Independent Peer Review

of the

Florida Keys Carrying Capacity Study
Draft Final Report

and

Carrying Capacity Impact Assessment Model

December 30, 2002

Sponsored by: South Florida Water Management District, United States Environmental Protection Agency, The Nature Conservancy, Sanctuary Friends of the Florida Keys and The National Oceanic and Atmospheric Administration

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Executive Summary

The Florida Keys Carrying Capacity Study (FKCCS) was undertaken in response to State of Florida Rule 28.20-100 that requires Monroe County to "determine the ability of the Florida Keys ecosystem and various segments thereof, to withstand all impacts of additional land development activities." The U.S. Army Corps of Engineers and the Florida Department of Community Affairs sponsored the FKCCS and produced a Carrying Capacity Analysis Model: First Draft (November 2001) (CCAM) that was critically reviewed by an NRC Review Committee and other interested parties. The NRC Review Committee was disbanded after publication of their report (NRC 2002).

The sponsors of the FKCCS have produced a Memorandum for the Record (July 2002) that highlights changes made to the study as a result of the review of the CCAM, a Test Carrying Capacity: Impact Assessment Model (July 2002) (CCIAM), and FKCCS Draft Final Report (September 2002). The latter two documents are the focus of this review by a peer review committee, referred to in this document as the Final Review Committee. The Final Review Committee consists of the same individuals that comprised the NRC Review Committee. This present review was not endorsed or sanctioned by the NRC. This peer review was funded by a public/private partnership and supported by the Florida Keys National Marine Sanctuary (FKNMS) Advisory Committee and the FKNMS Water Quality Protection Program Steering Committee.

This review was initiated to ascertain whether the comments and suggestions provided to the sponsors of the CCAM were incorporated into the draft final documents. Also, this report provides the first peer review of new components of the study, including the Canal Impacts Assessment Module. During the course of the review, it became obvious that the Final Review Committee had significant concerns over implementing the model in its current state. Those concerns over implementation, and recommendations to improve the model, are included in this report and were not part of the original scope-of-work for this review.

The Final Review Committee commends the sponsors' bold and innovative vision that initiated this unprecedented study. The revised documents contain many, but not all, of the recommendations provided by the NRC (2002), including use of 2000 census data, elimination of unsubstantiated thresholds and some inappropriate socioeconomic indicators, inclusion of suitability analysis for development of vacant land, a hurricane evacuation model, more terrestrial species, and elimination of the misleading Marine Module from the model.

A main contribution of the FKCCS is the compilation of the spatial databases that underlie the CCIAM.

The FKCCS concludes with four general recommendations for future development in the Florida Keys:

1. Prevent encroachment into native habitat because of severe depletion by historic development activities;

2. Continue restoration and land acquisition programs, implement the wastewater and stormwater master plans, and continue ongoing research and management activities in the FKNMS;
3. Concentrate on redevelopment and infill for future development; and
4. Increase efforts to manage remaining habitats and resources.

The Final Review Committee agrees with these recommendations and is glad that these recommendations are supported by the model. We are particularly gratified that the model recognized that a significant amount of upland (hammock) habitat has been lost and/or severely fragmented which jeopardizes the continued existence of many plant and animal species.

Although improvements were made to many modules, there remain severe deficiencies in the model. There is no documentation on data structure for the database nor any information on data quality procedures used. Many linkages were broken during the revision of the model after the NRC (2002) report and the overall logic of module linkages needs to be re-thought. Also, lack of rigorous calibration and sensitivity testing of the model, and a limited number of model runs, precludes the use of the CCIAM as it stands as a credible tool for evaluation of all (or most) impacts of development in the Keys. As it exists, the model cannot fulfill the original vision of a tool to assess "carrying capacity" of the region and the ability of the Florida Keys to "withstand all impacts of land development activities."

Overall, the Socioeconomic Module presents very limited insight into the socioeconomic effects of growth in the Keys. The module is almost completely uncoupled from the rest of the CCIAM, and the five indicators that are calculated within it are not used as input by any other module. There is no clear link between the indicators that are calculated and the quality of life or socioeconomic welfare of residents of the Keys. This module suffers a particularly serious defect for an impact assessment tool in that it relies on a series of constant coefficients that do not change over time or from scenario to scenario. Thus, it is not capable of predicting changes in housing prices, commuting patterns, sources and levels of income, or other socioeconomic trends that may result from different policy choices or scenario assumptions.

The Fiscal Module was, and remains, one of the more straightforward and useful parts of the model. However, endpoints from module calculations are not translated into any measure of "carrying capacity" and do not provide a basis to determine limits on future land uses.

The Human Infrastructure Module takes a very restricted view of infrastructure that is limited to traffic congestion on U.S. 1 and hurricane evacuation times. It relates median speed on U.S. 1 to land use through a simple linear regression between observed speeds and density of tourist-related development in a highway reach. Unfortunately, this relationship has very limited predictive power and, as a consequence, level of service predictions associated with different growth scenarios are not convincing.

The Integrated Water Module applies traditional first-order engineering models of stormwater and wastewater to the Keys and is appropriate to estimate long-term, time-averaged stormwater and wastewater loads, but it is not event based and cannot compute discharges associated with

individual storm scenarios. We opine that application of this module should only be performed by technically competent professionals who are familiar with the nature of the available data and the nuances of the processes being simulated or naïve overestimates of management practices could be made. We are concerned with the mixture of ways in which water consumption is estimated in the CCIAM and question the assumption that per capita daily water consumption will remain constant when the data suggest that it has been steadily increasing. Module limitations imply an inability of the module to evaluate scenarios as a function of population changes. A better statement of its capabilities and limitations is needed.

Most major criticisms of the Terrestrial Module that were raised by the NRC (2002) have been addressed in the FKCCS and CCIAM. However, there remains a perhaps insurmountable problem in that the Module cannot evaluate impacts to terrestrial ecosystems that are not reflected in land-use changes. As a result, the Socioeconomic, Fiscal, Human Infrastructure, and Integrated Water Modules do not, for the most part, provide output that registers as an impact in the Terrestrial Module. For example, an increase in day-trippers has no impact on terrestrial habitats or endangered species in the model because they do not change land use. This is a serious limitation for a tool that was prompted by concerns over impacts of numbers of people on the carrying capacity of the environment, including sensitive habitats and endangered species.

As recommended by the NRC (2002) the Marine Module has been eliminated from the CCIAM. It must be recognized that the inability of the model to address the impacts of population increases and land use changes in the Keys on the nearshore marine environment is a very serious limitation in the FKCCS. We remain convinced that more innovative analyses of data sets may have revealed some convincing links between human activities and development and marine habitats and resources.

The goal of the Canal Impacts Assessment Module is to fill the void left by elimination of the Marine Module. The Canal Module provides the only link between simulated stormwater and wastewater loads and the receiving waters of the Florida Keys. It appears to provide a reasonable first-order estimate of canal water quality. However, long-term average loadings are used which precludes use of the module to assess impact of storms on water quality in the finger canals. Pathogens are not considered and may be an important consideration in recreational uses in canals. The module suffers from lack of rigorous calibration and sensitivity analysis.

In summary, the CCIAM, in its current state, may be a useful tool, but with substantial limitations. It seems to be capable of evaluating some useful, although imprecise, surrogate measures of the impacts of development on the terrestrial habitats in the Florida Keys. Because this is the first time this has been attempted, it is a substantial contribution to science-based analytical capability. However, significant improvements in the model are required before we have any confidence in its predictive capabilities for future scenario runs.

Even while such improvements in the CCIAM are initiated, Monroe County and the State can derive benefits from the FKCCS. The land use and other databases contained in this study, as

well as scenarios that were tested and land suitability analyses, can be utilized as appropriate in planning efforts and considerations concerning potential revisions to the Comprehensive Plan.

Chapter 1. Introduction

Purpose

The purpose of this document is to summarize the results of an independent evaluation of the Final Florida Keys Carrying Capacity Impact Assessment Model (CCIAM) (June 2002) and Florida Keys Carrying Capacity Study Draft Final Report (FKCCS) (September 2002). Conducted by qualified experts, this final peer review was performed to ascertain whether the Final FKCCS and its supporting information, assumptions, and conclusions are supported by adequate and sound science. In particular, the reviewers focused on the extent to which the final report and model reflect the recommendations contained in the National Research Council's "A Review of the Florida Keys Carrying Capacity Study" (NRC 2002). This present report also provides the first peer review by an independent evaluation panel of new components of the study, including the Canal Impacts Assessment Module.

During the course of this review, it became obvious to the sponsors of the review that the Final Review Committee had significant concerns over implementing the model in its current state. Those concerns over implementation, as well as recommendations to improve the model, are included in this review and were not part of the original scope-of-work.

This independent peer review is endorsed by the Florida Keys National Marine Sanctuary (FKNMS) Advisory Council and the FKNMS Water Quality Protection Program Steering Committee. Funding and administration of the review have been provided through a public/private partnership; participating organizations include the U.S. Environmental Protection Agency, the South Florida Water Management District, the National Oceanic and Atmospheric Administration, The Nature Conservancy, and Sanctuary Friends of the Florida Keys.

Background

The Florida Keys ecosystem is unique, ecologically rich and environmentally sensitive. In 1975, the State of Florida recognized its special character by designating the Florida Keys as an Area of Critical State Concern. Because of that designation, Monroe County, which includes the Florida Keys, must meet strict planning standards that address the ability of future development to sustain the ecological diversity and quality of life that exist in the Keys.

In 1993, Monroe County developed the "Monroe County Year 2010 Comprehensive Plan" (Comprehensive Plan). Several legal challenges to the Plan opined that the ecosystem was either at, or had already exceeded, several "carrying capacity indicators,

such as nearshore water quality, health of coral reefs and seagrasses, population of Key deer, and hurricane evacuation capability." Part of the Administrative Hearing Officer's ruling on these challenges concluded that the nearshore waters of the Florida Keys had exceeded their carrying capacity for assimilation of nutrients. In 1996, as a result of that decision, the Florida Administrative Commission and the Governor issued Rule 28.20-100, that contains a five-year work program for Monroe County aimed at correcting land-based sources of nutrient pollution to nearshore waters, as well as other matters. That Rule requires completion of a Florida Keys Carrying Capacity Study and Carrying Capacity Assessment Model (CCAM) in order to "determine the ability of the Florida Keys ecosystem and various segments thereof, to withstand all impacts of additional land development activities."

The U.S. Army Corps of Engineers (USACE) and the Florida Department of Community Affairs (FDCA) jointly sponsored the development of the FKCCS and CCAM, which was contracted out to URS Corp., Inc. Recognizing the need for an authoritative, independent technical review, the USACE and FDCA requested that the National Research Council (NRC) convene a committee to undertake that task.

The NRC selected a review committee to evaluate the "Florida Keys Carrying Capacity Study: Test Carrying Capacity Analysis Model, First Draft" (November 2001). The NRC Review Committee published "A Review of the Florida Keys Carrying Capacity Study" (NRC 2002). That review evaluated the scientific methods, principles, and data that form the bases for the FKCCS and CCAM. In addition, the NRC Review Committee was asked to assess the ability of the FKCCS to fulfill its stated goal of "determining the ability of the Florida Keys ecosystem to withstand all impacts of additional land development activities" and to determine the extent to which the conclusions reached were based on a sound scientific process.

The NRC Review Committee was specifically charged to review and comment on the following components of the FKCCS and CCAM:

- the overall design assumptions;
- the data used;
- the requirements, responses, limiting factors, and thresholds for the study categories selected;
- the determination of the manner in which land development activities affect study categories; and
- the adequacy and reliability of the study as a basis for local and state land management and planning decisions.

The NRC Review Committee recommended that the concept of developing a precise numerical model be abandoned and that the focus be shifted to the production of an "impact assessment tool" that can be used to compare the consequences of various development scenarios on environmental and social systems in the Keys. This change of emphasis was made and the name of the model was changed from CCAM to Carrying Capacity Impact Assessment Model (CCIAM).

The NRC Review Committee was officially disbanded after completion of their final report (NRC 2002), which was very critical of several components of the November 2001 FKCCS. As a result, the NRC Review Committee suggested that it was imperative an independent panel critically review the Final FKCCS and CCIAM, particularly as the final versions contained new elements that had not received any independent review heretofore. The FKNMS Water Quality Steering Committee (April 2002) and the FKNMS Advisory Committee (July 2002) endorsed such an independent peer review of the final products of the carrying capacity study.

As neither the USACE nor FDCA had the financial resources committed for an independent assessment of the final products, a public/private partnership was formed to sponsor this review. Members of the original NRC Review Committee were contacted and asked whether they were willing to participate in a peer review of the final products of the FKCCS. All members of the original NRC Review Committee enthusiastically endorsed such a review and agreed to participate. The members of the Final Review Committee, as well as their individual biographies, are given in Appendix A**.** Please note that although the membership of the Final Review Committee is identical to that of the NRC Committee, the National Research Council does not endorse the present review of the final products of the FKCCS. The Final Review Committee members are acting independently of the National Research Council and were selected to participate in this review because of their knowledge of the history of the process as a result of their involvement in the NRC Committee and because of their expertise in the various scientific and socio-economic disciplines involved in the model.

Structure of the Report

The report is divided into five chapters and five appendices. Chapter 1 is the introduction and provides an abbreviated history of the development of the FKCCS and explains why this review was conducted. Chapter 2 contains the bulk of the review of the FKCCS and CCIAM and provides a detailed review of the model through a discussions of the six modules previously reviewed by the NRC Committee, focusing on their conformity with those prior recommendations, any remaining issues or refinements necessary, and qualifications on use and interpretation. Chapter 3 provides a review of the new Canal Impacts Assessment Module. Chapter 4 summarizes cautions concerning implementation of the FKCCS based upon its limitations and suggests research and development needs. Chapter 5 provides the summary and conclusions of this report. Appendix A contains the biographies of the review committee, and Appendix B provides a list of acronyms contained in this review. Appendices C and D contain detailed comments on the FKCCS and CCIAM, respectively. Appendix E contains a Memorandum for the Record prepared by Deborah Peterson (USACE) that discusses changes made in the Draft CCAM as a result of review comments by the NRC Review Committee and others. Appendix F is a summary of a telephone conference call between the Final Review Committee, the USACE and FDCA, federal and State sponsors of the FKCCS and CCIAM, and URS Corporation, Inc., the contractor for the project. The conference call was held on November 9, 2002 and was summarized by Deborah Peterson (USACE). A main

purpose of the conference call was to summarize changes that were made to the November 2001 Test Model as a result of recommendations made by the NRC Review Committee and other reviewers. In addition, members of the Final Review Committee asked specific and detailed questions concerning the Final Draft FKCCS and CCIAM.

Chapter 2. Detailed Model Review

The CCIAM is composed of component modules that cumulatively evaluate the impact of additional development on the Keys. This chapter deals with the six modules previously evaluated during the NRC review processes. A seventh, the Canal Impacts Assessment Module, is completely new to this iteration of the model and is dealt with separately in Chapter 3. For each of the six modules, this review discusses its conformity with previous NRC recommendations, any remaining issues or refinements needed to the final module, and important qualifications on use and interpretation. In addition, a review of the spatial database is included to assist users in further understanding the model and its limitations. Cautions on future use of the model are discussed in more detail in Chapter 4.

Scenarios

The CCIAM was used to run five different scenarios that were selected by local planners, including a Smart Growth scenario. Smart Growth assumes construction of wastewater and stormwater treatment facilities, very limited population growth, and a focus on redevelopment. Because of the range in environmental improvements of the alternatives tested, Monroe County has some reasonable planning options that can be tested against public policy and cost effectiveness criteria.

Spatial Data and Analysis

The most important database supporting the CCIAM is the spatial database. Based on the general description of the database, how it was assembled, and the data sets included, the Final Review Committee believes that the database should represent a major contribution to the ability to analyze the impacts of alternative land use plans and policies throughout the Keys. The Final Review Committee's major impediments to drawing a firm conclusion in this regard are that it has seen no documented data structure for the database, nor has it had the opportunity to review the data quality control procedures used. The Final Review Committee assumes that the documentation exists and that the quality control was appropriate. That being said, applying GIS techniques to existing sources of information, such as coupling tax roll data and aerial photography, to craft a reasonably accurate land-use database is a valuable addition to planning efforts. It is important that the database, Graphical User Interface, and the model be maintained and updated. It is our understanding that the South Florida Regional Planning Commission will assist Monroe County in that function, a move the Final Review Committee supports.

Spatial analysis is handled by ArcInfo8.1, an industry standard package. The spatial resolution of the model is a function of the underlying data sets, which is not described in

the documentation reviewed by the Final Review Committee. Many of the model's spatial computations are based on distance between patches, parcels, and or features. The concept of distance (edge to edge, centroid to centroid distance, edge to centroid, pixel to pixel, etc.) is never defined nor discussed in the documentation. Different definitions may be appropriate for different computations in the model. This is especially important where parcels or patches may be of largely differing sizes, as is the case in the Keys.

The model also uses spatial analysis in implementing a hierarchical priority system for allocating development. The hierarchical criteria are given in Tables 4.1 and 4.2 in the CCIAM (July 2002). The version of Table 4.1 reviewed by the Final Review Committee is in error, with some land categories omitted and others duplicated. The Final Review Committee assumes that the errors are typographical and are not reflected in the model data. When hierarchical criteria are used in decision-making, the potential, and in this case the likelihood, exists for ties. The model must then use some alternative criteria, even if it is random selection, to break the ties. The tie breaking methodology is not described, and is potentially important. Unless tie breaking is consistent, separate runs of the same alternative can produce different and very hard to explain results.

The hierarchical development categories specified in Table 4.1 and 4.2 (July 2002) represent development based solely on preserving environmental values. Unfortunately for the environment, actual development decisions have other motivators. As a result, it is unlikely that actual development would proceed in the manner identified using the model's hierarchical strategy. Obtaining a more realistic picture of potential development will likely require other options (spatial algorithms) as approaches to determining the particular geographic locations of development to be evaluated.

Socioeconomic Module

The Socioeconomic Module remains one of the least well developed modules in the CCIAM. In principle, the Socioeconomic Module has the potential to provide important predictions about socioeconomic variables based on assumed scenario conditions. These predictions could play an important role in the CCIAM as a) input to other modules, and/or b) as measures for important socioeconomic endpoints. At present, however, the Module fails to deliver much of value on either score for three major reasons.

1. The Socioeconomic Module appears to be largely uncoupled from the rest of the CCIAM.
2. The Socioeconomic Module does not include endpoints measuring either quality of life or socioeconomic welfare of the residents of the Florida Keys.
3. The Socioeconomic Module relies on a series of constant coefficients that do not change from scenario to scenario. This point is a particularly serious defect for an impact assessment tool. Because of the approach taken, the Socioeconomic Module cannot predict increases in housing prices, changes in commuting patterns, or other important socioeconomic trends that may occur as a result of different policy choices or scenario assumptions.

While these issues limit the usefulness of the Socioeconomic Module, it does contain a useful compilation of socioeconomic data on the Florida Keys.

Conformity with NRC Recommendations

Three of the major concerns raised in the NRC's final report (NRC 2002) have been addressed. The census database (used for deriving coefficients and population estimates) has been updated from 1990 to 2000, a distinct improvement. Additionally, both the independent population projections and the Competitive Commerce Index have been deleted. The major concerns remaining raised by the NRC final report (pp. 21-25), however, have not been adequately addressed.

First, the NRC Committee raised a concern about the use of numerous constant coefficients in the Socioeconomic Module (p. 21). Many of those coefficients are likely to change over time and are likely to be sensitive to alternative scenario assumptions. The NRC Committee report listed three possible approaches for properly assessing the appropriateness of those constants (p. 22): (1) sensitivity analyses in which coefficients are assigned alternative values across a range of plausible values, (2) analysis of historic trends in coefficient values for the Keys, and (3) comparison of values of coefficients with those for other counties in Florida. To the reviewers' knowledge, none of those approaches has been tried.

The NRC Committee (pp. 22-23) further observed that the Affordable Housing Index included in the Draft CCAM could not be used for impact assessment because it was a static measure that did not respond to changes in the land use scenarios upon which the model was based. The NRC Committee stressed the importance of affordable housing as a model output and briefly described two alternative approaches to developing an index that could be a functional component of the CCIAM. The contractor chose, instead, to ignore the affordable housing issue. As a result, the Socioeconomic Module lacks the ability to predict changes in housing prices as a function of land use scenarios. The only reference to housing prices is a report of data on current housing prices.

Concerns were also raised on the range of endpoints computed from the Socioeconomic Module (pp. 23-24). None measured either quality of life or the socioeconomic welfare of the residents of the Florida Keys. While many of the indicators in the Socioeconomic Module are different, there is still no clear link between these indicators and the quality of life or socioeconomic welfare of residents of the Florida Keys.

The revised Socioeconomic Module, as it is presented in the third revision of the CCIAM (July 2002), is radically different from the module reviewed by the NRC Committee. Five of the eight indicators included in the Draft CCAM have been dropped: (1) projected new dwelling units, (2) required income, (3) affordable housing index, (4) retail concentration index, and (5) total employment. Two new indicators are now included in the module: (1) non-residential population ratio and (2) hotel population ratio. Three

indicators remain from the Draft CCAM: (1) total payroll, (2) added new construction cost, and (3) added taxable value

The CCIAM (in Table 2.3) and the Draft Final FKCCS (in Table 3.12) list two different measures as the socioeconomic indicators upon which alternative scenarios are evaluated: (1) population demand for non-residential uses and (2) business demand for employees. Population demand for non-residential uses is calculated in the module (CCIAM, Appendix C, SE 20) and is used to calculate one of the five indicators listed in Appendix C of the CCIAM, the non-residential population ratio (CCIAM Appendix C, SE 32). Business demand for employees is reported in the Draft Final FKCCS, but its calculation is not documented in the CCIAM. One of the variables upon which it is based, "employees available," is not documented in either report. (See further discussion of this topic in the following subsection.)

Putting aside issues as to how the indicators are calculated, a more fundamental question is whether these indicators reflect the quality of life or socioeconomic welfare of residents of the Florida Keys. Both "population demand for non-residential uses" and "business demand for employees" measures are really internal consistency checks on user inputs: does the amount of non-residential development match that of residential development? If these ratios are not close to 1.0, the user should redefine the inputs. Apart from using these indicators as an internal consistency check, however, there is virtually no reason to track them. Given the universe of possible socioeconomic indicators, it is unclear why these two indicators in particular were chosen.

The NRC also criticized the lack of incorporation of information from the Public Involvement and Information Plan (PIIP) into the Socioeconomic Module. There is a similar lack in the revised CCIAM.

Another NRC comment focused on the exclusion of estimates of "day-tripper" tourists from the module, arguing that these tourists are an important component of the Keys economy. Because neither the Socioeconomic Module nor the Fiscal Module calculates any measure of consumer spending or tax revenues, this issue is largely moot in so far as economic impacts are considered. However, it is important to account for day-trippers elsewhere in the CCIAM. This appears to have been done only in the Integrated Water Module, where computations of potable water demand and wastewater volumes are based on a method of estimating "equivalent dwelling units" used by the Florida Keys Aqueduct Authority that is said to capture the demands of day-trippers as well as those of transient tourists (those staying less than 30 days) and permanent and seasonal residents. Documentation available for the Miller Consulting hurricane evacuation model (see discussion under the Human Infrastructure Module), indicates that day-trippers are not included in calculating evacuation clearance times (Miller Consulting, Inc. 2001). Functional population, which excludes day-trippers, is the only population parameter calculated within the Socioeconomic Module (CCIAM Appendix C, SE 17, p. 181) that is used as an input elsewhere in the CCIAM. It is used in the fiscal module as the base for calculating per capita costs of public expenditures required under different growth scenarios (F 6, F 7, and F 8, pp. 184-185).

Finally, the NRC report complained of lack of reference and detail that hindered understanding calculations in the Socioeconomic Module. The Module has been simplified, making it easier to follow calculations in the Module than previously. However, there are still places where documentation is lacking, such as for the "employees available" variable that is used to calculate one of the Module indicators.

Issues and Refinements Concerning the Final Module

The Socioeconomic Module is almost completely uncoupled from the rest of the CCIAM. The five indicators now calculated by the revised module are not used as input to any other module. Only one parameter calculated in the module, functional population, is used as an input elsewhere in the CCIAM, and this only in the fiscal module.

Population input values generated by the Miller Consulting hurricane evacuation model are apparently derived from counts of dwellings units obtained from the scenario generator (CCIAM, p. 64). Potable water demand (IWM, p. 186), and wastewater volumes generated (IWM, p. 189) are based on counts of equivalent dwelling units derived from the land use scenarios and constants based on water consumption per EDU (CCIAM Table C.6) rather than population estimates (see further discussion under the Integrated Water Module).

The two socioeconomic indicators used in the scenario assessments presented in the CCIAM (in Table 2.3) (population demand for non-residential uses and business demand for employees) assess whether a user-generated scenario has adequately balanced increases in residential with increases in non-residential development and increases in non-residential development with the local labor supply (assuming that these ratios should remain constant). The justification for these two indicators is not adequately explained nor are the derivations of each clearly explained in the CCIAM.

Population required (demand) for non-residential land use (CCIAM Appendix C, SE 20) is an estimate of the number of people required to support the new total amount of non-residential floor area that results from a development scenario. This indicator is based on an estimate of gross floor area (GFA) per capita (CCIAM Appendix C, SE 6), that in turn is based on an estimate of GFA demand. GFA demand is reportedly derived from county tax roll data, but it is unclear what this parameter measures.

The population-required parameter is evidently intended to assess whether there is a proper balance of commercial and residential land use in a particular growth scenario. This balance is also reflected in a separate parameter, the non-residential population ratio (CCIAM Appendix C, SE 32). This parameter arguably provides better insight into the relationship of concern and ought to be used in the Draft Final FKCCS as the indicator. Furthermore, while it is listed as an indicator in the CCIAM, it is not employed as such in the FKCCS.

The non-residential population ratio (CCIAM Appendix C, SE 32) is calculated by dividing the permanent population (CCIAM Appendix C, SE 15) by the population-

required indicator (CCIAM Appendix C, SE 20), yet the population-required indicator is based on both the permanent and seasonal populations. This inconsistency in referent population base renders the ratios invalid.

This ratio also assumes that the GFA per capita ratio (CCIAM Appendix C, SE 6, CCIAM, p. 180) used to calculate the population required for non-residential land use (CCIAM Appendix C, SE 20) represents an equilibrium condition, i.e., that there was not an over-supply or excess demand for non-residential floor area at the time the data were collected that were used to calculate the ratio. The GFA per capita is likely to change in response to significant shifts in the average income of residents as the price of housing increases over the next 20 years.

It is unclear how the second socioeconomic indicator used in the Draft Final FKCCS, "business demand for employees" is calculated. It is defined (FKCCS, 2002, p. 81) as the ratio of the number of employees required to support the amount of gross floor area (GFA) of non-residential land use versus the size of the local labor force (number of employees available). It is meant to provide an indication of the extent to which needed employees will have to commute to the Keys from other areas (Ricardo Calvo, personal communication, November 9, 2002.)

The first parameter, the number of employees required to support the GFA of non-residential land use, is calculated in the module (CCIAM Appendix C, SE 22, p. 182), but the method of calculating estimates of the available local labor force (employees available) is not documented in the CCIAM. The contractor has indicated that this formula was inadvertently excluded from the CCIAM (Ricardo Calvo, personal communication, November 9, 2002.). It is reportedly calculated by multiplying a constant, which represents the percent of the Keys population that is employed, against the combined seasonal and permanent population predicted for a given scenario. Calculation of the ratio is not documented in Appendix C of the CCIAM, but is reported in the scenario results in the Draft Final FKCCS (in Table 4.3).

The contractor has assumed that additional employees required to staff new non-residential land uses will come from the additional residents who move to the Keys under scenarios that allow additional residential development (Ricardo Calvo, personal communication November 22, 2002). The justification for such an assumption is not supported by the trends in socioeconomic characteristics of the residents of the Keys. The assumption neglects the fact that housing prices have increased dramatically over the past 10 years and, as a result, the labor-force participation rates of the population have likely changed as well (see further discussion in next section). In the absence of any mechanism to predict changes in such socioeconomic characteristics, it is unwise to assume that future residents will provide the labor force needed by new non-residential land uses.

Cautions are also in order for three of the other socioeconomic indicators reported in Appendix C of the CCIAM:

1. *Total payroll:* (CCIAM Appendix C, SE 29, p. 183) The module assumes that the increased payroll that would result from increased non-residential land uses would accrue to residents of the Keys. As noted above, the module provides no support for this assumption.
2. *Added new construction cost:* (CCIAM Appendix C, SE 30, p. 183) This indicator provides a measure of construction cost that assumes no change in costs and is *not* a measure of the effect of land use change or population growth on the cost of new construction.
3. *Hotel population ratio:* (CCIAM Appendix C, SE 33, p. 183) This ratio is similar to the non-residential population ratio (CCIAM Appendix C, SE 32) discussed above. There are no inconsistencies in the population bases used for the numerator and denominator of the ratio, as both are based on estimates of the transient population. As with the residential population ratio, however, the ratio of hotel rooms to transients, (CCIAM Appendix C, SE 8) which is used to calculate the hotel population ratio, is assumed to represent an equilibrium state.

Qualifications on Use and Interpretation of Module Output

The Draft Final FKCCS argues that the low growth rate anticipated over the next 20 years makes it reasonable to assume that all socioeconomic coefficients will remain essentially stable. Comparison of median housing values between the 1990 and 2000 censuses strongly suggests that such an assumption is not justifiable. During the decade between the two censuses, the median value of an owner occupied housing unit increased from $151,200 to $241,200, an increase of roughly 60% (U.S. Census). This rate of increase was much faster for Monroe County than for the State of Florida, or the U.S. as a whole.

As a result of the rapid increase in housing values, the socioeconomic characteristics of the residents have changed. Residents are likely to have higher incomes and smaller household sizes, they are likely to be older, and the proportion of retirees is likely to be higher. Comparing figures from the 1990 and 2000 census would document this. In fact, the CCIAM (in Table 5.2) documents declines in two of the three labor force age cohorts (18-24 and 25-44) between 1990 and 1996 and an increase in the retiree cohort (65+). Such changes are very likely to affect consumer behavior and the composition of the resident labor force, two factors that directly affect the two new socioeconomic indicators listed in Table 2.3 of the CCIAM and Table 3.12 of the Draft Final FKCCS. In fact, the CCIAM documents that the portion of income from investments increased dramatically between 1971 and 2001, while that from wages declined. The Draft Final FKCCS documents that employment in the Florida Keys rose by 18.14% from 1990 to 1997 while resident population rose only 2% from 1990 to 2000.

The absence of sensitivity testing or comparative assessments of the constant coefficients used in the Socioeconomic Module provides CCIAM users with no sense of the appropriateness of the coefficients or of the conditions upon which they may depend. The user, therefore, has no basis for judging an appropriate level of uncertainty to ascribe to output from the module, nor will the user have any basis for judging when it may be appropriate to revise those coefficients.

Thus, the Socioeconomic Module presents very limited insight into the socioeconomic effects of future growth in the Florida Keys. There is no link between assumptions about changes in land use with changes in housing costs, or changes in the demographic or socioeconomic characteristics of the population. In turn, there is no capability for determining how such changes will affect the character of communities in the Florida Keys. The module cannot address concerns over affordable housing or increased prevalence of workers commuting from the mainland. The socioeconomic indicators do not address fundamental concerns about quality of life or important changes in socioeconomic conditions that may occur under different scenarios.

Fiscal Module

The goal of this module was to establish the cost of conducting the business of local governments and to document the additional costs of new development, including unfunded liabilities, under both existing conditions and a variety of future conditions, including smart growth.

Conformity with NRC Recommendations

The NRC report found the Fiscal Module that was presented in the Draft CCAM to be a very detailed collation of governmental expenditures derived from very recent data sets. The NRC Committee's suggestions on the Draft CCAM to include the costs of land acquisition and possible cost-sharing scenarios were accepted and appear in both the FKCCS and the CCIAM.

The NRC Committee's suggestions to provide more details on the loss of revenues as land is acquired and the impacts of changing demography on fiscal needs were not incorporated, however. One significant change from the previous version was incorporation of a variety of improvements to U.S. 1 in the model runs that resulted in the generation of a new entry in the costs of further development.

Issues and Refinements Concerning the Final Module

To measure the financial burden, the module assigns cost per capita using the functional population of the Keys. The implication is that increased costs per capita would trigger some method to raise revenues to cover the additional costs, which represents an additional burden on Florida Keys residents and visitors. These new costs, however, could be allotted to a number of other measures, such as per resident population, per land parcel, or some other unit measure. The most appropriate measure would depend in large

part on what form of tax assessment of the permanent population, visitors, or some combination thereof, is used to raise the revenue (e.g., property tax, hotel beds tax, etc.).

The CCIAM states that portrayal of the costs per resident is the most comprehensive measure of the fiscal impact, but provides no rationale for that conclusion. This lack is puzzling because the statement refers to functional population, rather than resident population, but fails to discuss the appropriateness of one measure over another. Later, a footnote to Table 11.4 supports use of functional population for facilities planning in Monroe County. Indeed, it may be more appropriate to list the costs according to several of the population units as a means to provide some sort of scale of new costs relative to existing costs. While Table 11.4 does incorporate some of these values, it is unclear whether all land acquisition is included in the annual expenditures. The table could be expanded to include this information.

The module also states that raising revenues through *ad valorem* and non-*ad valorem* taxes are the avenues in order to meet the government's fiscal needs. This short description is probably adequate because discussion of the possible sources of revenue that could be used to meet expanding local government needs is another issue. Yet, this may be the place to identify the loss of tax base as lands are purchased and put into the public sector (shown in Table 4.8 as nearly $500,000,000).

The FKCCS and CCIAM present various measures of the cost of providing municipal services and meeting unfounded liabilities, but it is unclear as to how the these costs translate into indicators of carrying capacity. This matter could be addressed in additional text, or endpoints could be transferred to a table that consists of "fiscal impacts" rather than indicators of carrying capacity.

Fiscal Component of Model Runs

Using five scenarios to depict somewhat different conditions does provide an appreciation of scale and scope to some of the fiscal issues regarding future development in the Keys. However, there is an apparent problem with the values applicable to Scenarios 1 and 3 that are presented in the FKCCS in Table 4.8. Specifically, the text describes all scenarios as including improvements to U.S. 1 to assist in facilitating evacuation, but Scenarios 1 and 3 do not associate any costs with these improvements. Further, U.S. 1 is a federal highway and it is difficult to understand whether the $72 million in improvements is entirely the local cost burden or a combination of federal and local costs.

Additionally, Scenario 3 incorporates 500,000 more annual visitors, but the wastewater treatment figures do not show increased costs associated with increased wastewater output. The additional population might be accommodated without additional expenditures in wastewater treatment, but in Figure 4.9 something causes higher expenditures in Scenario 3 than in Scenario 1, which is at odds with the scenario costs presented in Table 4.8. Further, the representations of the data presented for several of the scenarios in Figure 4.9 do not agree with the values of similar data presented in Table

4.8. Without additional description, it is difficult to ascertain how these two data sets were established or represented and, by extension, what are the bases of the discrepancies.

Once the differences in Table 4.8 and Figure 4.9 have been cleared up, it is suggested that the table incorporate an additional column to portray the costs associated with Smart Growth, for comparison. It may also be valuable to add a few more rows to the table to show cost per capita per permanent resident, per functional resident, and per parcel (and/or per Planning Area).

According to scenario descriptions, the FKCCS models run in the FKCCS portion of the report include major improvements to U.S. 1 that are apparently intended to alleviate specific bottlenecks in the highway to allow an increase in the rate of evacuation. It is unclear as to whether this cost is entirely a local government responsibility. These improvements may not be consistent with the information presented to the reviewers early on in the review process, to wit: no additional lanes will be added to U.S. 1, no widening will occur, no increased capacity will be incorporated. More information is needed that establishes the suitability of these improvements and decisions concerning limiting the capacity of U.S. 1.

The purpose of the Fiscal Module procedure comes to the fore again when considering a scenario where all improvements are made and costs covered in the process of accommodating the new land uses. If the unfunded liabilities were necessarily met as a condition to proceeding to some next step in incremental growth, redevelopment, and restoration, a spreadsheet model could depict the impact of costs to any measure of population or to Planning Areas.

Qualifications on Use and Interpretation of Module Output

As stated above, the fiscal component of this project is a combination of a ledger of expenditures and unfunded liabilities for the Florida Keys. The case is made for a substantial increase in per capita costs to residents and visitors to meet the needs of all of the scenarios projected into the future. However, the endpoints from the Fiscal Module are not translated into carrying capacity and are not a basis to determine limits of future land use.

It would seem that the Fiscal Module in its present state could create a multi-functional spreadsheet that would produce a cost calculation of a range of options to meet existing demands before looking at land-use changes and their fiscal impacts. If so, then this could be a valuable output that is independent of the model runs; and this tabular output could provide a comparative measure of demands/impacts in the fiscal domain. It could be a useful product, similar to the accumulation of information and other data assembled in the course of completing this project.

Human Infrastructure Module

The Human Infrastructure module of the CCIAM focuses on two related concerns that will be affected by future growth in the Florida Keys: (1) traffic congestion on U.S. 1 and (2) hurricane evacuation clearance times. The Draft Final FKCCS also addresses potable water supply as part of the Human Infrastructure Module, but because it has been treated as part of the Integrated Water module in all versions of the CCIAM, our review of the potable water supply component is presented in the section discussing that module.

Traffic Component

Traffic impacts can be evaluated against explicit standards. The level-of-service standard (LOS) adopted by Monroe County and the Florida Department of Transportation for U.S. 1 is LOS C (overall speed of 45 to 47.9 mph). Current median speeds are below the adopted LOS standard for 14 of the 26 planning units (CCIAM, Table 7.3, p. 61), which suggests that LOS is an important indicator of carrying capacity.

Conformity with NRC Recommendations

In its review of the Draft CCAM, the NRC Review Committee raised concerns about the use of 10-year old coefficients from national census data to estimate the numbers of additional trips that would be generated from increased growth in the Keys (NRC 2002). The NRC also raised several questions about the methods used to estimate trip lengths and recommended that sensitivity testing be conducted to assess the influence of the trip generation coefficients on LOS estimates for U.S. 1.

The CCIAM reports that attempts to calibrate the trip generation module failed. As a result, an effort was made to develop a regression model that could be used to predict median speed based on the density of residential and tourist-related commercial land use within each planning unit per mile of U.S. 1 through the planning unit. In addition, the revised traffic component includes a residential capacity estimator used by the U.S. 1 Task Force that estimates the reserve capacity of U.S. 1 as a whole, based on the total number of residential units on the Keys.

Given the decision to abandon the trip generation method, other NRC comments concerning the traffic component are no longer relevant.

Issues and Refinements Concerning the Final Module

The regression model now used to estimate median speed on U.S. 1 has several limitations:

1. the model is based on a single independent variable that explains only about 30 percent of the variation in median speed on U.S. 1;
2. the model is evidently based on only one year of data;

3. the model includes an obvious outlier (per Figure 7.1 of the CCIAM) that affects the slope of the line and, therefore, the coefficient estimated by the model (Ricardo Calvo, personal communication November 9, 2002.); and
4. the model estimate is linear, despite a scatter plot that suggests that some other functional form might provide a better fit to the data.

Additionally, the Draft Final FKCCS indicates that the results of the scenarios that have been tested yield changes in traffic volumes and median speeds that are less than the annual fluctuations observed over the two most recent years of monitoring data (2000-01 and 2001-02). The implication is that the effects of growth on traffic will be inconsequential. Given the fact that the LOS thresholds are already exceeded in more than half the planning units and the limitations of the model, such a conclusion cannot be supported.

Qualifications on Use and Interpretation of Module Output

Estimates based on a single parameter coefficient, limited data, and questionable model form offer little predictive utility and should not be relied upon. Further modeling efforts that address these deficiencies are needed to produce a traffic module that can be used with any degree of confidence for assessing the effects of alternative growth scenarios. In any case, sensitivity analysis by the user is warranted where scenario runs indicate that segments of U.S. 1 are at or near LOS standards.

Because LOS estimates on a segment-by-segment basis are the endpoint of concern (per CCIAM Table 2.3), the residential capacity estimator is of limited use in the CCIAM, as acknowledged in the Draft Final FKCCS.

Hurricane Evacuation Component

As with traffic impacts, evacuation clearance times can be evaluated against explicit standards. Florida's local planning requirements stipulate that local comprehensive plans must include objectives and policies that maintain or reduce hurricane evacuation clearance times (§§9J-5.12(3)(b)(7) and (3)(c)(3), *Florida Administrative Code*). In addition, the Monroe County Rate of Growth Ordinance (ROGO) stipulates that clearance times should not exceed 24 hours (CCIAM 2002). Although the CCIAM and the FKCCS provide conflicting information about the current evacuation clearance time for the Florida Keys (estimated evacuation clearance times to Florida City for the year 2000 is given as 24 hours and 42 minutes in the FKCCS (p. 90) and 24 hours and 58 minutes in the CCIAM (p. 133)), it is evident that the 24-hour ROGO standard has already been exceeded by current conditions and that some growth scenarios will result in further increases in evacuation clearance times, even with construction of the improvements to U.S. 1 recommended by Miller Consulting, Inc. (2001). Thus, evacuation clearance time represents one of the crucial carrying capacity indicators.

Conformity with NRC Recommendations

The NRC Review Committee's concerns about the hurricane evacuation component of the infrastructure module focused primarily on the linear extrapolation of clearance time estimates from an analysis conducted by Miller Consulting, Inc. in 2001 for the Florida Department of Transportation. The NRC Review Committee recommended direct incorporation of the Miller Consulting model into the CCIAM, along with sufficient documentation to enable users to interpret the outputs from the sub-model.

The Miller Consulting model has been incorporated in the revised CCIAM as recommended. According to URS staff (Ricardo Calvo, personal communication November 9, 2002), the model provided to URS is locked and cannot be manipulated by the user. Inclusion of the sub-model is a significant improvement over the previous approach taken to estimating the effects of land use change on evacuation clearance times for the Keys. Current documentation is insufficient, however, to allow users to properly interpret outputs from this component.

The NRC Review Committee also inquired about the extent to which future sea level rise had been accounted for in the evacuation clearance model. While the CCIAM (p. 146) acknowledges the fact of sea level rise, it states that its effects cannot be modeled because the predicted increases of 1.5 to 2 inches per decade are much smaller than the minimum contour elevation data available (5 feet). A comparable statement is not found in the FKCCS.

Issues and Refinements Concerning the Final Module

As stated above, there is insufficient documentation in the CCIAM and the FKCCS to allow the user to assess the assumptions and uncertainties imbedded in the Miller Consulting sub-model. While the CCIAM briefly describes the nine modules that comprise the sub-model, it provides no information about the specific input parameters, model algorithms, coefficients, or assumptions.

One particularly important example is the lack of documentation available for understanding the storm scenarios that provide the basis for the model runs. According to URS staff, only two storm-intensity scenarios are available, a Category 1-2 storm and a Category 3-5 storm (Ricardo Calvo personal communication, November 9, 2002). Informed use requires, at a minimum, information on the storm surge elevations and maximum sustained surface wind speeds that are used in these storm scenarios. Other model assumptions should be explicated as well.

The connection between sea-level rise, storm surge levels, and evacuation clearance times is of concern with regard to the elevation datum used in determining flooding of the major evacuation artery, U.S. 1. The age of the elevation datum (NGVD1929, NAVD1988, or some newer extrapolation) does matter: the older the datum, the greater the effect of subsequent sea-level rise in reducing the time to flood low portions of the

road, and in exacerbating choke points in the evacuation route. If, for example, the base elevation of a bridge or causeway on U.S. 1 is based on NGVD1929, then the true elevation of that highway feature relative to current sea level is *lower* than indicated, and the effects of an additional sea level rise of 2 to 4 inches over the 20-year planning period will be more important to accurately predicting inundation time of that highway segment and its effects on the evacuation clearance time window. This is important information that should be included as part of the documentation of the Miller Consulting model. The same point applies to the flood ratings on the FEMA Flood Insurance Rate Maps.

Qualifications on Use and Interpretation of Module Output

Incorporation of the Miller Consulting model marks a significant improvement over the previous approach taken to estimate the effects of land use change on evacuation clearance times for the Keys. Informed use, however, is important to proper interpretation of the model outputs. This is especially critical given the fact that under current conditions, the ROGO standard of 24 hours is exceeded and that any scenarios that do not include construction of the improvements recommended in the Miller Consulting report will likely further increase evacuation clearance times. Therefore, efforts should be made to provide more complete documentation of the model.

Integrated Water Module

The Integrated Water Module (IWM) is one of the most substantial parts of the CCIAM. It consists of stormwater and wastewater components, that have been used to generate loadings of total phosphorus (TP), total nitrogen (TN), biochemical oxygen demand (BOD), and total suspended solids (TSS) to the near-coastal waters of the Florida Keys. The IWM thus generates "land-side" loads from "wastesheds" on the many islands of the Florida Keys. The integration of the IWM with the GIS and Scenario Generator (for land use and population projections) is very thorough and represents a significant and commendable effort on the part of the contractor.

Conformity with NRC Recommendations

The IWM remains one of the workable components of the CCIAM. Although the NRC Review Committee had several areas of concern with the Module presented in the Draft CCAM, these did not and do not prevent it from being applied for estimates of long-term, time-averaged stormwater and wastewater loads from the many wastesheds of the Keys. Because neither the stormwater component nor the wastewater component are calibrated (due to lack of monitoring in the Keys), it is inappropriate for the loads from each component to be summed, and the contractor has followed the advice of the NRC in this regard, with the exception of loadings to the new Canal Module (see Chapter 3).

For instance, it is appropriate for each component to be used to evaluate relative changes that might occur with implementation of Smart Growth scenarios and the *Monroe County Stormwater Master Plan* (Monroe County Growth Management Division, 2001a,b) and *Sanitary Wastewater Master Plan* (Monroe County Growth Management Division,

2000). It is worth reiterating that unless these plans are fully implemented, anticipated reductions in loadings under Smart Growth scenarios will not occur. This is probably most important with regard to implementation of the *Sanitary Wastewater Master Plan*, since rapid input of wastewater discharges into Keys near-shore waters are well documented (Kruczynski and McManus, 2002).

The Draft CCAM attempted to link stormwater and wastewater discharges to receiving waters through the Marine Module. Following NRC advice, the Marine Module has been withdrawn pending future revisions (see following section). Hence, IWM impacts can only be assessed in terms of load reductions under various scenarios and through its use as a driver to the new Canal Module. Again following NRC suggestions, the contractor has prepared a first-cut Canal Module, which now serves as the only link between stormwater and wastewater loads and receiving water impacts. See Chapter 3 for an evaluation of the Canal Module component of the CCIAM.

Other NRC comments were not addressed, particularly with regard to future research and enhancements regarding wastewater and stormwater issues. Notwithstanding the IWM's usefulness for load comparisons, these additions could be carried out so as to make the module more useful and reliable. As they deal largely with future refinements, discussion of these issues can be found in the next subsection.

Issues and Refinements Concerning the Final Module

Issues Related to Wastewater and Stormwater

A variety of future research and enhancements could be undertaken to improve the module's utility. The IWM still does not consider pathogens, including bacteria and viruses, that may cause beach closings and potentially impact human health. Although the contractor indicates in the Draft Final FKCCS that lack of data prevents any meaningful analysis, there are enough literature citations (e.g., Kruczynski 1999, Kruczynski and McManus 2002) to provide a more comprehensive commentary about such problems than are included in the FKCCS. (Please note that Kruczynski and McManus (2002) is largely an updated version of Kruczynski (1999)). Then at least a *qualitative* evaluation of such problems could be made as a part of growth scenarios.

Direct loadings to marine waters from wastewater discharges from vessels are still not considered, which may increase with population growth (both permanent and transient) in the Florida Keys. Again, this is an area for which lack of data apparently prevented a quantitative approach. Additional surveys and monitoring might be able to determine the magnitude of discharges from vessels in comparison to wastewater loads as an indication of the magnitude of resources that should be addressed to this problem. This deficiency in the Draft CCAM may be considered moot because of EPA's determination, effective July 2002, that all State waters in the FKNMS are a no discharge zone (NDZ) for sewage from vessels greater than 27 feet in length. However, enforcement of the NDZ remains problematic.

While it is probably appropriate to consider wastewater discharges as continuous, long-term averages, the reviewers still question the wisdom of treating stormwater loads in this manner, particularly when these loads are being used to create impacts in canals that might have short residence times (unexplored in development of the Canal Module). The contractor states that event loadings have not been considered because the CCIAM is a steady-state model with a 20-year planning horizon. It is therefore possible that critical short-term impacts on receiving waters may be missed in evaluation of scenarios, an item for future research and enhancement.

In the absence of any stormwater and best management practice (BMP) monitoring in the Keys, the contractor has used best available data from elsewhere in Florida, taken mainly from the *Monroe County Stormwater Master Plan*. Event mean concentrations (EMCs) and BMP removal efficiencies are shown in the CCIAM in Tables C.8 and C.9, respectively. Even though these values are taken from the *Master Plan*, it would be useful to document the locations in Florida from which they were derived so that the water professional who uses the CCIAM may exercise best professional judgment about the applicability of given EMCs and BMPs to a given Keys location.

The contractor's use of *Stormwater Master Plan* removal efficiencies for estimating BMP effectiveness is apparently consistent with current engineering practice in Florida. However, as an item for future research and CCIAM enhancement, the efficiency ratio method is generally a poor way to characterize most BMPs; the best alternative as determined through evaluation of the EPA/ASCE BMP Database (http://www.bmpdatabase.org/) is probably the effluent probability method (URS et al. 1999). In any event, application of the IWM should only be performed by technically competent professionals familiar with the nature of the available data and the nuances of the processes being simulated. Otherwise, less knowledgeable users may naïvely overestimate BMP effectiveness.

Issues Related to Water Use

As noted in the above discussion of the Socioeconomic Module, potable water demand and wastewater volumes are based on counts of EDUs derived from the land use scenarios and constants based on water consumption per EDU (CCIAM, Table C.6), rather than population. The method of estimating EDUs, which is based on the demand methods used by the Florida Keys Aqueduct Authority (FKAA), is said to capture the demands of permanent and seasonal residents, tourists, and day-trippers (CCIAM, p. 73). Population estimates are *not* used in these computations, though these computations do in turn influence population estimates in the Socioeconomic Module.

The CCIAM states that the computations are aggregated for each of the planning units and "adjusted at the planning unit level for functional populations, and then summed to produce the estimated total potable water requirement for the entire study area." This approach is not reflected in the computations presented in Appendix C of the CCIAM.

Thus, the water consumption impacts described for the scenarios in the FKCCS Draft Final Report appear to result from a mix of methods. Estimates for the Smart Growth Scenario and Scenarios 1, 2, 4, and 5 appear to have been generated by running the CCIAM. (Scenarios 1, 2, and 4 assume the same amount of growth as the Smart Growth Scenario; Scenario 5 is the only other bona fide run of the model with a new land use estimate and, therefore, a change in water consumption as estimated by the model.)

Scenario 3 of the Draft Final Report, describes a situation in which there are 500,000 additional annual visitors, or an equivalent functional population of 7,142. Water use for Scenario 3 increases by 0.7 mgd, as shown in Table 4.9, p. 88, but wastewater loads do not change (per Table 4.12). Hence, the impact of additional annual visitors on water use is apparently computed on an *ad hoc* basis by multiplying a per capita daily use of 100 gallons (the basis for which is not given in the Draft Final FKCCS) by the additional 7,142 functional population. Directly linking water use to the transient population (not just EDUs) would make the CCIAM easier to understand and is definitely needed to reflect this impact on generated wastewater loads.

The transient population estimate does *not* capture day-trippers. As defined by the CCIAM, transients are visitors who *stay* less than 30 days. Visitors who do not stay overnight in a hotel, motel, or condominium therefore are not counted as part of the transient population. However, the EDU estimates reported in Table C.6 and based on the FKAA's methods allegedly do account for day-trippers in an indirect way: total water consumption is divided by EDU for each planning unit. All scenarios except Scenario 3 assume that water consumption rates will remain constant for the duration of the 20-year planning periods, but those constants are the EDU-based consumption rates for individual planning units tabulated in Table C.6 of the CCIAM.

A validation check on the reasonableness of these assumptions could be performed using data taken directly from the Draft Final FKCCS. Permanent population estimates for years other than 2000 may be calculated from the growth data on p. 80 of the Draft Final FKCCS. If it is assumed (as in the model) that the temporary population has and will remain constant at 86% of the permanent population (discussed further below), the functional population can then be calculated to be 186% of the permanent population, yielding the values shown in Table 1.

Table 1: Functional Population Calculations

Year	Functional Population
1970	97,767
1980	117,514
1990	145,132
2000	148,035
2020 Smart Growth	155,556
2020 Scenario 3	162,709

Combining the functional population estimates above with the total annual water withdrawal data of Final Report Fig.4.10 suggests that per capita consumption has been steadily increasing, from 69.9 gpd in 1980 to 84.9 gpd in 1990 and 111 gpd in 2000. If per capita consumption continues to increase along with the functional population, the Smart Growth demand could be well beyond the 17.8 mgd given on Final Report p. 87 and might even exceed the 22 mgd capacity of the existing water treatment plant and the 25 mgd of the expanded plant now under construction. Scenario 3 would lead to an even higher demand. These population-based estimates should be compared to the FKAA land use-based estimates of CCIAM Table C.6.

The Draft Final FKCCS notes that "ongoing FKAA regulatory initiatives may help reduce water use." It is unclear, however, as to how sensitive the outcome for water use is on the assumption that past trends can be halted. This and other conclusions may be further compromised by the assumption that the ratio of temporary visitors to permanent residents will stay constant at 86%. Controls on housing or even hotels may not necessarily limit day-trippers and campers. If the ratio of visitors to permanent residents has been increasing over the longer term, it would explain some (perhaps most) of the increase in per capita water consumption because that would result in an overestimate of the functional population in 1980 and 1990. But water demand problems would likely still exist, because if the ratio of visitors to permanent residents has been increasing, that increasing trend may well continue. In that case, the model is underestimating functional population in 2020, and thus underestimating people-related demands and impacts.

Qualifications on Use and Interpretation of Output

The above analysis and discussion indicates a strong need for a sensitivity analysis, not to routine changes in coefficients of linear equations, but to underlying assumptions in CCIAM drivers, such as population and water demand assumptions. Unjustified assumptions (e.g., 100 gpd per capita water use for Scenario 3) about coefficients remain a critical concern with this analysis, particularly given the inability of the CCIAM to estimate changes in population that will result from alternative land use change (growth) scenarios.

In addition, uncertainty in IWM coefficients is noted for some parameters (e.g., EMCs through concentration percentiles), but not others (e.g., BMP efficiencies, waste effluent concentrations). Because almost all relationships within the CCIAM are linear, sensitivity analyses shown on pp. 68-70 of the Draft Final Report are welcome, but incomplete. It is useful to know that stormwater loads are relatively insensitive to BMP efficiencies (per FKCCS Figure 3.14) since the efficiencies are so poorly known for the Keys. The insensitivity is due to the fact that only a limited portion of the surface runoff can be captured. On the other hand, stormwater loads should be highly sensitive (one to one) to highly variable (per CCIAM Table C.8) EMC values, but this is not demonstrated. Wastewater loads are sensitive to the assumed effluent concentration (should be one to one). Thus, it should come as no surprise that implementation of the *Monroe County Sanitary Wastewater Master Plan* under Smart Growth has a big positive effect in the new Canal Module in reducing simulated concentrations in finger canals.

Generally, the most sensitive model components warrant the most effort for refinement. For the IWM, loads should be sensitive to the stormwater EMCs and wastewater effluent concentrations as just discussed.

The biggest source of uncertainty regarding potable water use is the highly tenuous link between population and EDU estimates of water use. Obvious questions about the impact of day-trippers on water use (and wastewater generation) cannot be addressed by the CCIAM.

Overall, the IWM may be used within the constraints described above, but the model documentation (CCIAM) and the Draft Final FKCCS imply an ability to evaluate scenarios as a function of population changes that cannot be achieved with the model in its present form. A better statement of its capabilities – and its limitations – is urgently needed.

Terrestrial Module

The Terrestrial Module of the FKCCS has consistently been an easily understood module. Model runs have emphasized the consequences of future growth on terrestrial systems. The FKCCS states clearly that "development in the Florida Keys has surpassed the carrying capacity of upland habitats to maintain their ecological integrity," and "development in the Florida Keys has surpassed the capacity of several protected species to withstand the effects of future development activities."

The module is based upon straight-forward relationships between changes in land use and shifts in habitat suitability for individual species. These shifts are measured as direct impacts to individual species, changes in species richness, and direct and indirect impacts to habitat. The individual species chosen, as well as those included in the species richness index, are appropriate and representative of a wide range of habitat types. These species include endangered and threatened species, as well as easily recognized species that have well known habitat suitability requirements based upon previous detailed studies and modeling efforts. The choice of species permit the module to be sensitive to changes in land use for upland hardwood and pine forests, as well as fresh water wetlands, coastal wetlands, and beach/dune communities.

Conformity with NRC Recommendations

The NRC recommended that the fiscal consequences of various land acquisition scenarios be included as model outputs. The contractor has explicitly addressed that issue, adding information on costs for land acquisition as output in the fiscal module.

In response to NRC concerns regarding decay coefficients for habitat degradation, the contractor has completely removed the use of the controversial Relative Habitat Degradation Index (RHDI) calculation, which was based upon measures of "emergy." The indirect impact to habitat has been recalculated by assuming that indirect impacts occur up to 500 feet from developed areas, a commonly accepted norm for such

measurements. While the indirect impact output is now greatly simplified, it still provides the user with some indication of such impacts and offers a way to determine the likely or plausible additional habitat effected by development. The indirect impact is still measured by a constant, but the method used is now a much more traditional method, and therefore understandable for the majority of users.

The contractor has improved the measure of direct impacts to single species, a concern raised by the NRC Review Committee, by adding four more species, bringing the total count to 11. The Lower Keys marsh rabbit, white crowned pigeon, and five interior forest birds have been joined by the Key deer, Silver rice rat, Key Largo wood rat, and the Schaus swallowtail butterfly. Partial or unclear results for interior forest birds in the previous draft have also been clarified. All of the above represent a significant improvements.

In particular, the contractor's willingness to incorporate the Key deer, as well as the Silver rice rat, the Key Largo wood rat, and the Schaus swallowtail butterfly effectively addresses the public's expectation that high-profile, well known endangered species would be explicitly included in the outputs for direct impacts to individual species, as the NRC Review Committee noted. While incorporation of these species may seem a minor improvement, since several of these species have extremely limited and well protected habitat, the inclusion will be appreciated for its value in clarifying the potential impacts of future growth to such high-profile species.

The NRC Review Committee noted reference to a species-area habitat equation was vaguely included in Appendix C of the previous draft (November 2001 but not in the text itself). Such references have been deleted from the appendices in the Draft Final FKCCS. The NRC Review Committee also recommended that references to color coded thresholds should be deleted from the draft or should be made user-defined; they were deleted.

An NRC recommendation that has not been addressed is the suggestion that limitations and arbitrary assumptions be identified and clarified; limitations and assumptions are many and varied and are always best known by the authors of a written document. The detailing of such limitations and assumptions would have added to the credibility of the Draft Final; however, this subject is unfortunately not addressed in the Draft Final.

The NRC Review Committee commented that "all vacant lands are not created equal." Reviewers hoped that this issue was to be addressed in the new section on Availability, Suitability, and Development Capacity of Vacant Lands. Unfortunately, this exercise only looked at vacant land for development purposes and included no separate application of the evaluation of vacant lands for conservation and wildlife habitat values. The treatment of all vacant land identically is a limitation of the current land categorization process (which is beyond the control of the contractor) and further discussion of this limitation is warranted.

As with the Human Infrastructure Module, the NRC Review Committee inquired on the impact of sea level rise on habitat. In the Draft Final report, the contractor makes a

strong case for inability to address this important issue, but this inability should be identified as a limitation. As noted by the reviewers as well as the contractor, sea level rise will ultimately impact every aspect of life in the Keys and some narrative text regarding the sensitivity of module output to short term impacts (20 years) is warranted. After all, even a 2 to 4 inch rise in sea level in 20 years could drastically affect fresh water wetlands via salt water intrusion in ground water. Such changes could also impact the root zones of some species in upland plant communities.

The NRC's report also pointed out the shortcomings and oversimplifications in applying a constant indirect impact measure to all land uses. Land uses, such as recreational and open space, as well as commercial and two- and four-lane highways, will have increasing functional human population impacts per unit area related to day trippers and tourists that are not well captured in a static coefficient for their distance from habitat. This is another limitation the Final Review Committee felt could have been addressed or at least should have been clearly stated.

Issues and Refinements Concerning the Final Module

Future land use decisions regarding the Key deer will be addressed using the Habitat Conservation Plan (HCP) for that species. Since that plan is not complete at this time, there is no way of knowing whether the outcomes will be similar from the FKCCS model and the HCP. Once the HCP is completed, the manner in which it affects land use changes and this species' habitat and survival should be incorporated into the module for future model runs. Until that time, this limitation should be clearly stated.

Scenario 2 examines the cost of restoring areas to connect habitats, but is overly simplistic and unrealistic. It resulted in no change in land use from Scenario 1, but clearly some real-world rules could be applied in such a land restoration program. Such rules would include information on habitat fragmentation theory, island biogeography theory, and data from individual species models identifying preferable habitat associations, as well as habitat corridors for movement and gene exchange. These types of land restoration activities would most likely cause actual changes in land use that would register as new habitat in the terrestrial module. This scenario was run "outside" the model and only results in output as costs of land restoration in the Fiscal Module. Please note that if this interpretation of the scenario is incorrect, it may indicate some ambiguities that would lead other readers to have difficulty in understanding this scenario's outputs in terms of the Terrestrial Module.

In addition to the need to clearly identify important issues or problems that they could not address or resolve, it would have been useful if the contractors presented and discussed a detailed "wish list" for future projects, new databases, and future improvements in the model.

Qualifications on Use and Interpretation of Module Output

Any changes to scenarios that are not explicit changes in land usage, are not measurable in the Terrestrial Module and may lead the reader to overlook potential real-world impacts from such changes. If a reader focuses on output from the Fiscal, Socio-economic, Integrated Water, or Human Infrastructure Modules, and does not review impacts in the Terrestrial Module, they may completely miss this problem. For example, the transient population is only used as an input to the Fiscal Module and thus the impacts from the additional 500,000 people in the transient population for Scenario 3 cannot be evaluated in the Terrestrial Module. Such subtleties may be lost on most evaluators of model runs.

It is essential that reviewers understand that some of the new, as well as potential future, scenario runs only "register" changes in some modules. This is particularly important, because a change in functional population that has fiscal consequences, or hurricane evacuation time consequences, but does not reflect any change in habitat quality, may be misleading as well as unrealistic. Additional population that is addressed "outside" the model or in only some modules, does have unmeasured effects on species and habitat (both direct and indirect); however the Terrestrial Module simply has no way of measuring those impacts.

As discussed in previous subsections, indirect impact is still measured by a constant. Though the constant used is now more traditional and by extension more widely understood, the use of a constant still removes the ability to adjust it for changes in the functional population that do not explicitly shift land use.

In addition, the current "disconnect" between the Terrestrial Module's Key deer model and the eventual outcome of the final HCP for land use planning is both bothersome and serious as it will greatly affect land use changes, species habitat, and species survival, per the discussion in the previous subsection. Such effects cannot be certain until the results of the final HCP are incorporated into the module. This 'disconnect' is beyond the control of the contractor, but the problem should be clearly addressed in the narrative under "limitations" and should be remedied once the final HCP is available.

Marine Module

A healthy marine ecosystem is extremely important to the economy of the Florida Keys. However, the Marine Module is the least useful part of the CCIAM. As noted in the NRC report, there are some data sets available in the literature that address reduction in sea grass density and subsequent impacts on fishes and other nekton density and diversity, but those data sets were not used in an innovative manner (e.g., propeller scaring reduces density and coverage of sea grasses and thus detrimentally affects nekton) by the contractor in the Draft Final Report. While the marine ecosystem and species are discussed in the CCIAM and FKCCS, the Marine Module has been de-

coupled from the model, and the newly developed Canal Module (see Chapter 3) now serves as the link between stormwater and wastewater loads to the marine environment.

Conformity with NRC Recommendations

Given the apparent lack of appropriate data sets on the impacts of development on the marine environment, the NRC Report (2002) indicated the incompleteness of the module and recommended its removal from the CCIAM. This has been done in the Draft Final FKCCS. In its place, the contractor developed the Canal Module discussed in Chapter 3. The contractors did provide a *qualitative* discussion of potential impacts on marine environments and concluded that these data were not of sufficient quality to be useful in their modeling approach.

Issues and Refinements Concerning Final Module

The Final Review Committee feels that, particularly in regard to the benthic study conducted by Florida International University (pp. 113-114), a better description needs to be provided on the communities that the contractors actually analyzed and to what extent significant relationships were noted. Reading the text in the Draft Final Report one gets the feeling that benthic organisms were statistically examined spatially and temporally over the course of the study. In fact, only temporal analysis was conducted on macrophyte area using GIS. The Draft Final Report does mention some Keys-wide spatial variability in *benthic communities* (macrophyte coverage) over time, location or land use, but the general conclusion varied between Key Largo/Marathon and Big Pine Key/Key West. A more clear view of these differences and their magnitude would be useful.

Figure 4.27 (FKCCS, p. 113) appears to be unable to separate seagrass and macroalgae, which provide quite different habitats for important nekton species and may partially explain the failure to note temporal changes. It appears that the contractor was comparing vegetated bottom, sand, and coral with the temporal analysis. Should a significant area of macrophytes change from *Thalassia testudinum* to macroalgae, it would be important to quantitatively summarize those data, particularly if that change reflected some level of development and change in nutrient levels. Finally, on p. 114 of the Draft Final FKCCS, the contractors mention that “two modeling approaches identified potential relationships between a few individual taxa, taxa groups, nutrient parameters, and land use, but very few of these relationships are significant throughout the Florida Keys.” Unfortunately, those relationships are not explored nor provided to the reader.

Issues Related to Lack of Quantitative Data Sets

The Final Review Committee feels, given the lack of quantitative data sets relating development to impacts on the marine environment, that State and federal agencies charged with such issues develop science research programs that specifically deal with establishing quantitative relationships. If these data become available, they can be added to the CCIAM in the future and significantly enhance its utility

Chapter 3. Canal Impacts Assessment Module

The Canal Impacts Assessment Module is an entirely new addition to the model, added in response to NRC comments. As such, the following description traces out the module's purpose, methods, and issues in somewhat greater detail than the modules discussed in the previous chapter, which received similar treatment in the NRC (2002) review.

Purpose and Description

The contractor's stated goal with this module was to fill a void left by the lack of a Marine Module. In that module's absence, the Canal Module provides the only link between simulated stormwater and wastewater loads and the receiving waters of the Keys. The objective was to demonstrate consequences of changes in wastewater and stormwater loadings on canal water quality. The model uses the measured canal geometry and tidal prism and simulated surface water and groundwater loads to simulate concentrations in residential canals. The contractor states that the model is consistent with guidance and direction provided by the oversight government agencies.

The model simulates a finger canal as a series of continuous-flow, stirred-tank reactors (CFSTRs), from which concentrations in the well-mixed segments can be extracted along the canal length. The CFSTR-type model is a reasonable first-cut for evaluating canal water quality and has been widely applied to environmental problems of this type (Chapra 1997). Such a model is easily coded in a spreadsheet and easily manipulated to extract the desired information. The results of the model are also consistent with our expectations: high constituent concentrations at the dead ends, tapering to lower ambient values at the ocean boundary location.

The model has been used to simulate steady-state conditions using long-term average loadings. The mode of operation to reach steady-state conditions is unclear: it could be formulated as the solution to a set of simultaneous linear equations, which are solved for concentration in each segment, or as the asymptotic solution to the transient case (i.e., the transient model is allowed to run until steady-state conditions are reached). The latter form is perhaps more useful because it offers the option for examination of residence times in the canals. This study, however, has not seized the opportunity to study residence times.

Four water quality parameters were simulated as conservative constituents: BOD, TN, TP, and TSS. All ten simulated canals had some minimal sampling data. Model results fell within the typically broad range of samples in most cases, as driven by groundwater loads (due to wastewater and time-averaged stormwater infiltration) and surface water loads (from time-averaged stormwater discharges). It is probably inappropriate to add the stormwater and wastewater loads together to drive the canal model, as neither set of loads has been independently calibrated. The impacts of Smart Growth scenarios are more easily evaluated, however, when the loads are summed. Smart Growth assumes full

implementation of the *Monroe County Stormwater Master Plan* and *Wastewater Master Plan*; simulated canal water quality improves markedly with implementation of the latter and only marginally with implementation of the former. It is to be expected that elimination or reduction of noxious cesspits and other wastewater discharges to the ground will certainly improve canal water quality. One important local (canal) water quality parameters was not simulated, however, due to lack of data: bacteria and other pathogens. Both can affect fishing and water contact recreation, and both are difficult to simulate. Nonetheless, concentrations of those parameters would also be expected to decrease with reduction of wastewater loads, simulated or not.

Issues

Ten canals were chosen for simulation from among a group of finger canals in the Keys for which limited water quality monitoring has been performed. This selection is somewhat confusing, however, because one of the criteria for selecting canals for this model was the presence of water quality data. Government officials in the Keys listed the canals at Little Venice as their first choice of canals because water quality has been monitored in those canals weekly since May 2001. Thus, it is odd that no canals at Little Venice were chosen for the model.

A constant minimum mixing depth of –5 ft was used for all canals, as was a "dead zone" of deep-water from –5 to –15 ft, in which there is no mixing because of hypothetical stratification. It would be more satisfying to use the actual minimum depths of the canals and to document whether or not a dead zone exists (warranting special attention for anaerobic conditions and likely impaired water quality). There is no explanation for the use of constant depths other than the likely need for expediency in development of the model. Apart from lengths, which were taken from actual canal data, it is unclear as to whether the Module used actual cross sectional areas or instead estimated areas from canal surface widths from aerial photos. Cross-sectional areas are important in order to define tidal mixing volumes (the "tidal prism"). Finally, since no mixing occurs below the –5 ft depth, it is unclear what, if any, effect the assumed –15 ft depth to the bottom of the dead zone has on any computation and, by extension, why it is included in the model at all.

The limitations of the Canal Module reflecting these dead zone issues are clearly stated in Appendix C of the Draft Final FKCCS. More attention could still be paid, however, to the dead zone via the literature, in which water quality problems are documented due to temperature and salinity stratification (Kruczynski and McManus 2002). Depths greater than about 6 ft may serve as sinks for organics and sediment and often have dissolved oxygen (DO) values less than 4 mg/L (a Florida Water Quality Standard). Because the deeper portions are directly linked to groundwater inflows, the wastewater treatment practices simulated in the CCIAM have an impact on canal water quality in these deep zones. A first-cut modeling analysis might be provided by a one-dimensional vertical model in which oxygen and nutrient dynamics are linked to stratification, benthic exchange, and loadings, and the reviewers recommend this be undertaken as future research and to enhance the CCIAM.

No sensitivity analysis was documented for any model parameters, such as the assumed –5 ft maximum mixing depth or the 250-ft radius at the canal entrance that represents the interface with offshore waters at the canal entrances. If the model is sensitive to the maximum mixing depth – and it should be – then it might be worthwhile to use actual instead of assumed bottom depths for the canal modeling. Water quality concentrations at the boundary of the 250-ft radius are taken as concentrations interpolated from available near-shore Keys data. Some mixing zone at the canal entrance is certainly warranted, but more information is needed with specific regard as to how the 250-ft radius was selected.

Summary

The presentation of canal water quality in the Keys is generally perfunctory: although several studies are cited that document degraded water quality in finger canals, neither Appendix C of the CCIAM nor Chapter 4 of the Draft Final FKCCS draws any strong inferences on overall canal water quality issues or topics of critical concern, unlike sources such as Kruczynski and McManus (2002). This omission is a missed opportunity. General background information from the cited literature and/or site-specific information (preferable) for the simulated canals could also be used to justify assumptions about the –5 to –15 ft dead zone.

The contractor was charged with developing a model to simulate only the steady-state impacts of mixing of surface and groundwater loadings in finger canals. Because similar CFSTR models are often used to evaluate residence times (Chapra 1997), it is regrettable that this task was not within the contractor's charge, since evaluation of residence times could be used to address questions related to flushing of short-term discharges, the importance of decay, and whether or not it is reasonable to treat stormwater loadings as long-term averages. Nonetheless, within the same caveats as applied to the Integrated Water Module (see Chapter 2) regarding lack of calibration and sensitivity analysis, the contractor has successfully addressed the specified goal.

The Canal Impacts Assessment Module does contribute usefully to a carrying capacity analysis. It demonstrates what would be expected, namely if the *Monroe County Sanitary Wastewater Master Plan* is adopted and cesspits and poorly functional septic tanks are eliminated, water quality in the canals will improve. The simulated improvement might be the right order of magnitude. Nevertheless, on the basis of the contractor's documentation it is unclear as to whether canal issues may not be so site-specific and strongly influenced by local conditions that land use changes simulated by the CCIAM will have little effect on existing canals. Thus, assuming no new finger canals will be built, the Canal Module is likely effective in demonstrating the type of water quality improvement possible with Smart Growth (or *Sanitary Wastewater Master Plan* implementation) and is therefore a useful adjunct to the Integrated Water Module. But the CCIAM and FKCCS have missed an opportunity to describe documented water quality issues of current canals due to a lack of interpretation and evaluation of the literature and data cited in the reports. These issues strongly influence the water quality

of canals and near-shore waters near canal entrances and should be factors evaluated in assessing population growth and land use changes in the Keys.

As a matter for future research (not as part of the contractor's study), finger canal water quality can be enhanced by better hydraulic design. One possibility places a large basin at the upstream end, pushing a bigger tidal prism back and forth through the canal. Canal 70 at Rock Harbor hints at this. Another possible design connects the dead ends of canals through culverts, especially if the connections can be to canals with more distant outlets (e.g., across a small island). Small tidal differences can create net flushing in one direction and improve water quality, and this type of improvement can be retrofitted. It is important that the water quality within canals be improved by eliminating, or significantly reducing, the sources of pollution into the canals before improvements to flushing are considered.

Chapter 4. Cautions on Implementation, and Recommendations on Research and Development and Future Planning Efforts

Limitations and Cautions to Users

The CCIAM, in its current state, may be a useful tool, but with substantial limitations. It seems to be capable of evaluating some very useful, although imprecise, surrogate measures of the impacts of development on the terrestrial habitat in the Florida Keys. Because the CCIAM and its underlying database have made it possible to evaluate these kind of measures for the first time, the FKCCS has made a substantial contribution to science-based analytical capability. It is important for the reader to note that the Final Review Committee that prepared this report did so using only the CCIAM and FKCCS reports. The Final Review Committee has not used the CCIAM, nor has it seen a live demonstration of data input or model runs. We have not reviewed the program documentation, the users manual for the CCIAM, or the data model for the ArcInfo data-base. Thus, this review of the CCIAM in particular is based on less than complete information.

Terrestrial Issues

The terrestrial measures (which are covered in more detail in the review of the terrestrial module) include:

Acres of habitat
Number of patches
Size of patches
Habitat areas subject and not subject to indirect effects

It is important for the user to remember that the values estimated for these measures depend heavily on parameters such as minimum patch size, distance over which indirect effects occur, patch size distribution, and suitability criteria that are input directly to the model. While the parameters the model uses are reviewed in other portions of this report, and are generally scientifically defensible estimates, they are not precise, nor universally applicable. Moreover, the modules do not (and cannot) include all relevant information. Thus the model's estimates of surrogate measures are also imprecise, and alternatives should not be differentiated based on small changes in the surrogate measures. In other words, if the evaluations are close, the science is probably not good enough to tell the alternatives apart.

Water Demand and Loading Issues

The CCIAM provides a convenient way to obtain first cut estimates of water demands, wastewater flows, overall pollutant loadings to groundwater and the marine environment and impacts on canals. With these estimates, one can compare alternatives. They are not precise, however, and techniques other than the CCIAM can provide better estimates.

Lack of Analysis in Critical Modules

Very little actual fiscal analysis is provided by CCIAM. Cost estimates are prepared as input to the model, and then reported, or divided by population and then reported. These estimates are no better than the input data, and other input to the model does not change the estimates. CCIAM does not estimate revenues. Users must assess the appropriateness of the input to the model before using the costs. In general, users will do well to make their own estimates of costs and the distribution of costs outside the CCIAM.

Likewise, very little socio-economic analysis is provided by CCIAM. The method the CCIAM uses to estimate level-of-service on US1 has very little skill, and is not sensitive to any kind of road improvements or population changes. The theoretic and methodological foundations for the other measures provided in the socio-economic model are questionable.

Calibration Issues

The user should note that many of the parameters used in the model are supported by data from outside the Keys rather than from the Keys themselves. This is largely because Keys specific data and/or parameters are unavailable. In the Final Review Committee's view, this means that many, if not most, of the CCIAM modules are uncalibrated, especially with regard to predicting historical changes in impacts. The precision, and even the accuracy, of uncalibrated models are often questionable. CCIAM results must be used with care and with some degree of skepticism.

Suitability Criteria

The CCIAM GUI allows the user to make large-scale changes in land use by specifying a set of rules to be followed in making the changes. This is convenient, however, the format of the rules and the options allowed may or may not allow the user to input the scenarios that he or she desires. CCIAM then uses its own internal suitability criteria in assigning the actual parcels to be changed. While this is also convenient, the user must be aware that the CCIAM suitability rules are somewhat arbitrary, and may not be what the user intended. Although it is not documented, the Final Review Committee has been

informed that the user can create scenarios independent of the GUI, using the ArcInfo interface to the underlying database, and then use the CCIAM to perform an evaluation. Many users may find it necessary to utilize this method in order to assess their desired scenarios with the model.

It is probable that if the GUI does not easily allow an evaluation of creative alternatives they will not be proposed or evaluated. Thus, there is a need to restructure the user interface to make it easy and straightforward to evaluate all alternatives imagined. A more thorough discussion on the present limitations of the GUI is provided below.

Limited Model Testing

The Final Review Committee has the distinct impression that the CCIAM has been run a very limited number of times, and always on very similar scenarios. It is doubtful that a rigorous program of model testing has been undertaken; such a program has certainly not been reported. Budget limitations and long run times make this situation understandable. However, it is incumbent on the user to check for potential logical inconsistencies in the outputs of the model. We found such inconsistencies in the test runs made with the model. It is likely that unrealistic results may be produced by any relatively untested model, and the CCIAM is no exception. The Final Review Committee urges users to carefully check that model results seem logical before using them.

Carrying Capacity

Finally, the CCIAM is not suited to determining the carrying capacity of the Florida Keys. No technically-based model could perform that task. In addition to the lack of adequate scientific information to precisely and accurately describe the implications of development on important resources on land and particularly in the sea, there is no consensus among technical specialists concerning even the definition of the term carrying capacity. The CCIAM can provide some useful information concerning the tradeoffs between patterns of commercial and residential development and environmental impacts, but it cannot make the determination as to which tradeoffs are appropriate or desirable. That determination is legal and political, not scientific.

Recommendations for Research and Development

The Final Review Committee believes that the basic goal of the FKCCS study - establishing the carrying capacity of the Florida Keys - was unachievable for two reasons. First, there was and is no suitable definition of carrying capacity. Secondly, even if a *reasonable* definition existed, the scientific basis for relating development to carrying capacity was lacking. The Final Review Committee believes that research can help overcome both of these obstacles in the long term.

One major conclusion the Final Review Committee has reached regarding the limitations of the FKCCS study is that the state of scientific research, in many relevant subjects, is insufficient to permit definitive assessment of development impacts on the Keys. In our opinion, however, some near-term research activities could profitably improve the database and/or shed insights on potential development impacts on the land and waterways of the Keys, and could be performed at relatively modest cost.

Certainly, research alone cannot define the carrying capacity of the Florida Keys. The definition of carrying capacity will involve tradeoffs between environmental, social, and individual objectives, and that tradeoff must involve political processes and legal decisions. In the end, the government of Monroe County and its subdivisions will decide the restrictions placed on Keys development, within the restrictions placed upon it by State and federal law. Social and political research can better describe the social and environmental objectives of the citizens of Monroe County. To some extent, such research can provide descriptions of such objectives that can be evaluated using science-based tools, and this will be of great value in helping to design better tools for future analysis of alternatives. Legal and policy research would be very useful in determining the bounds placed on Monroe County and its subdivisions by State and federal legislation and regulations. In its most useful form, such research would provide methods for testing whether or not local regulatory alternatives pass muster. The lack of science available to support many of the CCIAM modules points to the need for additional scientific research.

Marine

The Marine Module had to be eliminated due to lack of scientific support. Marine research requirements range from a basic understanding of the short and long term circulation patterns around the Keys to cause-effect information on the effects of ranges of nutrient and toxic loadings on ecological community structures. The relative influence of local and distant sources (e.g., Mississippi River) needs to be understood. Clearly the probability of toxic spills increases with development and decreases with at least some regulatory controls, but there is no way to evaluate the risks or consequences. The direct effects of groundings are relatively obvious, but there seems to be no clear methodology for relating the density of boats, or characteristics of channels and navigation aids and policies, to reductions in damage. Such tools must be developed or enhanced.

Terrestrial

The terrestrial module is among the most useful in the model. It could be improved with a better understanding of the minimum habitat size needed by varying species. In particular, an assessment of the probability of a patch supporting individuals or groups as a function of size would give a more realistic picture of overall habitat value than the simple size cutoffs used in the model. Similarly, the impacts of indirect effects on habitat could be described in a probabilistic manner, and differentiated by species and human activity. The shape of patches may also be an important indicator of their suitability as

habitat; some species may prefer more compact habitat of a given acreage, and others less compactness. There may also be a relationship between the type and density of vegetation in a patch and its habitat value.

Perhaps the single most important development item for the terrestrial module is improved data sets. Calibration of the module involves demonstrating its ability to predict changes in species composition based on changing land use. This requires at least two, and preferably more, intensive surveys of species in areas where land use is changing, or preferably Keys-wide. The surveys must be linked to corresponding land use mappings. Collecting these data would provide a basis for more detailed and comprehensive scientific investigations into the relationships between land development and ecology.

Integrated Water

The Integrated Water module is dependent on parameters that link land use to EDU's and then to wastewater flows, volumes, and loads. These parameters are assumed to remain constant, although there is historical evidence to suggest otherwise. Research aimed at developing parameters that are better suited to future conditions, or which are dependent on other variables, such as land use, changes in property values, and the relative levels of permanent, transient, residents and day visitors, would be useful. The effectiveness of stormwater treatment facilities is often site dependent, and there is little or no data in the Keys. The CCIAM uses values appropriate for much of Florida, but there is some question as to the relevance of those parameters in the Keys. Further evaluation will improve the estimates of wastewater loadings. A full understanding of the fate of pollutants in both shallow and deep aquifers is lacking. Any evaluation of the impacts of wastewater discharges in the Keys depends on that knowledge. Further development of the Canal Module depends on the research described above.

Fiscal

The fiscal module needs further development. It should modify estimates of costs for land acquisition and for wastewater treatment based on land use and wastewater generation produced by the model. It should make revenue estimates, which are effected by land use, and allow the user to modify the assumption on which those estimates are based.

Human Infrastructure

The Human Infrastructure Module would greatly benefit from more effective means of estimating highway level of service based on land use. That estimate should also depend on population distribution, kind of development, and road improvements. Research is needed to refine estimates of water consumption with parameters that are sensitive to

future conditions, rather than held constant at current values. Changes in ratios of transient and day visitors to permanent population should also effect water use. The data to support such models needs to be collected, and as in the case of the terrestrial model, several data sets are required to develop a calibrated model.

Given the importance of making an accurate measure of the population of the Keys at any given time and the existence of U.S. 1 as the only avenue of entrance and exit, some research tailored to the conditions is warranted. Such research should occur prior to revisions to the Monroe County Comprehensive Plan. Numbers and expenditures of day trippers and campers can be assessed by intercept surveys. Also, campgrounds can be monitored to determine numbers of campers.

Socioeconomic

An entirely new initiative is needed to create a Socioeconomic Module that is capable of predicting the effects of land use change on the socioeconomic conditions of the County including the price of housing, the socioeconomic characteristics of the population likely to result from housing prices, shifts in demand for products and services as population characteristics change, effects of those changes in the labor pool, on worker commuting patterns, and on activities likely to affect terrestrial and marine ecosystems. An initiative also is needed to better predict changes in tourist numbers and activities as a result of land use, infrastructure, and public services and the resultant effects on local expenditures, tax revenues, and activities likely to affect terrestrial and marine ecosystems.

Linkages

Overall, the linkages between the modules in the CCIAM need to be re-thought and re-developed. Many of the linkages were broken during the revision of the model after the NRC report. The overall logic of the module linkages needs to be re-thought and re-implemented. Changes to the model resulting from the research recommended in this report may (and probably will) require changes to the GUI. As the CCIAM evolves, the logical organization of the GUI and its screens should change. Developing a more effective GUI for the CCIAM will be a substantial research and development effort.

Graphical User Interface

The primary user interface to the CCIAM is the Graphic User Interface (GUI), which allows the user to modify end-state land use for evaluation by the model. The GUI for the model is simple and straightforward. It was clearly designed to facilitate the evaluation of the Smart Growth Scenario and minor modifications to that scenario. In is not very

flexible, however, and does not seem to provide a user with the feedback necessary to develop other creative alternatives.

The GUI allows the user to modify land use by classes of parcels only. In order to implement a scenario, the user defines a class of parcels on which land use changes may be made, and then specifies the use to which the parcels are to be changed. All or a portion of the identified "change from" parcels may be affected. If not all are affected, then the CCIAM chooses which parcels to change according to a pre-programmed, hierarchical priority system. Apparently, the user can repeat the "change from"/"change to" process as many times as are necessary to implement an alternative. The Final Review Committee believes that this method is fully consistent with the underlying assumption that regulatory policy will determine land use and that land use will determine the bulk of the changes in environmental, social, and economic impacts.

Our Committee cannot fully review the strengths and weaknesses of the GUI because the two reports present only a few of the apparently many categories by which parcels can be identified. The reports reviewed by our Committee do not contain a comprehensive set of GUI screens, and so we are not aware of the range of possibilities for identifying either "change from" parcels or "change to" uses. Thus, we are uncertain of the number of options provided to the user. However, the screens presented do illustrate some of the limitations of the GUI.

In the GUI, a user can only select parcels based on the data attributes and choices presented in the dialog boxes. These choices are limited to basic zoning type (four choices), ecological characteristics (four choices), subdivision development level (four choices), proximity to US1 (five choices), waterfront (yes/no), within 300' of 10 undisturbed acres or public conservation lands (yes/no), flood vulnerability (three choices) and, in the draft final report, but not in the model report, PAED. At first blush this may seem a comprehensive set of options.

However, the options presented in the GUI screen Figure 4.3b (July 2002, p. 29) do not match the options selected to evaluate the Smart Growth scenario (Table 11.1 , July 2002, p. 130). Thus, the GUI, as presented in the report, may not be capable of properly evaluating the Smart Growth Scenario. Even if the GUI has been modified so that Smart Growth can be evaluated, this example illustrates the point that the format for GUI input places unnecessary restrictions on the user's flexibility. Adding a screen that would allow users to create their own query, based on all relevant fields in the database, would provide full flexibility.

The GUI does not to allow for manipulating parcel boundaries. If so, policies which allow some development on limited areas of parcels while preserving or restoring open space on the rest of the parcel cannot be evaluated. The graphs presented to the Final Review Committee do not allow the direct visual comparison of land use changes between current conditions and the alternative or between alternatives. This is because changes in land use cannot be directly highlighted. Such graphs would be very useful in evaluating alternatives.

The Final Review Committee has been assured that it is possible to develop scenarios outside the GUI, using the ArcInfo interface to the underlying database. This means that fairly sophisticated users can create essentially any scenario and produce customized outputs. Our Committee believes that many, if not most, of those who use CCIAM will use the ArcInfo interface directly to the database.

Recommendations on Future Planning Efforts

Although providing suggestions on future planning efforts is beyond the scope of this technical review of the FKCCS and CCIAM, The Final Review Committee thought it might be helpful to planners to present our insights into this matter in light of the fact that the FKCCS cannot provide clear direction in its present form.

Monroe County and the State of Florida took on this project to develop a guidance instrument to shape public and private land use and infrastructure decisions in the County. Development of the FKCCS and CCAM as a guidance methodology for future growth was mandated by the Administration Commission. After receiving the NRC Review Committee's report (NRC 2002), the Contractor has made improvements in the model and study. Yet, the results are far from the guidance instrument originally envisioned.

In assimilating our critique of the FKCCS and CCIAM and assessing the next steps, it is well to consider the closing words of the original NRC Report, words that continue to be valid:

> It is important to measure...success against the difficulty of the charge they were given and the time available for the work. In many ways this was a pioneering effort and its major long-term benefit may lie in the heuristic value of the exercise and in the personal interactions and exchanges among members of the public, environmental scientists, and planners who took part in the process of model development. The current knowledge base in the environmental and social sciences is simply not yet adequate to enable anyone to 'determine the ability of the Florida Keys ecosystem to withstand all impacts of additional land development activities.' That knowledge cannot be ordered up no matter how badly it is needed or desired. It will only come from patient work and support, rare moments of creative insight, and a continuing investment in synthetic efforts such as the one reviewed here. In this effort there is no failure, only slower or faster rates of learning and progress. (p. 50)

We believe the rates of learning and progress can be speeded up, especially given the data assembly, suitability analysis, scenario testing and other recent improvements cited above. Because the contractor's obligations have been completed, however, it is not realistic to anticipate major changes to the present material, and a process of next steps is still to be determined. The Final Review Committee offers this guidance to assist State and local officials in moving forward.

Maintenance and Updating of the Database and the Graphic User Interface

The database and the tool for testing scenarios are probably the most significant and most long-lasting products of the FKCCS. Their use requires trained people and an institutional setting in which they can be maintained and updated and where they can be made available to government and private sector users for future scenario testing -- both on a Keys-wide and on a Planning Unit or even smaller area basis. Fortunately, that aspect of implementation has apparently been assured. The South Florida Regional Planning Council (SFRPC) has agreed to house the database and provide trained staff for its use. The URS contractor team has prepared a maintenance manual and conducted initial training sessions for SFRPC and Monroe County staff. It is our hope that sufficient budget for staff training and long-term maintenance will be allocated from SFRC, Monroe County, and other sources. Moreover, budget and personnel should be allocated to create the Routine Planning Support Tool (pp. 71-2 FKCCS) that will permit government and private parties to utilize the internet for access to the material.

Updating and Revising the Monroe County Comprehensive Plan.

Updating and revising the Monroe County Comprehensive Plan is an important future task, particularly because the original terms of the ROGO land control system will expire during 2003 and be replaced by an instrument based on the FKCCS. It is our opinion that the Smart Growth Scenario, and its derivatives, represents solid bases for crafting plan revisions. Smart Growth allows population and development to increase at modest rates. If the land suitability evaluations prevail, significant environmental constraints will be maintained or enacted on where such growth may occur. Of major importance, the land acquisition and infrastructure improvement programs explicit in these scenarios can be implemented to protect and/or remediate environmental quality in the Keys.

Disturbed sites should be the prime focus for future growth in the Keys, but it is unclear whether Monroe County currently has adequate standards to guide redevelopment in an environmentally sensitive fashion. Matters such as densities for the array of potential uses, pervious and impervious sites, extent of building coverage, landscaping, and parking are all items not discussed in the FKCCS or CCIAM. These matters merit investigation and incorporation into a system of planning and design control. Other areas of Florida could be used as models to develop new standards into such a guidance instrument.

Funding the Acquisition and Infrastructure Programs

Adequate funding is essential to any strategy for protecting and enhancing the environmental quality in the Keys. From the acquisition standpoint this means obtaining all the remaining CARL lands and adjacent habitat areas and additional right-of-way for the landscaping and any road improvement or expansion project. Infrastructure will mean full implementation of the sewer and stormwater plans and improvements to U.S. 1.

The South Florida Water Management District will need to be involved from the critical standpoint of water capacity. These extremely expensive items will doubtless involve all levels of government. Whether the County or the State should spearhead a coordinated budgeting and implementation plan is undetermined, but creating the appropriate structure should be an early implementation task.

An Affordability Task Force

Although an affordability index has been dropped from the model, the reality of housing prices, both sales and rental, will continually be an issue in the Keys and must be addressed. Of particular importance is the widening gap between service workers income, especially in the tourism industry, and the price of available housing. Any growth of service personnel will face this dilemma, and future reliance on importing workers daily over long distances from Dade County may be highly impractical. Innovative solutions are available on the affordable housing front, but concerted effort, creative finance, and good will are essential to mobilize them. Aside from Keys carrying capacity issues, Monroe County has established ensuring affordable housing as a priority concern. This concern should carry over to detailing County staff and outside experts to establish a "housing affordability element" for any Comprehensive Plan revision.

Chapter 5. Summary and Conclusions

General

The Final Review Committee remains impressed with the bold and innovative vision that initiated the work reviewed here and we are mindful that the task put before the contractor was unprecedented. We also appreciate the contractor's responsiveness to our many questions throughout the review process.

The three documents considered in this review, the CCIAM, Final Draft FKCCS, and Memorandum for the Record dated June 17, 2002, comprise over 700 pages of text, tables and figures that presented a considerable challenge given the time available and the limited opportunity for close interaction among the Final Review Committee members. In spite of these circumstances, however, we believe that we have been able to consider both the FKCCS and the CCIAM in sufficient detail to justify the conclusions presented in expanded form earlier and summarized below. Information contained in the Memorandum for the Record was useful in determining how comments the Draft were considered and addressed but was not critiqued by the Final Review Committee. The Memorandum is included in its entirety in Appendix E.

The contractor responded to many, but not all, of the recommendations provided in the NRC (2002) review of the Draft CCAM. As a result, some of the most troubling parts of the earlier version of the model have been eliminated. Important examples include:

- unifying and updating of the human population estimates and coefficients based on the 2000 census
- elimination of unsubstantiated thresholds and associated color-coded output maps
- presentation of a reasonable accurate land-use database
- elimination of some inappropriate socioeconomic indicators
- preparation of alternatives scenarios for testing
- inclusion of development suitability analysis for vacant land
- inclusion of a separate hurricane evacuation model
- inclusion of more terrestrial species for specific habitat assessments
- improvements in the calculation of the impact of disturbance and development on terrestrial habitat values
- elimination of the misleading module that attempted to deal with the impact of land use on the marine environment

The FKCCS presents four main guidelines for future development in the Florida Keys:

1. Prevent encroachment into native habitat. A wealth of evidence shows that terrestrial habitats and species have been severely affected by development and further impacts would only exacerbate an already untenable condition.
2. Continue and intensify existing programs. Many initiatives to improve environmental conditions and quality of life exist in the Florida Keys. They include land acquisition programs, the wastewater and stormwater master plans, ongoing research and management activities in the Florida Keys National Marine Sanctuary, and restoration efforts throughout the Keys.
3. If further development is to occur, focus on redevelopment and infill. Opportunities for additional growth with small, potentially acceptable, additional environmental impacts may occur in areas ripe for redevelopment or already disturbed.
4. Increase efforts to manage the resources. Habitat management efforts in the Keys could increase to effectively preserve and improve the ecological values of remaining terrestrial systems.

The Final Review Committee agrees that these guidelines provide important guidance to future development decisions in the Florida Keys. These guidelines are supported by the comprehensive body of knowledge that was collected during the development of the FKCCS. However, this guidance summarizes information and direction that was generally known before this study was undertaken. The FKCCS does provide detailed maps that can be used to discern and quantify areas of habitat loss and fragmentation and the study confirms the conclusions that funding and execution of the stormwater and wastewater master plans and intensified acquisition of vacant lands for habitat enhancement are essential to ensure the environmental viability of the Florida Keys.

Since so much land has been lost to development and the remainder of natural habitats are fragmented, we opine that preservation of remaining habitats and restoration of important habitats are two important approaches that must be actively pursued in the Florida Keys. It is our opinion that an innovative, scientifically sound approach can be pursued to connect important habitat corridors through developed areas and disagree with a conclusion of the FKCCS that restoration of habitats would be too costly to pursue because of the high costs of currently developed land. However, we agree with the conclusion that continuing and intensifying acquisition and restoration of vacant lands may provide faster results. Also, we wish to emphasize the conclusion that Monroe County should place increased priority on redevelopment as a focus of any approved new growth, so as to preserve remaining natural habitats.

In spite of the many improvements in the current version of the model, we find that the model continues to suffer from serious limitations and failings. These are not spread evenly throughout the model and some modules, for example the Integrated Water Module, are more useful than others, such as the Socioeconomic Module.

The model as a whole contains a very large spatially explicit database containing information on land use, infrastructure, and natural resources that should serve as a powerful resource to aid in future land use planning in the Keys. Scenarios tested in this exercise, especially the Smart Growth Scenario, which embodies principles of concentrated development and environmental conservation as endorsed by EPA and the National Governor's Association, can serve as a good beginning for planning alternatives.

Some modules can also serve usefully as part of the planning process when combined with experience, common sense, and trained professional judgment. But the fact that essentially none of the modules have been calibrated, that there has been little or no sensitivity analysis of the model as a whole or any of its parts, and that all of the coefficients used are fixed for the twenty-year time frame precludes use of the CCIAM, as it has been developed thus far, as a credible tool for evaluating all or most of the impacts of development in the Keys. Certainly, it cannot fulfill the original vision of a tool that could be used to assess the "carrying capacity" of the region and "…determine the ability of the Florida Keys ecosystem, and the various segments thereof, to withstand all impacts of additional land development activities." The major reasons for this conclusion are summarized below for individual components of the model and more fully in Chapter 2.

Spatial Database

As noted earlier, we believe that the compilation of the spatial database that underlies the CCIAM is a major contribution. Based on the general description of the database, how it was assembled, and the data sets included, the Final Review Committee believes that the database should represent a useful contribution to the ability to analyze impacts of alternative land use plans and policies throughout the Keys. The Final Review Committee's major impediments to drawing a firm conclusion in this regard are that it has seen no documented data structure for the database, nor has it had the opportunity to review the data quality procedures used. The Final Review Committee assumes that the documentation exists and that the quality control was appropriate.

Graphical User Interface (GUI)

While many of the model's computations are based on distances between patches, parcels, or features, the concept of distance is never discussed or defined in the reports. As a result, we do not know if or when the calculations are based on distances from edge to edge, from center to center, from edge to center, from pixel to pixel, etc. The model also implements a hierarchical priority system for allocating development, but no description is given of the process used to break ties that are likely to arise. This is a potentially important consideration. Unless tie breaking is consistent, separate runs of the same scenario could produce different and hard to explain results. We are also concerned that hierarchical development choices are based solely on preserving environmental

values. This seems highly unrealistic and will give a misleading picture of the direction of future development.

The GUI itself appears straightforward and easy to use, but we are disappointed with its apparent lack of flexibility. For example, the user cannot modify coefficients, constants, or many of the selection menus used to define scenarios. This has to be done by a GIS/computer technician who must edit the algorithms and/or lookup tables of the model.

Socioeconomic Module

This component of the model has been changed considerably since the NRC (2002) review, but it has not been improved. In our view it is the weakest part remaining in the model. The Socioeconomic Module is almost completely uncoupled from the rest of the CCIAM, and the five indicators that are calculated within it are not used as input by any other module. There is no clear link between the indicators that are calculated and the quality of life or socioeconomic welfare of residents of the Keys. There is virtually no incorporation of information gathered in the Public Involvement and Information Plan into the Socioeconomic Module. We also continue to be concerned that the methods by which, and the extent to which, tourists and day-trippers are included in various parts of this and other modules are not clear in the reports and may well be inconsistent. The reasoning behind the calculation of several socioeconomic indicators is not clear to us and, in at least one case (the non-residential population ratio) the calculation as documented is invalid. The Socioeconomic Module suffers a particularly serious defect for an impact assessment tool in that it relies on a series of constant coefficients that do not change over time or from scenario to scenario. Because of this approach, the Socioeconomic Module is not capable of predicting changes in housing prices, changes in commuting patterns, changes in sources and levels of income, or other important socioeconomic trends that may result from different policy choices or scenario assumptions. The assumption in the model that growth in population over the next twenty years will be sufficiently slow that it is appropriate to use constant coefficients neglects the fact that housing prices in the Keys have increased dramatically during the past ten years of slow growth, that employment in the Keys rose by over 18% between 1990 and 1997 while the resident population rose only 2%, that the age structure of the population has shifted, and that sources of income have changed markedly. There is no link in the model between assumptions about land use changes and changes in housing costs or changes in socioeconomic characteristics of the population. Even though Monroe County has significant problems with affordability of housing, especially for service personnel, the module cannot address concerns over affordable housing or the increased prevalence of workers commuting from the mainland. Overall, the Socioeconomic Module presents very limited insight into the socioeconomic effects of growth in the Keys.

Fiscal Module

The Fiscal Module was and remains one of the more straightforward and useful parts of the model. It is a basic ledger of expenditures and unfunded liabilities for the Keys that provides evidence for a substantial increase in per capita costs for residents and visitors in all of the scenarios tested. However, the endpoints from the module calculations are not translated into any measure of "carrying capacity" and do not provide a basis to determine limits on future land use. Our only technical concern is that costs per resident in the module are based on the functional rather than the resident population. This assumes that a mix of property and tourist related taxes will be used to raise revenues. While such an assumption seems reasonable, it would be more clear cut to express costs in several ways so that users could see a range of fiscal impacts depending on the mix of revenue sources.

Human Infrastructure Module

This module takes a very restricted view of infrastructure and is limited to traffic congestion on U.S. 1 and hurricane evacuation times, both of which can be evaluated against explicit standards. Traffic congestion is captured as level of service expressed as median speed. The Human Infrastructure Module relates median speed on U.S. 1 to land use through a simple linear regression between observed speeds in various reaches of the Keys and the density of tourist-related development in the reach. Unfortunately, the relationship has very limited predictive power and other formulations provide a better fit to the observations. As a consequence, the level of service predictions associated with different growth scenarios are not convincing and we do not believe the model can be relied upon in this area.

Hurricane evacuation times are not related to median speed calculations but come from an independent Hurricane Evacuation Model developed by Miller Consulting. While we believe that this is an improvement over earlier approaches, we are concerned that there is insufficient documentation in the CCIAM and the FKCCS to allow the user to assess the assumptions and uncertainties imbedded in the Miller Consulting model. A particularly important example is the lack of documentation available for understanding the storm scenarios that are the basis for the model runs. Our understanding is that only two storm scenarios are available, a Category 1-2 storm and a Category 3-5 storm. Informed use requires, at a minimum, information on storm surge elevations and maximum sustained surface wind speeds that are used in these storm scenarios. It is also important to know what elevation datum is used in the model and this is not provided. The older the datum, the greater the effect of subsequent sea-level rise in reducing the time to flood low portions of the road, and in exacerbating choke points in the evacuation route. Proper interpretation of the Miller Consulting model is particularly important since the 24 hour evacuation standard set in the Monroe County Rate of Growth Ordinance (ROGO) is already exceeded and any scenarios that do not include

construction of the improvements recommended in the Miller Consulting report will likely increase evacuation times. We therefore urge that efforts be made to improve the documentation of this part of the module.

Integrated Water Module

This is the most substantial part of the CCIAM. The module essentially applies traditional first- order engineering models of stormwater and wastewater to the Keys. As noted in the NRC (2002) review, the module is appropriate to estimate long-term, time-averaged stormwater and wastewater loads, but it is not event based and cannot compute discharges associated with individual storm scenarios. This may be less of a limitation than it first appears because there is no longer a "downstream" marine module to receive and respond to individual storm runoff. Because neither the stormwater or wastewater models have been calibrated, we believe they should only be used to evaluate relative changes in each source separately. The module continues to exclude any consideration of pathogens, such as bacteria and virus concentrations that may result in beach closings and/or may impact human health.

While the Integrated Water Module is consistent with accepted engineering practice, we believe that its application should only be performed by technically competent professionals familiar with the nature of the available data and the nuances of the processes being simulated. One example of the reasons for our caution in this regard is the fact that the efficacy of various best management practices in reducing stormwater pollution in the model is taken from observations made elsewhere in Florida. Situations in the Keys may be quite different from those where the measurements were taken, and it is important for the user to understand and appreciate this lest naïve overestimates of management practices be made.

Perhaps our most serious concern with this module arises from the mix of ways in which water consumption is estimated in the CCIAM. There is a highly tenuous link between Equivalent Dwelling Units (the link between land use and water consumption used in the model) and population, and we are not convinced that "day-trippers" are adequately accounted for in the water or wastewater budgets. We also question the assumption that per capita daily water consumption will remain constant when the data suggest that it has been steadily increasing. The optimistic calculations in the FKCCS Final Report regarding the supply of potable water should be viewed skeptically. Overall, we believe that the Integrated Water Module may be used with a number of constraints identified in the body of our review, but the model documentation and the FKCCS Final Report imply an ability to evaluate scenarios as a function of population changes that cannot be achieved with the model in its present form. A better statement of its capabilities and its limitations is urgently needed.

Terrestrial Module

Most of the major criticisms of this module that were raised in the NRC (2002) review have been addressed in this draft. There remains, however, the perhaps insurmountable problem that the Terrestrial Module cannot evaluate impacts to terrestrial ecosystems from changes in other modules that are not reflected in land-use changes. As a result, the Socioeconomic, Fiscal, Human Infrastructure, and Integrated Water Modules do not, for the most part, provide output that registers as an impact in the Terrestrial Module. For example, since the transient population is only used as an input to the Fiscal Module, a large increase in transients would appear in the CCIAM to have no impact on the terrestrial environment. Similarly, increases in day-trippers can have no impact on terrestrial habitats or endangered species in the model because they do not change land use. This is a serious limitation for a tool the development of which was prompted in large part by concerns over the impacts of development on the carrying capacity of the environment for endangered biological species.

We are also concerned that the module evaluates vacant land only for development, and that there is no evaluation of vacant land for conservation and wildlife habitat value. We recognize that this is driven by the current land categorization process in the Keys that is beyond the contractor's control, but this is an important limitation that deserves explicit discussion in describing the limitations of the model. Another important limitation is that the model applies a constant measure of indirect impact on habitat to all land uses. As a result, the model does not recognize that land uses such as recreational and open space will have very different impacts on wildlife than commercial and four lane highways when they are located at an equivalent distance from a wildlife habitat.

Finally, we believe that the report should recognize that future land-use decisions regarding the Key deer will be made on the basis of the Habitat Conservation Plan (HCP) for that species. Since the HCP is not yet completed, we do not know how it will compare to the output for Key deer in the CCIAM. Once the HCP is completed, the manner in which it affects land use changes and this species' habitat and survival should be incorporated into the Terrestrial Module for future model runs. The current "disconnect" between the models is beyond the contractor's control, but it should be recognized as a potentially serious limitation of the CCIAM.

Marine Module

As recommended by the NRC (2002), this module has been eliminated from the CCIAM. It must be recognized that the inability of the model to address the impacts of population increases and land use changes in the Keys on the nearshore marine environment is a very serious limitation in the FKCCS. While the contractor did provide a narrative that outlined potential impacts on the marine environment in a qualitative way, we remain unconvinced that more innovative analyses of the data sets discussed could have revealed some convincing links between development and marine habitats and resources. For

example, we are left with the impression that the analysis of the very large FIU data set is not well described or documented and that the contractor may not have pursued space for time substitutions and other techniques of analyses as creatively as possible in this and other Keys data sets.

Canal Impacts Assessment Module

The contractor's goal for this model was to fill the void left by the elimination of the Marine Module. It provides the only link between simulated stormwater and wastewater loads and Keys receiving water quality. The model has been used to simulate steady-state concentrations of biochemical oxygen demand, total nitrogen, total phosphorus, and total suspended solids in a set of ten finger canals using long-term average loadings from the Integrated Water Module. As emphasized earlier with that module, this means that the Canal Module cannot be used to assess the impacts of storms on water quality in the finger canals. No pathogens are considered, and the four constituents that are included are treated as conservative substances. The mode of operation used to reach steady state is unclear.

The criteria used to select the ten test canals are not stated. For example, a consideration of the canals at Little Venice was listed as a first priority by government representatives, but none of those canal systems were included. A constant minimum mixing zone of the surface five feet was used in all of the canals and a constant "dead zone" of five to fifteen feet was assumed to have no mixing in all of the canals. Canal lengths were taken from charts, but it is not clear if actual cross sectional areas were used or if estimates were made based on canal widths at the surface. No sensitivity analysis was documented for any of the model parameters, nor was any reason given for the choice of a 250-foot radius used as a mixing zone or interface with offshore waters at the mouth of each canal.

While the Canal Impacts Assessment Module is poorly documented, lacking in any rigorous calibration or sensitivity analysis, and very simplified, it appears to provide reasonable first-order results with no surprises. We believe that the contractor missed an opportunity to use the model to develop preliminary estimates of water residence time in the canals. The discussion of canal water quality in the Keys is generally perfunctory and the contractor again missed an opportunity to present strong inferences about overall water quality issues and development in the Keys. This is obviously a topic of critical concern. Overall, this module may be of some use in assessing the impacts of changes in wastewater and stormwater on the finger canals, but it is hardly a substitute for a model relating development to coastal water quality and marine resources.

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Appendix A: Final Review Committee Member Biographies

George H. Dalrymple
Everglades Research Group, Inc.

George H. Dalrymple is chief scientist of the Everglades Research Group, Inc. He previously served for 17 years as an associate professor in the Department of Biological Sciences at Florida International University. His areas of expertise include wildlife and environmental biology, vertebrate zoology, herpetology, natural resources management, and Everglades, wetlands, and restoration ecology. Dr. Dalrymple received his BA in zoology from Rutgers University and his Ph.D. in vertebrate zoology from the University of Toronto in Canada.

Robert E. Deyle
Florida State University

Robert E. Deyle is an associate professor in the Department of Urban and Regional Planning at Florida State University. His expertise is in environmental planning and policy analysis, coastal hazards planning and management, and plan implementation. Recent research focuses on risk-based taxes for hazard management and planning for hazard mitigation and post-disaster recovery. Dr. Deyle received his BA in biology from Dartmouth College, his M.S. in environmental management from Duke University, and his Ph.D. in environmental science from the State University of New York, Syracuse.

Wayne C. Huber
Oregon State University

Wayne C. Huber is professor of civil, construction, and environmental engineering at Oregon State University. Prior to coming to Oregon State in 1991, he served for 23 years on the faculty at the University of Florida, where he engaged in several studies involving the hydrology and water quality of South Florida regions. His research principally involves surface hydrology, stormwater management, nonpoint source pollution, and transport processes related to water quality. He is one of the original authors of the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM) and continues to maintain the model for the EPA. Dr. Huber received his B.S. in engineering from the California Institute of Technology and his M.S. and Ph.D. in civil engineering from the Massachusetts Institute of Technology.

Scott W. Nixon
University of Rhode Island

Scott W. Nixon is professor of oceanography at the University of Rhode Island. His research interests include the ecology of estuaries, bays, lagoons, marshes, and other coastal systems. Recent research focuses on the fundamental processes that determine the primary and secondary productivity of these environments, with particular emphasis on the importance of nutrient enrichment and other forms of anthropogenic impact. He also conducts ecosystem-level experiments using mesocosms and comparative and historical ecology. Dr. Nixon received a BA in biology from the University of Delaware and a Ph.D. in botany/ecology from the University of North Carolina, Chapel Hill.

Mark S. Peterson
University of Southern Mississippi

Mark S. Peterson is a professor in the Department of Coastal Sciences of the Institute of Marine Sciences at the University of Southern Mississippi. His research focuses on nekton (fish and decapods) resource ecology with particular emphasis on factors affecting recruitment success in estuarine-dependent fishes and the tradeoffs made by nekton when living in different habitats. Specific research projects include the ecology and impact of non-native fishes in coastal marsh ecosystems; delineation and mapping of essential fish habitat of ecologically and economically important nekton; and comparison of habitat use along natural and anthropogenically altered marsh landscapes. Dr. Petersen received his B.S. in marine science from Coastal Carolina University, his M.S. in bio-environmental oceanography from the Florida Institute of Technology, and his Ph.D. in biological sciences from the University of Southern Mississippi.

Stephen Polasky
University of Minnesota

Stephen Polasky is the Fesler-Lampert Professor of Ecological/Environmental Economics in the Departments of Applied Economics and Ecology, Evolution, and Behavior at the University of Minnesota. Before taking his current position at the University of Minnesota, he served as senior staff economist for environment and resources for the President's Council of Economic Advisors from 1998 to 1999. His research interests include biodiversity conservation, common property resources, and environmental regulation. Dr. Polasky holds a B.A. from Williams College and a Ph.D. in economics from the University of Michigan. He has also studied at the London School of Economics.

Norbert P. Psuty
Rutgers University

Norbert P. Psuty is a professor in the Department of Marine and Coastal Sciences at Cook College, Rutgers University. In addition, Dr. Psuty serves as associate director of the Institute of Marine and Coastal Sciences. His areas of expertise include coastal geomorphology, shoreline erosion, and coastal zone management. Recent research focuses on coastal zones with a specialization in shoreline processes and sedimentation related to sea-level rise. Dr. Psuty received a B.S. in geography from Wayne State University, an M.S. in geography from Miami University of Ohio, and a Ph.D. in geography from Louisiana State University.

Malcolm D. Rivkin
University of Maryland

Malcolm Rivkin has been a senior fellow in the School of Public Affairs at the University of Maryland, served as executive director of the Smart Growth Alliance, a consortium of business, environmental, and civic groups in the Washington, D.C. region, and was a commissioner of the Maryland National Capital Park and Planning Commission. His expertise is in "smart growth" issues and urban planning. A principal in Rivkin Associates of Bethesda, MD, he focuses on resolving environment/development conflicts and has helped develop county-wide comprehensive plans in the Mid-Atlantic states. In Florida, he has held planning or research assignments in Pensacola, St. Petersburg, Jacksonville, and Palm Beach County. Much of Rivkin's previous work was overseas, including service as resident advisor to Turkey's Ministry of Reconstruction. Dr. Rivkin received his A.B. in social relations from Harvard and his M.C.P. and Ph.D. in city planning from the Massachusetts Institute of Technology. He was a Fulbright scholar at the University of Amsterdam.

Daniel P. Sheer
Hydrologics, Inc.

Daniel P. Sheer is the founder and president of Hydrologics, Inc., located in Columbia, MD. His expertise is in integrated management of water resource systems, modeling water supply operations, and computer-aided conflict resolution of water resource allocation. Dr. Sheer received a B.S. in natural sciences and a Ph.D. in environmental engineering from The Johns Hopkins University.

Appendix B: Acronyms and Abbreviations

BMP: best management practice

BOD: biochemical oxygen demand

CCIAM: Carrying Capacity Impact Assessment Model

CFSTR: continuous-flow, stirred tank reactor

COE: U.S. Army Corps of Engineers

Comprehensive Plan: Monroe County Year 2010 Comprehensive Plan

DO: dissolved oxygen

DIN: **dissolved inorganic nitrogen**

EDU: equivalent dwelling units

EMC: event mean concentration

GFA: gross floor area

GUI: graphical user interface

FDCA: Florida Department of Community Affairs

FIU: **Florida International University**

FKAA: Florida Keys Aqueduct Authority

FKCCS: Florida Keys Carrying Capacity Study

FKNMS: Florida Keys National Marine Sanctuary

HCP: Habitat Conservation Plan

IWM: Integrated Water Module

LV: load volume

mgd: million gallons per day

mg/L: milligrams per liter

NRC: National Research Council

PIIP: Public Involvement and Information Plan

ROGO: Rate of Growth Ordinance

SFRPC: South Florida Regional Planning Council

SFWMD: South Florida Water Management District

TOC: total organic carbon

TP: total phosphorus

TN: total nitrogen

TSS: total suspended solids

VI: volume in

VO: volume out

VT: tidal volume

U.S. 1: U.S. Route 1

USACE: U.S. Army Crops of Engineers

Appendix C: Detailed Comments on the FKCCS

This appendix summarizes some detailed questions and inconsistencies observed in the FKCCS by the Final Review Committee. It is not meant to be an all-inclusive summary of concerns, but rather a compilation of criticisms that have not been addressed elsewhere in this report, or may have been addressed elsewhere in less detail than given here.

Socioeconomic Module

1. p. 12, the annual population of visitors to the Keys is regarded to be 2.5 million here, but on p. 41, the statement is that 3.0 million people visited the Keys, with 2.5 million going there for recreation purposes. A difference of 0.5 million visitors would seem to be important and produce different stresses on the system (roads, water supply, etc.). Indeed, one of the five scenarios had an increased visitation of 0.5 million persons. So, it would seem to be a significant number to address.

2. p. 40, Figure 5.5. This figure portrays a marked change in the size of the units that are being constructed. It is unclear as to whether there was some major change from single family housing to townhouses and condominiums that drove the very large decrease in unit size. Further, the cost seems to have risen from about $65 per square foot to $230 per square foot according to this figure. The first question deals with whether the data on the figure are accurate. If not, the correct numbers need to be ascertained. If the data are accurate, then the factors involved that would alter the land use patterns and perhaps some of the demands on the infrastructure, the utilities, the tax base for generating community income, and the value of the undeveloped land that be purchased in some of the future scenarios must be identified.

Human Infrastructure Module

1. p. 60, Figure 7.1., regarding the relationship between land use and median speed on U.S. 1. This correlation should be redone with the outlier removed. The slope of the regression line is unduly influenced by the single value that is very far from the cluster. It is clear that the linear trend of decreasing speed associated with increased acres of development has a slope largely associated with the grouping on the left side of the scatter diagram. If planning is to be accomplished on the basis of the experiences of most of the situations in the Keys, then it is appropriate that the single instance at odds with the overwhelming majority of cases should not be allowed to modify the trend line. This is very important, because the current value of y= -0.016x under predicts the rate of speed decrease with increased development, which is the worst possible scenario for the Keys.

2. pp. 62-63, regarding Hurricane Evacuation. This segment focuses on the variables that affect the speed of the exiting traffic and apparently considers the structure of roadway, its bottlenecks, distribution of the population, types of users, and a number of variables that have been evaluated in past evacuations. That is a good approach to establishing

whether the population can be evacuated in 24 hours. There is a comment in the CCIAM, p. 62, that road flooding was among the items considered in evaluating the evacuation times. Whereas road flooding probably is the main concern with evacuation from an area such as the Keys, it seems that flooding is accommodated as an additional complication and not a threat in the 24 hours allowed for evacuation. Just as road bottlenecks are evaluated for impacts on evacuation time, low elevations along U.S. 1 could be part of the evaluation process. If the areas that are most prone to flooding because of low elevations are known, then thresholds could be established for rates of storm surge that would result in road flooding and their subsequent effects on evacuation rates. This would be more important for the Category 3-5 hurricanes because of their higher storm surges. It would also be important to know road elevations in terms of a modern sea-level datum, so that road elevations are not stated in terms of static (old) datums that have been partially compromised by sea-level rise.

Terrestrial Module

1. p. 85, regarding Historic (*sic*) Vegetation Map. It is surprising to see that "beach berm" is listed as a vegetation type. It is unclear whether this category refers to the beach and dune ecology that does have a specific "pioneer" vegetation associated with it, or whether it refers to the sand beach that is devoid of vegetation. A beach berm in coastal geomorphological terms is the bare sand that is above the wet beach face, and it is a land surface. However, on the bottom of p. 85, there is an "other" category that seems to include surfaces that are not covered with vegetation. The characterization of the categories does matter in those cases where restoration is part of the land-use scenario because these are two different environments and either would be difficult to re-create along the active margin of the islands.

2. pp. 94-95, regarding deer population viability analysis. Table 9.3 and Figure 9.5. The discussion about the additional average mortality needs some sort of time scale associated with it. It is presumed that the scale is annual additional average mortality after the period of buildout.

3. pp. 104-105, Table 9.7. The first point is that the measure of distance has no units associated with it. The reviewers have to assume that the units are feet, but they could easily be yards or meters. The reviewers assume that they are English units rather than metrics because metric units don't appear elsewhere in the document. However, the apparent precision of 49-66, and 246, etc. is rather comical because they are conversions from metrics that were rounded off in the original reference. For example, 15-20 meters translates to 49-66 feet, but it's unclear why some other rounding, say 50-65 feet, or something similar was not used. This demonstrates the spurious precision that is displayed in the table. This conversion problem could be handled in a single sentence that either conveys the issues of conversion, or it could just as easily identify rounding of the English units.

4. p. 133, Table 11.4. It is difficult to determine if the unfunded liabilities include expenditures for acquisition of undeveloped land in this table. The text associated with the table does not indicate its inclusion, yet the future scenarios were to acquire and convert undeveloped land into public space.

p. 146, regarding sea level rise. I applaud the report for mentioning sea-level rise and suggesting that it will impose additional constraints to development in the Keys. One paragraph in about 700 pages draws attention to an issue that has been driving some of the changes that were described as occurring over the past centuries, and that is increasing the exposure of the functional population to impacts of many natural and cultural hazards. Because elevation is a critical value in determining the effects of sea-level rise in any time scale, it is important to know the date of the datums that are used in elevation determinations. If, for example, the elevations of some land unit are based on the 1929 National Geodetic Vertical Datum, there has been 70 years of sea-level rise to alter the mean water level and to encroach upon the Keys, and in another 20 years there will be nearly a century of sea-level rise affecting those elevations. If, on the other hand, the datum is a mean sea level based on the most recent tidal epoch (mean water level over a period of 17 years), elevations referenced to that datum will not be affected as much by sea-level rise in the next two decades.

Canal Module

1. p. 93 and Appendix C, p. 183, Table 8. "Minimum % Change" apparently means Minimum Negative % Change" and "Maximum % Change" apparently means "Maximum Positive % Change." Otherwise, "Minimum % Change" and "Maximum percent Change" are reversed. Change to the negative is still change.

2. p. 110. The Nature Conservancy's volunteer-based sampling program was the Bay Watch Program. The sentence that states "TN was lower in sampling stations near developed areas than in natural shorelines" is misleading. The averages are probably not significantly different and more importantly, both sites are open water sites. The way it is written it may appear that developed areas are canals that have lower N than natural shorelines. Instead, mean N concentrations along open shorelines were slightly lower off developed areas compared to undeveloped reaches of the shoreline.

3. p. 111. The data cited by Kruczynski and McManus (2002) for three canals are from the Bay Watch data set. It is not a separate data set as implied.

4. Appendix C, p. 152. It is more than anecdotal data that demonstrate the presence of a nutrient "halo" ("aura" is too mysterious a term) around Keys Islands. Some supporting literature is cited in the report itself on p. 154. In addition, Jones and Boyer (2002) state that there is "A clear gradient of elevated DIN, TP, TOC, and turbidity from nearshore to offshore". Also, Keller and Itkin (2002) conclude that there are inputs of nitrogen and phosphorus to marine waters along the shoreline and an associated increase in the concentration of phytoplankton.

5. Appendix C, p. 152. It is wrong to state that there is a "lack" of pertinent data on disease indicators. Fecal coliform bacteria counts are available for some canals (FDEP 1985, 1987, 1990) and infectious viruses were found at 69% of Keys sites sampled (Griffin et al., 1999; Lipp et al. 2001). There may not be enough information to model, but is not lacking.

6. Appendix C, p. 153-154. Some of the cited references are not in the Final Report reference list or do not match their listing in the references.

7. Appendix C, p. 154. Existing Data Acquisition, third bullet. The sentence implies there is one year's data from April 2001 to April 2002, when in fact there are just two sampling dates. Fourth bullet: Data have been taken weekly (including bacteria) in Little Venice Canals since May 2001.

8. Appendix C, p. 172. In any canal segment, the tidal volume, VT, is known (measurable) from canal geometry and tidal levels. Why is this not used as a constant such that VT = VI + LV – VO at every segment, where VI = volume in (from upstream segment), VO = volume out (to downstream segment), and LV = load volume (from surface and groundwater)? This would lead to a negative sign in front of the LV term in the top equation on p. 172. The equation as formulated would seem to lead to a conceptual series of uneven water levels along the canal. Whether or not this is important to the solution for concentration depends on the relative magnitude of tidal prism vs. surface and groundwater volumes. If the former is large compared to the latter two inflows, then the model should be relatively insensitive to the schematization.

Appendix D: Detailed Comments on the CCIAM

This appendix summarizes some detailed questions and inconsistencies observed in the CCIAM by the Final Review Committee. It is not meant to be an all-inclusive list of concerns, but rather as a compilation of criticisms that are not addressed elsewhere in this report, or that may have been addressed elsewhere in less detail than given here.

Graphical User Interface

1. p. 55, Figure 3.11, regarding Example GUI Screen. The example shows two groupings of hurricane categories, 1-3 and 4-5. The text describes the groupings as 1-2 and 3-5.

Fiscal Module

1. pp. 75-86. As per comments in Chapter 2, Table 4.8 and Figure 4.9 do not have the same values presented even though they apparently represent the same information. Further, the values for the scenarios in Table 4.8 do not seem to agree with the discussions of what is to be included presented in the earlier pages.

Terrestrial Module

1. pp. 65-66, Table 3.11, regarding Effects of Development on Adjacent Habitats, see comment 3, Terrestrial Module Comments, Appendix C.

p. 67, Table 3.12. Carrying Capacity Indicators. Many of these indicators are related to impacts rather than carrying capacity. This is a mix of measurements of change and directions of changes.

APPENDIX E

The following is a Memorandum for the Record Prepared by Deborah Peterson (USACE) that addresses the revisions made to the FKCCS and CCIAM based upon comments made by the NRC Review Committee (2002) and other reviewers. Please note that the explanations given in this Memorandum do not necessarily represent the view of the NRC Review Committee or Final Review Committee that prepared this current report.

Memorandum for the Record Prepared by Deborah Peterson, USACE

CESAJ-PD-PN 17 June 2002

Memorandum For Record

Subject: Florida Keys Carrying Capacity Study (FKCCS), Revisions to Delivery Order (DO) 11 Test Model Report based upon National Academy of Science, Other Stakeholders and Government Study Team Review

The following major concerns resulted from the review of the subject November 2001 Test Model report by NAS, other stakeholder organizations and agencies and the Government Study Team:

Overall

1. Overall, the NAS concludes that the Terrestrial, Fiscal and Scenario Generator modules can be used with minor corrections, while the Human Infrastructure, Socioeconomic and Quality of Life, and Integrated Water module could be used with revision. The Marine Module (diffusion model) should not be used at all.

2. Carrying Capacity Analysis Model (CCAM) vs Carrying Capacity Impact Assessment Model (CCIAM)— The FKCCS goal is "to determine the ability of the Florida Keys ecosystems to withstand all impacts of additional land development activities." The draft CCAM is a good step toward evaluating the impacts of development in the Florida Keys, but it cannot provide quantitative estimates of carrying capacity due to the current lack of scientific knowledge and data. The modules can be used, with revisions, as an impact assessment tool to guide land development activities. **The name of the model has been changed to CCIAM.**

3. Calibration--**The population component of the CCIAM has been calibrated to the U.S. Census 2000 population data. Population and land use change are the principal drivers of the CCIAM.**

4. Model Sensitivities and Uncertainty—**Sensitivity testing of the CCIAM has been performed during development of the CCIAM. The revised report discusses uncertainties associated with each module.**

5. Tourism—NAS and other stakeholders have pointed out the apparent omission of the effects of tourism in the CCIAM. **The CCIAM incorporates tourists as part of the population present in the Keys on any given day, and directly measures their impact on water consumption, demand for non-residential land uses, and government expenditures. Data for other tourism-related parameters, such as boating or diving, are insufficient or inappropriate to establish predictive relationships between land use activities and those parameters. However, direct human impacts on marine resources is discussed qualitatively in the revised report, including propeller scarring in seagrasses and boat groundings on coral reefs, snorkeling and diving impacts on coral and recreational fishing.**

Scenario Generator

6. Presenting a Context of the Florida Keys—**Revised report presents the context of the Florida Keys, including (a) government has significant control of land uses, (b) tourism and recreation along U.S. 1 are not common for traditional communities, and (c) myriad of rare and endangered plants (including unique tropical hardwood hammock and pine rockland) and animals.**

7. Scenario Description—NAS did not agree with the term Smart Growth scenario. **Scenario was developed and named by the Local Planner Working Group. Revised report will provide complete details of the scenario.**

8. Graphic User Interface—NAS wants the user to be able to set and adjust all carrying capacity thresholds within the interface. **The CCIAM is going to be utilized by decision-makers to determine if and how their Comprehensive Plans should be revised, which may lead to revising Land Development Regulations and policies. Therefore, the carrying capacity thresholds that have been researched and based upon rules and laws (e.g. endangered species recovery plans, hurricane evacuation, potable water permitted) should not be subject to random change by a potentially unknowledgeable user. Thresholds residing within the look up tables of the CCIAM can be changed in the future as new science or knowledge indicates the need.**

9. Vested Development—The NAS stated the remaining number of vested development permitted lots should be incorporated into the CCIAM. **The number of vested development parcels was available during the completion of the Monroe County Comprehensive Plan in the late 1980's and early 1990's. Due to complete turnover of county staff, the number of remaining vested development parcels remaining**

(those that have not been built) are not retrievable until a building permit is requested for the parcel. Therefore, the remaining number of vested development of permitted lots is not known and cannot be incorporated into the CCIAM at this time. If that number becomes available in the future, it can be incorporated at that time.

Socioeconomic Model

10. 2000 U.S. Census Data—**2000 U.S. Census data was not available for the November 2001 Draft CCIAM and report. All 2000 U.S. Census data is now available and the model has been revised and calibrated using the 2000 U.S. Census data.**

11. Use of Independent Population Projections—the November 2001 draft report utilized two population projections. One was based upon the scenario being evaluated, and the other projection provided an independent check of that population. The NAS did not feel the independent population projection was needed or appropriate. **The independent population projection has been deleted from the CCIAM and report.**

12. Affordable Housing Index (AHI)—The NAS recommended deleting the AHI since it did not change between scenarios. **The AHI is used to describe the current condition only, and has been deleted from the CCIAM for future development scenario evaluations.**

13. Competitive Commerce Index (CCI)—The NAS recommended deleting this CCI since it was not fully explained and its significance was unclear. **The CCI has been deleted from the CCIAM.**

14. Community Character—The community character evaluation was not fully explained in sufficient detail. **Revised report includes an explanation of the use and evaluation of the community character information.**

Fiscal Module

15. Land Acquisition—**The cost of land acquisition has been incorporated into the CCIAM.**

Human Infrastructure Module

16. Land Use Trip Generation Rates—Per the NAS, the ITE Trip Generation Manual, 6th Edition should be used since it is a non-local source. **Monroe County and FDOT use the ITE Trip Generation Manual, 6th Edition, therefore, it is utilized in the CCIAM.**

17. Hurricane Evacuation Model-The NAS recommended that the CCIAM use the recently approved Miller Hurricane Evacuation model within the CCIAM since it addresses evacuation bottlenecks, impacts of low lying areas and alternate storm

scenarios. **The Miller Hurricane Evacuation model has been incorporated into the CCIAM.**

Integrated Water Module

18. Calibration of Stormwater Event Mean Concentration (EMC's) and wastewater loads—The NAS wanted the stormwater loads to be based on data from the Keys and calibrated against water quality sampling in the nearshore waters. The NAS also thought that the wastewater loads should be calibrated using actual water quality sampling in the nearshore waters. **There is no data available for the nearshore water quality nor for the stormwater Best Management Practice (BMP) for the Keys specifically. The Florida Keys National Marine Sanctuary (FKNMS) Water Quality Protection Program (WQPP) has been monitoring water quality within the FKNMS since 1993, however, the monitoring stations are not close enough to shore for use in calibration and a nearshore water quality sampling program was not within the scope of the FKCCS. The EMC's used were all from Florida from similar soil types. Wastewater effluent loads developed for Monroe County by the U.S. Environmental Protection Agency, Florida Department of Environmental Protection and Florida Department of Health are used in the CCIAM.**

19. Water Quality—The NAS and other stakeholders expressed concern that pathogens, canal water quality and live aboard boat impacts on water quality are not included in the CCIAM. **Pathogens and live aboard impacts on water quality are important points, however, the data is not available to develop a scientifically valid relationship between these parameters and land development activities within the CCIAM. The information that is available is outlined in the report.**

A Dead End Canal Module will be incorporated into the final CCIAM and FKCCS report that will enable users to understand the differential effects of alternative scenarios on water quality in representative canal segments and the region immediately adjacent to the canal discharge points, relative to current conditions. The development of the scope of this Dead End Canal Module has included discussion and review by U.S. EPA (Bill Kruczynski), FDEP (Gus Rios) and the Monroe County Director of Marine Resources (George Garrett). This coordination with USEPA, FDEP and Monroe County will continue until the completion of the Dead End Canal Module. The revised Test CCIAM report will refer to the development of the Dead End Canal Module and it's incorporation into the final CCIAM and FKCCS report.

20. Event Loadings—The NAS and other stakeholders (SFWMD, USEPA) recommended the use of event loading into nearshore waters, such as from rainfall events. The NAS acknowledges that the loadings will dissipate quickly. **The planning horizon for the FKCCS is 20 years. The CCIAM is a steady state model. Therefore, rainfall events are added and averaged over the planning horizon.**

21. Lime Rock Uptake—The NAS acknowledges the assumption of uptake by lime rock is conservative, but believes more scientific research is needed. USEPA also included a comment to this effect. **Additional research is needed to field verify laboratory results and the effect of organic material in effluent. The parameter may be updated if the research indicates the need.**

Marine Module

22. Propeller Scarring, Reef Impacts, Fishing Pressure--The NAS and other stakeholders were concerned that no direct correlation was found between these parameters and land development activities and/or tourism impacts. **The current state of data and scientific knowledge limits the ability to develop a relationship between these parameters and land development activities and/or tourism impacts. However, direct human impacts on marine resources is discussed qualitatively in the revised report, including propeller scarring in seagrasses and boat groundings on coral reefs, snorkeling and diving impacts on coral and recreational fishing.**

23. Diffusion Model—The NAS and many other stakeholders were dissatisfied with the simplistic diffusion model used to predict and describe water circulation in and around the study area. The NAS pointed out that the diffusion model does not accurately reflect possible eddies that occur along shorelines and is a very conservative approach (i.e. predicted loads would be greater than what is diffusely input into the marine environment). The NAS does not believe that loads generated should be used to make inferences as to marine water quality. **The marine diffusion module has been "turned off" in the CCIAM. A water circulation model is being developed as part of the Florida Bay and Florida Keys Feasibility Study and can be incorporated into the CCIAM in the future.**

Terrestrial Module

24. Sea Level Rise—The NAS and other stakeholders (Environmental Land Use and Law Center) have pointed out the need to take sea level rise into account for long term planning. **Sea level rise is predicted by U.S. EPA to be on the order of 3 to 4 inches for the 20 year planning horizon for the FKCCS. The resolution of the topographic data available for Monroe County is on the order of 5 feet. Therefore, the CCIAM cannot incorporate the impact of a 3 to 4 inch sea level rise. The revised report acknowledges sea level rise and the potential impact on marine water encroachment on low-lying areas, detectable saltwater intrusion into freshwater lenses, and habitat effects.**

25. Number of Species—**The number of species evaluated by the CCIAM was increased from 7 in the November 2001 model and report to 16 in the revised CCIAM and report, including the key deer and lower Keys marsh rabbit.**

26. Habitat Degradation Decay Coefficients and Index—The NAS points out that the method of determining the coefficients may not be appropriate. **The revised CCIAM and report uses literature citing impact distances from development, the same concept currently used to set the distance of development around eagles nests.**

/s/
Deborah H. Peterson, P.E.
USACE Planning Technical Leader

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APPENDIX F

The following is a Memorandum for the Record prepared by Deborah Peterson (USACE) that summarizes a teleconference held on November 9, 2002 between the Final Review Committee, sponsors of the FKCCS (USACE and FDCA), and Ricardo Calvo, URS Corp., Inc., contractor for the study. A main purpose of this teleconference was to allow the Final Review Committee to ask specific questions on the CCIAM and FKCCS directly to the contractor. Additional questions were addressed via e-mail at a later date. The Final Review Committee and the sponsors of this review thank the USACE, FDCA, and URS, Corp., Inc. for the opportunities to ask questions to the contractor and for their willing participation in these efforts.

Memorandum for the Record Prepared by Deborah Peterson, USACE

CESAJ-PD-PN 9 November 2002

Memorandum For The Record

SUBJECT: Florida Keys Carrying Capacity Study (FKCCS)

1. A teleconference was held today to answer questions and provide clarification for the final review of the Draft Final FKCCS report, dated September 2002, and the Test Carrying Capacity Impact Assessment Model (CCIAM) report, dated July 2002. The final review committee (RC) is the same committee that participated in the National Research Council (NRC) review of the Test Carrying Capacity Impact Analysis Model (now CCIAM) dated November 2001, however this final review does not include the NRC. Participating on the teleconference were the following:

Scott Nixon	RC
George Dalrymple	RC
Robert Deyle	RC
Wayne Huber	RC
Stephen Polasky	RC
Norbert Psuty	RC
Malcolm Rivkin	RC
Daniel Sheer	RC
Jody Thomas	The Nature Conservancy (review sponsor)
Bill Kruczynski	U.S. Environmental Protection Agency (review sponsor)
Ricardo Calvo	Contractor

Ann Lazar	Florida Department of Community Affairs (FKCCS sponsor)
Deborah Peterson	U. S. Army Corps of Engineers (FKCCS sponsor)

Note: Mark Peterson is also a final review committee member however he was not available to participate in the teleconference.

2. Teleconference discussions follow. Comments and questions are from the RC unless specifically noted.

3. Scott Nixon, as chairman of previous review committee provided the following opening remarks: The Contractor's efforts and responsiveness to the suggestions made in the previous review are appreciated and have resulted in a much improved product, over the November 2001 version of the test model. The marine module has been dropped from the model since there are no credible predictive relationships, which provides a sad commentary on the state of that science. The Dead End Canal (DEC) module appears to be a good addition, the threshold color comparisons have been dropped, the model has been updated to the 2000 census, and the independent population estimates were dropped. The fiscal module is clearer since some of its troublesome aspects have been dropped. These were major steps that provided significant improvement in the model.

4. Deborah Peterson provided the following opening remarks: It is requested that the review committee keep in mind the goal of and purpose for the FKCCS as they complete their review. The FKCCS is required by a Florida Administration Commission rule, which is the result of the litigation in the early 1990's regarding Monroe County's Comprehensive Plan. The goal of the FKCCS is to "determine the ability of the Florida Keys ecosystem to withstand all impacts of additional land development activities." The purpose of the FKCCS is to provide a tool for planners to use to enable decision-makers to determine if and how their comprehensive plans should be revised to ensure the Florida Keys ecosystem is not further degraded. The local planners were included in the development of the FKCCS and the model and are pleased with and eager to obtain the model and the Routine Planning Tool.

5. Jody Thomas facilitated the teleconference. The following format was followed for teleconference discussions:

a. Clarification for changes to the model, module by module,

b. Dead End Canal module,

c. Input / Output issues, and

d. Implementation.

6. Ricardo Calvo made the following opening remarks towards a concise and productive teleconference. The last three years have involved gathering, organizing and assimilating lots of data. The contractor earnestly tried to address concerns of the NRC, other

government agencies, non-government organizations, other interest groups, and individual citizens. An attempt was made to model the marine environment, however, the NRC comments resulted in the removal of the marine model. Also, in response to NRC comments, the name of the model has been changed from Carrying Capacity Analysis Model to Carrying Capacity Impact Assessment Model. Most of the NRC comments on the socioeconomic and fiscal modules were addressed. A limited scope DEC module was added. The contractor found relatively little data that were actually useful to develop valid relationships, which points out the reality of data limitations. There are three primary conclusions to draw from the FKCCS:

a. The terrestrial habitats of the FKCCS suffer from over fragmentation and the endangered species of the Florida Keys are in peril.

b. Major government expenditures and funding will be required in the next ten to twenty years to implement the Monroe County Sanitary Wastewater and Stormwater Management Plans and to acquire conservation lands.

c. Some infrastructure elements are at their borderline of acceptable limits, e.g. traffic level of service and potable water supply.

The FKCCS and the CCIAM provide the state and county with a solid framework to develop comprehensive plan amendments and development standards.

Socioeconomic Module

7. Question: Can you provide a sense for significant changes in the definition of endpoints and indicators for the socioeconomic module?
Answer: The intent was for the module to predict the effects of change and distribution of people on employment, income, and demand for infrastructure. The indicators in Table 2.3 of the Test CCIAM report provides a few indicators to assist the local governments and the state to identify when the socioeconomic environment is in a precarious state. There are two primary socioeconomic situations of concern in the Florida Keys, (1) commuting of workers and (2) housing affordability vs income.

8. Comment: The issues of commuting and housing affordability should be added to the socioeconomic discussion in the Final FKCCS report, even though it is understood that these issues cannot be addressed in the model. The county needs to know about these issues so they can be addressed in the future.
Answer: The issues of commuting and housing affordability arose as insights gained during the development of the FKCCS, not as a result of the CCIAM. These issues will be included in the socioeconomic discussions of the Final FKCCS report.

9. The number of employees available is the number of people coming into the Keys from new residential development, i.e. permanent plus seasonal population.
Question: How does transient population factor in to the demand for hotel employees and tourist-related industries, e.g. restaurants and hotels.

Answer: Transient population does not factor in to the demand for hotel employees and tourist related industries. However, transient population is included in the functional population, so that demand for infrastructure services (e.g. roads, water supply, etc.) is based upon the population in the Florida Keys on any given day.

10. A new construction cost indicator has been added.
Question: Regarding the measure on consumer spending on new housing, how is that translated through payroll or other indices?
Answer: This is kept separate because new construction cost is not the steady state condition and the model provides a steady state end result.

11. Question: Added taxable value doesn't seem to go anywhere. Should it be factored in to offset government expenditures?
Answer: Since the fiscal module looks only at expenditures, there is no attempt to estimate revenues generated.

12. Question: Why was expenditure per functional population chosen versus expenditure per permanent population?
Answer: It was assumed that services and government incurred expenses in the Florida Keys serve all of the population in the Keys on any given day, e.g. roads, water supply, etc.

13. Comment: Discussion in the text refers only to ad valorem taxes, which reflects only residential population. It should also cover sales tax, hotel/motel tax, etc.

14. Question: Table 2.3 in the Test CCIAM report has two socioeconomic outputs. There seem to be other socioeconomic outputs. Explain the link between Table 2.3 as key outputs of the socioeconomic section and concerns for affordable housing and commuting. Why is the focus on the socioeconomic outputs in Table 2.3?
Answer: There was an attempt to incorporate issues of commuting and affordable housing. Recall that the previous NRC review pointed out that the Affordable Housing Index did not respond to the socioeconomic dynamics of the future. It was acknowledged, discussed and removed from the predictive capabilities of the model.

Fiscal Module

15. The contractor noted that the scenarios account for an increase in population of four to seven percent. However, government expenditures associated with the scenarios require an increase of forty to fifty percent. A review committee member pointed out that the relationship of increase in population versus increase in required government expenditures needs to be pointed out in the report.

16. Question: Are land acquisition costs based on land value or acquisition plus administration?

Answer: The model calculates only cost of the land but the final draft report acknowledges the underestimated taxable value of the parcel plus administration costs and management for perpetuity will add to the burden of government expenditures.

17. Question: Regarding the additional acquired lands, how is tourism demand impacted when there is additional land to recreate on?
Answer: This is not codified in the model but is part of the understanding of the situation.

18. Comment: The burden on communities regarding full land acquisition costs should be incorporated into the report.

Infrastructure Module

19. Question: The regression slope of the Level of Service (LOS) for U.S. 1 is controlled by an outlier, a one mile section of U.S. 1 at Stock Island. Why is this left in?
Answer: The outlier has less of an effect than it seems. The Test CCIAM report (November 2001) discusses the initial approach, which was to look at trips generated by land use. However, it was realized that the output from this initial approach was not connected to reality. Given that this is a land use based model, an attempt was made to connect land use and median speed. Multivariate equations were tested, but nothing increased the value of the regression coefficient. Fluctuations of median speeds throughout the Keys were looked at. This varied a lot but was not explained by land use. The changes in residential and non-residential (tourist) related land uses to the sensitivity of the regression equations indicate the results are in the noise of the equation.
Comment: The report should include a stronger manner of stating these new results.

20. Question: Does the model apply a segment specific LOS or is it for the entire length of U.S. 1?
Answer: No, it is applied by planning unit.

21. Question/Comment: The tourist population has no impact on the LOS on U.S. 1? It is not explicit in the description of the model, especially in regard to Scenario 3. It should be stated in the report that since the model in based on land use, the number of tourists do not impact the LOS on U.S. 1.
Answer: The contractor noted that the county traffic analysis is performed annually in February or March, during the peak of the tourist season. The capacity formula calculates the number of residences that can be built based upon the LOS of U.S. 1 during the peak of tourism.

22. The contractor noted that the Miller hurricane model was performed by a separate contractor, under a separate effort. The Miller model is an Excel spreadsheet model, with locked equations, and it was connected to the CCIAM user interface.

23. Question: Were certain levels of hurricane intensity identified?

Answer: The Miller model used levels 1 – 3 and 4 – 5. Those are the levels included on the CCIAM Graphic User Interface (GUI).

Integrated Water Module

24. Question: Regarding potable water demands and influence on wastewater levels, how is transient population included?
Answer: Potable water demand is based on dwelling units and typical consumption and occupancy percentage (the latter two are obtained from Florida Keys Aqueduct Authority records). The standard assumption of one person uses approximately 100 gallons per day is not built in to the model. It is used to understand and discuss the impact of transient population on potable water demand.

25. Question: Is this standard assumption of 100 gallons per day per person valid?
Answer: Water usage has increased greatly since the 1990 census, however, population has increased very little. Potable water is sold to cruise ships, which may account for this discrepancy. The Navy also has a water plant and they only use about fifty percent.
Comment: The urgency and constraint of water usage is not evident in the report and it needs to be.

26. Page 134 of the Test CCIAM report, July 2002, provides the model's prediction of potable water consumption. How does this prediction compare to actual consumption rates?
Answer: The model is not intended to predict actual consumption of potable water. The draft final report compares relative changes to current conditions, rather than attempt to predict actual consumption.
Comment: The report should be written to ensure the reader understands that the model compares relative changes, rather than attempt to predict actual consumption.

27. Contractor: A significant change to this report was to adopt a different look up table for wastewater values. The table was provided by the USEPA / Florida Department of Environmental Protection (FDEP) and was based on work done during determination of nutrient reduction credits.

28. Comment: The revised model is improved by not summing wastewater and stormwater loads.

Terrestrial Module

29. Comment: The contractor did a good job at incorporating the NRC comments. There are no substantive outstanding comments, except, there could be more text regarding the results of the scenarios. The bottom line is there can be no additional impact. Scenario 2, which would have added most additional land to preservation, indicates there would be no significant improvement over Smart Growth.
Answer: Scenario 5 and Scenario 2 are the same, but preservation is Scenario 2 does not differ from Smart Growth.

30. Comment: The report should explicitly make the distinction that the analysis of Scenario 2 on pp. 106 to 108 of the FKCCS Draft Final Report is an attempt to investigate the feasibility of using the FKCCS to identify areas for preservation and restoration by creating connectivity and appropriately sized habitat patches and it is not the results of Scenario 2 as provided by the CCIAM.

Table 3.4

31. Comment: Table 3.4 should have twelve entries, but it doesn't. It would be useful to have a paragraph on the table describing the logic behind the most suitable, moderately suitable, marginally suitable and least suitable rankings.
Answer: The Final FKCCS report will discuss the logic behind Table 3.4.

Marine Module

32. Comment: The benthic community map should have been replaced with seagrass beds.
Answer: No, because the benthic community map includes corals and other species.
Comment: This should be clarified in the text.

Dead End Canal (DEC) Module

33. The USACE stated that the DEC module was created through a team effort, which included the FKCCS team plus USEPA, FDEP, Monroe County and the South Florida Water Management District.

34. Contractor: The NRC recommended disconnecting the marine module that was included in the November 2001 version of the Test model, which was done. There was a "feeling of void" in some stakeholders, therefore, the DEC module was developed. Since it was added so late in the FKCCS process, the main purpose of the DEC was to answer, "can we tell relative consequence of different management scenarios" on different canals. The conclusions of the DEC suggest that implementation of the wastewater and stormwater master plans will significantly affect the water quality in the canals.

35. Question: Does the report reflect what is known about canals from the literature? How is literature reconciled with the canal issue? For example, the 1999 USEPA report regarding water quality in the Keys provided an anecdotal statement that water quality in the canals may be related to the anaerobic condition of the canals.
Answer: The DEC module was simplified and doesn't attempt to investigate the biology of the canals.

36. USEPA: The report states that there is anecdotal information only regarding the "nutrient aura", but there is more than only anecdotal information. A canal in Little Venice should have been used. There should be justification for the mixing zone.

Miscellaneous

37. Comment: The Glossary on p. 330 includes two definitions for Floor Area Ratio. The second definition is acceptable in the field and should be used in the report.

38. Comment: Indicator should be used instead of threshold.

Usability

39. Question: The previous NRC review recommended the user have the ability to alter the coefficients. Can this be done and how is it done?
Answer: The model contains sixty to seventy lookup tables. The Graphical User Interface does not allow the user to change the data or coefficients. User and Maintenance Manuals have been produced, which have been reviewed by the clients and the South Florida Regional Planning Council (RPC). These manuals include step by step instructions regarding how the lines in the model and the data can be changed.

40. Question: Will the maps be displayed via the Internet?
Answer: The model will not be run over the Internet. When Monroe County wants to run a future scenario, they will contact the steward, the RPC. The Internet will provide the information compiled through the FKCCS.

41. Question: On the GUI, does the user have to provide "change from" and "change to" for all planning units.
Answer: Yes.

42. Comment: The RPC will provide a human interface for the model. It is a benefit that the local governments will not be required to undergo widespread training on GIS or the model.

43. Comment: When the JPEG's are assembled, the "direct effects" polygons are laid over and obscure the polygons below them, reducing the visual impact of those maps.

44. Question: Can three versions of one layer be run in the model?
Answer: The default model will run each scenario entirely through each planning unit. The model can run partial scenarios, but it would be outside of the overall default model.

45. Contractor: An entire scenario can be input into the GUI in approximately one hour.

46. Question: There is no query that uses the parcel number or parcel identifier. Can a utility be added that queries by parcel number?
Answer: From the beginning of the FKCCS, it has been stated that the model will not be designed to be run on a parcel by parcel basis.

47. Comment: "This is a real winner now. An extraordinarily useful tool."

Implementation

48. FDCA: Ann Lazar review the history of the Florida Keys Area of Critical State Concern and the oversight provided by the FDCA and the Administration Commission (Governor and Cabinet). FDCA then read the sections of 28-20 Florida Administrative Code (FAC) that related directly to implementing the FKCCS and the required timeline.

49. Comment: Paragraphs from the FAC Rule should be added into the last page of the FKCCS report and would be very useful for the reader.

50. Reviewer: Do you have a context of how Monroe County will treat these regulations and the implementation?
FDCA: The FDCA, local governments and interested parties will work to change the Comprehensive Plan and the Land Development Codes. For example, Monroe County has currently proposed a three tier process to prioritize the lands to be developed.

51. Reviewer: Will Monroe County carry over the land suitability analysis to establish what the tiering should be?
FDCA: The implementation process is interactive between several parties. I do not know what the final implementation will be.

/s/
Deborah Heibel Peterson, P.E.
Planning Division
U.S. Army Corps of Engineers

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