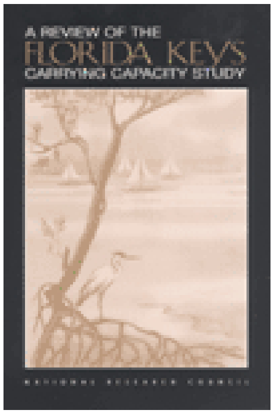


**A Review of the Florida Keys Carrying Capacity Study**

Committee to Review the Florida Keys Carrying Capacity Study, National Research Council

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# A REVIEW OF THE FLORIDA KEYS CARRYING CAPACITY STUDY

Committee to Review the Florida Keys Carrying Capacity Study
Ocean Studies Board
Water Science and Technology Board

Division on Earth and Life Studies
National Research Council

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This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in the review of this report:

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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by Dr. Robert Frosch of Harvard University, Cambridge, MA, who served as Monitor and by Dr. Donald Boesch, University of Maryland, Cambridge, MD, who served as Coordinator. Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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# Executive Summary

Nearly thirty years ago the Florida Keys were designated as an Area of Critical State Concern. The state recognized that Monroe County contained many valuable natural, environmental, historical, and economic resources that required thoughtful management. In 1996, as a result of many years of discussion, negotiation, and litigation, the Florida Administration Commission issued an Executive Order requiring the preparation of a "carrying capacity analysis" for the Florida Keys. To fulfill this requirement, the U.S. Army Corps of Engineers and the Florida Department of Community Affairs jointly sponsored the Florida Keys Carrying Capacity Study (FKCCS). The key component of this study is a carrying capacity analysis model (CCAM) that provides a technical tool for state and local jurisdictions to "determine the ability of the Florida Keys ecosystem, and the various segments thereof, to withstand all impacts of additional land development activities."

This National Research Council (NRC) report provides a critical review of the *Florida Keys Carrying Capacity Study: Test Carrying Capacity Analysis Model, First Draft* (URS Corporation, Inc., 2001a), hereafter referred to as the Draft CCAM. This independent review offers critical commentary in order to assist the sponsors and contractors in making final adjustments to their report and the Carrying Capacity Analysis Model. The committee (Appendix A) was charged with the task of reviewing the Draft CCAM and submitting their report within 13 weeks. Given the short timeline for this review, the committee was unable to comment on the inner workings of the model, examination of input data, or future data collection. The committee was able to present a thorough review of the Draft CCAM and the data and calculations presented in that document as required by the statement of task (below). (Note: This NRC Committee also provided an *Interim Review of the Florida Keys Carrying Capacity Study* [National Research Council, 2001] in March 2001 [Full text included in Appendix B]).

The Draft CCAM is composed of several modules: Socioeconomic, Fiscal, Human Infrastructure, Integrated Water, Marine, and Terrestrial. These modules are designed to work together to evaluate the impact of further development in the Florida Keys. In addition, the Draft CCAM includes a Graphic User Interface (GUI) for a Scenario Generator, a tool that allows the user (through a series of menus) to specify different land use change scenarios, including new development, redevelopment of existing urban uses, and restoration of disturbed or developed land. The GUI enables the user to specify the type and intensity of land use change at scales ranging from individual parcels to whole-island planning units. Outputs from the Scenario Generator, generally reported at the planning unit scale, serve as inputs that drive other model modules.

The GUI is a useful interface to the Draft CCAM. It appears to be appropriate and flexible. Though user-friendly, its present design does not allow the user to specify parameters (coefficients) within the individual modules. In addition, the GUI lacks a method to represent directly the impacts of tourism, or model the impacts of vested developments. These limitations result in uncertainties with regard to future population size, corresponding numbers of dwelling units, and commercial floor areas. The inability to estimate separately tourist populations also precludes modeling of the direct effects of tourist activities such as boating, fishing, and diving. These constraints, in turn, affect the model's analysis of any future growth scenarios and limit the other modules' utility. Two alternative scenarios—Current Conditions and Smart Growth—were tested in the Draft CCAM but neither was explained in detail.

The Socioeconomic Module produces population estimates that serve as input for all the other modules. These estimates implicitly account for tourism, but the method used is too simplistic. In addition, the module produces no useful quality of life indicators. Although the Affordable Housing Index could be useful, it currently lacks a functional link to the user-defined land use change scenarios.

The Fiscal Module produces some useful indicators of fiscal impact and seems ready for use with some adjustment. It lacks consideration of local/non-local cost sharing, costs of land acquisition, and tax losses, however. It also suffers from an assumption of constant demographic composition, which makes it unable to evaluate shifts in population patterns (e.g., a larger percentage of retired residents or school-age children).

The Human Infrastructure Module deals exclusively with traffic impacts. It produces estimates of additional trips, level of service, and hurricane evacuation times. Level of service estimates are constrained by a lack of local trip generation coefficients. Hurricane evacuation clearance time estimates do not account for the spatial distribution of new development.

The Integrated Water Module produces estimates of wastewater and stormwater generation and seasonal average pollutant loads to marine waters. While the marine loadings can be used to compare alternatives, they are not adequate to evaluate the effect on the near-shore marine environment.

The Marine Module suffers from a lack of input information and should not be used to draw any meaningful conclusions on impact due to current or future development activities. This module lacks good data, leaves out important factors, and uses a dispersion model that is only appropriate for point source loading. It would need major revision in order to be useful within the context of the CCAM.

Issues of terrestrial habitat and species richness appear to be reasonably well addressed by the Terrestrial Module. This module produces a number of measures of environmental impact, particularly with regard to a representative set of species (including endangered species). There are some important technical concerns that need to be addressed, however. The methods used are appropriate given the available science, but the results are imprecise. In some cases, the coefficients used in this module are inappropriate.

The Draft CCAM does show great improvement over the version presented to the committee a little over a year ago. Nevertheless, several data and structure issues remain. Nomenclature and consistency in terminology continue to be a source of confusion to the reader. Several of the modules calculate various output measures using Census data from 1990 instead of 2000. Errors based on these old population figures resonate throughout the Draft CCAM. The usefulness of the model and integration of the modules are constrained by the lack of calibration and sensitivity testing. In addition, several of the modules lack direct statements regarding the uncertainty and the limitations of the data and analysis, yet output described in the text includes color coded maps that apply threshold values that imply a precision that simply does not exist.

Many of the currently available models used in the Draft CCAM require that restoration, land acquisition for conservation, and conversion of septic tanks and cess pits to higher levels of treatment all occur immediately. All these actions require significant funds to implement but are nevertheless assumed to occur in the Draft CCAM. Results, therefore, cannot be used to draw conclusions about impacts from future development, and non-critical use of the CCAM may provide misleading results.

In general, the Scenario Generator, Fiscal, Integrated Water, and Terrestrial Modules can be useful in estimating impacts to the Florida Keys with some relatively minor technical adjustments. As it exists, the Marine Module will require almost complete revision to be a functional part of the CCAM. The Socioeconomic and Human Infrastructure Modules also need major revision to remain useful parts of the CCAM. Detailed suggestions and recommendations are provided for the CCAM as a whole and for each module in both the text and the appendices.

The contractors did an admirable job of working with the data available. Time and money constraints aside, however, the task was perhaps too ambitious an undertaking for the data and level of knowledge that currently exist for Florida Keys ecosystems. In its present stage of development, the CCAM is not ready to "determine the ability of the Florida Keys ecosystem . . . to withstand all impacts of additional land development activities" as mandated by Florida Administration Commission Rule 28.20-100. Significant improvement of the CCAM is required in several key aspects if it is to be useful as an impact assessment tool.

Endeavors such as the CCAM tend to obscure significant scientific uncertainty and project an unrealistic understanding of complicated environmental issues. What is needed and what the committee would like to express in this review, are expert opinion, common sense, and stakeholder consensus. The CCAM has important information to bring to the table, particularly where its modules have been based upon good and reliable scientific data. In the end, however, the decision to be made will be social not scientific. Once management has been implemented, science can make further progress toward understanding the natural system through modeling endeavors such as this one.

# 1

# Introduction

## BACKGROUND OF THE STUDY

The Florida Keys are the third largest barrier reef ecosystem in the world and the only one of its kind in the United States. Given the area's ecologically rich, culturally significant, and environmentally sensitive nature, the State of Florida designated the Florida Keys as an Area of Critical State Concern in 1975 (Florida Statute, 1986; Florida Administrative Code §28-29, 1975). As a result of this designation, Monroe County, which includes the Florida Keys, must meet strict planning standards in order to address future development and to sustain the unique resources and quality of life that exist in the Keys.

In the early 1990's, the Monroe County Board of Commissioners developed the *Monroe County Year 2010 Comprehensive Plan* adopted in 1993 (Monroe County Growth Management Division, 1993). Over a four-year period the plan was subjected to legal challenges that highlighted several aspects of the Florida Keys ecosystem as potential "carrying capacity indicators," including the near-shore water quality, the health and extent of native seagrasses, population and distribution of the endangered Key deer, and hurricane evacuation capability.

After a lengthy process of public debate and legal proceedings, the Florida Administration Commission and the Governor issued Rule 28.20-100 in 1996, which contains a five-year work program for Monroe County (Florida Administration Commission Rule 28.20-100, 1996). This rule required the completion of the Florida Keys Carrying Capacity Study (FKCCS) and its companion, the Carrying Capacity Analysis Model (CCAM). According to the Rule, the CCAM was to be designed "... to determine the ability of the Florida Keys ecosystem, and the various segments thereof, to withstand all impacts of additional land development activities." Both the FKCCS and the CCAM are sponsored by the U.S. Army Corps of Engineers (USACE) and the Florida Department of Community Affairs (FDCA) and are contracted out to the URS Corp., Inc. Since this is the first time that a comprehensive analysis of this type has been carried out in Florida, the outcome is of great interest to local officials and to the general public. Recognizing the need for an authoritative, independent technical review, the USACE and the FDCA requested that the National Research Council establish a committee to undertake this task.

## SCOPE AND APPROACH

The appointed committee (Appendix A) was charged to review and evaluate the scientific methods, principles, and data that form the basis for the Florida Keys Carrying Capacity Study and the accompanying Carrying Capacity Analysis Model being developed by the State of Florida. In addition, the 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 were reached based on a sound scientific process.

The committee was specifically charged to review and comment on the following:

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

To provide rapid feedback to the project managers the committee first produced an *Interim Review of the Florida Keys Carrying Capacity Study* (National Research Council, 2001; Appendix B). That report was based on presentations made by contractors from the URS Corporation and their discussions with the NRC Committee at a two-day workshop held in Key Largo, Florida, on January 9–10, 2001, where they described the progress to date in designing the CCAM.

In late November 2001, the USACE and the FDCA submitted the *Florida Keys Carrying Capacity Study: Test Carrying Capacity Analysis Model First Draft*, (hereafter referred to as the Draft CCAM), to the NRC committee for review (URS Corporation, Inc., 2001a). The committee was then given 13 weeks to assess the Draft CCAM and submit a review based on the charge outlined above. This time limit allowed the committee to review the Draft CCAM Report with some degree of thoroughness but prohibited a careful assessment of the inner-workings of the model, examination of input data, or comparison to similar modeling endeavors elsewhere. All parties involved recognized that the Draft CCAM document was not a final version and understood that changes would be made in the final draft of the CCAM. The Draft CCAM submission included a series of appendices outlining terminology, acronyms, formulas, and explanation of the methodology used in the Marine Module. The NRC Committee requested several supplementary documents cited in the Draft CCAM for review and clarification that are listed at the end of the report. In addition, the committee submitted a set of over 150 questions to the contractors at URS Corp., for which they provided written answers prior to attending a public meeting with the committee in January 2002 (Appendix D).

## ORGANIZATION OF THIS REVIEW

The remainder of this report is organized into ten sections and four appendices. Section 2 provides an overview of the committee's crosscutting concerns relating to all of the Draft CCAM modules. Sections 3–9 contain comments on each individual module (Scenario Generator, Socioeconomic, Fiscal, Human Infrastructure, Integrated Water, Marine, and Terrestrial). The final section, 10, contains the committee's overall conclusions. Several appendices provide background information and a glossary. Appendix A contains committee member biographies; Appendix B presents the *Interim Review of the Florida Keys Carrying Capacity Study*; Appendix C provides a glossary of terms and acronyms; and Appendix D contains both detailed comments on the Draft CCAM and the questions submitted by the committee in December 2001 and the contractor's responses, provided in January 2002.

# 2

# Overarching Comments and Concerns

## UTILITY

The Draft CCAM was developed in order to provide a tool that could help establish a carrying capacity for the Florida Keys—the maximum level of development that could be supported without damage to the natural and human resources of the area. The Draft CCAM is a valuable first step in the development of analytical tools to evaluate the impacts of development in the Florida Keys, but it is not capable of providing quantitative estimates of carrying capacity. As the committee emphasized in its interim report, it is not at all clear that it is possible to create a tool capable of credibly evaluating the impact of development on all of the Keys' varied natural resources in such a short period of time, if at all (National Research Council, 2001).

That said, the Draft CCAM is currently the only analytical tool available that attempts to integrate quantifiable data from multiple sources and contexts to evaluate the environmental impacts of development in the Florida Keys. It incorporates information on land use, socio-economics, transportation, infrastructure, stormwater and wastewater management, and marine and terrestrial ecology. Though it is not as comprehensive as was intended, and although it does not estimate carrying capacity in the ecologically relevant sense of the term, it is nonetheless an important piece of work and has the potential to be a useful tool in managing the fragile ecosystems of the Florida Keys. Significant improvement is required in several key respects, however, if the CCAM is to be a useful impact assessment model. An impact assessment model differs from a model capable of fulfilling the mandate to determine carrying capacity—which may be beyond any modeling endeavor given the current level of understanding and data available.[1] The CCAM can be used to guide professional judgement by knowledgeable experts, as long as its assumptions, uncertainties, and limitations are clearly acknowledged and understood.

The CCAM can be used to evaluate some of the impacts of development on the Keys, but not with great precision due to the very nature of the techniques used and the data available. Given the policy decision to avoid new data collection as well as the short timeframe for the study, the consultants were forced to rely on standard techniques and parameters developed for general application that were not refined to reflect the unusual conditions found in the Florida Keys. As a result, much of the basic science underlying the model can be characterized as crude, and does not support the precise estimates of impacts necessary to establish impact thresholds and carrying capacity.

When combined with a consideration of non-quantitative impact estimates based on professional judgement, the Draft CCAM can be used to guide decision-making. Such choices require a judicious balancing of uncertain impacts on the environment and quality of life with more certain financial consequences and impacts on individuals. Given the uncertainties involved, it may be advisable to make incremental decisions, monitor results, and proceed accordingly. The CCAM and other information can be used to guide research and data gathering efforts, the importance of which cannot be overstated. Adaptive management techniques that make use of tools like the CCAM as well as the fruits of information-gathering efforts may be the most appropriate way to ensure the continued vitality of the natural and human resources of the Florida Keys. The issues discussed below are not particular to any single module but are cut across all of the modules.

## Calibration Concerns

Almost all of the individual models used in the Draft CCAM modules (e.g., the model that derives population estimates from land use, the model that estimates the impact of development on habitat for individual species, etc.) are highly simplified representations of the real world. When such models are used, it is customary to adjust the parameters (coefficients) in the model so that it predicts historical values of the outputs given historical values of the inputs, a process called calibration. Though the NRC Committee is generally satisfied with the form of the models used, virtually all of the modules are uncalibrated.

For example, to estimate wastewater loading the Wastewater Module multiplies a coefficient by the number of dwelling units within a planning unit assumed to be served by a given wastewater management technology. The coefficient

[1]See NRC, 2001 (Appendix B) Section 1 for a discussion of Carrying Capacity Model vs. Impact Assessment Tool.

used is based on average water usage in gallons per day for the planning unit, as reported in the *Monroe County Sanitary Wastewater Master Plan* (Draft CCAM Appendix C; Monroe County Growth Management Division, 2000). The coefficient for each planning unit is based on averages that reflect the mix of land uses and socio-economic structure of the population within the planning units at the time they were calculated. The coefficients cannot be calibrated because they are not calculated from variables that actually determine water usage and associated wastewater generation. This does not mean, particularly in this case, that the model should not be used, or that it is inappropriate to use regional average values. It does mean that the model is uncalibrated and that the predictions made by the model are not precise and they may be biased toward high or low values.

### Incomplete Knowledge Base

Lack of data and/or science has limited the ability of the Draft CCAM to represent a wide range of important processes, so in this sense the model is incomplete. Important but unmodeled processes exist in virtually every module. These include but are not limited to: the impact of external demand for vacation properties on land values, impacts on water quality in canals, explicit consideration of the impact of tourist activities, consideration of external sources of pollution loadings, and any consideration of marine biology. This does not invalidate the Draft CCAM, but it does mean that its results must be weighed against common sense and historical experience.

### Model Uncertainty

Sensitivity testing is critical when attempting to use uncalibrated models because it allows the user to assess the amount of change in predictions induced by changing assumptions about parameters (coefficients) within reasonable ranges. If the sensitivity to the change in a parameter is small, then confidence in the model's predictions increases. Conversely, if sensitivity is large, then further research is warranted in order to improve the accuracy of the estimate for that parameter. The Draft CCAM included no sensitivity testing. While it is possible that some testing occurred, a full sensitivity testing would require a very large effort, as the CCAM is very complex and involves many parameters, many of which would need to be varied concurrently. Since the run time for a single scenario is about two days, full sensitivity testing probably lies beyond the scope of the current effort.

The Draft CCAM's imprecision makes it important that the output displays produced by the model be designed to avoid communicating a false sense of precision. This task is made more difficult by the lack of sensitivity testing of the underlying models. The application of threshold values to CCAM output implies a precision that simply does not exist. For example, if a minimum patch size of

50 acres were the threshold for the survival of a species, then a patch would be coded red at 49.5 acres and green at 50.5 acres. The policy implied by those codings is quite different, despite a gap of only one acre: in the case of the latter, the patch would be added to the bird's habitat, but not in the former. The nature of the models makes it impossible to establish that birds would in fact, colonize one site but not the other. To avoid the appearance of precision, continuous color shading could be applied to graphical displays or a weighting scheme could be devised to partially value habitats and other endpoints that fall at or near thresholds. Regardless of the method used, the uncertainty inherent in the modeling must be reflected in the displays of the results and should be fully described for each module.

### Endpoints Not Considered

A number of endpoints (e.g., areal extent of propeller scarring, direct impacts on the coral reef, canal water quality, etc.) were proposed during briefings at a workshop in January 2001, but were not included in the Draft CCAM. Many (perhaps all) of these were dropped due to insufficient scientific basis for their inclusion in a quantitative analysis, which is well and good. Lack of ability to quantify impacts does not imply that useful information is unavailable, however. There needs to be recognition of the importance of these excluded endpoints, so that those who use the model can seek expert opinion, or otherwise consider those factors in decision making. A complete listing of the endpoints considered but not included and the rationale for excluding those endpoints should be a prominent part of the final CCAM documentation.

### Draft CCAM Conclusions

Extreme caution is required when portraying Draft CCAM results as evidence of what would actually happen if a particular land use alternative should actually come to pass. The uncalibrated nature of the model and its lack of precision make it impossible to draw firm conclusions, particularly when those conclusions are called into question by existing data or anecdotal evidence. This does not mean that it is impossible to draw any conclusions. With implementation of the *Monroe County Sanitary Wastewater Master Plan (*Monroe County Growth Management Division, 2000)*,* for example, it is quite reasonable to conclude that pollution loads to surrounding waters will be substantially lower in the long run than they would be if current conditions persist. It is important to note, however, that in the short run the background level of pollution due to past human activity may cause further deterioration. How significant such deterioration might be and how long it might persist is simply not known.

It is not possible to conclude that current or projected levels of development do not or will not have significant impacts on the marine environment. Model results do indicate that the incremental contribution of some pollutants from land based sources should be small relative to background loads. This outcome contradicts evidence of beach closings due to elevated fecal coliform counts, historical measurements of decreased visibility for divers on the reefs, and trends in incidence of coral disease. Existing science is simply inadequate to establish a clear cause and effect relationship between land development in the Keys and these trends. Draft CCAM model results are, however, inadequate to allow the user to draw the conclusion that there is currently or will be no substantial impact. In general, model results must be considered in the context of historical experience. The uncalibrated nature of the model, its lack of completeness in terms of both processes and endpoints, and the lack of sensitivity testing of the model results must temper any conclusions to be drawn from the Draft CCAM.

## Documentation

There are a great many editorial issues that must be dealt with by the contractor in both the text and appendix components of the Draft CCAM. Perhaps the most important is that the model logic as described in the documentation (particularly the appendices) does not match the logic as described by the contractor. The documentation clearly needs to be reviewed in order to ensure conformity with the actual model calculations.

There are three general issues in relation to citations that are of concern to the NRC Committee. First, many citations are non-peer-reviewed documents that are almost impossible to acquire, and the committee expressed concern over the confidence placed in such documents. Some of those documents are not cited in the Literature Cited section and were not made available to the NRC Committee. Second, there are a number of documents noted in the answers to the NRC Committee's questions (Appendix D) that were never seen by the committee (e.g., Delivery Order Reports).

Finally, literature is poorly cited in general. A large number of citations throughout the text and appendices of the Draft CCAM cannot be found in the Literature Cited section. This is particularly true in the Appendices, where some are cited incorrectly. These citation issues need to be corrected in the final version of the CCAM report to provide maximum guidance to future users of the document.

Besides the issues of citations discussed above, there is also a need for clear documentation of terminology and nomenclature. In the Draft CCAM, for example, any parcel of land with a structure on it is considered developed, regardless of whether structures occupy the entire parcel or only a fraction of the land area. The term "footprint" is used to depict the entirety of this developed land. If an undeveloped parcel is fitted with a single house or a shopping center, the entire parcel is included in the increased "footprint"; however, if an obsolete gas station is replaced with a strip mall, the "footprint" of the parcel does not change. Such use of the term "footprint" does not match the standard usage of the term in the design professions,[2] which may confuse the reader.

Another example is the use of the term "polygon," a Geographic Information System (GIS) term that might be familiar to practitioners, but not to a general reader, such as a decision-maker or activist especially interested in the CCAM. Terms like these should be defined more clearly and more broadly if they are to be used as an instrument that may become the basis for development control.

[2]In the design professions, the term footprint normally describes only that area of a site that is actually covered with a structure.

# 3

# Scenario Generator

The Scenario Generator is a tool (using a series of screens, buttons, and menus) that enables users to define land use changes at the parcel level, the planning unit level, and at intermediate scales using the "rubber banding" option. This flexibility is a major strength of the Draft CCAM that will make it useful for numerous planning applications. While the output scale to other modules is principally at the planning unit scale, parcel-level data are evidently output to the Water Module in order to permit aggregation to the catchment level for storm-water and wastewater loadings calculations.

## PRESENTING A CONTEXT

The CCAM is meant to be a tool to help decision-makers guide the development and environmental conservation for the future of the Florida Keys. To be both useful and functional, the tool and its background material must be written clearly and must be readily understandable by both decision-makers and lay readers representing a wide range of interest groups. In setting the scene for the CCAM, existing characteristics of the Florida Keys (i.e., land use, economy, demography, travel patterns, etc.) merit ample description. The issues that have precipitated the need for the Carrying Capacity research also demand clarification near the beginning of the project report. Additional essential matters to be presented include: how the tool will be used, who will use it, and with what frequency it will be updated. As of January 2002, both the clarity of text and the details of the context are matters still missing from the Draft CCAM.

## DESCRIBING THE FLORIDA KEYS AS THE BASIS FOR SCENARIOS

The Draft Report depicts the Florida Keys as "anyplace" USA, with few of the nuances that characterize Monroe County's land use, economy, or travel patterns. The Scenario Generator (Draft CCAM Section 3.1.2) classifies land uses as residential (at three density levels), commercial (retail, office, services, entertainment, hotel/motel, marina, golf course), institutional, and industrial. Little information is provided about the character of the land uses that will be given quantitative dimensions in the scenarios to be tested and that are the components of the model. Based on field observations from Key Largo to Key West, three examples are given below illustrating matters that should be described in considerable detail:

### (1) Visitor-Dependent Land Use/Economy

U.S. Route 1 is the arterial spine of the Florida Keys along which the preponderance of non-residential land uses are arrayed. Commercial land use dominates mile after mile, from the tip of Key Largo to the monument at the base of Key West. These uses include resorts and motels, restaurants and bars, marinas, attractions (e.g., Theatre of the Sea), gift shops, boat yards, dive shops, and scooter and jet-ski rentals along with real estate and other services geared to the tourist industry. Supermarkets, drug stores, and gas stations exist, but appear to be as much oriented to transients as to residents, and they pale in contrast to the large chain shopping centers and department stores at the entrance to the Florida Keys in southern Miami-Dade. Except for local government operations, office space appears to be concentrated in small freestanding buildings, unlike office complexes in some other communities of comparable size. The visual impression of non-residential uses is that of a strongly visitor-dependent economy.

The heavily tourism-based economy makes it extremely important that the CCAM relate in detail how issues relating to non-residential uses are analyzed, as standard formulae may not work in such a setting.

### (2) The Pulse of Visitor Demand and Traffic

Functional population is defined in the glossary of the Draft CCAM as "the sum of permanent and temporary populations in the Florida Keys." Temporary population is further defined as the sum of transient (those people who stay in the Florida Keys for less than 30 days, typically vacationers) and seasonal (those people who stay for 30–180 days). Nothing more is presented in the discussions of population and human infrastructure (hurricane evacuation) about the scale, habits, and demands of the transient population, who may very well be a major element in peak demand for infrastructure and services.[3] Absolutely nothing in the presentation of the modules relates to day or weekend trippers and their potential impacts on land use, marine environments, or the economy. Observations during a weekend in January (perhaps typical for a peak season) reported heavy traffic along U.S. Route 1 in both directions, including a large presence of sport utility vehicles towing boats of various kinds, many with Florida license plates. Highway turnout areas for parking and shoreline fishing from Key Largo to Key West were filled with vehicles, and even "informal" shoulder parking was crowded. People lined the turnouts, fishing from bridges and sections of the old railroad provided with public access. The impact of these peak period visitors, from solid and liquid waste disposal to part-time jobs for retirees and students, can be quite significant and certainly affects the "carrying capacity" of the Florida Keys.

### (3) Government Presence in Recreational Attractions and Economy

Except for a statement in the Smart Growth scenario that "two additional parks of 5–10 acres each will be developed in the lower Keys," no information is provided on the significant public presence that generates visits to segments of the Florida Keys and presumably generates jobs for the economic base. Government-managed parks, visitor's sites, and beaches in the Florida Keys are far from rare. In fact, many such areas are found from Key Largo to Key West, joining commercial recreation and deep-sea fishing as key revenue generators. Indeed, there may be few counties in the United States that have a comparable array of federal, state, and even local attractions along their entire length. These types of areas are not described in the Draft CCAM, and portrayal of government presence is confined to open space and regulation.

## SCENARIO DESCRIPTIONS

Two scenarios are presented in the Draft CCAM report, a 'Current Conditions' and a 'Smart Growth' scenario. The former is a rough attempt to calibrate the model and the latter represents a future development scenario that poses a modest rate and extent of growth for testing purposes. The *Interim Review of the Florida Keys Carrying Capacity Study* (National Research Council, 2001) was written with the understanding that different alternatives would be tested prior to final recommendations. It is clear that no conclusions can be drawn about the carrying capacity of the Florida Keys based on the limited testing that has

[3]The Miller Consulting Model (2001) for estimating hurricane evacuation clearance time does differentiate tourists from residents. In this model however, the contractor's use of a linear extrapolation of the clearance times from that model based on total functional population essentially ignores those distinctions.

occurred, even if the model were suited to this purpose. It would be helpful for the CCAM discussion to include the types of scenario runs that might be included in the final draft.

Another troubling issue is the lack of explicit description of the two scenarios that appear in the Draft CCAM Report. Except for the numerical information in Section 4.0 of the Draft CCAM, description of the Current Conditions scenario is confined to a single sentence. While the "Smart Growth" scenario is given considerably more attention, the Scenario Generator only allows the user to specify land use changes. The "Smart Growth" scenario is, therefore, a very simplified representation of all that smart growth is understood to encompass as specified in the National Governor's Association statement of smart growth principles (National Governors Association, 1999).

The Draft CCAM strays far from a document prepared by the URS Corporation in July, 2001 entitled *Florida Keys Carrying Capacity Study Scenario Development Guidelines*, produced as a follow-up to a workshop with local planners (URS Corporation, Inc., 2001b). The guidelines set out a checklist of items to be covered in any scenario. The document also includes: first, a directive stating "a scenario should be described in words. This description will help both the local planners and the contractor evaluate and determine the option choices in the checklist . . . ," and second, a sample description of a basic scenario. That description is particularly relevant as an example, because it begins with a paragraph that is not reflected anywhere in the Draft CCAM's depiction of either scenario.

> The overall 20-year vision in this Keys-wide scenario is to reinforce a pattern of development articulated as a hierarchy of urban, 'suburban' and open space components. Growth will be guided and reallocated into 'nodes' or regional centers of urban activity where mixed uses and higher densities are expected to reduce the need for development to grow outward, while decreasing the level of vehicular trips and unit cost for infrastructure (URS Corporation, Inc., 2001b).

Although the Current Conditions scenario is not intended to accompany a vision of the future it fails to provide the reader with any text that describes the current pattern of development. Moreover, while the contractor's January 2 response to the NRC Committee's questions (Appendix D) included several paragraphs purporting to describe the Smart Growth alternative provided by "local" planners, it did not—with the exception of a single sentence—indicate the principles behind the parameters or why the scenario represented "Smart Growth."

## GRAPHIC USER INTERFACE

The contractors acknowledge that the Draft CCAM is limited by lack of data on the availability of public infrastructure (other than water supply) for defining the suitability of land for development (Draft CCAM Section 3.1.3). This limitation influences the manner in which new development is allocated amongst eligible property parcels in setting up alternative future growth scenarios in the Graphic User Interface (GUI). The Draft CCAM also acknowledges (Draft CCAM Section 3.1.3) the presence of errors in the Monroe County Tax Roll zoning data set. This constraint also influences the accuracy with which new development is assigned to different property parcels based on assumptions about zoning constraints.

Most modules include built-in constants and coefficients set by the consultant and not amenable to change by the user through the GUI. The user should be afforded the option of altering all such parameters so as to permit both sensitivity analysis and updating of these variables. The committee recommends that options be added to the GUI so that the user can set all parameters, including those currently treated as "built-in constants and coefficients," (e.g., Draft CCAM Table 3.3, Tables 4.4–4.8, and Table 6.1).

According to contractors at URS Corp. (Appendix D), no reliable data could be found on vested developments, which results in an undefined level of uncertainty about the true future population size and corresponding numbers of dwelling units, the numbers of commercial structures and future floor areas, and the resultant impacts of any future growth scenarios analyzed with the model. This uncertainty affects nearly all of the indicators in every model module, although the magnitude of the effects cannot be quantified without some estimate of the number of vested parcels. The "Assumptions & Uncertainties" subsection of the Scenario Generator (Draft CCAM Section 3.13) should clearly identify this uncertainty. URS Corp. should also attempt to obtain a range of estimates of the numbers of vested developments and their resultant residential and commercial land use impacts, and conduct sensitivity analysis of the potential impacts of these ranges.

Thresholds are defined for one or more indicator variables for each module of the model (Draft CCAM Appendix C) and constitute the parameters used to indicate the relative acceptability of any future growth scenario analyzed with the model. The definition of thresholds requires value judgments about acceptable levels of the indicator variables, and as currently designed, those value judgments appear to have been made by the consultants.[4] In some cases, near-shore ambient water quality for example, thresholds are based on state or federal regulatory standards (Draft CCAM Appendix C, Equation 193). Users may wish to set thresholds differently, even where state or federal standards pertain (e.g., where there may be evidence that certain species or biological communities are negatively affected by conditions less severe than those currently permitted [United

[4]Section 3.8 of the Draft CCAM reports that feedback from public meetings was used "to help determine the components of each module, and the end points and criteria used for determining carrying capacity thresholds for quality of life issues." The Committee's discussion with the consultants on January 10, 2002, indicated that criteria thresholds were set by the consultant.

States Environmental Protection Agency, 1999]). Therefore users should be clearly informed about how thresholds are set and should be afforded the option of setting alternative threshold levels. In addition, sources for the thresholds reported in Appendix C of the Draft CCAM should be clearly identified. Users should be provided the opportunity in the GUI to set all threshold levels.

Thresholds in the Draft CCAM are misleading and should not be defined where the range of uncertainty in parameter estimates used to calculate indicator variables exceeds the range of variation in the indicator. Output should be limited to indicator estimates, and should be accompanied by uncertainty ranges. The committee also recommends that the user be provided with options through the GUI to select alternative output formats including (1) simple numerical estimates for indicator parameters, and (2) alternative color schemes for numerical or threshold outputs.

The suitability assumptions and alternatives for redevelopment scenarios in the Draft CCAM are not explicit. The discussion in the narrative (Draft CCAM, Section 3.1.2) and the information presented in Tables 3.1 and 3.2 do not reflect the range of choices in the GUI and the elaboration provided in response to questions from the NRC committee. The committee recommends that the narrative be revised to more fully document the options available to the user to define redevelopment scenario parameters. In addition, the contractors should explain how development suitability is used in the allocation of new development (Draft CCAM Section 3.1.2) per response to the NRC Committee's Question #27 (Appendix D), and clarify assumptions used in the scenario selection process per their responses to Questions #94–95, 109–110, 112, and 114–115 (Appendix D). The GUI should be modified to allow for options described in response to the NRC Committee's Questions #96 and 99 (Appendix D) and do the same for the settings discussed in Questions #97–98 and 100–104 (Appendix D).

The Scenario Generator section lacks clear description of the output data format for specific modules of the Draft CCAM, rather only general output data formats are described (Draft CCAM Section 3.1.2). The committee recommends that the text clarify which modules produce land use data at the planning unit level (Socioeconomic, Fiscal, and Potable Water?) and which at the parcel level (Stormwater, Wastewater, and Terrestrial?).

# 4

# Socioeconomic Module

The Socioeconomic Module provides population projection inputs to the Fiscal and Human Infrastructure Modules and residential and commercial development data to the Infrastructure Module. These inputs were often derived in a simple, straightforward and reasonable manner using readily available data, which makes it easy for the user to understand the module and should help the user modify assumptions and integrate new information. The choice of planning units also seems reasonable, as it matches both local governmental planning units and census tracks.

## MAJOR CONCERNS

### Use of 1990 United States Census Figures

The Socioeconomic Module, as it stands in the Draft CCAM report, uses 1990 U.S. Census data to estimate coefficients, which are assumed to be constant. In fact, these coefficients are not constant (see discussion below) but instead evolve over time. Using 2000 U.S. Census data rather than 1990 data will substantially reduce the error in the starting values for these coefficients. It is worth emphasizing that errors in the base population figures will propagate throughout the CCAM because population is used in the Fiscal and Human Infrastructure Modules to calculate various intermediate and final output measures. Although the 2000 U.S. Census data may not have been initially available, most of it has now been made available. Using that data, rather than the 1990 U.S. Census data would significantly strengthen the CCAM.

The decennial U.S. Census is the most "official" population count of jurisdictions, as well as smaller area tracts and blocks in existence. Not only does the Draft CCAM Report indicate a 19 percent lower population count for the year 2000 than the census, but its "Smart Growth" scenario for the year 2020 shows fewer people than the census established for 2000. Since final 2000 Census figures are now available, re-estimation is imperative, particularly if projections are to be legally defensible.

### Use of Independent Population Projections

Two methods were used to obtain population estimates in the Socioeconomic Module: a) independent population projections, and b) population derived from scenario-based land use. The Draft CCAM consistently employed the second method. Given growth restrictions in place in the Florida Keys and the limited supply of land available for development, it makes logical sense to start from the amount of land for each type of development as defined by the scenario. Combining the scenario-based land use map along with the assumption that development will occur on suitable land and a coefficient for the number of people per unit for each development type yields an estimate of the increase in population. The first method, which begins with population and projects land use changes based on population changes, is used only in the socioeconomic section and is justified "as a frame of reference" or internal consistency check. Population growth in the Florida Keys is certainly affected by public policies such as the Rate of Growth Ordinance (ROGO). In addition, future growth is likely to be determined in large part by public policy. It is advantageous to make the consequences of land use regulation on population growth explicit as is done in the second method.

Regardless, one consistent method for developing population projections should be used throughout the Draft CCAM. Employing two different methods in the Socioeconomic Module is both unnecessary and confusing. It would be best if all references to the independent population projections were deleted from the Draft CCAM, including references in both the main body of the text and in Appendix C of the Draft CCAM and the socioeconomic section rewritten accordingly.

### Use of Constant Coefficients

The Socioeconomic Module makes use of numerous coefficients that are assumed to be constant throughout the analysis. The use of constant coefficients makes the analysis easy to follow and may be justified in some cases on the grounds that certain relationships are relatively constant, at least over the range of analysis considered in the scenarios. There is a danger in assuming constant coefficients, however, especially for models such as the CCAM that are being used as impact assessment tools. Coefficients may in fact be functions of scenario assumptions. As described in Appendix C (Draft CCAM Section 1.0), residential densities in each planning unit are assumed to remain constant at their current value. As suitable land for development becomes scarce, these densities are likely to increase due either to market forces or regulatory decisions. Increased scarcity of suitable land is also likely to cause an increase in housing prices, which may cause changes in community composition that may, in turn, change everything from the demographic structure of the community to the average number of persons per dwelling. It is incorrect to assume, as is done in Section 3.2.2 of the Draft CCAM, that densities "will remain essentially constant" because of limited population growth.

The analysis could be improved in several ways. At the very least, a sensitivity analysis should be run that allows various coefficients to assume different values. It should also be possible to analyze historical trends in these coefficients to see how they have changed in Monroe Country over time. Comparing coefficient values in Monroe County to coefficient values in other Florida counties may also yield important information. A more sophisticated approach would attempt to estimate these coefficients on the basis of underlying conditions.

## The Affordable Housing Index

Affordable housing is an important socioeconomic indicator to track. In Monroe County, average housing prices are very high relative to state and national averages. The Draft CCAM calculates the Affordable Housing Index (AHI) using existing data on housing prices and income. The study does not attempt to predict what would happen to housing prices under various scenarios, which means that the AHI is a constant, not a function of the scenario. From simple reasoning about supply and demand, it would be expected that allowing less land to be available for development would lead to higher housing prices.

Some care should be exercised in interpreting the AHI. A rise in property values has different implications for different sectors of the economy. For property owners, a rise is good news because it increases the value of their assets. It is also good news for local governments, that increase their tax base with a rise in property values. For those looking to buy property, however, an increase in property values is bad news. In addition, a significant portion of the demand for property in the Florida Keys comes from people living outside of the Florida Keys area. For this segment of demand it is their income, not Keys income, that determines the affordability of the property.

It should be noted that housing affordability is a serious concern for Monroe County and that the County is attempting to find means to provide it, presumably for rental as well as for sale. The County has issued a Request for Qualifications to consultants that specialize in housing to identify possible experts to assist a five-member Affordable Housing Oversight Committee.

As it currently stands, the AHI cannot be used as part of an impact assessment tool to assess outcomes of various scenarios. The measure is static and does not depend on the conditions assumed in the scenario. In order to make the AHI a useful impact assessment variable (IAV), a model of housing demand for the Florida Keys would need to be developed. Though there is a large existing literature on housing demand, existing housing demand models would need to be customized for application to the Florida Keys. At a minimum, such an approach would allow changes in developable land to affect housing prices. A more sophisticated approach might also try to account for the effect on property values given changes in environmental amenities, the major reason why the Florida Keys are in such demand.

## The Competitive Commerce Index

Two sets of questions are generated by the description of the Competitive Commerce Index (CCI). First, on a practical level, the process used to compute the CCI is unclear. The description of the CCI in Section 3.3.4 of the Draft CCAM does not agree with the description in Appendix C of the same report which describes a "Retail Concentration Index" but not the CCI. The average disposable income (ADI) used to calculate the CCI is not mentioned in Appendix C of the Draft CCAM. There is no description of the data source for the ADI, whether it is given by planning unit or for the entire county, or whether it attempts to include spending by tourists.

Second, it is unclear as to how to interpret the CCI or what its significance is; it is unclear if the CCI is an important measure on its own and if it impacts traffic flow patterns or other impact assessment variables. There are no threshold values for the CCI defined in Appendix C of the Draft CCAM as there are for the AHI. The CCI should be clearly defined and explained or it should be left out.

## Missing Endpoints

The AHI and CCI are the only two impact assessment variables generated by the Socioeconomic Module in Section 3.3.4 of the Draft CCAM report. These measures clearly fail to provide a comprehensive or accurate representation for the quality of life or socioeconomic well-being of people in the Florida Keys. It is unclear why the Draft CCAM did not include measures of income, fishing, recreation, and various social indicators. If the AHI and the CCI are the only two measures assessed, the write-up of the Socioeconomic Module should indicate that the CCAM is not attempting to incorporate or track quality of life or socioeconomic well-being in any systematic manner.

## Public Involvement and Information Plan

The Quality of Life portion of the Draft CCAM consists of a two-page write-up of the contractor's Public Information and Involvement Plan (PIIP) (Draft CCAM, pp. 69–70; United State Army Corps of Engineers, Planning Division, 2000; The Market Share Company. 2001.). The PIIP was developed to allow public input on the CCAM development (United State Army Corps of Engineers, Planning Division. 2000; The Market Share Company. 2001). During the PIIP, participants were asked to rank several quality of life issues. Section 3.8 of the Draft CCAM report states that "many of the important Impact Assessment Variables (IAV) that are CCAM outputs are related to quality of life issues as put forth by the community." The IAVs, however, do not match closely with results from the PIIP as listed in Table 3.21 of the Draft CCAM report. Maintaining current community character (ranked 3rd), views about government regulation (ranked 5th, 8th, 9th, 11th, 15th and 16th), improved safety on U.S. Route 1 (ranked 7th), tourism (ranked 10th, 14th and 17th), and recreational opportunities (ranked 12th and 13th) lack closely related IAVs. Of the Socioeconomic Module IAVs, affordable housing is ranked 6th. Nothing listed in Table 3.21 of the Draft CCAM compares to the CCI.

Encouraging community involvement in order to generate issues against which endpoints can be measured is an important process for the URS Corp. Attendance at public meetings allows input from certain sectors of the community, but is unlikely to gather feedback from the entire community. The contractors should have exerted greater effort to include community input at an early stage. In addition, more insight can be gleaned from the information in hand than has been obtained to date.

## Tourism

A large part of the economy of the Florida Keys depends upon tourism, both those visitors on an extended stay and day-trippers. The number of extended stay visitors are tied to the number of hotel rooms and rental properties available. The number of day-trip visitors, however, are tied more to recreational opportunities, fishing in particular, rather than any measure explicitly related to land use. A number of governmental units collect information on recreation demand. The National Oceanic and Atmospheric Administration (NOAA) has several documents on the subject readily available on the web (National Oceanic and Atmospheric Administration, 1996). This information should have been investigated and incorporated into the Draft CCAM. In failing to incorporate this information, a large part of the economy of the Florida Keys has not been adequately represented in the Draft CCAM.

## Lack of Adequate Documentation

Few references are given for the Socioeconomic Module. Even when a reference is provided, it includes little detail on where the relevant information can be found within the reference. The report's description of the Socioeconomic Module in Appendix C contained insufficient information to gain an understanding of particular calculations. Specific comments on these points are given in Appendix D of this report.

# 5

# Fiscal Module

The Fiscal Module of the Draft CCAM brings together data sets that describe the costs of providing public services in the Florida Keys. Tabulations are compiled from the annual reports of expenditures during FY 1999–2000 for each of the communities. These values are subsequently divided by a population figure to provide per capita costs and reassembled into "planning units." The actual costs (derived from the tables) plus unfunded liabilities were used to project government expenditures associated with the scenarios.

## MAJOR CONCERNS

### Use of 1990 Census Data

The methodology applied to the establishment of existing operating costs is rather straightforward. The data are available in Annual Reports, and thus are recorded directly. The addition of the unfunded costs associated with inadequate classroom space and needed wastewater and stormwater improvements are important considerations associated with any future growth and quality issues.

The translation of the funded and unfunded expenditures into a per capita cost faces the same criticism levied on other aspects of this study: 1990 figures are used instead of the most recent census data to calculate any population-based value. These should be updated to the 2000 Census data, which would require repeating nearly all subsequent calculations. The additional unfunded expenditure discussed below should also be incorporated into the calculations.

## Demography

The assignment of per capita costs assumes a constant demography in the Florida Keys despite the fact that many factors could change aspects, including the proportion of school-age children, the need for medical care, the demand on recreational services, etc. The Final CCAM report should introduce some discussion of this variable and its application.

## Stormwater/Wastewater Improvements

Because the Smart Growth Scenario assumes wastewater and stormwater improvements, the scenario should incorporate these costs—for operation as well as construction—into its output. Upgrades will likely include some sort of subsidy that can be proportionately similar to historical ratios.

## Land Acquisition and Conversion

Acquiring the land being converted into open space also carries a cost, estimated at $48.7 million. While the Draft CCAM report identifies this cost, the Fiscal Module does not include it. In order to incorporate "all possible expenses," this particular unfunded cost should be factored into the module. Indeed, it could be assigned an output value using some proportion of local versus non-local shares in open-space generation. Furthermore, converting and managing public land incurs another cost that should be incorporated into future scenarios.

New costs associated with the growth scenarios also need to be presented as output values. Historical trends and FY 1999–2000 expenditures do not capture the acquisition, conversion, or management costs of changing land use and therefore should not be a part of unfunded costs.

## Revenue

Converting private land to public land removes land from the tax base. The effect of the diminished tax base is diminishing the government's capacity to generate revenue. The Fiscal Module should account for this decrease through an output that calculates the tax rate needed to support scenario-based government expenditures given in the scenario's tax base.

## Editorial Comments

The title of Table 4.10 in the Draft CCAM report should indicate that the calculations presented are annual expenditures. In addition, the fourth column from the left is entitled "percentage," but the values given are not in terms of percent. Either the heading or the values should be changed. The values for unfunded liabilities need to be updated to incorporate the 2000 Census data.

## ADJUSTMENT OF FISCAL MODULE

The items addressed in the Fiscal Module are largely spreadsheet-type data sets that can be adjusted and updated fairly easily. Additional components can be easily included in the unfunded expenditures. The solution for incorporating changes in the tax base is less clear. The document should make clear whether the assignment of revenue on a per capita basis accomplishes that distribution by incorporating a percentage increase for each of the steps in implementing the growth scenarios.

Costs associated with land use changes, environmental quality improvements, and infrastructure improvements should be incorporated into the Fiscal Module, as they will ultimately be part of the cost of functioning in the communities or planning districts. This information included as input to the Fiscal Module in the "Smart Growth" scenario and any other scenario with adaptations that go beyond current practices such as an addition, carries with it the need for continuous recalculation because these input values will be changing through time.

# 6

# Human Infrastructure Module

The Human Infrastructure Module focuses on two major connected issues: traffic on U.S. Route 1 and hurricane evacuation. The traffic component of the module uses level of service (LOS) as an indicator based on the speed of traffic moving along U.S. Route 1. Hurricane evacuation clearance times are independently estimated and are based solely on population using linear extrapolation of estimates from a previous study (Miller Consulting, 2001). Comments on each component are presented below and detailed comments are reported in Appendix D of this review.

## TRAFFIC ON U.S. ROUTE 1

Given that LOS for U.S. Route 1 has a mandated role in Florida's concurrency requirements (Florida Administrative Code §9J-5.0055[2][a][1]), the indicator is an important indicator to be included in the model. Though the LOS component appears to need only minor documentation revisions, it is not possible to fully validate the methods used to calculate it given its current presentation. The use of non-local data and 10-year-old coefficients warrants some sensitivity testing.

### Land-Use Trip Generation Rates

Land-use-specific trip generation rates are not available for Monroe County, therefore the consultants used national data from the Institute of Transportation Engineers trip generation manual (Institute of Transportation Engineers, 1998).

The committee therefore recommends that an "Assumptions and Uncertainty" subsection be added to Section 3.4.1 of the Final CCAM report. That subsection should provide a statement that characterizes the probable margin of error associated with using non-local coefficients. In addition, sensitivity analysis for LOS estimates should be conducted using an appropriate range of variation for the national trip generation values.

### Trips Generated Outside the Florida Keys

The percent of trips generated from outside the Florida Keys is based on the Monroe County Long-Range Transportation Plan (Draft CCAM Section 3.4.1). It is not clear how or when that coefficient was calculated, or what range of uncertainty should be associated with it in projecting LOS for different future scenarios. It also is not clear from the Draft CCAM report nor from the consultant's response to the NRC Committee's Question 3 (Appendix D) how this factor is used to estimate traffic volumes and calculate LOS within planning units. The "Assumptions and Uncertainty" subsection provides a statement that acknowledges a probable margin of error associated with using this dated coefficient for the percent of trips originating outside the Florida Keys. In addition, the committee recommends including a description of how this variable is used in estimating traffic volumes and calculating levels of service within planning units. As with the trip generation rates discussed above, it is important to conduct sensitivity analysis for LOS estimates using an appropriate range of variation for this coefficient.

### Trip Lengths

It is unclear how trip lengths are estimated for calculating internal-internal, internal-external, external-internal, and external-external trips for planning units. Average trip length estimates (Draft CCAM Table 3.4) are generated from 1992 data for which no source is given. It is not clear if the average of the six sites in Table 3.4 is used for all planning units, or if trip lengths for some planning units are based on one of the six sites. The Committee recommends that the contractors provide a description in the text of how trip lengths are estimated for individual planning units and are partitioned among internal-internal, internal-external, external-internal, and external-external trips in different planning units. The "Assumptions and Uncertainty" subsection recommended above, should provide a statement that trip lengths are based on 1992 data and a characterization of the uncertainty resulting from the 10-year difference in land use and socioeconomic conditions that presumably determine trip lengths. As recommended above, a sensitivity analysis should be conducted for LOS estimates using an appropriate range of variation for the trip length values.

## HURRICANE EVACUATION

Florida's local planning requirements (Florida Administrative Code §9J-.12[3][b][7]; Florida Administrative Code §9J-.12[3][c][3]) stipulate that local plans must include objectives and policies for maintaining or reducing hurricane evacuation clearance times, making it important to include that indicator in the mode. The Draft CCAM, however, exhibits a paucity of information pertaining to this important issue of personal safety and public policy. The evacuation clearance time is presented as accurate based on linear extrapolation of estimates from a separate study called the *Florida Keys Hurricane Evacuation Study, Final Report* (Miller Consulting, Inc., 2001). No documentation is provided for the methods, assumptions, limitations, or constraints of the primary model upon which the estimates are based or of the margins of error that result from the simplistic extrapolation used to predict the effects of future development on evacuation clearance times. This topic begs for more background information; better documentation of how important variables are treated such as evacuation behavior, road elevations, and storm surge flooding; and a sensitivity analysis centered on major assumptions and uncertainties.

The Draft CCAM estimates evacuation clearance times by assuming a linear relationship between total population within the Florida Keys and the aggregate clearance time for the islands (Draft CCAM Section 3.4). These estimates do not account for the impact of growth on clearance times within the seven individual evacuation analysis zones used in the Miller Study (Miller Consulting Inc., 2001), or on the effects of that growth on the five bottlenecks along U.S. Route 1 identified by Miller Consulting, Inc. As a result, the projected evacuation clearance times are invalid estimates of aggregate clearance times for the Florida Keys. Furthermore, the Draft CCAM does not identify the population base upon which this linear extrapolation is based, nor does it explain the basis for the three "threshold" population estimates reported in Equations #95–97 of the Hurricane Evacuation section in Appendix C of the Draft CCAM report.

In addition, the Draft CCAM presents none of the Miller (2001) study information required to interpret the evacuation clearance time estimates. In the absence of such information, the estimates seem to be based entirely on the capacity of the single road connecting the Florida Keys. This assumption fails to acknowledge that bottlenecks at intersections and along segments of U.S. Route 1 constitute critical factors that determine evacuation clearance times. The draft report also fails to address the assumptions and uncertainties implicit in the use of only two hurricane intensity scenarios as to (Category 1-2 and Category 3) to compare evacuation times. As a result, it is unclear which bottlenecks are the critical determinants of aggregate evacuation clearance time under different storm scenarios. Furthermore, the Draft CCAM is silent about where U.S. Route 1 is most vulnerable to flooding from hurricanes of different intensities and the associated probabilities of evacuation being terminated under different storm scenarios.[5]

The margin of error resulting from the linear extrapolation used in the Draft CCAM cannot be estimated without testing the Test Carrying Capacity Model (CCAM)(C. Miller, pers. com.). The Committee recommended, therefore, that this element of the CCAM be deleted or that the Miller (2001) model be incorporated as a sub-model in the Final CCAM. The Miller model is a spreadsheet that calculates clearance times based on estimates of the numbers of dwelling units in each analysis zone as differentiated into three categories: (1) mobile home dwelling units, (2) other residential dwelling units, and (3) tourist residential units (Miller Consulting Inc., 2001). It seems straightforward to produce such inputs from the CCAM Scenario Generator, which makes it possible to produce evacuation clearance time estimates that can be properly compared to those produced by previous evacuation clearance studies conducted for Monroe County.

If the Miller model is incorporated into the CCAM, the Graphical User Interface (GUI) should be redesigned to allow the user to specify important starting conditions for running the model, including hurricane category and evacuation response assumptions (Miller Consulting, Inc., 2001). The inputs, outputs, and mechanics of the Miller model should be summarized in the CCAM, including documentation of how bottlenecks, low-lying areas, and alternative storm scenarios are accounted for. All assumptions embedded in the Miller model should be explicitly described in an "Assumptions and Uncertainty" subsection.

[5]It may be that these have been accounted for in the Miller model, but since the NRC Committee did not see that documentation we cannot know exactly how.

# 7

# Integrated Water Module

The Integrated Water Module (IWM) is one of the most substantial parts of the Draft CCAM. It consists of stormwater and wastewater components, which 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.

Stormwater runoff is generated based on seasonal average rainfall, which is converted to runoff using coefficients that are a function of land use and thus subject to change in the model. Runoff volumes are, in turn, converted to loads using event mean concentrations (EMCs) for the four constituents as a function of land use, with the option for load reduction by best management practices (BMPs). EMCs and BMP efficiencies are extrapolated from studies elsewhere in Florida, and in some cases, from other states; there are no regional EMC or BMP data for the Florida Keys. A "spreadsheet approach" is used to generate the seasonal loadings from the wastesheds that is consistent with first-order estimates of stormwater routinely used in engineering practice. The stormwater loads are entirely uncalibrated, however. While the loads may be suitable for comparing one management option or land use to another, they should not be used to make inferences about receiving water quality in the absence of any local data for calibration and verification of the load estimates. Time averaging also makes calculated loads inappropriate for making decisions about predicted water quality.

Wastewater loads are generated based on relatively accurate water use data for the Florida Keys. Water demand reflects all users (permanent and transient); hence, wastewater loads as a function of land use also reflect all landside population factors at the time the water use data was collected. Use per equivalent dwelling unit will not necessarily remain constant, however, if the mix of land uses changes over time. This coefficient will need to be recalibrated at regular intervals to be reliable. Possibly significant loadings from small craft discharges directly into receiving waters are not included in the estimates, however, because the contractor had no basis for such estimates. The extent to which these direct discharges impact water quality is thus not included in the Draft CCAM.

Wastewater loads are a function of type of treatment (e.g., septic systems, secondary treatment) and type of disposal into the ground. Only deep well injections (e.g., the 2000-ft injection well at Key West) are not expected to migrate quickly (hours to days) to the near-shore region. The limestone that underlies almost all of the Florida Keys is assumed to provide no reduction of any constituent except TP, for which a 50% reduction is assumed. Wastewater loading estimates also reflect general engineering practice for such an effort, but the estimates are similarly uncalibrated and reflect gross estimates for both the wasteshed and the season. Again, comparisons of management options (e.g., upgrading of treatment facilities) are likely to be useful, but the wastewater loadings should not be used to drive a receiving water model without calibration and verification. Moreover, without some verification of loading estimates, it would be dubious to even compare relative magnitudes of stormwater and wastewater loads, the comparison of which is implied in Tables 4.14 through 4.19 of the Draft CCAM report.

## MAJOR CONCERNS

### Water Quality

In general, the Draft CCAM predicts improved water quality in the form of reduction in stormwater and wastewater loadings given the implementation of the Smart Growth scenario. It is important to emphasize that reduced loadings depend entirely upon the implementation of the *Monroe County Stormwater Management Master Plan* (Monroe County Growth Management Division, 2001a,b) and *Sanitary Wastewater Master Plan* (Monroe County Growth Management Division, 2000). Without the political will to implement and fund the improvements that these plans require (typically over a 20-yr period), the predicted reduced loadings and possible improved receiving water quality associated with the Smart Growth scenario will not occur.

The current version of CCAM does not include several important water quality considerations that impact receiving waters in the Florida Keys. In particular, the model is missing:

- consideration of pathogens, such as coliforms, that may cause beach closings, affect shellfish harvests, and impact human health;
- consideration of water quality in dead-end canals ("finger canals") that are heavily impacted by local runoff from adjacent urbanization and which tend to be poorly flushed in the Florida Keys due to small tidal amplitude; and
- direct loadings to marine waters from illicit waste dumping from small craft, which may increase with population growth (both permanent and transient) in the Florida Keys.

Possible limits to growth based on these factors therefore cannot be assessed by the current version of the CCAM.

## Loadings

The seasonal average loadings generated by the IWM do not allow for event-based analysis or continuous simulation, which might provide extremes and a distribution of concentrations for receiving water analysis. For instance, beach closings due to bacterial contamination are short-lived events; the present version of CCAM could not be used to evaluate such events even if bacteria were included as a parameter. In principle, however, the model could be modified to use given hourly rainfall data with which to generate event-based loadings.

Although no load reductions are assumed for any parameter except TP while traveling through groundwater on the Florida Keys (certainly conservative assumptions), even the assumed 50% TP reduction may be too high over the long term if sorption sites are filled through continuous discharge of septic systems and through shallow wells. More study is needed to determine the long-term phosphorus assimilative capacity of the underlying limestone.

## Coefficients

The entire CCAM contains many sets of coefficients, not all of which may be adjusted by users; those that may be changed are generally identified in Appendix C of the Draft CCAM report. One example from the IWM is the BMP removal efficiencies given in Appendix C—Table 4.5 of the Draft CCAM. These efficiencies were selected based on expert judgment of the contractors and their stormwater experts. Future users of the model may be tempted to take BMP removal efficiencies at their face value and assume that a given BMP "device" may be employed and will provide the indicated reductions regardless of where it is implemented and whether or not it is appropriate for that location. As the Draft CCAM mentions, however, the effectiveness of any stormwater BMP on the Florida Keys is suspect if BMP relies on data from areas with dissimilar geology. In the future then, the IWM should be applied by informed professionals not by those without knowledge of the particular component being examined. This need for good engineering and scientific judgment extends to information taken from other documents, such as the *Monroe County Stormwater Management Master Plan*, which similarly needs to be implemented with advice from appropriate professionals (Monroe County Growth Management Division, 2001a,b).

## MINOR POINTS

Percentiles (10% and 90%) are provided for EMC values in Table 4.4 in Appendix C of the Draft CCAM report. Although these percentiles were apparently not used in the CCAM, there should be some discussion in the report about the significance of these values since they are provided.

Most of the stormwater coefficients and numbers (e.g., EMC values, BMP effectiveness) are taken directly from the *Monroe County Stormwater Management Master Plan* (Monroe County Growth Management Division, 2001a,b). In principle, this document is accessible, but in practice it is not. It would be useful to identify the geographical locations (cities) used to derive EMC values and BMP effectiveness.

Parking lots are a principal source of stormwater runoff and a dominant land use in some sections of the Florida Keys. The revised report should include Table 4.6, "Runoff Coefficients by Land Use category" (Draft CCAM Appendix C) in the main body of the text along with some comments on the significance of these coefficients.

## CONCLUSIONS

In summary, the IWM may reasonably be used to compare seasonal stormwater load estimates for alternative land use and control options. Wastewater loadings can be compared on the same basis. In the absence of any monitoring to confirm the magnitude of these estimates, they should not be used to drive a receiving water module, such as the Marine Module, nor can the two loadings realistically be compared to each other. The remarkable load reduction predicted by the Smart Growth Scenario might well occur, but only if the *Monroe County Stormwater Management Master Plan* (Monroe County Growth Management Division, 2001b) and *Monroe County Sanitary Wastewater Master Plan* (Monroe County Growth Management Division, 2000) are implemented in their entirety and only if maintenance and oversight is provided to ensure that their provisions function properly over time. These caveats should be emphasized in any conclusions regarding water quality drawn from the application of the CCAM.

# 8

# Marine Module

The Marine Module consists of a dispersal model that predicts near-shore concentrations of nutrients, metals, and pollutants. It uses nutrient and pollutant loadings generated by the Integrated Water loads. Components of the model include patterns of circulation, water depth and loading.

From the beginning, the NRC committee hoped that the Marine Module would be the most developed and integrated component of the entire CCAM. This feeling was based, in part, on comments expressed by both URS Corporation, Inc., staff and professional biologists during the 2-day workshop in Key Largo in January 2001. When it received the Draft CCAM in November 2001, the Committee was therefore surprised that the only input to the marine ecosystem came from the Integrated Water Module and that the Smart Growth scenario showed no measurable impact on the marine ecosystem. It is inappropriate to make such an inference using the current version of the Marine Module, as will be explained below.

The contractors examined considerable literature (both peer-reviewed and gray literature) in their search for quantitative data on the impacts of population increases on marine ecosystems. Their presentation at the National Research Council meeting in January 2001 in Key Largo, Florida, was compelling, and the NRC Committee felt at that time that they were well on the way to establishing this relationship for impacts on seagrass, fishes, and coral-reef communities (National Research Council, 2001). As they could not find a direct and appropriate data set in the literature on these impacts relative to population growth, however, URS Corporation, Inc., did not consider other approaches. This is particularly disturbing because significant direct impacts of land use and population growth have occurred in the Florida Keys, as pointed out by both the URS staff in the Terrestrial Module and by professional biologists.

## MAJOR CONCERNS

The lack of data on seagrass loss from propeller scars and on the impact on fish species might still have been overcome if URS Corp. had used the quantitative data on these issues (Sogard et al., 1987; Koenig and Coleman, 1998; Thayer et al., 1999) in an innovative manner. It appears, however, that the contractors did not attempt this approach or the use of other data sets, such as creel surveys in state and national parks to assess fishing effort relative to population increases. This approach is particularly important for day or weekend visitors who are not included in land use pattern estimates.

Historical changes in marine resources were not considered in the Marine Module as they were in the Terrestrial Module. Current resource conditions could be set within a historical framework using historical maps of marine resource distribution and (GIS) technology.

The Marine Module also lacks data on boat pollution loadings, pathogens, and fecal coliforms. In addition, canal water quality was not considered because of the scale of the diffusion model used despite the fact that canal water quality is an important issue for near-shore environments and is a major public concern.

The background levels of metal concentrations in surface seawater are based on out-dated standards that should be revised (Draft CCAM Appendix D). Using the new standards would markedly increase the incremental calculations computed for stormwater and wastewater impacts, but would lower total concentrations below levels of concern. More current values (Pilson, 1998) include Cd = 0.01 μg/L, Cu = 0.25 μg/L, Pb = 0.002 μg/L, and Zn = 0.4 μg/L.[6]

The final CCAM report should provide the user with a more complete view of what was actually considered relative to establishing the relationships needed for input into the Marine Module. The approaches used need to be clearly stated.

Given the lack of inputs into the Marine Module, it is not possible to draw any meaningful conclusions on the impact or lack of impact of current or future development activities (see Overarching Comments). The findings from the Smart Growth scenario reported in the Draft CCAM assume complete fulfillment of all water module and terrestrial management plans outlined in the document. If those actions are not completed, the Smart Growth scenario findings are invalid, since they would be based on assumptions and conditions that are not met. Finally, the URS Corp. should address the important issue of the lag time between development and subsequent measurable impacts on marine resources. In order

[6]Draft CCAM values are Cd = 0.05 μ/L, Cu = 3.0 μg/L, Pb = 0.03 μg/L, and Zn = 5.0 μg/L.

to track ecosystem management, the module needs to consider the length of time needed for specific marine resources to "rebound" from the current conditions.

### Diffusion Model

The diffusion model used as the basis of the Marine Module is based on the solution for a vertical line source (Fischer et al., 1979). As indicated in the Draft CCAM report, the line-source solution requires that the velocity, u, be perpendicular to the shoreline in order to ensure an "infinite" zone for lateral dispersion, (i.e., a zone with no lateral boundaries). On the basis of Figure 4.7 in the Draft CCAM, it appears that this is how the mode is used. It is not clear, however, as to how the GIS layer is interrogated to obtain this velocity. If a non-perpendicular velocity vector is used, the line-source equation cannot be applied as indicated because the vector violates the assumption of an infinite lateral extent. (Image sources are a possible solution to this problem.) By extension and more seriously, there cannot be a solely offshore velocity; a return flow must exist that would bring offshore water back onshore between the plumes (analogous to the onshore flow near a rip tide). The line-source solution method discussed in the Draft CCAM report does not account for such likelihood. Finally, the line-source solution assumes a constant depth, when in fact, the depth increases offshore reducing the velocity, u, and increasing the vertical mixing zone. These effects are not accounted for in the solution methodology.

The appealing simplicity of the line-source solution (in lieu of a complex numerical model) therefore prevents all but questionable applications of the module to areas in which velocities are not entirely offshore or in which depths vary. The type of condition for which the line-source solution is suitable is a steady-state discharge from a source of constant concentration (e.g., the discharge of a waste treatment plant through an ocean outfall into shallow water of constant depth).

Wastewater discharges for the Florida Keys are roughly constant in time but emerge, as the Draft CCAM report points out, from shallow aquifers in a continuous fashion along the shoreline, not as a point source per watershed. The loading is assumed to include stormwater discharges, but in reality these are episodic and likely distributed along the length of the shoreline rather than concentrated at one location per wasteshed. In fact, the current line-source model may well overpredict concentrations by ignoring the distributed nature of the loadings. The time scale for mixing in the near-shore zone between storms may result in a relatively uniform distribution of discharged constituents in that zone, but there is no way of determining such a distribution from the line-source mixing model. A two-dimensional, steady-state model with provisions for exchange with offshore waters might suffice to distribute conservative constituents discharged continuously, on the average. A truer representation of marine water quality awaits development of a transient, 2-D model, perhaps using the GIS system to interpolate and extract needed velocity vectors for an x-y grid in the shallow, near-shore water. The current line-source solution, interrogated at 100-m increments and summed over adjacent "plumes," is inadequate for inferring marine water quality.

In short, the Marine Module is not an adequate tool for generating predictions on marine water quality or other important environmental endpoints given the limitations of its diffusion model. The Draft CCAM Marine Module should not be used to make inferences about marine water quality.

# 9

# Terrestrial Module

The Terrestrial Module is a series of spatially explicit models that measure impacts from changes in land use categories. Impacts are measured as changes in habitat area, direct and indirect effects on an index of species richness, and direct effects on habitat requirements for seven single species. In general, the Terrestrial Module is both simple and straightforward, and can assist in evaluating impacts on terrestrial ecosystems and species and in guiding future land use in the Florida Keys. The apparent simplicity of the models in this module belie the amount of effort that went into their creation, and the contractors at URS Corporation, Inc., are to be congratulated for their efforts.

The brief and effective narrative of the history of habitat fragmentation makes it clear that so much habitat has been lost that the majority of damage from development has already been done to the Florida Keys terrestrial ecosystems and communities. It is not surprising, therefore, that the Smart Growth scenario describes minimal or negligible changes in the module's numerical outputs.

From the outset of their work on this module, the contractors have described their intention to measure impacts using a GIS to depict shifts in land use categories. They have indeed produced a system that maps and measures changes in the space occupied by single species or groups of species (as measured by their species richness outputs) given changes in land use categories. In doing so, the contractors recognize that certain arbitrary assumptions were made regarding shifts in conditions or circumstances. Once these arbitrary assumptions and their limitations are understood and accepted, the module can be seen to meet its intended objectives.

The contractors did an excellent job of summarizing existing ecological and natural history for both ecosystems and specific species in the document prepared as part of Delivery Order #2 for Tasks 3, 4, 6, and 7 (URS Corporation, Inc., 2000). While this information provides useful background material, it is clear that most of it could not be incorporated into model elements for the module given the degree of technical information available.

The module's habitat model is very straightforward, resulting in an easy-to-follow set of outputs: the number and size of habitat patch fragments. This model calculates the number and size of patches after land use changes have occurred and presumes that more and smaller habitat patches indicate increased habitat fragmentation, a worsening of conditions for terrestrial ecosystems and species. The narrative uses an appropriate level of scientific references to fully justify this approach in the Draft CCAM report. Outputs include summary statistics as well as detailed tables of changes in habitat types (e.g., freshwater marsh, mangrove, hammock).

Seventeen species are used to calculate the measures of species richness. Individual species chosen are all well studied, and the bibliography and previous deliverables include extensive references on their habitat requirements. URS Corp has made a strong effort to include species whose habitat requirements cover the complete range of habitat types, including upland hardwood and pine forests, mangrove forests, fresh water communities, and coastal herbaceous communities, including dunes. The existing models were developed by the Florida Fish and Wildlife Conservation Commission, the United States Fish and Wildlife Service, or both, to evaluate habitat use and habitat requirements, and they are sensitive to critical habitat types measured in the module. Important changes in land use in any traditional Florida Keys species' habitat type are incorporated in the model. For many of these models the contractors made an additional effort to reduce grid size to a 30 by 30-ft grid cell system for evaluating changes in land use. Direct impacts due to changes in land use are measured using the change in the sum of the number of species present in every habitat patch based upon the habitat requirement models. The attempt to develop an indirect impact measure for species richness using a Relative Habitat Degradation Index (RHDI) was less successful (see below).

Finally, GIS overlay analysis is used to evaluate the direct effects on the published habitat requirements of seven single species: the Lower Keys marsh rabbit, the white-crowned pigeon, and five forest interior bird species. Habitat requirement models for the rabbit and pigeon incorporated multiple factors, while those for the five forest interior birds were based solely on the minimum hammock patch size requirements given in published studies. The model presumes that a species is extirpated from a patch when size and/or conditions are reduced below the minimum standard as set in the existing models for that the species. Effects of land use changes are thus measured using change in the number of patches and total acres of habitat available for each species.

Much of the potential criticism of this module could focus on the lack of dynamic measurements of processes, the lack of connections between land use and other types of human population impacts, the use of a constant decay coefficient for indirect impacts for each land use type, and the lack of temporal modifiers, such as lag times. The amount of background material that the contractors reviewed in Delivery Order # 2 (URS Corporation, Inc., 2000) and in the Draft CCAM report might suggest that the development of much more sophisticated models may have been possible. It is easy to see that attempts to add such process-oriented functions and/ or temporal conditions to the models would have resulted in even more assumptions and complications. URS Corp's approach may not have resulted in the most sophisticated models possible, but the results produced are easy to comprehend. The recommended correction of the RHDI will allow this module to remain straightforward while allowing it to provide a better measure of the impacts of development on species remaining in habitat fragments.

## MAJOR CONCERNS

### Limitations and Assumptions

The overarching criticism of this module must be its lack of clarity with regard to the limitations and arbitrary assumptions used in the component models. Explicitly stating and discussing these limitations and assumptions in the CCAM narrative can readily solve most of these problems.

### Status of Vacant Land

The contractors produced a clear and effective database for the GIS analyses based upon the Florida Marine Research Institute's Advanced Identification of Wetlands (ADID) map, along with historical aerial photographs and ground-truthing at random points (URS Corporation, Inc., 2001c). The remote mapping approach, however, is not able to detect variation in the quality of natural habitat in large contiguous patches or remaining habitat on portions of developed lots. Exotic pest plant invasion, feral cat populations, trash, and other human related impacts have degraded some of this habitat. A major concern is that the mere switch in land use classification from "vacant land with buildable lots" to "open space purchased by a conservation organization" does not automatically make this land good habitat regardless of the ADID cover code. If this 'open space' habitat is not really very good, as measured using some independent method other than the ADID label, then the results may be misleading or unrealistic. The problem with the actual status of vacant lots cannot be addressed without an updated inventory of the status of natural habitat lands and "vacant land with buildable lots" and developing a classification system for the relative costs and lag times (or recovery times) required for restoration. Since such additional data collection is outside of the scope of work of the project, it seems most reasonable to simply recommend that the narrative section identify this uncertainty as one of the module's limitations.

## Sea Level Rise (SLR)

The use of a historical approach to establish the magnitude and distribution of change in terrestrial habitat is valuable in recognizing the extent of the human manipulation of the cover within the span of a few centuries. It is important, however, to recognize that the natural system is undergoing changes during this same time period and that human alteration of the landscape will occur with natural system dynamics to limit recovery of some of the island habitats in the growth scenarios. An important variable in all coastal environments is rising sea level. Data from the Key West tide gauge on a web-site maintained by the National Oceanic and Atmospheric Administration (NOAA) indicate that the rate of SLR is 2.3 mm/yr for the past 90 years. According to Wanless et al. (1994), this rate is about six times the mean rate of rise during the past 3200 years and is causing a breakdown in the coastal habitats created during an earlier slow rate of rise. Furthermore, the rate of SLR is expected to increase in the twenty-first century (National Research Council, 1987; Titus and Narayanan, 1995) with continuing modification of shoreline habitats, and increased exposure to hurricane surge and inundation throughout the Keys.

Hardening of the shoreline by bulkheads, walls, and roadbeds, and the emplacement of landfill at the water's edge in the Keys is placing an artificial barrier on the migration of near-shore habitats of mangrove and marshland and will therefore limit space for recovery of these lowland resources (Wanless et al., 1994; Titus, 1998). The result is that the landscape cannot revert to a pre-disturbed condition when it is converted to public land because the topography has been altered.

The historical perspective of the change in the terrestrial habitat is appropriate in the Florida Keys to portray the scale of manipulations. It is likewise appropriate to portray the scale of the change in sea level as an element in the planning for revisions of land use and habitat restoration. If relationships between sea level rise and shifts in habitat status and quality cannot be accomplished based upon the data available, then the module should emphasize the above limitations in a narrative section.

## Fiscal Consequences of Scenarios as Outputs

In both the Terrestrial and the Fiscal Modules, the implications of the assumptions about shifts in land use categories to "conservation lands" must be made clear. The amounts of money that would be required to purchase, restore, and manage all of the vacant land presumed to be "100% restored" in a scenario need to be made explicitly clear in the narrative, and should be listed as explicit outputs in the Draft CCAM's Fiscal Module.

### Decay Coefficients for Habitat Degradation

In an effort to extend the species richness model and make it sensitive to the indirect impacts of various adjacent land use practices, the contractors included a modifier called the Relative Habitat Degradation Index (RHDI). The contractors thoroughly reviewed the scientific literature and mentioned in brief the complexities and diversity of opinions regarding the nature and distances from natural habitat at which various types of human activities would impact wildlife (URS Corporation, Inc., 2000; Table 3.16 of Draft CCAM). They could not, however, find a method for incorporating all that information into a single set of decay coefficients for land use categories.

In the Draft CCAM, a set of constant decay coefficients for land use categories was taken from studies in which impacts were measured as changes in emergy in landscape development (the contractors cite a number of reports by Brown *et al.*). While the work on emergy is both detailed and scientifically valid, there are serious problems with its use in this model for the purpose of evaluating habitat degradation for a suite of 17 species. The contractors listed no refereed, published reports on the use of this measure, in this particular fashion, and the validity of using emergy to measure the effects of adjacent land uses and human activities such as noise pollution, house cats, and automobiles on wildlife is currently unknown. The decay coefficients chosen resulted in impacts dissipating at very short distances (e.g., 90% decay at 35.5 feet for low density residential and 211 feet for a 4-lane highway). These short distances are at odds with the many distances quoted in the extensive literature review used in the Draft CCAM narrative.

As it stands now, the RHDI does not realistically track the distances most types of impacts are actually thought to travel. Alternative decay coefficients based upon recognized midrange or modal distance values for major types of impacts such as microclimate, noise pollution and/or habitat buffer zones might be considered. The contractors are currently trying to find an alternative set of decay coefficients. If they cannot, the Committee recommends deleting the indirect impact model for species richness from the Draft CCAM. Removing this measure will not severely alter the use of the species richness measure, since the difference between direct and indirect impacts noted in the model runs for scenarios is a constant (Draft CCAM Tables 4.20–4.21).

### Habitat Degradation Index and Human Population

The use of constant decay coefficients for the measurement of the RHDI is inappropriate for at least some of the land use types, including recreational/open space, commercial and two and four lane highways. These land use types could be expected to have increasing indirect impacts on adjacent conservation lands due to increases in the functional human population that are not captured in a static decay coefficient. The Committee does not feel that the current method of measuring functional human population in relation to land use categories does an effective job of capturing the increasing numbers of day-trippers and their impact on and near recreational lands. Since recreational lands are frequently in or adjacent to "conservation lands," such an impact is important. Again in this case, it would be better to delete the use of the RHDI and the indirect impacts element of the model.

## Habitat Requirements of Single Species

Results of model runs for the Lower Keys marsh rabbit and the white-crowned pigeon clearly identify losses in additional habitat from changes in land use categories, even in the Smart Growth scenario. The contractors were recalculating the results for the forest interior birds in the Draft CCAM at the time of this review due to inconsistencies between the text and Table 4.22 of the Draft CCAM. It is expected, however, that these simple GIS overlay analyses of habitat requirements should also show clear, if small, effects in the Smart Growth scenario run as well.

## Florida Key Deer

This species was excluded from the module's single species element because a detailed habitat conservation plan for future land development and management now exists for the Florida Key deer. One of the 17 species included in the species richness model, the deer's habitat requirements were taken into consideration to some extent. Carrying capacity discussions revealed, however, that the species' popularity and prominence meant that its inclusion as a single species had been expected and would improve the model's appeal. Including the Key deer into the CCAM's final single species element should be a simple task.

## Species-Area Habitat and Thresholds

The species-area habitat equation, along with its threshold values, is vaguely referenced in Appendix C of the Draft CCAM (Draft CCAM Section 6.0) as being calculated based upon equations 167 and 169. It is presumed that this equation was deleted from the text purposefully, in which case the equation and threshold should also be deleted from the appendix. If not, some significant explanatory text for the equation must be added to the main text of the Final CCAM report. As mentioned in other parts of this review, color-coded thresholds should either be completely deleted from the CCAM or should be able to be user-defined.

# 10

# Conclusions

URS Corp. has been generally responsive to the concerns raised in the NRC Committee's interim report (National Research Council, 2001), and the CCAM has been brought to a state of development beyond that anticipated at the time the interim report was submitted. The Committee greatly appreciates the contractor's responses to its many questions, both written and oral, during the preparation of this final review. The ambitious vision that stimulated the development of the CCAM and the effort made by the contractor to fulfill that vision remain impressive.

At its present state of development, the six CCAM modules and the Scenario Generator have reached very different levels of development and consist of assumptions, formulations, and coefficients of widely varying credibility. As noted in Section 2 of this report, virtually all of the components suffer from several common fundamental problems and, as detailed in Sections 3–9 of this report, each module has a unique set of strengths and weaknesses. Given the many concerns described in this report, the Committee does not believe that the current version of the CCAM is ready to be used "as an impact assessment tool to support regional land use policy decisions" or to provide "an effective framework to determine whether scenarios fall within the carrying capacity of the Florida Keys, determined by a set of ecological, socioeconomic, and human infrastructure thresholds and criteria." (URS Corporation, Inc., 2001a).

On a more positive note, several of the modules can be used in their current state, or with a modest level of additional effort, as tools to help assess a limited set of environmental, socioeconomic, fiscal, and infrastructure impacts of land use change in the Florida Keys. Even in those cases, however, it should be emphasized that the outcomes calculated by the Draft CCAM modules must be considered carefully and evaluated in the context of observational data, experience, and professional judgement.

The reliability and utility of the individual modules have been assessed as follows:

**Scenario Generator**—While the lack of a good description of current conditions in the Florida Keys hinders the development and evaluation of scenarios, the NRC Committee has no major technical criticisms of the Scenario Generator of the CCAM. It appears to be appropriate and flexible. The GUI should be modified to allow users to set coefficients and thresholds for individual modules, and the model threshold output should be modified to generate continuous color-density gradients rather than three-color thresholds.

**Socioeconomic and Quality of Life Modules**—As currently constructed, these modules are seriously compromised and should not be used without the extensive modifications described in Section 4 of this review. Using current data to calculate the Affordable Housing Index (AHI) means that it cannot be used as an impact assessment variable to analyze different scenarios. In order to be useful, the AHI must change as scenario conditions change. Furthermore, the Competitive Commerce Index (CCI) has no clear meaning or significance. These two measures—the only socioeconomic/quality of life indicators calculated—fail to provide a comprehensive or accurate representation of the quality of life or socioeconomic well-being of people in the Florida Keys. The Committee was surprised to see that tourism has not been adequately considered in the model, thus ensuring that a large part of the Florida Keys economy is poorly represented at best.

**Fiscal Module**—This module is straightforward and credible. A few modifications and additions have been suggested, but this component of the CCAM seems ready for use with little additional effort.

**Human Infrastructure Module**—This module has two interrelated yet uncoupled components: level of service on U.S. Route 1 and hurricane evacuation clearance time. The first component is currently useful and needs only minor improvements in documentation. The hurricane evacuation component, however, has serious flaws. The model makes the unrealistic assumption of a linear relationship between total population within the Florida Keys and evacuation times. As a result, it fails to account for spatial differences in growth and the interaction of these differences with bottlenecks along U.S. Route 1. This component of the CCAM should not be used unless the time and resources are available to incorporate the existing evacuation clearance model prepared by Miller Consulting into the CCAM. If that model is added, all of its methods, assumptions, and uncertainties should be fully documented in the CCAM report.

**Integrated Water Module—**This module has three components, one dealing with stormwater runoff, one with wastewater, and the last with potable water supply and sewage. Taken as a whole, the Integrated Water Module is one of the most substantial parts of the CCAM. It will be useful as a first order tool after only minor revisions and additions, and may prove helpful to address certain questions dealing with water issues. The lack of calibration and the time averaging of runoff make the module unsuitable for drawing inferences about the impact of runoff or sewage on receiving water quality, an important limitation.

**Marine Module—**It is most unfortunate that a component of the Florida Keys environment that generates much public concern and constitutes the major tourist attraction of Monroe County is represented by the weakest component of the CCAM. The contractor appears to have made a serious effort to create a useful Marine Module, but was unable to develop convincing quantitative relationships between land use, population, and environmental conditions in near-shore waters. Such relationships could be developed in some cases, but it seems extremely unlikely that they will be discovered and included as part of the current effort. Moreover, the Integrated Water Module's treatment of nutrients and metals delivered to the coast is so crude that in this regard, the Committee believes the model is more misleading than it is helpful. The Committee recommends that this module not be used at all unless it undergoes drastic revision. The near-shore environment of the Florida Keys will have to be the subject of a more focused effort with more support and time at some point in the future.

**Terrestrial Module—**In contrast to the Marine Module's handling of the marine environment, issues of terrestrial habitat and species richness appear to be reasonably well addressed by the Terrestrial Module. Section 9 of this report identified several important technical concerns that will require only a modest effort to make this component useful for relating land use changes to wildlife habitat in the Florida Keys.

## SUMMARY

In summary, the Marine Module should not be used in its current form, nor should the Socioeconomic Module and hurricane evacuation component of the Human Infrastructure Module without thorough revision. The remaining modules need relatively modest technical adjustments and corrections before they can play a helpful, if limited, role in estimating some of the impacts of various land use scenarios in the Florida Keys.

This assessment will disappoint many of those who had hoped for a powerful new tool that would provide credible predictions of the environmental and social consequences of human decisions and actions. These conclusions must also come as a disappointment to those who took on what was, in truth, an impossible task and gave it their best effort. It is important to measure their 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.

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# Appendices

# Appendix A

# Committee Member Biographies

**Scott W. Nixon,** ***Chair***
**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 ecosystems. 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 has previously served on three NRC committees and is currently serving as the vice-chair of the Committee on the Restoration of the Greater Everglades Ecosystem. Dr. Nixon received a B.A. in biology from the University of Delaware and a Ph.D. in botany/ecology from the University of North Carolina, Chapel Hill.

**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 B.A. 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 B.A. 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 of the Department of Environmental Engineering Sciences 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. He is currently a member of the NRC's Committee on the Restoration of the Greater Everglades Ecosystem.

**Mark S. Peterson**
**University of Southern Mississippi**

Mark S. Peterson is an associate 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. Peterson 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, including shoreline erosion, coastal dune processes, and estuarine 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 D. Rivkin is a senior fellow in the School of Public Affairs at the University of Maryland and executive director of the Smart Growth Alliance, a consortium of business, environmental, and civic groups in the Washington, D.C., region. Previously he was a principal of the Bethesda, Maryland-based Rivkin Associates and served as a commissioner of the Maryland National Capital Parks and Planning Commission. His expertise is in smart growth issues and urban planning. At Rivkin Associates, he helped develop county-wide comprehensive plans in the Mid-Atlantic states and incentives for alternative transportation supported by major employers and local government, and specialized in resolving environment/development conflicts. Much of Rivkin's previous work has been overseas, including serving as resident adviser to Turkey's Ministry of Reconstruction. Dr. Rivkin received his A.B. (Bachelor of Arts) 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**
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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 previously served on two NRC committees and was a founding member of the Water Science and Technology Board. He received a B.S. in natural sciences and a Ph.D. in environmental engineering from The Johns Hopkins University.

# Appendix B

# Interim Review of the Florida Keys Carrying Capacity Study

# Interim Review of the Florida Keys Carrying Capacity Study

National Research Council
Division on Earth and Life Studies
Ocean Studies Board & Water Science and Technology Board
Committee to Review the Florida Keys Carrying Capacity Study

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

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# THE NATIONAL ACADEMIES

National Academy of Sciences
National Academy of Engineering
Institute of Medicine
National Research Council

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. William A. Wulf is president of the National Academy of Engineering.

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The work of this committee was overseen by the Ocean Studies Board and the Water Science and Technology Board of the National Research Council.

## COMMITTEE TO REVIEW THE FLORIDA KEYS CARRYING CAPACITY STUDY

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# Acknowledgments

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report: John Adams (University of Minnesota), David Godschalk (University of North Carolina), Lance Gunderson (Emory University), Steven McCutcheon (U.S. Environmental Protection Agency), James Porter (University of Georgia), and Kathleen Segerson (University of Connecticut).

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by Dr. Robert Frosch (Harvard University). Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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# Summary

This brief interim report provides initial feedback from a committee of experts asked to review the Florida Keys Carrying Capacity Study (the Keys Study). The committee first reviewed the Scope of Work for the Keys Study (United States Army Corps of Engineers, 1998) and then attended a two-day public workshop in January 2001 during which the study team explained their goals and their progress to date. Based on this brief preliminary review, the committee concludes that it is feasible to create a semi-quantitative tool (referred to in the Keys Study as the "Carrying Capacity Analysis Model" or [CCAM] for assessing the broad impacts of alternative future development scenarios on important biological, environmental, social, and economic factors. To ensure that the final product of the Keys Study is useful and scientifically credible, the report provides several suggestions for CCAM designers at this time:

- Place a greater emphasis on definition of concepts and agreement on desired outcomes
- Ensure a higher level of coordination between the different modules that make up the CCAM
- Make better use of the expert advisors who have been involved in the process and could offer valuable ongoing feedback
- Set clear priorities, overall and within each module, to ensure that the most important elements are addressed first.

More detailed suggestions for completing the individual modules are also included. This report will be followed by a more thorough examination of the Draft CCAM once it is completed later this year.

# 1

# Introduction

## PURPOSE OF THIS REPORT

For years policy makers at local and state levels have been working to achieve a balance between economic development, quality of life, and environmental protection in the Florida Keys. After a lengthy process of public debate and legal proceedings, Florida Administration Commission Rule 28.20.100 was issued in 1996, requiring the preparation of a "carrying capacity analysis . . . designed to determine the ability of the Florida Keys ecosystem, and the various segments thereof, to withstand all impacts of additional land development activities." That ruling led to the initiation of the Florida Keys Carrying Capacity Study and its companion Carrying Capacity Analysis Model, which are sponsored by the U.S. Army Corps of Engineers (the Corps) and the Florida Department of Community Affairs and are being carried out by the contractor URS (formerly Dames and Moore). The Corps and the Florida Department of Community Affairs, in turn, requested that the National Academy of Sciences/National Research Council establish a committee to provide an authoritative, independent technical review of this ambitious effort.

The charge to this committee was as follows:

> "[R]eview and evaluate the scientific methods, principles, and data that form the basis for the Florida Keys Carrying Capacity Study and the accompanying Carrying Capacity Analysis Model being developed by the State of Florida. The committee will assess the ability of the Keys Study to fulfill its stated goal of 'determining the ability of the Florida Keys ecosystem to withstand all

impacts of additional land development activities,' and the extent to which the conclusions were reached based on a sound scientific process.

Specifically the committee will review and comment on the following:

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

The Keys Study is moving forward on a strict and very rapid schedule. Pending its outcome, strict limits have been placed on further development in the Keys through a rate-of-growth ordinance. These limits and a strong public desire to move beyond the impasse toward a long-term solution provide strong motivations to move forward as quickly as possible without sacrificing the credibility of the end product.

To provide rapid feedback to the project managers the National Research Council agreed to provide this interim report. The report is based largely on presentations made by the contractor at a two-day workshop held in Key Largo, Florida, January 9–10, 2001 (referred to in this report as the January workshop), where the contractor described progress to date in designing the CCAM. The committee will prepare a second, more detailed report when the contractor presents a complete working version of the CCAM, scheduled for June 2001.

The Keys Study is an innovative endeavor, and the committee is unanimous in its appreciation of the ambitious vision it represents. The committee members are also very aware that our understanding of the details of the study is limited by our recent and relatively brief exposure to it. The committee also remains mindful that the study is a work in progress. Although various enhancements and mid-course corrections may already have been made by the time this report is received, the committee nevertheless believes that an independent assessment of progress to date will remain useful to the project's sponsors and program managers. In some cases the observations and recommendations in this report echo those made publicly by participants at the January workshop. In all cases the comments contained in this report reflect a consensus of this committee, based on intensive discussions throughout the workshop and the following day and in subsequent correspondence.

## KEYS STUDY PHILOSOPHY, TERMINOLOGY, AND OBJECTIVES

Before addressing the specifics of project management and the technical content of the CCAM, it is worth examining the Keys Study's broader philosophy and objectives. Although the following discussion focuses on the use of particular terms (such as "carrying capacity," "thresholds," and "model"), the committee believes that the inconsistent use of these terms reflects underlying conceptual challenges in the Keys Study, and the conflicting perspectives and needs of different end-users.

The term "carrying capacity" is not easy to define. The glossary in the scope of work for the Keys Study defines "carrying capacity" as "maximum population impacts an area can sustain over time with a given level of technology and societal preferences." This definition is rooted in the concepts of regional planning (Godschalk, Parker, and Knoche, 1974) and implies that there are defined thresholds given certain assumptions. Under this view, carrying capacity is limited by a set of maximum impacts that can be tolerated—a question involving human preferences about the quality of the environment and nature of communities. These impacts can also be modified if suitable technologies exist and are purchased. Such an approach will be most useful to the Florida Department of Community Affairs and other planning entities that have been directed by Florida Executive Order 96-108 to "adhere to and implement the findings of a carrying capacity analysis as it relates to and affects the rate of growth and permit allocation in Monroe County."

The scope of work also clearly states that "[t]he carrying capacity analysis shall consider aesthetic, socio-economic (including sustainable tourism), quality of life and community character issues, including the concentration of population, the amount of open space, diversity of habitats, and species richness." These factors are important for residents and local leaders who care deeply about the impacts of alternative land development scenarios on the local economy, community character, and the environment.

On the other hand, the scope of work elsewhere explains that "[a] broad approach was chosen where elements of human society would be included as explicit variables in the modeling *yet the value of protecting non-human species and the ecological system would establish the fundamental basis of the study*" [emphasis added] and that the Keys Study will "determine the level of land development . . . that can be supported by a healthy, balanced, functioning ecosystem in the Florida Keys." These goals reflect an attempt to apply the theoretical notion of *ecological* carrying capacity to assess relative environmental impacts.

Unfortunately there simply are no objective scientific criteria for determining "a healthy, balanced, functioning ecosystem . . ." Natural systems rarely exhibit quantifiable "thresholds" for species success and ecosystem functioning. In other words, there are no clear limits that separate healthy and non-healthy conditions. Whereas the habitat requirements for a few threatened and endangered species are reasonably well known, this is not the case for most components of the Keys ecosystem. Most evidence suggests that plants and animals respond to change in extremely complex ways, sometimes gradually and reversibly, sometimes with sudden non-linearities. For similar reasons, the terms "indicator species" and "keystone species" do not have clear meanings, as discussed in Section 6 of this report.

Furthermore, both ecosystems and human communities are dynamic systems. The ability of an ecosystem to sustain viable populations shifts over time, in response to natural and human factors that vary over the short term (e.g., annual and decadal disturbances and cycles) and the long term (e.g., climate change). Community preferences also shift over time, as do technological alternatives for mitigating the impacts of human development. Thus, the notion of carrying capacity as the basis for determining limits for development depends on value judgments made by stakeholders about the desired state of the natural and built environments and will always be a moving target that must be regularly reassessed.

The use of the word "model" is itself problematic. Although the concept of a carrying capacity analysis model for the Florida Keys human and natural ecosystems is appealing, the construction of a precise mechanistic model that simulates all human and natural systems and their interactions, as suggested by the scope of work, is simply not possible within the current limits of funding, time, and basic knowledge. More realistic is the more modest goal of producing a useful planning tool that can be combined with other public policy efforts to help "determine the level of land development activities that will avoid (or at least minimize) further irreversible and/or adverse impacts to the Florida Keys ecosystem." De-emphasizing the goal of creating a full numerical simulation model will also make it easier to incorporate less tangible, but critical, factors that affect the quality of life.

As a first step, the Keys Study should downplay the concept of producing a precise numerical "model" and focus instead on the production of a semi-quantitative "impact assessment tool" that can be used to help illustrate the consequences of various development scenarios on the environmental and social systems in the Keys. In keeping with this view, this report refers to the CCAM as an assessment tool, offering suggestions as to how the tool can be refined and focused in keeping with available knowledge and resources. The actual terminology to be used in the draft CCAM should be carefully considered by the design team.

Although the Keys Study must, of course, stay within the intent and spirit of the legal order that set it in motion, the sponsors and contractor will ultimately have to decide and agree on what can be meaningfully achieved. The contractor, the Corps, the Florida Department of Community Affairs, Monroe county managers, and other interested parties should acknowledge the existence of conceptual ambiguities and differing user needs, and continue to discuss realistic expectations for the Keys Study's products, particularly the CCAM. Continued use of inconsistent definitions or reliance on an unrealistic picture of nature will make it difficult to achieve a common understanding of the goals for this vast and complex undertaking.

# 2

# Project Structure and Management

The committee finds that it was wise, and even necessary, to divide the CCAM into more manageable subsections or modules. The time constraints alone require such a breakdown, but the range of required technical expertise is also too great for any single team to cover. The companion to this decentralized approach is a need for detailed planning and frequent communication between the module teams. This kind of coordination appears to be missing. As a result, there were duplicated efforts (e.g., in water modeling), gaps in coverage (e.g., inadequate coverage of mangrove areas), and a serious lack of clarity about what inputs each module needed from the others and what outputs each was expected to provide. Seeing this kind of disconnect almost halfway through the life of the project is cause for concern and calls for immediate changes in project structure if a functional product is to be delivered by the June deadline. The various module-specific teams should be brought together as soon as possible to hammer out a roadmap detailing the needed inputs to and outputs from each module and precisely describing the connections and feedback between them. Frequent and regular contact (at least monthly and possibly weekly) should then be maintained to compare notes, discuss unforeseen difficulties, and amend the roadmap as needed. High-level planning and inter-module coordination should receive attention and resources from the study sponsors and the contractor on a par with the investment being made in each module. If it does not already exist, an appropriate task should be created under the Corps contract to cover coordination efforts.

The committee was impressed by the caliber and dedication of the large group of experts who attended the initial planning sessions and participated in the January workshop. These individuals represent an invaluable resource that has not been used as thoroughly and effectively as it might have been. Although frequent large workshops may be impractical, an efficient and highly cost-effective approach might be for each module team to meet and/or hold conference calls regularly with small (2–4 person), subject-specific advisory groups who could offer technical input, criticism, and encouragement along the way. Of course, all experts will not agree on every issue; however, the broad discomfort expressed with basic aspects of the CCAM modules during the January workshop was surprising and reflected a lack of ongoing communication between the contractors and the expert advisors.

Due in part to the factors mentioned above, the rate of progress on the CCAM has been slower than will be needed to meet the ambitious timeline. The committee was not presented with a comprehensive picture of the level and distribution of resources for the project, so it is not possible to comment on this aspect. Some workshop participants suggested that the "task order" contractual arrangement between the contractor and the Corps may create a drag on progress by emphasizing sequential rather than parallel tasks. If this is the case, a serious effort should be made to initiate multiple, overlapping tasks, including some open-ended tasks that address overall coordination and long-range project planning. Whatever the solution, the pace will have to increase considerably, or the goals will have to be scaled down, if the project is to be completed in a satisfactory manner by the completion date. Alternatively, the Keys Study sponsors might consider amending the timeline.

# 3

# Development of the Assessment Tool

## GENERAL COMMENTS

In addition to defining the inputs, outputs, and linkages between the individual modules (as discussed in the previous section) project managers should also immediately address: (1) the nature of the external inputs to the CCAM, from data sources or as specified in future scenarios; (2) the mechanisms and thresholds used in each module; and (3) the final outputs generated for the users. External data sources are discussed in greater detail in Section 6, and inputs from future scenarios in Section 5. The nature and acceptable format of all these inputs should be specified from the start and included in the coordination process called for in Section 2. The inner workings of each module are also discussed in Section 4. This section focuses on the final outputs from the assessment tool and on the determination of practical "thresholds." As discussed in Section 1, clear, objective biological and social thresholds of viability rarely exist. Stakeholders, users, and technical experts should be consulted to help define thresholds and outputs that meet the project's dual objectives for comprehensive planning and environmental impact assessment.

## SPECIFICATION OF OUTPUTS

It is clear that the CCAM development team recognizes the importance of creating an assessment tool that addresses the diverse concerns of many stakeholders. The team has expended substantial energy consulting with the intended CCAM users, including Monroe county, its municipalities, and the concerned public, through extensive interviews and public meetings. Although these efforts helped generate a list of topics of concern (included in the contractor's User Needs Assessment Report, URS Corporation, 2000), participants in the January workshop were not shown a comprehensive, prioritized list of environmental and socio-economic variables for which assessments will be conducted and final outputs provided. The design of the entire CCAM should be *driven* by the environmental and socio-economic impacts of greatest concern to stakeholders, users, and technical experts, recognizing the need to prioritize in light of time and money constraints.

A limited set of appropriate outputs should be selected as needed for the likely applications of the assessment tool, including periodic reviews of comprehensive plans, proposed changes in land development regulations, assessments of specific large-scale changes in land use, permitting, enforcement, and adaptive management (see Section 5). Evaluation criteria should then be defined for the variables of greatest concern. Due to resource constraints, not every useful or desirable output can be included. Difficult choices must be made by the design team, with input from expert advisors and stakeholders. (The emphasis on using a geographic information system base throughout the CCAM will facilitate the output process and is one excellent feature of the current plan.) It is urgent that output specifications be defined promptly to ensure that each module and the overall project is properly designed to meet user needs. The results of this exercise should also be fed directly into the module coordination process discussed in Section 2 to ensure that each module design team knows what it is responsible for producing.

## CREATING A FUNCTIONAL DEFINITION OF CARRYING CAPACITY THRESHOLDS

As discussed in Section 1, the current design of the CCAM may not achieve the objectives of all end-users. In particular, the Florida Department of Community Affairs and Monroe county planners must be able to determine the extent of additional development that can be supported by the ecological and human support systems of the Keys. The CCAM currently generates impact evaluations but does not explicitly determine whether carrying capacity thresholds will be exceeded under alternative land development scenarios.

Although it is not feasible to accurately define ecological thresholds for all species and ecosystems in the Keys (due to limitations in data and understanding or the inherent complexity of nature), it is still possible to meet the needs of potential users. To do so, however, will require a shift in how the CCAM is conceptualized.

As described at the January workshop, outputs from the CCAM assessment tool will consist of an array of environmental and socio-economic parameters, the values of which are presented on simplified ordinal impact scales, such as high, medium, and low or red, yellow, and green. The module designers would assign these values based on their best professional judgment. This vision will not provide state agencies or local planners with clear answers about when critical thresholds have been exceeded, as required by Administration Commission Rule 28.20.100 and Executive Order 96-108. This approach will also produce an insensitive assessment tool, offering users little information about the relative impacts of alternative land development scenarios.

This committee suggests consideration of an alternative approach to designing the CCAM, in which users and experts agree on thresholds for specific evaluation criteria (similar to the process suggested in NRC, 1995). These consensus thresholds can then be used to exclude land development scenarios from further consideration if they pose significant threats to environmental or community integrity. At least three kinds of critical thresholds might exist:

1. externally mandated thresholds, such as federal water-quality standards, state hurricane evacuation clearance times, or legal requirements of the federal Endangered Species Act;
2. thresholds for environmental parameters, which if exceeded would pose a significant threat to the long-term survival of individual species or biological communities in the Keys ecosystems, based on the best professional judgment of technical experts;
3. thresholds for selected socio-economic measures, which if exceeded would significantly degrade the quality of life in the Keys, based on a consensus of representative residents.

These thresholds could then be used, not to define the maximum human population that could be sustained but to assess how specific changes in land development affect the survival of species or biological communities, compliance with regulatory standards, and quality of life measures. Any development scenario (whether based on changes to comprehensive plans, land development regulations, or specific permits) whose impacts would exceed one of the thresholds would be judged as likely to exceed the human and/or biological carrying capacity of the Keys. An alternative that does not exceed *any* of the exclusionary criteria can be further evaluated to minimize harmful impacts and maximize positive impacts based on a broader range of user-defined evaluation criteria included in the assessment tool.

Under this approach CCAM outputs could use one color (e.g., red) to quickly indicate values that exceed a critical threshold. For some simple, well-defined parameters, such as coliform levels in recreational waters, a simple green/red, or okay/not okay scale may be sufficient, if not very informative. Most parameters, however, would be better presented on some kind of ordinal scale with many levels, depending on the range of variation of the parameter and the levels at which significant biological or quality-of-life impacts might occur. The scales would need to be developed with the advice of technical experts and users.

# 4

# Technical Content of the Assessment Tool

## CROSS-CUTTING ISSUES

Each of the technical modules that comprise the CCAM is discussed in detail later in this section. In assembling these comments it became clear that similar issues were raised for many of the modules. By first understanding and addressing these cross-cutting issues, progress can be made in many areas.

**i. Inputs and outputs**—Immediate and clear decisions should be made about exactly what inputs and outputs are needed for each module and for the CCAM as a whole. This problem was discussed in greater detail in Section 2, but it bears repeating.

**ii. Setting priorities**—Creation of an all-encompassing assessment tool such as the CCAM would be a challenging undertaking under any circumstances: The existing severe limitations on time and money make it an even greater challenge. Each module should, before proceeding any further, have clear priorities for what processes and subsystems will be included and at what level of detail. These should be driven by the desired outputs from the entire assessment tool. Technical experts (including the module designers, the outside experts, and this committee!) appreciate all the complexities of the human and natural systems being explored and are reluctant to oversimplify. For the purposes of the CCAM, however, it will be necessary to focus on a subset of primary, driving mechanisms and ensure that these are accurately modeled.

**iii. Data quality**—CCAM designers should be selective about the data sets used. Once decisions are made about essential inputs and outputs, and then about which mechanisms and processes will be included, it should be easier to determine which data sets are most critical. Appropriate quality assurance/quality control (QA/QC) should be performed for every data set used in module calculations. The contractor should ensure that all data used are reviewed for reasonableness and their authenticity and range documented to the best degree possible.

**iv. Definition of terms**—In Section 1, this report discussed the ambiguities inherent in such terms as "carrying capacity" and "thresholds." In the modules, similar difficulties occur with the use of terms such as "keystone species" and "indicator species." Project designers should clearly define, or avoid, potentially ambiguous concepts. The expert advisors might be helpful in this task.

**v. Use of expert opinion—**As discussed in Section 2, for many important endpoints (such as the minimum habitat required to sustain a given species), quantitative measures have not been or cannot be defined. In these cases it will be necessary to rely on the consensus of an appropriate group of experts or relevant stakeholders. This kind of consensus judgement is preferable to an unreliable, inexact, or otherwise inappropriate "objective" measure.

**vi. Spatial and temporal scales**—Consideration of the spatial and temporal scales in and between modules is critical. Time- and space-averaged quantities will not always reveal critical information. For example, the nearly instantaneous effect of a heavy rainfall event on water quality and public bathing in the halo zone may be a significant output. Conversely, the slow rate of sea-level rise should be examined as an output of the dynamic nature of coastline habitats that will undergo spatial shifts along the edges of the Keys, especially the lower-lying middle Keys. Spatially, the near-shore distribution of propeller scars, boat groundings, and marina impacts may be of most importance because of the greater likelihood of thresholds being achieved, although there are certainly many human impacts farther offshore.

**vii. Uncertainty and variability**—Every data set and numerical output that is part of the CCAM should include some measure of its variability. Variability can often be indicated by customary measures such as standard deviations, coefficients of variation, quantiles (e.g., 10 percent and 90 percent values), ranges, or frequency histograms. This kind of statistical variability is just one source of uncertainty in the output. Other sources of uncertainty include lack of complete understanding of the systems being modeled, modeling simplifications, scale issues (e.g., application of data collected at a small scale to a much large study area), non-linearities that affect scaling, changes that occur between the time of original measurements and the time of application, and incorporation of unquantifiable factors such as public attitudes. End-users should be clearly informed about the different levels of uncertainty in the outputs—even when these values cannot be easily quantified—and be advised of the implications of these uncertainties for assessing alternative policies, regulations, or actions. Sensitivity analyses should be performed on all outputs when the draft CCAM is complete. These analyses will provide guidance about which input variables most influence the ultimate outputs and therefore warrant the greatest effort in ensuring their reliability. At the same time, sensitivity analyses will aid in selecting the critical processes to be included in the modules.

**viii. Future updates**—Section 6 discusses the benefits that could be realized by maintaining and updating the CCAM over the coming years. Although this decision will probably not be made until later, a small effort now can make a huge difference in facilitating later updates. Each module should identify key data sets and other factors that are likely to change over time and processes that are likely to become better understood. Documentation should then include specific recommendations and instructions aimed at future maintenance and improvement.

The suggestions above are of high priority and apply to all the modules. They are not repeated in the analysis of each module that follows, although specific examples are pointed out in some sections. The following sections are intended primarily for those directly involved in module development. Thus these comments include more terminology and a greater level of detail than previous sections.

## SOCIO-ECONOMIC/LAND USE/ HUMAN INFRASTRUCTURE MODULE

This module plays three critical roles in the CCAM.

1. It is the interface through which alternative plan amendments, land development regulations, and other scenarios are input into the assessment tool.
2. It must produce appropriate outputs, such as land use changes and population projections, to be used as inputs to the other modules in evaluating impacts on natural systems.
3. It must provide a range of important performance-measure outputs of its own.

All of these functions will need to be accomplished successfully if the overall carrying capacity study is to be successful. The module, as described and presented by the project team, is not now sufficiently developed to accomplish these crucial tasks.

As with all the modules, many uncertainties remain concerning inputs and outputs. In addition, this module has not yet developed a detailed approach for delivering useful socio-economic, quality-of-life, community character performance measures and other important issues. The project team also needs to establish a more realistic portrait of where future development is likely to occur and what patterns that development may take. As it stands, the module has a narrow focus on development that excludes redevelopment potential and the influence of land development regulations. This module will need to provide information about what development or redevelopment activities occur and where these activities occur, at a scale and in a format consistent with the approaches taken by the terrestrial, marine, and water modules.

The current plan to provide output as acres of development in general categories (as population and dwellings for 29 area units) does not appear consistent with the input needs of the other modules. For example, fragmentation of habitat, which depends on the location and not just the total acreage of development, is important to the terrestrial ecosystems and species module. In determining wastewater volume and contaminants it is important to know the types of development that occur—fish processing plants versus shopping centers, for example—rather than aggregate categories. It is also important to account for land development regulations that govern the quantity and quality of stormwater generated, such as limits on total impervious surface or design and performance standards for stormwater detention, retention, or treatment.

The socio-economics, land use, and human infrastructure module must be able to link population growth estimates (both in number, type, and location) to resultant plausible land use scenarios in order to produce GIS-based maps of appropriate quantities, both for use as final outputs and as input to the other modules. It is highly unlikely that population and economic growth will be concentrated on undeveloped, privately owned, upland sites. With 70 percent of the Keys' land already in public ownership, and most of the residual private property developed in some fashion, pristine available sites are apparently quite limited despite an inventory of unbuilt platted lots. This is especially true in considering demand for non-residential space (i.e., commercial, service, or hotel). Construction of non-residential facilities has been greatly constrained, perhaps even more so than for residential units, during the Rate of Growth Ordinance period. Instead, the main focus of future development, whether limited by growth restrictions or simply in response to market demands, is likely to be on currently developed sites already disturbed beyond their pristine state.

Some existing sites may be candidates for redevelopment, in other words, the replacement of old or obsolete structures by new uses at contemporary standards of construction. Other sites may be underutilized, that is, occupied by commercial or residential structures built well below current zoning potential, to which new uses at higher densities will be attracted. Given the physical configuration of the Keys and the evolution of development there over more than 150 years, such conclusions appear inevitable. The very fact that Route 1 is the only major road and its adjacent lands form the only corridor providing easy accessibility for commercial and other non-residential uses (including public facilities such as schools and libraries) drives these conclusions. The module design team should identify sites that are the most realistic *re*development targets and then design several redevelopment scenarios to assess the impacts of build-out to maximum allowable densities and intensities on the human and natural environments.

To do so this module will need to accept input parameters that reflect potential amendments to land development regulations or changes to comprehensive plans and future land use maps. These sorts of changes will alter the impacts of development and redevelopment on such output measures as environmental quality, socio-economic conditions, and quality of life. Based on the January workshop presentations, it appears that the study team is treating potential development as an "on/off" switch. The team seemed to include only new growth (i.e., new dwelling units, square feet of retail, acres of commercial) and the extent to which it "disturbs" land, thereby presenting an overly simplistic view of ecosystem impacts and effectively ignoring socio-economic and quality-of-life impacts.

Different comprehensive plan policies and land development regulations can produce very different levels and kinds of disturbance. For example, a clustered, zero-lot-line project, with stormwater source controls and substantial open space, may be more environmentally benign than a subdivision on conventional quarter acre lots with engineered stormwater retention or detention systems. Developments with the same numbers of dwelling units can have significantly different occupancy rates and can attract substantially different types of residents whose impacts on the natural environment and on public facilities and infrastructure may also be significantly different. Thus the module should be able to account for an array of land development regulation alternatives and the variable impacts that result.

The project team should consider the use of a regional economics model capable of providing information on different sectors of the economy. The current aggregate approach overlooks differences in environmental and human impacts that arise from different types of economic activity. Looking in more detail at various sectors will allow the project team a more accurate picture of the types of development pressure likely to face Monroe county and the likely environmental impacts that may result. The use of a more detailed regional economics model also allows projection of employment and income patterns, important economic performance measures in their own right. Given the time and budget constraints, the team should adopt an existing regional economic model, supplied with Monroe county data and adapted to fit local conditions.

Tourism is the principal economic activity in Monroe county and should be an integral part of the CCAM. According to the U.S. Census's *County Business Patterns* (1998), more than 55 percent of the employment in the county was in two tourism-oriented sectors: (1) accommodations and food service and (2) retail. It is appropriate that projections of future tourist levels are being included in estimates of functional population, but this is not enough: Land use, facility character, water access requirements, and traffic impacts of tourism should also be examined. Tourism experts should be enlisted to assist in estimating the effects of alternative land development scenarios on the number and type of tourists likely to be attracted to Monroe county. Attention should also be given to identifying affordable housing options for tourism industry support staff. Based on the geography of the Keys, long-distance commuting or labor shortages are not viable options in this sector.

The existing market analysis framework assumes that housing demand is fixed and exogenous, instead of modeling the demand as a function of housing prices. Housing prices are determined by considerations of supply and demand, with prices rising and falling to equate supply and demand. Ignoring price effects in the housing market is a serious deficiency. Monroe county currently has the highest median house price of any county in Florida. Because of continuing pressure on the housing market and concerns over affordable housing, projections of land and housing prices should be an important performance measure. In the context of the Keys, where physical and regulatory constraints largely limit the supply of developable land, changes in demand essentially translate into changes in price.

One essential Keys Study goal is to assess the impacts of alternative land development scenarios on the local economy and community. To date, factors other than fiscal impact analysis, land use, and population projections have been largely ignored, although the carrying capacity study was charged with considering socio-economic, quality-of-life, and community character issues. The range of expertise on the project team (including the expert advisors) should be expanded to include individuals conversant with aesthetic, socio-economic, quality-of-life, and community character issues and those knowledgeable about relevant design and performance standards that may be incorporated in future land development regulations.

## WATER AND WASTEWATER MODULE

The original scope of work required the Keys Study to "describe site specific interactions between geology, surface water, coastal water, land use, nutrients, pollutants, runoff, erosion, and vessels." This is a tall order, and central to achieving it will be understanding the nature of water flows throughout the Keys. In the general area of water systems modeling, the CCAM identifies three primary subareas: stormwater, wastewater, and receiving water. These are further subdivided in the contractor's water-modeling flow chart, but it is these three subareas that are the focus of the discussion that follows. The stormwater submodule is farthest along toward completion, followed by the wastewater submodule. Tracking water-quality constituents from their generation on land to their fate in near-shore receiving waters is a very complicated process. In particular, the receiving-water modeling effort has the potential for massive complexity and this element remained purely conceptual at the time of the January workshop. Given the pressing time constraints, the contractor should make every effort to identify essential components that cannot be omitted or simplified and focus resources on those components. Establishment of clear aquatic ecological indicators and the performance of sensitivity analyses on important parameters and forcing functions will help guide the effort.

The following comments are to a significant degree based as much on what is planned as on what has been accomplished to date. In addition to participating in the January workshop, the committee has drawn some inferences based on verbal evaluations of the water module made by the expert advisors who attended the January workshop.

## General Comments

Overall, the committee finds that the stormwater modeling effort is on track. The contractor is using a simplified runoff prediction method based on daily rainfall records and runoff coefficients (a "spreadsheet" approach). This approach can be justified by the lack of a need for surface flow routing (which would require shorter time step computations) and the current goal of evaluating only those receiving-water-quality indicators that respond over a long time period. However, the committee notes that hourly or even 15-minute runoff estimates (consistent with available rainfall data) could be performed by the same spreadsheet method if necessary and could be helpful in analyzing certain kinds of scenarios.

The linkage between this module and land-use descriptions is consistent with the need for data on imperviousness and other parameters that influence runoff. Use of event mean concentrations is a reasonable way to develop water-quality loads (WEF and ASCE, 1998; NRC, 2000). The committee understands that event mean concentration data are not currently available for the Keys, but the contractor should investigate the transferability of urban data for South Florida, especially for impervious surfaces. The limerock and sand stratigraphy of the Keys make it harder to evaluate the impact of some stormwater best management practices, since studies elsewhere reflect the mitigating effects of greater depths and different types of soil. (The level of uncertainty introduced with any such extrapolation should also be assessed.)

Wastewater loadings can reasonably be based on documented effluent quality of the treatment devices currently in use in the Keys (NRC, 2000), including cesspools, septic tanks, aerobic septic systems, on-site wastewater nutrient reduction systems, and wastewater treatment plants, as proposed by the contractor, with attention to the quality and variability of the different data sets. Although gaps exist, a good effort has been made at defining the extent of each type of disposal system in the Keys and at assessing long-term plans for upgrading inferior systems. Nevertheless, the quality of the effluent that reaches the coast following seepage from residential systems or discharge from shallow (60–90 ft) boreholes for small wastewater treatment plants is unknown. The ultimate fate of wastewater injected into shallow or deep wells is also unknown. If long-term solutions for the disposal of treated wastewater focus on injection wells, it will be important to know whether upward migration of the effluent plumes will occur. Finally, wastewater loadings should account for the transient nature of population in the Keys, including the relatively recent appearance of large cruise ships in Key West. Initial estimates should be made of wastewater loadings caused by the influx of persons from such ships to determine whether these will be significant and to determine the impact of such short-term loading peaks on the performance of the Key West wastewater treatment plant.

### Detailed Comments

1. It is unclear what final parameters will be generated to evaluate the Florida Keys carrying capacity based on aquatic water quality. The focus area seems to be the halo zone, 50-100 m of salt water adjacent to the islands' beaches (defined at the January workshop as water approximately 1 m deep or less). Specific aquatic end points mentioned were seagrass coverage in the halo zone, the extent and location of benthic communities, coral reef status, the species associated with the previous three communities, and water clarity, perhaps including water clarity in finger canals.

The method for evaluating receiving-water quality in the halo zone is still under development. The outline as presented at the workshop was to drive a steady-state receiving-water-quality model using residual near-shore currents based on the Corps' Florida Bay model or some alternative Florida Keys circulation model yet to be defined. Steady-state modeling was justified by the response of seagrass—assumed to be the primary aquatic endpoint—which occurs over a period of many months, making short-term variations in loadings and currents unimportant. This assumption may be correct for seagrass, but concerns remain regarding the necessary timescales. Some questions include the following:

- To evaluate seagrass growth, what water-quality parameters are needed, both in the receiving water and from stormwater and wastewater runoff estimates? If dissolved inorganic nitrogen is to be used in a receiving-water-quality model, can the necessary loadings be provided to drive the model? The contractors should consider the successful seagrass modeling performed in Tampa Bay.
- What parameters are required to estimate water clarity?
- Can receiving-water quality be estimated solely on the basis of long-term loadings, allowing for use of a steady-state model, or is there also a need for short-term modeling for bacteria, pathogens, or biological oxygen demand (BOD)? For instance, water-quality standards for coliform bacteria exist for Class III marine waters. These standards might serve as appropriate performance measures in the CCAM (§62-302.503 Florida Administrative Code). Other standards for Class III marine waters, such

as those for biological integrity, dissolved oxygen, BOD, pH, transparency, and turbidity should also be considered possible performance measures and may be appropriate inputs to the marine ecosystem module. It may be appropriate to incorporate the prohibitions that result from designation of most of the waters surrounding the Keys as outstanding Florida waters (§62-4, Florida Administrative Code).

- Is the water quality in finger canals an important CCAM output? If so, a different level of receiving-water model will be needed.
- Although the health of coral reefs was identified as an issue of concern in the scope of work, the modeling of reef response to anthropogenic forcing functions is very complex. Will it be possible to do this quantitatively within current project constraints? If not, how will this endpoint be evaluated?
- What are the implications for the Keys of possible long-term changes in the water quality of Florida Bay, and will the CCAM be able to incorporate such changes?

Consideration of these questions is important to guide further development of this module and allocate resources wisely. Appropriate land-side loadings and temporal and spatial definitions will need to be resolved quickly to meet the needs of receiving-water modeling. Far-field forcing functions (such as regional current models) should also be better linked to the near-shore modeling efforts.

2. The water systems experts must know what water-quality parameters (such as receiving-water concentrations) will be needed to evaluate the status of various important aquatic species.

3. There is an urgent need to provide quality assurance/quality control on the data used in the water modules. For example, in the wastewater module the effluent quality predictions for BOD, Total Suspended Solids, Total Nitrogen, and Total Phosphorous presented by the contractor were probably overly optimistic, based on the immediate feedback from the experts.

4. Related to the issue of quality assurance/quality control are those of variability and uncertainty. The contractor should continue to seek out the best available data sources for items such as stormwater event mean concentrations or wastewater treatment performance measures. The use of these data, however, must be qualified by their inherent variability. Variability can be assessed by using several sources of stormwater quality data in South Florida and variations over time at individual sites. A realistic range of effluent quality should also be employed for evaluation of wastewater discharges.

5. Because the water calculations are driven by weather, the nature of the long-term weather patterns input to the CCAM will strongly influence the water-quality endpoints. For instance, a wet year generally provides higher loadings than a dry year. With this in mind, the basis of the weather scenarios should be clarified. Use of a number of representative conditions (e.g., dry, average, or wet

for stormwater modeling and calm, average, or windy for circulation modeling) is one option for evaluating the impact of climatic variations. Continuous hydrological modeling (i.e., a rainfall and meteorological time series lasting over a period of years) is another, more complex option that could be used to ensure realistic variability. However it is achieved, the water module should incorporate variations in climatic conditions and should quantify these variations and their impacts on module outputs.

## TERRESTRIAL ECOSYSTEMS AND SPECIES MODULE

This module, like most, was in a very early stage of development at the time of the workshop. The module designers were unable to answer many questions, because they had not yet considered all the important issues. The largest efforts so far seem to have been made in reducing the list of species to be considered in evaluating the impacts of development. As of January 2001 the list had been reduced from an initial 128 to 17 and was reduced further over the course of the workshop. The species chosen include federally listed endangered species (both threatened and endangered), a rare-plant community complex, a suite of fruit-producing species (incorrectly described as keystone species), some species that are dependent on fire and pineland, and several species that are good indicators of hardwood hammock habitat.

This module cannot and was perhaps not intended to function as an ecological population dynamics model that might typically be used to quantify biological carrying capacity. The module was also not intended to be a dynamic habitat or ecosystem function model. Instead, it provides a very simplified measure of future habitat losses and fragmentation. The processes, database, and methods described at the January workshop will produce an assessment tool that provides a basic illustration of probable degrees of impact from future development.

Other modules may require maps of upland and wetland habitat distribution. Such maps are the basis for all impact evaluations planned for this module, however it is not clear that up-to-date and professionally agreed coverage maps for these habitats currently exist. It also appeared that the actual geographic distributions for some of the species being examined are in dispute (e.g., the lower Keys marsh rabbit). For some species (e.g., the white-crowned pigeon) information for the lower Florida Keys will be needed in addition to the information being relied upon for the upper Keys. Such information will have to be obtained and integrated immediately if these species are to be included.

To date, no habitat- or ecosystem-level outputs based on physical factors or processes have been developed. The design team agreed that any additional losses of hammock or pineland would be unacceptable for many of the chosen indicator species or groups (e.g., Schaus's butterfly, wooly croton, rare plants, tree snails, wood rat, Key deer, tree cactus, forest birds). The team stopped short of concluding that mapping additional habitat fragmentation or loss of acreage in pinelands or hammocks would in itself serve as an effective output to identify development impacts. This is a simple and obvious addition to this module's outputs, but it requires input from the socio-economic module that is spatially explicit about where land use changes will occur.

As mentioned above with respect to pinelands and hammocks, the contractor expressed an intention to look more closely at habitats or ecosystems, but no specific proposal was presented for review. Of particular concern at this time is the lack of any clear plan for reviewing the distribution, status, or impacts of development on wetlands. Some indirect evaluation would be derived from looking at single species that depend on freshwater wetlands, such as the mud turtle. Some level of wetland response may also be derived from the assessment of red mangrove impacts. However, no habitat level assessment of tidal wetlands is currently included in the module. Wetlands compose nearly 60 percent of the study area and have a history of direct and secondary cumulative adverse impacts from development. The wetlands areas deserve a much higher profile and level of evaluation than allocated to date. Different parts of this evaluation may involve the water, terrestrial, and marine modules. Some level of gradient analysis of water quality in tidal wetlands should be included as an output from the CCAM.

In the case of the Key deer the opinions of the module design team appear to be at odds with accepted scientific information and opinion. For example, workshop participants were told that the information necessary to conduct a population viability analysis was not available for any of the team's chosen species, however a thorough population viability analysis was performed for the Key deer in 1990 (Seal et al., 1990). The module design team should take advantage of the extensive information available on this well-studied endangered species. The outside expert advisors could be very helpful with this task. Doing a top-notch job with this high-visibility species would add a good deal of credibility to the overall effort.

The module-design team had previously agreed upon using geographic, spatially explicit mapping of habitat loss and fragmentation as the means for evaluating various development scenarios. To date, the impact analyses have been made by selecting specific habitat patch sizes below which a given species will no longer inhabit that patch. The outputs produced are summary statistical tables and color-coded maps indicating the number of patches from which a species is eliminated due to a particular development scenario. The scenarios tested to date simulate losses of habitat caused by additional upland development. The rules that determine minimum patch sizes needed are generally well thought out, easy to understand, and easy to measure, however these rules have not been fully developed or accepted by a consensus of experts. Additional consultation and review will be needed to ensure the credibility of the outputs. It is essential, as noted above, that the output from the socio-economic and land use module provide spatially explicit data about where land use change will occur.

Beyond the basic rule on patch size described above there is some concern that within-patch variability has been ignored. All patches of a given size are not the same from a species point of view. Consideration of inter-patch variability for such features as time since last fire, presence of specific host species, or sources of drinking water could significantly and easily improve the module output. By including information on conditions immediately surrounding each patch (e.g., type of development, availability of drinking water, prevailing wind direction) the outputs can be made more detailed with relatively little effort.

## MARINE ECOSYSTEMS AND SPECIES MODULE

This module was also in a very preliminary stage of development at the January workshop. The contractor presented some interesting concepts, such as the approach to assessing the impacts of boat scarring on seagrass beds, but many elements of the module were still undeveloped. As discussed in Section 2, lack of sufficient coordination between modules has been a major barrier to progress. For example, the marine and water modules will need to reach an immediate decision about the modeling of Florida Bay waters and their impacts on Keys water quality. Much of the effort to date in the marine module has been spent on gathering useable data sets, anticipating the data that may be generated by other modules, and exploring other potentially available data.

Three main metrics were identified for marine ecosystems: seagrass cover, water clarity, and contaminant loads. Because the data are relatively sparse and the diversity of marine fauna is high, the module design team decided to focus on a process-oriented approach rather than a species-specific approach as used in the terrestrial module.

Although seagrasses play a central role in determining the overall health of the marine ecosystem under the proposed approach, the maps of species-specific seagrass distribution were not well developed. Because all seagrasses are not the same (in terms of growth patterns, nutrient requirements, recovery time after prop scarring), further work will be necessary to map the distribution of seagrasses around the Keys.

Up until now almost no effort has been made to understand either the impacts of fishing on marine ecosystems or the impacts on fish populations of other activities. There was some reference to gathering data on the increase in marinas and boats, but it was unclear how such data would be used. If such information is desired, it should be produced as an output from the socio-economic and land use module. With little time remaining, many important issues remain to be investigated: collisions with manatees, fishing pressure per boat, size of boats (which relates probably non-linearly to the number of fishers per boat), and reef damage due to recreational diving, boat anchors, and removal of upper level predators. These constitute real impacts to the health of the Florida Keys.

Because the marine module design team's approach so far is spatially explicit and does not consider temporal aspects, the assessment tool will be able to provide only a basic visualization of relative degrees of impact and fragmentation from future development, and only for a limited marine community. For example, the current approach would produce a tool that could not examine the impacts of such short-term events as sediment pulses from storms on communities of concern at some vital time in organism or community development. It would also be unable to assess synergistic or cumulative issues. Furthermore, the spatial arrangement of impacts (mangroves to seagrass to inshore patch reefs to offshore reefs) should be examined, given the juxtaposition of these important habitat types in space and the documented connections between these important habitats and proper nursery function throughout the Keys (e.g., for snappers, grunts, and groupers).

Finally, the marine module does not currently look at species on the Federal Endangered Species List or the Official Lists of Florida's Endangered Species and Species of Special Concern, such as the manatee, crocodile, mangrove rivulus, and numerous marine turtles. It also does not consider important intertidal marine habitats, like mangroves. The inclusion of these federal- and state-protected species in this module is vital and will provide important performance measures for the carrying-capacity analyses.

# 5

# Applications of the Assessment Tool

## BASIC REQUIREMENTS

If properly designed, implemented, and maintained, the CCAM assessment tool could be extremely useful for a number of applications. Foremost, the tool is intended to help evaluate proposed comprehensive plan amendments as well as the regulations designed to implement those plans. This is evident from the list of future scenarios developed for testing, some of which are described in terms of land use patterns (as for a comprehensive plan) and some of which are described in terms of regulatory policy (e.g., no more than 10 permits per year in Islamorada). Although the project team described how to input and thus assess a particular snapshot of land use, the committee saw no obvious input mechanism for evaluating regulatory policies.

To serve its main purpose, the CCAM must be capable of accepting inputs either as an end-of-period land use picture or as a set of regulatory policies designed to achieve such land uses. In other words, it must accommodate spatially explicit build-out scenarios based on future land use plans, zoning regulations, and other land development regulations that govern density and intensity of land use. From these scenario characteristics the CCAM should generate the parameters needed as inputs to the ecosystem, water-quality, and socio-economic and land use modules. The CCAM should be capable of assigning new development and redevelopment to specific land parcels to generate spatially explicit outputs that represent development impacts.

## ADDITIONAL OPPORTUNITIES

The assessment tool could have several very valuable additional applications. Although there will probably not be enough time to develop all of these applications immediately, it will be helpful to keep them in mind during the design phase in order to facilitate their addition at a later date. To ensure that actual development on the ground is consistent with amended comprehensive plans or land development regulations, the CCAM should be able to serve two additional functions: evaluation of permit applications and adaptive management. Once the comprehensive plans are amended and supporting regulations developed based on the results of the Keys Study, the permit limitations and conditions implied by those regulations can be incorporated into the assessment tool. The CCAM could then automate many of the labor-intensive functions required for evaluation of permits, resulting in reduced administrative costs and more consistent evaluations. This is an extension of the role currently envisioned for the routine planning tool, a still undeveloped component of the CCAM that, as described, would only make the underlying *data* in the CCAM available for use in the evaluation of permits.

To implement adaptive management it is important to know whether local comprehensive plans and their implementing regulations are having the desired effect over time. Because of the unpredictable influence of natural variables, it is necessary to use models to assess the extent to which actual impacts are consistent with original expectations. If the CCAM databases are updated to include newly permitted development, then the predicted impacts can be compared to the results of actual monitoring. Assuming that the original CCAM went through a rigorous validation process, deviations between predicted and observed conditions could uncover ongoing violations of environmental permits or indicate that regulations are not achieving what was intended. In either case the CCAM could be revised as appropriate and then used to develop improved adaptive-management actions.

## SCENARIO DEVELOPMENT

Scenario testing serves several functions in the CCAM, and as many tests as possible should be run. Such testing will provide sensitivity analyses and help to identify errors by uncovering anomalous results. In consultation with the expert advisors, a battery of test scenarios should be designed for the sole purpose of exploring the performance and limitations of the assessment tool.

Of course, scenario testing is also at the heart of the goal of the Keys Study. By examining a range of possible futures for population growth, economic and land development, and environmental management in the Keys, planners can make meaningful, well-informed choices about the future. The alternatives currently being considered (as listed in the Project Strategy Outline, Dames & Moore, 2000a) are described in very different ways. Although some are described in terms of land use patterns, others depict potential land development regulations designed to manage future development. It is not at all clear how the CCAM will handle such scenarios as input, nor is it clear how land development regulations will be converted into the kinds of spatially explicit inputs that will be needed by the other modules to determine the impacts of alternative scenarios. As mentioned above, efforts will be required either to develop an input format for such regulations or to craft reasonable protocols for automatically or manually converting such scenarios into spatially explicit data suitable for analysis.

Evaluation of one or more hurricane disaster scenarios can provide useful information to state and local land use planners about the relative vulnerability of different future development patterns (Deyle et al., 1998). It is much more difficult, however, to develop hurricane impact scenarios for biological communities that will provide useful information for the evaluation of planning and land use alternatives. While a comprehensive evaluation of the full range of possible hurricane scenarios is not possible under current time and budget constraints, it may be feasible to assess one or more scenarios that simulate the likely damage to the built environment from a Category 3 or Category 4 hurricane. Local disaster mitigation policies and programs can help lessen the impacts of hurricanes of this magnitude, while catastrophic storms (Category 5) generally are viewed as "acts of God" beyond feasible mitigation (Godschalk, Brower, and Beatley, 1989). Such a vulnerability assessment should be possible using existing land use and property data available from county and municipal agencies in the Keys and the TAOS software available from the Florida Department of Community Affairs. TAOS can be used to estimate damage from storm surge, wave height, maximum sustained surface winds, and inland flooding (Watson, 1995; Florida Department of Community Affairs, 1998). It also may be worthwhile to explore the effect of sea-level rise on storm surge levels 25 and 50 years into the future to assess the altered vulnerability of the built environment.

# 6

# Follow-up for the Assessment Tool

Given the significant investment being made in this innovative tool it would be a shame to use it only in the next round of comprehensive plan amendments. However, any future use of the CCAM, including the additional applications described above, will be possible only if the CCAM is maintained. Although the study team indicated that discussions about the CCAM's future have been initiated, and the scope of work refers to development of a fiscal and administrative framework for this purpose, this issue should be given substantially more attention, now, during the design phase. Suitable provisions should be made in each module to ensure that future updates, revisions, or enhancements are possible. Changes will certainly occur in the development patterns and overall economy of the Keys. Changes may also occur in nature (such as sea-level change), in local culture, or in our fundamental understanding of human and ecological systems.

The ultimate creation of a continuing implementation mechanism will depend on future decisions by the Florida Department of Community Affairs, the Army Corps of Engineers, and Monroe County and is clearly beyond the scope of the current contract. Nevertheless, one relatively simple task under this contract should be to provide a blueprint for such implementation while the contractor and subcontractors are still familiar with the inner workings of the CCAM. The blueprint should include at least the following elements:

1. Suggestions for plausible organizational mechanisms for maintaining and updating the assessment tool (for example, within a state or county government agency or a university);

2. A description of the number and kinds of staff required;
3. An estimate of the initial and subsequent annual budgets required, along with any special logistical and equipment needs.

Based on considerable experience with comparable large projects, the committee recommends that design of a detailed implementation program be one output of the present effort.

# 7

# Conclusion

The Florida Keys Carrying Capacity Study is an ambitious effort, and this committee fully appreciates the technical and policy challenges facing the study team and sponsors. The challenge of creating a comprehensive, flexible, and reliable assessment tool is compounded by a highly charged political atmosphere surrounding land development and environmental issues in the Keys. The study team is to be commended for its efforts to date and the many areas where progress has been made in the Carrying Capacity Analysis Model and the overall study.

The committee notes that this brief interim report is based primarily on presentations made during a two-day workshop that attempted to describe a major activity still in progress. The committee appreciates the cooperation and explanations offered by the study team and recognizes that its exposure to the assessment tool has been limited. The comments and advice provided are offered in a spirit of constructive criticism with the understanding that many changes and improvements to the assessment tool may already have been made since the workshop.

The major concerns raised by the committee at this time, along with some suggested remedies, are summarized below. Many more detailed observations and recommendations are contained throughout the text of the report.

The concept of creating an assessment tool to guide the development and environmental future of the Florida Keys is intriguing; however, the goal established for this study, "to develop a model capable of determining the ability of the Keys ecosystem to withstand all impacts of additional land development activities," contains ambiguities and imprecision that must be addressed. Some expectations for the Keys Study exceed current scientific understanding and modeling capabilities. Much of the terminology employed in the scope of work is also unclear. For example, the term "carrying capacity" is not easy to define or measure. Nevertheless, the term could be incorporated into the planning tool if its usage and the ways it is to be measured are defined carefully and clearly.

Although many of the goals set and words used were not chosen by the study team members, nevertheless, they should quickly develop a clear and consistent terminology for the study and work to educate all interested parties about the inherent limitations of this ambitious effort. By reviewing some of the published literature on ecological and social system modeling and obtaining more regular input from the expert advisors, the study team can help explain how the final product can best be used by land use planners, other decision makers, and the public in the Florida Keys.

Despite these limitations, the study team's efforts in data collection and process modeling should still be very useful. Rather than creating a fully predictive numerical simulation model the study team should aim to create an "impact assessment tool" that can be used to help visualize the consequences of various land development scenarios on the Keys' environmental and social systems. Such a tool could be used in analyzing future development scenarios and could be a powerful aid in helping decision makers understand how the Keys might change under a variety of development scenarios.

The study team should also place an immediate, strong emphasis on specifying the procedures by which the sub-modules will interact. A high level "roadmap" should be constructed, showing every input to and output from each module. In addressing this task it will be best to start at the end, obtaining agreement from key stakeholders about what the final CCAM outputs will be, and how they will be presented. The next step should be to determine the nature of the CCAM scenario inputs. Knowing more about the initial inputs and ultimate outputs will guide much of the module development. Finally, whenever one module produces an output to be used as input to another module, a clear understanding must be reached between the module teams about the space and time scales, level of precision, and units required. Seamless coordination between modules represents one of the greatest challenges to the study team, but not enough resources and time have yet been devoted to this effort.

Although the "big picture" design should be a top priority, the CCAM will only provide meaningful results if each module translates inputs to outputs in a reasonable way, based on an understanding of the parameters and processes involved. To do this to the limits of current knowledge would far exceed the time and money available. Thus, difficult choices will have to be made about which elements to include in each module and at what level of detail. Greater reliance on the expert advisors should be helpful in making these choices.

This committee has been asked by the Keys Study sponsors to provide a second, more detailed review after the draft CCAM is completed in June 2001. For that review to be successful the committee will require relevant CCAM documentation, including a clear summary document, before it begins deliberations. In particular, the committee will need to consider such materials as the following:

1. documents that precisely describe the inputs to and outputs from each module, provide clear explanations of the process for getting from inputs to outputs in each module, and include other relevant information about the inner workings of the CCAM;
2. documentation of the data used in each module, including their sources, dates, and quality assurance/quality control procedures and results;
3. explanations of the uncertainties associated with each output from each module and results of sensitivity testing, as discussed in Section 4 of this report;
4. results of any scenario tests conducted, describing the input parameters, the data transfers between modules, and the module outputs, both numerically and graphically.

Due to the preliminary nature of this interim report, and the rapid turnaround required by the sponsors, the committee's full evaluation of the final CCAM product may differ in many respects from the statements made here. Nevertheless, the committee hopes that this report will help the CCAM design team achieve a better end-product.

The committee looks forward to continued interactions with the study team and to playing a useful role in evaluating this innovative tool for land use planning and public policy formulation in the Florida Keys.

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# APPENDIX A

## Supporting Documents

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*Note: Appendix B of the Interim Report is not reprinted here, because the information is the same as Appendix A of the Review of the Florida Keys Carrying Capacity Study Final Report.*

# Appendix C

# Glossary of Terms and Acronym List

## GLOSSARY

**Affordable Housing Index (AHI):** An index number that relates the cost of housing to the average income for a community or planning unit. The value of the number expresses the ability of the average population to afford housing in the community.

**Available Land:** The amount of land remaining available for a land use change or action in a scenario generation after all applicable constraints have been applied.

**Benefit-Cost Measure:** A ratio comparing the monetary returns or other benefits of a project or action to the costs of implementation. A value greater than one indicates that the benefits are greater than the associated costs.

**Calibration:** the process of altering a model's input parameters in a systematic and reasonable way in order to produce model output that optimally agrees with corresponding measurements.

**Carrying Capacity:** The amount of use an area, resource, facility or system can sustain without deterioration in quality.

**Carrying Capacity Analysis Model (CCAM):** A GIS-based model developed to determine the ability of the Florida Keys ecosystem to withstand all impacts of additional land development activities.

**Coefficient:** A numerical value within a formula or computation that expresses a relationship and is applied in a mathematical function.

**Competitive Commerce Index (CCI):** An index number comparing the required commercial revenue to disposable income of a community or planning unit, used to estimate whether there is sufficient income to support commercial activities.

**Cost of Services:** The cost for a governmental unit to develop infrastructure and other services to the local community.

**Creel Survey:** A survey that estimates the amount of angling activity and the harvest of different kinds of fishes in number and weights.

**Developable Land:** Land available for development, that is not constricted or precluded due to physical factors, regulatory restrictions, or public ownership, etc.

**Emergy:** The solar energy needed to produce a certain resource, good, or service. It is the basis for establishing the real value of a product or service of nature and humanity.

**End Point:** A point marking the completion of a process or stage of a process.

**Evacuation Capacity:** In this study, this refers to the ability of the highway system (i.e., U.S. Route 1) to allow people to leave the Florida Keys in a given period of time when hurricane warnings are issued.

**Exotic Species**: A species introduced into a community that is not normally a constituent of that community - non-native species.

**Expert Judgment:** A qualified opinion made by a person or persons who are recognized as experts in the specific field of expertise and who are sufficiently familiar with local conditions and the relevant scientific literature to reduce the level of uncertainty.

**Field:** A term used to define the portion of a database that contains all the data entries for a specified item or parameter, such as all “Land Use Type” entries; analogous to a column in a data table.

**Gross Floor Area:** The total commercial or industrial floor area (in square feet) for a facility or area.

**Groundwater:** The volume of water naturally occurring under the land surface.

**Habitat Conversion:** The change of natural habitat to different land uses through the process of clearing for residential, agricultural, or other land uses.

**Habitat Fragmentation:** The dividing of contiguous or whole habitat units, such as forest stands, into smaller units by the conversion of some parts of the habitat to other land uses.

**Historic Baseline:** The set of conditions in the Florida Keys defining the natural ecosystem, prior to settlement by European colonists.

**Housing Unit**: A house, an apartment, a mobile home or trailer, a group of rooms, or a single room occupied as separate living quarters or, if vacant, intended for occupancy as separate living quarters.

**Hurricane Evacuation:** The movement of all permanent residents and visitors from the Florida Keys to a safe location on the mainland in anticipation of an approaching hurricane. In this study, this refers to evacuation along the road system.

**Impact Assessment Tool:** A procedure, method, or model (such as CCAM) that can be used to aid in the prediction or measurements of impacts from specific causes.

**Impact Assessment Variables (IAV):** Environmental and socio-economic variables for which assessments will be conducted and final outputs provided. These are generally outputs from each of the module components.

**Independent Population Projection:** An estimate that has been developed in response to documented demographic and economic trends and conditions instead of a future physical development scenario.

**Indicator Species:** A plant or animal species for which the responses to a particular stimulus are well documented and typical of other species responses in an area that can be used as a measure or indicator of the extent of effects on an ecological community or group of species.

**Indirect Impact (Loss):** An impact that occurs as the result of an action, but which is not immediately caused by the action. An example would be loss of habitat to build a road needed for a new development. The loss of habitat would be a direct impact of the road, but an indirect impact of new development.

**Infrastructure:** The basic facilities and equipment necessary for the effective functioning of a town, such as the means of providing water service, sewage disposal, electric and gas connections, and street networks. For the CCAM, adequate data is currently available only for water service and sewage.

**Input:** Data that are entered into the CCAM.

**Land Use:** A description and classification of how land is occupied or utilized (e.g., residential, office, parks, industrial, commercial, etc).

**Level of Service (LOS):** The quality and quantity of existing and planned public services and facilities, rated against an established set of standards to compare actual or projected demand with the maximum capacity of the public service or facility in question.

**Mitigation:** Actions or measures taken to alleviate the impacts or effects of certain development activities.

**Model:** A system of data, assumptions, and calculations used to represent and visualize reality.

**Module:** One of several major parts of the Carrying Capacity Analysis Model. A module is comprised of components.

**New Development:** Development that occurs in vacant or unoccupied land, as opposed to a change within already developed land.

**Open Space:** Land devoted to uses characterized by vegetative cover or water bodies, such as agricultural uses, pastures, meadows, parks, recreational areas, lawns, gardens, cemeteries, ponds, streams, etc.

**Output:** A result that is either used as an input to another CCAM module or as an end-point in an analysis.

**Parameter:** A quantity or constant whose value varies with the circumstances of its application or is used as a reference for determining other variables.

**Parcel:** Any quantity of land and water capable of being described with such definiteness that its location and boundaries may be established and identified.

**Planning Unit:** See Wastewater Planning Unit.

**Polygon:** A multisided feature representing an area on a map, with the boundary of the polygon defined by arcs.

**Population Density:** The number of people or individuals within a specified unit area, such as per acre.

**Population, Functional:** The sum of permanent and temporary populations in the Florida Keys.

**Population, Permanent:** That segment of the population that spends more than half of the year in the Florida Keys.

**Population, Seasonal:** That segment of the population that stays in the Keys for 30–180 days usually during the summer or winter "seasons."

**Population, Temporary:** The sum of the transient and seasonal population.

**Population, Transient:** That segment of the population that stays in the Florida Keys for less than 30 days; they are typically vacationers.

**Potable Water:** Water that is suitable and approved for human consumption; drinking water.

**Potable Water Consumption:** The amount or rate of water use.

**Public Land:** Refers to land owned by the municipalities in Monroe County or any other governmental entity or agency thereof.

**Qualitative:** A number that is not based on a discrete number or unit of measure. This is often an estimate and may be expressed on a relative scale of magnitude.

**Quantitative:** A measurement that is based on a number that has known, discrete units of measure.

**Redevelopment:** Refers to public and/or private investment made to re-create the fabric of an area that is suffering from physical, social or economic problems related to the age, type, and condition of existing development. Redevelopment can help to meet market needs for residential and/or commercial development in older parts of the town.

**Restoration:** The conversion of developed lands into natural areas.

**Routine Planning Tool:** An Internet-based mapping tool to support daily planning activities in Monroe County.

**Rubber-banding:** The process of selecting geographic areas smaller than planning units, which are the standard level of analysis in the CCAM, by aggregating adjacent property parcels.

**Runoff:** Rain water that moves across the land surface to exit a property or area; stormwater runoff.

**Scarified:** Refers to an area of land that is cleared of native vegetation, or topographically modified such that the land is not presently in a successional sequence leading to the establishment of vegetative communities that were previously cleared or disturbed.

**Scenario:** A change in land use described by the location, type, extent, and configuration of the land use change. Changes in land use may include new development, redevelopment, and restoration.

**Scenario Generator:** A series of screens, buttons, and menus built within the CCAM to assist the user in defining a land development scenario.

**Seagrass:** A type of submerged vascular plant (as distinguished from algae) that can form dense stands or beds in shallow marine water that are important marine habitats and energy sources for marine animals. Turtle grass is the main seagrass species in the Keys.

**Socioeconomic:** Relating to both social and economic factors.

**Stormwater Management:** Refers to the natural and/or constructed features of a property that function to treat, collect, convey, channel, hold, inhibit, or divert the movement of runoff.

**Subdivision:** The division of a lot, tract, or parcel of land into two or more lots, plats, sites, or other divisions of land for the purpose, whether immediate or future, of sale, rent, lease, or building development for all types of land uses, located on an existing, new, widened, or extended street, and requiring the extension of municipal utilities or construction of private on-site systems. It includes re-subdivision and when appropriate to the context, relates to the process of subdividing or to the land or territory subdivided.

**Tax Revenue:** Revenue that is derived from various taxes by governmental agencies.

**Threshold:** A point separating conditions that will produce a given effect from conditions of a higher or lower degree.

**Unfunded Liabilities:** The costs of facilities or actions that a government jurisdiction has responsibility for based on existing regulations or to meet some code or requirement that are currently not included in its budget and for which funds are not currently available to cover the item.

**Use:** The specific activity or function for which land, a building, or a structure is designated, arranged, occupied, or maintained.

**Vested Development:** Development projects that have received some form of government approval, such as recording of a subdivision plat, prior to the adoption of Monroe County's Regulation of Growth Ordinance, that would be issued building permits once the ROGO limits on growth are lifted.

**Wasteshed:** The land area above a discharge point that includes all sources of wastewater discharging to that point. In this study, wastesheds have been defined with the same boundaries as watersheds.

**Wastewater:** Liquid waste that is treated through some type of sanitary treatment system.

**Wastewater Planning Unit:** One of twenty-eight areas throughout the Florida Keys that were used in the Monroe County Sanitary Wastewater Master Plan analysis and documentation.

**Wastewater Treatment System:** A facility for processing sanitary wastewater by removing contaminants, nutrients, and pathogens. For example, central treatment systems, septic tanks, and cesspits.

**Water Quality Criteria:** Regulatory criteria setting the maximum or minimum value of water constituents for specific purposes, either within water bodies (ambient water quality) or in a discharge stream (discharge criteria).

**Watershed:** A catchment area that is otherwise draining to a watercourse or contributing flow to a body of water.

**Zoning:** The regulatory mechanism through which a town regulates the location, size, and use of properties and buildings. Zoning regulations are intended to promote the health, safety, and general welfare of the community, and to lessen congestion, prevent overcrowding, avoid undue concentration of population, and facilitate the adequate provision of transportation, water, sewage, schools, parks, and other public services.

## ACRONYM LIST

| | |
|---|---|
| ADI | Average Disposable Income |
| ADID | Advanced Identification of Wetlands |
| AHI | Affordable Housing Index |
| ATU | Advanced Treatment Unit |
| AWT | Advanced Wastewater Treatment |
| BAT | Best Available Technology |
| BOD | Biochemical/Biological Oxygen Demand |
| BFE | Base Flood Elevation |
| BMP | Best Management Practice |
| CARL | Conservation and Recreational Lands |
| CCAM | Carrying Capacity Analysis Model |
| CCI | Competitive Commerce Index |
| EDU | Equivalent Dwelling Unit |
| EMC | Event Mean Concentration |
| FDCA | Florida Department of Community Affairs |
| FKCCS | Florida Keys Carrying Capacity Study |
| GFA | Gross Floor Area |
| GIS | Geographic Information System |
| GUI | Graphic User Interface |
| HUD | U.S. Department of Housing and Urban Development |
| IAV | Impact Assessment Variable |
| IWM | Integrated Water Module |
| LOS | Level of Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NRC | National Research Council |
| NRC Committee | The National Research Council Committee to Review the Florida Keys Carrying Capacity Study |
| PIIP | Public Involvement and Information Plan |
| RHDI | Relative Habitat Degradation Index |

| | |
|---|---|
| ROGO | Rate of Growth Ordinance |
| SLR | Sea Level Rise |
| TN | Total Nitrogen |
| TP | Total Phosphorous |
| TSS | Total Suspended Solids |
| URS Corporation | URS Corporation is the prime technical contractor for the FKCCS. In 1999, URS Corporation acquired Dames and Moore Group, the company originally selected to conduct the FKCCS. |
| USACE | United States Army Corps of Engineers |

# Appendix D

# Detailed Comments and Questions

## SECTION I.
## DETAILED COMMENTS

This section provides detailed recommendations and comments on specific sections, equations and definitions included in the Draft CCAM report. Many refer to Appendix C of the Draft CCAM, which contains equations and tables of coefficients for each module.

### SCENARIO GENERATOR

- Correct the planning unit labels on Figure 2.3 per the response to Question #12 in Appendix D.
- Expand the definition of "scarified" in the Glossary (Draft CCAM p. 150) per response to Question #13 Appendix D.
- Revise the definition of "retrofitting" per the response to Question #14 on January 2, 2002 (Appendix D).
- Add a definition of "PC codes" to the Glossary.
- Make it clear that wetlands are defined using the US Army Corps of Engineer's criteria.
- Revise Tables 3.1 and 3.2 and the accompanying text to make it clear that all A-zones and V-zones are treated as areas with flood hazards regardless of whether or not base flood elevations (BFEs) are mapped (i.e., not just AE and VE zones).

- Clarify use of the terms "clustered" and "spread" in describing the "Configuration" options of the scenario generator per response to Question #25 in Appendix D.

## SOCIOECONOMIC MODULE

- Drop those variables that are based on the Independent Population Projections, which includes sections 1.2, 1.3, 1.6.
- The Planning Unit Capture Rate should be dropped. The amount of development within a planning unit is a function of the scenario-based land use decision.
- Introduce multiplier to convert permanent population to functional population; in addition more detail is needed as to how the figure 1.86 was derived. It should read the multiplier to convert permanent population to functional population = 1.86 (not vice versa).
- Provide more details with regard to how the multiplier to estimate seasonal population (0.33) was derived. It should read "to estimate seasonal population from permanent population = 0.33" (not vice versa).
- The persons per household variable does not mean the same thing as reported in 1990 Census. The 1990 Census is the data source, not the definition of the variable. A number of variables are set equal to their data sources. The Committee recommends making changes so that equal signs are only used to define variables. A description is needed of the census variables from which persons per household is derived.
- More information is needed as to how the residential densities are derived including the year for which it was derived and the base source of information. A similar comment holds for many of the following variable definitions where the Committee recommends "provide more details."
- More information is needed as to how Floor area ratio was derived.
- More information is needed as to how Hotel/motel room density was derived.
- Gross floor area per capita is defined as gross floor area demand divided by population. Gross floor area demand is defined as gross floor area per capita times population, which presents a problem of circularity. Neither variable indicates the source for gross floor area or gross floor area demand.
- The hotel rooms per transient person variable uses independent population projections as a basis for estimating transient persons.
- The employment per 1,000 square feet of gross floor area variable comes from the Monroe County tax roll database and County Business Patterns. But no detail is provided as to what information comes from what source. Clarification is needed as to how this variable was derived.

- The hotel employees per room variable comes from County Business Patterns and Florida Statistical Abstracts, but no detail is provided as to what information is taken from what source. Clarification is needed as to how this variable was derived.
- More information is needed as to how per unit construction costs were derived as well as the data source, *Means Construction Cost*. Clarification is needed as to what types of construction (e.g., residential, hotel/motel, commercial, industrial) this cost estimate includes.
- More detail is needed with regard to how per unit average taxable value was derived.
- It is unclear whether “average” price of house indicates the “mean.” More details is needed about the rationale for using appraiser data in some cases and market sales data in others?
- The source for the 3.57 value of the qualifying income ratio is unclear. It should read “qualifying income ratio = 3.57” (not vice-versa).
- More detail is needed with regard to how mean household income was derived and why U.S. Department of Housing and Urban Development (HUD) data rather than census data was used?
- More detail is needed with regard to how multiple dwelling units were incorporated into median housing value and how this variable was derived.
- More detail is needed with regard to how average annual wage per employee was derived.
- Variables 26–28 (Section 1.4) are important constants and deserve scrutiny. It is unclear as to why they are based on historical data for each planning unit rather than on design principles.
- For variables 29–31, it is uncertain whether population per household can really be held constant across low, medium, and high-density dwelling units.
- The relationship between support population, permanent population and functional population is unclear.
- The second definition for support population is mystifying. Variable 37 is defined as variable 35 divided by variable 9. Variable 35, however, is defined as population divided by variable 9. So variable (37) is simply population. It is unclear why the extra manipulation is necessary.
- The definition of hotel support population is also mystifying. It is defined as variable 34 divided by variable 10, but variable 10 is defined as variable 34 divided by transient population. Variable (38) would then seem to define the transient population.
- It is unclear as to why gross floor area is not divided by 1000 in the employment demand calculations. Furthermore, the distinction between this variable (#39) and variables 41 and 43 is also uncertain.
- The distinction between hotel employment demand (#40) and variable #42 and #44 is unclear.

- The assumptions regarding square feet of new construction are unclear in the calculations for new residential construction costs. It's also uncertain whether variable #13, commercial construction cost, is appropriate for residential construction.
- "New commercial construction costs" may be a better moniker for Variable #46. It is unclear why the variable is divided by 1,000,000.
- It is uncertain whether it is valid to use variable #13, commercial construction cost, for new hotel/motel construction cost. It is also unclear why the variable is divided by 1,000,000?
- It is unclear why residential taxable value is divided by 1,000,000.
- Variable #14 is based on the taxable value of a single-family residence. It is unclear why it is being used to define the value of square foot of nonresidential gross floor area in the calculations of nonresidential taxable value
- Variable #14 is based on the taxable value of a single-family residence. It is unclear why it is being used to define the value of a hotel room in the calculations for hotel taxable value, nor is it clear why the latter is being divided by 1,000,000.
- The same variables are used for both projected and existing total dwelling units so it appears that this variable for projected new units will always be zero. More clarification is needed.
- Required income, #52, is unnecessary.
- It is unclear as to how the retail concentration index is defined and how it relates to the CCI.
- It is unclear why total employment wasn't simply defined as the number of employees per gross floor area times the gross floor area plus the number of employees per hotel room times the number of hotel rooms.
- The range from red to yellow to green for the threshold for affordable housing index seems to be a narrow range.

## FISCAL MODULE

- The description of the trip generation method is not consistent with the equations detailed in Appendix C, nor does Appendix C fully explain how trips are apportioned among the planning units.
- Various formulas in Appendix C contain errors. The explanation for how speed is calculated does not refer to other equations in the appendix.
- The parameters for calculating internal-internal trips per segment are not explained: it is unclear if $TP_I$ refers to equation #85 and the source for the 0.85 coefficient is not readily apparent. The calculation for the "n" value for internal-external trips per segment and external-internal trips per segment is not clear. Explanation is needed as to how "distance per trip" is calculated.

- The calculation for the "m" value for external-external trips per segment is also unclear: explanation is needed as to how "distance per trip" is calculated.
- There is no explicit use of the trip attraction per segment variable, though it appears that this should be involved in calculating external-internal trips.

## HURRICANE EVACUATION

- No explanation is provided of the basis for the three "threshold" population estimates reported in Appendix C, equations 95–97. If the population extrapolation method is retained despite the above recommendations, the rationale for this choice should be explained.

## SECTION II. QUESTIONS & COMMENTS

This section contains a set of questions posed by the NRC during the period of December 21–23, 2001 after receiving the Draft CCAM. The contractors provided answers (indicated in bold) prior to a public meeting held on January 17, 2002.

## GENERAL COMMENTS

The concern for the well-being of the ecological system and the people who inhabit the Keys is laudable. The effort to limit growth and to protect the remaining habitat is a meritorious societal issue and requires sound theory and scientific backing if it is to achieve its objectives. Part of the concern is based on the population at risk because of the threat of hurricane storm surge whereas other parts of the concern regard the quality of the natural and cultural environments.

I worry about any and all development in the coastal zone that proceeds with the assumption that the system is static or that the dynamics are too difficult to model or too modest to accommodate within the planned modification of the environment. The coastal zone is very dynamic and is constantly undergoing change as a product of sea-level rise, sediment mobility, biotic processes, and cultural impacts. Sea-level rise is an especially important variable in low-lying coastal systems because it is altering the spatial associations of boundaries and is encroaching on all of the static elements within the purview of coastal development.

Sea-level rise as determined by the Key West tide gauge (NOAA website) is modest, on the order of 1 inch per decade. In terms of the planning horizon of two decades, the slight rise in mean sea-level during this time would seem to be a minor item as indicated in the report (p. 21). However, the Keys are relatively low and development has flattened much of the pre-existing topography. Thus, small elevational increases in storm surge levels caused by SLR could translate into sizeable horizontal excursions through the developed communities. SLR is encroaching on all of the static infrastructure in the Keys. Any item that incorporates elevation as a variable is being compromised and it, in turn, is affecting all related development, such as: road elevations, clearance under bridges, gravitational hydraulic head, storm sewer drainage, etc.

Further applications of the SLR variable in the existing report would seem to be of importance in the establishment of categories of vulnerability to flood and to the creation of buffer zones separating development from biotic systems. In the case of the former situation, FIRM maps of the Federal Emergency Management Agency are used to rank exposure/suitability of land parcels to flood (X, AE, and VE categories in Table 3.1). Because FIRM maps are established relative to a base flood elevational datum, the application of SLR would cause the inundation lines to shift through time to accommodate the changing base. Indeed, if the existing FIRM maps are a decade or more old, their utilization and subsequent projection several decades hence is under-estimating the flood potential (as applied in the Smart Growth Scenario, Residential, p. 72). A second situation would apply to the horizontal dimensions of buffer zones separating development from protected habitats. If the protected habitat were wetland, for example, the wetland zone would shift spatially under the influence of SLR. The dimensional shift would be dependent on the slope of the adjacent land and the presence of obstacles. However, the net effect would be to reduce the dimensions of the buffer and compromise the intention of the buffer.

Coastal zones are dynamic and subject to a range of natural and cultural processes. They are hazardous areas and will likely become more hazardous as SLR elevates the effects of any class-interval storm and as the natural protective buffers are removed or compromised by cultural development. Planning and management of the coastal zone should at least recognize the existence of this dynamic process, identify its effects within the system, and should have a long-range goal of reducing the population and infrastructure at risk in these hazardous environments.

There are many pieces of the scenario development package presented in these pages. There are many data sets identified. However, there seems to be a paucity of conclusions that are determined from the application of the approach.

**We appreciate the comments regarding SLR. While the model may not able to detect such small, anticipated changes, SLR adds to environmental constraints of development in the Florida Keys.**

**The paucity of conclusions evident in our report is due to the fact that our efforts to date have been focused on testing whether the model works. It is premature to put too much weight on results until we are satisfied with the workings of the model and its internal consistency.**

## GENERAL CONCERNS

1. The model seems to assume that the value of each coefficient remains constant regardless of changes in the population, available land, and other state variables. For example, the cost/house remains constant despite reductions in available land and increasing population and property values do not change with changes in the "quality of life" parameter. Is this correct, and if so, is there any evidence that such constancy is, in fact, observed with the growth levels anticipated of the Keys?

**Yes. This is commonly accepted practice when preparing land use forecasts in urban planning. See references in standard texts such as F. Stuart Chapin and Edward J. Kaiser, *Urban Land Use Planning, 3rd Edition*. Besides, the small amount of projected population growth expected in the Keys will significantly limit the amount that an average, or per capita, land use coefficient can be changed. See the expanded draft report on the socioeconomic module, "Documentation of Socioeconomic Module for the Florida Keys CCAM" (DO9) for a more complete description of these relationships.**

2. The model does not seem to deal in much detail with visitors (seasonal, short-term or day trippers) except through projected demands for hotel rooms. For example, shouldn't tourists contribute to the CCI? Another example is on p. 41 where it is stated that traffic on Rt. 1 is related to land use using national data, but how are projected changes in traffic due to changes in different tourist components handled?

**The database for tourists and other seasonal or temporary residents is of only marginal accuracy throughout Florida (and especially the Keys), and measurement of their impacts on local competitive advantage would have a large amount of uncertainty. There is no known reliable source of "day-tripper" data for the Florida Keys.**

**The traffic calculations take into account observed traffic levels which, in turn, consider *all* traffic in the Keys, both residents and tourists.**

**Monroe County uses "functional population" as the basis for planning—functional population is the average number of people in Keys on any given day.**

3. On P. 43. Is evacuation time really a linear function of population? Wouldn't it be some power function?

**We applied the most parsimonious approach.**

4. Please rationalize the population basis. It is incredible that the U.S. Census has come up with 19% more population than the Contractor team has established for the year 2000, and that the population estimates for the year 2020 that are the basis for the model are significantly less than the Census produces for Monroe County in 2000. Also, given the information presented on page 84, the contractor's scenarios estimate significantly less "functional population" in 2020 than today. Please explain.

**In the model, permanent population is calculated in terms of number of households, people per household, and percent households occupied by permanent residents. We calculated the number of permanent residents for 2000 and compared the result to the Census result, which shows a difference of 19%. The land use database that served as the foundation for population estimates for 2000 was provided by the Monroe County Property Appraiser. The calculated population for Key West is significantly lower than that reported in the Census, and accounts for much of the 19% difference throughout the Keys. The discrepancy in Key West is being evaluated.**

**The population calculated for the Smart Growth Scenario is lower because it is calculated on the same land use database. The model is consistent in that a small amount of growth led to a small increase in population.**

**Once the discrepancy between the current conditions calculations and the Census count is resolved, the scenarios should fall into place as well.**

5. Why does the draft model report not reflect the Scenario Development Guidelines produced in July 2001? Each of the two scenarios "Current" and "Smart Growth" should be preceded by a narrative that spells out their "vision."

**The GUI and scenarios reflect the guidelines developed in July 2000. Both the GUI and the guidelines were sent to the NAS in mid-December.**

**There is no vision associated with "current conditions." Current conditions were run to check whether model results conform with known aspects of the Keys (see page 71 of the report).**

**Attached at the end of this document, please find the "Smart Growth" scenario, as provided to us by the local planners.**

6. What is the Current Conditions Scenario? Is it a portrait of existing conditions that would be maintained for a time till 2020? Practically no community can maintain "stable" demographic and economic conditions over such a long period of time, and there is plenty of experience to demonstrate that. This would be a totally unrealistic option over the period to 2020.

**Current conditions were run only to test whether the model produced results that resembled observed conditions in the Keys. For example, this test helped us identify the discrepancy between observed (Census data) and calculated (model-based) population numbers discussed in Question 4 above.**

7. Were other scenarios tested?

**No.**

8. How do you treat "parking," which for non-residential uses, is probably the largest source of impervious surfaces and one of the biggest contributors to stormwater runoff?

**A land use is designated for each developed and undeveloped parcel as part of the geo-spatial database of the CCAM. Imperviousness for each parcel is determined by a user manipulated look-up table in the Stormwater Component that assigns a runoff coefficient (c) to each of the defined land uses, and this coefficient value is consistent with Monroe County's adopted *Stormwater Management Master Plan* (CDM, 2001). Parking lots are not treated as a separate component of the parcel, but are included as an aggregate component of the parcel. Consideration of parking lots has been factored into the runoff coefficient assigned to each land use.**

## BACKGROUND AND LEGAL MANDATE

9. Do the Monroe County Comprehensive Plan sub-areas correspond with the Sanitary Wastewater and Stormwater Master Plan sub areas (p.7)?

**The numbered planning areas used in the CCAM have a one-to-one correspondence with the wastewater planning units identified in the *Sanitary Wastewater and Stormwater Master Plan*. The designated hotspots and focus areas are identified in the Wastewater Component by the same names. However, the sub-units of the numbered planning areas, called wastesheds in the Wastewater Component and catchments/watersheds in the Stormwater Component, have no equivalent in the *Sanitary Wastewater* and *Stormwater Master Plan*.**

## SCENARIO GENERATOR

10. Explain how land use change is specified for a given spatial unit of analysis: Does the term "footprint," as it is used in explaining the "type" of land use change (p. 22), refer to the footprint of a structural improvement on an individual property parcel? If not, to what does it refer?

**The future land use pattern conveyed by a given scenario can be derived from the following sources of change:**

- Conversion of vacant land to a new use (e.g., "new development");
- Conversion of previously developed land to a different use (e.g., "redevelopment," "restoration"); or
- Increased or decreased intensity of development in previously developed land, while maintaining the same use (e.g., "redevelopment," "retrofitting").

**The term "footprint" indicates the physical extent of development activities or land uses contemplated by an overall scenario or a particular scenario element. The term is used to define land use types for individual parcels, and not the structural improvement per se.**

11. Can the "Scenario Type" only be set for one of the four options for a given wastewater planning unit: (1) new land development, (2) redevelopment, (3) restoration, or (4) retrofitting—or does the "Other (rubber band)" setting in the "Target Area" menu of the GUI allow different scenario types to be defined within a single planning unit for individual or multiple property parcels?

**The model only accounts for the four "types" of development, whether in a planning unit or a rubber-banded area. Within a planning area (or rubber-banded area), different sub-areas can be subjected to different development types.**

12. Where are the following planning units (not shown on Figure 2.3): (1) Marathon Secondary, (2) PAED 22?

**Marathon secondary has been renamed to Key Colony Beach. PAED 22, a small unit located in northern Key Largo, is not labeled. This will be corrected in the final report.**

13. Can you expand on the term "scarified", p. 23 and p. 150 in the glossary? Does this mean any lot in a subdivision, whether it has been developed or not?

**The term is used in the same manner as is currently applied in the Monroe County Code. It refers to parcels that have been environmentally disturbed through the removal/clearing of native vegetation or through topographic modification.**

14. Can you give a more direct and clear description of "retrofitting" than is contained on p. 23?

**Retrofitting refers to improvements made to existing infrastructure systems (e.g., stormwater, wastewater, potable water, etc.) in order to bring them in line with modern practices, state-of-the-art technologies, and/or changing regulatory requirements.**

15. Can someone clarify the statement regarding non-residential development on p. 25: "It was assumed that most types of nonresidential development will be attracted first to vacant land that is visually and functionally accessible to US 1." I would quarrel strenuously with that statement. For the following reason: Any "vacant" land currently accessible to Route 1, especially given the long history of development in the Keys, probably has serious problems attached to it (environmentally or ownership). As a planner I would see the biggest attraction for non-residential development to occur in already-developed parcels that consist of obsolete or significantly undeveloped projects. Slipping something into currently "vacant" pieces would seem to be very difficult.

**No need to quarrel. Visibility from U.S. 1 has historically been a key consideration for nonresidential development in the Florida Keys. In addition to being adjacent to U.S. 1, it is assumed that the land most likely to be developed first for nonresidential uses will also be free of habitat and flood-related constraints. The suitability scale does not assume that development on a vacant parcel adjacent to U.S. 1 is preferable to a vacant parcel in the same situation, but that, among all vacant land available for nonresidential development, parcels that meet these three conditions would most likely be developed before others that do not.**

***"Land Use change from conditions" input screens***

16. What "conservation" and "open space" designations were used to classify otherwise vacant land as unavailable for development (p. 24)?

**The PC codes from the Monroe County Property Appraiser's tax roll were used to identify which lands are in public ownership. However, we have recently become aware that these codes might also include parcels assigned for other land uses. In the final model these PC Codes will be checked against the (corrected) zoning data to avoid inaccuracies.**

17. How does the wetland vegetation data used to classify otherwise vacant land as unavailable for development (p. 24) correspond to the classifica-

tion systems used by the US Army Corps of Engineers and the State of Florida to identify wetlands for which development would be prohibited?

**All wetlands are unavailable for development unless the user chooses, in the GUI, to ignore current regulatory constraints regarding development in wetlands.**

18. How are property parcels that are located in an A flood zone or V velocity zone for which no base flood elevation (BFE) has been specified included in a scenario? (Note that the keys to tables 3.1 and 3.2 (p. 26) indicate that the "AE" flood hazard area designation applies to all A-zones, not just those with BFEs, and the "VE" velocity zone applies to all areas with velocity hazards, not just those with BFEs.)

**The model assumes that for all future development, compliance is required with current flood elevation regulations. The distinction with regard to "suitability" is based on consideration of both the flood hazard and additional cost related to mitigating that hazard. Therefore, land is considered most likely to be developed first where conditions would allow for the most cost-effective construction.**

***"Land use change to conditions" input screens***

***Vacant land***

19. How do the density and intensity coefficients used to define development capacity of vacant land correspond to those in the current zoning code (i.e. in what ways have they been "adopted or adjusted") (paragraph 5, p. 27)?

**The density and intensity coefficients used come directly from current regulations contained in the Monroe County and City of Key West Land Development Regulations. The "adjustments" referred to were made in conjunction with the corrections to the data in the zoning field of the tax roll, which contained outdated zoning categories (old Code), typographical errors, or other shortcomings. For example, if a record showed the code "0S" (zero-S) under the zoning field, this was adjusted to "OS", Offshore Island, and assigned the corresponding density allocation.**

20. Is this done parcel by parcel using all of the existing zoning classifications? Or has there been some aggregation of zoning classes? If so,

please provide a table that compares the aggregate density and intensity coefficients with those for each of the subsumed zoning classes.

**This is done parcel by parcel using the zoning data available in the tax roll. However, as explained in (19) above, some equivalencies were established only in cases where an outdated zoning category was shown in the database, or where a typographical error was found.**

21. What is the extent of the inaccuracies in the zoning data set contained on the Tax Roll (paragraph #5, p. 28)? How much of an effort is required to make the needed corrections? Is such an effort beyond the scope of the current contract?

**Data creation is out of the scope of the project but, corrections have been made, to the extent possible, using hard copy zoning maps for Monroe County, Key West, Layton, and Key Colony Beach. No zoning maps were available for Islamorada or Marathon, which have only recently undergone or are currently undergoing comprehensive plan and land development regulation processes. For these two "new" municipalities, County zoning designations were used, but can be modified/updated when the zoning is finalized.**

22. If sewers are not currently available, is new development permitted under current zoning in some or all zoning districts?

**Current zoning regulations specify the type of development, if any, that is permitted under each zoning district. The model, by using the density and intensity allowances from these regulations, takes existing constraints under consideration**

***Land suitable for redevelopment***

23. What are the explicit criteria used to define land suitable for redevelopment (paragraph 4, p. 27)?

**The criteria for selection of developed land suitable for redevelopment were identified in collaboration with, and in many cases recommended by, local planners, and include the following options that are shown in the GUI:**

**For Residential Redevelopment Activities*:***

- **Existing trailers/mobile homes**
- **Waterfront parcels**
- **Parcels <5,000 sq. ft.**

- **Structures older than 25 years**
- **Structures <1,200 sq. ft.**

**For Nonresidential Redevelopment Activities (Commercial/Industrial/ Institutional):**

- **Parcels developed at <19% F.A.R**
- **Structures assessed at <33% of the land value**
- **Structures >20 years**
- **Structures <1,200 sq. ft.**

24. Are these criteria applied within a given target area only where the target area is greater than the land area required to accomplish the specified amount of redevelopment? In other words, can a user specify a set of property parcels within a planning unit to which they want redevelopment to be applied and thereby define their own criteria for which parcels are to be redeveloped? Does this process apply to retrofit scenarios as well?

**One or more criteria can be selected by the user to "find" parcels meeting those criteria, or the user can specify a target "redevelopment" area ("Other") within a planning unit.**

***Development configuration***

25. How is the distinction between "cluster" or "spread" development operationalized in defining land use scenarios (paragraph #1, p. 23)?

**A clustered pattern of development may be generated by selecting blocks of "contiguous" parcels that meet other desired criterion or criteria (e.g., scarified, within a certain distance of U.S. 1; within platted subdivisions only, etc.).**

***Residential input screen***

26. What is meant by the "per current condition" density setting—Does this invoke the density allowed under current zoning for every parcel in the target area?

**Yes, the "per current condition" option does invoke the density allowed under current zoning for parcels in the target area.**

27. How do the magnitude settings work? If the target area is an entire planning unit, where do the new dwelling units get assigned under each of the magnitude options: (1) number of dwelling units, (2) percent of selected parcels, (3) land area? How is "development suitability" (page 25) used in the allocation of new development? How is the assignment accomplished if the target area is a specified set of property parcels within a planning unit?

**The dwelling units get assigned based on their suitability ranking. Those parcels with the highest suitability get developed first. Within suitability rankings, parcels are selected randomly.**

28, How does the density setting interact with the magnitude setting (e.g., if the number of dwelling units specified under "Magnitude" exceeds the allowable density)?

**The options in the Residential "Magnitude" screen are an "either/or" statement (i.e., the user can choose to specify the magnitude of development by total number of anticipated units), or by entering a fraction (percentage) of the total available land selected in the "Change from" screens for development, or by choosing a density allocation from among four options that include the current allowable density. This allows the input of scenarios that assume changes in the regulations to increase (or decrease) current densities.**

29. Are the "single family residential detached," "single family residential attached," and "multifamily residential" settings mutually exclusive (i.e., is it possible to use the residential landuse change to conditions screen to set up all three types of residential land uses for a given target area)?

**After careful consideration, these parameters have been subsequently removed from the GUI because the data currently available does not support their use in any of the model components.**

***Commercial input screen***

30. How does one specify a scenario for build-out to maximum allowable commercial density and intensity under existing or modified land development regulations?

**Such a build-out scenario would be specified by selecting for development, from the "Change from" screens: (a) all vacant land, (b) zoned for commercial use (other criteria could be specified to further constrain the universe of available commercial land, if so desired), and specifying, under**

**the "Change to" screens, the applicable floor area ratio (including current allowable).**

31. How do the magnitude settings work? If the target area is an entire planning unit, where do the new commercial units get assigned under each of the magnitude options? How is the assignment accomplished if the target area is a specified set of property parcels within a planning unit?

**Please see #27.**

***Restoration input screen***

32. What is the data source for determining the historic vegetation type?

**The data source is the DO7 historical vegetation map. Debbie Peterson (USACE) can provide a copy of the Historical Vegetation Mapping report.**

33. What assumptions are made about habitat quality if a parcel/area is designated as "restored"? Is the parcel assumed to have the full complement of plant and animal species immediately? After some specified period of time? Is the parcel assumed to have the full complement of plant and animal species and adequate population sizes regardless of parcel size?

**It is assumed that the parcel is restored to the natural state indicated by the historical vegetation map as an end-state condition, 20 years in the case of the CCAM.**

***Environmental interventions input screens***

34. When will sewer infrastructure data be available for use as a criterion in defining available vacant land (paragraph #4, p. 28)?

**Unknown.**

***Scenario Outputs***

35. For which impact modules are outputs aggregated by land use category by planning unit (paragraph #1, p. 28) (i.e., land use changes are not defined at any greater level of geographic specificity than the planning unit)?

**Land use change occurs at the parcel level; however, CCAM results are calculated and reported at the planning unit level.**

### *Scenario Comparisons*

36. Explain how "actual intensity of development" calculations (paragraph 3, p. 27) are used in comparing the two test scenarios. I don't see such a comparison.

**These comparisons are part of a series of pre-modeling checks to determine if the user defined scenario is realistic. The user has the option to modify the scenario based upon these checks or to proceed with the current selections. The actual intensity of development calculations were not compared in the test model.**

## SOCIOECONOMIC MODULE

37. An outcome of the Housing Affordability Index (Table 4.9) is the dichotomy between the economic status of the full-time residents and the part-time residents. This translates into future development being dependent upon investment from outside the area. How does this dichotomy drive changes in land use and impacts on the system?

**Since a large proportion of the new development in all urban areas results from investment by "outsiders" who move into an area and create demands for new housing, commercial centers, community facilities, etc., this is not an unusual condition to be found in Monroe County. In the situation expressed in the Florida Keys, it is expected that affluent new residents will purchase the more expensive new housing while the less affluent will purchase older units of more moderate price. Again, the small amount of total population growth will result in a minimal change in land use pattern and individual neighborhood markets.**

38. One of the main objectives in the socioeconomic section is to forecast "future land use demand" from an independent population projection. How does this fit with the rest of CCAM? Doesn't the rest of the model begin with scenario driven land use decisions, which are then used to project population changes?

**It is the control value to test the reasonableness of a scenario. See report entitled "Demographic and Economic Analysis of Alternative Development Scenarios in the Florida Keys." (DO9) This report shows that the residential component of the Smart Growth Scenario IS consistent with independent**

**population projections, but the nonresidential components of this Scenario ARE NOT consistent with demographically driven land use demands for the Smart Growth Scenario.**

39. In deriving the independent population projections, what is assumed about land/housing prices? Is "demand" a "demand curve" as economists would understand it or is it instead a prediction about the equilibrium of supply and demand? If it is the latter, what is assumed about "supply" ( i.e., what is assumed about local growth controls and land use policies)?

**The demand is expressed in terms of an equilibrium relationship with supply. Both are related to the documented growth trends of the past decade under ROGO. This is a conservative approach that should be consistent with either a continuation of a ROGO-like regulatory system or a lessening of regulations in the future. When land use demands, such as those for hotels or multi-family projects, can be significantly constrained by growth management policies and ordinances, they are identified. See "Demographic and Economic Analysis of Alternative Development Scenarios in the Florida Keys" and "Housing Construction Rates and Prices in the Florida Keys" (both DO9 reports available from D. Peterson) for more detailed discussions of these phenomena.**

40. The two IAVs from the socioeconomic module are the Competitive Commerce Index (CCI) and the Affordable Housing Index (AHI). Why wasn't there an attempt to tie the socioeconomic measures to the results of the PIIP?

**The results of the PIIP are tied to all model results through a comparison of model results to people's ranking of environmental and socioeconomic concerns (Table 4.23, page 108).**

41. For the CCI: of all of the socioeconomic measures that could be measured, why the CCI? Why is it so important? Given that it is measured, what is the population profile for which disposable income is calculated? Does it include tourists?

**The CCI was used as a means of responding to strip commercial development and the phenomenon of linear trade areas discussed in the report entitled "Socioeconomic Environment of the Florida Keys." (DO9). The primary purpose of a measure such as the CCI is to identify locations that have the strongest potential for concentrating and managing future commercial development that is consistent with both market conditions and**

**growth management objectives. Simply, the CCI measures indicate the most probable locations of continued commercial development, as well as those that have not expressed a strong trend for these activities in the past.**

**An income measure is not part of computing the CCI. Instead, retail sales per household or retail GFA per capita are normally used to estimate space demands from the existing resident population. Retail sales per household are derived from the latest Census of Retailing. Tourist expenditures are factored into this average.**

42. For the AHI: how will you make predictions of future housing costs given various scenario assumptions? It is clear how the current AHI can be calculated given current data but not how to predict the AHI under various future conditions.

**They will not be made. The purpose of the AHI is to identify the areas in which future housing development that is affordable by moderate-income households is more likely to take place. These locations are discussed in "Demographic and Economic Analysis of Alternative Development Scenarios in the Florida Keys" (DO9) in terms of potential residential locations for future labor force. Affordable prices for owner-occupied housing was used in this study because of the previously described difficulty in securing commitments for high percentages of the total County allocation of housing units in a single multi-family project.**

**These existing conditions, as expressed by the AHI, are considered to be reliable measures of the affordability of individual neighborhoods (Planning Areas). It is well established that residential areas with rapidly increasing housing values are part of the upward trend of a "neighborhood life cycle" and more expensive housing continues to be built within them. Conversely, neighborhoods that have become stable or started to decline in quality and value (but not blighted) will continue this trend and serve as the location for less affluent households. This is typically referred to as the "filter down effect." Identification of these areas through the model indicates the opportunities for lower cost housing in the future.**

43. How does the spatial resolution of the assumptions and analysis of the socioeconomic module fit with the spatial resolution in other modules?

**The spatial resolution of socioeconomic and land use conditions is the same as in other modules. All results are aggregated to the planning unit level.**

44. Explain how the constraints imposed by ROGO would affect the time period over which the Smart Growth scenario would be effected (i.e., could it actually be accomplished in 20 years)?

**The population required to support the residential component of Smart Growth is consistent with the independently generated 20-year population forecasts by the County and State. This indicates that this portion of the Smart Growth Scenario is achievable within the two decades if the population projections occur.**

45. Can you tell us what are the coefficients for the socio-economic module in Table 3.3? There are some fairly acceptable national standards, and it would be good to see what these folks have come up with.

**All socioeconomic coefficients for this module were developed from documented conditions in the Florida Keys. There was no need to use coefficients used in other areas or for different purposes.**

46. Can you tell us what was the range of parameters that you used to test varying the scale of temporary population (p. 33)?

**Yes, this was discussed in the report entitled "Housing Construction Rates and Prices in the Florida Keys" and in the report entitled "Socioeconomic Environment of the Florida Keys." The seasonal population and functional population, including their bases, are discussed in both of these reports (DO9).**

47. Can you share with us the factors that went into the presentations of Tables 3.4-6?

**All factors are described in Appendix C. These tables exemplify calculations made in the CCAM.**

## FISCAL MODULE

48. To what extent does the totality of expenditures incorporate conducting these activities in a hazardous environment, as opposed to ordinary expenses of governmental operation?

**The basis used for projecting expenditures were actual current and past year expenditures of the existing governmental entities located in Monroe County. Therefore, by definition, the expenditures are based on the costs of conducting governmental operations in Monroe County.**

49. Is there a factor, even among the unfunded liabilities, that tries to incorporate exposure and risk to hurricane damage as part of the cost of occupying the Keys?

**Each of the Governmental Entity's expenditures includes a risk management component that includes a higher cost (typically based on actual experience) of insurance in Monroe County (high hazard area).**

50. Is there a planning option to move development and re-development to areas of lower risk (higher elevations and out of V-zones) to reduce expenditures?

**Expenditures were projected based on continuing future governmental operations in the same manner as current operations.**

51. There are references to the Monroe County Wastewater and Stormwater Master Plans, especially on p. 40. Can you tell us what these documents have recommended and how they change current conditions?

**We understand the Government Study Team provided these documents to the NAS.**

## HUMAN INFRASTRUCTURE MODULE

52. Does hurricane evacuation take into account the low elevations along U.S. 1 and the effect of flooding on the capacity to handle traffic?

**As with other parts of the model, we used State-mandated studies as reference. This includes the Hurricane Evacuation Study and the Stormwater and Wastewater Master Plans. No further assumptions were made on the Hurricane Evacuation component.**

53. Would it be possible to relate the elevations of low portions of the highway to recurrence-interval storm flood levels and thereby provide some additional choices to the evacuation scenarios? If so, this same approach could incorporate the effects of SLR in adjusting the effects of recurrence-interval storms and relate the flooding frequencies to populations capable of being evacuated.

**See response to Question 52 above.**

54. The discussions associated with the Fiscal Module and the Infrastructure Model in the Test Scenario Results are not well presented (pp. 81–85). There are inconsistencies within the text and the information included in Tables 4.10 and 4.12.

**Results of the Fiscal Module are described correctly. Table 4.10 did not include a column to show the % change in current conditions when unfunded liabilities are included.**

**Table 4.12 is correct—the text associated with it should reflect the change in LOS for many of the planning units. This will be corrected in the revised version of the report.**

## INTEGRATED WATER MODULE

55. The stormwater runoff model seems to be run with monthly mean rainfall. Is this really correct? Since storm runoff is event driven (hourly-daily), please explain how long-term mean deposition rates can be used to estimate water or pollutant runoff or their impact on the marine module.

**The CCAM is not a conventional event simulation model that uses a fixed time-step and a series of specific simulation events to predict time variable flow, stage and pollutant flux values for specific locations. The Florida Keys have very little conventional drainage infrastructure and virtually no treatment facilities. Existing facilities are generally not mapped and no data is available on the actual discharge characteristics of stormwater runoff to the receiving waters. Consequently, the CCAM was developed to consider normal seasonal effects in a quasi-steady-state modeling environment, using available data, for planning purposes.**

**Pollutant discharges to the marine environment from discrete planning units are developed for a steady state—translated as a consistent rainfall input with a consistent discharge output. This approach is coupled with the Groundwater Module approach of a consistent daily discharge of pollutants to the halo zone to generate a continuous pollutant stream entering marine waters.**

56. I was surprised to see desalinization excluded from consideration since it is already used in some Caribbean Islands. Have you really looked into this question?

**No. This issue has been mentioned sparsely throughout the two years of the study. However, to our knowledge, no serious plans exist for desalination. Neither the Government Study Team, their panels of experts, other**

**State agencies, environmental organizations or the public have pursued this issue.**

57. The description about watershed delineation using roads and canals is not at all clear. How did you do this?

**Topographic definition in the Florida Keys is very limited, generally to a 5′ and sometimes a 10′ contour on available mapping. No additional topographic mapping was done for this study. During limited field visits the Project Team Field observed that the roadway system is typically one of the highest topographic features in the general terrain and it was used—in the absence of more accurate information—as "ridges" for the definition of the catchment areas used in CCAM. Similarly, canals provide a good basis for defining interior drainage patterns.**

58. On p.52. Do pollutants from stormwater runoff that enter groundwater reach or not reach the marine module? The report seems to say that sewage that goes into groundwater does reach the coast, but runoff does not? The issue of monthly mean runoff estimates are problematic also.

**The flow component (water volume) associated with the stormwater runoff that percolates into the groundwater system underlying the islands is discharged to the halo zone waters adjacent to the receiving water boundary of each catchment. The pollutants contained in the percolated runoff volume are numerically processed by the Groundwater Component, which provides treatment based upon a user manipulated look-up table that assigns a removal coefficient (% mass reduction) for each of the evaluated pollutants, and this coefficient value is consistent with available literature in the Florida Keys.**

59. What are the assumed stormwater event mean concentration values used for each land use category (p. 51), and what are the sources upon which these values are based [need full citations]?

**Stormwater event mean concentration values used in CCAM are based on an analysis of reported Florida EMC values. The specific EMC values, their variability and their sources are discussed in detail in the Stormwater Component section of the Delivery Order-8 Report.**

60. What are the runoff coefficients used for each land use category (p. 51), and what are the sources upon which these values are based [need full citations]?

**Stormwater runoff coefficient values for specific land uses that are used in CCAM are based on common drainage practices in Florida, and are consistent with the runoff coefficient values in Monroe County's adopted *Stormwater Management Master Plan* (CDM, 2001). Specific runoff coefficient values are discussed in detail in the Stormwater Component section of the Delivery Order-8 Report.**

61. What assumptions are made about percent impervious surface for different land uses?

**Impervious area coefficient values for specific land uses that are used in CCAM are based on common drainage practices in Florida, and are consistent with the runoff coefficient values in Monroe County's adopted *Stormwater Management Master Plan* (CDM, 2001). Specific runoff coefficient values are discussed in detail in the Stormwater Component section of the Delivery Order-8 Report.**

62. Are these assumptions based on current land development regulations in Monroe County?

**The EMC values and the runoff and impervious area coefficient values for specific land uses have been adopted by Monroe County and, based upon limited field visits by the Project Team, are believed to be generally consistent with current land development regulations. However, no detailed study was authorized to field verify runoff and impervious area coefficient values for specific land uses, or to correlate these values with parcels that have been developed in full compliance with current land development regulations.**

63. Can these assumptions be modified to simulate the effects of modifying existing land development regulations governing amounts of allowable impervious surface?

**Yes.**

64. How are EMCs and runoff volumes for different land use types aggregated to calculate area-weighted total loadings within a watershed (p. 51)?

**The GIS algorithm aggregates within the individual areas all parcels with like land use codes, to produce a temporary working table of total area by specific land use code.**

- **Runoff volumes are calculated for each land use type by multiplying the runoff coefficient value for the land use by the total area of all**

**parcels of the land use type and then multiplying the resultant value by the rainfall depth. The runoff volume generated by each land use type is then summed to produce the total runoff volume generated in the catchment.**

- **Pollutant loads are calculated for each land use type by multiplying the EMC value for the land use by the total runoff volume generated by all parcels of the land use type. The pollutant loads generated by each land use type are then summed to produce the total pollutant loads generated in the catchment.**

65. Please provide a copy of the look-up table of storm water Best Management Practice (BMP) treatment performance plus formal citations to sources (p. 51). Are these based on actual system performance or on ideal design field tests or bench tests? Are they specifically based on comparable karst bedrock? If not, what were the soils/bedrock conditions for each literature value?

**Virtually no structural stormwater BMPs exist in the Florida Keys and no Keys-specific test data has been identified during the development of the CCAM. Consequently, we utilized the BMP treatment performance characteristics from Monroe County's adopted *Stormwater Management Master Plan,* which were generally derived from reported literature values from field tests. The look-up table for BMP treatment performance contained the Stormwater Component section of the Delivery Order-8 Report. The impact of karst bedrock on BMP performance was not specifically examined in this work, but may be indirectly reflected in the performance data developed in Florida communities that are underlain by karst formations.**

*Allocation of discharged storm water pollutant loads*

66. How is the location of a parcel taken into consideration in assigning storm water discharges/loadings to surface waters versus ground water (p. 52)?

**The catchments used in the CCAM are relatively small, and all catchments have a well-defined interface with the receiving waters. The relative location of a parcel within a given catchment is not considered in assigning stormwater discharges/loadings to surface waters versus groundwater. Consequently, all parcels of a specific land use type are assumed to have the same differential allocation of stormwater discharges/loadings to surface waters versus groundwater.**

67. Are parcel-specific or watershed-specific soils data used (p. 52)? It appears from paragraph #2, p. 53 that such data are not available.

**The surface materials in the Florida Keys are not "soil" in the traditional sense, and do not generally function as soils do in terms of water storage or pollutant removal. Detailed soils data is not available in the Florida Keys. No attempt has been made to assign parcel-specific soils characteristics.**

68, How do the following wastewater treatment technologies differ (Table 3.12, p. 54):

—Secondary treatment
—Advanced secondary treatment
—Advanced wastewater treatment (AWT)
—Best available technology (BAT)

**The listed general wastewater treatment technologies and associated effluent characteristics standards in Table 3.12 are referenced from Monroe County's adopted *Sanitary Wastewater Master Plan* (Master Plan). These treatment technologies and effluent characteristics were evaluated by URS, and subsequently adopted for use in the CCAM, to maintain uniformity with the Master Plan. It should also be noted that these effluent quality standards, set forth by the State, do not specify treatment technologies to be used. Rather, State standards specify effluent quality standards that must be achieved by the treatment process. The general established technology definitions or levels of treatment as defined in the adopted Master Plan are as follows:**

- ***Secondary Treatment*: A biological treatment where organic material in the wastewater is stabilized via biochemical oxidation. Conventional activated-sludge is the most commonly used method of secondary treatment. The effluent characteristics associated with this treatment level listed in the Master Plan are BOD= 20 mg/l, TSS= 20 mg/l, TN= 20 mg/l, TP= 5 mg/l.**
- ***Advanced Secondary Treatment*: Typically a more robust biological treatment and including filtration and disinfection providing additional removal of nutrients (i.e., Nitrogen and Phosphorus). Defined in the Master Plan by the effluent characteristics of: BOD= 5 mg/l, TSS= 5 mg/l, TN= 10 mg/l, TP= 1 mg/l.**
- ***Advanced Wastewater Treatment* (AWT): The term advanced wastewater treatment can have many definitions but typically refers to**

**any additional treatment process or systems required beyond conventional secondary treatment to further remove any constituents of concern. Commonly used treatment processes in advanced wastewater treatment to obtain a higher quality effluent include chemical coagulation, flocculation and sedimentation, activated carbon, ion exchange, microfiltration and reverse osmosis. The effluent characteristics listed in the Master Plan for this level of treatment are BOD= 5 mg/l, TSS= 5 mg/l, TN= 3 mg/l, TP= 1 mg/l.**

- ***Best Available Technology*** **(BAT): Defined in the Master Plan by the effluent limitations of BOD= 10 mg/l, TSS= 10 mg/l, TN= 10 mg/l, TP= 1 mg/l. These statutory effluent standard limitations were set forth by the Florida legislature and are part of a compliance schedule for on-site and community wastewater facilities. The Master Plan recommends adopting BAT standards for Community Wastewater Systems less than or equal to 100,000 gpd and AWT standards for systems greater than 100,000 gallons per day (gpd). The Master Plan recommends On-site Wastewater Nutrient Reduction Systems (OWNRS) as BAT for on-site systems. For community wastewater treatment systems, advanced secondary or AWT would achieve the specified effluent quality standards.**

69. What percent of EDUs are served by unknown wastewater treatment systems (p. 55)? Is this information available by planning unit?

**The Master Plan, based on Department of Health records, estimates 23,000 private on-site systems exist in the Florida Keys. The Cesspool Identification and Elimination Program identified 7,200 as "unknown systems" and approximately one third of the unknown systems were confirmed as cesspools.**

**Records did not correlate wastewater treatment or EDU information with specific lots. Although the Master Plan estimates the distribution of total number of permitted systems, ATU's and unknown systems in Monroe County and within planning units, it does not assign a specific type of wastewater treatment or EDU data to individual parcels. Approximately 80% of its database parcels were incomplete or labeled as "unknown system". It is clear that 80% of the parcels in Monroe County are not cesspools or illegal systems.**

**Using the treatment type distribution per planning area in the Master Plan and best engineering practice, the Project Team assigned corresponding treatment systems to every parcel (nearly 80,000 parcels) in the database that was either incomplete (no treatment system designation) or labeled as "unknown system". Distribution of the type of onsite system to individual parcels was made according to the numbers provided in the Master Plan and**

**per planning unit. As in the Master Plan, cesspools were assigned to the older buildings within the planning unit. Subsequently, EDUs were assigned to parcels using available lot information and water use records. The result of this exercise is that each EDU now has a designated treatment system designation within the database, allowing parcel level analysis of wastewater effluent discharge characteristics and loads.**

70. Can you explain the comments in the final paragraph of page 51? If there are no significant BMPs in effect in Monroe County, what did you use to evaluate potential performance? I am particularly interested in local regulation to mandate pervious surfaces for parking lots/space, which might considerably reduce the stormwater management problem.

**While there are no significant BMPs in effect in Monroe County, BMPs have been extensively implemented and investigated in other coastal communities in Florida, and BMP performance data has been used as the basis for evaluating potential benefits that might be achieved through retrofitting existing development and requiring effective stormwater management systems and BMP in new development and redevelopment.**

**Many parking lots in the Florida Keys are unpaved and visual observation of runoff from these unpaved lots indicates typically high level of suspended solids. A number of the demonstration projects proposed in the *Stormwater Management Master Plan* involve paving of unpaved parking areas at boat ramps. The approach is intended to reduce surface erosion and subsequent transport of the solids into the near-shore waters.**

## TERRESTRIAL MODULE

71. The decay coefficients in Table 3.17 seem rather arbitrary and are attributed only to Mark Brown as personal communication. Are there any data to support them? If I compare the distance required to reduce the habitat degradation index to 10% of its max. value, the distances seem very short compared with the "impact distances" summarized in Table 3.16. For example, low density residential would drop to 10% in just 38 ft and even a four lane highway or industry would go to 10% in 230 ft while the Spackman and Hughes citation reports a buffer requirement of 490–575 ft for 90–95% of bird species. Perhaps the use of relatively rapid decay coefficients leads to the very modest habitat impacts the model calculates.

**The K coefficients are based on the empower density (emergy per time per unit area) and the assumption of a negative exponential decay of empower away from its source to background empower densities. Emergy is**

**Table 3.17 Decay Coefficients by Land Use Type**

| Land Use Type | Empower Density[1] (sej/m$^2$*yr$^{-1}$) | K Value | Distance to Reduce Impacts to 10% |
|---|---|---|---|
| Low density residential | 8.5E+12 | 0.0645882 | 35.5 |
| Medium density residential | 2.19E+13 | 0.0250685 | 92 |
| High density residential | 5.49E+13 | 0.0100000 | 230 |
| Low intensity commercial | 2.88E+13 | 0.0190625 | 121 |
| High intensity commercial | 3.27E+13 | 0.0167890 | 137 |
| Industrial | 5.01E+13 | 0.0109581 | 210 |
| 2-lane highway | 3.08E+13 | 0.0178247 | 129 |
| 4-lane highway | 5.02E+13 | 0.0109363 | 211 |
| Recreational/Open space | 8.3E+12 | 0.0661446 | 35 |

[1]Empower is Emergy per unit time per unit area. Emergy is quality corrected energy; units are solar emergy joules (abbreviated sej).

quality corrected energy expressed as solar emergy joules (sej). Empower is emergy per time (sej/time) and empower density is emergy per time per unit area (sej/m2*yr-1).

The decay coefficients in Table 3.17 in the report were actually carried to 7 significant figures, but for simplicity, rounded off to 2 significant figures in the report, thus the differences in the table below compared to the one in the report. The table below has empower density for each of the land uses. These data are based on studies of urban land uses in Ft. Myers and Gainesville, FL (Brown 1980) Jacksonville, FL (Whitfield, 1994) and additional studies of urban land uses in Gainesville, FL in 1999 (Brown, M.T.; unpublished) The work on empower density and Landscape Development Intensity index of urban land uses is ongoing (Brown et al 1998 and Brown and Tighe, 1989) and we recently have written a working paper describing the LDI (Brown, et al 2002)

The distances described in Table 3.16 range from a modest 25 feet to a maximum of 1,640 feet. These are distances based on a variety of factors and include home ranges, flushing distances, and so forth. Our use of the concept of a relative habitat degradation index was based on loss of habitat values not on home range data or flushing distance. We estimated our decay coefficients based the empower density decay such that the distance where degradation was zero corresponded to the point where the empower density that resulted from a "development source" was equivalent to the empower density of the surrounding natural environment.

References for these data are as follows:

**Brown, M.T. 1980. Energy basis for hierarchies in urban and regional systems. Ph.D. dissertation, Department of Environmental Engineering Sciences, University of Florida, Gainesville**

**Brown, M.T. B Vivas, and J. Kasbar. 2002. Landscape Development Intensity Index: a quantitative measure for assessing cumulative impacts of development. Working Paper 02–01. Center for Wetlands, University of Florida, Gainesville. 8 pp**

**Brown, M.T. , N. Parker, and A. Foley. 1998. *Spatial Modeling of Landscape Development Intensity & Water Quality in the St. Marks River Watershed.* Final Report to Florida Department of Environmental Protection,. Center for Wetlands, University of Florida, Gainesville 143 pp**

**Brown, M. T., and R. Tighe. 1989. *A Florida Pilot Study for the Evaluation of Created and Restored Wetlands.* Final Report to the U.S. Environmental Protection Agency. Center for Wetlands, University of Florida, Gainesville. 51 pp.**

**Whitfield, D.F. 1994. Energy Basis for Urban Land Use Patterns in Jacksonville, FL. MA Thesis. Department of Landscape Architecture, University of Florida. Gainesville. 259 p.**

72. I was not able to ascertain whether the variable of minimum patch size was incorporated in the test scenario results. Does the change of habitat for the seven faunal species (Table 4.22) mean that there are more areas with minimum patch sizes? The text indicates (pp. 97–98) that hammocks smaller than 13 acres are "all edge." Does the "all edge" classification affect the suitability of habitat for any of the species of concern?

**The CCAM evaluates habitat-based variables and species-based variables. Patch size, as discussed in Section 4.2.7, pages 97-98, refers only to habitat. Results show upland habitat fragmentation, and a significantly high proportion of small patches. In the Conclusions (Sect. 5.2, page 110), we state that, because of small patch sizes, ". . . ecological function in upland areas may be depressed in the Florida Keys."**

73, Equation on page 67, is "d" in feet or meters?

**"*d*" is the distance from the developed area in feet.**

74, Equation on page 68 not clear to me—needs clarification.

**The equation should read:**

**Species Richness Index (including indirect impacts) =**

**The equation calculates the average number of species per cell, reduced by its % degradation per cell.**

75. On page 107, the "Forest Interior Bird" results don't make sense—clarify—either text is incorrect or Table 4.22 is incorrect.

**Results will be re-run for verification.**

76. Also re: page 107—what percentage of the acres of "vacant land' were in ADID categories used for the Forest Interior Bird habitat use calculations? Can this be broken down by locations? Put results in a table?

**This will be included in the revised report.**

77. Confusion re: conclusions . . . on page 110 in Section 5.2 it says "The test run of the current conditions scenario show a severe loss of upland habitats in the Florida Keys, as well as further impacts through secondary effects of development. The current distribution of upland habitat patch sizes, in which the vast majority of the patches are small, suggests that ecological functions in upland habitats may be depressed throughout the Florida Keys." . . . But, in Section 4.2.7 for the results of the Smart Growth run, results indicate either "minimal" or "negligible" change from the current conditions run for the Habitat Impacts element and for the Species Richness elements in this module. The Marsh Rabbit shows a 3.5% reduction in habitat, and there appears to be habitat loss for the White Crowned Pigeon, but the model says nothing more about these levels of change. (The results for the Forest Interior birds were confusing and need clarification, see # 4 above). . . . One would think there would be more than a "negligible" or "minimal" effect with additional growth of 10.2%. If the difference is in the reclassification of vacant lands to habitat as 'open space," it is not made clear. If current conditions are so bad that the additional changes with Smart Growth simply can't make it much worse, then that should be said clearly. Otherwise, if the module can't pick up a difference it may need to be modified to be more sensitive to such a level of change?

**"Severe loss" refers to the loss accrued from historical conditions to current conditions. The additional habitat loss and fragmentation from current conditions to smart growth is small. The small effect of smart growth, despite a 10.2% additional growth, reflects the "smartness" of the scenario in selecting mainly low quality, infill lots for new development.**

78. The Land use module does a good job of summarizing results in tables and I'd like to see that used in the Terrestrial Module more effectively. For example, since the majority of population increase in the Smart Growth scenario is on specific locations (e.g., Ocean Reef/PAED 21, Plantation Key, etc.). It would have been very useful to see the relative impacts of the scenario on these specific sites in a tabular form (before and after).

**Results will be presented by planning unit in the revised report.**

*Disturbed habitat*

79. What criteria are used to define a property parcel as a "disturbed habitat area"—the presence of any exotics or some minimum percent cover of exotics?

**The "exotics" ADID classification is used to determine the disturbed habitat portion of a parcel. Only those areas classified as "exotics" in the ADID dataset were defined as disturbed.**

80. What is the data source for determining the presence of exotics?

**The ADID GIS layer from the Florida Marine Research Institute.**

*Environmentally sensitive areas*

81. What criteria are used to define a property parcel as an "environmentally sensitive area"?

**Any of the wetland vegetation types from the ADID data.**

82. What is the data source for defining environmentally sensitive areas?

**The Florida Marine Research Institute's Advanced Identification of Wetlands GIS layer.**

*Undisturbed habitat*

83, What criteria are used to define "at least 10 acres of contiguous undisturbed habitat"? Must the 10 acres be within a single property parcel, or can the 10 acres be constructed by aggregating multiple property parcels?

**This criterion is based on current Monroe County regulations related to vegetative community connectivity. The 10 acres can be aggregated from areas of undisturbed habitat on multiple, contiguous parcels.**

84. What vegetative cover types are used to define "undisturbed habitat"?

**Any ADID vegetation type other than "developed" or "exotic."**

85. What is the data source for defining undisturbed habitat?

**The Florida Marine Research Institute's Advanced Identification of Wetlands GIS layer.**

86. Has any use been made of the State Game and Freshwater Fish Commission's 1994 report, "Closing the GAPs," to identify important habitat areas?

**We used the updated (2000) version of the study extensively. We used their methods to develop habitat models for seven species. The habitat richness map and index were created using their approach and species selected from their study.**

## QUALITY OF LIFE

87. The quality of life section is so vague that I have no idea how it was developed and calculated. Can you give us a better description of this component? For example, how were the values in Table 3.21 calculated and how were they used "to help determine the components of each module, and the end points . . . quality of life issues."? (p. 70).

**The PIIP (prepared by another contractor) describes the methods by which the seventeen criteria or parameters were ranked. In the test CCAM, we looked at the sign (+ or -) of the change in each parameter based on the results of the model.**

**We understand the PIIP has been provided to the NAS.**

## SCENARIO SELECTION PROCESS

88. What are the implications of changing a land use category to "open space" (Table 4.1, p. 73)? Does this preclude future development of all kinds? Does it require public acquisition?

**The underlying assumption is that public acquisition is involved, and that these lands would be preserved for conservation (i.e., undeveloped) in perpetuity.**

89. What is a "red flag" wetland (Table 4.1, p. 73)

**Definition taken from the Florida Keys Advance Identification of Wetlands (ADID) Project Technical Summary Document, 1998: "Red flag wetlands were those that clearly exhibited a high level of integrity in community**

**structure, size, landscape position and other features." Monroe County has imposed strict limits for development in these wetlands.**

90. How are lands listed for CARL acquisition treated?

**For the Smart Growth scenario, all vacant land (according to the parcel data) within a CARL boundary were selected and converted to open space, with the exception of Ocean Reef Club.**

91. Explain the extent to which the "Smart Growth" scenario differs from a scenario that would represent build-out in conformance with the current future land use element of the Monroe County comprehensive plan and applicable land development regulations.

**The "Smart Growth" scenario, developed by local planners, assumes extensive public acquisition of vacant land for conservation purposes and a heavy emphasis on redevelopment and infill, which local regulations have not explicitly or particularly favored until recently. Therefore, a build-out scenario would result in significant additional growth as compared to smart growth.**

***Publicly owned conservation areas***

92. What criteria are used to define these—CARL lands already acquired?

**The PC Code, in conjunction with both ownership and zoning data in the Taxroll, was used to identify publicly owned conservation areas.**

93. What assumptions are made about habitat type and quality of these areas?

**No assumptions are made about the habitat type or quality of the publicly owned areas. Information regarding the habitat type for a particular area is derived from the ADID dataset in the terrestrial module.**

***Subdivisions***

94. Is the percent of subdivision development based on the number of individual parcels developed or on the percent of allowable density that has been built?

**The percentage is calculated from the number of parcels developed within the subdivision.**

95. When a partially developed subdivision is included as "vacant land" is it only the vacant portion of the subdivision that is included in the scenario?

**Yes, only vacant lands become developed.**

96. How are property parcels that are more than 300 feet from US 1 included in a scenario?

**Proximity to US 1 is used as a suitability criterion and as an option in the GUI. Regarding the suitability analysis, vacant parcels close or adjacent to US 1 are more suitable for commercial development than those that are not. The final model will have a GUI option allowing the user to choose parcels without regard to distance from US 1.**

***Residential land use input screen***

97. Why are parcels < 5000 sq. ft. considered substandard (Table 4.1, p. 73)?

**See response to (23) above. In order to input the Smart Growth scenario into the model, the team had to interpret to some extent the use of the term "substandard," the criteria for consideration were primarily suggested by the local planners.**

98. Why are structures < 1200 sq. ft. considered substandard (Table 4.1, p. 73)?

**See response to (23) and (97) above.**

99. How are structures 5 years old or less included in a scenario?

**Structures less than 5 years old would generally be considered less likely candidates for redevelopment. Such structures would be included in the scenario by not checking the option to select land according to age of structure. The final model will have a GUI option to disregard the age of structure in the residential change from conditions.**

***Commercial land use input screen***

100. How are structures 20 years old or less included in a scenario?

**The age of the structure is only a factor in a redevelopment scenario. This criterion was recommended to the contractor for redevelopment scenarios by local planners, based upon their experience in the Florida Keys. If warranted, alternatives to the age of structure may be added to the GUI in the final model.**

101. Why are commercial parcels developed at < 19% FAR considered "blighted" (Table 4.1, p. 73)?

**The under-development/under-utilization criterion is not used by itself in this scenario to indicate blight, but as one of several conditions, which together constitute substandard conditions or likely candidates for redevelopment.**

102. Why are commercial structures assessed at < 33% of the land value considered "blighted" (Table 4.1, p. 73)?

**See response to 101.**

103. Why are commercial structures > 20 years old considered "blighted" (Table 4.1, p. 73)?

**See response to 101.**

104. Why are commercial structures < 1200 sq. ft. considered "blighted" (Table 4.1, p. 73)?

**See response to 101.**

***Parameter settings for the two scenarios presented in the draft report***

105. How was the "Current Conditions" scenario defined?

**The PC code from the current Monroe County Property Appraiser's Office was used to define current conditions land use.**

106. Were existing land uses assigned parcel by parcel?

**Yes, using the PC code from the Monroe County Property Appraiser's tax roll.**

107. How was the "Smart Growth" scenario defined?

**The "Smart Growth" scenario was developed by the local planners after a series of working sessions with the study team. The scenario was discussed at this workshop with the other local planners, who agreed it was one plausible vision for the future development of the Florida Keys.**

108. How was vacant land defined for this scenario?

**Vacant lands are all lands with a tax roll PC code of 00, 10, 40, or 70.**

109. What is meant by "habitat lands" in the section entitled "Maximum protection of conservation lands" (pp. 71–72) and by "habitat polygons" in Table 4.1 (p. 73)?

**Habitat lands include all areas with upland or wetland vegetation cover. This does not include exotics.**

110. How were the new park sites selected on Big Pine and Sugarloaf Keys (p. 72)?

**It is assumed that the conversion of vacant land to open space will result in the creation of the parks.**

111. How were the 3,000 dwelling units allocated to subdivisions with 75% or greater development to simulate "a random lottery system" (p. 72 and Table 4.1, p. 73)?

**The queries to find parcels that met these criteria resulted in less than 3,000 units. Therefore, all of those parcels were developed in this scenario. Otherwise, the units are allocated based on the parcel's suitability for development.**

112. What type of residential development is assumed to occur under "current zoning restrictions" in redeveloped trailer parks and on substandard residential lots (p. 72 and Table 4.1, p. 73)?

**The smart growth scenario referred to substandard structures, not necessarily substandard lots. The replacement development complies with the current zoning.**

113. How was commercial redevelopment assigned to 25% of the "blighted" commercial parcels among the planning units (p. 72)?

**The commercial redevelopment criteria resulted in a very small number of eligible parcels to be redeveloped. Therefore, all parcels that met the criteria were redeveloped in this scenario.**

114. How did the redeveloped commercial use differ from the existing use besides application of default stormwater and wastewater management—maximum allowable FAR? (Table 4.1, p. 73)?

**Yes, maximum FAR and stormwater and wastewater treatment.**

115. How was the 700,000 square feet of new/expanded commercial development allocated among the planning units, i.e., if all other conditions are equal, how is it decided in which planning unit to place a given amount of new commercial development? (p. 72 and Table 4.1, p. 73)

**The commercial development element of the smart growth scenario provided specific criteria that defined the selection of the vacant commercial lands. These criteria provide the constraints for available land in each planning unit. Parcels are chosen randomly from within this selected set for each planning unit.**

116. What methods of stormwater management for existing industrial and marine sites and county owned buildings are considered to be "consistent with current regulations" (p. 72)? How realistic are these for existing development retrofits, e.g., is there land available upon which to construct the systems?

**A variety of structural and non-structural BMPs have been implemented in other coastal communities in Florida to treat stormwater originating from existing industrial and marine sites and county owned buildings, and there is no reason to believe that these BMPs would not perform equally well in the Florida Keys. Some of the potentially implementable controls include:**

| **Structural Controls** | **Non-Structural Controls** |
|---|---|
| **Perimeter Swales** | **Porous Pavement** |
| **Contained Constructed Wetland Systems** | **Periodic Sweeping** |
| **Detention Ponds with Skimmers** | |
| **Retention Ponds with Skimmers** | |
| **Pre-Treatment Ponds Connected to Wetlands** | |
| **Sedimentation Vaults** | |
| **Treatment Vaults** | |

**In the general scheme of overall environmental management in the Florida Keys, we believe that these controls are realistic for existing development retrofits. Several of the demonstration projects proposed in the *Stormwater Management Master Plan* involve retrofitting existing areas and illustrate that water quality management can be achieved at reasonable costs.**

117. How were the blighted individual industrial and marine sites selected to accomplish the specified 50% retrofitting, i.e., how was it decided which of the blighted sites should be retrofitted (Table 4.1, p. 73)?

**Due to the small number of parcels meeting these criteria, all areas that met the blighted industrial and marine sites were selected.**

118. What form of landscaping is assumed for retrofitted industrial and marine sites, county owned buildings, and US 1 (p. 72)?

**The use of maintained landscaped area—essentially a shallow intermittent pond area—for attenuating and treating stormwater runoff relies upon two design concepts:**

- ***Depression Storage* is used to attenuate flows to reduce discharge rates and allow sedimentation to reduce suspended solids concentrations prior to discharge to receiving waters.**
- **Planted areas in dry ponds, preferably sod in the central portions of the depression areas, can provide limited benefits in terms of reduction of fine solids, fixation of metals, sorption of oils/greases on vegetative surfaces, and bio-fixation of nutrients.**

**The surficial deposits and underlying geology of most of the Florida Keys prevent the maintenance of a wet pond system, thereby generally precluding the use of a littoral shelf. Similarly, the lack of real "soils" also precludes filtration of finer particles and binding of metals in the soils matrix, which benefits much of the peninsular portion of the State.**

119. What specific stormwater management techniques are assumed to be used as a result of implementing the Stormwater Master Plan for all state and county highways and new developments (pp. 72, 86)?

**The *Stormwater Management Master Plan* suggests that the retrofitting process be accomplished through a large number of small projects over a continuing long-term implementation process. Specific management techniques are discussed in some detail in the *Stormwater Management Master Plan***

**The demonstration projects discussed in the *Stormwater Management Master Plan* generally focus on retrofitting existing areas, but the techniques can be used equally well in new development and redevelopment, often at lower overall costs, and illustrate that water quality management can be achieved at reasonable costs.**

120. What are the "default" stormwater treatment methods referred to in Table 4.1 (p. 73)?

**On-site retention of stormwaters.**

121. What are the "default" wastewater treatment methods referred to in Table 4.1 (p. 73)?

**The treatment methods referenced to as "default" in Table 4.1 of the Delivery Order-11 draft report are the treatment methods and standards recommended for implementation in Monroe County's adopted Master Plan. The Master Plan specifies treatment levels according to the existing/proposed WWTP's location and size.**

122. Which "default" wastewater management technology is assumed to be used in place of existing cesspits (p. 72 and Table 4.1, p. 74)?

**The "default" wastewater management technology the Wastewater Component uses to replace existing on-site systems located in lower density areas of the Keys is the On-site Nutrient Reduction Systems (OWNRS) as prescribed in the adopted Master Plan.**

123. What other wastewater management changes are assumed to be accomplished through "full implementation" of the Wastewater Master Plan (p. 72)? Are these the changes summarized on p. 86? If so, why are some upgraded existing and new WWTPs assumed to be BAT versus AWT?

**Other changes that are incorporated in the Wastewater Component include the following "upgrades" recommended in the County's Master Plan:**

- **Existing on-site systems located in lower density areas of the Keys be replaced or upgraded with On-site Nutrient Reduction Systems (OWNRS).**
- **Development of "community" wastewater collection and treatment systems for 12 specific service areas**
- **Development of "regional" wastewater collection and treatment systems for 5 specific service areas**

- **WWTPs with design flows less than or equal to 100,000 gpd are converted to systems that will achieve BAT standards for effluent discharges**
- **WWTPs with design flows greater than 100,000 gpd are converted to treatment systems that will achieve AWT treatment standards for effluent discharges**

124. How do assumptions about water conservation affect scenario outputs (p. 72)?—Reduced wastewater loadings? Other impacts?

**Implementation of water conservation measures are directly factored into the consumption rates for EDUs, which in turn produce reductions in accumulated flows by planning unit which impacts aggregate demand, thereby eliminating/delaying expansion of wellfield and water treatment capacities. Similarly, the reduction in potable water demands at the planning unit level directly reduces the cumulative flow rates in the FKAA pipeline, thereby eliminating/delaying expansion of supply pipeline and pumping capacities.**

**In a parallel consideration, reduction of potable water flow will reduce wastewater generation rates. Water conservation measures are expected to occur in the form of more efficient toilets and low-flow showerheads, which reduces the volume of wastewater but tends to increase the concentration of pollutants. We anticipate that water conservation measures should have virtually no effect upon the net pollutant load.**

## TEST SCENARIO RESULTS

125. I am confused about Table 4.12. This table compares LOS along Rt. 1 under current conditions and with the smart growth scenario. The last sentence on p. 84 concludes that "The LOS remains unchanged in the Smart Growth scenario for all planning units except Plantation Key." However, it seems to me that 21 out of 26 units show a decline in LOS between current conditions and smart growth. And Plantation Key drops from C to F, not D to F as stated in the text. What am I missing? This point comes up again on p. 85, Part 2, because LOS interacts with hurricane evacuation and you have assumed no change in LOS despite the fact that Table 4.12 seems to show a large number of declines, some quite severe (e.g., Upper Matecumbe goes from A to D).

**These results came out of the computer late in the document production process and the text was not edited to reflect the corrected results. The table is correct. The text is not.**

126. How do you relate the Test Scenario Results on page 74, which indicate there is an increase in non-residential development of 550 acres under the smart growth scenario and 5.9 million sq. ft. on p. 78, with the narrative on p 72 that only 700,000 sq. ft. will be permitted on vacant land and effectively no increase in redeveloped lands?

**In our continuing efforts to test the model, we found that an incorrect selection statement was made in the smart growth scenario, by which *all* vacant non-residential lots were selected for development.**

127. How is it possible (p. 74) that "Vacant land residential is the second largest land use" in the Smart Growth scenario?

**The smart growth scenario resulted in very little development throughout the Keys; therefore, leaving many of the vacant parcels undeveloped.**

128. On p. 81, the Housing Affordability Index discussion indicates that most of the planning areas have income levels well below what will be needed to purchase housing. That's important, but how relevant is this to likely economic conditions of the Keys? If there is an emphasis on tourism and hotel employment, workers in those industries (who are essential and may well be transient) are unlikely to consider buying property. Beyond housing purchase, what is the situation regarding the affordability of renting apartments and houses, and are there any initiatives on the part of the hotel industry to provide housing for their workers?

**The primary purpose of the Housing Affordability Index is to identify potential locations for housing that is affordable by moderate-income households.**

## ADDITIONAL CCAM QUESTIONS 1/2/02

These questions deal almost exclusively with the Integrated Water Model.

## SECTION 3.5

129. P. 45. Use of Central Values. Does this imply that the median concentration, etc., has been used? Or is the mean used? Although it would not seem reasonable to take the maximum or a high percentile from such a range, neither does use of the median or mean seem like a very conservative assumption. The 10th and 90th percentiles are listed along with

the median(?) in Appendix C (Table 4.4, p. 198). How were these values used?

**Mean values are used in the reporting of Event Mean Concentration (EMC) values per the protocols established by USEPA for the stormwater aspect of their NPDES Program. Use of the mean concentration values for pollutant concentrations is a standard practice in stormwater management programs.**

**The 10th and 90th percentile values are not currently used in the computation of pollutant loads in stormwater runoff, but were included to allow the user to assess the uncertainty associated with the default values that have been used in the look-up table in the Stormwater Component.**

130. P. 48. Rainfall. Monthly rainfall values were used to drive the stormwater runoff model, for average, wet, and dry years. These averages not only miss extremes (e.g., high intensity bursts during typical thunderstorm rainfall) but also ignore the variation inherent in a long-term rainfall record (e.g., sequences of wet and dry periods). Please justify the use of monthly averages over, at least, daily values (apparently available for the Keys), or better, hourly rainfall values. Why wasn't continuous simulation used, since it could be employed even on a spreadsheet with the simple runoff and loading models used? If a sensitivity analysis or other comparative analysis was performed to justify the use of monthly averages, please show this. There is no list of stations used or other background presented in Appendix C. Please provide tables or other documentation of:

a. Rainfall locations analyzed.
b. Availability of hourly and daily data.
c. Any statistical comparisons made.
d. Any comparisons made using monthly averages vs. continuous simulation using daily or hourly values.

**The Project Team appreciates the significance of rainfall event variability and the importance of hourly rainfall in developing rainfall-runoff models and the significance in annual variability and cyclic rainfall patterns. However, the CCAM is not a conventional event simulation model that uses a fixed time-step and a series of specific simulation events to predict time variable flow, stage and pollutant flux values for specific locations. The Florida Keys has very little conventional drainage infrastructure and virtually no treatment facilities. Existing facilities are generally not mapped and no data is available on the actual discharge characteristics of stormwater runoff to the receiving waters. To a large extent, the anecdotal observation**

**that "whatever hits the Keys is in the near-shore waters 20 minutes later" tends to have high creditability.**

**The CCAM was developed to consider normal seasonal effects in a quasi-steady state modeling environment, using available data, for planning purposes. Data limitations control the extent to which a detailed model can be developed. Time and budget constraints imposed upon CCAM development, coupled with limitations imposed by the size/scale of the model, its inter-module connectivity, and available computational/processing capacity, precluded the development of a more comprehensive simulation approach in CCAM, or the use of continuous simulation using daily or hourly values.**

**Sensitivity analysis was not conducted as part of this work. Detailed station listings and rainfall data characteristics are presented in the Delivery Order-8 report.**

131. P. 49. Atmospheric Deposition. Presumably any atmospheric deposition will be incorporated into "background" effects. Since atmospheric deposition may be expected to increase with increasing population around the Gulf, is there any basis for assessing the relative impact on marine waters (e.g., vs. stormwater, wastewater, groundwater loadings)?

**Atmospheric deposition has been treated in two different manners within the CCAM in the Stormwater and Marine Components of the Integrated Water Module:**

- **Atmospheric deposition was considered to be a component of the pollutant load washed off land surfaces, which was accounted for in the EMC values used for specific land uses. The runoff volume, with its attendant pollutant load, is routed to both the near-shore waters and groundwater system depending upon the impervious characteristics of the individual land uses.**
- **Atmospheric deposition was also included as an input source for the marine waters for selected pollutants.**

132. P. 51. Computation of EMC Values. What are the ten communities from which data were used to estimate stormwater loads. What were the results of the uncertainty analysis?

**Detailed information on the communities that were used in developing the EMC values for the selected pollutants, as well the EMC values for the communities, are presented in the Delivery Order-8 report.**

133. P. 51. Stormwater BMPs. Please present some additional explanation (in lieu of having the Monroe County Stormwater Master Plan) about

how conventional BMPs evaluated elsewhere in Florida are expected to perform in the geology of the Keys. How was expert opinion used in estimating BMP effectiveness (p. 110)? Who were the experts consulted?

**Detailed discussion of the rationale for adopting BMP performance characteristics from other Florida communities for use in the Florida Keys, as well as the performance characteristics, are presented in the Delivery Order-8 report. Eric Livingston of the Florida Department of Environmental Protection, and Scott McClelland of CDM (Monroe County's stormwater consultant) were consulted with respect to the values and the potential issues arising from the surface materials and geology of the Keys.**

134. P. 52. Pollutant Load Reductions. Are constant removal rates (load reductions) used regardless of incoming concentrations? There is some evidence (Strecker et al., 2001) that BMPs tend to produce a defined output concentration range regardless of the influent concentration. Was the ASCE-BMP database of any use here? (http://www.bmpdatabase.org/)

**Strecker, E.W., Quigley, M.M., Urbonas, B.R., Jones, J.E. and J.K. Clary (2001) Determining Urban Storm Water BMP Effectiveness. *J. Water Resources Planning and Management*, Vol.127, No. 3, pp. 144-149.**

**Constant load reductions are used in the Stormwater Component since the CCAM does not consider highly variable pollutant input concentrations and, consequently, has no provision for variable treatment efficiencies.**

**The ASCE-BMP database was reviewed as part of this work to see if any Keys-specific data was available for any BMP—there was no data. Consequently, the BMP efficiencies from Monroe County's adopted Stormwater Management Master Plan were utilized in the Stormwater Component.**

135. P 54. Treatment Loads. How is the impact of cruise ships at Key West included in waste treatment loads? Is there any dumping problem from small craft in harbor areas? Is the small craft population included in EDUs?

**Increased wastewater loads associated with cruise ships in Key West were reviewed as part of this work. The Project Team concluded that, in the context of the CCAM, that there would be no appreciable impacts because the wastewater flows are intermittent, are treated in the Key West WWTP, and are relatively minimal in terms of flow and loading impacts on the WWTP. Perhaps the more important factor in the finding of no appreciable impact is the fact that the Key West WWTP discharges to a deep-well (2,000+**

**feet) disposal system and is idealized in the Groundwater Component as being "lost" forever with no return to the marine waters.**

**No way of estimating equivalent EDU and assigning spatial coordinates, based upon the existing small craft population (approximate numbers only, no geo-spatial data), has been devised—despite a number of attempts—that the Project Team felt was viable and technically defensible. Consequently, wastewater flows associated with small craft are not included in the current version of the CCAM.**

136, P. 56. Gross Pollutant Loads. There is some discussion of pathogens (e.g., bacteria) late in the report (p. 110) and in Appendix C (pp. 214+). It would seem like beach closing, violation of coliform standards, etc. are well-defined impacts of population growth, sewage discharges etc. Why is there not more attention paid to pathogens? Similarly, water quality in finger canals will likely be more objectionable to residents than in open coastal waters. Would this highly localized water quality result in some limit on growth, especially since finger canals are difficult to protect using stormwater BMPs?

**The Project Team is aware of several studies of pathogens and a number of beach closings related to pathogen concentrations. Unfortunately, the available data is not sufficient to document background conditions within the Florida Keys, develop a defensible GIS coverage, or support development of an algorithm for generation/decay and transport of human pathogens.**

**Little detailed information is available concerning the depth and cross-section characteristics of canals, their flushing characteristics, or ambient water quality data.**

## SECTION 3.6

137. P. 58. Dispersal Model. The model essentially predicts the concentration in a plume discharged perpendicular to the shore, well illustrated in Figure 4.7 (p. 91). What are Florida's mixing zone regulations? How are comparisons made with the sampled data for N:P of Figs. 4.8–4.11? That is, how are the localized, individual plumes combined for comparisons of the type discussed on p. 92?

**The marine waters of the Florida Keys are designated as Outstanding Florida Waters. State regulations prohibit discharges that would increase the concentration of the pollutant over ambient levels. The main comparison we made was between the highest predicted concentration and ambient values recorded through the Water Quality Monitoring Program (EPA).**

138. P. 58. Dispersal Model. Is there any calibration or verification of the dispersal model? How was a choice of transverse dispersion coefficient (1 $m^2/s$) made?

**Based on the data of Okubo, (1971) as reported by Fischer et al. (1979) and Chapra (1997) we estimated the horizontal turbulent diffusion coefficient was at the midrange of the coefficients characteristic of lakes and oceans. In the next several months we will program the look-up tables in the spatial simulation portions of the dispersal model with other values to evaluate the impact of using both lower and higher values on resulting water quality. However, so far the dilution effect of near-shore waters are the controlling variable.**

**References;**

**Chapra, S.C. 1997. Surface Water Quality Modeling. The McGraw-Hill Companies, New York. 844 p.**

**Fischer, H.B., E.J. List, R.C.Y. Koh, J. Imberger, and N.H. Brooks. 1979. Mixing in Inland and Coastal Waters. Academic Press, New York. 483 p.**

**Okubo, A. 1971. Oceanic Diffusion Diagrams. Deep Sea Research 18:789-802.**

139. P. 59. Dispersal Model. If depth varies, velocity, u, will not be constant. In fact, would not a 2-dimensional formulation for velocity be more appropriate (using flow per unit width instead of velocities) if measured circulation patterns are used?

**Possibly. In our original formulation of the dispersal model we anticipated acquiring velocity data with a much higher spatial resolution than we actually were able to obtain. In light of this fact, we could have used the 2-dimensional formulation suggested. However, as dilution is the main controlling parameter in the determination of concentrations of nutrients and pollutants in the marine environment, the reformulation of velocity may not make much difference.**

**We used depth and velocity data from independent sources. Depth was obtained from bathymetric maps, and velocities were extracted from existing effort to measure circulation patterns in the Florida Keys.**

140. P. 59. Dispersal Model. The concentration decreases continuously with distance off shore. At what distance or location are predictions made for later comparisons with standards? Are concentrations from overlapping plumes combined?

**We compared concentrations at the highest point—immediately nearshore—against ambient data.**

**Concentrations from overlapping plumes are summed.**

***Section 4 Test Scenario Results***

141. General questions: A remarkable result of the Study is that water quality gets better as more growth occurs, due to use of better technology for stormwater management and wastewater disposal. How realistic is the assumption that 1) the technology will work, and 2) the technology will be implemented as proposed? Does the Smart Growth scenario assume that 100% of stormwater runoff, including highways, will be retrofitted and controlled? Similarly, will 100% of existing cesspits be upgraded? Apparently there is a 20-year time frame for implementation of the Smart Growth scenario. Will the schedule of implementation keep up with the forecast of population growth (so that the rate of population increase and its increase in loadings will not outpace the rate of improvements due to implementation of improved technology)?

**The model runs assumed that the technology will work and that it will be implemented as proposed in the Stormwater and Wastewater Master Plans. Master plans have a 20-yr implementation schedule.**

**We will not comment on whether these assumptions are "realistic."**

142. P. 85. Hurricane Evacuation. The evacuation times with and without population increase seem highly optimistic (on the order of 27 hours). What provisions are available for the people unwilling or unable to leave during a hurricane?

**No provisions are made to account for people unwilling or unable to leave.**

143. Pp. 85+. Apologies if this is explained clearly elsewhere, but how are the seasonal population changes and influx/efflux of tourists included in EDUs used to drive the wastewater loadings?

**Seasonal population variations—consisting of seasonal residents, tourists, and day trippers driving down from Miami—were taken into consideration by correlating FKAA water sales records for the Keys with the parcel database. As in Monroe County's adopted *Sanitary Wastes Master Plan*, all the potable water provided to the Keys was converted into wastewater. Total EDUs represent approximately 185% of the permanent resident EDU, showing the significant loads imposed on the Keys by seasonal population.**

144. Pp. 87+. Several tables are presented of pollutant loads but they are separated for each component. Please present one or more tables with *all* loads by source (i.e., stormwater, wastewater, groundwater, etc.) so that an easier comparison can be made of the relative contributions of each. Do this for the current and proposed scenarios discussed, loading reductions by BMPs and treatment, etc. The idea is to be able to identify the most important sources and the most likely reductions.

**The pollutant loads developed, treated and routed in the CCAM are contained within temporary work tables that are manipulated through the GIS programming, but not saved as an output report. Due to our intent of returning comments to NAS within a short time, we cannot comply with this data management/reporting request.**

**We will work on the development of an integrated load-tracking table after the issuance of these review comment responses that will provide a summary of pollutant load components for a representative catchment for both scenarios. We will bring this summary table to the interview session on January 17th and will be prepared to discuss its basis and contents.**

145. Pp. 87+. Are there any loading tables for specific locations (e.g., Key West), that are contrary to the reduction in loads forecast for the overall Keys? Do the all-inclusive tables for the overall Keys hide any local problems? Is it safe to generalize the fairly optimistic loading scenario based on these overall tables?

**We are not sure what is being asked in this question. Loadings are developed for each catchment, and then aggregated to the level of the planning unit, and thence to the entire Study Area. It is possible that there may be one or more largely undeveloped catchments that, when fully developed in a scenario with whatever structural interventions are elected by the CCAM user, may show increased water quality impacts. We have not checked the current scenarios for this possibility.**

**The "fairly optimistic" characterization of the reported loading scenario represents a value judgement on the part of the reviewer—the Project Team has made no judgment as to whether the loading scenario is optimistic, pessimistic or otherwise. We believe that it is a fair and accurate assessment of current loading conditions based upon available data.**

146. Were there any comparisons of water model predictions (concentrations, loads, etc.) with monitored data, either on land or in the coastal zone? That is, are there any calibration or verification studies?

**Besides the comparisons discussed above between calculated and observed concentrations, no other data exist to verify the loads.**

## MARINE MODULE

147. Fishing pressure—appendix (pg 200) indicates that it will be treated graphically and not spatially in CCAM. However, I cannot find any mention of it in the actual text.

**As with other marine issues, insufficient data exist to "model" a relationship between "land development activities" and parameters such as prop scars and fishing pressure. We understand that many of these issues are management issues, not land development-dependent issues.**

**Graphs of fishing pressure are shown in the report on pages 203–205. Additional graphs showing trends in Catch Per Unit Effort for all indicator species are shown in the errata for Appendix D, pages 3–4.**

148. The Water Module serves as an input to the Marine module but the definitions of watershed areas are unclear as presented. They use watershed and catchment interchangeably but define only watershed in appendix (p. 153) and on pg 51 of the text. I have always viewed a catchment as smaller than a watershed and I think they should use only one, well-defined term throughout the document.

**Watersheds and catchments have been used interchangeably within the context of the Integrated Water Module. We agree that a catchment is a subset of a watershed. Having said this, each of the planning units could conceivably be defined in terms of two watersheds—The Florida Bay watershed containing those catchments that discharge to Florida Bay, and the Atlantic watershed containing those catchments that discharge to the Atlantic Ocean. However, given the relatively small size of the resulting watersheds, there is no particular benefit to creating watersheds for each planning unit. We will revise the discussion of the subunits in the Water Component to use the term catchment exclusively.**

149. It appears to me that the issue of the lack of quantitative data relative to the issue of seagrass loss from propeller scars and fisheries species might still be used if the CCAM authors use only the segment of the relationship where it is linear. It is clear from Thayer *et al.* 1999 that seagrass density is related to fish density regardless of any non-linearities that might exist. That is, reduction of seagrass, regardless of species

composition changes, is quantitatively linked to fish density of canopy species. I think the CCAM authors should reconsider this omission. The CCAM authors should also examine Koenig and Coleman 1998 (*Transactions of the American Fisheries Society* 127:44–55) for similar data from Florida on seagrass density and density estimates of groupers and Sogard *et al*. 1987 (*Marine Ecology Progress Series* 40:25–39) for data from Florida Bay seagrass.

**The CCAM intends to determine the ability of the Florida Keys ecosystems to withstand all impacts of "additional land development activities". Insufficient data exist to make a connection between land development and loss of seagrass. Another report within our study, prepared by Florida International University did not find a significant statistical relationship between developed areas and the distribution and composition of benthic communities within 1 km from shore.**

## TERRESTRIAL MODULE

150. The CCAM apparently does not consider the key deer directly in the document. They indicate on pg. 68 that an ongoing HCP is underway and that the "Scenarios incorporate the findings of the HCP." I cannot find where this has occurred and is a large and continual oversight of the CCAM.

**The Key Deer HCP is nearing completion. Monroe County has already committed to a moderate amount of development in Big Pine Key for the next 20 years. This is reflected in the definition of the Smart Growth Scenario. Any future scenario will incorporate the same amount of development in Big Pine Key.**

151. The CCAM authors apparently did not consider our interim report document as we indicated that mangroves must be considered either as part of the marine or terrestrial sections. Mangroves on their own are important and as indicated in the terrestrial module, they are critical habitat for a number of species (Tables 3.15, 3.18, and 3.19) that the CCAM does address. Mangroves are being impacted and fragmented and must be incorporated into CCAM.

**Mangroves are included in the Terrestrial Module, just like any other habitat type. The smart growth scenario avoids development in mangroves, thus no impacts are detected.**

**Our historical vegetation study shows a 16% decrease in the total acreage of saltwater wetlands (including mangroves) and an increase of 74% in the number of saltwater wetland polygons from 1945 to 1995. Mangroves *have been* impacted and fragmented, but the smart growth scenario includes *no additional impacts* to mangroves.**

## GENERAL ISSUES

152. There are a great number of misspellings, citations not found in Literature Cited (many!), incorrect (old) scientific names (pink shrimp, p. 200) and other editorial requirements that must be corrected prior to the final document. The document is also poorly organized.

**Results were pouring in to the last minute of report preparation. The report itself will be edited and improved as it is revised.**

153. I think it would be very useful to have a table somewhere early in the document that organizes all data input and output by the "scale" of calculation. This would allow us to directly access these important data.

**Appendix C includes all look-up values, relationships, and thresholds used in the model.**

### *Smart Growth Scenario*

*(as provided to us by the local planners)*

**A Smart Growth initiative will be implemented in Monroe County to preserve the natural environment, redevelop blighted commercial and residential areas, remove barriers to innovative design concepts, reduce sprawl and direct future growth to appropriate infill areas.**

**All CARL lands and any adjacent habitat areas will be closed to future development and purchases in an accelerated acquisition program, In sparsely developed areas, a one thousand (1000 ft. ) buffer will be designated around the boundary of the CARL/Habitat areas and any land within this boundary also designated for purchase.**

**Infill will only be permitted on suitable parcels and will include those subdivisions, that are at least 75% (50%?) developed. The number of lots (maximum of 3,000) remaining in these subdivisions that are scarified will be permitted in a lottery system over the next 20 years. Scattered lands**

within subdivisions that contain habitat or redflag wetlands will be purchased and a conservation easement placed on the lots to prevent future development. Ocean Reef and other subdivisions, that are vested will continue to build out on lots with habitat, but red flag wetland lots will not be filled and developed.

In the Urban Residential District and the Suburban Commercial District in Key Largo/Tavernier, and from Stock Island to Big Coppit an additional 500 multi-family, affordable housing units will be developed on scarified lands at a density of 15 to 20 units per acre. Redevelopment of trailer parks and other substandard housing throughout the Keys will be at the existing density, above base flood, and with sanitary sewer.

Twenty-five percent of the existing commercial stock will be redeveloped, resulting in improved stormwater management and landscaping. Infill sites for commercial development will be within 200 feet of existing commercially developed areas. A total of 700,000 square feet of commercial will be permitted over the next 20 years either in expansion of existing uses or in infill sites. Institutional uses will be deducted from the 700,000 square feet, although they will not have to compete for square footage.

Fifty percent of the existing Industrial and Marine Industrial sites will be cleaned up and redeveloped with stormwater management and landscaping. Future uses will be of a more light industrial nature. All County owned buildings would be landscaped and retrofitted for stormwater management.

Two additional Parks of 5–10 acres each will be developed in the lower Keys; one on Big Pine Key and one on Sugarloaf.

With full implementation of the Overseas Heritage Trail and the Scenic Highway program, US#1 will be landscaped the full length. The stormwater management plan will be implemented on State and County roadways and for all new development. The sewer master plan will be fully implemented with the removal of all cesspits. An active program of water conservation will be instituted for existing development; the building code will assure new development conserves water.