRD 2008). The worst case modeled scenario occurred in August 2007, when the flow above the ECWRF was approximately 2.7 cfs. DO impairments were observed in multiple reaches when data were collected in August, and the calibrated model showed exceedances in multiple reaches as well, with nocturnal DO readings as low as 3.4 mg/L (see Figure 8.1, Table 8.2). The DIURNAL model predicted that all reaches would be maintained above 4.0 mg/L with an additional 5 cfs, or a total of 7.7 cfs above ECRWRF during this time (SBWRD 2008).

8.3.2.3 Channel Narrowing/Bank Stabilization

Narrowing the low-flow channel of East Canyon Creek was examined as a possible implementation measure by the HydroQual modeling study (SBWRD 2008). Narrowing the low-flow channel of the creek would have many of the same effects as augmenting flow: it would reduce the width-to-depth ratio, increase reaeration of the creek, and increase velocity. As with increased flow, channel narrowing was assessed within the DIURNAL model for its effectiveness in raising DO. Two scenarios were modeled: a 25% narrowing and a 33% narrowing of the channel to which the model was calibrated (SBWRD 2008). Narrowing was not as effective as the other measures that were modeled (reduction of photosynthesis and establishment of a protected base flow). Under the 25% width reduction, the acute standard for DO was not met in all reaches. The standard was barely met (a minimum of 4.1 mg/L) under the 33% reduction scenario. As discussed in Section 8.3.2.4 (Constraints on Implementation), channel narrowing would require acquisition of additional hydraulic and geomorphic information in order to assess feasibility.

Although channel narrowing is not currently feasible, further channel widening could be prevented through bank stabilization. Bank stabilization is recommended as a means to protect riparian plantings and vegetation, prevent further channel widening, and reduce fine sediments in the creek. The Stream Erosion Condition Inventory (SECI) conducted in conjunction with the SVAP (ECRFC 2002) documented extensive active erosion along East Canyon Creek. Bank stabilization measures would not directly improve the DO conditions in the creek, but would prevent further degradation as other implementation strategies take effect. Baker et al. (2008) found that streambank erosion contributes a significant amount of organic matter (2.3 to 7.2 tons/year) and nutrients to the stream, contributing to oxygen demand and low DO concentrations.

Bank stabilization would also protect riparian vegetation that provides shade from erosion as well as new plantings. Stabilizing riparian banks would also reduce sediment delivery to East Canyon Creek, suitable substrate for macrophyte growth and hence macrophyte biomass. Although this effect has not been quantified in the TMDL, it provides additional assurance that a 25% reduction in primary productivity could be achieved through the implementation measures outlined in this plan.

It is recommended that only "soft" armoring approaches and streambank bioengineering techniques be used for bank stabilization projects. Numerous technical references, such as the NRCS's (1998b) Practical Streambank Bioengineering Guide, are available that document these approaches. Techniques may include, but are not limited to, willow fascines, conifer revetments, vegetated soil lifts, and willow walls.

8.3.2.4 Constraints on Implementation

8.3.2.4.1 Constraints on Shading

Although stream shading through establishment of riparian vegetation is relatively effective and feasible, its implementation has several limitations. First, the growing season in the area is short, and riparian plantings are slow to mature. Thus, plantings can take many years before they effectively shade the creek. Second, plantings may require considerable maintenance. Herbivory by beavers and smaller rodents can limit the establishment and growth of plantings, and may require regular mitigation (e.g. fencing, wrapping, or painting plantings with sandy paint). The time required to establish mature vegetation and reduce depredation from herbivory could be reduced through planting larger stock; however, this approach has a higher cost for the plant materials. Plantings are also affected by seasonal climate fluctuations, and can suffer high mortality rates during drought years if they are not irrigated. The local Conservation District has had recent success with stream plantings during the fall season, which avoids high water levels in the spring and dry summer conditions (personal communication between Brendan Waterman, Kamas Valley CD, and Greg Larson, SWCA, on July 21, 2008). Finally, shading is only effective when there is sufficient water in the creek. During extreme low-flow periods (such as 2003, when the creek dried up completely), even 100% canopy cover cannot prevent impairment of beneficial uses.

8.3.2.4.2 Constraints on Establishing a Protected Base Flow

Several obstacles have prevented base flow protection from occurring to date, and could limit its future implementation. Until recently, in-stream flow rights in Utah could only be held by the Utah Division of Wildlife Resources and the Division of State Parks and Recreation. Currently Trout Unlimited (TU), a nonprofit organization, may lease in-stream flow rights from willing sellers. Second, because of the rapid development in the East Canyon watershed and a lack of storage, water rights are extremely expensive due to high demand. Thus, securing "wet" water rights (that can actually deliver water during the extremely high demand of the critical summer months) is very difficult and expensive.

8.3.2.4.3 Constraints on Channel Narrowing

Channel narrowing has several limitations on its effective implementation. First, implementation would require significant hydraulic and geomorphic data that are not currently available. Although narrowing the channel may improve DO levels during low-flow periods, the channel must be large enough to convey large spring runoff flows. Although a typical summer low-flow above the ECWRF outlet may only be 4 cfs, spring runoff often runs at greater than 200 cfs. Thus, any reduction of channel width and capacity must account for high flows in order to prevent excessive flooding, property damage, and increased erosion downstream. Anecdotal evidence suggests that the creek's channel has become wider and shallower than it was historically, but there are no data to document this. Detailed geomorphic data would be required to appropriately design projects that do not threaten downstream segments with downcutting or flooding. Second, channel narrowing would likely require significant disturbance and heavy equipment in order to be implemented. For these reasons, narrowing is not included in this implementation plan, although it is recommended that it be considered for future implementation if needed.

8.3.2.5 Summary of Implementation Approaches

Each of the implementation approaches described above has different time frames for implementation, certainty of success, and feasibility for implementation (Table 8.1). In general, shading has the lowest risk of failure due to its high feasibility and high certainty of success. However, it has a long time frame for effectiveness, particularly if young stock or cuttings are used. Once implemented, base flow protection has the fastest and most certain level of effectiveness. However, the feasibility of securing senior water rights is not very good, as well as the long-term sustainability of in-stream flow rights. Narrowing the stream channel has a low level of certainty and is not recommended at this time. Its feasibility and time frame depend on the techniques selected and future studies of the creek.

Table 8.1. Trade-offs in Time Frame, Uncertainty, and Feasibility for East Canyon Creek Implementation Measures

Measure	Time Frame	Certainty	Feasibility
Shading	Slow	High	High
Base Flow Restoration	Fast	High	Moderate
Channel Narrowing	Variable	Low	Moderate

8.3.3 PRIORITIZATION OF STREAM REACHES

8.3.3.1 Prioritization for Shading and for Establishing a Protected Base Flow

The reaches defined in the SVAP study are used in this implementation plan to divide the creek into homogeneous segments. Results from the Baker et al. (2008) study and the DIURNAL modeling results conducted by HydroQual (SBWRD 2008) were matched to these SVAP reaches to provide a more comprehensive understanding of each reach. Whereas the SVAP data provides an overall summary of geomorphic condition, the Baker et al. (2008) study provides detailed information on macrophyte and periphyton biomass and nutrient cycling for 6 of the 14 SVAP reaches (reaches 14, 18, 19, 21, 23, and 25). The DIURNAL model was calibrated to the same 6 reaches studied by Baker et al. (2008); however, model output was generated for each of the SVAP reaches under baseline (current) conditions as well as for the shading and increased flow scenarios. Together, the results from these three studies were used in prioritizing reaches for shading and base flow protection in East Canyon Creek.

Each SVAP reach was assigned a priority of 1 (high) to 5 (low) for implementation of shading and flow augmentation measures. These prioritizations were based on several factors: (1) observed and modeled DO levels and impairment, (2) riparian zone condition from the SVAP, (3) location relative to the ECWRF, and (4) canopy cover. Because canopy cover was almost uniformly less than 20% in each SVAP reach, the rankings were largely determined by the other parameters. Reaches with DO impairments were prioritized as either a priority 1 or a priority 2 on the basis of their position relative to the ECWRF.

Because reaches downstream of the ECWRF are less prone to extremely low (or zero) flow conditions due to the discharge of treated effluent, those reaches were assigned a slightly lower priority. Reaches without impairments were prioritized on the basis of their DO levels and the condition of their riparian zone (SVAP). These categories and the resulting prioritization are shown in Figure 8.1 and Table 8.2, along with selected values from the SVAP (ECRFC 2002) and the Baker and HydroQual studies associated with each reach. The prioritizations are further summarized in Table 8.4.

Table 8.2. Summary of Reach-specific SVAP, DIURNAL Model Output, and Baker et al. (2008) Study Results and Priority Rank: Shade

			SVAP Results[a]							SVAP Combined Ratings				USU/HydroQual Findings													
Shade Priority Rank	SVAP Reach Number	Length (miles)	Channel Function	Channel Condition	Hydrologic Alteration	Bank Stability	Pools	Canopy Cover	Canopy Cover (%)	Excess Nutrients	Fisheries Habitat	Riparian Habitat	Channel Function	USU/HydroQual Site	Stream Metabolism (August GPP, gO2/m2/day)	Stream Reaeration Coefficient	Baseline Min DO in August (reach minimum)	Baseline Min DO in August (reach average)	Observed DO Impairment	Modeled DO Impairment	25% Reduction in Pmax (Min DO in August)	25% Reduction in Channel Width (Min DO in August)	5 cfs Additional Flow (Min DO in Aug)	Epilithon Chl a (g/m2)	Epiphyton (g/m2)	Macrophyte (g/m2)	Sediment Organic Matter
1	22	1.5	Good	7	9	6	3	1	<20%	6.67	4.43	3.5	7.33				3.6	3.6		Yes	4.5	4.1	4.6				
1	23	1.3	Good	8	8	6	6	1	<20%	6.67	4.14	3.0	7.33	Blackhawk	7.86	17.7	3.4	3.8	Yes	Yes	4.3	3.8	4.5	168	52	157	0.30
1	21	1.0	Good	6	9	5	3	1	<20%	6.00	4.43	3.5	6.67	Above ECWRF	9.85	13.7	3.6	4.4	No	Yes	4.5	4.1	4.7	354	8	32	1.30
2	17	1.6	Poor	9	3	5	7	1	<20%	5.50	7.00	5.0	5.67				3.7	3.7		Yes	4.6	4.3	4.4				
2	18	3.0	Poor	7	3	6	3	1	<20%	5.50	6.14	4.5	5.33	Bear Hollow	21.4	21.3	3.7	4.5	Yes	Yes	4.7	4.0	4.6	70	6	46	1.10
3	19	1.3	Poor	2	8	8	6	1	<20%	2.67	4.57	1.0	6.00	Below ECWRF	3.63	10.8	4.8	4.8	No	No	5.5	4.9	5.3	116	8	67	0.57
3	24	0.9	Poor	8	6	5	4	1	<20%	4.25	3.79	1.0	6.17				4.8	4.8		No	4.9	4.6	4.9				
3	26	2.2	Good	8	9	8	2	1	<20%	6.00	4.86	1.5	8.33				n/a	n/a		n/a	n/a	n/a	n/a				
4	16	1.5	Poor	5	6	3	3	1	<20%	3.50	4.43	5.0	4.67				5.1	5.2		No	5.1	4.5	4.9				
4	20	0.9	Good	9	9	7	3	1	<20%	3.67	4.00	5.0	8.33				5	5.6		No	5.3	4.8	5.4				
4	15	2.9	Poor	7.5	7	3	3	1	<20%	3.50	5.29	2.5	5.83				5.4	6.2		No	5.4	4.8	5.2				
5	14	1.9	Good	9	3	8	3	3	20–50%	5.00	5.43	5.5	6.67	RV Park	7.16	54.8	6.2	6.4	No	No	6.5	6.3	6.4	73	14	51	0.84
5	25	1.0	Good	9	9	10	7	1	<20%	7.25	7.57	4.5	9.33	Kimball Creek	4.22	16.1	n/a	n/a	No	n/a	n/a	n/a	n/a	202	3	56	4.40

Table 8.3. Summary of Reach-specific SVAP, DIURNAL Model Output, and Baker et al. (2008) Study Results and Priority Rank: Bank Stabilization

			SVAP Results[a]						SECI[b]	SVAP Combined Ratings				USU/HydroQual Findings													
Bank Stabilization Priority Rank	SVAP Reach Number	Length (miles)	Channel Condition	Hydrologic Alteration	Bank Stability	Pools	Canopy Cover	Canopy Cover (%)	Tons/Year/Mile Erosion	Excess Nutrients	Fisheries Habitat	Riparian Habitat	Channel Function	USU/HydroQual Site	Stream Metabolism (August GPP, gO2/m2/day)	Stream Reaeration Coefficient	Baseline Min DO in August (reach minimum)	Baseline Min DO in August (reach average)	Observed DO Impairment	Modeled DO Impairment	25% Reduction in Pmax (Min DO in August)	25% Reduction in Channel Width (Min DO in August)	5 cfs Additional Flow (Min DO in Aug)	Epilithon Chl a (g/m2)	Epiphyton (g/m2)	Macrophyte (g/m2)	Sediment Organic Matter
1	24	0.9	8.0	6	5	4	1	<20%	168.8	4.25	3.79	1.0	6.17				4.8	4.8		No	4.9	4.6	4.9				
1	21	1.0	6.0	9	5	3	1	<20%	155.9	6.00	4.43	3.5	6.67	Above ECWRF	9.85	13.7	3.6	4.4	No	Yes	4.5	4.1	4.7	354	8	32	1.30
2	15	2.9	7.5	7	3	3	1	<20%	145.4	3.50	5.29	2.5	5.83				5.4	6.2		No	5.4	4.8	5.2				
2	18	3.0	7.0	3	6	3	1	<20%	140.0	5.50	6.14	4.5	5.33	Bear Hollow	21.40	21.3	3.7	4.5	Yes	Yes	4.7	4.0	4.6	70	6	46	1.10
3	16	1.5	5.0	6	3	3	1	<20%	121.2	3.50	4.43	5.0	4.67				5.1	5.2		No	5.1	4.5	4.9				
3	17	1.6	9.0	3	5	7	1	<20%	118.6	5.50	7.00	5.0	5.67				3.7	3.7		Yes	4.6	4.3	4.4				
3	20	0.9	9.0	9	7	3	1	<20%	78.6	3.67	4.00	5.0	8.33				5.0	5.6		No	5.3	4.8	5.4				
4	23	1.3	8.0	8	6	6	1	<20%	44.3	6.67	4.14	3.0	7.33	Blackhawk	7.86	17.7	3.4	3.8	Yes	Yes	4.3	3.8	4.5	168	52	157	0.30
4	22	1.5	7.0	9	6	3	1	<20%	42.0	6.67	4.43	3.5	7.33				3.6	3.6		Yes	4.5	4.1	4.6				
5	19	1.3	2.0	8	8	6	1	<20%	7.2	2.67	4.57	1.0	6.00	Below ECWRF	3.63	10.8	4.8	4.8	No	No	5.5	4.9	5.3	116	8	67	0.57
5	14	1.9	9.0	3	8	3	3	20–50%	5.7	5.00	5.43	5.5	6.67	RV Park	7.16	54.8	6.2	6.4	No	No	6.5	6.3	6.4	73	14	51	0.84
5	25	1.0	9.0	9	10	7	1	<20%	4.4	7.25	7.57	4.5	9.33	Kimball Creek	4.22	16.1	n/a	n/a	No	No	n/a	n/a	n/a	202	3	56	4.40
5	26	2.2	8.0	9	8	2	1	<20%	1.1	6.00	4.86	1.5	8.33				n/a	n/a		No	n/a	n/a	n/a				

[a]SVAP ranking definitions (NRCS 1998a): Channel condition refers to a stream's qualitative naturalness or level of alteration, proper function (as evidenced by downcutting, aggradation, or lateral movement), restriction of floodplain access (by dikes or levees), and the amount of riprap and channelization present. Hydrologic alteration refers to the effects withdrawals on a reach's habitat, as well as the streams' connection to floodplains in the reach. Bank stability incorporates measures of perceived stability, root protection of eroding areas, and the extent of observed erosion. Pools are measured in terms of depth and abudance. Canopy cover is assessed on the basis of the percentage of the stream that is shaded by riparian canopy and the degree of shading in upstream reaches. Rankings are from 1(low) to 5(high). Combined SVAP rankings incorporate severate SVAP results into one overall measure.

[b]SECI: The Stream Erosion Condition Inventory (SECI) was conducted in conjunction with the SVAP study and documented extensive active erosion along East Canyon Creek.

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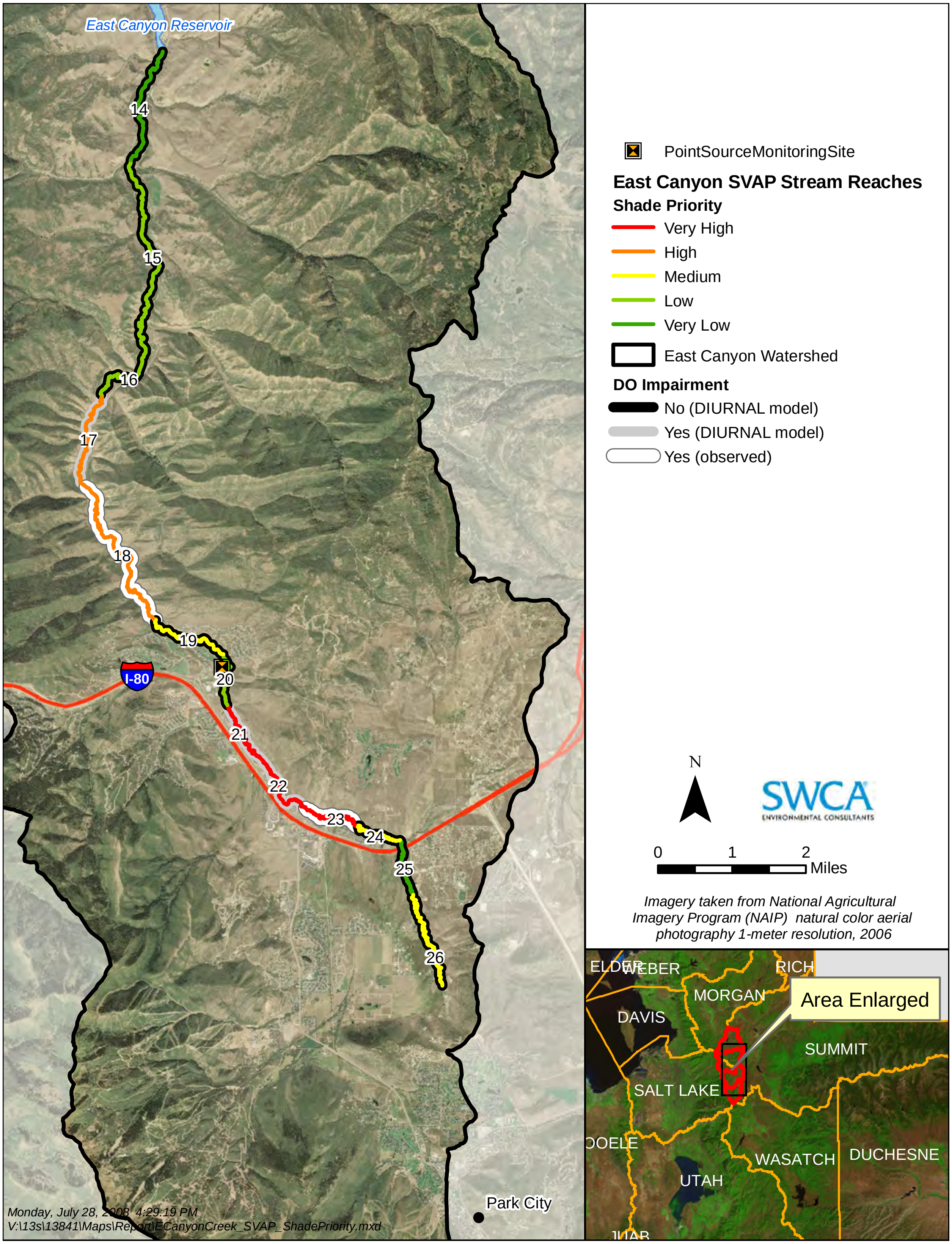

Figure 8.1 Map of priority reaches for shading and base flow protection.

Table 8.4. Summary of Shading and Base Flow Protection Prioritization

Priority	SVAP Reaches	Total Stream Length (miles)	Rationale
1 (high)	22, 23, 21	3.8	Dissolved oxygen impairment, downstream of ECWRF
2	17, 18	4.6	Dissolved oxygen impairment, upstream of ECWRF
3	19, 24, 26	4.4	Minimum DO <5.0, poor riparian zone
4	16, 20, 15	5.3	Minimum DO <6
5 (low)	14, 25	2.9	Minimum DO >6 with good riparian habitat and good channel function (SVAP)

8.3.3.2 Prioritization for Bank Stabilization

Each SVAP reach was assigned a separate priority ranking for bank stabilization. As with shading and with establishing a protected base flow, the priority levels ranged from 1 (high) to 5 (low). Two factors were considered for these prioritizations: (1) the estimated bank erosion in tons/year/mile, as identified in the 2001 Stream Erosion Condition Inventory (SECI) that was completed as part of the SVAP study (ECRFC 2002); and (2) bank stability ratings from the SVAP. Because the SECI protocol involved direct measurement of the eroding area in each reach, it is far more robust than the SVAP bank stability ranking. Therefore, the rankings were determined exclusively by the SECI erosion estimates. The prioritization categories and the resulting rankings are summarized in Table 8.5 and shown in more detail in Figure 8.2 and Table 8.3, along with selected values from the SVAP (ECRFC 2002) and Baker/HydroQual (Baker et al. 2008; SBWRD 2008) studies associated with each reach.

Table 8.5. Summary of Bank Stabilization Prioritization

Priority	SVAP Reaches	Total Stream Length (miles)	Rationale
1 (high)	21, 24	1.9	>150 tons/year/mile active bank erosion
2	15, 18	5.9	125–150 tons/year/mile active bank erosion
3	16, 17, 20	4.0	50–125 tons/year/mile active bank erosion
4	22, 23	2.8	10–50 tons/year/mile active bank erosion
5 (low)	14, 19, 25, 26	6.4	<10 tons/year/mile active bank erosion

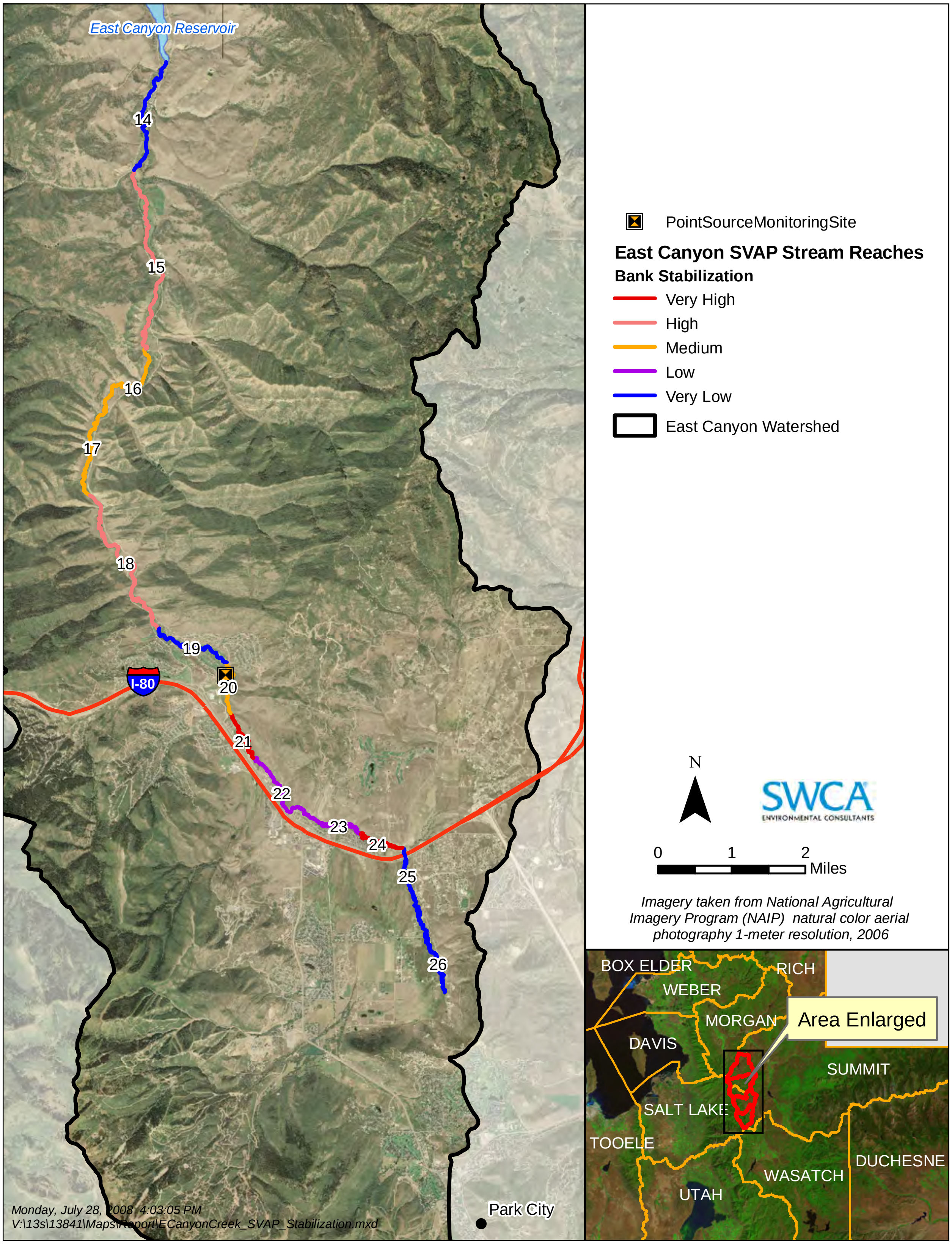

Figure 8.2 Map of priority reaches for bank stabilization.

8.3.4 RECOMMENDED IMPLEMENTATION STRATEGY

The recommended implementation strategy for meeting the water quality goals of East Canyon Creek includes establishing a protected base flow, shading by riparian plantings, and bank stabilization. Because each of these measures has a different timescale over which they will become effective, as well as different limitations on their implementation, the overall strategy relies on concurrent implementation and monitoring.

8.3.4.1 Establishing a Protected Base Flow

The first step toward base flow restoration in East Canyon Creek would be to enforce existing water rights and agreements pertaining to stream flows in the creek. In addition, it is recommended that an in-stream flow right be secured to augment base flows in East Canyon Creek during the critical summer months. The delivery of this water right would ideally be based on the flow and DO conditions observed in the creek, with water delivery adjusted to ensure a flow of 7.7 cfs above the ECWRF during the critical late summer period. That flow was selected based on the HydroQual modeling results showing that approximately 5 cfs of additional flow is needed to meet the 4.0 mg/L acute DO standard with a small margin of safety (Figure 8.3). The amount of water required to maintain a 7.7-cfs minimum flow and the length of time additional flow would be needed depends on the climatic conditions and snowpack of that particular year. A variety of scenarios are included in Table 8.6, which shows the amount of water that would be needed to maintain a discharge of 7.7 cfs under different conditions, including different baseflow levels.

The scenarios assume that the critical summer period is from July 1 until September 15 each year. This period was selected because the low flow period begins as early as late June (Figure 8.3) and no exceedances of DO criteria have been observed in late September. However, there is considerable variation in the beginning and end dates of the critical period from year to year. The beginning of the critical period is controlled largely by the timing of snowmelt runoff. As the summer progresses and the length of time because runoff increases, warmer water temperatures, increased macrophyte growth, and lower discharge all contribute to deteriorating DO levels. The end of the critical period is controlled by fall precipitation, temperature, and slowing productivity as the days become shorter.

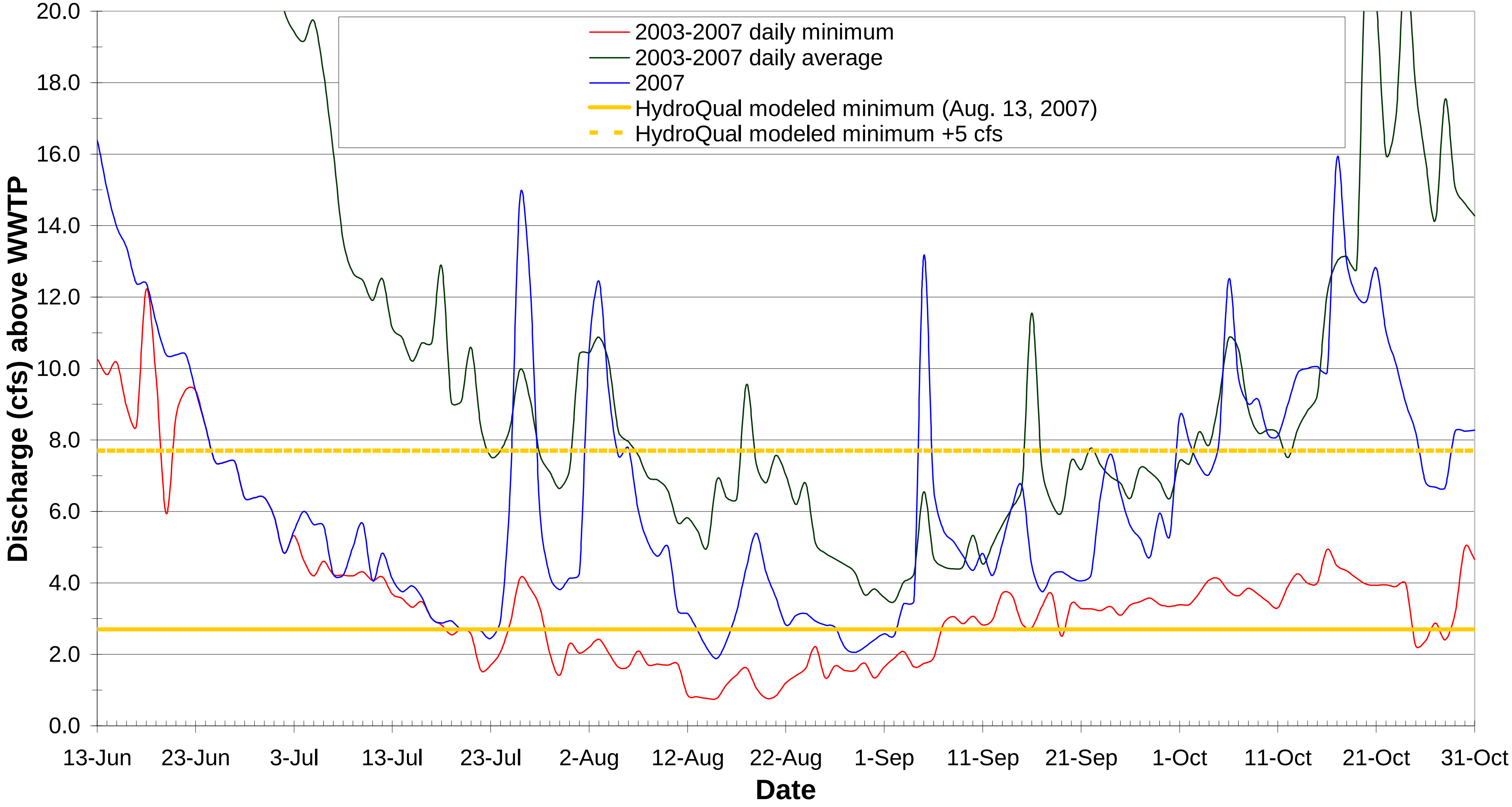

Figure 8.3 Modeled and study-period hydrology.

Table 8.6. Additional Flow Needed to Maintain a 7.7-cfs Discharge Upstream of the ECWRF during the Critical Summer Period (July 1–September 15)

Conditions Scenarios	Acre-feet of Augmentation Needed	Equivalent Average Augmentation Discharge (over 77 days)	Date Discharge First Below 7.7 cfs	Date Discharge Last Below 7.7 cfs
Average[1] 2003–2007	379	2.5 cfs	July 23	October 3
Worst Case[2] 2003–2007	793	5.2 cfs	June 25	November 10
2007[3]	504	3.3 cfs	June 25	October 2
2003[4]	765	5.0 cfs	July 2	November 10

[1] Based on the 2003–2007 average discharge for each date (as shown in GRAPH).
[2] Based on the 2003–2007 minimum discharge for each date (as shown in GRAPH).
[3] 2007 was the year modeled by HydroQual (SBWRD 2008). The year 2007 was within the normal range historically and was not a "wet" or "dry" year.
[4] 2003 was a historically "dry" year.

Based on this analysis, it is recommended that a minimum of 500 acre-feet be secured to augment summer flows in East Canyon Creek. This augmentation would add an average of 3.3 cfs to the creek during the critical period of July 1 to September 15, and in most "average" years would be protective of the cold water fishery use in the creek. Securing approximately 793 acre-feet for base flow protection would ensure the creek would meet water quality endpoints immediately, even in very dry years (worst case). Establishment of a protected base flow should be implemented upstream of SVAP reach 23, and the in-stream flow should remain in the creek until at least reach 17. This conclusion generally agrees with the findings of the flow augmentation study (SBWRD 2005), which suggested that approximately 408 acre-feet per year would be required to maintain a flow of 6 cfs in East Canyon Creek near its confluence with Kimball Creek. However, the report also concluded that less than 300 acre-feet would be needed to maintain 6 cfs, if done in conjunction with better management of water diversions and enforcement of water rights (SBWRD 2005). In fact, the report found that improved management and enforcement of water rights are important under any augmentation scenario in order to assure the protection of in-stream flow rights and other water rights. Water rights secured for this purpose should either be from new water sources that do not depend on a priority date, or should have a priority date of no later than 1865. Rights with priority dates later than 1865 are not likely to be senior enough to keep flow in the stream during periods of drought.

A variety of means could be used to establish a protected base flow, as described by the SBWRD report (2005). The simplest mechanism is to enforce existing water rights and agreements in the watershed. For instance, water could be purchased, leased during low flow periods, pumped from wells, diverted from another basin, or pumped from lower parts of the basin.

8.3.4.2 Implementation of Shading

It is recommended that all priority 1 and priority 2 reaches (23, 22, 21, 18, and 17) be vegetated to achieve a 50% canopy cover of the creek. The 50% canopy cover recommendation was derived through a correlation between the biomass-reduction recommendations (25%) and riparian shade using an equation obtained from Ferminella et al. (1989). As estimated in the DIURNAL model (SBWRD 2008), this level of shading is needed in impaired reaches in order to meet the TMDL endpoints. Increasing canopy cover should be an iterative process of planting, maintenance, and monitoring. Planting should be continued and monitored until at least 50% canopy cover is measured in each priority reach, as measured by aerial photography or in the field with a spherical densitometer. Other reaches of lower priority should also be planted as funding permits. Reduction of water temperature and primary productivity in upstream reaches will also benefit downstream reaches. All wide and/or shallow segments of priority 3 and priority 4 reaches should be planted to at least 50% canopy cover as well, in order to ensure that water quality endpoints are met during warm and dry summers. Wide and/or shallow segments can be determined relative to the average conditions of the reach, focusing on areas less than 1 foot deep and greater than 15 feet wide at low flow, as well as areas with heavy macrophyte growth.

Due to potential damage from beavers and other herbivores, all plantings should be monitored and protected. Protection measures may include exclosures and covering stems and trunks with fencing or sanded paint. Irrigation may be necessary in some locations or during drought years. Finally, because of the slow rate of growth in the area, shade plantings of larger trees should be considered for greater success. It is recommended that 100% of the length of the priority reaches be planted at sufficient density to account for 50% mortality over time. Mortality above 50% should be replaced. If monitoring reveals that 50% canopy cover has not been reached in segments of the priority reaches those areas should be replanted.

It's important that shade plantings should be initiated as soon as possible along the creek, and should continue even if an in-stream flow right is secured. Riparian canopy cover is only effective if there is water in the creek to shade, so base flow protection may be required in perpetuity.

Table 8.7. Shading Implementation

Priority	SVAP Reaches	Total Stream Length (miles)	Action
1 (high)	22, 23, 21	3.8	Plant 100% of stream length to achieve 50% canopy cover along entire reach.
2	17, 18	4.6	
3	19, 24, 26	4.4	Plant to achieve 50% cover of all wide, shallow, or slow reaches, as needed where planting occurs in shading priority reaches.
4	16, 20, 15	5.3	
5 (low)	14, 25	2.9	None

As shown in Table 8.7, approximately 8.4 stream miles (priority 1 and 2) are recommended for riparian planting (other than already shaded areas) with the goal of achieving 50% canopy cover along their length. An additional 9.7 miles are recommended for plantings in the widest, shallowest, or slowest reaches, which have the greatest potential for macrophyte growth and heat inputs.

8.3.4.3 Implementation of Bank Stabilization

Reaches were prioritized for bank stabilization on the basis of their annual erosion rate per stream mile, which indicates the relative severity of active erosion in each reach. In the SECI reaches (the same as the SVAP reaches), anywhere from 0.7% to 19.7% of the banks were inventoried as actively eroding (Table 8.8).

Table 8.8. SECI Results with Priority Rankings and Length of Stabilization Recommended by Reach

From SECI (ECRFC 2002)					Computed
SECI Reach	Total Length Actively Eroding Bank (feet)	% Banks Actively Eroding	Lateral Recession Rate (feet)	Tons/Yr/Mile from Actively Eroding Banks	Length Stabilization (feet) Needed to Reach 50 Tons/year/mile
14	338	1.5%	0.15	6	-
15	3,346	11.1%	0.40	145	2,195
16	2,751	11.3%	0.45	121	1,616
17	2,966	14.0%	0.45	119	1,716
18	4,424	14.7%	0.48	140	2,844
19	145	0.7%	0.38	7	-
20	1,390	13.2%	0.30	79	506
21	3,512	19.7%	0.35	156	2,386
22	846	7.1%	0.25	42	-
23	1,926	11.3%	0.18	44	-
24	944	13.2%	0.53	169	664
25	279	2.4%	0.10	4	-
26	158	0.7%	0.13	1	-
Total					**11,927**

As of the 2001 SECI study, the average erosion rate along East Canyon Creek was approximately 82 tons/year/mile (ECRFC 2002). There is no endpoint for the creek that is directly associated with bank stability, but a reduction in bank erosion will indirectly reduce thermal and light pollution, as well as stream sedimentation. Bank stability would also help to limit macrophyte overgrowth by reducing the amount of sediment that provides substrate for growth. Submerged and emergent aquatic plants trap fine sediment and organic material that facilitate the establishment and expansion of algae and macrophytes. Baker et al. (2008) and HydroQual (SBWRD 2008) determined that the overabundance of aquatic macrophytes in the creek is primarily driven by sediment accumulation and widened channel conditions. This plan recommends a 40% reduction in the average erosion rate along the creek's length, to 50 tons/year/mile or less, as measured by the SECI methods. To achieve this goal, approximately 11,927 linear feet of streambank will need to be treated to prevent erosion (see Table 8.8). Bank stabilization projects in priority reaches should be targeted at severely eroding areas, wide and shallow portions of the stream that are prone to macrophyte growth, and areas planted with woody riparian vegetation.

8.3.5 Time Frame for Implementation

Base flow protection is recommended for immediate establishment because it has the greatest potential for meeting the TMDL endpoints quickly. Enforcement of existing water rights and agreements could and should occur immediately. Acquisition of in-stream rights will take more time due to legal, logistical, and financial obstacles. More complex solutions (such as trading of flow rights for downstream rights) may be pursued over time. It is expected that establishing a protected base flow may take from one to five years to implement, depending on the availability of funds for purchasing senior rights, the potential for water right donations in the basin, and the timescale for development of new water sources. New water sources likely have the longest timescale for implementation, due to the legal and technical complexities associated with construction and water rights. The purchase or donation of senior water rights is unlikely to meet the full 500 acre-feet of senior rights needed, but would provide a benefit in improving DO conditions and progressing toward the creek's endpoints.

Due to its importance as a long-term solution for meeting water quality endpoints in the creek, shading should also be pursued immediately, with reaches treated in their order of priority. Shading should also be pursued as quickly as possible due its relatively long timescale for improving in-stream conditions. Shading will be implemented iteratively, with additional plantings in response to monitoring results. Where photo points and canopy monitoring reveal high mortality or insufficient growth, additional plantings must continue. Riparian vegetation plantings should be pursued regardless of progress toward securing in-stream flow rights. Shading is the most secure means of long-term improvement of creek conditions, and would provide assurance that endpoints could be met as additional water development occurs in the basin or in the event that in-stream flow rights can no longer legally be held for the creek.

As with shading, bank stabilization efforts should be ongoing. However, it is anticipated that fewer areas will need ongoing treatments if stabilization projects are well designed and coordinated with plantings. Bank stabilization should be prioritized according to the recommendations previously mentioned, with the goal of preventing further impairment rather than directly improving DO conditions.

8.3.6 Reasonable Assurance

UDWQ recently sponsored research conducted by researchers at USU to examine the relationships between nutrients, primary productivity, and metabolic processing in East Canyon Creek. This study (Baker et al. 2008), in conjunction with the DO modeling study (SBWRD 2008) and Kleinfelder flow augmentation study (SBWRD 2005) provide strong support and assurance for the implementation measures proposed in this plan to address DO impaired reaches in East Canyon Creek.

8.3.6.1 Linkage between Recommended Implementation Measures and Dissolved Oxygen Impairment

The impairment of East Canyon Creek is related to low nighttime DO caused by excess macrophyte and periphyton growth. The East Canyon Creek TMDL (2000) had assumed that excess macrophyte and periphyton growth was driven primarily by high nutrient concentrations (principally phosphorus) in the water column (UDEQ 2000b). Phosphorus reductions were intended to produce significant reductions in nuisance macrophyte and algal growth. However, implementation of the 2000 TMDL does not appear to have reduced macrophyte and periphyton biomass. Baker et al. (2008) and HydroQual (SBWRD 2008) determined that the excessive growth of aquatic macrophytes in the creek is currently driven by sediment accumulation on the stream bed, widened channel conditions, shallow water levels, low streamflow during the summer, and a lack of stream shading. Phosphorus concentrations were not identified as a controlling factor in macrophyte and algae densities.

Since the TMDL there have been dramatic reductions in point source phosphorus loads, whereas rapid growth and development in the upper watershed have resulted in increased water demand and nonpoint source nutrient and sediment inputs. Sediment loading from nonpoint sources, elevated water temperatures, and overgrowth of algae and macrophytes is currently the primary cause of water quality impairment in East Canyon Creek. Nitrogen has been identified as the most likely limiting nutrient in the water column, pore waters, and sediments, and phosphorus is no longer the primary factor contributing to low DO concentrations in the creek (Baker et al. 2008). Olsen and Stamp's 2000 study of East Canyon Creek water quality found 30% less macrophyte cover in stream reaches with stable banks, abundant overhanging vegetation, and low percentage of fine sediments. Further, Baker et al.'s 2008 study of East

Canyon Creek water quality identified a strong correlation between macrophyte density and low DO concentrations. Baker et al. (2008) also found higher photosynthetic rates in low-gradient, slow-flowing portions of the creek (see Sections 4.4 and 4.6.5). In support of these findings, the SBWRD (2008) DIURNAL model demonstrated that increased streamflow, increased riparian shading, and changes to stream geometry were all effective in reducing macrophyte productivity and increasing DO concentrations.

Improvement of physical stream conditions including increased flows, reduced sediment inputs, and increased shading will be required to achieve these endpoints. A 4.0 mg/L daily minimum was used to model water quality and diurnal DO concentrations in response to three management strategies for East Canyon Creek (SBWRD 2008): increased streamside shading, changes to channel width/depth; and base flow protection using the Bear Hollow and Blackhawk water quality monitoring stations (see Table 4.4). For the critical month of August there were modeled improvements in minimum DO levels at all impaired reaches using the baseline calibration from 2007 for all of the management scenarios (SBWRD 2008). A 25% reduction in photosynthetic rate (P_{max}) or an increase in flow of 5 cfs during August would lead to attainment of the DO standard throughout East Canyon Creek.

Multiple studies (Feminella et al. 1989; Hill et al. 1995; Kiffney et al. 2003) have demonstrated the effectiveness of riparian shading in limiting macrophyte and algal growth, and have direct applicability to identifying target conditions in East Canyon Creek. Feminella et al. (1989) found a significant negative relationship between periphyton biomass and riparian canopy percent cover ($r = -0.67$, $P<0.0001$) for a range of 0–15 mg/cm^2 ash free dry mass (AFDM) and 15–98% canopy cover. The empirical model described in this study was used to link the recommended 25% reduction in photosynthesis (SBWRD 2008) to a recommendation for stream shading. It is assumed that the correlation between periphyton and percent riparian shading identified by Feminella et al. (1989) is similar to the relationship between macrophytes and percent shade. The equation developed by Feminella et al. (1989) is

$$y = 7.75 – 0.06x$$

where x = % riparian cover and y = AFDM measured in mg/cm^2. Assuming a macrophyte biomass of 6.8 mg/cm2 (a value that is within the range of macrophyte biomass observed in East Canyon Creek), the model estimated that increasing riparian percent cover from 16% to 44% would reduce macrophyte AFDM by 25%.This model will be applied on a reach-by-reach basis to determine the amount of riparian shading needed to reduce macrophyte and algae cover to levels that support a minimum 4.0 mg/L DO concentration.

8.3.6.2 Feasibility of Riparian Plantings and Bank Stabilization

The East Canyon Watershed Committee, Upper Weber River Watershed Coordinator, Park City Corporation, Synderville Basin Water Reclamation District (SBWRD), and other stakeholders and landowners in the watershed have been actively engaged in riparian plantings and bank stabilization projects along East Canyon Creek and its tributaries. This work is expected to continue with emphasis on the priority reaches identified in this implementation plan. A federal earmark for East Canyon Creek restoration is being administered by the SBWRD with oversight and technical guidance provided by the Utah Association of Conservation Districts' Resource Coordinator for Summit County. This funding, in conjunction with other future funding opportunities (discussed in Section 8.6.2) will facilitate the implementation of riparian plantings and bank stabilization projects along the creek in the identified priority reaches. Because these reaches currently have less than 20% shade cover, plantings are expected to result in a significant improvement in stream shading. Stream shading of 50% overall shade is recommended for priority reaches based on the DIURNAL model and correlation between macrophyte/periphyton biomass and stream shade (Feminella et al. 1989).

8.3.6.3 Feasibility of Establishing a Protected Base Flow

The SBWRD retained Kleinfelder and others for the East Canyon Creek flow augmentation feasibility study (2005), which detailed the feasibility of adding flow to the creek to protect base flows and water quality for East Canyon Creek. Minimum streamflow goals for East Canyon Creek and Kimball Creek (the upper main stem of East Canyon Creek) were based primarily on flows required to maintain water quality and fish habitat (SBWRD 2005).

The Kleinfelder study (SBWRD 2005) examined 12 alternatives to improve minimum streamflow goals in East Canyon Creek, Kimball Creek, and McLeod Creek. No single alternative was found to be sufficient to meet the in-stream flow goals. Among the recommended alternatives in the short-term were the following:

- Improve management of water rights and diversions
- Purchase or lease irrigation water rights for in-stream flow
- Reduce diversions to the Silver Creek watershed

These alternatives could provide an estimated 0.5 cfs to 3.0 cfs (362–2,172 acre-feet/year) of flow to East Canyon Creek during critical periods with a high feasibility of implementation in the short-term (SBWRD 2005). In addition, a proposal to pump water from East Canyon Reservoir back to Snyderville Basin for residential, commercial, and agricultural use is currently under consideration. The proposed pipeline would deliver 5,000 acre-feet per year. As part of the agreement related to this project, Summit Water Distribution Company has agreed to provide a limited water right to the Utah Division of Wildlife Resources of up to 2 cfs (1,448 acre-feet/year) (SBWRD 2005). This water would be treated by the treatment plant and then discharged back into the creek. The plan would not increase base flows above the treatment plant.

Trout Unlimited has recently secured the legal ability to lease in-stream water rights on a trial basis. With the support of the Utah Division of Wildlife Resources and the East Canyon Watershed Committee, Trout Unlimited is actively pursuing opportunities for such leases and water donations. In addition, Park City Municipal Corporation is exploring the possibility of importing (from a trans-basin diversion) and/or storing water in the upper areas of the watershed, some of which could be released during the critical summer period to provide flow in East Canyon Creek.

8.4 COORDINATION PLAN

8.4.1 LEAD PROJECT SPONSORS

The East Canyon Watershed Committee has brought together citizens, stakeholders, and agencies to guide research and implementation directed to improve water quality in East Canyon Creek and Reservoir. This committee will continue to be the coordinating body and provide oversight on project conceptualization, cooperator selection, volunteer efforts during implementation, and sharing of information generated by projects with the wider East Canyon watershed community.

The Technical Advisory Committee, a subcommittee to the East Canyon Watershed Committee will oversee detailed project development, planning, implementation, administration, and reporting, and creation of fact sheets and educational materials. The Upper Weber River Watershed Coordinator will continue to facilitate communication between the East Canyon Watershed Committee, the Division of Water Quality, and stakeholders in the watershed.

The Utah Division of Wildlife Resources and the Snyderville Basin Water Reclamation District will act as the lead project sponsors for establishing a protected base flow for East Canyon Creek. The sponsors will work closely with the state engineer, the Utah Division of Water Rights, and other existing parties to water agreements to negotiate and enforce in-stream water rights in the watershed. The Utah Division of Wildlife Resources is willing to hold in-stream rights secured in the watershed.

8.4.2 COOPERATING GROUPS

The East Canyon Watershed Committee anticipates coordinating efforts for stream shading and bank stabilization with the following entities, agencies, and organizations, most of which are members of the committee itself:

- UACD–Technical planting design and oversight
- Utah Division of Water Quality –Monitoring and technical assistance
- Snyderville Basin Water Reclamation District–Administration of federal earmark for creek restoration
- NRCS–Administration of CRP and EQIP programs
- Utah Conservation Corps–labor and technical assistance with riparian plantings
- US Fish and Wildlife Program–WHIP program funding
- Park City Corporation–Funding and coordination of riparian plantings within city limits
- EPA–319 Funding for nonpoint source reduction

Snyderville Basin Water Reclamation District anticipates coordinating efforts for base flow restoration with the following other entities, agencies, and organizations:

- Utah Division of Wildlife Resources–Support for in-stream rights to protect fish. UDWR can hold permanent in-stream flow rights secured through funding by the legislature or donation
- Trout Unlimited–Support for in-stream rights to protect fish. Trout Unlimited can hold a 10-year in-stream flow right to improve habitat for one of three species
- Utah State Engineer's office–Advisory
- Utah Division of Water Resources–Advisory
- Utah Division of Water Rights–Administration and enforcement of existing water rights, existing agreements, and future in-stream water rights

8.5 MONITORING

The monitoring goals of this project are to:

- Document progress in achieving water quality endpoints as implementation measures are completed,
- Document and review the effectiveness of implementation measures, and
- Identify the need for additional implementation of any of the measures.

These three goals provide the basis for the sample design and sample parameters described below.

8.5.1 SAMPLING DESIGN AND PARAMETERS

8.5.1.1 Monitoring Endpoints

Annual monitoring of progress toward achieving water quality endpoints is recommended, with sampling focused on the critical summer low-flow period.

Diurnal DO monitoring should be conducted in mid to late August in those reaches with priorities 1, 2, or 3 (see Table 8.4). DO monitoring should be continuous (with a data sonde left in place to log data) for a 1–2 week period, in order to ensure than nighttime DO readings are recorded. The placement of additional sondes in segments where bank stabilization projects or riparian plantings have been completed is also recommended as a means of assessing the effectiveness of these projects.

Algal and macrophyte samples should also be collected annually to determine reductions in primary productivity, measured as ash-free dry mass (AFDM). Sampling of AFDM should also be conducted in all reaches of priority 1, 2, or 3 for shading and establishment of a protected base flow. Sampling is recommended twice per summer, in mid July and mid August.

8.5.1.2 Monitoring Riparian Shading

The goals of monitoring riparian shading are to document its effectiveness and determine the need for additional implementation or replacement of unsuccessful plantings. Sampling design and monitoring activities for riparian shading are shown in Table 8.9.

Table 8.9 Sampling Design and Monitoring Activities for Riparian Shading

Monitoring Activity	Sites	Frequency	Timing	Use
Photo-point monitoring	In all planting sites	Annually	Growing season (July–August)	Document planting success and growth of plantings.
GIS and aerial photo interpretation	All planting sites	GIS extent of all planting reaches at implementation; photo interpretation of canopy cover every 3 years or when new aerial photos are available	Dependent on aerial photos	Document aerial extent of canopy cover over time. Relate to direct canopy measurement.
Direct canopy measurement (spherical densitometer)	Representative sample of all planting sites	Every 2 years	Growing season (July–August)	Document change in canopy cover over time. Relate to photo interpretation.
Mortality assessment	In all planting sites	Annually	Growing season (July–August)	Direct replanting efforts where mortality is high. Guide mitigation efforts for herbivory, drought, etc.

8.5.1.3 Monitoring the Protected Base Flow

Monitoring the protected base flow should be implemented to document reaching the 7.7-cfs goal set for the creek above the ECWRF. Stream levels can be monitored through the USGS gage maintained by SBWRD and subtracting daily ECWRF effluent inputs to the creek. The volume of flow discharged to increase base flow will depend on the discharge point and may include staff gages and calibrated weirs.

8.5.1.4 Monitoring Bank Stabilization

The goal of monitoring bank stabilization projects is to document their effectiveness and determine the need for any repairs. Sampling design and parameters for bank stabilization are shown in Table 8.10.

Table 8.10 Sampling Design and Monitoring Activities for Bank Stabilization

Monitoring Activity	Sites	Frequency	Timing	Use
Photo-point monitoring	In all stabilization sites	Annually	Growing season (July–August)	Document stabilization success and need for maintenance.
Repeat Stream Erosion Condition Inventory (SECI)	Entire length of original survey	Once in 2 years; repeated in 7 years	Low flow	Document changes in SECI score and bank erosion following bank treatments and other implementation measures.
Channel cross sections	Representative sample of all stabilization sites. At repeatable monument locations.	Every 2 years	Low flow	Document change in channel cross section over time.

8.5.2 PROGRESS REPORTING

Annual reports from project sponsors should provide details about riparian plantings, base flow protection, in-stream DO concentrations, and percent shade achieved. Project-specific reporting will come from the East Canyon Watershed Committee, Utah Association of Conservation Districts, and Trout Unlimited. Progress toward achieving water quality goals will be reported by the Division of Water Quality every two years in the Integrated Report–Assessment of Water Quality for the State of Utah. Reports should be reviewed by the East Canyon Watershed Committee–Technical Advisory Subcommittee. The website maintained by the East Canyon Watershed Committee should be used as a forum for dissemination of progress reports to the public.

8.6 BUDGET

8.6.1 PROJECTED COSTS FOR IMPLEMENTATION

8.6.1.1 Costs for Establishing a Protected Base Flow

A search of water rights publicly available for sale in the East Canyon Basin (on http://waterrightexchange.com) showed prices in the Park City area to average approximately $15,000 per acre-foot. Assuming this cost is reflective of water costs on the open market, securing the recommended 500 acre-feet of water on the open market would cost approximately $7,500,000. However, the likelihood of this amount of water being available for sale is low. This means that water secured as part of new water developments, combined with some purchases and donations, is a more likely source for securing water for base flow protection. Although new water projects such as trans-basin diversions or an intra-basin reuse pipeline would have large associated costs, water for the protected base flow could be included as a form of mitigation for the identified environmental impacts of such a project, or to enjoy the economies of scale and financing associated with a major development project. The SBWRD augmentation report (SBWRD 2005) indicated several alternatives with acre-foot costs closer to $200, which would equate to approximately $100,000 in implementation costs. Finally, the BOR (2006) estimated a cost-per-acre-foot between $1,440 and $7,560, for a total cost of $720,000–$3,780,000 for 500 acre-feet. A range of cost estimates for various proposals is included in Table 8.11.

Table 8.11. Potential Cost to Secure 500 Acre-feet for Establishing a Protected Base Flow

Water Source	Cost Estimate Source	Cost per Acre-foot	Total Cost	Additional Major Capital Costs
Purchased irrigation water	SBWRD 2005	$7,000	$3,500,000	
Developed well water	SBWRD 2005	$6,500	$3,250,000	$400,00 per 2-cfs well
East Canyon pipeline	BOR 2006	$7,275	$3,637,500	Capital costs included in per acre-foot estimate
Lost Creek Canyon pipeline	BOR 2006	$7,560	$3,780,000	Capital costs included in per acre-foot estimate
Weber River via Weber-Provo Canal	BOR 2006	$1,440	$720,000	Capital costs included in per acre-foot estimate

8.6.1.2 Costs for Shading and Bank Stabilization

Implementation of the shading and bank stabilization BMPs, necessary to meet the water quality goals outlined in the East Canyon Creek TMDL, will require a significant allocation of financial resources from multiple sources. The total estimated costs for each of the recommended practices are listed in Table 8.12, 8.13, and 8.14. The sources of potential funds are described below in Section 8.6.2.

Unit-cost estimates listed for each BMP were obtained from the 2007 NRCS' Electronic Field Office Tech Guide cost sheet located at the Utah NRCS website. The practices used in the cost analysis were BMPs specific to the goals outlined in this implementation plan and are applied to enhance stream shading and provide for streambank stabilization. Other costs associated with implementation and operation and maintenance are listed in Table 8.12

The BMP costs in Table 8.12 for stream shading are listed by recommended planting densities in each priority reach based upon plant type, such as bare root shoots or 1-gallon potted plants. The planting densities listed are general guidelines for the establishment of dogwood, willow, or cottonwood trees (USDA 1993; and Carlson et al. 1995). Plant-specific specifications for establishment in the region may be found at the USDA plant database website at (see http://plants.usda.gov/checklist.html). This web page provides users the ability to search for fact sheets of individual plants appropriate for the Intermountain region's riparian areas. The costs are calculated based upon the priority reach goal and the range of plant density recommended from the literature.

The per-acre riparian forest buffer costs are taken from the NRCS cost list for that practice. Priority linear stream miles are converted to riparian acres based on an assumed riparian buffer width of 25 feet on each side of the stream (USDA July 2004). An average 50% mortality of all plantings has been assumed and calculated into the total planting costs. An example would be the priority 1 reaches 21 and 24. A treatment goal of 100% of the reach area will be planted with 50% canopy coverage. The ranges of total cost for the bare or potted plants are listed for each specific plant type. If a mixture of bare-root and potted plants is used in the reach, the total cost will be adjusted according to the percentage of each plant type installed. The range of costs for the plantings will vary greatly dependent upon the plant type used, the spacing of the planting, and plant mortality. Table 8.12 lists associated costs that will be included in the final cost of planting the riparian buffer. The associated costs may include chemical treatment, installation of a drip irrigation system, and/or fencing to limit access of livestock and wildlife to riparian plantings. Mechanical preparation of the riparian area is also included in the cost for the riparian forest buffer establishment.

Table 8.12. Cost Ranges by Priority Reaches for Stream Shading Enhancement BMPs

Reach Number	Total Length of Reaches (mi)	Area of Reach Treatment (ac)	% of Area Treated[3]	Riparian Forest Buffer (391)					
				Bare Plant[1]		1-gallon plants[2]		Soil Preparation–Mechanical Treatment	
				Low	High	Low	High	Low	High
22, 23, 21	3.8	11.5	100	$111,467	$1,003,200	$27,821	$111,467	$887	$1,520
17, 18	4.6	13.9	100	$134,933	$1,214,400	$33,678	$134,933	$1,073	$1,840
19, 24, 26	4.4	13.3	50	$64,533	$580,800	$16,107	$64,533	$1,027	$1,760
16, 20, 15	5.3	16.1	50	$77,733	$699,600	$19,401	$77,733	$1,237	$2,120
14, 25	2.9	8.8	0	$0	$0	$0	$0	$0	$0
Total	21.0	63.6		$388,667	$3,498,000	$97,006	$388,667	$4,223	$7,240

[1]Planting rates are based upon density of 1- to 3-foot spacing (1 sq feet=43,560 plantings per acres; 9 sq feet=4,840 plantings per acre).

[2]Planting rates are based upon density of 6- to 12-foot spacing (36 sq feet=1,210 plantings per acres; 144 sq feet=302 plantings per acre).

[3]Percentage of area treated as well as a 50% mortality rate for initial plantings (ranges from 8–100% mortality, USDA Plant Database).

To reduce streambank erosion and channel migration associated with streambank erosion, vegetative or structural features in the riparian area will be installed to stabilize and protect the streambank against scour and erosion. Practices may include the installation of vegetative plantings, installation of grasses or vegetative mats, and mechanical treatment of the shoreline including streambank shaping and fabric installation. The total cost for each of the treatments is for total linear feet of streambank on both sides of the stream and installation of the practice along that total distance. Costs for each type of streambank protection are listed in Table 8.13.

Table 8.13. Total Costs Associated with Priority Reaches for Streambank Protection

Reach Number	Total Length of Reaches (mi)	Area of Reach Treatment (ft)[1]	% of Area Treated	Streambank & Shoreline Protection (580)		
				Vegetative Plantings	Bank Protection (revetment, etc.)	Mechanical Treatment[2]
14	2.2	-	100	$0	$0	$0
15	2.9	2,195	100	$2,415	$7,245	$43,908
16	2.3	1,616	100	$889	$2,667	$32,322
17	2.0	1,716	100	$472	$2,831	$34,312
18	2.8	2,844	100	$782	$4,693	$56,880
19	2.0	-	100	$0	$0	$0
20	1.0	506	100	$139	$835	$10,116
21	1.7	2,386	100	$656	$3,936	$47,713
22	1.1	-	100	$0	$0	$0
23	1.6	-	100	$0	$0	$0
24	0.7	664	100	$183	$1,096	$13,288
25	1.1	-	100	$0	$0	$0
26	2.3	-	100	$0	$0	$0
Total	23.7	11,927		$5,536	$23,302	$238,537

[1]Area of reach treatment is linear feet of streambank on both sides of stream

[2]Mechanical treatment includes streambank excavation, shaping, geosynthetic fabric treatment, and vegetative planting. Total cost/per foot estimated at $20/foot.

Other costs will also be incurred with the installation of streambank BMPs, including costs associated with operation and maintenance. This includes the treatment of invasive weeds, the application of irrigation water to protect against drought and plant mortality, fencing to protect against depredation, and herbaceous cover to reduce erosion. If fencing is installed and livestock are present, offsite watering will be required to provide water to the livestock. Offsite watering costs will be determined based on the gallons of water storage provided offsite. Offsite water facilities are assumed to hold 1,000 gallons of water each. The cost associated with each offsite tank facility is approximately $2,000. The practices are listed in Table 8.14 Not all of the acres or linear feet of the streambank or riparian area will be treated, and the associated practices and costs of implementation will be adjusted accordingly.

Table 8.14. Costs for Associated Best Management Practices

Reach Number	Total Length of Reaches (mi)	Area of Reach Treatment (ac)	% of Area Treated	Chemical treatment (595)		Irrigation System, Micro-irrigation (441)	Fencing (382)	Riparian Herbaceous Cover (390)
				Low	High	Drip Irrigation	4-Wire, Wood Posts	Seeding Rate = 6 lbs/acre
22, 23, 21	3.8	11.5	100	$114	$203	$19,576	$54,775	$1,750
17, 18	4.6	13.9	100	$138	$245	$23,697	$66,306	$1,101
19, 24, 26	4.4	13.3	50	$132	$235	$11,333	$31,712	$40
16, 20, 15	5.3	16.1	50	$159	$283	$13,652	$38,198	$96
14, 25	2.9	8.8	0	$0	$0	$0	$0	$0
Total	21.0	63.6		$543	$965	$68,258	$190,991	$2,988

8.6.2 FINANCIAL AND LEGAL MEANS FOR IMPLEMENTATION

8.6.2.1 Means for Establishing a Protected Base Flow

Currently, several different tools for establishing a protected base flow exist for East Canyon Creek. First, the Utah Division of Wildlife Resources or Division of Parks and Recreation may also hold permanent flow rights for the propagation of fish or to preserve or enhance the natural stream environment. In addition, Trout Unlimited may legally lease in-stream flow rights (for up to 10 years) to protect or restore habitat for three native trout species in Utah (under Utah code 73-3-30), and can actively pursue the lease or donation of water rights for this purpose. Division rights may be purchased with funds approved by the legislature, or donated by other entities. Securing favorable water rights for an in-stream flow by either of these agencies, or Trout Unlimited, may require complex agreements or trading of water rights in order to secure water in the critical reaches of the creek relative to other users' points of diversion. SBWRD has explored the donation of an in-stream flow right supplied by a well near Kimball Junction, which could augment flows above the ECWRF by approximately 2.5 cfs in times of critical need. A variety of proposals and scenarios have been studied by the BOR (2006), Summit Water Company, and SBWRD (2005) for trans-basin and intra-basin diversions or pumping projects. Finally, Park City has considered the development of additional water storage in the upper basin, which could be used to augment flows during critical low water periods.

8.6.2.2 Means for Shading and Bank Stabilization

Since the majority of land in the watershed is privately owned, BMP implementation is a voluntary, incentive-based effort. Various programs are available to assist private landowners with the implementation of BMPs through cost-share incentive programs, grants, or low-interest loans. Program funds come from multiple sources such as EPA, NRCS, and the State of Utah. All programs require voluntary signup for participation, and some require eligible lands to qualify based on program requirements.

The NRCS administers a number of cost share programs to assist agricultural producers in installing BMPs on their privately owned lands such as the Environmental Quality Incentive Program (EQIP). EQIP is a Farm Bill program that offers technical and financial assistance in the design and implementation of conservation practices, paying up to 50–75% of the project's cost.

Other federal cost-share programs administered by the NRCS are the Wildlife Habitat Incentives Program (WHIP) and the Wetland Reserve Program (WRP), which are provided to establish habitat for wildlife and fish and to restore wetlands, respectively. Another federal cost-share program is the Conservation Reserve Program (CRP), which encourages farmers to convert highly erodable farmland or other highly sensitive acreages to permanent vegetative cover. The CRP is administered by the Farm Service Agency (FSA).

The State of Utah offers a low-interest loan program called the Agriculture Resource Development Loan (ARDL), which is administered by the Utah Department of Agriculture and Food (UDAF). The program offers loans for projects that conserve soil and water resources and improve water quality. Another UDAF program is the Grazing Improvement Program (GIP), which offers a competitive grant for fence repairs, reseeding of grazing land, and the replacement or development of water projects.

The Section 319 NPS program funded by EPA and administered through the Division of Water Quality may be employed to implement nonpoint source projects for the protection and improvement of water quality. The 319 program is a cost-share program that requires a 60:40 grant-to-cost share match.

Finally, the Snyderville Basin Water Reclamation District is currently administering a federal earmark for restoration of East Canyon Creek. The total funds available for implementation are approximately $278,000 and do not require cost-share. This program will permit installation of stream shading and bank stabilization projects beginning in the fall of 2008. This funding program will target over 9,000 feet of actively eroding streambank and will allow for the installation of practices such as streambank protection, channel vegetation, fencing, and associated watering facilities. Information and education for landowners will also be part of the program.

9. EAST CANYON RESERVOIR WATERSHED-BASED IMPLEMENTATION PLAN

9.1 INTRODUCTION

The East Canyon Reservoir watershed-based implementation plan outlines a strategy for reducing phosphorus in East Canyon Reservoir to attain water quality endpoints and to restore East Canyon Reservoir to full support status. When combined with existing implementation planning, management measures, and phosphorus reduction efforts, completion of the proposed implementation plan will result in a cleaner and healthier East Canyon Reservoir for current and future generations.

This implementation plan, in conjunction with portions of the TMDL, includes the nine key elements identified by EPA that are considered critical for achieving improvements in water quality (EPA 2003). EPA requires that these nine elements be addressed in watershed plans funded with incremental Clean Water Act Section 319 funds, and strongly recommends that they be included in all watershed plans intended to address water quality impairments. Although there is no formal requirement for EPA to approve watershed plans, the plans must address the nine elements discussed below if they are developed in support of Section 319-funded projects (EPA 2008).

EPA's nine elements are listed below in the order they appear in the guidelines; however, it should be noted that although they are listed as *a* through *i* because they do not necessarily need to be completed sequentially.

a. An identification of the sources that will need to be controlled to achieve the load reductions identified in the TMDL

b. An estimate of the load reductions expected for the management measures recommended in the implementation plan

c. A description of the nonpoint source management measures that will need to be implemented to achieve the load reductions required by the TMDL and an identification of the critical areas for implementation

d. An estimate of the amount of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan

e. An information/education component that will enhance public understanding of the project and encourage their early and continued participation in implementation

f. A schedule for implementing the nonpoint source management measures identified in this plan

g. A description of interim, measurable milestones for determining whether the recommended nonpoint source management measures are being implemented

h. A set of criteria that can be used to determine whether loading reductions are being achieved and whether substantial progress is being made toward attaining water quality standards and, if not, the criteria for determining whether the implementation plan needs to be revised

i. A monitoring component to evaluate the effectiveness of the implementation efforts over time

The East Canyon Reservoir implementation plan has been developed based on a 50% phosphorus reduction from nonpoint sources and a 50% reduction from internal reservoir sources. These source reductions have been determined to be sufficient to achieve DO criteria established for the reservoir. Future growth projections for the ECWRF require an additional allocation of 232 kg/year (35% increase) for this point source above the allocation provided in the 2000 TMDL (663 kgTP/year). The 50%

reduction from both nonpoint and internal reservoir sources has been identified to compensate for the increased phosphorus load required by ECWRF.

Recommendations for nonpoint source reductions consider all sources and are based on management measures that consider BMPs, effectiveness, attainability, cost, and the goal of distributing the responsibility for water quality improvement among all users in the watershed. Recommendations for reducing the internal sediment phosphorus released in the reservoir by 50% include alum treatment and hypolimnetic aeration.

Management strategies and BMPs compose the primary means for achieving phosphorus load reductions. This implementation plan is based on a review of other TMDLs written for reservoirs and watersheds in the Intermountain West with similar characteristics, and with consideration of implementation actions ongoing in the watershed. This plan also describes regulatory and voluntary management measures needed to achieve pollutant reductions specified by the TMDL.

A schedule with interim milestones for implementation of management measures and BMPs is provided in the implementation plan; however the plan is not static. It is a dynamic plan subject to modification as new information and data become available throughout the life of the plan. This implementation plan is designed to be a flexible tool for BMP implementation guidance and management. Actual implementation will be accomplished through the assistance of natural resource agencies, municipalities, land owners, and local conservation activities.

The following sections describe the implementation plan for East Canyon Reservoir in accordance with the nine elements recommended in EPA guidelines (EPA 2008).

9.2 KEY COMPONENTS OF THE IMPLEMENTATION PLAN

9.2.1 IDENTIFICATION OF SOURCES AND CURRENT LOAD SUMMARY

The East Canyon Reservoir watershed encompasses 92,498 acres in Summit and Morgan counties. Over 96% of the watershed area is privately owned and under private control. Forested and meadow (shrub/scrub) land cover types occur on 65,668 acres or 71% of the watershed area. The majority of the surface inflow into East Canyon Reservoir is from East Canyon Creek, which drains a 145-square-mile watershed. The total annual phosphorous load to East Canyon Reservoir from all sources is 3,350 kg/year. The East Canyon Water Reclamation Facility currently accounts for 483 kg (14%) of the total annual phosphorus load to East Canyon Reservoir. Nonpoint sources account for an additional 2,072 kg/year or 62% of the total load to the reservoir, and internal sources account for 795 kg (24%) of the annual total load to the water column.

9.2.1.1 East Canyon Water Reclamation Facility (ECWRF) Discharge

The only point source located in the East Canyon Reservoir watershed is the ECWRF, which is operated by the Snyderville Basin Water Reclamation District. The facility discharges to East Canyon Creek just north of I-80 below the confluence with Kimball Creek from the south and the unnamed creek from the north. During dry summer months, the effluent from the facility makes up the majority of flow in the creek. The Snyderville Basin Water Reclamation District completed an upgrade and expansion project of the ECWRF in September 2002. The upgrade included the addition of a chemical phosphorus reduction process to the plant which became effective in July 2003. The process mixes secondary effluent with alum (aluminum sulfate) and a polymer in solids-contact clarifiers, and then filters the liquid through a constant-backwash sand filter. The heart of the process is the use of alum to pull orthophosphorus out of solution by binding the phosphorus molecule to the alum. The polymer then joins the resultant molecules in a long chain for easier filtering. Finally, effluent passes though a UV disinfection process. Phosphorus-reduction upgrades to the ECWRF became effective in July 2003, with an average total phosphorus effluent of 0.12 mg/L. Median total phosphorus effluent from the ECWRF was 0.06 mg/L for water years 2003 through 2007. Orthophosphate concentrations were 0.024 mg/L during this same period.

On average, the ECWRF contributes 483 kg of total phosphorus per year to East Canyon Reservoir of which 93 kg is in the form of dissolved phosphorus. In general, the load from the ECWRF is far more constant than the load from nonpoint sources and has varied by less than a factor of 3.

9.2.1.2 Internal Reservoir Sources

Phosphorus contained in reservoir bed sediments could represent a significant loading source to the water column. The deposition, release, and dissolution of this phosphorus depend on both physical and chemical processes in the watershed and reservoir. Phosphorus in the water column of the reservoir occurs as suspended sediment-bound phosphorus and dissolved phosphorus. Suspended sediments, comprising particulate and organic matter, can act as a source of dissolved phosphorus due to changes in water chemistry as water depth increases. Significant release of iron-bound phosphorus from bed sediments has been observed under anoxic conditions. Operational conditions that control water depth may affect the availability of sediment-bound phosphorus and its potential to leach into surface water. Fluctuating water levels that periodically expose lake sediments or alter the redox at the sediment-water interface can contribute to the release of sediment-bound nutrients.

A phosphorus mass balance model was developed for East Canyon Reservoir to calculate monthly and annual total and net internal load from reservoir sediments. A net internal load refers to the total load that leaves the reservoir over a given period time (i.e. one year, one month) minus the total load that entered the reservoir during the same period of time. If the amount of phosphorus that leaves the reservoir is greater than that that entered during the same period of time, there is a net internal load. Conversely, if the amount of phosphorus leaving the reservoir is less than that that entered, the reservoir is acting as a sink during this time period. The phosphorus associated with a net internal load can be considered legacy or historic as it represents a previous phosphorus sink in reservoir sediments. The average annual net internal load is 795 kgTP/year, although annual net internal loads are estimated to be as high as 1,780 kgTP/year and as low as 294 kgTP/year. Attainment of water quality endpoints in East Canyon Reservoir requires that the internal reservoir load be reduced by 50%.

9.2.1.3 Nonpoint Sources

9.2.1.3.1 Forest Land Management, including Ski Area Management

The majority of the forested land in the upper part of the East Canyon Reservoir watershed is managed as part of several ski areas. Road construction and road use on forested lands associated with ski areas and off-highway vehicle (OHV) use can contribute to dissolved and sediment-bound phosphorus. Sediment and pollutants from forest roads deposited in streams during low flow can be rapidly re-suspended and transported to the reservoir during high flow events (Megahan 1972 and 1979; Mahoney and Erman 1984; Whiting 1997). Some agricultural grazing takes place on forested lands downstream of Jeremy Ranch. Grazing practices alter forested lands through soil compaction, manure deposition, and increased sediment and nutrient loading due to destabilization and erosion of forest soils.

There are two ski areas in the watershed that occupy approximately 2,982 hectares (7,369 acres) or 8% of the watershed in seven subbasins, including phosphatic shale areas in the Treasure Hollow, Spiro Tunnel, and Willow Draw subbasins. The Canyons Ski Resort is located in Summit County, and Park City Mountain Resort is located in Park City. Gorgoza Park, near Kimball Junction, is a tubing and sledding hill. The main source of phosphorus from ski areas is stormwater runoff containing sediment and nutrients. Stormwater runoff occurs as either overland flow or as concentrated flow in drainage ditches, ruts, trails or roads. Both types of flow can cause erosion and increase sediment and nutrient loads to streams. In particular, poorly designed, located, constructed, and maintained trails can cause significant erosion and sedimentation. Impervious cover associated with ski resort facilities also contributes to stormwater runoff in the watershed. The ski area land use contributes 316 kg/year of phosphorus, or 15% of the total annual nonpoint source phosphorus load in the watershed. Subbasins with phosphatic shales, (Treasure Hollow, Willow Draw, and Spiro Tunnel) contribute 98% (309 kg/year) of the annual phosphorus load from ski areas.

9.2.1.3.2 Golf Courses and other High Use Recreation

Pollutant sources from golf courses include sediment runoff and the erosion of exposed areas, excess fertilizer use, and nutrient release associated with flood irrigation. When phosphorus fertilizer is applied unnecessarily, stormwater washes away the excess phosphorus to local waterways. In addition, irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions is a major transporter of nonpoint source pollutants. Excessive water use can also contribute to reduced water levels and associated water quality issues such as increased nutrient concentrations, reduced flows, and increased water temperatures.

Golf courses comprise approximately 894 hectares (2,207 acres) or 2.4% of the watershed in six subbasins. There are currently four golf courses (Glenwild, Jeremy Ranch, Park City Municipal, and Park Meadows) in the watershed, a fifth under construction (The Canyons), and four additional golf courses proposed. Surface disturbance during golf course development can contribute sediment and pollutant loads directly to surface waters. Golf course operations can contribute to sediment and pollutant loads through surface irrigation and associated pollutant release, pollutant transport by overland flows, fertilizers and pesticide use, and increased runoff from impermeable (concrete) and semi-permeable (turf grass) surfaces. Golf courses contribute 137 kg/year (0.26 kg/ha) of phosphorus, or 7% of the total annual phosphorus load in the watershed. The Spiro Tunnel subbasin contains phosphatic shales and contributes 21% (28.4 kg/year) of the annual phosphorus load from golf course land uses.

High use recreation, including parks, soccer fields, ball fields, and bike trails, comprise 57 hectares (142 acres) or 0.2% of the watershed in the Silver Creek/Parley's Park, and Lower Springs subbasins. There are no phosphatic shales in these subbasins. This land use contributes 8.51 kg/year (0.06 kg/ha) of phosphorus, or <0.1% of the total annual phosphorus load in the watershed.

9.2.1.3.3 Agricultural Management and Grazing

Grazing occurs on large areas in the watershed, including forested land, ranch land, pasture, and horse properties, but it occurs almost exclusively on private lands. The phosphorus contained in manure is in a highly soluble and readily bioavailable form. Reduced vegetative cover from overgrazing and sheet and rill erosion from storm events both result in increased sediment transport to streams and channels. Similarly, overuse of pasture land can result in subsurface soil compaction, compression of the soil profile, and the formation of a dense low-permeability layer below the upper soil horizon. During storm events and spring snowmelt, water infiltration into this compacted layer is limited while the volume and velocity of overland flow is increased, as is the total suspended sediment and nutrient load. Vegetation in overused pasture areas is often insufficient to retain sediment, and deposited manure is easily transported directly into water or downstream in existing stream and irrigation channels (NRCE 1996).

Cattle affect riparian areas and stream channels through increased sediment and nutrient loading and the deposit of manure and urine in surface waters (Mosely et al. 1997). The loss or removal of riparian vegetation reduces bank stability due to reduced root mass, and prevents settling and sedimentation at the edges of the stream channel. As a result, streambanks have become unstable in many stream reaches. Cattle grazing in riparian areas is most common downstream of Jeremy Ranch. The removal of streamside vegetation results in increased water temperatures and promotes the dissolution of adsorbed phosphorus and other nutrients from sediment-bound forms. Erosion occurs from the removal or reduction of riparian vegetation by grazing cattle, and from the shearing action of hooves on streambanks, which destabilizes the soil and promotes the rapid erosion of loose sediments by flowing water.

Irrigation of pasture and hayland occurs in the valley floor of the watershed. To irrigate crop land, either surface water is diverted from numerous streams into developed delivery canal systems, or groundwater is pumped from the regional aquifers into canals or directly to irrigation systems. Irrigation recharge and surface runoff is diverted to local streams or returns via canal seepage, shallow groundwater flow, surface water bypass flow, or irrigation tail water. Irrigation practices that substantially increase subsurface flow facilitate phosphorus transport. In addition, inefficient irrigation water management practices can reduce stream flows unnecessarily and result in increased water temperatures. Surface irrigation practices can substantially lower the water table and may lead to changes in the mobility of phosphorus in shallow subsurface waters. These waters generally contain high concentrations of phosphorus and nitrogen compared to the ambient concentrations in local streams (Omernik et al. 1981; Shewmaker 1997).

Flood irrigation waters cause soil erosion and delivery of sediments and nutrients directly to waterways. Lands that are irrigated using water diverted from surface waters have the potential to carry sediment as well as nutrients from multiple sources (Omernik et al. 1981; Shewmaker 1997). Waters that infiltrate the subsurface can increase the soil delivery rate of phosphorus to the stream from subsurface flow (Hedley et al. 1995). Pollutant loading from grazing is influenced by the intensity, timing, duration, proximity to the riparian vegetation community, and location of watering areas. Impacts from pasturing and grazing include soil compaction (increasing runoff), manure deposition, and increased sediment and nutrient loading due to erosion resulting from loss of vegetation and hoof action (Platts and Nelson 1995; Mosely et al. 1997; Khaleel et al. 1980; Hedley et al. 1995; Sharpley et al. 1992).

Agricultural management and grazing land uses compose 572 hectares (1,414 acres) or 2.4% of the watershed in 13 subbasins. There are phosphatic shales in only one of these subbasins: Three Mile. These land uses contribute 54 kg/year (0.07 kg/ha) of phosphorus, or 1.5% of the total annual nonpoint source phosphorus load in the watershed.

9.2.1.3.4 Stormwater Runoff from Developed Lands and Construction Sites

Stormwater discharges from urban areas consist of concentrated flows that accumulate from streets, parking areas, rooftops, and other impervious surfaces. Primary sources of pollutants associated with rural subdivisions are sediment and nutrients present in both dissolved and sediment-bound forms from roadway and impervious-surface runoff and snowmelt, irrigation practices, and yard and vehicle maintenance. Park City and other subbasins in the upper portion of the watershed contain the highest density of development and associated stormwater runoff volume in the watershed.

The primary pollutant sources from active construction sites are stormwater and sediment runoff, mud and dirt deposition on streets, and stockpiled soils. Active construction land-use areas comprise 71 hectares (175 acres) or 0.2% of the watershed. The majority of the construction is occurring in Summit County, primarily in Snyderville Basin. Active construction contributes 26.1 kg/year (0.47 kg/ha) of phosphorus, or 1% of the total annual nonpoint source phosphorus load in the watershed. The only active construction that occurs near phosphatic shales is in the Willow Draw subbasin.

Residential land use comprises 5,715 hectares (14,121 acres) or 15% of the watershed across 23 subbasins, including areas with phosphatic shales in the Treasure Hollow, Spiro Tunnel, Willow Draw, and Three Mile subbasins. The primary sources of pollutants from residential land use are from runoff over impermeable and semi-permeable surfaces such as pavement and lawns. Nutrient-rich runoff from precipitation or snowmelt can enter the stormwater system from roadways and impervious surfaces and discharge to surface waters in the watershed. Septic systems have the potential to contribute nutrients indirectly to surface waters due to poor design, inadequate sizing, improper maintenance, and/or seasonal high groundwater tables. Excess application of phosphorus fertilizer can be washed from lawns and gardens to local waterways. Irrigation water in excess of what can infiltrate the soil surface can be similarly washed away and is a major transporter of nonpoint source pollutants. Some road de-icer products have been identified as potentially significant sources of phosphorus pollution, and sand may contain substantial amounts of phosphorus. These land uses contribute 354.2 kg/year (0.08 kg/ha) of phosphorus, or 17% of the total annual phosphorus load in the watershed. Subbasins with phosphatic shales contribute 6% (21 kg/year) of the annual phosphorus load from these land uses.

The primary sources of pollutants from commercial and urban land uses are from runoff over impermeable surfaces, such as pavement, excess fertilizer application, excess irrigation, and road de-icers and sand. Nutrient and snowmelt runoff from roadways and impervious surfaces can enter the stormwater system and discharge to surface waters in the watershed. Excess application of phosphorus fertilizer can be washed from landscaping to local waterways. Irrigation water in excess of what can infiltrate the soil surface can be similarly washed away and is a major transporter of nonpoint source pollutants. Some de-icer products have been identified as potentially significant sources of phosphorus pollution, and sand may contain substantial amounts of phosphorus. Commercial and urban land uses comprise 333 hectares (822 acres) or 1.0% of the watershed across 13 subbasins, including phosphatic shale areas in the Spiro Tunnel, Willow Draw and Three Mile subbasins. These land uses contribute 85 kg/year (0.26 kg/ha) of phosphorus, or 4% of the total annual phosphorus load in the watershed. Phosphatic shale areas contribute 52% (44 kg/year) of the annual phosphorus load from these land uses.

9.2.1.3.5 On-site Wastewater Treatment Systems (septic systems)

Large tracts of urban and residential development have been completed in the Snyderville Basin of the watershed. Most of this development is associated with the Park City and Kimball Junction areas, where the majority of urban and residential developments have access to sewer hookups. Septic tanks in the watershed are allowed in areas where central sewer systems are not feasible or present. The majority of these systems are found in the Silver Creek subbasin, which flows south into East Canyon Creek. Subdivisions located near areas of perennial surface water have the potential to contribute nutrient loads to surface waters in the watershed via leachfield contamination of groundwater that recharges streams, or they may contribute nutrient loads directly when leachfields fail. Well designed leachfields typically remove phosphorus through the process of adsorption and precipitation.

Construction sites have a very high potential to mobilize phosphorus to surface waters, especially in locations where sediment runoff and erosion control measures are either not installed or not functioning properly. Construction vehicles can cause debris and mud to be deposited on streets as they exit the construction site. Additionally, developers may stockpile topsoil that typically contains relatively high levels of phosphorus. Sand used on construction sites may also contain substantial amounts of phosphorus.

9.2.1.3.6 Stream Erosion and Reservoir Shoreline Erosion

Population growth has led to a rise in moderate- and high-intensity urban and commercial development in the watershed. The increase in impermeable surface area associated with development in the upper East Canyon Reservoir watershed has resulted in flashy peak flows that cause streambank erosion. Changes in land use from forest to ski areas or golf courses also contribute to the potential for increased runoff and erosion. Development of land adjacent to streams often results in the removal and disruption of riparian vegetation, as well as peak stormwater flows, which cause stream incising in some areas and stream widening in others. Eroding streambanks could be contributing 2.3–7.2 tons of organic matter a year to East Canyon Creek (Baker et al. 2008). Because there is limited agricultural activity on the lands immediately surrounding East Canyon Reservoir, erosion due to agricultural practices, such as pasturing animals, is minimal.

9.2.1.3.7 Natural Background Sources including Phosphatic Shales and ***Atmospheric Deposition***

Natural background loads are those nutrient loads that would naturally occur under undisturbed conditions. Natural processes that contribute to background sources consist of weathering of rock outcrops, atmospheric deposition, mobilization of plant based nutrients via wildlife excretion, natural sheet and rill erosion of soils, and stream channel formation. Local lithology for the East Canyon Reservoir watershed is primarily composed of sedimentary rock, fine-grained alluvial deposits, and glacial outwash, all of which contribute high sediment loads in East Canyon Creek (Olsen and Stamp 2000). Natural background sources include phosphatic shales and native forests throughout the watershed.

Permian phosphatic shale (Meade Peak Member of the Phosphoria Formation) occurs along the southern side of Threemile Canyon and in the extreme southeastern corner of the watershed in Park City. The Meade Peak Member generally forms slopes and is easily eroded. The phosphate-rich sediments of the Meade Peak Member formed in a warm, shallow, marine shelf environment where prolific marine life extracted and concentrated phosphate from upwelling ocean currents (Stokes 1986). Given these characteristics, Meade Peak Member has been identified as a primary source of total phosphorus in the watershed (BIO-WEST 2008). A large proportion of phosphatic shale areas have been disturbed by active developments that have likely increased the erosion of the shales and increased phosphorus loading in East Canyon Creek and East Canyon Reservoir (Olsen and Stamp 2000).

Phosphorus does not have a gaseous state; however, phosphorus contained in dust particles in the atmosphere can contribute a small load of phosphorus to the landscape and directly to waterbodies.

Background or natural nonpoint source areas include the estimated natural load from all 23 subbasins. Background sources contribute 616 kg/year (0.01 kg/ha) of phosphorus, or 30% of the total annual nonpoint source load. In the East Canyon watershed, phosphatic shales occur in the Treasure Hollow, Spiro Tunnel, Upper Spring Creek, Willow Draw and Three Mile subbasins. Subbasins with phosphatic shales contribute 7% (44 kg/year) of the background annual nonpoint source phosphorus load.

9.2.2 LOAD REDUCTION ESTIMATES

9.2.2.1 East Canyon Water Reclamation Facility

The load allocation for ECWRF in the revised East Canyon Reservoir TMDL is 895 kg/year. This is a 35% increase over the 2000 TMDL load allocation and is due to projected growth in the service district for the treatment facility.

9.2.2.2 Internal Reservoir Sources

Alum treatment has been effective on numerous other lakes with phosphorus control lasting for an average of 8 years and reducing internal phosphorus loading by more than 80% (Welch and Cooke 1999). Alum treatment on this scale will reduce internal phosphorus loads by more than 50%, as required by the TMDL.

9.2.2.3 Nonpoint Sources

Load reductions for the East Canyon Reservoir Watershed Implementation Plan rely heavily on nonpoint source reductions to achieve desired water quality and to protect designated beneficial uses. Estimated percent reduction values, and therefore estimated load reductions, are based on values from the peer-reviewed literature. Implementation of a suite of BMPs, as described in this and other plans, provides reasonable assurance that load reductions will be achieved and designated beneficial uses will be restored. Furthermore, the extent of implementation planning, participation, and activity in the watershed is very encouraging. Full implementation of recommendations in existing plans should result in attainment of TMDL goals. The lag time associated with BMP implementation and observed water quality improvement may have led to an overestimation of total load from nonpoint sources. Water quality improvement trends are expected to continue for East Canyon Reservoir. Monitoring and reporting will be conducted to verify effectiveness of implemented BMPs. If monitoring shows that load reductions are not occurring to the extent necessary, BMPs should be modified accordingly. This monitoring and modification "feedback loop" provides further assurance that estimated load reductions will be achieved by continuing implementation of BMP suites. In addition, in-stream erosion sources are expected to be reduced as a result of the East Canyon Creek TMDL. These reductions have not been quantified and are in addition to the estimated load reductions summarized in Table 9.1.

Table 9.1. Summary of Load Reductions Resulting from BMPs Implemented by Loading Source

Loading Source	Current Estimated Load from Source (kg/year)	Recommended BMPs	Land-use Acreage	Estimated Combined BMP Effectiveness	Load Reduction (kg/year)
Active Construction	26.1	• Continue enforcement of stormwater pollution prevention plans and erosion control plans for construction activities • Detention basins • Soil stabilization and management • Vehicle wash-down pads • Street sweepers	175	60%–90%	15.7–23.5
Residential	333.1	• Installation of new, properly functioning systems (I&E) • Soil testing and fertilizer rate reduction (I&E) • Stormwater management plans • Alternative de-icing methods • Test phosphorus content of de-icers	14,121	55%–85%	194.8–301.1
Commercial and Urban	85.3	• Stormwater management plans • Detention basins • Dry basins • Infiltration/ retention basin • Wetland • Sand filter • Improve irrigation ordinances and encourage water mgmt through I&E • Alternative de-icing methods. • Test phosphorus content of de-icers • Porous pavement	822	55%–85%	46.9–72.5

Table 9.1. Summary of Load Reductions Resulting from BMPs Implemented by Loading Source

Loading Source	Current Estimated Load from Source (kg/year)	Recommended BMPs	Land-use Acreage	Estimated Combined BMP Effectiveness	Load Reduction (kg/year)
Golf Course	136.9	• Continue O&M of detention ponds • Grass swales • Filter strip • Soil testing; nutrient mgmt plan • Irrigation management	2,207	45%–75%	61.6–102.7
Ski Area	315.7	• Trail design • Access road treatment • Road realignment/ decommissioning • Infiltration/retention basin	7,369	65%–90%	205.2–284.1
High Use Recreation	8.5	• OHV restrictions • Trail design • Septic tank maintenance	142	35%–55%	3.0–4.7
Agricultural Management and Grazing	54.5	• Irrigation system management • Pasture and hayland planting • Nutrient management • Prescribed grazing • Livestock exclusion from riparian areas • Off-site watering • Channel bank revegetation • Stream crossings • Riparian forest buffer	1,414	60%–85%	32.7–46.3
Forested and Meadow	474.7	• Access road treatment • Road realignment • Trail design • OHV restrictions • Prescribed grazing	65,668	55%–85%	261.1–403.5
Total Load (excluding Background Sources)	1,455.8		92,498		820.9–1,238.3
Average Expected Reduction					**1,030**
Target Reduction					**1,005**

9.2.3 Recommended Management and Implementation Measures

9.2.3.1 East Canyon Water Reclamation Facility

The Snyderville Basin Water Reclamation District is currently designing an expansion and upgrade project of the ECWRF. The ECWRF will be expanded from the current capacity of 4.0 MGD to 7.2 MGD. Several new features and pieces of treatment equipment will be included in the project. First, an additional bioreactor will be added (joining two existing), along with an additional clarifier (joining three existing). Both of these treatment components remove phosphorus biologically. Second, the existing equalization basin will be expanded to improve the biological removal of phosphorus for the entire 7.2-MGD treatment train. Third, the existing sand filters will be replaced with a pressure membrane system capable of treating the entire actual flow. Use of a membrane will increase the stability and reliability of chemical phosphorus removal (to meet TMDL allocations and permit limits).

9.2.3.2 In-reservoir Treatments

The reduction of external sources of phosphorus should eventually lead to a change in the trophic state of East Canyon Reservoir. However, this response may be delayed by the slow flushing rate, associated with the size and management of the reservoir, and the high recycling rate of phosphorus from the sediments into the water column during stratification. This lag time between watershed nutrient load reductions and trophic state change has been documented in other lakes and reservoirs with similarly slow flushing rates and high internal phosphorus recycling rates (Ahlgren 1977; Cooke et al. 1993).

Lakes and reservoirs similar in type to East Canyon Reservoir often require additional in-reservoir treatments to attain trophic change in a relatively short period of time (Cooke et al. 1993). In-reservoir treatments include inactivation of phosphorus in the sediment through the use of aluminum salts and/or the direct aeration of the hypolimnion to provide an interim refuge for cold water fish while the reservoir responds to nutrient reductions. However, in-reservoir treatments are only truly effective in the long term when they are combined with the reduction of external phosphorus loads (Ryding and Rast 1989) through the implementation measures outlined in the previous sections.

9.2.3.2.1 Phosphorus Inactivation Using Alum

The addition of aluminum salt in the form of alum (aluminum sulfate) or sodium aluminate to the water column is the most common method for sediment phosphorus inactivation in lakes and reservoirs. Alum inactivates sediment phosphorus through chemical binding and sorption, thereby reducing internal cycling of phosphorus during periods of anoxia. Alum treatment of East Canyon Reservoir would effectively seal the sediment layer at the sediment-water interface by binding to the phosphorus in the top several centimeters of sediment. As a secondary benefit, the formation of aluminum hydroxide ($Al(OH)_3$) would also remove particulate organic and inorganic matter with phosphorus from the water column, improving water clarity immediately (Cooke et al. 1993). In lakes with very low alkalinity (less than 50 mg/L $CaCO_3$), the addition of aluminum salts can cause a shift in pH (Cooke et al. 1993). The alkalinity of East Canyon Reservoir ranges from 144 to 192 mg/L $CaCO_3$, and so the reservoir should not be susceptible to pH shifts.

Estimating the dose of alum required to reduce internal phosphorus load to the water column of East Canyon Reservoir will require detailed design and study. However, typical dose rates for alum, in order to completely seal the sediments, are typically estimated to be five times the average summer internal phosphorus load. The average total phosphorus released from sediments in East Canyon Reservoir is 2,013 kg/season. This total includes phosphorus that has been in sediments for more than a year as well as the sediment phosphorus associated with spring inflows (of this 2,013 kg/year, only 795 is phosphorus that did not originate in the watershed during the previous year). Approximately 10,065 kg of alum (aluminum sulfate) would be required based on this typical dose rate for East Canyon Reservoir. This dose, spread across the entire reservoir, would result in an aerial application of 36.5 kg/ha (32.5 lbs/acre). Dose rates would be higher in the most phosphorus-rich areas of East Canyon Reservoir and slightly lower in less phosphorous-rich areas. Generally, alum treatment is not recommended in the shallow parts of the reservoir (less than 10 feet) because wind action can disturb sealed sediments.

9.2.3.2.2 Hypolimnetic Aeration

Hypolimnetic aeration aims to raise the oxygen level of the hypolimnion while preserving stratification (maintaining the thermocline) thus not releasing nutrients into the epilimnion (Cooke et al. 1993; Ryding and Rast 1989; Singleton and Little 2006). Oxygenation of anaerobic sediments disrupts the sediment-water interface and provides oxygen to microorganisms that break down organic sediments (Moore et al. 1996). This results in an increased sediment oxygen demand (SOD) for some time until organic sediments become saturated with oxygen and SOD levels taper off (Moore et al. 1996). In East Canyon Reservoir, as with other similar waterbodies, this process could provide immediate habitat and food supply for cold water fish species. Furthermore, aerobic sediments do not release iron-bound phosphorus. Hypolimnetic aeration is restricted to lakes deeper than 12–15 m (Cooke et al. 1993).

Hypolimnetic aeration can be accomplished with the use of airlifts, diffusers, or injection of compressed air (Singleton and Little 2006). Medium bubble diffusers would provide sufficient oxygen transfer in East Canyon Reservoir, because the reservoir is quite deep. The design of a hypolimnetic aeration system depends on the bathymetry of the reservoir, the extent of anoxia (across the reservoir during summer and winter), and specific project goals. The model developed by McCord et al. (2000) could be used to design an effective aeration system that maintains stratification in the summer and also prevents winter fish kills.

In the case of East Canyon Reservoir, hypolimnetic aeration would enhance the cold water fishery habitat in the interim while phosphorus reduction efforts in the watershed take effect. Reestablishment of the blue-ribbon trout fishery in East Canyon Reservoir may require hypolimnetic aeration indefinitely. Aeration should be used primarily when the reservoir is stratified in the summer and winter seasons. Aeration is only recommended where the deep hypolimnion experiences extended periods of anoxia, from the dam through the mid-lake monitoring site. In East Canyon Reservoir, an aeration system would likely be needed near the dam extending up the reservoir for at least 1/3 of a mile to cover the deepest and most anoxic sections of the reservoir. An aeration system of this size would typically require one to two blowers with motors that are 200–300 hp (personal communication between Erica Gaddis, SWCA, and Theron Miller, UDWQ).

9.2.3.3 Nonpoint Source Management Measures

All land uses in the East Canyon Reservoir watershed contribute dissolved and/or sediment-bound nutrient loads to the reservoir. The nonpoint source reduction implementation plan describes existing plans and additional BMPs that could be implemented and/or maintained for the purpose of reducing phosphorus and sediment loading to the reservoir and its tributaries. If the recommended and existing BMPs for load reduction are designed, installed, and maintained properly, the greatest possible phosphorus reduction will be achieved at the least cost. This could be achieved through full implementation of existing source-specific plans in the watershed. The systemization of individual BMPs (i.e., the designing of BMPs in cohesive systems rather than as stand-alone practices) further facilitates watershed planning and phosphorus reduction. Land uses identified in the East Canyon Reservoir watershed and associated phosphorus loads are listed in Table 9.2.

Table 9.2. Summary of Land Uses and Associated Phosphorus Nonpoint Loads

Land Use	Area Hectares (acres)	Area Weighted Phosphorus Load (kg/ha/year)	Total Phosphorus Load (kg/year)
Active Construction	71 (175)	0.47	26.1
Residential	5,715 (14,121)	0.08	354.2
Commercial and Urban	333 (822)	0.26	85.3
Golf Courses	893 (2,207)	0.26	136.9
High Use Recreation	57 (142)	0.06	8.5
Ski Areas	2,982 (7,369)	0.18	315.7
Agriculture/Grazing	572 (1,414)	0.07	54.5
Forested and Meadow	26,575 (65,668)	0.01	474.7

The overall project goals are to reduce nonpoint source phosphorus loading to East Canyon Reservoir by decreasing the amount of phosphorus runoff from the land uses identified above. Additional reductions in phosphorus loading can be achieved by informing and educating the community concerning nonpoint source pollution and the importance of managing natural resources in the watershed. Specifically, the project goals and objectives for the East Canyon Reservoir watershed are as follows:

Goal 1: Continue to improve site control for active construction sites to reduce sediment runoff to East Canyon Creek, its tributaries, and East Canyon Reservoir.

Goal 2: Improve golf course management practices to reduce nutrient and sediment loading to East Canyon Creek, its tributaries, and East Canyon Reservoir.

Goal 3: Continue to improve ski area management practices to reduce nutrient and sediment loading to East Canyon Creek, its tributaries, and East Canyon Reservoir.

Goal 4: Reduce nutrient and sediment loading to East Canyon Creek, its tributaries, and East Canyon Reservoir by implementing BMPs on agricultural and grazing lands.

Goal 5: Inform and educate the community concerning nonpoint source pollution and the importance of maintaining and improving water quality in the watershed.

Goal 6: Centralize implementation plan reporting in a database available to the public and stakeholders in the watershed. This database should include implementation monitoring (e.g. progress reporting), effectiveness monitoring (e.g. water quality monitoring results), and documentation of progress.

9.2.3.3.1 Overview of Best Management Practices (BMPs) and Implementation Planning

For the purposes of this implementation plan, BMPs refer to any action or measure implemented or maintained in the watershed to control nonpoint sources of phosphorus to East Canyon Reservoir. These include traditional structural and nonstructural BMPs as defined by the NRCS, the USFS, and in stormwater management plans, as well as actions and measures related to planning, education of landowners, and enforcement of stormwater ordinances.

Structural BMPs applied to the East Canyon Reservoir watershed may include practices such as installing construction silt traps (silt screen fencing, sock, straw bales), installing and maintaining detention basins, designing new trails or redesigning existing trails, treating access roads, stabilizing slopes, restricting cattle access to stream channels, and reinforcing or stabilizing eroded areas along East Canyon stream.

Nonstructural techniques include development of stormwater management plans; improving the operation, maintenance, and enforcement of existing stormwater management plans; testing soils and developing nutrient management plans; restricting OHV use and enforcing those policies; and implementing irrigation water management plans.

Implementation and maintenance of BMPs in the East Canyon Reservoir watershed is necessary to achieve water quality targets and TMDL endpoints. Installed BMPs are either structural or nonstructural practices used to protect the physical and biological integrity of waterbodies. These practices are most effective when installed in combination as a system of BMPs rather than in isolation. Some BMPs follow standards established by the USDA NRCS Field Office Technical Guide (NRCS 2007).

9.2.3.3.2 Existing Watershed Planning and Implementation

Numerous efforts have been made in the East Canyon Watershed to reduce nonpoint source sediment and phosphorus runoff. These efforts are detailed in management plans specific to municipal stormwater (PCMC 2003, Summit County Ordinance 281), ski resorts (MAG 2003, The Canyons Ski Resort 1999), golf courses (MAG 2003, Jeremy Golf and Country Club 2001), construction (MAG 2003), agriculture (ECWC 2004), in-stream erosion (ECWC 2004), and recreation (MAG 2003), and generally cover all of the major sources of phosphorus loading in the watershed. Each plan is currently in the process of being implemented with varying levels of completion. The plans themselves detail BMP implementation that is relevant, appropriate, and specific to locations throughout the watershed. The implemented BMPs are included in the calculated load reductions required for each source, as they are reflected in the load coefficients derived from monitoring data by subbasin collected in 2007 (BIO-WEST 2008). Generally, full implementation of each of these plans should result in attainment of the TMDL loads allocated to nonpoint sources in the East Canyon Reservoir. However, monitored loads in the East Canyon Watershed in 2007 (BIO-WEST 2008) indicate that full implementation has not yet been completed. A summary of the types of BMPs recommended for each land use are included in this nonpoint source reduction implementation plan for the watershed, however the reader is referred to the more detailed source-specific plans listed in Table 9.3 for more information. The watershed would benefit from a centralized database that tracks the progress and success of implementation projects throughout the reservoir. The East Canyon Watershed Committee hosts a website that currently serves as a clearing house for documents, contacts, and meetings. This website would be a good place to host a database of progress reporting, monitoring data, and load reduction estimates.

Table 9.3 Summary of Implementation Planning in the East Canyon Reservoir Watershed

Plan	Date	Phosphorus Source	Organization	Monitoring Plan	Status of Implementation	Schedule for Implementation?
East Canyon Watershed Restoration Action Plan	2004	All watershed sources	East Canyon Watershed Committee	Yes.	Implementation of most projects documented in 104(b) 3 Project Progress reports available from the NRCS.	No.
Park City Municipal Corporation Storm Water Management Plan	2003	Commercial, urban, residential, and active construction	Park City Municipal Corporation	Construction site visits and water quality testing.	Annual Reporting. Environmental Information Handbook (2003)	Ongoing. Annual projects prioritized as funding permits.
Snyderville Basin Recreation & Construction Industry Water Quality Improvements Project	2003	Recreation and Construction Industry	Mountainland Association of Governments. 2003	Yes.	Unknown.	Yes.
Golf Course Environmental Management Plan for The Jeremy Golf and Country Club	2001	Golf courses	Jeremy Golf and Country Club	No.	Unknown.	No.
Willow Draw Watershed Master Plan	1999	Ski resorts	The Canyons Ski Resort	No.	Unknown.	Completion target date: 2005.
Summit County Storm Water Ordinance (Ordinance 381)	Not available	Active Construction	Summit County	Construction site visits	Ongoing.	Ongoing.

9.2.3.4 Critical Areas for Management Measures

Total phosphorus loads have been summarized by land use in each of 23 subbasins in the East Canyon Reservoir watershed based on loads derived using load coefficients from the BIO-WEST watershed monitoring project in 2007 (BIO-WEST 2008) and adjusted proportionally to match total load to the reservoir observed from 2003 - 2007. Loads are summarized both as total load from each landuse-subbasin combination and as area-weighted loads (the total load divided by the area). Areas with high area-weighted loads indicate a large load per area and therefore an opportunity to address more loads with less implementation. These areas are generally more cost-effective to target for phosphorus reduction in terms of kg of phosphorus reduced per dollar spent. However, many of the areas with high area-weighted loads compose a very small proportion of the watershed and therefore do not contribute a significant load to the reservoir. Likewise, the largest contributor of total load in the watershed, forested and meadow land uses, have the lowest area-weighted load but the largest total land area. Therefore, these areas must be addressed, even though so doing many cost more per kg of phosphorus reduced. Both total load and area-weighted load were used in prioritizing critical areas to focus further implementation efforts. High priority areas (landuse-subbasin combinations) are those that have both a high area-weighted load (greater than 0.1 kg/ha/year) as well as a significant total load (greater than 10 kg/year). Medium priority areas are those that have either a high area-weighted load or a significant total load. Low priority areas have both low area-weighted loads (less than 0.1 kg/ha/year) and low total loads (less than 10 kg/year). A spatial summary of high, medium, and low critical priority areas, based on these criteria is displayed in Figure 9.1.

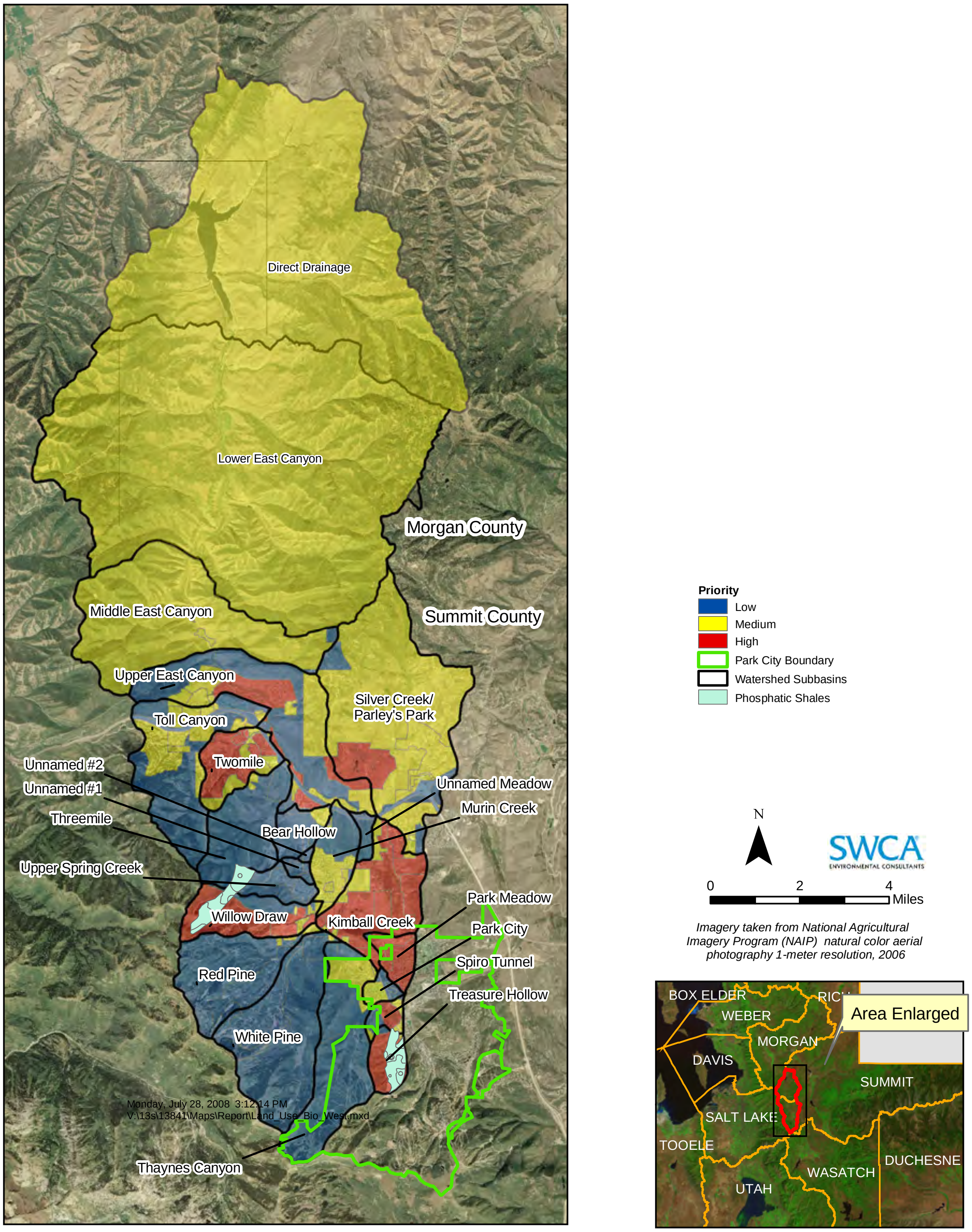

Figure 9.1 Map of critical priority areas for additional implementation for phosphorus reduction in the East Canyon Reservoir watershed.

9.2.3.5 Land Uses and Recommended BMPs

9.2.3.5.1 Active Construction

Summary of Construction BMP Implementation, Planning, and Enforcement

BMPs designed to reduce pollutant loads from construction sites include preservation of existing vegetation, installation of silt traps (silt screen fencing, sock, and straw bales), temporary stabilization of stockpiled soils, use of vehicle wash stations, and use of street sweepers. Infiltration basins are used on larger construction projects. Stormwater and sediment runoff from construction sites can be limited by continuing enforcement of requirements of a Storm Water Pollution Prevention Plan (SWP3) and Erosion Control Plan (ECP).

Summit County and Park City Municipal Corporation (PCMC) have numerous programs and regulations in place for construction controls. No significant construction activities are present in Morgan County. Summit County and PCMC have been coordinating with DWQ in developing SWP3s and each plan contains chapters that directly relate to water quality. Summit County Ordinance 381 and Park City’s Storm Water Management Plan (PCMC 2003) contain BMPs for Construction Site Runoff Controls and Post Construction Runoff Controls. Additional plans that address control of construction runoff include the East Canyon Watershed Restoration Action Plan (East Canyon Watershed Committee 2004) and the Snyderville Basin Recreation & Construction Industry Water Quality Improvement Project (MAG 2003).

In addition, PCMC conducts training sessions and workshops for local contractors to learn about BMPs for stormwater quality and environmental ordinances. PCMC requires that all construction must adhere to environmental ordinances and mitigation, and signed compliance to environmental ordinances is required for all projects that need a building permit. A "stop work" order is issued if stormwater BMPs are not implemented. A contractor must resolve the issue or the permit is revoked. In 2005, PCMC made 665 construction site inspections and issued 78 Stop Work Orders due to stormwater violations. Reductions in current pollutant loads from construction sites can be achieved by continued application and enforcement of these existing plans, programs, and ordinances.

Priority Areas for Continued BMP Implementation, Maintenance, and Enforcement

Implementation of BMPs to control active construction in the Willow Draw subbasin of Summit County is the highest priority for this source. Phosphatic shales in this subbasin contribute to the very high area-weighted load for active construction. Enhanced and additional BMPs may be required to control phosphorus load from these areas. The Kimball Creek, Park City, Two Mile, and Upper East Canyon subbasins are all medium priority areas for implementation of active construction BMPs. Although these subbasins have relatively high area-weighted loads for active construction, the small acreage associated with this land use results in a small total load contribution to the reservoir. Active construction in the White Pine subbasin is a low priority.

Table 9.4. Priority Subbasins and Recommended BMPs for Active Construction Areas in the East Canyon Reservoir Watershed

Subbasin	Jurisdiction	Phosphatic Shales in Subbasin?	Area of Land Use in Watershed (hectares)	Annual Load (kgTP/yr)	Area Weighted Load (kgTP/ha/yr)	Priority
Willow Draw	Summit Co.	Yes	17	17.6	1.01	High
Kimball Creek	Summit Co.	No	4	2.0	0.44	Medium
Park City	Park City	No	19	4.3	0.22	Medium
Two Mile	Summit Co.	No	3	0.6	0.20	Medium
Upper East Canyon	Summit Co.	No	8	1.2	0.16	Medium
White Pine	Summit Co.	No	19	0.4	0.02	Low

The effectiveness of total phosphorus reduction for BMPs applied to sources associated with active construction depends on the extent of application, the proportion of phosphorus that is particulate (bound to sediments), and operation and maintenance of the BMPs. Infiltration/sedimentation basins generally reduce total phosphorus by 50% to 80% (WDEQ 1999). Street sweepers are able to remove approximately 75% of phosphorus associated with dirt or sand from construction vehicles (USDOT 2008). Installation of silt traps, stabilization of stockpiled soils, and the use of vehicle wash stations would further reduce phosphorus load associated with construction activities. Assuming the appropriate BMPs are implemented a 60% – 90% of total phosphorus from current loads associated with active construction sources was assumed (15.7 to 23.5 kg/year).

9.2.3.5.2 Residential

Summary of BMP Implementation and Planning

The East Canyon Watershed Restoration Plan (ECWC 2004) contains goals and objectives to develop and implement residential homeowner BMPs to minimize contributions of nutrients from residential land uses. These goals and objectives include ongoing information and education programs targeted at homeowners, and development of a Comprehensive Information and Education Plan for the East Canyon Watershed. A residential outreach program is included in the comprehensive plan for the watershed. A detailed outline for the Comprehensive Information and Education Plan for the East Canyon Watershed has been developed and is available in the East Canyon Watershed Restoration Plan (ECWC 2004).

Park City Municipal Corporation has procured over 4,000 acres of open space partially funded by a $10 million open space bond. They have tried to focus on riparian and stream buffer zones to improve water infiltration and protection in these areas, which will in turn improve stormwater quality. PCMC has also installed 100 "No Dumping Drains to Watershed" signs on drains throughout the city and added silt traps to stormwater accumulation structures. The development and maintenance of sediment detention basins are ongoing projects. PCMC has also focused on educating the surrounding community. PCMC enforces a Conservation and Drought Management plan that includes BMPs for conserving water. The plan incorporates irrigation ordinances and water management priorities. The plan also recommends the distribution of public information about water conservation in brochures, in public service announcements on TV and radio, on posters, and on bus advertisements. The PCMC also publishes and distributes an

"Environmental Information Handbook" and a "Residential Stormwater Brochure" as well as information on invasive weed species and xeriscape gardening. In addition, they have placed signs throughout the watershed detailing proper management of dog waste and stormwater BMPs.

Runoff from impervious surfaces would be further limited by maintaining the Stormwater Management plans in place in the watershed and continuing to implement recommendations in the East Canyon Watershed Restoration Plan. These recommendations include the following specific actions. Nutrient loads from semi-permeable surfaces, lawns, and gardens should be limited by encouraging pre-fertilization soil testing and reduction of the use of residential fertilizer based on soil test recommendations. Reductions in pollutant loads from runoff and irrigation return flow may be achieved through the maintenance of irrigation ordinances and by encouraging water management through landscaping information and education. Also recommended are alternative de-icing methods that require testing of phosphorus content of de-icers and road sand and a resulting change of source if the phosphorus content is high.

BMPs designed to reduce pollutant loads from on-site wastewater treatment systems include repair of existing systems, addition of sand or recirculating filters, improved rates of regular maintenance of systems, or the complete removal of a malfunctioning system and replacement with properly functioning system. Installation of new, properly functioning systems has been found to be prohibitively expensive and to lead to very little progress in load reduction. However, a study of groundwater in the Silver Creek Estates development indicates that subsurface flow may be an important conveyance of phosphorus from residential land uses. This phosphorus could have originated from septic systems, or infiltration from heavily fertilized turf. Generally, there are no recommended BMPs for improving phosphorus treatment in septic tanks or leachfields. However, tanks and drainfields that are not installed correctly or not operating as designed should be modified, repaired, or fixed. Due to the high potential for growth in the watershed, an I&E program concerning the design, installation, and maintenance of on-site wastewater treatment systems should be initiated by the agency responsible for overseeing the permitting of new or replaced systems.

Priority Areas for Continued BMP Implementation

Residential development in the Kimball Creek, Park Meadows, and Two Mile subbasins are all high priority areas for implementation due to both high area-weighted loads and significant total load. Kimball Creek incorporates much of the recent development in Snyderville Basin. All of these areas, with the exception of Park Meadows, are under the jurisdiction of Summit County. Eleven additional subbasins are ranked as medium priority areas for stormwater BMP implementation. These areas span the watershed and include residential areas in Morgan County, unincorporated Summit County, and Park City. Several of these subbasins (Willow Draw, Treasure Hollow, Three Mile and Spiro Tunnel) contain phosphatic shales that should be considered concentrated source areas where enhanced BMPs may be required to mitigate naturally high soil phosphorus levels. The relatively low area-weighted load from residential areas in Park City, the most densely populated area of the watershed, is noteworthy and indicative of the efforts this municipality has made to treat stormwater and reduce impacts on water quality.

Table 9.5. Priority Subbasins and Recommended BMPs for Residential Land Uses in the East Canyon Reservoir Watershed

Subbasin	Jurisdiction	Phosphatic Shales in Subbasin?	Area of Land Use in Watershed (hectares)	Annual Load (kgTP/yr)	Area Weighted Load (kgTP/ha/yr)	Priority
Kimball Creek	Summit Co.	No	595	87.4	0.15	High
Park Meadows	Summit Co./Park City	No	89	14.7	0.17	High
Two Mile	Summit Co.	No	367	74.8	0.20	High
Direct Drainage	Morgan Co.	No	255	23	0.09	Medium
Lower East Canyon	Morgan Co.	No	156	14.1	0.09	Medium
Lower Springs	Summit Co.	No	222	14.5	0.07	Medium
Silver Creek / Parley's Park	Summit County	No	2,559	42.4	0.02	Medium
Spiro Tunnel	Park City	Yes	10	5.0	0.48	Medium
Thaynes Canyon	Summit Co./Park City	No	161	14.3	0.09	Medium
Three Mile	Summit County	Yes	16	2.9	0.17	Medium
Toll Canyon	Summit County	No	472	11.8	0.03	Medium
Treasure Hollow	Park City	Yes	3	1.6	0.48	Medium
Upper East Canyon	Summit County	No	527	26.3	0.05	Medium
Willow Draw	Summit County	Yes	27	7.2	0.27	Medium
Bear Hollow	Summit Co.	No	18	1.6	0.09	Low
Middle East Canyon	Summit Co.	No	27	2.5	0.09	Low
Park City	Park City	No	11	1.0	0.09	Low
Unnamed # 1	Summit Co.	No	48	3.2	0.07	Low
Unnamed # 2	Summit Co.	No	13	0.9	0.07	Low
Unnamed Meadow	Summit Co.	No	5	0.5	0.09	Low
Upper Spring Creek	Summit Co.	Yes	106	4.4	0.04	Low

The effectiveness of total phosphorus reduction for BMPs applied to sources associated with active construction depends on extent of application, the proportion of phosphorus that is particulate (bound to sediments), and operation and maintenance of the BMPs. Infiltration/sedimentation basins generally reduce total phosphorus in stormwater by 50% to 80% (WDEQ 1999). Other stormwater mitigation structures and practices (reduced fertilizer, alternative de-icing methods, and sediment traps) would further reduce total phosphorus associated with residential areas (International Stormwater Database 2007). Assuming the appropriate BMPs are implemented a 55% – 85% reduction of total phosphorus from current loads associated with residential areas was assumed. With the implementation of the recommended BMPs applied to treat stormwater from residential areas, the estimated phosphorus load reduction ranges from approximately 195 to 301 kg/year.

9.2.3.5.3 Commercial and Urban

Summary of BMP Implementation and Planning

The implementation measures employed by Park City Municipal Corporation to reduce stormwater impacts to East Canyon Creek and Reservoir are described in the residential land uses section and apply equally to commercial and urban land uses. Stabilization of eroding segments from streambanks has been accomplished by working with private landowners to implement stream erosion BMPs. In addition, the East Canyon Watershed Committee has supported the development and implementation of site specific private landowner management plans (East Canyon Watershed Restoration Plan (East Canyon Watershed Committee 2004).

An East Canyon Watershed Stream Restoration Project has been implemented by Mountainland Association of Governments. The accomplishments made in this project are summarized in the Nonpoint Source 319 (h) Project Progress Reports dated August 20, 2007 and September 21, 2007. With respect to urban land uses, these progress reports indicate that land owners between East Canyon Reservoir and the East Canyon Creek headwaters were contacted and the majority of them are interested in participating in the restoration efforts. Five implementation plans have been written, two have completed their projects and two are in progress. In coordination with the Swaner Nature Preserve, three additional restoration plans have been written for property owners adjacent to the preserve to restore approximately 5 miles of East Canyon Creek above the ECWRF.

Runoff from impervious surfaces could be further reduced by maintaining the Stormwater Management plans in the watershed and fully implementing recommendations contained in the plans. These recommendations include the following specific actions: 1) Nutrient loads from semi-permeable surfaces and landscaping should be limited by encouraging pre-fertilization soil testing and reduction of the use of landscape fertilizer based on soil test recommendations. 2) Reductions in pollutant loads from runoff and irrigation return flow may be achieved through the maintenance of irrigation ordinances and by encouraging water management through landscaping information and education. 3) Alternative de-icing methods that require testing of phosphorus content of de-icers and road sand and a corresponding change in the source if the phosphorus content is high.

Priority Areas for Continued BMP Implementation

Implementation of BMPs on commercial and urban land uses in the Willow Draw and Upper East Canyon subbasins is ranked as a high priority for the watershed (Table 9.5). Willow Draw contains phosphatic shales that contribute to the very high area-weighted phosphorus loads observed in those areas. The high priority areas are under the jurisdiction of Summit County. Spiro Tunnel, Two Mile, Toll Canyon, Three Mile, Silver Creek/Parley's Park, White Pine, Bear Hollow, Kimball Creek, and Red Pine subbasins are a medium level priority for implementing additional stormwater BMPs. Phosphatic shales are found in several subbasins with commercial and urban land uses including Spiro Tunnel (Park City), Three Mile (Kimball Junction), and Willow Draw (Summit County). The phosphatic shale portions of these subbasins should be considered concentrated source areas where enhanced BMPs may be required to mitigate the naturally high soil phosphorus levels in the area. The very low area-weighted load and total load from commercial and urban areas in Park City, the most densely developed area of the watershed, is noteworthy and indicative of the efforts this municipality has made to treat stormwater and reduce impacts on water quality.

Table 9.6. Priority Subbasins and Recommended BMPs for Commercial and Urban Land Uses in the East Canyon Reservoir Watershed

Subbasin	Jurisdiction	Phosphatic Shales in Subbasin?	Area of Land Use in Watershed (hectares)	Annual Load (kgTP/yr)	Area Weighted Load (kgTP/ha/yr)	Priority
Willow Draw	Summit Co.	Yes	80	37.2	0.47	High
Upper East Canyon	Summit Co.	No	72	12.0	0.17	High
Spiro Tunnel	Park City	Yes	14	6.9	0.48	Medium
Two Mile	Summit Co.	No	14	3.4	0.25	Medium
Toll Canyon	Summit Co.	No	15	2.8	0.20	Medium
Three Mile	Summit Co.	Yes	1	0.2	0.18	Medium
Silver Creek / Parley's Park	Summit Co.	No	46	8.3	0.18	Medium
White Pine	Summit Co.	No	14	2.5	0.18	Medium
Bear Hollow	Summit Co.	No	37	6.2	0.17	Medium
Kimball Creek	Summit Co.	No	3	0.5	0.17	Medium
Red Pine	Summit Co.	No	28	4.6	0.17	Medium
Lower Springs	Summit Co.	No	5	0.4	0.09	Low
Park City	Park City	No	3	0.1	0.04	Low

The effectiveness of total phosphorus reduction for BMPs applied to sources associated with commercial and urban land uses depends on extent of application, the proportion of phosphorus that is bound to sediments, and operation and maintenance of the BMPs. Infiltration/sedimentation basins generally reduce total phosphorus in stormwater by 50% to 80% (WDEQ 1999). Other stormwater mitigation structures and practices (reduced fertilizer, alternative de-icing methods, and irrigation management) would further reduce total phosphorus associated with commercial and urban areas (International Stormwater Database 2007). Assuming the appropriate BMPs are implemented, in addition to those already completed, a 55% – 85% reduction of total phosphorus from current loads associated with commercial and urban areas was assumed (47 to 73 kg/year). Though any single BMP may be applied, greater reductions are achieved when BMPs are implemented in conjunction with others.

9.2.3.5.4 Golf Courses

Summary of BMP Implementation and Planning

Potential projects for each golf course are outlined in the Snyderville Basin Recreation & Construction Industry Water Quality Improvements Project (MAG 2003) and adopted in the East Canyon Watershed Restoration Action Plan as implementation strategies for golf courses. Each golf course in the watershed has existing strategies and management practices (WRAPS Plans) in place. Based on interviews conducted with the respective golf course superintendents and managers, these strategies and management practices are consistent with those recommended in the Snyderville Basin Recreation & Construction Industry Water Quality Improvements Project (MAG 2003).

For example, Glenwild Golf Club has not applied phosphorus fertilizer to most of the course in the past three years and runoff from the golf course is filtered by natural areas, including wetlands (personal communication between Erica Gaddis, SWCA, and David Willis, Glenwild Golf Course, August 14, 2008). PCMC's Parks and Golf Department manages multiple sediment traps, sediment vaults, and buffer areas. In 2006, PCMC removed 10,000 cubic yards of sediment from a detention basin in Park City Municipal Golf Course.

It is noteworthy that two of the four golf courses, Glenwild Golf Club and Park City Municipal Golf Club, are currently or in the process of becoming "Audubon Certified Golf Courses". To become an Audubon Certified Golf Course, the superintendent of the golf course must complete a rigorous program and implement procedures that include Environmental Planning, Wildlife and Habitat Management, Chemical Use Reduction and Safety, Water Conservation, Water Quality and Management, and Outreach and Education (MAG 2003). Golf course employees must also undergo continued education and training on environmental practices.

Given that the golf courses in the watershed are currently following the BMPs outlined in the Snyderville Basin Recreation & Construction Industry Water Quality Improvements Project (MAG 2003), continuation of these BMPs for existing golf courses and implementation of these BMPs by new golf courses is recommended. These BMPs include: the continued operation and maintenance of detention ponds to reduce or prevent sediment runoff; pre-fertilization soil testing and reduction of fertilizer use based on soil test recommendations; the implementation of a nutrient management plan and continued irrigation management to reduce nutrient runoff; and the creation of riparian buffers and filter strips to filter nutrients from runoff before it enters receiving waters (MAG 2003).

Priority Areas for Continued BMP Implementation

Portions of each of the four golf courses in the watershed lie in a priority subbasin. Some of these areas are recommended for additional BMP implementation (Table 9.7). The portion of Jeremy Ranch that is in Toll Canyon is considered to be a low priority for additional implementation, whereas the Park City Golf Course, located in the Park City subbasin, is a medium priority for additional implementation The two high priority areas for improving golf course BMP implementation are at the Park City Golf Course and the Park Meadows Golf Course in the Spiro Tunnel and Park Meadows subbasins respectively. In particular, the Park City Golf Course in the Spiro Tunnel subbasin has a very high area weighted load (0.50 kg/ha/year). Because this golf course sits on phosphatic shales, enhanced BMPs may be required to fully mitigate the impacts of disturbance of this concentrated source.

Table 9.7. Priority Subbasins and Recommended BMPs for Golf Courses in the East Canyon Reservoir Watershed

Subbasin	Jurisdiction	Phosphatic Shales in Subbasin?	Area of Land Use in Watershed (hectares)	Annual Load (kgTP/yr)	Area Weighted Load (kgTP/ha/yr)	Priority
Spiro Tunnel	Park City Golf Course	Yes	56	28.0	0.50	High
Park Meadows	Park Meadows Golf Course	No	142	22.1	0.16	High
Silver Creek/Parley's Park	Glenwild Golf Course	No	264	36.8	0.14	High

Table 9.7. Priority Subbasins and Recommended BMPs for Golf Courses in the East Canyon Reservoir Watershed

Subbasin	Jurisdiction	Phosphatic Shales in Subbasin?	Area of Land Use in Watershed (hectares)	Annual Load (kgTP/yr)	Area Weighted Load (kgTP/ha/yr)	Priority
Upper East Canyon	Jeremy Ranch / Glenwild	No	304	38.3	0.13	High
Park City	Park City Golf Course	No	57	6.1	0.11	Medium
Toll Canyon	Jeremy Ranch Golf Course	No	71	5.1	0.07	Low

Detention basins have already been installed on many golf courses in the watershed. Total phosphorus through these basins is reduced by 30 to 90% depending upon the proportion of phosphorus that is bound to sediments, and operation and maintenance of the BMPs (International Stormwater Database 2007). Continued operation and maintenance of these basins will further improve total phosphorus removal effectiveness. Enhanced BMPs may include installation of grass swales and filter strips and would reduce associated total phosphorus loads by 20% – 40% and 30% to 80% respectively (International Stormwater Database 2007). Soil testing, nutrient management planning, reduced fertilizer application rates, and irrigation management would further reduce total phosphorus loads associated with golf courses. Assuming the appropriate BMPs are implemented and maintained, a 45% to 75% reduction of total phosphorus from current loads associated with golf courses is projected (62 to 103 kg/year)

9.2.3.5.5 Ski Areas

<u>Summary of BMP Implementation and Planning</u>

Currently each ski area in the watershed has an ongoing Watershed Restoration Action Plan (WRAP) that includes actions such as erosion control, re-vegetation of areas disturbed by construction, water bar control on roads and ski slopes, stormwater pond use, compliance with City and County erosion control ordinances, road reclamation, historic mine activity stabilization where applicable, and water quality monitoring (except Gorgoza Park and Park City Mountain Resort) (MAG 2003).

One of the objectives of the East Canyon WRAP is to implement the supplemental recommendations and projects identified for ski hills in the Snyderville Basin Recreation & Construction Industry Water Quality Improvements Project (MAG 2003). Projects that are applicable to multiple resorts include water quality monitoring, development of a guidance document for mountain roads, and supervisor training. More specifically, the Snyderville Basin Recreation & Construction Industry Water Quality Improvements Project (MAG 2003) identifies the following potential projects for ski resorts:

- *Water Quality Monitoring.* Participation in a water quality monitoring program is a potential project for all ski resorts. There is currently no consistent data collection method or database to evaluate the effectiveness of water quality BMPs. Participation in a water quality monitoring program using standardized parameters, sampling locations, and frequency would provide the appropriate data which could then be compiled in a database.
- *Mountain Road Guidance Document.* The development of a guidance document for mountain roads would identify both construction and long term criteria for mountain roads. Criteria to be

included are water bar construction, drainage issues, roadway widths, and roadway decommissioning.

- *Ski Area Supervisor Training.* The purpose of providing ski area supervisor training would be to educate personnel about water quality issues on the mountain and how their operations affect water quality.

Additional resort-specific projects are described in the Snyderville Basin Recreation & Construction Industry Water Quality Improvements Project (MAG 2003) and summarized below:

Park City Mountain Resort

- *Thaynes Canyon Stream Stability Survey*. The Thaynes Canyon drainage has been impacted by historic mining activities and grazing access. The channel area should be surveyed to determine the appropriate remedial action.
- *Restoration of Upper Treasure Hollow drainage.* The upper portion of the drainage (above 7,800 feet) has been impacted by mining activity, work roads and past snowmaking construction practices. Runoff is not well controlled and results in erosion of slopes.
- *Management plan for surface parking lots.* The surface parking lots are scheduled for replacement with underground parking. Prior to the development of underground parking, runoff from the ski runs needs to be diverted away from the lower lot to reduce sediment entering the storm drain system. Access to the mountain via the parking lots needs to be controlled to single points and combined with an improved, on-going lot sweeping program.
- *Utilize mapped phosphoric shale deposits.* A portion of the surficial material at Park City Mountain Resort consists of a phosphorus rich shale outcrop and its associated soils. Recent detailed mapping of these phosphorus-bearing deposits using GIS should serve as a guide to avoid disturbing these areas as much as possible.

The Canyons Resort

- *Completion of Upper Willow Draw restoration (Basin Hydrology, 1999).* Work to reduce erosion and improve channel stability in the vicinity of the Canis Lupis ski run should be evaluated and completed.
- *Possible re-activation of old detention structures.* The water detention pond near the Super Condor lift could be considered for activation as stormwater detention for runoff below the Sun Lodge.
- *Surfacing and semi-permanent storm water BMP's for ski area parking.* The upper employee and skier parking areas should have additional controls installed to reduce migration of material off-site from runoff and/or vehicle tracking. This will reduce the sediment load on the existing detention structure.
- *Utilize mapped phosphoric shale deposits.* A portion of the surficial material at The Canyons Resort consists of a phosphorus rich shale outcrop and its associated soils. Recent detailed mapping of these phosphorus-bearing deposits using GIS should serve as a guide to avoid disturbing these areas as much as possible.

Utah Olympic Park

- *Roadway slope stabilization.* The roadway cut and fill slopes require additional stabilization.
- *Jump slope stabilization.* The jump slopes require stabilization.

Gorgoza Park

- *Develop WRAPS*. Development of a WRAP will identify existing and proposed control measures that are being implemented at Gorgoza.

Priority Areas for Continued BMP Implementation and Maintenance

The highest priority areas for reducing total phosphorus load from ski areas are the portion of the Park City Mountain Resort located in the Treasure Hollow subbasin and the portion of the Canyons Resort in the Willow Draw subbasin. These areas both contain phosphatic shales. Enhanced BMPs and special caution to minimize disturbance are required for these concentrated source areas. Loads from Gorgoza Park are very low, thus additional BMP implementation in this area is a low priority for the watershed. Similarly, the portions of The Canyons Resort that are in the White Pine, Red Pine, and Thaynes Canyon subbasins also have low area-weighted loads and are low priorities for additional BMP implementation.

Table 9.8. Priority Subbasins and Recommended BMPs for Ski Areas in the East Canyon Reservoir Watershed

Subbasin	Jurisdiction	Phosphatic Shales in Subbasin?	Area of Land Use in Watershed (hectares)	Annual Load (kgTP/yr)	Area Weighted Load (kgTP/ha/yr)	Priority
Treasure Hollow	Park City Mountain Resort	Yes	254	186.6	0.74	High
Willow Draw	The Canyons	Yes	417	112.5	0.27	High
Spiro Tunnel	Park City Mountain Resort	Yes	13	9.3	0.74	Medium
Toll Canyon	Gorgoza Park	No	51	0.7	0.01	Low
White Pine	The Canyons	No	425	5.6	0.01	Low
Thaynes Canyon	Park City Mountain Resort	No	829	0.3	<0.01	Low
Red Pine	The Canyons	No	986	0.4	<0.01	Low

Sediment control has already been improved from ski resorts in the watershed. The effectiveness of additional implementation will further reduce phosphorus loads from these areas. Improved trail design can reduce total phosphorus load by 30% to 50%, whereas access road treatment in forested areas results in higher phosphorus reduction rates (80% to 95%) (Burroughs and King 1989). The use of infiltration and sedimentation basins reduces phosphorus runoff by 50% to 80% (Burroughs and King 1989; WDEQ 1999). Effectiveness of all of these measures is generally improved with routine maintenance. Assuming the appropriate BMPs are implemented, in addition to those already completed, a 65% to 90% reduction of total phosphorus from current loads associated with ski areas was assumed (205 to 284 kg/year).

9.2.3.5.6 High Use Recreation

Summary of Implemented BMPs

Swaner Nature Preserve will be installing fencing along trails near East Canyon Creek to protect riparian areas, dissuade users from creating new trails, and reduce pollution into the watershed. No other known efforts have been made to reduce the phosphorus load from high use recreation.

Recommended Additional BMP Implementation and Maintenance

Off-highway vehicles should be restricted to designated routes away from waterways to prevent bank destabilization and soil erosion along tributaries and in reservoir shorelines. Trail design should ensure that runoff water and drainage from the trail is collected in a stabilized area or sediment basin, thus handling runoff volume and velocity without risk of erosion or of sedimentation into waterways. Natural drainage patterns should not be disrupted or moved, as the runoff water and surface water may be providing moisture to wetlands downslope or downstream. Surveying the trail during wet months will help determine drainage patterns and the location of wetlands and saturated soils.

Priority Areas for Implementation

All of the high use recreation land-use areas are considered to be a medium level priority for the watershed because, although area-weighted loads are high, the total load from this land use is quite small, composing less than 1% of the total load to the reservoir. Subbasins are ranked based on normalized load in Table 9.9.

Table 9.9. Priority Subbasins and Recommended BMPs for High Use Recreation in the East Canyon Reservoir Watershed

Subbasin	Jurisdiction	Phosphatic Shales in Subbasin?	Area of Land Use in Watershed (hectares)	Annual Load (kgTP/yr)	Area Weighted Load (kgTP/ha/yr)	Priority
Silver Creek / Parley's Park	Summit Co.	No	18	2.9	0.16	Medium
Kimball Creek	Summit Co.	No	23	3.3	0.15	Medium
Lower Springs	Summit Co.	No	11	1.6	0.15	Medium
Two Mile	Summit Co.	No	5	0.6	0.12	Medium

Calculation of Load Reduction

With the implementation of the recommended BMPs applied in high use recreation land-use areas, the estimated phosphorus load reduction ranges from 4.5 to 7.1 kg/year (Table 9.9). Though any single BMP may be applied, greater reductions are achieved when BMPs are implemented in conjunction with others.

Improved trail design would reduce erosion and associated phosphorus on hiking and biking trails by 30% to 50% (Burroughs and King 1989). Implementation of the recommendations for reducing phosphorus load from high use recreation is assumed to result in a 35% to 55% reduction in total phosphorus from this source (3.0 to 4.7 kg/year).

9.2.3.5.7 Agricultural Management and Grazing

Summary of BMP Implementation

The East Canyon WRAP (2004) includes plans to address livestock grazing by implementation of site specific private land owner management plans such as fencing of riparian areas, rotational grazing, and creation of vegetative buffer zones to protect streambank and riparian areas from erosion or degradation. The East Canyon WRAP (2004) also recognizes the need to develop Comprehensive Nutrient Management Plans (CNMP) for landowners determined to have Animal Feeding Operations (AFO) or Confined Animal Feeding Operations (CAFO). A total of about 11 CNMP plans are anticipated to be completed in the watershed. All landowners with a CAFO/AFO are expected to have an individual plan by (2008).

A conservation management plan has been developed for the Peaceful Valley Ranch operated by Mike McFarlane. The ranch encompasses about 7,800 acres in the East Canyon Watershed and has several miles of East Canyon Creek on the property. The plan includes streambank fencing totaling 12,773 feet, prescribed grazing on 371.5 acres, wildlife fencing totaling 9,820 feet, riparian forest buffer totaling 41.5 acres, use exclusion for 21.5 acres and streambank and shoreline protection for 500 feet on East Canyon Creek. A tour of the project area was conducted to highlight the success of fencing off the stream and allowing the natural vegetation to re-establish itself (2002 Nonpoint Source 319(h) Project Progress Report).

The Wildlife Habitat Incentives Program and Snyderville Basin Water Reclamation project have involved businesses, local landowners, and organizations such as Swaner Nature Preserve (SNP) in restoring habitat in and around East Canyon Creek. Shrubs were planted to reduce streambank erosion, fences were installed to keep livestock from the riparian areas, water facilities were added for livestock, and pastures were reseeded to improve grazing management. In addition, SNP planted 3,000 willows to stabilize streambank soils, reduce sediment loads, and aid in reducing temperatures along the creek. In 2007 SNP planted native shrubs and installed tree revetments on 706 linear feet of the creek near the preserve (SNP 2008).

Additional Recommended Implementation Measures

Recommended BMPs for irrigated lands include filter strips, sprinkler irrigation, and pasture and hayland planting (NRCS code 512). Irrigation system management (NRCS codes 442, 443, 444, 449) and nutrient management (NRCS code 590) are also recommended. Together, these BMPs will reduce water use, increase pasture productivity, and reduce animal pressure on grazing lands. When sediment and nutrients are transported overland, filter strips installed at the field border will reduce sediment and nutrient inputs. Recommended BMPs for managing grazing in riparian areas and streams include livestock exclusion from streams and riparian areas (NRCS code 472), off-site watering (NRCS code 614), stream crossings and channel bank revegetation (NRCS code 578), riparian forest buffer (NRCS code 391), and prescribed grazing (NRCS code 528). All of these BMPs have proven effective in reducing phosphorus and sediment loading due to riparian area grazing in other watersheds (Line et al. 2000; Osmond et al. 2007; Miner et al. 1992).

Included in the prescribed grazing practices are management techniques, such as fencing and hardened crossings, which encourage animals to drink or cross at specified points. Hardened crossings may be installed in riparian areas where cattle show a tendency to cross the stream. Crossings may also be developed to protect the streambank and bed from tire damage from all-terrain vehicles and 4-wheel vehicles when they attempt to cross the stream. Hardened crossings create a layer of rock in the stream bed and provide protection directly from any contact, and thereby protect a stream reach from sediment and nutrient releases. The hardened crossing may also be developed in conjunction with watering structures and facilities such as riparian fencing and water gaps, providing livestock with watering areas that have easy access with limited sediment entering into the stream flow (Hoorman and McCutcheon, nd). Livestock have been shown to prefer watering sites where ease of access is provided including hardened crossings, and these BMPs have been shown to reduce trampling of streambanks (MSU 2000; Hoorman and McCutcheon, nd).

Priority Areas for Implementation

Addressing phosphorus load from agricultural land uses in the Kimball Creek subbasin is considered to be a high priority for the watershed. Additional installation of BMPs on agricultural property in the area draining directly to the reservoir, Two Mile subbasin, and Middle East Canyon subbasin are considered to be medium level priorities. Agricultural management in the remaining parts of the watershed contributes a very small phosphorus load to the reservoir and is therefore considered to be a low priority for the watershed.

The BMPs recommended from agricultural land uses primarily focus on nonstructural management. These BMPs have a range of effectiveness in reducing total phosphorus. Installation of vegetative buffers along fields has been found to be effective in reducing total phosphorus by 85% (Osmond et al. 2007). A heavily stocked dairy loafing pasture demonstrated a 79% reduction of TP (Line et al. 2000) and an 82% reduction in total suspended sediment in a stream after cattle were fenced out of a riparian area and a buffer was established (Osmond et al. 2007). Pollutant loads from cattle using streams as water sources were also significantly reduced when alternative water systems were provided (Miner et al. 1992). Cattle preferred to drink from a trough 92% of the time when alternative water systems were installed; this suggests that installation of troughs reduces the time that cattle spend in riparian areas and the overall impact they have on the stream. In this study, streambank erosion was reduced by 77%, total suspended solid concentrations in grab samples were reduced by 54%, and average concentrations of TP were reduced by 81% (Miner et al. 1992). Installation of irrigation management systems reduces total phosphorus by 70% to 90% (NRCE 1996). Prescribed grazing generally reduces phosphorus by 55% to 82% (Osmond et al. 2007). Assuming the appropriate BMPs are implemented a 60 to 85% reduction of total phosphorus from current loads associated with agricultural land uses was assumed (32.7 to 46.3 kg/year).

Table 9.10. Priority Subbasins and Recommended BMPs for Agricultural and Grazing Land Uses in the East Canyon Reservoir Watershed

Subbasin	Jurisdiction	Phosphatic Shales in Subbasin?	Area of Land Use in Watershed (hectares)	Annual Load (kgTP/yr)	Area Weighted Load (kgTP/ha/yr)	Priority
Kimball Creek	Summit Co.	No	140	20.7	0.15	High
Two Mile	Summit Co.	No	21	4.4	0.21	Medium
Middle East Canyon	Summit Co.	No	23	3.4	0.15	Medium
Direct Drainage	Morgan Co.	No	20	3.0	0.15	Medium
Lower East Canyon	Morgan Co.	No	109	9.7	0.09	Low
Bear Hollow	Summit Co.	No	14	1.2	0.09	Low
Three Mile	Summit Co.	Yes	86	6.9	0.08	Low

Table 9.10. Priority Subbasins and Recommended BMPs for Agricultural and Grazing Land Uses in the East Canyon Reservoir Watershed

Subbasin	Jurisdiction	Phosphatic Shales in Subbasin?	Area of Land Use in Watershed (hectares)	Annual Load (kgTP/yr)	Area Weighted Load (kgTP/ha/yr)	Priority
Upper East Canyon	Summit Co.	No	20	1.5	0.08	Low
Park City	Park City	No	3	0.1	0.05	Low
Thaynes Canyon	Summit Co. / Park City	No	33	1.7	0.05	Low
Silver Creek / Parley's Park	Summit Co.	No	34	0.6	0.02	Low
White Pine	Summit Co.	No	69	1.2	0.02	Low

9.2.3.5.8 Forested and Meadow

Pollutant Sources and Load

Pollutant sources from forested and meadow land uses include runoff and sedimentation from road construction and use, and erosion and sediment release from trail and OHV use. Runoff intercepted by roads becomes concentrated and channelized in drainage ditches or ruts. As a result, sediment is transported down-gradient as overland flow. Roads near streams become a direct conduit of increased flow and sediment to the stream channel and can increase sediment and nutrient loads. Road and trail erosion associated with forestry management and recreational use can also contribute to phosphorus loading via increased flows and sediment load to waterways (Daniels et al. 2004; Rashin et al. 1999).

Grazing in the upland areas can be a significant source of sediment and nutrient loads if the timing and intensity of the grazing are not controlled (Osmond et al. 2007). Over-grazing causes loss of vegetation and soil compaction due to hoof action, both of which increase sediment and nutrient loads (Mosley et al. 1997). Finally, manure deposition from the livestock subsequently delivers phosphorus from the forested areas to stream channels, which is then ultimately transported to the reservoir.

Forested and meadow land-use areas compose 26,575 hectares (65,668 acres) or 71% of the watershed and include 13 subbasins. Only the Willow Draw subbasin contains phosphatic shales. These land uses contribute 475 kg/year (0.01 kg/ha) of phosphorus, or 23% of the total annual phosphorus load in the watershed. Phosphatic shale areas contribute 1% (7 kg/year) of the annual phosphorus load from these land uses.

Summary of Implemented Source Controls

The East Canyon WRAP (2004) identifies the need to inventory road drainage controls along dirt road segments that are impacting East Canyon Creek and tributaries. This plan also proposes to develop and implement BMPs that reduce contributions of sediment and phosphorus from roads.

Summit County has made progress implementing some road drainage erosion BMPs by hardening the surface of the road from the Jeremy Ranch Golf Course up to the Summit/Morgan County line. Summit County has further improved road drainage by installing small berms along some sections of road (Nonpoint Source 319 (h) Project Progress Report dated September 21, 2007).

Recommended Implementation Measures

The first step in addressing nonpoint source phosphorus load from forested and meadow land uses is to conduct a detailed inventory of this source, similar to the inventories completed for other sources and land uses in the watershed (MAG 2003, ECWC 2004). Key items that should be addressed in the inventory include the following:

- Length and width of roads.
- Road condition (e.g., loose, exposed, non-vegetated, guttering/gully erosion).
- Road proximity to streams.
- Extent of logging.
- Extent of public access and OHV.
- Inventory of trails, frequency of use, and condition (bike, hiking, OHV).
- Extent of grazing.
- Field data sheets and photographic record.

Significant reduction of phosphorus load resulting from road-related erosion could be achieved through Access Road Treatment (NRCS code 560). Depending on local conditions road treatment can involve alignment to reduce road slope, installation of drainage structures, stabilization of side slopes, reduction of road width, and/or surfacing the road with gravel or other material. All of these efforts are aimed at reducing erosion from roads (NRCS code 560). In some cases, road realignment may be required to protect the stream channel and permanently reduce sediment loading. Off-highway vehicles should be restricted to designated routes away from waterways to prevent bank destabilization and soil erosion along tributaries and within reservoir shorelines. Trail design should ensure that runoff water and drainage from the trail is collected in a stabilized area or sediment basin, thus handling runoff volume and velocity without risk of erosion or of sedimentation into waterways. Natural drainage patterns should not be disrupted or moved, as the runoff water and surface water may be providing moisture to wetlands downslope or downstream. Surveying the trail during wet months will help determine drainage patterns and the location of wetlands and saturated soils.

Additional road improvement and management practices are provided in the Snyderville Basin Recreation & Construction Industry Water Quality Improvements Project (MAG 2003) and include:

- Create vegetative buffers between the edge of roadways and top edge of banks closest to waterways.
- Eliminate practice of grading road to top edge of bank.
- Plant vegetation and secure slopes at eroded areas.
- Suppress dust on road.
- Narrow roadways in close proximity to creek.
- Designate drainage pipe locations along roadways to prevent clogging of entrances during grading.
- Place rip-rap below drain pipe outlets to prevent scouring.
- Secure eroding roadside banks that were cut steeply.
- Direct sheet flow runoff to vegetated buffer areas, not directly to the waterways.
- Prevent unnecessary footpaths to waterways by limiting recreational access to designated areas.

Priority Areas for Implementation

All of the forested or meadow land-use subbasins are medium and low priority areas for implementation. These land uses contribute a significant load to East Canyon Reservoir due to their large areal extent; however, these land uses have the lowest area-weighted loads in the watershed. Furthermore, reducing nonpoint source phosphorus runoff from forests and meadows will be more difficult to assess, implement, and monitor due to the variety of phosphorus sources on private parcels and the extremely diffuse nature of the load.

Total phosphorus reductions associated with access road treatment range from 80 to 95%. Reductions associated with trail design range from 30 to 50% (Burroughs and King 1989). Together, the recommendations for forested land uses were assumed to result in a 55 to 85% reduction in total phosphorus or 261 to 404 kg/year.

Table 9.11. Priority Subbasins and Recommended BMPs for Forested and Meadow Land Uses in the East Canyon Reservoir Watershed

Subbasin	Jurisdiction	Phosphatic Shales in Subbasin?	Area of Land Use in Watershed (hectares)	Annual Load (kgTP/year)	Area Weighted Load (kgTP/ha/year)	Priority
Direct Drainage	Morgan County	No	7,650	186.1	0.02	Medium
Middle East Canyon	Summit County	No	2,530	61.5	0.02	Medium
Lower East Canyon	Summit County	No	11,111	193.2	0.02	Medium
Willow Draw	Morgan County	Yes	147	6.3	0.04	Low
Park Meadows	Summit County	No	9	0.3	0.03	Low
Kimball Creek	Park City	No	302	7.8	0.03	Low
Thaynes Canyon	Summit County/ Park City	No	310	8.0	0.03	Low
Park City	Park City	No	8	0.2	0.03	Low
Unnamed Meadow	Summit County/ Park City	No	77	1.9	0.02	Low
Unnamed # 2	Summit County	No	5	0.1	0.02	Low
Lower Springs	Summit County	No	203	4.9	0.02	Low
Unnamed # 1	Summit County	No	14	0.3	0.02	Low
Bear Hollow	Summit County	No	211	3.7	0.02	Low

9.2.4 TECHNICAL AND FINANCIAL NEEDS

This section identifies the types of technical assistance needed to implement the plan and the agencies, resources, and authorities that may be relied on for implementation. Funding and technical assistance are critical factors for implementing the plan, long-term operation, and maintenance of management measures, information//education activities, monitoring, and evaluation activities

9.2.4.1 Plan Sponsors and Resources

9.2.4.1.1 East Canyon Water Reclamation Facility

The Snyderville Basin Water Reclamation District has completed the initial design phase for the upgrade of the ECWRF and is in the process of securing funding for construction. SBWRD will coordinate, as necessary, with UDWQ to ensure that the expansion will continue to meet the phosphorus load allocated to this point source.

9.2.4.1.2 In-reservoir Treatment

The project sponsor for in-reservoir treatments would be UDWQ. However, the Bureau of Reclamation, as the federal agency responsible for reservoir management, would need to approve any in-reservoir treatment plans. This would require compliance with NEPA, most likely in the form of an environmental assessment. Cooperating agencies would likely include the Utah Division of Wildlife Resources and the Utah Division of State Parks and Recreation.

9.2.4.1.3 Nonpoint Source Management Measures

The East Canyon Watershed Committee will be the lead project sponsor for nonpoint source improvements. The committee is a coalition of public and private concerns that have a vested interest in restoring the watershed to a healthy state. The committee has several working groups including education, monitoring, and stream restoration. In addition, the committee maintains a web site as a public service to educate and inform those interested in the issues surrounding the East Canyon Creek Watershed.

Stakeholders that will be involved in technical assistance and execution of the implementation plan include:

- East Canyon Watershed Committee
- Snyderville Basin Water Reclamation District
- Park City Municipal Corporation
- Utah Association of Conservation Districts (UACD)
- Kamas Valley Conservation District
- Summit County Conservation District
- Utah Department of Environmental Quality, Division of Water Quality
- Utah Department of Natural Resources, Division of State Parks and Recreation
- individual golf courses
- individual ski resorts
- private land owners

Interagency coordination is an integral part of this implementation plan. Coordination between the Utah Department of Environmental Quality–Division of Water Quality, the Department of Natural Resources–

Division of State Parks and Recreation, and the Bureau of Reclamation is critical to ensuring implementation of the proposed BMPs on state and federal lands managed by these agencies.

The NRCS will assist in coordination between the State of Utah and private landowners regarding available funding to implement BMPs on private land. For agriculture, BMP implementation is a voluntary, incentive-based program. Federal cost-share incentives are available to agricultural producers. These programs include NRCS's Conservation Reserve Program (CRP), Wetland Reserve Program (WRP), WHIP, and the Environmental Quality Incentive Program (EQIP). The State of Utah also offers some loan and grant programs to agricultural producers for the installation of conservation BMPs. Participation from individual landowners, managers, and all stakeholders in the watershed is important to the successful outcome of the implementation plan.

9.2.4.2 Projected Costs for Implementation

9.2.4.2.1 East Canyon Water Reclamation Facility

The total cost of the expansion and upgrade project is estimated at $40,074,626. Although the SBWRD is currently in design, the construction date of the project will be determined by growth in their service area. Until then, the SBWRD's current phosphorus removal system will continue to meet both existing permit limits/TMDL allocations and the proposed allocations/permit limits in the revised TMDL.

9.2.4.2.2 In-reservoir Treatment

The cost of in-reservoir alum treatment is generally site-specific and depends on the length of phosphorus inactivation desired, the alum dose required, local availability and cost of alum, and the mechanism used for dispensing alum into the reservoir. Generally, the cost of alum treatment ranges from $280/acre treated to $700/acre treated (WDNR 2003). Based on this cost range, treatment of the entire acreage of East Canyon Reservoir would cost between $191,000 and $477,000. Treatment of only a portion of the reservoir is probably more realistic, because only the deep sections of the reservoir routinely experience hypolimnetic oxygen depletion, and associated phosphorus release. Treatment of one-half of the reservoir acreage is therefore estimated to cost between $95,000 and $238,000. This is a one-time cost that should inactivate sediment phosphorus for at least a 5-year period.

The cost of hypolimnetic aeration is also highly dependent on the design, spatial extent, and seasonal use of the system. The design of the system is likely to cost $5,000–$10,000 if designed internally by UDWQ. The cost of external engineering design would be higher. Initial estimates for a system sized for the needs of East Canyon Reservoir range from $250,000 to $1,000,000 for installation, operation, and maintenance over a 10-year period.

9.2.4.2.3 Nonpoint Source BMP Implementation

Implementation of the BMPs necessary to meet the water quality goals outlined in the TMDL will require a significant allocation of financial resources from multiple sources. Cost-benefit studies are recommended as a tool for identifying the most cost-effective strategies to prioritize throughout the reservoir. The implementation plan and costs outlined here is a general guide and not intended to be a comprehensive list of potential BMPs, priority areas, or required resources. Final decisions on project implementation will be made by land managers and owners based on their intricate knowledge of the watershed. Estimated costs for most recommendations are listed in Table 9.12. The sources of potential funds are described below in Section 9.3.4.2. Unit-cost estimates listed for each BMP are based on two separate sources. The agricultural costs were obtained from the NRCS electronic field office technical guide (eFOTG) cost sheet located at http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=UT.

Table 9.12. Summary of Costs Associated with Project Implementation Plan

Land Use	Source	Management Strategy	Resources Needed	Who	Units	Unit Cost
Stormwater, Erosion, and Sediment Runoff	Continue enforcement of requirements for a Storm Water Pollution Prevention Plan (SWP3) and Erosion Control Plan (ECP) for construction activities in Summit and Morgan counties.	County administrative staff and building inspectors to continue plan reviews, on-site inspections, and SWP3 enforcement	Morgan and Summit counties	Summit and Morgan Co		Not est.
Residential, Commercial, and Urban	Stormwater, erosion, and sediment runoff	Continue enforcement of stormwater management plans for Summit and Morgan counties		Summit and Morgan Co		
		Construct additional detention basins		Summit and Morgan Co	Acre	$100,000
	Septic sewage	Continue enforcement of county ordinances and provide I&E concerning the design, installation, and maintenance of new systems	Annual review and submission of grant applications to fund education efforts	Summit and Morgan Co		Not est.
	Excess fertilizer use	Fertilizer application I&E		Summit County Conservation District		Not est.
		Soil testing and fertilizer rate reduction		Homeowners	Test	$10
	Excess irrigation	Maintain and improve irrigation ordinances and encourage water mgmt through I & E		Summit and Morgan Co		Not est.
	Road de-icers and sand	Test phosphorus content of de-icers and sand		Summit and Morgan Co	Test	$10

Table 9.12. Summary of Costs Associated with Project Implementation Plan

Land Use	Source	Management Strategy	Resources Needed	Who	Units	Unit Cost
		Investigate alternative de-icing methods		Summit and Morgan Co	Ton	$650
Golf Courses	Sediment runoff	Continue operation and maintenance of detention ponds	No additional resources needed	Local golf courses		Not est.
		Install grass swales			Acre	$130,000
		Install filter strips			Acres	$275
	Excess fertilizer use	Soil testing and fertilizer rate reduction (I&E)			Test	$10
		Comprehensive nutrient management plan			Each	$4,000
	Excess irrigation	Irrigation water management			Acre	$5
Ski Areas	Sediment runoff intercepted by trails and roads and concentrated in ditches	Trail design		Local ski resorts	Acres of harvested land	$500
		Access road treatment			Miles of road	$500
		Road realignment/decommissioning			Miles of road	$9,500
		Infiltration/retention basin			Acre	$100,000
High Use Recreation	Reduced riparian cover and erosion caused by OHVs	OHV restrictions				Not est.
	Sediment runoff intercepted by trails and roads and concentrated in ditches	Trail design			Acres of harvested land	$500

Table 9.12. Summary of Costs Associated with Project Implementation Plan

Land Use	Source	Management Strategy	Resources Needed	Who	Units	Unit Cost
		Access road treatment			Miles of road	$500
		Road realignment/decommissioning			Miles of road	$9,500
Agricultural Management and Grazing	Flood irrigation	Irrigation system management	Secure grant funding	NRCS, Kamas Valley Conservation District, Local Landowners	Acres of agricultural land	$1,000
		Pasture and hayland planting			Acres of agricultural land	$110
	Pasturing and grazing	Comprehensive nutrient management plan			Each	$4,000
		Prescribed grazing			Acres of grazing	$4
	Grazing in riparian areas	Livestock exclusion from streams and riparian areas			Acres of riparian	$15
		Off-site watering			1,000-gallon trough	$1,650
		Stream crossings and channel bank revegetation			Crossings	$2,000
		Riparian forest buffer			See East Canyon Creek PIP	
		Prescribed grazing			Acres of forest	$4
Forested and Meadow	Sediment runoff from roads and trails	Access road treatment		Private land owners	Miles of road	$500
		Road realignment/decommissioning			Miles of road	$9,500
		OHV restrictions				Not est.
		Trail design			Acres	$500
	Grazing	Prescribed grazing			Acres of forest	$4

9.2.4.3 Financial and Legal Vehicles for Implementation

9.2.4.3.1 East Canyon Water Reclamation Facility

Funding for the ECWRF will come entirely from impact fees levied against new developments in Snyderville Basin. A portion of the required impact fees have already been collected. A 25-year revenue bond will fund the rest of the capital costs and will be repaid through collection of future impact fees. Funding for the ECWRF is available from the State of Utah Revolving Loan Fund. A loan for $22,000,000 has already been authorized by the Water Quality Board.

9.2.4.3.2 In-reservoir Treatment

In-reservoir treatment measures will be funded through UDWQ in the form of private grants or state or federal project funds. All in-reservoir treatment plans will require collaboration and approval with the Bureau of Reclamation.

9.2.4.3.3 Nonpoint Source BMP Implementation

Various programs are available for private landowners to assist with the implementation of BMPs through cost-share incentive programs, grants, or low-interest loans. The program funds come from multiple sources such as the EPA, the NRCS, and the State of Utah. All programs require voluntary signup for participation, whereas some require eligible lands to qualify, depending on program requirements.

The NRCS administers a number of programs for funding to assist agricultural producers in installing BMPs on their privately owned lands. One program is the EQIP, which is a federal Farm Bill program that offers assistance in the installation or implementation of conservation practices such as stream buffers and riparian restoration; cost-sharing incentives pay for 50%–75% of the costs.

Other federal cost-share programs administered by the NRCS are the WHIP, designed to establish habitat for wildlife and fish, and the Wetland Reserve Program (WRP), designed to restore wetlands. Another federal cost-share program is the Conservation Reserve Program (CRP), which encourages land owners to convert highly erodable farmland or other highly sensitive acreages to vegetative cover. The CRP is administered by the Farm Service Agency. All of the federal programs require landowners to voluntarily sign up, and all land enrolled must qualify based on rules associated with the respective programs.

The State of Utah offers a low-interest loan program titled the Agriculture Resource Development Loan (ARDL), which is administered under the Utah Department of Agriculture and Food (UDAF). The programs offer loans for projects that conserve soil and water resources and maintain and improve water quality. Another UDAF program is the Grazing Improvement Program (GIP), which offers a competitive grant for fence repairs, reseeding of grazing land, and the replacement or development of water projects.

The State of Utah Section 319 grant program is another financial program that may be employed by agricultural producers or conservation districts to implement nonpoint source projects for the protection or improvement of water quality. The 319 program is a cost-share program that requires a 60:40 grant-to-cost share match. The program is administered by the UDAF and funded through the UDWQ from an EPA Clean Water Act grant program.

9.2.5 INFORMATION AND EDUCATION

The information and education plan (I/E plan) described in this section is adapted from the plan outlined in the *East Canyon Watershed Restoration Action Plan* (WRAP), prepared by the East Canyon Watershed Committee (WRAP 2004). The I/E plan developed in the WRAP follows EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (EPA 2008). The plan also includes education initiatives that other entities have or are planning to implement. The goals and objectives of the I/E plan include contractor training, onsite training, employee training, age-appropriate school curriculum, and residential outreach. The I/E plan aims to a) develop a training program for winter sports area supervisors, b) draft a guidance document for road maintenance, and c) develop educational information regarding water quality and golf courses (ECWC 2004).

9.2.5.1 Define the Driving Forces, Goals and Objectives

The driving force of the I/E plan includes attainment of water quality standards through a) implementation of TMDL target phosphorus load reductions, b) the impairment to the cold water fishery, and c) engaging an environmentally conscious community in action items for the watershed. The goals of the I/E plan are as follow:

1. Contractor Training: Educate and train local contractors and builders and their employees on the stormwater control requirements for Summit County and Park City in accordance with the Storm Water Programs for these two entities.

   Objective 1: Conduct an annual mandatory training session in the spring of each year to educate local contractors and builders on the regulatory requirements of the Summit County and Park City Storm Water Programs.

2. On-Site Training: Provide field-based stormwater controls training for local builders and contractors to ensure proper selection, installation, and maintenance of BMPs for construction sites.

   Objective 2: Conduct a semi-annual, “hands on” seminar hosted by vendors to demonstrate proper selection, installation, and maintenance of stormwater control methods for local contractors and builders.

3. Employee Training: Provide stormwater training for municipal personnel involved in plan review and inspection to insure a clear understanding of requirements and standards for applicable stormwater programs.

   Objective 3: Conduct an annual training session for municipal personnel involved in building permits issuance, inspections, or stormwater compliance.

4. Residential Outreach: Develop a residential outreach program to educate homeowners on the BMPs for residential use of fertilizers to minimize nutrient contributions from residential areas.
5. School Age Education Program: An age-appropriate schools, curriculum will be developed to target 4th grade students in the watershed. This program will coordinate and support Goal #4 in regard to homeowner practices.
6. Winter Sports Supervisor Training: Develop a training program for winter sports area supervisors to facilitate selection, installation, and maintenance of appropriate BMPs for water quality improvement at each of the five winter sports venues in the East Canyon Reservoir Watershed.
7. Mountain Road Guidance Document: Develop a guidance document for maintenance of roads on winter sports venues to minimize water quality impacts.
8. Provide critical priority areas map to municipalities, contractors, residents, and employees of recreational industries to focus efforts to reduce erosion and phosphorus loss.

9.2.5.2 Identify and Analyze the Target Audiences

The target audience for the I/E plan consists primarily of contractors and builders, residential homeowners, and employees of recreational industries (golf and winter sports). Residential homeowners will be divided into neighborhoods in subwatersheds that are identified as critical priority areas in the watershed. Contractors operating in the Willow Draw subbasin will be the primary target of the I/E plan. Contractors operating in medium priority subbasins will also be included in the I/E plan. These subbasins include Kimball Creek, Park City, Two Mile, and Upper East Canyon subbasins. The highest priority areas for residential land uses are neighborhoods in the Kimball Creek, Park Meadows, and Two Mile subbasins. The highest priority golf courses for I/E plan are Park City Golf Course and the Park Meadows Golf Course, because they operate in subbasins with phosphatic shales and high phosphorus loss potential. Both ski resorts in the watershed, the Park City Mountain Resort and the Canyons Resort, are high priority areas for the I/E plan.

9.2.5.3 Create the Message

Specific messages will be developed for each I/E plan effort as implementation proceeds. However, the following are the primary messages that will be communicated in all I/E plan efforts:

1) Phosphorus contributes to the water quality impairments observed in East Canyon Reservoir.
2) Point source reduction of phosphorus by Snyderville Basin Water Reclamation District has resulted in substantial improvements in water quality in the reservoir in the past eight years.
3) Remaining phosphorus reduction requirements rely on nonpoint source management measures.
4) Phosphorus loss from the East Canyon Reservoir watershed occurs as a result of human activities on the landscape and naturally high phosphorus soils in some areas of the watershed.
5) Activities on phosphatic shale areas in the watershed should be limited and erosion control enhanced as a first priority.
6) Erosion control and reduction in fertilizer usage are the primary means by which individual residents and managers in the watershed can reduce phosphorus.

More specific appropriate message(s) for the identified target audiences will be developed for each I/E plan effort as implementation proceeds. The information obtained from the survey work to be completed to assess current levels of knowledge regarding water quality impairments will be utilized to develop the message(s).

9.2.5.4 Package and Distribute the Message

Each I/E plan component will require a different means to package and distribute the message. Successful I/E plan efforts already undertaken in the watershed relied primarily on workshops, trainings, and short informational materials.

9.2.6 Implementation Schedule

9.2.6.1 East Canyon Water Reclamation Facility Expansion

The load allocated to the ECWRF is expected to account for 20 to 30 years of growth in the area. The ECWRF expansion is scheduled to begin in 2011. The construction period required for the expansion is expected to be 3 years. Therefore, additional wastewater treatment capacity will be available to SBWRD beginning in 2015. However, based on current growth estimates for the service area the system is not expected to reach design capacity (7.2 MGD) until 2038. Should growth rates increase in the coming years, this date could be pushed to as early as 2030.

9.2.6.2 In-reservoir Treatment

In-reservoir treatment will be initiated by UDWQ by 2011, with a project completion target date of 2014. This five-year design and implementation window is a reasonable amount of time to identify targeted funding, design the system, and complete the necessary permitting and/or environmental compliance (i.e. NEPA) associated with the project. This will also provide an additional five years to monitor the impact of the actions on reservoir water quality before the TMDL is revisited in 2019.

9.2.6.3 Nonpoint Source Management Measures

Nonpoint source management measures are currently underway in the watershed. DWQ is currently in the process of hiring a watershed coordinator for the area who will be responsible for facilitating implementation of the watershed plan. Development of a detailed project-specific schedule for implementation will be among the first tasks assigned to the new watershed coordinator. Nonpoint source reductions are scheduled to continue at an aggressive rate through 2014 in order to allow for a five year period of monitoring to document improvement resulting from these efforts before the TMDL is revisited in 2019. The prioritization of nonpoint source measures identified in this implementation plan identifies areas for which implementation will be the most cost and time efficient.

9.2.7 Interim Implementation Milestones

Effectiveness monitoring is used to check if the selected strategies are reducing pollutant loading. Effectiveness monitoring may be quantitative (e.g., laboratory analysis of phosphorus concentrations in water from specific subbasins, or in water exiting private property or developments) or qualitative (e.g., visual observation of sediment reduction in the water passing through a fenced riparian area), depending on the BMP implemented and the overall scope of the project. Although quantitative monitoring methods will document progress toward improved conditions, qualitative methods can also provide an effective measurement of implementation progress. Other examples of qualitative effectiveness monitoring include photo documentation of improvement in streambank vegetation/cover in high use recreation areas, or vegetated grass swales at golf courses. Qualitative monitoring could also include documentation of relative sediment volume (i.e., high, medium, or low) collected from detention ponds or filters in stormwater treatment systems. Although these methods do not provide quantitative information on the effectiveness of the projects, they do illustrate progress and can be combined with other monitoring efforts to show success of implementation activities.

Quantitative effectiveness monitoring is required to document actual progress toward improved water quality conditions and can only be achieved through water quality assessments. Therefore, the success in reducing the load of phosphorus and sediment will be measured by contributions monitored at or near the mouths of major tributary points.

Monitoring of in-reservoir treatments should include detailed profiles of DO, temperature, and total phosphorus during periods of stratification throughout the reservoir. These data should help ensure that the thermocline is maintained during aeration such that the cold water fishery habitat, defined by low temperature and high DO, is maintained.

In-stream monitoring is scheduled to occur periodically throughout the year by UDEQ and includes physical, chemical, and biological parameters. In-reservoir monitoring is scheduled to occur periodically during the algal growth season and includes physical, chemical, and biological parameters. Each organization should monitor and report on the implementation and effectiveness of their management strategies, but not every organization is expected to implement its own water quality monitoring program. The following subsection outlines the proposed procedures for quantitatively monitoring the effectiveness of the proposed management strategies.

9.2.7.1 Sampling Design and Parameters

The quantitative monitoring plan requires water quality monitoring of sites located throughout the watershed that contribute directly to the annual phosphorus load. To assist in achieving the water quality goals, the initial monitoring plan should include the following:

- Seasonal monitoring throughout the year at reservoir monitoring sites and tributaries into the reservoir. Monitoring the selected sites for phosphorus, nitrogen, chlorophyll a, temperature, total suspended sediment, total organic carbon, in-reservoir DO profiles, green algae, and cyanobacteria.
- Monitoring streams above and below large BMP installation projects in order to determine effectiveness of individual projects.

The objectives of this monitoring plan consist of the following:

- Obtaining information necessary for ensuring that water quality loading and concentration targets for phosphorus are met
- Obtaining a detailed record of water quality data to assess whether the established target levels and threshold values are protective of beneficial uses
- Evaluating BMP effectiveness and load reductions resulting from implementation efforts

Successful development and implementation of the monitoring plan will provide flexibility for adapting changes to the implementation plan as the need arises.

9.2.8 Loading Reduction Targets

The primary contributor to low DO in East Canyon Reservoir is sediment oxygen demand related to annual algal blooms, legacy organic matter, and annual organic matter washed into the system. Modeling of the reservoir indicates that watershed-derived organic matter is a minor contributor to oxygen depletion and that internal phytoplankton production throughout the year is the primary contributor to oxygen depletion in the reservoir.

Algae-related endpoints were selected for East Canyon Reservoir based on the direct and indirect influence of algal biomass on DO concentrations in the hypolimnion during stratification and on nuisance algal thresholds protective of recreational beneficial uses. Nutrients fuel algal growth, which in turn consumes oxygen from the water column during respiration (D'Avanzo and Kremer 1994). In East Canyon Reservoir, when algae die and settle to the bottom of the waterbody, aerobic decomposition of the dead algae and other detritus (nonliving organic material) also depletes the oxygen supply in the overlying water, leading to oxygen depletion in the lower water column (hypolimnion). Due to reservoir stratification, mixing does not occur during the summer months so there is no natural means by which additional oxygen could be introduced to the hypolimnion. The mean seasonal chlorophyll *a* endpoint was derived from the Carlson Trophic State Index equation and corresponds to a chlorophyll *a* TSI of 50. A review of the recreational use literature indicates that nuisance algal concentrations for recreational beneficial uses range from 25 μg/L (Walker 1985; Raschke 1994) to 40 μg/L, with severe nuisance concentrations recognized as occurring above 60 μg/L (Heiskary and Walker 1995). Exceedance of a perceived nuisance threshold less than 10% of the time was found to be fully supportive of recreational beneficial uses (Smeltzer and Heiskary 1990). Periodic overgrowth of algae violates the narrative standard for waters established by the State of Utah. These endpoints were derived from a water quality analysis of the reservoir (see Chapter 3), a review of relevant scientific literature (see Chapter 7), and results from the East Canyon Reservoir W2 model developed by JM Water Quality LLC (see Chapter 5). Three algal-related endpoints were identified for East Canyon Reservoir:

- Mean seasonal chlorophyll *a* values of 8.0 µg/L (based on a mean trophic state index (TSI) value of less than 50).
- Chlorophyll *a* concentrations to exceed nuisance threshold of 30 µg/L less than 10% of the season (May – October).
- Dominance by algal species other than blue-green algae.

High concentrations of DO (6.0–8.0 mg/L or greater) are necessary for the health and viability of fish and other aquatic life. Low DO concentrations (less than 4.0 mg/L) increase stress to fish species, diminish their resistance to environmental stress and disease, and result in mortality at extreme levels (less than 2.0 mg/L). The DO endpoints for East Canyon Reservoir are consistent with existing water quality criteria and were developed in collaboration with the Utah Division of Wildlife Resources. During periods of complete mixing in the reservoir, all life-stage water quality criteria, established by the State of Utah, will be maintained across the reservoir and throughout at least 50% of the water column. The DO criteria include 4.0 mg/L as a 1-day minimum, 5.0 mg/L as a 7-day average, and 6.5 mg/L as a 30-day average. Cold water sport fish species are not known to reproduce in the reservoir, therefore the early life-stage criteria do not apply. During periods of thermal stratification, the minimum DO criteria of 4.0 mg/L and maximum temperature of 20^{o} C shall be maintained in a 2-m layer across the reservoir (aerial) to provide adequate refuge for cold water game fish. These criteria were determined to provide sufficient support for the cold water game fish beneficial use (3A) designated by the State of Utah for East Canyon Reservoir. Attainment of the acute 1-day criterion of 4 mg/L is considered to represent compliance with the 7-day and 30-day criteria. Therefore, the 1-day criterion was used to assess proposed reduction scenarios using the W2 model.

Total phosphorus endpoints for the reservoir are based on correlation between chlorophyll *a* targets and mean seasonal total phosphorus derived from the W2 modeling results. A mean seasonal chlorophyll *a* target of 8 µg/L has been correlated with reservoir mean total and dissolved phosphorus concentrations of 0.04 mg/L and 0.03 mg/L, respectively. Because attainment of DO endpoints specific to East Canyon Reservoir requires mean seasonal total and dissolved phosphorus concentrations of 0.03 mg/L and 0.02 mg/L, respectively, these concentrations are the nutrient endpoints for East Canyon Reservoir.

9.2.9 MONITORING

The monitoring goals of this project are to document progress in achieving improved water quality conditions in East Canyon Reservoir as nonpoint source control management strategies are implemented. To document this progress, a monitoring program is needed to examine and report on the performance of each management strategy. Two types of performance monitoring are proposed in this implementation plan: 1) implementation monitoring and 2) effectiveness monitoring. Implementation monitoring assesses whether the proposed management strategies were implemented and, if they have been implemented, the progress that has been achieved. Effectiveness monitoring is used to check if the selected strategies are effectively reducing pollutant loading. The following subsections present implementation and effectiveness monitoring methods proposed for organizations that will be involved in execution of this implementation plan.

9.2.9.1 Implementation Monitoring

Each organization should monitor implementation of management strategies by tracking the progress and accomplishments of each activity. The implementation tracking matrix in Table 9.13 is an example of a tool that could be developed into a centralized database and used by organizations to monitor implementation of the proposed management strategies. A status column should be added to the database to track actual implementation progress.

Table 9.13. Example of Implementation Tracking Matrix

Land Use	Source	Management Strategy	Resources Needed	Methods of Measure	Timeline
Active Construction	Stormwater, erosion, and sediment runoff	Continue enforcement of stormwater ordinances and implementation of plans.	County administrative staff and building inspectors to continue plan reviews, on-site inspections, and SWP3 enforcement.	Track number of inspections and violations	On-going
Residential, Commercial, and Urban	Stormwater, erosion, and sediment runoff	Construct additional detention basins;	County or municipal funding for construction.	Track number of ponds and quality of water released.	On-going
	Excess fertilizer use	Soil testing and fertilizer rate reduction (I & E)	Review and submission of grant applications to fund education efforts.	Track reviews and submissions	Ongoing
Golf Courses	Sediment runoff	Continue implementation of WRAPs	No additional resources needed.	Track inspection reports	Ongoing
Ski Areas	Sediment runoff from trails and roads	Continue implementation of WRAPs	No additional resources needed.	Track inspection reports	Ongoing
High Use Recreation	Sediment runoff from trails	Trail design			
Agricultural Management and Grazing	All sources	Continue implementation of watershed plans	Secure grant funding and matching funds.		
Forested and Meadow	Sediment runoff from roads and trails	Inventory forested land uses and identify key sources of phosphorus load	Resource personnel for data collection and summary.		
Reservoir	Sediment release during anoxic periods	Alum treatment Hypolimnetic aeration	Engineering design of in-reservoir treatments. Secure implementation funding.		

9.2.9.2 Progress Reporting in a Centralized Database

Annual reports will provide details about sediment and phosphorus reduction measures, operation efficiencies, and projected load reductions; reports should be submitted to the appropriate organization and agencies for their review. The watershed would benefit from a centralized database that tracks the progress and success of implementation projects throughout the reservoir. The East Canyon Watershed Committee hosts a website that currently serves as a clearing house for documents, contacts, and meetings. This website would be a good place to host a database of progress reporting, monitoring data, and load reduction estimates. The database would initially include water quality data and implementation planning efforts gathered as part of this implementation plan but could be expanded to incorporate implementation monitoring and other types of data generated in the watershed. Examples of the types of information that should be tracked in this database include:

Implementation monitoring

- Project lead agency/organization and contact information
- Coordinating plan under which project is implemented (i.e. MAG 2003, ECWC 2004)
- Source addressed, land use, and specific location (e.g., golf course, ski resort, or other landowner)
- Resources spent, secured, or needed
- Type of funding/matching funds
- Methods planned to measure success
- Timeline
- Status

Effectiveness monitoring

- Quantitative
  - Project specific water quality plans and results indicating BMP effectiveness (pre- and post- project if possible, and up and down stream of project)
  - Estimated total phosphorus reduced as a result of the project
- Qualitative (examples)
  - Photographic documentation (pre- and post- project; up and down stream of project)
  - Development and distribution of Information and Education materials
  - Documentation of irrigation control system upgrades
  - Record changes in sediment volume in collection basins (i.e., high, medium, or low)
  - Compile and publish ski resort and golf course Watershed Restoration Action Plans
  - Track enforcement and violation of Construction Storm Water Pollution Prevention Plans and Erosion Control Plans

9.3 CONCLUSIONS

Attainment of the East Canyon Reservoir TMDL endpoints requires continued reduction of phosphorus loads from nonpoint sources and internal reservoir sources, as well as the continued phosphorus removal efficiency of the East Canyon Water Reclamation Facility. This implementation plan recognizes that although the concentration of phosphorus in the ECWRF effluent will not increase significantly, future growth requires additional discharge from the facility and corresponding increased total phosphorus load. Allocation of this future load can be accomplished through implementation of existing watershed restoration action plans (WRAPs). The East Canyon Watershed Committee and various stakeholders have existing WRAPs that address significant nonpoint phosphorus sources. Priority areas for additional implementation efforts include enhanced BMPs on phosphatic shale areas of the watershed found in the Treasure Hollow, Willow Draw, Three Mile, and Spiro Tunnel subbasins, particularly those areas that are also on steep slopes and more susceptible to erosion. Specific land uses that require continued or improved BMP implementation include golf courses, construction sites, ski resorts, and residential and commercial areas. Forested land uses make up more than 70% of the watershed and represent the largest total load of nonpoint source phosphorus in the watershed. An inventory of potential phosphorus loads on forested lands (e.g., road and trail conditions and proximity to streams) is necessary to properly address the potential sources and BMPs for this land use.

Recommended in-reservoir treatments are anticipated to effectively and efficiently improve water quality in East Canyon Reservoir, thereby mitigating the lag-time associated with watershed source reductions. In-reservoir treatments would also improve cold water fish habitat. In-reservoir treatment is relatively inexpensive and when combined with implementation of existing WRAPs is expected to be successful in obtaining full support status for East Canyon Reservoir.

More systematic tracking and monitoring of projects throughout the watershed is necessary to prioritize additional future projects. Interest and involvement in the implementation of projects that will reduce phosphorus loading is very high among stakeholders, municipalities, and businesses in the East Canyon Reservoir Watershed. These efforts are expected to result in a cleaner, healthier watershed for current and future generations.

List of Abbreviations and Symbols

Acronym or Symbol	Definition
~	approximate
§303(d)	Refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired waterbodies required by this section
μ	micro, one to one thousandth
μg	microgram
§	Section (usually a section of federal or state rules or statutes)
^{o}C	degrees Celsius
^{o}F	degrees Fahrenheit
ac	acre
APHA	American Public Health Association
AUM	animal unit month
AWS	agricultural water supply
BAG	Basin Advisory Group
BLM	United States Bureau of Land Management
BMP	best management practice
BOD	biochemical oxygen demand
BOR	United States Bureau of Reclamation
BURP	Beneficial Use Reconnaissance Program
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeters
CN	curve number
CPUE	catch-per-unit-effort
cts	counts
CWA	Clean Water Act
CWAL	cold water aquatic life
DBU	designated beneficial use
DEM	digital elevation model

Acronym or Symbol	Definition
DEQ	Department of Environmental Quality
DGL	digital graph line
DGS	dissolved gas supersaturation
DO	dissolved oxygen
DOI	U.S. Department of the Interior
DWS	domestic water supply
ECRFC	East Canyon Riparian and Fisheries Committee
ECWRF	East Canyon Water Reclamation Facility
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
ET	evapotranspiration rate
FWS	U.S. Fish and Wildlife Service
FWPCA	Federal Water Pollution Control Act
GBT	gas bubble trauma
GIS	Geographical Information Systems
GOPB	Utah Governor's Office of Planning and Budget
h	hectare
HOD	hypolimnetic oxygen depletion
HRU	hydrologic response unit
HUC	Hydrologic Unit Code
INFISH	Federal Inland Native Fish Strategy
kg	kilogram
km	kilometer
km^2	square kilometer
L	liter
LA	load allocation
LC	load capacity
m	meter
m^3	cubic meter

Acronym or Symbol	Definition
MBI	macroinvertebrate biotic index
MGD	million gallons per day
mg	milligram
mg/L	milligrams per liter
mL	milliliter
mm	millimeter
MOD	metalimnetic oxygen depletion rate
MOS	margin of safety
MRLC	Multi-resolution Land Characteristics Consortium
MUSLE	Modified Universal Soil Loss Equation
MWMT	maximum weekly maximum temperature
n.a.	not applicable
N	nitrogen
NA	not assessed
NB	natural background
NCDC	National Climatic Data Center
nd	no data (data not available)
NED	National Elevation Dataset
NFS	not fully supporting
NHD	National Hydrography Dataset
N:P	nitrogen to phosphorus ratio
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTU	nephlometric turbidity unit
ORW	Outstanding Resource Water
PCMC	Park City Municipal Corporation
P	phosphorus
PCB	polychlorinated biphenyls
PCR	primary contact recreation
PFC	proper functioning condition
pH	measure of acidity: pH 1–6 = acidic, pH 7 = neutral, pH 8–14 = basic

Acronym or Symbol	Definition
ppm	part(s) per million
QA	quality assurance
QC	quality control
RHCA	riparian habitat conservation area
SBA	subbasin assessment
SBWRD	Synderville Basin Water Reclamation District
SCR	secondary contact recreation
SCS	Soil Conservation Service
SNOTEL	snow telemetry
SRP	soluble reactive phosphorus
SS	salmonid spawning
SSOC	stream segment of concern
SSURGO	Soil Survey Geographic (SSURGO) Database
STATSGO	State Soil Geographic (STATSGO) Database
STORET	EPA water quality database
SU	standard units
SWReGAP	Southwest Regional Gap Analysis Project
T	ton
TDG	total dissolved gas
TDS	total dissolved solids
T&E	threatened and/or endangered species
Tier 1	All land within 150 feet of either side of a stream
Tier 2	Low land, mostly irrigated crop and pastureland
Tier 3	Upland, mostly nonirrigated pasture
TIN	total inorganic nitrogen
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TP	total phosphorus
TS	total solids
TSI	trophic state index
TSS	total suspended solids

Acronym or Symbol	Definition
t/y	tons per year
UDEQ	Utah Department of Environmental Quality
UDNR	Utah Department of Natural Resources
UDWiR	Utah Division of Wildlife Resources
UDWQ	Utah Division of Water Quality
UDWaR	Utah Division of Water Resources
UDWRi	Utah Division of Water Rights
UGS	Utah Geological Survey
U.S.	United States
U.S.C.	United States Code
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture

Acronym or Symbol	Definition
USDI	United States Department of the Interior
USFS	United States Forest Service
USGS	United States Geological Survey
WAG	watershed advisory group
WBID	waterbody identification number
WLA	wasteload allocation
WQLS	water quality limited segment
WQMP	water quality management plan
WQS	water quality standard
WBWCD	Weber Basin Water Conservancy District
WRCC	Western Regional Climate Center
WWTP	wastewater treatment plant

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