Cooper Lake Project
FERC No. 2170

POTENTIAL COOPER CREEK PROTECTION, MITIGATION AND ENHANCEMENT MEASURES

DRAFT

CHUGACH
POWERING ALASKA'S FUTURE

CHUGACH ELECTRIC ASSOCIATION, INC.

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DHITTLE & ASSOCIATES, INC.

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August 2004

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PREFACE

Over the past year, as part of its FERC relicensing program, Chugach has been studying potential protection, mitigation and enhancement (PME) measures for providing enhanced flows and/or warmer water temperatures in Cooper Creek downstream of the dam. These studies have been requested by resource agencies with the premise that warmer water temperatures would provide more favorable spawning and rearing conditions for rainbow trout and salmon and, therefore, increase populations of those species.

Chugach, through its engineering consultant MWH Americas, Inc. (MWH), has performed studies of alternative PME measures and made presentations at public workshops. To date alternatives have entailed the following types of measures:

- Release water from Cooper Lake without supplementation from other sources
- Divert water from Stetson Creek to Cooper Lake and release to Cooper Creek from the dam
- Divert water from Stetson Creek to upper Cooper Creek
- Construct reservoirs to increase water exposure to solar heating and release to Cooper Creek

In addition, Chugach has briefly considered potential stream habitat enhancement measures in lower Cooper Creek as described herein.

This report contains full descriptions of the various alternatives studied to date. Many have been previously described in the Draft License Application (DLA) and their descriptions are expanded upon herein. Other alternatives have been studied since the DLA and were presented in the July 2004 Relicensing Workshop. This report also suggests other potential PME alternatives that have been studied briefly to date. These additional alternatives are described so they can be considered further or dismissed from further consideration.

This report also summarizes the potential temperature and flow increase estimates for the various alternatives. No judgment is provided as to the adequacy of the flows and temperatures for enhancing the fishery habitat. This analysis is provided in a separate report.

Finally this report displays and discusses the various cost components for evaluation of the alternatives. The components of cost include capital costs including capital recovery, operations and maintenance costs, and costs due to lost generation due to spilling water past the dam. The section on costs also provides rationale as to the cost methodology used herein.

It should be noted that the report draws no conclusions as to the most favorable alternative. Rather this report is meant to consolidate information gathered to date and presented in various forums.

COOPER LAKE PROJECT

POTENTIAL COOPER CREEK PROTECTION, MITIGATION AND ENHANCEMENT MEASURES

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1.0 PROJECT BACKGROUND

1.1 BACKGROUND

The Cooper Lake Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) Project No. 2170, is owned and operated by Chugach Electric Association, Inc. (Chugach). Located near Cooper Landing on the Kenai Peninsula, the Project provides power to southcentral Alaska as part of Chugach's electric generation and transmission system. The Project was originally licensed in May 1957, and the current license term expires at the end of April 2007. Construction of the Project began in September 1958 and operational tests were completed in April 1961. Dam construction was completed in November 1959.

The Project generally consists of the Cooper Lake Dam and reservoir, a powerhouse on Kenai Lake, an intake structure on Cooper Lake, a tunnel/penstock from the reservoir to the powerhouse, and a transmission line system extending to Anchorage. The Project dam and powerhouse are located within the Kenai Peninsula Borough, southcentral Alaska, approximately 55 miles south of Anchorage. Project facilities are located on Cooper Creek, Cooper Lake, and Kenai Lake.

Cooper Lake is a naturally occurring lake with an original lake level of about elevation 1168 feet above mean sea level (feet MSL). With the construction of the dam, the current maximum lake level has been raised to elevation 1210 feet MSL (i.e., the existing service spillway elevation). Since 1985 the lake has been held to a maximum level of 1194 feet MSL due to dam safety concerns. Outflow from Cooper Lake historically flowed uncontrolled from the north end of the lake into Cooper Creek. All natural inflow into the lake now is diverted to the powerhouse on Kenai Lake and averages about 103 cubic feet per second (cfs) based on plant operating records. No flow has been released from either the dam or spillway since construction and testing was completed.

Stetson Creek is a major tributary to Cooper Creek. A FERC license amendment issued on July 3, 1958, and later withdrawn, stated that water from Stetson Creek could be diverted to Cooper Lake via a diversion structure and canal to increase flow to the powerhouse. The amendment stipulated that flow could be diverted between May and November. Apparently, due to the estimated high cost of constructing the Stetson diversion and the low value of the increased generation, it was never constructed.

1.2 PROJECT DESCRIPTION

The primary components of the Project included in the existing FERC license are:

- Cooper Lake Dam, a rock-and-fill structure constructed across Cooper Creek at the outlet of Cooper Lake with a crest elevation of 1220 feet MSL, a maximum section height of 52 feet, and a crest length of 920 feet.
- Cooper Lake Dam spillway, located at the left abutment of the dam, consisting of an 800-foot long excavated channel with a 3-foot-high concrete weir. The weir has a crest length of 50 feet at elevation 1210 feet MSL.

- Cooper Lake, a natural lake that was increased in area to 2,910 acres by impoundment up to the currently licensed normal maximum operating elevation of 1210 feet MSL. The current normal maximum operating level is 1194 feet MSL, with a corresponding reservoir area of 2,620 acres.
- An intake structure, located on the Cooper Lake shoreline, approximately 5 miles southeast of the dam. The elevation of the invert of the opening to the tunnel/penstock is at 1151 feet MSL. Original design drawings indicate that the minimum operating water level is elevation 1166 feet MSL.
- A tunnel and penstock extending 10,686 feet east from the intake to the powerhouse on Kenai Lake.
- Cooper Lake powerhouse, containing two turbine/generator units, each rated at 9.69 megawatts (MW).

The layout and interrelationship of these features can be seen on Figure A-1 of the Draft License Application (Chugach 2004a).

1.3 PURPOSE OF STUDY

Cooper Lake Dam was constructed on Cooper Creek at the mouth of Cooper Lake, approximately 4.8 river miles upstream from the mouth of the creek. The Project powerhouse is located on the southwest shore of Kenai Lake. The powerplant operating regime, since commencement of operation, has been to divert 100 percent of the flow into Cooper Lake to the powerhouse—averaging 103 cfs annually. No flow has been released into Cooper Creek since construction of the dam in November 1958. Both the powerhouse flow to Kenai Lake and Cooper Creek flow into the Kenai River.

Since diversion of Cooper Lake water to the powerhouse (and thus loss of Cooper Creek releases from the natural lake), the warmest water contribution to Cooper Creek has been lost. Stetson Creek is now the major contributor to flow in Cooper Creek; this flow occurs from the confluence to its mouth as indicated in Section 1.4 below. Water from Stetson Creek is historically colder than that of Cooper Lake from spring through fall each year. Therefore, the temperature of Cooper Creek is now colder than prior to construction of the dam, though the exact differences are not known.

To investigate options for increasing flow and/or temperature in Cooper Creek during the months considered most important to fish resources (May through October[1]), several alternatives have been studied, including four general scenarios:

- Release water from Cooper Lake without supplementation from other sources
- Divert water from Stetson Creek to Cooper Lake and release to Cooper Creek from the dam
- Divert water from Stetson Creek to upper Cooper Creek

[1] Increasing flow/temperature during the period of June through October may or may not be beneficial to fish in Cooper Creek. This period was selected for study because the warmest temperatures experienced in the lake, based on recent data collection, occur during these months. The months of May and November could also be investigated but the effect would be to increase the cost for all alternatives due to early start-up of the facilities and late shut-down when snow will likely be problematic (e.g., snow removal). In addition, for those alternatives involving lost generation, generation losses would increase.

- Construct reservoirs to increase water exposure to solar heating and release to Cooper Creek

This study elaborates on the alternatives considered to date, their costs, and their potential ability to supplement flow and provide warmer water in Cooper Creek. This study also provides further analysis of potential stream habitat enhancement in lower Cooper Creek.

1.4 HYDROLOGY

The amount of actual historical hydrologic records is limited. Prior to construction of the Project, the outflow from Cooper Lake was to Cooper Creek. In August 1949, a USGS stream gage (USGS 15260000) was established at the outlet of Cooper Lake. This gage was at the site of the dam and was discontinued during construction of the dam in 1959. Storage in Cooper Lake impounded by the dam began in December 1959. USGS gages have also existed at the mouth of Cooper Creek and on Stetson Creek, as summarized in Table 1-1.

Table 1-1: USGS Gages on Stetson and Cooper Creeks

USGS Gage Number	USGS Gage Name	Drainage Area (sq.mi.)	Gage Datum (feet)	Period of Record
15260000	Cooper Creek near Cooper Landing	31.8	1166	August 1949 through July 1959
15261000	Cooper Creek at Mouth near Cooper Landing	48.6	450	October 1957 through January 1965 September 1998 through present
15260500	Stetson Creek near Cooper Landing	8.6	1100	June 1958 through September 1963

The ungaged area of Stetson Creek between the USGS gaging station and the confluence of Stetson Creek with Cooper Creek is small, on the order of about 0.1 square mile. Because there has been no outflow from Cooper Lake to Cooper Creek since construction of the dam, the tributary area of Cooper Creek has been effectively reduced from 48.6 square miles to 16.8 square miles. Stetson Creek includes about 51% of the remaining Cooper Creek effective tributary area.

Flow data for the early part of the record at the mouth of Cooper Creek following construction of the dam are presented in Table 1-2. Flows average 62.4 cfs over the period of record and 113.5 cfs for the June through October period.

Table 1-2: Post-dam Recorded Cooper Creek Flows (cfs) at USGS Gage 15261000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1959	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	14.5	-----
1960	10.5	7.5	7.0	9.0	90.1	87.2	68.1	54.3	58.2	37.0	22.6	28.8	40.2
1961	32.9	15.7	11.5	16.5	219.0	323.0	326.0	226.0	309.0	177.0	37.0	17.0	143.3
1962	14.0	11.0	8.0	12.0	58.3	212.0	228.0	79.8	52.1	23.0	26.0	13.0	61.7
1963	11.0	11.0	11.0	10.0	46.2	73.7	72.8	38.0	21.6	20.7	11.9	10.0	28.3
1964	8.0	7.0	6.0	17.8	42.6	152.0	75.4	52.5	33.5	35.9	21.6	11.3	38.7
1965	10.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Average	14.4	10.4	8.7	13.1	91.2	169.6	154.1	90.1	94.9	58.7	23.8	15.8	62.4

Chugach has had a stream gage installed in Cooper Creek upstream of the confluence with Stetson Creek since fall 2002. Summer-fall average monthly flow data, collected in 2003 and extrapolated data for 1999 through 2002, are shown in Table 1-3. Flow averages about 6.3 cfs throughout the year at the gage and averages 10.1 cfs from June through October.

Table 1-3: Average Monthly Cooper Creek Flows (cfs) above Stetson Creek

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1999	0.0	0.0	0.0	0.2	8.7	15.1	9.9	4.9	8.8	6.7	1.4	0.1	4.7
2000	0.0	0.0	0.0	0.4	9.3	17.0	11.1	5.3	3.6	3.3	2.8	1.6	4.5
2001	1.8	0.1	0.0	0.5	8.9	31.3	21.6	12.0	7.2	4.4	1.3	0.1	7.4
2002	0.4	0.0	0.0	0.5	15.8	18.5	10.2	4.2	4.3	23.3	20.0	7.8	8.8
2003	4.6	3.5	0.3	2.8	7.0	9.4	8.9	3.4	2.8	4.5	----	----	4.7
Average	1.4	0.7	0.1	0.9	9.9	18.3	12.3	5.9	5.3	8.4	6.4	2.4	6.0

Stetson Creek recorded flows for the available period of record have averaged about 25 cfs, as shown in Table 1-4. The average flow for the 5-month period from June through October is 43.3 cfs.

Table 1-4: Recorded Stetson Creek Flows (cfs) at USGS Gage 15260500

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1958	-----	-----	-----	-----	49.6	90.6	52.8	37.7	27.0	19.1	11.4	7.6	-----
1959	6.0	5.5	5.4	6.8	30.8	84.2	43.3	32.4	27.6	16.2	12.6	8.7	23.3
1960	7.0	5.6	4.3	4.8	46.8	65.3	49.4	41.6	38.3	21.0	12.5	15.5	26.1
1961	18.5	9.4	5.5	6.4	45.6	98.4	70.1	46.5	60.5	33.6	9.8	8.0	34.5
1962	7.0	5.0	5.0	5.9	19.0	74.5	47.2	21.4	19.5	15.1	16.4	7.9	20.4
1963	5.9	5.0	4.5	5.2	29.4	51.1	54.8	24.8	15.2	-----	-----	-----	-----
Average	8.9	6.1	4.9	5.8	36.9	77.3	52.9	34.1	31.4	21.0	12.5	9.5	25.2

The period of common record for the Stetson Creek gage and the gage at the mouth of Cooper Creek is from December 1959 through September 1963. By subtracting the flows at these two gages for the common period of record, the inflows to Cooper Creek below the dam and without Stetson Creek can be developed, as presented in Table 1-5. Again, it should be noted that this is a very short period, and therefore should only be viewed as an indicator of the order-of-magnitude of the flows at this location, based on a limited period of historical record.

Table 1-5: Local Inflows (cfs) to Cooper Creek below the Dam and Without Stetson Creek

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1959	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5.8	-----
1960	3.5	1.9	2.7	4.2	43.3	21.9	18.7	12.7	19.9	16.0	10.1	13.3	14.1
1961	14.4	6.3	6.0	10.1	173.4	224.6	255.9	179.5	248.5	143.4	27.2	9.0	108.8
1962	7.0	6.0	3.0	6.1	39.3	137.5	180.8	58.4	32.6	7.9	9.6	5.1	41.3
1963	5.1	6.0	6.5	4.8	16.8	22.6	18.0	13.2	6.4	-----	-----	-----	-----
Average	7.5	5.1	4.6	6.3	68.2	101.7	118.4	65.9	76.8	55.8	15.6	8.3	44.8

The contribution of Stetson Creek to post-dam flows at the mouth of Cooper Creek has averaged about 50%, based on a time-weighted average as presented in Table 1-6.

Table 1-6: Stetson Creek Flow as a Percentage of Post-dam Flow at the Mouth of Cooper Creek

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1959	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	60%	-----
1960	67%	74%	62%	53%	52%	75%	73%	77%	66%	57%	55%	54%	65%
1961	56%	60%	48%	39%	21%	30%	22%	21%	20%	19%	26%	47%	24%
1962	50%	45%	63%	49%	33%	35%	21%	27%	37%	66%	63%	61%	33%
1963	53%	45%	40%	52%	64%	69%	75%	65%	70%	-----	-----	-----	-----
Average	57%	56%	53%	48%	42%	52%	47%	47%	48%	47%	48%	55%	50%

1.5 COOPER LAKE LEVEL

The original Cooper Lake level prior to construction of the Project was elevation 1168 feet MSL and fluctuated with variations in the inflow to the lake. The currently licensed maximum operating level of Cooper Lake is Elevation 1210 feet MSL. However, since 1985, in deference to a potential dam safety issue regarding potential overtopping of the dam during the hypothetical probable maximum flood (PMF) event, the lake maximum operating level has been voluntarily kept at elevation 1194 feet MSL. Figure 1-1 shows variations in Cooper Lake over time and the period of potential temperature and flow mitigation as described in Sections 2.0 and 3.0.

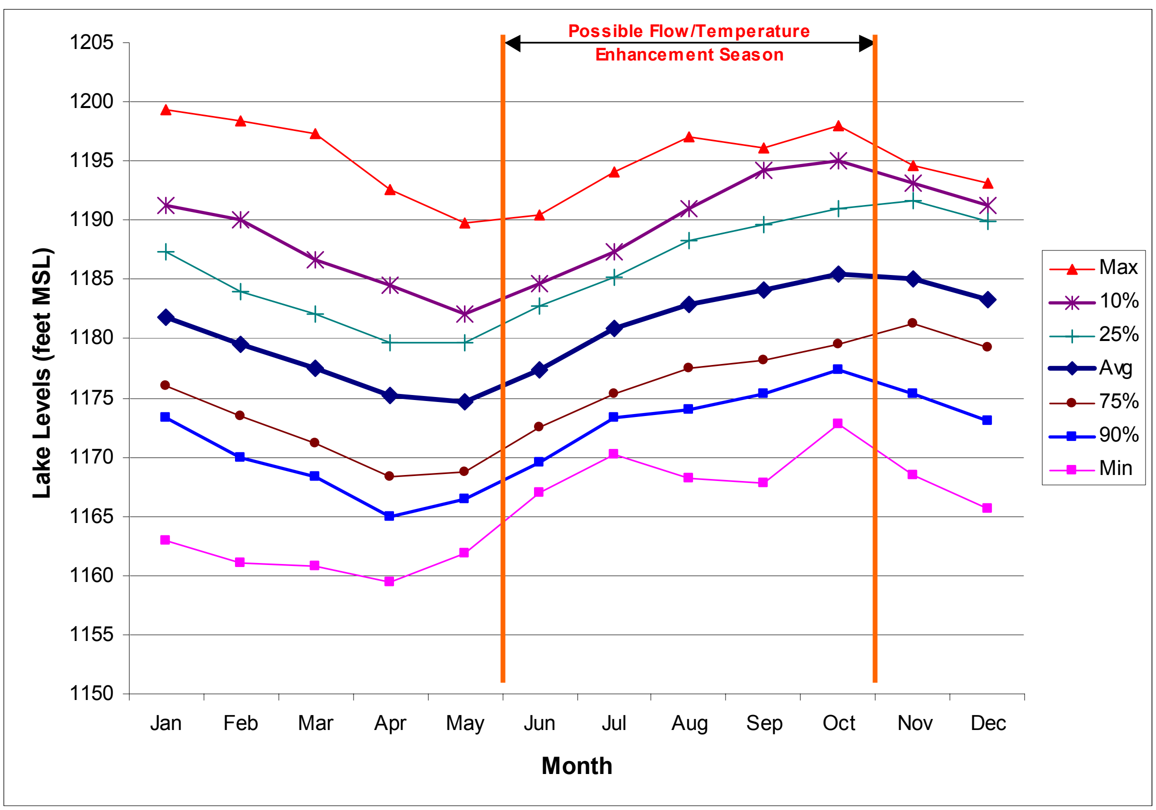

Figure 1-1: Historical Variations in Cooper Lake Level (1965 – 2002)

Chugach proposes to maintain the current operating regime of Cooper Lake; that is, to a maximum operating lake level of elevation 1194 feet MSL. This level will be exceeded only when there are large inflows to the lake unable to be controlled by the powerplant. Exceptions to this are noted under Alternatives 8 and 14 described in Section 2.0.

2.0 PROTECTION, MITIGATION AND ENHANCEMENT ALTERNATIVES

Several concepts have been investigated to provide warmer water to Cooper Creek in an effort to benefit fish in the reaches downstream of the dam. Some of the concepts also provide flow supplementation to Cooper Creek from other sources. Development of potential protection, mitigation and enhancement (PME) concepts has included the preparation of pre-design sketches, preparation of order-of-magnitude cost estimates, determination of operations and maintenance costs, and estimating the cost of lost generation at Cooper Lake powerhouse due to the reduced availability of water to release through the powerhouse, as applicable.

Alternatives 1 through 6 and their sub-alternatives were presented and discussed in the Draft License Application (DLA) (Chugach 2004a) for the Cooper Lake Project and will be reiterated herein for completeness of this report. In addition, four other alternatives have been studied since publication of the DLA. One of the alternatives (#10) relates to habitat enhancement in lower Cooper Creek and would not measurably affect water temperature and would not alter flow in the creek.

2.1 ALTERNATIVES STUDIED

The following lists the identified alternatives that have been studied to date:

Alternative 1. Cooper Lake Dam gravity outlet structure:

- 1a. 70 cfs outlet, with two inlet pipes
- 1b. 70 cfs outlet, with one inlet pipe
- 1c. 30 cfs outlet, with one inlet pipe

Alternative 2. Cooper Lake Dam gravity outlet structure for 30 cfs with one inlet pipe + additional heating

- 2a. Active heating
- 2b. Passive heating (warming pond)

Alternative 3. Stetson Creek diversion + Cooper Lake Dam gravity outlet structure:

- 3a. 70 cfs outlet
- 3b. 30 cfs outlet

Alternative 4. Cooper Lake Dam siphon outlet structure:

- 4a. 70 cfs outlet
- 4b. 30 cfs outlet

Alternative 5. Cooper Lake siphon outlet structure for 30 cfs + additional heating

- 5a. Active heating
- 5b. Passive heating (warming pond)

Alternative 6. Stetson Creek diversion + warming pond on Cooper Creek

Alternative 7. Stetson Creek diversion into upper Cooper Creek

Alternative 8. Cooper Lake Dam rubber dam outlet structure

Alternative 9. Warming pond on Stetson Creek

Alternative 10. Stream habitat enhancement of lower Cooper Creek

In addition, at the end of this section, there is a discussion of other alternatives that could be considered, some generated in response to questions raised at the July 2004 Relicensing Workshop (Chugach 2004b) held with the resource agencies and public in Anchorage.

2.2 STUDY ASSUMPTIONS

The analyses summarized in this study have been performed based on a number of assumptions, including the following:

- Environmental impacts are only briefly considered in this report. The environmental effects related to construction and operation of any potential PME alternatives included in Chugach's FERC license application would need additional consideration.
- Cooper Lake will be operated up to a maximum elevation of 1194 feet MSL and down to a minimum elevation of 1165 feet MSL. The lake would exceed elevation 1194 feet MSL only during large floods that cannot be controlled by the powerhouse. Exceptions to this assumption would be made for Alternatives 8 and 14 as discussed below.
- Alternatives have been developed to the degree necessary to support an initial consideration of potential PMEs. Only conceptual level studies have been performed for this report and alternatives are not fully developed in great detail of layout, operation, cost, or benefits.
- Though MWH is a consultant to Chugach, alternatives and associated capital and O&M costs have been developed by and large without input from Chugach at this point. It should be cautioned that estimates of probable costs are highly variable, especially at this early phase of study, given a fluctuating construction marketplace, variable inflation, uncertainty in the actual date of construction, uncertain future energy costs, etc. It should also be noted that the alternative layouts and estimated costs that have been developed are currently at the conceptual level without the benefit of site specific condition information, therefore, estimates should be used for comparison among the various alternatives only, rather than as a definitive indication of the expected final costs.
- Factors in evaluating costs from Chugach's business practice have been provided by Chugach and are presented herein.

2.3 ALTERNATIVE 1 – COOPER LAKE DAM GRAVITY OUTLET STRUCTURE

This alternative, and associated sub-alternatives 1a, 1b and 1c, would involve construction of an outlet structure at the dam that would enable the release of warmer, surface water from Cooper Lake by gravity into Cooper Creek. The alternatives are further defined as follows:

- 1a. 70 cfs outlet, with two inlet pipes
- 1b. 70 cfs outlet, with one inlet pipe

- 1c. 30 cfs outlet, with one inlet pipe

The outlet structure would be located near the right abutment adjacent to the dam crest. The outlet structure would consist of an intake channel, a reinforced concrete outlet tower with one (Alternatives 1b and 1c) or two (Alternative 1a) intakes, and an outlet pipe under the dam to a stilling basin adjacent to Cooper Creek downstream of the dam as indicated in Figures 2-1. In addition, if required, a low level, winter bypass intake and pipe, 18 inches in diameter, would extend from elevation 1160 feet MSL to the outlet structure tower to allow for year around instream flow releases. The current layout includes this pipe and assumes that a 5 cfs minimum instream flow would be released from November through May, a period of 7 months.

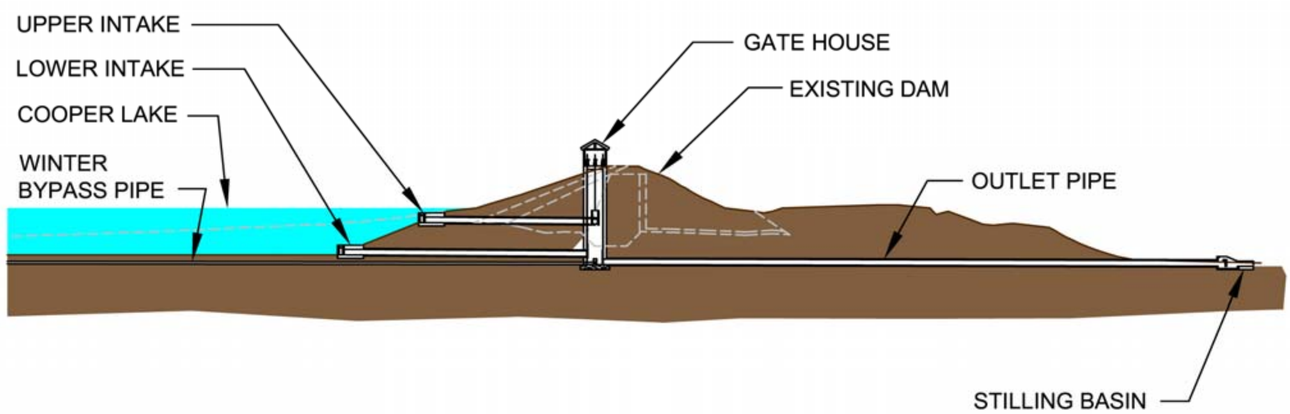

Figure 2-1: Section of Gravity Outlet Structure with Two Pipes

It is anticipated that the lake level would need to be lowered to elevation 1165 or lower to allow construction of the majority of the structures in the dry. Construction would start by excavating for the intakes, outlet structure tower and pipelines. Construction of these features would involve open-cut excavation techniques through the dam with a maximum cut 65 feet deep and with side slopes of about 1 horizontal to 1 vertical. The width of the excavation at the top of the dam would be about 140 feet wide. The total length of the initial excavation would be approximately 600 feet from upstream to downstream. From pre-Project subsurface investigations, the foundation immediately below the dam is comprised of compact glacial moraine and an outwash of sand, gravel, cobbles and boulders and should be capable of excavation by standard earth moving equipment. The intake channel would not initially be excavated to allow a "natural" cofferdam between the lake and the construction area.

Upon completion of the intake, outlet structure tower and pipelines, the open cut would be backfilled and well compacted. In addition, the zoned portion of the dam would be reconstructed in accordance with the original construction layout. This would require segregation, stockpiling and salvaging of the various dam materials as the dam is excavated. Once the open-cut excavation is backfilled the dam concrete facing, demolished during excavation, will need to be reconstructed around the new structures and the riprap on the downstream side of the dam will need to be replaced.

The intake channel would be excavated in the dry to the lake level and the winter bypass pipe installed. A small cofferdam would be required to construct the upstream portion of low flow inlet and pipe if the reservoir cannot be lowered additionally below elevation 1155 feet MSL. The cofferdam would be constructed of earthen material to allow construction of the upstream work in the dry. Installation and removal of the cofferdam will require in-lake work and would cause local turbidity. It is estimated that the entire outlet facility could be constructed in one summer-fall season. There would be generation losses during the period of construction to consider due to the lower reservoir elevation and reduced head.

During operation, flow from the inlet pipe(s) to the outlet pipe would be controlled by electric motor-operated slide gates. The configuration of the gravity outlet structure with two inlet pipes is shown in Figure 2-2. Figure 2-2 also shows the concept for the lake inlet(s) and the stilling basin downstream of the dam. The stilling basin is required to dissipate energy contained in the water being released through the outlet pipe. Head on the pipe at the stilling basin would vary from about 7 to 36 feet and water releases would scour the creek bottom if energy dissipation were not provided.

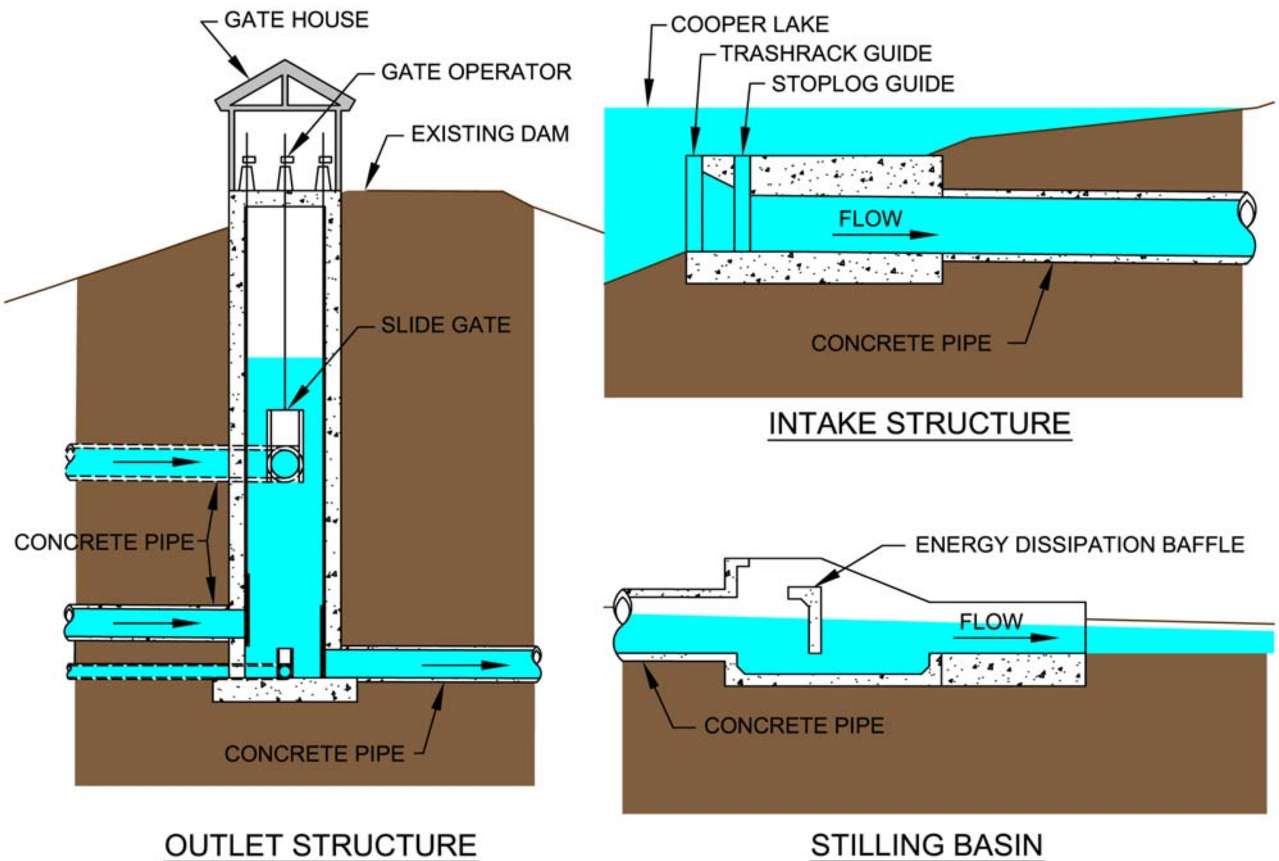

Figure 2-2: Components of Gravity Outlet Structure with 2 Pipes

Power would need to be provided to the outlet structure. The power supply could consist of either a new powerline from the Sterling Highway or onsite generation. For this study we have assumed that an onsite 50-kW propane generator would be sufficient to move gates on demand and would be less costly than 4 ½ miles of powerline constructed on rugged terrain.

The outlet structure would be capable of releasing maximum water flow rates ranging from 30 to 70 cfs (depending on the alternative) from the upper water column of Cooper Lake with a fluctuating reservoir level. The inlet pipe(s) for the 70 cfs alternatives (1a and 1b) would be 42 inches in diameter. The idea behind the concept of two inlet pipes spaced 20 feet apart vertically is that as the lake level fluctuates the withdrawal level would always be within 20 feet of the water surface in order to release the warmest water possible. Two intakes may not be necessary, as temperature measurements taken in the lake over the last two years indicate that the lake mixes thoroughly and temperatures during the summer and early fall are typically relatively constant to a depth of 30 feet or more. Refer to Section 3.2 for more information on lake temperatures.

The inlet pipe for the 30 cfs alternative (1c) would be 30 inches in diameter. It is assumed that the 70 cfs alternatives would release an average of 50 cfs from June through October, a period of 5 months. For the 30 cfs alternative, the average release is assumed to be 25 cfs from June through October.

The operating range of the outlet structure would be between elevations 1194 and 1165 feet MSL (a range of 28 feet), which is the current operating range of the reservoir. It would be necessary to install an additional stream gage downstream in Cooper Creek. This gage would communicate with the gate control and operation system, and thereby help maintain desired flows under variable reservoir levels.

These alternatives would both supplement flow in Cooper Creek and increase stream temperature. Estimated temperature increases in Cooper Creek downstream of the dam, as the result of the various alternatives are discussed in Section 3.0. Construction costs, operations and maintenance (O&M) costs, and the value of foregone generation are discussed in Section 4.0.

2.4 ALTERNATIVE 2 – COOPER LAKE DAM GRAVITY OUTLET STRUCTURE PLUS ADDITIONAL HEATING

Alternative 2 involves a gravity outlet structure at Cooper Lake Dam identical to that described as Alternative 1c above, with one inlet pipe and a 30 cfs maximum outlet, in combination with additional heating of the water released from Cooper Lake. Figure 2-3 shows the gravity structure with one pipe. Preliminary studies looked at either actively heating the water or providing additional passive solar heating. These alternatives are discussed below:

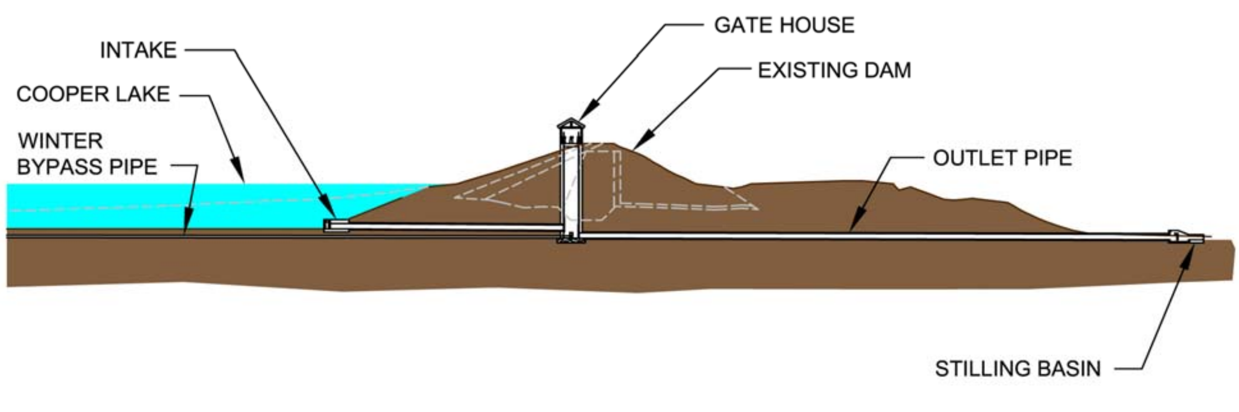

Figure 2-3: Section of Gravity Outlet Structure with One Pipe

2.4.1 Active Warming

Methods of physical warming and heat transfer (e.g., solar electrical, electrical generation, diesel or natural gas) were briefly studied. It was determined that it would take 57 million BTU per hour (1.4 billion BTU per day) to heat 30 cfs of water 4.7^{o} C, without consideration for various system efficiencies. For the solar electric heating option, based on conversations with a solar heating vendor, this would require a system of solar panels and a heat exchanging system. The required number of solar panels would need to be increased appreciably to store energy when the sun was not visible or was below the horizon. The estimated total cost for this system is roughly on the order of $20 million. Using diesel or natural gas would also be prohibitively costly. For these options, the estimated daily fuel cost would be on the order of $15,000 per day or $2.25 million for a 5-month heating period. To these costs the capital cost of the physical facilities would need to be added. Based on their doubtful feasibility, significant environmental disruption and/or prohibitive costs, these active warming scenarios were not considered further.

2.4.2 Passive Warming — Warming Pond

For the passive heating alternative, it was assumed that water would be released from Cooper Lake Dam through the outlet structure and flow into a warming pond immediately downstream. The warming pond would be impounded by an earth/rock fill dam approximately 120 feet in height, with a crest length of about 300 feet, and similar in construction to the existing Cooper Lake Dam. The dam would have an uncontrolled surface outlet spillway sized to provide continuous outflow equal to the inflow. The pond would have a surface area of 9.3 acres and a storage capacity of 218 acre-feet. The location of the outlet structure, dam and warming pond reservoir is shown in Figure 2-4.

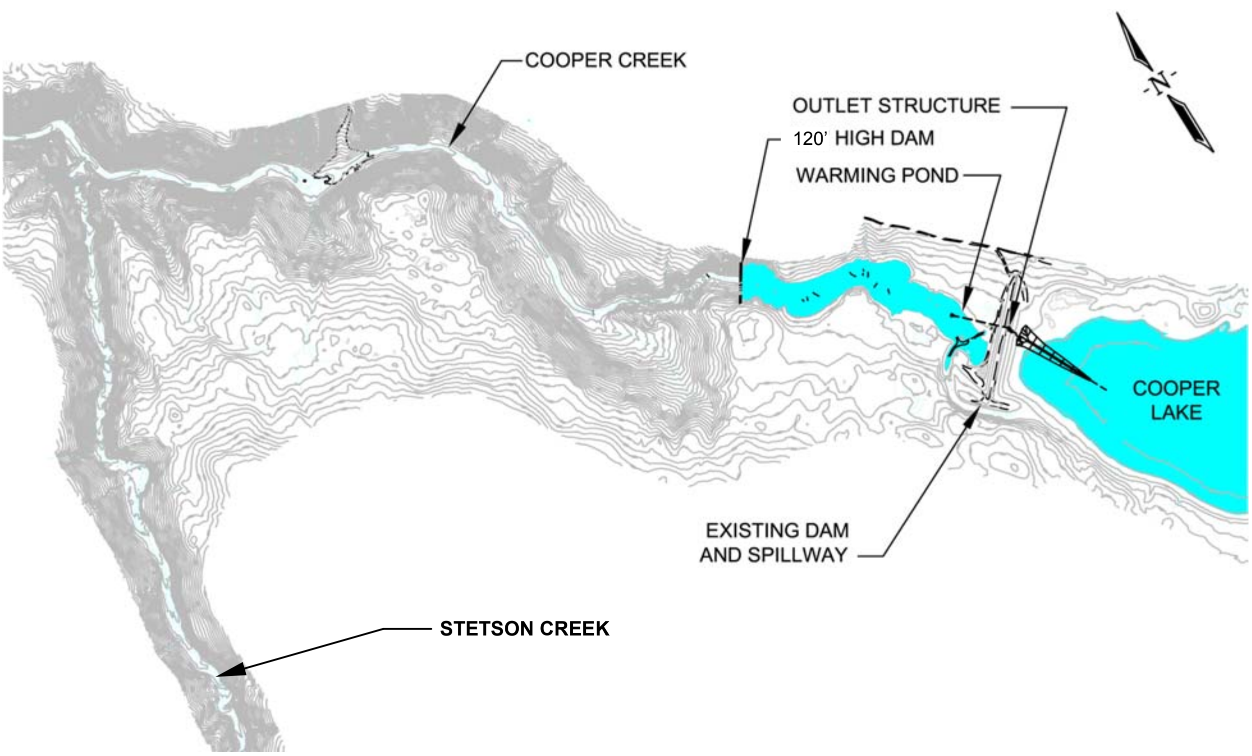

Figure 2-4: Outlet Structure and Warming Pond

Construction of the dam would involve 25 acres of clearing of vegetation and trees, excavation to a sound foundation in and adjacent to Cooper Creek, and borrow and hauling of 425,000 cubic yards (cy) of dam embankment material. The new dam would be comparable to Cooper Lake Dam and would require a major construction effort over two construction seasons.

This alternative (Alternative 2) would both supplement flow in Cooper Creek and increase stream temperature. Estimated temperature increases in Cooper Creek downstream of the dam for this alternative are discussed in Section 3.0. Construction cost, O&M costs, and the value of foregone generation are discussed in Section 4.0.

2.5 ALTERNATIVE 3 – STETSON CREEK DIVERSION PLUS COOPER LAKE DAM GRAVITY OUTLET STRUCTURE

Alternatives 3a and 3b would involve construction of a diversion structure on Stetson Creek at a point about 1 mile northwest of Cooper Lake Dam and diverting up to 70 and 30 cfs, respectively, from Stetson Creek to Cooper Lake. These alternatives would increase stream temperature in Cooper Creek but would not supplement flow downstream of the Cooper Creek/Stetson Creek confluence.

A 1958 amendment to the original license for the Project provided for diversion of water from Stetson Creek to Cooper Lake for the purposes of power generation. The amendment stipulated that the diversion of Stetson Creek flows could occur only during May through November, and that during these months minimum flows of 25 to 80 cfs were to be maintained in Cooper Creek as measured 0.7 miles upstream of its mouth.

This information provides a basis for selecting the range and timeframe of flows diverted from Stetson Creek for the current evaluation. Section 1.4 and Table 1-4 indicate that average monthly Stetson Creek flows range from about 77 cfs in June to 21 cfs in October, averaging 43.3 cfs during the period of June through October. Assuming an instream flow of 5 cfs in Stetson Creek, under Alternatives 3a and 3b, a maximum (instantaneous) flow volume of 30 to 70 cfs, respectively, would be diverted from Stetson Creek. No diversion would be made from November through May, because flows during the winter months typically average only 5 to 10 cfs, water temperatures would be similar to those in the lake, and icing of the diversion structure and conveyance line would be problematic.

For Alternative 3a, with a maximum diversion of 70 cfs and an average diversion of 50 cfs over the 5-month diversion period, there would be a net water loss of water from the lake of about 12 cfs because the average diversion rate would be about 38 cfs (43 cfs average less 5 cfs Stetson Creek instream flow). This was not accounted for in the DLA, but the lost generation costs are now included in those shown under Section 4.3. (The situation in which the diversion/release amounts are designed to provide a *net gain* of water in the reservoir for power generation is discussed below in section 2.13.1.)

Construction and future maintenance of the diversion structure would require an access road from Cooper Lake Dam to the diversion structure. In addition the road would become the right-of-way for the diversion pipeline. The road and pipeline construction would involve clearing about 17 acres of trees and vegetation along their alignments. Road construction would involve construction of a bridge across the spillway and excavating, filling and grading along a right-of-way corridor of 50 to 70 feet. As the road would be aligned along the east side of Stetson Creek, substantial rock cuts would be required to blaze a road into the remote diversion point. We estimate that over 20,000 CY of rock would need to be excavated by blasting and 14,000 CY of common excavation would be required for the access road and pipeline construction. Excavation of rock along the steep Stetson Creek canyon wall would be difficult and rock falls into the creek would be unavoidable.

The diversion structure on Stetson Creek would involve blasting and excavating to a sound rock foundation in and adjacent to the creek bed, requiring controlling and diverting the creek around the foundation area. The diversion structure would be constructed of conventional cast-in-place concreted or roller-compacted concrete (RCC). The diversion dam would be about 30 feet high and 20 feet from the foundation to the uncontrolled overflow crest at elevation 1310 feet MSL. The diversion structure, as shown in Figure 2-5, would also contain a sluice gate to pass sediments and gravel, trashrack and slide gate(s) to divert water to the pipeline. The gates would be manually operated, as power would not be brought into the diversion.

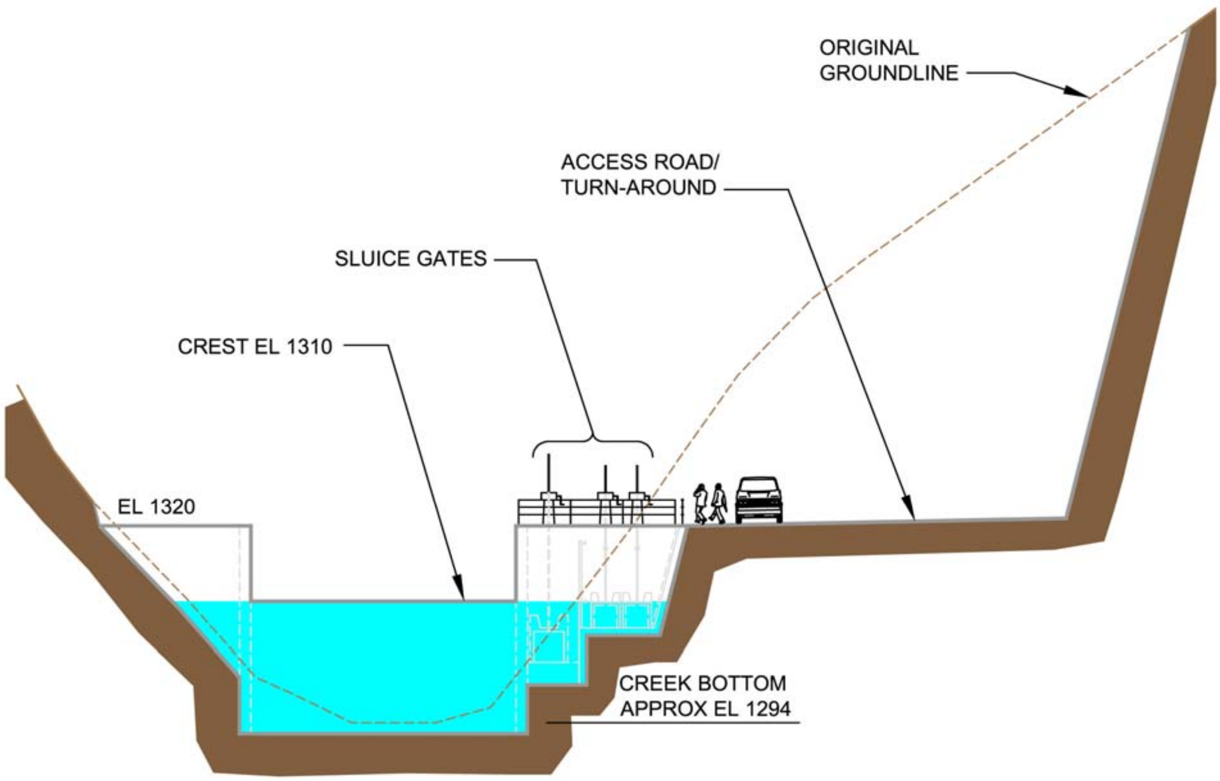

Figure 2-5: Section of Stetson Creek Diversion Structure

For the two alternatives 3a and 3b, the total length of the conveyance pipeline from Stetson Creek to Cooper Lake would be about 11,000 feet as shown in Figure 2-6. The pipeline would be trenched and buried and has been estimated to be 36 inches and 30 inches in diameter for Alternatives 3a and 3b, respectively. It is assumed the pipeline would be high-density polyethylene (HDPE) and reinforced concrete. Figures 2-7 and 2-8 show during-construction and after-construction views of the pipeline, indicating the width of clearing and ground disturbance. The pipeline would extend about 1,000 feet upstream of Cooper Lake Dam and water would be released deep into Cooper Lake so that cooler Stetson Creek water would not appreciably affect the thermocline and warmer surface water releases through the dam outlet structure. The pipe into the lake would be encased in concrete to protect it from icing of the lake requiring the lake to be lowered and/or underwater construction.

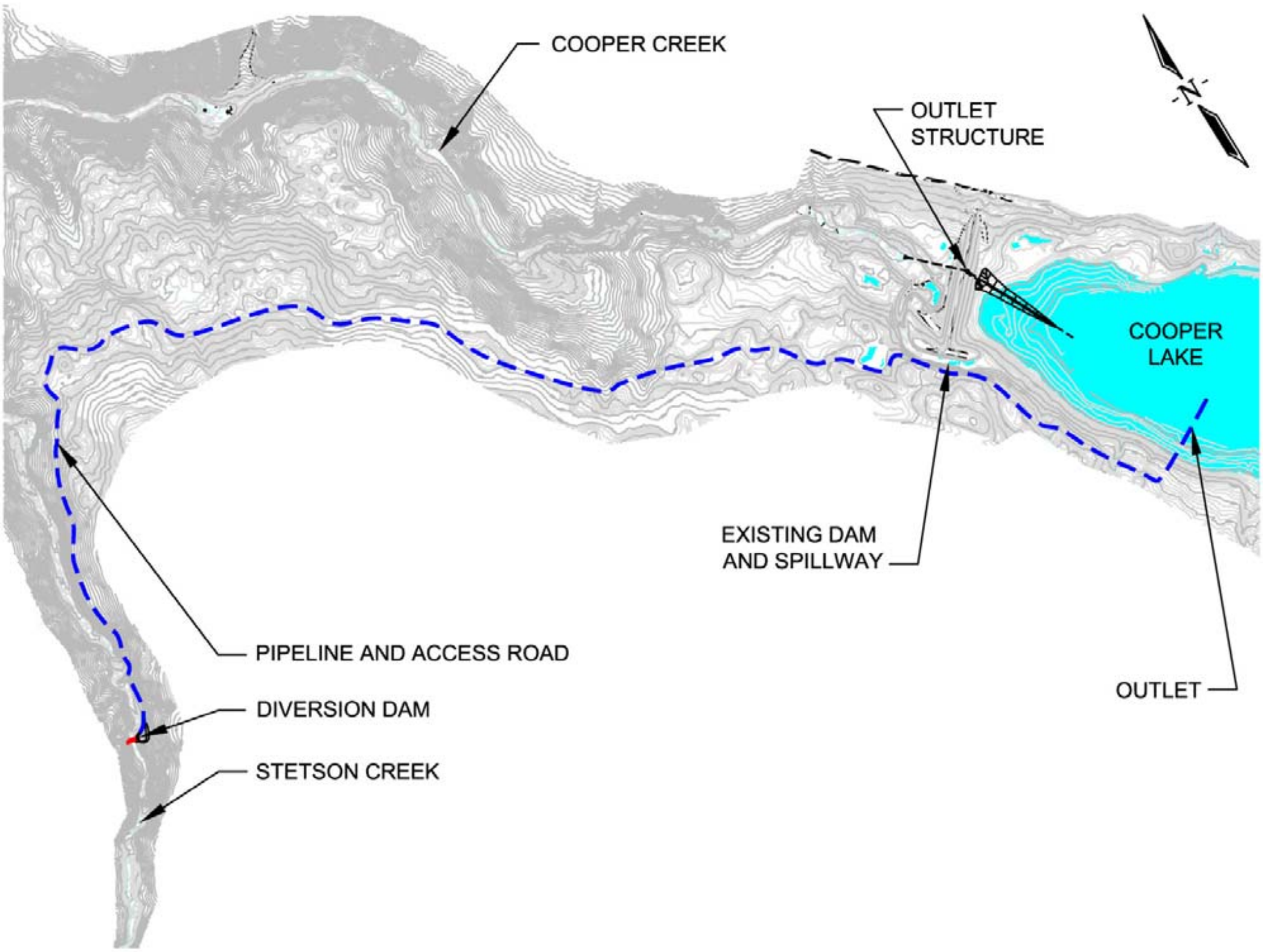

Figure 2-6: Plan of Stetson Creek Diversion, Pipeline and Gravity Outlet Structure

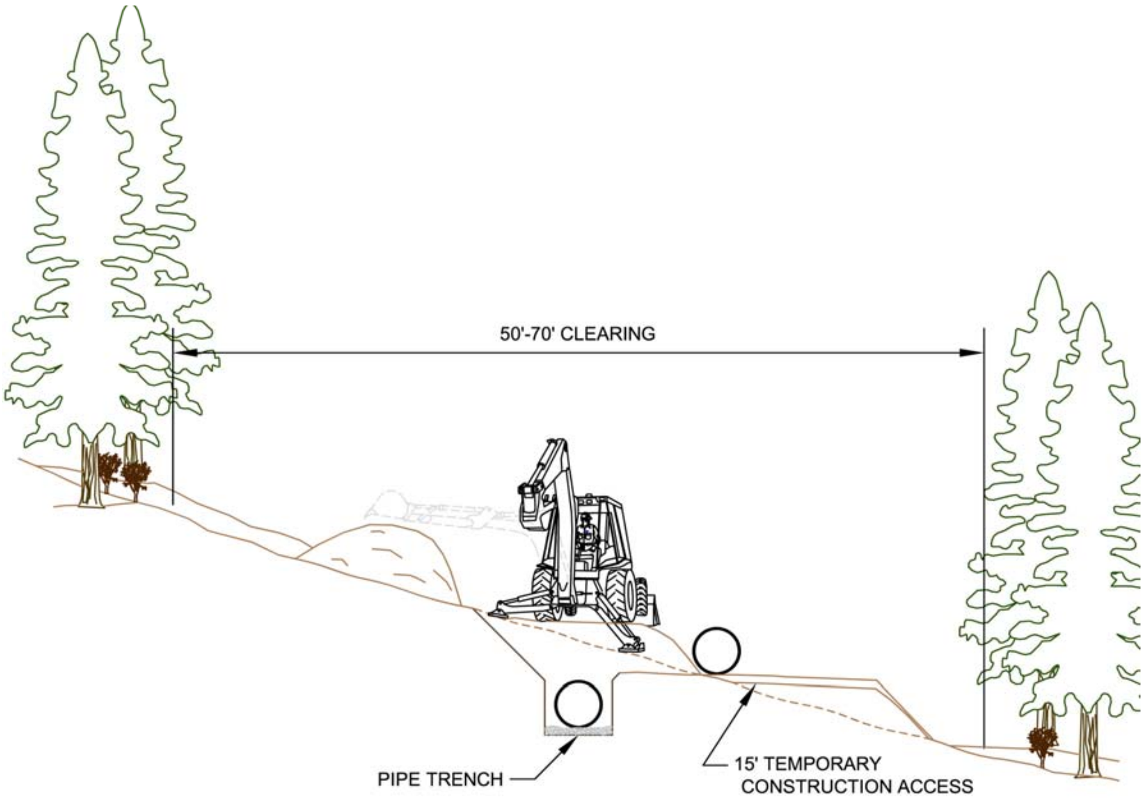

Figure 2-7: Stetson Creek Diversion Buried Pipeline – Construction Phase

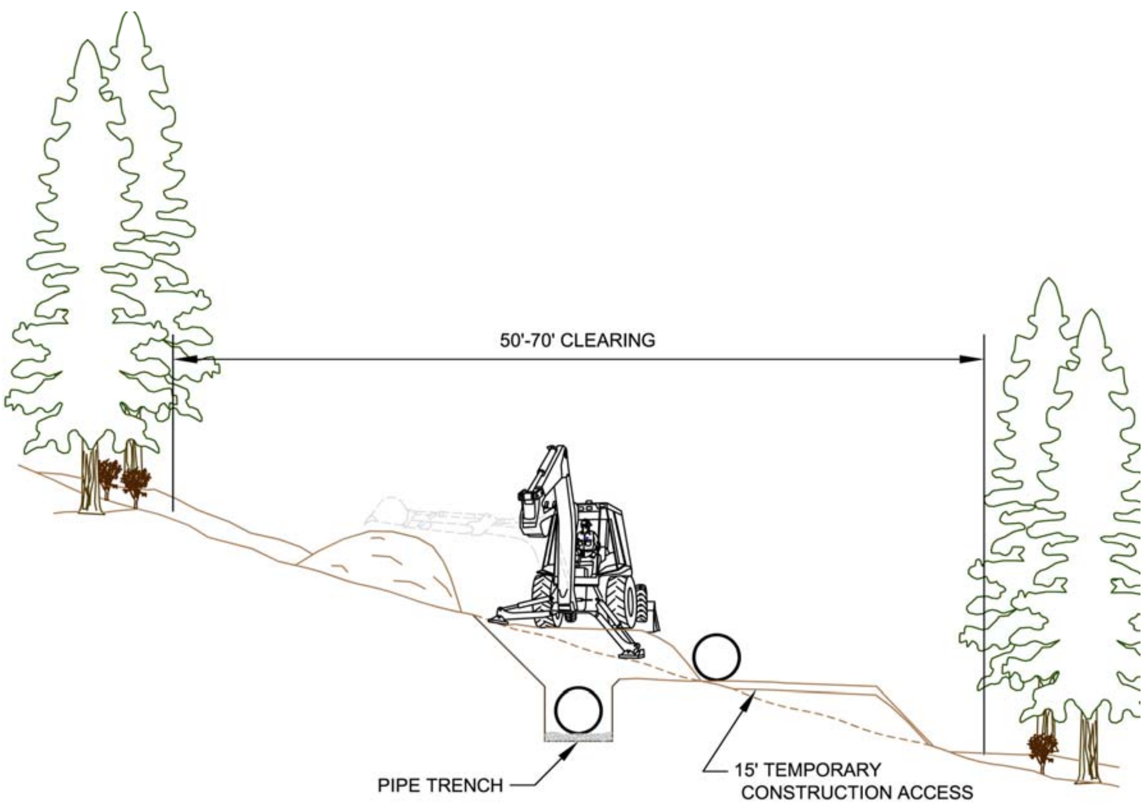

Figure 2-8: Stetson Creek Diversion Buried Pipeline – Operating Phase

The gravity outlet structure and associated releases would be as described under Alternatives 1a and 1c.

Estimated temperature increases in Cooper Creek downstream of the dam as the result of the various alternatives are discussed in Section 3.0. Construction costs, O&M costs, and the value of foregone generation are discussed in Section 4.0.

2.6 ALTERNATIVE 4 – COOPER LAKE DAM SIPHON OUTLET STRUCTURE

For Alternatives 4a and 4b a siphon outlet structure would be constructed at Cooper Lake Dam to release near surface water from Cooper Lake. The alternatives are defined as follows:

- 4a. 70 cfs outlet
- 4b. 30 cfs outlet

The siphon outlet structure would be located near the right abutment adjacent to the dam crest. The facilities would consist of an intake channel, a steel siphon diversion pipe through the dam, and a stilling basin situated adjacent to Cooper Creek downstream of the dam. In addition, pumps (housed in a small building) would be required to fill the downstream portion of the siphon pipe with water and create a vacuum to start siphon flow. Flow from the siphon to the outlet pipe would be controlled by an electric motor-operated slide gate. A concept-level drawing of the siphon outlet structure is provided in Figure 2-9.

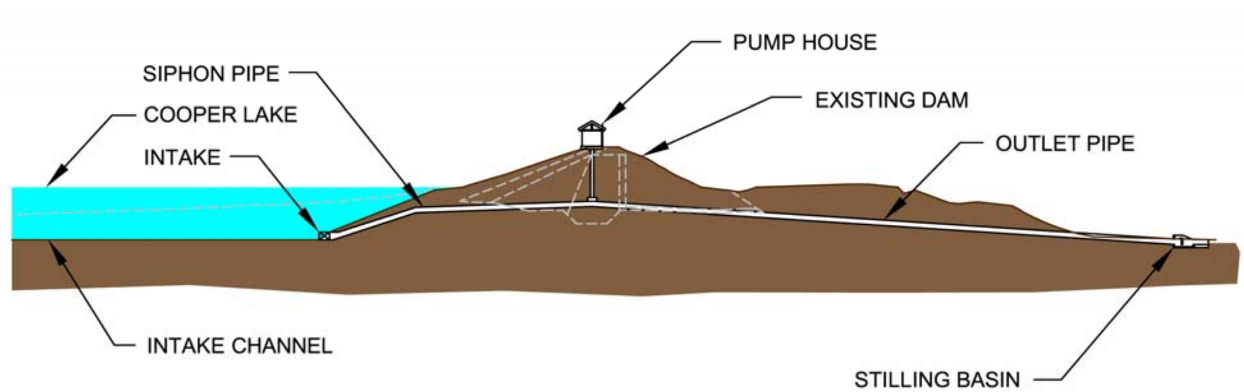

Figure 2-9: Section of Siphon Outlet Structure

Construction of the siphon outlet structure facilities would involve similar tasks, reservoir drawdown, and duration as described above for the gravity outlet structure. However, the depth and width of excavation would be shallower—about 45 feet maximum depth and 100 feet wide.

As with the gravity outlet structure, operation of the siphon pumps would require a source of power at the site (new powerline from the Sterling Highway or onsite generation). In this case, a 100-kW propane generator would be sufficient to intermittently operate the pumps. The siphon would be capable of releasing water at maximum flow rates ranging from 30 to 70 cfs, depending on the alternative, from the upper water column of the reservoir with a fluctuating reservoir level.

As with the gravity outlet structure described above, the operating range of the siphon outlet structure would be between elevations 1194 and 1165 feet MSL but only through a single withdrawal point. Likewise, it would also be necessary to install a stream gage downstream in Cooper Creek and a communication link to the siphon controls to maintain desired flows under variable reservoir levels.

These alternatives would both supplement flow in Cooper Creek and increase stream temperature. Estimated temperature increases in Cooper Creek downstream of the dam as the result of the various alternatives are discussed in Section 3.0. Construction costs, O&M costs, and the value of foregone generation are discussed in Section 4.0.

2.7 ALTERNATIVE 5 – COOPER LAKE DAM SIPHON OUTLET STRUCTURE PLUS ADDITIONAL HEATING

Alternative 5 involves a siphon outlet structure at Cooper Lake Dam identical to that described as Alternative 4b above, with a 30 cfs maximum outlet, in combination with additional heating of the water released from Cooper Lake. Preliminary studies looked at either actively heating the water or providing additional passive solar heating. As described under Section 2.4 active heating was prohibitively expensive and a warming pond was assumed to provide additional heating. Refer to Sections 2.4 and 2.6 for descriptions of the warming pond and the siphon outlet structure, respectively. Also refer to Figures 2-4 and 2-9.

This alternative would supplement flow in Cooper Creek and increase stream temperature. Estimated temperature increases in Cooper Creek downstream of the dam for this alternative are discussed in Section 3.0. Construction cost, O&M costs, and the value of foregone generation are discussed in Section 4.0.

2.8 ALTERNATIVE 6 – STETSON CREEK DIVERSION PLUS WARMING POND ON COOPER CREEK

For Alternative 6, water would be diverted from Stetson Creek directly into a warming pond downstream of the Cooper Lake Dam. The largest viable pond would be associated with a dam located immediately upstream of the Stetson Creek confluence and would extend 0.8 miles to the lower barrier falls at Cooper Creek river mile 4.3. The warming pond dam would be a major structure and would be approximately 120 feet tall with a crest length of 355 feet and be constructed of conventional concrete or RCC. The dam would have an uncontrolled surface outlet (spillway) sized to provide continuous outflow equal to the inflow. The maximum pond water level would be at elevation 950 feet MSL. The total volume of the pond would be 616 acre-feet with a surface area of 16.4 acres. The residence time of water in the pond, based on a 30 cfs release, would be about 10.4 days. The location of the dam and the warming pond reservoir is shown in Figure 2-10.

Construction of the dam would involve major construction activities and clearing of areas for a concrete batch plant and construction facilities. In addition, a site would need to be located to quarry rock materials for concrete aggregates. Construction of the dam could involve placement of an estimated 25,000 CY of concrete materials.

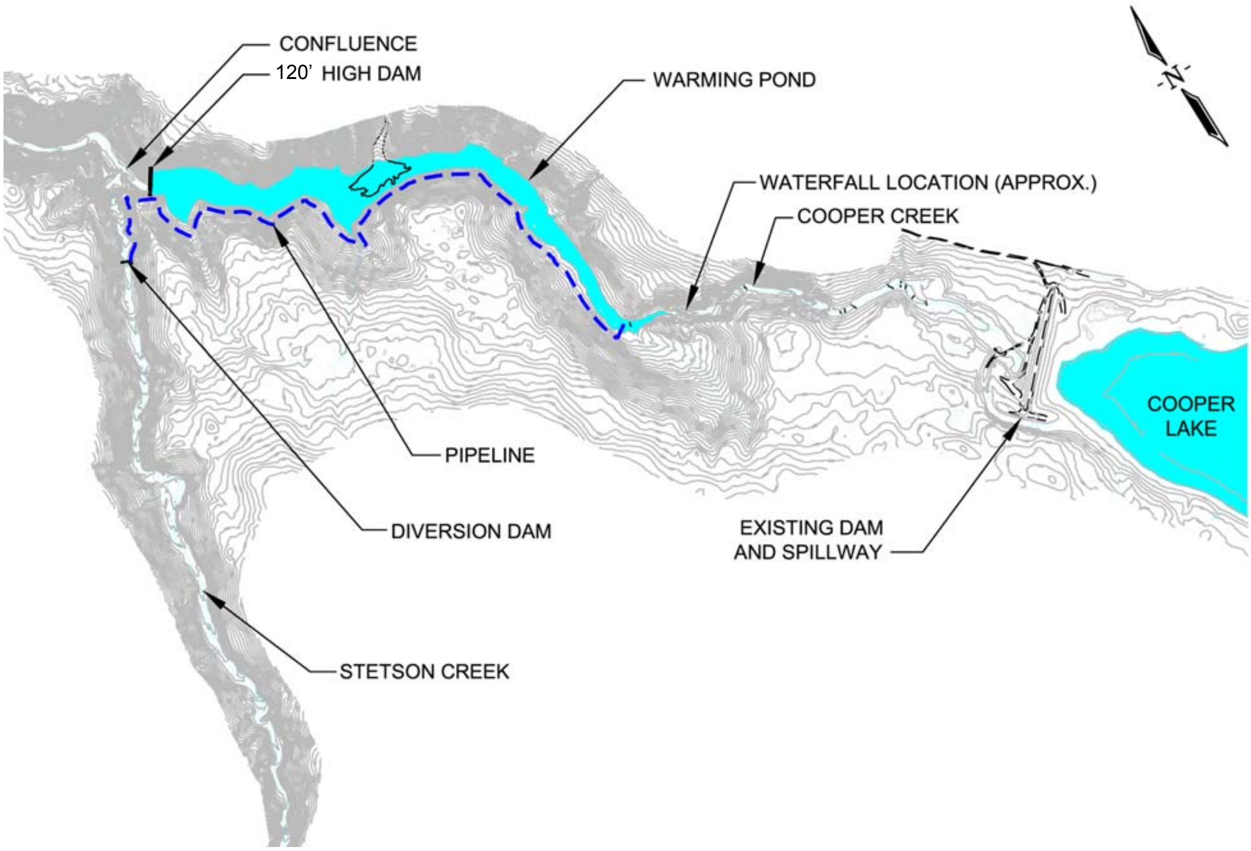

Figure 2-10: Plan of Stetson Creek Diversion, Pipeline and Warming Pond

The diversion structure from Stetson Creek would be similar to the one described under Alternative 3 and water would be conveyed about 7,000 feet in a buried pipeline directly to the upstream end of the warming pond. Construction techniques, difficulties and constraints would be similar to those described for Alternative 3.

This alternative would increase stream temperature but would not supplement flow. Estimated temperature increases in Cooper Creek downstream of the dam for this alternative are discussed in Section 3.0. Construction and O&M costs are discussed in Section 4.0.

2.9 ALTERNATIVE 7 – STETSON CREEK DIVERSION INTO UPPER COOPER CREEK

This alternative would involve a Stetson Creek diversion structure and pipeline to the downstream side of Cooper Lake Dam as shown in Figure 2-11. This alternative contains a similar diversion structure and initial pipeline length as described for Alternative 3. As the diversion pipeline leaves the diversion structure it would be buried in the canyon wall above the creek similar as to described for Alternative 3. Once the pipeline leaves the canyon it would be placed above ground and extend another 6200 feet to the downstream end of the Cooper Lake Dam spillway where water would be discharged. This would allow for ambient warming of the water in the pipe.

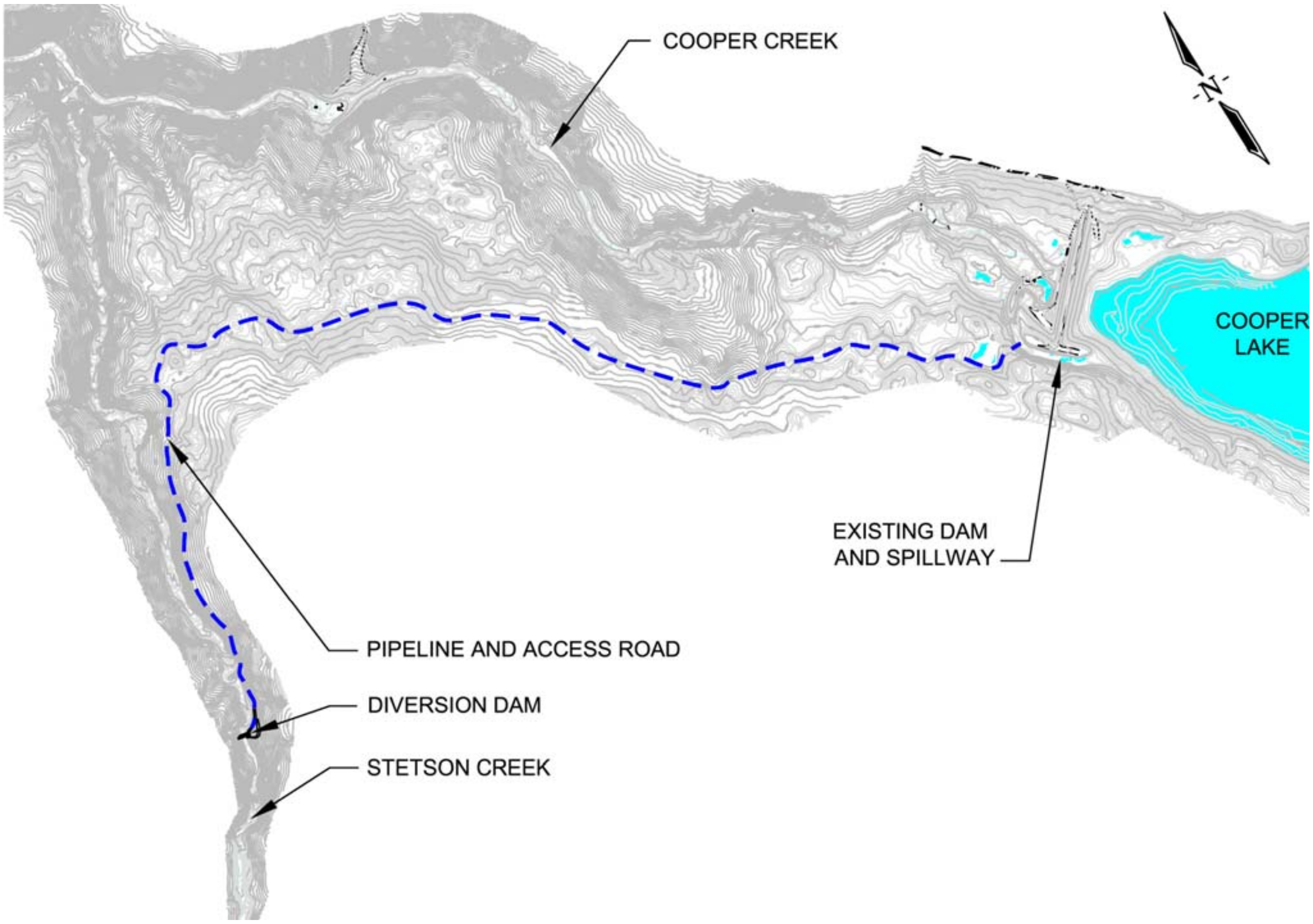

Figure 2-11: Plan of Stetson Creek Diversion and Pipeline to Cooper Creek

Construction of the diversion structure would be as previously described for Alternative 3. The above-ground pipeline would require clearing of trees for 50 feet on each side of the pipeline to keep trees from falling on and damaging the pipeline. The penstock would be placed on concrete saddle supports spaced at something in the order of 40 feet center to center. An access road would extend along the pipeline for inspection and maintenance. Figure 2-12 shows the final configuration of the pipeline/access road right-of-way.

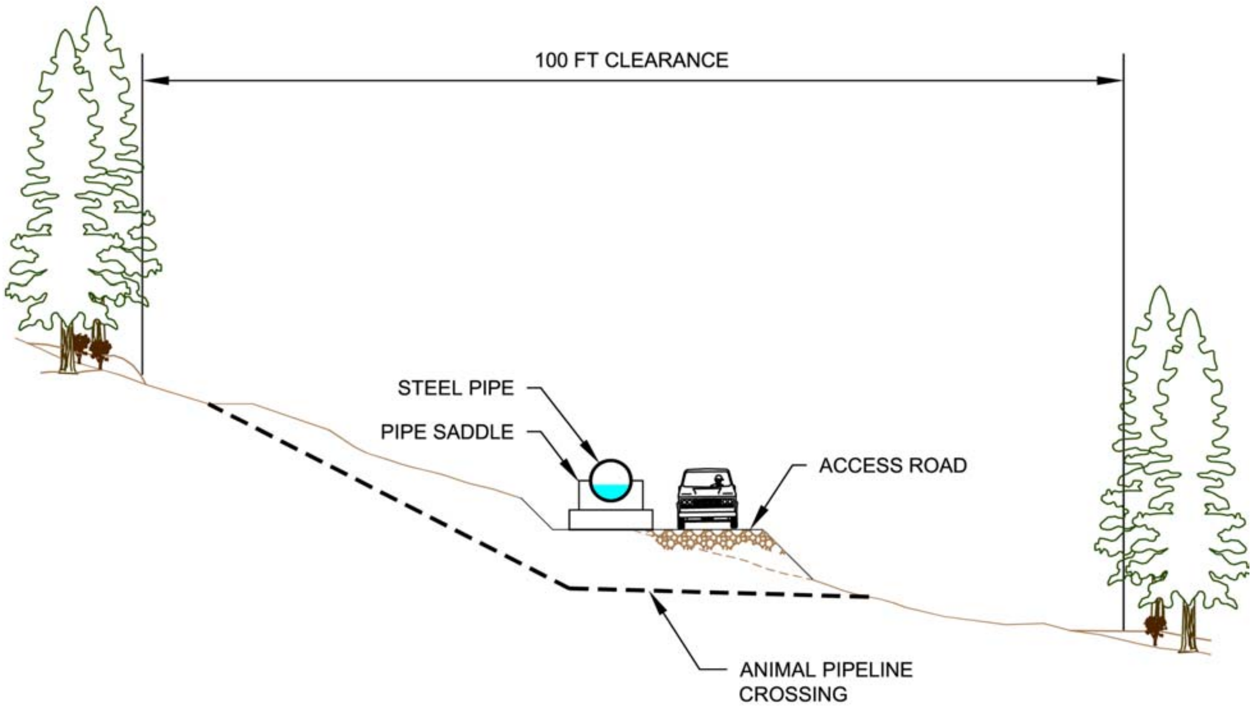

Figure 2-12: Stetson Creek Diversion Above-Ground Pipeline – Operating Phase

This alternative would increase stream temperature but would not supplement flow. Estimated temperature increases in Cooper Creek downstream of the dam for this alternative are discussed in Section 3.0. Construction and O&M costs are discussed in Section 4.0.

2.10 ALTERNATIVE 8 –COOPER LAKE DAM RUBBER DAM OUTLET STRUCTURE

This alternative involves constructing a so-called "rubber dam" structure in the Cooper Lake Dam spillway. Figure 2-13 shows the layout of this concept. A rubber dam is an air-inflated rubber bladder that can be deflated to allow flows to pass through the spillway. Refer to Figures 2-14 and 2-15 for views of the rubber dam structure. Though rubber dams can be made in any height up to 20 feet, this alternative involves placing a 20-foot high (diameter) rubber dam on a reinforced concrete foundation at the location of the 3-foot high existing weir in the spillway. The existing weir would be demolished and the spillway channel would be lowered by about 17 feet for a total lowering of the crest of the spillway by 20 feet. Spillway excavation would involve blasting and removal of about 30,000 CY of rock. A small air handling/equipment vault would be located adjacent to the rubber dam to contain housing for the air blower and control equipment. A small slide and water conduit would be located adjacent to the dam to allow for releases of water to downstream of the dam.

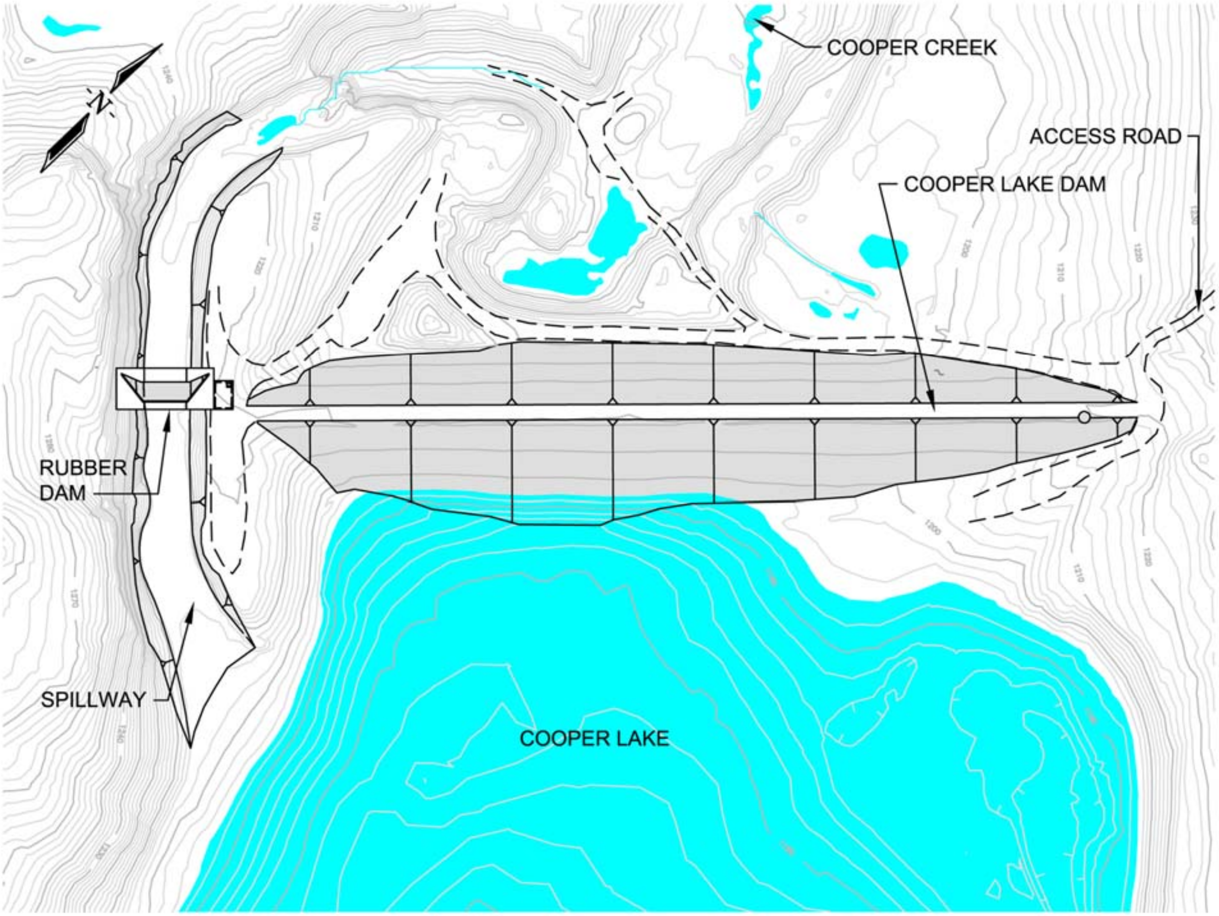

Figure 2-13: Rubber Dam Outlet Plan

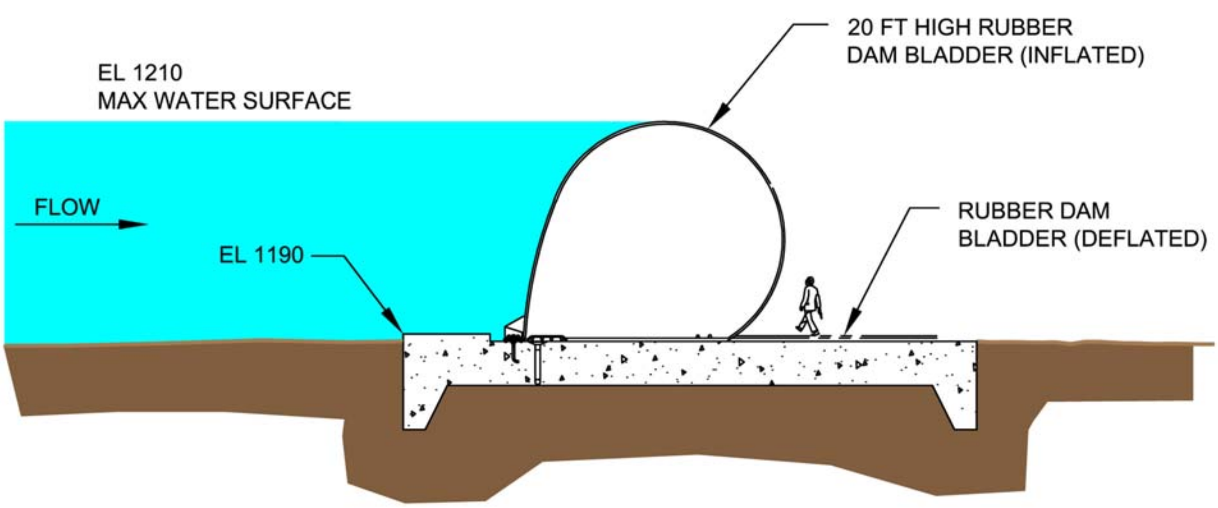

Figure 2-14: Rubber Dam Section

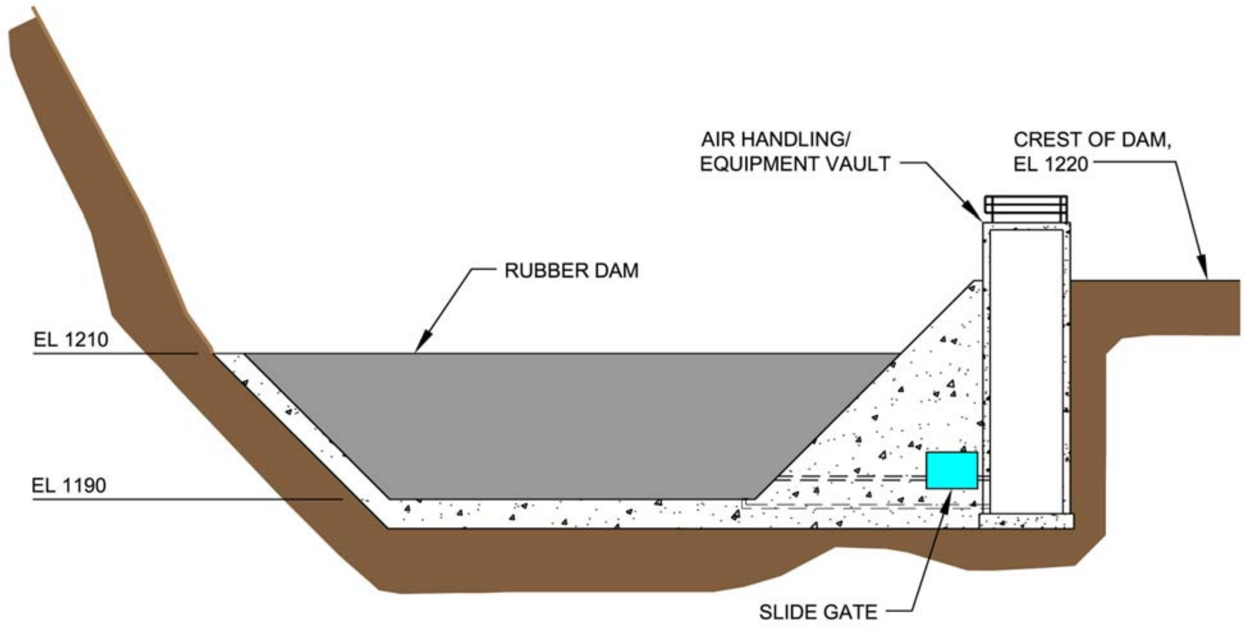

Figure 2-15: Rubber Dam Upstream Elevation in Existing Spillway

Once constructed the rubber dam would be operated in normally-inflated (up) mode with near surface lake water being released through the slide gate. This alternative has been sized for a 30 cfs release, but any release would be possible if the slide gate were sized for the outflow. By lowering the spillway crest by 20 feet, the PMF can be passed safely through the spillway even under a raised lake level. Therefore, for this alternative it would be proposed that the maximum allowable operating lake level be raised to elevation 1210 feet MSL. The rubber dam would be operated automatically and would deflate in response to lake levels above elevation 1210 feet MSL.

By raising the lake level some of the cost of lost generation would be recouped due to the increased head on the powerhouse turbines. This is discussed further under Section 4.3.

This alternative would both supplement flow in Cooper Creek and increase stream temperature. Estimated temperature increases in Cooper Creek downstream of the dam for this alternative are discussed in Section 3.0. Construction cost, O&M costs, and the value of foregone generation are discussed in Section 4.0.

2.11 ALTERNATIVE 9 – WARMING POND ON STETSON CREEK

This alternative would involve constructing a dam on Stetson Creek to lengthen the time that Stetson Creek water would be exposed to ambient warming. Stetson Creek is a steep gradient stream and, therefore, it would take a taller dam than the one considered above in Alternative 6 to impound enough volume of water to increase water temperatures prior to release downstream of the dam. For an initial layout a 200-foot high concrete or RCC dam was located as shown on Figures 2-16 and 2-17. The dam would have a crest length of about 850 feet long and form a reservoir with a surface area of about 12.4 acres with a volume of 1240 acre-feet.

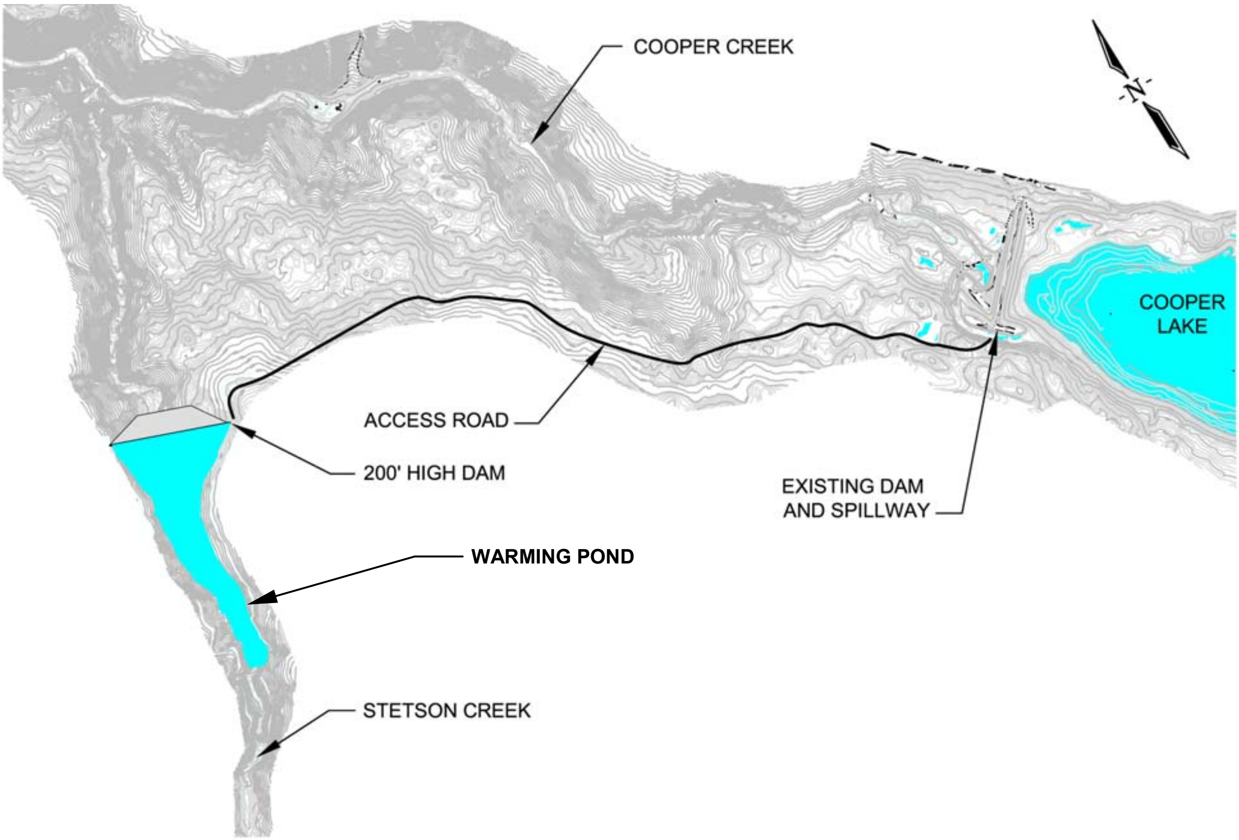

Figure 2-16: Plan of Stetson Creek Warming Pond

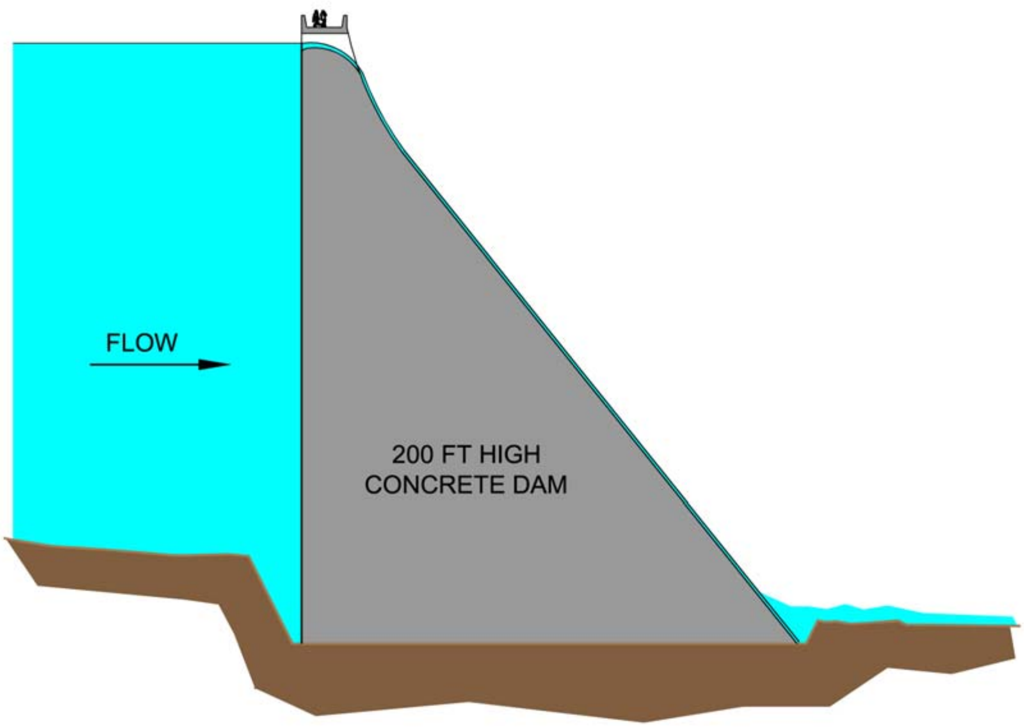

Figure 2-17: Section of Stetson Creek Warming Pond Dam

Construction of the dam would involve major construction activities and clearing of large areas for a concrete batch plant and construction facilities. In addition, a site would need to be located to quarry rock materials for concrete aggregates. Construction of the dam could involve placement of as much as 270,000 CY of concrete materials at a cost of over $40 million. Based on this rough cost estimate it was concluded that this alternative was not worth studying in any more detail.

2.12 ALTERNATIVE 10 – STREAM HABITAT ENHANCEMENT OF LOWER COOPER CREEK

The alluvial reach of Cooper Creek is about 0.7 miles in length and extends from the downstream end of Cooper Creek Canyon to the Kenai River. In the early 1900s hydraulic mining was performed in this area that involved major changes in the creek channel. Approximately 2000 to 2500 feet of the channel is available for enhancement because a campground is located on the lower portion of the reach as shown in Figure 2-18. No layout has been performed for this alternative but it is assumed that it would involve earthwork in and adjacent to the creek, providing sinuosity, planting and seeding, and placement of woody debris habitat.

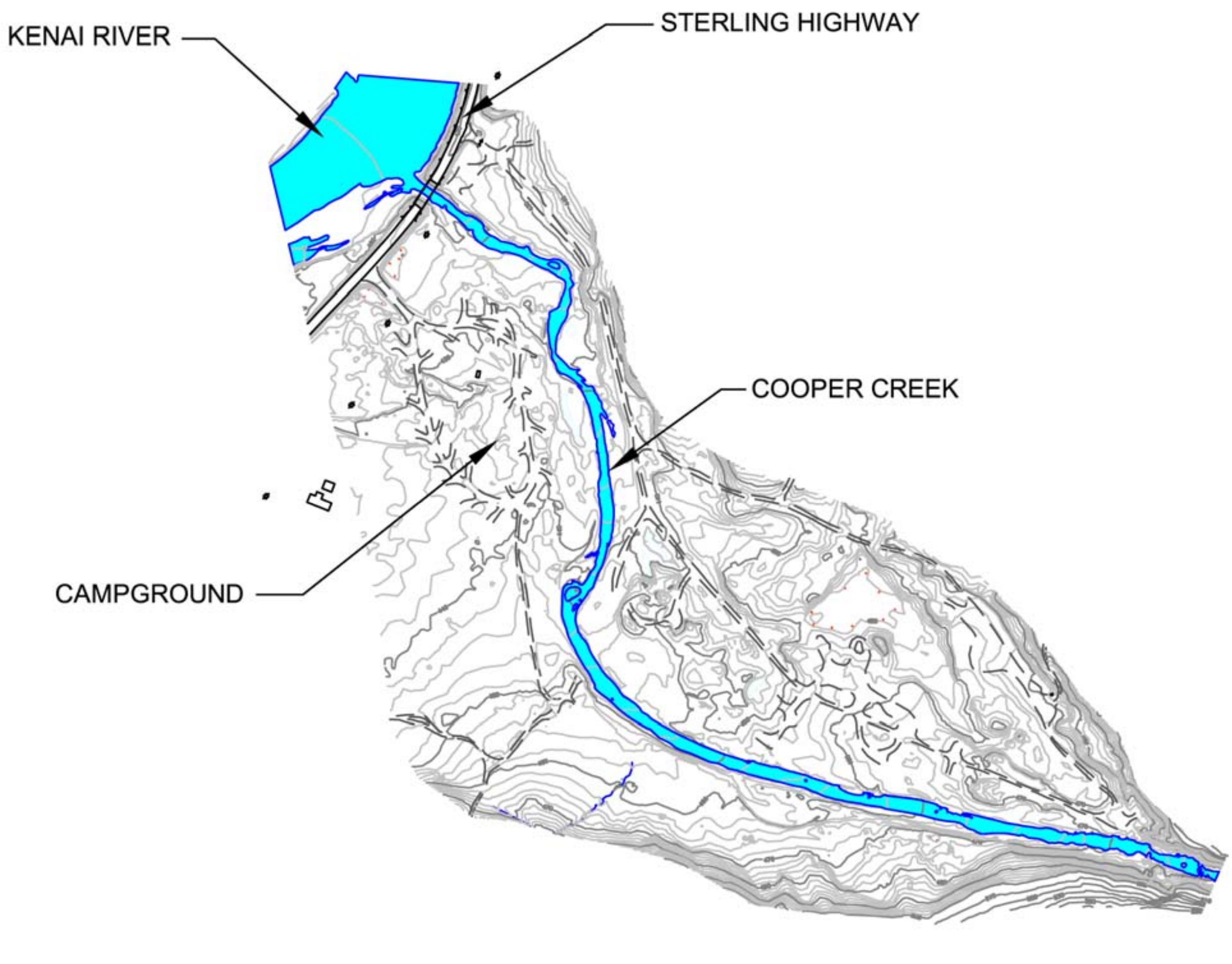

Figure 2-18: Map of Lower Cooper Creek (Alluvial Reach)

This alternative may only marginally increase stream temperature if the length of the creek is increased as discussed in Section 3.0. Construction cost and O&M costs are discussed in Section 4.0.

2.13 OTHER ALTERNATIVES

In addition to the alternatives presented in the DLA (Chugach 2004a) and the July 2004 Relicensing Workshop (Chugach 2004b), other alternatives may be possible. Other concepts that could be studied in more detail include the following with alternative numbers following the numbering above:

2.13.1 Alternative 11 - Divert Water from Stetson Creek and Retain a Portion for Power Generation

The alternative to divert water from Stetson Creek (Alternative 3) is described under Section 2.5. Alternatives 3a and 3b describe diverting up to 70 and 30 cfs, respectively into Cooper Lake and releasing the same quantity of water in the same pattern to Cooper Creek. As discussed above, the 70 cfs diversion alternative assumes an average release of 50 cfs over the 5-month temperature supplementation period. This is 12 cfs more than can be diverted on average from Stetson Creek[2] and results in a net loss of generation at the Cooper Lake powerhouse. However, if 10 (Alternative 11a) or 30 cfs (Alternative 11b) were released from the dam for 5 months, and the maximum flow were diverted from Stetson Creek, then the remainder of the diverted flow would be retained in Cooper Lake and available for use in generation. The result of this analysis would essentially involve constructing Alternative 3b and offsetting its capital cost with increased annual generation. For the 10 and 30 cfs releases, annual power generation could be increased by about 11.3% and 3.2%, respectively, if winter instream flow releases were not required. If 5 cfs were required to be released for the remaining 7 months, the increased generation of the 10 and 30 cfs release alternatives would be reduced to 8.5% and 0.4%, respectively. Section 4.3 discusses the monetary value of these alternatives.

This alternative would provide an increase in water temperature in Cooper Creek, but would not supplement flow below the confluence with Stetson Creek (HDR 2004b).

2.13.2 Alternative 12 - Add a Microhydro Unit to the Cooper Lake Dam Release

Any of the water-release alternatives discussed above could theoretically have a hydroelectric unit added to their discharges. Water flowing under head (pressure) could be harnessed to generate electricity. For the alternatives discussed, it is proposed to divert water for a period of 5 months. Typically, the cost of constructing a "microhydro" is not cost effective unless it is supplemented with other capital resources, e.g., placement in an already-funded water system. In addition, for only five months of operation, the economics do not normally show viability.

However, to display order-of-magnitude costs, Table 2-1 provides estimates based on experience with similar units. No layouts or detailed pricing has been performed for these estimates.

[2] As indicated in Section 1.4, the average Stetson Creek flow from June through October is about 43 cfs. Assuming an average Stetson Creek instream flow of 5 cfs, the average amount of flow that could be diverted to Cooper Lake would be 38 cfs.

Table 2-1: Order-of-Magnitude Costs for Microhydro Units

Plant Size	Low Partial Construction Cost	High Partial Construction Cost	5-month Energy Output (MWh)
100 kW plant (30 cfs @ 50 ft head)	$2350k (CRF 10% = $235k per year)	$2750k (CRF 10% = $275k per year)	360 (Increased generation = $9k to $22k per year)
350 kW plant (50 cfs @ 100 ft head)	$3050k (CRF 10% = $305k per year)	$4050k (CRF 10% = $405k per year)	1280 (Increased generation = $32k to $77k per year)

The costs shown in Table 2-1 are for the powerhouse and plant equipment and do not include costs for a penstock, site work, permitting and similar items. In addition, to each alternative a cost of $1.75 million was added for a 14.4 kV underground distribution line from a new step-up transformer at Cooper Lake Dam to Cooper Landing (4 ½ miles). Using the 10% capital recovery factor (CRF) indicated in Section 4.1, adding a microhydro unit does not make economic sense, especially given the fact that the microhydro plant would only be operational for 5 months per year (it is likely not feasible to design a plant also for a 5 cfs winter flow). Table 2-1 also shows the annualized costs and revenue for a microhydro installation. Each alternative would have a benefit (increased generation) to cost (partial construction cost) ratio of less than one[3].

A way to increase output to a microhydro unit is to increase the head on plant. This can be done where there is steep terrain and the penstock can be sloped steeply downstream. For example, this can be seen from the Project surge tank to the powerhouse. However, for less steep slopes (for example, immediately downstream of Cooper Lake Dam), the cost of lengthening the penstock installation typically does not prove to be cost effective. Based on the rough cost estimates above it was concluded that this alternative was not worth studying in any more detail.

2.13.3 Alternative 13 - Pump Water over Cooper Lake Dam

A pumping system could be installed to pump water over the dam. This would eliminate a deep excavation through the dam but would still require an intake channel to enable pumping when the lake level drops to elevation 1166 feet MSL. The system would involve a suction pipe from the lake to a pumphouse on top of the dam, an outlet pipe, and a stilling basin downstream of the dam on Cooper Creek.

Assuming that either 10 (Alternative 13a) or 30 cfs (Alternative 13b) was pumped against a maximum net head of 60 feet, a 100 kW or 300 kW propane or diesel generator, respectively, would be required. Pumping would require consumption of electricity totaling 310 MWh per year for the 10 cfs alternative and 915 MWh per year for the 30 cfs alternative. This would be in addition to the loss of generation due to the release of water.

[3] For the alternatives explored, divide the values of "increased generation" by the values of the "CRF" factor. A benefit to cost (B/C) ratio needs to be greater than 1 to allow payoff of the alternative. A B/C ration of less than 1 means a net loss of funds.

The costs for this alternative are shown is Section 4.0.

2.13.4 Alternative 14 - Raise the Operating Level of Cooper Lake

Chugach has previously performed a study for raising the operating lake level. The study indicated that the lake could be operated 6 feet higher, to elevation 1200 feet MSL, without alterations to the spillway, though it may necessary to install a parapet on top of the dam to prevent wave overtopping during a PMF. This would gain about 0.8% generation due to increased head on the Project powerplant. The study also indicated that that if the spillway weir were removed (less than 20 cy of concrete demolition) the maximum operating lake level could be raised to elevation 1206 feet MSL, or 12 feet above the current operating level. This would increase annual Project generation by about 1.6%.

Operating the lake at a higher maximum level may have environmental impacts due to inundation of additional shore land or due to operating the lake over a wider range. Examination of these effects are outside the scope of this report.

2.13.5 Alternative 15 - Release 10 cfs from Cooper Lake Dam

Engineering PME studies to date have focused on maximum flow releases by the dam varying from 30 cfs to 70 (25 cfs and 50 cfs average). Flows in this range may be required to affect the downstream Cooper Creek temperatures in a meaningful way. Flows from May through October average 113.5 cfs as measured at the gage at the mouth of Cooper Creek. Supplemental flows of 25 cfs and up would be at least 22%, on average, of those found in the creek below the confluence of Stetson Creek. Flows less than that would have a relatively minor effect on flow and temperature. However, flow upstream of the confluence currently average only about 10 cfs during the 5-month period of June through October. Flow releases of 10 cfs would, on average, double the flow in the upper reaches of Cooper Creek and have the potential to substantially affect temperatures in this portion of the creek. The cost in lost generation of a 10 cfs flow release for 5 months would be about 4% of that currently generated.

3.0 CHANGES TO TEMPERATURE AND FLOW IN COOPER CREEK

3.1 MEASURED TEMPERATURES IN COOPER AND STETSON CREEKS

Chugach has measured temperatures in Cooper Creek and Stetson Creek over the last two years and average temperatures are presented in Table 3-1.

Table 3-1: Average Baseline Cooper Creek and Stetson Creek Water Temperatures (° C)

Month	Cooper Creek Upstream Gage	Cooper Creek Downstream Gage	Stetson Creek
June	7.0	5.4	4.6
July	9.2	7.1	6.2
August	8.8	7.5	6.6
September	5.4	4.6	5.2
October	4.3	3.8	3.3
Average	**6.5**	**5.4**	**4.9**

NOTE: The Upstream Gage referred to in the tables is located in Cooper Creek immediately upstream of the Stetson Creek confluence. The Downstream Gage is the USGS gage located approximately 500 feet upstream of the mouth of Cooper Creek.

3.2 MEASURED COOPER LAKE TEMPERATURES

Over the last two years, Chugach has installed temperature probes at various elevations in the Cooper Lake near the dam. Temperatures have been measured and recorded for the late spring, summer and early-fall months when there is no ice on the lake. Figure 3-1 is a plot of temperatures at various depths in the lake on selected days. The temperatures have been plotted on a graph of average lake levels.

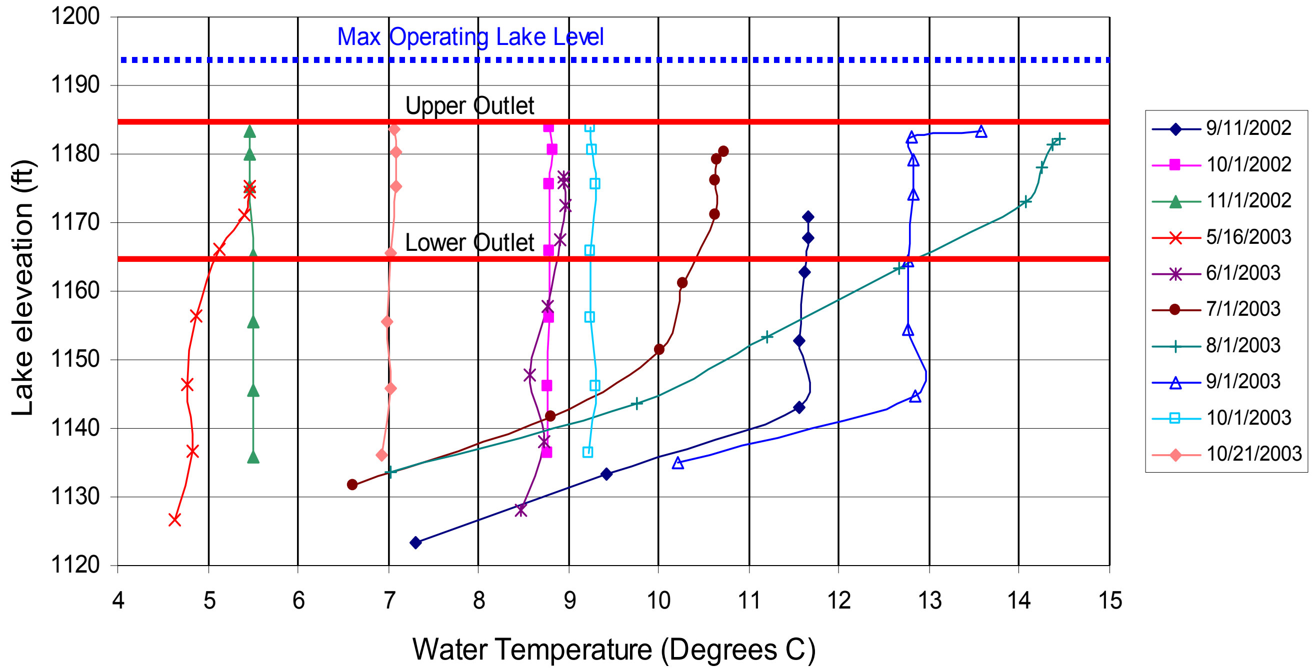

Figure 3-1: Cooper Lake Temperature Profiles (2002-2003)
Plotted on Average Historical Cooper Lake Levels

Figure 3-1 indicates that the lake mixes relatively uniformly from the water surface to Elevation 1150 feet MSL (depth of about 35 feet), or deeper, throughout the entire proposed release season of June through October. As can be seen, most surface temperatures are within about 0.5° C of those measured at a depth of 35 feet for all dates. The exceptions to this is that the measured temperature differences from the surface to 35 feet on May 16, August 1 and September 1, 2003 were about 1° C, 4° C and 1° C, respectively.

The gravity outlet structure described for Alternative 1a would be capable of releasing water from two elevations, 1185 and 1165 feet MSL. Based on average lake levels, an outlet at Elevation 1185 feet MSL would be at or below the lake level through the proposed release period and 9 feet below the maximum operating level. Under most lake levels and on most dates a single point outlet at Elevation 1165 (see Alternatives 1b, 1c, 2, 3b, 4a, 4b and 5) would release water of the same temperature as the surface water. The rubber dam structure described under Alternative 8 would always release surface water. For the sake of estimating the temperature warming effects of the various alternatives, it is assumed that either a one or two-level water release outlet would produce the same downstream temperatures.

3.3 TEMPERATURE MODELING

Alternatives 1 through 9 discussed in Section 2.0 would either change the flow regime or alter the temperature of Cooper Creek downstream of the dam, or both. While drawing conclusions as to the benefits of the estimated warming of Cooper Creek is beyond the scope of this report, predictions of water temperatures can be made.

A predictive temperature computer model for stream flows in Cooper Creek has been prepared, and modeling work performed as authorized by Chugach and results can be found in an HDR technical memorandum (HDR 2004a). The model contains data specific to Cooper Lake, Cooper Creek and Stetson Creek. Several model runs were made to make preliminary estimates of temperatures in Cooper Creek upstream of the Stetson confluence and downstream near the mouth due to variations in the flow regime. Though the model runs were not all identical to the engineering alternatives studied (see Section 2.0), they are similar enough to approximate the warming effect on Cooper Creek of the various alternatives.

Specifically the temperature model runs performed were as follows:

- **Model 1:** Reduced flow in Stetson Creek by 10, 30 or 50 cfs, except that a minimum of 6 cfs was left in the creek, diverted it to Cooper Lake and simultaneously released a like amount of near surface water from Cooper Lake into Cooper Creek. This model is similar to Alternatives 3a and 3b for flow releases of 50 and 30 cfs, respectively.
- **Model 2:** Reduced flow in Stetson Creek to 5 cfs and diverted the remainder to Cooper Lake and simultaneously released a like amount of near surface water from Cooper Lake into Cooper Creek. There is no engineering alternative corresponding to this model, but Alternative 3a could be operated after this manner up to maximum diversion of 70 cfs.
- **Model 3:** No diversion of Stetson Creek but released 10, 30 or 50 of near surface water from Cooper Lake into Cooper Creek. This model is similar to Alternatives 1a/1b/4a and 1c/4b/8 for flow releases of 50 and 30 cfs, respectively.
- **Model 4:** Reduced flow in Stetson Creek to 5 cfs and diverted the remainder to a warming pond downstream of Cooper Lake Dam which released a like amount of water into Cooper Creek. This model is similar to Alternative 6.

3.4 ESTIMATED TEMPERATURES

3.4.1 Estimated Temperatures due to Alternatives 1, 4 and 8

The HDR **Model 3** predicts the resulting Cooper Creek temperatures downstream of Cooper Lake Dam for each of the sub-alternatives of Alternatives 1, 4 and 8. Tables 3-2 and 3-3 show the estimated average temperature changes and resulting average creek temperatures, respectively for constant dam flow releases of 10, 30 and 50 cfs. The Upstream Gage referred to in the tables is located in Cooper Creek immediately upstream of the Stetson Creek confluence. The Downstream Gage is the USGS gage located approximately 500 feet upstream of the mouth of Cooper Creek.

Table 3-2: Alternatives 1, 4 and 8 - Average Cooper Creek Temperature Increase (° C) from Baseline Conditions with Near Surface Flow Releases from Cooper Lake Dam

	Upstream Gage			Downstream Gage		
Month	**10 cfs**	**30 cfs**	**50 cfs**	**10 cfs**	**30 cfs**	**50 cfs**
June	2.0	3.2	3.6	1.4	0.9	1.5
July	3.5	5.6	6.3	2.1	1.9	3.0
August	3.8	5.1	5.4	2.3	3.0	4.1
September	4.2	5.4	5.7	1.6	3.0	3.9
October	2.4	3.3	3.5	0.7	1.2	1.7
Average	**3.2**	**4.5**	**4.9**	**1.6**	**2.0**	**2.8**

Table 3-3: Alternatives 1, 4 and 8 - Average Cooper Creek Temperature (° C) with Near Surface Flow Releases from Cooper lake Dam

	Upstream Gage				Downstream Gage			
Month	**Existing Average**	**10 cfs**	**30 cfs**	**50 cfs**	**Existing Average**	**10 cfs**	**30 cfs**	**50 cfs**
June	7.0	9.0	10.2	10.6	5.4	6.8	6.3	6.9
July	9.2	12.7	14.8	15.5	7.1	9.2	9.0	10.1
August	8.8	12.6	13.9	14.2	7.5	9.8	10.5	11.6
September	5.4	9.6	10.8	11.1	4.6	6.2	7.6	8.5
October	4.3	6.7	7.6	7.8	3.8	4.5	5.0	5.5
Average	**6.9**	**10.1**	**11.5**	**11.8**	**5.7**	**7.3**	**7.7**	**8.5**

This data indicates that larger benefits result at the upstream gage, with temperature changes above baseline temperatures of approximately double those of the downstream gage under all flow releases. This is because Stetson Creek contributes the majority of flow (colder water) below the upstream gage. Average Cooper Creek temperatures at the upstream gage are consistently above 10^o C for all releases, whereas the downstream gage has relatively few months where the average creek temperature is above 10^o C. In fact, for dam releases of only 10 cfs, the average period temperature is within 1.4^o C and 1.7^o C of releases of 30 and 50 cfs, respectively—indicating a relatively large benefit for release of a relatively small amount of water. For the downstream gage with dam releases of only 10 cfs, the average period temperature is within 0.4^o C and 1.2^o C of releases of 30 and 50 cfs, respectively.

3.4.2 Estimated Temperatures due to Alternatives 2 and 5

Alternatives 2 and 5 have no comparable temperature model, however, the resulting temperatures would be greater than indicated above for Alternatives 1, 4 and 8. An estimate of the temperature effects of these alternatives can be derived by adding the results of **Model 1** and **Model 4**. This would be a high estimate because the warming pond described under these alternatives has about half of the surface area and one-third of the volume of the modeled alternative (Alternative 6). In addition, there are two other drawbacks to this comparison; (1) **Model 4** diverted all but 5 cfs of flow from Stetson Creek to the warming pond meaning that an average of about 38 cfs was diverted; and (2) the Upstream Gage is within the **Model 4** warming pond so it did not predict results for the upstream gage. (Note: The Upstream and the Downstream Gages referred to in the tables are located in Cooper Creek immediately upstream of the Stetson Creek confluence and near the mouth, respectively.) Given these limitations, adding the **Model 3** 50 cfs results to the **Model 4** results may serve as a crude approximation for comparison to other alternatives with a 50 cfs average release (70 cfs maximum). Table 3-4 provides this approximation.

Table 3-4: Alternatives 2 and 5 - Average Cooper Creek Temperature Increase (° C) from Baseline Conditions and Temperature with Near Surface Flow Releases from Cooper Lake Dam and a Warming Pond

Month	Upstream Gage				Downstream Gage			
	Existing Average	Model 3 50 cfs	Model 4	Approx. Creek Temp.	Existing Average	Model 3 50 cfs	Model 4	Approx. Creek Temp.
June	7.0	3.6	Unknown	10.6 +	5.4	1.5	1.4	8.3
July	9.2	6.3	Unknown	15.5 +	7.1	3	2.5	12.6
August	8.8	5.4	Unknown	14.2 +	7.5	4.1	2.1	13.7
September	5.4	5.7	Unknown	11.1 +	4.6	3.9	-0.5	8.0
October	4.3	3.5	Unknown	7.8 +	3.8	1.7	-1.8	3.7
Average	**6.9**	**4.9**	**Unknown**	**11.8 +**	**5.7**	**2.8**	**0.7**	**9.3**

Table 3-4 upstream gage resulting creek temperatures are the same as for Alternatives 1, 4 and 8 above with an unknown increase resulting from the warming pond. The downstream gage shows a small incremental gain or warming pond temperature gain (or loss). Again, these are crudely estimated temperatures and should be viewed in that light.

3.4.3 Estimated Temperatures due to Alternative 3

HDR **Model 1** closely simulates PME Alternative 3. The model ran Stetson Creek diversion of flows of 10, 30 and 50 cfs, when flows were available, to Cooper Lake and released 10, 30 and 50 cfs from the dam even if diverted Stetson Creek flows were less than that. The 30 and 50 cfs flow resemble those indicated in Alternatives 3a (25 cfs average) and 3b (50 cfs average). Table 3-5 and 3-6 show the estimated average temperature changes and resulting average creek temperatures, respectively for Stetson diversion and constant dam flow releases of 10, 30 and 50 cfs. The Upstream and the Downstream Gages referred to in the tables are located in Cooper Creek immediately upstream of the Stetson Creek confluence and near the mouth, respectively.

Table 3-5: Alternative 3 - Average Cooper Creek Temperature Increase (°C) from Baseline Conditions for Diversion of Stetson Creek to Cooper Lake and Flow Releases from Cooper Lake Dam

	Upstream Gage			Downstream Gage		
Month	**10 cfs**	**30 cfs**	**50 cfs**	**10 cfs**	**30 cfs**	**50 cfs**
June	2.0	3.2	3.6	0.7	2.3	3.1
July	3.5	5.6	6.3	1.2	3.6	5.1
August	3.8	5.1	5.4	2.1	5.2	6.1
September	4.2	5.4	5.7	2.0	3.9	4.7
October	2.4	3.3	3.5	0.8	1.7	2.3
Average	**3.2**	**4.5**	**4.9**	**1.4**	**3.3**	**4.3**

Table 3-6: Alternative 3 - Average Cooper Creek Temperature (°C) Conditions for Diversion of Stetson Creek to Cooper Lake and Flow Releases from Cooper Lake Dam

	Upstream Gage				Downstream Gage			
Month	**Existing Average**	**10 cfs**	**30 cfs**	**50 cfs**	**Existing Average**	**10 cfs**	**30 cfs**	**50 cfs**
June	7.0	9.0	10.2	10.6	5.4	6.1	7.7	8.5
July	9.2	12.7	14.8	15.5	7.1	8.3	10.7	12.2
August	8.8	12.6	13.9	14.2	7.5	9.6	12.7	13.6
September	5.4	9.6	10.8	11.1	4.6	6.6	8.5	9.3
October	4.3	6.7	7.6	7.8	3.8	4.6	5.5	6.1
Average	**6.9**	**10.1**	**11.5**	**11.8**	**5.7**	**7.0**	**9.0**	**9.9**

The temperature increases in the creek at the upstream gage are identical to those of Alternatives 1, 4 and 8 as indicated above in Tables 3-2 and 3-3. As with those alternatives, the data indicates that larger benefits result at the upstream gage, with temperature changes above baseline temperatures greater than those of the downstream gage under all flow releases. Average Cooper Creek temperatures at the upstream gage are consistently above 10^{o} C for all releases, whereas the downstream gage has average creek temperatures above 10^{o} C for 30 and 50 cfs during the months of July and August only. As with Alternatives 1, 4 and 8, for dam releases of only 10 cfs there is a relatively large benefit for release of a small amount of water at the upstream gage.

3.4.4 Estimated Temperatures due to Alternative 6

This alternative involves diverting 30 cfs from Stetson Creek to a warming pond constructed downstream of Cooper Lake Dam. For the purpose of maximizing the warming pond, a location immediately upstream of the Stetson confluence was chosen. For this case, the warming pond would inundate the Stetson reach and the upstream gage. HDR **Model 4** simulated this case. Table 3-7 shows temperature changes and predicted temperatures at the downstream gage.

Table 3-7: Alternative 6 - Average Cooper Creek Temperature Increase (° C) from Baseline Conditions and Temperature with a Diversion of 30 cfs from Stetson Creek to a Warming Pond on Cooper Creek

Month	Downstream Gage		
	Existing Average	30 cfs	Average Creek Temp.
June	5.4	1.4	6.8
July	7.1	2.5	9.6
August	7.5	2.1	9.6
September	4.6	-0.5	4.1
October	3.8	-1.8	2.0
Average	**5.7**	**0.7**	**6.4**

This alternative has relatively small warming potential. As measured at the downstream gage, the total average temperature warms the water over the period by only 0.7 ^{o} C.

3.4.5 Estimated Temperatures due to Alternative 7

There is not a predictive temperature model for this alternative, which involves diverting water from Stetson Creek, conveying it in an above-ground pipeline and releasing it into Cooper Creek immediately below Cooper Creek Dam. The concept is to lengthen the time that Stetson Creek water is exposed to ambient heating. Though there is not a temperature model approximating this alternative, computations were made to estimate the amount of warming there would be in a 10,000-foot long pipeline diverting 30 cfs to Cooper Creek. The average amount of warming of the diverted water in the pipeline due to solely average ambient air temperatures above that in Stetson Creek are shown in Table 3-8. Increases in temperature could also be expected if the pipeline could be oriented to be exposed largely to direct sunlight and due to diverted flows in the lake and falls reaches (2600 feet). To maximize exposure to sunlight a wider clearing width may be required than indicated in Section 2.9 above.

Table 3-8: Alternative 7 - Average Water Temperature Increase (° C) from Baseline Conditions and Temperature with a Diversion of 30 cfs from Stetson Creek to Cooper Creek

Month	Initial Average Temp. of Stetson Creek	Increase in Water Temp.	Temp. of Water Released in Cooper Creek
June	4.6	3.4	8.0
July	6.2	3.9	10.1
August	6.6	3.2	9.8
September	5.2	1.8	7.0
October	3.3	0*	3.3
Average	**5.2**	**2.5**	**7.6**

Note: * Assumed no heat gain. Actually small heat loss.

Of the 30 cfs diverted from Stetson Creek, on average, it would be warmed by about 50%. These computations are independent of the total flow in Stetson Creek, which averages about 43 cfs. Therefore, this alternative would increase flow at the upstream gage location, and probably would increase the temperature in four of the five months of diversion.

3.4.6 Estimated Temperatures due to Alternative 9

No predictive temperature model was performed for this alternative, creating a warming pond on Stetson Creek. However, the temperature increases would be less than those of Alternative 6 because the warming pond formed by damming Stetson Creek would have a smaller surface area and volume, and would be deeper than the one shown on Cooper Creek.

3.4.7 Estimated Temperatures due to Alternative 10

There has been no layout or predictive temperature modeling of enhancing stream habitat near the mouth of Cooper Creek. There would be no affect on creek temperatures, as measured in the upstream gage, and temperatures at the downstream gage would likely be minimally affected. If the alluvial reach of the creek was lengthened, then some minor warming could be assumed at the mouth of the creek, so long as the creek was not shaded any more than is currently existing.

3.4.8 Estimated Temperatures due to Other Alternatives

Section 2.13 considered other alternatives not previously presented in the DLA or at public workshops. Table 3-9 shows the alternatives and their potential for increasing temperature.

Table 3-9: Other Considered Alternatives and Cooper Creek Warming Potential

No.	Alternative Considered	Comment
11	Divert Stetson to Cooper Lake/ retain portion for power generation	Would have warming effect somewhat less than indicated for Alternative 3 above. Refer to *Instream Flow Study* (HDR 2004b).
12	Add Microhydro unit	This would be combined with another alternative. No additional effect on water warming.
13	Pump Water over Cooper Lake Dam	Results identical to Alternatives 1 and 4.
14	Raise Operating Level of Cooper Lake	No meaningful effect on water temperature.
15	Release 10 cfs from Cooper Lake	Nominal benefit to the Cooper Creek below the Stetson Creek confluence. Substantial benefit to Cooper Creek above the confluence. Temperatures for this alternative were estimated in **Model 3** (HDR 2004a).

3.5 FLOW AUGMENTATION

Several of the alternatives release water from Cooper Lake which adds to the total flow in Cooper Creek. Table 3-10 compares alternatives considered to their average flow increases to Cooper Creek at the upstream and downstream gages during the months of June through October.

Table 3-10: Average Flows in Cooper Creek from June through October With and Without Supplemental (Added) Flow (cfs)

No.	Alternative	Upstream Gage			Downstream Gage		
		Current	Added	% Increase	Current	Added	% Increase
1a	Gravity outlet structure, 70 cfs, 2 pipes	10.1	50	495%	113.5	50	44%
1b	Gravity outlet structure, 70 cfs, 1 pipe	10.1	50	495%	113.5	50	44%
1c	Gravity outlet structure, 30 cfs, 1 pipe	10.1	25	248%	113.5	25	22%
2	Gravity outlet structure, 30 cfs + additional heating	10.1	25	248%	113.5	25	22%
3a	Stetson diversion + gravity outlet structure, 70 cfs	10.1	12	119%	113.5	12	11%
3b	Stetson diversion + gravity outlet structure, 30 cfs	10.1	25	248%	113.5	0	0%
4a	Siphon outlet structure, 70 cfs	10.1	50	495%	113.5	50	44%
4b	Siphon outlet structure, 30 cfs	10.1	25	248%	113.5	25	22%
5	Siphon outlet structure, 30 cfs + additional heating	10.1	25	248%	113.5	25	22%
6	Stetson diversion + warming pond in Cooper Creek	10.1	0	0%	113.5	0	0%
7	Stetson diversion into upper Cooper Creek	10.1	25	248%	113.5	0	0%
8	Rubber dam outlet structure	10.1	25	248%	113.5	25	22%
11a	Stetson diversion + gravity outlet structure, 10 cfs out, retain 28 cfs	10.1	10	99%	113.5	-28	-25%
11b	Stetson diversion + gravity outlet structure, 30 cfs out, retain 8 cfs	10.1	30	297%	113.5	-8	-7%
13a	Pump water over dam, 10 cfs	10.1	10	99%	113.5	10	9%
13b	Pump water over dam, 30 cfs	10.1	30	297%	113.5	30	26%
15	Gravity outlet structure, 10 cfs, 1 pipe	10.1	10	99%	113.5	10	9%

4.0 DEVELOPMENT OF COST ESTIMATES

4.1 CONSTRUCTION COST ESTIMATES

In developing the capital cost estimates for the various alternatives, the following assumptions were made:

- Costs are developed and presented in January 2004 dollars. Further financial viability studies will require escalation to a date assumed to be the midpoint of construction.
- A range of costs, from low to high, was estimated based on cost databases, experience and engineering judgment considering the remoteness of the Project site.
- The existing access road to Cooper Lake dam is essentially a "Jeep" road and is accessible only with a 4-wheel drive vehicle. It was assumed that the existing 4-½ mile long access road to the dam would need to be improved to provide access for construction and future O&M activities. The cost of the road improvements included additional clearing, grading, drainage culverts, two stream crossings and gravel surfacing. It should be noted that even after improvement of the road, it would not be passable during the winter due to the high cost of snow removal and the potential for avalanches.
- A line item called "Unlisted Items" was added to each estimate and assumed to be 10% of the total of all construction items listed in the estimate. Unlisted Items covers miscellaneous items not determined at this conceptual design level of study.
- A contingency of about 25% was added to cover unforeseen and unknown costs due to the absence of information at this early stage of study[4].
- Costs for engineering, construction management and contract administration were added and were estimated as between 15 and 25% of construction costs of the alternative.
- Costs for environmental studies and permitting are **not** included in the estimates and could be substantial.

4.1.1 Construction Cost of Studied Alternatives

Tables 4-1 through 4-12 provide the probable cost estimates for the alternatives/sub-alternatives described in Sections 2.3 through 2.12. Because they have been determined to be infeasible based on preliminary analysis, as described above, cost estimates are not provided herein for Alternatives 2a, 5a and 9.

[4] The combination of 10% for "Unlisted Items" and 25% for contingency results in a "total contingency" of 35% which is not unreasonable for this phase of planning.

Table 4-1

ALTERNATIVE 1a
COOPER LAKE DAM GRAVITY OUTLET STRUCTURE
70 CFS OUTLET, WITH TWO INLET PIPES
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 100,000	$ 200,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
TRENCH/BACKFILL DAM	$ 870,000	$ 1,210,000
GRAVITY STRUCTURE/PIPING	$ 320,000	$ 410,000
ELECTRICAL/INSTRUMENTATION	$ 180,000	$ 240,000
UNLISTED ITEMS	$ 220,000	$ 300,000
CONSTRUCTION SUBTOTAL	$ 2,410,000	$ 3,300,000
CONSTRUCTION CONTINGENCY	$ 550,000	$ 750,000
CONSTRUCTION TOTAL	$ 2,960,000	$ 4,050,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 650,000	$ 800,000
TOTAL CAPITAL COST	**$ 3,610,000**	**$ 4,850,000**

Table 4-2

ALTERNATIVE 1b
COOPER LAKE DAM GRAVITY OUTLET STRUCTURE
70 CFS OUTLET, WITH ONE INLET PIPE
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 100,000	$ 200,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
TRENCH/BACKFILL DAM	$ 870,000	$ 1,210,000
GRAVITY STRUCTURE/PIPING	$ 260,000	$ 310,000
ELECTRICAL/INSTRUMENTATION	$ 180,000	$ 240,000
UNLISTED ITEMS	$ 210,000	$ 290,000
CONSTRUCTION SUBTOTAL	$ 2,340,000	$ 3,190,000
CONSTRUCTION CONTINGENCY	$ 530,000	$ 720,000
CONSTRUCTION TOTAL	$ 2,870,000	$ 3,910,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 650,000	$ 800,000
TOTAL CAPITAL COST	**$ 3,520,000**	**$ 4,710,000**

Table 4-3

ALTERNATIVE 1c
COOPER LAKE DAM GRAVITY OUTLET STRUCTURE
30 CFS OUTLET, WITH ONE INLET PIPE
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 100,000	$ 200,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
TRENCH/BACKFILL DAM	$ 870,000	$ 1,210,000
GRAVITY STRUCTURE/PIPING	$ 230,000	$ 280,000
ELECTRICAL/INSTRUMENTATION	$ 180,000	$ 240,000
UNLISTED ITEMS	$ 210,000	$ 290,000
CONSTRUCTION SUBTOTAL	$ 2,310,000	$ 3,160,000
CONSTRUCTION CONTINGENCY	$ 530,000	$ 720,000
CONSTRUCTION TOTAL	$ 2,840,000	$ 3,880,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 650,000	$ 800,000
TOTAL CAPITAL COST	**$ 3,490,000**	**$ 4,680,000**

Table 4-4

ALTERNATIVE 2
COOPER LAKE DAM GRAVITY OUTLET STRUCTURE
FOR 30 CFS + ADDITIONAL HEATING
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 250,000	$ 300,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
TRENCH/BACKFILL DAM	$ 870,000	$ 1,210,000
GRAVITY STRUCTURE/PIPING	$ 250,000	$ 300,000
ELECTRICAL/INSTRUMENTATION	$ 180,000	$ 240,000
WARMING POND	$ 2,860,000	$ 3,530,000
UNLISTED ITEMS	$ 510,000	$ 650,000
CONSTRUCTION SUBTOTAL	$ 5,640,000	$ 7,170,000
CONSTRUCTION CONTINGENCY	$ 1,290,000	$ 1,630,000
CONSTRUCTION TOTAL	$ 6,930,000	$ 8,800,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 1,050,000	$ 1,300,000
TOTAL CAPITAL COST	**$ 7,980,000**	**$ 10,100,000**

Table 4-5

ALTERNATIVE 3a
STETSON CREEK DIVERSION +
COOPER LAKE DAM GRAVITY OUTLET STRUCTURE FOR 70 CFS
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
STETSON CREEK DIVERSION/PIPELINE/ACCESS ROAD	$ 2,770,000	$ 3,430,000
MOBILIZATION	$ 250,000	$ 500,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
TRENCH/BACKFILL DAM	$ 870,000	$ 1,200,000
GRAVITY STRUCTURE/PIPING	$ 300,000	$ 370,000
ELECTRICAL/INSTRUMENTATION	$ 180,000	$ 240,000
UNLISTED ITEMS	$ 510,000	$ 670,000
CONSTRUCTION SUBTOTAL	$ 5,600,000	$ 7,350,000
CONSTRUCTION CONTINGENCY	$ 1,280,000	$ 1,670,000
CONSTRUCTION TOTAL	$ 6,880,000	$ 9,020,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 1,050,000	$ 1,350,000
TOTAL CAPITAL COST	**$ 7,930,000**	**$ 10,370,000**

Table 4-6

ALTERNATIVE 3b
STETSON CREEK DIVERSION +
COOPER LAKE DAM GRAVITY OUTLET STRUCTURE FOR 30 CFS
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
STETSON CREEK DIVERSION/PIPELINE/ACCESS ROAD	$ 2,270,000	$ 3,040,000
MOBILIZATION	$ 250,000	$ 500,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
TRENCH/BACKFILL DAM	$ 870,000	$ 1,200,000
GRAVITY STRUCTURE/PIPING	$ 240,000	$ 300,000
ELECTRICAL/INSTRUMENTATION	$ 180,000	$ 240,000
UNLISTED ITEMS	$ 450,000	$ 620,000
CONSTRUCTION SUBTOTAL	$ 4,980,000	$ 6,840,000
CONSTRUCTION CONTINGENCY	$ 1,130,000	$ 1,560,000
CONSTRUCTION TOTAL	$ 6,110,000	$ 8,400,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 1,050,000	$ 1,350,000
TOTAL CAPITAL COST	**$ 7,160,000**	**$ 9,750,000**

Table 4-7

ALTERNATIVE 4a
COOPER LAKE DAM SIPHON OUTLET STRUCTURE
70 CFS OUTLET
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 100,000	$ 200,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
TRENCH/BACKFILL DAM	$ 540,000	$ 770,000
SIPHON STRUCTURE/PIPING	$ 460,000	$ 590,000
ELECTRICAL/INSTRUMENTATION	$ 280,000	$ 345,000
UNLISTED ITEMS	$ 210,000	$ 280,000
CONSTRUCTION SUBTOTAL	$ 2,310,000	$ 3,125,000
CONSTRUCTION CONTINGENCY	$ 530,000	$ 710,000
CONSTRUCTION TOTAL	$ 2,840,000	$ 3,835,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 650,000	$ 800,000
TOTAL CAPITAL COST	**$ 3,490,000**	**$ 4,635,000**

Table 4-8

ALTERNATIVE 4b
COOPER LAKE DAM SIPHON OUTLET STRUCTURE
30 CFS OUTLET
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 100,000	$ 200,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
TRENCH/BACKFILL DAM	$ 540,000	$ 770,000
SIPHON STRUCTURE/PIPING	$ 370,000	$ 510,000
ELECTRICAL/INSTRUMENTATION	$ 280,000	$ 345,000
UNLISTED ITEMS	$ 200,000	$ 280,000
CONSTRUCTION SUBTOTAL	$ 2,210,000	$ 3,045,000
CONSTRUCTION CONTINGENCY	$ 500,000	$ 690,000
CONSTRUCTION TOTAL	$ 2,710,000	$ 3,735,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 650,000	$ 800,000
TOTAL CAPITAL COST	**$ 3,360,000**	**$ 4,535,000**

Table 4-9

ALTERNATIVE 5
COOPER LAKE SIPHON OUTLET STRUCTURE
FOR 30 CFS + ADDITIONAL HEATING
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 250,000	$ 300,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
TRENCH/BACKFILL DAM	$ 540,000	$ 770,000
SIPHON STRUCTURE/PIPING	$ 370,000	$ 510,000
ELECTRICAL/INSTRUMENTATION	$ 280,000	$ 345,000
WARMING POND	$ 2,860,000	$ 3,770,000
UNLISTED ITEMS	$ 500,000	$ 660,000
CONSTRUCTION SUBTOTAL	$ 5,520,000	$ 7,295,000
CONSTRUCTION CONTINGENCY	$ 1,260,000	$ 1,660,000
CONSTRUCTION TOTAL	$ 6,780,000	$ 8,955,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 1,050,000	$ 1,300,000
TOTAL CAPITAL COST	**$ 7,830,000**	**$ 10,255,000**

Table 4-10

ALTERNATIVE 6
STETSON CREEK DIVERSION +
WARMING POND IN COOPER CREEK
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 250,000	$ 300,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
STETSON CREEK DIVERSION/PIPELINE/ACCESS ROAD	$ 1,590,000	$ 1,850,000
WARMING POND	$ 2,240,000	$ 2,470,000
INSTRUMENTATION	$ 80,000	$ 100,000
UNLISTED ITEMS	$ 490,000	$ 570,000
CONSTRUCTION SUBTOTAL	$ 5,370,000	$ 6,230,000
CONSTRUCTION CONTINGENCY	$ 1,220,000	$ 1,420,000
CONSTRUCTION TOTAL	$ 6,590,000	$ 7,650,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 1,050,000	$ 1,250,000
TOTAL CAPITAL COST	**$ 7,640,000**	**$ 8,900,000**

Table 4-11

ALTERNATIVE 7
STETSON CREEK DIVERSION INTO UPPER COOPER CREEK
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 400,000	$ 450,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
STETSON CREEK DIVERSION/PIPELINE/ACCESS ROAD	$ 4,410,000	$ 5,080,000
INSTRUMENTATION	$ 80,000	$ 100,000
UNLISTED ITEMS	$ 560,000	$ 660,000
CONSTRUCTION SUBTOTAL	$ 6,170,000	$ 7,230,000
CONSTRUCTION CONTINGENCY	$ 1,400,000	$ 1,640,000
CONSTRUCTION TOTAL	$ 7,570,000	$ 8,870,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 1,050,000	$ 1,350,000
TOTAL CAPITAL COST	**$ 8,620,000**	**$ 10,220,000**

Table 4-12

ALTERNATIVE 8
COOPER LAKE DAM RUBBER DAM OUTLET STRUCTURE
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 250,000	$ 300,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
WEIR DEMOLITION/SPILLWAY EXCAVATION	$ 610,000	$ 760,000
RUBBER DAM/BUILDING EQUIPMENT	$ 1,580,000	$ 1,820,000
ELECTRICAL INSTRUMENTATION	$ 180,000	$ 240,000
UNLISTED ITEMS	$ 330,000	$ 410,000
CONSTRUCTION SUBTOTAL	$ 3,670,000	$ 4,470,000
CONSTRUCTION CONTINGENCY	$ 830,000	$ 1,010,000
CONSTRUCTION TOTAL	$ 4,500,000	$ 5,480,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 1,050,000	$ 1,350,000
TOTAL CAPITAL COST	**$ 5,550,000**	**$ 6,830,000**

Alternative 10 for stream habitat restoration of lower Cooper Creek has not been estimated in detail as no layouts for this alternative were performed. The cost range of this alternative has been determined by obtaining other stream restoration project cost data and order-of-magnitude costs for this alternative have been extrapolated on a per mile basis. On this basis it is estimated that the cost range for 0.4 miles of stream habitat restoration would be between $300,000 and $1,000,000.

4.1.2 Construction Cost of Other Alternatives

Estimates of Probable Cost for Alternatives 11a and 11b (divert the maximum amount of water from Stetson Creek, release a portion of the diverted flow into Cooper Creek and retain the remainder of the flow for power generation) would be the same as for Alternative 3b as indicated in Table 4-6.

Alternative 12, adding a microhydro unit is not cost effective as indicated in Section 2.13.2.

Estimates of Probable Cost for Alternatives 13 a and 13b for pumping 10 or 30 cfs over the dam are shown in Tables 4-13 and 4-14, respectively.

Table 4-13

ALTERNATIVE 13a
COOPER LAKE DAM PUMP OUTLET STRUCTURE
10 CFS OUTLET
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 100,000	$ 200,000
MAIN ACCESS ROAD	$ 890,000	$ 1,140,000
EXCAVATION/BACKFILL	$ 120,000	$ 140,000
PUMP STATION/PIPING	$ 190,000	$ 250,000
ELECTRICAL/INSTRUMENTATION	$ 130,000	$ 160,000
UNLISTED ITEMS	$ 140,000	$ 190,000
CONSTRUCTION SUBTOTAL	$ 1,570,000	$ 2,080,000
CONSTRUCTION CONTINGENCY	$ 360,000	$ 470,000
CONSTRUCTION TOTAL	$ 1,930,000	$ 2,550,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 650,000	$ 800,000
TOTAL CAPITAL COST	**$ 2,580,000**	**$ 3,350,000**

Table 4-14

ALTERNATIVE 13b
COOPER LAKE DAM PUMP OUTLET STRUCTURE
30 CFS OUTLET
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 100,000	$ 200,000
MAIN ACCESS ROAD	$ 890,000	$ 1,140,000
EXCAVATION/BACKFILL	$ 140,000	$ 170,000
PUMP STATION/PIPING	$ 350,000	$ 410,000
ELECTRICAL/INSTRUMENTATION	$ 190,000	$ 230,000
UNLISTED ITEMS	$ 170,000	$ 210,000
CONSTRUCTION SUBTOTAL	$ 1,840,000	$ 2,360,000
CONSTRUCTION CONTINGENCY	$ 420,000	$ 540,000
CONSTRUCTION TOTAL	$ 2,260,000	$ 2,900,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 650,000	$ 800,000
TOTAL CAPITAL COST	**$ 2,910,000**	**$ 3,700,000**

The capital cost to operate the reservoir at a higher level (Alternative 14), without major modifications to the dam or spillway, involve either placing a parapet on the dam crest and/or removing the spillway weir. The costs of these items have not been estimated but would likely be in the range of $500,000 to $1,000,000.

Alternative 15, to allow a release of 10 cfs, would be similar to Alternative 1c. To estimate the cost of this alternative a gravity outlet structure has been assumed. Table 4-15 indicates the estimated cost for this alternative.

Table 4-15

ALTERNATIVE 15
COOPER LAKE DAM GRAVITY OUTLET STRUCTURE
10 CFS OUTLET, WITH ONE INLET PIPE
ESTIMATE OF PROBABLE COST

DESCRIPTION	LOW COST TOTAL	HIGH COST TOTAL
MOBILIZATION	$ 100,000	$ 200,000
MAIN ACCESS ROAD	$ 720,000	$ 940,000
TRENCH/BACKFILL DAM	$ 870,000	$ 1,210,000
INTAKE/PIPING	$ 110,000	$ 140,000
ELECTRICAL/INSTRUMENTATION	$ 180,000	$ 240,000
UNLISTED ITEMS	$ 200,000	$ 270,000
CONSTRUCTION SUBTOTAL	$ 2,180,000	$ 3,000,000
CONSTRUCTION CONTINGENCY	$ 500,000	$ 680,000
CONSTRUCTION TOTAL	$ 2,680,000	$ 3,680,000
DESIGN/CONSTRUCTION MGMT/ADMINISTRATION	$ 650,000	$ 800,000
TOTAL CAPITAL COST	**$ 3,330,000**	**$ 4,480,000**

4.2 OPERATION AND MAINTENANCE COST ESTIMATES

Should any of the PME alternatives be constructed, they would require ongoing operational assistance and regular maintenance to ensure proper operation. To provide estimates for the O&M tasks, labor hours and purchased services/materials/equipment were estimated, high and low, for each alternative. Current Chugach labor costs were used. The following cost components contributed to the total estimated O&M costs for each alternative:

- **Weekly labor:** It has been estimated that for 5 months (22 weeks) of operation from June through October, labor would be required on a daily or weekly basis to perform routine maintenance to ensure that the structures perform in accordance with design requirements and respond to malfunctions and system failures. For the various alternatives the total weekly labor hours for routine O&M ranged between 10 to 36 hours over the 5-month period of operation.

- **Annual startup and shutdown:** Labor would be required to provide annual startup and shutdown of the facilities. As the structures would be operational approximately 5 months per year and be dormant over the winter, the facilities will require winterizing to preclude damage due to freezing and corrosion of electrical equipment. The structures would also be secured against vandalism. In the spring the facilities would be made operational for service. In addition, snow removal may be required during some years on some parts of the access road to allow access by O&M personnel. It is estimated that the range of hours for these tasks would be between 120 and 750 hours annually for the various alternatives.

- **Annual replacement costs:** A budget would be established for annual replacement of worn or broken equipment or repairs to structures. For the various alternatives the total annual replacement cost budget ranged between $15,000 and $50,000.
- **Annual surveying and dam inspections:** Typically FERC requires that dams and other structures be safe against failure to protect the public. Since new structures would be constructed that would affect public safety, annual surveying or dam inspections would be required. For the various alternatives these costs ranged between $5,000 and $30,000 per year.
- **Annual USGS stream gaging costs:** For each alternative it was assumed that a stream gage would be installed to monitor flow and perhaps temperature in Cooper Creek. A flat rate cost of $20,000 has been used for a USGS service contract.

The total estimated O&M costs for the various alternatives are shown below in Table 4-16.

Table 4-16: Estimated Annual Operations and Maintenance Costs

NO.	DESCRIPTION	TOTAL ANNUAL LOW O&M COST	TOTAL ANNUAL HIGH O&M COST
1a	Gravity Outlet Structure for 70 cfs with 2 inlet pipes	$60,000	$90,000
1b	Gravity Outlet Structure for 70 cfs with 1 inlet pipe	$60,000	$90,000
1c	Gravity Outlet Structure for 30 cfs with 1 inlet pipe	$60,000	$90,000
2	Gravity Outlet Structure for 30 cfs + Warming Pond	$100,000	$140,000
3a	Stetson Diversion + Gravity Outlet Structure for 70 cfs	$130,000	$190,000
3b	Stetson Diversion + Gravity Outlet Structure for 30 cfs	$130,000	$190,000
4a	Siphon Outlet Structure for 70 cfs	$80,000	$110,000
4b	Siphon Outlet Structure for 30 cfs	$80,000	$110,000
5	Siphon Outlet Structure for 30 cfs + Warming Pond	$110,000	$160,000
6	Stetson Diversion + Warming Pond	$120,000	$170,000
7	Stetson Diversion To Cooper Creek	$120,000	$170,000
8	Rubber Dam Outlet Structure for 30 cfs	$80,000	$120,000
11a	Stetson diversion + gravity outlet structure, 10 cfs out, retain 28 cfs	$130,000	$180,000
11b	Stetson diversion + gravity outlet structure, 30 cfs out, retain 8 cfs	$130,000	$180,000
13a	Pump water over dam, 10 cfs	$90,000	$130,000
13b	Pump water over dam, 30 cfs	$90,000	$130,000
15	Gravity outlet structure, 10 cfs, 1 pipe	$60,000	$100,000

4.3 ESTIMATED COST OF LOST GENERATION

4.3.1 Estimation of the Value of Energy

The majority of the alternatives studied involve release of water from Cooper Lake Dam to Cooper Creek. The alternatives where water is not diverted to replace the water released to the creek would involve a net loss of water to the powerplant system and, therefore, less power would be generated by the Project. Energy generation from the Project is fully utilized every year and directly offsets energy generation from Chugach's natural gas-fired combustion turbines. Any and all reductions in the energy generation capability of the Project must be replaced by a like amount of energy generation from natural gas-fired combustion turbines in order for Chugach to continue to meet the electrical needs of its customers. Consequently, the cost of generating power with combustion turbines is representative of the cost of replacing energy that would have been generated by the Project.

The primary costs associated with incremental energy generated by combustion turbines are fuel and O&M expenses. On average, Chugach's existing combustion turbines need 14.1 thousand cubic feet (Mcf) of natural gas[5] to produce one megawatt-hour[6] (MWh) of electric energy. At Chugach's current price of natural gas, approximately $2.40 per Mcf, the fuel cost for combustion turbine generation is $33.75 per MWh or 3.375 cents per kWh.

In addition to the cost of fuel, Chugach incurs O&M expenses associated with operation of its combustion turbines. A significant portion of the O&M expense is "fixed" in that the expense is incurred whether or not the combustion turbine is actually used to generate power. A portion of the O&M expense, however, is only incurred if the combustion turbine is running. This portion of the total O&M expense, identified as the "variable" O&M expense is estimated by Chugach to be approximately $4.60 per MWh.

Based on the current fuel and O&M costs shown above, the cost of combustion turbine energy generation is $38.35 per MWh (3.835 cents per kWh). These costs are expected to increase over time due to inflation and other factors. By 2014, the estimated cost of combustion turbine energy generation is projected to be $81.65 per MWh. A significant factor contributing to this increase is the expected increase in contracted natural gas prices in the Cook Inlet area.

It should be noted that the estimated costs of combustion turbine generation as shown do not include depreciation, capital recovery or other "fixed" costs. This is due to the fact that these costs would be incurred even without any incremental increase in generation output to replace lost energy generation by the Project. If it were necessary to construct or acquire a new combustion turbine power plant to replace the output of the Project, the fixed costs of the new plant would need to be factored in to the total cost of generation.

Further, there is a significant variation in the actual cost incurred by Chugach at various times to generate incrementally more power from its combustion turbines due primarily to which units are actually running at the time. For this reason, a range of costs has been used in the estimation of the replacement generation. The range of costs used in the analysis is from $25 per MWh to $60 per MWh at current price levels.

4.3.2 Estimation of Foregone Generation

Two release patterns were assumed for the alternatives involving unreplaced water; (1) a 70 cfs maximum release from the lake, released in a variable pattern from June through October each year and averaging 50 cfs over the period; and (2) a 30 cfs maximum release from the lake, released in a

[5] Based on weighted average fuel use of 14.1 Mcf per MWh as represented for Chugach's existing combustion turbines (excluding Beluga units 6, 7 and 8) in the Railbelt Energy Study (Beck 2004). Beluga units 6, 7 and 8 are combined cycle units that are fully utilized and unavailable to produce additional replacement energy.

[6] One megawatt-hour is equivalent to 1,000 kilowatt-hours (kWh).

variable pattern from June through October each year and averaging 25 cfs over the period. In addition, it was assumed that because releases from the lake would involve rewatering the lake reach, and substantially increasing the flow in the falls reach, that an instream flow of 5 cfs would be required for the 7 month period from November through May each year.

Based on these assumed average releases, lost generation was simply estimated by computing the total percent of water lost to Cooper Creek annually and multiplying times the total historical annual generation produced by Cooper Lake powerplant of 48,500 megawatt-hours (MWh). To determine the cost of lost generation, a range of energy values of between $25 per MWh to $60 per MWh was assumed as discussed above. Table 4-17 provides the assumed average flow regime, percentage of water released (lost) to Cooper Creek, the amount of energy lost, and the low and high lost energy costs.

Alternative 8 describes a rubber dam outlet structure that would involve lowering the spillway; allowing for safe passage of the PMF by Cooper Lake Dam under a raised maximum normal operating level. For this alternative it was assumed that the lake level would be raised from its maximum current operating level of elevation 1194 feet MSL to elevation 1210 feet MSL—a raise of 16 feet. Assuming that the entire operating range of the lake was raised by 16 feet, a net increase of the operating head on the powerhouse turbines would be about 2.1% (from 758 feet to 774 feet). There would still be a net loss in generation, but it is somewhat offset due to the increased operating head. Table 4-17 indicates this net loss.

Table 4-17: Estimated First-Year Annual Cost of Lost Generation
(Costs would increase in subsequent years)

NO.	DESCRIPTION	AVG. SUMMER-FALL FLOW IN CFS (5 MONTHS)	AVG. WINTER-SPRING FLOW IN CFS (7 MONTHS)	LOST FLOW (% OF ANNUAL)	LOST GENERATION (MWh)	ANNUAL LOST GENERATION LOW COST	ANNUAL LOST GENERATION HIGH COST
1a	Gravity Outlet Structure for 70 cfs with 2 inlet pipes	50	5	23.1%	11,180	$280,000	$670,000
1b	Gravity Outlet Structure for 70 cfs with 1 inlet pipe	50	5	23.1%	11,180	$280,000	$670,000
1c	Gravity Outlet Structure for 30 cfs with 1 inlet pipe	25	5	12.9%	6,280	$160,000	$380,000
2	Gravity Outlet Structure for 30 cfs + warming pond	25	5	12.9%	6,280	$160,000	$380,000
3a	Stetson Diversion + Gravity Outlet Structure for 70 cfs	12	5	7.7%	3,730	$90,000	$220,000
3b	Stetson Diversion + Gravity Outlet Structure for 30 cfs	0	5	2.8%	1,370	$30,000	$80,000
4a	Siphon Outlet Structure for 70 cfs	50	5	23.1%	11,180	$280,000	$670,000
4b	Siphon Outlet Structure for 30 cfs	25	5	12.9%	6,280	$160,000	$380,000
5	Siphon Outlet Structure for 30 cfs + Warming Pond	25	5	12.9%	6,280	$160,000	$380,000
6	Stetson Diversion + Warming Pond	0	0	0.0%	-	-	-
7	Stetson Diversion To Cooper Creek	0	0	0.0%	-	-	-
8	Rubber Dam Outlet Structure for 30 cfs *	25	5	12.9%	6,280	$160,000	$380,000
11a	Stetson diversion + gravity outlet structure, 10 cfs out, retain 28 cfs	-28	5	-8.5%	(5,225)	($130,000)	($310,000)
11b	Stetson diversion + gravity outlet structure, 30 cfs out, retain 8 cfs	-8	5	-0.4%	(200)	($10,000)	($10,000)
13a	Pump water over dam, 10 cfs **	10	0	4.0%	2,170	$50,000	$130,000
13b	Pump water over dam, 30 cfs **	30	0	12.1%	6,510	$160,000	$390,000
15	Gravity outlet structure, 10 cfs, 1 pipe	10	0	4.0%	1,960	$50,000	$120,000

Notes:
1. Average annual flow through powerhouse is 103 cfs.
2. Average annual generation is 48,500 MWh
3. * Includes increase in generation due to lake raise.
4. ** Includes decrease in generation due to pumping energy consumption.

4.4 COMPUTATION OF ANNUALIZED COSTS

4.4.1 Capital Recovery Costs

The costs of construction associated with improvements or additions to the Project facilities are expected to be paid for by Chugach with reserve funds on hand, loan proceeds or a combination of both. As with all of Chugach's electric plant facilities, the new improvements and additions should have a useful life that extends for many years into the future. Consistent with typical utility accounting procedures, the initial costs of construction of the new facilities will be capitalized, depreciated and amortized over a period of time related to the useful life of the facilities. Since the necessary monies are to be borrowed from internal funds or from outside lenders, a charge for interest is also applied.

The useful life of the specific new facilities will most likely vary, but 25 years is considered a reasonable approximation of the average useful life. At 25 years, the annual depreciation rate would be 4% per year. The interest rate that Chugach would incur for new loans is presently estimated to be approximately 6%. The combination of the 4% depreciation rate and the 6% interest rate results in a total capital recovery cost of 10% per year. This rate is appropriate for the evaluation of the cost impact of any new Project facilities, is applicable for the first 25 years of operation of the new facilities, and was used in comparison of alternatives as indicated in Table 4-16. Thereafter, the capital recovery costs will drop off and only the annual cost of O&M and lost generation will apply. In future years, beyond the initial capital recovery period, it could be expected that O&M costs related to annual maintenance and repairs would increase dramatically to make repairs to aging facilities in a harsh environment.

For the purpose of this analysis, an alternative 9% capital recovery factor has also been used to evaluate the sensitivity of bottom line results to a variation in the assumed capital recovery factor as indicated in table 4-17. The lower factor is considered representative of a longer depreciation period for the asset, 33 years and the same interest rate, or a lower interest rate and the 25-year depreciation rate used in the base case.

4.4.2 Summary of Annualized Costs

Tables 4-18 and 4-19 summarize each of the alternatives considered and their annualized costs for 10% and 9% capital recovery factors, respectively. Cost of generation lost is based on current costs and would increase in future years. Costs for permitting and environmental mitigation are not included in the Total Annual Cost for the various alternatives. Again, after the period of depreciation (e.g., 25 or 33 years), annual costs would be limited to O&M and lost generation.

Table 4-18: First Year Annualized Cost of Alternatives with 10% Capital Recovery Factor

No.	Description	Divert Stetson Creek	Release from Cooper Lake	Annual Interest/Depreciation		Annual O&M		Annual Generation Loss		Total Annual Cost	
				Low	High	Low	High	Low	High	Low	High
1a	Gravity outlet structure, 70 cfs, 2 pipes		✓	$ 360,000	$ 480,000	$ 60,000	$ 90,000	$ 280,000	$ 670,000	$ 700,000	$ 1,240,000
1b	Gravity outlet structure, 70 cfs, 1 pipe		✓	$ 350,000	$ 470,000	$ 60,000	$ 90,000	$ 280,000	$ 670,000	$ 690,000	$ 1,230,000
1c	Gravity outlet structure, 30 cfs, 1 pipe		✓	$ 350,000	$ 470,000	$ 60,000	$ 90,000	$ 160,000	$ 380,000	$ 570,000	$ 940,000
2	Gravity outlet structure, 30 cfs + warming pond		✓	$ 800,000	$ 1,010,000	$ 100,000	$ 140,000	$ 160,000	$ 380,000	$ 1,060,000	$ 1,530,000
3a	Stetson diversion + gravity outlet, 70 cfs	✓	✓	$ 790,000	$ 1,040,000	$ 130,000	$ 190,000	$ 90,000	$ 220,000	$ 1,010,000	$ 1,450,000
3b	Stetson diversion + gravity outlet, 30 cfs	✓	✓	$ 720,000	$ 980,000	$ 130,000	$ 190,000	$ 30,000	$ 80,000	$ 880,000	$ 1,250,000
4a	Siphon outlet structure, 70 cfs		✓	$ 350,000	$ 460,000	$ 80,000	$ 110,000	$ 280,000	$ 670,000	$ 710,000	$ 1,240,000
4b	Siphon outlet structure, 30 cfs		✓	$ 340,000	$ 450,000	$ 80,000	$ 110,000	$ 160,000	$ 380,000	$ 580,000	$ 940,000
5	Siphon outlet structure, 30 cfs + warming pond		✓	$ 780,000	$ 1,030,000	$ 110,000	$ 160,000	$ 160,000	$ 380,000	$ 1,050,000	$ 1,570,000
6	Stetson diversion + warming pond	✓		$ 760,000	$ 890,000	$ 120,000	$ 170,000	$ -	$ -	$ 880,000	$ 1,060,000
7	Stetson diversion to upper Cooper Creek	✓		$ 860,000	$ 1,020,000	$ 120,000	$ 170,000	$ -	$ -	$ 980,000	$ 1,190,000
8	Rubber dam outlet structure		✓	$ 560,000	$ 680,000	$ 80,000	$ 120,000	$ 160,000	$ 380,000	$ 800,000	$ 1,180,000
11a	Stetson diversion + gravity outlet structure, 10 cfs out, retain 28 cfs	✓	✓	$ 720,000	$ 980,000	$ 130,000	$ 180,000	$ (130,000)	$ (310,000)	$ 720,000	$ 850,000
11b	Stetson diversion + gravity outlet structure, 30 cfs out, retain 8 cfs	✓	✓	$ 720,000	$ 980,000	$ 130,000	$ 180,000	$ (10,000)	$ (10,000)	$ 840,000	$ 1,150,000
13a	Pump water over dam, 10 cfs		✓	$ 260,000	$ 340,000	$ 90,000	$ 130,000	$ 50,000	$ 130,000	$ 400,000	$ 600,000
13b	Pump water over dam, 30 cfs		✓	$ 290,000	$ 370,000	$ 90,000	$ 130,000	$ 160,000	$ 390,000	$ 540,000	$ 890,000
15	Gravity outlet structure, 10 cfs, 1 pipe		✓	$ 330,000	$ 450,000	$ 60,000	$ 100,000	$ 50,000	$ 120,000	$ 440,000	$ 670,000

Table 4-19: First Year Annualized Cost of Alternatives with 9% Capital Recovery Factor

No.	Description	Divert Stetson Creek	Release from Cooper Lake	Annual Interest/Depreciation		Annual O&M		Annual Generation Loss		Total Annual Cost	
				Low	High	Low	High	Low	High	Low	High
1a	Gravity outlet structure, 70 cfs, 2 pipes		✓	$ 320,000	$ 430,000	$ 60,000	$ 90,000	$ 280,000	$ 670,000	$ 660,000	$ 1,190,000
1b	Gravity outlet structure, 70 cfs, 1 pipe		✓	$ 320,000	$ 420,000	$ 60,000	$ 90,000	$ 280,000	$ 670,000	$ 660,000	$ 1,180,000
1c	Gravity outlet structure, 30 cfs, 1 pipe		✓	$ 320,000	$ 420,000	$ 60,000	$ 90,000	$ 160,000	$ 380,000	$ 540,000	$ 890,000
2	Gravity outlet structure, 30 cfs + warming pond		✓	$ 720,000	$ 910,000	$ 100,000	$ 140,000	$ 160,000	$ 380,000	$ 980,000	$ 1,430,000
3a	Stetson diversion + gravity outlet, 70 cfs	✓	✓	$ 710,000	$ 940,000	$ 130,000	$ 190,000	$ 90,000	$ 220,000	$ 930,000	$ 1,350,000
3b	Stetson diversion + gravity outlet, 30 cfs	✓	✓	$ 650,000	$ 880,000	$ 130,000	$ 190,000	$ 30,000	$ 80,000	$ 810,000	$ 1,150,000
4a	Siphon outlet structure, 70 cfs		✓	$ 320,000	$ 410,000	$ 80,000	$ 110,000	$ 280,000	$ 670,000	$ 680,000	$ 1,190,000
4b	Siphon outlet structure, 30 cfs		✓	$ 310,000	$ 410,000	$ 80,000	$ 110,000	$ 160,000	$ 380,000	$ 550,000	$ 900,000
5	Siphon outlet structure, 30 cfs + warming pond		✓	$ 700,000	$ 930,000	$ 110,000	$ 160,000	$ 160,000	$ 380,000	$ 970,000	$ 1,470,000
6	Stetson diversion + warming pond	✓		$ 680,000	$ 800,000	$ 120,000	$ 170,000	$ -	$ -	$ 800,000	$ 970,000
7	Stetson diversion to upper Cooper Creek	✓		$ 770,000	$ 920,000	$ 120,000	$ 170,000	$ -	$ -	$ 890,000	$ 1,090,000
8	Rubber dam outlet structure		✓	$ 500,000	$ 610,000	$ 80,000	$ 120,000	$ 160,000	$ 380,000	$ 740,000	$ 1,110,000
11a	Stetson diversion + gravity outlet structure, 10 cfs out, retain 28 cfs	✓	✓	$ 650,000	$ 880,000	$ 130,000	$ 180,000	$ (130,000)	$ (310,000)	$ 650,000	$ 750,000
11b	Stetson diversion + gravity outlet structure, 30 cfs out, retain 8 cfs	✓	✓	$ 650,000	$ 880,000	$ 130,000	$ 180,000	$ (10,000)	$ (10,000)	$ 770,000	$ 1,050,000
13a	Pump water over dam, 10 cfs		✓	$ 230,000	$ 300,000	$ 90,000	$ 130,000	$ 50,000	$ 130,000	$ 370,000	$ 560,000
13b	Pump water over dam, 30 cfs		✓	$ 260,000	$ 330,000	$ 90,000	$ 130,000	$ 160,000	$ 390,000	$ 510,000	$ 850,000
15	Gravity outlet structure, 10 cfs, 1 pipe		✓	$ 300,000	$ 400,000	$ 60,000	$ 100,000	$ 50,000	$ 120,000	$ 410,000	$ 620,000

As a cooperative electric utility, Chugach is owned by its member-customers and establishes its rates for electric service based on its costs. Chugach's rates are subject to review and approval by the Regulatory Commission of Alaska. Any revenues (including margins) Chugach earns are used to pay costs of providing electric service, including funding improvements and replacements of the electric system and paying debt. To the extent Chugach's financial health permits, after a period of years (currently 17) remaining margins are returned to Chugach's member-customers, effectively reducing the overall price paid for electricity. The costs of power production, which include costs related to the Project, are Chugach's most significant cost component. Any increases in the cost of power production, as estimated for the alternative configurations identified in Table 4-18, will cause a direct increase in Chugach's cost of electric service, which will be recovered from their member-customers through future electric rates.

5.0 REFERENCES

1. Chugach Electric Association, Inc., Draft License Application for the Cooper Lake Project FERC No. 2170, May 2004.

2. Chugach Electric Association, Inc., Cooper Lake Project Relicensing - Draft Meeting Summary, Anchorage, AK, July 14, 2004.

3. HDR Alaska, Inc. (Jason Kent), Draft Technical Memorandum: Cooper Creek Temperature Model – Cooper Lake Project (FERC No. 2170), February 2004.

4. HDR Alaska, Inc. (Jason Kent) and Northern Ecological Services (John Morsell), Draft Interim Report: Cooper Creek Instream Flow Study and Preliminary Evaluation of Potential Aquatic Habitat Benefits – Cooper Lake Project (FERC No. 2170), August 2004.

5. R.W. Beck, Inc., Railbelt Energy Study, January 15, 2004.