SUMMARY OF GROUND-WATER AND RAINFALL DATA FOR TUTUILA AND AUNUU ISLANDS, AMERICAN SAMOA, FOR JULY, 1984 THROUGH SEPTEMBER, 1995

By Scot K. Izuka

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
inch (in.)	2.54	centimeters
inch/month (in/mo)	2.54	centimeters per month
foot (ft)	0.3048	meter
cubic foot (ft^3)	0.02832	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
mile, statute (mi)	1.609	kilometers
square mile (mi^2)	2.590	square kilometers
gallon (gal)	3.785	liters
million gallons (Mgal)	3,785	cubic meters
million gallons per day (Mgal/d)	0.04381	cubic meter per second
gallons per minute (gal/min)	3.785	liters meter per minute

Abbreviations used in water-quality descriptions

mg = milligram
mg/L = milligrams per liter
L = liter

Vertical datum

All elevations in this report are referenced relative to mean sea level.

Summary of Ground-Water and Rainfall Data for Tutuila and Aunuu Islands, American Samoa, for July, 1984 Through September, 1995

By Scot K. Izuka

Abstract

Ground-water and rainfall data for the period from July 1984 through September 1995 from the islands of Tutuila and Aunuu have been summarized in time-series graphs that can be used to analyze for historical trends. The data include pumpage and chloride concentrations from 50 production wells on Tutuila and 3 production wells on Aunuu, water-level measurements from 12 wells on Tutuila, and rainfall from 2 gages on Tutuila.

Rainfall averaged 13.2 inches per month at the rain gage at Afono near Pioa Mountain and 17.6 inches per month at the rain gage at Aasufou over the period from 1984 to 1995. Late 1987 to early 1992 was a dry period with below-average rainfall, whereas rainfall in 1994 through September 1995 was higher than average.

The Tafunafou-Malaeimi-Mesepa well field and the Leone-Malaeloa well field each pumped about 2.4 to 4 million gallons per day. Chloride concentrations of water pumped from the well fields were usually less than 500 milligrams per liter but chloride concentrations have exceeded 500 milligrams per liter during periods when rainfall was below average. Iliili wells pumped about 1.3 to 1.4 million gallons per day from four production wells, three of which had chloride concentrations under 200 milligrams per liter, and the fourth having chloride concentrations usually under 500 milligrams per liter. Water in wells at Aua, Fagaitua, Alofau, Alao, Tula, and Sailele had chloride concentrations frequently in excess of 500 milligrams per liter. Water levels at Aua during pumping dropped as low as 60 ft below sea level. Chloride concentrations at Fagaalu, and Aoa have remained below 200 milligrams per liter and chloride concentrations at Fagasa have usually remained below 500 milligrams per liter. These well fields have been pumped for less than 5 years at pumpage rates of less than 0.1 million gallons per day at each well field. The Fagatogo and Pago Pago well fields have each produced about 0.75 to 1.0 million gallons per day while maintaining chloride concentrations below 100 milligrams per liter. Water levels in monitor wells in these well fields have dropped below sea level on occasion. Chloride concentrations on Aunuu frequently exceeded 500 milligrams per liter and reached nearly 2,000 milligrams per liter since the wells began pumping in 1992 at a rate of 0.01 to 0.03 million gallons per day each.

INTRODUCTION

The American Samoa Government, through the American Samoa Environmental Protection Agency (ASEPA), American Samoa Power Authority (ASPA), and the Department of Public Works (DPW), have maintained a cooperative effort with the U.S. Geological Survey (USGS) to collect the principal data needed to assess ground-water resources on Tutuila, the largest and most populated island in American Samoa, and the nearby island of Aunuu (fig. 1). This report summarizes pumpage, chloride-concentration data from 50 wells on Tutuila and 3 wells on Aunuu that were in production during the period July 1984 through September 1995. Water-level measurements from 12 wells on Tutuila monitored during this period are also summarized. Salinity and water levels are important limiting factors to the availability of water in midocean island settings such as Tutuila and Aunuu. In this report, the concentration of chloride ions is used as an indicator of the amount of salt in ground-water pumped at wells. Rainfall from two gages is also summarized in this report to facilitate comparisons with the ground-water data. The ground-water and rainfall data are plotted in time-series graphs that can be used to analyze for historical trends.

For convenience of discussion, the wells on Tutuila are grouped into three regions. Western Tutuila includes all of the Tafuna-Leone Plain and the well field in Aloaufou. Central Tutuila includes all the well fields surrounding Pago Pago Harbor, as well as Fagasa on the north coast and Laulii on the south coast just beyond the mouth of the harbor. Eastern Tutuila includes all of the wells east of Laulii.

SETTING

Tutuila is a volcanic island of about 53 mi^2 located in the tropical South Pacific (fig. 1). The island is narrow and elongate in the east-west direction and characterized mostly by steep, deeply eroded mountains that rise abruptly from the ocean to a maximum elevation of 2,140 ft. The exception to this general topography is the relatively flat Tafuna-Leone Plain in the southwest which extends from Tafunafou to Leone. The mountainous, main part of Tutuila is composed of Pliocene to Pleistocene shield-volcano basalts, andesites and trachytes that have relatively low permeabilities (Stearns, 1944; Macdonald, 1944, 1968; Davis, 1963; Bentley, 1975). The Tafuna-Leone Plain is composed of younger (Holocene), more permeable basaltic lava flows and pyroclastic cones (Stearns, 1944; Davis, 1963; Bentley, 1975). Ground-water production is high on the Tafuna-Leone Plain, where most wells are clustered in a few areas. Elsewhere on Tutuila, wells are located in small valleys in the rugged mountains or other low-lying areas near the coast. Wells drilled on the top of Olotele Mountain near Aloaufou are the only exception.

The island of Aunuu (0.6 mi^2), less than 1 mi off the southeastern shore of Tutuila is a tuff (consolidated volcanic ash) cone with a coastal plain about 2,000 ft wide and 4,000 ft long on its western side. The center of the tuff cone contains a marsh and a second marsh is located at the inland edge of the coastal plain. All ground-water development on Aunuu comes from the coastal plain sediments.

Acknowledgments

This report was produced under a cooperative agreement with the ASEPA. Data were collected by the ASPA. The author gratefully acknowledges Togipa Tausaga (Director, ASEPA), Abe Malae (Director, ASPA), Sheila Wiegman (ASEPA), and Wilfredo Carreon (ASPA), for their assistance.

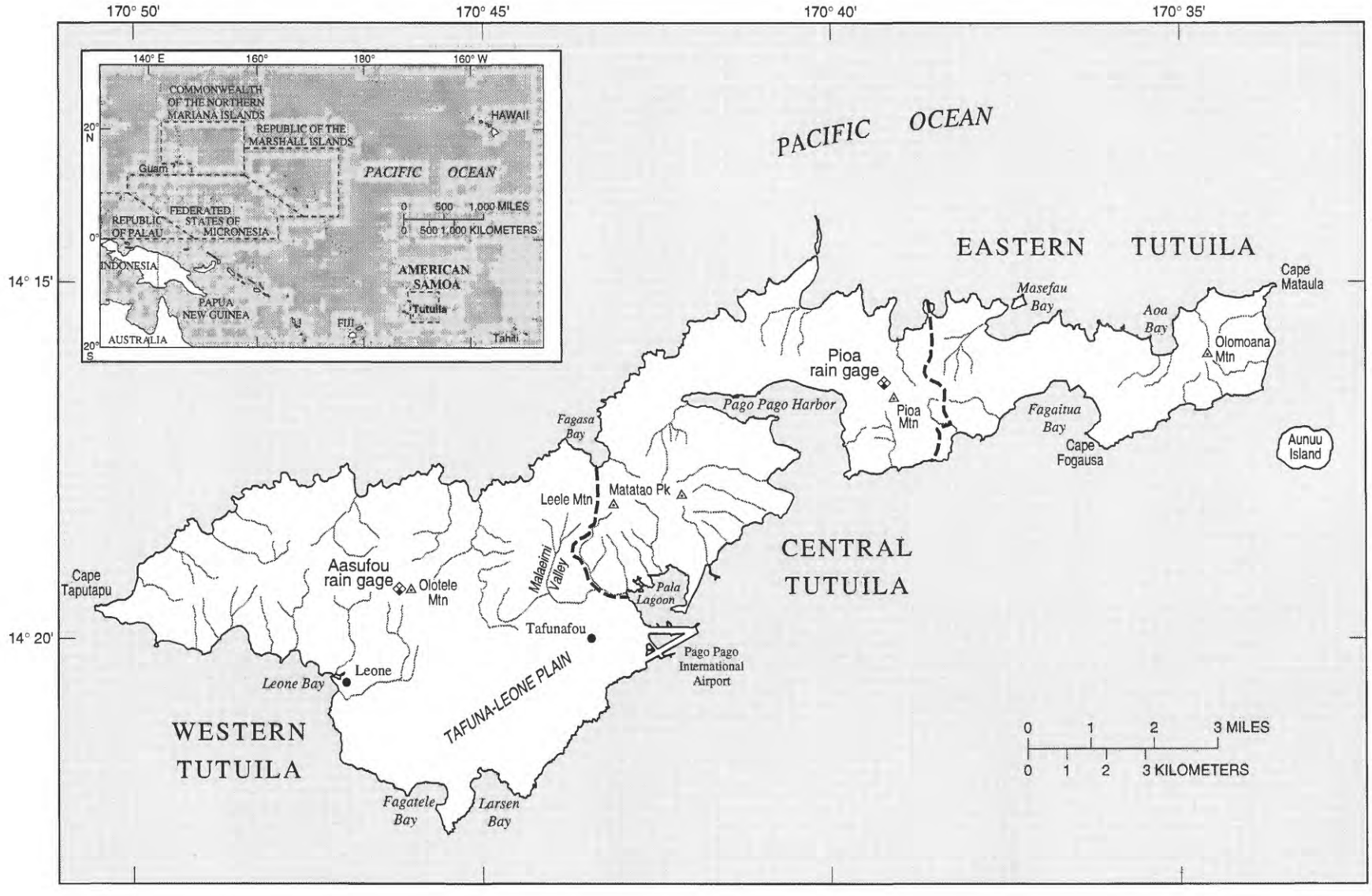

Figure 1. Tutuila and Aunuu Islands, American Samoa.

Rainfall Data

Rainfall averaged 13.2 in/mo at the Pioa rain gage in Afono near Pioa Mountain (fig. 1) and 17.6 in/mo at the Aasufou rain gage during the period January 1984 through September 1995. The plots of the monthly departures from the mean show a seasonal pattern of rainfall with peaks in January to March and troughs in July to August (fig. 2). Plots of the departure of the 3-month and 6-month backward moving average also show the seasonal cycle. Late 1987 to early 1992 was a dry period with below-average rainfall, whereas rainfall in 1994 through September 1995 was higher than average.

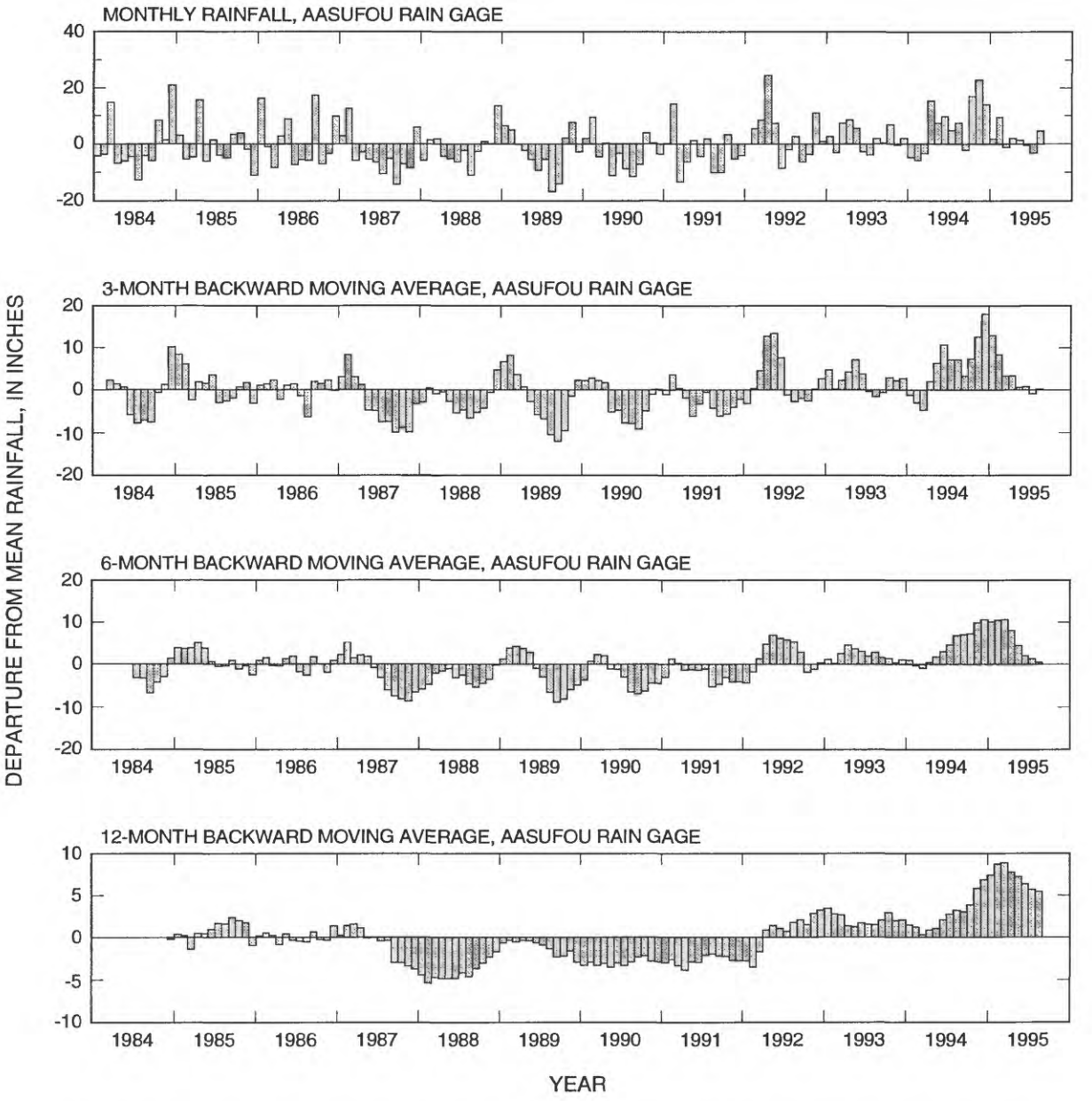

Figure 2. Departure of monthly from mean rainfall, and departure of 3-month, 6-month, and 12-month backward moving average from mean rainfall recorded at the Aasufou and Pioa rain gages, Tutuila, American Samoa.

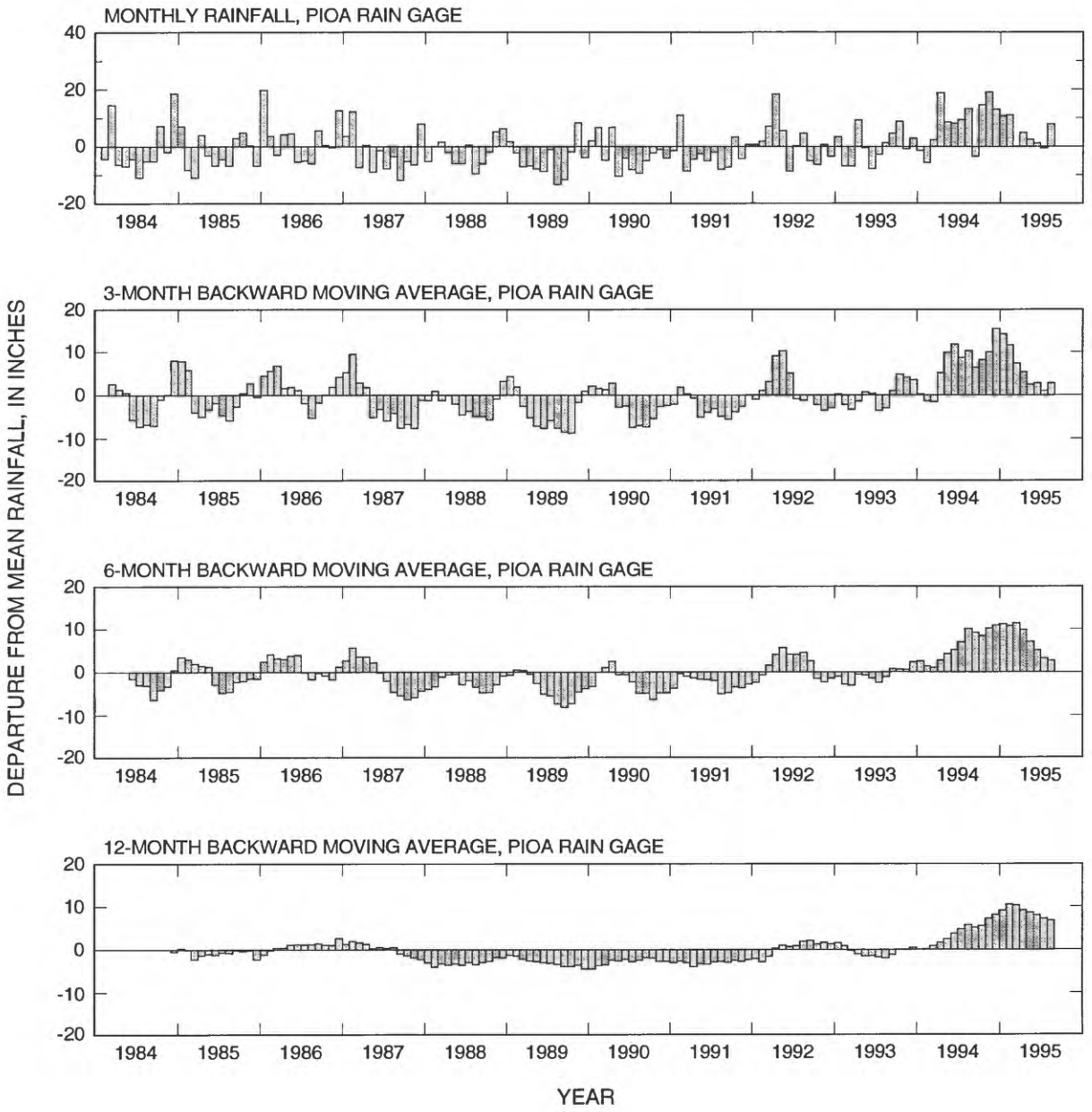

Figure 2. Departure of monthly from mean rainfall, and departure of 3-month, 6-month, and 12-month backward moving average from mean rainfall recorded at the Aasufou and Pioa rain gages, Tutuila, American Samoa--*Continued.*

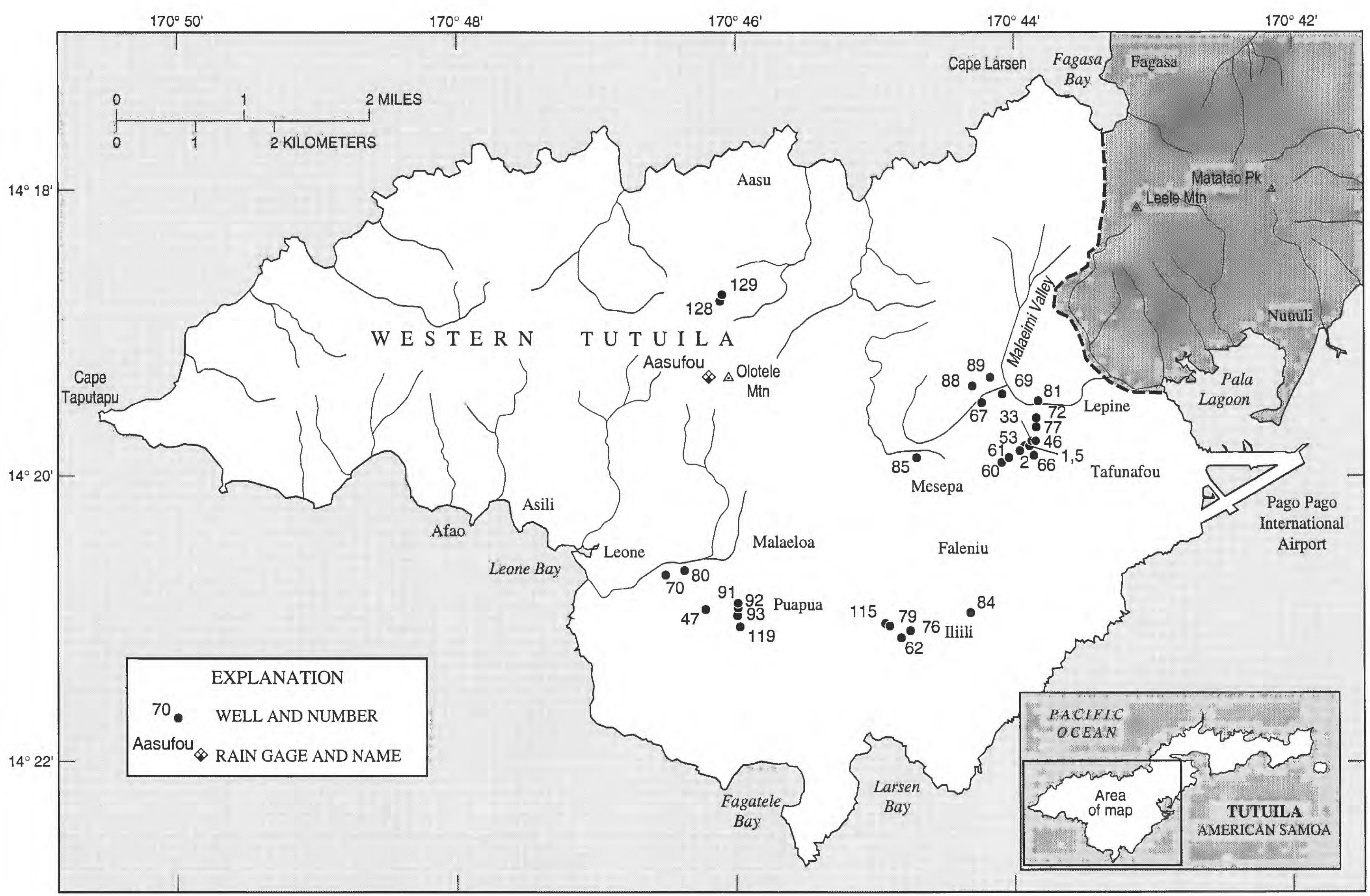

Figure 3. Wells in western Tutuila, American Samoa.

WESTERN TUTUILA GROUND-WATER DATA

Western Tutuila is the site of the most productive well fields on Tutuila, most notably the highly productive well fields on the Tafuna-Leone Plain, which include Tafunafou, Malaeimi, Mesepa, Iliili, and Malaeloa well fields (fig. 3). Also included in western Tutuila are the wells in Aloaufou near the summit of Olotele Mountain. For the purposes of this discussion, the many well fields in western Tutuila have been placed into four groups, based on their proximity to each other. These groups are (1) Tafunafou-Malaeimi-Mesepa, (2) Malaeloa-Leone, (3) Iliili, and (4) Aloaufou.

Tafunafou-Malaeimi-Mesepa

The Tafunafou-Malaeimi-Mesepa well fields are the most productive on Tutuila (fig. 4). Wells 33, 46, 53, 60, 61, 66, 72, 77, and 81 are part of a cluster of wells in the village of Tafunafou that produce a total of about 2 Mgal/d. Chloride concentrations at Tafunafou wells vary over a large range from 15 to over 1,500 mg/L. Brief rises in chloride concentration display a saw-tooth pattern, rising gradually during dry periods and dropping quickly when rainfall returns. In most of the Tafunafou well field, there does not appear to be any long-term trend in chloride concentrations.

Wells 67, 69, 88, and 89 are in nearby Malaeimi Valley, and well 85 is in the village of Mesepa (fig. 3). Chloride concentrations in nearly all of the wells in Malaeimi and Mesepa are less than 50 mg/L and show little variation (fig. 5). These low chloride concentrations were maintained during periods when four of the wells were each pumping 0.040 to 0.05 Mgal/d. The notable exception is well 69, where chloride concentrations rose over 500 mg/L during 1988-90 when the well was pumping at a rate of 0.01 to 0.02 Mgal/d. Chloride concentrations peaked during periods when rainfall at the Aasufou gage was below average (fig. 2). Water levels measured at well 88 dropped more than 50 ft below sea level during pumping.

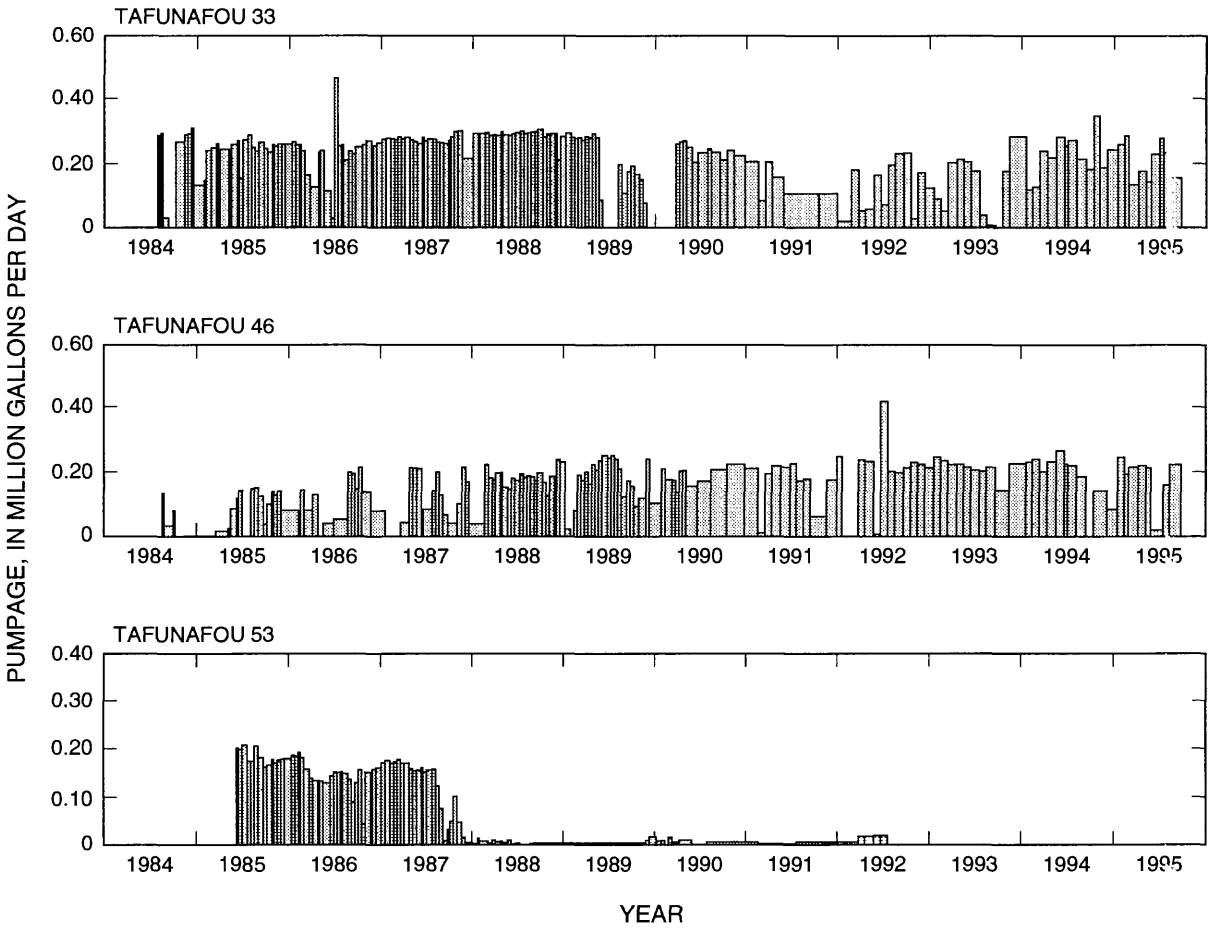

Figure 4. Pumpage, chloride concentrations, and water levels in the Tafunafou-Malaeimi-Mesepa well fields, Tutuila, American Samoa.

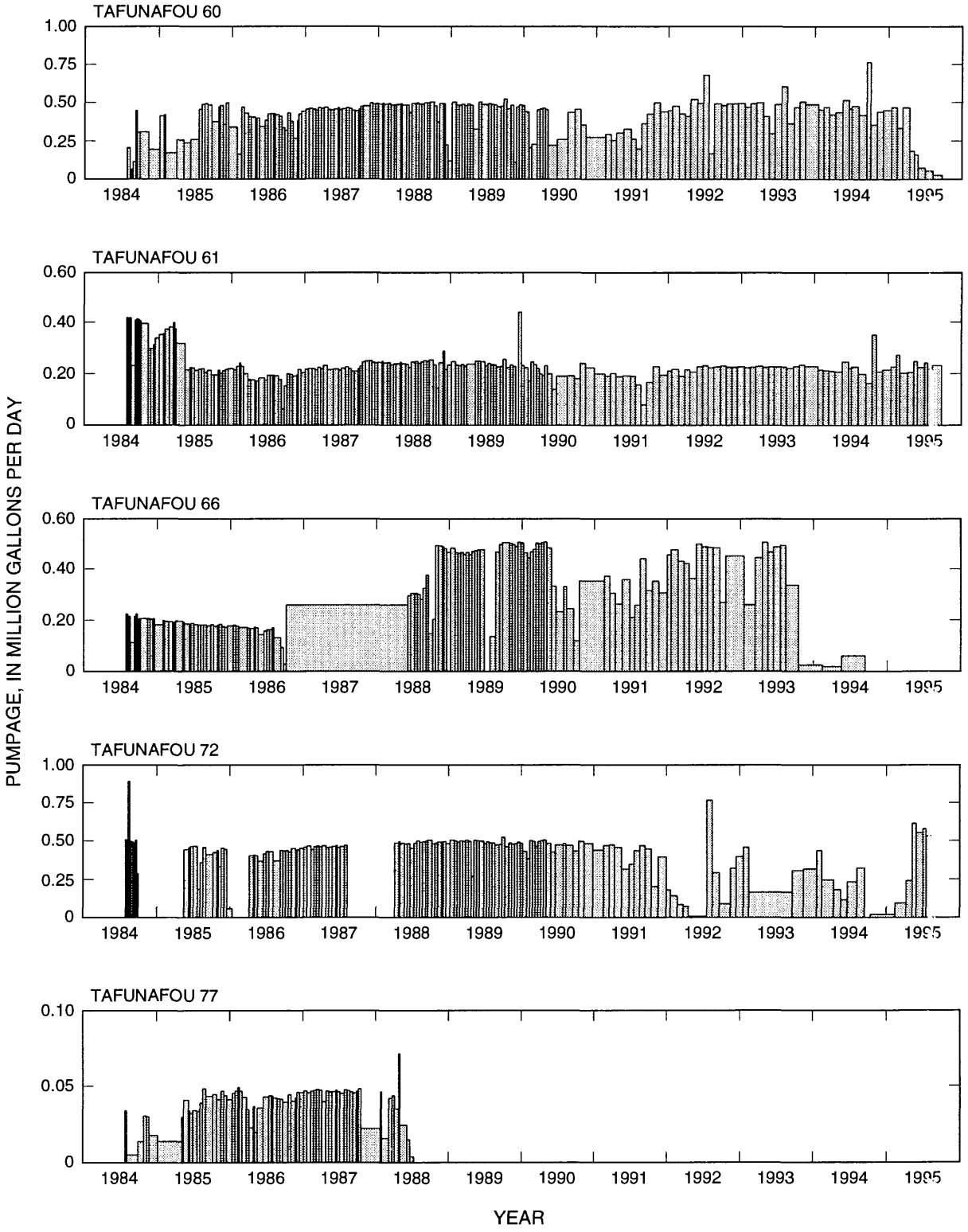

Figure 4. Pumpage, chloride concentrations, and water levels in the Tafunafou-Malaeimi-Mesepa well fields, Tutuila, American Samoa--*Continued.*

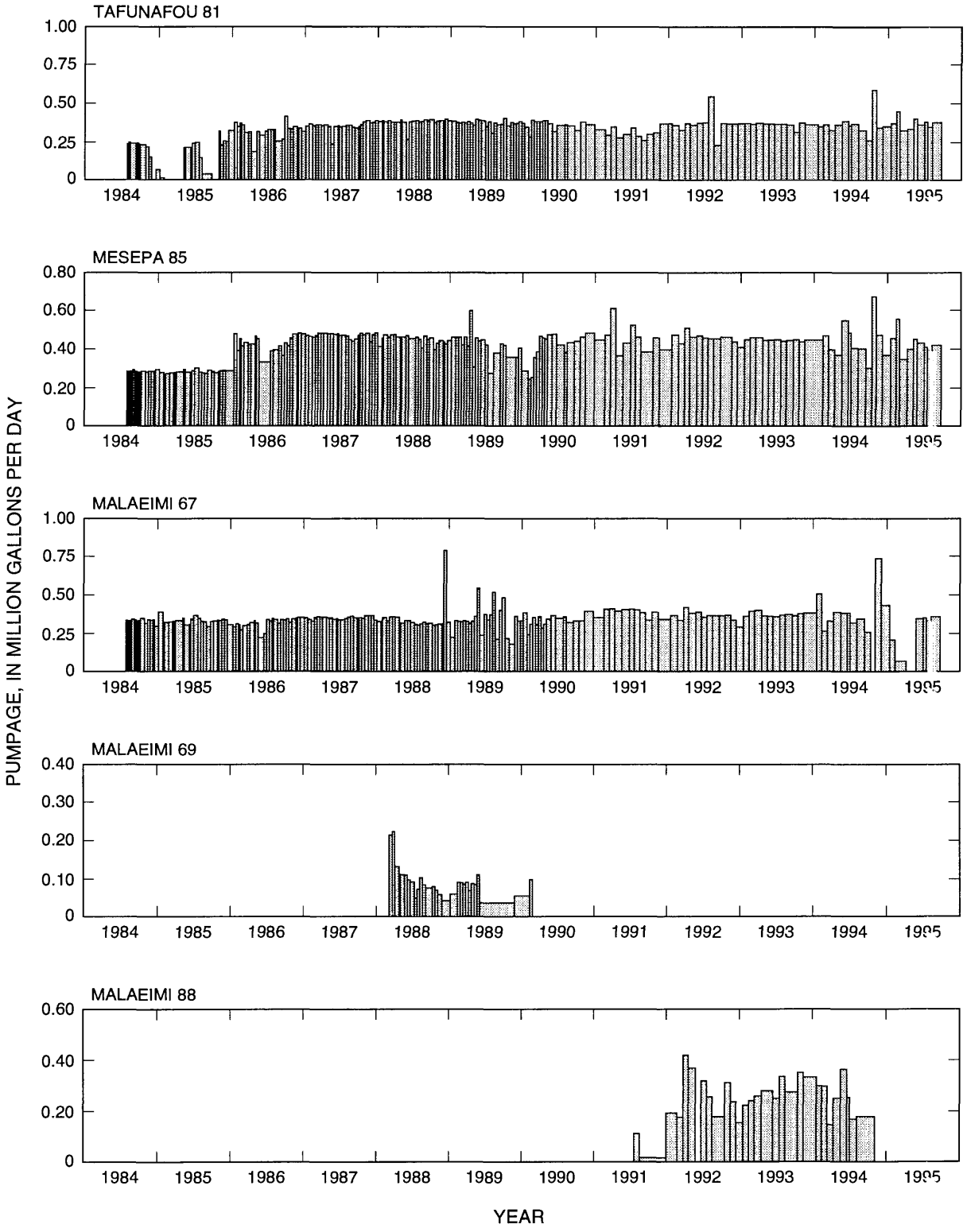

Figure 4. Pumpage, chloride concentrations, and water levels in the Tafunafou-Malaeimi-Mesepa well fields, Tutuila, American Samoa--*Continued.*

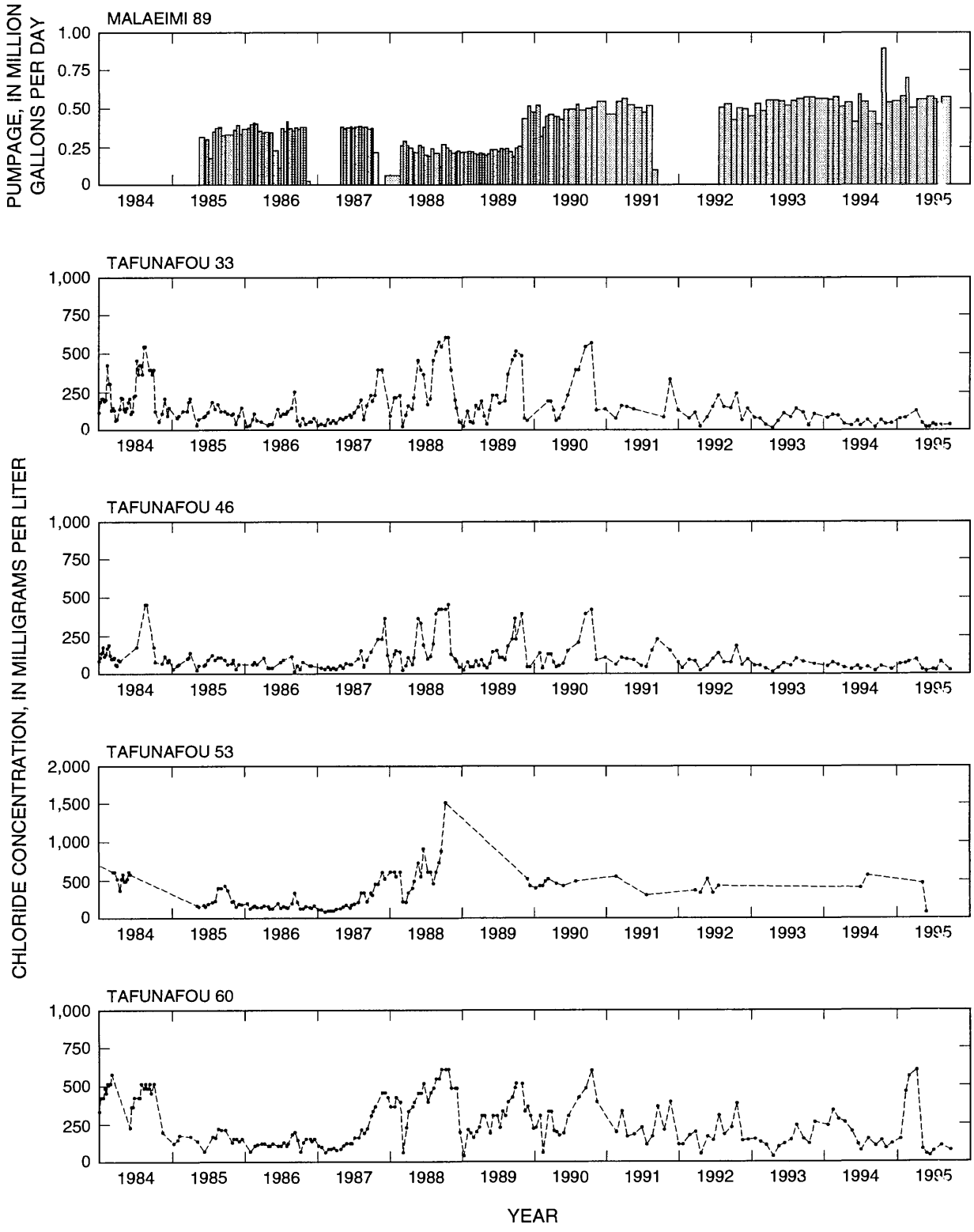

Figure 4. Pumpage, chloride concentrations, and water levels in the Tafunafou-Malaeimi-Mesepa well fields, Tutuila, American Samoa--*Continued.*

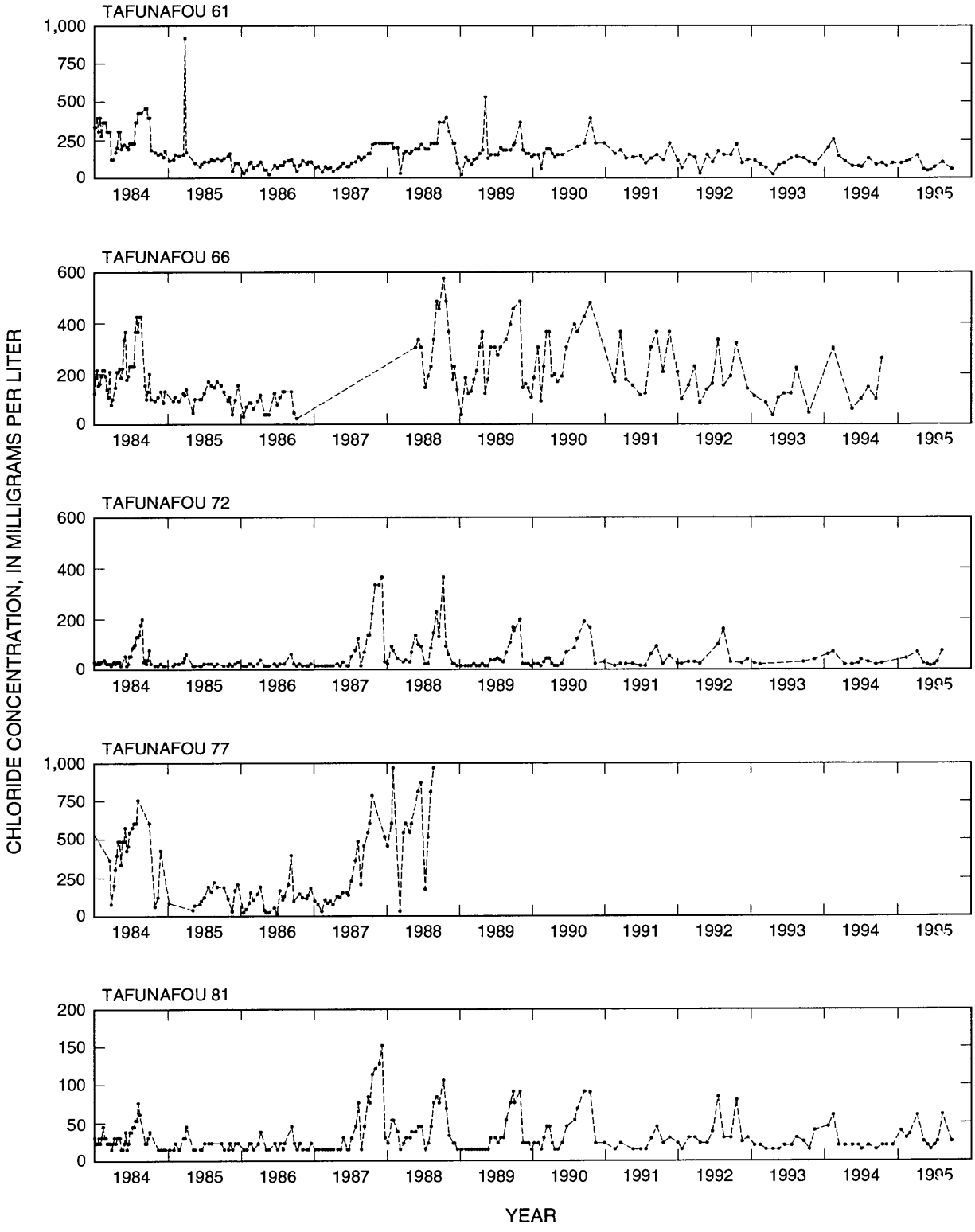

Figure 4. Pumpage, chloride concentrations, and water levels in the Tafunafou-Malaeimi-Mesepa well fields, Tutuila, American Samoa--*Continued.*

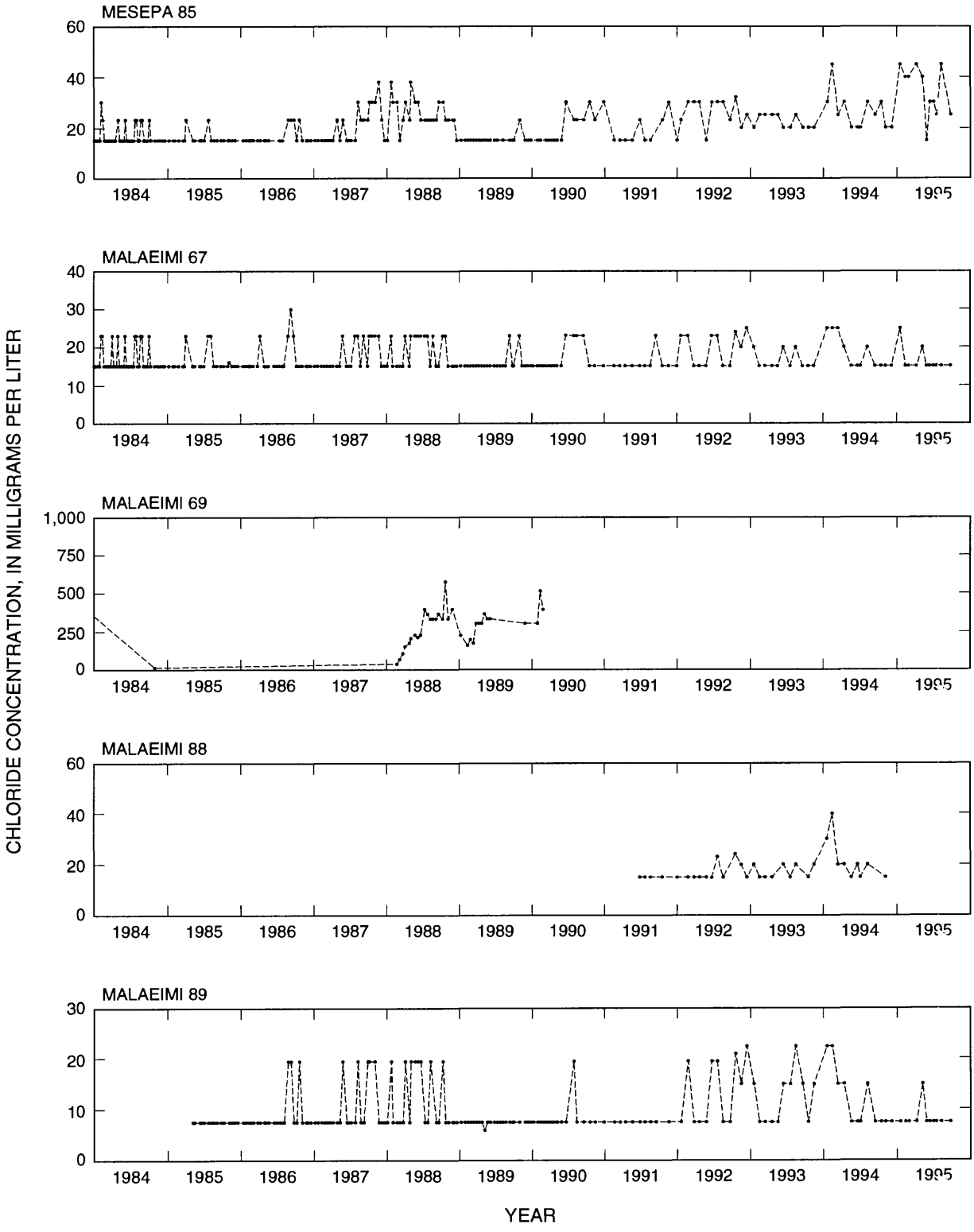

Figure 4. Pumpage, chloride concentrations, and water levels in the Tafunafou-Malaeimi-Mesepa well fields, Tutuila, American Samoa--*Continued.*

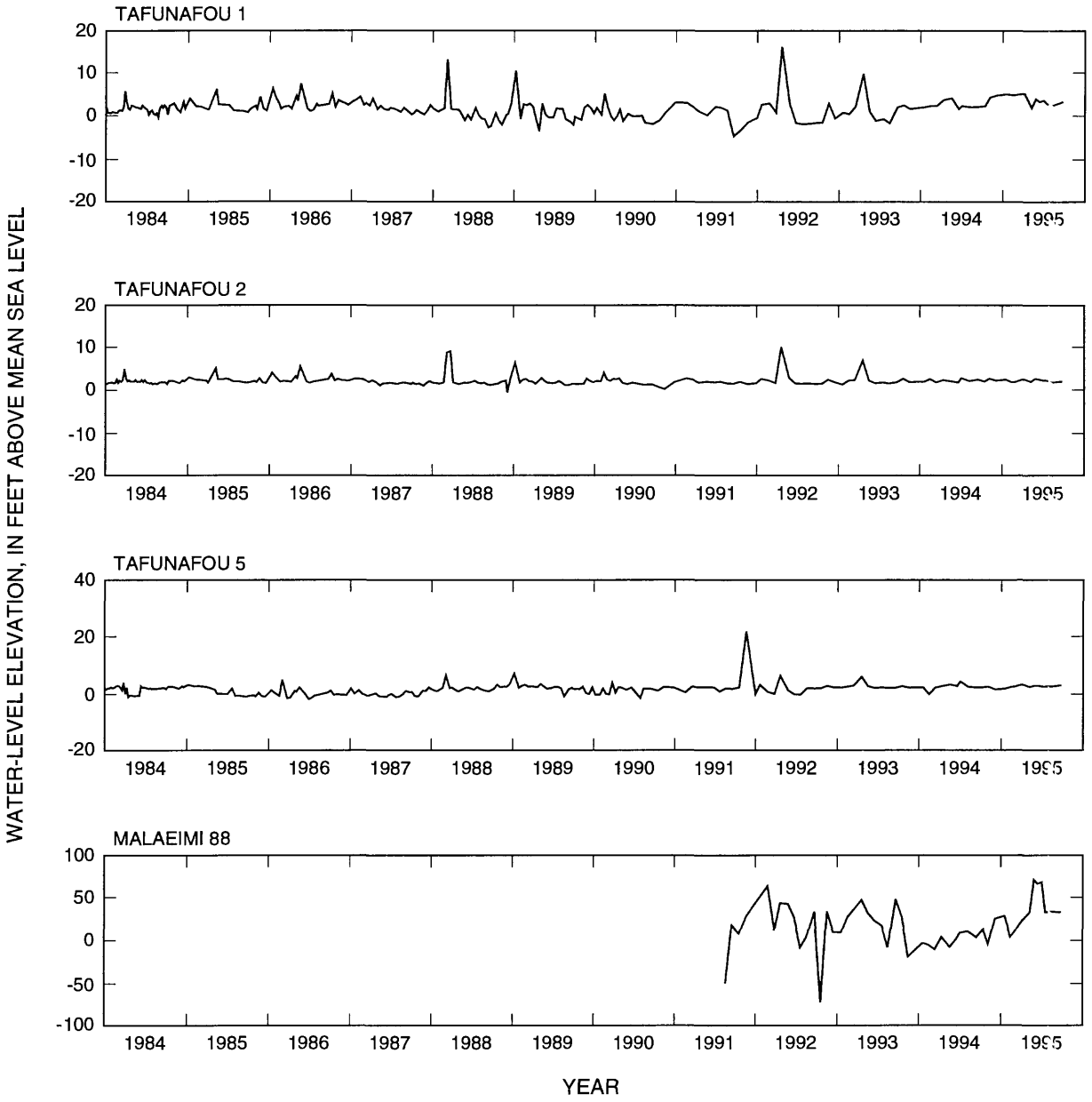

Figure 4. Pumpage, chloride concentrations, and water levels in the Tafunafou-Malaeimi-Mesepa well fields, Tutuila, American Samoa--*Continued.*

Iliili

The village of Iliili is located on the Tafuna-Leone Plain less than 1 mi from the southern coastline of Tutuila (fig. 3). Four wells were in production in 1995. Wells 62, 76, and 84 were pumping about 0.3 to 0.4 Mgal/d in the period from 1992 to 1995 (fig. 5). Well 79 was pumping about 0.2 Mgal/d in 1995. Chloride concentrations at wells 62, 76 and 79 remained below 200 mg/L over the entire pumping period. On the other hand, chloride concentrations in well 84 frequently exceeded 500 mg/L. Water levels, monitored at Iliili well 115, tend to be higher than in Tafunafou by about 2 to 3 ft.

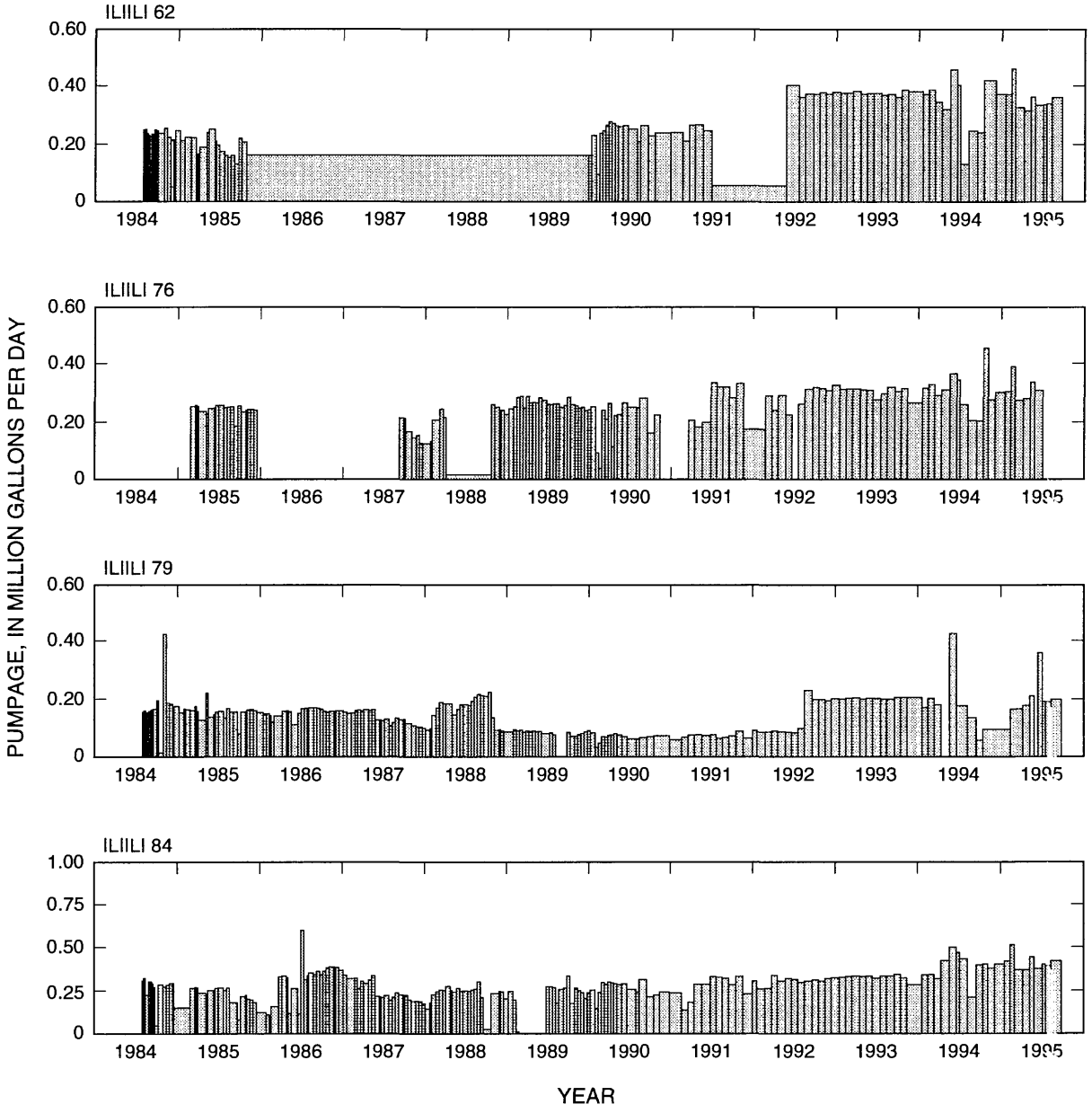

Figure 5. Pumpage, chloride concentrations, and water levels in the Iliili well field, Tutuila, American Samoa.

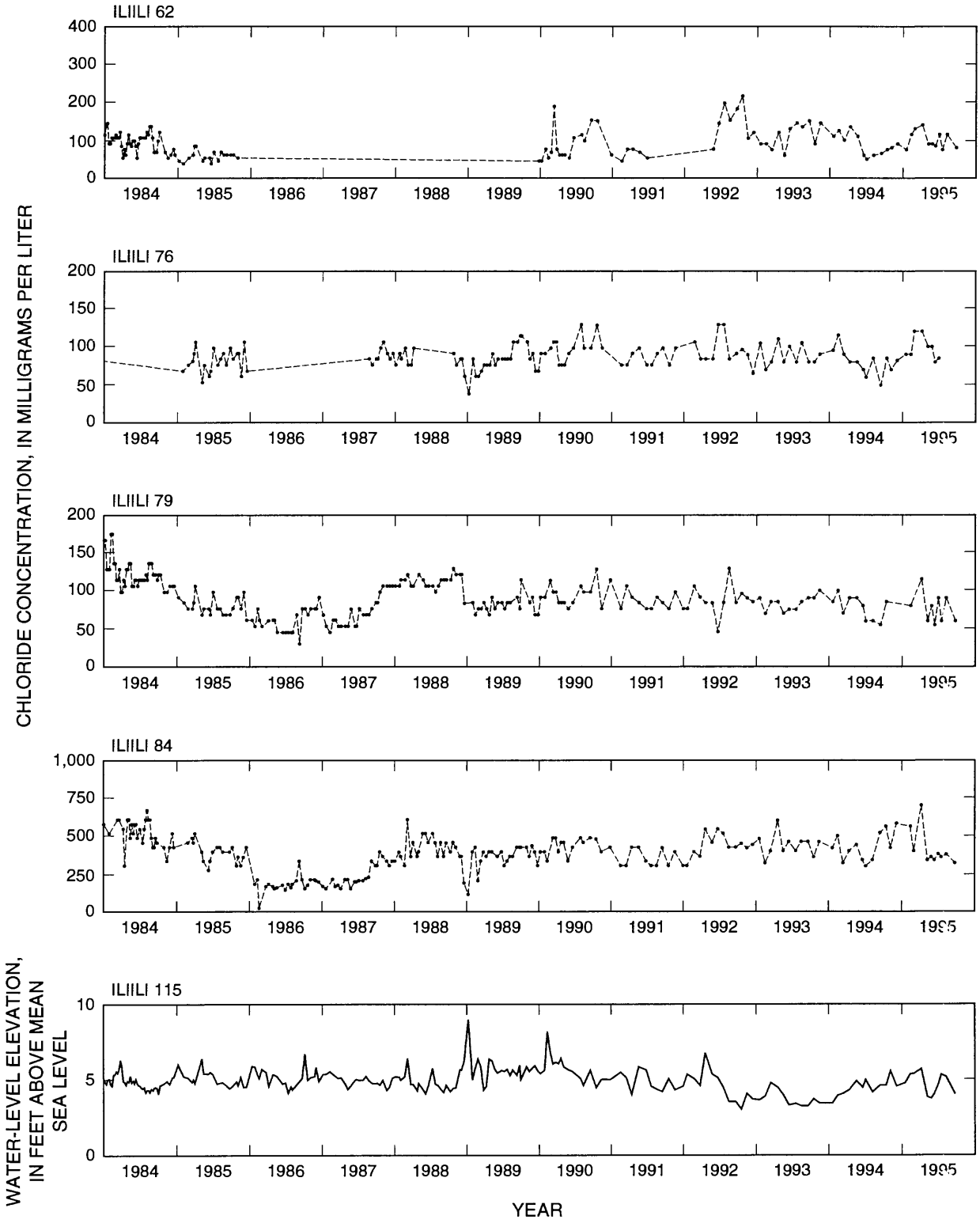

Figure 5. Pumpage, chloride concentrations, and water levels in the Iliili well field, Tutuila, American Samoa--*Continued.*

Malaeloa-Leone

The Malaeloa-Leone area (fig. 3) has 6 production wells, 70, 80, 91, 92, 93, and 119, which pumped at an average rate of 0.4 Mgal/d each from the mid to late 1980's through September 1995 (fig. 6). Chloride concentrations in wells 70, 80, 91 and 92 remained under 100 mg/L over the entire period of pumping. Chloride concentrations in well 93 periodically rose to about 100 mg/L but remained below 50 mg/L over most of its pumping period. Spikes in the chloride-concentration record occur during periods of lower-than-average rainfall in the Aasufou rainfall record (fig. 2). In well 119, chloride concentrations have exceeded 500 mg/L several times during the well's pumping history. As in well 93, the chloride concentrations in well 119 peak during periods of lower-than-average rainfall, except that the peaks are more frequent at well 119. Spikes in chloride concentration in both well 93 and well 119 display a saw-tooth pattern similar to those seen in the Tafunafou chloride-concentration record. Water levels monitored at wells 92 and 47 remained 1 to 10 ft above sea level during the entire pumping period.

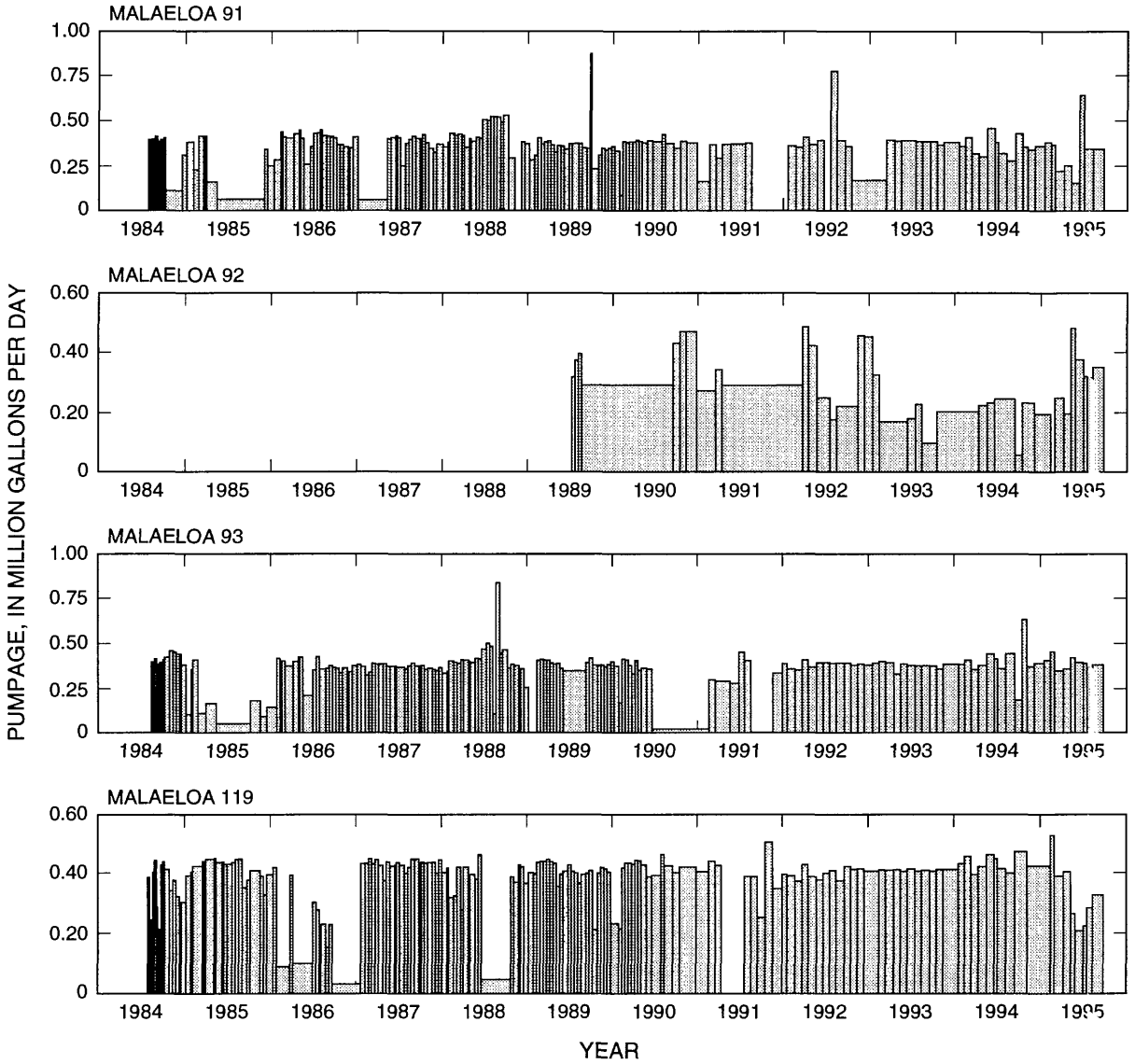

Figure 6. Pumpage, chloride concentrations, and water levels in the Malaeloa and Leone well fields, Tutuila, American Samoa.

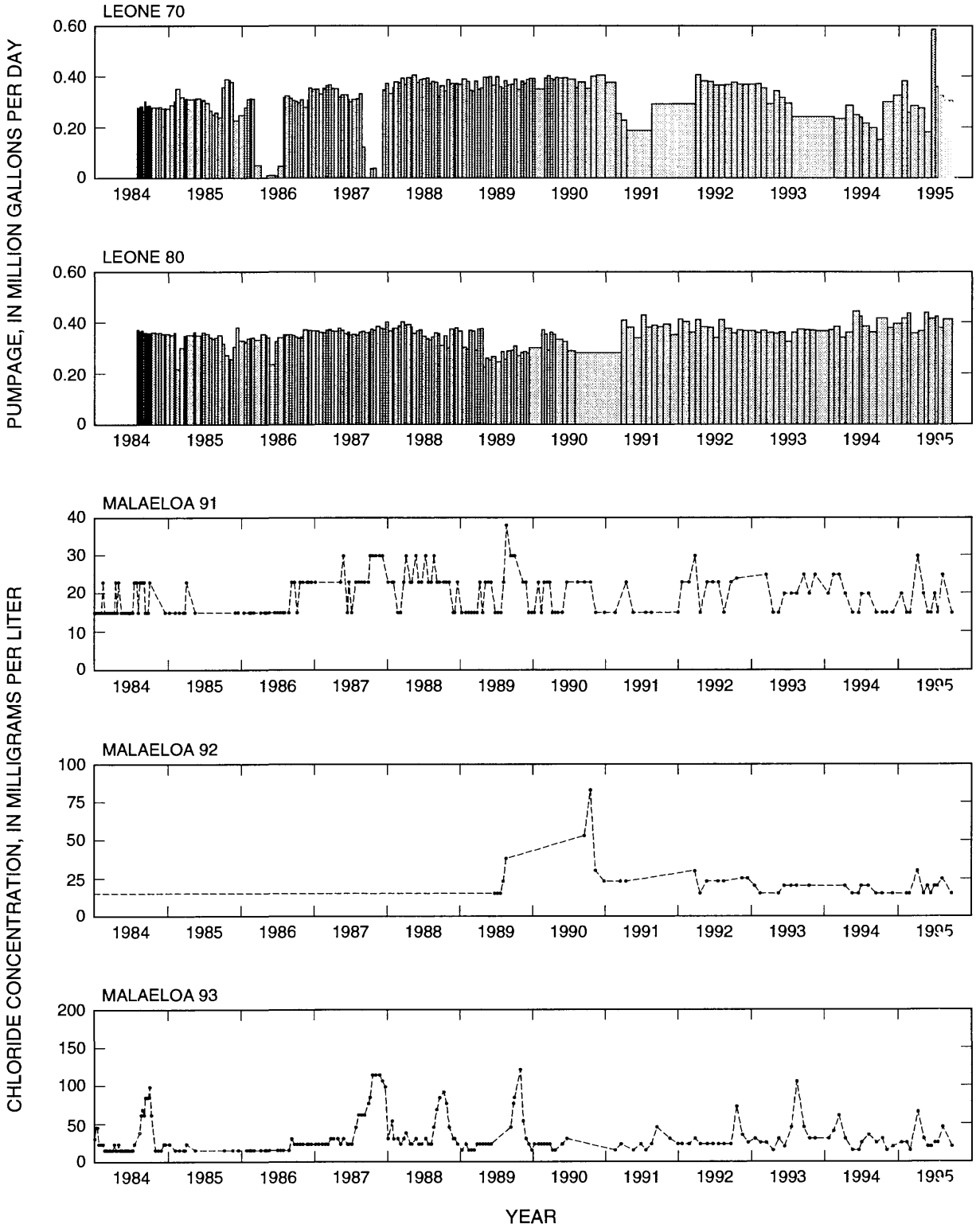

Figure 6. Pumpage, chloride concentrations, and water levels in the Malaeloa and Leone well fields, Tutuila, American Samoa--*Continued.*

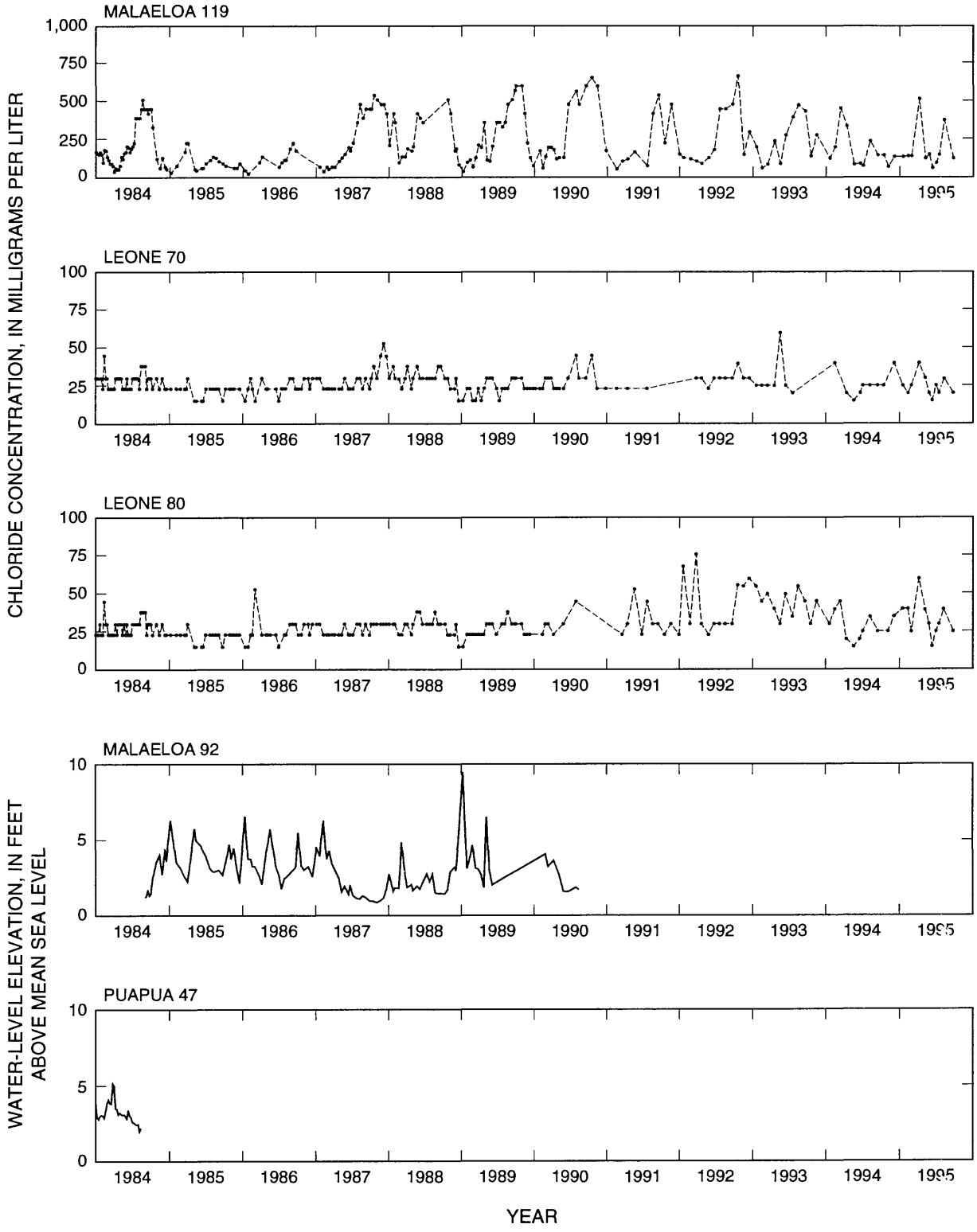

Figure 6. Pumpage, chloride concentrations, and water levels in the Malaeloa and Leone well fields, Tutuila, American Samoa--*Continued.*

Aloaufou

Wells 128 and 129 in Aloaufou (fig. 3) pump water from pyroclastic deposits that mantle the crest of Olotele Mountain (Bentley, 1975). The wells are new, having been put into production in 1994 at about 0.3 to 0.05 Mgal/d each (fig. 7). Chloride concentrations remained at a low 20 mg/L throughout the pumping period. Because the record is short, no trends in chloride concentration are apparent. No water levels have been reported for Aloaufou.

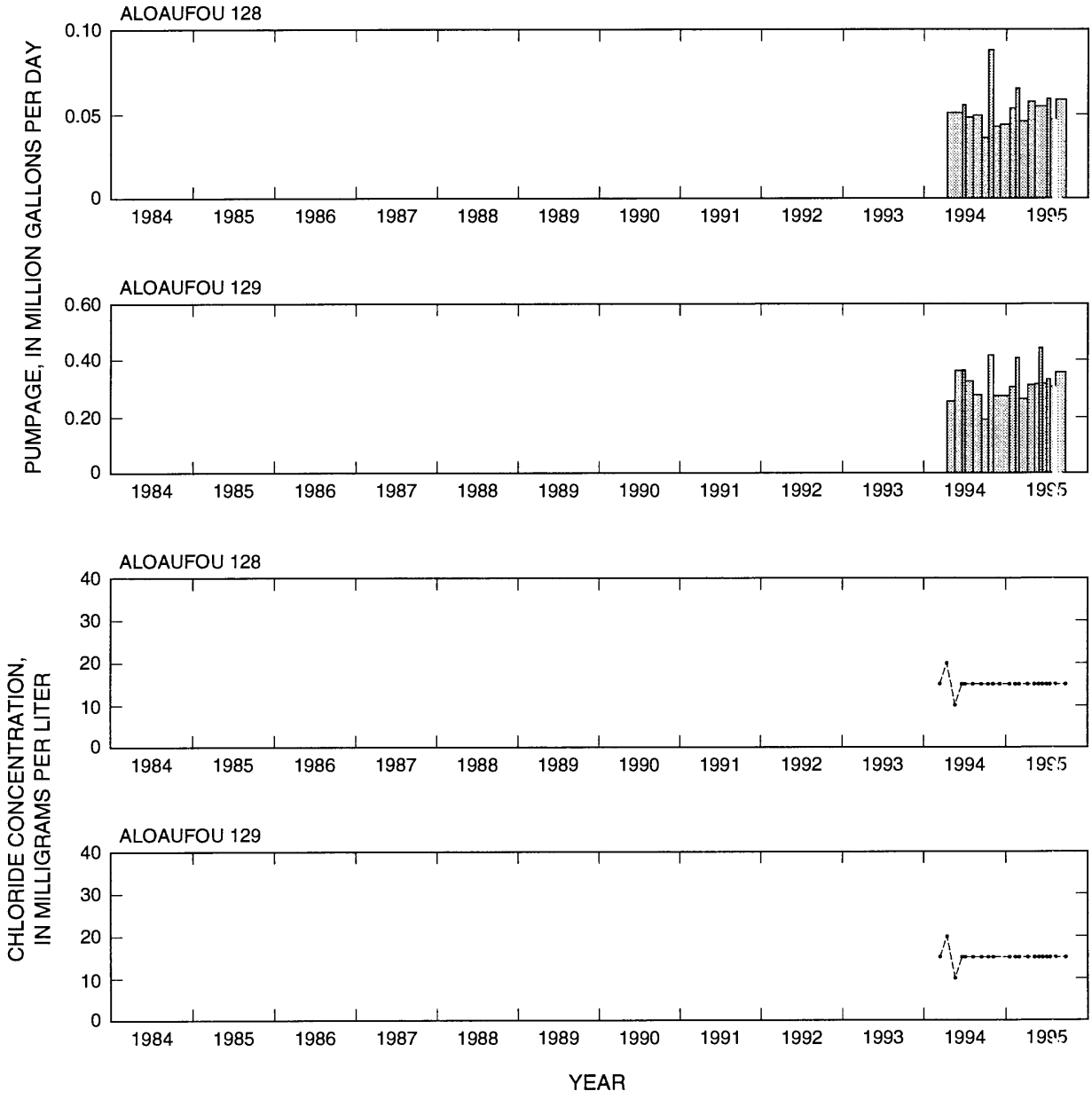

Figure 7. Pumpage and chloride concentrations in the Aloaufou well field, Tutuila, American Samoa.

Central Tutuila Ground-Water Data

Central Tutuila in this report includes the section of the island east of Fagasa Bay and Pala Lagoon up to and including the village of Laulii (fig. 8). Most of the well fields in central Tutuila lie in short valleys surrounding the large embayment of Pago Pago Harbor. The well fields of Fagaalu, Utulei, Fagatogo, Pago Pago, and Aua lie in valleys whose mouths open toward the harbor and form smaller embayments nested within the larger embayment of Pago Pago Harbor. To the north of the harbor a sheer cliff extends eastward from Pago Pago to Aua. Fagasa and Laulii well fields lie in valleys outside Pago Pago Harbor.

Because of the large natural harbor in Pago Pago, central Tutuila is the industrial center on the island. The population lives in villages located mostly on the relatively flat valley floors and coastal plain and extending a short distance up the adjoining hillsides. Ground water is developed mostly from wells in the valleys, but a pipeline connects the southern shore of central and eastern Tutuila with the highly productive well fields of western Tutuila. Fagasa is not connected to this water line but has its own wells.

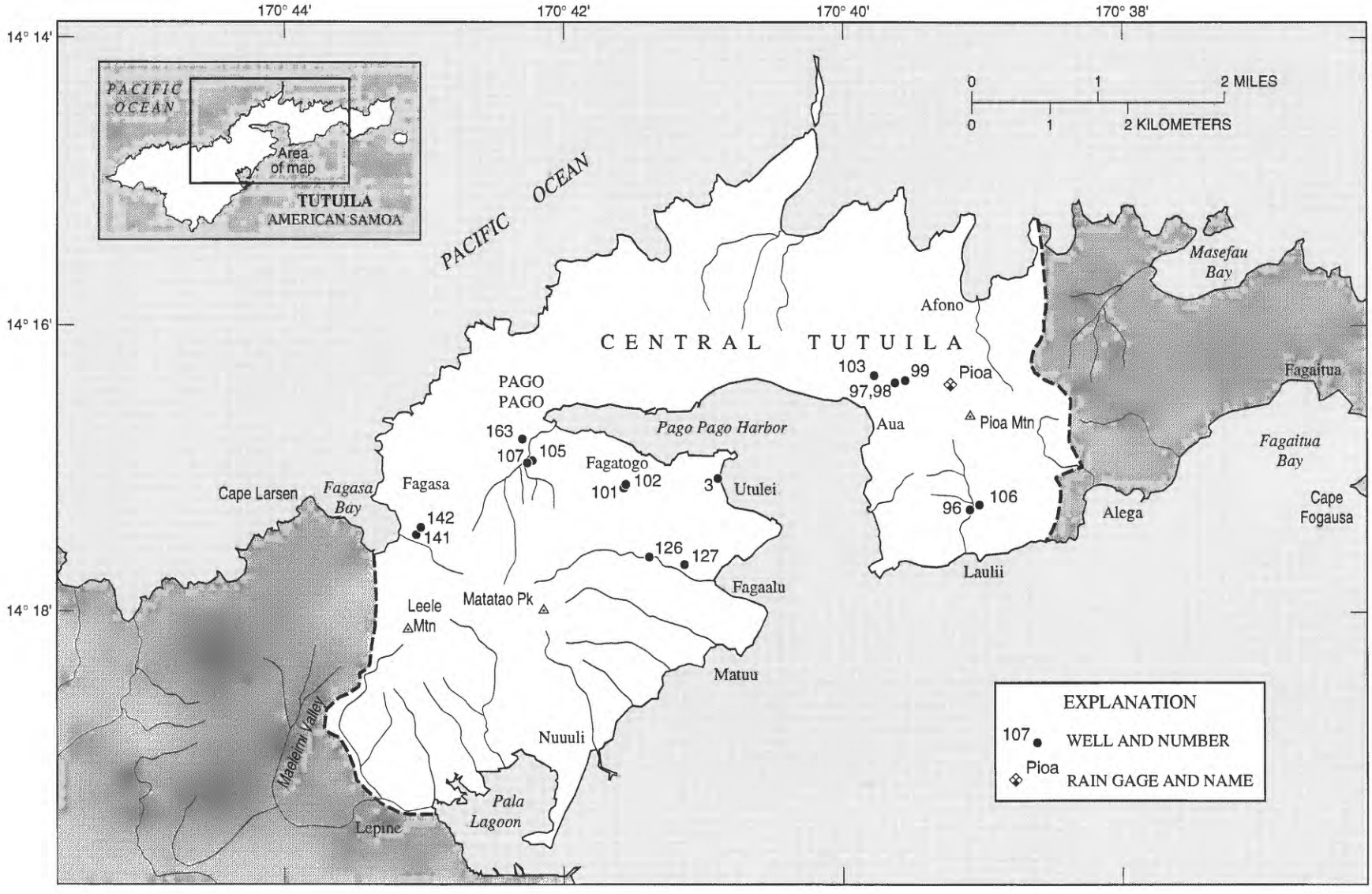

Figure 8. Wells in central Tutuila, American Samoa.

Fagaalu

Ground-water is developed in Fagaalu (fig. 8) from well 127, which is pumped intermittently and had an average pumpage of about 0.07 Mgal/d from 1993 through September 1995 (fig. 9). Chloride concentrations from this well during this period were below 100 mg/L, and usually below 50 mg/L.

Water levels in Fagaalu have been monitored at well 126 (drilled to an elevation of 171 ft below sea level) since 1987. Before 1989, water levels at well 126 were between 70 and 80 ft above sea level. This well was reportedly pumped at 60 gal/min during this period but this pumpage does not appear in the records from the data set of this study. When the well was deepened in 1989, and the upper part sealed to prevent seepage from a nearby stream, the water level dropped to about 25 ft above sea level. The pump was shut off and water levels climbed steadily to about 60 ft above sea level between 1989 and 1992. The water level plateaued in 1992, about the time well 127 was brought into production. A small rise in water level occurred in 1994. Higher-than-average rainfall was recorded at the Aasufou rain gage in the same period (fig. 2).

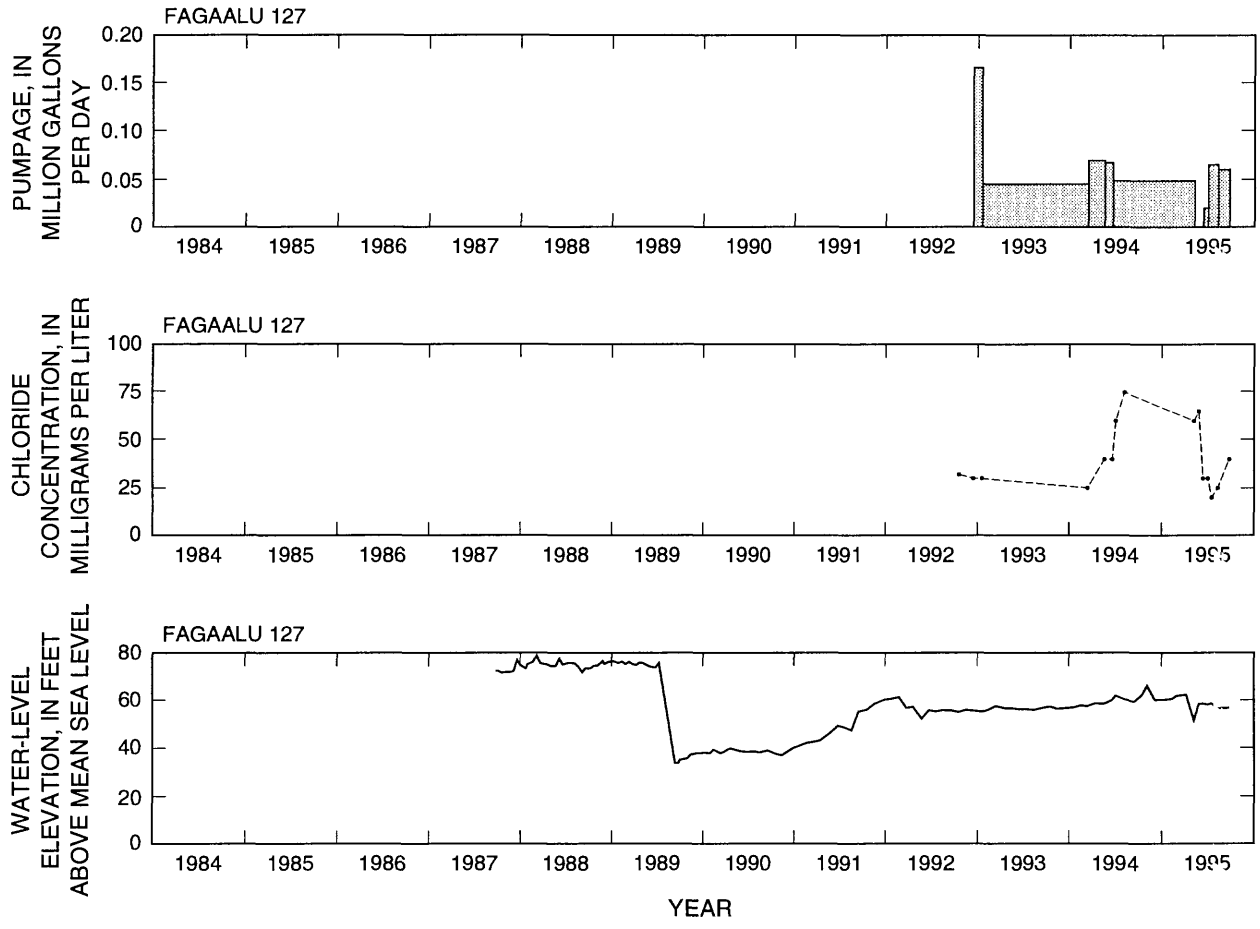

Figure 9. Pumpage, chloride concentrations, and water levels in the Fagaalu well field, Tutuila, American Samoa.

Utulei

Pumpage records for Utulei village in western Pago Pago Harbor (fig. 8) span the period from 1984 to 1990 when one production well (well 3) pumped about 0.010 to 0.02 Mgal/d (fig. 10). During this period, chloride concentrations fluctuated near 100 mg/L, occasionally exceeding 200 mg/L. In 1990 a leak was discovered in a water-transmission line near the well. When the leak was repaired, the chloride concentrations in the well rose, which prompted ASPA to conclude that the low chloride concentration in this well was an artifact of the leaking transmission line (Wilfredo Carreon, ASPA, oral commun., 1995). The well is no longer in production and no water-level data are available.

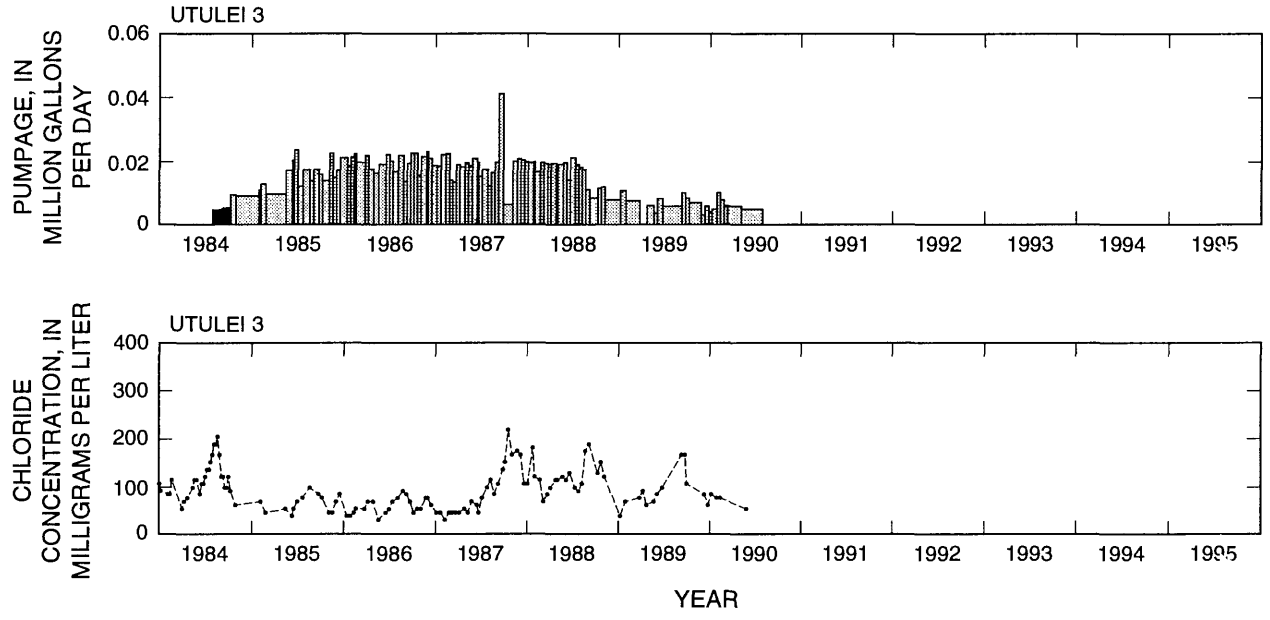

Figure 10. Pumpage and chloride concentrations in the Utulei well field, Tutuila, American Samoa.

Fagatogo

Pumpage in the Fagatogo area has alternated between wells 101 and 102 (fig. 8). Well 101 produced about 1 Mgal/d from 1986 to 1988, then well 101 was shut off and pumpage at 1 Mgal/d began at well 102 in 1988 and continued until 1992 (fig. 11). Pumpage was switched back to well 101 in 1992 but reduced to about 0.5 Mgal/d. When one well is pumped, the other well is used as a monitor well for water levels. Chloride concentrations in the pumped wells remained below 50 mg/L at both wells throughout their pumping history. Water levels in the monitor wells have dropped below sea level during this period.

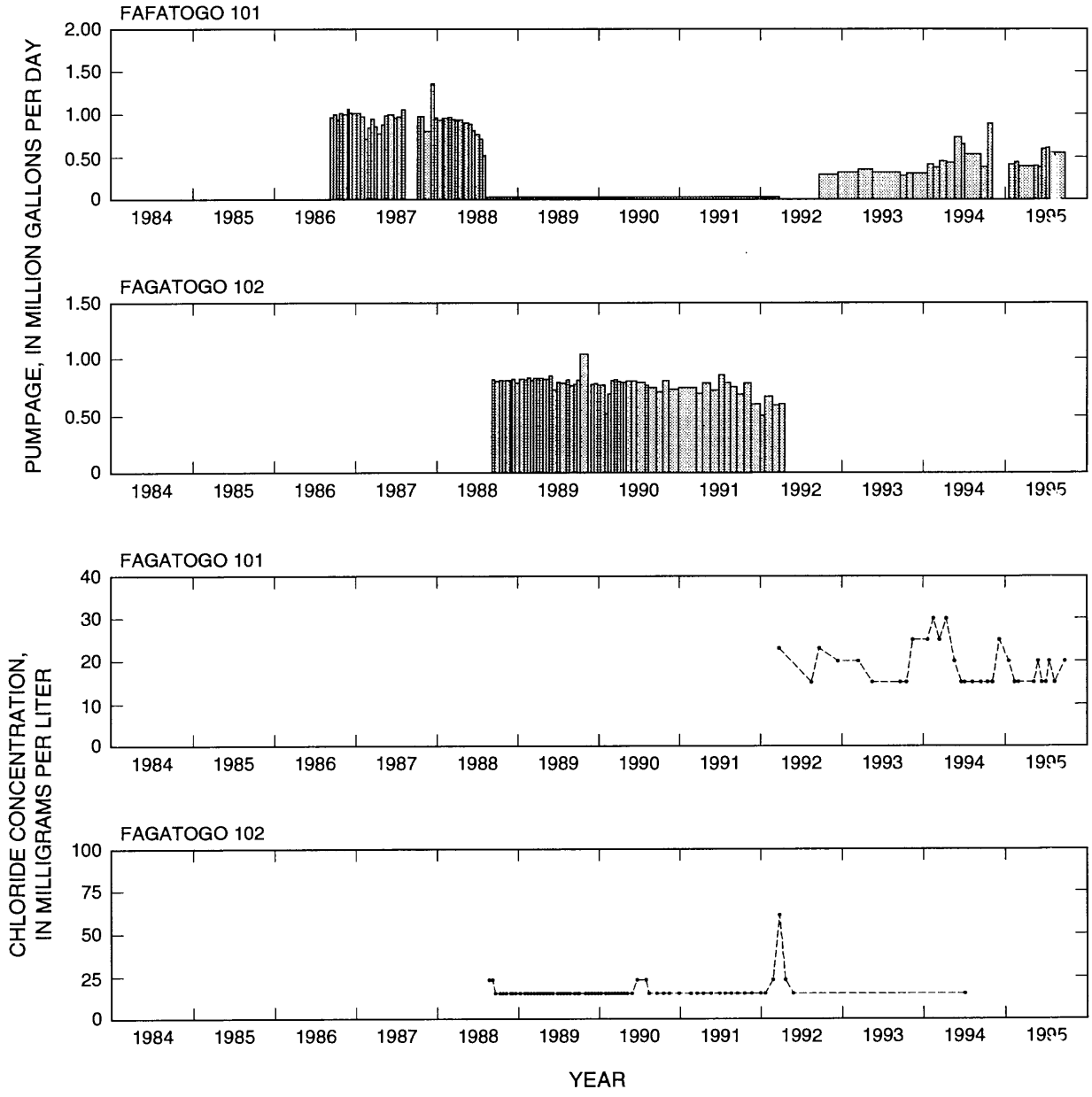

Figure 11. Pumpage and chloride concentrations in the Fagatogo well field, Tutuila, American Samoa.

Pago Pago

Pago Pago village is located at the farthest inland corner of Pago Pago Harbor (fig. 8). Three production wells are situated in this area. Well 105 has been pumped since late 1988 at rates of about 0.2 Mgal/d, while well 107 has been pumped about 0.5 Mgal/d (fig. 12). Well 163 began pumping in mid-1995 at about 0.04 Mgal/d. All of the Pago Pago wells have maintained chloride concentrations of less than 30 mg/L throughout their pumping history. Pre-pumping water levels at well 105 fluctuated between 45 to 50 ft above sea level. Pumping water levels are not available at well 105. Water levels at well 107 during pumping initially declined to about 3 ft above sea level and dropped as low as 1 ft below sea level between 1989 and 1990, but have fluctuated at about 3 ft above sea level since then.

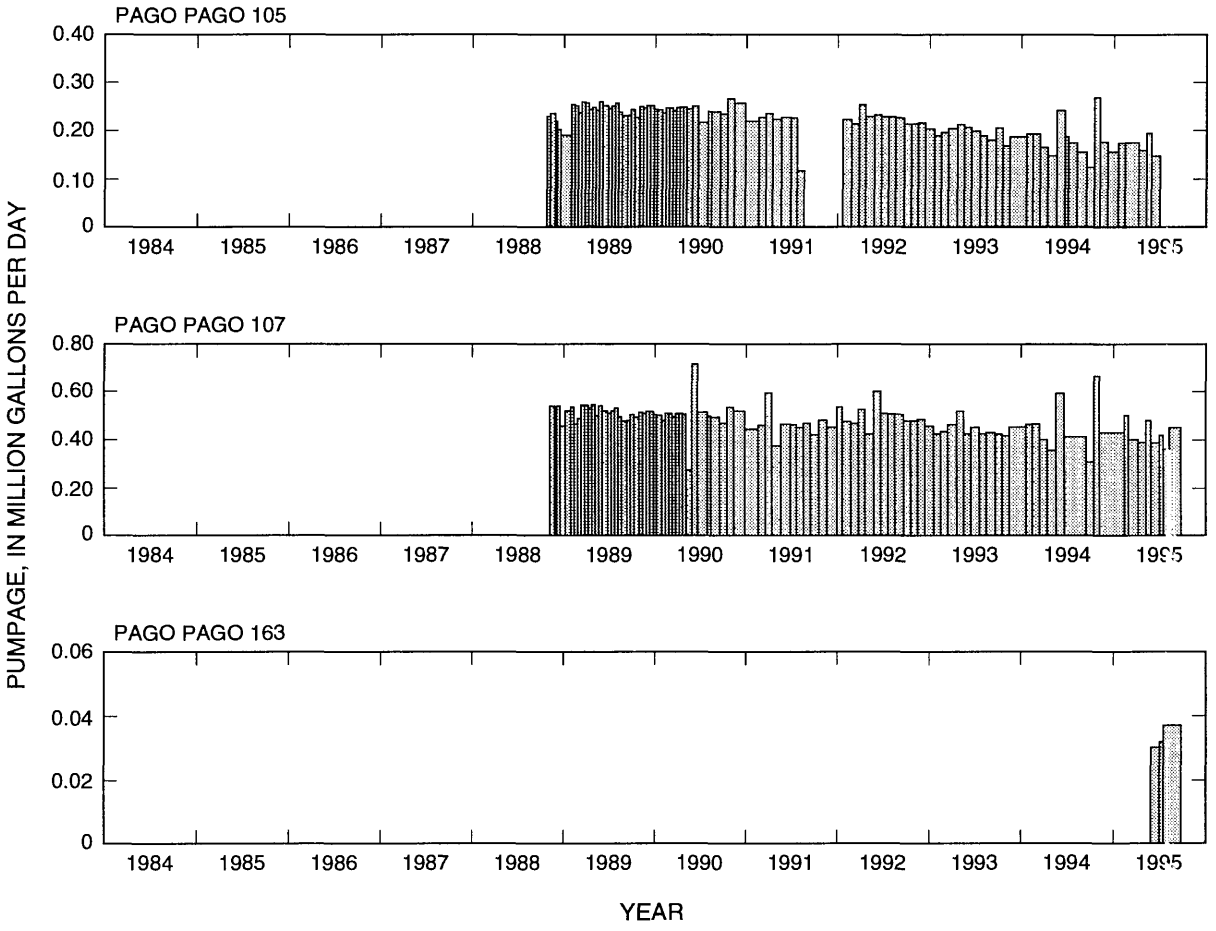

Figure 12. Pumpage, chloride concentrations, and water levels in the Pago Pago well field, Tutuila, American Samoa.

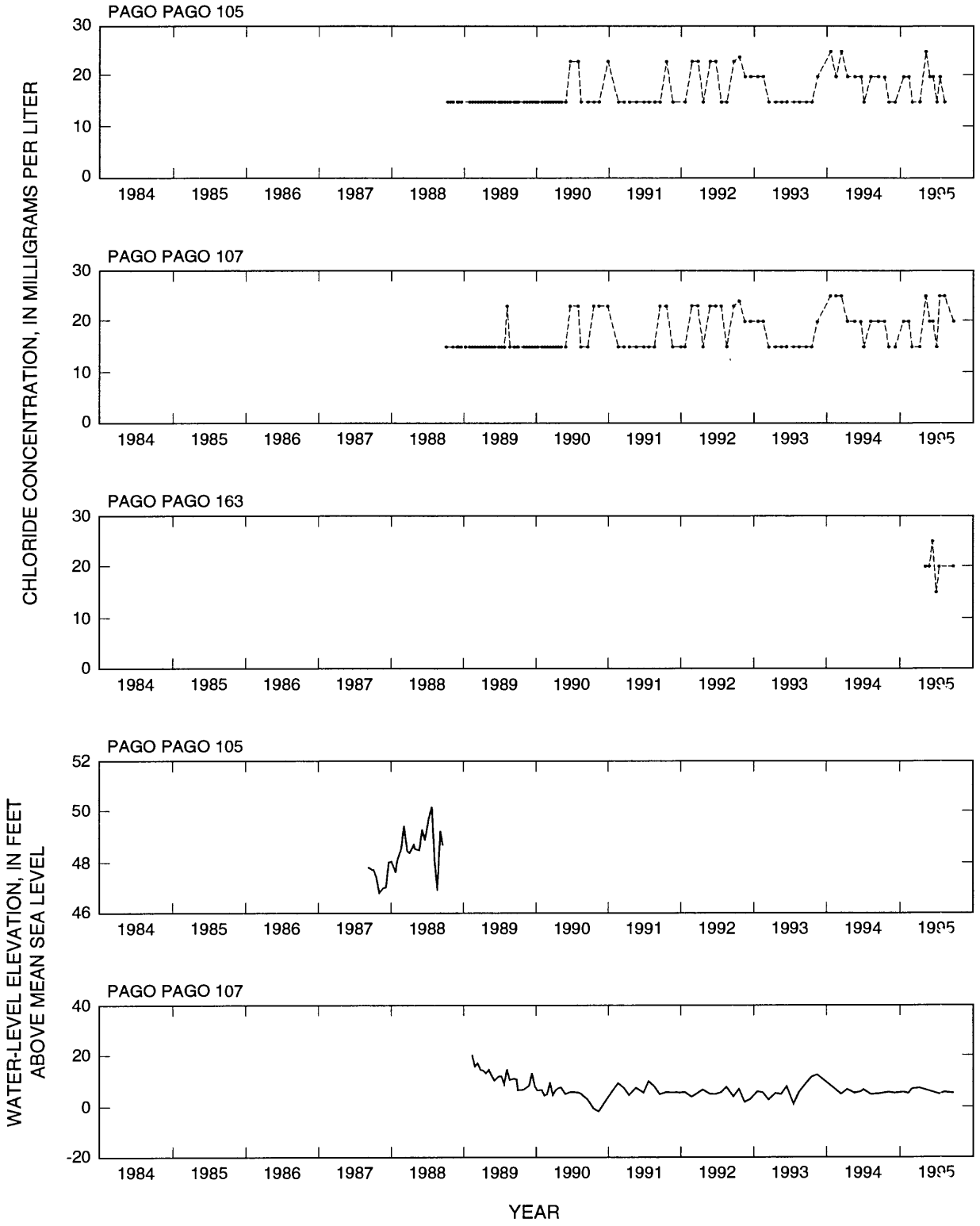

Figure 12. Pumpage, chloride concentrations, and water levels in the Pago Pago well field, Tutuila, American Samoa--*Continued.*

Aua

Aua has three wells that have pumpage records between 1984 and September 1995 (fig. 8). Wells 97 and 98 began pumping in 1984 and well 99 began pumping in 1985 (fig. 13). Wells 97 and 99 are still in production, whereas well 98 has not been pumped since 1987. Initial chloride concentrations were below 100 mg/L in all three production wells, but after about 2 to 3 years of pumping each well at 0.3 to 0.4 Mgal/d all of the wells had sharp increases in chloride concentrations. During the early 1980's when pumping was heaviest, water levels dropped as far as 60 ft below sea level (fig. 13). In the period between 1987 and 1991 after the initial rise in chloride concentration, pumpage at well 98 was halted and pumpage at well 97 was intermittent. Despite the reduction in pumpage, the chloride concentrations remained near 400 mg/L over most of the period and never returned back to the prepumping level. When a more steady pumpage of 0.4 Mgal/d at well 97 resumed in 1991, chloride concentrations rose to even higher levels than before, occasionally reaching nearly 900 mg/L.

At well 99, pumpage decreased from 0.035 Mgal/d prior to late 1989 to 0.015 Mgal/d between 1989 and 1994 (fig. 13). Chloride concentration decreased at the well during the same period. Pumpage increased to 0.05 Mgal/d in 1994-95; chloride concentrations increased to over 500 mg/L during this period.

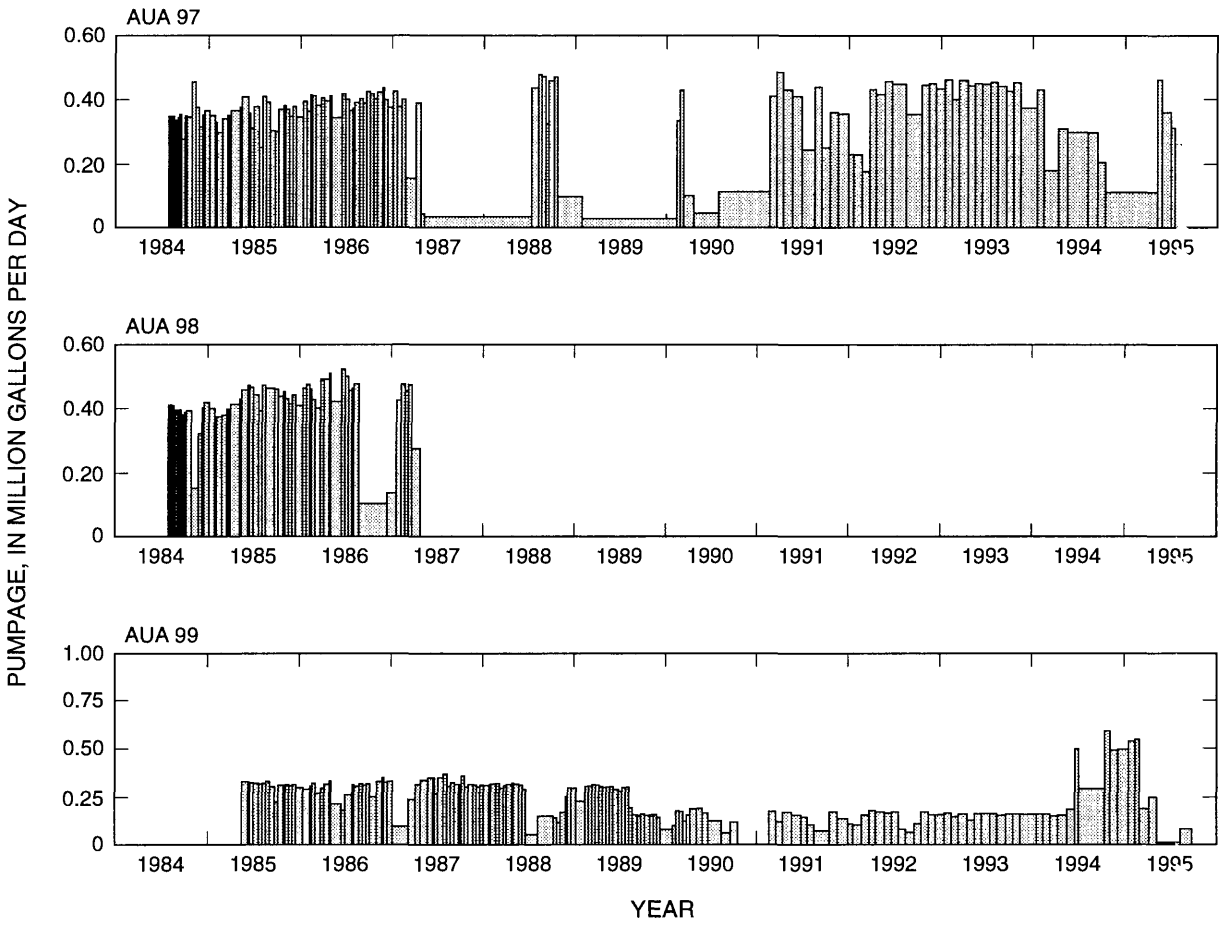

Figure 13. Pumpage, chloride concentrations, and water levels in the Aua well field, Tutuila, American Samoa.

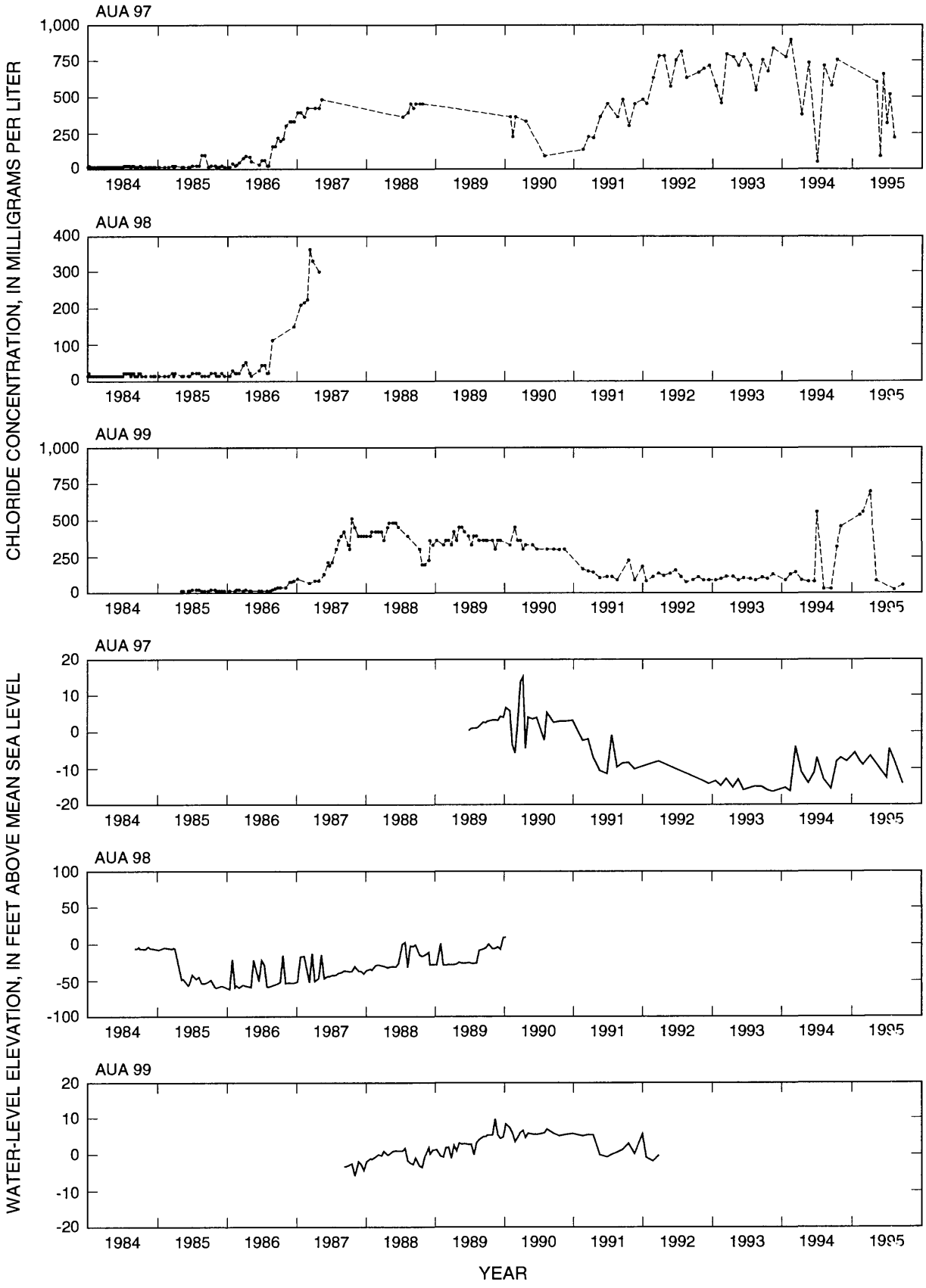

Figure 13. Pumpage, chloride concentrations, and water levels in the Aua well field, Tutuila, American Samoa--*Continued.*

Laulii

Laulii village on the south coast of Tutuila just outside the eastern end of Pago Pago Harbor has one pumping well (well 96) and one monitor well (well 106) (fig. 8). Pumpage at well 96 was maintained at about 0.06 to 0.10 Mgal/d from late 1988 through 1994 (fig. 14). Chloride concentrations in this well remained less than 100 mg/L over this period, even though well 96 was drilled to 229 ft below sea level, and water levels at well 106 have fluctuated between 15 and 27 ft above sea level.

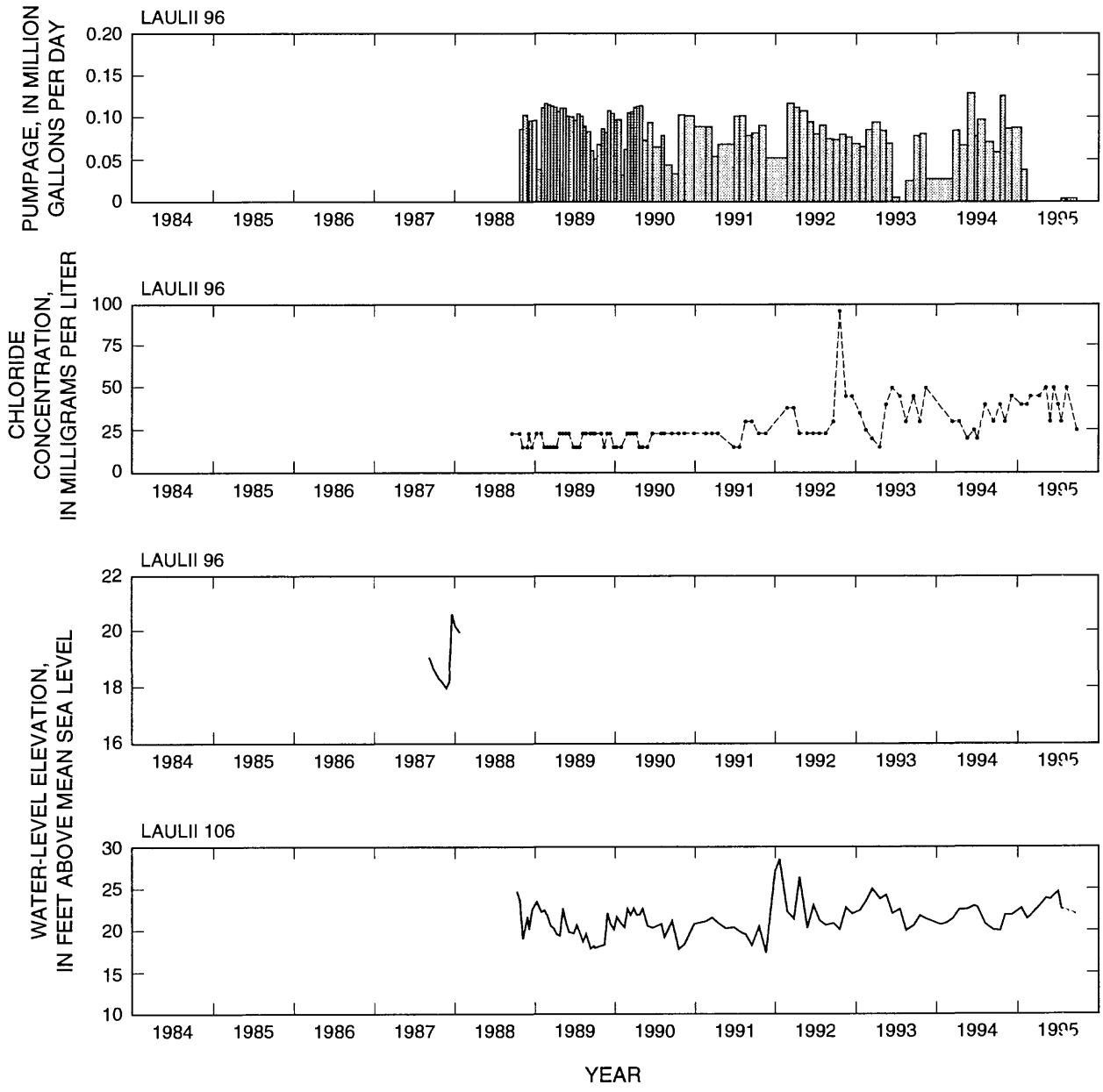

Figure 14. Pumpage, chloride concentrations, and water levels in the Laulii well field, Tutuila, American Samoa.

Fagasa

Fagasa village, on the northern central coast of Tutuila, has two production wells in the back of valleys that do not extend far from the sea coast (fig. 8). Well 141 has pumped at various rates between 0 and 0.03 Mgal/d with an average of 0.01 to 0.02 Mgal/d since 1991 (fig. 15). Chloride concentrations at this well rose gradually but were maintained below 100 mg/L from 1991 through early 1995. Chloride concentrations fluctuated greatly since then, exceeding 200 mg/L on two occasions. Well 142, which is shallower than well 141, also has been pumping since 1991, but only intermittently and at a lower rate. Chloride concentrations at well 142 were higher on average, varied over a greater range, and increased more steeply than at well 141 during this period.

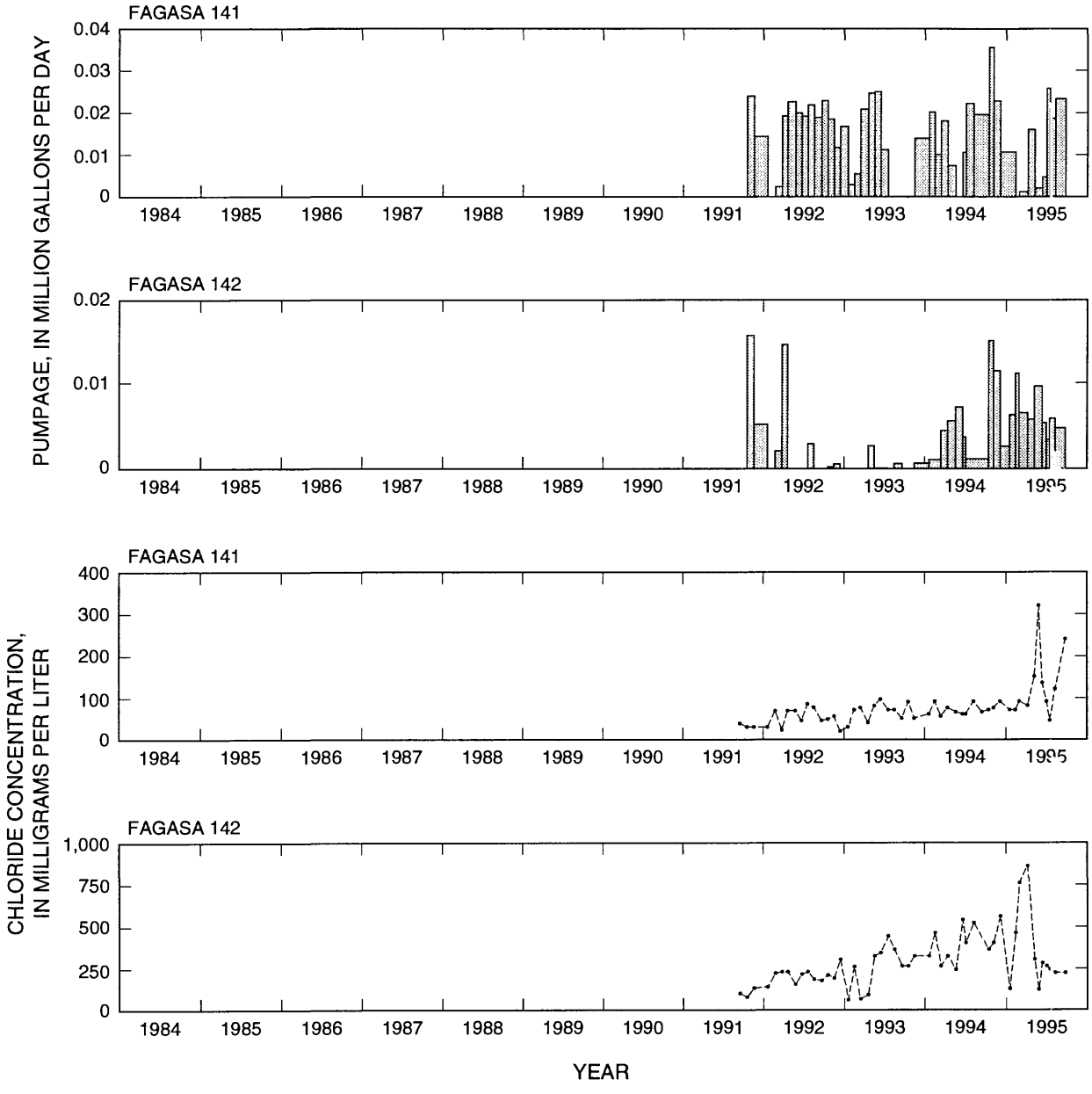

Figure 15. Pumpage and chloride concentrations in the Fagasa well field, Tutuila, American Samoa.

EASTERN TUTUILA GROUND-WATER DATA

Eastern Tutuila is formed by steep mountains that rise abruptly from the coastline. Short valleys have been cut by stream erosion and drowning of the lower valleys has created many embayments along both the northern and southern coasts (fig. 16). Valley fill and coastal sediments create the only flat-lying areas in this rugged part of the island. Eastern Tutuila is more sparsely populated than central and western Tutuila. Most of the population is distributed in the many small villages on the flat-lying terrain at the mouths of valleys. Ground-water development in eastern Tutuila includes 10 pumping wells which serve local populations in the villages of Fagaitua, Alofau, Alao, and Tula. All of the wells are located in low-lying areas near the villages.

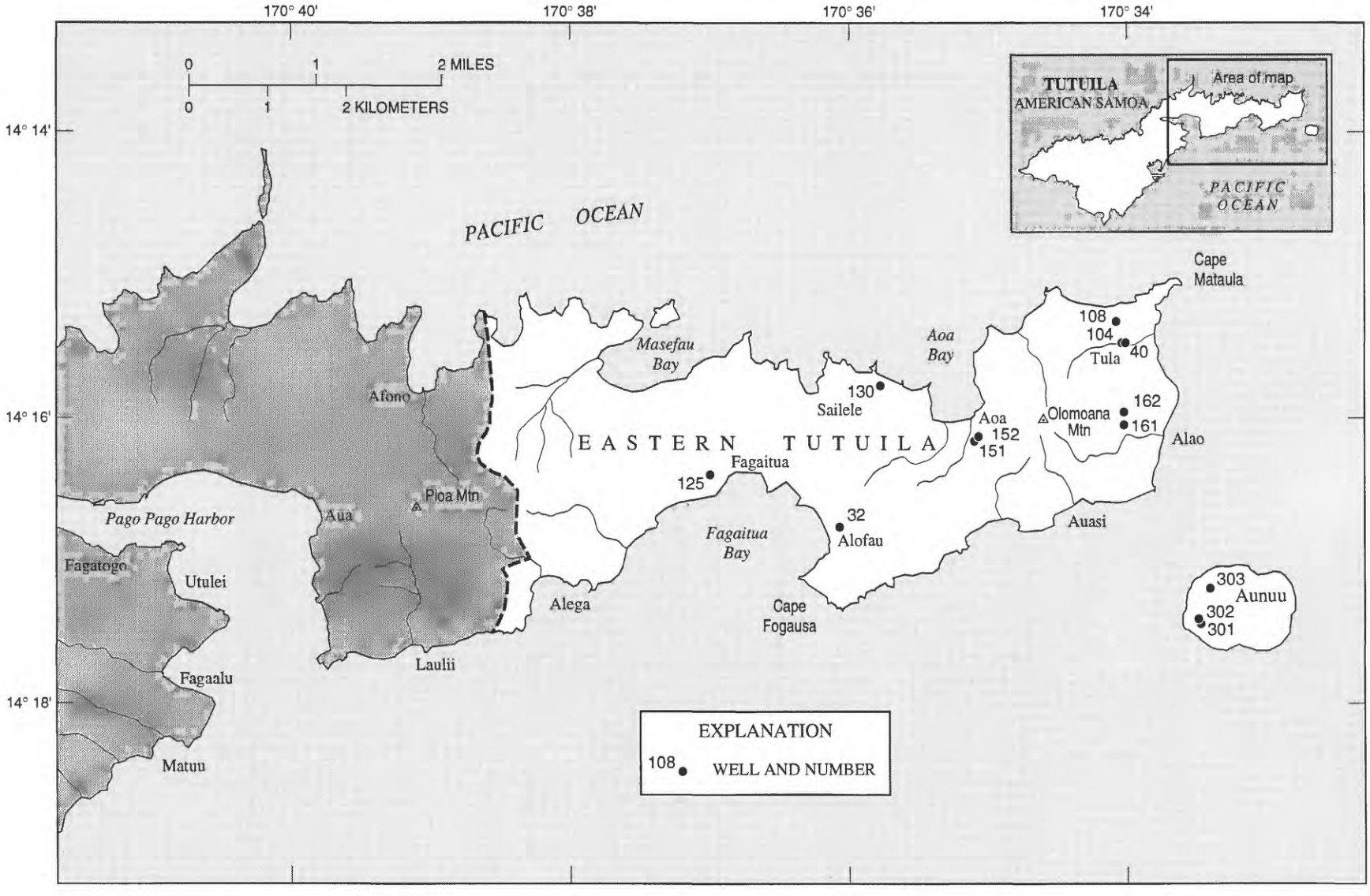

Figure 16. Wells in eastern Tutuila and Aunuu, American Samoa.

Fagaitua

One production well at Fagaitua village (well 125, fig. 16) on the southern coast of Tutuila has a short pumping record between 1989 to 1991, although the chloride concentration record extends back to 1988. The water meter was reported to be malfunctioning on April 24, 1989. It is not known how long prior to this date the meter was broken. At the beginning of the record, chloride concentrations were already higher than 1,000 mg/L (fig. 17). Chloride concentrations rose to nearly 2,000 mg/L in 1989 during a period when the well was pumping about 0.03 Mgal/d and rainfall at the Pioa rain gage was lower than average (fig. 2). Pumpage was reduced in late 1989 and stopped for a period in early 1990. Pumping resumed at about 0.010 Mgal/d per day in late 1990 to 1991. Chloride concentrations remained at about 1,000 mg/L over this period. There are no records of pumping beyond 1991 nor are there any records of water levels in this area.

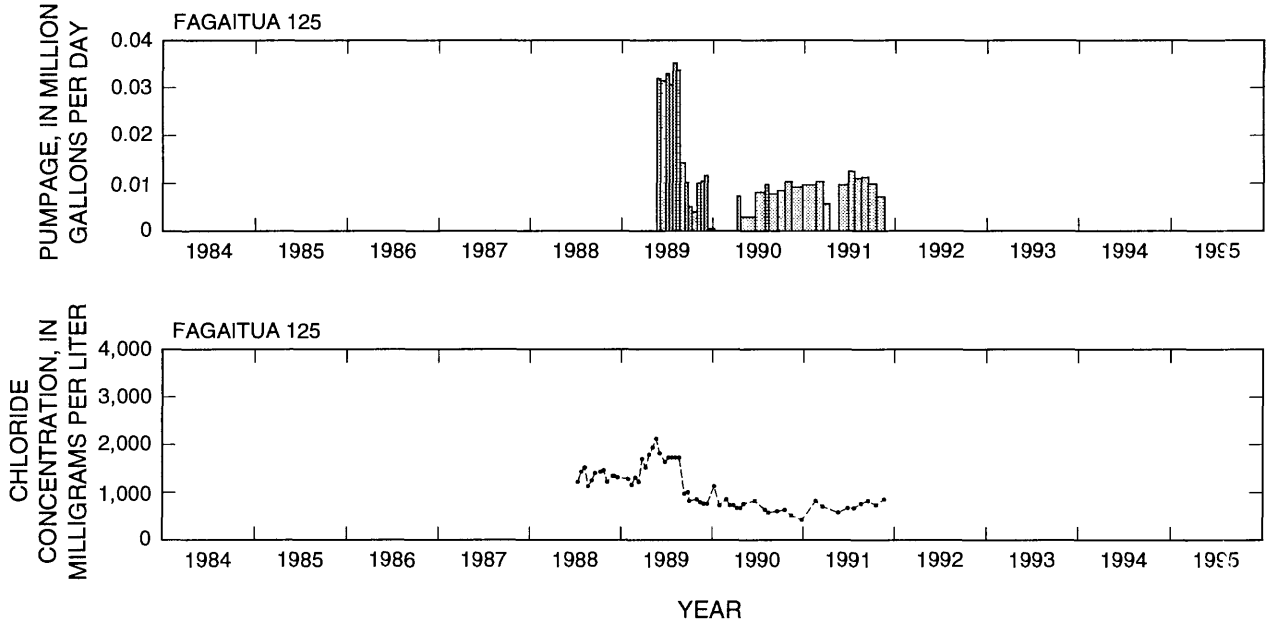

Figure 17. Pumpage and chloride concentrations in the Fagaitua well field, Tutuila, American Samoa.

Alofau

One production well at Alofau village on the southern coast of Tutuila (fig. 16) pumped at a rate of about 0.05 Mgal/d from 1988 to 1990 (fig. 18). During this period, chloride concentrations rose from less than 1,000 mg/L to over 2,000 mg/L. Pumpage gradually decreased to zero from mid 1990 to the end of 1991, at which time the chloride concentrations gradually returned to less than 1,000 mg/L. Pumpage resumed at a rate of 0.01 to 0.02 Mgal/d from late 1992 to late 1994. Chloride concentrations fluctuated mostly below 1,000 mg/L in 1995.

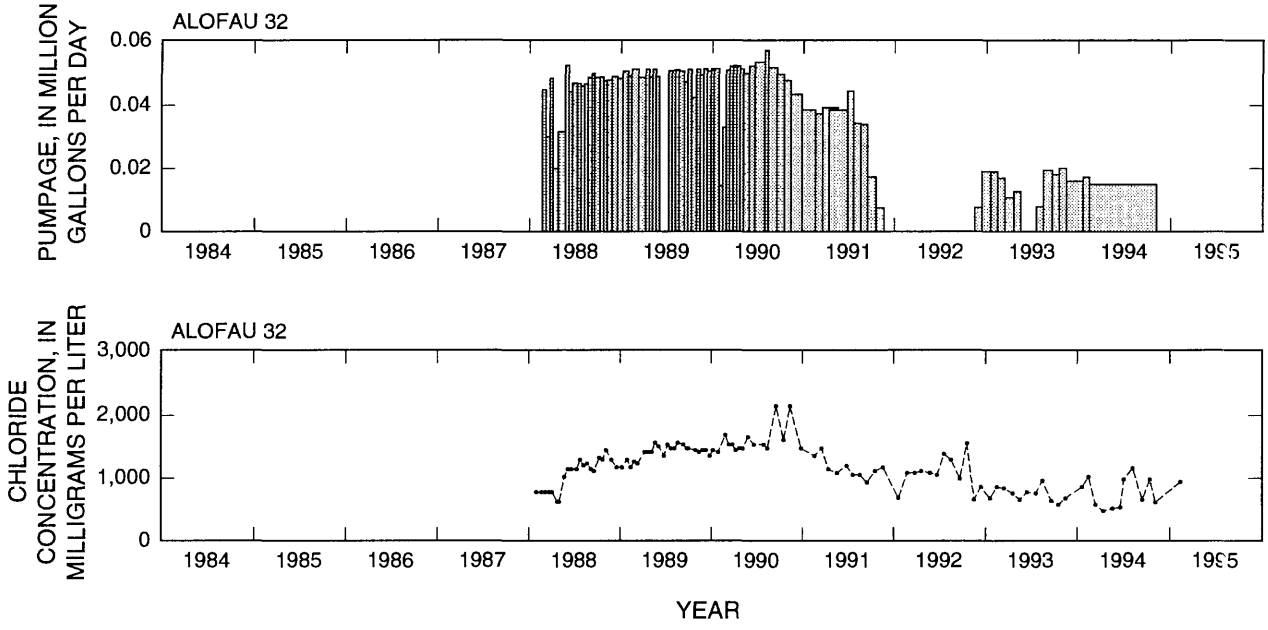

Figure 18. Pumpage and chloride concentrations in the Alofau well field, Tutuila, American Samoa.

Alao

The village of Alao has two production wells, 161 and 162 (fig. 16). Well 161 pumped about 0.02 Mgal/d from 1994 to 1995 (fig. 19). Chloride concentrations rose to over 1,000 mg/L during that period. The chloride concentration in well 162 has remained low during its short, irregular pumping history (fig. 19). Rainfall was higher than average at the Pioa rain gage during most of the pumping history of these two wells (fig. 2).

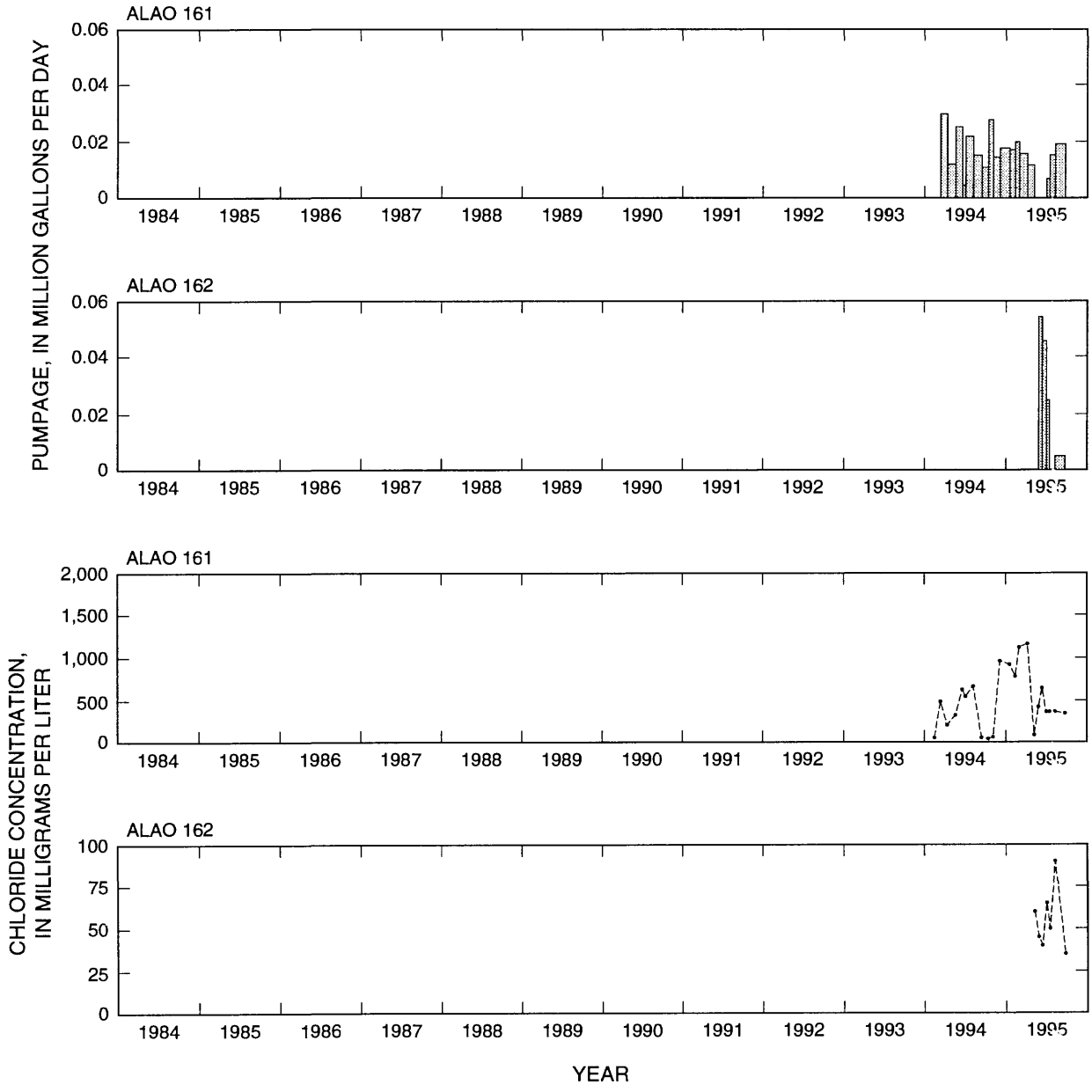

Figure 19. Pumpage and chloride concentrations in the Alao well field, Tutuila, American Samoa.

Tula

The village of Tula on the far eastern end of Tutuila has production wells 40, 104, and 108 (fig. 16). Records for well 40 began in 1991 when pumpage averaged 0.03 Mgal/d (fig. 20). The chloride concentration in the well at that time reached nearly 1,000 mg/L, but dropped to below 500 mg/L when the pumpage was reduced to about 0.015 Mgal/d. The well recently has been pumped only infrequently, and the chloride concentrations have not exceeded 200 mg/L. Records of well 104 began in 1987. Chloride concentration remained below 200 mg/L throughout most of the history of this well, which was pumped by as much as 0.05 Mgal/d in its early history but in 1994 and 1995 was pumped at less than 0.01 Mgal/d. In July to September 1995, the chloride concentration in this well took a sharp upward trend. Prolonged periods of pumpage of about 0.03 Mgal/d at well 108 were frequently followed by increases in chloride concentrations to over 200 mg/L, especially during low rainfall periods (figs. 2 and 20).

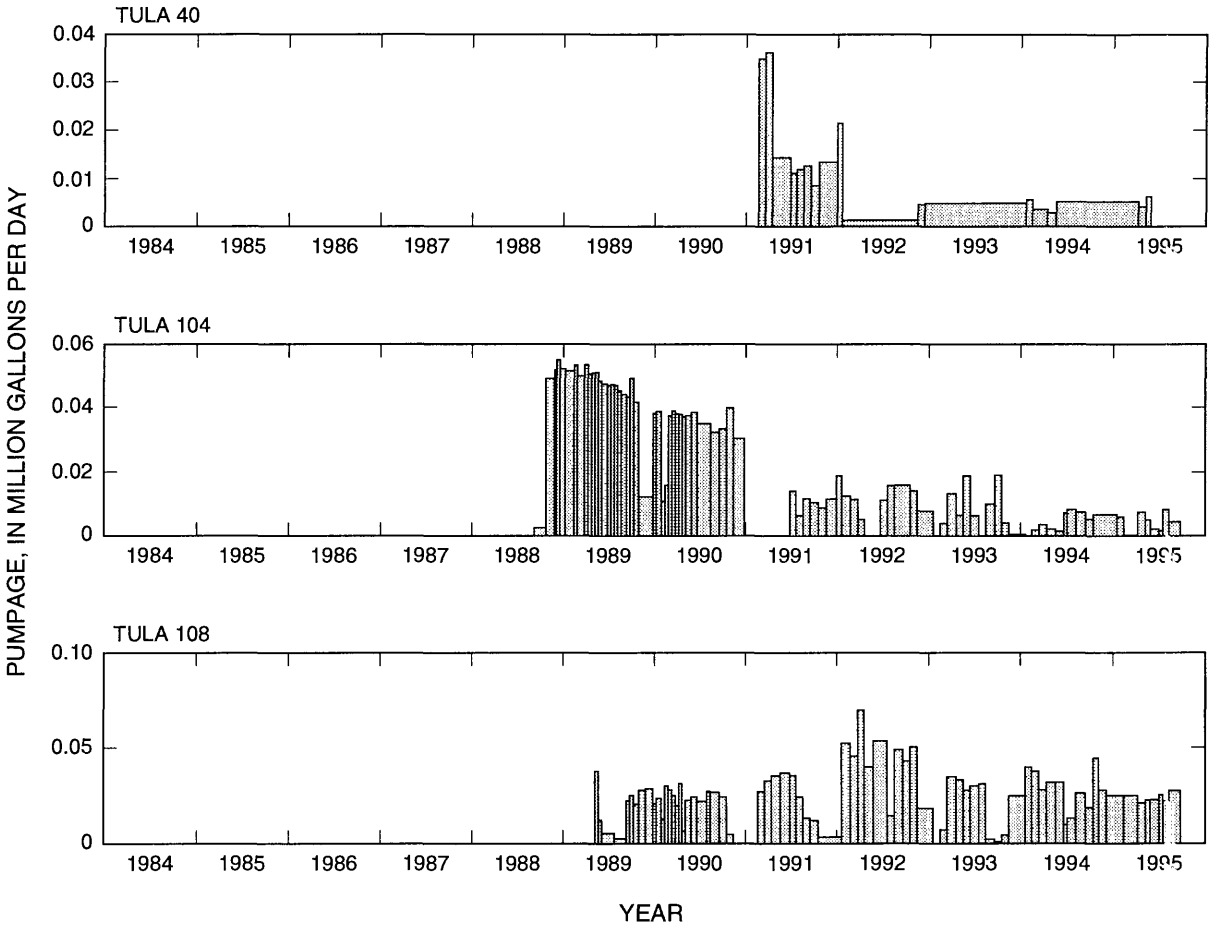

Figure 20. Pumpage and chloride concentrations in the Tula well field, Tutuila, American Samoa.

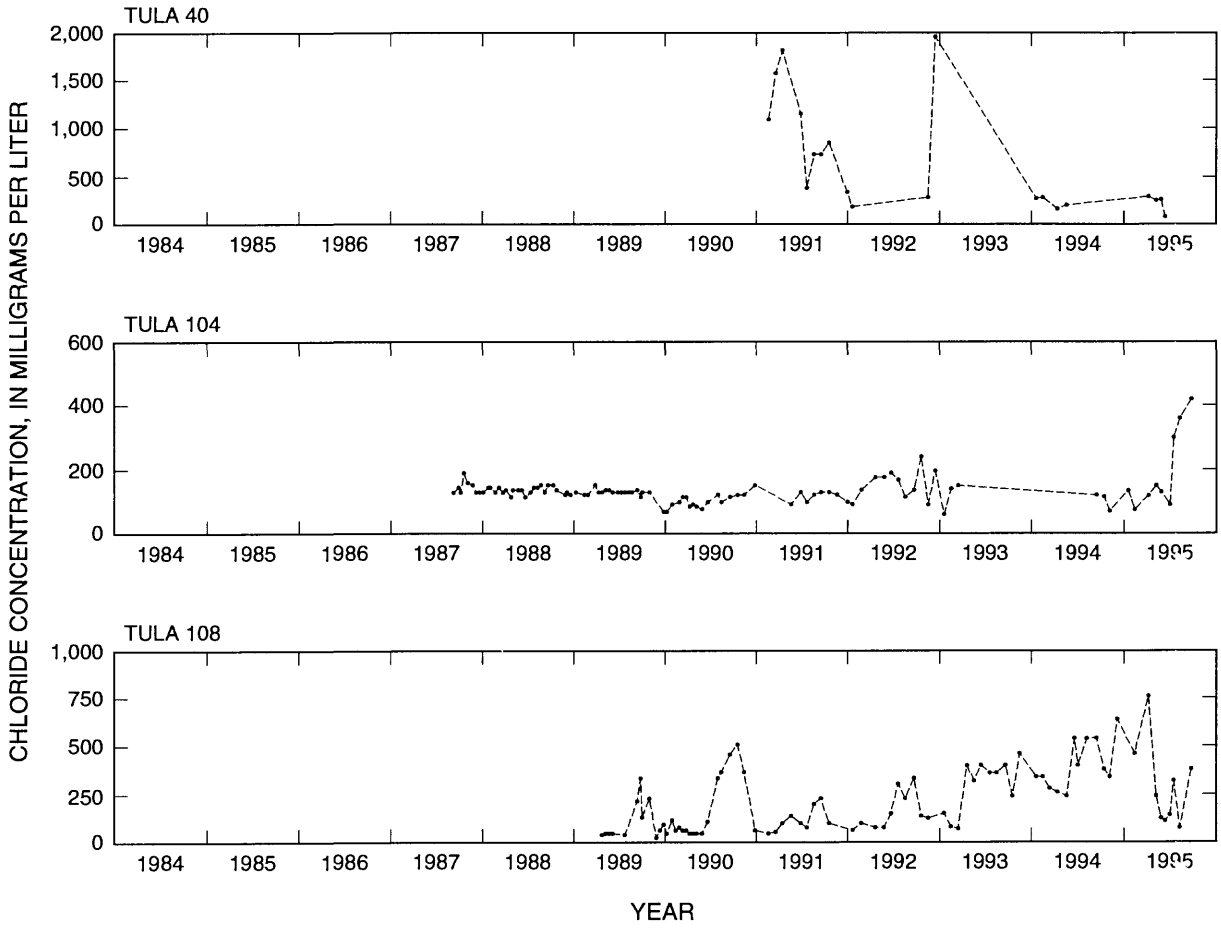

Figure 20. Pumpage and chloride concentrations in the Tula well field, Tutuila, American Samoa--*Continued.*

Aoa

Aoa village lies in an embayment on the north-eastern shore of Tutuila (fig. 16). Two production wells are sited here adjacent to a low-lying swampy depression in the back of Aoa Bay. Well 151 pumped 0.02 to 0.03 Mgal/d from the end of 1992 through September 1995, and well 152 pumped 0.03 to 0.04 Mgal/d in 1995 (fig. 21). Chloride concentrations in these wells rose to about 100 mg/L during their respective periods of pumping. Rainfall at the Pioa rain gage over the same period was higher than average (fig. 2).

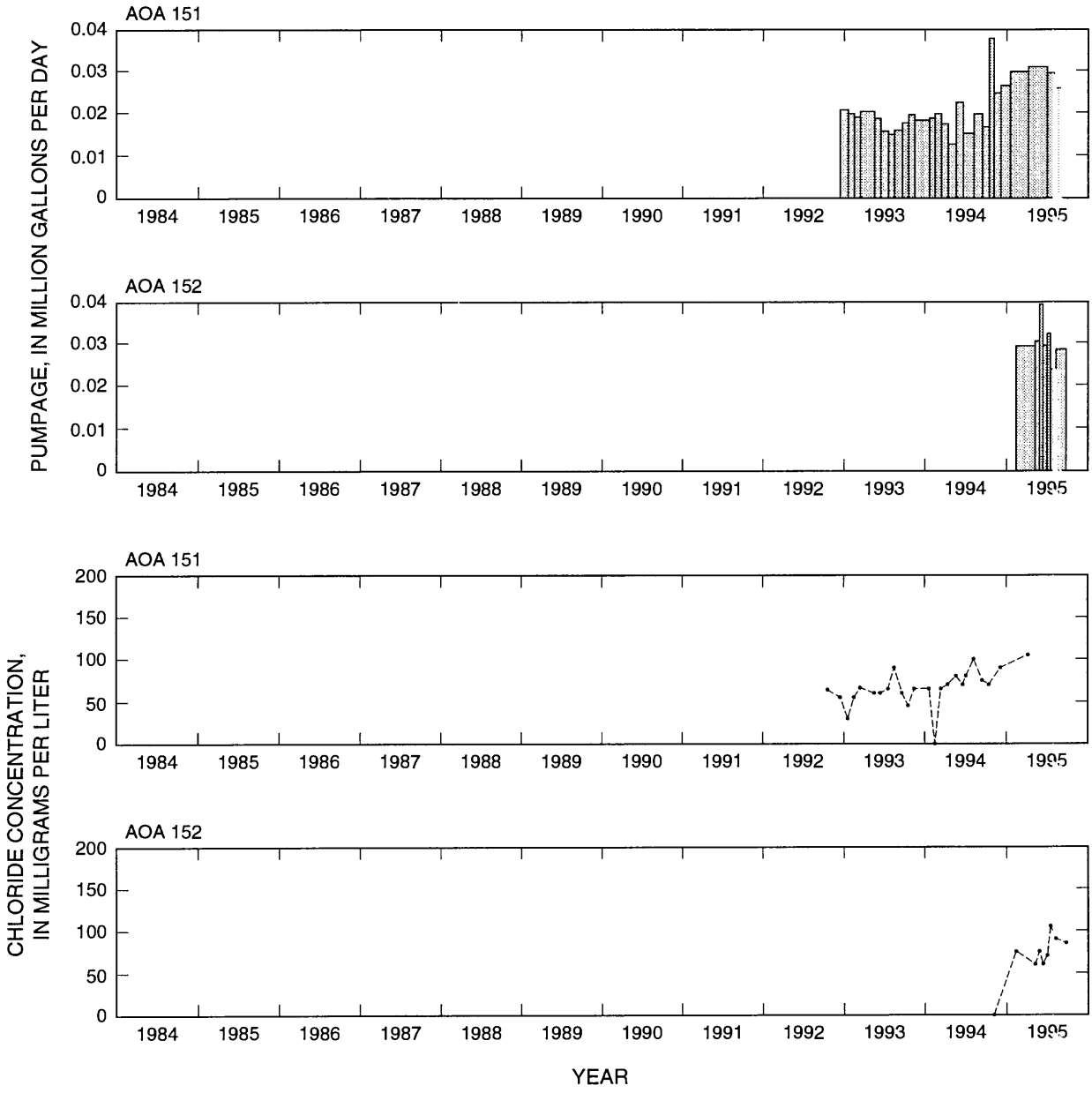

Figure 21. Pumpage and chloride concentrations in the Aoa well field, Tutuila, American Samoa.

Sailele

Sailele village on the northeastern coast has one production well (well 130, fig. 16) that has been pumped 0.015 to 0.030 Mgal/day from 1987 through September 1995 (fig. 22). Chloride concentrations were about 800 mg/L through the first 4 years of pumping, then rose gradually beginning in 1991 and exceeded 1,000 mg/L in 1993. This period of high chloride concentrations occurred during a period of below-average rainfall at the Pioa gage between 1987 and 1992 (fig. 2) and high pumpage in 1992 and 1993. There are no water-level data for Sailele.

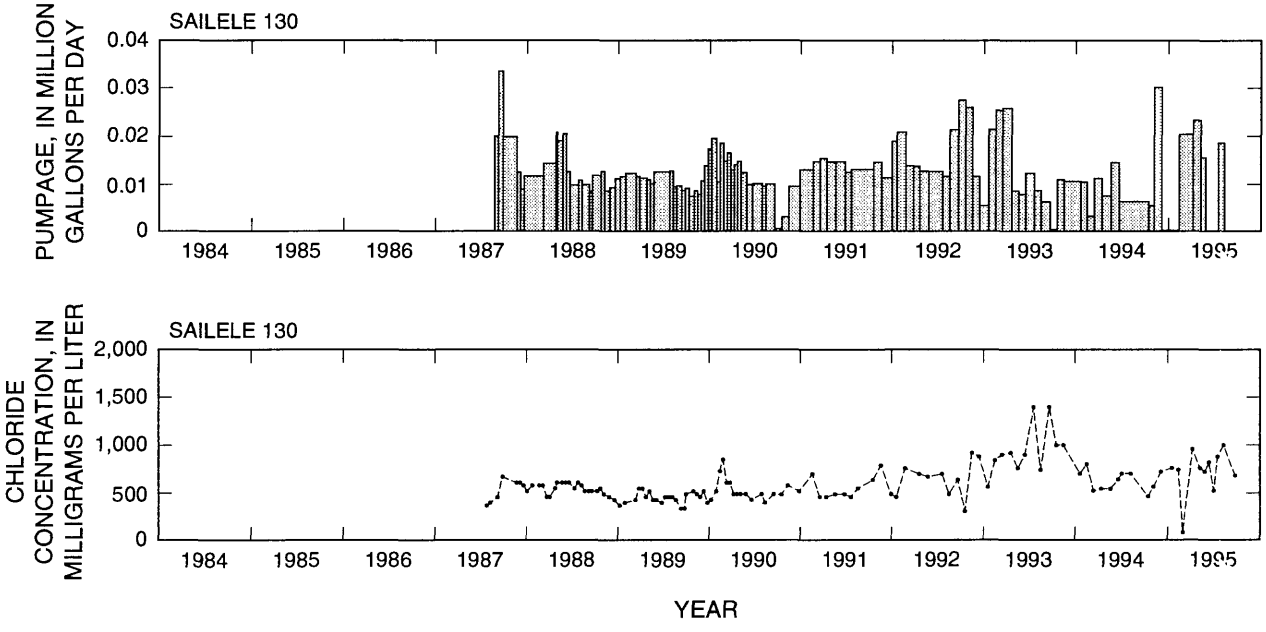

Figure 22. Pumpage and chloride concentrations in the Sailele well field, Tutuila, American Samoa.

Aunuu Ground-Water Data

Aunuu is an island off the southeastern shore of Tutuila (fig. 16). The population of Aunuu resides on the coastal plain on the western end of the island. Ground-water production on Aunuu comes from three infiltration galleries (wells 301, 302, and 303), also located on the coastal plain, that began pumping in 1992 each at about 0.01 to 0.03 Mgal/d (fig. 23). Chloride concentrations remained high throughout this period, varying from a few hundred to almost 2,000 mg/L. Chloride concentrations decreased in all three wells in 1995. During the same period, rainfall was higher than average at the Pioa rain gage (fig. 2). Total pumpage also decreased in and prior to that period, but most of the pumpage decrease was at well 302.

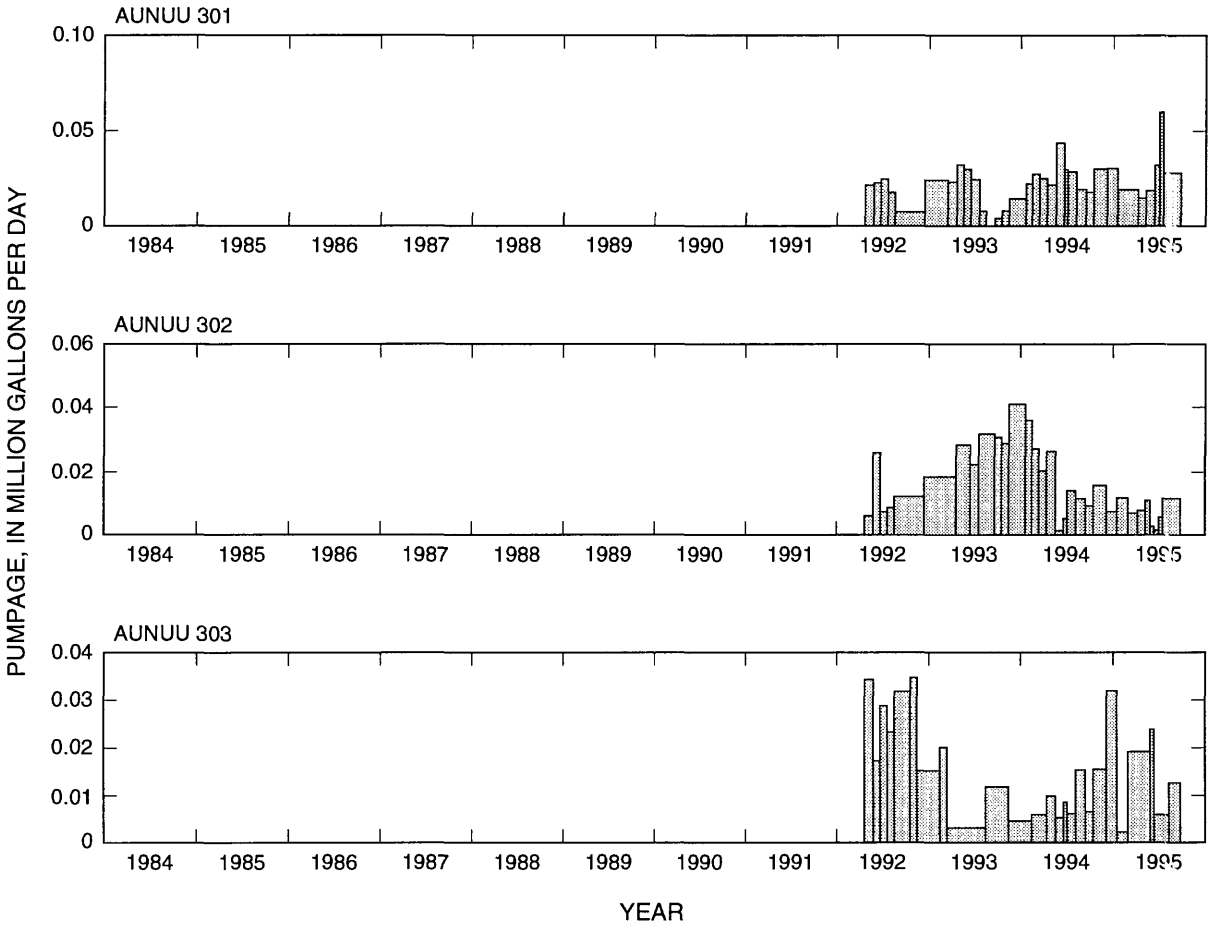

Figure 23. Pumpage and chloride concentrations in the Aunuu well field, Tutuila, American Samoa.

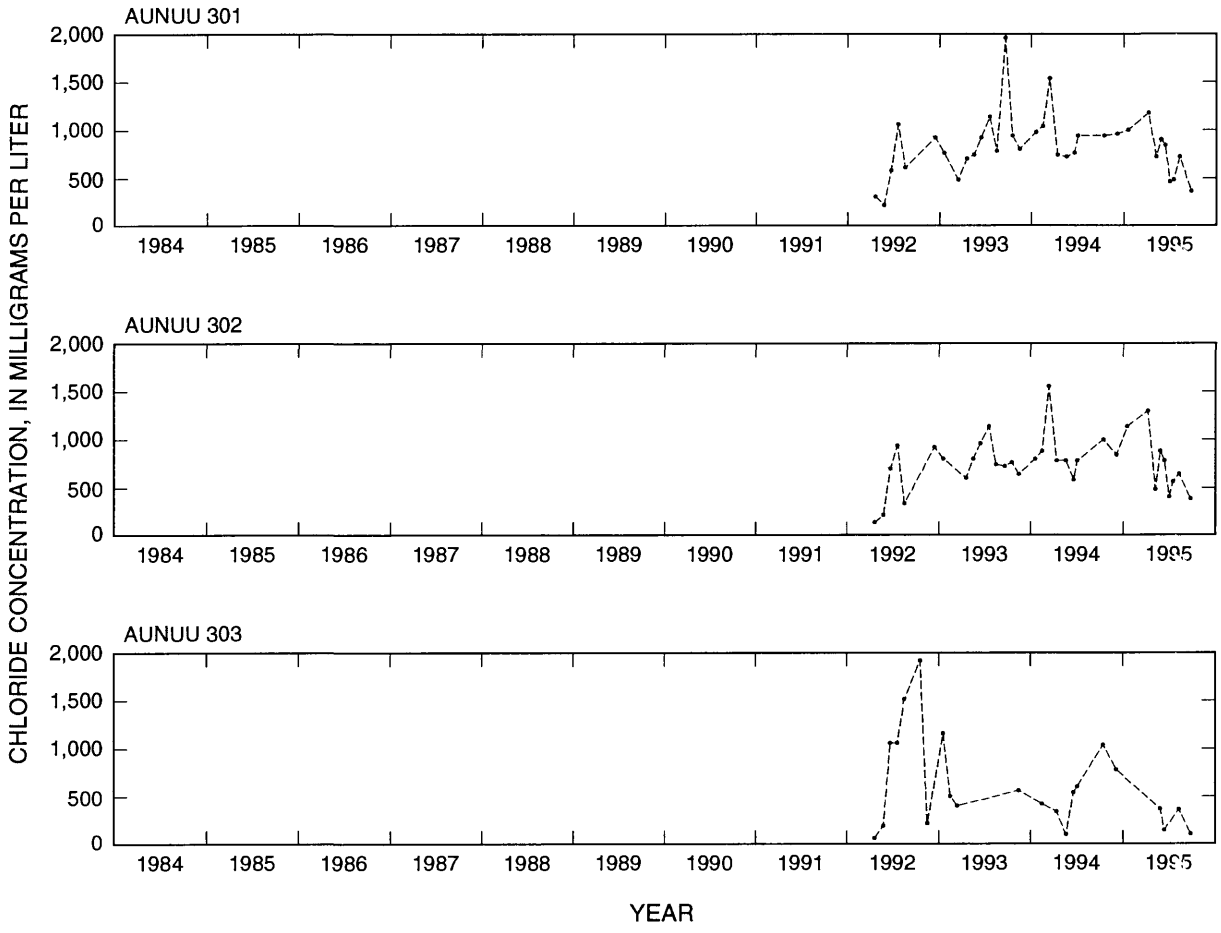

Figure 23. Pumpage and chloride concentrations in the Aunuu well field, Tutuila, American Samoa--*Continued.*

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APPENDIX

Data Processing

Pumpage and chloride concentration data of all pumping wells, water levels of selected non-pumping and pumping wells, and rainfall data were collected by ASPA and sent to the USGS. Daily rainfall recorded at the rain gages in this report were summed over each month to obtain monthly totals. The departure (difference) between each month's total rainfall and the mean monthly rainfall over the period from January 1984 to September 1995 was computed and plotted in time series. Backward-looking moving averages of 3-, 6-, and 12-months also were computed and plotted. The moving averages were computed by averaging a given month's rainfall with the rainfall of 3, 6, or 12 months immediately preceding it.

All chloride concentrations were determined by a field titration kit. A quality-control check was conducted in 1984 and 1985 in which splits of 123 ground-water samples from Samoa were analyzed using the field titration kits and laboratory titration. Comparison of the results indicated that for most of the samples, the field measurement was lower than the laboratory measurement. In four samples, the field measurement was more than 100 mg/L less than the laboratory titration. The cause of the discrepancy was not determined. More detailed records of the field titration have been kept since the 1984-85 check, but there have been no subsequent quality-control checks. Although a few measurements showed large discrepancies, 87 percent of the field determinations were within 50 mg/L of the laboratory measurement. For the purposes of this report, the accuracy of the chloride-concentration data is sufficient to track general trends in the quality of well water.

For the purposes of this report the pumpage totals were recalculated directly from the meter readings supplied by ASPA. Occasional discrepancies in the meter readings yielded negative pumpages or pumpages that were too high to have been obtained with the capacity of the pump in the well. The discrepancies were adjusted by first classifying the type and possible cause of the problem, then devising a means of adjusting the data. Simple typographical errors were identified and corrected. Other sources of discrepancies included (1) problems reading meters, (2) a resetting of a meter, or (3) a change in meter within an interval. The most common problem with meter readings was misplaced or omitted zeroes. Each water meter has a set of rotating digits that display the total amount of water pumped since the meter was reset. To the right of the rotating digits are one or more fixed zeroes, printed directly onto the dial face, which indicate how much water the first rotating digit represents. For example, on a meter with two zeros affixed to the right of the first rotating digit, the first digit represents hundreds of gallons, on a meter with three fixed zeroes, the first rotating digit measures thousands of gallons. If problems were indicated with the zeroes in the recorded data, the numbers of fixed zeroes on each meter was determined from ASPA records.

The next most common cause of discrepancies in pumpage records was the resetting of meters. When a meter reached its maximum capacity it reset to zero and continued recording. Intervals in which this occurred were recognized and adjusted in the data because the previous meter reading was near capacity and the next reading was very low.

In some cases no adjustments were possible. Sometimes the progression of the data indicated that a new meter had been installed between measuring intervals, but there was no way to determine how much water was pumped during the interval in which the change occurred. In other cases, no cause could be identified for a problem apparent with the meter readings. In such cases the reading was eliminated.

The ground-water data were initially collected on a weekly to biweekly interval but most recently the data were collected on an approximately monthly interval. Because the intervals between measurements were irregular, total pumpage in one interval was not directly comparable to total pumpage in another. The total pumpage per interval was therefore divided by the number of days in the interval to allow comparison. This procedure also allowed a more continuous record where data had to be eliminated for problems as discussed above. When data were removed, the pumpage was simply computed over the interval between the next two valid meter readings. The irregular intervals did not affect plots of instantaneous measurements such as water level and chloride concentration, because these data can be compared regardless of the frequency at which they were collected.