TROUT CREEK WATER SUPPLY SYSTEM

WATER USE PLAN

TECHNICAL BACKGROUND DOCUMENT ON HYDROLOGY, WATER USAGE AND RESERVOIR OPERATIONS

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1 INTRODUCTION

1.1 Background

The District of Summerland supplies water to domestic, commercial and agricultural users. There are approximately 4,100 single family, 269 commercial and 1,151 irrigation connections. The Trout Creek watershed supplies about 90% of the District water supply. There are 8 reservoirs in the headwaters of the Trout Creek watershed, which are currently operated by the District to provide flow regulation. The reservoirs that are currently operated are Thirsk, Crescent, Whitehead, Isintok and the four Headwaters Reservoirs. Water is released from the reservoirs as required to provide sufficient flow at the diversion structure on Trout Creek.

Summerland holds Water Licences to utilize approximately 15,000 acre feet of water per year from Trout Creek for irrigation and domestic purposes. The maximum use occurred in 1979 with consumption of 13,367 acre feet.

Summerland also holds Water Licences to store approximately 12,500 acre feet of water in 9 reservoirs within the Trout Creek watershed. Actual storage is calculated at 9,373 acre feet in all of the reservoirs combined including Tsuh Reservoir which has not been used for many years. During the storage use season from July 1 to October 31 the maximum use was 7695 acre feet in 1979.

The diversion structure supplies water to a balancing reservoir located on glacial outwash deposits of sand and gravel. Losses from the balancing reservoir have been estimated by the District. The District meters flow at the chlorination chamber downstream of the balancing reservoir.

The rate of reservoir drawdown in July and early August of 2003 created concerns regarding the adequacy of the supply to be able to provide both the community water supply and fish habitat flows in lower Trout Creek. Both irrigation and residential water use was cut back and fish flow releases to lower Trout Creek were reduced.

Following the drought of 2003, the District of Summerland initiated a Water Use Plan process modelled on the successful program originally developed by BC Hydro and participating provincial government agencies. The Water Use Plan Guidelines (1998) provide a step-by-step framework for undertaking Water Use Plans. For the Trout Creek Water Use Plan the participating stakeholders are the District of Summerland, Agricultural Water Users, the

Ministry of Water, Land and Air Protection, the Ministry of Agriculture Food and Fisheries, Fisheries and Oceans Canada and the Penticton Indian Band.

Two technical background documents were prepared for the Trout Creek Water Use Plan:

1. Hydrology, Water Usage and Reservoir Operations (this document)
2. Overview of Fish and Fish Habitat Resources and Aquatic Ecosystem Requirements in Trout Creek.

In addition a brief document entitled “Trout Creek Reservoirs Operating Agreement” provides a summary of the Water Use Plan.

1.2 Water Use Plan Process

The Water Use Plan (WUP) Process has been demonstrated to be successful in providing an effective framework for improved management of water resources particularly where there are reservoirs in the supply system. Over the past five years, draft Water Use Plans have been prepared for 18 BC Hydro facilities and another six are expected to be completed this year.

The Water Use Plan process was originally developed to assist the resolution of conflicts between BC Hydro water use and fish habitat needs. Several years of costly litigation had demonstrated that a better way had to be found to manage water resources in the Province. The goal of the WUP process is to achieve consensus on a set of operating rules that satisfies the full range of water use interests at stake.

The structured framework of the Water Use Plan approach provides clarity to the decision-making process particularly regarding the roles and responsibilities of the stakeholders. The licensee, in this case the District of Summerland, leads the process, which ensures that any proposed changes to operations are voluntarily entered into by the licensee. The participating regulatory agencies maintain their role of monitoring licensee performance in accordance with the Water Use Plan.

The key principles of Water Use Planning include:

- Recognition that tradeoffs (choices) have occurred and will occur.

- Operating alternatives are examined on the basis of existing infrastructure. The potential for new dams and reservoirs is not part of the Water Use Plan process. The intention is to better manage the existing water resource within the constraints of the supply system in place.

- No changes will occur to existing legal and constitutional rights and responsibilities. The purpose of the program is to clarify obligations in detailed operating plans while maintaining the regulatory powers of the federal *Fisheries Act* and the provincial *Water Act.*

- The process is collaborative, cooperative and inclusive. The program brings together a wide variety of people to be part of decision-making.

Water Use Plans are developed within the context of the *Water Act.* The Act governs the construction, operation and maintenance of works to ensure the beneficial use of the water resource and must consider the rights of the licensee as well as the public interest.

The outcome of the planning process may be to recommend a voluntary change to operations resulting in a diminishment of water rights.

The Guidelines state that if there are financial impacts on the licensee, from reduction in water rights, compensation for losses will be an important consideration in plan implementation.

The guidelines call for consultation to be flexible to meet local circumstances and needs. Participants in the WUP process have the responsibility to:

- Articulate their interests in water management;
- Listen to and learn about other water use interests;
- Develop an information base for discussion;
- Explore the implications of a range of operating alternatives;
- Seek compromises across water uses;
- Each process will strive for consensus.

The process should foster an atmosphere of shared resource stewardship among the interested parties. This leads to a better understanding and support for resource management decisions.

Once the revised operating regime is agreed to by the consultative committee of stakeholders the licensee drafts the plan which is reviewed by the Water Comptroller and then becomes part of the water licence.

Preparation of a Water Use Plan requires a detailed understanding of the hydrology of the supply system and a model of the reservoir operations so that alternative operating rules can be examined.

2 TROUT CREEK HYDROLOGY

2.1 Previous Studies

The hydrology of Trout Creek has been studied by the Provincial Government; Reksten (1973), Weiss (1981), and Letvak (1989). The Letvak report essentially updated the previous two studies.

The Letvak report estimated the mean annual runoff in Trout Creek watershed to be 65,499 acre-feet based on observed flow data for the period 1970 to 1982, data from the Summerland diversion and an estimate of the Brenda Mines diversion. The runoff model developed by Letvak estimated the mean annual natural runoff to be 50,480 acre-feet.

The Letvak report used a mean monthly distribution for monthly runoff. This is a significant limitation on the analysis as the distribution of runoff varies from year to year.

Northwest Hydraulic Consultants (2001) carried out an assessment of the hydrology of the Okanagan Lake Basin as part of a fish flow assessment. The mean annual natural runoff for Trout Creek watershed for an area of 759 km^2 was estimated to be 110 mm. This corresponds to a mean annual flow of 2.65 m^3/s or 68,000 acre-feet per year.

2.2 Watershed Model Inflows

2.2.1 Introduction

The modelling strategy developed by Water Management Consultants for this study was to first develop a watershed model for the unregulated recorded flows on Camp Creek, a subcatchment of the Trout Creek watershed. Once the model was calibrated for Camp Creek, it was expanded to natural flows for the entire Trout Creek watershed making adjustments for elevation differences and catchment areas.

The model used for this study was the WMC Watershed Model, which was originally developed for simulating runoff in semi-arid climates. The Trout Creek watershed was divided into subcatchments to facilitate calibration to monitoring locations and provide inflows to the reservoirs. The subcatchments are illustrated on Figure 2.1 and listed on Table 2.1.

Table 2.1 Subcatchments of Trout Creek Watershed

Area		Total Area (m^2) Below 600 m	600 m to 900 m	900 m to 1200 m	1200 m to 1500 m	1500 m to 1800 m	Above 1800 m	Total	Contributing Area
1	Headwaters Lakes	0	0	0	14,227,323	1,147,216	3,802,959	19,177,498	19,177,498
2	Crescent Lake	0	0	0	4,136,750	9,050,419	2,204,286	15,391,455	15,391,455
3	Whitehead Lake	0	0	0	6,710,492	0	0	6,710,492	6,710,492
4	Thirsk Reservoir	0	0	15,359,978	99,655,404	74,522,979	5,904,898	195,443,259	236,722,704
5	Camp Creek	0	0	7,747,184	15,454,731	12,776,611	1,361,975	37,340,501	37,340,501
6	Isintok Lake	0	0	0	0	10,422,940	5,882,346	16,305,286	16,305,286
7	Trout Creek at Intake	0	33,696,047	85,059,026	115,842,136	103,262,124	8,338,341	346,197,674	636,566,165
8	Trout Creek at Mouth	12,589,737	24,235,567	8,463,669	235,912	0	0	45,524,885	682,091,050
9	Darke Creek	0	20,833,954	26,647,730	18,257,298	10,937,920	0	76,676,902	758,767,952

Meadow Valley Irrigation District operates Darke Lake. Finley Creek and Lapsley Creek are diverted into Darke Lake. To account for the Meadow Valley operations it would be necessary to model the operations of this system. According to local information, there is very little flow in Darke Creek downstream of the Meadow Valley system. Therefore, the subcatchment of Darke Creek was excluded from the total Trout Creek watershed for the purposes of the current analysis.

The total watershed area of Trout Creek was determined from a GIS analysis to be 759 km^2. Excluding Darke Creek, the watershed area of Trout Creek is 682 km^2. The watershed area at the Summerland intake is 637 km^2.

2.2.2 Temperature and Precipitation

Temperature and precipitation data was available for a number of nearby sites including Summerland, Penticton, Osprey Lake and Brenda Mines. The last two stations although not active, provide an assessment of the impact of elevation and location within the catchment. Snow course data was available from Summerland (near Headwaters Lake), Isintok Lake and Trout Creek.

The temperature and precipitation data for Summerland is relatively continuous for the period 1916 to present with the few missing data points infilled with data for Penticton. Based on the available information, a correlation was derived for the upper reaches of the catchment and the Summerland data.

The temperature correlation used was:

$$T = T_s - \frac{(E-E_s)7.5}{1065} \quad \text{for } T_s > 0 \quad \text{and}$$

$$T = T_s\left(1 - \frac{(E-E_s)0.27}{1065}\right) - \frac{(E-E_s)7.5}{1065} \quad \text{for } T_s < 0$$

where T = required temperature
T_s = temperature at Summerland
E = elevation of calculation point
E_s = elevation at Summerland

The precipitation correlation used bgelow 900 m elevation was:

$$P = P_s(1+(E-E_s)/644) \quad \text{for winter months and}$$

$$P = P_s(1+(E-E_s)0.42/644) \quad \text{for summer months}$$

where P = required precipitation
P_s = precipitation at Summerland
E = elevation of calculation point
E_s = elevation at Summerland

Above 900 m elevation the relationship was:

$P = 2P_s$ for winter months and $P = 1.42P_s$ for summer months.

The distribution of precipitation to snow and rainfall assumed that all precipitation fell as rain if the average monthly temperature was greater than 2°C and all as snow if the average monthly temperature was below -2°C. In between the ratio of precipitation as snow was varied linearly with the temperature between -2°C and 2°C.

Calculations were carried out in 300 m bands beginning at below 600 m and going up to above 1800 m. The linear variation was calculated from data for Summerland and the midpoint of each elevation band.

2.2.3 Snow evaporation

Evaporation from snow (sublimation) is complex and requires tabulation of a number of variables for a rigorous determination. In this analysis, we have assumed that maximum sublimation is 0.3 mm/day. This was modified where necessary to meet site water balance requirements. Sublimation was allowed in the months November through April. Although sublimation rates may be high during snowmelt, the sublimation is often offset by night-time condensation into the snowpack. Sublimation therefore was not considered for May.

2.2.4 Adjustment for Snowpack Measurements

Snowpack was calculated based on the calculated precipitation and temperature distributions as described above. However, winter precipitation measurements are difficult to measure reliably. For this reason, the winter snowpack was adjusted using the measured snowpack on April 1 at the Summerland site (Headwater Lakes). The calculated snowpacks for each elevation band were multiplied by a snowpack factor and the ratio of the measured and calculated snowpack at the Summerland station. The snowpack factor allows for input of a correction factor to account for the relationship between the point measurement and the whole basin.

2.2.5 Snowmelt

Snowmelt is responsible for much of the available water in this region. Although snowmelt can be estimated, the required meteorological parameters are not available for this site. The snowmelt was estimated using a temperature index method. A first order estimate of the apparent losses were:

$$\text{Snowmelt (mm)} = 30(T-3).$$

Where T is the average monthly temperature.

This equation was used to estimate the potential snowmelt for each month. The actual snowmelt was up to the potential after considering the available snow after sublimation. The factors, (30 and 3) were determined by fit to available streamflow data. The water available each month was calculated as the sum of snowmelt and rainfall.

2.2.6 Evapotranspiration

The potential evapotranspiration (PET) in the watershed was estimated based on the average monthly temperature and modified by the site latitude and the number of days in the month. The monthly water balance was calculated assuming the soil profile could retain some moisture from month to month. A maximum soil moisture retention was defined. The balance considered losses and gains to soil moisture, rainfall and snowmelt, evapotranspiration and surplus water (available for infiltration and runoff). Evapotranspiration was limited by the soil moisture condition. Below the soil moisture capacity of the soil, the PET was reduced linearly with soil moisture. This calculation was completed for each elevation band.

During snowmelt, the ground may be frozen, preventing contribution of snowmelt to soil moisture, and thereby contributing more water to runoff. This is particularly noticeable in low snowpack years. This was addressed by preventing any contribution to soil moisture below a set temperature and ramping the water available to soil moisture up linearly to a second temperature.

Open water is assumed to evaporate at the full PET.

2.2.7 Infiltration

Infiltration was modelled at an adjustable rate that is dependent on surface conditions, soil permeability and available storage capacity. The infiltration rate was adjusted using two parameters, one a function of the quantity of water available for runoff and infiltration and the second a function of the subcatchment area.. The infiltration was accumulated within the groundwater compartment and released at a rate determined by the product of the volume of water in storage and a discharge factor. In this way, month-to-month storage was allowed within each subcatchment, allowing an increasing discharge rate with increasing storage.

2.2.8 Groundwater Discharge

Water is infiltrated into storage in each subcatchment. The water is discharged from storage as a product of a discharge factor and the total storage. Lower discharge factors result in larger accumulated storage with the same recharge. The effect of decreasing the factor is to cause a more uniform discharge rate.

2.2.9 Calibration to Camp Creek

Camp Creek flows have been measured since 1965. The model parameters were adjusted to achieve a best fit to measured flows in Camp Creek. The results for 1996 to 2003 are illustrated on Figure 2.2.

2.2.10 Calibration to Upper Reservoir Base Flows

The infiltration and groundwater storage discharge factors were adjusted for the Upper Reservoirs to match measured reservoir level increases over recent winters. The calibration was achieved primarily by adjusting the allowed infiltration rate and the groundwater discharge factor.

2.2.11 Summary

The model was calibrated by varying calibration parameters to achieve a best fit to Camp Creek flows and minor modifications to match base flows into the upper reservoirs. The mean annual runoff for the period from 1938 to 2002 determined from the model was 2.89 m^3/s (102 cfs) for a catchment area of 682 km^2 (excluding Darke Creek). This corresponds to an annual runoff of 134 mm (5.27 inches), about 20% higher than the estimate by Northwest Hydraulics (2001).

Based on the above calibration, an output of natural monthly flows was generated for each of the eight subcatchments that contribute to Trout Creek flows. These flows were used in a routing study through the reservoirs, described in Section 4.

3 WATER CONSUMPTION

3.1 Disaggregation of Consumption

The flow into the Summerland distribution system is measured with a flow meter at the chlorination house immediately downstream of the balancing reservoir. The water is used for agricultural irrigation, residential indoor and outdoor consumption, urban commercial use and unaccounted for losses. A plot of the recorded flows, presented as Figure 3.1 illustrates the annual variability of the demand, driven mostly by agricultural irrigation. Also illustrated on Figure 3.1 is an estimate of the residential/urban commercial indoor use, based on the winter flows. Residential outdoor use and agricultural irrigation are illustrated as the remainder of the flows. The trend in residential/urban consumption is increasing probably due to urban development and residential construction. There is a notable decline in irrigation consumption.

According to Neilsen et al (2004) the decline in irrigation consumption is likely due to improvements in irrigation technology and more intensive agriculture. About a third of the growers in the Summerland area are now using micro-irrigation techniques, which are better suited to intensification of production. Despite higher temperatures over the past 10 years, irrigation demands have dropped because of improved management practices which were introduced to increase fruit tree production. It is also likely that there has been a reduction in the area under irrigation.

For the model, the residential indoor component (includes urban commercial) was estimated by examining the Summerland winter demand. The winter consumption for 2001/2002 used in this analysis was 1.24 mig/day (5,600 m^3/day).

Based on studies reported by Water Management Consultants (2001) for the Vancouver area, the residential outdoor demand was estimated as a multiple of the indoor demand on a month-by-month basis. However, the evapotranspiration values for turf grass supplied by the BC Ministry of Agriculture (2002) are 75% higher in Summerland than in Vancouver and the outdoor demand was increased to account for this. There are uncertainties in this estimate because of differences in lot sizes and other climatic differences between the Vancouver area and Summerland. The outdoor demand was also increased in early spring, to account for increased water use measured in Summerland at that time.

The irrigation demand for 2002 was calculated by subtracting the residential indoor and outdoor water use derived as noted above from the total water used per month. The demand values for 2002 are presented on Figure 3.2.

3.2 Irrigation survey

This section provides the results of a calculation of the monthly irrigation water demands for optimum growing conditions based on irrigated areas by crop type, irrigation application method and weather conditions. The analysis also includes an estimate of the potential total crop water demands when all areas are accounted for on the Irrigation Roll including areas not currently irrigated.

The primary source of information in the analysis was the District of Summerland Water Coordination 2004 Report submitted by Joe Fitzpatrick on November 26 2004. That report provides areas of different crop types in Summerland broken down into different irrigation application systems. For this report the areas supplied by the Garnet Valley system were excluded from the summary and the data are shown in Table 3.2. Definitions of the terms in the table can be found in the Water Coordination 2004 Report.

Table 3.2: Areas in acres of crops and irrigation systems on the Irrigation Roll. (excluding the areas served by the Garnet Valley System)

Crop	Sprinkler	Trickle	Dual	Microjet	Gun	None	Total
Apple	629.40	203.38	240.52	27.13	0.00	0.00	1100.43
Apricot	23.41	4.40	0.35	3.76	0.00	0.00	31.92
Cherry	171.99	9.16	5.70	0.00	0.00	0.00	186.85
Cropland	70.95	4.25	0.00	0.00	0.00	0.00	75.20
Nectarine	2.28	1.26	0.50	1.50	0.00	0.00	5.54
Non Ag Island	0.00	0.00	0.00	0.00	0.00	2.54	2.54
No crop	0.00	0.00	0.00	0.00	0.00	101.32	101.32
Fallow	0.00	0.00	0.00	0.00	0.00	214.10	214.10
Ornamental	27.75	0.00	0.00	3.95	0.00	0.00	31.70
Pasture	365.70	0.00	0.00	0.00	59.50	13.50	438.70
Peach	77.39	4.33	19.45	11.83	0.00	0.00	113.00
Pear	48.60	3.14	7.00	4.00	0.00	0.00	62.74
Plum	9.17	0.25	2.13	5.00	0.00	0.00	16.55
Recreation	90.60	0.00	0.00	0.00	0.00	0.00	90.60
Vine	53.05	42.60	11.85	8.83	0.00	0.00	116.33
Total	1570.29	272.77	287.50	66.00	59.50	331.46	2587.52
Parcels with <2 roll acres							*516.10*
Total roll acres							3103.62

Calculations of the monthly moisture deficit at the Pacific Agri-Food Research Centre were summarized in the Water Coordination Report as shown in Table 3.3.

Table 3.3: Monthly moisture deficits in Summerland

		June	July	August	September	October
				millimetres		
2002	Evapotranspiration	148	168	140	91	48
	Effective Precipitation	2	3	2	0	0
	Moisture Deficit	146	165	138	91	48
2003	Evapotranspiration	156	181	156	97	53
	Effective Precipitation	0	0	0	0	9
	Moisture Deficit	156	181	156	97	44
2004	Evapotranspiration	148	172	139	77	51
	Effective Precipitation	22	0	36	11	3
	Moisture Deficit	126	172	103	66	48

Monthly crop water demands (in acre-feet) for the District of Summerland were calculated as follows:

- The Sprinkler areas in Table 3.2 were further subdivided into sprinkler types using a detailed Excel spreadsheet inventory provided by Joe Fitzpatrick.
- Monthly moisture deficits were obtained from Table 3.3.
- Irrigation application efficiencies for each irrigation application method were provided by the BC Ministry of Agriculture, Food and Fisheries.
- Crop coefficients, k_c for each crop type, by month, were also provided by the Ministry of Agriculture, Food and Fisheries.
- The irrigated areas for each crop type were reduced by eliminating those parcels served by the Garnet Valley system from the data in the detailed Excel table.
- The water demand in acre-feet was calculated for each month by using the irrigated area for each crop type, the monthly crop coefficient, the irrigation efficiency for the application method and the moisture deficit.
- The water demands for each irrigated area for each crop type were then summed to give a total irrigation water demand for the system supplied by Trout Creek.
- The monthly total water demands were then compared with the monthly recorded consumption less an estimate of the residential and commercial water use.

The results are shown on Figure 3.3. The analysis shows that in 2002, the irrigation usage was more than the calculated water demand for all months except October. In June and July 2003, the usage was also greater than the calculated demand. However, in August, September and October of 2003, the recorded water usage was less than the calculated demand demonstrating the efforts made by the community to reduce consumption. Similarly in 2004, with conservation measures implemented throughout the community, the actual usage was less than the calculated demand for all months except August.

The August difference was probably because the calculation assumes that the irrigators and the distribution system are able to precisely respond to the effective rainfall. This is not normally feasible for short duration rainfall events, particularly if they occur at night. If the effective rainfall of 36 mm in August is not accounted for in the calculation, the calculated demand would have been about 35% greater because the effective rainfall reduces the moisture deficit. If the effective rainfall is not included in the August 2004 calculation, the calculated demand would be higher than the actual use.

It should be noted that the calculation does not include any allowance for distribution system efficiency to allow for losses in pipe flows and inefficiencies in the response of the system to rapidly changing demands. For the part of the system downstream of the balancing reservoir, where the flows are recorded, the distribution system efficiency should be quite high, at least 90%. If a distribution system efficiency were to be included in the calculations the effect would be to increase the calculated water demand. This is because the amount of water required for delivery to the farms would be greater to compensate for the efficiency factor.

The calculated demand using the entire Irrigation Roll includes areas not irrigated in 2004. An estimate of the potential demand for these areas was made by assuming that they would have an average unit crop water demand and an application efficiency of the average of the methods used in Summerland. It was estimated that, if the entire area under the Irrigation Roll were to be irrigated, the actual monthly consumption would be higher by about 9%.

In the key irrigation months of July, August and September of 2002 the calculated demand was 78% of the actual usage. The records for 2004 indicate that the irrigators in Summerland were able to operate using no more than the calculated demand. Therefore it should be feasible to develop an operating system with irrigation consumption targets that are about 78% of the 2002 consumption. However, the rain in the summer of 2004 did not stress the irrigation systems and it would be more challenging to operate at the level of the calculated irrigation demand in a drought year. Therefore the irrigation consumption targets used for the Water Use Plan Agreement described in Section 6 were in the range of 80 to 90% of the 2002 consumption.

Responsible water use requires the irrigation district to operate an irrigation scheduling program to proactively target water use to crop water demands. Irrigation scheduling is a systematic method by which a producer can decide on when to irrigate and how much water to apply. The goal of an effective scheduling program is to supply the plants with sufficient water while minimizing loss to deep percolation or runoff. Irrigation scheduling depends on soil, crop, atmospheric, irrigation system and operational factors.

4 RESERVOIR OPERATION MODELLING

4.1 Model Structure and Operating Rules

The Reservoir Operation Model was set up within a spreadsheet format, with inflows generated into each of the subcatchments input from the hydrology model. The subcatchment boundaries are illustrated on Figure 2.1. The model was operated over the period from 1937 to 2002, the period when both local climate and snowpack data were available. The headwaters reservoirs were combined into one operating reservoir.

The reservoirs are not normally drawn down completely to the intake levels because of likely water quality degradation, particularly silt from eroding deposits in the floor of the reservoir. The standard currently in use by the Greater Vancouver Water District is to set the minimum reservoir levels 2 m above the intake. In the model, reservoirs were operated to allow live storage between a specified level above the intake (up to 6 feet above the intake) to the spillway crest. All additional water was spilled downstream.

The model operates by accumulating inflows and discharges over quarter-month periods. Quarter-month time steps were required for effective modelling of the relatively small reservoirs. Based on the volume of water in the reservoir in the preceding month, the reservoir area was determined and the evaporation losses calculated. Seepage losses were neglected, as seepage would continue downstream towards the intake from most reservoirs.

The reservoir operating rules incorporated in the model were based on the rules set out in Associated Engineering (1997) modified to account for current operation practices.

Water spilled from Crescent Lake or released from Crescent Lake was routed to Headwaters Lakes. Release from Crescent Lake was required in the model as soon as Headwaters Lakes fell below full volume. Water spilled from Headwaters Lakes or released from Headwaters Lakes was routed to Thirsk Lake. The first release from Headwaters lake effectively removed water from storage in Crescent Lake and the inflows in the same time period. The second release from Headwaters Lakes removed the water that could be refilled relatively reliably. The third release was the remaining live storage.

Water spilled from Whitehead Lake or released from Whitehead Lake was routed to Thirsk Lake. The first release from Whitehead Lake was water that would be refilled relatively reliably. The final release from Whitehead Lake was the remaining live storage.

Water spilled or released from Thirsk Reservoir was routed to the intake. When 80% of the storage was depleted, makeup releases were requested in a specified order from the upstream reservoirs and Isintok Reservoir. Releases from upstream were routed through Thirsk Reservoir whereas Isintok Reservoir releases reported to the intake.

Water spilled or released from Isintok Reservoir was routed to the intake.

The operating rules for the mouth of Trout Creek were as follows:

- Release makeup water from the reservoirs to meet water supply demand, losses and fisheries requirements; and

- Adjust demand according to volume of water in storage.

The operating rules for release from the reservoirs were in the following order:

1. Withdraw water from storage in Thirsk to the specified level above the intake. Begin releasing makeup water from other reservoirs when 80% of the Thirsk storage capacity has been depleted.

2. Withdraw water available from Crescent Lake first. In the model, this water was routed through Headwaters Lakes. Until the Headwaters reservoirs were filled, Crescent was held at the specified level above the intake.

3. Withdraw 432 ML of water from Whitehead Lake and hold at that level until the next drawdown of this lake or the demand was not required.

4. Withdraw 2339 ML from Headwaters Lakes and hold at that level until the next drawdown or the demand was not required.

5. Drawdown Isintok Lake to the specified level above the intake and pass any additional inflow until the demand is not required.

6. Draw down the remainder of Headwaters Lakes to the specified levels above the intakes and pass any additional inflow until the demand is not required.

7. Drawdown the remainder of Whitehead Lake to the specified level above the intake and pass any additional inflow until the demand is not required.

A summary of the operating drawdowns is presented on Table 4.1 using 6 feet above the intake as the specified level for the final drawdown. The reservoir capacity relationships were obtained from the Water Storage Dams O & M Manual prepared by UMA in 1990.

Table 4.1a Summary of operating reservoir drawdowns in m^3

Reservoir	Full Reservoir	First Drawdown		Final Drawdown	
	Volume	Feet remaining	Volume remaining	Feet remaining	Volume remaining
Thirsk	3,404,460	6	8,042	6	8,042
Crescent	769,704	6	284,939	6	284,939
Whitehead	1,248,302	8.81	816,688	6	519,304
Headwaters	4,472,671	8.9	2,133,790	6	1,326,383
Isintok	1,372,886	6	49,340	6	49,340
Total	11,268,023				2,188,007

Table 4.1b Summary of operating drawdowns in acre-feet

Reservoir	Full Reservoir	First Drawdown		Final Drawdown	
	Volume	Feet remaining	Volume remaining	Feet remaining	Volume remaining
Thirsk	2,760	6	7	6	7
Crescent	624	6	231	6	231
Whitehead	1,012	8.81	662	6	421
Headwaters	3,626	8.9	1,730	6	1,075
Isintok	1,113	6	40	6	40
Total	9,132				1,774

By leaving 6 feet of water over the intake, the amount left in storage and not used is 2.2 million cubic metres (1,770 acre-feet). This is about 19% of the total storage above the intakes in all reservoirs. The effective total live storage, leaving 6 feet of water over the intake, is 9.1 million m^3 (7,361 acre-feet).

The balancing reservoir is constructed in gravelly material. Losses in the balancing reservoir included both seepage and evaporation and were estimated to be about 5000 m^3/day (4 acre-feet per day). These losses were added to the demand removed from the Trout Creek at the intake. In addition it was estimated that the losses from the stream bed upstream of the intake were about 6,000 m^3/day (5 acre-feet per day).

4.2 Comparison with Operation Data

For the period 1993 to 2003, there is a record of reservoir levels, and therefore knowledge of the total volume of water in storage. Figure 4.1 is a presentation of measured and calculated total volume of water in storage, assuming that fish flow releases as specified in 1997 were met. The agreement between the modelled reservoir operations and observed data provides a verification of both the watershed model and the reservoir operation model.

4.3 Summerland Design Drought

The Trout Creek water supply system was designed based on a design drought of three consecutive years with flows 36% of average (Associated Engineering, 1997). It is likely that this condition was experienced in the 1930s. A separate reservoir operation model was set up to simulate this design condition. Three consecutive drought years have not occurred in the 67-year period of simulated runoff though, with the potential for climate change, this design condition should be considered in the scenario simulations.

Using the Trout Creek watershed model to develop a 67-year period of record, the following table shows the mean annual monthly runoff and the drought flows at 36% of the mean monthly runoff.

Table 4.2 Mean monthly and design drought total flows in Trout Creek

	Drought		Mean	
	m^3/s	ac-ft/day	m^3/s	ac-ft/day
Jan	0.15	10.51	0.41	28.72
Feb	0.22	15.41	0.60	42.03
Mar	0.53	37.13	1.48	103.67
Apr	1.85	129.59	5.15	360.76
May	3.94	276.00	10.93	765.65
Jun	4.29	300.51	11.91	834.30
Jul	0.49	34.32	1.37	95.97
Aug	0.23	16.11	0.64	44.83
Sep	0.18	12.61	0.50	35.03
Oct	0.30	21.02	0.84	58.84
Nov	0.16	11.21	0.45	31.52
Dec	0.15	10.51	0.41	28.72
Annual	1.04	72.85	2.89	202.44

5 OPERATING AGREEMENT

The Trout Creek Water Use Plan Consultative Committee met six times in 2004 and in early 2005 to develop an Operating Agreement for the Trout Creek Reservoirs.

The steps that were taken in developing the proposed Operating Agreement for operation of the Trout Creek water supply system were as follows:

- Each stakeholder on the Trout Creek Water Use Plan Consultative Committee presented their specific objectives in terms of their water requirements.
- It was demonstrated by modelling the Trout Creek water supply over a 67-year period, that it was not feasible to meet the objectives of all stakeholders in full.
- Operations for the "design drought" condition were incorporated in the modelling analysis to ensure that three consecutive years of drought could be managed.
- Compromises were made until a feasible operating regime was developed. This was the basis of the Operating Agreement.

5.1 Normal Operation

The fish flow releases are based on the lesser of the conservation flow (defined in the Fisheries Report) and a multiplier of the real-time Camp Creek flows available on the web from Environment Canada. Camp Creek is a tributary watershed of Trout Creek and provides an index of natural flow variations in Trout Creek. The general recession trend is used to determine Camp Creek flows; spikes caused by rainfall events are not included in the calculation. The fish flow multiplier is reduced when storage values in the reservoirs are at lower levels.

The District of Summerland as the licensee will continue to be responsible for operations of the Trout Creek water supply system under the Water Use Plan Operating Agreement.

The basis of the Operating Agreement is to use a Trigger Graph as shown on Figure 5.1 to make water use allocations. The total storage in the system is 9,132 acre-feet (excluding

Tsuh Reservoir) and the Trigger Graph indicates what the safe consumption would be for lower storage levels as the irrigation season progresses. The Operating Agreement-A, shown in Table 5.1 indicates the target water usage reductions for the community and the fish flow releases based on a multiplier of Camp Creek flows.

Table 5.1: Water Usage Reductions for Operating Agreement A

	Reduction Stage					
	1	2	3	4	5	
June	10	8	6	4	0	Fish flow x Camp
	90	85	80	70	0	Community target factor %
July	9	8	7	4	0	Fish flow x Camp
	90	85	80	70	0	Community target factor %
Aug	10	9	8	4	0	Fish flow x Camp
	90	85	80	70	0	Community target factor %
Sept	10	10	10	4	0	Fish flow x Camp
	90	85	80	70	0	Community target factor %
Oct	10	10	10	4	0	Fish flow x Camp
	50	50	50	50	0	Community target factor %

The District target water usage reductions are expressed as a percentage of the monthly 2002 water use.

Stage 1 usage reduction targets (based on 90% of 2002 water usage) will be in effect throughout the summer until reservoir storage levels drop below full pool at which time Stage 2 will be introduced. Stage 2 and Stage 3 will come into effect depending on the date and the Trigger Graph. The plan for usage reductions and fish flow releases is based on modelling of the watershed and supply system over the 67-year period. The modelling indicates that with Operating Agreement-A, the system would have avoided dropping into Stage 4 and Stage 5 at any time in the 67-year period.

The Trigger Graph is set so that if the reservoirs are not full in the month of June, Stage 2 will automatically be implemented. This will conserve early season storage water by implementing reductions in usage by both fisheries and the community. This will benefit all users later in the summer by reducing the likelihood of lower and more restrictive Stage Levels.

The fish flow releases in Operating Agreement-A are less than that required to sustain the aquatic resource. If these multipliers are increased to levels that provide adequate flows for fish habitat, there is a risk of the water supply system dropping into Stage 4. The modelling indicates that this would occur twice in the 67-year period with higher fish flows. The committee concluded that this level of risk was not acceptable for the existing water supply system. However, with the planned expansion of Thirsk Reservoir this risk will be removed as there will be sufficient storage to avoid the two occurrences of Stage 4 in the 67-year period. Therefore the Committee concluded that after the Thirsk Dam is raised, Operating Agreement–B would be used. The Trigger Graph remains the same but the fish flow multipliers are increased in Operating Agreement-B as shown in Table 5.2.

Table 5.2: Water Usage Reductions for Operating Agreement B

	Reduction Stage					
	1	2	3	4	5	
June	10	8	6	4	0	Fish flow x Camp
	90	85	80	70	0	Community target factor %
July	10	10	9	4	0	Fish flow x Camp
	90	85	80	70	0	Community target factor %
Aug	10	10	10	4	0	Fish flow x Camp
	90	85	80	70	0	Community target factor %
Sept	10	10	10	4	0	Fish flow x Camp
	90	85	80	70	0	Community target factor %
Oct	10	10	10	4	0	Fish flow x Camp
	50	50	50	50	0	Community target factor %

When the total reservoir storage levels are close to stage level changes on the Trigger Graph, the District will attempt to minimize the number of public notifications of stage changes by short-term forecasting of weather and streamflow conditions. This will minimize moving back and forth between stage levels.

Figure 5.2 shows examples of the modelled reservoir operation with Operating Agreement A for the inflow years of 1987, 2002 and 2003. If the agreement has been in place in those years the model indicates the variation in total storage through the year. Figure 5.2 shows that the minimum storage in 2002 and 2003 would have been about 3,500 acre-feet at the end of October. The actual recorded total storage in 2003 is also shown on Figure 5.2. For 1987, one of the worst inflow years on record, the minimum storage would have been about 2,100 acre-feet at the end of October.

The agricultural water users are accepting water usage reductions to make the current system work for all stakeholders and furthermore, there is land on the Irrigation Roll that is not currently irrigated. Therefore, any additional water realized from raising Thirsk Dam should first be allocated to the agricultural users

5.2 Emergency operation

The original design drought condition for the Trout Creek reservoir system was based on three consecutive years of drought with flows at 36% of mean flows. It is understood that this corresponds to the three consecutive drought years that occurred in the Okanagan Basin in 1929, 1930 and 1931. The Operating Agreement was established so that the design condition can be accommodated for both A and B scenarios. Figure 5.3 shows operation over three consecutive drought years with Operating Agreement-B.

Catastrophic events could occur such as major fires in the watershed, an infestation of mountain pine beetle or dam failures, which would compromise the capability of the system to operate normally. Planning of the system to operate for three consecutive drought years would partially address emergency events. However, more stringent measures could be required if the event resulted in a more serious situation.

5.3 Monitoring and Review

The Water Use Plan (WUP) should be reviewed within 5 years to address changing circumstances such as:

- Metering
- Appointment of a water conservation officer
- Climate change
- Thirsk expansion

Any of the parties to the Agreement can initiate the review. Consistent with the current Water Use Plan, the District would lead any review process.

In addition, continuation of the flow monitoring program is recommended to improve the understanding of the hydrology of Trout Creek and tributaries.

5.4 Reporting

The Consultative Committee recommends that a twice yearly report (July and November) be prepared by Summerland staff and distributed to Council and the regulatory agencies. The report would include graphs on reservoir operations, data on fish flow releases and monitoring data reports.

6 FLOOD CONTROL

Flood issues on Lower Trout Creek have been investigated by Hay and Company Consultants on behalf of the District of Summerland. In addition, the District is developing a management plan for dike maintenance involving DFO and WLAP. These flood management activities are normally considered to be outside the scope of water use plans, as they do not involve changes to reservoir operation.

The potential flood control benefits of reservoir operations were addressed in the Operation and Maintenance Manual for the Summerland Water Storage Dams that was prepared by UMA in 1991. In that report it was recommended that at the end of the irrigation season the reservoirs should be at low levels in order to prevent ice build-up on the spillways during winter operation and to provide potential for some attenuation of peak flood flows in the following spring. The storage of some flood runoff in the spring reduces the possibility of spillway channel erosion.

The end-of–season drawdown recommended in the 1991 report was the level at which the reservoir could be completely filled by the end of June in the following year if only 80% of the drought year runoff were to occur. This corresponds to a total end–of–season storage of 4,900 acre feet with about 4,200 acre-feet of available flood storage.

The draft Hay and Company report on the Trout Creek Flood Protection Review concluded that the 200-year design flood should have a peak daily flow of 78.3 m^3/s (2,764 cfs). For this report, it was estimated that the volume of water that would flow in Trout Creek prior to the flood peak would be about 100 million cubic metres (80,000 acre feet). The available flood storage of 4,200 acre-feet would correspond to about 5% of the flood volume prior to the peak. This relatively small storage volume would not be sufficient to have an effect on the magnitude of the flood peak. Therefore it is recommended that the District do not operate the reservoirs explicitly for flood control in the late fall. Nevertheless, if there is a large snowpack in a given year, pre-spill from the reservoirs could be undertaken which would not compromise water supply refilling.

7 CLIMATE CHANGE

Climate change would affect the reservoir operations in two ways; potential increases in temperatures would increase irrigation demand and changes in temperature and precipitation would impact the runoff in Trout Creek. It was proposed that the analysis of potential affects of climate change be based on available information on studies carried out in the Okanagan with modifications to account for specific conditions in Summerland and on Trout Creek.

The primary reference used for the analysis was the report Water Management and Climate Change in the Okanagan Basin by Stewart Cohen and Tanuja Kulkarni dated 2001. This reference provided climate change projections for the year 2020. The year 2020 was the future year used for this analysis. Additional information was also obtained from a 2003 report under the same program “Expanding the Dialogue on Climate Change and Water Management in the Okanagan Basin, BC”. A final report on the Environment Canada/UBC project will be available in November 2004. Denise Neilsen of the Agricultural Research Station in Summerland had a major involvement in these studies.

7.1 Increases in irrigation demand

Standard formulae for monthly crop water usage are primarily driven by monthly temperatures. An analysis was carried out of monthly temperatures in 2002 compared with recorded Summerland total demand. It was found that the monthly demand in Summerland is correlated strongly with mean monthly temperatures with a correlation coefficient of 0.96. For every degree increase in monthly temperature, the demand will increase by 37 MIG.

The Okanagan Basin Climate Change study projected an increase in temperature of about 1 degree centigrade for all months by 2020 based on Canadian climate models. Therefore the monthly Summerland base demand (2002 demand) would be expected to increase by 37 MIG for each month by the year 2020. This represents about a 10% increase in total demand from April to October which corresponds to about 940 acre feet.

7.2 Changes in watershed runoff

Changes in watershed runoff were evaluated using the WMC Trout Creek watershed model by modifying the inputs to reflect the anticipated changes from the Okanagan Basin climate change study. The seasonal changes in temperatures for the year 2020 were input to the model and the percent changes in precipitation. The Canadian climate models project about a 5% increase in precipitation in the winter, a 5% decrease in spring, a 2% increase in summer and a 4% increase in the fall.

The mean annual runoff hydrographs for Camp Creek generated by the future climate change projections are shown on Figure 7.1 compared with current conditions. Although the temperatures are one degree higher in the winter the high elevation snowpacks are maintained and the runoff quantities are in fact slightly greater because of the precipitation increase. However, the higher temperatures result in earlier melt so that although the average freshet peak is higher, the peak is earlier and the hydrograph recedes earlier. As a result, average flows would be slightly lower in July.

7.3 Impacts on water availability in Trout Creek

The projected earlier spring runoff with climate change in the year 2020 results in earlier storage use. Therefore the available storage in the Trout Creek reservoirs becomes more limiting. The increase in the base 2002 demand by about 10% also increases the reservoir usage.

The demand reductions and the fish flow releases based on the Operating Agreement were modelled with the projected changes in watershed runoff with climate change in 2020 and the projected increases in irrigation demand. It was found that there would be 26 occurrences of Stage 4 and four occurrences of Stage 5 over the 67-year modelling period. Stage 5 is failure of the supply. Without climate change, the Operating Agreement would provide zero occurrences of both Stage 4 and 5.

If the potential effects of climate change are considered, the modelling indicates that occurrences of Stage 4 and Stage 5 (failure of the supply) would occur. To avoid occurrences of Stage 4 and 5, fish flows and/or irrigation demands would have to be reduced from those established in the Operating Agreement.

The conclusion of the Consultative Committee from this analysis was that the existing infrastructure is inadequate in the event of climate change. Therefore more storage in the watershed would be required if the projected climate change is incorporated in the Water Use Plan. The Water Use Plan, based on existing infrastructure, is therefore based on current and historic climatic conditions, not potential future conditions.

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FIGURES

Figure 2.1 - Trout Creek Watershed

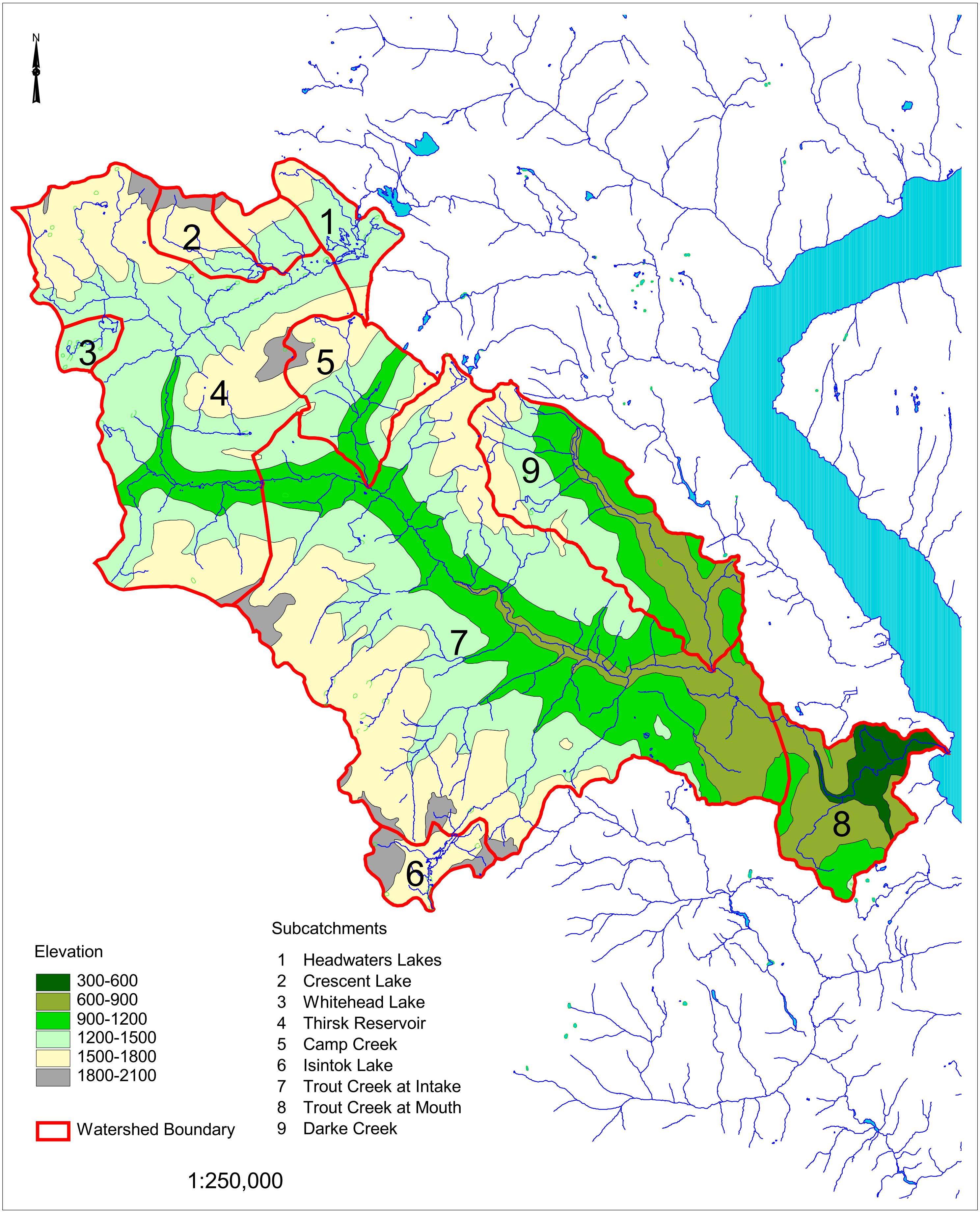
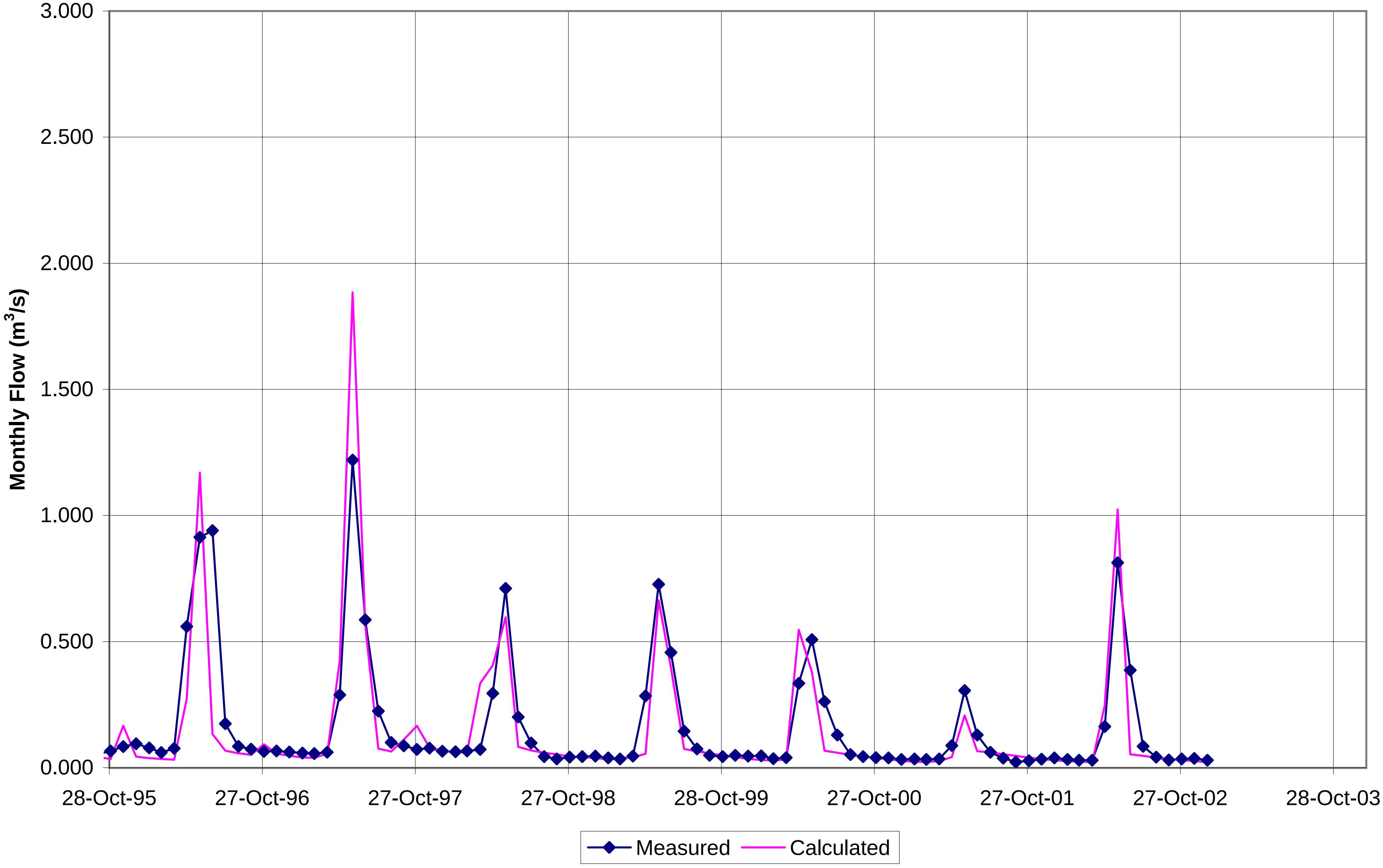


Figure 2.2 Camp Creek Measured and Calculated Monthly Flows



Trout Creek Water Balance.xls - Camp Creek Graph (3)

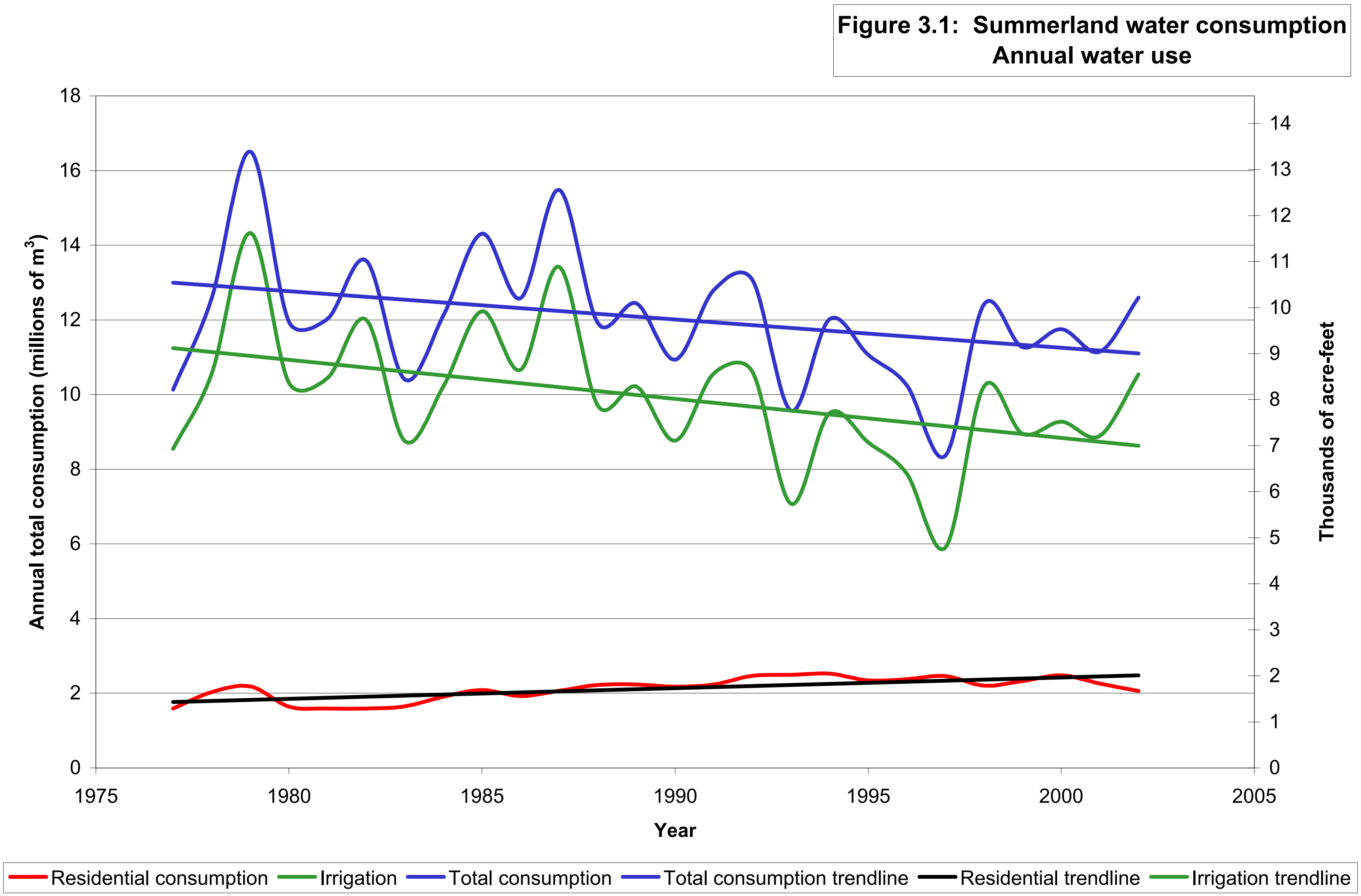


Figure 3.1: Summerland water consumption
Annual water use
Annual total consumption (millions of m³)
Thousands of acre-feet
Year
0
2
4
6
8
10
12
14
16
18
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
1975
1980
1985
1990
1995
2000
2005
Residential consumption
Irrigation
Total consumption
Total consumption trendline
Residential trendline
Irrigation trendline

Figure 3.2: 2002 Disaggregated Water Demand

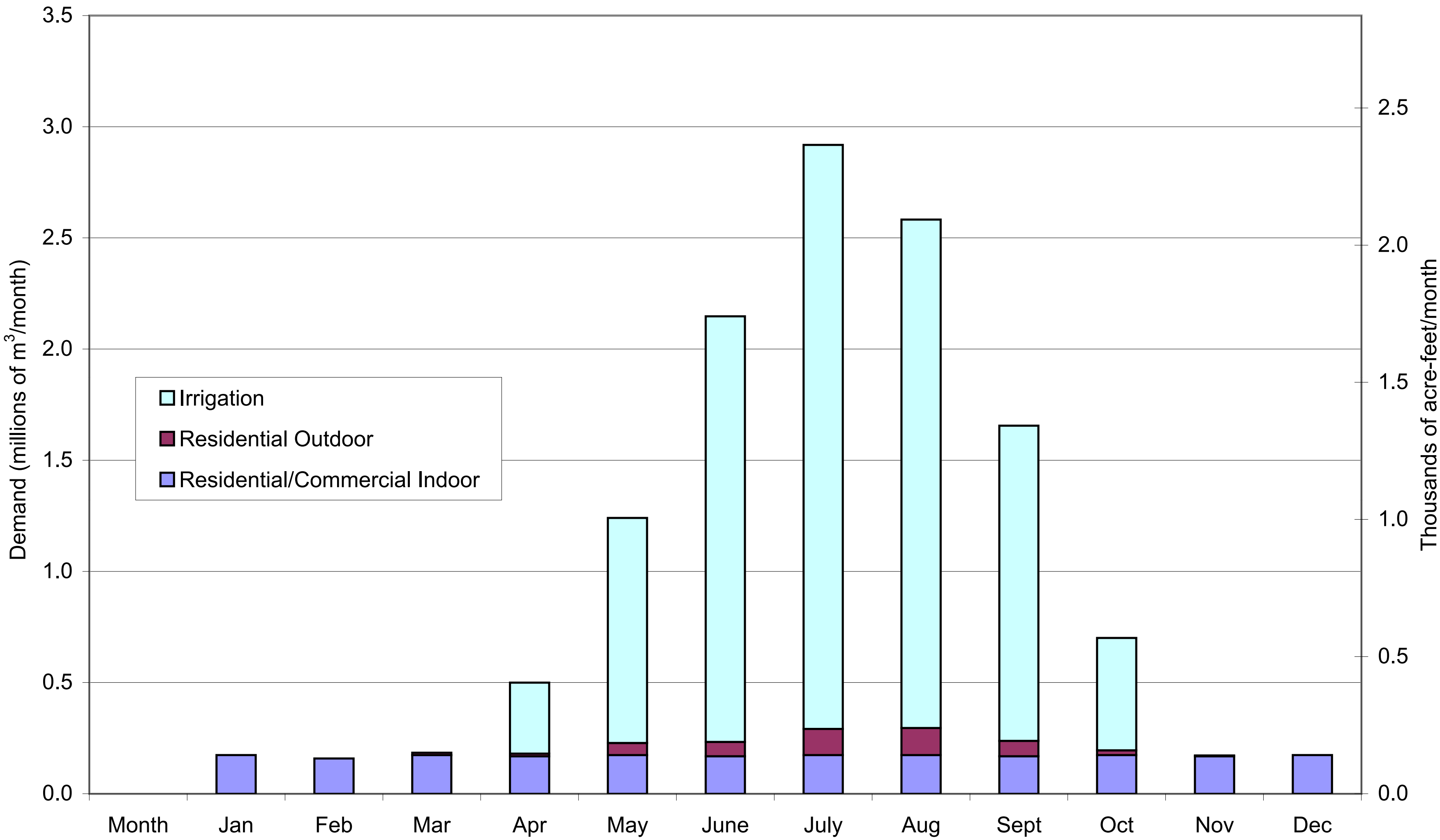


Figure 3.3: Summerland Calculated Agricultural Water Demand 2002-2004

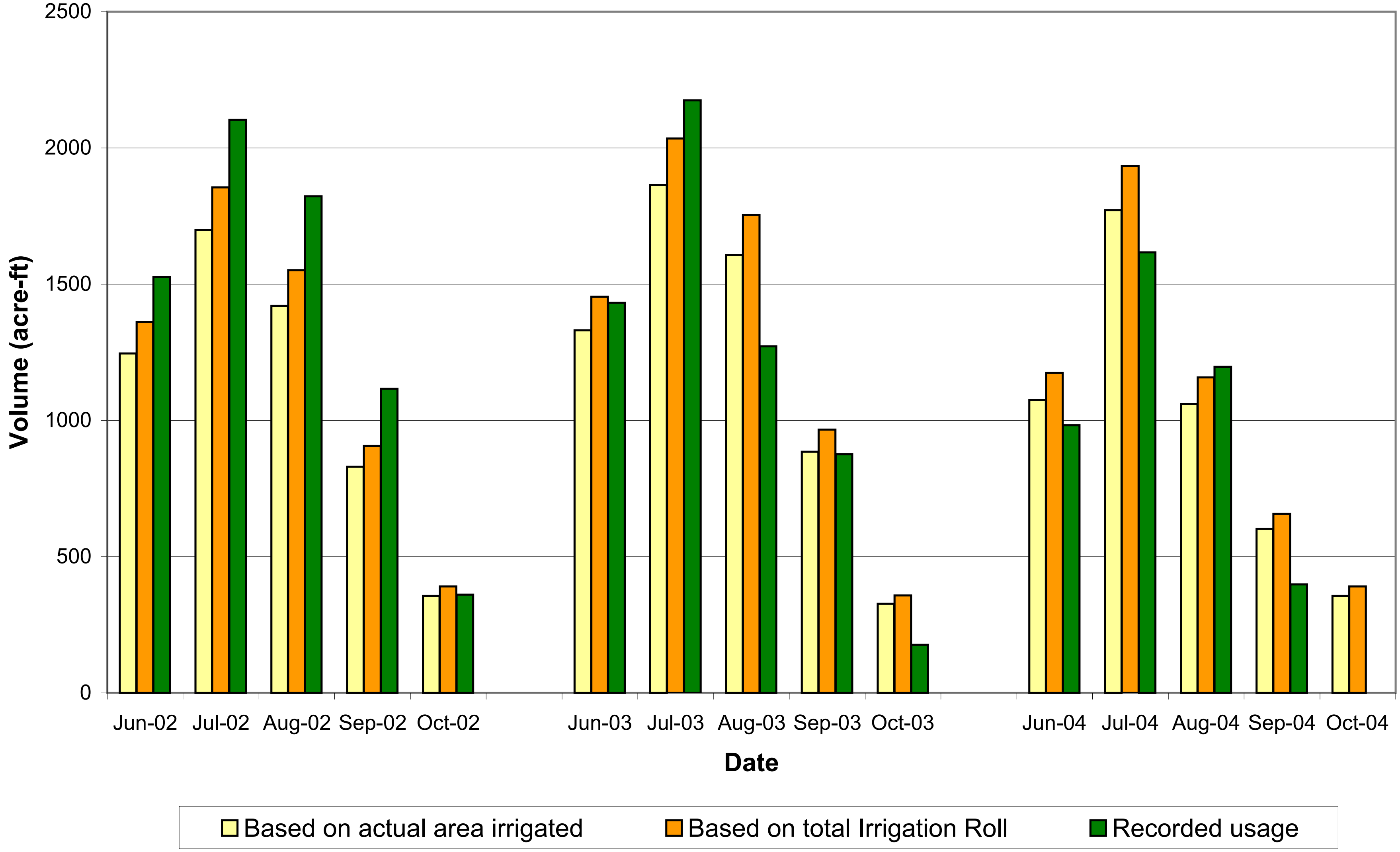
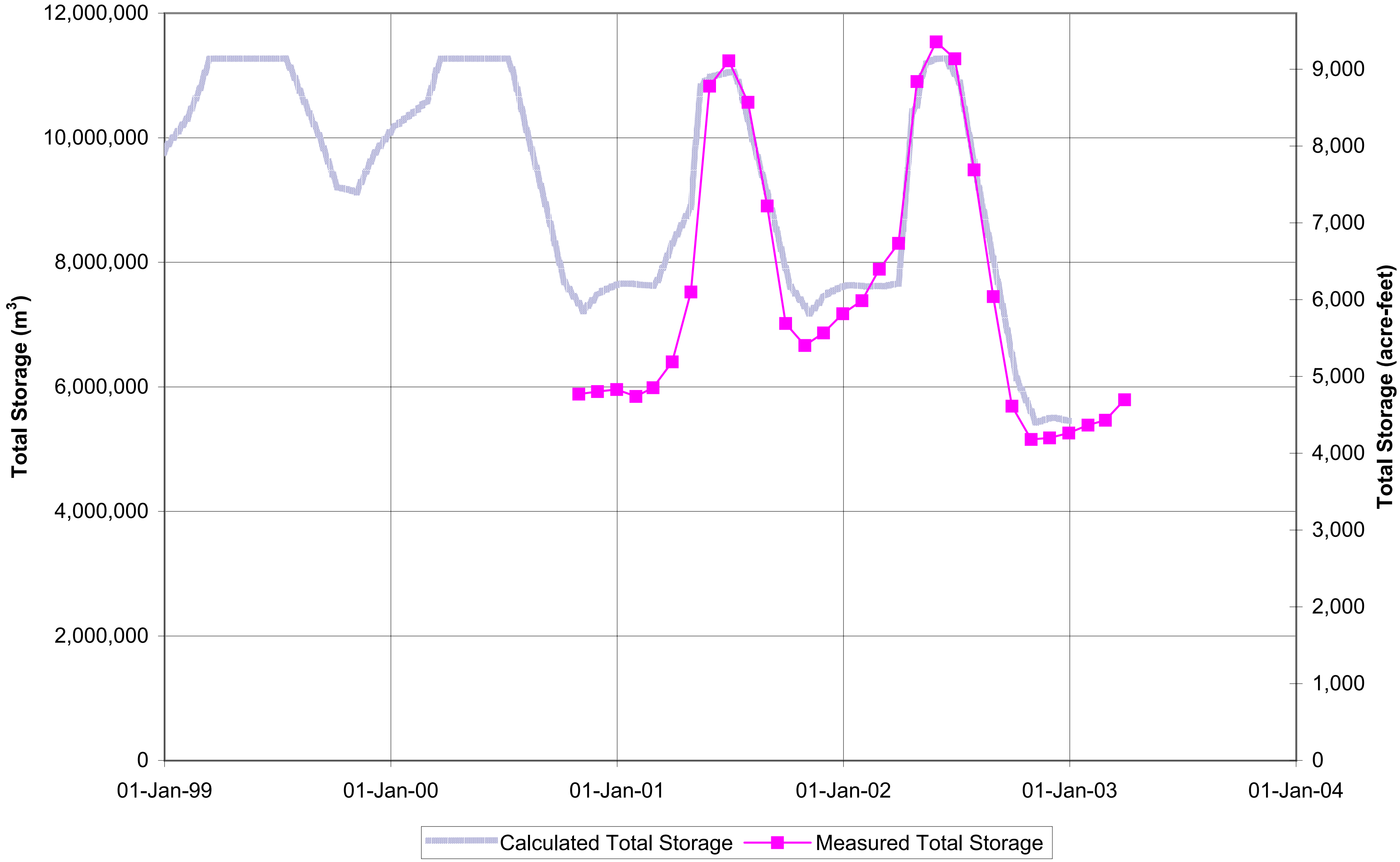


Figure 4.1: Measured and Calculated Total Volume of Water in Storage



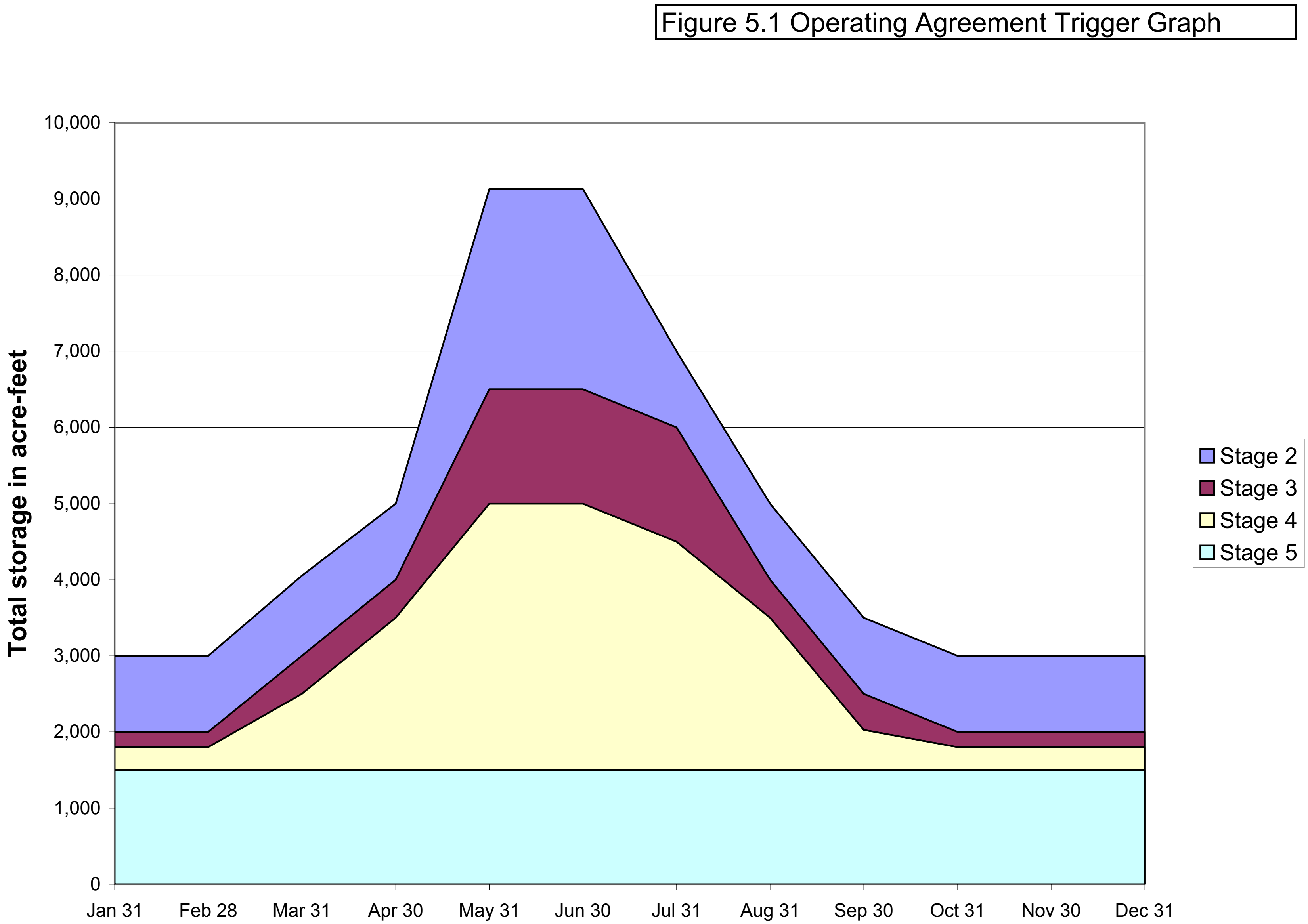
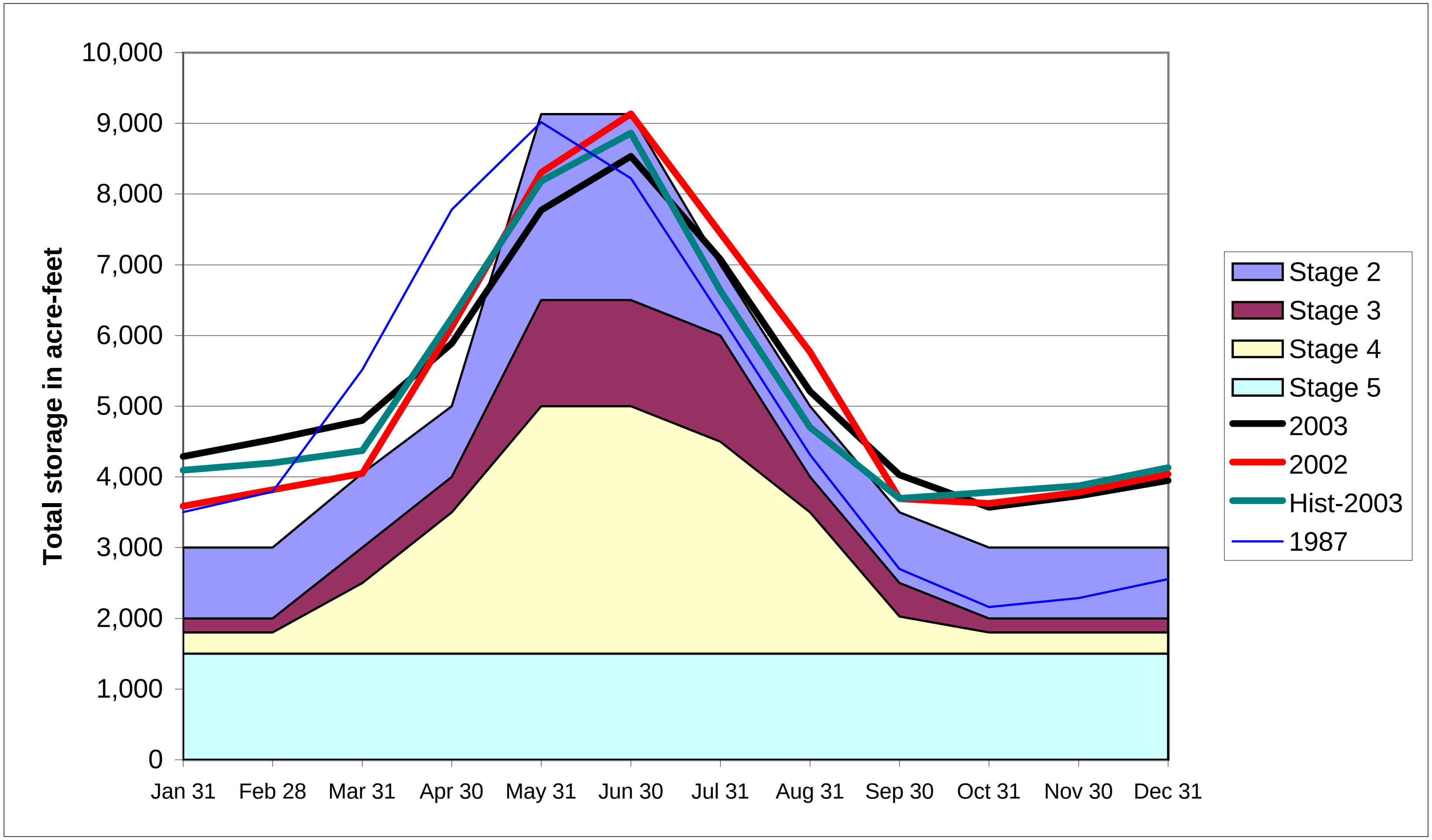


Figure 5.1 Operating Agreement Trigger Graph
Total storage in acre-feet
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan 31
Feb 28
Mar 31
Apr 30
May 31
Jun 30
Jul 31
Aug 31
Sep 30
Oct 31
Nov 30
Dec 31
Stage 2
Stage 3
Stage 4
Stage 5

Figure 5.2 Trigger Graph with Sample Years



Note: Sample years assume Operating Agreement A

Figure 5.3 Operation in three consecutive drought years

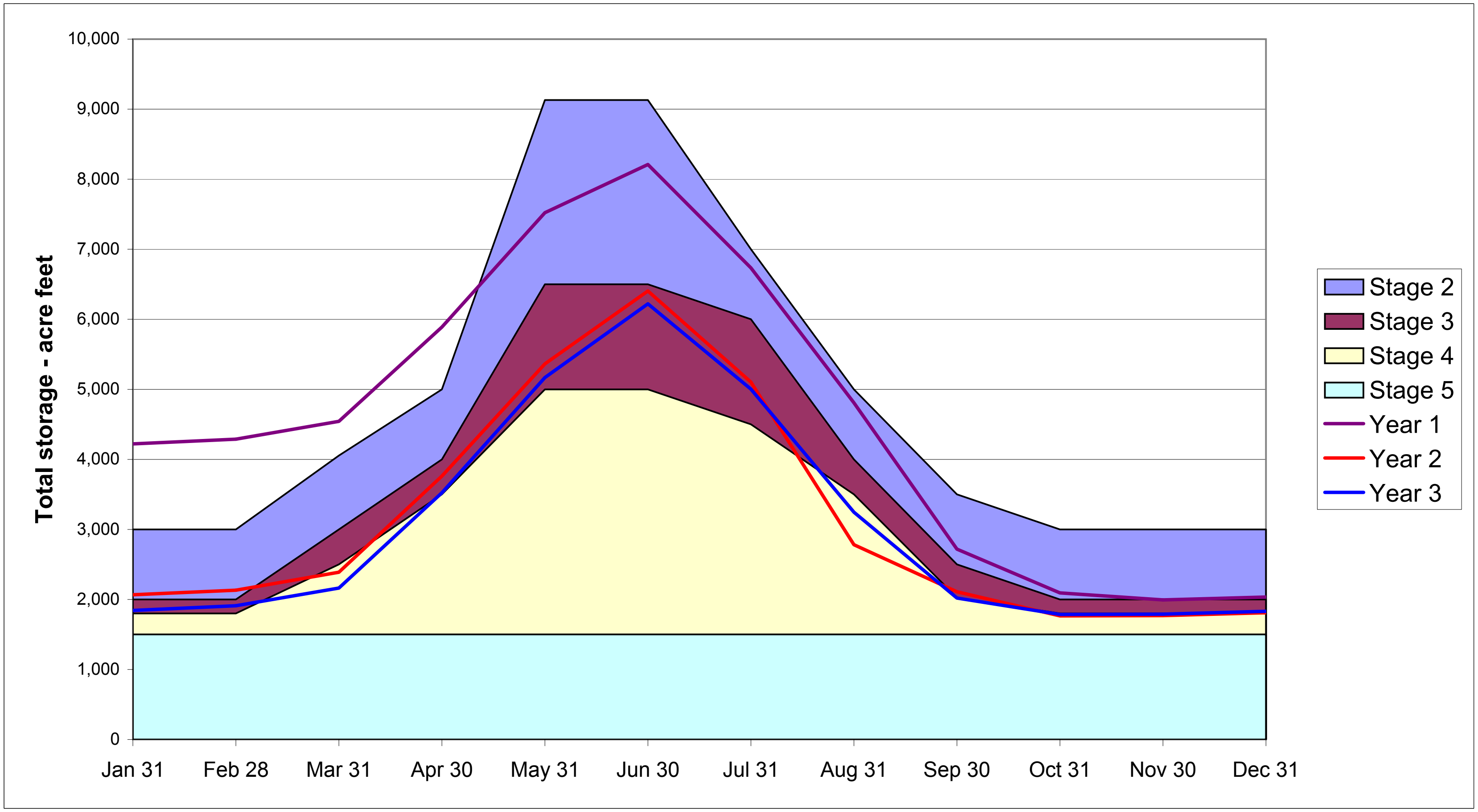


Figure 7.1: Impact of Potential Climate Change on Camp Creek Average Flows