A Study of Salinity in the Lower South Platte Basin

Compiled 5-Year Study

Northern Water
Northern Colorado Water Conservancy District

In Cooperation with: United States Bureau of Reclamation
9/23/2009

A Study of Salinity in the Lower South Platte Basin

Compiled 5-Year Study
Fiscal Year 2008
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Conducted by:
Northern Colorado Water Conservancy District

In Cooperation with:
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Table of Contents

Table of Figures

Table of Tables

Table of Equations

Appendices

INTRODUCTION

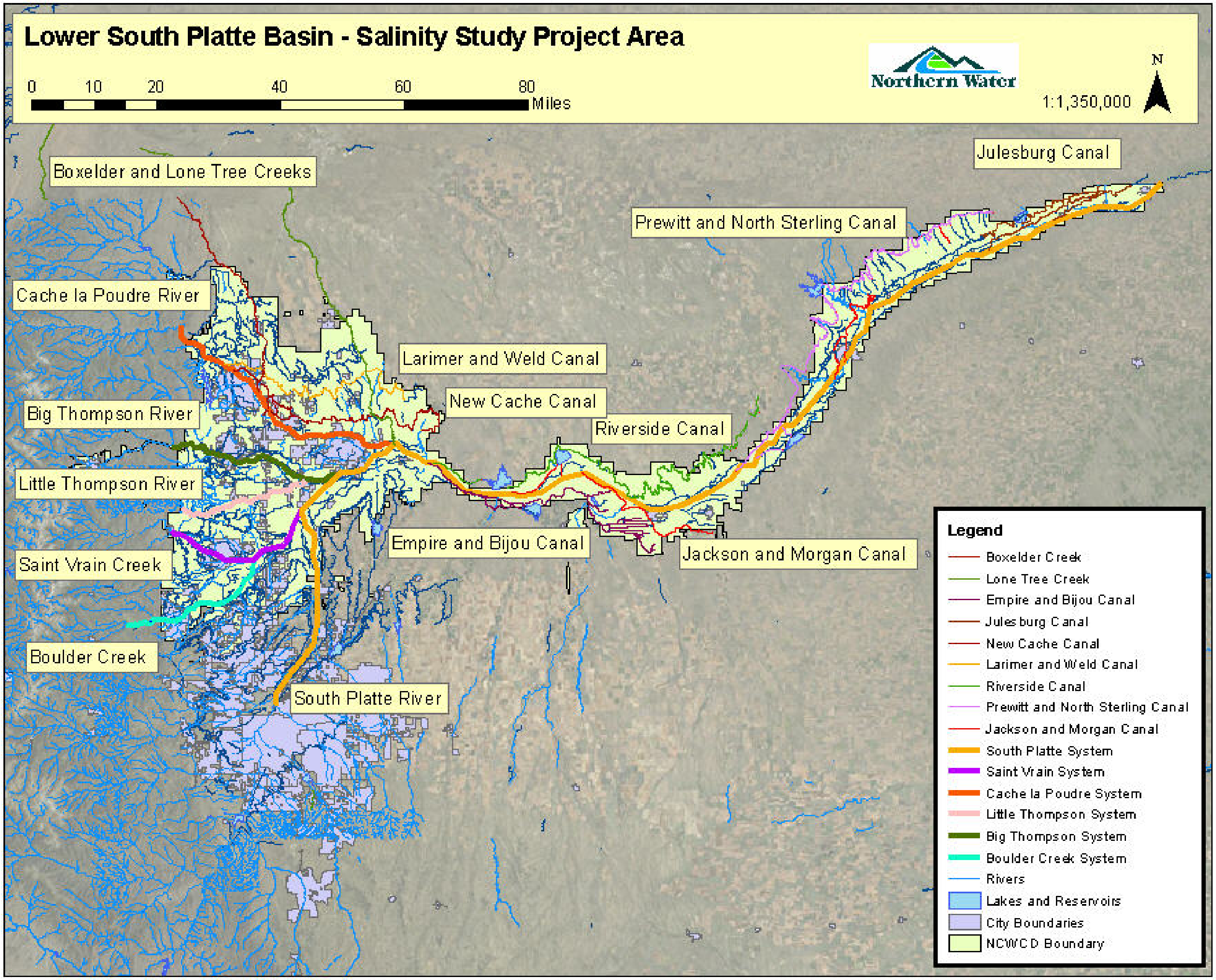
In 2006 the Northern Colorado Water Conservancy District (Northern Water), in cooperation with the United States Bureau of Reclamation (Reclamation), completed its final year of the assessment project entitled, “A Study of Salinity in the Lower South Platte Basin,” agreement number 00FC601426. Throughout the study period, Northern Water collected and compiled salinity data from a network of automated and manual surface water monitoring stations and groundwater observation wells within the project area. The project area is shown in Figure 1 below. Following each year of data, an annual report was written and submitted. Upon completion of the study, a compiled report was desired to include results from all five years of data.

This compiled report presents summaries of the data and general observations and comparisons. It does not include detailed data which were presented previously in the Annual Reports. Nor does it attempt to revisit the study program, sampling station selection, or sampling techniques.

Each year of the study contained challenges and changes for collecting samples. Each year also included various weather patterns including a severe drought in 2002. The amount of river water available for irrigation affected the study in many ways. For instance, in the worst case: no water meant no sampling. The weather and rainfall can affect the electrical conductivity of the water and thus the crops being irrigated by the water sampled in this study.

Based on the data gathered and summarized in this report, recommendations are made for future courses of action as related to salinity monitoring in the Lower South Platte Basin.

Figure 1: Project Area Map



PROJECT BACKGROUND

The purpose of this project was to collect information regarding salinity issues and their impacts on water quality and conservation within Northern Water boundaries. The project goal was to help build the foundation on which salinity issues are identified and from which management decisions will be developed.

Northern Water monitored surface water salinity levels throughout the water delivery system, including river systems and irrigation ditch systems. Additionally, groundwater salinity levels and water depths were monitored for a number of wells located inside Northern Water boundaries. Soil assessments were also conducted. From the information collected during the study period, a thorough database was developed.

Location maps for sampling stations and well locations are included in this report in Appendix A.

SALINITY BACKGROUND

Vast amounts of research have been conducted and published on salinity across the world. This should come as no surprise considering many believe that increasing salinity is the greatest irrigation-related threat to Western agriculture (Council 1989). In short, excess salts in irrigation water pose a negative effect on crop yield.

Literature Review

Several documents were reviewed during the development of this final compilation report for the Study of Salinity in the Lower South Platte Basin. Following are several quotes and references which should provide the reader with a basic background on salinity in order to better review the study results.

The *Irrigation and Drainage Paper #29* entitled *Water Quality for Agriculture* contains valuable information that is often referred to in other sources. A good overview of the salinity problem is quoted from this paper:

> *"A salinity problem related to water quality occurs if the total quantity of salts in the irrigation water is high enough that salts accumulate in the crop root zone to the extent that yields are affected. If excessive quantities of soluble salts accumulate in the root zone, the crop has extra difficulty in extracting enough water from the salty soil solution. This reduced water uptake by the plant can result in slow or reduced growth and may also be shown by symptoms similar in appearance to those of drought such as early wilting. Some plants exhibit a bluish-green color and heavier deposits of wax on the leaves. These effects of salinity may vary with the growth stage and in some cases may go entirely unnoticed due to a uniform reduction in yield or growth across an entire field. This mechanism of water uptake has been studied extensively and it now appears the plant takes most of its water from and responds more critically to salinity in the upper part of the root zone than to the salinity level in its lower depths when using normal irrigation practices (Bernstein and Francois, 1973). Thus, managing this critical upper root zone*

may be as important as providing adequate leaching to prevent salt accumulation in the total root zone."

"Crop tolerance is presented in the tables as if tolerance was a fixed value. This is not exactly true. Crop tolerance does change with water management practices as well as with stage of growth, with rootstocks, with varieties and with the climate. For many crops the germinating and early seedling stage is the most sensitive – sugar beets, rice, wheat, barley and several vegetables – and soil salinity (ECe) in excess of 4 mmhos/cm in the area of the germinating seed may delay or inhibit germination and early growth. The tolerance values as presented in Table 5 are based on the response from late seedling stage of growth to maturity." (Ayers 1976)

"High salt concentrations in soil-water can limit availability of water to the crop; as the salt ions interact with water they decrease the ease of water uptake by plants in proportion to salinity" (Ayers, Irrigation and Drainage Paper #29. Water Quality for Agriculture 1976). This is called the osmotic effect. Crops can tolerate a certain amount of salinity before reducing yield levels. Tables have been generated by several authors that show the crop tolerance levels and potential loss with increased salinity.

Table 5 referred to in the Ayers 1976 quote above from *Irrigation and Drainage Paper #29,* is the Crop Tolerance and Yield Potential of Selected Crops as Influenced by Irrigation Water Salinity (EC_w) or Soil Salinity (EC_e) and lists numerous field crops and the potential yield reductions at various salinity levels. A condensed adaptation of this table was published by Colorado State University Extension in paper no. 0.506, *Irrigation Water Quality Criteria* (Bauder n.d.) and is shown in Table 1 below:

Table 1. Potential Yield Reduction from Saline Water for Selected Irrigated Crops
(Adapted from *Quality of Water for Irrigation*) (Ayers 1977)

Crop	Potential Yield Reduction			
	0%	10%	25%	50%
Barley	5.3	6.7	8.7	12
Wheat	4	4.9	6.4	8.7
Sugarbeet	4.7	5.8	7.5	10
Alafalfa	1.3	2.2	3.6	5.9
Potato	1.1	1.7	2.5	3.9
Corn (grain)	1.1	1.7	2.5	3.9
Corn (silage)	1.2	2.1	3.5	5.7
Onion	0.8	1.2	1.8	2.9
Beans	0.7	1	1.5	2.4

EC_w = electrical conductivity of the irrigation water in dS/m at 25-degrees C

The above tolerances should be considered guidelines. Absolute tolerances vary based on climate, soil conditions, and cultural practices.

Many factors contribute to the crop yield potential beyond irrigation water salinity. This study collected only electrical conductivity data in river and ditch water systems as a measure of salinity (EC_w). Both water salinity (EC_w) and the sodium adsorption ratio (SAR) of the applied water affect the rate of infiltration of water into surface soil (Ayers 1985). Salinity is a dynamic property in soil: it is highly mobile and is related to the water content in the soil-moisture system. Additionally, soil structure plays a part in determining the effects of saline water on a crop.

"Water stored in reservoirs and conveyed through long reaches of canals becomes more saline as evaporation occurs. After application to fields, water is lost through both evaporation and crop transpiration, leaving salts behind which can accumulate over time and cause a decline in agricultural productivity. High soil salinity limits the availability of root extractable soil water and may result in ion toxicity to the crop" (Bernstein 1974).

In a 1997 thesis entitled *Assessment of Salinity in the South Platte River, Water Years 1963-1994*, the author concluded that "Total dissolved solids and constituent concentrations in the river over the past 32 years have remained relatively the same, and have maintained the same pattern of gain and loss along the river." (Lord 1997)

In the report titled *Impact of Utilizing Water Supplies from the South Platte Water Conservation Project on Crop Production*, a report made to Northern Water by Dr. Glenn J. Hoffman in 2004, several general recommendations were made where salinity is a concerned:

1) Monitor selected fields at least annually to ensure soil salinity is not becoming excessive.
2) Continue to measure the salt content of water sources.
3) If needed to reduce soil salinity, apply excess irrigation water in the off-season to leach the crop root zone.
4) Management practices can be implemented to alleviate the potential for crop yield losses due to salinity increases.

The literature reviewed helps to confirm the expected results of this study in many instances. However, when the results differ from those expected, it generates many questions.

SURFACE WATER ELECTRICAL CONDUCTIVITY RESULTS

In evaluating the following collected and analyzed data, it is beneficial to know the units and accuracy of the EC_w readings being reported. Electrical conductivity (EC_w) was measured using several different devices and is reported in dS/m (deciseimens per meter).

Values differ in accuracy based on the method or device used to collect the sample. For the automated stations, values above 1.0 dS/m have an accuracy of +/- 5% of the value. Values below 1.0 dS/m have an accuracy of +/- 10% of the value. The grab sample data have an accuracy of 0.5% of the value. Accuracies reported here are from the manufacturer's specifications.

Stream and River Systems

The six river systems included in this study are shown in Table 2 below, along with the station locations that were sampled and whether the sampling was automated or manual at each site.

Table 2. River Systems Station List

River System	Site Description	Site Abbreviation	Type of Site
Cache la Poudre System			
	Canyon Mouth	CLAFTCCO	automated
	Near Laporte	CLALAPCO	manual
	Fort Collins	CLAFORCO	manual
	Boxelder Creek	CLABOXCO	automated
	Below New Cache	CLARIVCO	automated
	Windsor across 7th St.	CLAWIN7ST	manual
	Greeley #3 near WCR 29	CLAGRLCO	automated
	Greeley	CLPGREELEY	manual
	Greeley near Airport	CLAGRECO	automated
Big Thompson System			
	Canyon Mouth	BTCANYCO	automated
	Namaqua Drive	BTCACRNAMQ	manual
	Loveland	BIGLOVCO	automated
	Across WCR 90 or LCR 1	BTACRLCWC	manual
	Milliken at HWY 257	BTMILH257	manual
	Near La Salle	BIGLASCO	automated
Little Thompson System			
	Canyon Mouth	LTCANYCO	automated
	83rd Street near Boulder & Weld County Line	LTACR83ST	manual
	LCR 21 near Boulder & Weld County Line	LTACRLC21	manual
	LCR 17 near 4E	LTACRLC17	manual
	WCR 7 near HWY 56	LTACRWC7	manual
	WCR 15 near 46 Rd	LTACRWC15	manual
	Near Platteville	LTMIL257	automated
Saint Vrain Creek System			
	Lyons	SVCLYOCO	automated
	Longmont	SVLONGCO	automated
	Longmont across 119 St.	SVLONGMONT	manual
	Below Longmont	SVCBLOCO	automated
	13 and 26.5 Rd.	SVCACRWC13	manual
	Near Platteville	SVCPLACO	automated
Boulder Creek System			
	Orodell	BOCOROCO	manual
	75th St. near Boulder	BOCNORCO_stream	automated
	75th St. near Boulder, WWTP effluent	BOCNORCO_waste	automated
	Boulder & Weld County Road near HWY 52	BOACBCWC	manual
	South of Longmont	BOLONGCO	automated

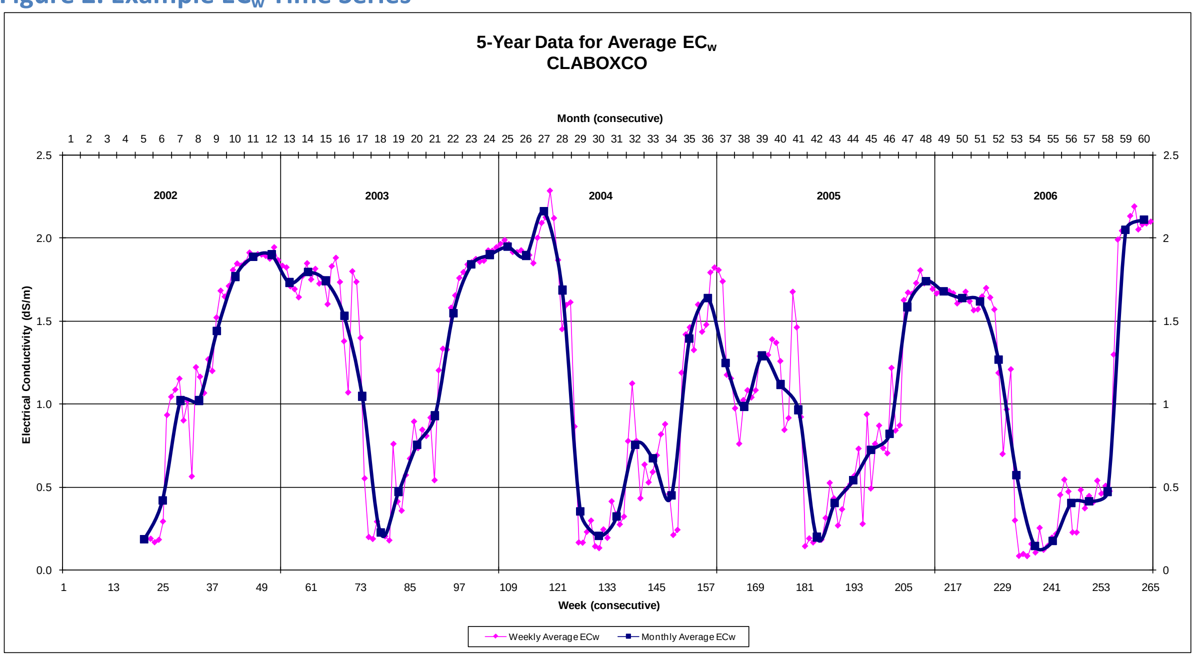
Table 2(continued). River Systems List

River System	Site Description	Site Abbreviation	Type of Site
South Platte System			
	Henderson	PLAHENCO	automated
	Fort Lupton	PLALUPCO	automated
	Platteville near WCR 32.5	PLAPLACO	manual
	HWY 60 near Milliken	PLAACRH60	manual
	Evans	PLAEVACO	manual
	Near Kersey	PLAKERCO	automated
	Kuner Feedlot	PLAKUNCO	manual
	Masters near Jackson Reservoir	PLAMASCO	automated
	Weldona	PLAWELCO	automated
	Fort Morgan	PLAMORCO	automated
	Cooper Bridge near Balzac	PLABALCO	automated
	Merino across LCR 55	PLAMERCO	manual
	Sterling	PLASTLCO	automated
	Iliff across LCR 55	PLALIFCO	manual
	Jumbo Diversion	PLAJUMCO	automated
	Sedgwick across HWY 59	PLASEDCO	manual
	Julesburg (Channel 1)	ONEJURCO	automated

Analysis Overview

Based on the data collected throughout the study, several graphs were generated to evaluate the overall trends in the electrical conductivity levels at each station and along each river system. The software programs Excel and Minitab were utilized for the graphical and statistical analyses that are presented in this report. The Weekly Average EC_w and the Monthly Average EC_w were plotted on a consecutive timeline, as shown in the example graph in Figure 2. This time series graph provides a view of the sampling results for the entire study period. The Monthly Average EC_w data smoothes out the weekly data also shown on the graph. These graphs display seasonal patterns, study-period trends, and outliers.

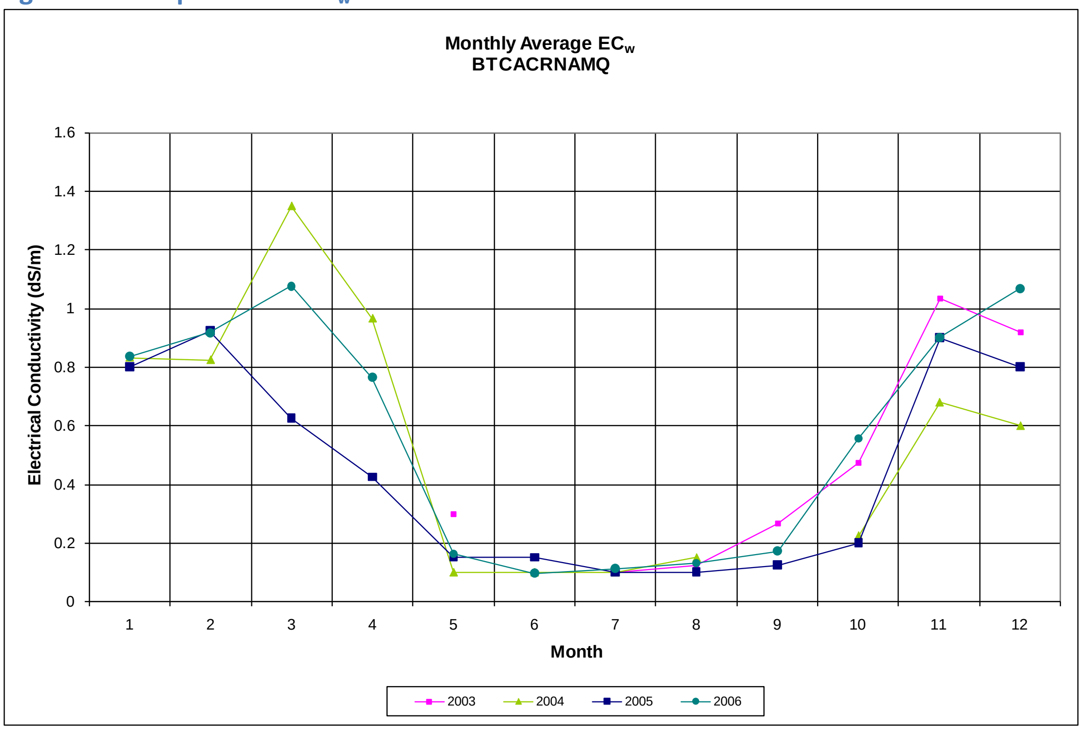
Figure 2. Example EC_w Time Series



Time series plots for all rivers systems are included in Appendix B of this report.

Average Monthly EC_w was also plotted for each station by year in order to overlap the annual data and observe any trends throughout a single year. For many of the stations, a “U” shaped graph appears. This indicates that the EC_w is lowest through the summer months and higher during the rest of the year. Considering that the river flow rates are typically highest during the summer months, it appears the data shows that lower EC_w values correspond to higher flow rates, which makes sense, as the increased flow dilutes the EC_w. Figure 3 is an example graph of the seasonal patterns.

Figure 3. Example Plot of EC_w Seasonal Patterns



Not all stations were sampled for the same time period. Although this was a 5-year study, it took some time to bring all the stations on-line and, therefore, many of the included stations do not include data for the first year or two of the study. Table 3 below shows each river system station and indicates which years data was collected.

Table 4 provides the Annual Average EC_w data and the Annual Standard Deviation for each river system station. The computed Historical Average refers to the numeric average of the Annual Average EC_w data collected for all years data were collected on a station. Table 5 shows the Maximum and Minimum daily average EC_w values for each river system station. As mentioned above, much of the observed variability in river EC_w is the result of seasonal flow variation and is not random. In general, within this report, all types of “averages” are computed as simple arithmetic means over the period of interest and are not flow weighted. For the stream stations, flow-weighted averages would tend to be lower than the reported averages since the higher concentrations would be weighted by lower flows and vice versa.

Table 3. River System Stations and Years of Data Collection

River System	Site Abbreviation	2001	2002	2003	2004	2005	2006
Cache la Poudre System							
	CLAFTCCO		x	x	x	x	x
	CLALAPCO	½ year	x	x	x	x	x
	CLAFORCO	½ year	x	x	x	x	x
	CLABOXCO		x	x	x	x	x
	CLARIVCO		x	x	x	x	x
	CLAWIN7ST				x	x	x
	CLAGRLCO				x	x	x
	CLPGREELEY			x	x	x	x
	CLAGRECO		x	x	x	x	x
Big Thompson System							
	BTCANYCO		½ year	x	x	x	x
	BTCACRNAMQ			x	x	x	x
	BIGLOVCO	3 pts	x	x	x	x	x
	BTACRLCWC			x	x	x	x
	BTMILH257			x	x	x	x
	BIGLASCO		x	x	x	x	x
Little Thompson System							
	LTCANYCO		x	x	x	x	x
	LTACR83ST				x	x	x
	LTACRLC21				x	x	x
	LTACRLC17			x	x	x	x
	LTACRWC7			x	x	x	x
	LTACRWC15			x	x	x	x
	LTMIL257			2 pts	x	x	x
Saint Vrain Creek System							
	SVCLYOCO		x	x	x	x	x
	SVLONGCO		½ year	x	x	x	x
	SVLONGMONT			x	x	x	x
	SVCBLOCO		x	x	x	x	x
	SVCACRWC13				x	x	x
	SVCPLACO		x	x	x	x	x
Boulder Creek System							
	BOCOROCO			x	x	x	x
	BOCNORCO_stream		2 pts			x	x
	BOCNORCO_waste				x		x
	BOACBCWC			x	x	x	x
	BOLONGCO			2 pts	x	x	x
South Platte System							
	PLAHENCO				x	x	x
	PLALUPCO			3 pts	x	x	x
	PLAPLACO			x	x	x	x
	PLAACRH60			x	x	x	x
	PLAEVACO			x	x	x	x
	PLAKERCO		x	x	x	x	x
	PLAKUNCO			x	x	x	x
	PLAMASCO				x	x	x
	PLAWELCO		½ year	x	x	x	x
	PLAMORCO		½ year	x	x	x	x
	PLABALCO		x	x	x	x	x
	PLAMERCO			x	x	x	x
	PLASTLCO				x	x	x
	PLALIFCO			x	x	x	x
	PLAJUMCO				x	x	x
	PLASEDCO			x	x	x	x
	ONEJURCO		½ year	x	x	x	x

Note: An "x" does NOT imply a complete year of data.

Table 4. River System Annual Average EC_w and Standard Deviation

Cache la Poudre System

	CLAFTCCO automated		CLALAPCO manual		CLAFORCO manual		CLABOXCO automated		CLARIVCO automated	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2001			0.23	0.09	0.30	0.18				
2002	0.12	0.09	0.27	0.11	0.24	0.17	1.33	0.58	1.04	0.30
2003	0.10	0.05	0.27	0.13	0.44	0.23	1.29	0.63	0.66	0.44
2004	0.10	0.04	0.22	0.12	0.38	0.30	1.12	0.75	0.94	0.45
2005	0.10	0.04	0.28	0.15	0.35	0.20	0.97	0.54	0.86	0.38
2006	0.07	0.03	0.19	0.12	0.25	0.16	1.04	0.75	0.81	0.54
Historical Average	0.10		0.24		0.33		1.15		0.86	

	CLAWIN7ST manual		CLAGRLCO automated		CLPGREELEY manual		CLAGRECO automated	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2001								
2002							1.26	0.15
2003					1.48	0.28	1.28	0.17
2004	0.89	0.45	1.17	0.30	1.43	0.33	1.31	0.24
2005	1.01	0.36	1.25	0.35	1.35	0.34	1.24	0.33
2006	0.98	0.46	1.33	0.31	1.47	0.22	1.29	0.17
Historical Average	0.96		1.25		1.43		1.28	

Big Thompson System

	BTCANYCO automated		BTCACRNAMQ manual		BIGLOVCO automated		BTACRLCWC manual	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2001					1.10	0.17		
2002	0.07	0.01			0.81	0.41		
2003	0.08	0.04	0.50	0.38	0.94	0.45	0.81	0.35
2004	0.06	0.02	0.62	0.43	0.88	0.52	0.96	0.34
2005	0.06	0.03	0.43	0.35	0.73	0.46	0.80	0.31
2006	0.07	0.02	0.49	0.42	0.87	0.48	0.91	0.30
Historical Average	0.07		0.51		0.89		0.87	

	BTMILH257 manual		BIGLASCO automated	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2001				
2002			1.42	0.21
2003	1.07	0.37	1.43	0.31
2004	1.21	0.28	1.41	0.32
2005	0.98	0.35	1.21	0.27
2006	1.23	0.25	1.46	0.21
Historical Average	1.12		1.39	

Table 4 (continued). River System Annual Average EC_w and Standard Deviation

Little Thompson System

	LTCANYCO automated		LTACR83ST manual		LTACRLC21 manual		LTACRLC17 manual		LTACRWC7 manual	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002	0.76	0.16								
2003	0.56	0.28					1.82	0.37	2.09	0.30
2004	0.42	0.21	0.54	0.19	0.94	0.32	1.67	0.70	2.04	0.42
2005	0.47	0.25	0.54	0.16	1.14	0.29	1.56	0.33	2.21	0.36
2006	0.64	0.12	0.64	0.34	1.21	0.51	1.68	0.56	2.24	0.43
Historical Average	0.57		0.57		1.09		1.68		2.15	

	LTACRWC15 manual		LTMIL257 automated	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002				
2003	2.05	0.27	2.15	0.05
2004	2.02	0.38	1.85	0.37
2005	2.08	0.33	1.97	0.29
2006	2.15	0.35	1.95	0.35
Historical Average	2.07		1.98	

Saint Vrain System

	SVCLYOCO automated		SVLONGCO automated		SVLONGMONT manual		SVCBLOCO automated	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002	0.08	0.03	0.43	0.06			1.08	0.10
2003	0.07	0.02	0.46	0.09	0.84	0.25	1.06	0.37
2004	0.06	0.02	0.38	0.11	0.95	0.28	1.17	0.27
2005	0.06	0.02	0.32	0.09	0.89	0.30	1.05	0.31
2006	0.04	0.01	0.35	0.09	1.06	0.20	1.25	0.25
Historical Average	0.06		0.39		0.93		1.12	

	SVCACRWC13 manual		SVCPLACO automated	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002			1.08	0.15
2003			0.96	0.30
2004	0.95	0.15	1.16	0.16
2005	0.94	0.24	1.12	0.27
2006	1.15	0.26	1.23	0.20
Historical Average	1.01		1.11	

Table 4 (continued). River System Annual Average EC_w and Standard Deviation

Boulder Creek System

	BOCOROCO		BOCNORCO_stream		BOCNORCO_waste		BOACBCWC		BOLONGCO	
	manual		automated		automated		manual		automated	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002			0.49	0.25						
2003	0.10	0.00					0.61	0.25	0.99	0.15
2004	0.13	0.06			0.69	0.04	0.63	0.17	1.19	0.30
2005	0.21	0.10	0.37	0.17	0.63	*N/A	0.61	0.19	0.94	0.36
2006	0.08	0.03	0.34	0.14	0.72	0.08	0.70	0.17	0.83	0.17
Historical Average	0.13		0.40		0.68		0.64		0.99	

*only one point in 2005

South Platte System

	PLAHENCO		PLALUPCO		PLAPLACO		PLAACRH60		PLAEVACO	
	automated		automated		manual		manual		manual	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002										
2003			1.20	0.07	0.94	0.21	1.00	0.27	1.12	0.29
2004	0.93	0.22	0.91	0.27	0.98	0.22	1.05	0.17	1.12	0.17
2005	0.83	0.26	0.91	0.21	0.97	0.18	1.01	0.21	1.09	0.24
2006	0.91	0.20	0.98	0.20	0.99	0.14	1.15	0.16	1.28	0.12
Historical Average	0.89		1.00		0.97		1.05		1.15	

	PLAKERCO		PLAKUNCO		PLAMASCO		PLAWELCO		PLAMORCO	
	automated		manual		automated		automated		automated	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002	1.39	0.33					1.59	0.14	0.87	0.11
2003	1.08	0.39	1.24	0.28			1.41	0.35	1.07	0.36
2004	1.40	0.24	1.23	0.20	1.21	0.16	1.54	0.26	1.79	0.28
2005	0.96	0.33	1.19	0.24	1.23	0.25	1.43	0.28	1.20	0.43
2006	1.38	0.12	1.35	0.14	1.39	0.10	1.60	0.13	1.58	0.20
Historical Average	1.24		1.25		1.28		1.52		1.30	

Table 4 (continued). River System Annual Average EC_w and Standard Deviation

South Platte System

	PLABALCO automated		PLAMERCO manual		PLASTLCO automated		PLALIFCO manual		PLAJUMCO automated	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002	1.58	0.18								
2003	1.41	0.20	1.62	0.23			2.04	0.19		0.00
2004	1.30	0.22	1.68	0.13	1.94	0.09	2.04	0.22	2.10	0.17
2005	1.40	0.39	1.67	0.15	1.86	0.24	1.98	0.29	2.03	0.34
2006	1.69	0.29	1.77	0.08	1.92	0.08	2.13	0.15	2.00	0.61
Historical Average	1.48		1.69		1.91		2.05		2.04	

*only one month of data in 2003 - deleted

	PLASEDCO manual		ONEJURCO automated	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002			1.97	0.39
2003	2.10	0.13	1.89	0.36
2004	2.23	0.18	1.75	0.36
2005	2.15	0.09	2.08	0.23
2006	2.14	0.38	2.22	0.08
Historical Average	2.16		1.98	

Table 5. River System Maximum and Minimum Daily Average EC_w

Cache la Poudre System

	CLAFTCCO automated		CLALAPCO manual		CLAFORCO manual		CLABOXCO automated		CLARIVCO automated	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2001			0.30	0.10	0.60	0.10				
2002	0.34	0.00	0.40	0.10	0.60	0.10	2.00	0.13	1.45	0.36
2003	0.28	0.02	0.50	0.10	1.00	0.10	2.03	0.14	1.65	0.02
2004	0.39	0.03	0.60	0.10	1.20	0.10	2.38	0.10	1.82	0.20
2005	0.20	0.04	0.50	0.10	0.60	0.10	1.93	0.12	1.62	0.001
2006	0.22	0.03	0.47	0.03	0.63	0.04	2.31	0.07	1.83	0.001

	CLAWIN7ST manual		CLAGRLCO automated		CLPGREELEY manual		CLAGRECO automated	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2001								
2002							1.56	0.73
2003					1.80	0.50	1.48	0.45
2004	1.70	0.10	1.76	0.41	1.83	0.40	1.70	0.55
2005	1.70	0.30	1.93	0.19	1.80	0.30	1.93	0.22
2006	1.74	0.40	1.97	0.53	1.91	0.82	1.61	0.75

Big Thompson System

	BTCANYCO automated		BTCACRNAMQ manual		BIGLOVCO automated		BTACRLCWC manual	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2001					1.45	0.37		
2002	0.10	0.05			1.69	0.21		
2003	0.23	0.03	1.10	0.10	1.73	0.13	1.30	0.20
2004	0.09	0.03	1.70	0.10	1.98	0.16	1.40	0.30
2005	0.19	0.03	1.10	0.10	1.81	0.10	1.30	0.10
2006	0.17	0.03	1.33	0.09	1.86	0.21	1.37	0.48

	BTMILH257 manual		BIGLASCO automated	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2001				
2002			1.97	0.99
2003	1.90	0.20	1.92	0.01
2004	1.80	0.40	1.95	0.56
2005	1.40	0.10	1.64	0.32
2006	1.81	0.73	1.83	0.18

Table 5 (continued). River System Maximum and Minimum Daily Average EC_w

Little Thompson System

	LTCANYCO automated		LTACR83ST manual		LTACRLC21 manual		LTACRLC17 manual		LTACRWC7 manual	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002	1.00	0.14								
2003	0.90	0.03					2.40	1.00	2.60	1.50
2004	0.89	0.15	0.80	0.20	1.30	0.30	3.87	0.40	2.60	0.80
2005	0.97	0.11	0.80	0.20	1.60	0.50	2.20	0.73	2.90	0.90
2006	0.91	0.30	2.48	0.26	2.61	0.45	2.54	0.67	2.82	0.56

	LTACRWC15 manual		LTMIL257 automated	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002				
2003	2.50	1.50	2.27	2.05
2004	2.50	0.90	2.36	0.90
2005	2.60	1.23	2.42	1.16
2006	2.69	0.97	2.50	1.19

Saint Vrain System

	SVCLYOCO automated		SVLONGCO automated		SVLONGMONT manual		SVCBLOCO automated	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002	0.18	0.04	0.55	0.31			1.32	0.77
2003	0.12	0.03	0.68	0.20	1.20	0.20	4.27	0.02
2004	0.12	0.03	0.62	0.08	1.50	0.30	2.07	0.46
2005	0.11	0.03	0.54	0.09	1.40	0.10	1.40	0.23
2006	0.07	0.03	0.57	0.11	1.63	0.62	1.78	0.54

	SVCACRWC13 manual		SVCPLACO automated	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002			1.54	0.70
2003			1.57	0.37
2004	1.10	0.60	1.66	0.72
2005	1.20	0.20	1.53	0.004
2006	2.12	0.72	1.91	0.55

Boulder Creek System

	BOCOROCO manual		BOCNORCO_stream automated		BOCNORCO_waste automated		BOACBCWC manual		BOLONGCO automated	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002			0.86	0.36						
2003	0.10	0.10					0.90	0.10	1.09	0.15
2004	0.30	0.10			0.79	0.60	0.90	0.30	1.54	0.48
2005	0.40	0.10	0.84	0.05	0.6315*	0.6315*	0.90	0.10	1.48	0.24
2006	0.15	0.03	1.04	0.05	1.06	0.41	1.02	0.29	1.28	0.32

*only one point in 2005

Table 5 (continued). River System Maximum and Minimum Daily Average EC_w

South Platte System

	PLAHENCO		PLALUPCO		PLAPLACO		PLAACRH60		PLAEVACO	
	automated		automated		manual		manual		manual	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002										
2003			1.53	1.13	1.20	0.40	1.20	0.30	1.60	0.50
2004	1.94	0.36	1.78	0.44	1.60	0.60	1.40	0.70	1.40	0.70
2005	1.47	0.21	1.34	0.41	1.20	0.50	1.20	0.40	1.33	0.50
2006	1.64	0.46	1.65	0.56	1.23	0.61	1.42	0.66	1.49	0.75

	PLAKERCO		PLAKUNCO		PLAMASCO		PLAWELCO		PLAMORCO	
	automated		manual		automated		automated		automated	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002	2.31	0.01					2.00	1.30	1.67	0.73
2003	1.61	0.26	1.50	0.60			2.06	0.40	2.22	0.36
2004	2.13	0.75	1.50	0.70	1.49	0.79	2.37	0.75	2.29	1.05
2005	1.54	0.07	1.40	0.60	1.53	0.55	1.84	0.64	1.91	0.18
2006	1.55	0.66	1.58	0.87	1.54	0.65	2.29	0.91	2.57	1.07

	PLABALCO		PLAMERCO		PLASTLCO		PLALIFCO		PLAJUMCO	
	automated		manual		automated		manual		automated	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002	1.91	1.23								
2003	1.73	0.45	1.90	1.00			2.40	1.20	0.01	0.01
2004	1.82	0.75	1.90	1.30	2.11	1.39	2.40	1.47	2.33	0.01
2005	1.96	0.003	1.88	1.00	2.18	0.77	2.40	0.90	2.55	0.86
2006	2.09	0.005	1.88	1.50	2.36	1.26	2.40	1.47	2.47	0.42

	PLASEDCO		ONEJURCO	
	manual		automated	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002			2.32	0.69
2003	2.40	1.90	2.38	0.69
2004	2.50	1.60	2.33	0.68
2005	2.40	2.00	2.45	1.02
2006	2.45	0.03	2.47	2.03

Statistical Analysis

River system data were analyzed with the statistical software program Minitab to characterize the study period data and also to determine if statistically significant trends existed within the study period. While a minimum of 10 years of data is preferable for performing statistical analysis, Northern Water has elected to perform the analysis with the available period of record which is typically five or fewer years. Additional data collected in years to come can be included in a future statistical analysis to evaluate longer term trends.

Seasons and Boxplots

From the time series plots, it is evident that the data is seasonal. Therefore, seasonality was accounted for in the statistical calculations. The year was divided into multiple seasons based on a review of several river system stations and associated Box and Whisker plots (or boxplots). Both four-season and three-season partitioning of the year were considered as follows.

Four seasons:

Month	Season
1 2 3 4	1
5 6	2
7 8 9	3
10 11 12	4

Three seasons:

Month	Season
1 2 3 4	1
5 6 7 8 9	2
10 11 12	3

For both of the above seasonal partitions (models), Box and Whisker Plots were created for the Average Monthly EC_w against the Year and Season. The within-season variability as indicated by the height of the box was much greater for the 3-season model than for the 4-season model, especially for season 2. This indicates that combining the spring and summer months into a single season is not advisable. Based on these graphical comparisons, the 4-season model was selected.

The following are Box and Whisker Plots for Station LTACRWC7 demonstrating the difference in using four seasons versus three seasons.

Figure 4. Boxplot for LTACRWC7 with Four Seasons

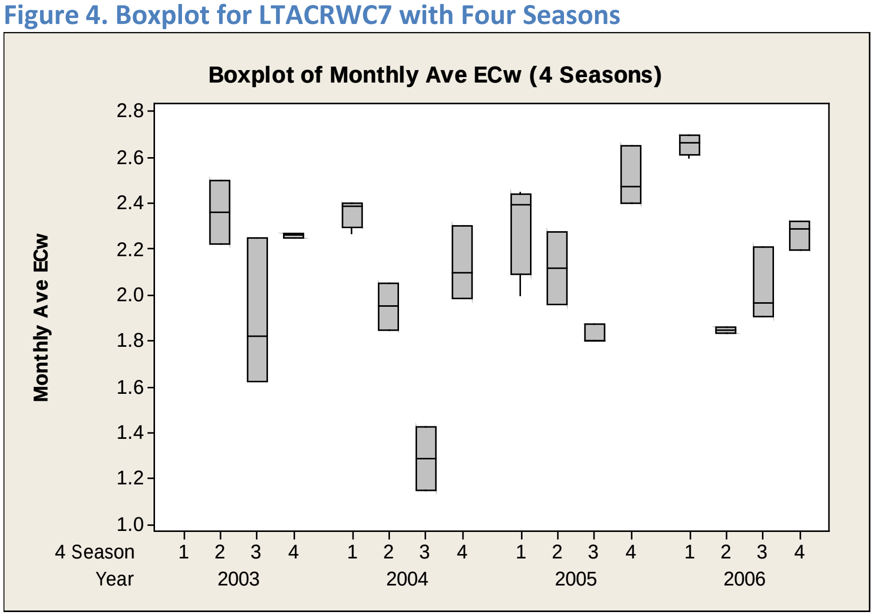
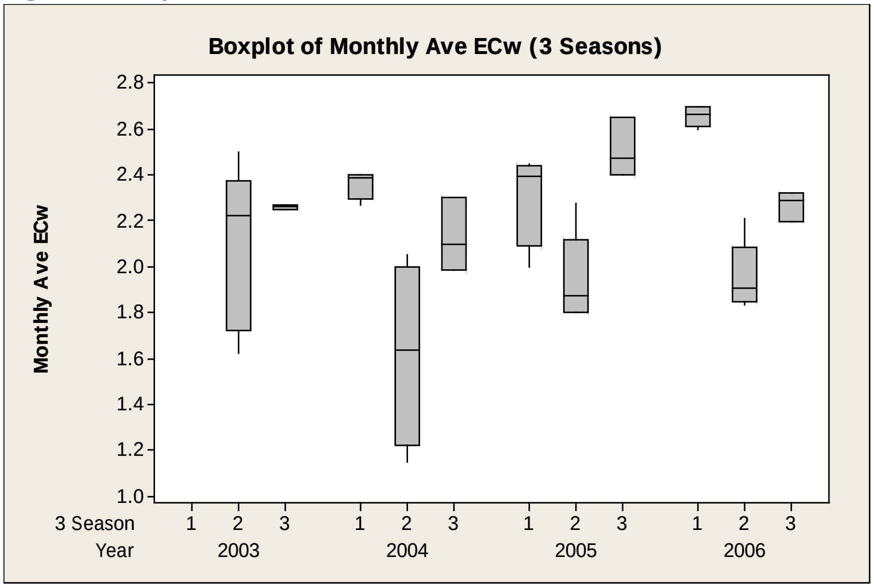


Figure 5. Boxplot for LTACRWC7 with Three Seasons



Similar (yearly by season) boxplots were generated for all river system sampling stations. These plots show the distribution of data over the study period and reveal seasonality quite simply. Each box and set of whiskers in these plots corresponds to the "season" for the plotted year. Within Minitab, calculations are performed to develop these graphs: the box corresponds to the middle 50% of the data in the group, the bottom of the box represents the 25th percentile, the top of the box represents the 75th percentile, and the horizontal line within the box is the 50th percentile (or median). The whiskers are extended based on the following Minitab calculations:

The upper whisker is extended to the highest value within the upper limit defined by:

Upper limit = Q3 + 1.5 (Q3-Q1)

Where Q3 is the third quartile or 75th percentile and Q1 is the first quartile or 25th percentile.

The lower whisker is extended to the lowest value within the lower limit defined by:

Lower limit = Q1-1.5(Q3-Q1)

The distance Q3-Q1 is equal to the length of the box.

Appendix C includes boxplots for all river systems.

Many of the river system data sets do not include enough points per box to produce any whiskers in the boxplots.

Trend Analysis Using Rank Regression

Several different methods for trend analysis of water quality data have been applied in practice documented in the literature. Of these, regression of the water quality variable against sampling date is the most straightforward and flexible and was, therefore, selected for this study.

Rank Transformation

Many statistical procedures, including regression, are strongly influenced by the presence of outliers or non-normally distributed observations. Unfortunately, water quality data tend to contain outliers and to be non-normally distributed, thus potentially invalidating conclusions regarding whether or not an observed trend is statistically significant. A convenient way to solve this problem is to use the rank transformation, substituting the rank of each data point for the measured value. Sometimes a log transformation is used instead. For this study, normal probability plots were examined and regressions were performed using both log and rank transformations for six stations. Better results were obtained using the rank transformation. Specifically, the rank transformation produced the best normality plots, highest R-squared values and lowest P-values. Thus, the rank transformation was used for all cases in this study, and the resulting tests for statistical significance of trend will not be affected by the distribution of the data.

However, to estimate trend magnitudes (slope of concentration vs. time plots) regression on the actual values is used. Inspection of the time series plots and trend lines will reveal any cases In which the trend estimate is unreasonably affected by outliers.

Seasonal Regression

Since EC_w (and many other water quality variables) exhibit strong seasonal patterns, it is very important to account for seasonal variation within any trend analysis. Otherwise, seasonal variation could be confused with random variability or with longer-term trends. Seasonality is most conveniently included in a regression model through the use of seasonal indicator variables that are assigned a value of 0 or 1 to indicate the season for each observation. The seasonal regression model requires one fewer indicator variable than the number of seasons. Thus three seasonal indicator variables are needed to model four seasons in this study.

The seasonal rank regression model used in this analysis to determine if statistically-significant trends existed for the study period is:

Equation 1. Seasonal Rank Regression Equation

$$\text{Rank } EC_w = B0 + B1 * I1 + B2 * I2 + B3 * I3 + B4 * Date$$

Where B0 is the overall intercept; the I’s are seasonal indicators defined below; and B4 is the regression coefficient for the date variable. In regression on ranks, B4 is used only to determine the significance of trend. In regression on the actual data, B4 is the trend magnitude. The coefficients B1, B2, and B3 are the seasonal adjustments to the overall intercept and are not utilized directly in this study.

Seasonal Indicator Variables

For each observation, the seasonal indicator variables are assigned a value of 0 or 1 to indicate which of the four seasons applies for that date. The values of the indicator variables for each season are shown in Table 6 below.

Table 6. Seasonal Indicator Variables

Months	Season #	I1	I2	I3
Jan-Apr	1	1	0	0
May-June	2	0	1	0
July-Sep	3	0	0	1
Oct-Dec	4	0	0	0

The input data set for analysis in Minitab consists of the date, measured EC_w, and values of the three indicators for each observation. Minitab computes the values of the regression coefficients B1 through B4 along with p-values for each coefficient. For this study, only the p-value associated with B4 is of interest. If the p-value for B4 is less than 0.1, the trend is said to be statistically significant at the 90% confidence level, and vice versa.

A statistically-significant trend means that there is statistical evidence (at the 90% confidence level for this analysis) to conclude there is a trend in the data analyzed. Concluding that there is a statistically significant trend does not imply that the trend is of any particular size, importance, or real-world significance. These conclusions must be made based on reviewing all the results.

If the P-value was less than 0.1, the final step in the statistical analysis was to perform a regression on the raw Monthly Ave EC_w data (not the Rank Monthly Ave EC_w) to calculate the slope of the trend line (the date coefficient in the regression equation).

A representation of the regression line was graphed with the Monthly Ave EC_w data for those stations with a statistically-significant trend over the study period. Those graphs are shown in Figures 6 through 27. (Note: the regression line shown on the graph does not exactly match the slope of the line reported in the table due to limited capability in Minitab.)

Limitations of Analysis

The statistical methods used to analyze the electrical conductivity data collected during this study provide a yes/no indicator as to whether or not an apparent trend is statistically significant over the study period. However, limitations do exist. For instance, with more data points in the analysis, a significant trend is more likely to be determined. (That is one reason that Monthly Ave EC_w data were used rather than Daily Ave EC_w data). The regression results should be compared to the graphical plots (boxplot and time series plots) to decide if there really is a trend that is of interest or importance.

A note of caution regarding the regression analysis performed on the salinity data in this study should be mentioned here. The goal for using regressions with the collected data was not to predict future EC_w values, but to determine if there are observations that can assist in understanding the EC_w values in the waters tested over the 5-year study period. General observations as to whether the EC_w value is increasing, decreasing, or remaining constant over time and throughout a river system may be made from the analysis only for the study period.

Table 7 shows the results of the statistical analysis in Minitab for the River Systems.

Table 7. River System Regression Results

River System	Site Description	Type	Site Abbreviation	Period of Record		Months	Days	Change over	Rank Regression		Slope if Significant	Notes
		(A or M)		Start	Stop			PoR	P-value	Significant Slope Y/N	dS/m per day	
Cache la Poudre System												
	Canyon Mouth	A	CLAFTCCO	7-02	12-06	54	1645	-0.03781855	0.006	Y	-0.00002299	
	Near Laporte	M	CLALAPCO	7-01	11-06	65	1979	-0.06829529	0.074	Y	-0.00003451	(missing 9 months of data)
	Fort Collins	M	CLAFORCO	7-01	11-06	65	1979	-0.12315317	0.068	Y	-0.00006223	(missing 7 months of data)
	Boxelder Creek	A	CLABOXCO	5-02	12-06	56	1706	-0.4860394	0.005	Y	-0.0002849	
	Below New Cache	A	CLARIVCO	5-02	12-06	56	1706		0.155	N		(missing 4/03 data)
	Windsor across 7th St.	M	CLAWIN7ST	5-04	12-06	32	975		0.350	N		(missing 6/04 and 9/04 data)
	Greeley #3 near WCR 29	A	CLAGRLCO	4-04	12-06	33	1005		0.254	N		
	Greeley	M	CLPGREELEY	5-03	12-06	44	1341		0.183	N		(missing 9/04 data)
	Greeley near Airport	A	CLAGRECO	3-02	12-06	58	1767		0.575	N		
Big Thompson System												
	Canyon Mouth	A	BTCANYCO	7-02	12-06	54	1645	-0.01814435	0.079	Y	-0.00001103	
	Namaqua Drive	M	BTCACRNAMQ	5-03	12-06	44	1341		0.838	N		(missing 6/03 and 9/04 data)
	Loveland	A	BIGLOVCO	1-02	12-06	60	1826		0.423	N		
	Across WCR 90 or LCR 1	M	BTACRLCWC	5-03	12-06	44	1341		0.703	N		(missing 9/04 data)
	Milliken at HWY 257	M	BTMILH257	5-03	12-06	44	1341		0.728	N		(missing 9/04 data)
	Near La Salle	A	BIGLASCO	4-02	12-06	57	1736		0.335	N		
Little Thompson System												
	Canyon Mouth	A	LTCANYCO	3-02	12-06	58	1767	-0.1579698	0.086	Y	-0.0000894	
	83rd St near Boulder & Weld CL	M	LTACR83ST	6-04	12-06	31	944		0.357	N		(missing 10/04 data)
	LCR 21 near Boulder & Weld CL	M	LTACRLC21	6-04	11-06	30	913		0.168	N		(missing 10/04 data)
	LCR 17 near 4E	M	LTACRLC17	5-03	11-06	43	1310		0.353	N		(missing 10/04 data)
	WCR 7 near HWY 56	M	LTACRWC7	5-03	12-06	44	1341		0.408	N		(missing 9/04 data)
	WCR 15 near 46 Rd	M	LTACRWC15	5-03	12-06	44	1341		0.954	N		(missing 9/04 data)
	Near Platteville	A	LTMIL257	11-03	12-06	38	1157		0.138	N		
Saint Vrain Creek System												
	Lyons	A	SVCLYOCO	7-02	12-06	54	1645	-0.0408289	0.000	Y	-0.00002482	(missing 4/03 data)
	Longmont	A	SVLONGCO	8-02	12-06	53	1614	-0.14845572	0.000	Y	-0.00009198	
	Longmont across 119 St.	M	SVLONGMONT	6-03	12-06	43	1310	0.26724	0.000	Y	0.000204	(missing 10/04 data)
	Below Longmont	A	SVCBLOCO	6-02	12-06	55	1675	0.145457	0.064	Y	0.00008684	
	13 and 26.5 Rd.	M	SVCACRWC13	7-04	12-06	30	914	0.4911836	0.000	Y	0.0005374	(missing 10/04 data)
	Near Platteville	A	SVCPLACO	4-02	12-06	57	1736	0.20981296	0.015	Y	0.00012086	
Boulder Creek System												
	Orodell	M	BOCOROCO	5-03	11-06	43	1310	-0.0494132	0.089	Y	-0.00003772	(missing 14 months of data)
	75th St. near Boulder	A	BOCNORCO_stream	5-02	12-06	56	1706	-0.47143604	0.000	Y	-0.00027634	
	75th St. near Boulder, WWTP eff	A	BOCNORCO_waste	9-04	12-06	28	852		0.301	N		(missing 2/05 thru 12/05)
	Boulder & Weld Cty Rd near HWY 52	M	BOACBCWC	5-03	12-06	44	1341		0.182	N		(missing 10/04 data)
	South of Longmont	A	BOLONGCO	11-03	12-06	38	1157	-0.4413955	0.001	Y	-0.0003815	
South Platte System												
	Henderson	A	PLAHENCO	1-04	12-06	36	1096		0.508	N		
	Fort Lupton	A	PLALUPCO	10-03	12-06	39	1188		0.562	N		
	Platteville near WCR 32.5	M	PLAPLACO	5-03	12-06	44	1341		0.757	N		(missing 9/04 data)
	HWY 60 near Milliken	M	PLAACRH60	5-03	12-06	44	1341	0.14061726	0.063	Y	0.00010486	
	Evans	M	PLAEVACO	5-03	12-06	44	1341	0.17884917	0.017	Y	0.00013337	
	Near Kersey	A	PLAKERCO	4-02	12-06	57	1736		0.792	N		
	Kuner Feedlot	M	PLAKUNCO	5-03	12-06	44	1341		0.122	N		
	Masters near Jackson Reservoir	A	PLAMASCO	5-04	12-06	32	975	0.2145	0.002	Y	0.00022	
	Weldona	A	PLAWELCO	7-02	12-06	54	1645		0.119	N		
	Fort Morgan	A	PLAMORCO	8-02	12-06	53	1614	0.6079938	0.002	Y	0.0003767	
	Cooper Bridge near Balzac	A	PLABALCO	6-02	12-06	55	1675	0.1948025	0.029	Y	0.0001163	
	Merino across LCR 55	M	PLAMERCO	5-03	12-06	44	1341	0.16893918	0.002	Y	0.00012598	
	Sterling	A	PLASTLCO	5-04	12-06	32	975		0.541	N		
	Iliff across LCR 55	M	PLALIFCO	5-03	12-06	44	1341		0.997	N		
	Jumbo Diversion	A	PLAJUMCO	5-04	12-06	32	975		0.412	N		
	Sedgwick across HWY 59	M	PLASEDCO	5-03	12-06	44	1341		0.743	N		(missing 4/04 and 10/04 data)
	Julesburg (Channel 1)	A	ONEJURCO	8-02	12-06	53	1614	0.52383984	0.000	Y	0.00032456	

Figure 6. CLAFTCCO Regression Line Graph

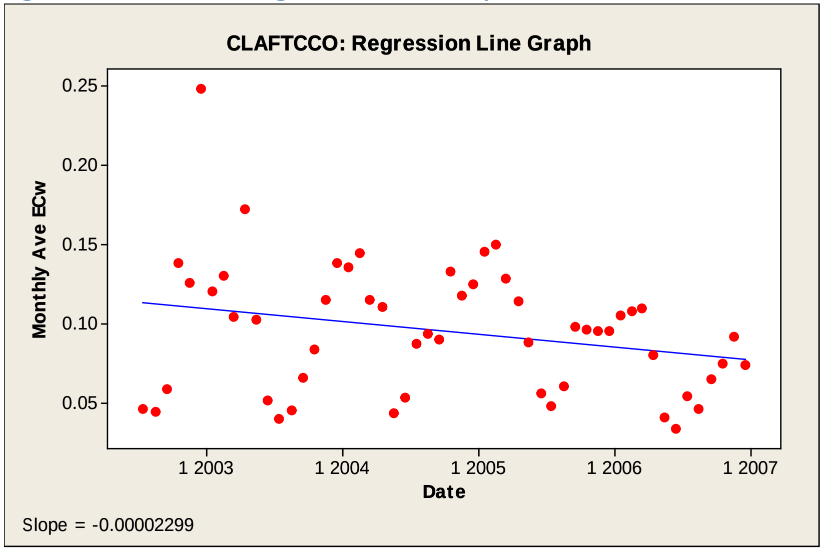


Figure 8. CLAFORCO: Regression Line Graph

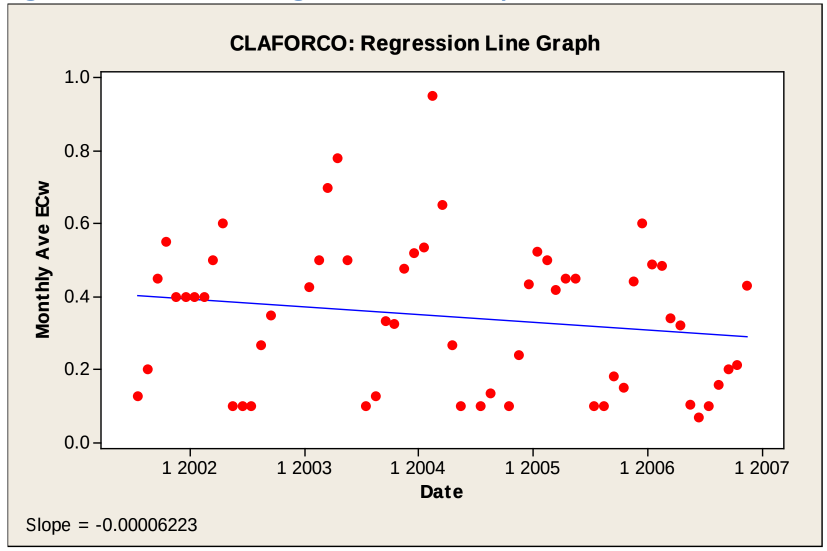


Figure 7. CLALAPCO Regression Line Graph

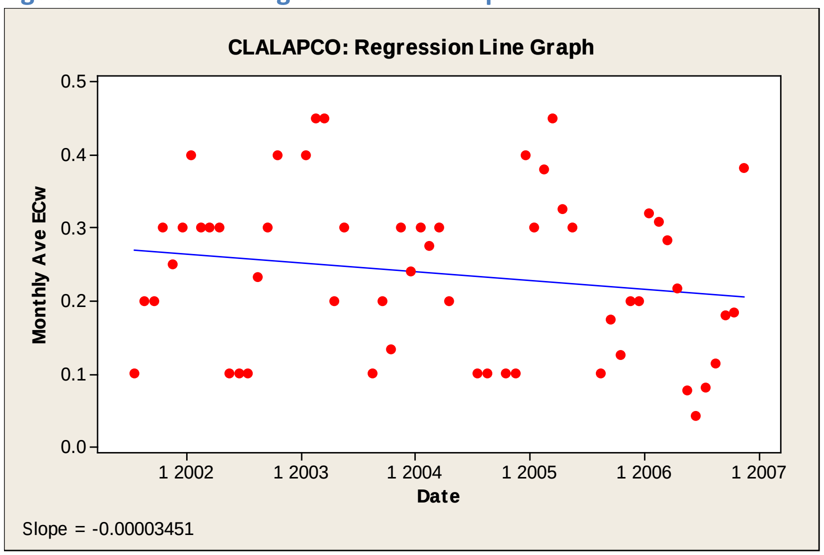


Figure 9. CLABOXCO: Regression Line Graph

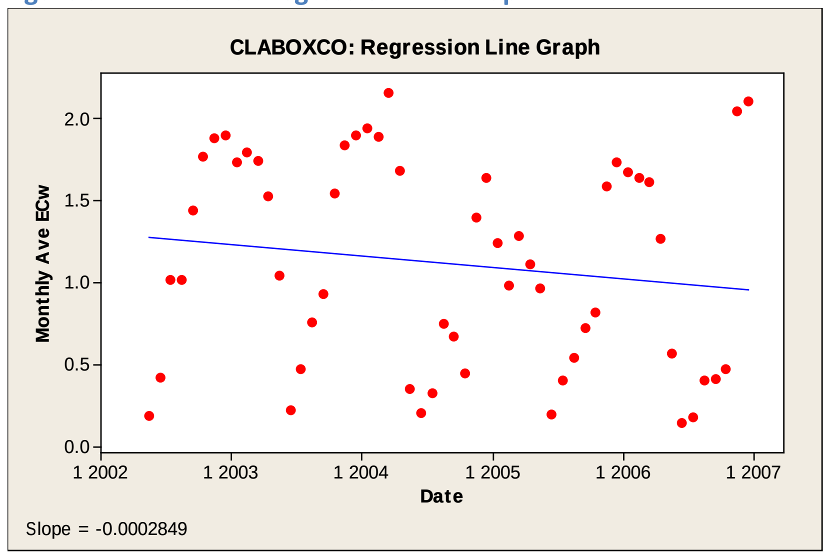


Figure 10. BTCANYCO: Regression Line Graph

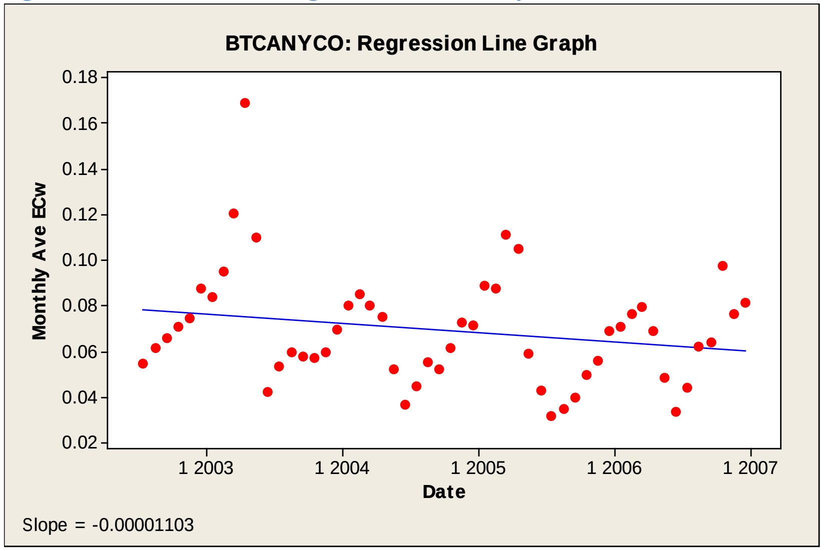


Figure 11. LTCANYCO: Regression Line Graph

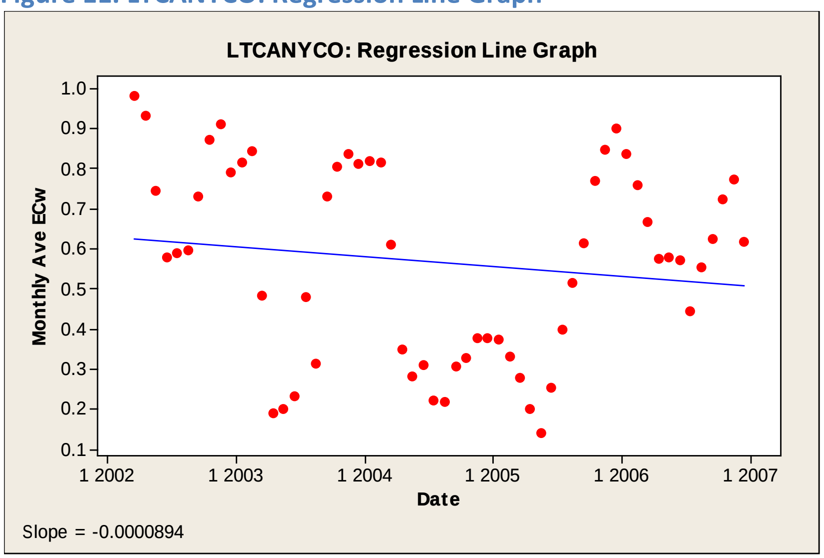


Figure 12. SVCLYOCO: Regression Line Graph

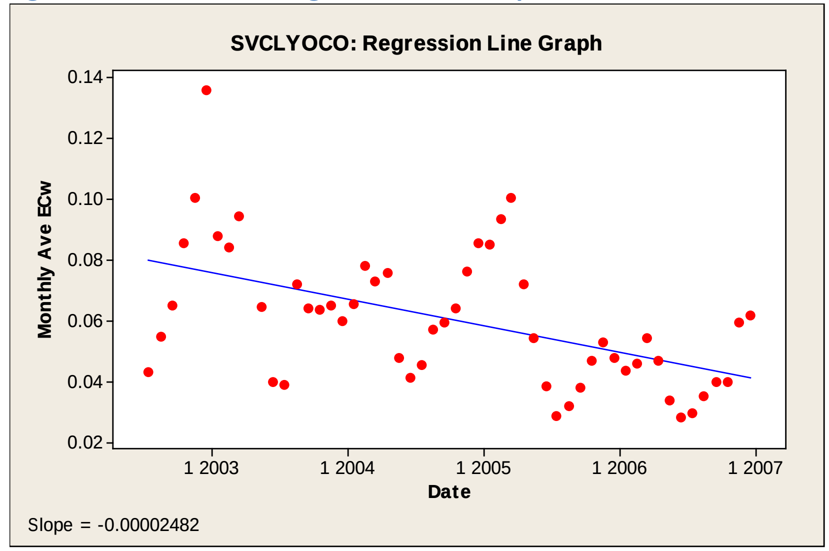


Figure 13. SVLONGCO: Regression Line Graph

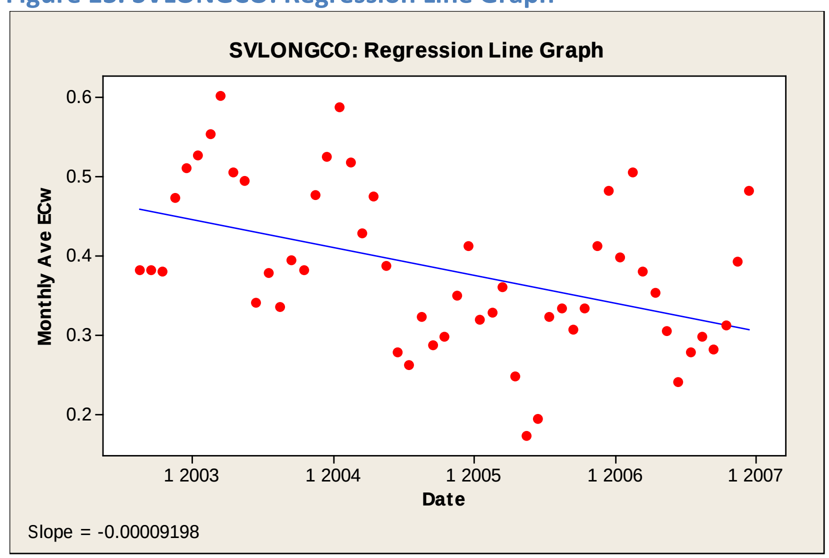


Figure 14. SVLONGMONT: Regression Line Graph

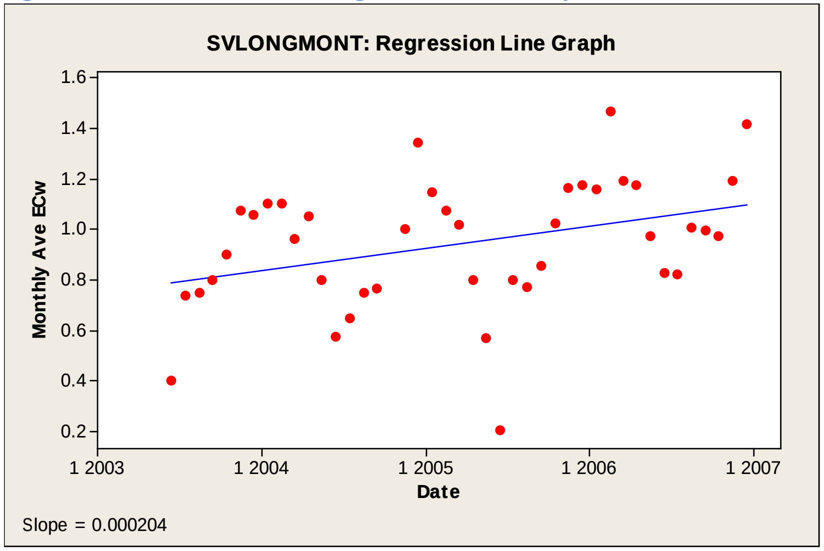


Figure 15. SVCBLOCO: Regression Line Graph

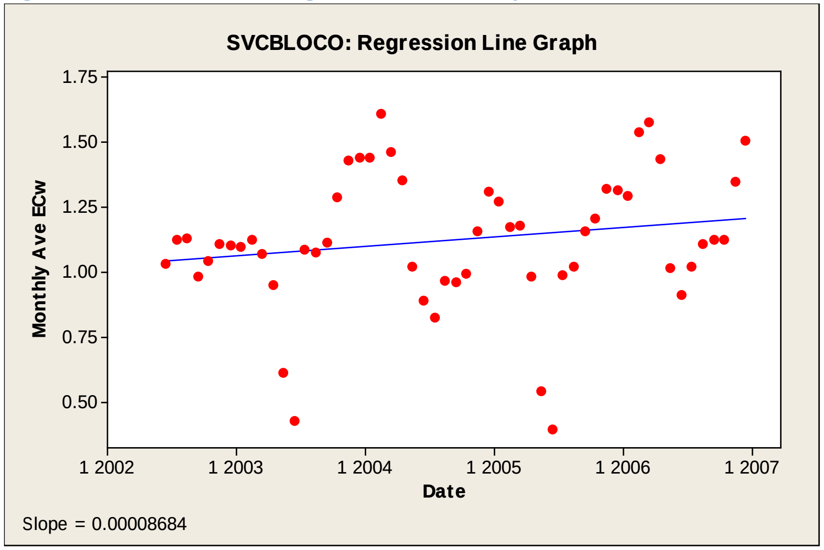


Figure 16. SVCACRWC13: Regression Line Graph

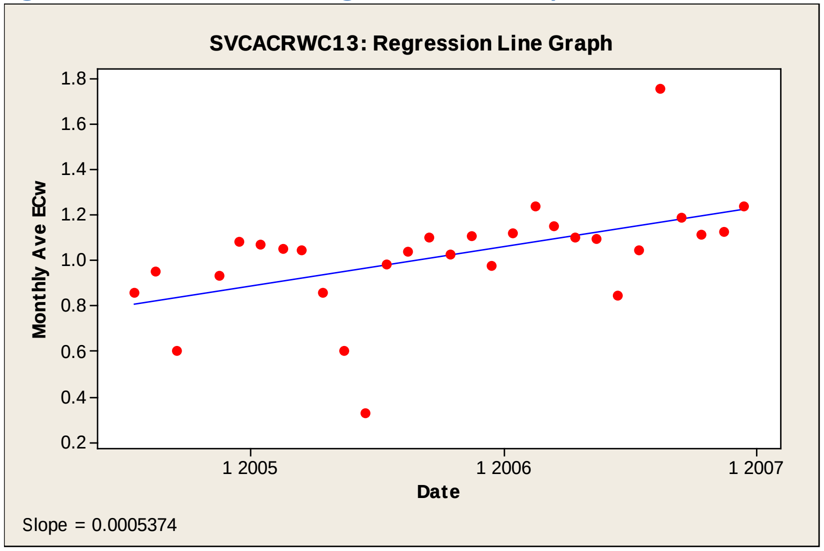


Figure 17. SVCPLACO: Regression Line Graph

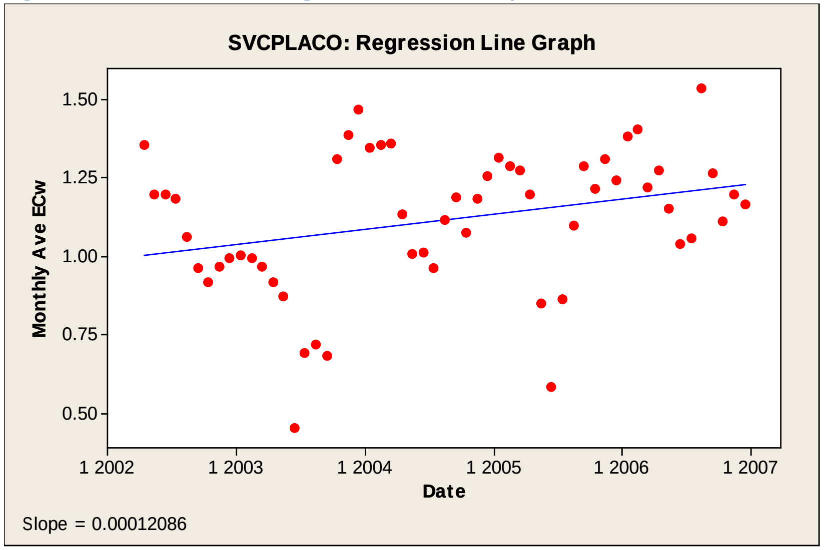


Figure 18. BOCOROCO: Regression Line Graph

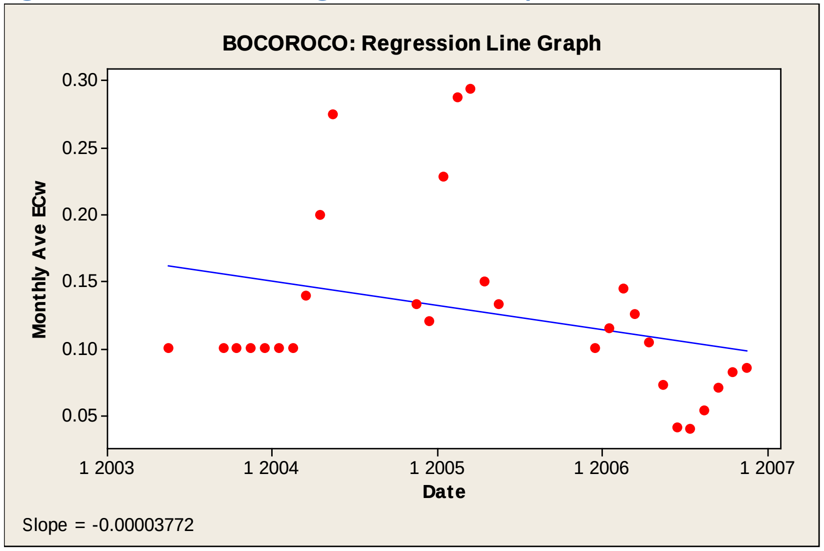


Figure 20. BOLONGCO: Regression Line Graph

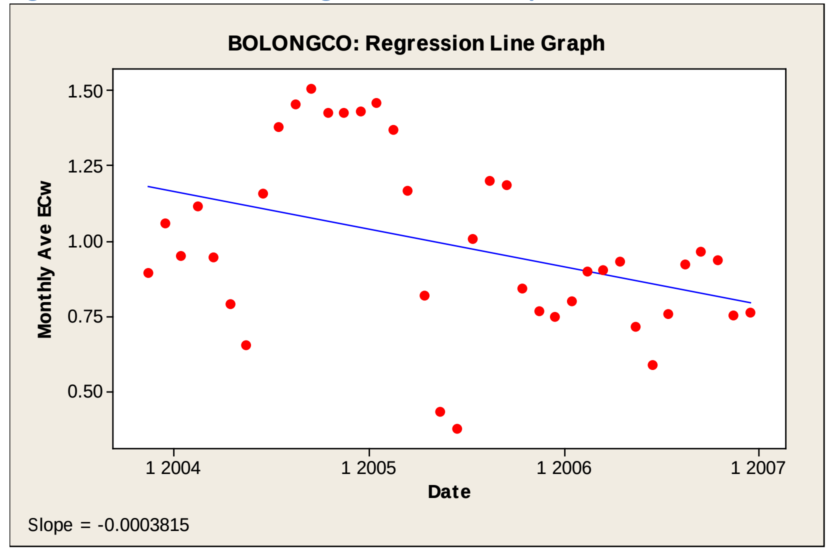


Figure 19. BOCNORCO_stream Regression Line Graph

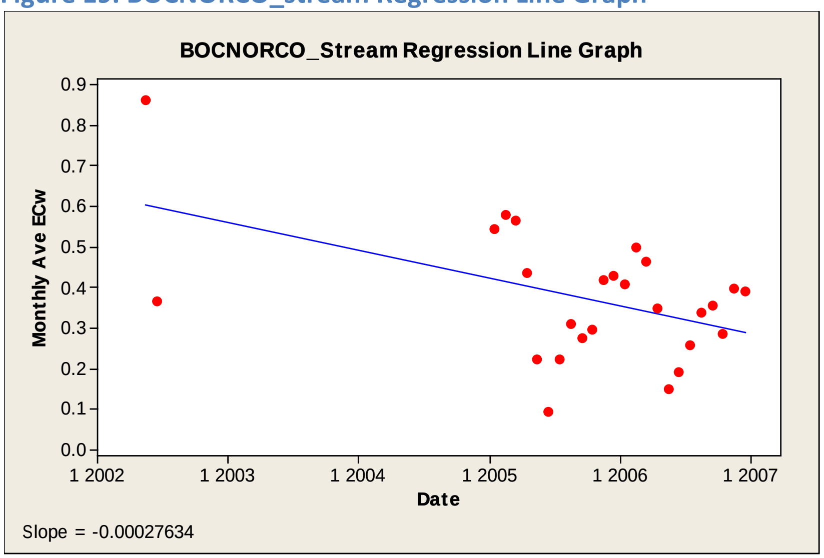


Figure 21. PLAACRH60: Regression Line Graph

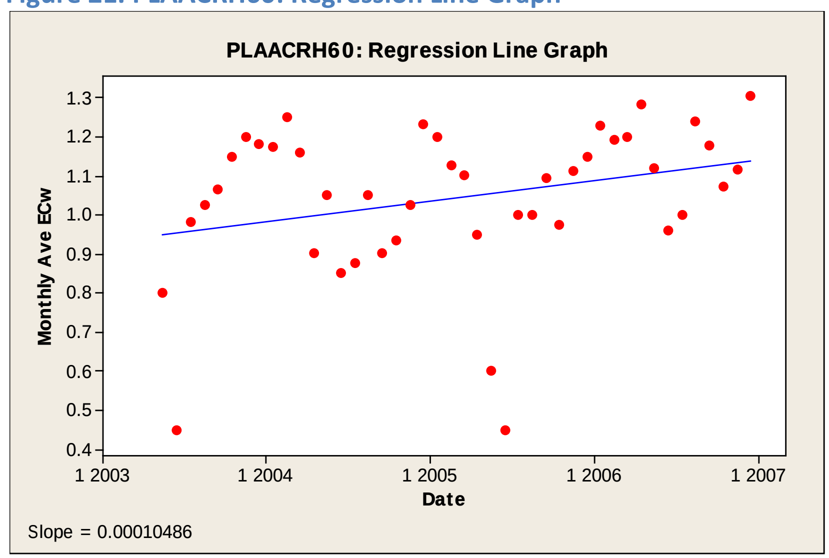


Figure 22. PLAEVACO: Regression Line Graph

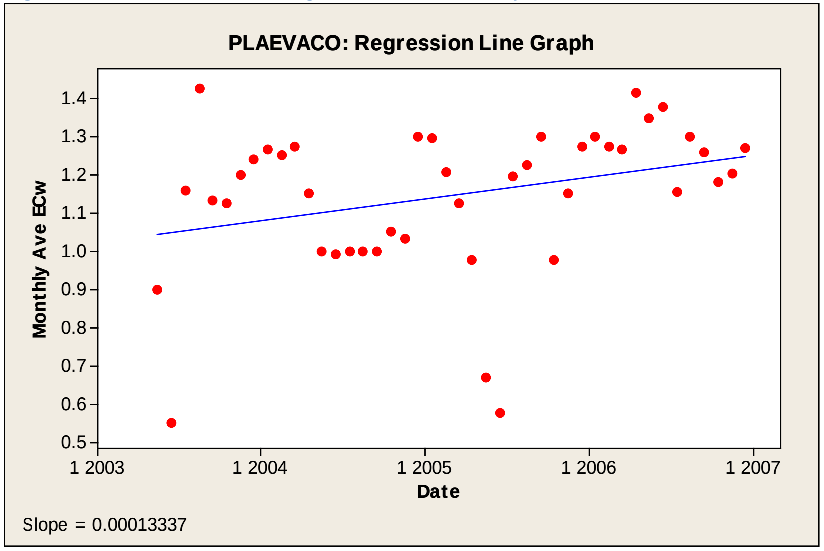


Figure 23. PLAMASCO: Regression Line Graph

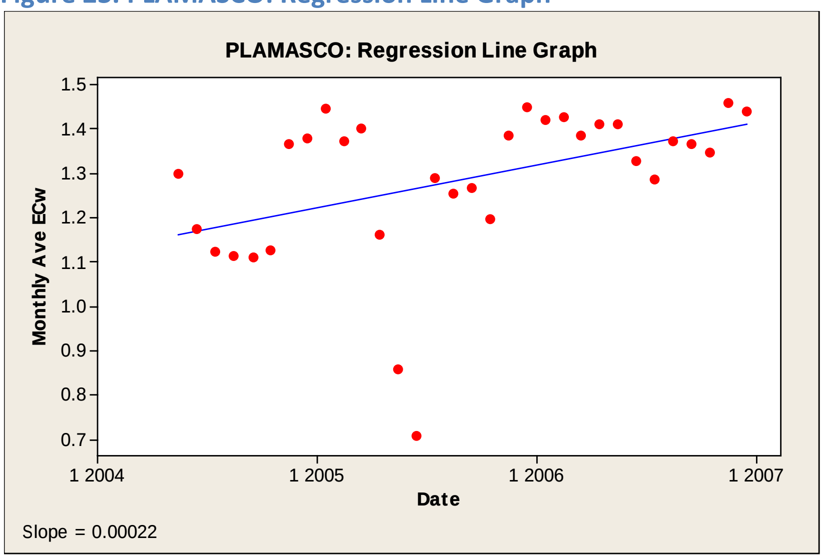


Figure 24. PLAMORCO: Regression Line Graph

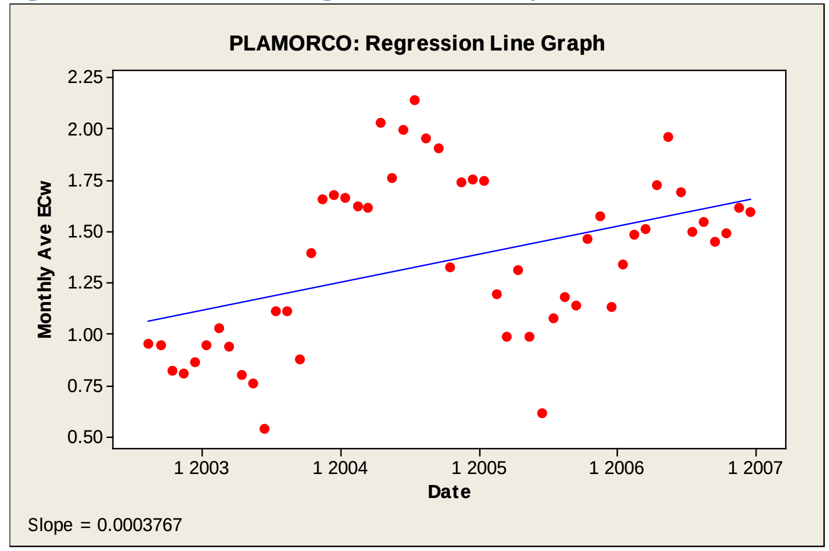


Figure 25. PLABALCO: Regression Line Graph

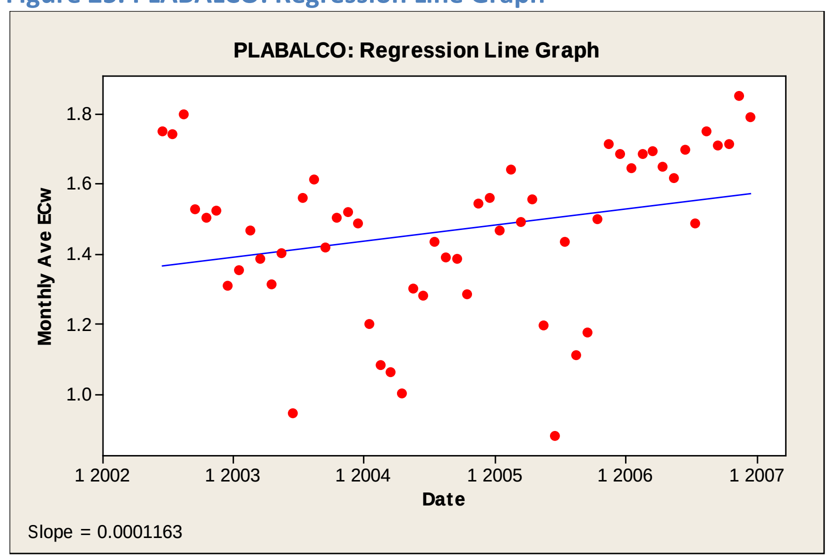


Figure 26. PLAMERCO: Regression Line Graph

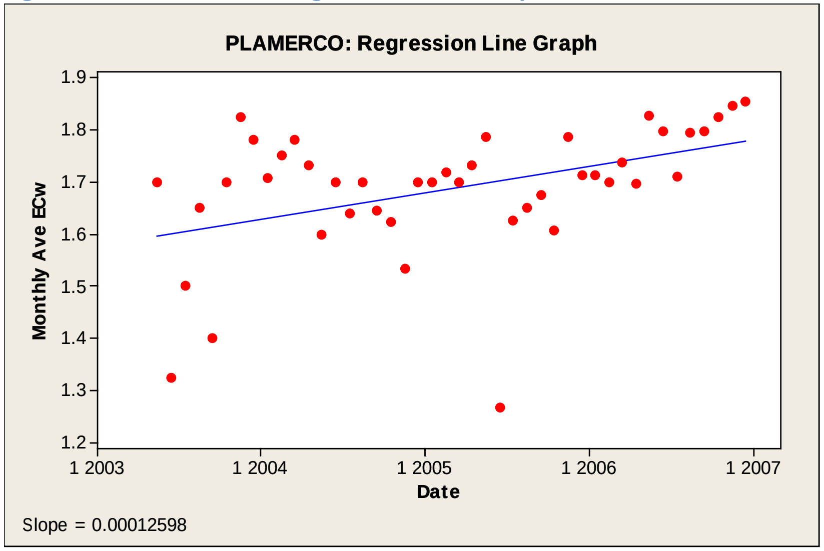
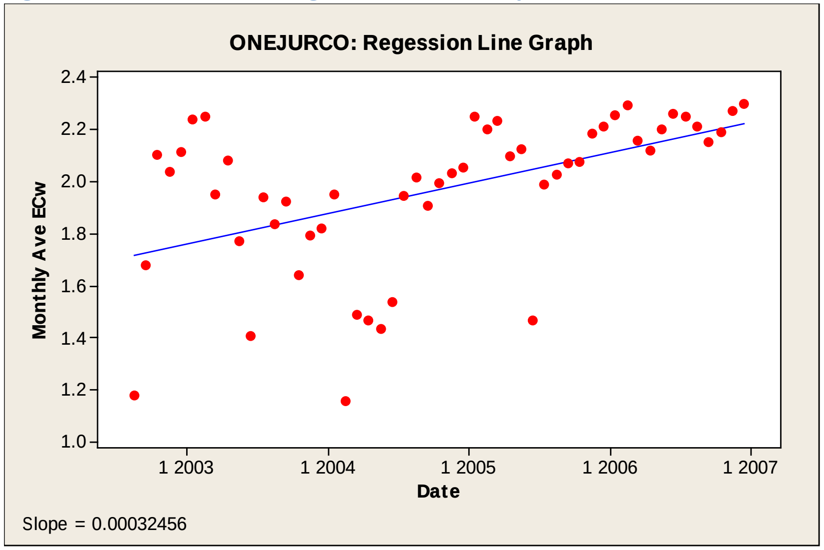


Figure 27. ONEJURCO: Regression Line Graph



Flow Effect

Of the 50 river system stations, only 13 have associated flow data. It is not possible to compare the effect of water flow across all the stations in the study. However, the flow data were used to analyze the effect on those 13 stations. Similar to transforming the raw Monthly Ave EC_w data to ranks, the flow data were also transformed to ranks and the regression model was:

Equation 2. Seasonal Rank Regression Equation with Flow Data Effect

$$Rank\ EC_w = B0 + B1*I1 + B2*I2 + B3*I3 + B4*Date + B5*Flow$$

Flow and seasonality are inter-related and while applying the seasonal regression may take into account the flow effects, including the rank flow data provides another means to evaluate the data.

The P-value of the date and rank flow were recorded. Again, where the P-value for date <0.1, the conclusion was that a statistically-significant trend existed during the study period. If the P-value of the rank flow was less than 0.1, the conclusion is also that the flow has a statistically significant effect on the regression and trend.

Table 8 shows the results of the analysis with flow data included.

There are two cases (CLAFORCO and CLABOXCO) where the analysis with flow adjustment changed the result to be no longer significant.

Table 8. Regression Analysis with Flow Adjustment

	With Seasonality and Flow Adjustment		Without Flow Adjustment	Significance Changed
Station	**P-value Date**	**P-value Rank Flow**	**P-value Date**	**With Flow Adjustment?**
CLAFTCCO	0.011	0.512	0.006	N
CLAFORCO	0.829	0.000	0.068	Y - no longer significant with flow adjusment
CLABOXCO	0.805	0.000	0.005	Y - no longer significant with flow adjusment
BTCANYCO	0.092	0.258	0.079	N
LTCANYCO	0.051	0.000	0.086	N
SVCLYOCO	0.000	0.125	0.000	N
SVCBLOCO	0.005	0.000	0.064	N
SVCPLACO	0.000	0.001	0.015	N
BOCNORCO_stream	0.001	0.075	0.000	N
BOLONGCO	0.001	0.683	0.001	N
PLAMORCO	0.002	0.189	0.002	N
PLABALCO	0.014	0.001	0.029	N
ONEJURCO	0.000	0.521	0.000	N

River System – Variation with Distance Downstream

The variation of EC_w with distance along the river was studied both graphically and via regression. EC_w vs. Distance Downstream graphs (henceforth called simply "Distance Downstream Graph") show the Annual Average EC_w at each station along the river. A corresponding linear regression equation and trendline was developed using Excel as follows:

Equation 3. Linear Trendline Equation

$$y = mx + b$$

Where $y = EC_w$
- x = downstream distance in miles
- m = slope in dS/(m-mi)
- b = y intercept

An associated R-squared value (between 0 and 1) indicates how closely the estimated values for the trendline correspond to the data collected in the field. An R-squared value equal to 1 indicates a perfect correlation between measured EC_w and distance downstream.

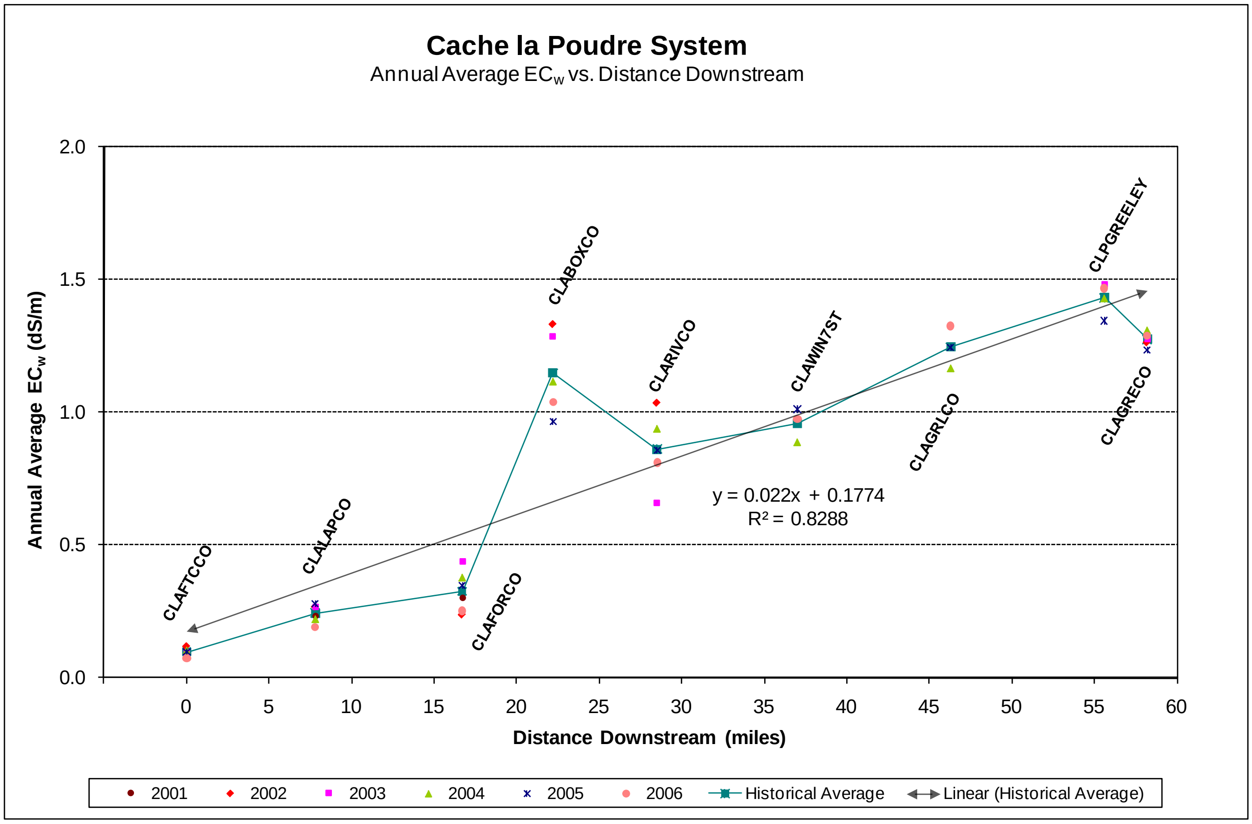
The goal for using linear trendlines with the collected data was not to predict future EC_w values, but to determine whether there were observable trends in the data collected during the study period.

Cache la Poudre System

Reviewing the Distance Downstream Graph that shows all stations on the Cache la Poudre System, Figure 28 below, the overall trend appears to be increasing EC_w as the water flows farther downstream. The linear trendline was developed from the Historical Average EC_w value which was calculated from the Annual Average EC_w data for the entire study period. For this graph, the R-squared value is 0.8288. The closer the R-squared value is to 1, the more reliable the trendline in representing the actual values as a function of distance downstream.

There are three stations with values markedly off the trendline: CLAFORCO EC_w values appear to be lower than the upstream stations, CLABOXCO typically has higher EC_w values than the next few stations downstream, and CLAGRECO has lower EC_w values than CLPGREELEY, the station just upstream of CLAGRECO.

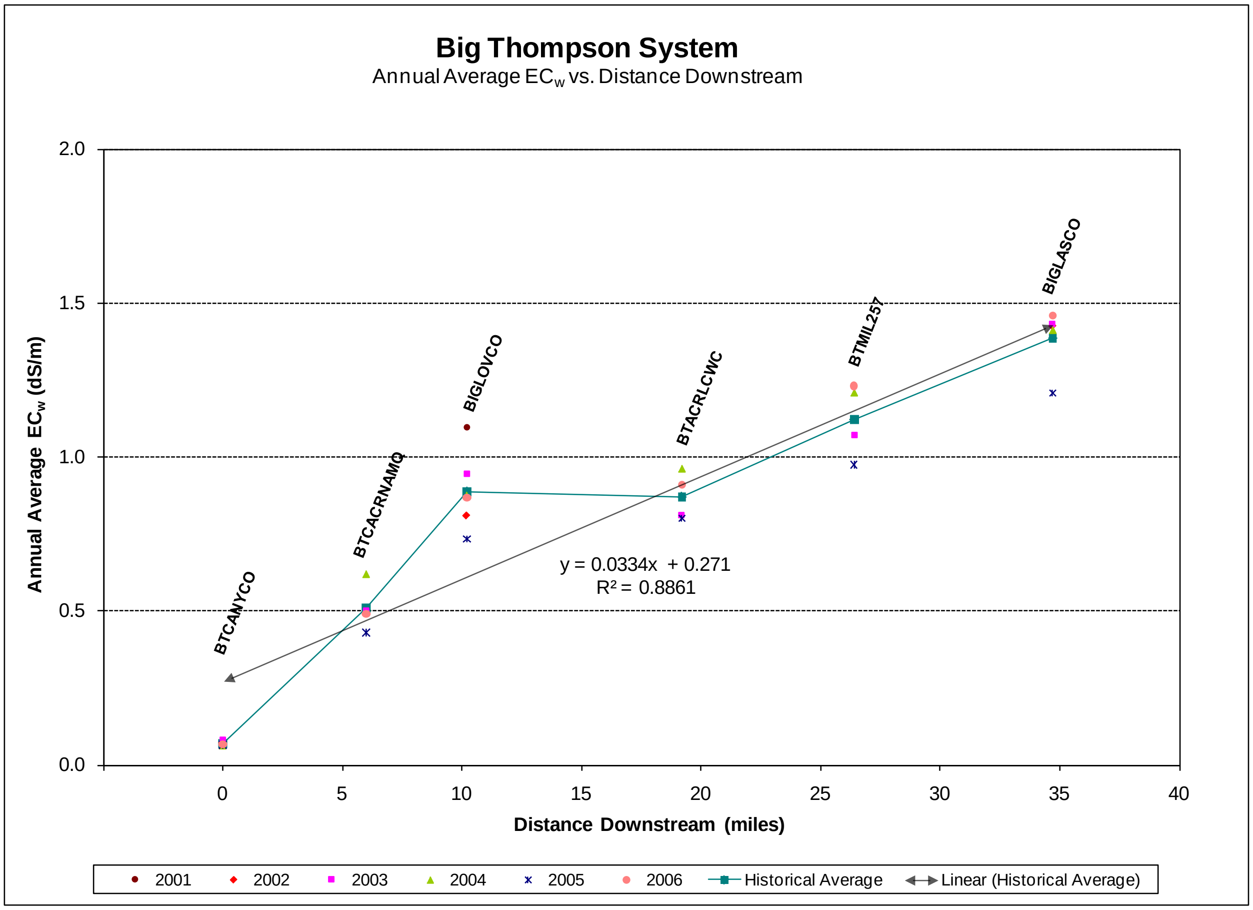
Figure 28. Cache la Poudre System Distance Downstream Graph



Big Thompson System

As shown in Figure 29 below, the Big Thompson System overall shows an increase in EC_w value as the water flows downstream. The linear trendline has an R-squared value of 0.8861. Generally, each consecutive station shows increased EC_w values. BIGLOVCO has similar EC_w values to BTACRLCWC, the next downstream station.

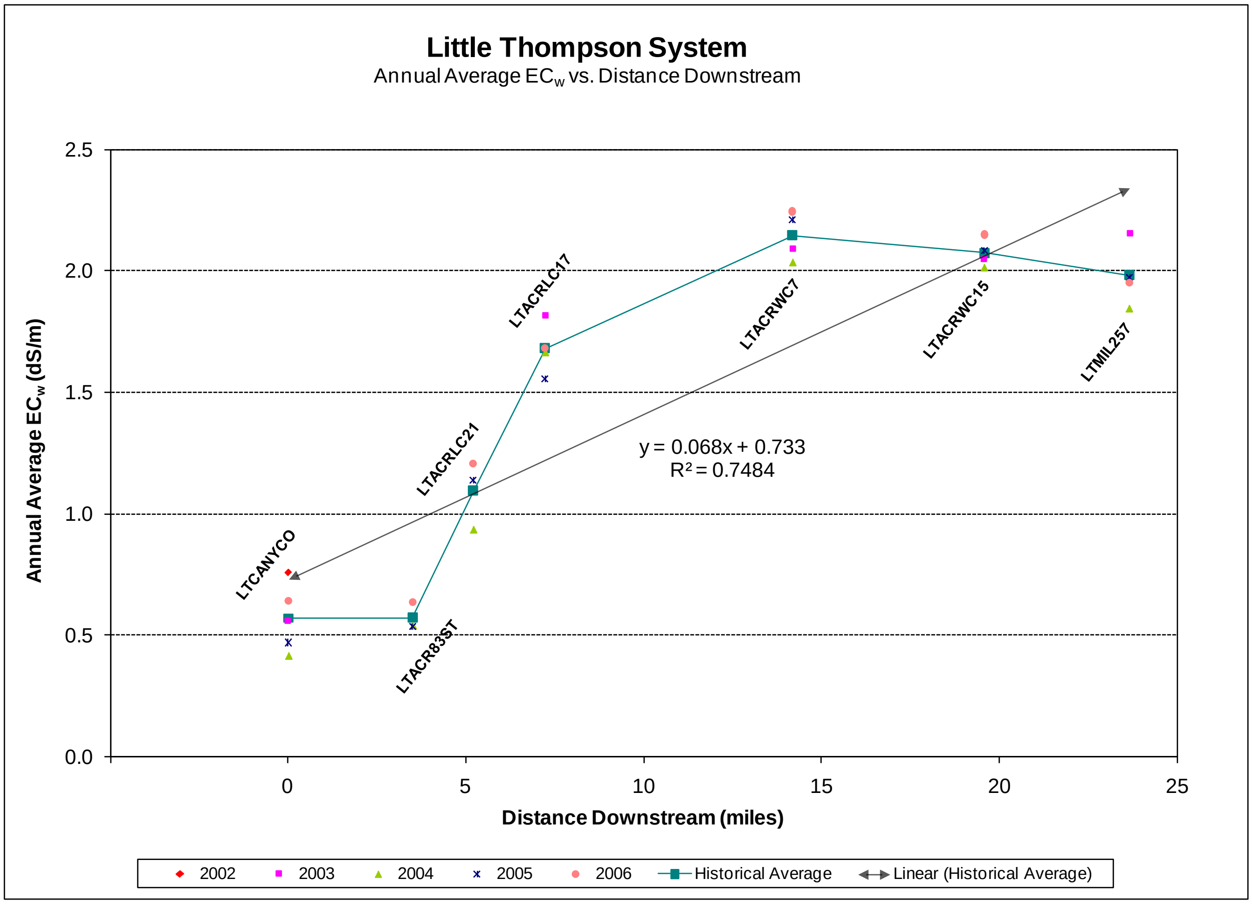
Figure 29. Big Thompson System Distance Downstream Graph



Little Thompson System

Overall, the Little Thompson System shows an increase in EC_w value as the water flows downstream. An R-squared value of 0.7484 is achieved when the historical average data points are fit to a trendline.

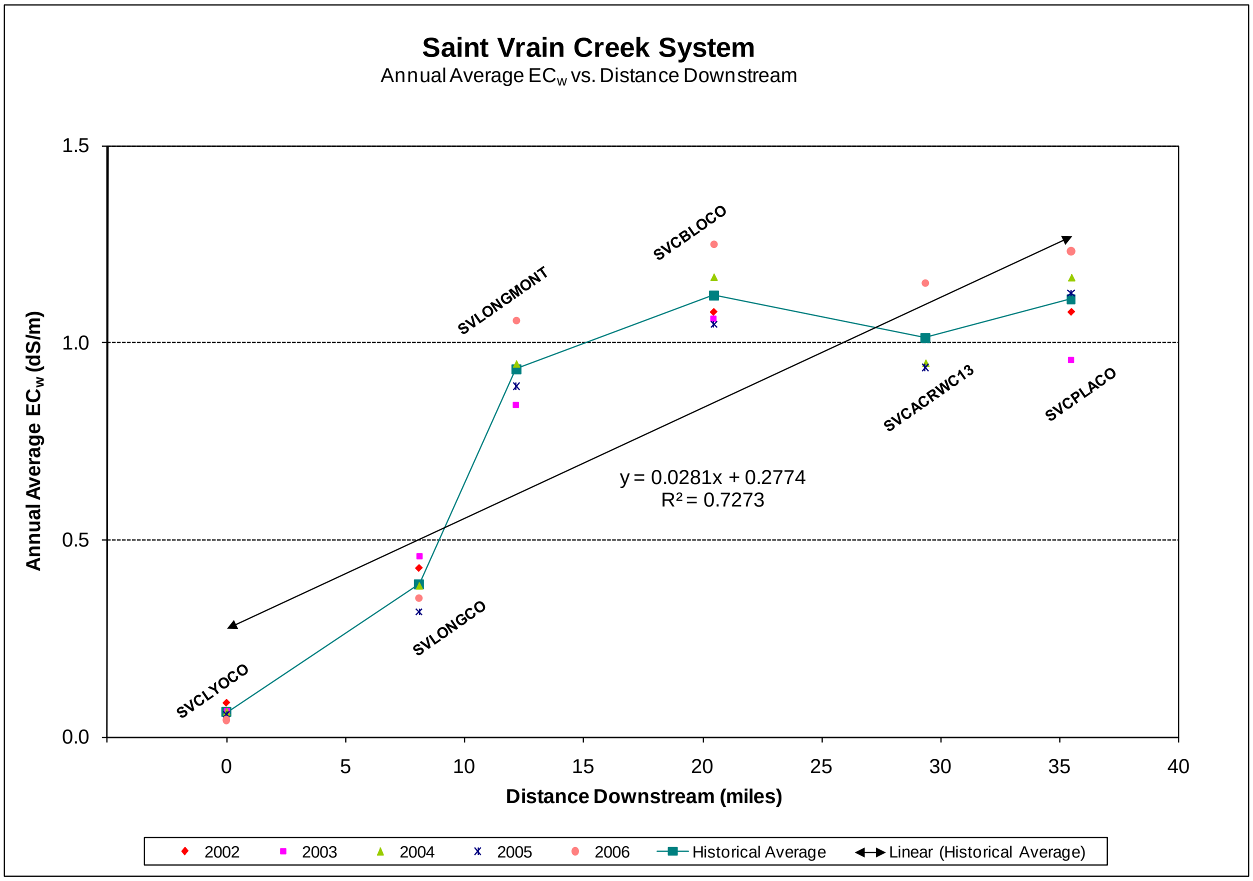
Figure 30. Little Thompson System Distance Downstream Graph



Saint Vrain Creek System

The Saint Vrain Creek System overall shows an increase in EC_w value as the water flows downstream. The linear trendline has an R-squared value of 0.7273. Stations SVLONGMONT and SVCBLOCO are the farthest off the trendline, with SVBLOCO actually having the highest 5-year historical average EC_w value of all the stations.

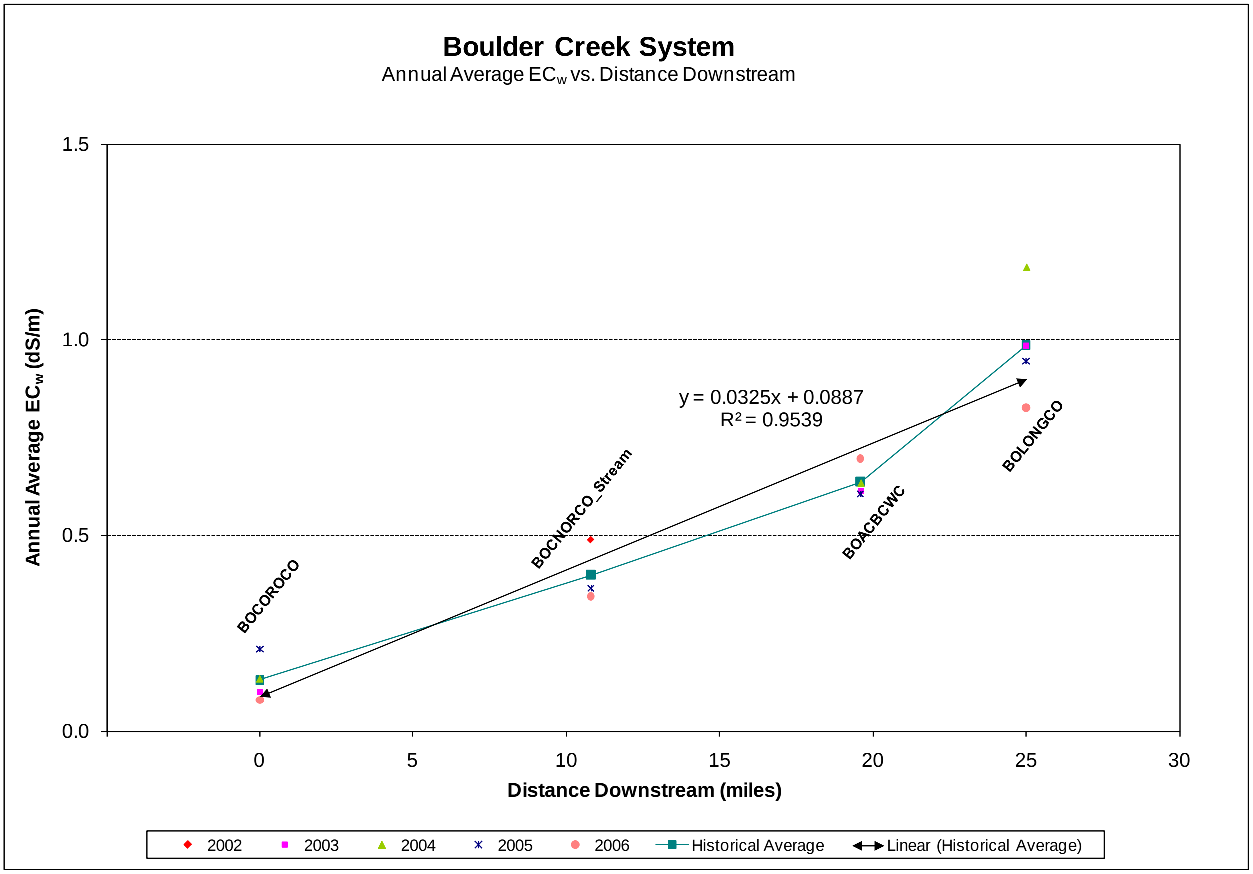
Figure 31. Saint Vrain Creek System Distance Downstream Graph



Boulder Creek System

The Boulder Creek System has a very good linear correlation for the historical average EC_w value found during the study period versus the distance downstream. (BOCNORCO_Waste was not included in this graph because the data is not actually in the stream.) The four stations graphed show increasing EC_w value as water flows downstream. The R-squared value of the linear trendline is 0.9539.

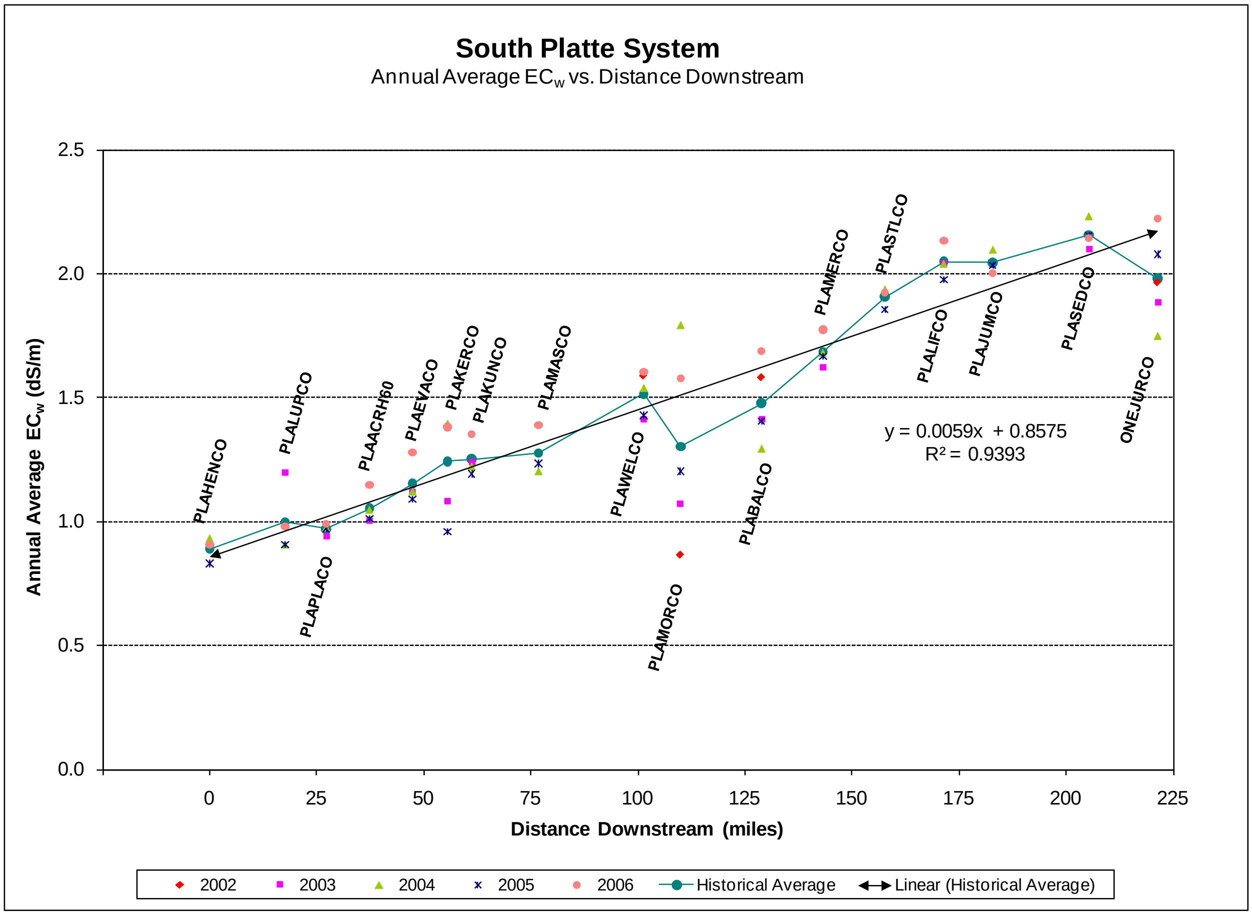
Figure 32. Boulder Creek System Distance Downstream Graph



South Platte System

The South Platte System Distance Downstream Graph shows an overall increasing EC_w value trend as water flows farther downstream. The linear trendline for this graph has an R-squared value of 0.9393.

Figure 33. South Platte System Distance Downstream Graph



Salt Loading, Flow Rate and Electrical Conductivity Relationships

For the stream and river systems, 22 EC_w sampling stations were located near stream flow gauging stations as well. For these stations, in the Annual Reports, salt loading values were calculated where possible based on the following equation:

Equation 4. Salt Loading

$$Q_{EC_i} = \overline{C}_i \overline{Q}_i t_i k ,$$

where Q_{EC_i} = salt load discharge in time interval *i* (English or metric tons),

$\overline{C}_i$ = mean salt concentration for time interval *i* (mg/L),

$\overline{Q}_i$ = mean water discharge for time interval *i* (ft^3/sec or m^3/sec),

t_i = duration of time interval *i* and

k = appropriate conversion factor for units used.

To convert EC_w from deciseimens per meter (dS/m) (which is how these data were recorded) to a salt concentration in milligrams per liter (mg/L), a multiplying factor of 640 has been used in all calculations. The value of the conversion factor *k* is 0.0027 when the units are mg/L for salt concentration, ft^3/sec for flow rate, and tons/day for salt load discharge.

It should be noted that this conversion only yields an approximate dissolved solids/salt concentration. The true conversion is complicated by the type of salts present, their relative concentrations, and the temperature of the water sample. While all of the sensors used by Northern Water are able to compensate for temperature, they do not have the ability to compensate for different ionic salts (ion chromatography is necessary for such distinctions to be made). Since not all salts conduct an electric current equally, any umbrella conversion from an EC_w reading to a concentration will result in some degree of error.

The method used to extrapolate the calculated salt load to a total annual salt load per sampling site (Q_{EC}) is explained via Equation 5:

Equation 5. Annual Salt Load

$$Q_{EC} = \sum_{i=1}^{n} Q_{EC_i} ,$$

Where the sample year has been divided into *n* time intervals.

The flow data used for these calculations were only provisional in most cases. The Colorado Division of Water Resources (DWR) and the United States Geological Survey (USGS), the entities responsible for the gauging stations, review and frequently revise flow data at the end of each water year.

The Annual Reports generally concluded that the flow rate and electrical conductivity have an inverse relationship: when the flow rate is low, the electrical conductivity is high, and vice versa. From the equation above (Equation 5), the salt-loading is dependent on both the EC_w and the flow rate. Likewise, it could be said that the EC_w value is dependent on the flow rate, as the salt-loading is subject to a mass balance calculation. That is, the salt is in the water and if the flow rate is high, the resulting EC_w will appear lower than if the flow rate is low, but it is the same salt-loading in either case.

For this compiled report, salt-loading was not calculated and reported because it was already shown in the Annual Reports. However; the study period flow rate and electrical conductivity correlation has been reviewed and graphed for several stations and is shown in Figures 34 through 45. The following graphs show that, in general, as the flow rate increases, the EC_w decreases. The data for a few graphs were further identified by the year collected to show the same relationship. A trendline for these relationships was often found to be a logarithmic, exponential, polynomial, or power function. The graphs verify that, in general, an inverse relationship exists between flow rate and EC_w.

Figure 34. CLAFTCCO Flow vs. EC_w Relationship

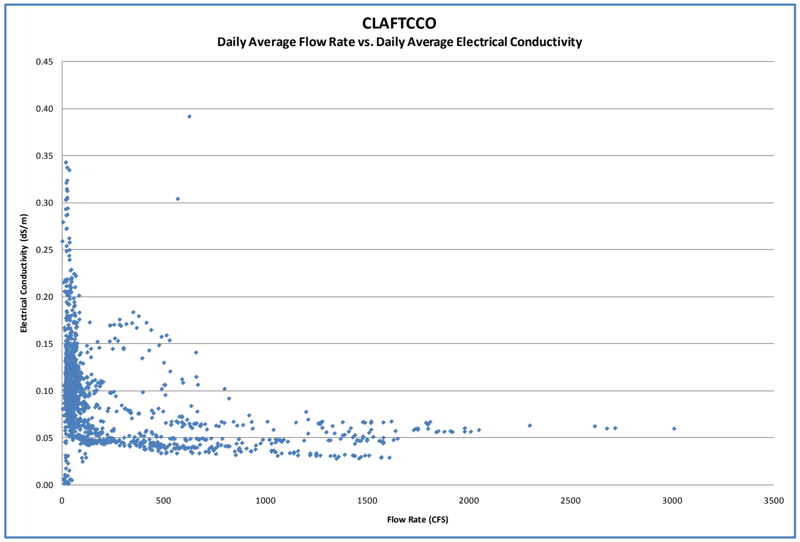


Figure 35. CLAFTCCO Flow vs. EC_w Relationship – By Year

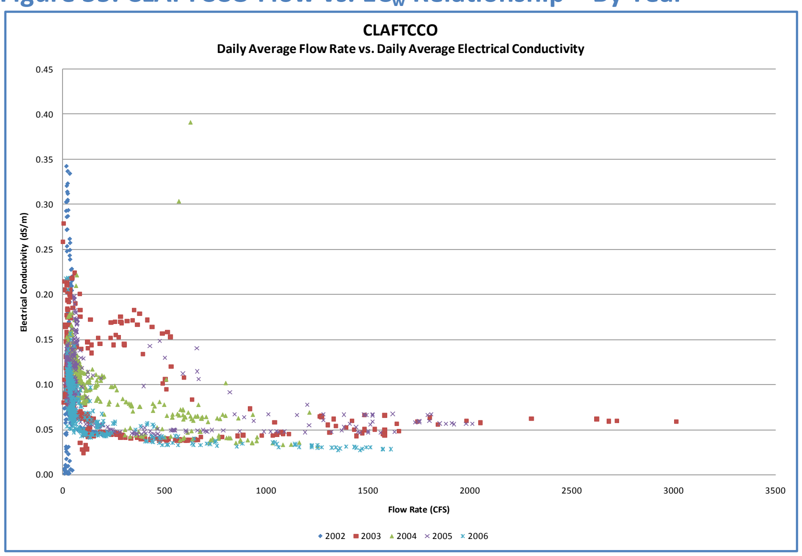


Figure 36. CLABOXCO Flow vs. EC_w Relationship

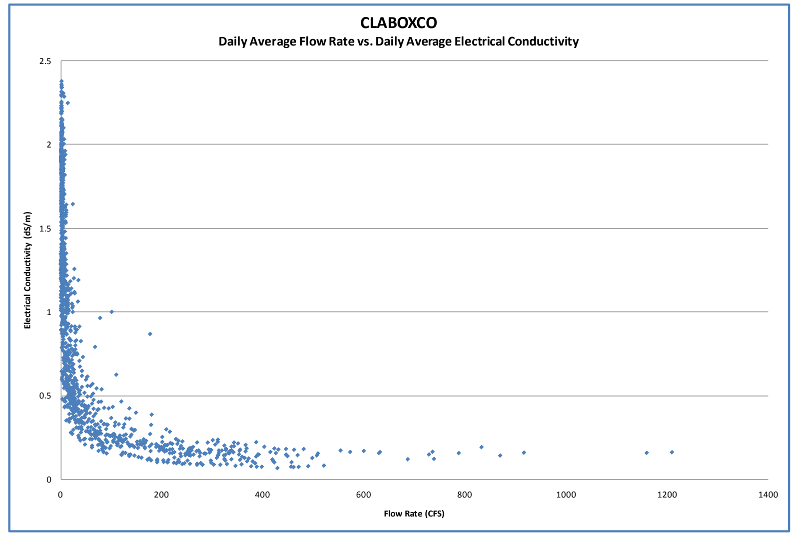


Figure 37. CLABOXCO Flow vs. EC_w Relationship - By Year

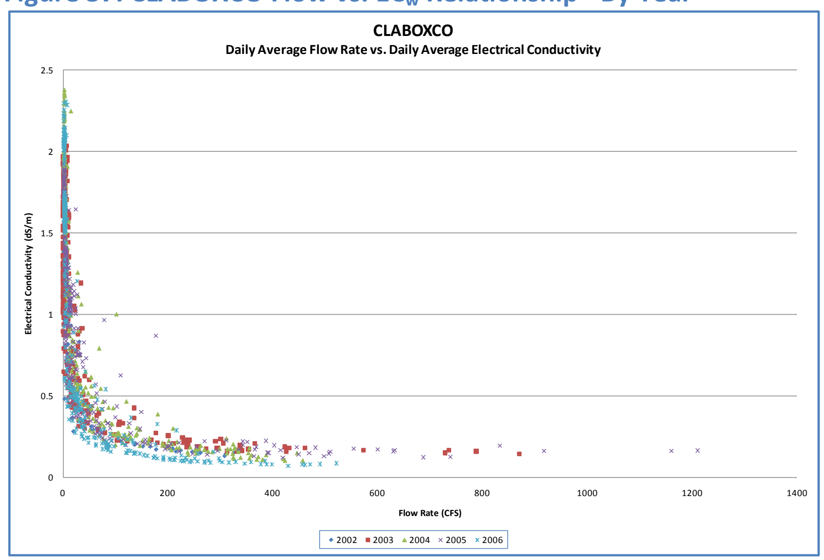


Figure 38. LTCANYCO Flow vs. EC$_w$ Relationship

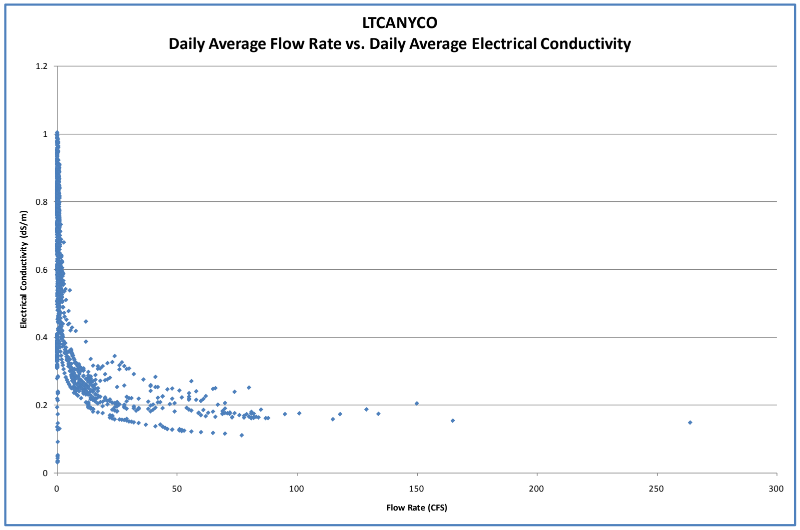


Figure 39. BIGLOVCO Flow vs. EC$_w$ Relationship

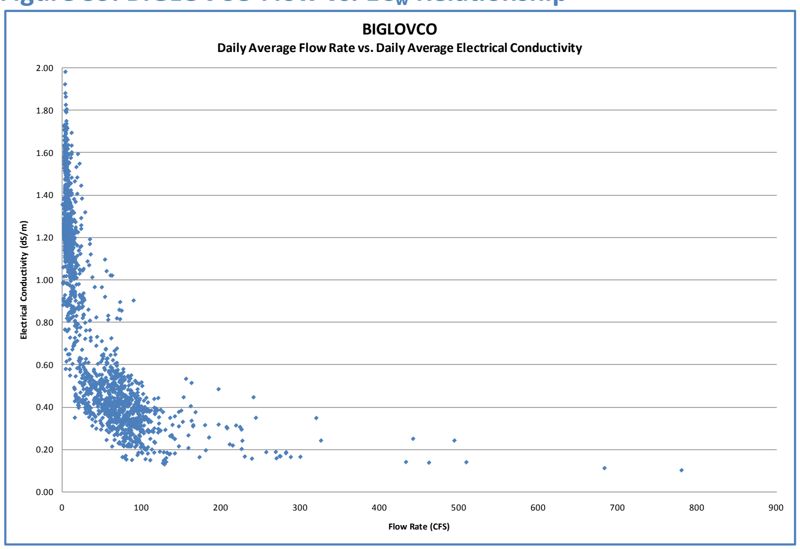


Figure 40. BTCANYCO Flow vs. EC$_w$ Relationship

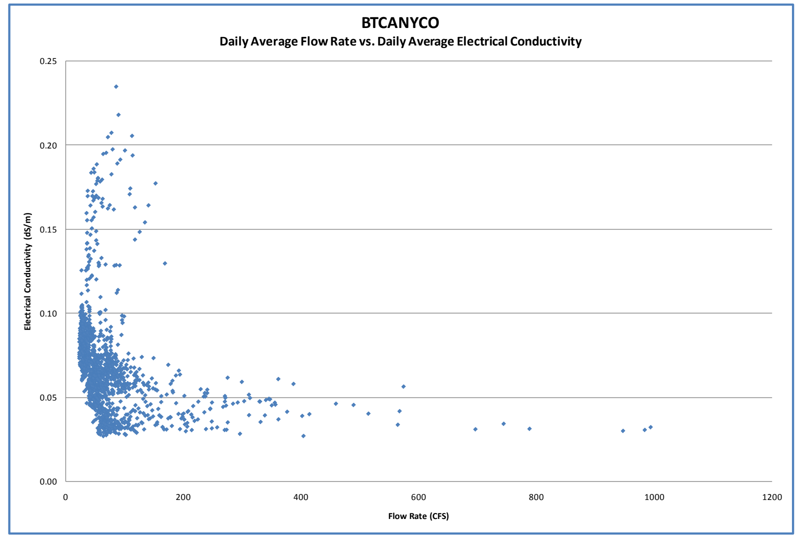


Figure 41. BOCNORCO Flow vs. EC$_w$ Relationship

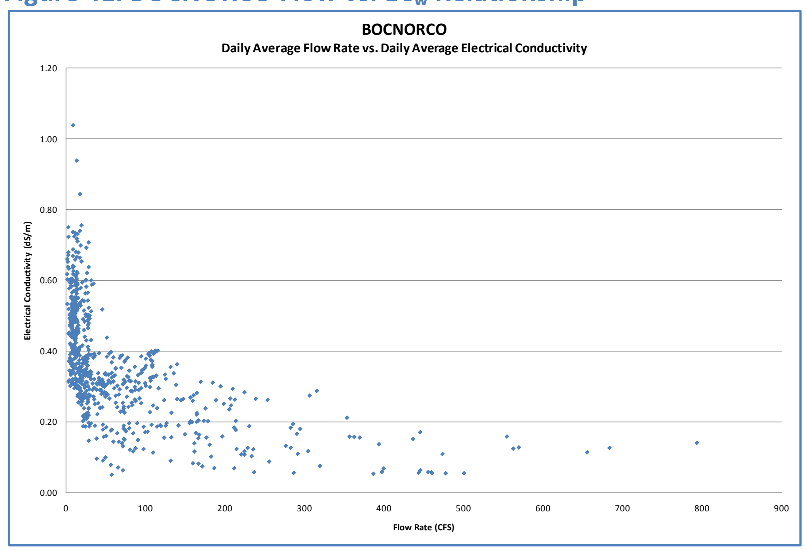


Figure 42. PLAHENCO Flow vs. EC_w Relationship

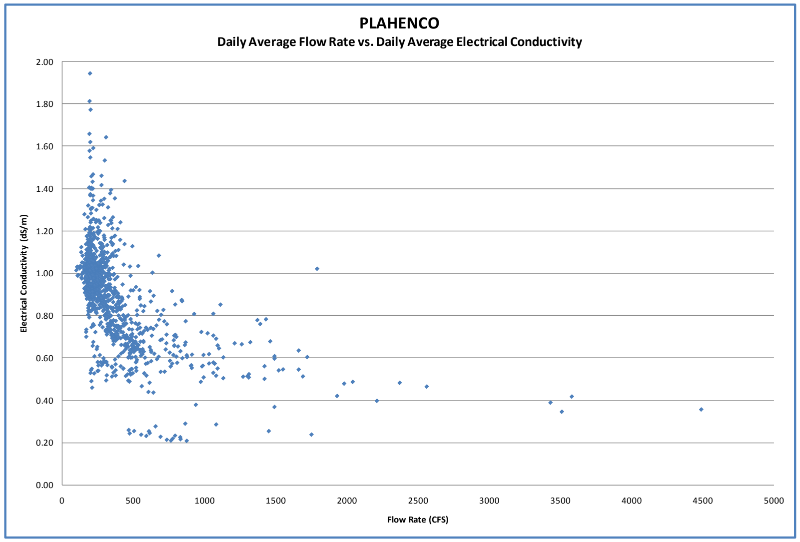


Figure 44. SVBLOCO Flow vs. EC_w Relationship

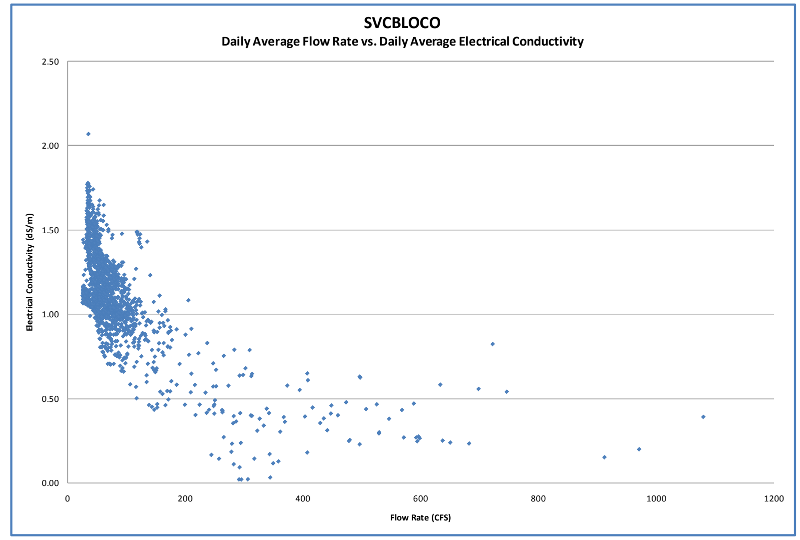


Figure 43. PLAHENCO Flow vs. EC_w Relationship - By Year

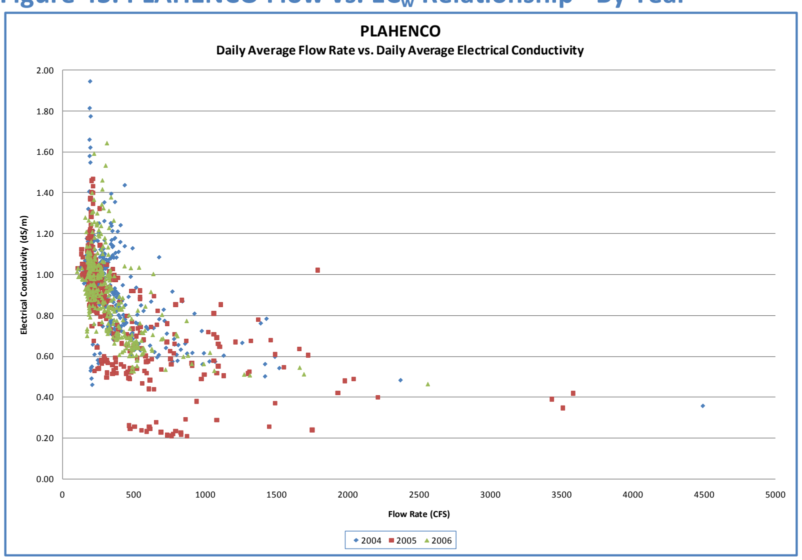
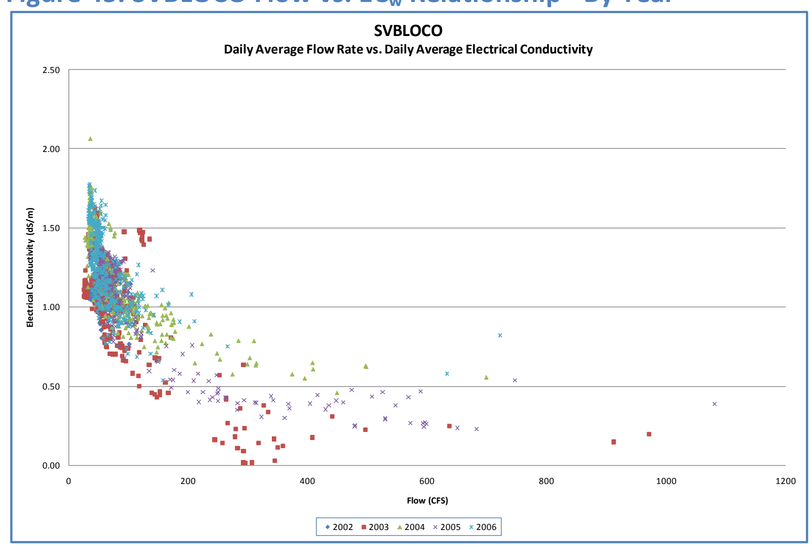


Figure 45. SVBLOCO Flow vs. EC_w Relationship - By Year



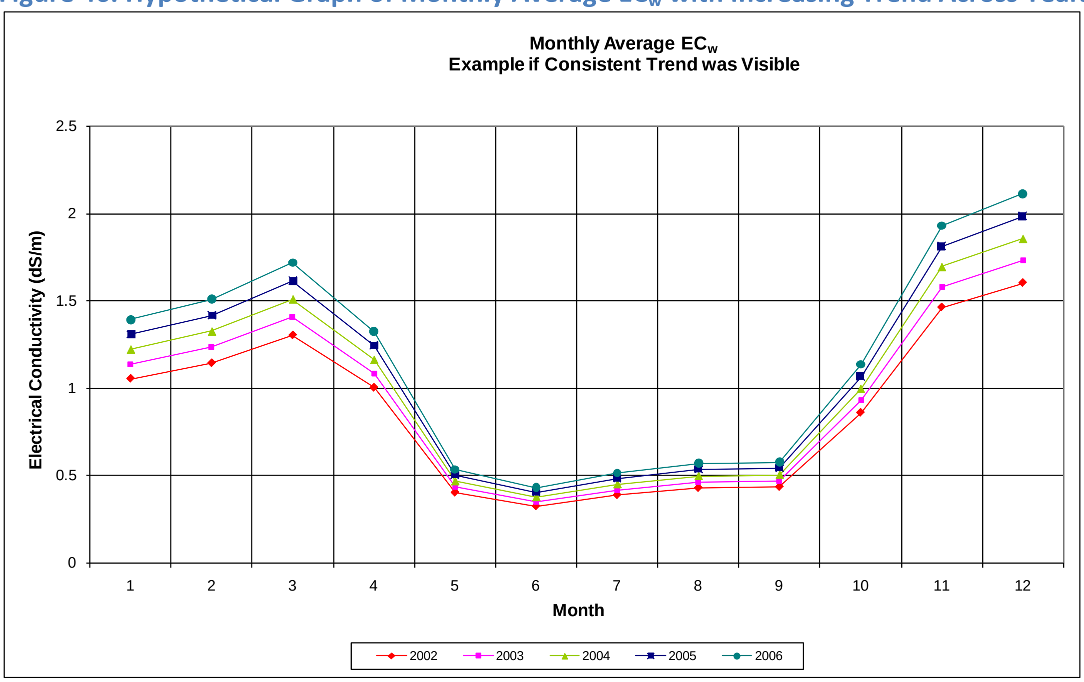
Conclusions

After reviewing the results of the electrical conductivity measurements for each stream or river station and each river system as a whole, a few conclusions can be made.

First, the seasonal pattern for most stations appears to be a “U” shaped graph of EC_w versus time where the lowest EC_w values were seen in the summer months and higher values were seen during the winter months.

The EC_w value did not consistently increase or decrease over the period of the study for any single station when viewed on an annual basis. A consistent trend over the years would have resulted in a graph similar to the hypothetical example graph provided below in Figure 46. However, the results show that actual EC_w values vary from year-to-year at each station without a consistent trend over the entire multi-year period.

Figure 46. Hypothetical Graph of Monthly Average EC_w with Increasing Trend Across Years



Secondly, the EC_w value increases in each river system as the water travels farther downstream and away from the mouth of the river. This can be seen in each of the distance downstream graphs.

Additionally, the high R-squared values indicate a good linear fit for the collected data. In summary, Table 9 shows the river system and associated linear trendline calculations for the distance downstream graphs.

Table 9. River System Distance Downstream Calculations Summary

River System	Linear Trendline Equation	R-squared Value	Slope dS/(m-mile)
Cache la Poudre	$y = 0.022x + 0.1774$	$R^2 = 0.8288$	0.022
Big Thompson	$y = 0.0334x + 0.271$	$R^2 = 0.8861$	0.0334
Little Thompson	$y = 0.068x + 0.733$	$R^2 = 0.7484$	0.068
Saint Vrain Creek	$y = 0.0281x + 0.2774$	$R^2 = 0.7273$	0.0281
Boulder Creek	$y = 0.0325x + 0.0887$	$R^2 = 0.9539$	0.0325
South Platte	$y = 0.0059x + 0.8575$	$R^2 = 0.9393$	0.0059

Although the overall trend is for the EC_w to increase downstream, the downstream river sampling stations may have shown a decreasing EC_w trend over the course of the study. For instance, BOLONGCO has a statistically-significant decreasing slope over the study period even though it is the last station on the Boulder Creek System.

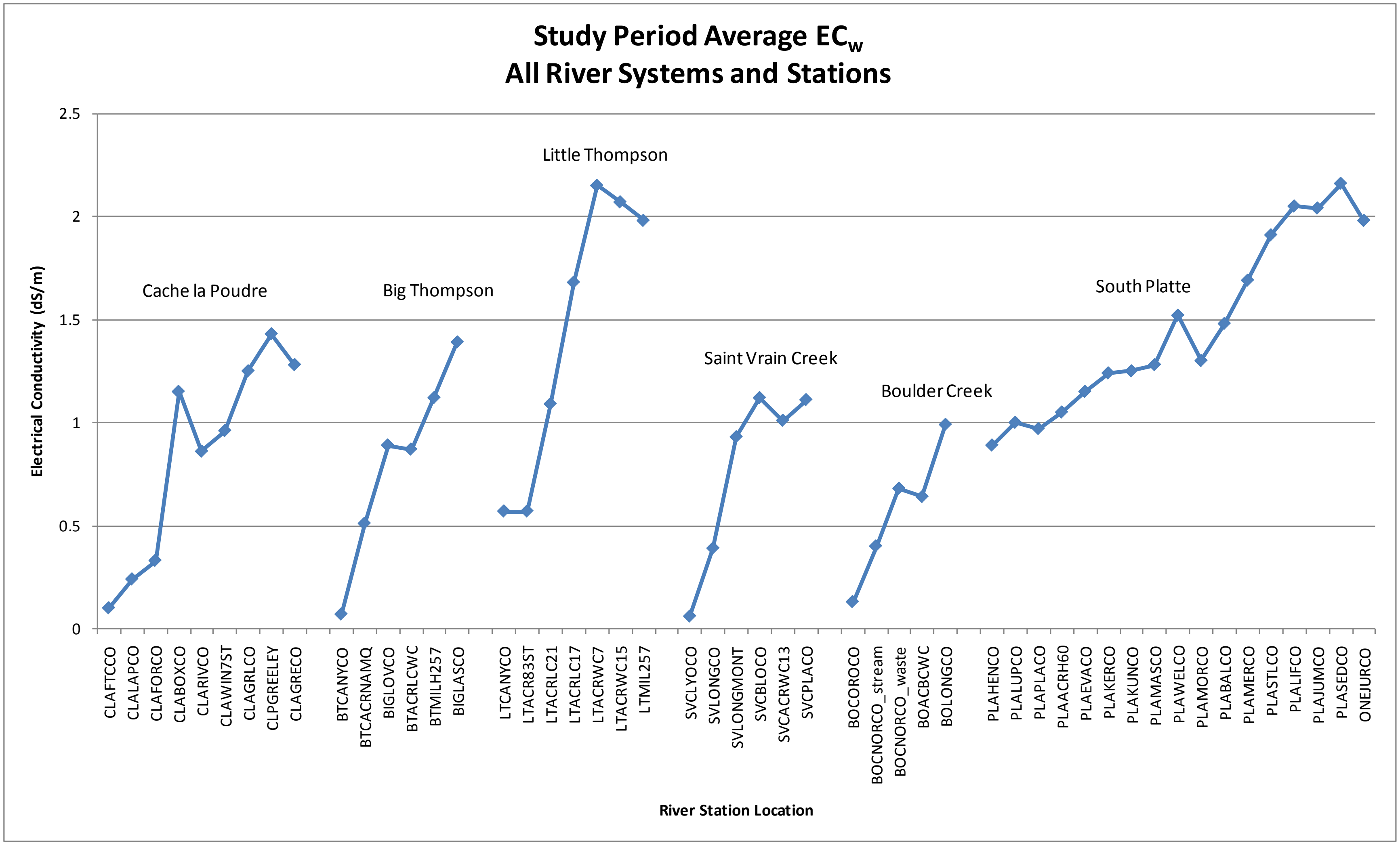
From Table 7, the River System Regression Results showed that all river systems contained at least one station with a statistically-significant trend over the study period, whether increasing or decreasing. The Saint Vrain River System is the only system that included some individual stations that increased and some stations that decreased over the study period.

If one station showed increasing EC_w over time, it did not necessarily impact the downstream station. That is to say, the variation of EC_w from year-to-year at a particular station appears to be independent of the other stations. Factors affecting the EC_w value at each station are numerous and have not been identified as part of this study. For instance, the surrounding soil salinity may affect the EC_w in the water at the sampling location. Non-point source and point source discharges along the river system may affect the EC_w at a single sampling point.

Figure 47 shows the Study Period Average EC_w value for each station on each river system (computed as the average of the annual averages for each station), providing a comparison between the river systems. While the stations are not graphed based on distance downstream, they are graphed in correct physical order within each river system. All stations sampled had an average EC_w less than 2.5 dS/m. The Cache la Poudre, Big Thompson, Saint Vrain Creek and Boulder Creek had average EC_w values less than 1.5 dS/m. Boulder Creek had average EC_w values less than 1 dS/m.

The salinity study provided a large quantity of electrical conductivity data for the river water at various sampling points over numerous consecutive years. The data was processed, evaluated, and compared to better understand trends in EC_w. Statistical analysis was completed on the river systems' electrical conductivity to determine whether statistically significant trends were observed over the course of the study.

Figure 47. Comparison of Study Period Average EC_w Between Stations and River Systems



Canal Irrigation Systems

Eight canal (or ditch) irrigation systems were included in this study. Within each canal system, multiple stations along the canal system were manually monitored and tested for EC_w. Table 10 lists the canal systems and sampling stations.

Table 10. Canal Irrigation Systems List

Ditch System	Site Description	Site Abbreviation
New Cache		
	New Cache at CLP River near Timnath	CLP4
	New Cache at Fossil Creek Reservoir Outlet	NCRFC
	New Cache at Timnath Reservoir Outlet	NCRT
	New Cache at Windsor Reservoir Outlet	NCRW
	New Cache north of Windsor	NC2
	New Cache east of Lucerne	NC5
	New Cache south of Galeton	NC6
	New Cache north of Barnesville	NC7
Larimer-Weld		
	Larimer-Weld Headgate at CLP River	LW1
	Larimer-Weld at Terry Lake Outlet	LWRT
	Larimer-Weld at Long Pond Outlet	LWRL
	Larimer-Weld at Windsor Reservoir #8 Outlet	LWR8
	Larimer-Weld Canal at LCR 3	LW2
	Larimer-Weld Canal at Hwy 257	LW3
	Larimer-Weld Canal west of Eaton	LW5
	Larimer-Weld Canal at Owl Creek Extension	LW8
Riverside		
	Riverside Reservoir Outlet Gauge	RSOUTLWR
	Riverside Canal Wildcat Siphon	RSWILDSI
	Riverside Canal Bruce Weir	RSBRCWEI
Prewitt and North Sterling		
	Prewitt Reservoir Inlet Flume	PRRESINLE
	Prewitt Reservoir Outlet Flume	PRRESOUT
	North Sterling Reservoir Inlet	NSRESINLE
	North Sterling Reservoir Outlet Flume	NSRESOUT
	North Sterling 1/3 Canal	NS13CAN
	North Sterling 2/3 Canal	NS23CAN
	North Sterling End Canal	NSENDCAN
Jackson and Morgan		
	Jackson Reservoir Inlet Gauge	JXRESINLE
	Jackson Reservoir Outlet Gauge	JXOUTGAG
	Morgan Canal Inlet Flume / Gauge	MORCANCO
	Morgan Canal Western Sugar Flume	MOWSTSUG
	Morgan Canal South Side Flume	MOSTHSFL
	Morgan Canal Badger Flume	MOBDGCRFL
	Morgan Canal Pawnee Power Plant #2	MOPAWPP2

Table 10 (continued). Canal Irrigation Systems List

Ditch System	Site Description	Site Abbreviation
Empire and Bijou		
	Empire Reservoir Inlet	EMRESINL
	Empire Reservoir Outlet	EMRESOUT
	Bijou Canal Diversion Flume / Gauge	BIJOUSCO
	Bijou Canal at Empire Reservoir	BICAEM
	Bijou Canal at #2 Reservoir	BICA2RES
	Bijou Canal Big Weir	BICABIWEI
	Bijou Canal 3-T Weir	BICA3TWEI
	Bijou Canal Chase Lateral	BICACHLAT
Julesburg		
	SETTLERS DITCH	
	Julesburg Settlers Ditch Start	JULSETSTR
	Julesburg East Settlers Ditch	JULEASSET
	Julesburg Settler Ditch End	JULSETEND
	HIGHLINE DITCH	
	Julesburg Reservoir Inlet Gauge	JULRESINLE
	Julesburg (Jumbo) Reservoir Outlet Canal	JULOUTGAU
	Julesburg East Highline 6ft Parshall	JULEASHIG
	Julesburg Harry Highline Ditch	JULHARHIG
	PETERSON DITCH	
	Julesburg Peterson Ditch Diversion	JULPETDIV
	Julesburg Peterson Ditch East	JULPETEAS
	Julesburg Peterson End / Stateline Ditch	STLINECO
Boxelder and Lone Tree		
	Boxelder Creek at WWTP	BOXWWTP
	Lone Tree Creek across Hwy 263	LTCHWY263

Analysis Overview

Table 11 shows all the stations on the canal systems and the years when samples were collected. The years of data vary between stations, and this should be noted when comparing data and results. For instance, New Cache / Greeley #2 Canal and Larimer-Weld Canal include only two years of data, while most of the other ditch systems include four years of data.

Daily EC_w readings were collected manually and in some cases, for a ditch system, all stations may not have been sampled on the same day. A day or two may have passed between sampling each station on a canal system. However, the data were processed to provide average monthly and average annual daily EC_w values.

Table 12 provides the Annual Average EC_w data and the Annual Standard Deviation for each canal system station. Table 13 shows the Maximum and Minimum EC_w values for each canal system station.

Table 11. Ditch Stations and Years of Data Collection

Ditch System	Site Abbreviation	2001	2002	2003	2004	2005	2006
New Cache							
	CLP4					x	x
	NCRFC					x	x
	NCRT					x	x
	NCRW				1 point	x	x
	NC2				1 point	x	x
	NC5				1 point	x	x
	NC6				1 point	x	x
	NC7				1 point	x	x
Larimer-Weld							
	LW1				1 point	1 point	x
	LWRT					x	x
	LWRL					x	x
	LWR8					x	x
	LW2					x	x
	LW3					x	x
	LW5				1 point	x	x
	LW8				1 point	x	x
Riverside							
	RSOUTLWR			x	x	x	x
	RSWILDSI			x	x	x	x
	RSBRCWEI			x	x	x	x
Prewitt and North Sterling							
	PRRESINLE			x	x	x	x
	PRRESOUT			x	x	x	x
	NSRESINLE			x	x	x	x
	NSRESOUT			x	x	x	x
	NS13CAN			x	x	x	x
	NS23CAN			x	x	x	x
	NSENDCAN			x	x	x	x
Jackson and Morgan							
	JXRESINLE			x	x	x	x
	JXOUTGAG			x	x	x	x
	MORCANCO	x		1 point	x	x	x
	MOWSTSUG			x	x	x	x
	MOSTHSFL			x	x	x	x
	MOBDGCRFL			x	x	x	x
	MOPAWPP2			x	x	x	x
Empire and Bijou							
	EMRESINL			x	x	x	x
	EMRESOUT			x	x	x	x
	BIJOUSCO			x	x	x	x
	BICAEM			x	x	x	x
	BICA2RES			x	x	x	x
	BICABIWEI			x	x	x	x
	BICA3TWEI			x	x	x	x
	BICACHLAT			x	x	x	x
Julesburg							
	SETTLERS DITCH						
	JULSETSTR			x	x	x	x
	JULEASSET			x	x	x	x
	JULSETEND			x	x	x	x
	HIGHLINE DITCH						
	JULRESINLE			x	x	x	x
	JULOUTGAU			x	x	x	x
	JULEASHIG			x	x	x	x
	JULHARHIG			x	x	x	x
	PETERSON DITCH						
	JULPETDIV			x	x	x	x
	JULPETEAS			x	x	x	x
	STLINECO			x	x	x	x
Boxelder and Lone Tree							
	BOXWWTP					x	x
	LTCHWY263					x	x

Note: An "x" does NOT imply a complete year of data.

Table 12. Canal Systems Annual Average EC_w and Standard Deviation

New Cache / Greeley #2 Canal

	CLP4		NCRFC		NCRT		NCRW	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002								
2003								
2004							0.44	NA
2005	0.66	0.45	0.60	0.07	1.00	0.52	0.59	0.28
2006	0.59	0.86	0.71	0.15	1.41	0.37	0.69	0.50
Historical Average	0.63		0.65		1.20		0.57	

**2004 - one day of data only* (NCRW)

	NC2		NC5		NC6		NC7	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002								
2003								
2004	0.32	NA	0.34	NA	0.35	NA	0.36	NA
2005	0.59	0.12	0.59	0.10	0.59	0.08	0.61	0.09
2006	0.53	0.17	0.58	0.20	0.57	0.18	0.58	0.19
Historical Average	0.48		0.50		0.50		0.52	

**2004 - one day of data only* (NC2) **2004 - one day of data only* (NC5) **2004 - one day of data only* (NC6) **2004 - one day of data only* (NC7)

Larimer-Weld Canal

	LW1		LWRT		LWRL		LWR8	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002								
2003								
2004	0.21	NA						
2005	0.10	NA	0.21	0.22	0.64	0.09	1.05	1.15
2006	0.22	0.56	0.71	0.25	0.71	0.07	0.76	0.60
Historical Average	0.18		0.46		0.67		0.91	

**2004 & 2005 - one day of data only* (LW1)

	LW2		LW3		LW5		LW8	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002								
2003								
2004					0.10	NA	0.09	NA
2005	0.32	0.20	0.24	0.17	0.27	0.15	0.26	0.12
2006	0.43	0.31	0.55	0.38	0.47	0.23	0.33	0.20
Historical Average	0.38		0.39		0.28		0.23	

**2004 - one day of data only* (LW5) **2004 - one day of data only* (LW8)

Table 12 (continued). Canal Systems Annual Average EC_w and Standard Deviation

Boxelder and Lone Tree Creeks

	BOXWWTP		LTCHWY263	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002				
2003				
2004				
2005	2.02	0.17	1.86	0.97
2006	2.07	0.57	2.97	0.54
Historical Average	2.05		2.42	

Riverside Canal

	RSOUTLWR		RSWILDSI		RSBRCWEI	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002						
2003	1.13	0.14	1.13	0.16	1.06	0.14
2004	1.30	0.13	1.31	0.16	1.26	0.22
2005	1.01	0.05	1.00	0.05	1.08	0.04
2006	1.40	0.09	1.39	0.08	1.34	0.05
Historical Average	1.21		1.21		1.19	

Prewitt and North Sterling Canal

	PRRESINLE		PRRESOUT		NSRESINLE		NSRESOUT	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002								
2003	1.80	0.29	1.52	0.31	1.54	0.24	1.28	0.19
2004	1.70	0.26	1.63	0.09	1.55	0.16	1.57	0.09
2005	1.65	0.33	1.43	0.04	1.57	0.19	1.33	0.08
2006	1.91	0.23	1.82	0.12	1.69	0.61	1.59	0.08
Historical Average	1.76		1.60		1.59		1.44	

	NS13CAN		NS23CAN		NSENDCAN	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002						
2003	1.40	0.09	1.14	0.39	1.41	0.23
2004	1.56	0.07	1.54	0.07	1.53	0.10
2005	1.30	0.00	1.30	0.00	1.31	0.02
2006	1.62	0.02	1.61	0.02	1.55	0.20
Historical Average	1.47		1.40		1.45	

Table 12 (continued). Canal Systems Annual Average EC_w and Standard Deviation

Jackson and Morgan Canal

	JXRESINLE		JXOUTGAG		MORCANCO		MOWSTSUG	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2001					1.29	0.18		
2002								
2003	1.32	0.29	1.42	0.35	1.50	0.00	1.32	0.23
2004	1.27	0.28	1.41	0.12	1.30	0.22	1.27	0.24
2005	1.27	0.34	1.32	0.04	1.14	0.27	1.20	0.26
2006	1.44	0.07	1.54	0.09	1.38	0.12	1.39	0.11
Historical Average	1.33		1.42		1.32		1.30	

	MOSTHSFL		MOBDGCRFL		MOPAWPP2	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2001						
2002						
2003	1.24	0.22	1.29	0.20	1.18	0.33
2004	1.15	0.19	1.19	0.20	1.21	0.21
2005	1.19	0.27	1.19	0.28	1.18	0.28
2006	1.40	0.07	1.40	0.08	1.41	0.09
Historical Average	1.25		1.27		1.24	

Empire and Bijou Canal

	EMRESINL		EMRESOUT		BIJOUSCO		BICAEM	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002								
2003	1.09	0.42	1.20	0.19	1.25	0.37	1.25	0.35
2004	1.24	0.21	1.34	0.12	1.28	0.25	1.24	0.22
2005	1.09	0.23	1.15	0.11	1.21	0.33	1.21	0.32
2006	1.35	0.11	1.35	0.27	1.38	0.19	1.26	0.25
Historical Average	1.19		1.26		1.28		1.24	

	BICA2RES		BICABIWEI		BICA3TWEI		BICACHLAT	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002								
2003	1.14	0.28	1.09	0.30	1.09	0.30	1.14	0.28
2004	1.26	0.23	1.23	0.25	1.26	0.25	1.28	0.27
2005	1.09	0.24	1.10	0.24	1.15	0.17	1.15	0.19
2006	1.38	0.12	1.42	0.09	1.41	0.11	1.42	0.15
Historical Average	1.22		1.21		1.23		1.25	

Table 12 (continued). Canal Systems Annual Average EC_w and Standard Deviation

Julesburg Canal

	JULRESINLE		JULSETSTR		JULOUTGAU		JULPETDIV		JULEASSET	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002										
2003	2.11	0.23	2.31	0.55	1.89	0.46	2.27	0.19	2.12	0.12
2004	2.21	0.20	2.52	0.18	2.01	0.11	2.30	0.15	2.15	0.10
2005	2.05	0.18	2.52	0.12	1.93	0.08	2.12	0.04	2.06	0.12
2006	2.04	0.46	2.61	0.05	1.88	0.52	2.36	0.17	2.27	0.16
Historical Average	2.10		2.49		1.93		2.26		2.15	

	JULEASHIG		JULHARHIG		JULSETEND		JULPETEAS		STLINECO	
	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)	Annual Average ECw (dS/m)	Annual Standard Deviation (dS/m)
2002										
2003	2.01	0.14	2.05	0.07	1.87	0.56	2.20	0.51	2.10	0.47
2004	2.02	0.12	2.03	0.12	2.06	0.10	2.31	0.22	2.22	0.17
2005	1.92	0.07	1.90	0.07	1.95	0.09	2.00	0.16	2.10	0.28
2006	2.12	0.47	1.86	0.62	2.19	0.51	2.28	0.09	2.41	0.11
Historical Average	2.02		1.96		2.02		2.20		2.21	

Table 13. Canal Systems Maximum and Minimum Daily Average EC_w

New Cache / Greeley #2 Canal

	CLP4		NCRFC		NCRT		NCRW	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002								
2003								
2004							0.44	0.44
2005	1.33	0.10	0.70	0.50	1.80	0.50	1.30	0.25
2006	3.89	0.12	1.11	0.51	1.84	0.75	2.02	0.15

**2004 - one day of data only* (NCRW)

	NC2		NC5		NC6		NC7	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002								
2003								
2004	0.32	0.32	0.34	0.34	0.35	0.35	0.36	0.36
2005	0.85	0.40	0.70	0.40	0.70	0.40	0.70	0.40
2006	0.94	0.25	1.06	0.27	1.04	0.28	1.08	0.29
	**2004 - one day of data only*		**2004 - one day of data only*		**2004 - one day of data only*		**2004 - one day of data only*	

Larimer-Weld Canal

	LW1		LWRT		LWRL		LWR8	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002								
2003								
2004	0.21	0.21						
2005	0.10	0.10	0.60	0.10	0.70	0.50	3.10	0.20
2006	2.32	0.04	1.58	0.57	0.82	0.64	1.91	0.28

**2004& 2005 - one day of data only* (LW1)

	LW2		LW3		LW5		LW8	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002								
2003								
2004					0.10	0.10	0.09	0.09
2005	0.67	0.10	0.67	0.10	0.50	0.10	0.50	0.10
2006	1.27	0.06	1.36	0.15	0.92	0.11	0.70	0.11
					**2004 - one day of data only*		**2004 - one day of data only*	

Table 13 (continued). Canal Systems Maximum and Minimum Daily Average EC_w

Boxelder and Lone Tree Creeks

	BOXWWTP		LTCHWY263	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002				
2003				
2004				
2005	2.30	1.80	3.00	0.30
2006	2.46	0.34	3.87	1.67

Riverside Canal

	RSOUTLWR		RSWILDSI		RSBRCWEI	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002						
2003	1.40	1.00	1.40	0.90	1.30	0.70
2004	1.40	1.00	1.50	0.90	1.40	0.70
2005	1.10	0.90	1.10	0.90	1.10	1.00
2006	1.51	1.15	1.46	1.19	1.45	1.28

Prewitt and North Sterling Canal

	PRRESINLE		PRRESOUT		NSRESINLE		NSRESOUT	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002								
2003	2.10	0.90	2.00	1.00	1.80	1.00	1.50	0.90
2004	2.00	1.10	1.80	1.50	1.80	1.20	1.70	1.40
2005	2.00	0.90	1.50	1.40	1.90	1.10	1.60	1.30
2006	2.12	1.49	2.04	1.60	3.33	0.57	1.63	1.33

	NS13CAN		NS23CAN		NSENDCAN	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002						
2003	1.60	1.30	1.50	0.10	2.10	1.30
2004	1.60	1.40	1.60	1.40	1.60	1.30
2005	1.30	1.30	1.30	1.30	1.33	1.30
2006	1.66	1.60	1.65	1.59	1.64	0.87

Table 13 (continued). Canal Systems Maximum and Minimum Daily Average EC_w

Jackson and Morgan Canal

	JXRESINLE		JXOUTGAG		MORCANCO		MOWSTSUG	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2001					1.50	0.70		
2002								
2003	1.80	0.40	1.90	0.10	1.50	1.50	1.60	0.60
2004	1.80	0.63	1.60	1.10	1.70	0.73	1.70	0.70
2005	2.30	0.70	1.40	1.30	1.40	0.70	1.40	0.70
2006	1.49	1.29	1.70	1.42	1.50	1.05	1.55	1.13

	MOSTHSFL		MOBDGCRFL		MOPAWPP2	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2001						
2002						
2003	1.50	0.80	1.50	0.80	1.50	0.60
2004	1.40	0.70	1.40	0.70	1.50	0.80
2005	1.40	0.70	1.40	0.70	1.40	0.70
2006	1.54	1.28	1.53	1.29	1.52	1.24

Empire and Bijou Canal

	EMRESINL		EMRESOUT		BIJOUSCO		BICAEM	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002								
2003	1.50	0.40	1.50	0.70	1.60	0.40	1.60	0.40
2004	1.53	0.87	1.50	0.90	1.60	0.70	1.60	0.80
2005	1.50	0.67	1.30	0.85	1.50	0.60	1.50	0.60
2006	1.49	1.12	1.54	0.57	1.61	0.86	1.55	0.74

	BICA2RES		BICABIWEI		BICA3TWEI		BICACHLAT	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002								
2003	1.50	0.40	1.50	0.40	1.50	0.60	1.50	0.60
2004	1.60	0.70	1.50	0.70	1.50	0.70	1.50	0.70
2005	1.40	0.60	1.40	0.60	1.30	0.70	1.30	0.60
2006	1.51	1.00	1.51	1.20	1.53	1.09	1.53	1.04

Table 13 (continued). Canal Systems Maximum and Minimum Daily Average EC_w

Julesburg Canal

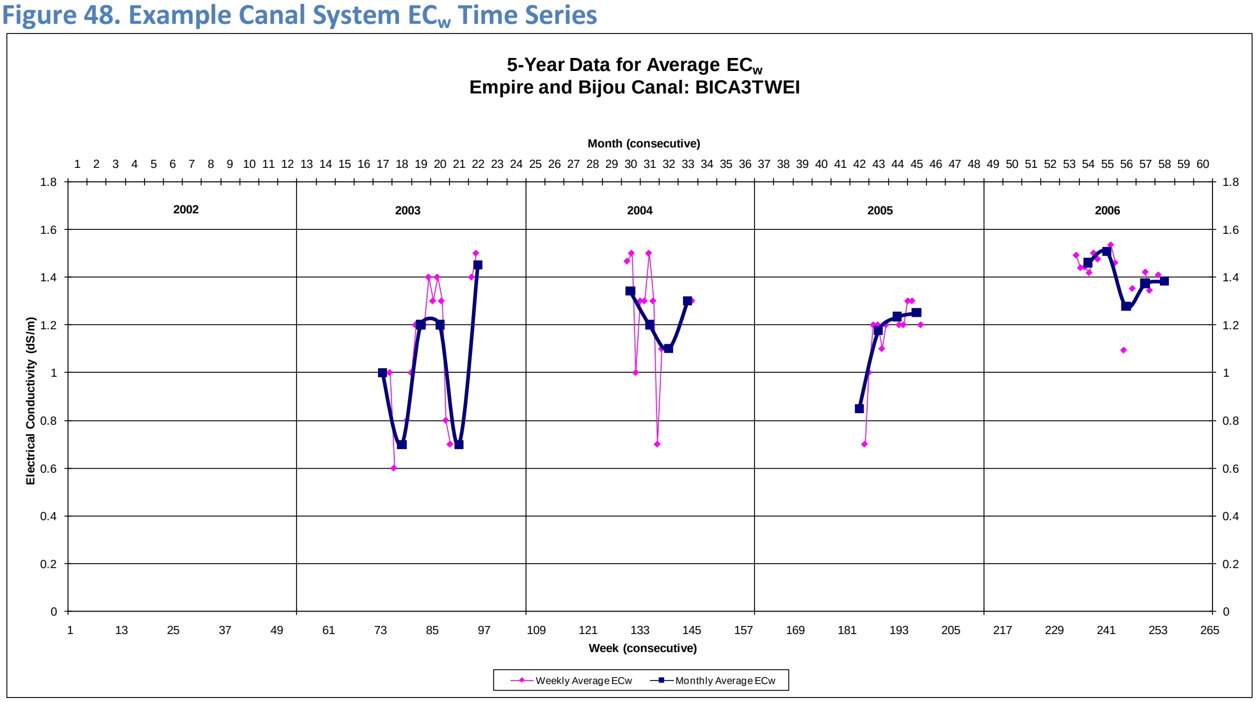
	JULRESINLE		JULSETSTR		JULOUTGAU		JULPETDIV		JULEASSET	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002										
2003	2.60	1.60	2.80	0.30	2.20	0.40	2.50	1.70	2.30	2.00
2004	2.80	2.00	2.80	1.90	2.10	1.73	2.60	2.00	2.30	2.00
2005	2.50	1.63	2.80	2.40	2.10	1.80	2.20	2.10	2.30	1.90
2006	2.44	0.65	2.75	2.52	2.35	0.60	2.65	1.87	2.73	1.98

	JULEASHIG		JULHARHIG		JULSETEND		JULPETEAS		STLINECO	
	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
2002										
2003	2.20	1.60	2.20	2.00	2.30	0.10	3.10	0.20	2.60	0.70
2004	2.10	1.70	2.20	1.77	2.20	1.90	2.93	2.00	2.50	1.90
2005	2.00	1.80	2.00	1.80	2.10	1.83	2.20	1.60	2.40	1.40
2006	2.47	0.33	2.35	0.46	3.67	1.15	2.54	2.17	2.56	2.24

Statistical Analysis

Similar to the analysis for the river systems, multiple graphs have been generated to display the results of the salinity sampling throughout the study period. The Weekly Average EC_w and the Monthly Average EC_w were plotted on a consecutive timeline, or time-series plot. Sampling for the canal systems was only conducted during the irrigation season when water was in the ditch. An example canal system station Average EC_w graph is shown in Figure 48.

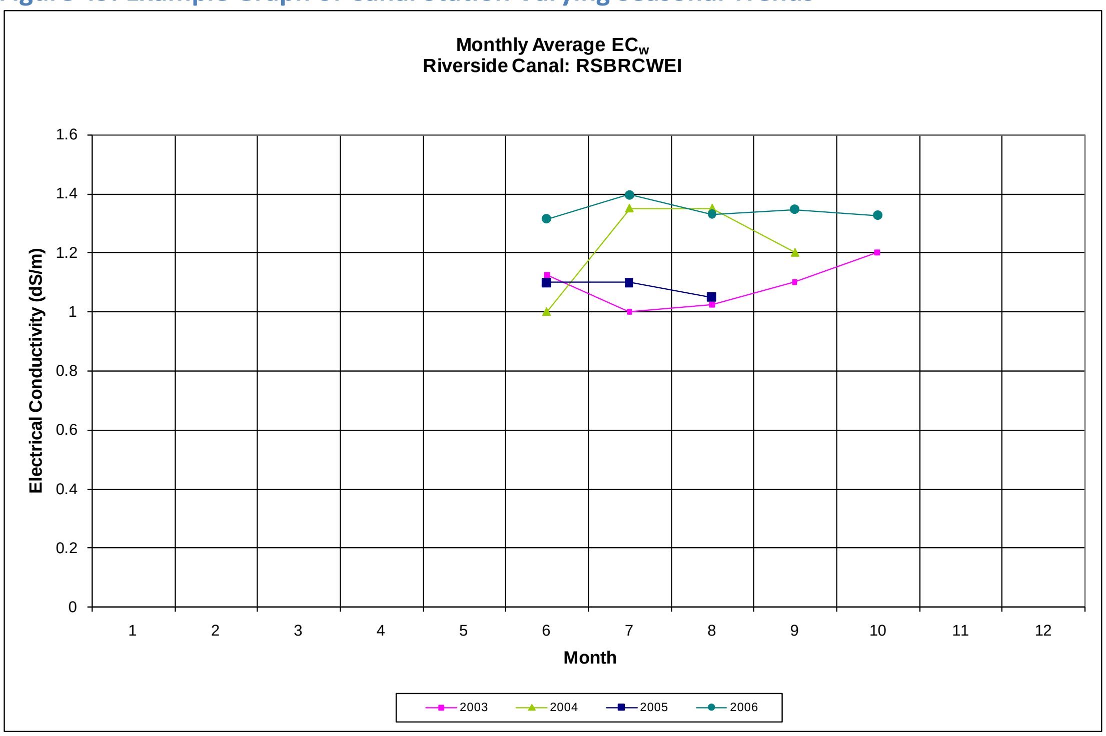
Figure 48. Example Canal System EC_w Time Series



To evaluate spatial patterns, the same regression analysis was performed on the distance downstream graphs for the canal systems. These graphs plot the Annual Average and Historical (study period) Average electrical conductivity for each station on the entire ditch as a function of the distance the station is located downstream from the start of the ditch. Each of these graphs will be shown for the individual ditch systems.

Seasonal patterns for the canals were different from those of the stream stations. Unlike the stream and river systems, the Monthly Average EC_w results did not appear as a “U” shaped trend. With data only taken during the irrigation season, very few stations exhibited any kind of a common trend from year to year of the study. Some of the data formed the “U” shaped graph with the lowest EC_w being recorded near the middle of the irrigation season. A few stations graphed an inverted “U” shape, with the highest EC_w occurring near the middle of the irrigation season. Some of the data tended to show increasing EC_w throughout the season, while others showed decreasing EC_w over the season. Nearly flat, or consistent, EC_w values were also observed for some ditch stations throughout a single year. Many stations included years of data that exhibited all of the above-mentioned seasonal patterns. In other words, there is not a prevailing yearly seasonal pattern related to EC_w in the ditch systems sampled during the study period. Figure 49 demonstrates a single ditch station that had varying results for each year of the study.

Figure 49. Example Graph of Canal Station Varying Seasonal Trends



The same statistical regression analysis in Minitab was performed for the canal system stations as described for the river system stations, including seasonal indicator variables. The results are compiled in Table 14 below and graphically shown in Figures 50 through 60.

Although stations JXOUTGAG and JULPETDIV have a statistically-significant trend over the study period, the associated Regression Line Graphs were not printed in the report because the regression line doesn’t match the actual statistically-calculated slope (due to limitations of Minitab).

Table 14. Canal Irrigation Systems Regression Results

Ditch System	Site Description	Site Abbreviation	Period of Record		Months	Days	Change over PoR	Rank Regression		Slope if Significant dS/m per day	Number of Months of Data
			Start	Stop				P-value	Significant Slope Y/N		
Riverside											
	Riverside Reservoir Outlet Gauge	RSOUTLWR	6-03	10-06	41	1249		0.214	N		18
	Riverside Canal Wildcat Siphon	RSWILDSI	6-03	8-06	39	1188		0.325	N		17
	Riverside Canal Bruce Weir	RSBRCWEI	6-03	10-06	41	1249	0.23676044	0.043	Y	0.00018956	17
Prewitt and North Sterling											
	Prewitt Reservoir Inlet Flume	PRRESINLE	1-03	6-06	42	1277		0.682	N		30
	Prewitt Reservoir Outlet Flume	PRRESOUT	6-03	8-06	39	1188	0.3636468	0.093	Y	0.0003061	20
	North Sterling Reservoir Inlet	NSRESINLE	1-03	11-06	47	1430		0.175	N		32
	North Sterling Reservoir Outlet Flume	NSRESOUT	5-03	8-06	40	1219		0.189	N		19
	North Sterling 1/3 Canal	NS13CAN	5-03	8-06	40	1219	0.13699122	0.014	Y	0.00011238	17
	North Sterling 2/3 Canal	NS23CAN	6-03	8-06	39	1188	0.4299372	0.001	Y	0.0003619	16
	North Sterling End Canal	NSENDCAN	6-03	8-06	39	1188		0.143	N		15
Jackson and Morgan											
	Jackson Reservoir Inlet Gauge	JXRESINLE	1-03	11-06	47	1430		0.771	N		29
	Jackson Reservoir Outlet Gauge	JXOUTGAG	1-03	8-06	44	1339	0.3671538	0.001	Y	0.0002742	20
	Morgan Canal Inlet Flume / Gauge	MORCANCO	6-01	10-06	65	1979		0.733	N		25
	Morgan Canal Western Sugar Flume	MOWSTSUG	1-03	10-06	46	1400		0.595	N		25
	Morgan Canal South Side Flume	MOSTHSFL	5-03	10-06	42	1280	0.23104	0.102	Y	0.0001805	20
	Morgan Canal Badger Flume	MOBDGCRFL	6-03	10-06	41	1249		0.186	N		20
	Morgan Canal Pawnee Power Plant #2	MOPAWPP2	5-03	10-06	42	1280	0.305664	0.101	Y	0.0002388	20
Empire and Bijou											
	Empire Reservoir Inlet	EMRESINL	6-03	11-06	42	1279		0.434	N		23
	Empire Reservoir Outlet	EMRESOUT	5-03	8-06	40	1219		0.125	N		25
	Bijou Canal Diversion Flume / Gauge	BIJOUSCO	5-03	10-06	42	1280		0.804	N		22
	Bijou Canal at Empire Reservoir	BICAEM	5-03	10-06	42	1280		0.918	N		24
	Bijou Canal at #2 Reservoir	BICA2RES	5-03	10-06	42	1280		0.172	N		23
	Bijou Canal Big Weir	BICABIWEI	5-03	10-06	42	1280	0.296704	0.020	Y	0.0002318	21
	Bijou Canal 3-T Weir	BICA3TWEI	5-03	10-06	42	1280	0.325888	0.010	Y	0.0002546	19
	Bijou Canal Chase Lateral	BICACHLAT	5-03	8-06	40	1219	0.3198656	0.063	Y	0.0002624	18
Julesburg											
	SETTLERS DITCH										
	Julesburg Settlers Ditch Start	JULSETSTR	6-03	10-06	41	1249	0.5303254	0.012	Y	0.0004246	27
	Julesburg East Settlers Ditch	JULEASSET	6-03	10-06	41	1249		0.237	N		21
	Julesburg Settler Ditch End	JULSETEND	6-03	10-06	41	1249		0.445	N		20
	HIGHLINE DITCH										
	Julesburg Reservoir Inlet Gauge	JULRESINLE	6-03	11-06	42	1279	-0.4970194	0.076	Y	-0.0003886	32
	Julesburg (Jumbo) Reservoir Outlet Canal	JULOUTGAU	6-03	10-06	41	1249		0.191	N		21
	Julesburg East Highline 6ft Parshall	JULEASHIG	6-03	11-06	42	1279		0.132	N		20
	Julesburg Harry Highline Ditch	JULHARHIG	6-03	10-06				0.669	N		20
	PETERSON DITCH										
	Julesburg Peterson Ditch Diversion	JULPETDIV	6-03	10-06	41	1249	0.1450089	0.082	Y	0.0001161	25
	Julesburg Peterson Ditch East	JULPETEAS	6-03	10-06	41	1249		0.216	N		26
	Julesburg Peterson End / Stateline Ditch	STLINECO	6-03	10-06	41	1249		0.134	N		20

Figure 50. RSBRCWEI: Regression Line Graph

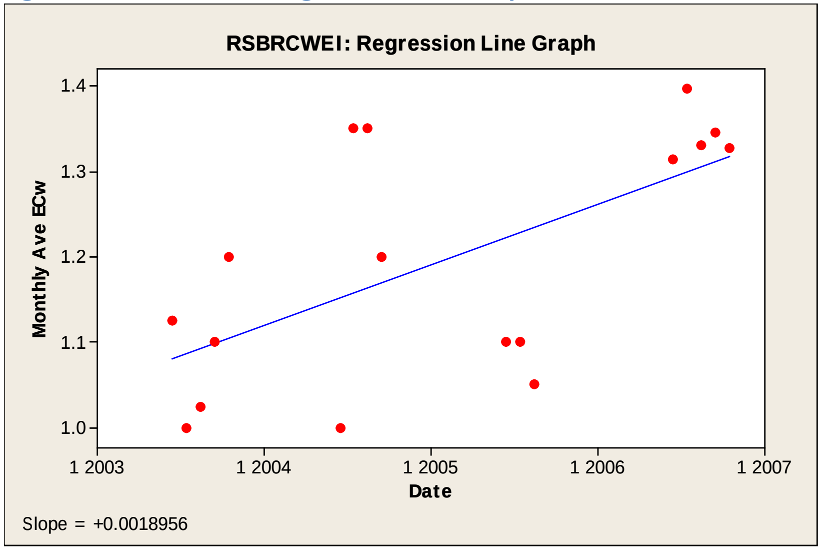


Figure 52. NS13CAN: Regression Line Graph

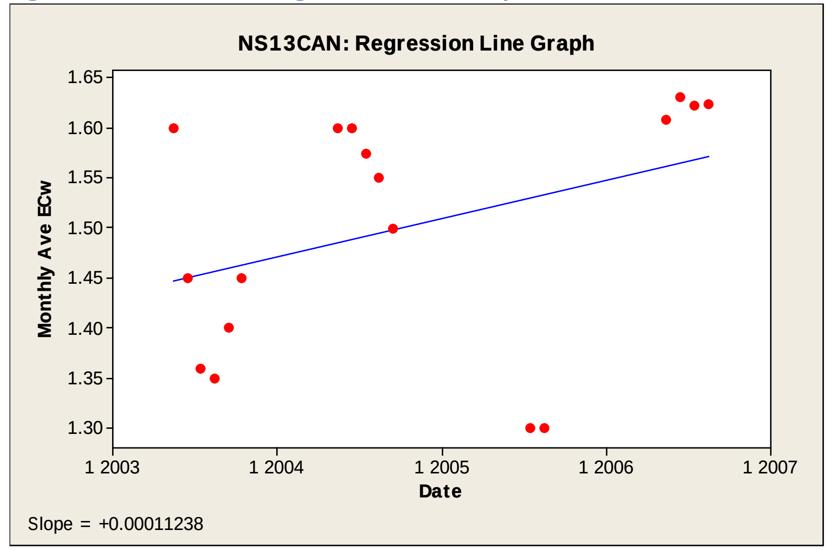


Figure 51. PRRESOUT: Regression Line Graph

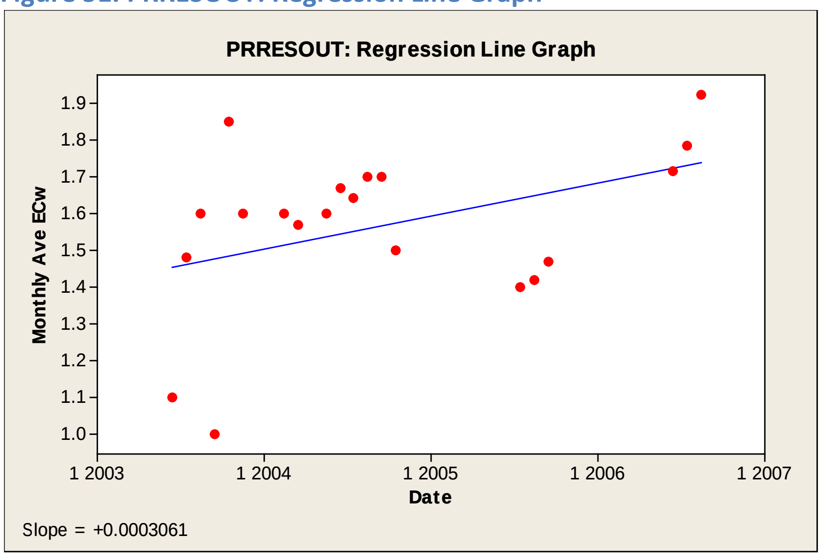


Figure 53. NS23CAN: Regression Line Graph

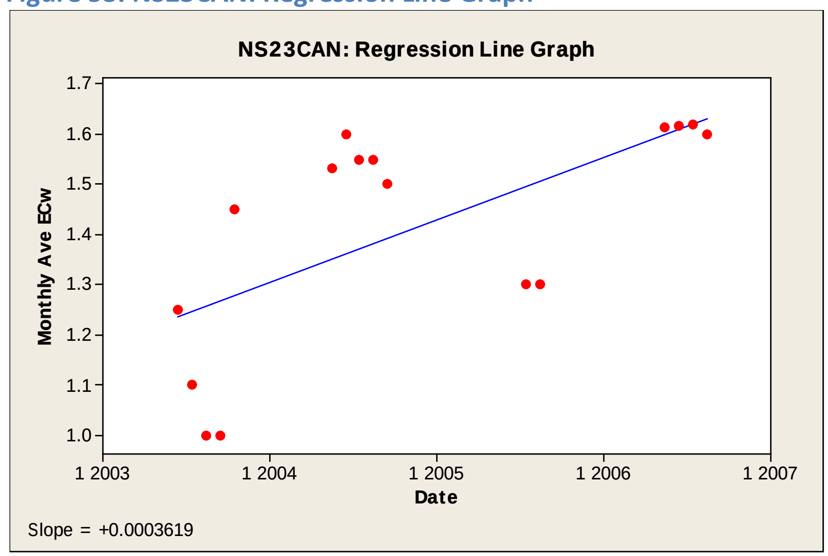


Figure 54. MOSTHSFL: Regression Line Graph

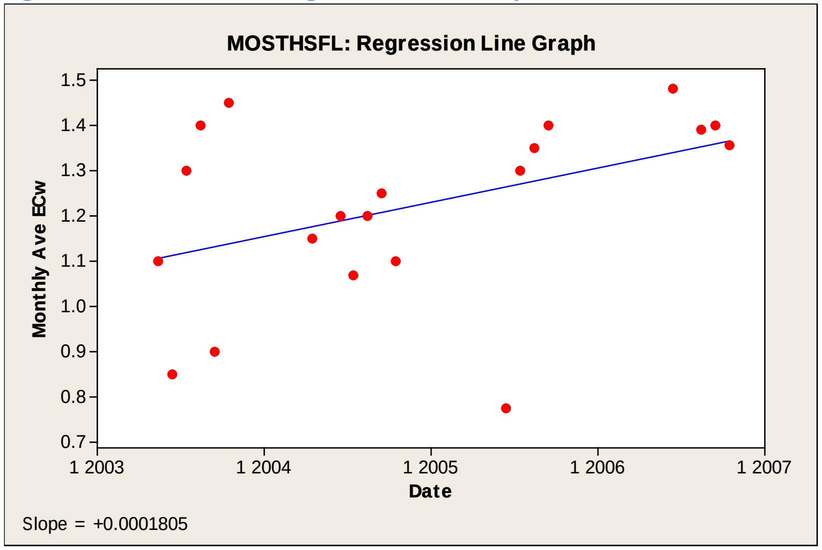


Figure 55. MOPAWPP2: Regression Line Graph

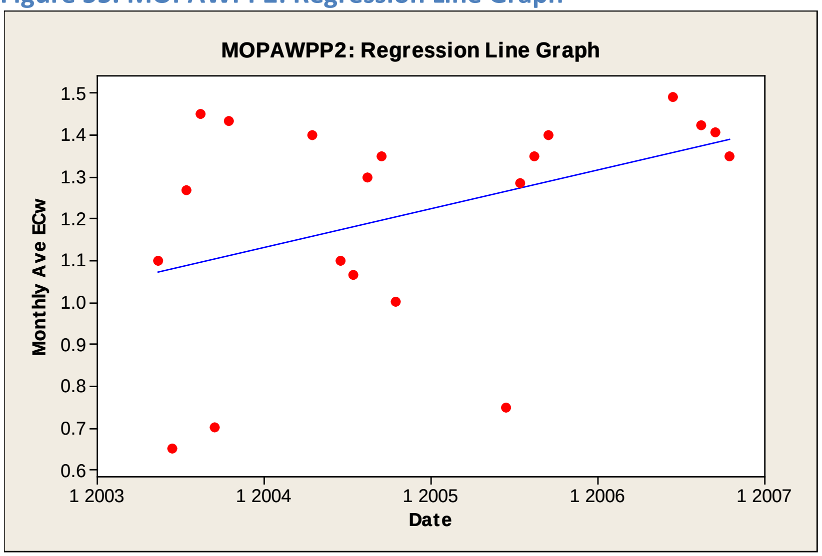


Figure 56. BICABIWEI: Regression Line Graph

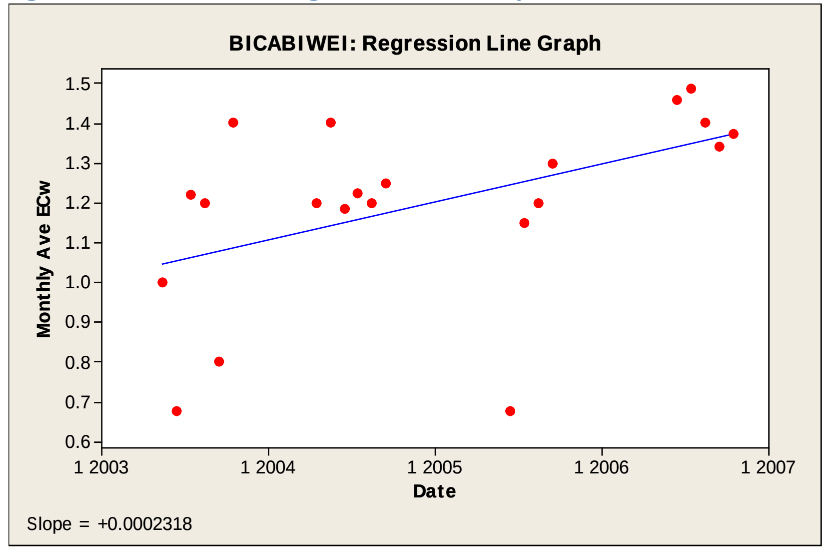


Figure 57. BICA3TWEI: Regression Line Graph

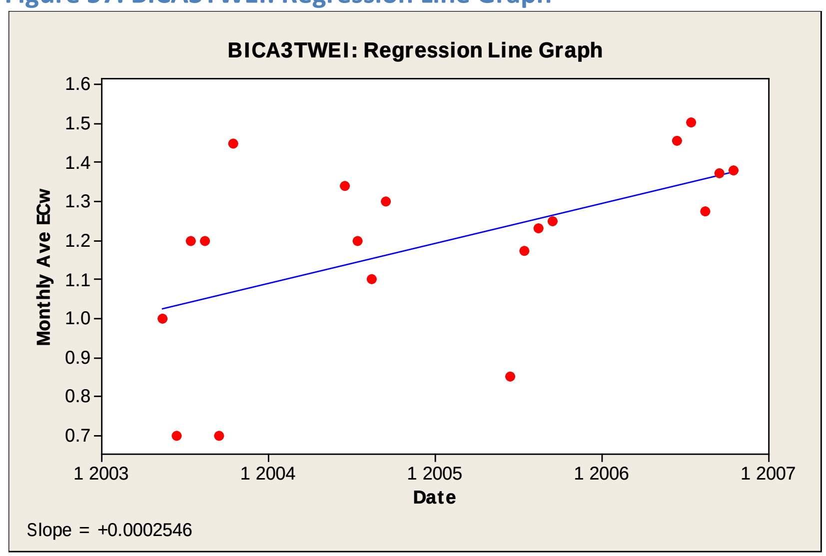


Figure 58. BICACHLAT: Regression Line Graph

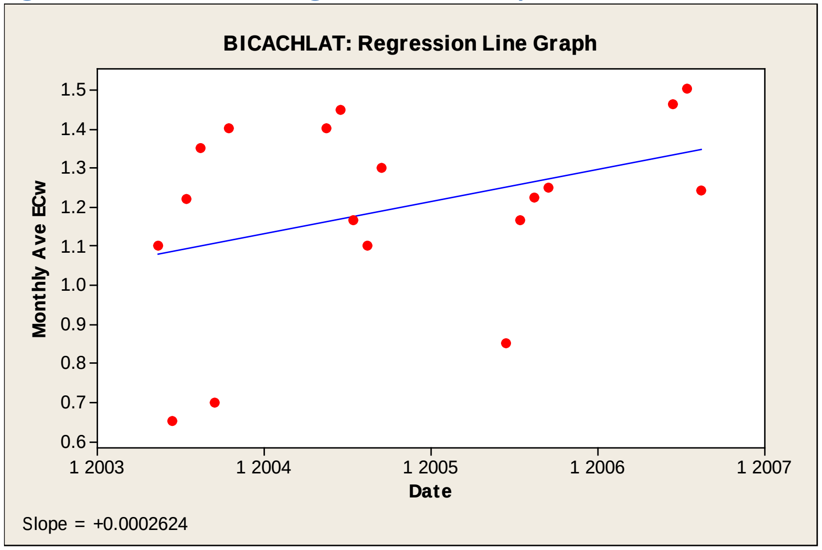


Figure 60. JULRESINLE: Regression Line Graph

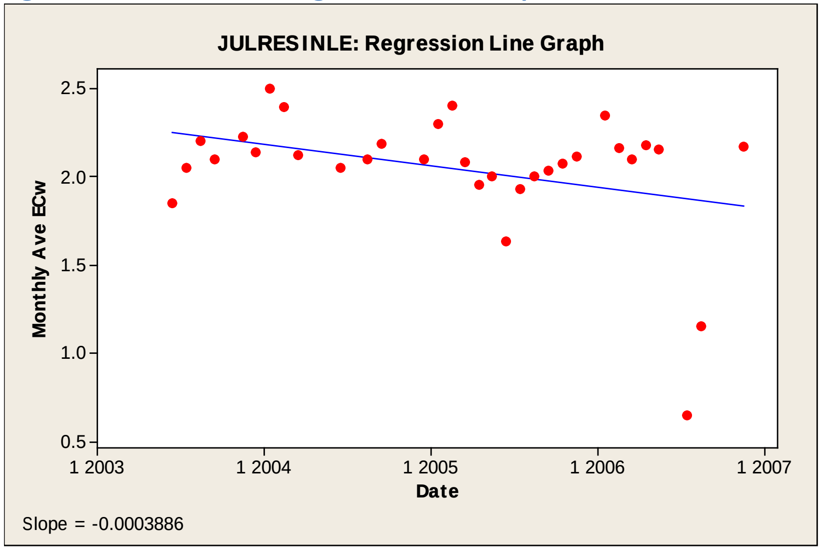
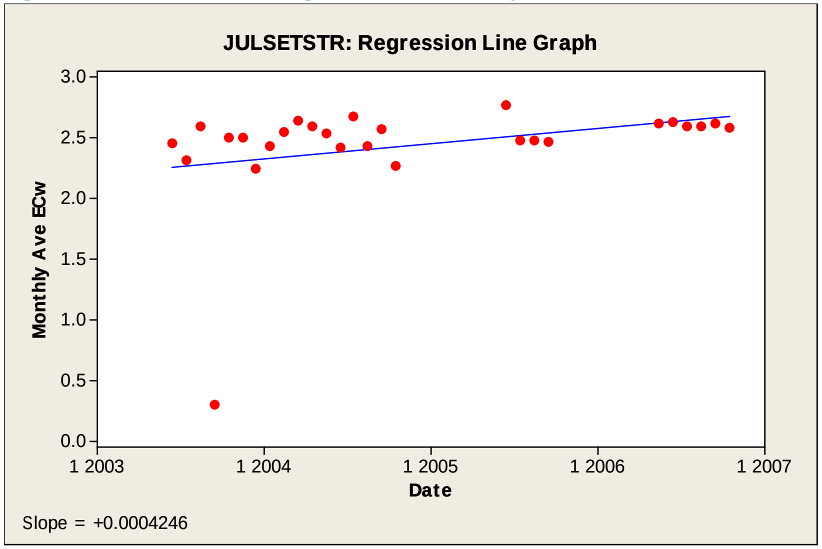


Figure 59. JULSETSTR: Regression Line Graph



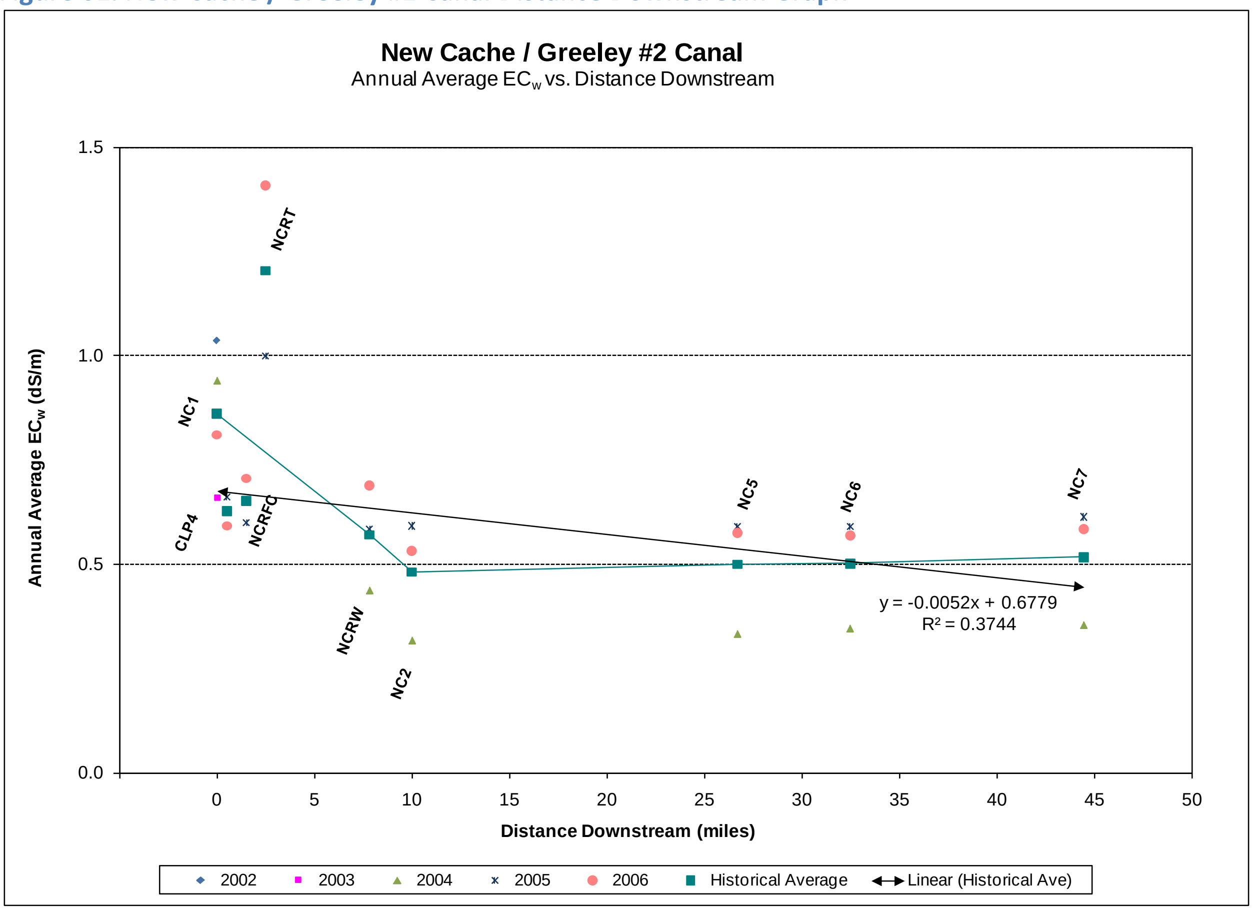
Canal Irrigation System – Variation with Distance Downstream

Following are the individual irrigation ditch and canal systems and station observations that are based on the analysis described earlier in this report.

New Cache / Greeley #2 Canal

For the New Cache / Greeley #2 canal, the EC_w vs. Distance Downstream Graph, Figure 61 (called Distance Downstream Graph for the remainder of this report), shows a decrease in the Annual Average EC_w based on the historical (study period) Average EC_w value, which is calculated as the average of the Annual Average EC_w values so that all years are equally weighted. Both linear and piecewise linear trend lines are shown. Neither trend line includes data from stations CLP4, NCRFC or NCRT (although they are shown on the graph) because they are not in-line in the New Cache canal.

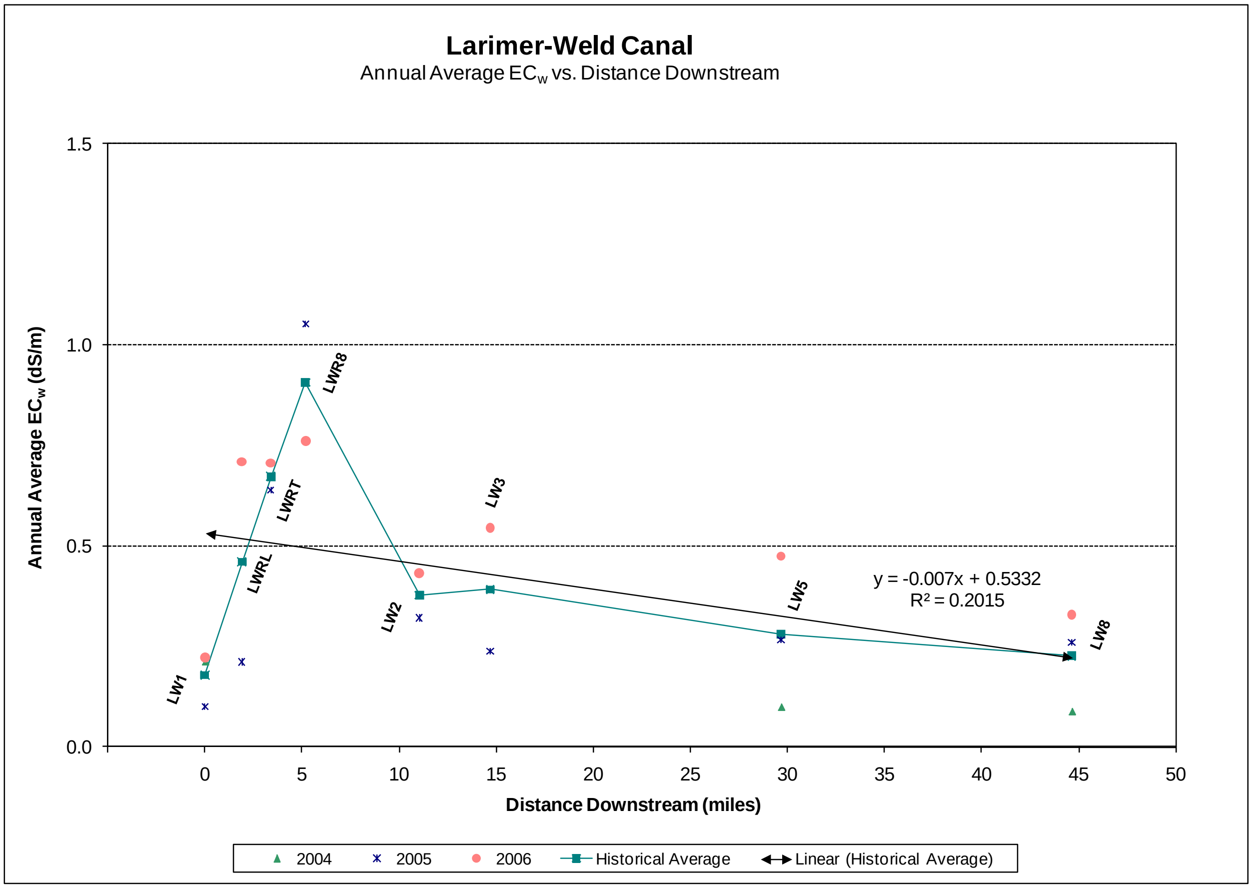
Figure 61. New Cache / Greeley #2 Canal Distance Downstream Graph



Larimer-Weld Canal

The Larimer-Weld Canal electrical conductivity results indicate that the EC_w value increases through the first four stations, then generally decreases downstream.

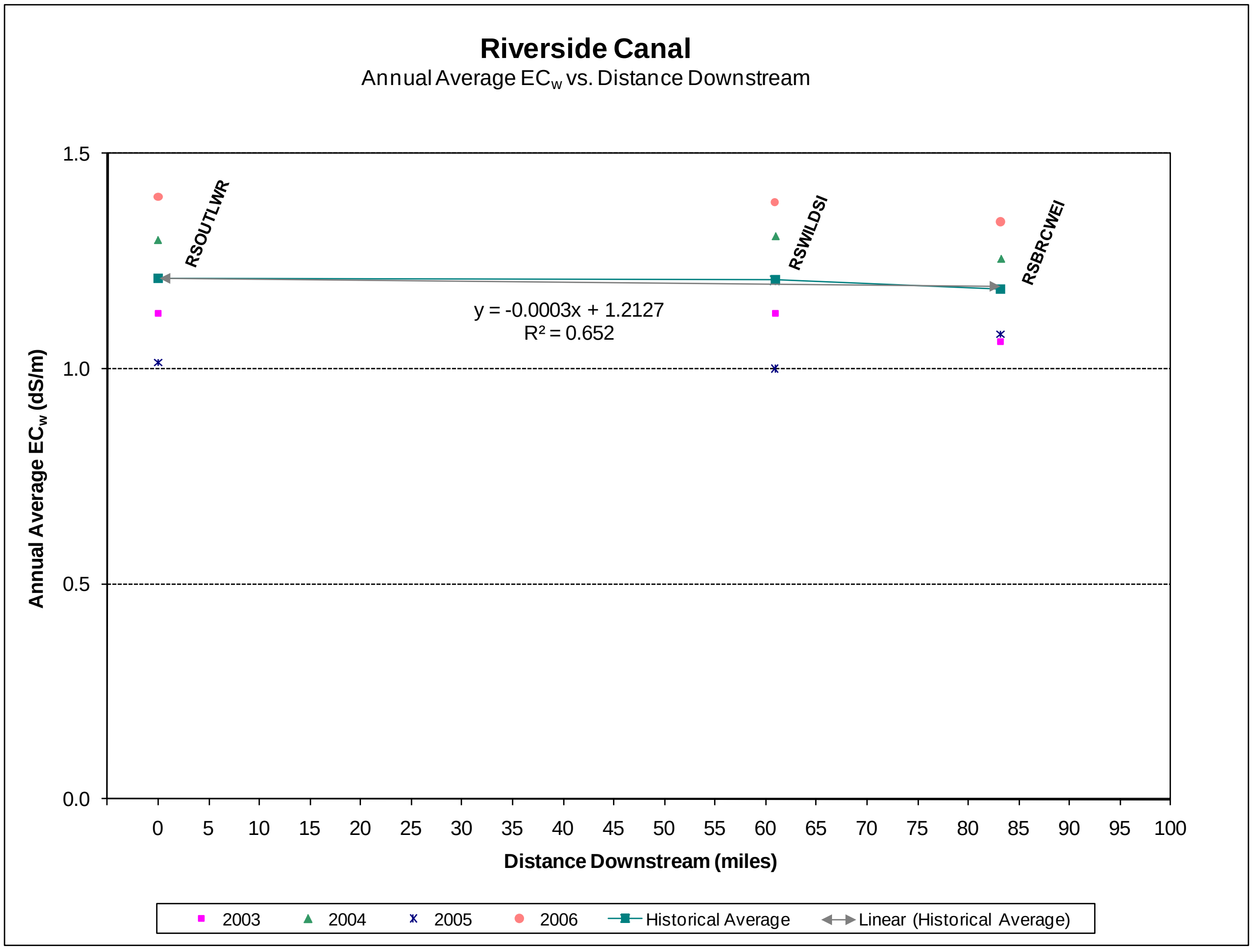
Figure 62. Larimer-Weld Canal Distance Downstream Graph



Riverside Canal

For the Riverside Canal, the R-squared value is 0.652 for the Distance Downstream graph, which shows a fairly steady EC_w value at all stations for the study period. This graph also shows very clearly that there was an increase in EC_w value at each station, in each year of the study.

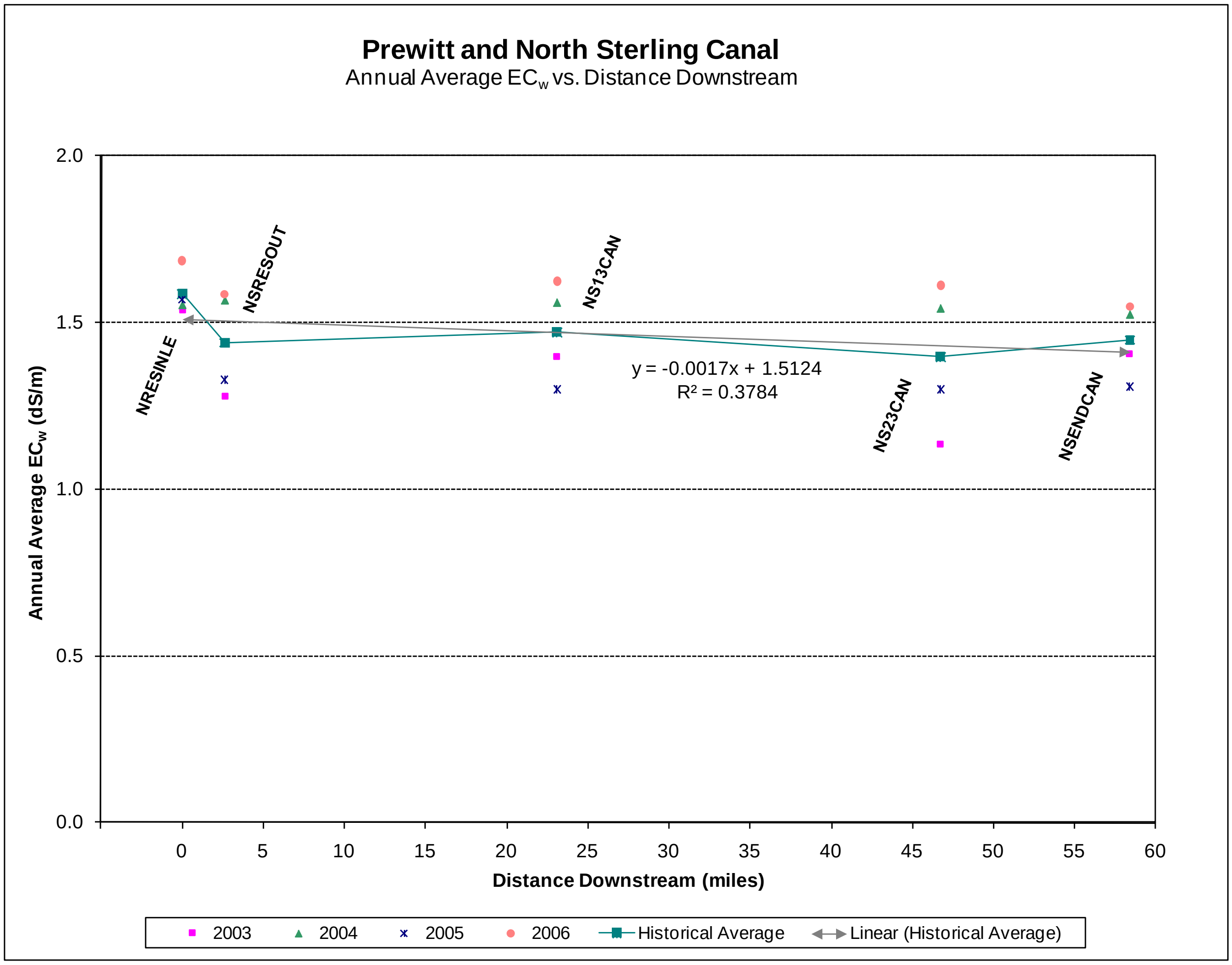
Figure 63. Riverside Canal Distance Downstream Graph



Prewitt and North Sterling Canal

The trendline for the Distance Downstream graph on Prewitt and North Sterling Canal stations indicates a reduction in EC_w values the farther downstream the water travels. The actual EC_w values and Annual Average show some increase and some decrease throughout the canal.

Figure 64. Prewitt and North Sterling Canal Distance Downstream Graph

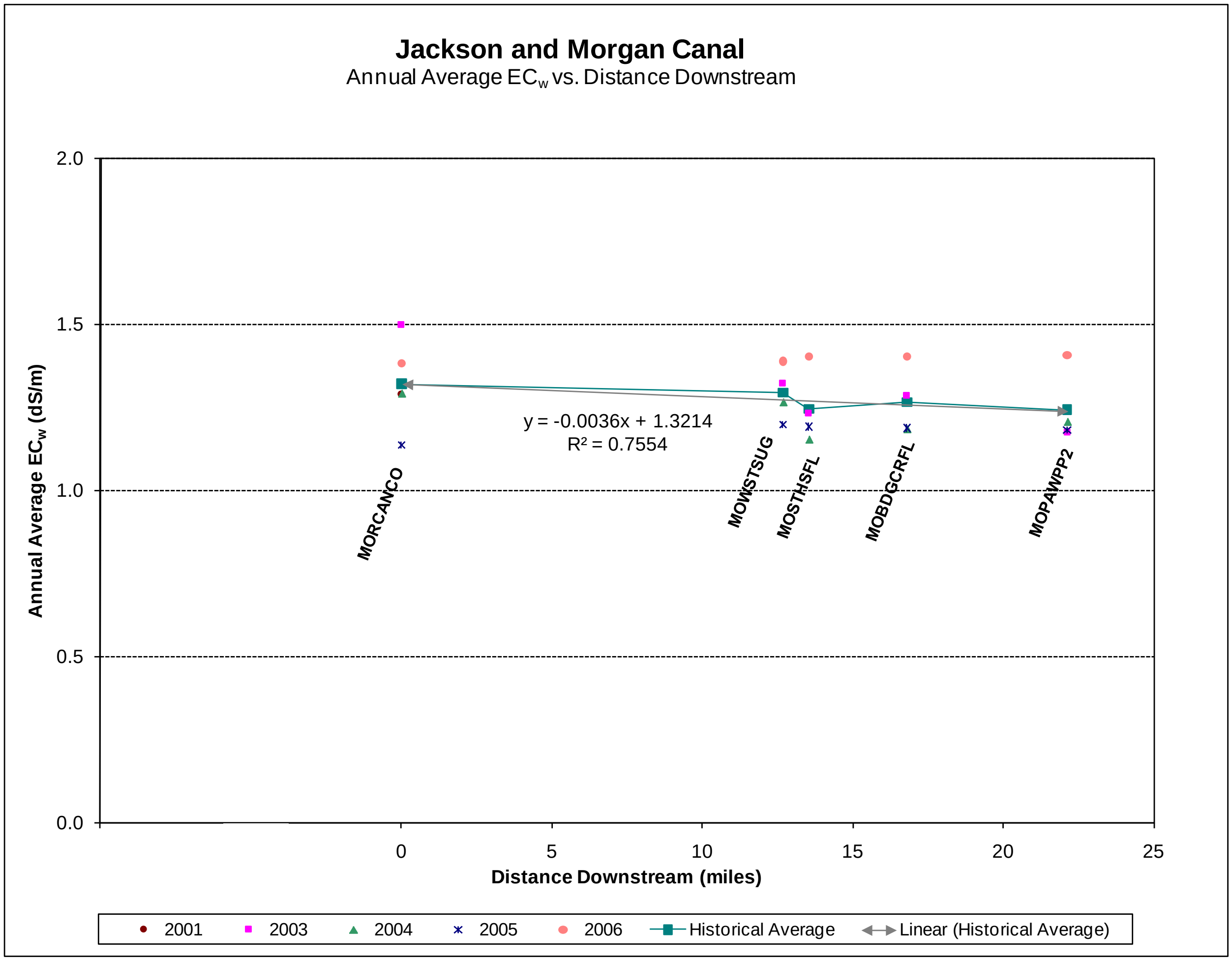


Not included in the Distance Downstream Graph are the stations PRRESOUT and PRRESINLE. PRRESOUT showed a trend for increased EC_w values throughout the study, while PRRESINLE showed a decrease. This may imply that the incoming water to the Prewitt Reservoir had decreased electrical conductivity values and upon exiting the reservoir, the water had increased in salinity. That phenomenon would be consistent with the logic that water leaving reservoirs is more saline due to water evaporation in the reservoir.

Jackson and Morgan Canal

Jackson and Morgan Canal also shows a trend for decreasing EC_w values as the water travels down the system. The trendline for this data has a reasonably high R-squared value of 0.7554. The data for 2006 indicates an increased EC_w value as the water travels downstream; however, the Historical Average EC_w shown on the graph indicates the opposite.

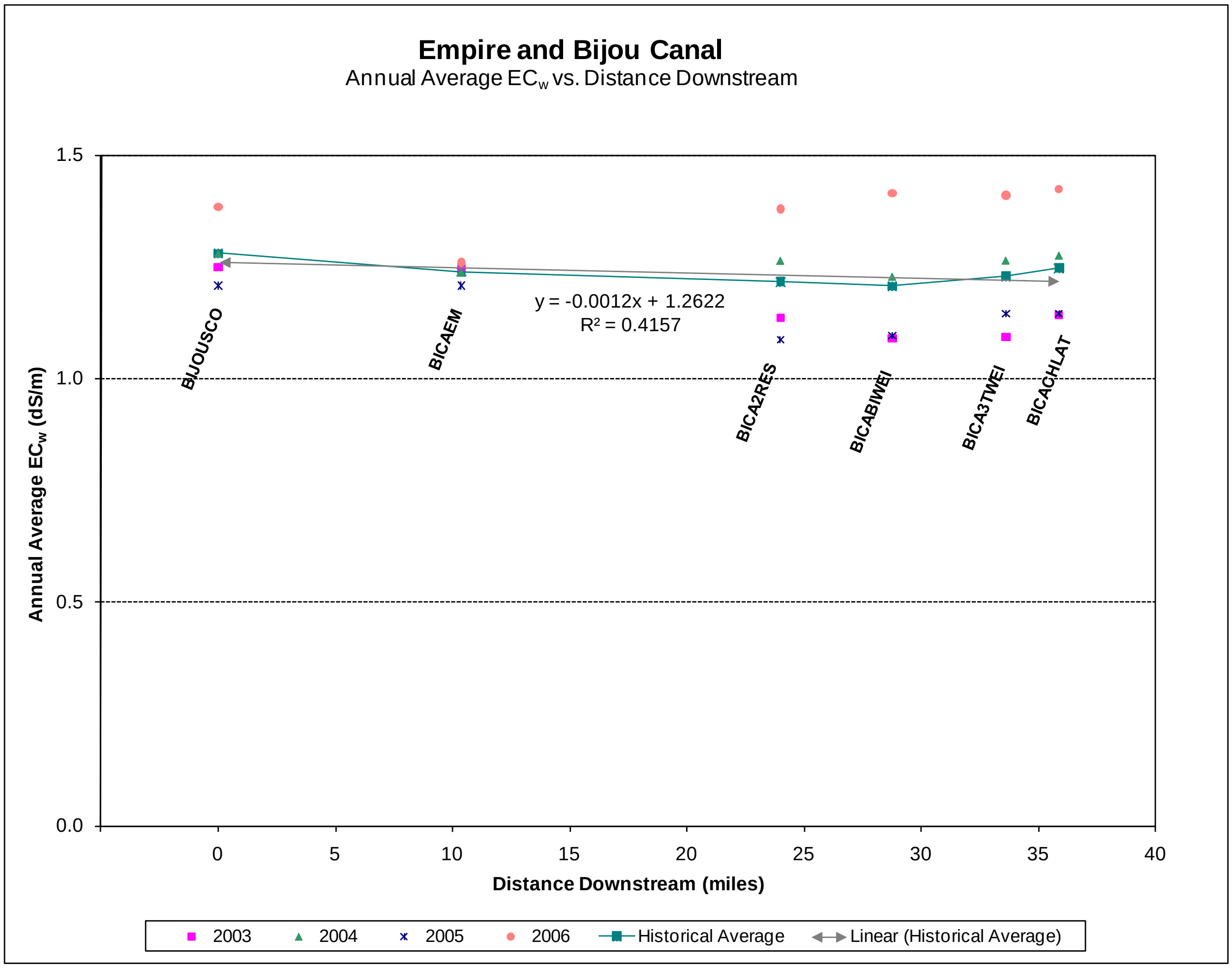
Figure 65. Jackson and Morgan Canal Distance Downstream Graph



Empire and Bijou Canal

Reviewing the graph for the Empire and Bijou Canal shows that the individual year data (2006 and 2005 in particular) have increasing EC_w values from BICA2RES on downstream. However, the Historical Average EC_w values produce a trendline that decreases downstream. This is an example of how the regression analysis should be reviewed in context of all the individual data and R-squared values, and also why it should not be used for future predictions of EC_w values. The individual station data with annual results may provide more reliable observations than calculations of the Historical Average EC_w values.

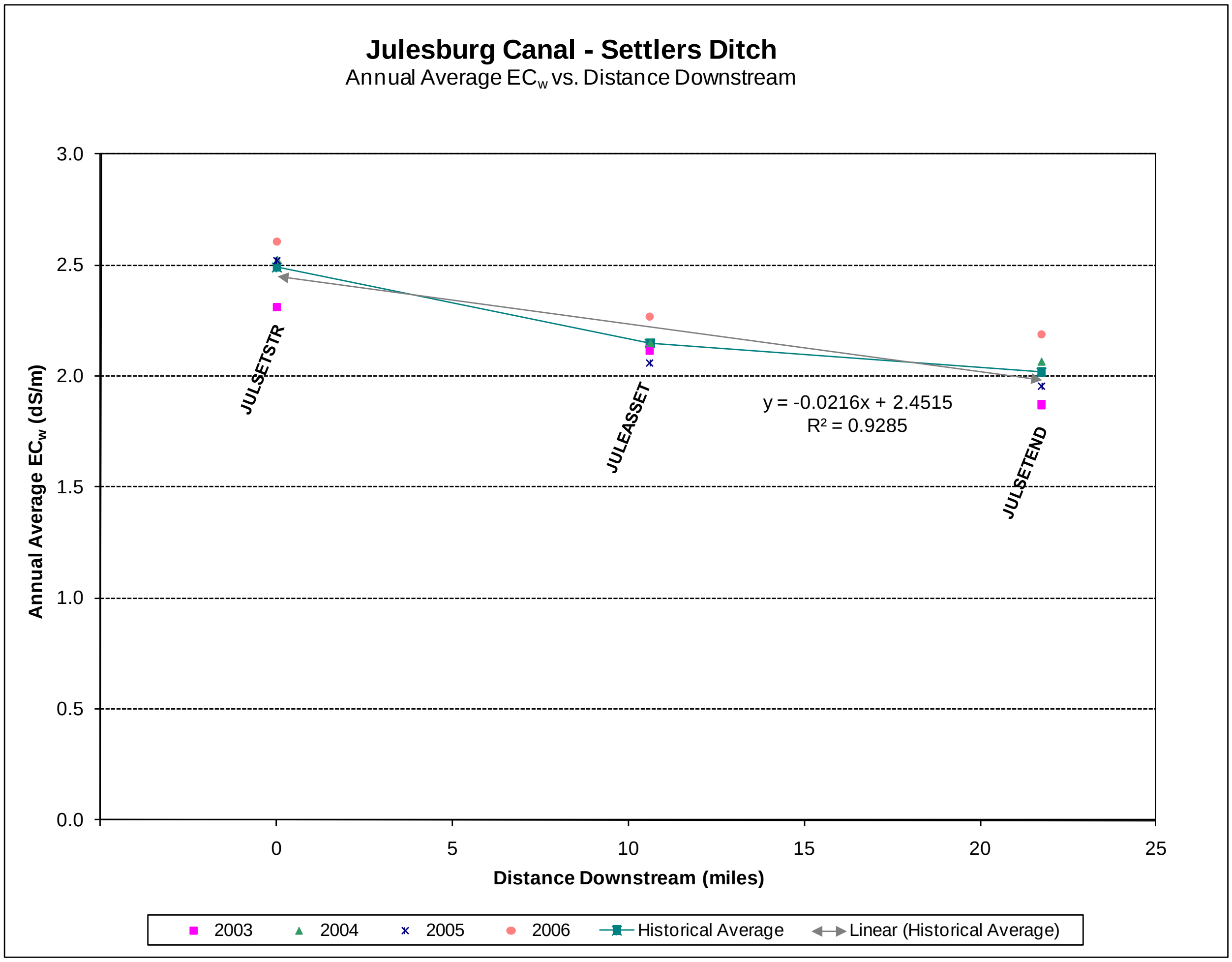
Figure 66. Empire and Bijou Canal Distance Downstream Graph



Julesburg Canal

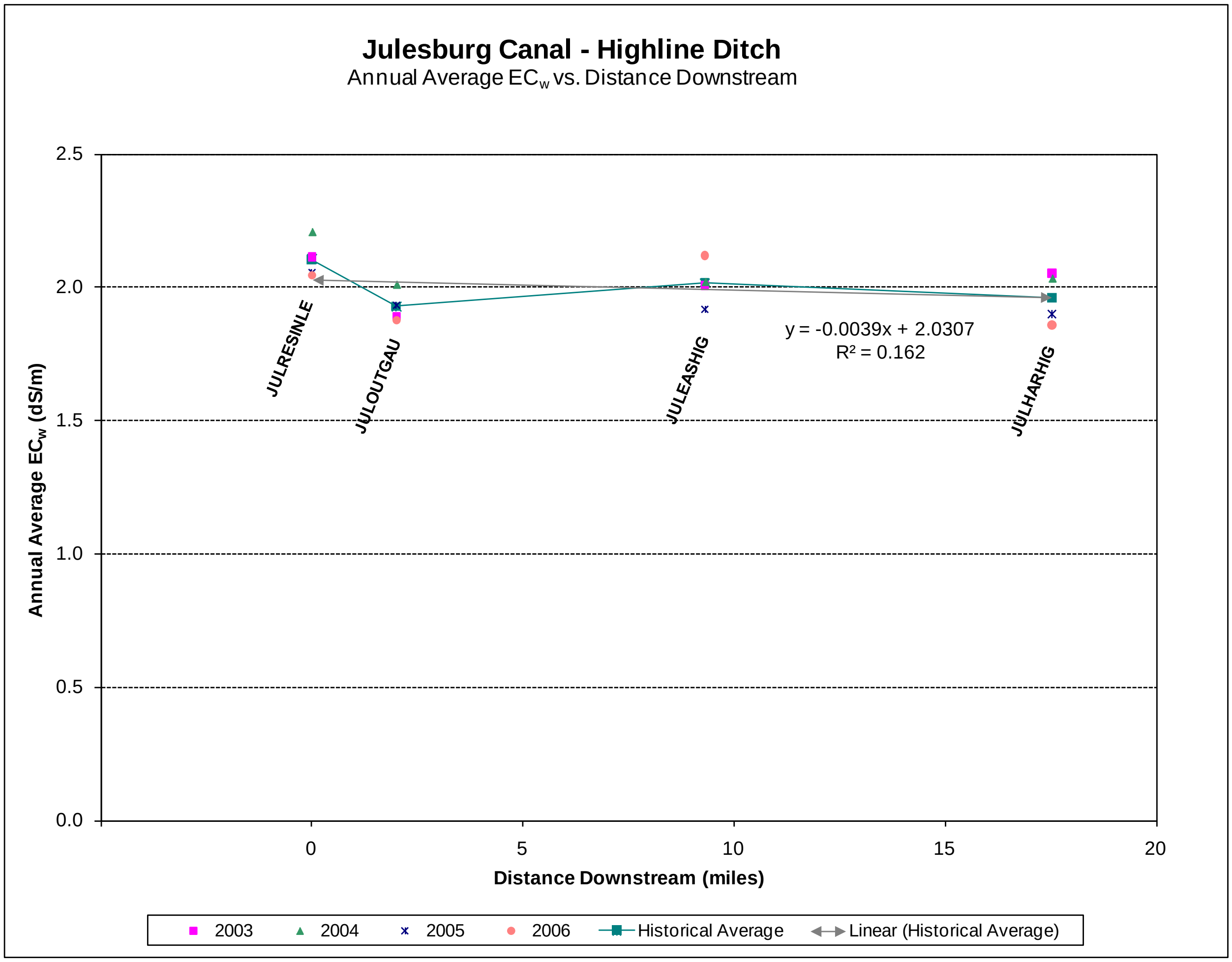
The Julesburg Canal is divided into three distinct sections: Settlers Ditch, Highline Ditch, and Peterson Ditch. Similar to the other irrigation canal results, the electrical conductivity data indicate decreasing values as the water travels downstream for each of the three ditches. For the Settlers Ditch, the individual station data also appears to decrease downstream in each year of the sample, while the EC_w values at each station increases each year.

Figure 67. Julesburg Canal - Settlers Ditch Distance Downstream Graph



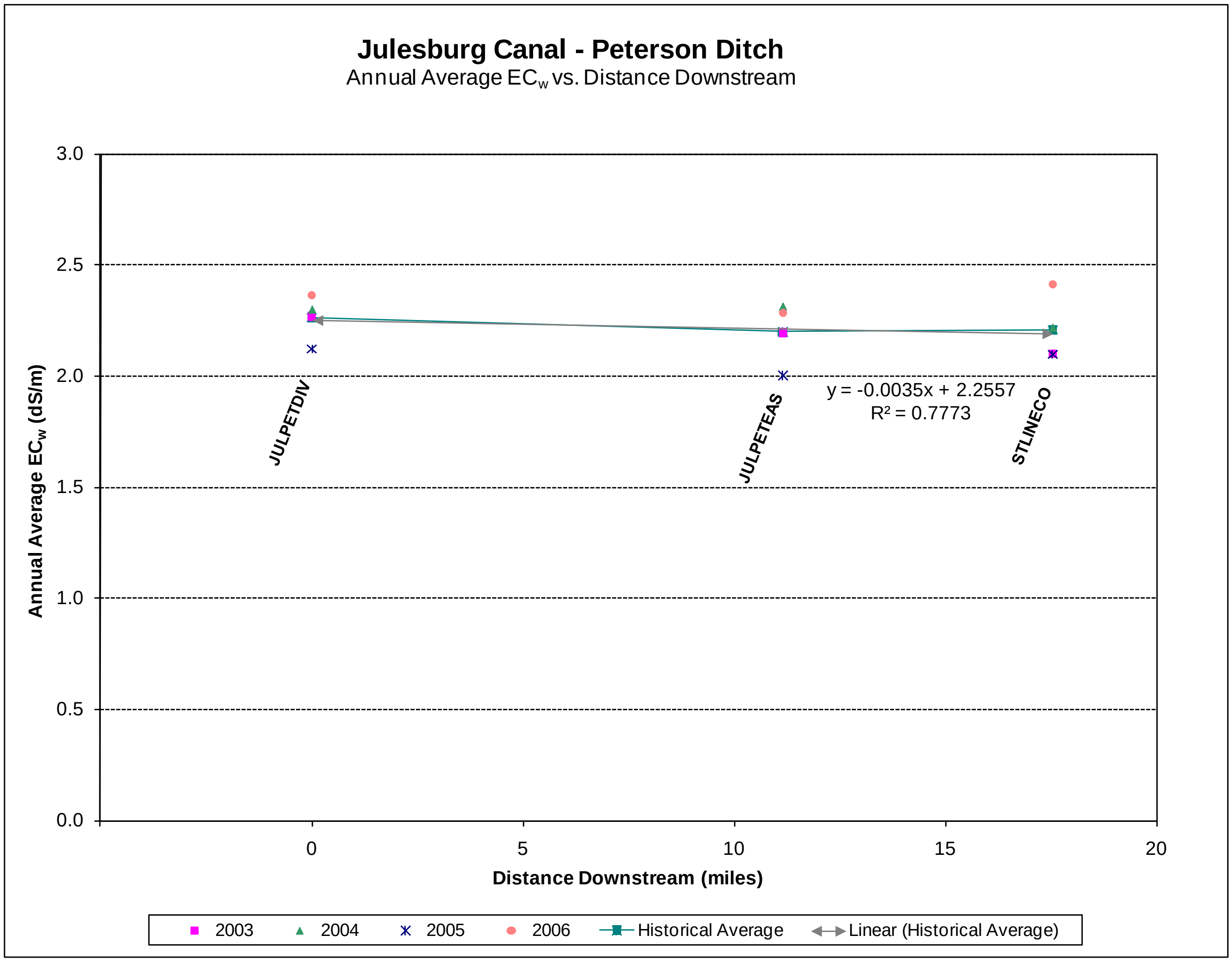
The Highline Ditch results vary from year-to-year, as well as with distance. The linear trendline is decreasing downstream.

Figure 68. Julesburg Canal - Highline Ditch Distance Downstream Graph



The Peterson Ditch stations analysis shows a high R-squared value for the trendline developed with the Annual Average EC_w values.

Figure 69. Julesburg Canal - Peterson Ditch Distance Downstream Graph



Reservoir Observations

On five of the canal systems, electrical conductivity was measured upstream and downstream of a reservoir. From the literature reviewed and the intuitive expectation, the EC_w should be higher on the reservoir discharge due to evaporation. The following graphs in Figures 70 through 74 show the Monthly Average EC_w plotted against time over the course of the study. Samples were not typically taken on the same day, or even the same week or month, for the inlet and outlet, primarily due to reservoir operation. The results do not consistently show higher EC_w at the outlet.

There are a number of variables that can affect the EC_w value in the reservoir. Unknown spatial patterns in the reservoirs may account for changes in EC_w: water enters at the top elevation and exits at the bottom elevation for instance. Ungauged water inflow may be affecting the EC_w in the reservoir. Cleaner water may enter and result in lower EC_w values or dirtier water may enter the reservoir and result in higher EC_w values at the outlet. Rain water, runoff water, and subsurface flows are all possible sources of ungauged water inflow into the reservoirs. Evaporation can affect the EC_w by concentrating the salts and increasing values at the outlet.

Further study on the reservoirs may result in some explanation for the values and patterns seen during this initial salinity study. Conducting a water balance (inflow water – evaporation = outflow water) for each reservoir may help to better understand if additional water is entering the reservoir. Operations and timing could be studied as well to better understand what may be affecting the electrical conductivity values while the water resides in the reservoir.

Figure 70. Prewitt Reservoir - Inlet and Outlet EC_w Comparison

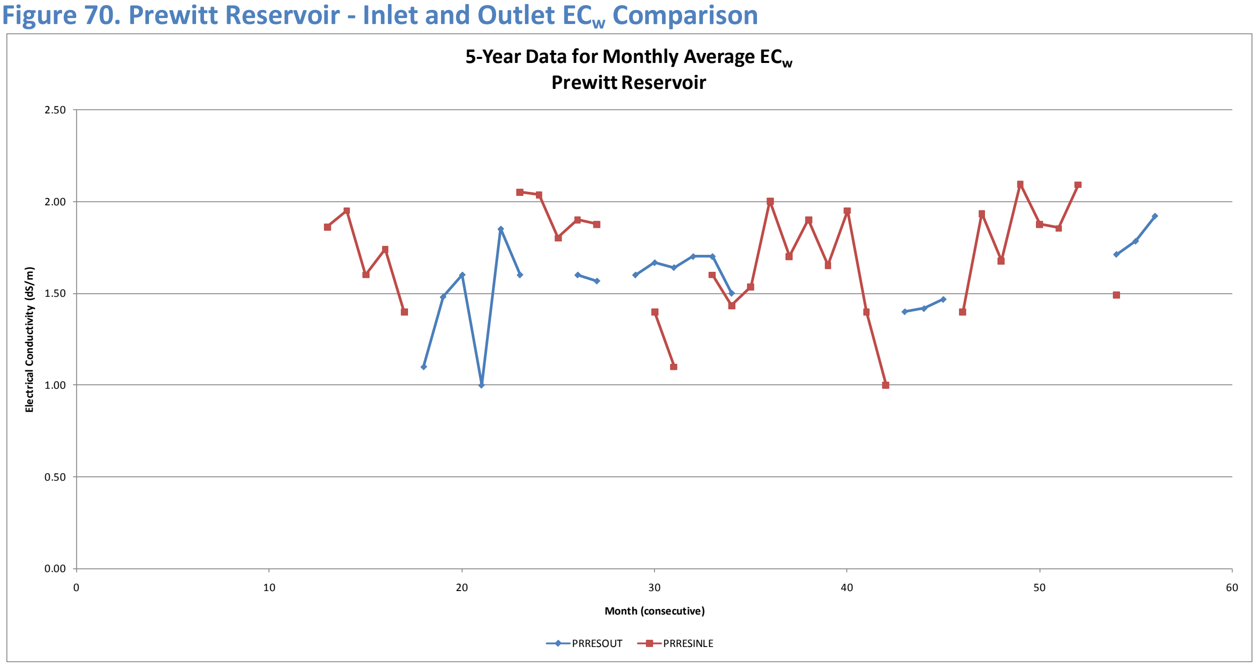


Figure 71. North Sterling Reservoir - Inlet and Outlet EC_w Comparison

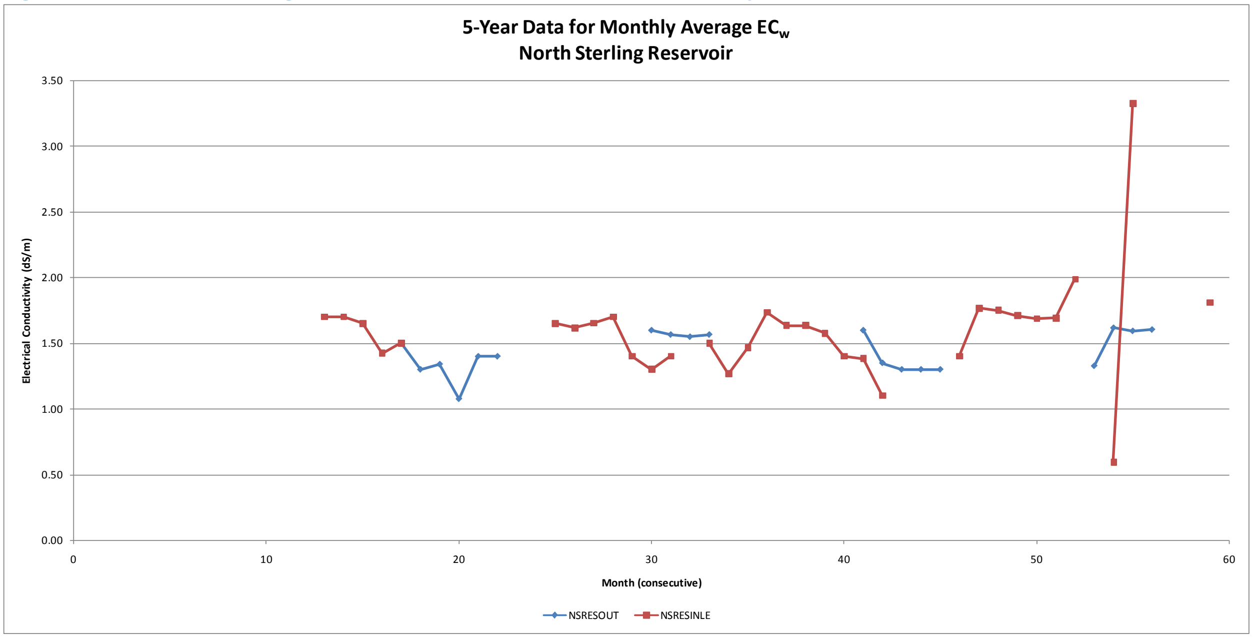


Figure 72. Jackson Reservoir - Inlet and Outlet EC_w Comparison

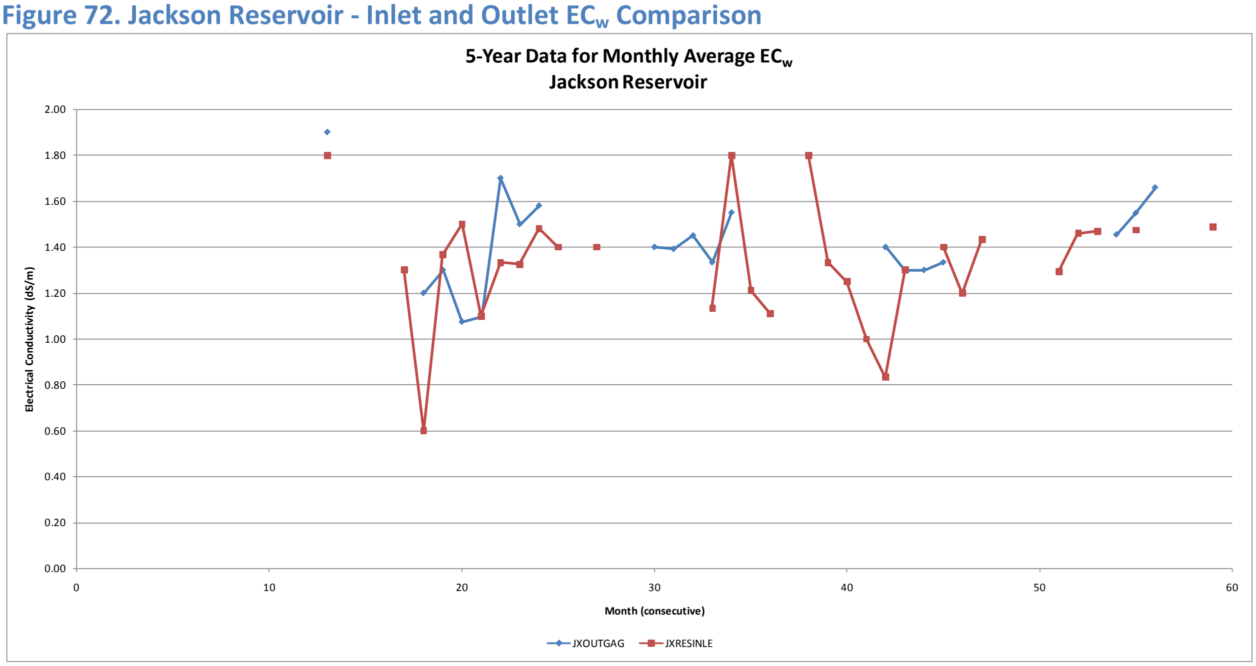


Figure 73. Empire Reservoir - Inlet and Outlet EC_w Comparison

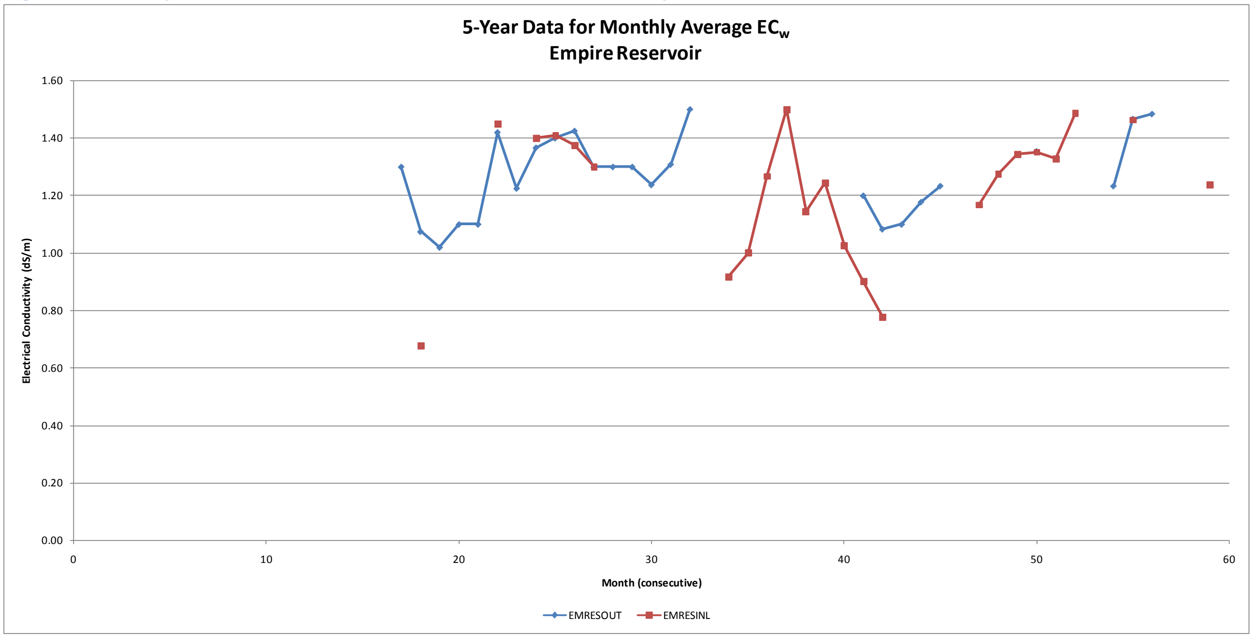
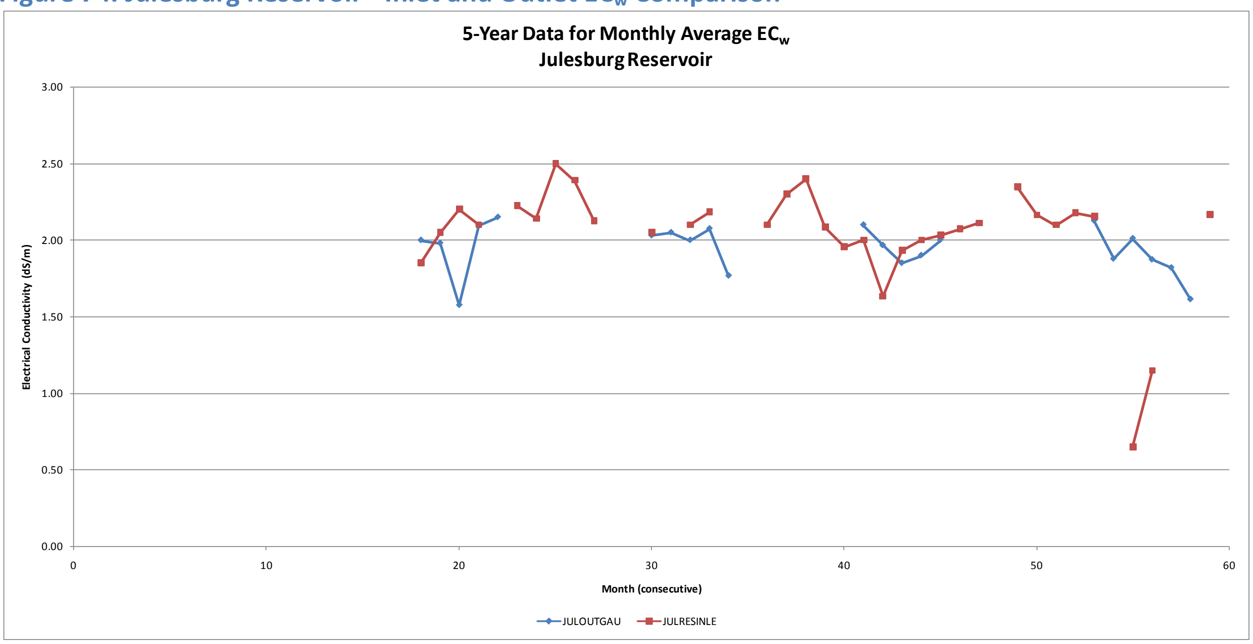


Figure 74. Julesburg Reservoir - Inlet and Outlet EC_w Comparison



Conclusions

Table 15 shows a summary of the Ditch System linear trendline equations and R-squared values for the Distance Downstream graphs that were included in the above section.

Table 15. Ditch System Distance Downstream Calculations Summary

Ditch System	Linear Trendline Equation	R-squared Value	Slope dS/(m-mi)
New Cache	y = -0.0097x + 0.83	$R^2 = 0.3235$	-0.0097
Larimer-Weld	y = -0.007x + 0.5332	$R^2 = 0.2015$	-0.007
Riverside	y = -0.0003x + 1.2127	$R^2 = 0.652$	-0.0003
Prewitt and North Sterling	y = -0.0017x + 1.5124	$R^2 = 0.3784$	-0.0017
Jackson and Morgan	y = -0.0036x + 1.3214	$R^2 = 0.7554$	-0.0036
Empire and Bijou	y = -0.0012x + 1.2622	$R^2 = 0.4157$	-0.0012
Julesburg - Settlers Ditch	y = -0.0216x + 2.4515	$R^2 = 0.9285$	-0.0216
Julesburg - Highline Ditch	y = -0.0039x + 2.0307	$R^2 = 0.162$	-0.0039
Julesburg - Peterson Ditch	y = -0.0035x + 2.2557	$R^2 = 0.7773$	-0.0035

The interesting, and unexpected, observation across the canal systems is that the slopes of the distance downstream trendlines are all negative, indicating decreasing EC_w values as the water moves downstream. This is the exact opposite result of the stream systems where all the slopes were positive, indicating increasing EC_w values as the water moves downstream. A logical, initial hypothesis would be that, in fact, EC_w should increase as the water moves downstream based on considerations such as runoff and fertilizer contributions; however, that was not the result found on these eight canal systems.

Why does the EC_w value appear to decrease in the canal systems? That is a question that this study cannot definitively answer. There are many unknown factors that may be affecting the individual station EC_w values. Further discussion on this topic is included in the Conclusions section of this report.

Although the EC_w value appears to decrease downstream in the canal systems, the variation and percentage of change may have various levels of importance. For instance, on the Larimer-Weld Canal system, the variation between the Maximum Historical Average EC_w value and the Minimum Historical Average EC_w value (maximum and minimum across all sampling locations) is large compared to the Average Historical Average. However, Riverside Canal has a very small variation with a correspondingly small percentage change overall. Table 16 below summarizes the EC_w variation and percentage change downstream for each ditch system.

As the EC_w values are computed from a Daily Average to a Monthly and then Annual Average, the importance of the variation may become skewed. It is important to look at the individual station data from year-to-year, as well as the Historical Average data that are plotted and used in the trendline analysis.

Table 16. Ditch Downstream Variation and Percent Change

Ditch System	EC_w Variation (dS/m)	Percent Change Downstream (%)
New Cache	0.38	66.29
Larimer-Weld	0.73	166.86
Riverside	0.02	1.73
Prewitt and North Sterling	0.37	24.00
Jackson and Morgan	0.18	13.79
Empire and Bijou	0.09	6.97
Julesburg - Settlers Ditch	0.47	21.20
Julesburg - Highline Ditch	0.18	8.85
Julesburg - Peterson Ditch	0.06	2.89

EC_w Variation = Maximum Historical Ave EC_w - Minimum Historical Ave EC_w

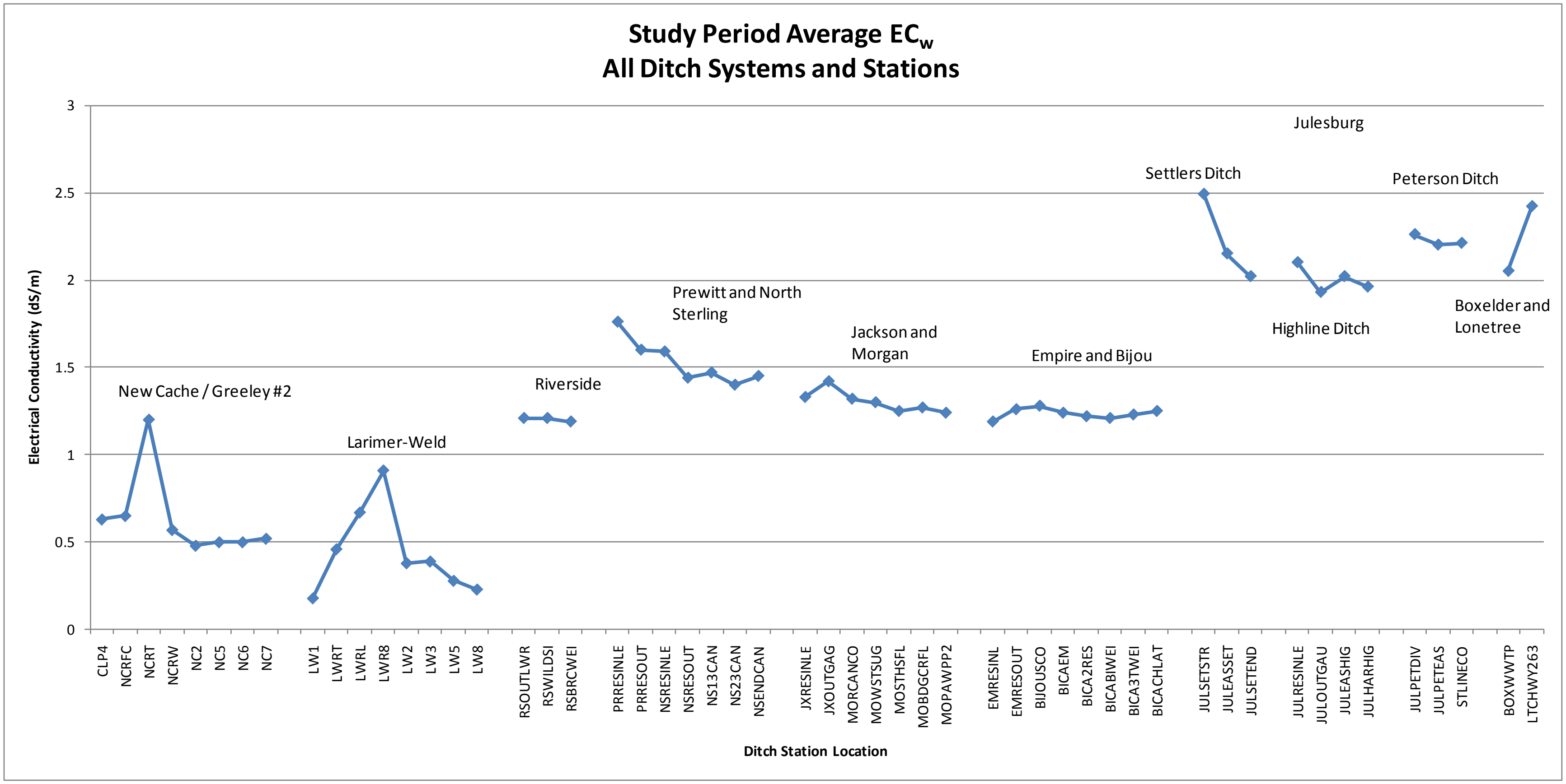
Percent Change Downstream = EC_w Variation / Average of Historical Averages

Figure 75 below shows the Historical Average (as computed as the average of the annual means over the study period) EC_w value for each station on each canal system, and summarizes the annual average results in a comparative graph. The stations are not graphed based on the actual distance downstream, but are graphed in the correct physical order within the canals. All stations sampled had an Average EC_w value less than 2.5 dS/m. Furthermore, of the 53 stations sampled in canals:

- 43 stations had Average EC_w values less than 2.0 dS/m
- 38 stations had Average EC_w values less than 1.5 dS/m
- 15 stations had Average EC_w values less than 1.0 dS/m
- 7 stations had Average EC_w values less than 0.5 dS/m

New Cache / Greeley #2 and Larimer-Weld canals had the lowest Average EC_w value results, while Julesburg Canal and Boxelder and Lonetree Creeks had the highest Average EC_w values calculated from the sample results.

Figure 75. Comparison of Study Period Average ECw Between Stations and Ditch Systems



GROUNDWATER RESULTS

Electrical conductivity of groundwater was sampled throughout this study period along with the water depth at each well. These samples included some automated data and some manual grab samples. The depth data is presented in the Annual Reports and is not repeated here.

Table 17 shows all the groundwater wells sampled and the years in which data exists for those wells.

Table 17. Groundwater Well List and Years of Data Collection

Well Site Abbreviation	2001	2002	2003	2004	2005	2006
319M02	x	x	x	x	x	x
319M03	x	x	x	x	x	x
319M04	x	x	x	x	x	x
319M05	x	x	x	x	x	x
319M06	x	x	x	x	x	x
319M07	x	x	x	x	x	x
319M08	x	x	x	x	x	x
319M09	x	x	x	x	x	x
319M10				x	x	x
319M11	x	x	x	x	x	x
319M12	x	x	x	x	x	x
319M13	x	x	x	x	x	x
319M14	x	x	x	x	x	x
319M15	x	x	x	x	x	x
319M16	x	x	x	x	x	x
A30W		x	x	x	x	x
B26W		x	x	x	x	x
B28W		x	x	x	x	x
C1A		x	x	x	x	x
C25W			x	x	x	x
D22W				x	x	x
D24W		x	x	x	x	x
F22W			x	x	x	x
G3W				1 point	x	x
G5W		x	x	x	x	x
G7W				1 point	x	x
H4W		x	x	x	x	x
H5W					x	x
H6W		x	x	x	x	x
H7W			x	x	x	x
H8W				1 point	x	x
H9W			x	x	x	x
I4W					x	
I5W		x	x	x	x	x
I6W			x	x	x	x
I8W				1 point	x	x
J14W		x	x	x	x	x
J15W		x	x	x	x	x
J17W		x	x	x	x	x
K4W		x	x	x	x	x
L4W		x	x	x	x	x
M3W		x	x	x	x	x
USGSJULS				x	x	x

Electrical Conductivity Analysis

The EC_w results over the study period have been summarized and analyzed similarly to the river and ditch systems. Table 18 shows the Annual Average EC_w, Annual Standard Deviation, Maximum Average EC_w and Minimum Average EC_w values for each groundwater well and each year of collected data.

Table 18. Groundwater Well Results Summary Table

Well Site Abbreviation	Year	Annual Average EC_w (dS/m)	Annual Standard Deviation (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
319M02	2001	2.18	0.13	2.30	2.00
	2002	2.10	0.18	2.40	1.60
	2003	2.28	0.22	3.30	2.10
	2004	2.32	0.23	2.60	1.80
	2005	2.45	0.36	3.80	1.95
	2006	2.28	0.12	2.45	2.09
	Historic Ave	2.27			
319M03	2001	1.62	0.04	1.70	1.60
	2002	1.86	0.21	2.10	1.00
	2003	1.81	0.13	2.00	1.50
	2004	2.05	0.13	2.20	1.80
	2005	1.89	0.24	2.13	1.40
	2006	1.87	0.09	2.04	1.72
	Historic Ave	1.85			
319M04	2001	1.66	0.13	1.80	1.50
	2002	1.73	0.28	2.20	1.30
	2003	2.32	0.38	2.60	0.50
	2004	2.51	0.43	3.00	1.50
	2005	2.44	0.30	2.80	1.70
	2006	2.57	0.25	2.84	2.05
	Historic Ave	2.20			
319M05	2001	1.52	0.10	1.70	1.40
	2002	1.52	0.17	2.10	1.20
	2003	1.75	0.60	4.80	0.90
	2004	1.77	0.09	1.90	1.60
	2005	1.75	0.27	2.80	1.60
	2006	1.59	0.06	1.74	1.44
	Historic Ave	1.65			
319M06	2001	1.97	0.13	2.10	1.80
	2002	1.89	0.17	2.20	1.40
	2003	1.92	0.18	2.10	1.30
	2004	2.05	0.10	2.20	1.80
	2005	1.90	0.15	2.20	1.70
	2006	1.95	0.19	2.23	1.71
	Historic Ave	1.95			

Table 18 (continued). Groundwater Well Results Summary Table

Well Site Abbreviation	Year	Annual Average EC_w (dS/m)	Annual Standard Deviation (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
319M07	2001	1.90	0.09	2.00	1.80
	2002	2.16	0.17	2.40	1.60
	2003	1.96	0.15	2.20	1.60
	2004	1.63	0.15	1.90	1.50
	2005	1.63	0.12	1.90	1.40
	2006	1.88	0.06	1.95	1.74
	Historic Ave	1.86			
319M08	2001	2.31	0.04	2.40	2.30
	2002	2.35	0.16	2.70	1.90
	2003	2.24	0.13	2.50	2.00
	2004	1.98	0.16	2.40	1.60
	2005	1.82	0.06	2.00	1.70
	2006	1.97	0.13	2.07	1.50
	Historic Ave	2.11			
319M09	2001	1.50	0.00	1.50	1.50
	2002	1.58	0.18	2.30	1.40
	2003	1.59	0.15	2.20	1.30
	2004	1.62	0.13	1.90	1.50
	2005	1.63	0.14	2.05	1.50
	2006	1.64	0.03	1.69	1.57
	Historic Ave	1.59			
319M10	2004	3.01	0.55	3.30	1.80
	2005	2.81	0.28	3.10	2.15
	2006	2.89	0.05	2.94	2.76
	Historic Ave	2.90			
319M11	2001	3.10	0.00	3.10	3.10
	2002	2.63	0.98	3.80	0.90
	2003	3.11	0.76	4.30	1.40
	2004	2.23	0.32	2.80	1.60
	2005	3.52	0.85	4.70	1.90
	2006	3.64	0.97	5.08	0.03
	Historic Ave	3.04			
319M12	2001	0.83	0.10	0.90	0.70
	2002	0.90	0.11	1.00	0.60
	2003	1.01	0.57	4.00	0.80
	2004	1.04	0.38	1.90	0.70
	2005	1.21	0.83	3.10	0.70
	2006	0.93	0.10	1.14	0.75
	Historic Ave	0.99			

Table 18 (continued). Groundwater Well Results Summary Table

Well Site Abbreviation	Year	Annual Average EC_w (dS/m)	Annual Standard Deviation (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
319M13	2001	1.76	0.15	1.90	1.50
	2002	2.14	0.22	2.30	1.40
	2003	2.38	0.38	2.80	0.80
	2004	2.28	0.36	2.90	1.70
	2005	3.07	0.55	4.00	2.38
	2006	3.81	0.21	4.05	3.66
	Historic Ave	2.57			
319M14	2001	3.18	0.29	3.40	2.60
	2002	3.40	0.30	4.10	2.30
	2003	3.17	0.59	4.20	2.20
	2004	2.77	0.66	3.70	1.70
	2005	3.52	0.26	4.20	3.10
	2006	3.58	0.40	3.98	2.33
	Historic Ave	3.27			
319M15	2001	1.98	0.05	2.00	1.90
	2002	2.15	1.04	7.00	0.60
	2003	2.07	0.10	2.30	1.90
	2004	2.12	0.15	2.30	1.70
	2005	2.48	0.58	4.40	2.20
	2006	2.37	0.06	2.46	2.25
	Historic Ave	2.19			
319M16	2001	2.26	0.09	2.40	2.20
	2002	2.79	1.00	7.80	2.20
	2003	2.56	0.18	2.90	1.70
	2004	2.35	0.27	2.60	1.60
	2005	2.32	0.23	2.50	1.50
	2006	2.46	0.08	2.62	2.24
	Historic Ave	2.46			
A30W	2002	1.53	0.08	1.60	1.40
	2003	1.53	0.10	1.70	1.40
	2004	1.54	0.11	1.80	1.40
	2005	1.57	0.33	2.40	1.30
	2006	1.54	0.06	1.67	1.46
	Historic Ave	1.54			
B26W	2002	2.25	0.11	2.30	2.00
	2003	2.25	0.07	2.50	2.20
	2004	2.08	0.33	2.40	1.00
	2005	2.39	0.39	3.15	1.20
	2006	2.49	0.05	2.60	2.39
	Historic Ave	2.29			

Table 18 (continued). Groundwater Well Results Summary Table

Well Site Abbreviation	Year	Annual Average EC_w (dS/m)	Annual Standard Deviation (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
B28W	2002	1.84	0.44	2.20	0.70
	2003	1.96	0.14	2.20	1.60
	2004	1.94	0.10	2.10	1.70
	2005	2.03	0.17	2.60	1.65
	2006	2.04	0.02	2.07	2.02
	Historic Ave	1.96			
C1A	2002	0.52	0.04	0.60	0.50
	2003	0.52	0.04	0.60	0.50
	2004	0.75	0.50	2.00	0.50
	2005	1.17	2.11	11.35	0.50
	2006	0.61	0.04	0.75	0.57
	Historic Ave	0.71			
C25W	2003	2.22	0.09	2.50	2.10
	2004	2.02	0.33	2.20	0.80
	2005	2.64	0.34	3.30	2.30
	2006	2.49	0.06	2.58	2.39
	Historic Ave	2.34			
D22W	2004	2.40	0.25	2.60	1.80
	2005	2.34	0.20	2.70	1.65
	2006	2.33	0.03	2.36	2.21
	Historic Ave	2.35			
D24W	2002	1.65	0.18	1.80	1.10
	2003	1.71	0.04	1.90	1.70
	2004	1.70	0.15	1.90	1.10
	2005	1.74	0.25	2.20	1.00
	2006	1.78	0.01	1.80	1.76
	Historic Ave	1.71			
F22W	2003	2.24	0.09	2.50	2.20
	2004	2.08	0.14	2.40	1.80
	2005	2.06	0.39	3.80	1.85
	2006	2.00	0.08	2.25	1.89
	Historic Ave	2.09			
G3W	2004	3.38	NA	3.38	3.38
	2005	3.14	0.95	3.80	0.50
	2006	3.63	0.32	4.74	3.22
	Historic Ave	3.38			
G5W	2002	2.98	1.14	7.80	0.90
	2003	3.19	0.77	5.40	2.30
	2004	2.65	0.33	3.00	1.80
	2005	2.79	0.28	3.60	2.60
	2006	2.67	0.41	3.88	1.42
	Historic Ave	2.86			

Table 18 (continued). Groundwater Well Results Summary Table

Well Site Abbreviation	Year	Annual Average EC_w (dS/m)	Annual Standard Deviation (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
G7W	2004	0.52	NA	0.52	0.52
	2005	0.87	0.77	2.60	0.40
	2006	0.49	0.12	0.65	0.00
	Historic Ave	0.63			
H4W	2002	1.82	0.23	2.60	1.50
	2003	1.53	0.38	2.30	0.20
	2004	1.52	0.18	2.00	1.40
	2005	1.41	0.36	2.63	0.50
	2006	1.39	0.06	1.49	1.30
	Historic Ave	1.53			
H5W	2005	3.00	0.50	3.88	2.08
	2006	3.32	0.57	4.32	1.96
	Historic Ave	3.16			
H6W	2002	1.87	0.26	2.50	1.40
	2003	2.97	1.33	6.40	1.60
	2004	1.98	0.56	2.90	0.30
	2005	1.63	0.43	2.50	0.50
	2006	1.75	0.45	3.42	1.46
	Historic Ave	2.04			
H7W	2003	1.76	1.08	4.20	1.10
	2004	1.50	0.20	1.90	1.30
	2005	1.38	0.23	2.20	0.95
	2006	1.71	0.74	3.62	1.33
	Historic Ave	1.59			
H8W	2004	3.00	NA	3.00	3.00
	2005	2.67	0.55	3.70	1.30
	2006	3.12	0.23	3.81	2.81
	Historic Ave	2.93			
H9W	2003	3.21	1.31	4.20	0.80
	2004	3.73	0.85	4.40	1.80
	2005	3.77	0.28	4.20	3.20
	2006	3.54	0.61	4.08	1.31
	Historic Ave	3.56			
I4W	2005	18.20	5.64	22.50	3.30
	Historic Ave	18.20			
I5W	2002	0.90	0.32	2.20	0.10
	2003	0.81	0.03	0.90	0.80
	2004	0.94	0.41	2.00	0.50
	2005	2.36	3.55	11.30	0.80
	2006	0.92	0.05	1.14	0.89
	Historic Ave	1.19			

Table 18 (continued). Groundwater Well Results Summary Table

Well Site Abbreviation	Year	Annual Average EC_w (dS/m)	Annual Standard Deviation (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
I6W	2003	1.39	0.04	1.40	1.30
	2004	1.41	0.36	1.94	1.20
	2005	1.78	0.39	2.20	0.80
	2006	1.99	0.18	2.63	1.73
	Historic Ave	1.64			
I8W	2004	1.52	NA	1.52	1.52
	2005	1.91	0.43	2.85	1.60
	2006	1.85	0.40	2.83	1.49
	Historic Ave	1.76			
J14W	2002	2.78	0.79	3.20	0.20
	2003	2.92	0.26	3.30	2.50
	2004	2.73	0.45	3.30	1.80
	2005	2.52	0.52	3.30	1.80
	2006	2.70	0.49	3.67	1.94
	Historic Ave	2.73			
J15W	2002	2.71	0.19	3.30	2.50
	2003	2.62	0.09	2.80	2.40
	2004	2.37	0.26	2.60	1.80
	2005	2.50	0.15	2.70	2.10
	2006	2.38	0.12	2.61	2.18
	Historic Ave	2.52			
J17W	2002	3.83	0.15	4.10	3.60
	2003	4.15	0.11	4.30	3.90
	2004	3.85	0.86	4.50	1.80
	2005	3.76	0.42	4.17	2.70
	2006	3.92	0.11	4.23	3.84
	Historic Ave	3.90			
K4W	2002	4.81	1.00	7.80	3.80
	2003	4.40	0.87	7.70	3.50
	2004	3.72	0.85	4.30	1.80
	2005	4.43	1.93	12.58	3.14
	2006	4.42	0.44	5.44	4.05
	Historic Ave	4.36			
L4W	2002	5.40	0.96	7.00	4.10
	2003	4.13	0.92	5.30	1.00
	2004	3.80	1.10	6.40	1.80
	2005	3.06	0.95	4.40	0.90
	2006	4.03	1.01	7.00	2.65
	Historic Ave	4.09			

Table 18 (continued). Groundwater Well Results Summary Table

Well Site Abbreviation	Year	Annual Average EC_w (dS/m)	Annual Standard Deviation (dS/m)	Maximum Daily Average EC_w (dS/m)	Minimum Daily Average EC_w (dS/m)
M3W	2002	4.45	1.36	6.20	1.20
	2003	2.48	1.39	4.90	0.90
	2004	1.49	0.47	2.20	0.90
	2005	3.09	2.57	14.00	1.63
	2006	2.30	0.79	3.80	1.47
	Historic Ave	2.76			
USGSJULS	2004	2.05	0.19	2.20	1.60
	2005	2.08	0.30	2.40	1.30
	2006	2.34	0.01	2.36	2.30
	Historic Ave	2.16			

Statistical Analysis

The groundwater well electrical conductivity data were analyzed in Minitab using the same method as the river systems and canal systems. Wells with data for at least four years were processed. Wells with data collected for less than four years were not analyzed. The data were ranked and deseasonalized for the statistical analysis. Although the groundwater EC_w results may not seem to be seasonal, because wells often run in conjunction with ditch water, the data were analyzed the same as surface water.

The majority of the wells did show a statistically-significant trend in the electrical conductivity values over the study period. Results are listed in Table 19 below and shown in Figures 76 through 102.

Table 19. Groundwater Well EC_w Regression Results

Site Description	Period of Record Start	Stop	Months	Days	Change over PoR	Rank Regression P-value	Significant Slope Y/N	Slope if Significant dS/m per day	Number of Months of Data
319M02	9-01	11-06	63	1917	0.277965	0.000	Y	0.000145	54
319M03	9-01	11-06	63	1917	0.205119	0.005	Y	0.000107	53
319M04	9-01	11-06	63	1917	0.856899	0.000	Y	0.000447	56
319M05	9-01	11-06	63	1917	0.147609	0.008	Y	0.000077	55
319M06	9-01	11-06	63	1917		0.733	N		56
319M07	9-01	10-06	62	1887	-0.369852	0.001	Y	-0.000196	48
319M08	9-01	11-06	63	1914	-0.566544	0.000	Y	-0.000296	53
319M09	11-01	11-06	61	1856	0.1392	0.001	Y	0.000075	52
319M11	9-01	11-06	63	1917	1.031346	0.015	Y	0.000538	51
319M12	9-01	11-06	63	1917	0.371898	0.042	Y	0.000194	56
319M13	9-01	4-06	56	1703	1.537809	0.000	Y	0.000903	39
319M14	9-01	10-06	62	1887		0.243	N		56
319M15	9-01	10-06	62	1887	0.518925	0.000	Y	0.000275	50
319M16	9-01	10-06	62	1887	-0.294372	0.105	Y/N	-0.000156	50
A30W	9-02	10-06	50	1522		0.682	N		42
B26W	10-02	10-06	49	1492	0.314812	0.005	Y	0.000211	41
B28W	9-02	10-06	50	1522	0.18264	0.008	Y	0.000120	39
C1A*	5-02	11-06	55	1675	0.256275	0.000	Y	0.000153	51
C25W	6-03	10-06	41	1249	0.673211	0.000	Y	0.000539	36
D24W	9-02	10-06	50	1522	0.19025	0.000	Y	0.000125	45
F22W	7-03	11-06	41	1249	-0.057454	0.068	Y	-0.000046	35
G5W	6-02	11-06	54	1644	-0.374832	0.003	Y	-0.000228	51
H4W	6-02	11-06	54	1644	-0.458676	0.000	Y	-0.000279	50
H6W	6-02	10-06	53	1614	-1.018434	0.001	Y	-0.000631	48
H7W	7-03	10-06	40	1219		0.989	N		32
H9W	7-03	11-06	41	1249		0.183	N		37
I5W	6-02	11-06	54	1644	1.502616	0.004	Y	0.000914	50
I6W	7-03	11-06	41	1249	0.651978	0.000	Y	0.000522	27
J14W	8-02	11-06	52	1583	-0.574629	0.001	Y	-0.000363	43
J15W	5-02	11-06	55	1675	-0.3953	0.000	Y	-0.000236	49
J17W	8-02	11-06	52	1583	-0.356175	0.007	Y	-0.000225	43
K4W	6-02	10-06	53	1614		0.188	N		46
L4W	7-02	11-06	53	1614	-0.858648	0.029	Y	-0.000532	49
M3W	7-02	11-06	53	1614		0.252	N		49

*** For Well C1A - the outlier value of 11.35 dS/m for December 2005 was omitted from the data set prior to running the statistical analysis.**

Figure 76. 319M02 Regression Line Graph

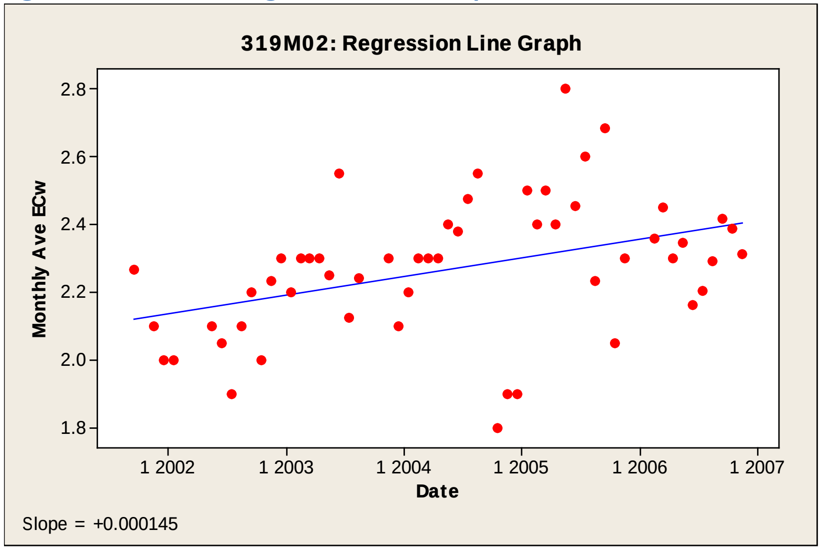


Figure 77. 319M03 Regression Line Graph

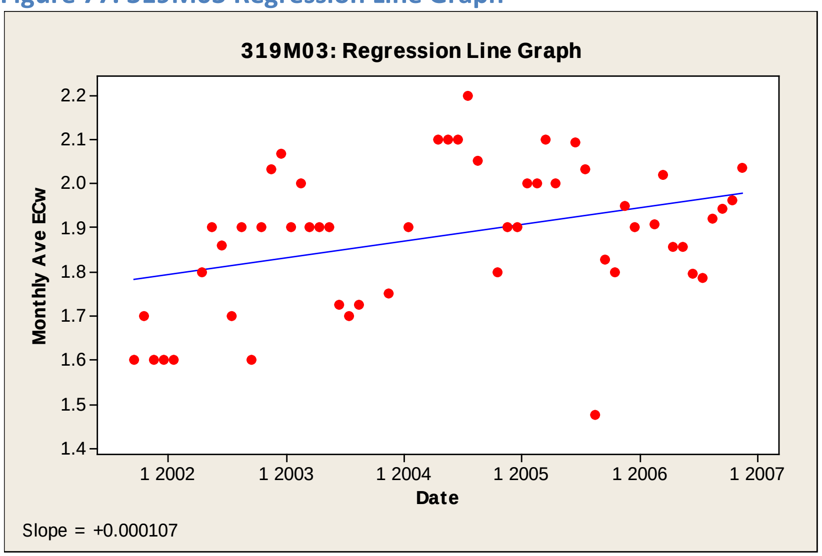


Figure 78. 319M04 Regression Line Graph

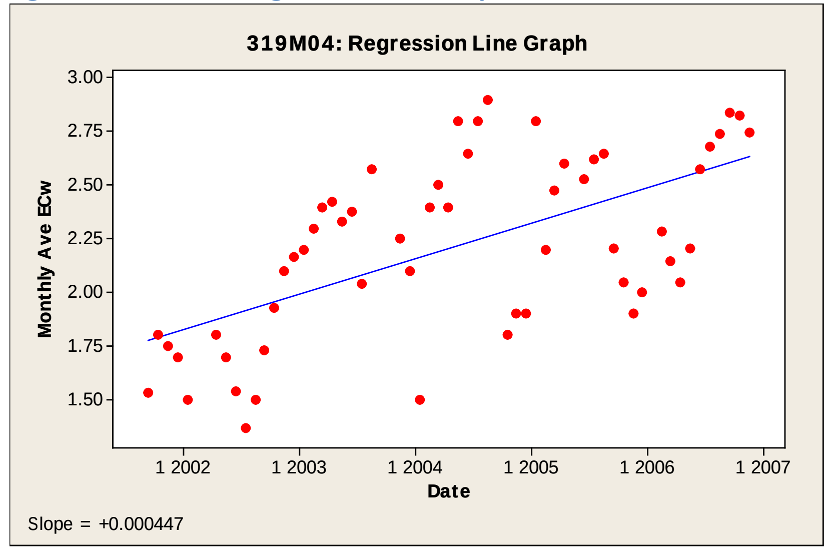


Figure 79. 319M05 Regression Line Graph

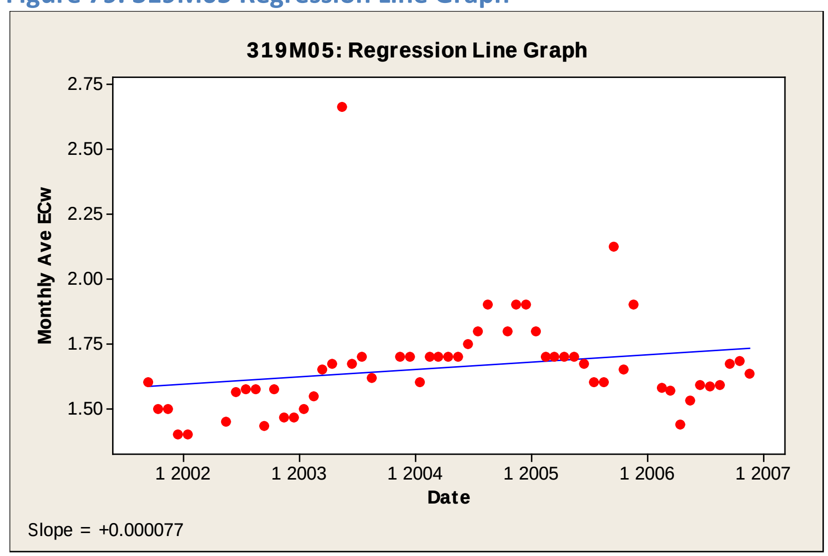


Figure 80. 319M07 Regression Line Graph

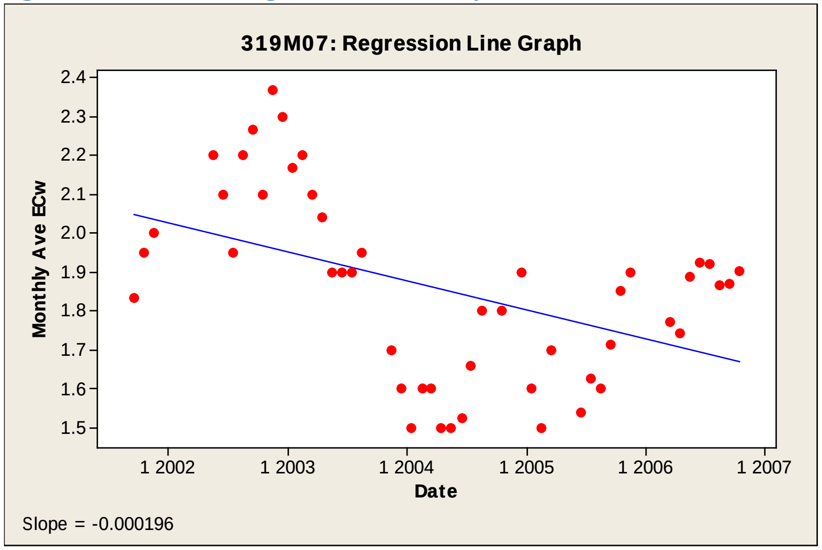


Figure 81. 319M08 Regression Line Graph

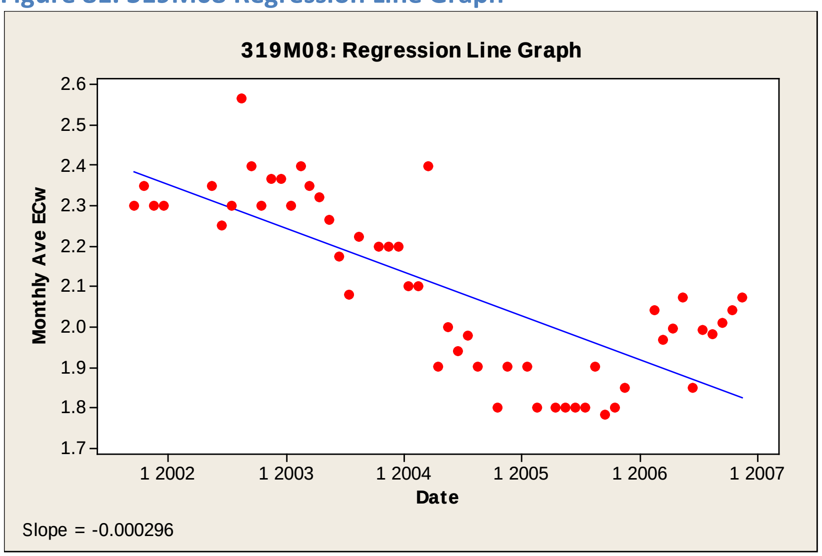


Figure 82. 319M09 Regression Line Graph

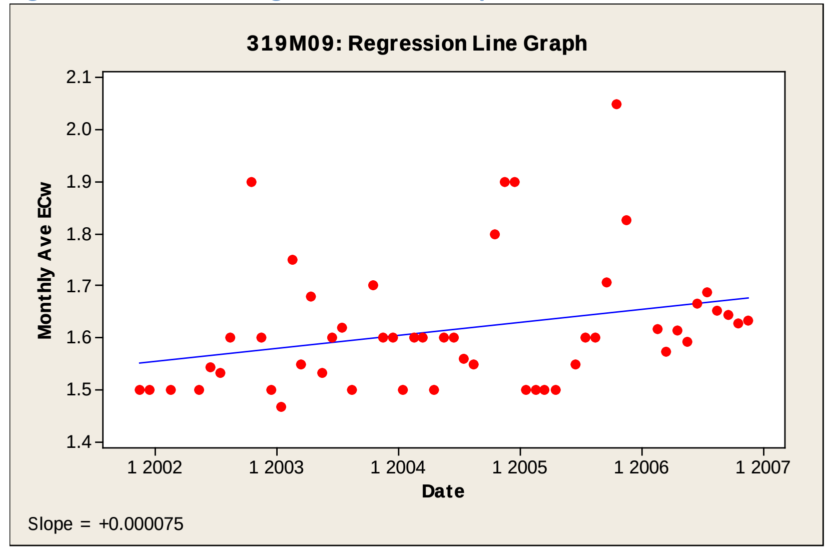


Figure 83. 319M11 Regression Line Graph

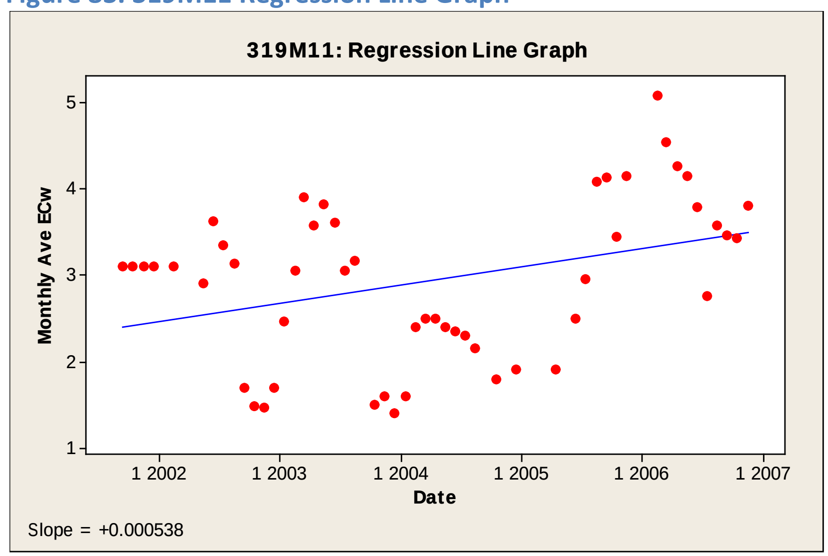


Figure 84. 319M12 Regression Line Graph

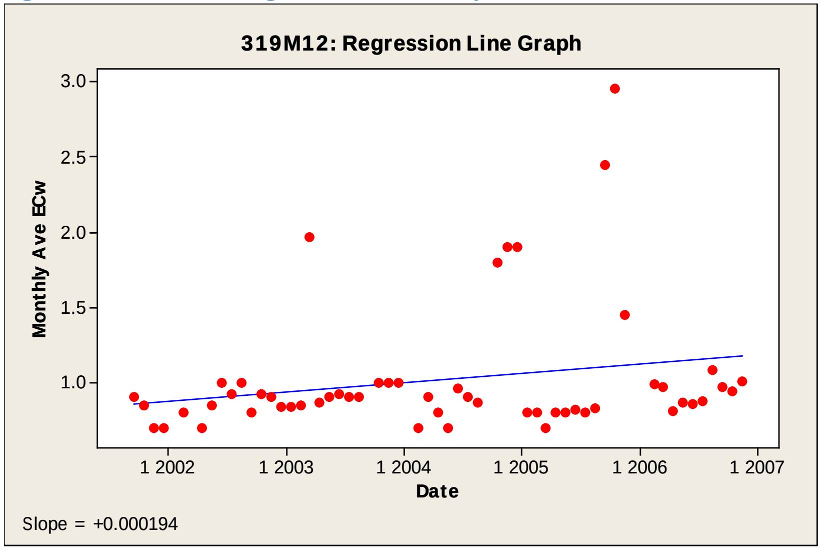


Figure 85. 319M13 Regression Line Graph

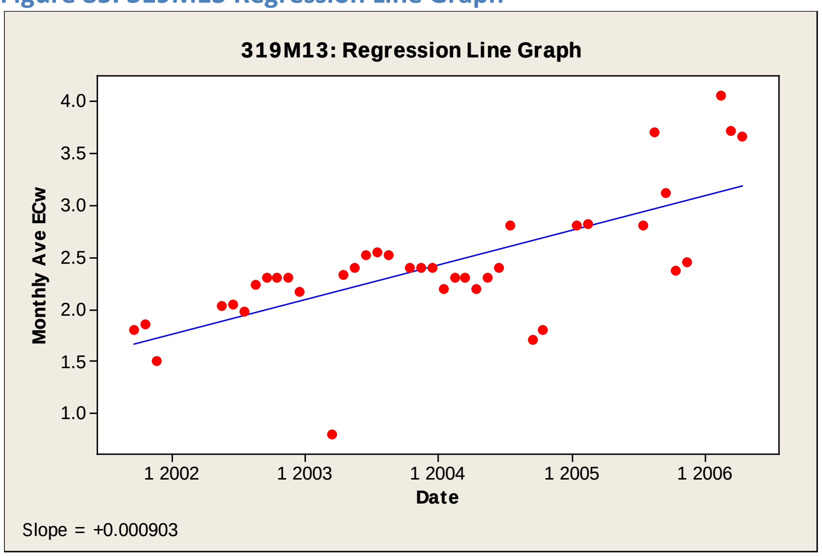


Figure 86. 319M15 Regression Line Graph

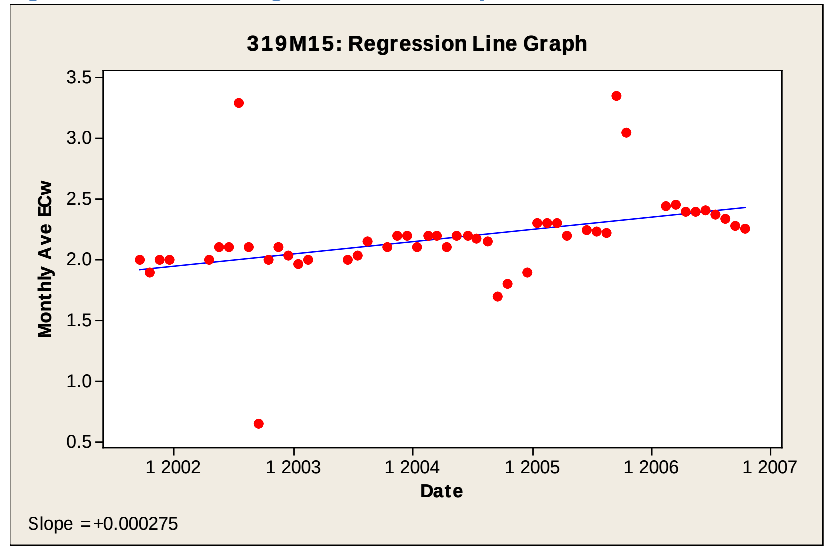


Figure 87. 319M16 Regression Line Graph

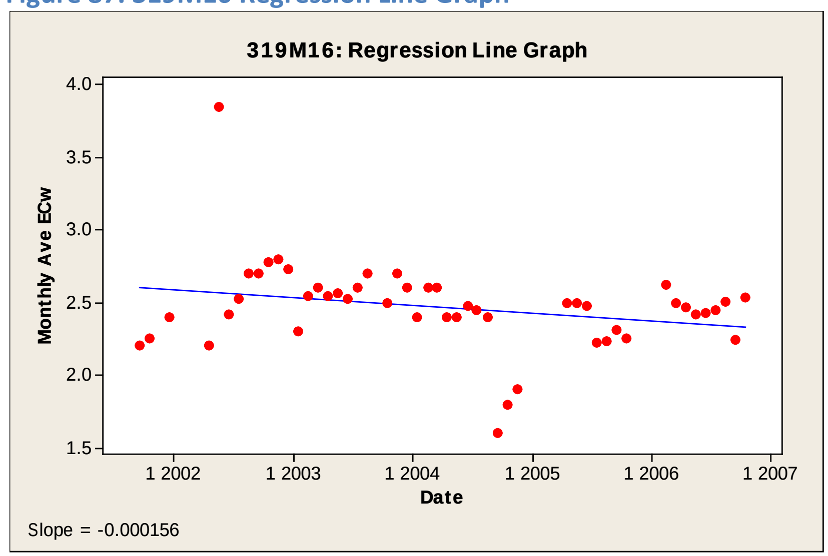


Figure 88. B26W Regression Line Graph

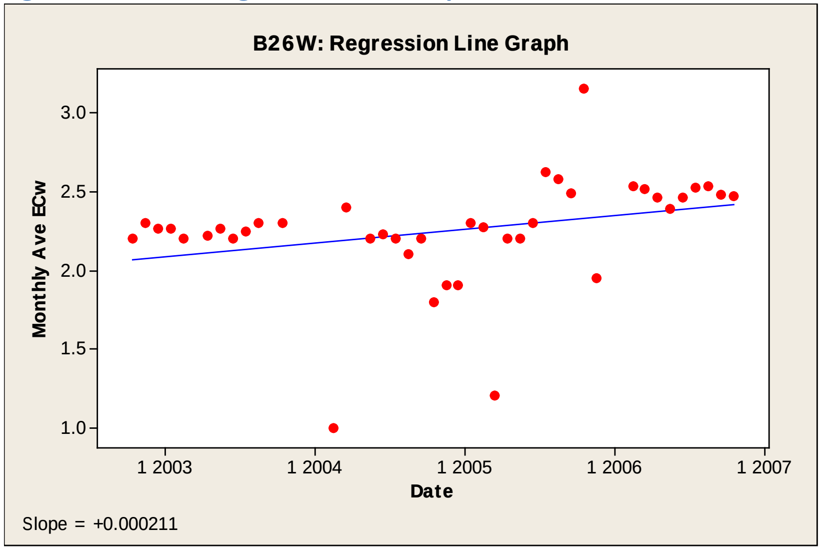


Figure 89. B28W Regression Line Graph

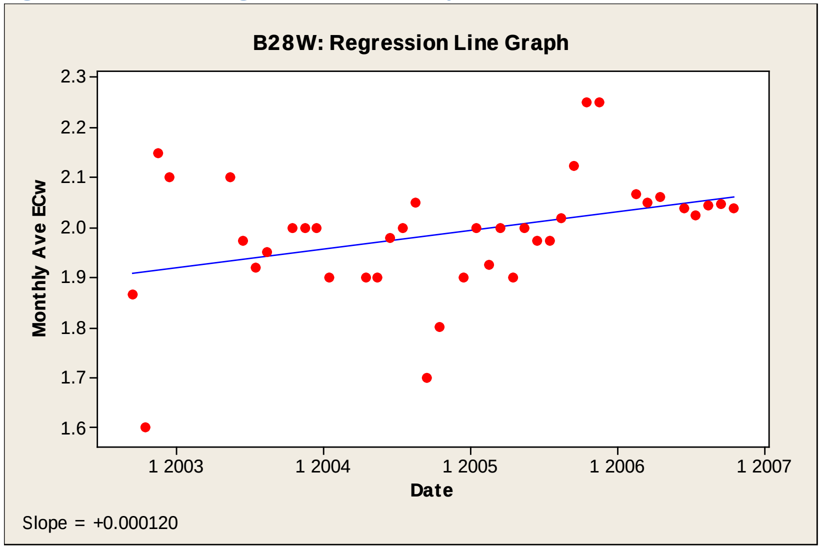


Figure 90. C1A Regression Line Graph

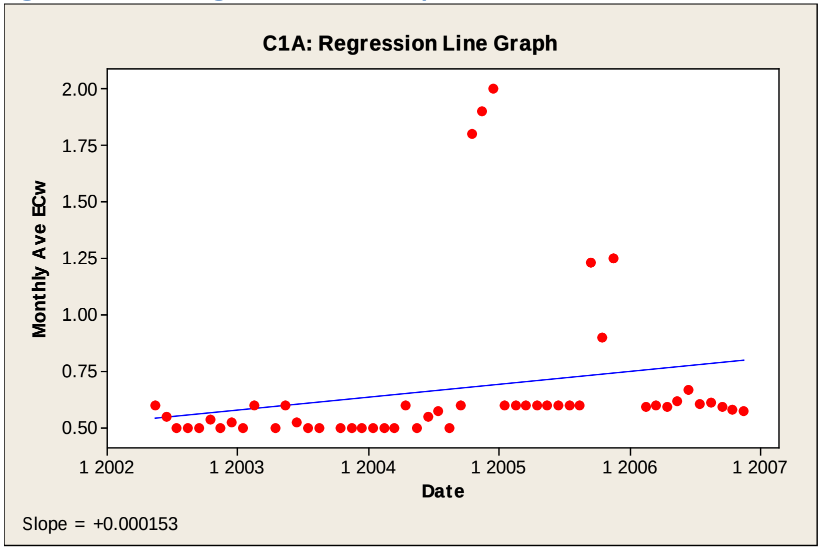


Figure 91. C25W Regression Line Graph

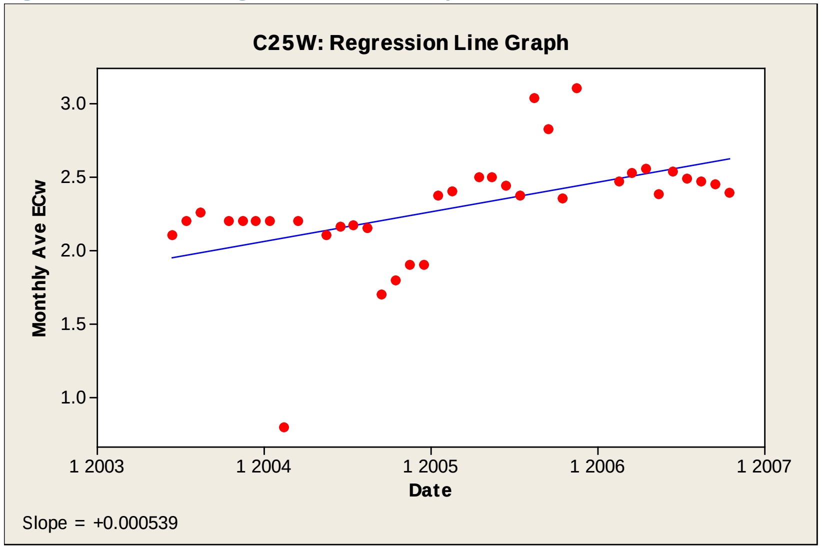


Figure 92. D24W Regression Line Graph

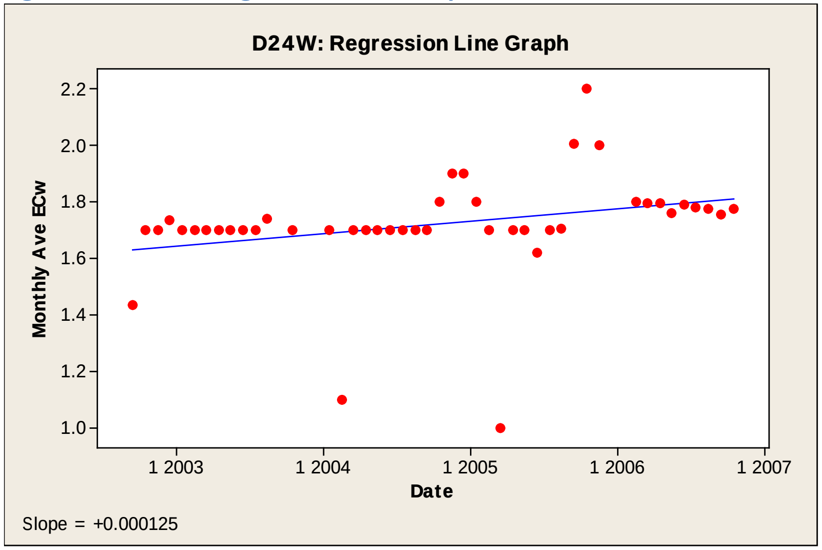


Figure 93. F22W Regression Line Graph

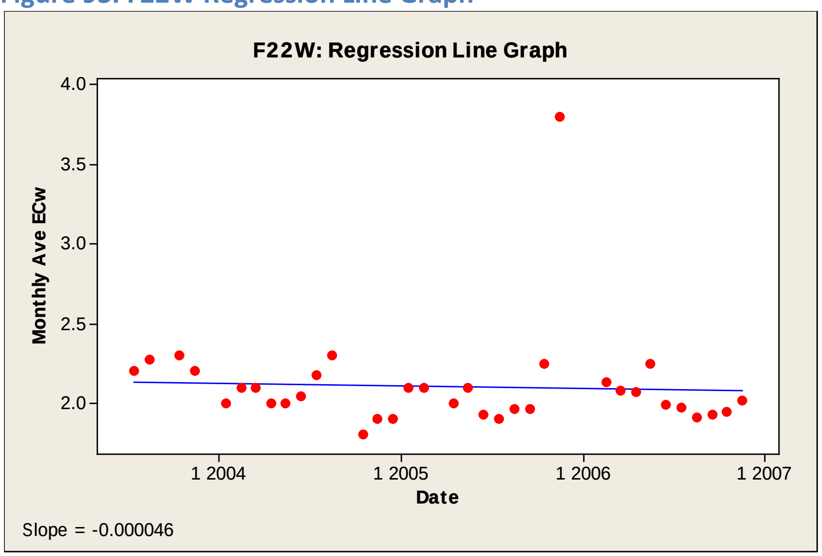


Figure 94. G5W Regression Line Graph

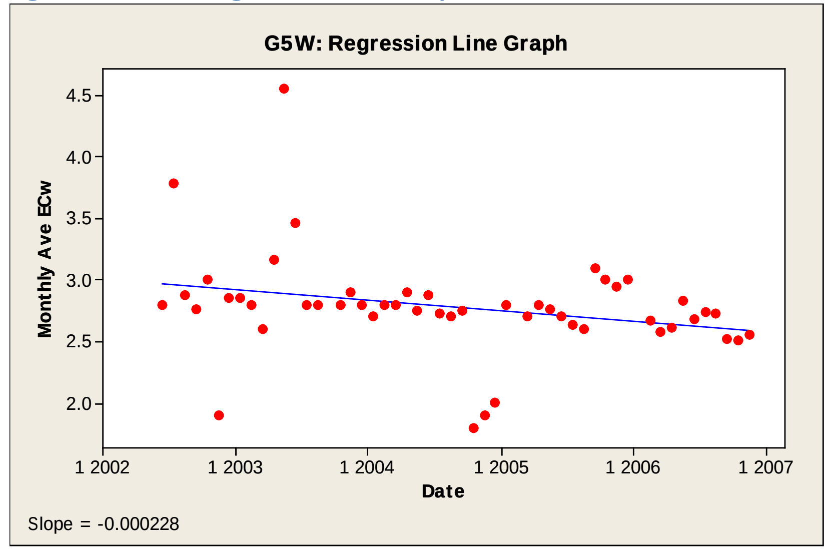


Figure 95. H4W Regression Line Graph

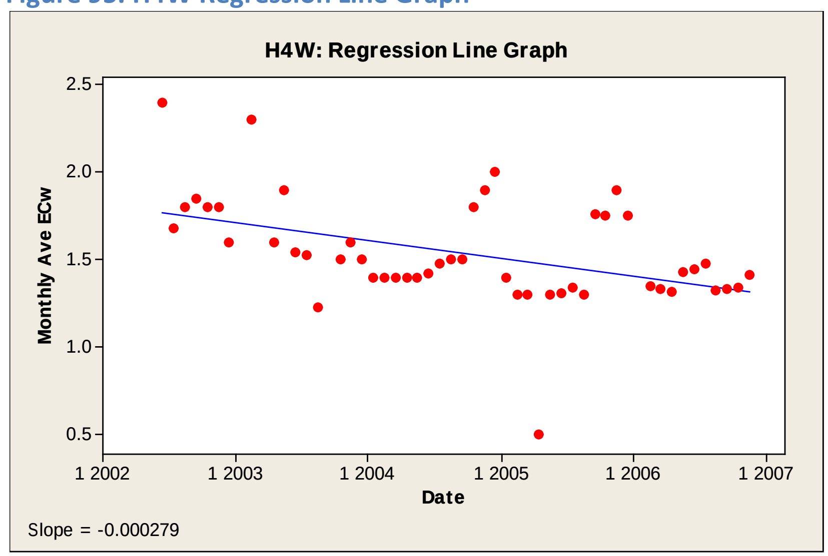


Figure 96. H6W Regression Line Graph

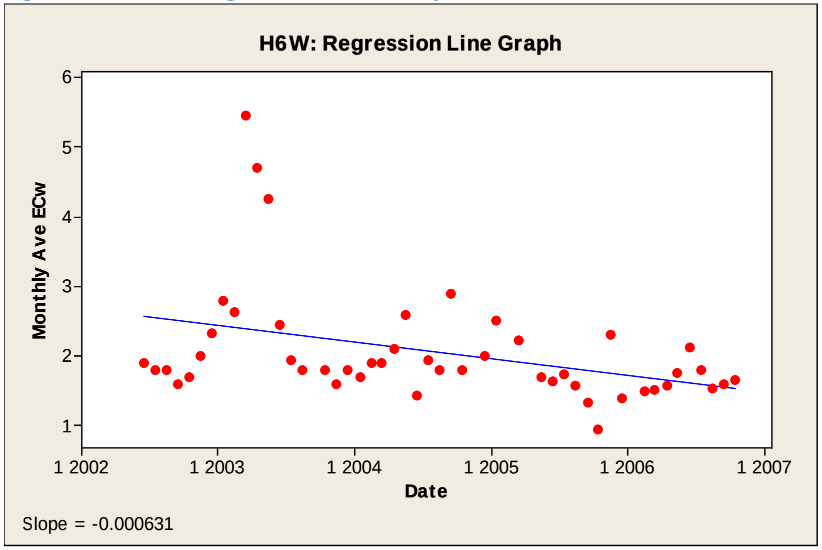


Figure 98. I6W Regression Line Graph

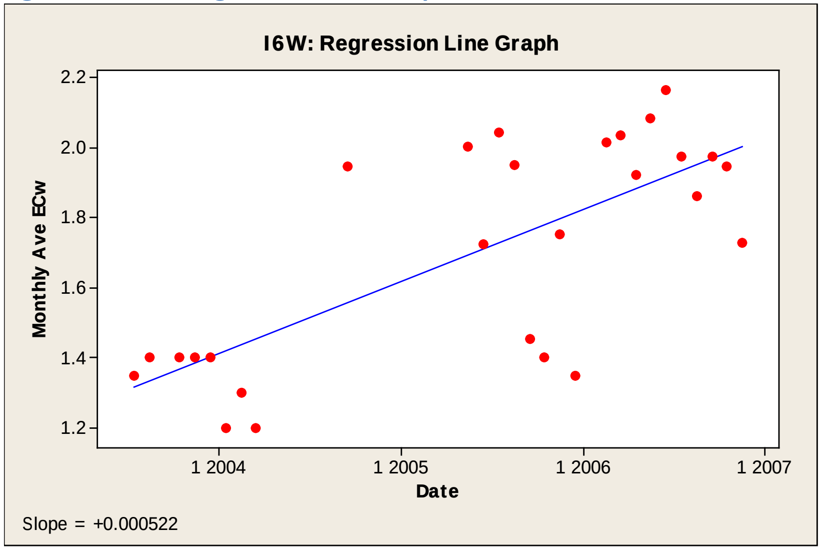


Figure 97. I5W Regression Line Graph

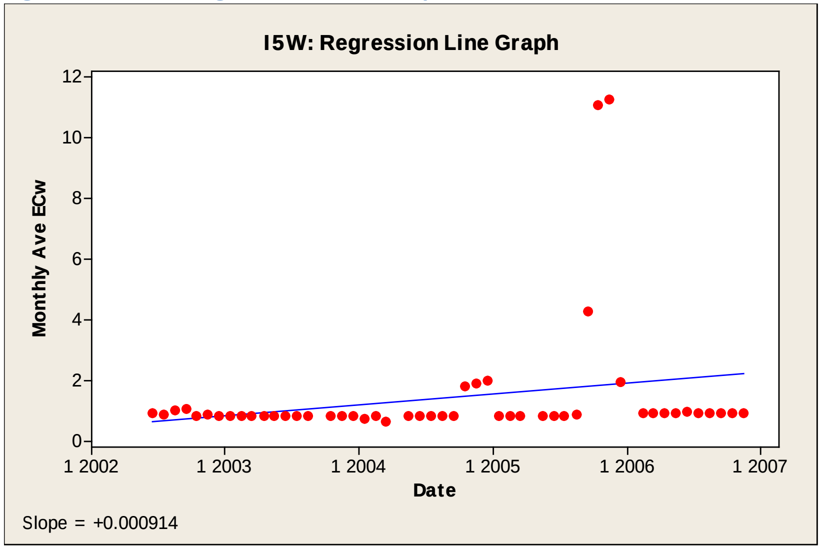


Figure 99. J14W Regression Line Graph

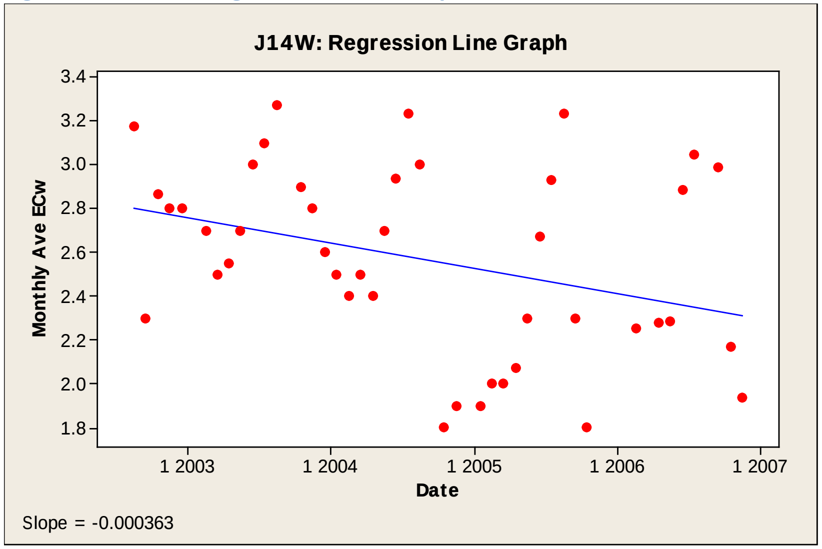


Figure 100. J15W Regression Line Graph

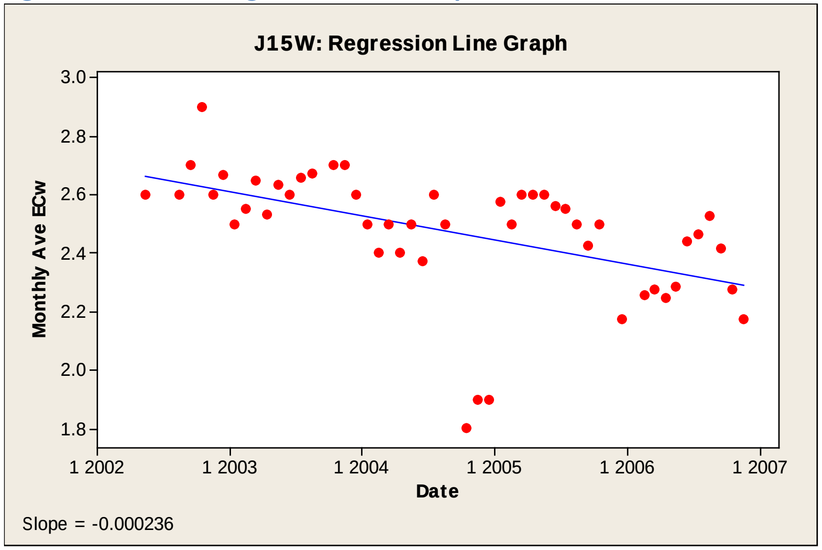


Figure 101. J17W Regression Line Graph

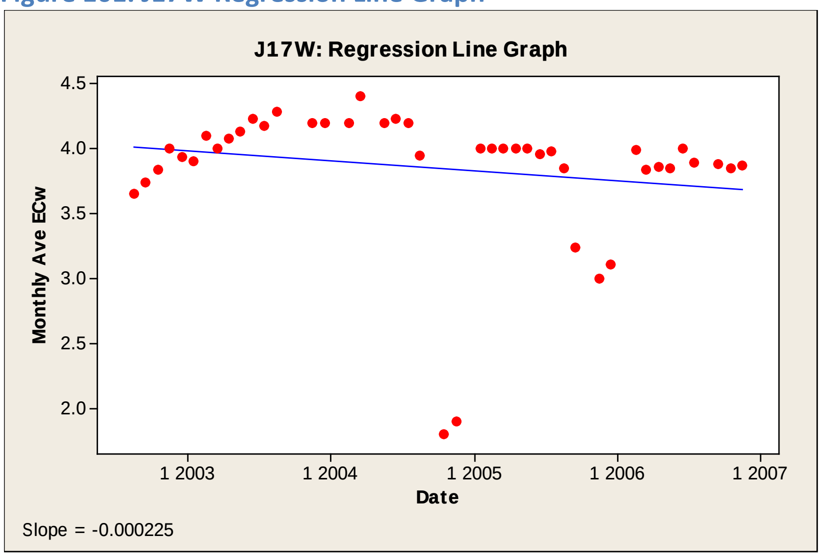
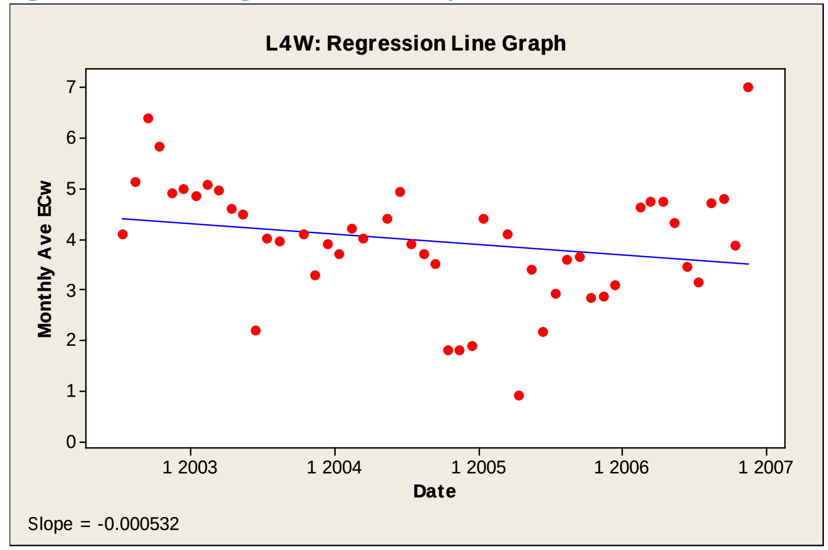


Figure 102. L4W Regression Line Graph



IRRIGATION WATER TOLERANCES

This report has documented the results of irrigation water salinity measurements for multiple water sources throughout Northern Water boundaries over a 5-year period. While five years is considered a short time frame when analyzing data and looking for trends, statistical calculations were performed on the available data. From these data, a desired conclusion may be whether or not this water is suitable for irrigation of agricultural lands and crops. Unfortunately, electrical conductivity data alone are not enough to make these types of statements.

Table 1, Potential Yield Reduction from Saline Water for Selected Irrigated Crops, was presented in the Literature Review section of the report. Additionally, the statement was made that: *The above tolerances should be considered guidelines. Absolute tolerances vary based on climate, soil conditions, and cultural practices.* The Potential Yield Reduction table was developed based on field studies conducted in Riverside, California. The geographic and climate differences between Riverside, California, and northeastern Colorado prevent this table from being directly applied to agricultural practices within the study area. Additionally, the salts found in irrigation water may differ between the Riverside study and the South Platte Basin, which would also make Table 1 inapplicable. The salt content in irrigation water in northeastern Colorado may not have the same effect on crops as in Riverside, California.

In addition to irrigation water salinity (as measured by electrical conductivity in this study), there are multiple factors that can affect agricultural crop growth and potential yield. Various sources of water inflow and outflow such as subsurface, rainwater, and snow, in addition to surface and well water affect crop growth. Water quality and quantity play a part in overall yield. The amount of soil drainage and leaching can affect salinity in the soil, as can the local soil type and near-surface geology. The seasonal climate and weather changes also affect crops. Management decisions directly influence the potential yield of a crop. For instance, fertilizer application, manure application, irrigation methods, and efficiency are all factors to consider when trying to maximize crop yield.

Given the numerous factors involved in a single crop’s production, it is not realistic to use the salinity results of this study alone to conclude how the irrigation water used today, or in the future, will potentially affect crop yield.

CONCLUSIONS

This report presented a great deal of data related to the electrical conductivity results from a number of river, canal, and groundwater well stations sampled. The goal of the study, and thus this final report, was to collect and present EC_w data along the Lower South Platte Basin. Based on the data collected, regression analyses were performed to determine general observations and trends at each station and along each river or canal system. The conclusions of the study, data processing, statistical analysis, and evaluation include:

1) The EC_w values in river systems increased downstream.
2) Many of the canal systems show decreased EC_w values as water moves downstream.
3) Stations on the river systems generally had an annual "U" shaped seasonal pattern in EC_w values with the lower values occurring during the summer months.
4) Stations on the canal systems had no notable annual trends in EC_w.
5) Many river system stations and canal system stations had a statistically-significant trend over the study period: some were decreasing EC_w and some were increasing.
6) The majority of the groundwater wells did show a statistically-significant trend: either increasing or decreasing EC_w over the study period.

Reviewing these results will certainly generate many questions: primarily, why? Why does the electrical conductivity of the water increase in the river systems? Why does it decrease in the canal systems? Why is the EC_w higher in some years at a particular station and lower in some years? Why is the EC_w higher in some stations and then lower at the adjacent downstream station, or vice versa? Why aren't there more conclusive results and trends in the salinity on the Lower South Platte Basin? These are all valid questions and certainly worth investigating. However, this study did not undertake the detailed investigations and testing that may be required to answer these questions.

To answer some of these questions would require not only additional electrical conductivity measurements, but measurements of many other factors as well. Considering the spatial variation throughout the system studied, an extreme amount of testing and analysis may be required to fully investigate the issues at hand and confidently draw conclusions to the questions presented. How far could this research go? The desired information would have to be clearly defined before starting additional studies in order to specify the required field work.

Pending additional studies, some thoughts regarding why the EC_w value appears to decrease in the canal systems are presented here only to spark additional ideas and discussion as this may be the most puzzling result of the study. Reviewing the Distance Downstream graphs, many of the canal systems show decreased EC_w values. The amount of change is small in some cases and therefore might be considered insignificant. Is it possible that the accuracy of the measurement devices and human error cause this small change? Is it possible that the composition of the salts is changing from point to point which affects the EC_w readings? If that is a valid explanation, further Total Dissolved Solids (TDS) sampling over the length of the canal could be done to determine if the TDS to EC_w ratio stays the same.

The results of this study are a good basis and start to long term data collection and should be analyzed with future results at the 10-year mark next.

RECOMMENDATIONS

Future Monitoring

As previously stated, this study produced a good, 5-year database of electrical conductivity results for the Lower South Platte Basin. This data will become more valuable if the measurements are ongoing and analyzed again when 10 years of results can be analyzed together. Future monitoring is recommended at all the river system and canal system sites documented in this report. If funding is available, automating the current manual sites would provide additional data resulting in more confident trend analysis.

Future Mitigation

Due to the many unknown factors that impact crop yield, it is nearly impossible to make statements regarding the potential crop yield based on irrigation water salinity alone and apply those statements across the board to all agricultural areas within the Lower South Platte Basin.

To better understand the affects of irrigation water salinity in this area, it is recommended that a Potential Crop Yield Reduction study be developed and conducted within the Lower South Platte Basin. Using representative land and soils, as well as crops and water, would provide a more accurate result of how EC_w impacts the agricultural crops in the study area. This study would be similar in nature to the well-known Riverside, California, study. It would be a huge undertaking and would require numerous entities to participate. However, the results would be extremely beneficial to those involved in agricultural production in northeastern Colorado.

With results from a local study, it may be possible to draw conclusions about the potential yield reduction as the EC_w values change over time. Given this type of information, future mitigation may be proposed if known changes in yield are caused by changes in water quality.

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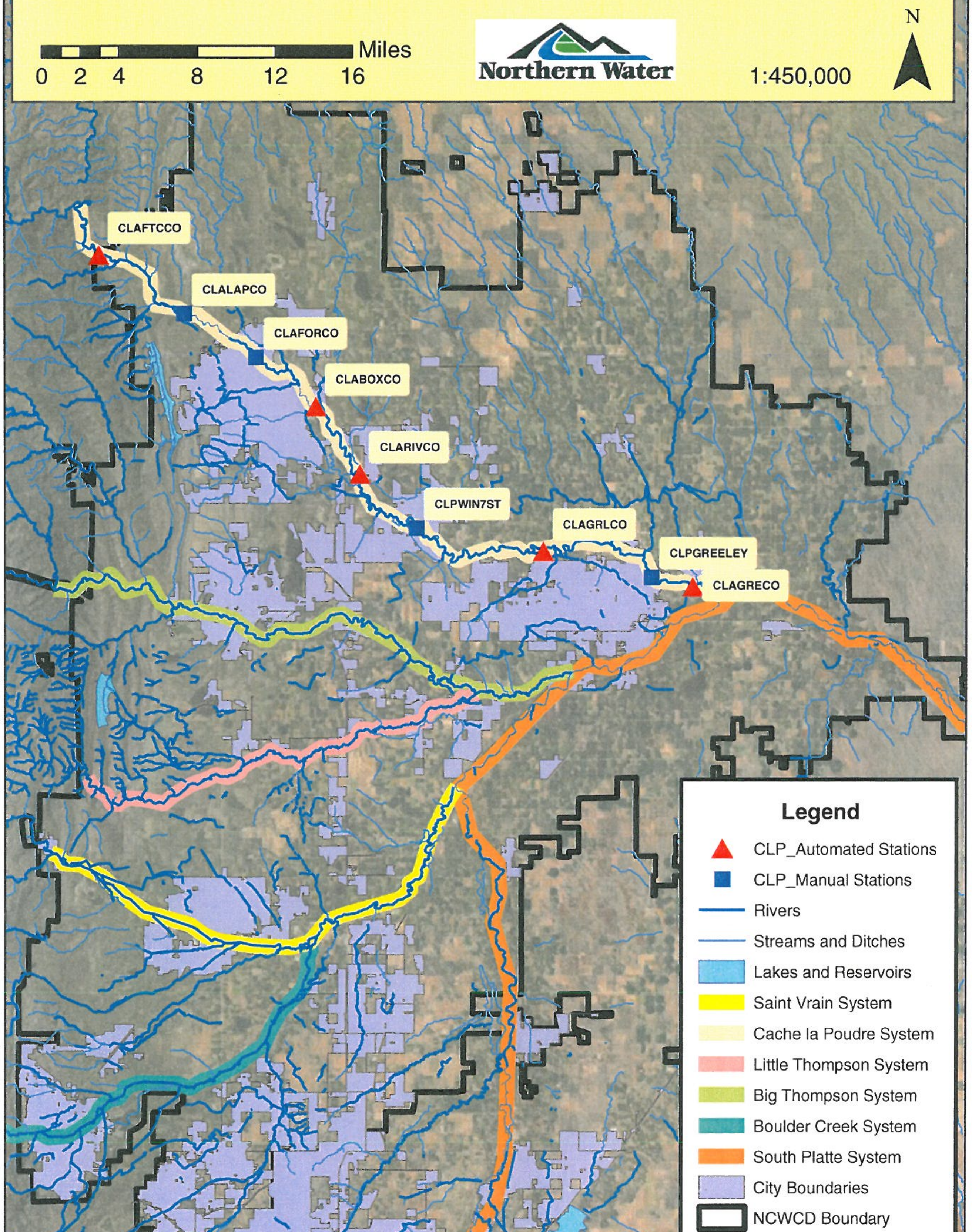
APPENDIX A

Site Maps

Figure 1: Cache la Poudre River System - Sampling Station Locations



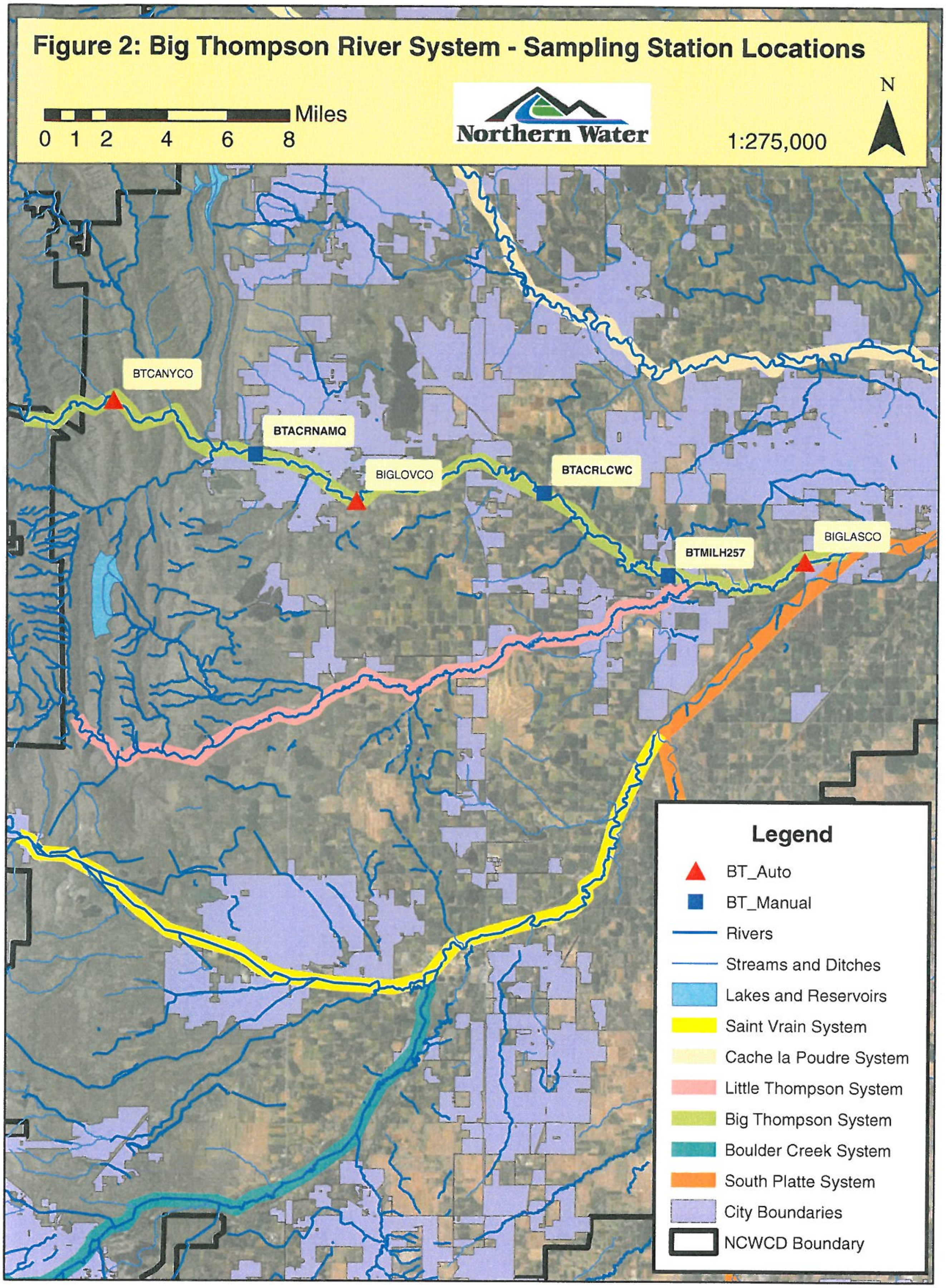
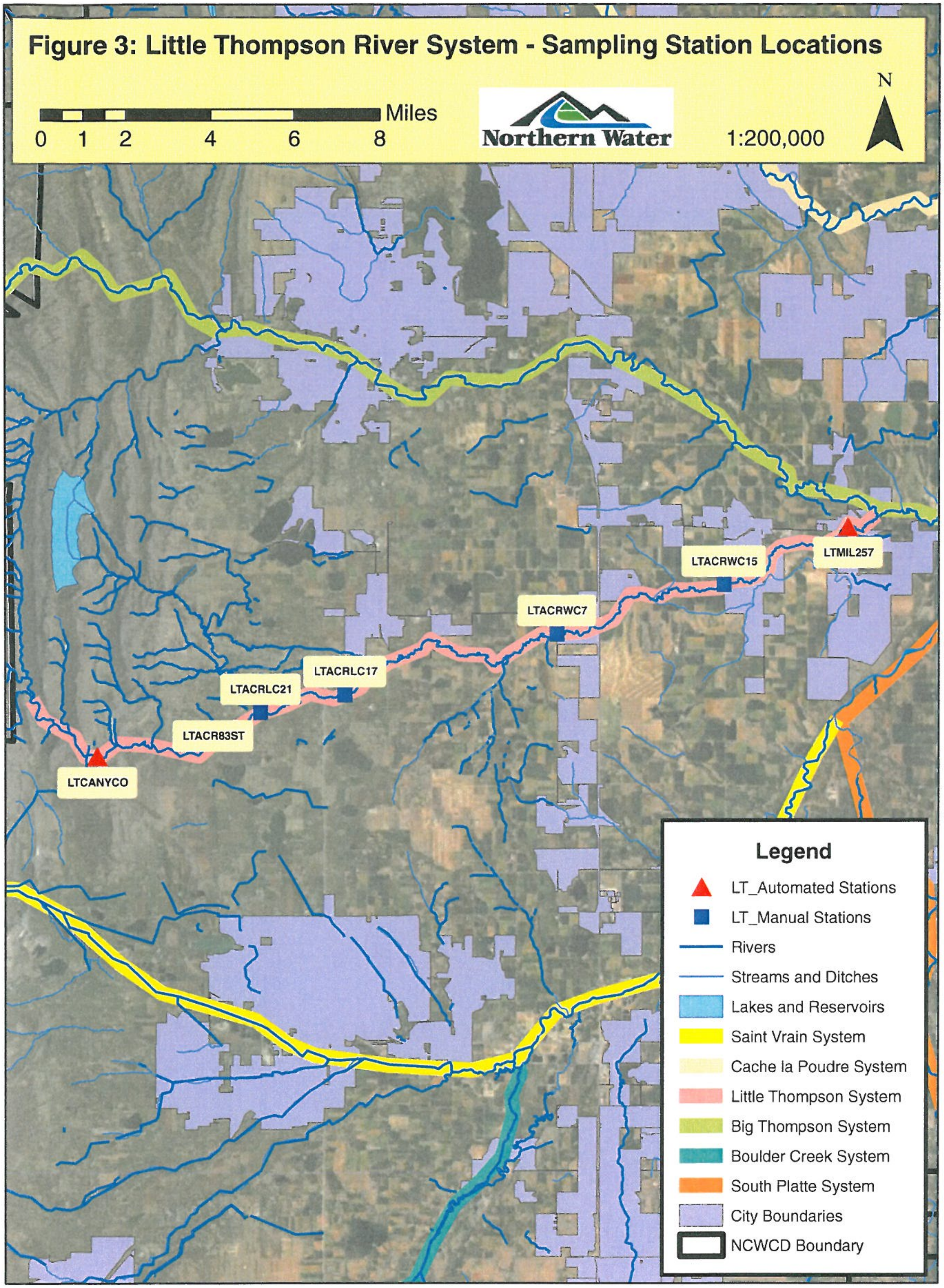


Figure 2: Big Thompson River System - Sampling Station Locations
Miles
0 1 2 4 6 8
Northern Water
1:275,000
N
BTCANYCO
BTACRNAMQ
BIGLOVCO
BTACRLCWC
BTMILH257
BIGLASCO
Legend
BT_Auto
BT_Manual
Rivers
Streams and Ditches
Lakes and Reservoirs
Saint Vrain System
Cache la Poudre System
Little Thompson System
Big Thompson System
Boulder Creek System
South Platte System
City Boundaries
NCWCD Boundary

Figure 3: Little Thompson River System - Sampling Station Locations



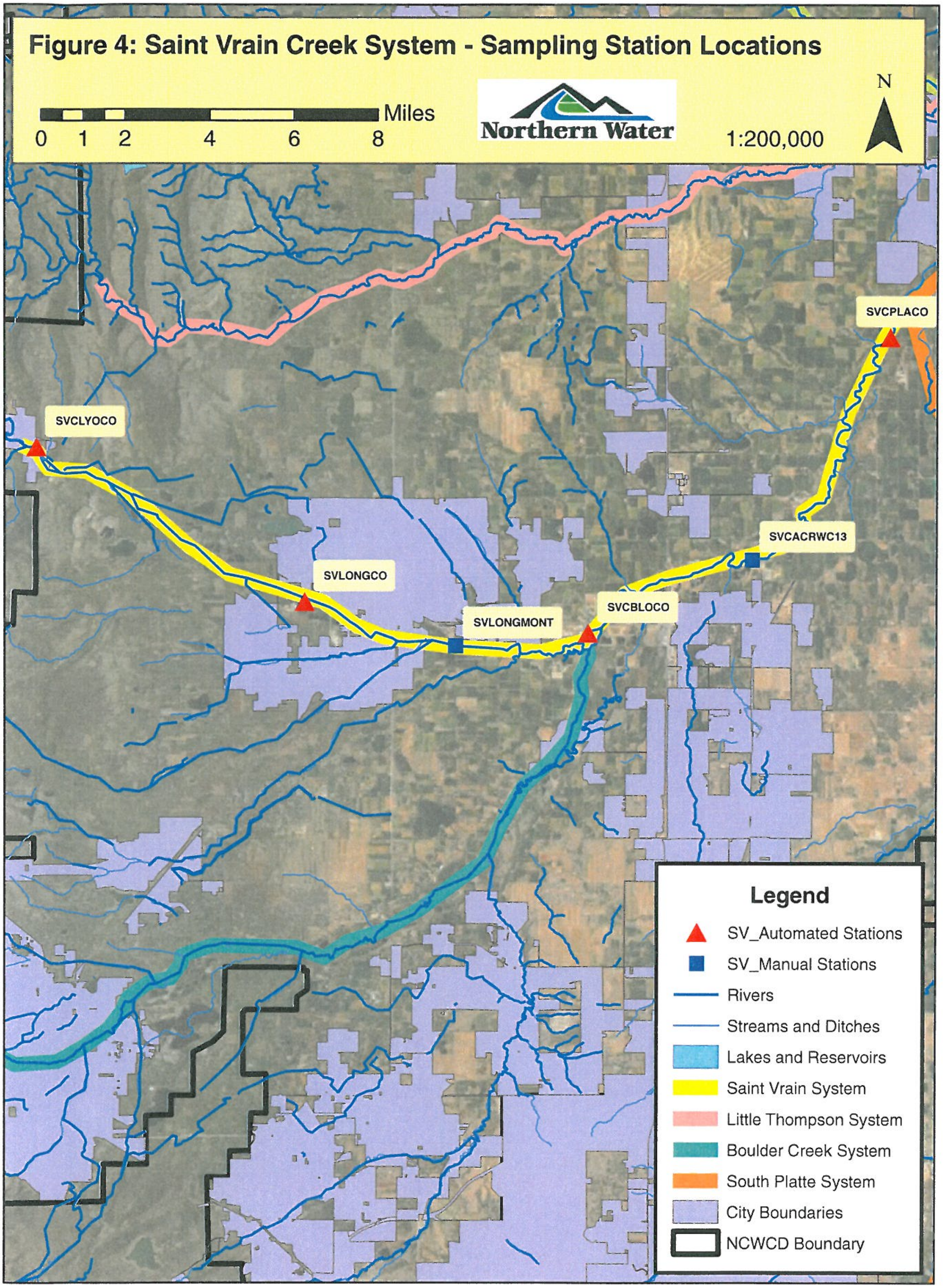


Figure 4: Saint Vrain Creek System - Sampling Station Locations
Miles
0 1 2 4 6 8
Northern Water
1:200,000
N
SVCLYOCO
SVLONGCO
SVLONGMONT
SVCBLOCO
SVCACRWC13
SVCPLACO
Legend
SV_Automated Stations
SV_Manual Stations
Rivers
Streams and Ditches
Lakes and Reservoirs
Saint Vrain System
Little Thompson System
Boulder Creek System
South Platte System
City Boundaries
NCWCD Boundary

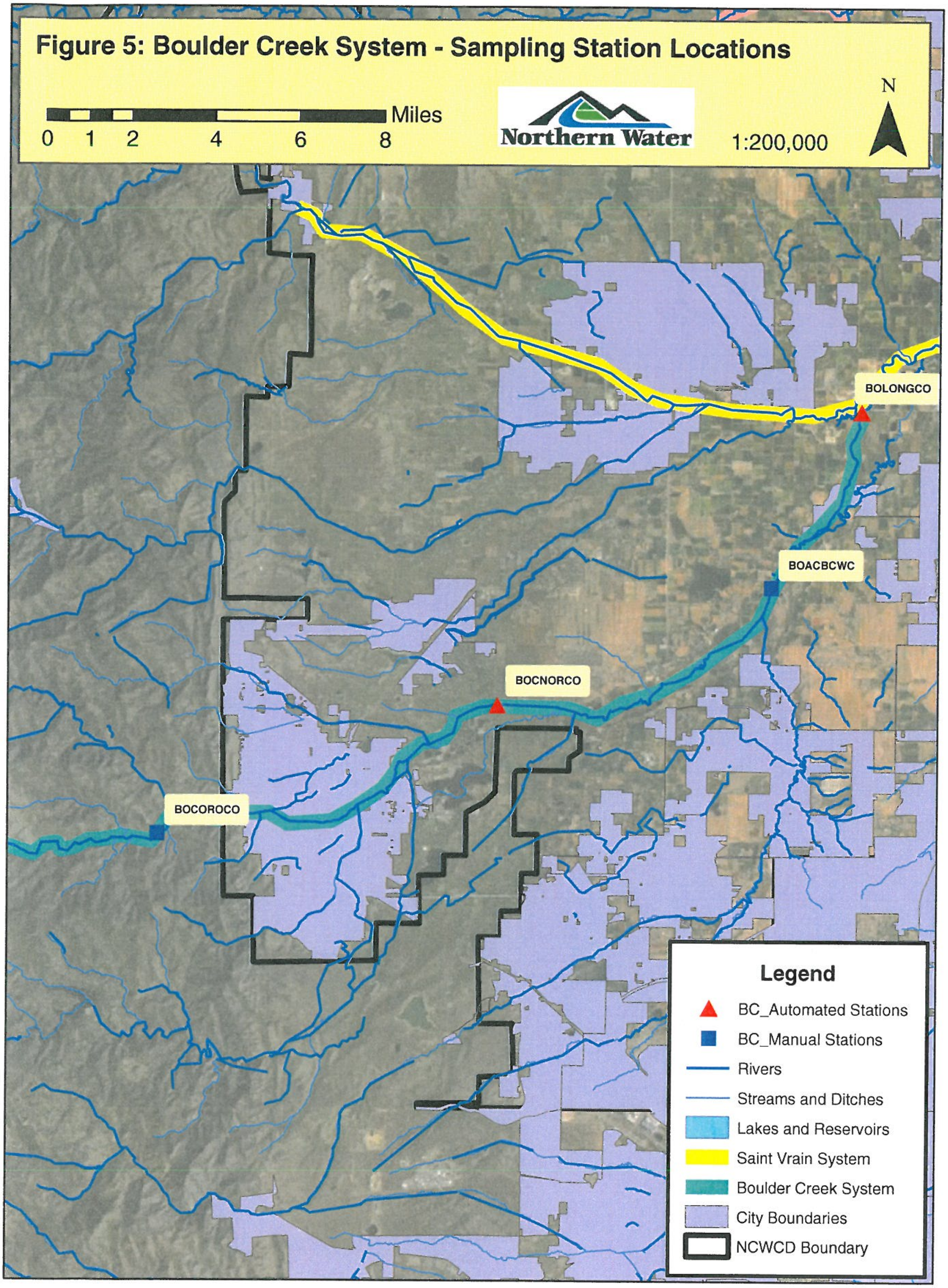


Figure 5: Boulder Creek System - Sampling Station Locations
Miles
0 1 2 4 6 8
Northern Water
1:200,000
N
BOLONGCO
BOACBCWC
BOCNORCO
BOCOROCO
Legend
BC_Automated Stations
BC_Manual Stations
Rivers
Streams and Ditches
Lakes and Reservoirs
Saint Vrain System
Boulder Creek System
City Boundaries
NCWCD Boundary

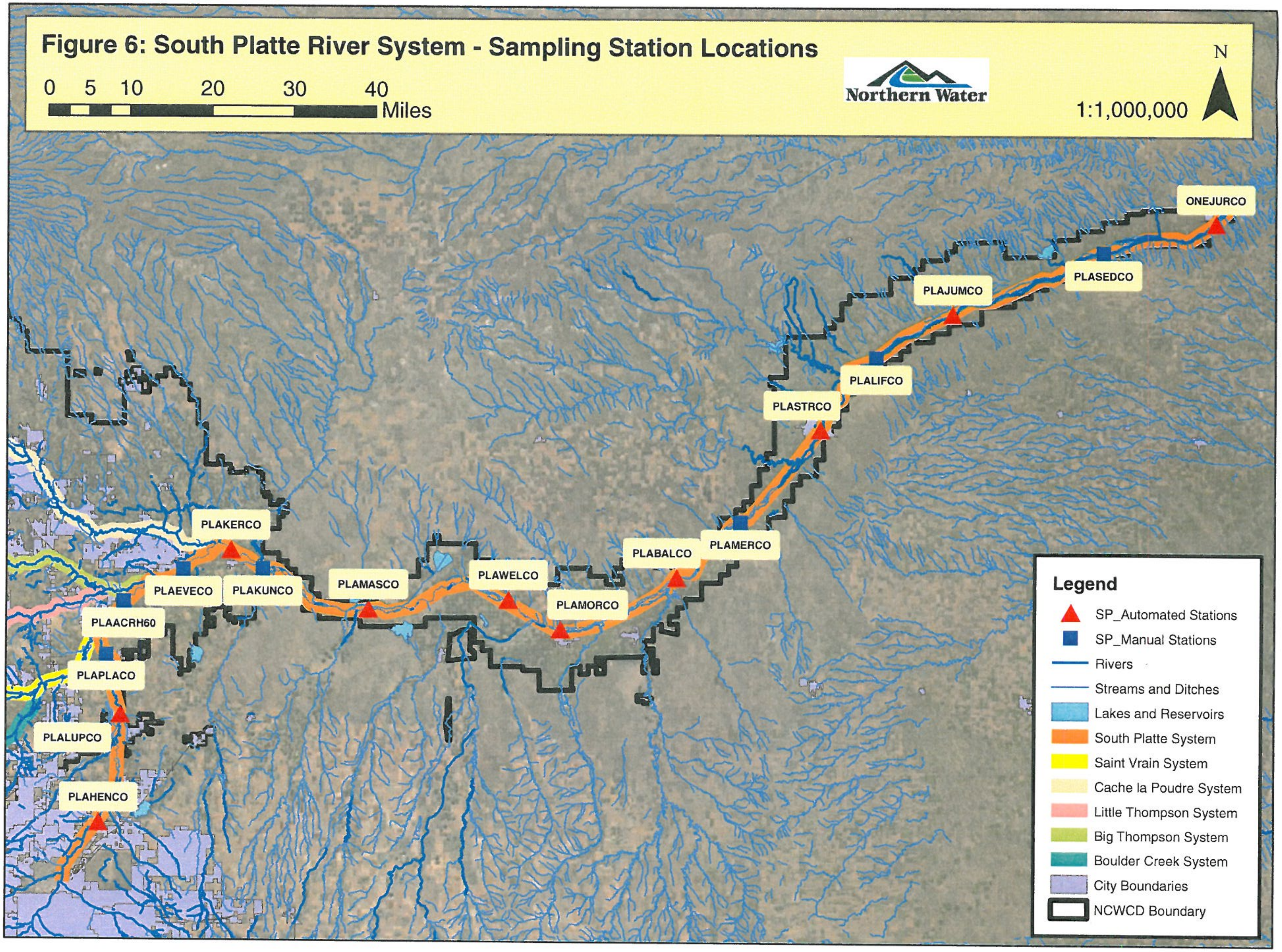


Figure 6: South Platte River System - Sampling Station Locations
0 5 10 20 30 40
Miles
Northern Water
1:1,000,000
N
ONEJURCO
PLASEDCO
PLAJUMCO
PLALIFCO
PLASTRCO
PLAMERCO
PLABALCO
PLAMORCO
PLAWELCO
PLAMASCO
PLAKUNCO
PLAKERCO
PLAEVECO
PLAACRH60
PLAPLACO
PLALUPCO
PLAHENCO
Legend
SP_Automated Stations
SP_Manual Stations
Rivers
Streams and Ditches
Lakes and Reservoirs
South Platte System
Saint Vrain System
Cache la Poudre System
Little Thompson System
Big Thompson System
Boulder Creek System
City Boundaries
NCWCD Boundary

Figure 7: New Cache / Greeley #2 Canal - Sampling Station Locations

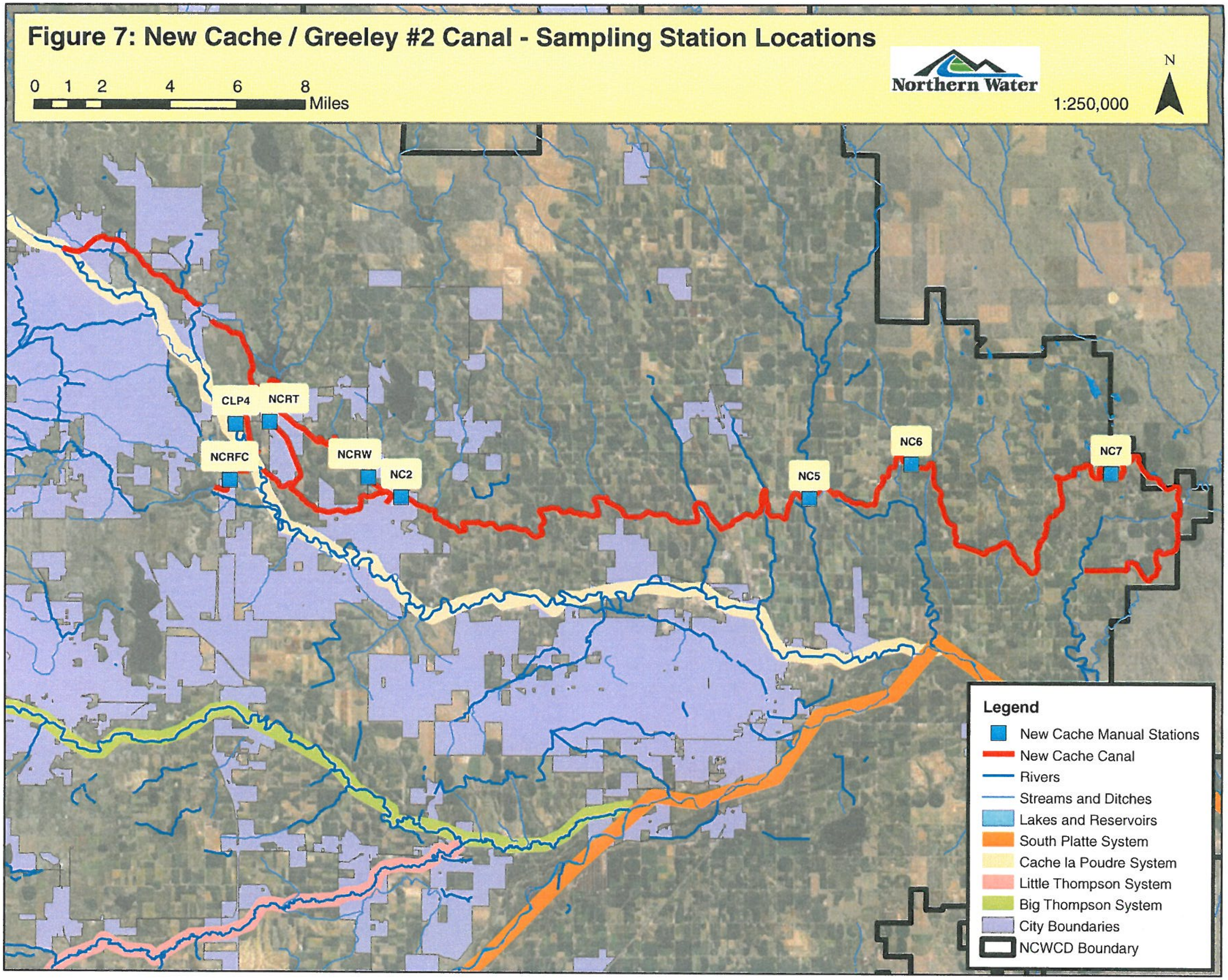


Figure 8: Larimer-Weld Canal - Sampling Station Locations

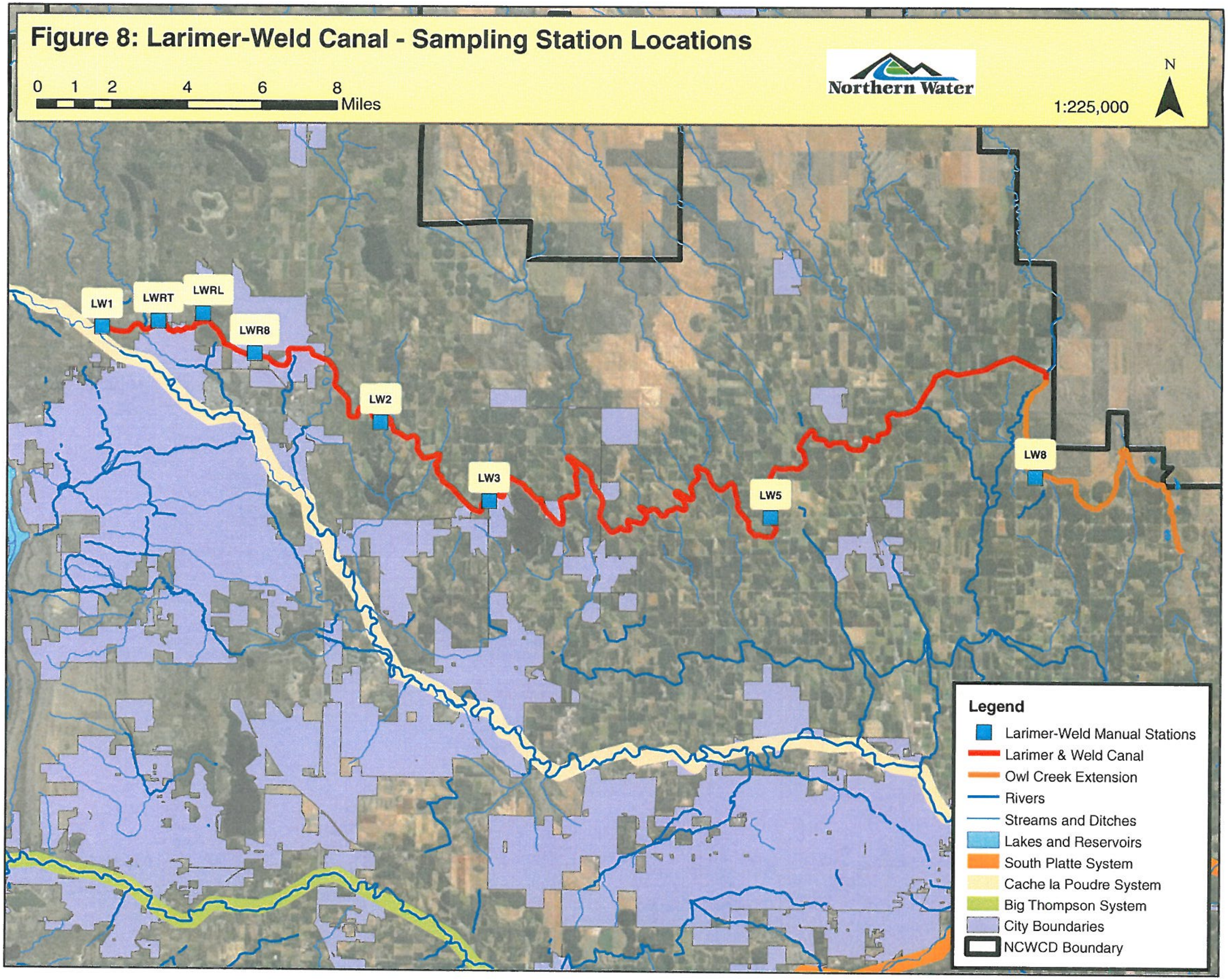


Figure 9: Riverside Canal - Sampling Station Locations

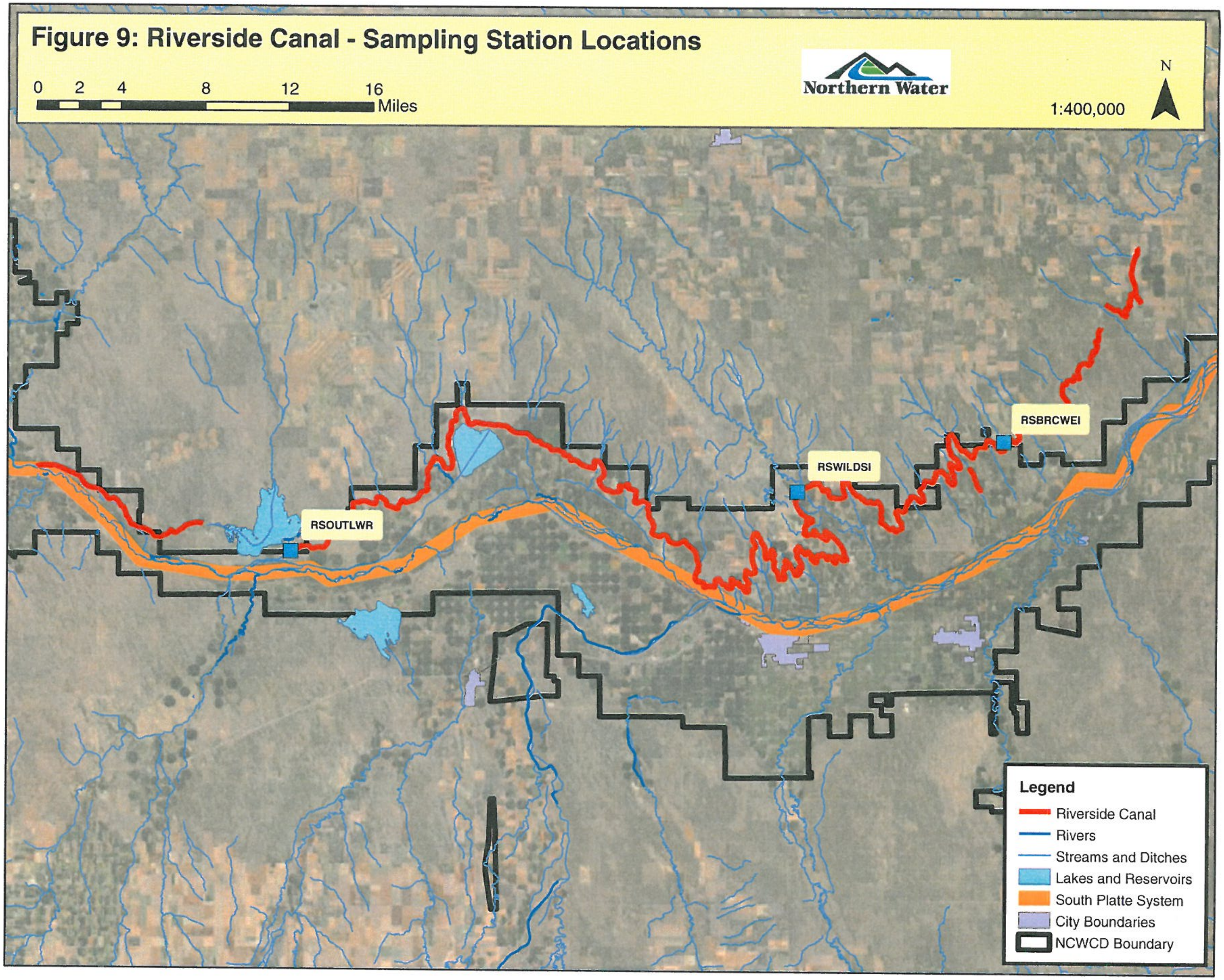


Figure 10: Prewitt and North Sterling Canals - Sampling Station Locations

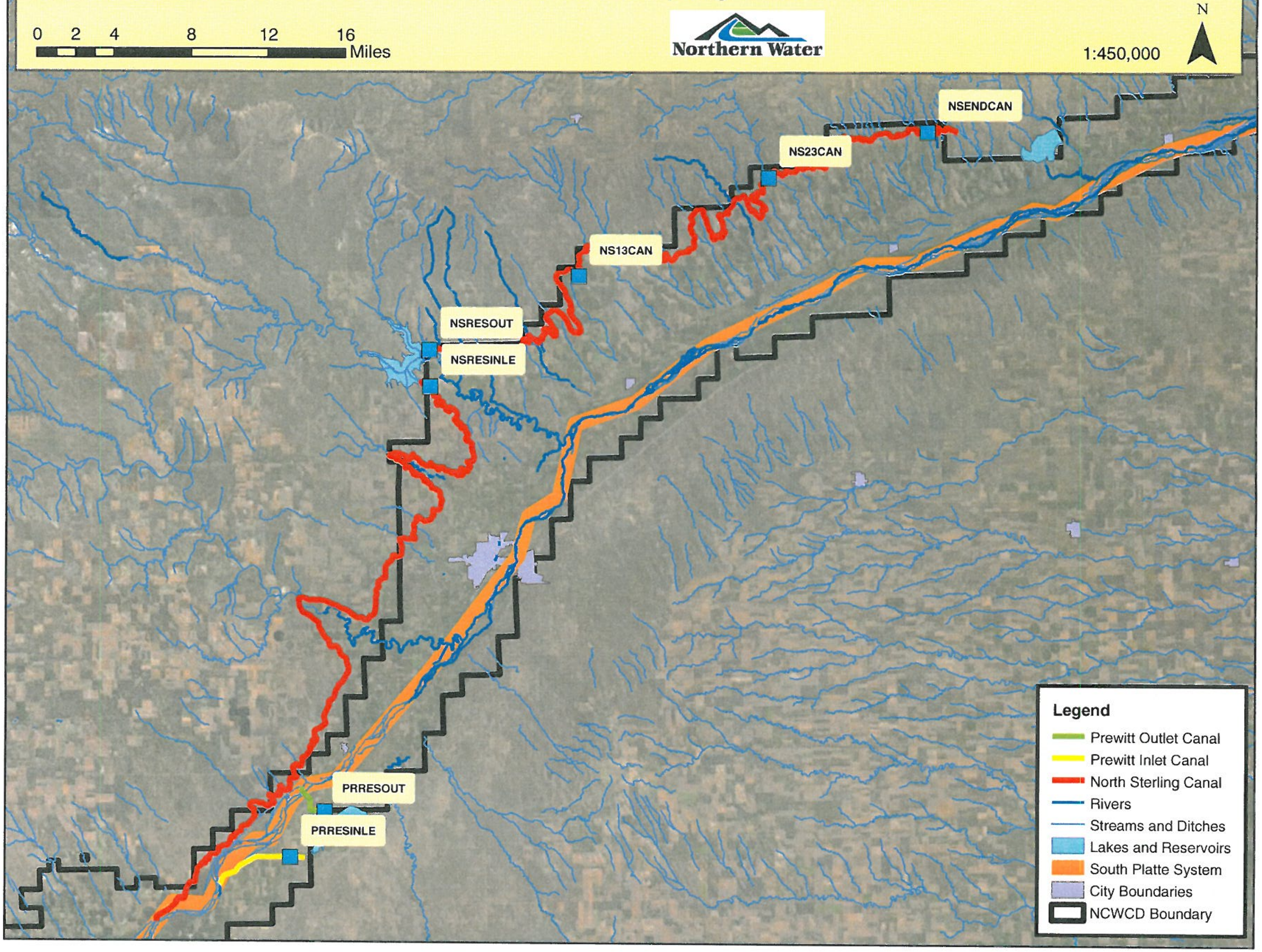


Figure 11: Jackson and Morgan Canal - Sampling Station Locations

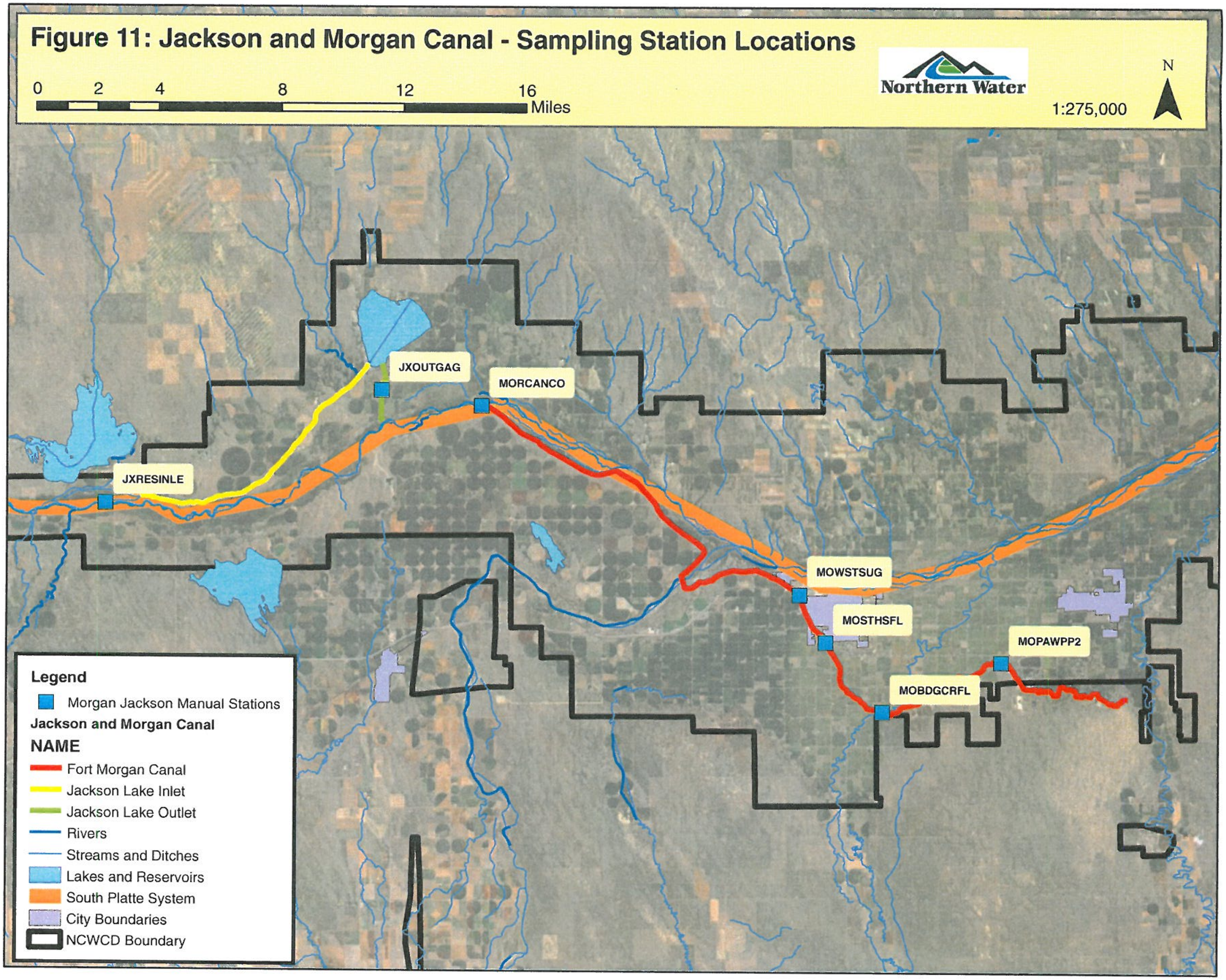


Figure 12: Empire and Bijou Canal - Sampling Station Locations

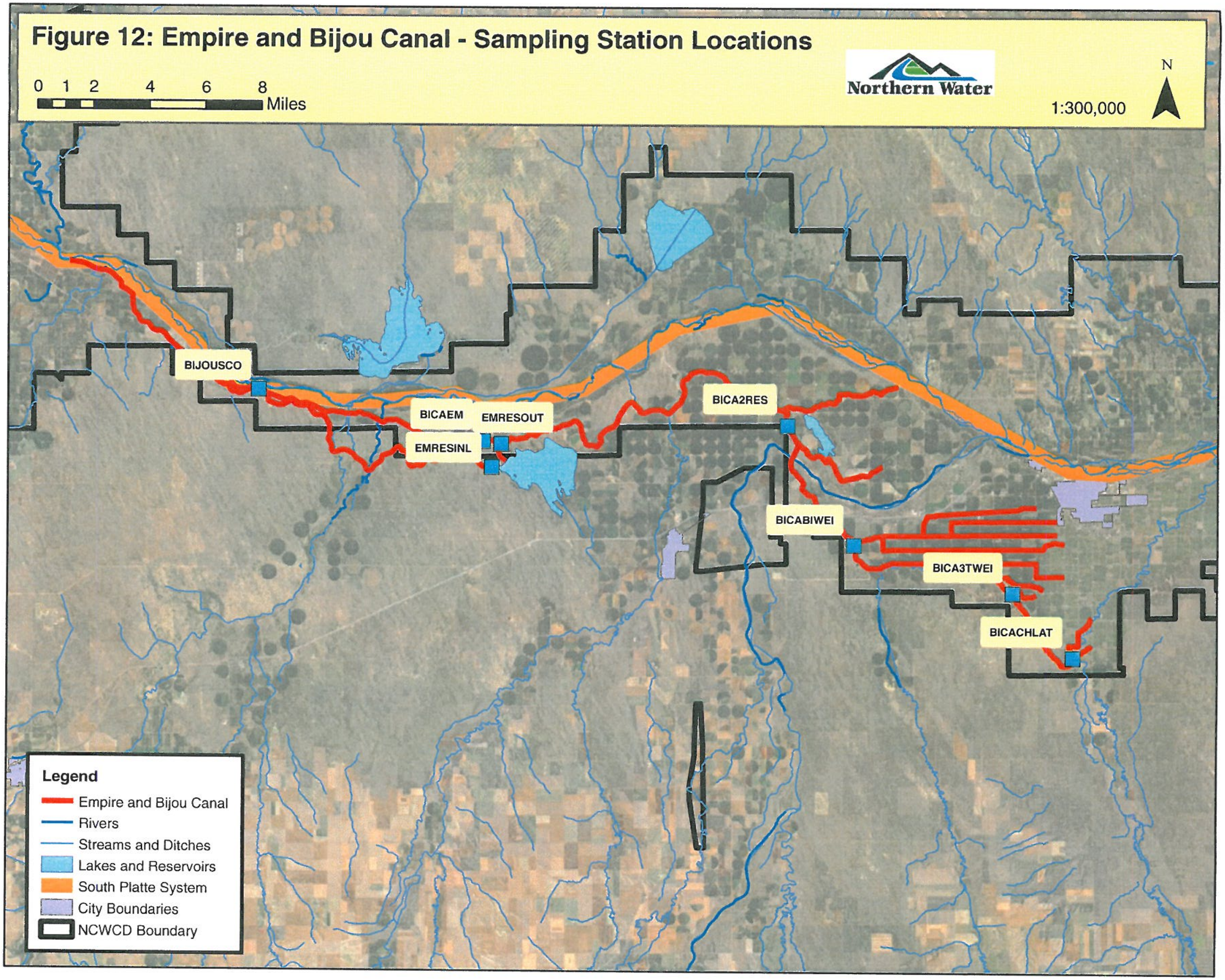


Figure 13: Julesburg Canal - Sampling Station Locations

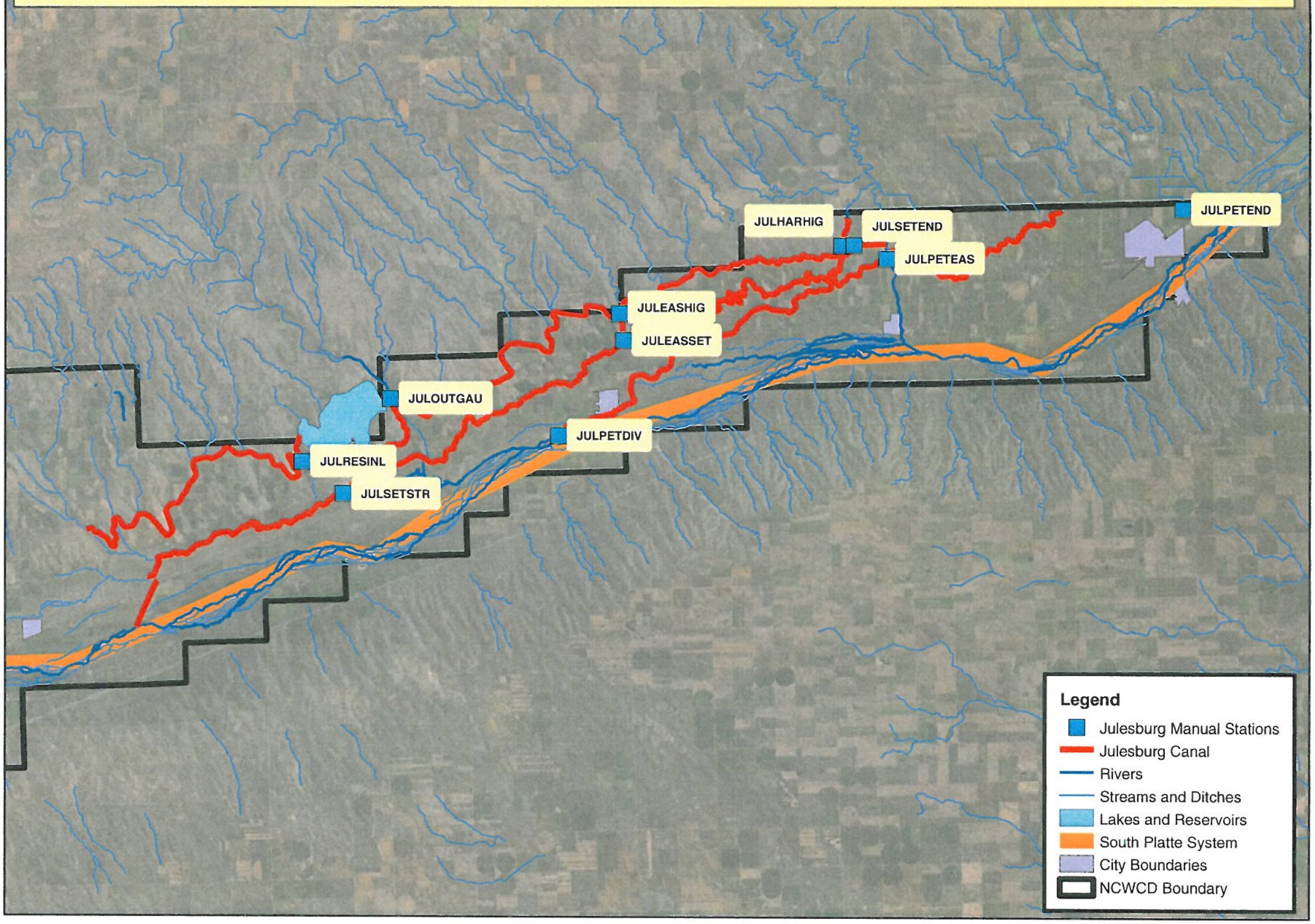
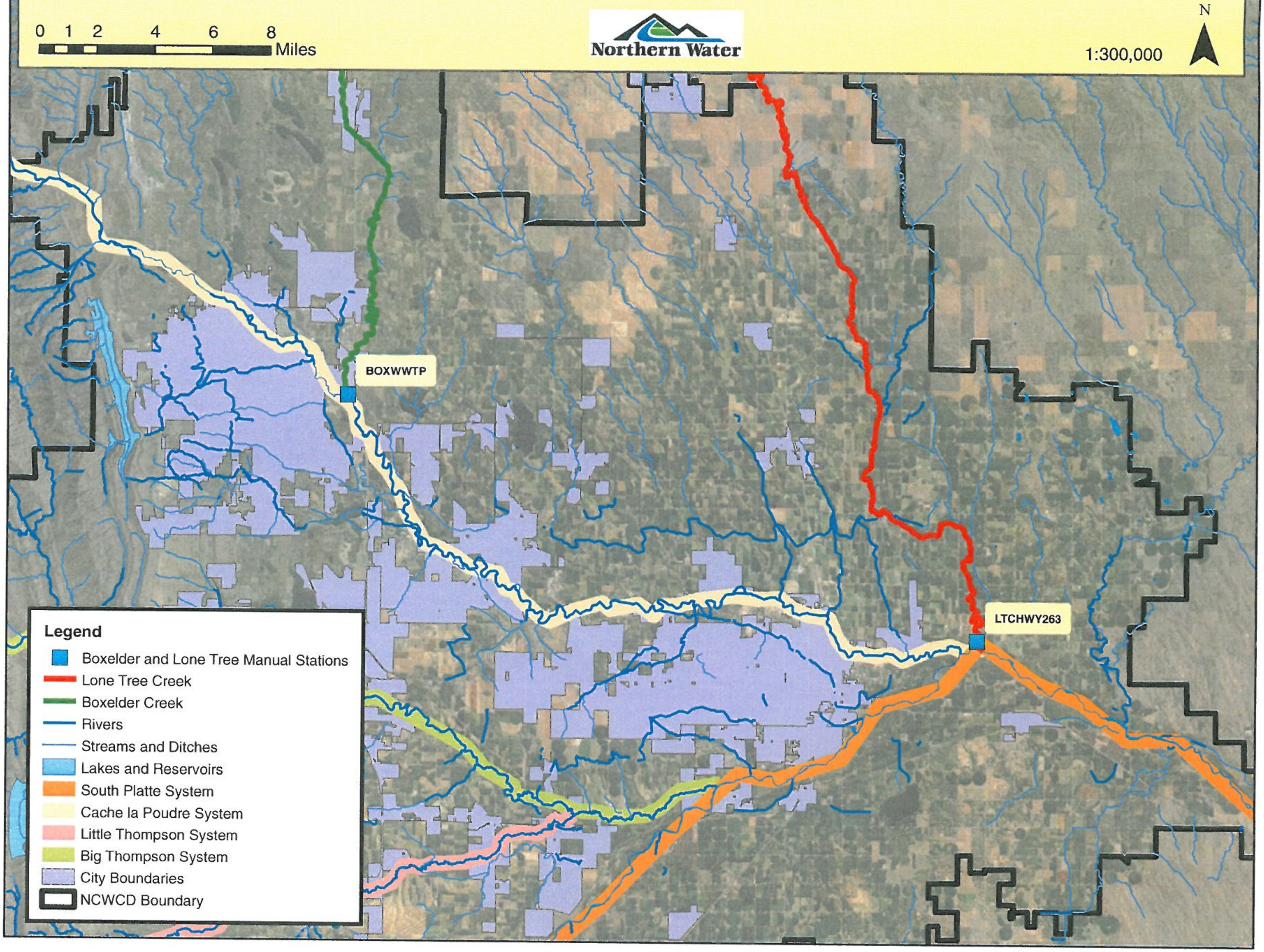


Figure 14: Boxelder and Lone Tree Creeks - Sampling Station Locations



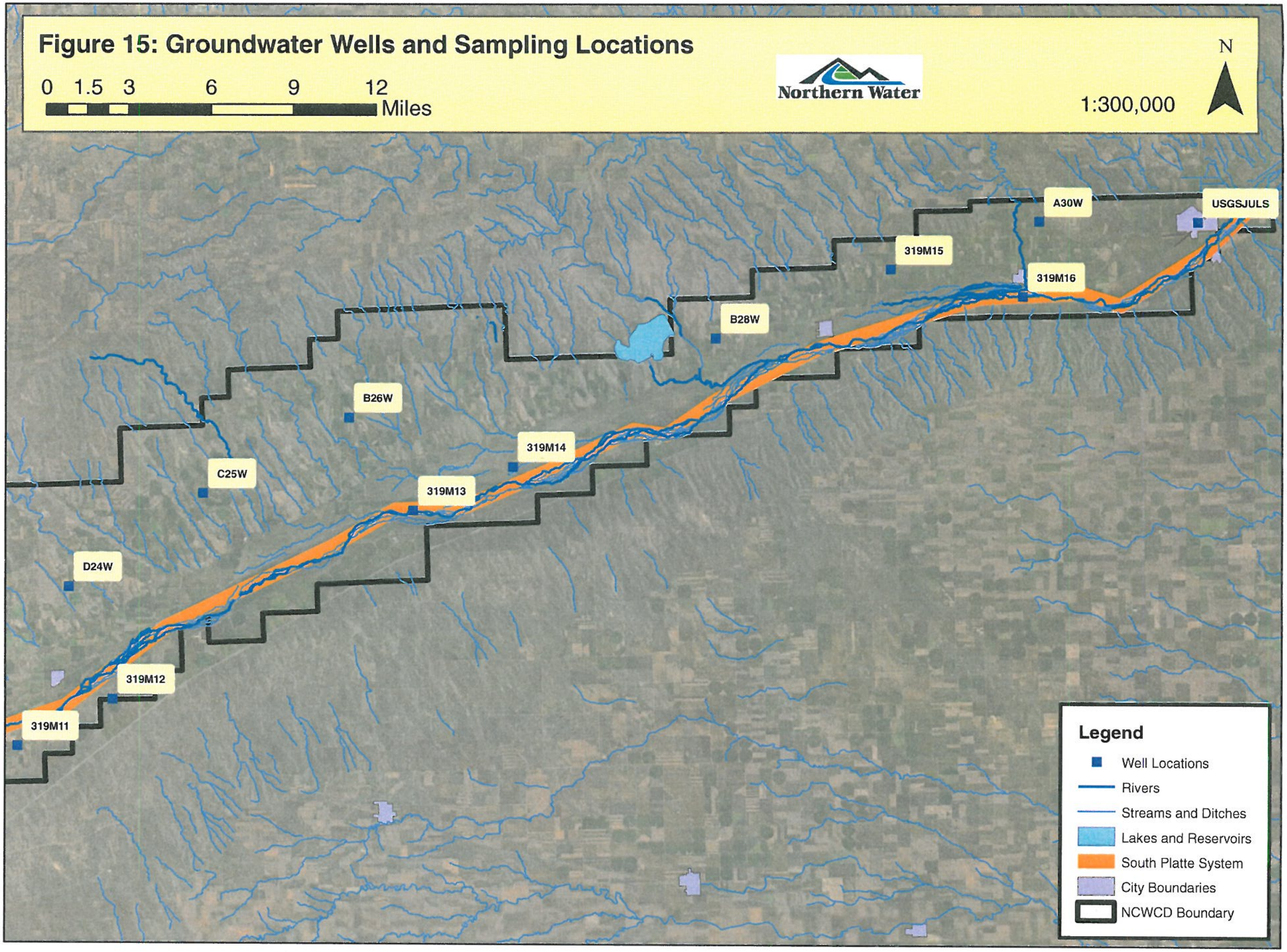


Figure 15: Groundwater Wells and Sampling Locations
0 1.5 3 6 9 12
Miles
Northern Water
1:300,000
N
USGSJULS
A30W
319M15
319M16
B28W
B26W
319M14
319M13
C25W
D24W
319M12
319M11
Legend
Well Locations
Rivers
Streams and Ditches
Lakes and Reservoirs
South Platte System
City Boundaries
NCWCD Boundary

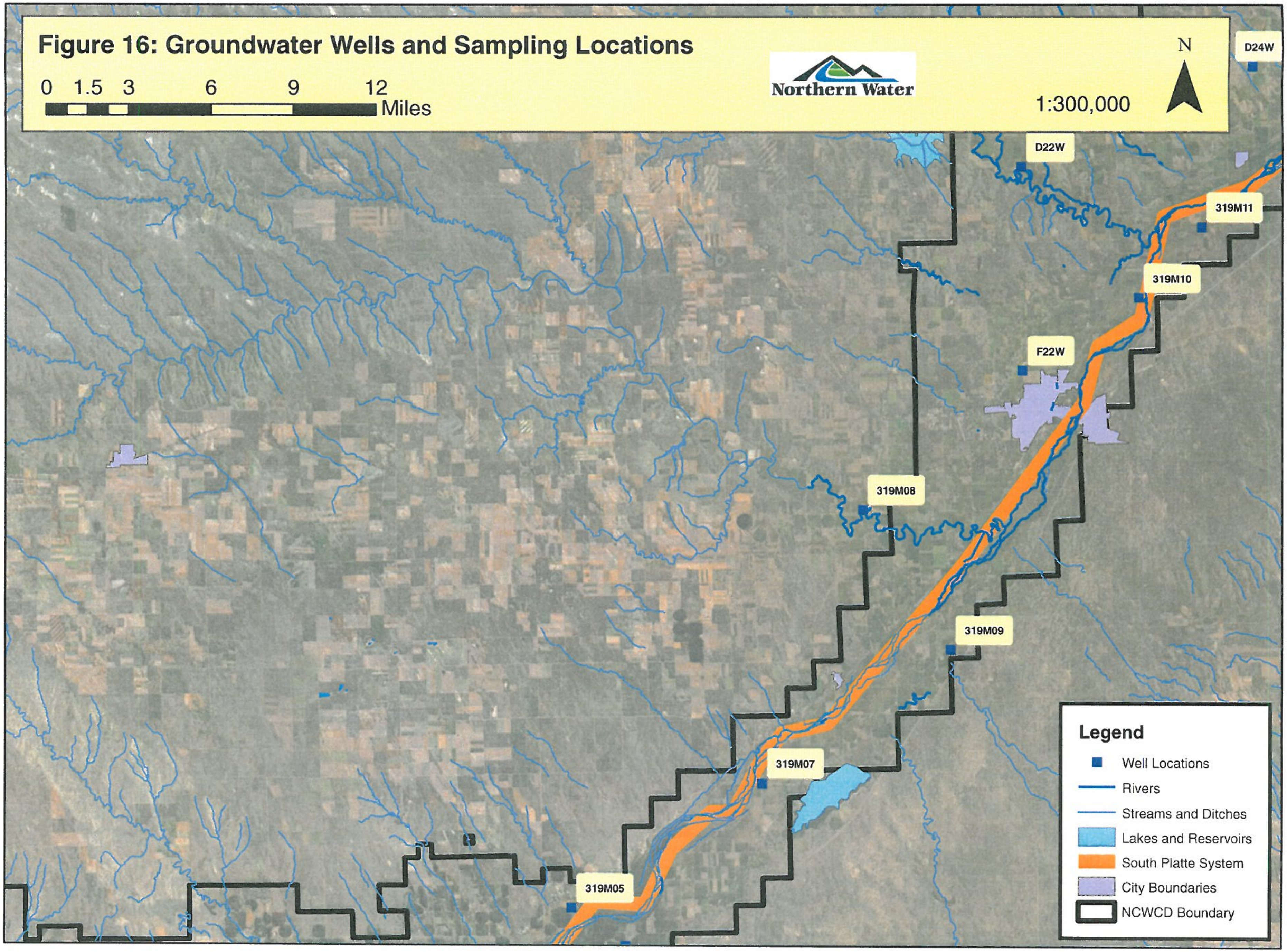


Figure 16: Groundwater Wells and Sampling Locations

Figure 17: Groundwater Wells and Sampling Locations

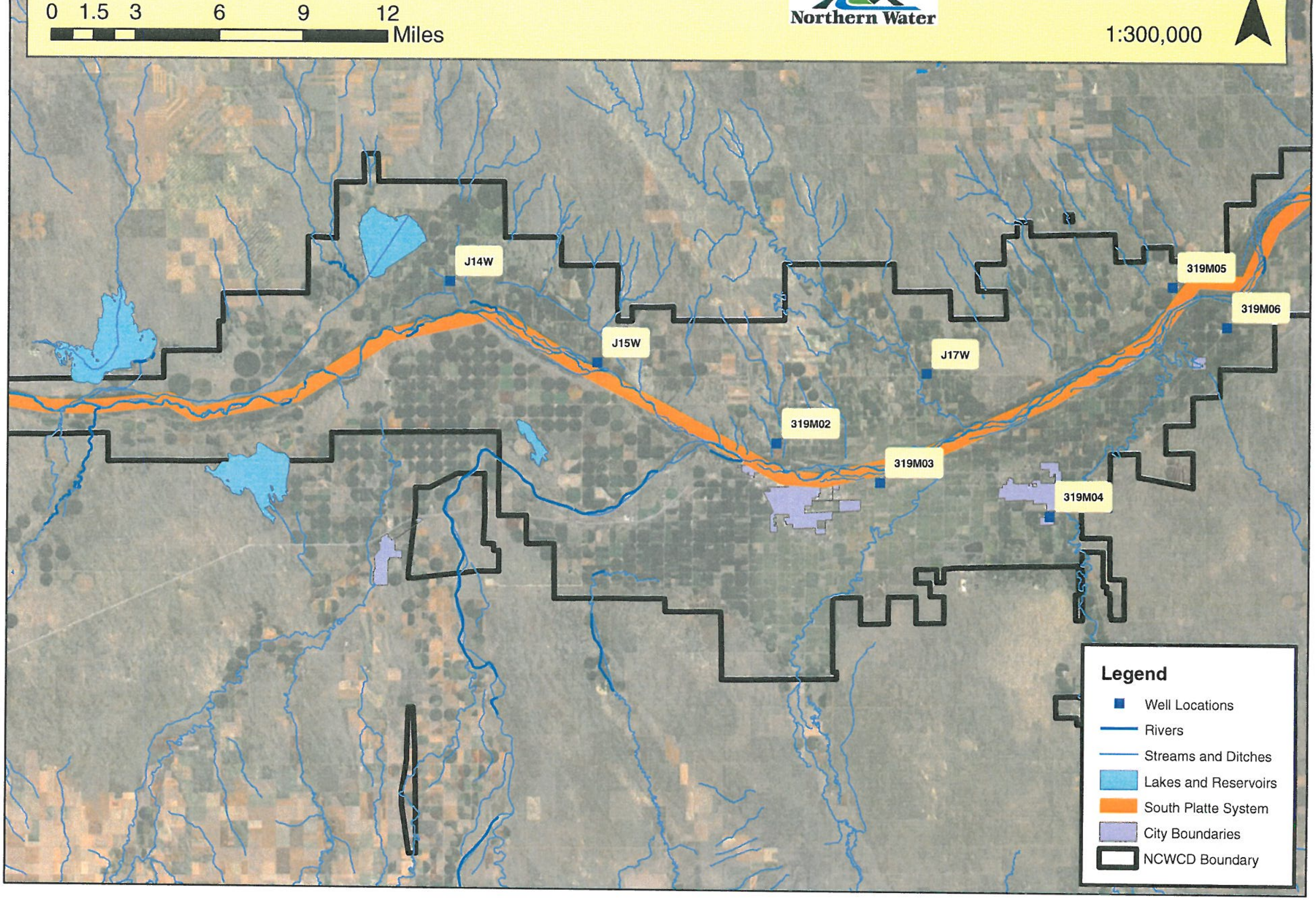
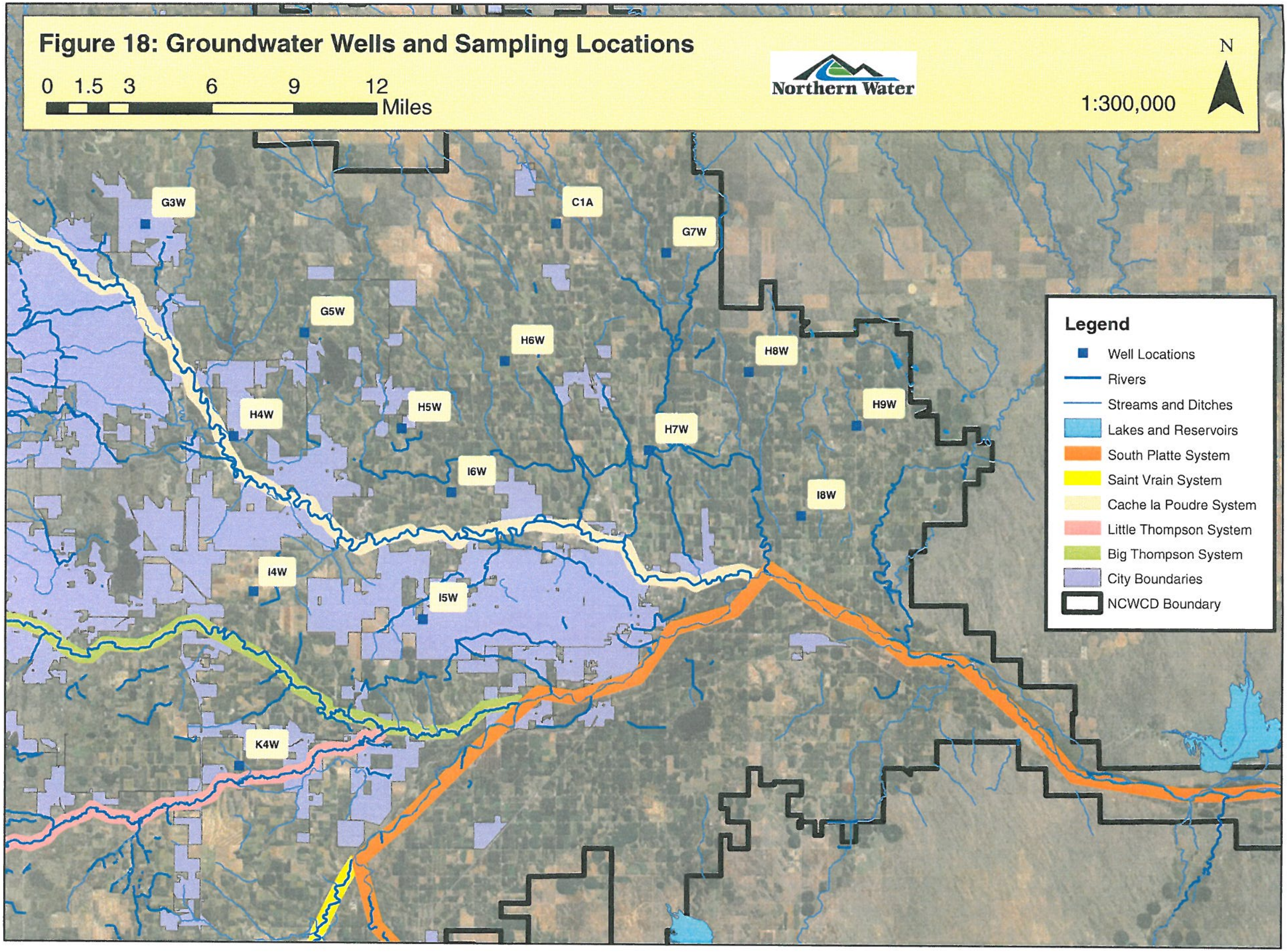


Figure 18: Groundwater Wells and Sampling Locations



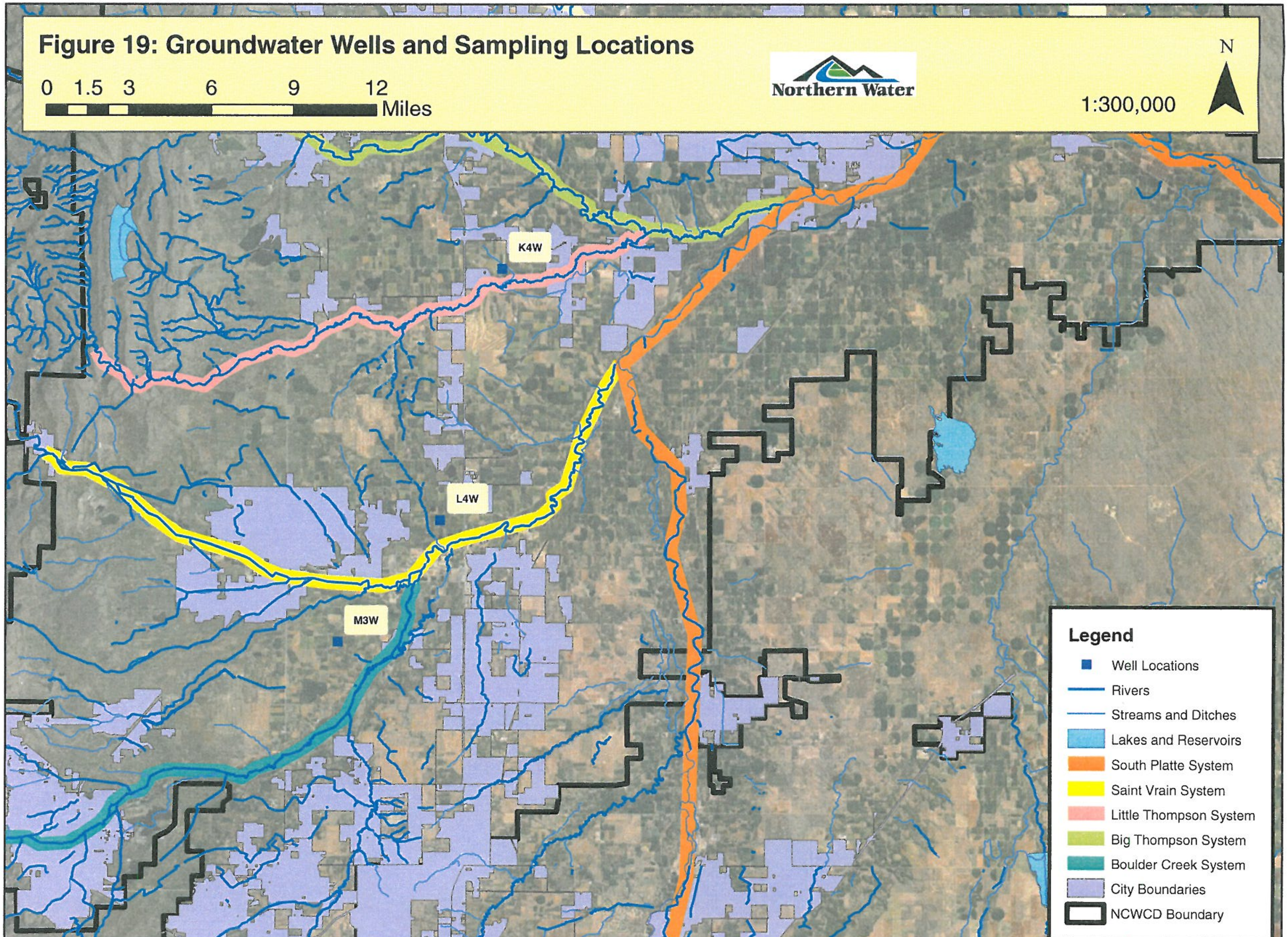
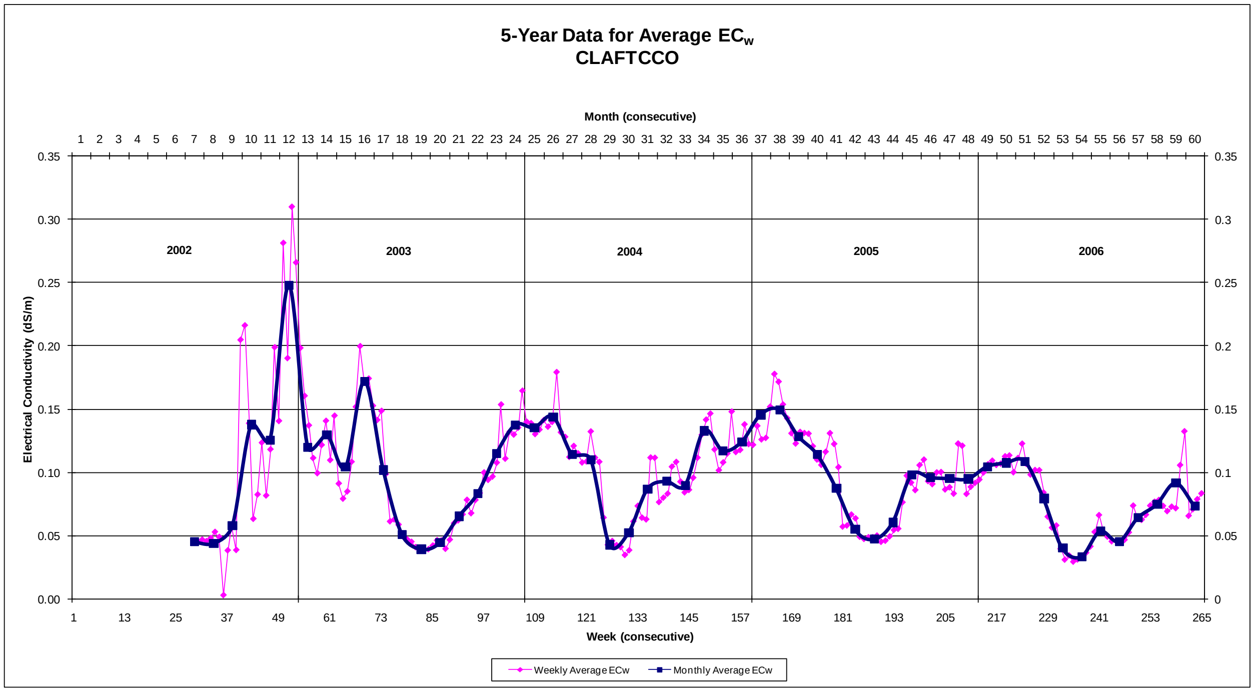


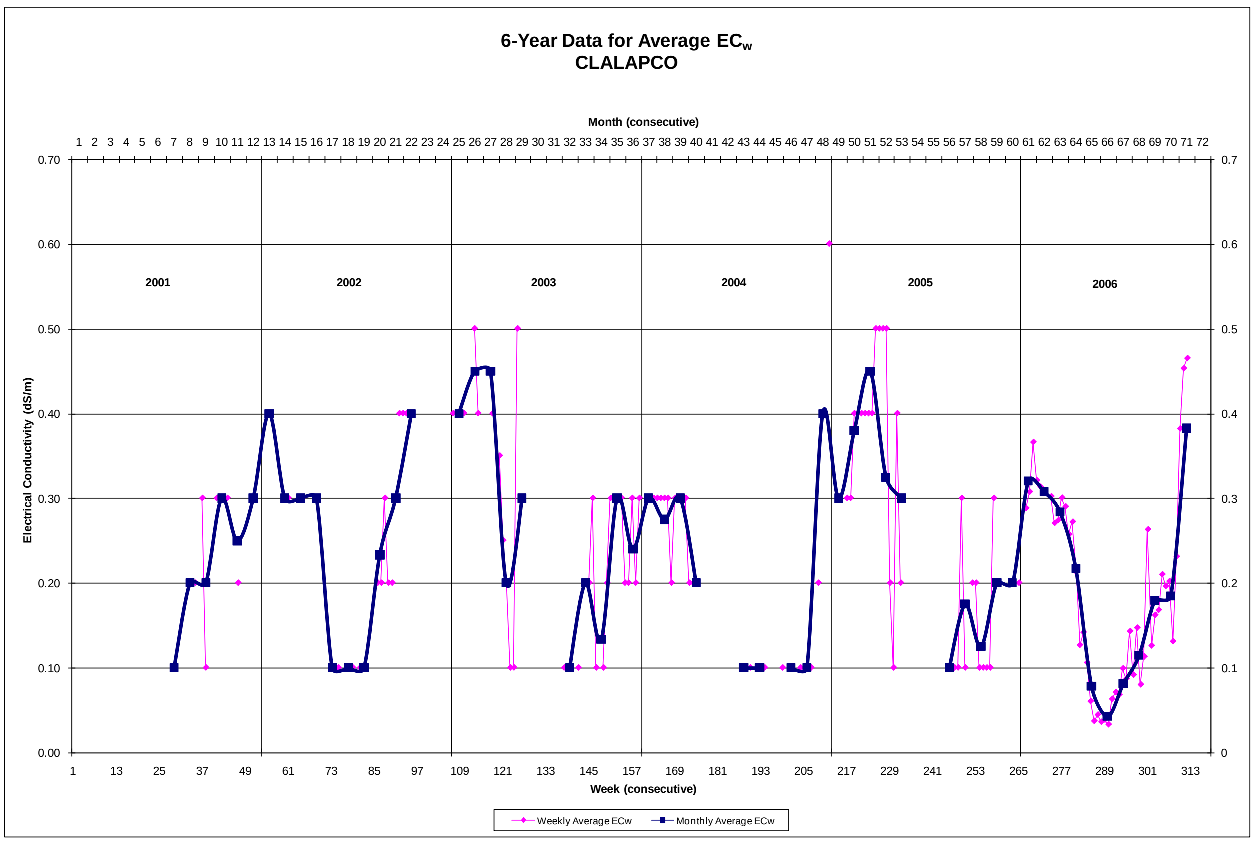
Figure 19: Groundwater Wells and Sampling Locations
0 1.5 3 6 9 12
Miles
Northern Water
1:300,000
N
K4W
L4W
M3W
Legend
Well Locations
Rivers
Streams and Ditches
Lakes and Reservoirs
South Platte System
Saint Vrain System
Little Thompson System
Big Thompson System
Boulder Creek System
City Boundaries
NCWCD Boundary

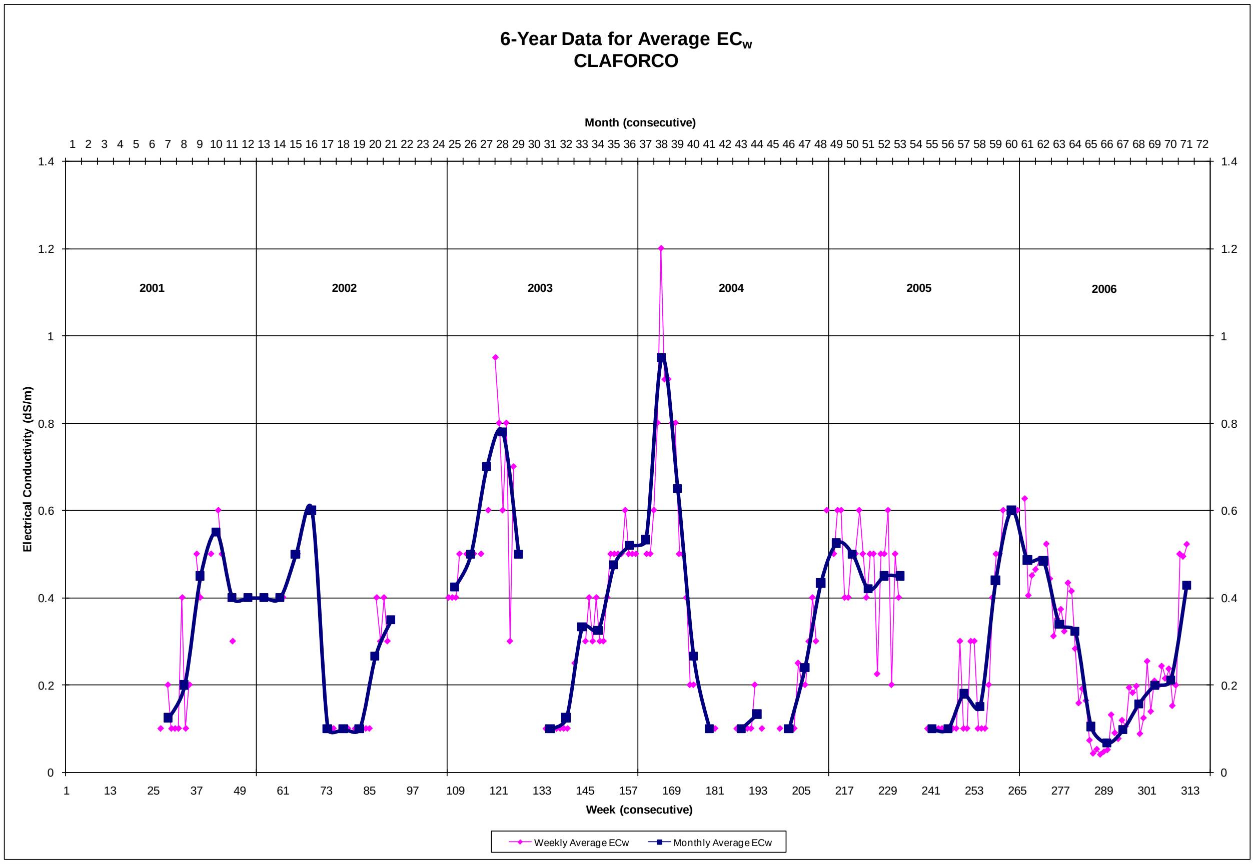
APPENDIX B

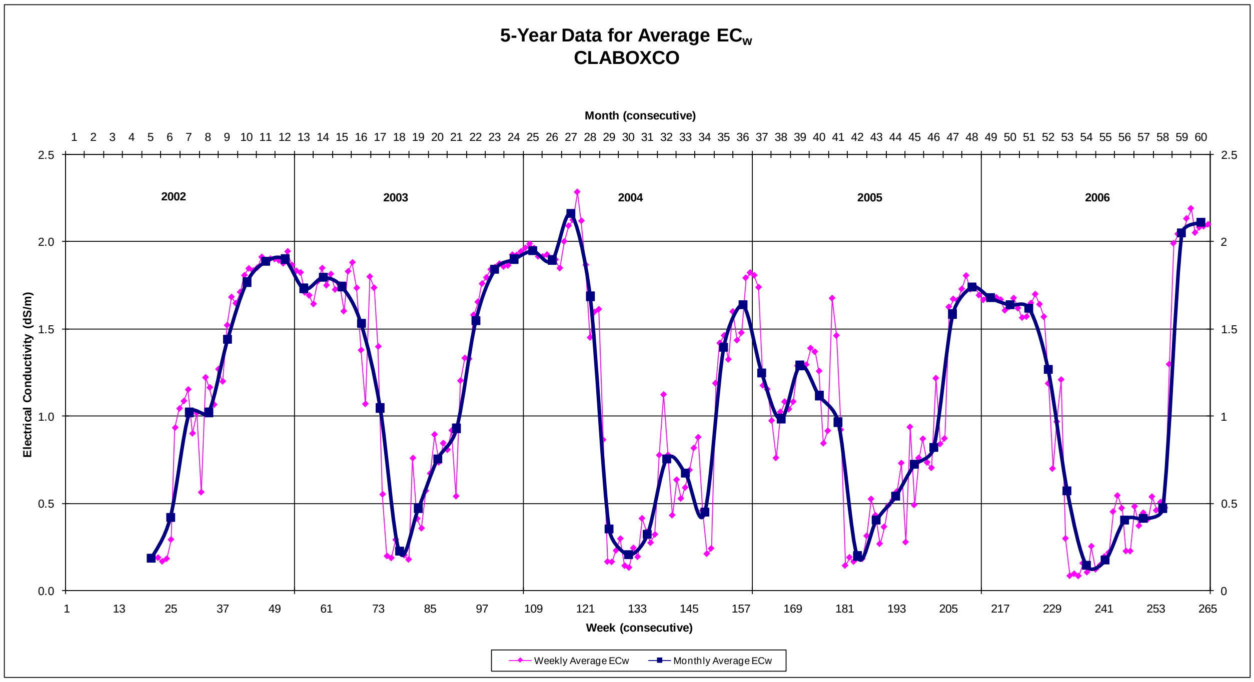
River System Time Series Plots

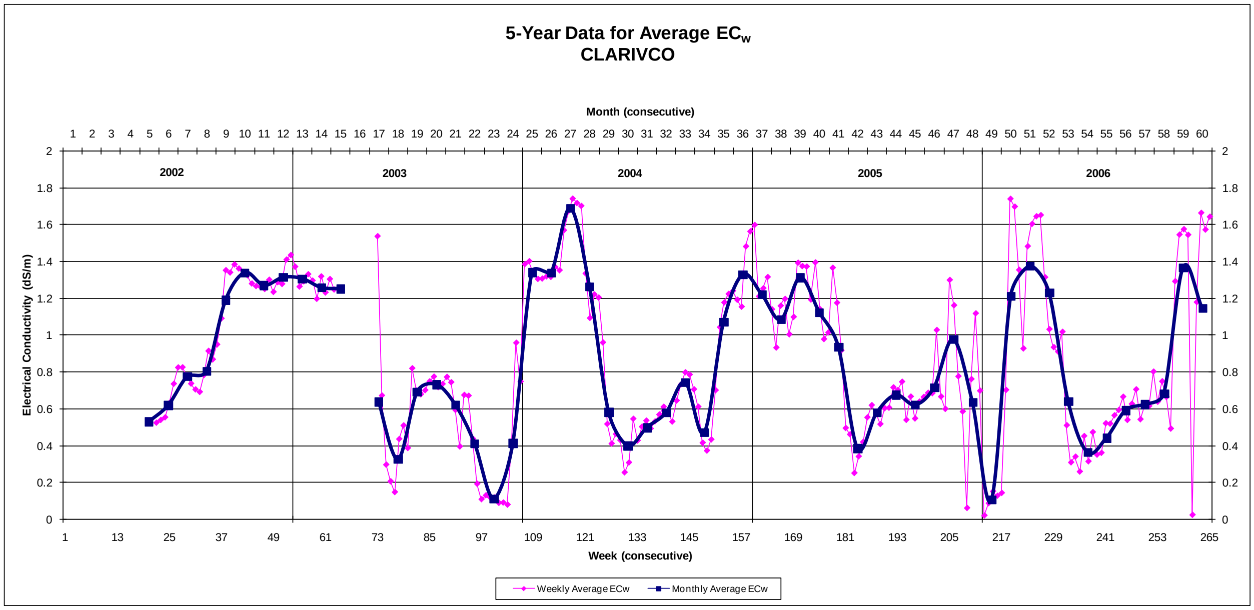
Cache la Poudre System

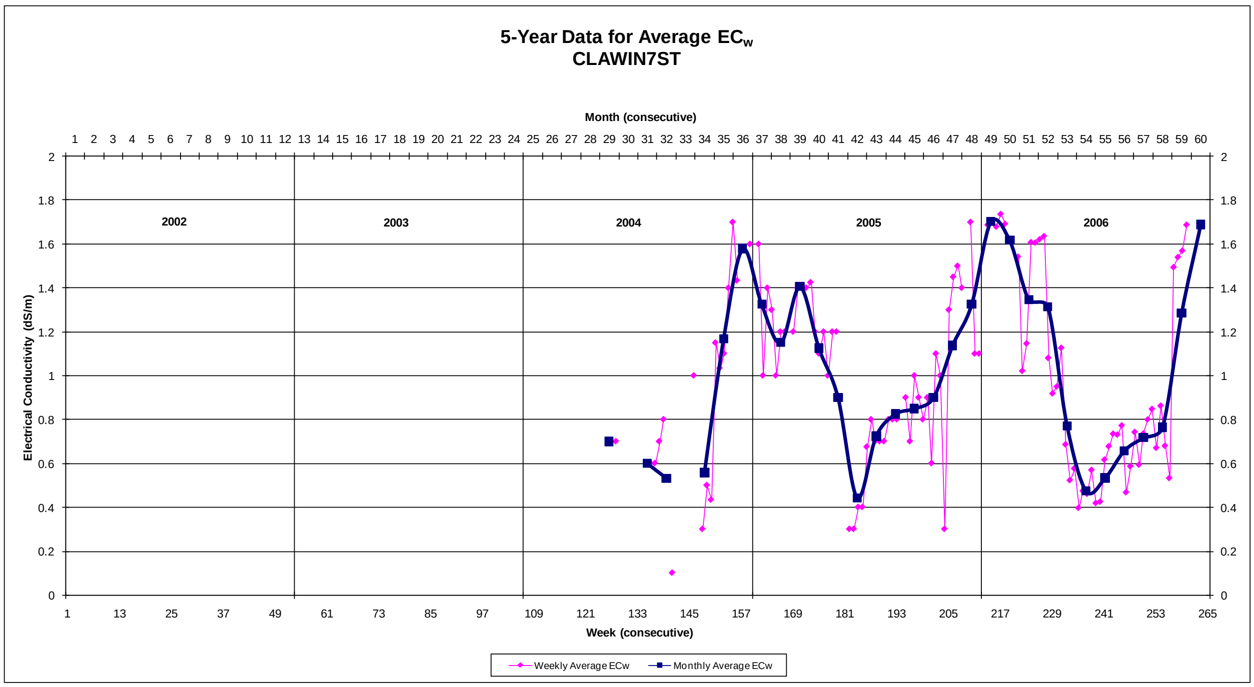


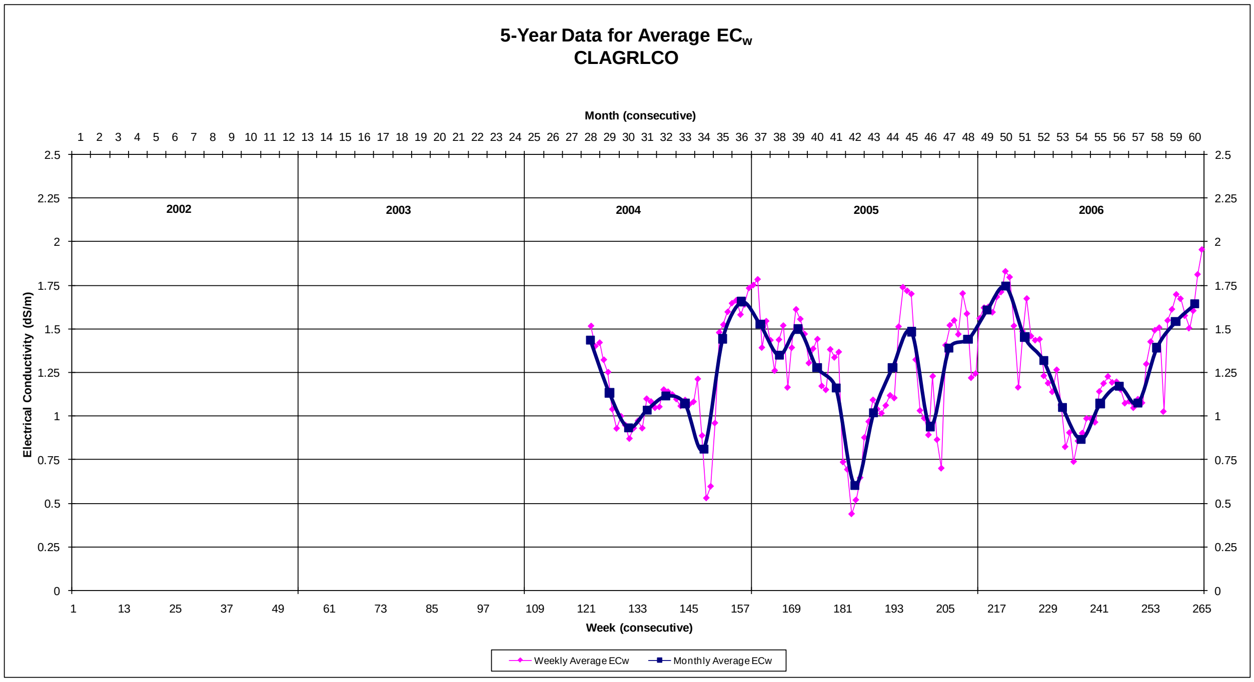


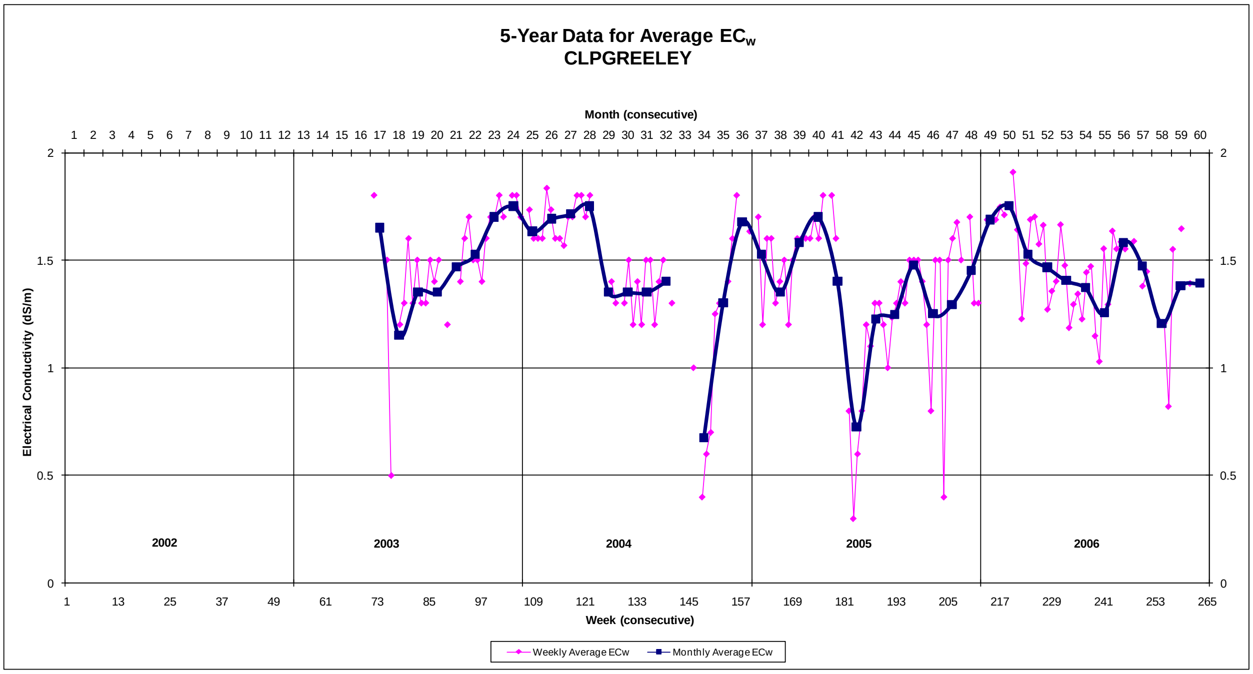

6-Year Data for Average EC_w
CLAFORCO
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

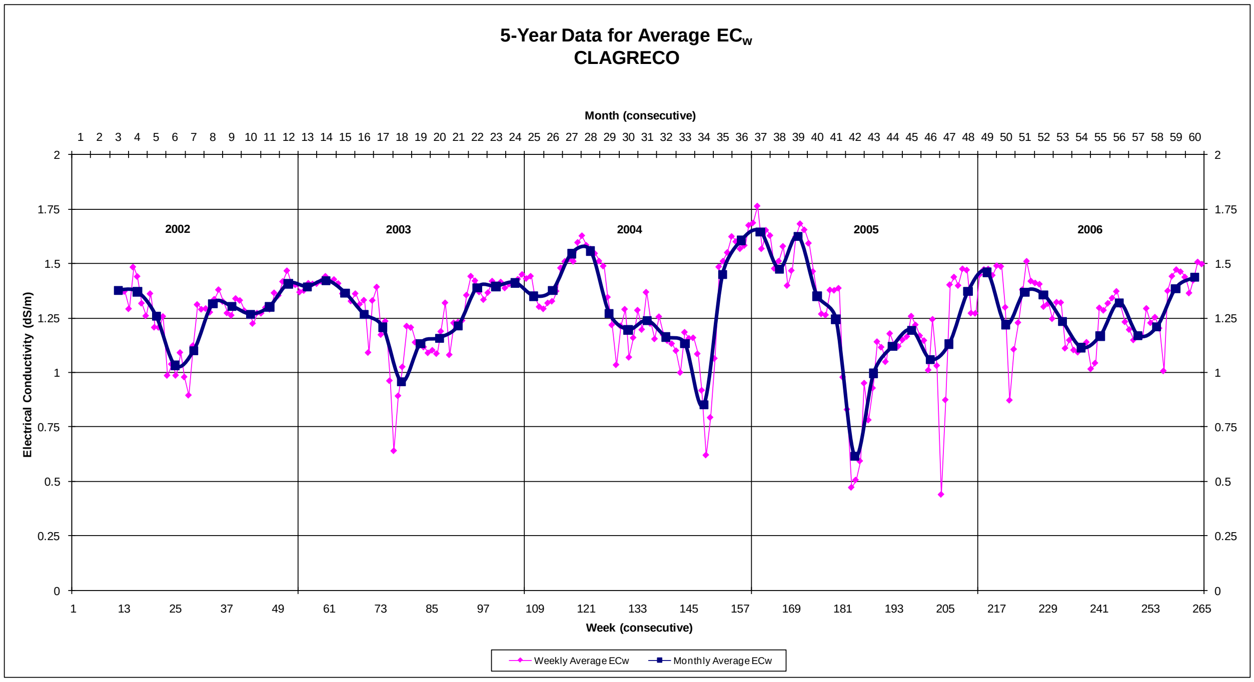

5-Year Data for Average EC_w
CLABOXCO
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average EC_w
CLARIVCO
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

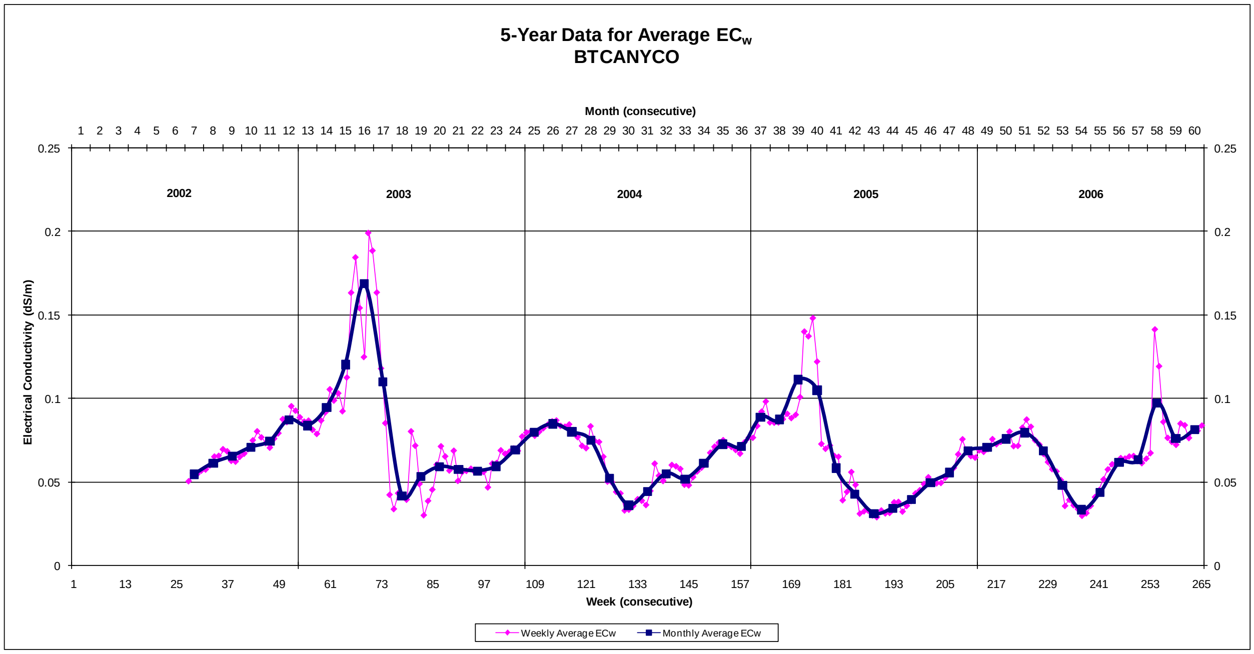

5-Year Data for Average EC_w
CLAWIN7ST
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

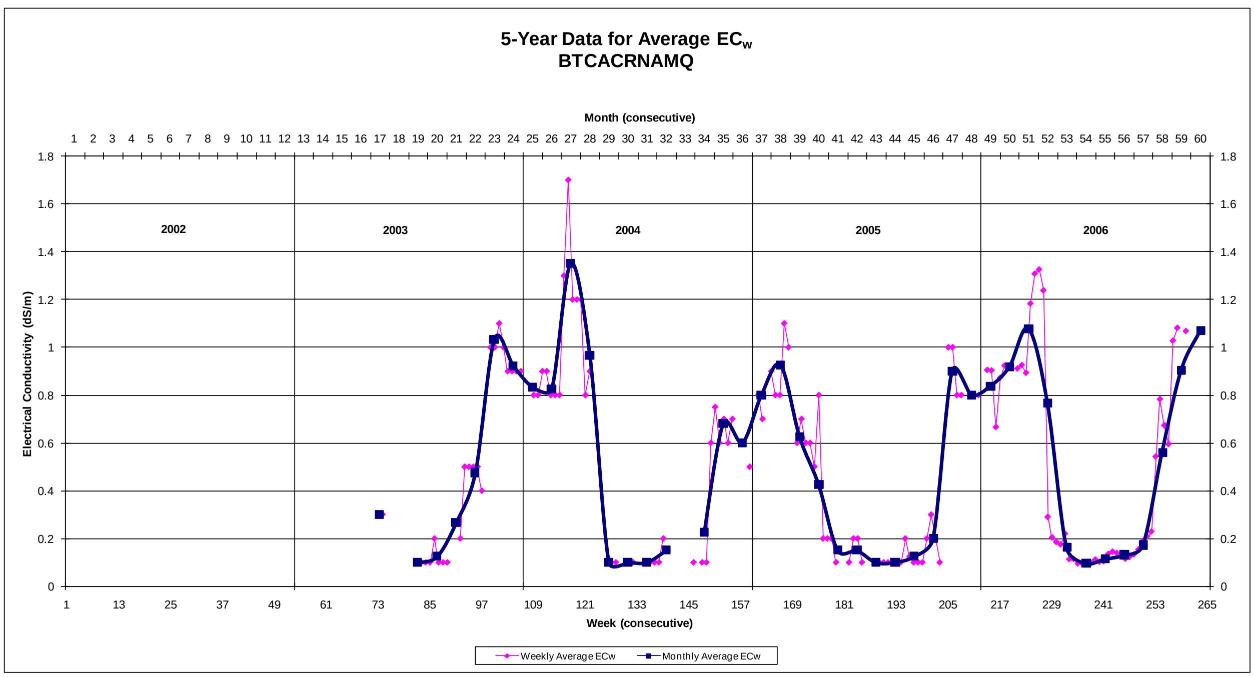

5-Year Data for Average EC_w
CLAGRLCO
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

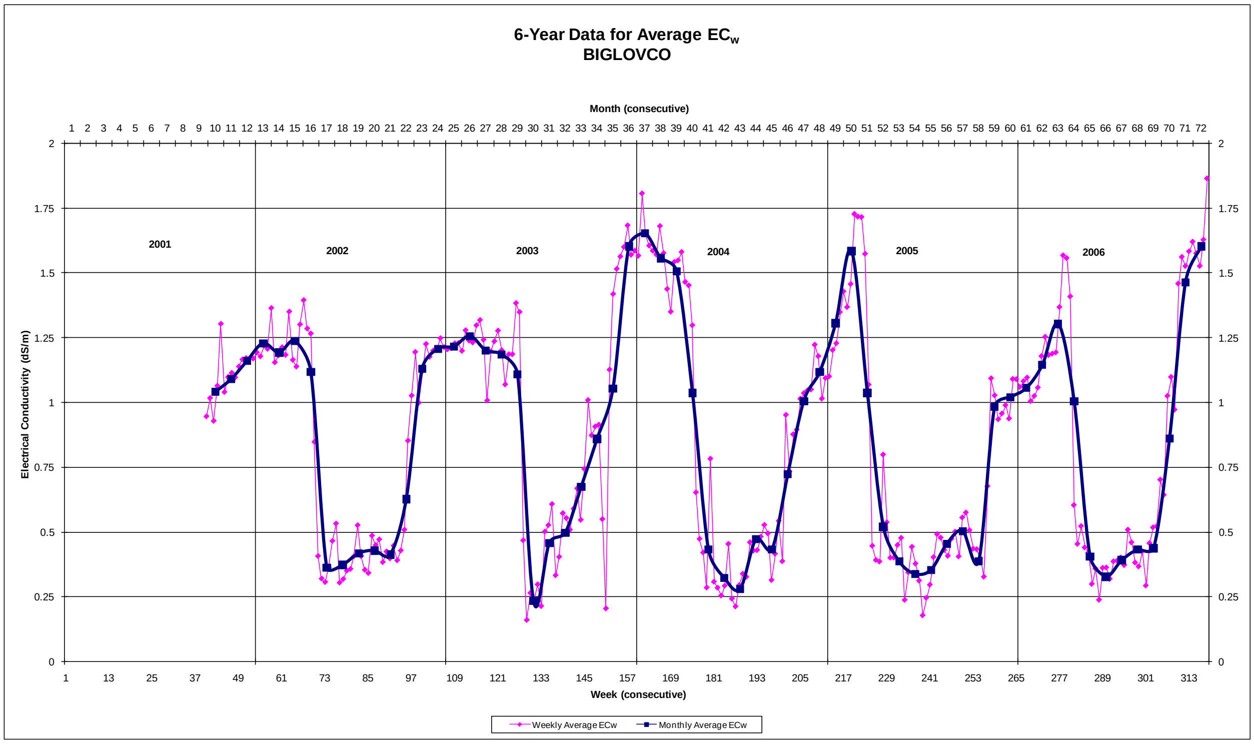

5-Year Data for Average EC_w
CLPGREELEY
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average EC_w
CLAGRECO
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

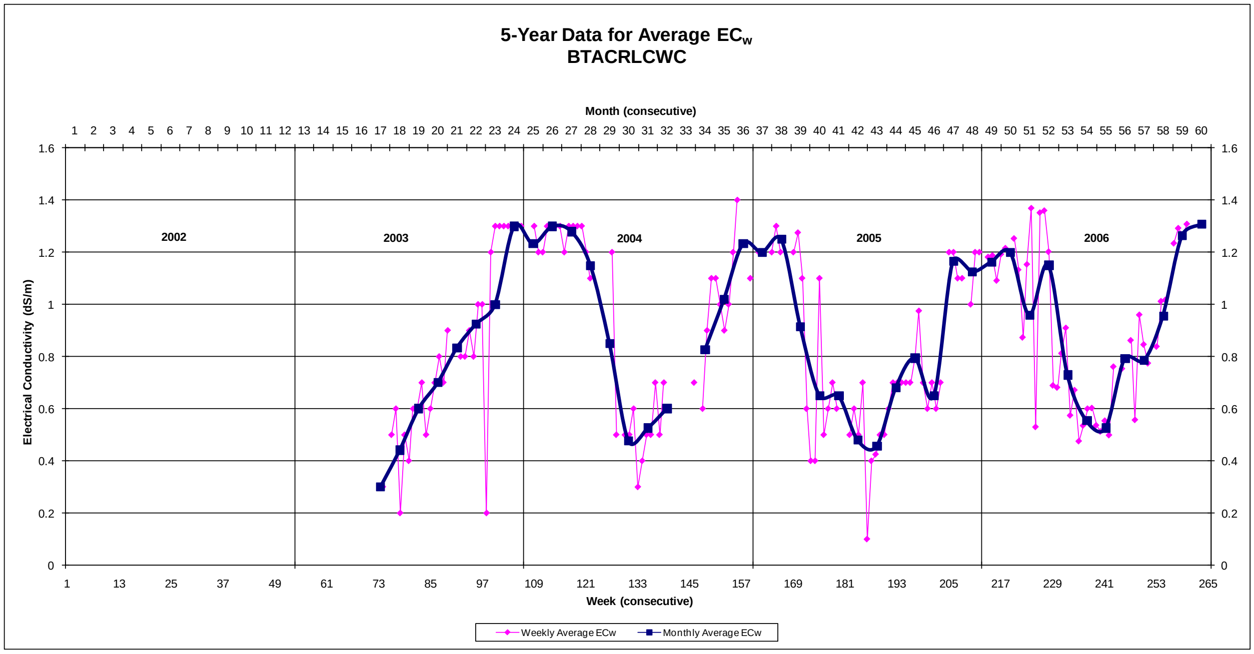
Big Thompson System



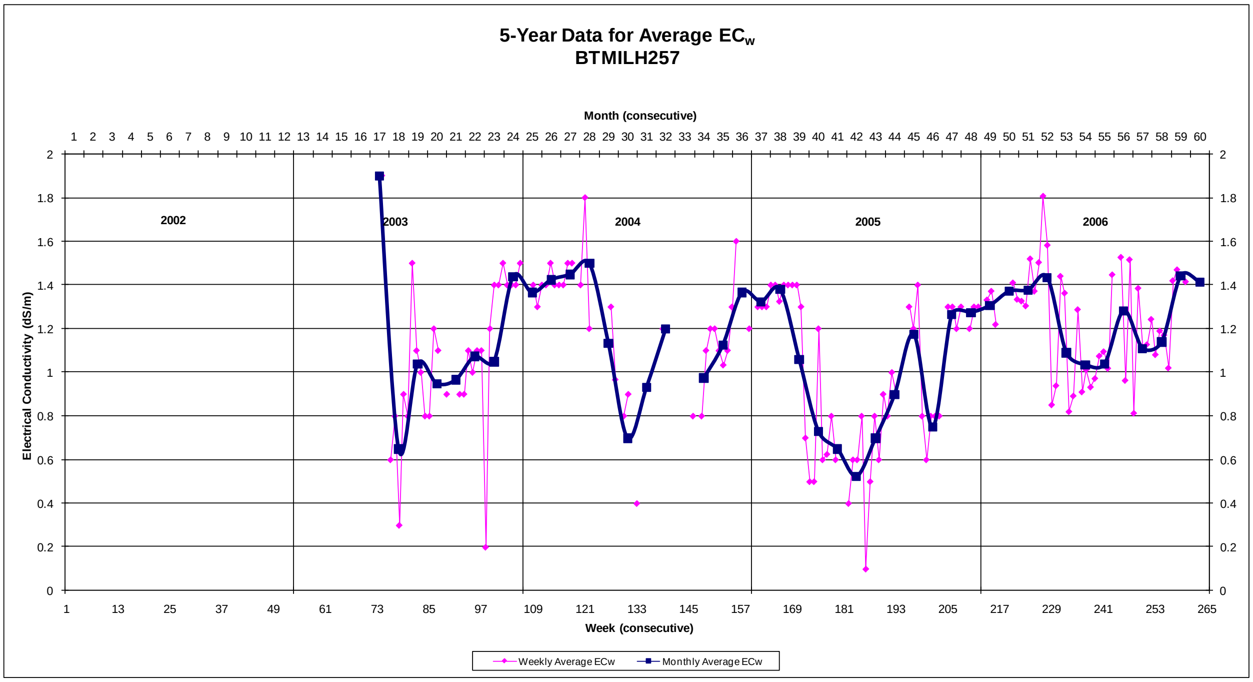


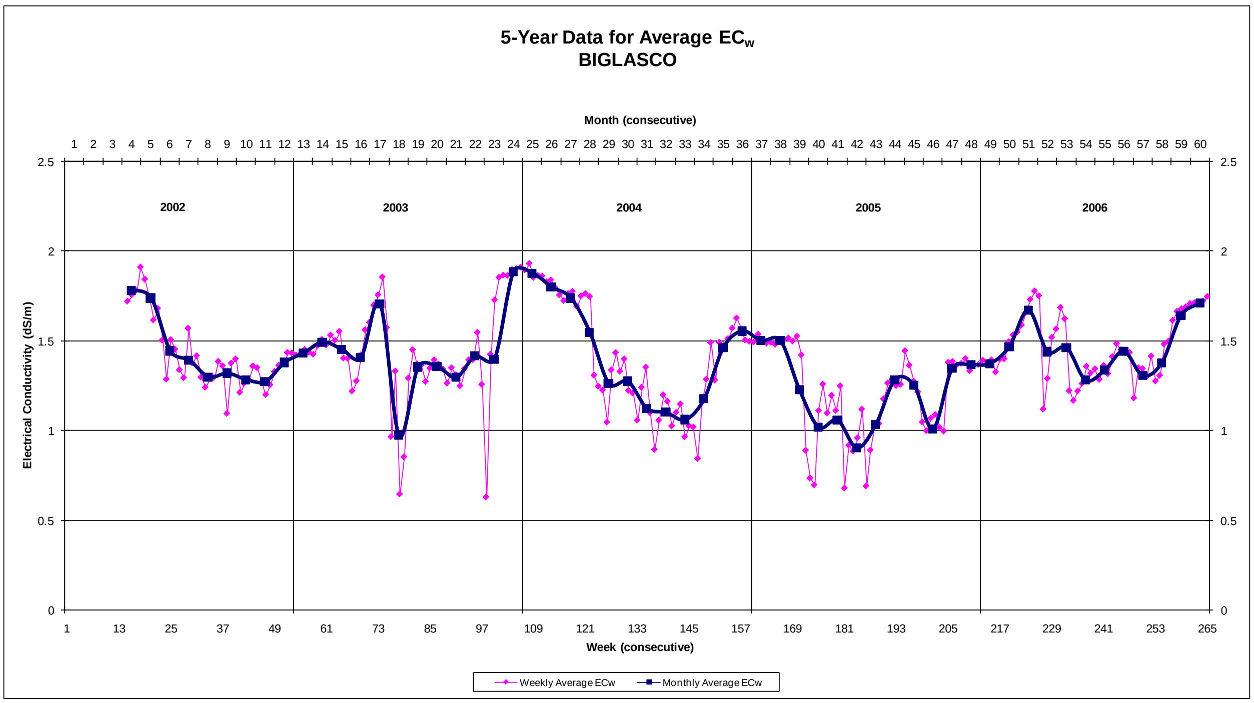


6-Year Data for Average EC_w
BIGLOVCO
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

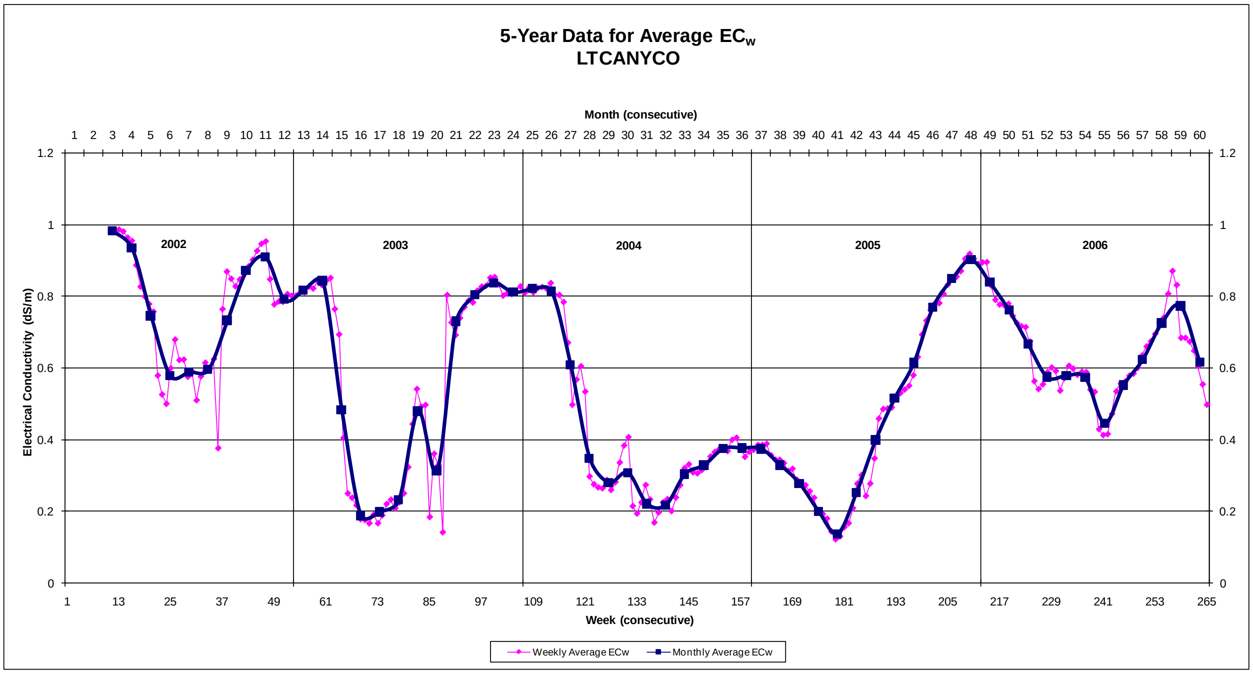


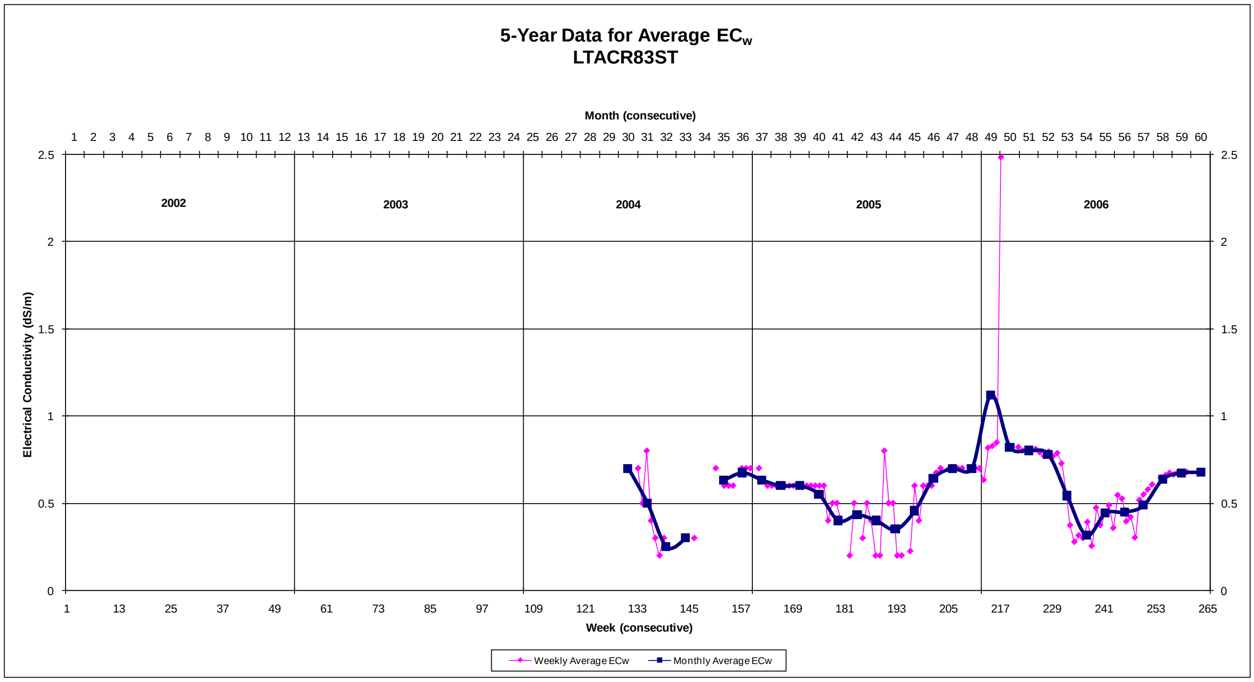
5-Year Data for Average EC_w
BTACRLCWC
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

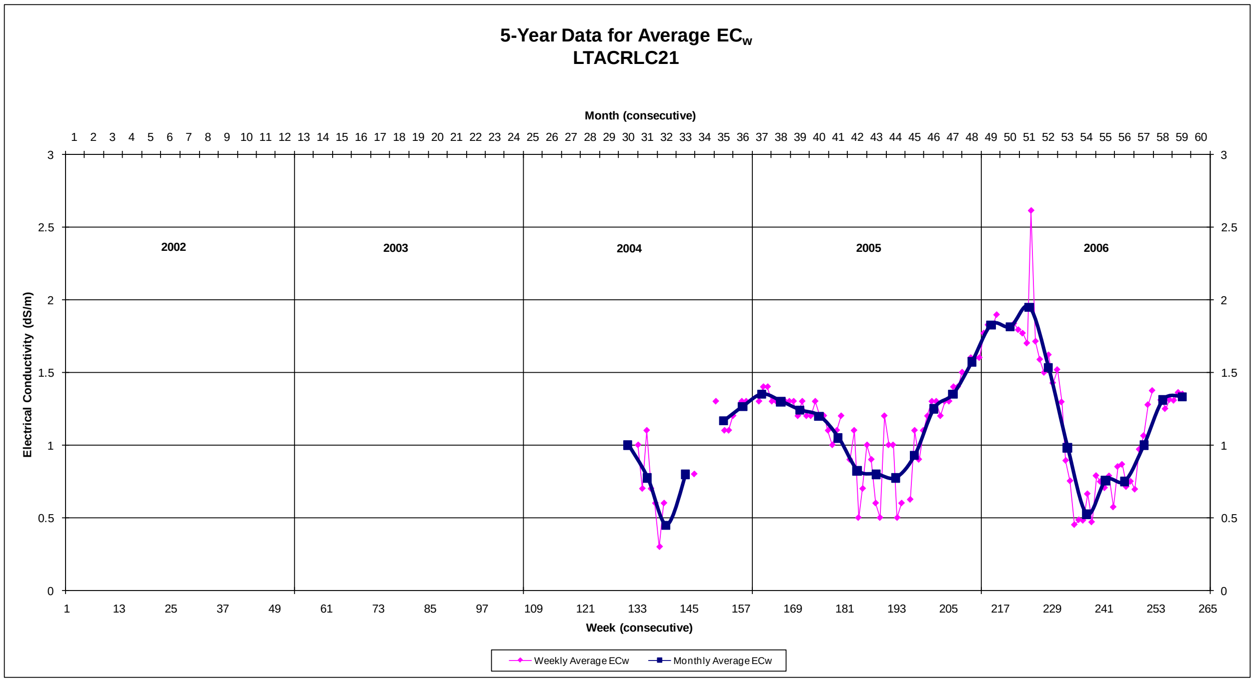

5-Year Data for Average EC_w
BTMILH257
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

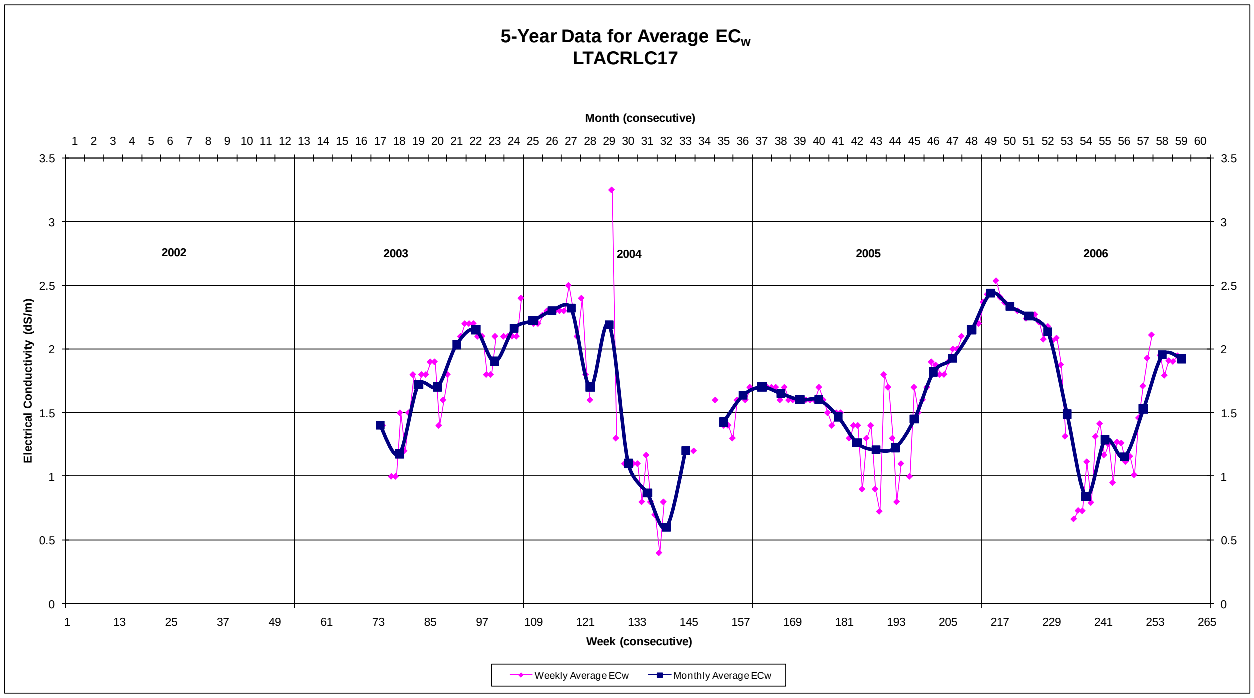

5-Year Data for Average EC_w
BIGLASCO
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

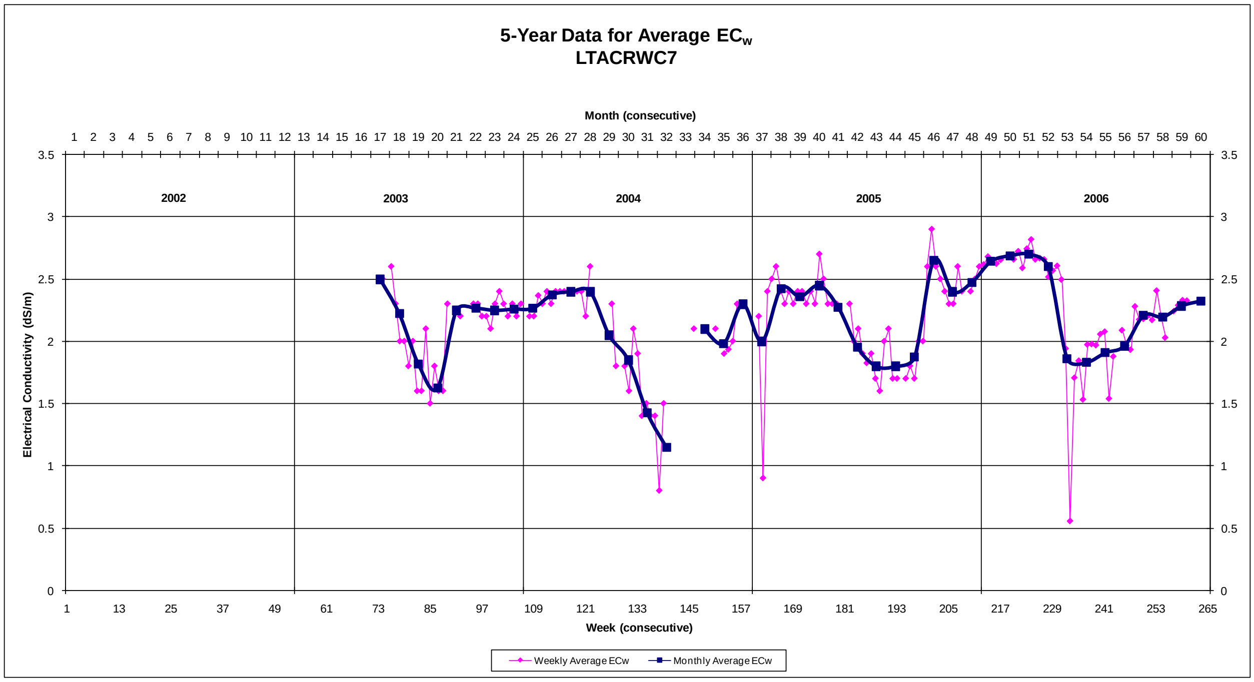
Little Thompson System

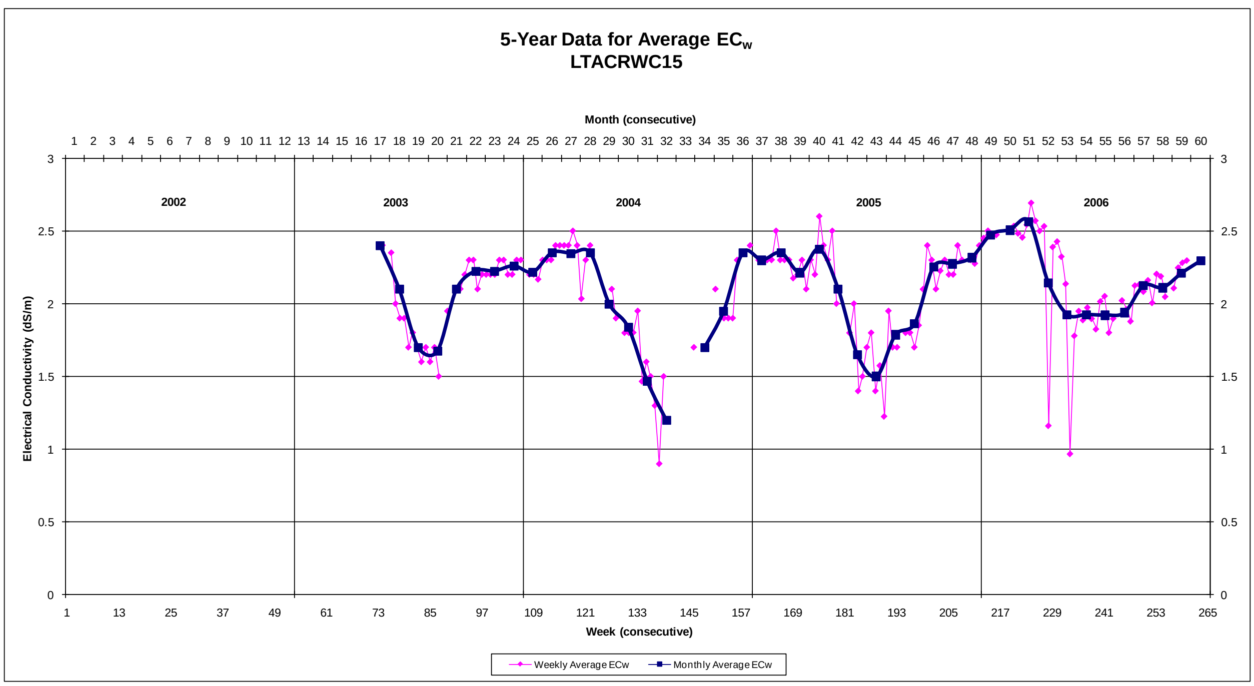


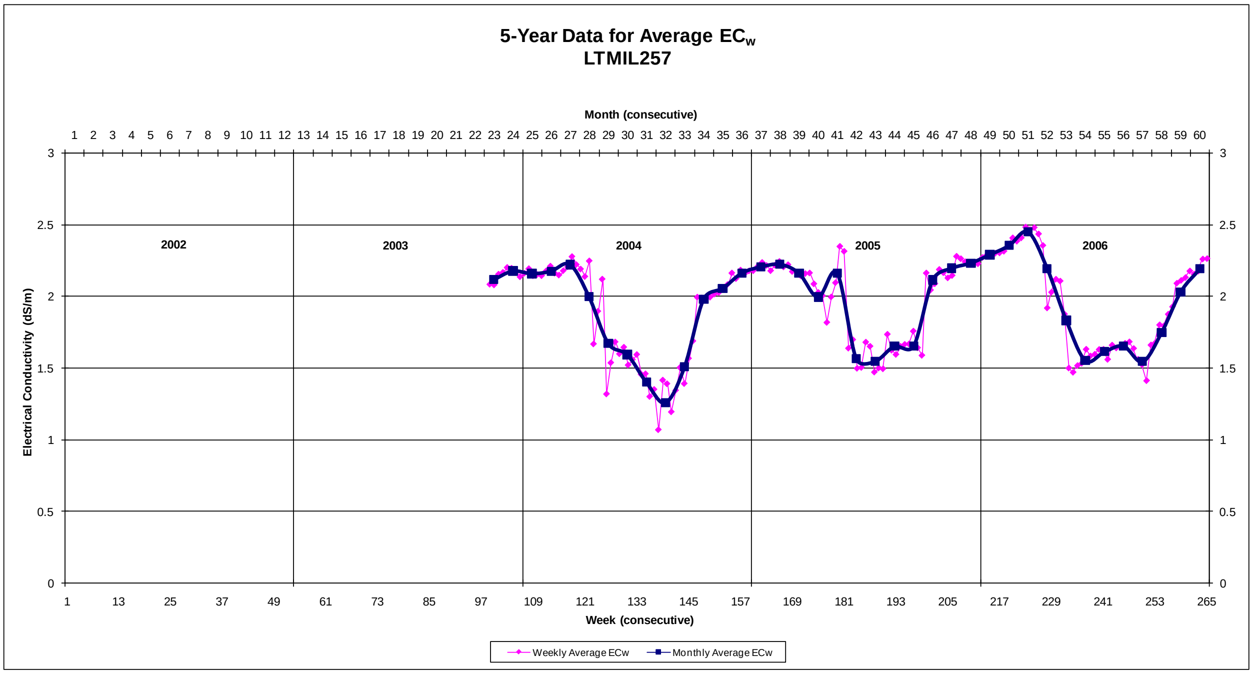



5-Year Data for Average EC_w
LTACRLC21
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

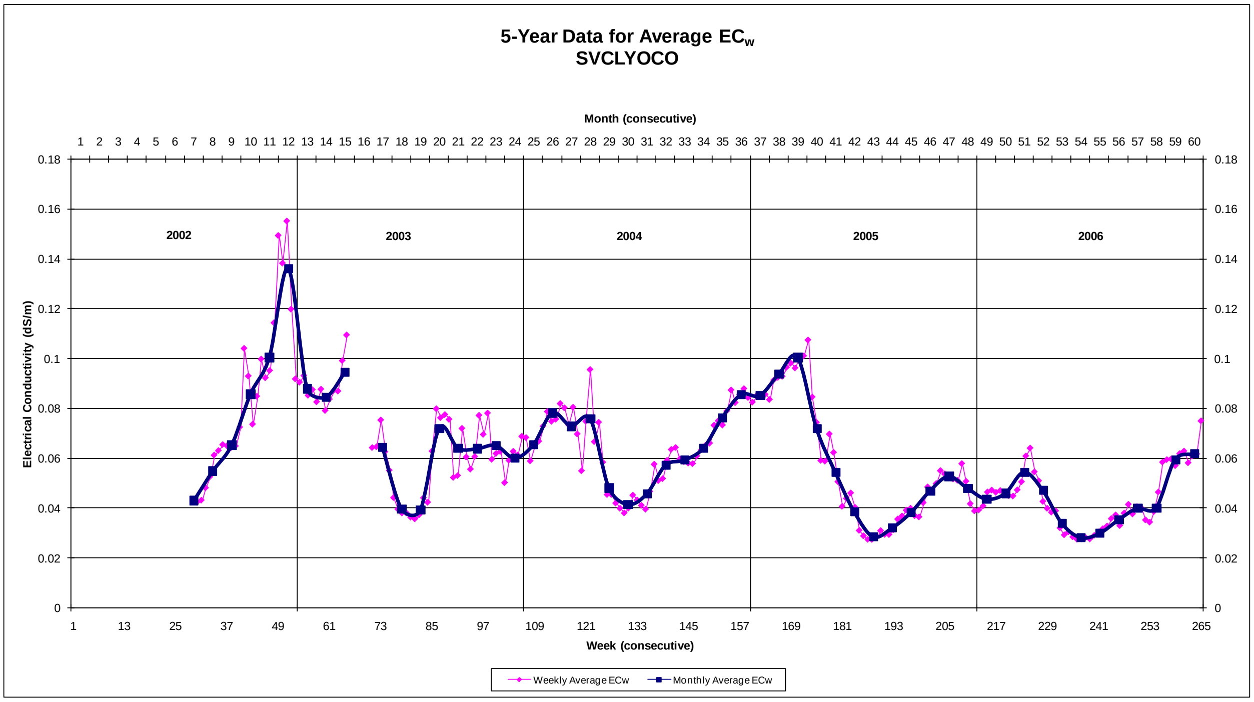

5-Year Data for Average EC_w
LTACRLC17
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

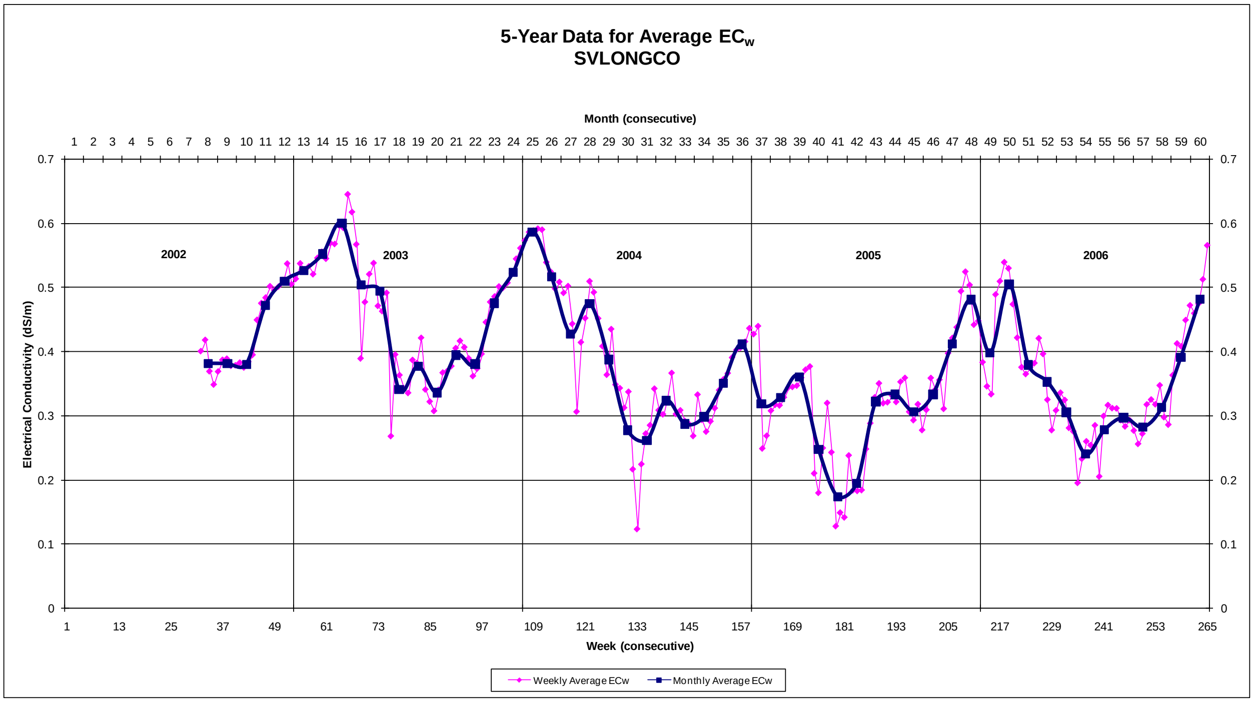

5-Year Data for Average EC_w
LTACRWC7
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

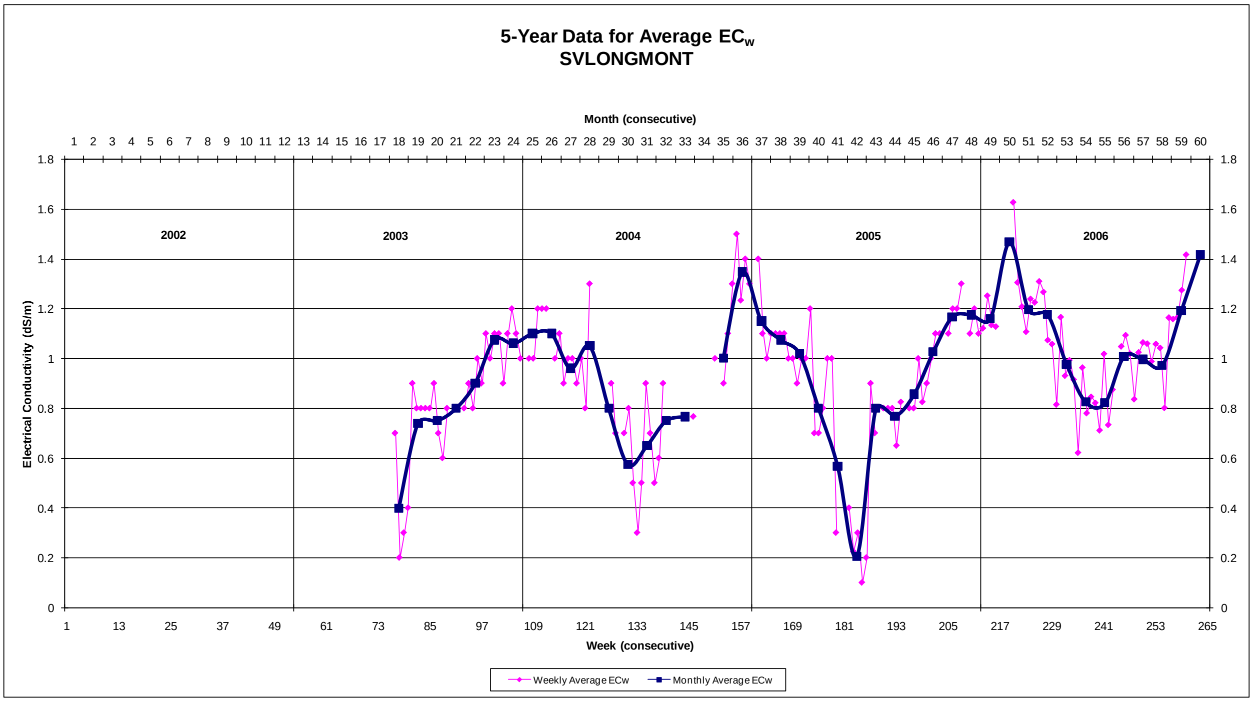

5-Year Data for Average EC_w
LTACRWC15
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

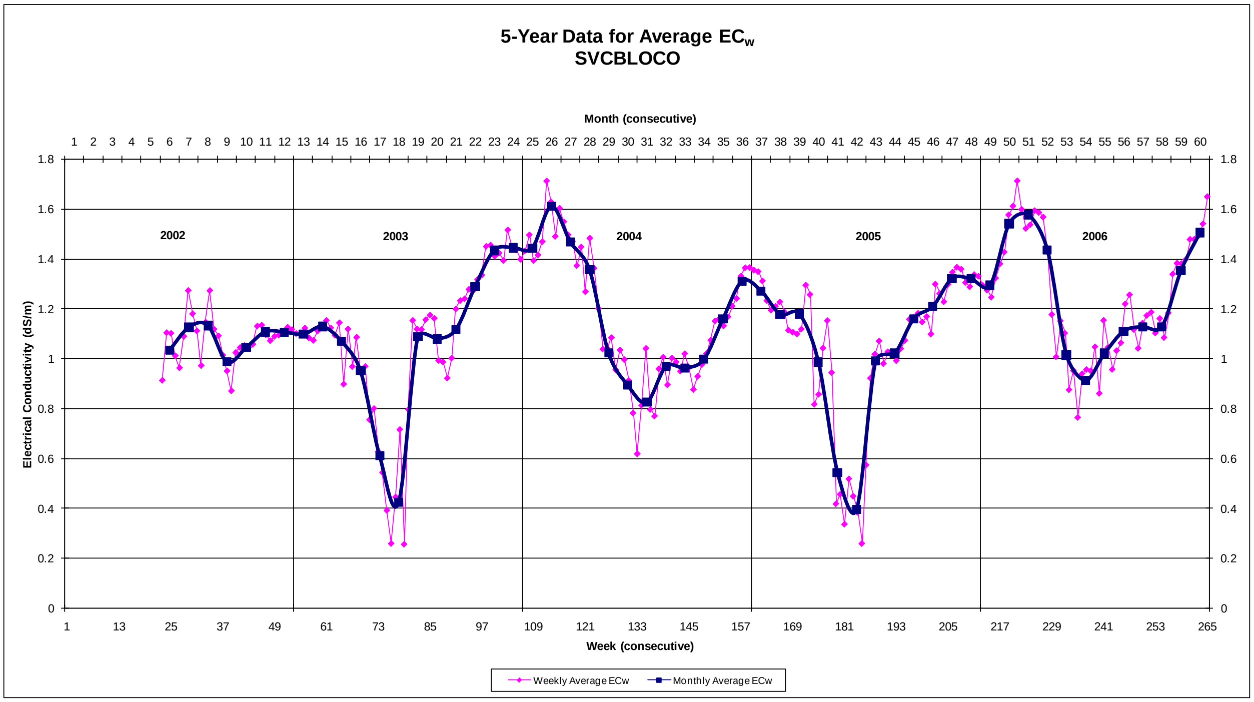

5-Year Data for Average EC_w
LTMIL257
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

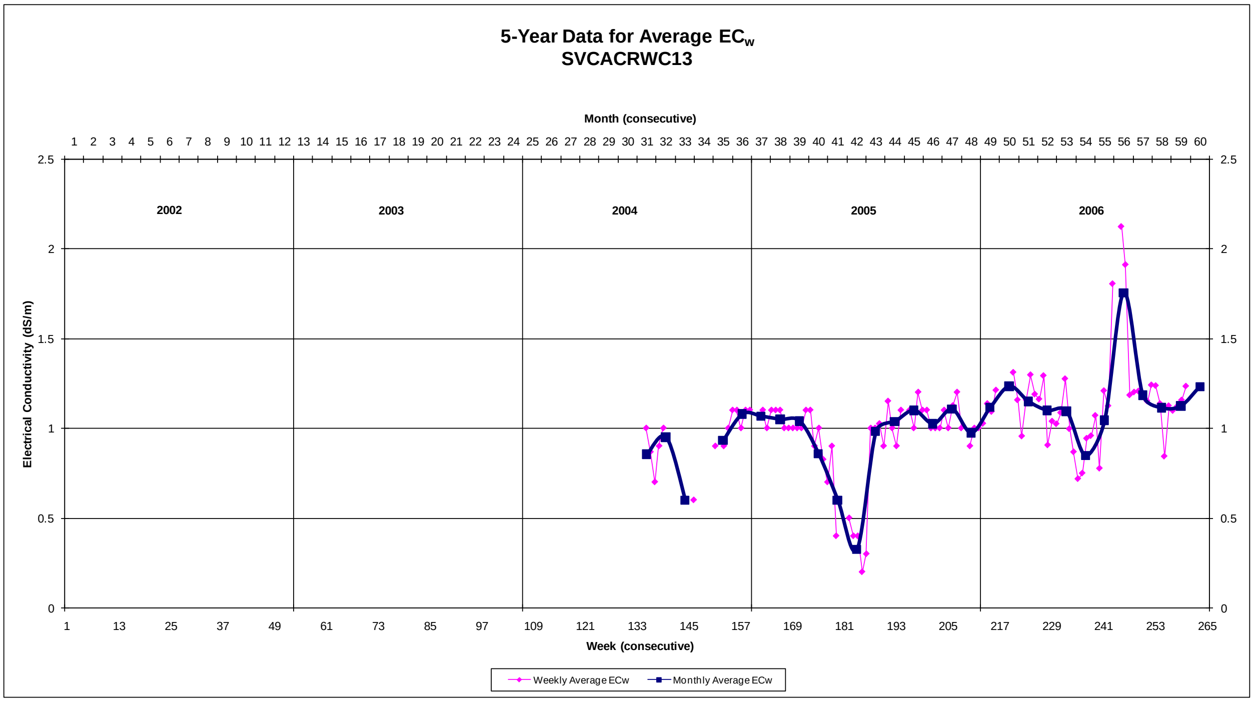
Saint Vrain Creek System



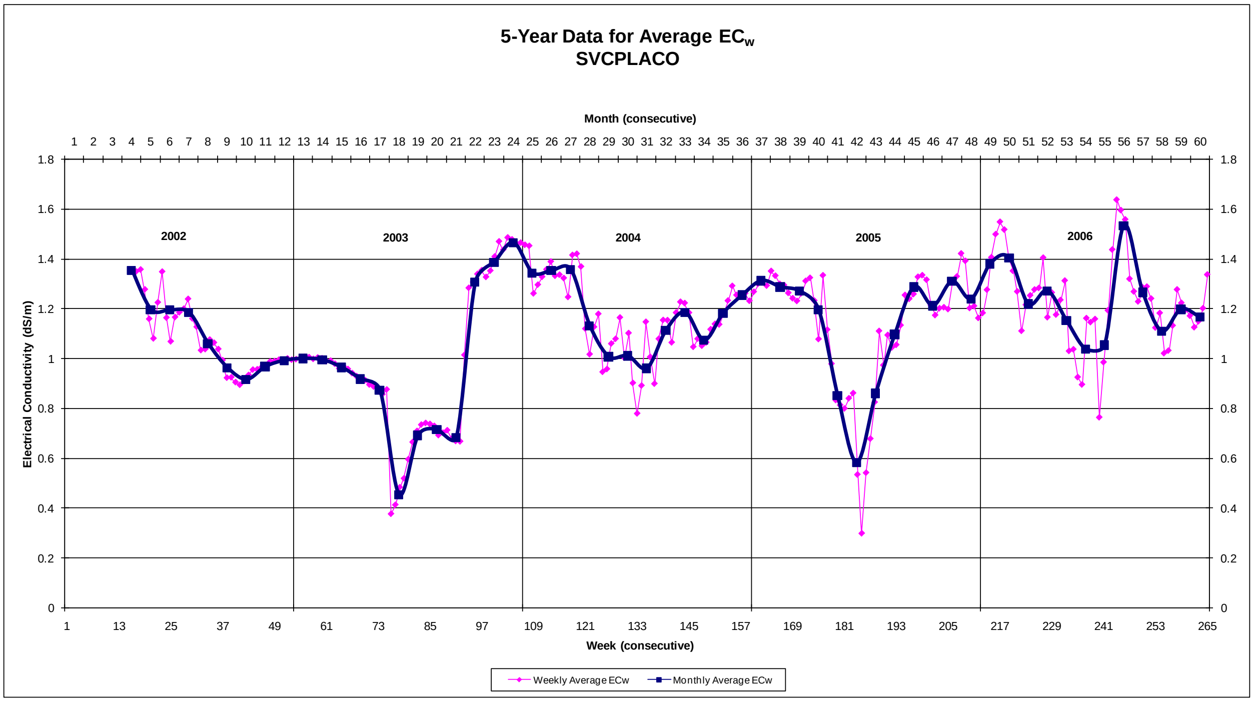



5-Year Data for Average EC_w
SVLONGMONT
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average EC_w
SVCBLOCO
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

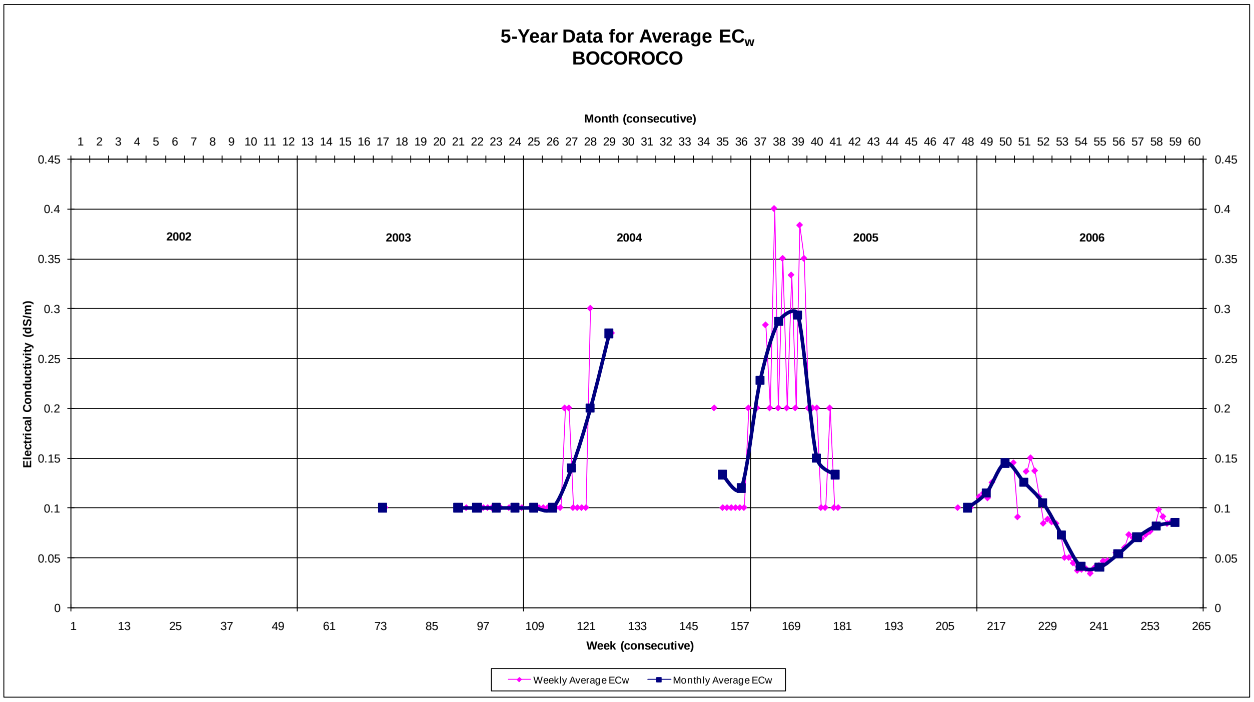


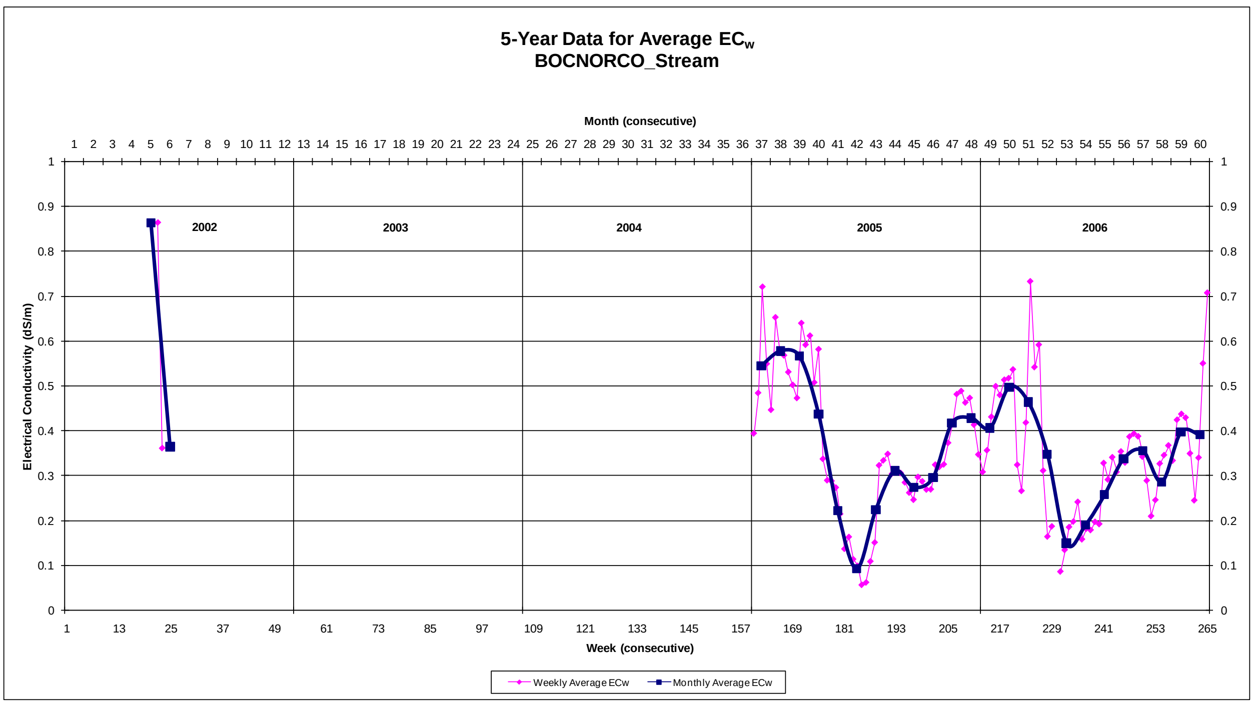
5-Year Data for Average EC_w
SVCACRWC13
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

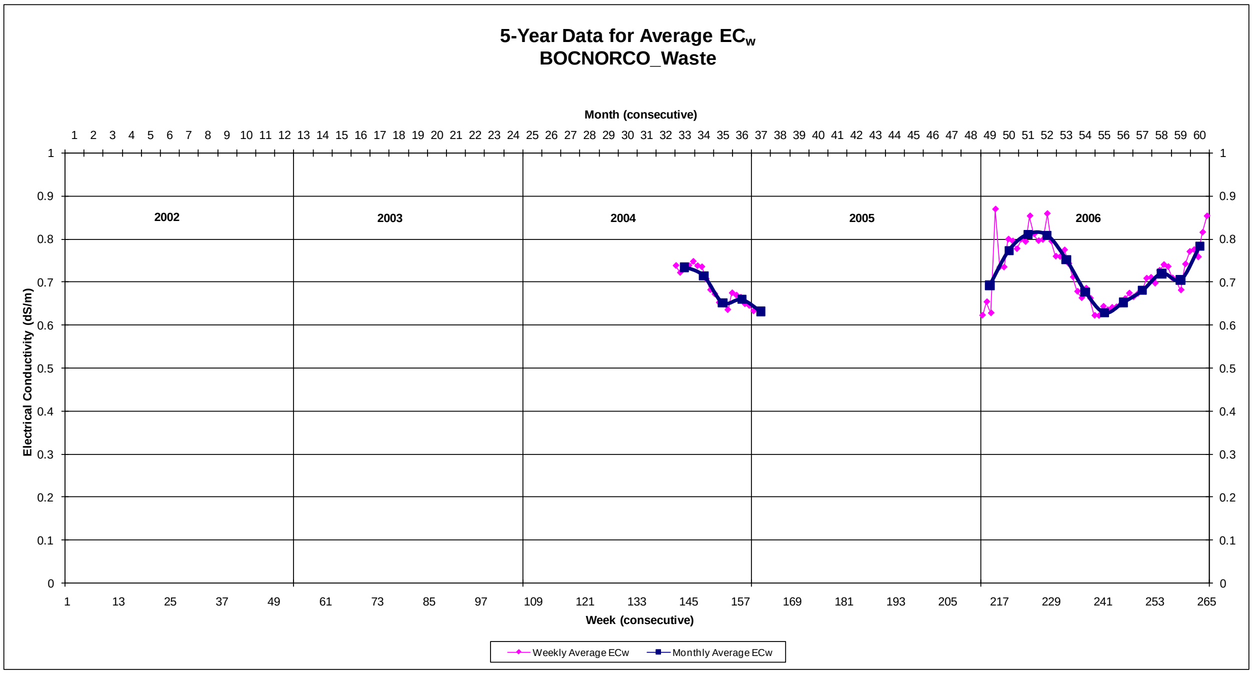


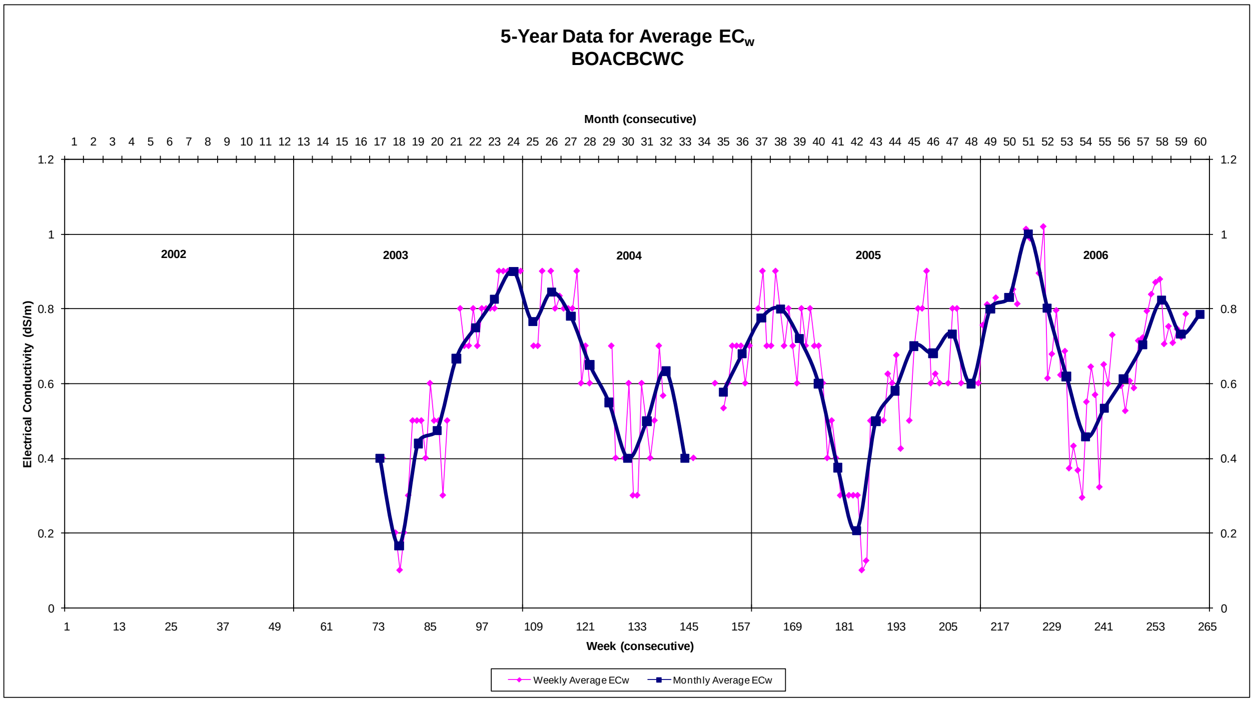
5-Year Data for Average EC_w
SVCPLACO
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

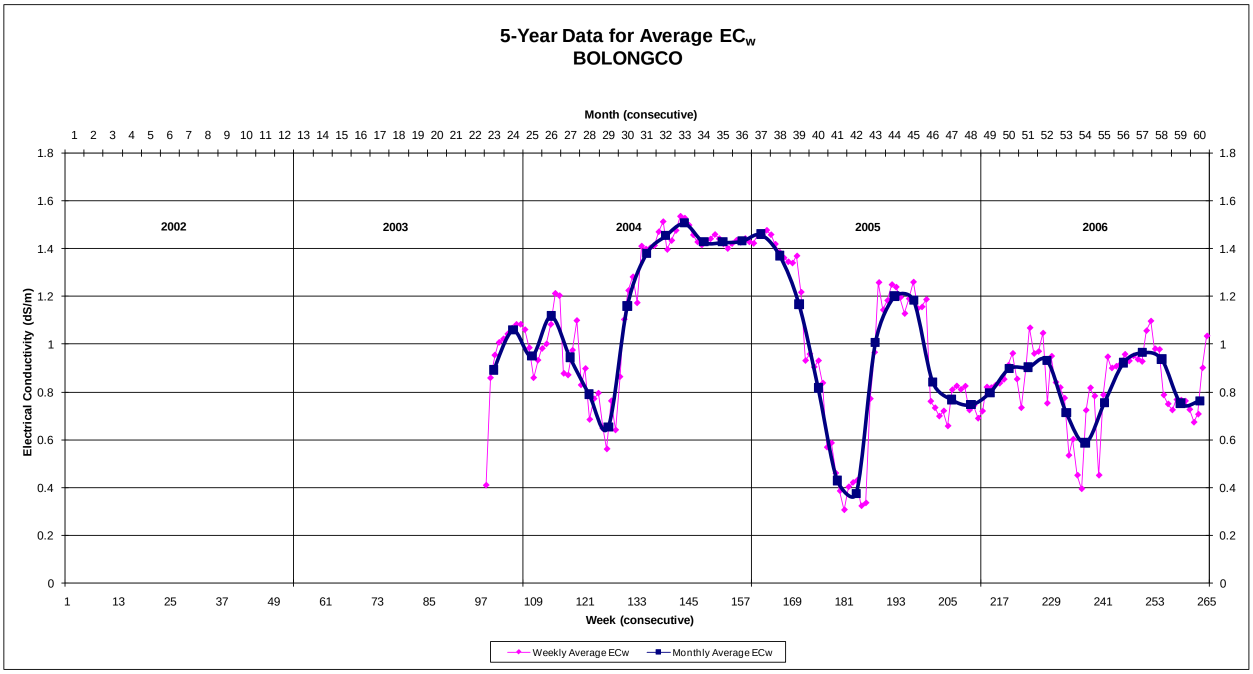
Boulder Creek System





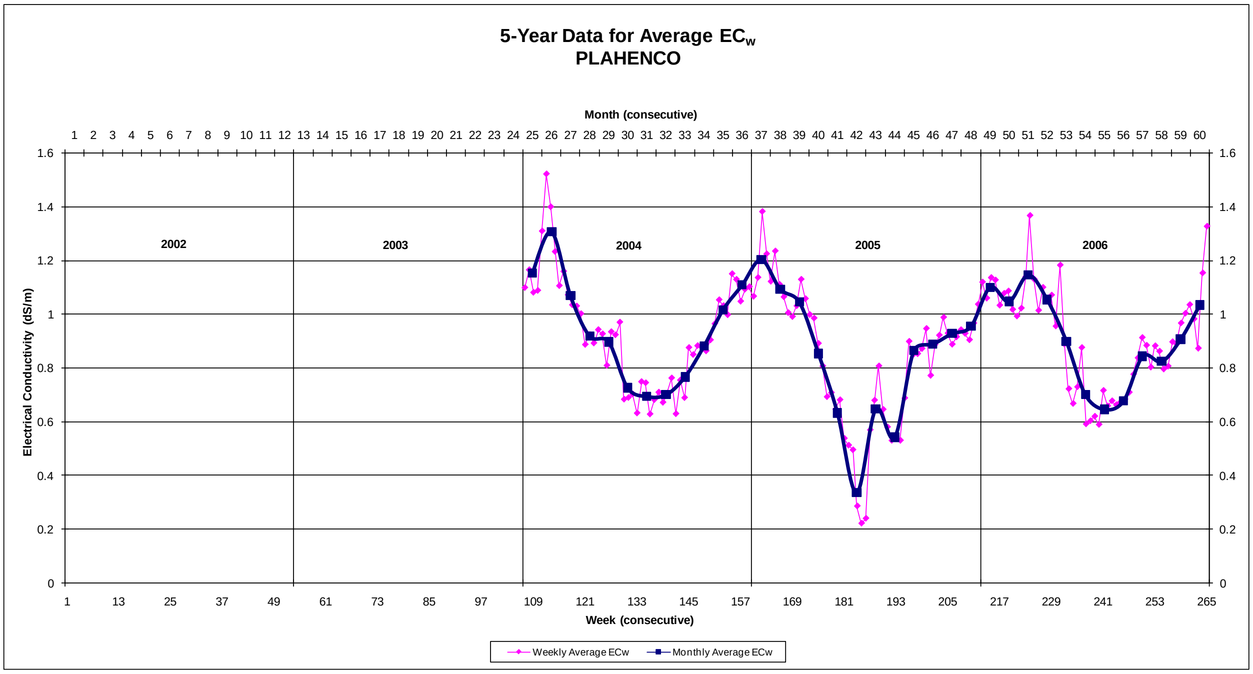

5-Year Data for Average EC_w
BOCNORCO_Waste
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

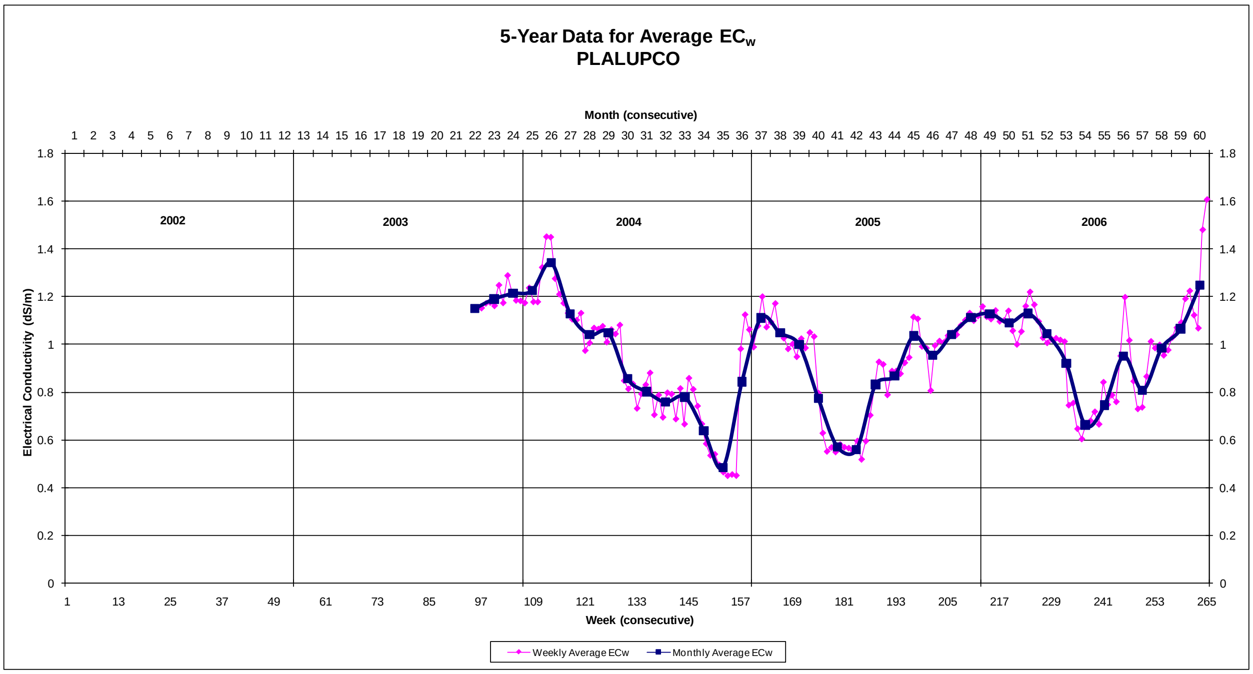

5-Year Data for Average EC_w
BOACBCWC
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

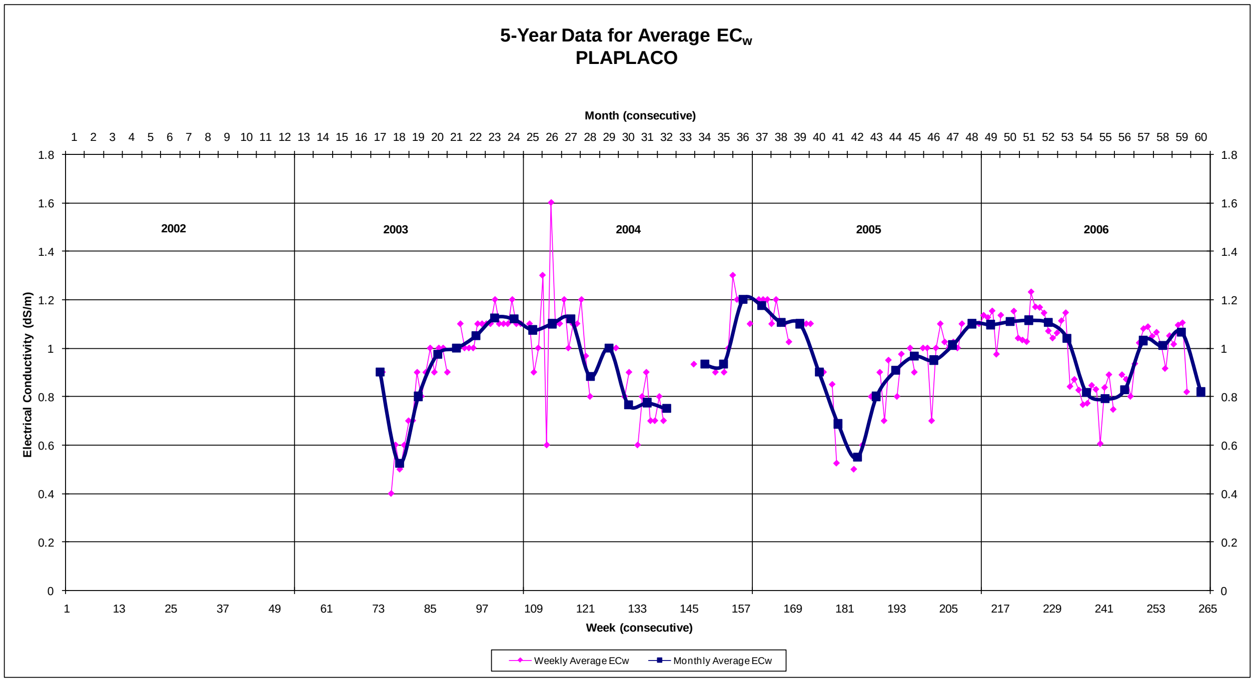


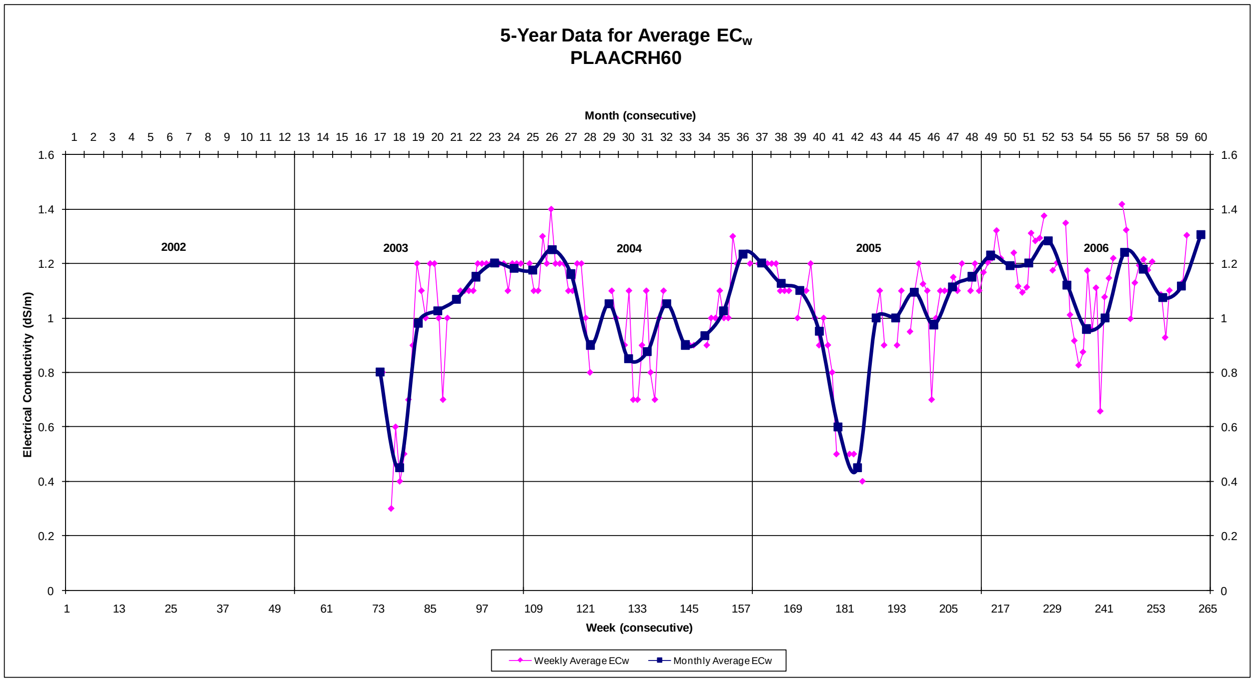
5-Year Data for Average ECw
BOLONGCO
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

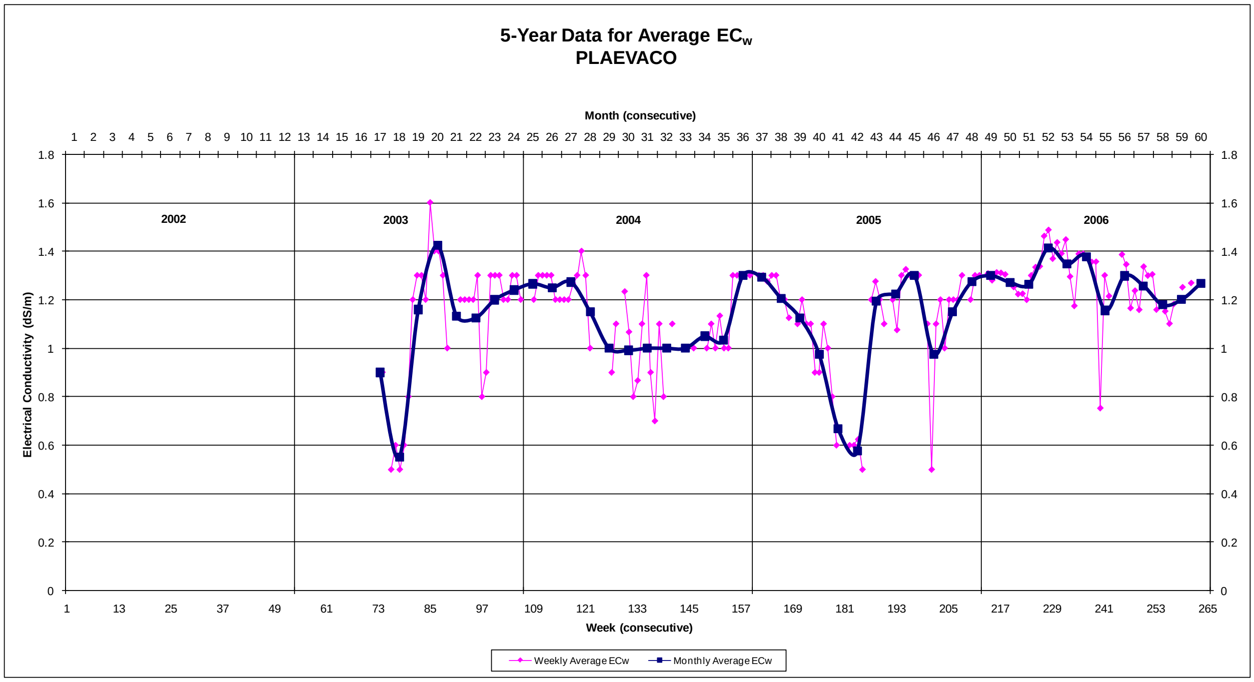
South Platte System



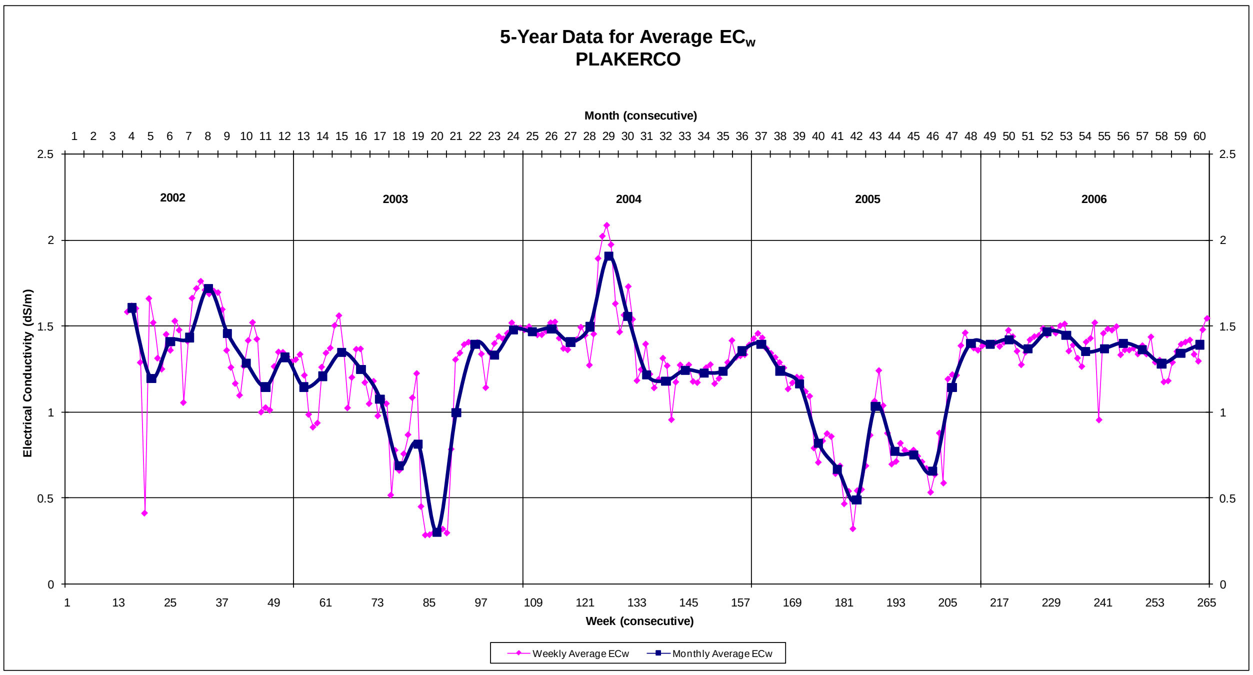



5-Year Data for Average EC_w
PLAPLACO
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

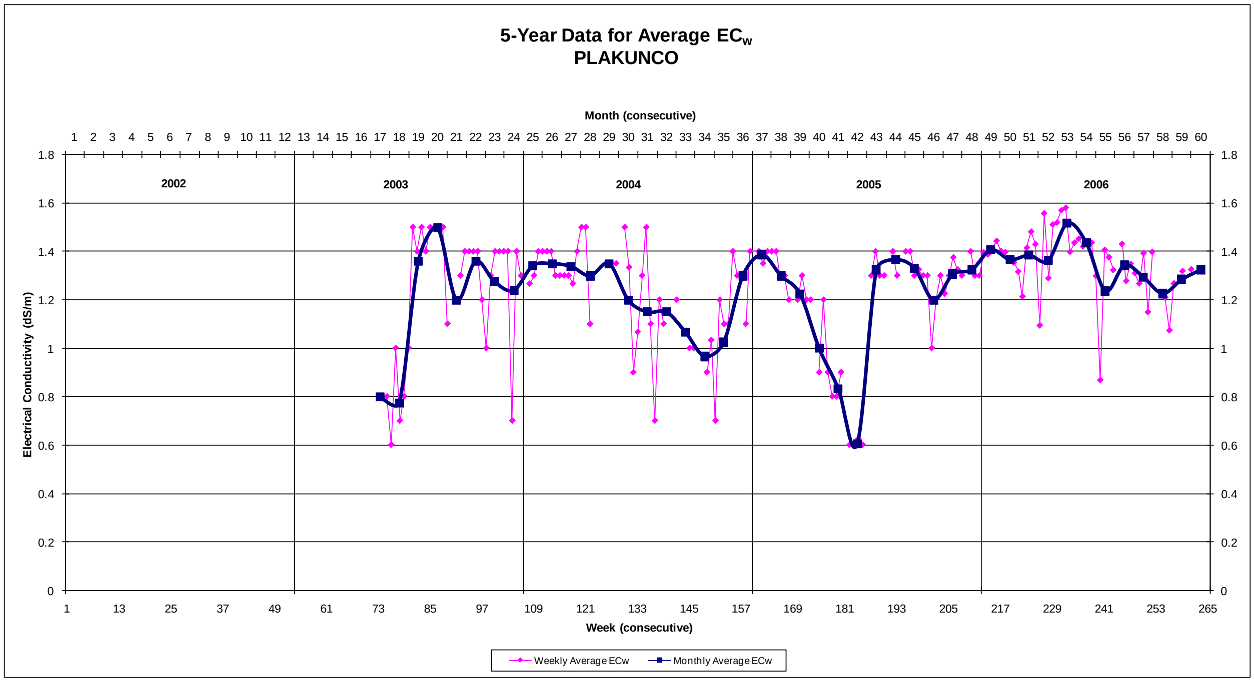

5-Year Data for Average EC_w
PLAACRH60
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw



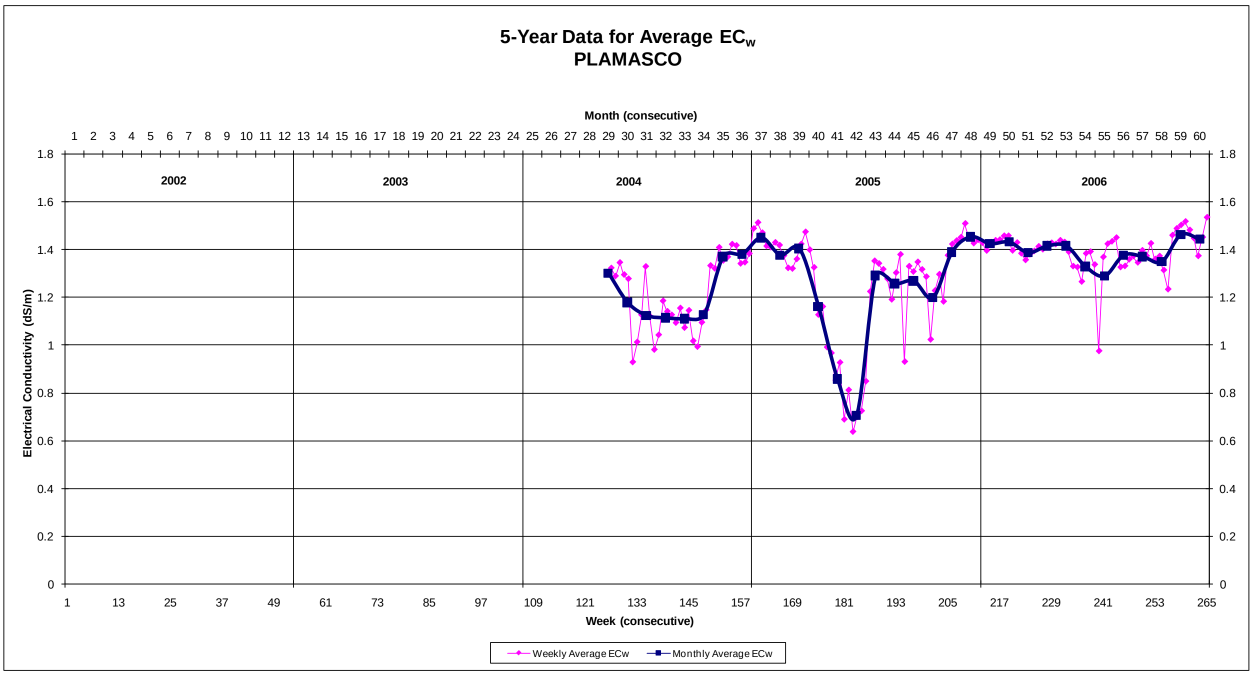
5-Year Data for Average EC_w
PLAEVACO
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw



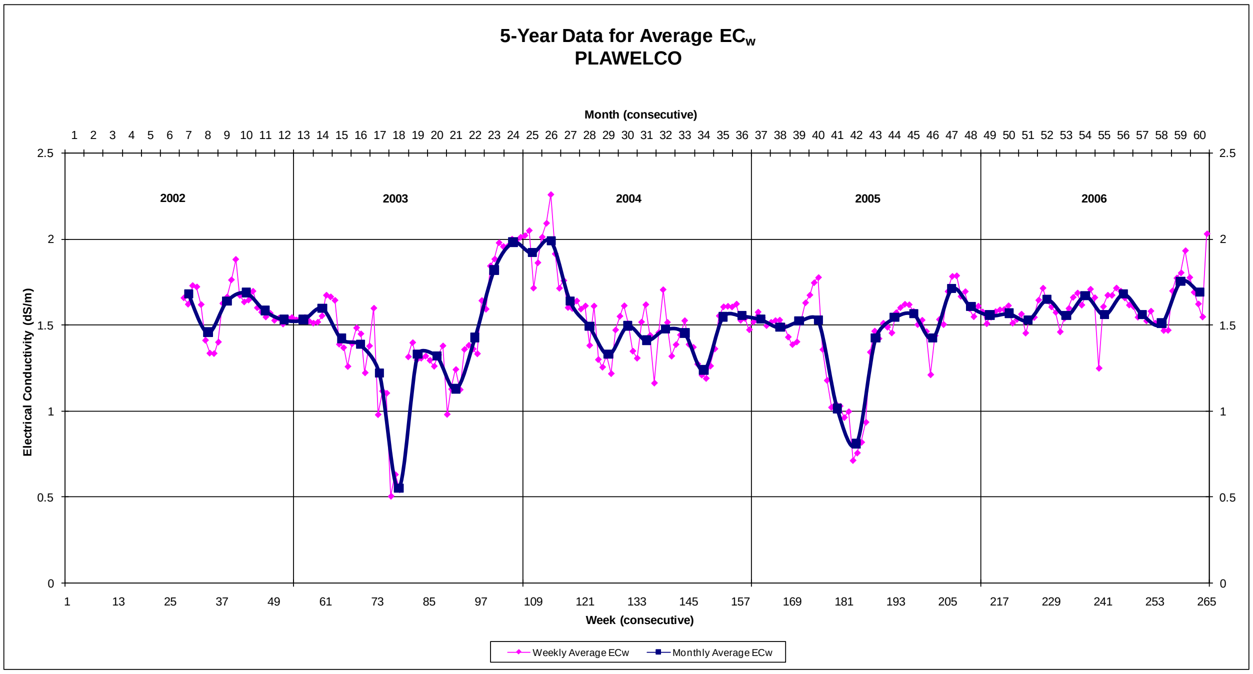
5-Year Data for Average EC_w
PLAKERCO
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw



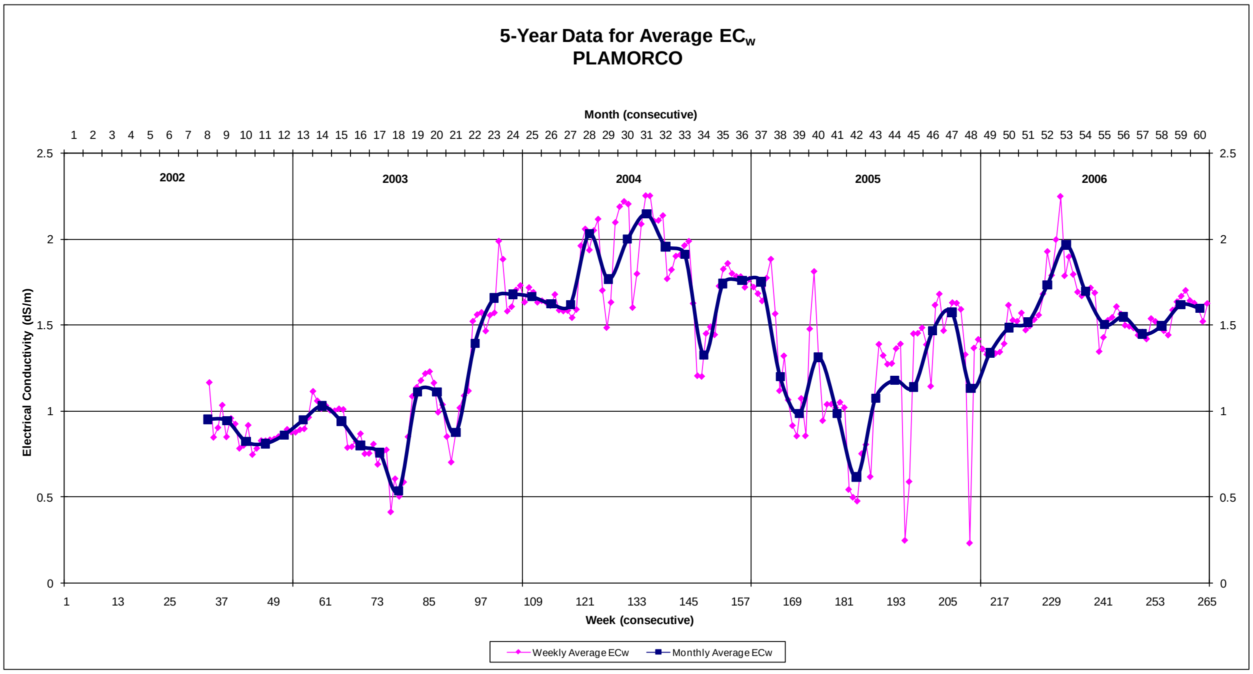
5-Year Data for Average EC_w
PLAKUNCO
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw



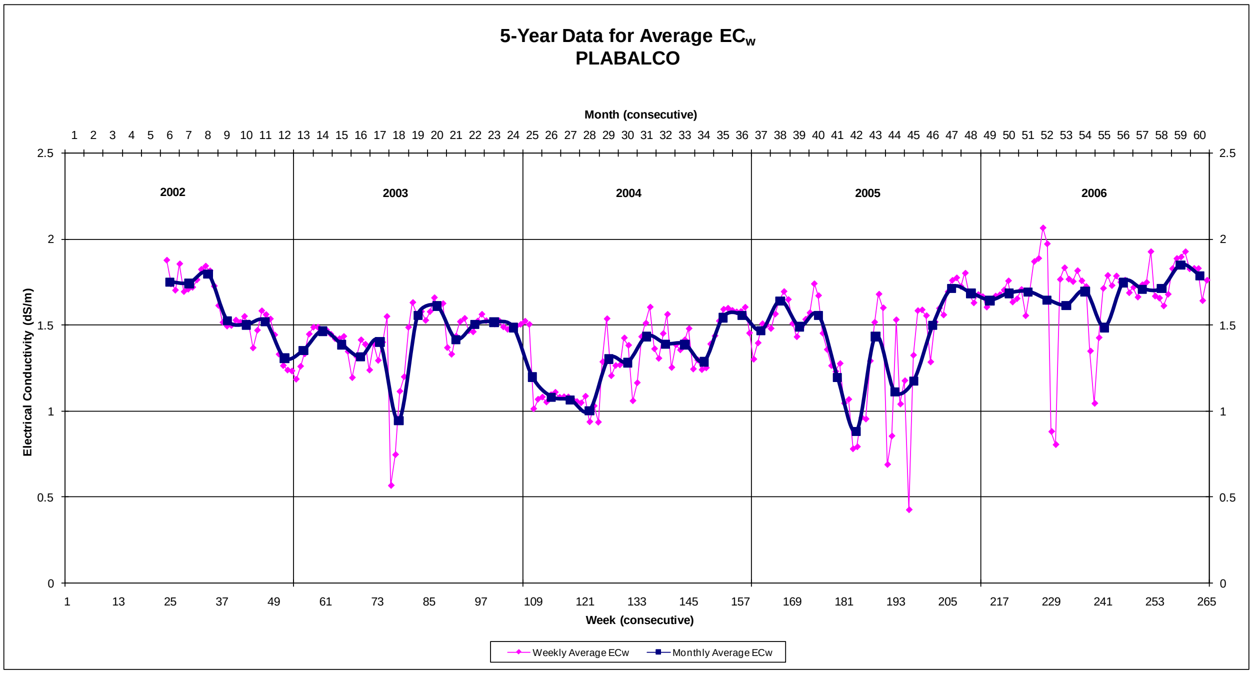
5-Year Data for Average EC_w
PLAMASCO
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw



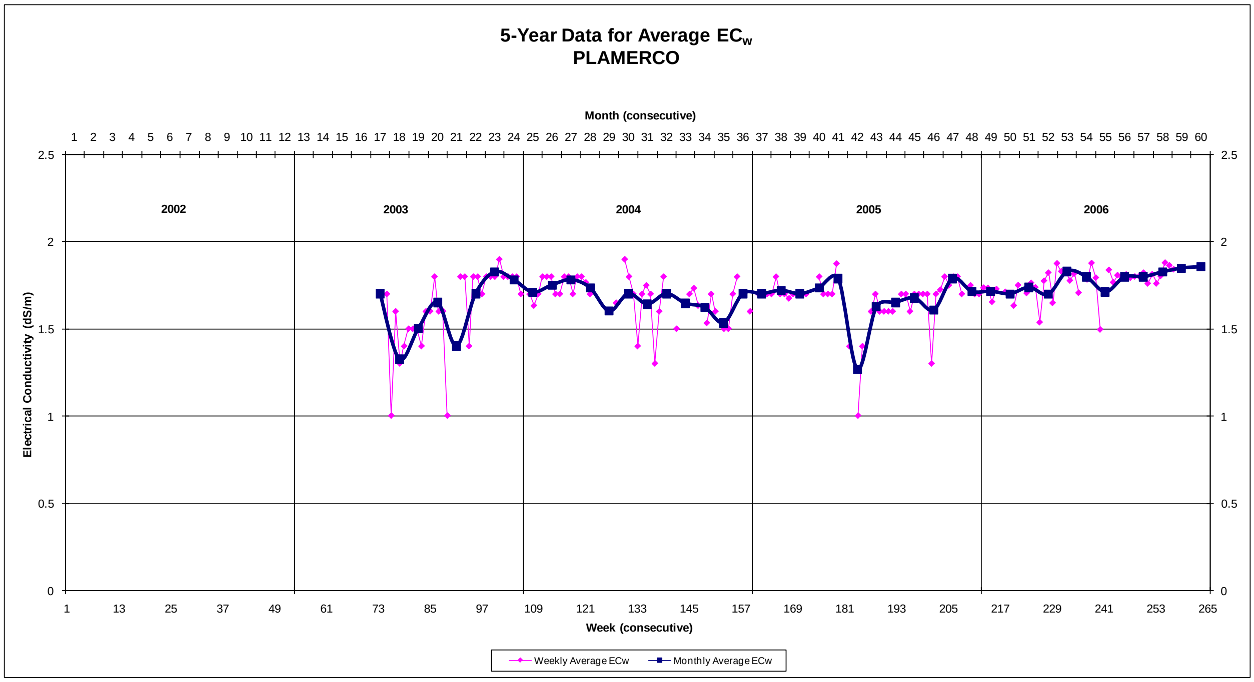
5-Year Data for Average EC_w
PLAWELCO
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw



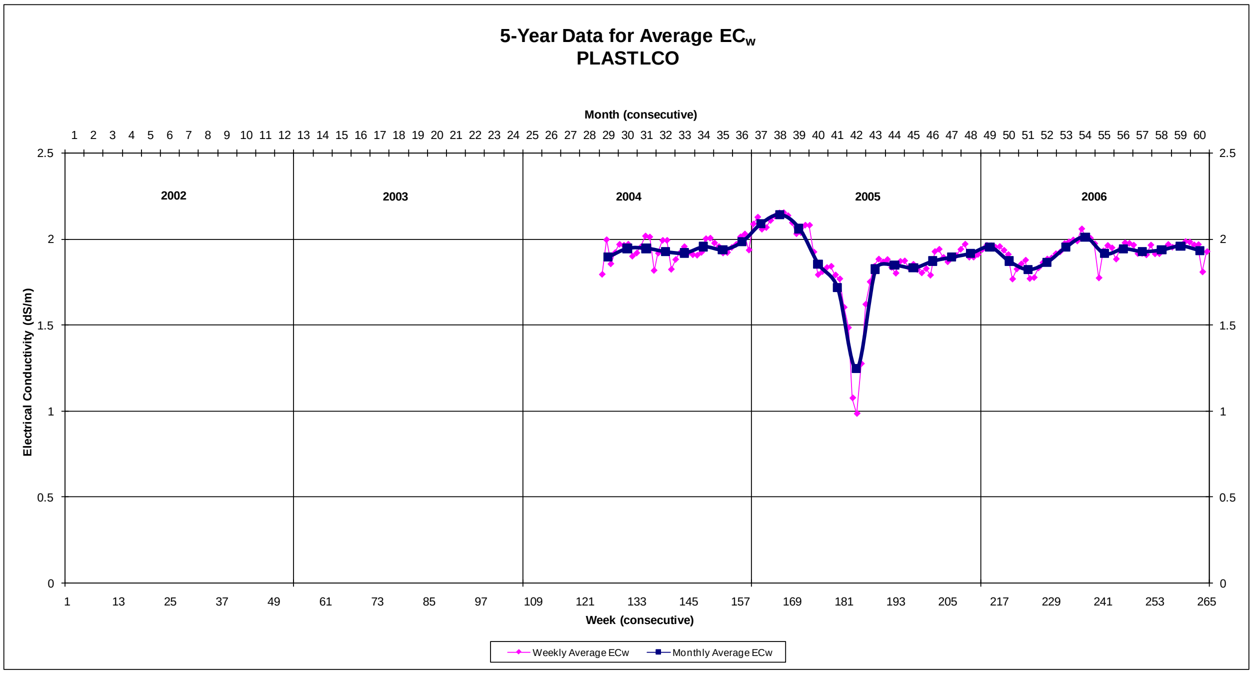
5-Year Data for Average EC_w
PLAMORCO
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw



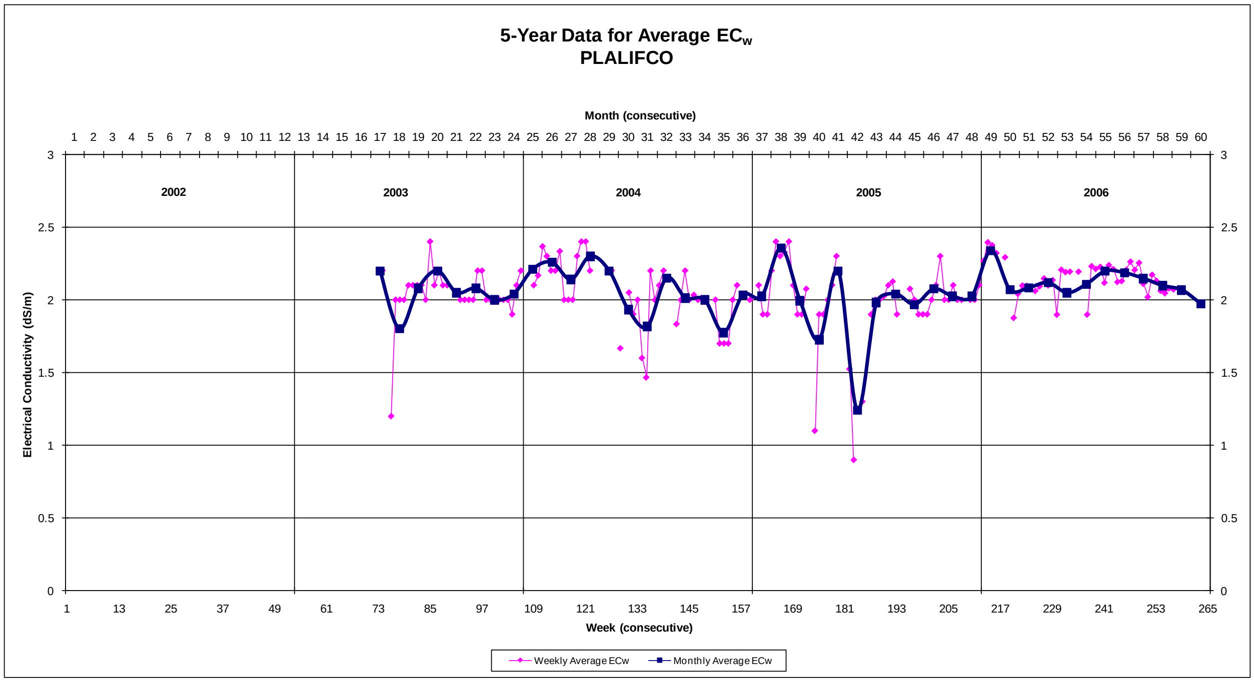
5-Year Data for Average EC_w
PLABALCO
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw



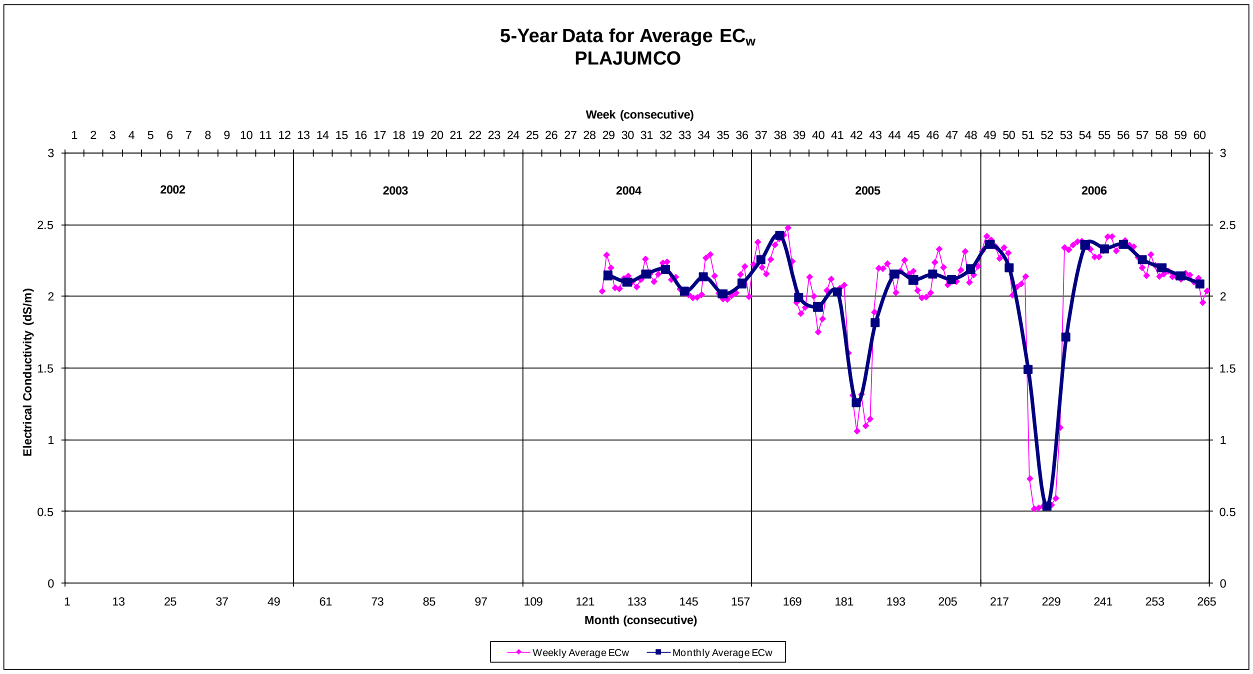
5-Year Data for Average EC_w
PLAMERCO
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

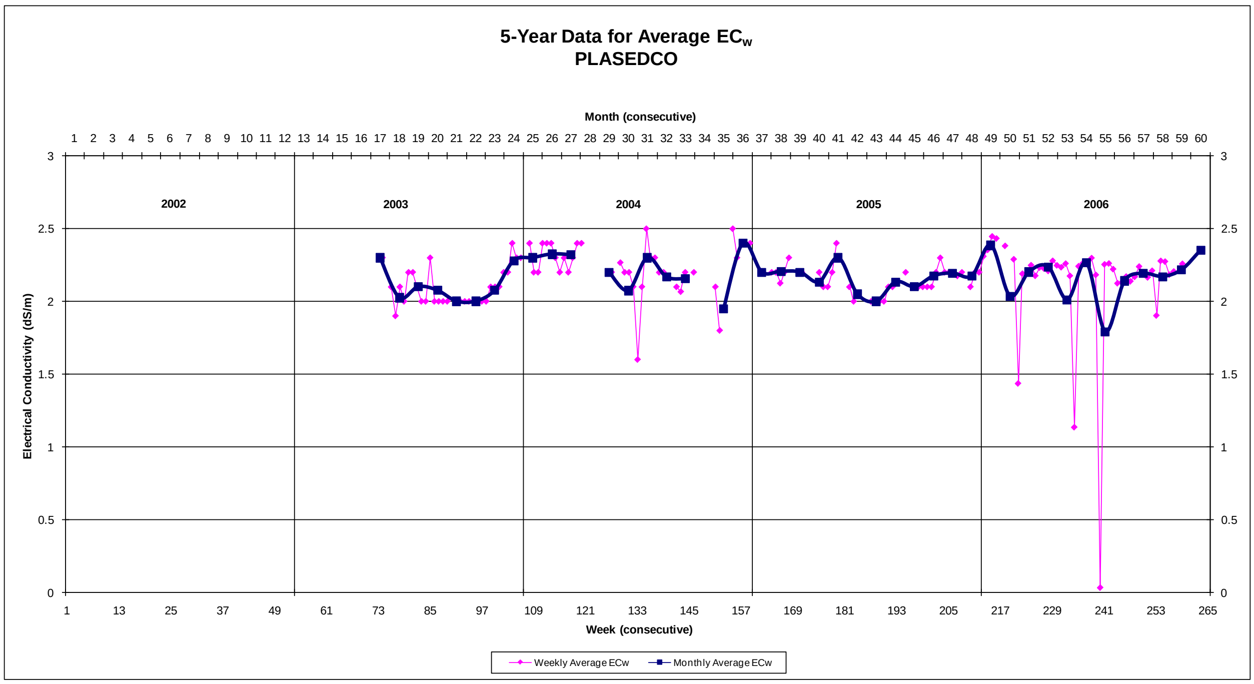


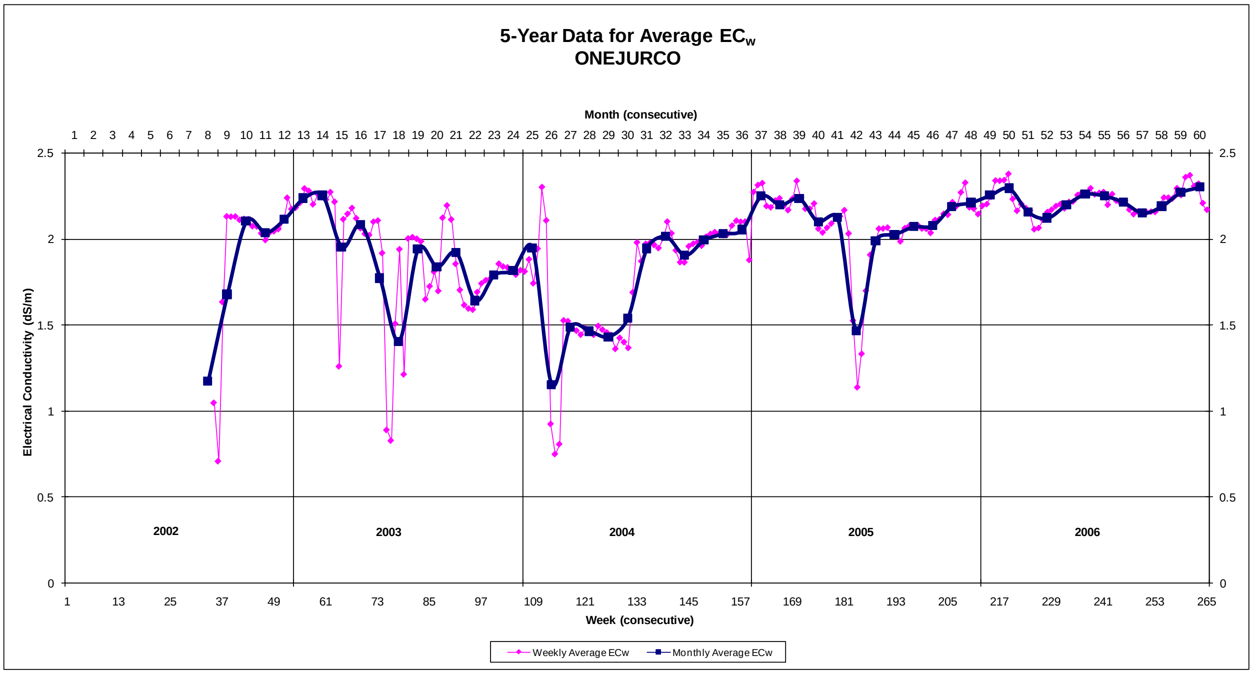
5-Year Data for Average EC_w
PLASTLCO
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw



5-Year Data for Average EC_w
PLALIFCO
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average ECw
PLAJUMCO
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Month (consecutive)
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average ECw
PLASEDCO
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

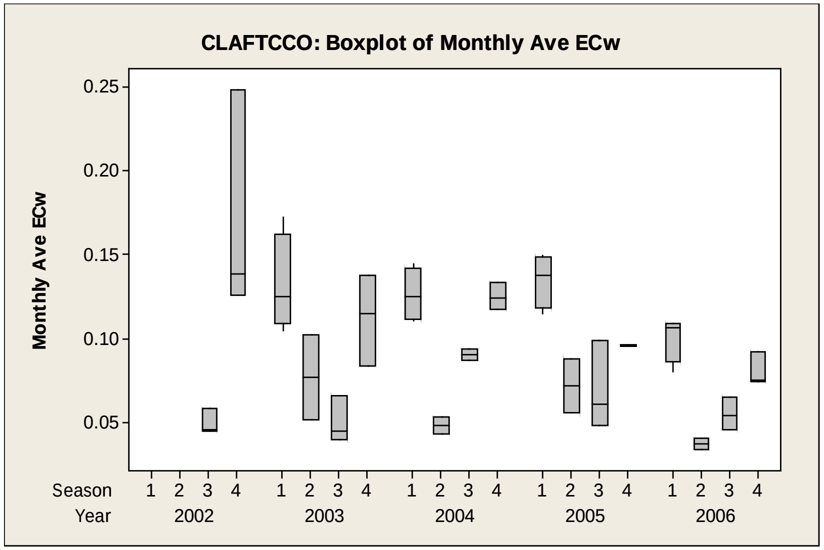


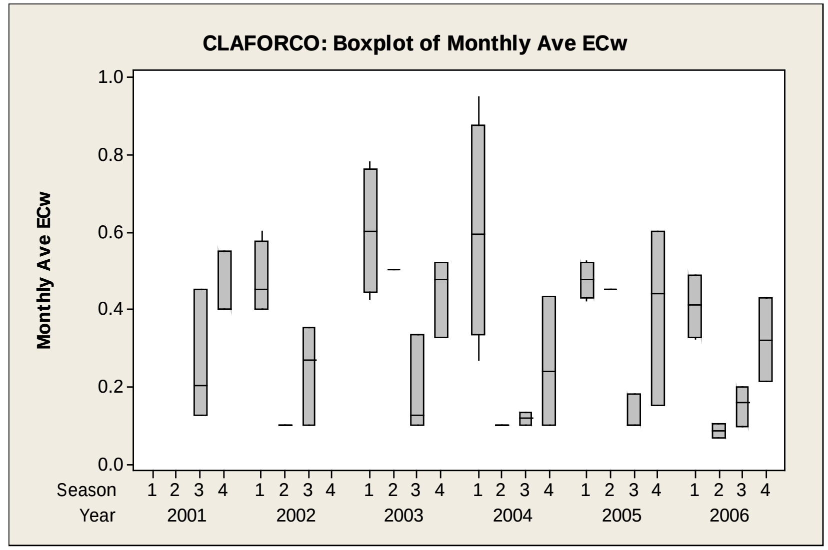
5-Year Data for Average ECw
ONEJURCO
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

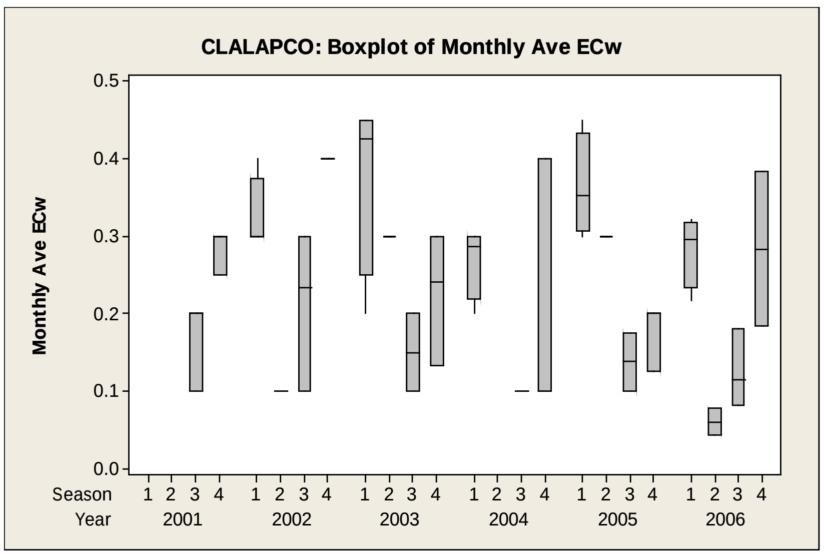
APPENDIX C

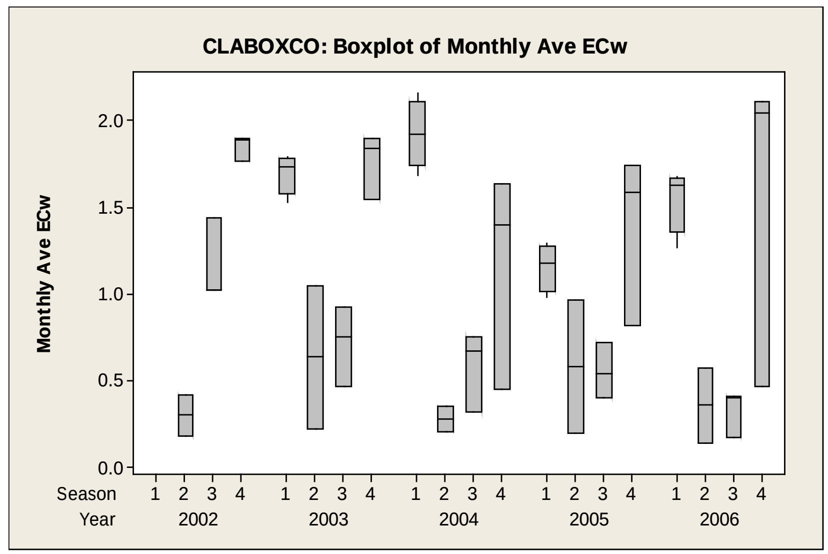
River System Box Plots

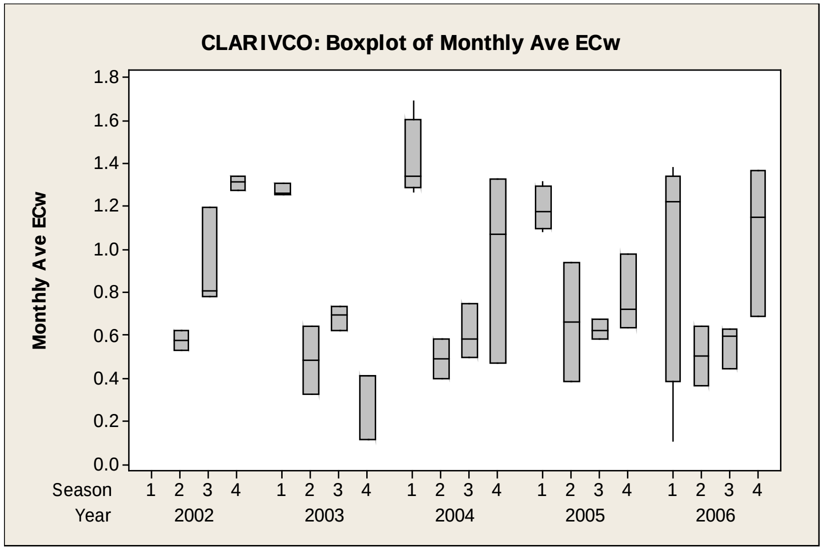
Cache la Poudre System

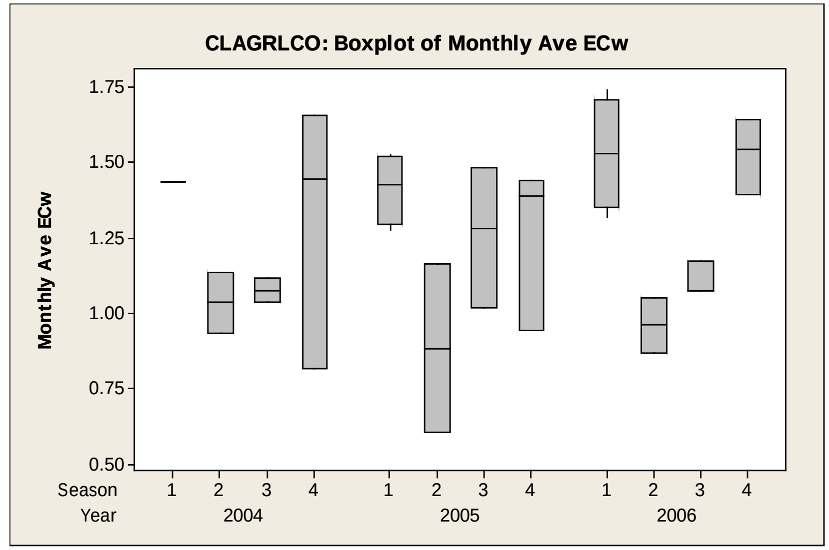


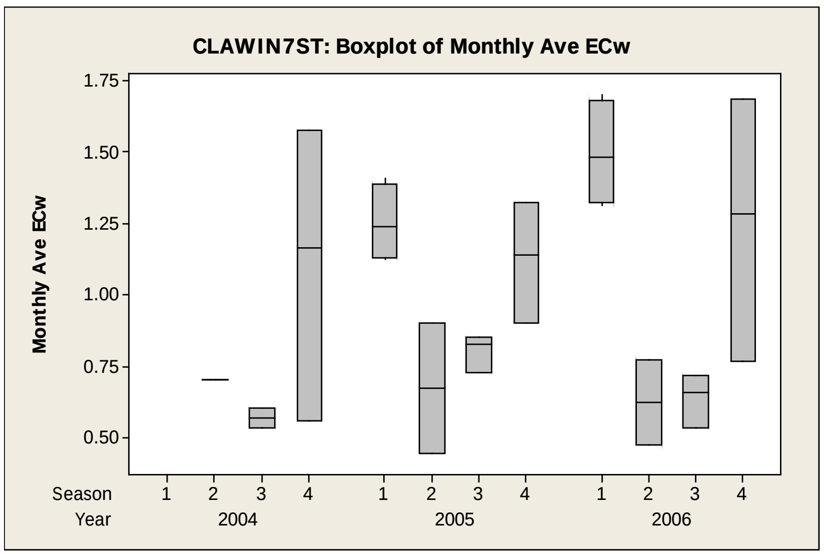


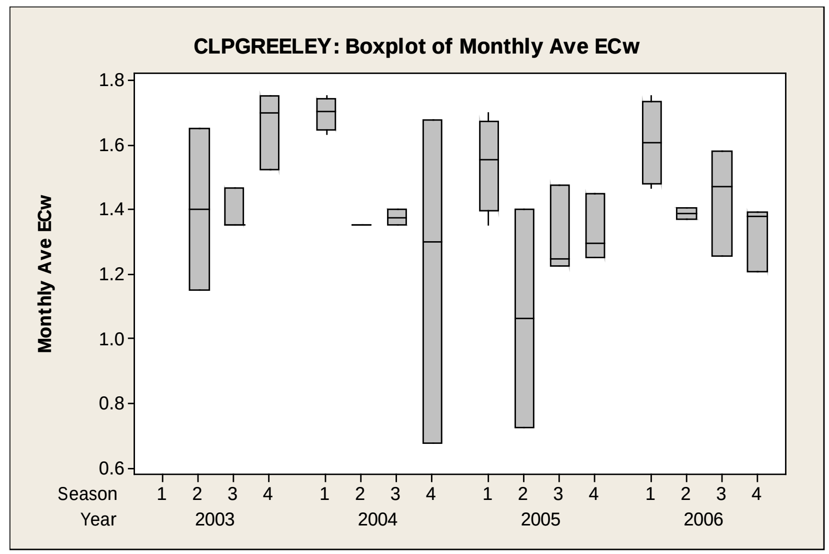


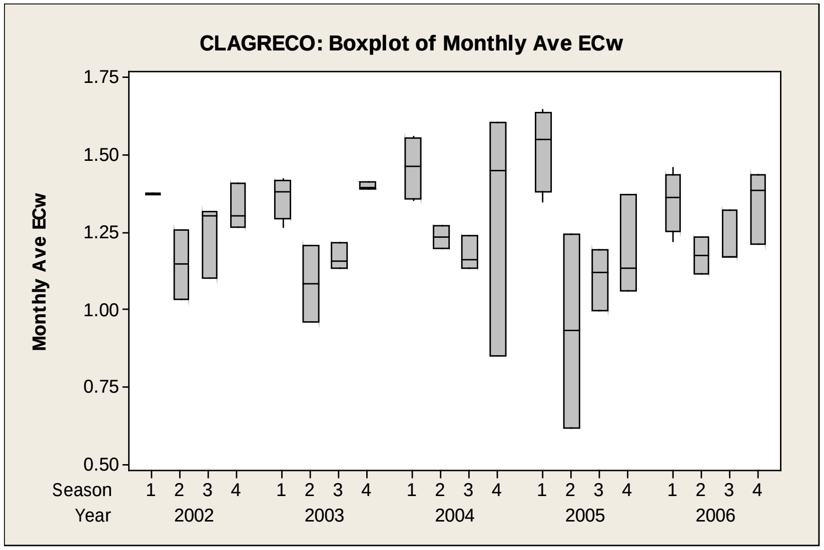



CLARIVCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006

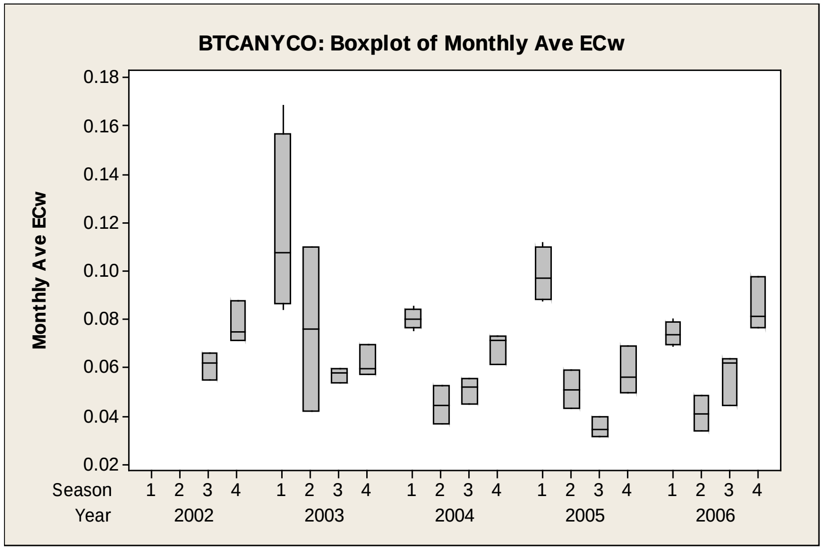

CLAGRLCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.75
1.50
1.25
1.00
0.75
0.50
Season 1 2 3 4 1 2 3 4 1 2 3 4
Year 2004 2005 2006

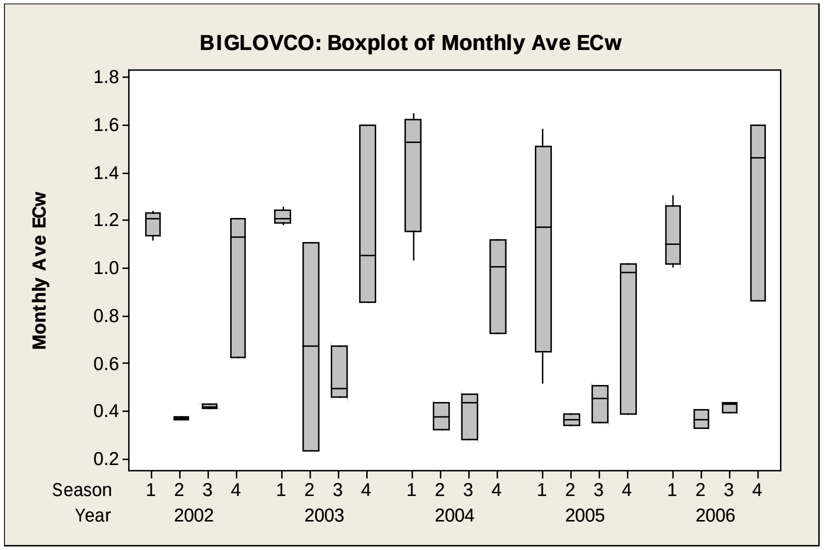

CLAWIN7ST: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.75
1.50
1.25
1.00
0.75
0.50
Season 1 2 3 4 1 2 3 4 1 2 3 4
Year 2004 2005 2006

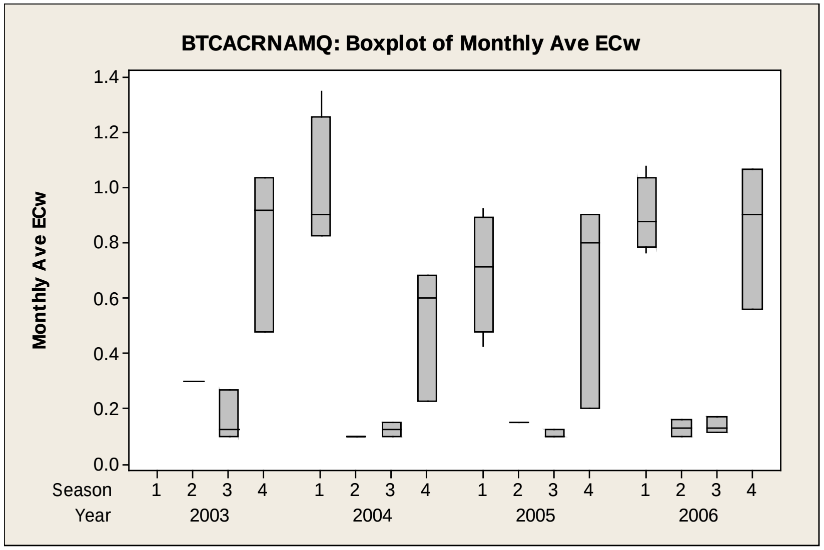

CLPGREELEY: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.8
1.6
1.4
1.2
1.0
0.8
0.6
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

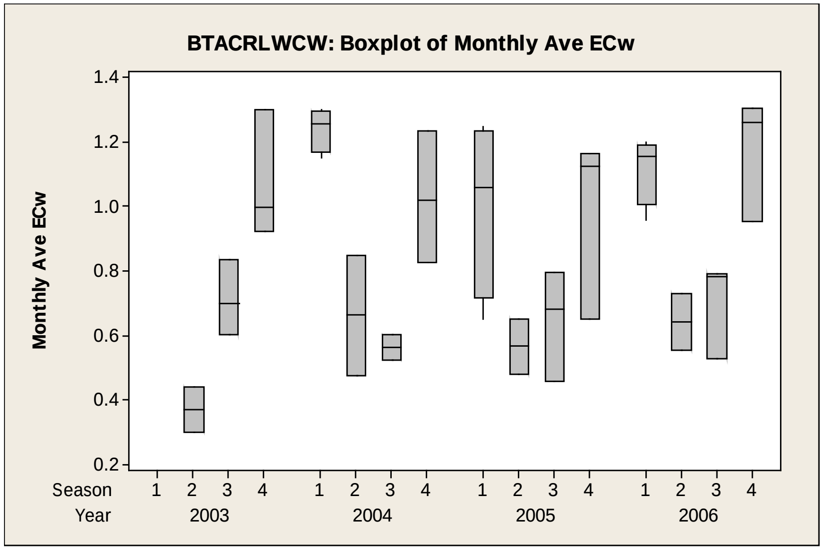

CLAGRECO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.75
1.50
1.25
1.00
0.75
0.50
Season
Year
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
2002
2003
2004
2005
2006

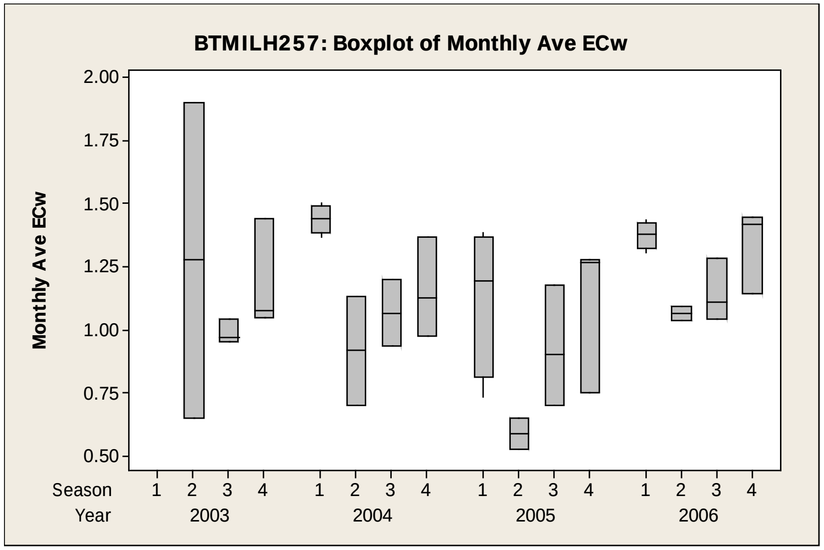
Big Thompson System

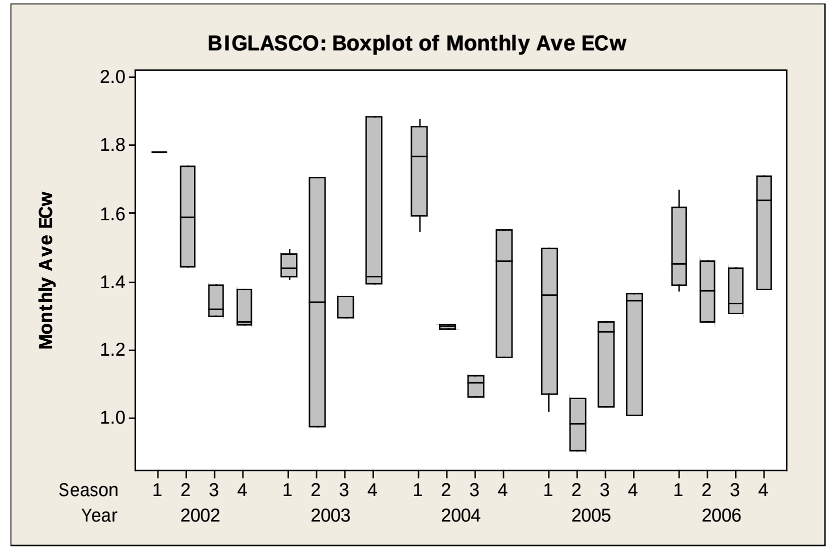




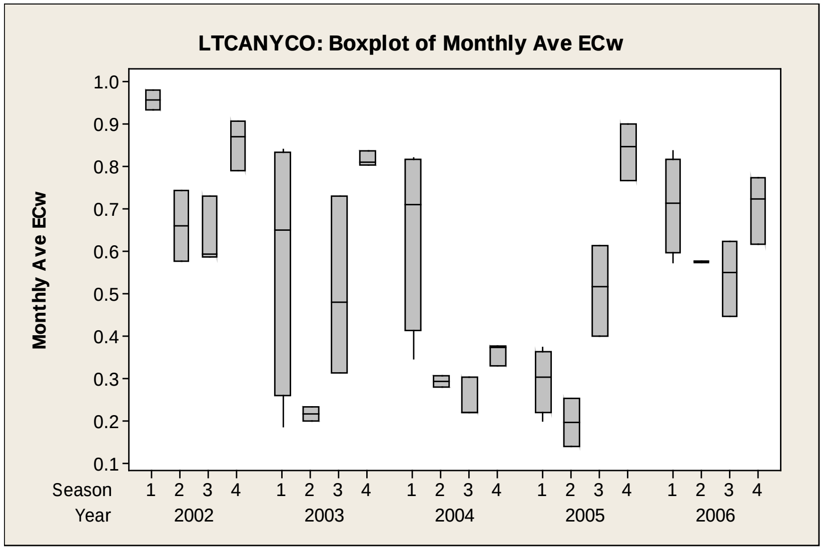


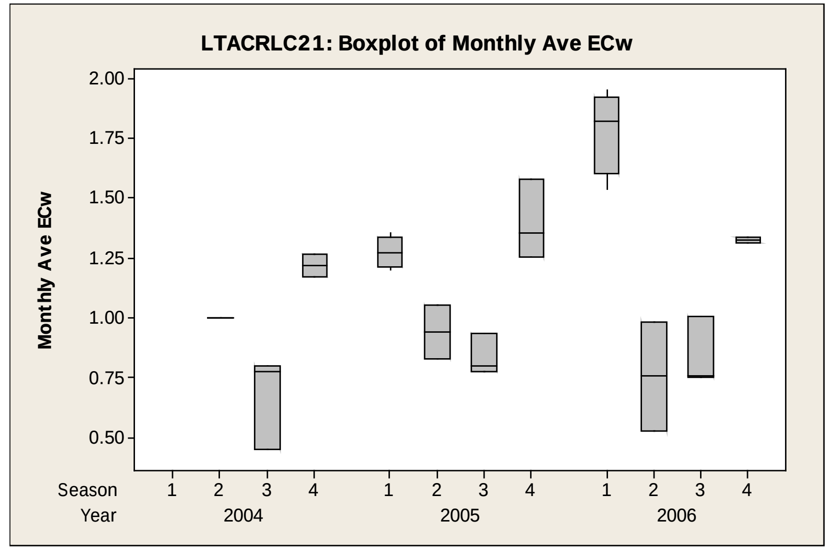


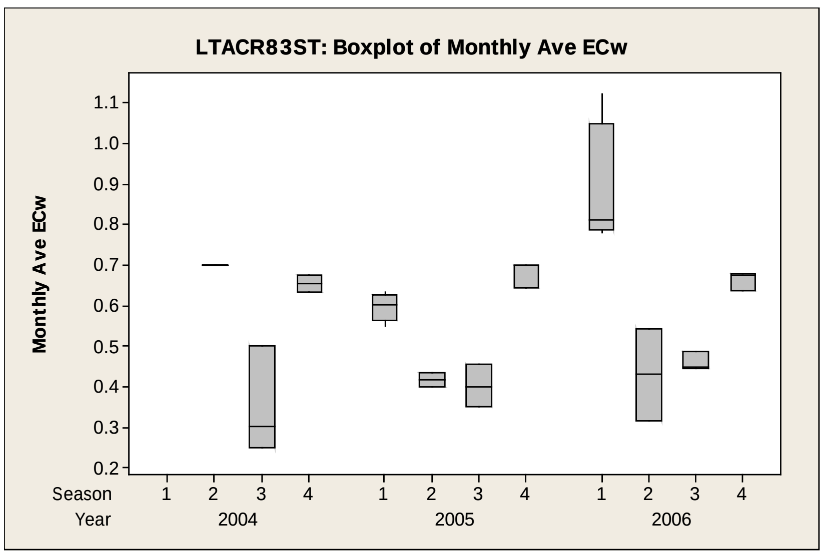

BTMILH257: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.00
1.75
1.50
1.25
1.00
0.75
0.50
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

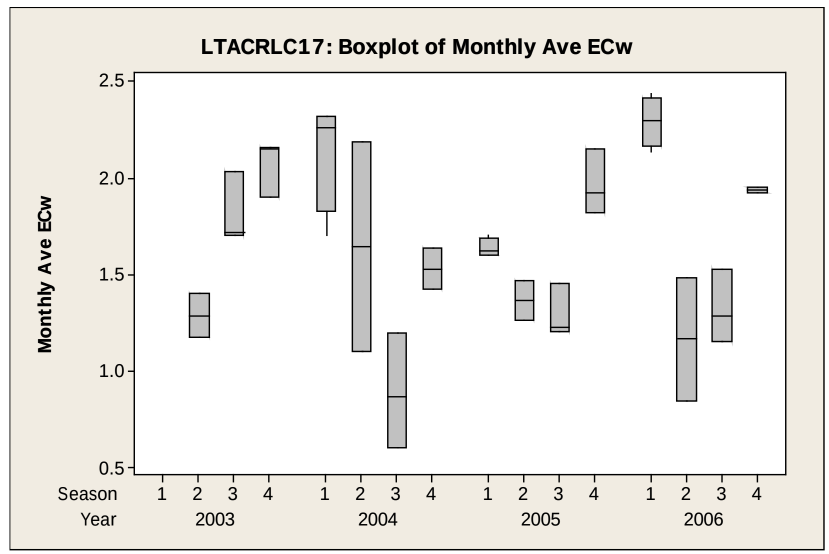

BIGLASCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.0
1.8
1.6
1.4
1.2
1.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006

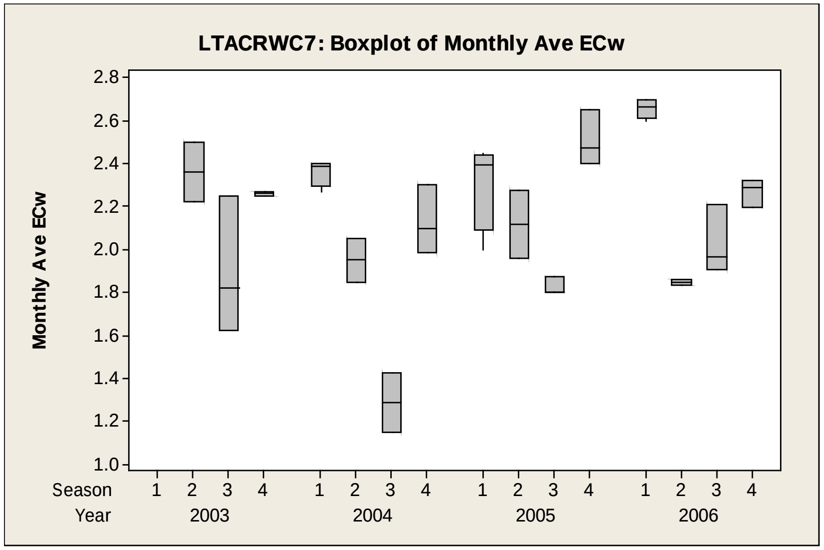
Little Thompson System

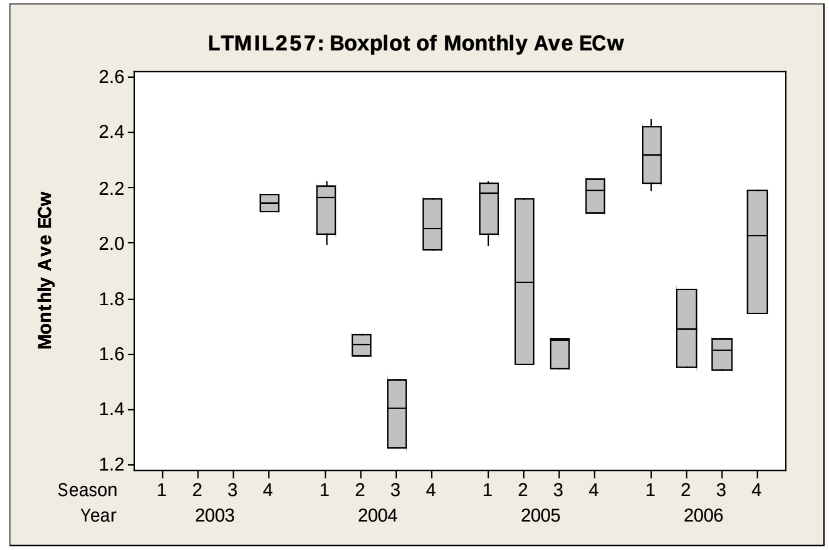


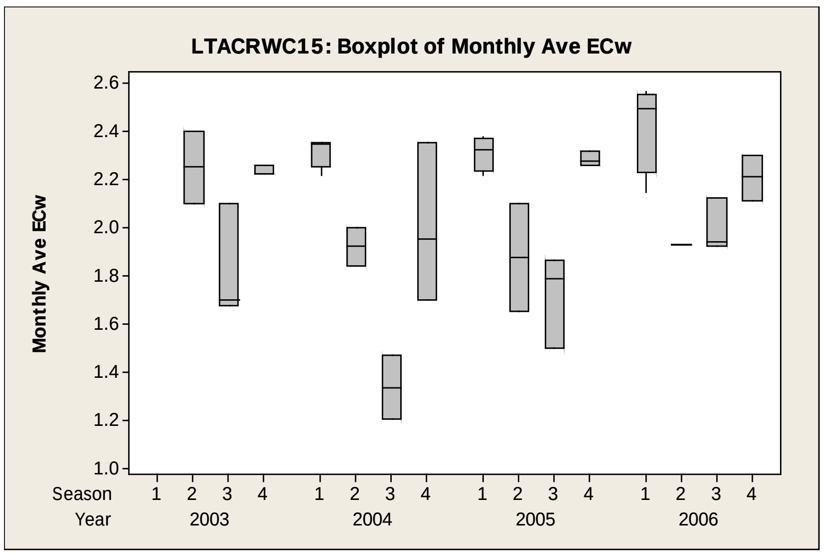




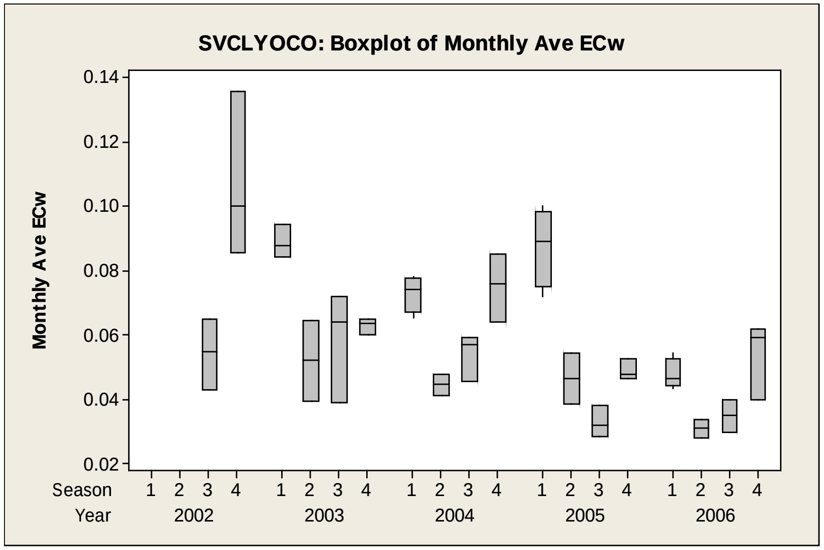


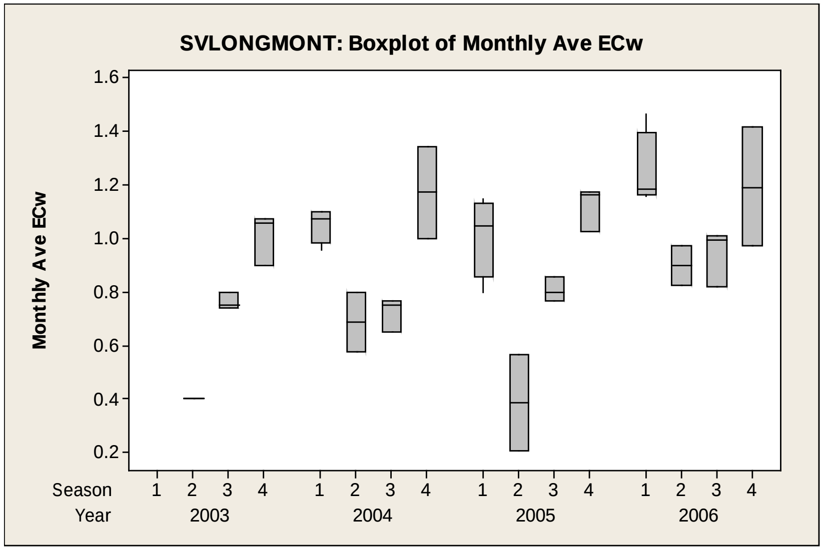

LTACRWC7: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

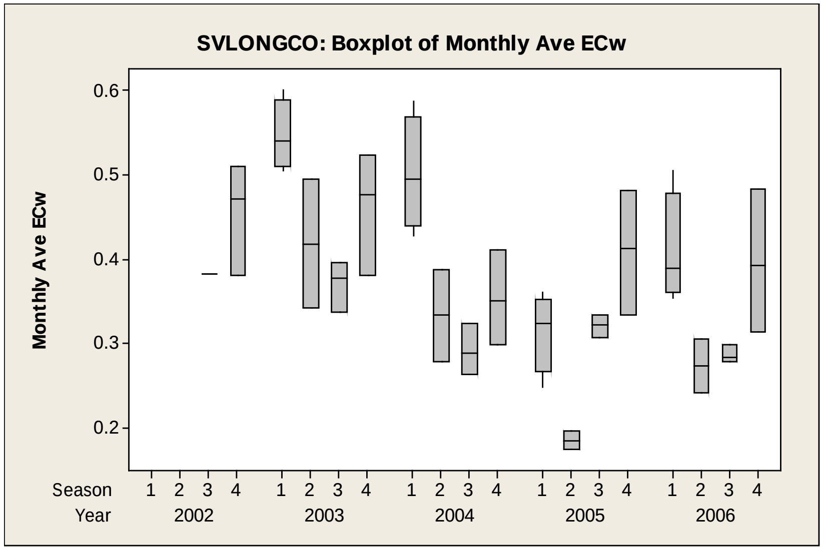

LTMIL257: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

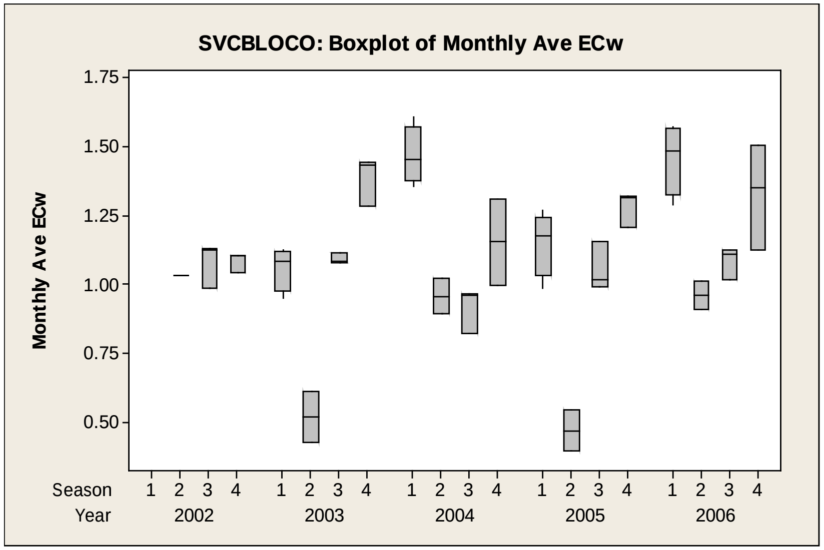

LTACRWC15: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

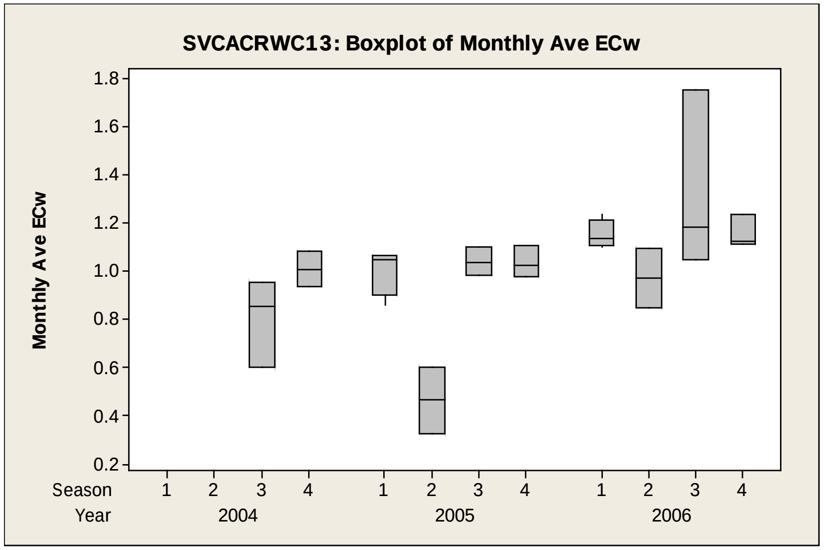
Saint Vrain Creek System

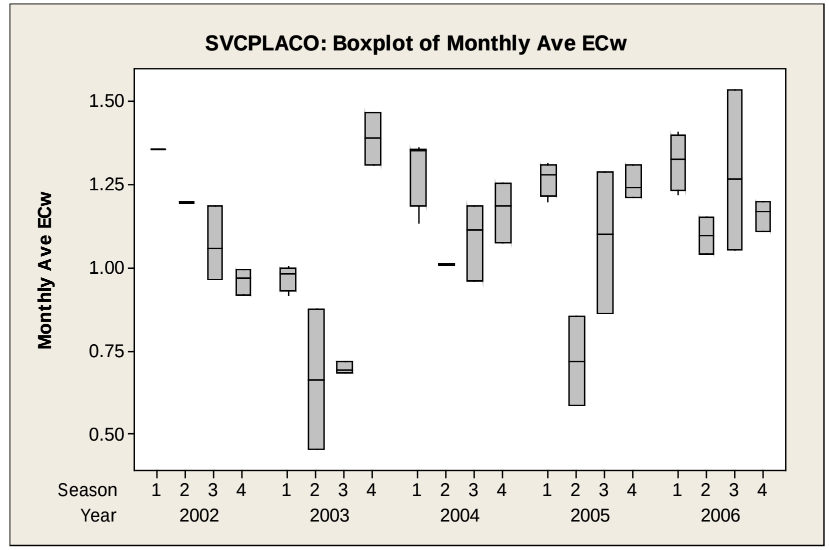




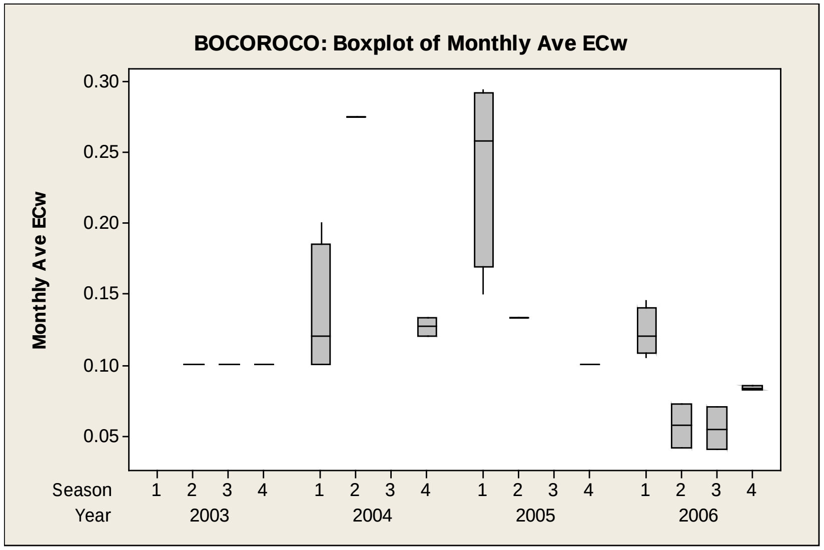


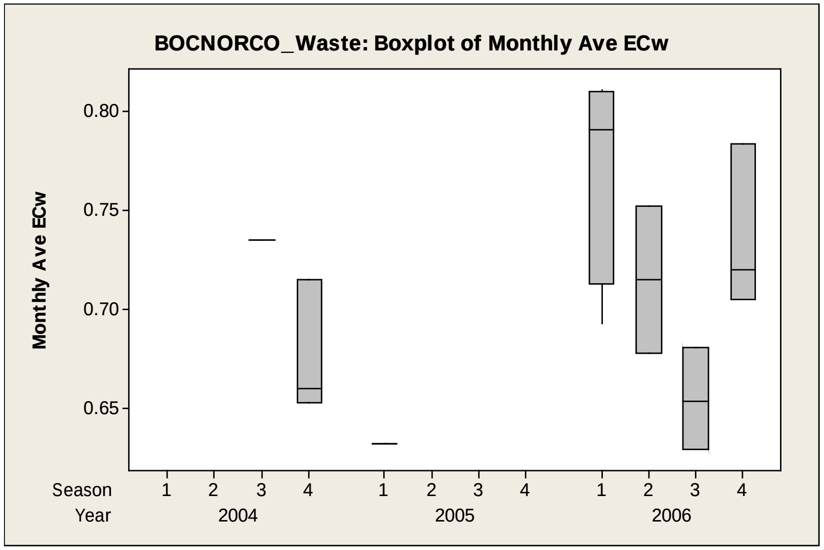


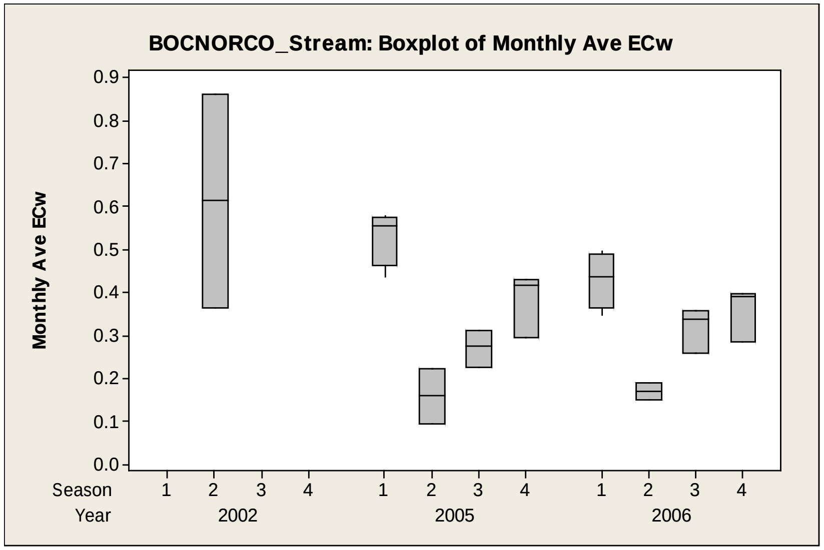

SVCACRWC13: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Season 1 2 3 4 1 2 3 4 1 2 3 4
Year 2004 2005 2006

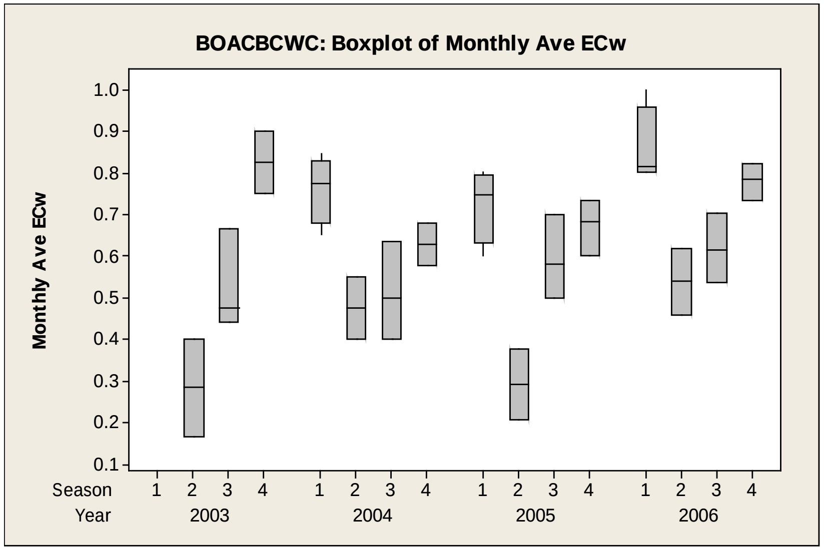

SVCPLACO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.50
1.25
1.00
0.75
0.50
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006

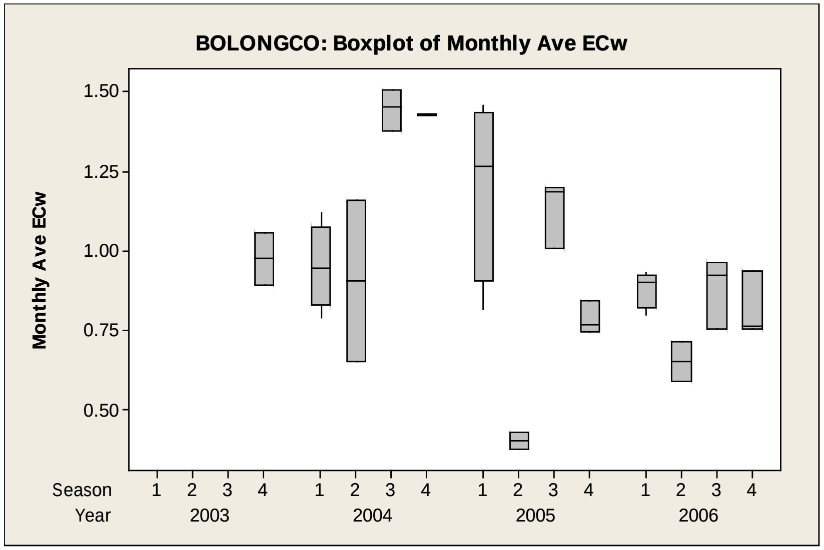
Boulder Creek System



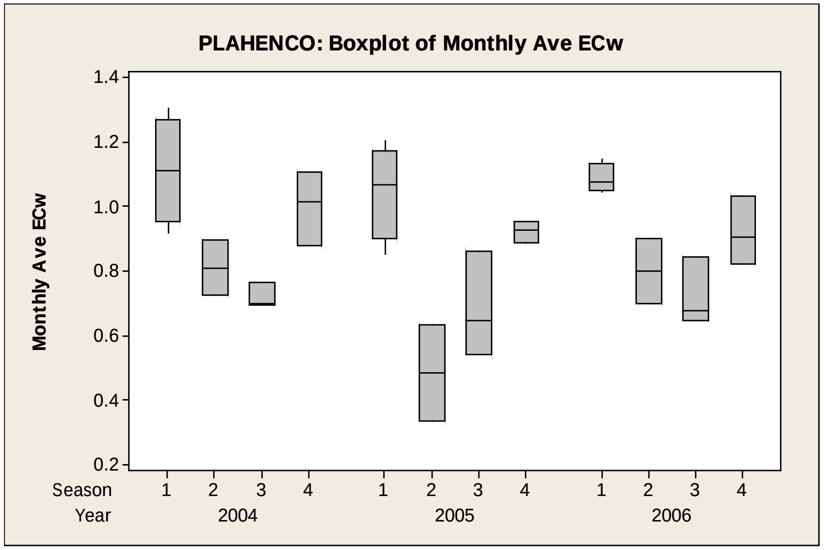


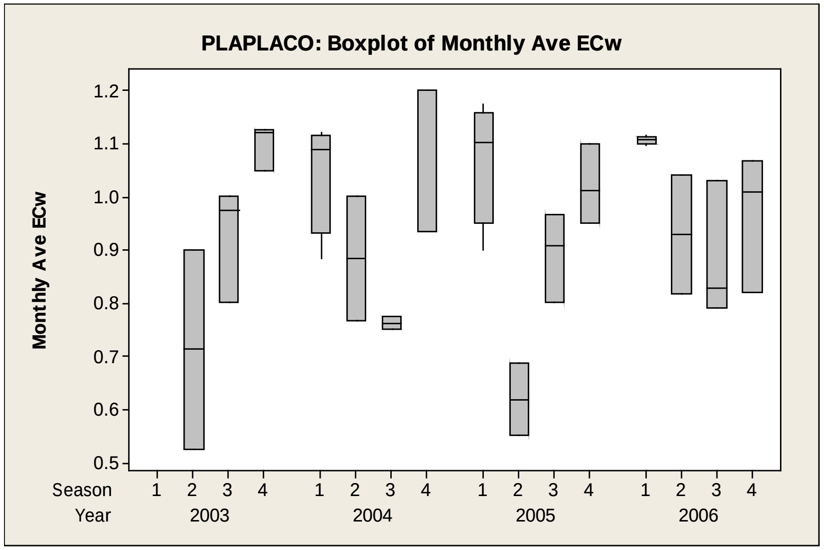


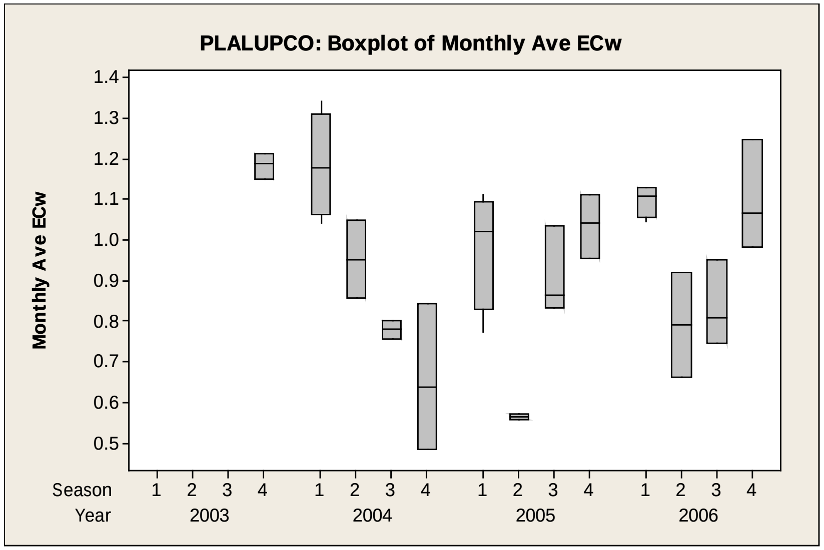


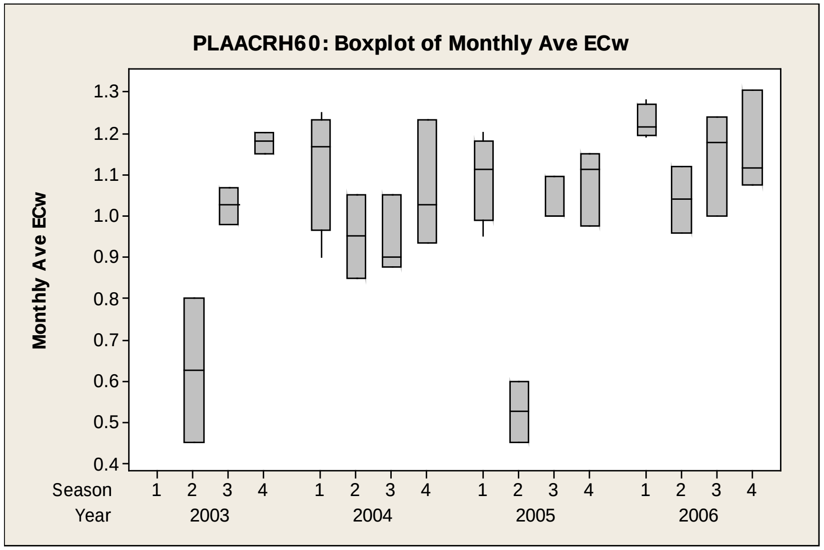

BOLONGCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.50
1.25
1.00
0.75
0.50
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

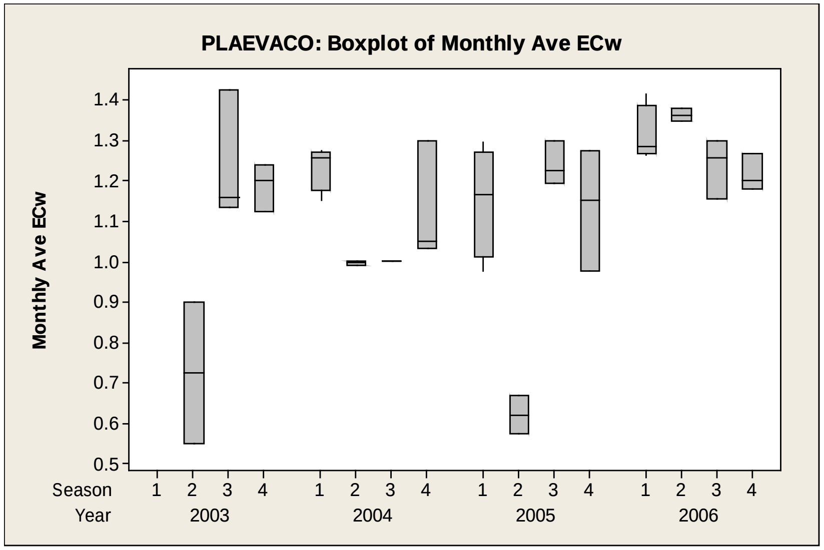
South Platte System

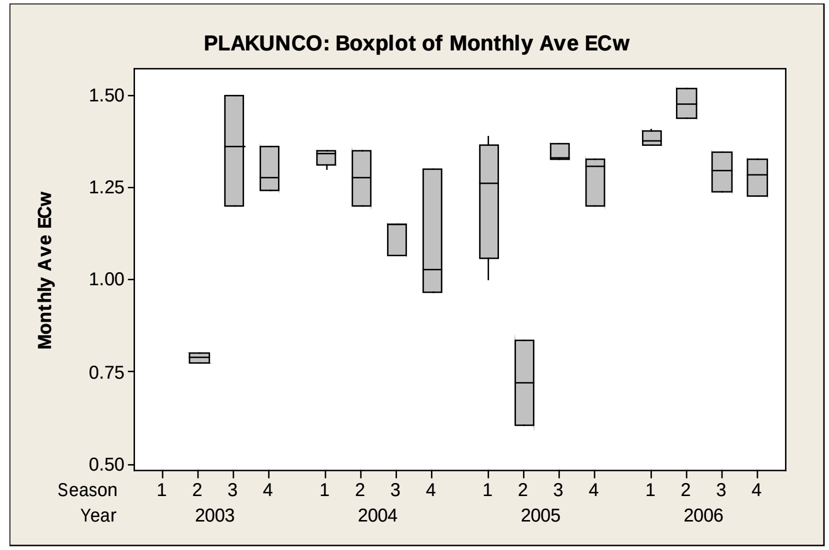


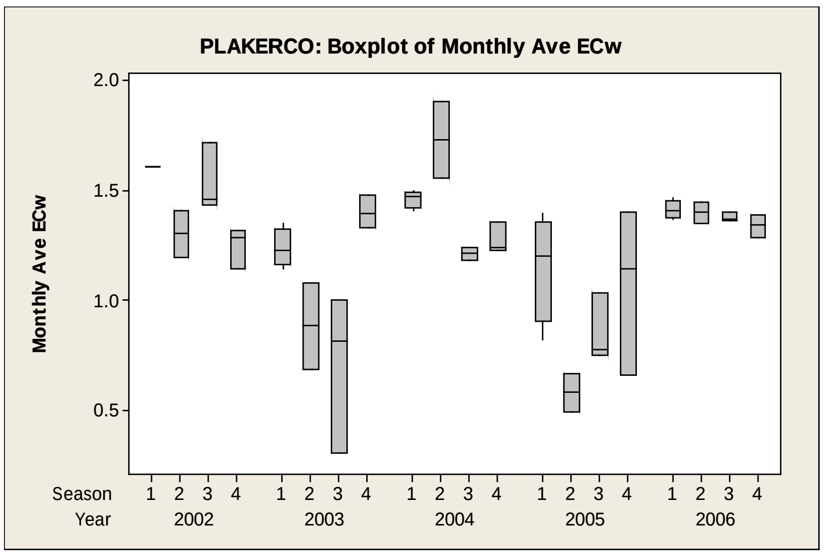


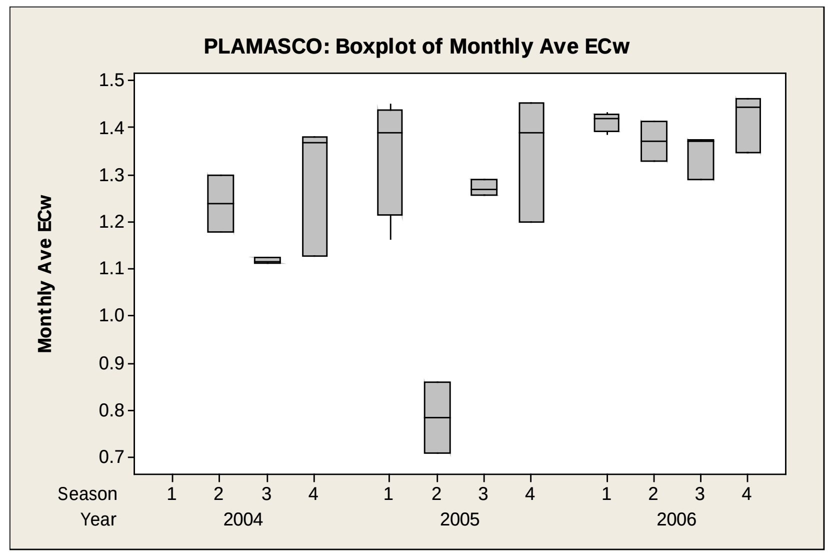


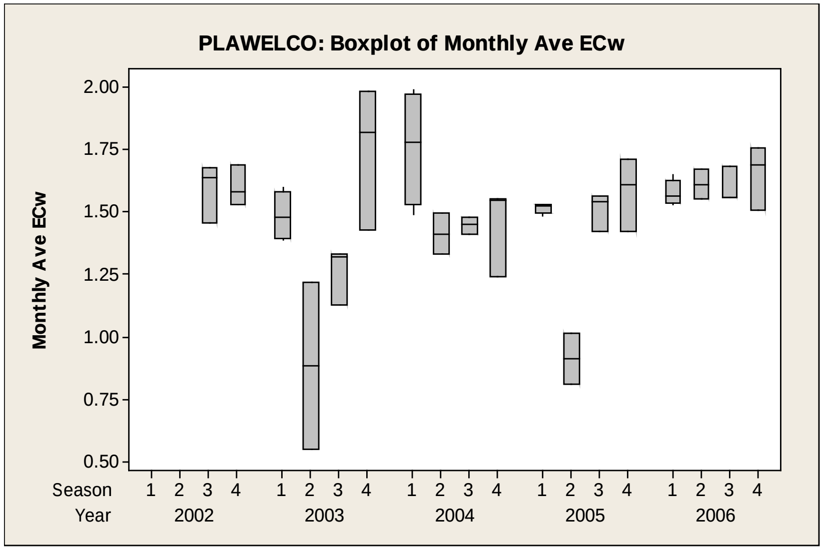


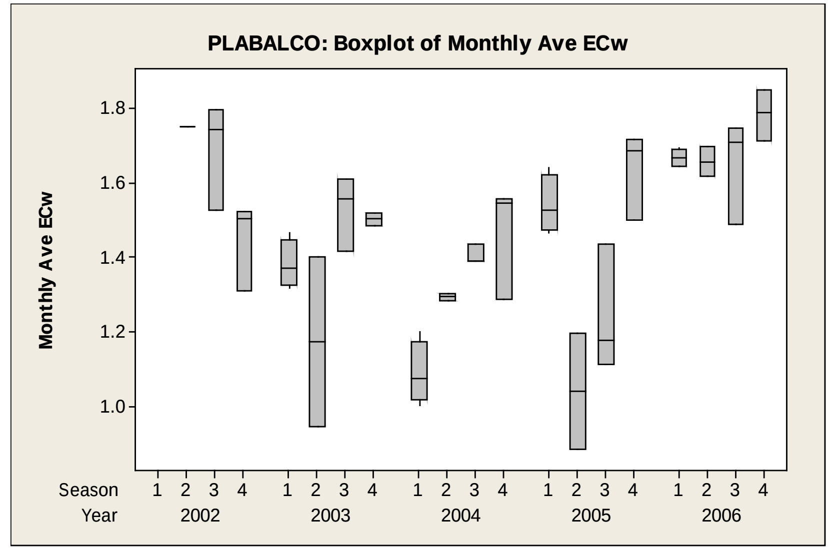

PLAEVACO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

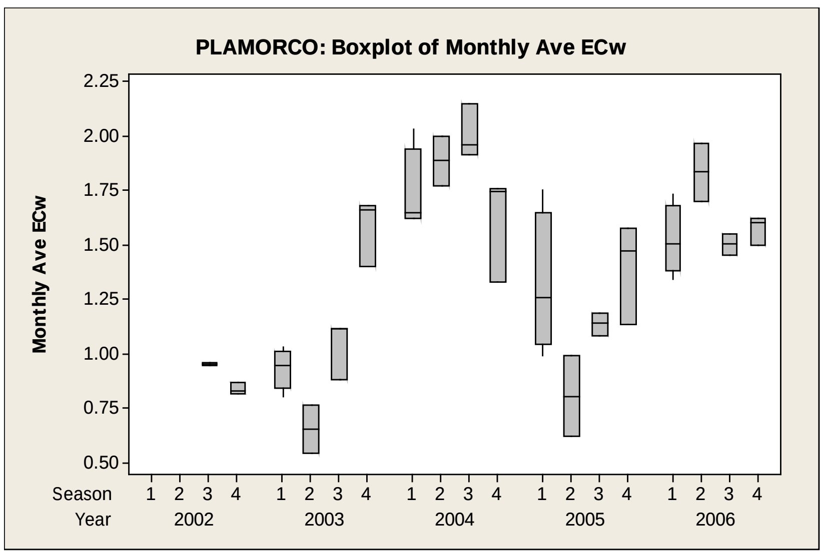

PLAKUNCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.50
1.25
1.00
0.75
0.50
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

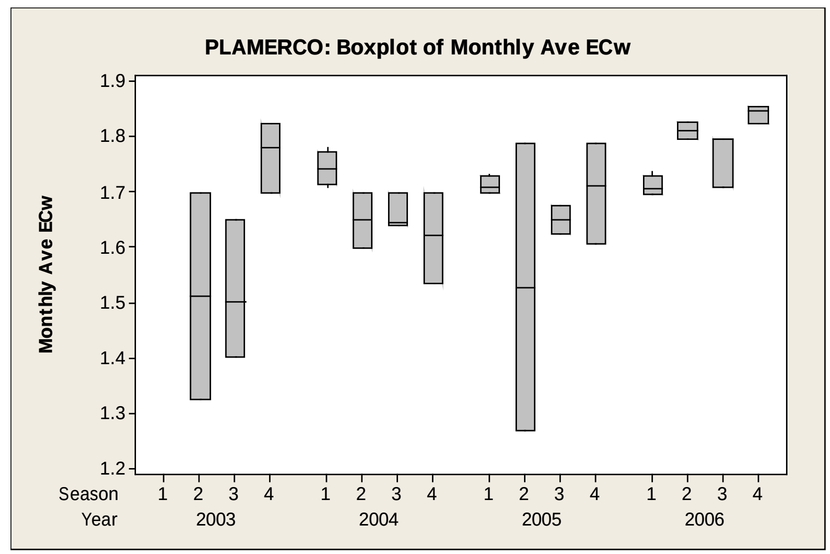

PLAKERCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.0
1.5
1.0
0.5
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006

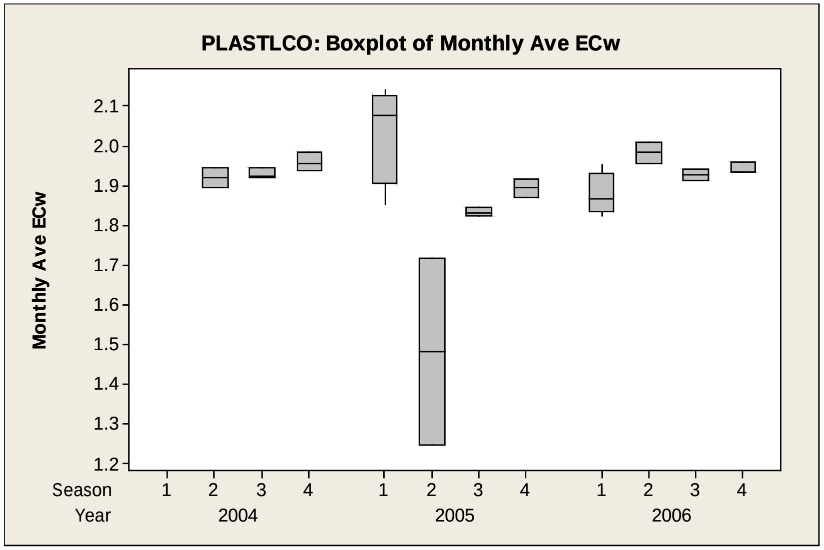

PLAMASCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
Season 1 2 3 4 1 2 3 4 1 2 3 4
Year 2004 2005 2006

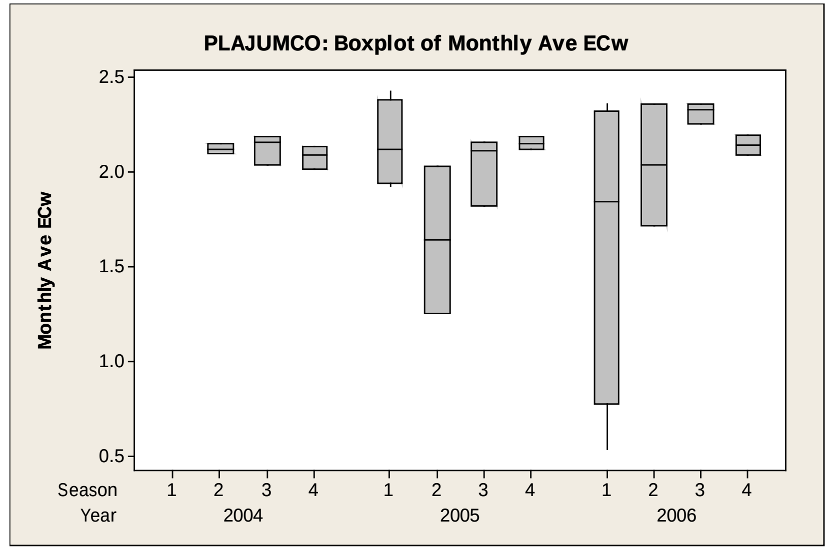

PLAWELCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.00
1.75
1.50
1.25
1.00
0.75
0.50
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006

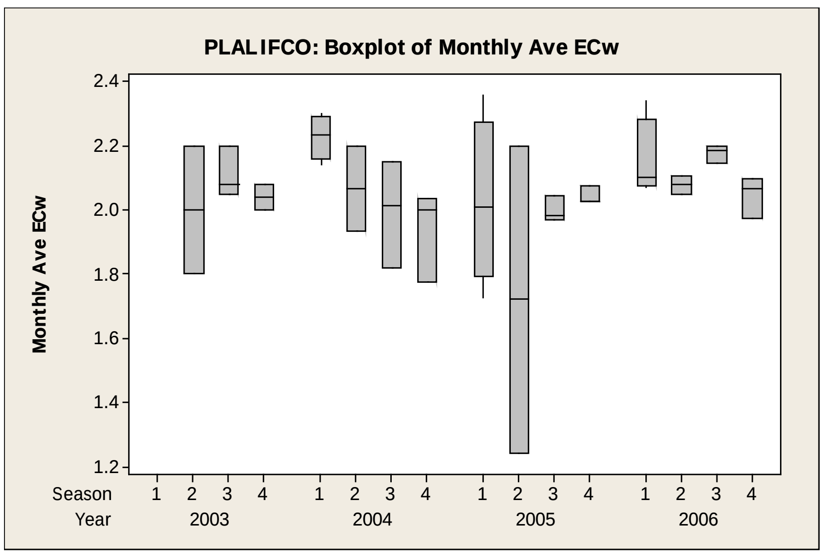

PLABALCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.8
1.6
1.4
1.2
1.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006

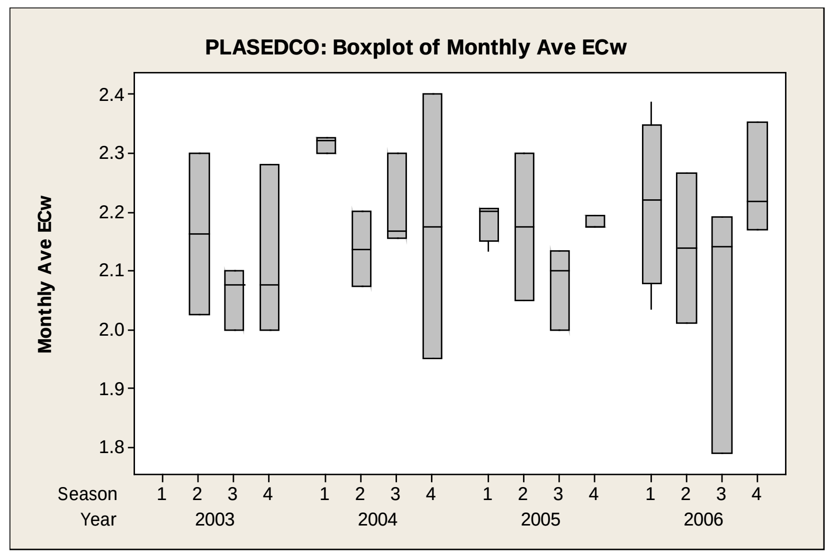

PLAMORCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006

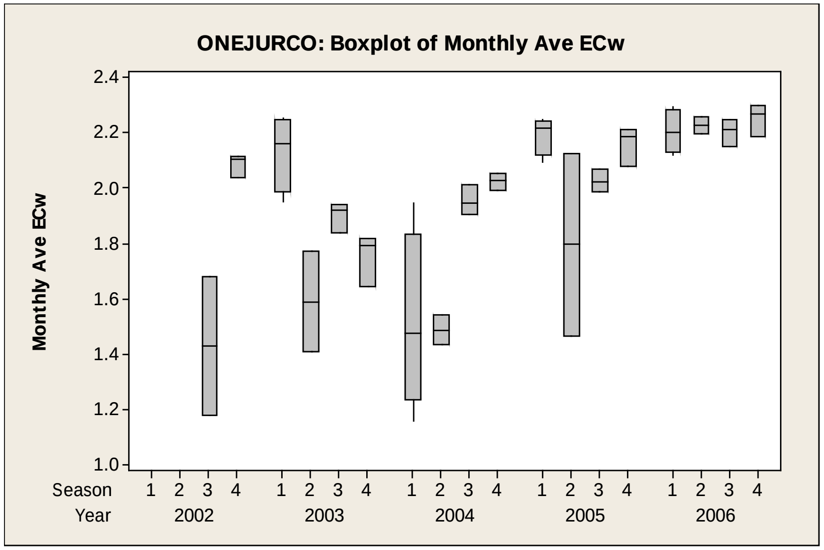

PLAMERCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006


PLASTLCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
Season 1 2 3 4 1 2 3 4 1 2 3 4
Year 2004 2005 2006


PLAJUMCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.5
2.0
1.5
1.0
0.5
Season 1 2 3 4 1 2 3 4 1 2 3 4
Year 2004 2005 2006


PLALIFCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.4
2.2
2.0
1.8
1.6
1.4
1.2
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

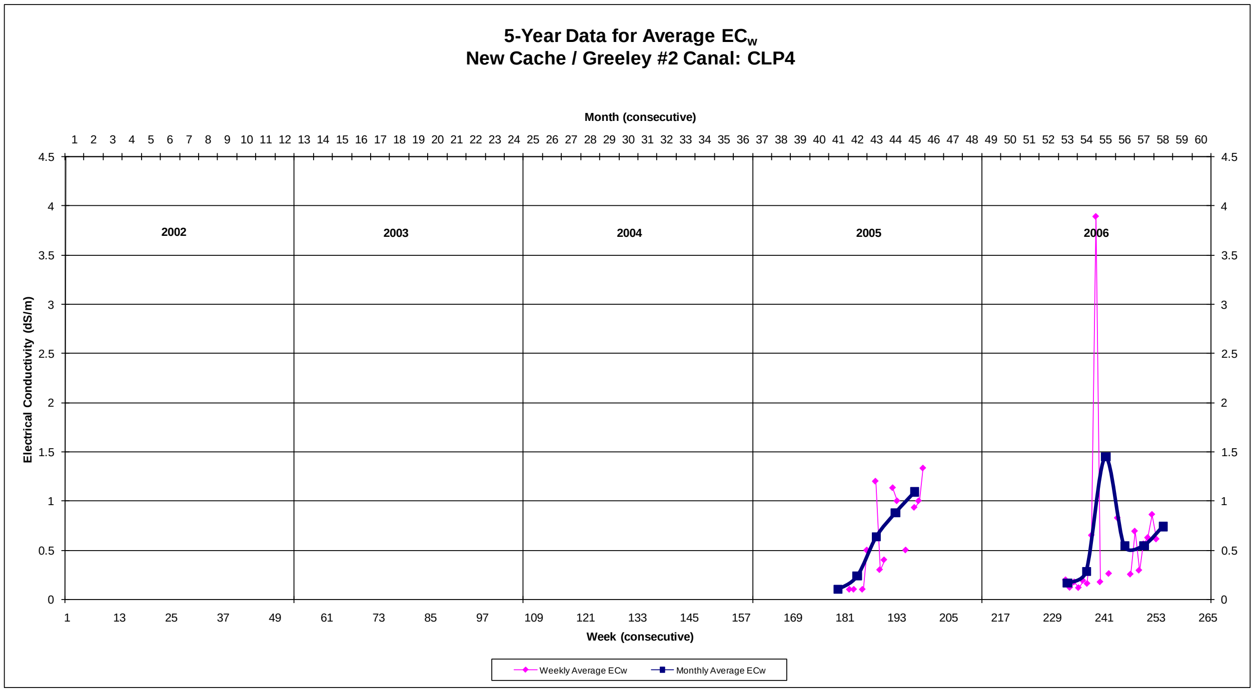

PLASEDCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.4
2.3
2.2
2.1
2.0
1.9
1.8
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

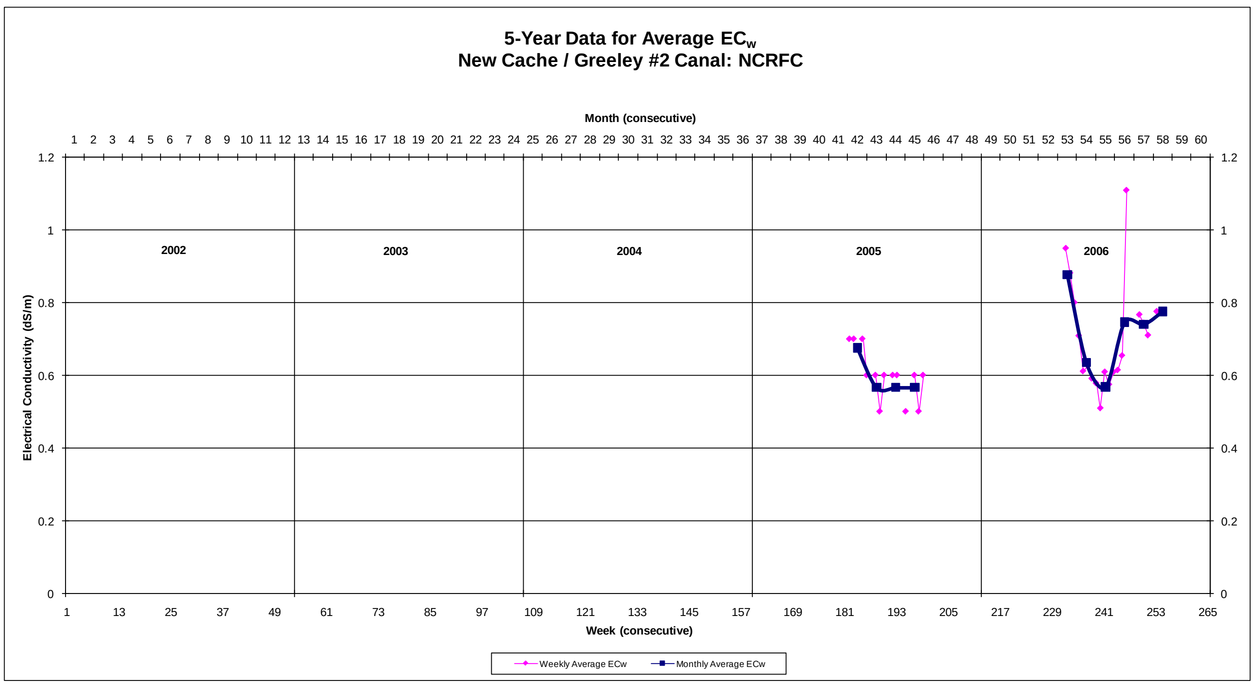

ONEJURCO: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
Season
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year
2002 2003 2004 2005 2006

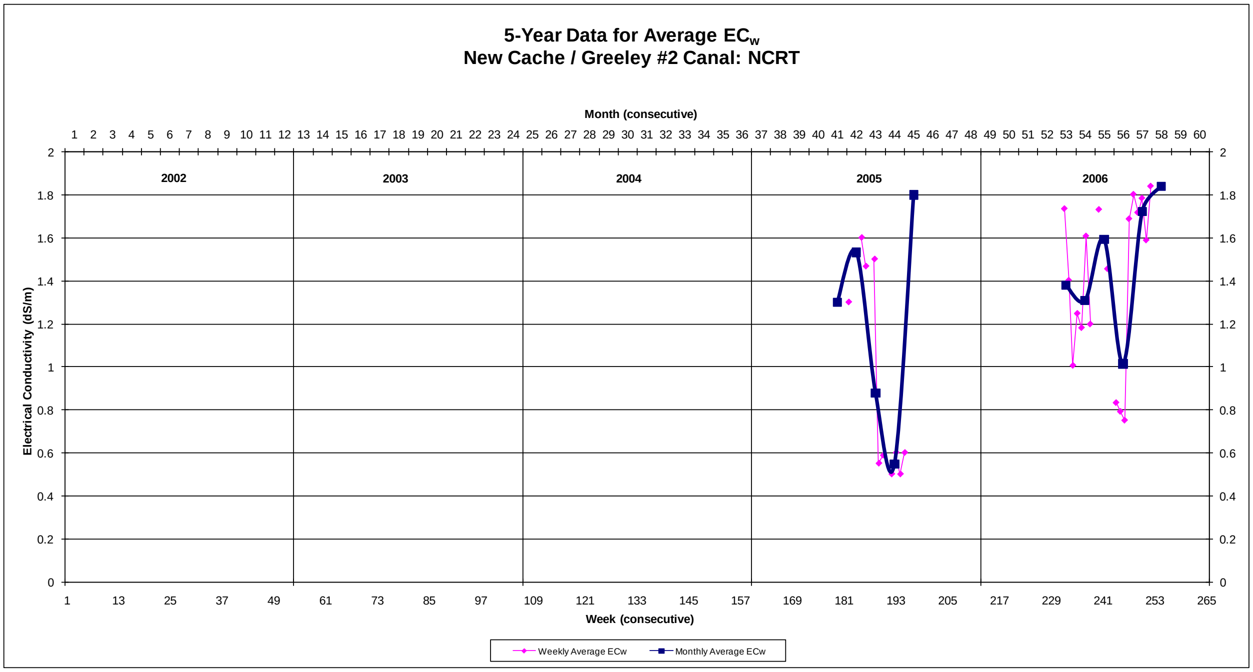
APPENDIX D

Irrigation Ditch System Time Series Plots

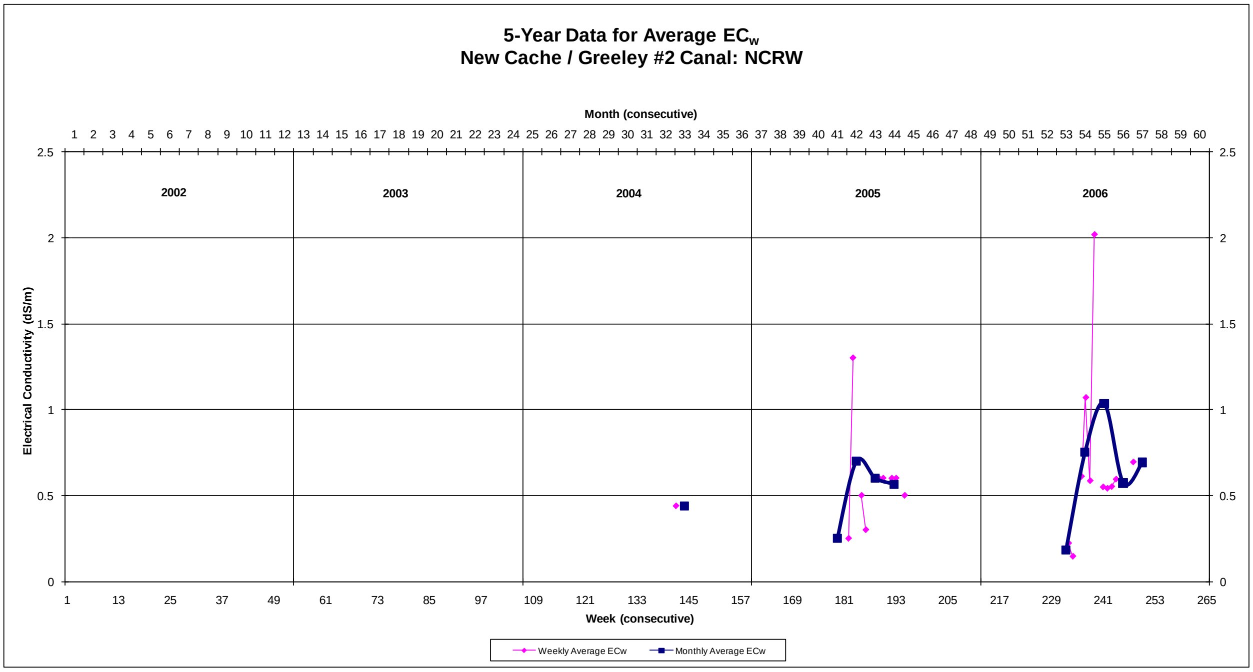
New Cache / Greeley #2 Canal



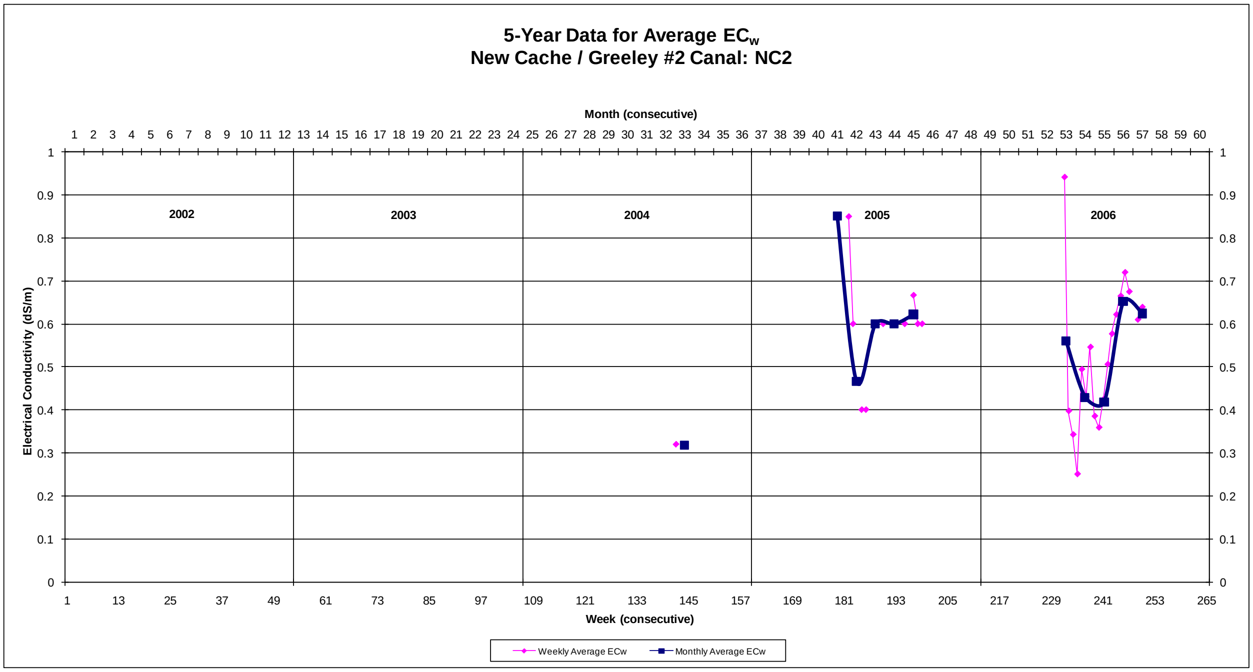


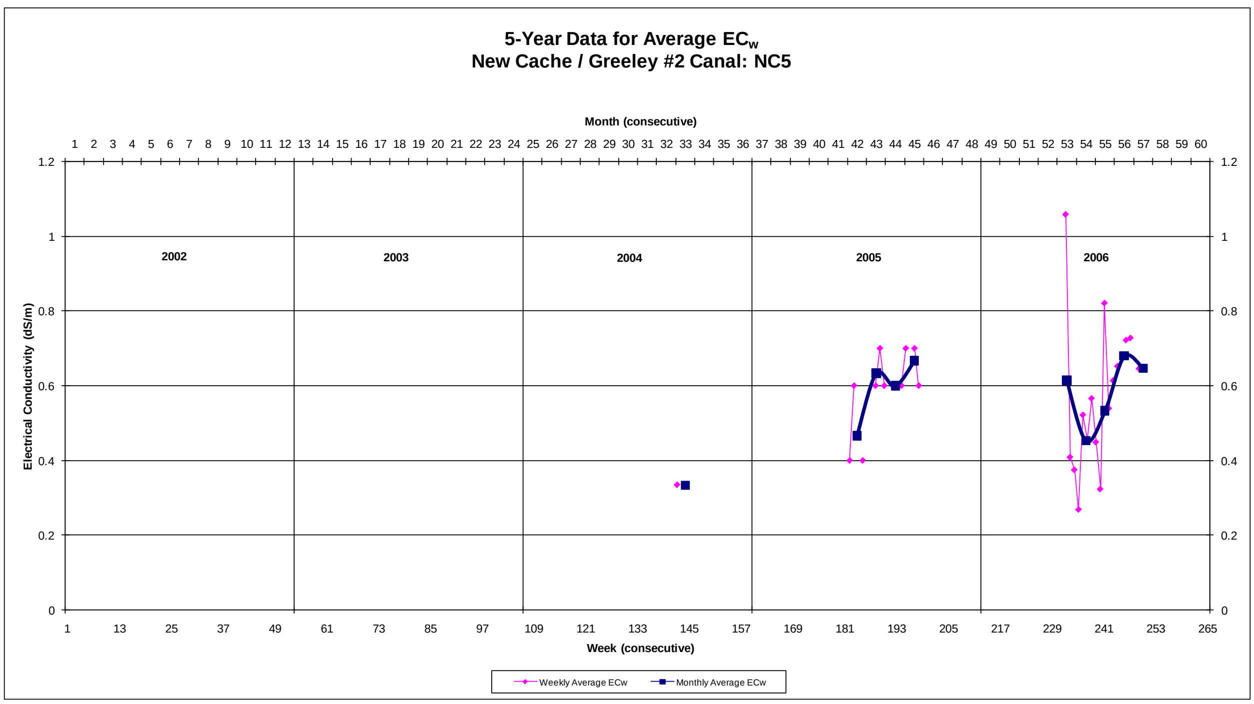


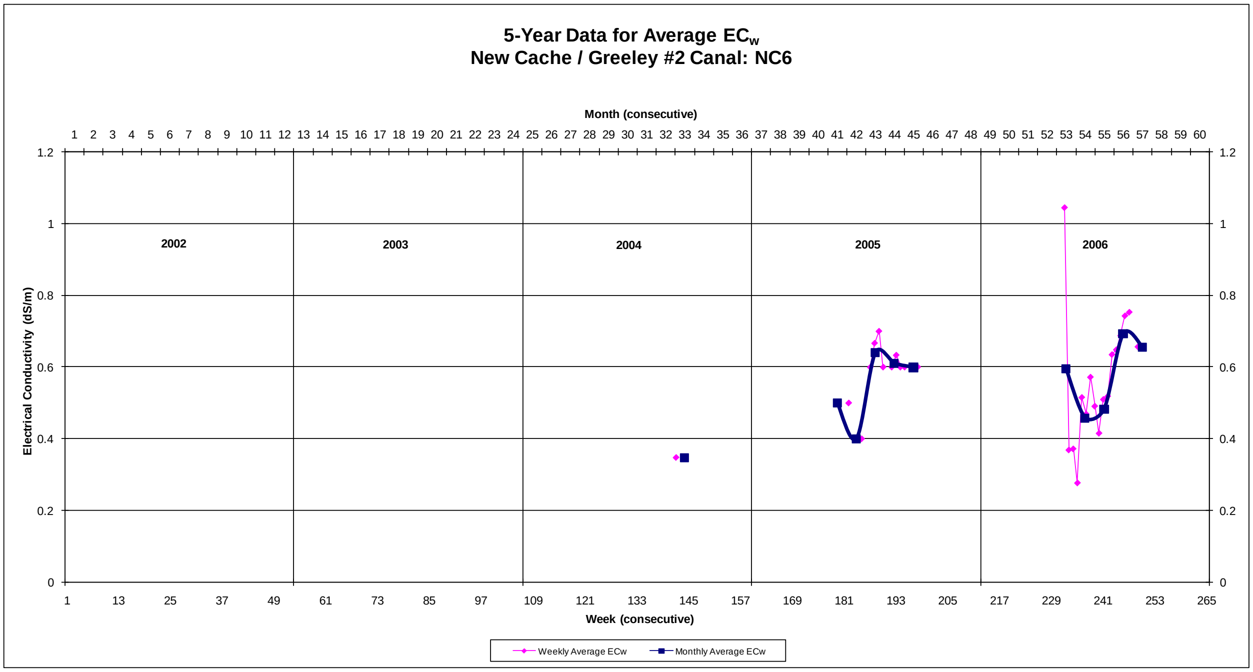
5-Year Data for Average EC_w
New Cache / Greeley #2 Canal: NCRT
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw



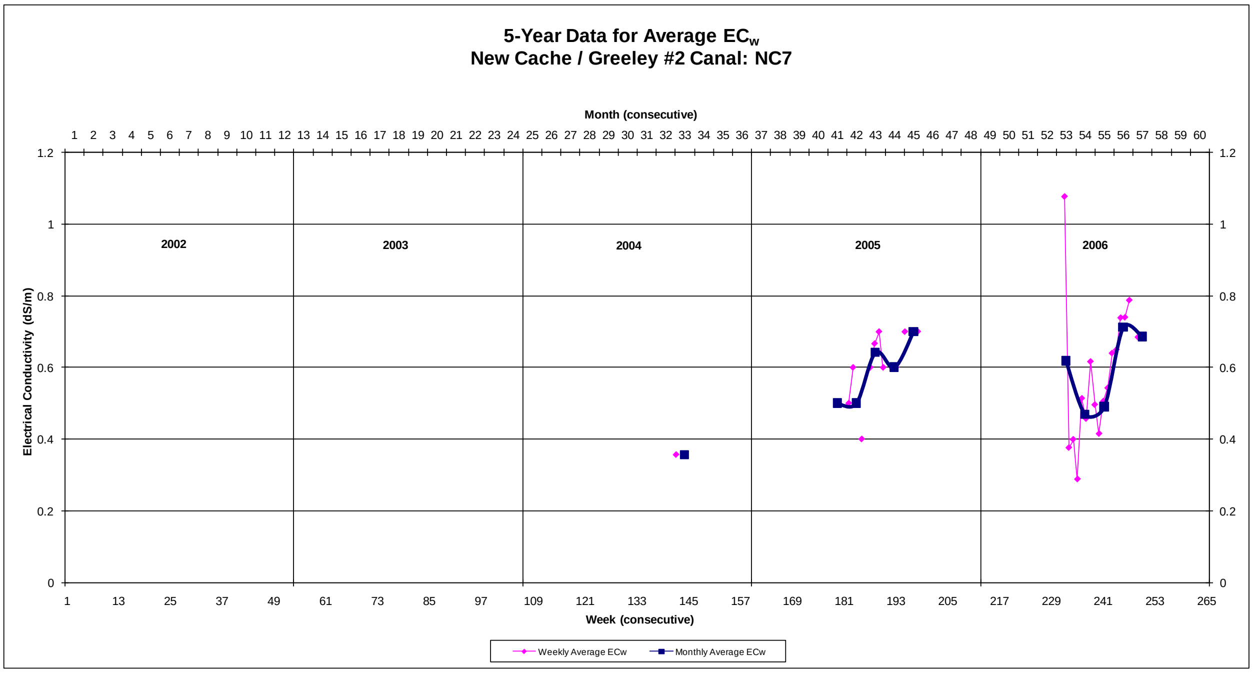
5-Year Data for Average EC_w
New Cache / Greeley #2 Canal: NCRW
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average ECw
New Cache / Greeley #2 Canal: NC2
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average ECw
New Cache / Greeley #2 Canal: NC5
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

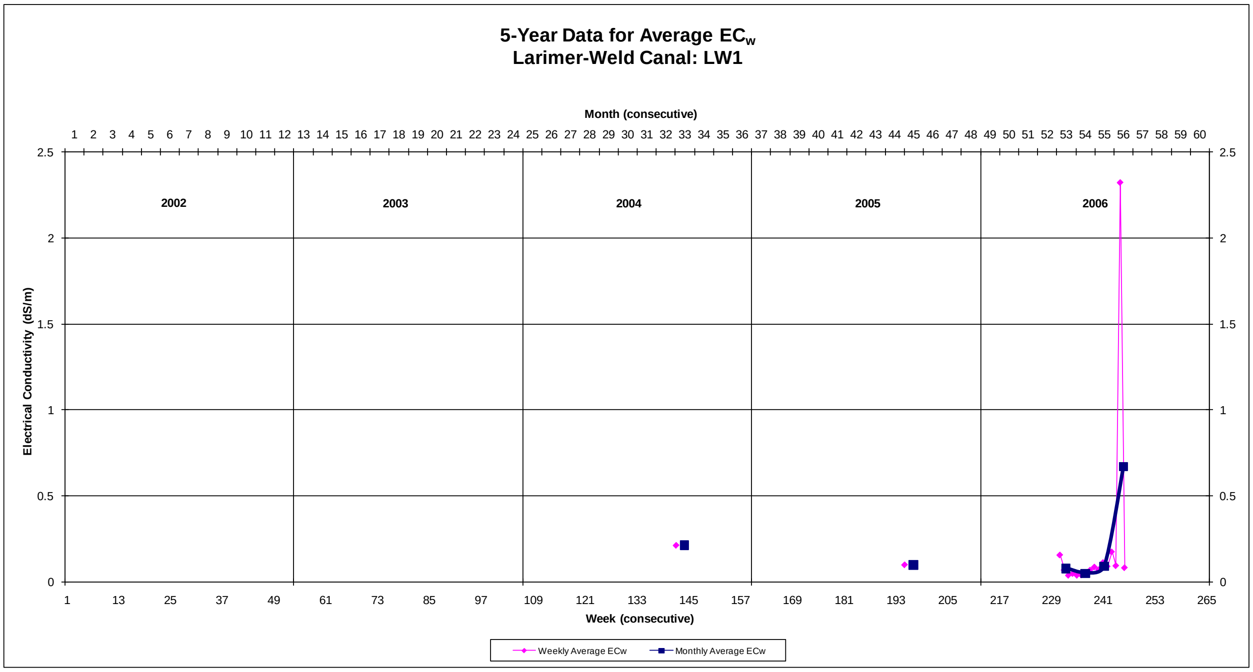


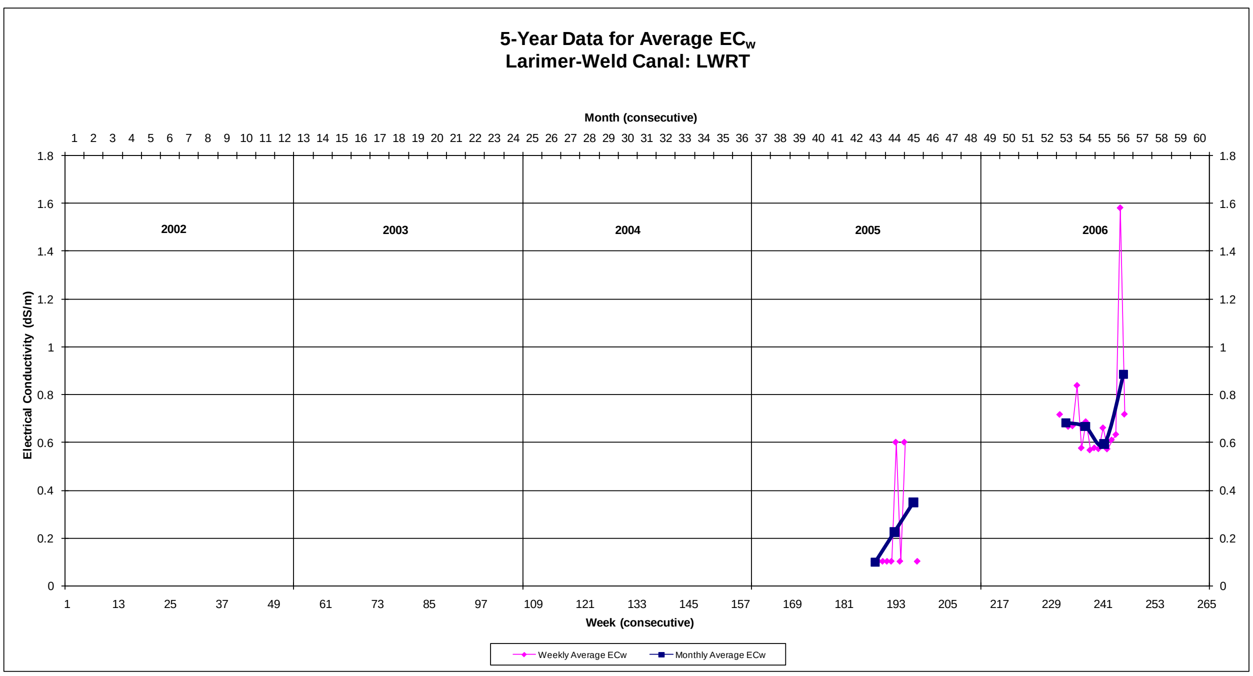
5-Year Data for Average ECw
New Cache / Greeley #2 Canal: NC6
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

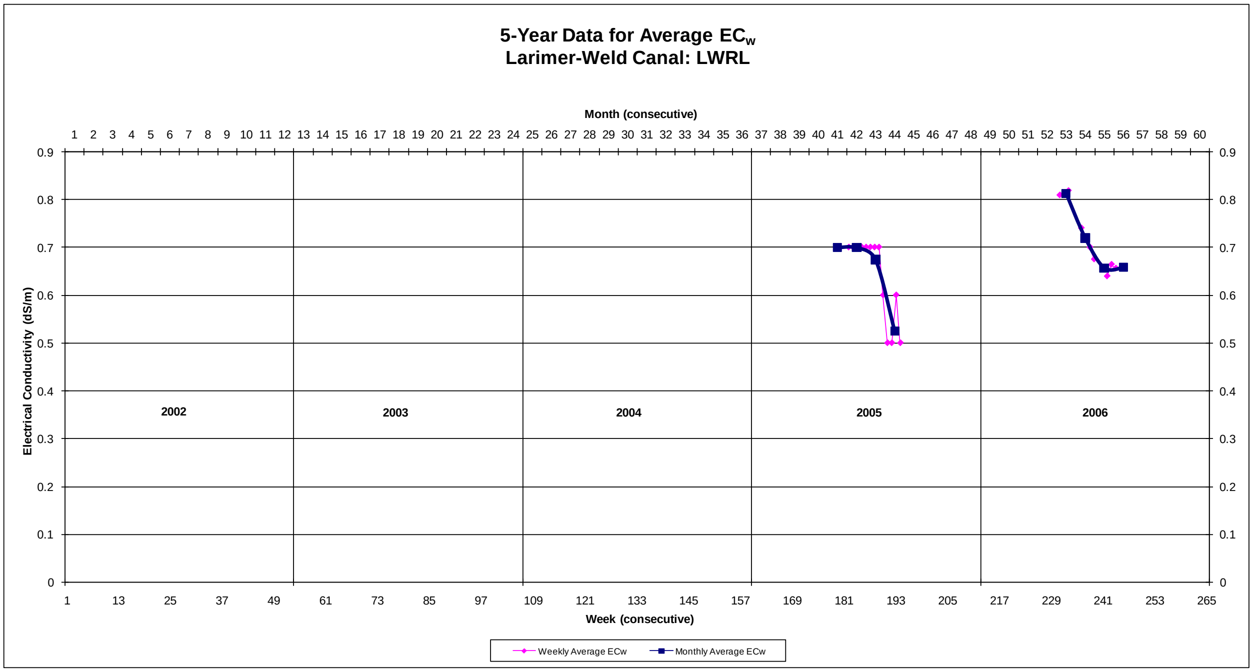


5-Year Data for Average ECw
New Cache / Greeley #2 Canal: NC7
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

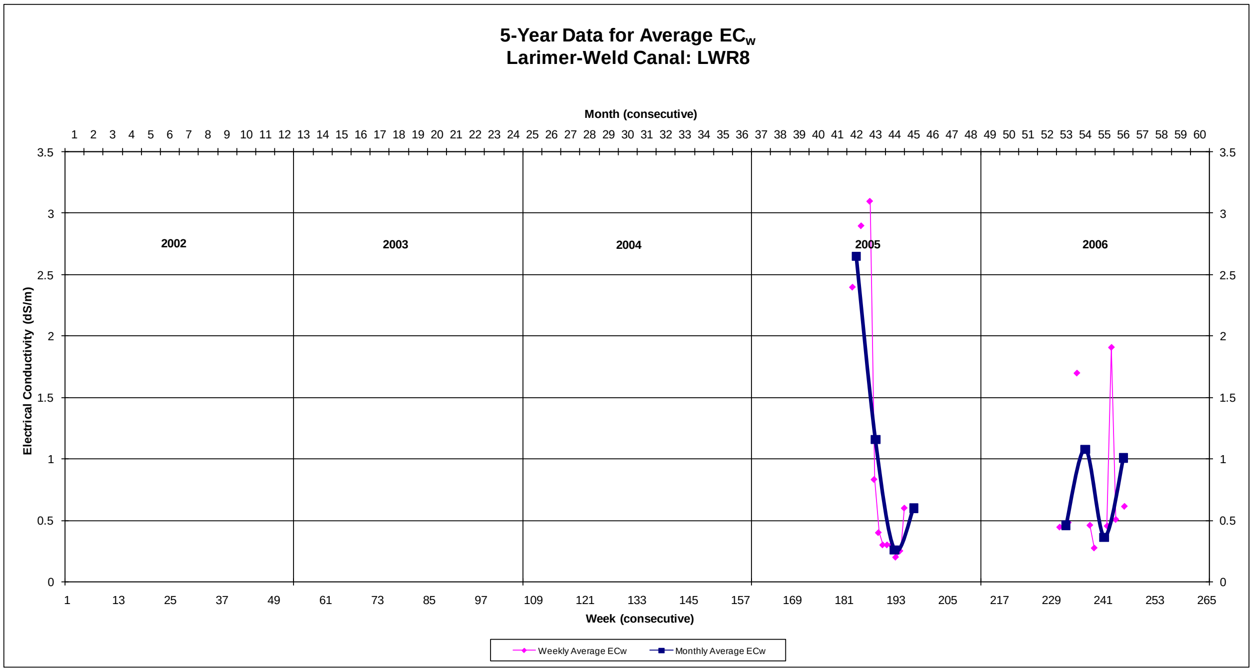
Larimer-Weld Canal



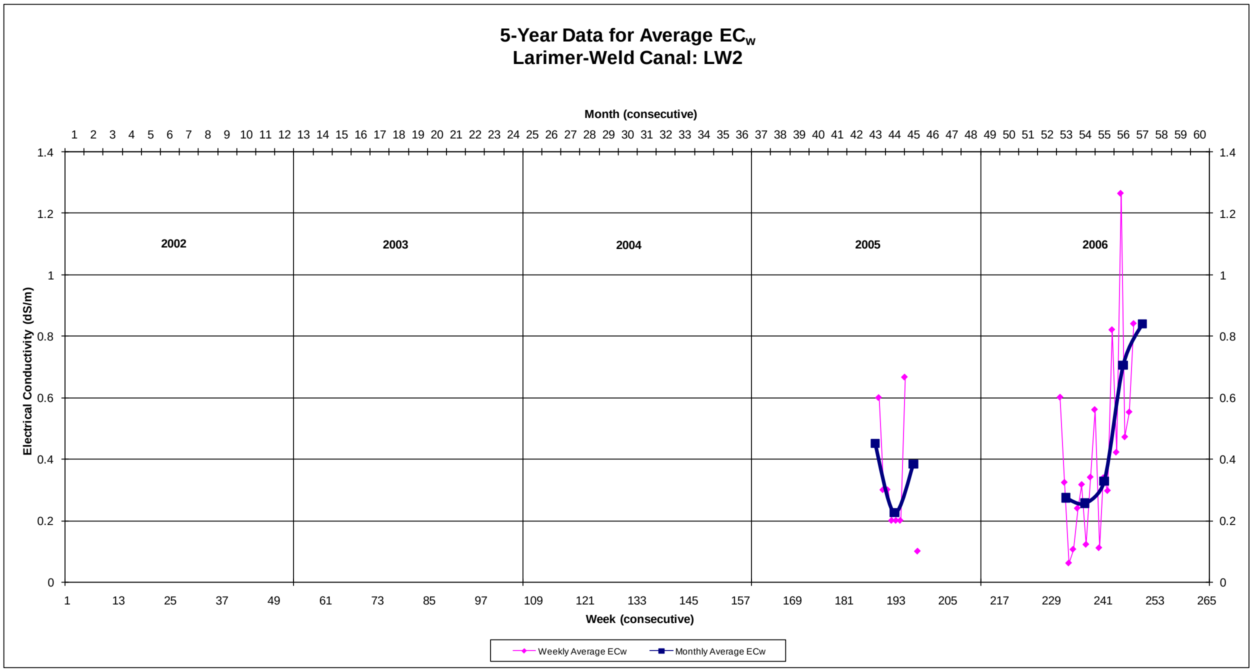


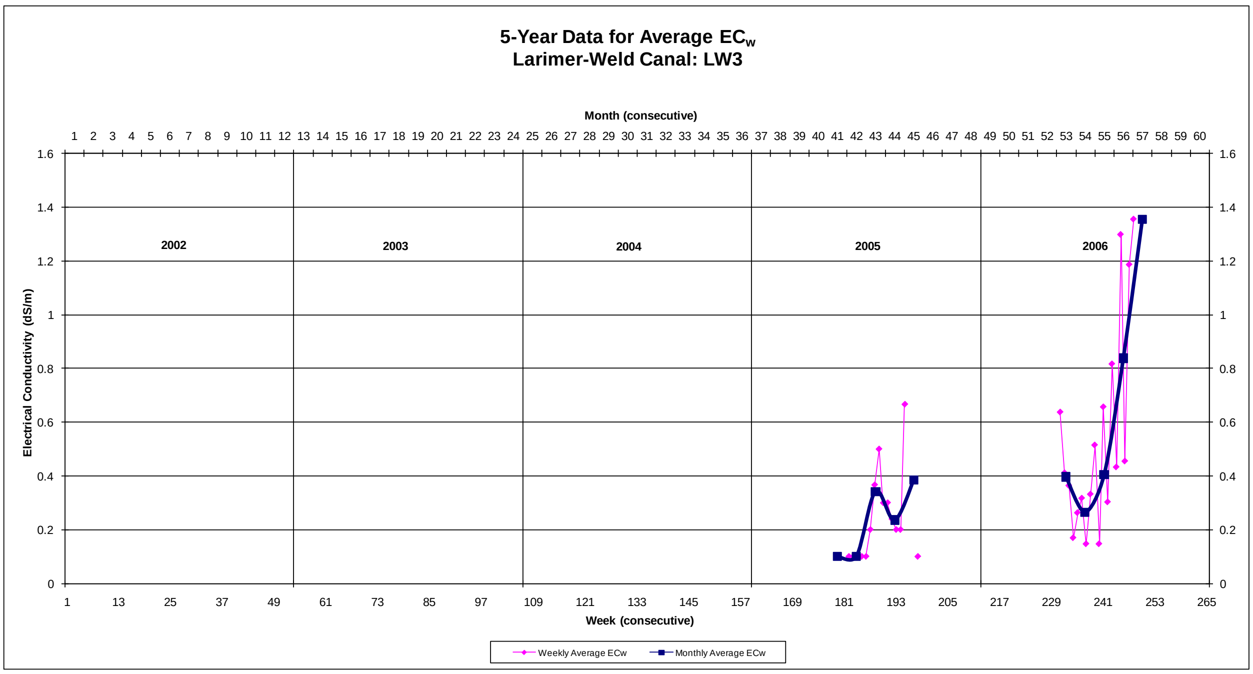


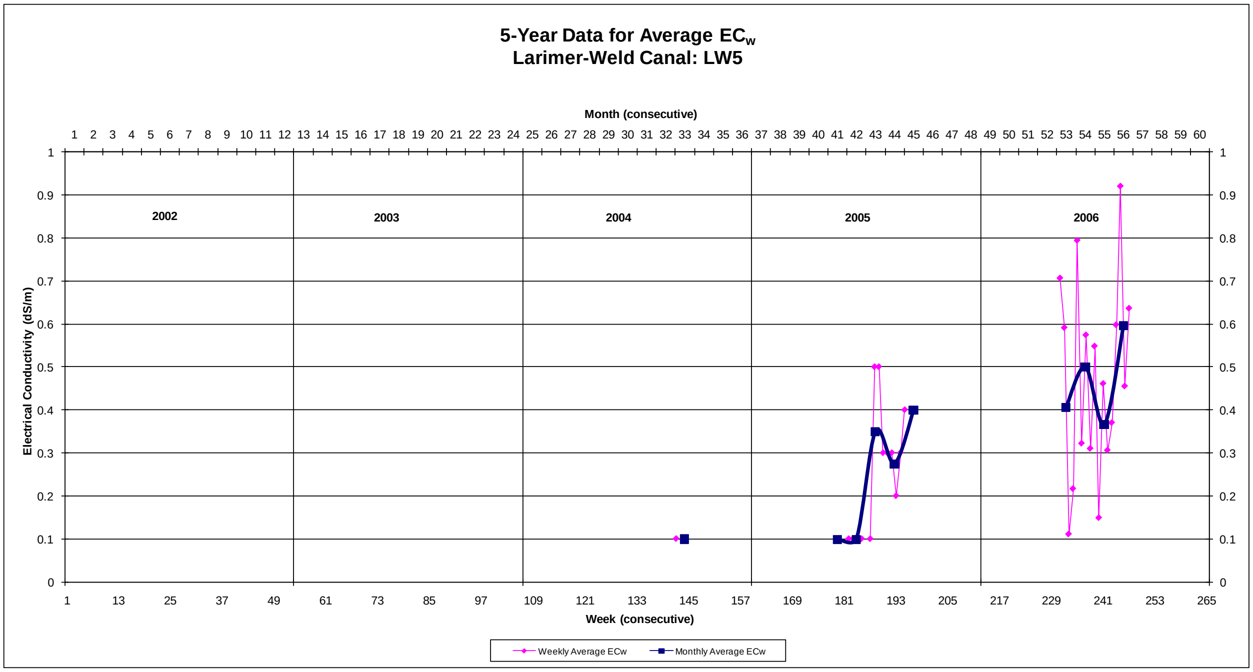
5-Year Data for Average EC_w
Larimer-Weld Canal: LWRL
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

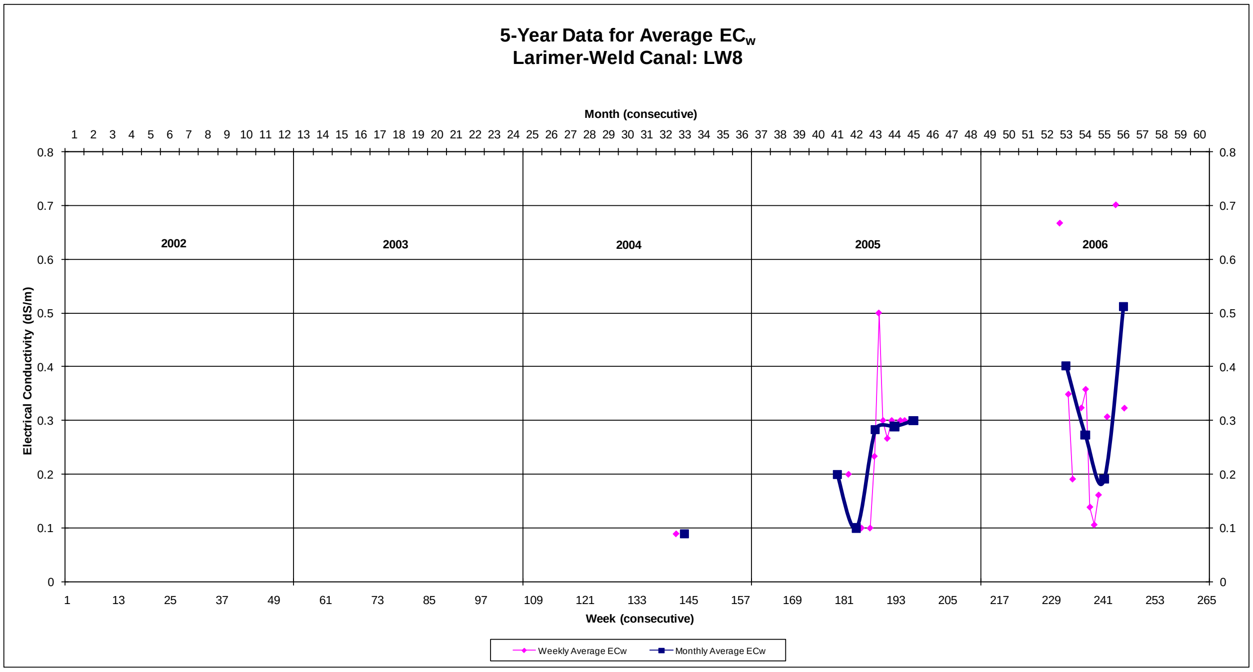


5-Year Data for Average EC_w
Larimer-Weld Canal: LWR8
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

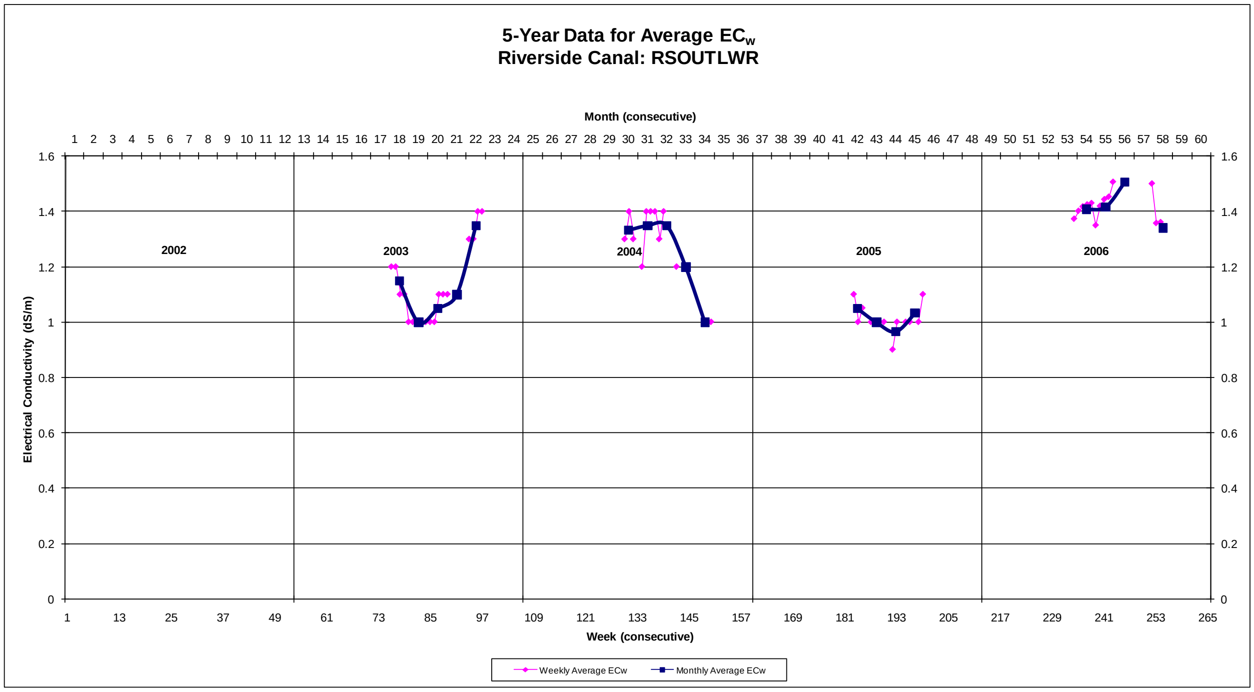

5-Year Data for Average EC_w
Larimer-Weld Canal: LW2
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

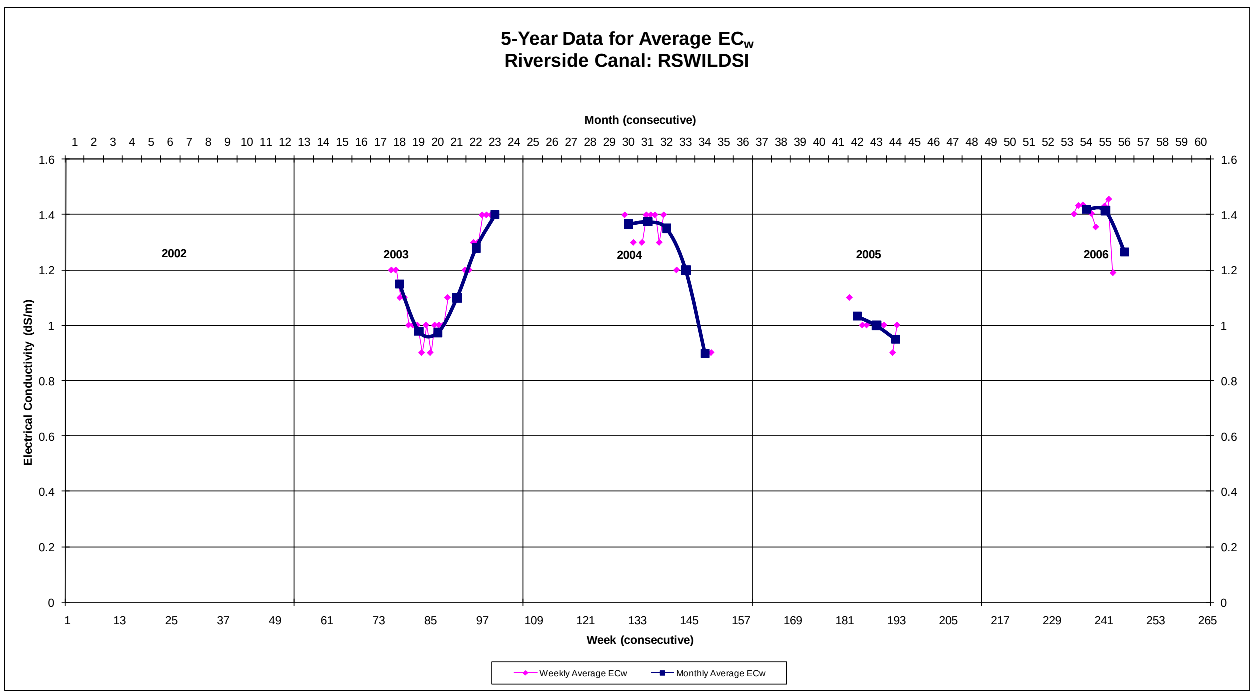

5-Year Data for Average EC_w
Larimer-Weld Canal: LW3
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

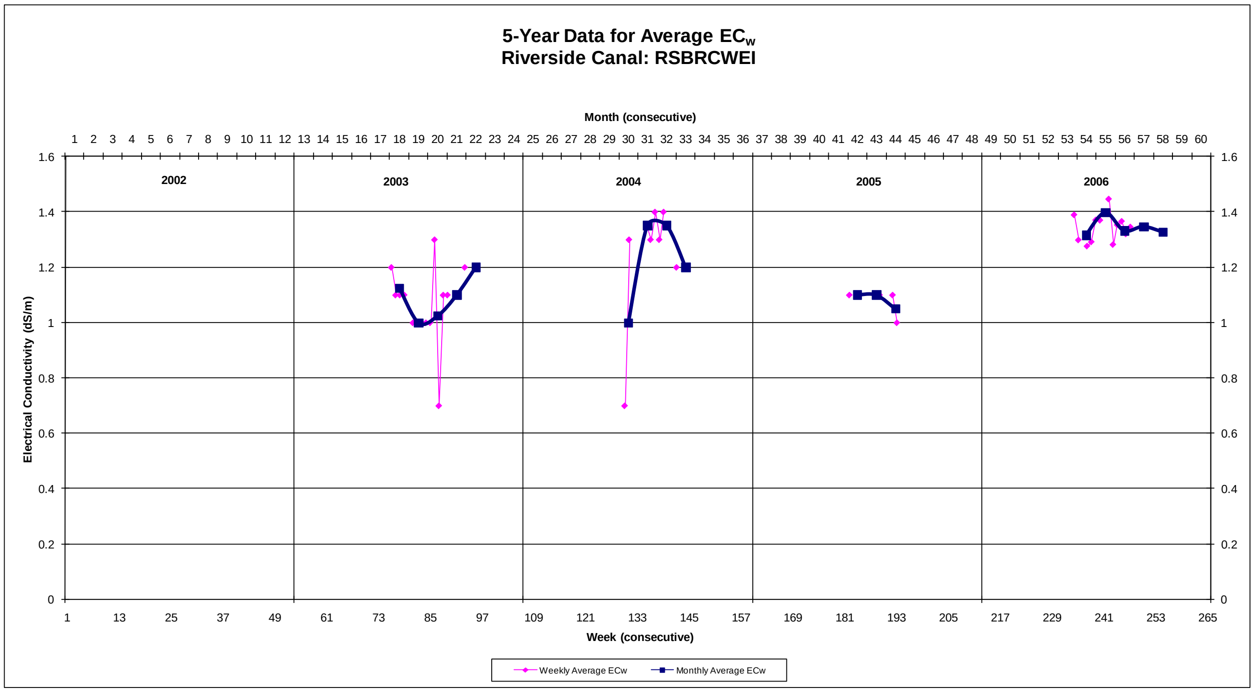

5-Year Data for Average ECw
Larimer-Weld Canal: LW5
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average ECw
Larimer-Weld Canal: LW8
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

Riverside Canal

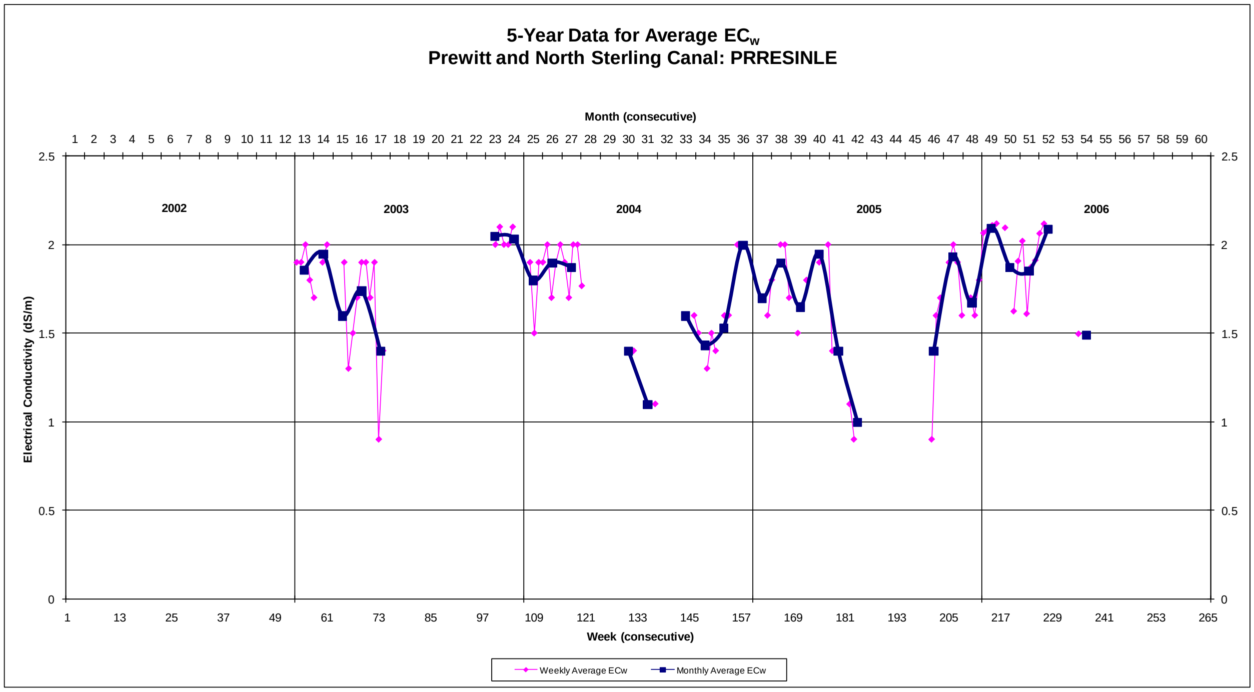


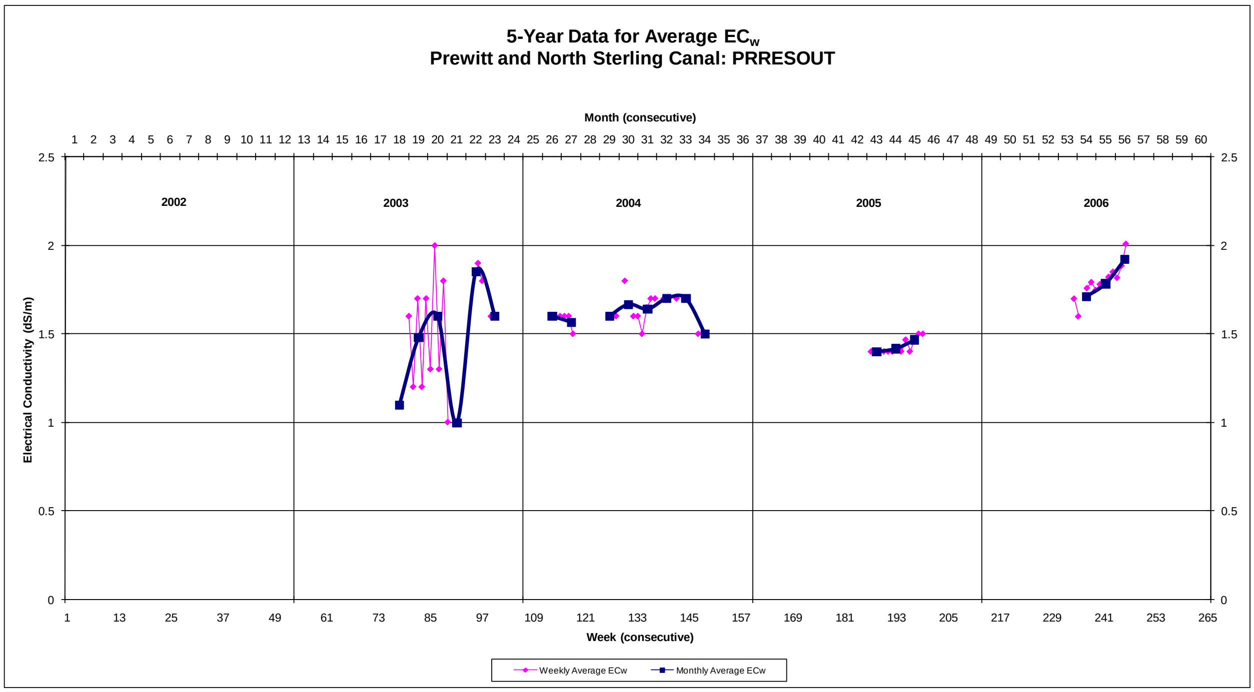


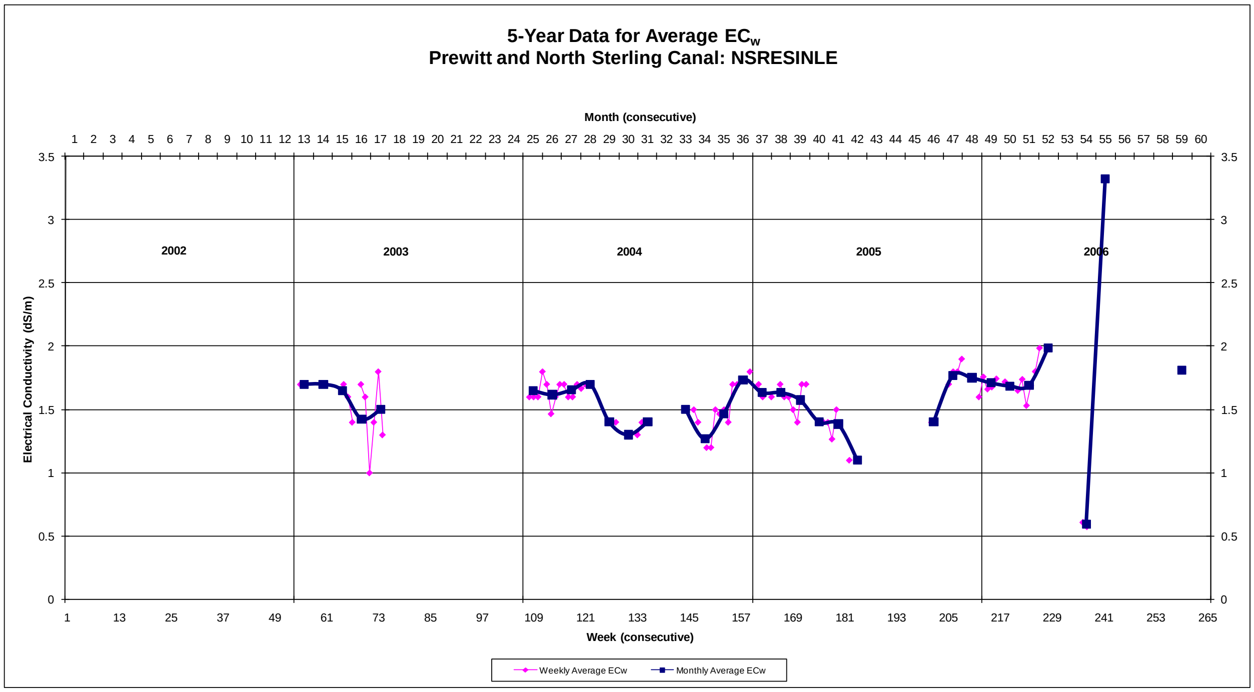


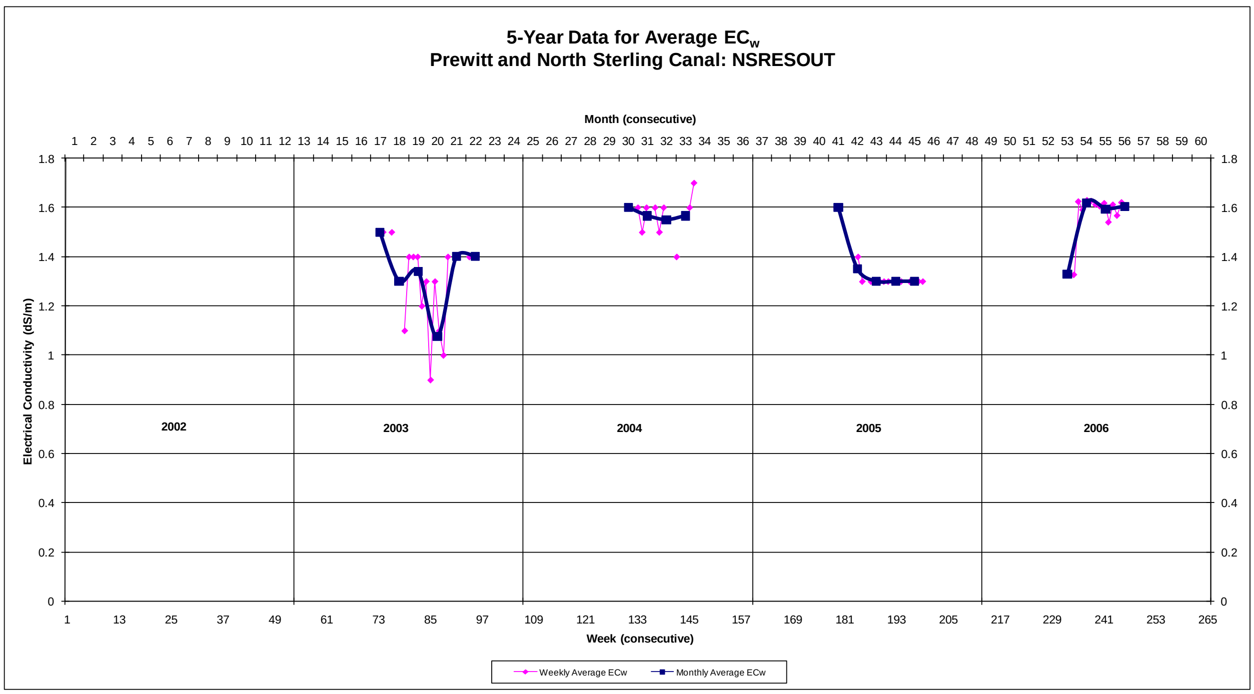
5-Year Data for Average EC_w
Riverside Canal: RSBRCWEI
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

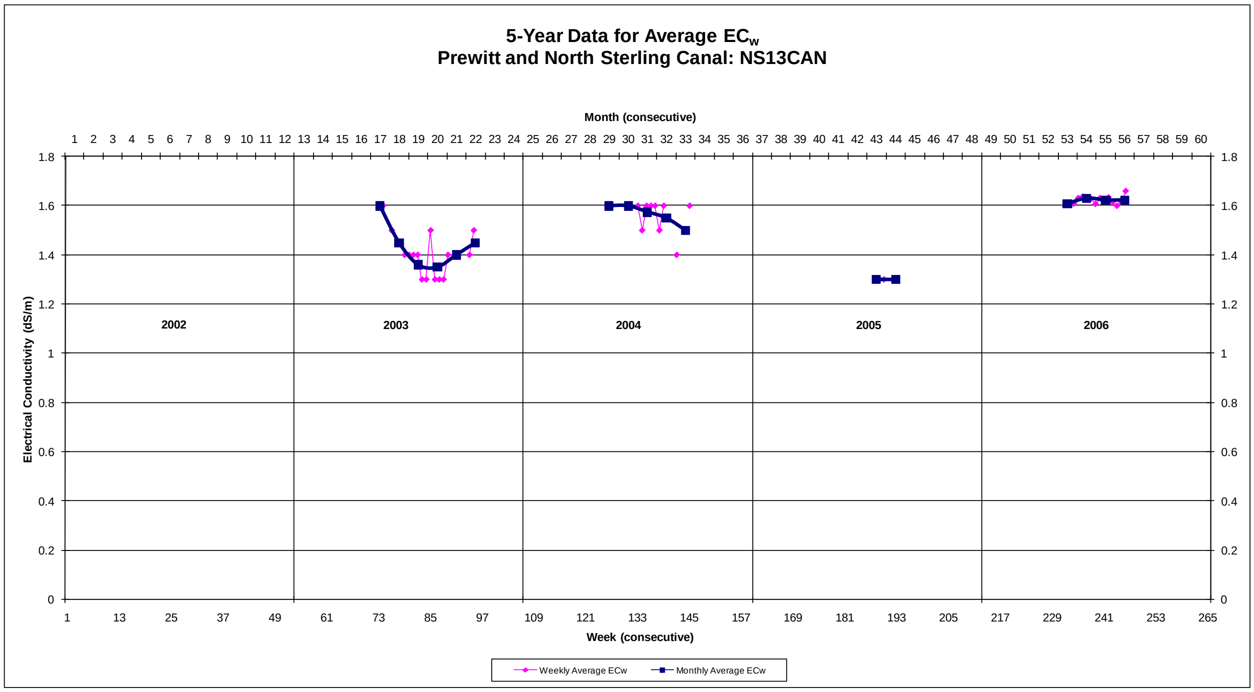
Prewitt and North Sterling Canal



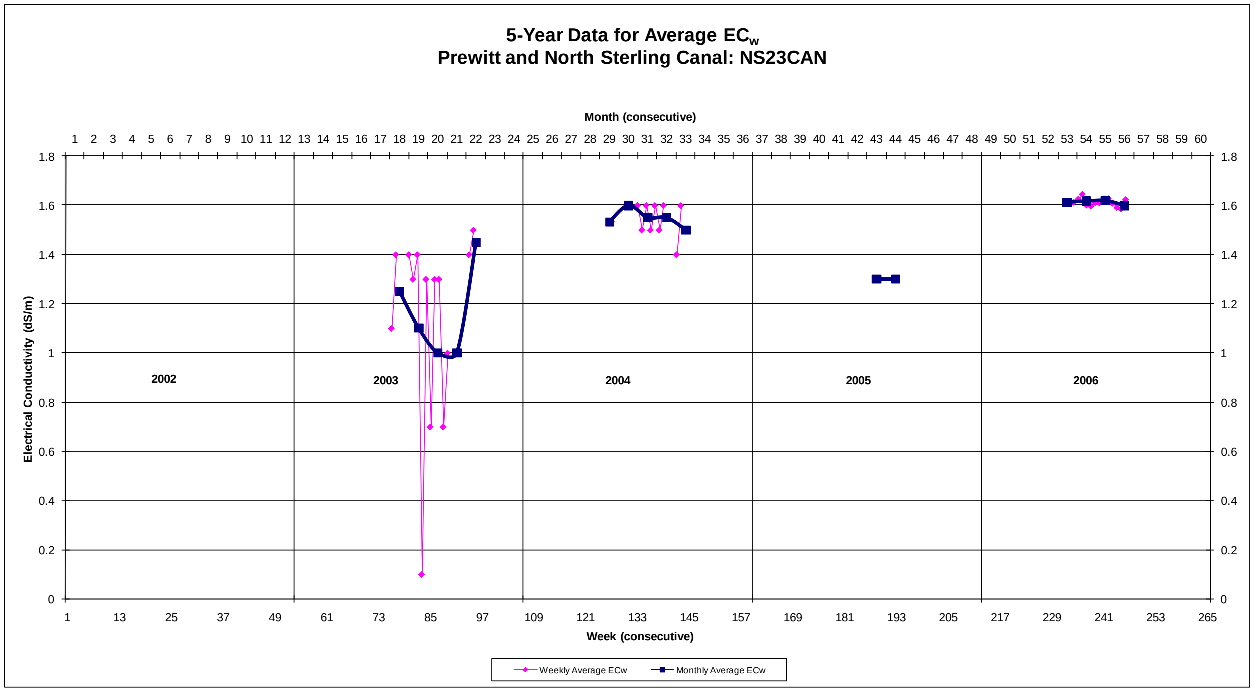



5-Year Data for Average EC_w
Prewitt and North Sterling Canal: NSRESINLE
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

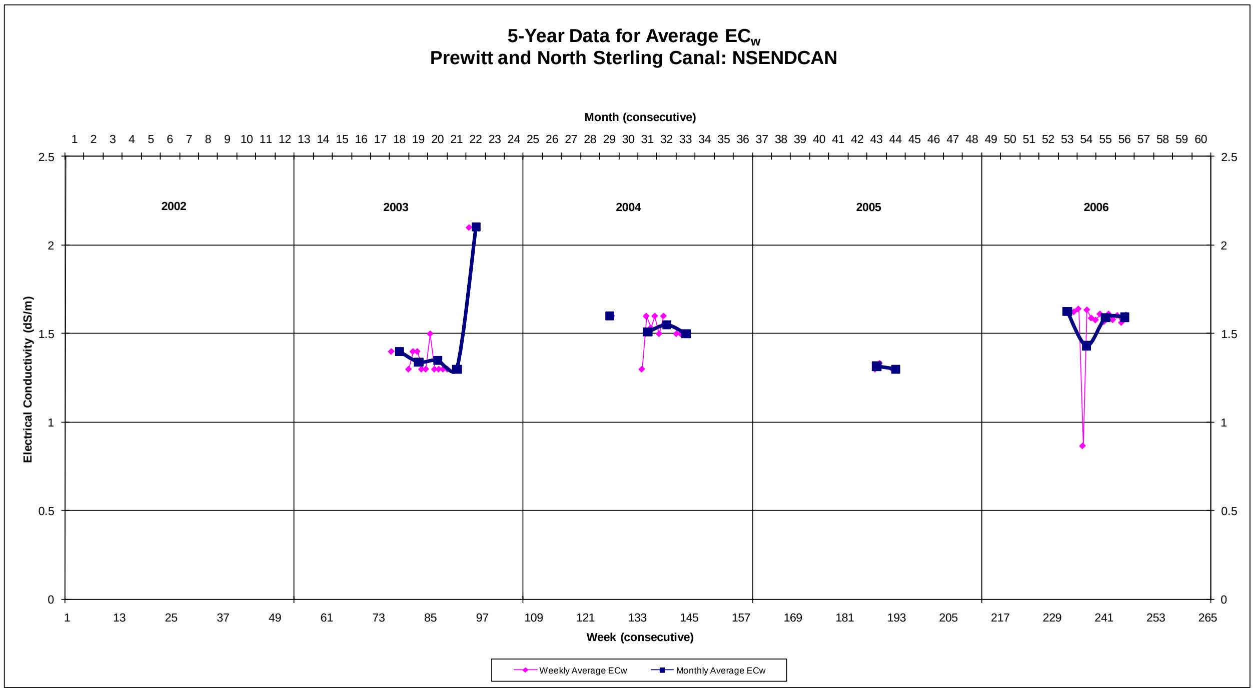

5-Year Data for Average EC_w
Prewitt and North Sterling Canal: NSRESOUT
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw



5-Year Data for Average EC_w
Prewitt and North Sterling Canal: NS13CAN
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

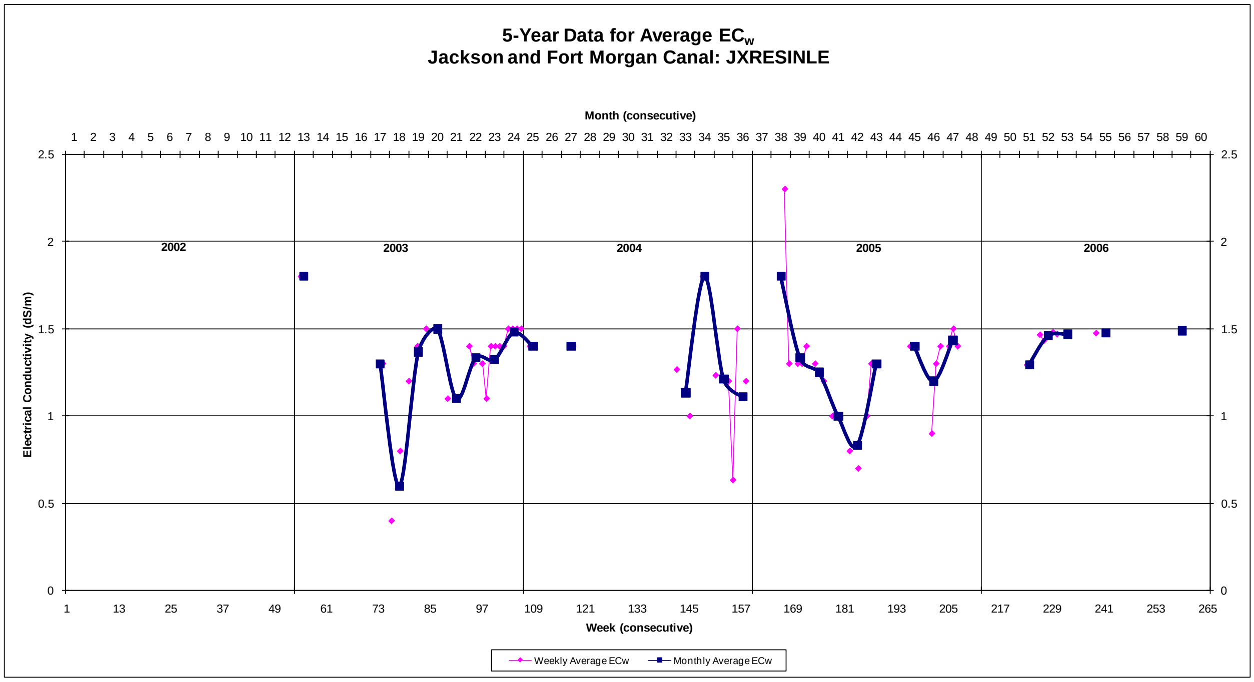


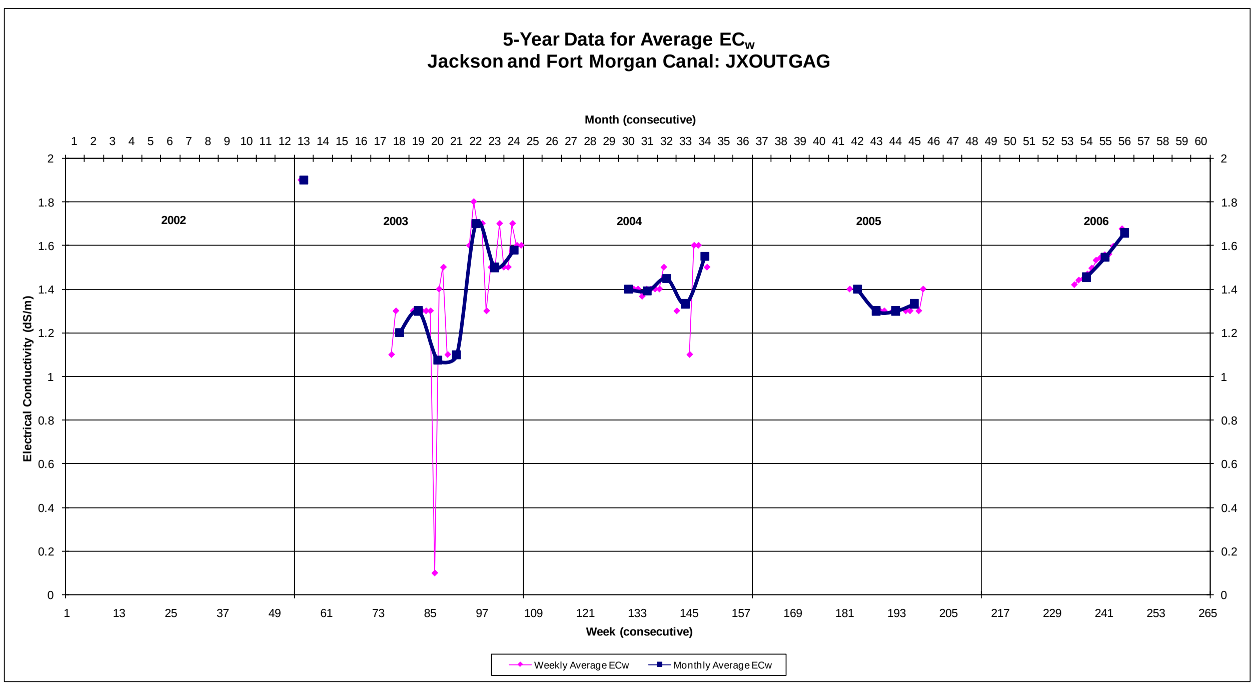
5-Year Data for Average EC_w
Prewitt and North Sterling Canal: NS23CAN
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

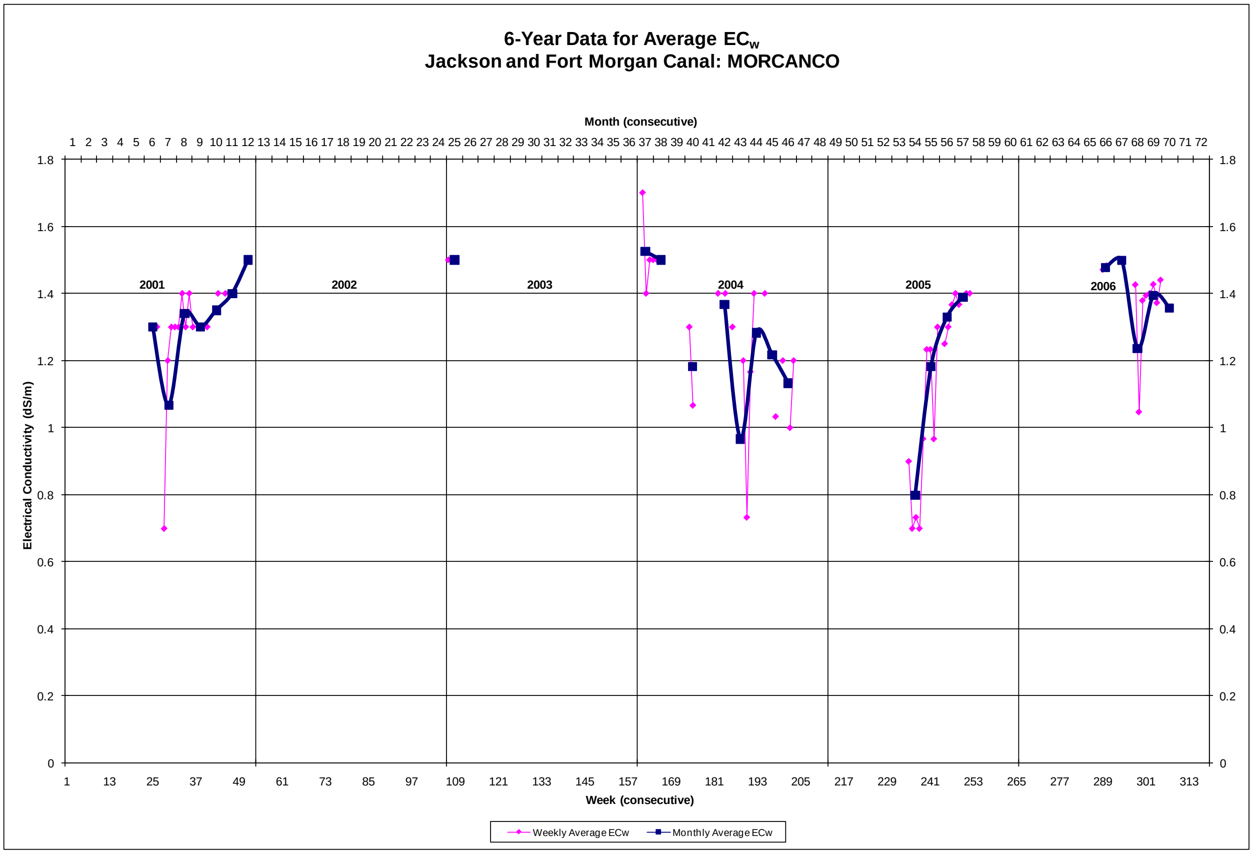


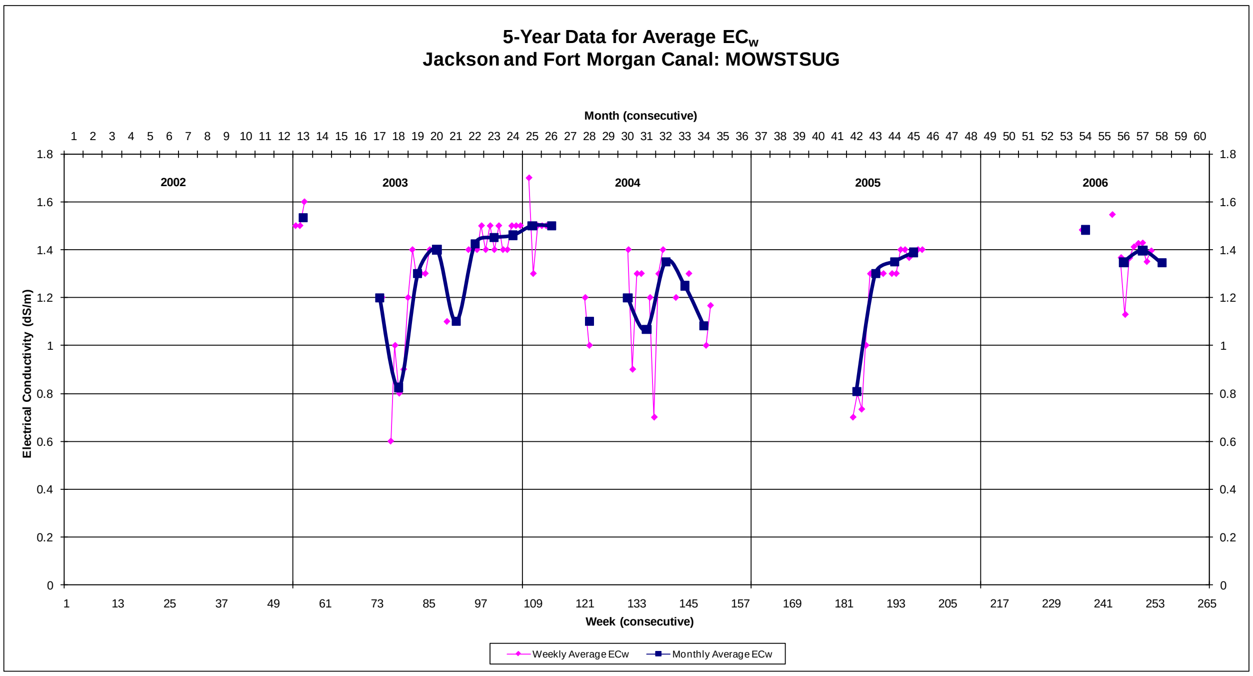
5-Year Data for Average ECw
Prewitt and North Sterling Canal: NSENDCAN
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

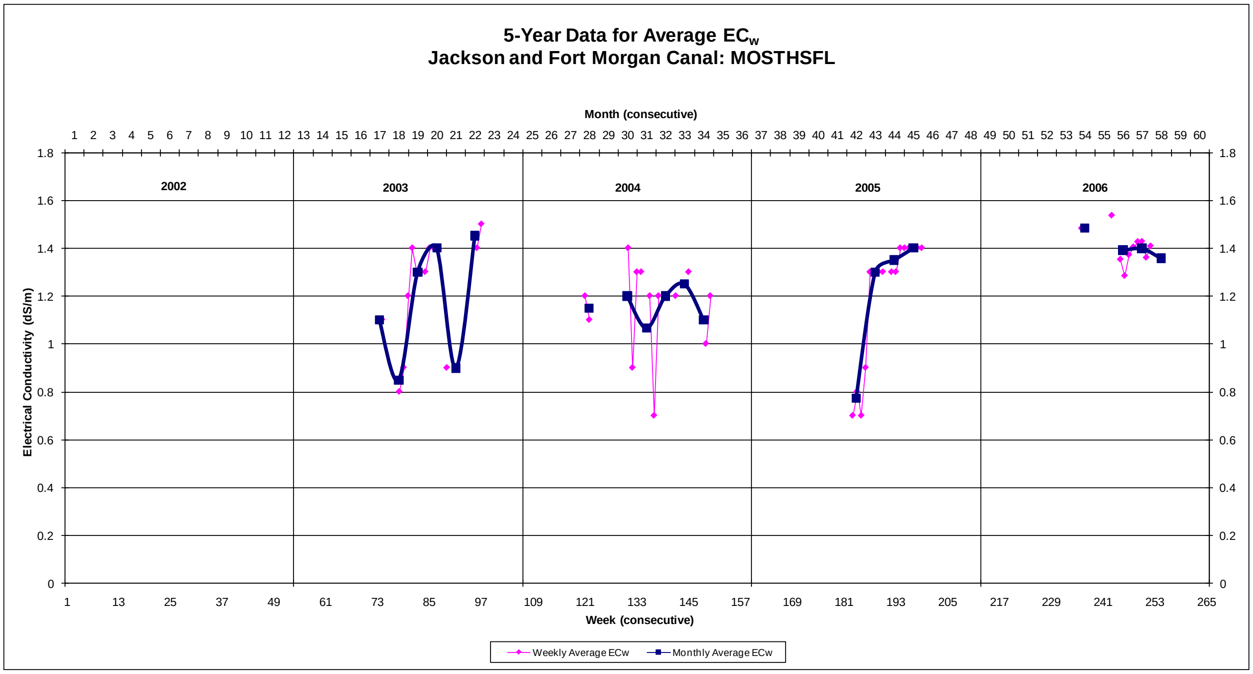
Jackson and Morgan Canal



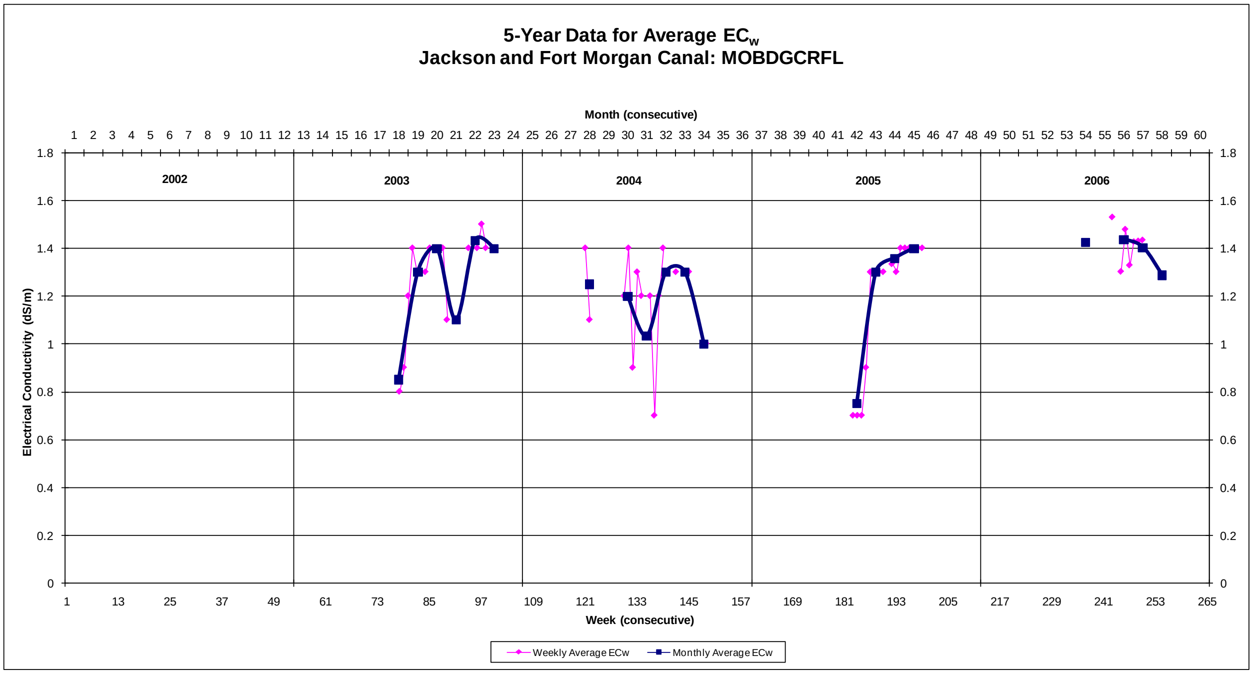



6-Year Data for Average EC_w
Jackson and Fort Morgan Canal: MORCANCO
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

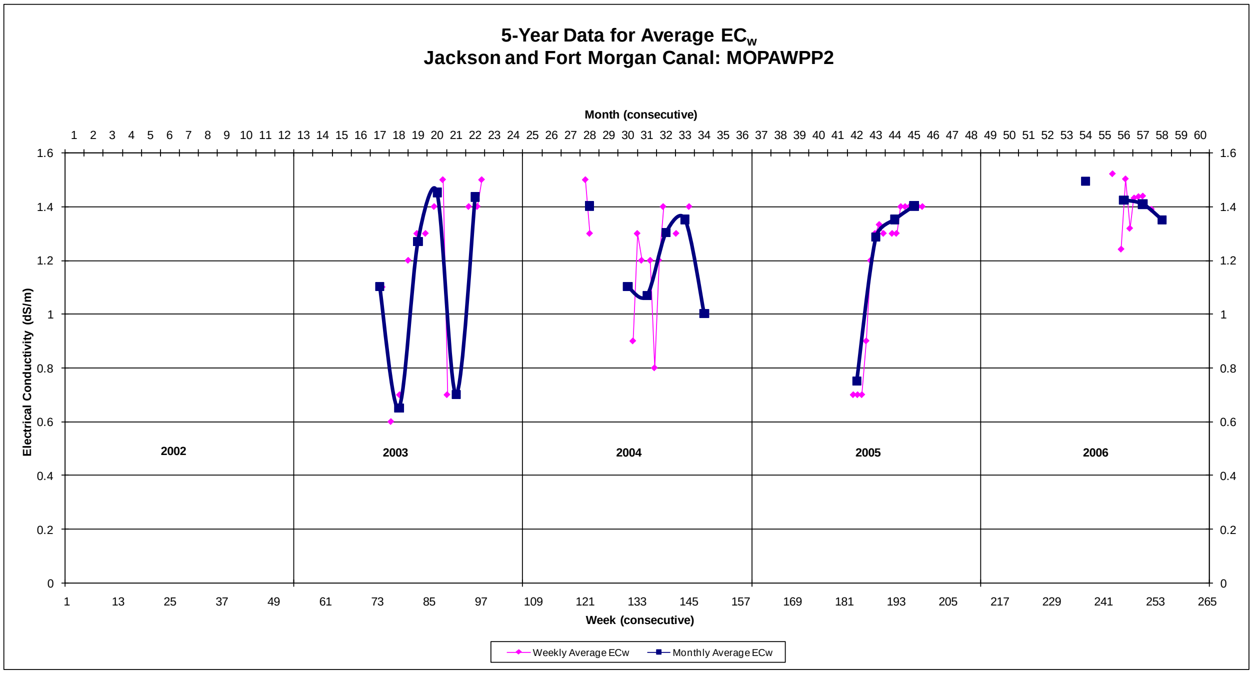

5-Year Data for Average EC_w
Jackson and Fort Morgan Canal: MOWSTSUG
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw



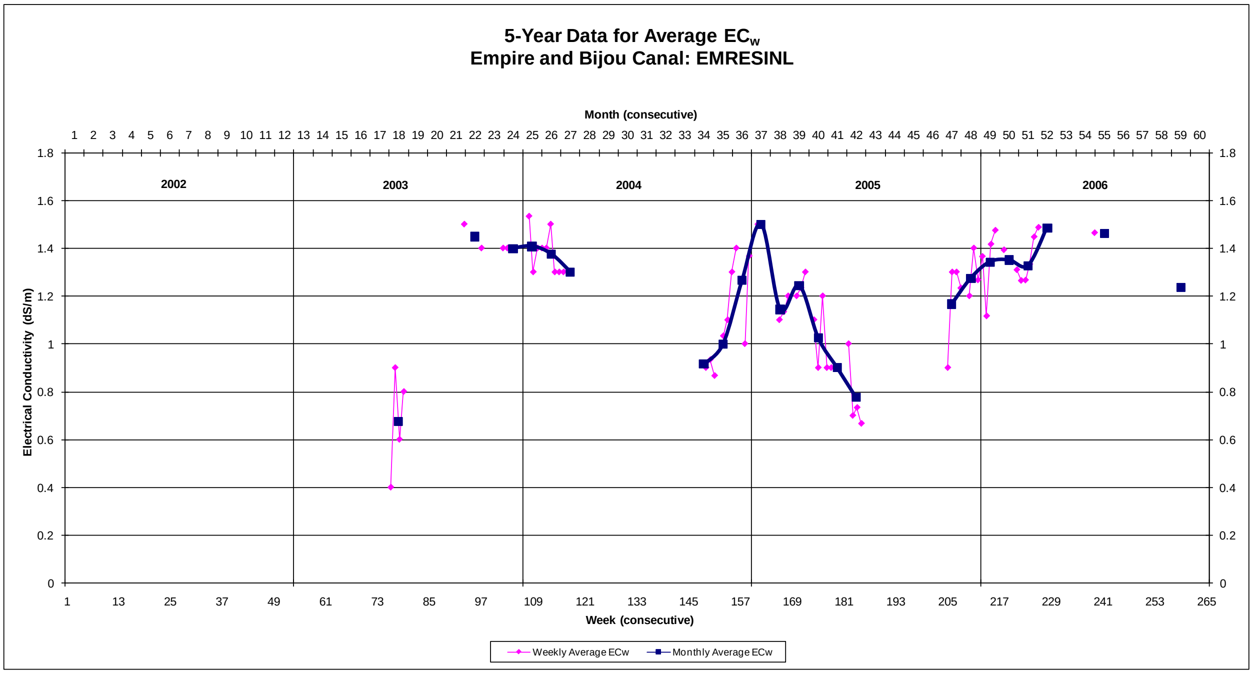
5-Year Data for Average EC_w
Jackson and Fort Morgan Canal: MOSTHSFL
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

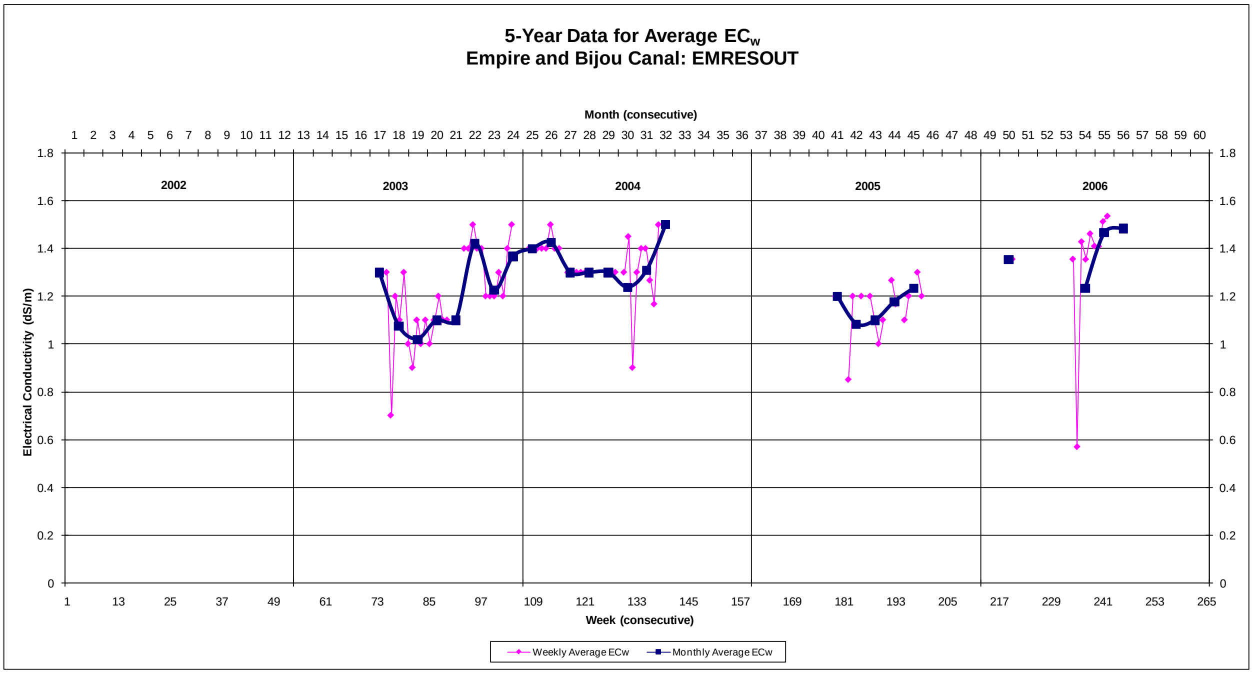


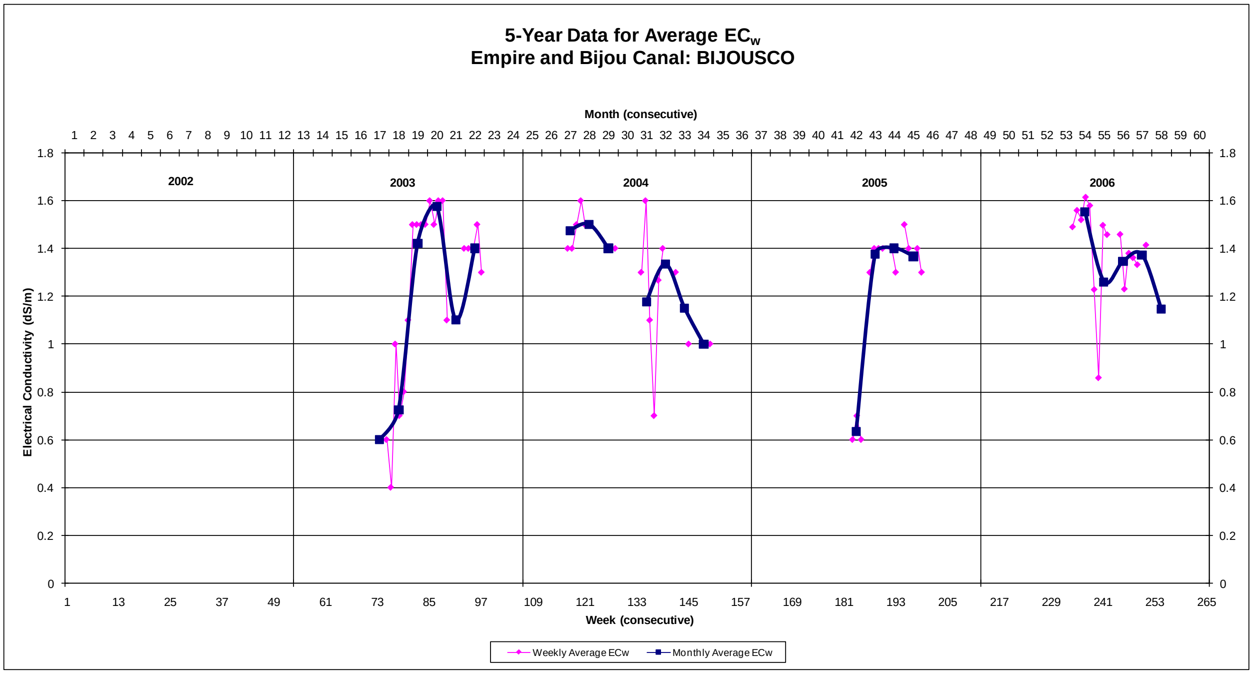
5-Year Data for Average EC_w
Jackson and Fort Morgan Canal: MOBDGCRFL
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average ECw
Jackson and Fort Morgan Canal: MOPAWPP2
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

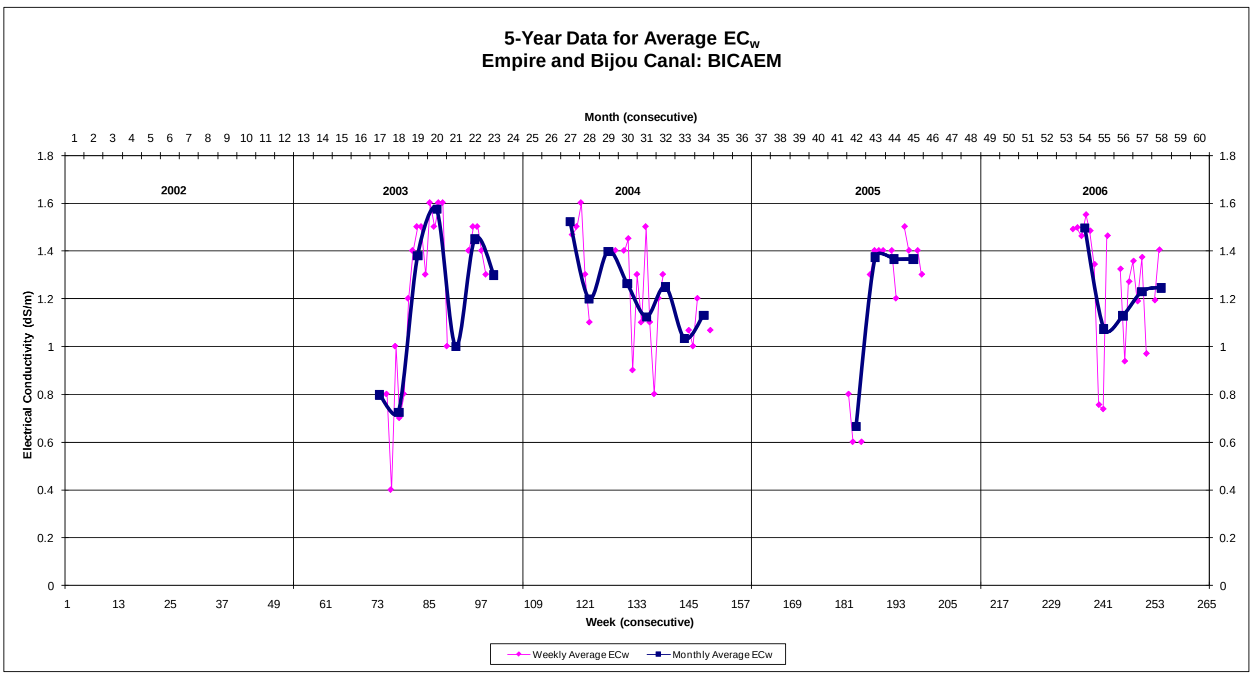
Empire and Bijou Canal



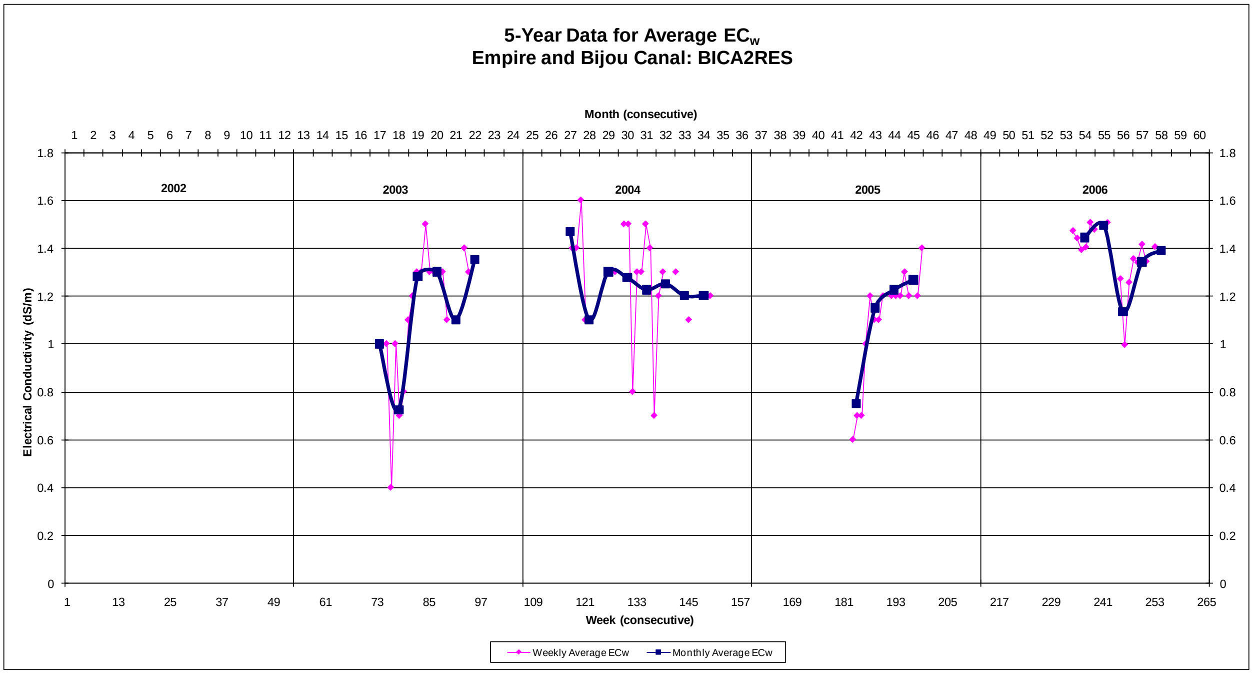




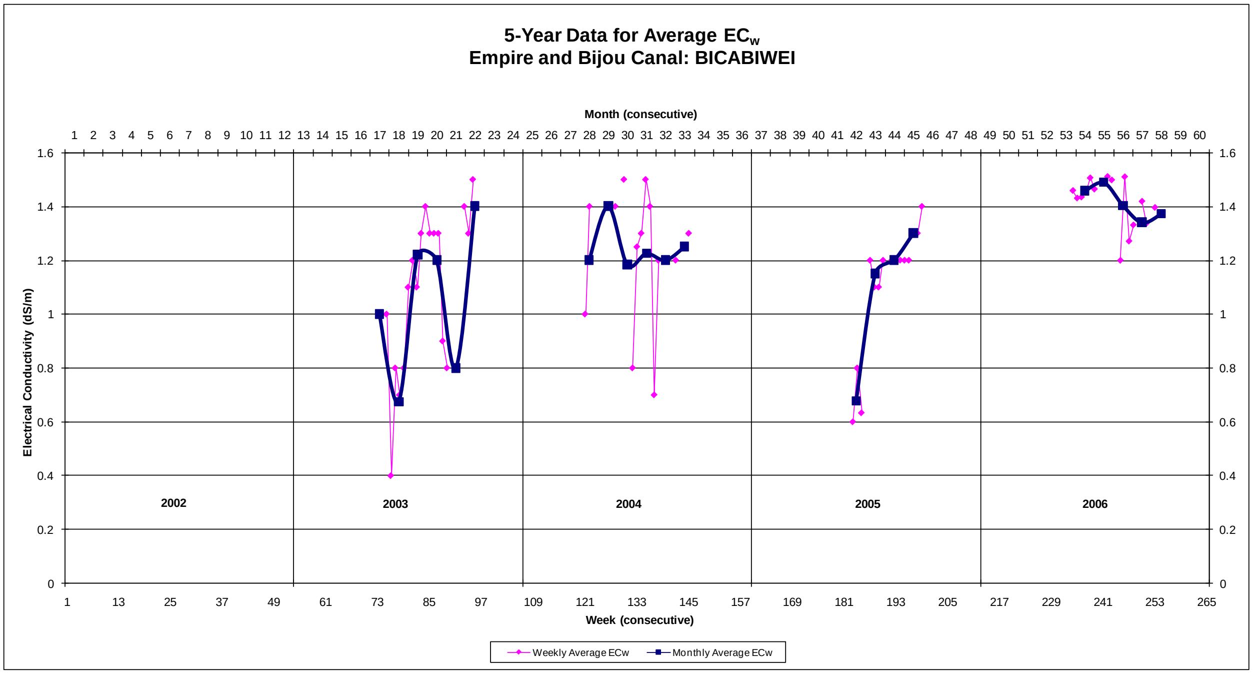
5-Year Data for Average EC_w
Empire and Bijou Canal: BIJOUSCO
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw



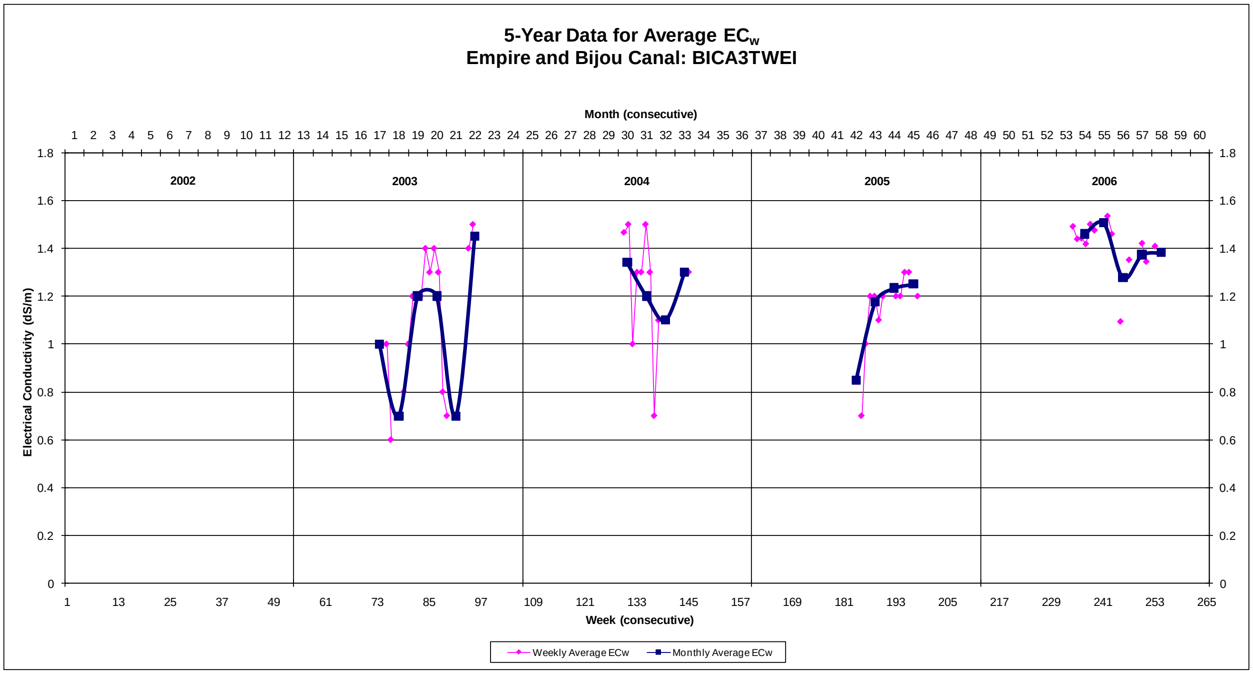
5-Year Data for Average EC_w
Empire and Bijou Canal: BICAEM
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

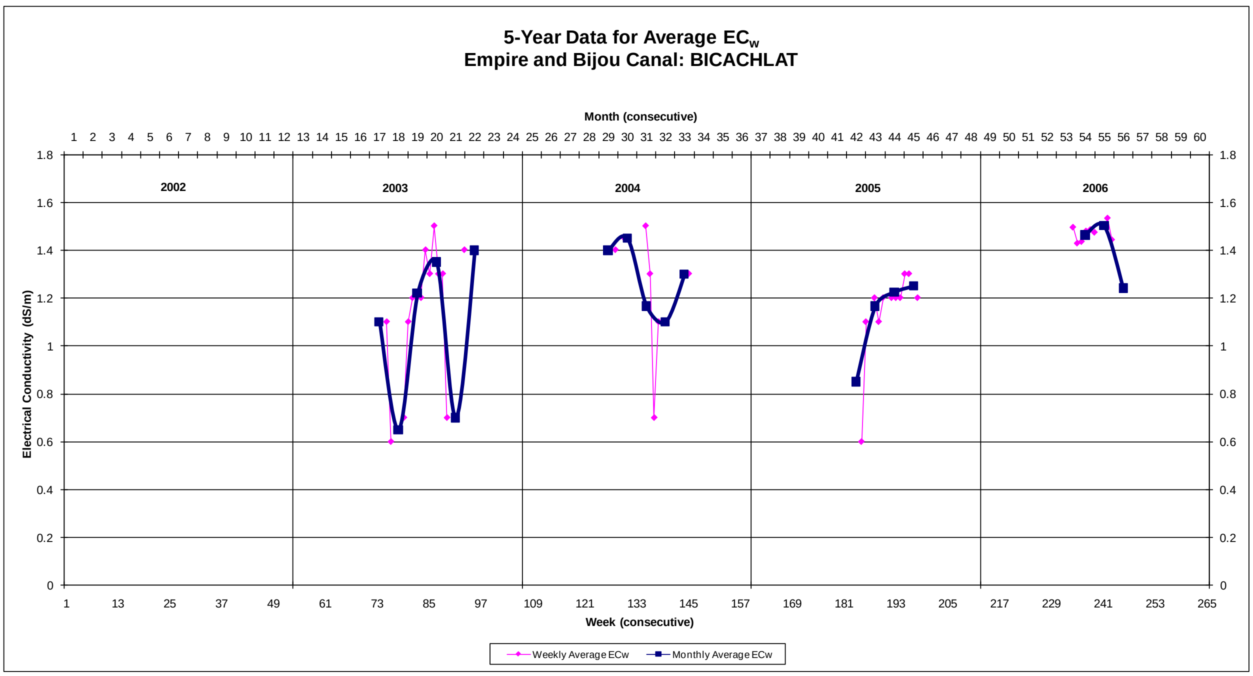


5-Year Data for Average EC_w
Empire and Bijou Canal: BICA2RES
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw



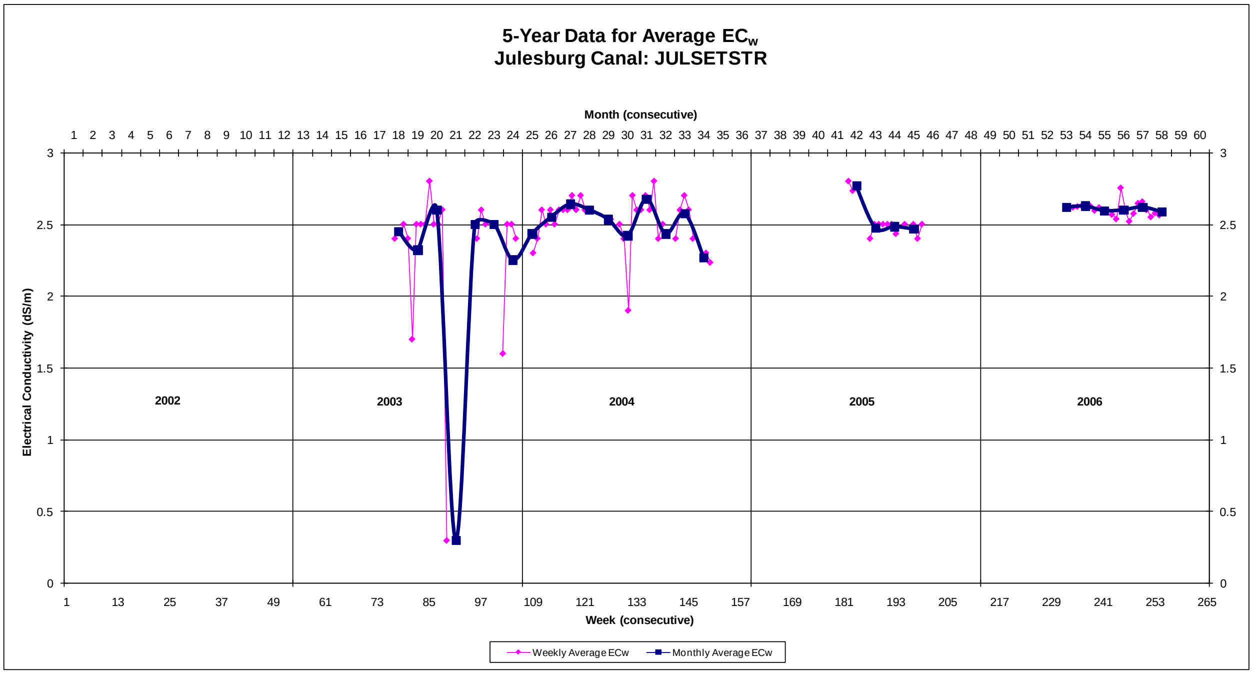
5-Year Data for Average EC_w
Empire and Bijou Canal: BICABIWEI
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

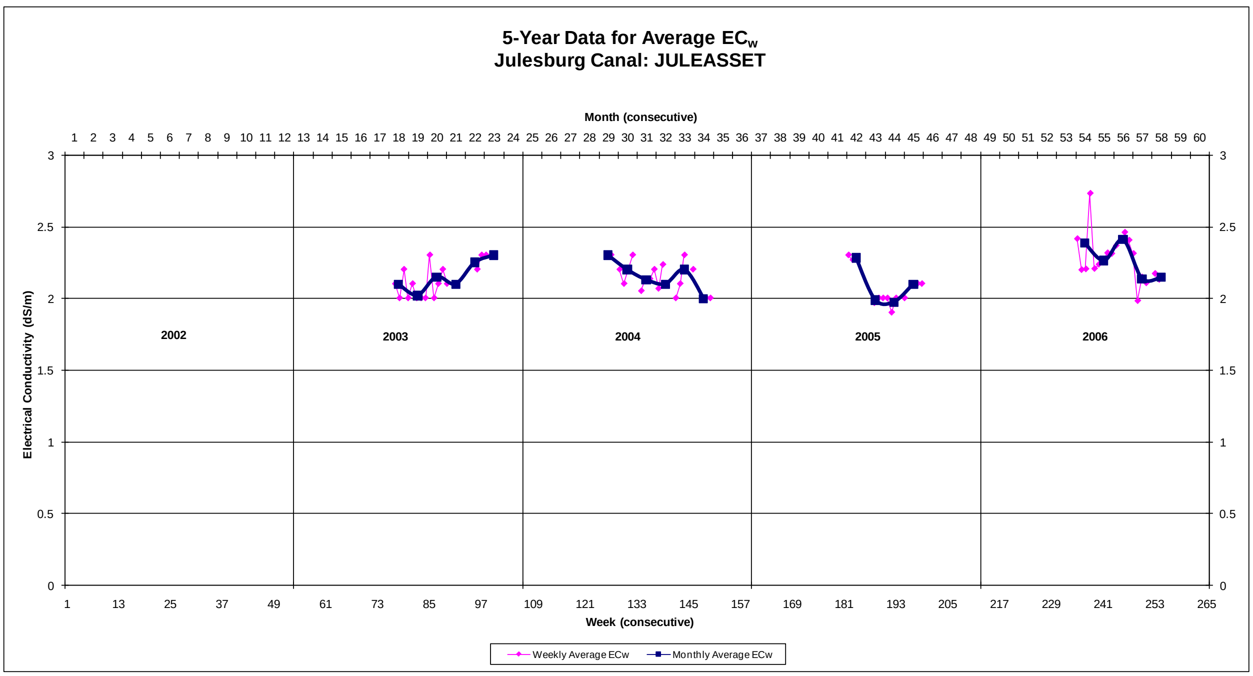

5-Year Data for Average EC_w
Empire and Bijou Canal: BICA3TWEI
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

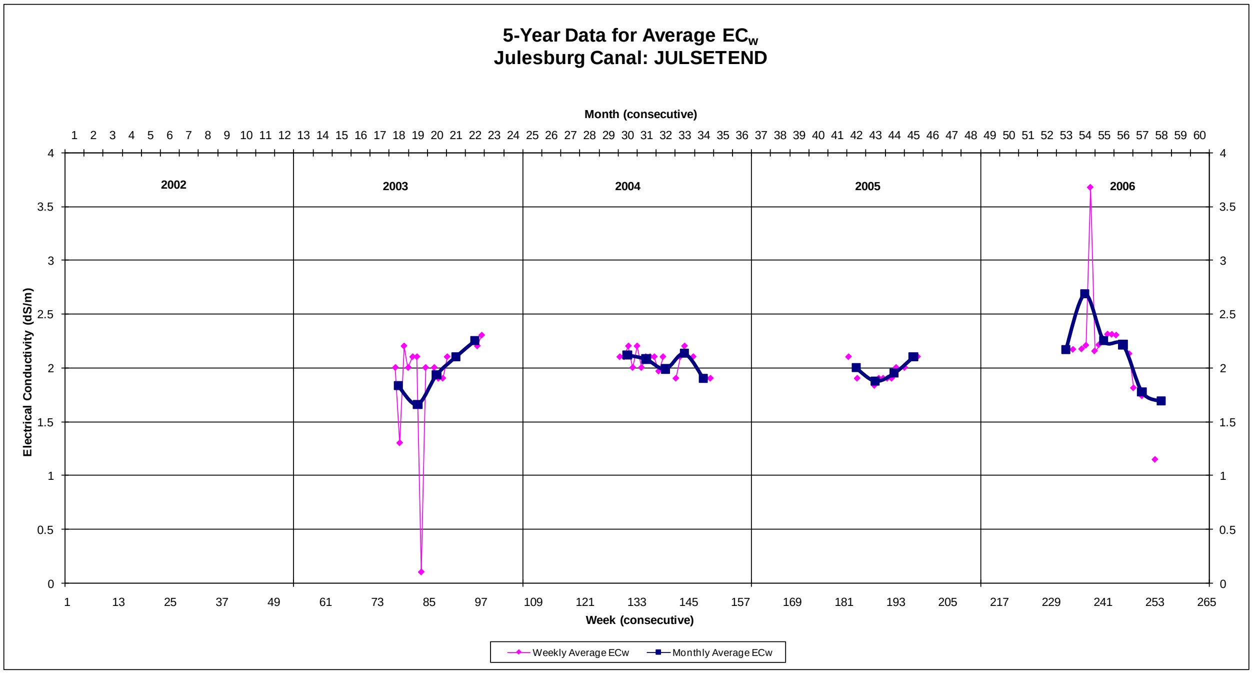

5-Year Data for Average EC_w
Empire and Bijou Canal: BICACHLAT
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

Julesburg Canal

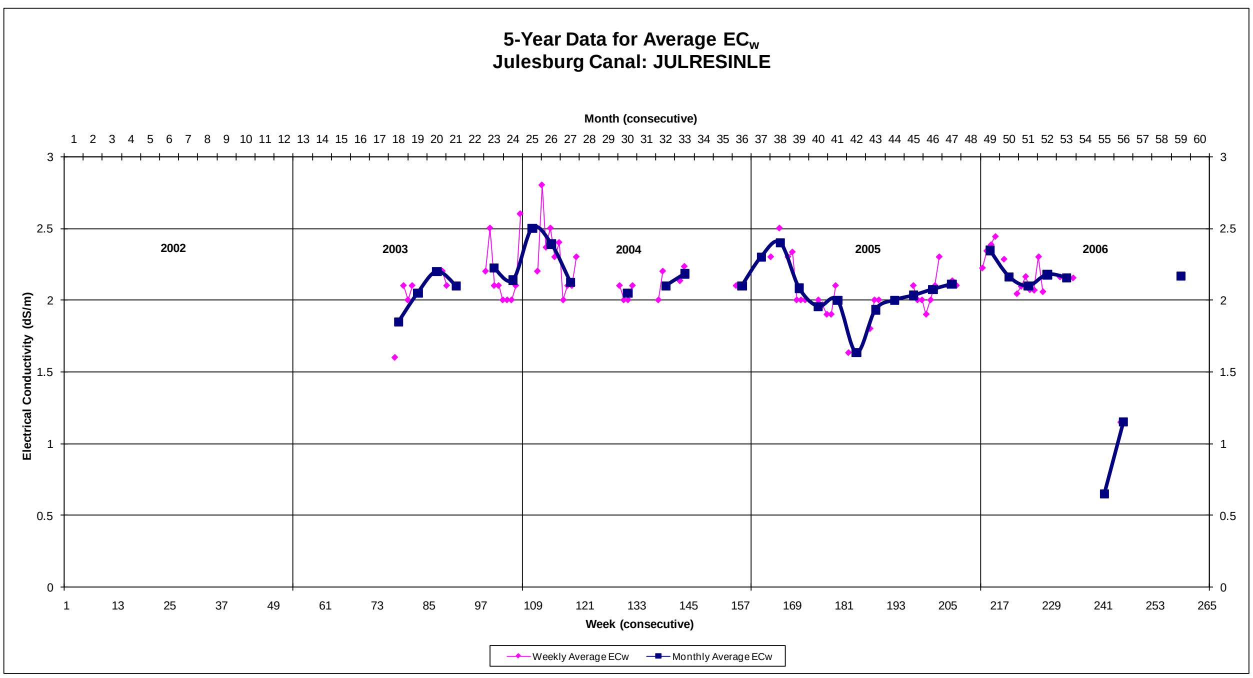
Settlers Ditch

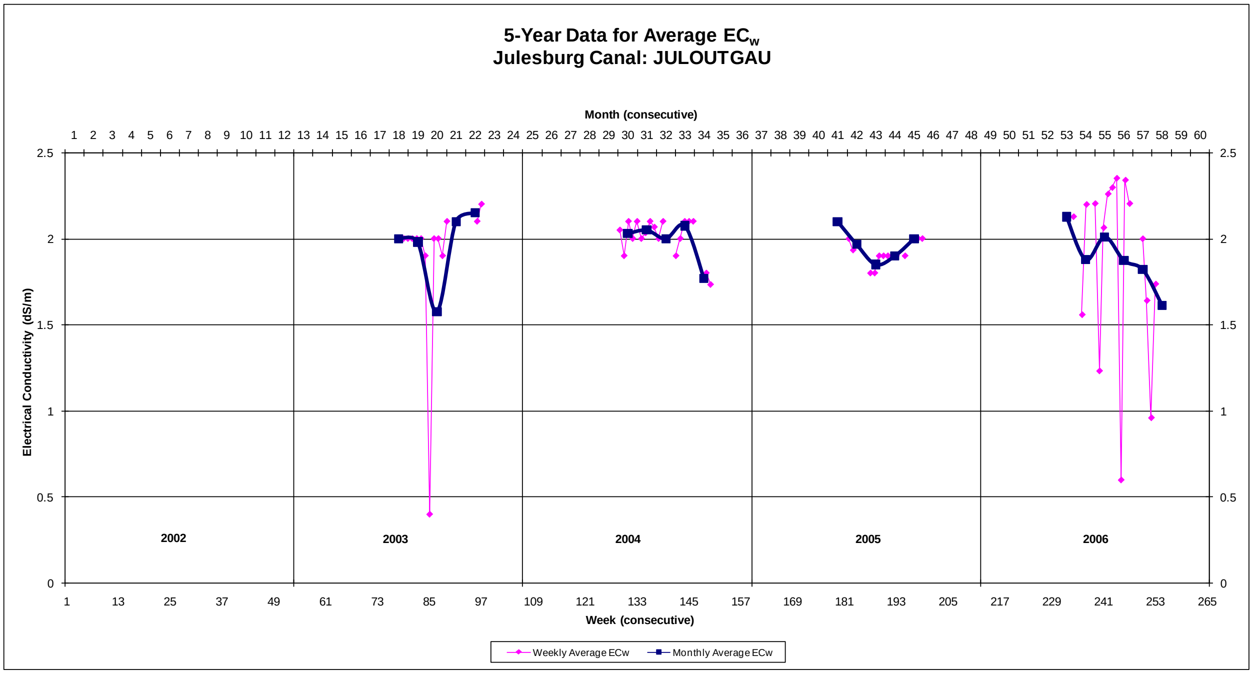


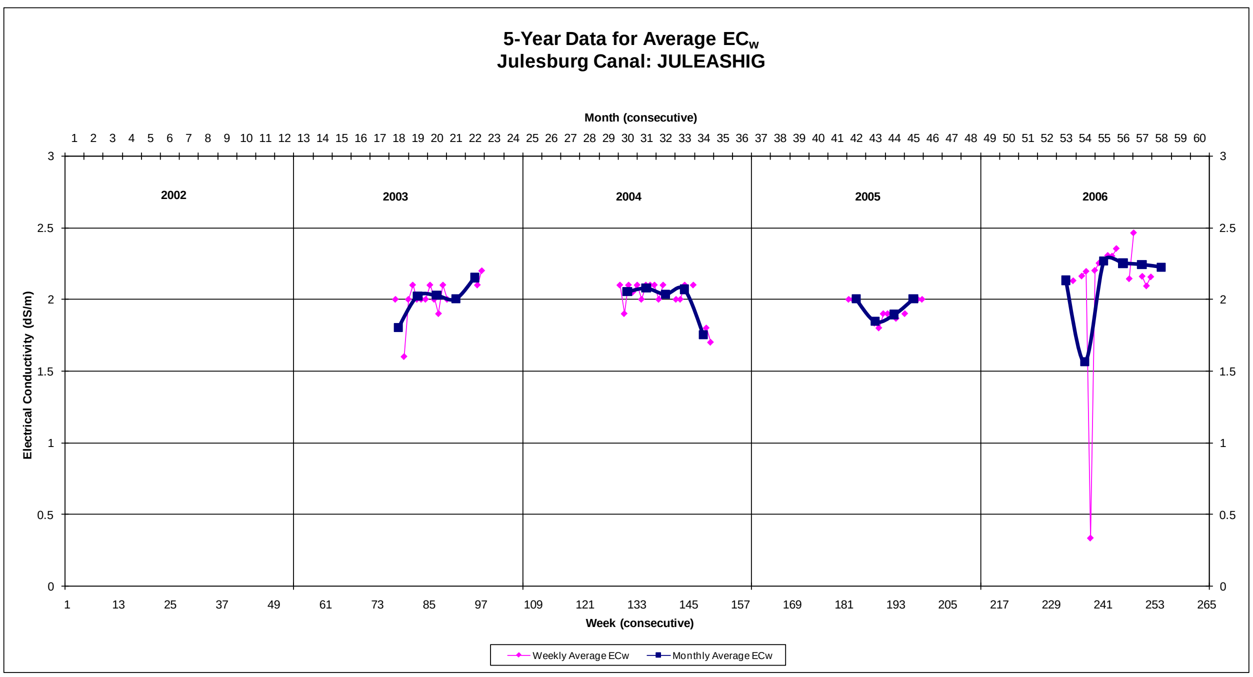


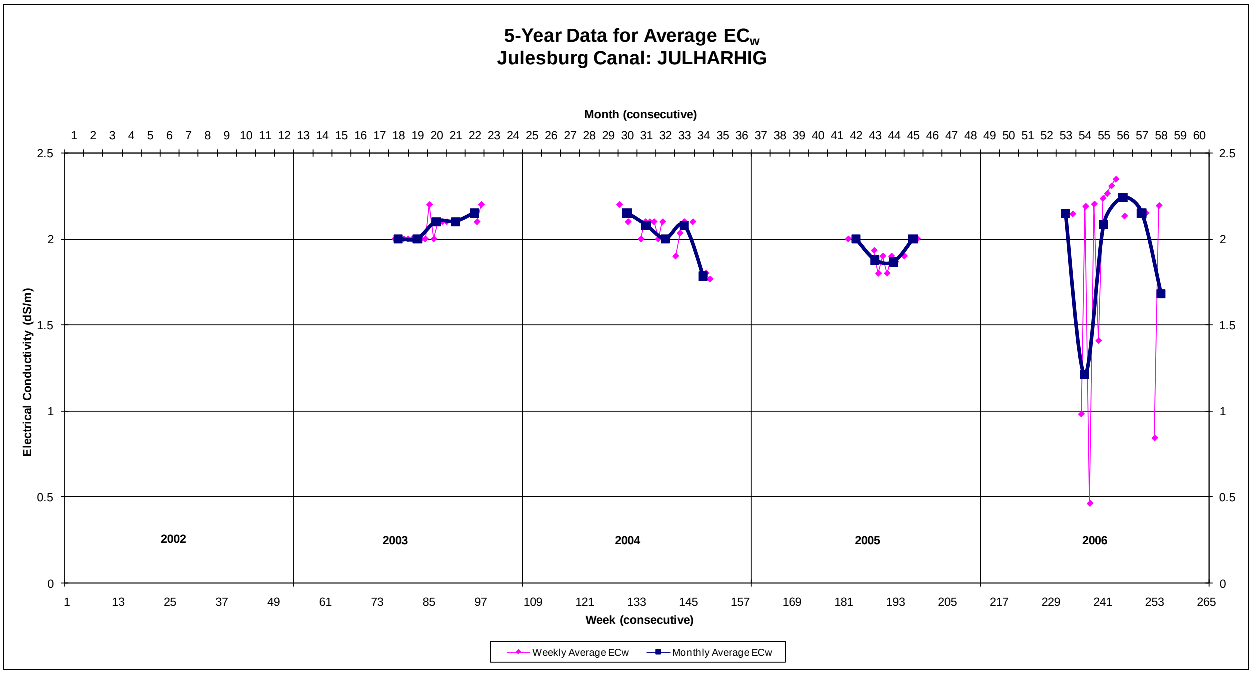


Highline Ditch

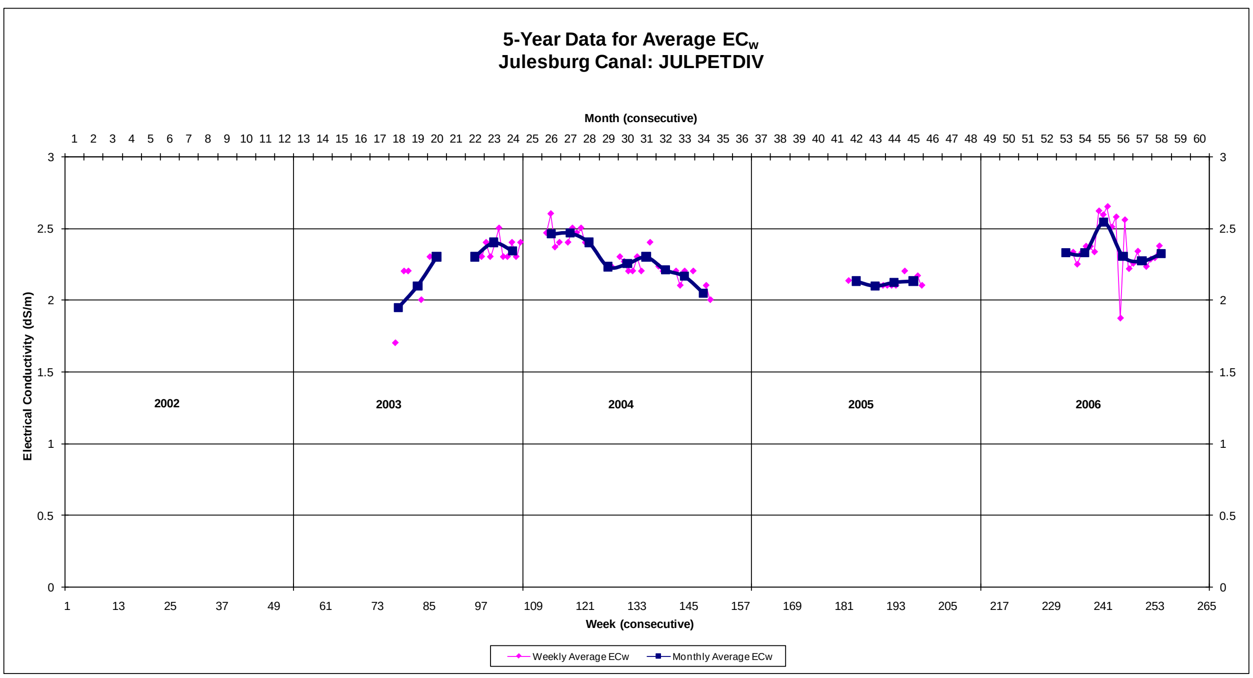


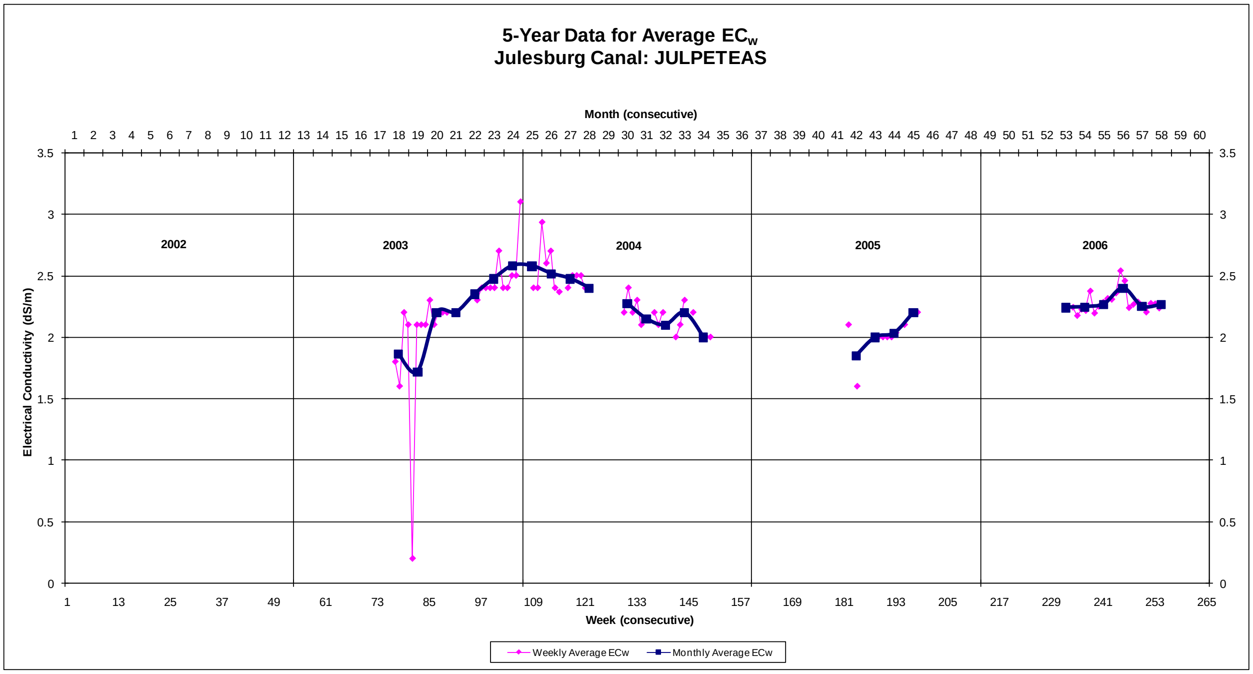

5-Year Data for Average EC_w
Julesburg Canal: JULOUTGAU
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

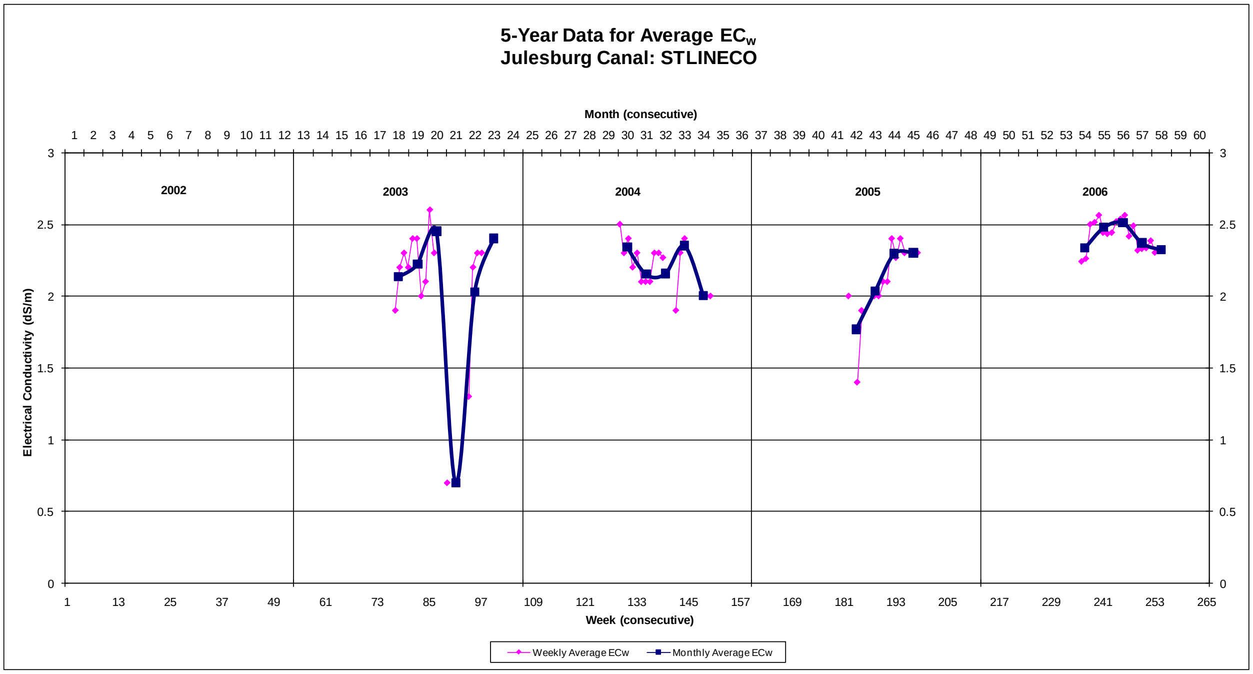

5-Year Data for Average EC_w
Julesburg Canal: JULEASHIG
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw



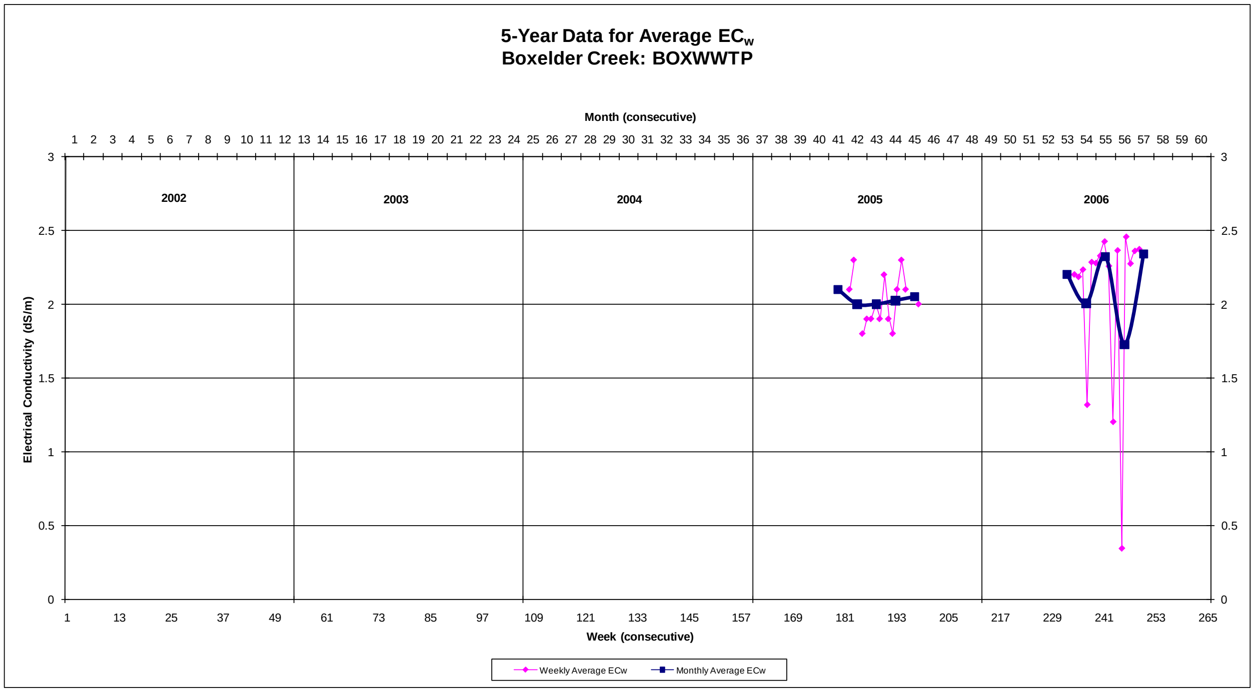
Peterson Ditch

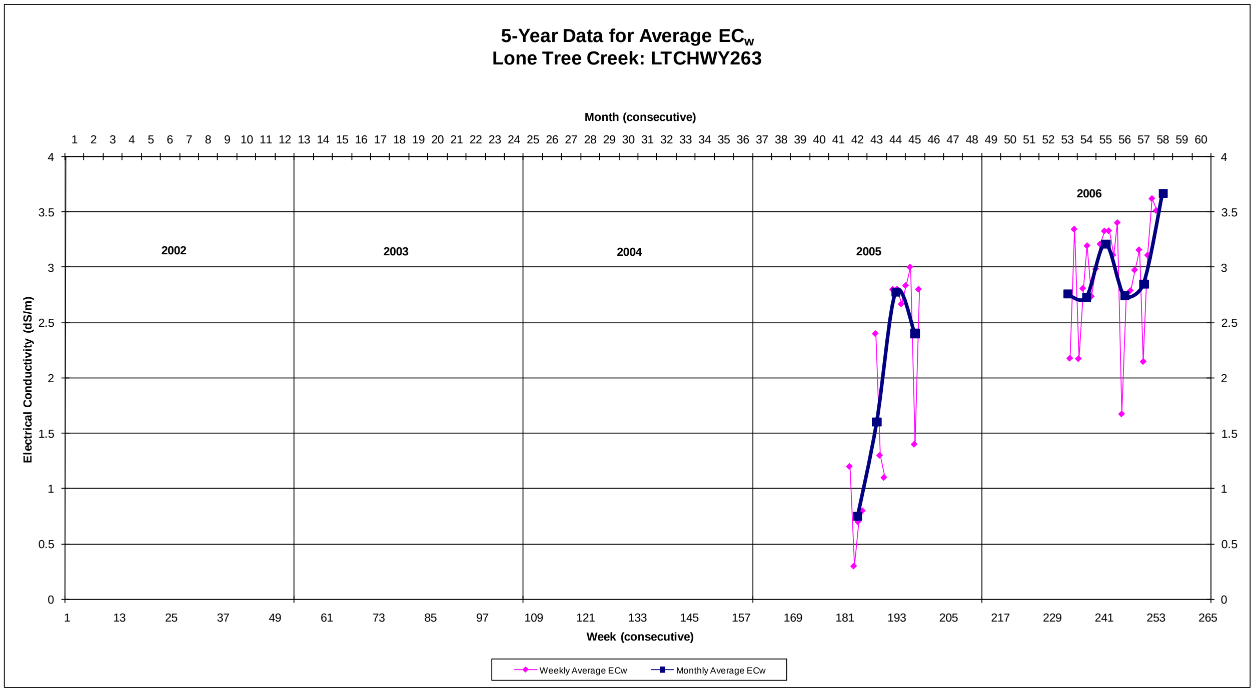



5-Year Data for Average EC_w
Julesburg Canal: JULPETEAS
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average EC_w
Julesburg Canal: STLINECO
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

Boxelder and Lone Tree Creeks

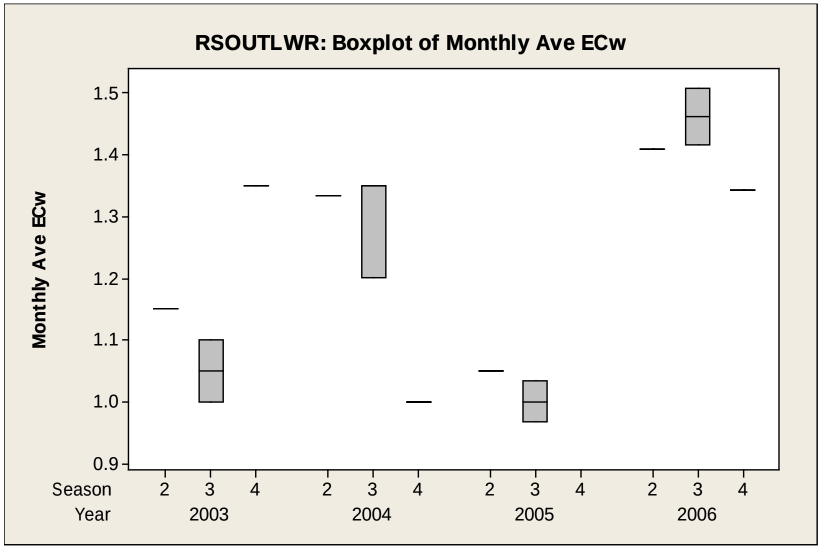


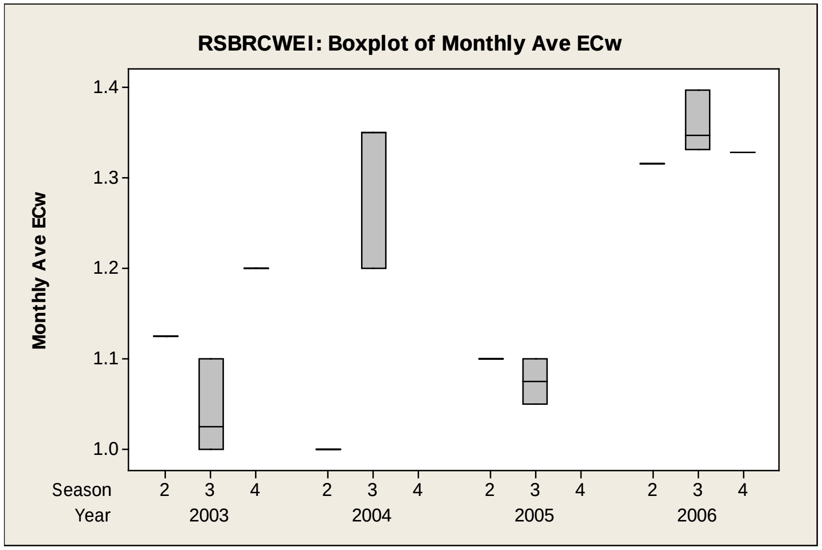


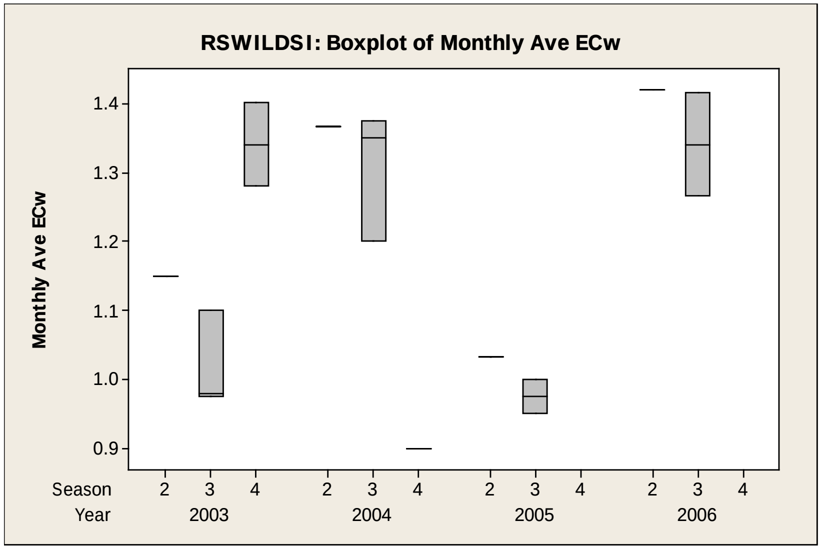
APPENDIX E

Canal System Box Plots

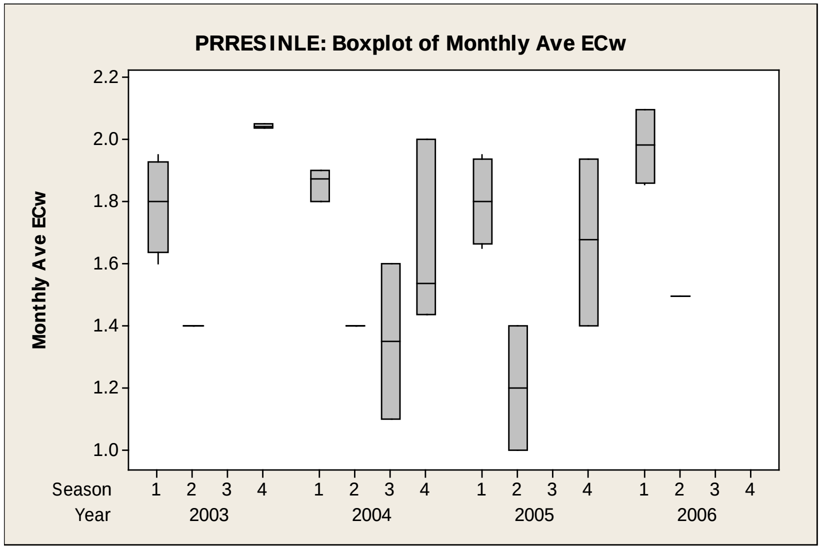
Riverside Canal

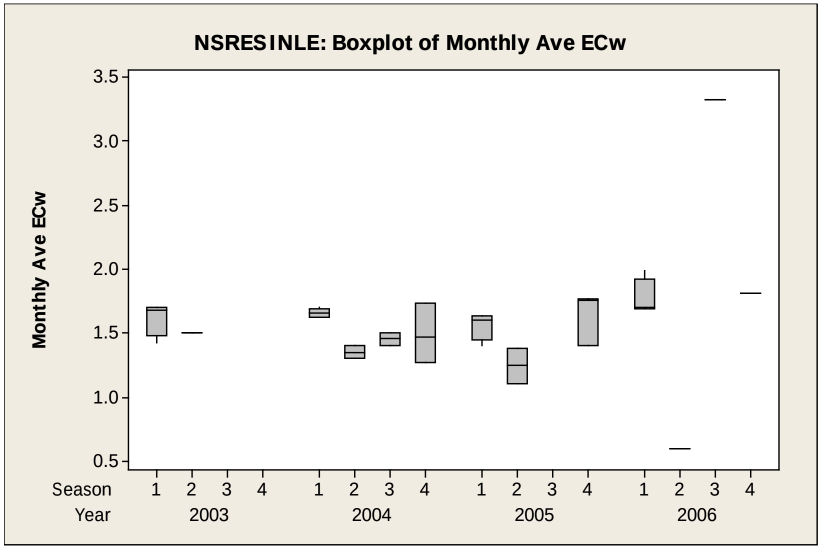


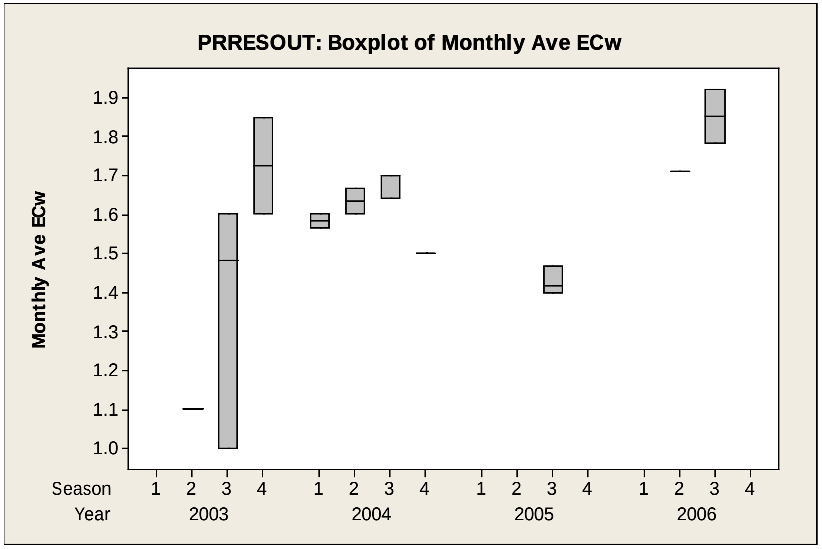


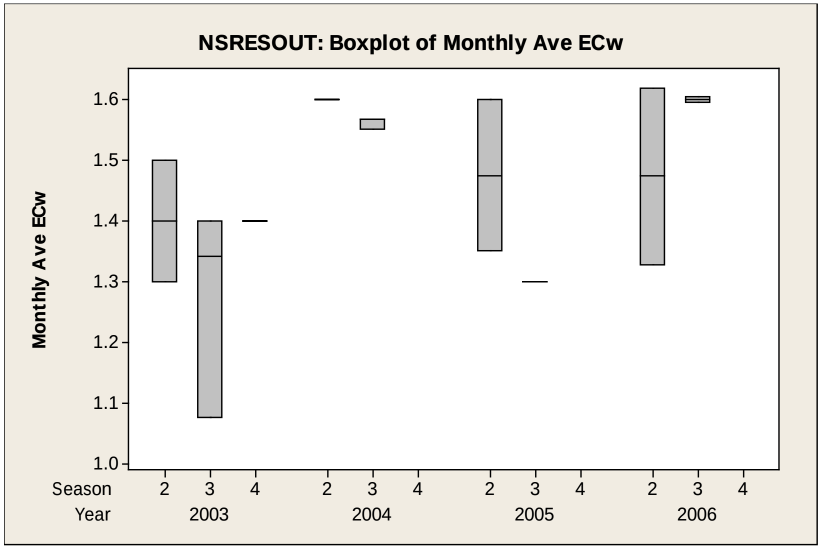


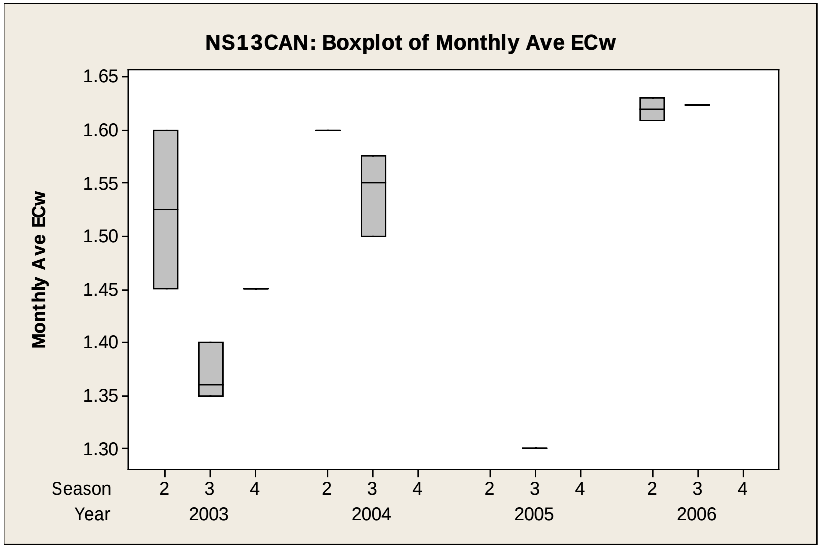
Prewitt and North Sterling Canal



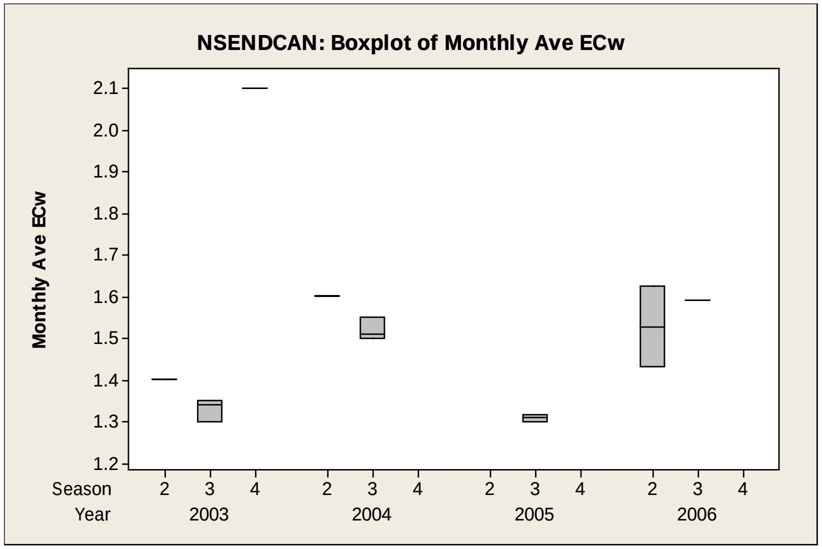




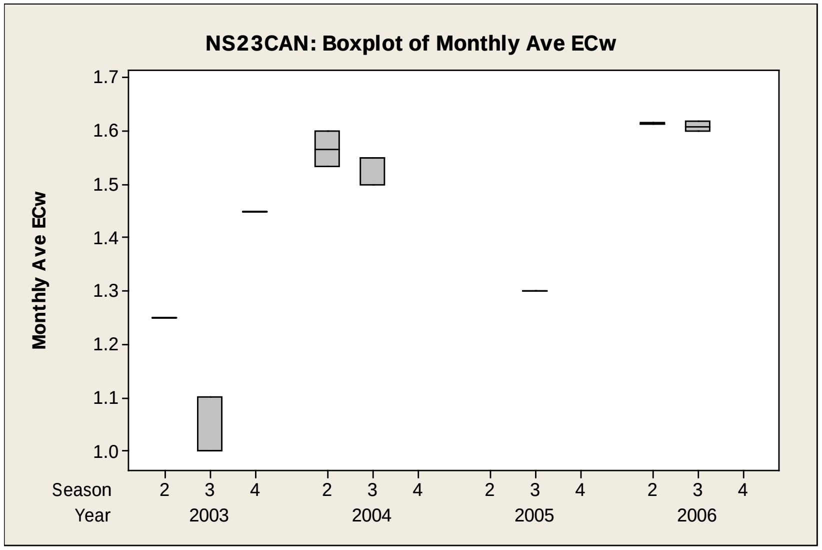




NS13CAN: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
Season 2 3 4 2 3 4 2 3 4 2 3 4
Year 2003 2004 2005 2006

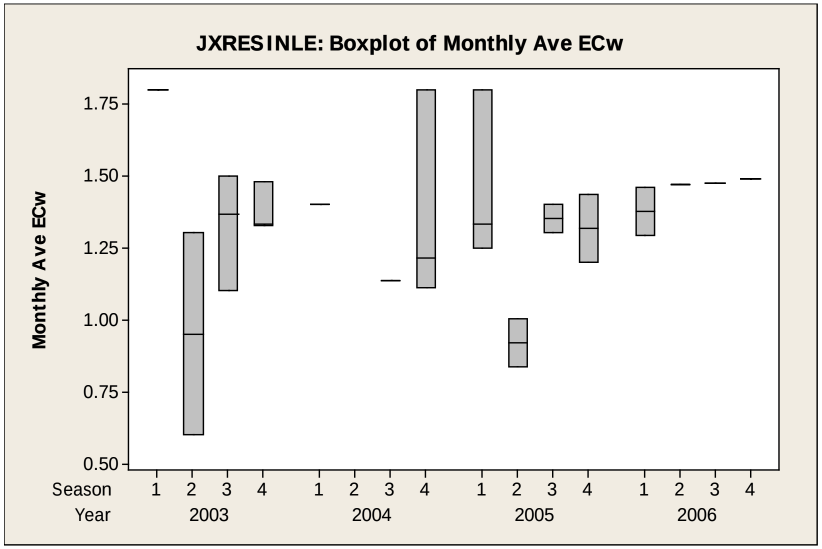


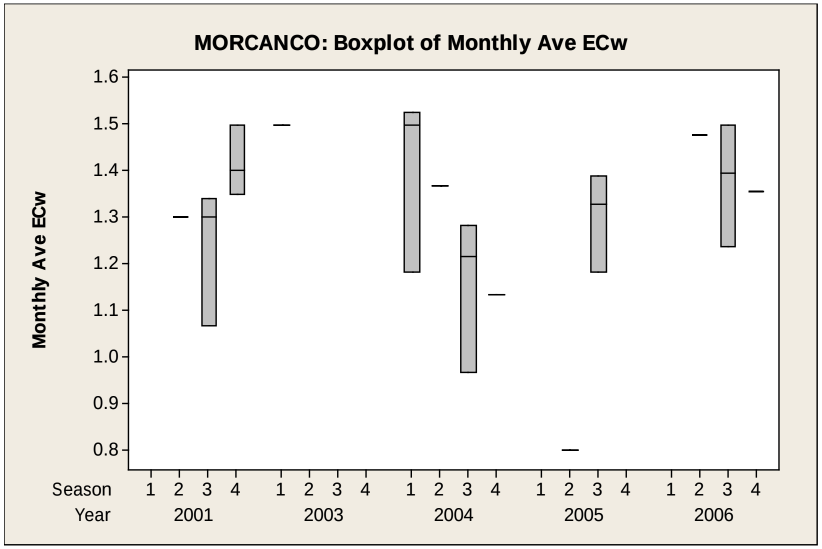
NSENDCAN: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
Season 2 3 4 2 3 4 2 3 4 2 3 4
Year 2003 2004 2005 2006

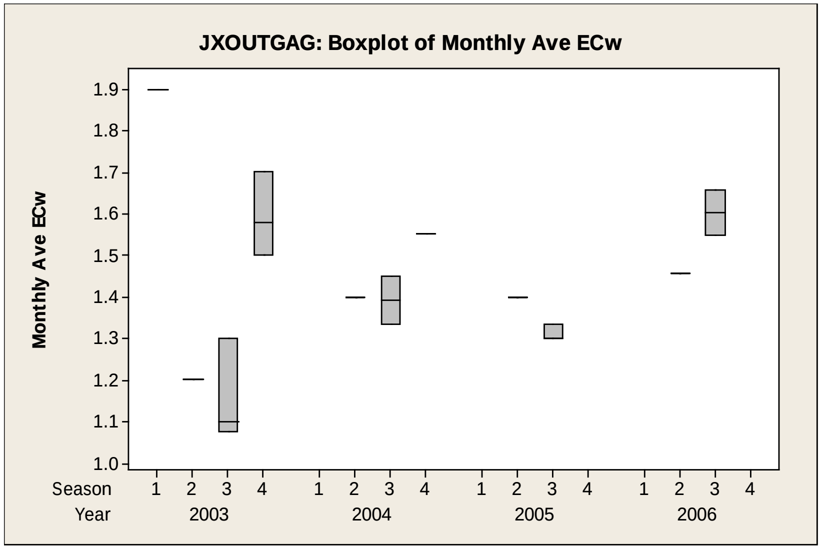


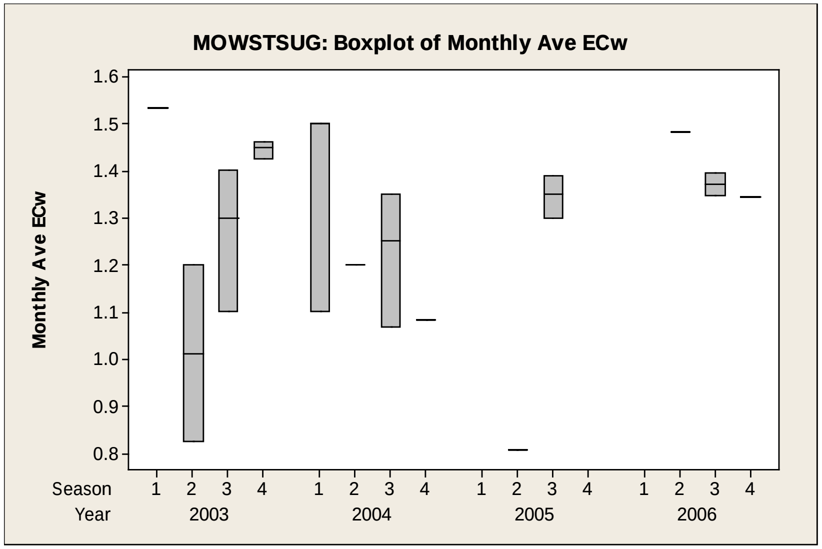
NS23CAN: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
Season 2 3 4 2 3 4 2 3 4 2 3 4
Year 2003 2004 2005 2006

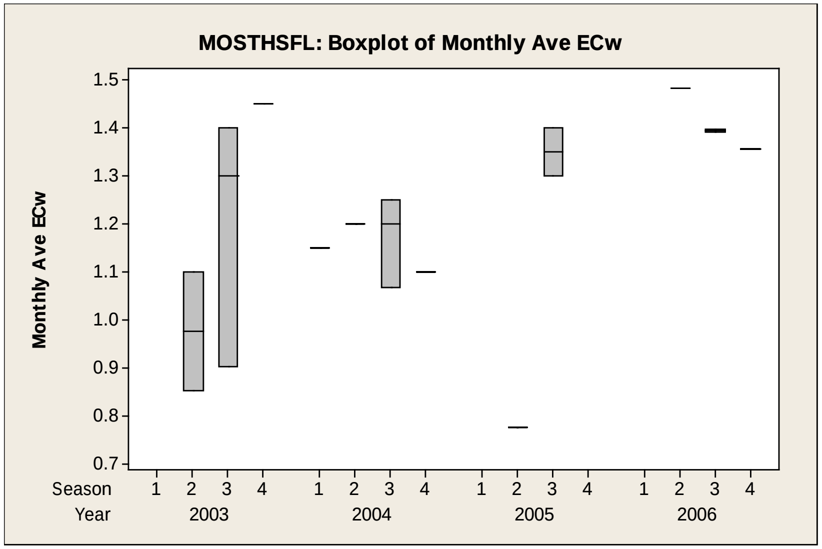
Jackson and Morgan Canal

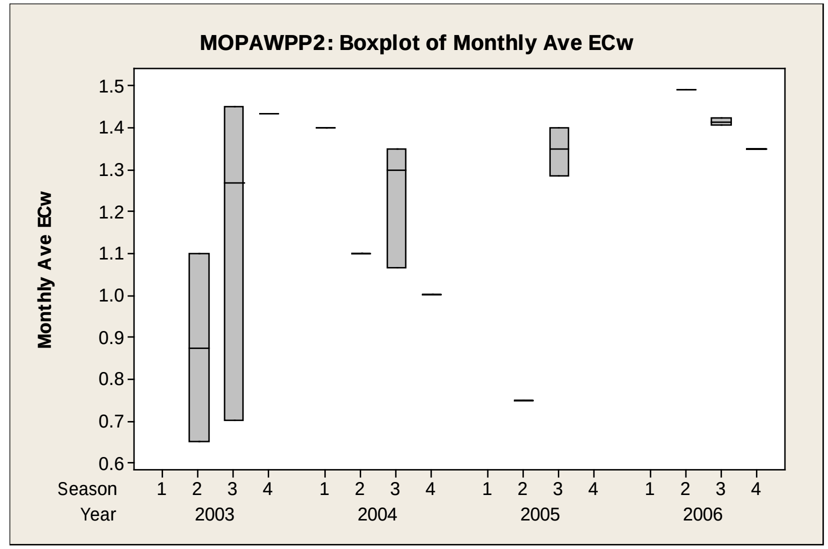


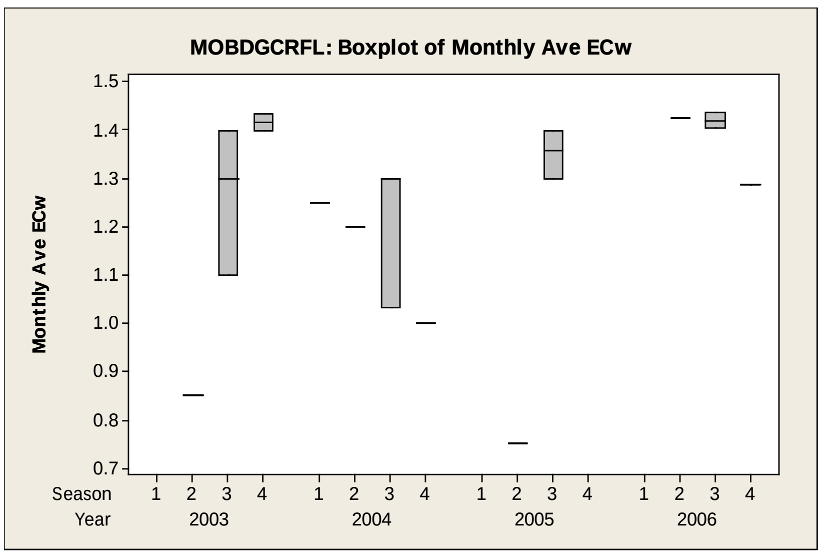




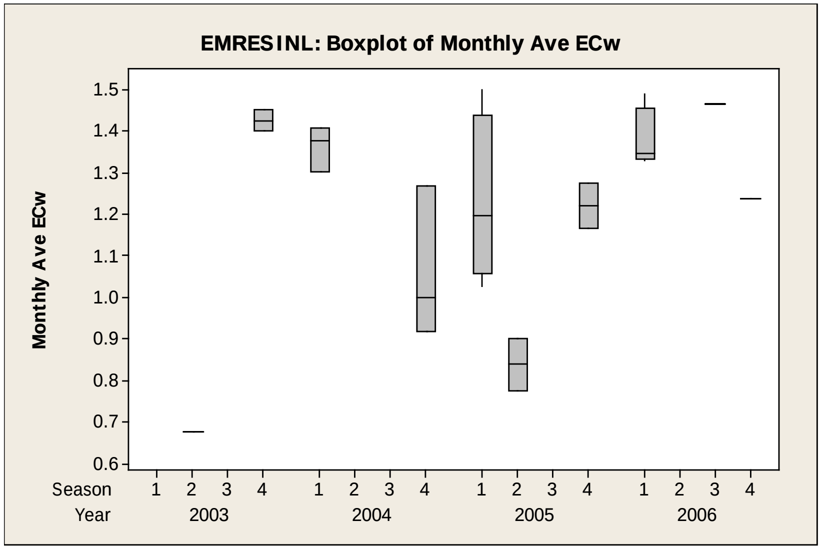


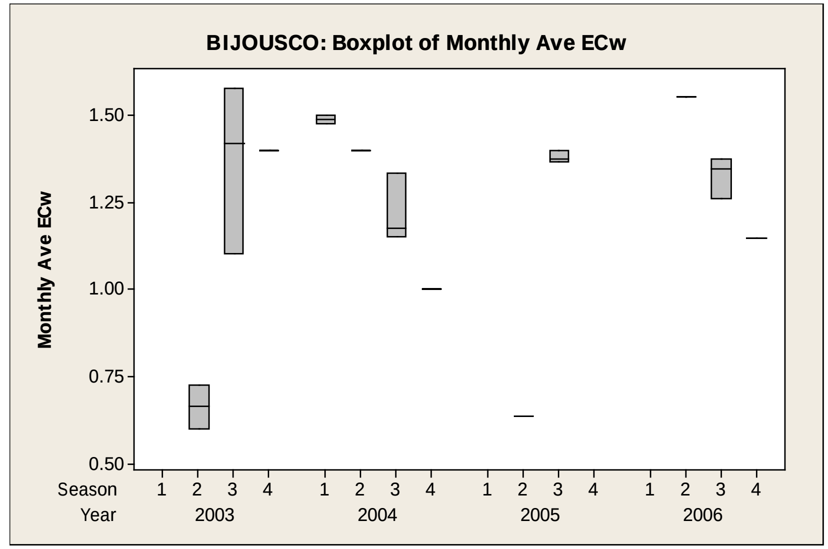

MOSTHSFL: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

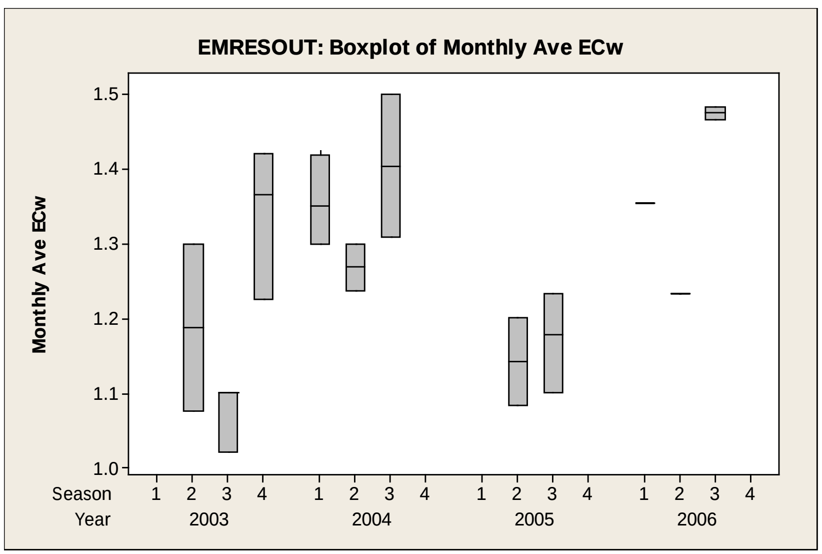

MOPAWPP2: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

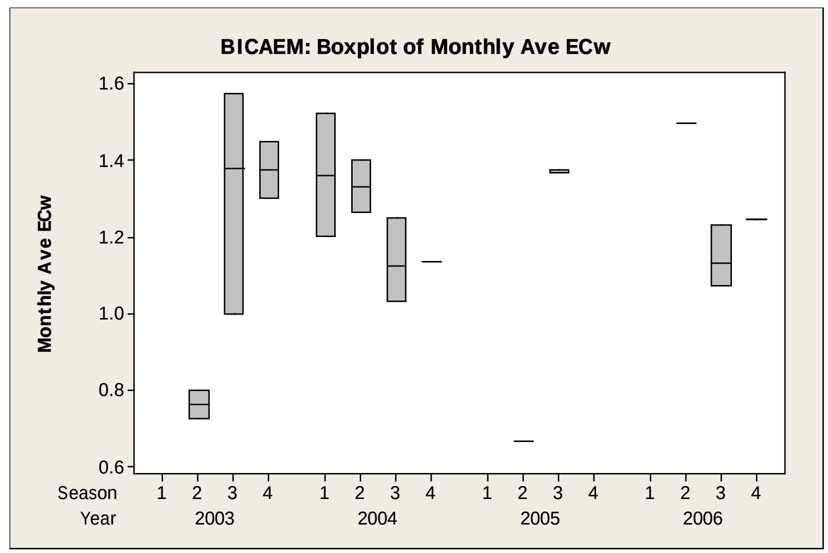

MOBDGCRFL: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

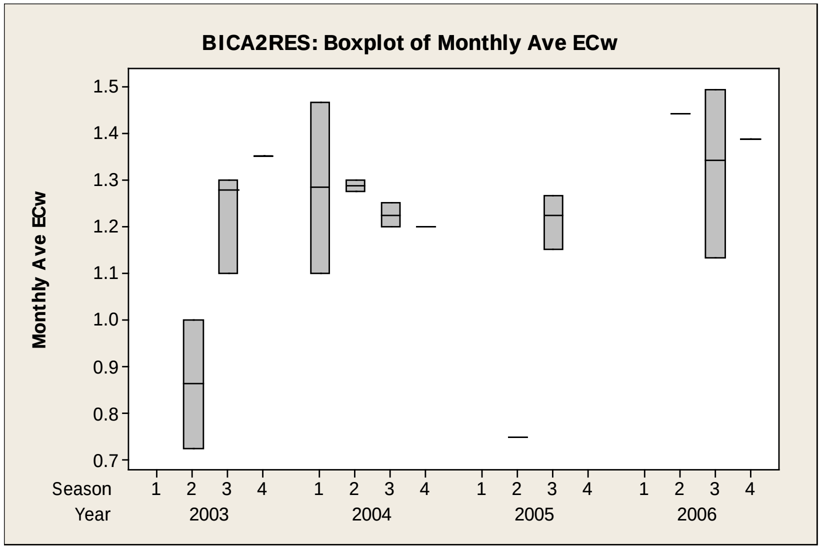
Empire and Bijou Canal

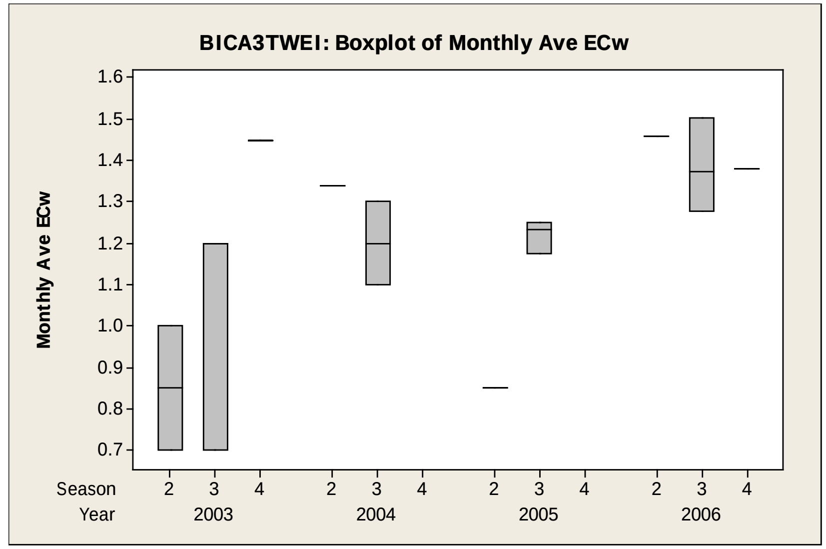


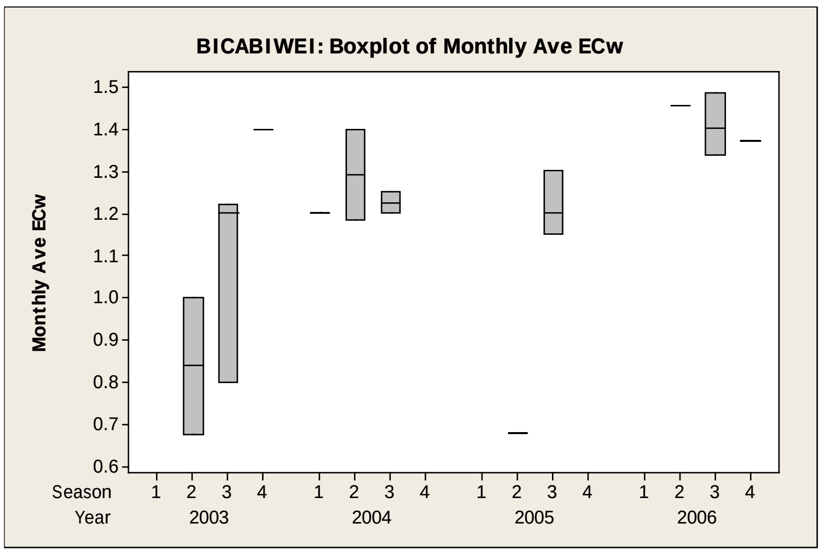


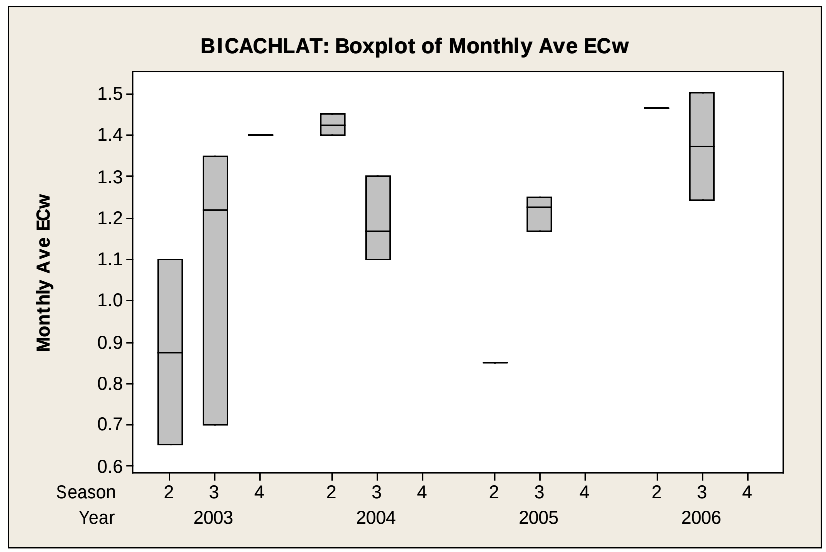





BICA2RES: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

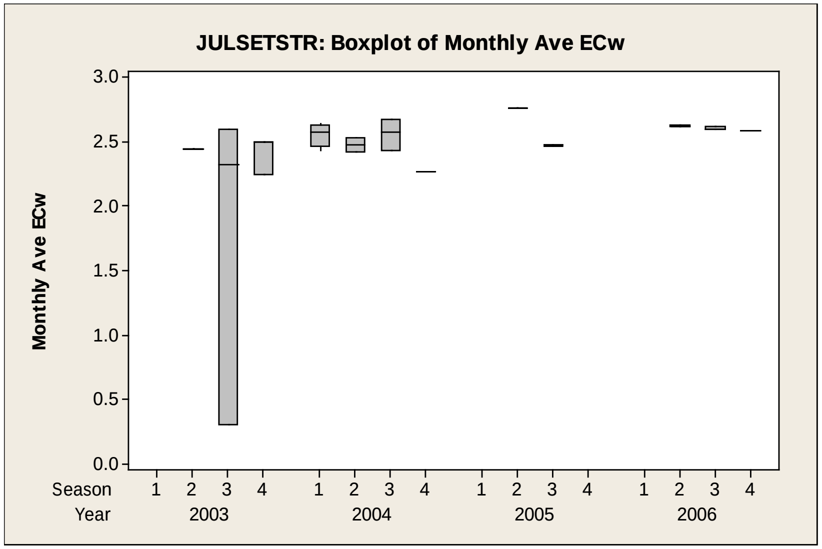

BICA3TWEI: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
Season 2 3 4 2 3 4 2 3 4 2 3 4
Year 2003 2004 2005 2006

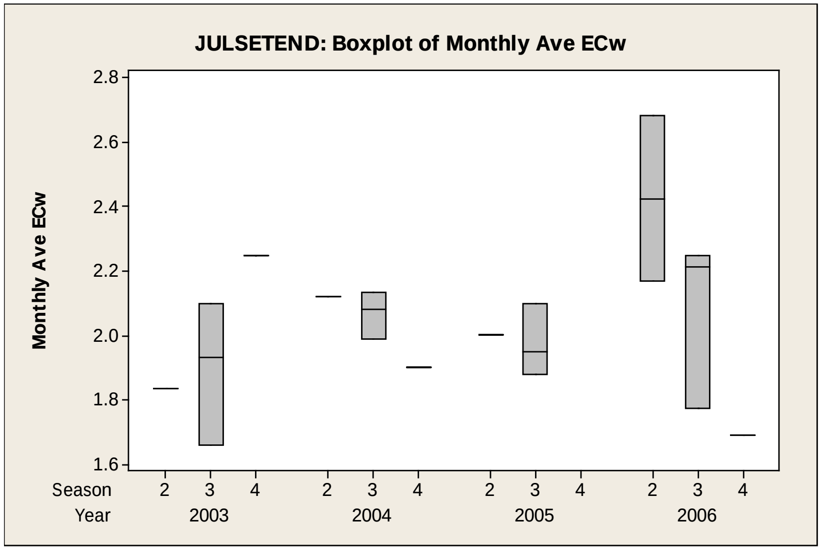

BICABIWEI: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

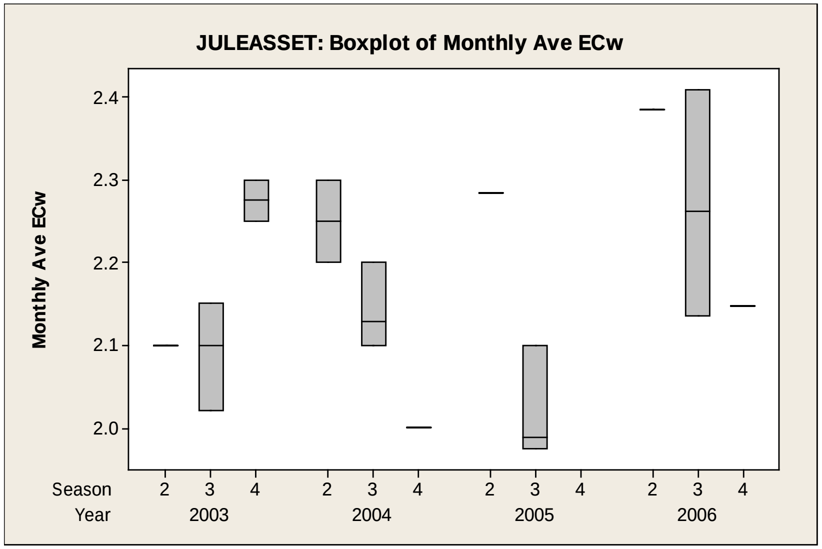

BICACHLAT: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
Season 2 3 4 2 3 4 2 3 4 2 3 4
Year 2003 2004 2005 2006

Julesburg Canal

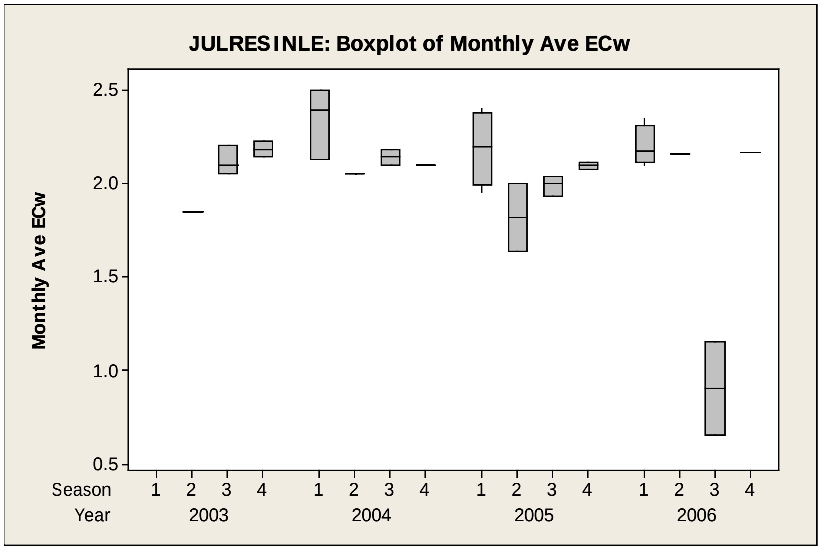
Settlers Ditch

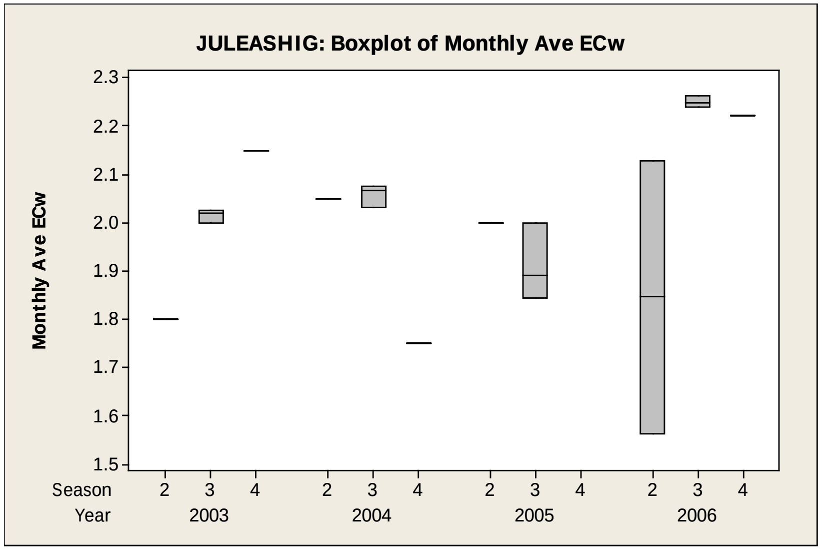


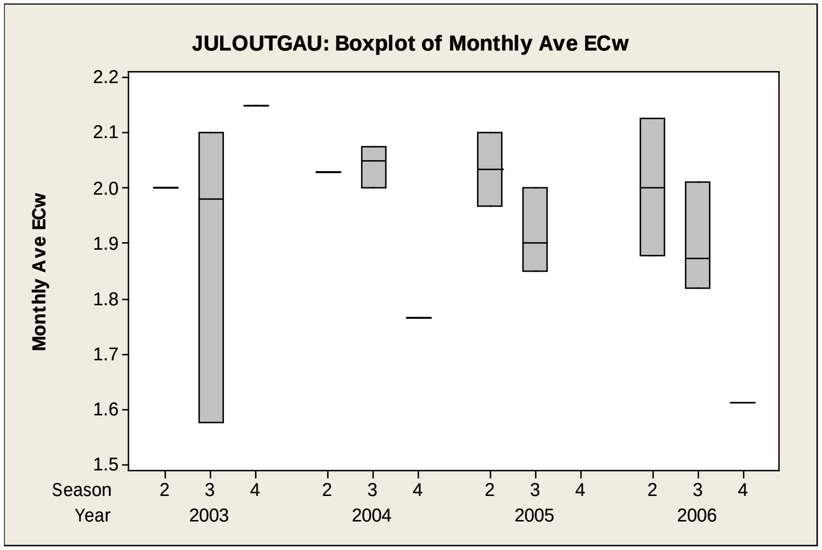


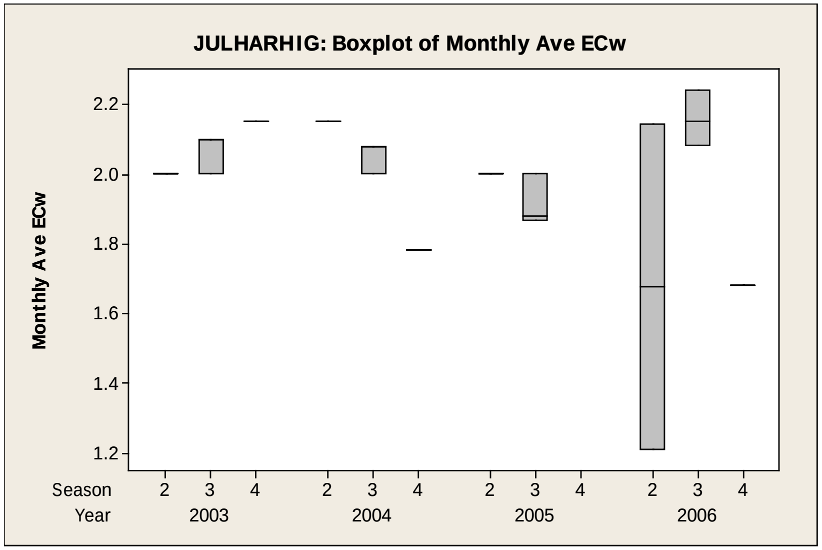


Highline Ditch

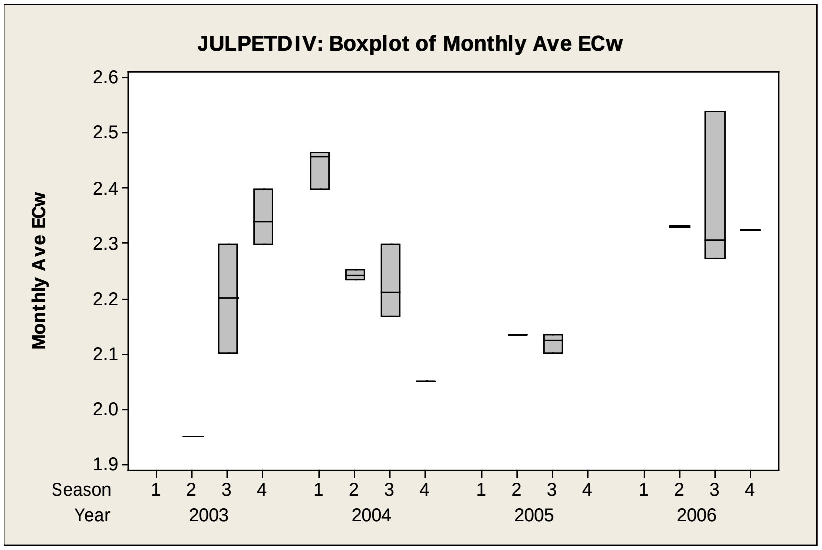


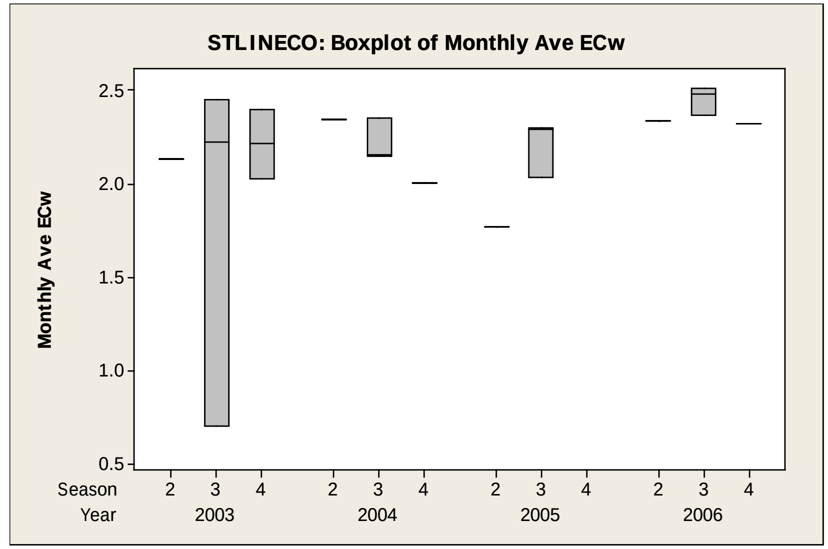


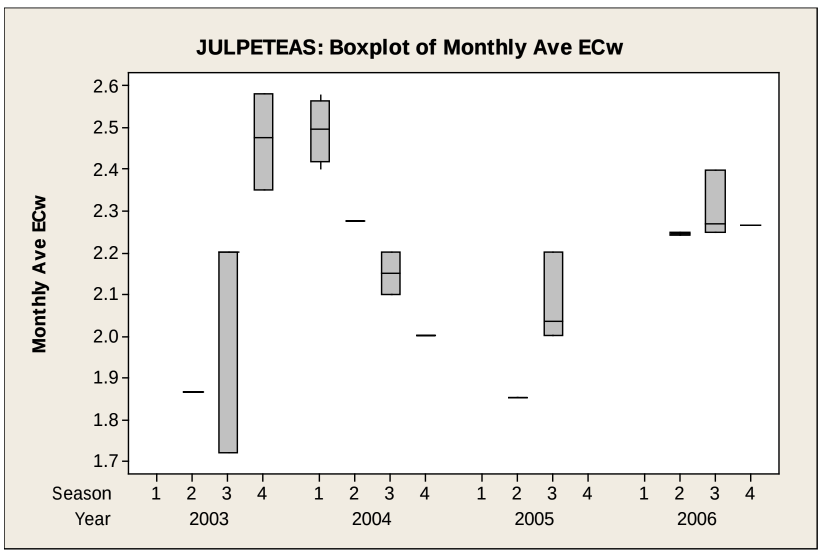




Peterson Ditch

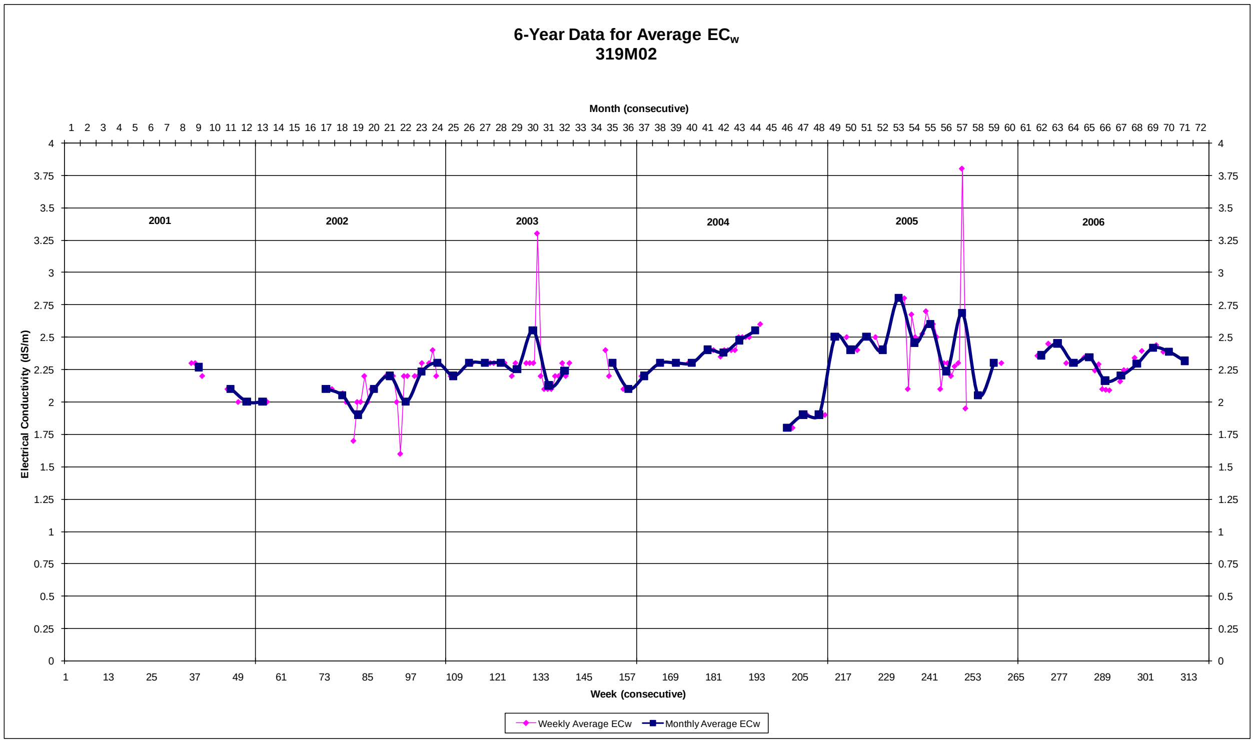


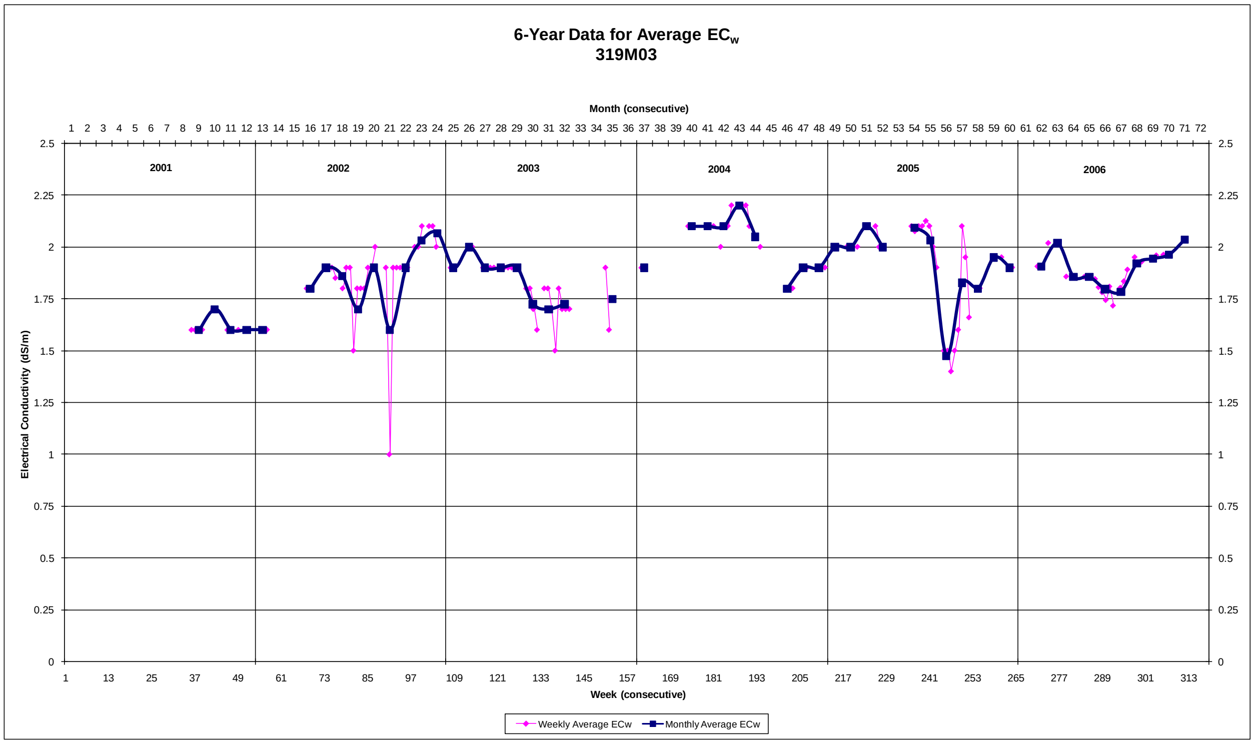


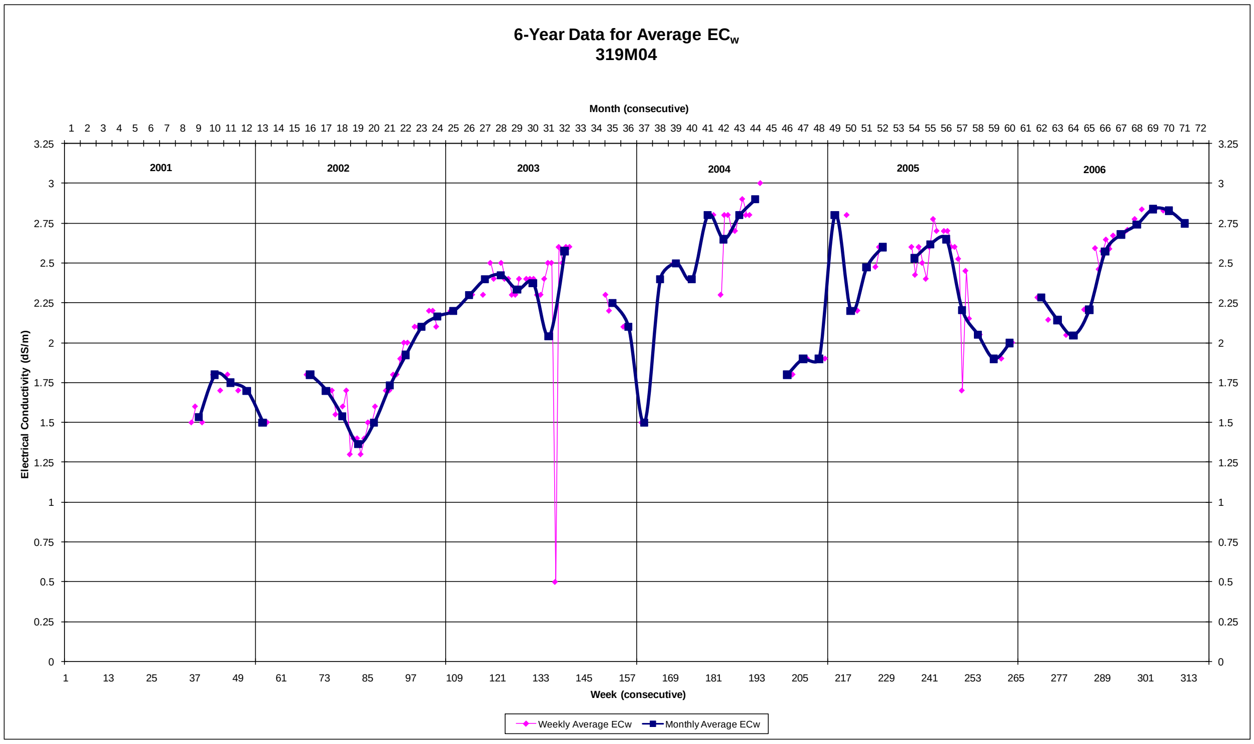


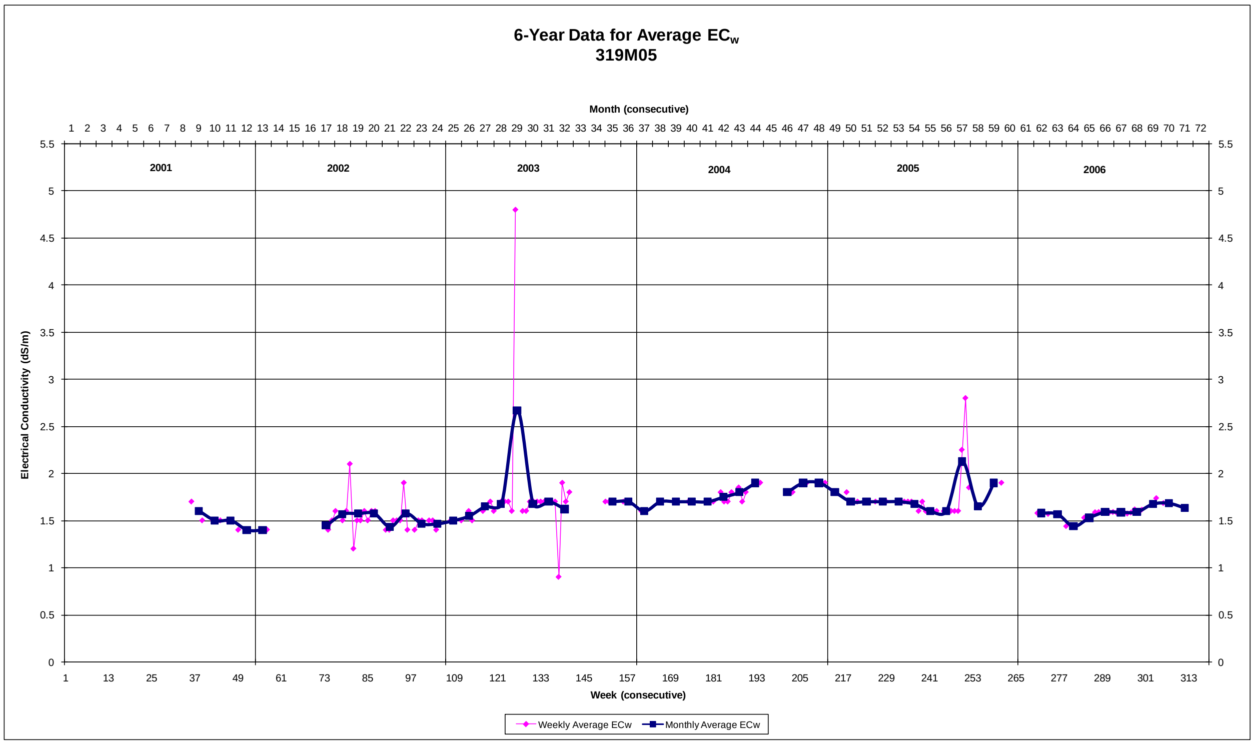
APPENDIX F

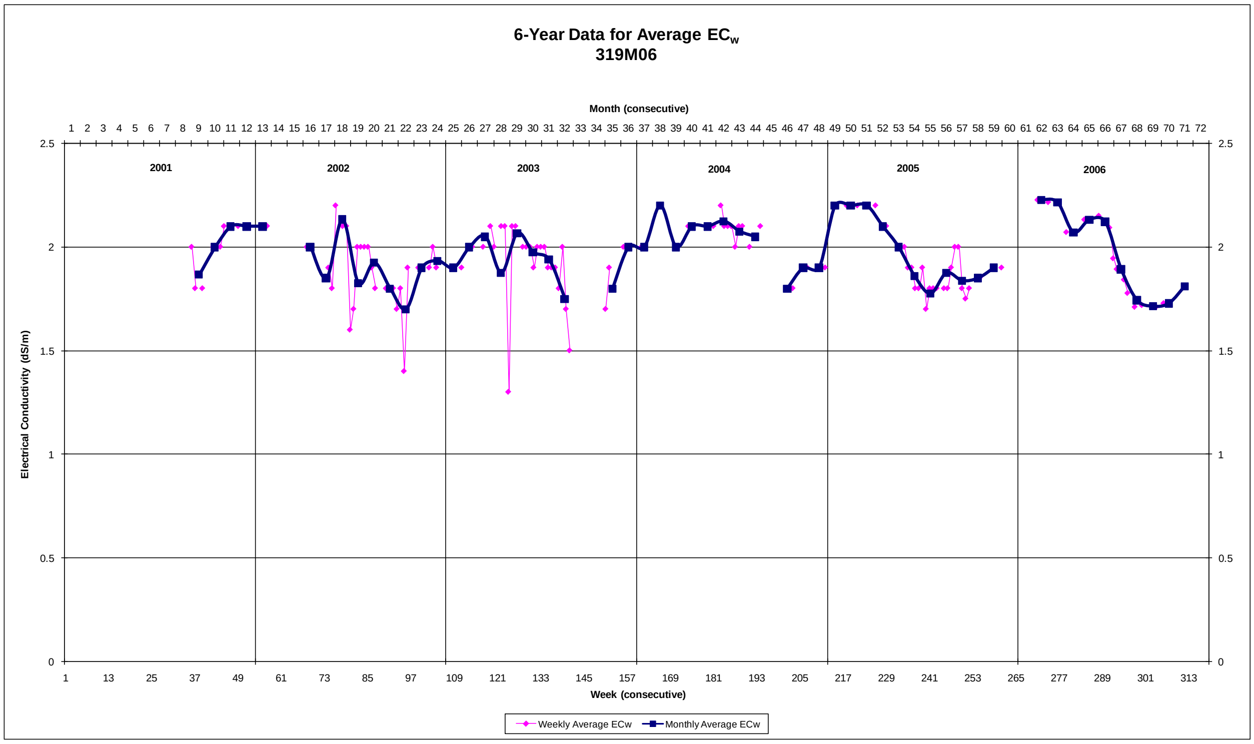
Groundwater Well Time Series Plots

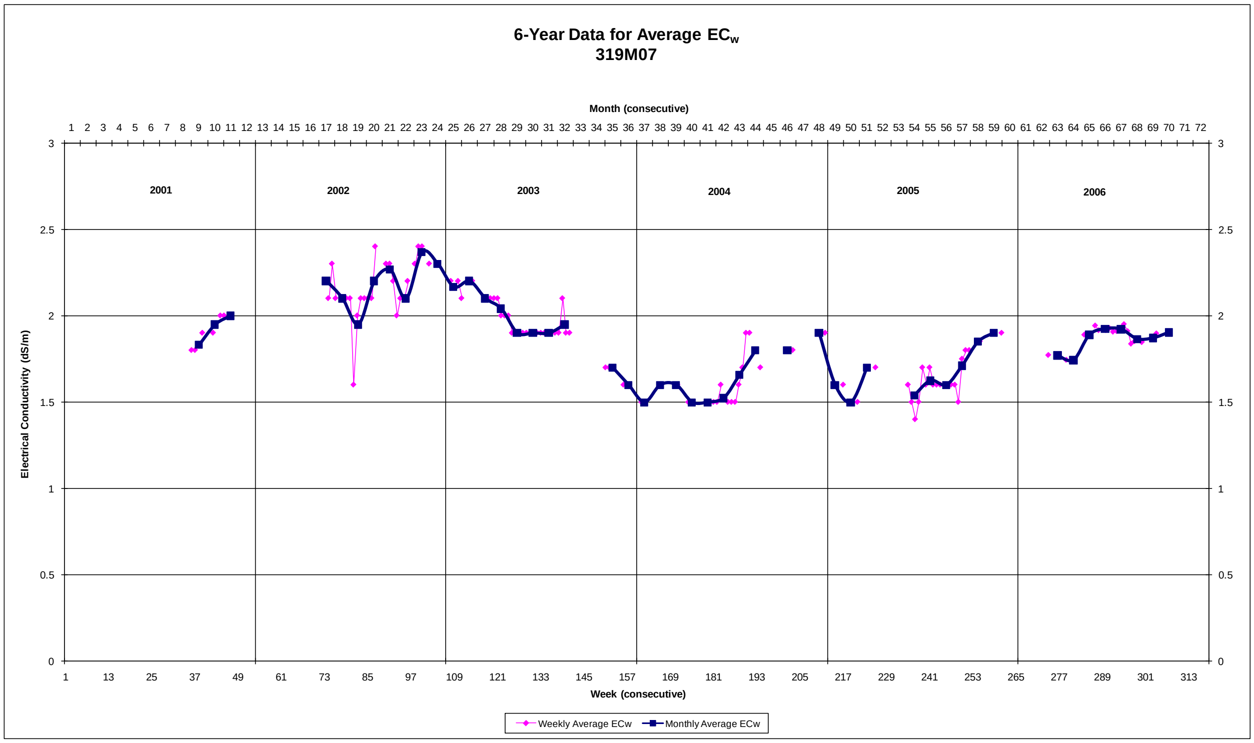

6-Year Data for Average EC_w
319M02
Month (consecutive)
Electrical Conductivity (dS/m)
2001
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

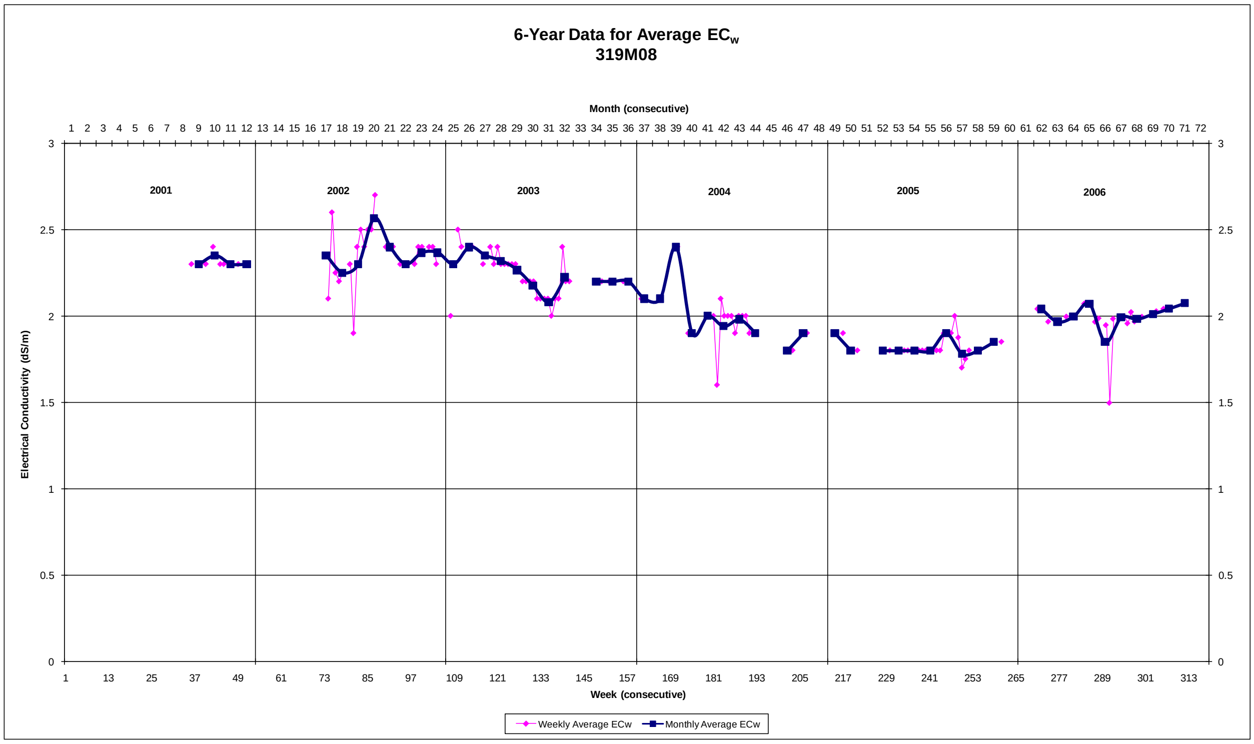

6-Year Data for Average EC_w
319M03
Month (consecutive)
Electrical Conductivity (dS/m)
2001
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

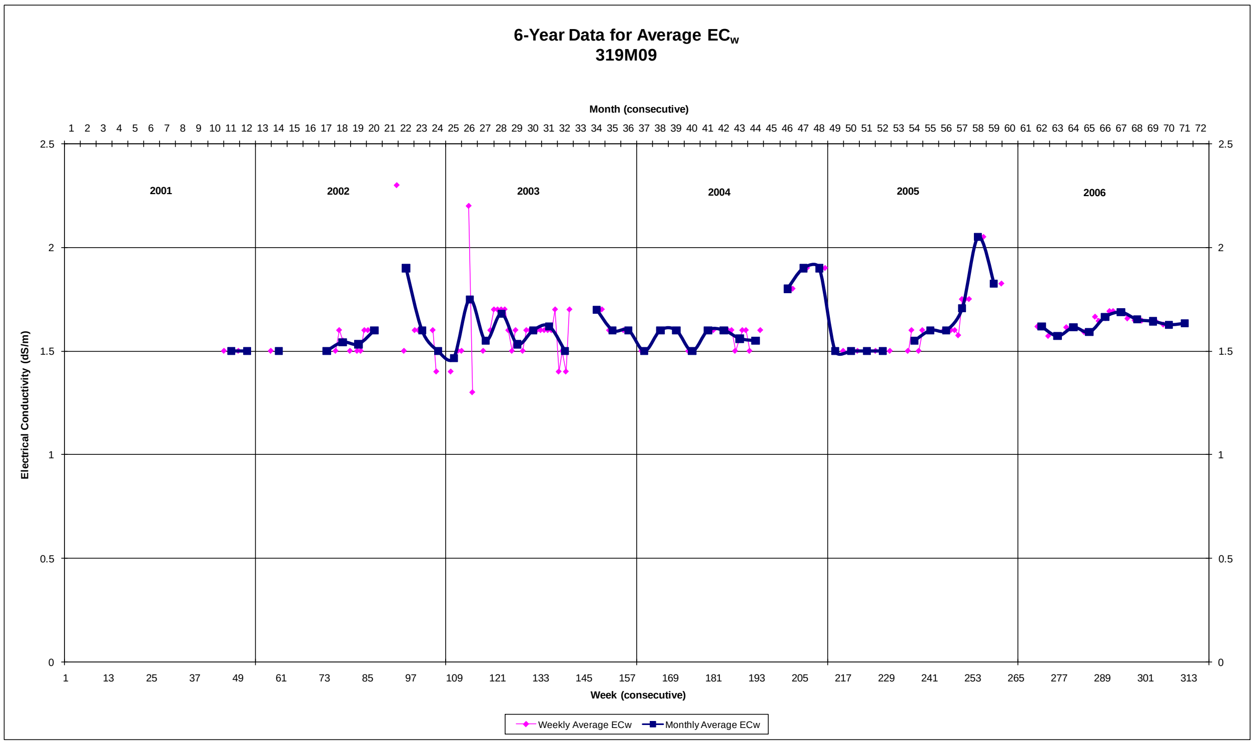

6-Year Data for Average EC_w
319M04
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

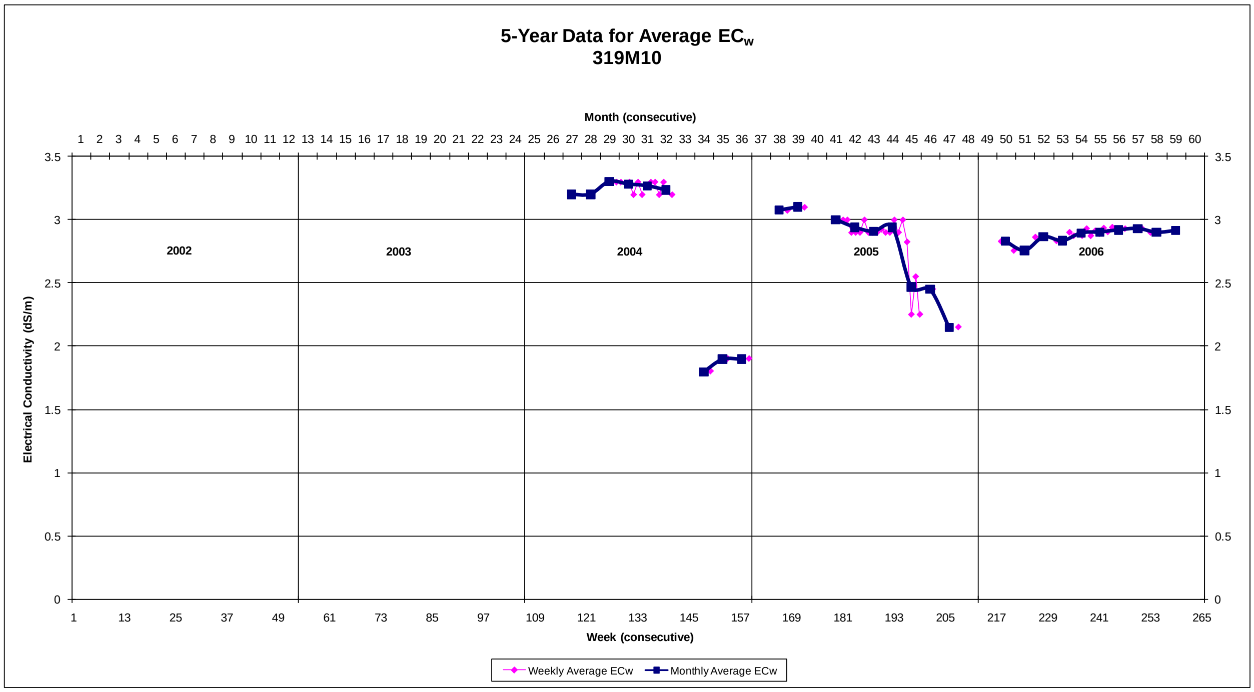

6-Year Data for Average EC_w
319M05
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

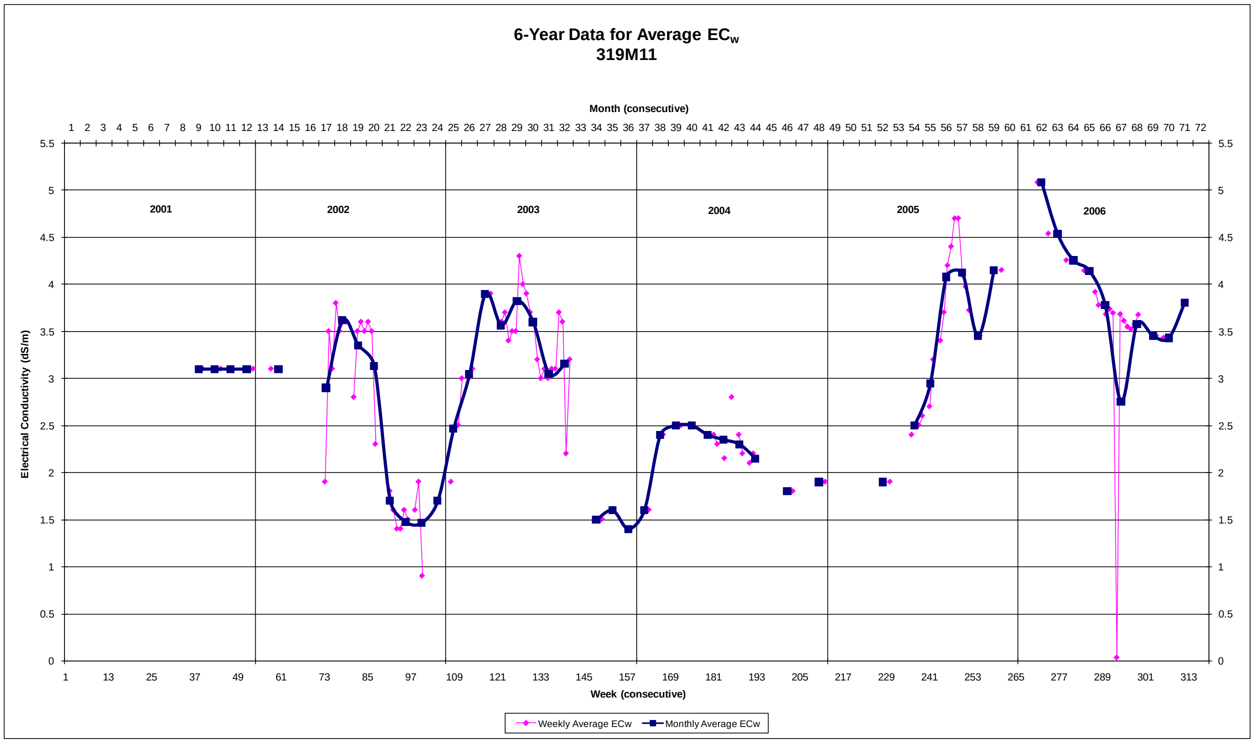

6-Year Data for Average EC_w
319M06
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

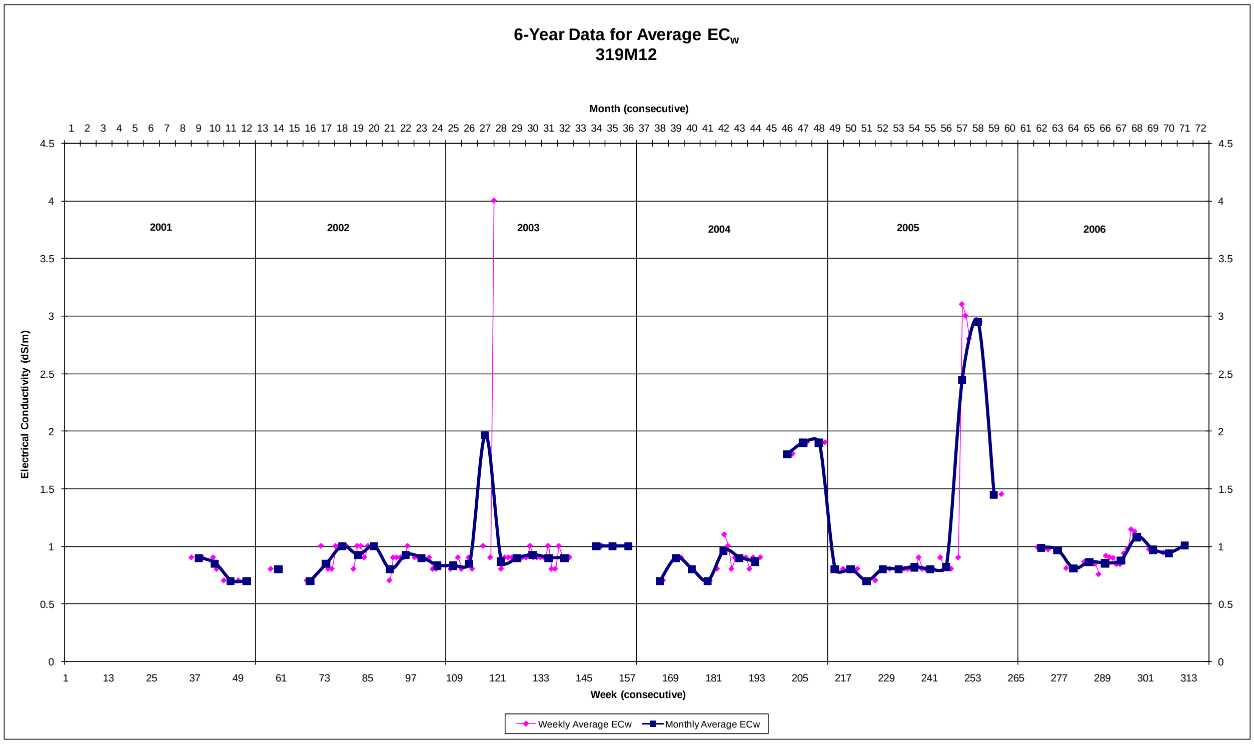

6-Year Data for Average EC_w
319M07
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw


6-Year Data for Average EC_w
319M08
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

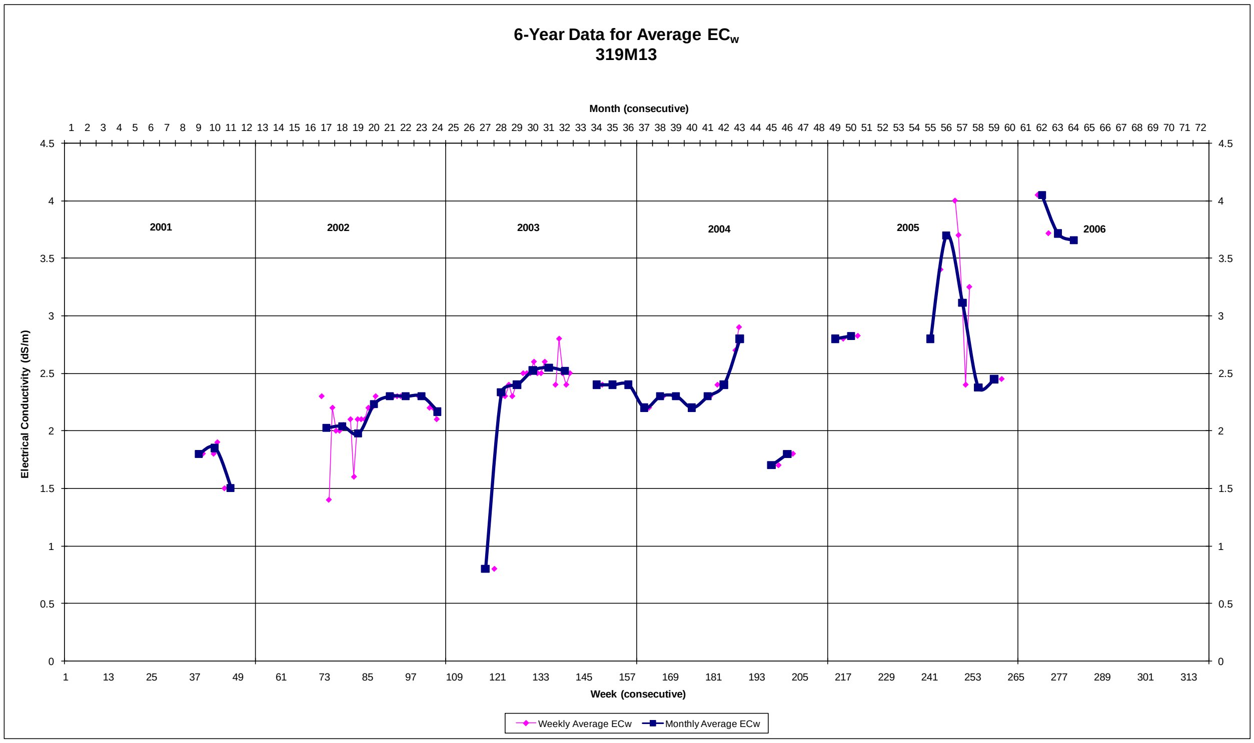

6-Year Data for Average EC_w
319M09
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average EC_w
319M10
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

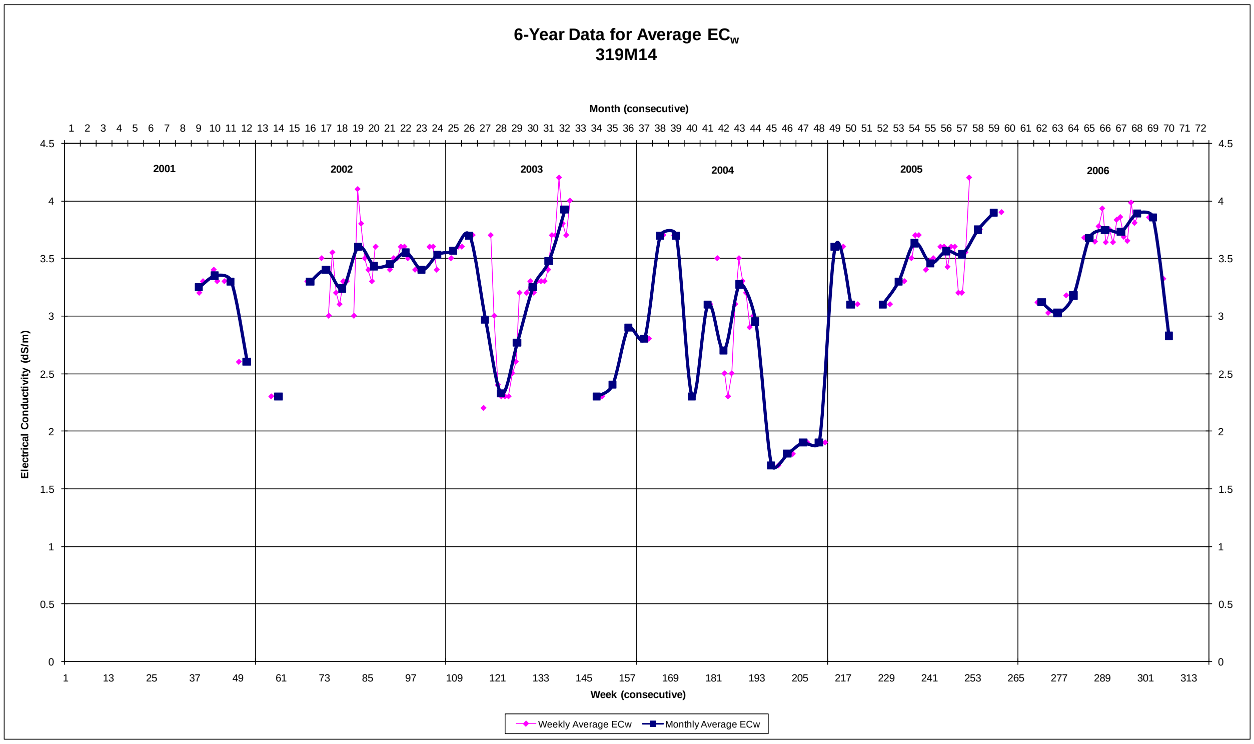

6-Year Data for Average EC_w
319M11
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

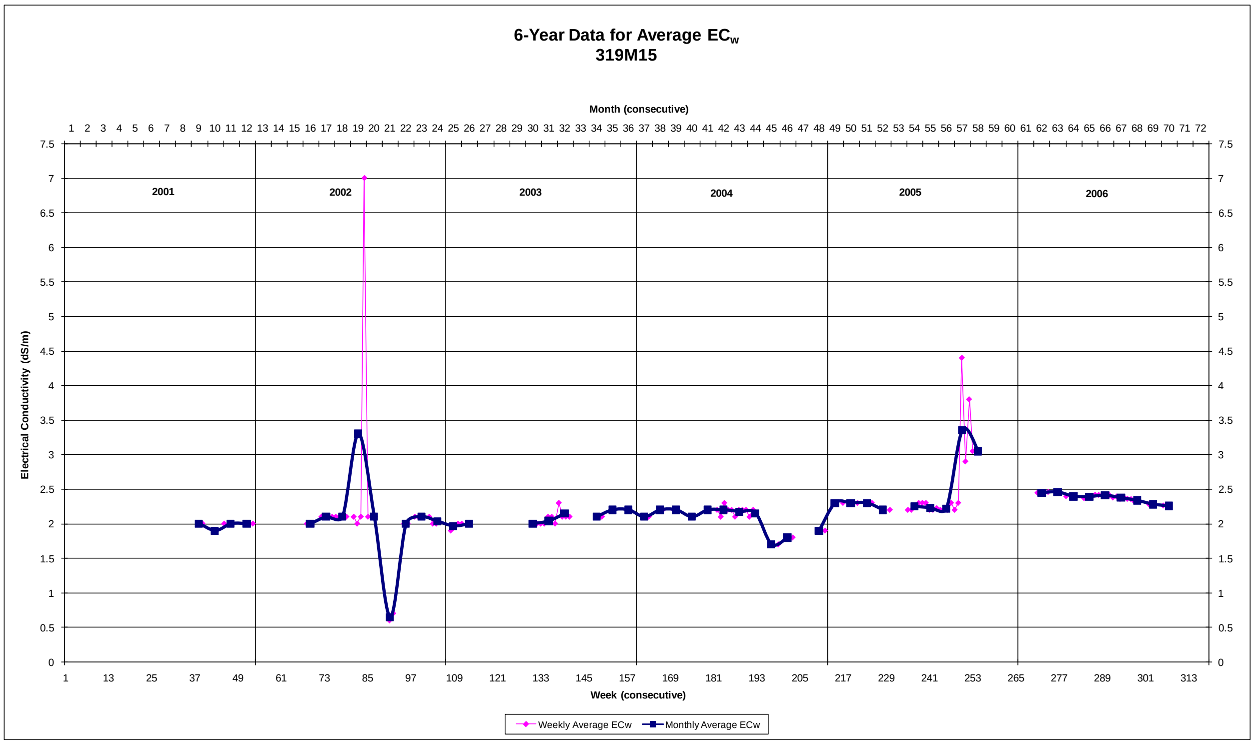


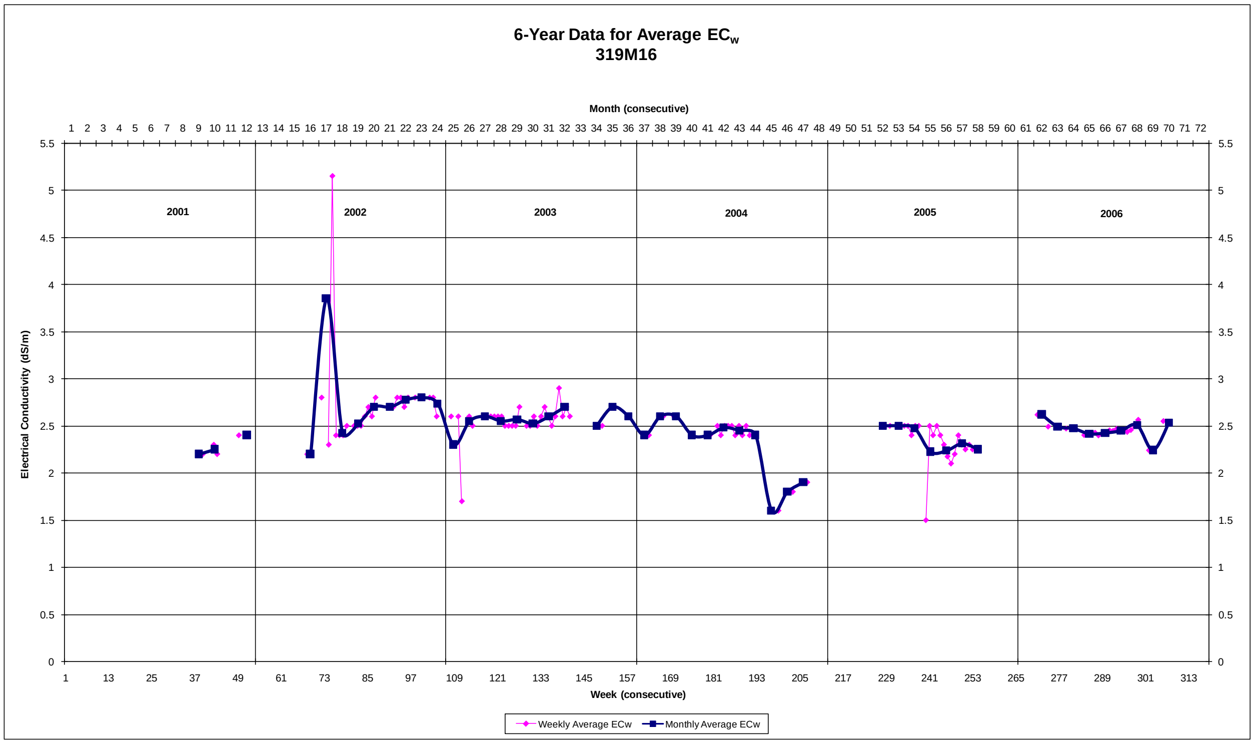
6-Year Data for Average EC_w
319M12
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

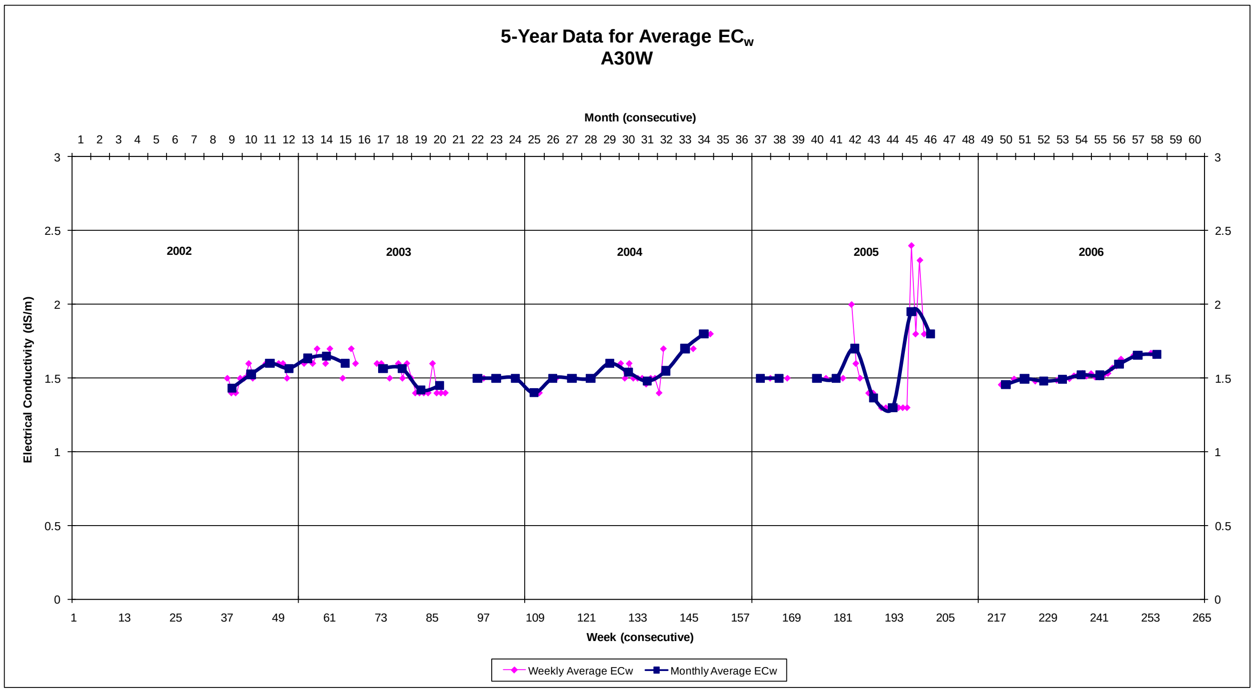


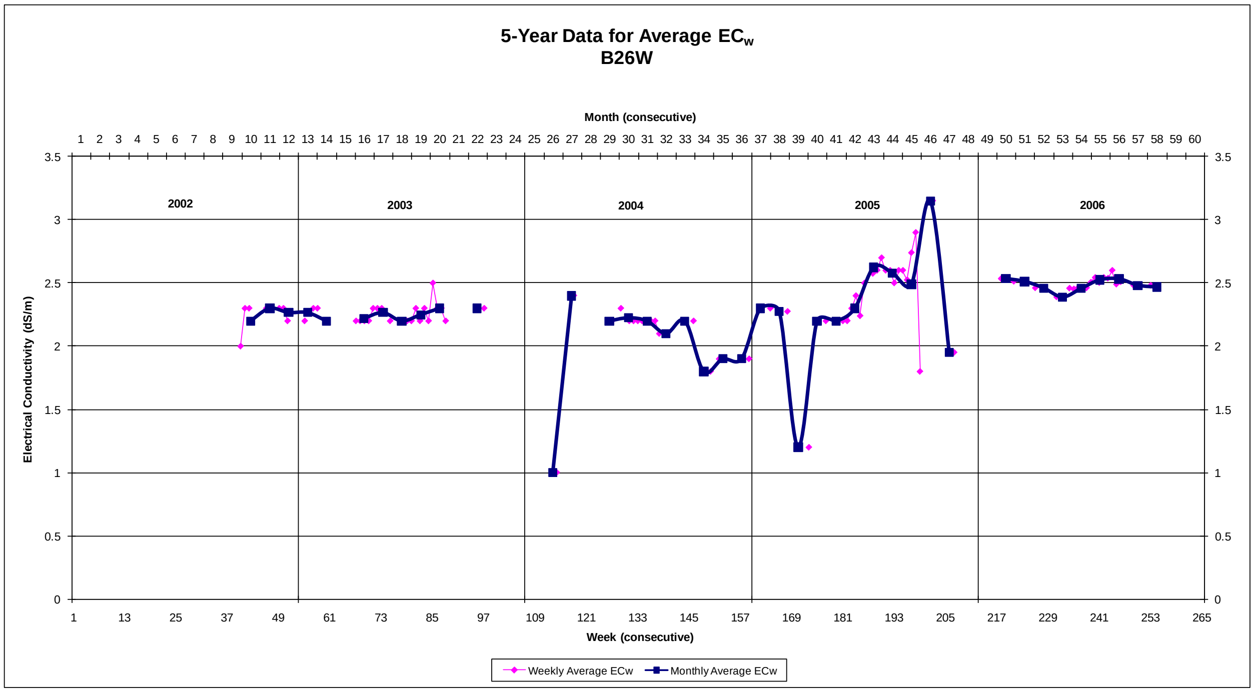
6-Year Data for Average EC_w
319M13
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2001
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

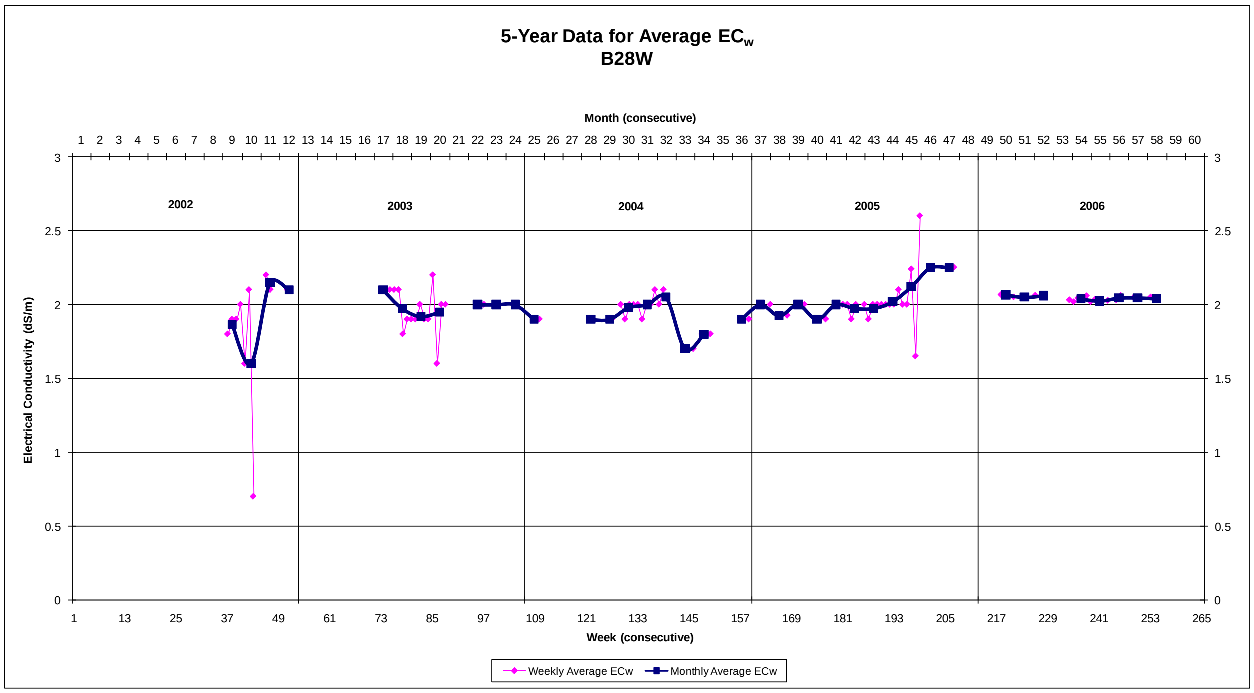

6-Year Data for Average EC_w
319M14
Month (consecutive)
2001
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

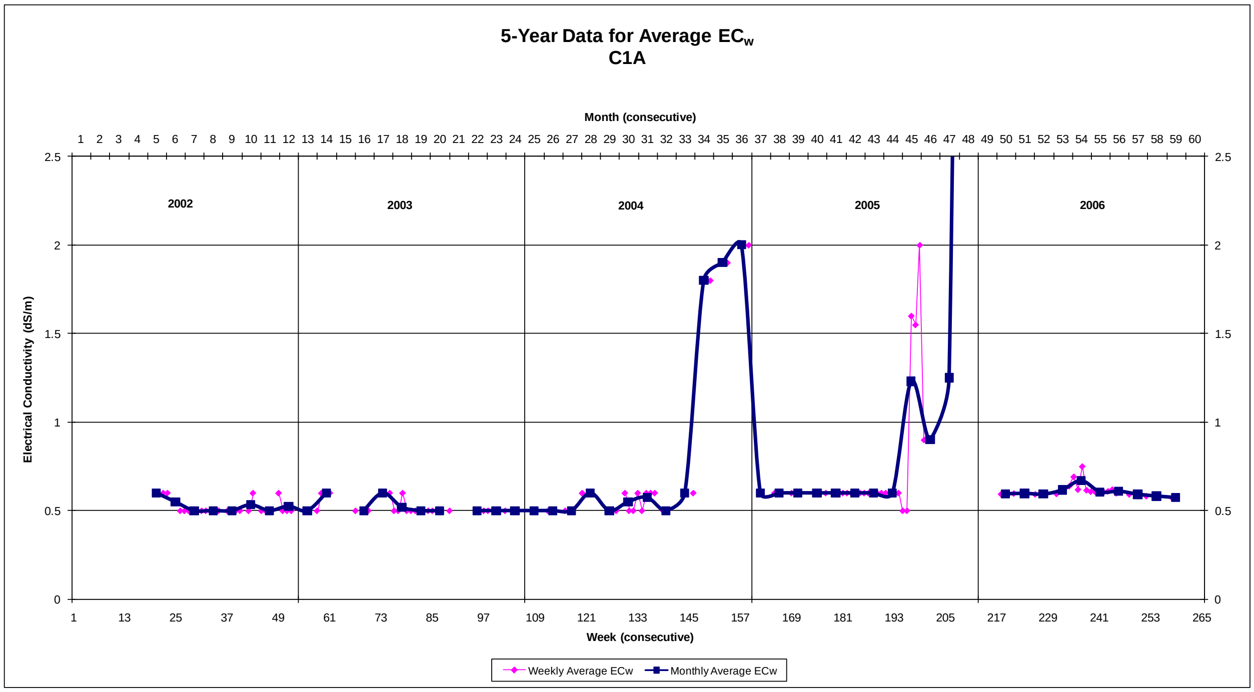

6-Year Data for Average EC_w
319M15
Month (consecutive)
2001
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw


6-Year Data for Average EC_w
319M16
Month (consecutive)
2001
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

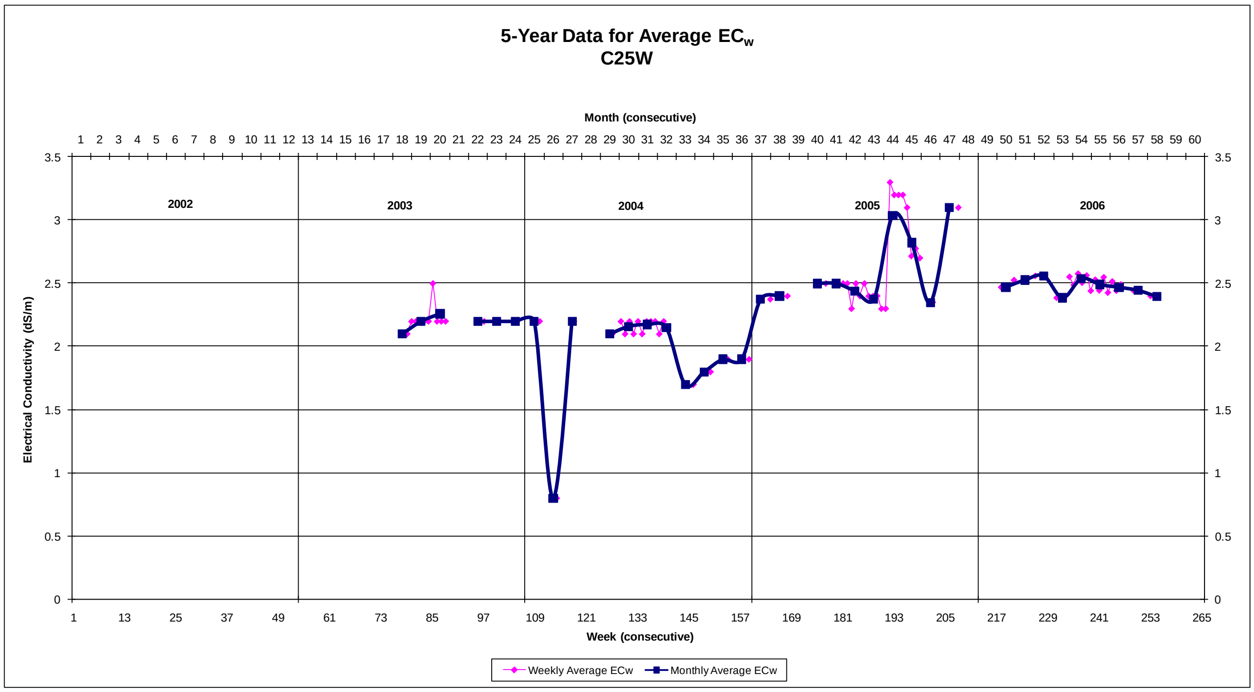

5-Year Data for Average EC_w
A30W
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average EC_w
B26W
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

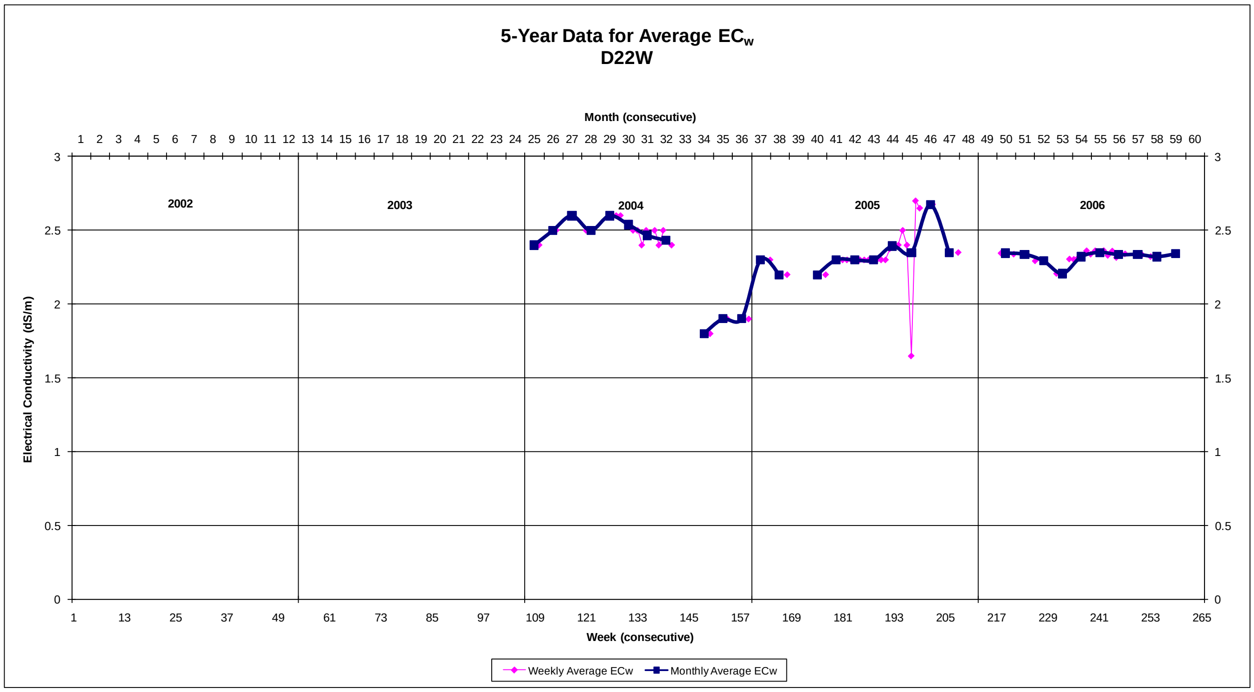

5-Year Data for Average EC_w
B28W
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw



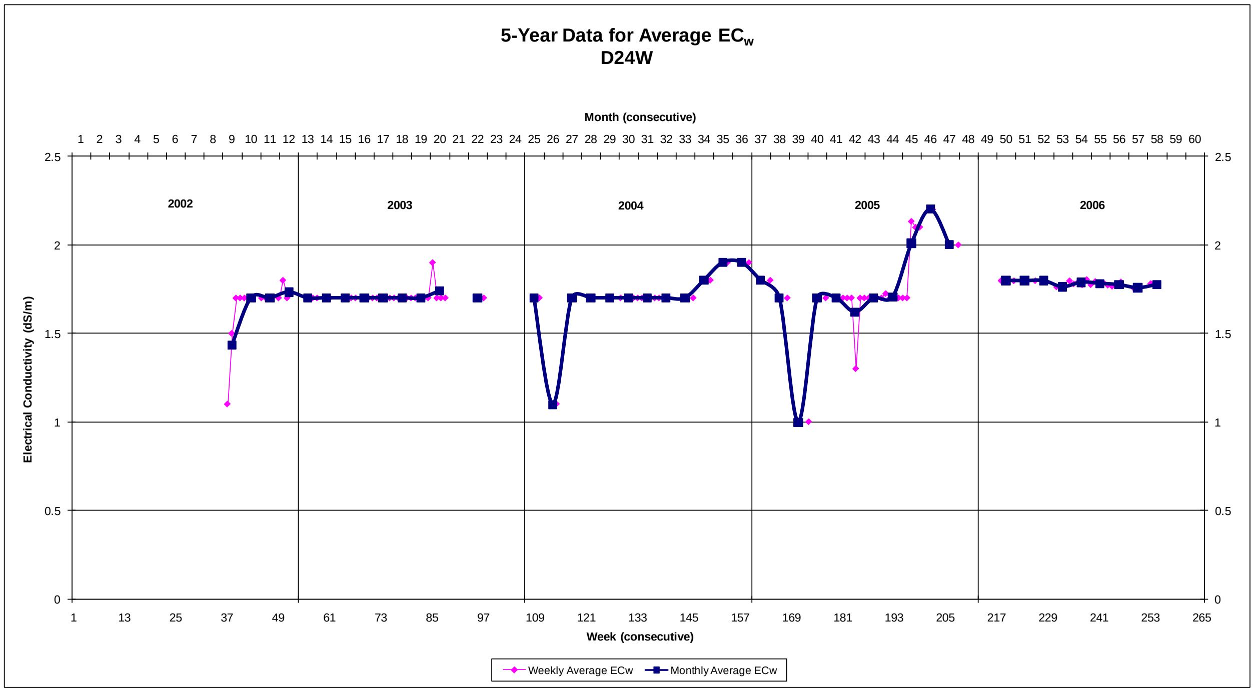
5-Year Data for Average EC_w
C1A
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw



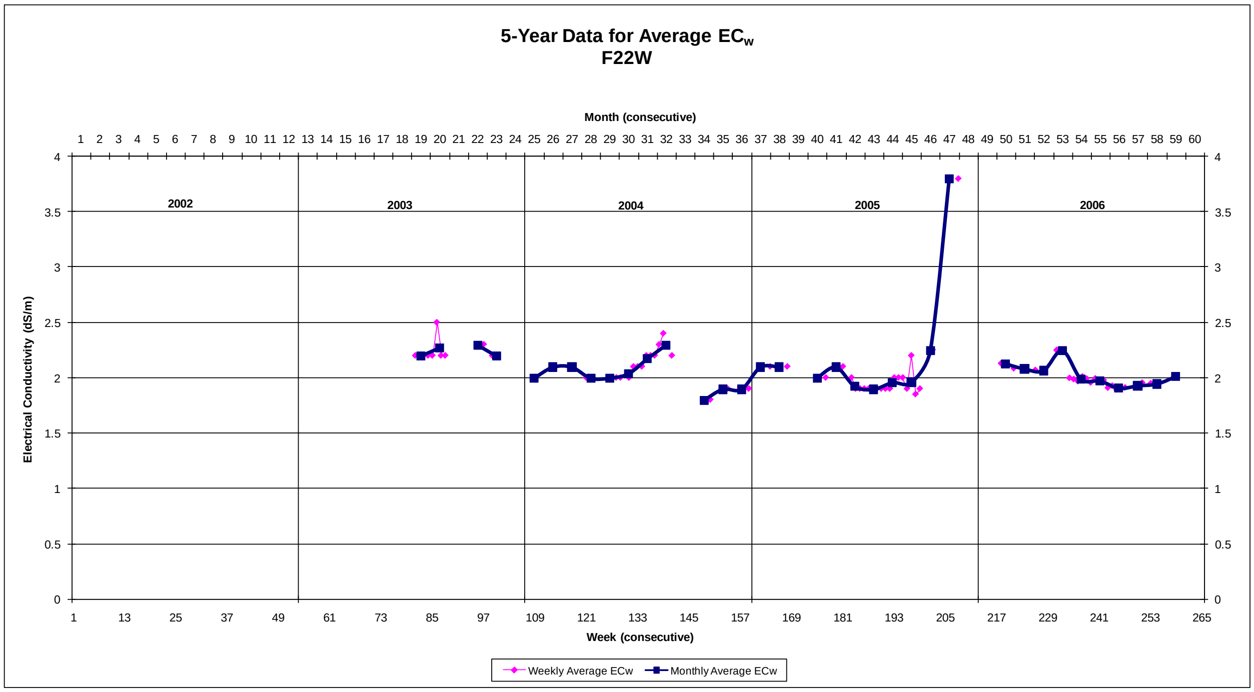
5-Year Data for Average EC_w
C25W
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

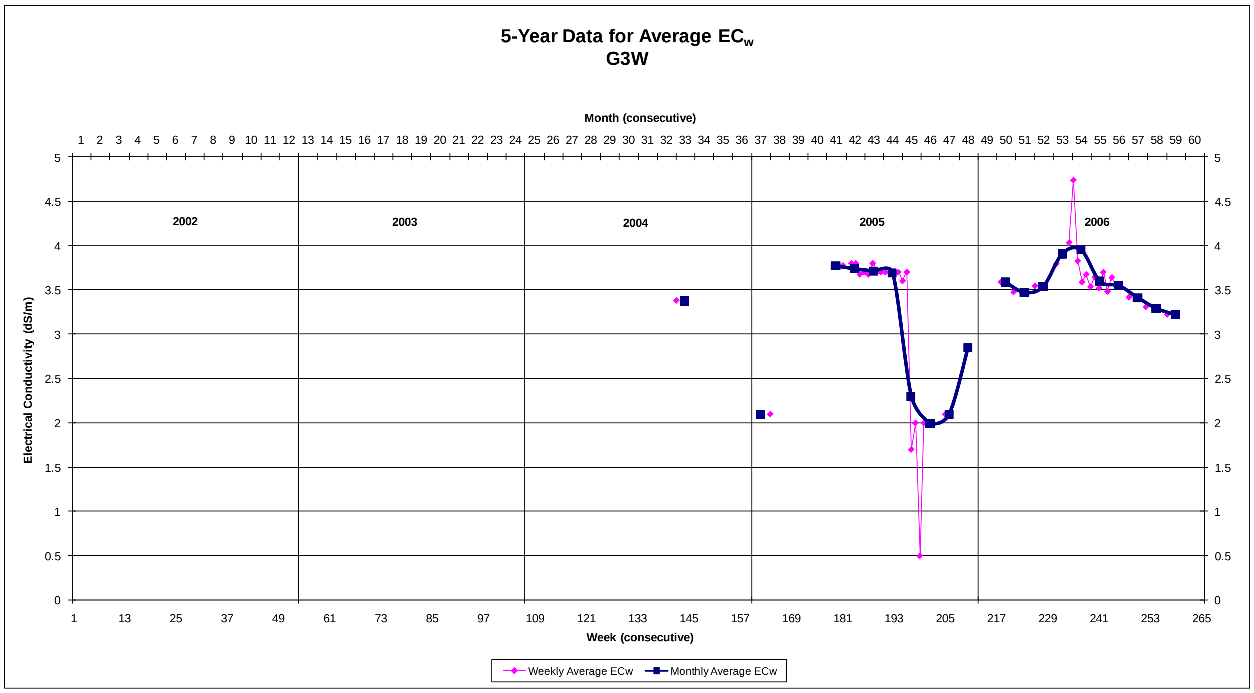


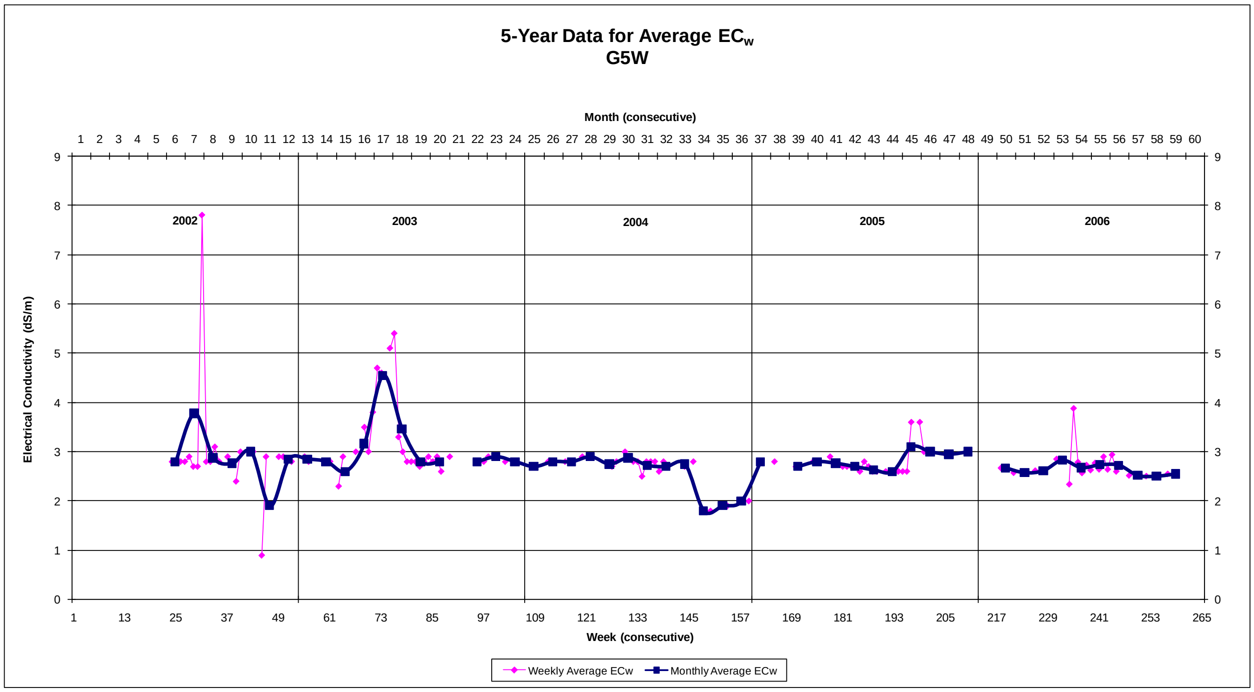
5-Year Data for Average EC_w
D22W
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

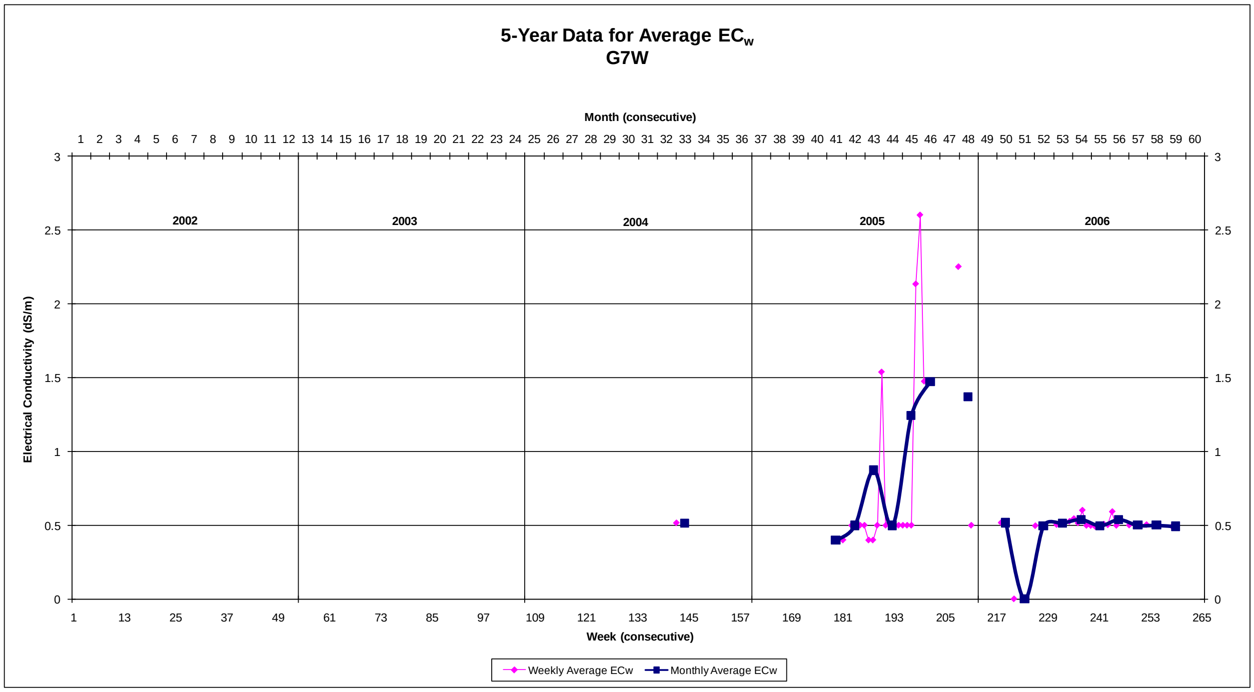


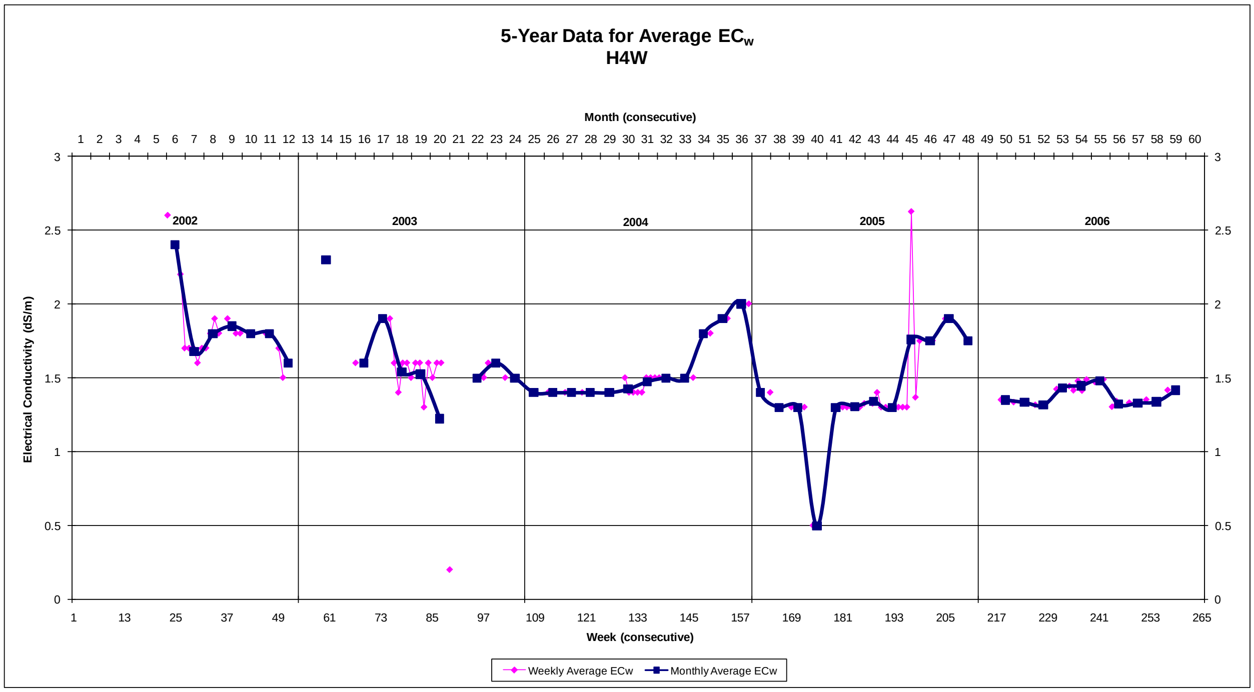
5-Year Data for Average EC_w
D24W
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average EC_w
F22W
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

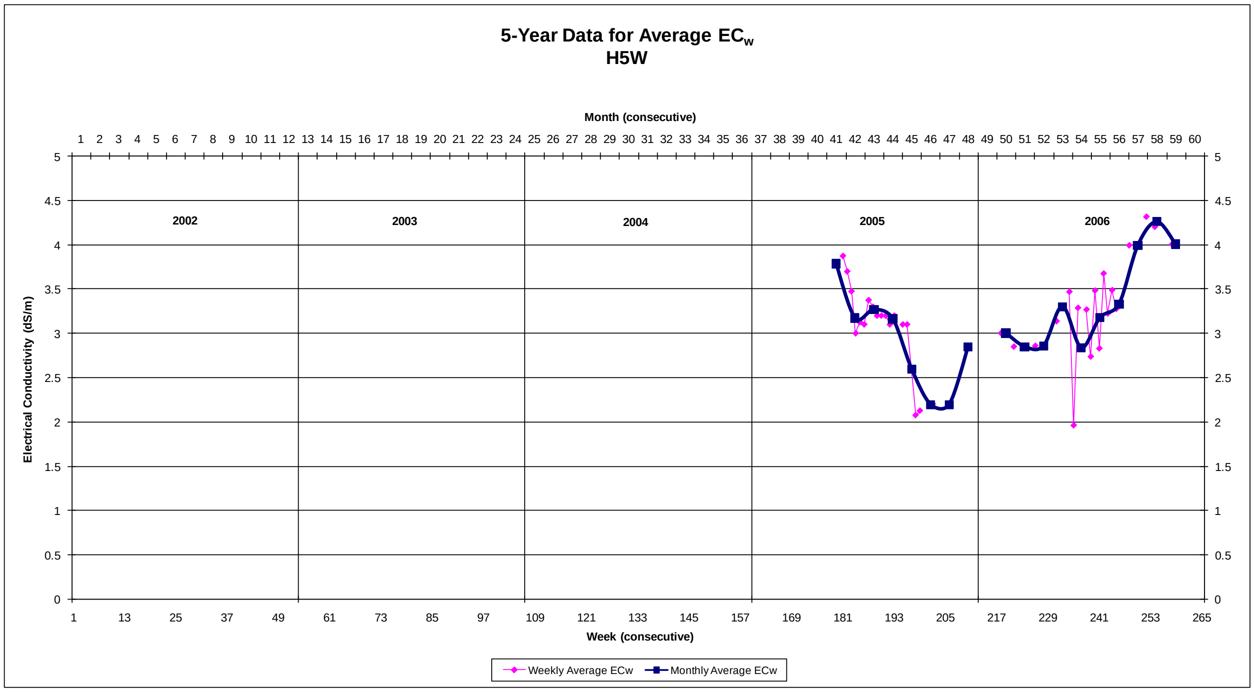

5-Year Data for Average EC_w
G3W
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average ECw
G5W
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

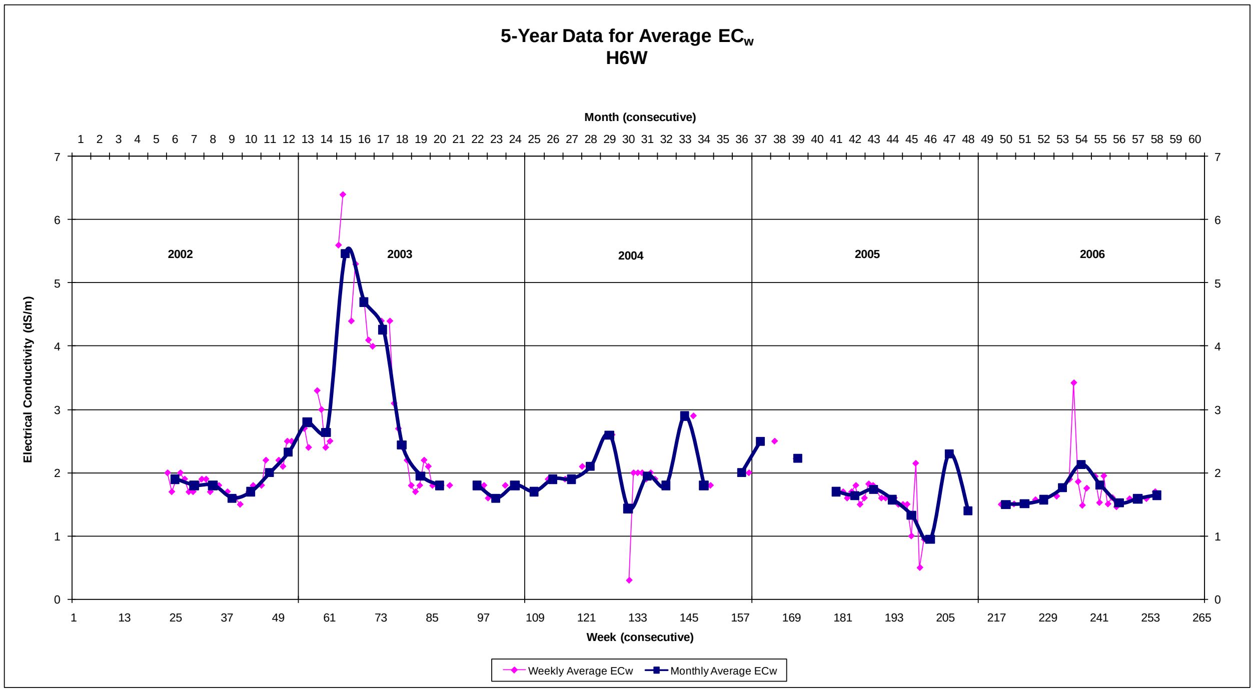

5-Year Data for Average ECw
G7W
Month (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Week (consecutive)
Weekly Average ECw
Monthly Average ECw



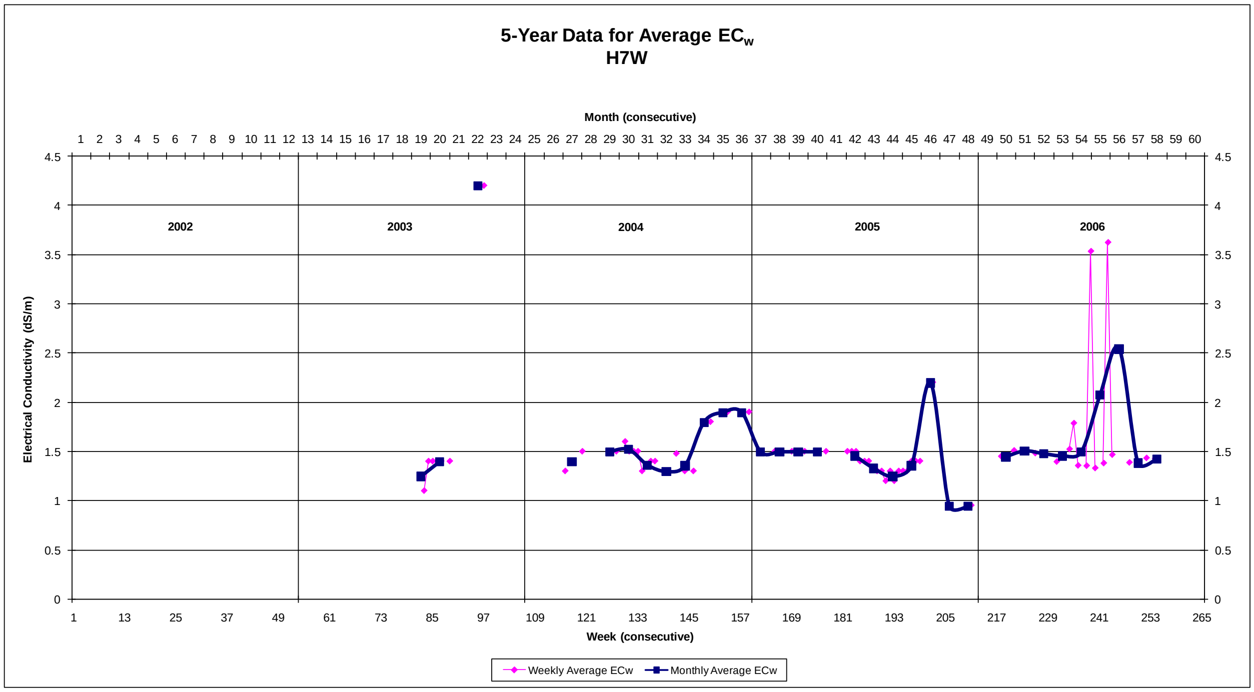
5-Year Data for Average EC_w
H4W
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw



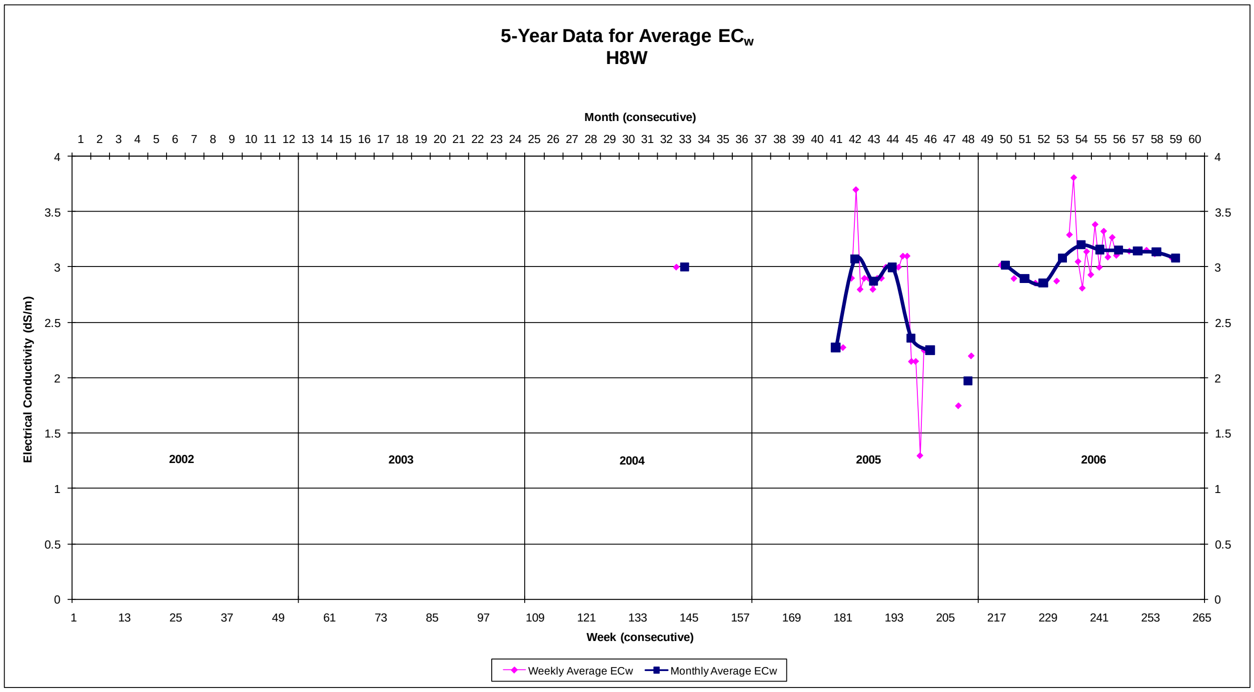
5-Year Data for Average EC_w
H5W
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

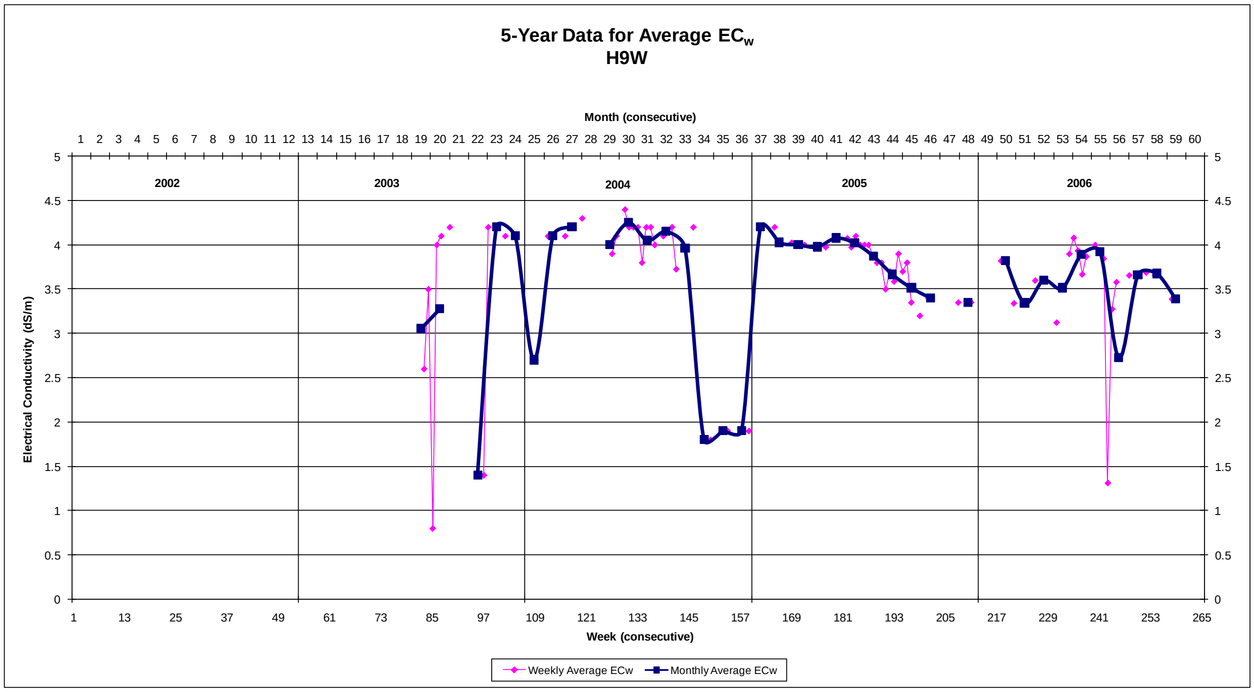


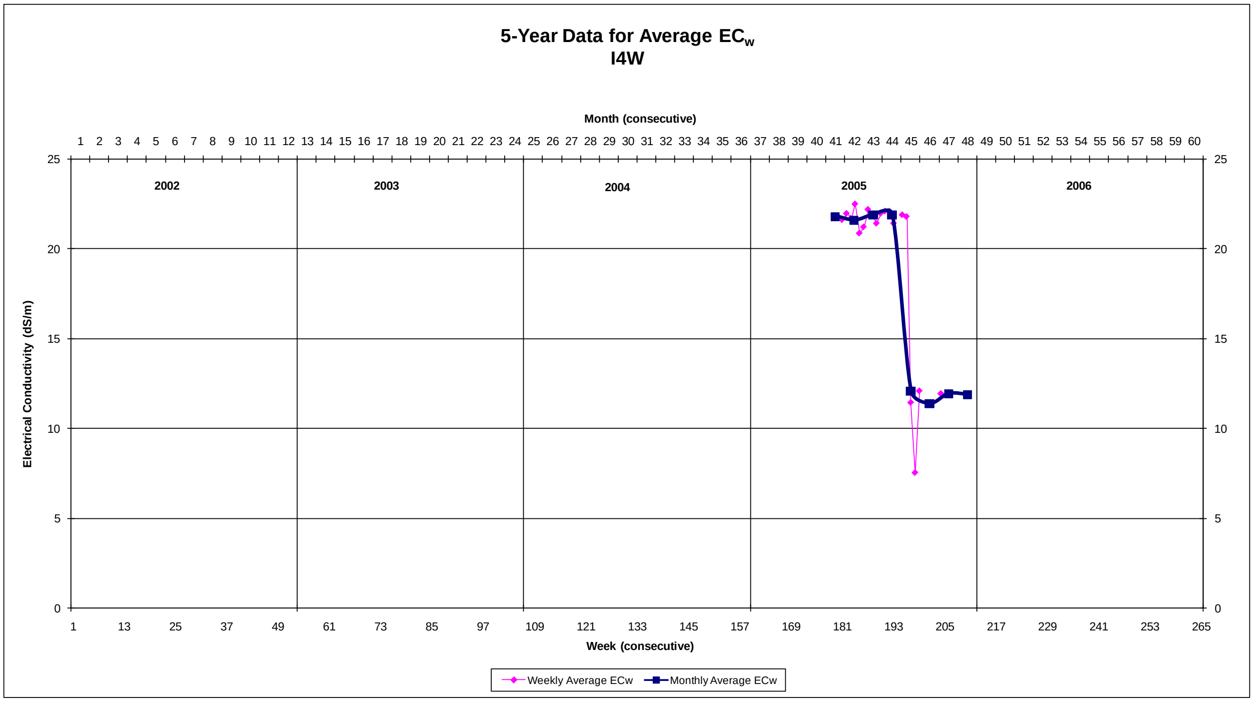
5-Year Data for Average EC_w
H6W
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

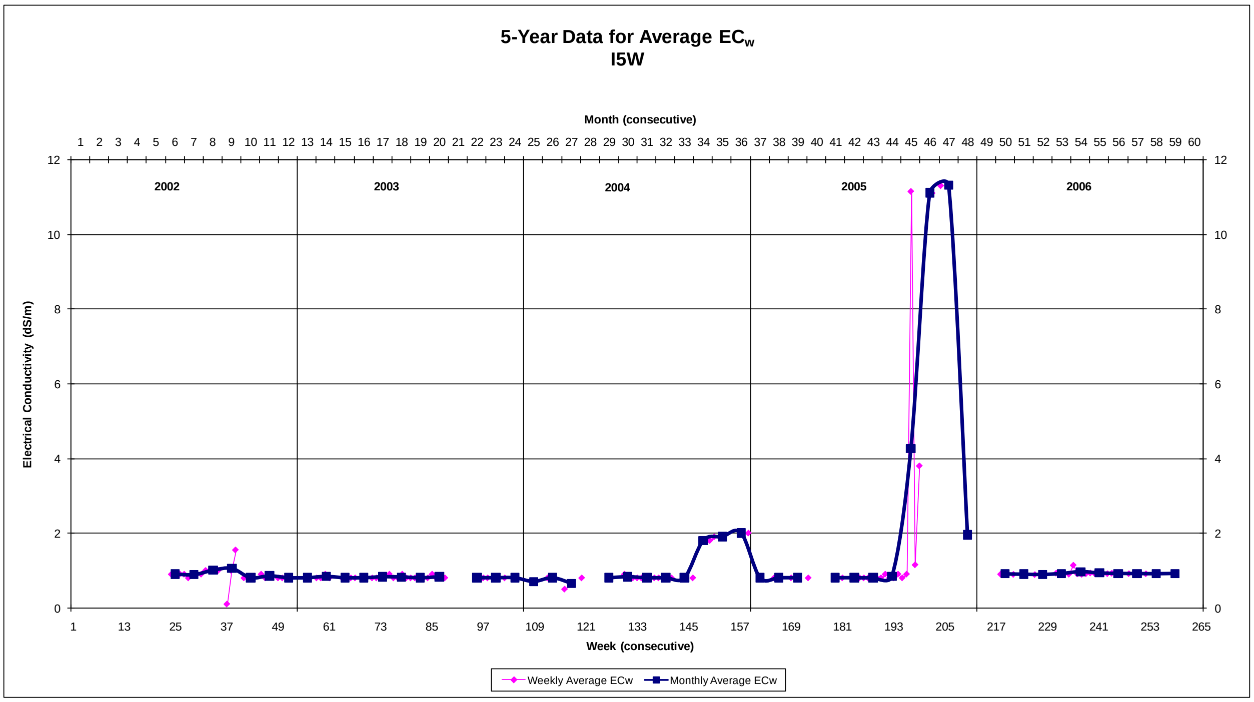


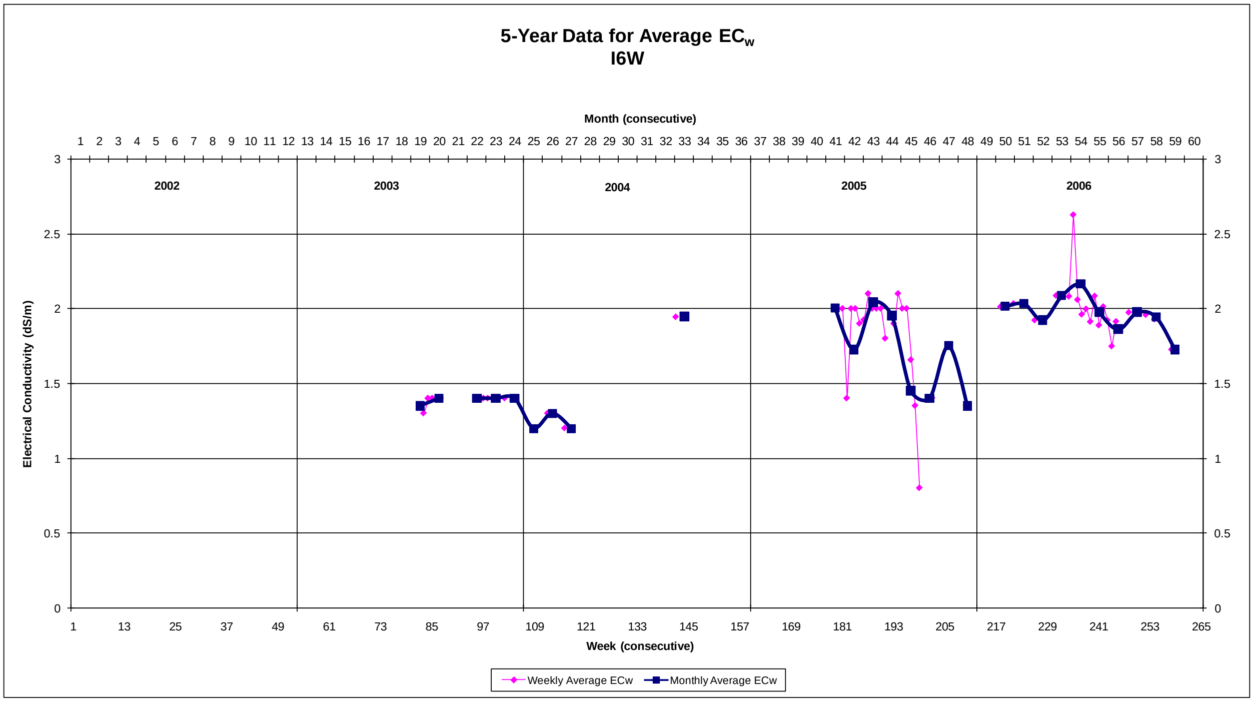
5-Year Data for Average EC_w
H7W
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

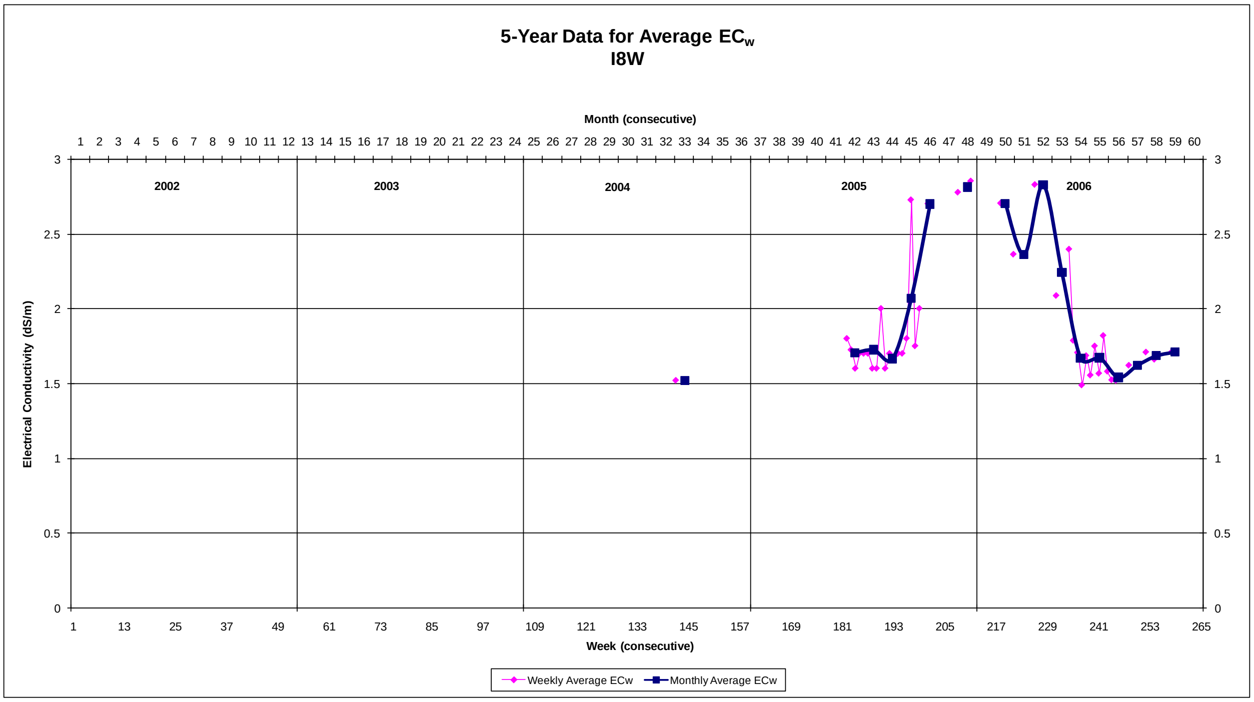

5-Year Data for Average EC_w
H8W
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

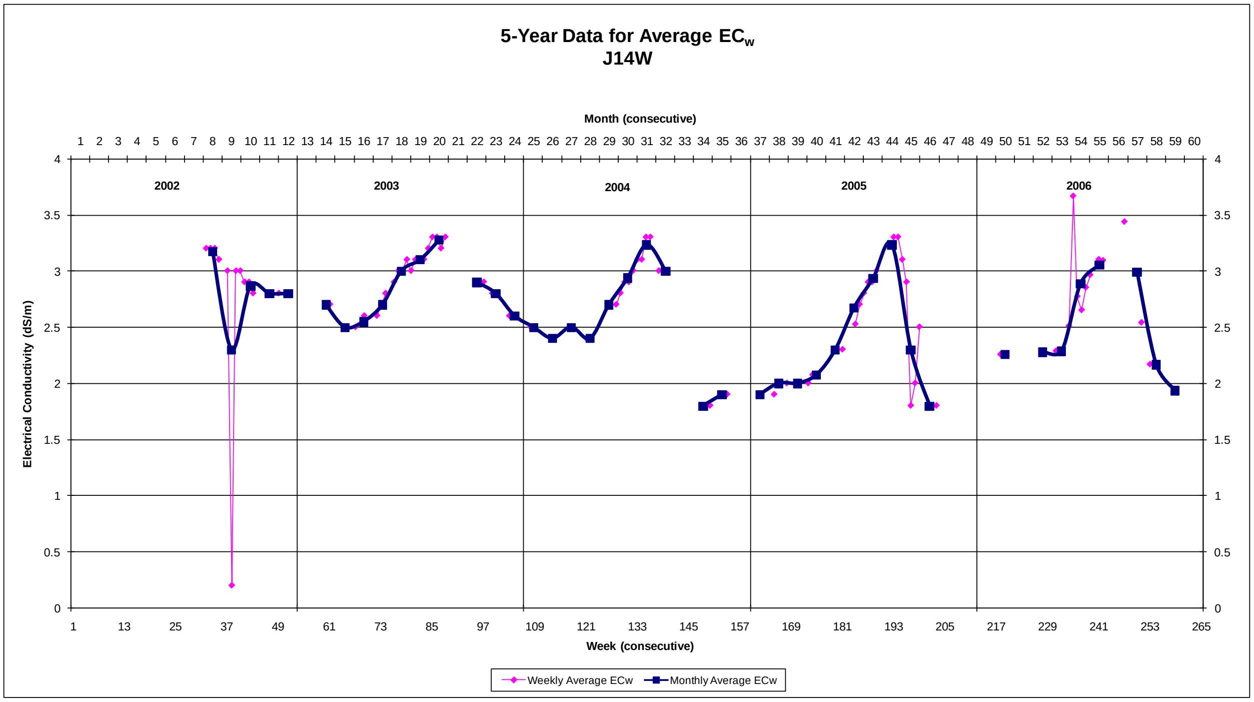

5-Year Data for Average EC_w
H9W
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

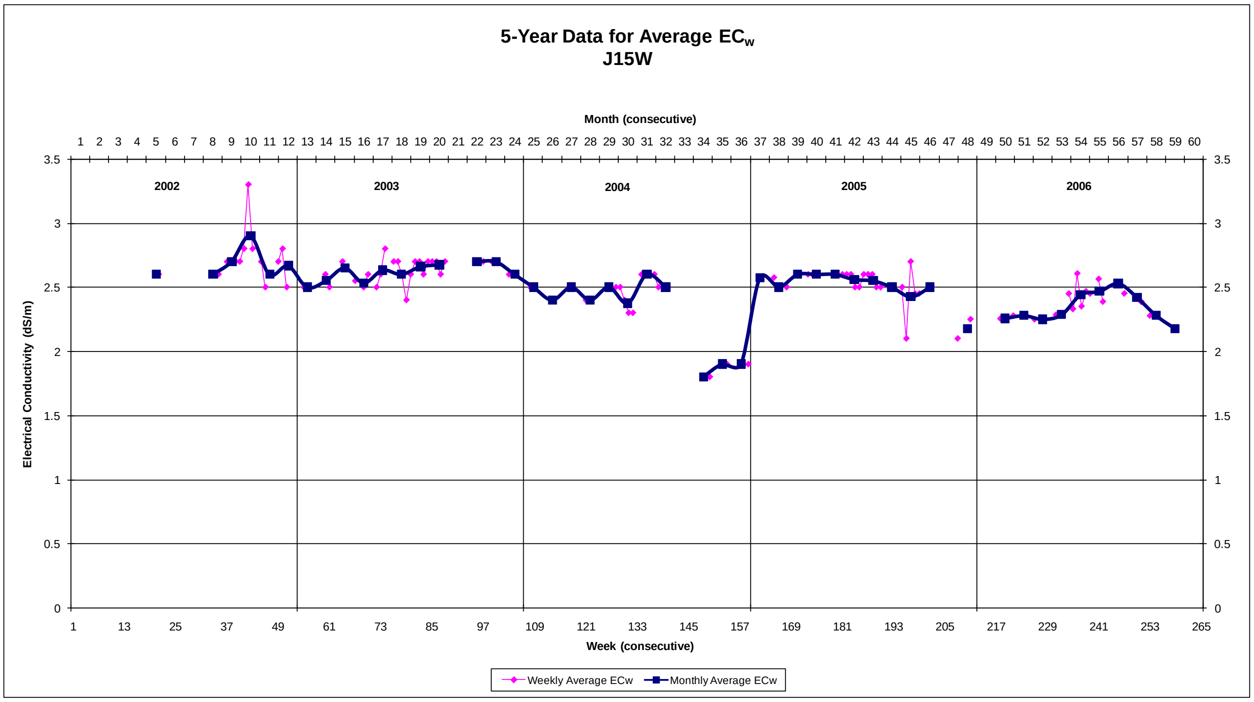

5-Year Data for Average EC_w
I4W
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

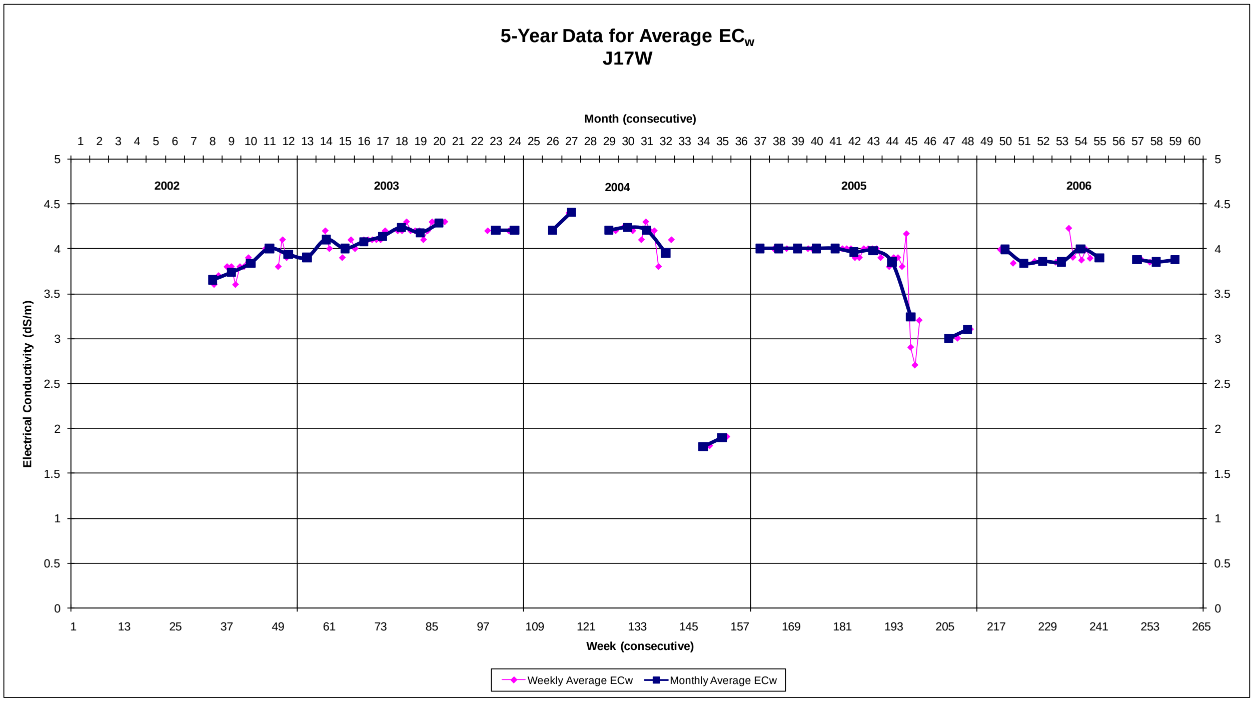

5-Year Data for Average EC_w
I5W
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average EC_w
I6W
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

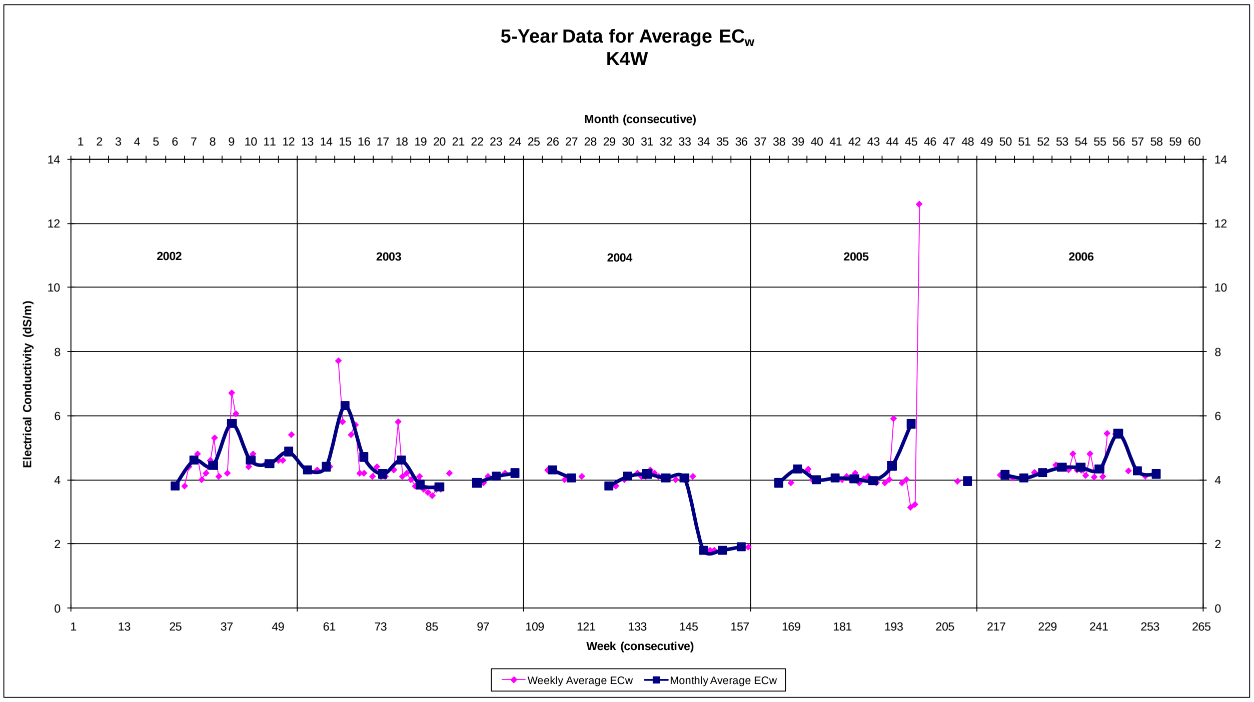

5-Year Data for Average EC_w
I8W
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average EC_w
J14W
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

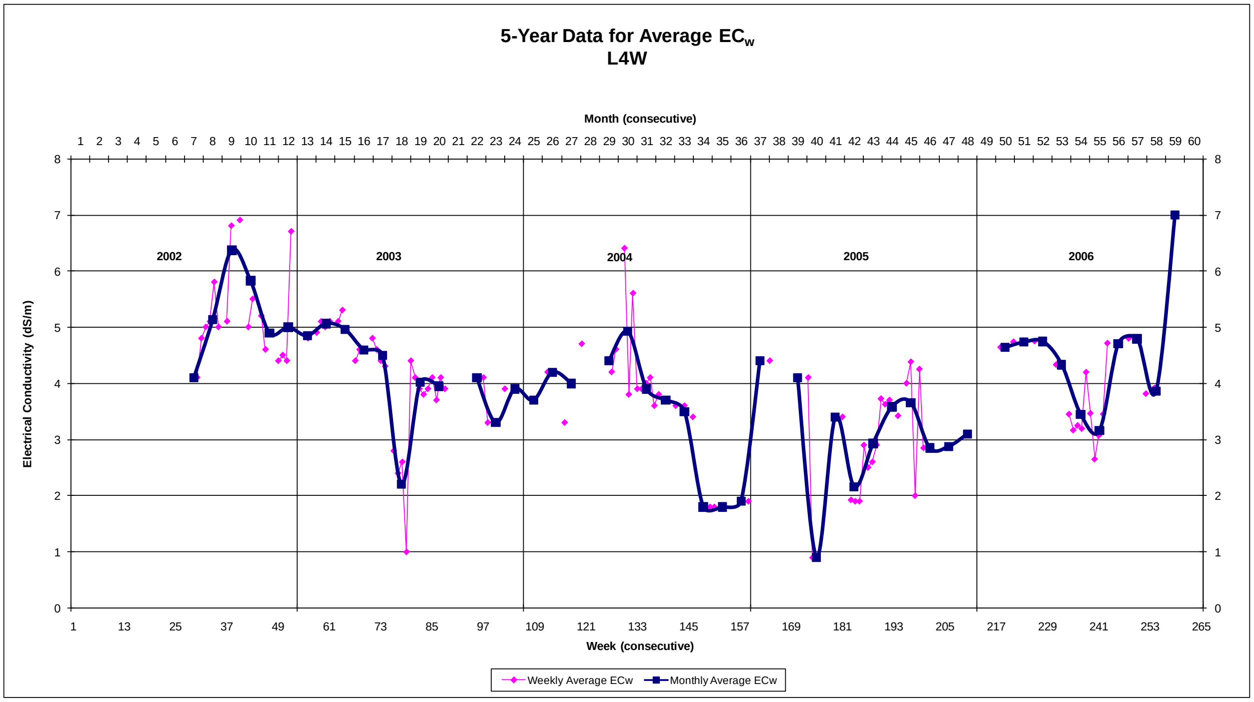

5-Year Data for Average EC_w
J15W
Month (consecutive)
2002
2003
2004
2005
2006
Electrical Conductivity (dS/m)
Week (consecutive)
Weekly Average ECw
Monthly Average ECw

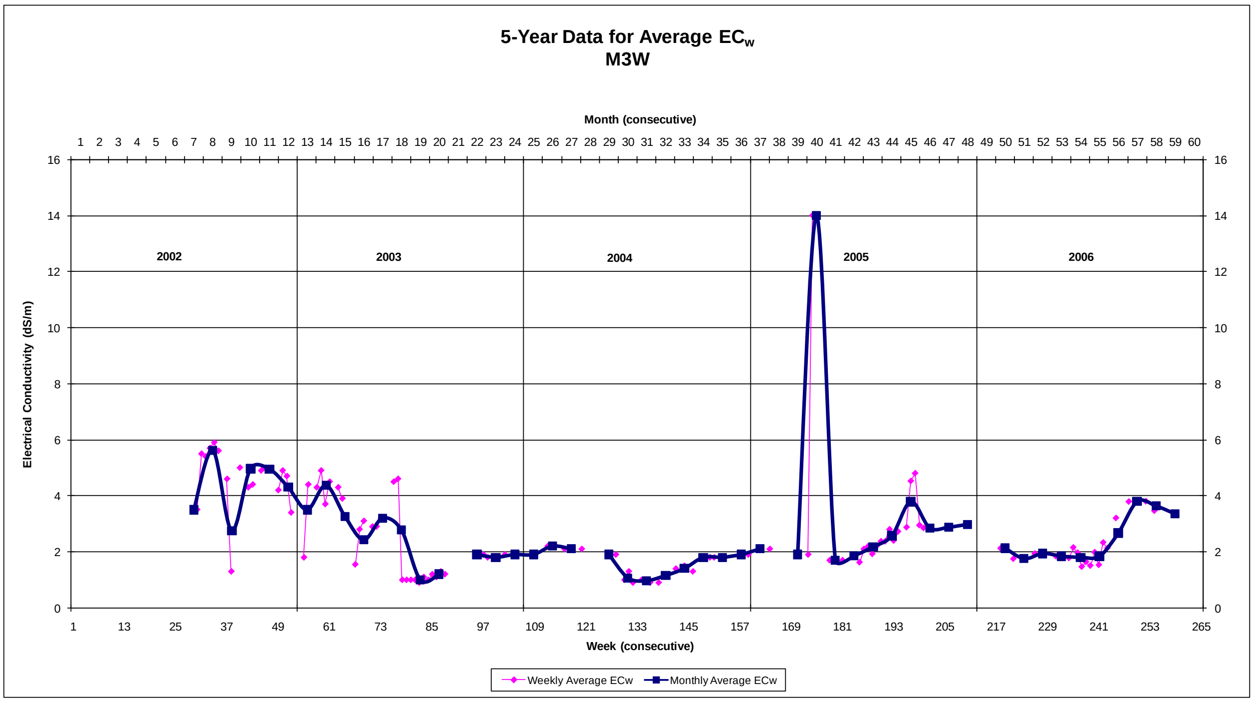


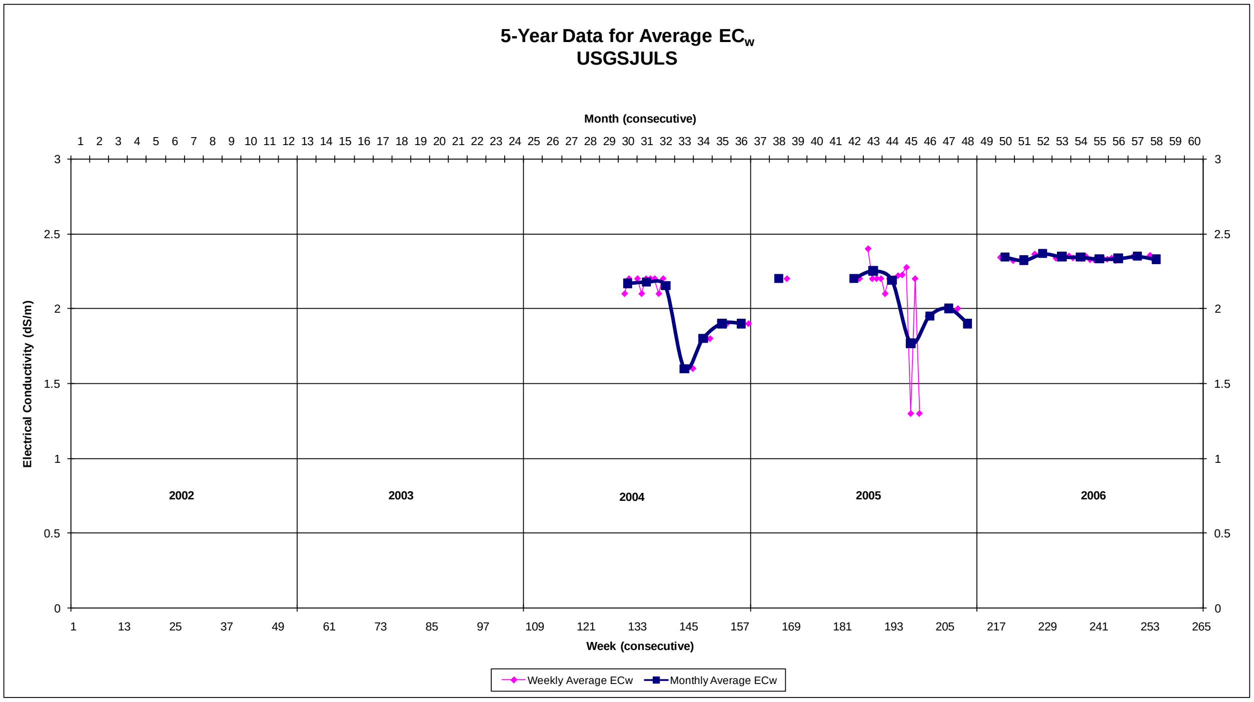
5-Year Data for Average EC_w
J17W
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw



5-Year Data for Average EC_w
K4W
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw


5-Year Data for Average EC_w
L4W
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

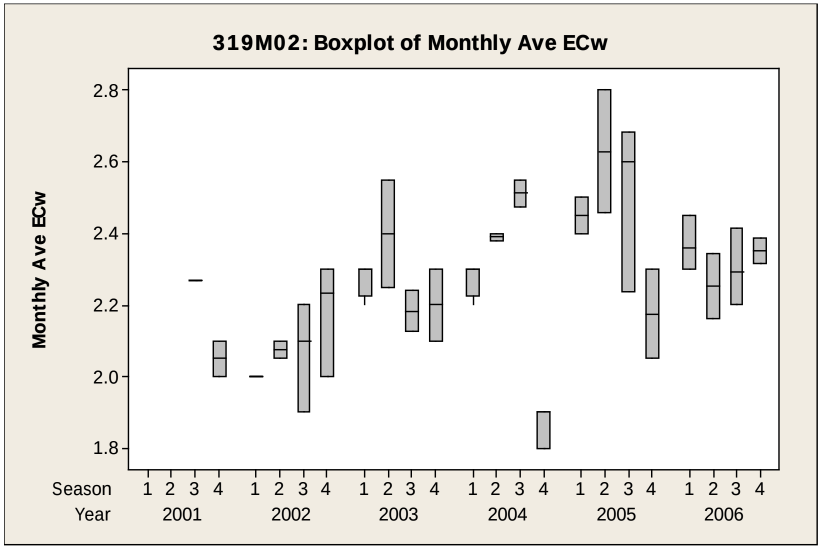

5-Year Data for Average EC_w
M3W
Month (consecutive)
Week (consecutive)
Electrical Conductivity (dS/m)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

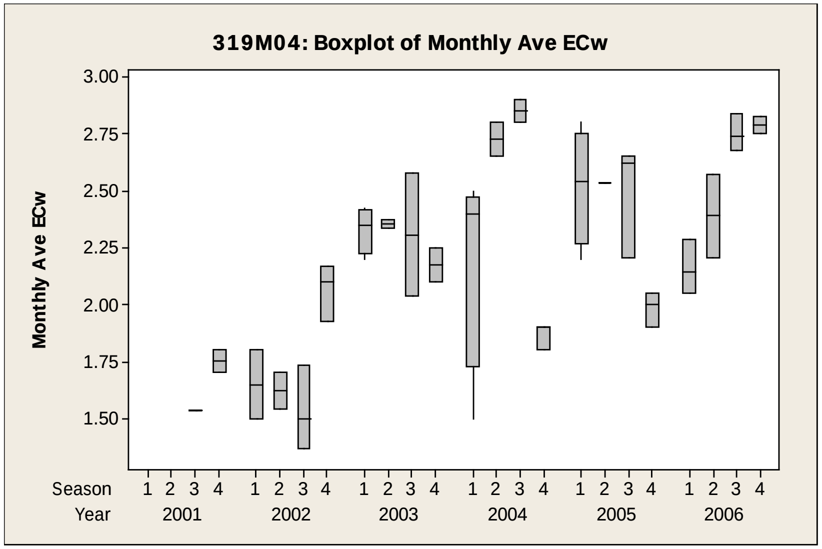


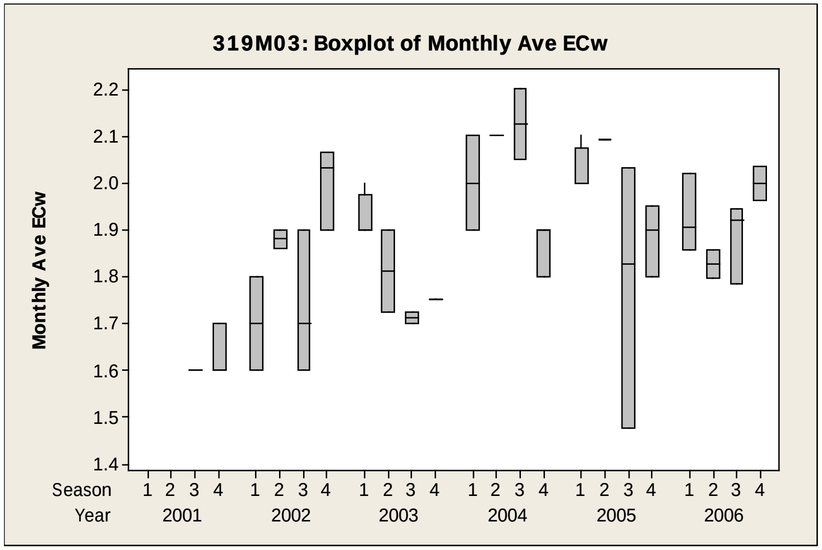
5-Year Data for Average ECw
USGSJULS
Month (consecutive)
Electrical Conductivity (dS/m)
Week (consecutive)
2002
2003
2004
2005
2006
Weekly Average ECw
Monthly Average ECw

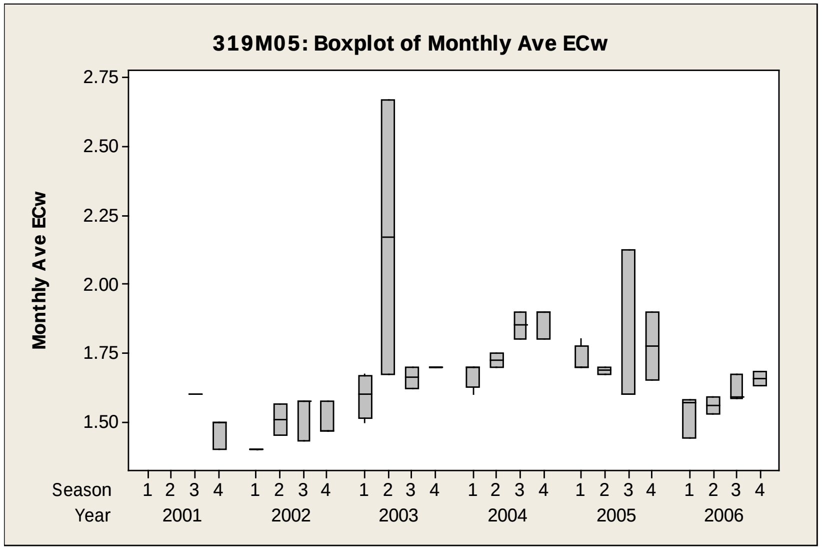
APPENDIX G

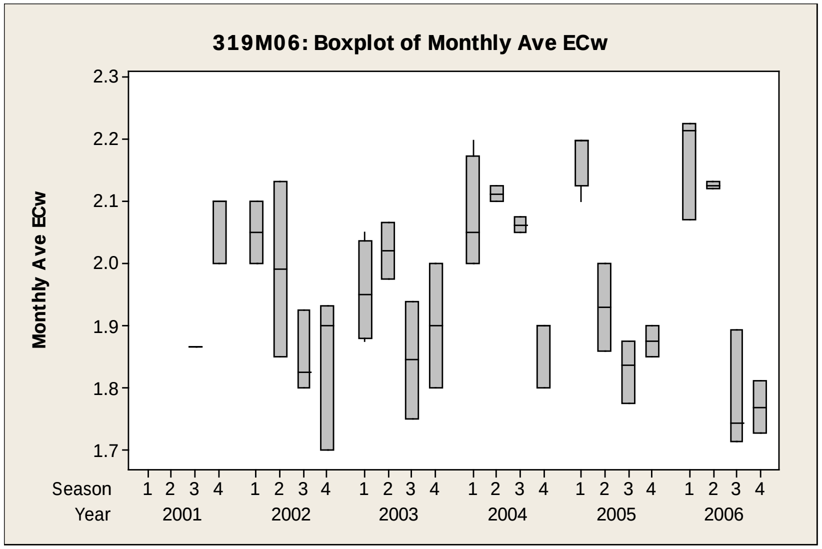
Well System Box Plots

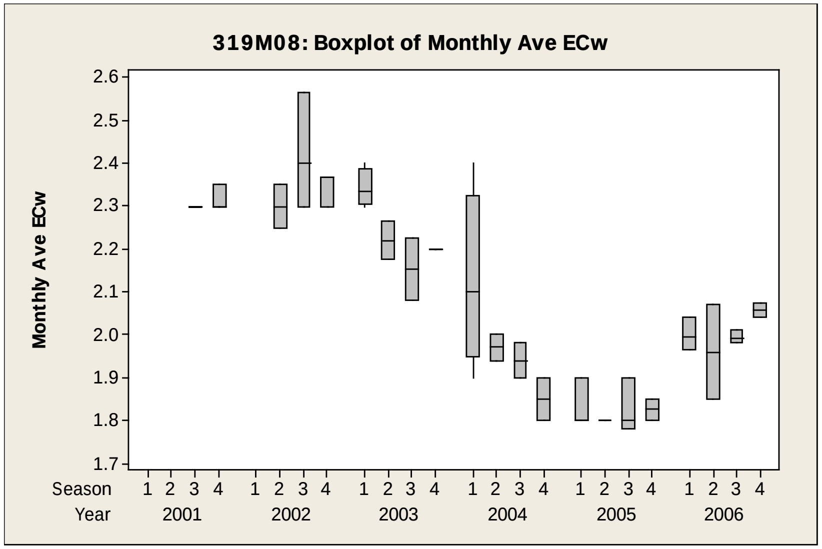

319M02: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.8
2.6
2.4
2.2
2.0
1.8
Season
Year
2001
2002
2003
2004
2005
2006

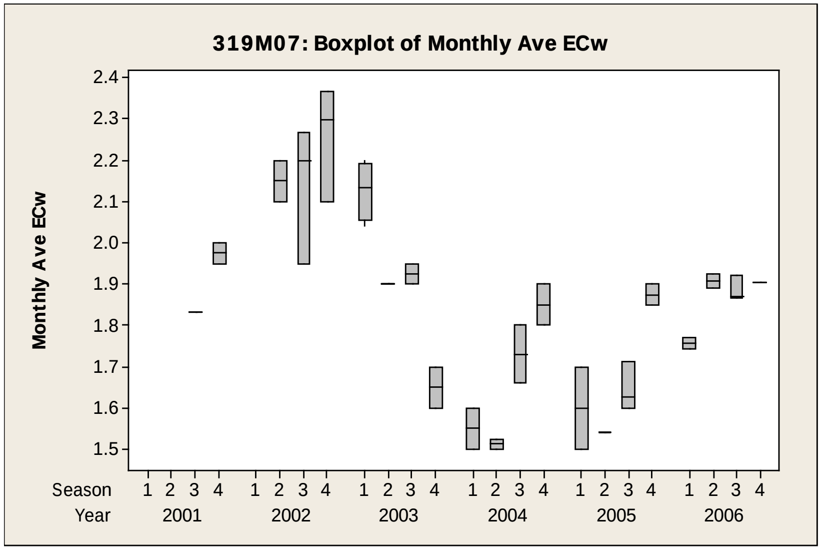

319M04: Boxplot of Monthly Ave ECw
Monthly Ave ECw
3.00
2.75
2.50
2.25
2.00
1.75
1.50
Season
Year
2001
2002
2003
2004
2005
2006

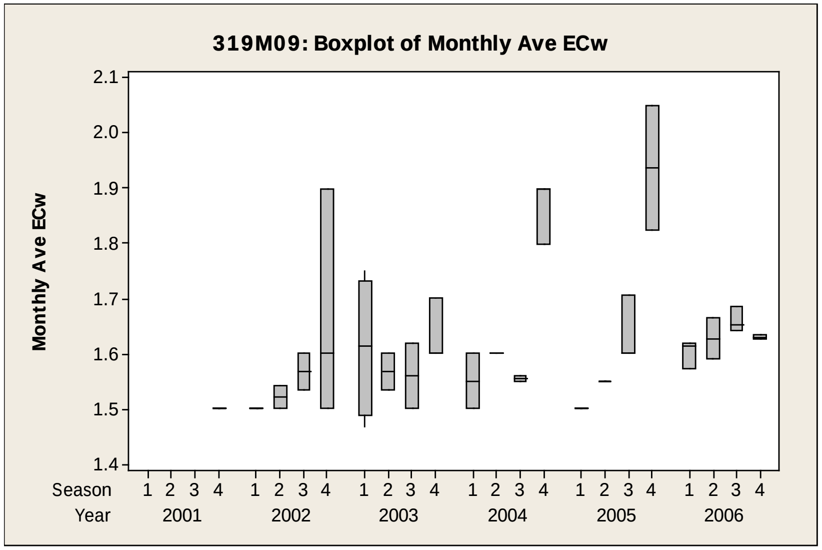

319M03: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
Season
Year
2001
2002
2003
2004
2005
2006

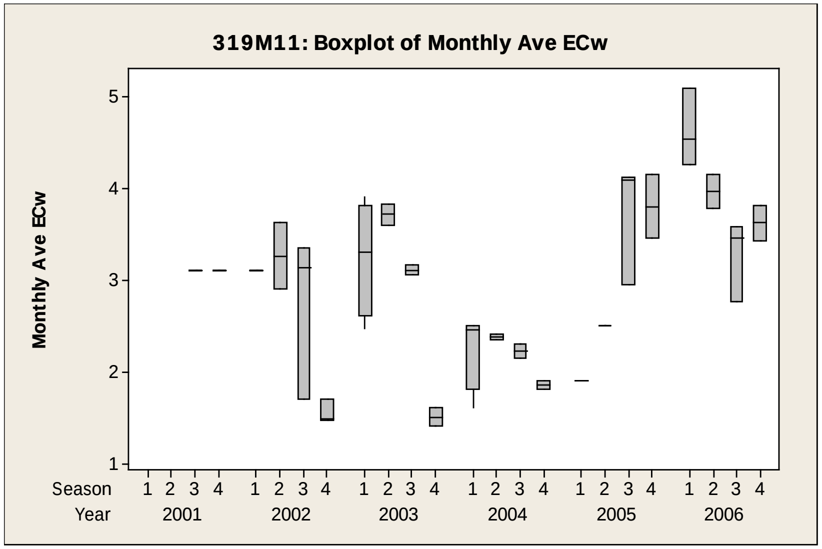

319M05: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.75
2.50
2.25
2.00
1.75
1.50
Season
Year
2001
2002
2003
2004
2005
2006

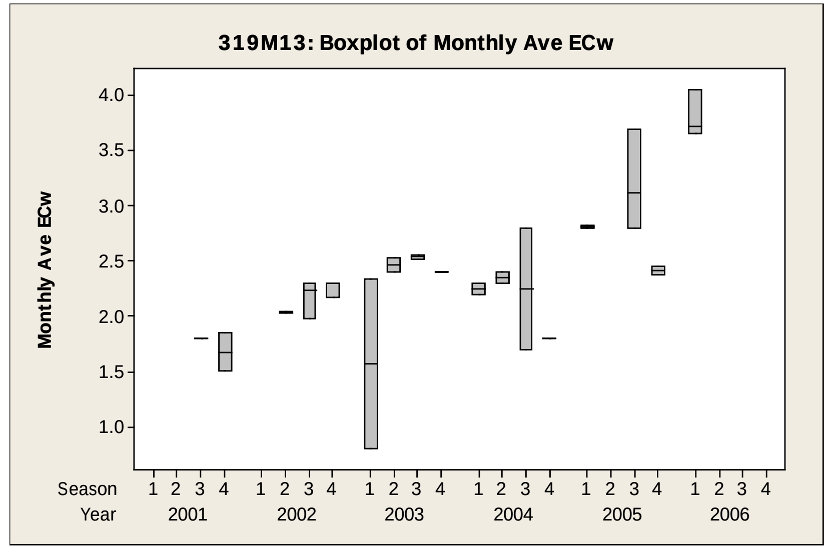

319M06: Boxplot of Monthly Ave ECw
Monthly Ave ECw
Season
Year
2001
2002
2003
2004
2005
2006

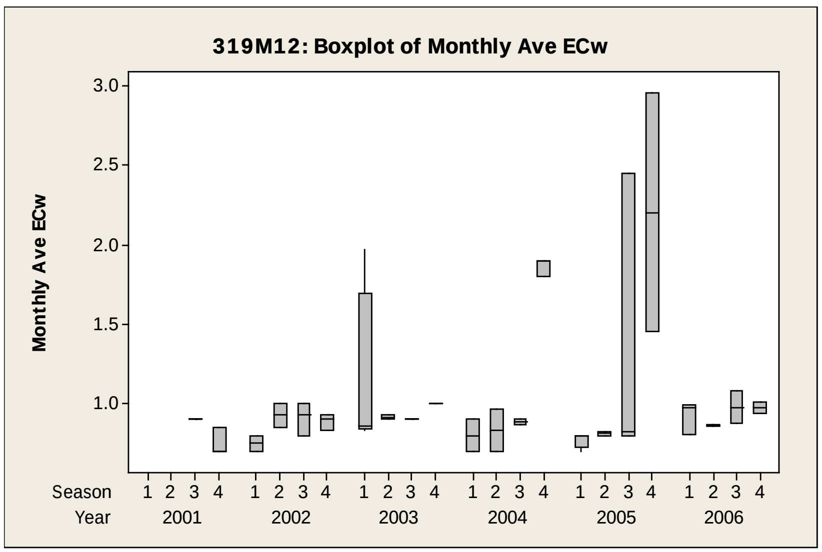

319M08: Boxplot of Monthly Ave ECw
Monthly Ave ECw
Season
Year
2001
2002
2003
2004
2005
2006

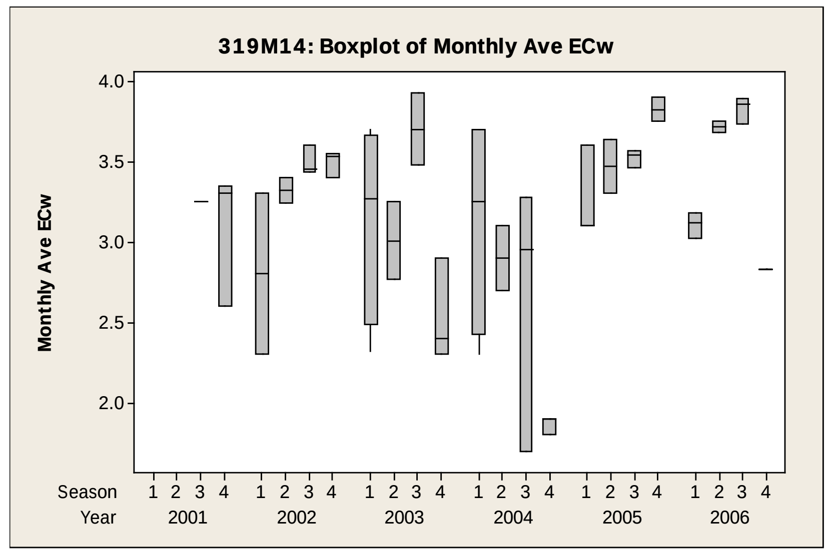

319M07: Boxplot of Monthly Ave ECw
Monthly Ave ECw
Season
Year
2001
2002
2003
2004
2005
2006

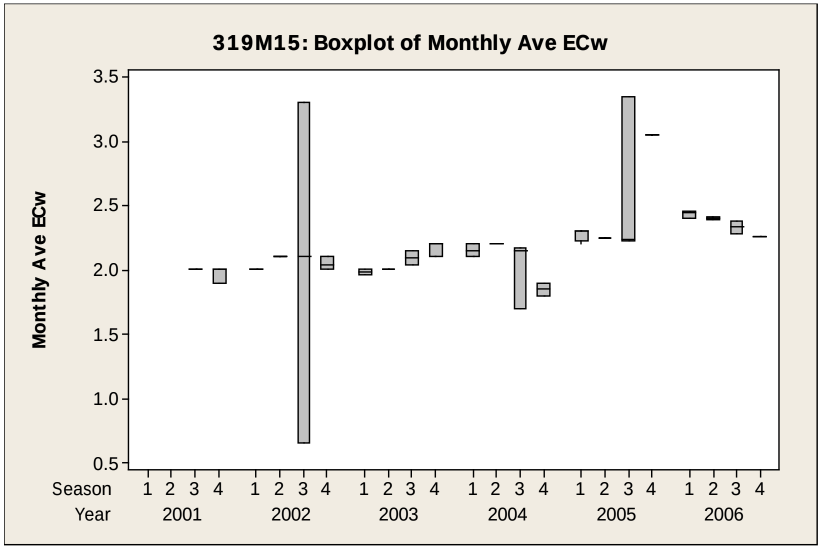

319M09: Boxplot of Monthly Ave ECw
Monthly Ave ECw
Season
Year
2001
2002
2003
2004
2005
2006


319M11: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1
2
3
4
5
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2001 2002 2003 2004 2005 2006

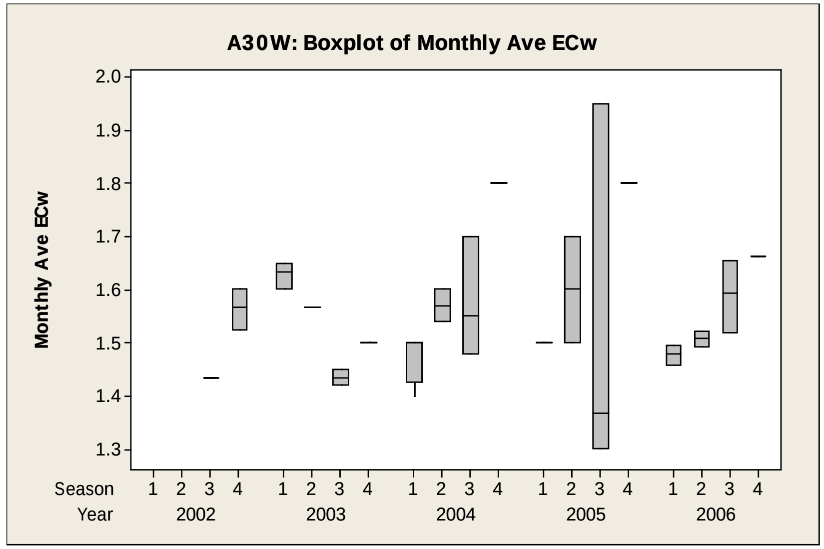

319M13: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2001 2002 2003 2004 2005 2006


319M12: Boxplot of Monthly Ave ECw
Monthly Ave ECw
1.0
1.5
2.0
2.5
3.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2001 2002 2003 2004 2005 2006

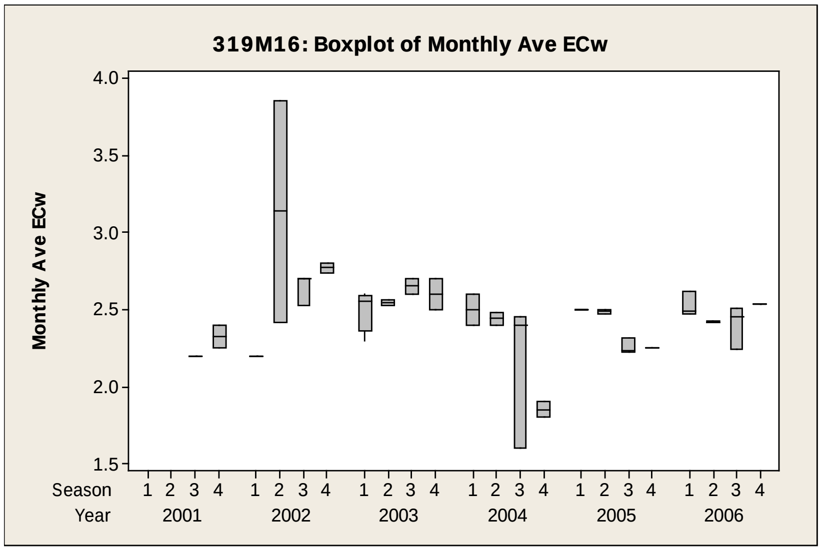

319M14: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.0
2.5
3.0
3.5
4.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2001 2002 2003 2004 2005 2006



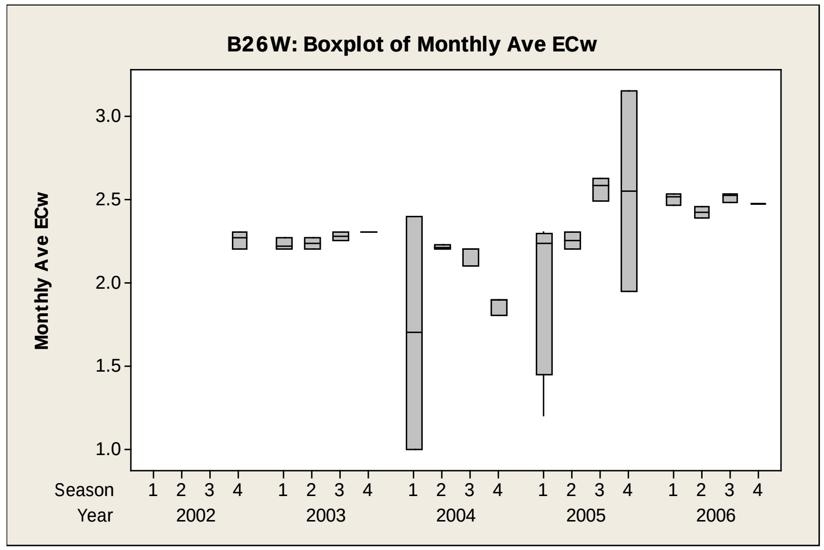
319M15: Boxplot of Monthly Ave ECw
Monthly Ave ECw
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2001 2002 2003 2004 2005 2006



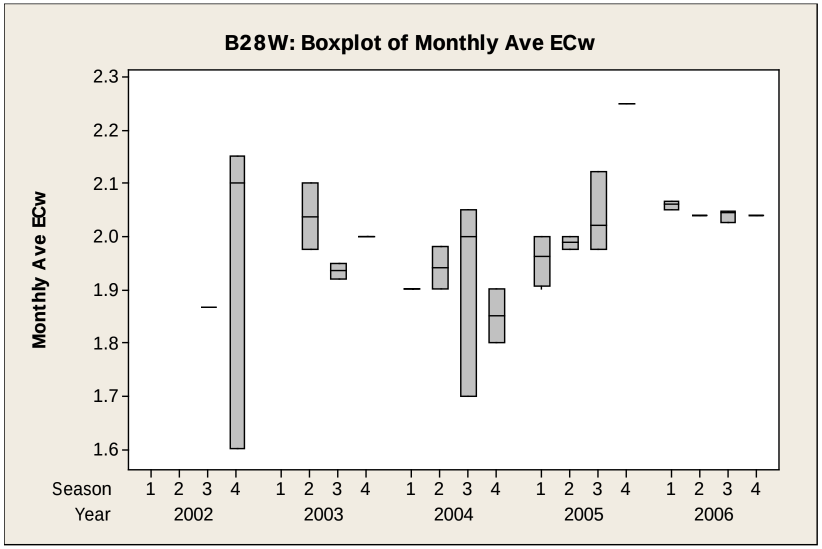
A30W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006

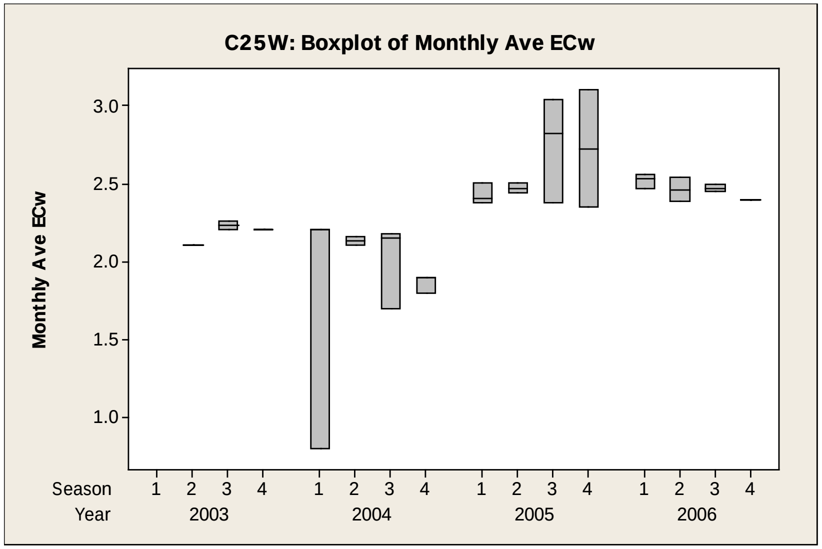


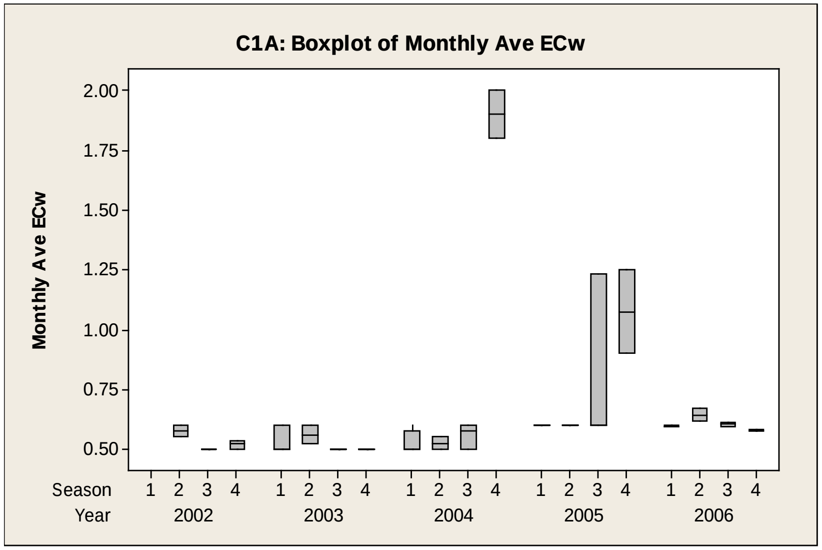
319M16: Boxplot of Monthly Ave ECw
Monthly Ave ECw
4.0
3.5
3.0
2.5
2.0
1.5
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2001 2002 2003 2004 2005 2006

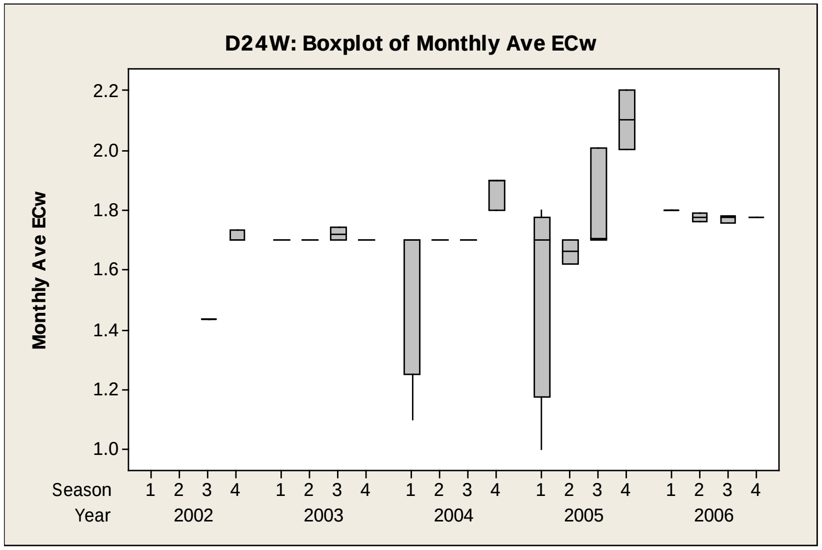


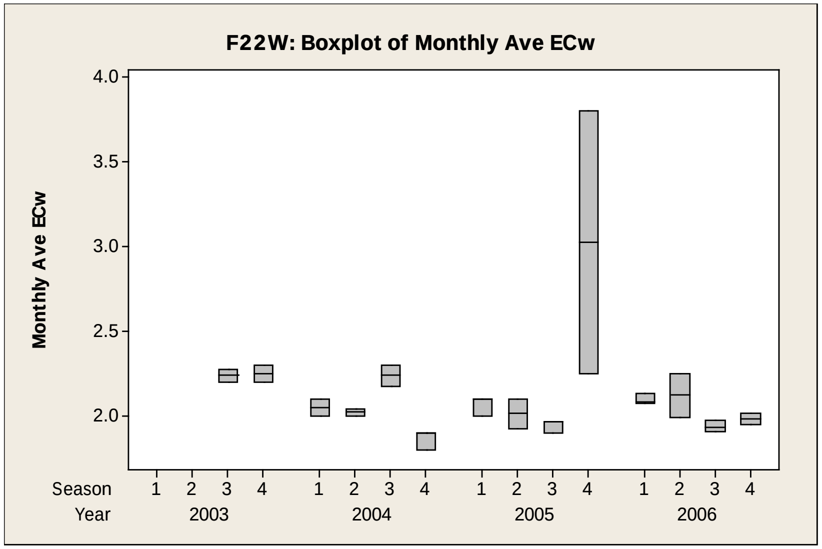
B26W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
3.0
2.5
2.0
1.5
1.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006

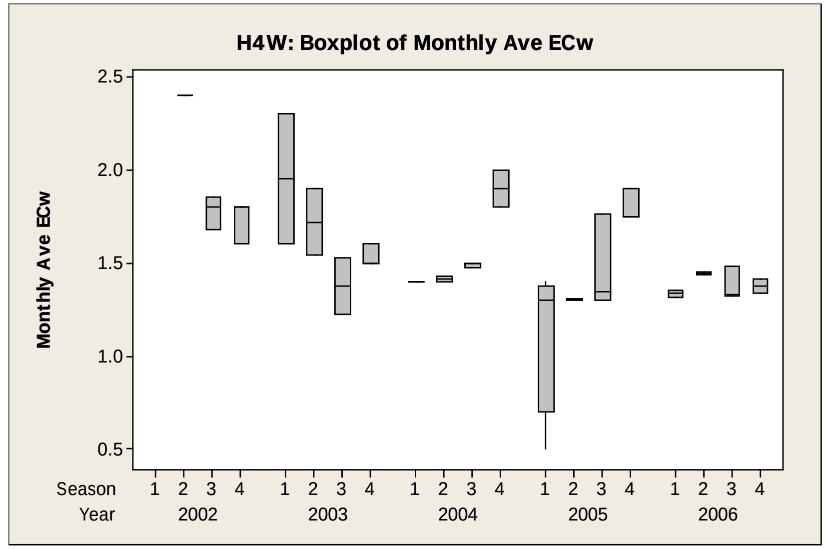

B28W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
Season
Year
2002
2003
2004
2005
2006

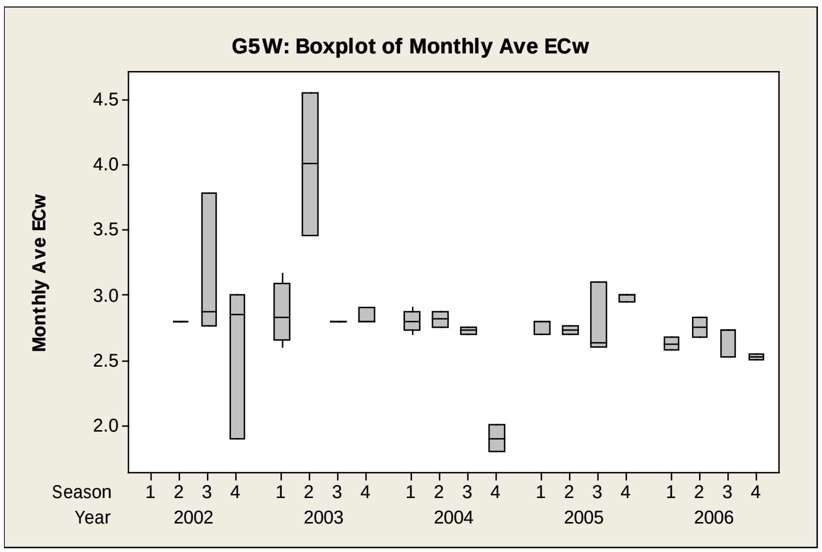

C25W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
Season
Year
2003
2004
2005
2006

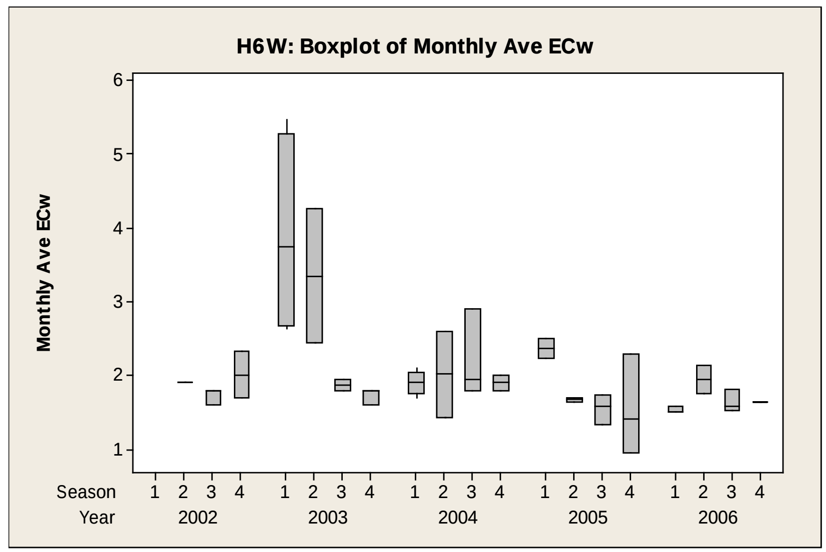

C1A: Boxplot of Monthly Ave ECw
Monthly Ave ECw
Season
Year
2002
2003
2004
2005
2006

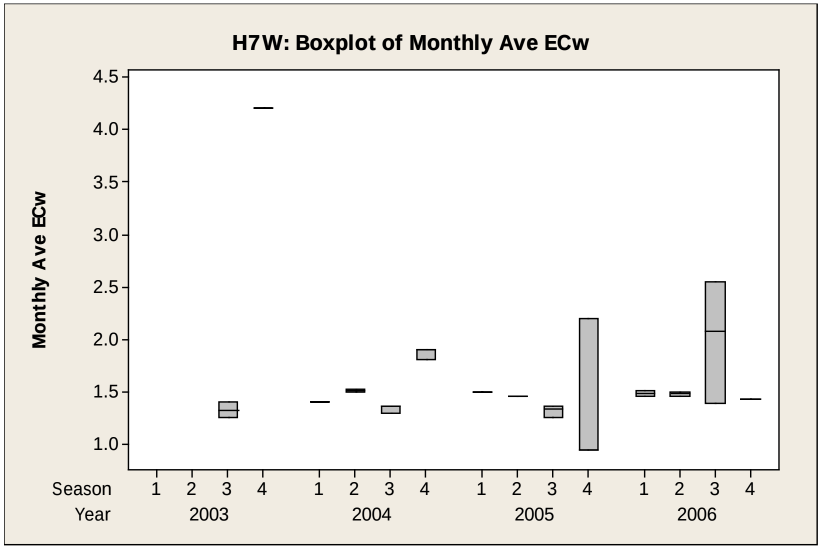

D24W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
Season
Year
2002
2003
2004
2005
2006

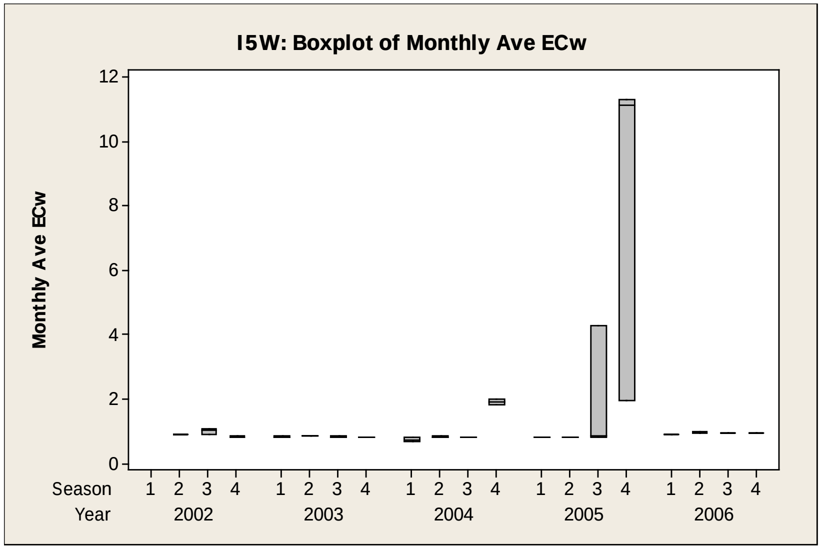

F22W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
4.0
3.5
3.0
2.5
2.0
Season
Year
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
2003
2004
2005
2006

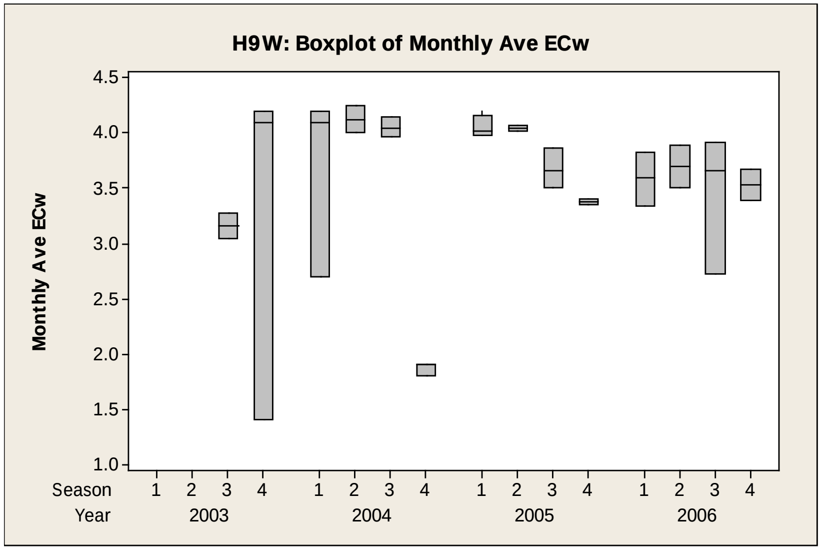

H4W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.5
2.0
1.5
1.0
0.5
Season
Year
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
2002
2003
2004
2005
2006

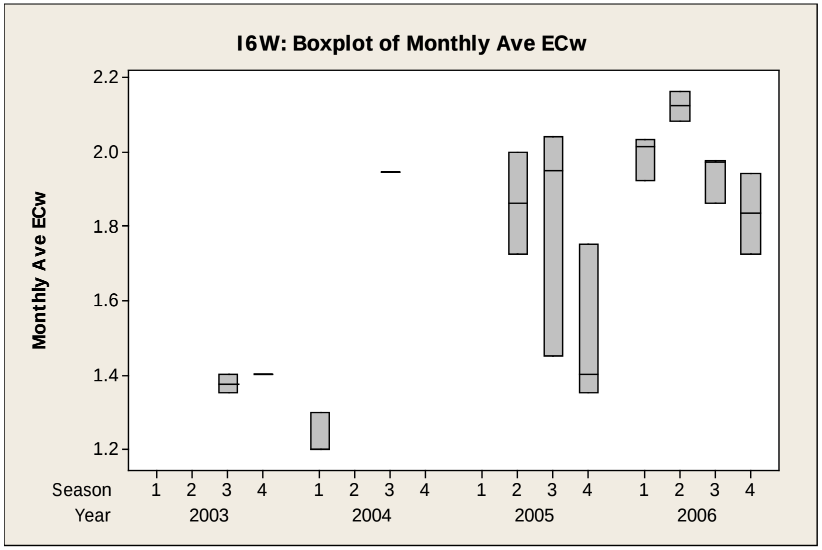

G5W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
4.5
4.0
3.5
3.0
2.5
2.0
Season
Year
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
2002
2003
2004
2005
2006

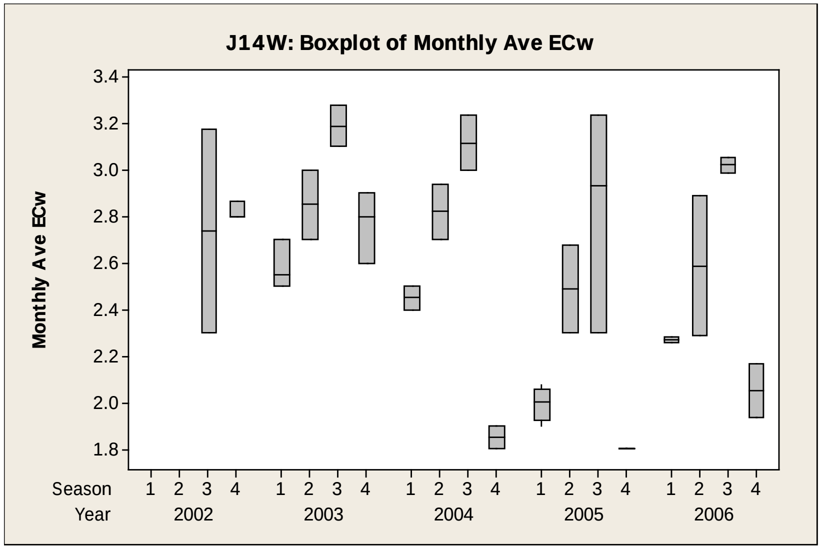

H6W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
6
5
4
3
2
1
Season
Year
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
2002
2003
2004
2005
2006

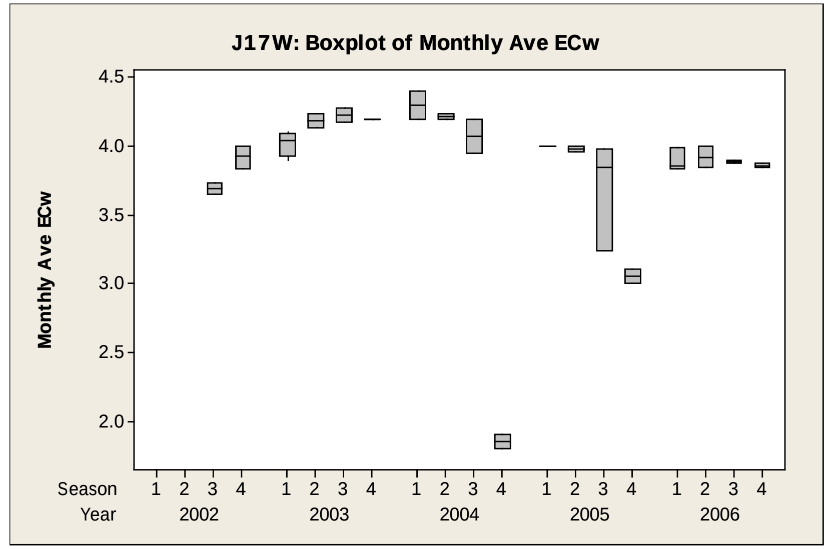

H7W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

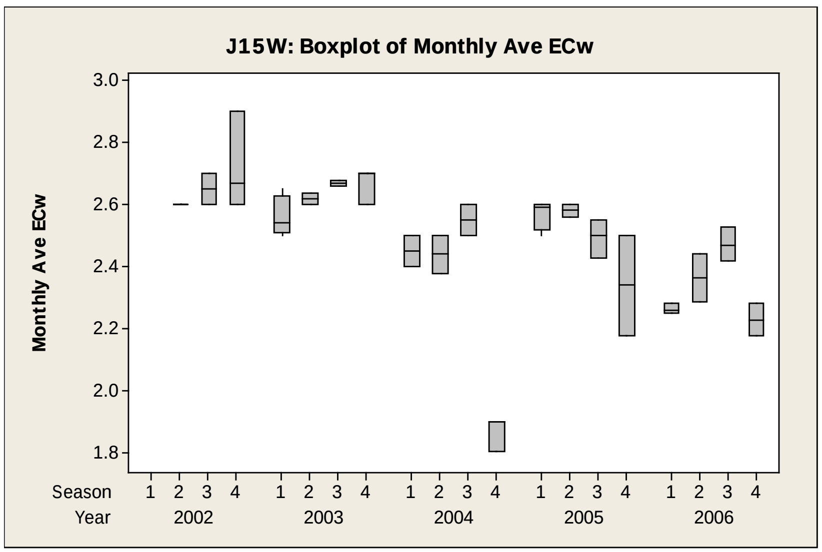

I5W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
12
10
8
6
4
2
0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006

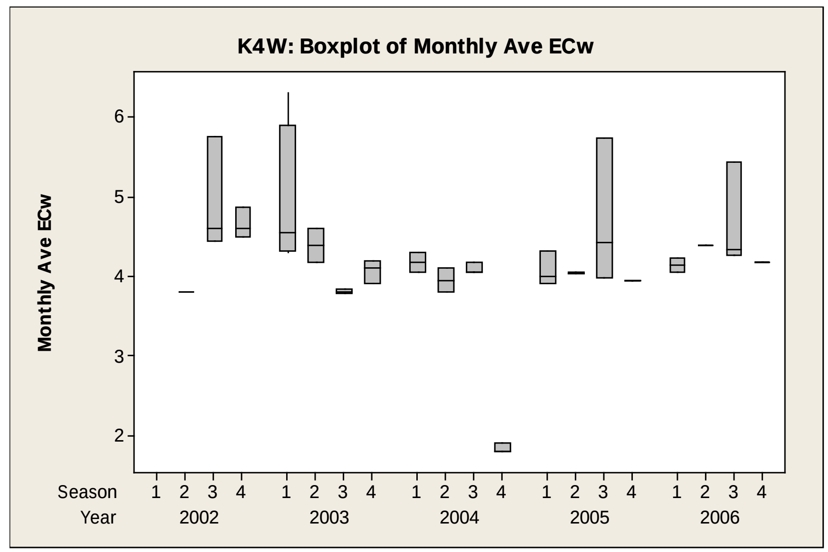

H9W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

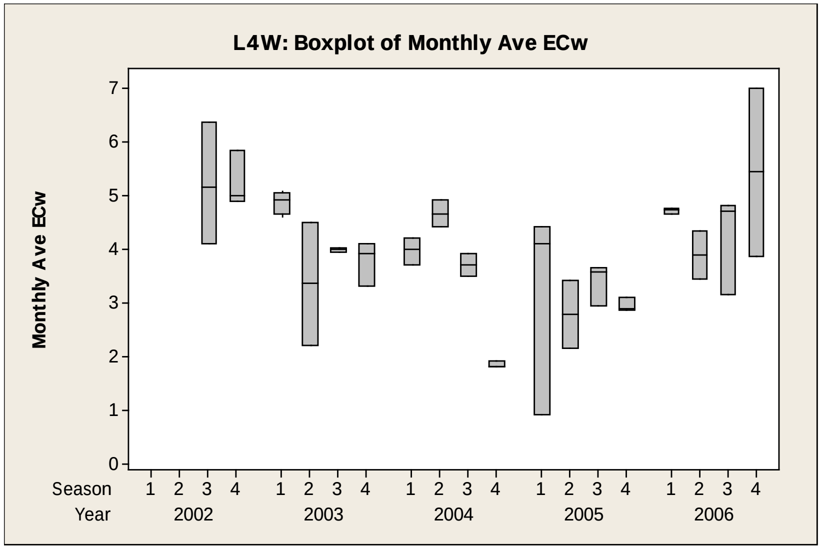

I6W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
2.2
2.0
1.8
1.6
1.4
1.2
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2003 2004 2005 2006

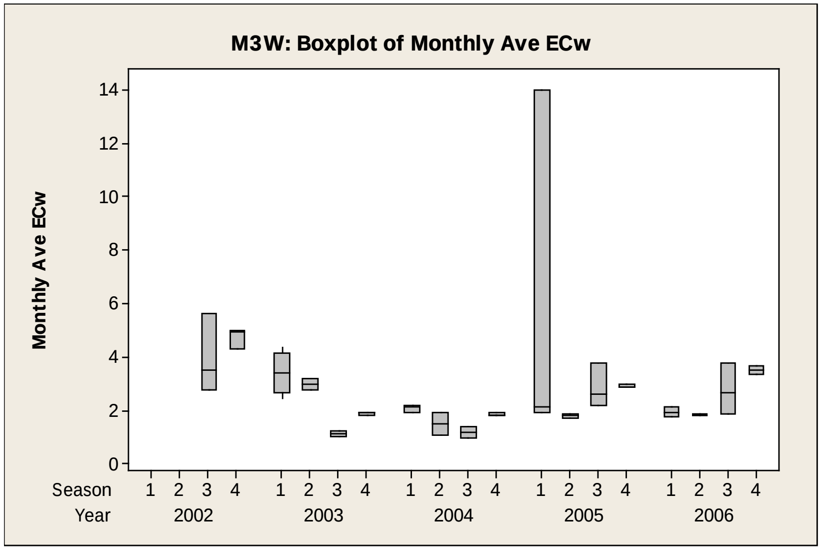

J14W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006


J17W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
4.5
4.0
3.5
3.0
2.5
2.0
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006


J15W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
3.0
2.8
2.6
2.4
2.2
2.0
1.8
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006


K4W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
6
5
4
3
2
Season 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Year 2002 2003 2004 2005 2006


L4W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
0
1
2
3
4
5
6
7
Season
Year
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
2002 2003 2004 2005 2006


M3W: Boxplot of Monthly Ave ECw
Monthly Ave ECw
0
2
4
6
8
10
12
14
Season
Year
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
2002 2003 2004 2005 2006