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 Cantannent and Air Operations areas. Pumping wells were either vertical or horizontal wells. At Cantannent, the pumping wells were located mostly in thick vegetation, described as coconut woodland by Stoddart (1971), whereas the horizontal wells were in gaps in those 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 Cantannent area included 80 vertical and horizontal wells (fig. 6A). Vertical wells typically extended from 10 to 30 feet below mean sea level and pumped about 10 to 12 gallons. Most of the vertical wells were grouped into modules, which were well fields of 2 to 9 vertical wells per module and pumped to a common collection and transfer tank. The remaining vertical wells were the four Quad wells in the northeast. Horizontal wells 81 through 87 at Cantannent had infiltration galleries about 3 feet below mean sea level, and typically pumped about 30 to 50 gallons. The bottom depth of the vertical and horizontal pumping wells were in unconsolidated sand, gravel, and coral fragments. Descriptions of the wells and the water production systems are from PRC Tours (1983) and reports of the U.S. Navy (1985).

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 to 15 feet below mean sea level, and wells AO-6 through AO-29 were horizontal wells located in gravel swales at the airfield. These horizontal wells had 400 to 800 foot infiltration galleries about 3 feet below mean sea level. Pumping rates for vertical and horizontal wells at Air Operations were similar to those at Cantannent.

Monitoring wells—Monitoring wells were scattered throughout the island, with 20 sites at Cantannent (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.

AREAL EXTENT OF THE FRESHWATER LEN

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 Cantannent and Air Operations were drawn on a map with water 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 feet, and correspond to the midpoint depth of the screened interval. Variations in the areal distribution of chloride concentrations can be attributed to part in differences in the depth of the wells, and is 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 1990 and September 1996. Although the month of March was not part of the typical wet season (September through February), March 1990 was an unusually wet month with about 15 inches of rainfall coming at the end of a wet season that was itself wetter than average. Conversely, September 1996 was an unusually dry month with less than 6 inches of rainfall and followed 2 months of rainfall that totaled about 3 inches. Pumpage increased from 17 to 39 million gallons at Cantannent between March 1990 and September 1996, but remained fairly steady at Air Operations. The size of a freshwater lens on a small island can respond quickly to below-average rainfall seasons (Hunt, 1991).

In March 1990, the areal extent of the lens at Cantannent was similar to that February 1984 (fig. 7A). But during the drier period of September 1996, the perimeter of the lens was decreased from 200 to 700 feet from the March 1990 freshwater lens (fig. 7B). In the 2 months prior to September 1996, the areal extent of the lens at Cantannent was reduced by 40 percent. At Air Operations, the areal extent of the lens in March 1990 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 200 feet from the March 1990 extent. The drier period of September 1996 resulted in the freshwater lens on the lagoon side of the island (Hunt, 1997). Hunt (written communication, 1997) further inferred that the freshwater lenses probably extend 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 portions of the island at Cantannent (fig. 7A) and Air Operations (fig. 7B). Land cover affects development of the freshwater lens by causing differences in ground-water recharge. In the Cantannent area, land cover varied from a concentrated area of buildings in the northeast to thick vegetation in the central region, intercepted with open gravel clearings. This combination of land covers results in moderate overall ground-water recharge because the gravelly zones increase recharge and offset low recharge in the northeast where buildings inhibit rainfall infiltration. Recharge was high at Air Operations because large gravel swales at the airfield received direct rainfall, and provided recharge zones for runoff from the extensive paved surfaces. The ground-water production areas at Industrial Site South, Transmitter Site, and GEODIS Site (fig. 1) had low ground-water recharge because of thick vegetation that likely caused greater evapotranspiration losses. The narrow width of these smaller production areas also contributed development of a freshwater lens at these areas.

The extent of the freshwater lens was analyzed to construct the hydraulic cross sections in figure 8. Wells were projected onto the lines where necessary.

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 1990 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 Cantannent and Air Operations (fig. 7). Because the central portions of the island 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 density and chloride concentrations on normal probability graph paper. The sections were computed from the shallowest monitoring wells at some sites, and were inferred from the most shallow monitoring-well data at other sites.

Spatial variations, cross-sectional view—Figure 8 shows the vertical extent of the freshwater lens in the two ground-water production areas. At Cantannent (fig. 8A), the freshwater lens is thickest in the northeast portion of the area. During the wet period of March 1990, the thickness of the lens was relatively flat, probably because of the more permeable underlying limestone layer in which freshwater and saltwater mixing is increased (PRC Tours, 1983, Hunt, 1991). Freshwater was thickest in the lagoon side of Cantannent, with the maximum thickness extended at about 70 feet below mean sea level. During the drier period of September 1996, the freshwater lens thinned. The decrease in thickness was about 10 feet near monitoring well 9L and AWL, and likely resulted from a combination of rainfall that was below the average, and above the average for March 1990. From March 1990 and September 1996 above average pumping from Cantannent (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 feet below mean sea level near BW10 in the March 1990 hydrologic section. During the drier period of September 1996, the maximum thickness of freshwater was about 60 feet below mean sea level.

Effects of pumping—Pumping patterns at Cantannent 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 average months for both rainfall and increased pumping produced saltwater upwelling below well AW16, indicated by a localized rise in the 250 mg/l chloride concentration line (fig. 8A). Upcoming 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 thicker.