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Funding for WRDS and the creation of this electronic document was provided by the Wyoming Water Development Commission (http://wwdc.state.wy.us)

Executive Summary

Cottonwood/Grass Creek Watershed Management Plan

Level I Study

Wyoming Water Development Commission

October 10, 2007

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SEH

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Prepared for Wyoming Water Development Commission

1.0 Introduction

1.1 Purpose and Scope

The primary purposes of the Cottonwood Creek Watershed Management Plan, Level I Study are to:

- Inventory all conditions in the watershed relevant to identification and characterization of water resource related issues and opportunities.
- Develop a watershed management and rehabilitation plan describing potential alternative projects and management strategies to address water resource related issues and potential water development opportunities identified in the watershed inventory, including but not limited to irrigation system rehabilitation projects, wildlife/livestock water developments, and surface water storage dams and reservoirs.
- Assess the potential environmental issues or constraints that may affect the projects/strategies identified in the watershed management and rehabilitation plan, and identify and characterize the permits/clearances and any associated environmental studies and/or mitigation that may be required.
- Develop conceptual-level estimates of the costs of the potential projects identified in the watershed management and rehabilitation plan.
- Perform preliminary economic analyses of major project alternatives (i.e., dams and reservoirs), including assessment of project benefits and sponsor ability to pay assuming WWDC financing, and identify and describe potential funding sources for all potential project types identified in the watershed management and rehabilitation plan.
- Compile a project GIS of relevant existing spatial data and additional coverages developed during the course of this study.

The scope of this study addresses each of the above primary purposes, and is fully responsive to the Scope of Services in Exhibit "A" of the Consultant Contract for Services.

1.2 Responsibility

This project was authorized by the Consultant Contract for Services effective June 16, 2006 between the Wyoming Water Development Commission (WWDC) and Short Elliott Hendrickson Inc. (SEH). The official contractual representative for the WWDC was Lawrence M. Besson, Director of the Wyoming Water Development Office (WWDO). Ron Vore served as the WWDO Project Manager and primary point of contact for SEH on both technical and administrative matters.

SEH's Project Manager for this study was Douglas M. Yadon, Wyoming PE No. 4650, and all engineering work on the project was performed under his responsible charge. Anderson Consulting Engineers, Inc. (ACE) of Fort Collins, Colorado performed the stream geomorphology and irrigation inventory and associated rehabilitation plan tasks, reviewed and utilized the existing Wind/Big Horn Basin plan hydrologic model, assisted in the remainder of the surface water hydrology task, and developed the project GIS. The work by ACE was led by Jay Schug under the direction of Brad Anderson, PE. Don Tranas of Greybull, Wyoming performed the assessment of range and related vegetation conditions, and assisted in the development of potential wildlife/stock watering projects and range management practices.

1.3 Overview of Study Area and Key Issues

The Cottonwood/Grass Creek watershed is located in Hot Springs and Washakie Counties as shown on Figure ES-1 – Study Area Location. The watershed is comprised of the combined drainage basins of Cottonwood Creek and its main tributary, Grass Creek. Lower Cottonwood Creek drains to the Bighorn River at Winchester, approximately four (4) miles north of Kirby. The watershed ranges from sagebrush dominated dissected hills in the east to forested lands in the Shoshone National Forest to the west.

The economy of the watershed is based on agriculture (primarily cattle ranching and associated forage production) and oil and limited natural gas extraction at two larger (Hamilton Dome and Grass Creek) and a number of smaller still active fields. A small open-cut coal mine and several small aggregate pits are also operated within the watershed. Recreation is an integral part of the local economy, including commercial horseback riding, use of a 4H lodge facility in upper Grass Creek, and forest access for hiking, picnicking and camping, among other activities. Existing infrastructure includes paved and maintained gravel roads, electric power transmission and distribution lines, telephone lines, and oil and gas pipelines. There are no towns or services available within the watershed, and relatively few full-time residents.

The Cottonwood/Grass Creek Coordinated Resources Management (CRM) group, comprised of a wide array of landowners, ranchers, irrigators, agency and entity staff, and other interested stakeholders, has been active in promoting studies, projects and best management practices in the watershed. During the course of this Level I study a group of landowners in the watershed began and are continuing to pursue establishing a watershed improvement district (WID) that would encompass essentially all of the Cottonwood/Grass Creek watershed and some contiguous lands. These two groups are supported by the local offices/representatives of numerous local, county, state and federal agencies.

These individuals, groups, and agencies have identified a number of key issues that formed the basis of the scope of work for this watershed management and rehabilitation plan study including, but not necessarily limited to, the following:

- Encroachment of juniper and limber/pinyon pine onto the lower slopes and into the valley bottoms of the mid to upper watershed.
- Encroachment of saltcedar (tamarisk) and Russian olive into the lower reach of Cottonwood Creek and locally into the middle portion of the watershed.
- Enhancement of watering opportunities for wildlife and livestock to better use available range land, and to support protection and/or continuing recovery of riparian and aquatic stream habitat and stream geomorphic stability.
- Rehabilitation of existing irrigation infrastructure to more efficiently utilize and manage available and potential additional irrigation water supplies.
- Additional surface water storage to address chronic irrigation shortages and provide, to the extent that physically and legally available water supply allows, other multiple-use benefits including, but not necessarily limited to: enhancement/establishment of late-season stream flows to benefit wildlife, riparian and aquatic habitat, and livestock; wildlife/livestock watering; reduction of flooding and improvement of stream channel/bank stability; lake fishery; water quality improvements; and seasonal recreation.
- Potential groundwater development as a source of supply for wildlife and livestock watering, and possibly local irrigation.

2.0 Conclusions and Recommendations

Summary conclusions are presented below regarding: the major water resource-related conditions and issues identified in the Cottonwood/Grass Creek watershed as developed in the Watershed Description and Inventory; permitting and environmental considerations; and costs and financing of dam and reservoir projects. Then key recommendations from the Watershed Management and Rehabilitation Plan are presented that address the major conditions and issues.

2.1 Conclusions

2.1.1 Watershed Description and Inventory

2.1.1.1 Land Uses and Management Activities

- ***Land Ownership*** - The spatial distribution of the multiple land ownership (private, state and federal) within the watershed presents both opportunities and challenges to the potential implementation of larger scope/scale water resources related management practices and rehabilitation/improvement projects.
- ***Infrastructure*** - Existing transportation and electric power infrastructure are generally adequate to support the recommended rehabilitation/improvement projects recommended in this Level I study. However, in some instances this infrastructure and existing oil/gas infrastructure may affect the siting/alignment of new facilities or require relocation of the existing infrastructure.
- ***Irrigated Lands*** - Existing irrigated lands (primarily forage crops) are adequate to support the current scale of livestock operations assuming that adequate irrigation water is available. If additional reliable water supplies beyond current

needs were available, it is possible that some new lands would be brought into production.

- ***Rangelands*** - Range conditions within the watershed are variable, but judged overall "high fair" to "good", with trends generally stable to slightly upward overall. Conditions are generally less favorable in the lower precipitation eastern portion of the watershed and in some riparian areas that are heavily utilized by wildlife and livestock for watering and forage. Wildlife and livestock watering opportunities in the upland rangelands are locally adequate, but insufficient to best utilize the available range in much of the watershed.

- ***Energy and Mining*** – Oil and some natural gas production have been occurring since the early 1900s. Although overall average annual production has been declining for some time, the rate of decline has been slowed over time by implementation of enhanced recovery technologies and recent substantial increases in crude oil prices. Existing production of coal and aggregate is small, and it is not anticipated that significant expansion in production of these or other mineral resources in the watershed will occur in the foreseeable future.

2.1.1.2 Natural Environment

- ***Climate*** - The climate of the Cottonwood/Grass Creek watershed is classified as semiarid, with average annual precipitation ranging from about 10-20 inches from the lower hills in the east to the mountains in the west. The drier eastern portion of the watershed receiving less than 10 inches of precipitation is marginal in terms of supporting high quality range. The watershed has been experiencing overall severe drought since 2000, with current outlooks for continuing to intensifying drought.

- ***Vegetation and Land Cover*** – Most of the watershed is broadly classified as rangeland, transitioning in the west through the 12-14 inch precipitation zone to forestland. Limber pine and juniper (and often sagebrush) have encroached on lower slopes and locally terraces and valley bottoms in the middle to higher elevations in the watershed. This encroachment has resulted in more rapid runoff accompanied by lower late season stream and spring flows and poorer quality rangeland for wildlife and livestock. Prescribed burns in the Grass Creek basin have substantially improved conditions where implemented. Saltcedar and Russian olive have invaded the riparian and adjacent lands in the lower watershed resulting in excess evapotranspiration estimated as on the order of 1,000 acre-feet/year over healthy riparian conditions. Various noxious and other undesirable weeds have also invaded the watershed resulting in locally diminished habitat and rangeland values.

- ***Soils*** – Soil types vary over the watershed in response to parent material, climate and topography. Soil productivity varies strongly with elevation (and thus precipitation) from as little as 200 lbs/acre in the lowest precipitation zone in the eastern-most watershed to as much as 2,300 lbs/acre in healthy riparian areas. Soils in the valley bottoms and alluvial terraces are well suited to irrigation of forage crops (alfalfa and grass hay).

- ***Geology*** – Geologic conditions in the watershed appear generally suitable for construction of dams in terms of foundation conditions and borrow material availability, and do not appear to present major challenges to construction of other improvements (e.g., irrigation system rehabilitation, wildlife/livestock watering systems, etc.). There are local bedrock and surficial deposit conditions

that may affect siting and/or design of dams and other facilities including, but not necessarily limited to: low strength (e.g., bentonite beds, coal seams, fine-grained alluvium); higher seepage potential (e.g., joints, fractures and faults in bedrock; coarse-grained alluvial deposits); and high compressibility (e.g., loose alluvial, colluvial and slopewash deposits).

Landsliding is common in the younger sedimentary rocks of volcanic origin in the higher precipitation western third of the watershed, and essentially absent elsewhere.

No active faults are present in the watershed and ground shaking from earthquakes is judged not to present a hazard to dams or other facilities that cannot be fairly readily mitigated.

- ***Groundwater*** – Groundwater occurs both in shallow alluvium/alluvial terraces and deeper bedrock aquifers. In general, production from wells developed in the alluvial aquifers ranges from a few to as much as 25 gallons/minute (gpm), with most less than 5-10 gpm. Wells in the shallower bedrock units vary widely in production, ranging again from about 5-25 gpm. Two wells have produced 140 gpm and 400 gpm, but these are judged not typical. Very deep aquifers underlying the watershed are estimated as being able to yield in the range of 50-500 gpm.

2.1.1.3 Watershed Hydrology

- ***Gaged Streamflow*** – Gage records in the watershed are sparse; a gage on Cottonwood Creek above Hamilton Dome has continuous records over the past 14 years, while a gage at Winchester at the confluence with the Bighorn River only operated for four years (from mid-1941 through mid-1945). Average annual flows at the upper gage range from 10,600 acre-feet/year prior to the beginning of the drought in 2000 to 2,500 acre-feet/year during the ongoing drought. Average annual flow at the lower gage (during a period of more normal precipitation) was 20,600 acre-feet/year (ranging from 7,500 to 30,300 acre-feet/year).
- ***Hamilton Dome Discharges*** - Discharges of treated water from the Hamilton Dome oil field to lower Cottonwood Creek apparently began at least by 1955, but were relatively minor until sometime in the early 1960s when larger pumps began to be installed in the field. Current annual discharges to the creek average about 9,000 acre-feet/year (12.5 cfs). Water production from the field has stabilized in the past 25 years, but the duration and amount of future discharges is unknown.

2.1.1.4 Stream Geomorphology

- Stream channel geomorphic stability is an important, interrelated factor in the overall health and function of the watershed. The results of an assessment of stream conditions are summarized on Figure ES-2 – Rosgen Level I Geomorphic Classification and briefly discussed below.
- Stream channels in the western portion of the watershed (on the lower slopes of the Absaroka Mountains) are generally laterally stable and geomorphically resilient to external impacts.
- Cottonwood Creek displays a relatively large degree of channel variability, but for the most part appears to be vertically stable with adequate connection to its

floodplain. Although some reaches are more entrenched F-Type channels, Cottonwood Creek is considered a C-Type channel throughout most of its reach.

- The smaller Grass Creek channel is dominated by sinuous, finer-grained E-Type channels that are moderately resistant to changes in hydrology or sediment load, but prone to local, rapid destabilization due to bank failure triggered by loss of vegetation.
- Many of the first-order tributaries in the watershed can be classified as G-Type channels or gullies. These channels are highly erosive and generate high sediment volumes. These characteristics can lead to loss of productive land and destabilization of upland conditions.
- Impairments to stream channels in the watershed fall into three broad categories: 1) channel degradation/incision; 2) bank erosion associated with channel migration and/or widening; and 3) effects of historic and current range management practices.

2.1.1.5 Irrigation Inventory

- Irrigation systems in the watershed are generally small, privately owned and managed, and typically old (some predating statehood). They range in size from ditches serving less than 20 acres to systems irrigating several hundred acres. Although most of the systems are still generally functional, many components of various of the ditches are suffering from age and deterioration as documented in the Level I field inventory (see Figure ES-3 – General Location of Inventoried Irrigation Ditches).
- More efficient water management (resulting in significant water savings) could be achieved by targeted rehabilitation (e.g., sediment removal, rehabilitation or replacement of diversion structures, conversion of open ditch to pipeline, lining or open ditches, replacement or repair of headgates, repair and/or reinforcement of breached or overtopped banks, etc.).

2.1.1.6 Water Quality

- ***Surface Water*** – Although surface water in the Cottonwood/Grass Creek watershed is generally suitable for agricultural uses (irrigation and livestock watering), there are some exceedances of published criteria for these uses. The most prevalent exceedances are for sulfate and specific conductance which are interpreted to be largely an unavoidable result of the natural geologic conditions in the watershed. Adequate drainage of irrigated lands using water with high specific conductance (indicating high salts content) is necessary to minimize the build-up of salts in the soils. The other lesser exceedances of criteria (e.g., locally TDS, pH, chloride and fluoride) are not judged as presenting a significant impediment to the use of these waters based in large part on the fact they have been used without apparent serious consequence for over 100 years.
- ***Groundwater*** – Groundwater is generally not used for irrigation in the watershed at present. If more use of groundwater for irrigation was envisioned, the relatively common exceedances of sulfate, specific conductance and TDS in many of the aquifers would require the same attention as some of the surface waters to adequate drainage to mitigate salt buildup in soils.
- ***Permitted Discharges and TMDLs*** – Currently permitted and active discharges are present in the watershed, but only the two treated water discharges from the Hamilton Dome oil field are significant in terms of volume. All of these

discharges appear to meet their permitted limits in terms of water quality (including the Hamilton Dome discharges given the recent adoption of site-specific standards for chloride and selenium in lower Cottonwood Creek). It is assumed that the current (2006) listing of lower Cottonwood Creek on the 303(d) list of impaired waters will be removed during the next update given the new stream standards for this reach.

2.1.1.7 Water Storage and Retention

- Based on the results of prior modeling under the Wind/Bighorn Basin Plan study, it appears that there are physically and legally available flows that could be stored within the Cottonwood/Grass Creek watershed. The Basin Plan model estimates that a total of 21,000 acre-feet are available during a normal (6 out of 10) year basis and 7,300 acre-feet on a dry (2 out of 10) year basis. These estimates are believed to be somewhat high, but within order of magnitude.
- Modeled irrigation shortages in the Cottonwood Creek drainage are approximately 5,200 acre-feet/year for the dry-year case and 2,400 acre-feet for the normal year case. In the Grass Creek drainage the comparable estimates are 1,800 acre-feet and 800 acre-feet, respectively. Actual shortages are believed to be greater than these model estimates.
- Given these estimated available flows and irrigation shortages, it appears that there is significant opportunity to mitigate at least a substantial portion of the irrigation shortages and provide some other multiple use benefits by building new storage at one or more locations identified within the watershed. A total of ten alternative sites were selected for more detailed evaluation to meet one or more of three storage concepts (supplemental irrigation by direct release only, supplemental irrigation by exchange, and multipurpose storage and operation).

2.1.2 Permitting and Environmental Considerations

- The primary environmental considerations in the Cottonwood/Grass Creek watershed in relation to permitting of dam and reservoir sites (and to a lesser degree other types of projects) appear to include: wetlands, sage grouse habitat (including especially leks), and crucial big game habitat. This is not to say that other considerations are not important or may not significantly influence the ability to permit a project.
- It is considered most likely that permitting of a dam and reservoir site would require that a full EIS process be followed under the lead of either the BLM or the COE, or possibly under their joint lead.

2.1.3 Costs and Financing of Dam and Reservoir Projects

- The estimated costs for development of reservoir storage vary substantially depending mainly on the size and overall efficiency of the dam and reservoir site. The total project cost of the ten selected alternatives studied in more detail range from about $900,000-$1,000,000 for the rehabilitation of the existing Lake Creek Dam or reconstruction of the breached Phelps Dam to $31,000,000-$53,000,000 for sites intentionally maximized to capture as much as possible of the estimated total available flow in the watershed and thereby provide the most potential for multiple uses and benefits. The capital costs for storage projects sized primarily to address existing irrigation shortages are in the range of $10,000,000-$22,000,000.

- The estimated costs per acre-foot of storage on a capital cost basis for the ten projects studied in more detail range from about $600 to $5,000. Costs per cubic yard of fill for these projects (again on a capital cost basis) range from about $12 to $24.
- Annual costs per acre of irrigated lands served range from about $2 to over $200 (assuming 90 percent grant funding) and $5 to over $700 (assuming 67 percent grant funding). The ranges of annual costs per acre-foot of yield under the same assumptions of grant funding are $5-$76 and $17-$250.
- The estimated maximum potential present value of direct and indirect irrigation benefits for the project alternatives evaluated ranges from approximately $1,300,000 to $2,100,000 except for the Phelps Reservoir Reconstruction. That project yields only about $300,000 in total benefits due to its very small yield. These costs can be compared to the total project costs above to gain some sense of the order-of-magnitude ratio of total project cost to irrigation benefit.
- Under the most favorable assumption of a 90 percent grant and the WWDC's standard loan terms for the remainder of the cost, the estimated sponsor's ability to pay (as a percentage of the sponsor's annual payment obligation) ranges from 230 percent for the Lake Creek Rehabilitation project to 8 percent for the Prospect project. The ability to pay percentages assuming 67 percent grant for the same projects are estimated as 70 percent and 2 percent.

2.2 Recommendations

2.2.1 Watershed Management and Rehabilitation Plan

2.2.1.1 Irrigation Supply Systems

- Potential solutions to the primary issues and problems for a total of 13 individual ditch systems were identified and conceptual-level costs estimated (see Table ES-1 – Irrigation System Rehabilitation Plan). Individual actions recommended range from sediment removal at a cost of approximately $500 to lining of nearly a mile of ditch at a cost of about $170,000.
- The recommended solutions for any system can be implemented individually, in combination, or as a complete package depending on the needs, preferences and financial ability of the owner. Funding assistance is available from a number of sources, especially the WWDC Small Water Project Program and various programs administered by NRCS.

2.2.1.2 Wildlife/Livestock Watering

- Providing additional facilities for wildlife and livestock watering at appropriate locations is recommended as the highest priority and best value means to improve rangeland condition and use and to maintain and/or support continuing recovery of riparian and associated aquatic habitat and stream channel stability in the watershed. These watershed values are significantly improved by decreases in bare ground, decreasing runoff and improved infiltration that result from the range management (grazing) practices made possible with adequate upland watering. It is important that any such improvements and practices be fully implemented and maintained by the landowner to attain the maximum overall benefits to the watershed.
- Existing upland range wildlife/livestock watering opportunities are shown on Figure ES-4A – Existing Wildlife/Livestock Watering Sites; this compilation

also includes certain projects that are in the final planning or design stage but not yet constructed. Additional potential sources of upland water and water developments are shown on Figure ES-4B – Alternative Wildlife/Livestock Watering Opportunities.

- Pipeline/tank systems appear to offer the most efficient and cost-effective means to provide adequate watering to large areas of rangeland. Water sources for these systems will depend on the location of the rangeland to be served and the available alternative sources. The most likely sources are wells or spring developments, although in some cases direct stream diversions or a diversion from a reservoir or pond may prove workable.
- Where gravity supply is not feasible or providing commercial electric service is not cost effective, solar powered pumping systems appear to offer an efficient, cost-effective means to supply water directly to a tank or pipeline system (or to a storage tank that in turn supplies water by gravity). In some cases wind turbines or existing electrical power may prove more feasible.
- Other types of watering facilities should be considered for smaller or more isolated service areas, where less frequent use is envisioned, or where the cost is prohibitive or the conditions otherwise make a pipeline/tank system impractical. Alternative facilities can include individual wells (with a solar- or wind turbine-powered pump or a conventional mechanical windmill-driven pump), single gravity-type spring/tank developments, ponds, or guzzlers.
- A total of 25 planned and potential wildlife/livestock watering developments were identified during the course of the project (see Table ES-2 – Wildlife/Livestock Watering Projects Plan), and there are opportunities for many more such projects including possibly one or more larger-scale cooperative projects. The currently identified projects include spring developments with one watering tank and spring- or well-supplied pipeline/tank systems with up to six tanks fed from a single water source.

2.2.1.3 Surface Water Storage

- ***Additional Study*** - Based on the results of existing modeling of available flows and irrigation shortages and careful evaluation of those results during this study, more detailed study of the potential for development of surface water storage in the Cottonwood/Grass Creek watershed is justified and recommended. Such a study would best be performed under the WWDC's Water Development Program as a Level II, Phase I study. The study should include, but not be limited to, more detailed hydrologic, water rights and reservoir operations modeling using the StateMod or an equivalently robust model to support refinement of the existing irrigation needs, available flows in the watershed, and opportunities to achieve multiple uses and benefits from one or more reservoirs.
- ***Site Identification and Screening*** – A total of 13 dam and reservoir sites were identified as selected alternatives for further evaluation during this Level I study. Key information about these sites is compiled on Table ES-3 – Alternative Surface Water Storage Projects and their locations are shown on Figure ES-5 – Alternative Surface Water Storage Sites. Estimated conceptual-level costs and the results of preliminary economic analyses for these projects (discussed above in Section 2.1.3) are summarized on Table ES-4A – Alternative Projects Cost Summary, Table ES-4B – Summary of Ability to Pay for Project Alternatives, and ES-4C – Annual Costs by Alternative Storage Sites. Evaluation of these

sites, including comparison of their relative ratings on a wide array of conditions and issues as shown on Table ES-3, resulted in identification of four sites for further study as discussed below.

- ***Recommended Sites*** - Based on the results of this Level I study, it is recommended that a Level II study focus on four of the selected alternative dam and reservoir sites evaluated herein. These include:
  - *Site 1 - Grass Creek Causeway* as a means to address all existing irrigation shortages on Grass Creek, and potentially as much as feasible of any additional shortages that may be identified on Cottonwood Creek below the confluence of Grass Creek;
  - *Site 2 – Putney Flat* to capture all available flows from the upper Cottonwood Creek watershed and serve as much of the existing irrigation shortage downstream as possible;
  - *Site 4 – Wales Reservoir Expansion* to store any remaining available flows below Putney Flat (or work in tandem with the Putney Flat reservoir to optimize the size of both reservoirs), and possibly to store any portion of the flows from Hamilton Dome that would not otherwise injure existing downstream uses of these flows; and
  - *Site 13 – Lake Creek Reservoir Rehabilitation* as a means to regain the original permitted storage capacity or as much of the natural flows from its drainage area as could be safely stored to address at least local shortages (if any) at the old Rhodes place above the Putney Flat site; storage in Lake Creek Reservoir would also reduce the required size of the Putney Flat reservoir.

2.2.1.4 Groundwater Development

- Development of shallow to moderately deep groundwater (up to a few hundred feet) appears feasible as a source of wildlife/livestock watering or small-scale irrigation. Given the unavoidable uncertainties in groundwater development, and the potential for less than desirable water quality from many of the shallower aquifers, it is recommended that site-specific studies be considered before committing to extensive groundwater development.
- Development of deep aquifers where the potential for more reliable, larger flows is present appears infeasible within the Cottonwood/Grass Creek watershed. This is due to the depth of wells necessary and their associated costs (both initial capital costs of drilling and pump purchase and installation and long-term pumping costs).

2.2.1.5 Other Management Practices and Improvements

- Development and implementation of an effective grazing management plan is strongly recommended to protect and enhance the value and health of both the rangeland and the riparian and aquatic habitat in the watershed. This is especially important to gain the full benefit of wildlife/livestock water developments discussed previously.
- Continued to accelerated removal of saltcedar and Russian olive, and implementation of measures to prevent re-invasion, are highly recommended as a very cost-effective means to increase flows in lower Cottonwood Creek and

avoid the potential for increased losses if these species were to spread higher into the watershed.

- Additional prescribed burns are strongly recommended in the mid to upper reaches of the Grass Creek, Cottonwood Creek and their major tributaries drainages. This measure has proven very effective in Grass Creek where implemented to date in significantly reducing runoff and substantially improving conditions for wildlife, livestock and the riparian and aquatic habitats of the watershed.
- Control of noxious weeds is important to promote the overall health and value of both the rangeland and riparian areas of the watershed.
- Development and implementation of an effective grazing management plan is also critical to the success of the salt cedar removal, prescribed burns, and noxious/undesirable plant control measures recommended above. Without effective management, the benefits of any or all of these measures can be lost.
- Channel restoration and stabilization efforts should be further evaluated and coordinated with planned and proposed upland wildlife/livestock water developments and with any proposed new reservoir storage projects in the basin. In the case of water developments, the projects themselves and accompanying grazing management can promote maintenance of or recovery to stable, healthy stream conditions. The effects of water storage projects both upstream and downstream of the reservoir site need to be carefully evaluated and accommodated in the design and operation of the project. In some cases it may be necessary and appropriate to implement "hard" engineering approaches to achieve stream stability. Such measures could include, for example, gradient restoration facilities (i.e., drop structures) or design and construction of a new stable channel in the existing floodplain and abandoning the previous alignment.

Table ES-1
Irrigation System Rehabilitation Plan

Rehabilitation Item Number	Description	Station (feet from headgate)	Priority	Cost
Alm #1, Alm #2, and Alm #3 Ditch System Improvements				
1	Alm #1: Install 4,500 LF of 10” HDPE pipe	0.0 - 4,500	2	$ 160,000
2	Alm #2: Remove sediment at diversion	0.0	3	$ 500
3	Alm #2: Replace wasteway structure	925	2	$ 3,000
4	Alm #2: Install 1 farm turnout structure	2,075	2	$ 2,500
5	Alm #2: Install measurement device (1)	2,075	3	$ 3,000
6	Alm #3: Install measurement device	300	2	$ 3,000
7	Alm #3: Install 30” diameter siphon to replace failing suspended CMP, 75-ft	6,275	1	$ 30,000
8	Alm #3: Repair breached portion of ditch	14,575	1	$ 2,000
Berry Ditch System Improvements				
9	Install check structure in creek at diversion	0	2	$ 30,000
10	Replace 2’ Parshall flume	1,050	2	$ 2,500
11	Increase channel capacity	1,950	2	$ 5,000
Butterfield Ditch System Improvements				
12	Install check structure in creek at diversion	0.0	2	$ 30,000
13	Install sediment trap/shoot at diversion	0.0	2	$ 10,000
14	Repair structural support for suspended pvc pipe crossing creek	9100	1	$ 10,000
Caledonia Ditch System Improvements				
15	Repair minor scour at diversion	0.0	3	$ 5,000
16	Stabilize ditch banks in vicinity of sediment trap/wasteway	1,225	2	$ 5,000
17	Replace 4’ Parshall flume	1,525	2	$ 6,000
18	Remove concrete splitter structure and install check structure and gate	4,860	2	$ 12,000
19	Remove steel splitter structure and install check structure and gate	5,400	1	$ 10,000
20	Re-grade ditches/consolidate parallel ditches, approx 3,000 LF (not parallel lateral)	5,400 - 9,800	2	$ 15,000
21	Install approximately 5 farm turnouts	To Be Determined	2	$ 12,500
22	Install approximately 5 check structures	To Be Determined	2	$ 20,000
23	Install approximately 5 measurement devices	To Be Determined	2	$ 15,000
Earl Ditch North and South				
--	No improvements recommended	--	--	$ -
Hilberry North Ditch System Improvements				
24	Stabilize creek at diversion	0.0	2	
25	Install check structure in creek at diversion	0.0	2	$ 20,000
26	Install headwall on headgate	0.0	2	$ 2,000
27	Stabilize scour hole at outlet of wasteway	2,150	3	$ 1,500
Kirby Ditch System Improvements				
28	Stabilize bank erosion in creek	0.0	1	$ 60,000
29	Replace headgate headwall	0.0	1	$ 5,000
30	Line approximately 5,000 LF of upper portion of ditch (geotextile)	0.0 to 5,000	2	$ 170,000
Little John Ditch System Improvements				
31	Rehabilitate diversion/ restore creek	0.0	2	$ 30,000
32	Replace headgate	0.0	2	$ 2,500
33	Replace sandtrap/wasteway	975	2	$ 10,000
34	Line approximately 1,000 LF of ditch	0.0 to 1,000	2	$ 20,000
35	Install approximately 6 farm turnouts	To Be Determined	2	$ 15,000
36	Install approximately 6 check structures	To Be Determined	2	$ 24,000
36	Install approximately 6 measurement devices	To Be Determined	2	$ 18,000
37	Re-grade ditch to increase capacity/consolidate parallel ditches	5,400 to 12,000	2	$ 60,000
LU Ranch Ditch System Improvements				
38	Install approximately 5,500 LF of 10” HDPE pipe	0.0 to 5,500	3	$ 200,000
Putney Ditch System Improvements.				
39	Install check/diversion structure in creek	0.0	1	$ 55,000
Robbins Ditch Improvement				
--	No improvements recommended	--	--	$ -
Wales Ditch System Improvements				
40	Rehabilitate diversion	0.0	2	$ 55,000
41	Install 30” underdrain culvert/re-grade ditch to repair gully erosion and sedimentation	125	1	$ 40,000
42	Replace 1.5ft Parshall flume	700	2	$ 2,000
43	Install check structure and gate to divert flow to Wales Reservoir	9,550	2	$ 25,000
Wilson Ditch System Improvements.				
44	Install check/diversion structure in creek	0.0	1	$ 55,000

Table ES-2
Wildlife/Livestock Watering Projects Plan

Project Number	Project Name	Water Source		Pipeline Length (ft)	Storage Tanks		Water Tanks (number)	Cost
		Springs (number)	Wells[1] (number)		Number	Size (gal)		
Grass Creek								
1	Upper Grass Creek Spirng Developments	5		1,000			5	$30,300
2	Mesaverde Water Supply Well #3 Conversion[2]		1					$39,300
3	Corral Relocation Project (includes new solar pump)[2]		(existing well)	1,700	1	2,200	3	$19,800
4	Grass Creek Spring Development	1		200			1	$6,100
5	NW Corner Grass Creek Basin		(existing well)	8,600			5	$32,400
6	Rankin Basin (includes new solar pump)		(existing well)	19,000	1	10,000	4	$69,200
7	East Basin		(existing well)	23,000			6	$67,400
8	North Ilo		1	10,000	1	8,000	3	$61,800
9	South Ilo	(existing spring)	(existing well)	20,000	1	10,000	5	$68,000
Little Grass Creek								
10	Little Grass Creek	2		23,700			6	$69,000
11	Grass Creek Divide	1		29,600			6	$64,700
Spring Gulch								
12	Adam Weiss North		1	11,000			4	$55,200
13	Adam Weiss North Extension		(existing well)	15,000			3	$41,600
14	Reds and Crook	1		20,800			4	$65,400
15	Spring Gulch and West Spring Gulch		1	17,700	1	10,000	6	$83,500
16	East Spring Gulch and North Spring Gulch		1	14,300			5	$56,700
Upper Cottonwood Creek								
17	Putney School Section	2		21,300			4	$52,900
18	Pats Draw/Putney Flat		1	22,900			5	$63,900
Twentyone Creek								
19	Dickie 21/Bear Creek	2		23,200			6	$68,100
Wagonhound Creek								
20	Wagonhound Extension and Prospect Connection	2		23,000			5	$61,000
21	Prospect Common South	1		23,000			5	$61,900
Prospect Creek								
22	Adam Weiss South		1	11,000			3	$52,600
23	North Prospect Common	3		14,600			5	$58,400
24	Prospect Extension	3		15,700			4	$41,900
25	Urwin/Wales/Otty	3		15,500			4	$41,400

[1] New wells include solar pump installations

[2] Well conversion, solar pump installation and new pipeline will serve both wildlife/livestock watering and irrigation of up to 60 acres

Table ES-3
Alternative Surface Water Storage Projects

Site Number	1	2	4	5	7	9	10	11	12	13
Site Name	Grass Creek Causeway - Small	Putney Flat	Wales Reservoir Expansion	Wagonhound	Spring Gulch	Lower Grass Creek	LU Cow Camp	Prospect	Phelps Reservoir Reconstruction	Lake Creek Reservoir Rehabilitation
Locational Information										
Tributary	Grass Creek/ Little Grass Creek	Cottonwood Creek	Cottonwood Creek	Cottonwood/ Wagonhound Creek	Grass Creek	Grass Creek	Grass Creek	Cottonwood Creek	Grass Creek	Lake Creek
Onstream / Offstream	Onstream	Onstream	Offstream	Onstream	Onstream	Onstream	Onstream	Onstream	Onstream	Onstream
Basin Characteristics and Hydrology										
Drainage Area (square miles)	47	72	4	149	100	138	24	197	33	4
Estimated PMF Flood Characteristics										
Estimated Peak Discharge (thousand cfs)	54	69	13	105	83	100	36	123	44	13
Estimated Runoff Volume (thousand acre-feet)	24	37	2	78	52	72	12	105	16	2
Reservoir Characteristics and Operation										
Demand										
Dry Year Shortages (ac-ft)	1,800	4,800	3,000	2,000	200	100	1,800	1,700	1,800	5,200
Normal Year Shortages (ac-ft)	800	2,400	1,400	900	30	0	800	700	800	2,400
Normal High Water										
Capacity (acre-feet)	5,000	3,000	8,000	3,500	25,000	25,000	5,000	10,000	200	1,400
Surface Area (acres)	125	106	374	222	591	686	135	377	14	59
Average Water Depth (feet)	40	28	21	16	42	36	37	27	14	24
Site Geology										
Geology										
Karst										
Seepage										
Structure										
Liquefaction Potential										
Dispersive/Soluble Soils										
Foundation Strength										
Reservoir Rim Conditions										
Landslide Deposits										
Borrow										
Relative apparent availability										
Relative apparent quality										
Site Environmental Conditions										
Environmental Issues										
NWI Wetlands (acres)	17	1	6	5	4	3	1	39	1	5
Stream Classification	2AB	2AB		2C / 3B [3]	2AB	2AB	2AB	2C	2AB	2B
Sage Grouse Leks		x						x		x
Big Game Habitat - Crucial	Mule Deer, Elk	Mule Deer	Mule Deer	Mule Deer	Mule Deer	Mule Deer, Antelope	Mule Deer, Elk	Mule Deer, Antelope	Mule Deer, Elk	Mule Deer
Big Game Parturition (Birthing Areas)										
Raptor Nesting Area						x				
Mineral Resources										
Coal Potential	Moderate	Moderate/ Low	Low	Moderate/ Low	Moderate/ Low	Moderate	Moderate/ Low	Moderate/ Low	Moderate/ Low	Low
Uranium										
Sulfur										
Bentonite										
Infrastructure and Ownership										
Infrastructure/Utilities Conflicts										
Residences/Facilities	0	0	0	0	3	0	2	0	0	0
Highways (miles)	0	0	0	0	3	0	0	3.6	0	0
Railroads (miles)	0	0	0	0	0	0	0	0		
Pipelines (miles)	0	0	0	0	9	4	0	0	0	0
Transmission Lines1 (miles)	0	0	0	0	0	0	0	5	0	0
Transmission Lines2 (miles)	0	0	0	0	0	0	0	8	0	0
Distribution Lines1 (miles)	1.8	0	0	0	5.5	0	0	3.2	0	0
Irrigated Lands (acres)	0	2	0	21	2	0	0	0	0	0
Energy Resources										
Oil Field					x					
Gas Field										
Land Ownership										
Private	x	x	x	x	x	x	x	x	x	x
State	x		x		x		x		x	
Federal	x		x	x	x	x		x		
Dam Characteristics and Hydraulic Structures										
Dam										
Total Crest Length (feet)	1,291	1,162	6,630	2,657	3,768	4,454	1,161	2,539	713	640
Maximum Dam Height (feet)	98	89	77	61	127	119	116	91	32	45
Foundation Excavation Volume (thousand cy)	243	161	492	247	739	840	228	404	14	0
Total Earthwork Fill Volume (thousand cy)	999	602	1,482	736	3,329	3,635	999	1,511	43	36
Storage Efficiency (ac-ft/1000cy)	5.0	5.0	5.4	4.8	7.5	6.9	5.0	6.6	4.7	38.9
Height Efficiency (feet/thousand ac-ft)	19.6	29.7	9.6	17.5	5.1	4.8	23.2	9.1	161.0	32.2
Outlet Works										
Proposed Type	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit		
Service Spillway										
Design Capacity (cfs)	5,300	6,800	1,200	10,400	8,300	10,000	3,600	12,300	800	200
Approximate Width (feet)	24	43	28	47	38	45	16	56	19	5
Emergency Spillway										
Design Capacity (cfs)	48,387	61,955	11,660	94,434	74,887	90,273	32,756	110,966	0	0
Approximate Width (feet)	300	600	300	600	340	410	150	500	0	0
Approximate Length (feet)	1,000	1,100	1,800	2,300	1,300	1,200	1,200	900	0	0
Cut Volume (cy/1000)	800	200	0	800	1,500[1]	1,500[1]	1,000[1]	1,500[1]	500[1]	500[1]
Supply and Delivery Facilities										
Supply Diversions										
Length (miles)			1.4[2]							
Terrain										
Delivery Canals										
Length (miles)										
Terrain										
Other										
Access										
Cultural Resources		x								
Costing										
Total Project Cost	$ 13,800,000	$ 10,200,000	$ 22,400,000	$ 12,400,000	$ 52,700,000	$ 49,400,000	$ 14,300,000	$ 31,000,000	$ 990,000	$ 850,000
Total Project Cost per cubic yard of fill	$ 13.83	$ 16.93	$ 15.08	$ 16.82	$ 15.82	$ 13.60	$ 14.29	$ 20.52	$ 23.06	$ 23.59
Total Project Cost per ac-ft of storage	$ 2,765	$ 3,397	$ 2,794	$ 3,537	$ 2,107	$ 1,978	$ 2,856	$ 3,102	$ 4,943	$ 607

Excellent or more than adequate
Favorable or adequate
Marginal or unfavorable value
Probable fatal flaw or very unfavorable value

[1] Cut volumes estimated
[2] Miles of ditch rehabilitation
[3] 2C - Cottonwood Creek / 3B - Wagonhound Creek

Table ES-4A
Alternative Projects Cost Summary

Site	Site Name	Storage Capacity (ac-ft)	Total Project Cost	Cost/Acre-ft Storage
1	Grass Creek Causeway - Small	5,000	$13,800,000	$2,800
1A	Grass Creek Causeway - Large	25,000	$42,500,000	$1,700
2	Putney Flat Alternative A	3,000	$10,200,000	$3,400
4	Wales Reservoir Expansion	8,000	$22,400,000	$2,800
5	Wagonhound Alternative A	3,500	$12,400,000	$3,500
7	Spring Gulch	25,000	$52,700,000	$2,100
9	Lower Grass Creek	25,000	$49,400,000	$2,000
10	LU Cow Camp	5,000	$14,300,000	$2,900
11	Prospect	10,000	$31,000,000	$3,100
12	Phelps Reservoir Reconstruction	200	$990,000	$5,000
13	Lake Creek Reservoir Rehabilitation	1,400	$850,000	$600

Table ES-4B

Summary of Ability to Pay for Project Alternatives - 67 % Grant

Alternative Number	Site	Level III Project Cost ($ Millions)	Sponsor's Share of Project Costs ($ Millions)	Sponsor's Annual Payment ($)	Sponsor's Maximum Ability to Pay ($)	Sponsor's Percentage Ability to Pay (%)
1	Grass Creek Causeway - Small	12.5	4.12	191,900	10,700	5.6
1A	Grass Creek Causeway - Large	38.4	12.68	590,300	Note 1	Note 1
2	Putney Flat	9.3	3.07	143,000	14,600	10.2
4	Wales Reservoir Expansion	20.2	6.66	310,000	9,900	3.2
5	Wagonhound	11.2	3.69	171,700	9,900	5.8
7	Spring Gulch	47.6	15.70	730,700	Note 1	Note 1
9	Lower Grass Creek	44.6	14.73	685,700	Note 1	Note 1
10	LU Cow Camp	12.9	4.25	198,000	10,700	5.4
11	Prospect	28.0	9.25	430,600	9,900	2.3
12	Phelps Reservoir Reconstruction	1.0	0.33	15,200	2,100	13.8
13	Lake Creek Reservoir Rehabilitation	0.9	0.28	13,100	9,200	70.2

Summary of Ability to Pay for Project Alternatives - 75 % Grant

Alternative Number	Site	Level III Project Cost ($ Millions)	Sponsor's Share of Project Costs ($ Millions)	Sponsor's Annual Payment ($)	Sponsor's Maximum Ability to Pay ($)	Sponsor's Percentage Ability to Pay (%)
1	Grass Creek Causeway - Small	12.5	3.12	145,400	10,700	7.4
1A	Grass Creek Causeway - Large	38.4	9.61	447,200	Note 1	Note 1
2	Putney Flat	9.3	2.33	108,300	14,600	13.5
4	Wales Reservoir Expansion	20.2	5.05	234,900	9,900	4.2
5	Wagonhound	11.2	2.80	130,100	9,900	7.6
7	Spring Gulch	47.6	11.89	553,500	Note 1	Note 1
9	Lower Grass Creek	44.6	11.16	519,400	Note 1	Note 1
10	LU Cow Camp	12.9	3.22	150,000	10,700	7.1
11	Prospect	28.0	7.01	326,200	9,900	3.0
12	Phelps Reservoir Reconstruction	1.0	0.25	11,500	2,100	18.3
13	Lake Creek Reservoir Rehabilitation	0.9	0.21	9,900	9,200	92.9

Summary of Ability to Pay for Project Alternatives - 90 % Grant

Alternative Number	Site	Level III Project Cost ($ Millions)	Sponsor's Share of Project Costs ($ Millions)	Sponsor's Annual Payment ($)	Sponsor's Maximum Ability to Pay ($)	Sponsor's Percentage Ability to Pay (%)
1	Grass Creek Causeway - Small	12.5	1.25	58,200	10,700	18.4
1A	Grass Creek Causeway - Large	38.4	3.84	178,900	Note 1	Note 1
2	Putney Flat	9.3	0.93	43,300	14,600	33.7
4	Wales Reservoir Expansion	20.2	2.02	93,900	9,900	10.5
5	Wagonhound	11.2	1.12	52,000	9,900	19.0
7	Spring Gulch	47.6	4.76	221,400	Note 1	Note 1
9	Lower Grass Creek	44.6	4.46	207,800	Note 1	Note 1
10	LU Cow Camp	12.9	1.29	60,000	10,700	17.8
11	Prospect	28.0	2.80	130,500	9,900	7.6
12	Phelps Reservoir Reconstruction	1.0	0.10	4,600	2,100	45.7
13	Lake Creek Reservoir Rehabilitation	0.9	0.09	4,000	9,200	230.0

Note 1 Analysis of associated economic benefits including multi-purpose uses and exchange with users below the confluence of Grass Creek and Cottonwood Creek is beyond the scope of this effort.

Table ES-4C
Annual Costs by Alternative Storage Sites

Site Number	Site Name	Irrigated Lands Served[1] (ac)	Annual Cost Per Acre Served			Assumed Yield[2] (ac-ft)	Annual Cost Per Acre-Foot Yield		
			With 67 Percent Grant ($/ac)	With 75 Percent Grant ($/ac)	With 90 Percent Grant ($/ac)		With 67 Percent Grant ($/ac-ft)	With 75 Percent Grant ($/ac-ft)	With 90 Percent Grant ($/ac-ft)
1	Grass Creek Causeway - Small	1,948	$99	$75	$30	1,842	$104	$79	$32
1A	Grass Creek Causeway - Large	1,948	$303	$230	$92	Note 1	Note 1	Note 1	Note 1
2	Putney Flat Alternative A	2,526	$57	$43	$17	2,000	$72	$54	$22
4	Wales Reservoir Expansion	1,422	$218	$165	$66	1,720	$180	$137	$55
5	Wagonhound Alternative A	1,226	$140	$106	$42	1,720	$100	$76	$30
7	Spring Gulch	974	$750	$568	$227	Note 1	Note 1	Note 1	Note 1
9	Lower Grass Creek	917	$748	$566	$227	Note 1	Note 1	Note 1	Note 1
10	LU Cow Camp	1,948	$102	$77	$31	1,842	$107	$81	$33
11	Prospect	1,015	$424	$321	$129	1,720	$250	$190	$76
12	Phelps Reservoir Reconstruction	1,948	$8	$6	$2.00	200	$76	$58	$23
13	Lake Creek Reservoir Rehabilitation	2,644	$5	$4	$1.51	750	$17	$13	$5

[1] "Irrigated lands served" is the sum of all existing irrigated lands located downstream from the reservoir to the confluence with the Bighorn River.

[2] The "assumed yield" is the estimated dry-year yield as presented in Table 6.2-1.

Note 1: Analysis of associated economic benefits including multi-purpose uses and exchange with users below the confluence of Grass Creek and Cottonwood Creek is beyond the scope of this effort.

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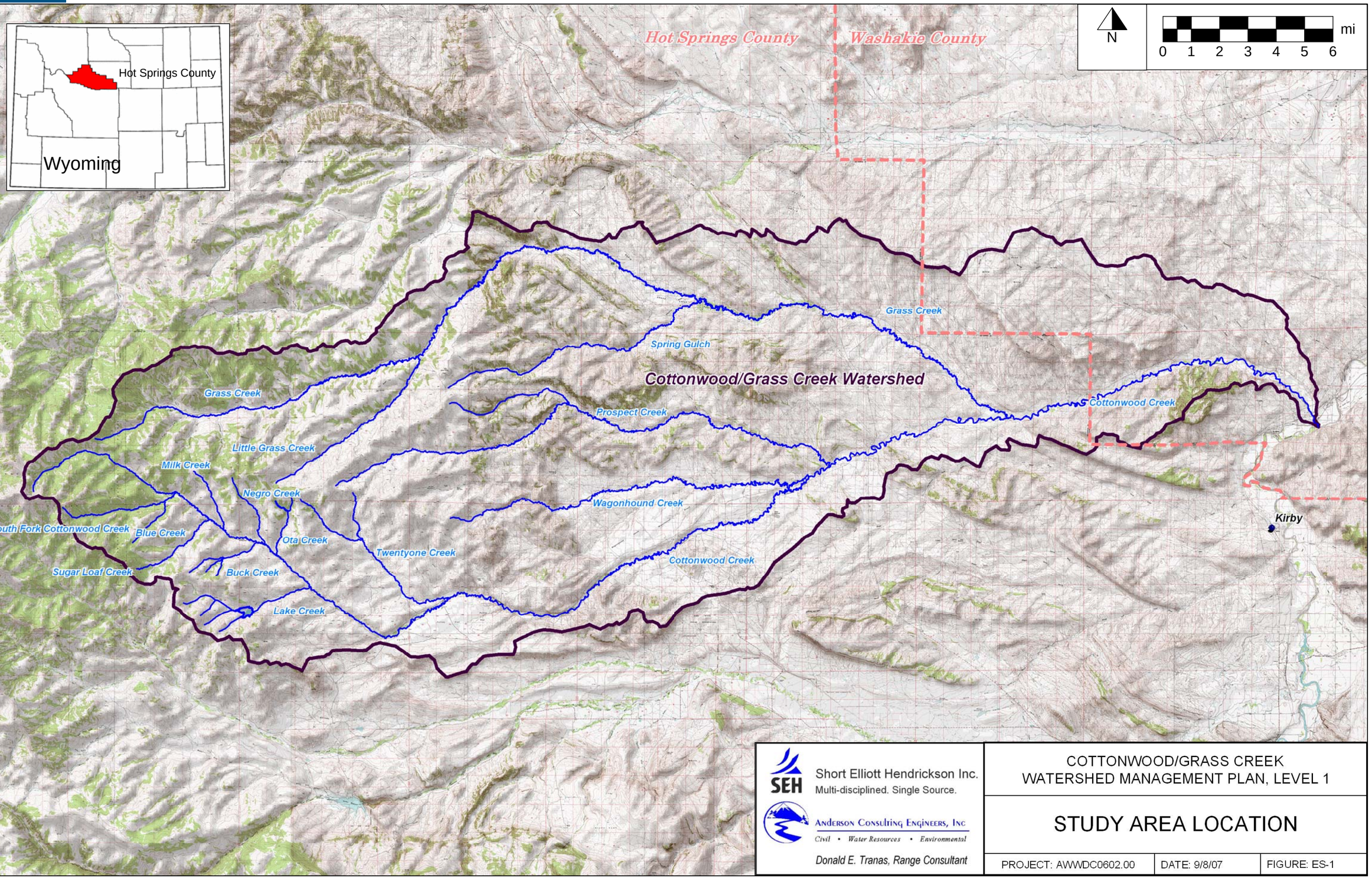

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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

STUDY AREA LOCATION

PROJECT: AWWDC0602.00	DATE: 9/8/07	FIGURE: ES-1

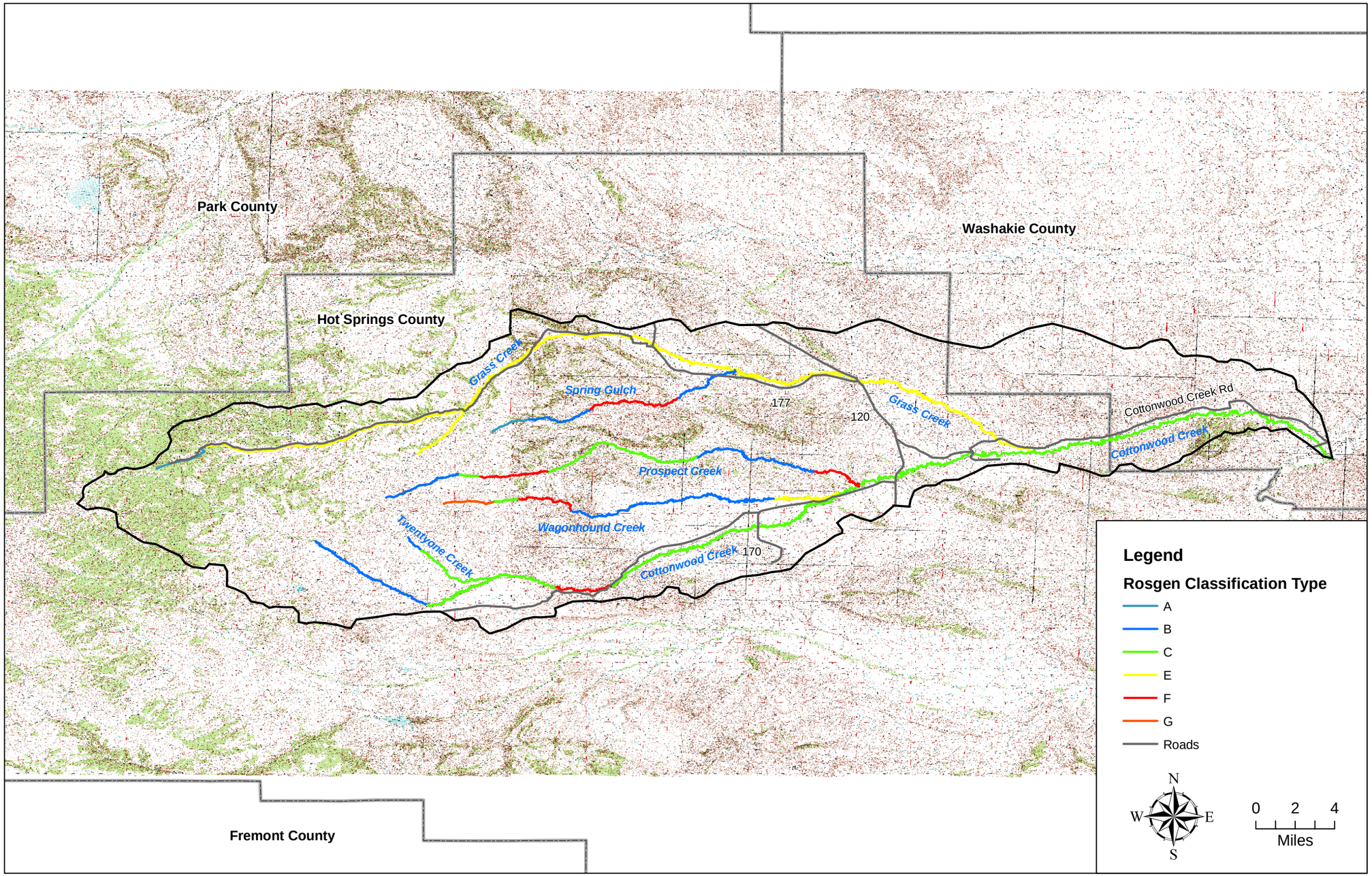

Figure ES-2: Rosgen Level I Geomorphic Classification.

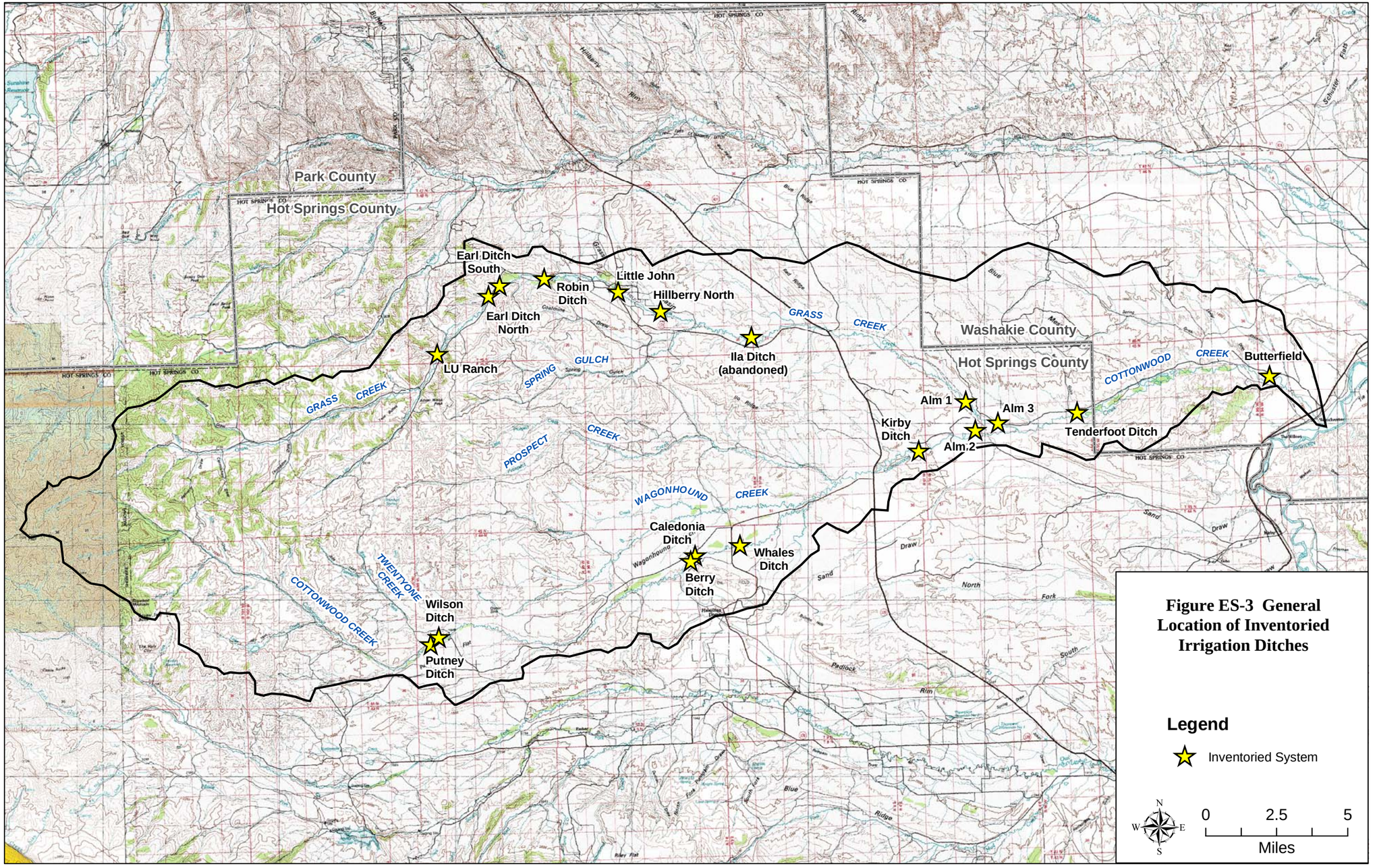

Figure ES-3 General Location of Inventoried Irrigation Ditches

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- Existing Pipeline/Stock Tank System
- Proposed/Planned Pipeline/Stock Tank System
- Existing Pond
- Guzzler
- Active Groundwater Well

N

0 1 2 3 4 5 6 mi

Kirby

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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

EXISTING WILDLIFE/LIVESTOCK WATERING SITES

PROJECT: AWWDC0602.00	DATE: 9/8/07	FIGURE: ES-4A

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Undeveloped Springs (>2 gpm)

Currently Non-functional Ponds

Permitted Active Wells

Power Lines

N

0 1 2 3 4 5 6 mi

Grass Creek

Spring Gulch

Cottonwood/Grass Creek Watershed

Prospect Creek

Cottonwood Creek

Grass Creek

Little Grass Creek

Milk Creek

Negro Creek

Wagonhound Creek

Kirby

South Fork Cottonwood Creek

Blue Creek

Ota Creek

Twentyone Creek

Cottonwood Creek

Sugar Loaf Creek

Buck Creek

Lake Creek

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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

ALTERNATIVE WILDLIFE/LIVESTOCK WATERING OPPORTUNITIES

PROJECT: AWWDC0602.00	DATE: 9/8/07	FIGURE: ES-4B

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Irrigated Land

N

0 1 2 3 4 5 6 mi

Sites 1 & 1A: Grass Creek Causeway

Site 12: Phelps Dam Reconstruction

Site 10: LU Cow Camp

Site 14: Dvarishkis

Site 13: Lake Creek Reservoir Rehabilitation

Site 2: Putnev Flat

Site 4: Wales Reservoir Expansion

Site 5: Wagonhound

Site 11: Prospect

Site 7: Spring Gulch

Site 9: Lower Grass Creek

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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

ALTERNATIVE SURFACE WATER STORAGE SITES

PROJECT: AWWDC0602.00	DATE: 9/8/07	FIGURE: ES-5