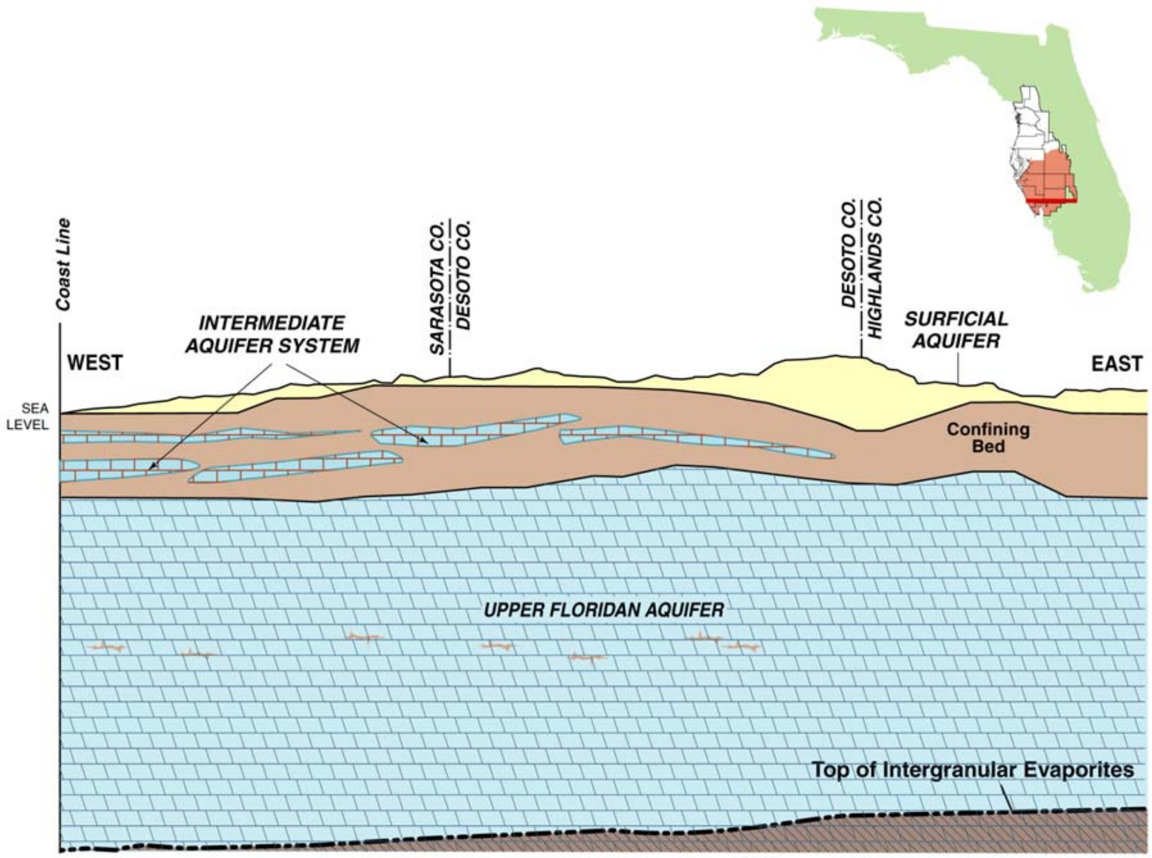
Assessment of Minimum Levels for the Intermediate Aquifer System in the Southwest Florida Water Management District



November 2005

Southwest Florida
Water Management District

Assessment of Minimum Levels for the Intermediate Aquifer System in the Southwest Florida Water Management District

A Southwest Florida Water Management District Technical Report

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November 2005

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The geological evaluation and interpretation contained in the report entitled *Assessment of Minimum Levels for the Intermediate Aquifer System in the Southwest Florida Water Management District* has been prepared by or approved by a Certified Professional Geologist in the State of Florida, in accordance with Chapter 492, Florida Statutes.

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Date: 11/15/2005

Executive Summary

The District has scheduled for adoption in 2005 minimum aquifer levels (MALs) for the intermediate aquifer system (IAS) where deemed technically feasible. The issue of technical feasibility centers on the regional extent and lateral continuity of the resource. The IAS was added to the Minimum Flow and Level (MFL) priority list due to concerns over declining aquifer levels and water quality deterioration in the coastal area of Manatee, Sarasota, and Charlotte counties. In addition, some domestic wells in Sarasota County were reported to have gone "dry" due to drought conditions and the cumulative effect of withdrawals from high densities of household wells.

The IAS lies between the surficial and Upper Floridan aquifers. Unlike the Floridan aquifer system, the IAS is comprised of thin, often discontinuous layers of limestone, dolomite, gravel, sandstone, or sand that make up individual permeable units that are interbedded within thick phosphatic clays. In descending order, the units of the IAS are described as follows: the uppermost producing zone of the IAS is Permeable Zone 1 (PZ 1), which consists primarily of thin limestone, dolomite, sand, and phosphatic gravel (Barr, 1996). Water level fluctuations in the aquifer closely follow those of the surficial aquifer and for that reason it has often been referred to as the "lower water table aquifer." The aquifer is of limited extent and has only been identified in coastal sections of southwest Manatee and Sarasota counties (Missimer and Associates, Inc. 2000). Due to its very low permeability, PZ 1 is used almost entirely for domestic supply.

Permeable Zone 2 (PZ 2) generally occurs within the Peace River Formation or upper parts of the Arcadia Formation within the Hawthorn Group and is comprised of discontinuous thin zones of limestone, sand, gravel, shell, and dolostone. PZ 2 appears to be the most geographically extensive zone within the IAS in that water-producing intervals can be defined in most of the Southern West-Central Florida Ground-Water Basin. The lateral continuity of the zone is problematic because the producing zones are thin, poorly productive, and imbedded within a clay matrix. Since the permeability is quite low, PZ 2 functions hydrologically as a localized aquifer. The PZ 2 unit is generally well-confined and there is little hydraulic connection between it and the overlying surficial aquifer (or PZ 1 where it exists) and the underlying lower zone of the IAS.

Permeable Zone 3 (PZ 3) is mostly composed of limestone interbedded with sand and clay that is represented by the Tampa Member or Nocatee Member of the Hawthorn Group or undifferentiated Arcadia Formation. Beginning in central Manatee and southern Polk counties, the base of the Tampa or Nocatee Member becomes mixed with clayey sand or sandy clay which forms the semi-confining bed between the PZ 3 unit and the Upper Floridan aquifer. PZ 3 is more permeable than the upper units of the IAS and it appears to be in moderate-to-good hydraulic connection with the Floridan aquifer.

Many questions regarding impacts to the IAS and water availability were addressed in the report entitled *Investigation of Water Use from the Intermediate Aquifer System in Sarasota County* (Missimer and Associates, Inc., 2000). In that study, co-funded by the District and Sarasota County, the consultant examined the issue of "dry" wells and concluded that impacts had occurred to less than one percent of existing wells. Most of the impacted wells were older, two-or-three inch diameter wells that had limited lift-capacity through the use of centrifugal pumps. The study also examined water level and water quality trends in all zones of the IAS and concluded that while there had been localized lowering of aquifer levels of up to 10 feet, on a regional basis water quality and water levels were stable.

In this report, the IAS has been reexamined across the entire Southern Water Use Caution Area (SWUCA). The District's conclusions have confirmed those earlier findings. While ground-water withdrawals have led to localized water-level declines in the upper and lower zones of the IAS, there is little evidence to suggest either regional lowering of water levels or that serious degradation has occurred to aquifer water quality or natural systems. The low permeability and often-discontinuous producing zones within the IAS inhibit widespread or regional impacts to the system.

The main issue regarding groundwater withdrawals from the IAS is local or sub-regional lowering of water levels due to the cumulative effect of mostly high-density domestic wells. There are over 28,000 domestic self-supply and home irrigation wells in Sarasota County west of Interstate 75. In the past, production-related problems have occurred in portions of the coastal zone due to the cumulative impacts from these wells during drought conditions. These problems have historically been resolved by replacing older, smaller diameter wells with lift-type pumps with four-inch diameter wells with submersible pumps. In addition, public assistance efforts by Sarasota County have reduced or lessened the impact on affected users through the formation of a county-wide rapid response team to investigate complaints, importation of water tankers to affected areas, and drought-related lawn watering restrictions. Over the long-term, the County's program of adding connections to public supply utilities and the elimination of permits to construct two and three-inch diameter water supply wells have continued to make significant contributions toward management of this issue. In Sarasota County, which currently has the highest density of domestic wells used for water supply, there were no production related complaints recorded during 2003, 2004, and through September 2005.

The establishment of minimum levels by the District has traditionally been for the protection of natural systems and to ensure sustainability of the resource by reducing the rate of regional saltwater intrusion. Because of the very localized nature of permeable zones within the IAS, there is little evidence to suggest that withdrawals from this system will lead to widespread degradation in aquifer water quality and natural systems or that imminent water supply problems will occur in any part of the SWUCA. In addition, because the individual permeable zones are thin, discontinuous, and imbedded within thick clays, the setting of minimum aquifer levels would be difficult to implement or enforce given the local variability of the system. Based on this information, District staff does not recommend establishing minimum aquifer levels in the IAS.

To minimize any future concern over water supply, it is recommended that the District, Sarasota County, and other local governments develop an IAS management plan that includes: 1) analyzing and monitoring changes in aquifer water levels and water quality through additional data collection and installation of monitor wells, 2) the development of a countywide IAS real-time monitoring system, 3) continued recording of well complaints, 4) increased water conservation, and 5) expansion of reuse water for irrigation. The management plan would be developed within the framework of the IAS Technical Advisory Committee (TAC) which is a cooperative effort between the District and Sarasota County that examines water use issues within the county. The TAC includes representatives from the District, Sarasota County, local governments, utilities, and private consultants. It is also recommended that the District re-evaluate the water resources of the IAS at five-year intervals within the framework of the regional water supply plan to continually monitor and update forecasting of future impacts to the system.

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1.0 INTRODUCTION

The District has scheduled for adoption in 2005 minimum aquifer levels (MALs) for the intermediate aquifer system (IAS) where deemed technically feasible. The IAS was added to the Minimum Flows and Levels (MFLs) priority list due to concerns over declining aquifer levels and water quality deterioration in the coastal area of Manatee, Sarasota, and Charlotte counties. In addition, some domestic wells in Sarasota County were reported to have gone "dry" due to drought conditions and the cumulative effect of withdrawals from high densities of household wells.

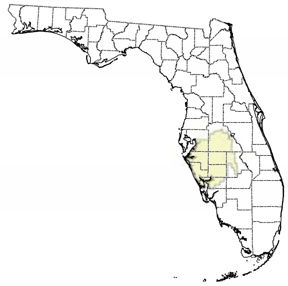
Many questions about the impacts to the IAS and water availability were addressed in the report entitled *Investigation of Water Use from the Intermediate Aquifer System in Sarasota County* (Missimer and Associates, Inc., 2000). In that study, co-funded by the District and Sarasota County, the consultant examined the issue of "dry" wells and concluded that impacts had occurred to less than one percent of existing wells. Most of the impacted wells were older, two-or-three inch diameter wells that had limited lift-capacity through the use of centrifugal pumps. The consultant also examined water level and water quality trends in all zones of the IAS and concluded that while there had been localized lowering of aquifer levels of up to 10 feet, on a regional scale, water quality and water levels were stable in the IAS.

This paper will again examine the water resources of the IAS, expanding the area from Sarasota County to the entire southern half of the District (Figure 1). The geology and hydraulics of the IAS will be discussed along with an examination of aquifer levels and water quality trends, followed by water use history and future demand projections out to the year 2025. The final chapter will summarize the state of the water resources and water availability and also provide a recommendation as to whether or not to establish minimum levels for the IAS.

1.1 MFL History at the District

Due to prolonged environmental impacts to wetlands and lakes from decades of groundwater withdrawals, the Florida Legislature amended Section 373.02 Florida Statutes (FS) in 1996 and 1997 to require the District to establish MFLs for the Northern Tampa Bay area. In October 1998, the District's Governing Board approved 41 minimum wetland levels, 15 minimum levels for lakes, and Floridan aquifer levels for seawater intrusion in the Northern Tampa Bay area. These levels were defined as the level of an aquifer or surface water body below which significant harm occurs to the water resources of the area.

The legislation also directed District staff to establish MFLs using the best available information without the requirement to collect additional data. In addition, policy considerations such as determining the role of structural alterations to a water body, clarifying the definition of "water resources of the area," and where to actually set the level (in a wetland or lake versus the aquifer below it) were largely resolved through an iterative process.



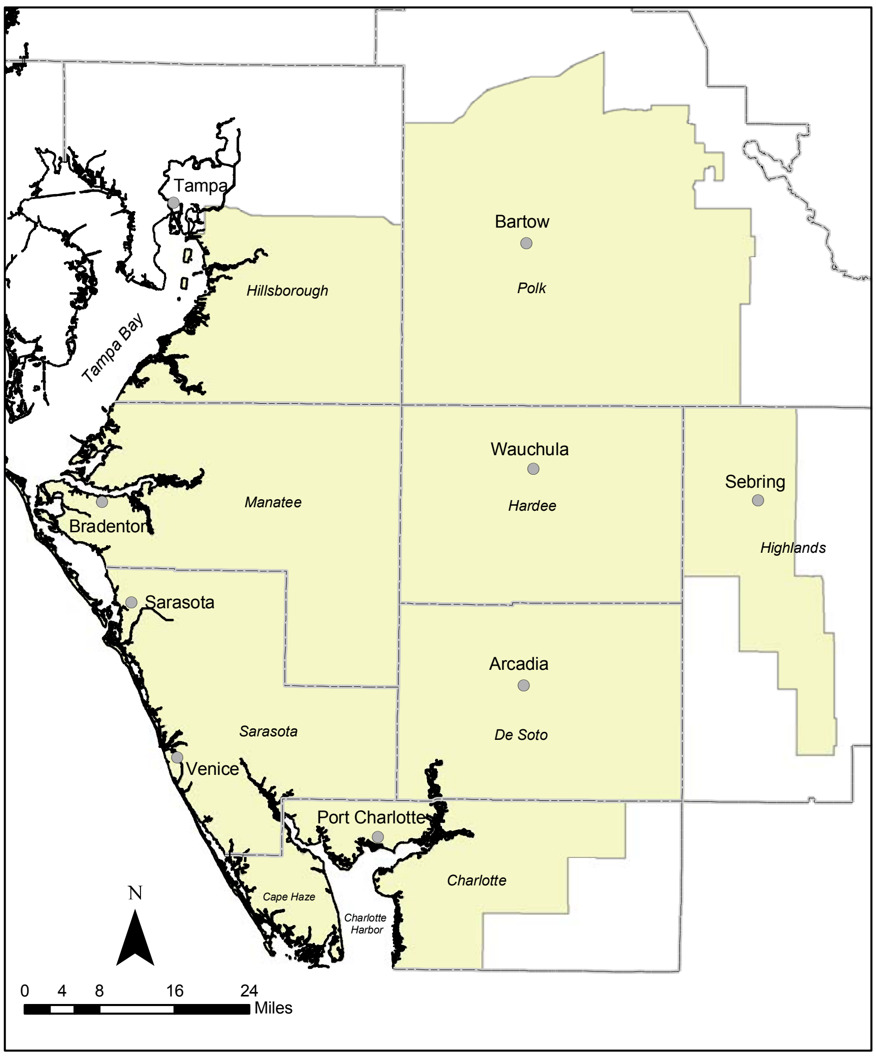


Figure 1. Location of the Southern Water Use Caution Area and the approximate extent of the IAS within the Southwest Florida Water Management District.

In the southern half of the District, the threat of saltwater intrusion due to declining groundwater levels prompted establishment of the Eastern Tampa Bay Water Use Caution Area (ETB WUCA) in 1989. In 1990, a "Most Impacted Area" was designated along the coastal margin of the ETB WUCA where no increases in permitted withdrawals were allowed from the Upper Floridan aquifer. The purpose for this designation was to stabilize long-term water level declines in the Floridan aquifer. In 1992, out of concern for the water resources of the entire groundwater basin, the District established the Southern Water Use Caution Area (SWUCA) which encompasses 5,100 square miles from Interstate 4 to the southern extent of the District. In 1993, a water resource assessment study of the Eastern Tampa Bay WUCA concluded that regional saltwater intrusion was occurring due to long-term decline in the potentiometric surface of the Upper Floridan aquifer (SWFWMD, 1993).

Based on the conclusions of the water resource assessment, the District proposed a minimum aquifer level for the Upper Floridan aquifer over the entire SWUCA as a long-term management strategy to significantly decrease regional saltwater intrusion. Though this level was determined to be scientifically valid during a subsequent administrative hearing on the proposed rules, the level was withdrawn following the invalidation of other parts of the rule.

In 2002, the District concluded additional research and modeling which refined the expected loss in the water supply due to regional saltwater intrusion over the next 50 years. Based on this effort, the District proposed a second minimum aquifer level for the Upper Floridan aquifer over the principle area of concern, namely the "Most Impacted Area" (MIA) of the SWUCA. The goal of these levels would be to limit the rate of regional saltwater intrusion. A 10-year average of Floridan aquifer water levels (1990-1999) from a series of monitor wells within the MIA was established to achieve the management strategy of not allowing saltwater intrusion to increase beyond current rates of movement (SWFWMD, 2002).

1.2 Minimum Aquifer Levels for the IAS

Chapter 373 Florida Statutes requires each water management district to annually update and submit a schedule for establishing MFLs for priority water bodies. Priority water bodies are those that could potentially experience significant harm. The District, where deemed technically feasible, has scheduled for adoption minimum aquifer levels (MALs) for the IAS in 2005. The issue of technical feasibility for the IAS centers on the regional extent and continuity of the resource. Unlike the Floridan aquifer system, the IAS is comprised of thin, often discontinuous layers of limestone, dolomite, gravels, sandstone, or sand that make up individual producing zones that are interbedded within thick phosphatic clays. The lateral continuity of these individual zones is highly uncertain, therefore it may not be technically appropriate to establish minimum aquifer levels for this localized system.

The process of establishing a minimum aquifer level begins with identification of a resource problem, developing cause and effect relationships, and determining the consequences of different courses of action. Once an understanding of the problem has been developed, a decision is made on what is an acceptable level of impact. This report will provide the basis for understanding the nature of the resource, extent of any resource problems, and recommendations regarding the need to develop minimum aquifer levels for the IAS. While this report provides technical information and recommendations on management of the resource, the District's Governing Board will make the ultimate decision on whether or not to set minimum aquifer levels for the IAS.

2.0 PHYSICAL SYSTEM

2.1 Previous Investigations

The earliest investigation of the IAS involved test drilling in Sarasota County by Sutcliffe and Joyner (1968). This early examination was followed by studies focusing on Charlotte County (Sutcliffe,1975) and the Myakka River Basin (Joyner and Sutcliffe, 1976). Each of these investigators identified water-producing zones of variable yield and water quality in Sarasota and Charlotte counties. Later reports by Sutcliffe and Thompson (1983), Wolansky (1983), Gilboy (1985), Duerr and others (1988), Duerr and Enos (1991), Hutchinson (1992), Broska and Knochenmus (1996), Barr (1996), Knochenmus and Bowman (1998), and Torres and others (2001) helped further refine the hydrostratigraphic nature of water producing zones and their regional extent within west-central Florida.

The first partitioning and naming of water-bearing zones was developed by Sutcliffe and Joyner (1968). They identified five artesian zones (1-5) with producing zones 1 and 2 included as part of the IAS. Zones 3-5 were part of the Floridan aquifer system. Wolansky (1983) divided the IAS into two major aquifers: the lower Tamiami/upper Hawthorn and the lower Hawthorn/upper Tampa. Later, Barr (1996) refined all previous work by identifying three permeable zones, PZ 1, PZ 2, and PZ 3 in Sarasota County. Barr's PZ 2 was essentially Wolansky's lower Tamiami/upper Hawthorn aquifer and his PZ 3 was the lower Hawthorn/upper Tampa aquifer. Barr's PZ 1 corresponded to Sutcliffe and Joyner's Artesian Zone 1, which consists of shell, sand, and limestone beds within the Tamiami Formation above the Venice Clay.

2.2 General Hydrogeology of the Southern West-Central Florida Ground-Water Basin

The IAS is located within the Southern West-Central Florida Ground-Water Basin (SWCFGWB) described by SWFWMD (1988). In general, the geology of this area consists of a series of clastic sediments underlain by carbonate rocks (Table 1). There are three recognized aquifer systems. At the surface and extending up to several tens of feet thick is the unconfined surficial aquifer system (SAS). It is generally comprised of unconsolidated quartz sand, silt, and clayey sand. Underlying the SAS is the confined intermediate aquifer system (IAS), which consists of a series of thin, interbedded limestone, sand, sandstone, shell, and phosphatic clays of typically low permeability. The third aquifer system, which underlies the IAS, is the confined Floridan Aquifer System (FAS). It is composed of a series of limestone and dolomite formations. The location of two hydrostratigraphic cross-sections depicting the subsurface flow system is shown in Figure 2. Individual cross-sections are illustrated in Figures 3 and 4.

The FAS is divided into the Upper Floridan and Lower Floridan aquifers which are separated by a middle confining unit consisting of a thick, massive sequence of evaporite materials of extremely low permeability (Miller, 1986). The Lower Floridan aquifer is comprised of interbedded dolomite and anhydrite that is hydraulically isolated from the Upper Floridan aquifer. It is generally low in permeability and brine-saturated. Because of it's poor water quality, deep depth, and limited ability to yield water, the Lower Floridan aquifer has only been used for disposal of industrial waste through deep well injection in the SWCFGWB. However, it is a source of potable water in east-central Florida outside the SWCFGWB.

Table 1. Hydrogeology of the SWCFGWB (modified from Miller,1986, Barr, 1996, and Tihansky and others, 1996).

<table>
<tr><th>Series</th><th colspan="3">Stratigraphic Unit</th><th colspan="2">Hydrogeologic Unit</th><th>Lithology</th></tr>
<tr><td rowspan="2">Holocene to Pliocene</td><td colspan="3" rowspan="2">Undifferentiated Surficial Deposits</td><td>Surficial Aquifer</td><td rowspan="2">Surficial Aquifer System</td><td rowspan="2">Sand, silty sand, clayey sand, peat, and shell</td></tr>
<tr><td rowspan="2">PZ 1</td></tr>
<tr><td rowspan="7">Miocene</td><td rowspan="7">Hawthorn Group</td><td colspan="2" rowspan="3">Bone Valley Member
Peace River Formation</td><td rowspan="8">Intermediate Aquifer System</td><td rowspan="5">Predominantly phosphatic clay, gray to green to brown, plastic, ductile, minor sand, phosphatic gravel, residual limestone and dolostone</td></tr>
<tr><td>Confining Unit</td></tr>
<tr><td rowspan="2">PZ 2</td></tr>
<tr><td colspan="2" rowspan="2">Arcadia Formation</td></tr>
<tr><td>Confining Unit</td></tr>
<tr><td rowspan="3"></td><td rowspan="3">Tampa or Nocatee Member</td><td>PZ 3</td><td rowspan="3">Limestone, gray to tan, sandy, soft, clayey, minor sand, phosphatic. Chert found locally</td></tr>
<tr><td rowspan="2">Confining Unit</td></tr>
<tr><td rowspan="2">Oligocene</td><td></td></tr>
<tr><td colspan="3">Suwannee Limestone</td><td>Upper Permeable Zone</td><td rowspan="3">Upper Floridan Aquifer</td><td>Limestone,cream to tan, sandy, vuggy, fossiliferous</td></tr>
<tr><td rowspan="3">Eocene</td><td colspan="3">Ocala Limestone</td><td>Semi-Confining Unit</td><td>Limestone,white to tan, friable to micritic, fine-grained, soft, abundant foraminifera</td></tr>
<tr><td colspan="3" rowspan="2">Avon Park Formation</td><td>Lower Permeable Zone</td><td rowspan="2">Limestone and dolomite. Limestone is tan, recrystallized. Dolomite is brown, fractured, sucrosic, hard. Peat found locally at top. Interstitial gypsum in lower part.</td></tr>
<tr><td colspan="2">Middle Confining Unit</td></tr>
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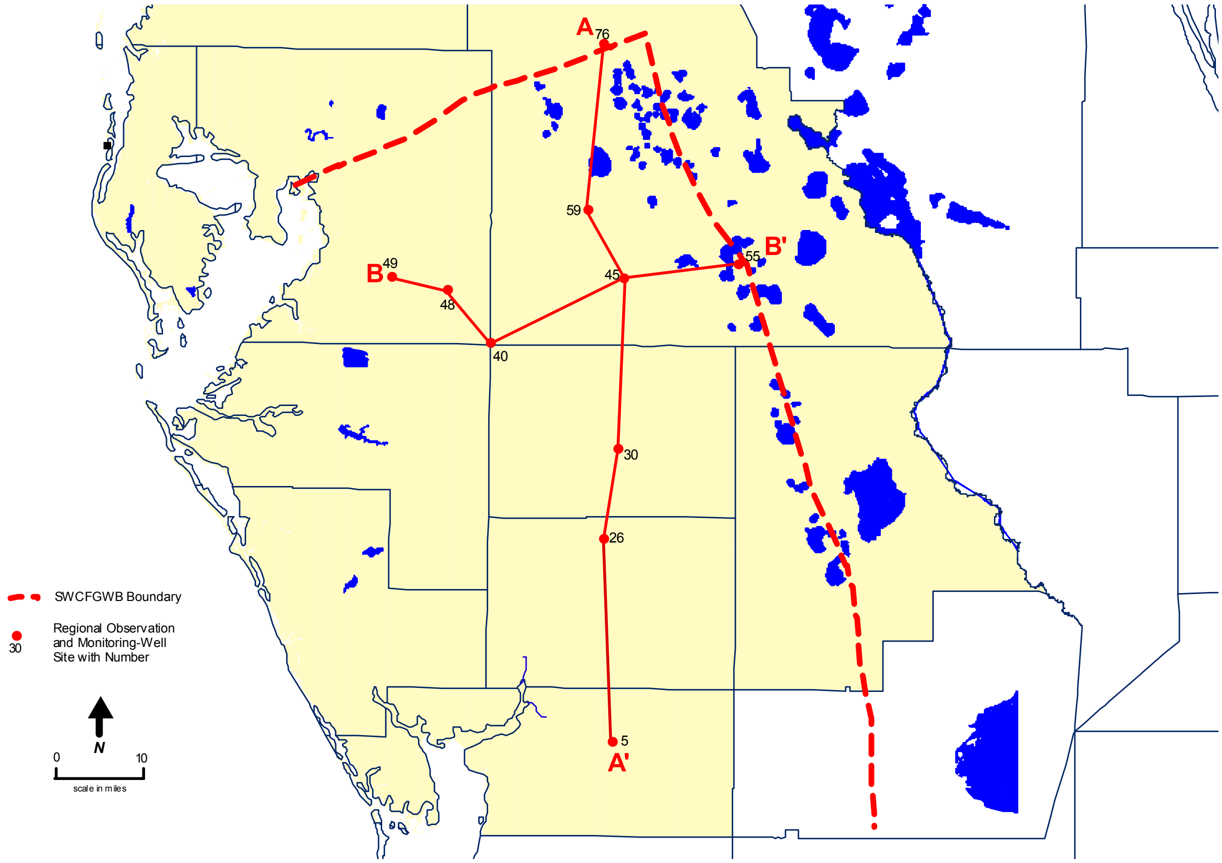

Figure 2. Location of hydrostratigraphic cross-sections A-A' and B- B'.

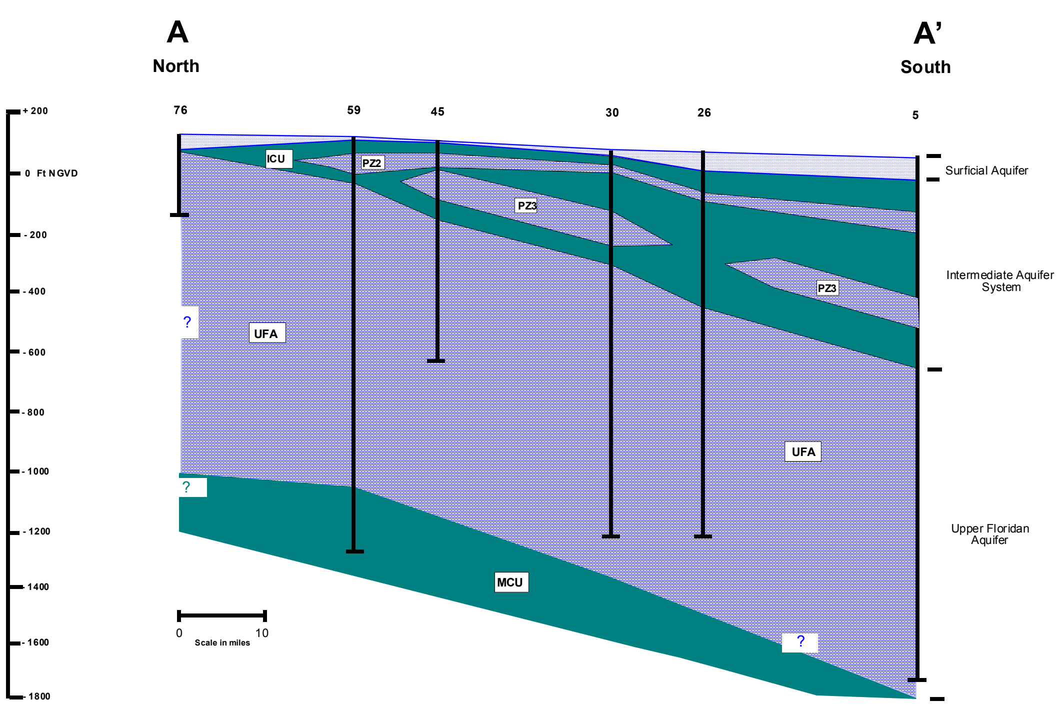

Figure 3. Hydrostratigraphic cross-section A-A'.

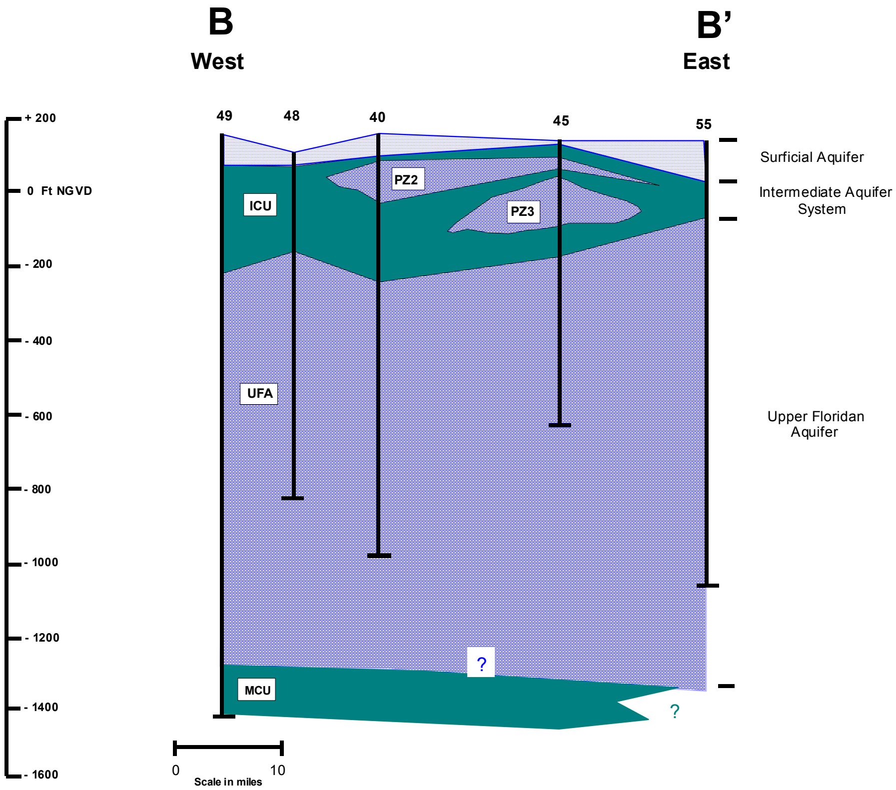

Figure 4. Hydrostratigraphic cross-section B-B'.

2.3 IAS Hydrogeology and Water-Bearing Zones

The lateral continuity and water-bearing potential of the various zones within the IAS are highly variable due to a mixture of shell, sand, gravel, dolomite, and thin limestone beds that are interbedded within a clay matrix. This heterogeneous sequence often leads to low permeability of the water bearing zones and complicates mapping the lateral extent of each zone. Basso (2002) reported hydraulic conductivities for the upper zone (PZ 2) indicative of a semi-confining bed of less than one foot per day (ft/day) in Manatee and Hardee counties. Even the more laterally extensive, mostly carbonate PZ 3 contained an average hydraulic conductivity of nine ft/day (Basso, 2002). This is roughly equivalent to unconfined surficial sand aquifer permeabilities in west-central Florida. A discussion of each water-bearing zone within the IAS follows:

<u>PZ 1 Unit</u>

The uppermost producing zone of the IAS is Permeable Zone 1 (PZ 1), which consists primarily of thin limestone, dolomite, sand, and phosphatic gravel (Barr, 1996). PZ 1 is of limited extent and is discontinuous over portions of coastal Manatee and Sarasota Counties (Figure 5). Where present, PZ 1 always overlies the Venice Clay. Water level fluctuations in the aquifer closely follow those of the surficial aquifer and for that reason it has often been referred to as the "lower water table aquifer" (Missimer and Associates, Inc., 2000).

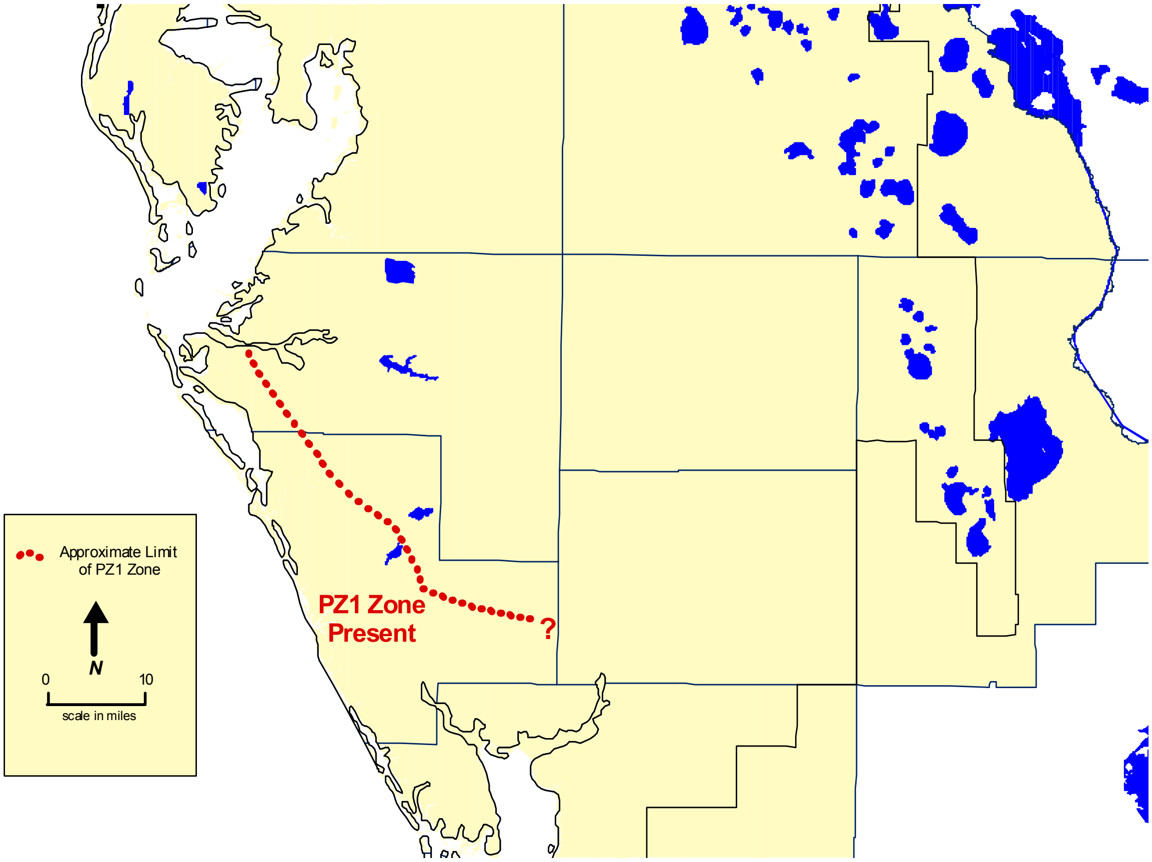

Figure 5. Location of PZ 1 (Missimer and Associates, Inc., 2000).

PZ 2 Unit

Permeable Zone 2 (PZ 2) generally occurs within the Peace River Formation or upper parts of the Arcadia Formation within the Hawthorn Group and is comprised of discontinuous thin zones of limestone, sand, gravel, shell, and dolostone. The upper portion may be located stratigraphically within the phosphate-rich Bone Valley member of the Peace River Formation in Polk County. The elevation of the top of PZ 2 is shown in Figure 6. The unit was defined and mapped based on whether a monitor well was completed into the zone in the District's Regional Observation and Monitoring-Well Program (ROMP) network. PZ 2 could exist locally outside the boundary shown in Figures 6 and 7. PZ 2 appears to be the most geographically extensive zone within the IAS in that water-producing intervals can be defined in most of the Southern West-Central Florida Ground-Water Basin. However, the lateral continuity of the zone is problematic because the producing zones are thin, poorly productive, and imbedded within a clay matrix. Since the permeability is quite low, PZ 2 may function hydrologically as a localized aquifer. The median thickness based on 22 sites within the SWCFGWB is 57 feet. Thickness of the PZ 2 unit is illustrated in Figure 7.

PZ 3 Unit

Permeable Zone 3 (PZ 3) is mostly composed of limestone interbedded with sand and clay that is represented by the Tampa Member or Nocatee Member of the Hawthorn Group or undifferentiated Arcadia Formation. It is generally the most productive aquifer within the IAS. Beginning in central Manatee and southern Polk counties, the base of the Tampa or Nocatee Member becomes mixed with clayey sand or sandy clay which forms the semi-confining bed between PZ 3 and the Upper Floridan aquifer. North of this location, it appears that the Tampa or Nocatee Member is largely carbonate throughout its entire sequence and is in direct hydraulic connection with the Upper Floridan aquifer. The PZ 3 unit thickens and dips toward the southwest (Figures 8 and 9). The median thickness based on 18 sites within the SWCFGWB is 131 feet.

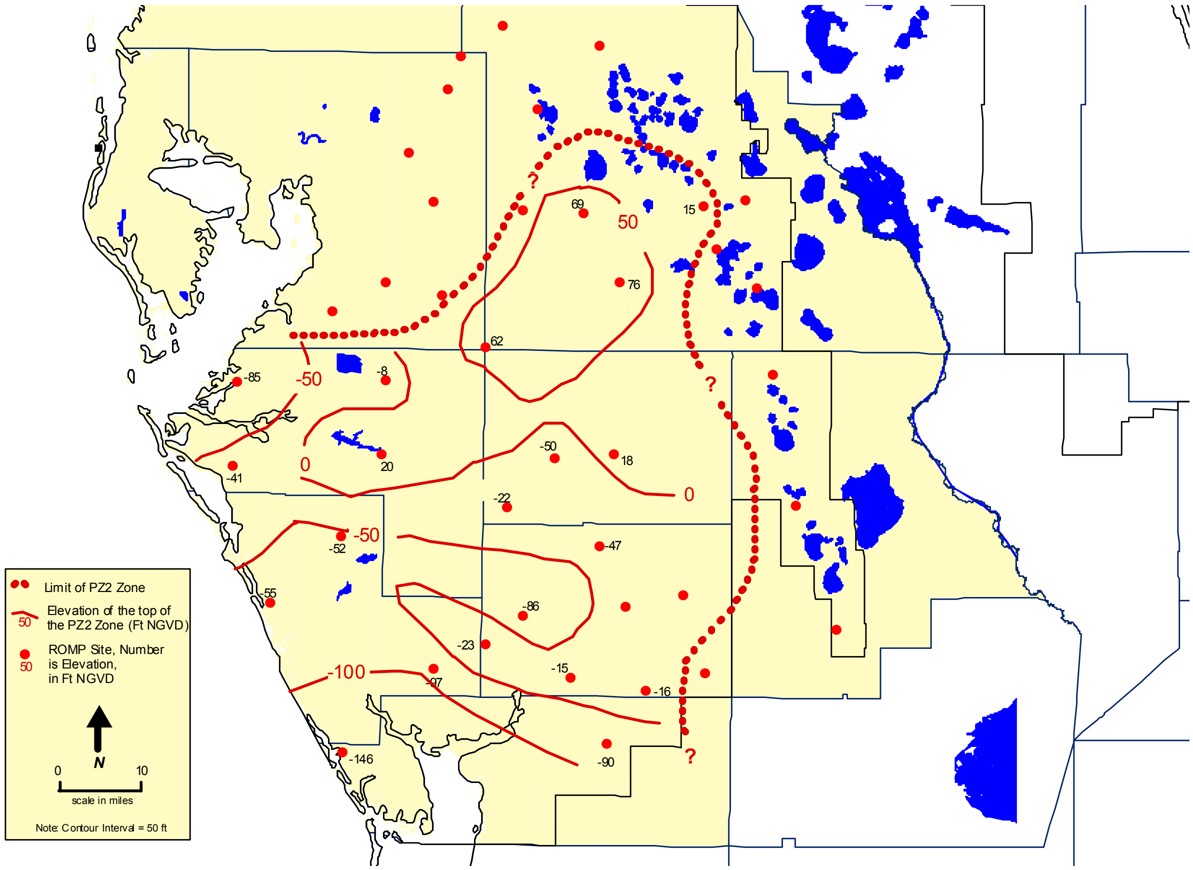

Figure 6. Elevation of the top of the IAS PZ 2.

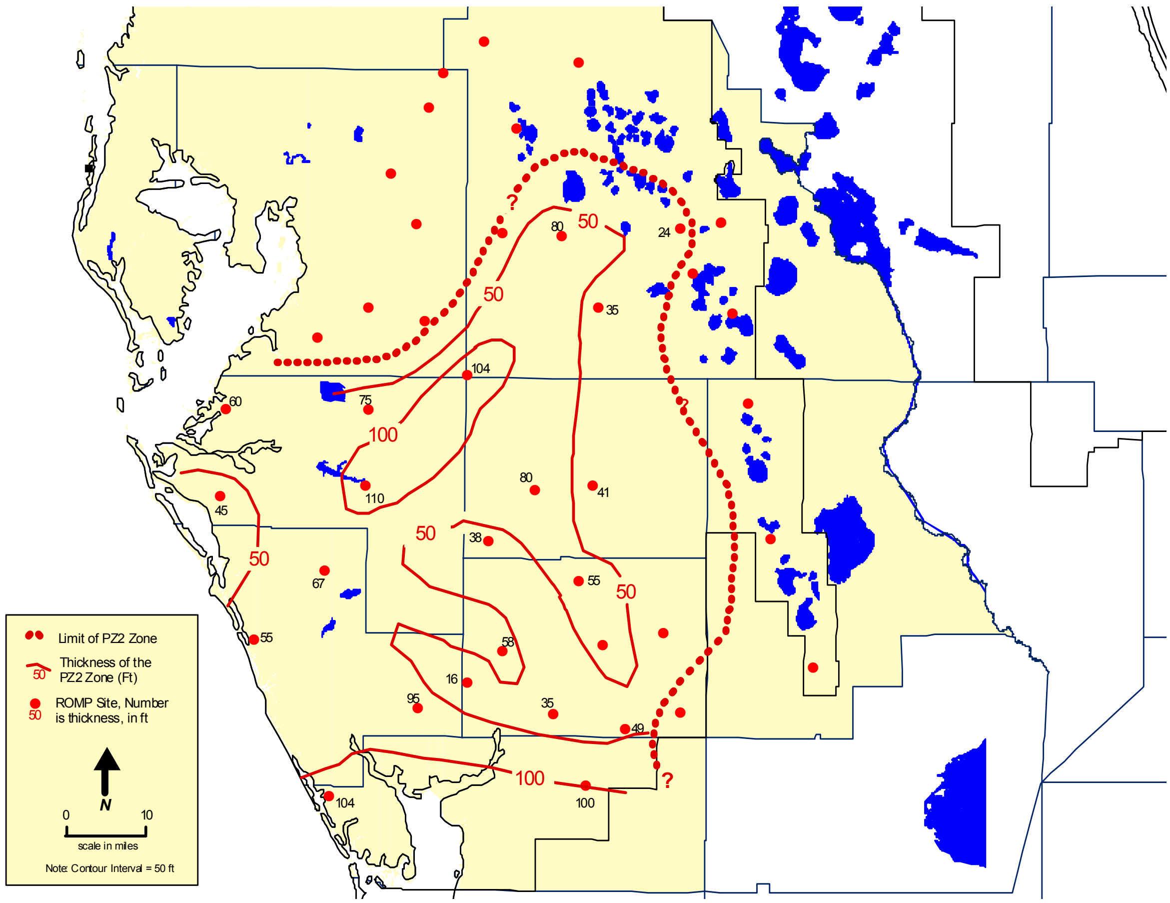

Figure 7. Thickness of IAS PZ 2.

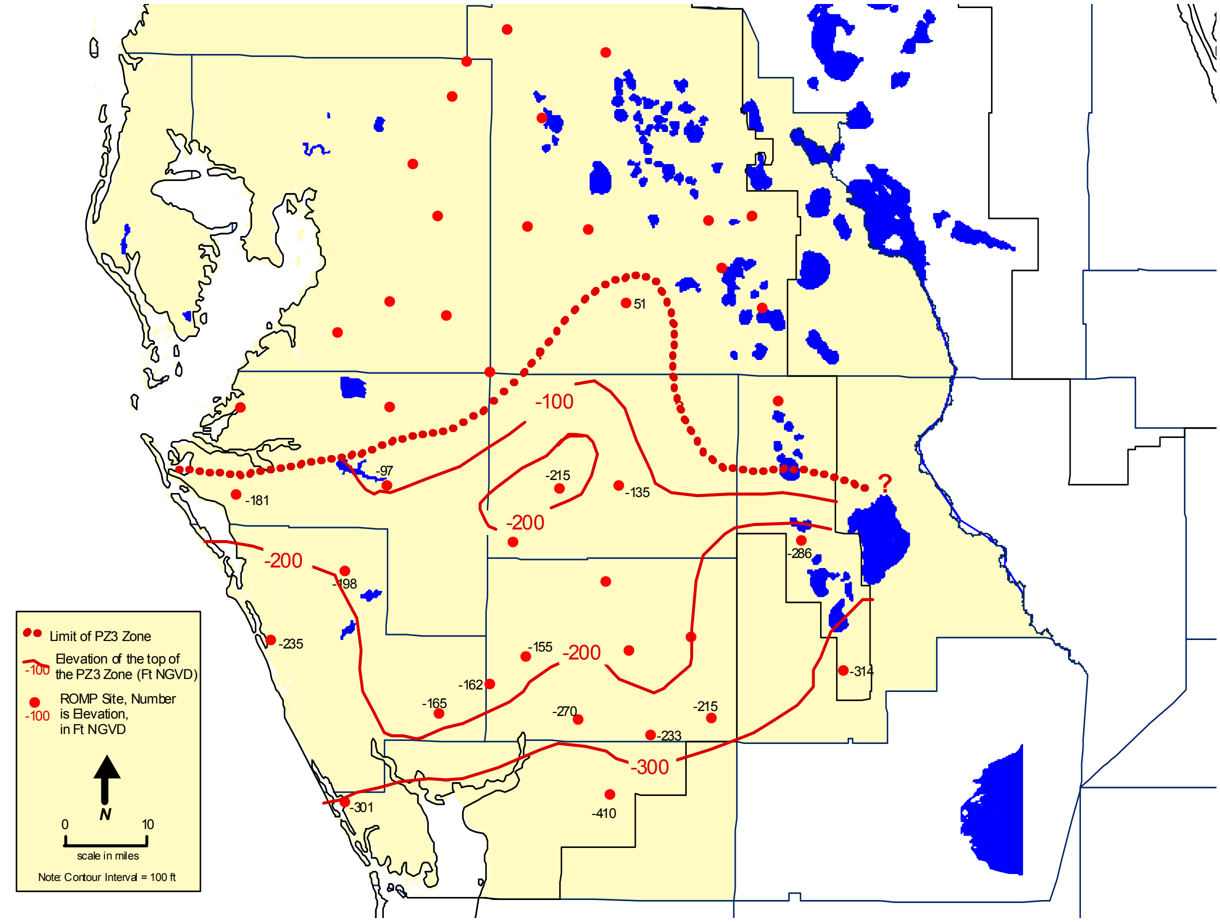

Figure 8. Elevation of the top of the IAS PZ 3.

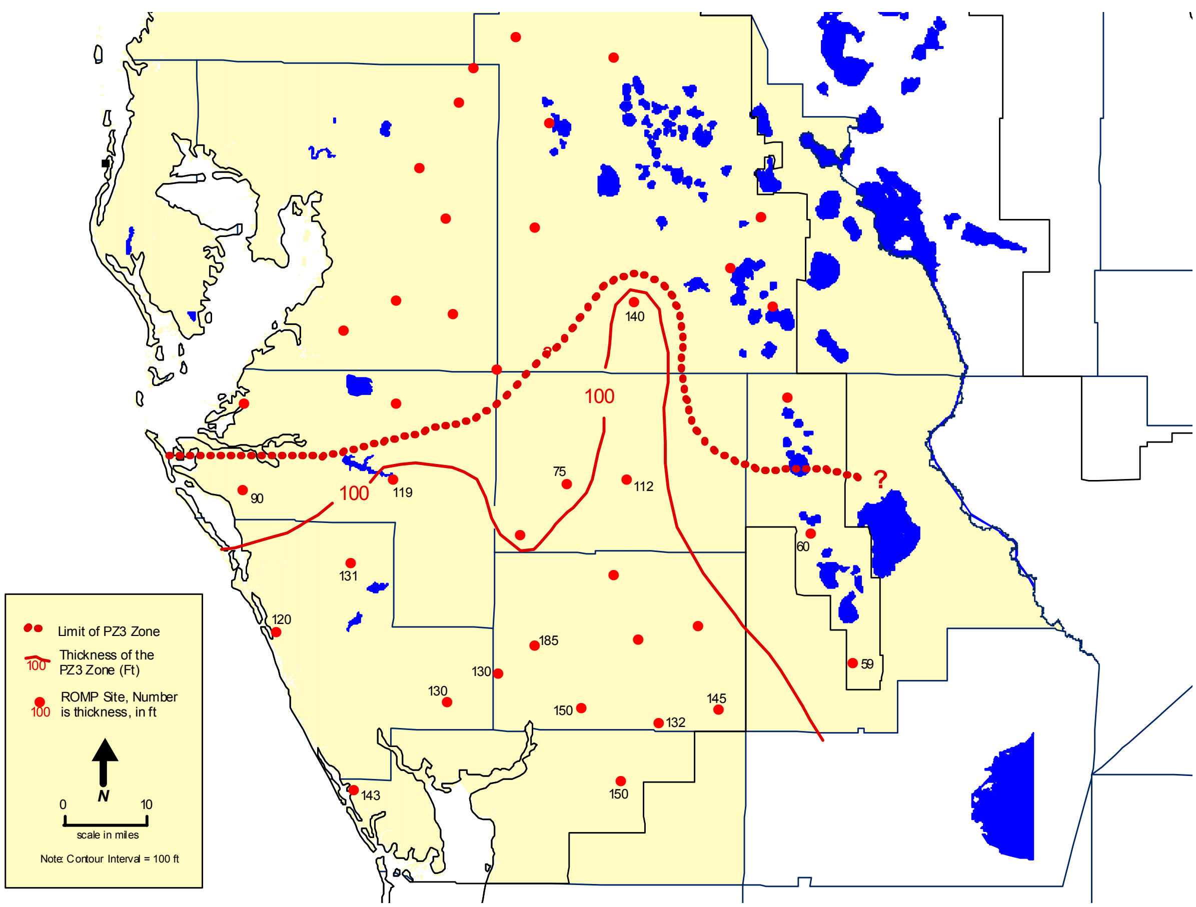

Figure 9. Thickness of IAS PZ 3.

2.4 Hydraulics

Data on the hydraulic properties of the IAS in the SWCFGWB varies considerably because of the highly variable nature of the lithology. For the most part, the ability of the IAS to yield water is low, with hydraulic conductivity values 10 to 100 times less than the underlying Upper Floridan aquifer. Transmissivity of the permeable units is generally less than 13,000 ft^2/day. Due to lithologic heterogeneity, it can vary considerably over short distances (Yobbi, 1996).

The permeability of PZ 1 is very low (two feet/day) based on aquifer tests in Sarasota County (Table 2). This zone is mostly used for household well supply. Horizontal hydraulic conductivity of PZ 2 varied by more than three orders of magnitude (0.01 to 112 ft/day), which illustrates its high degree of lithologic heterogeneity across the SWCFGWB (Table 2). At both ROMP 25 in southwest Hardee County and ROMP TR7-2 in southwest Manatee County, hydraulic conductivity values of PZ 2 were indicative of a semi-confining unit at less than 0.1 ft/day. At Osprey in northern Sarasota County, the hydraulic conductivity of PZ 2 was 36 ft/day and transmissivity reached 1,800 ft^2/day from a 50-foot interval. Typically, PZ 3 is the most permeable of all IAS zones because it is generally twice the thickness of PZ 2. PZ 3 hydraulic conductivity values ranged from 0.03 to 326 ft/day with a median value of 10 ft/d from 12 tests.

In general, the confining units in the IAS have very low hydraulic conductivity values and retard the movement of water between the overlying surficial and underlying Upper Floridan aquifer; though the confining units can allow water to leak from one aquifer to another depending upon hydraulic gradients and permeability of the confining material. Generally, the hydraulic connection between the surface and PZ 2 is low. One exception is PZ 1, where lithologic logs from sites TR4-1 and Romp 9 in Sarasota County indicate little confinement above this zone separating it from the SAS. Under these circumstances, PZ 1 may actually be part of the surficial aquifer system. The median leakance coefficient between the SAS and PZ 2 of the IAS based on numerical analysis of 10 aquifer performance tests (APTs) within the SWCFGWB was 5.9×10^{-5} ft/day/ft (Yobbi and Halford, written communication, 2005). Leakage across the upper intermediate confining bed was estimated at one inch per year or less from 10 of 12 sites in the SWCFGWB (Yobbi and Halford, written communication, 2005).

The hydraulic connection between PZ 2 and PZ 3 of the IAS is low based on existing data. The median leakance coefficient between the upper and lower zones of the IAS based on numerical analysis of 11 aquifer performance tests within the SWCFGWB was 2×10^{-5} ft/day/ft (Yobbi and Halford, written communication, 2005). Leakage across the middle intermediate confining bed was estimated at 1.5 inches per year or less from 8 of 10 sites in the SWCFGWB (Yobbi and Halford, written communication, 2005).

Head differences between aquifers and similar response in water levels can infer the relative degree of the hydraulic connection between the units. The District has installed cluster wells, which monitor discrete vertical horizons in each aquifer system at several locations in the study area (Figure 10). Water levels at six representative sites, ROMP Nos. TR4-1, 9.5, 26, 33, 40, and 45, are shown in Figures 11-16. Based upon review of the hydrographs, it appears that PZ 3 and the Upper Floridan aquifer exhibit moderate-to-good hydraulic connection. In contrast, large head differences between the surficial aquifer and the Upper Floridan aquifer seem to indicate relatively low hydraulic connection and tight confinement separating the systems.

2.5 Regional Continuity of the IAS

PZ 1 of the IAS is only found locally in parts of Manatee and Sarasota Counties. PZ 2, however, is the most regionally extensive within the SWCFGWB. It can generally be defined from extreme southern Hillsborough County to central Polk County and southward along the eastern boundary of Hardee and DeSoto counties (Figures 6 and 7). East of this location, along the Lake Wales Ridge, PZ 2 is more clayey and becomes part of the Intermediate Confining Unit. Even though the PZ 2

Table 2. Summary of transmissivity, thickness, and hydraulic conductivity of PZ 1, PZ 2, and PZ 3 based on SWFWMD aquifer tests within the SWCFGWB (Location of sites in Appendix A).

SWFWMD ROMP No.	County	PZ 1 Transmissivity (ft2/day)	Thickness (ft)	Hydraulic Conductivity (ft/day)
9	Sarasota	47	27	2
TR4-1	Sarasota	107	49	2
SWFWMD ROMP No.	**County**	**PZ 2 Transmissivity (ft2/day)**	**Thickness (ft)**	**Hydraulic Conductivity (ft/day)**
5	Charlotte	1,390	100	14
9	Sarasota	246	41	6
12	De Soto	5,500	49	112
20	Sarasota	1,800	50	36
25	Hardee	0.5	38	0.01
TR4-1	Sarasota	1,270	103	12
TR7-2	Manatee	0.6	45	0.01
	Median:	1,270	50	12
	Mean:	1,460	66	26
SWFWMD ROMP No.	**County**	**PZ 3 Transmissivity (ft2/day)**	**Thickness (ft)**	**Hydraulic Conductivity (ft/day)**
5	Charlotte	2,970	150	20
9	Sarasota	708	130	5
9.5	De Soto	10,900	130	84
12	De Soto	43,000	132	326
13	De Soto	766	82	9
14	Highlands	30	59	0.5
20	Sarasota	1,500	120	13
22	Sarasota	120	131	0.9
28	Highlands	162	60	3
TR4-1	Sarasota	3,840	365	11
TR7-2	Manatee	3	90	0.03
TR7-4	Manatee	2,600	150	17
	Median:	1,130	130	10
	Mean:	5,550	133	41

Sources: Gates (1997), Thompson (1997), Torres and others (2001), Clayton (1999a), Baldini (1999), Clayton (1999b), DeWitt and Thompson (1997), Thompson (1997), Gates (2000), DeWitt (written comm., 2003), Thompson and others (2000), Rappuhn (1995), and ROMP TR7-4 File.

unit can be defined as far north as Hillsborough and Polk counties, aquifer performance tests conducted by the District and others indicate that the "water-bearing zone" is more aquitard than aquifer in parts of Hillsborough, Manatee, and Hardee Counties. Hydraulic conductivity values of less than one ft/day are more indicative of a semi-confining unit than any significant water bearing zone.

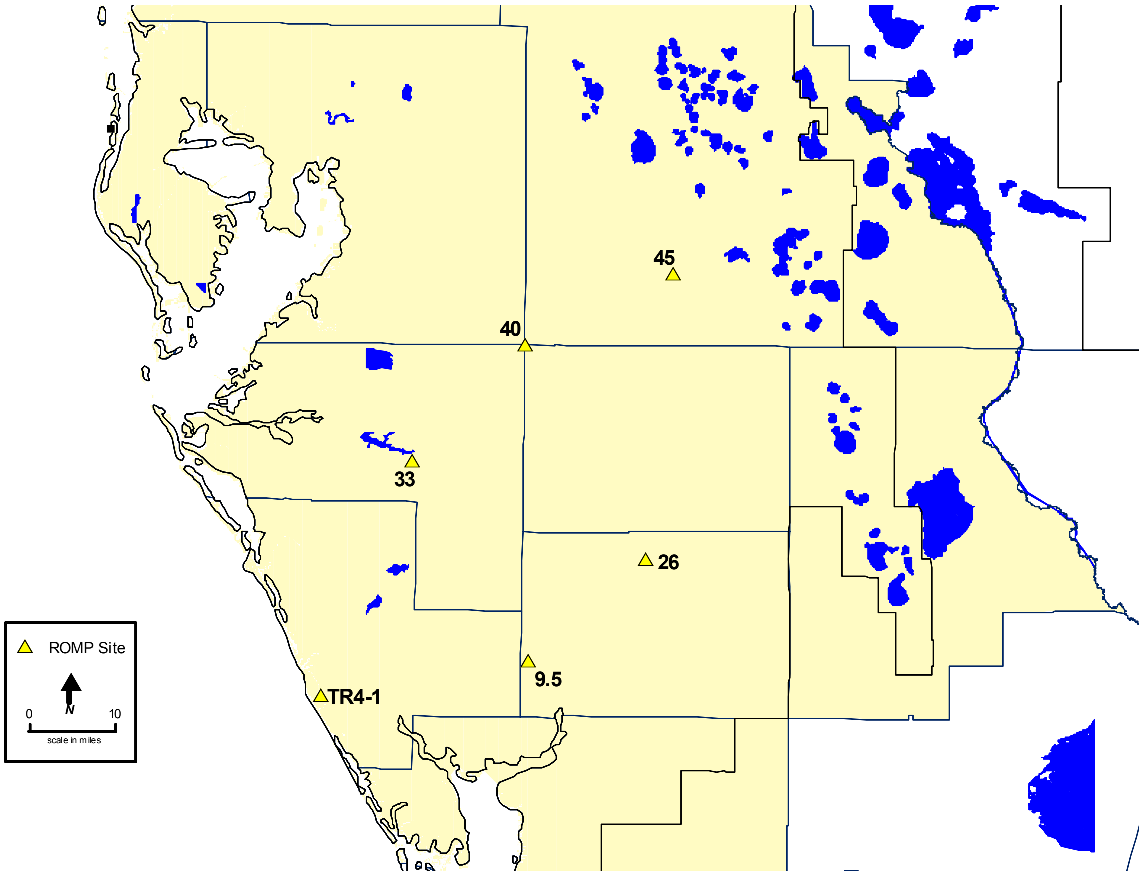

Figure 10. Location of selected ROMP well nests.

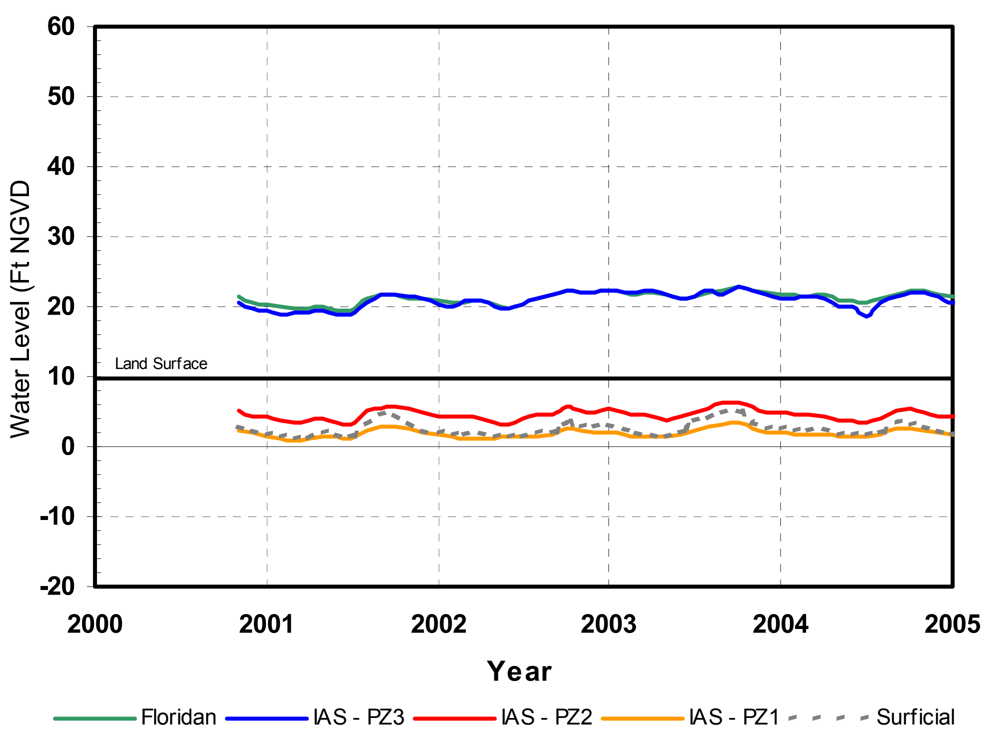

Figure 11. Water levels in the surficial aquifer, IAS, and Upper Floridan aquifer at ROMP TR4-1.

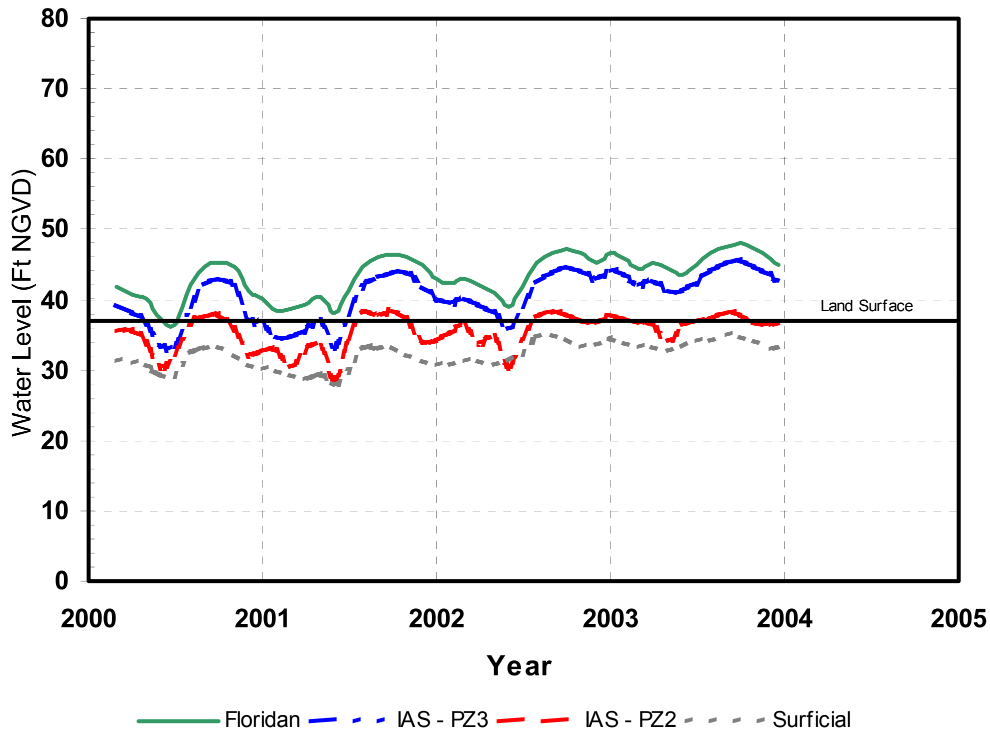

Figure 12. Water levels in the surficial aquifer, IAS, and Upper Floridan aquifer at ROMP 9.5.

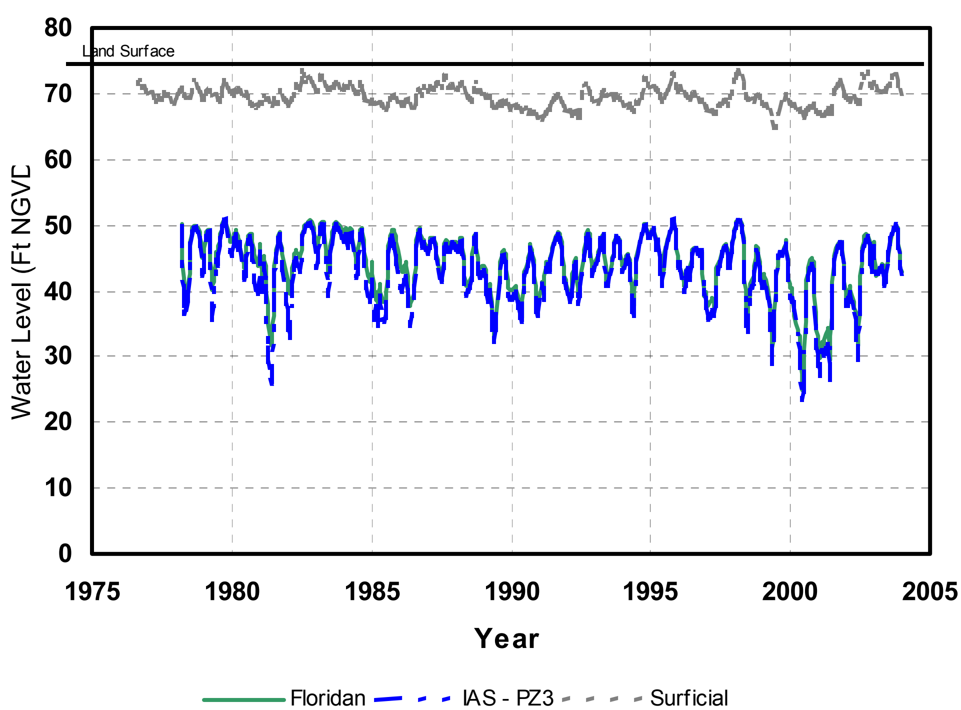

Figure 13. Water levels in the surficial aquifer, IAS, and Upper Floridan aquifer at ROMP 26.

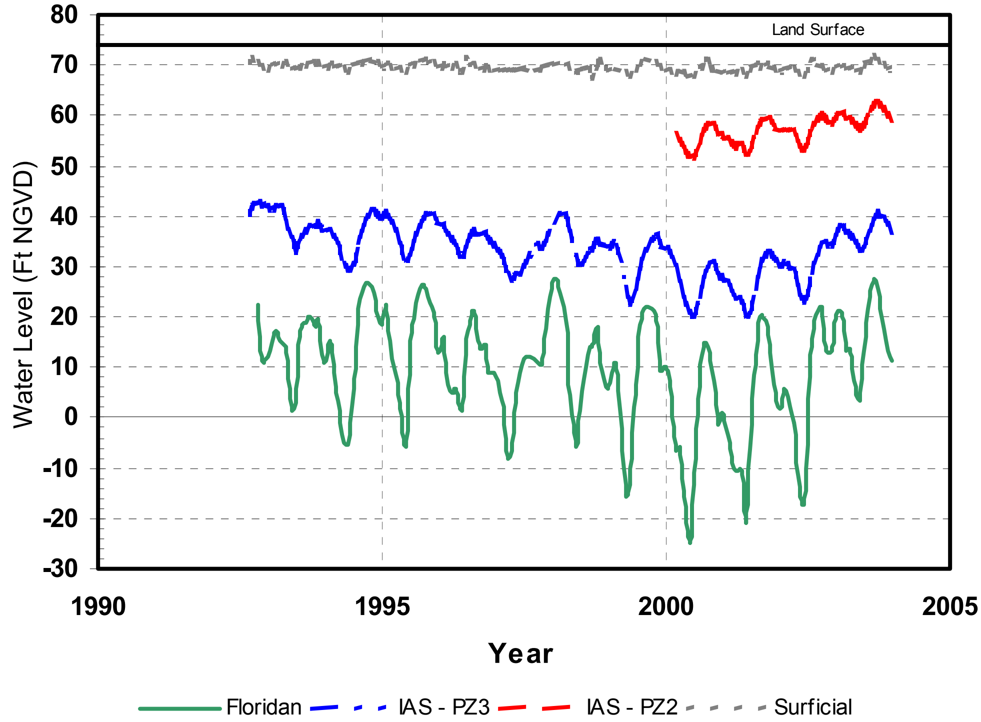

Figure 14. Water levels in the surficial aquifer, IAS, and Upper Floridan aquifer at ROMP 33.

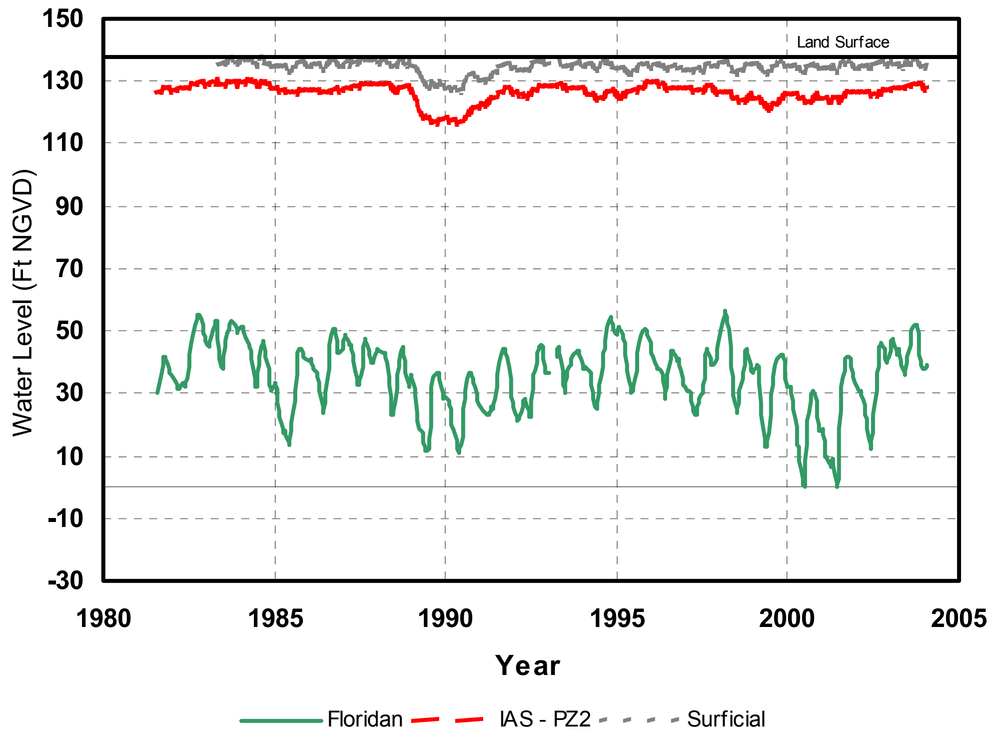

Figure 15. Water levels in the surficial aquifer, IAS, and Upper Floridan aquifer at ROMP 40.

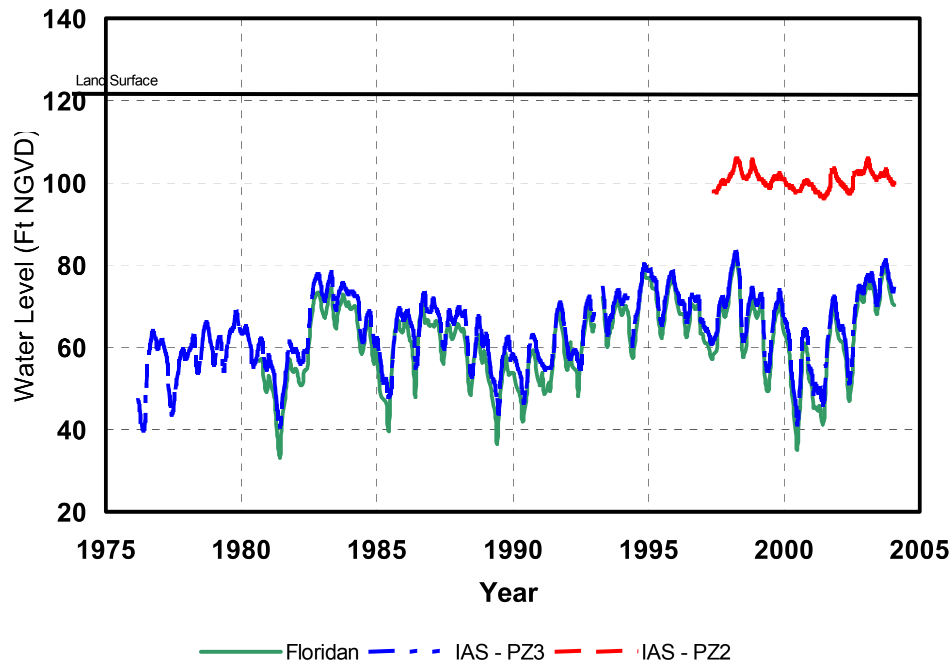

Figure 16. Water levels in the IAS and Upper Floridan aquifer at ROMP 45.

Maps of the thickness and top of PZ 2 and PZ 3 were constructed by contouring zones delineated from individual ROMP site reports. By contouring individual point data across the SWCFGWB, this may imply lateral continuity of PZ 2 across a several thousand square-mile area. As previously discussed, PZ 2 can consist of sand, gravel, shell, sandstone, limestone, and dolomite. Often many of the individual water bearing intervals are separated by clay or tight dolomitic limestone. The Floridan Aquifer System, in contrast, consists of a thick series of relatively homogenous limestone formations that span most of the Florida peninsula. The geologic heterogeneity of PZ 2 results in local variation in the permeability, thickness, and depth – making lateral extension of the unit problematic. The top of PZ 2 shown in Figure 6 more likely represents the elevation of local water bearing units, rather than a laterally extensive regional flow system. As an example of local scale heterogeneity, two lithologic logs are presented of PZ 2 from ROMP Nos. 5 and 12, located about 6 miles apart in Charlotte and southern De Soto Counties, respectively (Table 3). Both sites are at about the same land surface elevation.

Comparison of PZ 2 at both sites illustrates the difficulty in mapping the lateral extent of the unit. At Romp 12, PZ 2 is about 50 feet thick and begins at 57 feet below land surface (ft bls). At Romp 5, PZ 2 was defined at 130 ft bls and determined to be 100 feet thick. The lithologic heterogeneity is apparent from both logs with a mixture of dolomitic limestone, limestone, sand, phosphatic gravel, clay, shell, and fossils. At both sites, significant clay lenses are interspersed within more permeable carbonate sections.

In addition to local scale variability within the IAS, Knochenmus (written communication 2005) recently completed a regional analysis of PZ 2 based on its clay content and permeability. Sites with high clay percentage and very low transmissivity values were assigned confining unit status. This resulted in the geographic extent of PZ 2 shrinking to a smaller zone from extreme southern Manatee County to central DeSoto County south to the Charlotte/Lee County line. A separate area located within central and southern Polk Counties was also assigned to PZ 2 because permeabilities were higher. In between these two areas, however, PZ 2 was classified more as a confining unit than aquifer.

Table 3. Lithologic logs of PZ 2 from Romp Nos. 5 and 12.

Interval (ft bls)	Romp 5 Description		Interval (ft bls)	Romp 12 Description
130-139	Limestone, yellow-gray, interbedded quartz sand & phosphatic sand		57-64	Dolomitic limestone, yellow-gray, interbedded quartz sand, phosphatic sand, minor clay
139-144	Sand, gray, mixed with phosphatic gravel, fossils, and minor clay		64-74	Dolomitic limestone, light gray, minor sand, fossils
144-154	Limestone, yellow-gray, interbedded quartz sand & phosphatic gravel		74-79	Dolostone, light gray, chalky, minor limestone
154-159	Sand, gray, mixed with phosphatic gravel, fossils, limestone, sharks teeth, shell, and minor clay		79-85	Clay, light gray, minor sand, fossils
159-164	Limestone, yellow-gray, interbedded quartz sand & phosphatic gravel		85-94	Dolomite, silt-sized, mixed with clay, fossils, chalky, minor sand and phosphatic gravel
164-184	Limestone, yellow-gray, minor quartz sand		94-96	No samples
184-199	Clay, light gray to yellowish gray, minor sand, fossils		96-106	Dolostone, light gray, fossils, minor phosphatic sand
199-205	Limestone, yellow-gray, minor quartz sand, abundant fossils, phosphatic gravel			
205-219	Clay, light gray to yellowish gray, minor sand, fossils, phosphatic gravel			
219-229	Limestone, yellow-gray, minor quartz sand and clay, chalky, abundant fossils, phosphatic gravel			

Sources: Modified from Gates (1997) and Clayton (1999a)

PZ 3 exists along a line from central Manatee County and southern Polk County southward to the District's boundary (Figures 8 and 9). The zone also appears to exist along the southern portion of the Lake Wales Ridge in central and southern Highlands County, although aquifer tests indicate that it is extremely low in permeability there. PZ 3 may be more aquitard than aquifer in this region. PZ 3 is more laterally continuous than PZ 2 since it is largely carbonate and found in the Tampa Member or Nocatee Member of the Arcadia Formation. Of all the permeable zones within the IAS, PZ 3 most closely follows stratigraphic horizons of the Tampa or Nocatee members.

2.6 Water Quality

Trommer (1993) and SWFWMD (1993) provided some of the first regional descriptions of the saltwater interface along the west coast of Florida. Water chemistry of the IAS was further delineated for both the PZ 2 and PZ 3 units by Barr (1996). The District's Water Quality Monitoring Program (WQMP) routinely samples for saltwater intrusion by measuring chlorides and sulfates from a network of coastal monitoring wells. Tables summarizing average 2002 chloride and sulfate concentrations from monitor wells within each zone of the IAS are found in Appendix B.

In general, water quality of PZ 2 is better than the underlying PZ 3. Except for very near the coast in Sarasota and Charlotte counties, PZ 2 water quality is potable with respect to solute concentrations associated with the saltwater interface or mineralization. Chloride concentrations are generally less than 250 milligrams per liter (mg/l) except near Venice Beach, southeastern Sarasota County, and the Charlotte Harbor area (Figure 17). Sulfate concentrations exceed 250 mg/l in portions of coastal Sarasota County from the city of Sarasota to Venice along with the southern half of the Cape Haze peninsula (Figure 18).

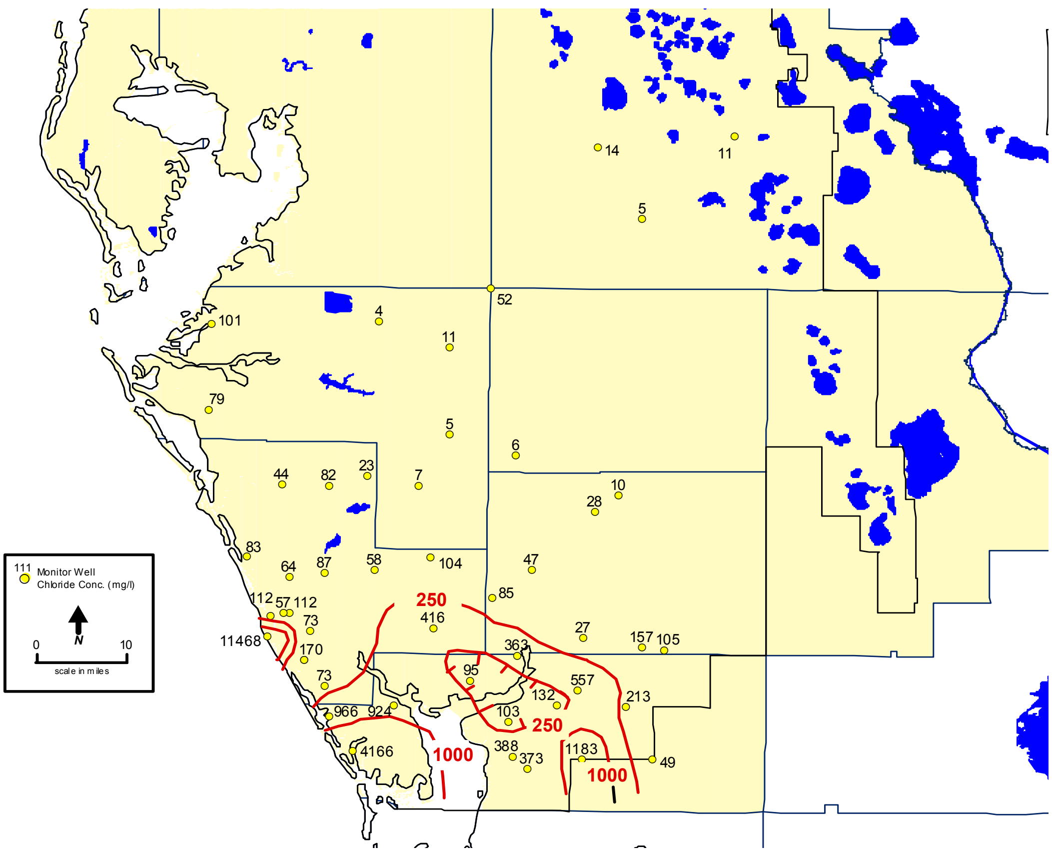

Figure 17. Chloride concentration from PZ 2 monitor wells (average of 2002 sampling).

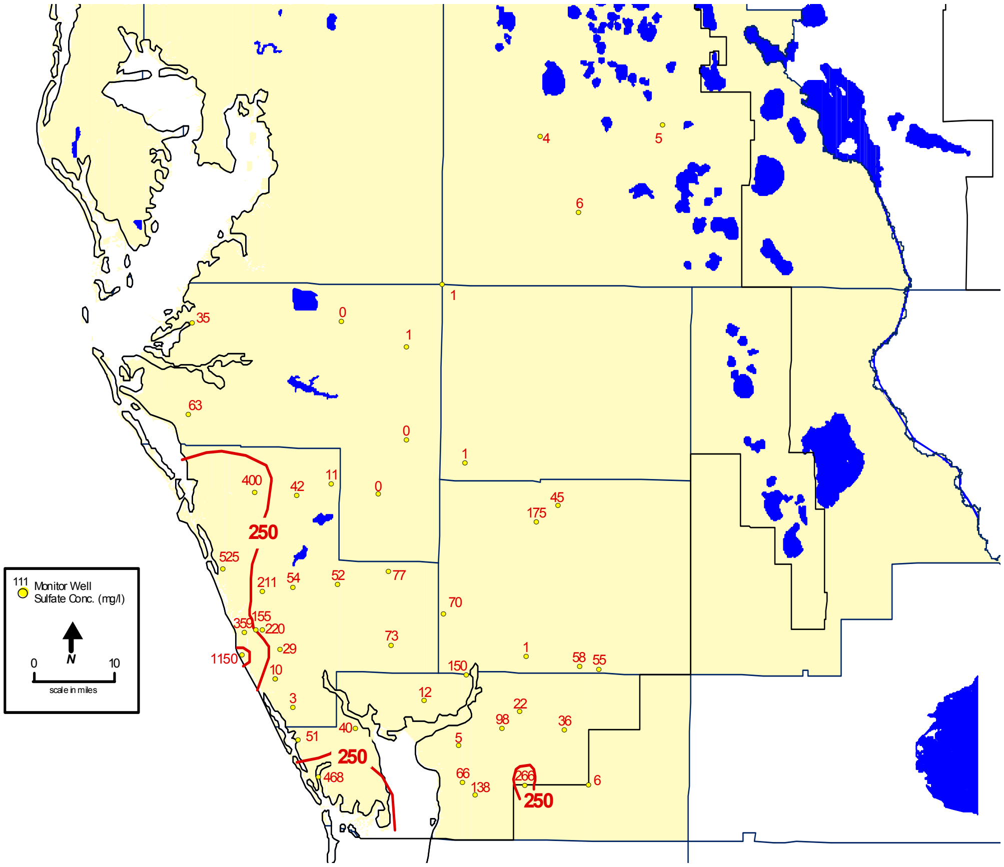

Figure 18. Sulfate concentration from PZ 2 monitor wells (average of 2002 sampling).

The water quality of PZ 3 is more mineralized than the overlying PZ 2. Chloride concentrations exceed the potable limit in southern Sarasota County, southwestern DeSoto County, and nearly all of Charlotte County (Figure 19). Chloride concentrations are greater than 1,000 mg/l on the Cape Haze peninsula (western Charlotte County). Sulfate concentrations exceed the state drinking water standard of 250 mg/l in a broad area from near the city of Sarasota southeast to central Sarasota County and stretching to the east of Charlotte Harbor (Figure 20). Sulfates exceed 1,000 mg/l in a smaller area in the northern coastal section of Sarasota County. Aside from these areas, the water quality in PZ 3 with respect to chloride and sulfate is potable in much of the remaining portion of the SWCFGWB.

It is important to understand the origin of high chloride ground water in the extreme southern part of the District differs from the remainder of the coastal zone further north. South of a line from about central Sarasota County east to central De Soto County, a transition-type ground water (chloride concentrations relatively equal to sulfate concentrations) and seawater-dominated ground water (chloride concentrations elevated relative to sulfate concentrations) exist in the intermediate and Upper Floridan aquifers. In this area, the freshwater/saltwater transition zone is diffuse and extends well above the base of the Upper Floridan aquifer. Relatively high concentrations of chloride are found all the way through the column from the upper IAS through the Floridan aquifer. In most cases, there is a gradual deterioration in water quality with depth. These high chloride levels are not the result of induced stress due to pumping (i.e. regional movement of saltwater interface) but rather the result of past marine inundations of the Floridan aquifer (DeHaven and Jones, 1996). The high chloride levels found here are naturally occurring because flushing of post-depositional seawater is still taking place due to sluggish groundwater flow, well-confined aquifers, and lack of recharge infiltrating down to the deeper aquifers because of increasing hydraulic head with depth.

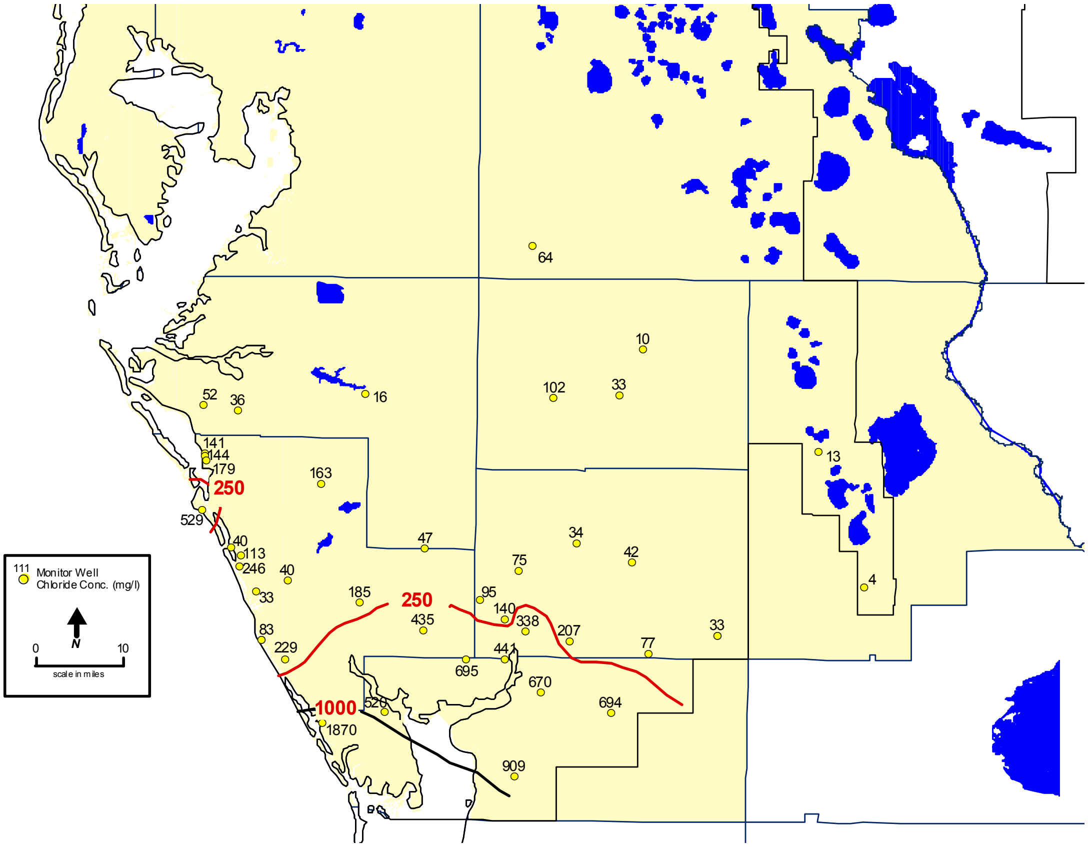

Figure 19. Chloride concentration from PZ 3 monitor wells (average of 2002 sampling).

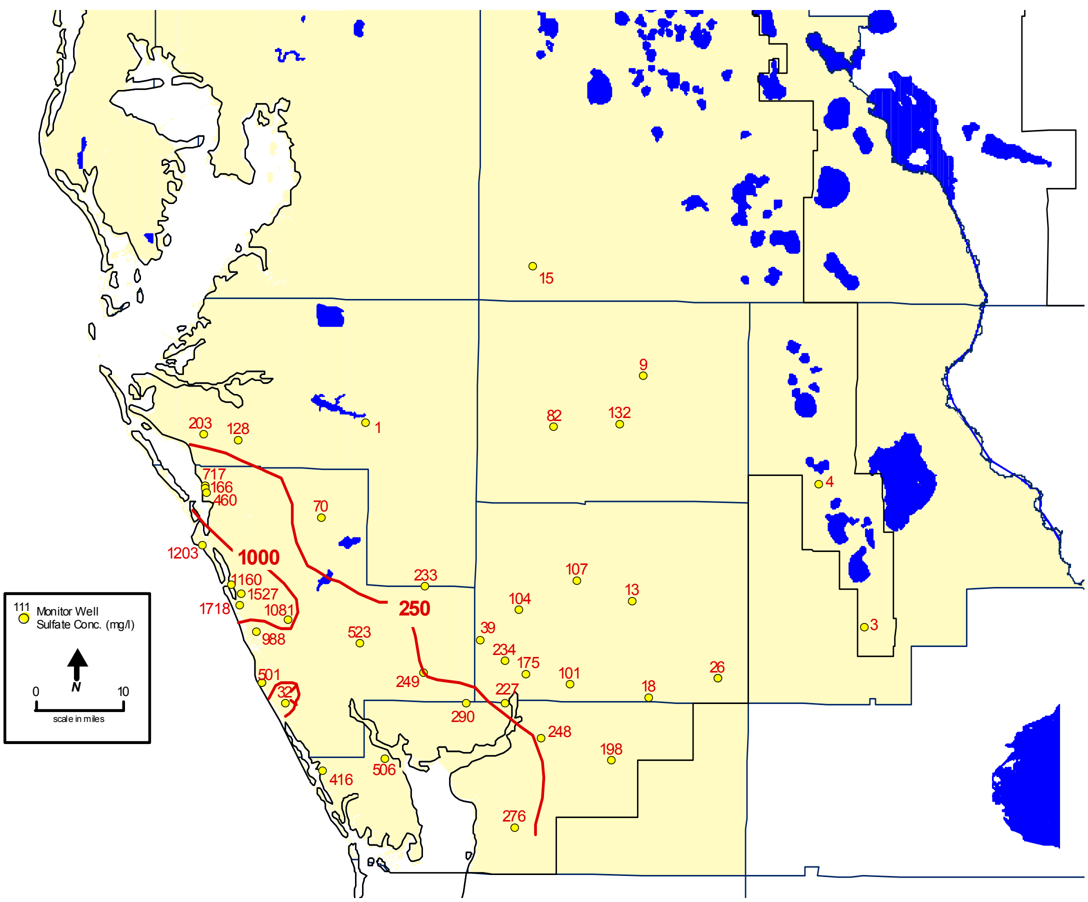

Figure 20. Sulfate concentration from PZ 3 monitor wells (average of 2002 sampling).

3.0 HYDROLOGIC CHANGES

3.1 Water Level History

The District maintains a water management database that contains aquifer water level measurements from a number of monitor wells throughout west-central Florida. Monitor wells were separated into respective upper and lower zones of the IAS based on construction characteristics and the elevation of each zone identified in Figures 6-9. A total of 46 PZ 2 and 45 PZ 3 monitor wells were identified throughout the southern half of the District (Figures 21 and 22). Appendix C contains well construction and other information regarding each IAS monitor well.

Mean annual water levels from each well were plotted to qualitatively note any long-term trends. The 10 percent (P10) , 50 percent (median), and 90 percent (P90) exceedance water levels for the period-of-record were also added to each plot. Percentiles were not generated for wells with less than five years of record. Graphs illustrating the water level history from each well are depicted in Appendix D.

3.1.1 PZ 2 Unit

In general, 2003 annual water levels were above the period-of-record median values for nearly 80 percent of the PZ 2 monitor wells. Of the 28 wells that had a continuous record and at least five years of data, the 2003 water level was higher than the period-of-record median water level for 22 wells. Overall, water levels in PZ 2 were lowest during the severe drought of 1999-2001 and have rebounded significantly due to above-average rainfall recorded during 2002-2003. In fact, 2003 water levels were at or above their 10 percent exceedance (P10) level for almost a third of the monitor wells.

Of the six wells where 2003 water levels were below their long-term median value, the ROMP 10 Upper Hawthorn well was the lowest with an abrupt 10-foot decline from 1999 to the year 2000. A review of the District's water use permits in the area indicates that no well withdrawals are within two miles of the site. The large shift in water levels was investigated and found to be a datum shift when new water level recording equipment was installed in 2000. Water level data prior to 2000 will be corrected to reflect the more recent 2000 datum (Pam Green, personal communication). Other wells such as Venice 35 and SR 74 in eastern Charlotte County appear to have long-term declining levels since the late-1960s. After 1995, water levels declined about two feet at the ROMP 19W Hawthorn well. The remaining two wells that are below their long-term median value are ROMP TR3-1 Hawthorn 160 and Lake Starr 1PNS-100 ICU. 2003 water levels at both of these wells were within 0.5 feet of their period-of-record median values.

To gain some perspective about long-term changes in PZ 2 water levels, hydrographs from the Venice 35, Englewood 14, SR 74, and the Punta Gorda Heights wells are shown in Figures 23-26. These monitor wells have the longest period-of-record of PZ 2 water levels with data collection starting in the late 1960s. Location of each well is depicted in Figure 27. Two of the four wells, Venice 35 and SR 74, indicate a decline in water levels of three-to-five feet since the late 1960s. PZ 2 water levels at the remaining two wells, Englewood 14 and Punta Gorda Heights, do not show a long-term trend.

In addition to analyzing annual water level history from individual wells, spatial distribution of water level change in PZ 2 was examined by taking the difference between two different time periods: 1994 and 2003 and 1996 and 2003 (Figures 28 and 29). The selection of the time periods was purely arbitrary and was a compromise between viewing differences over a sufficiently long period of time and maximizing the number of wells. While it would have been advantageous to examine water level changes over a longer period of time, only 13 out of 46 monitor wells have a

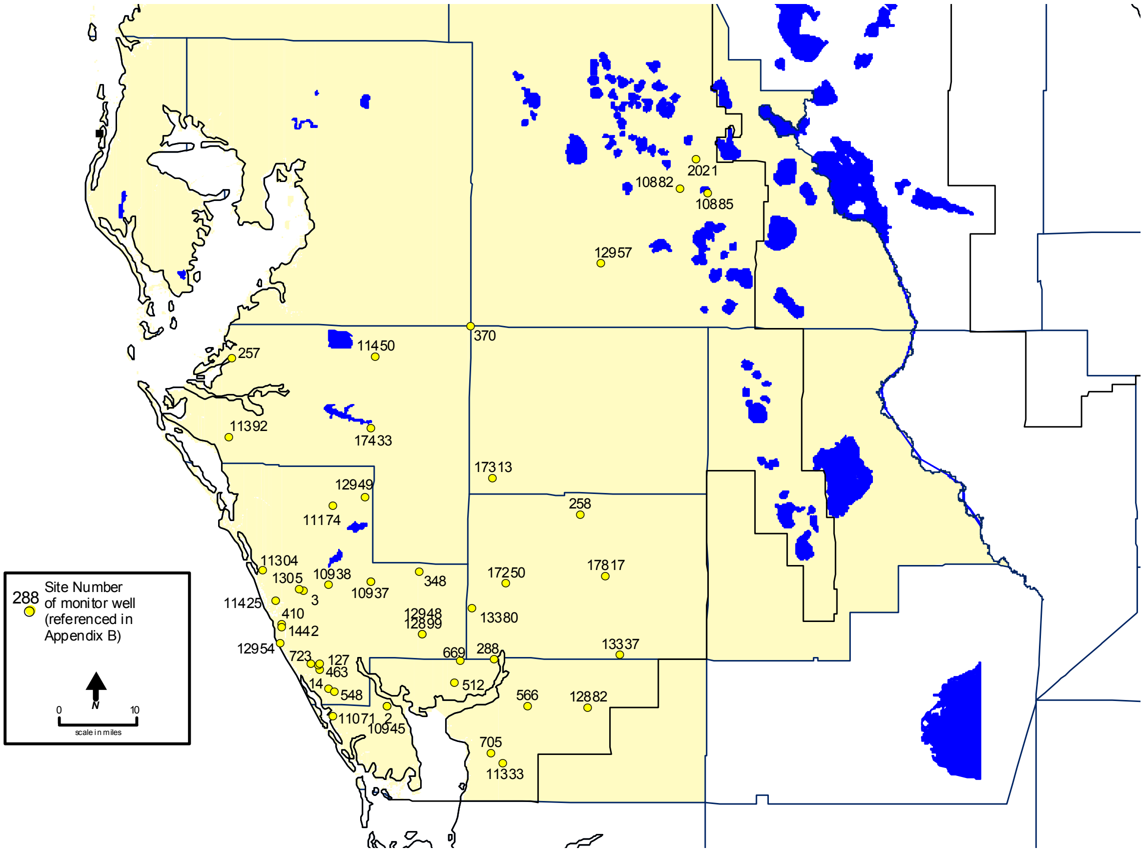

Figure 21. Location of PZ 2 water level monitor wells (site number referenced in Appendix C).

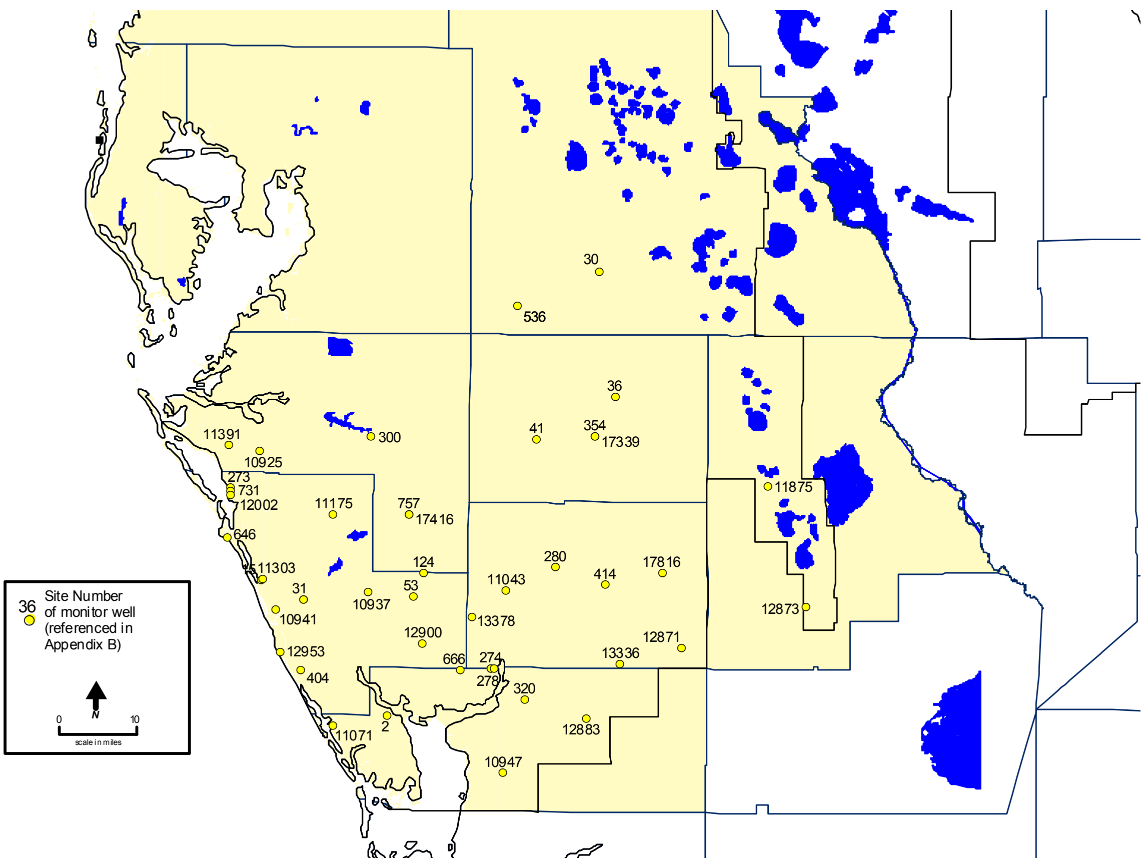

Figure 22. Location of PZ 3 water level monitor wells (site number referenced in Appendix C).

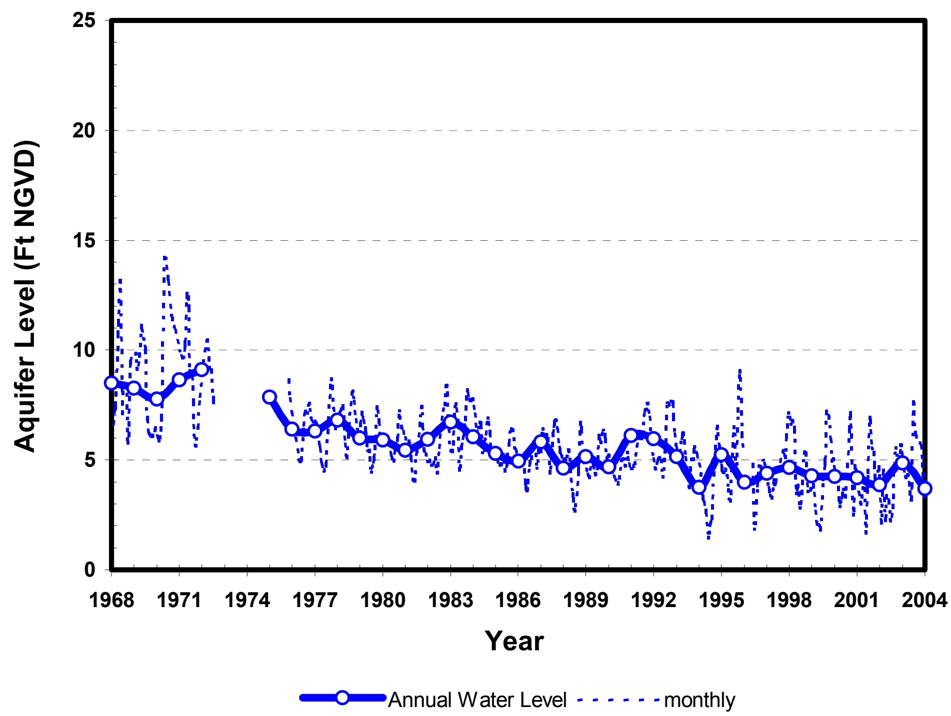

Figure 23. Water level history of the Venice 35 well.

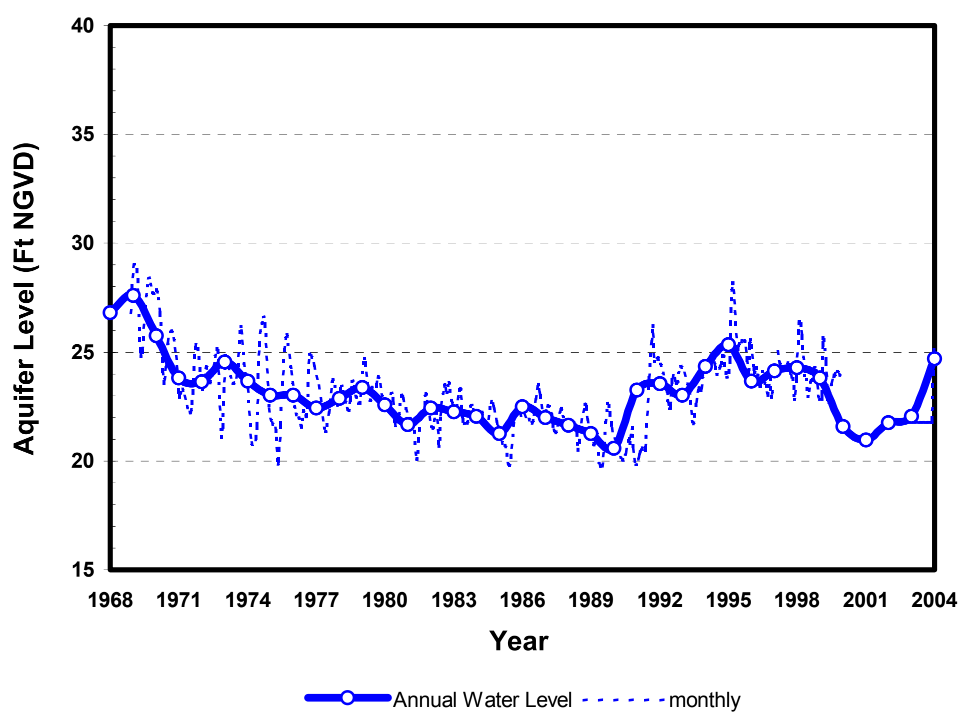

Figure 24. Water level history of the SR 74 well.

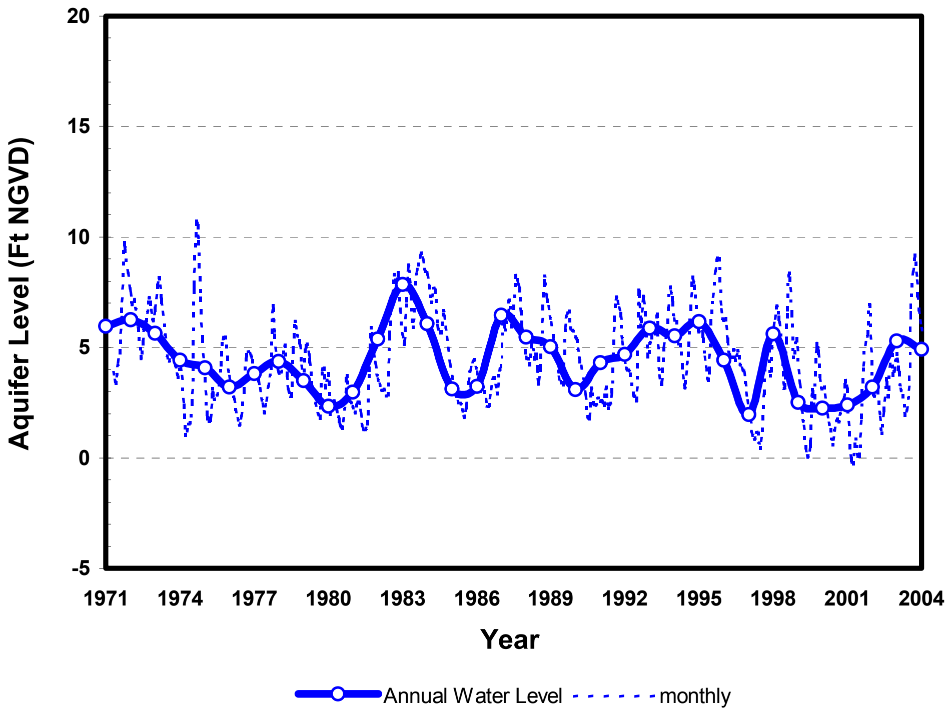

Figure 25. Water level history of the Englewood 14 well.

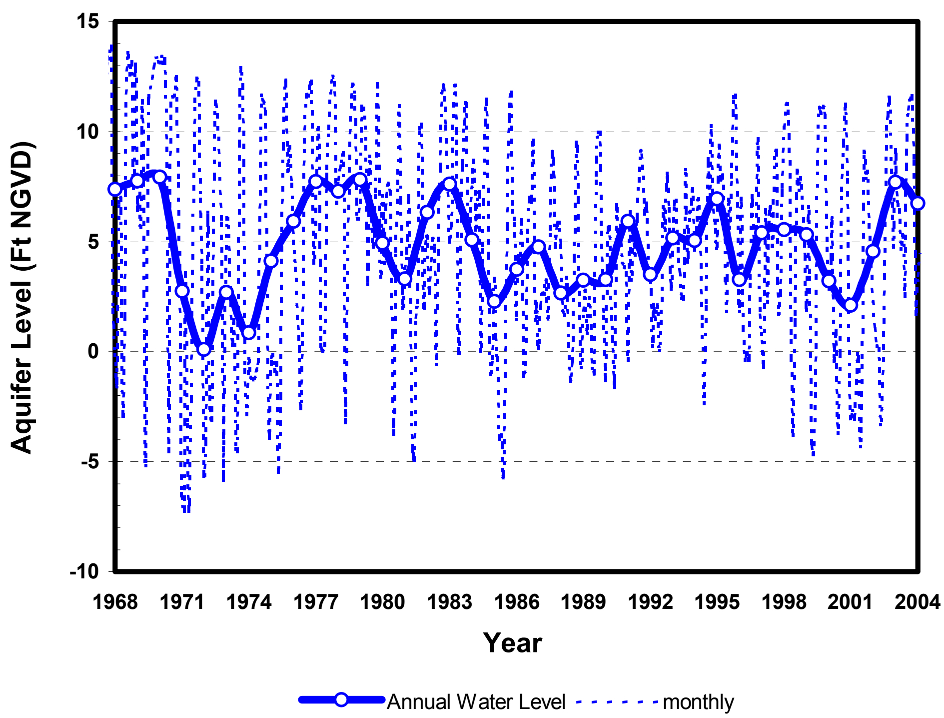

Figure 26. Water level history of the Punta Gorda Heights well.

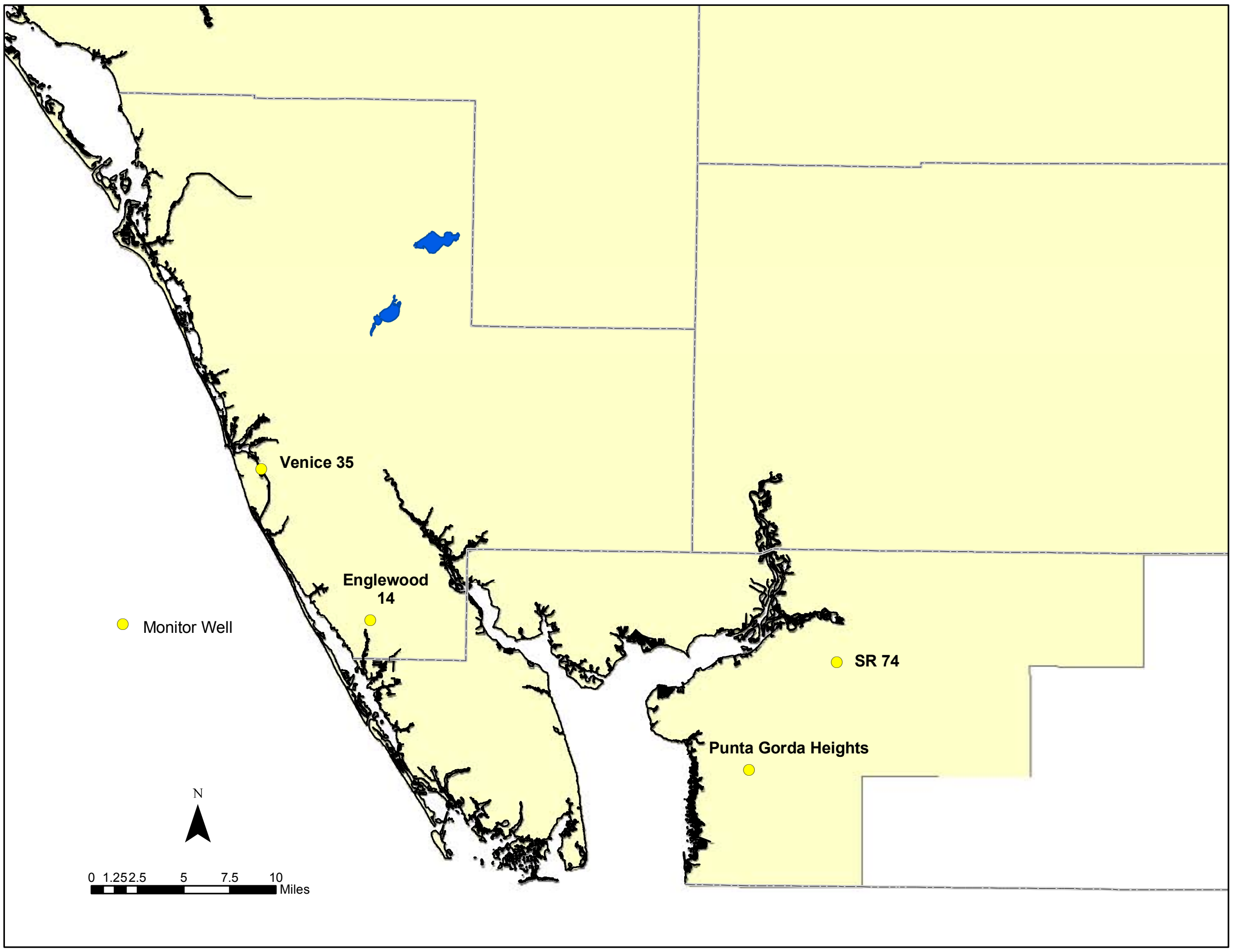

Figure 27. Location of PZ 2 long-term monitor wells.

continuous record that pre-dates 1990. These recent periods allow more wells to be used to note spatial patterns of change.

A review of the 1994-2003 difference in annual water levels from PZ 2 wells showed mostly an increase in aquifer heads (Figure 28). Five out of 17 wells showed a decline with the ROMP 20 Upper Intermediate well having the largest decline of -2.1 ft. Three of the five wells that showed declines were less than 0.3 ft. There was no apparent pattern of decline with a seemingly random pattern of change. In fact, water levels in wells from PZ 2 increased immediately adjacent to wells that declined. A review of the 1996-2003 water level difference indicated only three out of 19 wells declined, ranging from -0.1 to -0.9 ft (Figure 29). Interestingly, all five wells that illustrated a decline based on the 1994-2003 difference displayed an increase in water levels when 1996 was compared with 2003.

3.1.2 PZ 3 Unit

For PZ 3, 2003 annual water levels were above the period-of-record median values for nearly 85 percent of the monitor wells. Of the 26 wells that had a continuous record and at least five years of data, the 2003 water level was higher than the period-of-record median water level for 22 wells. With the exception of wells in south-central Polk County, PZ 3 water levels were lowest during the severe drought of 1999-2001 and have significantly rebounded due to wet climatic conditions experienced during 2002-2003. The Polk County wells were lowest in the mid-1970s. As evidence of rebounding water levels after the drought, 2003 annual water levels were higher than their P10 level at 11 out of 26 wells.

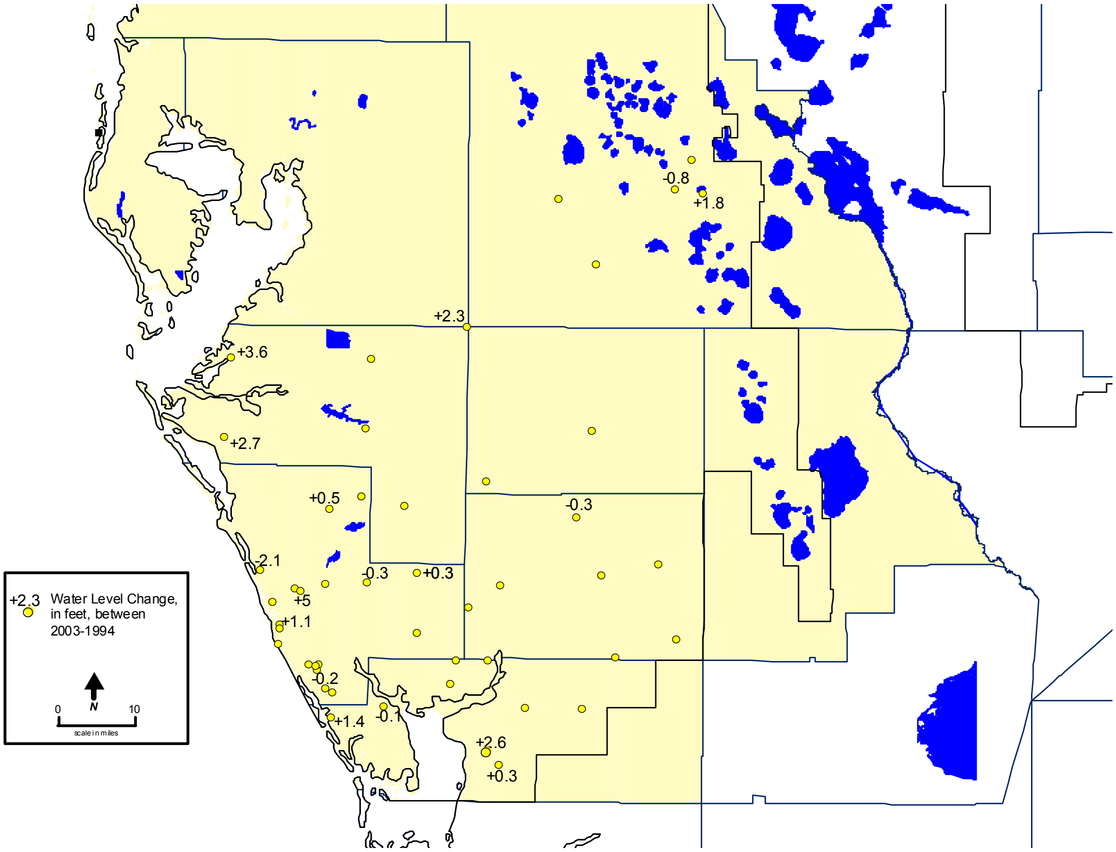

Figure 28. PZ 2 water level change from 1994-2003.

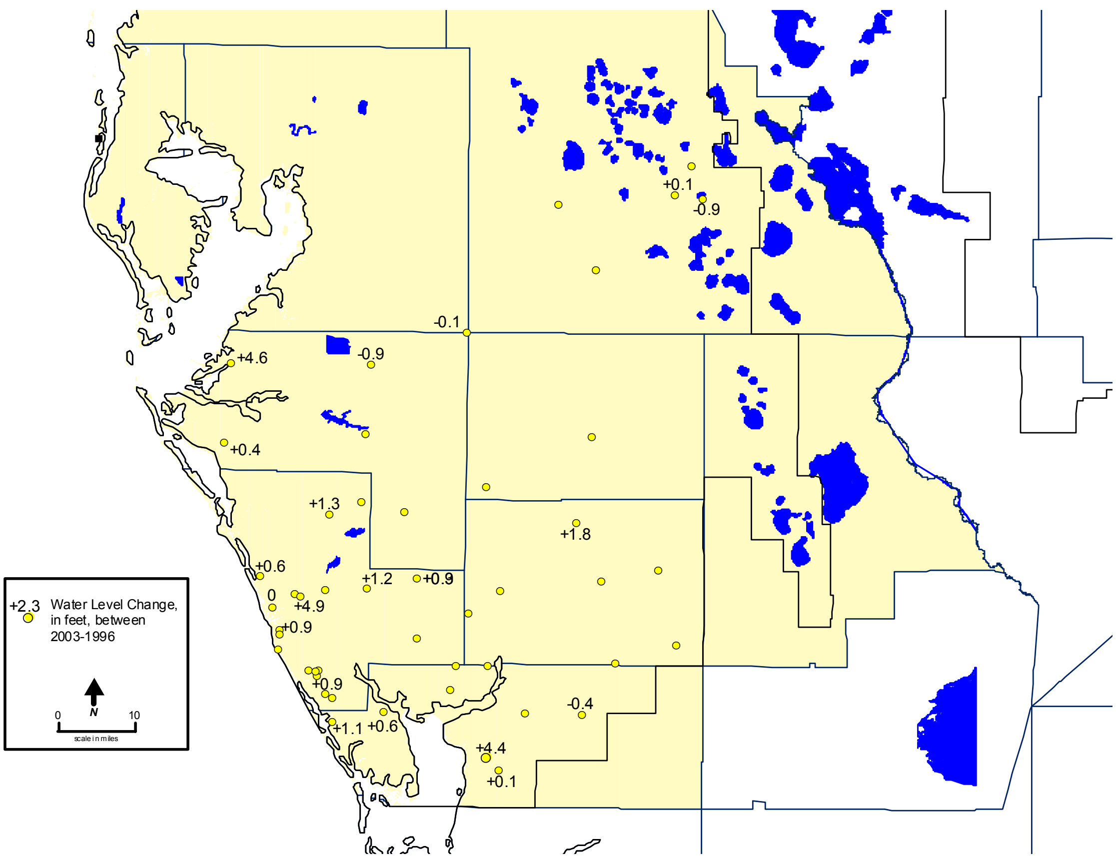

Figure 29. PZ 2 water level change from 1996-2003.

Of the four wells where 2003 water levels were below their long-term median value, the ROMP 10 Lower Hawthorn well was the lowest with an abrupt 12-foot decline from 1998 to the year 2000. This shift was similar to the ROMP 10 Upper Hawthorn well and is associated with the previously discussed datum change when new water level recording equipment was installed in 2000. The ROMP 11 Hawthorn well also shows a rather abrupt decline of 14 feet between 1987 and 1989. A review of current water use permits does not indicate any large withdrawals in the area. The well is located near the Shell Creek Reservoir, which is owned by the City of Punta Gorda. The remaining two wells with 2003 water levels below their long-term median value are ROMP TR6-1 (Seista Key) and TR5-1 (coastal Sarasota County), with both showing a three-to-five foot decline in PZ 3 water levels since the early-1980s.

Other wells such as Manasota 14 deep in southwest Sarasota County, Rowell Deep in Hardee County, and Osprey No. 9 (discontinued in 2002) in coastal Sarasota County indicate a decline in water levels varying from three to 13 feet since the late 1960s (Figures 30-32). In contrast, the Ft. Green Springs well in southwest Polk County illustrates an increase in water levels since the mid-1970s (Figure 33). Location of each well is shown in Figure 34. Since PZ 3 is in moderate-to-good hydraulic connection with the UFA, some of the regional long-term decline in the Upper Floridan appears to be reflected in this zone.

A review of the 1994-2003 difference in annual water levels from PZ 3 wells showed mostly an increase in aquifer heads, although a larger number of wells declined when compared with PZ 2 (Figure 35). Nine out of 21 wells showed a decline with the ROMP 10 Lower Intermediate well having the largest decline of -10.1 ft. As previously discussed, however, this decline is not real and is related to a datum change in 2000. The next largest decline was from ROMP 20 Lower Intermediate well at –1.6 ft. The remainder of the wells showed declines less than 0.9 ft. Unlike the random pattern seen in the PZ 2 wells, most of the decline was centered in a region from central Sarasota County east to central DeSoto County and southward. A review of the 1996-2003 difference was generally consistent with the 1994-2003 difference but showed fewer wells with declines. Only four out of 26 wells showed a decline ranging from -0.6 to -9.4 ft (Figure 36).

3.2 Water Quality Trends

3.2.1 Methodology

The WQMP section of the District monitors 92 wells that are completed in either PZ 2 or PZ 3 for a suite of water quality parameters that are typically indicative of saltwater intrusion. Approximately two-thirds of these wells have been monitored since the early 1990s as part of WQMP's Coastal Ground Water Quality Monitoring Network (CGWQMN). The CGWQMN was designed to monitor the freshwater/saltwater transition zone in coastal areas of the District. In 1999-2000, the CGWQMN was integrated with a new water quality monitor network, the Water Use Permit Water Quality Network (WUPNET). WUPNET is a geostatistically-based water quality monitor network that was designed to monitor trends in the confined aquifers of the District (WQMP, 2001).

The District water quality wells are illustrated for each IAS zone in Figures 37 and 38. Specifications and map identification numbers for wells completed in PZ 2 and PZ 3 are listed in Appendix E. The integrated CGWQMN/WUPNET yields an excellent spatial distribution of IAS wells in the SWCFGWB, but only 60 wells had an adequate number of data points for the chosen statistical trend analysis. Although 32 wells were not included in the trend analysis for this evaluation, scatterplots for dissolved chloride and sulfate versus time for all 92 monitor wells are presented in Appendix E. The scatterplots have been fitted with a Locally Weighted Scatterplot Smooth (LOWESS). LOWESS is a nonparametric method for estimating weighted least-square fits to localized subsets of data, where the subsets of data are determined using a nearest neighbor algorithm (Cleveland, 1979). The smoothness factor, which is used to determine how much of the data is used to fit each local regression, was set at 0.5 for the scatterplots.

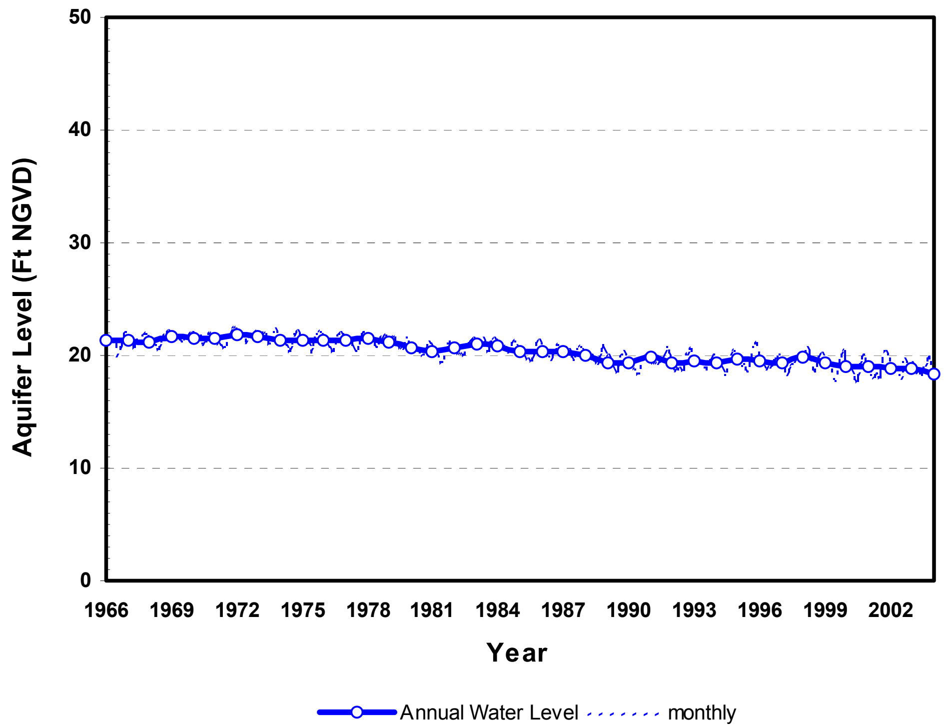

Figure 30. Water level history of the Manasota 14 well.

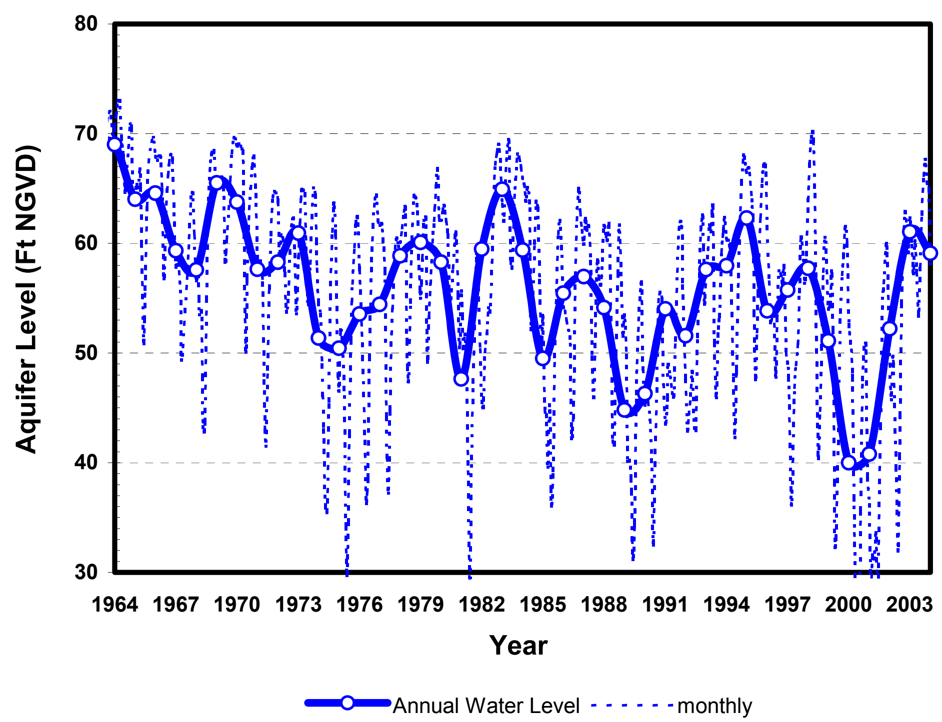

Figure 31. Water level history of the Rowell well.

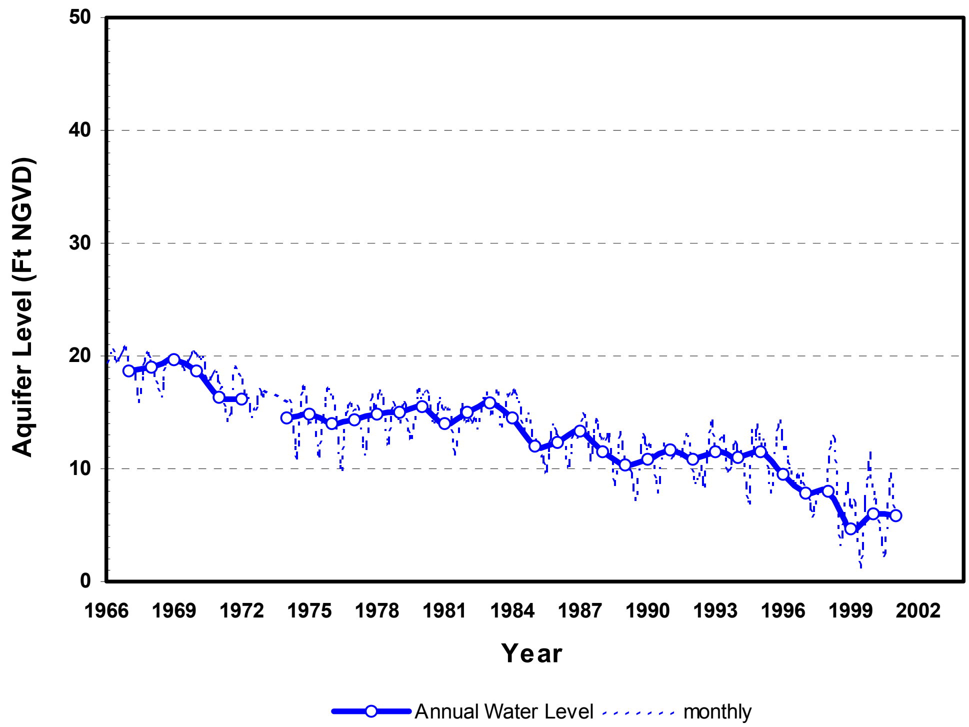

Figure 32. Water level history of the Osprey No. 9 well.

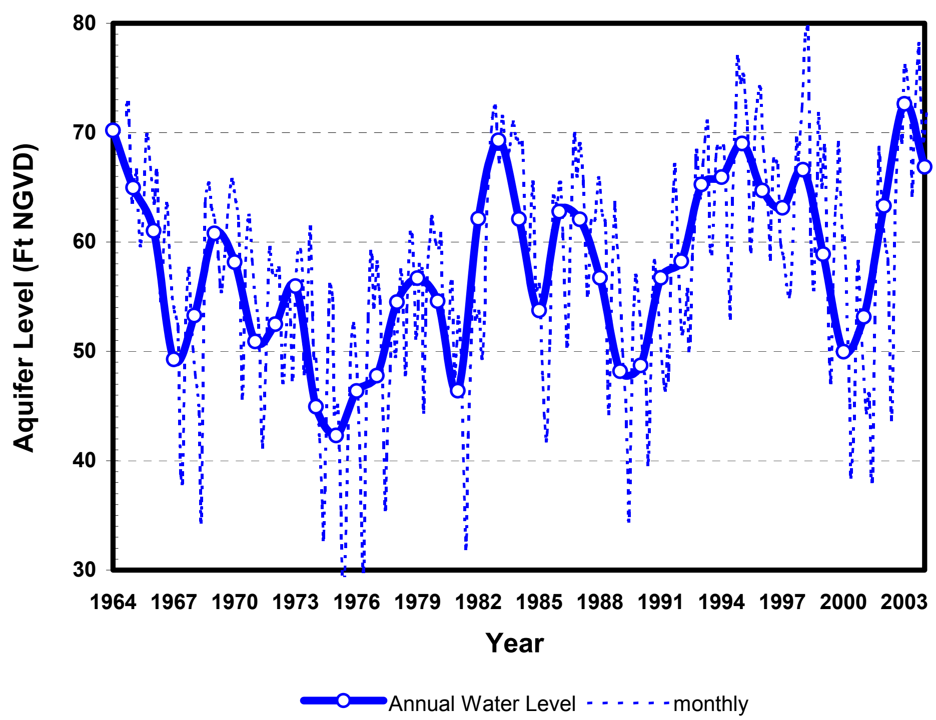

Figure 33. Water level history of the Ft. Green Springs well.

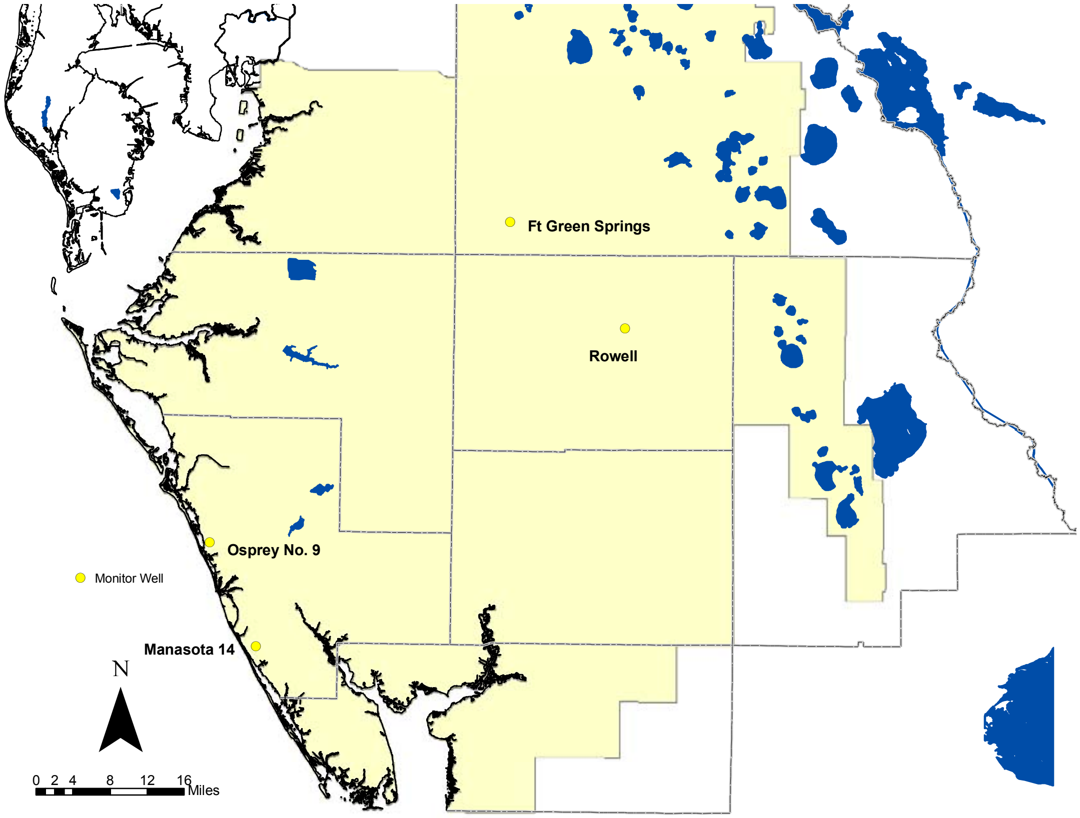

Figure 34. Location of PZ 3 long-term monitor wells.

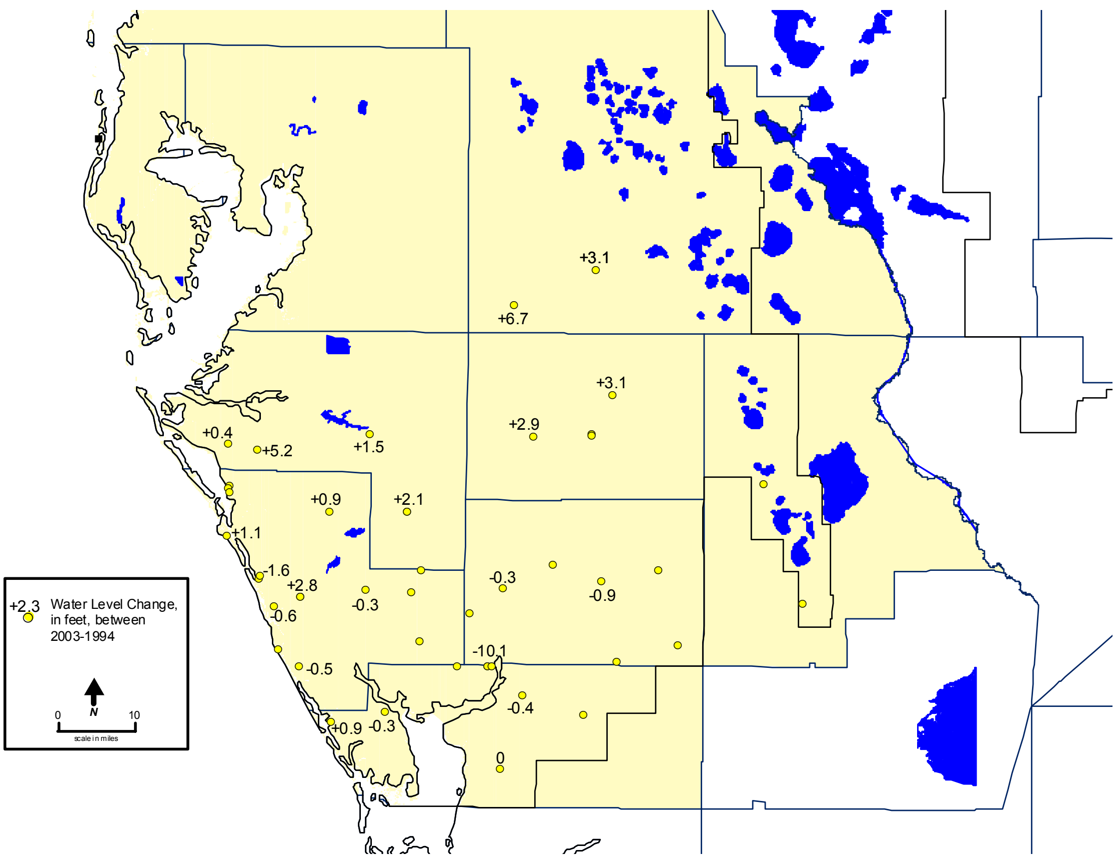

Figure 35. PZ 3 water level change from 1994-2003.

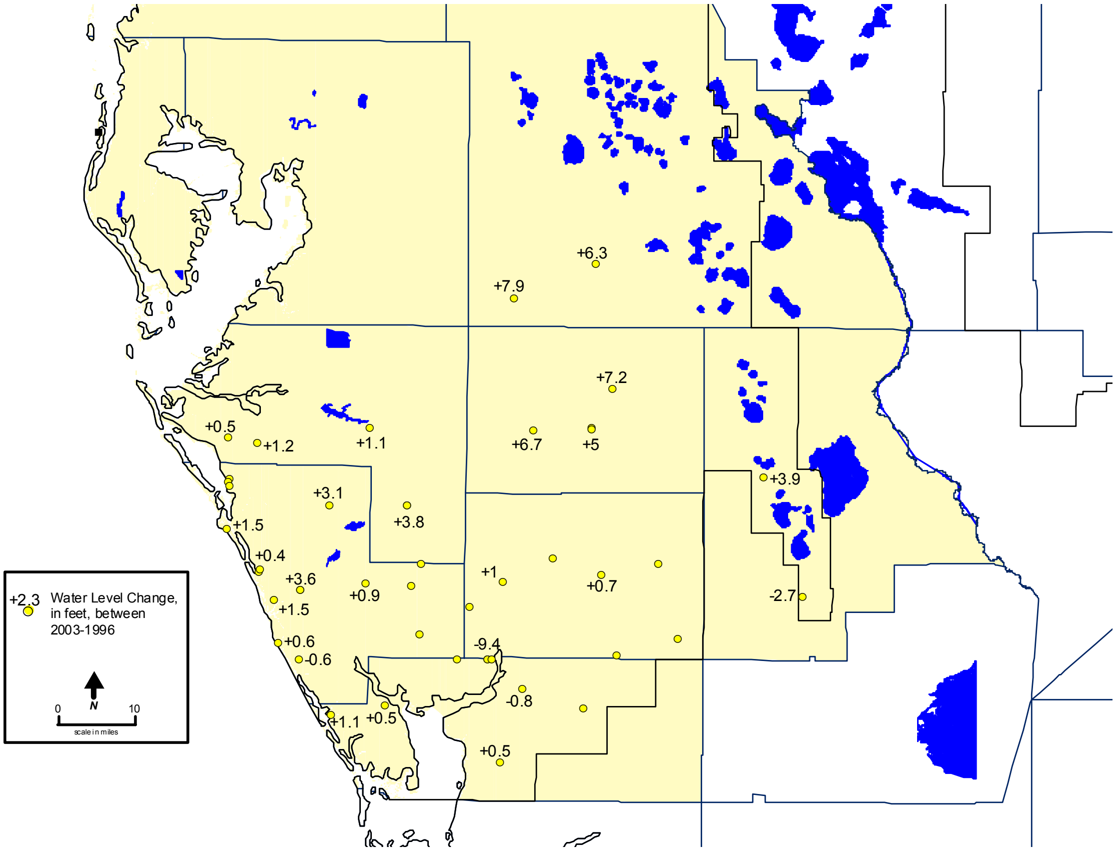

Figure 36. PZ 3 water level change from 1996-2003.

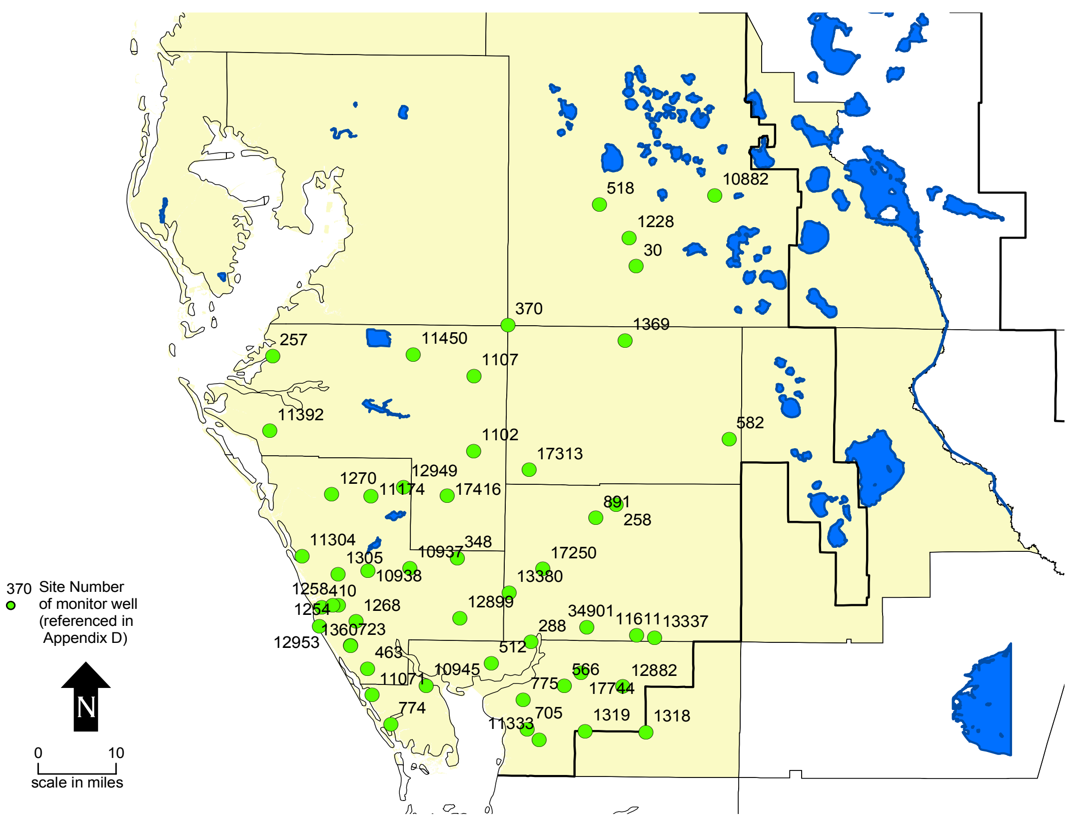

Figure 37. CGWQMN/WUPNet monitor wells of PZ 2.

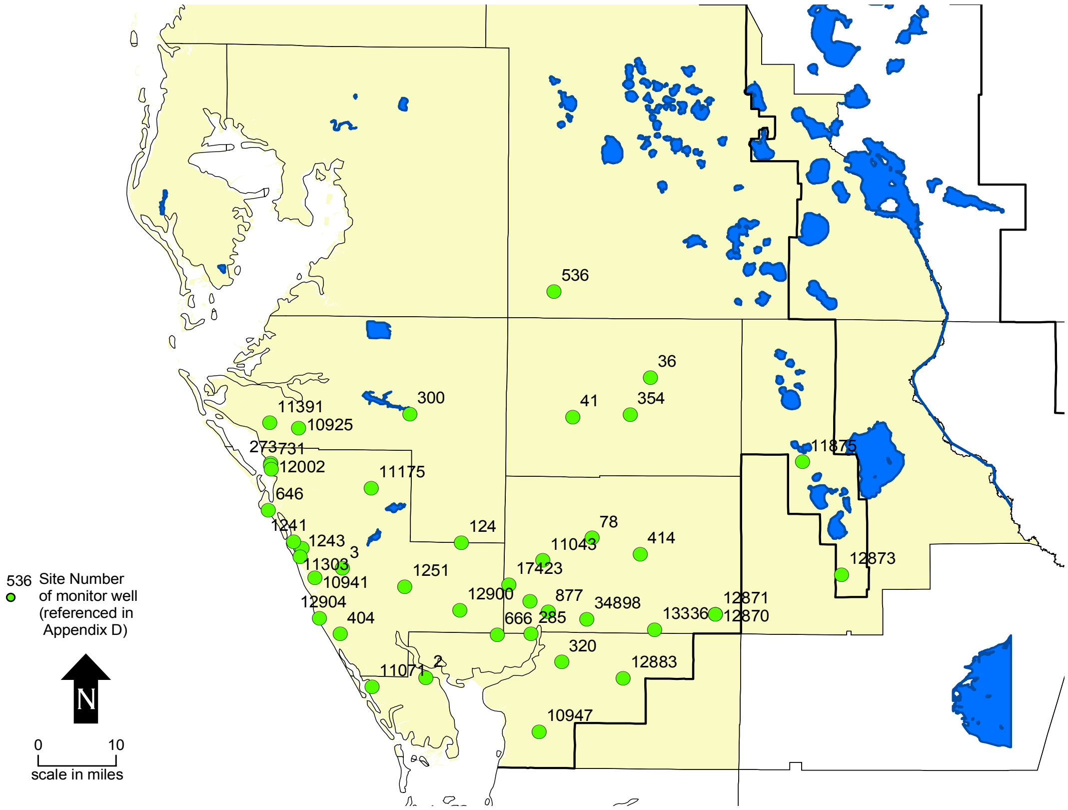

Figure 38. CGWQMN/WUPNet monitor wells of PZ 3.

LOWESS plots are a common data analysis tool and are often used as a precursor to statistical trend analyses. Trends can often be visually detected in the LOWESS plots. It is particularly useful in this evaluation because many of the inland wells currently do not have enough data points for a statistical trend analysis. Therefore, potential trends can be identified and noted for future statistical analyses.

Statistical trend analyses were completed for 60 of the water quality monitor wells. Of the 60 wells, 32 monitor PZ 2 and 28 monitor PZ 3. Dissolved chloride, dissolved sulfate, and the chloride/sulfate ratio are the water quality parameters that were evaluated. Chloride and sulfate are typically evaluated for monitoring saltwater intrusion and the chloride/sulfate ratio is often used to determine the source of salinity (WQMP, 2000). A nonparametric test, the Wilcoxon Rank-Sum Test, was used to determine if there was a significant difference between data collected during two different time periods. The last 10 years of data has been divided into two five-year increments; water quality data collected between April 20, 1993 and April 19, 1998 were allocated to Group 1 and data collected between April 20, 1998 and April 19, 2003 were allocated to Group 2. This methodology has been and is currently used by WQMP to monitor and detect groundwater water quality trends in the District. For this analysis, the number of wells and data points have been increased to include additional wells and data collected by WQMP for other water quality networks, that have not been included in previous CGWQMN/WUPNET reports (WQMP, 2000, 2001, and 2004).

First, a Shapiro-Wilk Normality test was run on each group of data for each IAS well. Most of the data did not follow a normal distribution, therefore a nonparametric Wilcoxon Rank-Sum Test was chosen for the trend analysis, with the results of both tests reported in Appendix F. The exact form of the Wilcoxon Rank-Sum Test was used because most of the groups of data had less than 10 data points per group, once the data was broken into Groups 1 and 2 as explained above. The

Wilcoxon Rank-Sum Test requires at least three data points within one of the comparison groups and at least five within the other. Sixty of the 92 IAS water quality monitor wells qualified for the trend analysis. The null hypothesis for this two-sided test was the probability of any given value from Group 2 was higher than any given value from Group 1 is one-half and the chosen alpha for the test was 0.05. Therefore at the 95% confidence level, if the calculated p-value of the Wilcoxon Rank-Sum two-sided test was less than or equal to 0.05, the two groups are significantly different.

3.2.2 Results and Discussion

As mentioned above, the CGWQMN/WUPNet has an excellent spatial distribution of intermediate wells, with many inland wells added to the network in 1999 and 2000. For this analysis, the best combination of spatial coverage and long-term data collection was reviewed. Using the last 10 years as the grouping period yielded the largest number of wells that qualified for the statistical analysis. A Wilcoxon Rank-Sum Test was run to compare data from April 20, 1993 - April 19, 1998 versus April 20, 1998 - April 19, 2003, and the results for each well are shown in Appendix F. The tables are grouped by permeable zone and then by water quality parameter. The results are also summarized in the following discussion and maps.

Of the 60 wells that have the minimum number of data points, many of the wells are located in coastal regions. To examine potential trends in inland wells, scatterplots and WQMP's latest trend analysis comparing April 20, 1999 - April 19, 2001 versus April 20, 2001 - April 19, 2003 was also reviewed.

3.2.3 PZ 2

There are 51 wells completed in PZ 2 with 32 having the minimum number of data points for the Wilcoxon Rank-Sum Test. Following are the results of the statistical test for each water quality parameter and a discussion of observations from scatterplots.

3.2.3.1 Chloride

Of the 32 wells tested, five showed increasing and four showed decreasing chloride trends (Figure 39). Over 70 percent of the evaluated wells did not show a significant change in chloride concentrations. All wells that showed significant trends were located in either Sarasota or Charlotte counties, and several wells with increasing trends were located near wells with decreasing trends.

There are six ROMP wells located in the inland counties of Polk (ROMP 40, 45, 57, and 59), Hardee (ROMP 25) and DeSoto (ROMP 26). None of these wells had the minimum number of data points for the trend analysis, but the scatterplots were reviewed for apparent trends. The chloride concentrations did not appear to be changing over time for the six wells, Appendix E.

Several of the PZ 2 wells did not show a statistically significant trend, but the calculated p-values for the Wilcoxon Rank-Sum Test were either close to 0.05 or the scatterplots demonstrated that there may be a trend that was not detected because of the time period that was chosen. The scatterplots for USGS TUCKERS CORNER INT and USGS C-3 INT showed slight increases in chloride, and the p-values for each were 0.08 and 0.07, respectively. The latest WQMP analysis indicates that USGS TUCKERS CORNER INT has a significantly increasing trend, when the time periods evaluated were shorter than it was for this analysis (WQMP, Draft, 2004). The scatterplot for VENICE SH WF 59 INT illustrates a decreasing chloride concentration, but this apparent trend is not statistically significant.

ENGLEWOOD 14 DEEP had a statistically significant increasing chloride trend over the time period that was used for this analysis, but the period of record data on the scatterplot appears to illustrate a decreasing trend. If the entire period of record was tested instead of the last 10 years, this well may not show a statistically significant trend.

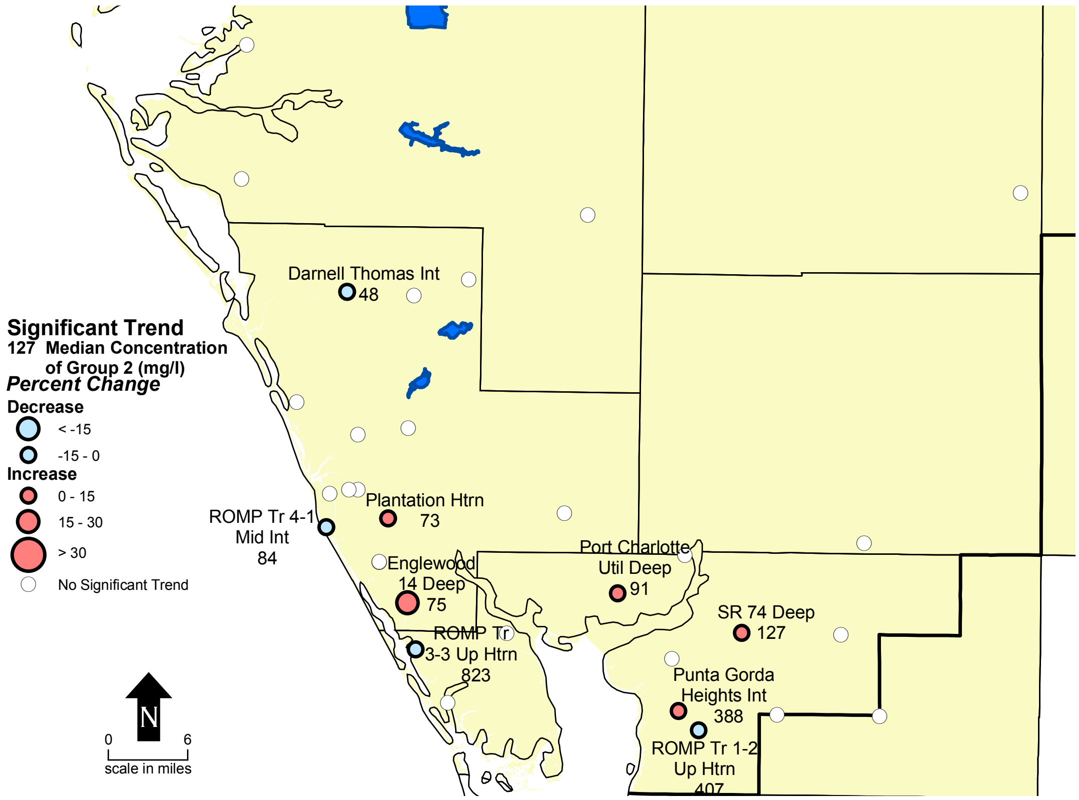

Figure 39. Chloride Trends in PZ 2.

3.2.3.2 Sulfate

Three PZ 2 wells showed significant increases and seven showed significant decreases in sulfate concentrations. As above, most wells with trends were located in either Charlotte or Sarasota counties (Figure 40). Sixty-nine percent of PZ 2 wells did not show significant changes in sulfate concentrations. Although 31% (10 of the 32 wells), demonstrated sulfate trends, the wells with trends were located relatively near wells without trends.

Scatterplots for six inland wells (ROMP 25, 26, 40, 45, 57, and 59) did not exhibit apparent changes in sulfate concentrations over time. Two wells that did not have enough data for the trend analysis appeared to have changes in sulfate concentrations over time on the scatterplots (ROMP 19 EAST HTRN with an apparent increase and ROMP 9.5 MW-18 UPZ INT with an apparent decrease). The scatterplot for VENICE SH WF 59 INT showed an apparent decrease in sulfate, but the trend was not significant.

3.2.3.3 Chloride/Sulfate Ratio

About one-third of the wells evaluated (11 wells), exhibited a significant trend in the chloride/sulfate ratio; seven had increasing trends and four had decreasing trends. Of the 11 wells with significant trends, three wells had not shown significant trends in either the individual chloride or sulfate analyses. Generally, wells with increasing chloride/sulfate ratios were found near coastal areas and wells with decreasing chloride/sulfate ratios were located more inland (Figure 41).

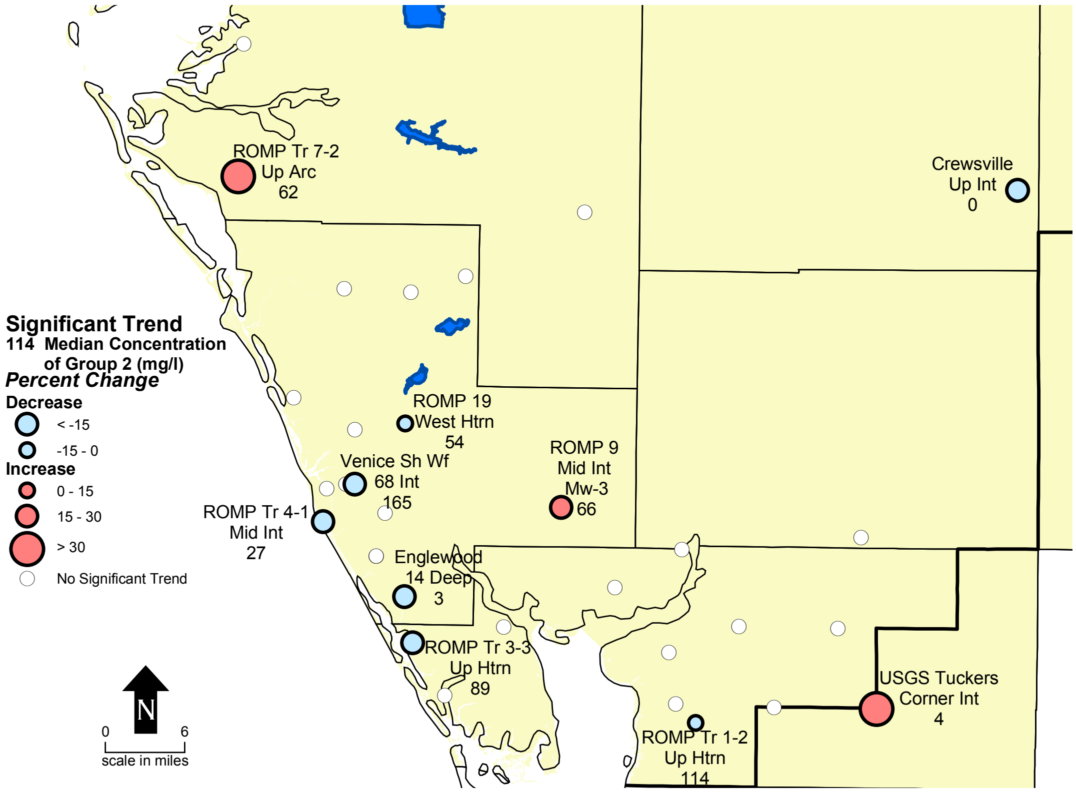

Figure 40. Sulfate Trends in PZ 2.

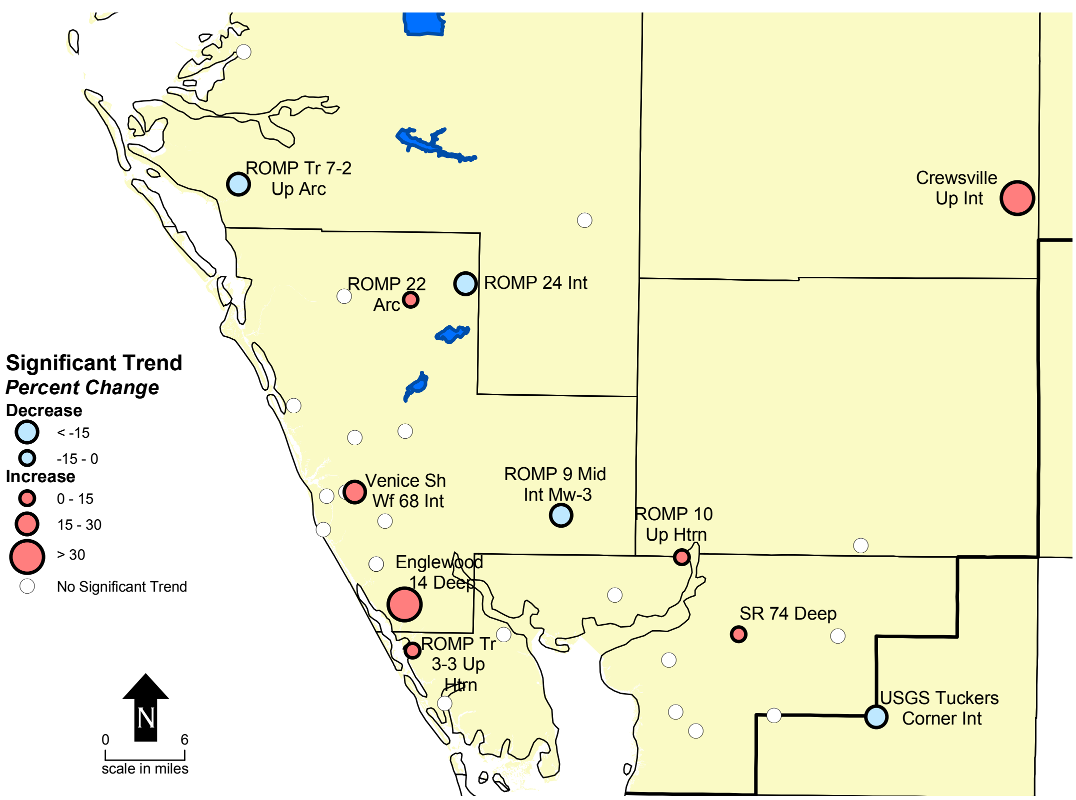

Figure 41. Chloride/Sulfate Ratio Trends in PZ 2.

When interpreting the results of the chloride/sulfate ratio, it is important to consider the changes that are occurring in individual chloride and sulfate concentrations and the magnitude of the differences between the chloride and sulfate concentrations. For example, the Crewsville Up Int well indicates a significant increase in the chloride/sulfate ratio, but individually, the chloride and sulfate concentrations are very low. The median concentrations for Group 1 are 6.1 mg/l for chloride and 0.4 mg/l for sulfate. For Group 2, the median concentrations are 6.42 mg/l for chloride and 0.32 mg/l for sulfate. The chloride increase is not significant, but the sulfate decrease is, therefore this relatively small change in sulfate concentration is causing a statistically significant increase in the chloride/sulfate ratio at this location.

Considering the results of the statistical analysis on the last 10 years of data and the scatterplots, there does not appear to be any pattern of regional water quality changes in chloride and sulfate concentrations in PZ 2. Of the 32 wells evaluated, 71% had no significant trend, 16% had an increasing trend, and 13% had a decreasing trend in chloride concentration. For the sulfate analysis, 69% of the wells had no significant trend, 9% had an increasing trend, and 22% had a decreasing trend (Table 4). There are many wells that are relatively close to each other showing changes, and the changes are sometimes in the opposite direction, i.e. one well will show an increase in concentration and a nearby well will show a decrease. Although there are several instances of water quality changes in PZ 2, the effects appear to be localized.

Table 4. Number and Percentage of wells with Significant Water Quality Trends in PZ 2.

Thirty-two wells monitored in PZ 2				
Water Quality Parameter	**Number of Wells with Significant Increase**	**Number of Wells with Significant Decrease**	**Percentage of Wells with Significant Increase**	**Percentage of Wells with Significant Decrease**
Chloride	5	4	16%	13%
Sulfate	3	7	9%	22%
Cl/SO4	7	4	22%	13%

3.2.4 PZ 3

There are 28 wells with the minimum number of data points for the Wilcoxon Rank-Sum Test out of a possible 41 wells completed in PZ 3.

3.2.4.1 Chloride

Six PZ 3 wells had significant trends over the period of analysis, with two wells showing increasing chloride concentrations and four wells with decreases. Seventy-nine percent of the wells did not demonstrate a significant chloride trend (Figure 42).

A review of the scatterplots indicate that although the trends at ROMP TR 6-1 HTRN and GDU WELL T-2 INT are not statistically significant, there appear to be increasing and decreasing trends, respectively, in chloride concentrations in these wells.

Scatterplots for wells located in the inland counties of Highlands, Polk, DeSoto, and Hardee were also reviewed and no apparent trends were observed in chloride concentrations.

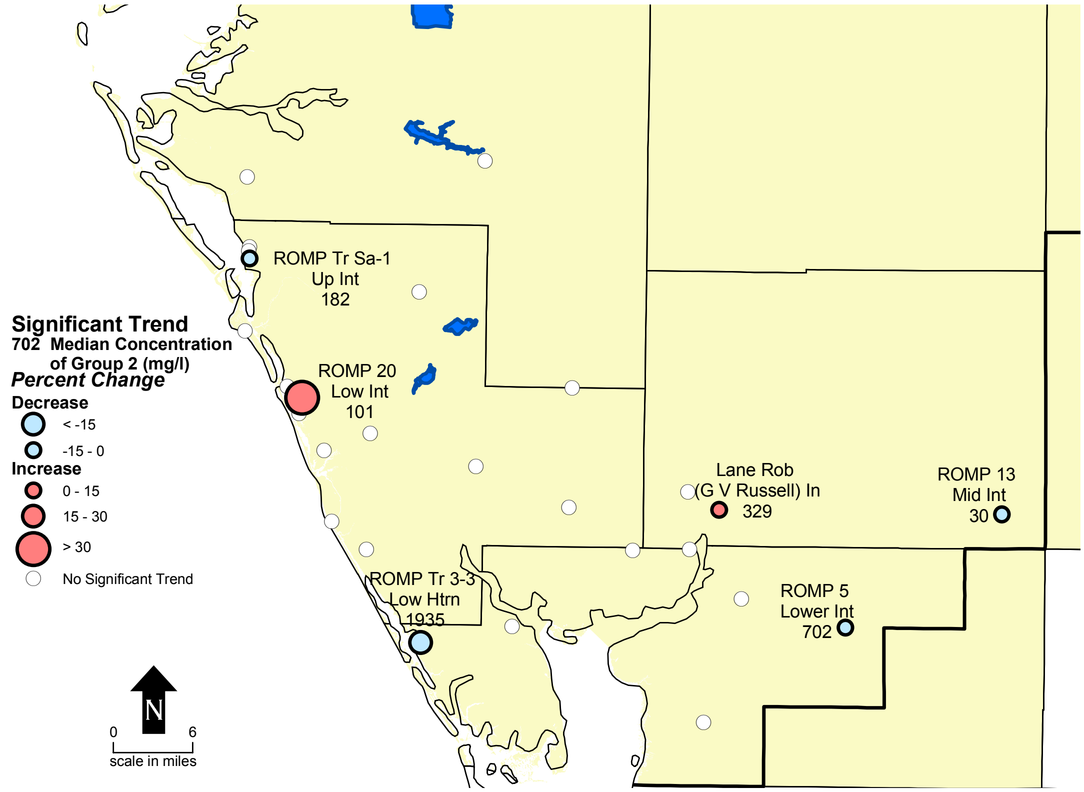

Figure 42. Chloride Trends in PZ 3.

3.2.4.2 Sulfate

For the analysis of sulfate changes in PZ 3, one well had an increasing sulfate trend and four wells had decreasing sulfate trends (Figure 43). Of the wells evaluated in PZ 3, 82% did not have a significant trend.

Although there were not an adequate number of data points for ROMP TR 7-4 HAWTHORN, the scatterplots illustrate an apparent decrease in sulfate concentrations over time. The latest WQMP analysis also indicates that there is a decreasing sulfate trend at this well (WQMP, 2004).

3.2.4.3 Chloride/Sulfate Ratio

Seven wells, 25%, showed a significant trend in the chloride/sulfate ratio; three wells had increasing trends and four wells had decreasing trends. Out of the seven wells with significant trends, two wells had not shown significant trends in either the individual chloride or sulfate analyses (Figure 44), and as mentioned above, the individual concentrations must be considered when interpreting the results of the chloride/sulfate ratio analysis.

Although there were several PZ 3 wells that demonstrated statistically significant changes in water quality over time, there were not apparent patterns in the spatial distribution of these wells. Regionally, water quality in PZ 3 does not appear to be significantly changing, with 79% of the wells showing no significant changes in chloride and 82% of the wells showing no significant changes in sulfate concentrations (Table 5). Similar to PZ 2, there do appear to be localized water quality changes in PZ 3.

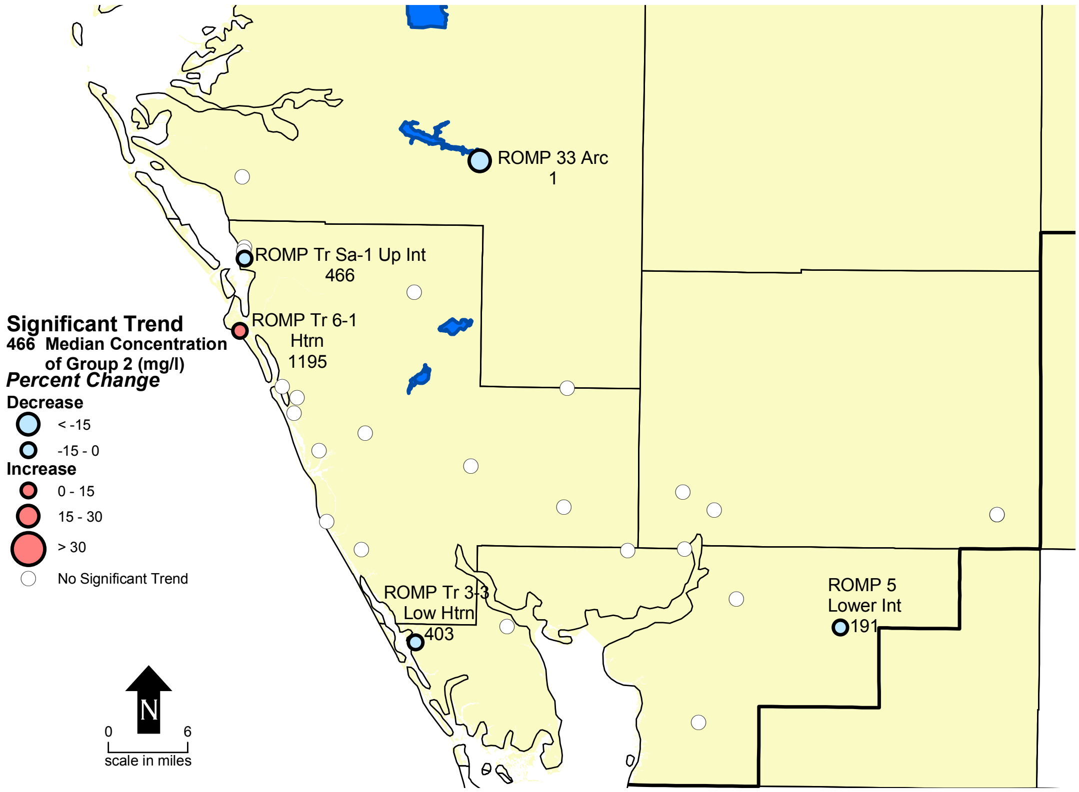

Figure 43. Sulfate Trends in PZ 3.

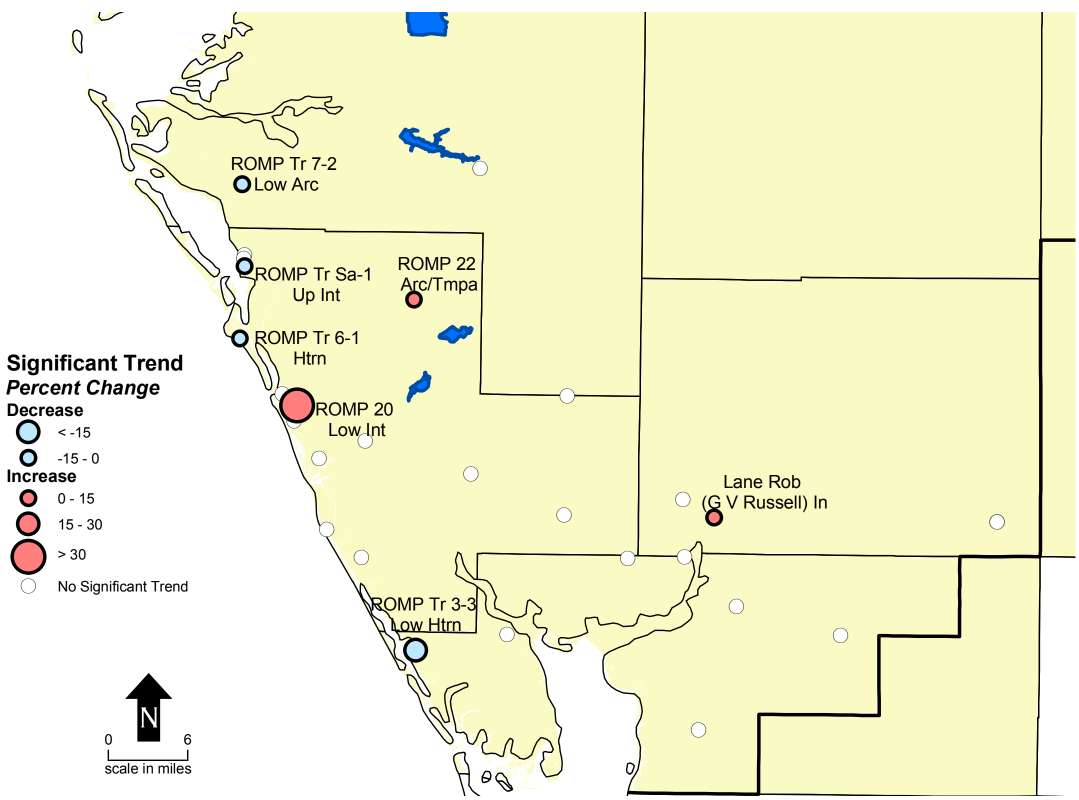

Figure 44. Chloride/Sulfate Ratio Trends in PZ 3.

Table 5. Number and Percentage of wells with Significant Water Quality Trends in PZ 3.

Twenty-eight wells monitored in PZ 3				
Water Quality Parameter	Number of Wells with Significant Increase	Number of Wells with Significant Decrease	Percentage of Wells with Significant Increase	Percentage of Wells with Significant Decrease
Chloride	2	4	7%	14%
Sulfate	1	4	4%	14%
Cl/SO4	3	4	11%	14%

3.2.5 Water Quality Summary

A previous WQMP study concluded that wells located in coastal areas and completed in the Upper Floridan aquifer are at a higher risk to contamination by saltwater intrusion than wells completed in the intermediate aquifer (WQMP, 2000). Results from solute transport modeling of the Eastern Tampa Bay Water Resource Assessment Project (ETB WRAP) show regional saltwater intrusion in the highly permeable Avon Park Formation and indicated little to no lateral intrusion in the Suwannee Limestone (SWFWMD, 1993). Because the IAS is not as laterally continuous or as permeable as the underlying Suwannee Limestone, the IAS is at an even lesser risk of regional saltwater intrusion than this lower unit. The results of this trend analysis show that water quality has changed for some coastal intermediate wells, but the changes are not regional. Wells with increasing trends were located relatively close to wells with decreasing trends. Therefore, the water quality changes in PZ 2 and PZ 3 appear to be localized. Many inland wells did not have the minimum number of data points to be included in the statistical test, but the scatterplots and WQMP's most recent trend analysis have shown that these inland wells generally do not demonstrate major water quality changes at this time.

3.3 Water Use

Duerr and others (1988) published the earliest information on region-wide IAS water use in southwest Florida. In 1985, they estimated that 69 million gallons per day (mgd) of ground water was withdrawn from the IAS over the SWCFGWB. This represented about 10 percent of total ground water withdrawn from the Floridan aquifer over the same area. The largest category of use was agriculture with withdrawals of 39 mgd followed by self-served domestic at 14 mgd, and public supply at 11 mgd. Water withdrawn from the IAS was estimated as a total for all water-bearing zones.

More recently, IAS water use was calculated for 1993 and 2001 based on the District's water use estimates. Kelly (2004) developed a ground water withdrawal dataset based on individual well quantities. Permitted wells were assigned a withdrawal quantity based on metered or estimated data. Self-served domestic wells were also assigned individual quantities by dividing the total county-wide domestic use by the number of wells. Domestic self-serve well quantities were then summed by square mile and located at the center of each section. Each well was geographically referenced based on latitude-longitude coordinates. The total depth of each well was used to place it within the surficial aquifer, PZ 2, PZ 3, or the Upper Floridan aquifer based on elevations/ thicknesses contained in Figures 6-9. If a well was open to multiple zones, withdrawal quantities for each zone were apportioned based on a ratio of transmissivity between the units. The transmissivity values were obtained from the Southern District Regional Groundwater Flow Model (Beach and others, 2004).

Using the previously described method, total IAS water use for 1993 and 2001 was 59 mgd and 70 mgd, respectively. PZ 2 withdrawals were 26 mgd in 1993 and 29 mgd in 2001. PZ 3 withdrawals were 33 mgd in 1993 and 41 mgd in 2001. The complete county totals for 1993 and 2001 are contained in Table 6. Roughly two-thirds of 2001 IAS ground-water withdrawals occurred in Charlotte, DeSoto, and Sarasota Counties. The spatial distribution of ground water withdrawals from PZ 2 and PZ 3 for the year 2001 is shown in Figures 45 and 46.

Table 6. Ground water withdrawn from the IAS during 1993 and 2001.

County	1993		2001	
	PZ 2	**PZ 3**	**PZ 2**	**PZ 3**
Hillsborough	2.4	N/A	2.1	N/A
Manatee	2.3	0.9	2.7	1.8
Sarasota	4.5	8.0	4.3	9.8
Charlotte	7.2	6.3	9.5	8.8
Polk	2.8	N/A	2.0	N/A
Hardee	3.5	5.2	4.0	5.6
DeSoto	3.3	8.5	4.7	10.5
Highlands	0.0	4.3	0.05	4.4
Total (mgd)	**26.0**	**33.2**	**29.4**	**40.9**

N/A = PZ 3 is not present.

3.4 Predicted 2025 IAS Water Level Change

The Southern Water Use Caution Area Recovery Plan estimates that the IAS and surficial aquifer together are capable of providing up to 35 mgd of water to meet growing demand over the next 20 years. To determine if these quantities are sustainable in the IAS, several withdrawal scenarios were developed across the SWCFGWB. Since it is not possible with a large degree of certainty to accurately know where the withdrawals would occur, various geographical distributions were simulated using the Southern District Regional Groundwater Flow Model (Beach and others, 2004). The most conservative case was assumed that all of the 35 mgd will be produced from the IAS so that maximum impacts could be predicted on aquifer levels. The Southern District Regional Groundwater Flow Model (SD Model) was run under steady-state conditions and aquifer drawdown is represented as the predicted decline in water levels over the next 20 years from current conditions.

There are a multitude of potential withdrawal distributions that could be used to predict the impact on IAS water levels from the extraction of an additional 35 mgd. This section offers three different types of general scenarios that would assist in determining possible impacts to future water levels. The three major scenarios include: 1) adjusting upward the current distribution of major IAS withdrawals, 2) equally distributing the withdrawals over cells that cover the IAS, and 3) placing major withdrawals five to ten miles apart in a rough grid pattern that is evenly spaced throughout the basin.

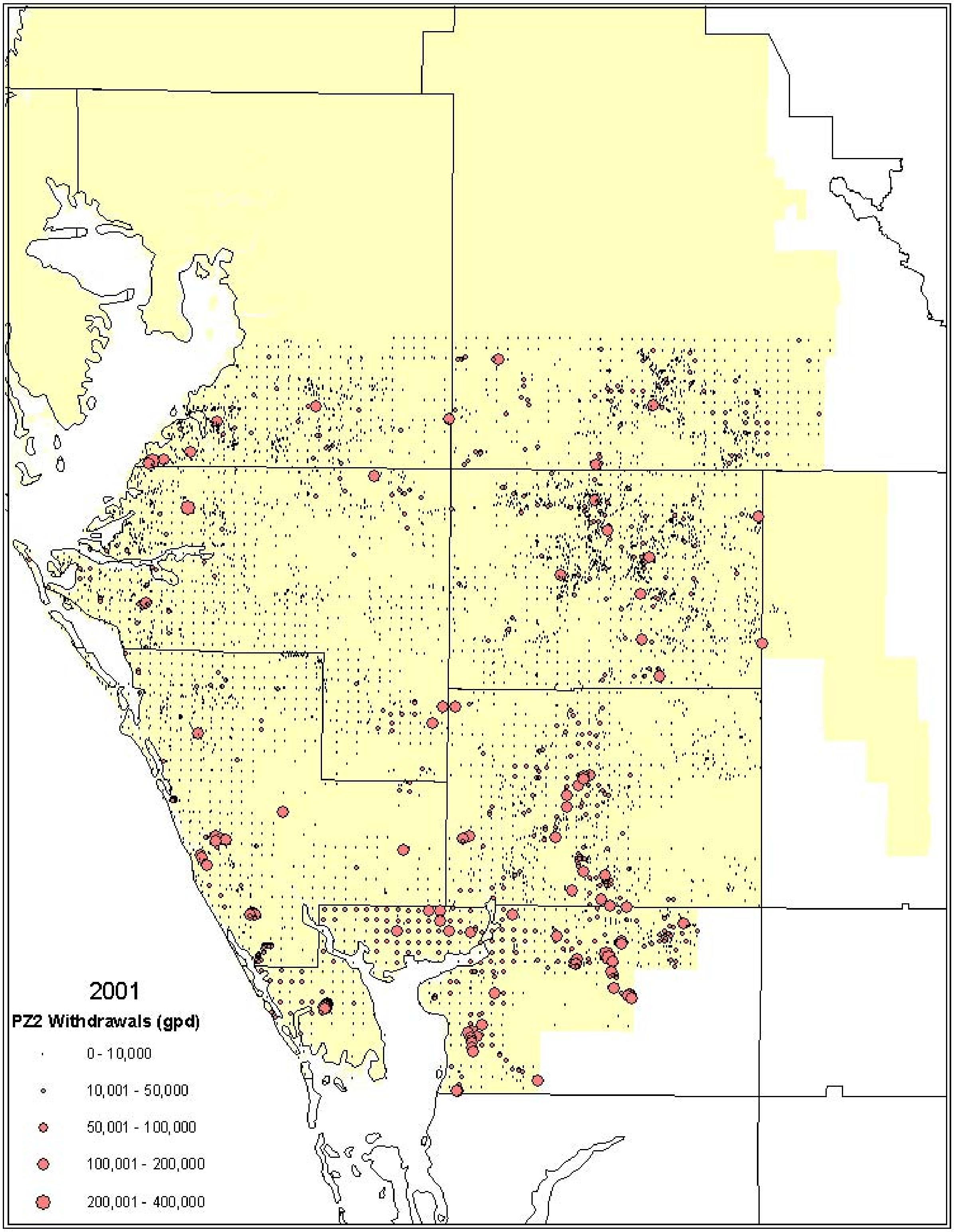

Figure 45. Geographic distribution of IAS PZ 2 withdrawals (units in gallons per day).

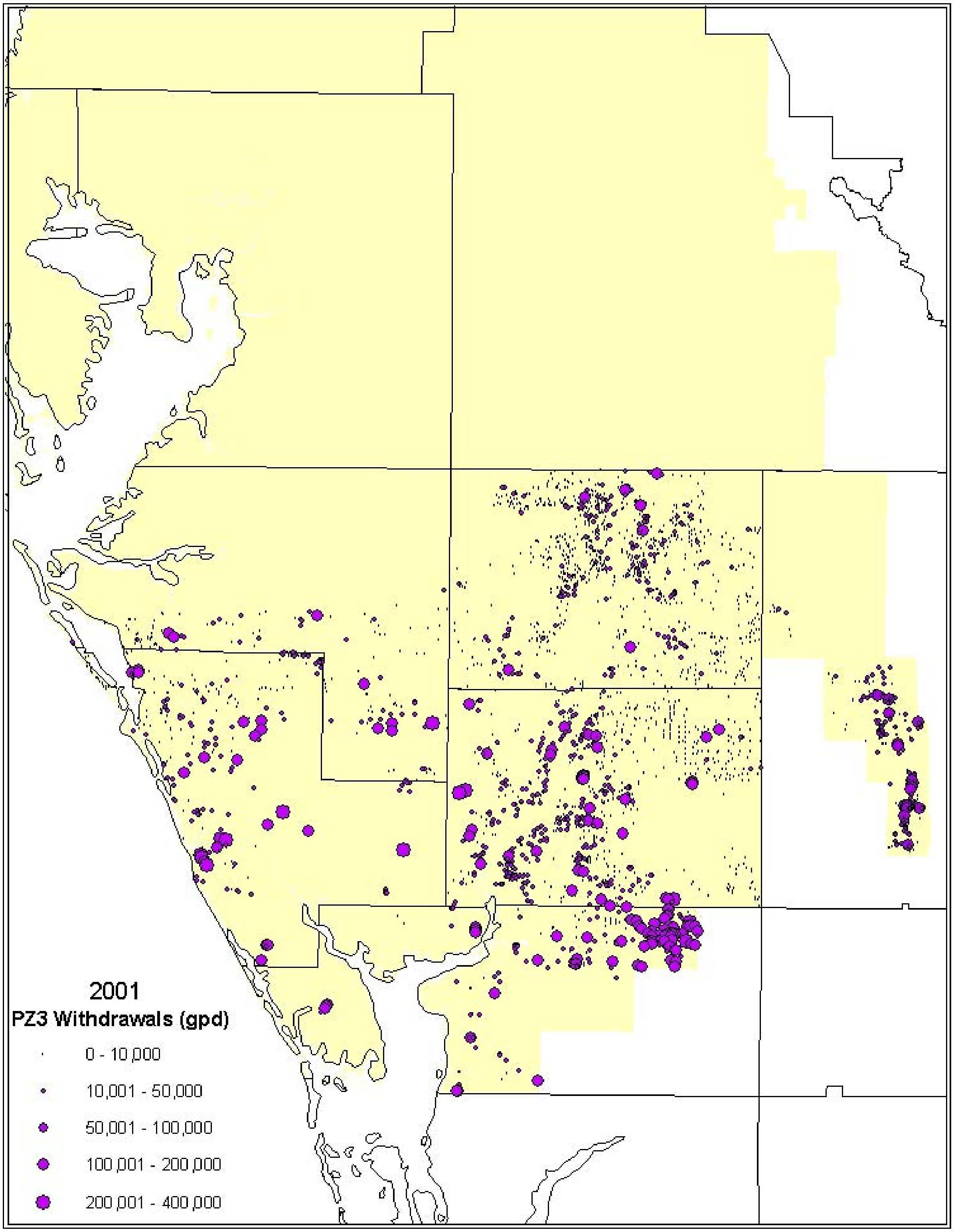

Figure 46. Geographic distribution of IAS PZ 3 withdrawals (units in gallons per day).

3.4.1 Scenario 1

In the first scenario, existing 1993 PZ 2 withdrawals in the SD Model were increased by a factor of 1.65 to add an additional 35 mgd of withdrawals. Model predictions showed more than five feet of drawdown for PZ 2 in northwest Sarasota County, southwest Manatee County, central Hardee County, and central DeSoto County (Figure 47). Elsewhere in the SWCFGWB, predicted drawdown was less than two feet. In a variation of scenario 1, groundwater withdrawals were split with 19 mgd from PZ 2 and 16 mgd from PZ 3 (Scenario 1A). The predicted drawdown for PZ 2 occurred in the same areas, but was less with two separate five-foot drawdown contours in northwest Sarasota-southwest Manatee County along with small five-foot cones of depression in central Hardee County (Figure 48). Predicted drawdown in PZ 3 was confined to an area between two and five feet located in coastal Charlotte and Sarasota counties (Figure 49).

3.4.2 Scenario 2

The second scenario consisted of evenly distributing withdrawals over the areal extent of PZ 2 within the SWCFGWB. Approximately 9,000 gallons per day (gpd) was withdrawn from each model cell over a total of 4,077 cells. The geographic distribution of withdrawals covered the extent of PZ 2 identified in Figure 6. Model predictions showed drawdown of two to five feet within PZ 2 over a large area that includes most of Manatee County, Hardee County, the north half of Sarasota County, and part of DeSoto County (Figure 50). A small area of drawdown greater than five feet was located in southeastern DeSoto County. Elsewhere, predicted drawdown was less than two feet.

3.4.3 Scenario 3

In the third scenario, a rough grid pattern was developed in both PZ 2 and PZ 3 whereby withdrawals were evenly spaced about five to ten miles apart. In the SD model, permeability in PZ 2 is greater in the southern-part of the District from central Sarasota County to central DeSoto County and southward. In this area, withdrawals of one mgd were applied to 13 cells scattered throughout the area. Further north, permeability of PZ 2 is much lower, and withdrawals of 0.2 mgd were simulated at 35 cells over the remainder of the basin. In PZ 3, 15 cells with withdrawals of one mgd each were simulated in a general arc from southern Sarasota County through DeSoto and Hardee counties.

Total withdrawals were 20 mgd from PZ 2 and 15 mgd from PZ 3. The results of this scenario depicted small "bulls eyes" of drawdown ranging from two to 10 feet in PZ 2 and from two to five feet within PZ 3 (Figures 51 and 52). A couple of small cones-of-depression greater than five feet were located in southwest Sarasota County in PZ 3.

3.4.4 Assessment of Model Scenarios

From a regional water resources perspective, it appears that all three water use scenarios could take place without causing significant degradation in natural systems or regional saltwater intrusion. These predictions represent an over-estimate of the areal extent of drawdown since the regional flow model assumes equivalent porous media throughout the model domain whereas the individual water-bearing zones of the IAS are discontinuous and localized. Currently, about 70 mgd is withdrawn from the IAS. Increasing these withdrawal quantities by 50 percent over 20 years would certainly lead to lower IAS water levels – with the groundwater flow model showing declines varying from less than two feet to more than 10 feet. In very local areas, withdrawals in PZ 2 could lower water levels up to 15 feet (Figure 51). Because the IAS producing zones are generally low in permeability, tightly-confined, and are often made up of discontinuous thin zones of limestone, sand, gravel, and dolostone, the effects of withdrawals tend to be "local", on the order of a few square miles. The results of scenario three illustrate this condition. If individual withdrawals are

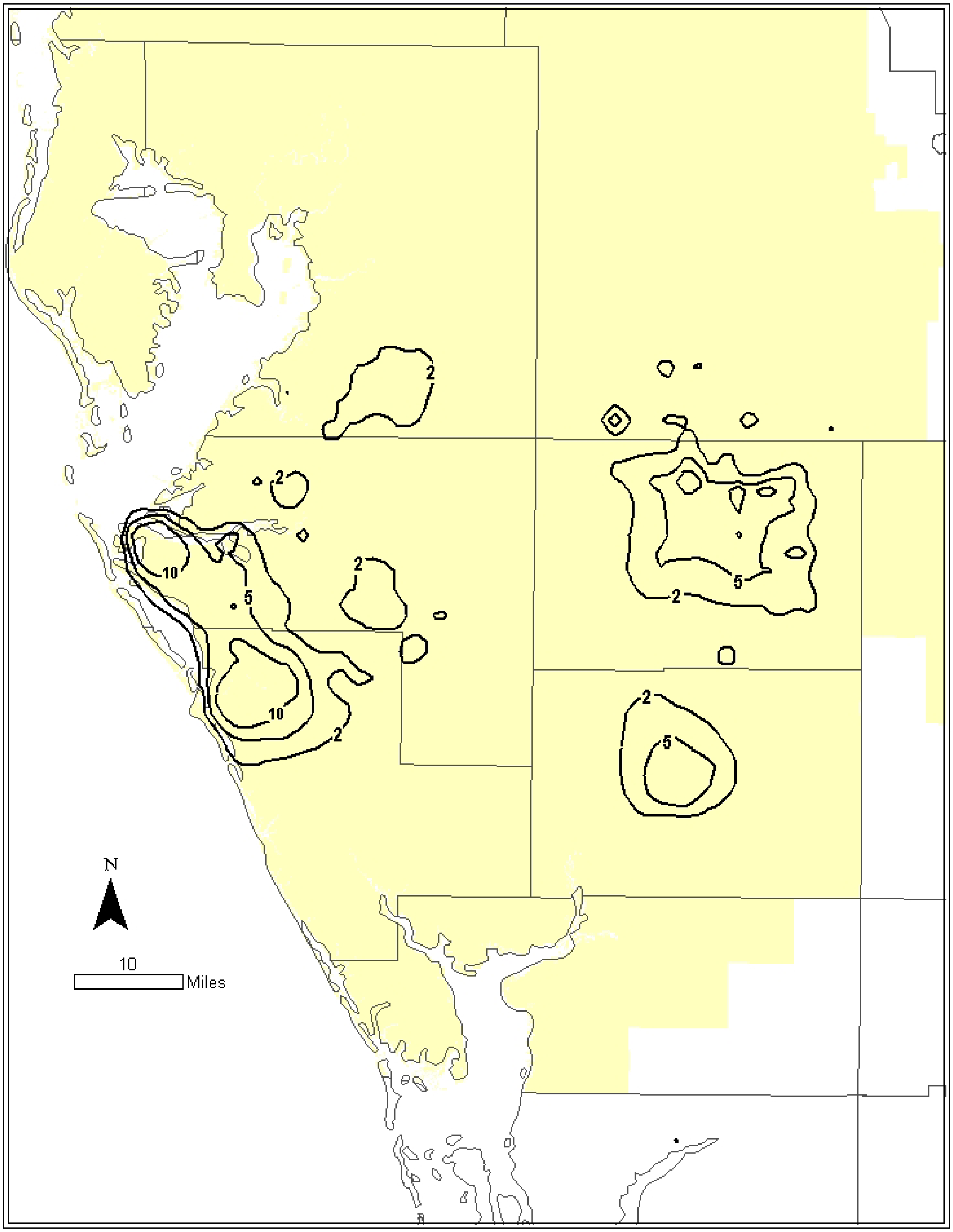

Figure 47. Predicted drawdown (in feet) in PZ 2 from 35 mgd of withdrawals (Scenario 1).

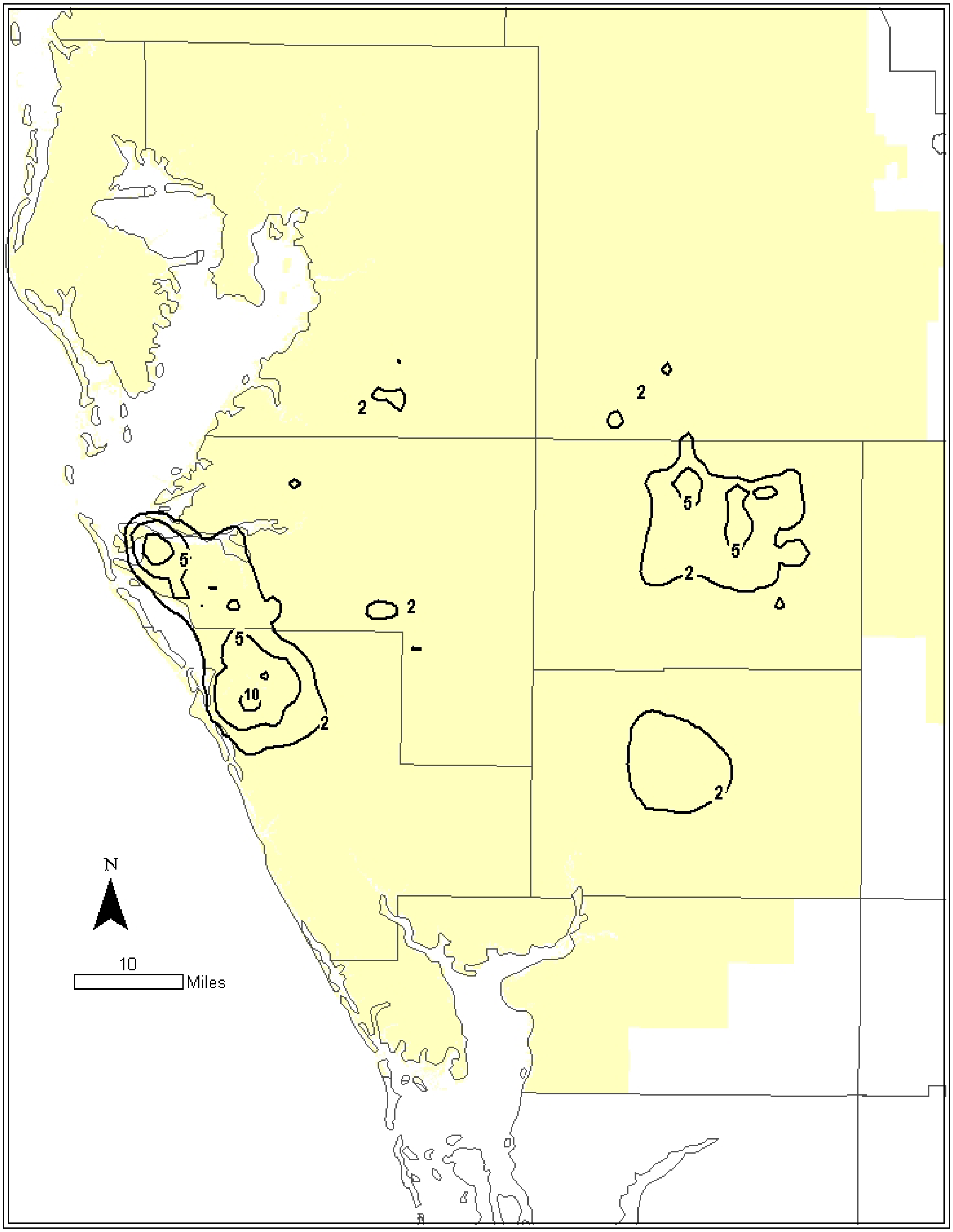

Figure 48. Predicted drawdown (in feet) in PZ 2 from 19 mgd of withdrawals (Scenario 1A).

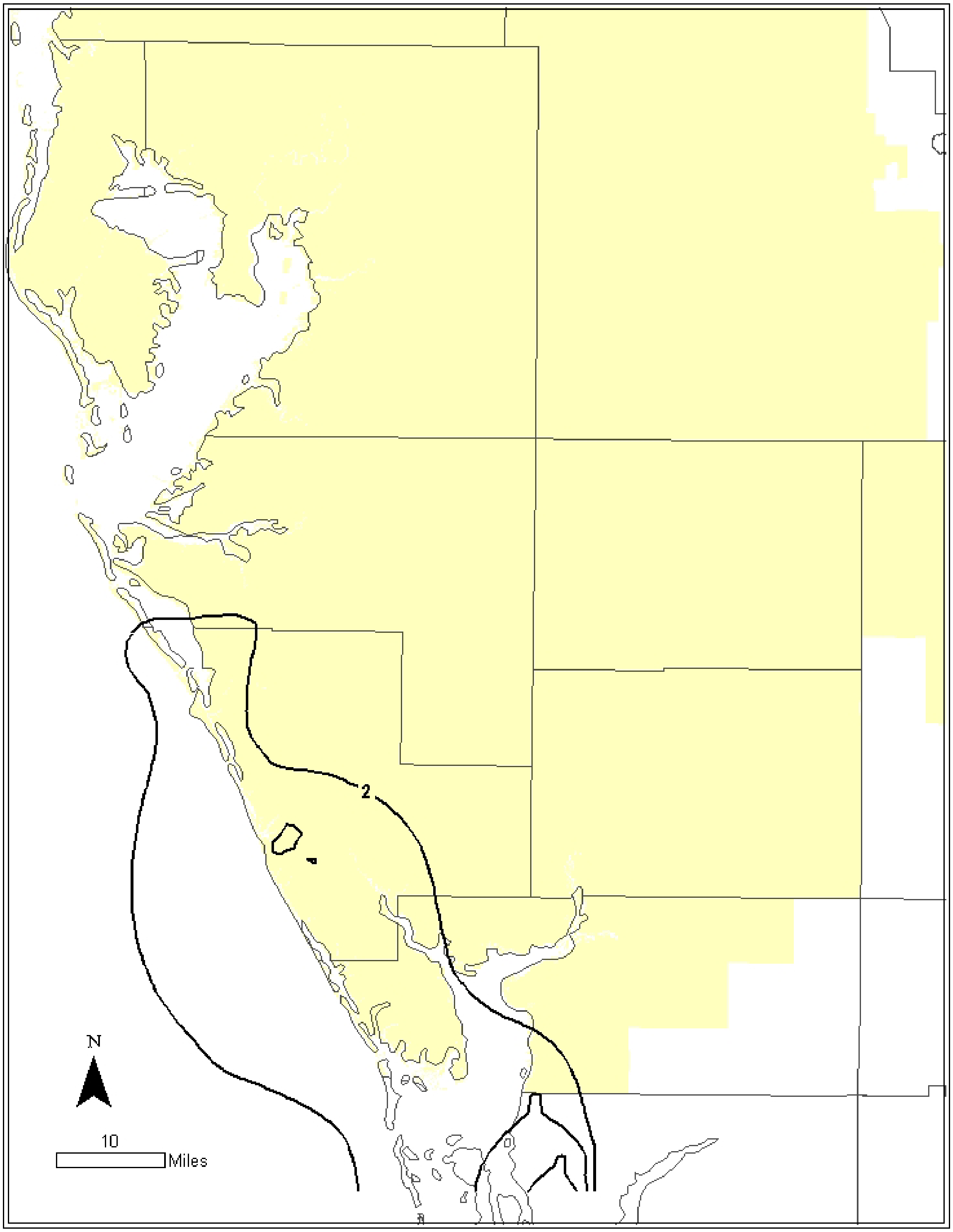

Figure 49. Predicted drawdown (in feet) in PZ 3 from 16 mgd of withdrawals (Scenario 1A).

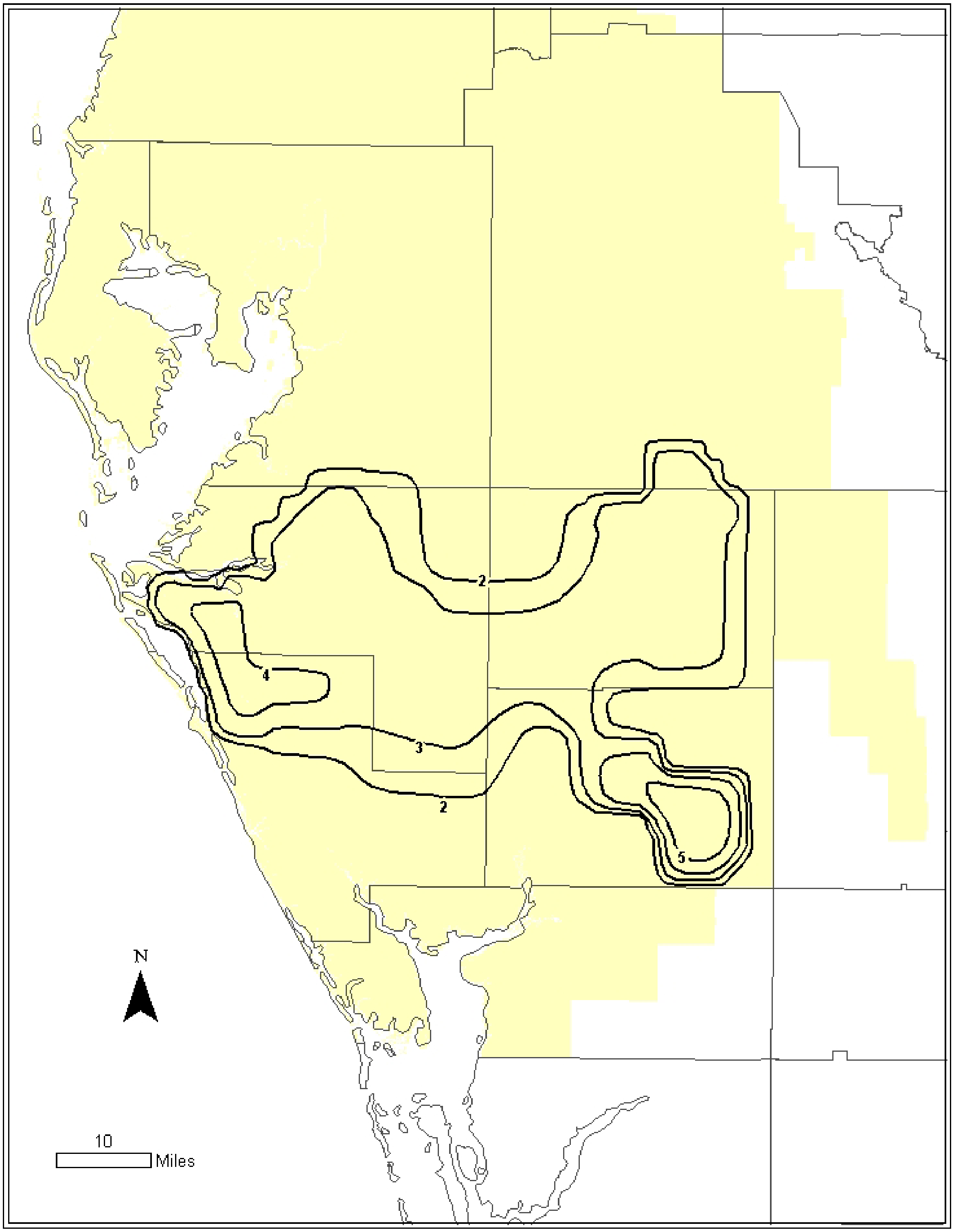

Figure 50. Predicted drawdown (in feet) in PZ 2 from 35 mgd of withdrawals evenly distributed over 4,077 model cells (Scenario 2).

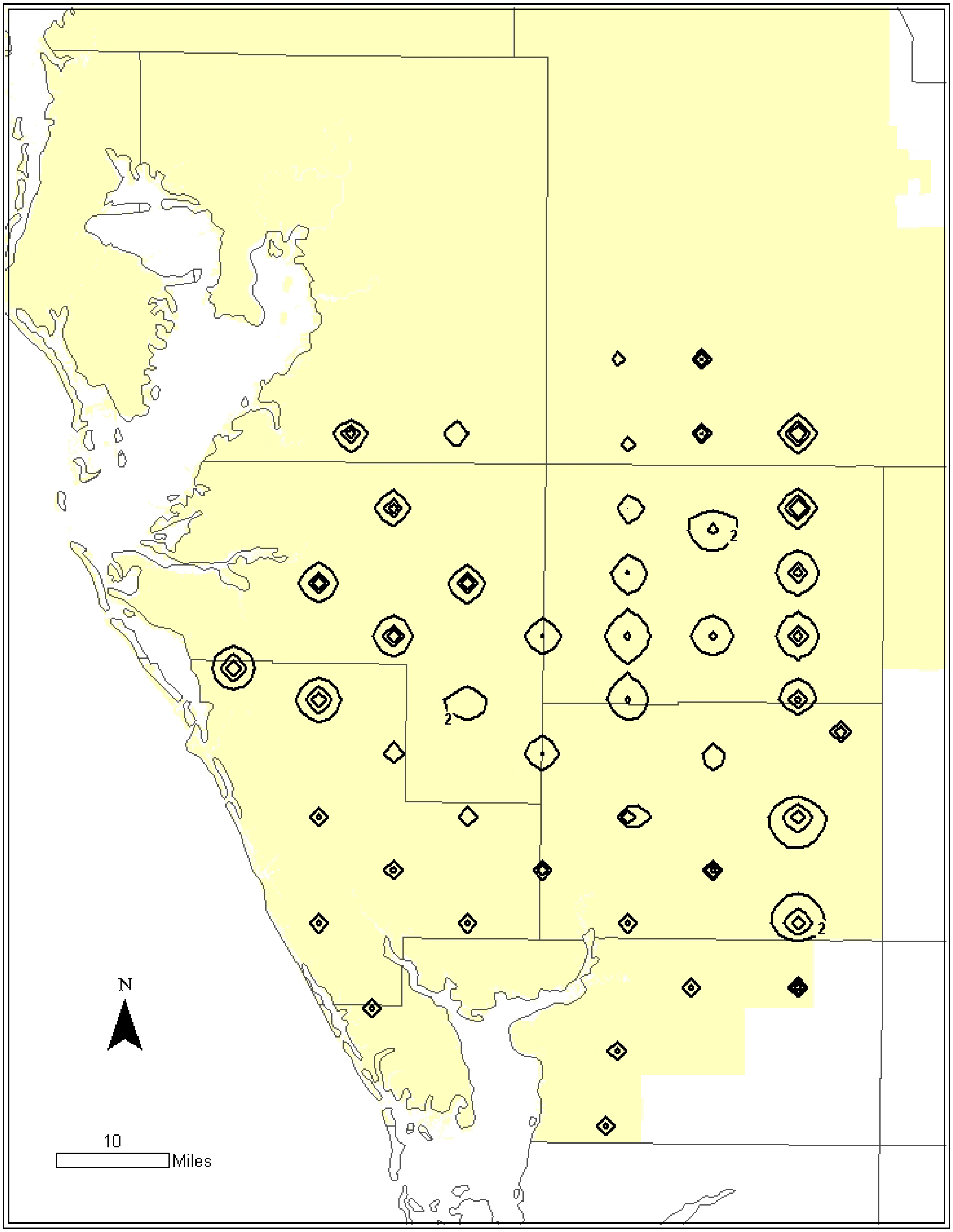

Figure 51. Predicted drawdown (contour interval 2, 5, 10, and 15 feet) in PZ 2 from 20 mgd of withdrawals (Scenario 3).

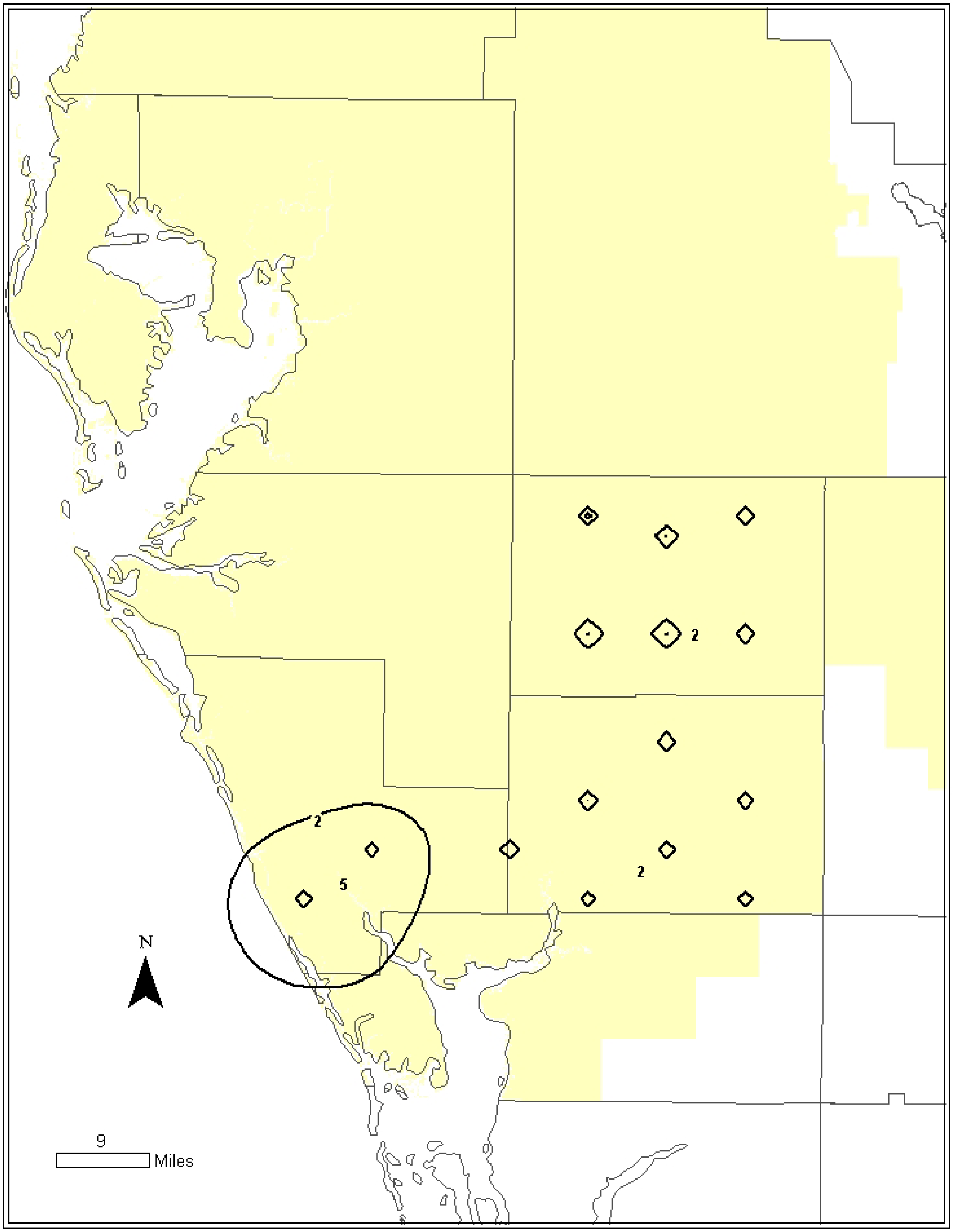

Figure 52. Predicted drawdown (in feet) in PZ 3 from 15 mgd of withdrawals (Scenario 3).

dispersed and small enough in magnitude, their effect on IAS water levels is localized. This is in contrast to the UFA in the SWCFGWB where overlapping cones-of-depression have led to regional lowering of the potentiometric surface over several-thousand square miles. The low permeability within the IAS causes the cones-of-depression to be small, deep, and steeply-sided. Due to the hydraulics and geology of the system, significant regional lowering of water levels is unlikely within the IAS.

Ground water withdrawals within the IAS are somewhat self-limiting due to the low permeability of the water-bearing zones. In scenario 3, individual withdrawals were limited to 200,000 gpd (138 gallons per minute) over most of the SWCFGWB north of central Sarasota and DeSoto counties. This is because PZ 2's ability to yield water is very low. Even at these relatively modest withdrawals, drawdown at some locations exceeded 10 feet. Therefore, over most of the basin, individual withdrawals would likely be small.

On a local level, the most severe impacts to the water resources system would be water level interference with adjacent users. For larger withdrawals, the District's Water Use Permit *Basis of Review* presumes that an adverse impact to an adjacent well user would occur if drawdown equals or exceeds five feet within a confined aquifer. Clearly, in all three scenarios, there are areas, usually small, where five feet or more of drawdown is projected. In this situation, applications for individual IAS withdrawals will either be reduced under the 40D-2 Water Use Permitting rules to limit drawdown to less than five feet or the individual entity would be required to mitigate any potential impacts to off-site well users. Other water resource concerns, such as adverse impacts to surface lakes, wetlands, and streams, or significant water quality degradation, would still need to be evaluated on an individual or site-specific basis, but there is little evidence these impacts would occur given the nature of the system. Widespread or regional impacts due to IAS withdrawals do not appear likely given the hydraulic characteristics of the system and their general absence under present pumping conditions. The qualities of the IAS itself – namely a well-confined system made up of discontinuous and poorly transmissive producing zones inhibits the regional lowering of IAS water levels, thereby reducing the risk of major impacts to the environmental system.

4.0 Minimum Aquifer Level Assessment

The District has scheduled the establishment of MALs for the IAS in 2005, where it is deemed technically feasible to do so. The issue of technical feasibility for the IAS centers on the regional extent and continuity of the resource. Unlike the FAS, the IAS is comprised of thin, often discontinuous layers of limestone, dolomite, gravel, shell, sandstone, or sand that make up individual producing zones that are interbedded within thick clays. The lateral continuity of these individual zones is highly uncertain, therefore it may not be technically appropriate to establish minimum aquifer levels for this very localized system.

The process of establishing a MAL begins with identification of a resource problem, developing cause and effect relationships, and determining the consequences of different courses of action. Once an understanding of the problem has been developed, a decision is made on what is an acceptable level of impact. This report provides technical support for our current understanding of the nature of the resource, extent of any resource problems, and recommendations regarding the need to develop minimum aquifer levels for the IAS.

4.1 Discussion of the Status of the Resource

A review of current monitoring data indicates that while there have been local or sub-regional water level declines within the IAS of up to 13 feet, there is little evidence of widespread or regional degradation of natural systems or water quality. Over the long-term, water levels within PZ 2 and PZ 3 in coastal Sarasota County and portions of Charlotte County have declined three-to-five feet since the late 1960s based on monitor wells in the area. In the Osprey area and parts of northwest

Sarasota County, long-term declines in IAS water levels have exceeded 10 feet. Based on the District's regional water quality monitoring network, these declines have not led to significant water quality degradation due to saltwater intrusion. Approximately three-quarters of the District's network wells show no significant trends in chloride or sulfate parameters which are key precursors for detection of saline water intrusion. There are some local changes in water quality, with the remaining 25 percent of wells showing about an equal number with increasing trends and an equal number with decreasing trends. Often wells with increasing trends are located adjacent to wells with decreasing trends – thereby illustrating the localized nature of changes in aquifer water quality. These localized changes in water quality are consistent with the predictions of saltwater intrusion models completed for the SWUCA (SWFWMD, 1993; 2002). The models showed no regional saltwater intrusion over the next 50 years in either the IAS or the Suwannee Limestone of the UFA, mainly due to the lower permeability of these units compared with the highly transmissive Avon Park Formation.

The most significant impact from IAS withdrawals is the localized reduction of water levels that can possibly adversely affect the ability of a nearby well to produce water. In 1999, numerous complaints regarding dry wells in the Osprey area of Sarasota County prompted an investigation into IAS water use. That study, entitled *Investigation of Water Use from the Intermediate Aquifer System in Sarasota County* was co-funded by the District and Sarasota County and completed in September 2000 (Missimer and Associates, Inc., 2000). In that study, the consultant concluded that historic drawdown in PZ 2 ranged from three to 10 feet in coastal Sarasota County and was due primarily to the combined withdrawals from a high density of individual domestic self-supply and irrigation wells. Projected additional drawdown over the next 10 years was about two feet. Well production problems occurred when aquifer water levels were at their seasonal lows during the spring dry season. Less than one percent of the total number of wells routinely failed on an annual basis. The majority of reported problems were related to lift pumps and older, small diameter wells (less than four-inches). It was concluded that constructing larger diameter wells that utilize submersible pumps could eliminate all of the failures. As an option in areas with concentrated withdrawals and large numbers of small-diameter wells, public supply lines could be extended to offer an alternative to well supply.

In the future, there is the possibility of small sub-regions where well interference caused by the cumulative effect of all users could impact the ability to obtain water from PZ 1 or PZ 2 of the IAS. Due to the low permeability of the upper zones, water levels can decline substantially on a local basis and reach seasonal lows during the spring dry season. For the foreseeable future, those declines should not seriously impact larger diameter wells (four inches or greater) that use submersible pumps. However, there is the potential to impact older two-to-three inch diameter wells that still utilize lift-type pumps for production. The highest probability of this situation occurring is in Sarasota County, where rapid development and competitive-use is occurring from relatively high densities of domestic wells. The Sarasota County Health Department issued over 2,000 permits for domestic wells in the North Port area alone in 2004.

4.1.1 Sarasota County Well Complaints (2000-2004)

Since the completion of the study of IAS water use in Sarasota County in 2000, a review of well complaints was undertaken to determine if any significant changes had occurred that altered or modified the conclusions of the earlier report. Since 1999, the Sarasota County Health Department (SCHD) has maintained a rapid response team that investigates individual well complaints and records pertinent information concerning the nature of the complaint in a database.

A total of 199 well complaints were received by the SCHD during the five-year period from 2000-2004 (Figure 53). Approximately 91 percent (182) were related to water production problems. The remaining 17 complaints were either mechanical, water quality, well construction, or unknown type of problems. Of the production related complaints, the vast majority (103) occurred in the year

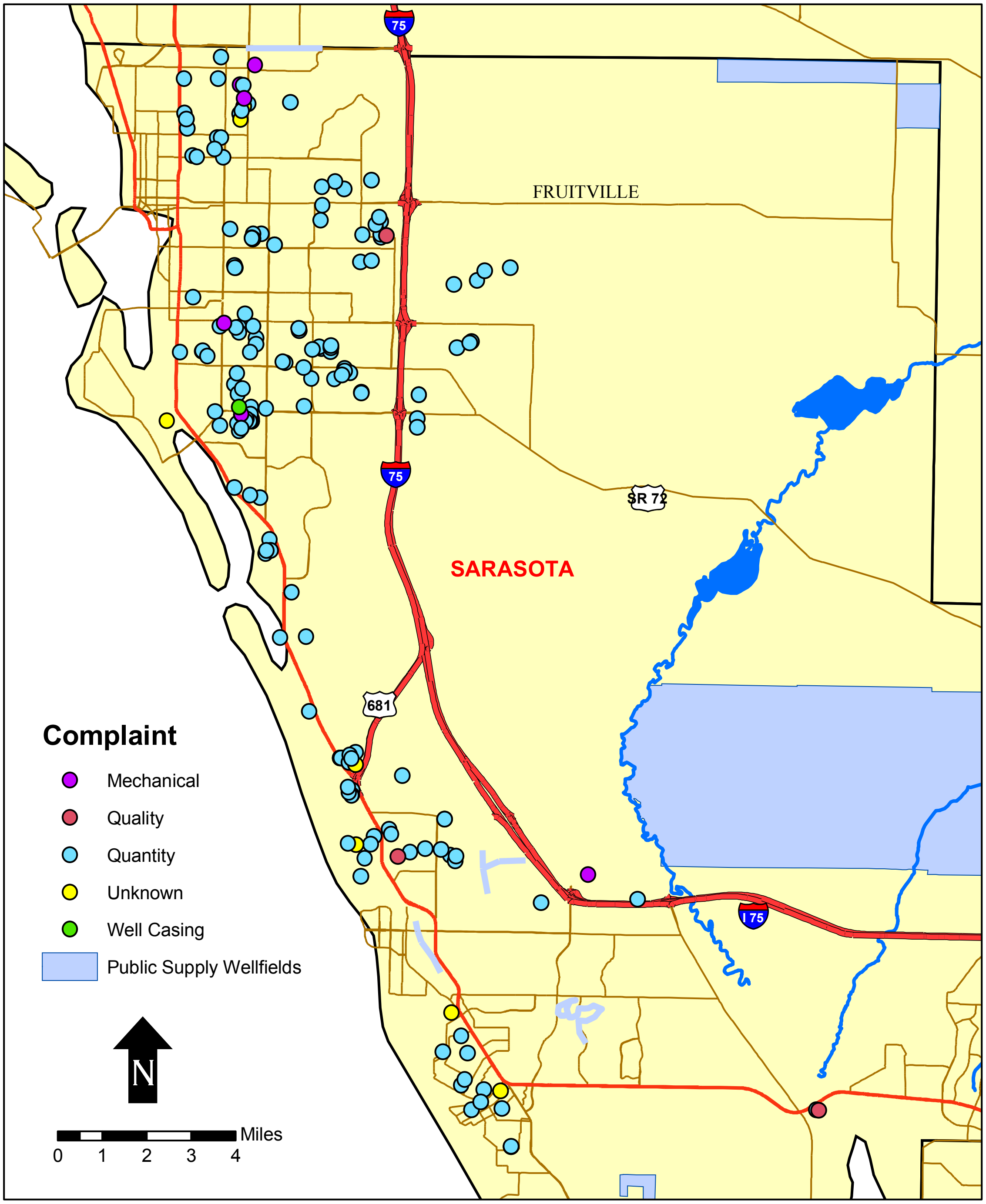

Figure 53. Location of well complaints recorded by the Sarasota County Health Department from 2000-2004.

2000, during an extreme drought period (Figure 54). Well production complaints have subsequently declined with 32 in 2001, 47 in 2002, and no production related complaints recorded during the years of 2003 and 2004.

Where pump type was known, 96 percent of the production problems were attributed to non-submersible pumps (Figure 55). Where the size of the well was recorded, nearly 80 percent of the production complaints occurred from wells that were either two or three inches in diameter. Approximately 91 percent of the production complaints (165) were recorded during the spring dry season months of April, May, and June. Based on the aforementioned data, the history of well complaints compiled by the SCHD over the last five years reaffirms the conclusions reached in the 2000 IAS water use study - that production problems are mostly limited to a small number of wells with lift-type pumps that occur during the spring dry season.

4.2 Recommendation Concerning MAL Establishment

While ground water withdrawals have led to localized water level declines in the upper and lower zones of the IAS, there is no evidence to suggest either regional lowering of IAS water levels or serious degradation in aquifer water quality or natural systems. The low permeability and often discontinuous producing zones within the IAS inhibit widespread or regional impacts to the system. Due to this nature, there is little technical justification for establishing MALs to protect against regional saltwater intrusion or large scale degradation to natural systems – because it doesn't exist now and is unlikely to occur in the future.

The most serious issue regarding groundwater withdrawals from the IAS is local or sub-regional lowering of water levels due to the cumulative effect of mostly high density domestic wells. There are over 28,000 domestic self-supply and home irrigation wells in Sarasota County west of Interstate 75. In the past, there have been production-related problems in portions of the coastal zone due to the cumulative impacts from these wells. These historically have been manageable through the replacement of older, small diameter wells with lift-type pumps by the drilling of four-inch diameter wells with submersible pumps. In addition, public assistance efforts by Sarasota County have reduced or lessened the impact on affected users through the formation of a county-wide rapid response team to investigate complaints, importation of water tankers to effected areas, and drought-related lawn watering restrictions. Over the long-term, plans for adding connections to public supply utilities and the elimination of permits to construct two and three-inch diameter water supply wells have all made significant contributions toward management of this issue. The SCHD has recently completed a household well survey in the city of North Port as a proactive measure to avert any potential issues related to water production in this rapidly growing area.

The setting of minimum levels by the District has historically been for the protection of natural systems and to ensure sustainability of the resource by reducing the rate of regional saltwater intrusion. It is not recommended that MALs be established for the protection of existing well users. Other measures, both regulatory and non-regulatory, can be implemented to alleviate this concern. Under Chapter 40D-2 rules, adverse impacts to existing well users are prohibited unless mitigated by the applicant. In the situation of high density household wells, well construction permitting has been delegated to Sarasota County or as with other counties, is regulated by the District. If the cumulative impacts due to a high density of domestic wells develops into a serious water supply problem, special rule changes within the 40D-3 construction code could be implemented or other non-regulatory means such as extending public supply service to an affected area could be undertaken by the county to ensure public health and safety. At the present time, there is no evidence to suggest any imminent or serious water supply problems that are likely to occur in any part of the SWCFGWB. In Sarasota County, which currently has the highest density of domestic wells used for water supply, there were no production related complaints recorded during 2003 and 2004.

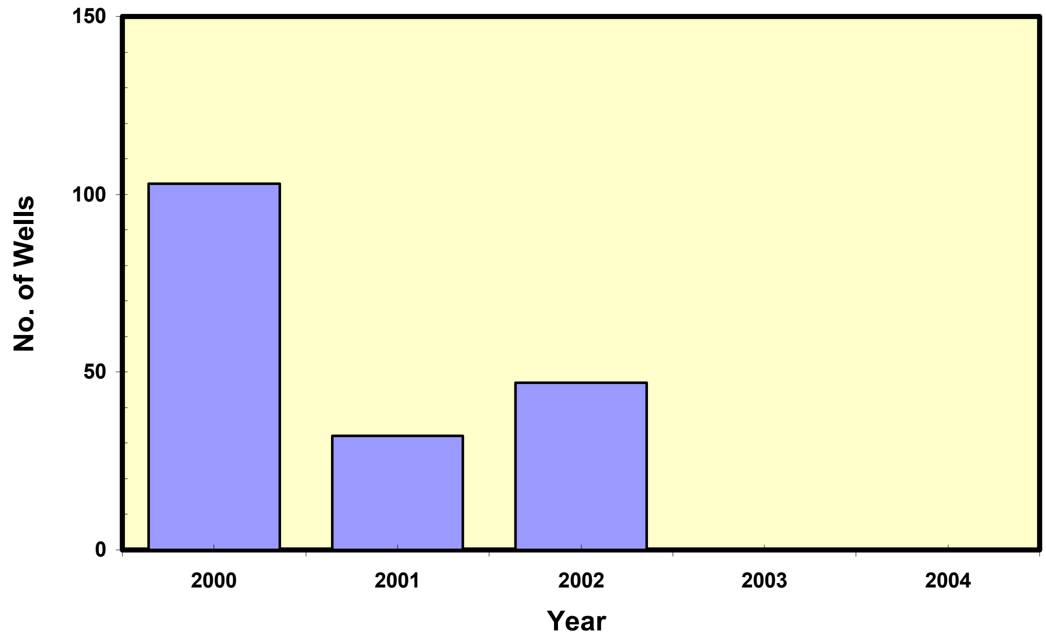

Figure 54. Number of well production complaints recorded each year by the Sarasota County Health Department from 2000-2004.

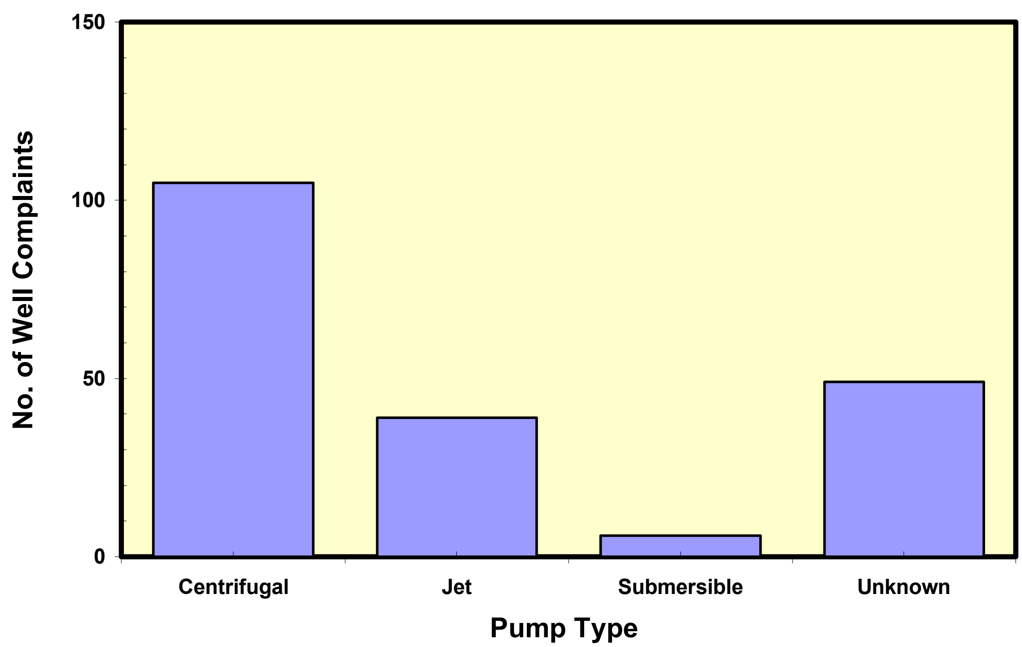

Figure 55. Type of pump associated with well production complaints recorded each year by the Sarasota County Health Department from 2000-2004.

To minimize any future concern over water supply, it is recommended that the District and Sarasota County develop an IAS management plan that includes: 1) analyzing and monitoring changes in aquifer water levels and water quality through additional data collection and installation of monitor wells, 2) the development of a countywide IAS real-time monitoring system, 3) continued recording of well complaints, 4) increased water conservation, 5) expansion of reuse water for irrigation, and 6) regular meetings through the IAS Technical Advisory Committee. It is also recommended that the District re-evaluate the water resources of the IAS at five-year intervals within the framework of the regional water supply plan to continually monitor and update forecasting of future impacts to the system.

5.0 Summary and Conclusions

The District has scheduled for adoption in 2005 minimum aquifer levels (MALs) for the intermediate aquifer system (IAS) where deemed technically feasible. The issue of technical feasibility centers on the regional extent and lateral continuity of the resource. The IAS was added to the MFL schedule because of concerns over declining aquifer levels and water quality deterioration in the coastal area of Manatee, Sarasota, and Charlotte counties.

The IAS is located within the Southern West-Central Florida Ground-Water Basin (SWCFGWB). In general, the geology within this area consists of a series of clastic sediments underlain by carbonate rocks. There are three recognized aquifer systems. At the surface and extending up to several tens of feet thick is the unconfined surficial aquifer system (SAS). It is generally comprised of unconsolidated quartz sand, silt, and clayey sand. Underlying the SAS is the confined IAS, which consists of a series of thin, interbedded limestone and phosphatic clays of typically low permeability. The third aquifer system, which underlies the IAS, is the confined FAS. It is composed of a series of limestone and dolomite formations.

In descending order, the units of the IAS are described as follows: the uppermost producing zone of the IAS is Permeable Zone 1 (PZ 1), which consists primarily of thin limestone, dolomite, sand, and phosphatic gravel (Barr, 1996). Water level fluctuations in the aquifer closely follow those of the surficial aquifer and for that reason it has often been referred to as the "lower water table aquifer". The aquifer is of limited extent and only exists in coastal sections of southwest Manatee and Sarasota counties. Permeable Zone 2 (PZ 2) generally occurs within the Peace River Formation or upper parts of the Arcadia Formation within the Hawthorn Group and is comprised of discontinuous thin zones of limestone, sand, gravel, shell, and dolostone. PZ 2 appears to be the most geographically extensive zone within the intermediate system in that water-producing intervals can be defined in most of the SWCFGWB. However, the lateral continuity of the zone is problematic because the producing zones are thin, poorly productive, and imbedded within a clay matrix. Since the permeability is quite low, PZ 2 may function hydrologically as a localized aquifer. Permeable Zone 3 (PZ 3) is mostly composed of limestone interbedded with sand and clay that is represented by the Tampa Member or Nocatee Member of the Hawthorn Group or undifferentiated Arcadia Formation. Beginning in central Manatee and southern Polk counties, the base of the Tampa or Nocatee Member becomes mixed with clayey sand or sandy clay which forms the semi-confining bed between the PZ 3 unit and the Upper Floridan aquifer. PZ 3 most closely follows stratigraphic horizons of all the producing zones within the IAS.

The permeability of the upper zones of the IAS, PZ 1 and PZ 2, is quite low. PZ 3 is slightly more permeable, with average hydraulic conductivity values similar to the SAS. For the most part, the ability of the aquifer(s) to yield water in the IAS is low, with hydraulic conductivity values 10 to 100 times less than the underlying Upper Floridan aquifer. Generally, PZ 2 of the IAS is tightly confined which limits hydraulic interaction with the SAS or underlying aquifers. The hydraulic connection between PZ 3 and the UFA is generally moderate-to-good due to the absence of thick clays that are found between the other units.

In general, water quality of PZ 2 is better than the underlying PZ 3 unit. Except for very near the coast in Sarasota and Charlotte counties, PZ 2 water quality is potable with respect to solute concentrations associated with saltwater intrusion or mineralization. Chloride concentrations are generally less than 250 mg/l except near Venice Beach, southeastern Sarasota County, and the Charlotte Harbor area. The water quality of PZ 3 is more mineralized than the overlying PZ 2 unit. Chloride concentrations exceed the potable limit in southern Sarasota County, southwestern DeSoto County, and nearly all of Charlotte County.

Annual water levels in 2003 were above the period-of-record median values for nearly 80 percent of the PZ 2 monitor wells. For PZ 3, 2003 annual water levels were above the period-of-record median values for nearly 85 percent of the monitor wells. Over the last nine years, the majority of wells in both PZ 2 and PZ 3 have shown increases in water levels. There was no apparent spatial pattern of wells that declined in PZ 2. For PZ 3, water level declines over the last nine years were from wells located from central Sarasota and DeSoto counties southward. Over the last 30 years, IAS water levels have declined from three-to-five feet in coastal Sarasota County and portions of Charlotte County with locally more than 10 feet in northwest Sarasota County.

The results of a trend analysis of PZ 2 and PZ 3 water quality showed that though concentrations have changed for some coastal intermediate wells, the changes are not regional. About three-quarters of the monitor wells showed no statistically significant trend in chloride or sulfate parameters. Of the remaining 25 percent, about half had increasing trends and the other half had decreasing trends. Wells with increasing trends were located relatively close to wells with decreasing trends. Therefore, the water quality changes in PZ 2 and PZ 3 appear to be localized. Many inland wells do not demonstrate major water quality changes at this time.

As of 2001, approximately 70 mgd of ground water is withdrawn from the IAS within the SWCFGWB. IAS withdrawals represent about 10 percent of total groundwater withdrawn in the basin. PZ 2 withdrawals were 29 mgd and PZ 3 withdrawals were 41 mgd in 2001. Roughly two-thirds of IAS ground water withdrawals occur in Charlotte, DeSoto, and Sarasota counties.

The SWUCA Recovery Plan indicates that the IAS and surficial aquifer together are capable of providing up to 35 mgd of water to meet growing demand over the next 20 years. To determine if these quantities are sustainable in the IAS, several withdrawal scenarios were developed across the SWCFGWB using the SD groundwater flow model. The three major scenarios included: 1) adjusting upward the current distribution of major IAS withdrawals, 2) equally distributing the withdrawals over cells that cover the IAS, and 3) placing major withdrawals in a rough grid pattern that is evenly spaced throughout the basin.

The results from the flow model scenarios indicate that from a regional water resources perspective, 35 mgd of additional groundwater withdrawals could take place without causing significant degradation in natural systems or lowering of water levels that would lead to widespread saltwater intrusion. Increasing IAS withdrawal quantities by 35 mgd over 20 years would lead to lower IAS water levels – with the groundwater flow model showing declines varying from less than two feet to more than 10 feet. In very local areas, withdrawals could lower water levels up to 15 feet. Because the IAS producing zones are generally low in permeability, tightly-confined, and are often made up of discontinuous thin zones of limestone, sand, gravel, and dolostone, the effects of withdrawals would be "local," on the order of a few square miles. The low permeability within the IAS causes the cones-of-depression to be small, deep, and steeply-sided. Due to the hydraulics and geology of the system, significant regional lowering of water levels is unlikely within the IAS.

A review of current monitoring data indicates that there have been local or sub-regional water level declines within the IAS of up to 13 feet. In the future, there is the possibility of small sub-regions where well interference caused by the cumulative effect of all users could impact the ability to obtain water from the PZ 1 or PZ 2 unit of the IAS. Due to the poor ability to yield water from the upper zone, water levels can decline substantially on a local basis and reach seasonal lows during the spring dry season. For the foreseeable future, those declines should not seriously impact larger diameter wells (four inches or greater) that use submersible pumps. However, there is the potential to impact older two-to-three inch diameter wells that still utilize lift-type pumps for production. The highest probability of this situation occurring is in Sarasota County, where rapid development and competitive-use is occurring from relatively high densities of domestic wells. During the five-year period from 2000-2004, a total of 199 well complaints were received by the SCHD. Approximately 91 percent (182) were related to water production problems. Of the production related complaints, the vast majority (103) occurred in the year 2000, during an extreme drought period. Well production complaints have subsequently declined with 32 in 2001, 47 in 2002, and no production related complaints recorded during the years of 2003 and 2004. Where pump type was known, 96 percent of the production problems were attributed to non-submersible pumps. Where the size of the well was recorded, it was found that nearly 80 percent of the production complaints occurred from wells that were either two or three inches in diameter. Based on the aforementioned data, the history of well complaints compiled by the SCHD over the last five years reaffirms the conclusions reached in the 2000 IAS water use study completed for the District by Missimer and Associates, Inc. - that production problems in Sarasota County are mostly limited to a small number of wells with lift-type pumps.

While ground water withdrawals have led to localized water level declines in the upper and lower zones of the IAS, there is little evidence to suggest either regional lowering of IAS water levels or serious degradation in aquifer water quality or natural systems. Due to these circumstances, there is no recommendation at this time to establish minimum aquifer levels for the IAS.

The most serious issue regarding groundwater withdrawals from the IAS is local or sub-regional lowering of water levels due to the cumulative effect of mostly high density domestic wells. It is not recommended that minimum aquifer levels be established for the protection of existing well users. Other measures, both regulatory and non-regulatory, can be implemented to alleviate this concern. At the present time, there is no evidence to suggest any imminent or serious water supply problems that are likely to occur in the IAS in any part of the SWCFGWB. In Sarasota County, which currently has the highest density of domestic wells used for water supply, there were no production related complaints recorded during 2003 and 2004.

To minimize any future concern over water supply, it is recommended that the District, Sarasota County, and other local governments develop an IAS management plan to analyze and monitor changes in the water resources of the IAS. It is also recommended that the District re-evaluate the water resources of the IAS at five-year intervals within the framework of the regional water supply plan to continually monitor and update forecasting of future impacts to the system.

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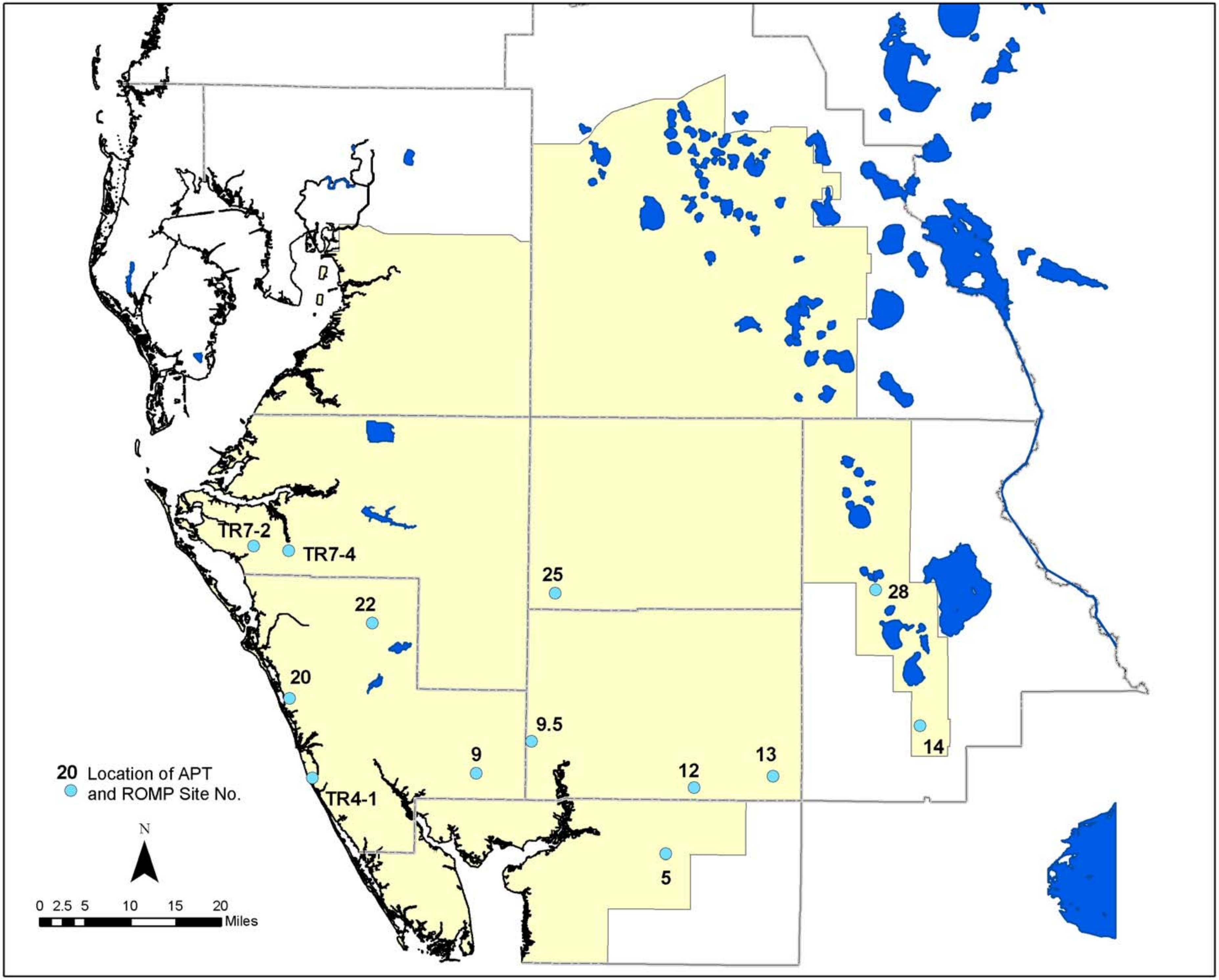
APPENDIX A



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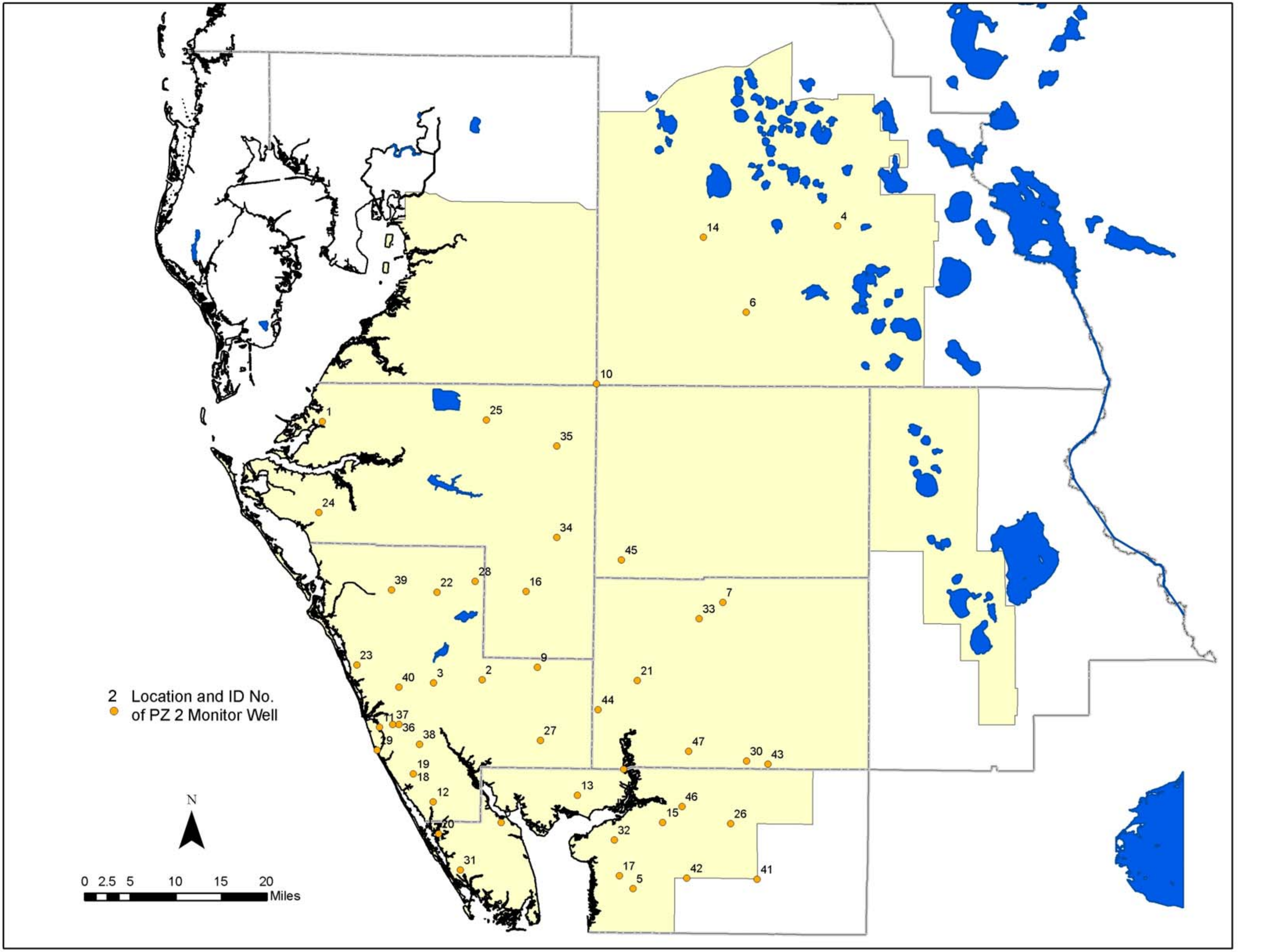
APPENDIX B

Table B-1. Summary information and 2002 water quality data from IAS PZ2 wells.

Well Name	Map Id	Latitude (decimal deg)	Longitude (decimal deg)	Land Elevation (Ft NGVD)	Casing Depth (ft)	Total Depth (ft)	2002 No. of Samples	Average Chloride Conc. (mg/l)	Average Sulfate Conc. (mg/l)
ROMP TR 3-1 HTRN 160	0	265639.42	821304.89	7.0	140	160	2	924	55
ROMP TR 8-1 UP HTRN	1	273459.66	823245.97	14.0	100	160	3	101	36
ROMP 19 EAST HTRN	2	271022.00	821515.99	31.0	80	121	3	58	165
ROMP 19 WEST HTRN	3	271001.48	822029.30	20.0	87	205	2	87	53
ROMP 57 HTRN	4	275413.04	813721.10	128.1	95	140	3	11	6
ROMP TR 1-2 UP HTRN	5	265025.35	815853.37	27.6	218	255	2	373	155
ROMP 45 HTRN	6	274551.27	814709.84	121.6	110	192	3	5	6
ROMP 26 HTRN	7	271758.85	814928.74	75.8	140	180	3	10	38
ROMP 10 UP HTRN	8	270152.87	820000.66	20.0	130	202	2	363	153
BIG SLOUGH DEEP	9	271135.80	820920.27	36.5	78	100	3	104	77
ROMP 40 HTRN	10	273852.39	820314.73	137.9	76	180	3	52	1
VENICE 35 INT	11	270540.88	822614.04	13.3	86	163	2	112	360
ENGLEWOOD 14 DEEP	12	265835.15	822023.84	10.6	44	55	3	73	3
PORT CHARLOTTE UTIL DEEP	13	265920.50	820455.32	14.0	128	156	2	95	24
ROMP 59 HTRN	14	275302.29	815151.13	118.7	50	60	3	14	5
SR 74 DEEP	15	265647.90	815546.71	19.0	194	280	2	132	99
ROMP 23 PZ2 INT	16	271853.39	821039.21	60.0	175	250	3	7	0
PUNTA GORDA HEIGHTS INT	17	265140.01	820022.74	23.0	84	125	2	388	68
ENGLEWOOD 5 PROD ZONE INT	18	270114.76	822232.05	13.9	37	66	2	170	12
ENGLEWOOD 5 HTRN	19	270114.22	822232.34	14.0	134	152	2	801	109
ROMP TR 3-3 UP HTRN	20	265532.22	821947.33	5.8	155	175	1	966	14
ROMP 17 IAS PZ-2 INT	21	271026.00	815836.00	22.0	100	160	2	47	11
ROMP 22 ARC	22	271843.82	822011.79	34.8	95	125	3	82	43
ROMP 20 UP HTRN	23	271138.59	822845.19	19.1	75	125	3	83	577
ROMP TR 7-2 UP ARC	24	272614.04	823300.90	19.0	60	105	2	79	75
ROMP 39 ARC	25	273519.35	821505.35	125.0	130	205	3	4	0
ROMP 5 UPPER INT	26	265644.95	814828.10	40.3	130	230	3	213	35
ROMP 9 MID INT MW-3	27	270434.90	820856.06	25.0	122	163	3	416	91
ROMP 24 INT	28	271948.80	821608.01	55.0	74	171	3	23	11
ROMP TR 4-1 UP INT	29	270329.05	822628.64	5.0	30	112	3	11468	1328
PRAIRIE CRK UP INT (WQMP)	30	270244.84	814649.02	Unk	60	80	2	157	59
ROTUNDA WATER PLANT 18 IN	31	265205.11	821723.13	6.0	121	146	1	4166	480
USGS C-3 INT	32	265505.23	820055.30	20.0	153	205	3	103	8
CAMP CHANYATAH INT	33	271624.86	815159.73	20.0	43	192	3	28	176
GALLAGHER PATRICIA INT	34	272406.16	820724.30	50.0	158	250	3	5	0
ESTECH HAWTHORNE 44 INT	35	273252.07	820728.03	120.0	145	250	3	11	1
VENICE SH WF 68 INT	36	270558.28	822409.57	10.0	76	110	2	112	205
VENICE SH WF 59 INT	37	270558.41	822449.39	10.0	82	190	1	57	163
PLANTATION HTRN	38	270405.89	822154.96	10.0	66	180	1	73	29
DARNELL THOMAS INT	39	271854.17	822507.32	25.0	83	166	3	44	452
ROMP TR 5-3 UPPER INT	40	270934.13	822412.63	12.0	63	140	2	64	216
USGS TUCKERS CORNER INT	41	265125.22	814536.28	35.0	212	235	3	49	7
USGS C-1 INT	42	265129.02	815308.75	Unk	214	264	3	1183	271
ROMP 12 UP INT	43	270228.19	814431.99	41.0	54	110	3	105	57
ROMP 9.5 MW-18 UPZ INT	44	270735.59	820248.01	38.0	61	77	3	85	68
ROMP 25 ARC/IAS	45	272159.11	820025.39	85.0	105	145	2	6	2
SHELL CREEK RV PARK INT	46	265821.37	815343.38	Unk	135	195	2	557	22
ROMP 16.5 UPPER INT	47	270340.02	815302.39	10000.0	56	90	3	27	1



2 Location and ID No. of PZ 2 Monitor Well
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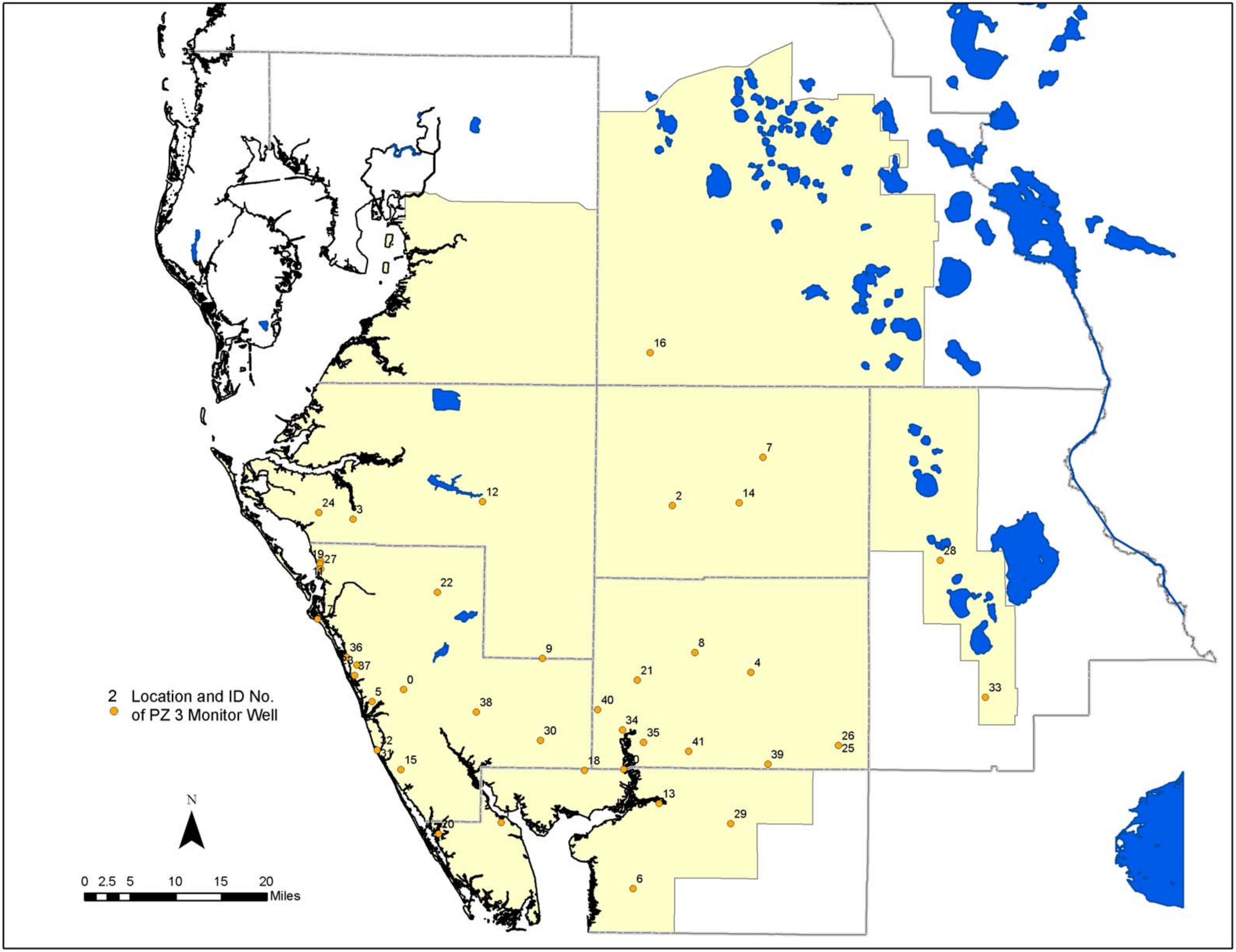
Table B-1. Summary information and 2002 water quality data from IAS PZ3 wells.

Well Name	Map ID	Latitude (decimal deg)	Longitude (decimal deg)	Land Elevation (Ft NGVD)	Casing Depth (ft)	Total Depth (ft)	2002 No. of Samples	Average Chloride Conc. (mg/l)	Average Sulfate Conc. (mg/l)
ROMP TR 5-2 LOW HTRN	0	270920.80	822341.66	15.0	245	265	3	40	1081
ROMP TR 3-1 HTRN 400	1	265639.32	821304.95	7.0	380	400	3	520	506
ROMP 31 HTRN/TMPA	2	272715.00	815458.57	78.4	130	350	1	102	82
ROMP TR 7-4 HTRN	3	272540.13	822920.68	17.0	213	268	3	36	128
ROMP 16 TMPA	4	271117.02	814624.79	64.0	300	340	3	42	13
ROMP TR 5-1 TMPA	5	270810.24	822704.87	11.6	275	289	3	33	988
ROMP TR 1-2 L HTRN/TMPA	6	265025.50	815853.22	25.0	520	600	3	909	276
ROWELL DEEP	7	273156.22	814516.81	98.1	39	267	2	10	9
ARCADIA 2 INT	8	271310.09	815226.67	29.3	263	372	3	34	107
MABRY CARLTON 6 INT	9	271228.25	820848.43	40.0	311	369	3	47	233
ROMP 10 LOW HTRN/TMPA	10	270153.31	820000.75	20.0	320	473	3	441	227
SARASOTA 27TH ST INT	11	272134.16	823246.58	6.8	45	343	2	141	717
ROMP 33 ARC	12	272728.22	821525.55	74.0	215	290	3	16	1
ROMP 11 HTRN	13	265837.67	815609.30	13.3	220	335	3	670	248
ROMP 30 TMPA	14	272733.45	814747.97	66.7	280	316	3	33	132
MANASOTA 14 DEEP	15	270138.91	822352.63	26.5	263	305	3	55	32
FORT GREEN SPRINGS INT	16	274154.68	815729.38	134.5	280	300	3	64	15
ROMP TR 6-1 HTRN	17	271601.37	823302.21	5.0	300	315	3	529	1203
PORT CHARLOTTE DEEP	18	270145.99	820413.33	25.0	312	350	1	695	290
WHITAKER BAYOU INT	19	272118.51	823250.17	9.9	54	337	2	144	166
ROMP TR 3-3 LOW HTRN	20	265532.22	821947.33	5.8	370	410	3	1870	416
ROMP 17 LOW HTRN	21	271028.49	815835.46	23.1	200	240	3	75	104
ROMP 22 ARC/TMPA	22	271843.75	822011.41	34.9	230	290	3	163	70
ROMP 20 LOW INT	23	271138.48	822845.34	21.8	250	370	3	113	1527
ROMP TR 7-2 LOW ARC	24	272614.04	823300.91	19.0	200	290	1	52	203
ROMP 13 LOW INT	25	270419.11	813658.42	61.4	514	592	3	33	26
ROMP 13 MID INT	26	270419.14	813658.26	61.4	282	417	3	30	14
ROMP TR SA-1 UP INT	27	272049.30	823245.08	6.5	328	388	3	179	460
ROMP 28 HTRN	28	272208.57	812607.38	83.0	370	420	2	13	4
ROMP 5 LOWER INT	29	265644.96	814827.87	40.6	450	600	3	694	198
ROMP 9 LOW HTRN MW-4	30	270434.83	820856.22	25.0	190	320	3	435	249
ROMP TR 4-1 LOW INT	31	270328.65	822628.30	5.0	272	645	3	229	501
ROMP TR 4-1 MID INT	32	270328.77	822628.40	5.0	121	224	3	83	28
ROMP 14 LOW HTRN	33	270859.65	812111.92	145.0	460	521	3	4	3
GDU WELL T-2 INT	34	270540.54	820010.25	Unk	393	496	2	140	234
LANE ROB (G V RUSSELL) IN	35	270429.49	815752.13	30.0	70	411	2	338	175
SARASOTA HIST SOC INT	36	271223.18	822951.33	10.0	220	450	2	40	1160
SOUTHBAY UTILITIES DEEP	37	271037.30	822857.97	15.0	220	450	2	246	1718
TEST 18 BLACKBURN INT	38	270715.19	821551.31	25.0	282	351	2	185	523
ROMP 12 LOW INT	39	270228.23	814432.32	41.0	280	409	3	77	18
ROMP 9.5 MW-8 LOWER INTER	40	270736.35	820249.87	Unk	205	330	3	95	39



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APPENDIX C

Table C-1. PZ 2 wells monitored for water level from the SWFWMD Water Management Data Base.

Well Name	Latitude (decimal deg)	Longitude (decimal deg)	Station ID	Site ID	Seq No.	Casing Depth (ft bls)	Total Depth (ft bls)	Period-of-Record
ROMP TR 3-1 HAWTHORN 270	265639.32	821304.95	2	2	0	250	270	1990-Present*
ROMP TR 5-2 UPPER HAWTHOR	270920.80	822341.66	1	3	1	100	120	1990-Present
ENGLEWOOD C-10	270037.21	822133.32	280	14	0	42	70	1978-1998
ENGLEWOOD 3 DEEP	270107.21	822140.32	284	18	0	109	135	1978-1997
ENGLEWOOD 8 PRODUCTION ZON	270113.21	822132.32	393	127	0	58	70	1979-1991
ROMP TR 8-1 UP HAWTHORN	273459.66	823245.97	5	257	0	100	160	1987-Present
ROMP 26 HAWTHORN	271758.85	814928.74	520	258	0	140	180	1978-Present
ROMP 10 UPPER HAWTHORN	270152.87	820000.66	536	288	0	130	202	1990-Present
BIG SLOUGH DEEP	271135.80	820920.27	614	348	0	78	100	1977-Present
ROMP 40 HAWTHORN	273852.39	820314.73	634	370	0	76	180	1981-Present
VENICE 35	270540.88	822614.04	676	410	0	86	163	1968-Present
ENGLEWOOD 14 DEEP	265835.15	822023.84	729	463	0	44	55	1971-Present
PORT CHARLOTTE UTIL DEEP	265920.50	820455.32	778	512	0	128	156	1967-1999
ENGLEWOOD TH6	265810.21	821939.32	814	548	0	45	65	1976-1998
SR 74 DEEP	265647.90	815546.71	832	566	0	194	280	1968-Present
PORT CHARLOTTE SHALLOW	270146.02	820413.32	932	669	0	84	89	1974-1998
PUNTA GORDA HEIGHTS	265140.01	820022.74	971	705	0	84	125	1967-Present
ENGLEWOOD 5 PRODUCTION ZON	270114.76	822232.05	989	723	0	37	66	1979-1990
ROMP TR 5-3 UP INTERMED	270934.13	822412.63	1766	1305	0	63	140	2000-Present
VENICE 36 INTERMEDIATE	270513.00	822619.00	2073	1442	0	58	68	1998-Present
LK STARR 1PNS-100 ICU	275733.10	813523.25	2804	2021	0	0	100	1996-Present
ROMP 57 HAWTHORN	275413.04	813721.10	170	10882	0	95	140	1981-Present
ROMP 57X HAWTHORN	275349.07	813354.25	16	10885	1	192	210	1988-Present
ROMP 19 EAST HAWTHORN	271022.00	821515.99	13	10937	0	80	121	1992-Present
ROMP 19 WEST HAWTHORN	271001.48	822029.30	14	10938	0	87	205	1987-Present
ROMP TR 3-1 TAMIAMI 75	265639.42	821304.89	2	10945	0	55	75	1988-Present
ROMP TR 3-1 HAWTHORN 160	265639.42	821304.89	2	10945	1	140	160	1989-Present
ROMP TR 3-3 UPPER HAWTHORN	265532.22	821947.33	1023	11071	1	155	175	1993-Present
ROMP 22 ARCADIA	271843.82	822011.79	1029	11174	0	95	125	1993-Present
ROMP 20 UPPER HAWTHORN	271138.59	822845.19	1031	11304	0	75	125	1994-Present
ROMP TR 1-2 UPPER HAWTHORN	265025.35	815853.37	229	11333	0	218	255	1993-Present
ROMP TR 7-2 U ARCADIA	272614.04	823300.90	1033	11392	0	60	105	1994-Present
ROMP TR 5-1 TAMIAMI	270810.21	822704.81	224	11425	0	40	60	1995-Present
ROMP 39 ARCADIA	273519.35	821505.35	1036	11450	0	130	205	1995-Present
ROMP 5 UP INT	265644.95	814828.10	1069	12882	0	130	230	1996-Present
ROMP 9 MID INTER MW-3	270434.90	820856.06	1070	12899	0	122	163	2000-Present
ROMP 9 UP HAWTHORN MW-2	270434.83	820856.37	1070	12948	0	40	65	2000-Present
ROMP 24 INTERMEDIATE	271948.80	821608.01	1085	12949	0	74	171	1997-Present
ROMP TR 4-1 UPPER INT	270329.05	822628.64	1087	12954	0	30	112	2000-Present
ROMP 45 SHALLOW	274551.46	814710.20	296	12957	0	38	58	1997-Present
ROMP 12 UP INTERMEDIATE	270228.19	814431.99	2075	13337	0	54	110	2000-Present
ROMP 9.5 MW-18 INTER UPZ	270735.59	820248.01	2091	13380	0	61	77	2000-Present
ROMP 17 IAS PZ-2	271026.00	815836.00	1027	17250	0	100	160	2000-Present
ROMP 25 ARCADIA/IAS	272159.11	820025.39	2188	17313	0	105	145	1999-Present
ROMP 33 INTERMEDIATE	272728.00	821530.00	564	17433	0	96	166	2000-Present
ROMP 16 INTERMEDIATE	271117.00	814625.00	221	17817	0	105	236	2000-Present

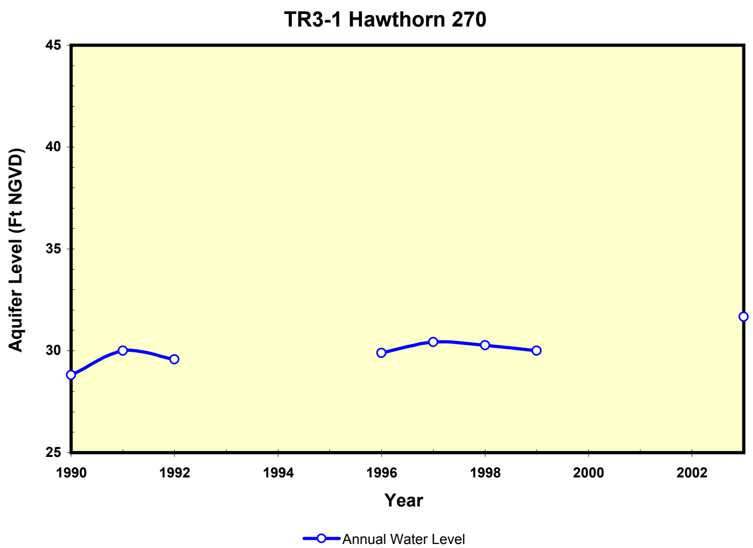
* Intermittent record

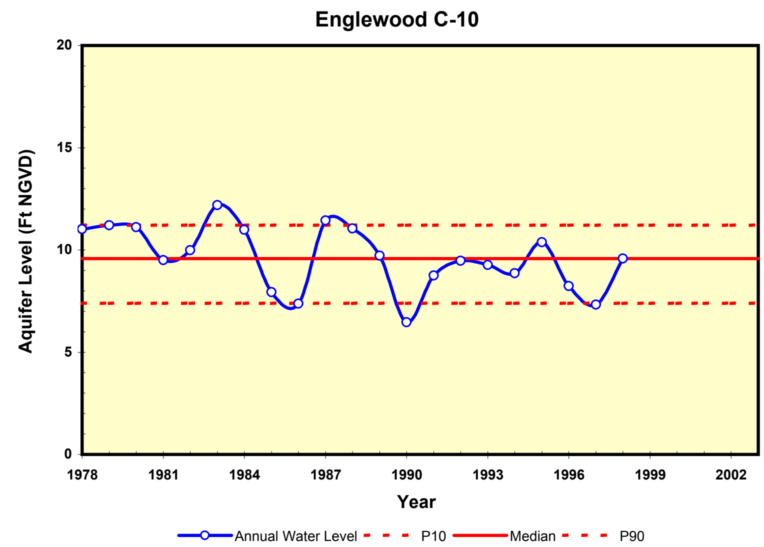
Table C-2. PZ 3 wells monitored for water level from the SWFWMD Water Management Data Base.

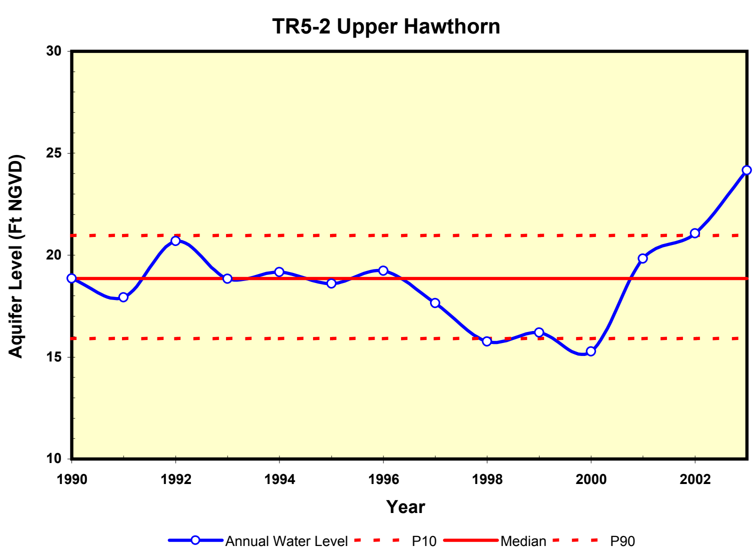
Well Name	Latitude (decimal deg)	Longitude (decimal deg)	Station ID	Site ID	Seq No.	Casing Depth (ft bls)	Total Depth (ft bls)	Period-of-Record
ROMP TR 5-2 TAMPA	270920.87	822341.65	1	1	1	360	400	1989-Present
ROMP TR 3-1 HAWTHORN 400	265639.32	821304.95	2	2	1	380	400	1990-Present
ROMP TR 5-2 LOWER HAWTHOR	270920.80	822341.66	1	3	0	245	265	1989-2002
OSPREY 9	271121.15	822852.56	281	15	0	157	255	1967-2001
ROMP 45 HAWTHORN	274551.27	814709.84	296	30	0	110	192	1976-Present
ROWELL DEEP	273156.22	814516.81	302	36	0	39	267	1963-Present
ROMP 31 HAWTHORN/TAMPA	272715.00	815458.57	209	41	0	130	350	1977-Present
MABRY CARLTON 13 NR MYAK C	270953.18	820958.31	319	53	0	65	287	1984-1998
MABRY CARLTON 6	271228.25	820848.43	390	124	0	311	369	1983-2002
CITY OF SARASOTA 27TH ST	272134.16	823246.58	539	273	0	45	343	1980-1997
ROMP 10 HAWTHORN/TAMPA	270153.20	820027.35	536	274	0	303	575	1975-1989
ROMP 10 HAWTHORN	270153.20	820027.30	536	278	0	110	270	1975-1989
ARCADIA 1	271311.24	815228.04	546	280	0	84	250	1970-1991
ROMP 10 L HAWTHORN/TAMPA	270153.31	820000.75	536	285	0	320	473	1989-Present
ROMP 33 ARCADIA	272728.22	821525.55	564	300	0	215	290	1992-Present
ROMP 11 HAWTHORN	265837.67	815609.30	586	320	0	220	335	1976-Present
ROMP 30 TAMPA	272733.45	814747.97	619	354	0	280	316	1981-Present
MANASOTA 14 DEEP	270138.91	822352.63	670	404	0	263	305	1966-Present
ROMP 16 TAMPA	271117.02	814624.79	221	414	0	300	340	1980-Present
FORT GREEN SPRINGS	274154.68	815729.38	802	536	0	280	300	1964-Present
ROMP TR 6-1 HAWTHORN	271601.37	823302.21	912	646	0	300	315	1979-Present
PORT CHARLOTTE DEEP	270145.99	820413.33	932	666	0	312	350	1966-1998
WHITAKER BAYOU	272118.51	823250.17	997	731	0	54	337	1962-2002*
ROMP 23 HAWTHORN/TAMPA	271853.48	821039.11	913	757	0	303	363	1986-Present
ROMP TR 7-4 HAWTHORN	272540.13	822920.68	211	10925	0	213	268	1989-Present
ROMP 19 EAST LOW HAWTHORN	271022.00	821515.99	13	10937	2	211	221	1992-Present
ROMP TR 5-1 TAMPA	270810.24	822704.87	224	10941	0	275	289	1983-Present
ROMP TR 1-2 LOW HAWTN/TPA	265025.50	815853.22	229	10947	0	520	600	1993-Present
ROMP 17 LOWER HAWTHORN	271028.49	815835.46	1027	11043	0	200	240	1992-Present
ROMP TR 3-3 LOWER HAWTHORN	265532.22	821947.33	1023	11071	0	370	410	1993-Present
ROMP 22 ARCADIA/TAMPA	271843.75	822011.41	1029	11175	0	230	290	1993-Present
ROMP 20 LOW INTERMEDIATE	271138.48	822845.34	1031	11303	0	250	370	1994-Present
ROMP TR 7-2 L ARCADIA	272614.04	823300.91	1033	11391	0	200	290	1994-Present
ROMP 28 HAWTHORN	272208.57	812607.38	1042	11875	0	370	420	1996-Present
ROMP TR SA-1 UP INTER	272049.30	823245.08	1039	12002	0	328	388	1998-Present*
ROMP 13 MID INTERMEDIATE	270419.14	813658.26	1037	12871	0	282	417	1999-Present
ROMP 14 LOWER HAWTHORN	270859.65	812111.92	1088	12873	0	460	521	1995-Present
ROMP 5 LOWER INTERMEDIATE	265644.96	814827.87	1069	12883	0	450	600	2000-Present
ROMP 9 L HAWTHORN MW-4	270434.83	820856.22	1070	12900	0	190	320	2000-Present
ROMP TR 4-1 MID INT	270328.77	822628.40	1087	12953	0	121	224	2000-Present
ROMP 12 LOW INTERMEDIATE	270228.23	814432.32	2075	13336	0	280	409	2000-Present

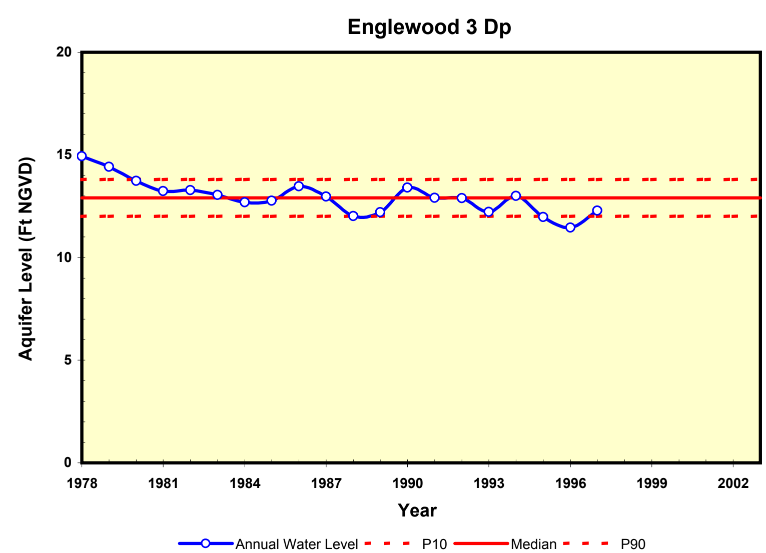
* Intermittent record

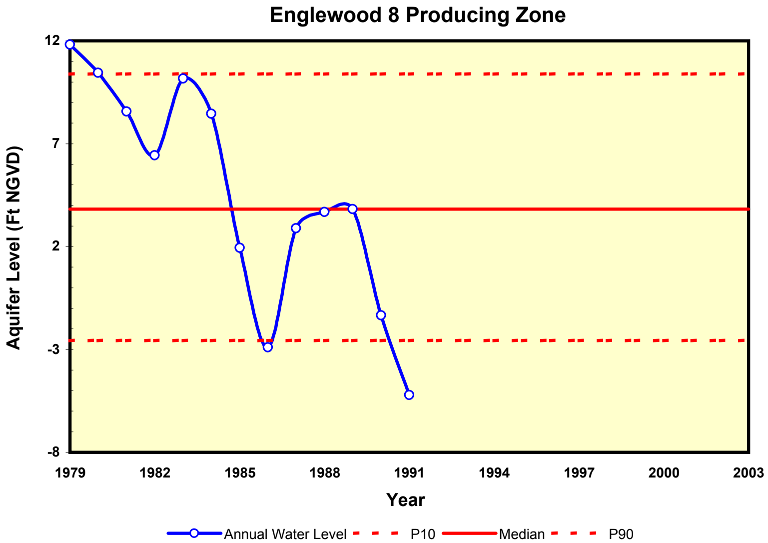
APPENDIX D

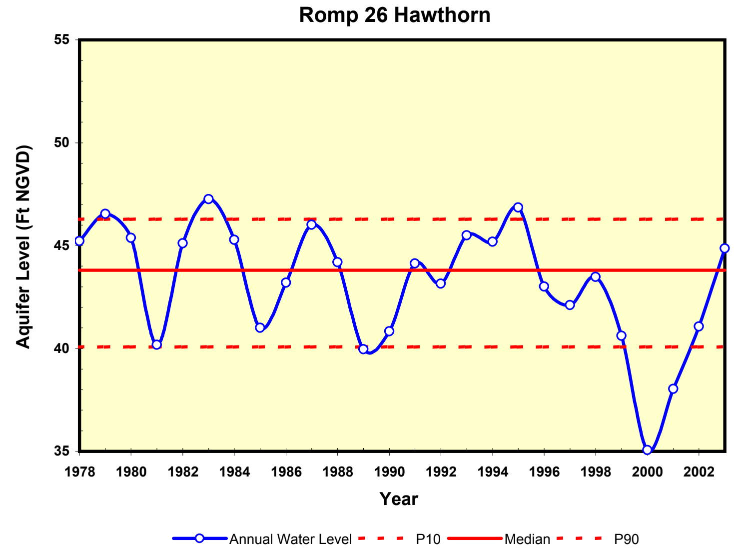

TR3-1 Hawthorn 270
Aquifer Level (Ft NGVD)
45
40
35
30
25
1990
1992
1994
1996
1998
2000
2002
Year
Annual Water Level

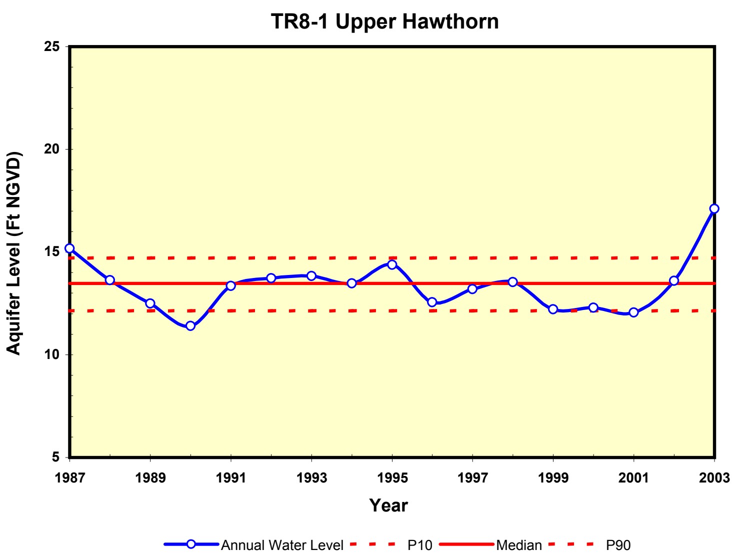

Englewood C-10
Aquifer Level (Ft NGVD)
20
15
10
5
0
1978
1981
1984
1987
1990
1993
1996
1999
2002
Year
Annual Water Level
P10
Median
P90

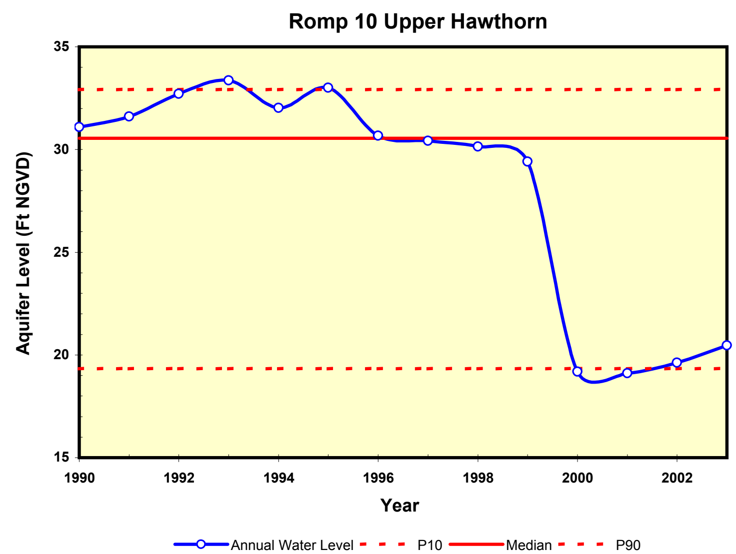

TR5-2 Upper Hawthorn
Aquifer Level (Ft NGVD)
30
25
20
15
10
1990
1992
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

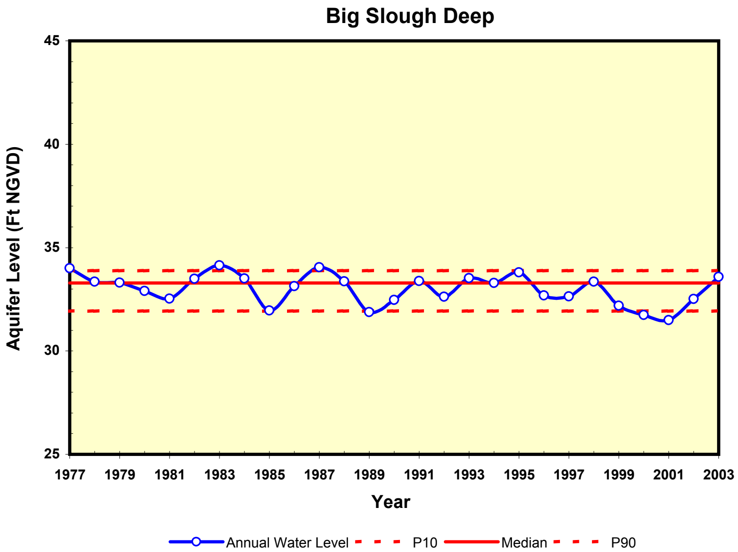

Englewood 3 Dp
Aquifer Level (Ft NGVD)
20
15
10
5
0
1978
1981
1984
1987
1990
1993
1996
1999
2002
Year
Annual Water Level
P10
Median
P90

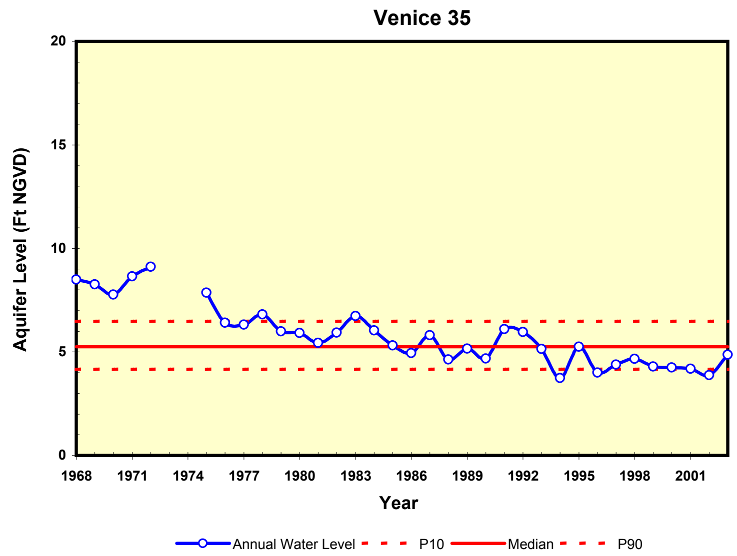

Englewood 8 Producing Zone
12
7
2
-3
-8
Aquifer Level (Ft NGVD)
1979
1982
1985
1988
1991
1994
1997
2000
2003
Year
Annual Water Level
P10
Median
P90

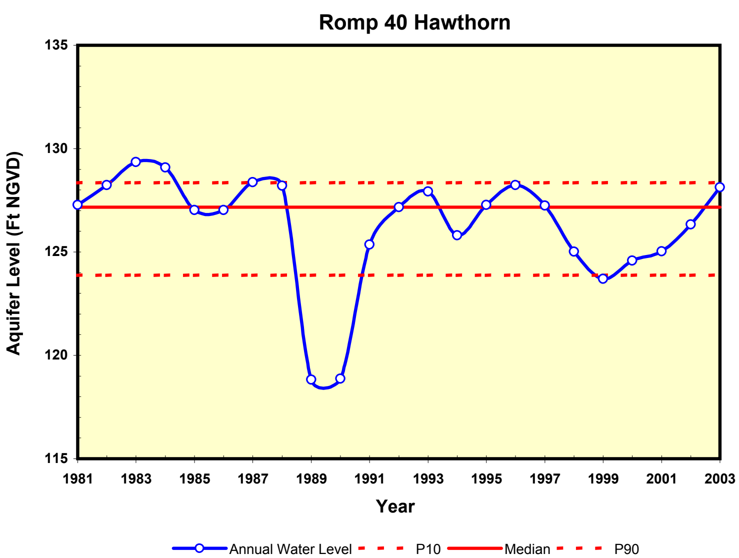

Romp 26 Hawthorn
55
50
45
40
35
Aquifer Level (Ft NGVD)
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

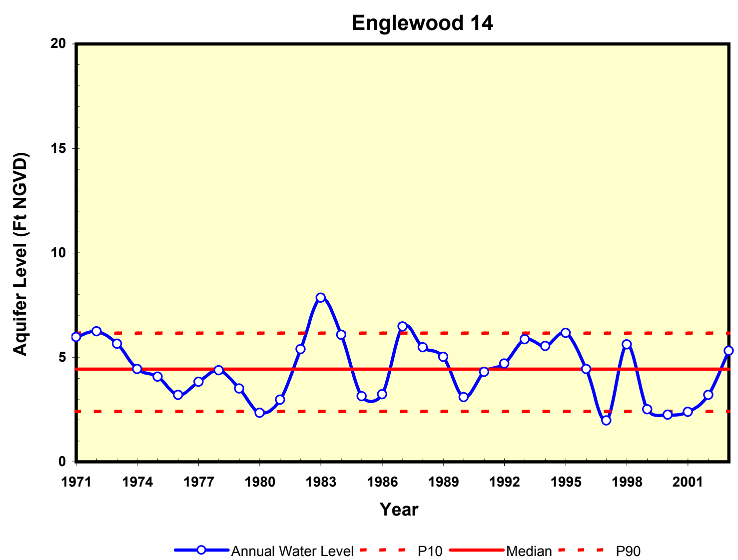

TR8-1 Upper Hawthorn
25
20
15
10
5
Aquifer Level (Ft NGVD)
1987
1989
1991
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

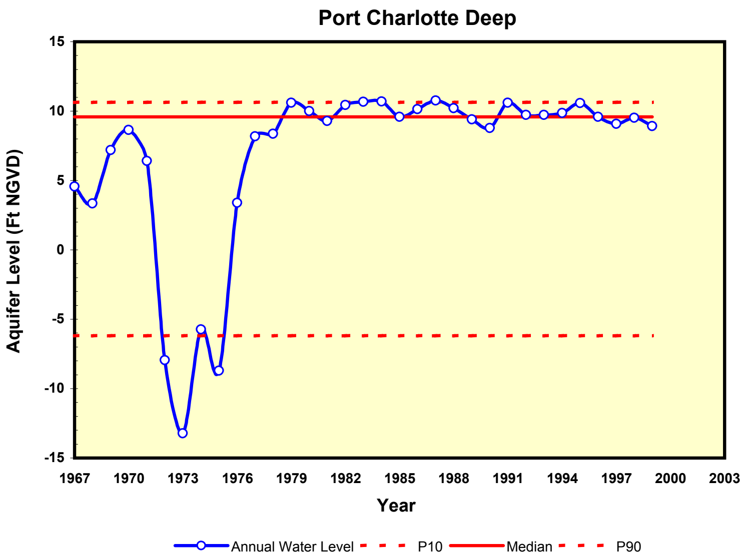

Romp 10 Upper Hawthorn
35
30
25
20
15
Aquifer Level (Ft NGVD)
1990
1992
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

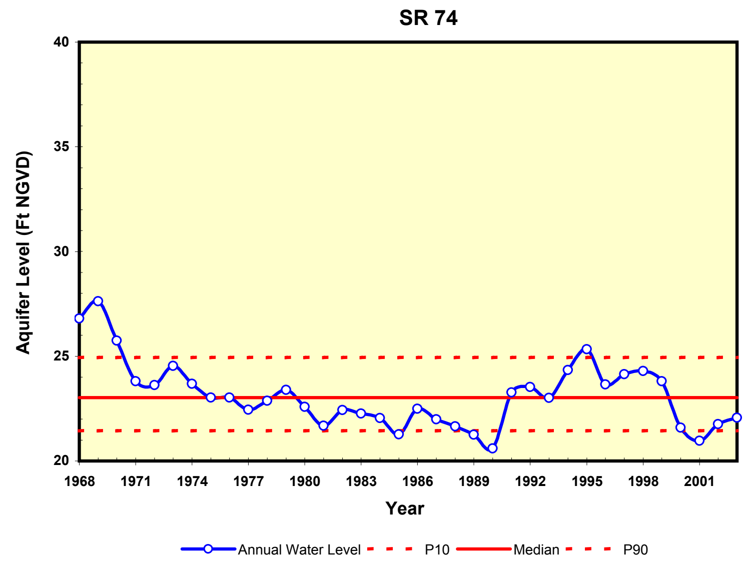

Big Slough Deep
45
40
35
30
25
Aquifer Level (Ft NGVD)
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

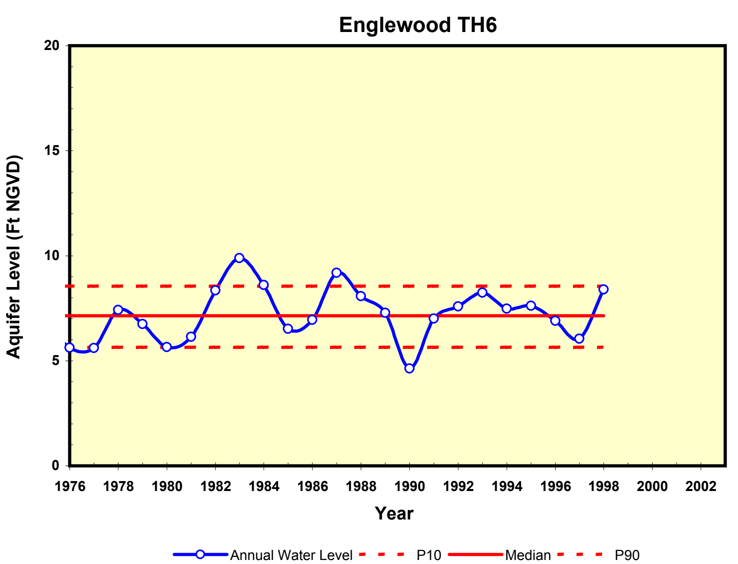

Venice 35
20
15
10
5
0
Aquifer Level (Ft NGVD)
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
Year
Annual Water Level
P10
Median
P90

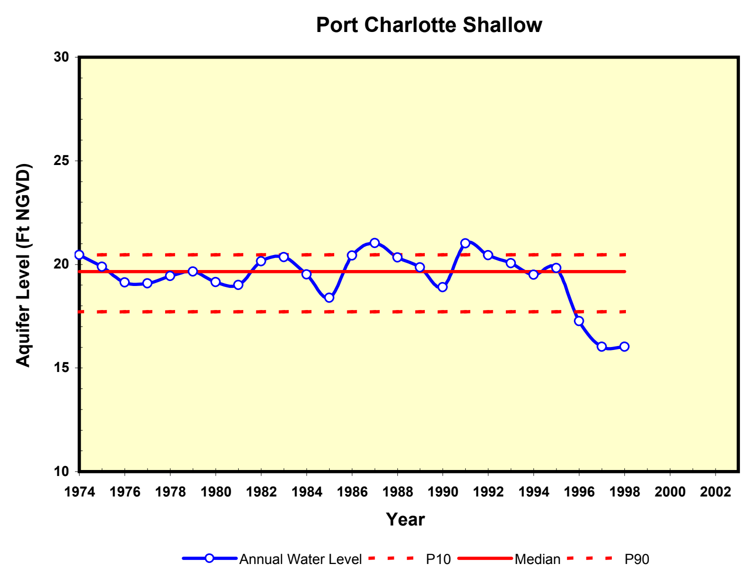

Romp 40 Hawthorn
135
130
125
120
115
Aquifer Level (Ft NGVD)
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

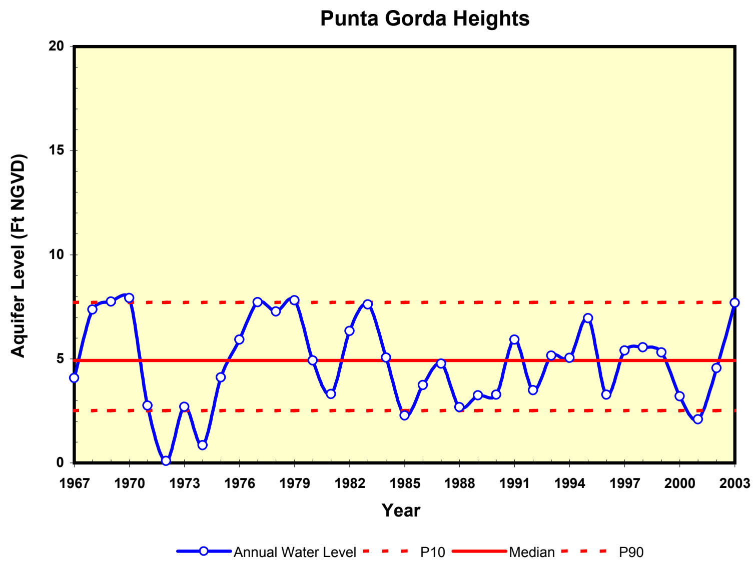

Englewood 14
20
15
10
5
0
Aquifer Level (Ft NGVD)
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
Year
Annual Water Level
P10
Median
P90

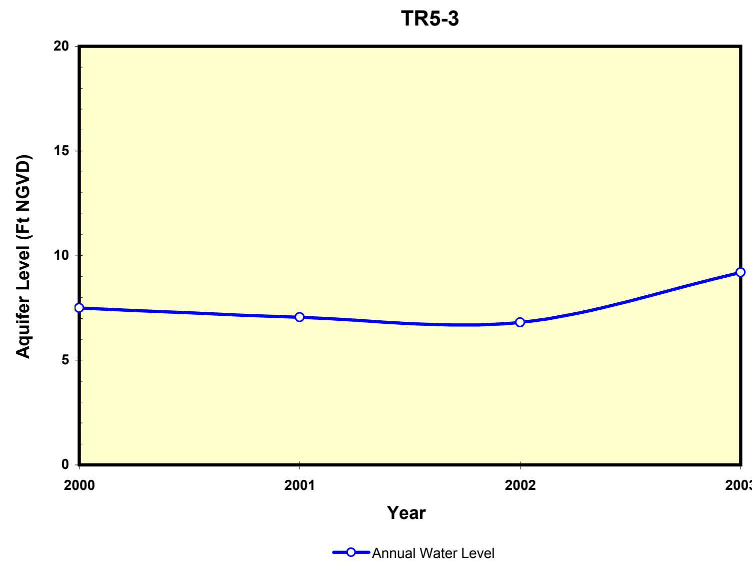

Port Charlotte Deep
Aquifer Level (Ft NGVD)
15
10
5
0
-5
-10
-15
1967 1970 1973 1976 1979 1982 1985 1988 1991 1994 1997 2000 2003
Year
Annual Water Level
P10
Median
P90

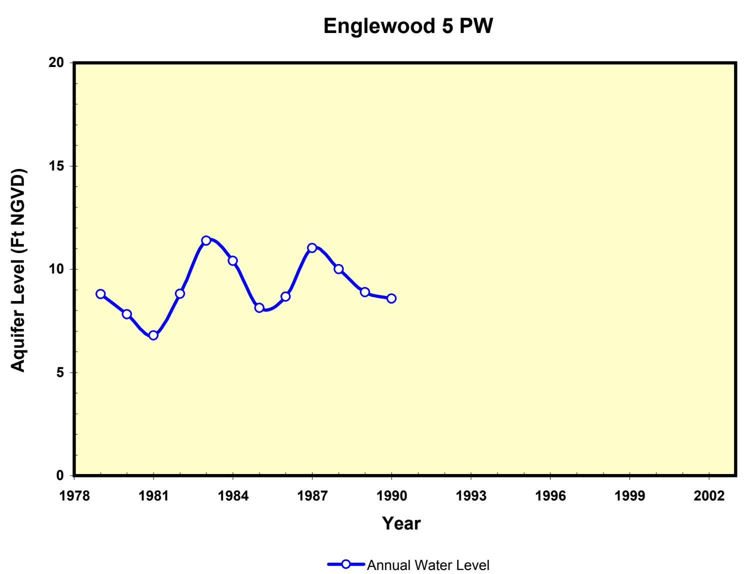

SR 74
Aquifer Level (Ft NGVD)
40
35
30
25
20
1968 1971 1974 1977 1980 1983 1986 1989 1992 1995 1998 2001
Year
Annual Water Level
P10
Median
P90

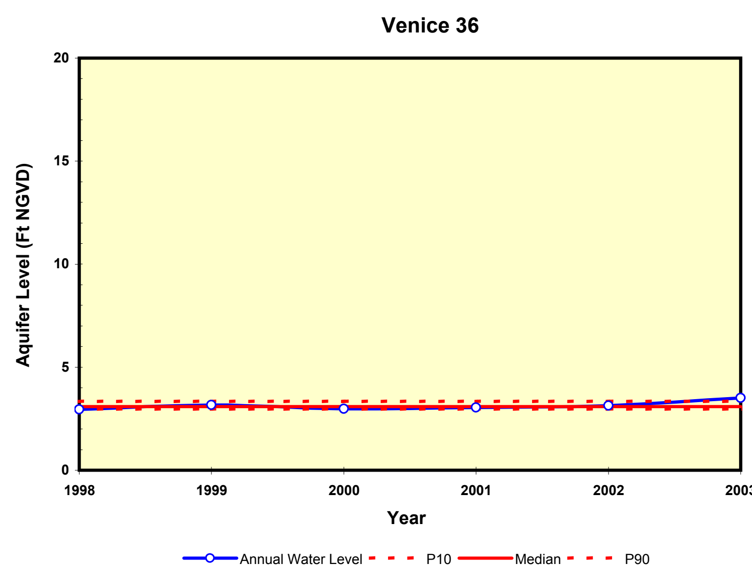

Englewood TH6
Aquifer Level (Ft NGVD)
20
15
10
5
0
1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002
Year
Annual Water Level
P10
Median
P90

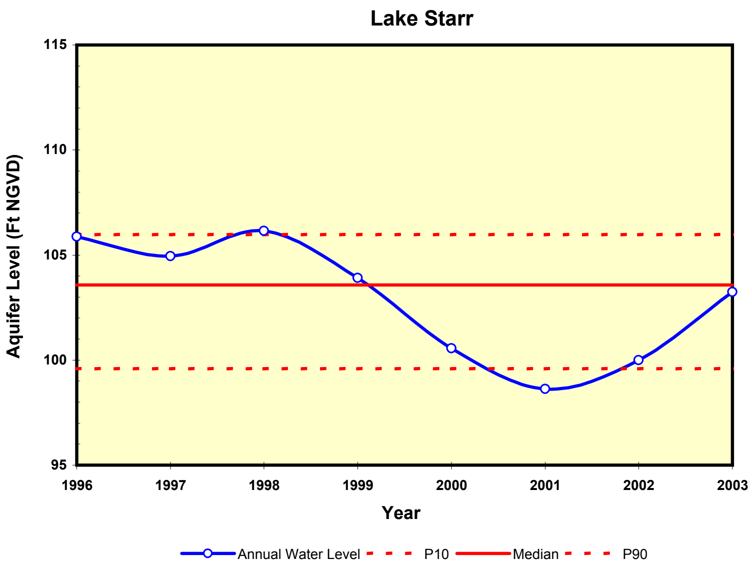

Port Charlotte Shallow
Aquifer Level (Ft NGVD)
30
25
20
15
10
1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002
Year
Annual Water Level
P10
Median
P90


Punta Gorda Heights
Aquifer Level (Ft NGVD)
20
15
10
5
0
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
Year
Annual Water Level
P10
Median
P90

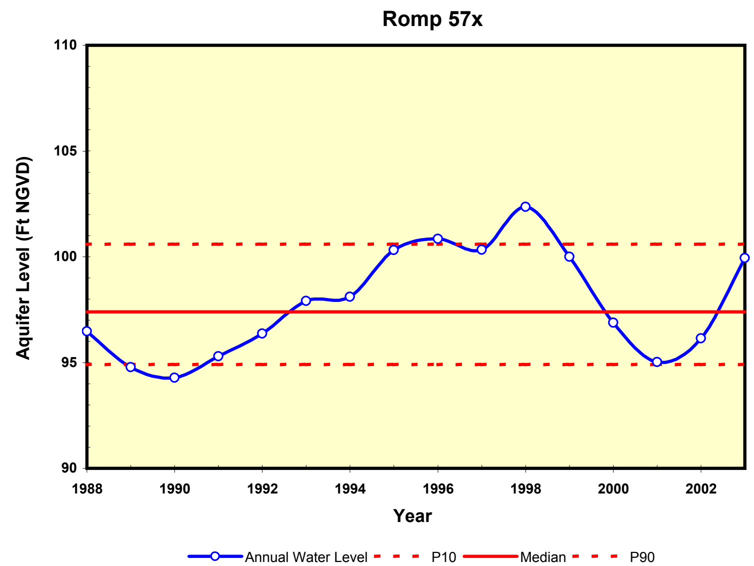

TR5-3
Aquifer Level (Ft NGVD)
20
15
10
5
0
2000
2001
2002
2003
Year
Annual Water Level


Englewood 5 PW
Aquifer Level (Ft NGVD)
20
15
10
5
0
1978
1981
1984
1987
1990
1993
1996
1999
2002
Year
Annual Water Level

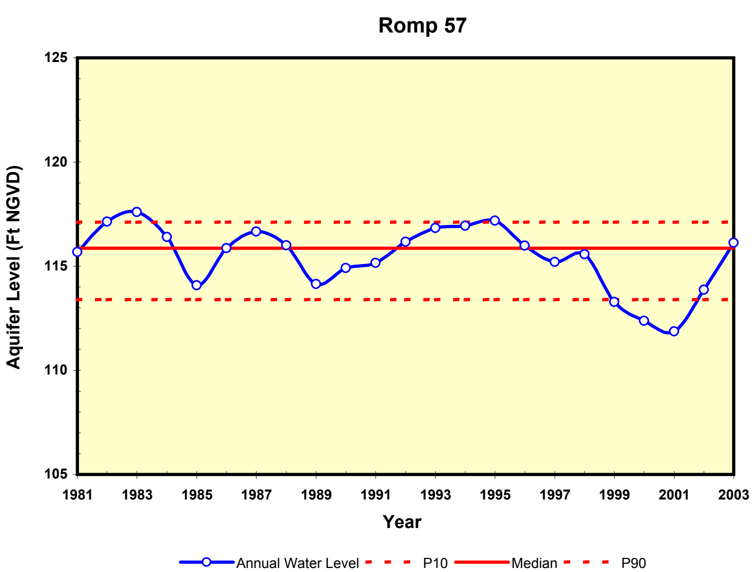

Venice 36
Aquifer Level (Ft NGVD)
20
15
10
5
0
1998
1999
2000
2001
2002
2003
Year
Annual Water Level
P10
Median
P90



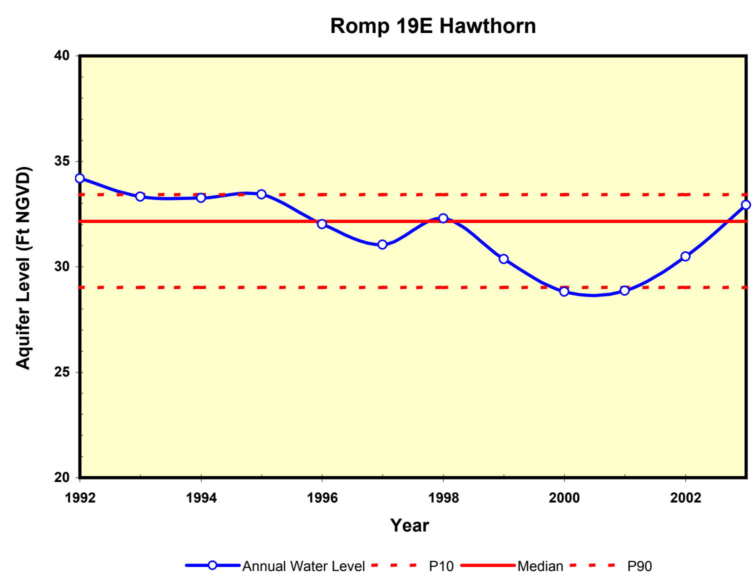
Lake Starr
115
110
105
100
95
Aquifer Level (Ft NGVD)
1996
1997
1998
1999
2000
2001
2002
2003
Year
Annual Water Level
P10
Median
P90



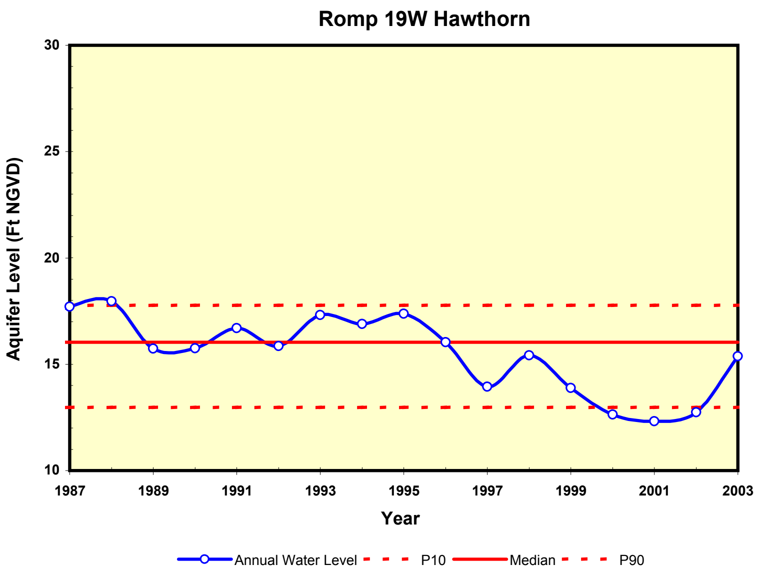
Romp 57x
110
105
100
95
90
Aquifer Level (Ft NGVD)
1988
1990
1992
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

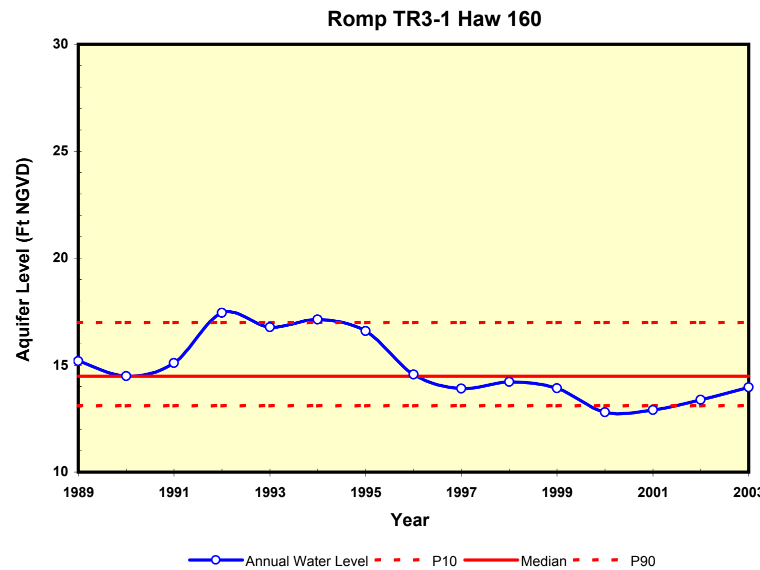


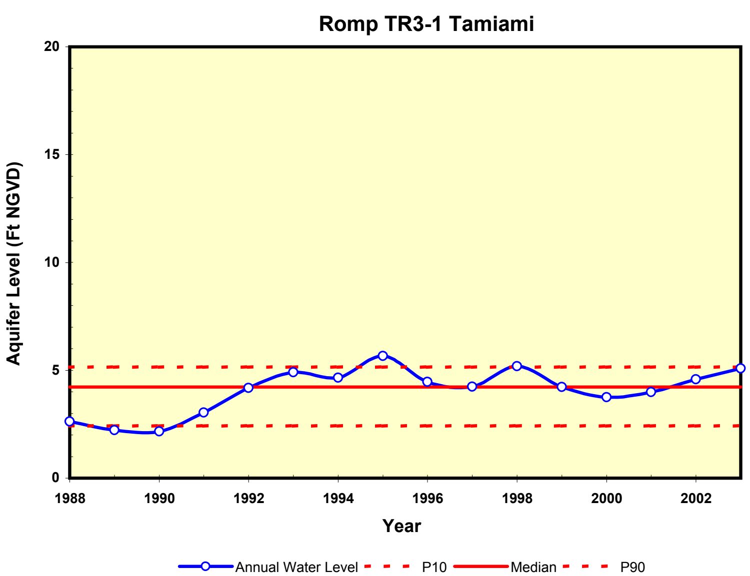
Romp 57
125
120
115
110
105
Aquifer Level (Ft NGVD)
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

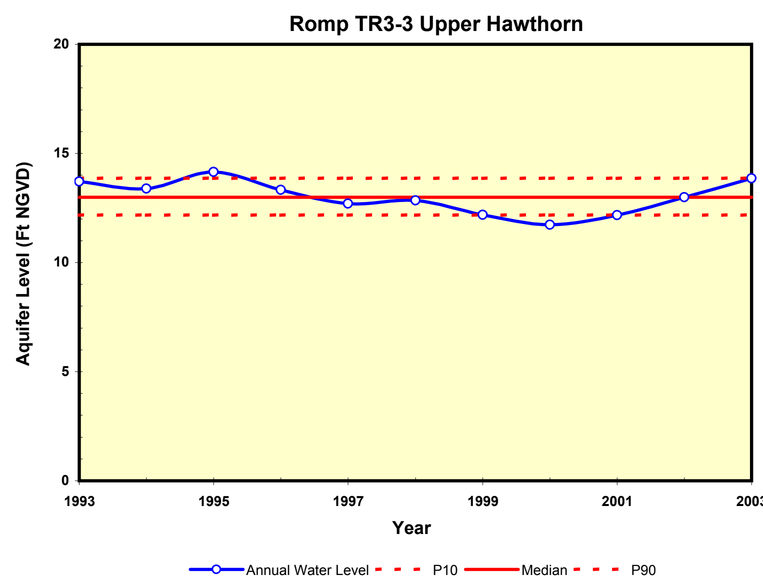


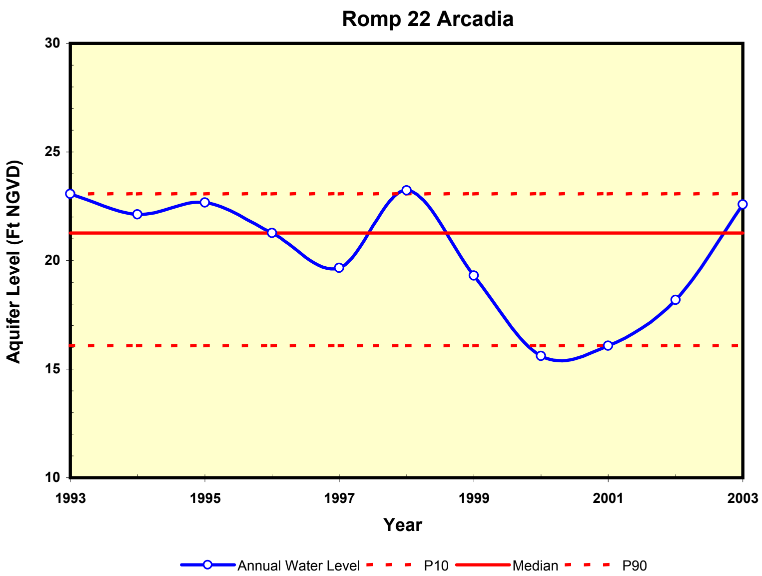
Romp 19E Hawthorn
40
35
30
25
20
Aquifer Level (Ft NGVD)
1992
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

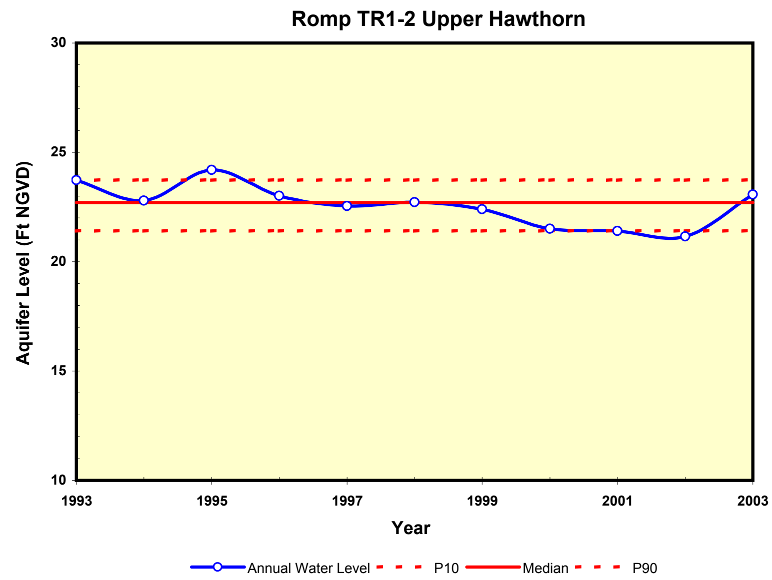

Romp 19W Hawthorn
Aquifer Level (Ft NGVD)
30
25
20
15
10
1987
1989
1991
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

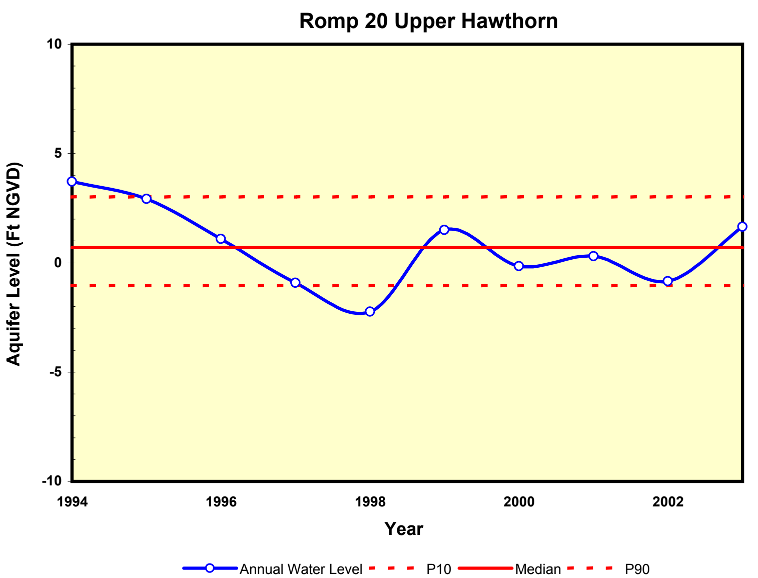

Romp TR3-1 Haw 160
Aquifer Level (Ft NGVD)
30
25
20
15
10
1989
1991
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

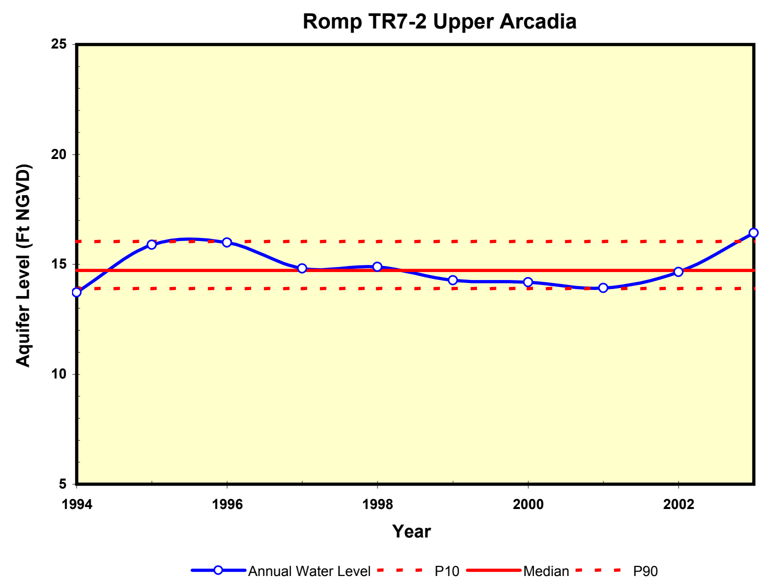

Romp TR3-1 Tamiami
Aquifer Level (Ft NGVD)
20
15
10
5
0
1988
1990
1992
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

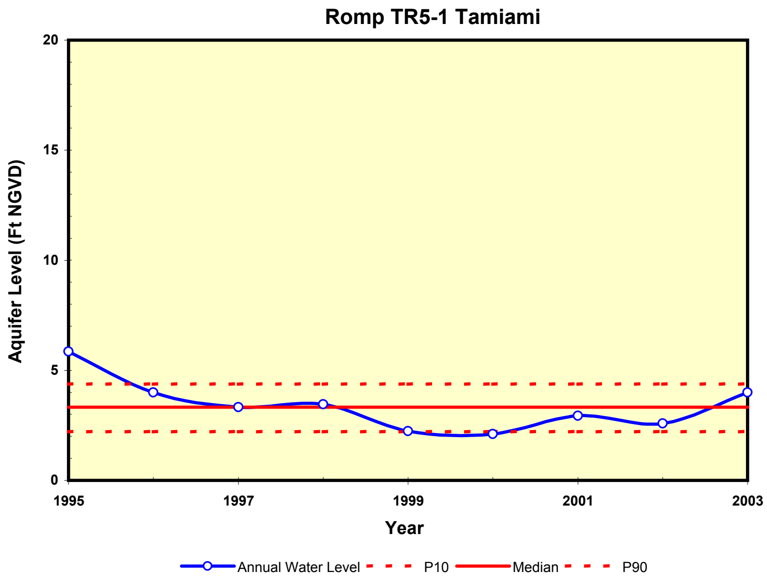

Romp TR3-3 Upper Hawthorn
Aquifer Level (Ft NGVD)
20
15
10
5
0
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

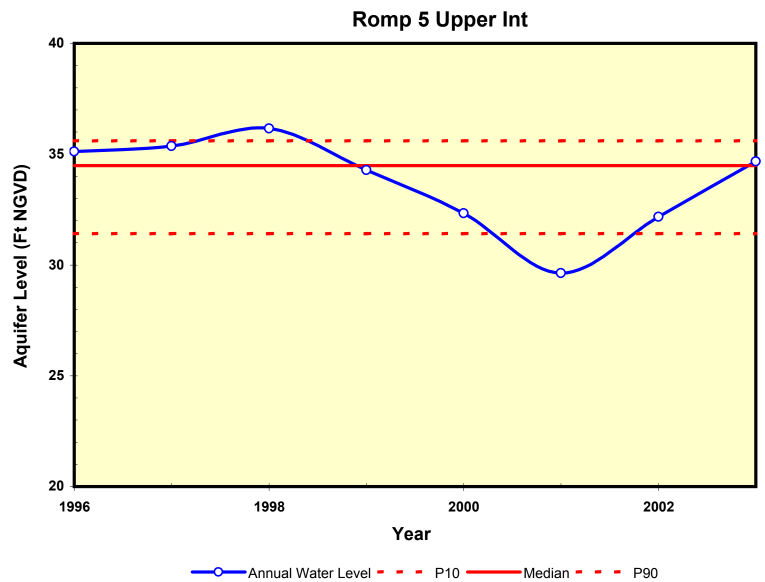

Romp 22 Arcadia
Aquifer Level (Ft NGVD)
30
25
20
15
10
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

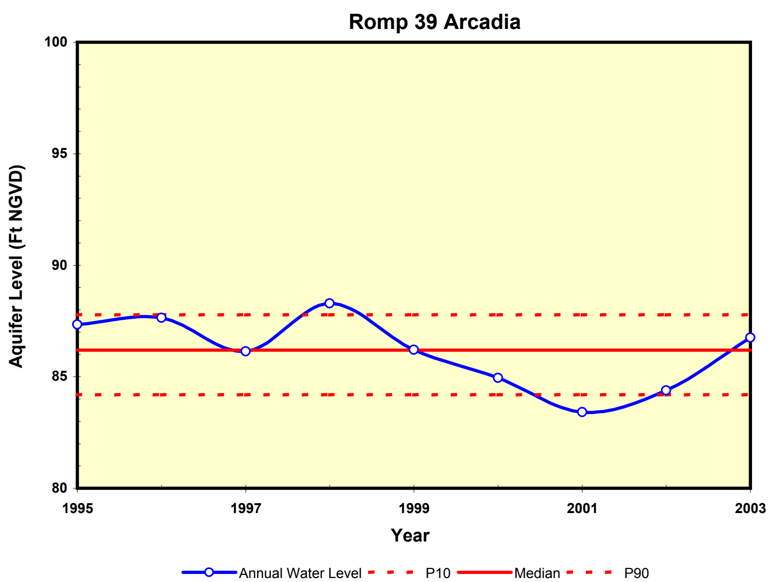

Romp TR1-2 Upper Hawthorn
Aquifer Level (Ft NGVD)
30
25
20
15
10
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

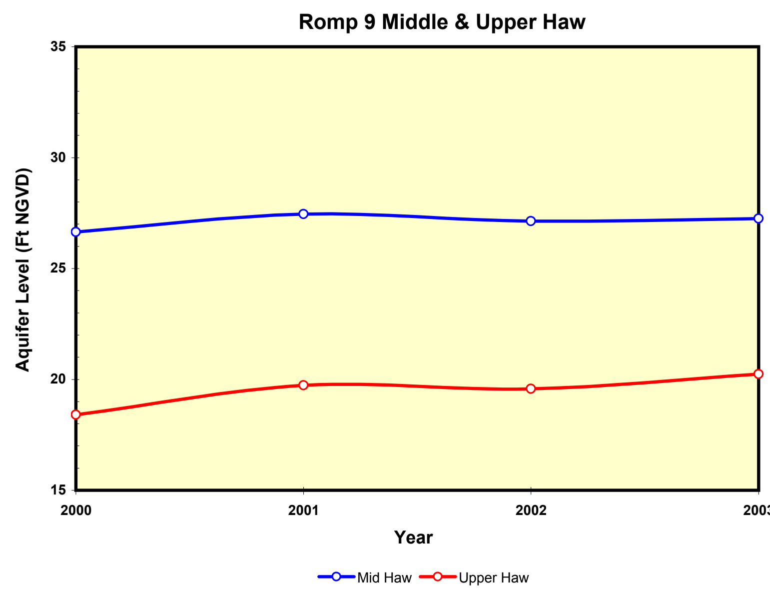

Romp 20 Upper Hawthorn
Aquifer Level (Ft NGVD)
10
5
0
-5
-10
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

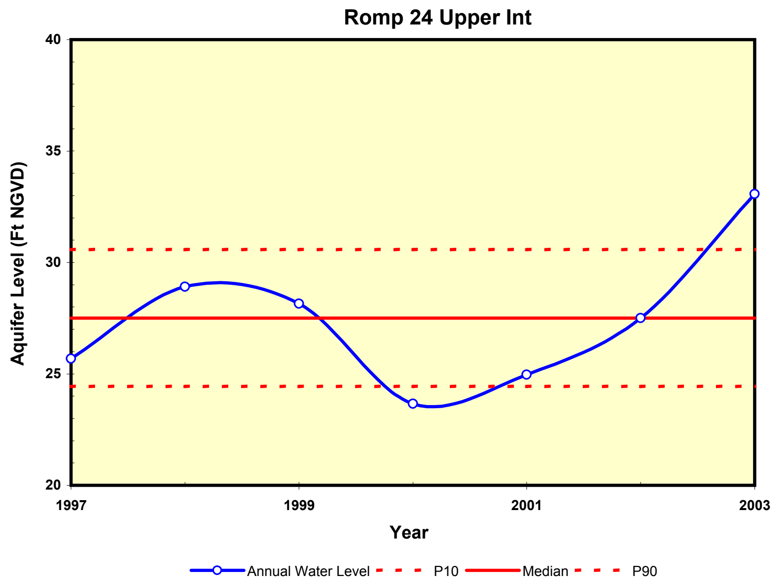

Romp TR7-2 Upper Arcadia
Aquifer Level (Ft NGVD)
25
20
15
10
5
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

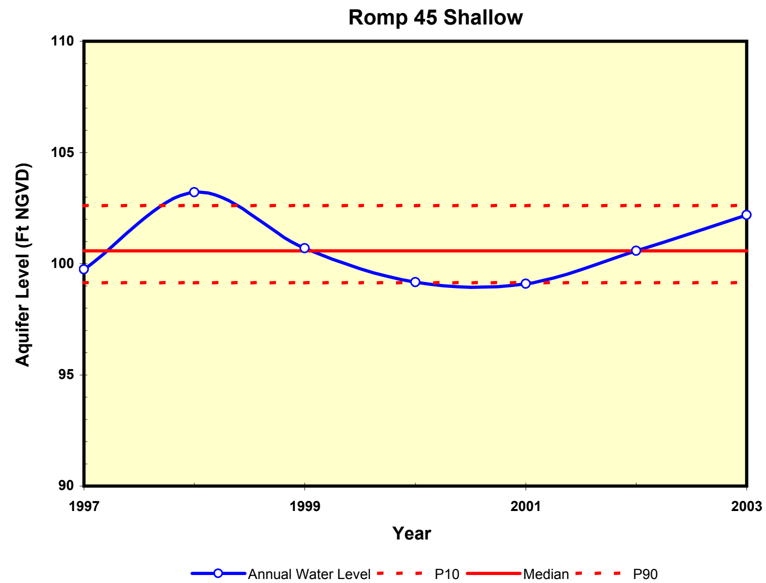

Romp TR5-1 Tamiami
Aquifer Level (Ft NGVD)
20
15
10
5
0
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

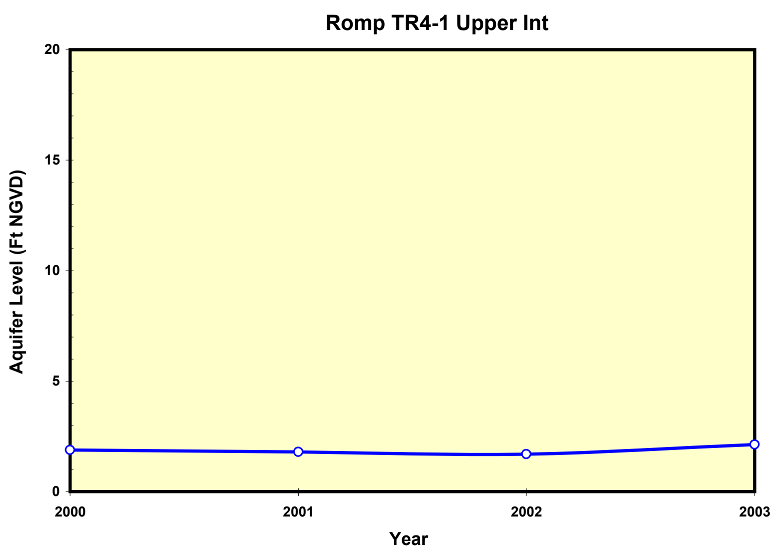

Romp 5 Upper Int
Aquifer Level (Ft NGVD)
40
35
30
25
20
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

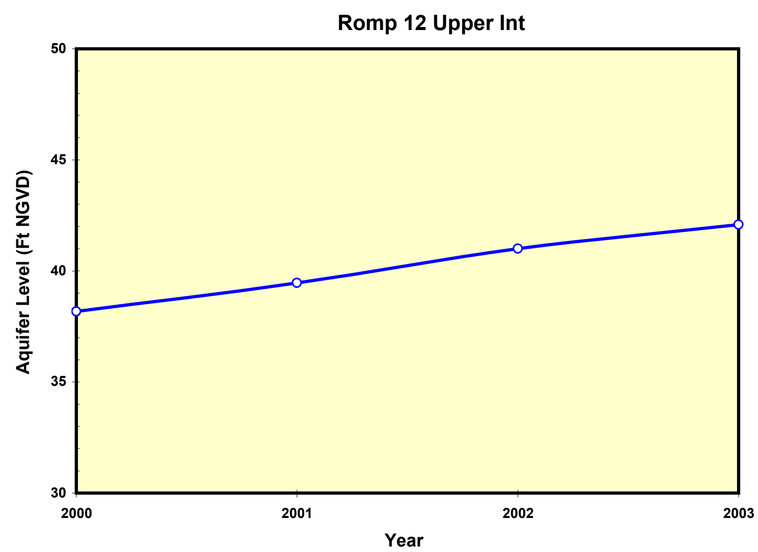

Romp 39 Arcadia
Aquifer Level (Ft NGVD)
100
95
90
85
80
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

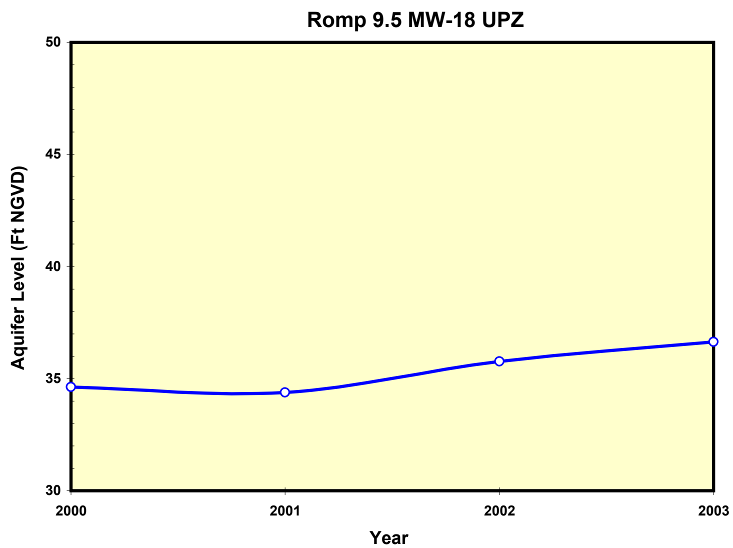

Romp 9 Middle & Upper Haw
Aquifer Level (Ft NGVD)
35
30
25
20
15
2000
2001
2002
2003
Year
Mid Haw
Upper Haw

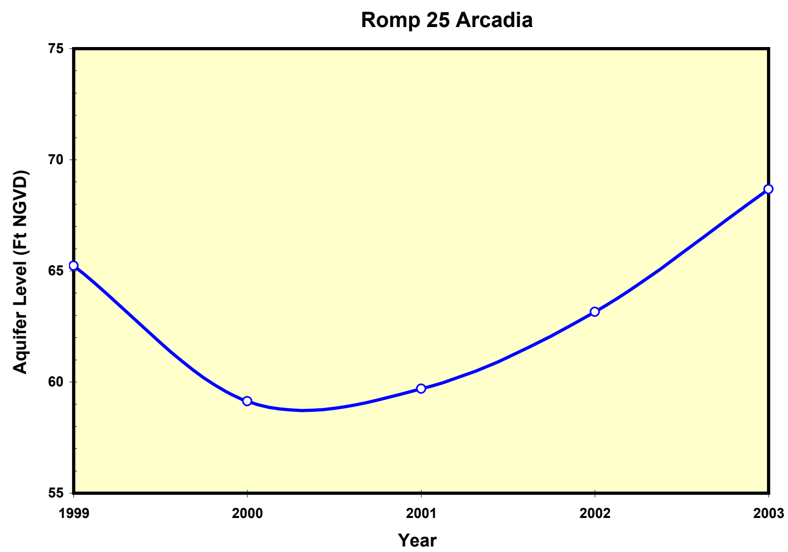

Romp 24 Upper Int
Aquifer Level (Ft NGVD)
40
35
30
25
20
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

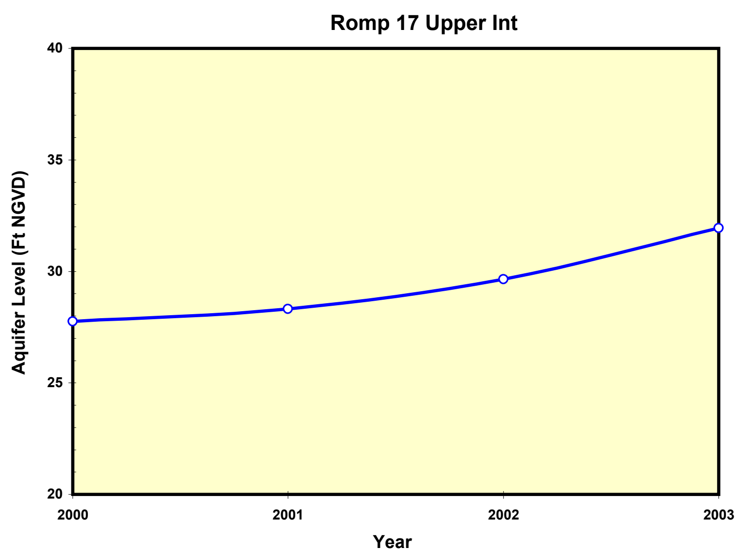

Romp 45 Shallow
Aquifer Level (Ft NGVD)
110
105
100
95
90
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

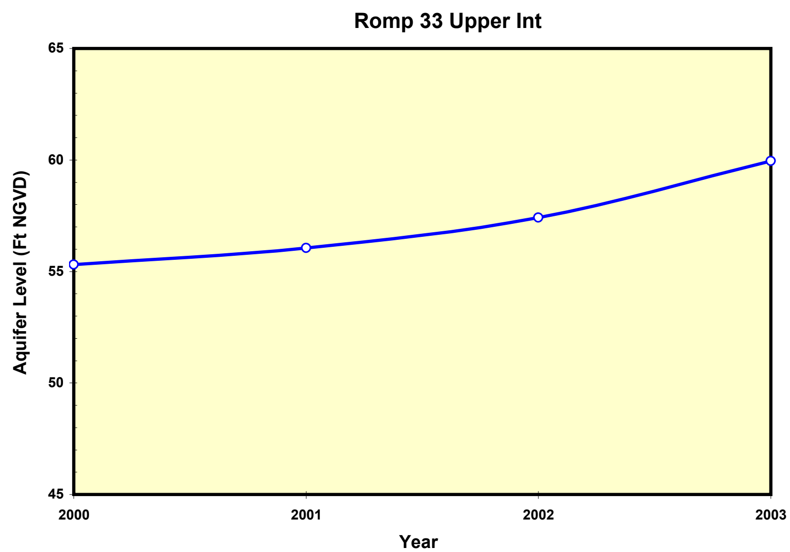

Romp TR4-1 Upper Int
Aquifer Level (Ft NGVD)
20
15
10
5
0
2000
2001
2002
2003
Year

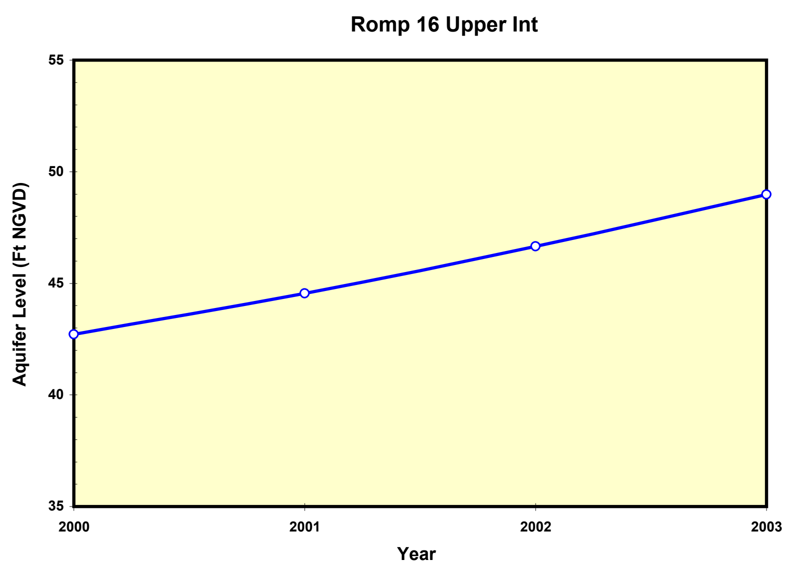

Romp 12 Upper Int
Aquifer Level (Ft NGVD)
50
45
40
35
30
2000
2001
2002
2003
Year

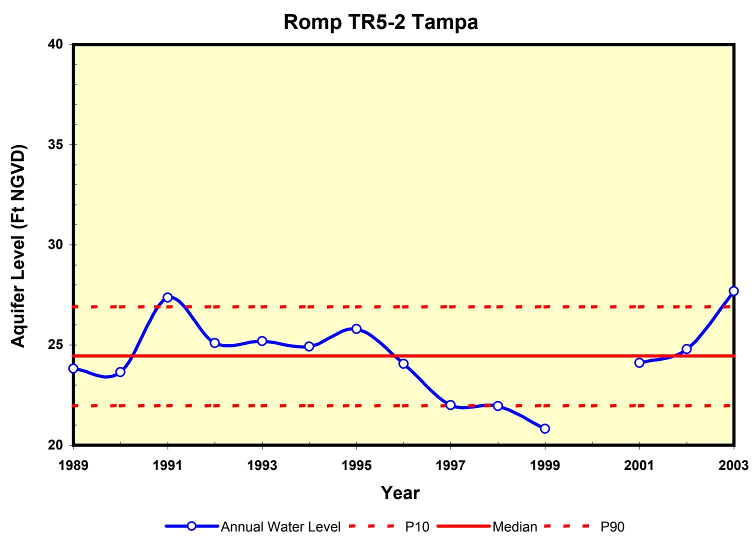

Romp 9.5 MW-18 UPZ
Aquifer Level (Ft NGVD)
50
45
40
35
30
2000
2001
2002
2003
Year

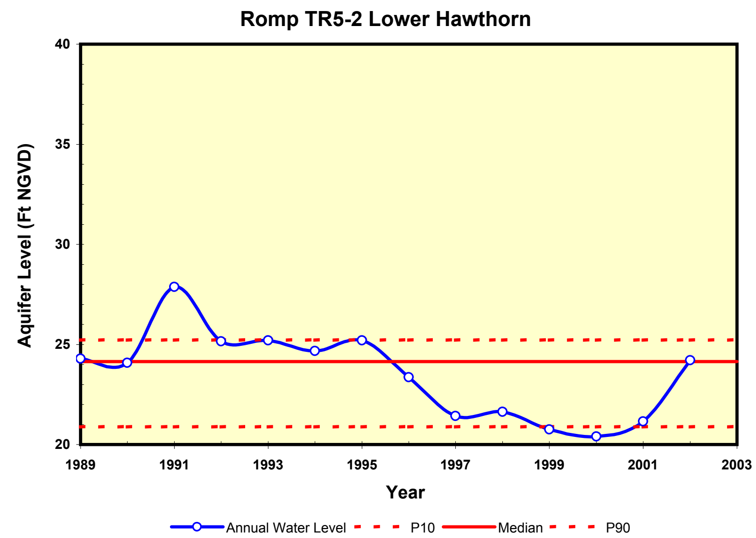

Romp 25 Arcadia
Aquifer Level (Ft NGVD)
75
70
65
60
55
1999
2000
2001
2002
2003
Year

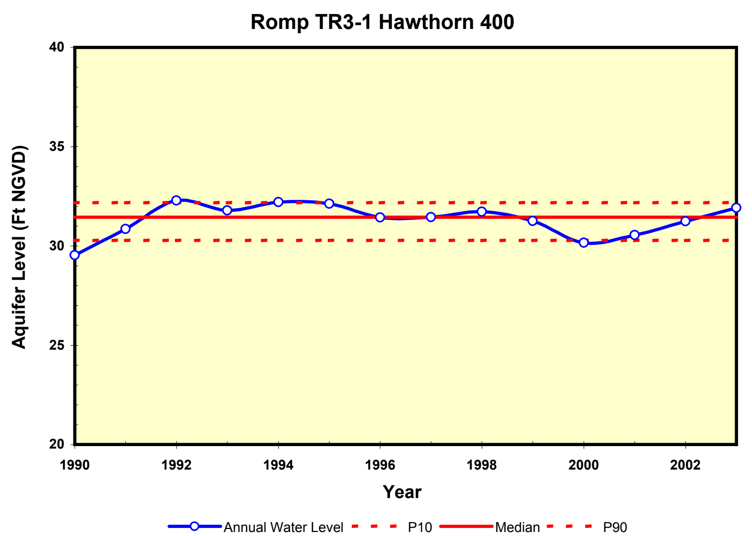

Romp 17 Upper Int
Aquifer Level (Ft NGVD)
40
35
30
25
20
2000
2001
2002
2003
Year

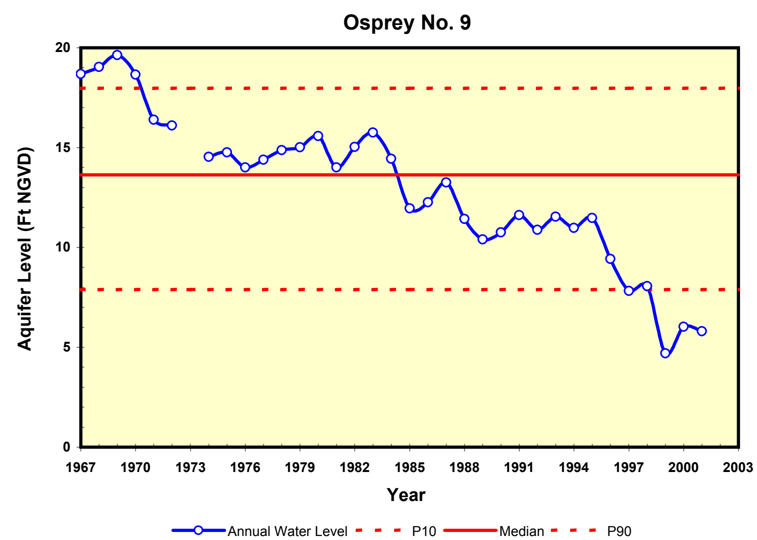

Romp 33 Upper Int
Aquifer Level (Ft NGVD)
65
60
55
50
45
2000
2001
2002
2003
Year

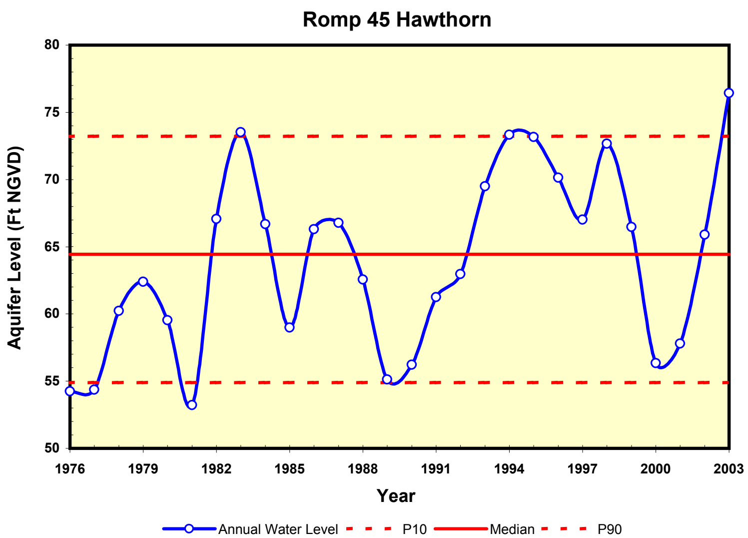

Romp 16 Upper Int
Aquifer Level (Ft NGVD)
55
50
45
40
35
2000
2001
2002
2003
Year

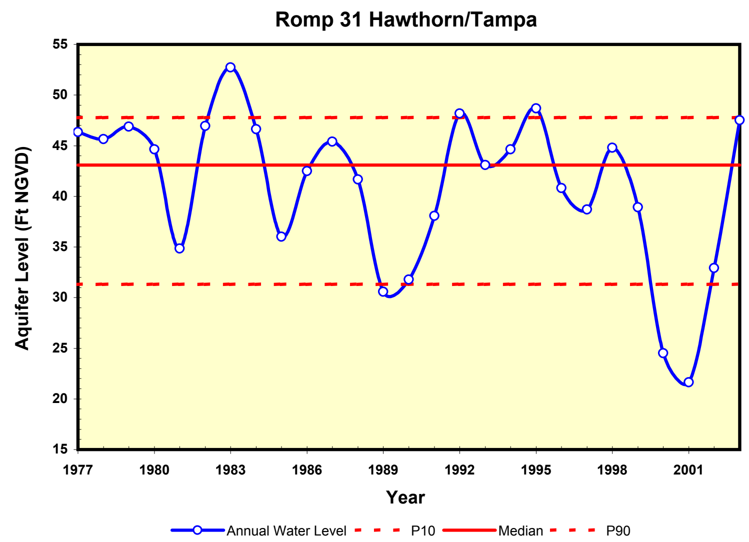

Romp TR5-2 Tampa
Aquifer Level (Ft NGVD)
40
35
30
25
20
1989
1991
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

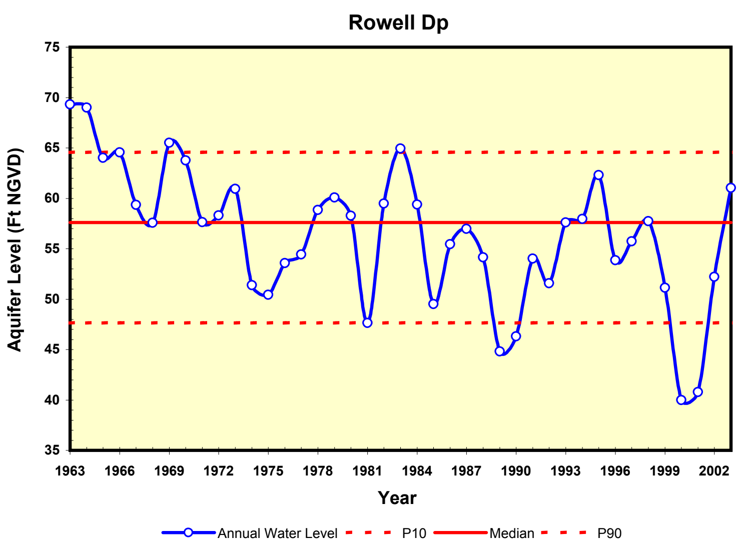

Romp TR5-2 Lower Hawthorn
Aquifer Level (Ft NGVD)
40
35
30
25
20
1989
1991
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

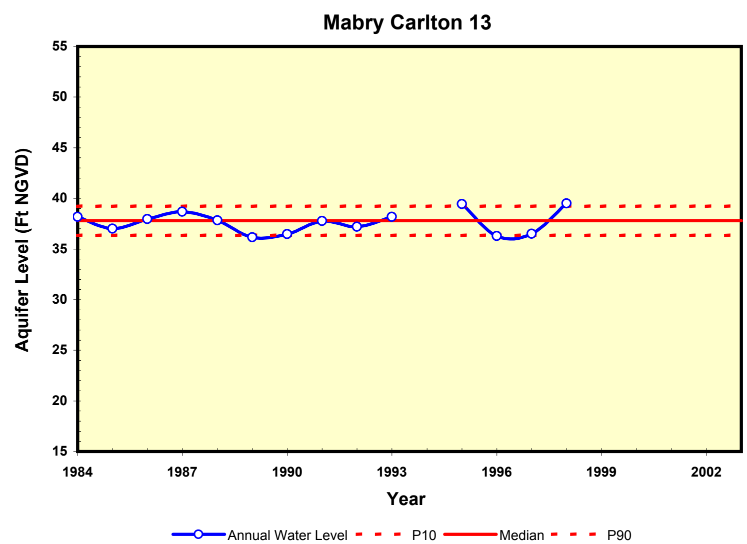

Romp TR3-1 Hawthorn 400
Aquifer Level (Ft NGVD)
40
35
30
25
20
1990
1992
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

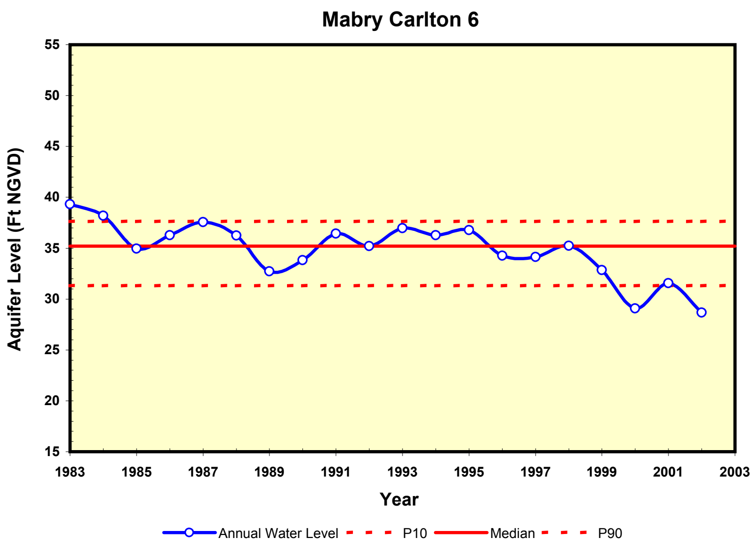

Osprey No. 9
Aquifer Level (Ft NGVD)
20
15
10
5
0
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
Year
Annual Water Level
P10
Median
P90


Romp 45 Hawthorn
Aquifer Level (Ft NGVD)
80
75
70
65
60
55
50
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
Year
Annual Water Level
P10
Median
P90

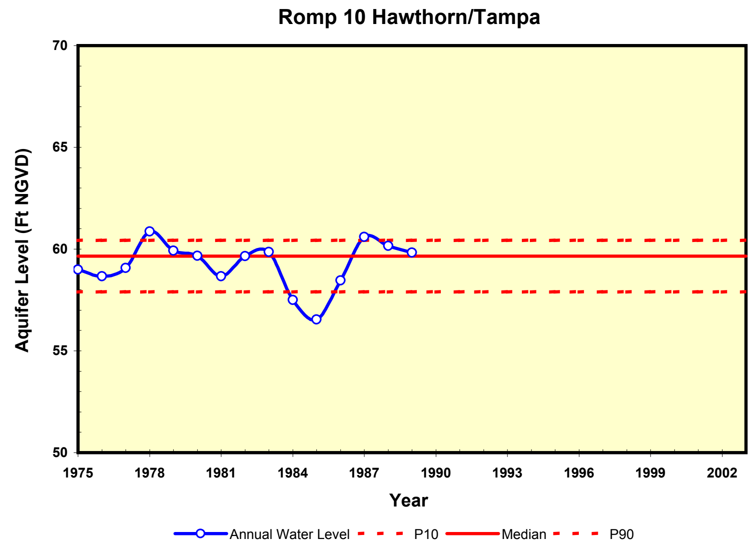

Romp 31 Hawthorn/Tampa
Aquifer Level (Ft NGVD)
55
50
45
40
35
30
25
20
15
1977
1980
1983
1986
1989
1992
1995
1998
2001
Year
Annual Water Level
P10
Median
P90


Rowell Dp
Aquifer Level (Ft NGVD)
75
70
65
60
55
50
45
40
35
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
Year
Annual Water Level
P10
Median
P90

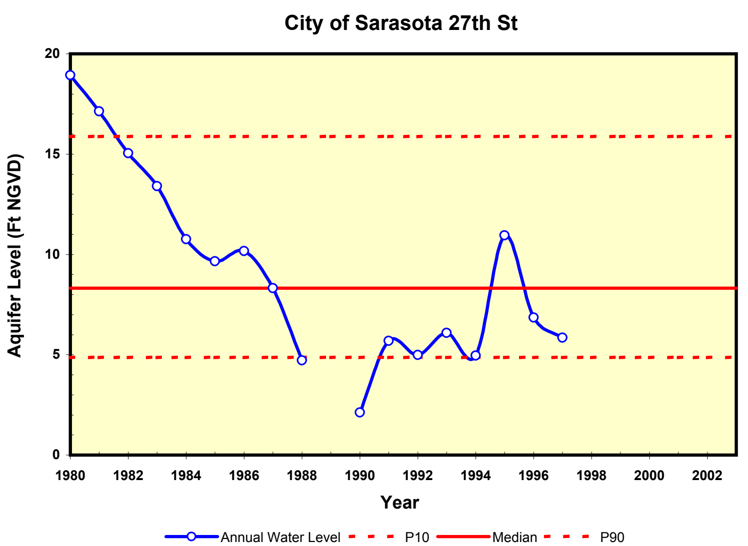

Mabry Carlton 13
Aquifer Level (Ft NGVD)
55
50
45
40
35
30
25
20
15
1984
1987
1990
1993
1996
1999
2002
Year
Annual Water Level
P10
Median
P90



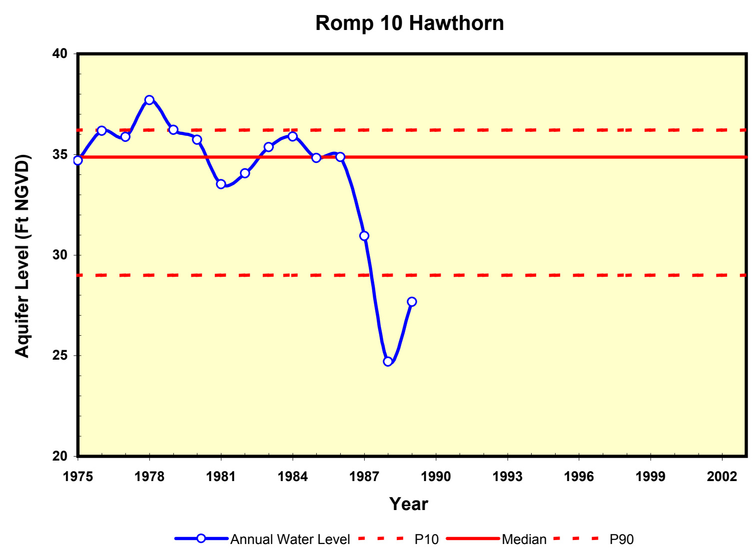
Mabry Carlton 6
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90



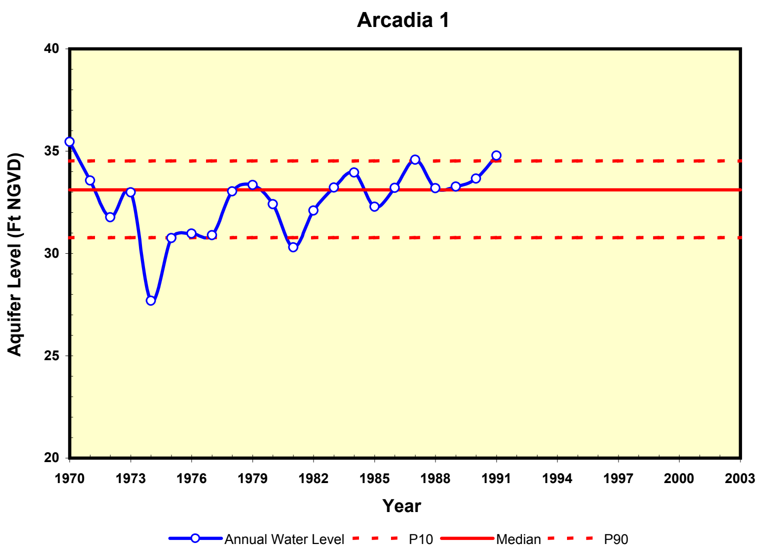
Romp 10 Hawthorn/Tampa
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

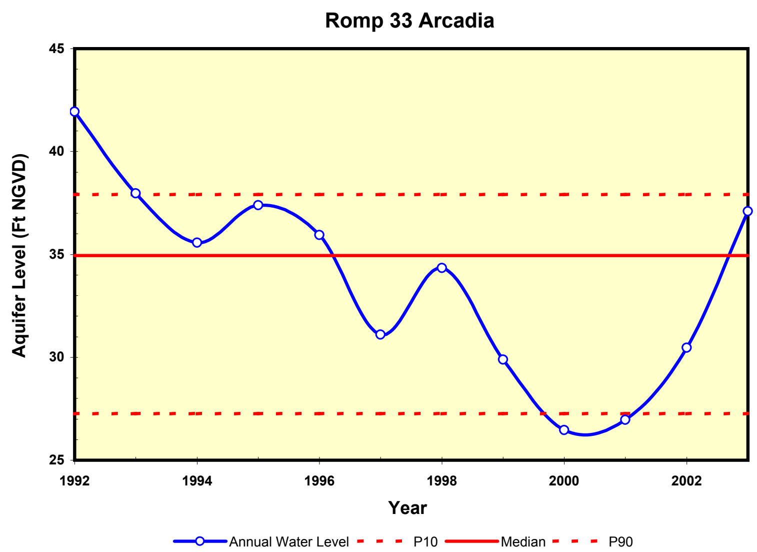


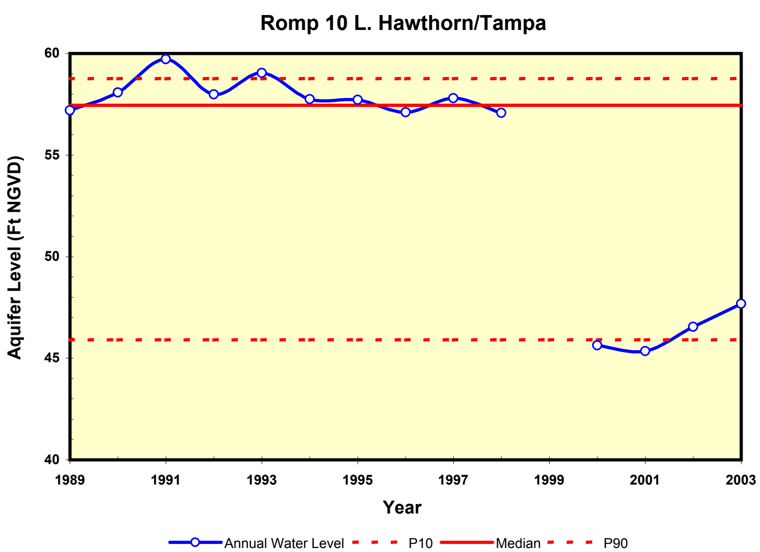
City of Sarasota 27th St
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

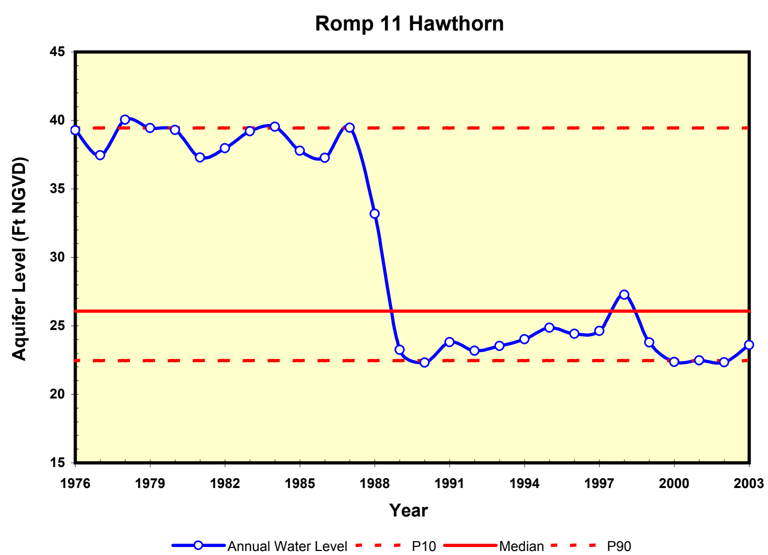


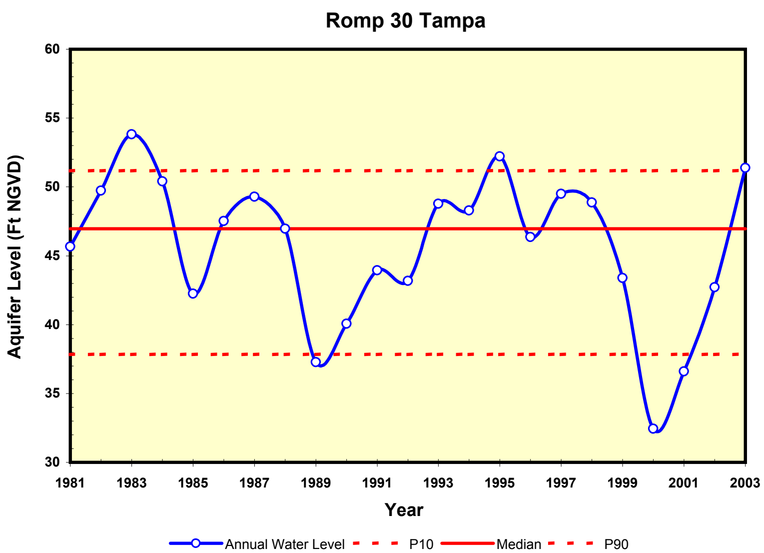
Romp 10 Hawthorn
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

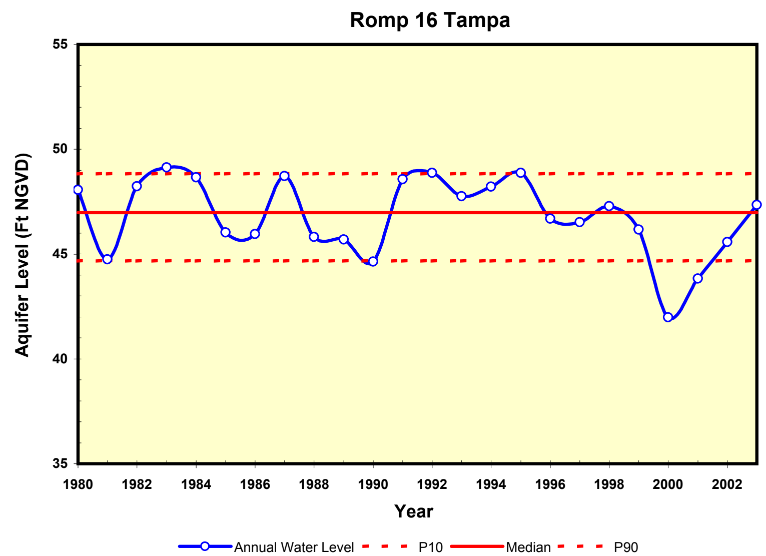

Arcadia 1
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

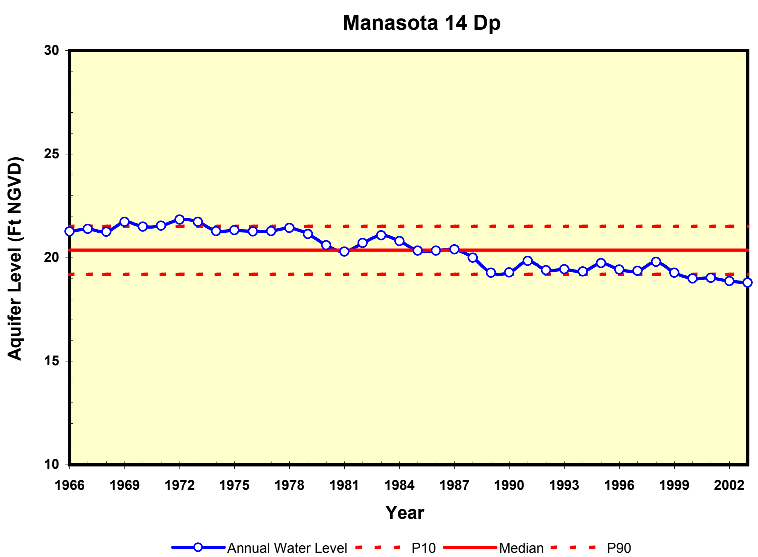

Romp 33 Arcadia
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

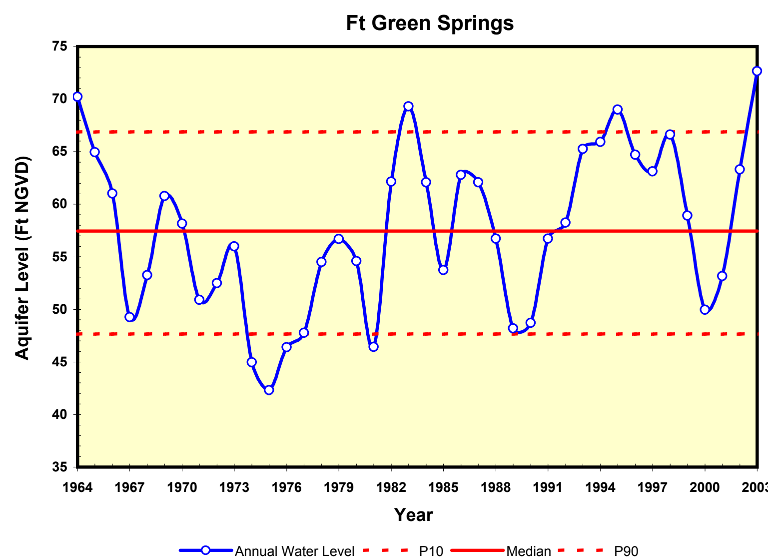

Romp 10 L. Hawthorn/Tampa
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

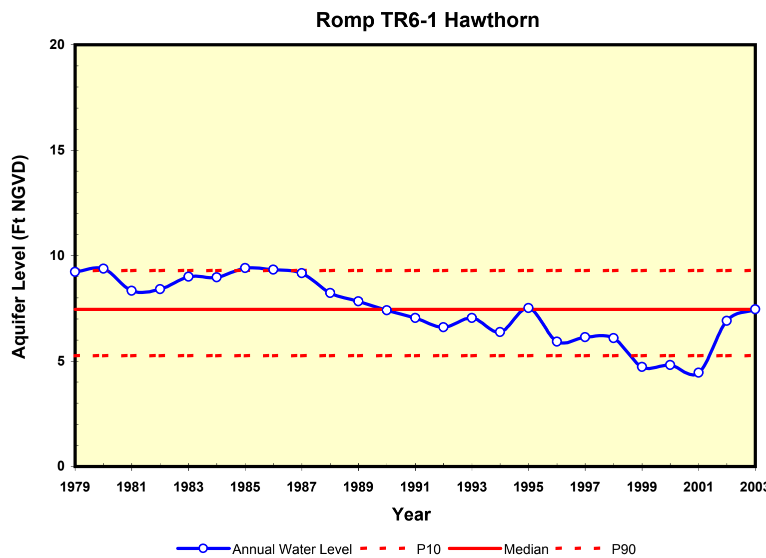

Romp 11 Hawthorn
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

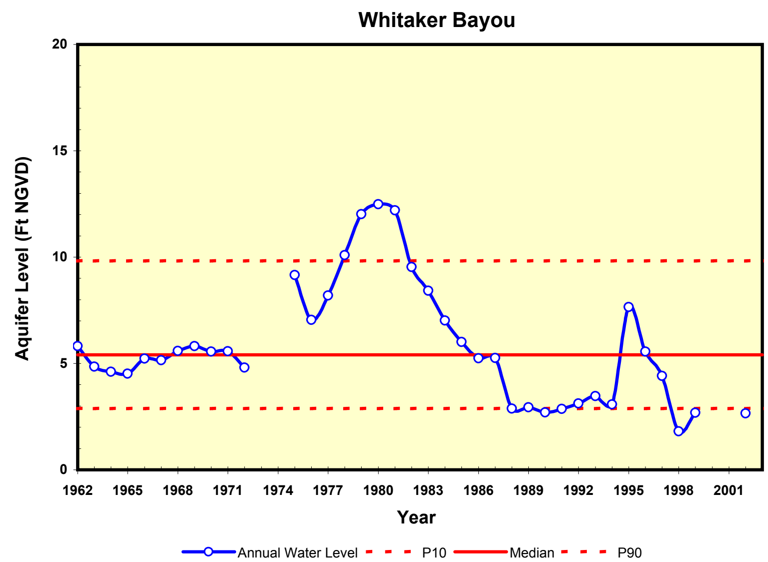

Romp 30 Tampa
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

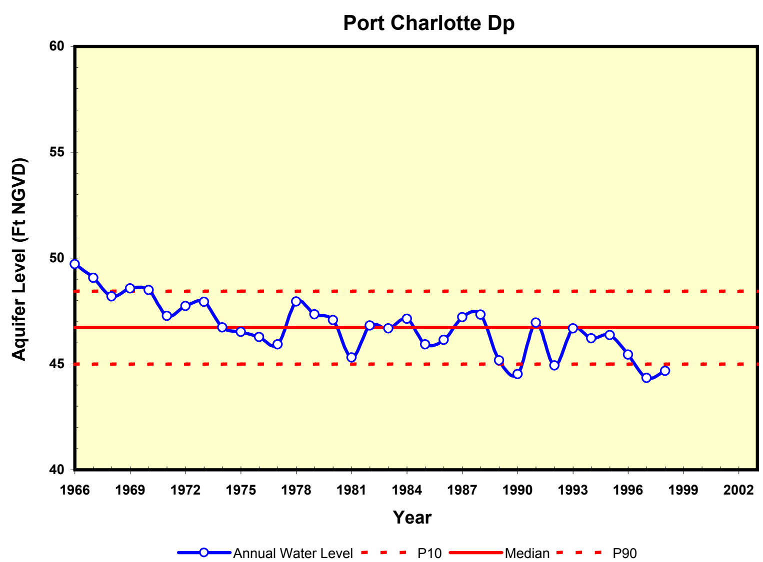

Romp 16 Tampa
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

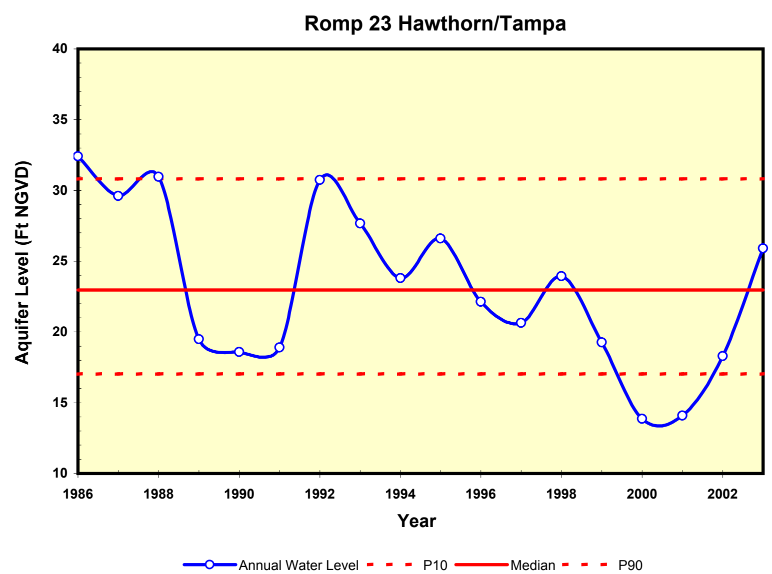

Manasota 14 Dp
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

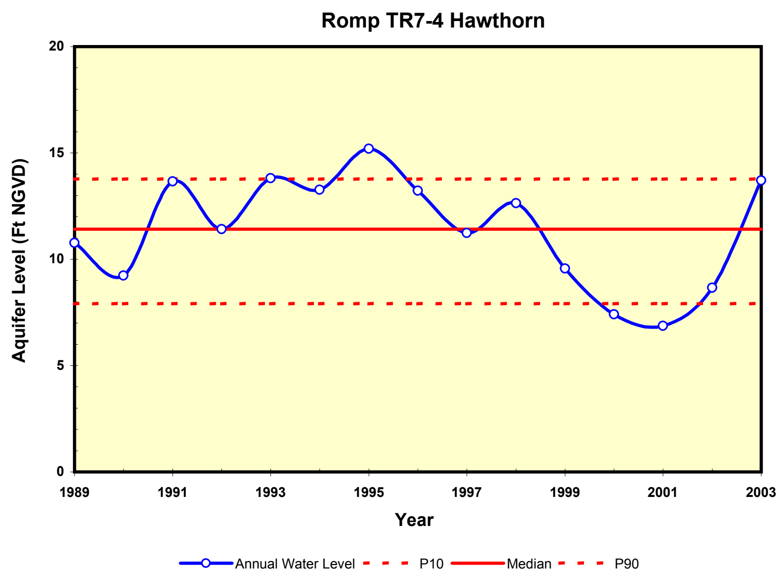

Ft Green Springs
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

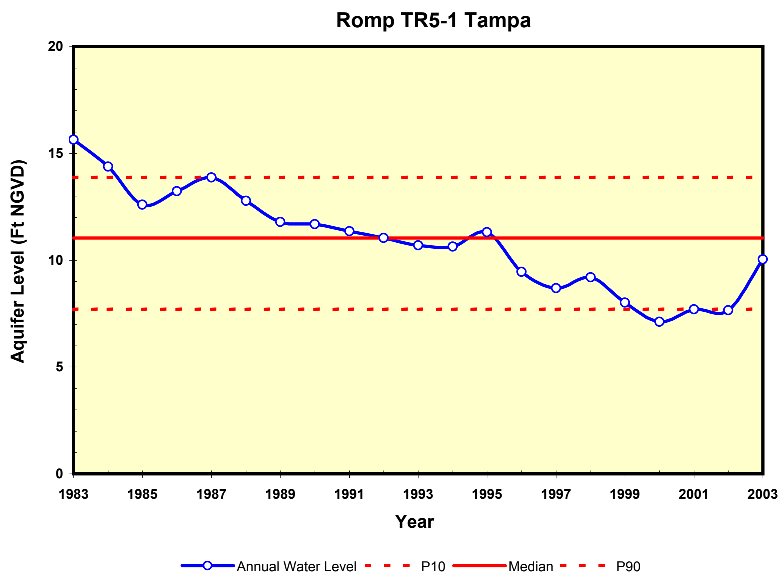

Romp TR6-1 Hawthorn
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

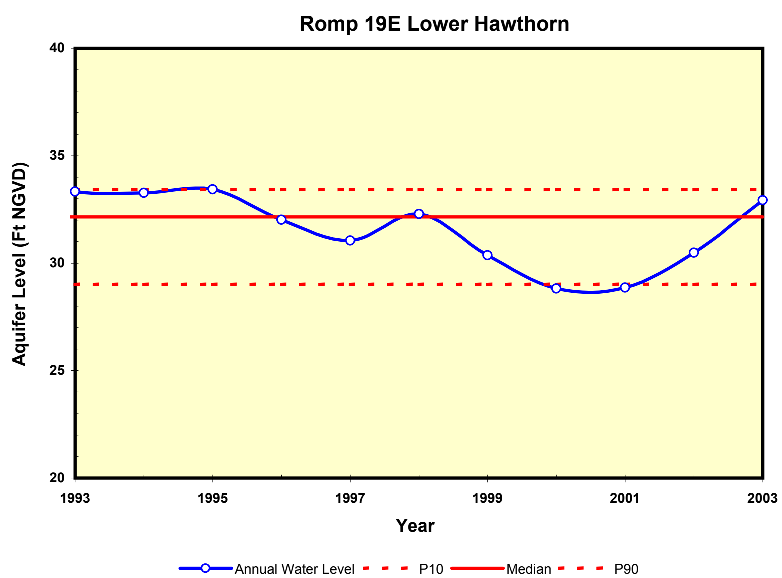

Whitaker Bayou
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

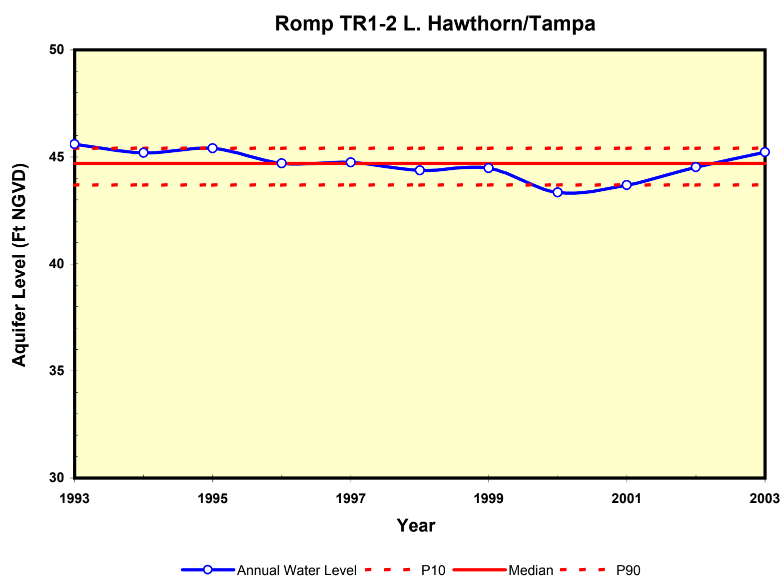

Port Charlotte Dp
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

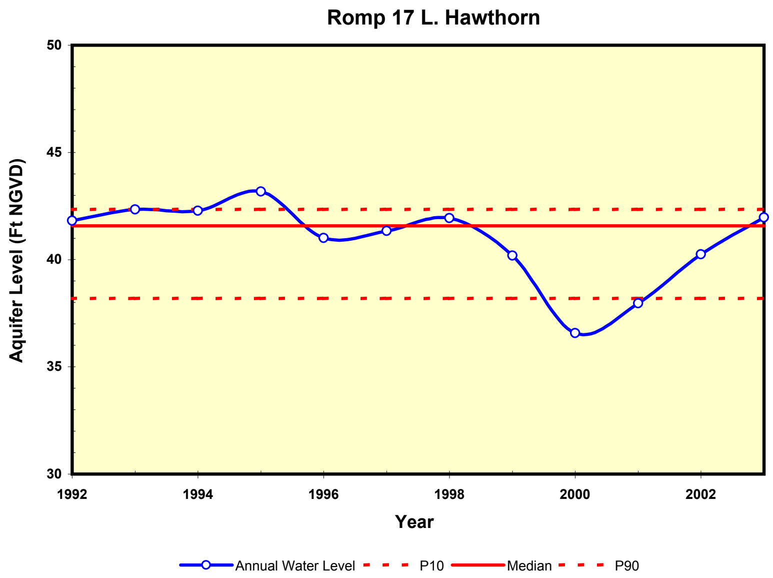

Romp 23 Hawthorn/Tampa
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

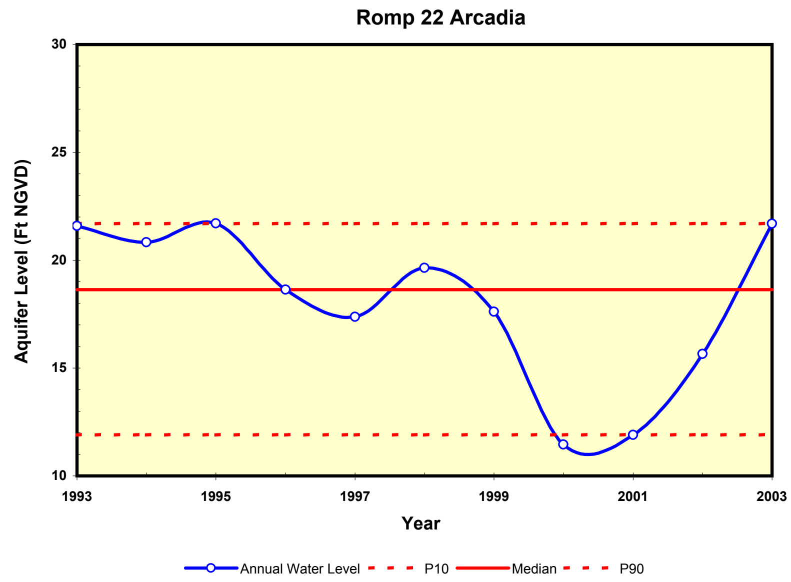

Romp TR7-4 Hawthorn
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

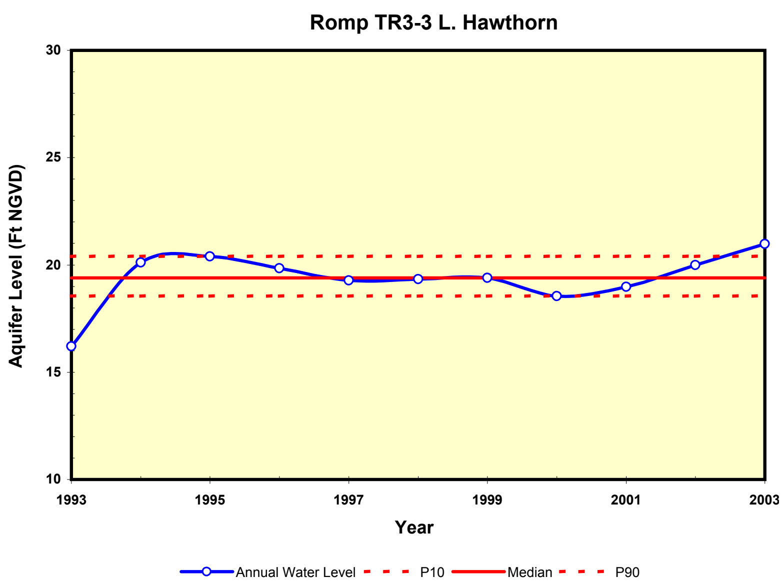

Romp TR5-1 Tampa
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

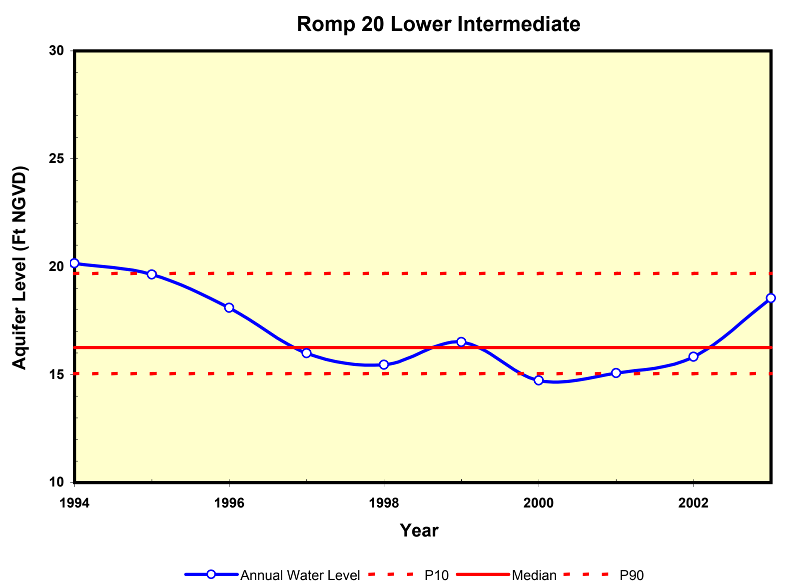

Romp 19E Lower Hawthorn
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

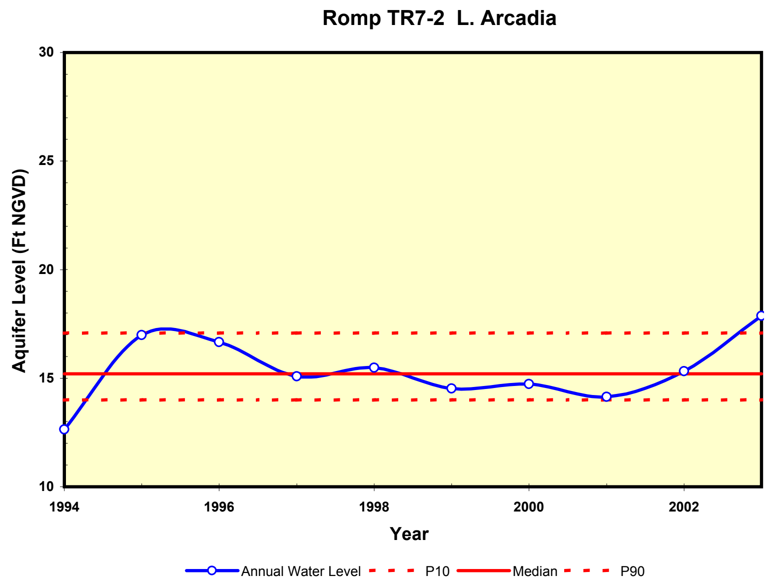

Romp TR1-2 L. Hawthorn/Tampa
Aquifer Level (Ft NGVD)
Year
Annual Water Level
P10
Median
P90

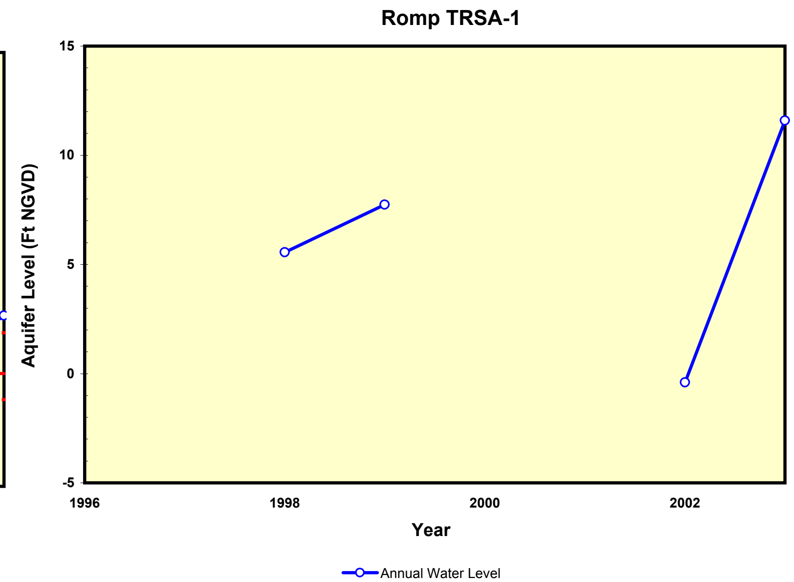

Romp 17 L. Hawthorn
Aquifer Level (Ft NGVD)
50
45
40
35
30
1992
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

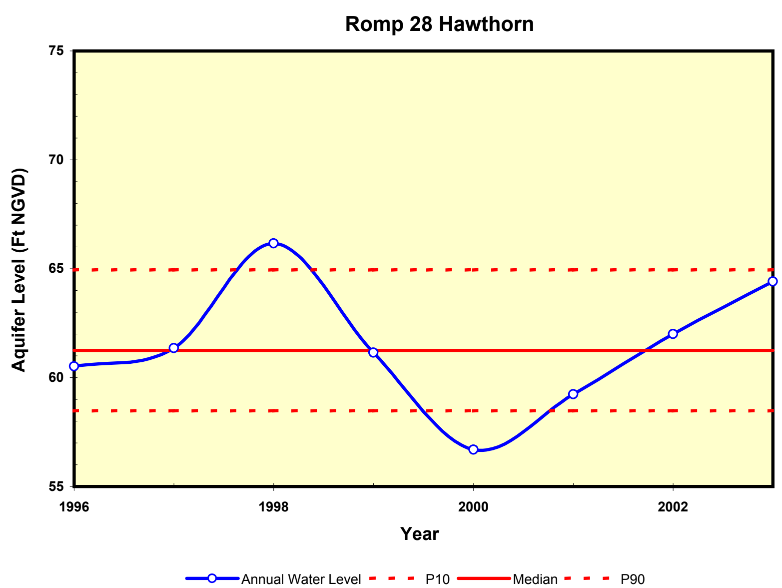

Romp 22 Arcadia
Aquifer Level (Ft NGVD)
30
25
20
15
10
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

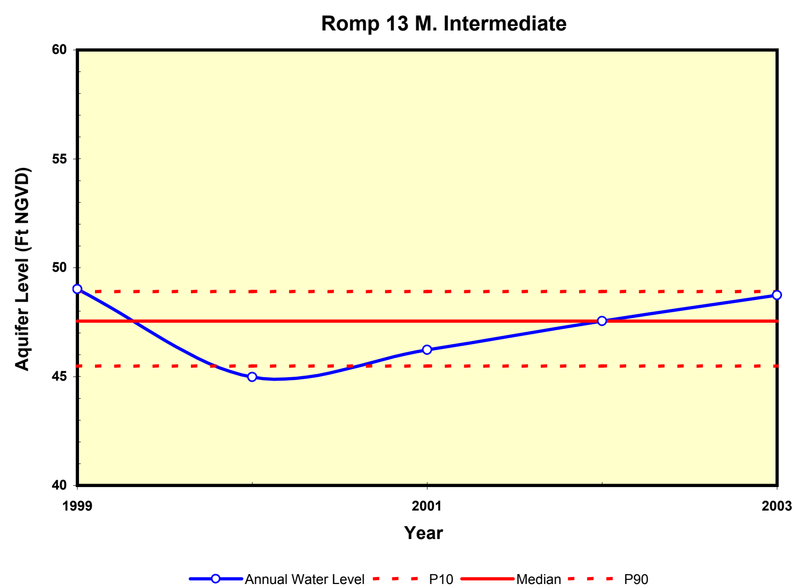

Romp TR3-3 L. Hawthorn
Aquifer Level (Ft NGVD)
30
25
20
15
10
1993
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

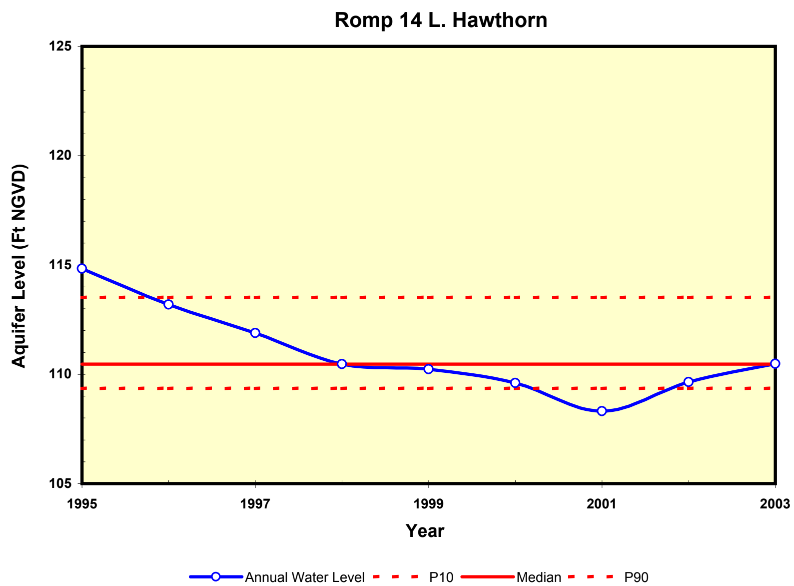

Romp 20 Lower Intermediate
Aquifer Level (Ft NGVD)
30
25
20
15
10
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

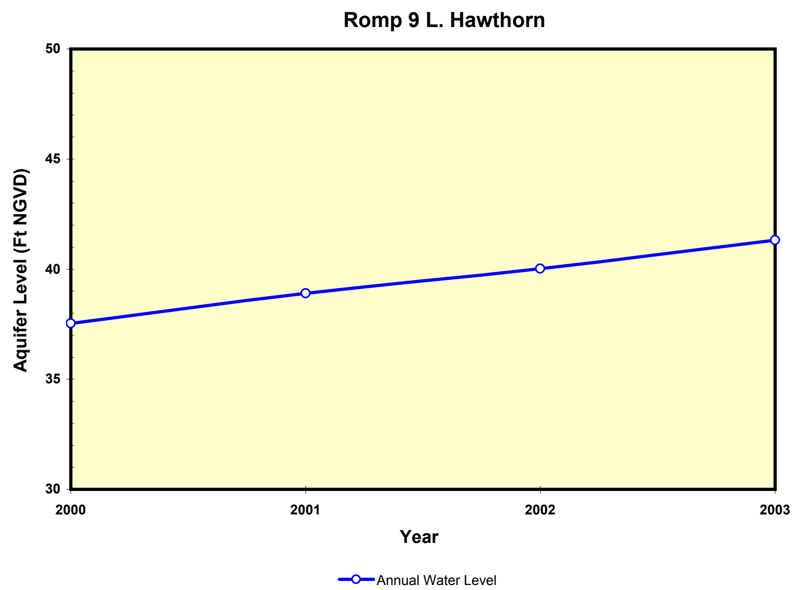

Romp TR7-2 L. Arcadia
Aquifer Level (Ft NGVD)
30
25
20
15
10
1994
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

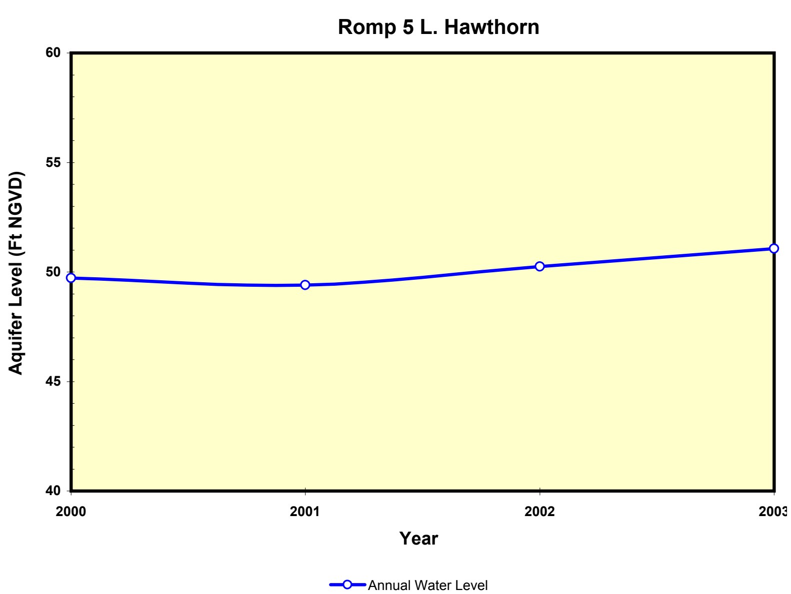

Romp TRSA-1
Aquifer Level (Ft NGVD)
15
10
5
0
-5
1996
1998
2000
2002
Year
Annual Water Level

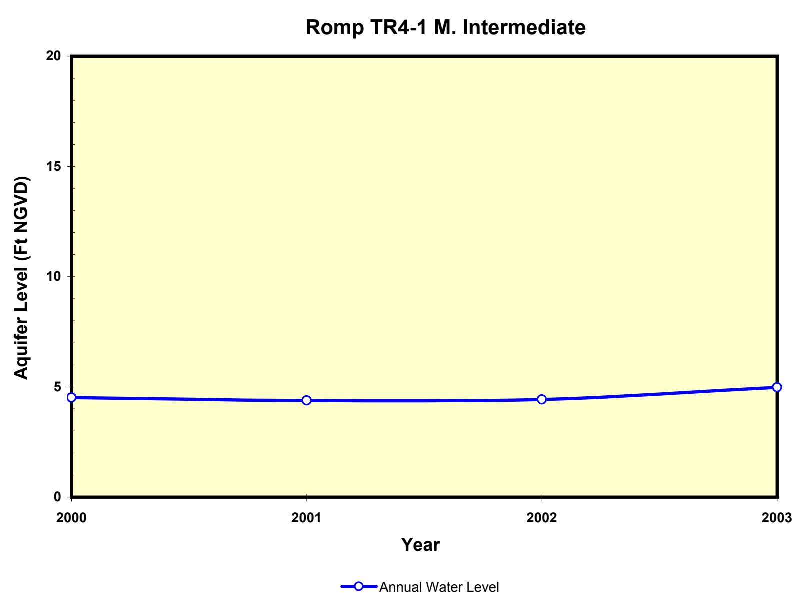

Romp 28 Hawthorn
Aquifer Level (Ft NGVD)
75
70
65
60
55
1996
1998
2000
2002
Year
Annual Water Level
P10
Median
P90

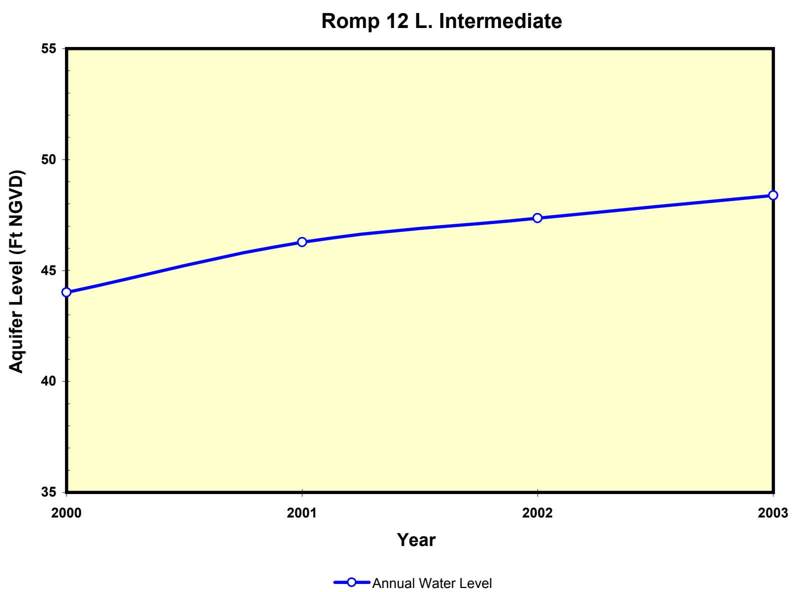

Romp 13 M. Intermediate
Aquifer Level (Ft NGVD)
60
55
50
45
40
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

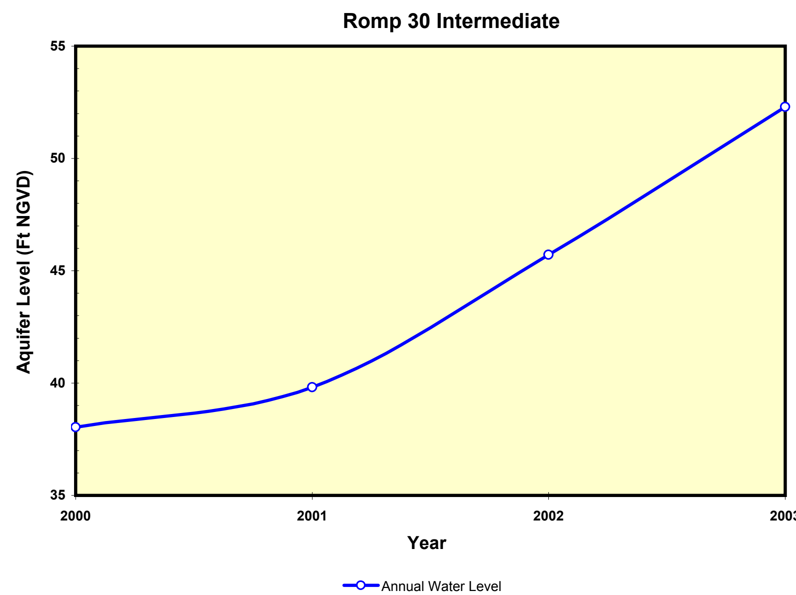

Romp 14 L. Hawthorn
Aquifer Level (Ft NGVD)
125
120
115
110
105
1995
1997
1999
2001
2003
Year
Annual Water Level
P10
Median
P90

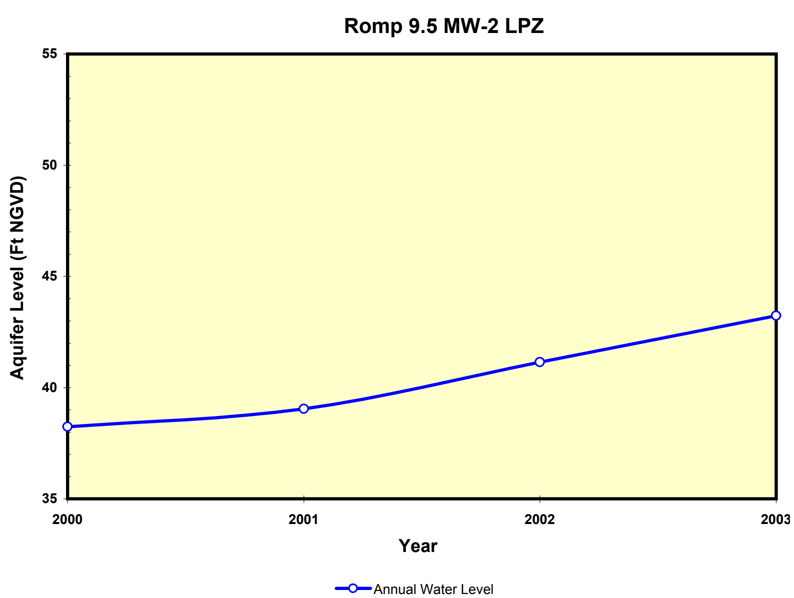

Romp 9 L. Hawthorn
Aquifer Level (Ft NGVD)
50
45
40
35
30
2000
2001
2002
2003
Year
Annual Water Level

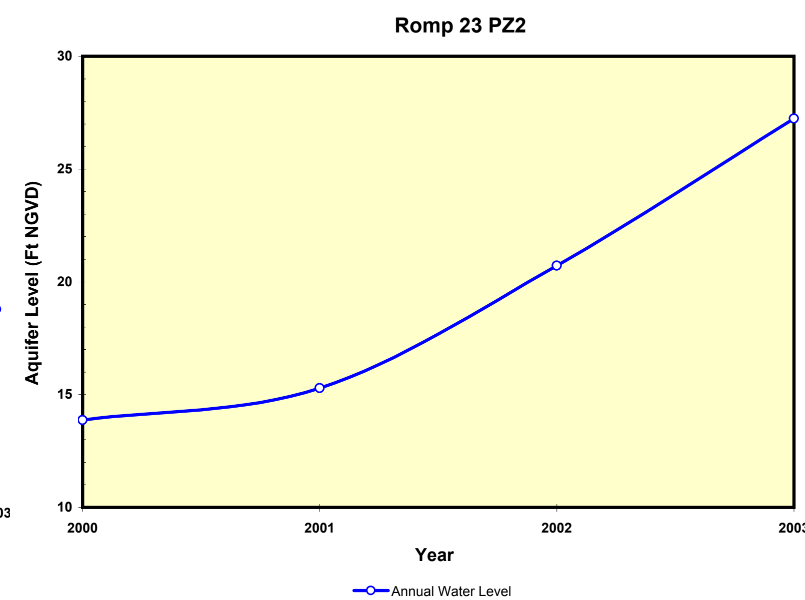

Romp 5 L. Hawthorn
Aquifer Level (Ft NGVD)
60
55
50
45
40
2000
2001
2002
2003
Year
Annual Water Level

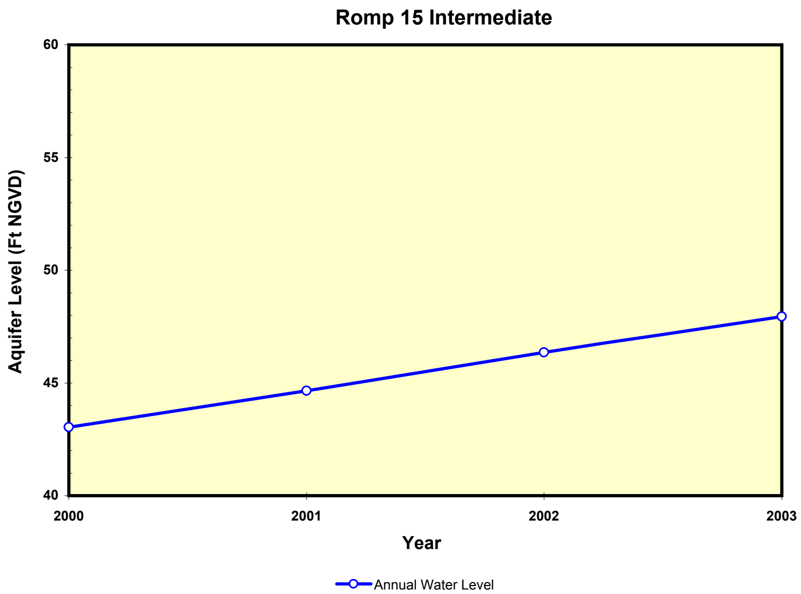

Romp TR4-1 M. Intermediate
Aquifer Level (Ft NGVD)
20
15
10
5
0
2000
2001
2002
2003
Year
Annual Water Level


Romp 12 L. Intermediate
Aquifer Level (Ft NGVD)
55
50
45
40
35
2000
2001
2002
2003
Year
Annual Water Level


Romp 30 Intermediate
Aquifer Level (Ft NGVD)
55
50
45
40
35
2000
2001
2002
2003
Year
Annual Water Level


Romp 9.5 MW-2 LPZ
Aquifer Level (Ft NGVD)
55
50
45
40
35
2000
2001
2002
2003
Year
Annual Water Level


Romp 23 PZ2
Aquifer Level (Ft NGVD)
30
25
20
15
10
2000
2001
2002
2003
Year
Annual Water Level


Romp 15 Intermediate
60
55
50
45
40
Aquifer Level (Ft NGVD)
2000
2001
2002
2003
Year
Annual Water Level

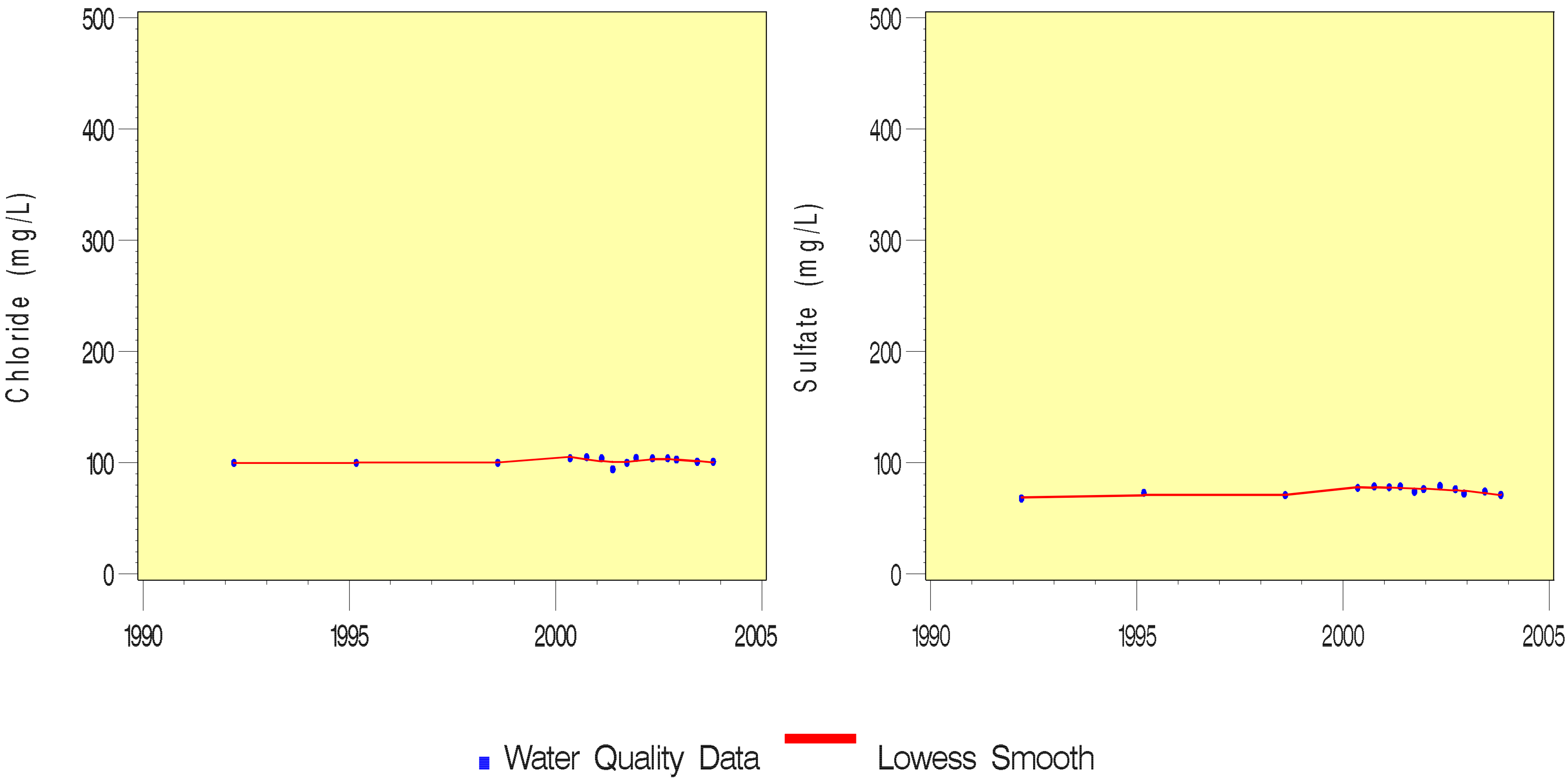
APPENDIX E

Specifications for wells completed in PZ 2

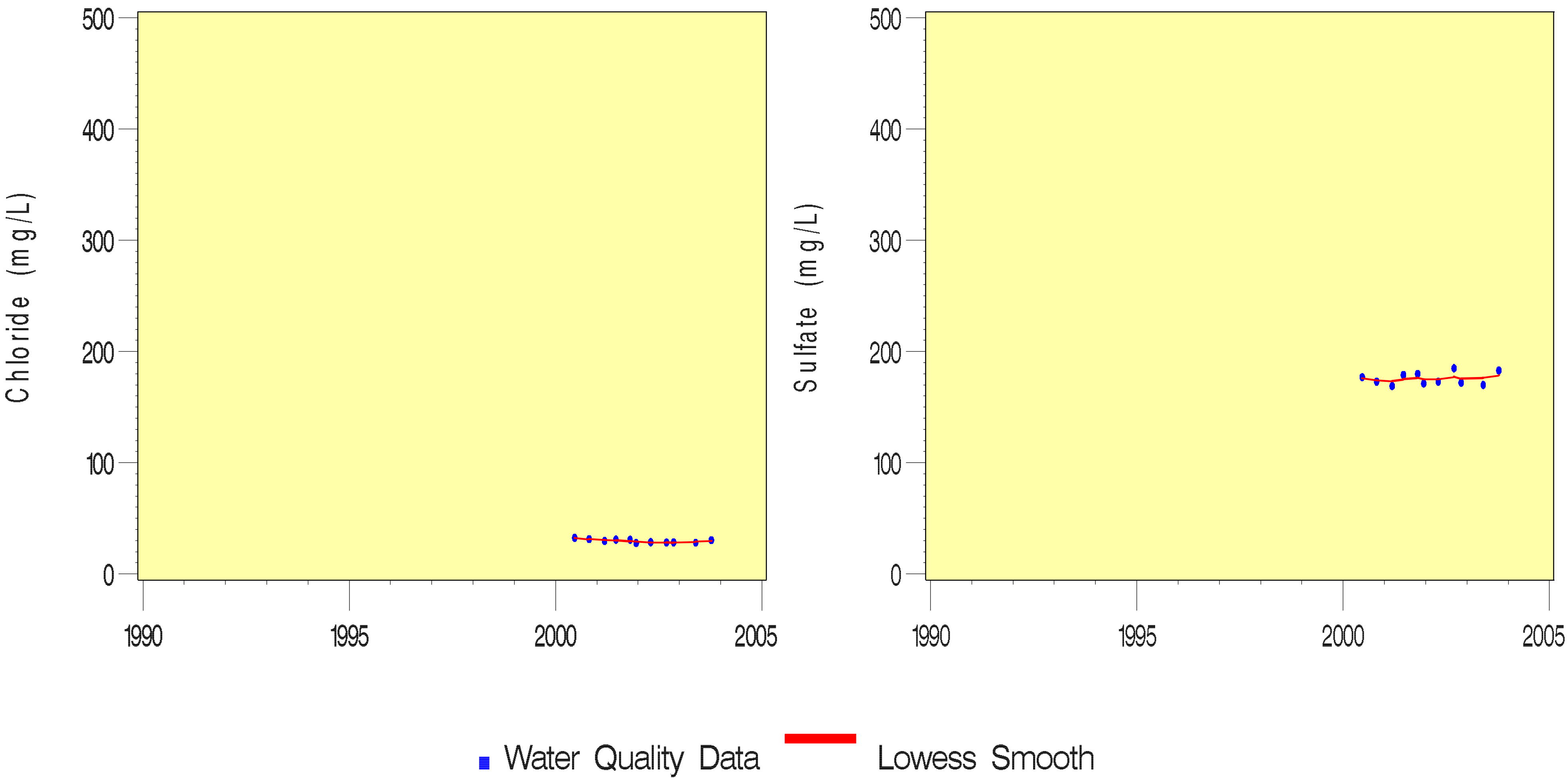
UID TYPE	UID STATION	UID SITE	UID SITE SEQ	UID SITENAME	LATITUDE	LONGITUDE	CASING DEPTH	TOTAL DEPTH
WEL	296	30	0	ROMP 45 HTRN	274551.27	814709.84	110	192
WEL	5	257	0	ROMP TR 8-1 UP HTRN	273459.66	823245.97	100	160
WEL	520	258	0	ROMP 26 HTRN	271758.85	814928.74	140	180
WEL	536	288	0	ROMP 10 UP HTRN	270152.87	820000.66	130	202
WEL	614	348	0	BIG SLOUGH DEEP	271135.80	820920.27	78	100
WEL	634	370	0	ROMP 40 HTRN	273852.39	820314.73	76	180
WEL	676	410	0	VENICE 35 INT	270540.88	822614.04	86	163
WEL	729	463	0	ENGLEWOOD 14 DEEP	265835.15	822023.84	44	55
WEL	778	512	0	PORT CHARLOTTE UTIL DEEP	265920.50	820455.32	128	156
WEL	779	518	0	ROMP 59 HTRN	275302.29	815151.13	50	60
WEL	832	566	0	SR 74 DEEP	265647.90	815546.71	194	280
WEL	848	582	0	CREWSVILLE UP INT	272544.65	813522.82	96	116
WEL	971	705	0	PUNTA GORDA HEIGHTS INT	265140.01	820022.74	84	125
WEL	989	723	0	ENGLEWOOD 5 PROD ZONE INT	270114.76	822232.05	37	66
WEL	1235	774	0	ROTUNDA WATER PLANT 18 IN	265205.11	821723.13	121	146
WEL	1236	775	0	USGS C-3 INT	265505.23	820055.30	153	205
WEL	1352	891	0	CAMP CHANYATAH INT	271624.86	815159.73	43	192
WEL	1563	1102	0	GALLAGHER PATRICIA INT	272406.16	820724.30	158	250
WEL	1568	1107	0	ESTECH HAWTHORNE 44 INT	273252.07	820728.03	145	250
WEL	1689	1228	0	HOMELAND DEP 4 INT	274909.74	814804.34	56	202
WEL	1715	1254	0	VENICE SH WF 68 INT	270558.28	822409.57	76	110
WEL	1719	1258	0	VENICE SH WF 59 INT	270558.41	822449.39	82	190
WEL	1729	1268	0	PLANTATION HTRN	270405.89	822154.96	66	180
WEL	1731	1270	0	DARNELL THOMAS INT	271854.17	822507.32	83	166
WEL	1766	1305	0	ROMP TR 5-3 UPPER INT	270934.13	822412.63	63	140
WEL	1866	1318	0	USGS TUCKERS CORNER INT	265125.22	814536.28	212	235
WEL	1867	1319	0	USGS C-1 INT	265129.02	815308.75	214	264
WEL	989	1360	0	ENGLEWOOD 5 HTRN	270114.22	822232.34	134	152
WEL	1908	1369	0	ST OF FLA PAYNES CRK INT	273711.76	814830.00	119	130
WEL	170	10882	0	ROMP 57 HTRN	275413.04	813721.10	95	140
WEL	13	10937	0	ROMP 19 EAST HTRN	271022.00	821515.99	80	121
WEL	14	10938	0	ROMP 19 WEST HTRN	271001.48	822029.30	87	205
WEL	2	10945	1	ROMP TR 3-1 HTRN 160	265639.42	821304.89	140	160
WEL	1023	11071	1	ROMP TR 3-3 UP HTRN	265532.22	821947.33	155	175
WEL	1029	11174	0	ROMP 22 ARC	271843.82	822011.79	95	125
WEL	1031	11304	0	ROMP 20 UP HTRN	271138.59	822845.19	75	125
WEL	229	11333	0	ROMP TR 1-2 UP HTRN	265025.35	815853.37	218	255
WEL	1033	11392	0	ROMP TR 7-2 UP ARC	272614.04	823300.90	60	105
WEL	1036	11450	0	ROMP 39 ARC	273519.35	821505.35	130	205
WEL	1165	11611	0	PRAIRIE CRK UP INT (WQMP)	270244.84	814649.02	60	80
WEL	1069	12882	0	ROMP 5 UPPER INT	265644.95	814828.10	130	230
WEL	1070	12899	0	ROMP 9 MID INT MW-3	270434.90	820856.06	122	163

UID TYPE	UID STATION	UID SITE	UID SITE SEQ	UID SITENAME	LATITUDE	LONGITUDE	CASING DEPTH	TOTAL DEPTH
WEL	1085	12949	0	ROMP 24 INT	271948.80	821608.01	74	171
WEL	1087	12953	0	ROMP TR 4-1 MID INT	270328.77	822628.40	121	224
WEL	2075	13337	0	ROMP 12 UP INT	270228.19	814431.99	54	110
WEL	2091	13380	0	ROMP 9.5 MW-18 UPZ INT	270735.59	820248.01	61	77
WEL	1027	17250	0	ROMP 17 IAS PZ-2 INT	271026.00	815836.00	100	160
WEL	2188	17313	0	ROMP 25 ARC/IAS	272159.11	820025.39	105	145
WEL	913	17416	0	ROMP 23 PZ2 INT	271853.39	821039.21	175	250
WEL	2333	17744	0	SHELL CREEK RV PARK INT	265821.37	815343.38	135	195
WEL	2336	34901	0	ROMP 16.5 UPPER INT	270340.02	815302.39	56	90

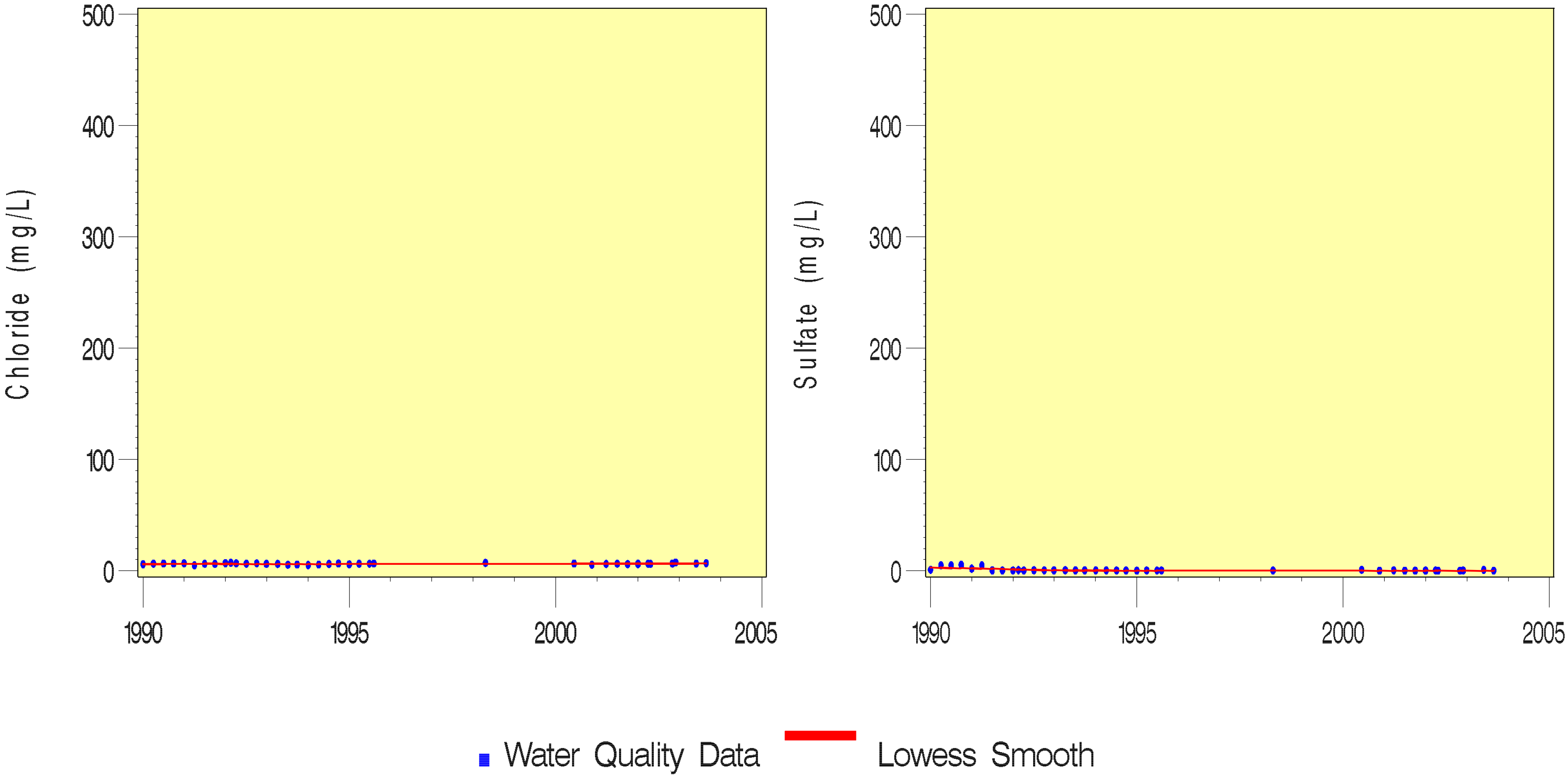
NAME=BIG SLOUGH DEEP SITE=348 SEQ=0



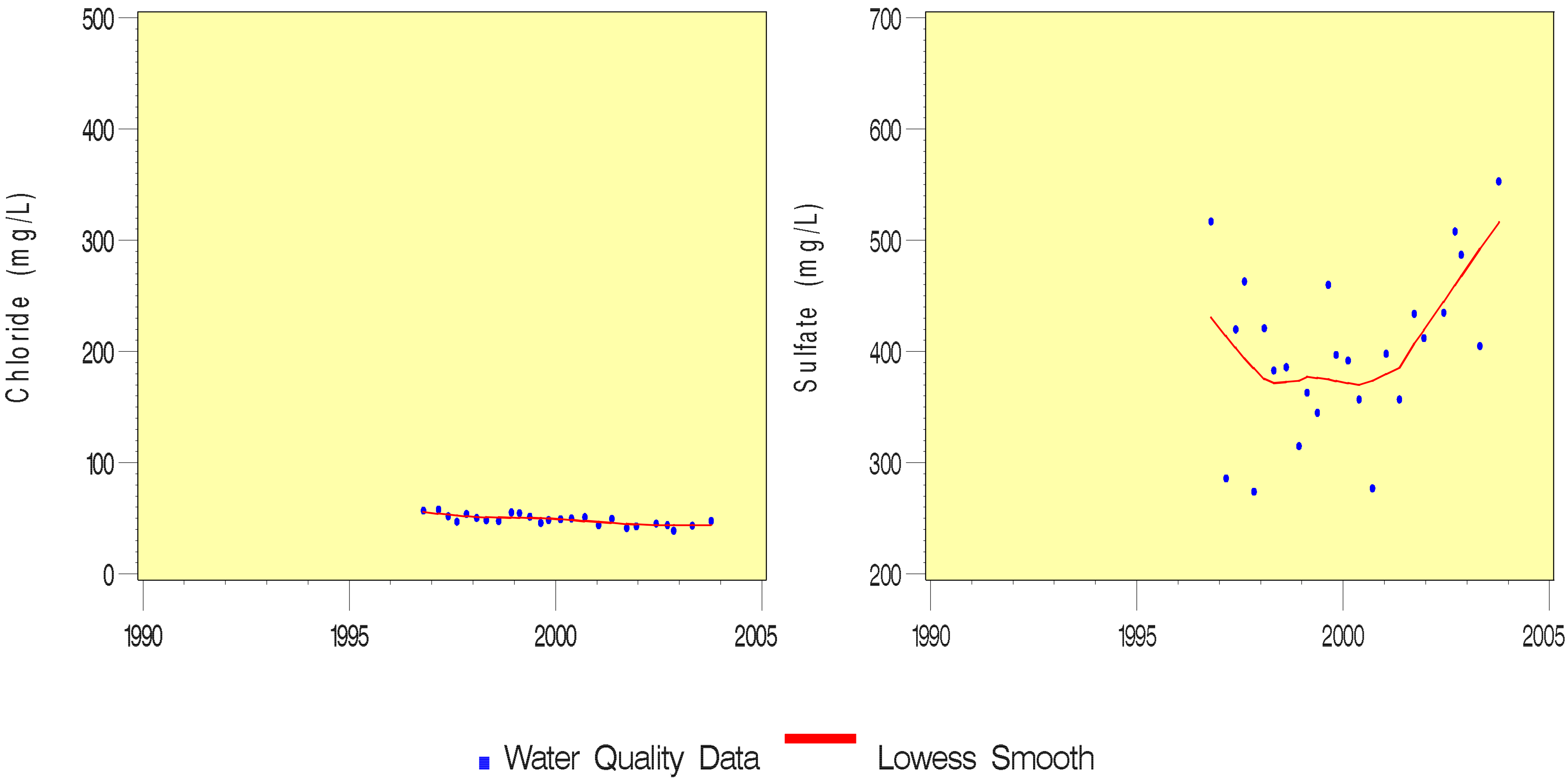
NAME= CAMP CHANYATAH INT SITE= 891 SEQ= 0



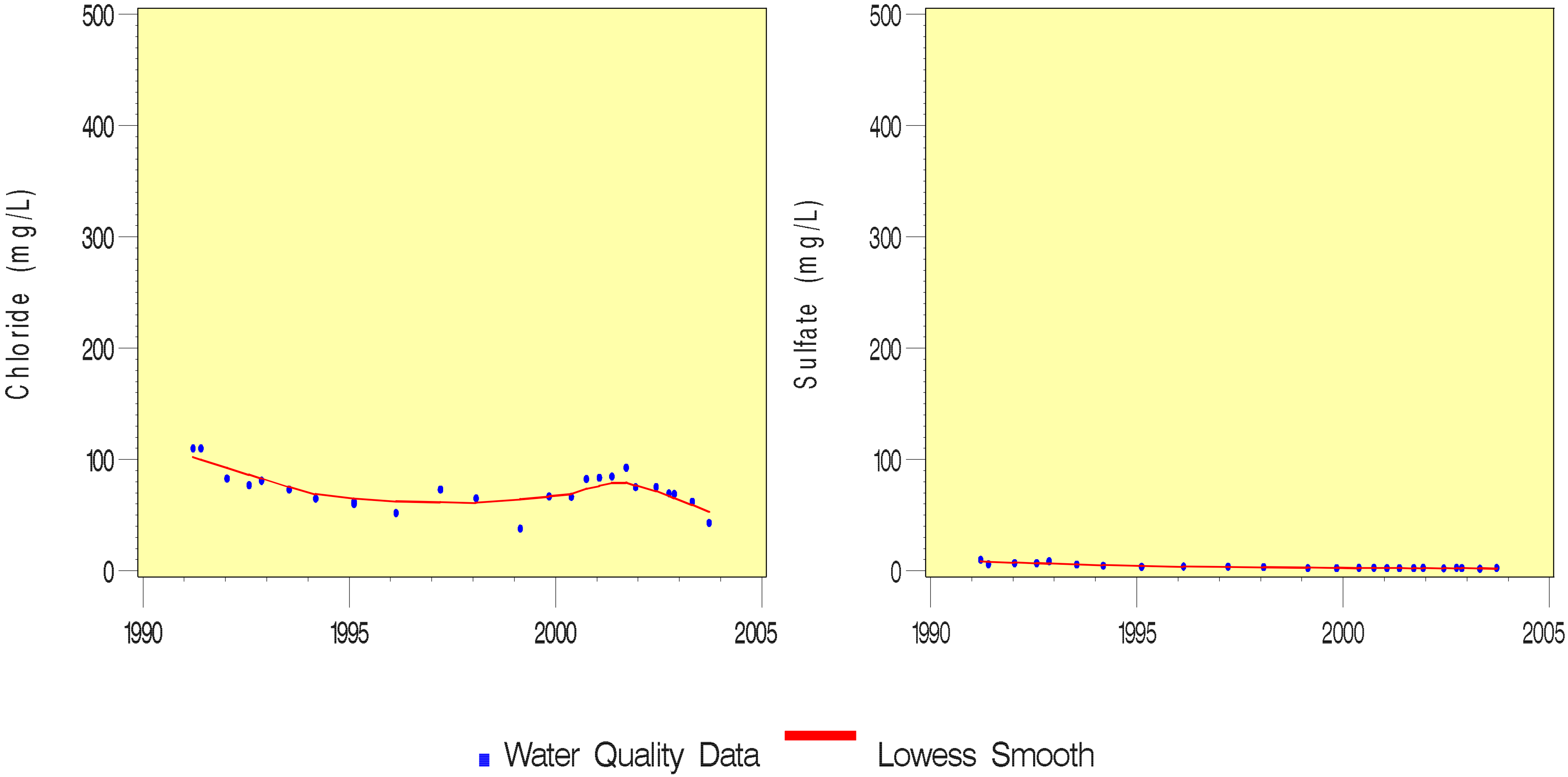
NAME= CREWSVILLE UP INT SITE= 582 SEQ= 0

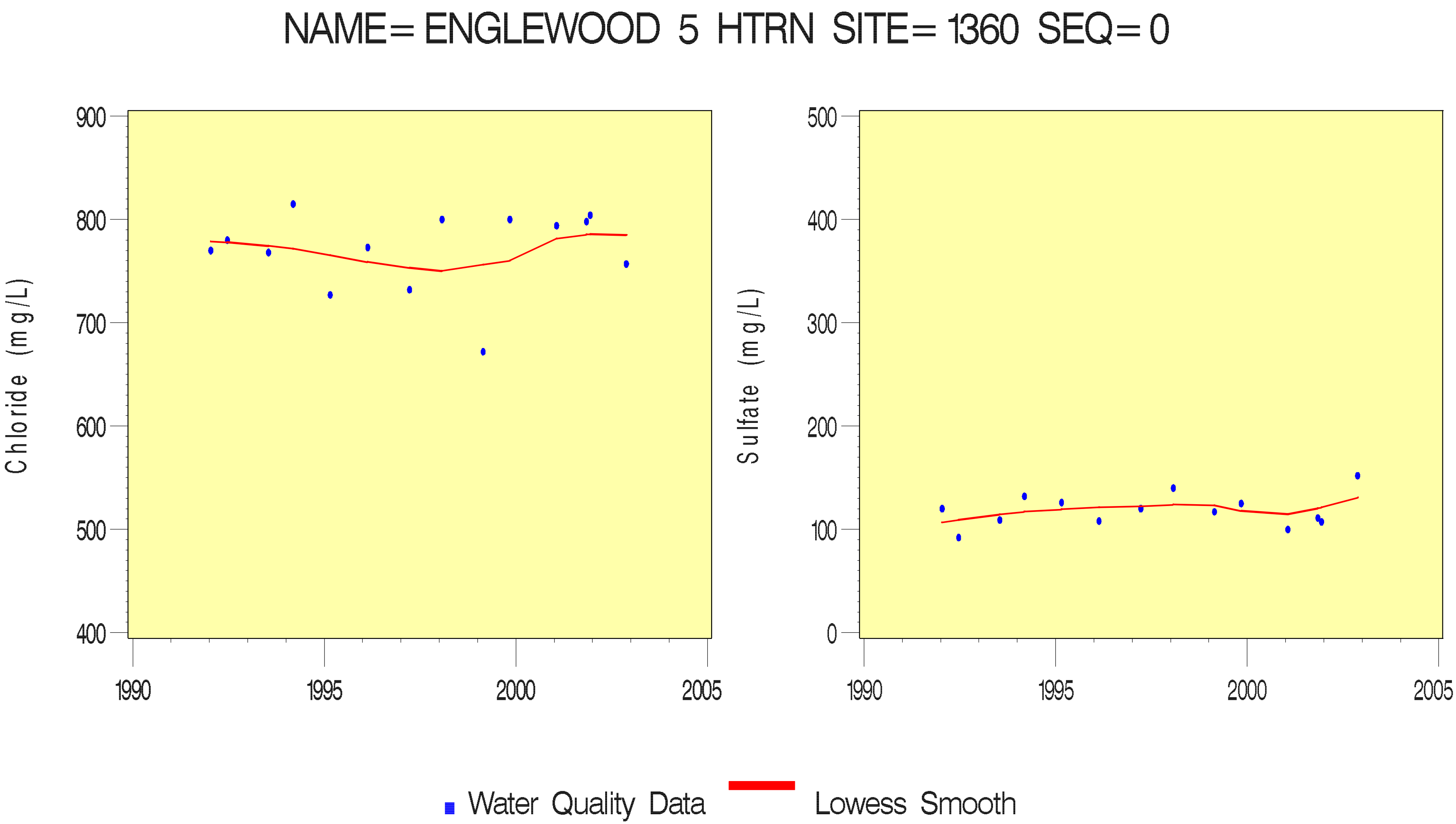


NAME= DARNELL THOMAS INT SITE= 1270 SEQ= 0

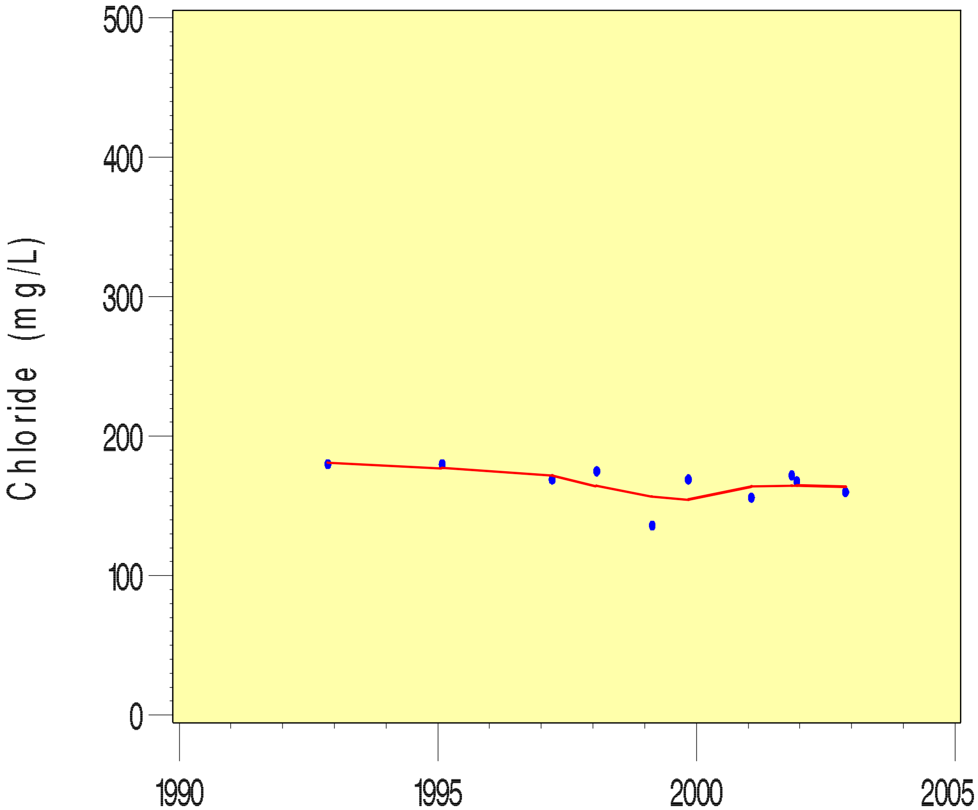


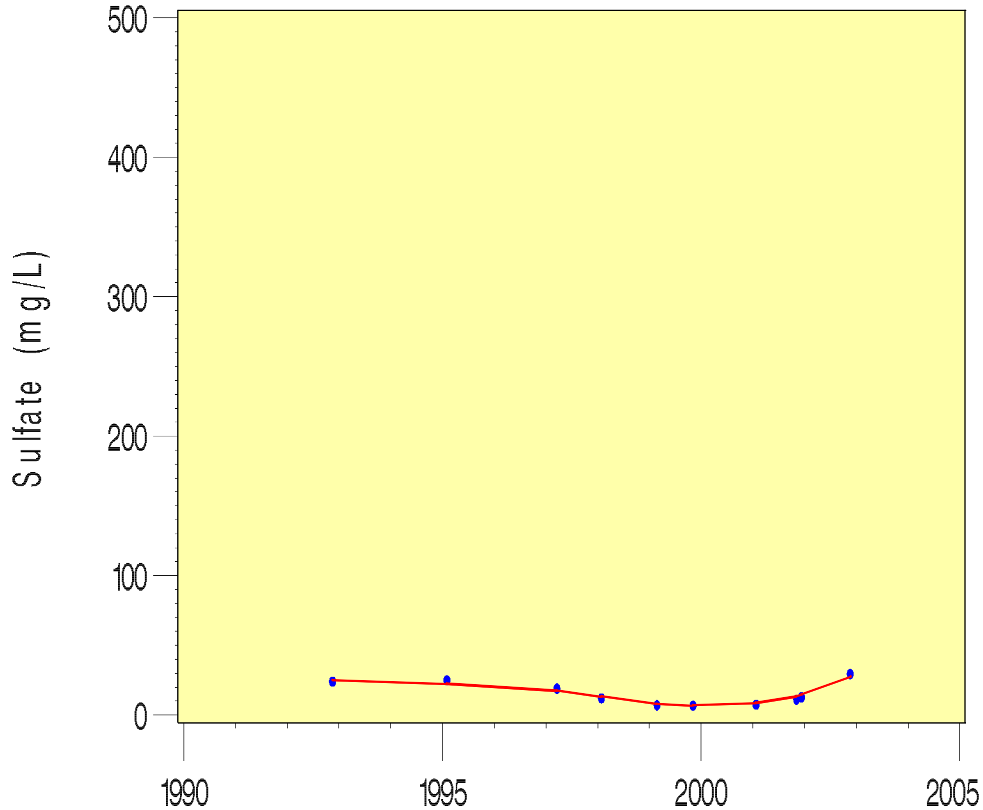
NAME= ENGLEWOOD 14 DEEP SITE= 463 SEQ= 0




NAME= ENGLEWOOD 5 HTRN SITE= 1360 SEQ= 0
Chloride (mg/L)
900
800
700
600
500
400
1990
1995
2000
2005
Sulfate (mg/L)
500
400
300
200
100
0
1990
1995
2000
2005
Water Quality Data
Lowess Smooth

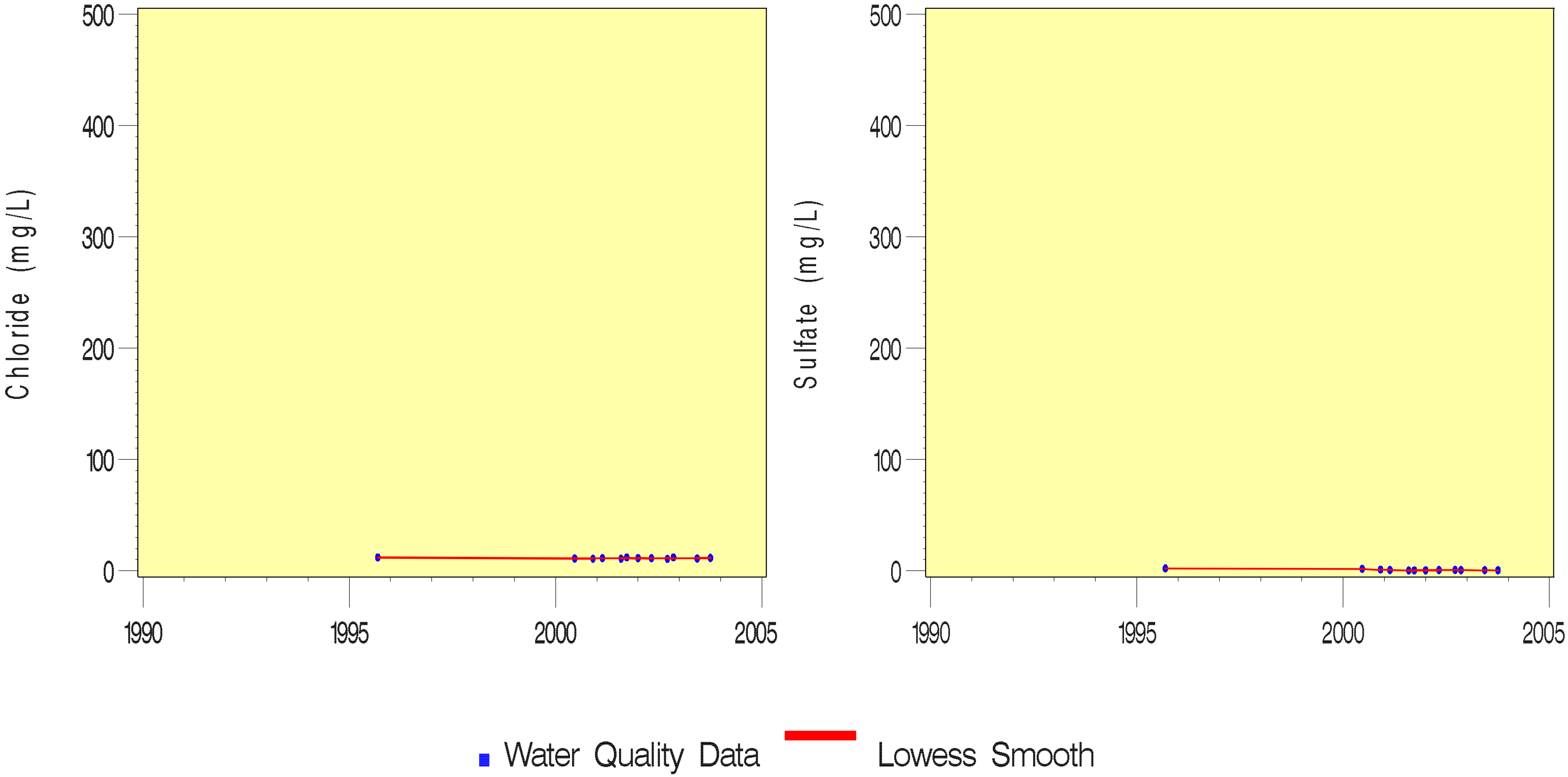
NAME= ENGLEWOOD 5 PROD ZONE INT SITE= 723 SEQ= 0



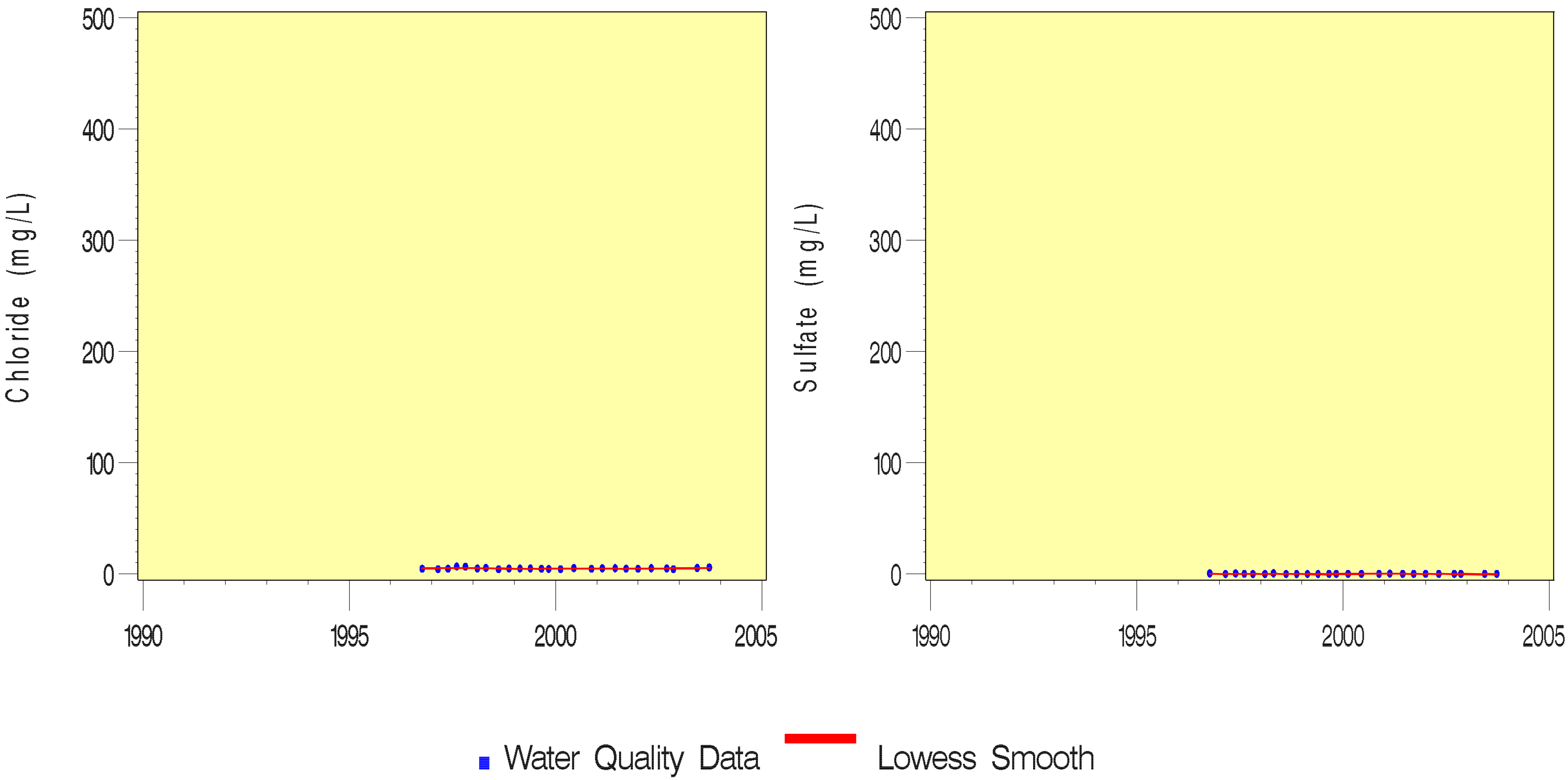


Water Quality Data   Lowess Smooth

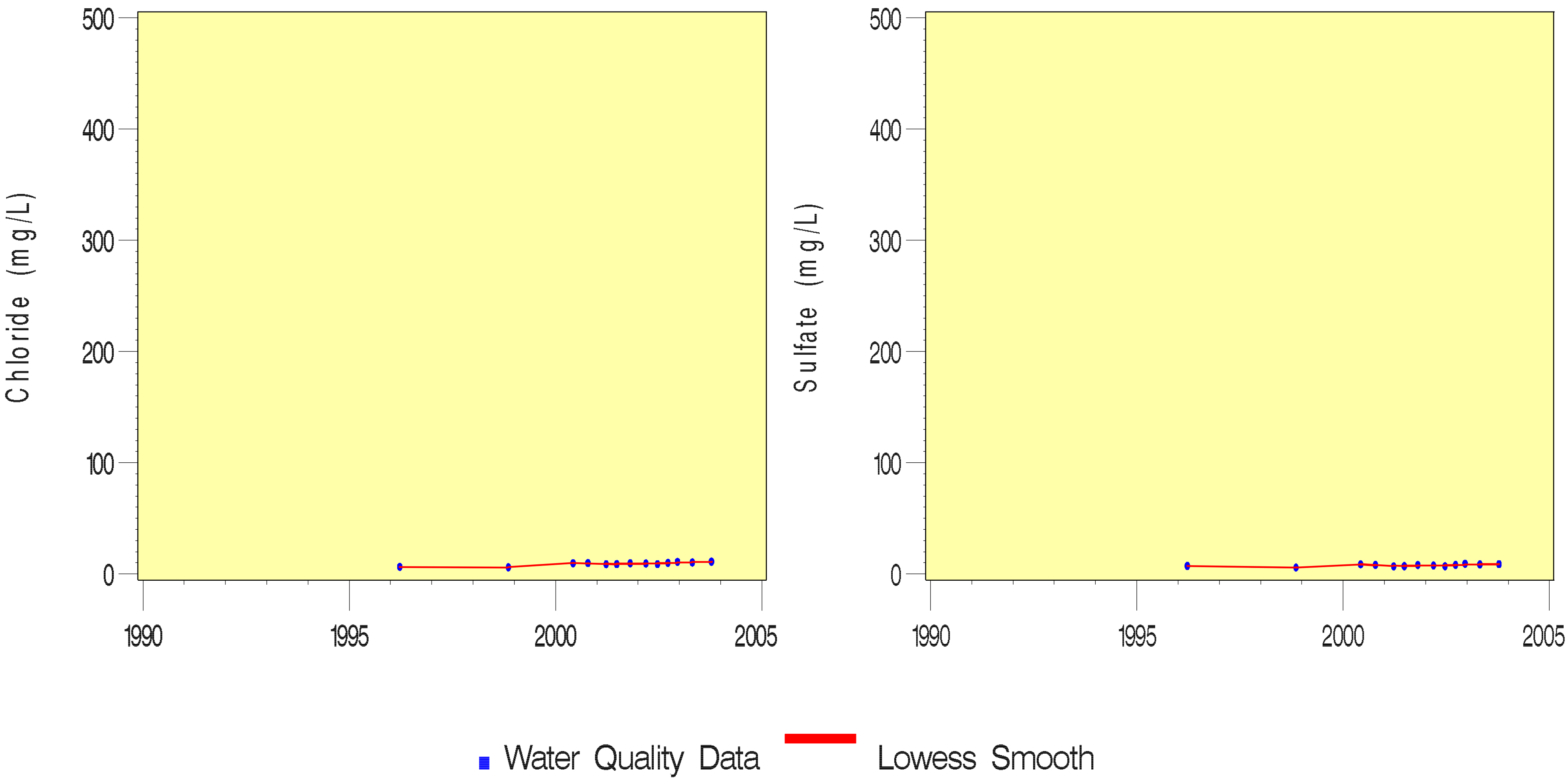
NAME= ESTECH HAWTHORNE 44 INT SITE= 1107 SEQ= 0



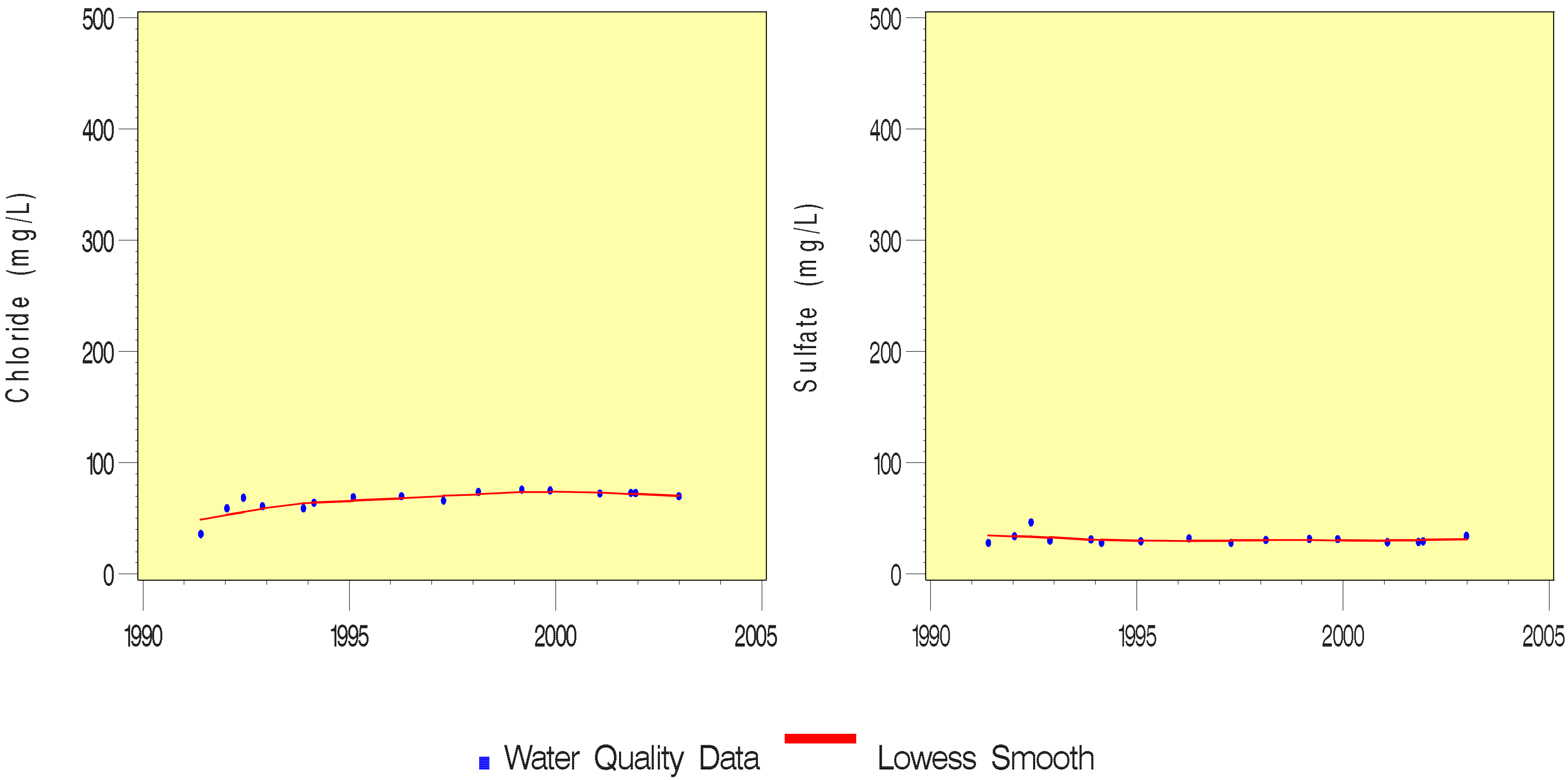
NAME= GALLAGHER PATRICIA INT SITE= 1102 SEQ= 0



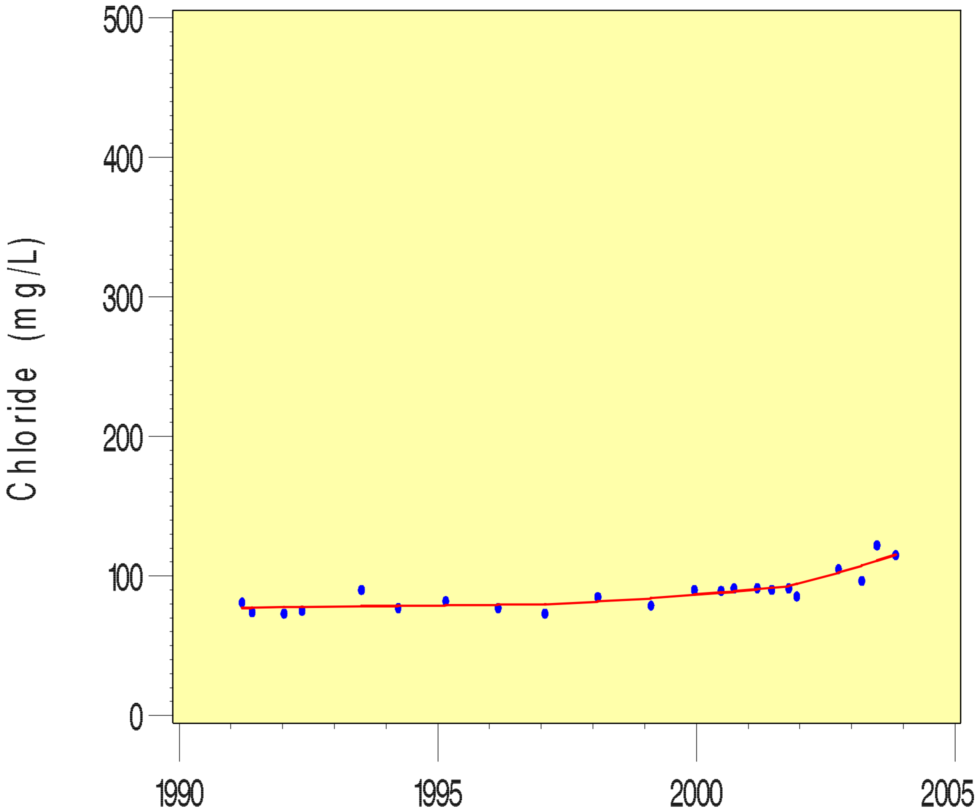
NAME= HOMELAND DEP 4 INT SITE= 1228 SEQ= 0

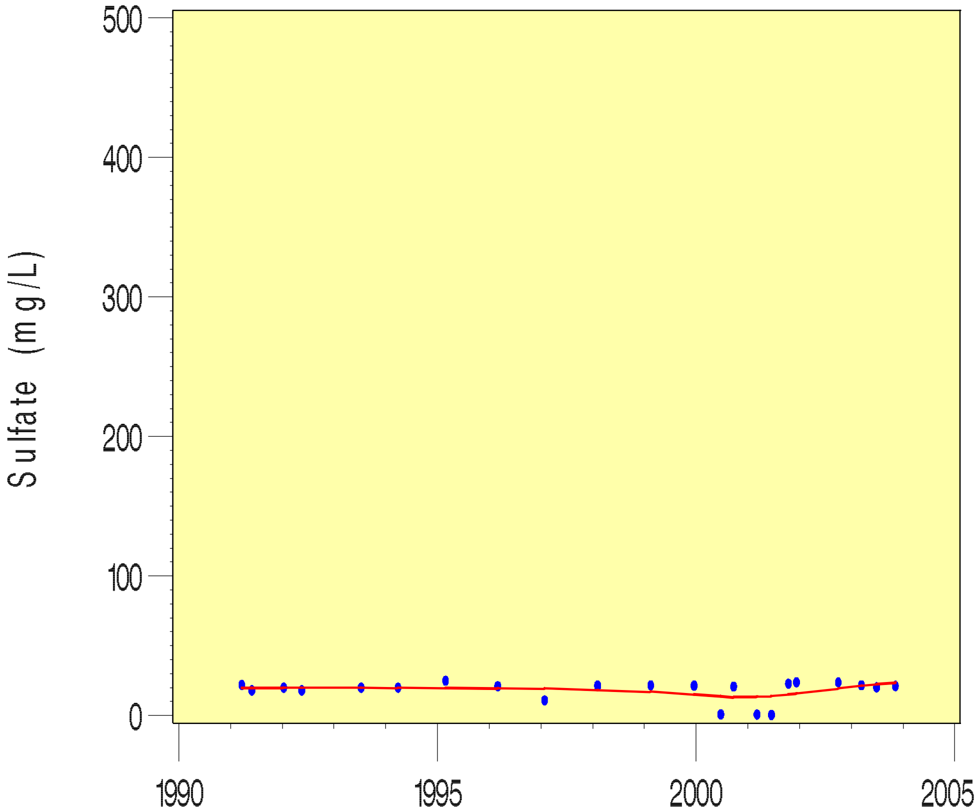


NAME= PLANTATION HTRN SITE= 1268 SEQ= 0

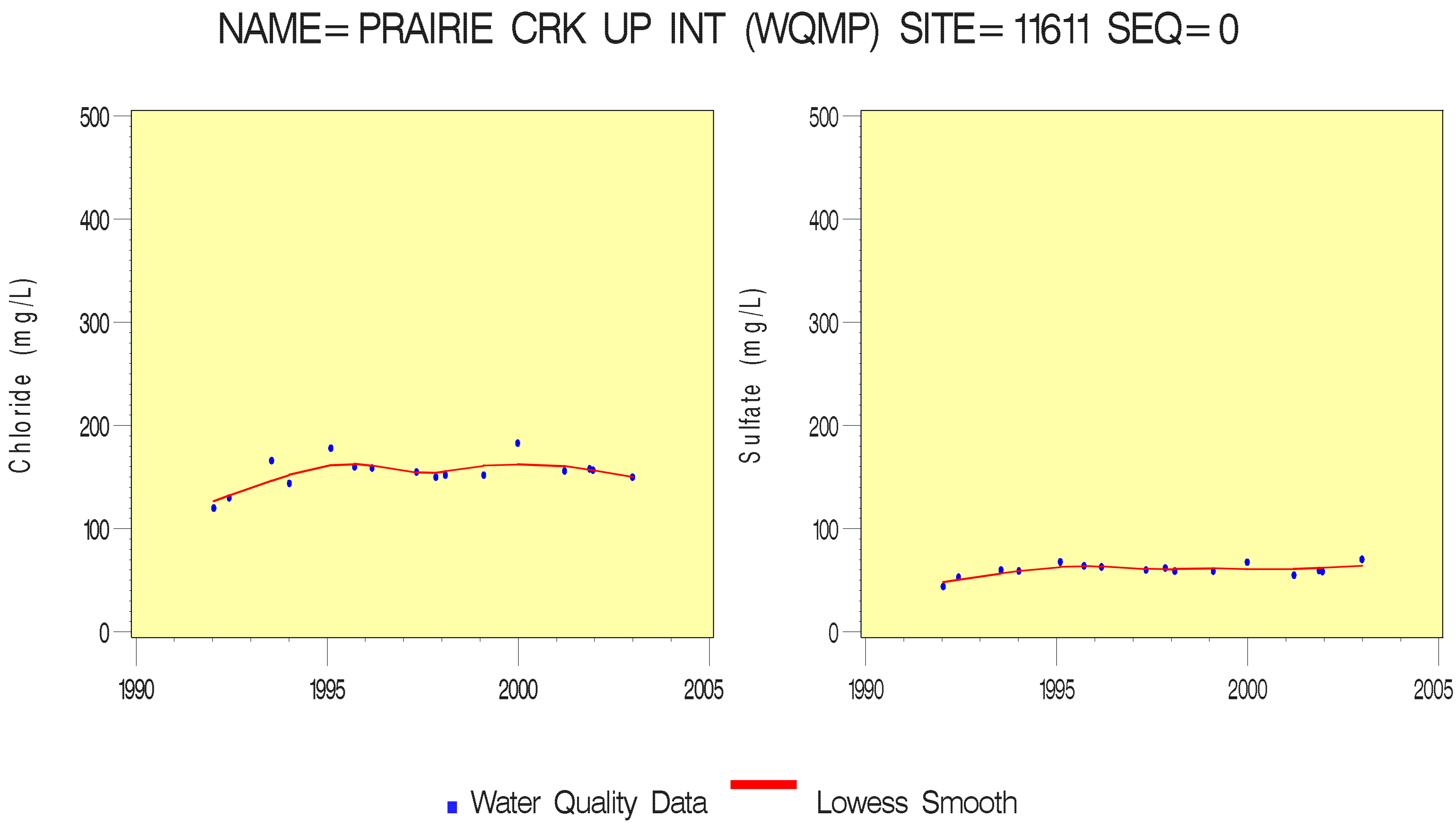


NAME= PORT CHARLOTTE UTIL DEEP SITE= 512 SEQ= 0

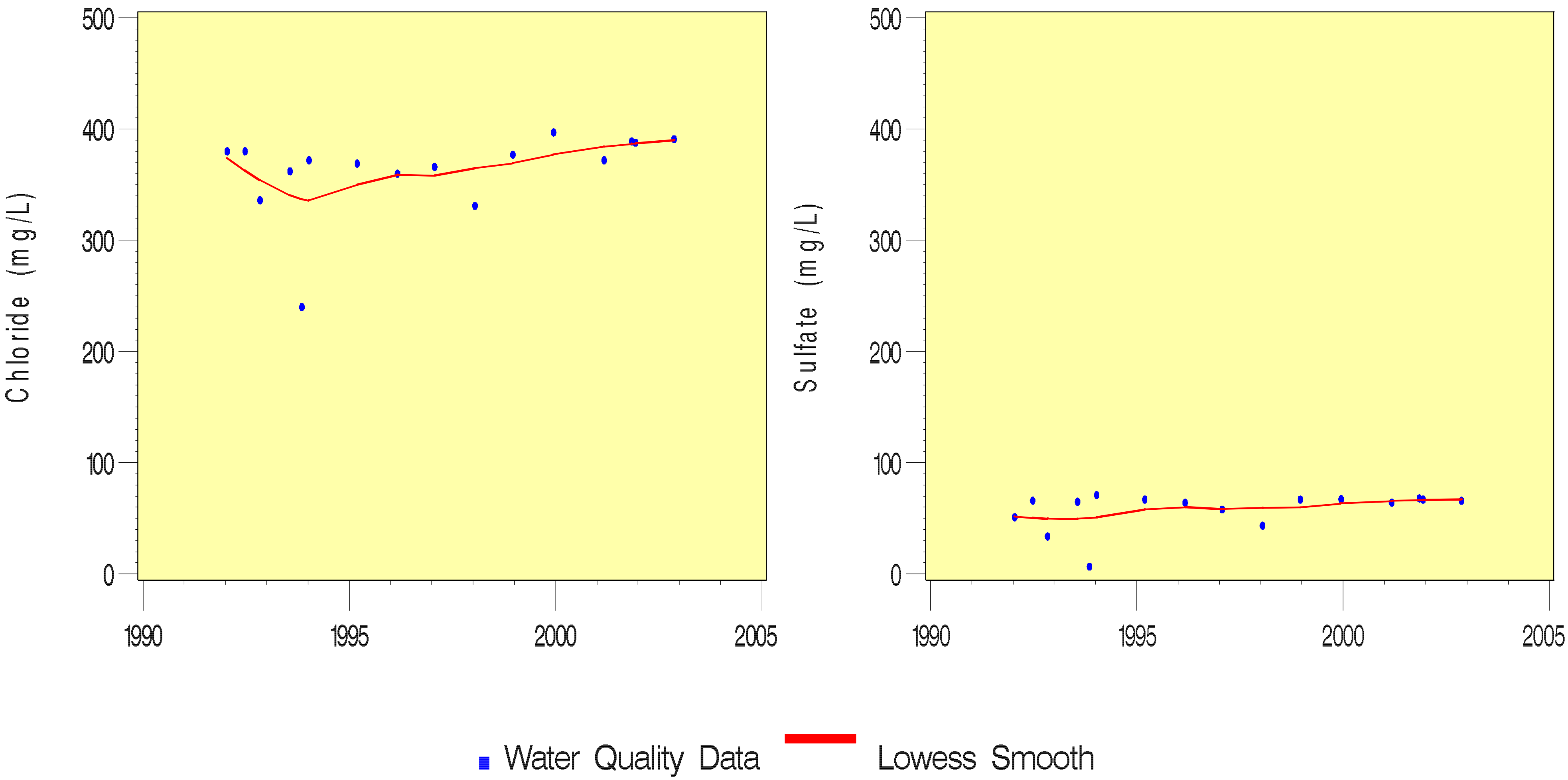




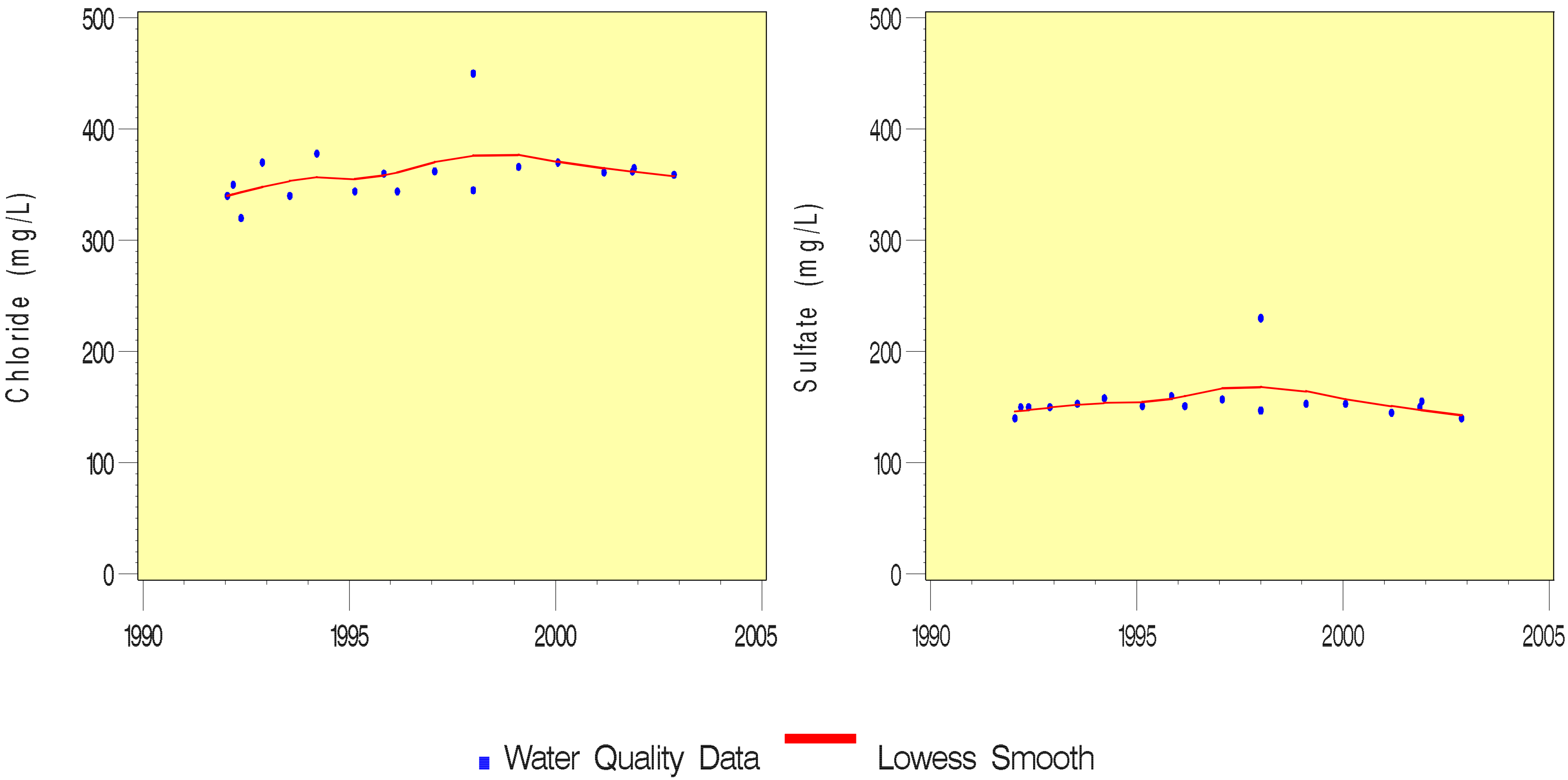
Water Quality Data   Lowess Smooth


NAME= PRAIRIE CRK UP INT (WQMP) SITE= 11611 SEQ= 0
Chloride (mg/L)
Sulfate (mg/L)
0
100
200
300
400
500
1990
1995
2000
2005
Water Quality Data
Lowess Smooth

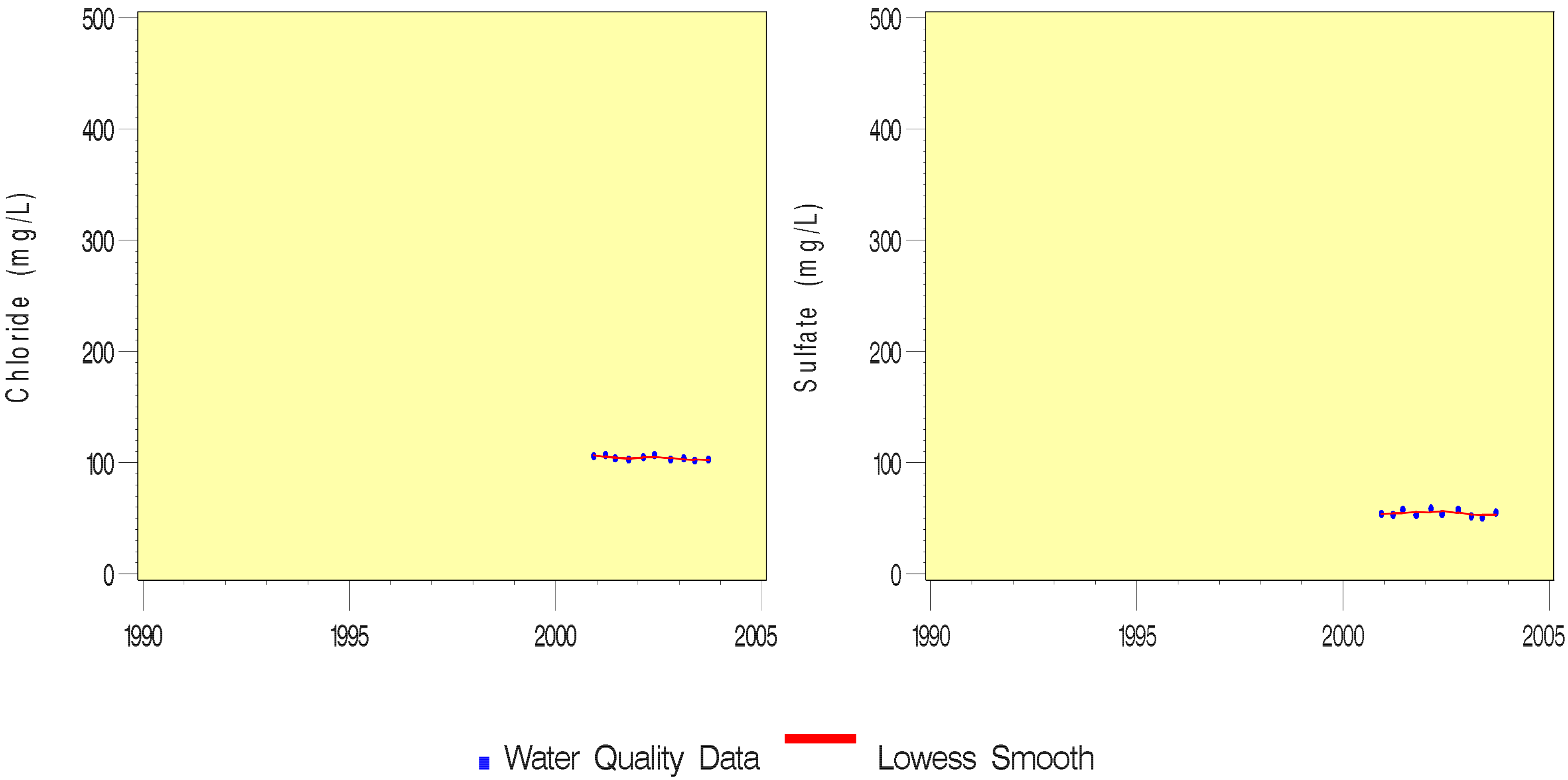
NAME= PUNTA GORDA HEIGHTS INT SITE= 705 SEQ= 0



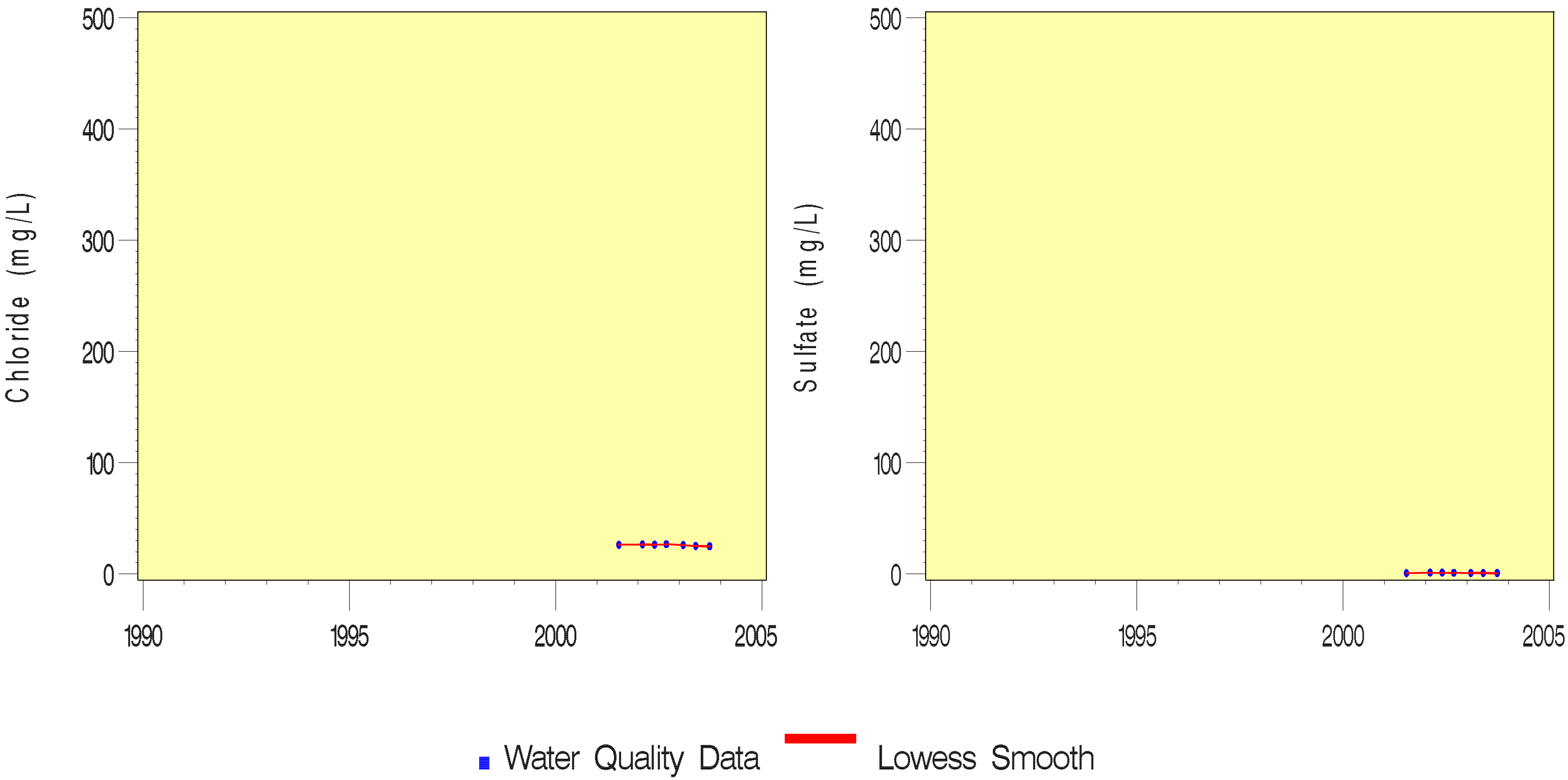
NAME= ROMP 10 UP HTRN SITE= 288 SEQ= 0



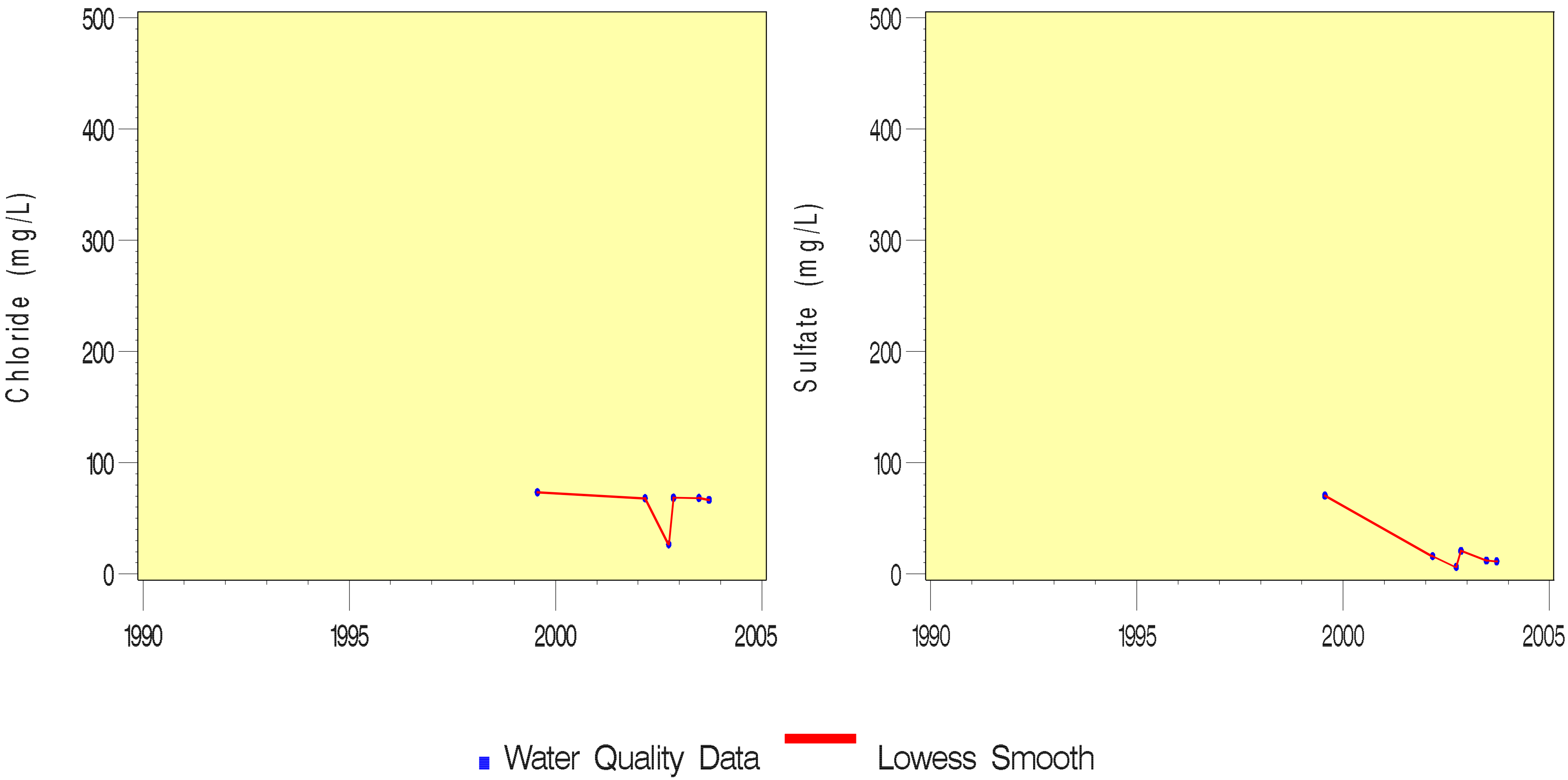
NAME= ROMP 12 UP INT SITE= 13337 SEQ= 0



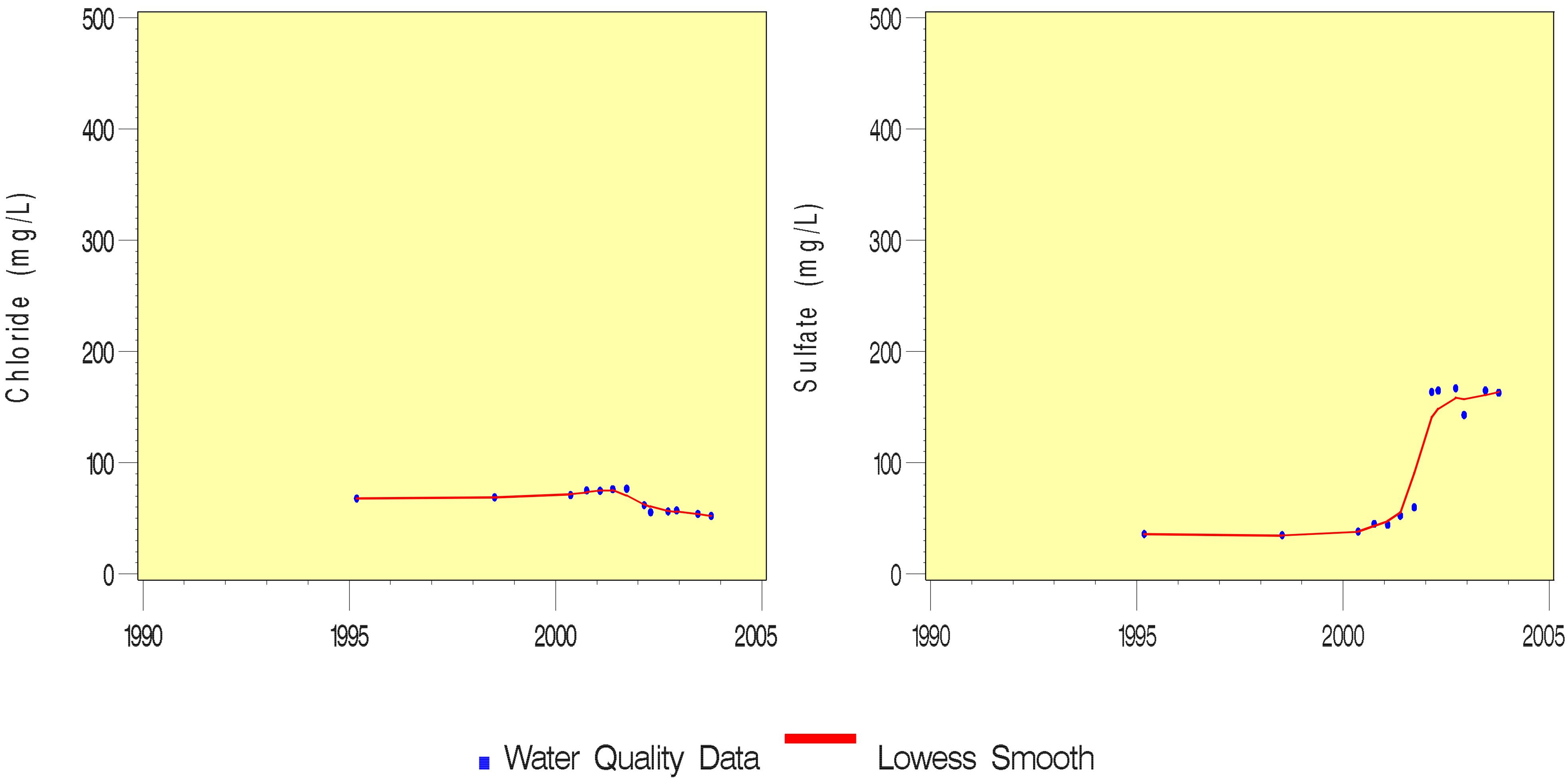
NAME= ROMP 16.5 UPPER INT SITE= 34901 SEQ= 0

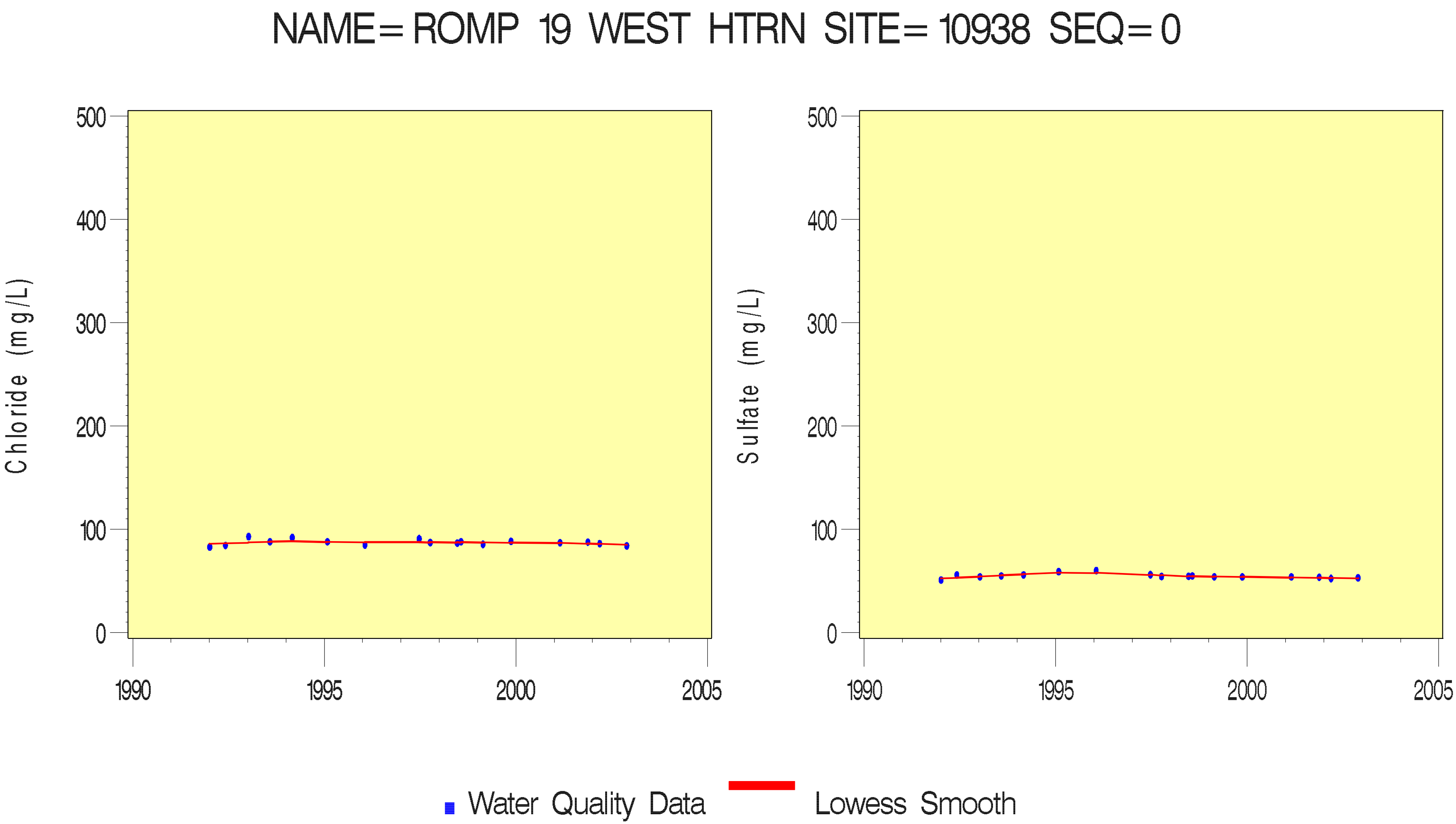


NAME= ROMP 17 IAS PZ-2 INT SITE= 17250 SEQ= 0

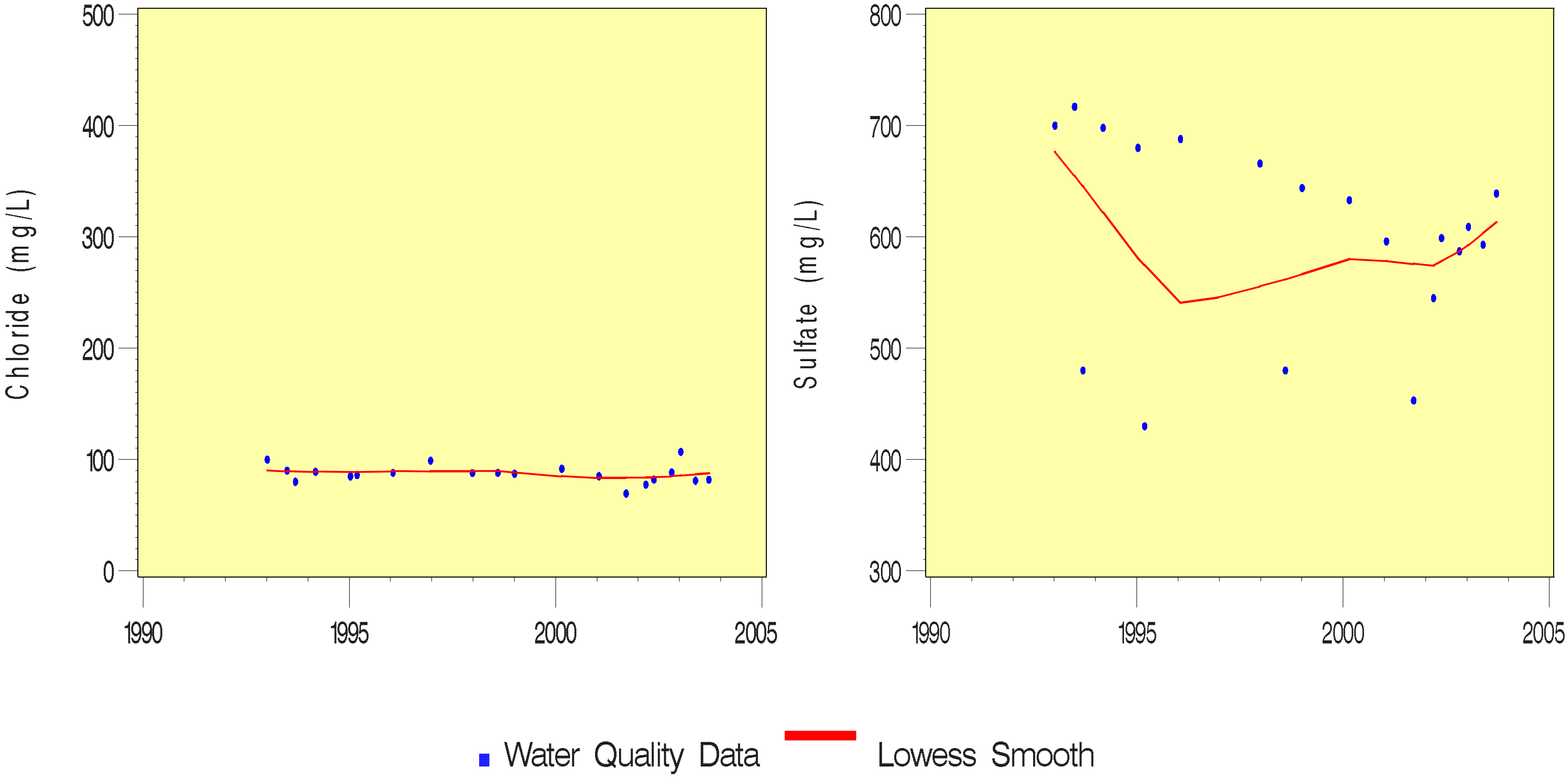


NAME= ROMP 19 EAST HTRN SITE= 10937 SEQ= 0

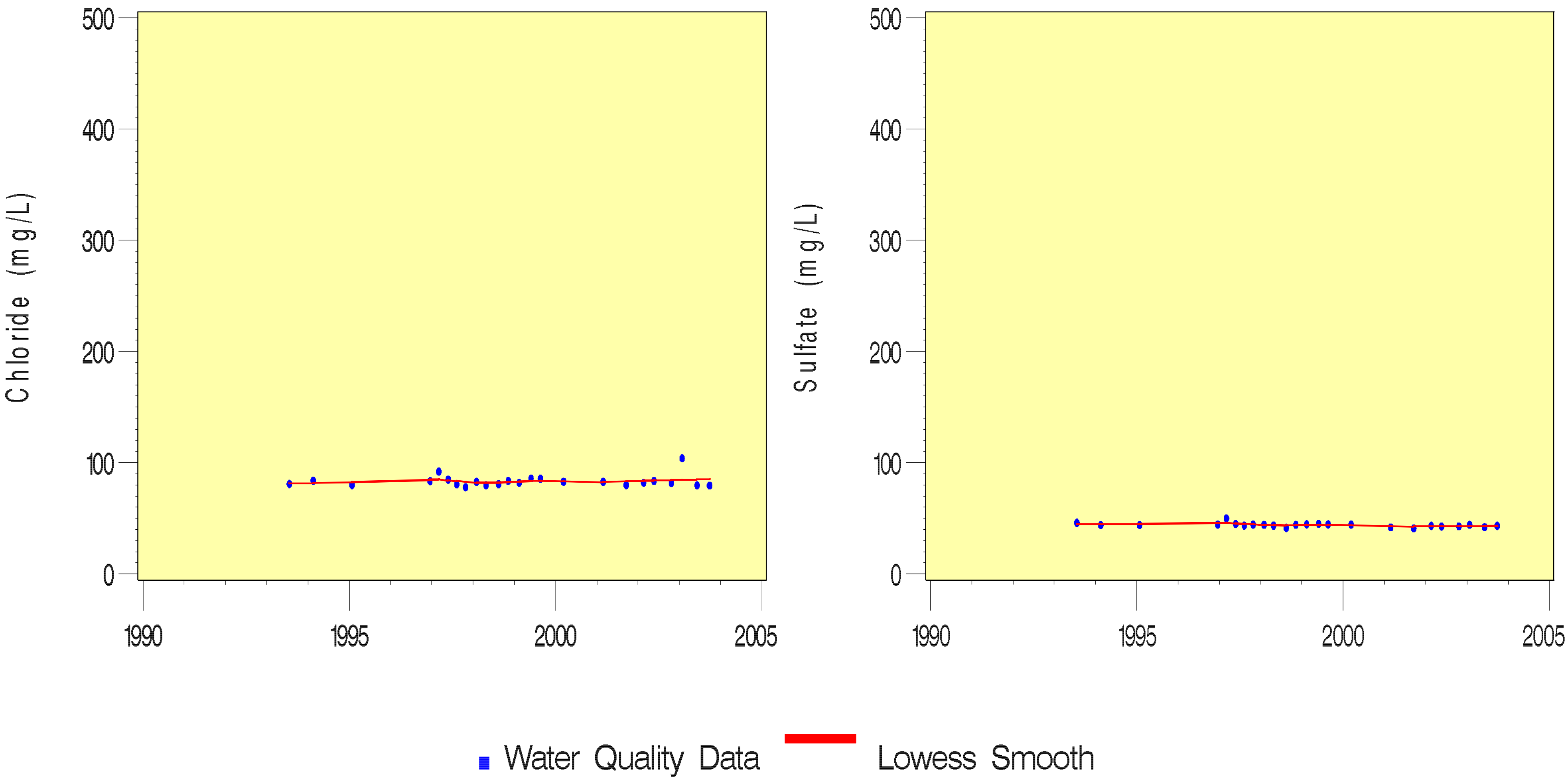



NAME= ROMP 19 WEST HTRN SITE= 10938 SEQ= 0
Chloride (mg/L)
Sulfate (mg/L)
500
400
300
200
100
0
1990
1995
2000
2005
Water Quality Data
Lowess Smooth

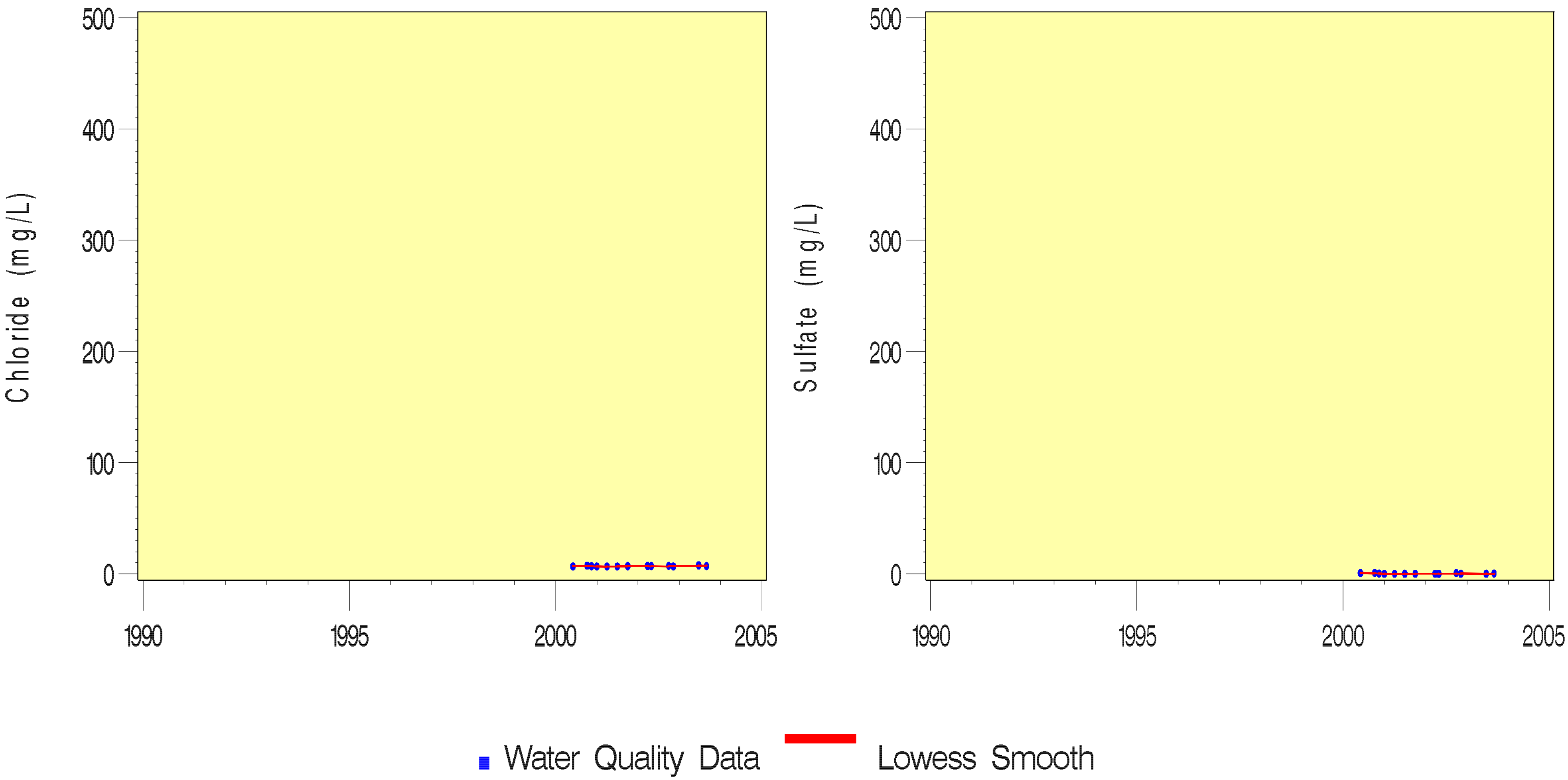
NAME= ROMP 20 UP HTRN SITE= 11304 SEQ= 0



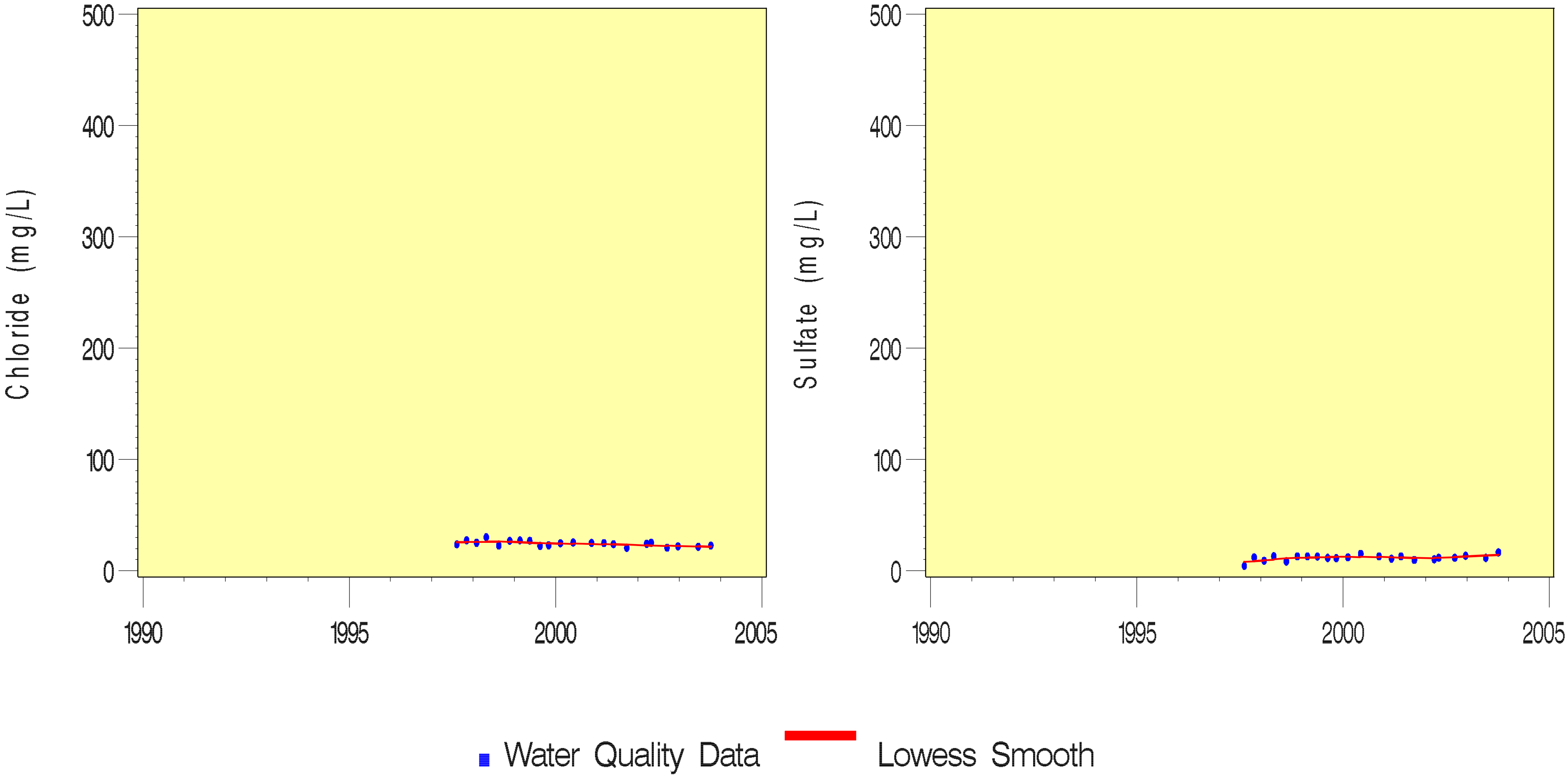
NAME= ROMP 22 ARC SITE= 11174 SEQ= 0



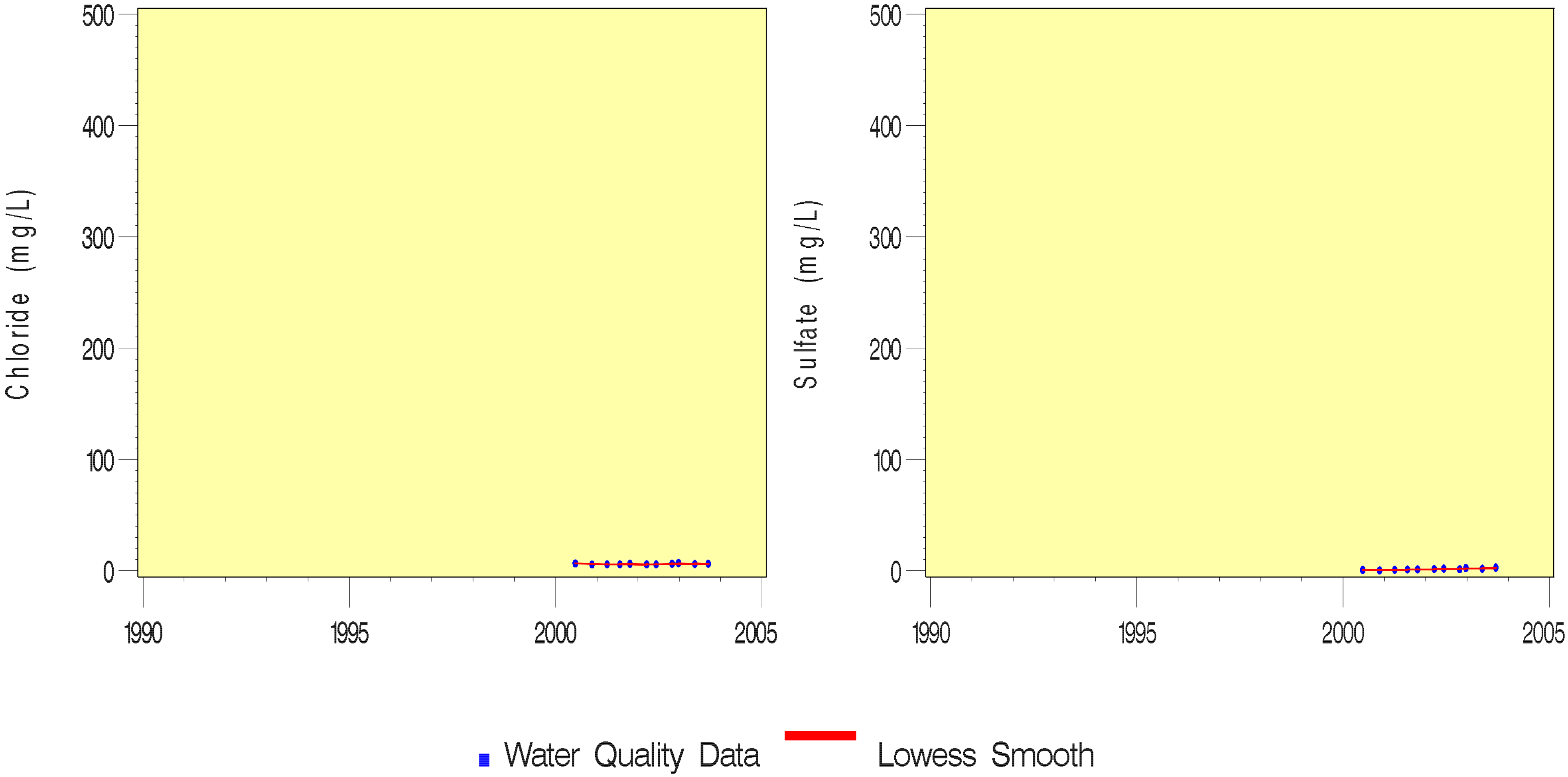
NAME= ROMP 23 PZ2 INT SITE= 17416 SEQ= 0



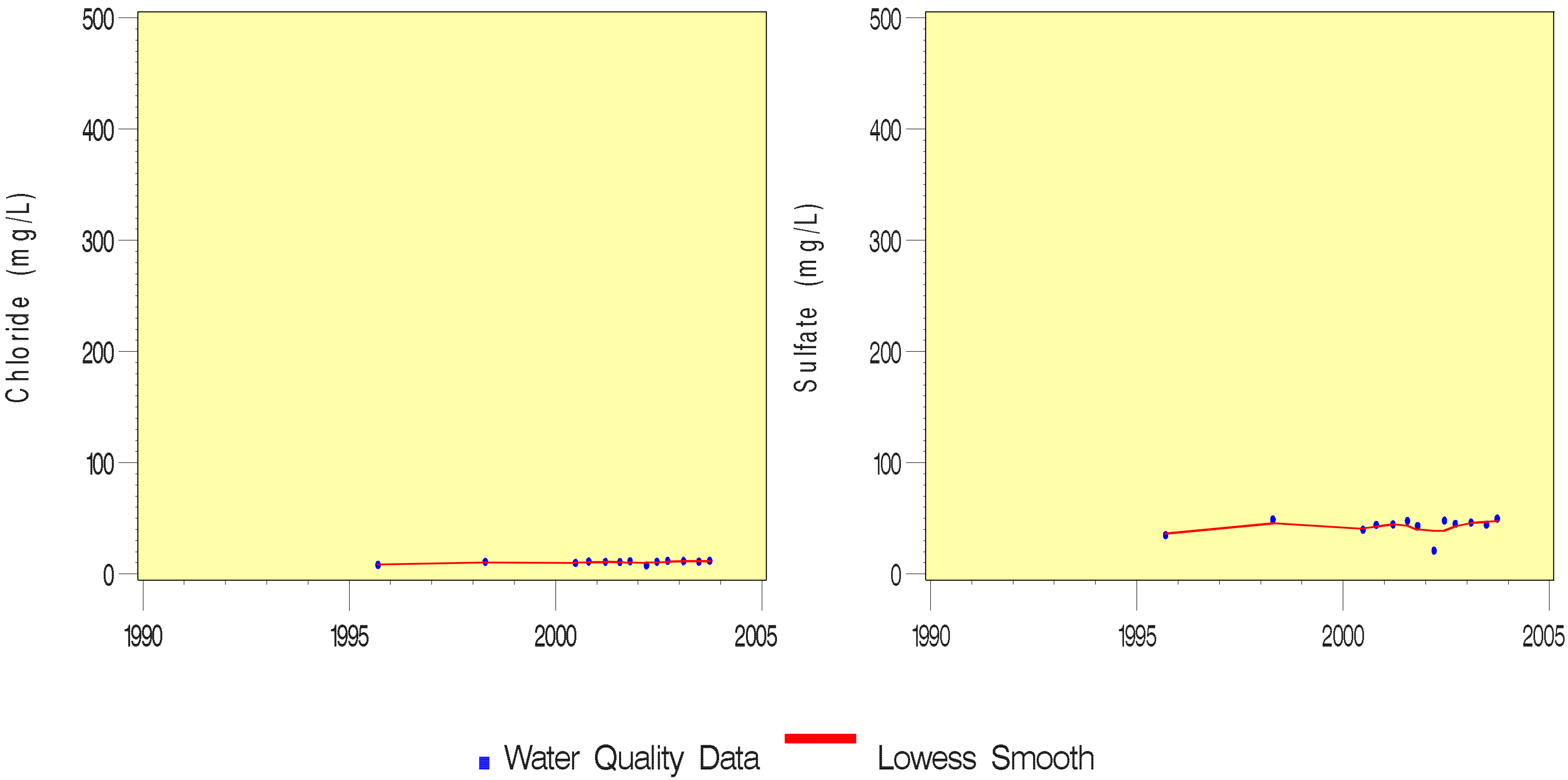
NAME= ROMP 24 INT SITE= 12949 SEQ= 0



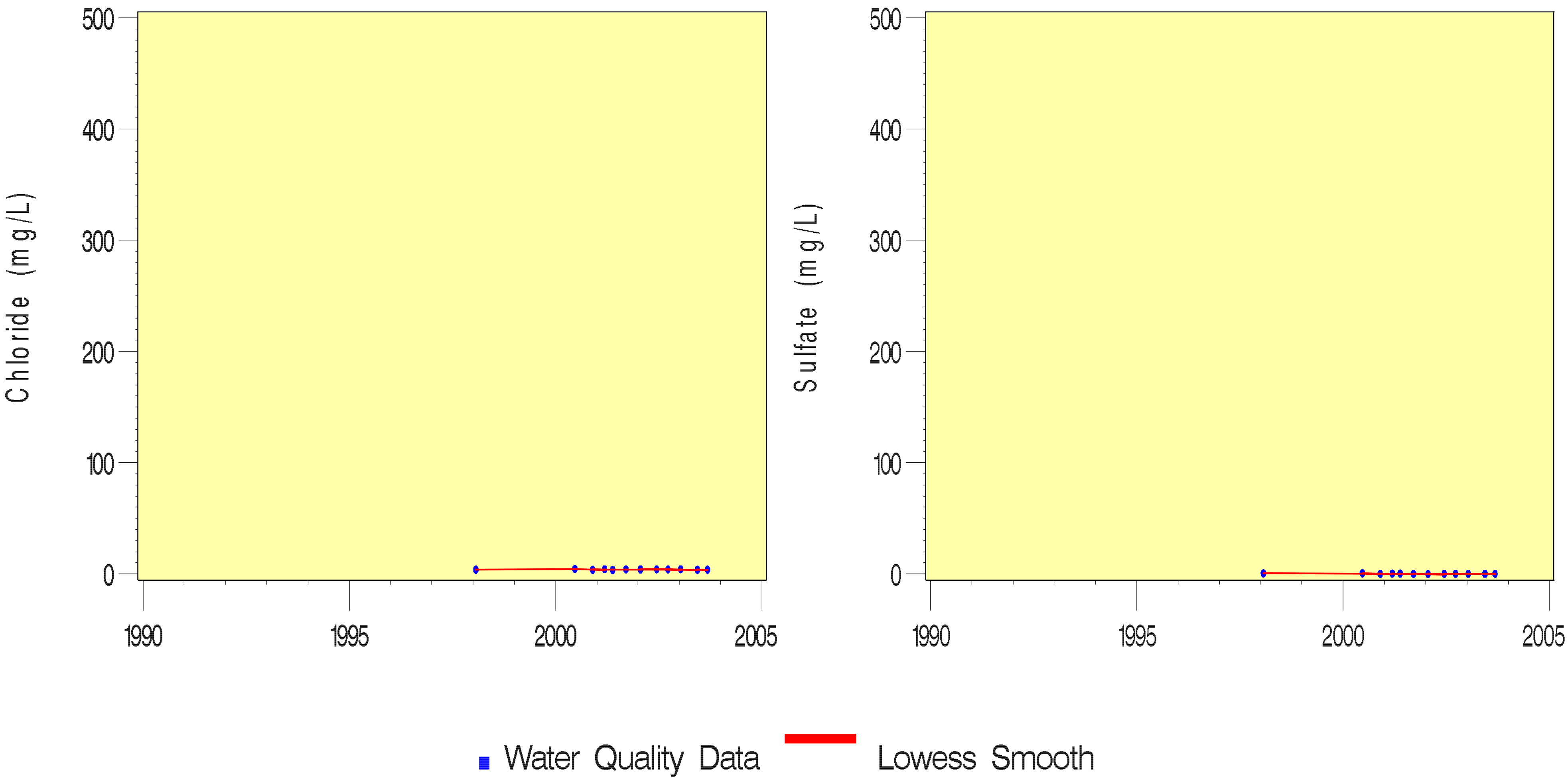
NAME= ROMP 25 ARC/IAS SITE= 17313 SEQ= 0



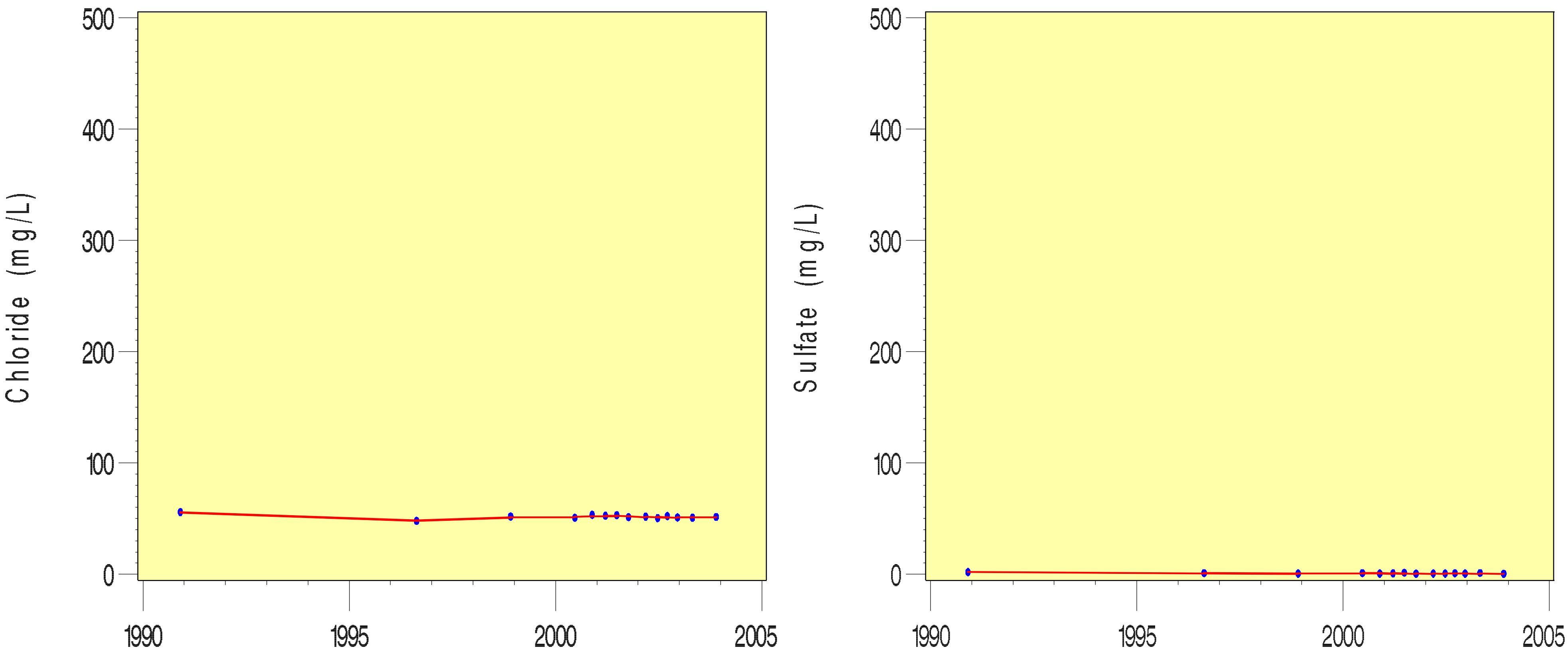
NAME=ROMP 26 HTRN SITE=258 SEQ=0



NAME= ROMP 39 ARC SITE= 11450 SEQ= 0

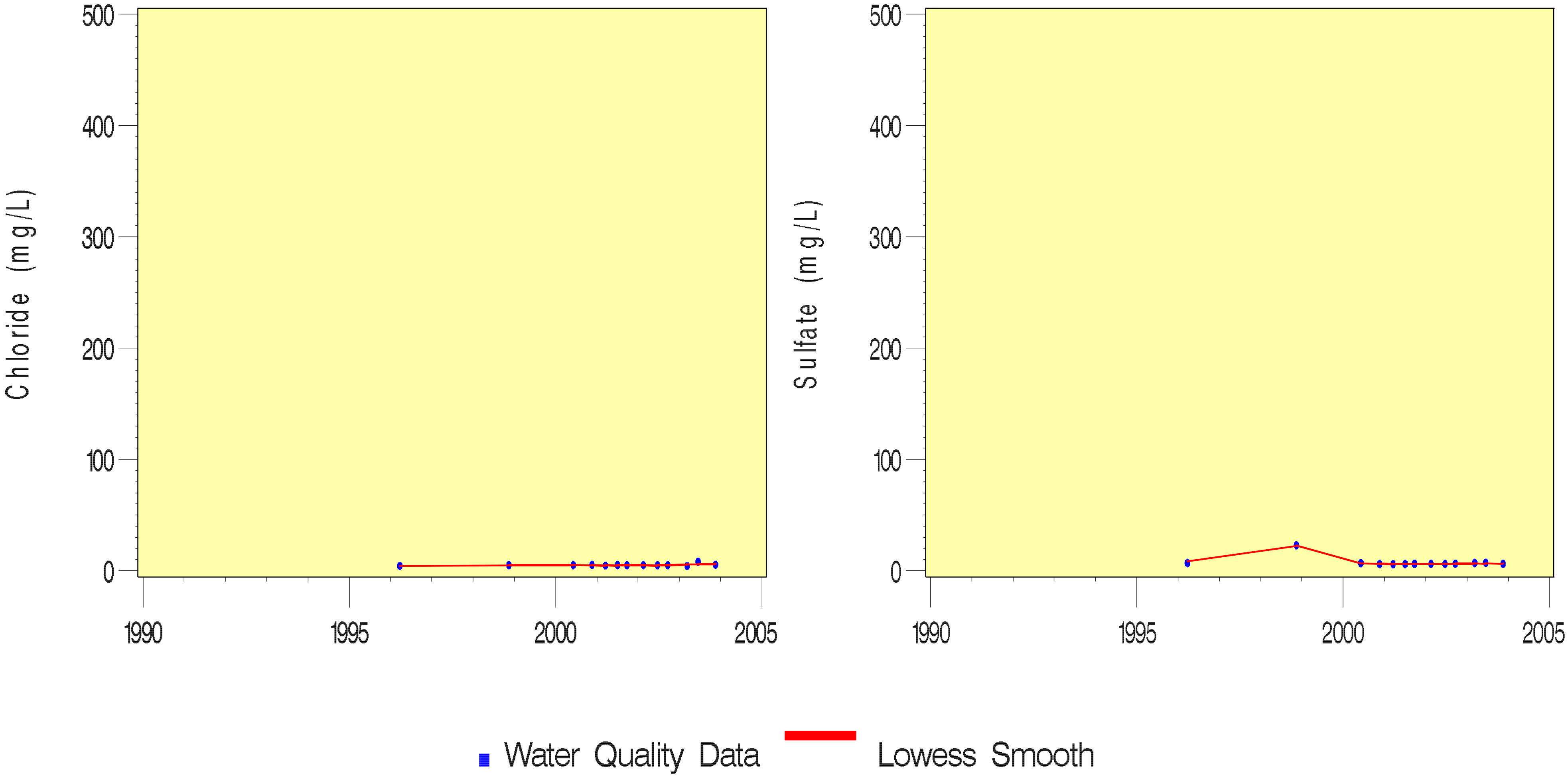


NAME= ROMP 40 HTRN SITE= 370 SEQ= 0

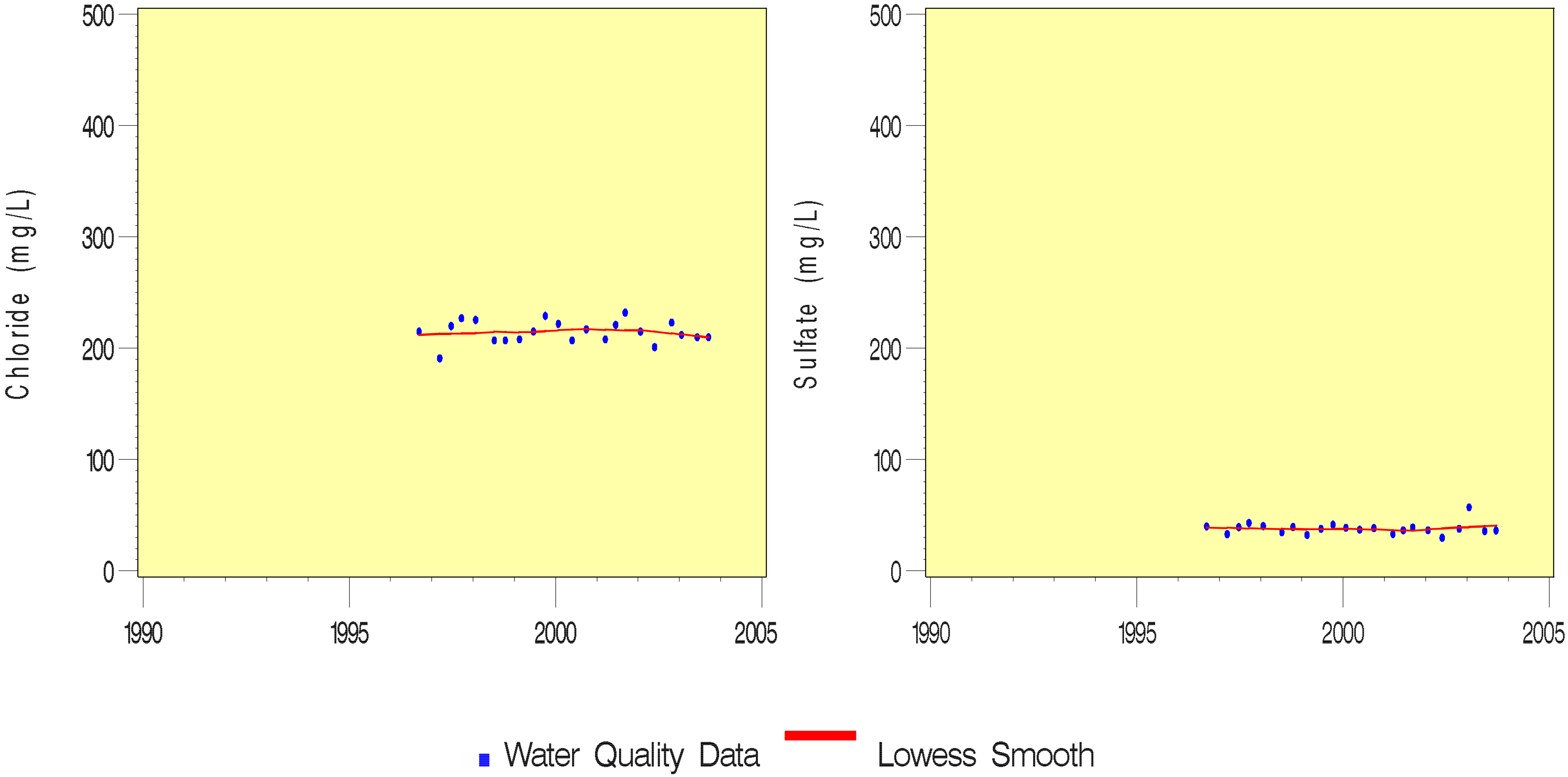


Water Quality Data   Lowess Smooth

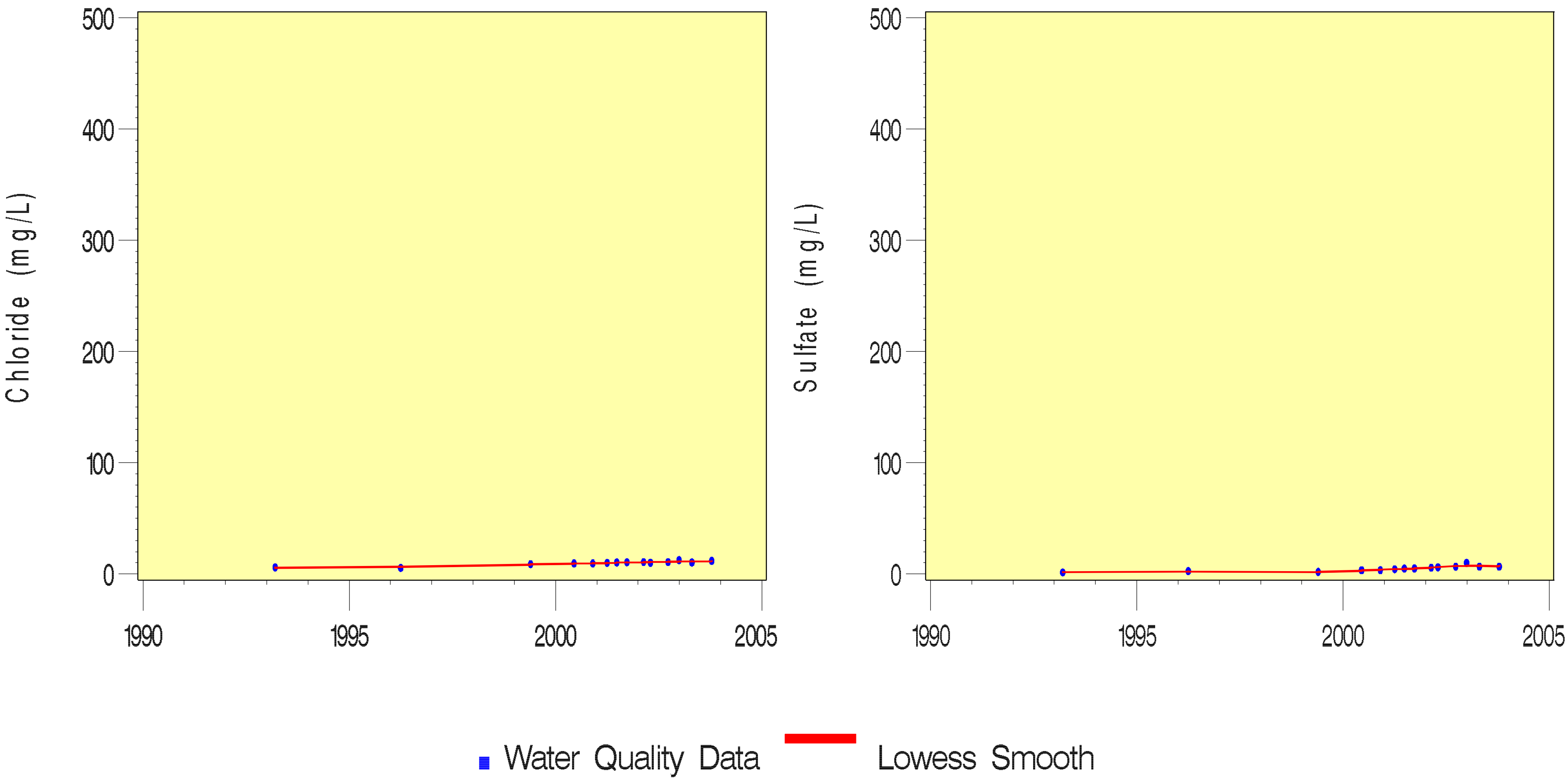
NAME= ROMP 45 HTRN SITE= 30 SEQ= 0



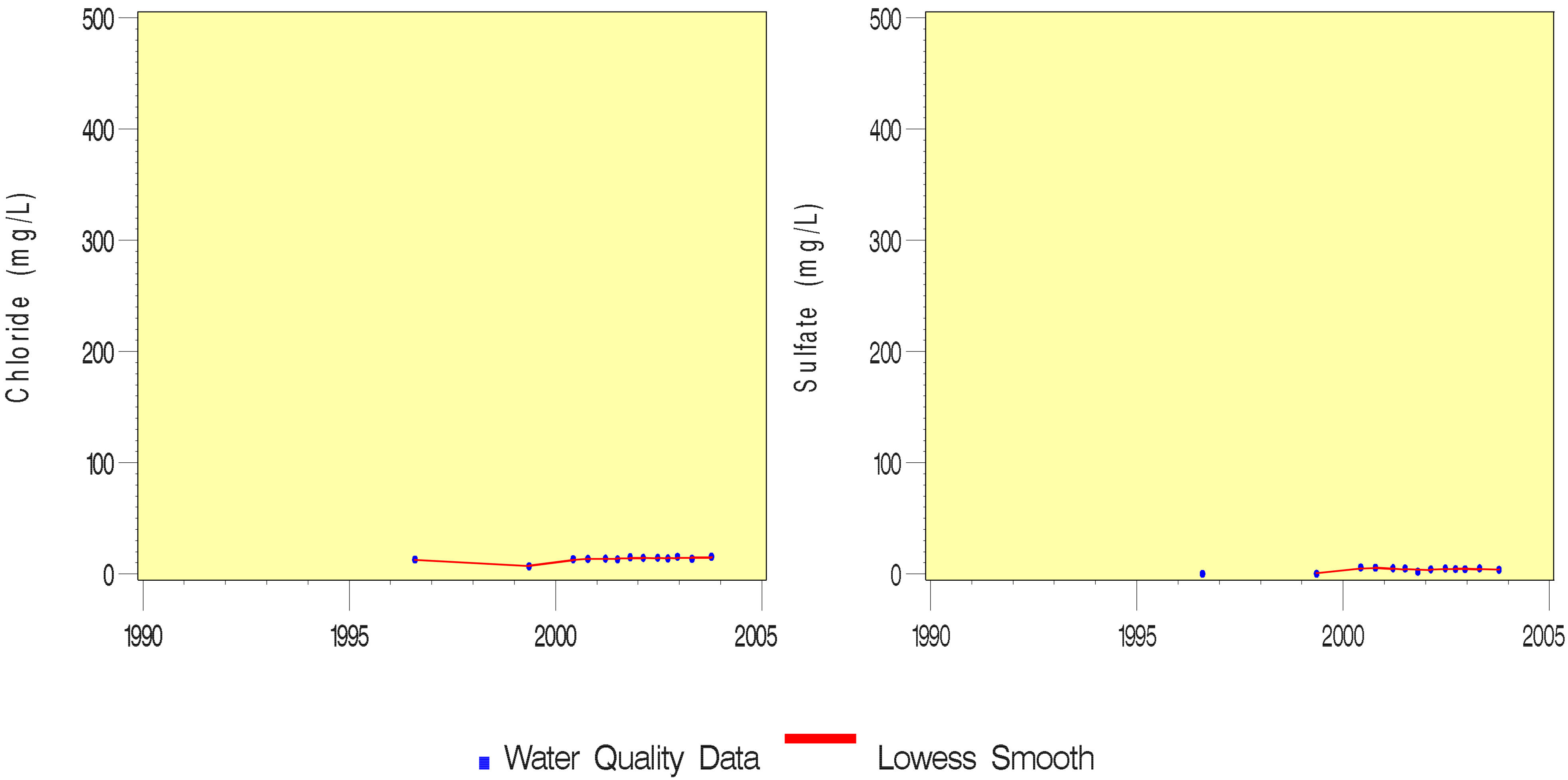
NAME= ROMP 5 UPPER INT SITE= 12882 SEQ= 0



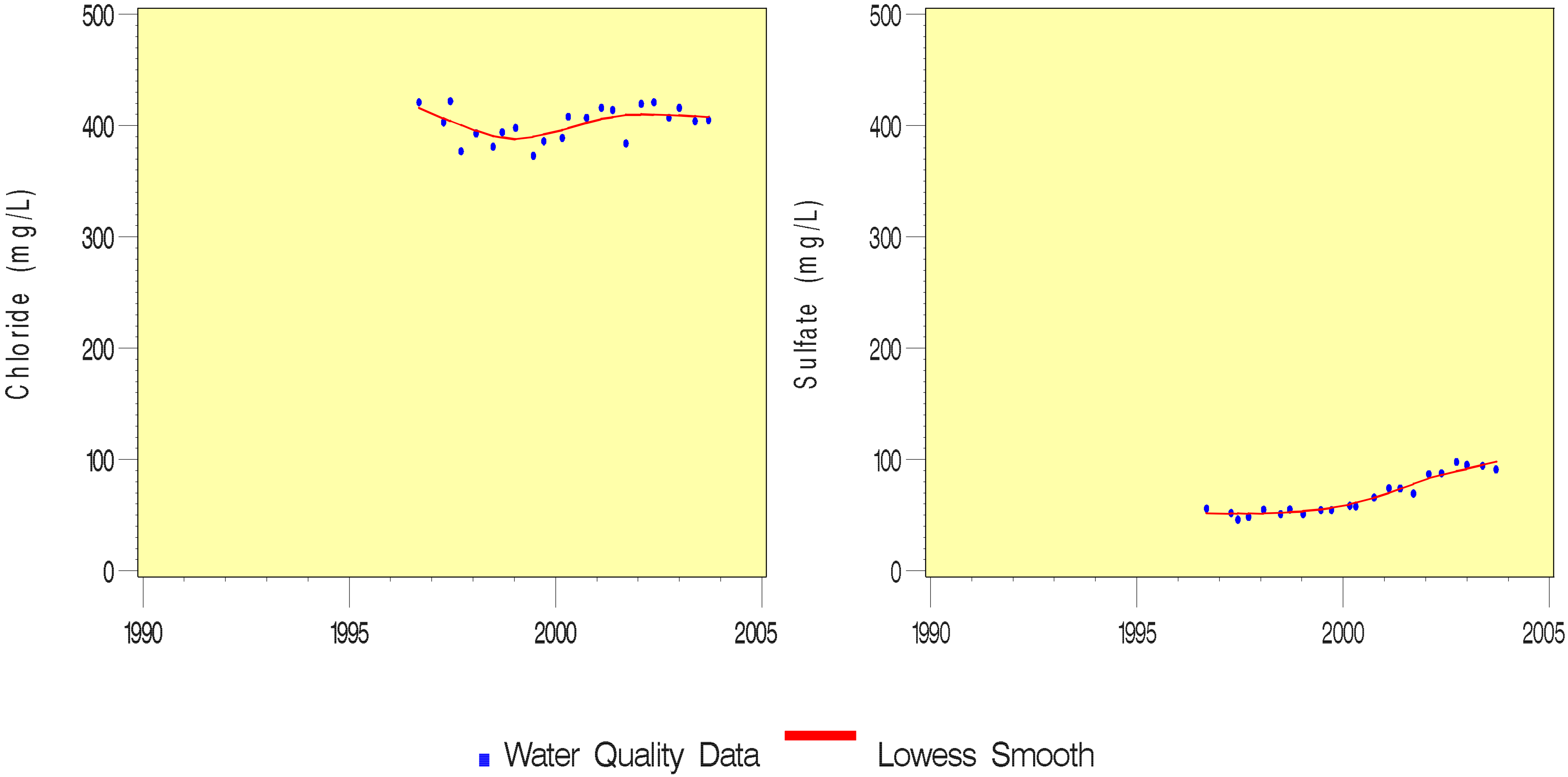
NAME= ROMP 57 HTRN SITE= 10882 SEQ= 0



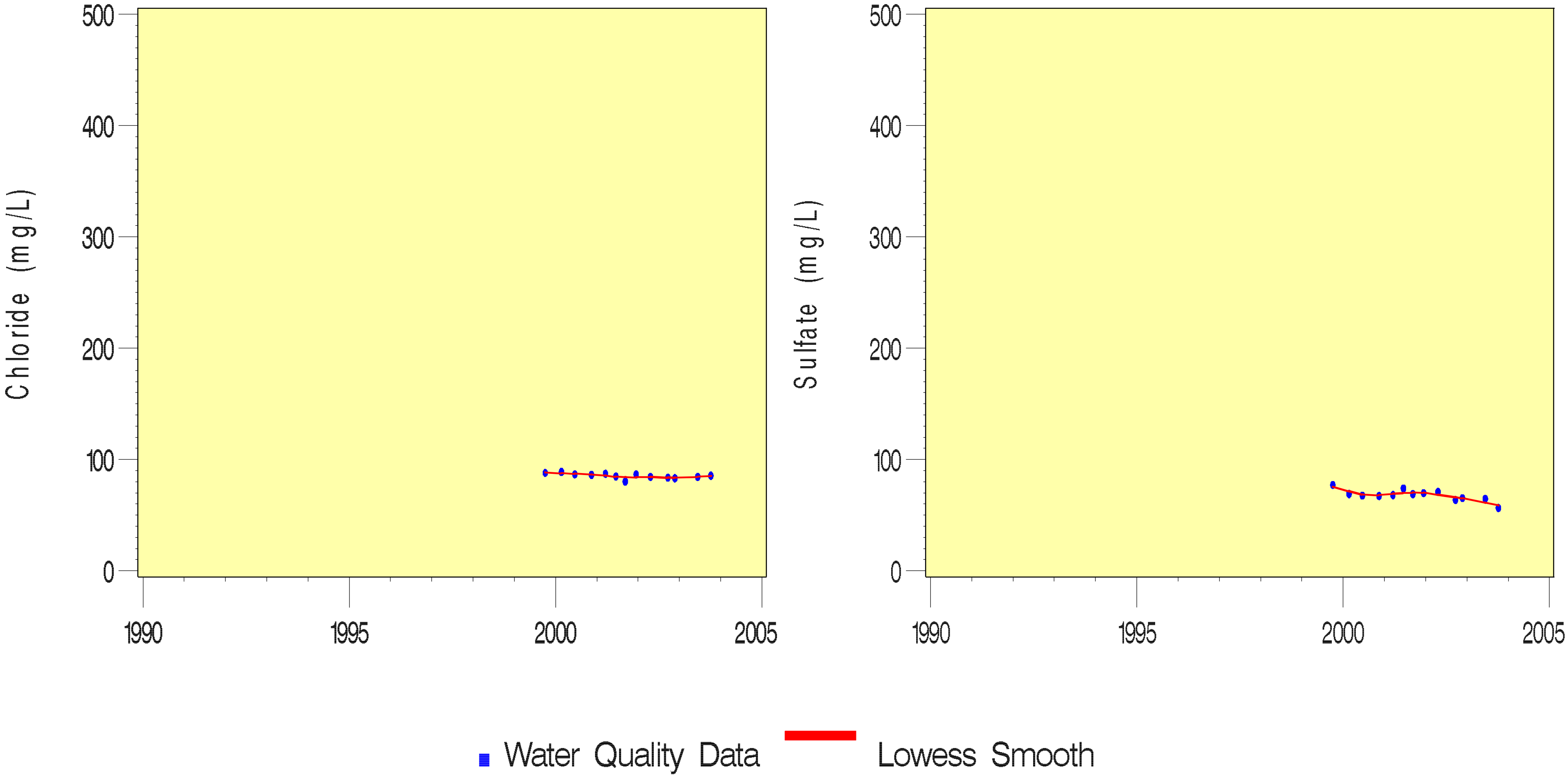
NAME= ROMP 59 HTRN SITE= 518 SEQ= 0



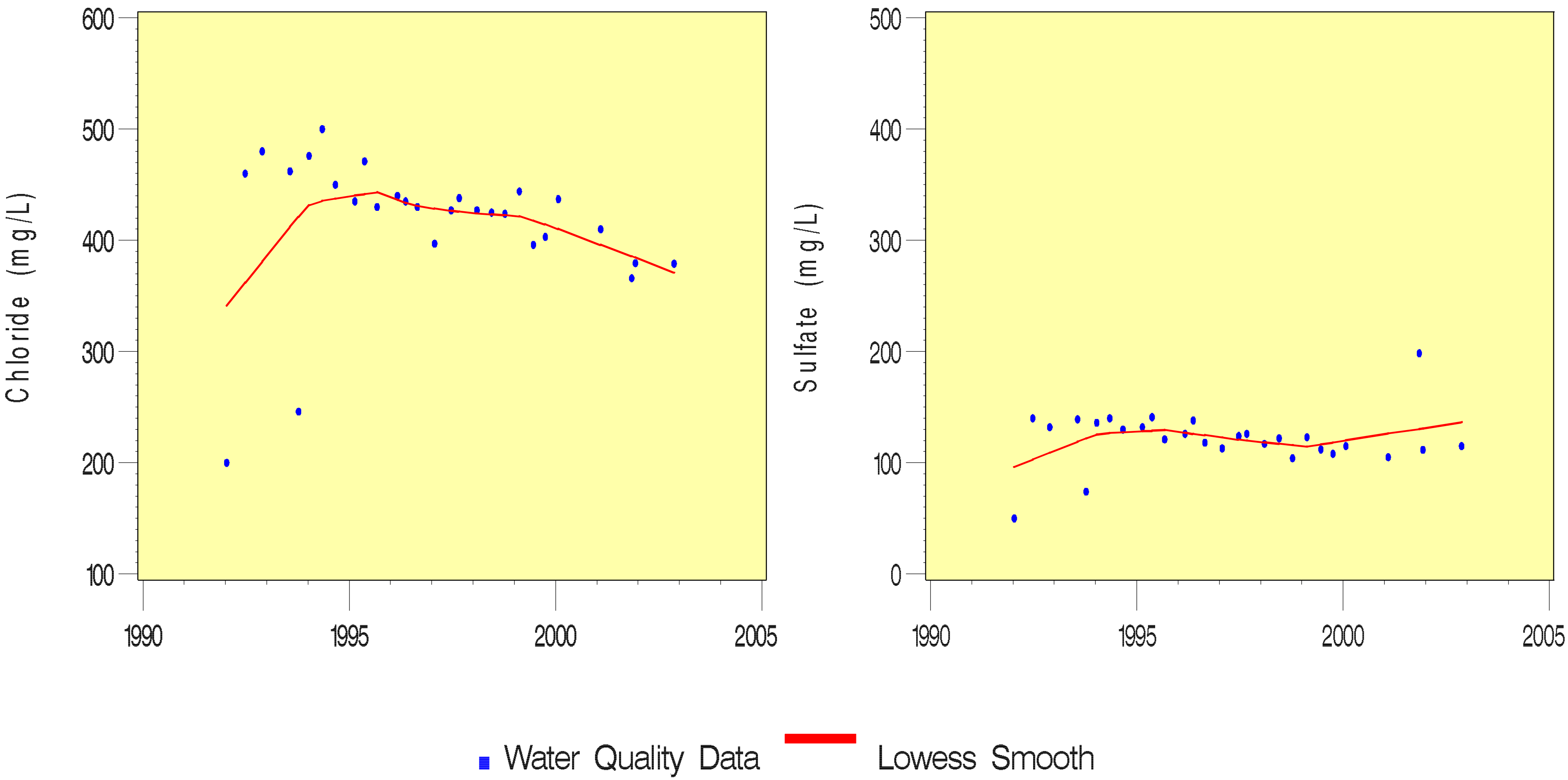
NAME=ROMP 9 MID INT MW-3 SITE=12899 SEQ=0



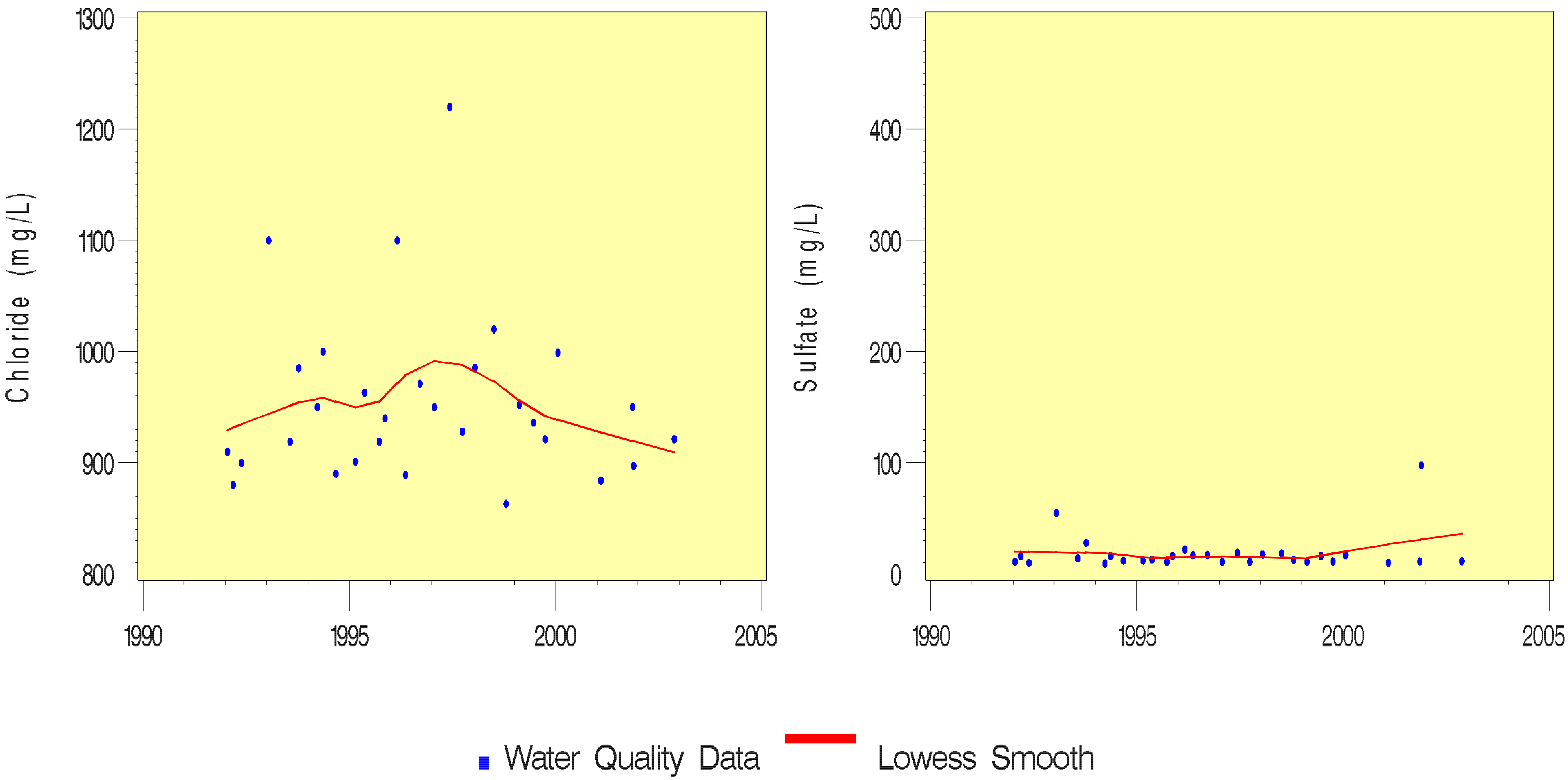
NAME= ROMP 9.5 MW—18 UPZ INT SITE= 13380 SEQ= 0

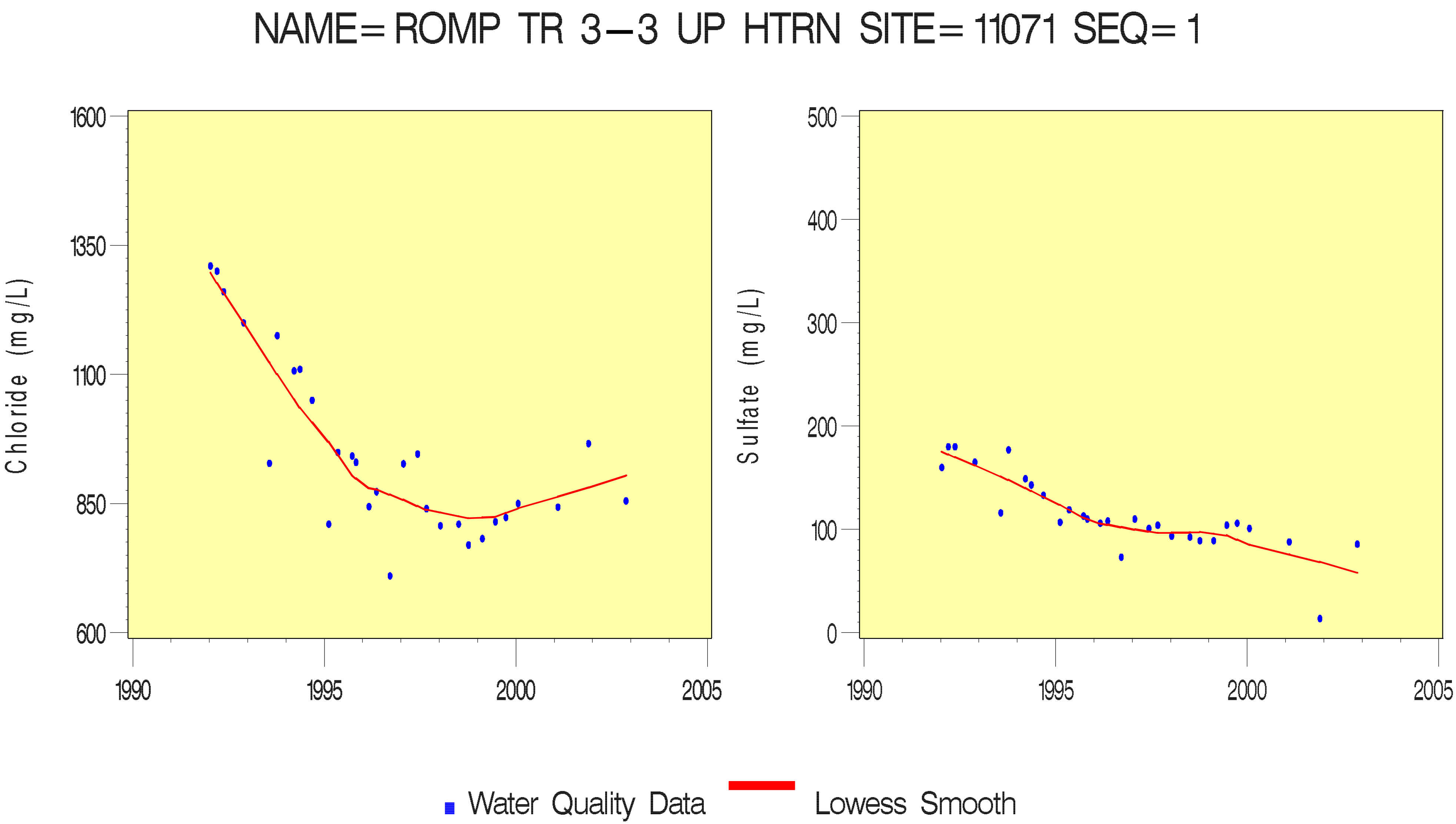


NAME= ROMP TR 1–2 UP HTRN SITE= 11333 SEQ= 0

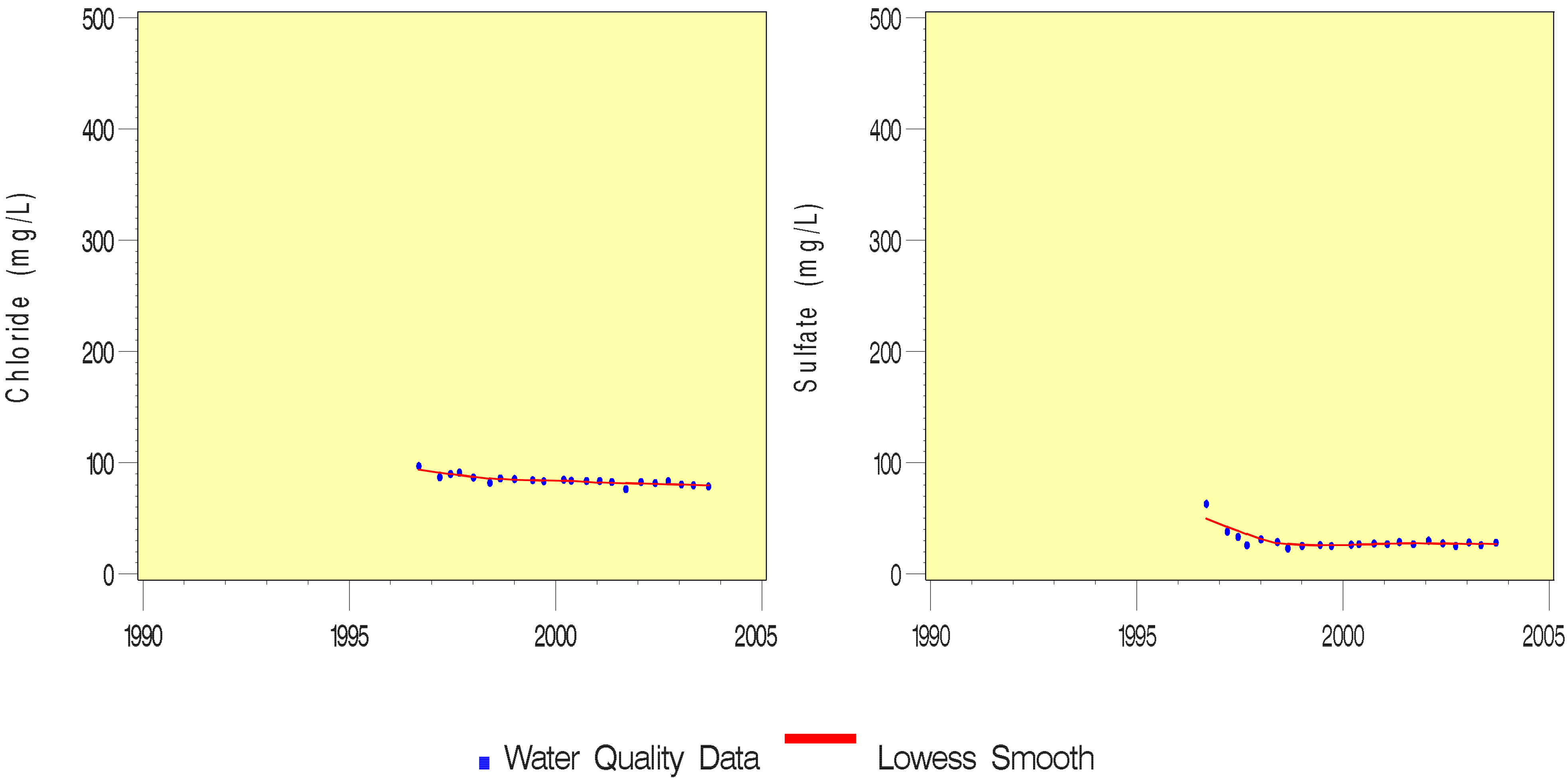


NAME= ROMP TR 3−1 HTRN 160 SITE= 10945 SEQ= 1

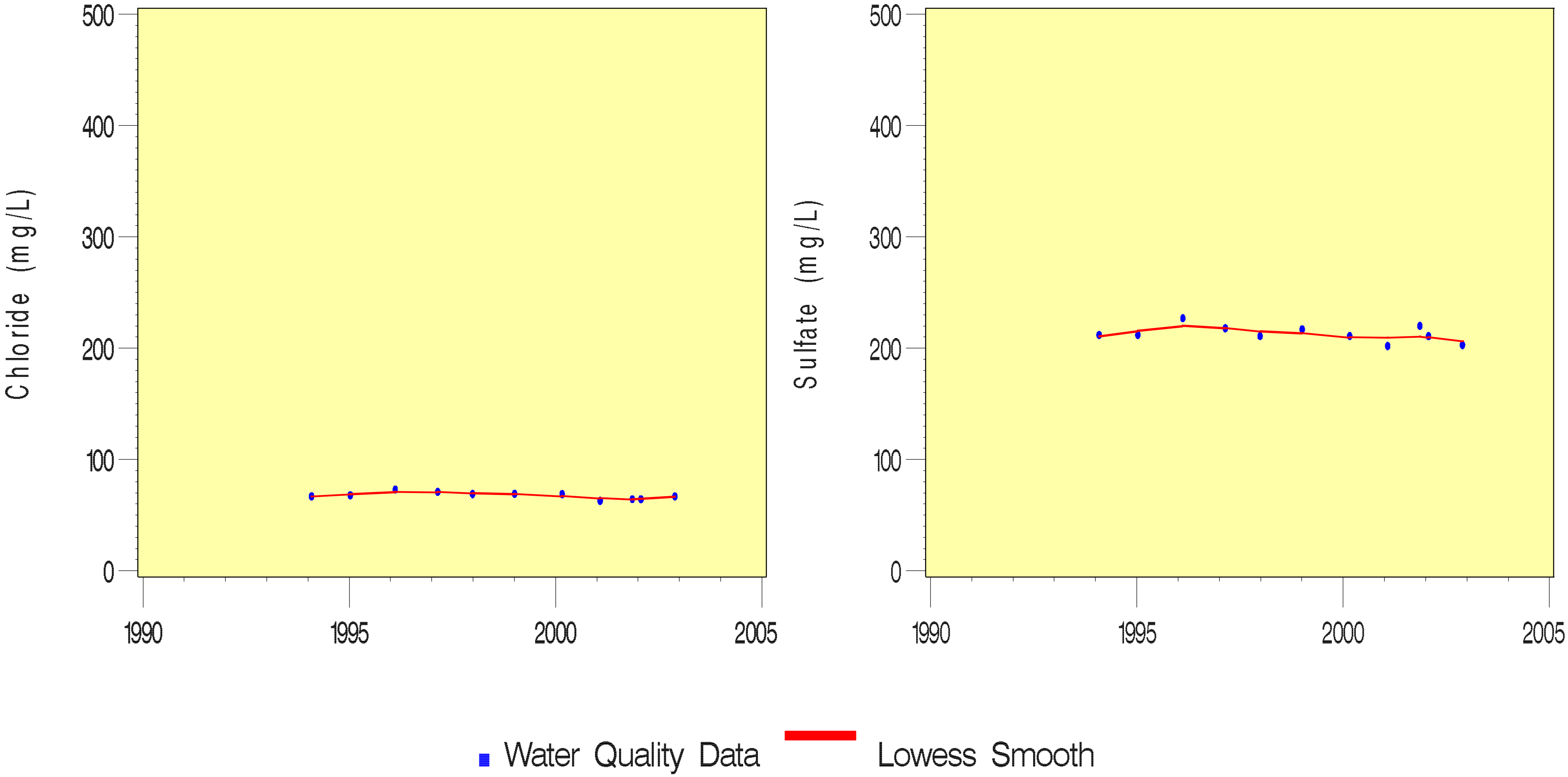


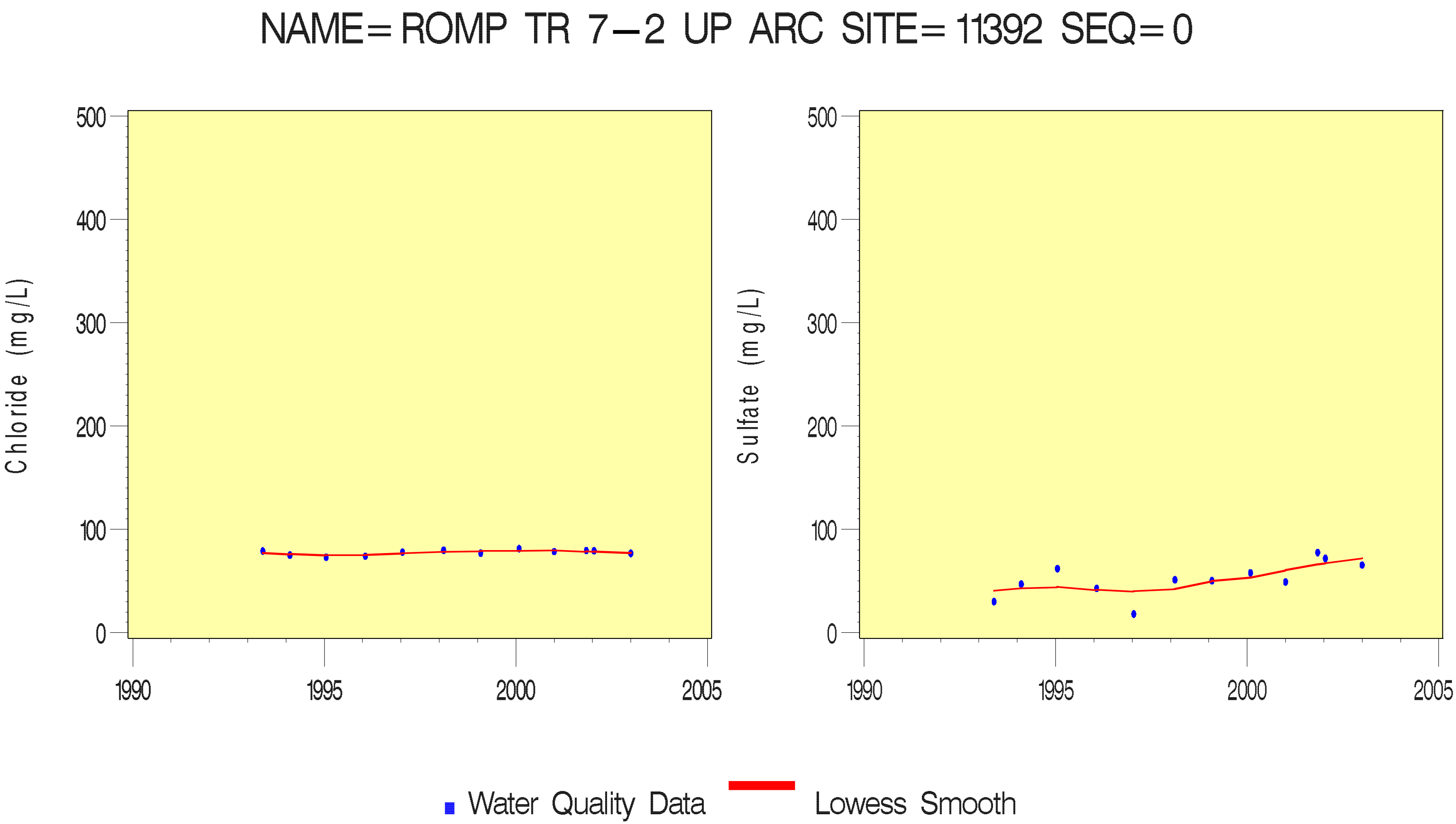

NAME= ROMP TR 3—3 UP HTRN SITE= 11071 SEQ= 1
Chloride (mg/L)
1600
1350
1100
850
600
1990
1995
2000
2005
Sulfate (mg/L)
500
400
300
200
100
0
1990
1995
2000
2005
Water Quality Data
Lowess Smooth

NAME= ROMP TR 4—1 MID INT SITE= 12953 SEQ= 0

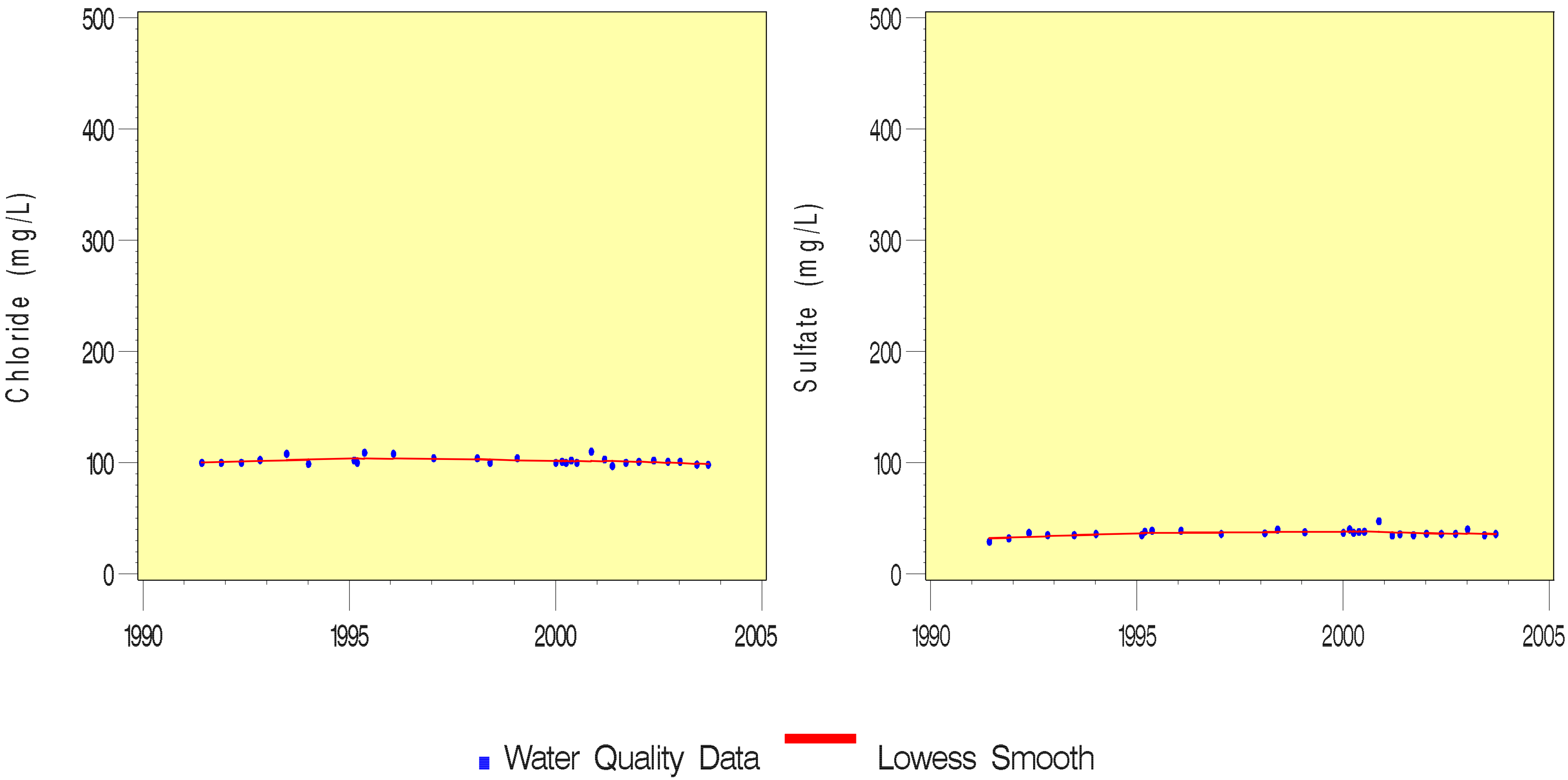


NAME= ROMP TR 5—3 UPPER INT SITE= 1305 SEQ= 0

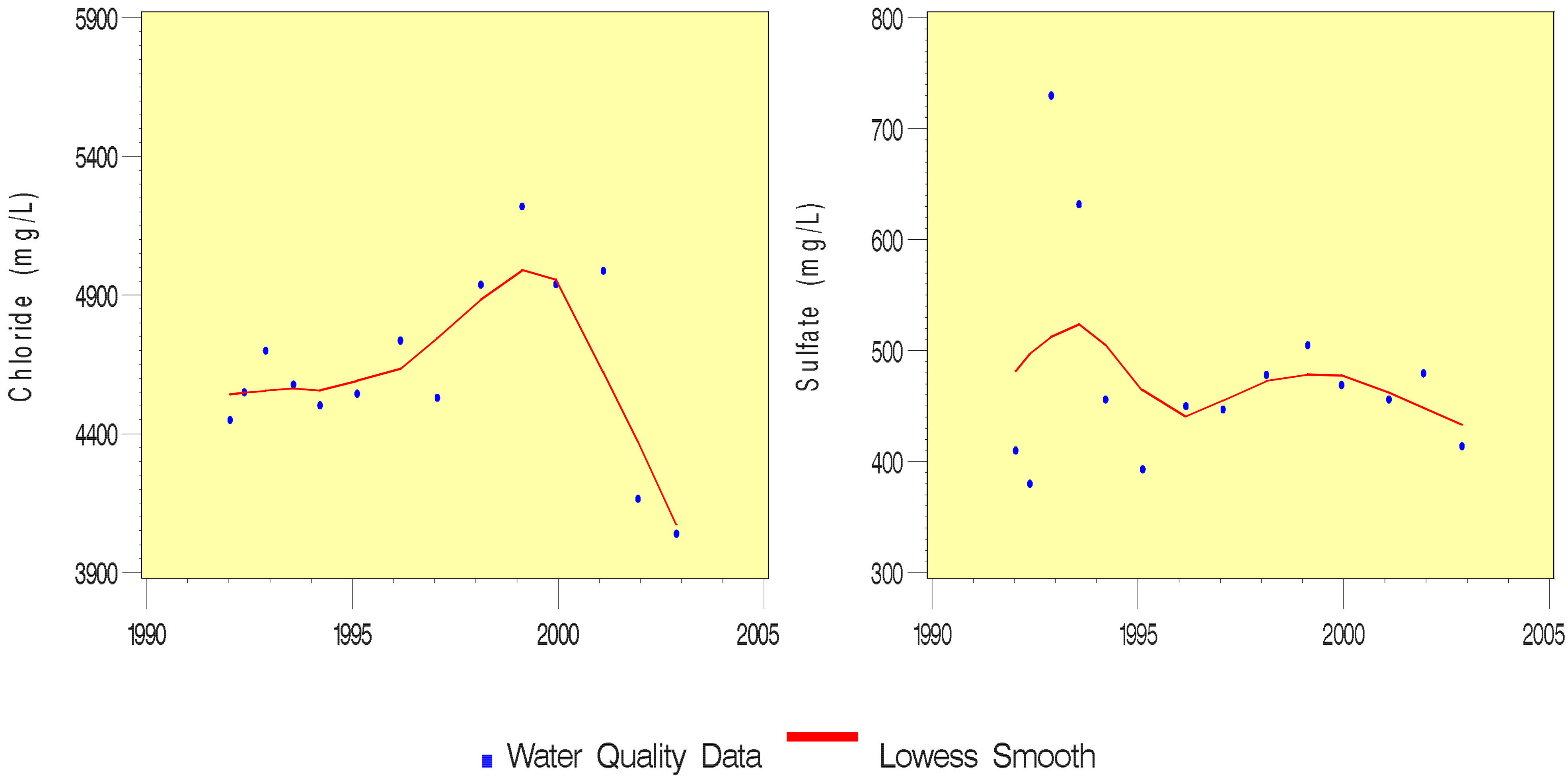



NAME= ROMP TR 7—2 UP ARC SITE= 11392 SEQ= 0
Chloride (mg/L)
Sulfate (mg/L)
0
100
200
300
400
500
1990
1995
2000
2005
Water Quality Data
Lowess Smooth

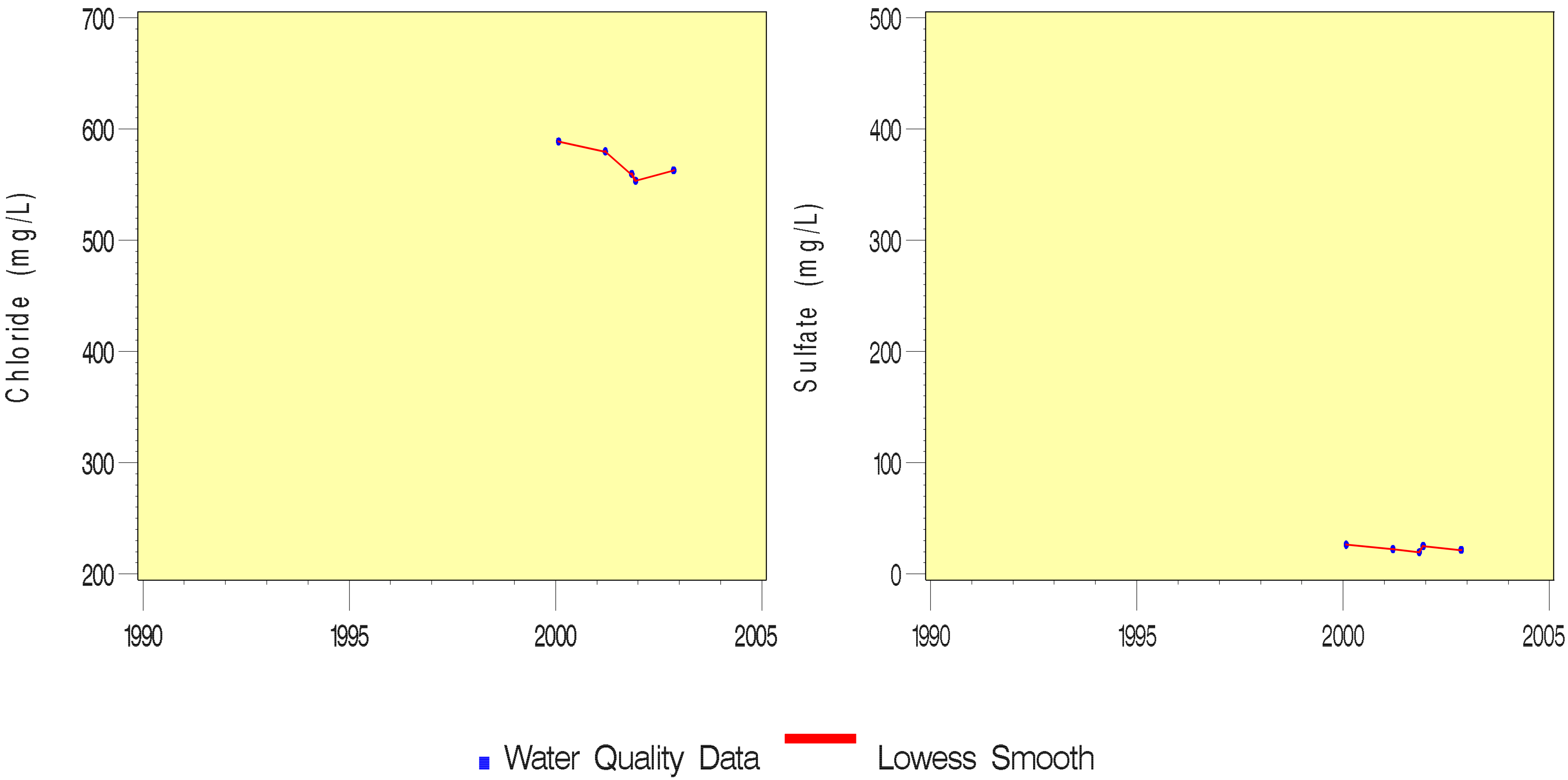
NAME= ROMP TR 8-1 UP HTRN SITE= 257 SEQ= 0



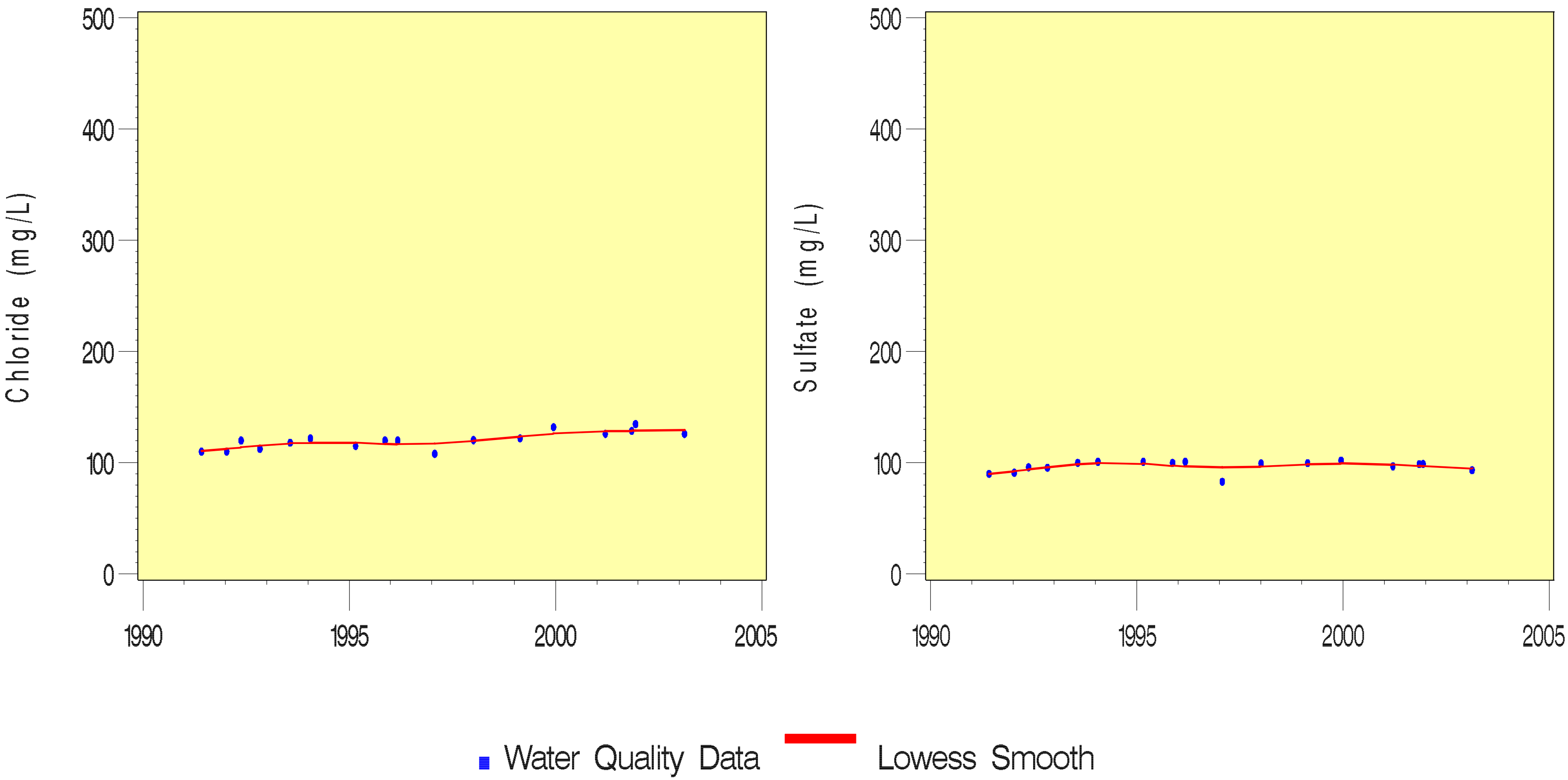
NAME= ROTUNDA WATER PLANT 18 IN SITE= 774 SEQ= 0



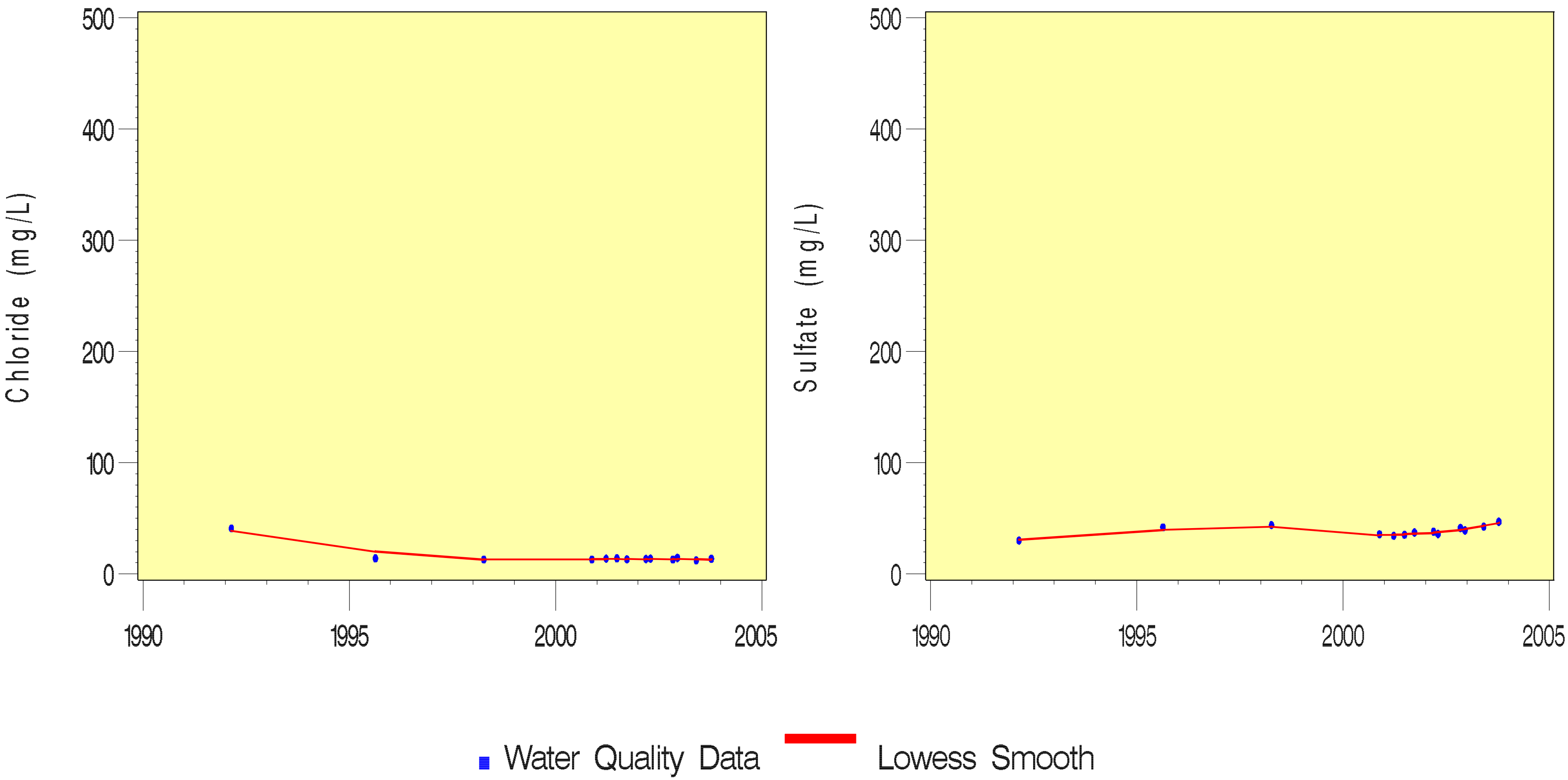
NAME= SHELL CREEK RV PARK INT SITE= 17744 SEQ= 0

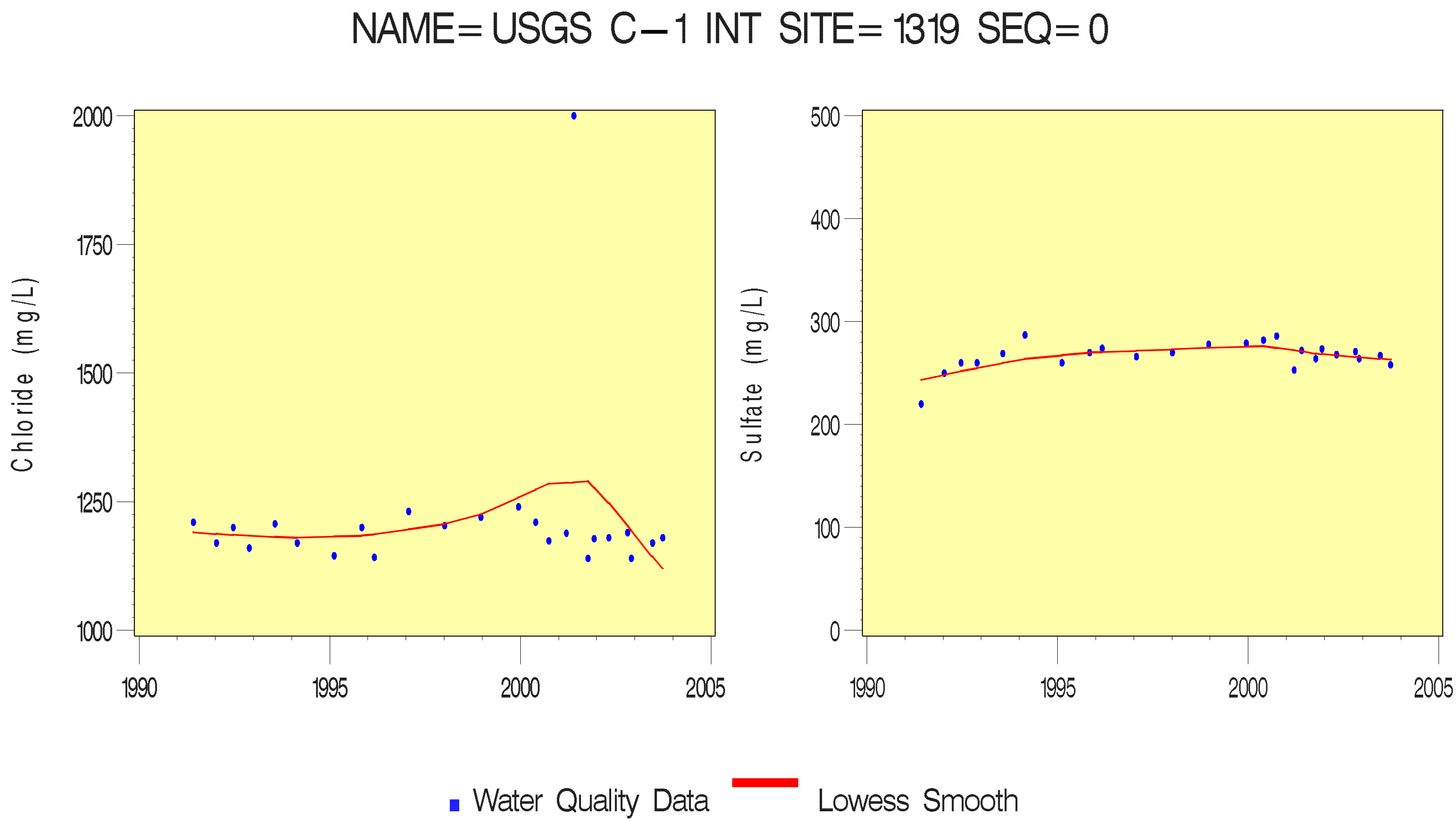


NAME= SR 74 DEEP SITE= 566 SEQ= 0

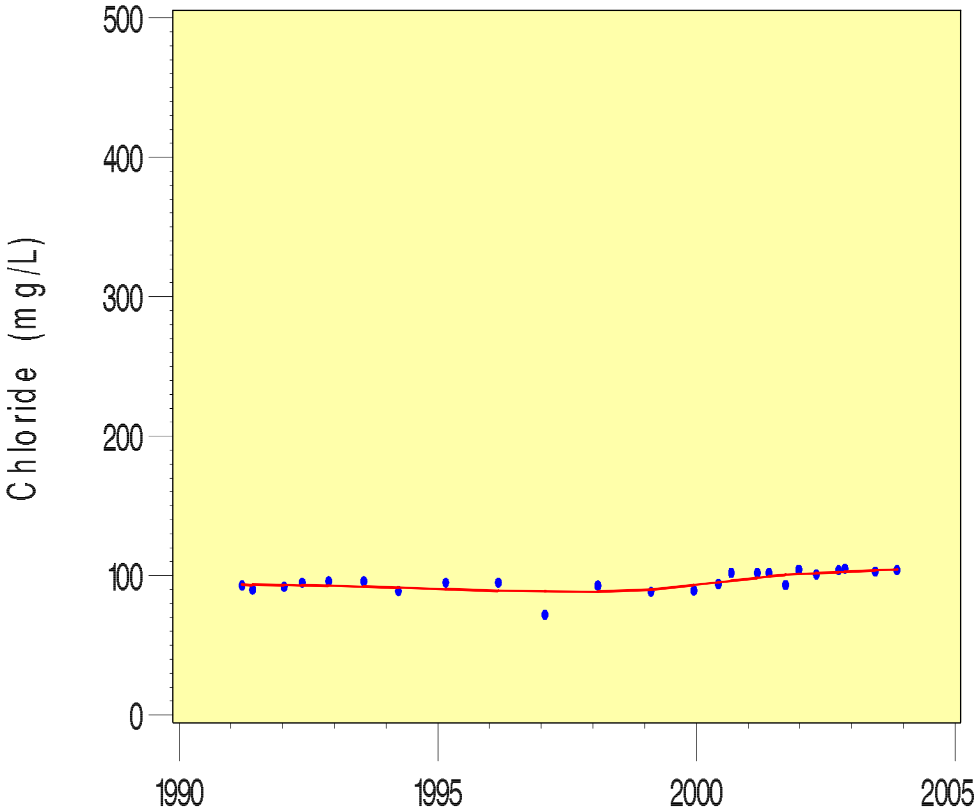


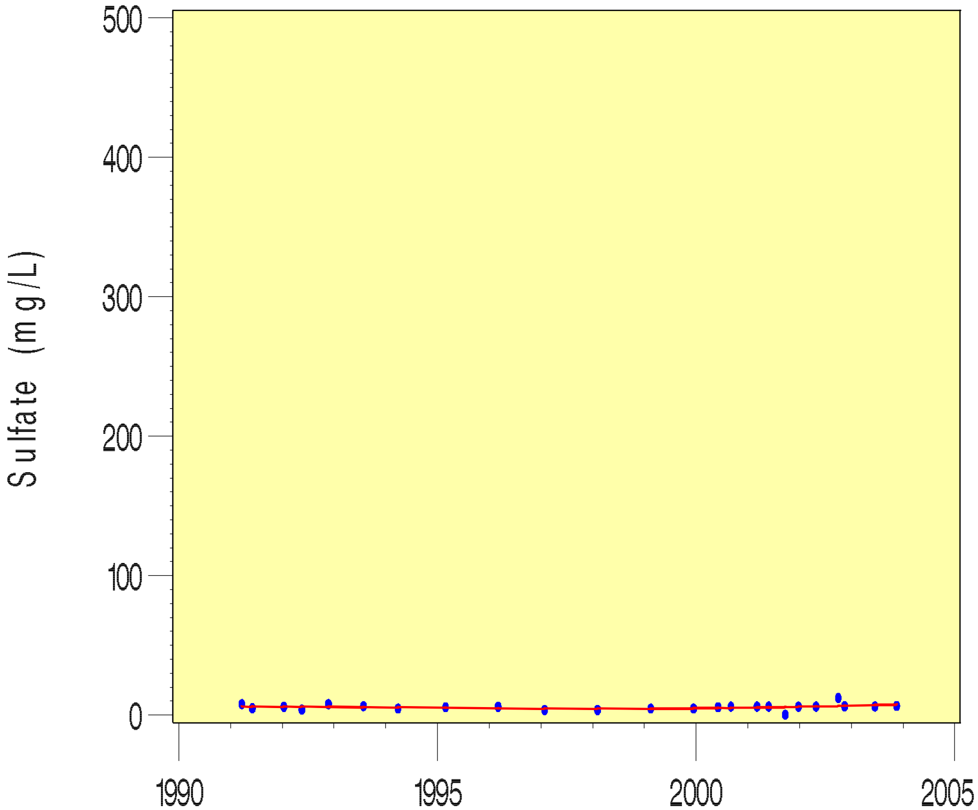
NAME= ST OF FLA PAYNES CRK INT SITE= 1369 SEQ= 0




NAME= USGS C-1 INT SITE= 1319 SEQ= 0
Chloride (mg/L)
2000
1750
1500
1250
1000
1990
1995
2000
2005
Sulfate (mg/L)
500
400
300
200
100
0
1990
1995
2000
2005
Water Quality Data
Lowess Smooth

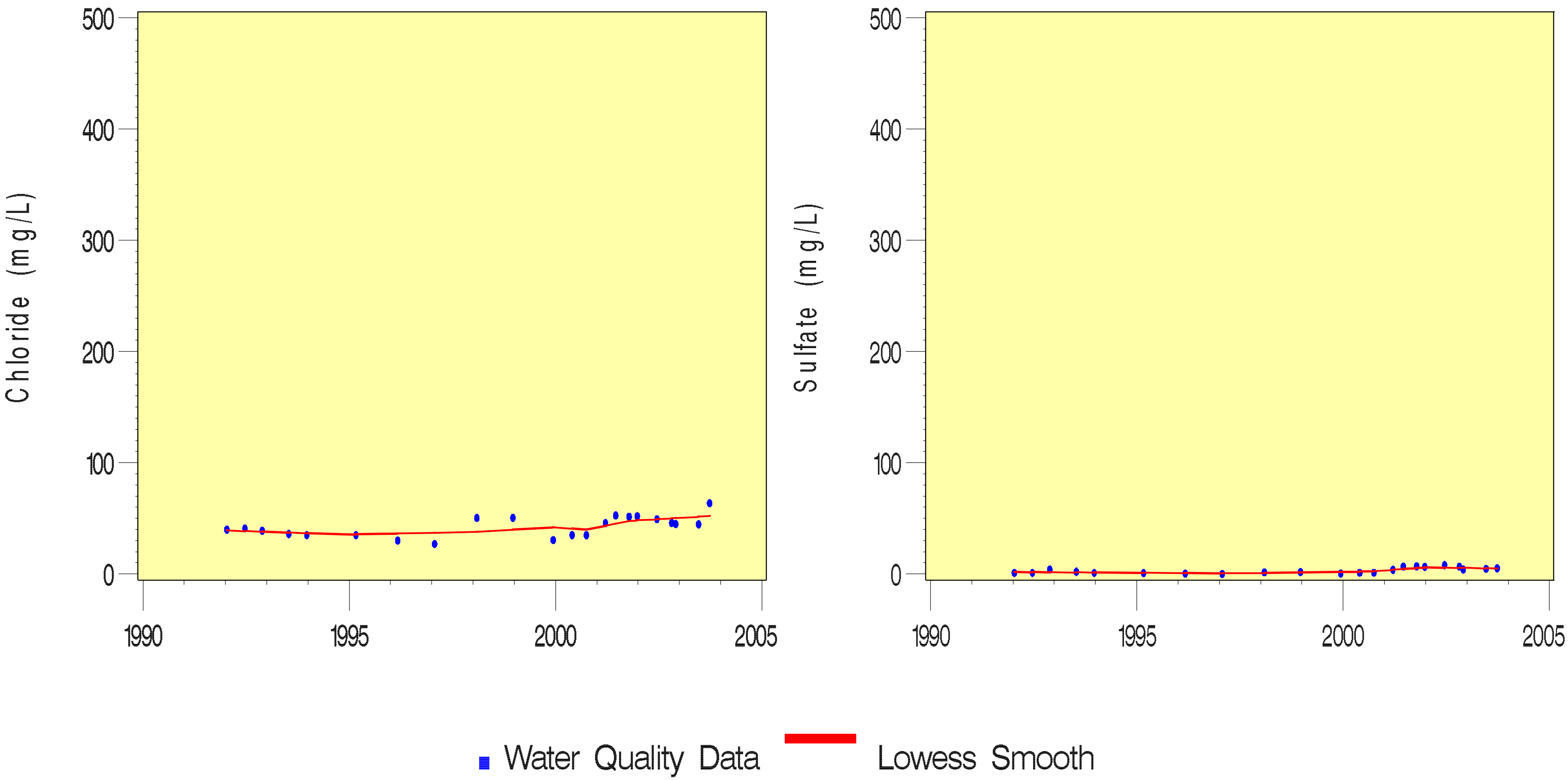
NAME= USGS C—3 INT SITE= 775 SEQ= 0



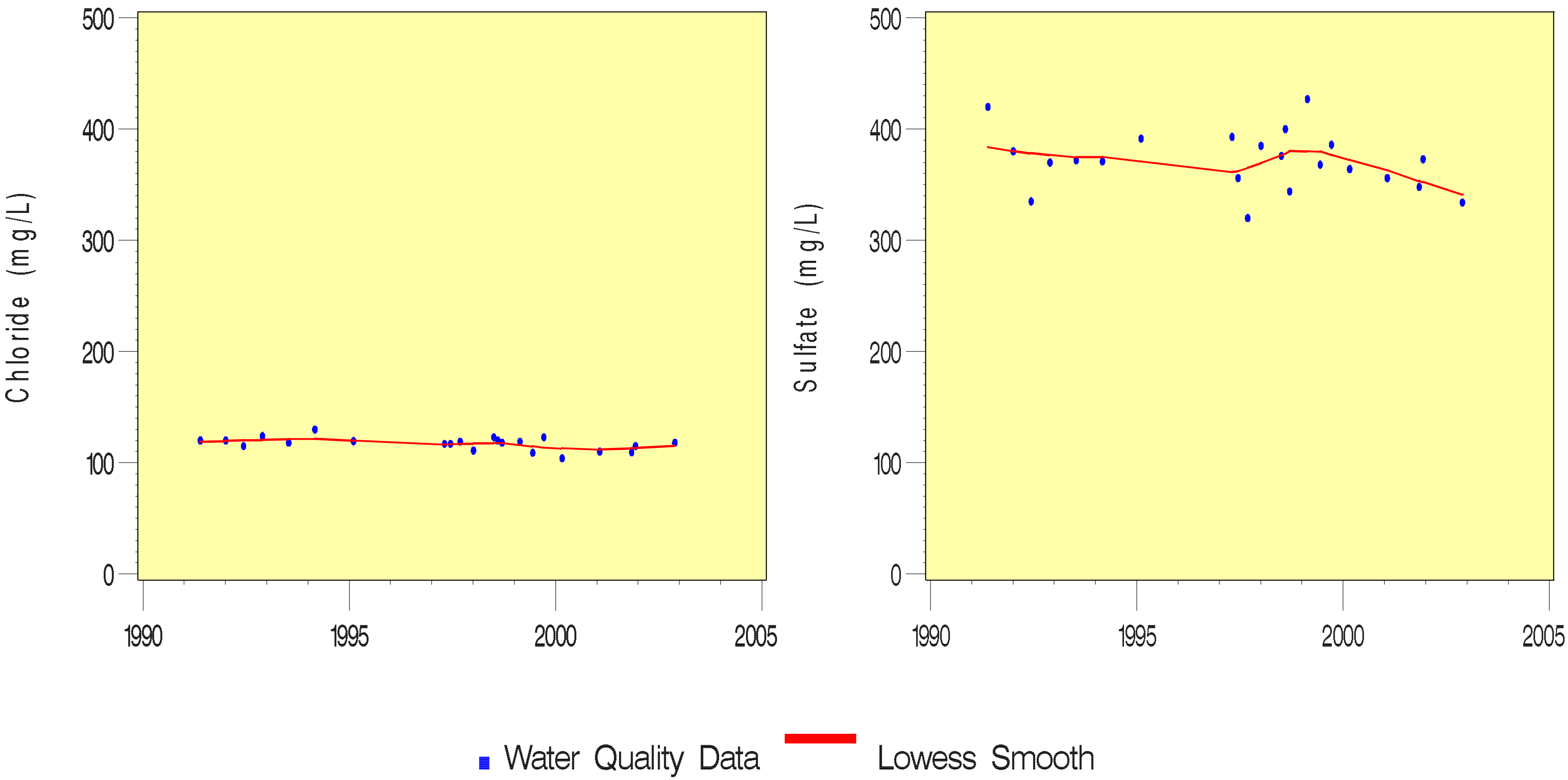


Water Quality Data Lowess Smooth

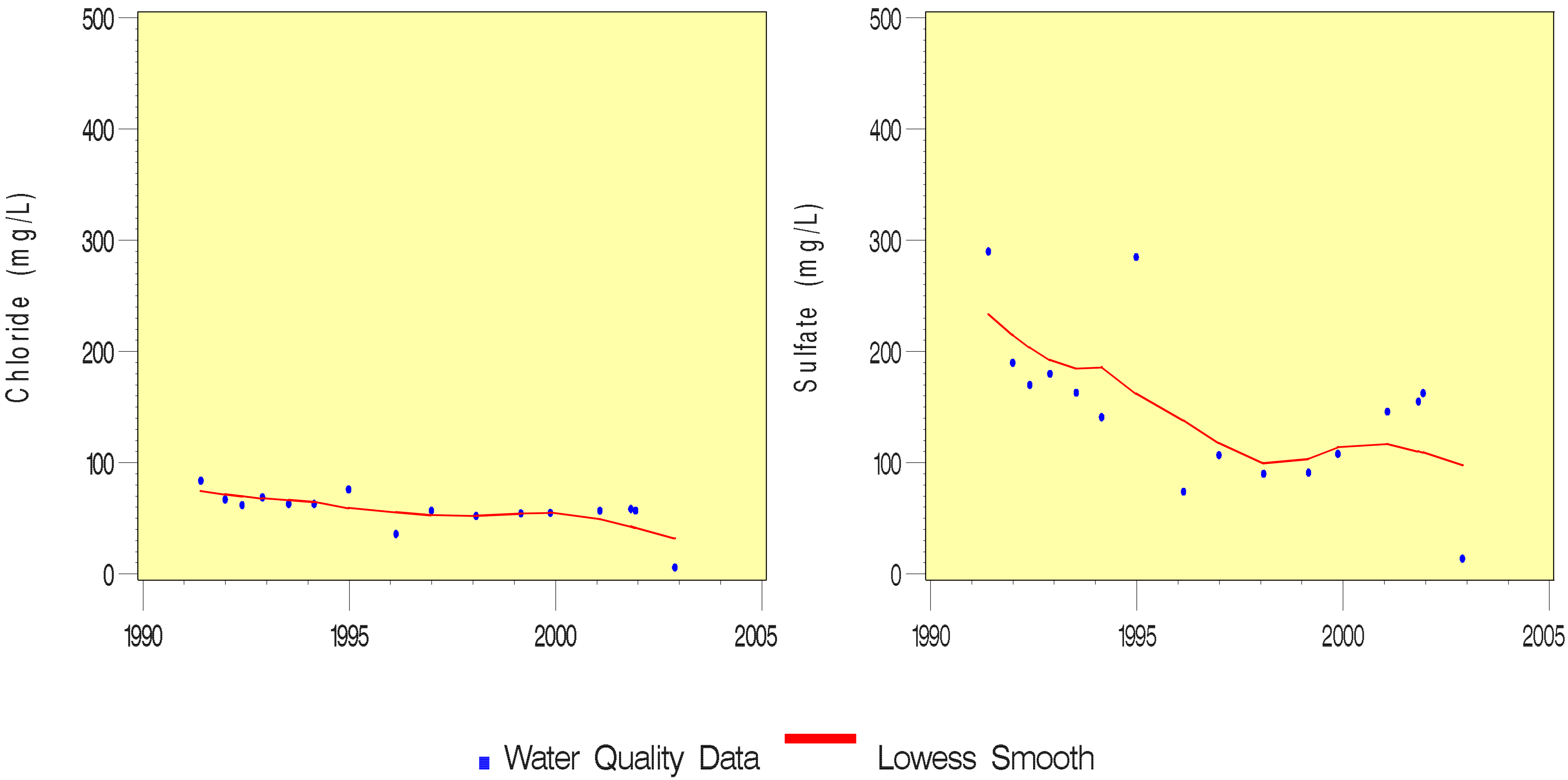
NAME= USGS TUCKERS CORNER INT SITE= 1318 SEQ= 0



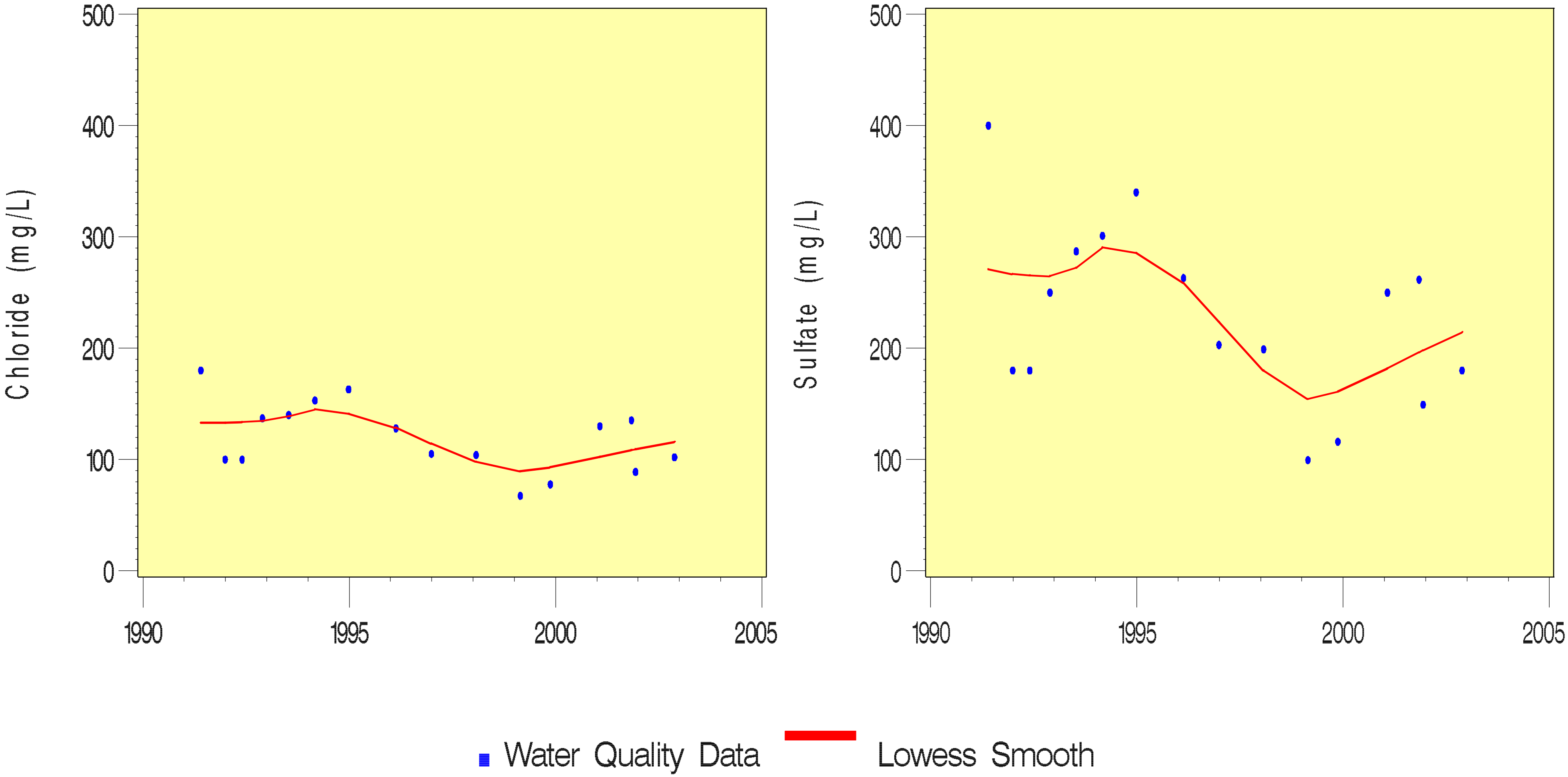
NAME= VENICE 35 INT SITE= 410 SEQ= 0



NAME= VENICE SH WF 59 INT SITE= 1258 SEQ= 0



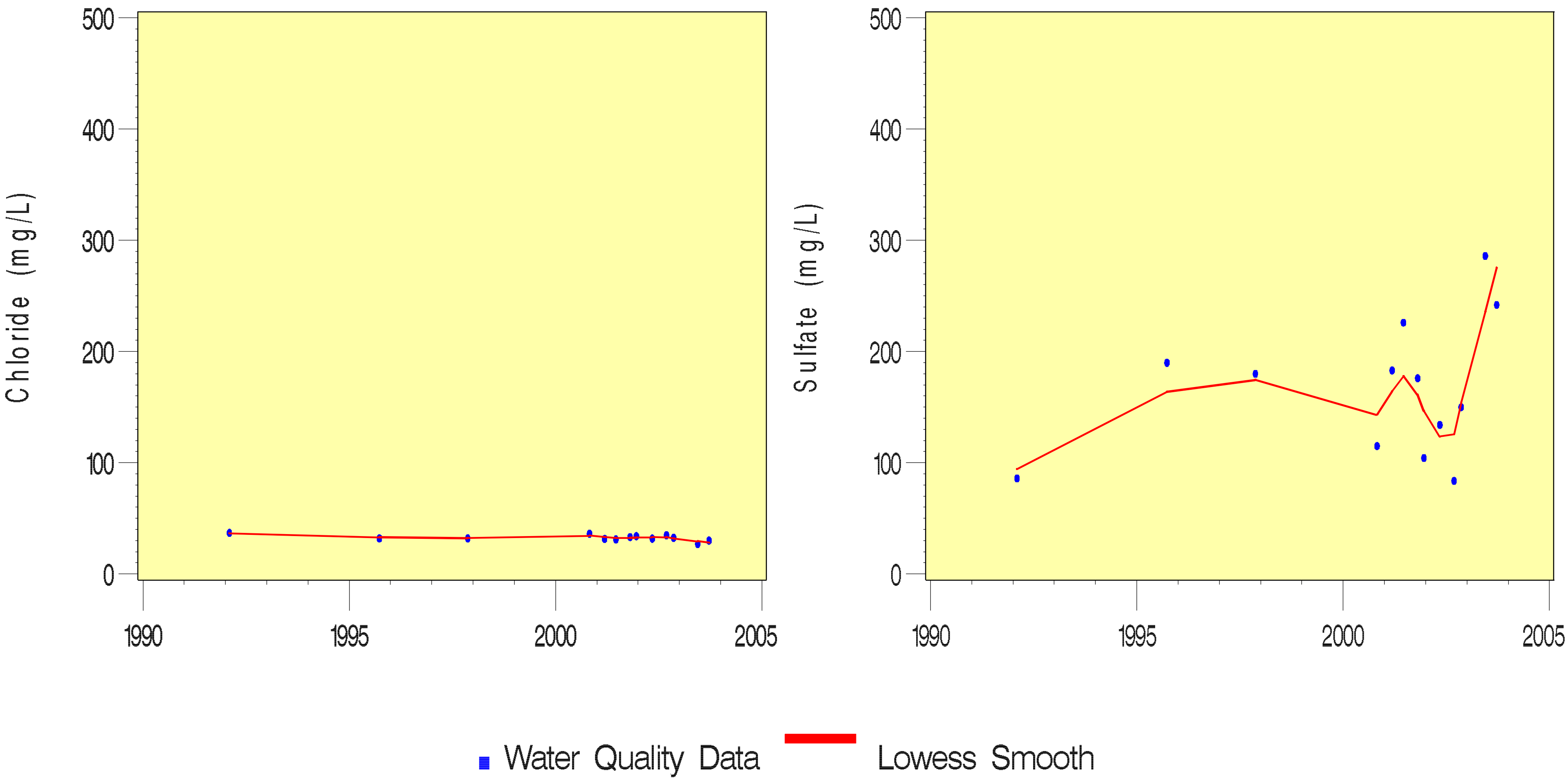
NAME= VENICE SH WF 68 INT SITE= 1254 SEQ= 0



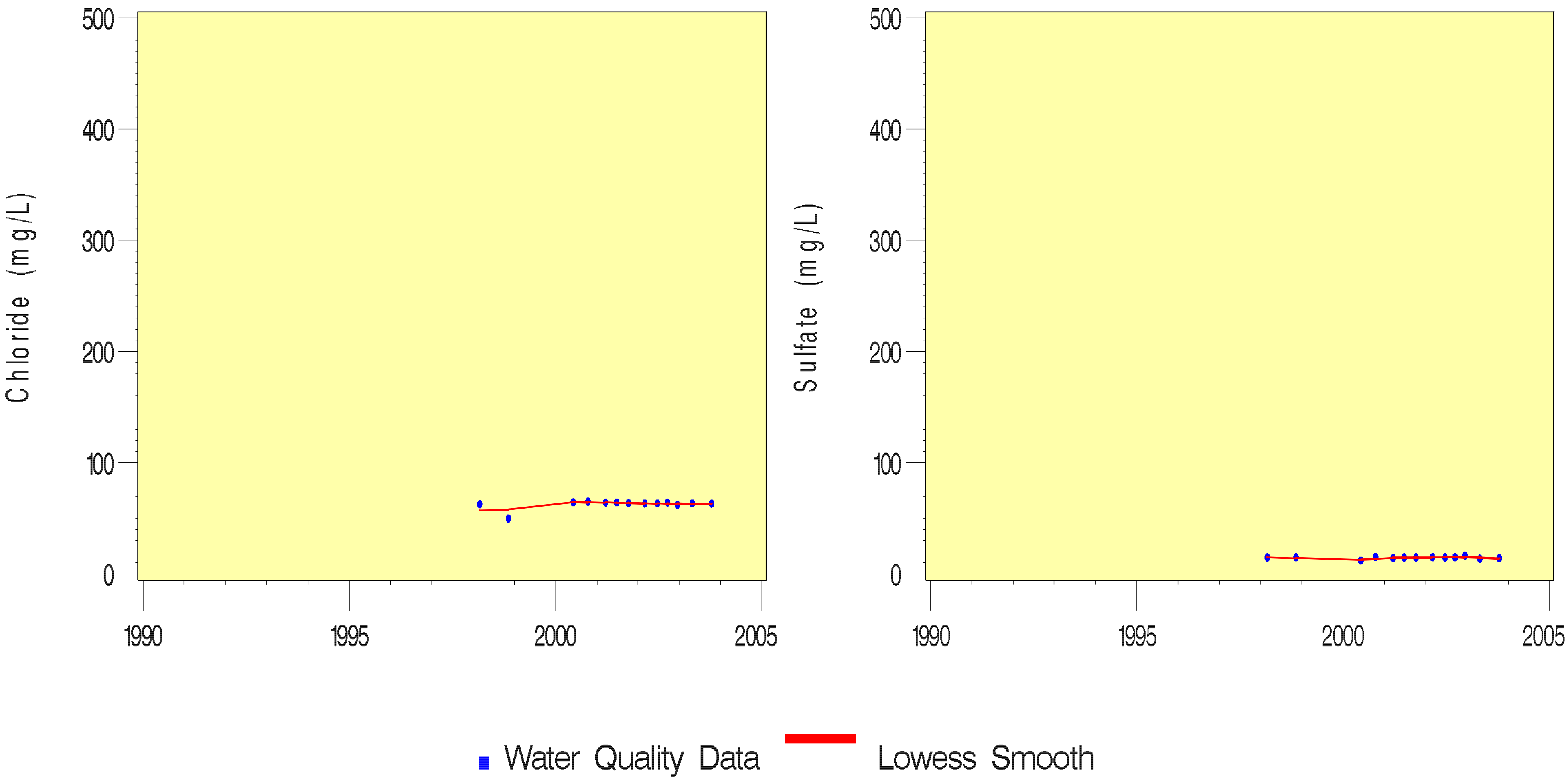
Specifications for wells completed in PZ 3

UID TYPE	UID STATION	UID SITE	UID SITE SEQ	UID SITENAME	LATITUDE	LONGITUDE	CASING DEPTH	TOTAL DEPTH
WEL	2	2	1	ROMP TR 3-1 HTRN 400	265639.32	821304.95	380	400
WEL	1	3	0	ROMP TR 5-2 LOW HTRN	270920.80	822341.66	245	265
WEL	302	36	0	ROWELL DEEP	273156.22	814516.81	39	267
WEL	209	41	0	ROMP 31 HTRN/TMPA	272715.00	815458.57	130	350
WEL	344	78	0	ARCADIA 2 INT	271310.09	815226.67	263	372
WEL	390	124	0	MABRY CARLTON 6 INT	271228.25	820848.43	311	369
WEL	539	273	0	SARASOTA 27TH ST INT	272134.16	823246.58	45	343
WEL	536	285	0	ROMP 10 LOW HTRN/TMPA	270153.31	820000.75	320	473
WEL	564	300	0	ROMP 33 ARC	272728.22	821525.55	215	290
WEL	586	320	0	ROMP 11 HTRN	265837.67	815609.30	220	335
WEL	619	354	0	ROMP 30 TMPA	272733.45	814747.97	280	316
WEL	670	404	0	MANASOTA 14 DEEP	270138.91	822352.63	263	305
WEL	221	414	0	ROMP 16 TMPA	271117.02	814624.79	300	340
WEL	802	536	0	FORT GREEN SPRINGS INT	274154.68	815729.38	280	300
WEL	912	646	0	ROMP TR 6-1 HTRN	271601.37	823302.21	300	315
WEL	932	666	0	PORT CHARLOTTE DEEP	270145.99	820413.33	312	350
WEL	997	731	0	WHITAKER BAYOU INT	272118.51	823250.17	54	337
WEL	1338	877	0	LANE ROB (G V RUSSELL) IN	270429.49	815752.13	70	411
WEL	1702	1241	0	SARASOTA HIST SOC INT	271223.18	822951.33	220	450
WEL	1704	1243	0	SOUTHBAY UTILITIES DEEP	271037.30	822857.97	220	450
WEL	1712	1251	0	TEST 18 BLACKBURN INT	270715.19	821551.31	282	351
WEL	211	10925	0	ROMP TR 7-4 HTRN	272540.13	822920.68	213	268
WEL	224	10941	0	ROMP TR 5-1 TMPA	270810.24	822704.87	275	289
WEL	229	10947	0	ROMP TR 1-2 L HTRN/TMPA	265025.50	815853.22	520	600
WEL	1027	11043	0	ROMP 17 LOW HTRN	271028.49	815835.46	200	240
WEL	1023	11071	0	ROMP TR 3-3 LOW HTRN	265532.22	821947.33	370	410
WEL	1029	11175	0	ROMP 22 ARC/TMPA	271843.75	822011.41	230	290
WEL	1031	11303	0	ROMP 20 LOW INT	271138.48	822845.34	250	370
WEL	1033	11391	0	ROMP TR 7-2 LOW ARC	272614.04	823300.91	200	290
WEL	1153	11671	0	GDU WELL T-2 INT	270540.54	820010.25	393	496
WEL	1042	11875	0	ROMP 28 HTRN	272208.57	812607.38	370	420
WEL	1039	12002	0	ROMP TR SA-1 UP INT	272049.30	823245.08	328	388
WEL	1037	12870	0	ROMP 13 LOW INT	270419.11	813658.42	514	592
WEL	1037	12871	0	ROMP 13 MID INT	270419.14	813658.26	282	417
WEL	1088	12873	0	ROMP 14 LOW HTRN	270859.65	812111.92	460	521
WEL	1069	12883	0	ROMP 5 LOWER INT	265644.96	814827.87	450	600
WEL	1070	12900	0	ROMP 9 LOW HTRN MW-4	270434.83	820856.22	190	320
WEL	1087	12904	0	ROMP TR 4-1 LOW INT	270328.65	822628.30	272	645
WEL	2075	13336	0	ROMP 12 LOW INT	270228.23	814432.32	280	409
WEL	2091	17423	0	ROMP 9.5 MW-8 LOWER INTER	270736.35	820249.87	205	330
WEL	2336	34898	0	ROMP 16.5 LOWER INT	270339.90	815302.39	347	460

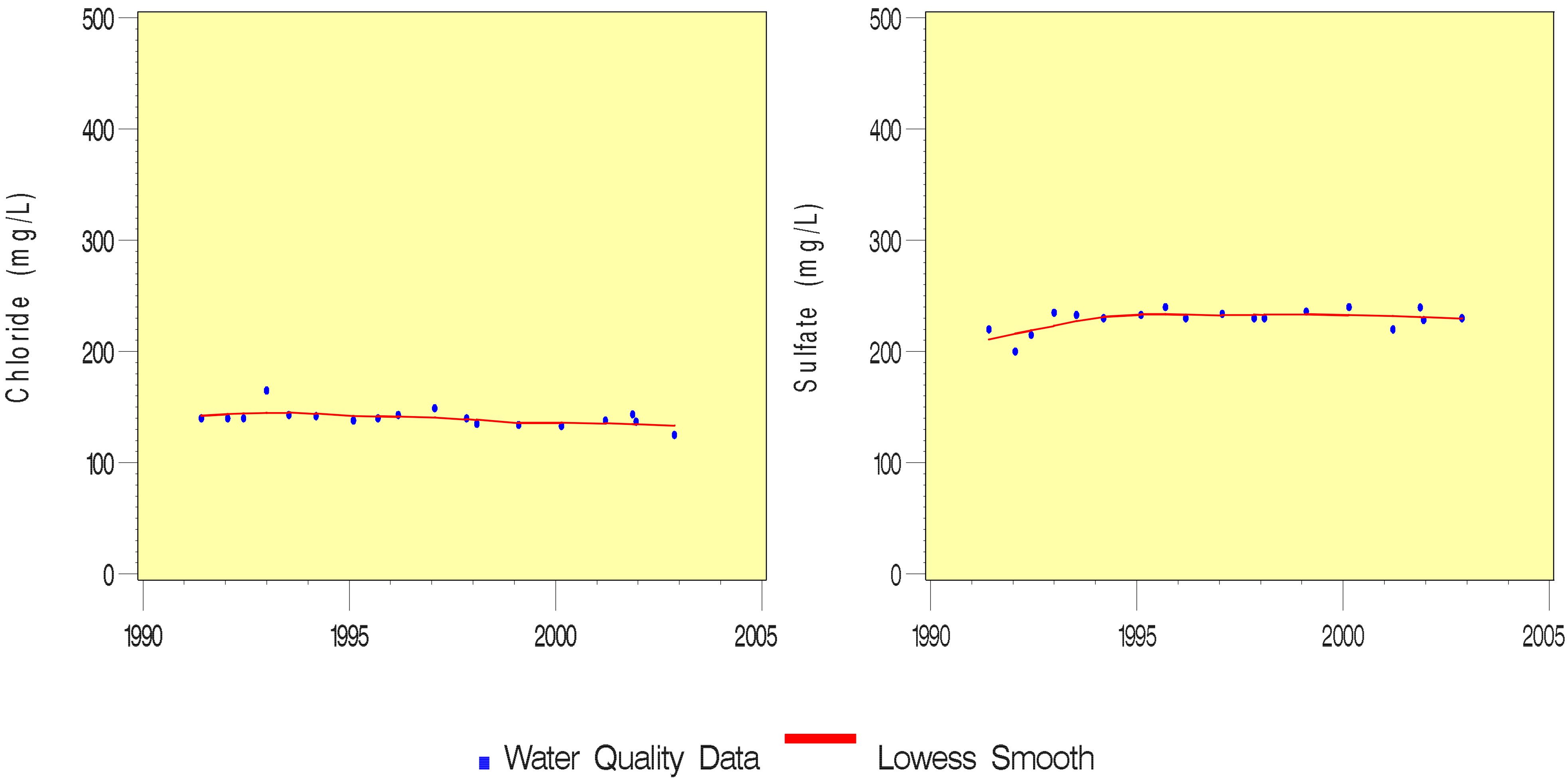
NAME=ARCADIA 2 INT SITE=78 SEQ=0



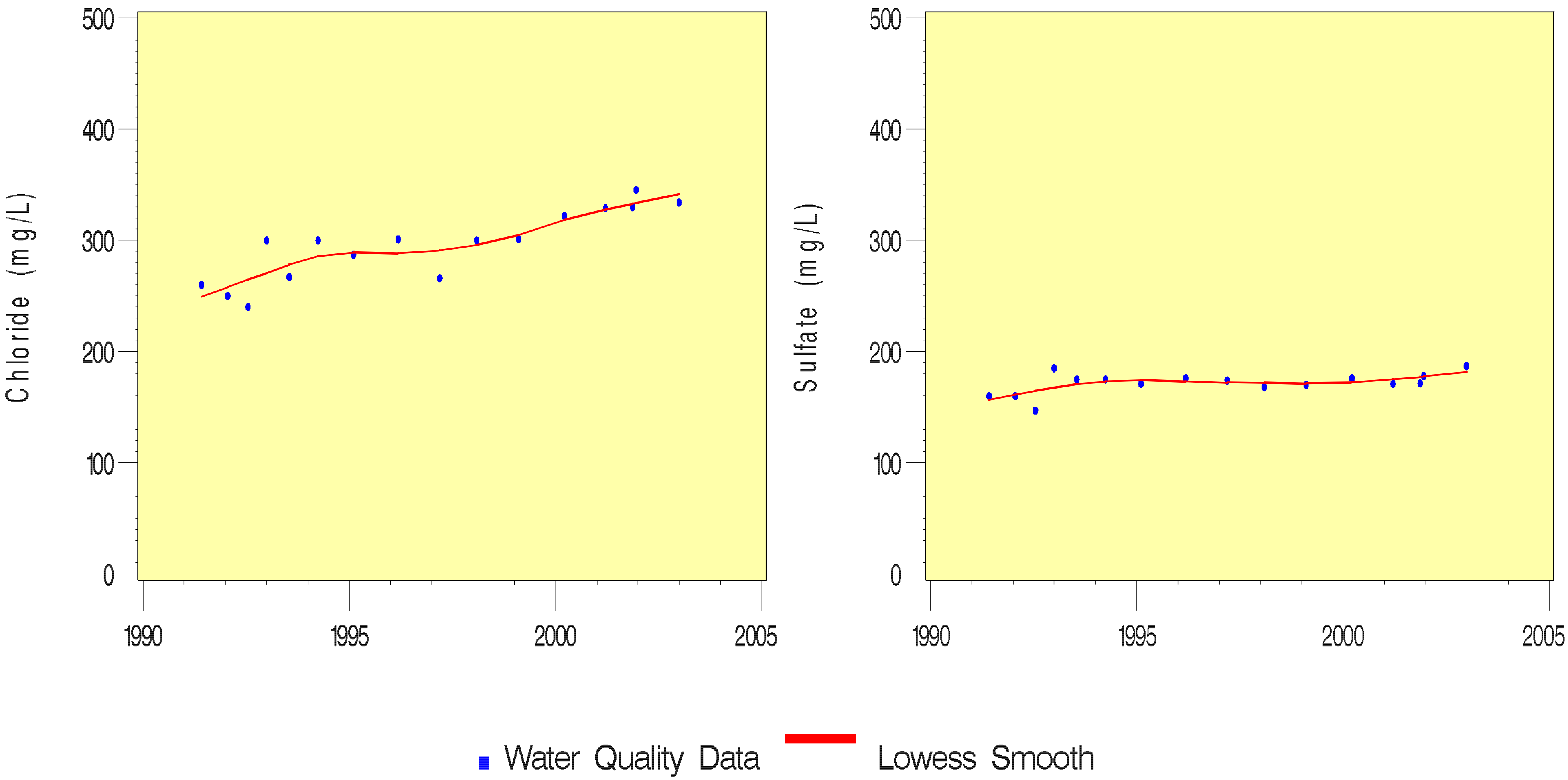
NAME= FORT GREEN SPRINGS INT SITE= 536 SEQ= 0



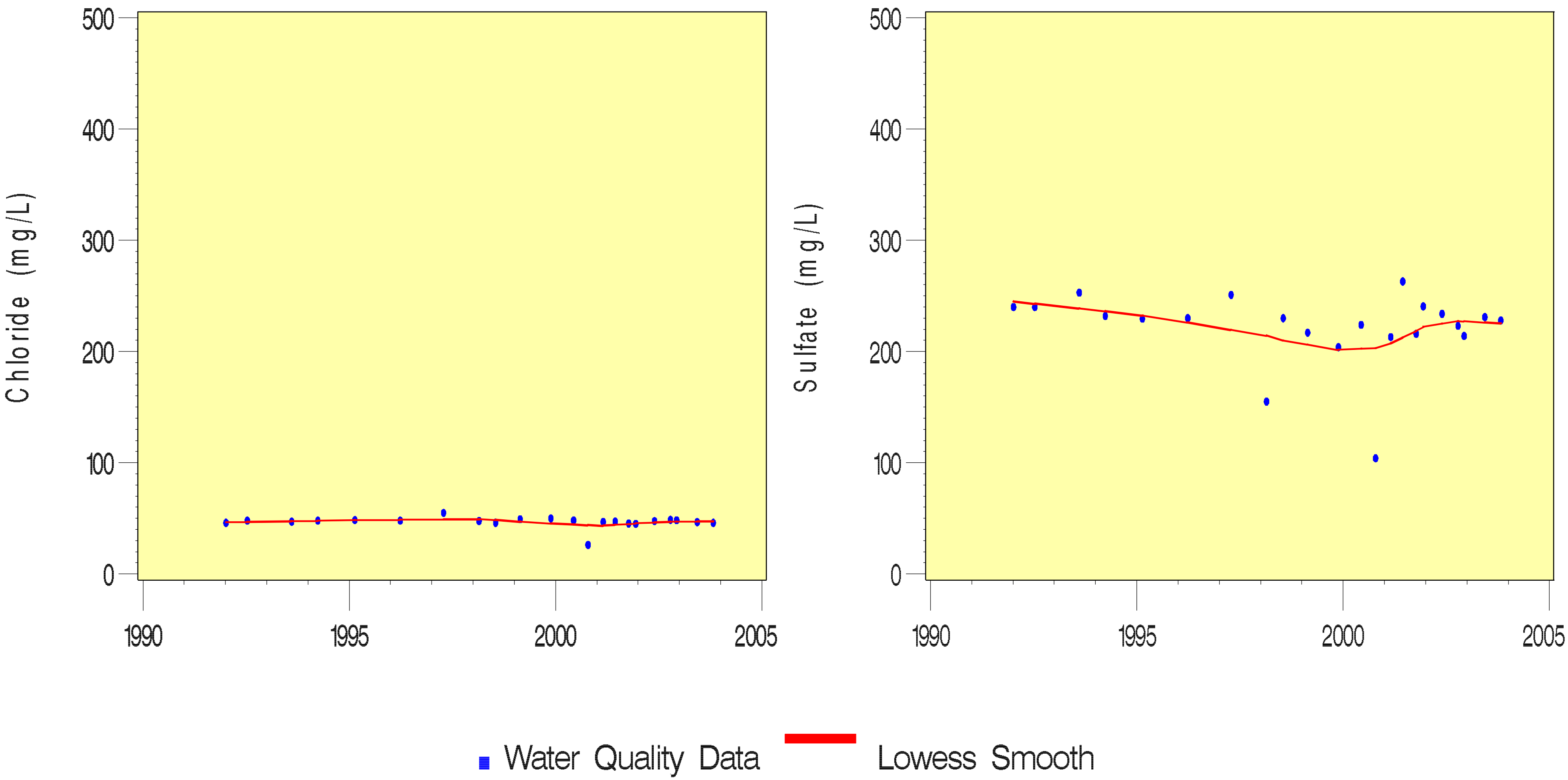
NAME= GDU WELL T-2 INT SITE= 11671 SEQ= 0



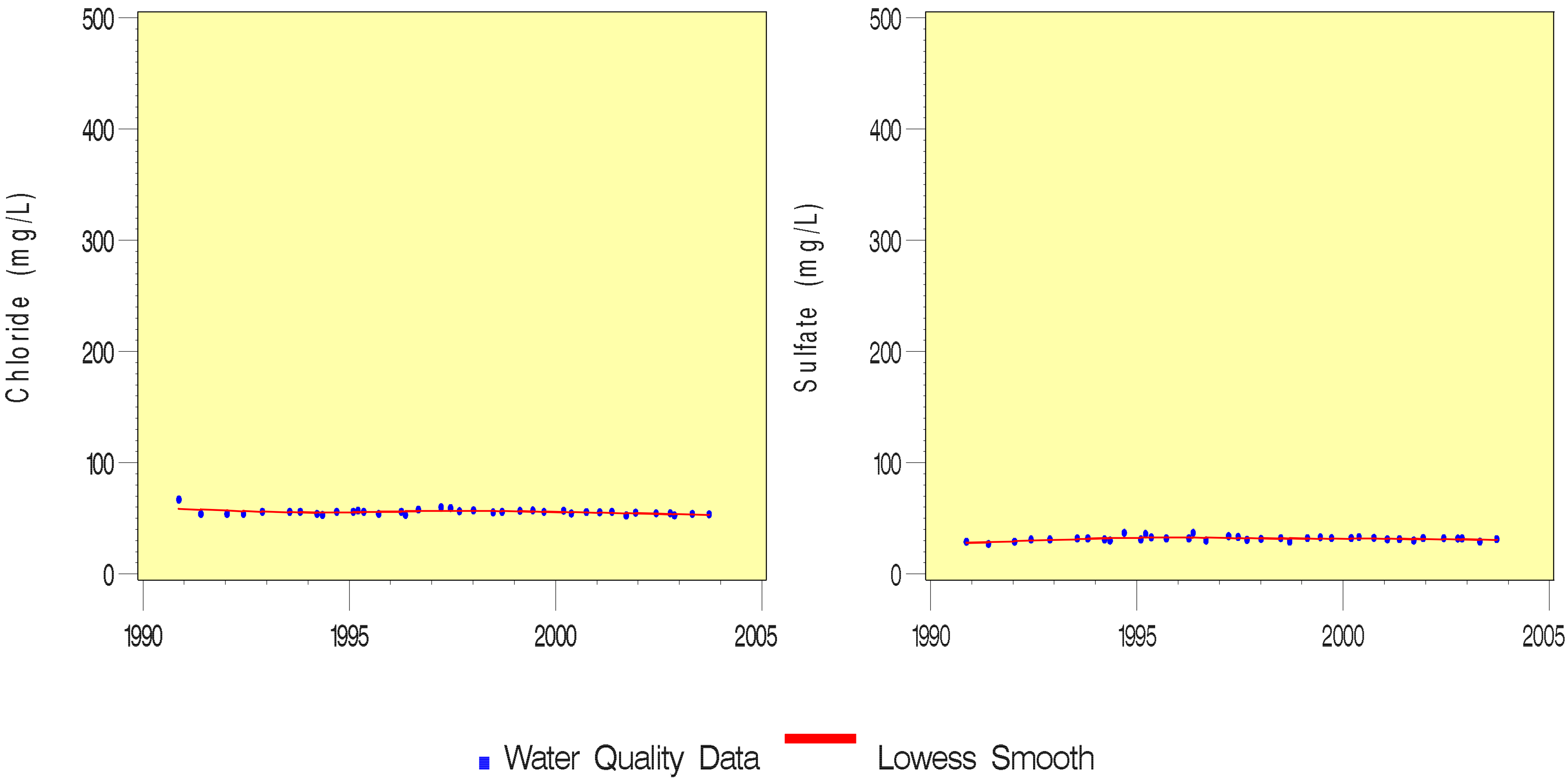
NAME= LANE ROB (G V RUSSELL) IN SITE= 877 SEQ= 0



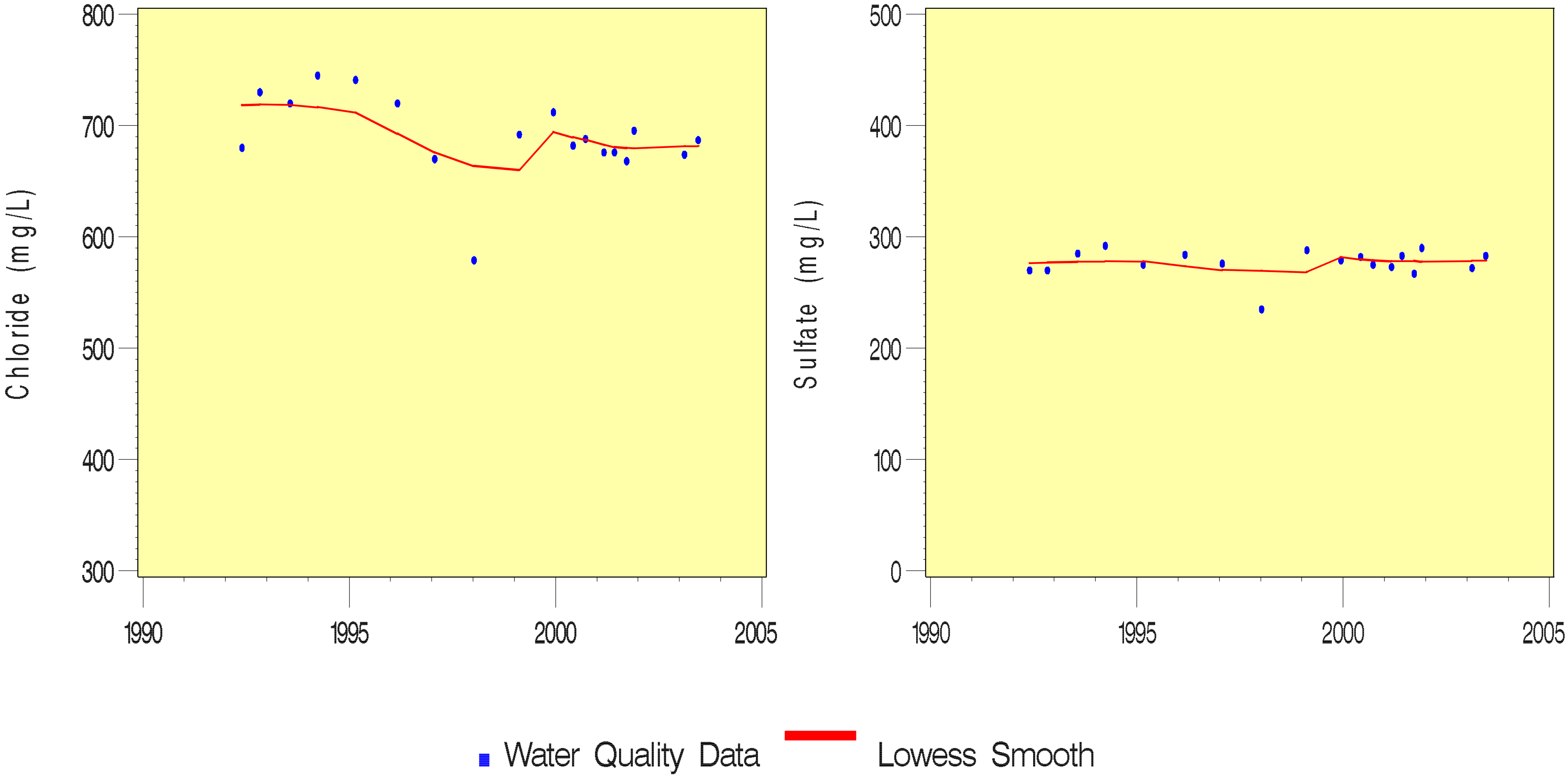
NAME= MABRY CARLTON 6 INT SITE= 124 SEQ= 0



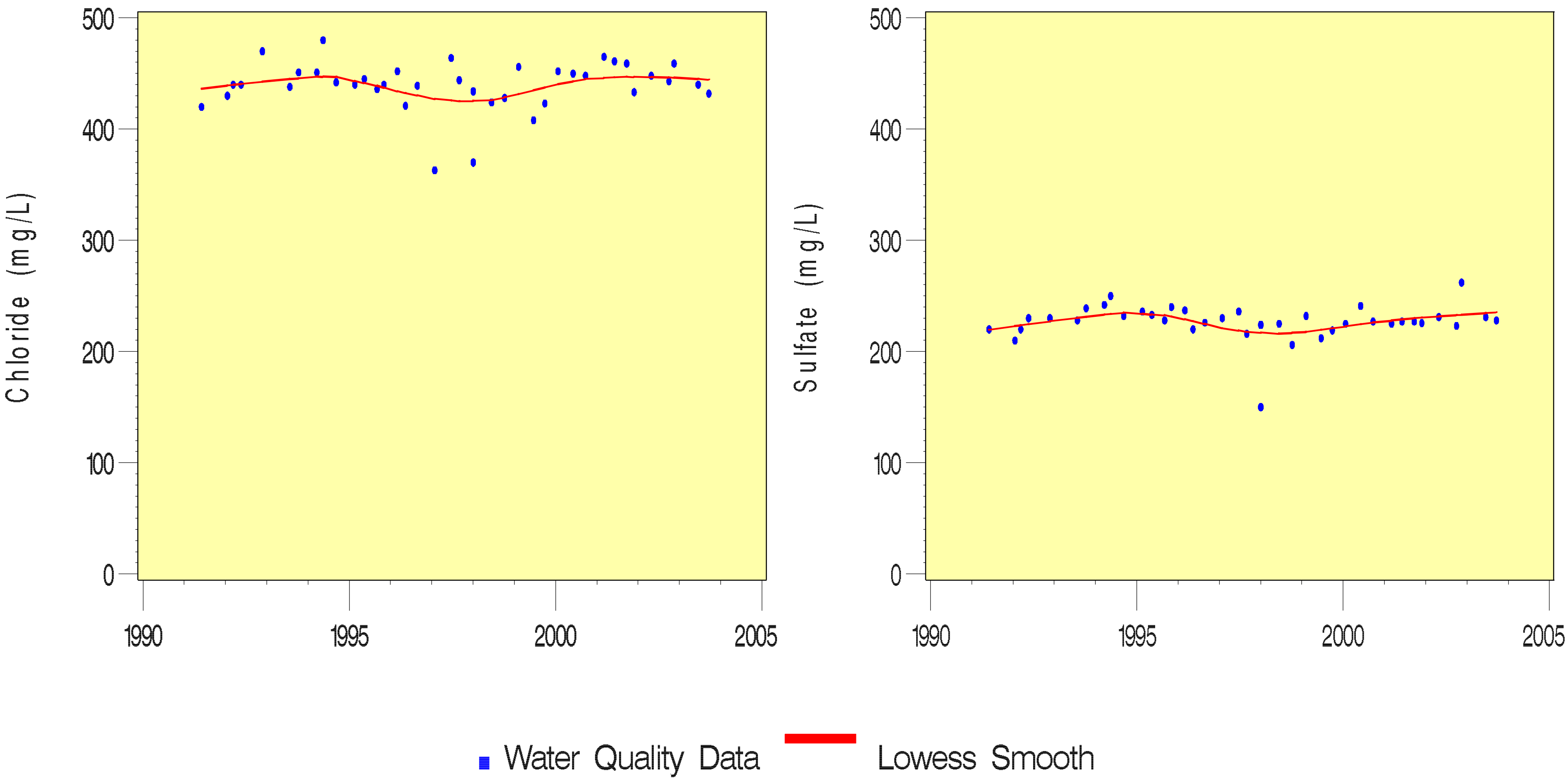
NAME= MANASOTA 14 DEEP SITE= 404 SEQ= 0



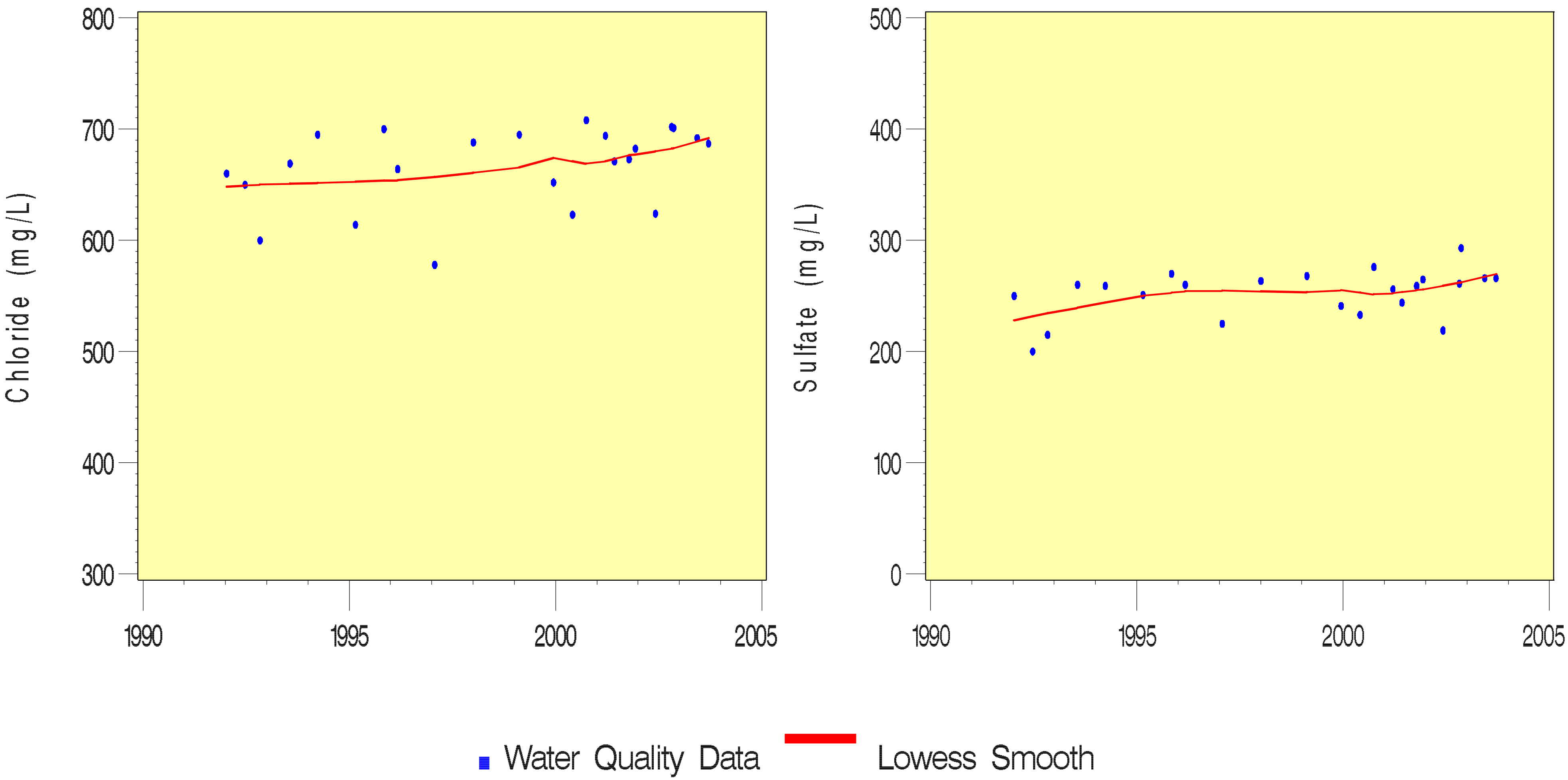
NAME= PORT CHARLOTTE DEEP SITE= 666 SEQ= 0



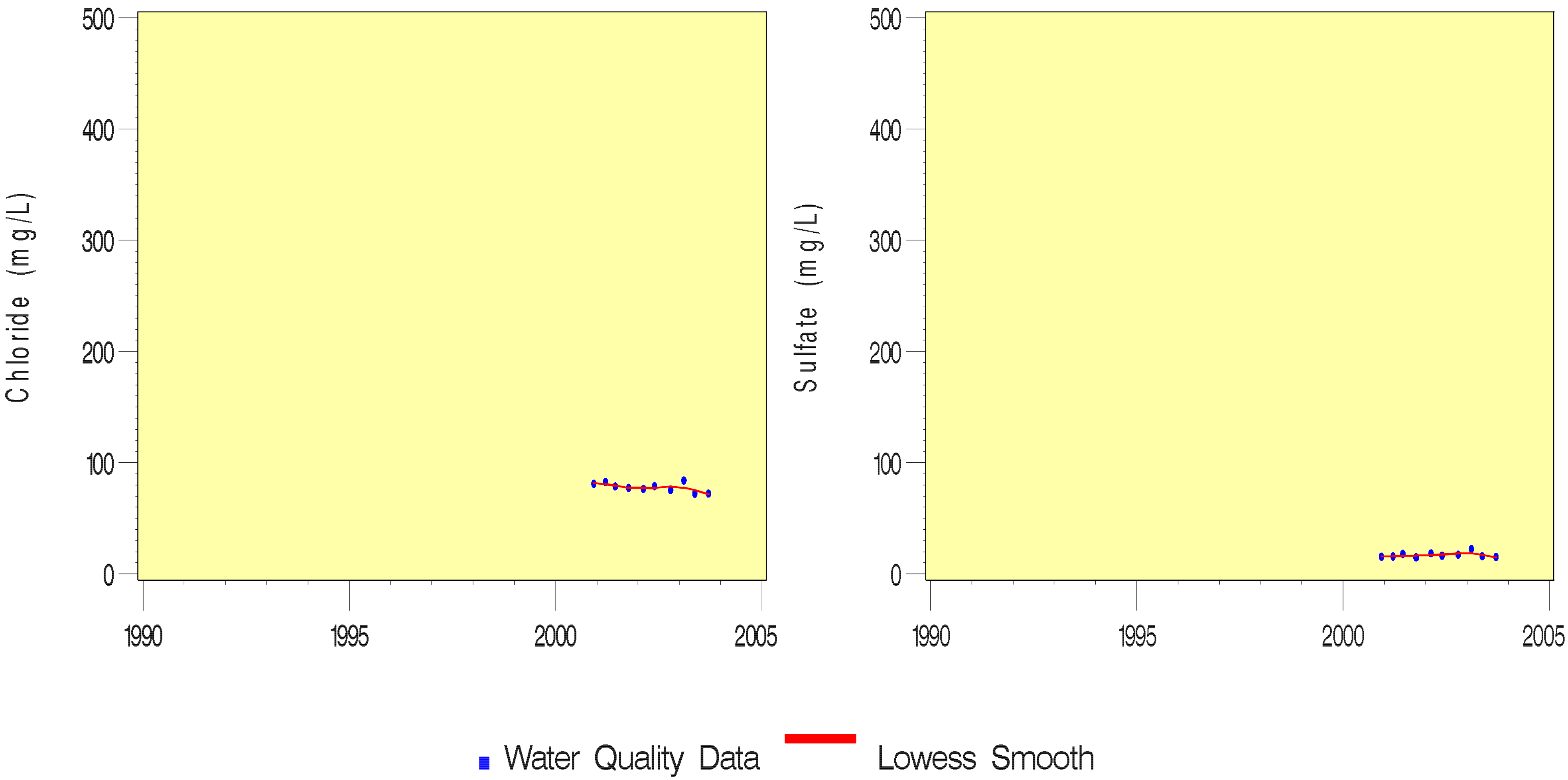
NAME= ROMP 10 LOW HTRN/TMPA SITE= 285 SEQ= 0



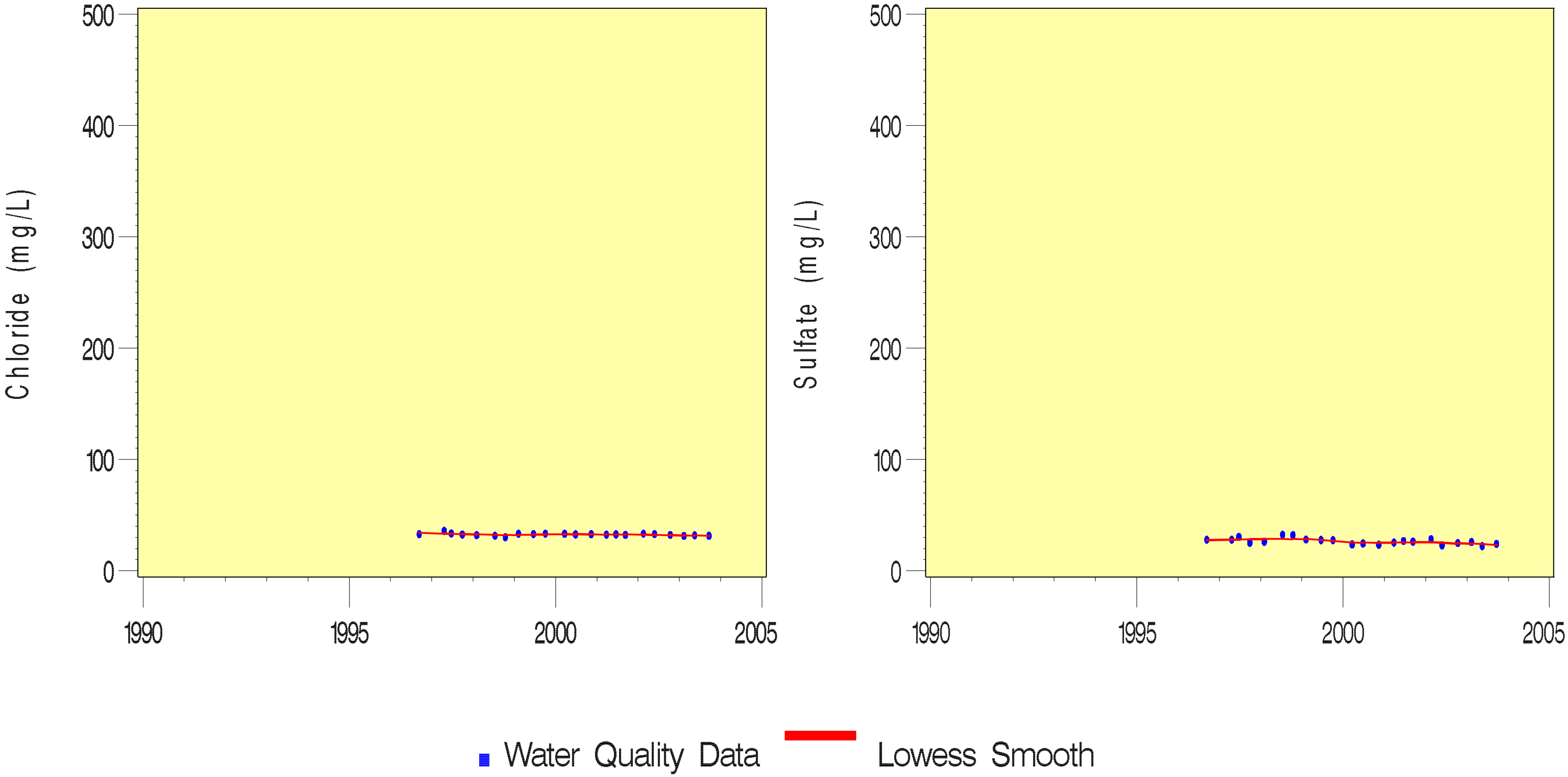
NAME= ROMP 11 HTRN SITE= 320 SEQ= 0



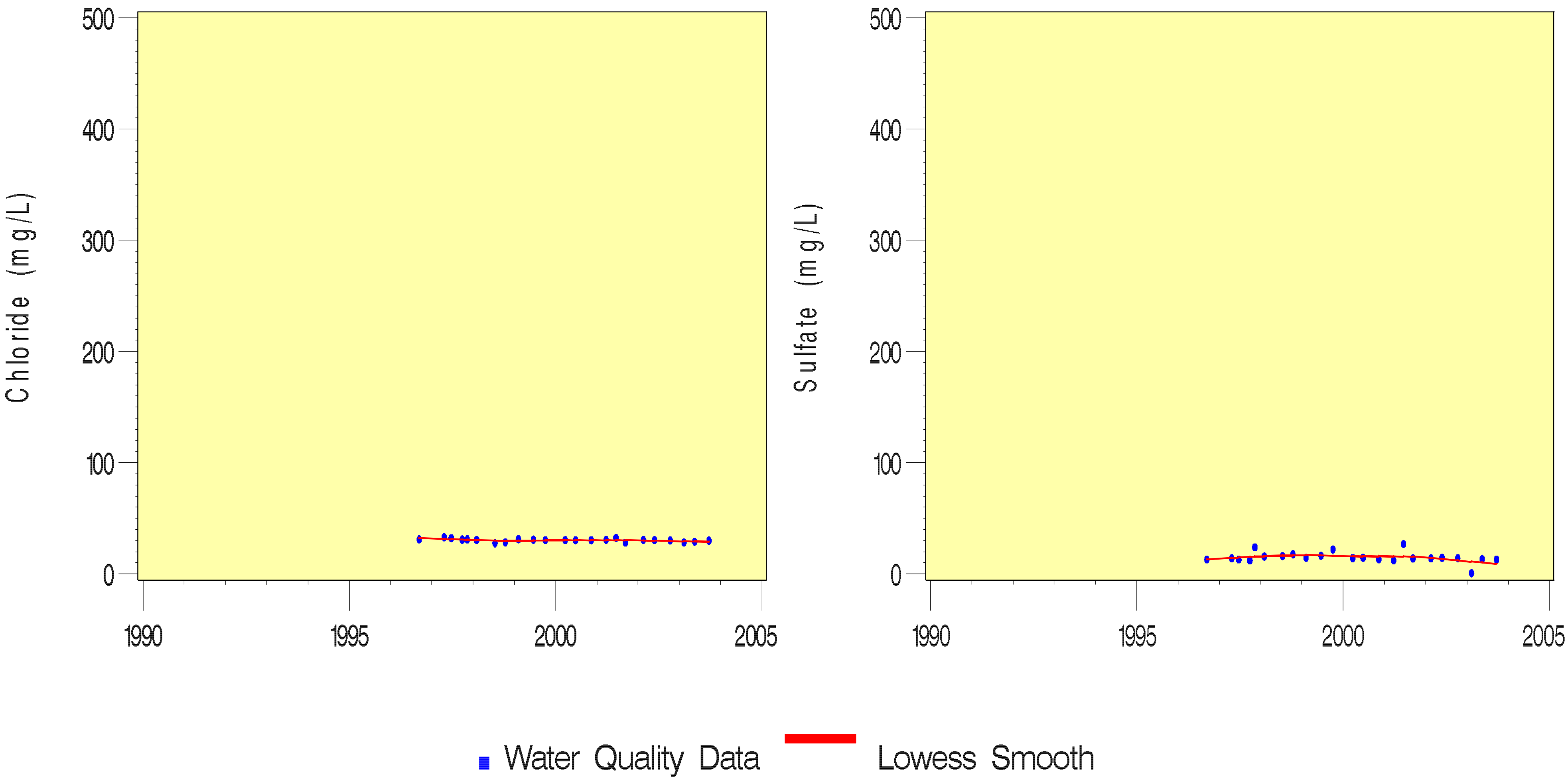
NAME= ROMP 12 LOW INT SITE= 13336 SEQ= 0



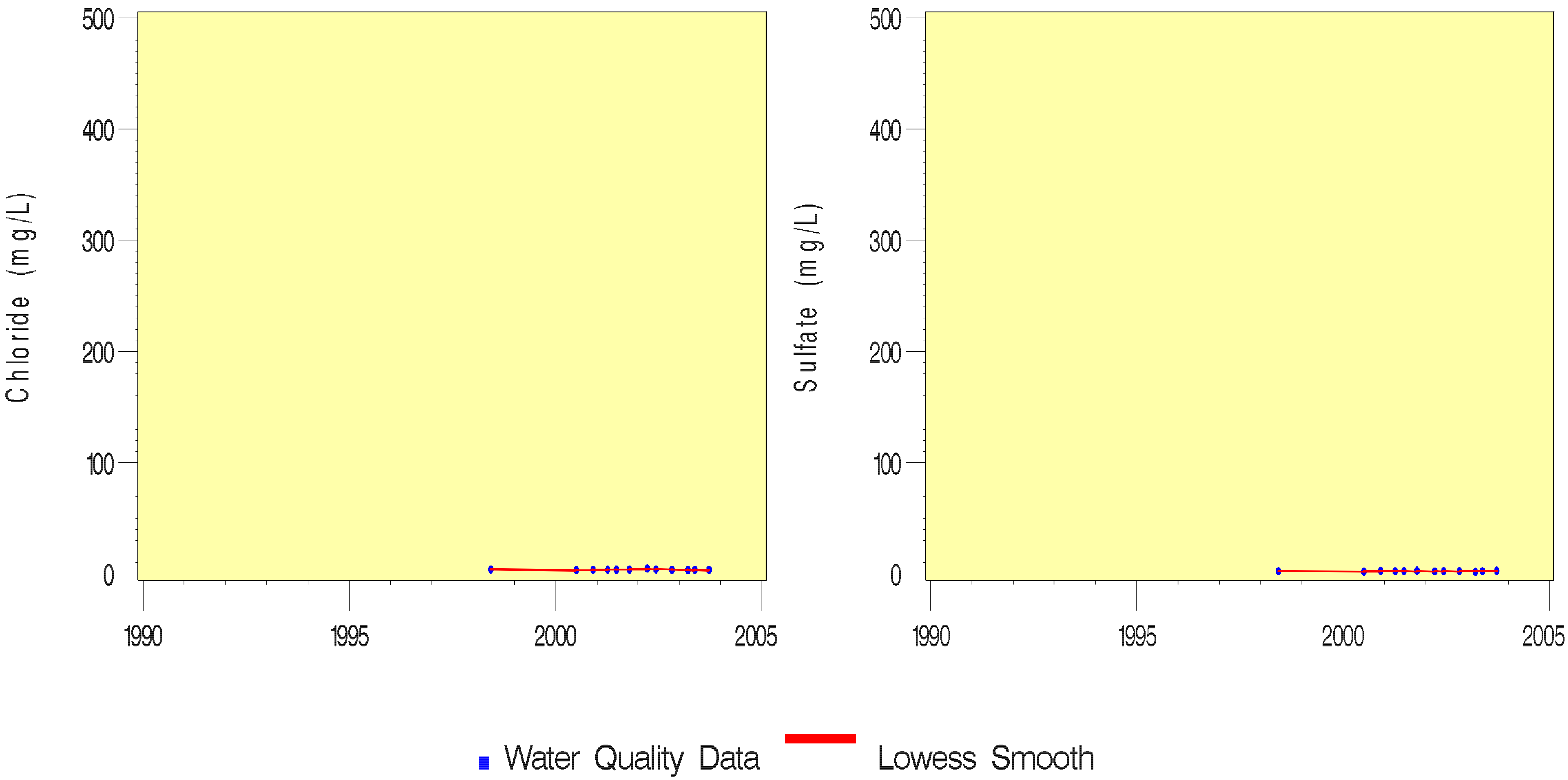
NAME= ROMP 13 LOW INT SITE= 12870 SEQ= 0



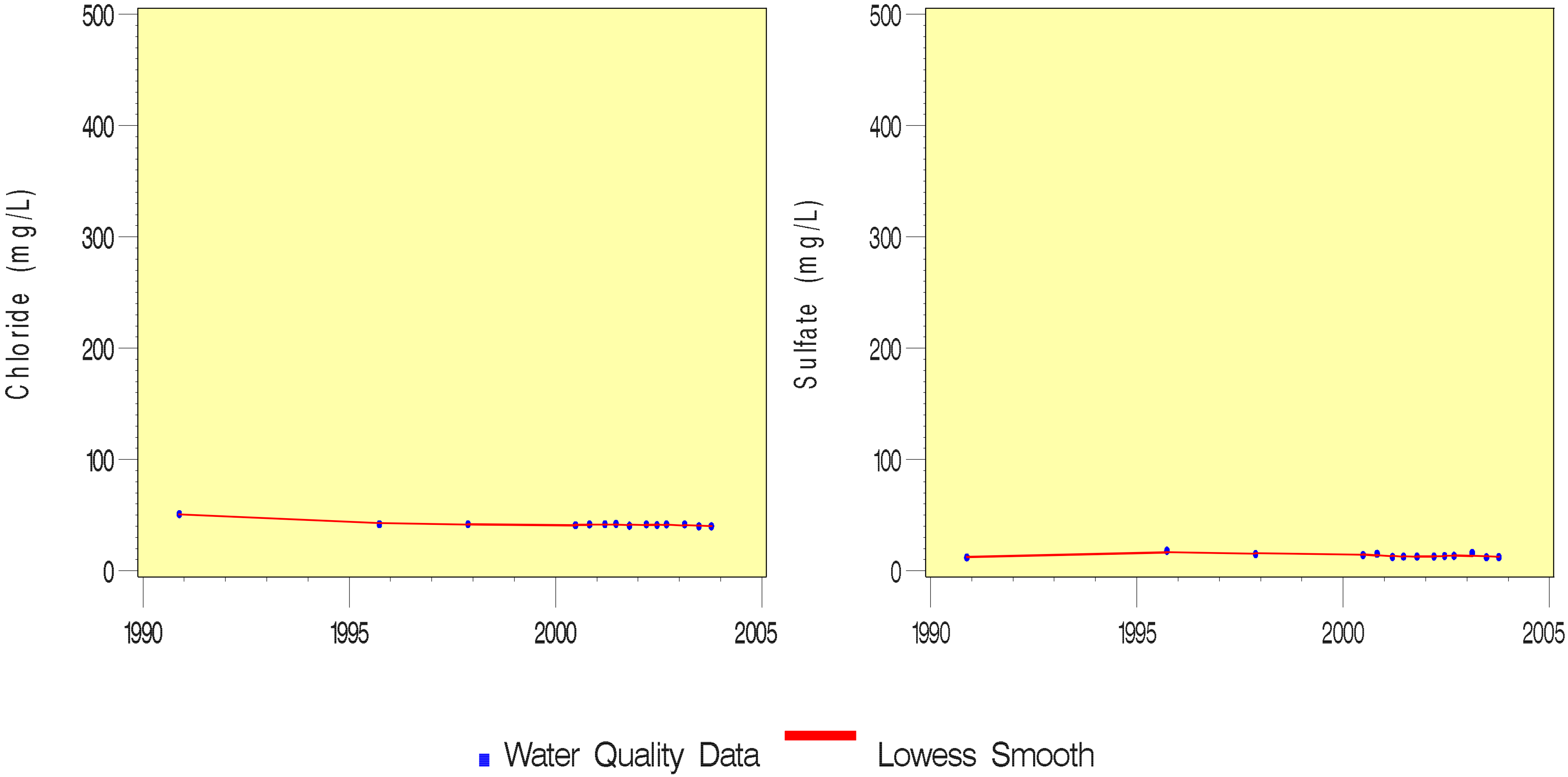
NAME= ROMP 13 MID INT SITE= 12871 SEQ= 0



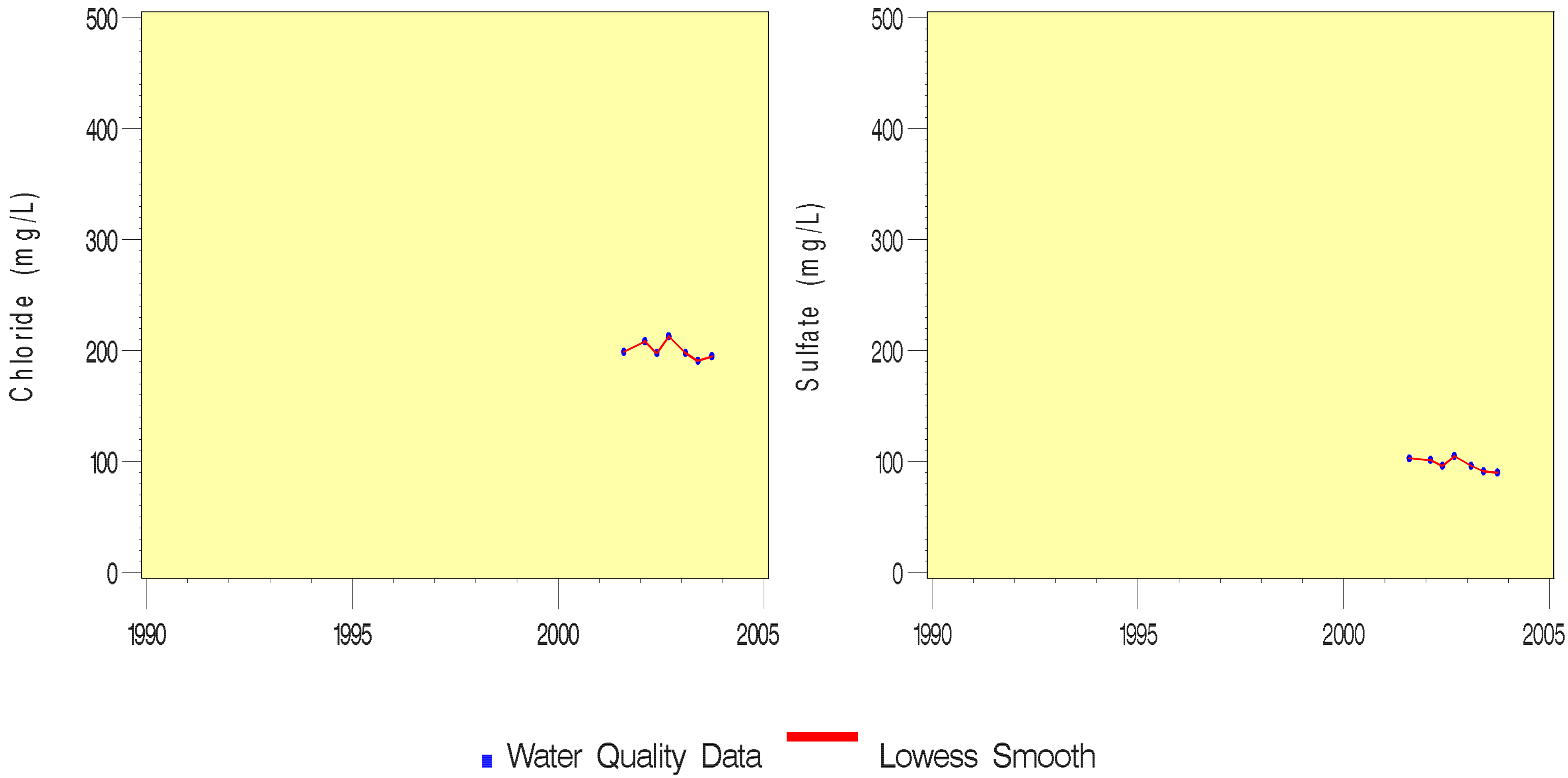
NAME= ROMP 14 LOW HTRN SITE= 12873 SEQ= 0



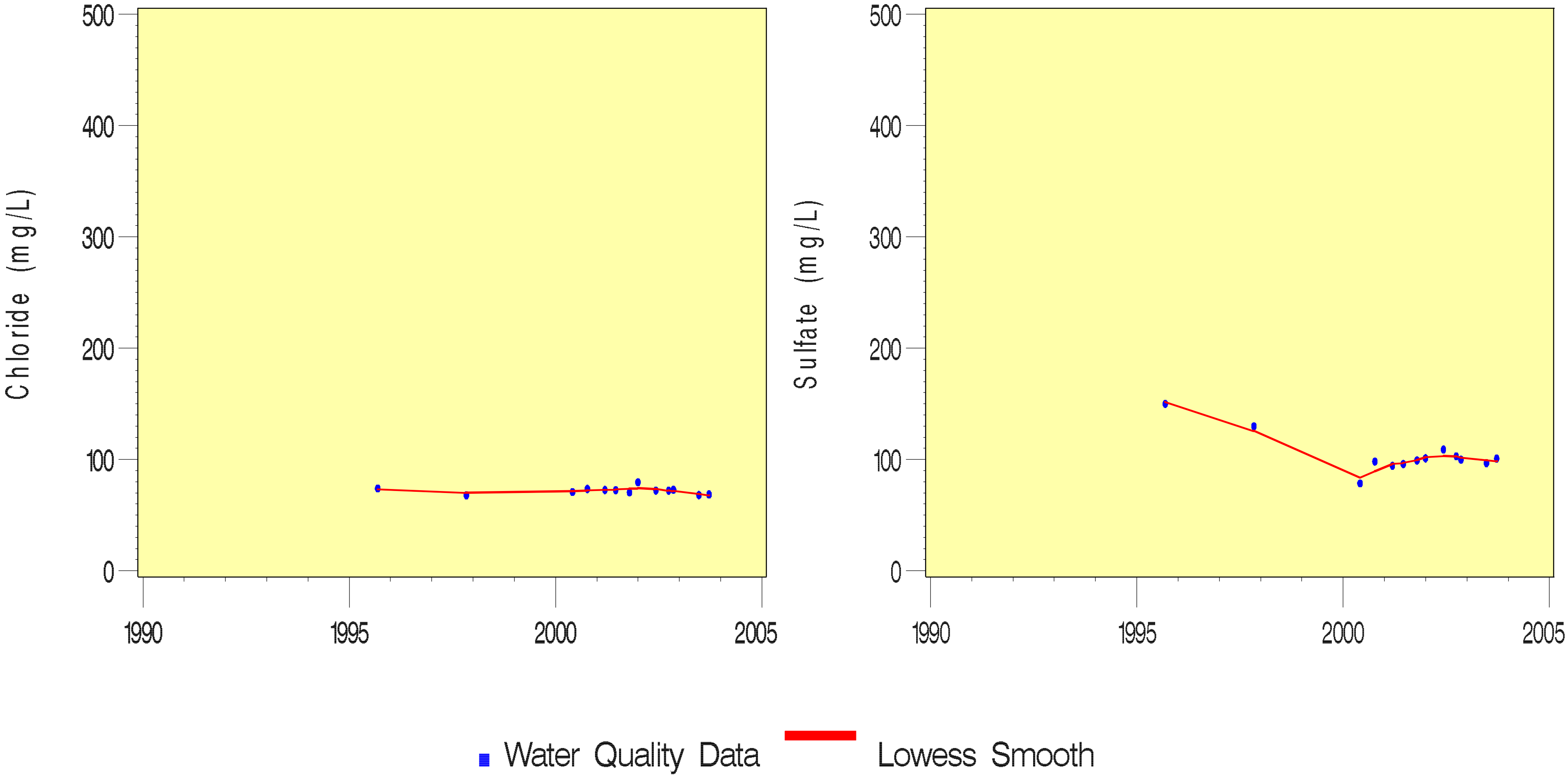
NAME= ROMP 16 TMPA SITE= 414 SEQ= 0



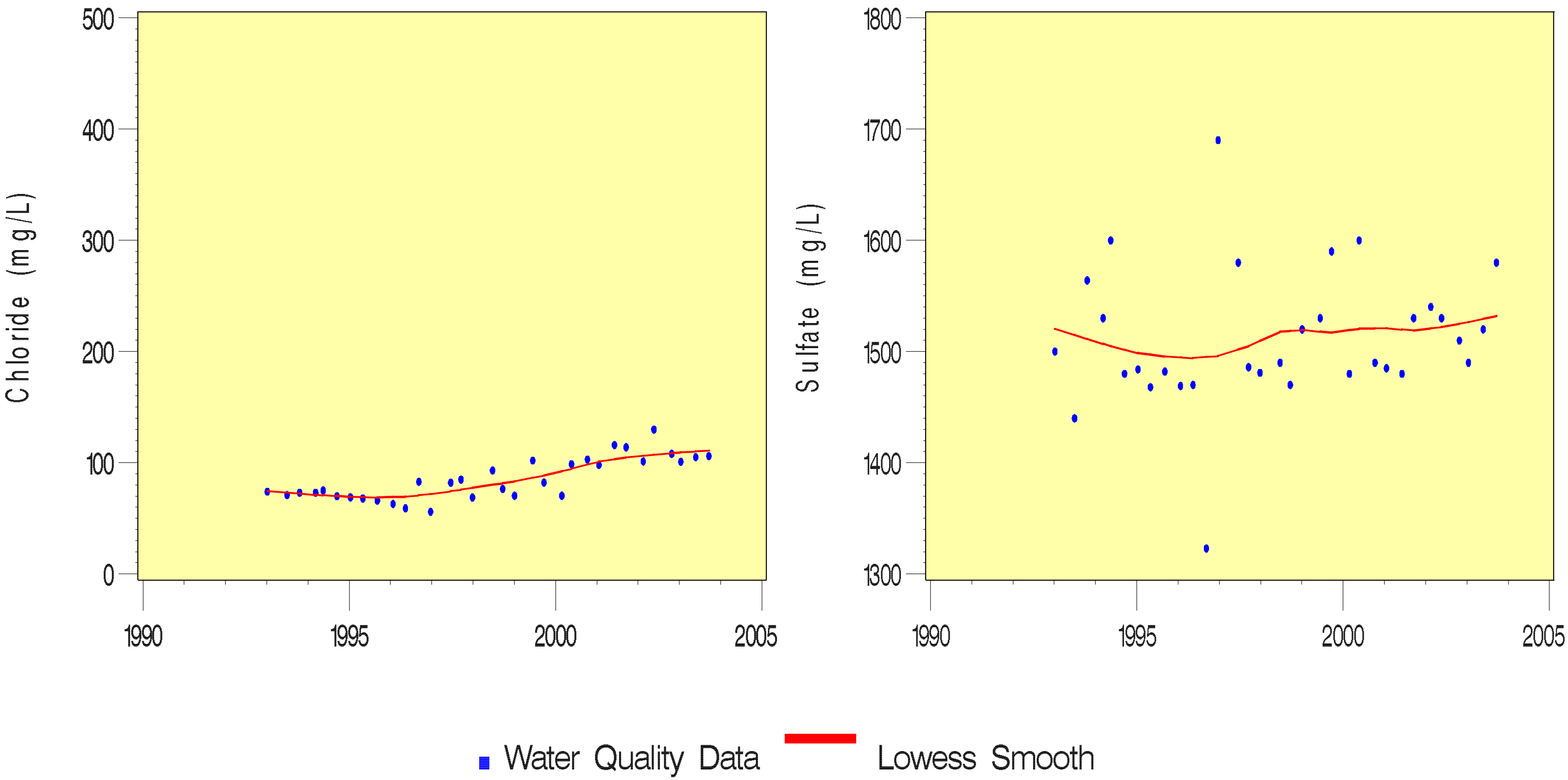
NAME= ROMP 16.5 LOWER INT SITE= 34898 SEQ= 0



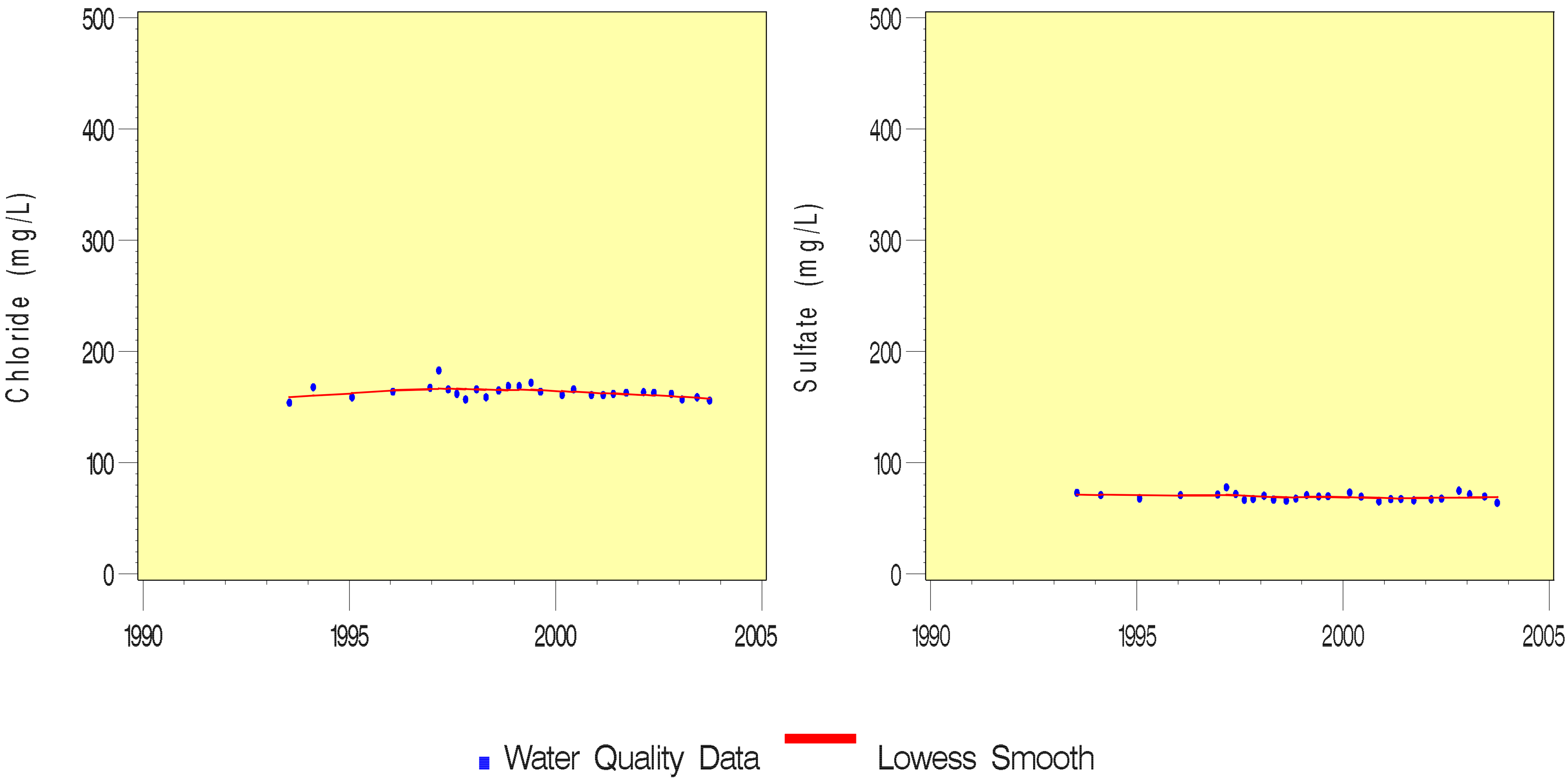
NAME= ROMP 17 LOW HTRN SITE= 11043 SEQ= 0

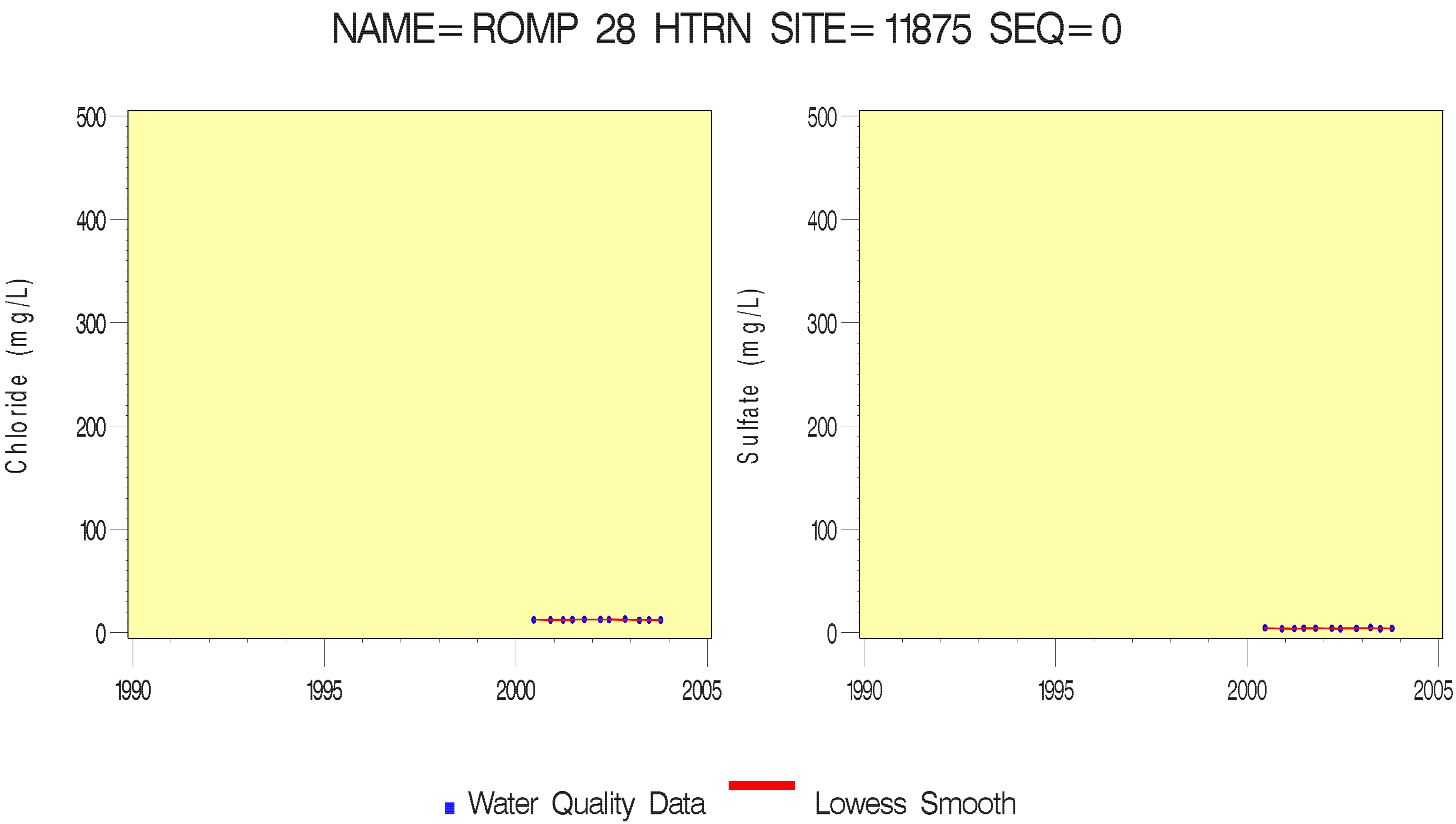


NAME= ROMP 20 LOW INT SITE= 11303 SEQ= 0

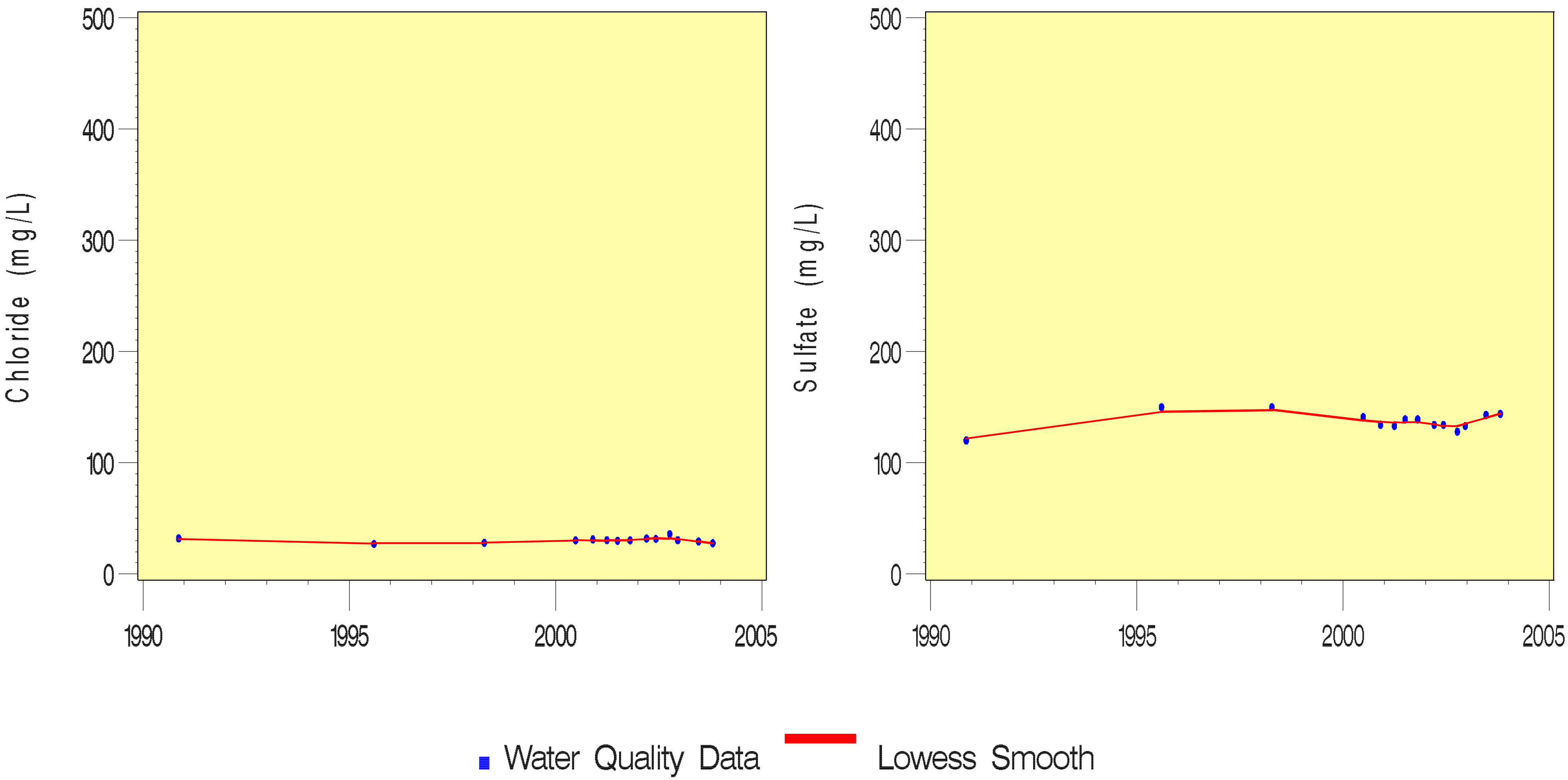


NAME= ROMP 22 ARC/TMPA SITE= 11175 SEQ= 0

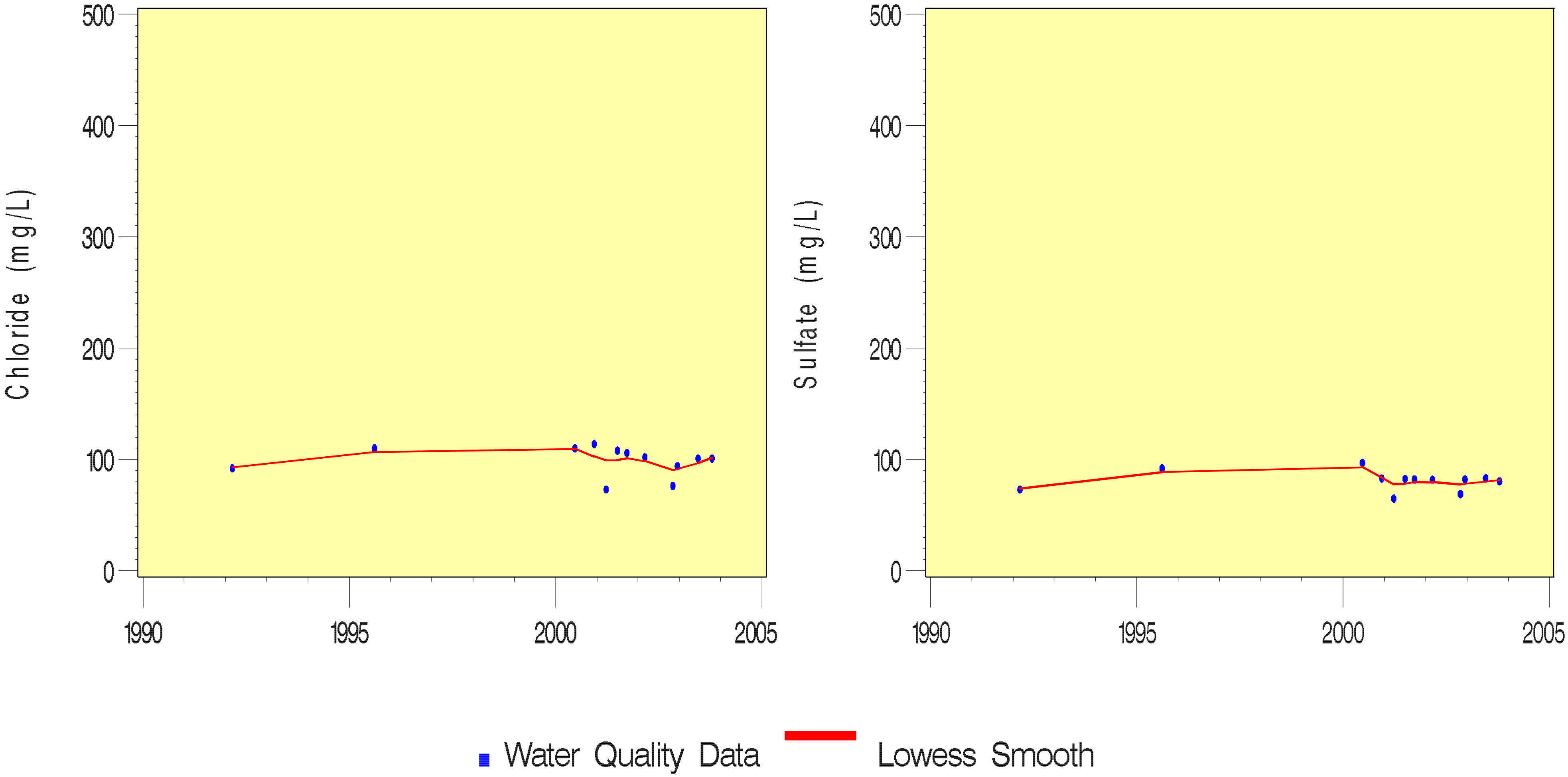


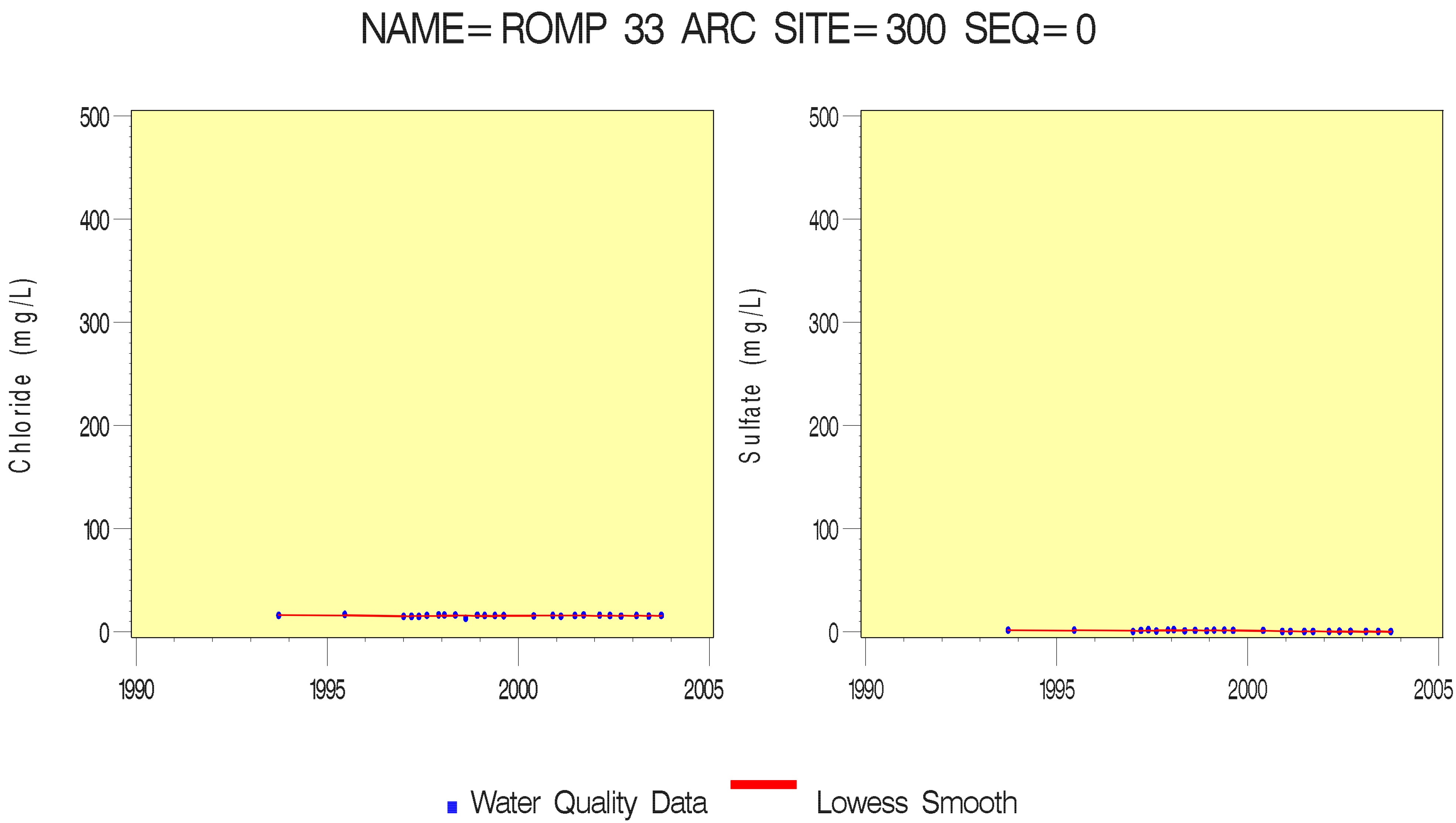

NAME= ROMP 28 HTRN SITE= 11875 SEQ= 0
Chloride (mg/L)
Sulfate (mg/L)
500
400
300
200
100
0
1990
1995
2000
2005
Water Quality Data
Lowess Smooth

NAME= ROMP 30 TMPA SITE= 354 SEQ= 0

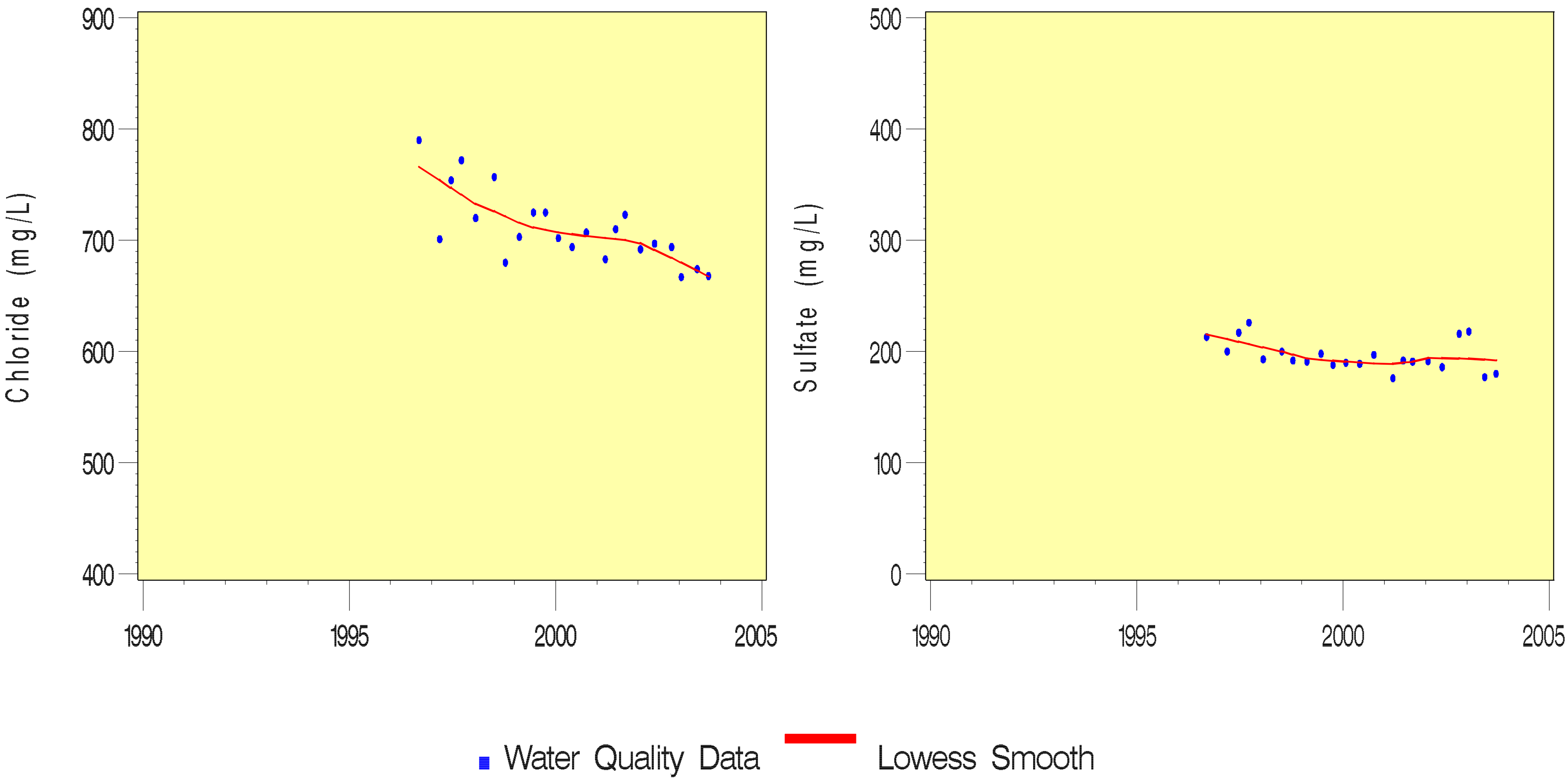


NAME= ROMP 31 HTRN/TMPA SITE= 41 SEQ= 0

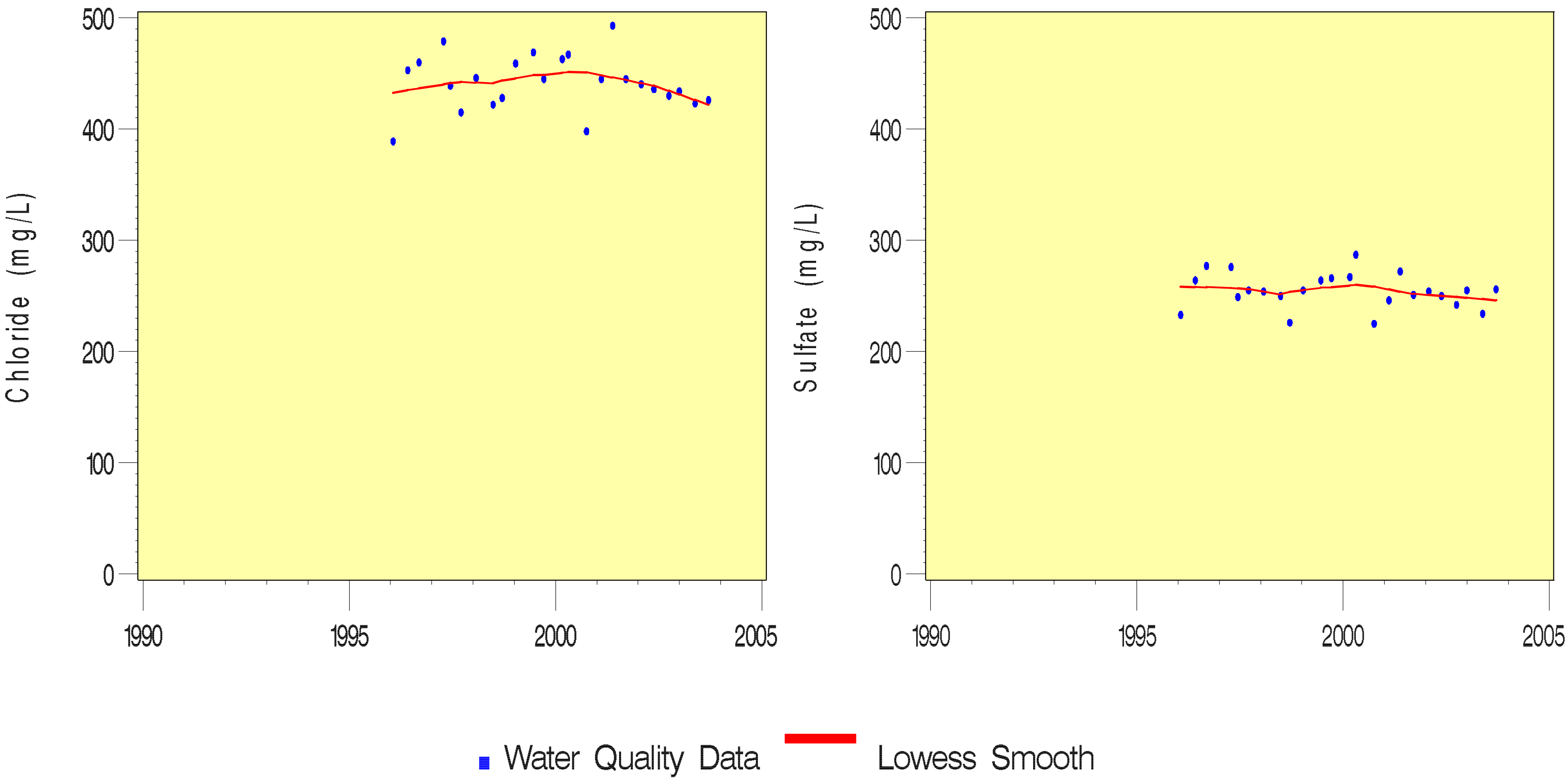



NAME= ROMP 33 ARC SITE= 300 SEQ= 0
Chloride (mg/L)
500
400
300
200
100
0
1990
1995
2000
2005
Sulfate (mg/L)
500
400
300
200
100
0
1990
1995
2000
2005
Water Quality Data
Lowess Smooth

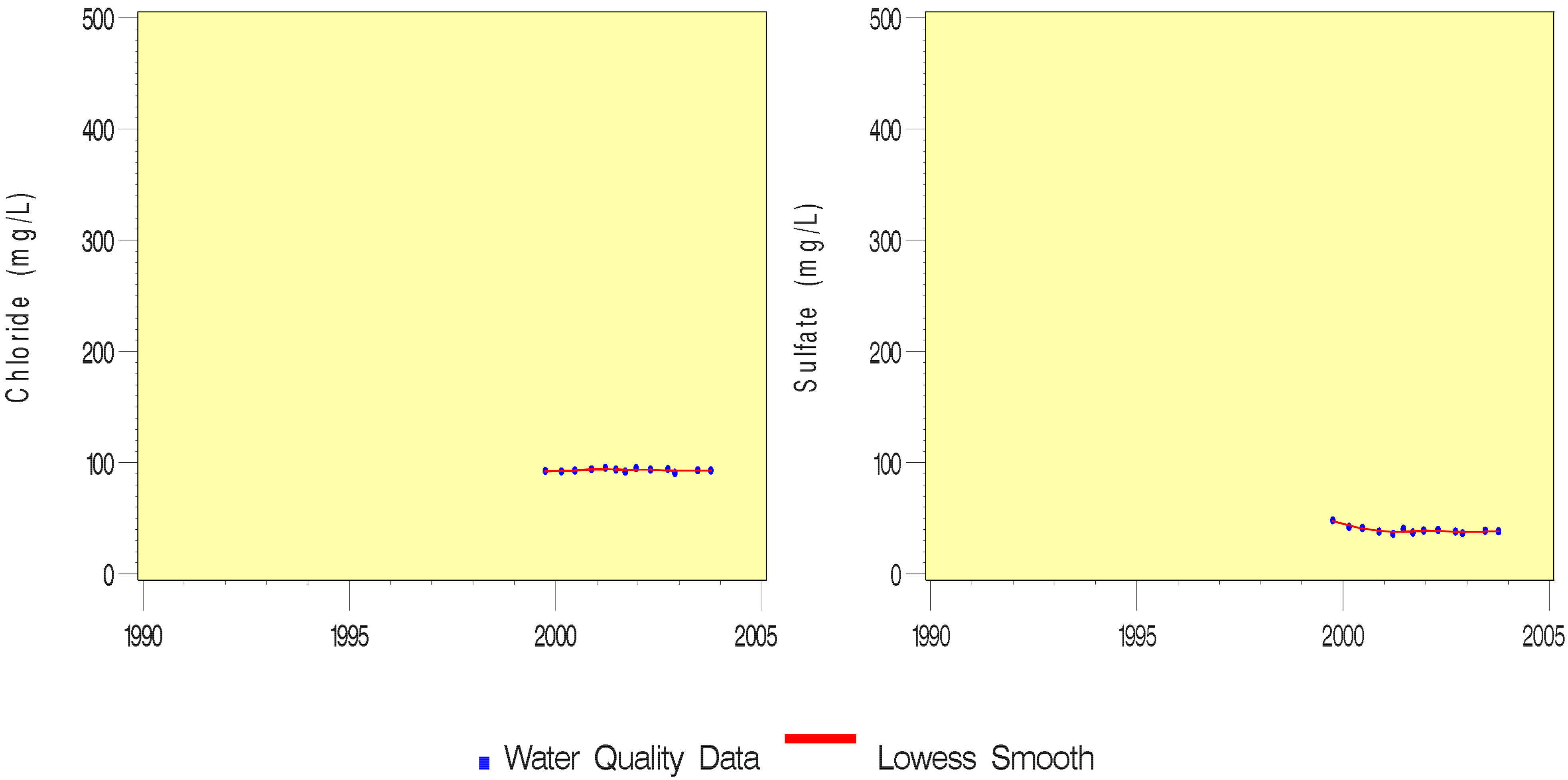
NAME= ROMP 5 LOWER INT SITE= 12883 SEQ= 0



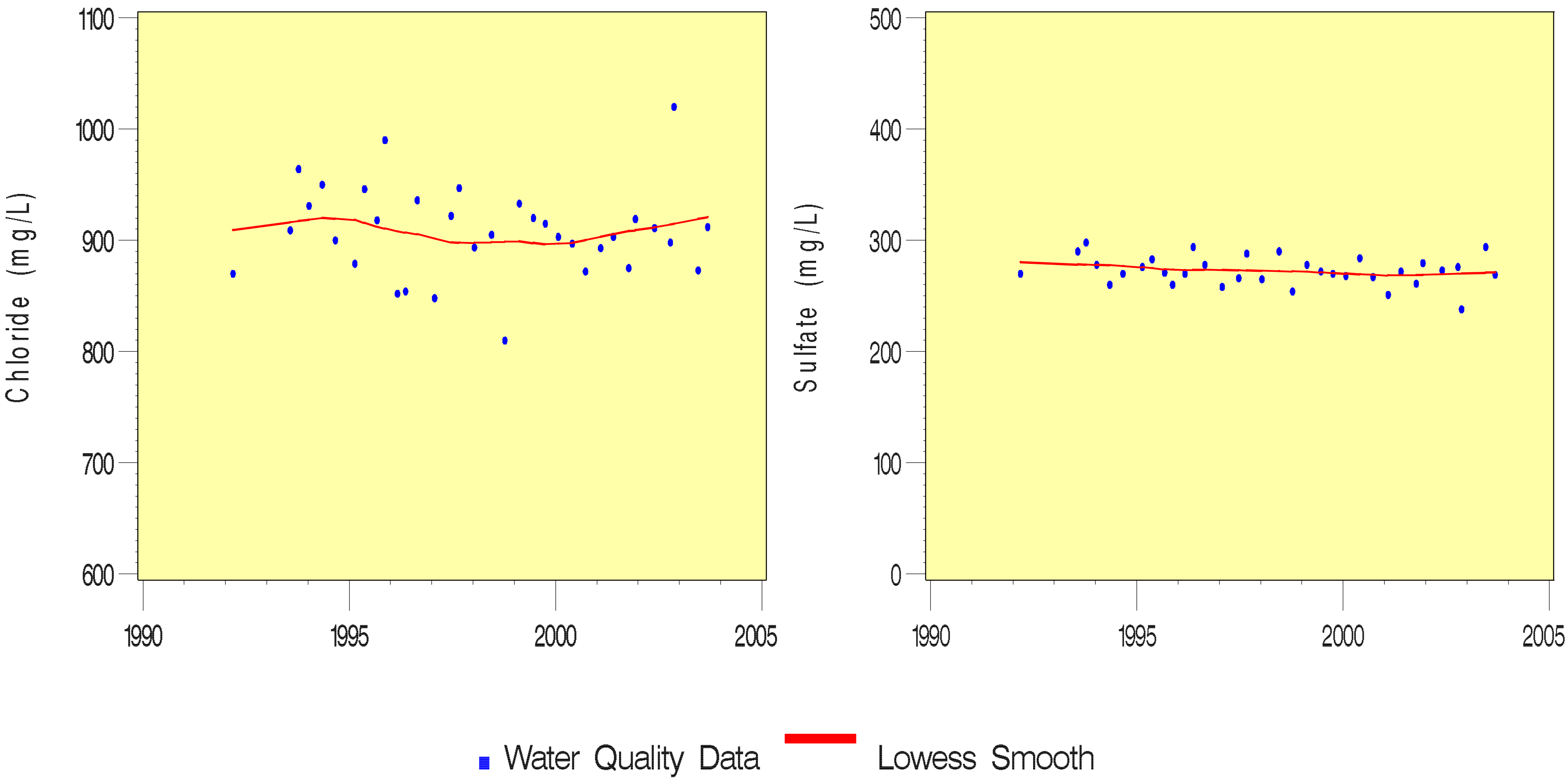
NAME= ROMP 9 LOW HTRN MW-4 SITE= 12900 SEQ= 0



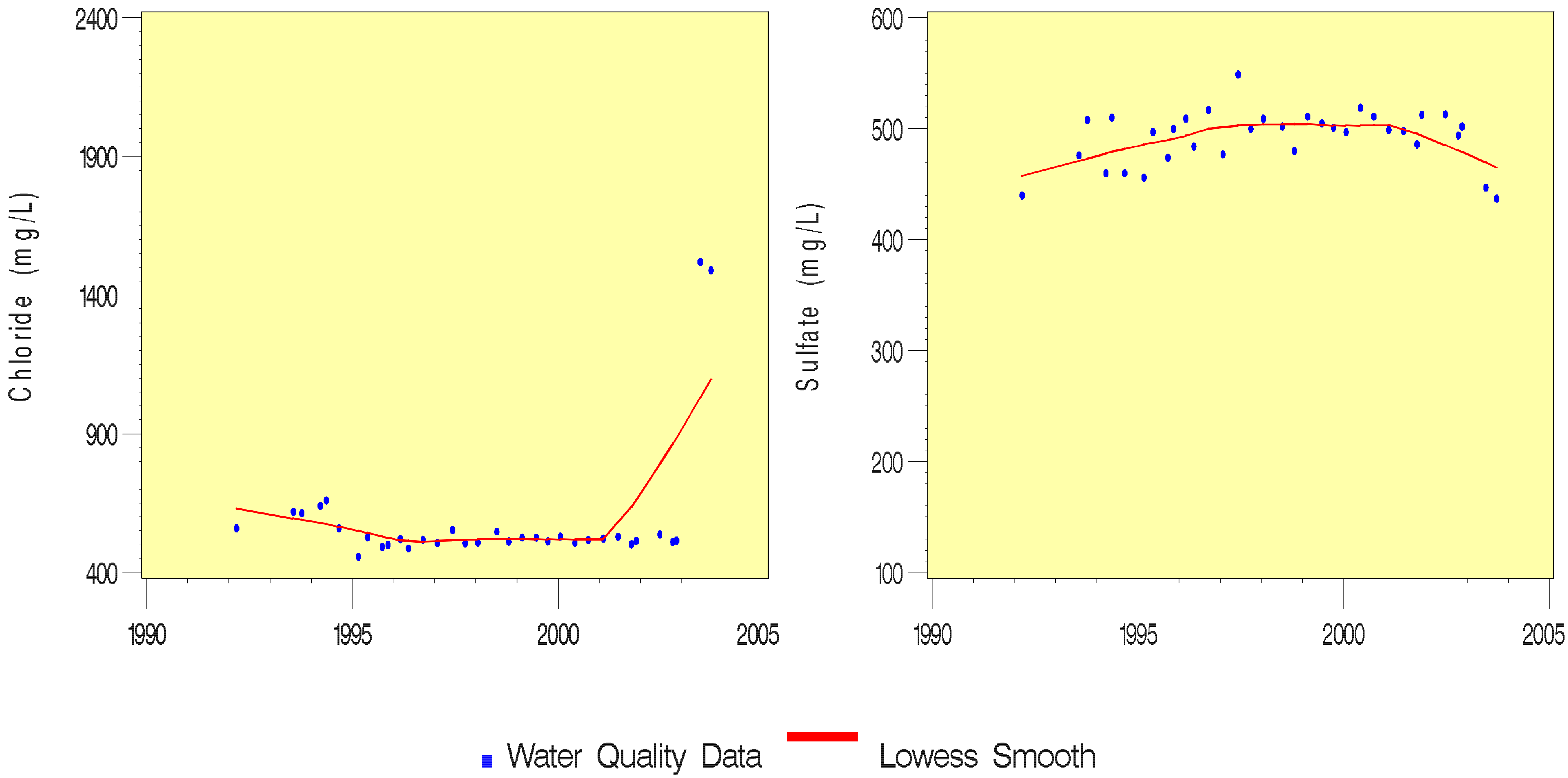
NAME= ROMP 9.5 MW-8 LOWER INTER SITE= 17423 SEQ= 0

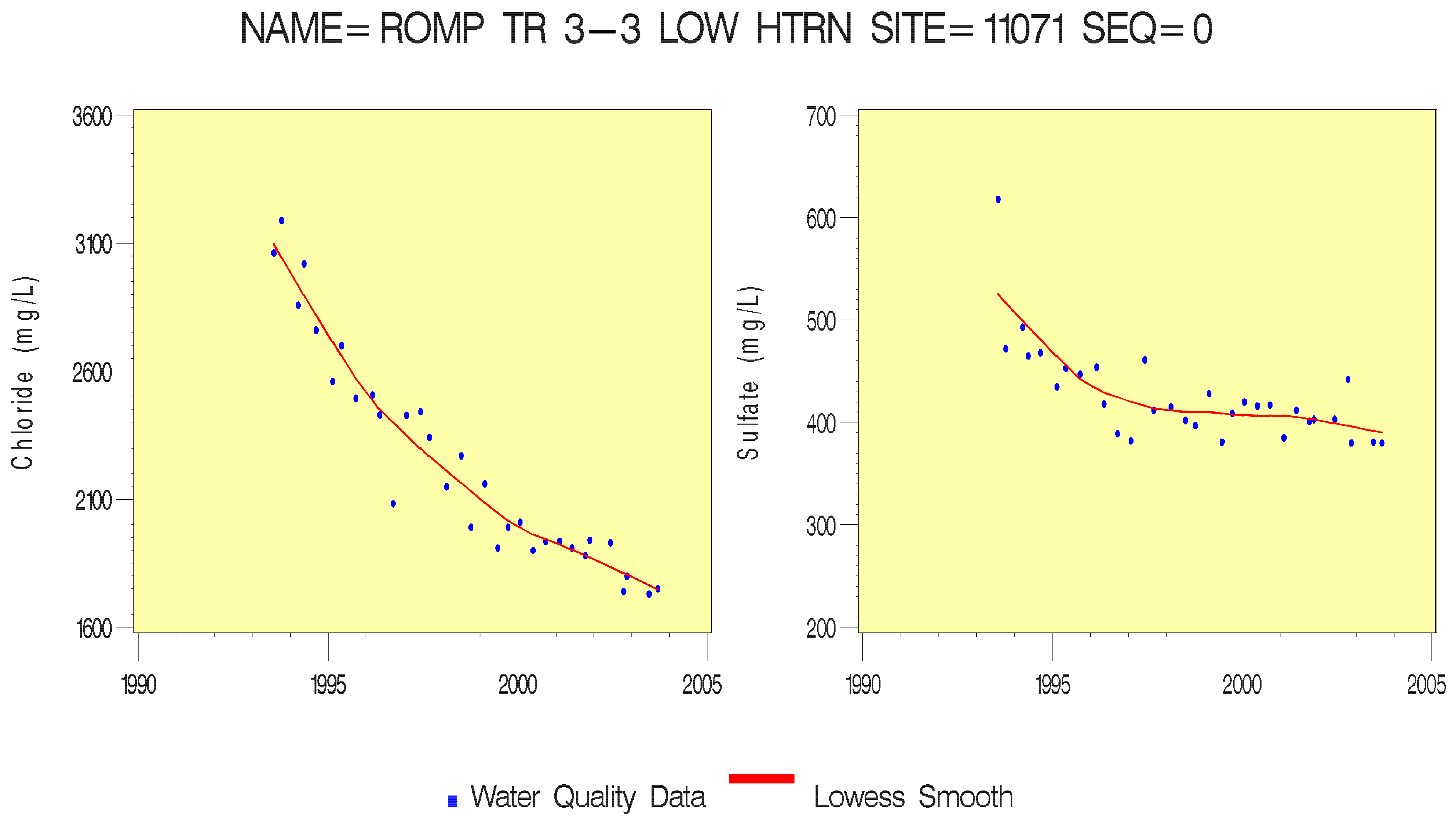


NAME= ROMP TR 1-2 L HTRN/TMPA SITE= 10947 SEQ= 0

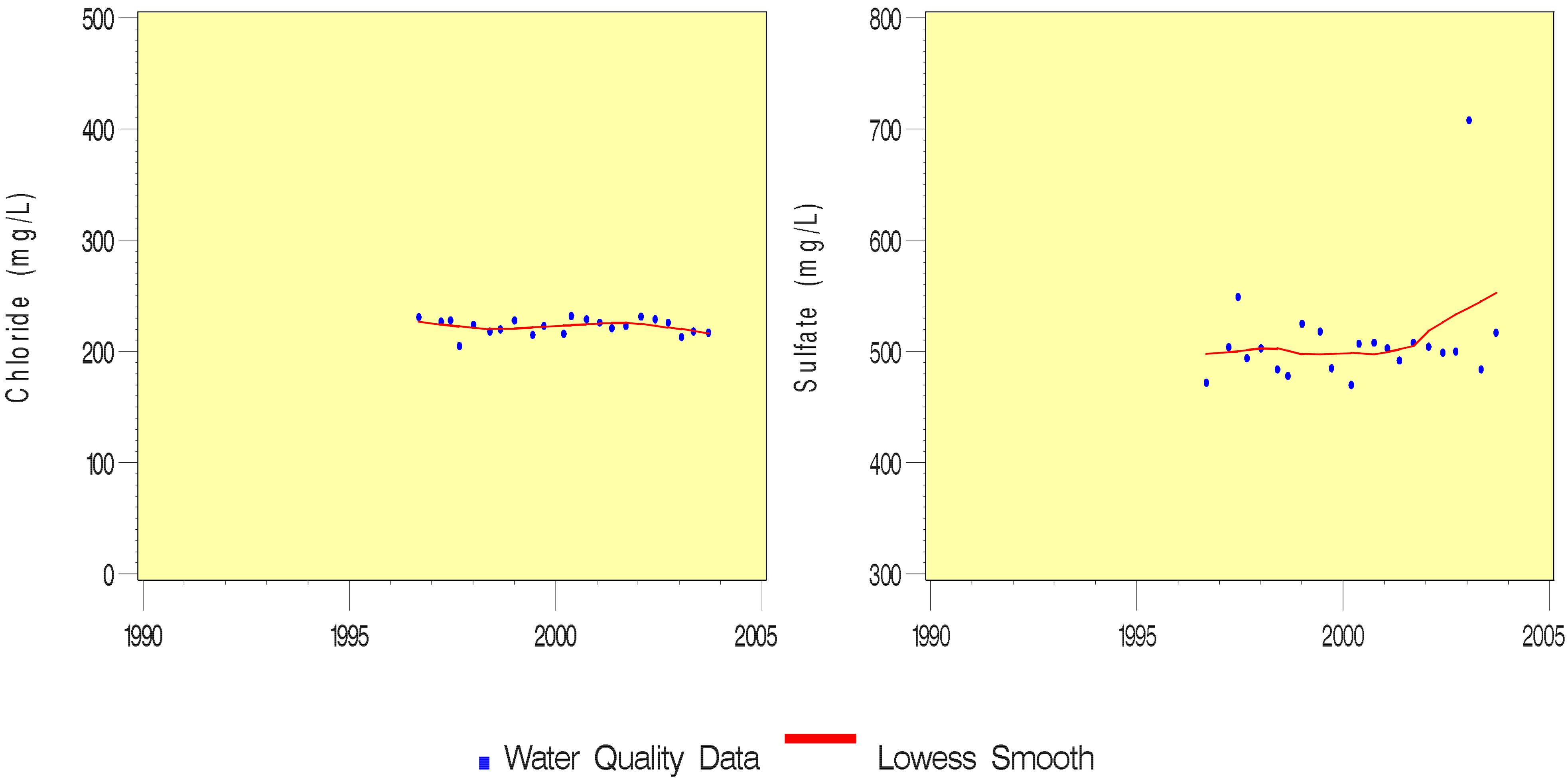


NAME=ROMP TR 3-1 HTRN 400 SITE=2 SEQ=1

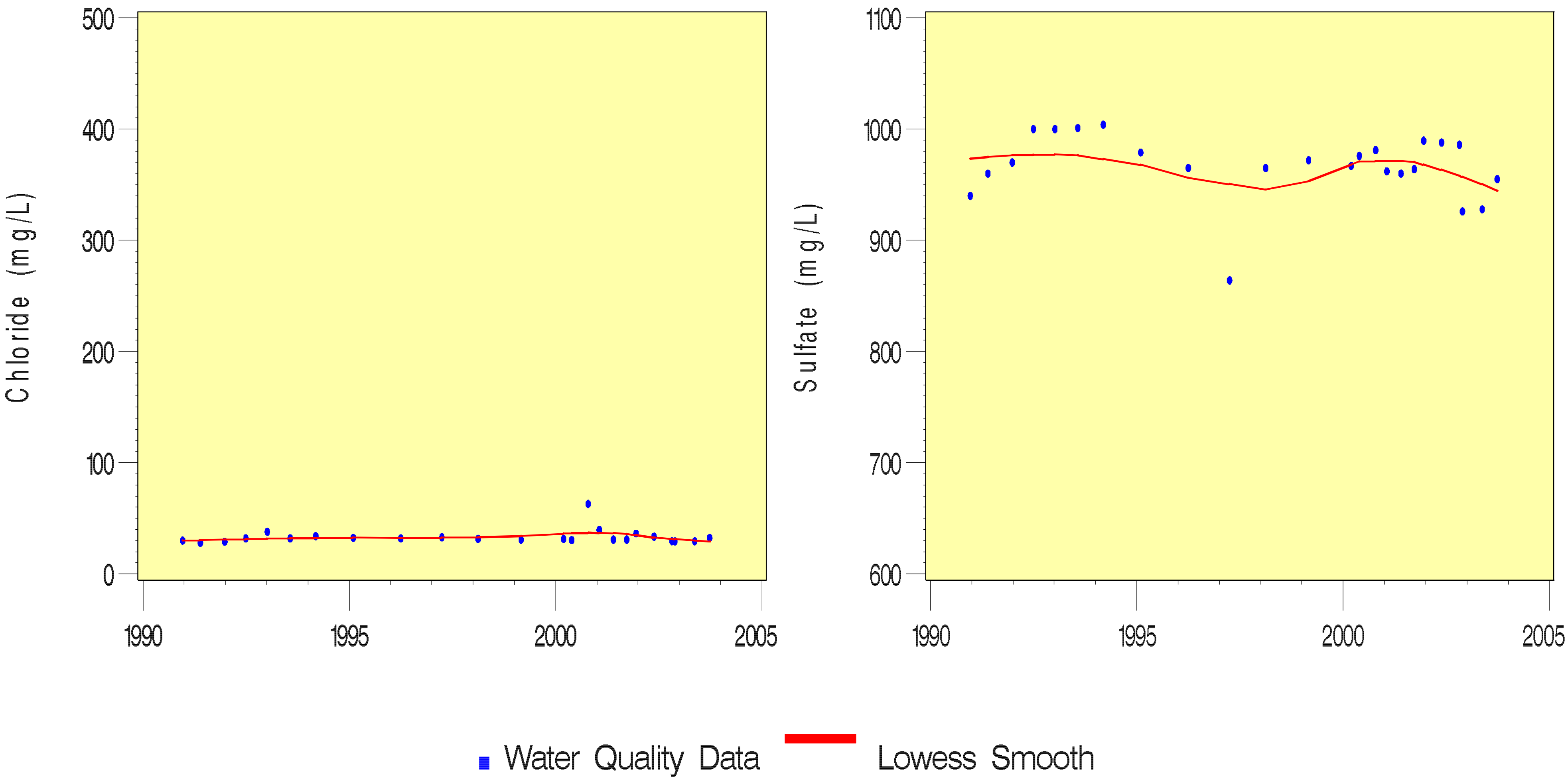


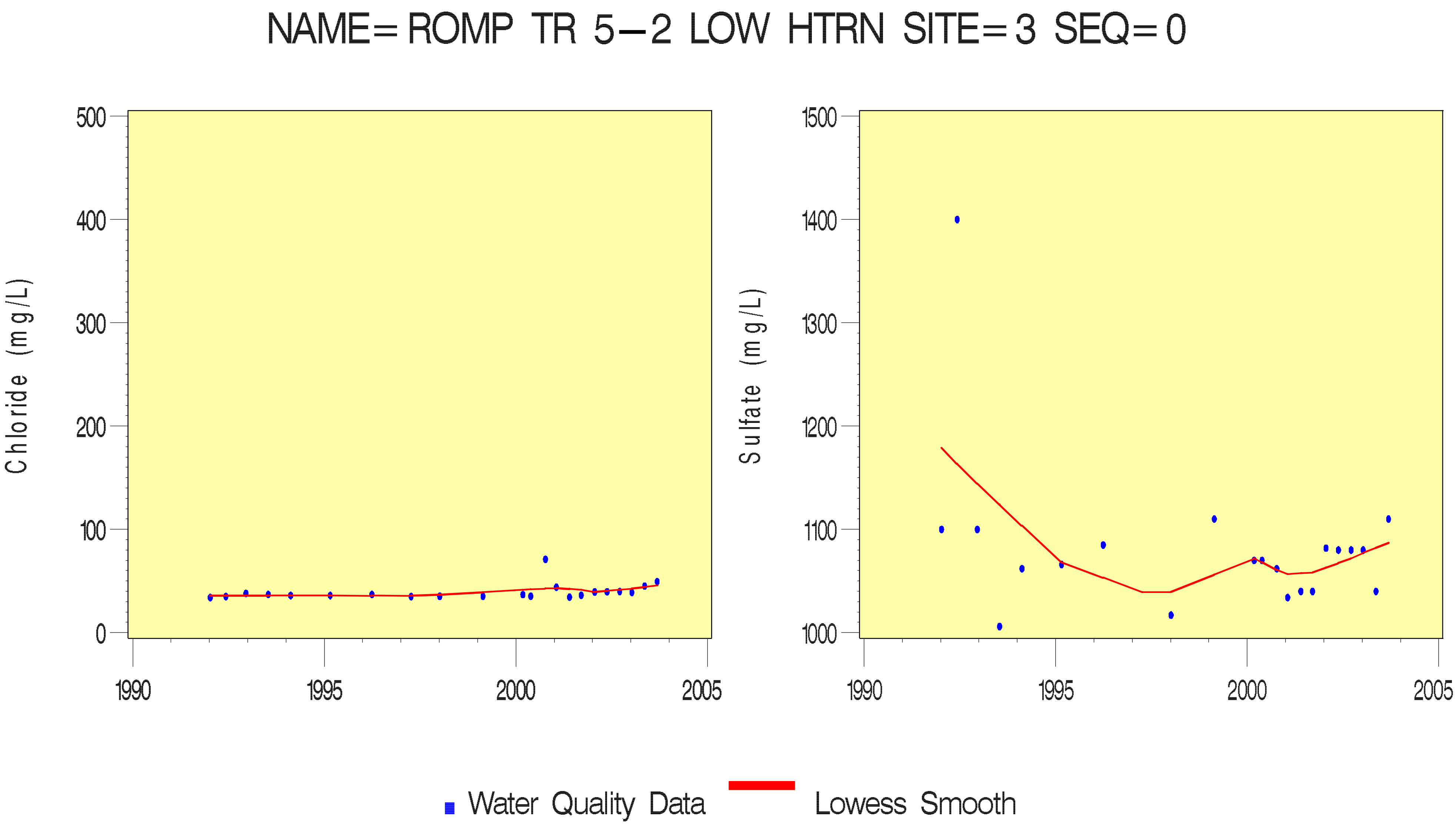

NAME=ROMP TR 3-3 LOW HTRN SITE=11071 SEQ=0
Chloride (mg/L)
3600
3100
2600
2100
1600
1990
1995
2000
2005
Sulfate (mg/L)
700
600
500
400
300
200
1990
1995
2000
2005
Water Quality Data
Lowess Smooth

NAME= ROMP TR 4—1 LOW INT SITE= 12904 SEQ= 0

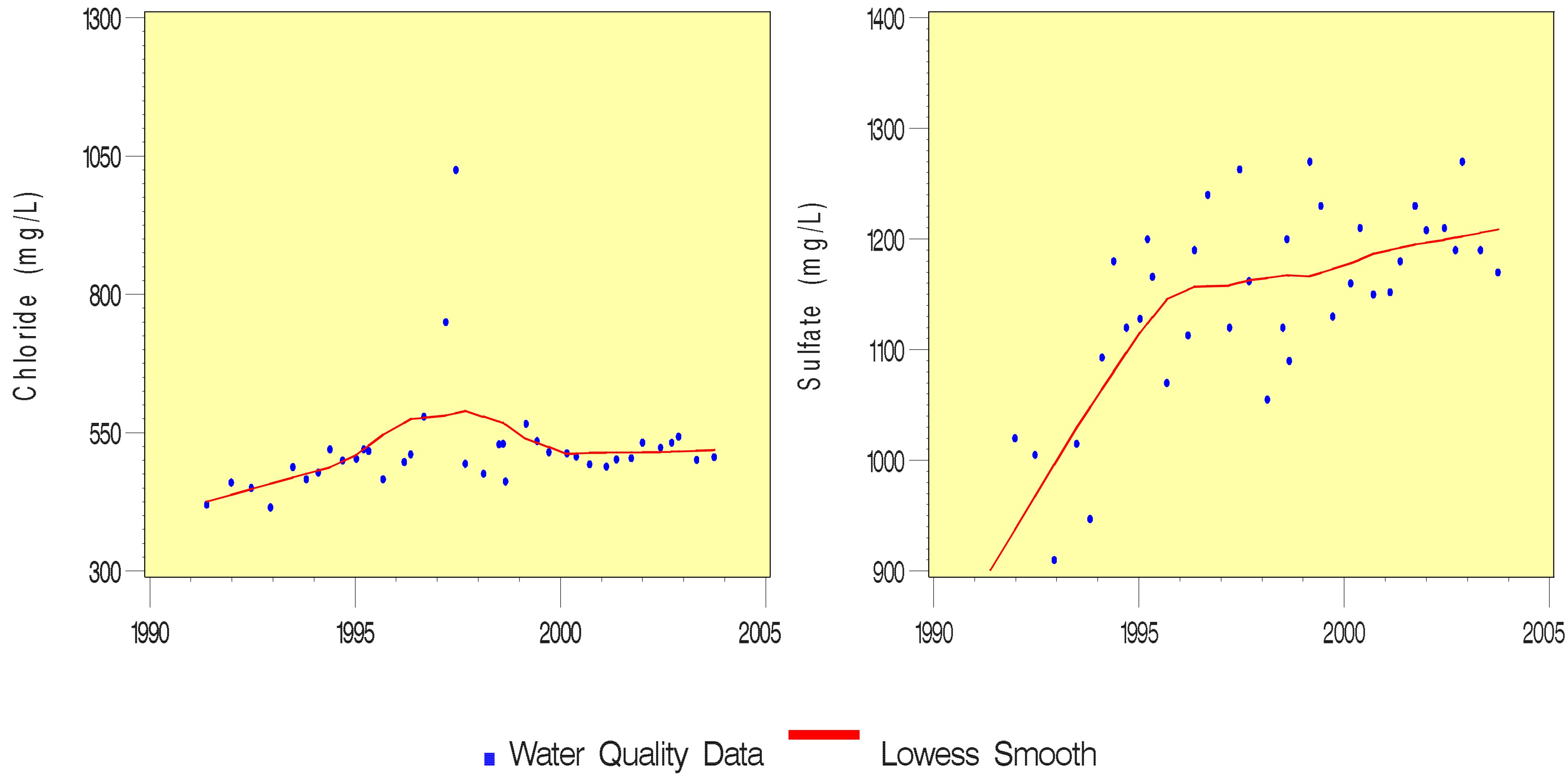


NAME= ROMP TR 5-1 TMPA SITE= 10941 SEQ= 0

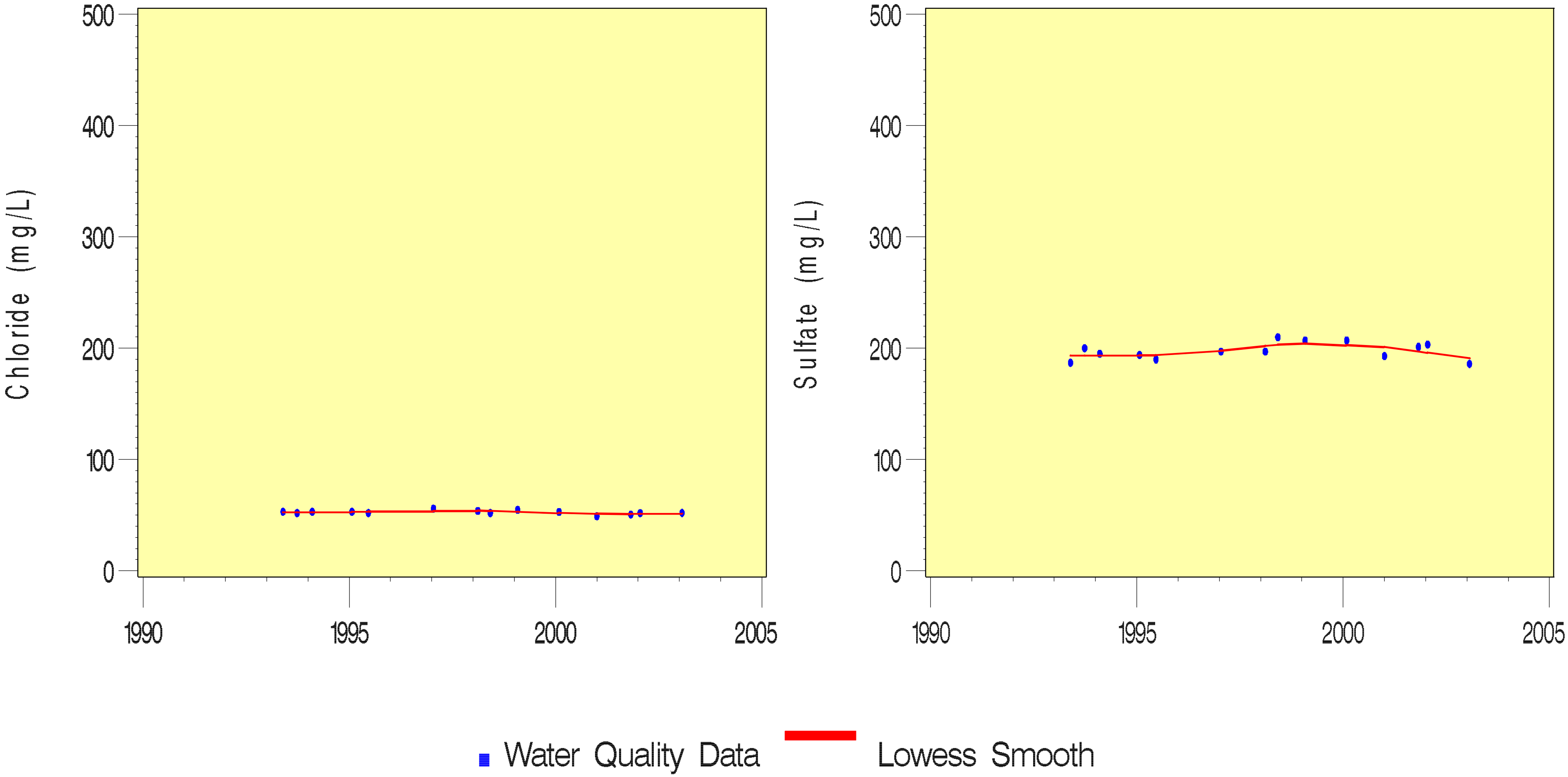



NAME= ROMP TR 5-2 LOW HTRN SITE= 3 SEQ= 0
Chloride (mg/L)
0
100
200
300
400
500
1990
1995
2000
2005
Sulfate (mg/L)
1000
1100
1200
1300
1400
1500
1990
1995
2000
2005
Water Quality Data
Lowess Smooth

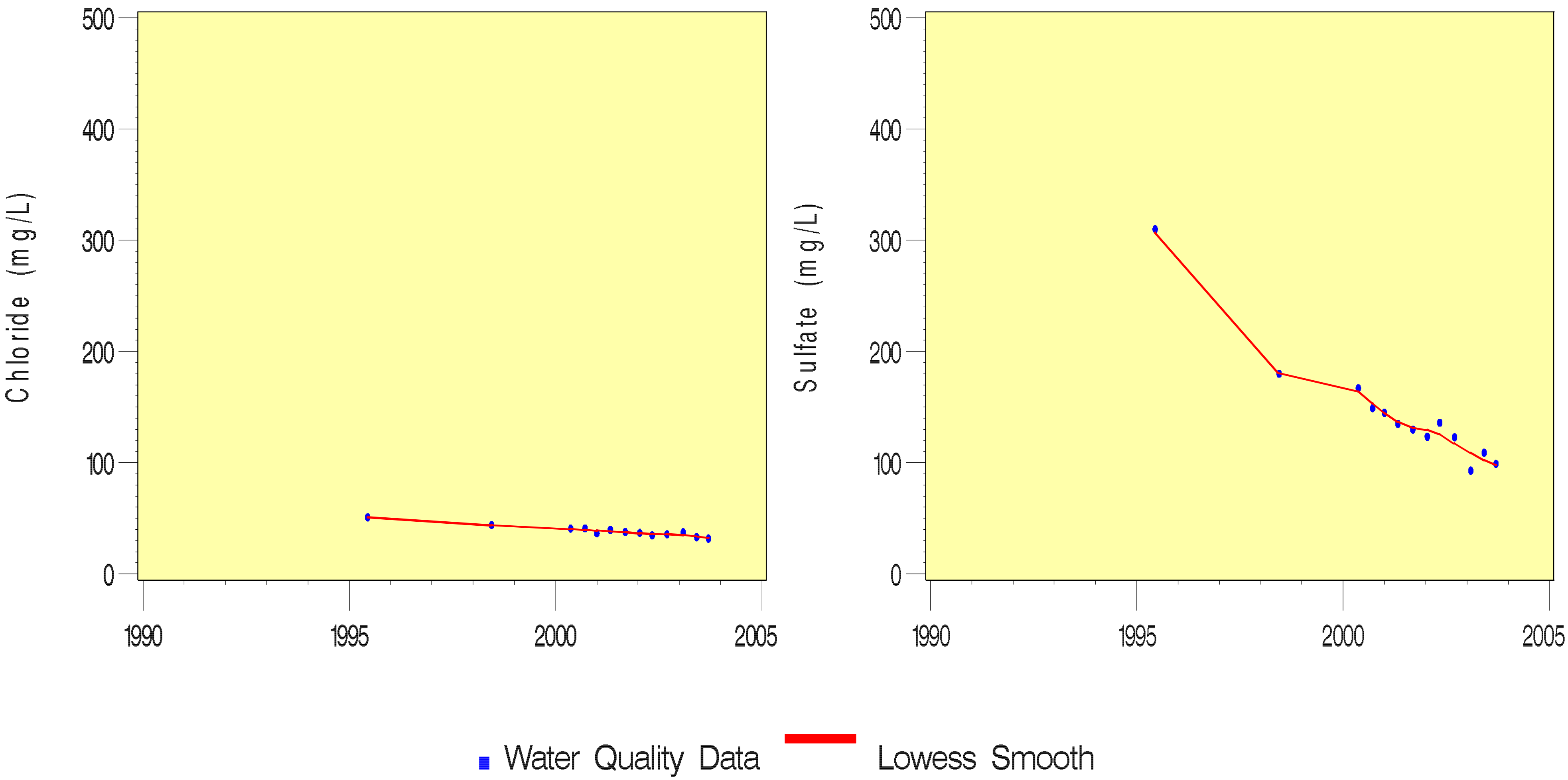
NAME= ROMP TR 6-1 HTRN SITE= 646 SEQ= 0



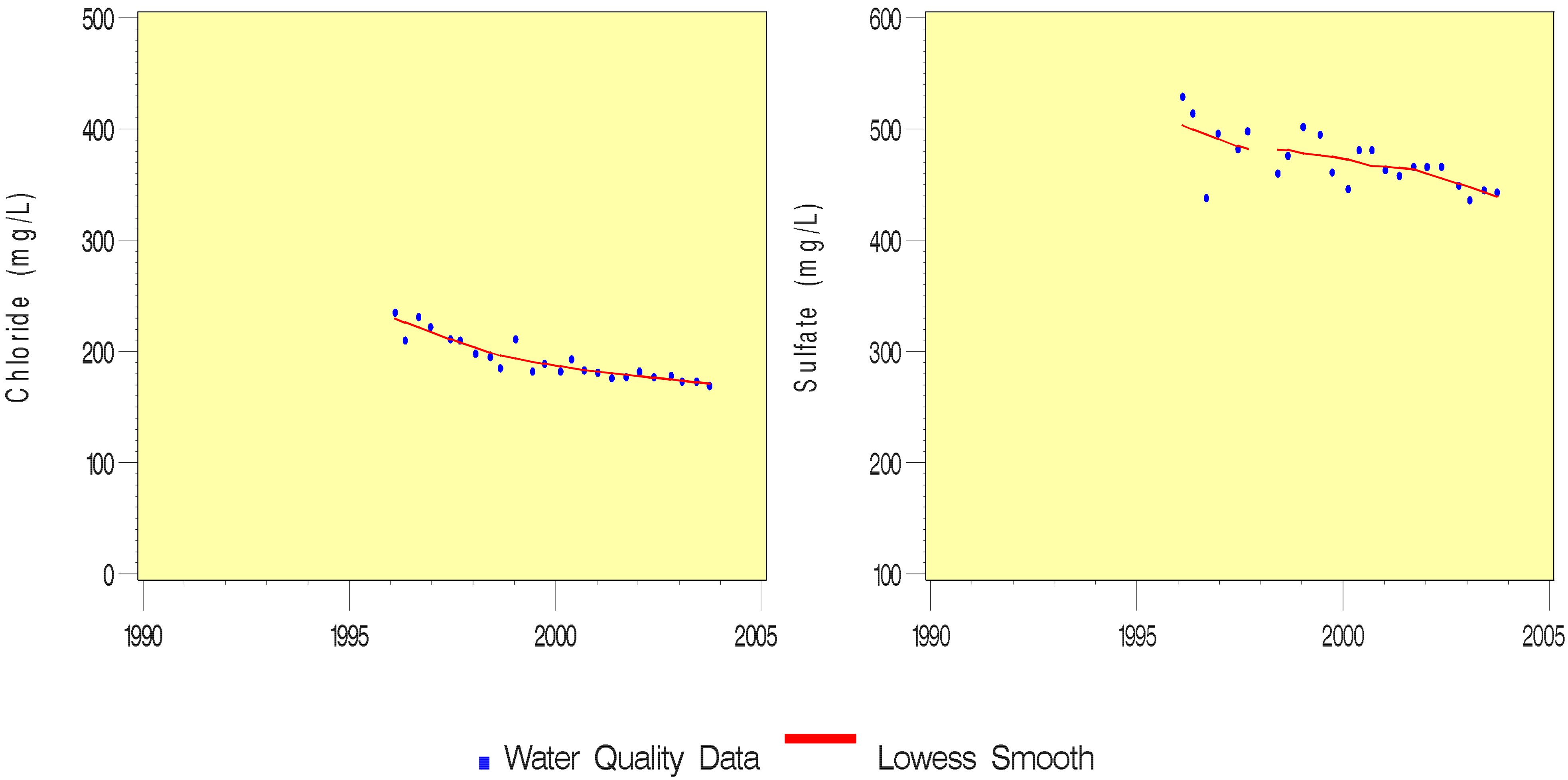
NAME= ROMP TR 7−2 LOW ARC SITE= 11391 SEQ= 0



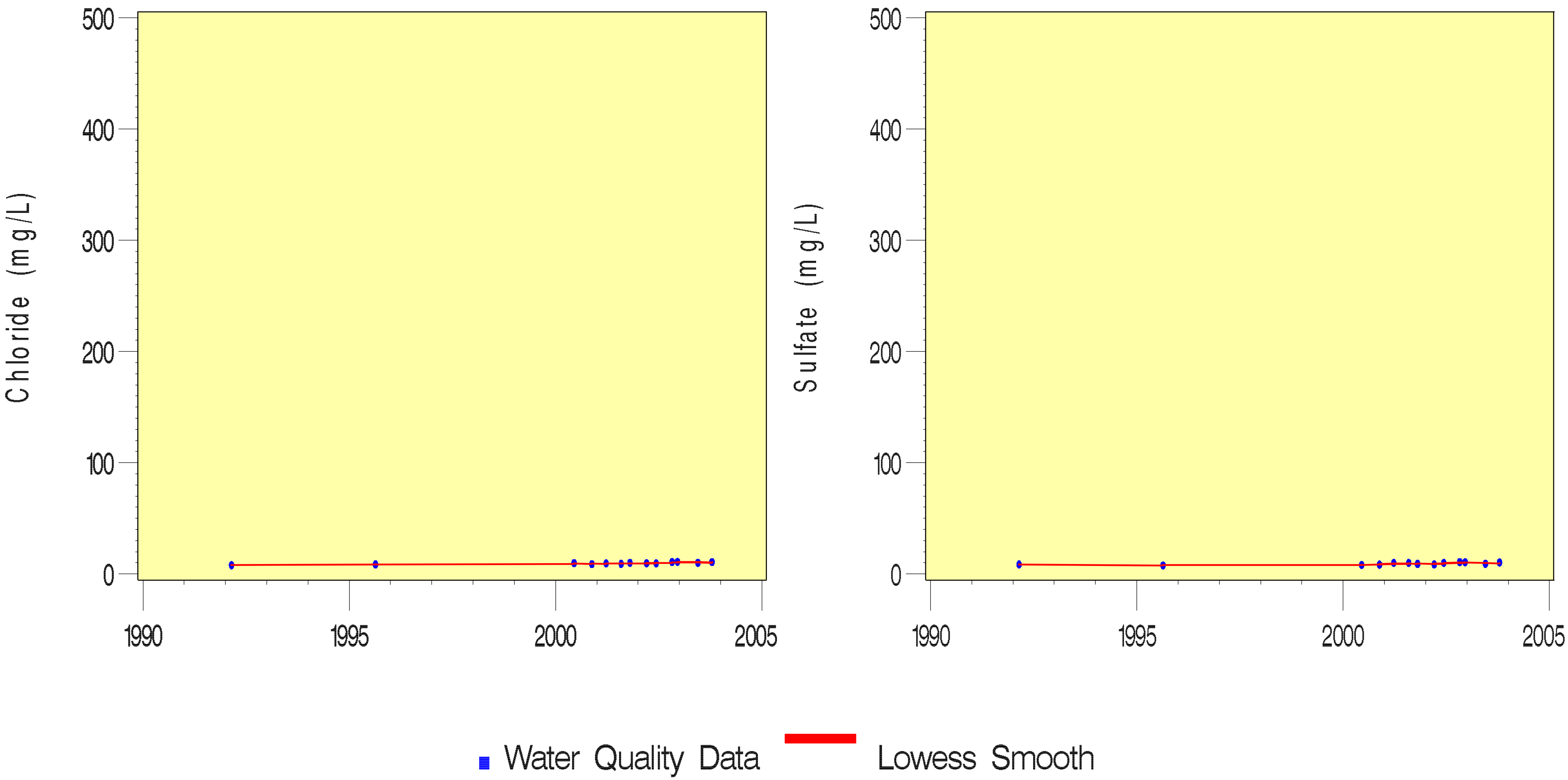
NAME= ROMP TR 7–4 HTRN SITE= 10925 SEQ= 0



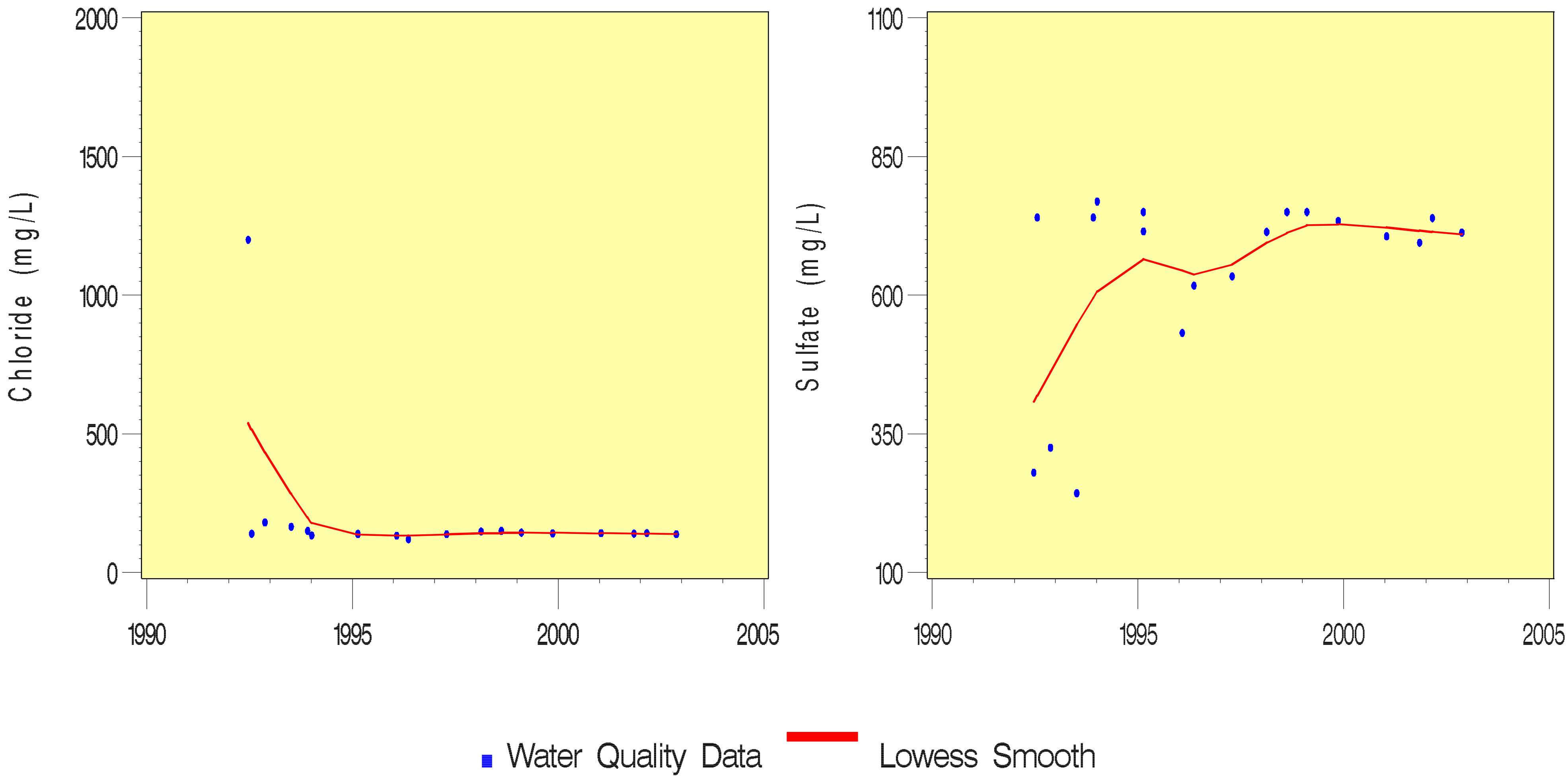
NAME= ROMP TR SA—1 UP INT SITE= 12002 SEQ= 0



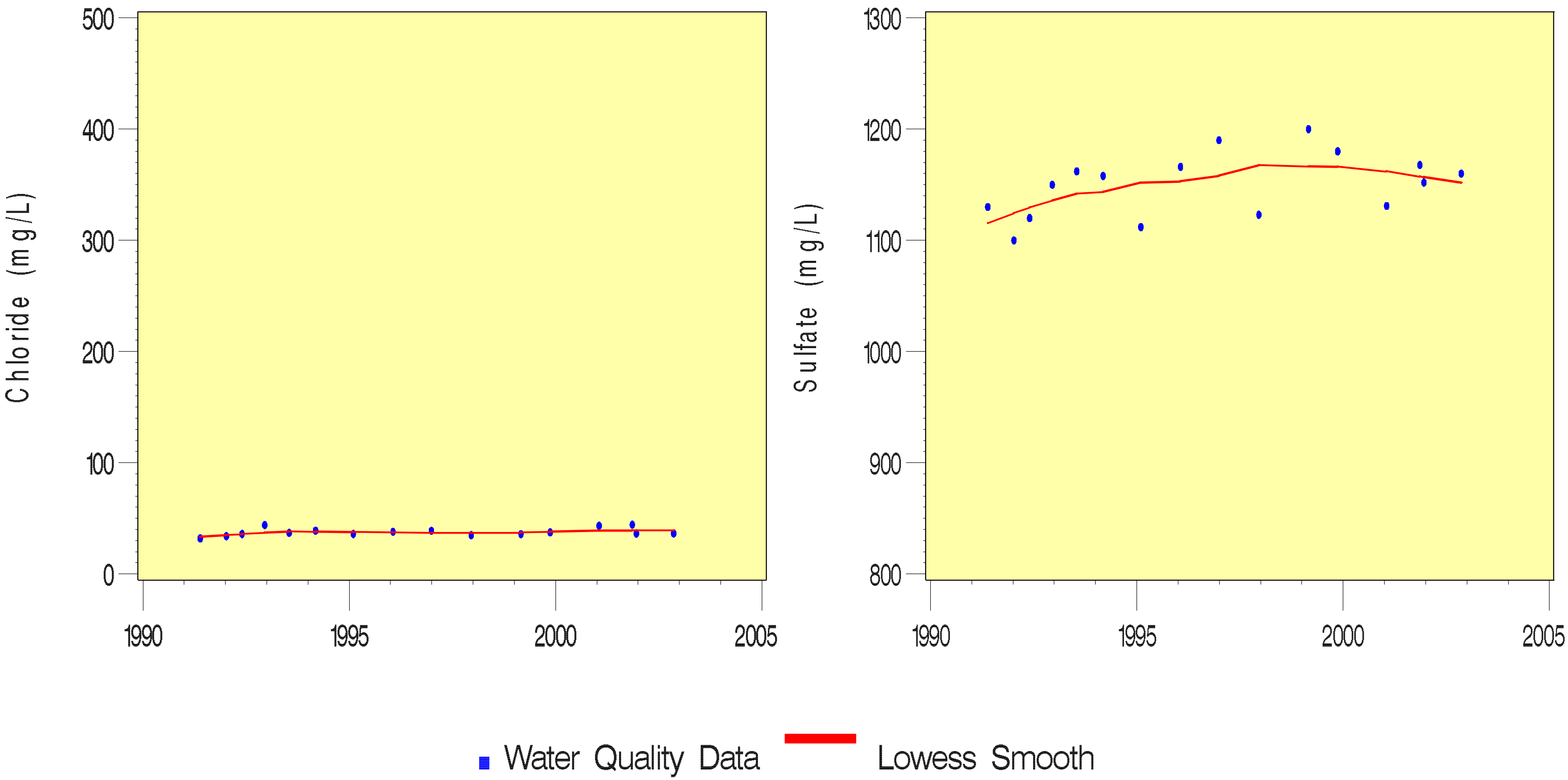
NAME= ROWELL DEEP SITE= 36 SEQ= 0



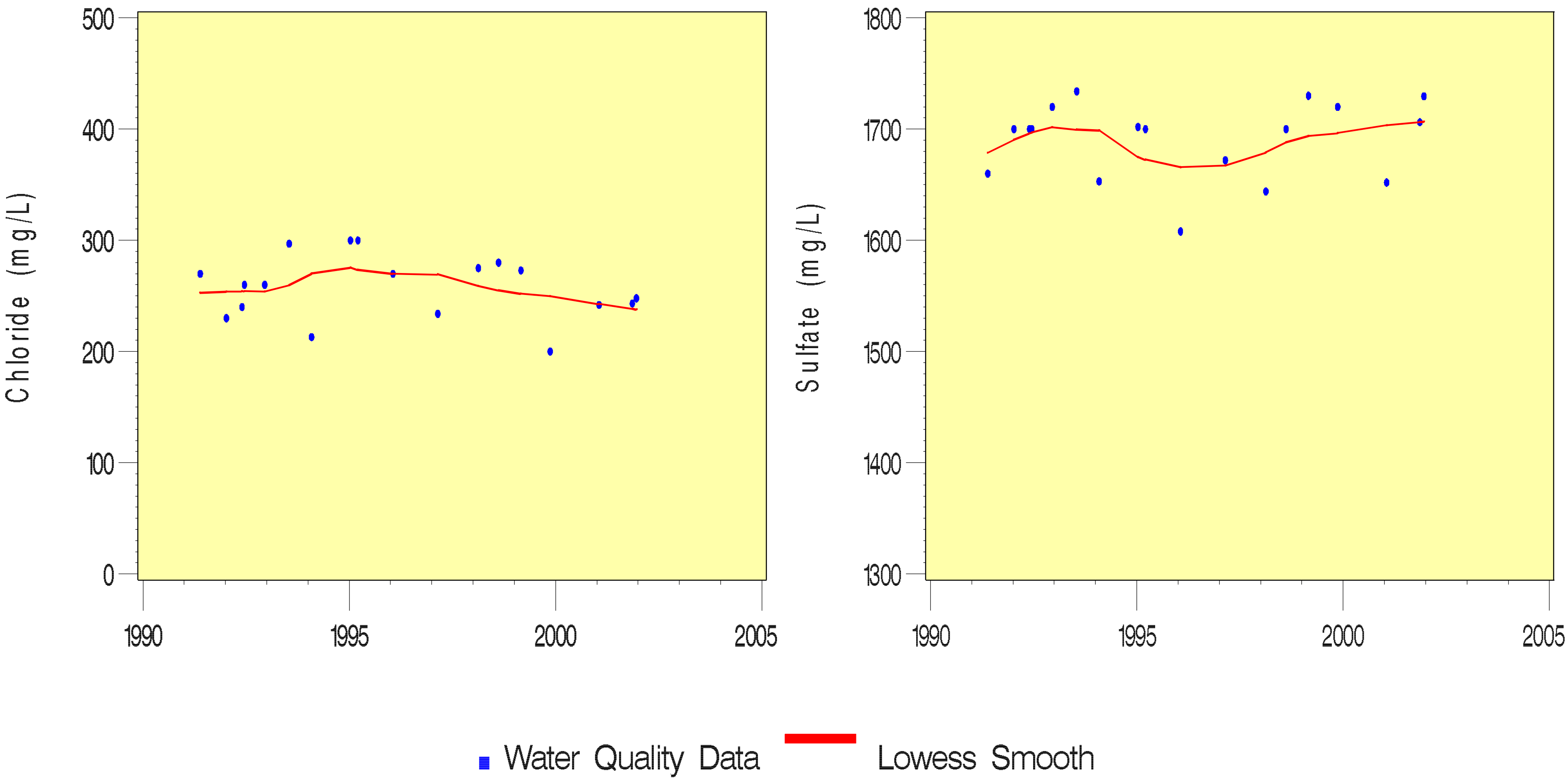
NAME= SARASOTA 27TH ST INT SITE= 273 SEQ= 0



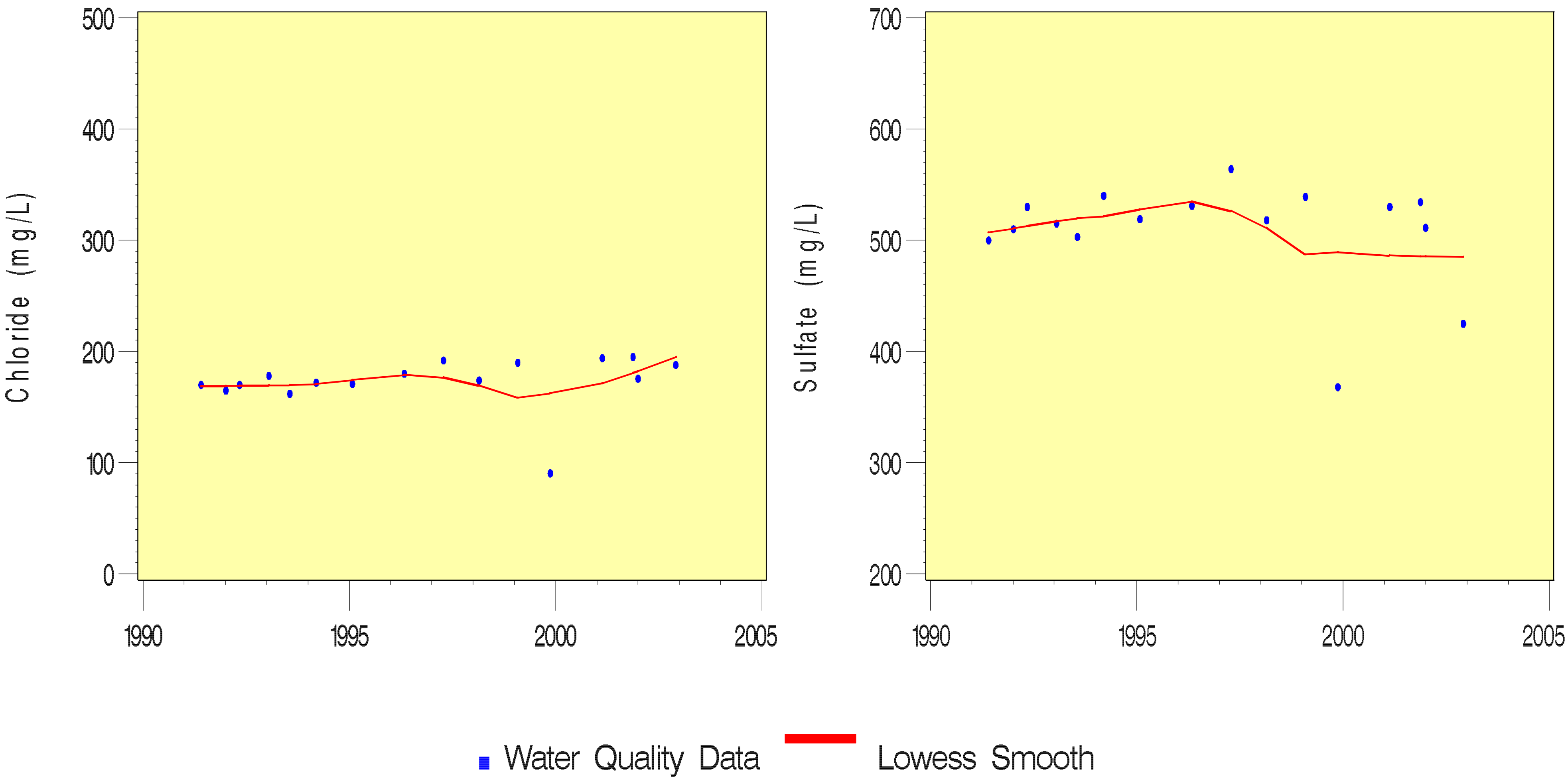
NAME= SARASOTA HIST SOC INT SITE= 1241 SEQ= 0



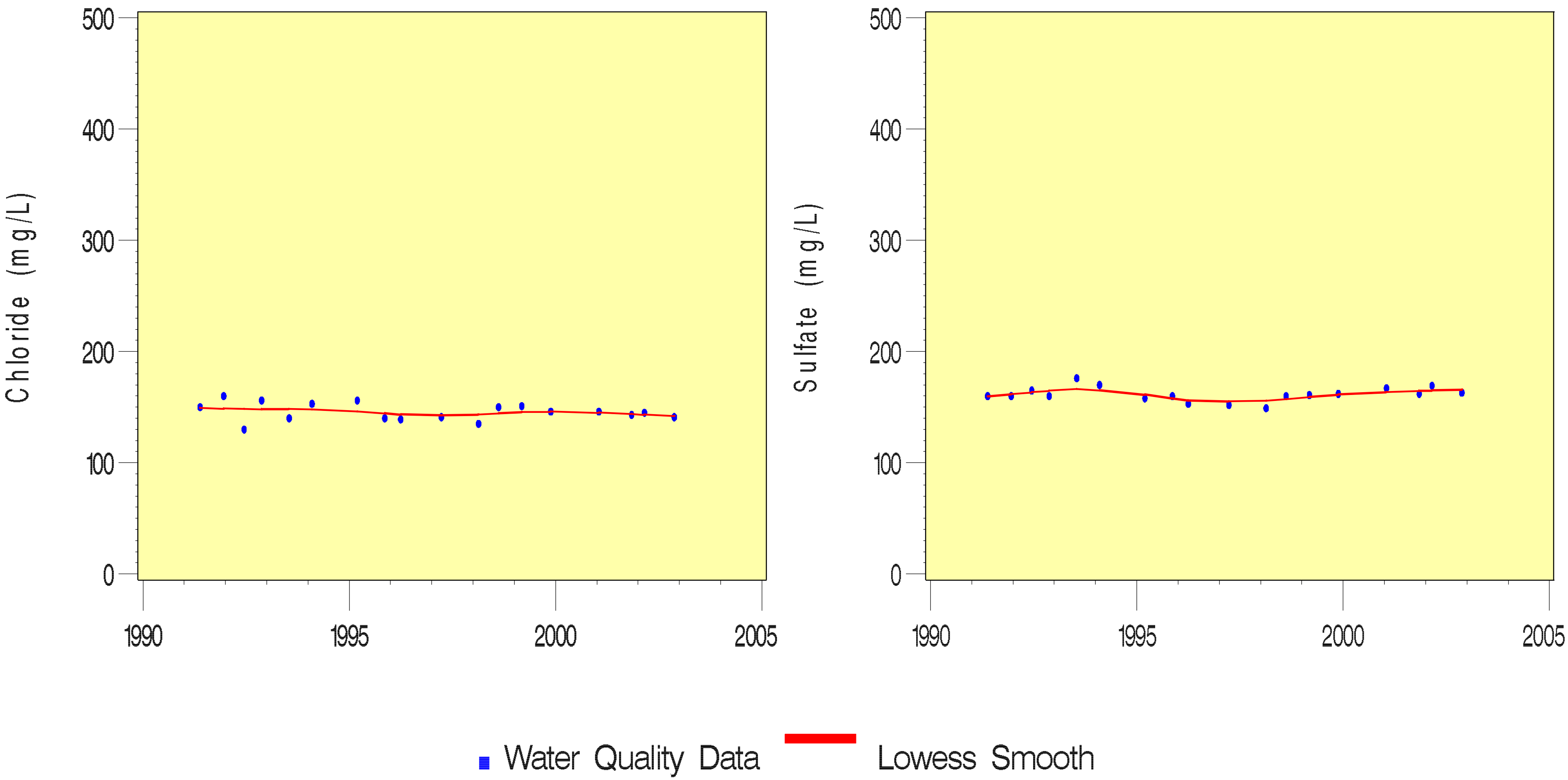
NAME= SOUTHBAY UTILITIES DEEP SITE= 1243 SEQ= 0



NAME= TEST 18 BLACKBURN INT SITE= 1251 SEQ= 0



NAME= WHITAKER BAYOU INT SITE= 731 SEQ= 0



APPENDIX F

PZ 2 Trends

Chloride

Station	Number of Samples per Group 1	Median of Group 1	Number of Samples per Group 2	Median of Group 2	P-Value of Shapiro-Wilk Normality Test for Group 1	P-Value of Shapiro-Wilk Normality Test for Group 2	P-Value of Wilcoxon Rank Sum Test	Percent Change of Median of Each Group
CREWSVILLE UP INT	10	6	12	6	0.40	0.30	0.15	6
DARNELL THOMAS INT	6	53	17	48	0.87	0.97	0.02	-9
ENGLEWOOD 14 DEEP	7	65	11	75	0.56	0.12	0.03	16
ENGLEWOOD 5 HTRN	6	771	6	796	0.58	0.01	0.85	3
ENGLEWOOD 5 PROD ZONE INT	3	175	6	164	0.90	0.19	0.06	-6
GALLAGHER PATRICIA INT	6	5	17	5	0.04	0.88	0.57	1
PLANTATION HTRN	6	68	6	73	0.98	0.68	0.03	8
PORT CHARLOTTE UTIL DEEP	6	80	10	91	0.81	0.25	0.01	14
PRAIRIE CRK UP INT (WQMP)	8	157	6	156	0.81	0.01	1.00	0
PUNTA GORDA HEIGHTS INT	7	362	6	388	0.00	0.59	0.00	7
ROMP 10 UP HTRN	8	353	6	363	0.00	0.87	0.33	3
ROMP 19 WEST HTRN	6	88	8	87	0.69	0.75	0.18	-1
ROMP 20 UP HTRN	8	88	9	87	0.37	0.61	0.62	-1
ROMP 22 ARC	9	83	13	83	0.21	0.00	0.73	0
ROMP 24 INT	3	25	17	25	0.83	0.82	0.42	-2
ROMP 5 UPPER INT	5	220	15	215	0.12	0.46	0.57	-2
ROMP 9 MID INT MW-3	5	403	15	407	0.53	0.27	0.69	1
ROMP TR 1-2 UP HTRN	15	435	10	407	0.00	0.75	0.01	-7
ROMP TR 3-1 HTRN 160	16	950	10	929	0.00	0.84	0.38	-2
ROMP TR 3-3 UP HTRN	16	929	9	823	0.56	0.09	0.04	-11
ROMP TR 4-1 MID INT	5	90	15	84	0.34	0.03	0.00	-7
ROMP TR 5-3 UPPER INT	5	69	6	66	0.82	0.35	0.08	-5
ROMP TR 7-2 UP ARC	6	77	6	79	0.43	0.67	0.24	3
ROMP TR 8-1 UP HTRN	8	104	15	101	0.38	0.00	0.11	-3
ROTUNDA WATER PLANT 18 IN	6	4562	5	4940	0.08	0.22	0.66	8
SR 74 DEEP	7	120	6	127	0.07	0.89	0.00	6
USGS C-1 INT	7	1200	11	1189	0.41	0.00	0.84	-1
USGS C-3 INT	6	94	11	102	0.01	0.03	0.07	9
USGS TUCKERS CORNER INT	6	35	11	46	0.19	0.04	0.08	31
VENICE 35 INT	7	118	11	118	0.14	0.33	0.49	0
VENICE SH WF 59 INT	6	60	6	56	0.82	0.00	0.37	-7
VENICE SH WF 68 INT	6	134	6	95	0.50	0.53	0.06	-29

Sulfate

Station	Number of Samples per Group 1	Median of Group 1	Number of Samples per Group 2	Median of Group 2	P-Value of Shapiro-Wilk Normality Test for Group 1	P-Value of Shapiro-Wilk Normality Test for Group 2	P-Value of Wilcoxon Rank Sum Test	Percent Change of Median of Each Group
CREWSVILLE UP INT	10	0	12	0	0.02	0.00	0.02	-20
DARNELL THOMAS INT	6	421	17	392	0.36	0.99	0.70	-7
ENGLEWOOD 14 DEEP	7	4	11	3	0.06	0.22	0.00	-33
ENGLEWOOD 5 HTRN	6	123	6	114	0.66	0.36	0.48	-7
ENGLEWOOD 5 PROD ZONE INT	3	19	6	9	0.92	0.01	0.26	-51
GALLAGHER PATRICIA INT	6	0	17	0	0.01	0.00	0.96	9
PLANTATION HTRN	6	30	6	30	0.47	0.35	0.55	1
PORT CHARLOTTE UTIL DEEP	6	21	10	22	0.10	0.00	0.81	5
PRAIRIE CRK UP INT (WQMP)	8	61	6	59	0.21	0.21	0.39	-3
PUNTA GORDA HEIGHTS INT	7	64	6	67	0.02	0.40	0.18	5
ROMP 10 UP HTRN	8	155	6	152	0.00	0.34	0.13	-2
ROMP 19 WEST HTRN	6	56	8	54	0.35	0.81	0.00	-4
ROMP 20 UP HTRN	8	673	9	596	0.04	0.16	0.33	-11
ROMP 22 ARC	9	45	13	44	0.00	0.26	0.07	-2
ROMP 24 INT	3	9	17	12	0.77	0.55	0.09	34
ROMP 5 UPPER INT	5	40	15	38	0.27	0.00	0.17	-6
ROMP 9 MID INT MW-3	5	52	15	66	0.63	0.06	0.02	27
ROMP TR 1-2 UP HTRN	15	126	10	114	0.00	0.00	0.02	-10
ROMP TR 3-1 HTRN 160	16	15	10	12	0.08	0.00	0.59	-19
ROMP TR 3-3 UP HTRN	16	110	9	89	0.14	0.00	0.00	-19
ROMP TR 4-1 MID INT	5	33	15	27	0.13	0.92	0.02	-20
ROMP TR 5-3 UPPER INT	5	212	6	211	0.08	0.53	0.19	-1
ROMP TR 7-2 UP ARC	6	45	6	62	0.91	0.60	0.04	37
ROMP TR 8-1 UP HTRN	8	36	15	37	0.17	0.00	0.52	2
ROTUNDA WATER PLANT 18 IN	6	453	5	469	0.06	0.88	0.57	4
SR 74 DEEP	7	100	6	99	0.00	0.71	0.28	-1
USGS C-1 INT	7	270	11	272	0.34	0.93	0.71	1
USGS C-3 INT	6	5	11	6	0.37	0.00	0.30	17
USGS TUCKERS CORNER INT	6	1	11	4	0.96	0.11	0.01	350
VENICE 35 INT	7	372	11	368	0.17	0.76	0.81	-1
VENICE SH WF 59 INT	6	124	6	127	0.19	0.24	0.94	2
VENICE SH WF 68 INT	6	275	6	165	0.56	0.43	0.03	-40

Chloride:Sulfate Ratio

Station	Number of Samples per Group 1	Median of Group 1	Number of Samples per Group 2	Median of Group 2	P-Value of Shapiro-Wilk Normality Test for Group 1	P-Value of Shapiro-Wilk Normality Test for Group 2	P-Value of Wilcoxon Rank Sum Test	Percent Change of Median of Each Group
CREWSVILLE UP INT	10	16	12	21	0.10	0.53	0.01	34
DARNELL THOMAS INT	6	0	17	0	0.05	0.66	0.56	1
ENGLEWOOD 14 DEEP	7	17	11	28	0.32	0.38	0.00	67
ENGLEWOOD 5 HTRN	6	6	6	7	0.16	0.82	0.48	11
ENGLEWOOD 5 PROD ZONE INT	3	9	6	17	0.42	0.91	0.26	94
GALLAGHER PATRICIA INT	6	64	17	40	0.41	0.00	0.82	-37
PLANTATION HTRN	6	2	6	2	0.12	0.03	0.09	5
PORT CHARLOTTE UTIL DEEP	6	4	10	4	0.05	0.00	0.31	12
PRAIRIE CRK UP INT (WQMP)	8	3	6	3	0.62	0.06	0.18	5
PUNTA GORDA HEIGHTS INT	7	6	6	6	0.00	0.79	0.73	3
ROMP 10 UP HTRN	8	2	6	2	0.04	0.55	0.00	6
ROMP 19 WEST HTRN	6	2	8	2	0.14	0.27	0.59	0
ROMP 20 UP HTRN	8	0	9	0	0.00	0.05	0.32	11
ROMP 22 ARC	9	2	13	2	0.37	0.00	0.01	3
ROMP 24 INT	3	3	17	2	0.30	0.68	0.02	-26
ROMP 5 UPPER INT	5	6	15	6	0.73	0.01	0.12	5
ROMP 9 MID INT MW-3	5	8	15	6	0.17	0.34	0.00	-20
ROMP TR 1-2 UP HTRN	15	3	10	4	0.59	0.00	0.20	3
ROMP TR 3-1 HTRN 160	16	65	10	74	0.99	0.01	0.62	14
ROMP TR 3-3 UP HTRN	16	8	9	9	0.39	0.00	0.04	9
ROMP TR 4-1 MID INT	5	3	15	3	0.94	0.29	0.05	15
ROMP TR 5-3 UPPER INT	5	0	6	0	0.82	0.78	0.43	-2
ROMP TR 7-2 UP ARC	6	2	6	1	0.07	0.47	0.04	-22
ROMP TR 8-1 UP HTRN	8	3	15	3	0.89	0.73	0.06	-4
ROTUNDA WATER PLANT 18 IN	6	10	5	10	0.15	0.59	0.93	1
SR 74 DEEP	7	1	6	1	0.23	0.46	0.01	8
USGS C-1 INT	7	4	11	4	0.39	0.00	0.61	-1
USGS C-3 INT	6	18	11	17	0.36	0.00	0.68	-5
USGS TUCKERS CORNER INT	6	39	11	11	0.00	0.00	0.01	-72
VENICE 35 INT	7	0	11	0	0.72	0.91	0.54	-3
VENICE SH WF 59 INT	6	0	6	0	0.85	0.36	0.82	-12
VENICE SH WF 68 INT	6	0	6	1	0.35	0.26	0.02	17

PZ 3 Trends

Chloride

Station	Number of Samples per Group 1	Median of Group 1	Number of Samples per Group 2	Median of Group 2	P-Value of Shapiro-Wilk Normality Test for Group 1	P-Value of Shapiro-Wilk Normality Test for Group 2	P-Value of Wilcoxon Rank Sum Test	Percent Change of Median of Each Group
GDU WELL T-2 INT	8	141	6	135	0.78	0.88	0.06	-4
LANE ROB (G V RUSSELL) IN	6	294	6	329	0.05	0.58	0.00	12
MABRY CARLTON 6 INT	6	48	12	47	0.00	0.00	0.32	-1
MANASOTA 14 DEEP	16	56	15	56	0.29	0.17	0.09	-1
PORT CHARLOTTE DEEP	6	720	9	682	0.06	0.53	0.26	-5
ROMP 10 LOW HTRN/TMPA	17	440	15	448	0.00	0.20	0.40	2
ROMP 11 HTRN	7	669	11	683	0.16	0.08	0.34	2
ROMP 13 LOW INT	5	33	15	33	0.30	0.01	0.41	-1
ROMP 13 MID INT	6	31	15	30	0.10	0.07	0.01	-2
ROMP 20 LOW INT	15	70	15	101	0.74	0.50	0.00	44
ROMP 22 ARC/TMPA	10	165	16	163	0.21	0.55	0.79	-1
ROMP 33 ARC	8	16	15	16	0.17	0.00	0.60	-1
ROMP 5 LOWER INT	5	754	15	702	0.79	0.62	0.03	-7
ROMP 9 LOW HTRN MW-4	7	446	15	445	0.82	0.94	1.00	0
ROMP TR 1-2 L HTRN/TMPA	16	920	15	903	0.68	0.02	0.31	-2
ROMP TR 3-1 HTRN 400	16	519	15	517	0.06	0.72	0.98	0
ROMP TR 3-3 LOW HTRN	15	2507	15	1935	0.67	0.08	0.00	-23
ROMP TR 4-1 LOW INT	5	227	15	223	0.05	0.57	0.75	-2
ROMP TR 5-1 TMPA	6	32	11	31	0.48	0.00	0.34	-4
ROMP TR 5-2 LOW HTRN	6	36	11	39	0.28	0.00	0.16	8
ROMP TR 6-1 HTRN	16	502	16	519	0.00	0.92	0.23	3
ROMP TR 7-2 LOW ARC	7	53	7	52	0.07	0.80	0.09	-2
ROMP TR SA-1 UP INT	7	211	15	182	0.56	0.02	0.00	-14
SARASOTA 27TH ST INT	9	138	7	142	0.76	0.33	0.31	3
SARASOTA HIST SOC INT	6	38	6	37	0.50	0.03	0.78	-2
SOUTHBAY UTILITIES DEEP	7	275	6	246	0.14	0.46	0.28	-11
TEST 18 BLACKBURN INT	6	173	6	189	0.74	0.00	0.24	9
WHITAKER BAYOU INT	7	140	7	146	0.07	0.72	0.22	4

Sulfate

Station	Number of Samples per Group 1	Median of Group 1	Number of Samples per Group 2	Median of Group 2	P-Value of Shapiro-Wilk Normality Test for Group 1	P-Value of Shapiro-Wilk Normality Test for Group 2	P-Value of Wilcoxon Rank Sum Test	Percent Change of Median of Each Group
GDU WELL T-2 INT	8	232	6	233	0.01	0.48	0.97	1
LANE ROB (G V RUSSELL) IN	6	175	6	174	0.20	0.16	0.56	0
MABRY CARLTON 6 INT	6	231	12	220	0.02	0.00	0.26	-5
MANASOTA 14 DEEP	16	32	15	32	0.03	0.03	0.91	1
PORT CHARLOTTE DEEP	6	280	9	279	0.04	0.88	0.71	0
ROMP 10 LOW HTRN/TMPA	17	232	15	226	0.00	0.02	0.12	-3
ROMP 11 HTRN	7	260	11	259	0.04	1.00	1.00	0
ROMP 13 LOW INT	5	28	15	26	0.75	0.22	0.43	-6
ROMP 13 MID INT	6	14	15	15	0.01	0.01	0.41	8
ROMP 20 LOW INT	15	1482	15	1510	0.13	0.04	0.20	2
ROMP 22 ARC/TMPA	10	71	16	68	0.34	0.25	0.09	-5
ROMP 33 ARC	8	2	15	1	0.19	0.01	0.03	-62
ROMP 5 LOWER INT	5	213	15	191	0.84	0.03	0.02	-10
ROMP 9 LOW HTRN MW-4	7	255	15	254	0.67	0.71	0.59	0
ROMP TR 1-2 L HTRN/TMPA	16	274	15	272	0.49	0.56	0.39	-1
ROMP TR 3-1 HTRN 400	16	499	15	502	0.38	0.75	0.18	1
ROMP TR 3-3 LOW HTRN	15	453	15	403	0.01	0.81	0.00	-11
ROMP TR 4-1 LOW INT	5	503	15	503	0.48	0.00	0.88	0
ROMP TR 5-1 TMPA	6	972	11	972	0.04	0.08	0.71	0
ROMP TR 5-2 LOW HTRN	6	1040	11	1070	0.53	0.29	0.13	3
ROMP TR 6-1 HTRN	16	1124	16	1195	0.95	0.87	0.03	6
ROMP TR 7-2 LOW ARC	7	195	7	203	0.72	0.30	0.12	4
ROMP TR SA-1 UP INT	6	497	15	466	0.59	0.84	0.03	-6
SARASOTA 27TH ST INT	9	714	7	734	0.01	0.35	0.47	3
SARASOTA HIST SOC INT	6	1160	6	1164	0.57	1.00	0.48	0
SOUTHBAY UTILITIES DEEP	7	1672	6	1713	0.96	0.11	0.19	2
TEST 18 BLACKBURN INT	6	525	6	521	0.82	0.06	0.39	-1
WHITAKER BAYOU INT	7	158	7	162	0.41	0.18	0.22	3

Chloride:Sulfate Ratio

Station	Number of Samples per Group 1	Median of Group 1	Number of Samples per Group 2	Median of Group 2	P-Value of Shapiro-Wilk Normality Test for Group 1	P-Value of Shapiro-Wilk Normality Test for Group 2	P-Value of Wilcoxon Rank Sum Test	Percent Change of Median of Each Group
GDU WELL T-2 INT	8	1	6	1	0.68	0.68	0.18	-5
LANE ROB (G V RUSSELL) IN	6	2	6	2	0.22	0.15	0.00	11
MABRY CARLTON 6 INT	6	0	12	0	0.01	0.98	0.82	3
MANASOTA 14 DEEP	16	2	15	2	0.08	0.09	0.55	-1
PORT CHARLOTTE DEEP	6	3	9	2	0.48	0.32	0.11	-2
ROMP 10 LOW HTRN/TMPA	17	2	15	2	0.00	0.58	0.06	3
ROMP 11 HTRN	7	3	11	3	0.57	0.71	0.10	4
ROMP 13 LOW INT	5	1	15	1	0.64	0.15	0.80	0
ROMP 13 MID INT	6	2	15	2	0.07	0.00	0.30	-12
ROMP 20 LOW INT	15	0	15	0	0.18	0.66	0.00	41
ROMP 22 ARC/TMPA	10	2	16	2	0.01	0.02	0.02	2
ROMP 33 ARC	8	9	15	24	0.00	0.02	0.11	152
ROMP 5 LOWER INT	5	4	15	4	0.23	0.01	0.35	5
ROMP 9 LOW HTRN MW-4	7	2	15	2	0.52	0.95	0.08	3
ROMP TR 1-2 L HTRN/TMPA	16	3	15	3	0.35	0.00	0.83	0
ROMP TR 3-1 HTRN 400	16	1	15	1	0.00	0.99	0.95	0
ROMP TR 3-3 LOW HTRN	15	6	15	5	0.88	0.07	0.00	-17
ROMP TR 4-1 LOW INT	5	0	15	0	0.36	0.00	0.44	1
ROMP TR 5-1 TMPA	6	0	11	0	0.03	0.00	0.46	-3
ROMP TR 5-2 LOW HTRN	6	0	11	0	0.05	0.00	0.81	5
ROMP TR 6-1 HTRN	16	0	16	0	0.00	0.74	0.02	-3
ROMP TR 7-2 LOW ARC	7	0	7	0	0.25	0.11	0.02	-6
ROMP TR SA-1 UP INT	6	0	15	0	0.09	0.78	0.00	-11
SARASOTA 27TH ST INT	9	0	7	0	0.00	0.04	0.30	-5
SARASOTA HIST SOC INT	6	0	6	0	0.98	0.04	0.70	-3
SOUTHBAY UTILITIES DEEP	7	0	6	0	0.04	0.49	0.14	-14
TEST 18 BLACKBURN INT	6	0	6	0	0.42	0.38	0.06	8
WHITAKER BAYOU INT	7	1	7	1	0.57	0.24	0.62	-2

APPENDIX G

Review of Report "Application of Minimum Levels to the Intermediate Aquifer System in the Southwest Florida Water Management District"

Mark Stewart, Ph.D., P.G.
October 3, 2005

This is a review of the draft document, "Application of Minimum Levels to The Intermediate Aquifer System in The Southwest Florida Water Management District", by Ron Basso, P.G., June, 2005. The review is divided into six sections:

1/ basic conceptualization of the Intermediate Aquifer System (IAS),
2/ completeness of the study,
3/ potential data gaps,
4/ methods of forecasting the effects of increases in withdrawals,
5/ reasonableness of results and conclusions,
6/ comments on report recommendations.

Basic conceptualization of the Intermediate Aquifer System (IAS)

The draft report conceptualizes the IAS as being comprised of two principal production zones or transmissive zones, PZ 2 and PZ 3, predominantly carbonate units, separated vertically and laterally by lower permeability silts, clays and tight carbonate units. An areally restricted and less productive upper zone, PZ 1, is present in the NW part of the IAS. In parts of the IAS, PZ 3 is well connected to the upper part of the Floridan Aquifer. PZ 2 is generally well-separated from both the overlying surficial aquifer and the underlying Floridan Aquifer. The transmissivities of both PZ 2 and PZ 3 are lower than values typical for the underlying Floridan Aquifer, but both zones are important sources of potable supplies in the southern part of the District. The permeable units of the IAS, particularly in PZ 2, may not be laterally continuous over distances of more than a few miles. This is in contrast to the units which comprise the Floridan Aquifer, which are laterally continuous over most of west central Florida and the Southern Ground Water Basin (SGWB). As described in the report, the IAS, especially zones PZ 1 and PZ 2, does not form an extensive, regionally-connected and continuous aquifer system in the SGWB, as does the Floridan Aquifer. This conceptualization is consistent with previous reports and available information on the IAS.

A review of water quality data supports the geologic and hydrologic conceptualizations of the IAS given in the report. The IAS water quality is generally good, and is largely dominated by Ca-Mg-bicarbonate waters. The occurrence and distribution of mineralized waters enriched in sulfate, and coastal waters affected saltwater intrusion are localized and limited. This is in contrast to the Floridan Aquifer, in which large volumes of the aquifer can be divided into one of three regional zones affected by relatively fresh calcium bicarbonate waters, sulfate waters influenced by deeper mineralized waters, and chloride-dominated waters affected by salt water. The distribution of water quality in the IAS and the absence of regionally significant trends in water quality as a result of upcoming of mineralized waters or salt-water intrusion support the conceptualization of the IAS as a lower transmissivity system with sub-regional, isolated permeable zones.

Completeness of the study

The draft report includes data from a regional set of monitor wells that provide information on potentiometric surface levels and water quality. The report does not contain a contour map illustrating the regional elevations of the potentiometric surface of zones PZ 2 and PZ 3, or a contour map illustrating regional changes in the potentiometric surface over time, as might be expected for a regional aquifer study. However, given the conceptualization of the IAS as zones of laterally-discontinuous permeable units, a regional contour map of the potentiometric surface does not have the same significance as for the Floridan Aquifer. Regional potentiometric surface maps imply regional ground-water flow, which probably is not the case in the IAS. In this characteristic, the IAS is 'intermediate' between the regional Floridan Aquifer and the very local Surficial Aquifer System. The principal significance of potentiometric surface trends is to determine where significant historical declines may be contributing to upward and lateral movement of high chloride or high sulfate waters. This information is provided for each of the PZ 2 and PZ 3 monitor wells and supports the conclusion that there is no regionally significant pattern of change in the potentiometric surface of the IAS.

To determine if long-term water-quality changes are occurring in the IAS, time-series water-quality data were tested with non-parametric trend analysis. Increasing chloride ion content may indicate salt-water intrusion, while increasing sulfate may indicate upwelling of deeper, mineralized waters. While some wells do show increasing trends in chloride and sulfate or the chloride/sulfate ratio, some show decreasing trends. The patterns are not regionally significant, other than noting that wells close to the coast and the southern part of the IAS system are more likely to have increasing trends. However, effects seem to be local, and there is no apparent significant regional pattern of increasing or decreasing trends in water quality. While other water-quality parameters are not examined, investigation of chloride and sulfate trends is sufficient to determine if withdrawals are inducing regional movement of saline or mineralized waters.

Potential data gaps

The type and density of information collated for this study are appropriate for the purpose of determining if regional trends in water levels or water quality require establishing a regulatory minimum level for the IAS. The distribution of data points is appropriate for a regional evaluation. However, the data network may not have sufficient density to reflect the local or sub-regional character of the IAS that results from the limited areal extent of permeable units in PZ 2 and PZ 3. Because of the limited extent of the permeable units, especially in PZ 2, as the distance between monitoring wells increases, the confidence that the wells are in the same hydrologic unit decreases. If a decision is made to institute specific management objectives in limited areas of the IAS, a higher density of monitoring wells will probably be required in those areas. As outlined in the report, some areas of the IAS, such as in Sarasota County west of I-75, may experience more stress from future or existing withdrawals than other areas. These areas will require a higher monitor well density for effective resource management.

Method of forecasting effects of increased withdrawals

Numerical ground-water flow models are used in the report to estimate the potential effects of increasing withdrawals in the IAS by 35 mgd. This is a widely used and accepted method for assessing effects on a resource from proposed or predicted withdrawals. The most significant problem with this approach is predicting the future distribution of withdrawals. To deal with this problem, the report uses three different distributions of future withdrawals. Scenario 1, where current withdrawals are increased by 65% to increase withdrawals by 35 mgd, is probably the most likely scenario, as current use is probably the best indication of future use. The other two scenarios distribute the increases more uniformly over the extent of the IAS, and provide some indication of the potential effects of regional increase in withdrawals.

It should be noted that while the discontinuity of permeable units in the IAS is accounted for to some degree by the distribution of hydraulic conductivities in the model layers that represent the permeable zones, the layers in the models are laterally continuous, while the permeable layers in the PZ’s are probably laterally restricted units within a general stratigraphic horizon designated as PZ 2 or PZ 3. In this sense, the three model scenarios may overestimate the regional effects of increased withdrawals, and underestimate the potential local effects. More accurately estimating the effects of the lateral discontinuity of permeable units would require considerably more stratigraphic information than seems to be available. As the current models are more likely to overestimate, rather than underestimate, regional effects from increased withdrawals, the model analysis is conservative form a resource evaluation standpoint.

Reasonableness of results and conclusions

The results of the analysis and the conclusions based on them are drawn from an appropriate conceptualization of the IAS which is in agreement with previous studies and the data collated for this study. The density of the data network is sufficient to assess the regional characteristics of the IAS. While it is not possible to predict the location and magnitude of future withdrawals, the modeling scenarios allow a reasonable regional assessment of the effects on the IAS of increased withdrawals to be made.

The report does not recommend establishing a regional minimum level for the IAS for two principal reasons. First, the permeable units of the IAS are not laterally continuous over the region, and a regional minimum level would not be hydrologically meaningful. Second, the high variability of the hydraulic properties of the IAS over relatively short distances makes it difficult to establish a monitoring network that has regional significance. For example, two adjacent monitor wells a few miles apart, open to PZ 2, may be monitoring different hydrologic units with PZ 2. The farther apart wells are in the IAS, the lower the confidence that they are monitoring the same permeable unit, making the establishment of a regionally-significant minimum level problematic, and the value of a regional minimum level open to question.

As recommended in the report, a sub-regional monitoring and management network of the IAS may be more appropriate than a regional minimum level, given the hydrologic and geologic character of the IAS. Monitoring and management actions could be concentrated in those sub-regions likely to experience resource problems, allowing a data network to be established that would be more representative of the local conditions that characterize much of the IAS.

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Review of Report "Application of Minimum Levels to the Intermediate Aquifer System in the Southwest Florida Water Management District", by Ron Basso, P.G., June, 2005

USGS, Lari Knochenmus, P.G.
USGS, Dann Yobbi, P.G.
October 31, 2005

As requested by the District, the review focuses on the following five major issues:

1. Basic conceptualization of the intermediate aquifer system (IAS)
2. Completeness of the study
3. Potential data gaps
4. Reasonableness of results and conclusions
5. Comments of report recommendations

Basic conceptualization of the intermediate aquifer system

Generally the hydrogeologic framework is consistent with published reports and draft reports prepared by the USGS, SWFWMD, and consultants. The basic framework includes as many as three water-bearing zones separated by confining units. The water-bearing zones likely are not laterally contiguous across the study area. The geographic extent of PZ1 is limited to the southern part of the study. PZ1 has been described in the portion of the study area underlying all of Sarasota, Charlotte, and Lee Counties, and parts of Manatee and De Soto Counties (Sutcliffe, 1975; Wedderburn and others, 1982; Barr, 1996; Reese, 2000) but is best recognized in southern Sarasota and coastal Charlotte Counties). The middle and lower zones (PZ2 and PZ3) are of greater geographic extent but likely are sub-regional in scale.

The framework presented in Table 1, particularly the stratigraphic designation for PZ2 is inconsistent with the draft text and most hydrogeologic sections found in published reports (Barr, 1996, Duerr and Wolansky, 1986, Broska and Knochenmus, 1996, Knochenmus and Bowman, 1998, and Knochenmus, in review). The permeable zones often cross stratigraphic boundaries. For example, PZ2 is not found solely within the Peace River Formation except at ROMP 5 and ROMP 48. The Bone Valley Member is included in Table 1 but according to FGS, the Bone Valley Member was not identified on lithologic logs from ROMP sites in the study area. PZ3 should straddle the Tampa/Arcadia boundary (above and below) to represent the portions of the study area where the Tampa is absent and the water-bearing zone is in the undifferentiated Arcadia Formation.

Hydraulic properties, particularly in PZ2, are highly variable and range from low permeability (transmissivity values less than 100 ft^2/d) to moderate permeability (transmissivity values less than 10,000 ft^2/d). Transmissivities throughout the intermediate aquifer system are lower than the underlying Upper Floridan aquifer.

Definition of PZ1 needs to be clarified. On page 11 it is stated that "In general, the hydraulic connection between the surface and the IAS appears to be low, except for PZ1 which may actually be part of the surficial aquifer system." Is the PZ1 part of the SAS or is it part of the IAS, where the IAS is unconfined? Even when the UFA is unconfined, it is not defined as the SAS.

Comparisons between PZ2 and PZ3 in terms of importance and extent are contradictory within the text. For example, on page 7, PZ3 is described as the more regionally extensive and productive zone; whereas, on page 8, PZ2 appears to be the predominant aquifer within the IAS.

The water quality data presented in the draft report supports the hydrogeologic conceptualization of the aquifer system. The water chemistry is predominantly calcium-magnesium bicarbonate ions reflecting the mineralogical makeup of the aquifer framework in the IAS. Sodium-chloride type water is found throughout the IAS and UFA south from southern Sarasota and De Soto Counties as you state on page 19. The lack of statistically significant trends in most of the water-quality data and contradictory trends (increasing and decreasing trends) among well sites located near one another indicate localized rather than regional changes in water quality in the study area further supporting the conceptualization of the IAS as a sub-regional ground-water flow system.

Note: On page 21, (last paragraph) the draft text implies that water-level changes are shown in figure 22 and 23. Figures 22 and 23 show the network used to compute differences and the head differences are actually shown in figures 28 and 29.

Completeness of the study

The appropriate data were compiled for this study. Selecting data primarily from ROMP sites provides a consistent and controlled data set. Because these wells were designed to monitor discrete water-bearing zones it is possible to make reasonable comparisons and contrasts among permeable units within the intermediate aquifer system. As new ROMP sites are added to the network, the hydrologic and geochemical data should be analyzed in the context of the hydrogeologic conceptualization to further the spatial consistency or lack thereof.

Potential data gaps

The distribution of data sites is appropriate for regionally analyzing the hydraulic and chemical characteristics of the intermediate aquifer system. In the inland counties, particularly Hardee and De Soto Counties, data are sparser but this condition is being rectified by ongoing test and monitor well drilling. This new data should be incorporated as soon as possible to improve the regional characterization of the intermediate aquifer system and connectivity to adjacent aquifers.

Localized lowering of water levels and changing water quality should be closely monitored and additional data collection sites may need to be constructed in areas where hydrologic conditions appear to be changing. The distance between adjacent sites makes it difficult to accurately assess the lateral connectivity of the water-bearing zones across the study area, and therefore, makes it difficult to impose a management criterion defining the minimum levels within zones in the intermediate aquifer system. In the southern part of the study area, the intermediate aquifer system is most widely used and correspondingly the area is experiencing water-level declines and gradient reversals. These conditions should be closely monitored and may require a higher monitor well density to fully understand the implications of resource development in the southern part of the study area.

Reasonableness of results and conclusions

Conceptualization of the hydrogeologic framework is comparable to previous reports and supports data presented in the draft report. However, a verification check for contradictory statements concerning the relative permeability, particularly between PZ1 and PZ2 should be made. In general PZ1 (where it exists) has a higher permeability than PZ2. Additionally, a check for contradictions in terms of confinement between the SAS and upper IAS should be made. Clearly state that confinement is greater between SAS and PZ2 but where PZ1 exists often PZ1 is in good hydraulic connections to the SAS—if this is what you mean. Leakance values tend to be in the same order of magnitude between the SAS and PZ2 and between PZ2 and the UFA.

The numerical ground-water flow models presented in this report are used to evaluate the potential effects of increased ground-water withdrawals on levels in the intermediate aquifer system. Three different production well distributions area evaluated. We think that the most likely scenario is to increase withdrawals from existing wells and therefore should be accentuated in the discussion. Discussion of the other two well distribution scenarios serves as a comparison to potential changes when withdrawals are regionally distributed.

Comments on report recommendations

We concur with the report recommendations of not establishing a regional minimum water level in the intermediate aquifer system. The geologic, hydraulic, and chemical data indicate a highly heterogeneous aquifer system in which the permeable zones are not laterally continuous making the establishment of a minimum level problematic, open to challenge, and of questionable merit. We also concur with the alternative recommendation to analyzed and monitor changes in the water resources of the intermediate aquifer system by concentrating monitoring and management actions in the sub-regions experiencing the greatest hydrologic changes. Of greatest concern is the cumulative effects caused by relatively high density withdrawals than could impact the ability to obtain water, particularly from the upper water-bearing zones. Low permeability of the water-bearing zones may result in substantial localized water-level declines and therefore water quality changes should be carefully monitored.