7.0 Conclusions and Recommendations

The results of this project comprehensively characterize the status and trends of the watershed conditions within the Charlotte Harbor study area. Together with the monitoring data collected by the CHNEP partners, the results and integrated trend databases should provide a useful and flexible tool for the Program. The results range from broad level characterizations on a regional scale to very detailed presentations of data from individual stations, and the results are presented in an interactive fashion so that the users of this document and CD may examine broad level patterns and explore the supporting details behind the patterns.

The results characterized:

- rainfall conditions,
- stream flow conditions,
- groundwater quality conditions, and
- surface water quality conditions.

Rainfall Conditions

The results of the rainfall analyses indicated that there were essentially no overall trends in rainfall for the rainfall data period of record (approximately 1950's to 2000) or for the period of record for which water quality trends were tested (approximately 1980's to 2000). The results also indicated that rainfall varied greatly from year-to-year and in a relatively predictable fashion within each year. The rainfall trend analyses were very robust statistically, and they were applied to 20 to 50 years of monthly rainfall data. Clear seasonal signals were accounted for by the seasonal Kendall Tau analysis in every case tested. Based on these observations, it is unlikely that any trends observed in the surface water quality data for the basins of the Charlotte Harbor study area can be attributed to changes in rainfall alone.

It should be noted that although there were essentially no overall rainfall trends, there was one statistically significant trend for rainfall for the Matlacha Pass basin in both the rainfall period of record for Matlacha Pass (1950 to 2000) and the water quality trend period of record (1980 to 2000). The rate of change detected in both cases was approximately a 1-third of an inch increase in total precipitation per year. However, at the alpha level applied to the trend testing of 0.05, one would expect to have one out of twenty trend tests be incorrectly identified as having a significant trend. This one significant result is well within the one out of twenty expectations. Thus, there is not compelling evidence that any significant overall rainfall trends have occurred for any of the basins during these times periods.

Although overall long-term rainfall trends were not observed, year to year short-term changes in rainfall are likely to be the primary cause of some short term trends in surface water quality. This is particularly true for the most recent years from 1998

to 2001 where a large number of surface water quality samples were collected. In general, the earlier years of this period were unusually wet, and the later years of this period were unusually dry. Thus, there are often short-term trends in surface water quality over these years corresponding to this short-term rainfall trend. For example, as discussed in Chapter 6, there were strong significant increases in salinity observed for several of the Sarasota County Myakka River groups of stations over a period of 1995 to 2001. There may be other trends in surface water quality that are obscured by this strong short-term relationship with rainfall, and these trends may be detected in future years as these monitoring programs continue.

Stream Flow Conditions

The results of the stream flow trend analyses indicated that there have been many changes to stream flow for many of the streams at the gage locations monitored for the period of record. Importantly, some of the stream gage locations reported presented relatively little change in stream flow over the period of record. These rare stream gage locations represent relatively unimpacted aquatic environments in terms of hydrologic impacts. Conversely, the stream flow changes in the streams that have been impacted have occurred in terms of timing of flows and volume of flows among the 32 aspects of the Index of Hydrologic Alteration (IHA). From these results, it may be concluded that changes to stream flow have been occurring at statistically significant rates for many streams over the period of record.

With respect to regional changes in stream flow, the results indicate that many alterations to the hydrology have occurred in the tributaries of the Estero Bay watershed and Cape Coral peninsula, and the Upper Peace River. To a lesser extent, significant trends in the IHA parameters were detected for the Myakka River. It should be noted that the flow stations with the longest periods of record, such as those for the Peace River are more likely to exhibit trends that those with shorter periods of record due to development activities and other alterations that have occurred over decades.

Many of the IHA stream flow changes where observed to occur in the Cape Coral peninsula area and the Estero Bay watershed, and these locations were locations where changes in water quality were detected. Many of the water quality changes in these areas were characterized as declining water quality. These results do not indicate directly that changes in stream flow were the primary reason for the changes in water quality, but the results do present a coincidence over the years of changes in stream flow timing and volume with changes in surface water quality. Other potential sources of surface water quality declines include increased pollutant loading from nonpoint sources in the watershed, point sources, and or atmospheric deposition. The detailed interactive appendices of this report provide a means for assessing the likelihood of links between stream flow changes and surface water quality changes and a tool for exploring management action priorities.

Groundwater Quality Conditions

The groundwater quality data were more limited than the rainfall, stream flow and surface water quality data for the Charlotte Harbor study area. Thus, the watershed or basin scale conclusions to be drawn from these data are limited. Overall, groundwater quality conditions were observed to be as expected. Conductivity in the groundwater was observed to be higher along the coast and lower upstream as expected. This was found to be true for each aquifer. Orthophosphate was found to be highest in the Floridan and Intermediate aquifers of the Upper Peace River basins near Bartow. There was a similar spatial trend, but to a lesser degree, in the Surficial Aquifer data. The pH median values were observed to be highest in the Upper Peace River basins in the Floridan and Intermediate aquifers.

With respect to drinking water standards, groundwater fluoride levels were more often exceeded in the coastal basins for the Floridan and Intermediate aquifers. In particular, the primary fluoride standard was frequently exceeded in the Floridan Aquifer in the Estero River portion of the Estero Bay basin, and in the Intermediate and Floridan Aquifers in the Matlacha Pass basin. Color and pH standards were often exceeded at many locations in the study area, and this was particularly true for the Surficial Aquifer. Sulfate standards were often exceeded in the Floridan Aquifer in the coastal areas of the study area.

Surface Water Quality Trends

The results of the surface water quality trends and status analyses indicated that there have been many recent changes to the surface water quality in many of the basins in the Charlotte Harbor study area. These changes have been reported for particular areas of the study area as described below, and these areas offer an opportunity for regionally focused water quality improvements.

As discussed previously, some of these changes may be attributed to or influenced by recent short-term rainfall trends from 1998 to 2002 (e.g., Sarasota County data for Lower Myakka strata). In general, the recent decreases in rainfall would be expected to result in short-term improvements in water quality conditions for parameters such as dissolved oxygen, chlorophyll, nutrients, and BOD due to reduced Stormwater pollutant inputs. One exception to this generalization is that in certain areas the increased rainfall quantities observed in the wet years would have resulted in better water quality due to reductions in hydrologic residence time. Many of the longer-term water quality changes were observed over periods long enough to have not been influenced greatly by short-term changes in rainfall.

Nutrients concentrations in surface waters were observed to have mixed trends for the Peace River Region. Ammonia was observed to have shallow declines or no significant changes between Bartow and Arcadia. Nitrites and nitrates were observed to have steep increases near Arcadia, but shallow decreases at Bartow and

upstream of Bartow. Steep decreases in total phosphorous were observed in the northern Peace River region, and these decreases are reported for stations in the Winter Haven Chain of Lakes and its immediate tributaries.

Nutrients were not observed to have broad patterns of significant change for the Lower Myakka River region, and total coliform bacteria values were observed to have mixed trends in the Lower Myakka river region. Dissolved oxygen values were observed to have shallow increases or no significant changes in the Lower Myakka River and north coastal areas. This was true even in the context of the shallow temperature increases attributed to changes in sampling schedules. All other factors being equal, warmer waters would provide less capacity for dissolved oxygen.

Dissolved oxygen was found to have no significant changes in Charlotte Harbor Proper or Pine Island Sound. Chlorophyll a, turbidity, and color were observed to have no significant trends in Charlotte Harbor proper.

Many relatively large changes (i.e., $>5\%$ of the median value per year) were observed in the water quality conditions for the southern basins of the study area. The stations that were observed to be responding in groups included the Cape Coral peninsula south of Interstate 75, the north shore of the Caloosahatchee River north of Interstate 75, the coastal bays near Pine Island, and the Estero Bay watershed. These changes are readily observable in the summary maps of the trend results. Overall, dissolved oxygen declines, and generally worsening water quality were observed in these areas. Coincident with these dissolved oxygen declines, biological oxygen demand declines were observed on the northern side of the lower Caloosahatchee River and in the Estero Bay watershed.

Overall, total suspended solids were observed to have steep increases in the entire southern portion of the study area, including the full extent of Charlotte Harbor Proper. The only exception was that these trends were relatively less steep in the Estero Bay watershed stations.

Surface Water Quality Status

Based on the results of the surface water quality status analyses one may conclude that a pattern of similar water problems exists across the Charlotte Harbor region. Florida surface water standards were frequently exceeded for many basins for dissolved oxygen (both instantaneous and daily average), and ammonia, and to a lesser extent for chlorophyll and bacteria. Similar results were observed in comparing the reported data from the 1996 to 2000 status period to the Florida Impaired Waters Rule (FAC 62-303.100) approach. It is important to note that this is not directly comparable to the official Florida IWR results that are prepared and published on a much smaller watershed (WBID) basis than the CHNEP basins.

The results of the comparison of current water quality conditions to three candidate nutrient criteria suggest that the nutrient criteria examined may not be appropriate for the basins of the Charlotte Harbor Study area (except for the more lagoonal systems such as Dona and Roberts Bays). These nutrient criteria were frequently exceeded for chlorophyll, phosphorus, and nitrogen. The Secchi disk depth criteria were exceeded for several basins, and the turbidity criteria were rarely exceeded. The current data (1996-2000) were compared to three sets of nutrient criteria that were requested by the CHNEP Technical Advisory Committee Water Quality Subcommittee. The Program is currently working towards the determination of appropriate indicators and criteria for water quality, and the comparison of these three sets of criteria was completed in support of this effort. Other nutrient criteria could have been used in place of these criteria, such as those developed by the Tampa Bay Estuary Program for Tampa Bay, or those developed by the Florida Department of Environmental Protection for the Caloosahatchee River C-43 Basin.

Recommendations

Together with the monitoring data continuing to be collected by the CHNEP partners, the results and integrated trend databases of this project should provide a useful tool for the Program to address the goals for the CCMP.

The water quality status and trends project results will provide the information and tools needed to support the CCMP.

- The results can be used to prioritize areas of the estuary for improvements by first, examining the regional water quality trend maps to identify candidate priority areas, and second, through examining the supporting trend analysis details to confirm the priority areas.

- The results can be overlaid with potential habitat restoration, protection and enhancement areas to identify conditions that may threaten habitats or provide opportunities for habitat enhancement.

- The water quality responses to sources of pollution may be used to prioritize source reduction efforts to pollutants with the greatest impacts or greatest worsening trends.

- The results may be used to identify regional and local impacts to freshwater inflows and salinity regimes of the estuarine portions of the river systems.

- The results may provide background scientific results for incorporation into public education materials such as the opportunity for improving water quality through local stormwater management.

- The results may provide a statistical framework for future monitoring of the effectiveness of management actions. For example, the stream flow (IHA) results may provide baseline conditions against which future responses may be compared.