PREPARED IN COOPERATION WITH THE
U.S. DEPARTMENT OF THE NAVY, NAVY SUPPORT FACILITY, DIEGO GARCIA
AND THE
U.S. DEPARTMENT OF THE AIR FORCE, PACIFIC AIR FORCES

PUMPING WELLS AND MONITORING WELLS

Vertical and horizontal pumping wells scattered islandwide were used for freshwater supply. Monitoring wells were used to collect chloride-concentration data within the lens.

The five ground-water production areas (fig. 1) combined had 102 pumping wells as of 1996. The primary production areas were the Cantonment and Air Operations areas. Pumping wells were either vertical wells or horizontal wells. At Cantonment, the vertical pumping wells were located mostly in thick vegetation, described as coconut woodland by Stoddart (1971), whereas the horizontal wells were in grassy areas that were cleared of trees. Pumping wells at Air Operations were located within the active airfield. The area was cleared of all shrubs and trees, leaving large grassy areas surrounding the paved surfaces of the airfield. Monitoring-well sites were scattered throughout the island in the ground-water production areas.

Pumping wells.--Pumping wells in the Cantonment area included 80 vertical and horizontal wells (fig. 6A). Vertical wells typically extended 10 ft below mean sea level, and pumped about 10 to 12 gal/min. Most of the vertical wells were grouped into modules, which were well fields of 2 to 9 vertical wells that pumped to a common collection and transfer tank. The remaining vertical wells were the four Quad wells in the northeast. Horizontal wells H1 through H7 at Cantonment had infiltration galleries about 3 ft below mean sea level, and typically pumped about 50 to 75 gal/min. The bottom depths of the vertical and horizontal pumping wells were in unconsolidated sand, gravel and coral fragments. Descriptions of the wells and the water-production system are from PRC Toups (1983) and records of the U.S. Navy (unpub. data, 1996).

The Air Operations area had 18 pumping wells, and included vertical and horizontal wells (fig. 6B). Wells AO-2 through AO-5 were vertical wells which extended about 10 ft below mean sea level, and wells AO-6 through AO-19 were horizontal wells located in grassy swales at the airfield. These horizontal wells had 400-ft long infiltration galleries about 3 ft below mean sea level. Pumping rates for vertical and horizontal wells at Air Operations were similar to those at Cantonment.

Monitoring wells.--Monitoring-well sites comprised one to four vertical wells, with each well having a short screened interval 2 to 5 ft at the bottom of the well. Each well at a monitoring site bottomed at a different depth, usually between 10 and 100 ft below mean sea level. Some deeper wells tapped the transition zone between freshwater and saltwater. Monitoring-well sites were distributed islandwide, with 20 sites at Cantonment (fig. 6A) and 8 at Air Operations within the active airfield (fig. 6B). Additional monitoring-well sites were located away from the airfield, and at Industrial Site South and Transmitter Site. Water samples collected from monitoring wells were analyzed for chloride concentration to estimate the areal extent and thickness of the freshwater lenses.

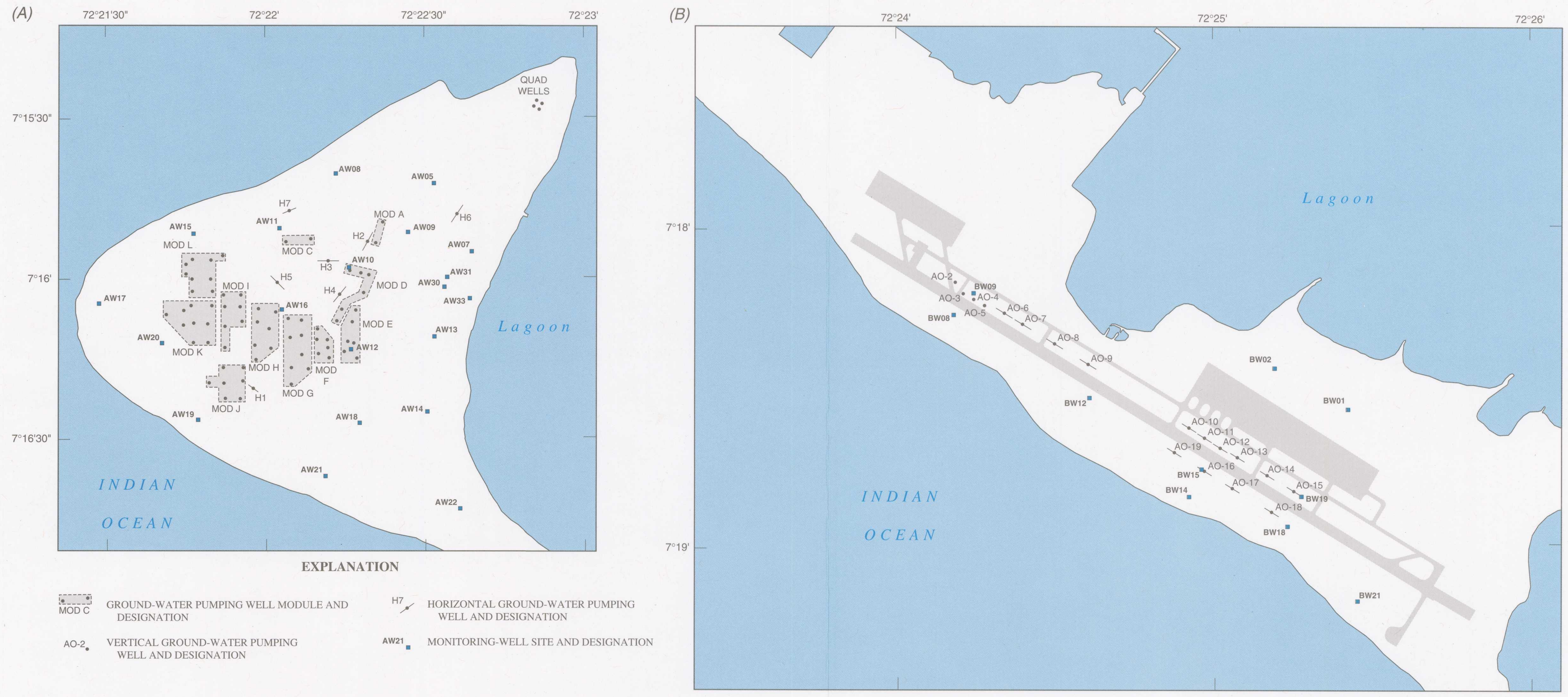

Figure 6. Ground-water pumping wells and monitoring wells, Diego Garcia. *(A)* Cantonment ground-water production area; *(B)* Air Operations ground-water production area.

AREAL EXTENT OF THE FRESHWATER LENS

The freshwater lens extends throughout the widest portions of the island, and where land cover is favorable.

The areal extent of the freshwater lenses at Cantonment and Air Operations were drawn on a map with freshwater defined by a limit of 250 mg/L chloride concentration (fig. 7). The map is based on chloride concentrations of water sampled from the shallowest well at each monitoring site. Sample depths range from 7 to 52 ft, and correspond to the midpoint depth of the screened interval. Variations in the areal distribution of chloride concentrations can be attributed in part to differences in the depth of the wells, and in the length of the screened portion at the bottom of the well.

Spatial variations, map view.--Figure 7 shows the areal extent of the lenses for two snapshots in time, March 1995 and September 1996. Although the month of March is not part of the typical wet season (September through February), March 1995 was an unusually wet month with almost 15 inches of rainfall coming at the end of a wet season that was itself wetter than average. Comparatively, September 1996 was an unusually dry month with less than 6 inches of rainfall and followed 2 months of rainfall that totalled about 3 inches. Pumpage increased from 0.7 to 0.9 Mgal/d at Cantonment between March 1995 and September 1996, but remained fairly steady at Air Operations. The size of a freshwater lens on a small island can respond quickly to a below average rainfall season (Hunt, 1991).

In March 1995, the areal extent of the freshwater lens paralleled the shoreline at Cantonment (fig. 7A). But during the drier period of September 1996, the periphery of the lens was displaced 200 to 700 ft inland of the March 1995 freshwater approximation. The low rainfall in September 1996 and in the 2 months prior decreased the amount of ground-water recharge to the lens.

At Air Operations, the areal extent of the lens in March 1995 closely paralleled the shoreline on the ocean side of the airfield (fig. 7B). During the drier period of September 1996, the perimeter of the lens shifted inland by 100 to 300 ft of the March 1995 estimation. The 1982 areal extent of the lens on the lagoon side extended to very near the pre-1983 shoreline (PRC Toups, 1983). The filled area beyond the airfield was added in 1983 using dredged material from the lagoon. Decreasing chloride concentrations with time from water samples collected in the filled area suggests that the increase in land area likely extended the freshwater lens on the lagoon side of the island (Hunt, 1997). Hunt (written commun., 1997) further inferred that the freshwater lens probably extends far into the filled area, which could provide additional areas for ground-water development.

Development of ground water.--Freshwater is most abundant at the widest parts of the island at Cantonment (fig. 7A) and Air Operations (fig. 7B). Land cover affects development of the freshwater lens by causing differences in ground-water recharge. In the Cantonment area, land cover varied from a concentrated array of buildings in the northeast to thick vegetation in the central region, interspersed with open grassy clearings. This combination of land covers results in moderate overall ground-water recharge because the grassy areas enhance recharge and offset low recharge in the northeast where buildings inhibit rainfall infiltration. Recharge was high at Air Operations because large grassy swales at the airfield received direct rainfall, and provided infiltration zones for runoff from the extensive paved surfaces. The ground-water production areas at Industrial Site South, Transmitter Site, and GEODSS Site (fig. 1) had low ground-water recharge because of thick vegetation that likely caused greater interception and evapotranspiration losses. The narrow width of land in these smaller production areas also constrained development of a freshwater lens.

Lines of section.--Lines *A-A'* and *B-B'* were used to construct the hydrologic cross sections in figure 8. Wells were projected onto the lines where necessary.

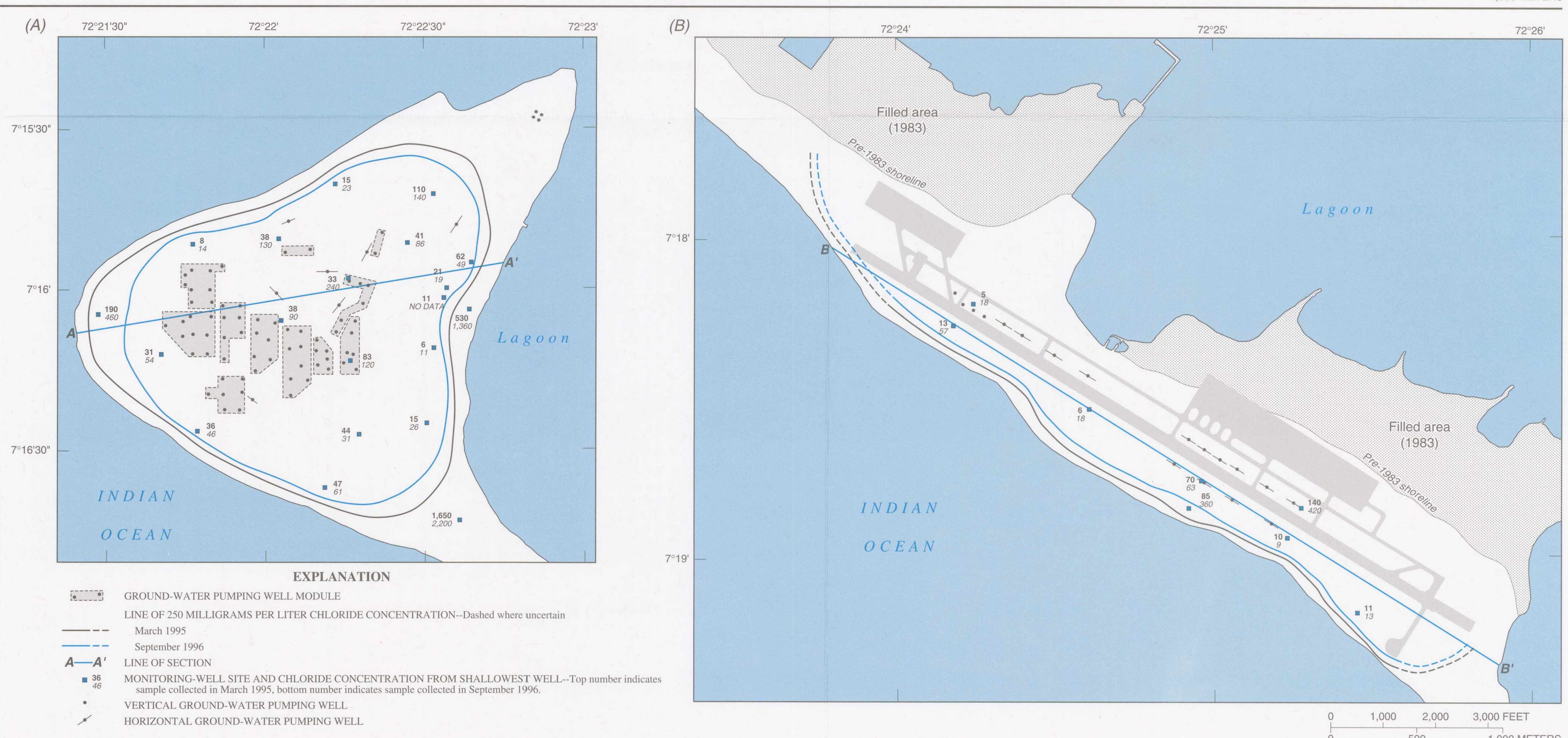

Figure 7. Chloride concentrations of ground water from monitoring wells, and lines of section, Diego Garcia. *(A)* Cantonment ground-water production area; *(B)* Air Operations ground-water production area.

THICKNESS OF THE FRESHWATER LENS

The freshwater lens is thickest in the widest portions of Diego Garcia; however, the thickness varies in response to rainfall and pumping patterns.

Cross sections of chloride concentration (fig. 8) were drawn using data from March 1995 and September 1996, corresponding to data used in the areal freshwater maps in figure 7. The sections cut across central portions of the ground-water production areas at Cantonment and Air Operations (fig. 7). Because the central portions are the widest part of the island, the freshwater lens is expected to be thickest in these areas. The line of 250 mg/L chloride concentration defines the thickness or vertical extent of freshwater. Below this line the chloride concentration is greater than 250 mg/L, marking the top of the transition zone between freshwater and saltwater. The sections were prepared using the method described by Vacher (1974) in which the depth corresponding to 250 mg/L chloride concentration is interpolated after plotting depth and chloride concentrations on normal probability graph paper. Data in figure 8 were extrapolated below the deepest monitoring wells at some sites, and were inferred laterally between and beyond monitoring sites.

Spatial variations, cross-sectional view.--Figure 8 shows the vertical extent of freshwater in the two primary ground-water production areas. At Cantonment (fig. 8A), the freshwater lens was asymmetric through the central portion of the area. During the wet period of March 1995, the base of the lens was relatively flat, probably because of the more permeable underlying limestone layer in which freshwater and saltwater mixing is increased (PRC Toups, 1983; Hunt, 1991). Freshwater was thicker on the lagoon side of Cantonment, with the maximum thickness estimated at about 70 ft below mean sea level. During the drier period of September 1996, the freshwater lens thinned. The decrease in thickness was about 10 ft near monitoring wells AW20 and AW30, and likely resulted from a combination of rainfall that was below the average monthly for July through September and above average pumping from Cantonment (fig. 5).

The freshwater lens at Air Operations (fig. 8B) was also asymmetric with the thickest part at the southeast end of the airfield. Freshwater reached a maximum thickness of about 75 ft below mean sea level near well BW18 in the March 1995 hydrologic section. During the drier period of September 1996, the maximum thickness of freshwater was about 68 ft below mean sea level.

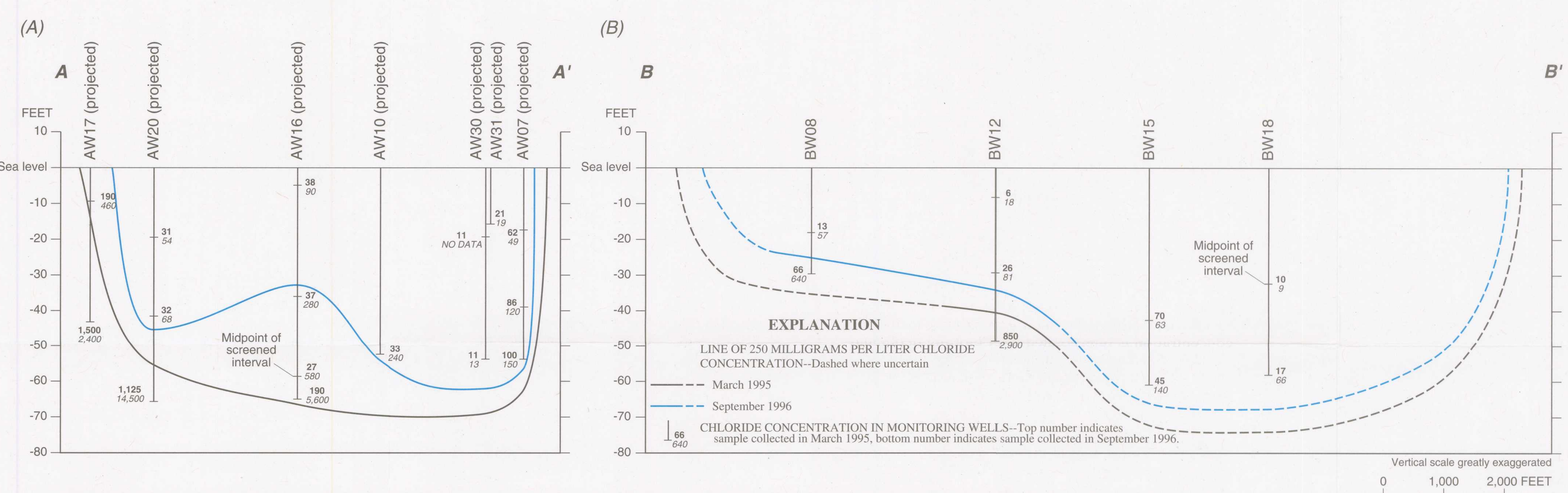

Figure 8. Thickness of the freshwater lens, Diego Garcia. *(A)* Cantonment ground-water production area; *(B)* Air Operations ground-water production area. Lines of section are shown in figure 7.

Effects of pumping.--Pumping patterns at Cantonment and Air Operations changed in response to increased water demand. In September 1996, the freshwater lens was thinnest at monitoring well AW16. July through September 1996 were drier than the averages for those months, and the combination of low rainfall and increased pumping produced saltwater upconing below well AW16, indicated by a localized rise in the 250 mg/L chloride concentration line (fig. 8A). Upconing results from pumping wells that are too deep or located where the lens is too thin, or from pumping rates that are too high. Thinning of the freshwater lens during dry periods is minimized by maintaining low pumping rates from many scattered wells located where the lens is thickest.

ABBREVIATIONS

ft	feet	gal/min	gallons per minute
sq mi	square miles	Mgal/d	million gallons per day
in/yr	inches per year	mg/L	milligrams per liter

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GROUND-WATER RESOURCES AT DIEGO GARCIA, 1985–96

by
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