Assessment of Habitat Conditions for Chinook Salmon and Steelhead in Western Placer County, California

(Combined deliverable for Task 3.2. Characterize Salmonid Habitats of Western Placer County and Task 3.3. Develop Species Assessment Models)

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Acronyms and Abbreviations

DO	dissolved oxygen
DFG	California Department of Fish and Game
cfs	cubic feet per second
DFG	Department of Fish and Game
DSDD	Doty South Diversion Dam
ESA	Endangered Species Act
EPA	Environmental Protection Agency
EFH	essential fish habitat
FAM	Functional Assessment Model
MSA	Magnuson-Stevens Act
msl	mean sea level
mgd	million gallons per day
NPDES	National Pollutant Discharge Elimination System
NID	Nevada Irrigation District
RBD	Red Bluff Diversion Dam
the Delta	Sacramento and San Joaquin Rivers; and the Sacramento–San Joaquin Delta
SAM	species assessment model
SIDDD	Sutter Irrigation District Diversion Dam
WTP	Water Treatment Plant

Chapter 1
Introduction

Overview

The proposed overarching planning goal for Placer County is to restore and maintain stream and river conditions that support in-river life stages of naturally reproducing Central Valley fall/late fall–run Chinook salmon (*Oncorhynchus tshawytscha*) and Central Valley steelhead (*Oncorhynchus mykiss*). In addition, Placer County permits, implements, and funds activities that potentially affect streams in western Placer County and could result in adverse effects on listed species (i.e., Central Valley steelhead), as defined by Section 9 of the federal Endangered Species Act (ESA) (63 FR 53:13347-13371, March 19, 1998), and essential fish habitat (EFH) (i.e., Central Valley fall/late fall–run Chinook salmon), as defined by the EFH provisions of the Magnuson-Stevens Act of 1996 (MSA). Consequently, clear methods are needed that will facilitate understanding of the existing condition of rivers and streams in western Placer County relative to the production of Chinook salmon and steelhead and that will provide a basis for identification and prioritization of restoration actions and development of measures that avoid and minimize take of listed species and their habitat.

This report describes the Species Assessment Model (SAM) for Chinook salmon and steelhead in western Placer County streams. The streams covered by the assessment include Bear River, Coon Creek, Doty Ravine, Auburn Ravine, Dry Creek, Antelope Creek, Secret Ravine, and Miners Ravine. The condition of rivers and streams in western Placer County that have the potential to support Chinook salmon and steelhead is assessed based on available information. In addition, the report identifies information needed to better understand limiting factors and to identify effective restoration actions and measures protective of existing habitat for listed and other special-status species.

Environmental conditions individually or synergistically determine the biological performance for steelhead and Chinook salmon populations (i.e., productivity and capacity) (Figure 1). The SAM assesses effects of selected environmental conditions that are components of habitat for life stages of Chinook salmon and steelhead that occur in western Placer County streams. Environmental conditions are selected based on the potential to be modified by human activities and the potential to measurably affect fish populations (i.e., through changes in survival and fecundity). For example, land grading for road construction may result in

erosion that could increase input of fine sediment to the stream. Increased fine sediment within spawning gravel could adversely affect survival during incubation of eggs and larvae of Chinook salmon and steelhead.

The environmental conditions affecting biological performance, except where noted, are the same for Chinook salmon and steelhead. Consequently, the SAM is applicable for both Chinook salmon and steelhead and is not repeated for each species. The selected environmental conditions include:

- Migration habitat quality,
- Spawning habitat area,
- Rearing habitat area,
- Water temperature,
- Food,
- Fine sediment,
- Scour,
- Contaminants,
- Predation,
- Harassment, and
- Entrainment.

Hypotheses relating a change in environmental conditions to life stage response (e.g., survival) are summarized in Table 1. The potential species response is described in the following text. To the extent possible, the life stage response is based on documented relationships from published studies. Where data are not available, the expected response is assigned based on professional judgment.

As indicated in Figure 1, productivity and capacity are indicators of the potential biological performance relative to support Chinook salmon and steelhead populations in western Placer County streams. For the sake of simplicity and clarity, productivity is defined as the survival a population experiences regardless of the species abundance (Lestelle et al. 1996). Survival is dependent on the environmental condition (i.e., the quality of the environment). Productivity is the product of survival that a life stage and subsequent life stages experience within a stream (Figure 2).

Capacity reflects the potential abundance of a life stage within a given stream. Capacity regulates the density-dependent response of a population (Lestelle et al. 1996). Ideally, cumulative capacity would be evaluated over the entire life cycle for a species population, integrating both the productivity and capacity at each life stage to provide an overall estimate of production (i.e., the expected number of juveniles leaving the stream and the number of adults expected to return to their natal streams to spawn). For simplicity, and given the limited availability of data for western Placer County streams, capacity is evaluated and presented in this report only for specific life stages (Figure 2).

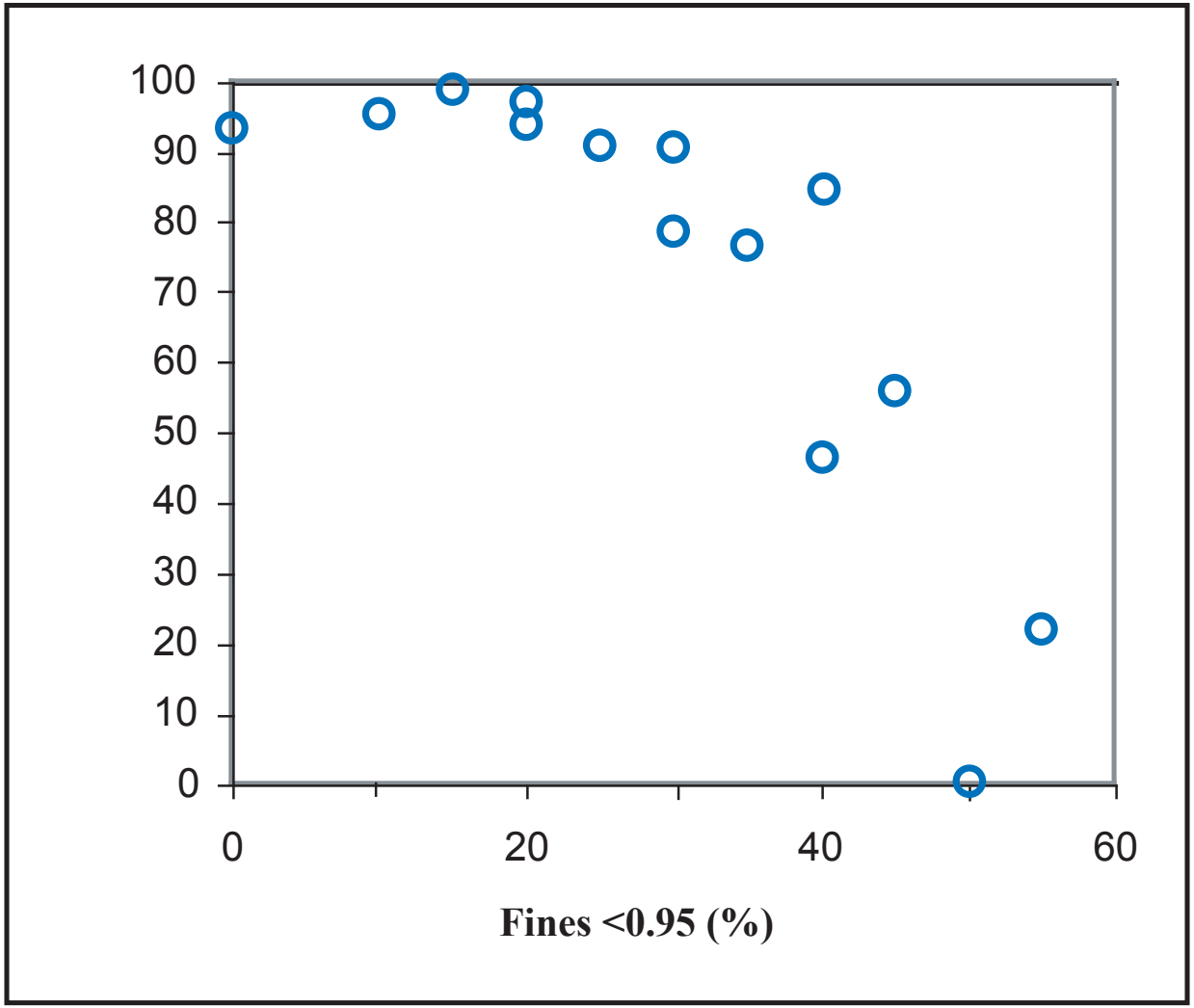

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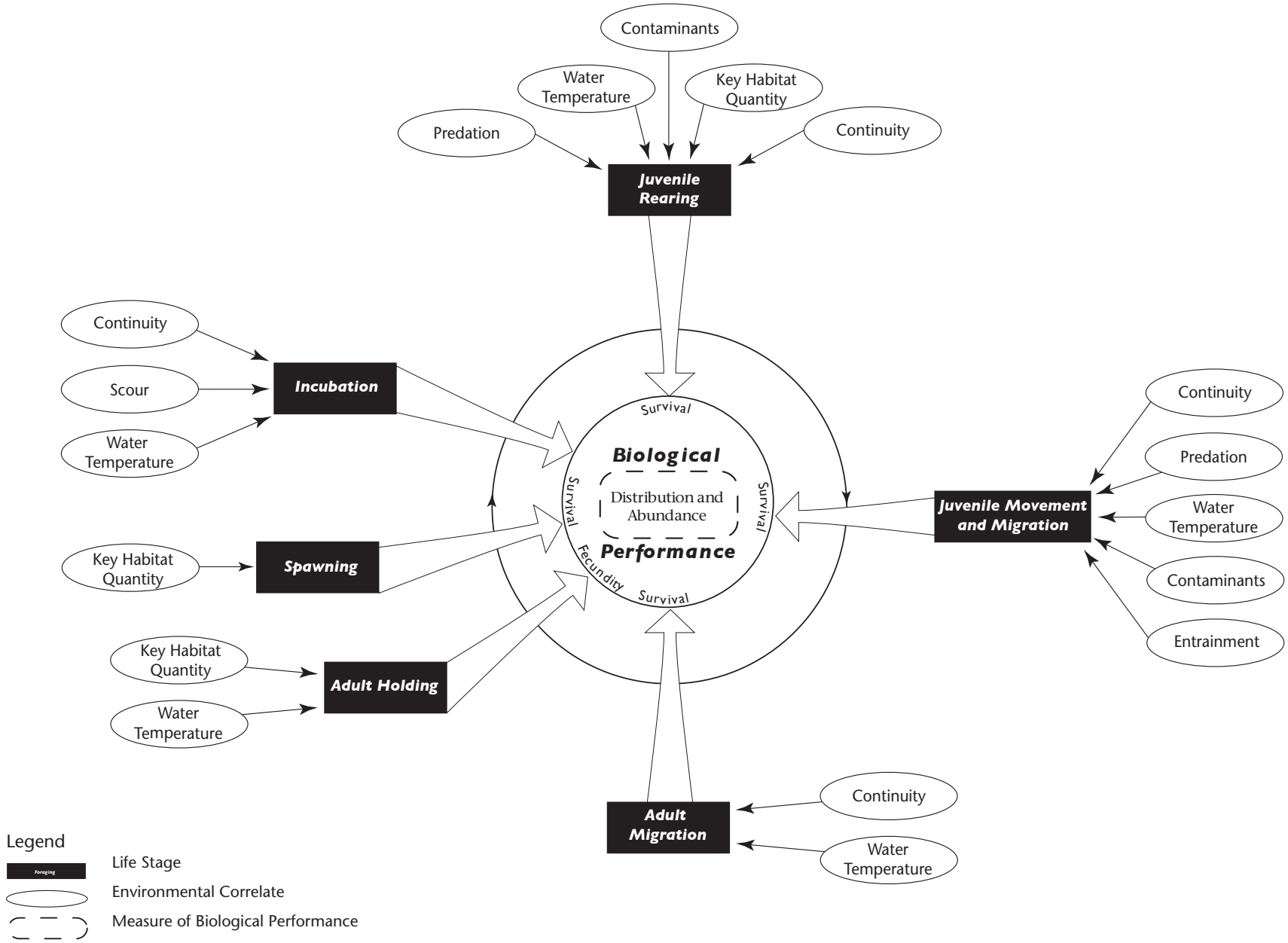
Figure 3
The Relationship Between the Percentage of Fines and Survival of Chinook Salmon Eggs from Spawning to Emergence (Based on data in Tappel and Bjornn 1983)

Table 1. Hypotheses for Chinook Salmon and Steelhead Responses to Selected Environmental Conditions

Environmental Condition	Included in the Current Assessment	Hypothesis Relating Change in the Environmental Condition to Life Stage Response	Influential Environmental Processes
Migration habitat quality	Yes (qualitative)	Barriers block or delay adult migration and reduce fecundity	Flow
	No	Shallow depth blocks or delays adult migration and reduces fecundity	Flow, geomorphic processes (i.e., sediment erosion, deposition, and transport)
Spawning habitat area	Yes	Spawning habitat area is dependent on gravel abundance within the wetted stream channel	Flow, geomorphic processes
Fine sediment	Yes	Egg and larval survival is reduced by increased fine sediment levels in spawning gravel during incubation	Flow, geomorphic processes
Scour	Yes (qualitative)	Scour of eggs and larvae reduces survival during incubation	Flow, geomorphic processes, channelization
Rearing habitat area	No	Rearing habitat area is dependent on depth, velocity, and cover within the stream channel	Flow, geomorphic processes, riparian processes
	No	Rearing habitat area is dependent on floodplain inundation (Chinook salmon only)	Flow, geomorphic processes, channelization
Water temperature	Yes (qualitative)	Reduced riparian shade warms water temperature and reduces survival	Riparian processes
	No	Increased stream width to depth ratio warms water temperature and reduces survival	Flow, geomorphic processes, riparian processes
Food	No	Reduced food availability reduces growth and survival of juveniles	Flow, geomorphic processes, riparian processes, channelization, contaminant sources
Contaminants	Yes (qualitative)	Contaminants reduce survival	Flow, riparian processes, contaminant sources
Predation	Yes (qualitative)	Reduced instream cover reduces survival of juveniles through increased predation-related mortality	Flow, riparian processes, geomorphic processes, biological community
Harassment	Yes (qualitative)	Harassment reduces fecundity	Flow, riparian processes, geomorphic processes, human intrusion
Entrainment	Yes (qualitative)	Water diversions entrain migrating juveniles and reduce survival	Flow, fish screens



Note: Environmental conditions that support environmental correlates not shown.

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Figure 1
Conceptual Species Assessment Model for Steelhead and Chinook Salmon
July 26, 2004

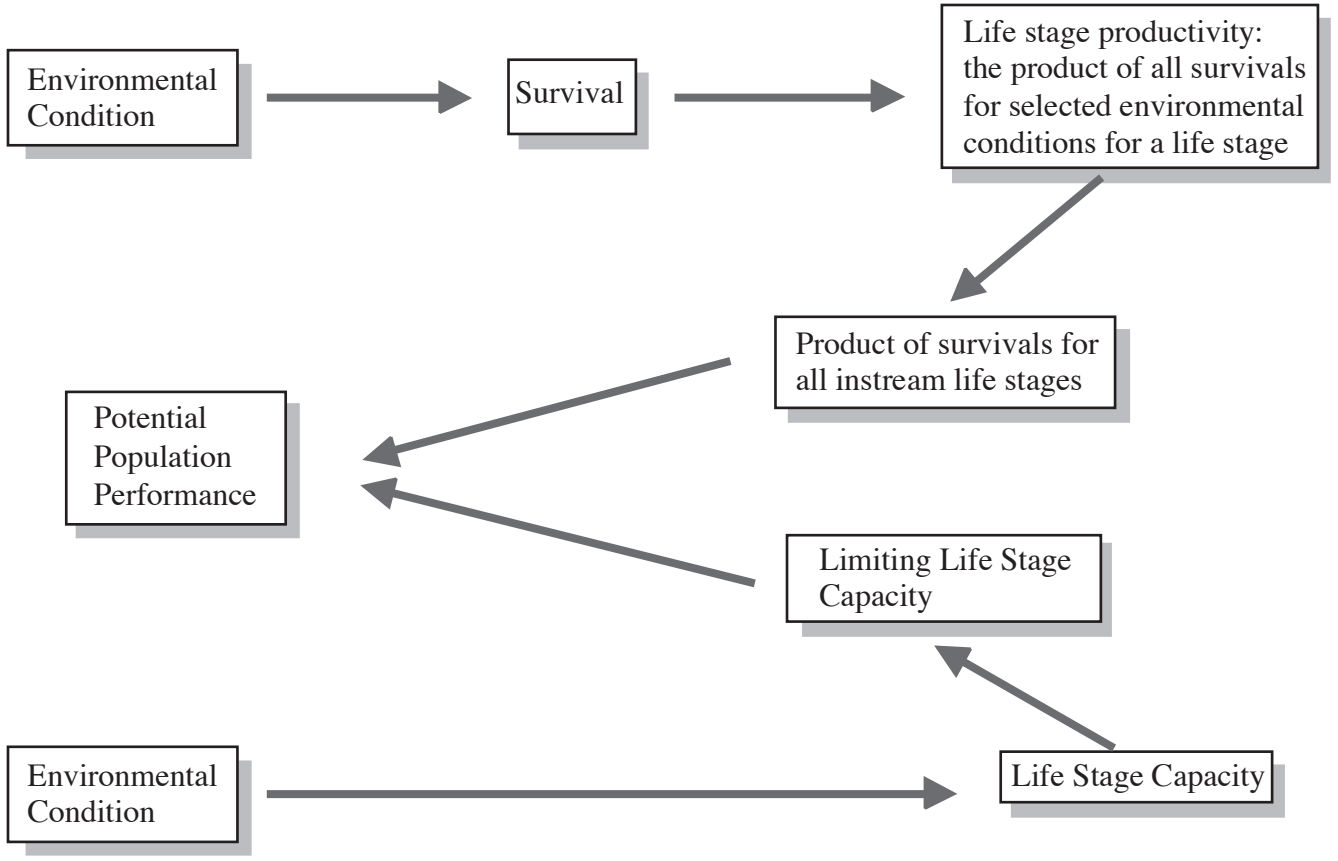

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Figure 2
Structure of the Species Assessment Model

Central Valley Steelhead and Chinook Salmon Status and Life History

Central Valley Steelhead

Status

The Central Valley steelhead is listed as threatened under the ESA and as a species of special concern by the California Department of Fish and Game (DFG). Critical habitat was designated for this species but was later withdrawn (U.S. District Court for the District of Columbia, April 30, 2002).

Distribution and Occurrence

The Central Valley steelhead historically inhabited large and small streams throughout the Sacramento–San Joaquin watershed. It is now restricted to the upper Sacramento River downstream of Keswick Reservoir; the lower reaches of large tributaries downstream of impassable dams; small, perennial tributaries of the Sacramento River main stem and large tributaries of the Sacramento and San Joaquin Rivers; and the Sacramento–San Joaquin Delta (the Delta) and San Francisco Bay system. Central Valley steelhead spawn and rear, or have the potential to spawn and rear, in western Placer County streams, including Coon Creek, Doty Ravine, Auburn Ravine, Secret Ravine, and Minors Ravine.

Life History

Steelhead exhibit one of the most complex life histories of any salmonid (i.e., trout or salmon) species. Mixed genetic stock from past hatchery releases and changes in flow timing and magnitude associated with water resources development projects may have altered the life stage occurrence of Central Valley steelhead. Steelhead in the Sacramento River migrate upstream from July to March (Table 2). Within western Placer County streams, migration is dependent upon adequate flow and suitable water temperature that usually occur following storms in October and November. Spawning in the Sacramento River basin typically occurs from late December to April, with most spawning occurring from January to March. Unlike Chinook salmon, which die after spawning, steelhead can survive spawning, return to the ocean, and spawn again. Steelhead require relatively clean, cool (less than 14ºC [57°F]) water to spawn successfully. The eggs hatch anywhere from 19 days to 80 days after spawning, depending on water temperature (warmer temperatures result in faster hatching times), and the young remain in the gravel for several weeks before emerging as fry.

Steelhead juveniles spend a minimum of 1 year, but typically 2 years, in fresh water before emigrating to the ocean as smolts. Smolt emigration generally

occurs from November to May, although based on salvage data at the state and federal pumping plants in the Delta, the peak months for emigration in most years appear to be March and April. After spending 2 to 3 years in the ocean, steelhead return to their natal stream to spawn when they are 4 or 5 years old.

Reasons for Decline

Factors related to the decline of Central Valley steelhead include loss of habitat in river reaches blocked by dams, degradation of habitat conditions (e.g., water temperature), and entrainment in water diversions. Loss of habitat has the greatest effect on steelhead abundance. Major dams are the primary barriers to steelhead access to Central Valley rivers and streams. Dams at low elevations on all major tributaries block access to an estimated 95% of historical spawning habitat in the Central Valley (Reynolds et al. 1993; National Marine Fisheries Service 1996). Below dams, remnant steelhead populations are affected by varying flow conditions and high summer and fall water temperatures. Unscreened agricultural, municipal, and industrial diversions in the Delta and rivers cause entrainment losses of emigrating juvenile steelhead.

More than 90% of the adult steelhead in the Central Valley are produced in hatcheries (Reynolds et al. 1990). Hatchery-produced fish may substantially affect the genetic integrity of wild populations. Adult and juvenile steelhead are harvested by sport anglers in the Central Valley watershed. There is no commercial or sport fishery for steelhead in the ocean and, for unknown reasons, steelhead are rarely taken by commercial or sport salmon trollers (Skinner 1962).

Central Valley Fall/Late Fall–Run Chinook Salmon

Status

The MSA governs the conservation and management of ocean fisheries. The purpose of the MSA is to take immediate action to conserve and manage the fishery resources off the U.S. coasts (including anadromous species) and promote the protection of EFH. EFH is the aquatic habitat (water and substrate) necessary for fish to spawn, breed, feed, or grow to maturity (NOAA Fisheries 1998) that will allow a level of production needed to support a long-term, sustainable commercial fishery and contribute to a healthy ecosystem. Consultation with NOAA Fisheries is required for all projects with the potential to affect EFH for any MSA species. Central Valley fall/late fall–run Chinook salmon is an MSA managed species.

Distribution and Occurrence

In the Central Valley, fall/late fall–run Chinook historically spawned in all major streams draining the Sierra Nevada, but fish passage has since been blocked by

Table 2. Life Stage Timing and Distribution of Central Valley Fall-Run Chinook Salmon and Central Valley Steelhead

	Distribution	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Central Valley Fall-Run Chinook Salmon													
Adult migration and holding	San Francisco Bay to Upper Sacramento River and tributaries												
Spawning[a]	Upper Sacramento River and tributaries												
Egg incubation[a]	Upper Sacramento River and tributaries												
Juvenile rearing (natal stream)	Upper Sacramento River and tributaries												
Juvenile movement	Upper Sacramento River and tributaries to San Francisco Bay												
Steelhead													
Adult migration	San Francisco Bay to Upper Sacramento River and tributaries												
Spawning	Upper Sacramento River and tributaries												
Egg incubation	Upper Sacramento River and tributaries												
Juvenile rearing	Upper Sacramento River and tributaries to San Francisco Bay												
Juvenile movement	Upper Sacramento River and tributaries to San Francisco Bay												

Low probability of occurrence, not included in the assessment of project effects.

Primary occurrence included in the assessment of project effects.

Notes:

[a] Spawning and incubation occurs from October to February in the Feather, American, and Mokelumne Rivers.

Sources: McEwan 2001; Moyle 2002; Hallock 1989.

dams (Moyle 2002). Currently, fall/late fall–run Chinook salmon compose about 80% of the total Chinook salmon produced in the Sacramento and San Joaquin drainages (Kjelson et al. 1982). Fall/late fall–run Chinook salmon spawn in the Sacramento and San Joaquin Rivers and most of their tributaries. Central Valley fall/late fall–run Chinook salmon spawn and rear, or have the potential to spawn and rear, in western Placer County streams, including Bear River, Coon Creek, Doty Ravine, Auburn Ravine, Dry Creek, Antelope Creek, Secret Ravine, and Miners Ravine.

Life History

After 2–5 years in the ocean, adult Chinook salmon leave the ocean and migrate upstream to the Sacramento River and its numerous tributaries to spawn. Spawning occurs in the cool reaches of Central Valley rivers that are just downstream of the terminal dams and in small tributary streams. Adult fall/late fall–run Chinook salmon spawn soon after entering fresh water. Chinook salmon deposit their eggs in redds (i.e., gravel nests) located on riffles, runs, and pool tails. The optimal water temperature for egg incubation is 44.1–54.0ºF (6.7–12.2ºC) (Rich 1997). Eggs generally hatch in 6–9 weeks, and yolk-sac larvae remain in the gravel for several more weeks. Newly emerged fry remain in shallow, lower-velocity edgewaters, particularly where debris accumulates and makes the fry less visible to predators (California Department of Fish and Game 1998). Juvenile Chinook salmon may rear along the channel edge and on inundated floodplains during their movement downstream. Juvenile Chinook salmon may remain in fresh water for 3–6 months.

Adult fall/late fall–run Chinook salmon migrate into the Sacramento River and its tributaries from July to December (Table 2). Within western Placer County streams, migration is dependent upon adequate flows and suitable water temperatures, which usually occur following storms in October or November. Fall/late fall–run Chinook salmon spawn from early October through February, and incubation takes place from October through December. The peak of spawning for fall-spawning fish is in October and November, as water cools. Within western Placer County streams, juvenile Chinook salmon tend to migrate from February through June, and migration of smolt peaks from March to May (ECORP 2003).

Reasons for Decline

Many factors have contributed to the population decline of naturally-produced Central Valley fall/late fall–run Chinook salmon, including loss and degradation of spawning and rearing habitat, alteration of streamflows, overharvest, entrainment into water diversions, blockage of migration routes, exposure to toxins, and, possibly, loss of genetic viability from interbreeding with hatchery stocks. The abundance of fall-run Chinook salmon is maintained at a relatively high level by hatchery augmentation. The human-caused factor that perhaps has had the greatest effect on the naturally produced populations of Chinook salmon

runs is loss of habitat, primarily in the rivers upstream from the Delta. Major dams block upstream access to most Chinook salmon habitat in Central Valley rivers and streams. Smaller dams (e.g., the Red Bluff Diversion Dam [RBDD]) in the lower watersheds also delay migration of adults or increase predation on downstream-migrating juvenile salmon (Bureau of Reclamation 1983). Harvest rates on wild stocks are also a potential cause of the population declines.

Chapter 2
Assessment Methods

Species Assessment Model: Life Stage Response Relationships

Measurements of environmental conditions are expressed in units that include linear meters (feet) or hectares (acres) of habitat, degrees Celsius (Fahrenheit), meters (feet) per second, cubic feet per second (cfs), number of fish, and proportion of the population. Hypotheses regarding the response to variation in environmental conditions are identified for applicable species' life stages (Table 1) and are translated into equations or models that indicate the potential species response. The response of each species to changes in environmental conditions is determined by the ecology and physiology of a species' life stage.

Measures of a species response to changes in environmental conditions ideally quantify predicted survival or fecundity and habitat capacity (numbers of fish). Predicted survival and fecundity support the assessment of changes in a species' productivity. The relationship of change in an environmental condition to a species response may be accomplished through various means. An equation may estimate survival or fecundity; for example, a water temperature–survival relationship.

The available information may not support development and use of relationships and equations to quantify the potential response of a specific species. Consequently, assessment of the response to environmental conditions may be based on professional judgment and qualitative interpretation of the species responsiveness to changes in environmental conditions. For example, the responsiveness of a species to change in an environmental condition could be described as ranging from low to very high (Table 3). Where appropriate, these ranges of responsiveness could be used in the description of the assessment relationships for each life stage.

Certainty is an important component in the assessment of the weight given a species response to a selected environmental condition. Certainty indicates the potential that the species response or an index of the species response is reliable, adequate, accurate, and precise. An indication of certainty is the scientific support for the hypotheses, ranging from speculative relationships (i.e., minimal certainty) to those relationships that are thoroughly established, generally

accepted, and supported by peer-reviewed evidence (i.e., high certainty) (Table 4). Certainty is also related to the accuracy and precision of measured or simulated environmental conditions and the resulting index of the species response. Certainty is addressed in the discussion and conclusions section of this report.

Migration Habitat Quality

Migration habitat quality is an important factor affecting the distribution of adult and juvenile steelhead and Chinook salmon. However, the importance of migration habitat quality to the distribution, habitat use, and survival of juvenile steelhead and Chinook salmon is partially captured by other relationships for other environmental conditions, including rearing habitat quantity and entrainment. Additional information is needed to understand the potential relationship between the location of passage barriers and use of upstream juvenile rearing habitat in western Placer County streams. Effects of migration habitat on downstream movement, other than the effect discussed for entrainment in diversions, predation, water temperature, and contaminants (Figure 1), are assumed to have minimal consequence to the survival of juveniles.

Migration habitat quality affects the distribution of adults and the use of spawning habitat. Two hypotheses are identified relative to environmental conditions affecting adult migration (Table 1):

- Barriers block or delay adult migration and reduce fecundity, and
- Shallow water depth blocks or delays adult migration and reduces fecundity.

Barriers include natural features such as beaver dams and tree falls and human-made features such as diversion dams and weirs, pipeline and utility crossings, road crossings, culverts, and gradient control structures. Barriers can delay run timing and restrict the geographical distribution of adult Chinook salmon and steelhead. Fish may congregate upstream and downstream of barriers, increasing vulnerability to predators (including humans), and may create conditions that increase disease incidence.

Whether or not a structure is a barrier to fish movement is dependent on the physical and hydraulic features of the structure and on the physiology and behavior of the fish. Barriers may create velocity, depth, and slope conditions that fish cannot physically overcome. Jumping ability is greatly affected by staging pool depth, jump angle, and the horizontal distance of the leap (Powers and Orsborn 1985, Reiser and Peacock 1985). The ratio of the staging pool depth to barrier height should be greater than 1.5 (Robison et al. 1999, Stuart 1962, USDA Forest Service 1977). The conservative vertical limit for jumping by adult fish is 1.4 meters (4.5 feet) for steelhead and 0.9 meters (3.0 feet) for Chinook salmon.

High water velocity may occur at water control structures, road crossings, and culverts. Culverts are characteristically uniform and designed to optimize flow

Table 3. Example Species Responsiveness Assigned to Change in an Environmental Condition

Response	Definition
Low	Change in an environmental condition causes a relatively small species response. Fecundity or life stage survival is expected to change by less than 2.5% in response to a 10% or larger change in an environmental condition. Although the species response may be minimally affected by small changes in an environmental condition (less than 10% change), significant impacts may result from larger changes.
Medium	Change in an environmental condition causes a moderate response. Change in fecundity or life stage survival is approximately proportionate to change in the environmental condition (i.e., a 10% change in an environmental condition would result in a 10% change in survival or fecundity).
High	Change in an environmental condition causes a large species response. Fecundity or life stage survival is expected to change by more than 10% and up to 20% in response to a 10% change in an environmental condition.
Very high	Change in an environmental condition causes a very large species response. Change in fecundity or life stage survival may exceed 20% in response to a 10% change in the environmental condition.

Table 4. Certainty of the Assessment Relationships

Level of Certainty	Definition
Minimal	The relationship is speculative and has little empirical support.
Low	Theoretical cause-and-effect relationship supported by some evidence from experiments and observation. The magnitude of species response cannot reliably be predicted from a given magnitude change in an environmental condition. Contradictory theoretical relationships may be equally supported.
Medium	Theoretical cause-and-effect relationship supported by evidence from experiments and observations. The magnitude of species response can be predicted from a given magnitude of change in an environmental condition. The accuracy and precision of the relationship have not been statistically evaluated. Contradictory theoretical relationships are possible, but they are unlikely to be as well supported by experiments and observations.
High	Cause-and-effect relationship is thoroughly established, generally accepted, and supported by peer-reviewed evidence. The magnitude of species response can be predicted from a given magnitude change in an environmental condition. The accuracy and precision of the relationship has been statistically evaluated. Contradictory theoretical relationships are unlikely and poorly supported.

efficiency. The presence of a large scour pool at the downstream end of a culvert is a good indicator that velocity may be a barrier to fish passage, especially at high flow (Washington Department of Fish and Wildlife 1999). The velocity a fish can overcome in moving through a culvert is also dependent on the length of the culvert. The longer the culvert, the lower the velocity must be for a fish to pass successfully. In general, water velocity should be less than 0.9 meters (3 feet) per second for any culvert greater than 30.5 meters (100 feet) in length and less than 1.5 meters (5 feet) per second for culverts less than 30.5 meters (100 feet) in length (California Department of Fish and Game 1999).

Water depth over barriers may also be insufficient to support passage. A minimum water depth of 1 foot, in conjunction with appropriate velocity and vertical jump conditions, would support upstream passage by adult Chinook salmon and steelhead.

Depth, velocity, and vertical jump should support passage of Chinook salmon and steelhead over all barriers along the migration pathway during the primary months of adult migration. For the purposes of the SAM, blockage during a month is considered a loss of fecundity equal to the proportion of the adult population that would be expected to spawn during the month. The effect also considers the location of the barrier relative to the distribution of spawning habitat and the proportion of fish expected to pass the barrier. The expected annual change in fecundity of the population in response to effects of barriers is calculated:

$$\text{Change in Fecundity} = \sum [(1-H_{upstream}) + (H_{upstream} \times (1-P_{block}))] \times P_{month}$$

Where $H_{upstream}$ is the proportion of habitat area upstream of the barrier, P_{month} is the proportion of the population spawning in each month, and P_{block} is the proportion of fish encountering the barrier that are blocked. The product is summed for all months of spawning and for all barriers.

For example, fall-run Chinook salmon spawn from October through December. Assume that flow conditions support upstream movement over all potential barriers during November and December and that equal proportions of the population spawn each month (i.e., 0.33). One barrier is assumed to block upstream movement of 80% of the fish encountering the barrier in October and 20% of the spawning habitat occurs upstream of the barrier. The expected annual change in fecundity of the population in response to effects of the barrier would be:

October = [(1-0.2) + (0.2 x (1-0.8))] x 0.33 = [0.8 + (0.2 x 0.2)] x 0.33 = [0.8 + 0.04] x 0.33 = 0.84 x 0.33 = 0.28

November = [(1-0.2) + (0.2 x (1-0))] x 0.33 = [0.8 + (0.2 x 1)] x 0.33 = [0.8 + 0.2] x 0.33 = 1.00 x 0.33 = 0.33

December = [(1-0.2) + (0.2 x (1-0))] x 0.33 = [0.8 + (0.2 x 1)] x 0.33 = [0.8 + 0.2] x 0.33 = 1.00 x 0.33 = 0.33

The annual change in fecundity attributable to the effects of this one barrier would be 0.94 (i.e., 0.28 + 0.33 + 0.33).

Although shallow depth is known to block or delay adult migration, the depth conditions required for passage are variable depending on local channel conditions, water temperature, and other factors. For the purposes of this analysis, any channel segment with a maximum depth less than 0.2 meters (0.5 feet) extending over a linear distance of 30.5 meters (100 feet) or more is assumed to block passage. The annual effect on fecundity is calculated by the same method applied to barriers.

Spawning Habitat Area

Spawning habitat area is dependent on gravel abundance within the wetted stream channel (Table 1). Spawning gravel area has been measured for accessible sites in Coon Creek, Doty Ravine, Auburn Ravine, Antelope Creek, Secret Ravine, and Miners Ravine (Jones & Stokes 2004). Observed redd size for Central Valley Chinook salmon ranges from 7.0 square meters (75 square feet) to 60.4 square meters (650 square feet) (Reynolds et al. 1990). Steelhead redds are substantially smaller. For the purpose of the SAM, a redd size of 5.2 square meters (56 square feet) is assumed for steelhead and 9.3 square meters (100 square feet) is assumed for Chinook salmon. Many of the measured gravel patches fell below the criteria of 5.2 and 9.3 square meters (56 and 100 square feet), so total square footage per reach surveyed was used to calculate the estimated number of redds. The total gravel area calculated for each reach was divided by 5.2 square meters (56 square feet) to provide an estimated number of redds for steelhead, and by 9.3 square meters (100 square feet) to provide an estimated number of redds for Chinook salmon. The estimated number of redds provides an indication of spawning habitat capacity.

Fine Sediment

Egg and larval survival is reduced by increased fine sediment levels in spawning gravel during incubation (Table 1). Relationships between particle size, permeability, intragravel flow, hydraulic gradients, and embryo survival are not fully understood. In general, a high percentage of fines decreases permeability, which reduces velocity for a given pressure gradient. This may be intensified under low-flow conditions because low velocity allows settling of fines (Johnson 1980). In addition to particle size, the rate of intragravel flow is related to the permeability of the substrate, substrate compaction, and hydraulic pressure that is a function of stream gradient (Vyverberg et al. 1997).

Particle size has been defined as one of the main factors that affect embryo survival, time of emergence, and size of emergent fry (Bjornn and Reiser 1991). Fines greater than 30% to 40% by volume exceed the threshold value where embryo survival is significantly reduced. A high percentage of fines reduces the

supply of oxygen to the embryos and impedes movement of fry from the redd (Tappel and Bjornn 1983, Chapman 1988, Waters 1995).

Based on a model developed by Tappel and Bjornn (1983), survival from spawning to emergence in the Stanislaus River ranges from 58.6% to 76.5% (Mesick 2001). Approximately 43% fines corresponds to 58.6 % survival (Figure 3). In the Stanislaus River, fines smaller than 9.5 millimeter (0.4 inches) range from 3.4% to 55.6% by substrate volume and fines smaller than 0.85 millimeter (0.03 inches) range from 0.1% to 16.9%. Studies in the Tuolumne River indicate a lower survival rate for Chinook salmon eggs, ranging from 0% to 68% and averaging 34% (EA Engineering, Science and Technology 1992 in Mesick 2001).

Mesick (2001) suggested that Tappel and Bjornn's (1983) estimated survival rates are excessively high in comparison to field studies conducted in the Tuolumne River. For the Tappel and Bjornn (1983) studies, embryos were incubated in a hatchery prior to planting in test gravel mixtures. Laboratory conditions maintained intragravel dissolved oxygen (DO) levels at near saturation.

For the purpose of the SAM, survival is assumed to decline linearly with increasing fines, with 100% survival in the absence of fines and no survival at 50% or more fines (Table 5).

Table 5. Assumed Relationship between Percentage of Fines and Egg Survival

Fines (%)	Egg Survival (%)
0	100
10	80
20	60
30	40
40	20
>50	0

Scour

The increase in urban areas within watersheds has been shown to increase impervious surfaces and increase peak streamflow (Im et al. 2003). Increased peak streamflow may lead to increased channel erosion that may result in scour of Chinook salmon and steelhead redds. Information on peak streamflow and effects on stream channel morphology is currently not available for western Placer County streams.

Scour of eggs and larvae reduces survival during incubation. The potential loss of redds requires information by stream reach on the frequency of flows sufficient to mobilize spawning gravel. Initially, streamflow and stage data

needs to be collected to determine if an increase in urban areas will increase peak streamflow to a level of that could increase the frequency of spawning gravel mobilization. If peak streamflow is expected to increase, a relationship between the critical discharge for incipient motion and the discharges causing substantial gravel transport might be used to evaluate potential increases in redd loss. This relationship would need to be field verified by observation of effects on redds for a range of high flow conditions.

Rearing Habitat Area

Rearing habitat for salmonids is defined by environmental conditions such as water temperature, dissolved oxygen, turbidity, substrate, area, water velocity, water depth, and cover (Jackson 1992, Bjornn and Reiser 1991, Healey 1991). Environmental conditions and interactions between individuals, predators, competitors, and food sources determine habitat quantity and quality and the productivity of the stream (Bjornn and Reiser 1991). Rearing areas for juvenile Chinook salmon and steelhead in western Placer County streams include all riffles, runs, and pools, and for Chinook salmon, inundated floodplains. Everest and Chapman (1972) found juvenile Chinook salmon and steelhead of the same size utilizing similar in-channel rearing areas. For the purposes of the SAM, in-channel rearing areas are assumed to be the same for Chinook salmon and steelhead. Inundated floodplains are assumed to be of negligible importance to juvenile steelhead rearing.

Two hypotheses were identified relative to selected environmental conditions affecting rearing habitat area for steelhead and Chinook salmon (Table 1):

- Rearing habitat area is dependent on depth, velocity, and cover within the stream channel, and
- Rearing habitat area is dependent on floodplain inundation (Chinook salmon only).

Rearing area varies with flow. High flow increases the area available to juvenile Chinook salmon because they extensively use submerged terrestrial vegetation on the channel edge and the floodplain. Deeper inundation provides more overhead cover and protection from avian and terrestrial predators than shallow water (Everest and Chapman 1972 in Jackson 1992). In broad low-gradient rivers, a change in flow can greatly increase or decrease the lateral area available to juvenile Chinook salmon, particularly in riffles and shallow glides (Jackson 1992). During low-flow periods, juvenile Chinook salmon in the lower American River are most likely found in riffles.

Use of floodplain habitat by juvenile Chinook salmon has been well documented (Jones & Stokes 1993, 1999; California Department of Water Resources 1999; Sommer et al. 2001). Sommer and others found that floodplains provide better rearing and migration habitat for juvenile Chinook salmon than the main river channel. For example, the apparent growth rate of Chinook salmon in the Yolo Bypass ranged from 0.55 to 0.80 millimeters (0.022 to 0.03 inches) per day,

while growth rates in the main channel of the Sacramento River ranged from 0.43 to 0.52 millimeters (0.017 to 0.02 inches) per day. The faster growth rate in the Yolo Bypass may be attributed to increased prey consumption associated with greater availability of drift invertebrates and warmer water temperatures than in the main channel. Invertebrate production on the floodplain may be stimulated by availability of detritus in the food web, habitat available for benthic invertebrates, and a relatively long hydraulic residence time. Long residence time reduces the rate at which nutrients and drifting invertebrates are flushed out of the system. The existing data also indicate that survival of young salmon rearing in the Yolo Bypass may be enhanced relative to survival in the main stem Sacramento River. Enhanced survival may be attributable to faster growth rates and reduced exposure to predatory fish.

Juvenile steelhead are year-round residents and generally use riffles and runs in the main and secondary channels, along with the head and tail of pools. Shallow riffles are the most important channel type for steelhead during their first year (Barnhart 1986). Steelhead also use seasonal habitats of intermittent streams for rearing (McEwan 2001). Floodplain does not appear to provide significant rearing habitat for steelhead.

Although, juvenile Chinook salmon do not appear to prefer a particular depth (Jackson 1992), Brett (1952 in Jackson 1992) reported water depths from 0.3 to 1.2 meters (1 to 4 feet) as optimal for juvenile Chinook salmon rearing. Raleigh et al. (1986) reports preferred water depth ranging from 0.2 to 0.9 meters (0.5 to 3.0 feet). Bovee (1978 in Barnhart 1986) showed that steelhead fry are most commonly found in water 0.09 to 0.4 meters (0.3 to 1.2 feet) deep. Juvenile steelhead are commonly found in water 0.24 to 0.48 meters (0.8 to 1.6 feet) deep.

Water velocity is particularly important factor in determining where juvenile salmonids occur because it determines the energetic requirements for maintaining position and the amount of food delivered to a particular location. Juvenile salmonids tend to select positions that maximize energetic gain, but these positions can be altered by interaction with other fish and the presence of cover (Shirvell 1990). Preferred water velocity used by Chinook salmon varies with size. Larger fish occupy higher velocity and deeper areas than small fish, potentially gaining access to abundant food and avoiding predatory birds (Bjornn and Reiser 1991, Jackson 1992). The mean water column velocity preferred by juvenile Chinook salmon is between 0.09 to 0.5 meters (0.3 and 1.5 feet) per second.

Griffith (1972 in Raleigh et al. 1984) measured water velocity between 0.1 to 0.22 meters (0.32 and 0.72 feet) per second associated with occurrence of rainbow trout (i.e., the resident life history type of steelhead). Sheppard and Johnson (1985) found similar results for juvenile steelhead with velocity ranging from 0.12 to 0.24 meters (0.40 to 0.80 feet) per second.

Stream substrates are important for juvenile salmonids, in particular fry, and for production of aquatic invertebrates that are food for salmonids (Bjornn and Reiser 1991). Waters (1995) and Bjornn and Reiser (1991) indicated the importance of interstitial space in riffles for fry, relating to fry density and stream

carrying capacity. The summer and winter carrying capacity of a stream declined when fine sediments filled the interstitial spaces of the substrate. Where winter temperature is cooler than about 41ºF (5ºC), a condition that would rarely occur in western Placer County streams, fish density decreased when interstitial spaces in riffle substrate filled with fines (Chapman and Bjornn 1969, Bjornn 1977, and Hillman et al. 1987, all in Waters 1995). When water temperature cooled in the fall, juvenile Chinook salmon in the Red River in Idaho were observed to leave riffles that were 70% embedded with fines (Hillman et al. 1987 in Waters 1995).

Juvenile salmonids occur over a wide variety of substrate and substrate does not appear to be a critical criterion determining rearing area selection. Baltz and others (Baltz et al. 1987 in Jackson 1992) found that temperature was a better predictor of habitat utilization by rainbow trout and other native fish species than mean water velocity and substrate. Hampton (Hampton 1988 in Jackson 1992) found that substrate was an important factor for rearing when large cobbles or boulders were used as velocity shelters in riffles and runs. This adaptation increases energetic gain or minimizes energy expenditure.

Organic debris and gravel have been observed to be the preferred substrate for Chinook salmon fry in the Mokelumne River (Bovee 1978 in California Department of Fish and Game 1991). Substrate 0.5 centimeter (0.2 inches) in diameter was preferred by juvenile Chinook salmon in the Sacramento River (California Department of Fish and Game 1991). Fry and juvenile steelhead prefer cobble and rubble (Bovee 1978 in Interagency Ecological Program Steelhead Project Workteam 1999).

Instream and overhead cover, in the form of undercut banks, downed trees, and overhanging tree branches, is important for juvenile rearing. Streamside riparian vegetation is a primary source of cover. The root systems of riparian vegetation and large organic debris (such as fallen logs) in the stream channel provide refuge from predators and high flow conditions. Degraded riparian vegetation results in part from the expansion of urban areas into riparian corridors. Trees and shrubs are often removed to accelerate floodwater conveyance in the channel or to make way for adjacent land uses.

The addition of cover increases spatial complexity and may increase productivity. Food abundance and competitor and predator occurrence determine cover value. Fine textured instream woody material provides the hydraulic diversity necessary for selection of suitable velocities, access to drifting food, and escape refugia from predatory fish. An area of cover greater than 15% of the total habitat area may provide adequate cover for juvenile salmonids (Raleigh et al. 1984).

Table 6 summarizes data on fish densities observed in selected rivers of California. Jackson (1992) estimated density in riffles, runs, glides and pools. Riffles and glides supported similar densities of Chinook salmon, 0.88 and 0.82 fish per square meter (0.26 and 0.25 fish per square foot), closely followed by runs at 1.22 fish per square meter (0.37 fish per square foot). Pools supported the highest density—4.86 fish per square meter (1.46 fish per square foot). During

low flow, riffles had the highest density of Chinook salmon greater than 100 millimeters (3.9 inches) in length.

Table 6. Estimated Juvenile Chinook Salmon Density for Selected California Streams

Stream	Fish Size in Millimeters (inches)	Density (Range) fish/meter^2 (fish/foot$^{2)}$	Reference
Lower San Joaquin River	44 to 70 (1.7 to 2.8)	0.04 to 0.32 (0.01 to 0.1)	McFarland and Weinrich 1987
Lower American River	50 to 120 (2 to 4.7)	0.88 to 4.86 (0.26 to 1.46)	Jackson (1992)
American River	50 to 100+ (2 to 3.9+)	0.4 to 5.6 (0.12 to 1.68)	USFWS (1984)
Tuolumne River	30 to 110 (1.2 to 3.9)	1 to 2 (0.3 to 0.6)	Ford and Brown 2001

Juvenile density in the Tuolumne River from 1992 to 1997 ranged from less than 1 fish per square meter to about 9 fish per square meter (less than 0.3 to about 2.7 fish per square foot). Density during most years ranged from 1 to 2 juvenile Chinook salmon per square meter (Ford and Brown 2001). Jones & Stokes (1999) reported a juvenile Chinook salmon density of 0.72 fish per square meter (0.22 fish per square foot) on the inundated floodplain of the lower American River. The density for steelhead in streams ranges from 0.1 to 0.9 fish per square meter (0.03 to 0.27 fish per square foot) (Hall and Knight 1981).

Rearing habitat capacity is the product of rearing area and assumed juvenile density. Density is highly variable and dependent on multiple interacting environmental conditions, including water temperature, cover, food availability, fish community structure, and fish size. Rearing habitat area, however, cannot be calculated with the available data for streams in western Placer County.

Water Temperature

Temperature criteria generally include a threshold measure and average duration of exposure. The threshold represents the temperature that would cause an adverse biological response. The exposure period affects the magnitude of the biological response (Sullivan et al. 2000). As water temperature increases toward the extremes of the tolerance range of a fish, biological responses such as impaired growth and risk of disease and predation are more likely to occur (Myrick and Cech 2001, Sullivan et al. 2000). Temperature criteria for Chinook salmon and steelhead are based on experimental tolerance studies, a use recommended by the Environmental Protection Agency (EPA) and Armour (in Sullivan et al. 2000).

Temperature survival indices were estimated for Chinook salmon and steelhead life stages, including adult migration, spawning and incubation, rearing, and smolt migration (Table 7). The temperature survival indices are estimated from curves fitted to available survival data.

Water temperature effects on fish are well established and can be used to predict survival. As water temperature increases toward the extremes of the tolerance range of a fish, biological responses such as impaired growth and risk of disease and predation are more likely to occur (Myrick and Cech 2001; Sullivan et al. 2000). Acceptable water temperatures identified in the available literature for Chinook salmon and steelhead life stages fall within a relatively broad range. Conclusive studies of the thermal requirements completed for Chinook salmon and steelhead in Central Valley streams are limited (Myrick and Cech 2001). Based on a literature review, conditions supporting adult Chinook salmon migration deteriorate as temperature warms between 12 and 21ºC (54 and 70ºF) (Hallock 1970 as cited in McCullough 1999). For Chinook salmon eggs and larvae, survival declines with increasing water temperature between 12 and 16ºC (54 and 61ºF) (Myrick and Cech 2001; Seymour 1956 cited in Alderice and Velsen 1978). For juvenile Chinook salmon, survival declines as temperature warms from 18 to 24ºC (64 to 75ºF) (Myrick and Cech 2001; Rich 1987). Relative to rearing, Chinook salmon require cooler temperatures to complete the parr-smolt transformation and to maximize their saltwater survival. The rate of successful smolt transformation deteriorates at temperatures ranging from 17 to 23ºC (63 to 73ºF) (Marine 1997 as cited in Myrick and Cech 2001; Baker 1995). Based on information on migration of juveniles, Baker et al. (1995) developed a statistical model to estimate the influence of temperature on the survival of Chinook salmon smolts migrating through the Sacramento–San Joaquin Delta. The model estimated that Chinook salmon released at Ryde and migrating to Chipps Island undergo 50% mortality at 22 to 24ºC (71.6 to 75.2ºF).

For steelhead, the rate of successful adult migration and holding deteriorate as water temperature warms between 11 to 21ºC (52 and 70ºF). Adult steelhead appear to be much more sensitive to thermal extremes than juveniles (National Marine Fisheries Service 1996a; McCullough 1999). Conditions supporting steelhead spawning and incubation deteriorate as temperature warms between 52 and 59ºF (Myrick and Cech 2001). Juvenile rearing success deteriorates at water temperatures ranging from 17 to 25ºC (63 to 77ºF) (Raleigh et al. 1984; Myrick and Cech 2001). Relative to rearing, smolt transformation requires cooler temperatures and successful transformation occurs at temperatures ranging from 6 to 10ºC (43ºF to 50ºF). Juvenile steelhead, however, have been captured at Chipps Island in June and July at water temperatures exceeding 68ºF (Nobriega and Cadrett 2001). Given the movement of steelhead at water temperatures warmer than required for successful smolt transformation, the water temperature criteria applied to migration of steelhead smolt are assumed to be the same as those applied to assess water temperature effects on Chinook salmon smolt migration. Given that juvenile steelhead are more tolerant of warmer temperatures than juvenile Chinook salmon, the application of Chinook salmon indices may be conservative. However, additional research is warranted to better understand juvenile steelhead migration and smoltification in the Sacramento–San Joaquin system.

Table 7. Temperature Survival Indices for Chinook Salmon and Steelhead

	Chinook Salmon				Steelhead			
Water Temperature (°F)	Adult Migration	Spawning/ Incubation	Juvenile Rearing	Smolt Migration	Adult Migration	Spawning/ Incubation	Juvenile Rearing	Smolt Migration[1]
50	100%	100%	100%	100%	100%	100%	100%	100%
51	100%	100%	100%	100%	100%	100%	100%	100%
52	100%	100%	100%	100%	100%	100%	100%	100%
53	100%	100%	100%	100%	100%	100%	100%	100%
54	100%	100%	100%	100%	100%	98%	100%	100%
55	100%	99%	100%	100%	100%	91%	100%	100%
56	100%	96%	100%	100%	99%	80%	100%	100%
57	100%	90%	100%	100%	98%	63%	100%	100%
58	99%	82%	100%	100%	96%	37%	100%	100%
59	97%	69%	100%	100%	94%	0%	100%	100%
60	94%	52%	100%	100%	90%	0%	100%	100%
61	91%	29%	100%	100%	87%	0%	100%	100%
62	87%	0%	100%	100%	82%	0%	100%	100%
63	81%	0%	100%	100%	76%	0%	100%	100%
64	74%	0%	100%	100%	69%	0%	100%	100%
65	66%	0%	100%	99%	61%	0%	100%	99%
66	57%	0%	97%	96%	52%	0%	100%	96%
67	46%	0%	93%	92%	42%	0%	98%	92%
68	33%	0%	87%	87%	29%	0%	95%	87%
69	18%	0%	77%	79%	16%	0%	90%	79%
70	0%	0%	65%	69%	0%	0%	83%	69%
71	0%	0%	48%	57%	0%	0%	73%	57%
72	0%	0%	27%	42%	0%	0%	61%	42%
73	0%	0%	0%	23%	0%	0%	45%	23%
74	0%	0%	0%	0%	0%	0%	25%	0%
75	0%	0%	0%	0%	0%	0%	0%	0%

[1] Survival indices for chinook salmon smolt migration are assumed to apply to steelhead; indices for adult migration, juvenile rearing, and juvenile migration of chinook salmon are assumed to apply to coho salmon in the Trinity River.

Note: The survival indices in this table support the comparison of alternatives and should not be considered as specific management recommendations or targets for water temperature management in Central Valley rivers.

Water temperatures are broken into three classifications for the purposes of presentation in this report:

- Unsuitable – temperatures that will not support the completion of a life stage.
- Suitable – temperatures that support at least some level of survival for completion of a life stage.
- Ideal – little or no temperature related mortality expected during a life stage.

Water temperature thresholds for ideal (i.e., upper threshold) and unsuitable (i.e., lower threshold) classifications are shown in Table 8. Survival can be expected at temperatures exceeding the lower "unsuitable" threshold. However, the threshold represents temperature conditions not expected to provide habitat that would contribute to species production.

Table 8. Water Temperature Thresholds for Ideal and Unsuitable Classifications for Central Valley Fall-Run Chinook Salmon and Central Valley Steelhead

Species/Life Stage	Upper Ideal Threshold in Degrees Celsius (°F)	Lower Unsuitable Threshold in Degrees Celsius (°F)
Chinook salmon		
Adult migration	12 (54)	21 (70)
Spawning/incubation	12 (54)	16 (61)
Juvenile rearing	18 (64)	24 (75)
Juvenile migration	17 (63)	23 (73)
Steelhead		
Adult migration	11 (52)	21 (70)
Spawning/incubation	11 (52)	15 (59)
Juvenile rearing	17 (63)	25 (77)
Juvenile migration	16.7 (62)	23 (74)

Two hypotheses were identified relative to selected environmental conditions affecting water temperature conditions for steelhead and Chinook salmon in western Placer County streams (Table 1):

- Reduced riparian shade warms water temperature and reduces survival, and
- Increased stream width to depth ratio warms water temperature and reduces survival.

A water temperature model would be necessary to precisely evaluate the effect of shade and stream width to depth ratio on water temperature. However, the available water temperature data provides an indication of the potential

sensitivity of water temperature survival conditions to changes in shade and width to depth ratio.

Existing riparian shade was estimated from aerial photographs and used to provide a basis for evaluating the relationship between shade and water temperature conditions and the survival of steelhead and Chinook salmon. Riparian shade was evaluated from aerial photographs and from a GIS analysis of land cover. Riparian shade was generally evaluated for stream reaches nearest the spawning gravel surveys. The level of shade from riparian vegetation was assessed from the aerial photographs based on the following:

- 76–100% shade – vegetation on both sides of the stream obscures stream surface;
- 50–75% shade – vegetation sporadically along both banks or continuously on one bank;
- 25–49% shade – vegetation sporadically along either bank; and
- 0–24% shade – no apparent riparian vegetation shading the stream surface.

For the entire length of assessed streams, the level of shade provided by land-cover within the stream corridor (i.e., land within 20 m of the stream centerline) was assessed through a GIS-based analysis. Streams were subdivided into segments with relatively homogeneous vegetation, and these segment locations are given in Appendix B. For each segment, the area covered by each land-cover type was tabulated. Riparian forest was considered to provide a high level of shade, woodlands a moderate level of shade, and other land-cover types with trees or shrubs were considered to provide a low level of shade. Agricultural, herbaceous plant-dominated (e.g., grassland) and developed land-cover types were not considered to provide shade.

Insufficient information is available to evaluate the sensitivity of water temperature to existing stream channel width to depth ratios. A critical unknown is whether or not stream width and depth would be expected to change in response to human activities within the western Placer County watersheds (i.e., in response to expected changes in flow and geomorphic processes).

Food

The analysis for rearing habitat quantity discussed above is assumed to reflect the potential effects on food for juvenile Chinook salmon and steelhead. Reduced food availability reduces growth and survival of juveniles (Table 1). The assessment is based on the hypothesis that food production and availability is directly related to inundated channel and floodplain areas.

The relationship between river flow and food availability for juvenile Chinook salmon and steelhead, however, is relatively unknown for western Placer County streams. As discussed above, Sommer and others (2001) found that floodplains provide better rearing and migration habitat for juvenile Chinook salmon than the

main river channel, which may be attributable to increased prey consumption associated with greater availability of drift invertebrates and warmer water temperature. The apparent growth rate of Chinook salmon in the Yolo Bypass ranged from 0.55 to 0.80 millimeters (0.022 to 0.03 inches) per day, while growth rates in the main channel of the Sacramento River ranged from 0.43 to 0.52 millimeters (0.017 to 0.02 inches) per day. Similar benefits may be expected from inundated floodplain along western Placer County streams. In addition to flow and connectivity to the floodplain, riparian vegetation, fine sediment input, and contaminants have an effect on food availability that cannot currently be quantified.

Contaminants

Land use in western Placer County affects water quality through the input of contaminants. Poor water quality is often related to nonpoint-source pollution from agricultural land use, seepage from septic tanks, and urban surface water runoff. Gas and oil often contaminate stormwater runoff from paved surfaces. Runoff from golf courses and residential lawns may carry fertilizers, pesticides, and herbicides into local waterways. Healthy riparian vegetation may help maintain water quality by filtering sediment and nutrients and moderating the duration and magnitude of storm runoff.

Treated wastewater from treatment plants typically meet National Pollutant Discharge Elimination System (NPDES) requirements. Treated wastewater discharged to streams, however, may affect water temperature and nutrient levels. Effects of discharged treated water are highest under low-flow conditions.

Contaminants can impact survival and growth rates, as well as the reproductive success of fish and other aquatic organisms. The potential magnitude of biological effects resulting from contaminants depends on a number of factors, including the proximity of the stream to contaminant sources; the type, amount, concentration and solubility of the contaminant; and the timing and duration of the discharge. The level of effect depends on species and life stage sensitivity, duration and frequency of exposure, condition or health of individuals (e.g., nutritional status), and physical or chemical properties of the water (e.g., temperature, dissolved oxygen).

Data on contaminants in western Placer County streams and the response of salmonids is limited and does not support a quantitative assessment of effects on survival.

Predation

The introduction of nonnative fish species has substantially altered the fish communities in foothill streams. Nonnative fishes may affect Chinook salmon and steelhead through competition, predation, and change in trophic dynamics

(i.e., the availability of prey). Introduced fish are abundant in the western Placer County streams (Placer County Planning Department 1999, City of Lincoln Community Development Department 1999), and they likely have substantially affected the abundance and distribution of many native species. Nonnative predatory species are often more suited to altered habitat conditions such as channelization and warm water temperature. For example, largemouth bass can persist in water temperatures up to 97–99ºF (36.1–37.2°C). Nonnative fish species that occur in western Placer County streams may prey on juvenile Chinook salmon and steelhead and are tolerant of warm water temperature; these nonnative species include largemouth and spotted bass, bluegill, white crappie, brown bullhead, and green sunfish. Smaller-size fish are also affected by avian predators such as herons and egrets, but to what degree is unknown.

Reduced instream cover reduces survival of juveniles through increased predation-related mortality (Table 1). Cover provides juvenile Chinook salmon and steelhead the ability to avoid predation by native and nonnative predator fish species and by piscivorous birds and mammals. For the purposes of the SAM and in the absence of measured cover data, riparian shade is assumed to provide an indicator of susceptibility to predation. As indicated under "Water Temperature" above, the level of shade from riparian vegetation was assessed. The following assumptions were made as a qualitative assessment of predation risk:

- 76–100% shade – predation-related mortality at natural levels;
- 50–75% shade – predation-related mortality slightly increased (e.g., less than 10% increase);
- 25–49% shade – predation-related mortality is moderately increased (e.g., up to a 50% increase); and
- 0–24% shade – predation-related mortality is substantially increased (e.g., up to a 100% increase).

Harassment

Harassment refers to poaching and human disturbance of fish. Harassment during spawning by adults can lead to abandonment of redds and unsuccessful spawning attempts, ultimately reducing fecundity (Table 1). Chinook salmon and steelhead in small streams are especially vulnerable to harassment because the fish are highly visible and accessible given the relatively shallow water depth and narrow stream width. The proximity of urban areas has the potential to substantially increase harassment by humans, especially if streams are made more accessible by trails and other public infrastructure. Reduced instream and overhead cover may also intensify susceptibility to harassment. Instream and overhead cover reduces the visibility of adult Chinook salmon and steelhead. In addition, riparian vegetation can limit access to the stream. For the purposes of the SAM, riparian shade and proximity of urban development are assumed to provide an indicator of susceptibility to harassment. As noted under "Water

Temperature," the level of shade from riparian vegetation was assessed. The following assumptions were made as a qualitative assessment of harassment risk:

- 100% shade and greater than a quarter mile to urban development – harassment and effects on fecundity are at natural levels;
- 50% shade and with a quarter to a half mile of urban development – harassment and effects on fecundity are slightly increased (e.g., less than 10% increase);
- 25% shade and within an eighth to a quarter mile of urban development – harassment and effects on fecundity are moderately increased (e.g., up to a 50% increase); and
- 0% shade or urban development abuts the stream channel – harassment and effects on fecundity are substantially increased (e.g., up to a 100% increase).

Entrainment

Water diversions entrain migrating juvenile Chinook salmon and steelhead and reduce survival. Entrainment of fish with diverted streamflow has been identified as a primary concern for these two species. The environmental conditions that influence the number of fish lost to diversions include:

- Abundance, distribution, and movement of fish in the stream;
- Diversion location, volume, duration, frequency, and timing (i.e., seasonal and diurnal);
- Effects of streamflow on the movement of fish;
- Efficacy of fish screens; and
- Predation vulnerability at and downstream of the diversion.

Information on the location, volume, timing, duration, and frequency of diversion from Placer County streams is not readily available. A juvenile Chinook salmon or steelhead passing a diversion point may be entrained with the diverted flow. The probability of entrainment and subsequent mortality is a function of the size of the diversion; the location of the diversion; the behavior of the fish; and other factors such as fish screens, presence of predatory species, and water temperature. Larger diversions would be expected to entrain proportionately more fish than small diversions. For the purpose of the SAM, the proportion of fish entrained is less than the proportion of flow diverted for diversions of up to 50% of the flow (Table 9). The low proportion is consistent with field studies of diversions on the Sacramento River (Hanson 2001). For diversion of more than 50% of the flow, the proportion of fish entrained is assumed to exceed the proportion diverted until all the flow and fish are diverted.

Table 9. Assumed Percentage of Juvenile Chinook Salmon and Steelhead Entrained Relative to the Percent of Flow Diverted

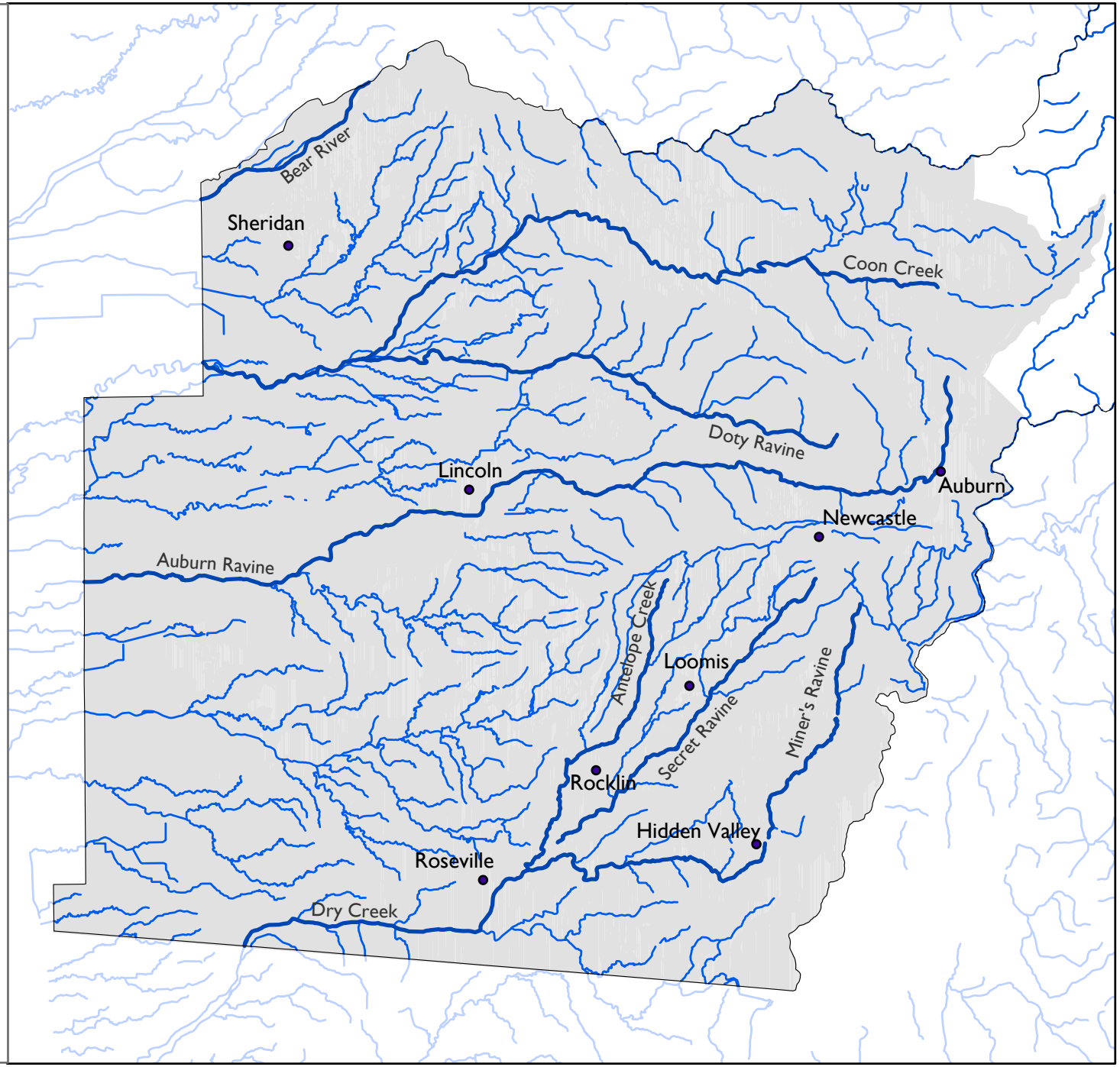
Percent of Flow Diverted (%)	Percent Juveniles Entrained (%)
10	2
20	9
30	21
40	35
50	50
60	65
70	79
80	91
90	98
100	100

Application of Assessment Model to Western Placer County Streams

The streams covered by the species assessment include Bear River, Coon Creek, Doty Ravine, Auburn Ravine, Dry Creek, Antelope Creek, Secret Ravine, and Miners Ravine (Figure 4). The species assessment for each stream uses data from a review of available literature and data. These data sources included:

- Water temperature data from Bailey Environmental collected during 1999-2003 along Antelope Creek, Dry Creek, Miners Ravine and Secret Ravine, and additional water temperature data reviewed in Bailey 2003;
- Water quality monitoring data collected by the Regional Water Quality Control Board, Dry Creek Conservancy, Placer County's Wastewater Treatment Plant, and Lincoln High School;
- Benthic macroinvertebrate monitoring data collected by the Dry Creek Conservancy along Dry Creek, Miners Ravine and Secret Ravine, and by the Auburn Ravine Group along Auburn Ravine;
- Spawning gravel surveys by Jones & Stokes along Antelope Creek, Auburn Ravine, Coon Creek, Doty Ravine, Miners Ravine and Secret Ravine;
- Stream flow data from the U.S. Geological Survey and EcoLogic Consulting Engineers, (Stream flow data was also requested from Placer County Water Agency but none was available);
- AirPhotoUSA 2000 aerial photography and the vegetation map of Western Placer County based on that photography (Jones & Stokes 2002);

Figure 4
Streams Included in Species Assessment



Legend

- Cities
- Assessment Streams
- Streams
- Project Study Area
- Placer County

N

2.5 1.25 0 2.5 5 Miles

Jones & Stokes

- Unpublished data from the 2003 Placer County stream videography project;
- Descriptions of barriers to fish passage in Placer County 2002, DWR 2002 and Bailey 2003;
- Fish and habitat surveys conducted by CDFG, Dry Creek Conservancy, Bailey Environmental, Jones & Stokes and others, and summarized by Bailey (2003); and
- Relevant data in environmental planning documents, including the City of Roseville Regional Wastewater Treatment Service Area Master Plan DEIR (1996), Teichert Aggregate Facility FEIR 1999, City of Lincoln Wastewater Treatment and Reclamation DEIR (1999), Auburn Wastewater Facility Plan FEIR (City of Auburn 1997), the City of Auburn Wastewater Treatment and Disposal Master Plan DEIR (1992), and the Draft Biological Assessment/Essential Fish Habitat Assessment for the Antelope Creek Bicycle and Pedestrian Trail (Jones & Stokes 2004).

Chapter 3

Antelope Creek

Antelope Creek is a short, perennial creek approximately 9.5 miles long that flows southwest to its confluence with Dry Creek (Figure 4). Antelope Creek drains the northwest section of the Dry Creek watershed, a primarily urban and suburban area. Local winter rainfall and urban runoff is the primary source of flow in this creek. Flow data are not available for Antelope Creek.

Antelope Creek provides minimal habitat for Chinook salmon and steelhead. Juvenile rearing habitat may be supported, but warm summer water temperature limits habitat availability (ECORP 2003). Juvenile Chinook salmon and steelhead may temporarily rear in Antelope Creek during migration out to the ocean (Jones & Stokes 2000). Dry Creek is a migration pathway to and from Antelope Creek. The conditions described above for Dry Creek must also be considered for adult and juvenile Chinook salmon in Antelope Creek relative to success of upstream and downstream migration.

Migration Habitat Quality

Migration habitat quality along Antelope Creek has been reduced by barriers to upstream passage of adult and juvenile Chinook salmon and steelhead in Antelope Creek. Potential barriers include man-made structures, shallow water due to low-flow conditions, and beaver dams (ECORP 2003, Bailey 2003, Jones & Stokes 2003). In particular, the asphalt-bottomed culvert under Sunset Blvd. in Rocklin probably is a barrier under low, and possibly moderate, flows, and a dam upstream of the railroad bridge in Rocklin has formed a large wetlands complex that also may be a barrier (Bailey 2003). Also, during the Western Placer stream videography project (Placer County, unpublished data), four beaver dams and two other channel obstructions were observed. Though these barriers are likely to be affecting salmonids in Antelope Creek, the effect on the creek's salmonid population cannot be quantified in the SAM model without additional information, in particular regarding water depth at these locations during migration.

Spawning Habitat Area

Antelope Creek had a mostly sandy bottom throughout 1.82 kilometers (1.13 miles) of the surveyed reach (Jones & Stokes 2004). The spawning gravel area is 20 square meters (213 square feet) (Table 11). Although only 25% of the potential spawning reaches in Antelope Creek were surveyed (Table 12), Antelope Creek has highly degraded salmonid habitat and is unlikely to support substantial spawning (ECORP 2003)

Fine Sediment

The amount of fines measured during the spawning gravel surveys was approximately 77% for Antelope Creek (Table 13) (Jones & Stokes 2004). Based on the survival relationship discussed previously (Table 5), eggs and larvae would not be expected to survive.

Scour

The flow and geomorphic information currently available is insufficient to evaluate scour. Although the substantial urban area surrounding Antelope Creek likely indicates peak flows substantially higher than historic levels, scour is likely a minor issue considering that spawning habitat is minimal and that the level of fines would result in minimal survival of eggs and larvae.

Water Temperature

Appendix A summarizes the temperatures recorded in Antelope Creek. (See Antelope Creek figures in Appendix A). Bailey Environmental recorded water temperatures from May 30, 2003, to August 4, 2003, at three locations—311 Sunset (38.47.193N, 121.14.998W), Antelope Creek Drive (38.46.200N, 121.15.520W), and the Myers Residence (38.47.976N, 121.14.064W).

Based on the timeframe of the data recorded in Antelope Creek, water temperatures are within the suitable range but above ideal conditions for rearing steelhead and rearing and migrating juvenile Chinook salmon. Water-related mortality would be expected. Additional data is needed to determine the occurrence of unsuitable water temperatures later in the summer.

Aerial photographs were evaluated for the reach extending from approximately 610 meters (2,000 feet) downstream of Highway 65 and upstream approximately 5.1 kilometers (3.2 miles) (Figure 4). In the 3.2 miles evaluated, approximately 15% of the reach had low shade, 5% had no shade, 65% had moderate shade, and 15% had high shade (Table 10). Less shade occurred in the downstream reaches. The levels of shade indicate that temperature conditions may be warmed under

Table 10. Shade Provided by Riparian Vegetation on Western Placer County Streams as a Percentage of Reach Length[1]

			Percentage of Segment Area (%)			
Stream Segment	Length (miles)	Overall Shade[2]	High Shade[3]	Moderate Shade[3]	Low Shade[3]	No Shade[3]
Antelope Creek Segment 1	9.5	Moderate	51	13	7	30
Auburn Ravine Segment 1	4.2	Low	26	6	0	68
Auburn Ravine Segment 2	8.1	High	86	1	6	8
Auburn Ravine Segment 3	2.5	Moderate	58	4	9	29
Auburn Ravine Segment 4	8.3	High	90	5	2	3
Auburn Ravine Segment 5	4.1	Low	0	35	20	45
Bear River Segment 1	5.5	Low	36	4	0	58
Coon Creek Segment 1	8.3	Moderate	54	8	1	37
Coon Creek Segment 2	15.2	High	55	33	5	8
Doty Ravine Segment 1	4.2	Moderate	52	2	1	45
Doty Ravine Segment 2	2.9	High	82	1	3	14
Doty Ravine Segment 3	6.7	High	41	38	11	10
Dry Creek Segment 1	8.4	High	81	1	0	18
Miner's Ravine Segment 1	11.8	Moderate	61	14	12	14
Miner's Ravine Segment 2	3.3	Low	5	32	42	22
Secret Ravine Segment 1	10.2	Moderate	45	26	24	5

Notes:

[1] GIS analysis based on the corridor of land within 20 m of the stream centerline (i.e., 20 m on each side of the centerline).

[2] High overall shade corresponds to stream corridors with > 75% of stream corridor in land-cover providing high or moderate levels of shade; Moderate overall shade corresponds to stream corridors with 50-75% of their area in land-cover types providing moderate to high levels of shade; Low overall shade corresponds to stream corridors with < 50% of their area in land-cover types providing moderate to high levels of shade.

[3] Riparian forest was considered to provide high levels of shade, woodlands were considered to provide moderate levels of shade, other natural vegetation types with trees and shrubs were considered to provide low levels of shade, and herbaceous natural vegetation (e.g., grassland) and agricultural and developed land-cover were not considered to provide shade.

low and moderate shade conditions. The GIS analysis of stream corridor land cover indicated a moderate level of shade along Antelope Creek (Table 10, Figure 5).

Contaminants

Due to relatively high input of runoff from urban areas, contaminants probably affect the aquatic ecosystem of Antelope Creek. Antelope Creek receives treated effluent from one sewage disposal pond located north of the Highway 65 road crossing. Antelope Creek also receives urban runoff, and other inputs of contaminants from multiple sources, and these inputs have not been well documented; consequently, effects on juvenile and adult survival are unknown.

Benthic macroinvertebrate data collected along Antelope Creek by the Dry Creek Conservancy (unpublished data) suggest that contaminants have altered the creek's aquatic ecosystem. These data were collected at one site in 2000 and at four sites in 2001 (and were summarized in Bailey [2003]). In these samples, the benthic macroinvertebrate community was dominated by pollution-tolerant organisms.

Predation

Although only limited data are available on its fish community, species that have been observed in Antelope Creek include black bullhead, brown bullhead, carp and green sunfish (Bailey 2003). These species prey on juvenile Chinook salmon and steelhead. However, Chinook salmon and steelhead could benefit from cover that could minimize predation. (The moderate levels of shade [described under *Water Temperature*] indicate the existence of this cover is indicated by.)

Harassment

The levels of shade, especially in the downstream reaches, indicate that adult Chinook salmon and steelhead could be susceptible to harassment. Urban development and access to Antelope Creek, especially in spawning habitat and at partial barriers, translates to a relatively high potential for harassment and reduced fecundity.

Entrainment

Available data do not document the percentage of stream flows removed by diversions. However, there is a dam on Antelope Creek and three dams downstream on Dry Creek (Table 15) whose associated diversions may be active.

Chapter 4
Auburn Ravine

The headwaters of Auburn Ravine are located just north of the city of Auburn (Figure 4). Auburn Ravine upstream of Virginiatown is characterized by a high gradient with steep-sided banks. Large boulders and cobbles dominate the substrate. Habitat complexity includes scour pools, waterfalls, and high-velocity chutes. Riparian vegetation is abundant. Downstream of Virginiatown to the city of Lincoln, the stream's gradient decreases substantially, and the substrate is characterized by sand, gravel, and cobble. Pools and riffles are common, and trees and shrubs dominate the riparian zone. The channel contains large woody debris and bank erosion increases relative to the upper reach.

West of the city of Auburn, the gradient of Auburn Ravine averages of 2.5%, with the dominant substrate being bedrock, boulders, and cobble. The gradient in Auburn Ravine decreases to a less than 1% average upstream of the City of Lincoln. Within the city limits of Lincoln, Auburn Ravine changes to low gradient runs with sandy bottoms. The riparian vegetation is characterized by a more open tree canopy with an understory dominated by blackberries and shrubs. Channel banks consist of alluvial and clay soils and are typically vertical, 1.2–1.5 meters (4–5 feet) high. Downstream of Lincoln, primarily rice farms and livestock ranches border the stream. There, the stream is largely channelized. Stream channel substrate is mostly clay and fine sediments, with occasional pieces of large woody debris. Grazing and channel maintenance activities restrict the development of riparian vegetation. The lower 4 kilometers (2.5 miles) of Auburn Ravine was rerouted and leveed to flow into the East Side Canal. Some channelization and levee construction occurs along the lower 7.1 miles (Placer County 2002). The East Side Canal flows into the Cross Canal and the Cross Canal flows into the Sacramento River near Verona.

Winter flow in Auburn Ravine is dominated by runoff from rainfall events and water imported for domestic and agricultural diversion. Winter flows range from less than 3 cfs to an estimated 100-year flow event exceeding 14,000 cfs. Summer flows are high relative to natural conditions. Auburn Ravine conveys imported water diverted from the Yuba, Bear, and American Rivers. Imported water provides Auburn Ravine with spring and summer flows that range from 30 to 175 cfs (Nevada Irrigation District, daily flow in Auburn Ravine below Highway 65, 1976 through 1998). In September or October, flow is substantially decreased as irrigation demands diminish or cease. Flow during the fall may often be less than 3 cfs.

Auburn Ravine's artificially high flow in the summer months provides more and substantially different aquatic habitat than would exist under natural flow conditions. Reduced flow in September and October substantially reduces the area of aquatic habitat relative to habitat available in the summer.

Chinook salmon and steelhead spawn and rear in the upper reaches of Auburn Ravine. Population abundance and distribution data are currently unavailable.

Migration Habitat Quality

Along Auburn Ravine, the quality of migration habitat for salmonids has been substantially reduced by beaver dams, and by diversion dams and their associated water diversions.

Beaver dams have been observed at several locations on Auburn Ravine and may prevent passage of adult Chinook salmon and steelhead, especially during low-flow periods. For example, during the Western Placer County stream videography project in 2003 (Placer County, unpublished data), five beqaver dams were observed. Other blockages to passage included a large tree across Auburn Ravine near Turkey Creek. Woody material had collected behind the tree and appeared to create conditions that would block passage of adult Chinook salmon (Jones & Stokes 2003).

There are approximately nine small seasonal diversion dams in Auburn Ravine, most typically less than 3 meters (10 feet) high, that pond water for diversion (Placer County 2002). Upstream fish passage is not provided at any of the diversion dams. At some sites, flashboard dams are seasonally constructed. The installation and maintenance of seasonal dams in the spring and throughout the summer and fall impair migration of adult Chinook salmon and steelhead. Thus, these dams potentially block fish passage from April through November (State Water Resources Control Board records). In addition, the NID 1 Dam near Chili Hill Road is a year-round barrier to Chinook salmon and steelhead, except at very high stream flows approaching drown-out (Bailey 2003).

In addition to the effects of their associated dams, diversions may completely deplete downstream flow and effectively block upstream and downstream migration during the irrigation season from April through November.

Adult Chinook salmon migration is likely to be blocked in many years because diversion dams can remain in place and flow can be diverted through November, coinciding with most of the adult migration period (Table 2). Storm events may result in flow sufficient to provide upstream passage in October and November, but the amount of flow required to facilitate passage over diversion weirs that remain in place is currently unknown. All Chinook salmon passage to spawning habitat may be blocked by diversion dams and beaver dams in drier years.

Steelhead migration occurs during the winter months when diversions do not occur and the diversion weirs are removed (Table 2). Adult migration also

coincides with winter storm events that may provide passage conditions over beaver dams or other currently unknown obstructions. Except under extremely dry conditions, storm events likely ensure passage of adult steelhead from December through March.

In summary, along Auburn Ravine, the quality of migration habitat for Chinook salmon has been substantially reduced, and for steelhead migration habitat has been reduced (and substantially reduced upstream of NID's dam near Chili Hill Road.) However, full evaluation of migration habitat quality for the SAM will require additional information on barriers, including barriers located in the Cross Canal and Auburn Ravine, and flow conditions.

Spawning Habitat Area

The reach upstream from Memorial Park upstream is 3.04 kilometers (1.89 miles) long and supports a spawning habitat area of 5,151 square meters (55,424 square feet) (Table 11). The reach extending approximately 1.34 kilometers (0.83 miles) upstream from Turkey Creek golf course supports a spawning habitat area of 1,966 square meters (21,153 square feet). The Fowler Road reach is approximately 0.5 mile long and supports 1,176 meters (12,651 square feet) of spawning habitat.

The gravel area in these reaches is sufficient to support approximately 1,594 steelhead and 893 Chinook salmon redds. Redd numbers may be underestimated because spawning habitat was not surveyed throughout all potential spawning reaches that may be accessible to adult Chinook salmon and steelhead. Also, some spawning habitat did not meet the length and width criteria for the spawning gravel assessment, although Chinook salmon and steelhead could still use these smaller gravel patches for spawning.

Table 12 provides an estimate of the length of potential spawning reaches for Auburn Ravine. Approximately 39% of the length of spawning reaches were surveyed. Based on the ratio of the length of surveyed to potential spawning reaches, substantially more spawning habitat may be available.

Fine Sediment

The lower reaches of Auburn Ravine have predominantly sandy and fine sediment bottoms. Grazing, other land use practices and channel instability may have contributed to the level of fine sediment input into Auburn Ravine. However, the bedload of fine sediment under natural conditions is unknown, and may be considerable.

Spawning gravels in Auburn Ravine contain high levels of fine sediment. The amount of fines measured during the spawning gravel surveys ranged from 28% to 90% for Auburn Ravine (Table 13). Approximately 70% of the gravel surveyed was dominated by fines at levels exceeding 50%. Based on the survival relationship discussed previously (Table 5), eggs and larvae would not be expected to survive. The best survival that could be expected would be about 40%.

However, adult Chinook salmon and steelhead clean fine sediments from the gravel during spawning. As long as fine sediment did not reenter the redd, survival could be expected.

Scour

The flow and geomorphic information currently available is insufficient to evaluate scour.

Water Temperature

Water temperature has been recorded at several locations on Auburn Ravine, including Aitken Ranch (38.51.525N, 121.23.388W), Bitters Property (38.51.988N, 121.21.928W), Davis Bridge (38.51.168N, 121.30.392W), Fowler Road (38.53.576N, 121.13.294W), and Nelson Lane (38.52.630N, 121.20.630W) (data provided by Bailey Environmental).

Temperature is mostly within the suitable range for all life stages of Chinook salmon and steelhead during their periods of occurrence. However, water temperatures often exceed ideal levels from March through November, depending on the life stage, indicating that survival and fecundity would be affected. For adult migration and for spawning and incubation of Chinook salmon, ideal temperatures generally do not occur until early November. Unsuitable water temperatures may occur into October, indicating the potential for very low or no survival. Water temperatures are within the ideal range for the period of occurrence of juvenile rearing at Nelson Ranch, Aitkens Ranch, and Bitters Road.

Water temperature for adult steelhead migration is generally ideal through the winter, although some water temperature-related mortality could be expected during late March (see Auburn Ravine figures in Appendix A). Temperature-related mortality of eggs and larvae could be expected beginning in March, depending on location and complete mortality would be expected for any eggs incubating after mid-June. Temperature-related mortality of juveniles would be expected from approximately May through September, depending on the location of rearing habitat and occurrence of unknown temperature refugia associated with deep pools and cool groundwater accretion.

Aerial photographs were evaluated for the reach extending from approximately 3,658 meters (12,000 feet) downstream of Highway 65 and continued upstream for about 16 kilometers (10 miles) (Figure 4). Along this reach there were varied levels of shade. Downstream of Highway 65, the stream displays a moderate level of vegetative shade (Table 10). From Highway 65 to 1 mile upstream, a low level of shade is present. Shade is at a moderate level from 1 mile upstream of Highway 65 to about 914 meters (3,000 feet) upstream of Highway 93. Shade then continues at a high level until about 305 meters (1,000 feet) downstream of the Turkey Ranch Golf Course. The shade is low to moderate from Turkey Ranch Golf Course to Lake View Farms. The remaining upstream reaches evaluated have a moderate level of shade. Water temperature may be warmed under low and moderate shade conditions.

The GIS analysis of stream corridor vegetation also indicated varied levels of shade along Auburn Ravine. Low levels of shade were indicated in the downstream segment and in the vicinity of Auburn, with higher levels of shade in the intervening length of stream (Table 10, Figure 5).

Contaminants

Available data are insufficient to determine the extent to which contaminants are affecting salmonids; however, available information does suggest that contaminants are having an ecologically significant effect on the aquatic ecosystem of Auburn Ravine.

Auburn Ravine receives discharge from the City of Auburn's Wastewater Treatment Plant (WWTP) and the City of Lincoln's WWTP (Placer County 2002) . Prior to a plant upgrade, tests from the flows below the Auburn WWTP showed that lead and three banned chlorinated pesticides (DDT, endosulfan, and endrin) had the potential to exceed the water quality criteria, while free ammonia sometimes exceeded the criteria by less than 1% in low-flow conditions. Recent upgrades to the plant, however, have reduced or eliminated these effects.

Recent analysis showed that contaminant levels in Auburn Ravine did not exceed National Toxics Rules standards (City of Lincoln 1999). With the exception of mercury, contaminants were below levels expected to have either acute or chronic effects on aquatic organisms (U.S. Environmental Protection Agency 1986). Although Auburn Ravine water contained mercury at about 0.001 mg/L, exceeding the level identified as potentially having chronic effects (i.e., 0.000012 mg/L), the form of mercury was not identified. If mercury is in a form other than methylmercury, chronic affects may not occur. Acute effects would not be expected for existing levels of mercury in Auburn Ravine.

After expansion of the City of Lincoln's WWTP, discharge of treated effluent will be limited to periods when discharge is less than 5% of the flow in Auburn Ravine (Placer County 2002).

Urban runoff is a source of contaminant input to Auburn Ravine. Urban development in the area has the potential to increase runoff and contaminant input. Steps are being taken by both Lincoln and Auburn to reduce urban runoff into Auburn Ravine (Placer County 2002).

Rice farms result in substantial return flow to the reaches downstream of Highway 65. The return flows likely contain dissolved solids, nutrients, and pesticides and may be warmer than the ambient creek temperature. The reaches affected by agricultural return flows provide primarily adult and juvenile migration habitat, although some rearing could be expected during the winter and spring, especially by juvenile Chinook salmon. The pattern of return flows has not been documented, and effects on juvenile and adult survival are unknown.

Benthic macroinvertebrate data collected along Auburn Ravine by the Auburn Ravine Citizens Group (unpublished data) suggest that contaminants have altered the creek's aquatic ecosystem. These data were collected at two sites in 2000 and at one site in 2001 (and were summarized in Bailey [2003]). In these samples, the benthic macroinvertebrate community was dominated by pollution-tolerant organisms.

Predation

Fish captured in Auburn Ravine included Sacramento pikeminnow, redear sunfish, and green sunfish (City of Lincoln 1999, field observations by S. Theis and R. Bailey on March 31,1999). Other species that have been observed in Auburn Ravine include black bullhead, pumpkin seed, largemouth bass and bluegill (Bailey 2003). Pikeminnow and largemouth bass prey on small fishes, including juvenile Chinook salmon and steelhead. However, Chinook salmon and steelhead currently benefit from existing cover along Auburn Ravine (as indicated by the high levels of shade described under *Water Temperature*) that may minimize predation.

Harassment

Although relatively moderate to high levels of shade indicate relatively low susceptibility to harassment of adult Chinook salmon during spawning activities, urban development and access to Auburn Ravine is of concern. Under current and especially future conditions, harassment could be a substantial factor affecting spawning success in the reaches within and immediately upstream of the City of Lincoln.

Entrainment

Diversions from Auburn Ravine are primarily for agricultural uses. Diversions reduce streamflow and entrain fish into pumps and conveyance facilities. Most

diversions in Placer County are currently unscreened. Numerous agricultural diversions occur throughout Auburn Ravine that reduce flow and entrain juvenile Chinook salmon and steelhead (Table 14).

Nearly all irrigation water is diverted from Auburn Ravine, including diversions downstream of Highway 65 and in the Cross Canal, during the irrigation season. Although precise proportions of the juvenile Chinook salmon and steelhead populations affected cannot be calculated from the available data, fish attempting to migrate to the Sacramento River after April 1 are likely to be entrained and survival is expected to be very low. During wetter years, diversions may not occur until May or June and streamflow may remain higher during the spring. Consequently, entrainment-related mortality may be substantially lower in wetter years. Based on existing information, juvenile Chinook salmon and steelhead migrating downstream prior to April 1 are likely to avoid entrainment mortality. Documentation of year-round diversion and flow conditions, in addition to monitoring the movement of juvenile Chinook salmon and steelhead from Auburn Ravine, would facilitate calculation of expected entrainment and subsequent survival of annual juvenile production in Auburn Ravine.

Chapter 5
Bear River

Headwaters for the Bear River are in the vicinity of Emigrant Gap and Lake Spaulding in Nevada County. The Bear River generally flows southwesterly to a point approximately 8 miles north of Auburn, where it turns west and flows to its confluence with the Feather River in the vicinity of Nicolaus in Sutter County (Figure 4). The Bear River is the second largest tributary of the Feather River. Elevations within the Bear River basin range from about 38.1 meters (125 feet) mean sea level (msl) to over 1,738 meters (5,700 feet msl).

The Bear River historically experienced high winter flows and low summer flows, but today flow timing and volume is highly regulated by storage reservoir releases and diversions. Camp Far West is the largest storage reservoir on the Bear River. The exportation of water diverted from the Bear River watershed is made through the conveyance facilities of Nevada Irrigation District (NID) and PG&E. These diversions supply nearly all of the water imported to Coon Creek, Doty Ravine, and Auburn Ravine. The flow is diverted for irrigation, power generation, and domestic supply uses in the Auburn area. The upstream diversions from the Bear River basins have depleted the streamflow downstream of the Sutter Irrigation District Diversion Dam (SIDDD), located just downstream of Camp Far West Reservoir. Minimum flow releases are 25 cfs in the spring and 10 cfs during the rest of the year. Flows in the Bear River below SIDDD range between 0 and 40 cfs from June to December. Currently, winter flows during wet years are similar to unimpeded flows, averaging 2,500 to 5,200 cfs. Summer flows are currently 30–50% less than the unimpaired flows (NOAA Fisheries 2001).

SIDDD is the upstream limit of anadromous fish migration in the Bear River. Anadromous fish have access to 15 miles of the Bear River downstream to the Feather River. Habitat for Chinook salmon and steelhead is limited by inadequate streamflow and the high incidence of fine sediment, which is partially attributable to the relatively low gradient and reduced streamflow.

During heavy rain events, flow spills from Camp Far West Reservoir, and Chinook salmon and steelhead may migrate and spawn in the lower Bear River (NOAA Fisheries 2001).

Water temperatures were recorded at Upper Patterson and Lower Patterson in the Bear River between May 29, 2003, and August 3, 2003, by Bailey Environmental (see Bear River figures in Appendix A). Beginning in July, water temperatures in the lower reaches of the Bear River were above the suitable level for steelhead

rearing; the ideal level had already been exceeded in mid-June. In the upper reach, water temperatures exceeded the ideal range in late June but were within the suitable level for steelhead through July.

The aerial photographs of the upper 4 miles of the Bear River from Camp Far West Reservoir downstream indicate relatively poor riparian shade. About half of the reach has no shade and the remaining stream has moderate shade (Table 10). The low level of shade is characteristic of the lower reaches as well (Table 3, Figure 5). The poor shade conditions likely result in relatively quick warming of flow released from Camp Far West Reservoir.

Spawning gravel surveys were not conducted on the Bear River, but cursory surveys did not indicate the occurrence of spawning habitat. Substantial fine sediments were present, indicating unlikely spawning success. The Bear River also receives agricultural runoff that may adversely affect water quality through input of contaminants and additional warming of the streamflow.

Although Chinook salmon and steelhead may occur in the Bear River, the level of fecundity among adults and the survival of subsequent life stages are expected to be minimal, given the apparent absence of spawning habitat. Self-sustaining populations are likely absent in the Bear River.

Figure 5
Shade Conditions along Assessed Streams

Legend

- Segment endpoints
- High level of shade
- Moderate levels of shade
- Low levels of shade
- Streams
- Placer County boundary
- Project study area

Note: High levels of shade are streams with > 75% of their stream corridor (i.e., land within 20 m of channel's centerline) covered by vegetation providing high or moderate levels of shade (i.e., woodlands and riparian forest).

Moderate Level of Shade are stream corridors with 50-75% of their area covered by vegetation providing high or moderate levels of shade.

Low Levels of Shade are corridors with < 50% of their area in vegetation providing high or moderate levels of shade.

N

2.5 1.25 0 2.5 5 Miles

Jones & Stokes

H:/GIS/PROJECTS/PLACER_CO/00000_00/ARCMAP/SHADE_FIG_01.MXD (7-24-04)

Chapter 6
Coon Creek

Coon Creek originates near Auburn and flows westward (Figure 4). Coon Creek is intercepted by the East Side Canal downstream of Highway 65. The East Side Canal flows into the Cross Canal. The Cross Canal joins the Sacramento River immediately downstream of the confluence of the Feather and Sacramento Rivers near Verona. Coon Creek historically flowed into the American River basin, an historical wetland area that is now principally rice fields and urban neighborhoods.

In the lower reaches of Coon Creek, runs are the most dominant channel structure element, followed by low-gradient riffles, glides, dammed pools, midchannel pools, lateral scour pools, and channel confluence pools (Jones & Stokes 1996). Generally, the channel structure lacks complexity and variability. Minimal amounts of instream cover (i.e., woody debris and undercut banks) and overhead cover (i.e., riparian vegetation) are present. Streamside vegetation is sparse in many places in response to grazing by livestock. Channel instability and the resultant bank cutting may minimize the establishment of vegetation. Stream channel substrates consist predominantly of cobble, gravel, sand, and silt- and clay-sized particles.

Flow is an essential component of fish habitat. Low-flow conditions can result in lack of depth for adult fish passage, minimal flow over redds (e.g., increased siltation of redds and reduced levels of oxygen to the eggs), and reduced space for juvenile rearing.

The natural flow pattern for small foothill streams is a gradual decline in flow during the spring, summer, and early fall, until the first rainstorms begin in late fall. In Coon Creek, most of the streamflow present during the late spring through early fall is from water imported from the Bear, Yuba, and American Rivers (Placer County 2002). Coon Creek conveys imported flow to downstream agricultural diversions.

Coon Creek historically had little or no summer flow in the lower reaches. Coon Creek receives a daily discharge of around 2 cfs from the Placer County Sewer Maintenance District #1 (SMD-1) Waste Water Treatment Plant. NID discharges an additional 7.5 cfs during the summer and fall (i.e., about April 15 through October 15). Flow in Coon Creek is controlled by releases from Orr Creek Reservoir, operated by NID. The last downstream diversion receiving NID deliveries of water is near Gladding Road. Streamflow is managed to have no

excess flow at Highway 65 (i.e., essentially dry) (Placer County Planning Department 1999).

The current distribution and abundance of steelhead in Coon Creek is unknown; however, given the year-round occurrence of rainbow trout (i.e., resident form of steelhead) in the upper reaches, it would be reasonable to expect that steelhead could occur in some years. Information on the historical occurrence of Chinook salmon in Coon Creek is limited. DFG records from the early 1960s document the occurrence of spawning fall-run adults near the Garden Bar Road bridge (California Department of Fish and Game 1996). Adult fall-run Chinook salmon occasionally were observed in Coon Creek in the mid-1990s near Garden Bar Road (Placer County Planning Department 1999). Stream conditions in the downstream reaches of Coon Creek and the Cross Canal often become unfavorable for juvenile Chinook salmon after about mid-April when water temperature is too warm and streamflow is reduced by diversions.

Migration Habitat Quality

Migration habitat quality along Coon Creek has been reduced by barriers to upstream passage of adult and juvenile Chinook salmon and steelhead. These barriers include waterfalls and cascades, beaver dams, diversion dams and weirs (Bailey 2003; Jones & Stokes 2003; Placer County, unpublished data). From Highway 49 to McCourtney road, Coon Creek flows over several bedrock cascades that may be barriers to salmonid passage, particularly the small waterfall between Bell and Garden Bar roads. Within this segment of Coon Creek, there also is a NID Diversion Dam.

Further downstream, from McCourtney Road to the county line, there are a number of beaver and diversion dams (Placer County, unpublished data; Bailey 2003). Along this segment of Coon Creek there are at least four diversion dams. During the Western Placer County stream videography project (Placer County, unpublished data), five beaver dams were observed, and additional beaver dams may be present in the downstream reaches outside of Placer County.

In addition to migration barriers in Coon Creek, diversion dams and weirs located in the Cross Canal may also block upstream passage. Although not explicitly assessed, migration habitat quality within the Cross Canal is critical to the occurrence of adult Chinook salmon and steelhead in Coon Creek.

Adult Chinook salmon migration is likely to be blocked in many years because diversion dams can remain in place and divert flow through November, coinciding with most of the adult migration period (Table 2). Storm events may result in flow sufficient to provide upstream passage in October and November, but the amount of flow required to facilitate passage over diversion weirs that remain in place is currently unknown. All Chinook salmon passage to spawning habitat may be blocked by diversion dams and beaver dams in drier years.

Steelhead migration occurs during the winter months when diversions do not occur and the diversion weirs are removed (Table 2). Adult migration also coincides with winter storm events that may provide passage conditions over beaver dams or other currently unknown obstructions. Except under extremely dry conditions, storm events probably ensure passage of adult steelhead from December through March.

In summary, barriers probably are substantially affecting migration of Chinook salmon in Coon Creek but having a much lesser effect on steelhead. However, a full evaluation of migration habitat quality for the SAM will require additional information on barriers (e.g., water depths during migration), including barriers located in the Cross Canal and Coon Creek, and flow conditions.

Spawning Habitat Area

Gravel in most stream reaches was angular and not round. The reach surveyed in Coon Creek was approximately 0.85 mile long. One potential spawning site was identified, with a length of 22 meters (71 feet) and a width of 1.8 meters (6 feet). Total area was 39.6 square meters (426 square feet) (Table 11).

Table 11. Total Spawning Habitat Area by Stream Reach Surveyed, and the Potential Number of Redds Supported in Each Reach

Stream Reach	Spawning Habitat Area in Square Meters (Square Feet)	Number of Potential Redds	
		Steelhead	Chinook Salmon
Secret Ravine	109 (1,176)	21	12
Antelope Creek	20 (213)	4	2
Miners Ravine (Preserve)	48 (515)	9	5
Miners Ravine (Main)	10 (108)	2	1
Doty Ravine (Garden Bar)	77 (833)	15	8
Doty Ravine (Crosby)	200 (2,148)	38	22
Coon Creek	40 (426)	8	4
Auburn Ravine (Memorial)	5,151 (55,424)	990	554
Auburn Ravine (Turkey Creek)	1,966 (21,153)	378	212
Auburn Ravine (Fowler)	1,176 (12,651)	226	127
Totals	**8,796 (94,647)**	**1,691**	**947**

The gravel area is sufficient to support approximately eight steelhead and four Chinook salmon redds. Redd numbers may be underestimated because spawning habitat was not surveyed throughout all potential spawning reaches that may be accessible to adult Chinook salmon and steelhead. Also, some spawning habitat did not meet the length and width criteria for the spawning gravel assessment,

although Chinook salmon and steelhead could still use these smaller gravel patches for spawning.

Table 12 provides an estimate of the length of potential spawning reaches for Coon Creek. Approximately 12% of the length of spawning reaches was surveyed. Based on the ratio of the length of surveyed to potential spawning reaches, substantially more spawning habitat may be available.

Table 12. Comparison of Surveyed Reaches to Potential Spawning Reaches

Stream Name (Reach Name)	Actual Surveyed Reaches in Kilometers (Miles)	Potential Spawning Reaches in Kilometers (Miles)	Potential Spawning Habitat Surveyed (%)
Secret Ravine	1.5 (0.94)	15.35 (9.54)	9.8[a]
Antelope Creek	1.82 (1.13)	7.32 (4.55)	25[a]
Miners Ravine (preserve property)	0.8 (0.5)	8.00 (5.00)	60[a]
Miners Ravine (main)	4.0 (2.5)	–	–
Doty Ravine (Garden Bar Rd.)	0.8 (0.5)	9.66 (6.00)	16[a]
Doty Ravine (Crosby Harold Rd.)	1.5 (0.93)	–	–
Coon Creek	1.4 (0.85)	11.00 (6.81)	12[a]
Auburn Ravine (Memorial Park)	3.04 (1.89)	13.41 (8.33)	39[a]
Auburn Ravine (Turkey Creek)	1.34 (0.83)	–	–
Auburn Ravine (Fowler Rd.)	0.8 (0.5)	–	–

[a] If more than one reach was surveyed for a stream, the surveyed lengths were added and then divided by the length of the potential spawning reach to calculate the percentage of potential spawning habitat surveyed.

Fine Sediment

Grazing, land use practices, channel instability, and channelization have affected the level of fine sediment input into the streams within Placer County. The bedload of fine sediment under natural conditions, however, is unknown and may be considerable.

The lower reaches of Coon Creek have predominantly sandy bottoms with fines and gravels as a secondary but common component. Cattle grazing and agricultural activities, as well as channel geology and morphology, have led to the abundance of fine and sand sediments.

At the only site along Coon Creek where sediment composition was measured during the spawning gravel surveys, fines accounted for 56% of the sediment (Table 13). Based on the survival relationship discussed previously (Table 5),

Table 13. Percentage of Substrate in Each Particle Size Category for Each Gravel Site

Creek	Site Number	Category 1 (<2mm) [<0.08 in]	Category 2 (2–5mm) [0.08–0.2 in]	Category 3 (5–25mm) 0.2–1 in]	Category 4 (25–102mm) [1–4 in]	Category 5 (102–152mm) [4–6i n]
Secret Ravine	03-SECR-GRAV-001	52%	30%	13%	4%	0%
	03-SECR-GRAV-002	26%	25%	13%	30%	6%
	03-SECR-GRAV-003	47%	21%	15%	17%	0%
	03-SECR-GRAV-004	56%	22%	9%	14%	0%
Antelope Creek	03-ANTE-GRAV-001	49%	28%	14%	3%	5%
Miner's Ravine (Preserve)	03-MRNP-GRAV-001	42%	27%	27%	4%	0%
	03-MRNP-GRAV-002	48%	27%	22%	3%	0%
Miner's Ravine (Main)	03-MINEM-GRAV-001	32%	18%	34%	16%	0%
Doty Ravine (Garden)	03-DOTY-GRAV-001	38%	20%	31%	11%	0%
	03-DOTY-GRAV-002	36%	29%	34%	1%	0%
	03-DOTY-GRAV-003	20%	33%	45%	3%	0%
Coon Creek	03-COON-GRAV-001	24%	32%	37%	7%	0%
Doty Ravine (Crosby)	03-DOTC-GRAV-001	40%	24%	16%	20%	0%
	03-DOTC-GRAV-002	44%	31%	25%	0%	0%
Auburn Ravine (Memorial)	03-AUB1-GRAV-001	61%	19%	18%	2%	0%
	03-AUB1-GRAV-002	59%	13%	17%	10%	0%
	03-AUB1-GRAV-003	39%	40%	17%	3%	0%
	03-AUB1-GRAV-004	32%	15%	24%	29%	0%
	03-AUB1-GRAV-005	47%	25%	22%	6%	0%
	03-AUB1-GRAV-006	35%	28%	29%	8%	0%
	03-AUB1-GRAV-007	33%	25%	27%	14%	0%
	03-AUB1-GRAV-008	33%	22%	32%	13%	0%
	03-AUB1-GRAV-009	34%	15%	22%	29%	0%
	03-AUB1-GRAV-010	31%	21%	30%	17%	0%
	03-AUB1-GRAV-011	48%	28%	11%	12%	0%
	03-AUB1-GRAV-012	30%	24%	18%	29%	0%
	03-AUB1-GRAV-013	56%	19%	16%	9%	0%
	03-AUB1-GRAV-014	47%	19%	19%	15%	0%
	03-AUB1-GRAV-015	24%	22%	31%	23%	0%
	03-AUB1-GRAV-016	12%	33%	40%	14%	0%
	03-AUB1-GRAV-017	66%	24%	7%	3%	0%
	03-AUB1-GRAV-018	9%	22%	40%	29%	0%
	03-AUB1-GRAV-019	2%	26%	58%	14%	0%
	03-AUB1-GRAV-020	18%	40%	25%	17%	0%
	03-AUB1-GRAV-021	8%	30%	43%	19%	0%

Table 13. Continued

Creek	Site Number	Category 1 (<2mm) [<0.08 in]	Category 2 (2–5mm) [0.08–0.2 in]	Category 3 (5–25mm) 0.2–1 in]	Category 4 (25–102mm) [1–4 in]	Category 5 (102–152mm) [4–6i n]
	03-AUB1-GRAV-022	8%	45%	27%	20%	0%
	03-AUB1-GRAV-023	19%	45%	16%	20%	0%
Auburn Ravine (Turkey Cr.)	03-AUBT-GRAV-001	2%	40%	40%	18%	0%
	03-AUBT-GRAV-002	4%	77%	15%	4%	0%
	03-AUBT-GRAV-003	7%	40%	35%	18%	0%
	03-AUBT-GRAV-004	36%	38%	23%	3%	0%
	03-AUBT-GRAV-005	43%	29%	12%	16%	0%
	03-AUBT-GRAV-006	17%	40%	24%	18%	0%
	03-AUBT-GRAV-007	21%	47%	20%	12%	0%
	03-AUBT-GRAV-008	5%	36%	42%	17%	0%
	03-AUBT-GRAV-009	32%	30%	26%	11%	1%
Auburn Ravine (Fowler Rd.)	03-AUBF-GRAV-001	6%	40%	38%	17%	0%
	03-AUBF-GRAV-002	7%	30%	34%	30%	0%
	03-AUBF-GRAV-003	8%	55%	19%	16%	2%
	03-AUBF-GRAV-004	3%	50%	23%	23%	0%

eggs and larvae would not be expected to survive. However, adult Chinook salmon and steelhead clean fine sediments from the gravel during spawning. As long as fine sediment did not reenter the redd, survival could be expected.

Scour

The flow and geomorphic information currently available is insufficient to evaluate scour.

Water Temperature

Water temperatures in Coon Creek were recorded at three sites (Coon Creek Trap Club [38.56.262N, 121.25.124W], Nicolaus Road [38.54.446N, 121.30.361W], and the Tahti Residence [38.58.181N, 121.17.458W]) between September 14, 2001, and August 4, 2003, (data provided by Bailey Environmental).

Data collected in Coon Creek indicates that water temperature is often warmer than the suitable and ideal range for Chinook salmon and steelhead (see Coon Creek figures in Appendix A). For adult migration of Chinook salmon, temperatures are warmer than ideal through early November, indicating that some adult or prespawn egg mortality may occur. Similarly, egg mortality within the redds would be expected for all spawning that occurred prior to mid-November and total mortality may occur through October depending on the occupied spawning habitat location. Juvenile survival would be minimally affected by water temperature through March or April. Some temperature-related mortality of juveniles would be expected in April through June.

Water temperature for adult steelhead migration is generally ideal through the winter, although some water temperature-related mortality could be expected during late March (see Coon Creek figures in Appendix A). Temperature-related mortality of eggs and larvae could be expected beginning in March, depending on location, and complete mortality would be expected for any eggs incubating after mid-June. Temperature-related mortality of juveniles would be expected from approximately May through September, depending on the location of rearing habitat and occurrence of unknown temperature refugia associated with deep pools and cool groundwater accretion.

Aerial photographs were evaluated for the reach extending from Gladding Road upstream to about 914 meters (3,000 feet) above Garden Bar Road (Figure 4). Between Gladding Road and McCourtney Road, the shade is low to moderate (Table 10). From McCourtney Road upstream approximately 2 miles, the shade level is low to moderate. The shade level is moderate for the upper reaches of the site. Water temperature may be warmed under low and moderate shade conditions. The GIS analysis of land cover indicated moderate to high levels of shade along Coon Creek, with the higher levels in the upper segment (Table 10, Figure 5).

Contaminants

Available data are insufficient to determine the extent to which contaminants are affecting salmonids; however, available information does suggest that contaminants are having an ecologically significant effect on the aquatic ecosystem of Coon Creek.

SMD-1 wastewater treatment and disposal facilities are located on the northern end of Auburn. Discharge and surface drainage from the wastewater treatment plant is to Rock Creek, a tributary of Dry Creek. Discharge from the plant to Rock Creek is estimated to average 1.5 million mgd during summer months and 5–8 mgd during winter months. The higher discharge during winter months is the result of leaky sewers (Placer County Planning Department 1999). NID has a diversion downstream of the discharge that diverts flows into the Camp Far West canal, where they are commingled with NID water and eventually discharged to Coon Creek (Placer County Planning Department 1999). Based on data for existing fish communities in Coon Creek, the treated effluent does not have any apparent effect on fish survival.

Rice farms contribute to substantial return flows to Coon Creek downstream of Highway 65. The return flows likely contain dissolved solids, nutrients, and pesticides and may be warmer than the ambient creek temperature. The reaches affected by agricultural return flows provide primarily adult and juvenile migration habitat, although some rearing could be expected during the winter and spring, especially by juvenile Chinook salmon. The pattern of return flows has not been documented and effects on juvenile and adult survival are unknown.

The very limited data that are available regarding the benthic macroinvertebrate community of Coon Creek are consistent with contaminants having adversely affected the creek's aquatic ecosystem. Data were collected by the Auburn Ravine Citizens Group (Auburn Ravine Citizens Group, unpublished data) during 2000 at one site. (These data were summarized in Bailey [2003]). In this sample, the benthic macroinvertebrate community was dominated by pollution-tolerant organisms.

Predation

Fish captured in Coon Creek in 1994 and 1995 included Sacramento pike minnow, bullhead, channel catfish, and green sunfish (Jones & Stokes 1996). Other species along Coon Creek include white catfish and bluegill (Bailey 2003). These species prey on juvenile Chinook salmon and steelhead. However, Chinook salmon and steelhead could benefit from cover along Coon Creek that would minimize predation. (The existence of this cover is indicated by the high levels of shade described under *Water Temperature*)

Harassment

Although low levels of shade indicate potential susceptibility to harassment of adult Chinook salmon during spawning activities, urban development and access to Coon Creek is limited. Under current conditions, harassment is likely a minor factor affecting spawning success of adult Chinook salmon and steelhead on Coon Creek.

Entrainment

Diversions from Coon Creek are primarily for agricultural uses. Diversions reduce streamflow and entrain fish into pumps and conveyance facilities. Most diversions in Placer County are currently unscreened.

According to State Water Resources Control Board (SWRCB) files, eight water diversions are permitted along Coon Creek in Placer County, between Placer Road and Gladding Road. In Sutter County, from Placer Road downstream to the Sacramento River, 41 more permits to divert water have been granted, most for diversions along the Cross Canal and East Side Canal. The timing, magnitude, and methods of permitted diversions vary. In general, diversions along Coon Creek, the East Side Canal, and the Cross Canal are permitted from as early as April 1 through and November 30. Diversion rates vary from 0.34 cfs to 168 cfs, but most diversions are less than 5 cfs (California State Water Resources Control Board records). Although most of this water is diverted using pumps, at least 3 diversions on Coon Creek use a combination of pumps and flashboard or sack dams. The permitted diversion season for the three diversions that use temporary dams are May 1–November 1, April 1–October 1, and April 1–November 30. The period of April 1–November 30 applies to a flashboard dam on private property that is not equipped with a fish passageway such as a fish ladder.

Nearly all irrigation water is diverted from Coon Creek just downstream of Highway 65 during the irrigation season (i.e., April 1 through October). Downstream flows accrete from groundwater and agricultural return flow (Placer County 2002). Although precise proportions of the juvenile Chinook salmon and steelhead populations affected cannot be calculated from the available data, fish attempting to migrate to the Sacramento River after April 1 are likely to be entrained, and survival is expected to be very low. During wetter years, diversions may not occur until May or June and streamflow may remain higher during the spring. Consequently, entrainment-related mortality may be substantially lower in wetter years. Based on existing information, juvenile Chinook salmon and steelhead migrating downstream prior to April 1 are likely to avoid entrainment mortality. Documentation of year-round diversion and flow conditions, in addition to monitoring the movement of juvenile Chinook salmon and steelhead from Coon Creek would facilitate calculation of expected entrainment and subsequent survival of annual juvenile production in Coon Creek.

Chapter 7

Doty Ravine

Doty Ravine originates west of Auburn and flows into Coon Creek (Figure 4). The streambed in the headwaters consists primarily of gravel and cobbles with some larger granitic boulders. Doty Ravine upstream of Gladding Road flows through oak woodland and is bordered by rural residential and ranch lands. Downstream of Gladding Road, the bordering lands experience increased livestock use, and the ravine is considered highly disturbed (Placer County 2002).

Doty Ravine receives water from deliveries by NID as well as natural runoff. Import of NID deliveries and conveyance down Doty Ravine is generally completed by October. Winter flows can exceed several thousand cfs, but during the irrigation season the flows generally average under 20 cfs and are usually substantially less (Placer County 2002). All irrigation water is diverted at the Doty South Diversion Dam (DSDD) west of Crosby Harold Road. Downstream of the DSDD, flow in the stream accretes from leakage at the DSDD, groundwater, and agricultural runoff. During the nonirrigation season, the flows are around 5–6 cfs.

DFG stream surveys in 1964 estimated that Doty Ravine may be capable of supporting approximately 400 Chinook salmon redds in the reach beginning at the confluence with Coon Creek and upstream to Gold Hill Road (California Department of Fish and Game file information). However, the estimates appear to be based on professional judgment and not on measured habitat.

The current distribution and abundance of steelhead in Doty Ravine is unknown. As indicated for Coon Creek, stream conditions in downstream reaches, including the migration pathway along Coon Creek and the Cross Canal, often become unfavorable for juvenile Chinook salmon after about mid-April when water temperature is too warm and streamflow is reduced by diversions.

Migration Habitat Quality

The quality of migration habitat along Doty Ravine has been reduced by barriers to upstream passage of adult and juvenile Chinook salmon and steelhead. Just west of Crosby Harold Road, NID's Doty Ravine South Diversion Dam and the associated diversion reduce flow and probably block fish passage, especially under lower flows (Placer County 2002; Bailey 2003). A second barrier is the

culvert under Garden Bar Road that blocks salmonid passage under most flows (Bailey 2003).

In addition to these man-made structures, beaver dams are common on Doty Ravine and also may interfere with fish passage. For example, Doty Ravine at Crosby Harold Road had a beaver dam at the beginning of the reach and another a quarter mile above the starting point of the spawning gravel survey (Jones & Stokes 2003). During the Western Placer County stream videography project in 2003 (Placer County, unpublished data), five other beaver dams were observed along Doty Ravine. Beaver dams, although not observed, may also be present in the downstream reaches.

In addition to these migration barriers in Doty Ravine, diversion dams and weirs located in the Cross Canal may also block upstream passage. Although not explicitly assessed, migration habitat quality within the Cross Canal is critical to the occurrence of adult Chinook salmon and steelhead in Doty Ravine.

Adult Chinook salmon migration is likely to be blocked in many years because diversion dams can remain in place and flow diverted through November, coinciding with most of the adult migration period (Table 2). Storm events may result in flow sufficient to provide upstream passage in October and November, but the amount of flow required to facilitate passage over diversion weirs that remain in place is currently unknown. All Chinook salmon passage to spawning habitat may be blocked by diversion dams and beaver dams in drier years.

Steelhead migration occurs during the winter months when diversions do not occur and the diversion weirs are removed (Table 2). Adult migration also coincides with winter storm events that may provide passage conditions over beaver dams, thorough the culvert at or other currently unknown obstructions. Except under extremely dry conditions, storm events probably allow passage of adult steelhead from December through March. However, passage through the culvert at the Garden Bar Road crossing may still be problematic if stormflows are not sufficient to create backwater conditions at the crossing (Bailey 2003).

In summary, Chinook salmon habitat quality along Doty Ravine has been substantially reduced and for steelhead migration quality may be reduced. However, full evaluation of migration habitat quality for the SAM will require additional information on barriers (e.g., water depths during migration), including barriers located in the Cross Canal and Coon Creek.

Spawning Habitat Area

The reach surveyed in Doty Ravine near Garden Bar Road was approximately 0.8 kilometer (0.5 mile) long. Gravel was relatively square and flat. Three potential spawning sites were identified, and the total area was 77 square meters (833 square feet) (Table 11). A second reach near Crosby Harold Road was approximately 1.5 kilometers (0.93 mile) in length. The two potential spawning sites in the second reach provide 200 square meters (2,148 square feet) in total.

The gravel area is sufficient to support approximately 53 steelhead and 30 Chinook salmon redds (Table 11). Redd numbers may be underestimated because spawning habitat was not surveyed throughout all potential spawning reaches that may be accessible to adult Chinook salmon and steelhead. Also, some spawning habitat did not meet the length and width criteria for the spawning gravel assessment, although Chinook salmon and steelhead could still use these smaller gravel patches for spawning. An estimate of the length of potential spawning reaches for Doty Ravine is provided in Table 12. Approximately 16% of the spawning reaches were surveyed. Based on the ratio of surveyed to potential spawning reaches, substantially more spawning habitat may be available.

Fine Sediment

Grazing, land use practices, channel instability, and channelization have affected the level of fine sediment input into the streams within Placer County. The bedload of fine sediment under natural conditions is unknown, however, and may be considerable.

The upper 2 miles of Doty Ravine have a moderate to high gradient (average 3.2%). Most of the substrate consists of bedrock, boulder, cobble, and gravel. The lower 10 miles of Doty Ravine have less than 1% gradient. As the stream travels downstream, it widens, with smaller material dominating the riffles. It also has increased levels of bank erosion. The lower reaches of Doty Ravine have predominantly sandy bottoms with fines and gravels as a secondary but common component. Banks are relatively noncohesive when vegetative cover is absent. Cattle grazing and agricultural activities, road infrastructure, and channel geology and morphology have led to the abundance of fine and sand sediments (Placer County 2002).

The amount of fines measured during the spawning gravel surveys was between 53% and 75% for Doty Ravine (Table 13). Based on the survival relationship discussed previously (Table 5), eggs and larvae would not be expected to survive. However, adult Chinook salmon and steelhead clean fine sediments from the gravel during spawning. As long as fine sediment did not reenter the redd, survival could be expected. The mobility of fines into clean gravels has not been observed for redds in any western Placer County streams, therefore expectations of spawning success should err on the conservative side.

Scour

The flow and geomorphic information currently available is insufficient to evaluate scour.

Water Temperature

Water temperature data was not available for Doty Ravine. However, water temperature would likely be similar to water temperatures described for Coon Creek. Water temperatures for all life stages are expected to be warmer than the suitable and ideal range for Chinook salmon and steelhead from April through October.

Aerial photographs were evaluated for the reach extending from about 610 meters (2,000 feet) downstream of Gladding Road to about 1 mile upstream of Wise Road (Figure 4). From Gladding Road to McCourtney Road, the vegetative shade increases to a moderate level, and upstream of McCourtney Road the vegetative shade increases to a high level (Table 10). The relatively high levels of shade in this reach indicate that temperature may not be substantially warmed in response to shade conditions. The GIS analysis of stream corridor vegetation indicated moderate to high levels of shade along the entire length of Doty Ravine (Table 10, Figure 5).

Contaminants

Interpretable information on contaminants was not available for Doty Ravine. Doty Ravine receives both agricultural and urban runoff, however. The pattern of input has not been documented and effects on juvenile and adult survival are unknown.

The limited data available on the benthic macroinvertebrate community of Doty Ravine are consistent with contaminants having adversely affected the aquatic ecosystem of Doty Ravine. Data were collected by the Dry Creek Conservancy (Dry Creek Conservancy, unpublished data) during 2000-2002, at one site. (These data were summarized in Bailey [2003]). In these samples, the benthic macroinvertebrate community was dominated by pollution-tolerant organisms.

Predation

Though little information exists regarding its fish community, Doty Ravine likely supports a fish community similar to that described for Coon Creek, which includes species that prey upon juvenile salmonids. However, Chinook salmon and steelhead currently benefit from substantial cover along Doty Ravine (as indicated by the high levels of shade described under *Water Temperature*) that would minimize predation.

Harassment

Relatively moderate and high levels of shade indicate the potential for minimal harassment of adult Chinook salmon and steelhead during spawning activities. Urban development and access to Doty Ravine is limited. Under current conditions, harassment is likely a minor factor affecting spawning success of adult Chinook salmon and steelhead on Doty Ravine.

Entrainment

Diversions from Doty Ravine are primarily for agricultural uses. Diversions reduce streamflow and entrain fish into pumps and conveyance facilities. Most diversions in Placer County are currently unscreened. The DSDD diverts nearly all of the flow from Doty Ravine during the irrigation season. As described for Coon Creek, substantial diversions also occur from Coon Creek and the Cross Canal. Nearly all irrigation water is diverted from Doty Ravine and Coon Creek. Although precise proportions of the juvenile Chinook salmon and steelhead populations affected cannot be calculated from the available data, juvenile steelhead and Chinook salmon attempting to migrate to the Sacramento River after April 1 are likely to be entrained, and survival is expected to be very low. During wetter years, diversions may not occur until May or June, and streamflow may remain higher during the spring. Consequently, entrainment-related mortality may be substantially lower in wetter years.

Based on existing information, most juvenile Chinook salmon and steelhead migrating downstream prior to April 1 are likely to avoid entrainment mortality. Documentation of year-round diversion and flow conditions, in addition to monitoring the movement of juvenile Chinook salmon and steelhead from Doty Ravine, would facilitate calculation of expected entrainment and subsequent survival of annual juvenile production.

Chapter 8

Dry Creek

Dry Creek is approximately 17.6 miles long, extending from the confluence with Steelhead Creek (historically known as the Natomas East Main Drainage Canal) upstream to the mouth of Antelope Creek (Figure 4). The primary tributaries to Dry Creek include Miners Ravine, Secret Ravine, and Antelope Creek. The Dry Creek gradient is low (i.e., generally less than 1%). The channel is well defined with sandy bottoms and bordering riparian vegetation.

The average flow in Dry Creek in 1997, a wet year, was 1,350 cfs (measured at Vernon Street). The 1997 minimum flow approached 130 cfs and the maximum flow was approximately 15,000 cfs. Most of the flow is from precipitation, with summer flow composed of urban runoff, releases from the City of Roseville's Wastewater Treatment Plant (WWTP), and groundwater accretion. The WWTP drains into Linda Creek and ultimately Dry Creek. Spring flow in 2000 and 2001 averaged approximately 95 cfs, summer flow averaged 78 cfs, fall flow averaged 34 cfs, and winter flow averaged 195 cfs. (ECORP 2003).

California Department of Fish and Game (DFG) conducted periodic Chinook salmon spawning escapement surveys in the Dry Creek watershed, mostly upstream of the confluences with Miners and Secret Ravines . In 1964, the estimated Chinook salmon population was over 1,000 fish, with most found in Secret and Miners Ravines. Current estimates of steelhead in the Dry Creek watershed number a few hundred fish, with most occurring in Secret and Miners ravines .(ECORP 2003).

Migration Habitat Quality

Dry Creek is primarily a migration pathway for adult steelhead and Chinook salmon migrating to spawning habitat in Miners and Secret Ravines and juvenile steelhead and Chinook salmon migrating downstream to the ocean. Low-flow migration barriers are created by sewer and water line crossings. Concrete encased pipelines are known to temporarily stop upstream migration during low-flow conditions. Improvements are being made at the Dry Creek sewer line near the confluence with Cirby Creek to improve passage conditions (ECORP 2003). Some fish have been observed to pass beyond the barrier under low-flow conditions, but the majority congregate in the area below the barrier. Storm flows improve passage conditions.

Beaver dams, seasonal flashboard dams, concrete dams, and natural waterfalls also hinder fish passage in Dry Creek. Two other partial barriers identified in the Dry Creek Coordinated Resources Management Plan (ECORP 2003) include Hayer Dam and a rubble dam just downstream of Watt Avenue. Barriers also occur in Steelhead Creek in Sacramento County that block the access of adult steelhead and Chinook salmon to Dry Creek and its tributaries.

In summary, the quality of migration habitat for both Chinook salmon and steelhead along Dry Creek has been reduced by barriers. However, full evaluation of migration habitat quality for the SAM will require additional information on barriers (e.g., water depths during migration), including barriers located in Steelhead Creek in Sacramento County.

Spawning Habitat Area

Dry Creek substrates are generally composed of a high percentage of fine sediment and spawning habitat appears to be minimal (ECORP 2003). Dry Creek was not included in the spawning gravel surveys (Jones & Stokes 2004). Chinook salmon and steelhead spawn primarily in its tributaries (ECORP 2003).

Water Temperature

Water temperatures recorded above and below the effluent outfall for the Roseville WWTP have shown that from June through September the water temperature exceeds the water quality standards established for the effluent. Temperature cools downstream of the effluent discharge. In October through December, water temperatures warm downstream of the outfall and exceed the required water quality standards. (ECORP 2003.)

Appendix A summarizes water temperature recorded in Dry Creek (see Dry Creek figures in Appendix A). Water temperatures were recorded at two sites, below Riverside Drive and above the confluence with Cirby Creek, between June 16, 2001, and June 16, 2002, by Bailey Environmental.

Dry Creek is primarily important as a migration pathway, and water temperature is of concern during adult and juvenile migration. Water temperature ranges from ideal to suitable for migrating adult Chinook salmon and steelhead, although unsuitable conditions may occur at times for Chinook salmon during the summer and early fall. Water temperatures are unsuitable for juvenile steelhead rearing during the late summer, indicating that Dry Creek is not likely to provide rearing habitat for juvenile steelhead. Water temperatures are generally suitable for rearing and migrating juvenile Chinook salmon, but the ideal levels are exceeded in early April and some temperature-related mortality would be expected.

The GIS analysis of stream corridor vegetation indicated a high level of shade along Dry Creek (Table 10, Figure 5). The high level of shade minimizes warming from solar radiation.

Contaminants

Available data are insufficient to determine the extent to which contaminants are affecting salmonids; however, available information does suggest that contaminants are having an ecologically significant effect on the aquatic ecosystem of Dry Creek.

Dry Creek receives effluent from the Roseville WWTP and Dry Creek WWTP. Maximum discharge capacity is 18 million gallons per day (mgd) but is typically under 15 mgd. The volume is a relatively small proportion of Dry Creek flow during winter flow conditions, but during low-flow periods, the treated effluent can make up as much as 50% of the streamflow (ECORP 2003). Because this area is being rapidly developed, there is an anticipated increase over time of effluent discharge released to the stream. Dry Creek also receives inflow from a sewage disposal pond near Rio Linda Central Park and a sewage disposal area near Midtown Park. It also receives substantial urban runoff.

There is evidence that the Roseville WWTP affects Dry Creek's water quality. Dry Creek above Roseville WWTP has slightly elevated conductivities ranging between 141 and 221 micromhos/centimeter, probably due to natural chemical weathering of minerals from the surrounding soil and rock. However, the conductivity almost doubles downstream of the WWTP, an inevitable result of current sewage treatment technologies. Excessive nutrient loads are due to the WWTP and urban and agricultural runoff (ECORP 2003). Along Dry Creek, contaminant inputs from multiple sources are likely, but have not been well documented, and the overall effects of pollutants on juvenile and adult salmonids survival are unknown. However, given the relatively high input of runoff from urban areas, adverse effects of contaminants could be expected.

Available data on the benthic macroinvertebrate community of Dry Creek are consistent with this expectation (i.e., that contaminants are adversely affecting the aquatic ecosystem). Data were collected by the Dry Creek Conservancy (Dry Creek Conservancy, unpublished data) during 2000 and 2001, at one site each year. (These data were summarized in Bailey [2003]). In these samples, the benthic macroinvertebrate community was dominated by pollution-tolerant organisms.

Predation

The lower portions of Dry Creek are low grassland streams that are characterized by warmer temperatures and populated with temperature-tolerant native and nonnative fish populations. In Dry Creek, spotted bass and Sacramento

pikeminnow, both of which prey on juvenile steelhead and Chinook salmon, are commonly found (ECORP 2003). Bluegill, green sunfish and smallmouth bass have also been observed in Dry Creek, and these species also prey on juvenile salmonids (Bailey 2003). However, along Dry Creek, Chinook salmon and steelhead benefit from cover that would minimize predation. (The existence of this cover is indicated by the high levels of shade described under *Water Temperature*)

Harassment

Urban development and access to Dry Creek likely results in harassment of adult Chinook salmon and steelhead. Harassment would primarily affect passage at areas of partial or total blockage of upstream movement of adult Chinook salmon and steelhead.

Entrainment

The percentage of streamflows removed by diversions along Dry Creek has not been documented. However, three dams have been identified along Dry Creek and the associated diversions are probably active and unscreened (Table 14).

Chapter 9
Miners Ravine

Miners Ravine is approximately 15.2 miles long, flowing south and then west and northwest to its confluence with Dry Creek (Figure 4). Miners Ravine is entrenched within an alluvial valley floor. Livestock grazing has resulted in unstable banks.

The presence of bedrock, limited soil permeability, urban development, and limited flow capacity result in frequent flooding along Miners Ravine. Summer flow can be less than 1 cfs while flood flows can be as high as 8,430 cfs at the confluence with Antelope and Dry Creeks. Summer flow originates from springs and urban runoff (i.e., excess landscape water and treated effluent). An HEC-1 model analysis determined that 2-year flows near Itchy Acres Road would be 641 cfs, 650 cfs for a 5-year flow, 1,837 cfs for 10-year flows, and 4,465 cfs for the 100-year flows. Frequently, the 5-year flows are greater than the channel capacity. (ECORP 2003).

Both fall-run Chinook salmon and steelhead have been observed spawning in Miners Ravine (Department of Water Resources 2002). In the 1950s, up to 100 adult Chinook salmon were estimated to occur in Miners Ravine; however, there is little current information regarding the abundance of spawning Chinook salmon in Miners Ravine. During some years, primarily during the 1980s and 1990s, DFG planted as many as 100,000 juvenile Chinook salmon from the Feather River hatchery in the lower reaches of Miners Ravine.

Dry Creek is a migration pathway to and from Miners Ravine. The conditions described above for Dry Creek must also be considered for adult and juvenile Chinook salmon in Miners Ravine relative to success of upstream and downstream migration.

Migration Habitat Quality

A large number of barriers substantially reduce the quality of migration habitat in Miner's Ravine (DWR 2002). Excluding beaver dams, Miners Ravine has up to 21 barriers, including six road crossings, one culvert, eight dams , and three natural barriers. Cottonwood Dam, built in the 1950s, appears to pose a complete barrier to fish passage under all flow conditions, although steelhead may pass upstream during flood-flow conditions. Moreover, over 80 beaver dams were observed on this creek in one survey (Department of Water Resources 2002).

(Miners Ravine had seven beaver dams in the reach surveyed during the spawning gravel survey (Jones & Stokes 2004).) Other human-made structures, such as fences, trap floating debris during high flows and cause obstructions to fish passage.

Adult Chinook salmon migration is likely to be blocked in many years because low-flow conditions coincide with most of the adult migration period (Table 2). Storm events may result in flow sufficient to provide upstream passage in October and November, but the amount of flow required to facilitate passage over beaver dams and infrastructure is currently unknown. All Chinook salmon passage to spawning habitat may be blocked by beaver dams and infrastructure in drier years. Barriers on Dry Creek may prevent adult Chinook salmon from reaching Miners Ravine.

Steelhead migration occurs during the winter months (Table 2). Adult migration also coincides with winter storm events that may provide passage conditions over beaver dams or other currently unknown obstructions. Except under extremely dry conditions, storm events probably ensure passage of adult steelhead from December through March. However, passage at some infrastructure is questionable (i.e., culverts and Cottonwood Dam).

In summary, the quality of migration habitat for both Chinook salmon and steelhead along Miner's Ravine has been reduced by barriers. However, However, full evaluation of migration habitat quality for the SAM will require additional information on barriers (e.g., water depths during migration), including barriers located in Dry and Steelhead Creeks.

Spawning Habitat Area

The surveyed reach within the Miners Ravine Preserve property was approximately 0.8 kilometers (0.5 mile) in length. Two potential spawning sites were identified with a total spawning habitat area of 48 square meters (515 square feet) (Table 11). The main reach of Miners Ravine surveyed was located west of the Miners Ravine Preserve property and was approximately 4.0 kilometers (2.5 miles long). One potential site provided 10 square meters (108 square feet) of spawning habitat (Table 11).

The gravel area is sufficient to support approximately 11 steelhead and six Chinook salmon redds (Table 11). Redd numbers may be underestimated because spawning habitat was not surveyed throughout all potential spawning reaches that may be accessible to adult Chinook salmon and steelhead. An estimate of the length of potential spawning reaches for Miners Ravine is provided in Table 12. Approximately 60% of the accessible spawning reaches were surveyed. Based on the ratio of the length of surveyed to potential spawning reaches, limited spawning habitat may be available. Currently inaccessible reaches may also have additional spawning habitat.

Fine Sediment

Livestock grazing and removal of riparian vegetation have resulted in an increase in bank instability, and, ultimately, in an increase in fine sediment input to Miners Ravine (ECORP 2003). The bedload of fine sediment under natural conditions is unknown, however, and may be considerable.

The amount of fines measured during the spawning gravel surveys was between approximately 50% and 75% for Miners Ravine (Table 13). Based on the survival relationship discussed previously (Table 5), eggs and larvae would not be expected to survive, although other studies have indicated a relatively lower level of embeddedness in riffles of the upper reaches of Miners Ravine (i.e., less than 25%) (ECORP 2003). The comparability of the methods is not known, however. Also, adult Chinook salmon and steelhead clean fine sediments from the gravel during spawning. As long as fine sediment did not reenter the redd, survival could be expected.

Scour

The flow and geomorphic information currently available is insufficient to evaluate scour. Substantial changes to the watershed appear to have resulted in peak flows substantially higher than historic levels. Thus, scour is likely and could result in considerable reduction in survival of eggs and larvae.

Water Temperature

Appendix A contains figures of the temperatures recorded in Miners Ravine (see Miners Ravine figures in Appendix A). Water temperatures were recorded in Miners Ravine between June 1, 2003, and August 4, 2003, by Bailey Environmental at four sites—Barton Road (38.45.545N, 121.11.550W), Cavitt Stalman Road (38.45.420N, 121.13.372W), Miners Ravine Road (38.45.093N, 121.10.535W), and Olympus Point (38.45.548N, 121.15.356W).

During the period when data were recorded, Miners Ravine experienced water temperatures warmer than both the ideal and suitable ranges for steelhead rearing. Unsuitable water temperatures in the reaches monitored could indicate high mortality for juvenile steelhead. Survival would depend on the location of rearing habitat and occurrence of unknown temperature refugia associated with deep pools and cool groundwater accretion. Temperature data were not recorded during the time in which Chinook salmon would be present in Miners Ravine.

Aerial photographs were evaluated for the reach extending 5 miles upstream from Roseville (Figure 4). The shade level is moderate to high over the next 5 miles upstream. The low to moderate levels of shade indicate that temperature conditions likely warm in response to low shade in the lower reaches. Moderate to high shade in the 5-mile upstream reach minimize warming of stream

temperature. The GIS analysis of stream corridor land cover along the entire length of Miners Ravine indicated a low to moderate level of shade (Table 10, Figure 5).

Contaminants

Available data are insufficient to determine the extent to which contaminants are affecting salmonids; however, available information does suggest that contaminants are having an ecologically significant effect on the aquatic ecosystem of Miner's Ravine.

Miners Ravine receives effluent discharge from the Placer County SMD-3 facility. Its design capacity is 0.75 mgd. In the wet season, the discharge constitutes approximately 2–3% of the flow volume in Miners Ravine; in the dry season, it contributes less than 10% of the flow. The facility is currently operating at about 20% of its design capacity. Future operation approaching full capacity may result in a discharge of effluent that constitutes as much as 50% of the streamflow in Miners Ravine (ECORP 2003).

Miners Ravine receives inflow from two sewage disposal ponds located north of the Granite Bay golf course and near the Dick Cook road crossing. Heavy metals are considered an issue in Miners Ravine, probably due to former placer mining activities (ECORP 2003). Miners Ravine also receives urban and agricultural runoff. Contaminant inputs from multiple sources have not been well documented and effects on juvenile and adult survival are unknown. Given the relatively high input of runoff from urban areas, adverse effects from contaminants could be expected.

Available data on the benthic macroinvertebrate community of Miners Ravine are consistent with the expectation of adverse effects due to contaminants. Data were collected by the Dry Creek Conservancy (Dry Creek Conservancy, unpublished data) during 2000 and 2001, at one and two sites, respectively. (These data were summarized by Bailey [2003]). In these samples, the benthic macroinvertebrate community consisted almost entirely of pollution-tolerant organisms.

Predation

Fish community data is limited, but introduced fish that have been observed in Miners Ravine include largemouth bass, brown bullhead, channel catfish, bluegill and green sunfish (Bailey 2003). These species prey on juvenile Chinook salmon and steelhead. The moderate to high levels of shade along much of Miners Ravine (as previously described under *Water Temperature*) indicates that Chinook salmon and steelhead are likely benefiting from cover that may minimize predation. However, low levels of vegetation in the lower two miles indicate a scarcity of cover and increased vulnerability to predation.

Harassment

The moderate to high levels of shade indicate that adult Chinook salmon and steelhead may have substantial cover and may be moderately susceptible to harassment. However, urban development and access to Miners Ravine combined with low to moderate levels of shade and cover in the lower 2-mile reach could indicate a relatively high potential for harassment and reduced fecundity. Sensitivity may be especially high in spawning habitat and at barriers.

Entrainment

The percentage of streamflows removed by diversions along Miners Ravine, and from Dry Creek downstream, has not been documented. However, there are nine dams along Miners Ravine and at least some of their associated diversions probably are active and unscreened (Table 14).

Chapter 10
Secret Ravine

Secret Ravine is a 7.8-mile long perennial tributary of Dry Creek (Figure 4) (ECORP 2003). Granitic bedrock and a narrow riparian zone characterize the upper reaches of Secret Ravine above 67-meters (220-feet) msl. Below an elevation of 67 meters (220-feet) msl, the bedrock is composed of volcanic cap rock. Upland soils are relatively shallow and impermeable, resulting in rapid surface and subsurface runoff. Channel substrates throughout Secret Ravine include bedrock, small cobbles, and deposits of sand. Secret Ravine is relatively straight with few meanders.

Urban runoff from lawn irrigation and excess drainage, sewage effluent, tailwater delivered by the PCWA's irrigation releases, and small amounts of freshwater seeps contribute most of the dry season flow. Summer flows are two or three times the historic unimpaired flow. Flows in Secret Ravine range from 0.5 cfs to 3 cfs in the fall. February flows have been recorded at 25 cfs in the lower reaches and 5–10 cfs in the upper reaches. Peak flood events have been estimated around 625 cfs, and 100-year flood events have been estimated around 3,184 cfs (ECORP 2003).

Both spawning fall-run Chinook salmon and steelhead have been recorded in Secret Ravine. Since the late 1990s, estimates of fall-run Chinook salmon within Secret Ravine averaged about 160 fish per year (ECORP 2003). Surveys conducted for steelhead in the Dry Creek watershed have shown that most of the suitable spawning and rearing habitat occurs in Secret Ravine.

Dry Creek is a migration pathway to and from Secret Ravine. The conditions described above for Dry Creek must also be considered for adult and juvenile Chinook salmon in Secret Ravine relative to success of upstream and downstream migration.

Migration Habitat Quality

Barriers reduce the quality of migration habitat in Secret Ravine. During the spawning gravel surveys conducted by Jones & Stokes (2004), potential barriers were observed in Secret Ravine. These potential barriers included well-established beaver dams from 0.6 to 1.2 meters (2 to 4 feet) high and about 0.6 meter (2 feet) wide across the top. These dams are migration barriers under low-flow conditions. Secret Ravine also has at least one barrier created by a pipeline

and several utility pipe crossings that could be obstacles to migrating adult Chinook salmon and steelhead (ECORP 2003).

Adult Chinook salmon migration is likely to be blocked in many years because low-flow conditions coincide with most of the adult migration period (Table 2). Storm events may result in flow sufficient to provide upstream passage in October and November, but the amount of flow required to facilitate passage over beaver dams and infrastructure is currently unknown. All Chinook salmon passage to spawning habitat may be blocked by beaver dams and infrastructure in drier years. Barriers on Dry Creek may prevent adult Chinook salmon from reaching Secret Ravine.

Steelhead migration occurs during the winter months (Table 2). Adult migration also coincides with winter storm events that may provide passage conditions over beaver dams or other currently unknown obstructions. Except under extremely dry conditions, storm events probably ensure passage of adult steelhead from December through March.

In summary, along Secret Ravine, barriers have substantially reduced migration habitat quality for Chinook salmon and has reduced migration habitat quality for steelhead. However, full evaluation of migration habitat quality for the SAM will require additional information on barriers, including barriers located in Dry and Steelhead Creeks.

Spawning Habitat Area

There were four potential spawning sites within the 0.95 mile reach surveyed in Secret Ravine. The total area for the four sites was 109 square meters (1,176 square feet) (Table 11). Gravel patches were found toward the downstream end of the surveyed reach. The substrate was sandier at the upstream end of the surveyed reach.

The gravel area is sufficient to support approximately 21 steelhead and 12 Chinook salmon redds (Table 11). Redd numbers may be underestimated because spawning habitat was not surveyed throughout all potential spawning reaches that may be accessible to adult Chinook salmon and steelhead. Also, some spawning habitat did not meet the length and width criteria for the spawning gravel assessment, although Chinook salmon and steelhead could still use these smaller gravel patches for spawning. An estimate of the length of potential spawning reaches for Secret Ravine is provided in Table 12. Approximately 10% of the spawning reaches were surveyed. Based on the ratio of the length of surveyed to potential spawning reaches, substantially more spawning habitat may be available.

Fine Sediment

Rapid urban development, cattle grazing, off-road vehicle use, and equestrian use have resulted in a reduction of upland permeability, an increase in bank erosion, and, ultimately, an increase in fine sediment input to Secret Ravine (ECORP 2003). The bedload of fine sediment under natural conditions is unknown, however, and may be considerable.

The amount of fines measured during the spawning gravel surveys was between 51% and 82% for Secret Ravine (Table 13). Based on the survival relationship discussed previously (Table 5), eggs and larvae would not be expected to survive. However, adult Chinook salmon and steelhead clean fine sediments from the gravel during spawning. As long as fine sediment did not reenter the redd, survival could be expected.

Scour

The flow and geomorphic information currently available is insufficient to evaluate scour. The extensive urban area surrounding Secret Ravine likely indicates peak flows substantially higher than historic levels. Therefore, scour is likely and could result in considerable reduction in survival of eggs and larvae.

Water Temperature

Appendix A contains figures of the temperatures recorded in Secret Ravine (see Secret Ravine figures in Appendix A). Bailey Environmental recorded water temperatures at two sites in Secret Ravine—at the AM/PM on Rocklin Road and at Loomis Basin Park. Temperature data is available for the period between May 30, 2003, and August 4, 2003. Temperatures warm as the water moves downstream because of limited riparian shade and increased solar exposure.

During the period when data were recorded, Secret Ravine experienced water temperatures warmer than both the ideal and suitable ranges for steelhead rearing. Unsuitable water temperatures in the reaches monitored could indicate high mortality for juvenile steelhead. Survival would depend on the location of rearing habitat and occurrence of unknown temperature refugia associated with deep pools and cool groundwater accretion. Data was not recorded during a period in which Chinook salmon would be present in Secret Ravine

Aerial photographs were evaluated for the reach upstream of Highway 65 (Figure 4). The level of shade is high for the first mile upstream (Table 10). The shade level is low to moderate over the next 914 meters (3,000 feet). Shade is at a high level for most of the remaining evaluated reach. The moderate to high levels of shade indicate that temperature conditions would be sensitive to removal of shade. The GIS analysis of stream corridor land cover indicated a moderate level of shade along Secret Ravine (Table 10, Figure 5).

Contaminants

Secret Ravine receives inflow from two sewage disposal ponds, located near Interstate 80 and Gilardi Road. Secret Ravine also receives urban runoff. Contaminant inputs from multiple sources have not been well documented and effects on juvenile and adult survival are unknown. Given the relatively high input of runoff from urban areas, adverse effects of contaminants could be expected.

Available data on the benthic macroinvertebrate community of Secret Ravine are consistent with the expectation of adverse effects due to contaminants. Data were collected by Fields (1999) and the Dry Creek Conservancy (Dry Creek Conservancy, unpublished data) during 1999 and 2000-2001, respectively. (These data were summarized in Bailey [2003]). Fields concluded that the benthic macroinvertebrate community was characteristic of streams adversely affected by organic pollutants, while in the data collected by the Dry Creek Conservancy, the benthic macroinvertebrate community was dominated by pollution-tolerant organisms.

Predation

Fish community data is limited, but introduced fish that have been observed in Secret Ravine include common carp, smallmouth bass, largemouth bass, spotted bass, black bullhead, brown bullhead, white catfish, bluegill, redear sunfish and green sunfish (Bailey 2003). Smallmouth bass, largemouth bass, and spotted bass prey on small fishes, including juvenile Chinook salmon and steelhead. However, the moderate to high levels of shade along Secret Ravine (as previously described under *Water Temperature*) indicate that Chinook salmon and steelhead are likely benefiting from cover that may minimize predation.

Harassment

The moderate to high levels of shade indicate that adult Chinook salmon and steelhead may have substantial cover and may be moderately susceptible to harassment. Urban development and access to Secret Ravine, especially in spawning habitat and at partial barriers, could indicate a relatively high potential for harassment and reduced fecundity.

Entrainment

The percentage of streamflows removed by diversions along Secret Ravine, and from Dry Creek downstream, has not been documented. However, there are three dams along Dry Creek whose associated diversions may be active and unscreened (Table 14).

Table 14. Potential Barriers Identified on Streams of Western Placer County

Stream	Latitude	Longitude	Barrier Type	Diversion	Source	Name
Coon Creek	38.97133	-121.1515	Dam	Yes	Bailey 2003	NID Diversion Dam
Coon Creek	38.9708	-121.28684	Dam	Yes	Bailey 2003	
Coon Creek	38.934	-121.407	Dam	Yes	Bailey 2003	
Coon Creek	38.9655	-121.310667	Dam	Not Known	2003 Videography[1]	
Coon Creek	38.96964	-121.296	Dam	Not Known	2003 Videography[1]	
Coon Creek	38.9689	-121.29887	Dam	Not Known	2003 Videography[1]	
Coon Creek	38.971167	-121.15833	Rocks/Waterfall	No	2003 Videography[1]	
Coon Creek	38.969	-121.16583	Rocks/Waterfall	No	2003 Videography[1]	
Dry Creek	38.73453	-121.39255	Dam	Not Known	2003 Videography[1]	
Dry Creek	38.7337	-121.28945	Dam	Not Known	Bailey 2003	
Dry Creek	38.74091	-121.28583	Dam	Not Known	Vanicek 1993[2]	
Dry Creek	38.744033	-121.283633	Rocks/Waterfall	No	Vanicek 1993[2]	
Auburn Ravine	38.88323	-121.29805	Gauging Station	No	Placer County 2002	NID Gauging Station near HWY 65
Auburn Ravine	38.8566	-121.492	Dam	Yes	Placer County 2002	South Sutter Diversion Dam - Van Dyke's
Auburn Ravine	38.8541	-121.5016	Dam	Yes	Placer County 2002	Davis Ranch Diversion Dam
Auburn Ravine	38.8605	-121.465	Dam	Not Known	Placer County 2002	
Auburn Ravine	38.8584	-121.38678	Dam	Yes	Placer County 2002	South Sutter Diversion Dam - Aitken Ranch
Auburn Ravine	38.872833	-121.3565	Dam	Yes	Placer County 2002	South Sutter Diversion Dam - Near Moore Road
Auburn Ravine	38.877167	-121.343833	Dam	Yes	Placer County 2002	Private Diversion Dam near Nelson Lane
Auburn Ravine	38.8611	-121.4228	Dam	Yes	Placer County 2002	Private Diversion Dam east of Brewer Road

Table 14. Continued

Stream	Latitude	Longitude	Barrier Type	Diversion	Source	Name
Auburn Ravine	38.89667	-121.252	Dam	Yes	Placer County 2002	NID Hemphill Diversion Dam
Auburn Ravine	38.88967	-121.11908	Rocks/Waterfall	No	Placer County 2002	Ophic Tunnel Cascade
Auburn Ravine	38.898	-121.158	Dam	Yes	Placer County 2002	NID Auburn Ravine #1 Diversion Dam
Miners Ravine	38.75627	-121.2243	Culvert	No	DWR 2002	Sierra College Boulevard
Miners Ravine	38.75835	-121.20649	Dam	Not Known	DWR 2002	
Miners Ravine	38.75963	-121.19931	Rocks/Waterfall	No	DWR 2002	
Miners Ravine	37.75835	-121.20649	Dam	Not Known	DWR 2002	
Miners Ravine	38.75321	-121.1808	Debris jam	No	DWR 2002	
Miners Ravine	38.75185	-121.17961	Rocks/Waterfall	No	DWR 2002	
Miners Ravine	38.75087	-121.17689	Rocks/Waterfall	No	DWR 2002	
Miners Ravine	38.75307	-121.17195	Culvert	No	DWR 2002	
Miners Ravine	38.75263	-121.16431	Rocks/Waterfall	No	DWR 2002	
Miners Ravine	38.76408	-121.15918	Dam	Yes	DWR 2002	Cottonwood Dam
Miners Ravine	38.78379	-121.1495	Dam	Not Known	DWR 2002	
Miners Ravine	38.78833	-121.14917	Dam	Not Known	DWR 2002	
Miners Ravine	38.79279	-121.14017	Rocks/Waterfall	No	DWR 2002	
Miners Ravine	38.79316	-121.14024	Crossing	No	DWR 2002	
Miners Ravine	38.79819	-121.13535	Dam	Not Known	DWR 2002	
Miners Ravine	38.79893	-121.13187	Culvert	No	DWR 2002	
Miners Ravine	38.80026	-121.13016	Culvert	No	DWR 2002	
Miners Ravine	38.80095	-121.12988	Rocks/Waterfall	No	DWR 2002	
Miners Ravine	38.81192	-121.12524	Dam	Not Known	DWR 2002	
Miners Ravine	38.81747	-121.12566	Dam	Not Known	DWR 2002	

Table 14. Continued

Stream	Latitude	Longitude	Barrier Type	Diversion	Source	Name
Miners Ravine	38.82211	-121.12688	Dam	No	DWR 2002	
Secret Ravine	38.75936	-121.25642	Crossing	No	Bailey 2003	
Antelope Creek	38.786167	-121.250117	Culvert	No	Bailey 2003	Sunset Blvd. Culvert
Antelope Creek	38.798729	-121.235098	Dam	Not Known	Bailey 2003	
Doty Ravine	38.937167	-121.254667	Dam	Yes	Bailey 2003	NID Doty South Diversion Dam
Doty Ravine	38.9337	-121.228317	Culvert	No	Bailey 2003	Garden Bar Road Crossing

Notes:

[1] – Placer County Planning Department, Unpublished data from the 2003 videography project for the streams of Western Placer County.

[2] – In Bailey 2003.

Chapter 11

Discussion and Conclusions

Insufficient data is currently available to complete the SAM and determine the population performance for each stream. However, the available information is sufficient to provide a preliminary assessment of the magnitude and importance of factors potentially limiting the production of steelhead and Chinook salmon in western Placer County streams.

In the Bear River, the SIDDD restricts Chinook salmon and steelhead to 15 miles of low gradient stream channel on the valley floor. Habitat within the accessible reach of the Bear River is severely restricts the production of Chinook salmon and steelhead because of limited amounts of spawning habitat, excessive amounts of fine sediment, and warm water temperatures from March through October (Table 15). Fine sediment results in low survival of eggs and larvae, and warm temperature causes high mortality of Chinook salmon adults and eggs and steelhead eggs and juveniles.

Chinook salmon access to Coon Creek and Doty and Auburn Ravines is severely restricted by the combined effects of diversion dams (and beaver dams) and low flow on passage conditions for adult migration during the fall (Table 15). In addition, the area of spawning habitat appears to be limiting in Coon Creek, although surveys of additional stream reaches are needed to confirm the conclusion. Spawning habitat in Auburn and Doty Ravines may not be limiting. Fine sediment is likely to result in relatively high mortality of eggs and larvae in all streams. Water temperatures will limit the distribution of juvenile steelhead to the upstream reaches, and mortality of Chinook salmon adults and eggs is expected. Juvenile Chinook salmon and steelhead leaving Coon Creek and Doty and Auburn Ravines after April are unlikely to survive because of entrainment in agricultural diversions from both the streams themselves and the Cross Canal. Access and egress is clearly a substantial problem for Chinook salmon and steelhead in Coon Creek and Doty and Auburn Ravines.

Adult Chinook salmon access to Dry Creek, Antelope Creek, Secret Ravine, and Miners Ravine is restricted by beaver dams and infrastructure in combination with low flow in the fall (Table 15). In addition, the area of spawning habitat appears to be limiting. Fine sediment is likely to result in relatively high mortality of eggs and larvae in all streams. Water temperatures will limit the survival of juvenile steelhead in Dry and Antelope Creeks. Temperature will limit the distribution of steelhead to the upstream reaches of Secret and Miners Ravines. Temperature-related mortality of Chinook salmon adults and eggs is expected in all streams. Scour, contaminants, and harassment are likely

environmental conditions affecting the survival and fecundity of Chinook salmon and steelhead in Dry Creek, Antelope Creek, Secret Ravine, and Miners Ravine. Urban development is the primary factor contributing to adverse scour, contaminant, and harassment conditions.

Certainty

As indicated previously, certainty is an important component in the assessment of the weight given a species response to a selected environmental condition. Certainty indicates the potential that the species response or an index of the species response is reliable, adequate, accurate, and precise. An indication of certainty is the scientific support for the hypotheses, ranging from speculative relationships (i.e., minimal certainty) to those relationships that are thoroughly established, generally accepted, and supported by peer-reviewed evidence (i.e., high certainty) (Table 4). Certainty is also related to the accuracy and precision of measured or simulated environmental conditions and the resulting index of the species response. Table 16 indicates the levels of certainty for each environmental condition potentially included in the SAM.

Understanding and addressing uncertainty is most important for those environmental conditions expected to limit production of Chinook salmon and steelhead in western Placer County streams (Table 15). Limited resources and funding should be expended first on those environmental conditions that are both important to the production of the target species and have a relatively high level of certainty (Table 16). These include migration habitat quality, spawning habitat area, fine sediment, water temperature, and entrainment. Scour, contaminants, and harassment are clearly important, but specific documentation of effects and implementation of focused management actions will require collection of substantial additional information. The effort and cost may not be warranted if those environmental conditions that are relatively well understood and documented preclude support of in-river life stages of Chinook salmon and steelhead.

Relationship to the Functional Assessment Model for Riparian Ecosystems

Full application of the SAM requires substantial future commitment of funding and other resources for additional data collection and analysis. A potential alternative or complementary approach to the SAM is to use the more broadly applicable Functional Assessment Model (FAM) (Jones & Stokes 2004) to provide a basis for identification and prioritization of protective and restoration actions.

The purpose of the draft FAM is to assess the functions provided by riparian ecosystems associated with perennial and seasonal streams in western Placer

Table 15. Summary of Existing Environmental Conditions Expected to Limit Production of Chinook Salmon and Steelhead in Western Placer County Streams

Stream	Migration Habitat Quality	Spawning Habitat Area	Fine Sediment	Scour	Water Temperature	Contaminants	Harassment	Entrainment
Bear River		Data needed, but capacity is likely limiting	Substantial egg mortality likely, data needed		Survival of juvenile steelhead and Chinook salmon adults and eggs			
Coon Creek	Substantial blockage of Chinook salmon	Likely limiting	Substantial egg mortality		Distribution of juvenile steelhead; survival of Chinook salmon adults and eggs			High mortality of juvenile Chinook salmon and steelhead after April
Doty Ravine	Substantial blockage of Chinook salmon	Not limiting	Substantial egg mortality		Distribution of juvenile steelhead; survival of Chinook salmon adults and eggs			High mortality of juvenile Chinook salmon and steelhead after April
Auburn Ravine	Substantial blockage of Chinook salmon	Not limiting	Substantial egg mortality		Distribution of juvenile steelhead; survival of Chinook salmon adults and eggs			High mortality of juvenile Chinook salmon and steelhead after April
Dry Creek	Substantial blockage of Chinook salmon	Data needed, but capacity is likely limiting	Substantial egg mortality	Potential egg mortality	Survival of juvenile steelhead and Chinook	Potential egg and juvenile mortality from urban runoff	Potential adult mortality and reduction in fecundity	

Table 15. Continued

Stream	Migration Habitat Quality	Spawning Habitat Area	Fine Sediment	Scour	Water Temperature	Contaminants	Harassment	Entrainment
					salmon adults and eggs			
Antelope Creek	Substantial blockage of Chinook salmon	Limiting	Substantial egg mortality	Potential egg mortality	Survival of juvenile steelhead and Chinook salmon adults and eggs	Potential egg and juvenile mortality from urban runoff	Potential adult mortality and reduction in fecundity	
Secret Ravine	Substantial blockage of Chinook salmon	Limiting	Substantial egg mortality	Potential egg mortality	Distribution of juvenile steelhead; survival of Chinook salmon adults and eggs	Potential egg and juvenile mortality from urban runoff	Potential adult mortality and reduction in fecundity	
Miners Ravine	Substantial blockage of Chinook salmon	Limiting	Substantial egg mortality	Potential egg mortality	Distribution of juvenile steelhead; survival of Chinook salmon adults and eggs	Potential egg and juvenile mortality from urban runoff	Potential adult mortality and reduction in fecundity	

Table 16. Certainty of the Species Response to Environmental Conditions

Environmental Condition	Scientific Support of Relationships[1]	Data Sufficiency	
		Environmental Condition	Species Response
Migration Habitat Quality	High: Cause-and-effect relationship is thoroughly established	Additional information is needed on the barrier location, barrier structure, flow conditions, and flow relationships to depth, velocity, and vertical drop	Observations of adult movment (e.g., radio tags) or habitat use are needed to document passage
Spawning Habitat Area	High: Cause-and-effect relationship is thoroughly established	Surveys need to be completed for remaining reaches	Observations of habitat use are needed to document species preferences that may be influenced by environmental conditions currently not considered
Fine Sediment	High: Cause-and-effect relationship is thoroughly established	Surveys need to be completed for remaining reaches	Observations of redds are needed to confirm expected levels of mortality and potential effects of redd construction on fine sediment levels within the redd
Scour	Low to medium: cause-and-effect relationship supported by evidence from experiments and observations	Additional information is needed on flow conditions and the mobilization of spawning gravel within western Placer County streams	Scour is not completely predictable and observations of redds is warranted to document actual scour of redds
Rearing Habitat Area	Low: cause-and-effect relationship supported by some evidence from experiments and observation; for Chinook salmon, the relationship is complicated by special variability in habitat use and availability associated with inundation of floodplain	Measurement of stream area and habitat types are needed	Measurement of habitat use and preference is warranted to document the environmental conditions most important to definition of rearing habitat
Water Temperature	Medium to high: cause-and-effect relationship supported by evidence from experiments and observations; relationships are based primarily on controlled laboratory conditions that may not be completely translatable to stream conditions (e.g., presence of refugia in deep pools and areas of cool ground water accretion)	Continued collection of water temperature data over multiple reaches to improve understanding of environmental conditions that affect temperature (e.g., flow, shade, and stream depth and width)	Measurement of fish occurrence and density for use in correlation with water temperature data

Table 16. Continued

Environmental Condition	Scientific Support of Relationships[1]	Data Sufficiency	
		Environmental Condition	Species Response
Food	Minimal: the relationship is speculative and has little empirical support; clearly, food is of critical importance; however, relationships between environmental conditions, food production, and food availability to the species are complex and difficult to quantify	No clear recommendations at this time	No clear recommendations at this time
Contaminants	Minimal to High: dependent on the contaminant concentration; duration, frequency, and timing of occurrence; the presence and type of other contaminants and environmental conditions (e.g., water temperature)	Monitoring of contaminants is warranted, especially contaminants associated with urban runoff; monitoring should include concentration, duration, frequency, and timing	Monitoring should include fish abundance and aquatic community structure, including fish and invertebrates
Predation	Minimal: the relationship is speculative and has little empirical support; clearly, predation is of critical importance; however, relationships between environmental conditions, predation, and the effect on a given species are complex and difficult to quantify	No clear recommendations at this time	No clear recommendations at this time
Harassment	Low: cause-and-effect relationship supported by some evidence from experiments and observation	Monitor changes in access to spawning reaches; monitor human activities at barriers	Monitor proportion of un-spawned females to total females; monitor the number of successful redds
Entrainment	High: Cause-and-effect relationship is thoroughly established	Document the number, magnitude, timing, duration, and frequency of diversions; fish screens; and flow volume	Monitor outmigrants (e.g., juvenile trapping in the stream and in diverted flow)

[1]See Table 4 for definitions of the level of certainty assigned the relationships

County. The FAM consists of three indicators of functional capacity and integrity (Jones & Stokes 2004):

- Cover of natural vegetation on the floodplain and adjacent land (natural vegetation);
- Hydraulic connectivity of the floodplain and stream channel (hydraulic connectivity); and
- Quantity of runoff from the floodplain and adjacent land (runoff).

These broad indicators encompass many ecological functions that affect environmental conditions included in the SAM (i.e., environmental conditions that determine the biological performance for steelhead and Chinook salmon populations) (Table 17). For the natural vegetation indicator, acreage of natural vegetation on the floodplain and adjacent land is a measure of functional capacity (Jones & Stokes 2004). The percentage of the floodplain and adjacent land in natural vegetation is a measure of integrity. For the hydrologic connectivity indicator, the inundated area weighted by frequency of inundation is a measure of functional capacity. Integrity is the degree to which floodplain inundation approximates unaltered conditions. Finally, runoff per hectare (acre) for a watershed is a measure of the functional capacity for runoff. Integrity is the difference between runoff under natural vegetation and runoff under current land cover.

As illustrated in Table 17, these indicators provide information that illustrates the directional effect on environmental conditions affecting the biological performance of fish populations. Human activities that move the indicators in a positive direction will also improve environmental conditions for fish species.

Many land management activities and associated mitigation measures implemented, funded, or permitted by Placer County can be evaluated with the FAM. The process is likely to ensure that stream and river conditions that support in-river life stages of Chinook salmon and steelhead are maintained. However, the FAM may not provide the necessary level of detail required for development and implementation of actions required for restoring stream and river conditions that support in-river life stages of Chinook salmon and steelhead. In addition, actions within the stream channel (e.g., work in the stream channel and modifications to the stream channel) may result in take or minimization and avoidance of take that the FAM would not clearly represent for the purposes of implementing the provisions of the ESA. The FAM lacks the detail related to magnitude of effects on listed species that may be required for compliance with the ESA. Therefore, some combination of the FAM and certain components of the SAM may be necessary for identification and prioritization of restoration actions and development of measures that avoid and minimize take of listed species and their habitat.

Table 17. The Relationship of Environmental Conditions to Ecological Functions Encompassed by the Indicators Included in the Functional Assessment Model (FAM)

Environmental Conditions	Functional Assessment Model Indicators		
	Natural Vegetation	Hydraulic Connectivity	Runoff
Migration Habitat Quality	Groundwater recharge and surface water storage affect the magnitude and duration of flow Sediment transport and sediment storage affects channel dimension and form (i.e. geomorphic processes)	Floodplain connectivity (i.e., frequency and degree of floodplain inundation) increases the surface area for recharge and water storage Floodplain connectivity increases the surface area for sediment storage and slows flow velocity that influences sediment transport	Increased runoff indicates reduced groundwater recharge and surface water storage Increased runoff indicates reduced area for sediment storage and increased potential for sediment transport (i.e., increased velocity)
Spawning Habitat Area	Groundwater recharge and surface water storage affect the magnitude and duration of flow Sediment transport and sediment storage affects channel dimension and form (i.e. geomorphic processes), indirectly determining channel slope and substrate size	Floodplain connectivity increases the surface area for recharge and water storage Floodplain connectivity increases the surface area for sediment storage and slows flow velocity that influences sediment transport Floodplain, depending on duration of inundation, may directly provide spawning habitat (i.e., splittail)	Increased runoff indicates reduced groundwater recharge and surface water storage Increased runoff indicates reduced area for sediment storage and increased potential for sediment transport
Fine Sediment	Groundwater recharge and surface water storage affect the magnitude and duration of flow, subsequently determining the movement of spawning gravel and transport and deposition of fine sediment Sediment transport and sediment storage affects channel dimension and form (i.e. geomorphic processes), directly determining the input of fine sediment to the stream channel	Floodplain connectivity increases the surface area for recharge and water storage Floodplain connectivity increases the surface area for sediment storage and slows flow velocity that influences sediment transport	Increased runoff indicates reduced groundwater recharge and surface water storage Increased runoff indicates reduced area for sediment storage and increased potential for sediment transport (i.e., increased input of fine sediment)
Scour	Surface water storage affects the magnitude and duration of flow, including peak flows that may be associated with high levels of scour	Floodplain connectivity increases the surface area for recharge and water storage Floodplain connectivity increases the surface area for sediment storage and moderates the energy of peak flows	Increased runoff indicates reduced groundwater recharge and surface water storage, potentially resulting in increased peak flows

Table 17. Continued

Environmental Conditions	Functional Assessment Model Indicators		
	Natural Vegetation	Hydraulic Connectivity	Runoff
Rearing Habitat Area	Groundwater recharge and surface water storage affect the magnitude and duration of flow, affecting stream area Sediment transport and sediment storage affects channel dimension and form, subsequently affecting depth, velocity, and habitat-type diversity Riparian vegetation provides overhead cover and instream woody material that provide habitat-type diversity	Floodplain connectivity increases the surface area for recharge and water storage Floodplain connectivity increases the surface area for sediment storage and slows flow velocity that influences sediment transport Floodplain, depending on duration of inundation, may directly provide rearing habitat (i.e., Chinook salmon and splittail)	Increased runoff indicates reduced groundwater recharge and surface water storage Increased runoff indicates reduced area for sediment storage and increased potential for sediment transport
Water Temperature	Groundwater recharge and surface water storage affect the magnitude and duration of flow, subsequently maintaining cooler water temperature Sediment transport and sediment storage affects channel dimension and form, subsequently affecting stream width/depth ratios Riparian vegetation provides shade	Floodplain connectivity increases the surface area for recharge and water storage Floodplain connectivity increases the surface area for sediment storage and slows flow velocity that influences sediment transport	Increased runoff indicates reduced groundwater recharge and surface water storage Increased runoff indicates reduced area for sediment storage and increased potential for sediment transport
Food	Groundwater recharge and surface water storage affect the magnitude and duration of flow that increases stream area Sediment transport and sediment storage affects channel dimension and form, subsequently affecting habitat area and habitat-type diversity for prey organisms Riparian vegetation provides nutrients to the stream	Floodplain connectivity increases the surface area for recharge and water storage Floodplain connectivity increases the surface area for sediment storage and slows flow velocity that influences sediment transport Floodplain connectivity may directly provide access to food and provide input of nutrients to the stream	Increased runoff indicates reduced groundwater recharge and surface water storage Increased runoff indicates reduced area for sediment storage and increased potential for sediment transport

Table 17. Continued

Environmental Conditions	Functional Assessment Model Indicators		
	Natural Vegetation	Hydraulic Connectivity	Runoff
Contaminants	Groundwater recharge and surface water storage affect the magnitude and duration of flow available for dilution of contaminants Riparian vegetation adsorption, storage, and transformation of non-nutrient metals Riparian vegetation adsorption, storage, and degradation of pesticides	Floodplain connectivity increases the surface area for recharge and water storage Floodplain connectivity increases the surface area for adsorption, storage, degradation, and transformation of non-nutrient metals, pesticides, and other contaminants	Increased runoff indicates reduced groundwater recharge and surface water storage Increased runoff indicates increased potential input of contaminants
Predation	Sediment transport and sediment storage affects channel dimension and form, subsequently affecting depth, velocity, and cover Riparian vegetation provides overhead cover and instream woody material that provide cover	Floodplain connectivity increases the surface area for sediment storage and slows flow velocity that influences sediment transport Floodplain, depending on duration of inundation, may directly provide cover and habitat with fewer predators	Increased runoff indicates reduced area for sediment storage and increased potential for sediment transport
Harassment	Sediment transport and sediment storage affects channel dimension and form, subsequently affecting depth, velocity, and cover Riparian vegetation provides overhead cover and instream woody material that provide cover Riparian vegetation provides a buffer between the stream channel and human activities	Floodplain connectivity increases the surface area for sediment storage and slows flow velocity that influences sediment transport Floodplain provides a buffer between the stream channel and human activities	Increased runoff indicates reduced area for sediment storage and increased potential for sediment transport
Entrainment	Groundwater recharge and surface water storage affect the magnitude and duration of flow, affecting the proportion of flow diverted	Floodplain connectivity increases the surface area for recharge and water storage	Increased runoff indicates reduced groundwater recharge and surface water storage

Chapter 12

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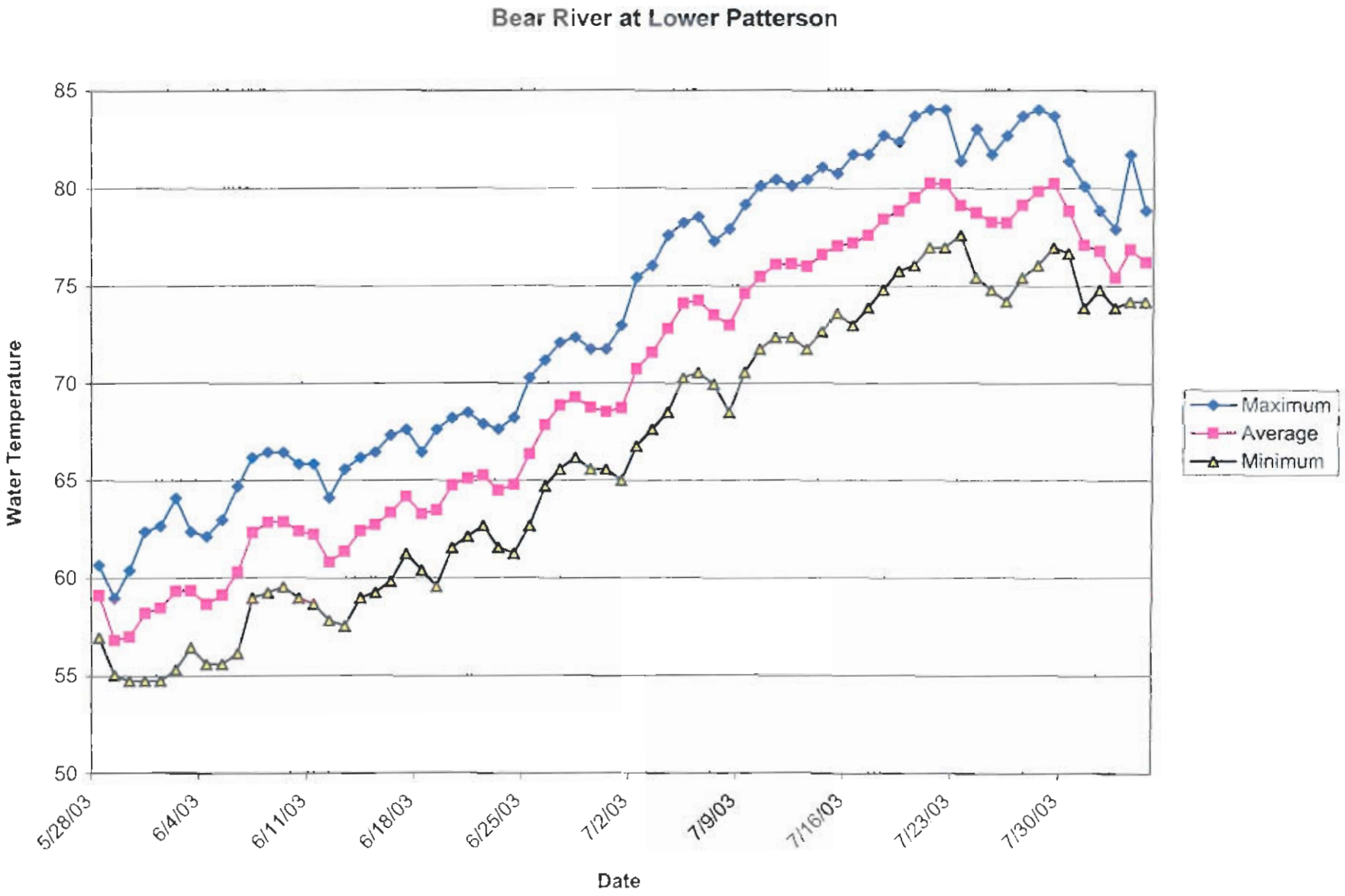
Appendix A

Daily Water Temperatures


Bear River at Lower Patterson
Water Temperature
85
80
75
70
65
60
55
50
5/28/03
6/4/03
6/11/03
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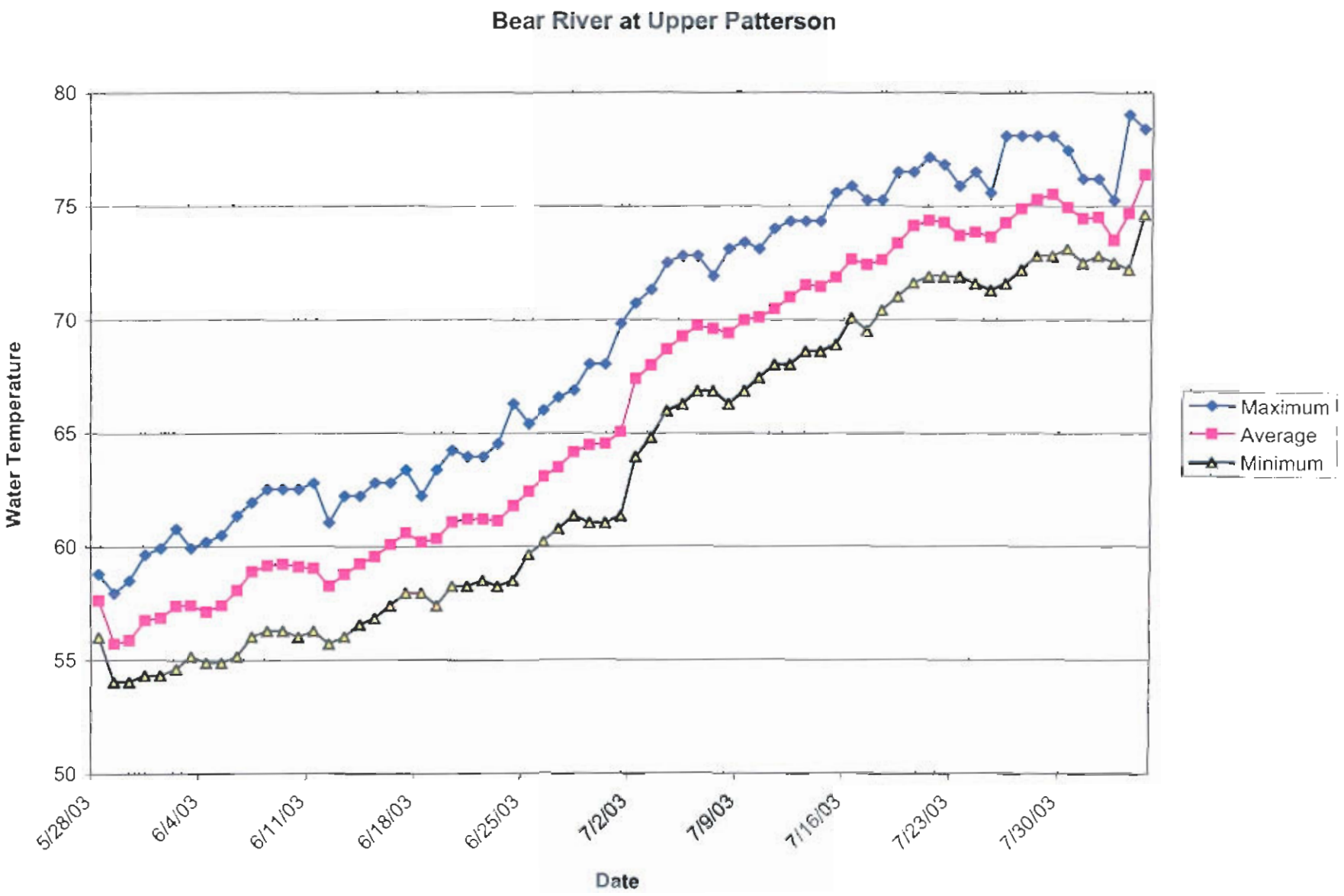
7/23/03
7/30/03
Date
Maximum
Average
Minimum


Bear River at Upper Patterson
Water Temperature
80
75
70
65
60
55
50
5/28/03
6/4/03
6/11/03
6/18/03
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7/30/03
Date
Maximum
Average
Minimum

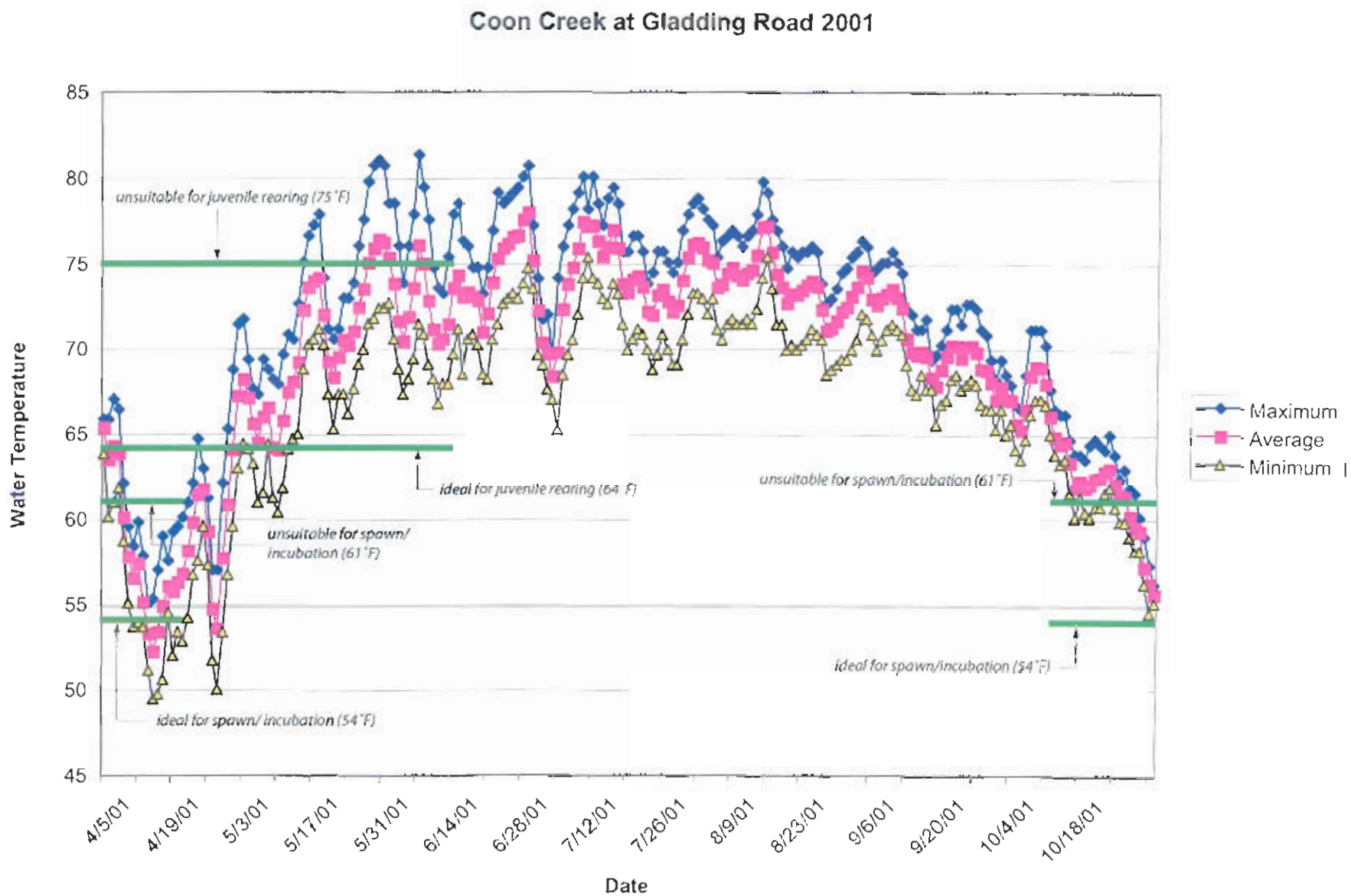

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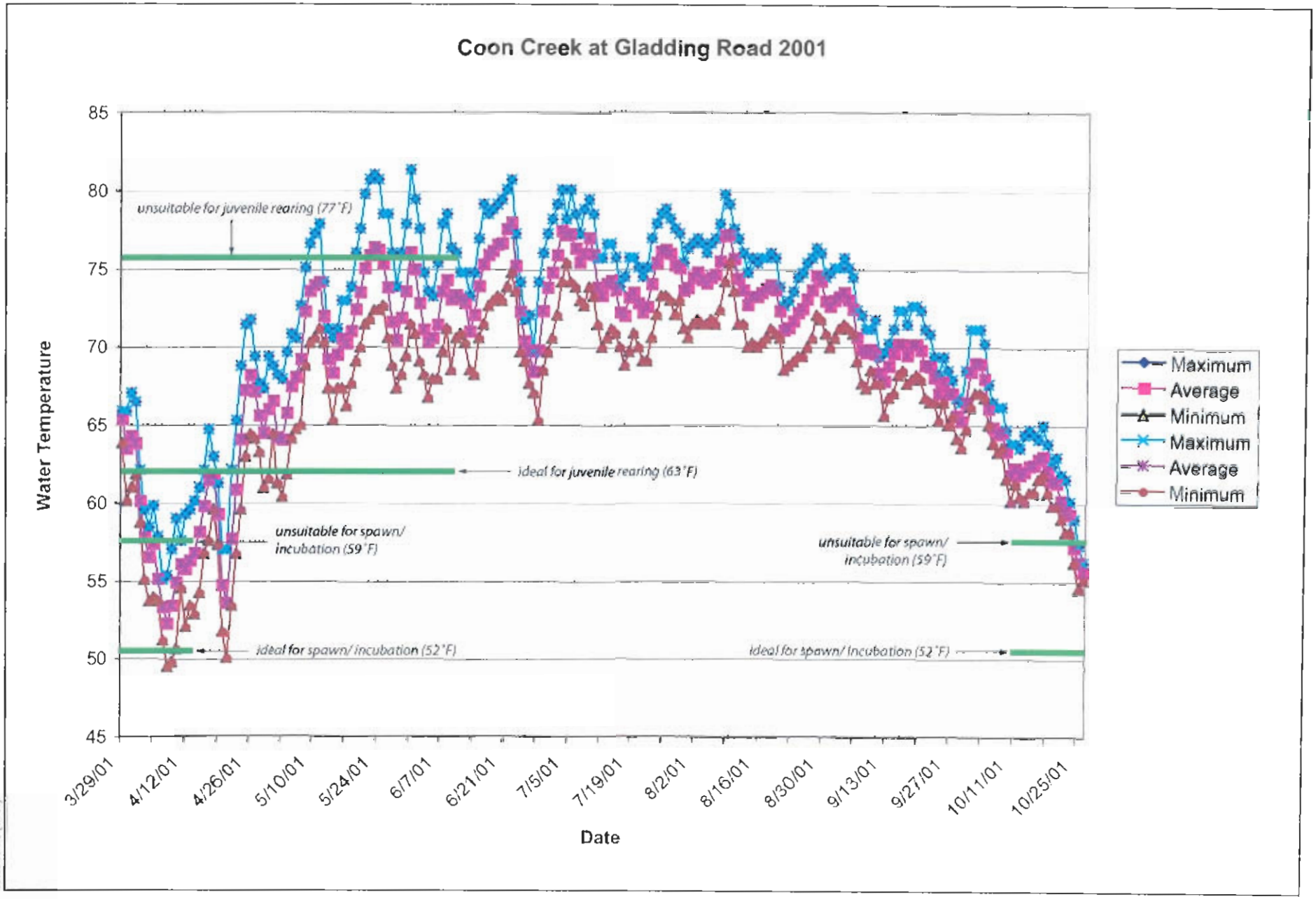
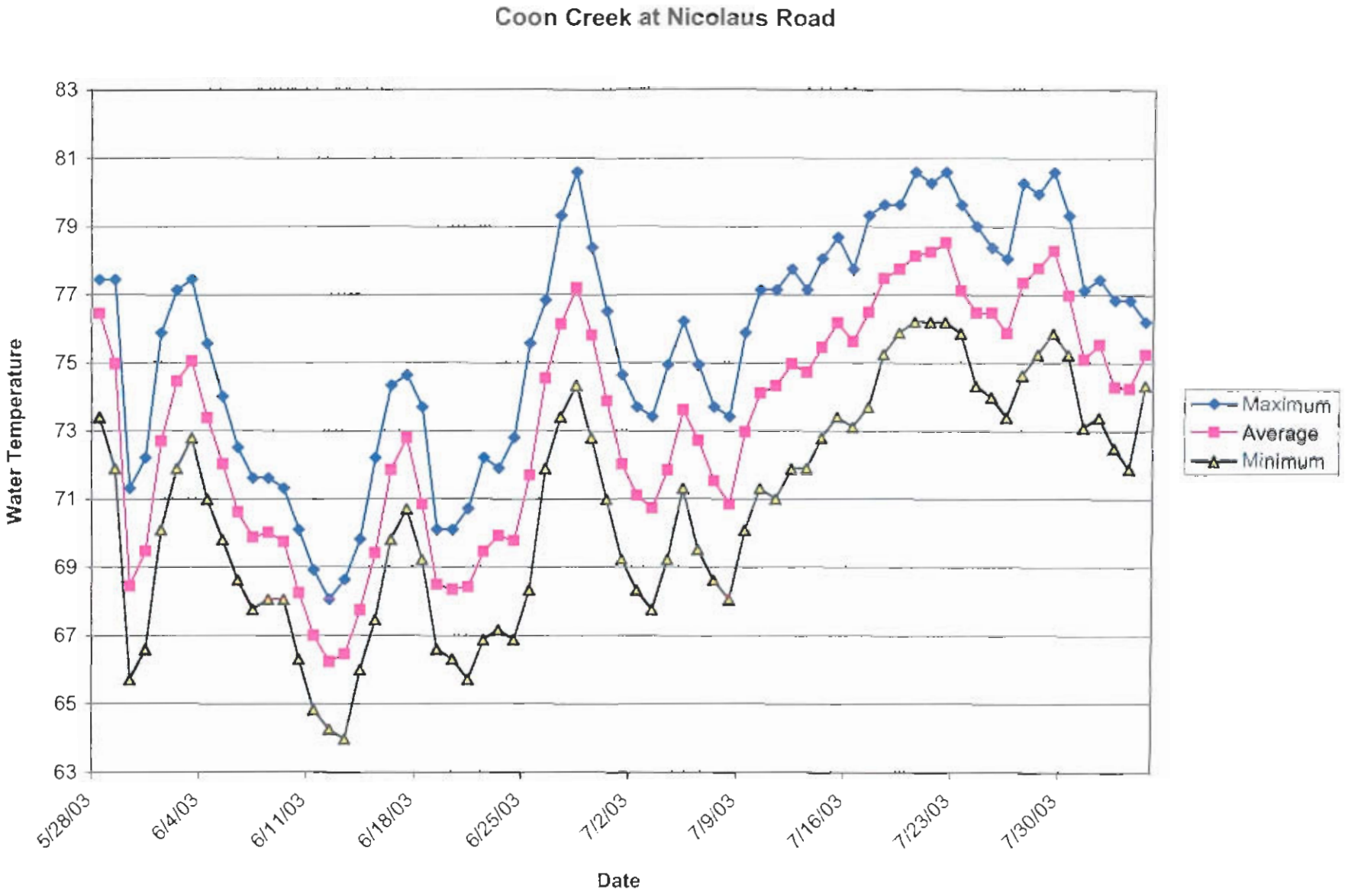
Figure 5
Water temperature in Coon Creek at Gladding Road in 2000 relative to the lower limit of unsuitable water temperature thresholds and ideal water temperature thresholds for Chinook salmon spawning/incubation and rearing life stages



Jones & Stokes

Figure 6
Water temperature in Coon Creek at Gladding Road in 2000 relative to the lower limit of unsuitable water temperature thresholds and ideal water temperature thresholds for steelhead spawning/incubation and rearing life stages


Coon Creek at Nicolaus Road
Water Temperature
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81
79
77
75
73
71
69
67
65
63
5/28/03
6/4/03
6/11/03
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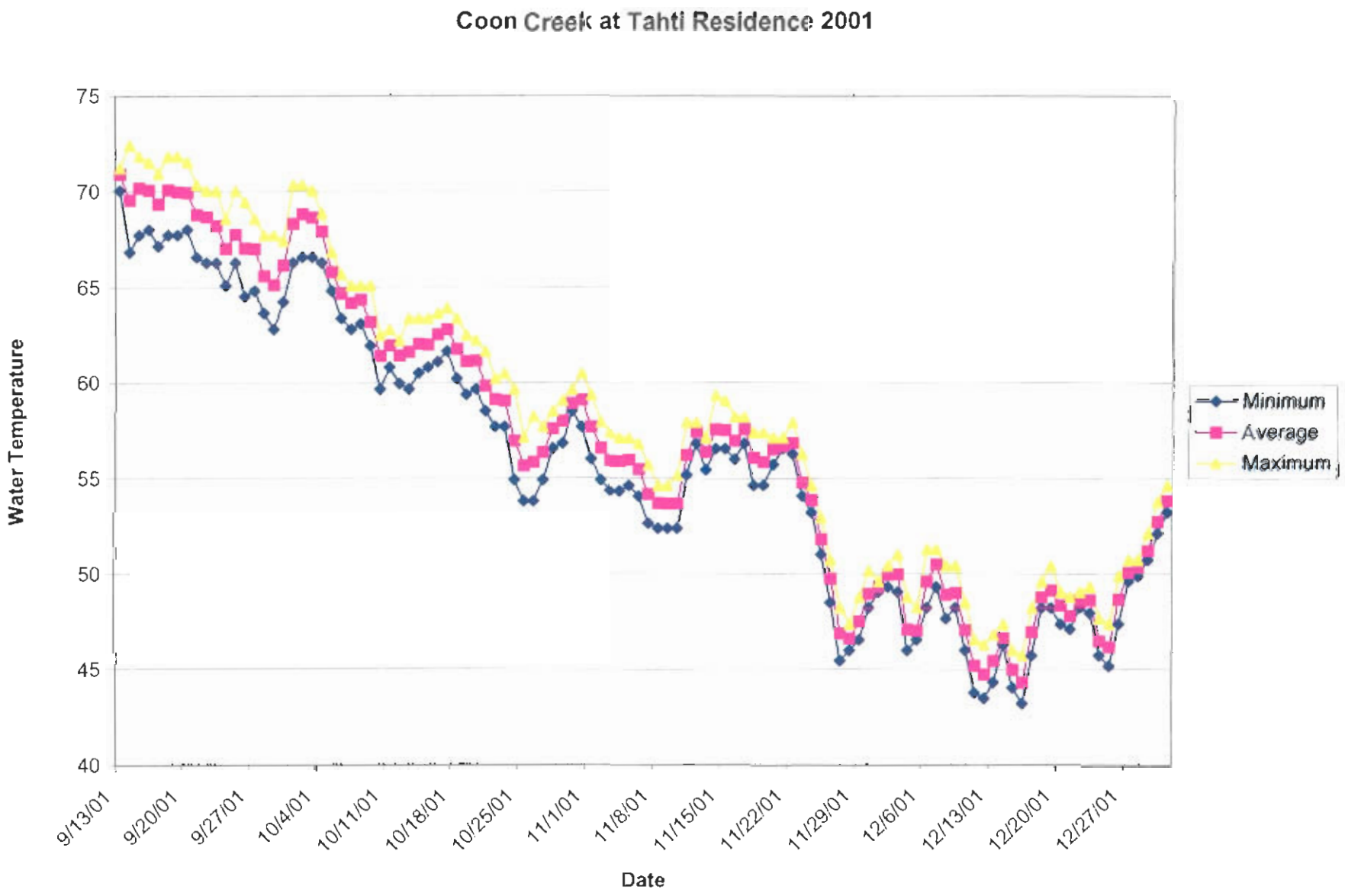
7/30/03
Date
Maximum
Average
Minimum


Coon Creek at Tahti Residence 2001
Water Temperature
75
70
65
60
55
50
45
40
9/13/01
9/20/01
9/27/01
10/4/01
10/11/01
10/18/01
10/25/01
11/1/01
11/8/01
11/15/01
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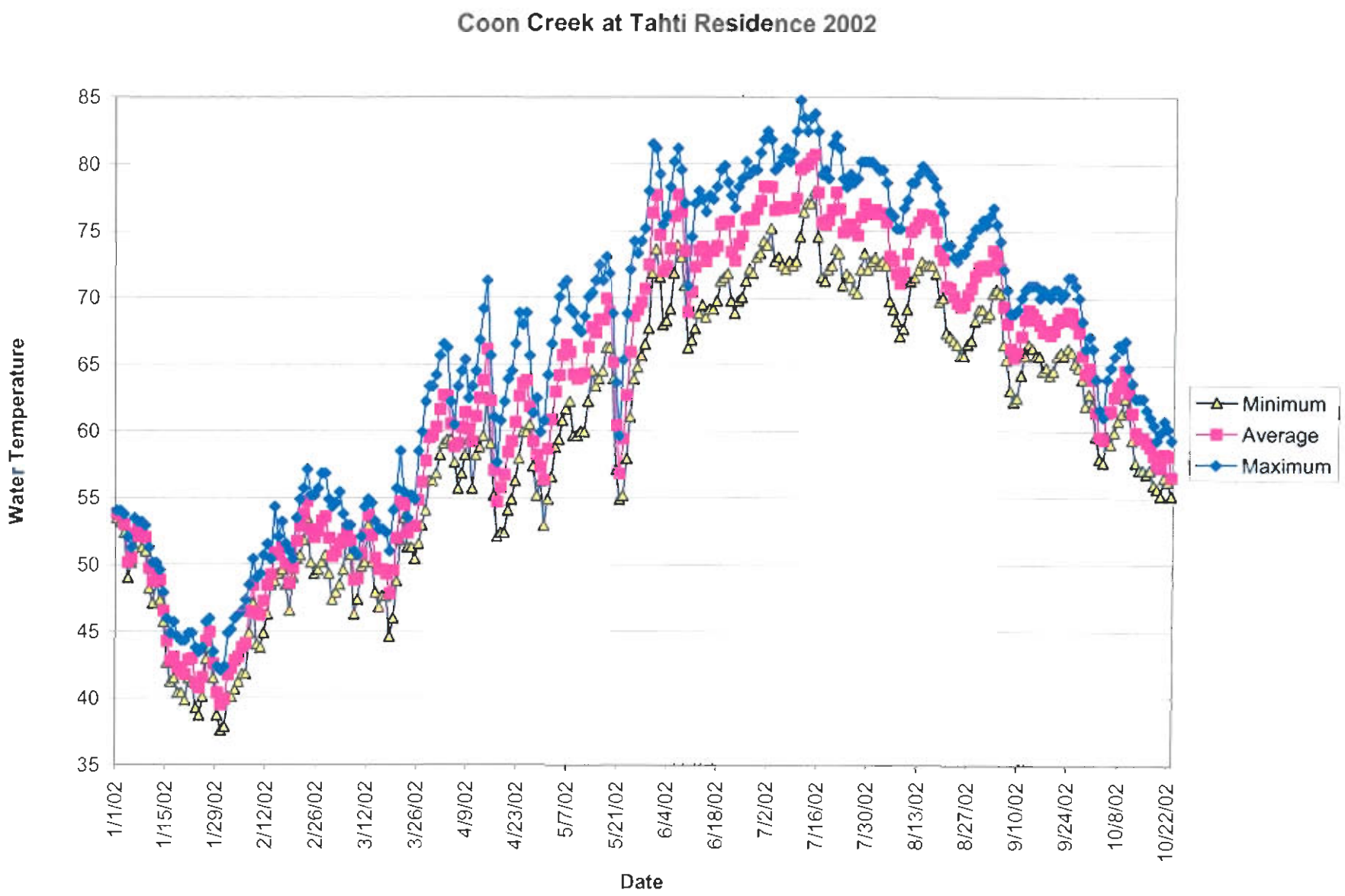
12/13/01
12/20/01
12/27/01
Date
Minimum
Average
Maximum


Coon Creek at Tahti Residence 2002
Water Temperature
85
80
75
70
65
60
55
50
45
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35
1/1/02
1/15/02
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2/12/02
2/26/02
3/12/02
3/26/02
4/9/02
4/23/02
5/7/02
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7/2/02
7/16/02
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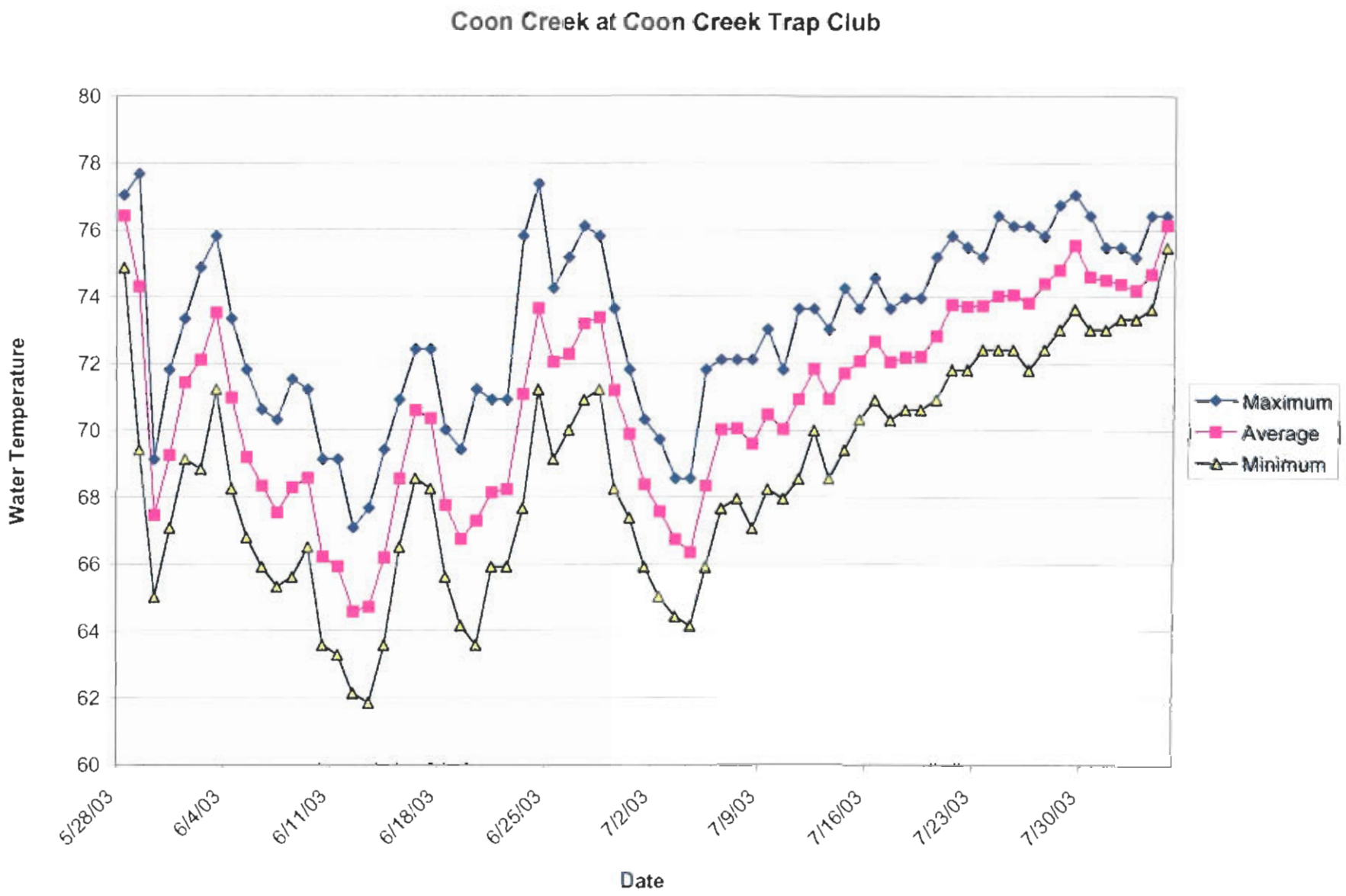
Date
Minimum
Average
Maximum


Coon Creek at Coon Creek Trap Club
Water Temperature
80
78
76
74
72
70
68
66
64
62
60
5/28/03
6/4/03
6/11/03
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7/30/03
Date
Maximum
Average
Minimum

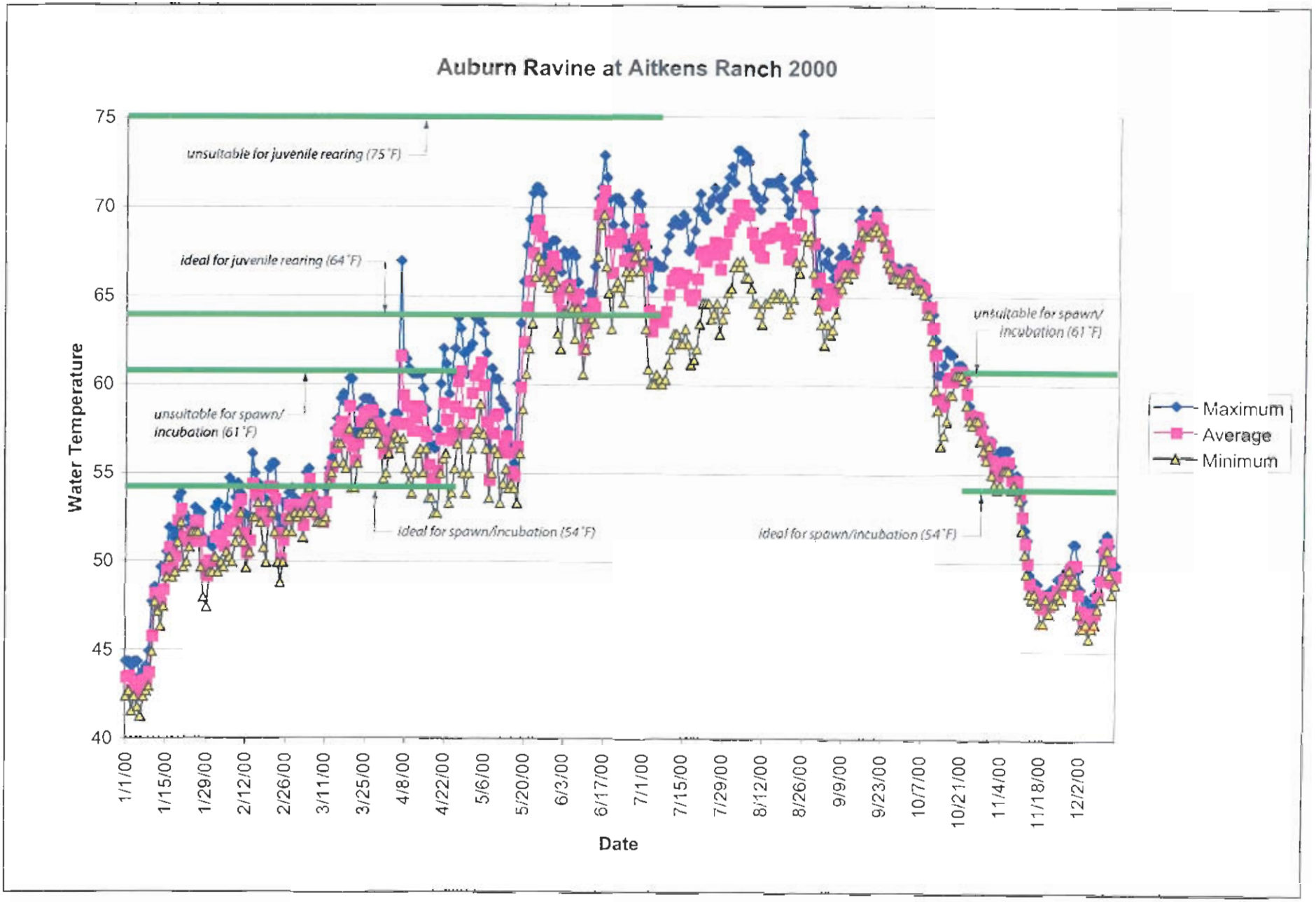

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Figure 1
Water temperature in Auburn Ravine at Aitkens Ranch in 2000 relative to the lower limit of unsuitable water temperature thresholds and ideal water temperature thresholds for Chinook salmon spawning/incubation and rearing life stages

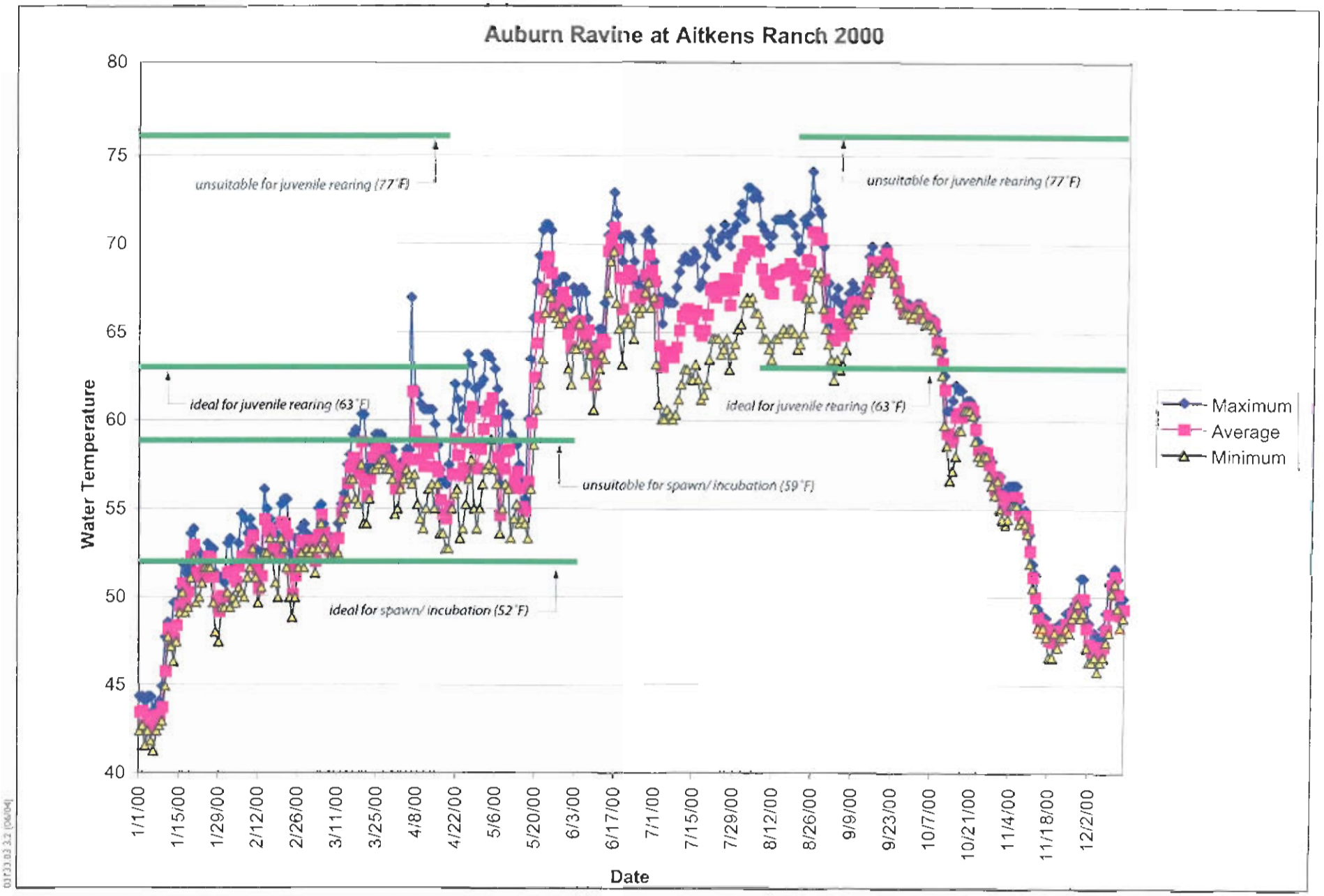

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Figure 2
Water temperature in Auburn Ravine at Aitkens Ranch in 2000 relative to the lower limit of unsuitable water temperature thresholds and ideal water temperature thresholds for steelhead spawning/incubation and rearing life stages

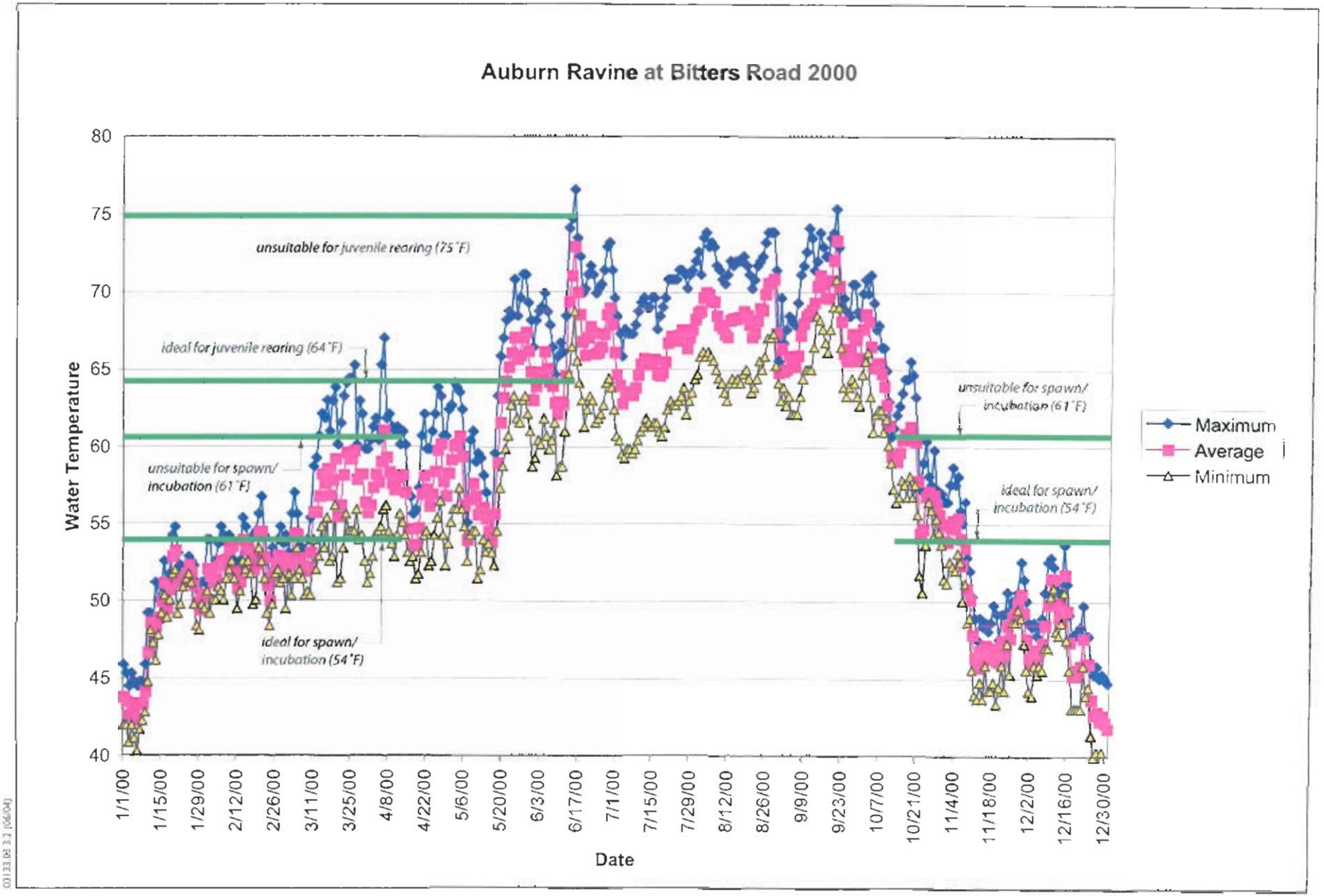

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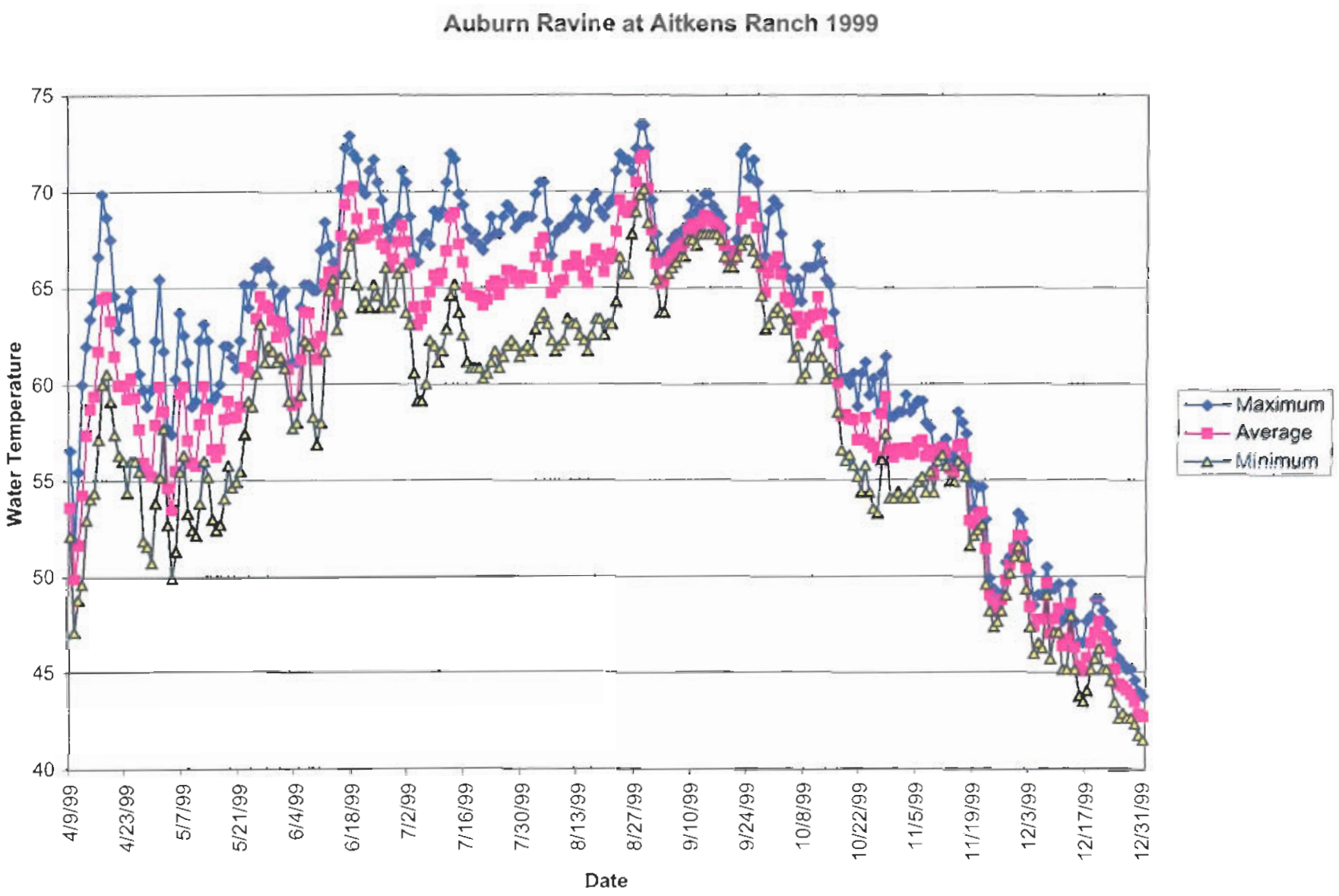
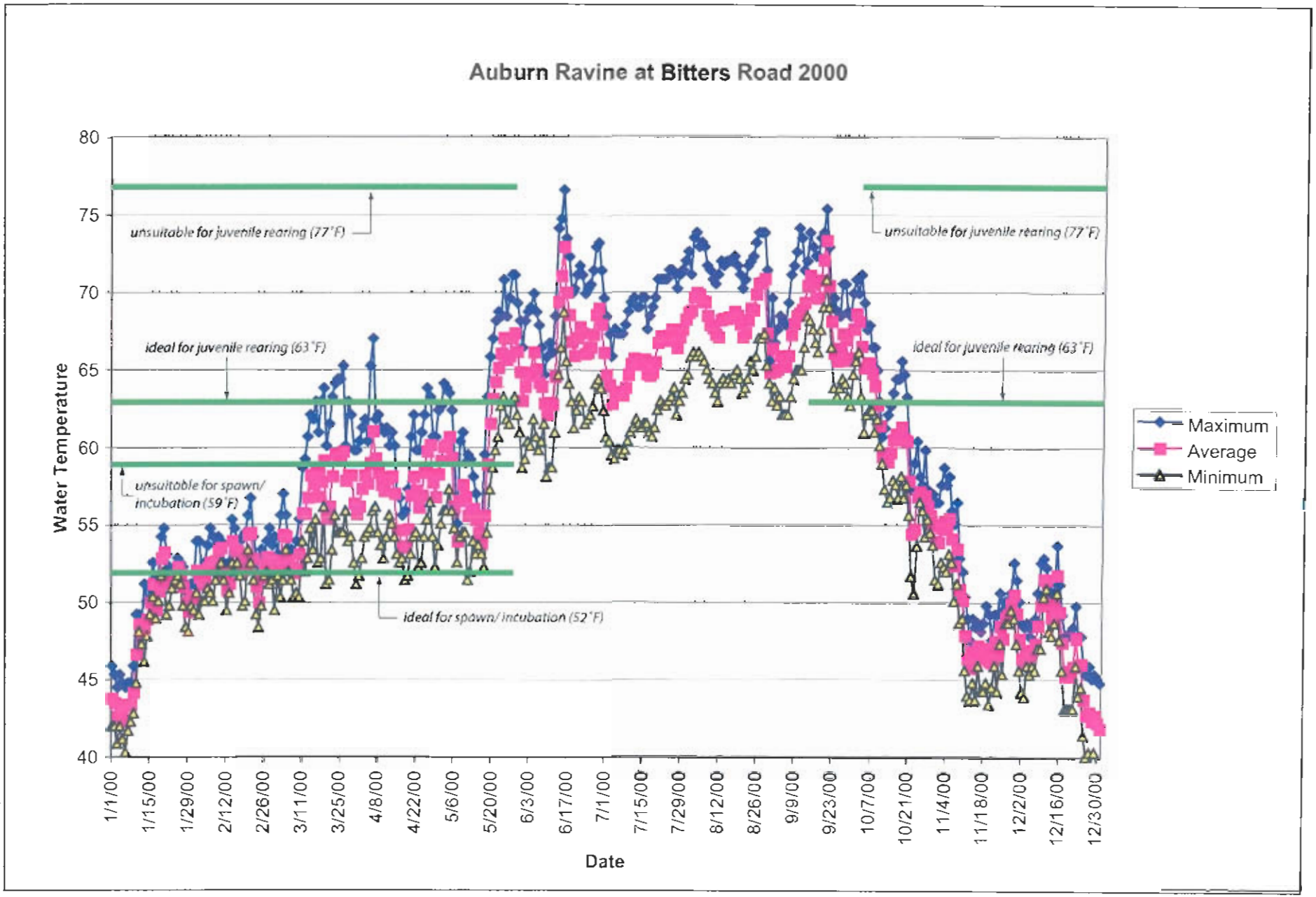
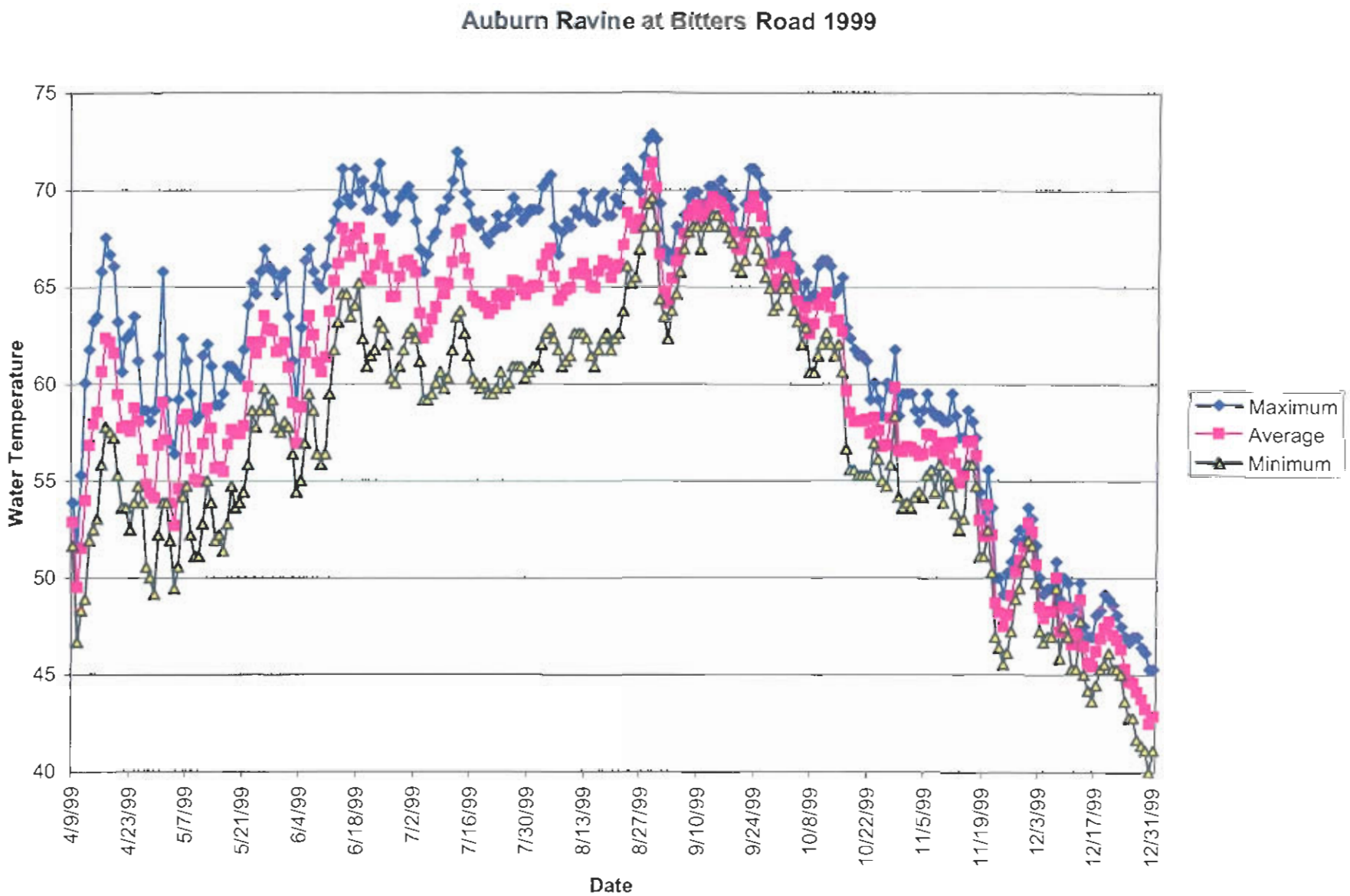
Figure 3
Water temperature in Auburn Ravine at Bitters Road in 2000 relative to the lower limit of unsuitable water temperature thresholds and ideal water temperature thresholds for Chinook salmon spawning/incubation and rearing life stages

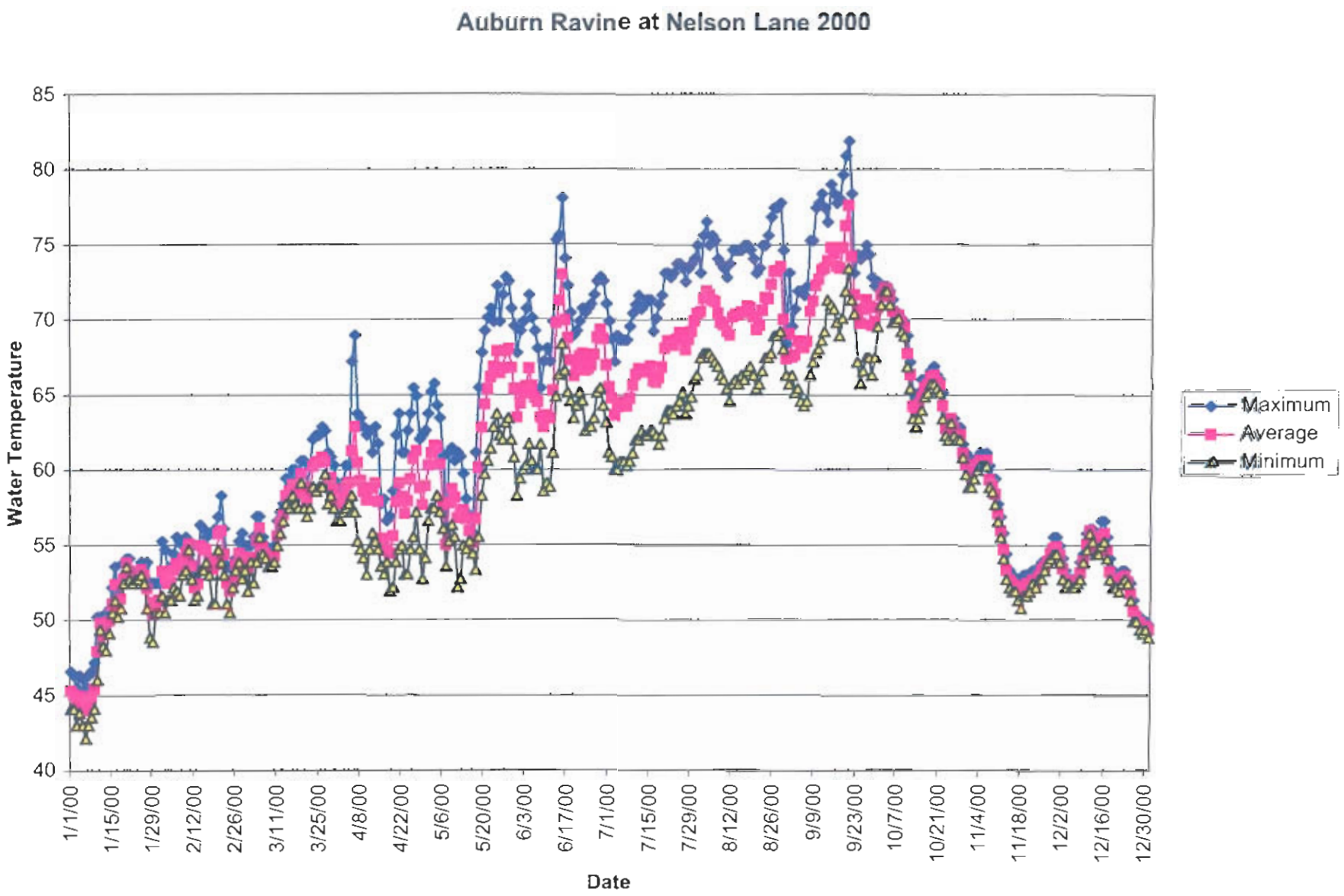

Auburn Ravine at Aitkens Ranch 1999
Water Temperature
75
70
65
60
55
50
45
40
4/9/99
4/23/99
5/7/99
5/21/99
6/4/99
6/18/99
7/2/99
7/16/99
7/30/99
8/13/99
8/27/99
9/10/99
9/24/99
10/8/99
10/22/99
11/5/99
11/19/99
12/3/99
12/17/99
12/31/99
Date
Maximum
Average
Minimum

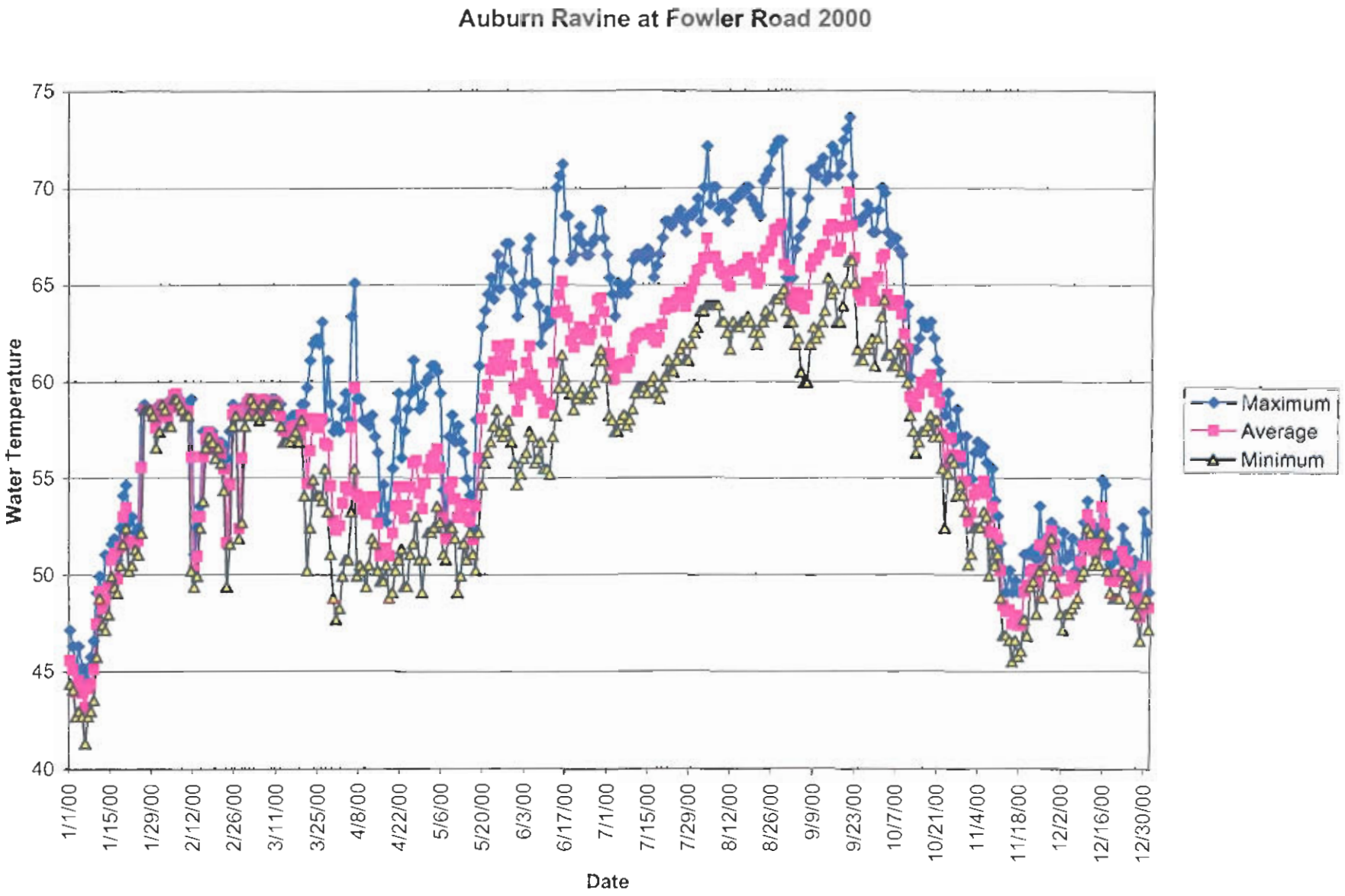


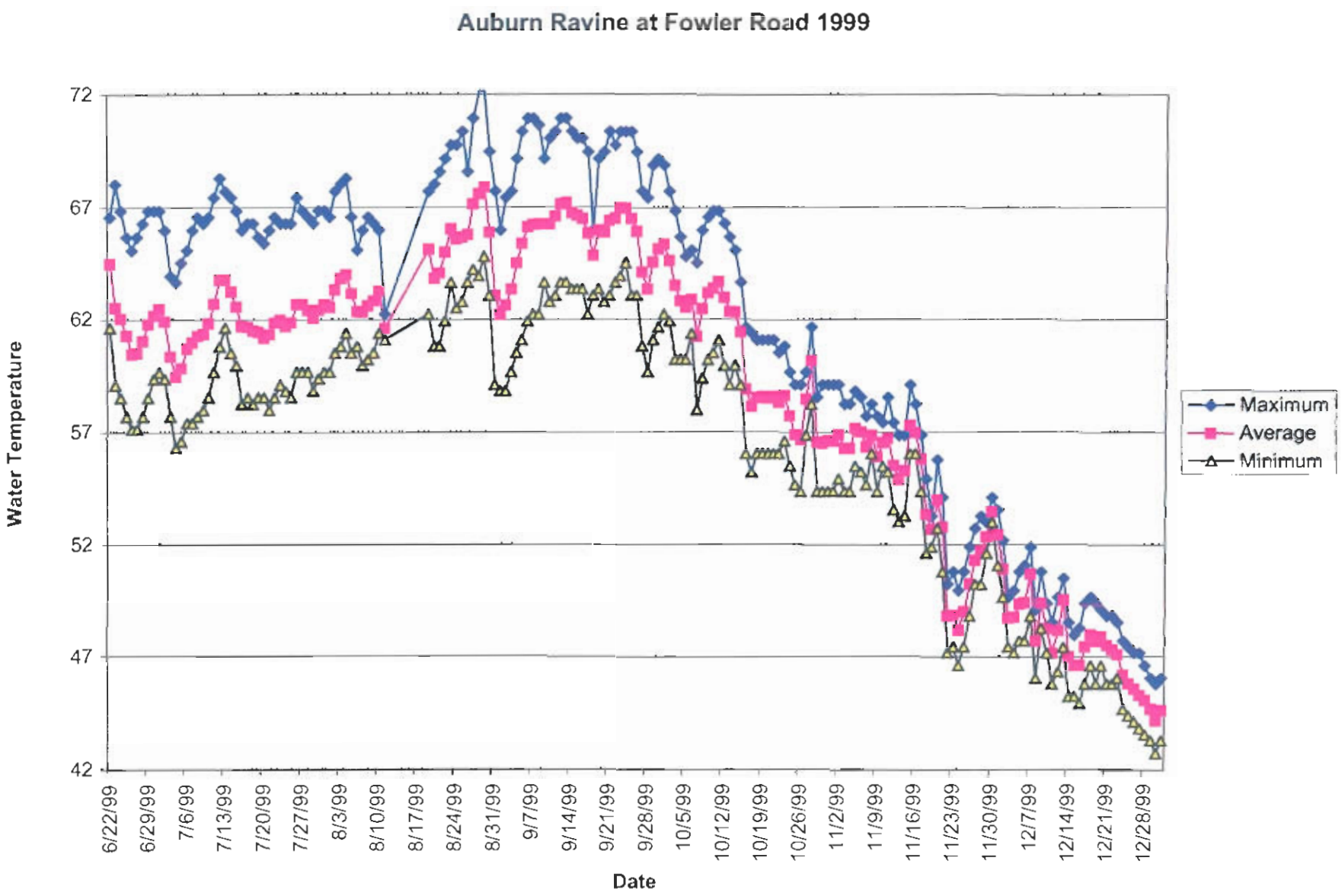
Jones & Stokes

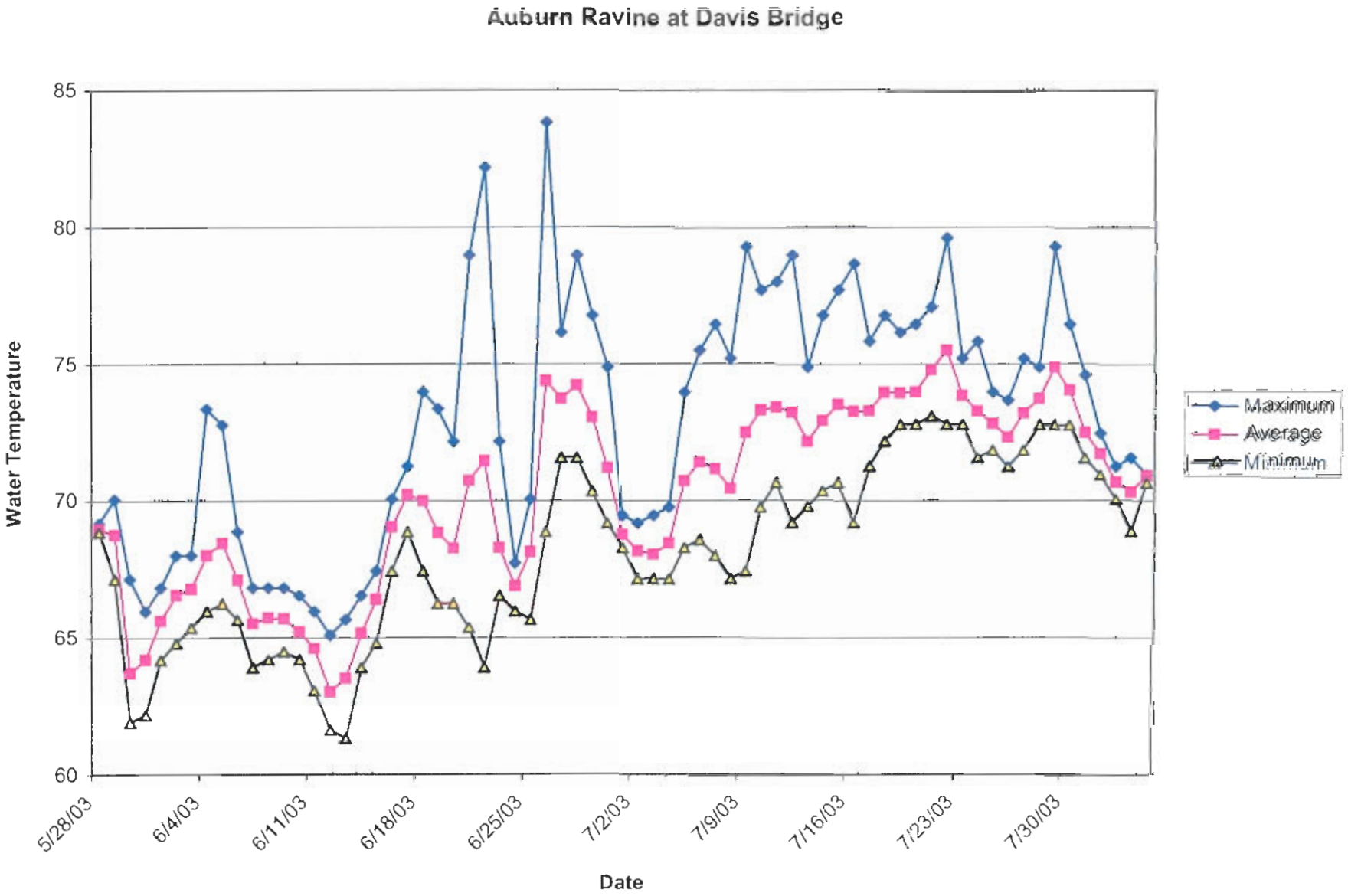
Figure 4
Water temperature in Auburn Ravine at Bitters Road in 2000 relative to the lower limit of unsuitable water temperature thresholds and ideal water temperature thresholds for steelhead spawning/incubation and rearing life stages

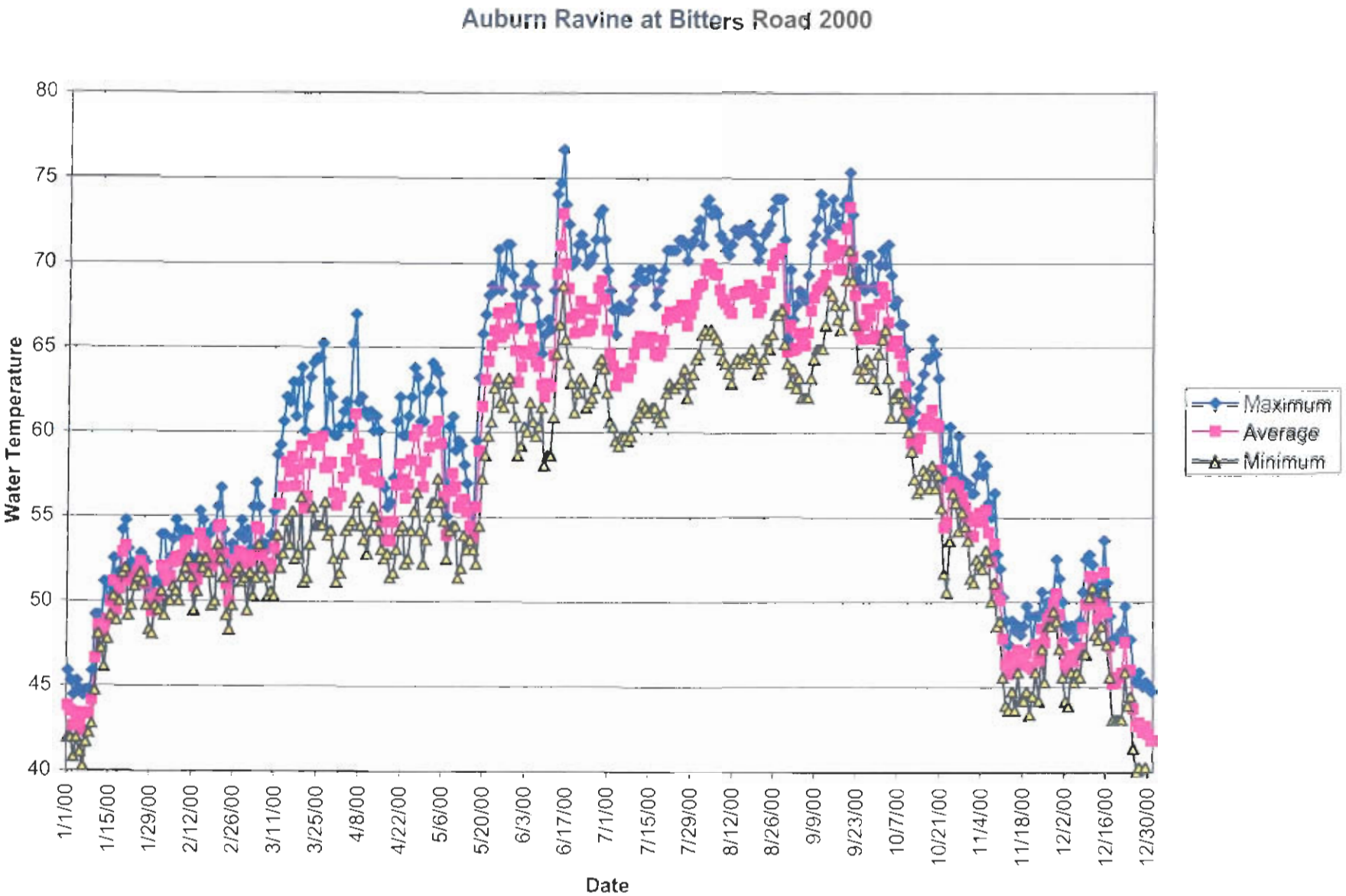

Auburn Ravine at Bitters Road 1999
Water Temperature
75
70
65
60
55
50
45
40
4/9/99
4/23/99
5/7/99
5/21/99
6/4/99
6/18/99
7/2/99
7/16/99
7/30/99
8/13/99
8/27/99
9/10/99
9/24/99
10/8/99
10/22/99
11/5/99
11/19/99
12/3/99
12/17/99
12/31/99
Date
Maximum
Average
Minimum

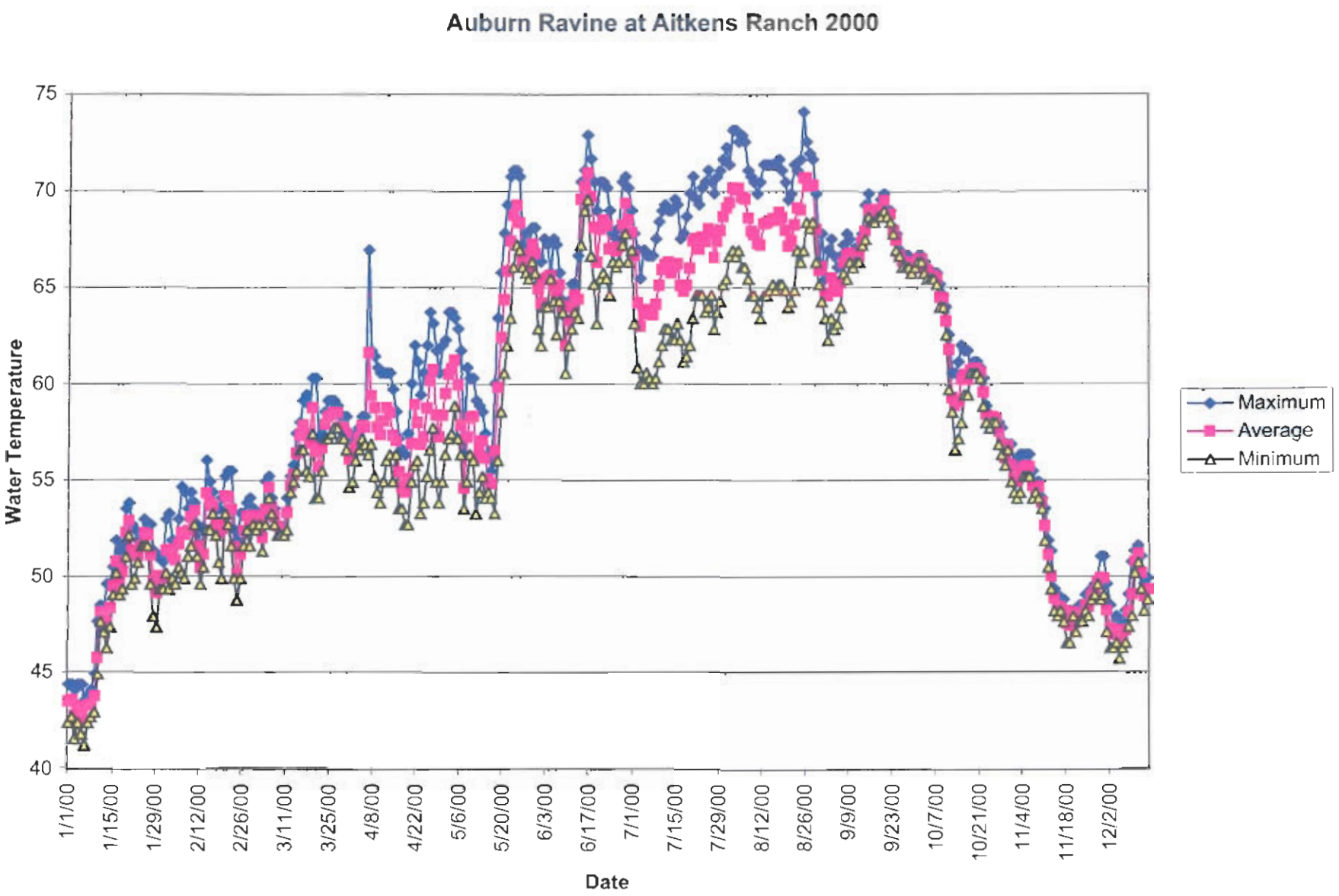

Auburn Ravine at Nelson Lane 2000
Water Temperature
85
80
75
70
65
60
55
50
45
40
1/1/00
1/15/00
1/29/00
2/12/00
2/26/00
3/11/00
3/25/00
4/8/00
4/22/00
5/6/00
5/20/00
6/3/00
6/17/00
7/1/00
7/15/00
7/29/00
8/12/00
8/26/00
9/9/00
9/23/00
10/7/00
10/21/00
11/4/00
11/18/00
12/2/00
12/16/00
12/30/00
Date
Maximum
Average
Minimum

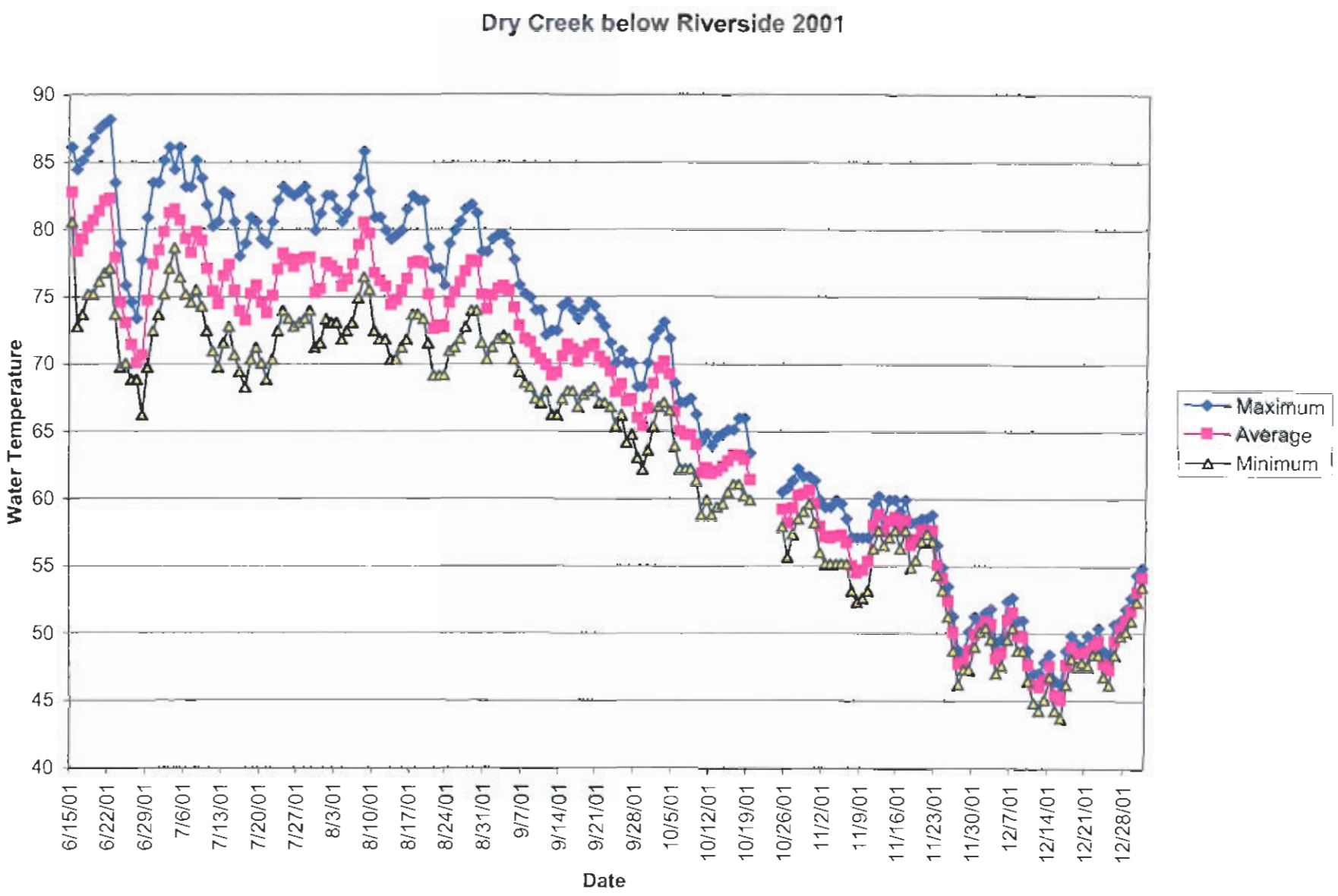

Auburn Ravine at Fowler Road 2000
Water Temperature
75
70
65
60
55
50
45
40
1/1/00
1/15/00
1/29/00
2/12/00
2/26/00
3/11/00
3/25/00
4/8/00
4/22/00
5/6/00
5/20/00
6/3/00
6/17/00
7/1/00
7/15/00
7/29/00
8/12/00
8/26/00
9/9/00
9/23/00
10/7/00
10/21/00
11/4/00
11/18/00
12/2/00
12/16/00
12/30/00
Date
Maximum
Average
Minimum

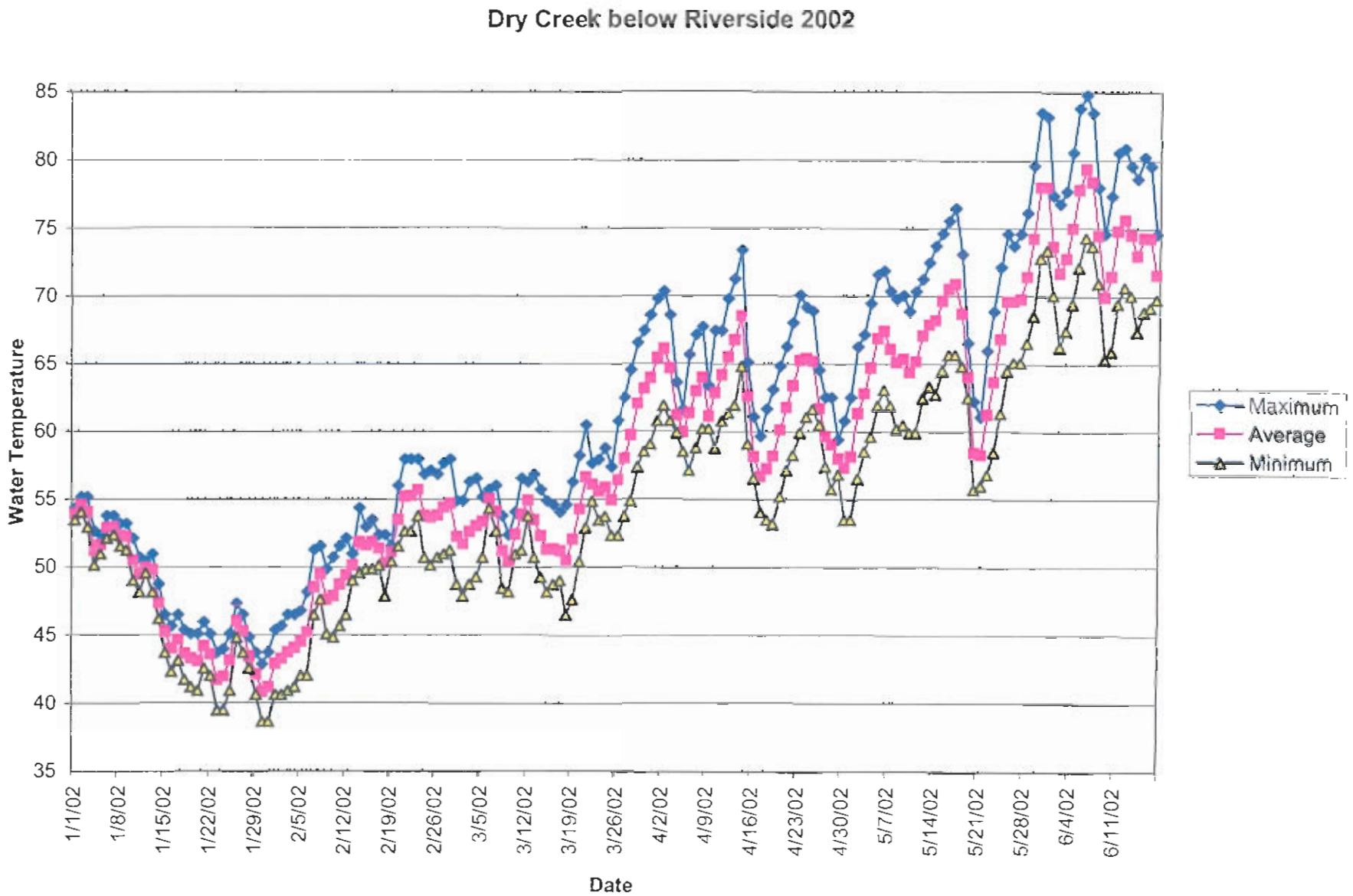

Auburn Ravine at Fowler Road 1999
Water Temperature
72
67
62
57
52
47
42
6/22/99
6/29/99
7/6/99
7/13/99
7/20/99
7/27/99
8/3/99
8/10/99
8/17/99
8/24/99
8/31/99
9/7/99
9/14/99
9/21/99
9/28/99
10/5/99
10/12/99
10/19/99
10/26/99
11/2/99
11/9/99
11/16/99
11/23/99
11/30/99
12/7/99
12/14/99
12/21/99
12/28/99
Date
Maximum
Average
Minimum

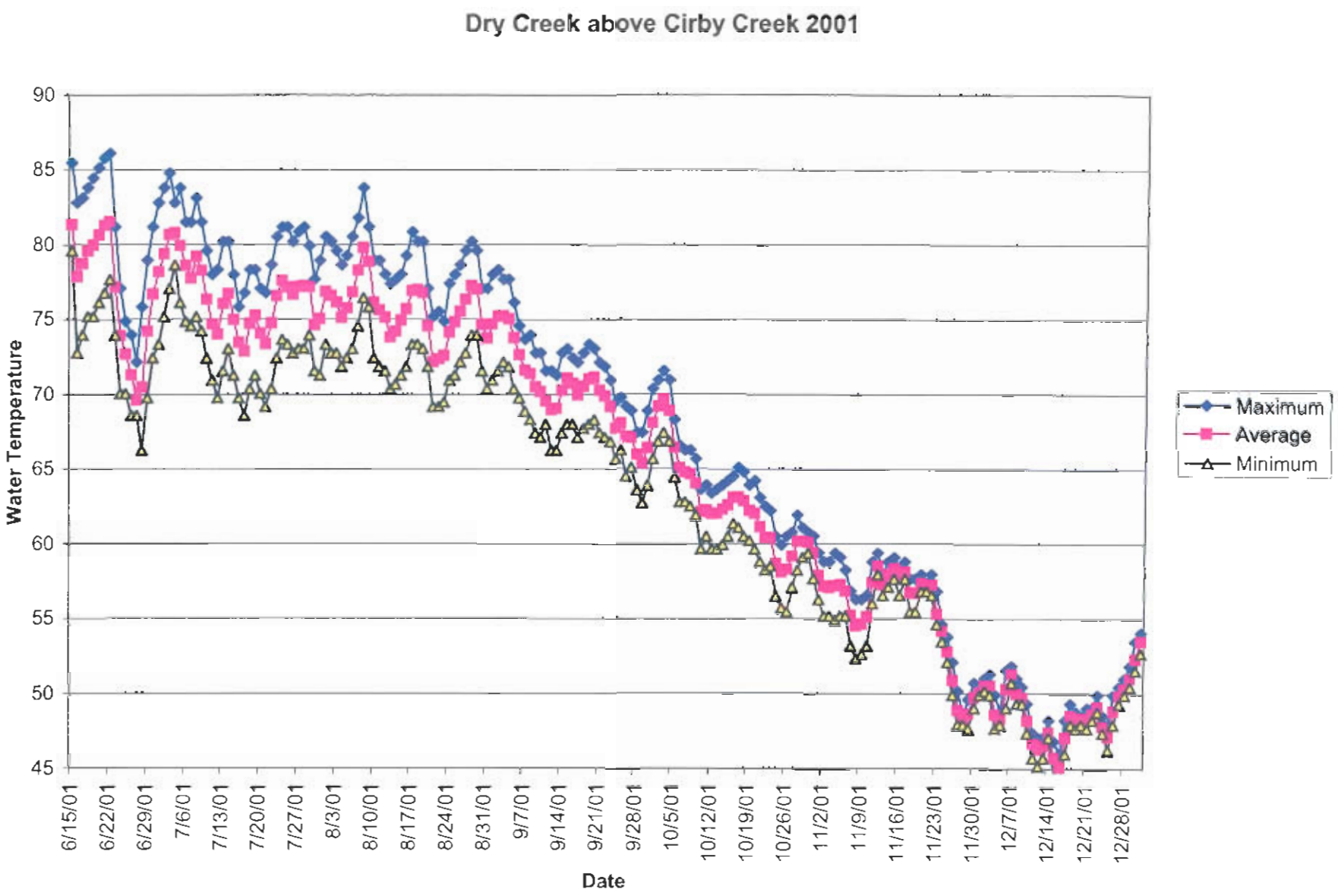

Auburn Ravine at Davis Bridge
Water Temperature
85
80
75
70
65
60
5/28/03
6/4/03
6/11/03
6/18/03
6/25/03
7/2/03
7/9/03
7/16/03
7/23/03
7/30/03
Date
Maximum
Average
Minimum

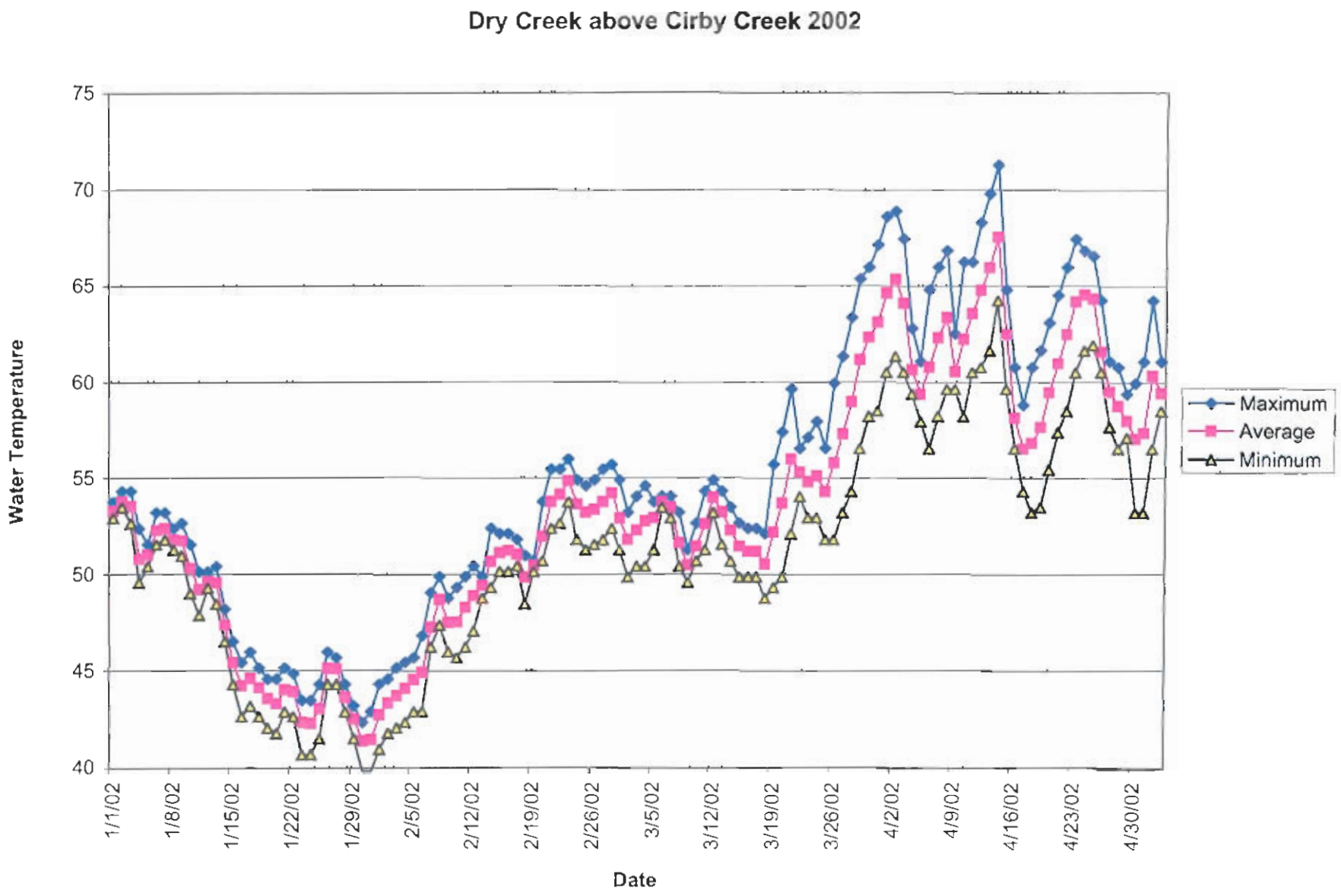

Auburn Ravine at Bitters Road 2000
Water Temperature
80
75
70
65
60
55
50
45
40
1/1/00
1/15/00
1/29/00
2/12/00
2/26/00
3/11/00
3/25/00
4/8/00
4/22/00
5/6/00
5/20/00
6/3/00
6/17/00
7/1/00
7/15/00
7/29/00
8/12/00
8/26/00
9/9/00
9/23/00
10/7/00
10/21/00
11/4/00
11/18/00
12/2/00
12/16/00
12/30/00
Date
Maximum
Average
Minimum

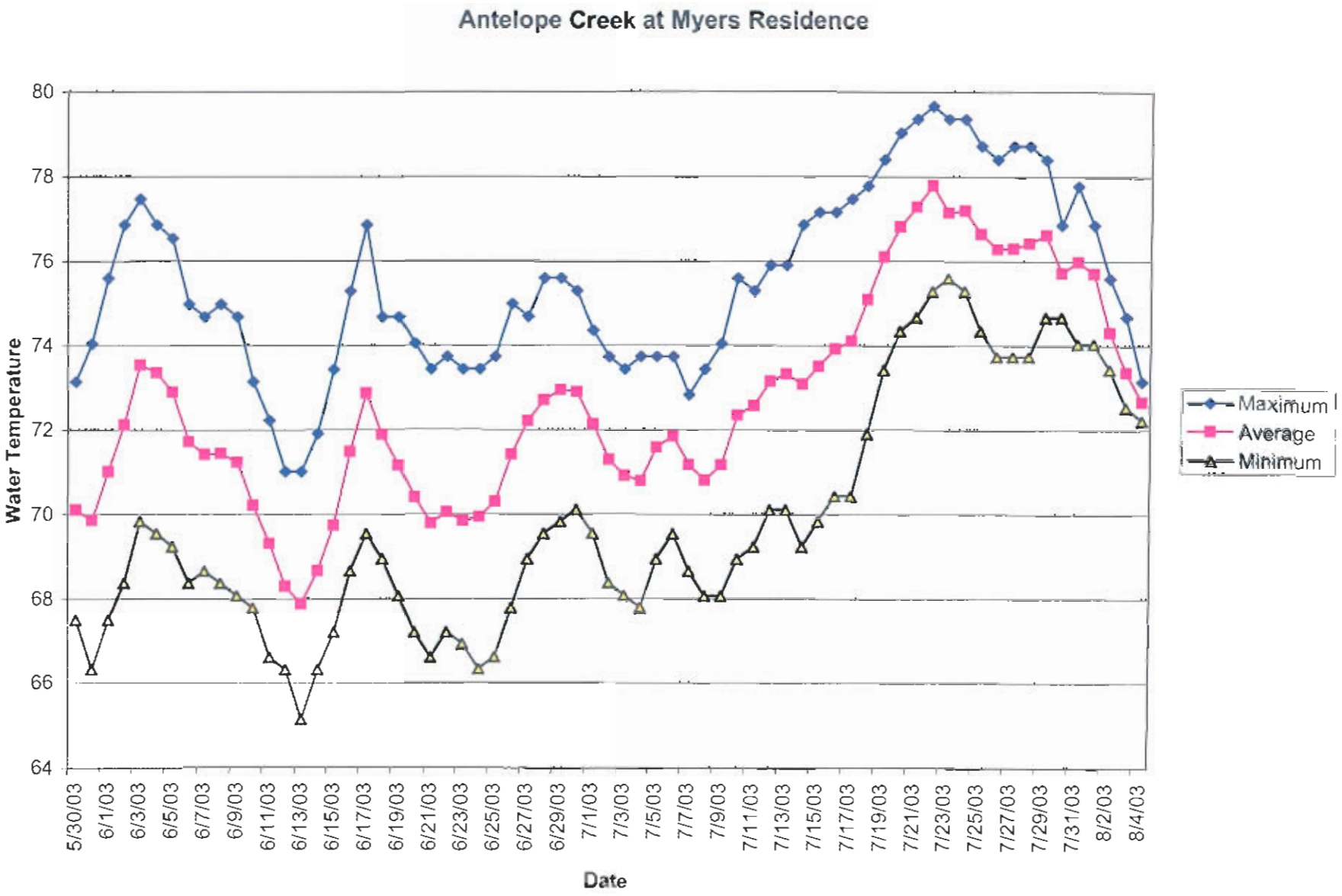

Auburn Ravine at Aitkens Ranch 2000
Water Temperature
75
70
65
60
55
50
45
40
1/1/00
1/15/00
1/29/00
2/12/00
2/26/00
3/11/00
3/25/00
4/8/00
4/22/00
5/6/00
5/20/00
6/3/00
6/17/00
7/1/00
7/15/00
7/29/00
8/12/00
8/26/00
9/9/00
9/23/00
10/7/00
10/21/00
11/4/00
11/18/00
12/2/00
Date
Maximum
Average
Minimum

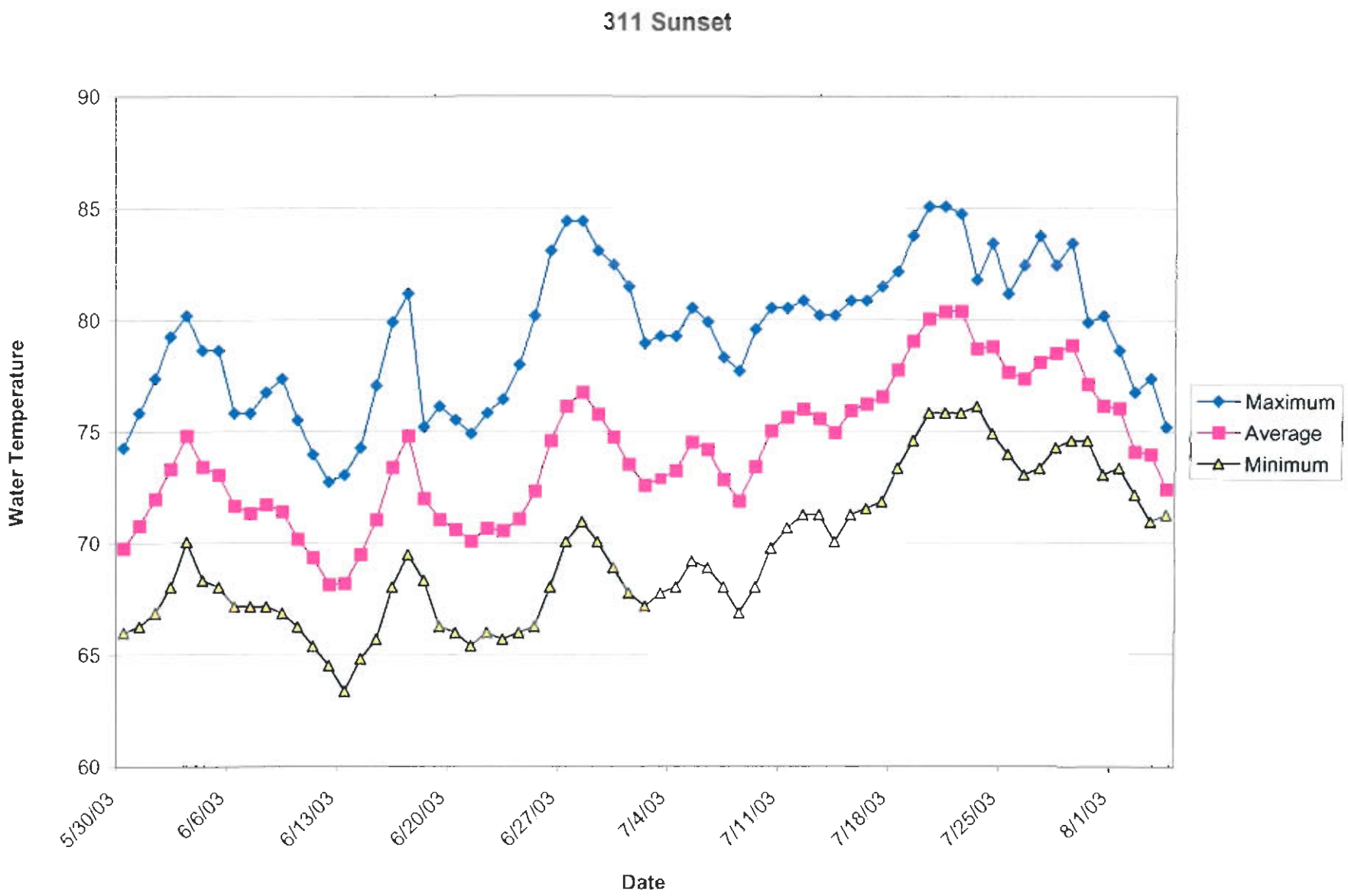

Dry Creek below Riverside 2001
Water Temperature
90
85
80
75
70
65
60
55
50
45
40
6/15/01
6/22/01
6/29/01
7/6/01
7/13/01
7/20/01
7/27/01
8/3/01
8/10/01
8/17/01
8/24/01
8/31/01
9/7/01
9/14/01
9/21/01
9/28/01
10/5/01
10/12/01
10/19/01
10/26/01
11/2/01
11/9/01
11/16/01
11/23/01
11/30/01
12/7/01
12/14/01
12/21/01
12/28/01
Date
Maximum
Average
Minimum

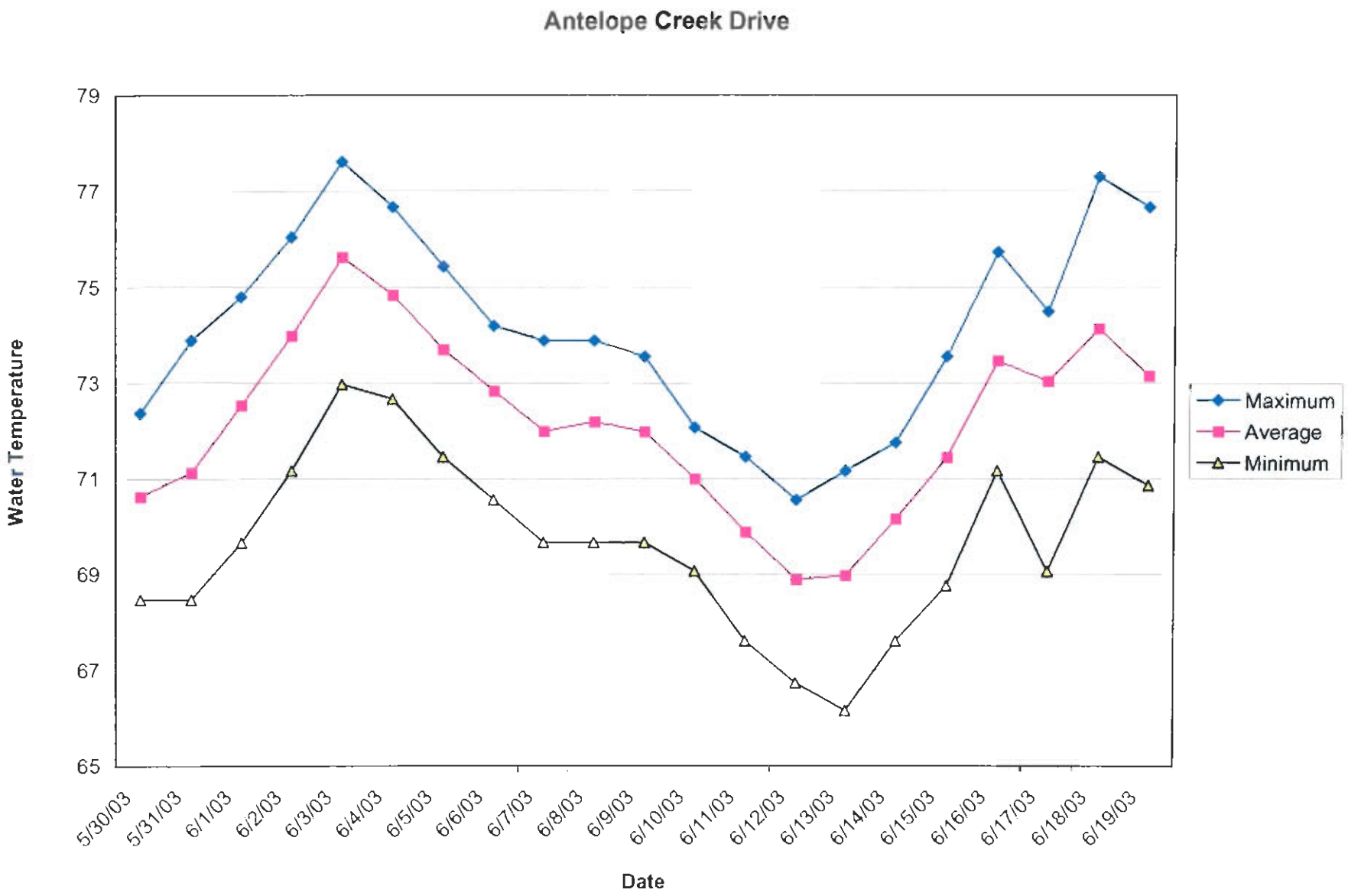

Dry Creek below Riverside 2002
Water Temperature
85
80
75
70
65
60
55
50
45
40
35
1/1/02
1/8/02
1/15/02
1/22/02
1/29/02
2/5/02
2/12/02
2/19/02
2/26/02
3/5/02
3/12/02
3/19/02
3/26/02
4/2/02
4/9/02
4/16/02
4/23/02
4/30/02
5/7/02
5/14/02
5/21/02
5/28/02
6/4/02
6/11/02
Date
Maximum
Average
Minimum

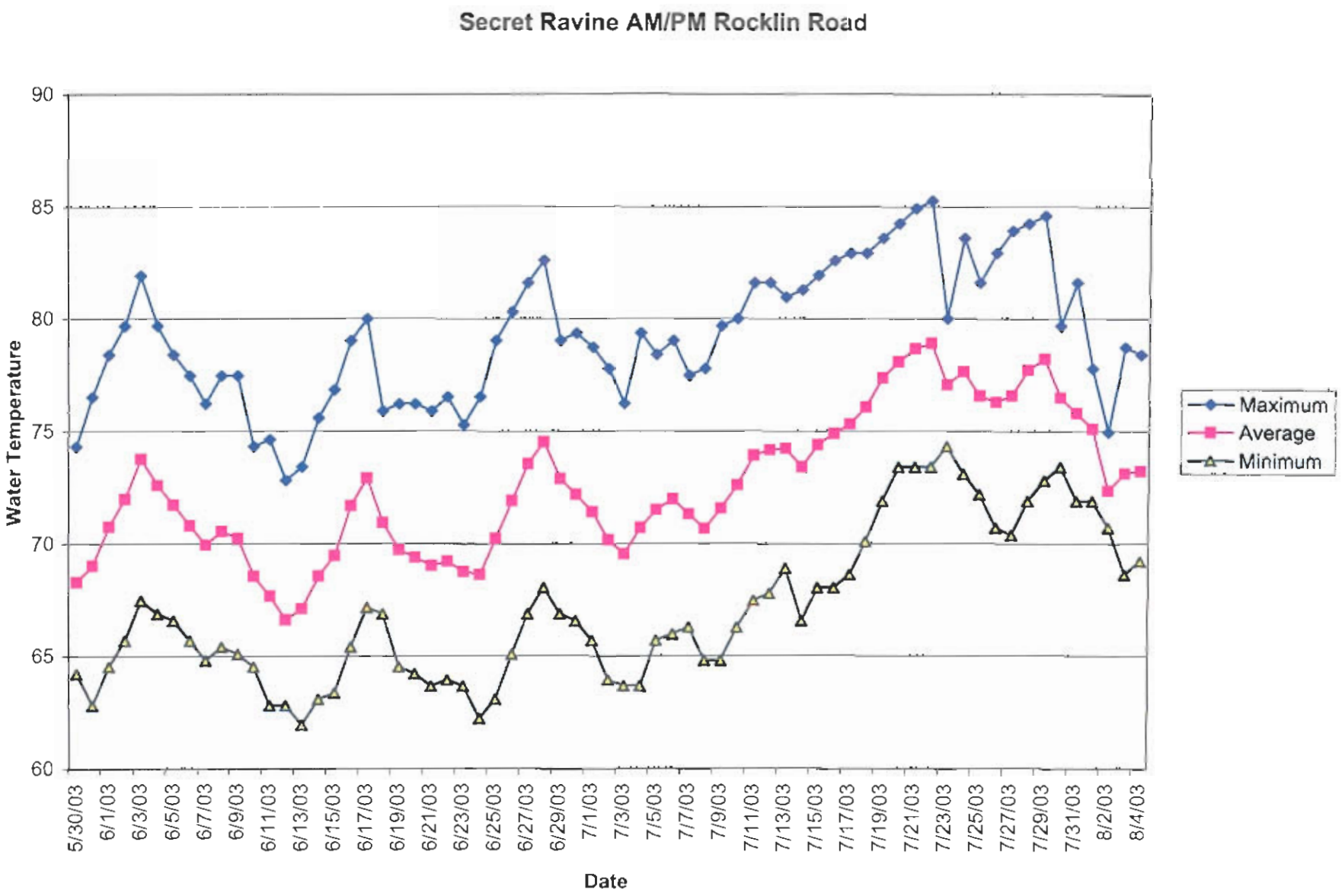

Dry Creek above Cirby Creek 2001
Water Temperature
90
85
80
75
70
65
60
55
50
45
6/15/01
6/22/01
6/29/01
7/6/01
7/13/01
7/20/01
7/27/01
8/3/01
8/10/01
8/17/01
8/24/01
8/31/01
9/7/01
9/14/01
9/21/01
9/28/01
10/5/01
10/12/01
10/19/01
10/26/01
11/2/01
11/9/01
11/16/01
11/23/01
11/30/01
12/7/01
12/14/01
12/21/01
12/28/01
Date
Maximum
Average
Minimum

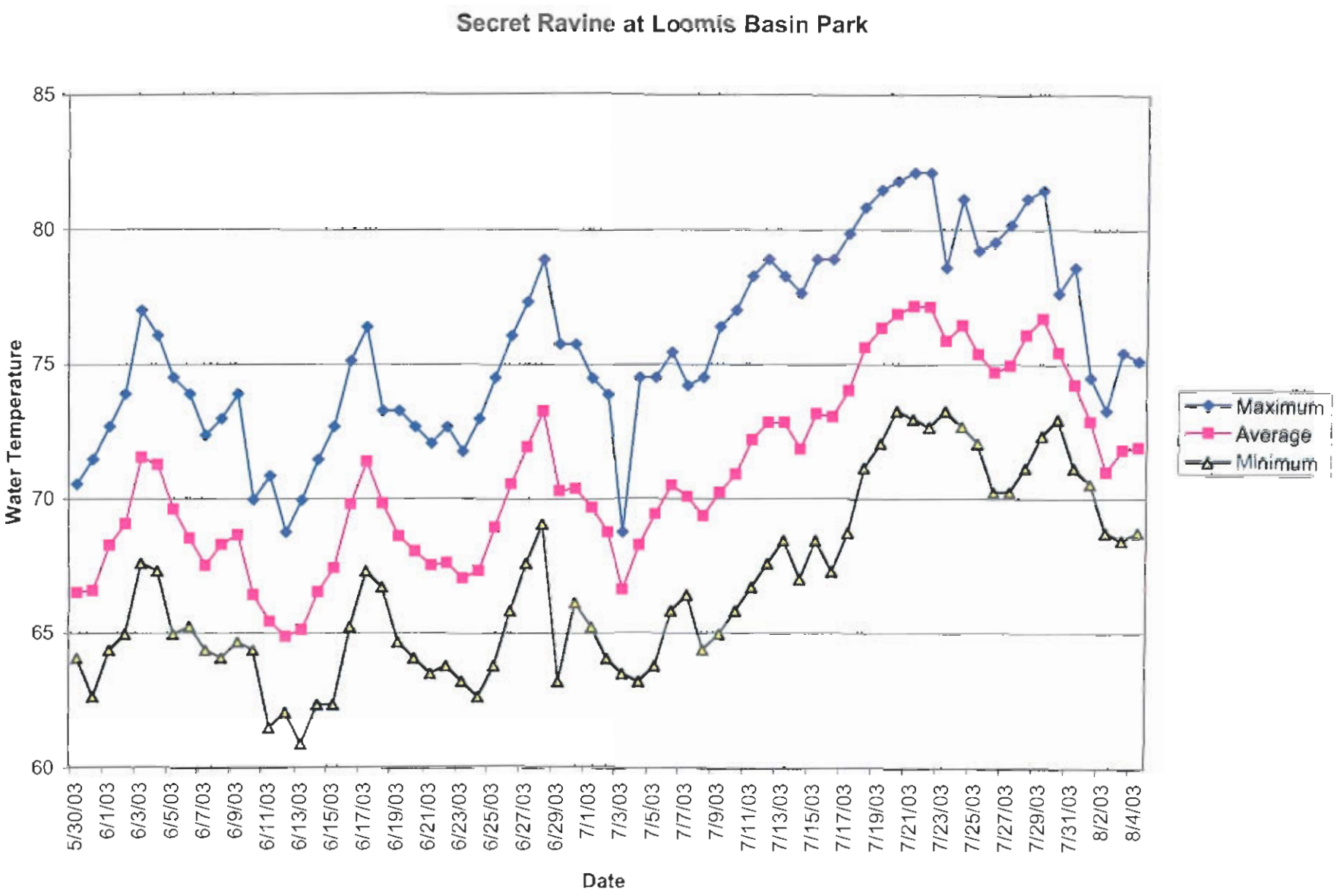

Dry Creek above Cirby Creek 2002
Water Temperature
75
70
65
60
55
50
45
40
1/1/02
1/8/02
1/15/02
1/22/02
1/29/02
2/5/02
2/12/02
2/19/02
2/26/02
3/5/02
3/12/02
3/19/02
3/26/02
4/2/02
4/9/02
4/16/02
4/23/02
4/30/02
Date
Maximum
Average
Minimum

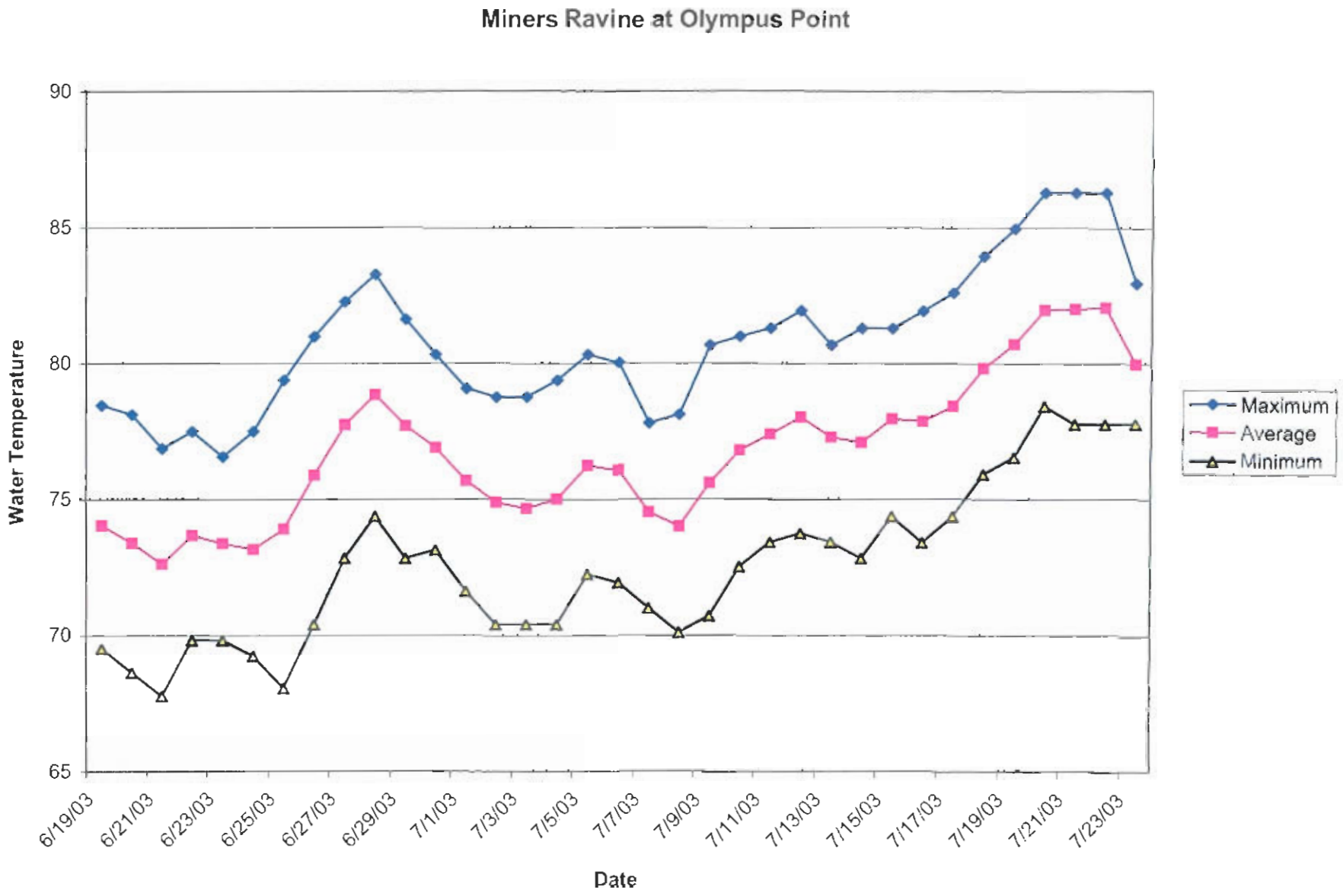

Antelope Creek at Myers Residence
Water Temperature
80
78
76
74
72
70
68
66
64
5/30/03
6/1/03
6/3/03
6/5/03
6/7/03
6/9/03
6/11/03
6/13/03
6/15/03
6/17/03
6/19/03
6/21/03
6/23/03
6/25/03
6/27/03
6/29/03
7/1/03
7/3/03
7/5/03
7/7/03
7/9/03
7/11/03
7/13/03
7/15/03
7/17/03
7/19/03
7/21/03
7/23/03
7/25/03
7/27/03
7/29/03
7/31/03
8/2/03
8/4/03
Date
Maximum
Average
Minimum

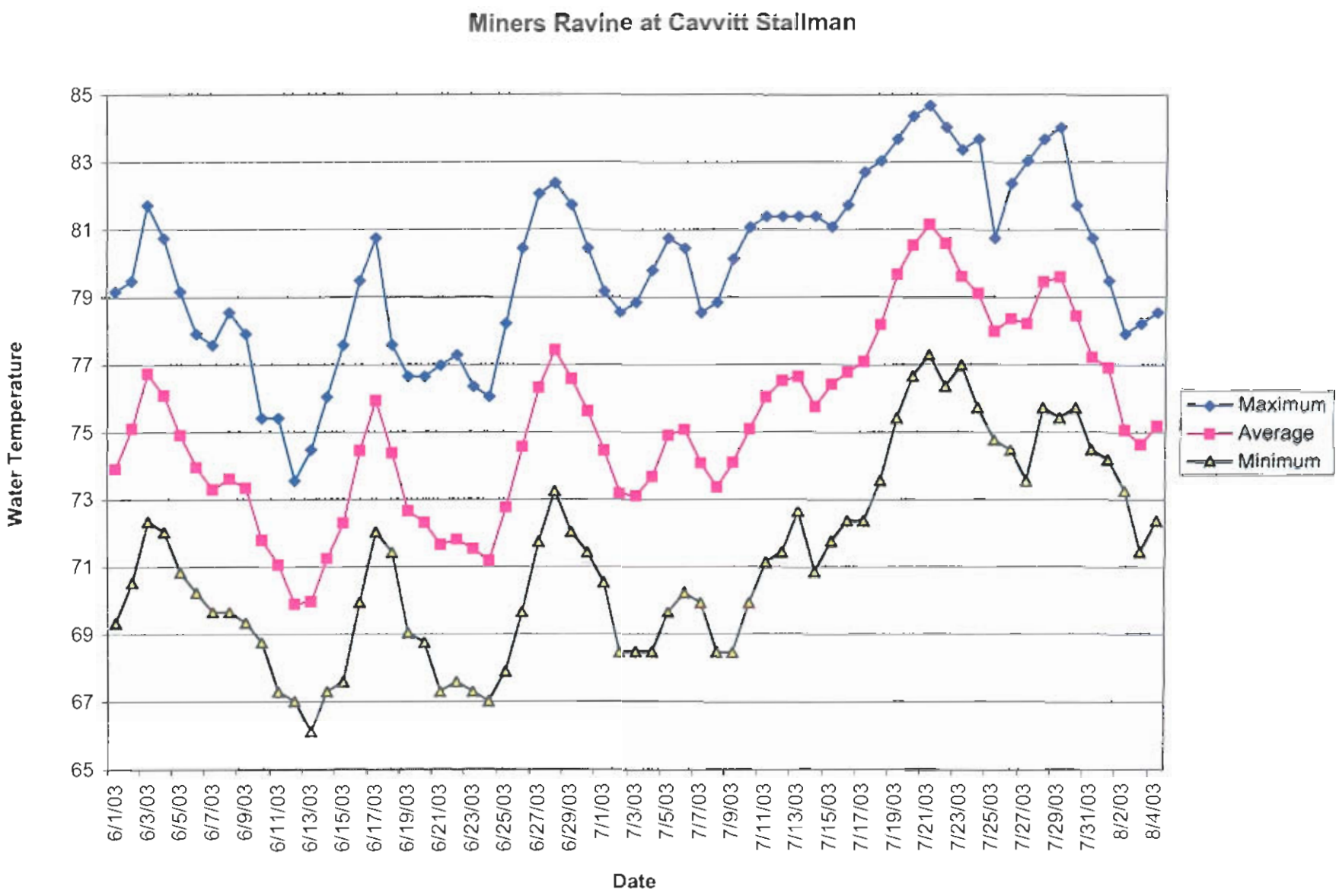

311 Sunset
Water Temperature
90
85
80
75
70
65
60
5/30/03
6/6/03
6/13/03
6/20/03
6/27/03
7/4/03
7/11/03
7/18/03
7/25/03
8/1/03
Date
Maximum
Average
Minimum

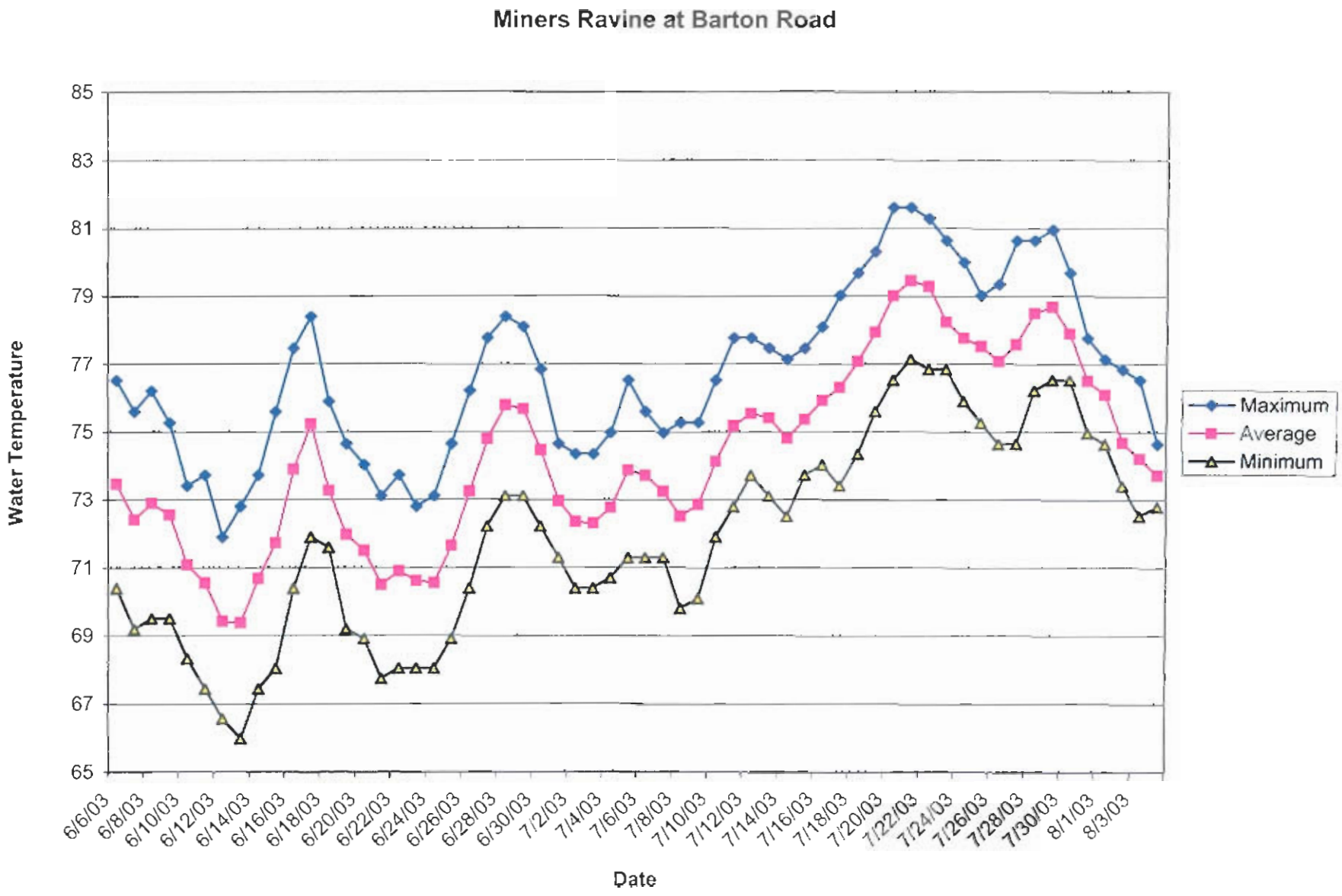

Antelope Creek Drive
Water Temperature
79
77
75
73
71
69
67
65
5/30/03
5/31/03
6/1/03
6/2/03
6/3/03
6/4/03
6/5/03
6/6/03
6/7/03
6/8/03
6/9/03
6/10/03
6/11/03
6/12/03
6/13/03
6/14/03
6/15/03
6/16/03
6/17/03
6/18/03
6/19/03
Date
Maximum
Average
Minimum

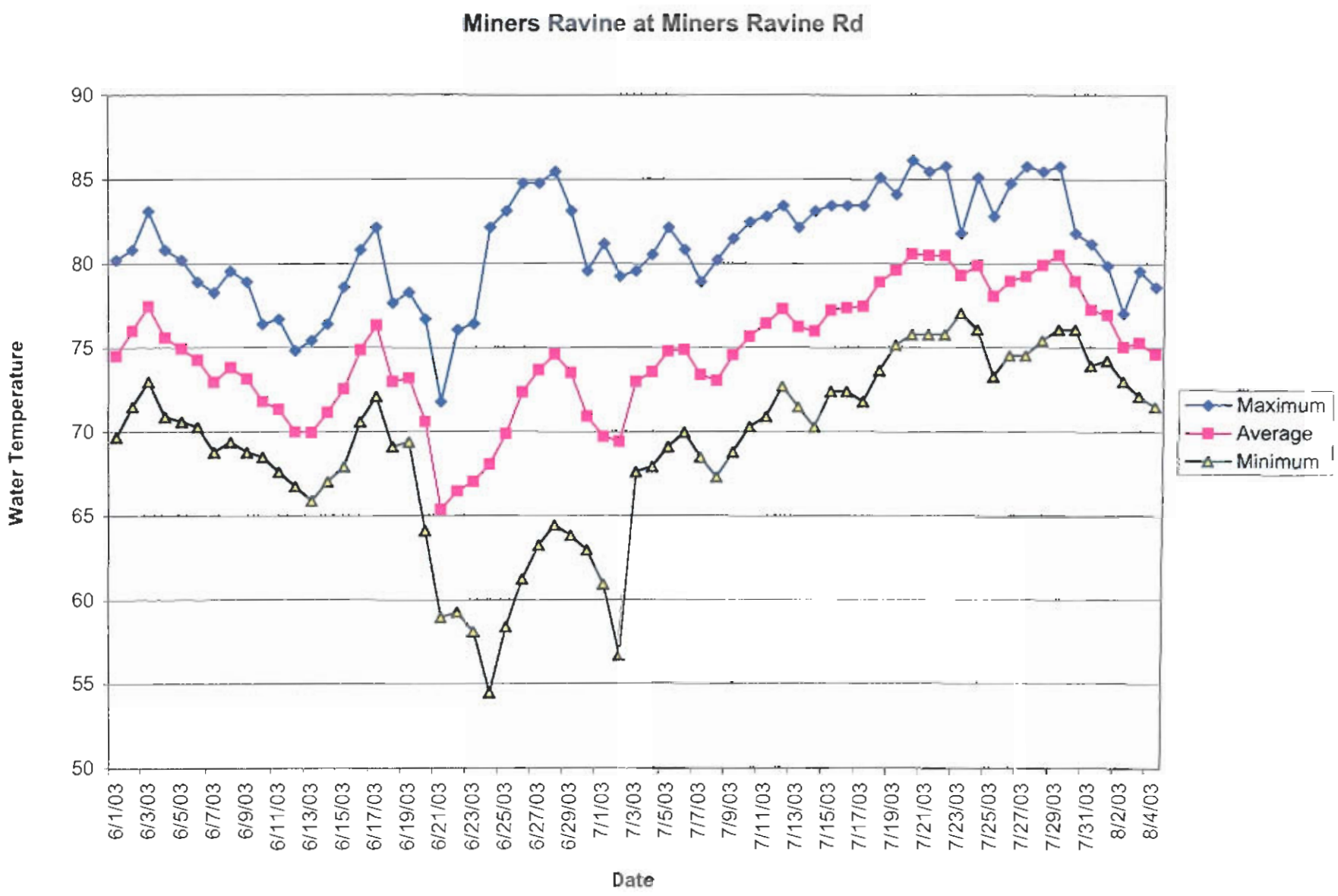

Secret Ravine AM/PM Rocklin Road
Water Temperature
90
85
80
75
70
65
60
5/30/03
6/1/03
6/3/03
6/5/03
6/7/03
6/9/03
6/11/03
6/13/03
6/15/03
6/17/03
6/19/03
6/21/03
6/23/03
6/25/03
6/27/03
6/29/03
7/1/03
7/3/03
7/5/03
7/7/03
7/9/03
7/11/03
7/13/03
7/15/03
7/17/03
7/19/03
7/21/03
7/23/03
7/25/03
7/27/03
7/29/03
7/31/03
8/2/03
8/4/03
Date
Maximum
Average
Minimum


Secret Ravine at Loomis Basin Park
Water Temperature
85
80
75
70
65
60
5/30/03
6/1/03
6/3/03
6/5/03
6/7/03
6/9/03
6/11/03
6/13/03
6/15/03
6/17/03
6/19/03
6/21/03
6/23/03
6/25/03
6/27/03
6/29/03
7/1/03
7/3/03
7/5/03
7/7/03
7/9/03
7/11/03
7/13/03
7/15/03
7/17/03
7/19/03
7/21/03
7/23/03
7/25/03
7/27/03
7/29/03
7/31/03
8/2/03
8/4/03
Date
Maximum
Average
Minimum


Miners Ravine at Olympus Point
Water Temperature
90
85
80
75
70
65
6/19/03
6/21/03
6/23/03
6/25/03
6/27/03
6/29/03
7/1/03
7/3/03
7/5/03
7/7/03
7/9/03
7/11/03
7/13/03
7/15/03
7/17/03
7/19/03
7/21/03
7/23/03
Date
Maximum
Average
Minimum


Miners Ravine at Cavvitt Stallman
Water Temperature
85
83
81
79
77
75
73
71
69
67
65
6/1/03
6/3/03
6/5/03
6/7/03
6/9/03
6/11/03
6/13/03
6/15/03
6/17/03
6/19/03
6/21/03
6/23/03
6/25/03
6/27/03
6/29/03
7/1/03
7/3/03
7/5/03
7/7/03
7/9/03
7/11/03
7/13/03
7/15/03
7/17/03
7/19/03
7/21/03
7/23/03
7/25/03
7/27/03
7/29/03
7/31/03
8/2/03
8/4/03
Date
Maximum
Average
Minimum


Miners Ravine at Barton Road
Water Temperature
85
83
81
79
77
75
73
71
69
67
65
6/6/03
6/8/03
6/10/03
6/12/03
6/14/03
6/16/03
6/18/03
6/20/03
6/22/03
6/24/03
6/26/03
6/28/03
6/30/03
7/2/03
7/4/03
7/6/03
7/8/03
7/10/03
7/12/03
7/14/03
7/16/03
7/18/03
7/20/03
7/22/03
7/24/03
7/26/03
7/28/03
7/30/03
8/1/03
8/3/03
Date
Maximum
Average
Minimum


Miners Ravine at Miners Ravine Rd
Water Temperature
90
85
80
75
70
65
60
55
50
6/1/03
6/3/03
6/5/03
6/7/03
6/9/03
6/11/03
6/13/03
6/15/03
6/17/03
6/19/03
6/21/03
6/23/03
6/25/03
6/27/03
6/29/03
7/1/03
7/3/03
7/5/03
7/7/03
7/9/03
7/11/03
7/13/03
7/15/03
7/17/03
7/19/03
7/21/03
7/23/03
7/25/03
7/27/03
7/29/03
7/31/03
8/2/03
8/4/03
Date
Maximum
Average
Minimum

Appendix B

Stream Segments used in GIS Analysis of Shading by Stream Corridor Vegetation

Table B-1. Stream Segments used in GIS Analysis of Shading by Stream Corridor Vegetation.

Reach Name	Endpoint	Northing	Easting
Antelope Creek Segment 1	Downstream	4290861.49541	650623.04216
Antelope Creek Segment 1	Upstream	4302463.00191	656041.73527
Auburn Ravine Segment 1	Downstream	4302139.82228	632879.37337
Auburn Ravine Segment 1	Upstream	4302333.14197	639058.96994
Auburn Ravine Segment 2	Downstream	4302333.14197	639058.96994
Auburn Ravine Segment 2	Upstream	4306272.94249	649694.11492
Auburn Ravine Segment 3	Downstream	4306272.94249	649694.11492
Auburn Ravine Segment 3	Upstream	4305811.52344	653156.07216
Auburn Ravine Segment 4	Downstream	4305811.52344	653156.07216
Auburn Ravine Segment 4	Upstream	4306046.07908	664984.74612
Auburn Ravine Segment 5	Downstream	4306046.07908	664984.74612
Auburn Ravine Segment 5	Upstream	4310662.49980	667087.35314
Bear River Segment 1	Downstream	4317410.68968	637358.61136
Bear River Segment 1	Upstream	4322147.75398	643968.04964
Coon Creek Segment 1	Downstream	4310915.10410	637501.31731
Coon Creek Segment 1	Upstream	4311132.00092	643823.77970
Coon Creek Segment 2	Downstream	4311132.00092	643823.77970
Coon Creek Segment 2	Upstream	4314631.41762	647625.03252
Coon Creek Segment 3	Downstream	4314631.41762	647625.03252
Coon Creek Segment 3	Upstream	4314238.00305	666653.23549
Doty Ravine Segment 1	Downstream	4311132.00092	643823.77970
Doty Ravine Segment 1	Upstream	4310780.92795	649636.31671
Doty Ravine Segment 2	Downstream	4310780.92795	649636.31671
Doty Ravine Segment 2	Upstream	4310717.66629	653685.81407
Doty Ravine Segment 3	Downstream	4310717.66629	653685.81407
Doty Ravine Segment 3	Upstream	4308324.00102	662716.45193
Dry Creek Segment 1	Downstream	4287716.60536	639401.98428
Dry Creek Segment 1	Upstream	4290861.49541	650623.04216
Miner's Ravine Segment 1	Downstream	4290861.49541	650623.04216
Miner's Ravine Segment 1	Upstream	4296688.50418	662816.09152
Miner's Ravine Segment 2	Downstream	4296688.50418	662816.09152
Miner's Ravine Segment 2	Upstream	4301592.95043	663705.35577
Secret Ravine Segment 1	Downstream	4291972.99696	651799.15637
Secret Ravine Segment 1	Upstream	4302579.99594	661935.96896

Note:
[1] Coordinates are UTM Zone 10, NAD 27.