Canyon Creek Meadows Dam Evaluation Report Grant County, Oregon Sections 28 and 29, T15S, R33E, W.M.

August 2012

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Dam Evaluation Report
Grant County, Oregon
Sections 28 and 29, T15S, R33E, W.M.

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Report Date:	August 29, 2012
Project Number:	2923018

Canyon Creek Meadows
Dam Evaluation Report
Grant County, Oregon
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This report, sealed by a Professional Engineer registered in the State of Oregon, contains information and data developed by a team of professionals including, geologists, engineers, and other professionals. This report contains design plans and specifications.

Submitted By:

Digitally signed by Timothy Otis
Date: 2012.08.29 20:46:37 -07'00'

Timothy L. Otis, PE, Senior Engineer

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ACRONYMS

BLM	Bureau of Land Management
CES	Cascade Earth Sciences
cfs	cubic feet per second
cy	cubic yards
Dam	Canyon Creek Meadows Dam
DOGAMI	Department of Geology and Mineral Industries
EAP	Emergency Action Plan
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center River Analysis System
MOUs	Memorandums of Understanding
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
ODFW	Oregon Department of Fish and Wildlife
OSGC	Oregon State Game Commission
OWRD	Oregon Water Resources Department
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RFP	Request for Proposals
SHPO	Oregon State Historic Preservation Office
USACE	U.S. Army Corps of Engineers
USFS	U.S. Department of Agriculture Forest Service
WEST	WEST Consultants, Inc.

EXECUTIVE SUMMARY

The Canyon Creek Meadows Dam was constructed in 1962. The reservoir was first filled in 1964, when it was observed that the dam was leaking. In July through September of 1964, a grout curtain was constructed on the left abutment in an attempt to alleviate the leakage. The attempt did not noticeably slow down the leakage. In 1980, the spillway was found to be inadequate. In 1982, the dam crest and spillway were rebuilt to alleviate the spillway inadequacy.

Over the years since initial fill, the dam and reservoir have been studied several times to determine a way to repair the dam. An economical and affordable way to achieve this has not been forthcoming. Previous studies have also indicated concerns for dam failure that would pose a threat to life and property if left in its current condition. The dam is classified as a high hazard dam due to potential for loss of life downstream in the event of dam failure.

The dam and reservoir are located on the site of an old landslide. This study finds the foundation conditions are not conducive for a successful dam and reservoir facility at this site. This study recommends, and includes plans and technical specifications for, removing the dam and restoring a section of the upstream channel.

1.0 INTRODUCTION

The Canyon Creek Meadows Dam and Reservoir, owned by the Oregon Department of Fish and Wildlife (ODFW), was evaluated to determine whether the dam should be removed or repaired. On March 30, 2009, the ODFW issued a Request for Proposals for this evaluation, with tasks including public relations, consultation with other agencies, and development of recommendations. Technical evaluation of sediment stability, hydrology, and fish habitat are core elements of the project. Cascade Earth Sciences (CES) was selected to complete this evaluation. The goals, as outlined by ODFW, for this project are:

- Participate in outreach activities with the public and partner government agencies,
- Evaluate the sediment transport, habitat impacts, hydrologic and other factors affecting the watershed due to the continued presence of the dam and its potential removal,
- Prepare a report describing findings from the evaluation and public outreach. The report is to include assessment for repair and removal alternatives and construction cost estimates for each,
- Assist the ODFW in preparation of permits required for the preferred alternative, and
- Prepare the construction drawings and specifications for the preferred alternative, including habitat restoration, following ODFW recommendations.

2.0 HISTORY OF CANYON CREEK MEADOWS DAM

A condensed history of the dam was developed based on information from ODFW and U.S. Department of Agriculture Forest Service (USFS) files and personal interviews. Some of the site details discussed below are shown on Sheet G-3.

2.1 1959-1962

Between 1959 and 1962, several Memorandums of Understanding (MOUs) between the USFS and the Oregon State Game Commission (OSGC), which later became the ODFW, were signed and updated. The MOUs provided detailed agreements to jointly develop facilities. The USFS would provide the land for the dam and reservoir and would develop and maintain recreational facilities. The OSGC would construct and maintain the dam and manage the fishery resources. Several other dams and reservoirs were constructed on USFS administered lands around the state under the authority of the original MOU. Several interagency memos from this period are on file, including one that mentions recognition of 'slide rock' or landslides at the proposed Canyon Creek Meadows dam site (USFS, 2008).

2.2 1962-1972

Construction of the dam began in July 1962 and was completed in November 1963. On October 2, 1962, an inspection trip was made to the dam by USFS and OSGC personnel to observe the ice conditions encountered during the excavation of the spillway. On the south side of the dam, a considerable area was found to have voids completely filled with ice. In an October 22, 1962 letter from W.W. Gano, USFS Regional Engineer, to George Kernan, OSGC Chief Engineer, it was noted that as water fills the reservoir the ice will melt and seepage pathways will form. As a result, it was noted that extensive blanketing of impervious material might be required.

The reservoir was first filled with water in the spring of 1964. It was constructed as planned to provide recreational opportunities for fishing and camping. The USFS, Malheur National Forest, constructed the campground adjacent to the reservoir. It became immediately apparent that the dam leaked, and a letter from the District Watermaster to the State Engineer's office (now the Oregon Water Resources Department [OWRD]) documented the details observed on May 14, 1964 (OWRD, 1964). The Watermaster noted leaks under the concrete spillway, in the right bank, and along the left bank. Based on these observations, the water level in the reservoir was immediately lowered 10 feet. In July to September 1964, the left abutment was grouted. This grouting occurred in 19 drilled holes, located at 5- and 10-foot spacing, ranging in depth from 5 to 60 feet (see Sheet G-3). Subsequent measurements showed no apparent reduction in leakage following this work. In 1966, along with the extension of the gunnite spillway lining, the upstream impervious bentonite/clay blanket was extended approximately 200 feet on the left abutment, and again, there were no significant reductions in leakage.

The USFS, the OSGC, and the Oregon Department of Geology and Mineral Industries (DOGAMI) conducted a series of studies to determine the extent of the leakage and possible remedies. The dam was inspected on April 10, 1968 and the initial analysis indicated that leakage was occurring in the rhyolite talus rock slope that forms the shore upstream from the left (south) abutment. On May 6, 1968, Herbert Schlicker, an Engineering Geologist from DOGAMI, sent a letter to the OSGC concluding that:

> "The left abutment appears to be in a landslide which extends upstream about 300 feet in the reservoir where apparently solid rock is exposed in place. The slide is more than 600 or 700 feet high and extends to the top of the slope. The grout curtain is not sufficient to dam off the water, and it is doubtful that it could be done here by that method within economic limits" (DOGAMI, 1968).

On that same day (May 6, 1968), scuba divers inspected the left abutment from the end of the clay blanket to the rock pinnacle area, about 700 feet of bank. Numerous leaks were detected along the toe of the slide. After reviewing the results of this work, Stanley A. Thorn, a USFS Civil Engineer, concluded that "the whole area covered, about 700 feet, should be sealed by means of an impervious blanket stretching from the bottom of the reservoir to slightly above the high water elevation" (USFS, 1968).

During a November 21, 1969 meeting at the OSGC, George Kernan, OSGC Chief Engineer, explained two options for restoring the reservoir for use. One was to install an additional impervious blanket along the left bank. This, according to Mr. Kernan, would not guarantee sealing the leak. The second option was to investigate removal of the dam and building a new dam a short distance upstream, which would create a smaller lake, about 26 acres. It was decided that the OSGC would proceed with core drilling at the proposed upstream site to evaluate the suitability for a new dam (OSGC, 1969).

On June 19, 1970, Herbert Schlicker, Zean Moore (Mining Engineer), Ed Farr (USFS), Ron Burgman (USFS), George Kernan and Don James (USFS) visited the site. On July 6, 1970, Schlicker sent another letter to the OSGC recommending completion of seven corings to evaluate the suitability of the existing Dam site or another possible site upstream near a rock outcrop (USFS, 1970a). On July 31, 1970, Zean Moore described the reason for the geologic investigation as follows: "Investigate the geologic conditions that are causing the present dam site to leak, and to help determine the feasibility and geologic condition for a second dam site." He proposed a complete geologic investigation, including drilling cores, at a new dam site approximately 600 feet upstream from the present Dam (Moore, 1970).

On August 14, 1970, a MOU between the USFS and OSGC was prepared to share the costs of the investigation to determine the feasibility of the upstream dam site. The MOU also stated that "A joint report will be furnished, giving the results of the exploration and a recommendation as to future action, within 30 days of completion of drilling" (USFS/OSGC, 1970).

Ron Burgman prepared a report of his geologic investigation dated August 28, 1970 (USFS, 1970b). He recommended that if the existing dam were to be utilized, an impermeable membrane should be placed on the reservoir bottom and sides covering the entire area of the slide. He also recommended that a decision to construct a new dam should not be made until the subsurface investigation was completed.

Between September 24 and October 12, 1970, Medford Diamond Drill Contracting Company performed two borings at the proposed location of the new dam. Upstream distance of the drilling from the existing dam was not recorded. One boring was at a 45 degree angle into the proposed south abutment, and the second was in the center of the meadow along the projected dam axis.

On May 5, 1971, the USFS and the OSGC signed and issued a recommendation for future action regarding the proposed upstream dam (USFS/OSGC, 1971). The August 28, 1970 Ron Burgman Geology Report was also reviewed (USFS, 1970b), and the following results were summarized from the core drilling and geologists reports:

- The core from the 76-foot deep hole in the left abutment shows all fractured rock with evidence of water in the seams.
- The core from the 43-foot deep hole in the lake bottom shows all gravel and organic matter. The hole did not get into hard rock.
- Pump tests made at 10-foot intervals in the 76-foot hole showed the rock would accept the maximum pump flow of 3.5 cubic feet per minute.
- Ron Burgman's report indicated that it is not feasible to repair the existing site and dam, or to construct a new dam.
- Clifford Okeson's report states chances are very slim for constructing a tight reservoir at this upstream location (USFS/OSGC, 1971).

The above cited joint recommendation for future action included the following recommendations:

- "The Forest Service and the Oregon State Game Commission agree to not invest more funds in reconstruction of the existing dam or reservoir site or to construct a new dam within the existing reservoir site.
- Annually the Forest Service and Oregon State Game Commission will meet jointly to agree on use of the lake and site.
- The Forest Service and Oregon State Game Commission agree to utilize as much as possible the existing facility with its limitations to provide some recreation.
- The use of the lake in 1971 as a put and take fishery in no way means that the two agencies have plans to further develop or enlarge Canyon Meadows Lake" (USFS/OSGC, 1971).

On August 16 and 24, 1971, the USFS performed a soil study to examine the immediate reservoir area for suitable soil material that could be used to construct a clay blanket. The study noted that OSGC had allocated $12,000 to place a clay blanket fill along the south side of the reservoir impoundment (USFS, 1971). On November 30, 1971, USFS and OSGC staff met to discuss the OSGC's proposal to place a clay blanket on the bottom and south side of the reservoir; however, no conclusion was reached. On January 20, 1972, USFS engineer Stanley Thorn wrote a memo noting that OSGC and USFS staff had decided not to pursue the clay blanket repair to the dam for reasons including inadequate funding and lack of adequate suitable clay material nearby (USFS, 1972). He also noted, "One point that has been overlooked is that the right side of the reservoir (the campground location) also appeared to be part of an old slide" and "stability and impermeability of this area are suspect as well as the rocky left bank" (USFS, 1972).

<u>2.3 1980-1990</u>

On July 23, 1980, personnel from the OWRD and U.S. Army Corps of Engineers (USACE) inspected the dam as a part of the National Dam Safety Program. They concluded that the spillway was inadequate and needed increased capacity to pass 50% of the Thunderstorm Probable Maximum Flood. They also concluded that:

- "Canyon Creek Meadows Dam is in satisfactory condition for continued operation.
- Geologic evaluation found the abutments and foundation to be performing adequately.
- Embankment stability analyses conducted for both upstream and downstream sloped under various conditions of loading yielded acceptable factors of safety against sliding.
- Visible portions of the structural/mechanical features were inspected and found to be in good condition."

The report recommended increasing spillway capacity, developing an Emergency Action Plan, as well as a number of other maintenance and monitoring items (OWRD/USACE, 1980).

Drawings were completed for modifications to the dam crest on January 14, 1982. These plans are assumed to be in response to the concerns raised in the USACE report regarding the inadequacy of the spillway. Improvements included an 8-inch thick concrete cut-off wall between the rebuilt crest and spillway and a 3-foot high by 17-foot wide gabion cap, which extended the height of the entire crest and increased the spillway capacity. Based on as-built plans, this work was completed in the summer of 1982 (ODFW, 1982).

On November 1, 1988, Errol Claire and Bob Dodge, ODFW, inspected the dam and noted water leaking through the right abutment at an elevation of about 5,010 feet above mean sea level; he also noted that this leakage had been previously reported (ODFW, 1988). They noted, "...considerable revetment had settled and a hole developed under the riprap. Water could be heard cascading into this area." This water was reappearing in the original streambed about 250 feet downstream of the crest of the dam. The original streambed was dry down to this point, and the seepage flow was running clear at about 2 cubic feet per second (cfs). They reported no leakage in the left abutment at this low pool condition, but noted leakage on the left side occurring at higher pool elevations. They recommended placing an additional impervious blanket on the upstream face of the dam and on the upstream left abutment for a total of about 850 feet, noting that the previously placed impermeable blanket on the left abutment extended about 200 feet upstream of the dam, with no apparent effect on the leakage in the left abutment. Plans were made to reassess the repair to the dam during the 1989 construction season.

On June 19, 1989, the site was visited by H. G. Schlicker (Geologist), Errol Claire (Fish Biologist), and Bradley Smith, all with ODFW, and J. W. Ferguson, a geological engineering consultant with David J. Newton Associates. The purpose of the meeting was to develop a budget estimate and recommendations for characterizing leakage and designing an improvement to reduce leakage. They recommended development of a cost/benefit evaluation. If the results of the cost/benefit evaluation were favorable, they would recommend further investigation and analysis, including subsurface explorations, to assess the left and right abutment areas and the area through and beneath the dam. Cost estimates were developed for this work. They also recommended another visit to the dam at a low water level to observe the depression on the upstream face of the dam. However, no record of this additional visit was found in the files (ODFW, 1989).

2.4 1994-Present

On January 25, 1994, staff at the USFS Malheur National Forest met to discuss the Canyon Creek Meadows Dam and Reservoir. Mark Lysne prepared a memorandum summarizing the history of the site and the discussion, conclusions, and recommendations from this meeting (USFS, 1994). The feasibility and cost of a liner were discussed. He also indicated that in reviewing the ODFW files, the original subsurface foundation investigation was not on file. He noted that apparently the test drilling was done prior to, or concurrent with, the grouting work, but he could not find detailed information on subsurface conditions on file. The recommendation from this meeting was to perform a cost/benefit analysis on the option of sealing the reservoir.

On September 14, 1995, Joe Bailey (USFS Regional Geologist), Bill Powell (USFS Geotech Leader), Mark Lysne (USFS Forest Geologist) and Tom Hunt (retired OSGC employee) visited the site. Following the meeting, Joe Bailey prepared a memorandum discussing the options of grouting, soil lining, and synthetic liner installation (USFS, 1995).

On May 17, 1996, Mark Lysne prepared a memorandum recommending contacting a synthetic liner manufacturer to evaluate the site and make recommendations for lining the reservoir (USFS, 1996a). On September 9, 1996, Mr. Lysne prepared a Preliminary Liner Feasibility Report based on an August 29, 1996 field visit with a liner installation company representative and a private contractor (USFS, 1996b). The preliminary cost estimate to cover approximately eight acres of the site with a geosynthetic liner was between $1,000,000 and $1,500,000. This cost represents tree and stump removal, removal of the jagged point along the south shoreline, smoothing of the reservoir floor and walls, bedding material (soil) to cushion the liner, geotextile on both sides of the liner, a covering layer of soil, and finally, a coarse rocky cover to control erosion. During this visit to the site, Mark Lysne noted that the subsidence area in the lower right abutment was considerably larger than the approximate 2 cubic yard (cy) depression noted in the September 1994 Bailey report (USFS, 1994). On a September 5, 1996, visit Mr. Lysne noted that the subsidence area had 10 to 15 cy of "missing" material in the depression, and that materials upslope appeared to be loosening and sliding down into the subsidence area.

On September 23, 1996, John Falk, Dam Safety Engineer with the OWRD, assessed the structure at the request of the District Watermaster. In particular, he was asked to evaluate the apparent increase in the size of a depression in the right, upstream side of the dam. He estimated the flow into this depression at 25 gallons per minute at zero head and noted, the springs where this flow entered the stream channel beginning about 100 yards downstream of the dam (OWRD, 1996). He made a recommendation for routine maintenance items, and recommended "immediate arrangements to update the Emergency Action Plan (EAP) for this dam and reservoir," including development of a notification list of downstream property owners.

On November 7, 1996, David Cary, Grant County Emergency Program Manager, wrote a letter to Paul Johnson, Chief Engineer with ODFW, expressing concern regarding the high risks and costs associated with the dam and its limited benefits, suggesting that removal of the Dam should be considered (Grant County, 1996).

On June 26, 1997, John Falk again visited the site; following this visit, John Falk recommended immediate implementation of a monitoring program and that the outlet gate be left open (OWRD, 1997).

On August 13, 1998, Carl Pence, USFS Malheur National Forest Supervisor, sent a letter to Jim Greer, Director of the ODFW, discussing the history of the project and expressing concern about the depressions on the upstream face of the dam, now 10 years since first noted by ODFW staff (USFS, 1998). He also noted, "Our technical personnel are very concerned about the eventual dam failure based on their observances. It is difficult to predict when failure might occur, but we feel it is nearing the time that something has to be done. Either the dam should be repaired or removed."

In September 1999, the USACE Portland District completed a Dam Safety Evaluation and Alternatives Report for the ODFW. The evaluation included embankment stability during flow-through conditions and cost estimates for alternative actions (USACE, 1999).

The executive summary of this Dam Safety Evaluation and Alternatives Report is as follows:

> "In October of 1998, the Oregon Department of Fish and Wildlife requested that the U.S. Army Corps of Engineers make an evaluation of Canyon Creek Meadows Dam to determine the significance of depressions that had been observed on the upstream face of the Dam. Canyon Creek meadows Dam was inspected by the Corps on November 19-20, 1998 and found to be in an unsatisfactory but non-hazardous condition. Settlement of the lower upstream face indicates that at full pool the hydraulic gradient through the structure is not sufficient to cause a catastrophic failure of the structure. Continued operation of the Dam in its existing condition could eventually result in erosion and failure of the right abutment. The following actions are recommended:
>
> a. Maintain reservoir in a drained condition to the extent possible.
> b. Monitor embankment and downstream springs closely during periods when the elevation of the pool is above the lowest depression.
> c. Repair or remove the structure when funds are available.
>
> Seven alternatives were evaluated and a preliminary cost estimate was generated for each.

Alternative	Estimated Cost
1. Removal of the Dam	$180,000.00
2. Alteration and Abandonment	$93,000.00
3. Repair to Original Condition	$98,000.00
4. Addition of a Membrane Liner	$159,000.00
5. Addition of a Concrete Facing	$245,000.00
6. Replacement of the Dam	$300,000.00
7. Left Bank Impervious Blanket	$495,000.00

> All alternatives provide acceptable risk against catastrophic failure. Alternatives 3 through 7 provide for continued use of the reservoir. Alternative 2 appears to be the least costly. Alternative 4 provides the greatest protection against future problems and can be combined with construction of an additional 250 feet of left bank blanket to further control leakage. Since the cost of abandonment is about the same [as] the cost to repair, we recommended that the structure be repaired to allow continued operation" (USACE, 1999).

The report included, in its conclusions section, a statement that the structure should not be left in this condition for more than a few seasons (USACE, 1999).

On January 7, 2000, John Falk sent a letter to Paul Johnson, Chief Engineer at the ODFW, following his review of the USACE Dam Safety Evaluation document. He noted two concerns: first, the document does not mention that the dam becomes a High Hazard structure when the reservoir is full, meaning that loss of life would likely occur if the dam were to fail a full pool; and second, no reference was made to the depressions and seepage in the right, upstream side of the dam, noted as early as 1988.

On November 28, 2000, John Falk sent another letter to Paul Johnson following a meeting at the dam on November 1, 2000 (OWRD, 2000). Mr. Falk's letter agreed with the USACE report that the dam was in unsatisfactory condition, but did not pose a significant threat to downstream life and property provided the outlet gate remained open to prevent permanent reservoir storage. He also strongly recommended that, in order to prevent permanent storage, the outlet gate should be locked open or removed until the dam is "modified, repaired, rebuilt, or removed."

On April 25, 2001, a group of USFS, ODFW, OWRD, and USACE staff visited the dam and met to update the stakeholders on the status of the dam. Allan Tschida, USFS engineer, prepared a memorandum summarizing the meeting (USFS, 2001). Discussion included removal and repair options, funding for work at the dam, and the National Environmental Policy Act (NEPA) process.

A three part document, "Emergency Action Plan/ Preventative Action Plan/Operation and Maintenance Plan," was prepared by the ODFW (2001) which updated information from the previous EAP. The document included inundation maps that were prepared for the updated report. The maps indicate that with a breach during a 100-year flood condition, the resulting flood wave would be approximately 12 feet deep in Canyon City within about 2.5 hours and the flood water depth in John Day would be about 2 feet deep within 3.25 hours.

Beginning in the fall of 2002, the USFS began a watershed analysis for the entire Canyon Creek Watershed, which was completed in June 2003. This study characterizes the ecosystem at the watershed scale and includes key questions, current conditions, reference conditions, and recommendations (USFS, 2003).

Of particular interest for the dam evaluation are the suggested uses of the watershed analysis, which include the following:

- Facilitate program and budget development by identifying and setting priorities for social, economic, and ecological needs within and among watersheds;
- Establish a consistent, watershed-wide context for project-level NEPA analyses; and
- Establish a watershed context for evaluating management activity and project consistency.

In addition, the following sections from the watershed analysis report are pertinent to the dam evaluation (USFS, 2003):

- 5-6.2.1.4 - Fish Blocks
- 5-6.2.1.4 - Non-Native Fishes
- 5-6.2.2.4 - Water Quality Parameters
- 5-6.2.2.5 - Recommendations and data gaps - Aquatic Habitats

In the spring of 2005, the USFS informally requested that the ODFW update the EAP, noting many of the landowners' closest to the dam site had changed. The most recent EAP the USFS had on file was from 2001, and the ODFW indicated they did not have anything more recent. The ODFW agreed to have the EAP updated, but because of staffing shortages, did not expect the EAP to be completed until sometime in 2006.

Between July 16 and 18, 2005, the ODFW and USFS implemented a three-pass protocol Eastern brook trout eradication project in a section of Canyon Creek immediately above the dam. Eight ODFW biologists, four USFS biologists, and eight volunteers removed 16,435 brook trout. Following their removal, it was estimated that over 8,000 brook trout still remained in that specific section of Canyon Creek and "the feasibility of eradication was deemed impossible."

According to USFS records, the winter of 2005/2006 produced a larger than average snow-pack. USFS personnel monitored the reservoir regularly during the peak runoff period between April 25 and the end of May 2006. The reservoir pool level reached its peak level, within 1-2 feet below the spillway elevation, on or about May 19, 2006. This level was attained despite leakage through and around the Dam and with the drain valve open. During the summer of 2006, the ODFW installed a security structure around the slide gate and gate valve controls used to operate the drain. The ODFW also used hand crews to excavate about 20 cy of materials that had slumped onto and covered the drain outlet many years earlier. This was in preparation for an inspection of the integrity of the drain and gate valve mechanisms, which was done in the fall of 2006 using a motorized camera that traveled inside the pipe from the outlet end.

The USFS requested an updated EAP in February 2008. Later in 2008, the USFS received two copies of an updated "Canyon Creek Meadows Dam Emergency Action Plan – Preventative Action Plan – Operation and Maintenance Plan" (ODFW, 2008).

On November 17, 2008, George Robison, Dam Safety Coordinator for OWRD, wrote a letter to ODFW, summarizing his October 28, 2008 site visit. He noted in particular that the intake of the 18-inch reservoir drainpipe could become blocked with rocks, which would cause the dam to remain full longer during the spring runoff period. He notes:

> "The chance of this happening is considerable and causes me <u>not to share</u> the same conclusion that others had in a November 28, 2001 memorandum that the dam poses no threat to life and property as long as the outlet gate remains permanently open" (OWRD, 2008).

ODFW requested and received funds from the State of Oregon economic stimulus bill (Senate Bill 388) to evaluate the dam for either removal or repair, and on March 30, 2009 issued a Request for Proposals (RFP) for this evaluation. A 'no-action' option was not included in the RFP. On May 5, 2009, CES was retained to complete this work.

3.0 GEOLOGY AND GEOTECHNICAL INFORMATION

Following is a summary of geological and geotechnical information gathered at the site.

3.1 Background: 2009 Field Trip and Research – CES

According to the Oregon Geologic Data Compilation web map produced by the DOGAMI (2009a), the area of the dam is mapped as near the boundary between two distinct geological units, the

Triassic Olds Ferry terrain to the west (downstream) and the Miocene Strawberry Volcanics to the east (upstream). The dam surface appears to be composed of highly fractured rhyolite assigned to the Strawberry Volcanics. The rock appears to be the same as the rock type observed immediately south of the dam and likely mined for the construction of the dam (Photographs 1 and 2). The rhyolitic rocks are reportedly underlain by Jurassic Keller Creek Shales, which outcrop less than one mile below the dam (OWRD/USACE, 1980). The nearest mapped fault is approximately ½ mile southwest of the dam. Two inferred faults have been mapped less than ½ mile west. None of the faults are believed to be active.

Photograph 1: Looking south from the top of Canyon Creek Meadows Dam at area of relatively freshly exposed rock presumed to have been the source for the construction/repair of the dam (6/19/09).

Photograph 2: Looking south from a point adjacent to the south abutment at relatively freshly exposed (i.e., orange color versus more weathered gray), highly fractured rhyolite similar to that found on the dam face (6/19/09).

The area in the immediate vicinity of the Dam is also mapped as a landslide on the DOGAMI Statewide Landslide Inventory Data for Oregon website (DOGAMI, 2009b). A large landslide area is mapped on the south side encompassing the area both below and above the dam (Photographs 3 and 4). The landslide area is mapped as extending over 1,000 feet upstream (east) of the dam (Sheets C1 and C2). Based on a site reconnaissance, topographic maps, and previous studies, it appears that the meadow area above the dam was formed as a result of the blocking of Canyon Creek just upstream of the dam by a large landslide. The landslide is mapped as coming from the south, which consists of steep terrain in the Strawberry Volcanics. The cliff that borders the meadow to the south was also observed to have fresh rocks exposed at the base (Photograph 5), as evidenced by an orange color as opposed to the weathered gray seen elsewhere, indicating continued mass movement of the rock.

Photograph 3: Looking southeast from the top of the dam at loose rock in the apparent landslide area (6/19/09).

Photograph 4: Looking east from the top of the dam upstream; landslide area is to the right and landslide debris forms the base of the reservoir for an estimated 1000 feet upstream of the dam (6/19/09).

Photograph 5: Looking south from a campground at the cliff face east (upstream) of the dam. Note the freshly exposed rock at the base of the cliff from continued mass movement of the highly fractured rhyolitic rock (6/19/09).

The following account of site visits and reports document the nature of this geology and landslide.

3.1.1 1968

In April 1968, Herbert Schlicker, an engineering geologist for the State of Oregon DOGAMI, inspected the dam with Albert Petska of the State Engineer's office to determine geologic conditions at the dam and make recommendations for correcting the leakage. In the subsequent report, Herbert Schlicker reported that the left (south) abutment was in a broken rhyolite extending about 600 feet above the dam. He further reported, that layers of bentonitic type (expands when wet) and weathered perlite (expands when heated) were observed on the canyon walls immediately downstream from the left abutment. The left abutment was reported as containing broken rock from a landslide that continued about 300 feet upstream from the dam and 600 to 700 feet above the dam vertically. In support of this, Herbert Schlicker noted that, based on photos and an aerial view, "the left abutment is located in a landslide which has formed a cirque-like notch at the head of the slide" and that "the dimensions of the slide are such that the disruption of rocks could be too deep to grout economically." In relation to this, he noted that previous measures had included installation of an approximate 50 foot grout curtain from the left abutment to the rock slope and the placement of an impermeable blanket on the bottom and sides of the reservoir from the dam upstream approximately 200 feet. Neither measure appeared to reduce the leakage first observed in 1964, although he noted that the impermeable blanket was about 100 feet short of what would be necessary to encompass the broken rock from the landslide (DOGAMI, 1968).

3.1.2 1980

The dam underwent an inspection in July 1980 to identify any conditions which could threaten public safety and to provide timely correction for any such conditions. The inspection was documented in a report signed by G.L. Oberholtzer, P.E. (OWRD/USACE, 1980).

The geology section of the report stated that it was believed that an ancient massive landslide from the left or south side filled the canyon, forming a natural lake and depositing alluvial material in the valley floor. Downcutting of the slide material resulted in formation of the canyon in which the dam site was placed. According to the report, "the foundation material was identified as glacial till overlain in some areas by boulders and slide material." Based on initial tests prior to construction, it was concluded that, "the foundations and abutments were of sufficient strength to support the proposed structure." The 1980 inspection concluded that water ice present in voids in the left abutment slide debris likely accounted for the apparent water tightness during the original drilling and pressure testing. Later testing, following filling of the reservoir and presumed melting of the ice, indicated an increase in permeability, i.e. leakage (OWRD/USACE, 1980).

The engineering geology portion of the report found no defects of the abutments. However, four separate areas of leakage were identified below the dam, one in the stream channel about 200 feet below the dam, and the remainder further downstream in the lower left abutment. In addition, minor sliding was noted to have occurred at three places in the downstream left abutment likely as a result of saturation, erosion, and undercutting of surface soil (OWRD/USACE, 1980).

3.1.3 1995

Joe Bailey, Regional Geologist for the Malheur National Forest, visited the site, with Regional Geotech Leader Bill Powell and Forest Geologist Mark Lysne, on September 14, 1995. In a summary memorandum regarding reservoir leakage abatement, he noted that when the dam was constructed "in '62 – 63," it "was built without due consideration of the defective nature of the foundation and a large landslide forming the left, and portions of the right abutment." He went on to say that the landslide debris extended about 1000 feet upstream of the dam. He estimated that an investigation to characterize the subsurface related to depth to rock tight enough to hold water would cost at least $68,000. There was no available record that the drilling program was conducted (USFS, 1995).

3.2 Geology and Geotechnical Summary

The following provides a summary of the geology associated with the dam and is based on a series of studies beginning in, at least, 1968 by geologists, engineering geologists, and engineers:

- The dam's south abutment and extending upstream, at least 600 feet, is composed of broken rhyolite (an extrusive volcanic rock), rhyolitic tuffs (rocks composed of rhyolite ash), pumice breccias (solidified frothy lava rocks containing broken fragments of other rocks), ashy beds, and other volcanic rocks emplaced by a large landslide originating on the south side of the valley. The unconsolidated nature of these deposits is the presumed cause of the leakage.

- Layers of expanding-type clay were observed on the canyon walls downstream from the south abutment. The presence of this clay under, or abutting, the dam could result in the failure of the dam if the clay became saturated and expanded. However, there are no reports that it is present at or above the dam.
- Grout curtains and impermeable blankets have been installed to reduce leakage but have not been effective.
- A pair of geology reports from two different geologists in 1971 indicated that it was not feasible to construct a new dam, repair the existing dam, or construct a tight reservoir.
- A 1999 report by the USACE indicated the dam was unsatisfactory, but non-hazardous; however, continued operation would result in erosion and failure of the north abutment (USACE, 1999).
- A 2009 investigation by Foundation Engineering concluded that there is a low probability that leakage at the dam site can be halted and that there is significant risk of leaks redeveloping under or around the dam, and it recommend removal of the existing structure. The complete report is included in Appendix D.

CES concludes, based on a site reconnaissance and a review of the dam's history related to geology, that the dam cannot be repaired without an extensive drilling investigation, followed by an additional attempt at a grout curtain and impermeable barrier for the reservoir floor. Further, based on past attempts, even with those remedial measures there is no assurance that the dam will be usable or safe from failure. Previous studies also indicate that no nearby alternative dam site was identified.

4.0 HYDROLOGIC ANALYSIS

In 2009, CES subcontracted WEST Consultants, Inc. (WEST) to conduct a hydrologic analysis to characterize the impacts of the dam on existing and future hydrologic conditions of the Canyon Creek watershed. Three scenarios were assessed: 1) Existing conditions - leaving the outlet gate locked open and not allowing the reservoir to maintain a pool, 2) Dam removed - removal of the dam and reservoir to allow Canyon Creek flows to pass downstream unimpeded, and 3) Dam repaired - repair of the dam such that the reservoir pool is maintained in the spring and summer recreation period and the outlet gate is set to maintain a minimum flow of approximately 3 cfs.

The hydrologic analysis for the Canyon Creek watershed was conducted using the Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS). The model was created to simulate the continuous hydrologic processes that contribute to surface flows in order to estimate the discharges in the stream network. Rainfall, snowmelt, evapotranspiration, and temperature data were used to develop the model. The HEC-HMS model parameters were adjusted for the purpose of calibrating the model to streamflow data available within the watershed.

The results of the modeling were used to evaluate the magnitude of change in the downstream hydrology of the basin of existing conditions compared to the two alternative scenarios. Specifically, annual flow-duration curves were developed for three locations including: just below the dam, below the confluence with the Middle Fork, and below the confluence with the East Fork. The flow-duration curves were evaluated to help understand how the discharge exceedence probabilities are modified by the dam in its current condition, as well as under the dam repaired scenario, and to understand how far downstream these modifications remain evident. Results of the flow-duration analysis indicated that the modifications to the downstream hydrology of Canyon Creek are greatest immediately downstream of the dam site and diminish in the downstream direction. Below the confluence with the East Fork, the flow-duration curves for the three scenarios are nearly identical.

The ability of the dam to provide flood control for the communities of Canyon City and John Day was analyzed. Annual peak discharge-frequency curves were developed downstream of the dam to understand if there is a statistical difference in the flood frequency relationships for the existing conditions and dam repaired scenario compared to the dam removed scenario. A statistical analysis was performed on the annual peak discharge results from the HEC-HMS model for various locations along Canyon Creek in order to estimate the discharge-frequency relationships for each scenario. Results of the analysis show that the flood frequency curves for the dam removed and dam repaired scenarios are slightly different from the existing condition. However, the flood frequency curves for both scenarios fall within the 5- and 95-percent confidence limits of the existing conditions flood frequency curve. Therefore, there is considered to be no significant difference between the flood frequency relationships of the three scenarios evaluated. In other words, neither the existing dam nor the repaired dam provides a flood control benefit. The complete report is included in Appendix A.

5.0 GEOMORPHIC AND SEDIMENT TRANSPORT ANALYSIS

In 2009, CES subcontracted WEST Consultants, Inc. (WEST) to conduct a qualitative geomorphic assessment to characterize the current conditions along Canyon Creek and the expected morphologic responses associated with both dam removal and dam repair. In addition, the volume of sediment deposited in the Canyon Creek Meadows Reservoir was estimated and an evaluation of the erosion potential of the accumulated sediments was performed. A complete copy of the assessment is included as Appendix B.

The existing operation of the dam is to maintain the outlet gate in a fully opened position. This has an effect on the sediment transport capacity of the channel in the reach upstream of the reservoir. During high flows that exceed the capacity of the outlet culvert, transport of bed material is significantly reduced and sediment is deposited in the channel and overbank areas that are inundated by the reservoir pool. As the reservoir inflow rate drops below the outflow rate of the culvert, the reservoir pool drops and flow is concentrated into the low flow channel within the reservoir. As a result, sediment transport capacity increases. Where the flow is concentrated in the low flow channel, deposited sediments are remobilized and transported to downstream reaches. In the overbank areas affected by the reservoir pool, sediment deposits are not remobilized unless local storm events cause surface erosion by overland flow. A permanent sediment deposit has accumulated in a topographically wide area located approximately 350 feet upstream of the dam, between the dam and an upstream constriction caused by an ancient landslide. The volume of the sediment deposit was estimated to be approximately 650 cubic yards. The sediment deposit consists of silt, sands, and gravels.

A relatively wide, flat bottom, vegetated meadow exists in the reservoir pool upstream of the constriction caused by an ancient landslide. The landslide created a natural lake that over geologic time filled with sediment. In the reach above the landslide, Canyon Creek is a highly sinuous single thread channel and appears to be similar to the channel that existed prior to completion of the dam. No excessive sedimentation was observed along Canyon Creek upstream of the landslide as a result of the operation of the dam. Any additional sedimentation within the meadow that has resulted from operation of the dam has likely deposited in a more or less uniform manner over the meadow and is protected from erosion by existing vegetation.

A hydraulic analysis was performed for a portion of Canyon Creek within the reservoir, between the upstream toe of the dam and the downstream portion of the meadow, approximately 565 feet upstream. This was done in order to evaluate the erosion potential of the sediment deposits, located in the topographically wide area located just upstream from the dam, if the dam were to be removed. For the discharges modeled (1-, 2-, 5- and 10- year events), the calculated shear stresses exceed the permissible shear stress necessary for the transport of median size channel bed material. Unless stabilized, a headcut is expected to form in the sediment deposits. The headcut will migrate in the upstream direction until it reaches the larger, more erosion resistant, rock materials that are present along the downstream edge of the landslide. Given that the landslide and the natural meadow existed prior to the construction of the dam, the headcut is not expected to extend upstream through the landslide and into the meadow.

If the dam is to be removed and the existing sediment deposits located just upstream of the dam are not stabilized or removed, a portion of the deposited sediment that is eroded by a headcut is expected to be transported downstream. However, this is not expected to cause long-term changes in the morphology of the downstream channel. The volume of deposited sediment is relatively small and the sediment grain sizes (very fine gravel) are small enough that the majority of sediment will be transported as wash load along the downstream channel. Short-term localized deposition may occur in areas of low velocity, such as upstream of culverts or diversion structures, but over the long-term, the sediment will be transported through Canyon Creek to the John Day River. No significant impacts to the morphology of Canyon Creek and the John Day River are expected as a result of the dam removal.

If the dam is to be repaired and the operation adjusted to maintain a maximum pool for recreation purposes, Canyon Creek downstream of the dam is not expected to experience appreciable changes to its morphology. The reach immediately downstream of the dam would experience a reduced supply of fine sediment (silts and sand). Further, the channel has long since adjusted to the reduced supply of bed material load resulting from the ancient landslide that essentially cut off the supply of coarse sediment. Therefore, repair of the dam is not expected to affect the morphology of Canyon Creek below the dam.

The portion of Canyon Creek upstream of the dam that would be inundated by the reservoir pool would be altered by the operation of a repaired dam. The repaired dam is expected to be operated to maintain a nearly full reservoir pool during the summer recreation period. The pool is expected to slowly drop over the winter. As a result of submergence, the vegetation that currently inhabits the meadow would likely die off and no longer provide protection from surface erosion. Once inundated by the reservoir pool, sediment will likely begin to fill in the existing channel. As the pool drops over the winter, the sediment in the channel within the reservoir pool would be remobilized and redeposited in other locations within the reservoir. This would be followed in the spring by increased erosion during the first high flows prior to filling the reservoir pool. If the dam is repaired and the operation adjusted to maintain a maximum pool for recreation purposes, the morphology of the channel upstream of the dam is expected to change and the existing meadow is likely to be lost.

If the potential, yet minor, short-term impacts to the morphology of Canyon Creek that could result from removal of the dam are considered undesirable, the existing sediment deposit immediately upstream of the dam could be stabilized or partially removed. Grade control structure(s) could be constructed to prevent a headcut from occurring. Another option would be to excavate a stable channel through the sediment deposits and stabilize the banks with vegetation.

6.0 DAM BREACH ANALYSIS

CES also subcontracted WEST to assess the potential flood inundation from a hypothetical dam failure. The dam site is located 19 miles southeast of Canyon City in Grant County, Oregon. A breach of the dam is expected to flow through the canyon and into the valley downstream. From there, the flood wave will flow parallel to Highway 395 to Canyon City. The floodwaters will continue through the City of John Day and spread out over the floodplain of the John Day River. The cities of John Day and Canyon City will be significantly impacted by a dam breach. A complete copy of the assessment is included in Appendix C.

Three dam breach scenarios were evaluated: 1) an overtopping failure caused by the Local Storm Probable Maximum Precipitation (PMP) 6-hour storm event, 2) an overtopping failure caused by the General Storm PMP 72-hour storm event, and 3) a "Sunny Day" event where the dam failure is triggered by earthquake or internal dam erosion (piping).

A hydrologic model of the Canyon Creek Meadows Reservoir and contributing drainage basin was developed using the HEC-HMS. The hydrologic model was used to determine the Probable Maximum Flood (PMF) inflow hydrographs from the Local PMP and General Storm PMP precipitation estimates. An unsteady Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulic model of Canyon Creek was developed to simulate a breach of the dam. The model was constructed using geometry defined by a Digital Terrain Model and field measurements, PMF inflow hydrographs, and dam breach parameters.

The Local Storm PMF, General Storm PMF, and Sunny Day failure scenarios were run to estimate maximum water surface elevations in the study area. The results were compared to the dam breach analysis results conducted as part of the EAP (ODFW, 2008).

The Local PMF dam failure event provides similar results to that of the EAP dam breach analysis. Of the three failure scenarios evaluated, the Sunny Day failure is considered the most probable (USACE, 1999), but results in the least amount of flood inundation compared to the Local and General PMF events. However, the peak discharge in Canyon Creek resulting from the Sunny Day failure is similar to the Federal Emergency Management Agency (FEMA) 500-year peak discharge. According to the Flood Insurance Rate Maps for the Cities of John Day and Canyon City, the 500-year flood event causes significant flooding along Canyon Creek (FEMA, 1982 and 1987).

Of the three dam breach scenarios evaluated, the maximum flood inundation is caused by failure during the Local PMF event. For both the General PMF and Local PMF, the existing spillway did not have adequate capacity to prevent the dam from overtopping. As a result, if the dam were to be rehabilitated or replaced, a larger capacity spillway and/or higher dam crest elevation would be required in order to safely pass the PMF without overtopping. Significant flooding would occur in the communities of Canyon City and John Day for both PMF events. As a result, it is expected that significant property damage and loss of life would occur.

7.0 WATER RIGHTS

CES completed an evaluation of the water rights associated with the dam. According to the OWRD Aqua Book on water rights, the following four fundamental provisions are outlined in the Oregon Water Code (OWRD, 2009a):

- **Beneficial purpose without waste** - Surface or groundwater may be legally diverted for use only if it is used for a beneficial purpose without waste.
- **Priority** - The water right priority date determines who gets water in a time of shortage. The more senior the water right, the longer water is available in time of shortage.
- **Appurtenancy** - Generally, a water right is attached to the land described in the right, as long as the water is used. If the land is sold, the water right goes with the land to the new owner.
- **Use required** - Once established, a water right must be used as provided in the right at least once every five years. With some exceptions established in law, after five consecutive years of non-use, the right is considered forfeited and is subject to cancellation.

Water rights are granted by applying for a permit. Once the permit is approved, the applicant must "prove up" the right by demonstrating beneficial use. Following approval of the beneficial use, the OWRD will review and "perfect" the right, which means a Water Rights Certificate is awarded.

The OWRD maintains a web-based library of water rights permits, certificates, platcards, and maps (OWRD, 2009b). A review of the interactive map along Canyon Creek between the dam and the confluence with the John Day River indicates that there are over 80 water rights on or immediately adjacent to Canyon Creek. Of these, four are associated with the reservoir (Water Rights Certificates #36592, #36593, #52193, and #52194) in the SE ¼ of Section 29, Township 15 South, Range 33 East, Willamette Meridian (SE¼, Sec 29, T15S, R33E, W.M.). These four rights are discussed in detail below.

The next closest water right on Canyon Creek to the reservoir is located over seven river miles downstream in the SE ¼ Sec 34, T15S, R32E, W.M. This right (Certificate #84837), with a priority of 1901, was awarded to Carol Still in October 2008 and grants a diversion from two locations on Canyon Creek to irrigate 6.5 acres of land. Four tributaries, including the West Fork and the Middle Fork of Canyon Creek, converge with Canyon Creek between the Dam and the Still water right.

7.1 John Day Decree

By decree of the Circuit Court of Grant County, Oregon on January 13, 1939, relative water rights were established on the John Day River and its tributaries, including Canyon Creek. Priority dates were established based on historical records. Two of the rights approved in the "John Day River Decree" were for E.J. Bayley and M.L. Braught. The water for both rights was obtained from ditches diverting water from Canyon Creek in the town of John Day, approximately 34 river miles downstream from the current location of the Canyon Creek Meadows Reservoir. However, both of these rights were later conveyed to the OSGC (predecessor to the ODFW) with the place of use changed to the location of the dam site.

7.2 Bayley Water Right

The first water right related to the dam site was a right to irrigation water for 1.25 acres on a property in the City of John Day. Water Right Certificate #24876 was granted to E.J. Bayley with a priority date of 1882. The right was for "1/40 cubic foot per second per acre irrigated through June 1 and 1/80 cubic foot per second per acre thereafter; further limited to one acre foot per calendar month to June 1 and four acre feet per acre during season April 1 to September 30, measured at the point of diversion." The location was listed as NE¼, NW¼, Sec 26, T13S, R31E, W.M.

7.3 Braught Water Right

The second water right (Certificate #3752) was granted to M.L. Braught to irrigate 2.5 acres in the NE¼, NW¼, Section 26, T13S, R31E, W.M. in the City of John Day. The irrigation amount was for 0.03 cfs, or its equivalent, in case of rotation. The priority date was July 18, 1919.

7.4 OSGC/ODFW Water Rights

October 28, 1960, an application to Lewis A. Stanley, State Engineer from the OSGC, was approved for a change in use, place of use, and point of diversion related to the Bayley and Braught water rights. The application proposed to change the use from irrigation to maintenance of a pond for fish propagation and public fishing in the SW ¼ of Sec 28, and SE ¼ of Sec 29, T15S, R33E, W.M. and to change the point of diversion to a point located 1,333 feet north and 1,452 feet west from the SE corner of Sec 29 and within the NW ¼ of the SE ¼, Sec 29, T15S, R33E, W.M., or, as noted above, approximately 34 miles upstream from the original place of use for both rights.

According to the 1960 application approval letter, the two then-current owners of the properties for which the Bayley and Braught water rights applied (C.B. and Madeline Wilson for the former

Bayley right, and Jack and Edit Pocock and Clifton Lemons for the former Braught right), conveyed, in writing, all their interest in the said water rights to the OSGC. The approval of the application thus canceled the Bayley and Braught water rights.

The Bayley water right was superseded by Water Right Certificate #36592 granted to the OSGC "for the purpose of maintenance of pond for fish propagation and public fishing." The right granted an amount of water not to exceed "0.31 cubic feet per second to June 1 and 0.12 cubic feet per second thereafter; further limited to 1.25 acre feet per calendar month to June 1, and 5.0 acre feet during season April 1 to September 30, measured at the point of diversion." The location was listed as W ½ SW ¼, Section 28, SE ¼, Section 29, T15S, R33E, W.M., the existing location of the Canyon Creek Meadows Reservoir. A permit, identified as Permit # "John Day River Decree," and dated March 14, 1961, had a hand written notation indicating that the original right was for 1.25 acres and the 0.31 cfs right was "an enlargement of the right" and a "Big Error".

The Braught certificate was superseded by Water Right Certificate #36593 issued to the OSGC. The certificate, together with Certificate #35692, confirmed a change in use, point of use, and point of diversion. The change on this certificate related to amount of water, which was revised to not exceed "0.03 cubic feet per second or its equivalent in case of rotation and shall be further limited to 10 acre feet during the season April 1 to September 30 measured at the point of diversion."

On May 21, 1962, Certificate #52193 was granted to the ODFW for storage of no more than 400 acre feet of water each year for Canyon Creek in the Canyon Creek Meadows Reservoir for the purpose of recreation and fish culture.

A second certificate (#52194) was granted to the ODFW on May 21, 1962, for the maintenance of Canyon Creek Meadows Reservoir, which had been constructed under Permit R-2872, and for fish propagation right under Permit 28010. According to the certificate, the amount of water was limited to "the period when the flow of the John Day River is more than 30 cubic feet per second at United States Geologic Survey Gage No. 14-0465 and more than 20 cfs at USGS Gage No. 14-0480."

In May 1996, F. Carl Pence, Forest Supervisor for the Malheur National Forest, sent a letter to the District 4 Watermaster, Kelly Rise, related to the ODFW rights conveyed to them in 1960 (Certificates #36592 and 36593). The letter indicated that ODFW wanted to cancel those rights and, according the letter, the USFS understood that the ODFW may have been considering a transfer of the rights for instream flow rights or fisheries protection. The USFS had no issue with the action as long as it was understood that any construction of water diversion or transmission facilities on National Forest administered lands would be subject to an environmental analysis as required by the NEPA of 1969 (USFS, 1996c).

A January 2000 letter from Tim Unterwegner, District Fish Biologist for ODFW, to John Falk of the OWRD, defended the beneficial use of the water at the Canyon Creek Meadows Reservoir (ODFW, 2000a). The letter was in response to a letter Falk wrote to Paul Johnson, ODFW Engineer, discussing cancellation of the water rights if the water was not put to beneficial use for five consecutive years (ODFW, 2000b).

The ODFW defended the beneficial use in that even though the reservoir only impounded water in winter and spring, people could still fish or boat when the pond level was adequate. However, ODFW stated that they would not stock the reservoir unless the dam was repaired and screening was installed to prevent loss of hatchery fish. The ODFW finished by stating that they wanted to maintain the water right for storage (ODFW, 2000a).

In summary, the Canyon Creek Meadows Reservoir and Dam currently have the following four associated water rights:

Certificate #	Beneficial Use
#36592	maintenance of pond for fish propagation and public fishing
#36593	maintenance of pond for fish propagation and public fishing
#52193	storage of water for recreation and fish culture
#52194	maintenance of Canyon Creek Meadows Reservoir

Water Rights Certificates #36592 and #36593 were granted to the OSGC/ODFW in 1960 as conveyed from previous holders of instream water rights. The previous rights were for irrigation and had a point of diversion over 30 miles downstream from the dam with priority dates of 1882 and 1918. The remaining two rights were granted in May 1962. The closest water right to the dam is approximately seven river miles downstream and would not likely be affected by dam replacement, repair, or removal. Based on our research, no other water rights would be directly affected by the replacement or removal of the dam.

8.0 FISH RESOURCES

The following is an account of fish resources at the site.

8.1 Site Description

The Canyon Creek watershed lies within the John Day River sub-basin in the southern Blue Mountains of east-central Oregon, part of the greater Columbia River basin (Mid-Columbian Sub region). The eastern portion of the watershed straddles the Strawberry Mountain Range, the portion of the watershed west of lower Canyon Creek lies in the heart of the Aldrich Mountains. To the south, the Canyon Creek watershed is bounded by Bear Valley and the hills north of Bear Creek (USFS, 2003). The Canyon Creek watershed covers 73,972 acres (approximately 115 square miles) of federal, private, and state lands (Figure 1). The USFS and the Bureau of Land Management (BLM) share federal management of the watershed with 59,580 acres and 2,445 acres, respectively. Private landowners hold 11,927 acres, and the State of Oregon owns approximately 2 acres.

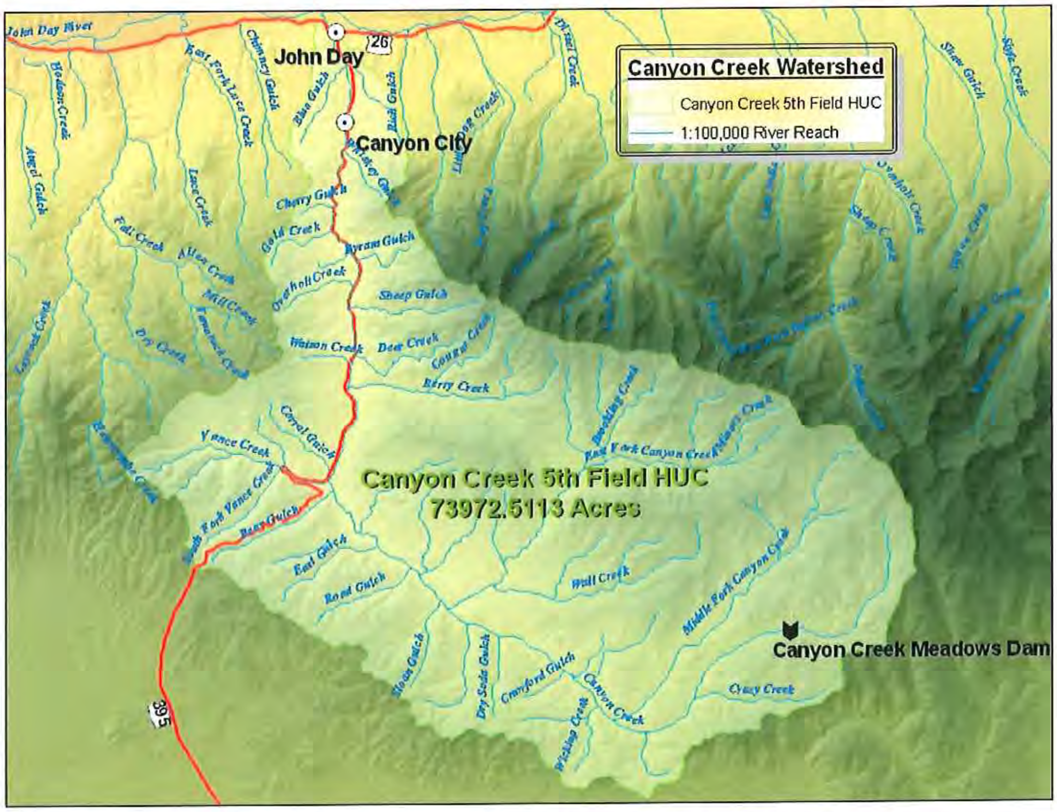

Figure 1. Canyon Creek Watershed and Canyon Creek Meadows Dam Location.

Mainstem Canyon Creek originates above the meadows from the Strawberry Mountain Wilderness area at an elevation of 7,124 feet. It originates in a high mountain basin with a southerly facing aspect and flows for 4.1 miles before reaching the meadows. Canyon Meadows, prior to dam construction, consisted of a one mile long marshy meadow with several beaver dams. The creek has a summer time flow of 1.2 cfs of water meandering through the site that rarely exceeds 55° F. Immediately below the meadows, the stream drops through a steep and narrow gorge 2,000 feet long and contains a 5 foot high falls and another 8 foot high falls, both with no jump pool (USFS, 2003).

The reaches of Canyon Creek that flow through the Canyon Meadows subwatershed generally have a low to moderate stream shading utilizing native shrub and tree species. Forty five percent of the stream has low riparian shading, thirty eight percent has moderate, and seventeen percent has high levels of shade (USFS, 2003). Eighty eight percent of the Canyon Meadows subwatershed has a low potential for large woody debris recruitment, 11% moderate, and 1% high potential (USFS, 2003).

8.2 Fish Species

8.2.1 Mid-Columbia Summer-run Steelhead / Redband Trout (*Oncorhynchus mykiss gairdneri*)

Two life-history forms of fishes exist within the Canyon Creek watershed: resident and anadromous. The resident (redband) trout typically spawn at the age of 2 or 3 years, are relatively small in size (6 to 10 inches long), and inhabit smaller streams containing clear, cool water (Behnke, 2002). The Canyon Creek redband trout species is considered to be Columbia Basin redband trout, although similarities exist in redband found in the Silvies Great Basin system (Bisson and Bond, 1971). The anadromous form (Mid-Columbia summer-run steelhead) spends one to three years rearing in fresh water before smolting. After one to two years in the ocean, returning adults begin to move into Canyon Creek as early as January, with the largest influx occurring from April to June. Mid-Columbia summer Steelhead is federally listed as a threatened species under the Endangered Species Act (ESA) of 1973, as amended.

Redband and steelhead are found throughout the fish-bearing streams of Canyon Creek (USFS GIS Data) (Figure 2). The reservoir currently affects downstream steelhead habitat by trapping spawning gravels, slightly altering peak flows and stream temperature, for a short distance downstream, when stored water is forced below the dam and re-enters Canyon Creek at slightly cooler temperatures during the summer months.

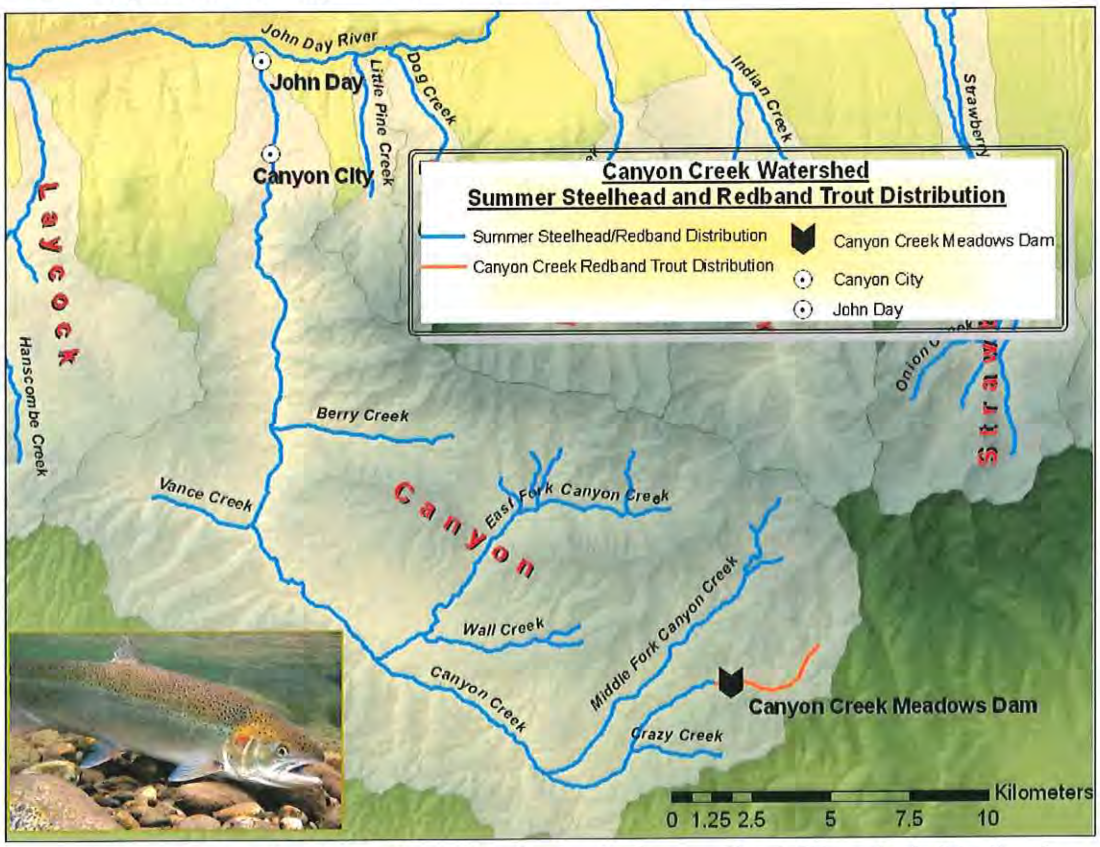

Figure 2. Summer Steelhead / Redband Distribution in Canyon Creek Watershed. Steelhead upstream distribution stops below Canyon Meadows Dam while some redband trout exist above the dam.

Non-native rainbow trout (hatchery domesticated *O. mykiss*) were stocked in the Canyon Meadows Reservoir from 1964-96. Stocking was initiated to bolster the recreational fishery opportunity. Stocking rates of non-native rainbow and brook trout combined averaged 8,036 fish per year. From the mid 1970's to the mid 1980's, between 200-300 angler hours were recorded each year. No stocking occurred after 1997 when the reservoir outlet pipe was permanently opened due to potential impacts to steelhead (ESA listed a year later) and cutthroat. Any future reservoir stocking program would be evaluated by the ODFW and would only resume if steelhead were delisted and native cutthroat concerns were addressed.

8.2.2 Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*)

The resident and fluvial (migrates between small streams and rivers) forms of westslope cutthroat trout are found in the Canyon Creek watershed (Sheppard et al, 2002). The westslope cutthroat trout differ from other fish in their relatively small size and their feeding habits. These fish specialize as invertebrate feeders and consequently do not compete directly with more piscivorous (fish-eating) species like bull trout (Behnke, 2002). In addition to habitat degradation, hybridization with native redband trout and displacement by brook trout in small streams represent the common biological threats to the species (Figure 3). In the Canyon Creek watershed, cutthroat is considered a genetically unaltered species illustrating greater than 99% genetic purity. Consequently, they have been identified as a core conservation population (Shepard et al, 2002).

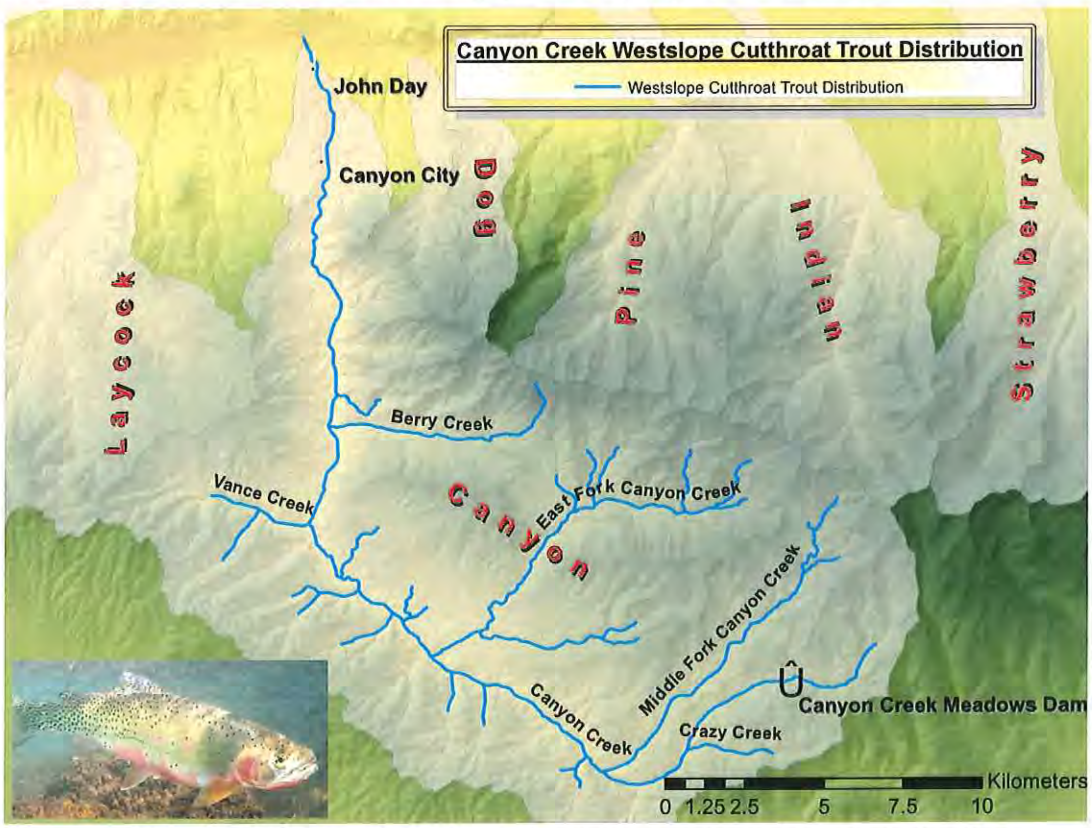

Figure 3. Westslope Cutthroat Trout Distribution in Canyon Creek Watershed (distribution is approximate)

8.2.3 Spring Chinook Salmon (*Oncorhynchus tshawytscha*)

Chinook salmon are anadromous and semelparous (die after spawning once). The Chinook tend to spend one or more years as a fry or parr in freshwater before migrating to sea. They will return to their natal river in the spring or summer several months prior to spawning after spending 1-4 yrs in the ocean. Spring Chinook adults are rarely found spawning in Canyon Creek although juveniles are present throughout the lower reaches, having migrated there from the mainstream John Day River (Figure 4). Spring Chinook are protected under the federal Magnuson Stevens Act but are not listed by the state or federal endangered species acts.

Figure 4. Spring Chinook Distribution in Canyon Creek Watershed

8.2.4 Brook Trout (Salvelinus fontinalis)

The native range of brook trout is northeastern North America, and their introduction to the intermountain west has posed serious threats to native trout, particularly bull trout (Behnke, 2002). Brook trout spawn in late August through October and, as a result, young brook trout are able to feed and grow for several months before westslope cutthroat trout are hatched. Brook trout feed opportunistically on westslope cutthroat and other native salmonids as part of their diet (Behnke, 2002).

Brook trout were introduced into Canyon Creek sometime prior to the 1950's and were present throughout the upper reaches in 1964 when the dam was constructed. Brook trout were stocked along with non-native rainbow trout in Canyon Creek Meadow Reservoir from 1964 through 1996.

Brook trout distribution is primarily limited to the reaches of Canyon Creek above the dam. Brook trout now dominate the cutthroat habitat above the dam. Higher water temperatures far below the dam prevent them from dominating downstream reaches but, where present, they compete for food and space with steelhead, redband and cutthroat. Therefore, the presence of brook trout in the Canyon Creek watershed is a concern for the fecundity of other salmonids (USFS, 2003).

During July 2005, the ODFW and USFS implemented a backpack electroshocker brook trout eradication project in a section of Canyon Creek immediately above the dam. Eight ODFW biologists, four USFS biologists, and eight volunteers counted 2 cutthroat and 16,435 brook trout in Canyon Meadows and only 6 of the brook trout were over 8 inches long. Following their removal, it was estimated that over 8,000 brook trout remained in that specific section of Canyon Creek, and the feasibility of backpack electroshocker by eradication was deemed impossible. Brook trout are considered a sportfish species and are not protected by state or federal ESAs. The brook trout fishery throughout Canyon Creek Meadows is a key angling opportunity.

8.2.5 Bull Trout (Salvelinus confluentus)

Bull trout are currently absent from the Canyon Creek watershed but were historically present (ODFW, 2002). Bull trout are federally listed as a threatened species under state and federal ESAs.

8.2.6 Other Fish Species

Several other native fish species occur in the Canyon Creek watershed including Sculpin (*Cottus sp.*), Redside Shiners (*Richardsonium sp.),* Speckled Dace (*Rhinichthys osculus*), Longnose Dace (*Rhinichthys cataractae*), Bridge lip sucker (*Catostomus columbianus*), Pacific lamprey (*Lampetra tridentata*), and Northern Pike Minnow (*Ptychocheilus oregonensis*).

8.3 Future Fish Habitat Considerations

If the dam is repaired, several precautions must be taken to avoid immediate and future adverse effects to fish resources. The construction would be required to occur during the instream work window (July 15 - August 31) to minimize potential impacts to downstream steelhead reds. All flowing water must be diverted around the repair site to avoid downstream siltation and a fish salvage conducted prior to instream work with the fish returned to an undisturbed reach upstream. Additionally, significant repair of the dam triggers the statute requirement for fish passage ladder according to Oregon law.

If the dam were removed, several precautions would also be taken to avoid immediate and future adverse impacts to fish resources. The construction would be required to occur during the instream work window (July 15 - August 31) to minimize potential impacts to downstream steelhead reds. All flowing water must be diverted around the construction site to avoid downstream siltation, and a fish salvage must be conducted prior to instream work with the fish returned to an undisturbed reach upstream. All rock and clay core material would be removed and placed on the surrounding uplands. Potential stream head cutting and channel stability through Canyon Creek Meadows would need to be addressed with placement of grade control structures that meet Oregon fish passage criteria. Vegetative restoration at the dam site would occur including topsoil placement and grass/sedge/hardwood planting. Riparian vegetation would need to be reestablished throughout the previously inundated meadow above the dam.

9.0 ARCHAEOLOGY/STATE HISTORIC PRESERVATION

On June 26, 2009, on behalf of the ODFW, CES requested that the Oregon State Historic Preservation Office (SHPO) make a determination of historic resources in the Canyon Creek Meadows Dam project area. On July 7, 2009, the SHPO office responded, noting that there have been no previous cultural resource surveys completed near the proposed project area, but the project "lies within an area generally perceived to have a high probability for possessing archaeological sites" (SHPO, 2009). The SHPO office noted that if the project included federal funding, permitting, or oversight, there should be coordination with a federal agency representative to ensure compliance with Section 106 of the National Historic Preservation Act (NHPA). Since this project is on lands administered by the USFS, it is recommended that the USFS archeology staff work with ODFW to provide this compliance.

The SHPO further noted that if, during construction activities, any cultural materials are discovered, all work should cease immediately until a professional archaeologist can assess the discovery (SHPO, 2009).

In evaluating the probability of discovering cultural material during the removal or repair of the dam, it was noted that most of the construction work would take place within the area previously disturbed during the original construction of the dam; therefore, discovery of cultural materials in this area is unlikely.

10.0 PUBLIC INVOLVEMENT

The following is an account of public involvement concerning the dam and reservoir.

10.1 Overview of August 18, 2009 Public Input Meeting

On Tuesday, August 18, 2009, a meeting was held at the USFS Building, 431 Patterson Bridge Road, John Day, Oregon. The purpose of this meeting was to seek public comment on the Canyon Creek Meadows Dam evaluation project. The meeting was open to the public, including landowners and all interested parties. This was the first of three planned public meetings for this project. Thirty-six people signed in at this meeting. The meeting included: 1) an initial presentation by Doug Bochsler, Program Manager for the ODFW, who provided an overview, brief history, and current conditions of the project; 2) an overview of fish resources in Canyon Creek provided by Kevin Blakely, ODFW John Day Watershed District Manager; and 3) a project overview and timeline provided by Tim Otis, CES Senior Engineer.

Following the presentations, the participants were split randomly into three groups. Each group had a facilitator and recorder to write down the public comments. Feedback from participants was organized into two categories, by each group's facilitator as either comments or questions, and a summary is included as Appendix F.

10.2 October 14, 2009 Petition to Repair the Dam

On October 14, 2009, the ODFW received a letter from Gordon Larson supporting the repair of the dam and including a petition, with 67 signatures, endorsing the following statement:

> "We, the undersigned, are concerned citizens who urge our leaders to act now to repair and restore Canyon Creek Meadows Dam to its original and intended use. We strongly oppose any efforts to remove or abandon Canyon Creek Meadows Dam" (Larson, 2009).

11.0 DESIGN ALTERNATIVES

The following four alternatives were selected based on discussions with the ODFW and CES' understanding of the history of the site and surrounding features.

Alternative 1 – Dam removal, including restoration of the stream
Alternative 2 – Dam repair, using a geosynthetic liner only
Alternative 3 – Dam repair, using a soil liner only
Alternative 4 – Dam repair, using a double liner (geosynthetic liner plus soil liner)

The following sections provide a brief summary of the alternatives, assumptions, and estimated costs. Cost estimates will be revised as new information is gained or additional design details are developed. Current cost estimates are preliminary and are intended for comparison of alternatives. Once a preferred alternative is selected, a more detailed cost estimate can be developed suitable for budgeting.

11.1 Alternative 1 - Dam Removal

This alternative includes removal of the dam and associated restoration of Canyon Creek. This alternative would consist of excavating, hauling (~500 feet), and placing approximately 14,000 cubic yards of material from the dam in the stockpile storage areas (Sheet C3). Based on the drawings, the stockpile storage areas would total about 1.4 acres. Construction activities are proposed to be performed using a large excavator, a D-8 Dozer, 3, 30-cy dump trucks, a diesel pump and dewatering equipment, a project trailer, and erosion control and grade check equipment. Restoration also includes placement of topsoil and seeding. It is assumed topsoil would be placed over all excavation and stockpile areas 6 inches deep.

As a part of this alternative, restoration of Canyon Creek is proposed to meet the following objectives:

- Maximize habitat for fish species by restoring riverine conditions and meadow function,
- Provide for fish passage upstream and downstream, and
- Provide for grade control to minimize movement of sediment during peak runoff event.

To meet these objectives, an 800 foot long section of reconstructed stream channel is proposed as shown in Sheets C1- C5 (attached). Riparian planting is proposed upstream in the meadow area to stabilize stream banks and improve habitat functions.

11.2 Alternative 2 - Geosynthetic Liner

This alternative includes placement of a geosynthetic liner under the reservoir to control seepage. This estimate assumes that in order to eliminate seepage under the reservoir there would need to be a low permeability liner installed under the reservoir. Assumed area for the liner would be 9.8 acres (See Sheet C4). This estimate assumes a 60 mil HDPE liner would be needed. Since this type of liner cannot be used in uneven terrain, the entire acreage would need to be graded to reduce slopes and sharp angles between slopes. There would also be a need to protect the liner against sharp edges of rock, so we assumed a three foot deep cushion material (soil) would need to be placed over the entire area to protect against the sharp edges of the talus. A sheet pile cutoff is included to cutoff flows from the upper end of the lined area. A cover over the geosynthetic liner is also provided to a two foot depth to protect the liner against rock fall and bed load in the stream flow. If this alternative is selected for additional design effort, the area to be lined will need to be verified with field-testing.

11.3 Alternative 3 - Soil Liner

This alternative includes placement of a soil liner under the reservoir to control seepage. This option is similar to Alternative 2, except it is assumed approximately 80,000 cy of a clay soil would be purchased and imported. It still includes costs for grading to achieve a stable slope for soil compaction, as a cushion layer was assumed necessary to act as support between the clay soil and the talus that is naturally occurring. For cost estimation purposes, the same area shown on sheet C-4 used for Alternative 2 is used for soil liner installation.

11.4 Alternative 4 - Double Liner

This alternative includes placement of a soil and geosynthetic liner under the reservoir to control seepage. This estimate assumes that in order to eliminate seepage under the reservoir a low permeability liner under the reservoir is needed. Assumed area for the liner would be 9.8 acres as shown on Sheet C4. Since a soil liner has already been implemented unsuccessfully, this estimate assumes a double liner would be necessary to adequately eliminate seepage and piping of fine soils. With a double liner, a leak in one layer would be intercepted by the other layer, which would slow down any failure mechanism that develops. This estimate assumes a 60 mil HDPE liner installed over a two foot thick soil liner of clay type soils. Since this type of liner cannot be used in uneven terrain, the entire acreage would need to be graded to reduce slopes and sharp angles between slopes. We assumed a three foot thick cushion layer could be graded adequately to provide a filter barrier between the course material of the reservoir and dam and the fine clays used in the underlying clay liner; therefore, we assumed a three foot deep cushion material (soil) would need to be placed over the entire area. A sheet pile cutoff is included to cut off flows from the upper end of the lined area. A cover over the geosynthetic liner is also provided to a two foot depth to protect the liner against rock fall and bed load in the stream flow. Soils containing organics or otherwise deemed unsuitable for underlying soils would need to be removed from the lined area.

It must be pointed out that any lining plan designed to cover this area would carry a high risk of failure, based on previous efforts at the site. It is recommended that if any liner option is chosen, adequate money be set aside for cost increases (use high end cost estimate). We also recommend that all stake holders be made aware of the risk and be alerted to the possibility that further repairs may be needed after the project is put into operation.

11.5 Operations and Maintenance

As part of the evaluation, the operation and maintenance of the alternatives were evaluated. We assumed that brush clearing, outlet cleaning, earthmoving to keep outlet works clear, inspections, and an EAP would need to be done regularly for the next 50 years for any alternative that include repair or rehabilitation of the dam. If the dam is removed, it was assumed an annual inspection of the area would be required. Present value was computed using a period of 50 years and an interest rate of 3%. These assumptions should be checked by discussing operations with people who have direct site experience before any values are finalized.

11.6 Cost Estimate Summary

Category	Alternatives			
	Dam Removal	Geosynthetic Liner	Soil Liner	Double Liner
Construction	$451,000	$2,117,000	$4,032,000	$4,327,000
Design*	$45,000	$106,000	$202,000	$216,000
Construction Management*	$45,000	$106,000	$202,000	$216,000
Administration	$23,000	$106,000	$202,000	$216,000
Total Capital**	**$564,000**	**$2,435,000**	**$4,638,000**	**$4,975,000**
Present Worth – O&M**	**$77,000**	**$540,000**	**$540,000**	**$540,000**
Total Present Worth	**$641,000**	**$2,975,000**	**$5,178,000**	**$5,515,000**
-25% Range	**$481,000**	**$2,231,000**	**$3,884,000**	**$4,136,000**
+75% Range	**$1,122,000**	**$5,206,000**	**$9,062,000**	**$9,651,000**

Notes: * = 10% of Construction used for dam removal, 5% of Construction used for other alternatives.
** = Present worth based on n = 50 years and i = 3%.
O&M = Operations and Maintenance

11.7 Evaluation of Alternatives

Of the four alternatives evaluated, dam removal is the least cost alternative. The rehabilitation alternatives range from 4.6 to 8.6 times the cost of removal. In addition, the rehabilitation alternatives carry a high probability of failure to meet the objective of providing for a safe and reliable reservoir at this site.

11.8 Data Gap Assessment for Dam Repair

Under any repair alternative, it is assumed that a fish ladder would be required to provide upstream and downstream passage. If a fish ladder was constructed, it would need to provide passage over approximately 55 feet of head. No cost estimate was prepared for a fish ladder at the dam, and a conceptual design would be required to estimate costs. An order of magnitude estimate could be used from other similar projects. For example, in 2003, a Technical Memorandum was prepared regarding fish passage at the J.C. Boyle Dam on the Klamath River. The estimate for a pool and weir type ladder, providing passage over 60.2 vertical feet, was $6 million.

To evaluate the repair of the dam, the present condition of the dam and subsurface conditions must be assessed. Loss of material into the right upstream face of the dam is indicated by depressed areas where water actively flows into the dam, as previously discussed. The depressions are shown in Sheet C6. An estimate of the cost to perform preliminary geotechnical services to evaluate the dam's condition is $82,000 (Appendix E). An additional civil engineering assessment of approximately $40,000 would also be required for a combined total of approximately $122,000. Following this detailed assessment of conditions, dam repair options could be evaluated and construction costs estimated for repair. Repair of the dam is not recommended without first performing this detailed assessment, and the current information is not suitable for completion of this assessment. Even if this detailed assessment is completed, the construction challenges with dam repair, now evident, suggest that repair costs will likely be significant. The costs estimates for dam repair should be considered the minimum amounts required and are based on an estimate prepared by the USACE and detailed in the Dam Safety Evaluation and Alternatives Report (1999).

12.0 CONCLUSION

Based on the findings of this evaluation, CES recommends removal of the dam as soon as funds become available. Streambed restoration should be included as a part of the removal project. Construction plans and technical specifications for the removal and streambed restoration are provided in addition to this report.

In the interim period, the current operational plan for the dam is to lock open the 18" diameter corrugated metal underdrain pipe. When stream flows exceed the capacity of this pipe, typically during spring snow melt, a pool forms behind the dam, in some years filling the reservoir to capacity before flows decrease and the reservoir drains. CES recommends continued monitoring and maintenance as described in the 2001 Emergency Action Plan/ Preventative Action Plan/Operation and Maintenance Plan.

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TABLE

Table 1. Canyon Creek Meadows Dam Information

Table 1. Canyon Creek Meadow Dam Data

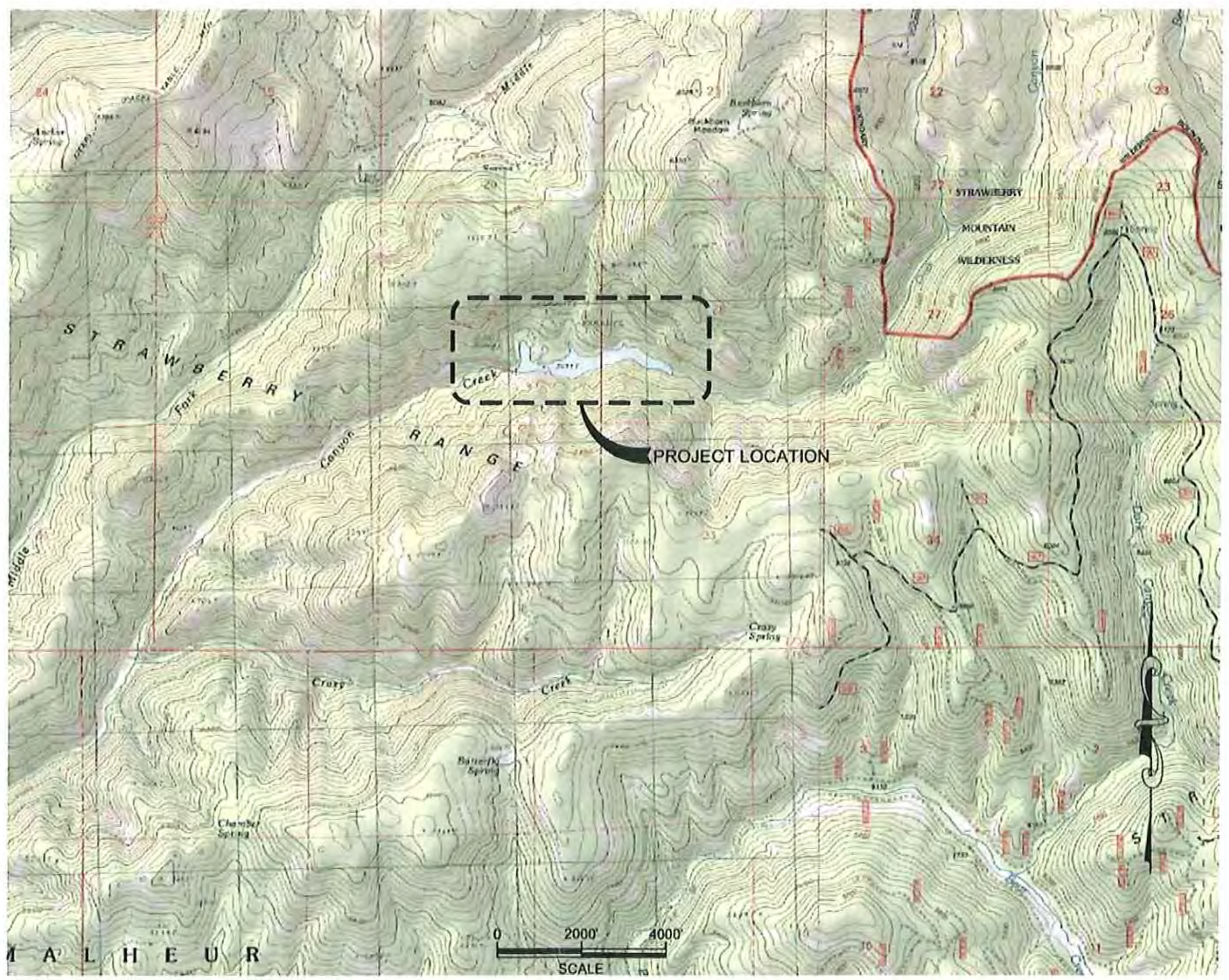
Name:	Canyon Creek Meadows Dam
Owner:	Oregon Department of Fish and Wildlife (ODFW)
Location:	Grant County, Oregon, Sections 28 and 29, T15S, R33E, W.M.
Land Ownership:	United States Forest Service (USFS), Malheur National Forest
Purpose:	Recreation
Dist. from John Day:	22 miles
Hazard Category:	High hazard, intermediate category
Drainage	
Area:	5.77 square miles
Elevations:	5010 ft. (below dam) to 7650 ft. (top of watershed)
(NAVD 88 datum, all elevations)	
Precipitation:	35 inches average annual
Reservoir	
Capacity:	246 acre-feet at normal pool
Area:	27.5 acres at normal pool
Embankment	
Type:	Zoned rock fill with sloping clay core in upstream portion
Max Height:	56 ft. above natural ground
Max Width:	220 feet at base
Max Length:	173 feet at crest
Slopes:	2 ½ : 1 Upstream, 1 ½ :1 Downstream
Crest Elev.:	5056 ft.
Crest Width:	15 feet
Spillway	
Width:	30 ft.
Elevation:	5045.3 AMSL (NAVD 88 datum)
Exit Slope:	2%
Regulation Outlet	
Type:	Corrugated Metal Pipe with manual slide gate at inlet.
Size:	18 inch diameter
Length:	215 feet

SHEETS

Sheet G-1.	Site Location and Index of Drawings
Sheet G-2.	Existing Topographic Map and Survey Control
Sheet G-3.	Site Details
Sheet C-1.	Plan and Profile
Sheet C-2.	Cross Sections
Sheet C-3.	Earthwork Detail
Sheet C-4.	[Not used]
Sheet C-5.	Stream Restoration Details

CANYON CREEK MEADOWS DAM REMOVAL
OREGON DEPARTMENT OF FISH AND WILDLIFE
MALHEUR NATIONAL FOREST

VICINITY MAPS



(SOURCE: USGS 7.5' Map from TOPO! ® ©2003 National Geographic)

SITE LOCATION MAP

INDEX OF DRAWINGS

SHEET	GENERAL
G-1	SITE LOCATION & INDEX OF DRAWINGS
G-2	EXISTING TOPOGRAPHIC MAP AND SURVEY CONTROL
G-3	SITE DETAILS
	CIVIL
C-1	CANYON CREEK PLAN AND PROFILE
C-2	CROSS SECTIONS
C-3	EARTHWORK DETAIL
C-4	NOT USED
C-5	STREAM RESTORATION DETAILS

PROJECT NOTES:

PROJECT DESCRIPTION

THE CANYON CREEK MEADOWS DAM, OWNED BY THE OREGON DEPARTMENT OF FISH AND WILDLIFE (ODFW), WAS EVALUATED TO DETERMINE WHETHER IT SHOULD BE REMOVED OR REPAIRED. THE GOALS, AS OUTLINED BY ODFW, FOR THIS PROJECT WERE:

- CONDUCT OUTREACH ACTIVITIES WITH THE PUBLIC AND WITH PARTNER GOVERNMENT AGENCIES.
- EVALUATE THE SEDIMENT TRANSPORT, HABITAT IMPACTS, HYDROLOGIC AND OTHER FACTORS AFFECTING THE WATERSHED DUE TO THE CONTINUED PRESENCE OF THE DAM AND POTENTIAL REMOVAL.
- PREPARE A PRELIMINARY REPORT DESCRIBING FINDINGS OF THE EVALUATION AND PUBLIC OUTREACH, INCLUDING AN ASSESSMENT OF REPAIR AND REMOVAL ALTERNATIVES, AND CONSTRUCTION COST ESTIMATES FOR EACH.
- PREPARE THE CONSTRUCTION DRAWINGS AND SPECIFICATIONS FOR PREFERRED ALTERNATIVE, INCLUDING HABITAT RESTORATION, FOLLOWING ODFW RECOMMENDATION.

ODFW HAS RECOMMENDED REMOVAL OF THE DAM AS THE PREFERRED ALTERNATIVE. THESE CONSTRUCTION DRAWINGS AND SPECIFICATIONS ARE FOR REMOVAL OF THE CANYON CREEK MEADOWS DAM. ADDITIONAL INFORMATION RELATED TO THE DEVELOPMENT OF THESE PLANS CAN BE FOUND IN THE FINAL CANYON CREEK DAM EVALUATION REPORT (REPORT). SINCE THIS PROJECT IS NOT CURRENTLY FUNDED, RECOMMENDATIONS FOR MAINTENANCE DURING THE INTERIM PERIOD, PRIOR TO DAM REMOVAL, HAVE INCLUDED IN THE REPORT.

OREGON DEPARTMENT OF FISH AND WILDLIFE
MALHEUR NATIONAL FOREST

REV #	DESCRIPTION	BY	DATE

DES. BY TLO
DRG. BY RKB
CHK. BY JEW
DATE 8/28/2012
JOB No. 2923018

STAMP: REGISTERED PROFESSIONAL ENGINEER 14,477 — Digitally signed by Timothy Otis — OREGON — TIMOTHY OTIS — EXPIRES 12-31-2012

CES — CASCADE EARTH SCIENCES
A Valmont Industries Company
CALL 1-800-728-8322 FOR NATIONAL OFFICE LOCATIONS

SITE LOCATION AND INDEX OF DRAWINGS
CANYON CREEK MEADOWS DAM REMOVAL

SHEET G-1

FEATURES

(1) EDGE ROCK.

(2) EDGE GUNITE, NOTE SOME AREAS EDGE IS COVERED, LOCATED VISIBLE EDGES ONLY.

(3) METAL STANDPIPE TYPE UNKNOWN, 2-IN. DIA. HT. VARIES

(4) GRADE BREAK GUNITE

(5) GABION TOP

(6) TOP RIP-RAP.

(7) TOE RIP-RAP.

(8) FOUND 3-IN. BRASS DISK GROUTED IN CONCRETE. ELEV.=5022.47 FT.

(9) DAM OUTLET, PIPE INVERT NOT VISIBLE.

(10) CONCRETE CUT-OFF WALL, W=6-IN., TOP ELEV.=5060.35 FT. HEIGHT ABOVE CONCRETE FOOTING (SPILLWAY)=9.0 FT.

(11) CONTROL PT./BENCH MARK, SET 5/8" IRON ROD WITH 2-IN. ALUMINUM CAP MARKED "JOHN THOMPSON AND ASSOCIATES INC. 160-011 2009" ELEV.=5059.92 FT.

(12) CONTROL BOX, CONCRETE TOP ELEV.=5059.61 FT. VAULT FLOOR VARIES ELEV.=5055.27 FT., TOP 6-IN. CONTROL PIPE ELEV.=5056.07

(13) CONTROL PT./BENCH MARK, SET 5/8" IRON ROD WITH 2-IN. ALUMINUM CAP MARKED "JOHN THOMPSON AND ASSOCIATES INC. 160-001 2009" ELEV.=5059.72 FT.

(14) WIRE FENCE WITH STEEL POSTS & CABLE GUYS (POOR CONDITION)

(15) CONTROL VALVE OIL FILL STANDPIPE, 4-IN. G.I.P. UP 0.3 FT., CAP ELEV.=5056.84 FT.

(16) GUY WIRE WITH 1-IN. STEEL ANCHOR PINS (LOG BOOM)

(17) LOG BOOM, 10-IN. TO 12-IN. LOGS (TYP.) STEEL CABLE CONNECTIONS.

(18) CONTROL STEM PIPE, 4-IN. DIA. STEEL, WITH 1-IN. DIA. PIPE ATTACHED (NORTH)

(19) GATE BOX, W/ REBAR TRASH RACK, LOWER AREA OBSTRUCTED, TOP WALL ELEV.=5013.49 FT. SLIDE GATE (18-IN. DIA.) AT 10 O'CLOCK POSITION ELEV.=5010.05 FT.

(20) TOE OF ROCK

(21) DITCH DRAINAGE (DRY)

(22) STREAM BANK TOP.

(23) WETLAND AREA EDGE (NOT DELINEATED)

(24) WETLAND AREA (NOT DELINEATED)

(25) STREAM BANK TOP (DRY)

(26) CONTROL PT./BENCH MARK, SET 5/8" IRON ROD WITH 2-IN. ALUMINUM CAP MARKED "JOHN THOMPSON AND ASSOCIATES INC. 160-002 2009" ELEV.=5026.08 FT.

(27) STREAM C/L CANYON CREEK

(28) EDGE GRAVEL (SHOULDER).

(29) DITCH DRAINAGE (INTERMITTENT FLOW)

NOTES

1. EXISTING GROUND MAP COMPILED FROM GROUND SURVEY DATA COLLECTED 08-25-2009
2. HORIZONTAL DATUM IS BASED ON NAD83(CORS96) EPOCH 2002.0, OREGON STATE PLANE NORTH ZONE (3601)
3. VERTICAL DATUM IS NAVD 88
4. UNITS ARE INTERNATIONAL FEET
5. CONTOUR INTERVAL IS 1 FOOT

PRIMARY SURVEY CONTROL DATA TABLE

PT.	NORTHING	EASTING	ELEV.	DESCRIPTION
1	212749.3549	8653080.8661	5059.72	5/8" IRON ROD W/2" ALUM. CAP "160-001 2009"
2	212817.0643	8654061.7140	5026.08	5/8" IRON ROD W/2" ALUM. CAP "160-002 2009"
11	212619.5360	8653111.5436	5059.92	5/8" IRON ROD W/2" ALUM. CAP "160-011 2009"

OREGON DEPARTMENT OF FISH AND WILDLIFE
MALHEUR NATIONAL FOREST

REV #	DESCRIPTION	BY	DATE

DES. BY TLO
DRG. BY RKB
CHK. BY JEW
DATE 8/28/2012
JOB No. 2923018

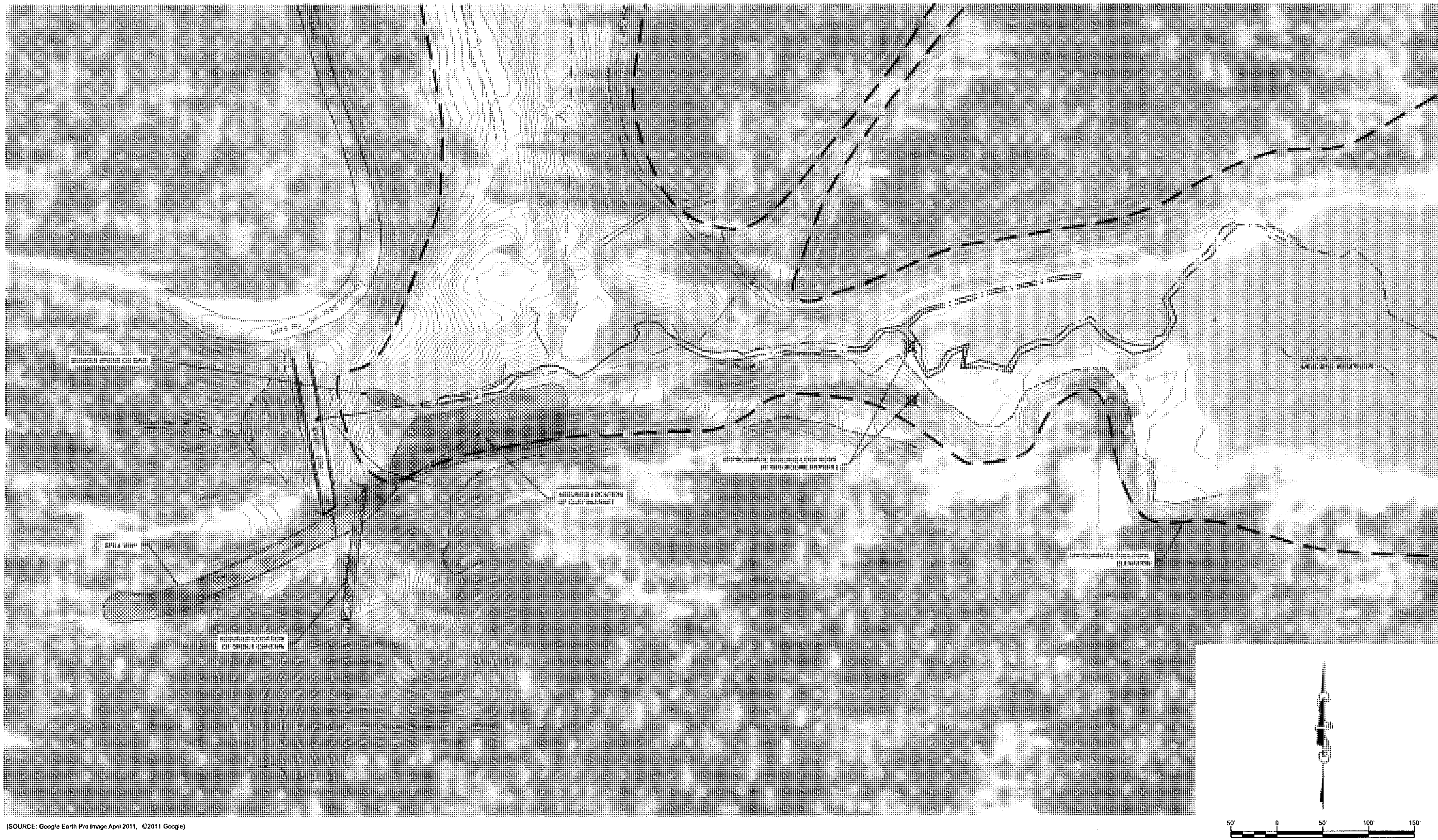
STAMP
REGISTERED PROFESSIONAL ENGINEER
OREGON
TIMOTHY OTIS
EXPIRES

CES
CASCADE EARTH SCIENCES
A Valmont Industries Company
CALL 1-800-728-8322
FOR NATIONAL OFFICE LOCATIONS

EXISTING TOPOGRAPHIC MAP AND SURVEY CONTROL

CANYON CREEK MEADOWS DAM REMOVAL

SHEET
G-2



(SOURCE: Google Earth Pro Image April 2011, ©2011 Google)

OREGON DEPARTMENT OF FISH AND WILDLIFE
MALHEUR NATIONAL FOREST

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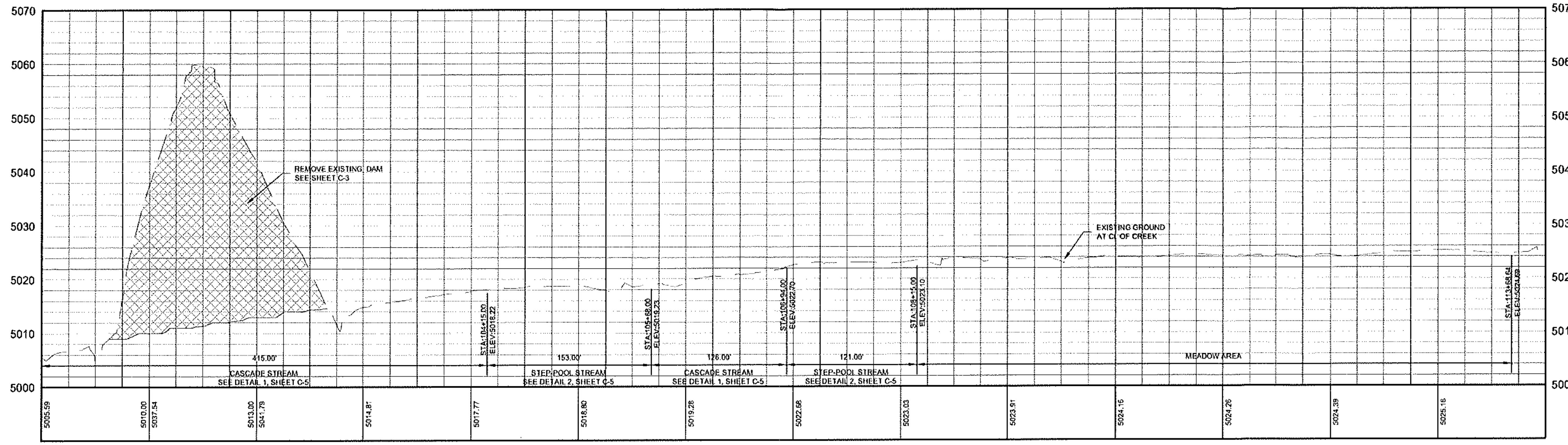
SITE DETAILS

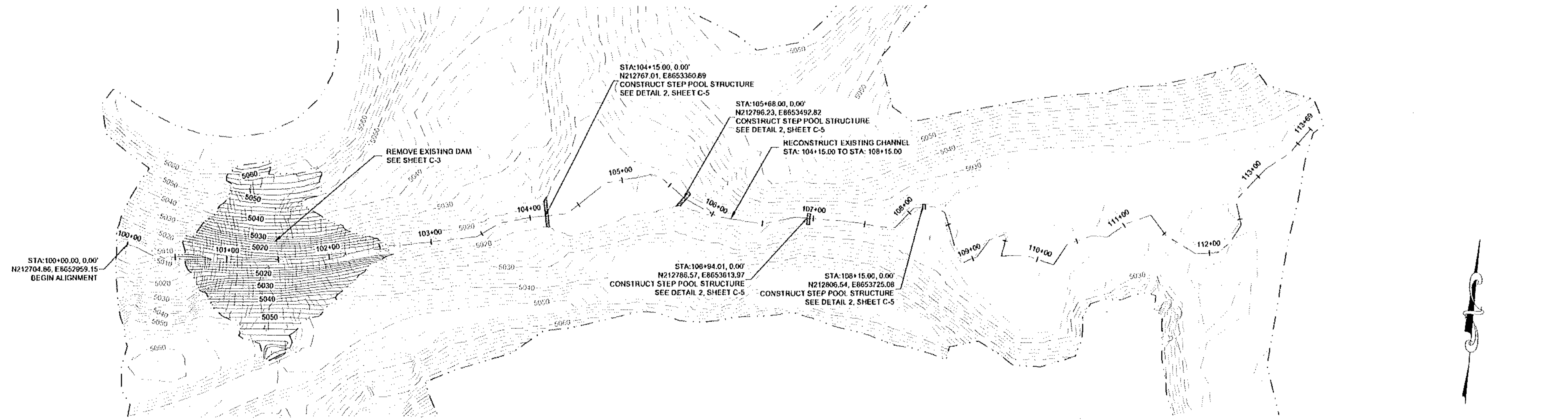
CANYON CREEK MEADOWS DAM REMOVAL

SHEET G-3



PROFILE VIEW

SCALE:
HORIZ. 1"=50'
VERT. 1"=10'



PLAN VIEW

OREGON DEPARTMENT OF FISH AND WILDLIFE
MALHEUR NATIONAL FOREST

REV #	DESCRIPTION	BY	DATE

DES. BY TLO
DRG. BY RKB
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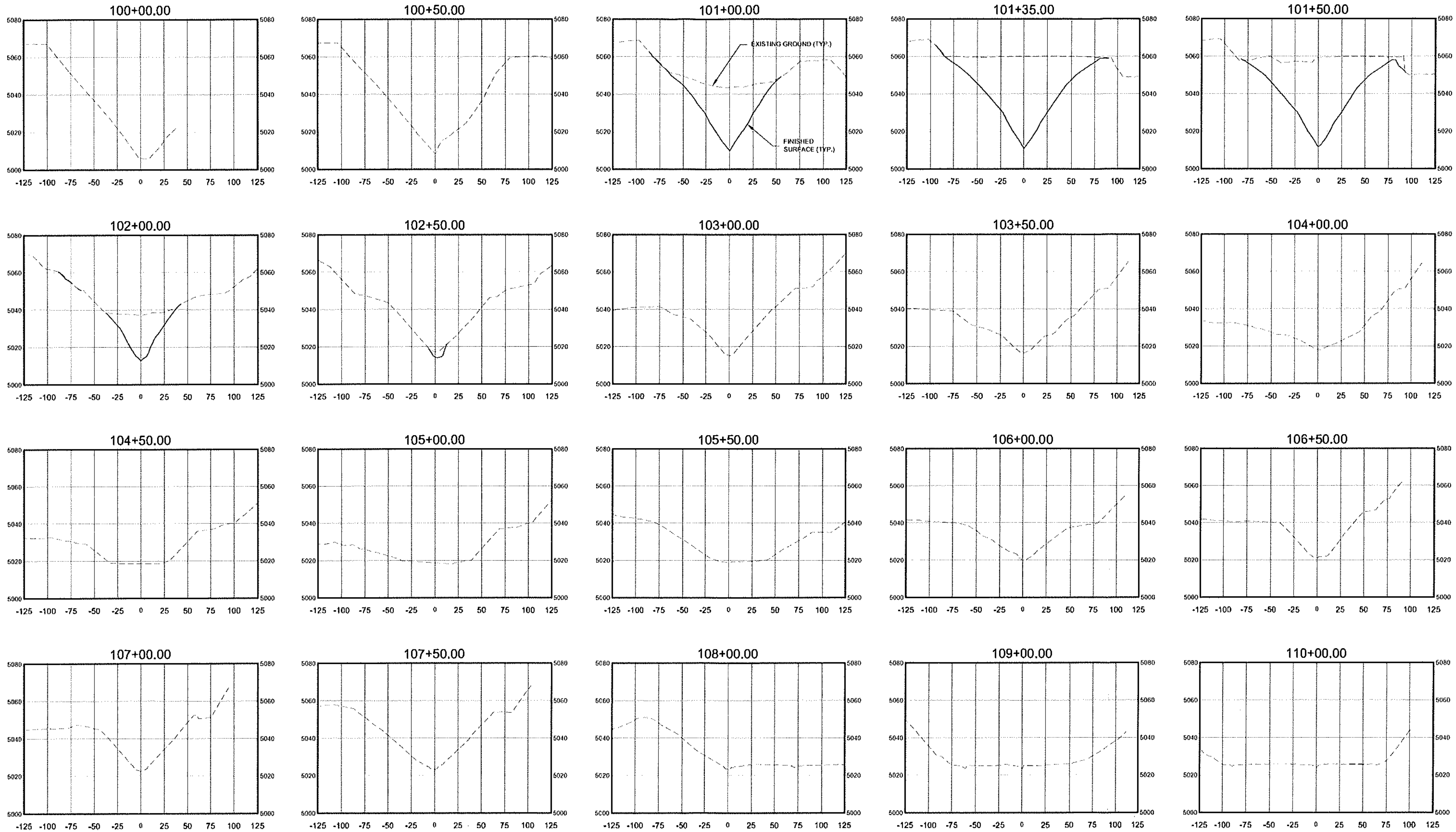
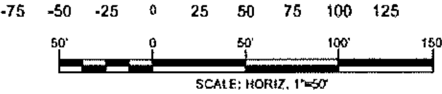
PLAN AND PROFILE

CANYON CREEK MEADOWS DAM REMOVAL

SHEET C-1





OREGON DEPARTMENT OF FISH AND WILDLIFE
MALHEUR NATIONAL FOREST

REV #	DESCRIPTION	BY	DATE

DES. BY TLO
DRG. BY RKB
CHK. BY JEW
DATE 8/28/2012
JOB No. 2623018

STAMP
REGISTERED PROFESSIONAL ENGINEER
OREGON
TIMOTHY OTIS
EXPIRES: 12-31-2012

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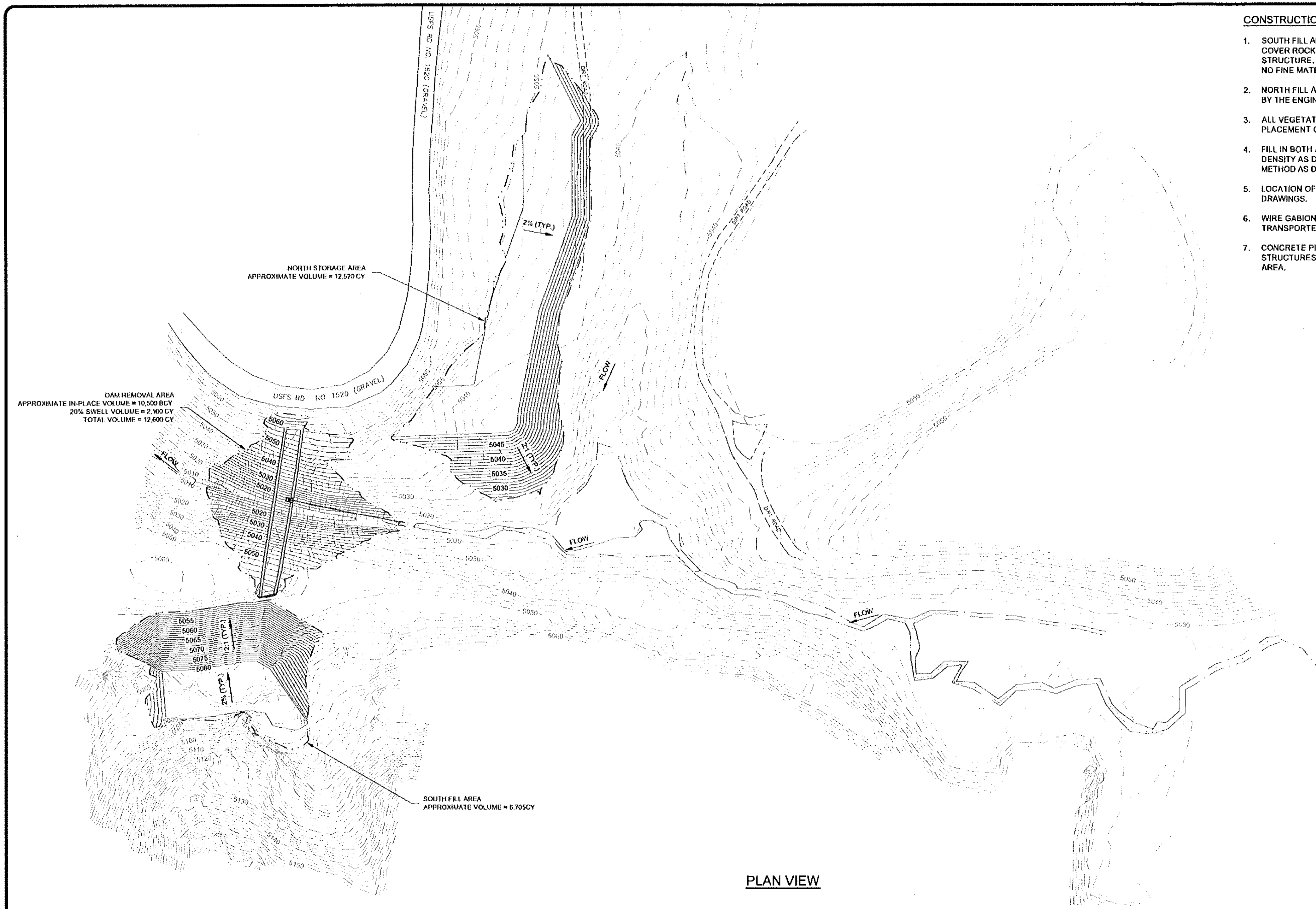
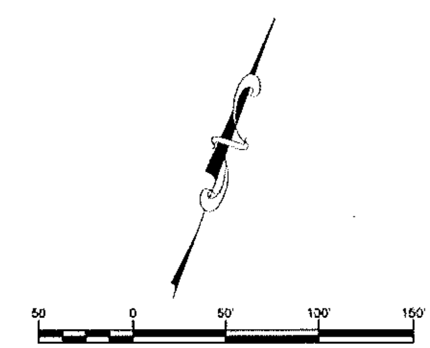
CROSS SECTIONS
CANYON CREEK MEADOWS DAM REMOVAL

SHEET
C-2



PLAN VIEW



CONSTRUCTION NOTES:

1. SOUTH FILL AREA SHALL BE CONSTRUCTED WITH LARGEST SIZED DAM COVER ROCK, AND LARGEST ROCK FROM WITHIN THE DAM STRUCTURE. ALL FILL IN SOUTH FILL AREA SHALL BE GRANULAR, AND NO FINE MATERIAL SHALL BE PLACED IN THIS AREA.
2. NORTH FILL AREA SHALL BE UNCLASSIFIED FILL, PLACED AS DIRECTED BY THE ENGINEER.
3. ALL VEGETATION SHALL BE STRIPPED FROM FILL AREAS PRIOR TO PLACEMENT OF FILL.
4. FILL IN BOTH AREAS SHALL BE COMPACTED TO 90% OF MAXIMUM DENSITY AS DETERMINED BY MODIFIED PROCTOR METHOD, OR OTHER METHOD AS DIRECTED BY THE ENGINEER.
5. LOCATION OF FILL AND FILL SLOPES SHALL BE AS SHOWN ON THE DRAWINGS.
6. WIRE GABIONS AND OTHER METAL COMPONENTS SHALL BE TRANSPORTED OFF-SITE AND RECYCLED.
7. CONCRETE PIECES FROM SPILLWAY GUNNITE AND CONCRETE STRUCTURES MAY BE INCLUDED IN UNCLASSIFIED FILL IN SOUTH FILL AREA.

OREGON DEPARTMENT OF FISH AND WILDLIFE
MALHEUR NATIONAL FOREST

REV #	DESCRIPTION	BY	DATE

DES. BY TLO
DRG. BY RKB
CHK. BY JEW
DATE 8/26/2012
JOB No. 2623018

STAMP: REGISTERED PROFESSIONAL ENGINEER, OREGON, TIMOTHY OTIS, EXPIRES 12.31.2012

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EARTHWORK DETAIL

CANYON CREEK MEADOWS DAM REMOVAL

SHEET C-3

Construction Notes

Cascade Stream Section (Sta. 105+68 to 106+94)

1. All rock for this construction shall be from on-site sources
2. Contractor shall first excavate the channel to depths shown, and dispose of excavated material on-site, above the bank-full elevation of Canyon Creek, and as staked.
3. Cascade Section boulders shall be placed in a random pattern, allowing multiple flow paths at low water.
4. Excavate channel bed so that substrate rock shall be a minimum of 24 inches in thickness. Excavated channel material shall be placed in South Fill Area.
5. Substrate Rock Gradation shall be as follows:

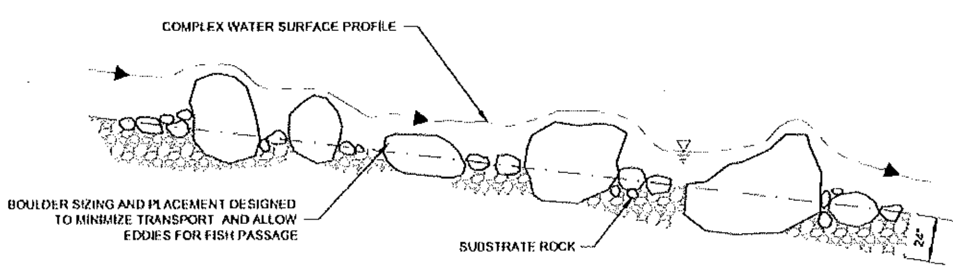
Percent Passing by Weight	Average Particle Size (in)
100	18
85	12
50	8
30	6
15	4

6. Cascade Boulder Sizing shall be as follows:

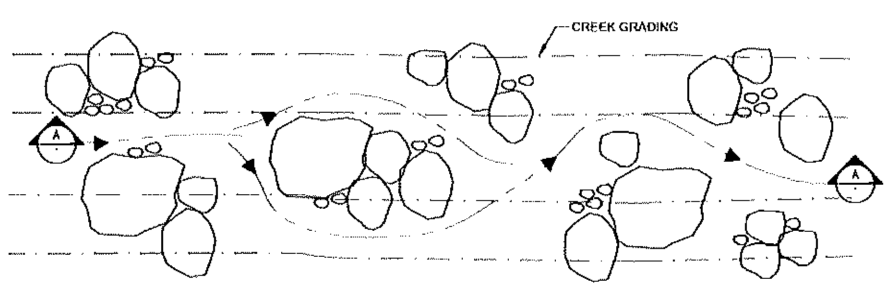
Typ. Boulder Diameter (in)	Number in 126 ft of length
36-48	20
30-36	30
24-30	76
Total	126

Step Pool Stream Sections (104+15 to 105+68 and 106+94 to 108+15)

1. Step-pool Weir Structures shall be placed at downstream end of Step-Pool Sections (Stations 104+15 and 106+94)
2. Armored cobble area shall be constructed using Substrate Rock Gradation in Note 5, above.
3. Weir rock shall be placed in proportions shown in Boulder Sizing in Note 6, above.
4. All rock for this construction shall be from on-site sources
5. Riparian Plantings shall be placed in the 6 ft. wide stream bank areas as shown on the plans, and shall include the following plant list:
   a. 175 Willow cuttings from native plants near Canyon Creek.
   b. 45 Red Osier Dogwood
   c. 200 Native Sedge
   d. 200 Native Rush

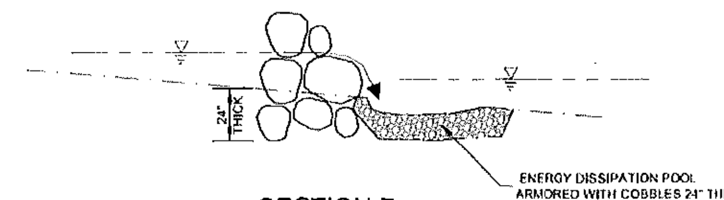


SECTION A

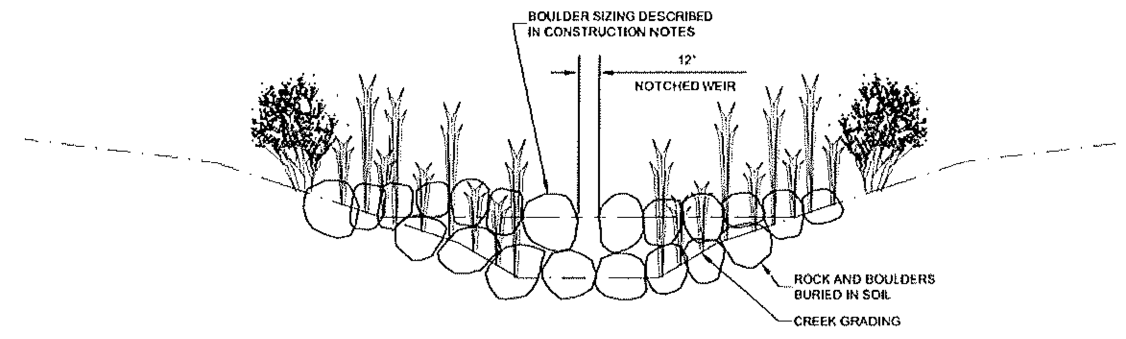


PLAN VIEW

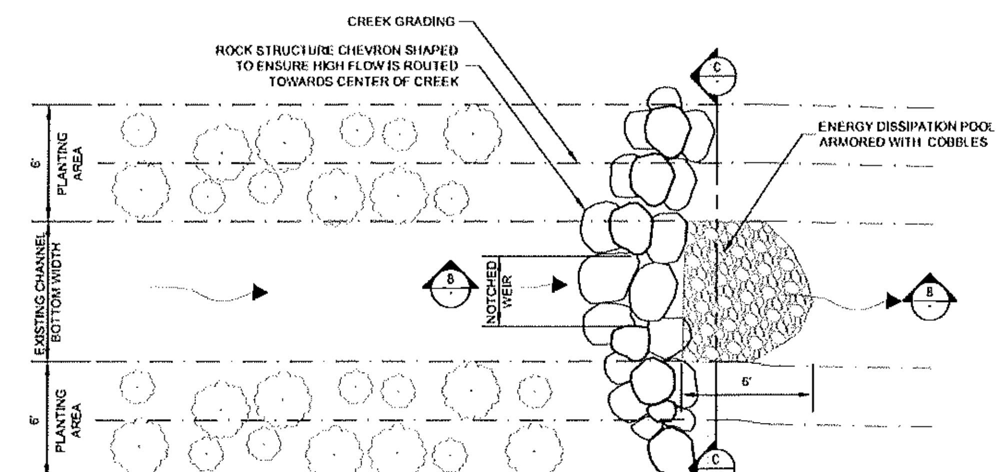
1 CASCADE STREAM DETAIL
NOT TO SCALE



SECTION B



SECTION C



PLAN VIEW

2 STEP-POOL STREAM DETAIL
NOT TO SCALE

OREGON DEPARTMENT OF FISH AND WILDLIFE
MALHEUR NATIONAL FOREST

REV #	DESCRIPTION	BY	DATE

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STREAM RESTORATION DETAILS
CANYON CREEK MEADOWS DAM REMOVAL

SHEET C-5

TECHNICAL SPECIFICATIONS

CES A valmont COMPANY
Conserving Resources. Improving Life.

Oregon Department of Fish and Wildlife

Canyon Creek Meadows Dam Removal Project

(PN: 2923018)

Technical Specifications

CES A valmont COMPANY
Conserving Resources. Improving Life.

TECHNICAL SPECIFICATION INDEX

OREGON DEPARTMENT OF FISH AND WILDLIFE
CANYON CREEK MEADOWS DAM REMOVAL PROJECT

DIVISION 01 - GENERAL

DIVISION 02 - SITEWORK

DIVISION 01

SECTION 01090

MOBILIZATAION

PART 1 - GENERAL

This item is intended to compensate the Contractor for operations including, but not limited to, those necessary for the movement of personnel, equipment, supplies, and incidentals to the project site; for payment of premiums for bonds and insurance for the project; and for any other work and operations which must be performed or costs that must be incurred incident to the initiation of meaningful work at the site and for which payment is not otherwise provided for under the contract.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

DIVISION 01

SECTION 01110

SUMMARY OF WORK

PART 1 - GENERAL

1.1 Summary

A. Description of Work: Furnishing labor, equipment, supplies, and materials to remove the dam and appurtenances, install step pools, and route Canyon Creek into an energy dissipation streambed section.

B. Project Work Description: The work will consist of, but not be limited to (1) dewatering an area of the Canyon Creek as necessary to gain access to the stream bed; (2) removing the existing rock dam; (3) demolishing and removing the water intake structure; (4) demolishing and removing the spillway piping and structure; (5) constructing the stream bed with step pools; and (6) restoring the surface area.

C. The total price for each item or task of the project shall cover all work shown on the Drawings, Technical Specifications, and other Contract Documents. All costs in connection with the work, including furnishing all materials, equipment, supplies, and appurtenances; providing all construction equipment, tools, incidentals; and performing all necessary labor and supervision to fully complete the work, shall be negotiated prior to starting work.

PART 2 - PRODUCTS

2.1 General

Materials for the work shall generally be obtained from approved borrow sources on site.

2.2 Incidentals

Incidentals are work activities for which there is no additional charge to the OWNER. The cost of all such incidentals shall be included in various related budget items negotiated with the CONTRACTOR.

PART 3 - EXECUTION

Work required under this contract shall be as detailed in the following items.

3.1 Mobilization/Demobilization

A. General: The work includes those actions necessary for the transportation and movement of personnel, equipment, supplies and incidentals to the project site; necessary permits; the establishment of all offices and facilities necessary to work on the project; traffic control; and other work and operations that must be performed, or costs incurred, before beginning work on the various items on the project site.

B. Work Included:

1. Prepare and submit a Work Schedule, a Work Plan that includes dewatering approach, Contractor's Company Health and Safety Plan, and certification that Contractor has reviewed and understands all existing regulatory permits for the project; and
2. Provide all labor, tools, equipment, materials, and incidentals necessary to complete the work as specified.

3.2 Work Area Dewatering

The area designated for the water intake structure will be dewatered in accordance with the design plans and Best Management Practices. Dewatering will continue in this area until work is complete.

3.3 Dam Removal

A. General: Excavate the rock dam to lines and grades shown on Drawings. Stockpile materials as shown on Drawings.

B. Demolish and remove the intake structure, spillway piping, and other materials and stockpile as shown on Drawings.

3.4 Construct new stream bed with step pools

Construct streambed with step pools and cascade sections as shown on Drawings.

3.5 Site Restoration

Upon the completion of all the civil work, the contractor shall grade the site to grade. Seed all areas designated by the ENGINEER.

END OF SECTION

DIVISION 01

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.1 Description

Make submittals to the OWNER or Designated Representative.

1.2 Shop Drawings

A. Verify all dimensions, sizes and quantities and see that all items fit properly into the work.

B. Provide a schedule of shop drawings and product data submittal dates within 15 days after award of the CONTRACT.

C. Submit shop drawings and product data on or before the dates specified in the schedule accepted by the ENGINEER in accordance with the following procedure:

1. Submit bound copies of shop drawings and program data.
2. For shop drawings and product data, submit a minimum of two (2) copies.
3. Submit all items from each section of the work at one time if possible, but do not delay submittals for lack of one or two items.

1.3 Contractor's Approval

The OWNER or Designated Representative will not review the submittal unless the CONTRACTOR has first reviewed the supplier's submittal and given written approval using a stamp with the date reviewed and the reviewer's name written in ink. The CONTRACTOR shall clearly denote all submittal exceptions to the Drawings and specifications.

1.4 Review

The OWNER or Designated Representative will review the required submittals and indicate his opinion and the action to be taken. No work shall be done or equipment purchased until the engineering review of submittals is completed and accepted by the OWNER.

Note: The submittal notes and approval does not authorize any increase in cost for the approved item, installation or related coordination.

1.5 Samples

Submit samples to the OWNER or Designated Representative for review, as required by the specifications and in accordance with the following procedures:

Make or provide samples of actual size where possible and of the specified type, material and finish. Unless otherwise noted, submit two samples of each item to be approved for color or material.

END OF SECTION

DIVISION 01

SECTION 01800

ENVIRONMENTAL PROTECTION

PART 1 - GENERAL

1.1 Description

A. The CONTRACTOR shall undertake environmental protection measures to ensure that spills, construction debris, and sediment do not contaminate or damage the environment.

B. The work shall also comply with all other applicable environmental regulations, including federal, state, and local requirements related to air quality, water quality, and hazardous material management.

C. Contractor shall prepare a Stormwater Pollution Prevention Plan (SWPPP) in accordance with US Environmental Protection Agency (EPA) guidelines and requirements for construction activities.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 General

A. The CONTRACTOR shall meet all applicable requirements of the contract documents, as well as any permit requirements related to protection of the environment.

B. CONTRACTOR work methods shall be such as to minimize disturbances to the environment.

3.2 Erosion and Sediment Control

A. All required sedimentation/erosion control facilities must be constructed and in operation prior to clearing and/or other construction to ensure that sediment-laden water does not flow off-site. All erosion and sediment facilities shall be maintained in a satisfactory condition until such time that clearing and/or construction is completed and potential for on-site erosion has passed. The CONTRACTOR shall be responsible for the design implementation, maintenance, replacement, and additions to erosion/sedimentation control systems.

B. The CONTRACTOR shall submit an erosion/sedimentation control plan for review by the OWNER that meets the requirements of a SWPPP under EPA guidelines. It shall be the CONTRACTOR'S obligation and responsibility to revise or modify the erosion control facilities to meet any new conditions that may be created by the CONTRACTOR'S activities and to provide additional facilities, over and above the minimum requirements, as may be needed to protect adjacent properties and water quality of the receiving drainage system.

C. Review of the erosion/sedimentation control plan by the OWNER does not remove any responsibility of the CONTRACTOR.

3.3 Spill Prevention Plan

The CONTRACTOR shall prepare and submit for a review a spill prevention/emergency response plan specific to the project needs. The plan shall, at a minimum, meet the requirements defined herein. All requirements of the State of Oregon, EPA, OWNER, and any other agency having jurisdiction over the environment shall be met by the plan.

END OF SECTION

DIVISION 02

SECTION 02100

SITE PREPARATION

PART 1 - GENERAL

1.1 The Requirements

The work of this Section includes all those measures required during the CONTRACTOR'S move onto the site for clearing, grubbing and stripping.

1.2 Site Inspection

Prior to moving onto the project site, the CONTRACTOR shall visit and inspect site conditions, pipeline routes, and related facilities, including property, right-of-way lines, easements and limits of construction.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Clearing, Grubbing, and Stripping

A. Within the limits of construction (excavation are, stream restoration area, and stockpile), areas requiring grading, excavation or other improvements shall be cleared of shrubs, roots, brush, grass and weeds to a minimum of twelve (12) inches, or the depth required to remove all unsuitable materials, and cleared of structures, concrete or masonry debris, upturned stumps, loose boulders and any other objectionable material of any kind that could interfere with the performance or completion of the work, create a hazard to safety, or impair the work's subsequent usefulness or obstruct its operation. Natural vegetation outside the limits of construction shall be protected from damage during construction.

B. Within the limits of clearing, the areas below the natural ground surface shall be grubbed to a depth necessary to remove all stumps, roots, and all other objectionable material. All objectionable material from the clearing and grubbing process shall be removed from the Site and wasted in approved safe locations.

END OF SECTION

DIVISION 02

SECTION 02130

CLEARING AND GRUBBING

PART 1 - GENERAL

1.1 Description

This item shall consist of clearing, grubbing, removing and disposing of all vegetation, dead woody material, and debris within the clearing limits except objects designated to remain. Specifications for other items may refer to these specifications.

1.2 Areas to be Cleared and Grubbed

The limits of clearing and grubbing will be established by this Section, by other Section items, or on the Drawings. The clearing and grubbing limits will normally coincide with the designated working limits, however, the ENGINEER may also designate individual trees and snags outside the clearing limits for selective removal and disposal, or he may designate areas within the working limits where clearing and grubbing is not required or allowed within the provisions of this specification.

A. Grading Limits: Area that is to be excavated or covered with additional materials during construction.

B. Working Limits: Area consisting of the grading limits plus room for equipment to maneuver to perform the necessary clearing and grubbing. These limits, to be held to a minimum, will be designated for each project.

C. Clearing Limits: Area consisting of the working limits plus any additional area for a boom or other above ground clearance requirement.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 General

Clearing and grubbing shall be confined to designated areas. The ENGINEER will designate the trees, shrubs, and other plants and objects to remain. The CONTRACTOR is to keep the clearing to a minimum and to exercise care to not damage trees and shrubbery within clearing limits when there is no reason for grubbing.

3.2 Felling

Trees shall be felled within the clearing limits, usually towards the center, to prevent damage to the trees that are to be left standing. When necessary to prevent damage to structures, other trees or property, or to minimize danger to traffic, trees shall be cut in sections from the top downward.

3.3 Clearing Area Within Grading Limits

Clearing shall consist of the removal of all biodegradable material (trees, snags, shrubs, brush, dead woody debris, or plants). Branches of trees extending over the grading limits shall be trimmed.

3.4 Grubbing Area Within Grading Limits

A. Embankment Areas - In embankment sections where the total depth of fill will be less than three feet above undisturbed earth, grubbing shall consist of the removal of all biodegradable material (stumps, roots larger than two inches in diameter, matted roots, duff, and other protruding or surface objects). The resulting depressions shall be filled and compacted with material specified for the embankment.

   In embankment sections where the total depth of fill will be three feet or greater above undisturbed earth, all loose biodegradable material shall be removed. Undisturbed stumps, roots, and nonperishable solid objects which will be a minimum of three feet below the finished surface of embankments, except those in embankments designed to impound water, need not be removed. The stumps that remain shall be cut off not more than six inches above the original ground line.

B. Areas to be Excavated - In cut sections, the removal of stumps and roots shall be done to such depth that in no case will any portion remaining extend closer than 18 inches to any subgrade or slope surface.

3.5 Area Outside Grading Limits but within Clearing Limits

On areas designated for clearing and grubbing outside of the grading limits, stumps may be cut within four inches of the ground and left, in lieu of being removed. All trees, shrubs, and other protruding or surface objects shall be cleared, except the vegetation and objects designated to remain.

3.6 Trimming of Trees

All required trimming shall be done in accordance with approved horticultural practices.

3.7 Timber Used by the Contractor

Timber cut from within the clearing limits, meeting specification requirements, may be utilized by the CONTRACTOR for constructing temporary structures, false-work, etc., as required in the project and also for camp purposes, provided written authorization for such use is obtained from the ENGINEER.

3.8 Timber to be Saved

A. All sound, green logs or poles, not used by the CONTRACTOR in the project, having a top diameter of two inches or more and a length of four feet or more, as determined by the ENGINEER, shall be saved. Material to be saved shall be trimmed of limbs and tops, sawed into such lengths designated below, and stacked in an area readily accessible for loading and hauling equipment, and where they will not interfere with the grading. Skidding timber outside staked working limits will not be approved.

B. All timber designated to be saved will be cut as follows:

1. Logs over 15 inches in diameter are to be cut in eight-foot lengths.
2. Logs with diameters between eight inches and 15 inches will be cut in 12-foot lengths.
3. Limbs, treetops, etc., from two inches to eight inches in diameter will be cut in maximum four-foot lengths (two-foot lengths within campground areas).

C. Title to all such timber cut from National Forest land shall remain with the United States, subject to disposal by the Forest Service, U.S. Department of Agriculture, in accordance with its regular procedures, unless otherwise specified.

3.9 Protection of Adjacent Plant Life

Construction work shall disturb a minimum of the existing terrain and plant life adjacent to the grading limits. Only trees, shrubs, stumps, and major roots, which interfere, may be removed. When excavation reveals the major roots of a live and significant tree nearby, the CONTRACTOR shall not remove the tree unless it interferes with the construction and removal is authorized by the ENGINEER.

3.10 Disposal of Refuse

Debris and refuse shall be disposed of as directed by ENGINEER or stockpiled onsite to be used as part of the reclamation activities.

END OF SECTION

DIVISION 02

SECTION 02135

WASTE MATERIAL DISPOSAL

PART 1 - GENERAL

1.1 Description

This item shall consist of the loading, handling, transporting, and placing of excess excavation material and construction debris. The waste disposal area shall be shown on the Drawings or designated by the ENGINEER.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

All excavated material not used in the construction of embankments, backfilling of trenches, or other specified areas within the project limits, along with clearing debris, shall be hauled to the designated disposal area. After this material has been hauled to the disposal area, the piled material shall be sloped to 2:1 or flatter. The size and shape of the piled waste material shall be designated by the ENGINEER.

END OF SECTION

DIVISION 02

SECTION 02200

EARTHWORK

PART 1 - GENERAL

1.1 The Requirement

The CONTRACTOR shall perform all earthwork indicated and required for construction of the work, complete and in place, in accordance with the contract documents.

1.2 Contractor Submittals

The CONTRACTOR shall submit samples of all materials proposed to be used in the work. Sample sizes shall be as determined by the testing laboratory.

PART 2 - PRODUCTS

2.1 Suitable Fill and Backfill Material Requirements

A. General: Fill, backfill, and embankment materials shall be suitable selected or processed clean, fine earth, rock, or sand, free from grass, roots, brush, or other vegetation.

B. Fill and backfill materials to be placed within 12 inches of any structure or pipe shall be free of rocks or unbroken masses of earth materials having a maximum dimension larger than 3 inches.

C. Materials not defined as unsuitable below (PART 2.2) are defined as suitable materials and may be used in fills, backfilling, and embankment construction subject to the indicated limitations. In addition, when acceptable to the ENGINEER, some of the material listed as unsuitable may be used when thoroughly mixed with suitable material to form a stable composite.

D. Suitable materials may be obtained from on-site excavations, may be processed on-site materials, or may be imported. If imported materials are required by this Section, or to meet the quantity requirements of the project, the CONTRACTOR shall provide the imported materials at no additional expense to the OWNER, unless a unit price item is included for imported materials in the bidding schedule.

E. The following types of suitable materials are defined:

1. Type A (Bedding for Flexible Pipes): Bedding material for pipe shall be well-graded, clean, granular material. Material shall have 100 percent passing a 3/8-inch sieve and not more than 8 percent passing a no. 200 sieve, and have a minimum sand equivalent of 50.

2. Type C (Clean-washed Sand): Uniformly graded sand with 100 percent passing a No. 10 sieve, at least 90 percent passing a No. 20 sieve, less than 2 percent passing the No. 200 sieve, and a sand equivalent value not less than 80.

3. Type D (Imported Backfill) durable crushed gravel or rock; or naturally occurring sands and gravels free from wood, bark, roots or other extraneous material, meeting the requirements for aggregate for gravel base, with the percent passing the No. 200 sieve limited to 5% maximum.

F. Gravel base shall consist of granular material, either naturally occurring or processed. It shall be essentially free from various types of wood waste or other extraneous or objectionable materials. It shall have such characteristics of size and shape that it will compact readily and shall meet the following test requirements:

Stabilometer "R" Value 72 min.

Swell pressure 0.3-psi max.

1. The maximum particle size shall not exceed 2/3 of the depth of the layer being placed. Gravel base shall meet the following requirements for grading and quality when placed in hauling vehicles for delivery to the roadway or during manufacture and placement into a temporary stockpile. The exact point of acceptance will be determined by the ENGINEER.

Sieve Size	**Percent Passing**
2" square	75-100
US No. 4	22-100
US No. 200	0-10
Dust Ratio: % Passing US No. 200; % Passing US No. 40	2/3 max
Sand Equivalent	27 min

All percentages are by weight.

2. Gravel base material retained on a U.S. No. 4 sieve shall note contain more than 0.20% by weight of wood waste.

   a. Type E (Structural Over-excavation Backfill): Fractured rock meeting the requirements of crushed surfacing base course as in Section G below.

   b. Type F (Drain rock): Crushed rock or gravel meeting the following gradation requirements:

Sieve Size	**Percent Passing**
2-inch	100
1.5-inch	90-100
1-inch	20-55
¾-inch	0-15
No. 200	0-3

   c. Type G (Aggregate Base): Crushed surfacing shall be manufactured from ledge rock, talus, or gravel. The materials shall be uniform in quality and substantially free from wood, roots, bark, and other extraneous material and shall meet the following test requirements:

Los Angeles Wear, 500 Rev	35% max
Degradation Factor — Top Course	25 min
Degradation Factor — Base Course	15 min

G. Crushed surfacing of the various classes shall meet the following requirements for grading and quality when placed in hauling vehicles for delivery to the roadway, or during manufacture and placement into a temporary stockpile. The ENGINEER will determine the exact point of acceptance.

Sieve Size	Base Course (Type G)	Top Course and Keystone (Type H)
	Percent Passing	
1 ¼" square	100	
1" square	80-100	
¾" square		100
5/8" square	50-80	
½" square		90-100
U.S. No. 4	25-45	46-66
U.S. No. 40	3-18	8-24
U.S. No. 200	7.5 max	10.0 max
% Fracture	75 min	75 min
Sand Equivalent	32 min	32 min

All percentages are by weight.

H. The fracture requirement shall be at least one fractured face and will apply to material retained on each specification sieve size U.S. No. 10 and above if that sieve retains more than 5 percent of the total sample.

I. The portion of crushed surfacing retained on a U.S. No. 4 sieve shall not contain more than 0.15 percent wood waste.

1. Type H (Top Course Keystone): Top course keystone material shall be composed of hard, durable, sound pieces. Top course materials shall meet the requirements of crushed surface for Top Course and Keystone.
2. Type I (Native Material): Native materials will be considered suitable for use in backfilling if the material is not sensitive to moisture (compactable if moisture content is greater than optimum). Material shall be mineral earth with no deleterious or organic materials. All materials shall pass the 3-inch sieve.
3. Type J (6-inch Rip Rap): Type J material shall be 6-inch riprap. Riprap shall be graded rock having a range of individual rock weights as follows:

Weight Of Stone	Percent Smaller by Weight
10 Pounds	100
5 Pounds	80-100
2 Pounds	45-80
1 Pound	15-45
½ Pound	5-15
Below ½ Pound	0-5

Specific gravity shall be between 2.5 and 2.82.

4. Type K (Native Topsoil): Stockpiled topsoil material, which has been obtained at the site by removing soil to a depth not exceeding 6 inches. Removal of the topsoil shall be done after the area has been stripped of vegetation and debris. Native topsoil shall be free from sticks, rocks, trash, and other deleterious materials.

5. Type L (Controlled Density Fill [CDF]): Controlled density fill shall be a mixture of cement, fly ash, fine aggregates and water, conforming to the following proportions (CDF maximum compressive strength shall be 100 psi):

Material	Batch Weight/Cubic Yard
Mixing Water	50 lb / cu yd
Portland Cement	30 lb / cu yd
Fly Ash	200 lb / cu yd
Fine Aggregate	3200 lb / cu yd

Material requirements:

i. Portland Cement: Type I or II
ii. Fly Ash (mineral filler admixture): ASTM C618, Class F, or approved pozzolans
iii. Fine Aggregate: Coarse sand, 100% passing 3/8-inch sieve, 60-100% passing No. 4 sieve, and 0-5% passing No. 200 sieve
iv. Mix CDF in accordance with ASTM C94

6. Type M (Trench Plug): Low permeable fill material, a non-dispersible clay material having a minimum plasticity index of 10.

7. Type N (Bedding for Rigid Pipe): Type N material shall be well-graded, clean, granular gravel material, commonly known as pea gravel. Bedding material shall meet the following requirements:

U. S. Standard Sieve Size	Percent Passing
3/8-inch square opening	100
No. 8 sieve	0 - 5

8. Type P (Creek Bedding): As specified in plans.

2.2 Unsuitable Material

Unsuitable materials include the materials listed below:

A. Soils which, when classified under ASTM D 2487, fall in the classifications of peat (Pt), organic clay or organic silt (OH or OL), fat clay (CH), or elastic silt (MH).

B. Top soil; frozen materials; construction materials and materials subject to decomposition; clods of clay and stones larger than 3 inches; organic silts, too wet to be stable.

C. Soils, which cannot be compacted sufficiently to achieve the density, specified for the intended use.

D. Materials that contain hazardous or designated waste materials including petroleum hydrocarbons, pesticides, heavy metals, and any material which may be classified as hazardous or toxic according to applicable regulations.

E. Soils that contain greater concentrations of chloride or sulfate ions or have a soil resistivity or pH less than the existing on-site soils. Topsoil, except as allowed below.

2.3 Use of Fill, Backfill, and Embankment Material Types

A. The CONTRACTOR shall use the types of materials as designated herein on all required fill, backfill, and embankment construction hereunder.

B. Where these Specifications conflict with the requirements of any local agency having jurisdiction or with the requirements of a pipe material manufacturer, the ENGINEER shall be immediately notified. In case of conflict between types of bedding/backfills, the CONTRACTOR shall use the agency-specified material if that material provides a greater degree of structural support, as determined by the ENGINEER.

C. Fill and backfill types shall be used in accordance with the Fill/Backfill/Compaction Schedule presented in this section, supplemented as follows:

1. Where pipelines are installed on grades exceeding 4 percent, and where backfill materials are graded such that there is less than 10 percent passing a Number 4 sieve, trench plugs of Type M material shall be provided at maximum intervals of 200 feet unless indicated or otherwise noted on the Drawings.

2. Trench backfill and final backfill for pipelines under structures shall be the same material as used in the pipe zone, except where concrete encasement is required by the CONTRACT DOCUMENTS.

3. All structures, including vaults, manholes, sidewalks, etc. shall be constructed atop imported Type E gravel placed by over-excavation. Over-excavation shall be 6-inch minimum, greater where indicated in the Drawings.

4. The top 6 inches of fill on areas to receive landscaping or hydro seeding shall consist of Type K material, topsoil.

2.4 Materials Testing

A. All soils testing of samples submitted by the CONTRACTOR will be done by a testing laboratory of the OWNER'S choice and at the OWNER'S expense (passing tests only). At its discretion, the ENGINEER may request that the CONTRACTOR supply samples for testing of any material used in the work.

B. Particle size analysis of soils and aggregates will be performed using ASTM D 422 - Method for Particle-Size Analysis of Soils.

C. Determination of sand equivalent value will be performed using ASTM D 2419 - Test Method for Sand Equivalent Value of Soils and Fine Aggregate.

D. Unified Soil Classification System: References in this Section to soil classification types and standards shall have the meanings and definitions indicated in ASTM D 2487 -Classification of Soils for Engineering Purposes. The CONTRACTOR shall be bound by all applicable provisions of said ASTM D 2487 in the interpretation of soil classifications.

PART 3 - EXECUTION

3.1 Excavation – General

A. General: Except when specifically provided to the contrary, excavation shall include the removal of all materials of whatever nature encountered, including all obstructions of any nature that would interfere with the proper execution and completion of the WORK. The removal of said materials shall conform to the lines and grades indicated or ordered. Unless otherwise indicated, those areas that are to be excavated or filled shall be stripped of all vegetation and debris, and such material shall be removed from the site prior to performing any excavation or placing any fill. The CONTRACTOR shall furnish, place, and maintain all supports and shoring that may be required for the sides of the excavations. Excavations shall be sloped or otherwise supported in a safe manner in accordance with applicable State safety requirements and the requirements of OSHA Safety and Health Standards for Construction (29CFR1926). Sloped excavations shall not endanger any structures or adjacent landscaping or properties.

B. Dewatering: The CONTRACTOR shall remove and exclude water, including stormwater, groundwater, irrigation water, and wastewater, from all excavations. Water shall be removed and excluded until backfilling is complete and all field soils testing have been completed.

C. Excavation of Unsuitable Material: Where foundation conditions (soils) are not suitable for support of the pipe or structure, the unsuitable soils shall be removed to the depth required to obtain competent foundation conditions. When excavation of subgrade soils is required as a result of failure to dewater properly, the cost of the additional excavation will be borne by the CONTRACTOR. When the excavation of unsuitable material is not a result of improper construction methods by the

CONTRACTOR, the cost for the excavation and backfill will be paid for by the OWNER at a negotiated price.

1. Over-Excavation (shown): Where indicated to be over-excavated, excavation shall be to the depth indicated, and backfill shall be installed to the grade of the bottom of the pipe bedding and/or structure bedding.

2. Over-Excavation (not shown): When ordered by the ENGINEER, the subgrade shall be over-excavated beyond the depth and/or width shown. Such over-excavation shall be to the dimensions ordered. Backfill as follows:

   a. Pipe/Utility Trench Over-Excavation: The trench shall then be backfilled to the grade of the bottom of the pipe bedding. Over-excavation up to 6 inches below the limits on the Drawings shall be done at no increase in cost to the OWNER. When the over-excavation ordered by the ENGINEER is greater than 6 inches below the limits shown, additional payment will be made to the CONTRACTOR. Said addition payment will be made under separate unit price bid items for over-excavation if such bid items have been established; otherwise, payment will be made in accordance with a negotiated change order.

   b. Structure Over-Excavation: Over-excavation beyond that shown in the Drawings shall be as directed by the ENGINEER and shall be considered a change order.

3. Over-Excavation Not Ordered or Indicated: Any over-excavation carried below the grade ordered or indicated shall be backfilled to the required grade with the indicated material and compaction. Such work shall be performed by the CONTRACTOR at no additional cost to the OWNER.

D. Borrow: Earth for the construction of weirs may be obtained from areas indicated on the plans. Borrow areas shall be sloped to drain with minimum slope of 4 horizontal to 1 vertical. Disturbed areas, that are sloped, shall be hydroseeded to prevent erosion after completion of the work.

E. Notify local, One Number Locator Service, two working days in advance of performing excavation work.

3.2 Contingency Planning

A. Prior to construction, the CONTRACTOR shall also prepare a contingency plan to mitigate the effects of excessive settlement or movement of existing site features. The contingency plan is not to restrict the CONTRACTOR from using the best construction methods available to meet the conditions but is required to demonstrate a reasonable preparedness to mitigate the effects of excessive movement or settlement. The following are minimum requirements for a contingency plan:

1. The CONTRACTOR shall prepare a contingency plan, outlining steps to be taken to protect structures, utilities, or gas pipes and stop excessive movement or settlement identified by the settlement-monitoring program.

2. The CONTRACTOR shall have all material, manpower, equipment, and other items identified in the contingency plan available at all times while excavations are ongoing or excavated areas are open.

3.3 Structure, Roadway, and Embankment Excavation

A. Excavation for Structures: Excavation for structures shall extend to the bottom of the indicated subgrade (including required over-excavation). After such excavation has been completed, the exposed surface shall be brought to optimum moisture content, rolled with heavy compaction equipment to 95 percent of maximum density and then graded to provide a smooth surface for placement of the crushed rock.

B. Excavation for Paved Areas: Excavation for areas to be paved shall extend to the bottom of the aggregate base. After the required excavation has been completed, the top 12 inches of the exposed surface shall be scarified, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density. The finished subgrade shall be even, self-draining, and in conformance with the slope of the finished pavement. Areas that could accumulate standing water shall be re-graded to provide a self-draining subgrade, prior to finish grading.

C. Excavation for Embankments: Except where otherwise indicated for a particular embankment or ordered by the ENGINEER, excavation shall be carried to the subgrade elevation shown. Subgrade areas beneath embankments shall be excavated to remove not less than the top 12 inches of native material and where such subgrade is sloped, the native material shall be benched horizontally. After the required excavation or over-excavation has been completed, the exposed surface shall be scarified to a depth of 6 inches, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

D. Notification of ENGINEER: The CONTRACTOR shall notify the ENGINEER at least 3 days in advance of completion of any structure excavation and shall allow the ENGINEER a review period of at least one day before the exposed foundation is scarified and compacted or is covered with backfill or with any construction materials.

3.4 Pipeline and Utility Trench Excavation

A. General: Unless otherwise indicated or ordered, excavation for pipelines and utilities shall be open-cut trenches with widths as indicated in the typical trench section.

B. Trench Bottom: The bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe bedding. Excavations for pipe bells shall be made as required.

C. Trench Width: The maximum trench width will be limited to the dimensions shown in the typical pipe trench section in the Drawings. Trenches shall be kept as vertical as possible, yet meeting the trench safety shoring requirements to avoid conflicts with existing structures or waterways (wetland boundaries).

D. Open Trench: The maximum amount of open trench permitted in any one working location shall be 200 feet in populated areas. Trenches shall be fully backfilled at the end of each day or, in lieu thereof, shall be covered by heavy steel plates adequately braced and capable of supporting vehicular traffic in those locations where it is impractical to backfill at the end of each day. Trenches in agricultural fields where construction activities are controlled access will be allowed to remain open over night, not to exceed three continuous days.

E. Where pipelines are to be installed in embankments, or structure backfills, the fill shall be constructed to a level at least one foot above the top of the pipe before the trench is excavated.

F. If a moveable trench shield is used during excavation operations, the trench width shall be just wider than the shield so that the shield is free to be lifted and then moved horizontally without binding against the trench sidewalls. If the trench walls cave in or slough, the trench shall be excavated as an open excavation with sloped sidewalls or with trench shoring.

3.5 Disposal of Excess Excavated Material

A. The CONTRACTOR shall remove and dispose of all excess excavated material on site in an area designated by the ENGINEER.

B. The CONTRACTOR shall obtain all required permits, landowner, and agency approvals for disposal of excess excavated material and shall pay all costs associated with the removal and disposal.

3.6 Backfill – General

A. Backfill shall not be dropped directly upon any structure or pipe. Backfill shall not be placed around or upon any structure until the concrete has attained sufficient strength to withstand the loads imposed. Proof of the load-carrying capacity of the new concrete will be required of the CONTRACTOR for backfill prior to the 28-day concrete strength tests (cylinder breaks).

B. Backfill shall be placed after all water is removed from the excavation, and the trench sidewalls and bottom have been dried to moisture content suitable for compaction.

C. If a moveable trench shield is used during excavation, pipe installation, and backfill operations, the shield shall be moved by lifting the shield free of the trench bottom or backfill and then moving the shield horizontally, The CONTRACTOR shall not drag trench shields along the trench causing damage or displacement to the trench sidewalls, the pipe, or the bedding and backfill.

D. Immediately prior to placement of backfill materials, the bottoms and sidewalls of trenches and structure excavations shall have all loose soil and rock materials removed. Trench sidewalls shall consist of excavated surfaces that are in a relatively undisturbed condition before placement of backfill materials.

3.7 Placing and Spreading of Backfill Materials – General

A. Backfill materials shall be placed and spread evenly in layers. The layers shall be evenly spread so that when compacted, each layer shall not exceed 12 inches in uncompacted thickness.

B. During spreading, each layer shall be thoroughly mixed as necessary to promote uniformity of material in each layer. Pipe zone backfill materials shall be manually spread around the pipe so that when compacted, the pipe zone backfill will provide uniform bearing and side support.

C. Where the backfill material moisture content is below the optimum moisture content, water shall be added before or during spreading until the proper moisture content is achieved.

D. Where the backfill material moisture content is too high to permit the specified degree of compaction the material shall be dried until the moisture content is satisfactory.

3.8 Placement and Compaction of Fill, Backfill, and Embankment

A. Each layer of backfill materials as defined herein, where the material is graded such that at least 10 percent passes a No. 4 sieve, shall be mechanically compacted to the indicated percentage of density. Equipment that is consistently capable of achieving the required degree of compaction shall be used and each layer shall be compacted over its entire area while the material is at the required moisture content.

B. Each layer of Type C, K and M backfill materials shall be compacted by means of at least 2 passes from a flat plate vibratory compactor.

C. Flooding, ponding, or jetting shall not be used for work on this project.

D. Equipment weighing more than 10,000 pounds shall not be used closer to structure walls than a horizontal distance equal to the depth of the fill at that time. Hand operated power compaction equipment shall be used where use of heavier equipment is impractical or restricted due to weight limitations.

E. Backfill around and over pipelines shall be compacted using light, vibratory compactors and rollers. After completion of at least two feet of compacted backfill over the top of pipeline, compaction equipment weighing no more than 8,000 pounds may be used to complete the trench backfill.

F. Placement and Compaction of Materials: Placement and compaction of fill, backfill, and embankment materials shall comply with the following Table 02200-1.

TABLE 02200-1
FILL/BACKFILL / COMPACTION SCHEDULE

Location or Use of Fill	Backfill Material Type$^{(1)(2)}$	Percentage of Maximum Density$^{(2)}$
Pipe over-excavation zones under bedding for flexible pipe, including trench plugs	G	90
Pipe trench initial backfill for plastic pipe	A	90
Pipe trench initial backfill for rigid pipe (DI, steel, and RCP)	N	90
Pipe trench subsequent backfill	D, H, or I$^{(3)}$	90
Pipe trench final backfill, not beneath paved areas, gravel surfacing, or structures	l or D	90
Pipe trench final backfill beneath paved areas, gravel surfacing, or structures	D	95
Trench plug	M	85
Pipe Trench Bedding	A	95
Aggregate base	G	95
Aggregate top coarse	H	95
Backfill beneath structures	E	95
Embankments and fills for Impoundment	I	95
Topsoil	K	80
Gravel roadway and other gravel surfacing	G or H	95

Notes:

(1) Type I material must be approved by ENGINEER prior to use in the work.

(2) Where a utility or permitting agency or project plans specifies different materials or higher levels of compaction for specific portions of the work, those requirements shall take precedent.

(3) In agricultural fields type I material can be used. After bedding the pipe, fill may be uncompacted except at roadway crossings and where pipe extends through or under canal sections.

3.9 Fill and Embankment Construction

A. The area where a fill or embankment is to be constructed shall be cleared of all vegetation, roots and foreign material. Following this, the surface shall be excavated to a depth of 12", moistened, scarified to a depth of 6 inches, and rolled or otherwise mechanically compacted. Embankment and fill material shall be placed and spread evenly in approximately horizontal layers. Each layer shall be moistened or aerated, as necessary. Unless otherwise approved by the ENGINEER, each layer shall not exceed 12 inches of uncompacted thickness.

B. When an embankment or fill is to be made and compacted against hillsides or fill slopes steeper than 5:1, the slopes of hillsides or fills shall be horizontally benched to key the embankment or fill to the underlying ground. A minimum of 12 inches of existing material normal to the slope of the hillside or fill shall be re-compacted as the embankment or fill is brought up in layers. Material thus cut shall be re-compacted along with the new material at no additional cost to the OWNER.

C. Where embankment or structure fills are constructed over pipelines, the first 4 feet of fill over the pipe shall be constructed using light placement and compaction equipment that does not damage the pipe. Heavy construction equipment shall maintain a minimum distance from the edge of the trench equal to the depth of the trench until at least 4 feet of fill over the pipe has been completed.

3.10 Pipe and Utility Trench Backfill

A. After compacting the backfill to the level of the pipe bottom, the CONTRACTOR shall perform a final trim using a stringline for establishing grade, such that each pipe section when first laid will be continually in contact with the bedding along the extreme bottom of the pipe. Excavation for pipe bells shall be made as required.

B. The pipe zone shall be backfilled with the indicated backfill material. The CONTRACTOR shall exercise care to prevent damage to the pipeline coating, and the pipe itself during the installation and backfill operations.

C. If a movable trench shield is used during backfill operations, the shield shall be lifted to a location above each layer of backfill material prior to compaction of the layer. The CONTRACTOR shall not displace the pipe or backfill while the shield is being moved.

D. Agricultural field backfill may be mounded for the top one foot if approved by the ENGINEER.

3.11 Field Testing

A. General: All field soils testing will be done by a testing laboratory of the OWNER'S choice at the OWNER'S expense except as indicated below. Compaction testing results shall comply with Paragraph 02200 - 3.8 F.

B. Where soil material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content will be determined in accordance with Method C of ASTM D1557. Where cohesionless, free draining soil material is required to be compacted to a percentage of relative density, the calculation of relative density will be determined in accordance with ASTM D 4253 and D 4254. Field density in-place tests will be performed in accordance with ASTM D 1556 - Test Method for Density of Soil in Place by the Sand-Cone Method, ASTM D 2922 - Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth), or by such other means acceptable to the ENGINEER. Moisture content of the soil (soil-aggregate) mixture will be determined using ASTM D-3017 Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (shallow depth), or by using ASTM D-2216 - Method of Laboratory Determination of Water (Moisture) Content of Soil, Rock and Soil-Aggregates. The ENGINEER must approve any other test methods prior to use.

C. In case the test of the fill or backfill show non-compliance with the required density, the CONTRACTOR shall accomplish such remedy as may be required to insure compliance. Subsequent testing to show compliance shall be by a testing laboratory selected by the OWNER and shall be at no additional cost to the OWNER (i.e. the CONTRACTOR shall pay for retesting of failed tests).

D. The CONTRACTOR shall provide test trenches and excavations including excavation, trench support, and groundwater removal for the OWNER'S field soils testing operations. The trenches and excavations shall be provided at the locations and to the depths required by the OWNER. All work for test trenches and excavations shall be provided at no additional cost to the OWNER.

END OF SECTION

DIVISION 02

SECTION 02801

SEEDING

1.0 GENERAL

1.1 Description

A. This item shall consist of broadcast seeding designated areas using specified seed mixtures with fertilizer.

B. The areas to be seeded shall be all cut slopes, fill slopes and other disturbed areas, and as designated on the Drawings.

PART 2 - PRODUCTS

2.1 Seed

The seed mix shall be as shown on the Drawings.

2.2 Fertilizer

A. The fertilizer shall be 16% total nitrogen, 16% available phosphoric acid, 16% total water soluble potash, and 20% sulfur applied at the rate of 200 pounds per acre.

B. Fertilizer shall be dry, free-flowing type suitable for application with broadcast seeding. It shall be a standard commercial fertilizer supplied separately or in mixtures in standard containers with name, weight, and guaranteed analysis of contents clearly marked. Fertilizer that has become wet or otherwise damaged in transit or storage will not be accepted.

2.3 Mulch

Mulch shall consist of 100% agricultural straw certified as weed free.

PART 3 - EXECUTION

3.1 General

A. The specified seed mixture, with fertilizer, shall be uniformly spread on the designated areas to the density in pounds of live seed per acre as specified.

B. Each area, or suitable section of the area, to be seeded shall be seeded as soon as the grading and finishing work have been completed and the area prepared and approved for seeding. Seeding shall follow the finishing work as closely as feasible and, if possible, before the ground has become packed or hardened. No regard shall be given to the season of the year, except that no seeding shall be done during windy weather or when the ground is excessively wet or deeply frozen.

3.2 Preparation of Seeding Area

Cut slopes, fill slopes, embankments or other areas to be seeded shall be shaped and finished as specified under the Sections involved. The area, where necessary, shall be worked such that the surface is loose to a depth of at least one inch. Each area shall be approved for seeding by the ENGINEER before seed is applied.

3.3 Seeding and Mulching

A. The seed or seed mixtures, with or without fertilizer, shall be accurately proportioned as stipulated and thoroughly mixed. They shall be remixed as necessary so that a uniform mixture will result as each loading of the seeder is made. Seed, with fertilizer, shall be applied with a rotary hand seeder or other approved type commercial seeder or by an agreed upon method. All portions of the area shall be uniformly covered to the required density.

B. Mulch straw is to be applied at a depth of two to four inches using certified weed-free straw, except for areas located in shady areas, in which case mulching is not required. The CONTRACTOR shall install mulch on the embankment slopes and other exposed areas when they are finished seeding. All mulched areas will be thoroughly wetted following application. For slopes steeper than 2:1, mulch will be disked or spiked into the soil.

3.4 Maintenance of Seeded Area

A. The CONTRACTOR will not be required to maintain an area that has been satisfactorily seeded, except that the CONTRACTOR shall protect the area against traffic by warning signs, barricades or other methods approved by the ENGINEER.

B. When a seeded area has become damaged by a storm, or otherwise, prior to final acceptance of the project, the ENGINEER may order the area reworked. The damage shall then be repaired as directed and the area reseeded.

END OF SECTION

APPENDICES

Appendix A.

WEST Consultants - Hydrologic Analysis

Canyon Creek Meadows Dam and Reservoir
Hydrologic Analysis
(WEST Consultants, Inc.)

Executive Summary

A hydrologic analysis was conducted to characterize the impacts of the Canyon Creek Meadows Dam on existing and future hydrologic conditions of the Canyon Creek watershed. Three scenarios were assessed; 1) Existing conditions - leaving the outlet gate locked open and not allowing the reservoir to maintain a pool, 2) Dam removed - removal of the dam and storage area in order to pass flows downstream unimpeded, and 3) Dam repaired - repair of the dam such that the reservoir pool is maintained in the spring and summer recreation period and the outlet gate is set to maintain a minimum flow of approximately three cubic feet per second.

The hydrologic analysis for the Canyon Creek drainage basin was conducted using the Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS). The model was created to simulate the continuous hydrologic process that contributes to surface flows in order to estimate the discharges in the stream network. Rainfall, snowmelt, evapotranspiration, and temperature data were used to develop the model. The HEC-HMS model parameters were adjusted for the purpose of calibrating the model to streamflow data available within the watershed.

The results of the modeling were used to evaluate the magnitude of change in the downstream hydrology of the basin between the existing conditions and the two alternative scenarios. Specifically, annual flow-duration curves were developed for three locations including just below the dam, below the confluence with the Middle Fork, and below the confluence with the East Fork. The flow-duration curves were evaluated to help understand how the discharge exceedence probabilities are modified by the dam in its current conditions as well as under the dam repaired scenario and to understand how far downstream these modifications remain evident. Results of the flow-duration analysis indicate that the modifications to the downstream hydrology of Canyon Creek are greatest immediately downstream of the dam site and diminish in the downstream direction. Below the confluence with the East Fork, the flow-duration curves for the three scenarios are nearly identical.

The ability of the dam to provide flood control for the communities of Canyon City and John Day was analyzed. Annual peak discharge-frequency curves were developed downstream of the dam to understand if there is a statistical difference in the flood frequency relationships for the existing conditions and dam repaired scenario compared to the dam removed scenario. A statistical analysis was performed on the annual peak discharge results from the HEC-HMS model for various locations along Canyon Creek in order to estimate the discharge-frequency relationships for each scenario. Results of the analysis show that the flood frequency curves for the dam removed and dam repaired scenarios are slightly different than for the existing condition. However, the flood frequency curves for both scenarios fall within the 5- and 95-percent confidence limits of the existing conditions flood frequency curve. Therefore, there is considered to be no significant difference between the flood frequency relationships of the three scenarios evaluated. In other words, neither the existing dam nor the repaired dam provides a discernible flood control benefit.

Introduction

The Canyon Creek watershed is located in Grant County, Oregon. Canyon Creek originates on the southern slopes of the Strawberry Mountains and flows approximately 5 miles before reaching Canyon Creek Meadows Dam. It then travels another 24 miles to the confluence with the John Day River. It flows in a westerly direction for approximately 9 miles to the confluence with the Middle Fork of Canyon Creek. From this location, it flows in a northwesterly direction for 9 miles to the confluence with Vance Creek. From here, it travels north for 11 miles before entering the John Day River. The total drainage basin area at the confluence with the John Day River is 116 square miles. Figure 1 shows a map of the watershed. The basin is flanked by the Aldrich Mountains to the south and west and the Strawberry Mountains to the east. Canyon Creek Meadows Dam is 24 stream miles from the confluence with the John Day River and the contributing drainage area to the dam is 6.3 square miles.

Watershed Characteristics

General Characteristics

Canyon Creek watershed is primarily forested uplands, consisting of Ponderosa pine, Douglas fir, Grand fir, and Western juniper. Non-forested uplands and riparian areas are also present to a lesser extent. Irrigated agricultural land is present in the valley bottom lands. Approximately two square-miles of the basin are within the corporate limits of the City of John Day and Canyon City. Historic land use in the basin included placer mining, railroad logging and grazing large herds of sheep and cattle (USFS, 2003). Current land use within the Malheur National Forest includes timber management, outdoor recreational activities, and livestock grazing. Agriculture, livestock grazing, and residential land use predominates in the rural areas of private land ownership. Within the communities of John Day and Canyon City, land use is primarily urban, residential, and commercial uses.

Topography

The watershed varies in elevation from approximately 3,050 feet at the confluence to 7,999 feet at Canyon Mountain on the eastern boundary of the watershed. Canyon Creek Meadows Dam is at elevation 5,050 feet. Over half of the watershed relief ranges from 35-percent to 60-percent. (USFS 2003). Approximately 8-percent of the basin has a slope of 150-percent or greater and is located along the eastern boundary in the Strawberry Mountain range (USFS 2003). Topographic aspect varies in the basin as a result of the change of flow direction of Canyon Creek. From the headwaters to the confluence with Vance Creek, Canyon Creek generally flows in a westerly direction. In this reach, the terrain south of Canyon Creek slopes in a northerly direction; conversely north of Canyon Creek, the aspect is in a southerly direction. From the confluence of Vance Creek to the confluence with the John Day River, the creek flows to the north and the aspect changes to an east-west orientation.

Climate

The Canyon Creek watershed is located within the John Day River basin in the Blue Mountains of eastern Oregon. The climate is semi-arid and is characterized by moderate mean annual temperatures, with severe seasonal temperature extremes. The basin is in the rain shadow of the Cascade Range and moderated by prevailing westerly flow of maritime air from the Pacific Ocean, with occasional influxes of polar air masses causing brief periods of cold temperatures.

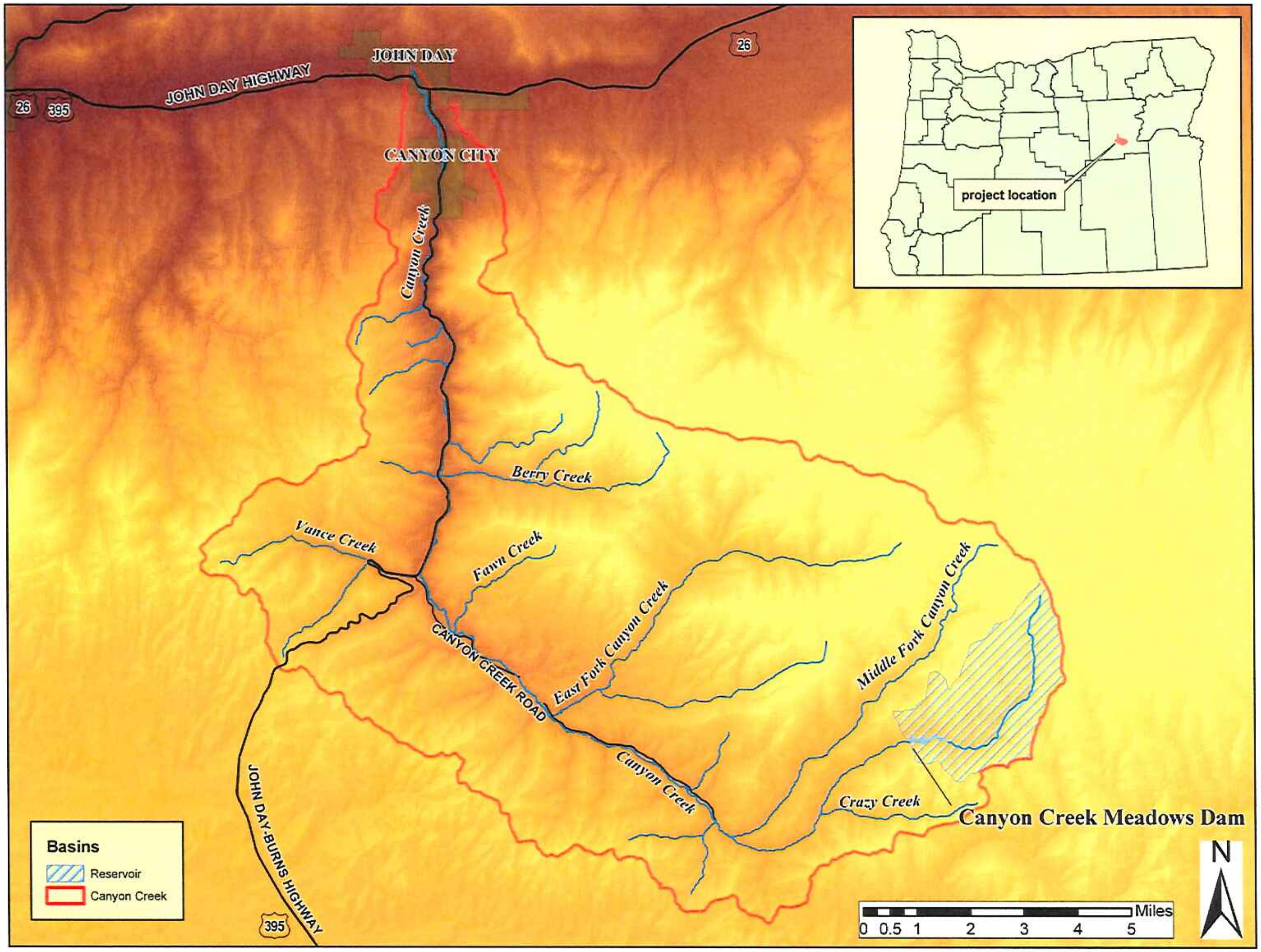

Figure 1. Canyon Creek Watershed and Canyon Creek Meadows Reservoir Sub-basin

The climate stations located in the Cities of John Day and Seneca provide typical climate conditions of the watershed. The City of John Day, at an elevation of 3,120 feet, is situated at the confluence of Canyon Creek and the John Day River. The City of Seneca is approximately 7 miles south of the Canyon Creek – Silvies River watershed divide and is at an elevation of 4,690 feet. Average minimum air temperatures occur in January for both stations; 9.0 °F in Seneca and 22.1 °F in John Day. Average maximum temperatures occur in July; 81.8 °F in Seneca and 88.4 °F in John Day. According to the PRISM Annual Precipitation Map, the mean annual precipitation over the watershed varies from approximately 13 inches for the City of John Day to 40 inches in the upper reaches of the watershed (OSU 2006). Figure 2 shows the monthly average precipitation for both climate stations. The largest amount of precipitation occurs in the months of April through June for John Day, with a seasonal average of 1.3 inches per month. The Seneca climate station, the greatest amount of precipitation occurs from November through January, and averages 1.5 inches per month. Figure 3 shows the location of the Seneca and John Day climate stations

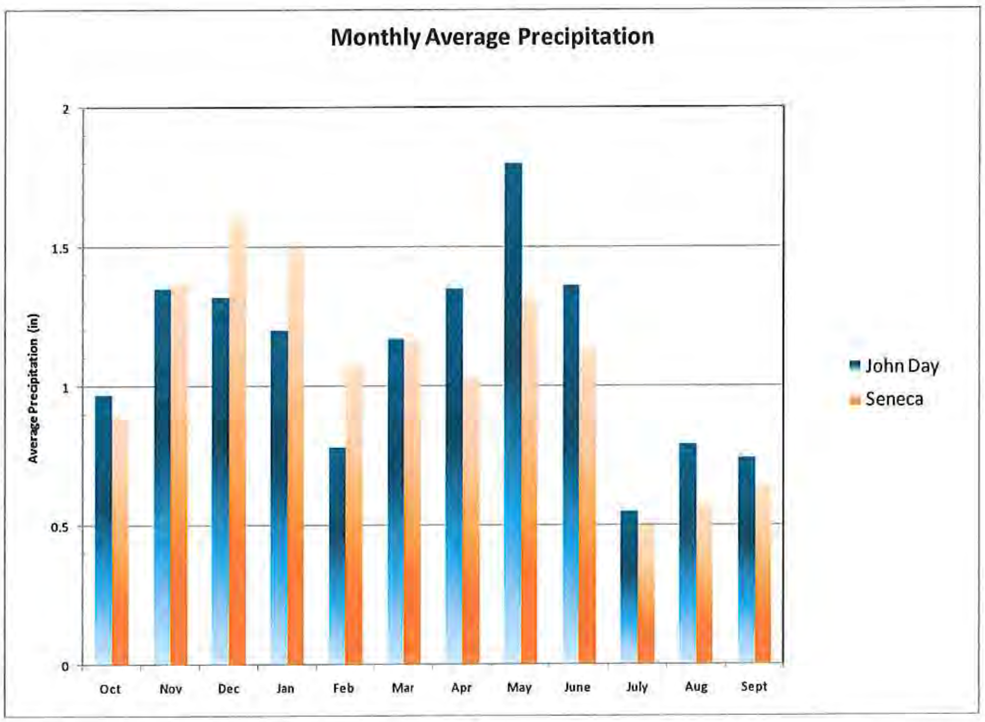

Figure 2. Monthly average precipitation for John Day and Seneca

Figure 4 shows the monthly average snowfall for both climate stations. As seen in Figure 4, the majority of the snowfall occurs in the months of December, January, and February. Due to it location at a greater elevation, the Seneca station receives a larger percentage of precipitation as snowfall than John Day. Monthly average cumulative snowpack for the Starr Ridge SNOTEL site is shown in Figure 5. The location of the Starr Ridge SNOTEL site is shown in Figure 3. As seen in Figure 5, snow typically begins to accumulate in the month of November, peaks in the month of February, then tapers off in March and April.

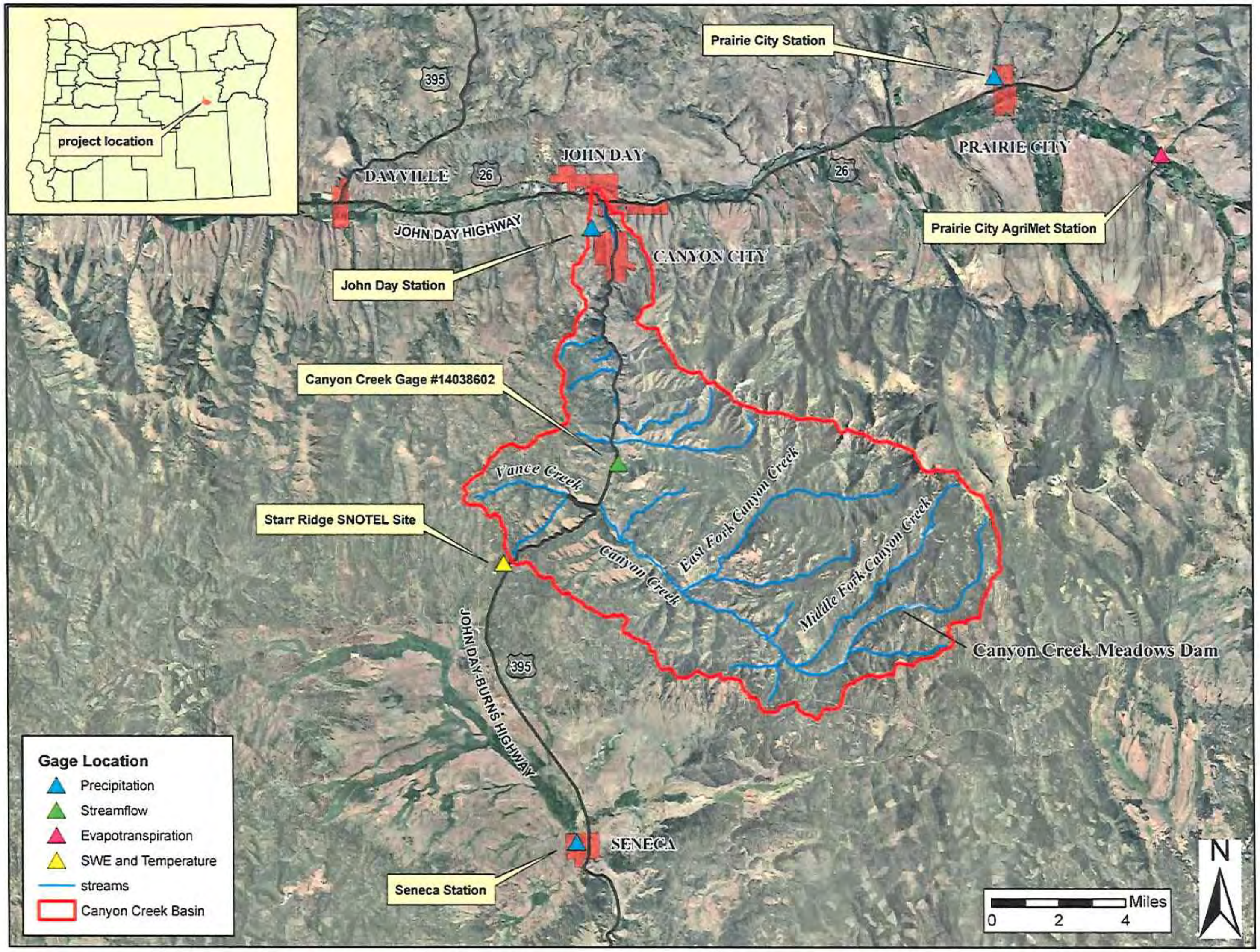

Figure 3. Location of Gage Stations used for hydrologic model development

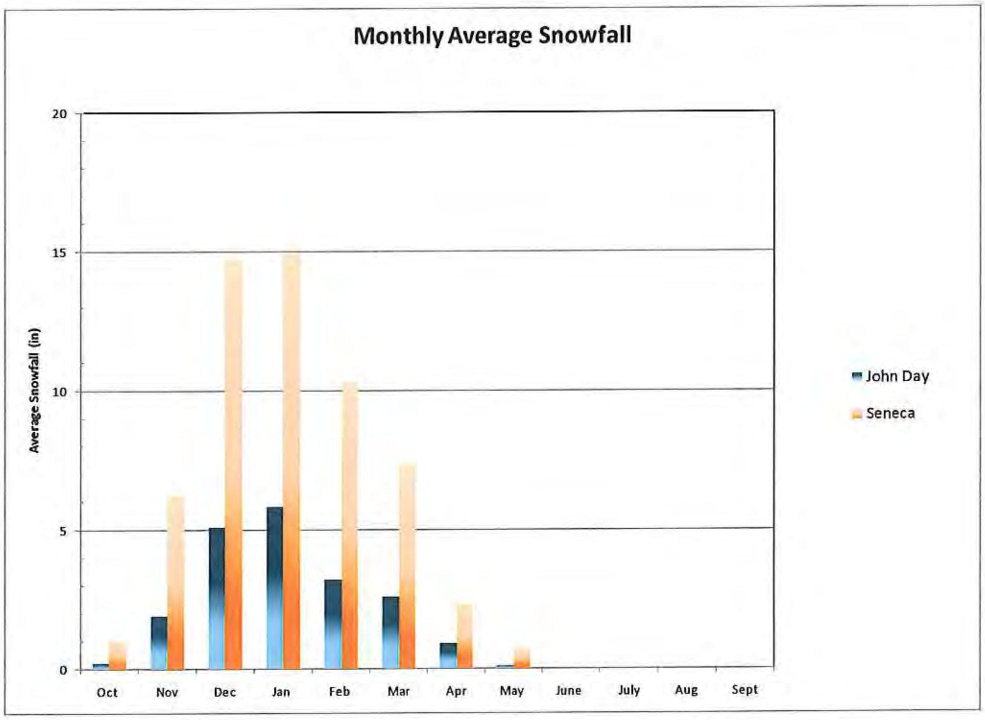

Figure 4. Monthly average Snowfall for John Day and Seneca

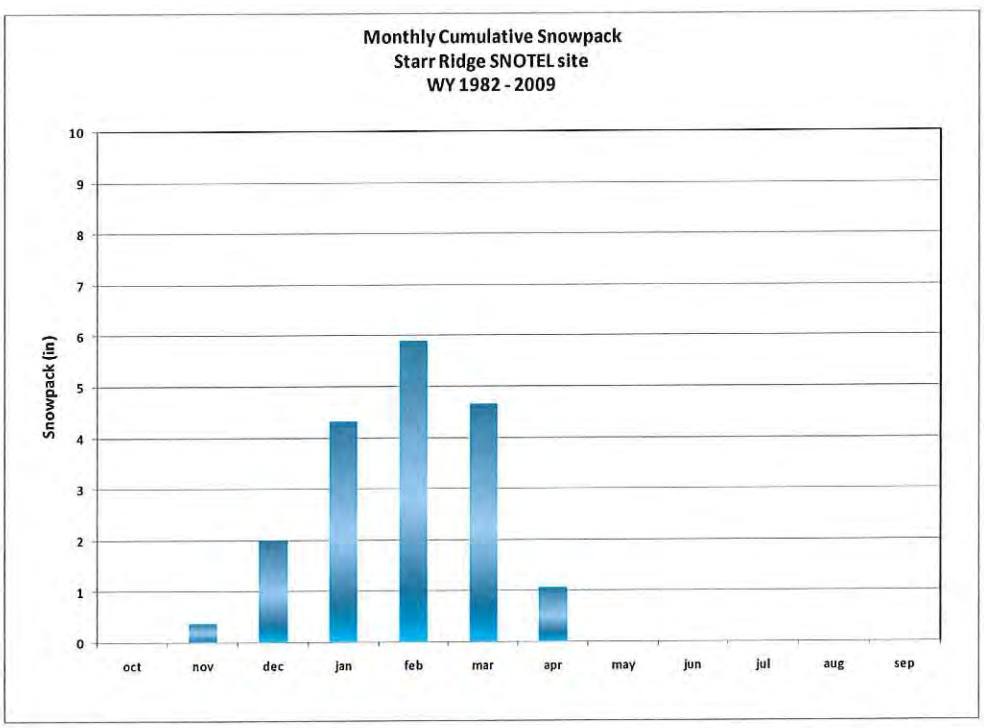

Figure 5. Starr Ridge SNOTEL site Monthly Average Cumulative Snowpack

Hydrology

The Canyon Creek watershed is located within the Blue Mountains, where snow is the predominate form of precipitation in the higher elevations of the watershed. Snowmelt, spring rains, and rain-on-snow events are the primary peak flow generating processes for Canyon Creek (WPN 2001).

Historical Streamflow data for Canyon Creek was provided by Oregon Water Resources Department (OWRD) Gage No. 14038602, Canyon Creek near Canyon City. The gage is located on Canyon Creek below the confluence with Vance Creek. The location of the gage is shown in Figure 3. Average, minimum, and maximum mean daily discharges for the period of record from October 1, 1980 to September 30, 2002 are shown in Figure 6. The highest flows of the annual hydrograph typically occur in the spring months, as a result of spring rains and snowmelt. The annual hydrograph indicates that high flows can occur during the winter months and may be a result of rain-on-snow events.

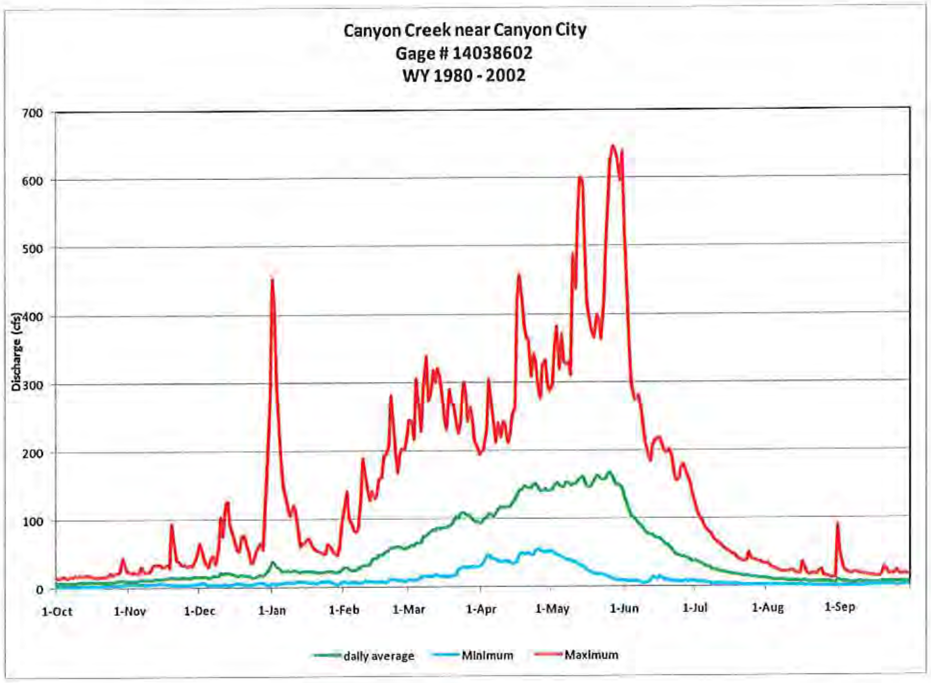

Figure 6. Average, minimum, and maximum discharges for Gage # 14038602

Flooding

Statistical analyses were performed by the OWRD on several gages within and near the Canyon Creek watershed in order to determine the discharge-frequency relationships from the available gage data (OWRD 2006). Log-Pearson analyses were performed for the following gages; Gage 14038602, Canyon Creek near Canyon City; Gage 14038550, East Fork Canyon Creek near Canyon City; Gage 14038600, Vance Creek near Canyon City. Also included is Gage 14037500, Strawberry Creek above Slide Creek (elevation 4,909 feet), which is a basin adjacent to the Canyon Creek watershed and is at an elevation similar to Canyon Creek Meadows Dam (elevation 5,050 feet). Relevant information for the available gages is summarized in Table 1.

Table 1. Summary of Peak Discharges on Stream Gages in Canyon Creek Watershed

location	Gage #	Drainage Area (mi^2)	Period of Record	Record Length (years)	Peak Discharge						
					2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Canyon Creek	14038602	86.2	1981-2002	22	287	468	596	763	890	1,020	1,320
E.F. Canyon Creek	14038550	24.8	1965-1979	15	176	241	275	310	332	350	384
Vance Creek	14038600	6.54	1964-1979	14	18	27.8	34.7	43.8	50.8	57.8	75.3
Strawberry Creek	14037500	7.0	1931-2002	70	94.7	147	185	234	272	311	407

Figure 7 shows the recurrence interval for annual peak flow events for the gages listed in Table 1. Examining recurrence interval, instead of magnitude of peak flow, allows the comparison of peak events of basins of differing areas. All peak flow events for the Canyon Creek gage (14038602) with the exception of one year, occurred during April or May, which demonstrate the prevailing peak flow generating processes are snowmelt, spring rains, and rain-on-snow events. The greatest recorded peak discharge for Canyon Creek gage 14038602 occurred on May 27, 1983 and had a recurrence interval of 13.5 years. The largest peak event for the Strawberry Creek gage (14037500) also occurred during the same time period. The peak event for this gage occurred four days later, on May 31, 1983, and had a recurrence interval of 204 years.

The largest recorded peak flow event for other gages in the Canyon Creek basin was the flood that occurred on December 21, 1964. This event was recorded at both the East Fork Canyon Creek gage (14038550) and the Vance Creek gage (14038600) and had a recurrence interval of approximately 15 to 20 years. In contrast, the peak flow for the Strawberry Creek gage had recurrence interval of only 3 years and did not occur until June 5, 1965. This suggests that the Strawberry Creek gage, which is located at a higher elevation, is less prone to winter rain-on-snow events.

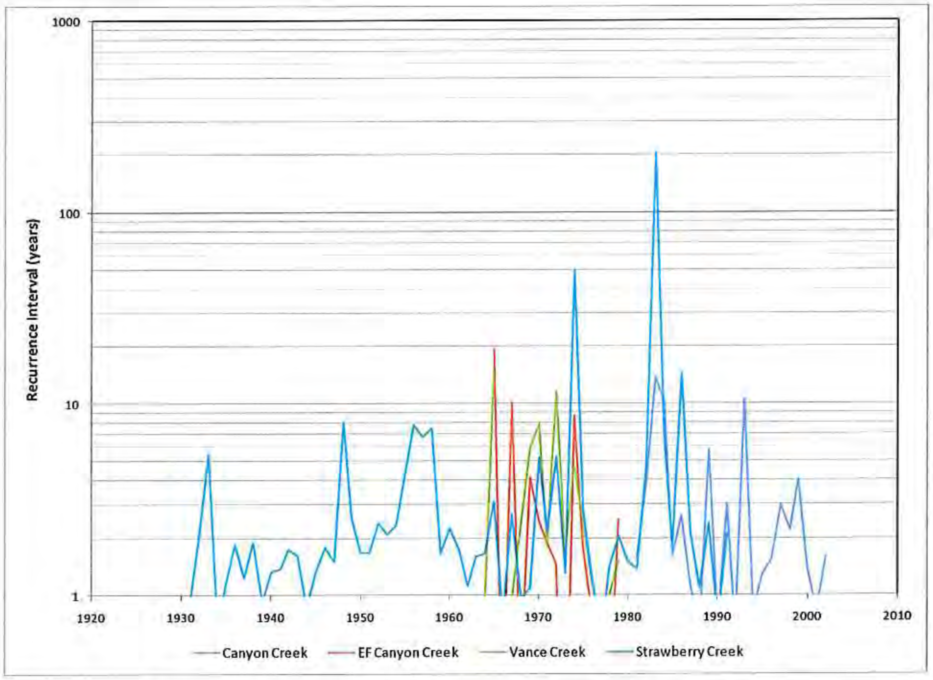

Figure 7. Recurrence intervals of annual peak flows

Data Collection

Streamflow Data

Streamflow data was provided by OWRD for Gage No. 14038602 - Canyon Creek near Canyon City. The gage is located on Canyon Creek below the confluence with Vance Creek and the location is shown in Figure 3. The periods of record for the gage available are from October 1, 1992 to October 1 2001, and from June 27, 2007 to October 22, 2009. Data was available 15 minute and daily average intervals. A summary of data available for OWRD Gage No. 14038602 is shown in Table 2.

Table 2. Summary of Stream Flow Data

Gage	Time Increment	Start Time	End Time
Canyon Creek near Canyon City	15 min	09/30/1991	10/1/2001
		06/27/2007	10/22/2009
	Daily average	10/01/1980	10/22/2009
	Peak Discharge	1980	2002

Meteorological Time Series Data

Data from two temporal precipitation gages were available for this study. The first gage is at Prairie City, Oregon, located near the study basin and is approximately 15 miles northeast of the Canyon Creek Meadows Dam. The gage is located at an elevation of about 3,540 feet. The period of record for the gage is from October 25, 1980 to May 5, 2009 and is available in 15 minute intervals. The data from the Prairie City gage were used for both the model calibration and long-term simulation of the watershed. The data set was obtained from the National Oceanic and Atmospheric Administration (NOAA) National Climate Data Center. Precipitation data was also collected from the John Day Airport climate station, which is located near the downstream end of the watershed. The gage is located at an elevation of 3,690 feet. The period of record for the gage is from November 29, 2006 to October 22, 2009 and is available in 20 minute intervals. The data for this gage were not used in the hydrologic simulation because the period of record was relatively short compared Prairie City. However, the John Day Airport precipitation record was used to verify that the precipitation for Prairie City was similar to the precipitation record for John Day Airport. Figure 3 shows the location of both climate stations.

Evapotranspiration rates were provided by the U.S. Department of the Interior AgriMet website. Monthly average evapotranspiration rates from the AgriMet Station located near Prairie City, Oregon were used in the development of the hydrologic model. The period of record used for computation of the monthly average evapotranspiration values is from 1989 to 2008. Figure 3 shows the location of the AgriMet Station.

Snowpack data for the Canyon Creek watershed was provided the Natural Resources Conservation Service (NRCS) Snowpack Telemetry (SNOTEL) site located at Starr Ridge. The Starr Ridge SNOTEL site is located near the southwest boundary of the watershed and is at an elevation of about 5,250 feet. Figure 3 shows the location of the SNOTEL site. The period of record for the gage is from October 01, 1980 to present, with data available up to October 22, 2009 at the time of data acquisition. Snow Water Equivalent (SWE), daily precipitation, minimum air temperature, and maximum air temperature at daily intervals are available for this site. The SWE and temperature data were used in the long-term HEC-HMS simulation of the watershed. The precipitation data for the site could not used because the reporting interval is daily totals rather than hourly or fractions of an hour reporting needed by the model. Temperature data from the Starr Ridge SNOTEL site provided temperature at hourly intervals from January 24, 1994 to October 12, 2009 and was used for calibration and the long-term HEC-HMS simulation of the watershed.

Table 3 provides a summary of the meteorological data used in the development of the Canyon Creek hydrologic model.

Table 3. Summary of Meteorological Data

Type	location	Elevation (ft)	Period of Record	Time interval	Purpose
Precipitation	Prairie City	3,540	10/25/1980 – 05/05/2009	15 minute	Model Calibration Long-term Simulation
Precipitation	John Day Airport	3,690	11/29/2006 – 10/22/2009	20 minute	Comparison to Prairie City precipitation
Evapotranspiration	Prairie City	3,752	1989-2008	Mean monthly average	Model Calibration Long-term Simulation
Snow Water Equivalent	Starr Ridge SNOTEL	5,250	10/01/1980 – 10/22/2009	Daily	Model Calibration
Temperature	Starr Ridge SNOTEL	5,250	01/24/1994- 10/12/2009	1 hour	Model Calibration Long-term Simulation

Basin Parameters

A 30-m seamless Digital Elevation Model (DEM) for the area along with an aerial image of the Canyon Creek drainage basin was obtained from the USGS National Map Seamless Server through the website at (http://seamless.usgs.gov/index.php). All digital data have a North American Datum 1927 (NAD27) horizontal datum and Universal Transverse Mercator (UTM), Zone 11N projection. The DEM was extracted as a grid and used to define topography of Canyon Creek watershed.

Digital and spatial data on soil type and distribution was obtained from the Soil Survey Geographic Database (SSURGO) for Oregon (NRCS 2004). Soil infiltration rates for the HEC-HMS model were obtained from the SSURGO database.

Spatial data for the stream network within the Canyon Creek watershed was derived from 1:100,000-scale River Reach data layer for the Pacific Northwest Stream published by the U.S. Geological Survey in 2001.

Field Reconnaissance

A field reconnaissance was conducted by WEST Consultants staff in September, 2009. Field observations were made of the channel and overbank of Canyon Creek, from the outlet of Canyon Creek Meadows Dam to the confluence of the John Day River. Canyon Creek was divided into several reaches, based on stream gradient and valley width, and representative channel geometry was approximated for each of the stream reaches. Channel and overbank roughness characteristics were also noted for each reach. The representative channel geometry was used to define reach geometry for flow routing in the HEC-HMS model.

HMS Model Development

A hydrologic analysis of the Canyon Creek watershed was conducted using the Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) which is designed to simulate the precipitation-runoff processes of dendritic watershed systems. The program is a generalized modeling system capable of continuous simulation with a multiple layer soil moisture accounting method.

The information required for developing the models include a topographic representation of the watershed, land use, geologic/soil type, meteorological data, and observed flow data. Sub-basins were delineated in ArcGIS using the topographic data for the watershed. Hydrologic characteristics necessary for model development were defined using stream reach and soil type GIS layers. The meteorological data required for the model consists of time series for precipitation, temperature and evapotranspiration. Since one of the primary peak flow generating processes is snowmelt, it is represented in the model using the temperature index methodology.

Sub-Basin Methodology

Infiltration is calculated in the HEC-HMS model sub-basin loss method sub-routine. The soil moisture accounting loss method was chosen for the continuous hydrologic simulation of the Canyon Creek watershed. This methodology uses multiple layers to represent the dynamics of water movement above and in the soil. Layers include canopy interception, surface depression storage, soil, upper groundwater, and lower groundwater. Groundwater layers represent shallow interflow processes that provide baseflow to the stream, and are not intended to represent deep recharge of an aquifer. This method provides for seasonal wetting and recovery cycles necessary to simulate long periods of continuous simulation. Loss input parameters were estimated from soil characteristics, land cover, and were refined during model calibration using actual stream flow and precipitation records.

Surface runoff calculations are performed by the sub-basin transform method. The Clark Unit Hydrograph is used to transform excess precipitation into surface runoff. This methodology accounts for attenuation affects of a basin by routing the hydrograph through a linear reservoir. Transform method input parameters include time of concentration and a storage coefficient for each sub-basin which were estimated from sub-basin topography characteristics.

Subsurface flow processes are calculated in HEC-HMS by the baseflow method sub-routine. The linear reservoir baseflow method was chosen for the continuous hydrologic simulation of the Canyon Creek watershed. The linear reservoir simulates the routing of subsurface flow through soil and groundwater storage to the stream as baseflow. When used in conjunction with the soil moisture accounting loss method, the infiltration is connected to the lateral outflow of the groundwater layers. Initial discharge from the groundwater layer is estimated from the Canyon Creek gage (14038602) average mean daily discharge annual hydrograph.

Model Extents

The sub-basin delineation for Canyon Creek watershed is shown in Figure 8. The Canyon Creek basin was divided into thirty-three sub-basins based on the topography, channel network, and hydrologic characteristics. General information about the sub-basins is provided in Table 4.

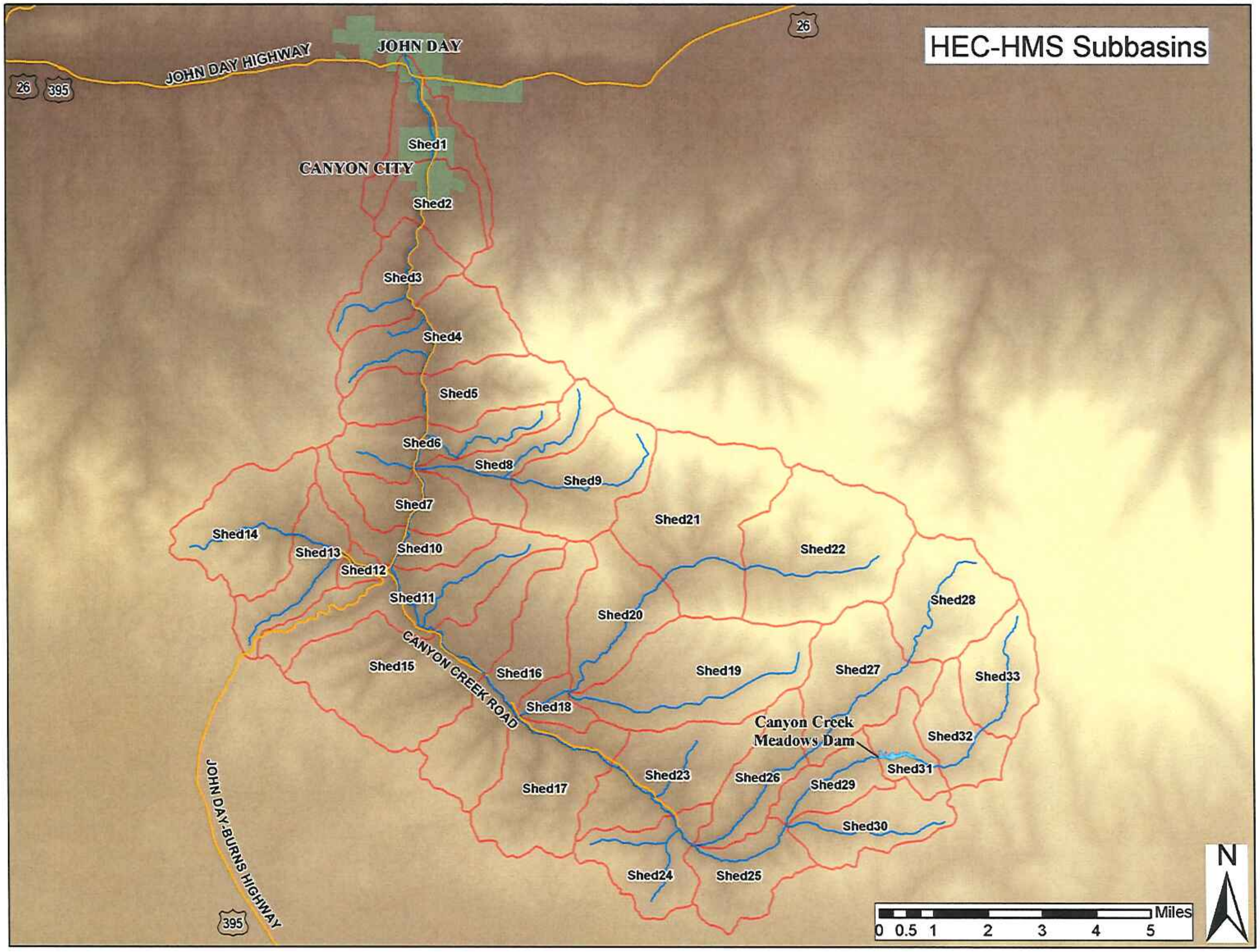

Figure 8. Canyon Creek Sub-basin delineation

Table 4. Sub-basin Information

Subbasin	Drainage Area (mi^2)	Reach length (ft)	Mean Slope (%)
Shed01	2.71	17,490	17.1
Shed02	2.45	11,003	28.3
Shed03	2.67	17,499	37.4
Shed04	3.88	15,157	37.7
Shed05	3.91	13,857	45.6
Shed06	3.05	17,490	37.9
Shed07	1.98	9,865	28.7
Shed08	2.88	22,997	46.5
Shed09	3.95	18,045	40.0
Shed10	2.27	13,402	25.4
Shed11	4.62	22,829	28.8
Shed12	0.47	6,121	44.9
Shed13	2.60	14,030	38.2
Shed14	4.37	11,574	30.4
Shed15	7.37	13,568	29.0
Shed16	5.17	13,193	23.9
Shed17	4.68	15,088	32.8
Shed18	0.87	7,846	14.7
Shed19	6.42	25,903	26.1
Shed20	3.55	21,122	31.5
Shed21	7.02	17,947	40.0
Shed22	6.91	14,050	40.1
Shed23	4.31	13,154	26.5
Shed24	2.86	10,005	27.5
Shed25	2.76	10,984	30.7
Shed26	2.71	20,416	33.4
Shed27	4.38	19,683	33.2
Shed28	4.00	14,804	33.3
Shed29	1.85	11,518	31.4
Shed30	2.77	16,675	26.8
Shed31	1.47	7,393	32.5
Shed32	2.14	12,775	30.7
Shed33	2.55	13,150	34.8

Hydraulic Routing

Runoff computed by the HEC-HMS model is routed through the stream system using Muskingum-Cunge hydraulic routing. The Muskingum-Cunge routing method is advantageous because it provides attenuation of the flood wave based on stream characteristics. The input for this routing method includes reach length, slope, Manning's roughness coefficients for the channel and overbanks, and a representative reach cross section geometry.

Cross section geometry for the various reaches along Canyon Creek were provided by the HEC-RAS hydraulic model (WEST 2009) developed for the dam breach analysis of Canyon Creek Meadows Dam. The model extends from the confluence with the John Day River to Canyon Creek Meadows Reservoir. The cross sections were extracted from the USGS 30-meter DEMs using HEC-GeoRAS and supplemented with field reconnaissance measurements for the channel geometry. For reaches not included in the HEC-RAS model, cross section geometry was estimated from HEC-RAS model cross sections located in a comparable sized basin and from field observations. Hydraulic structures, with the exception of Canyon Creek Dam, were not included in the model because the floodwater storage at these structures was deemed insignificant to cause appreciable attenuation of flow.

Meteorological Data Adjustments

The meteorological data required for the HEC-HMS model consists of a time series for precipitation and temperature. As previously mentioned, the Prairie City precipitation gage was used for both the model calibration and long term simulation. The Prairie City gage is located near the study site and has a record of 29 years.

Annual precipitation in the watershed varies from 13 inches in the City of John Day (elevation 3,050 feet) to 40 inches in the upper elevations of the watershed (8,000 feet). In order to account for orographic effects of terrain on precipitation, rainfall depths for each sub-basin were adjusted using the PRISM mean annual precipitation GIS coverage layer (OSU 2006). A ratio of the sub-basin mean precipitation to Prairie City's mean precipitation was applied to each of the thirty three sub-basins. The correction ratio averaged 1.4, and ranged from 1.1 to 2.2.

For the snowmelt component in HEC-HMS, a temperature time series was applied as an atmospheric boundary condition for the model. A temperature lapse rate of 3.56 °F/1000 ft was applied to each sub-basin in order to account for colder temperatures at higher elevations. The temperature time series data was assigned an elevation of 5,250 ft (based on the elevation of the SNOTEL site) as a reference point for the lapse rate. Each sub-basin was partitioned into three elevation zones using 30-meter DEM in Arc-GIS. A temperature/elevation correction factor was assigned to each of the three elevation zones within the sub-basin.

Calibration

The HEC-HMS program uses mathematical equations to represent physical processes. The input variables are estimated based on the best available data. Therefore, it is important that the model be calibrated to ensure that the results are representative of actual conditions. Calibration consists of comparison of actual data to model output. This comparison included: (1) mean runoff volume for the simulation period in acre-feet (ac-ft); (2) hydrograph shape, (3) peak discharge for high spring runoff events, and 4) SWE for watersheds at similar mean elevation as the Starr Ridge SNOTEL site.

The HEC-HMS model was developed using the precipitation data from the Prairie City, Oregon gage and the flow data measured at the Canyon Creek gage (14038602) located just downstream of the confluence with Vance Creek. Calibration of the model was conducted by adjusting several key sub-basin parameters in order to best match the shape of the hydrograph, the total volume and the spring runoff peaks of Canyon Creek gage. Because the watershed seasonal hydrograph is governed by spring snowmelt runoff, the SWE was adjusted for applicable sub-basins in order to best match the model output to the measured total flow volume. Soil infiltration parameters were then adjusted in an attempt to best match the magnitude of peak flows and general shape of the seasonal hydrograph.

The time period between August 2007 and August 2008 was selected for calibration. This period was chosen because for this period the dam outlet gate was locked open and all the required meteorological data were available. In addition to model calibration, model verification was conducted to test the ability of the model to predict runoff from the watershed. Years 2000 and 2002 were selected for verification of the model. The calibration and verification results for annual runoff volume are summarized in Table 5.

Table 5. Calibration Results of Runoff Volumes

Period	Observed Value	Values from Canyon Creek HEC-HMS Model	
		Simulated Value	Percent Difference
Runoff Volume (ac-ft)			
Calibration - 2008	36,260	40,400	+ 11.4
Verification - 2000	28,631	27,774	- 3.0
Verification - 2002	18,642	17,994	- 3.5

Results of the calibration and verification runs show that the HEC-HMS model both over-predicts and under-predicts the annual runoff volume. The modeled flow volume ranged from +11.4 to -3.5 percent of the observed volume. The runoff volume calibration is considered to be good. The hydrograph shape calibration was considered to be fair. In general the model output follows the season pattern of runoff but does not capture all the storm events occurring in the basin. The peak flow calibration was also considered to be fair. Individual storm events shown within the annual peak hydrographs were not well represented by the model. This is likely due to the lack of appropriate precipitation data in the upper basin. It is believed that precipitation data from the Prairie City gage is not entirely representative of the storm events that occur in the Canyon Creek Basin and is therefore not sufficient to develop a fully calibrated model of the basin. However, because the influence of the reservoir on the hydrology is mainly a modification to downstream runoff volumes and the model predicted annual runoff volumes that were similar to those recorded at the stream gage, the model is considered to be sufficient for comparisons between the scenarios evaluated.

Modeled Scenarios

Three HEC-HMS model simulations were developed; 1) Existing conditions, 2) Dam removed, and 3) Dam repaired.

For the existing conditions scenario, the outlet gate for the18-inch culvert was maintained in the fully opened position. This scenario results in the minimum amount of storage occurring in the reservoir during the spring snowmelt season. The outflow discharge is regulated by the capacity of the culvert. When inflows exceed the capacity of the culvert the reservoir level increases. When inflows are less than the capacity of the culvert the reservoir level drops.

For the dam removed condition, the dam and storage area were removed from the model and all flows were allowed to pass downstream unimpeded.

For the dam repaired scenario, the operating rules for the dam were not provided. A rule similar to how the dam was operated prior to 1999 was therefore used. Prior to 1999, the gate on the existing culvert was kept fully closed. Flow in the downstream channel was maintained due to leakage through the dam. With the dam repaired, it was assumed that no leakage would exist. Therefore, a smaller culvert was used in the model to represent the existing culvert with the gate partially closed to maintain a flow of approximately 3 cfs in the downstream channel. This allows for the reservoir pool to be maintained during the spring and summer recreation period and then slowly lowered during the winter months.

Results and Conclusions

Flow-Duration Curves

HEC-HMS model output was developed for three locations including just below the dam, below the confluence with the Middle Fork, and below the confluence with the East Fork. The modeled flows were used to develop flow duration curves for each modeled scenario.

Figure 9 shows the flow duration curves for Canyon Creek below the outlet of the dam. As seen in the figure, flows below ~15 cfs have nearly the same exceedence probability for the existing condition and the dam removed condition. This indicates that the outlet culvert beneath the dam passes flows below ~15 cfs essentially unimpeded (no storage in the reservoir). Flows between 15 and 30 cfs have a greater exceedence probability for the existing condition because this is the operating range over which the culvert typically releases water from storage in the reservoir. Above 30 cfs, the culvert is near its maximum capacity, and therefore, the exceedence probability for the existing condition is significantly less than the dam removed scenario.

For the dam removed scenario, flows below about 3 cfs have nearly the same exceedence probability as this was the assumed gate opening that would be used for the repaired dam scenario. No storage occurs in the reservoir for flows below 3 cfs. For flows above 3 cfs, the exceedence probability is reduced compared to the dam removed scenario as a result of storage in the reservoir. However, because the culvert outlet capacity is much smaller than for the existing condition, the reservoir fills much earlier in the runoff season, and then passes the inflows over the spillway. For this reason, flows above 30 cfs occur more often under the dam repaired scenario than for the existing condition. However, the flow duration curves indicate that some attenuation of these larger flows would occur for the dam repaired scenario compared to the dam removed scenario. The attenuation results from minor flow storage in the reservoir as water passes over the spillway.

Figure 10 shows the influence of the three scenarios on a typical seasonal hydrograph for Canyon Creek below the dam. As seen in the figure, at the start of the snowmelt season the existing condition and dam repaired scenarios are nearly identical; the outlet culvert passes the flows below ~15 cfs, and no storage occurs in the reservoir. Above ~15 cfs, the reservoir begins to store water for the existing condition and outflows are reduced compared to the dam removed scenario. As the snowmelt season continues, water is stored in the reservoir and released at a more even rate than for the natural condition, resulting in a longer duration of flows above 15 cfs. Once the storage is exhausted, the release rates for the dam once again match the natural condition.

For the dam repaired scenario, all early season snowmelt runoff above ~3 cfs is stored in the reservoir. Because of the reduced release rate, the reservoir storage is filled at faster rate than for the existing condition. Once the reservoir becomes full, the outflow from the dam is nearly identical to the natural condition (with the exception of a slight decrease in peak flow) as runoff into the reservoir is released over the spillway.

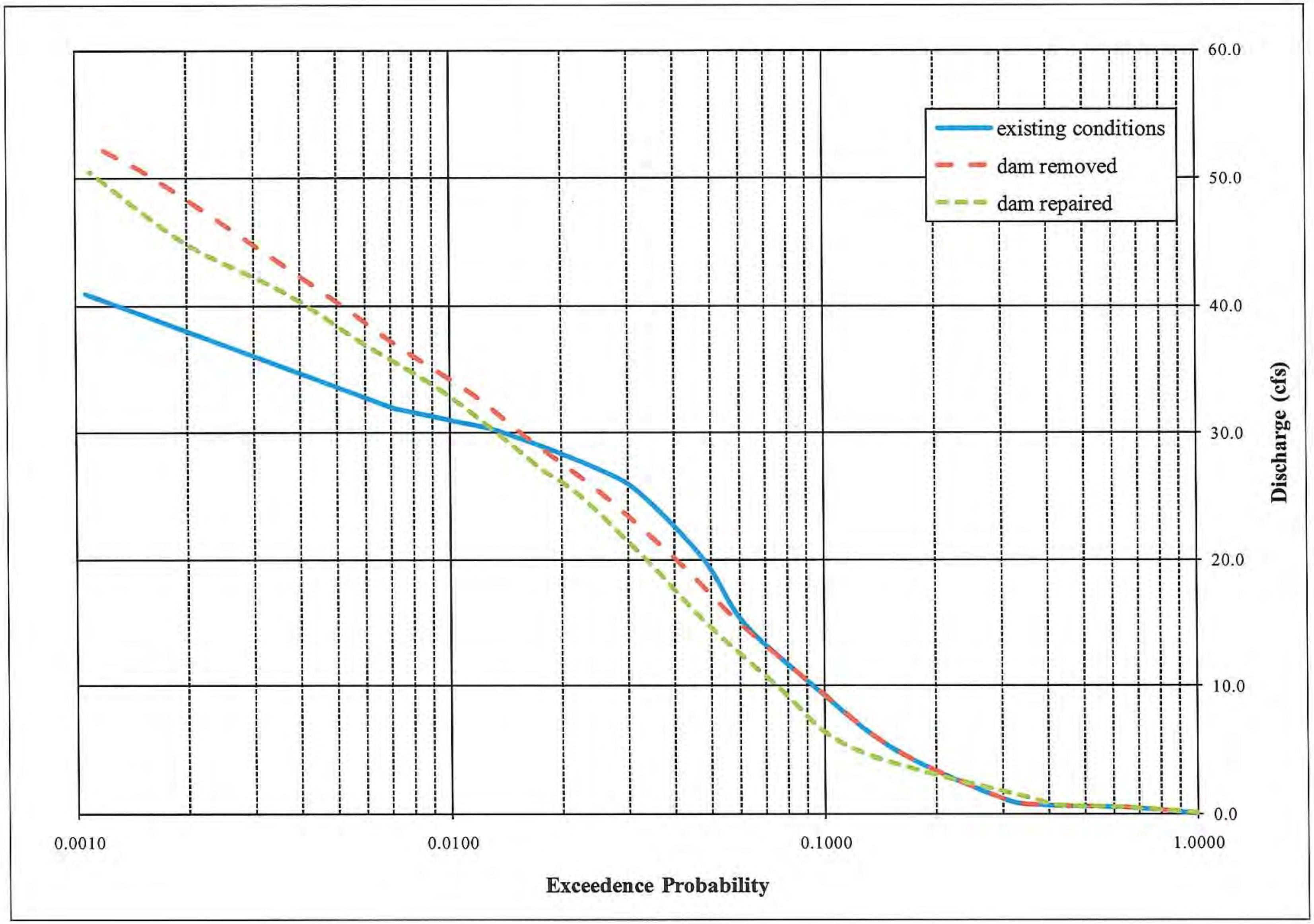

Figure 9. Flow Duration for Canyon Creek below outlet of Canyon Creek Dam

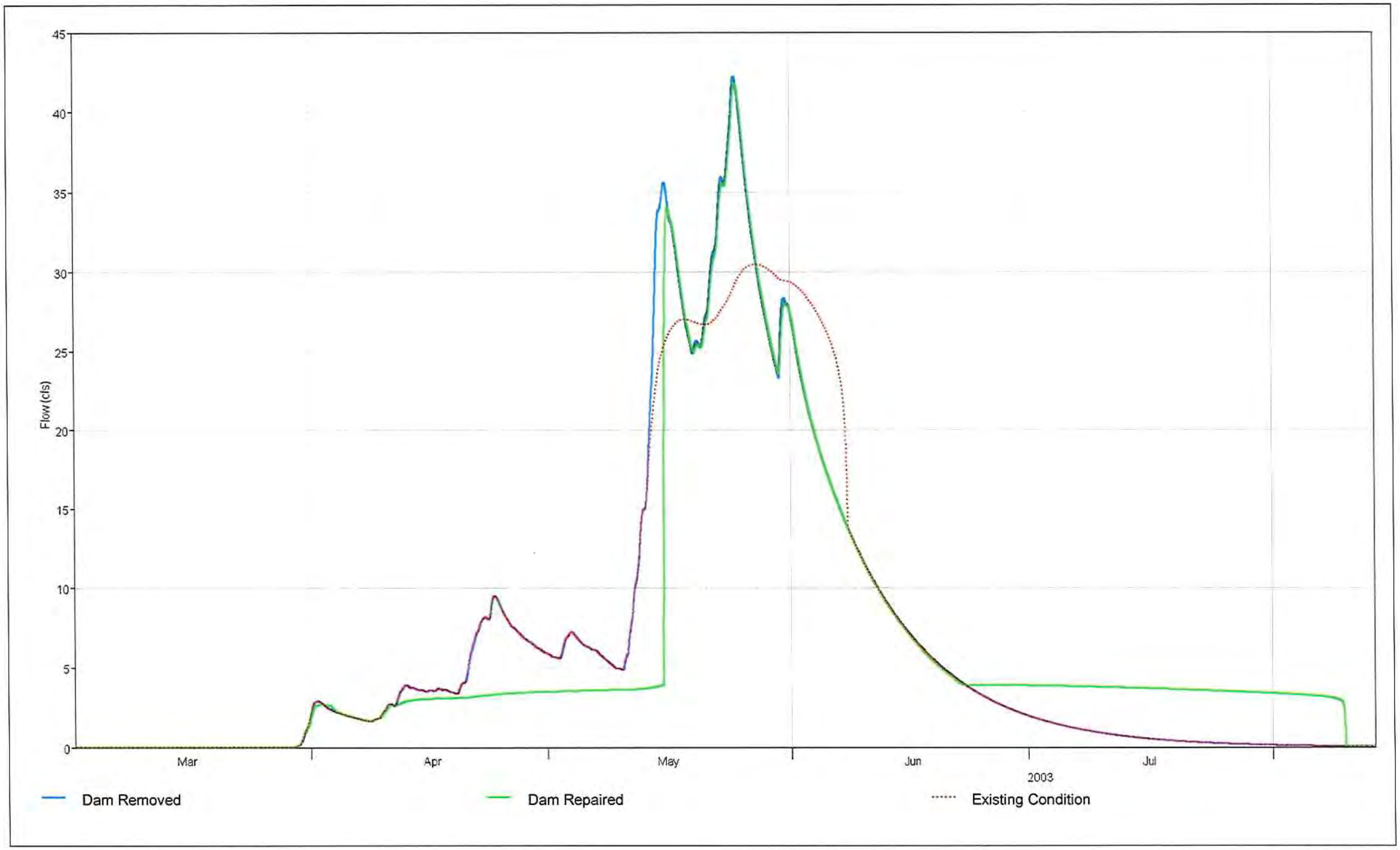

Figure 10. Example Seasonal Hydrograph of Canyon Creek directly downstream of Canyon Creek Meadows Dam

Figure 11 shows the flow duration curves for Canyon Creek below the confluence with the Middle Fork. The curves have a similar shape as those at the dam outlet, but there is less of a difference in exceedence probabilities for the three scenarios. The drainage area controlled by the dam is approximately 25 percent of the total drainage area upstream of this location. The additional flow from the Middle Fork is reducing the influence of the altered hydrology at the dam. However, for this location storage in the reservoir for the existing condition and dam repaired scenario is causing flows ~125 cfs to occur less often than if the dam were removed.

Figure 12 shows the flow duration curves for Canyon Creek below the confluence with the East Fork. As seen in the figure, the curves are nearly identical. The drainage area controlled by the dam is approximately 10 percent of the total drainage area upstream of this location. The altered hydrology that results from the dam does not significantly influence the hydrology of Canyon Creek at or downstream of this location.

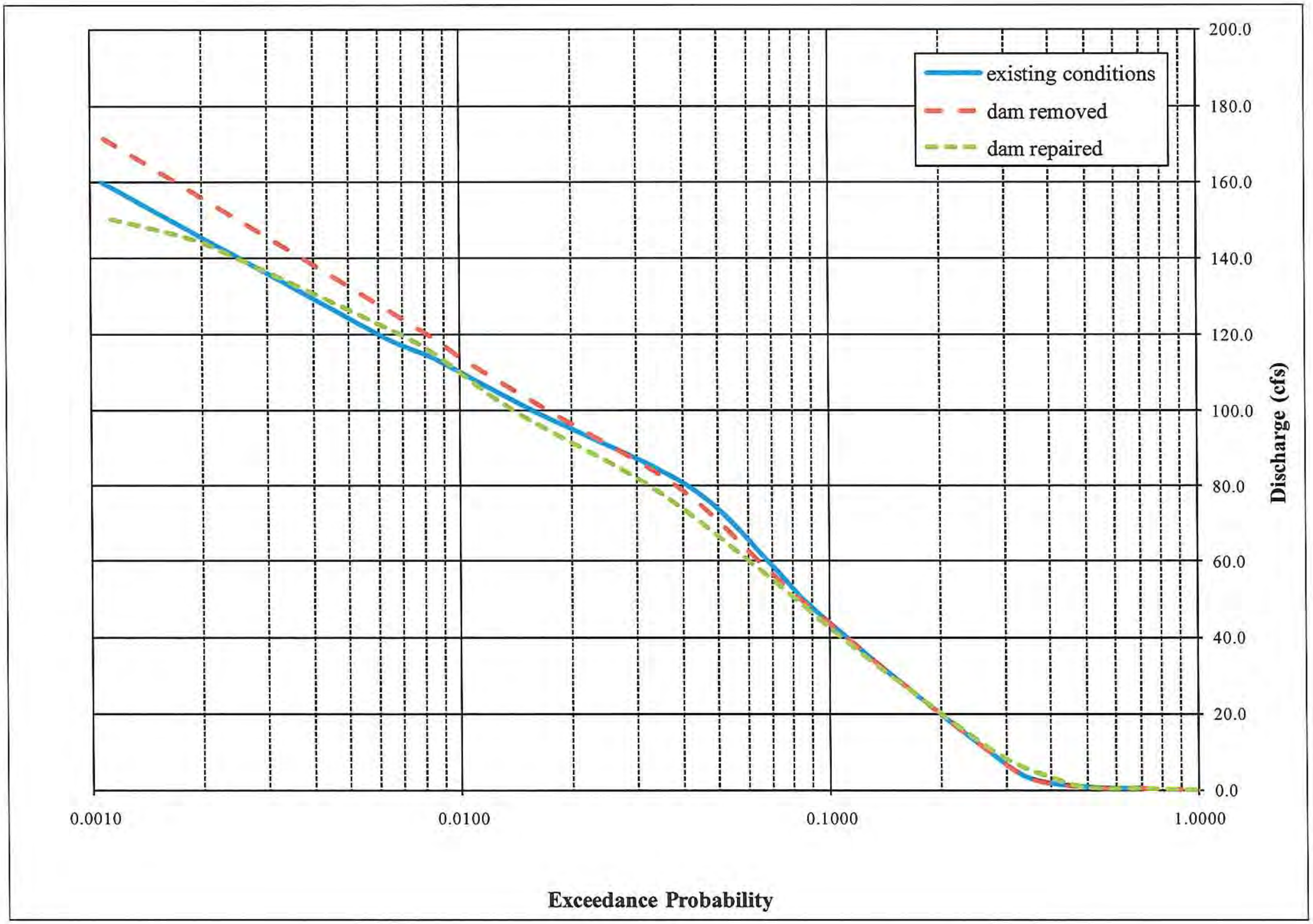

Figure 11. Flow Duration for Canyon Creek below the Middle Fork Confluence

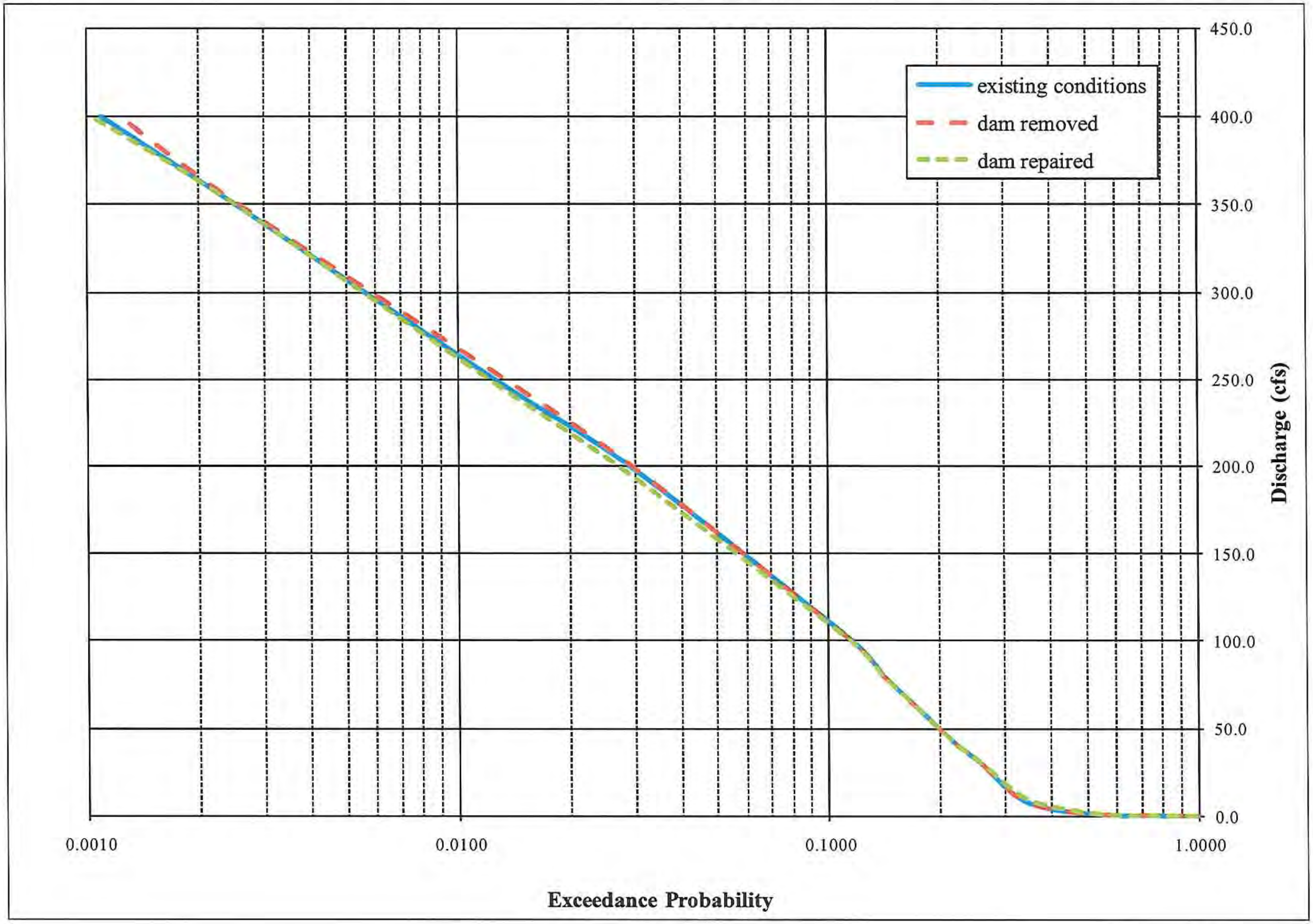

Figure 12. Flow Duration for Canyon Creek below the East Fork Confluence

Flood Frequency Analysis

A flood frequency analysis was performed on annual peak flow results from the HEC-HMS continuous simulation models in order to compare peak discharge-frequency relationships below Canyon Creek Meadows Dam. Peak discharge-frequency relationships were evaluated for the existing operating condition, for the dam removed scenario, and for the dam repaired scenario.

The analysis was completed using the HEC Statistical Software Package (HEC-SSP) computer program (USACE, 2008). This software performs flood flow frequency analysis using the procedure and methodology documented in *Bulletin 17B, Guidelines for Determining Flood Flow Frequency* (USGS, 1952). Only station skew was used in the evaluation, and no adjustments were made to account for a regional skew. The period of record for the analysis was from 1985 to 2008. A comparison of the flood frequency curves is provided in Figure 13.

As seen in Figure 13, the flood frequency curves for the dam removed and dam repaired scenarios are slightly different than for the existing condition. However, as seen in the figure, the flood frequency curves for both scenarios fall within the 5- and 95-percent confidence limits of the existing conditions flood frequency curve. Therefore, there is considered to be no significant difference between the flood frequency relationships of the three scenarios evaluated. In other words, neither the existing dam nor the repaired dam provides a discernible flood control benefit.

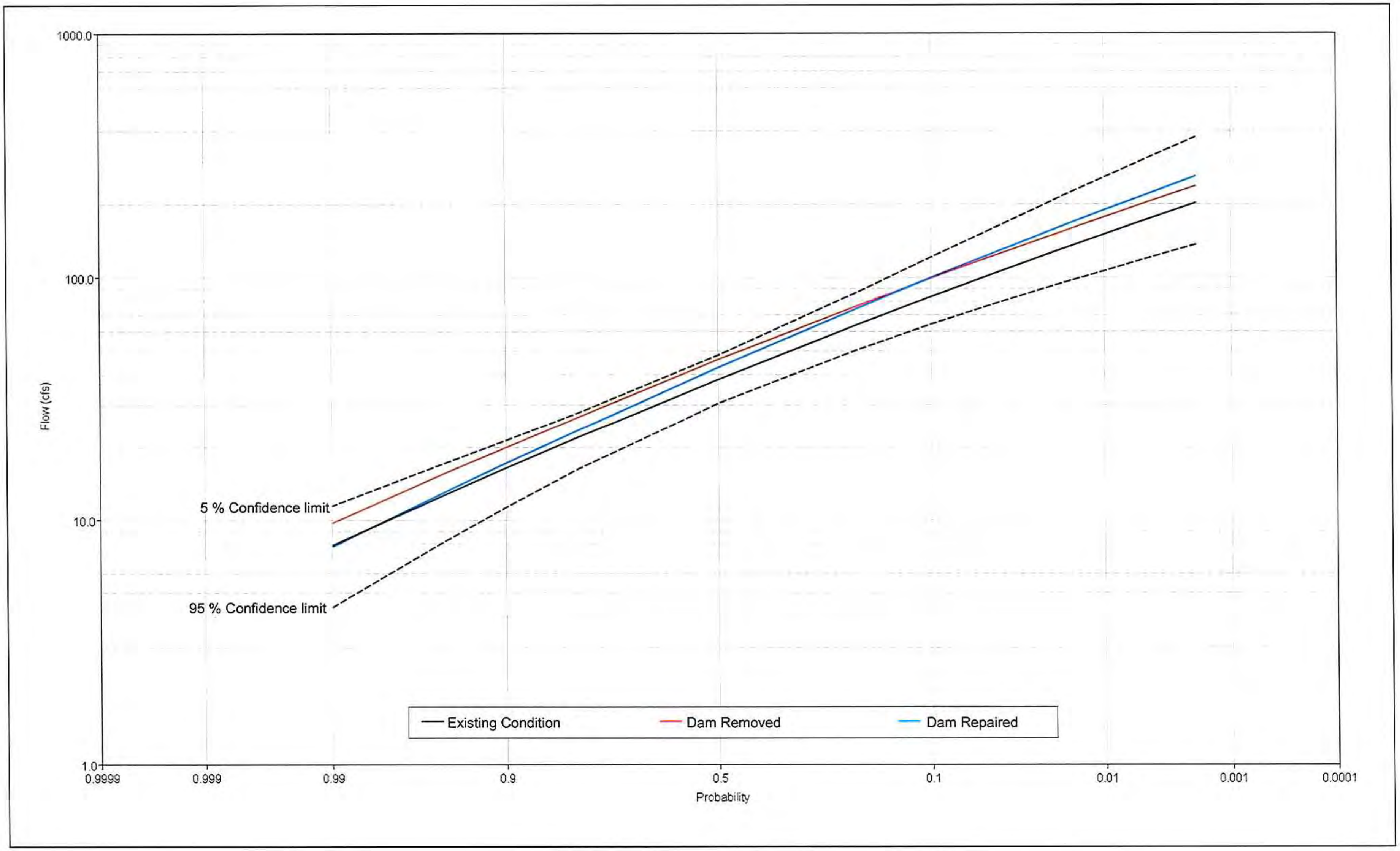

Figure 13. Flood Frequency Analysis for Canyon Creek below the Canyon Creek Meadows Dam

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