3.0 CARRYING CAPACITY/IMPACT ASSESSMENT MODEL

3.1 KEY CONCEPTS AND PROCESSES

The Carrying Capacity/Impact Assessment Model (CCIAM) is a spatially explicit, Geographic Information Systems (GIS) based, automated computer model that evaluates the end-state effects of additional land development activities on the Florida Keys ecosystems, including impacts on socio-economics, fiscal, and human infrastructure. Land development activities modify land use patterns, including the type, location, intensity, and distribution of land uses. Therefore, changes in land use trigger the CCIAM analysis. The user defines alternative scenarios by modifying land use patterns and specifying stormwater and wastewater treatment types. The model recognizes three types of development actions: new development, redevelopment, and restoration. New development considers the conversion of undeveloped areas, whether disturbed or in a natural state, to a developed land use. Redevelopment either converts developed land from one type of use to another or changes the intensity of the land use. Restoration reverts developed land to a “natural” or restored habitat. CCIAM is designed so that all coefficients, databases, and algorithms can be updated when more current data and/or scientific understanding becomes available.

Throughout this report, the following key terms are used frequently. A glossary is found in Appendix E.

- **Modules:** A module is a self-contained analysis unit with distinguishing inputs and outputs that may be derived from, or provided to, other modules. Each of the major categories of assessment (e.g., terrestrial habitats and species) is represented by a module, within which all operations relating to that category are executed.
- **Components:** Modules consist of components, which are discrete subsets of inputs, calculations, and outputs. For example, the Integrated Water Module includes the Stormwater and Wastewater components.
- **Elements:** Elements include algorithms, coefficients, data tables, and other computational aspects within each component. One or more elements may constitute a component.
- **Planning Units:** For the analysis, the Florida Keys were divided into 28 planning units (Table 3.1; Map 1) which approximately correspond to the planning units used in the Monroe County Sanitary Wastewater Master Plan (CH2MHILL 2000):

Major Road
Map Tile Boundary
Planning Unit Boundary
Municipality
Unincorporated Area
FKCCS Study Area
Lower Keys
Middle Keys
Upper Keys
Gulf Of Mexico
Florida Bay
South Florida
Atlantic Ocean
Ocean Reef Club
PAED 21
PAED 22
PAED 19 and 20
Key Largo
Plantation Key
Upper Matecumbe
PAED 18
PAED 17
PAED 16
PAED 15
ISLAMORADA
Plantation Key
Long Key/Layton
Lower Matecumbe Key
Upper Matecumbe Key
LAYTON
Marathon Primary
Big Pine Key
Upper Sugarloaf
Summerland Key
Stock Island
Bay Point
MARATHON
Long Key
Windley Key
Big Pine Key
No Name Key
Boot Key
Duck Key
Key Colony Beach
Lower Matecumbe
Cudjoe Key
KEY COLONY
KEY WEST
Sugarloaf Key
Bahia Honda Key
Key Colony Beach
Boca Chica Key
Key West
Bahia Honda Key
Cudjoe Key
Ramrod Key
Boca Chica
Lower Sugarloaf
Key West
N
W
E
S
5
0
5
10
Miles
Map 1
Reference Map

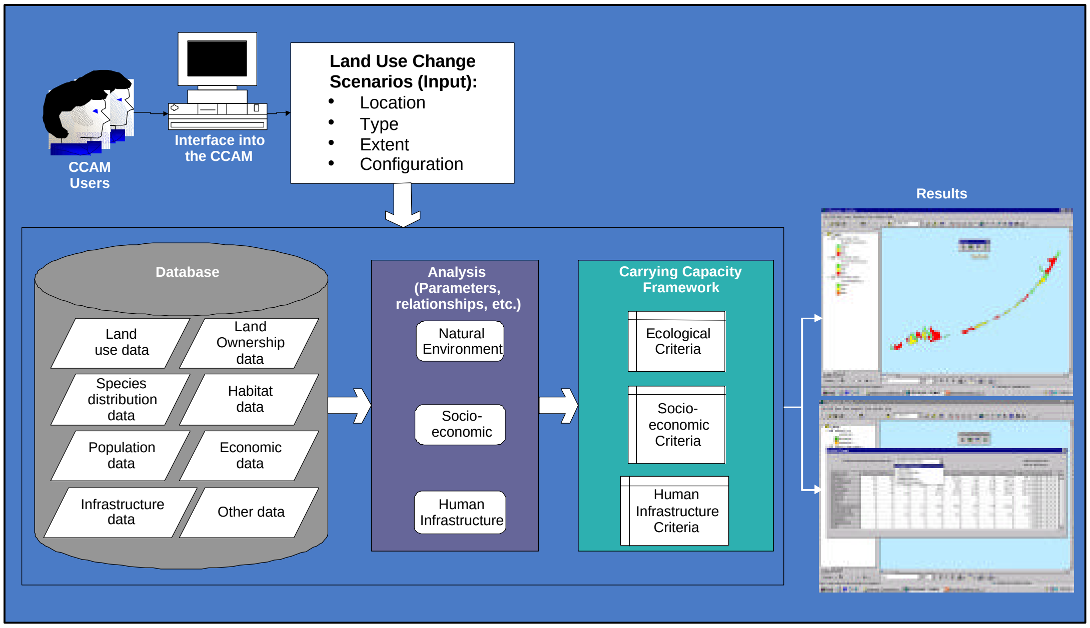
TABLE 3.1
FKCCS PLANNING UNITS

Wastewater Planning Unit Name	
Ocean Reef Club	Marathon Primary
PAED 21 (North Key Largo)	Bahia Honda Key
PAED 22 (Cross Key)	Big Pine Key
PAED 19 and 20 (Garden Cove)	Big/Mid Torch Key
PAED 18 (John Pennecamp State Park)	Little Torch Key
PAED 17 (Rock Harbor)	Ramrod Key
PAED 16 (Rodriguez Key)	Summerland Key
PAED 15 (Tavernier)	Cudjoe Key
Plantation Key	Upper Sugarloaf
Windley Key	Lower Sugarloaf
Upper Matecumbe	Bay Point
Lower Matecumbe	Boca Chica
Long Key/Layton	Stock Island
Key Colony Beach	Key West

The structure and key processes of the CCIAM encompass the following four elements (Figure 3.1):

- **Data:** Datasets were identified, compiled, assimilated, and organized into a series of databases for use in the model. Examples of key data required include land use and land cover, land ownership, population, socio-economics, infrastructure, terrestrial habitat, and species distributions.
- **Scenarios:** Scenarios represent specific sets of land use conditions that the user defines for analysis. Land use conditions are defined in terms of the location, type, extent, and configuration of the land use change.
- **Analysis:** Effects of land use changes on the human infrastructure, socioeconomic conditions, and natural environment within the study area are evaluated. Relationships between land use change and model elements define the analytical basis of the CCIAM.
- **Carrying Capacity Indicators:** Thresholds, limiting factors, and other criteria associated with the ecological, socioeconomic, and human infrastructure categories of the model help evaluate overall carrying capacity. These indicators are used to evaluate results of the analysis and assess whether modeled scenarios are likely to exceed the carrying capacity indicators.

FIGURE 3.1
CCIAM PROCESS



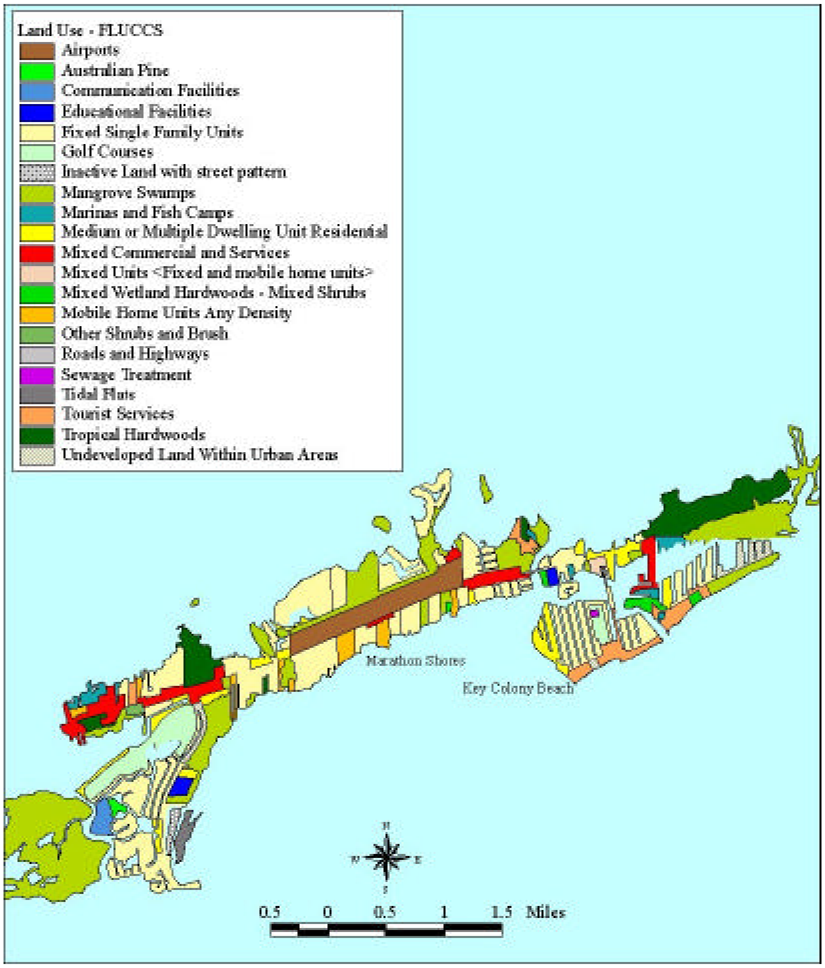
The two primary functional parts of the model are the Scenario Generator and the Analysis Modules. The Scenario Generator is a Graphic User Interface (GUI) and a set of preliminary calculations that create a land use GIS layer from the user-defined scenario. Using these new land use conditions, the Analysis Modules calculate scenario effects on each of the impact assessment variables (IAV). Finally, the Analysis Modules compare resulting IAVs with indicator values and identify conditions that may exceed these indicators.

3.2 DATA SUITABILITY

3.2.1 Land Use/Land Cover Data

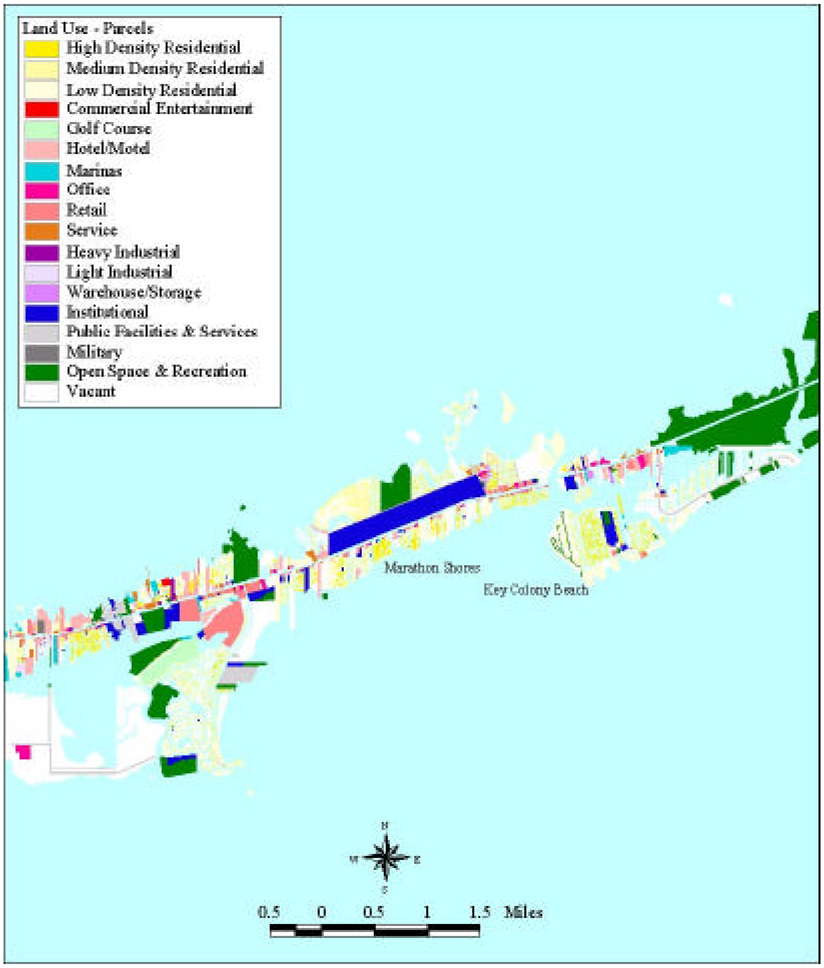
Land use is the fundamental dataset in the model and establishes the initial conditions against which any scenario is defined. Because there are no up-to-date land use maps for Monroe County, three potential sources of land use data were evaluated. First, the Monroe County Growth Management Office provided the Florida Keys Carrying Capacity Study (FKCCS) with a multitude of Digital Exchange Files (DXF). DXF data have no geographic coordinate system and, therefore, could not be translated into a GIS data format for the CCIAM. In addition, there are no attribute fields associated with these DXF data. Second, the South Florida Water Management District (SFWMD) maintains a 1995 land use and land cover map that applies the Florida Land Use, Cover, and Forms Classification System (FLUCFCS) (Figure 3.2). The FLUCFCS is widely used in Florida for planning and environmental applications. For this study, however, the FLUCFCS was insufficient, as it omits information such as vacancy or land ownership.

FIGURE 3.2
EXAMPLE FLUCFCS LAND USE DATA IN THE FLORIDA KEYS



Third, the parcel GIS layer from the Monroe County Property Appraiser's Office is a parcel-by-parcel map of the Florida Keys (Figure 3.3). Its associated Tax Roll database includes numerous fields of information about each parcel, including ownership, development status, taxable value, and sale price, among others. The combination of a spatial coverage linked to a detailed database made the parcel dataset more appropriate for the study than the FLUCFCS map. However, the parcel GIS layer and the Tax Roll were developed to serve specific purposes related to maintaining official taxing and property records. These purposes are quite different from those of the FKCCS. In particular, the spatial data and the tabular data were not designed to provide land use or zoning information, nor are the data required to be accurately geo-referenced in order to serve their purpose for the Property Appraiser. Therefore, the study team faced several challenges in order to effectively use the parcel database and the Tax Roll in this study.

FIGURE 3.3
EXAMPLE LAND USE FROM THE PARCEL DATASET



For example, when overlaid on other spatial data, such as Digital Ortho Quarter Quadrangle (DOQQ) aerial photography, the Monroe County parcel GIS layer is "shifted" (Figure 3.4).

FIGURE 3.4
PARCELS PRIOR TO MANUAL CORRECTION

Technically, the data exhibits rotations, skews, and shifts throughout the Florida Keys. The spatial discrepancy increases from the Lower to the Upper Keys and with increasing distance from U.S. 1. The Study Team and the Florida Marine Research Institute (FMRI) developed a simple method to manually shift the parcels to achieve a "best fit" using the 1995 DOQQ as a visual reference (Figure 3.5). While this method is not appropriate for cadastral mapping, it provided sufficient accuracy for a regional planning model such as the CCIAM.

FIGURE 3.5
PARCELS AFTER MANUAL CORRECTION OF SPATIAL SHIFT

The Property Appraiser's Office downloaded a portion of their Tax Roll dataset for use in the FKCCS. The resulting DBASE file contains 54 columns or "fields" of data for each of the approximately 70,000 parcels in the Florida Keys. For example, the property code (PC) field can take one of 99 values that represent land use for that property.

Two other fields, termed "LL1" and "LL2," show one of 297 possible values, which denote environmentally sensitive areas, a wide variety of commercial uses, or unique residential characteristics. The study team allocated a considerable amount of effort to understand the characteristics, limitations, and appropriate use of these fields, including numerous interactions with FMRI and the Property Appraiser's Office. Ultimately, the values from the PC field were used to define the land use categories used throughout the model (Table 3.2).

TABLE 3.2
PC CODES UTILIZATION TO DEFINE LAND USE CATEGORIES FOR THE FKCCS

Land Use in the FKCCS	Corresponding PC Values in the Tax Roll
Vacant Land	00, 10, 40, 70
Residential (high, medium, low density)	01, 02, 03, 04, 05, 06, 07, 08, 09, 36
Retail	11, 12, 13, 14, 15, 16
Office	17, 18, 19, 23, 24
Service	21, 22, 25, 26, 28, 29, 30, 61
Marina	27
Commercial Entertainment	31, 32, 33, 34, 35, 37
Golf Course	38
Hotel/Motel	39
Light Industrial	41, 44, 45, 46
Heavy Industrial	42, 43, 47
Warehouse/Storage	48, 49
Public Facilities and Services	83, 84, 85, 91, 94
Institutional	20, 71, 72, 73, 74, 75, 76, 77, 78, 79, 90
Agriculture	69
Open Space and Recreation	80, 82, 86, 87, 88, 89, 92, 99
Military	81
Submerged Lands	95

Similar to land use, no GIS-based zoning data exists for the Florida Keys. The Property Appraiser’s Office attempts to assign a zoning category to each parcel in the Tax Roll, but these data do not constitute an official zoning map. However, this information is the best available in the Florida Keys. After additional coordination with the Property Appraiser, the available zoning data was linked to the parcel GIS layer. In addition, numerous inspections of available, recent aerial photography (First American Realty Solutions 2001) helped address and clarify obvious discrepancies or missing zoning values.

Model tests showed inconsistencies between the number of dwelling units and population calculated for the current conditions versus those reported by the Census 2000 (reported in the November 2001 draft of the Test CCIAM Report). This discrepancy suggested anomalies in the PC values or in the application of those values to certain land uses. Further evaluation of the Tax Roll and aerial photography revealed that parcels coded as “county” (PC = 86) or “federal” (PC = 88) were categorized as “open space” when, in fact, the parcel had other land uses. For example, Dredgers Key, in Key West, has a PC code of 88 (open space and recreation), but includes over 100 housing units (Figure 3.6). Similarly, the Key West Airport was coded 86 and initially interpreted as “open space.” Corrections based on these findings resulted in the calibration of current condition housing units to within 5 percent of the Census 2000 values Keys-wide (48,792 and 51,571, respectively).

FIGURE 3.6
LAND USE AND PROPERTY CODE DISCREPANCY

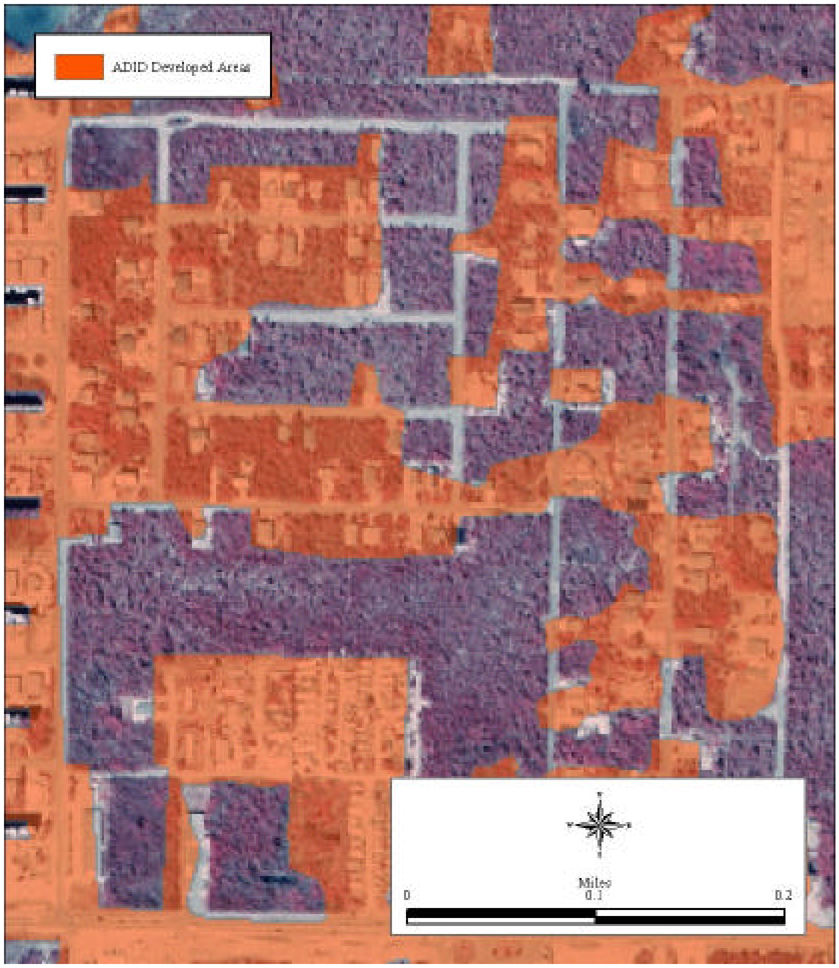
The parcel data and Tax Roll database from the Monroe County Property Appraiser's Office, after adjustments, constituted the land use basis for the study.

3.2.2 Spatial Databases for Terrestrial Habitats and Species

Advanced Identification of Wetlands Map

Several spatial databases regarding terrestrial ecosystems and species are available for the Florida Keys. The Advanced Identification of Wetlands (ADID; FMRI 1995) GIS layer is the best source of spatial terrestrial habitat data available. It classifies land cover into 15 types, based on photo-interpretation of 1991 DOQQs. Its main purpose was to identify wetlands in the Keys under the USACE federal criteria for delineation of wetlands (Environmental Laboratory 1987). For this model, the ADID vegetation classification system, resolution, and spatial accuracy are superior to both the statewide FLUCFCS and the Habitat and Land Cover layer of the Florida Fish and Wildlife Conservation Commission (FWC). A limitation of the ADID map for the CCIAM is that some patches mapped as developed encompass smaller undeveloped patches of various habitat types (Figure 3.7).

FIGURE 3.7
APPARENT HABITAT WITHIN ADID DEVELOPED POLYGONS



Exotic Vegetation Map

Kruer et al. (2000) developed an exotic vegetation map of the Florida Keys based on 1996 fieldwork. The map documents nearly 7,000 acres of exotic vegetation. While the area of infestation was confirmed, the GIS spatial data was based on the Property Appraiser parcel coverage. Therefore, the preparation of the map involved “rubbersheeting” the parcel coverage (T. Armstrong letter to FMRI, dated August 25, 2000). Due to the unknown spatial accuracy of the exotic vegetation GIS layer, the layer was not incorporated into the model.

Historic Habitat Map

A map of the historic distribution of habitats in the Florida Keys, developed for the FKCCS under Delivery Order 7, provided a benchmark to evaluate the effect of development on the extent and distribution of habitat types in the Florida Keys. The mapping approach used for this study is similar to that of Strong and Bancroft (1994). The primary sources of information used to interpret historic vegetation include three aerial photograph series, ranging from 1945 to 1959, which are the earliest available for the entire study area. Other sources included field visits, other historic maps, topography, and soils. The low resolution of the historic photography limited the number of community types identified in the historic map. Therefore, the fifteen ADID categories were aggregated into eight categories, including five vegetation types (hammocks, pinelands, freshwater wetlands, saltwater wetlands, and beach berm) as well as developed land, exotics, and open water. The FKCCS included a second mapping effort to extrapolate vegetation types beyond the 1945 map to pre-development conditions using the same eight categories.

Species Richness Map

A species richness map was developed for the FKCCS using a combination of sources (Table 3.3). Species included in the species richness map met the following criteria:

1. Currently listed by federal or state agencies as an endangered (E), threatened (T), or imperiled species (S2) or species of special concern (SSC) in Monroe County by the federal (F) or state (S) governments. The S2 designation includes species imperiled in Florida because of vulnerability to rarity (6 to 20 records of occurrence or less than 3,000 individuals) or because of vulnerability to extinction due to some natural or man-made factor.

2. There is an existing potential habitat model for the species, for which at least a “Fair” model accuracy rating was given in the Habitat Conservation Needs of Rare and Imperiled Wildlife in Florida (FWC GAP II; Cox and Kautz 2000). The “Fair” model rating indicates that the potential habitat model is sufficiently accurate to allow an assessment of habitat (Cox and Kautz 2000).

3. Species for which other existing potential habitat models were readily available. These GIS layers were obtained from the U.S. Fish and Wildlife Service (USFWS) and FMRI.

4. The species determined to be suitable based on the previous three criteria were further reviewed and selected to balance the representation of upland and wetland species and habitat. Mr. Randy Kautz of the FWC kindly reviewed the list of selected species. The set of species includes an almost equal representation of upland and wetland species.

TABLE 3.3
SPECIES INCLUDED IN THE SPECIES RICHNESS MAP[1]

Taxonomic Class	Scientific Name	Common Name	Model Source
Reptiles	*Alligator mississippiensis*	American alligator	Cox and Kautz 2000
	Malaclemys terrapin rhizophorarum	Mangrove terrapin	Cox and Kautz 2000
	Drymarchon corais couperi	Eastern indigo snake	Cox and Kautz 2000
	Kinosternon baurii	Lower Keys striped mud turtle	USFWS
	Crocodylus acutus	American crocodile	USFWS
	Chelonia mydas (nesting habitat)	Green sea turtle	FMRI ESI
Birds	*Pelecanus occidentalis*	Brown pelican	Cox and Kautz 2000
	Plegadis falcinellus	Glossy ibis	Cox and Kautz 2000
	Pandion haliaetus	Osprey	Cox and Kautz 2000
	Dendroica discolor paludicola	Florida prairie warbler	Cox and Kautz 2000
	Columba leucocephala	White-crowned pigeon	FMRI/ESI
Mammals	*Oryzomys paustris natator*	Silver rice rat	USFWS
	Sylvilagus palustris hefneri	Lower Keys marsh rabbit	USFWS
	Odocoileus virginianus clavium	Florida Key deer	USFWS
	Neotoma floridana smalli	Key Largo woodrat	USFWS
	Peromyscus gossypinus allapaticola	Key Largo cotton mouse	USFWS
Vascular Plant	*Pilosocereus robinii*	Key tree cactus	USFWS

1 Models were rerun, using the ADID as the base habitat layer, for the American alligator, mangrove terrapin, Eastern indigo snake, brown pelican, glossy ibis, osprey, and Florida prairie warbler.

For 10 of the 17 species, the USFWS or FMRI developed the habitat models used in the CCIAM. For the other 7 species, the Technical Contractor developed new potential habitat maps using the FWC GAP II model methods. The models were re-run substituting the ADID for the FWC Habitat and Land Cover layer. Given the higher resolution of the ADID layer, the size of grid cells was reduced from 100 x 100 meters in the GAP II models to 30 x 30 feet for the FKCCS. Some of the model criteria were varied slightly to incorporate Keys-specific habitat considerations into the regionally developed model methods. An overlay of the 17 habitat models provides a measure of species richness in which the value of each 30 x 30 foot cell is the total number of species whose potential habitat are located in that cell. Although the maximum value possible for the species richness layer is seventeen, the maximum number of species found in a given cell in the study area was ten.

Additionally, species-specific spatial data was also used to address species impacts for the Key deer, Lower Keys marsh rabbit, and silver rice rat (Section 4.0).

3.2.3 Other Spatial Databases Used in the Study

Numerous state, federal, and local agencies and organizations provided datasets for potential use in this study. The FMRI was the primary database contractor for the study. Spatial datasets were reviewed to determine their suitability for inclusion according to the following criteria:

- Spatial coverage of data;
- Resolution of the data and concurrence with map accuracy standards for that level of resolution;
- Completeness of data;
- Vintage of data;
- Accuracy of data set attribution;
- Accuracy in polygon closure, edge mapping, and other topology parameters;
- Completeness of documentation or metadata;
- Degree of spatial error and ability to match to other data sets;
- Ability to be analyzed with other data sets;
- Accuracy and documentation of data acquisition methods; and
- Projection parameters.

Two important factors determining data suitability are spatial accuracy and applicability to the needs of the CCIAM. In several cases, a particular dataset contained critical information not available from another source, but was in an incompatible format or contained discrepancies or was incomplete. If data limitations did not represent a fatal flaw, necessary steps were performed to bring the dataset to an acceptable state for use in this study.

The following spatial databases were incorporated into the study:

- Monroe County parcel GIS layer and associated Tax Roll database from the Monroe County Property Appraiser.
- Planning units and other spatial data from the Monroe County Sanitary Wastewater and Stormwater Master Plans (CH2MHILL 2000, CDM 2000).
- The FMRI ADID dataset, which provided terrestrial habitat distribution data.
- Habitat distribution within the FMRI benthic communities' dataset.
- Terrestrial and marine species distribution from the USFWS, the FWC, and FMRI.

3.2.4 Non-Spatial Data

The CCIAM utilizes over 60 look-up tables, which hold factors, coefficients, or initial conditions. These include Census data, government expenditures, effluent characteristics, event mean concentrations (EMCs), species-specific habitat requirements, and traffic data, among others.

The FKCCS benefited from recently completed or ongoing studies, some of which were provided as part of in-kind contribution to the study from the State of Florida. Because each of these studies had been accepted as final, the Technical Contractor did not attempt to verify the data, methods, results, or conclusions of the studies. Studies included the Monroe County Stormwater Master Plan, the Monroe County Sanitary Wastewater Master Plan, the Monroe County Population Estimates and Forecasts 1990 to 2015, the Monroe County Canal Study (ongoing), the Regional Habitat Conservation Plan for Big Pine and No Name Keys (ongoing), the 2001 and 2002 Monroe County Public Facilities Capacity Assessment, and the Monroe County 2002 U.S. 1 Arterial Travel Time and Delay Study, among others.

3.3 INFORMATION TECHNOLOGY

The CCIAM is implemented as a customized ArcInfo 8.1 map document (MXD). This MXD houses the Visual Basic for Applications (VBA) code that automates the analysis, result reporting, and graphical user interface. ArcInfo 8.1 is the latest GIS technology and is widely used in both Florida and the United States. Agencies such as the FWC, Monroe County Property Appraiser's Office, and the DCA employ ArcInfo.

CCIAM testing and refining activities generated over 50 gigabytes of data. The final model including the 7 scenarios consists of approximately 25 gigabytes of data. Some datasets are large, both in number of records and fields (attributes) in the associated tables. For example, there are approximately 70,000 records in the parcel dataset, 13,500 in the benthic communities' dataset, and 9,700 in the ADID dataset. In addition, there are 54 attributes associated with the parcel dataset and most analyses in the CCIAM add at least one field (column) to several different tables. The CCIAM relies on several personal geodatabases and ArcInfo workspaces to manage, access, and generate data. Personal geodatabases employ Component Object Model (COM) technology and are implemented as Microsoft Access 2000 databases. ArcInfo workspaces are unique to the grid and coverage formats of the GIS software vendor, Environmental Systems Research Institute (ESRI).

Study team programmers used VBA to manipulate ArcObjects and execute structured query language (SQL) statements that, in turn, automate all analytical processes in the model. All code is documented both within the code itself and in technical manuals. Additional VBA code displays and operates the GUI as forms within ArcInfo 8.1. Finally, VBA code was also written to display results as maps, charts, and tables from within the GIS software package.

Data compiled and resulting from the FKCCS will be delivered to the general public and local planners via the Internet. Arc Internet Map Server (ArcIMS) is currently available as an "off the shelf" software package for the delivery of GIS information via the Internet. The study team built a Routine Planning Support Tool using ArcIMS as the technology solution. Minor customizations, using Java Script, were made to the "out of the box" solution to enhance the application. The Internet application will supplement the model, provide wide access to the CCIAM information base, and allow for data downloads.

3.4 SCENARIO GENERATOR

In the context of community planning, the term "scenario" is often used interchangeably with the term "vision." A vision, however, typically provides only general direction, usually articulating values and goals of the community for its future. In the CCIAM, scenarios may be interpreted as the land use result of alternative policies. Each scenario involves a particular combination of variables – although the simulation can be replicated any number of times using different combinations of variables.

Users can describe and input alternative scenarios according to the location, type, extent, and configuration of additional development activities. The model uses land use change as the currency for scenarios, instead of "additional development," in order to accommodate scenarios that consider reversion of developed areas to undeveloped conditions. The model utilizes modifications to the Wastewater Planning Units (CH2MHILL 2000) as the analysis unit, and, therefore, as the means to determine the location of development. The type, extent, and configuration of land use change may vary within and among analysis units. For example, two different units may experience different types of development, or different areas within a unit may experience different configurations.

The user may choose among three types of development: new development, which results in vacant land being developed; re-development, which changes the character of developed parcels; and restoration, which reverts developed lands to a natural state. Within each type, development may be residential, commercial, industrial, or recreation, among others. The user may also specify the intensity or magnitude of development defined as area or number of units. For example, residential development may be low density or high density. Finally, the distribution of the development defines the spatial configuration of the user-defined scenario.

3.4.1 Graphical User Interface

The CCIAM provides a GUI, which consists of several computer screens that allow users to select among menu options and, in some cases, to input specific values such as number of dwelling units, percent of parcels, or acreage affected. The following are examples of CCIAM GUI screens:

Land Use "Change From" Conditions Screens. These screens allow the user to select the type of land use to be modified (Figure 3.8). Secondary menus allow for selecting a specific set of conditions defining the parcels to be affected. Users may select for parcels that meet all specified criteria (e.g., scarified parcels within 100 feet of U.S. 1) or that meet any of the criteria (e.g., scarified <u>or</u> within 100 feet of U.S. 1; Figure 3.9).

FIGURE 3.8
VACANT LAND CHANGE FROM GUI SCREENS

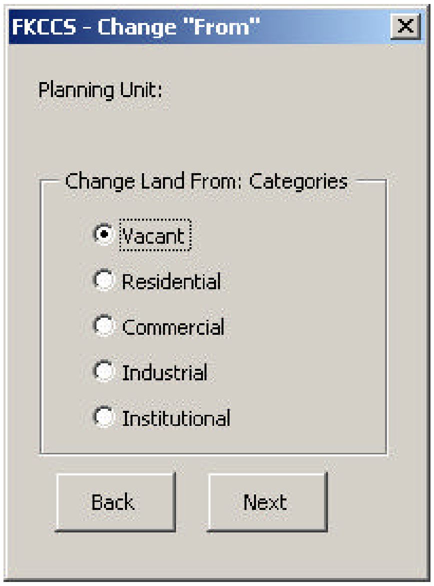
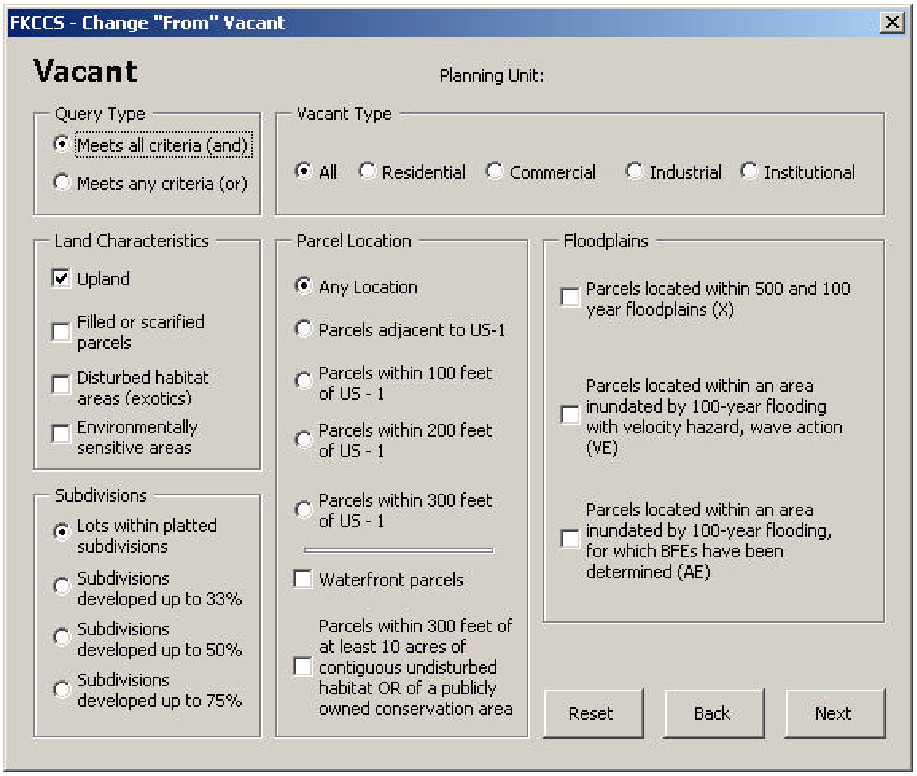
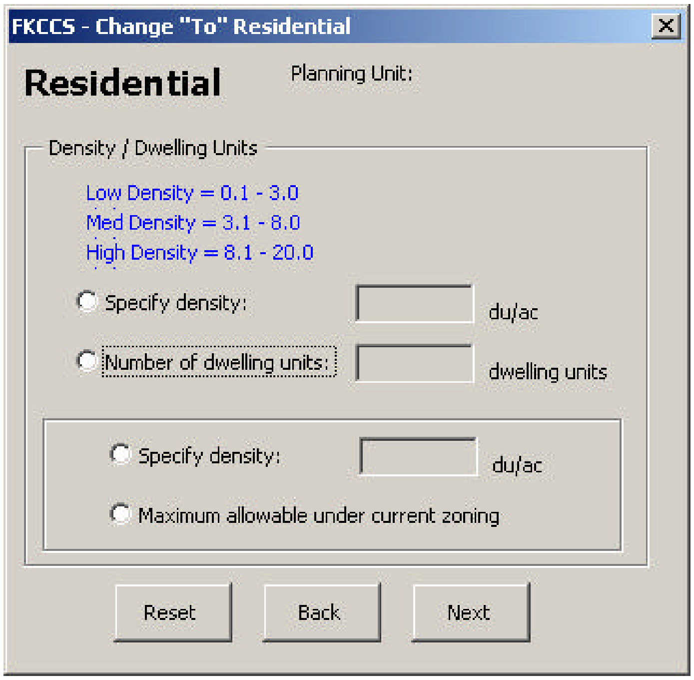


FIGURE 3.9
VACANT LAND CHANGE FROM GUI SCREENS



Land Use "Change To" Conditions Screens. These screens allow the user to define the future land use for the selected areas. This also leads to secondary screens where the user can specify type of activity, density of development, magnitude of change, and percent of parcels affected (Figure 3.10).

FIGURE 3.10
RESIDENTIAL CHANGE TO GUI SCREENS



Other screens provide options for implementing the Stormwater or Wastewater Master Plans, retrofitting, or selecting Best Management Practices (BMPs) for stormwater treatment. Once the user has navigated the CCIAM interface and input criteria for the selected scenario, the scenario is saved and the model creates a new land use GIS layer and associated attributes that represent the future conditions as defined by the user.

3.4.2 Basis for Land Use Change in the Scenario Generator

The scenario choices determine a new spatial pattern of land use, which triggers each of the modules' impact evaluation. Therefore, land use change is the primary basis of the CCIAM. The GUI includes options to allow users to choose a subset of lands for development. For those cases, the model selects specific areas based on a predetermined suitability ranking that reflects common planning standards and regulations in Monroe County. The suitability analysis represents a "pre-processing" activity in the CCIAM (i.e., the analysis was done manually to prepare the data for use in the scenario definition). The following steps were followed to complete the land use and suitability analysis.

Determine the Availability, Suitability, and Development Capacity of Vacant Land

"Vacant lands" were identified in the parcel GIS layer. In conventional land use analysis, the "vacant land" category may provide an adequate measure of future development capacity. However, in the Florida Keys this approach would ignore the existence of stringent regulatory constraints (e.g., zoning, development standards, and environmental protection measures) and socioeconomic aspects (e.g., ownership pattern, location preferences, and cost-related factors such as pre-existing infrastructure), which influence the probability that vacant land will be developed. Therefore, the availability, development suitability, and development capacity of vacant land was evaluated.

The objectives of the vacant lands evaluation were:

- To generate an effective vacant land inventory by excluding unavailable vacant land from the total vacant land inventory. Criteria included ownership (private vs. public), use (conservation and open space), or absolute environmental restrictions (vacant land characterized by wetland vegetation).
- To determine how much of the effective inventory of vacant land is allocated for future development in four main land use categories: residential (PC Code = 00), commercial (PC Code = 10), industrial (PC Code = 40), and institutional (PC Code = 70).
- To identify criteria to rank the intrinsic development suitability of vacant land. The ranking system is based on the assumption that the presence, nature, and extent of certain constraints may make parcels less suitable for development. For example, parcels characterized by hammock vegetation, while usually developable to some extent, tend to rank lower in the development suitability scale because local regulations impose additional constraints to development in those types of parcels. However, the user may override this constraint and specify any degree of development.
- To determine the suitability of available vacant land within each of the above future land use categories. If data were available, specific criteria were applied to be consistent with current policy and the existing regulatory framework. For example, criteria for residential land included location in a legally platted subdivision, availability of infrastructure, high flood base elevation, and absence of natural habitat vegetation cover (i.e., hammock), (Table 3.4). The ADID layer was used in conjunction with the parcels to provide a land use and land cover base map for the study. Floodplain designation was obtained from the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM). In the case of nonresidential land, this list was modified to incorporate proximity to U.S. 1 as a determinant (Table 3.5). It was assumed that most types of nonresidential development would be attracted first to vacant land that is visually and functionally accessible to U.S. 1. To avoid applying arbitrary distances, physical adjacency of the parcel to the highway was used to define proximity.

- To estimate the development capacity of vacant land selected for conversion in the scenario. Unless otherwise directed by the user for a specific scenario run, the model does this by applying appropriate density and intensity coefficients adopted from local zoning regulations.

TABLE 3.4
SPECIFIC CRITERIA FOR SUITABILITY RANKING OF RESIDENTIAL LAND

	Criteria								
	Platted Subdivision Infill		Infrastructure (Availability of Water Service)		Floodplain Designation			Vegetation Cover (Hammock)	
Ranking	**Yes**	**No**	**Yes**	**No**	**X**	**AE**	**VE**	**Yes**	**No**
Most Suitable	¦		¦		¦				¦
	¦		¦			¦			¦
Moderately Suitable	¦		¦				¦		¦
		¦	¦		¦				¦
		¦	¦			¦			¦
		¦	¦				¦		¦
	¦		¦		¦			¦	
	¦		¦			¦		¦	
Marginally Suitable	¦		¦				¦	¦	
	¦			¦	¦			¦	
	¦			¦		¦		¦	
	¦			¦	¦				¦
	¦			¦		¦			¦
	¦			¦			¦		¦
	¦			¦			¦	¦	
		¦	¦			¦		¦	
		¦	¦				¦	¦	
Least Suitable		¦		¦			¦		¦
	¦			¦	¦			¦	
	¦			¦		¦		¦	
	¦			¦			¦	¦	
		¦		¦	¦			¦	
		¦		¦		¦		¦	
		¦		¦			¦	¦	

Notes:
Floodplain Designation: X = Outside of 100-year and 50-year floodplain.
AE = Area inundated by 100 year flooding.
XE = Area inundated by 100 year flooding with velocity hazard.

TABLE 3.5
SPECIFIC CRITERIA FOR SUITABILITY RANKING OF NONRESIDENTIAL LAND

Ranking	Criteria						
	Proximity to U.S. 1		Floodplain Designation			Vegetation Cover (Hammock)	
	Yes	No	X	AE	VE	Yes	No
Most Suitable	¦		¦				¦
Moderately Suitable	¦			¦			¦
	¦				¦		¦
		¦	¦				¦
		¦		¦			¦
		¦			¦		¦
Marginally Suitable	¦		¦			¦	
		¦	¦			¦	
Least Suitable	¦			¦		¦	
	¦				¦	¦	
		¦		¦		¦	
		¦			¦	¦	

Notes:
Floodplain Designation: X = Outside of 100-year and 50-year floodplain.
AE = Area inundated by 100 year flooding.
VE = Area inundated by 100 year flooding with velocity hazard.

The zoning data provided in the Tax Roll were used to define an appropriate set of density and/or intensity coefficients. For example, vacant parcels zoned as Improved Subdivision, or an equivalent classification, were assumed to yield one dwelling unit per lot. Applicable density and intensity coefficients were multiplied by the total acreage of land in each vacant land subcategory to calculate the potential gross number of dwelling units and/or amount of nonresidential floor area that a scenario will generate.

Determine the Intensity of Existing Development

The intensity of existing development was determined to support scenarios involving conversion of developed land from one use to another or for a change in the intensity of development. The number of existing residential dwelling units, or the amount of existing nonresidential floor area, was divided by the total acreage in each developed land subcategory.

Identify Developed Land Suitable for Redevelopment Activities

Criteria for selection of developed land suitable for redevelopment activities were identified in collaboration with local planners and were based on the assumption that the presence, nature, and extent of certain combinations of conditions may affect the likelihood of redevelopment. These conditions, for which data are available in the Tax Roll, are combined to identify potential redevelopment areas for use in the CCIAM:

- Residential/commercial structures older than 20 years.
- Residential/commercial structures less than 33 percent of the land value.

- Residential structures smaller than 1,200 square feet.
- Commercial structures with a floor area ratio (FAR) of less than 19 percent.
- Waterfront properties.

Once a scenario has been fully defined by the user, the model produces a new GIS layer that represents the new land use pattern. These outputs include:

- Maps illustrating the future land use pattern resulting from the scenario definition.
- Attributes for each land use category including acreage, gross density (in dwelling units/acre) and intensity (in FAR) of development, and number of dwelling units and/or amount of nonresidential floor area generated by the scenario.

The suitability analysis does not identify "vested" development, which exist in areas of the Florida Keys. As the state and local governments explore different development scenarios, vested developments may constitute a scenario. At this time, no detailed listing of vested developments is available at Monroe County.

The selected ranking criteria represent a subset of all potential suitability criteria. The analysis omitted several commonly used factors, including soil type, topography, and quality of adjacent development, because they have lower applicability and impact on the development potential of land in the Florida Keys.

Availability of infrastructure is typically an important development suitability criterion. The Florida Keys Aqueduct Authority (FKAA) provided the only useable data regarding availability of water service. In the future, additional infrastructure data can be incorporated into the model by modifying the selection criteria.

3.5 ANALYSIS MODULES

Scenarios are analyzed in modules (Table 3.6). Inputs and outputs are exchanged among certain modules. For example, population from the socio-economic module and costs of potable water infrastructure from the water module are used as inputs for the fiscal module.

TABLE 3.6
CCIAM ANALYSIS MODULES AND COMPONENTS

CCIAM Module	Module Components
Socioeconomic	Population/Residential; Economic/Nonresidential; Socioeconomic Indicators
Fiscal	Government Expenditures
Infrastructure	Potable Water, Traffic, Hurricane Evacuation
Integrated Water	Wastewater, Stormwater
Terrestrial	Habitat Conversion and Fragmentation Secondary Impacts; Species-Specific Effects
Canals	Pollutant loads and water quality

In summary, the CCIAM evaluates the following effects of land use change:

- **Effects of land use changes on population (Socioeconomic Module):** Changes in land use may result in changes in the population of the study area. This can include changes to the permanent, seasonal, and transient populations.
- **Effects of land use change and subsequent effect of population changes on socioeconomic parameters and government expenditures (Socioeconomic and Fiscal Modules):** Changes in the number and distribution of people result in changes in economic variables, such as employment, income, and demand for services and infrastructure. These in turn affect the government expenditures required to meet population demands.
- **Effects of land use change and subsequent effect of population changes on infrastructure (Infrastructure Module):** Changes in the number and distribution of people also result in changes in the demand for potable water. It also affects traffic patterns, which in turn affects the time required for hurricane evacuation.
- **Effects of land use change on the dynamics of water and the demand for water supply (Integrated Water Module):** Changes in land use and the application of BMPs may result in changes in the impervious surface area, thereby altering stormwater runoff and the volume of water discharged into groundwater and the marine environment. BMPs determine the treatment level for stormwater and affect the pollutant load discharge into the marine environment. Population changes resulting from changes in land use also affect water consumption and the production of wastewater, which ultimately may affect water quality in nearshore waters.
- **Direct and indirect effects of land use change on terrestrial habitats and species (Terrestrial Module):** Conversion of undeveloped land into developed land results in a corresponding decrease in habitat area. This reduction in habitat area results in habitat fragmentation and degradation. In restoration scenarios, developed lands are reverted to natural conditions, increasing habitat area.

3.6 SOCIOECONOMIC MODULE

The socioeconomic module calculates population and other socioeconomic indicators that result from the user-defined development scenario. The module links the number of dwelling units and square footage of nonresidential land uses resulting from the scenario to people and the amount of land necessary to accommodate the specified land uses. In turn, it estimates the businesses' demand for employment and resulting payroll. The Socioeconomic Module produces the following outputs, based on user-specified development scenarios, for each planning unit:

- Population required to support the dwelling units resulting from the development scenario;

- Population ("customers") available and required to support the nonresidential component of the scenario;
- Employees available and required to support the nonresidential component of the scenario;
- Payrolls that will result from development of the nonresidential component of the scenario;
- Taxable value of new development; and
- Construction value of new development.

The basic data input for the Socioeconomic Module is land use. However, other information supports the outputs of the module. The following types of data are used in this module:

Demographic Data. Examples of this information include persons per household, population growth rates during 1990-2000, and ratios of employment per 1,000 square feet of building space for major land use categories.

Demographic coefficients (e.g., persons per household) were calculated and calibrated for each planning unit in the study area using information from the 2000 Census.

Other demographic coefficients address the ratio of employees per 1,000 square feet of gross floor area (GFA) for each of the nonresidential land use categories. The ratio of employees per 1,000 square feet of building space and user-defined area of commercial and industrial development provide an estimate of required employment.

Per capita floor area coefficients were calculated and calibrated for each nonresidential land use category on a countywide basis. Retail market areas and labor sheds of most businesses extend beyond the boundaries of individual planning units, and people will shop or work in locations remote from their homes. These coefficients were developed from the Property Appraiser's database for Monroe County.

Property Values. This information is used to measure several socioeconomic impacts, such as taxable value of new development and construction cost of new development.

In this module, the primary financial coefficient is the taxable value of new development. The taxable values were computed from the current Monroe County Tax Roll. The calculation was completed by summing the GFA and taxable value of each land use category. Then, the total GFA was divided into the total taxable value to compute an average value per square foot of GFA. Due to the high degree of variation, this computation is reported in each planning unit. Added taxable value is a measure of development quality, as well as fiscal resources to the County.

Construction Costs. An estimate of per-unit construction costs is used to calculate the value of new development established in the scenario. Data from *Means Square-Foot Construction Costs*, a nationally recognized estimating manual, was used to estimate these coefficients. This is a standard reference for preparing pre-design estimates of construction costs by architects, builders, and feasibility analysts. The basic values were adjusted by the manual's cost index to reflect averages in the region.

Wage Rates. Average annual wage rates per employee were extracted from the current edition of *County Business Patterns*, an annual publication of the U.S. Department of Commerce. These wage rates were equated to the land use categories used in the module. *County Business Patterns* was used because of its uniformity of data collection throughout the nation, as well as its long history of publication.

The fundamental assumption of this module is that future growth in the Florida Keys will likely proceed in a stable manner, without significant deviations from recent historical trends. This assumption is supported by the low rate of population growth from 1990 to 2000 (2 percent), and the consistency of Monroe County's program to limit growth since 1992. Other important assumptions are as follows:

- Demographic characteristics, especially those that strongly affect land use demand, will remain relatively unchanged during the study time frame of 20 years. The slow rate of population growth documented by results of the U.S. Census Bureau counts in 1990 and 2000 indicate that overall countywide averages have not changed significantly over the past ten years. In addition, the future growth rates projected by Monroe County and the Florida Bureau of Business Research (BEBR) at the University of Florida are comparable to that exhibited during recent history. These small projected growth rates will have limited influence on overall population characteristics that drive land use demand.
- Because of the limited population growth expected in the future, the ratios between population size and land use area will remain essentially constant over the study time frame. These ratios include average household size and per capita measures of major land use groups, such as square feet of retail, office, and industrial space.

3.7 FISCAL MODULE

The Fiscal Module of the CCIAM estimates the potential cost of user-defined development scenarios and the resulting impact on government expenditures. The primary indicators of a governmental entity's fiscal condition are revenues, expenditures, operating position, debt structure, unfunded liabilities, and the condition of capital facilities, infrastructure, and community need. The module uses annual government expenditures per capita as the primary indicator of the fiscal impact of development. The essential underlying assumption for this approach is that local governments will set *ad valorem* tax millage rates at levels necessary to meet expenditures. Therefore, a scenario that results in a higher per capita government expenditure indicates pressure on government to increase revenue, including increasing taxes.

The module's base conditions reflect the current level of expenditures of government jurisdictions that have revenue-generating authority to levy *ad valorem* taxes (City of Marathon; Islamorada, Village of Islands; City of Key Colony Beach; City of Key West; City of Layton; Monroe County; Florida Keys Mosquito Control; SFWMD; Monroe County Housing Authority; Monroe County School Board; and the Lower Florida Keys Hospital District).

Expenditures are derived from a combination of operating costs and debt service costs. The annual governmental expenditure figure for each local government jurisdiction was summed from the categories in their annual operating budget, including public schools. Annualized fixed capital costs were included under the debt service category. The annual operating expenditure amount (everything other than debt service) and annual fixed capital (debt service) expenditure amount for each governmental jurisdiction was calculated from these data. Per capita expenditure was obtained by dividing the annual operating and fixed capital expenditure by the functional population for current conditions.

In addition, expenditures are also projected and adjusted for unfunded liabilities for current needs. Unfunded liabilities include known expenditures, currently beyond funded levels of government budgets, necessary to address current deficiencies (e.g., actions necessary to comply with the Wastewater and Stormwater Master Plans).

Under a user-defined scenario, the model adjusts current expenditures to account for unfunded liabilities and all expenditures associated with the scenario. This establishes the baseline for all liabilities rather than just those accounted for in current governmental budgets. This also allows a comparison of the effects of currently unfunded liabilities and the effects of the scenario conditions. The unfunded liabilities used in this analysis include school deficiencies, and capital costs for stormwater, wastewater, and potable water treatment. The module also addresses land acquisition and road improvements for the scenarios analyzed in the FKCCS.

The CCIAM uses GIS to overlay the boundaries of the planning areas and the governmental jurisdictions to determine the amount of each governmental jurisdiction within each planning area. The planning area was expressed as a percentage of the governmental jurisdiction on an acreage basis. Total expenditures across each planning area were calculated by summing the total expenditure of each governmental jurisdiction within the planning area. The endpoint of this module is an estimate of government expenditures for user-defined scenarios. Results allow the evaluation of potential tax rate costs for individual citizens within jurisdictions or wastewater planning units, and the evaluation of total costs for each governmental jurisdiction.

This module interfaces directly with the Socioeconomic Module and the Integrated Water Module, receiving inputs from both of those modules in terms of population and per capita costs of water supply and treatment respectively.

Data for this module was identified and acquired from the local governments in Monroe County; local government annual financial reports provided to the Florida Department of Banking and Finance, Bureau of Accounting for the 1998-1999 and 1999-2000 fiscal years; and fiscal indicators included in the International City Managers Association Fiscal Impact Analysis Manual. This module uses the following inputs:

Population Estimates. The functional population estimate is taken from the socio-economic component of the model.

Government Jurisdiction Expenditures Data. Each local government jurisdiction's total annual expenditures for the 1999-2000 Fiscal Year, taken from the Annual Local Government Financial Report provided to the Florida Department of Banking and Finance, Bureau of Accounting was summarized and provides initial conditions.

Government Jurisdiction Expenditures Not Presently Funded. These are projected expenditures necessary to meet current government commitments. They include additional space for the Monroe County School System (Monroe County 2001), and the implementation of the provisions of the Wastewater (CH2MHILL 2000) and Stormwater (CDM 2000) Master Plans. These unfunded liabilities are added to current expenditures.

Wastewater Planning Area/Government Jurisdiction Relationship. This includes a GIS layer of the wastewater planning areas included within each government jurisdiction.

Fixed Capital Costs/Annual Debt Service Expenditures Conversion Tables. These tables project bond financing of fixed capital facilities for a 20-year term at 5.5 percent financing including bond transaction costs, thereby resulting in the annual debt service expenditure that would be incurred by the appropriate government jurisdiction.

3.8 HUMAN INFRASTRUCTURE

3.8.1 Potable Water

The Potable Water Component develops an estimate of daily potable water demand for each scenario and then compares the estimate against the allowable groundwater withdrawal of FKAA's current consumptive water use permit and the existing potable water infrastructure. The comparison determines whether the existing water system has adequate supply and treatment capacity to meet the required water demand. The Potable Water Component addresses the following four elements:

Allocation of Current Potable Water Demands to Existing Equivalent Dwelling Units. Efforts initiated by the Monroe County Sanitary Wastewater Master Plan to allocate the existing total number of equivalent dwelling units (EDUs) to specific developed land parcels were completed in this study in order to spatially assess existing and future potable water demands. Additionally, representative daily demands were calculated based upon FKAA water use records for each planning unit.

Estimation of Potable Water Demand. Daily potable water demand is calculated for each scenario using land use categories, converted to EDUs, and current specific water consumption rates computed for each planning unit. Computations are aggregated to the level of the 28 wastewater planning units (including Key West), adjusted at the planning unit level for functional populations, and then summed to produce the estimated total potable water requirement for the entire study area.

Adequacy of the Permitted Supply. The component compares the controlling constraints, such as the permitted groundwater withdrawal rate established for the water supply source and the treatment facility capacity, against the estimated potable water demand of a scenario. The component estimates potable water demand from consumers and then multiplies total demand times 1.16 to account for waters loses and unmetered uses (U.S. Geological Survey (USGS) 2002). The resulting number is compared to the permitted withdrawal volume.

Adequacy of the Existing Conveyance Facilities. Transmission pipeline throughput requirements are calculated based upon the potable water demand of a scenario and an assumed maximum average daily velocity of 7 feet per second in the transmission main segments. The component compares the capacity constraints established for each FKAA aqueduct segment against the estimated cumulative potable water demands calculated for each of the planning scenarios.

3.8.2 Traffic Component

The traffic component includes two independent tools to assess the effect of development on traffic in the Florida Keys. First, it applies a regression equation to relate acres of residential and tourist-related land uses and median traffic speed on U.S. 1, by planning unit, throughout the Florida Keys. Using the parcel database, the acreage of different land uses was summarized. A regression analysis revealed a statistically significant correlation ($p < 0.01$) between the density of tourist-related commercial and residential land uses per mile of U.S. 1 and the observed median speed along U.S. 1:

Median Speed = -0.016*((residential acres + tourist-related acres)/miles of U.S. 1) + 49.97

The regression, while statistically significant, explains only about 30 percent of the variance in median speed among planning units. Undoubtedly, other factors affect median speed. Further examination of available information points to the effects of traffic lights and road capacity. For example, Key Deer Boulevard is a two-lane road with a traffic light and shows the lowest median speed. For any user-defined scenario, therefore, the resulting median speed can be estimated as a function of land use by applying the regression equation above; the median speed is directly related to the level of service (LOS). The regression equation is used in the CCIAM to estimate the resulting median speed as a function of land use in the user-defined scenario.

Second, every year Monroe County estimates capacity for additional residential development based on the reserve traffic volume for U.S. 1. A formula developed by the U.S. 1 Task Force relates reserve volume with residential capacity, as follows (Monroe County 2001):

Residential Capacity = Reserve Volume /(Trip Generation Rate * % Impact on U.S. 1)

In 2001, the reserve volume was 44,513 daily trips, for a residential capacity of 6,955 units (Monroe County 2001). In 2002, the reserve volume decreased to 38,949 daily trips and, consequently, the estimated residential capacity also decreased to 6,086.

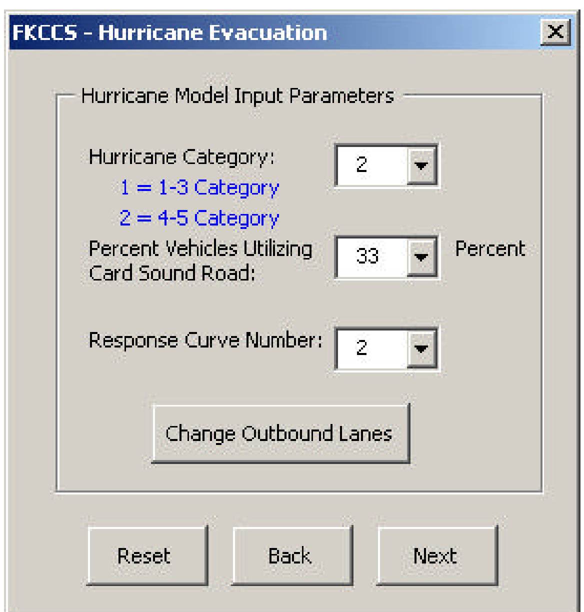
Therefore, the number of additional housing units generated in a user-defined scenario is compared with the residential capacity to determine if it surpasses the trip capacity of U.S. 1.

3.8.3 Hurricane Evacuation

The CCIAM adopted the recently completed *Florida Keys Hurricane Evacuation Study* (FKHES) produced for the Florida Department of Transportation (FDOT) (Miller Consulting Inc. 2001), which estimates the time required to evacuate the Florida Keys up to Florida City in the event of a hurricane. The objectives of the FKHES were to create a documented public domain computer model to improve the traffic analysis subsystem and to automate the traffic assignment system. A special advisory team was assembled to discuss and agree upon all input variables required to run the model.

The FKHES is a Microsoft Excel model that is executed in the CCIAM using VBA. The number of dwelling units produced in each CCIAM scenario is input into the FKHES. The FKHES was not altered in any manner, other than to increase or decrease the number of dwelling units and other input parameters resulting from a land use scenario. Tabular outputs from the FKHES are available in conjunction with the outputs resulting directly from the CCIAM. The CCIAM output removes 52 minutes from the FKHES, in order to report clearance time to Florida City, instead of Florida International University.

FIGURE 3.11
EXAMPLE CCIAM GUI SCREEN FOR HURRICANE EVACUATION



3.9 INTEGRATED WATER MODULE

The Integrated Water Module addresses the volume, fate, and pollutant loads from stormwater and wastewater. The stormwater component utilizes land use from the contributing drainage areas and associated pollutant loading rates to estimate pollutant loads generated within each watershed. It also calculates pollutant load reductions attributable to stormwater BMPs, and calculates the net pollutant loads discharged to the receiving surface water and groundwater systems.

The wastewater component utilizes permanent and functional populations, local wastewater generation rates, local wastewater characteristics, and point source discharge data from the contributing wastesheds to estimate pollutant loads generated within each wasteshed. It also calculates the levels of load reduction attributable to treatment systems, and calculates the net pollutant loads of the effluent discharged to the receiving groundwater systems.

The groundwater component simulates groundwater system interactions, including groundwater flows and pollutant transport in the subsurface environment underlying each of the modeled islands in the Florida Keys and estimates groundwater discharges to the nearshore waters.

3.9.1 Stormwater Component

The Stormwater Component calculates gross pollutant loads and BMP-based reductions, and then routes the resulting net pollutant load discharges to either the groundwater system or the nearshore waters. The component includes the following elements:

Delineation of Watersheds. Watersheds, smaller drainage areas within each planning unit, were delineated primarily using the network of local roadways and canals as boundaries.

Computation of EMC Values. The EPA has designated a number of Florida communities as Municipal Separate Storm Sewer Systems (MS4s), and subsequently required them to collect stormwater discharge characterization data. Because of the absence of stormwater discharge monitoring data in the Florida Keys, EMC data from representative Florida communities were used to calculate the pollutant and nutrient loads in the study area. Constituents incorporated into the Stormwater Component include total nitrogen (TN), TP, 5-day biochemical oxygen demand (BOD), and total suspended solids (TSS).

Runoff Volumes. The Stormwater Component develops an area-weighted runoff coefficient for each delineated watershed using the aggregated land use data for the watershed, a look-up table that maps specific land uses into generalized classes of land use, and a data table of runoff characteristics for generalized land use classes. Runoff volumes are computed for each watershed using the area-weighted runoff coefficient from the aggregate land use data and rainfall volume.

Runoff Pollutant Loads. Pollutant loads are calculated with a simple washoff model, commonly used in most Florida MS4s, that utilizes the EMC database for generalized land uses in the study area. Pollutant loads are calculated for each watershed using the watershed's runoff volume and area-weighted EMC values for the selected pollutants.

Stormwater BMPs. Few structural BMPs exist in the Florida Keys and virtually no performance data has been collected on existing BMPs. The array of current stormwater BMPs was evaluated based upon their potential suitability in the study area. A look-up table of treatment performance by specific BMP was developed based upon literature values and values from the Stormwater Management Master Plan adopted by Monroe County.

Pollutant Load Reductions due to BMPs. Stormwater BMPs, selected by the user, form the basis for calculating the reduction of discharged pollutant loads. Pollutant load reductions are calculated for each catchment on the basis of the user-specified extent of BMP coverage (drainage areas served) and the default removal rate from a data table of potential BMPs.

Allocation of Discharged Pollutant Loads. The final step involves allocating the net discharged pollutant volumes and loads by receiving waters. Significant portions of stormwater runoff percolate into the surficial region of the localized groundwater systems due to the highly porous soils in the Keys. Allocation of the discharged stormwater volumes and pollutants is based upon the governing transport mechanism. Initial loss to the Groundwater Component due to percolation/infiltration is based upon the nature of the soils and the treatment mechanisms of the implemented BMPs. The remainder of the discharge, occurring due to direct runoff, is allocated to the nearshore waters.

The outputs of the stormwater component are:

- Estimated stormwater runoff volume generated by each catchment.
- Estimated pollutant load in the stormwater runoff from each catchment.
- Estimated pollutant load removed from stormwater runoff in each catchment attributable to the implemented BMPs.
- Estimated net runoff volume discharged into the Groundwater Component via percolation/infiltration from each catchment.
- Estimated pollutant load discharged into the Groundwater Component via percolation/infiltration from each catchment attributable to the implemented BMPs.
- Estimated net runoff volume discharged into the nearshore via surface runoff from each catchment.
- Estimated pollutant load discharged into the nearshore waters via surface runoff from each catchment attributable to the implemented BMPs.

3.9.2 Wastewater Component

The Wastewater Component utilizes the water use estimates from the Potable Water Component (Human Infrastructure Module), parcel ownerships, GIS mapping and datasets, raw wastewater characteristics, treated wastewater effluent characteristics per treatment method, and discharge/disposal method data from the contributing wastesheds. These data are used to estimate pollutant loads discharged to groundwater systems and then discharged to the nearshore water.

The Wastewater Component operates in an extensive parcel-based geo-spatial data set that locates and characterizes the existing onsite systems and wastewater treatment facilities within the study area. It utilizes the same watersheds as in the Stormwater Component. Calculation elements address 1) wastewater volumes to be treated by specific treatment methods, 2) pollutant loads associated with each treatment method, and 3) aggregation of the effluent volume and pollutant loads for each wasteshed by disposal method.

Estimation of Wastewater Volumes by Treatment Method. For each scenario, the Wastewater Component calculates the 1) daily wastewater volumes at the parcel level given each parcel's number of EDUs, 2) existing wastewater generation rates, 3) and the specified treatment method associated with each parcel. Computations of wastewater volumes are initially executed at the parcel level and then aggregated at the wasteshed level by specific treatment types. This analysis uses the revised database from the Monroe County Sanitary Wastewater Master Plan. These wasteshed characteristics are further aggregated to the level of the 28 Wastewater Planning Areas and then summed to produce the estimated total wastewater generated, by specific treatment type, for the entire study area for the given scenario.

Estimation of Pollutant Loads Associated with Each Treatment Method. Pollutant loads are estimated at the wasteshed level for the aggregated flows being treated by either onsite wastewater technology or wastewater treatment plants. Computations of wastewater pollutant loads are executed at the wasteshed level for each treatment technology, then aggregated to the level of the 28 planning areas, and then summed to produce the estimated total wastewater pollutant load for the entire study area for each scenario. The CCIAM applies effluent characteristics established by the Florida Department of Environmental Protection (FDEP) during the Monroe County nutrient credit evaluation undertaken by the DCA, Department of Health, and FDEP in April 1999 (Table 3.7). These characteristics are the default in the CCIAM pursuant to FDEP and EPA recommendations.

TABLE 3.7
EFFLUENT CHARACTERISTICS BY TREATMENT METHOD, PER FDEP AND EPA

Treatment Method	BOD (mg/l)	TSS (mg/l)	Total N (mg/l)	Total P (mg/l)
None (Raw Sewage) and Cesspits	200	200	35	6
Substandard (Unpermitted) On-Site Treatment and Disposal Systems	140	85	32	6
Approved On-Site Treatment and Disposal Systems	10	10	25	5
Secondary Treatment	20	20	25	5
Best Available Technology, Including On-Site Treatment and Disposal Systems with Nutrient Removal	10	10	10	1
Advance Waste Treatment	5	5	3	1

Aggregation of Effluent Volumes and Pollutant Loads by Disposal Method. Effluent pollutant loads from each onsite wastewater treatment system and wastewater treatment plant are aggregated by respective disposal methods. Computations of effluent pollutant loads are executed at the wasteshed level by specific treatment technologies and then accumulated at the planning unit level by disposal method.

The wastewater module produces the following outputs:

- Total daily pollutant load of specific modeled pollutants, discharged to the groundwater system in a given wasteshed.
- Total daily wastewater effluent volume discharged to the groundwater system in a given wasteshed.
- Total daily pollutant load of specific modeled pollutants, discharged to the deep well disposal systems, in a given wasteshed.
- Total daily wastewater effluent volume of wastewater discharged to deep well disposal systems, in a given wasteshed.

3.9.3 Groundwater Component

The Groundwater Component calculates the discharged groundwater volumes and pollutant loads generated by infiltrated stormwaters and wastewater treatment system effluents. The calculation assumes additional treatment is provided by flow through the limestone underlying the Florida Keys. The four elements of this component calculate the gross loads to the groundwater system: the in-aquifer treatment, the transport through the aquifer, and the eventual discharge load and location at the shoreline.

Gross Pollutant Loads. The watersheds and wastesheds previously discussed in the Wastewater and Stormwater Components are also used for volume and load accounting in this component. The shallow groundwater pollutant mass loadings are allocated to specific wastesheds depending on the point of origin for TN, TP, BOD, and TSS. Pollutant loads and volumes entering each wasteshed in the Groundwater Component are passed as aggregated values for effluents from on-site disposal systems and wastewater treatment plants from the Wastewater Component. Similarly, stormwater volumes and loads from percolated stormwater runoff are also passed as aggregated values from the Stormwater Component.

Pollutant Treatment. Existing literature and data indicate that pollutant load reductions due to in-aquifer treatment mechanisms are not time-dependent. Rather, pollutant mass introduced to the groundwater will be reduced by a constant percentage at a fixed distance from the source and then remain relatively unchanged thereafter. Pollutant reductions in the groundwater system for the simulation period, based upon the conceptual construct of the groundwater aquifer, are calculated as one-time, fixed percentage reductions that are pulled from a look-up table containing groundwater system reduction values based upon reported literature values for the Keys.

Volumetric and Pollutant Transport. Hydraulic transport rates are not calculated in the Groundwater Component since pollutant treatment is not dependent upon time. Hydraulic transport rates reported in the literature and field observations indicate that effluents from on-site disposal systems and percolated stormwater runoff are very quickly transported to the surface waters. Therefore, given the conceptual construct of the groundwater aquifer system, pollutant transport to the nearshore waters is treated as an instantaneous, steady state process without any time-phased delays or storage of flows.

Discharge Location. The volumes and net pollutant loads calculated for each wasteshed are transported to the shoreline based upon the idealized hydraulic transport of groundwater along the path of least resistance. The shallow groundwater loads simulated in the Groundwater Component for each wasteshed are totaled and assumed to enter the marine environment.

The outputs of this component are:

- Total daily groundwater volume discharged from a given catchment to nearshore waters.
- Total daily pollutant load of specific modeled pollutants discharged from a given catchment to nearshore waters.

3.10 CANAL IMPACT ASSESSMENT MODULE

The Canal Impact Assessment Module (CIAM) applies a tidal flush modeling approach to examine the effects of pollutant loads on water quality in dead-end canals (see Appendix C for full description of the module). There are approximately 480 canals in the Florida Keys. The Technical Contractor developed and applied the module to 10 representative canals. EPA (Dr. Bill Kruczynski), FDEP (Mr. Gus Rios), Monroe County (Mr. George Garrett), and the Government Study Team assisted in selecting the canals.

For each of the 10 canals, the Technical Contractor defined the contributing watershed and divided the canals into segments. For each canal segment, the flushing model incorporates the incoming loads and tidal cycles in order to estimate a resulting pollutant concentration. The module is intended to address the differential effects of land use and stormwater and wastewater treatment scenarios on the resulting water quality along canals.

The CIAM operates as an Excel spreadsheet model, linked to the CCIAM through VBA code. Stormwater and wastewater loads from the Integrated Water Module are input into the CIAM spreadsheet. Outputs are transferred to the CCIAM for display.

3.11 TERRESTRIAL MODULE

The CCIAM measures direct and indirect impacts from land development scenarios on terrestrial habitats and species (Table 3.8). Direct loss of habitat due to development is the most recognizable and easiest impact to measure. The module evaluates direct land use impacts on terrestrial ecosystems and species by calculating a species richness index, statistics on overall habitat characteristics, and impacts on 11 individual species. Indirect or secondary impacts of development are also calculated for overall habitat characteristics. All analyses in this module are spatially explicit and are performed using GIS processes. The basic inputs for the Terrestrial Module include the user-defined land use scenario, the ADID vegetation map, a species richness map, and species habitat requirements.

TABLE 3.8
TERRESTRIAL MODULE COMPONENTS AND ELEMENTS

Component	Elements
Direct Impacts	
Species Richness	Composite species richness index Areas supporting 17 individual species
Overall Habitat Statistics All Upland Habitats Greater Than 13 Acres	Number of Patches Patch Size (total area, minimum, maximum, mean) Frequency distribution of patch sizes (0-5, 5-10, 10-20, >20 acres) Number of Patches Patch size (total area, mean)
Species-specific habitat statistics	Lower keys marsh rabbit Key deer Silver rice rat Key Largo woodrat Schaus swallowtail butterfly White-crowned pigeon Black-whiskered vireo White-eyed vireo Northern flicker Yellow-billed cuckoo Mangrove cuckoo
Indirect Impacts	
Overall Habitat Statistics All Upland Habitats Greater Than 13 Acres	Number of Patches Patch Size (total area, minimum, maximum, mean) Frequency distribution of patch sizes (0-5, 5-10, 10-20, >20 acres) Number of Patches Patch size (total area, mean)

3.11.1 Direct Impacts

<u>Direct Impacts to Species Richness</u>

This module component estimates the direct impacts of development to habitat availability for seventeen species. This approach provides a surrogate measure of land use effects on species richness by focusing on a subset of the terrestrial species of the Florida Keys for which sufficient data exists. The CCIAM overlays developed areas from the user-defined scenario land use map with the species richness map to calculate impacts for each planning unit. Development effects on the 17 species are expressed 1) as a species richness index and 2) for each individual species. The richness index represents an average of the number of species per cell; developed cells have a value of 0:

Species Richness Index for Direct Impacts = ? (# of species per cell)/total # of cells

Direct habitat impacts for each of the 17 species are reported as acres remaining per planning unit.

Direct Impacts to Habitat

Land use change affects the number and size of habitat patches as well as the overall amount of available habitat in terrestrial environments. Patch statistics provide a means to assess the direct habitat displacement or restoration due to land use change. Outputs, calculated as summary statistics for each habitat type, include the number of patches, patch size (total area, minimum, maximum, mean), and frequency distribution of patch sizes. Together, these statistics provide a measure of habitat loss and fragmentation. The number of patches less than 5 acres, 5 to 10 acres, 10 to 20 acres, and greater than 20 acres are calculated for each habitat type. For example, an increase in the number of small patches of hammock with a loss of total hammock acreage indicates that habitat has been reduced and fragmented; therefore, the hammocks may not be able to maintain ecosystem integrity or support the life history requirements of some species. Statistics calculated and reported for each of the 15 ADID habitat categories, as well as for upland habitat types that exceed 13 acres in size include: number of patches, patch size (total area, minimum, maximum, mean), and frequency distribution of patch sizes.

Direct Impacts to Species-Specific Habitat

In addition to the species richness analysis, GIS overlay techniques are used to analyze the direct impacts of development on habitat for 11 terrestrial species for which more detailed habitat models are available: Key deer, Lower Keys marsh rabbit, silver rice rat, Key Largo woodrat, Schaus swallowtail butterfly, white-crowned pigeon, black-whiskered vireo, white-eyed vireo, northern flicker, yellow-billed cuckoo, and mangrove cuckoo. For each user-defined scenario, the CCIAM evaluates the effects of direct habitat conversion on each of the species.

The CCIAM incorporates habitat maps developed from extensive research performed in other studies for the Key deer, Lower Keys marsh rabbit, and the silver rice rat. The Population Viability Analysis (PVA) for the Florida Key deer produced a habitat suitability map, which is used in the CCIAM to evaluate impacts to this species. The map shows three types of areas, or "tiers" (Figure 3.12). Development in Tiers 2 and 3 is of lower consequence to the Key deer. Development in Tier 1 results in significant impacts. Thus, a scenario is reported to exceed thresholds if any new development occurs within Tier 1. Throughout the range of the species, outside of Big Pine and No Name Keys, any habitat loss outside subdivisions is also considered to surpass a carrying capacity indicator.

The Lower Keys marsh rabbit is highly endangered, with a high probability of extinction in considerably less than 100 years (Forys and Humphrey 1999). The CCIAM assesses encroachment on marsh rabbit habitat as determined in the USFWS GIS habitat layer. The model is constructed such that no further loss of the marsh rabbit is allowed under any scenario. A scenario is reported to exceed thresholds if new development occurs on or within 500 meters of marsh rabbit habitat.

FIGURE 3.12
HABITAT SUITABILITY FOR KEY DEER

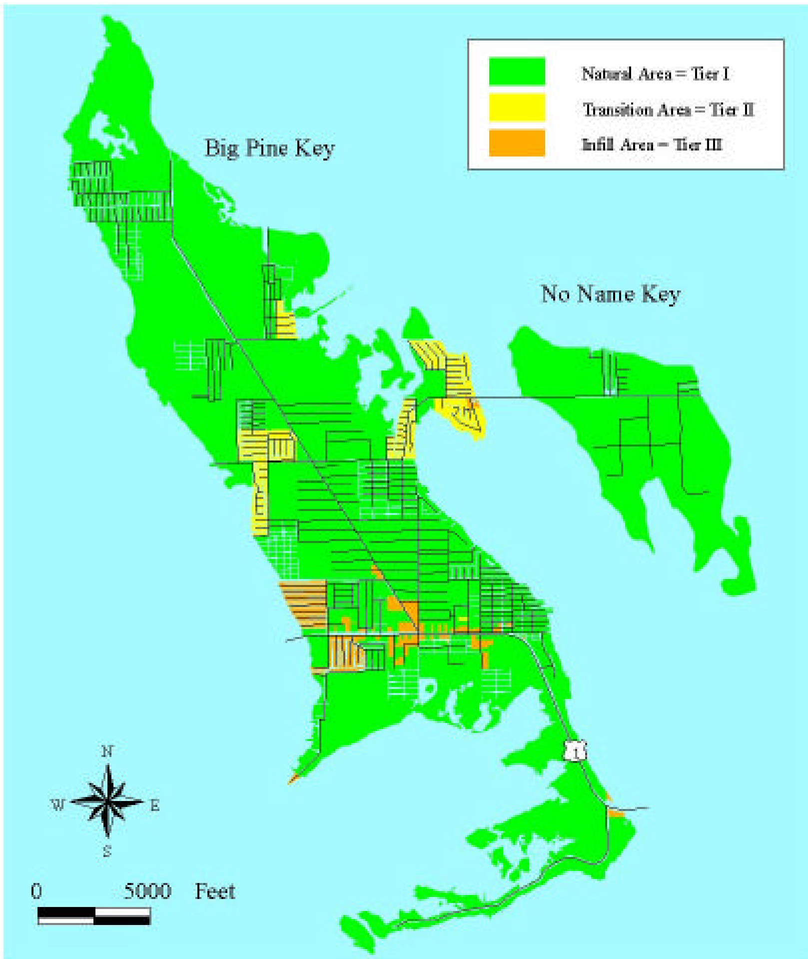


TABLE 3.9
WHITE-CROWNED PIGEON HABITAT REQUIREMENTS[1]

Parameter	Threshold
Nesting areas – habitat	Mangroves
Immature – dispersal habitat	Hammock patch of at least 12 ac
Immature – dispersal distance	6.8 miles
Mature – habitat	Hammock patches of at least 2 ac

[1] Strong and Bancroft, 1994.

The other nine species are incorporated in the CCIAM by assessing either encroachment into existing habitat (silver rice rat, Key Largo woodrat, Schaus swallowtail butterfly), specific habitat requirements (white-crowned pigeon, Table 3.10), or minimum patch size requirements (forest-nesting birds, Table 3.10).

TABLE 3.10
HAMMOCK PATCH SIZE REQUIREMENTS FOR FOREST INTERIOR BIRDS[1]

Parameter	Threshold
Black-whiskered vireo	0.2 ac
White-eyed vireo	2.3 ac
Northern flicker	3.5 ac
Yellow-billed cuckoo	7.5 ac
Mangrove cuckoo	12.8 ac

[1] Bancroft et al., 1995.

3.11.2 Indirect Impacts

A variety of indirect and secondary impacts from adjacent developed land uses affect habitat quality. These effects include noise, domestic predators, light pollution, runoff, and invasion of exotic plants, among others. There is ample evidence that indirect and secondary impacts do occur, and that they decrease with increasing distance from development. The available data, however, is less precise regarding 1) the specific biological consequences of these impacts, 2) the differential response of species, 3) the rate at which effects decrease with distance, or 4) differential land use effects (Table 3.11).

Most studies show indirect impacts to habitat between 200 to 500 feet away from development, depending on development type and intensity. The CCIAM assumes that indirect impacts occur up to 500 feet around developed areas without attempting to quantify the magnitude of the impact. Habitat parameters calculated for indirect impacts are the same as those calculated for direct impacts. For all ADID vegetation types and upland habitat greater than 13 acres, summary statistics calculated include: number of patches, patch size (total area, minimum, maximum, mean), and frequency distribution of patch sizes. The statistics are reported for those areas not affected by the 500-foot buffer, and therefore, represent habitat in which neither direct nor indirect impacts occur.

TABLE 3.11
EFFECTS OF DEVELOPMENT ON ADJACENT HABITATS

Effect Distance	Effect	Reference
Microclimate and Edge Effects		
98	Climatic structural edge influences into a forest (west side).	Ranney et al., 1981
300	Negative impacts on wildlife species from edge effects.	Brown and Schaefer, 1987
450	Changes in air temperature and relative humidity.	Ledwith, 1996
16,404	Edge effects within a reserve boundary.	Janzen, 1986
Surface Water Quality		
35	Less than this is not enough to sustain long-term protection of aquatic resources.	Tjaden and Weber, 1997
35-100	Most common minimum buffer widths for use in water quality and habitat maintenance.	
45	Buffers equal to or greater than this have proven effective in reducing some pesticide contamination of streamflow.	Palone and Todd, 1997
49-66	Minimum buffer for low slopes.	Karr and Schlosser, 1977
75-200	Suggested buffer width for flood control.	Tjaden and Weber, 1997
75	Wetland buffer to minimize sedimentation from coarse sand.	Brown et al., 1990
200	Wetland buffer to minimize sedimentation from fine sand.	
200	Buffer for development adjacent to Aquatic Preserves.	JEA et al., 2000
300	The zone most influential to surface water quality.	Brown et al., 1990 Florida Division of Forestry, 1979
450	Wetland buffer to minimize sedimentation from silt.	Brown et al., 1990
Air Quality and Urban Glow		
492	Minimum recommended distance from beach for lights mounted higher than 16 ft.	Witherington and Martin, 2000
Noise and Vibration		
246	Distance from roadway centerline range for which the acceptable noise range for single-family residential uses is 60 to 65 dB(A), 60 to 70 dB(A) for schools, and less than 70 dB(A) for parks.	City of Monterey Park, 2001
1,640	Area within which breeding bird densities of 3 grassland bird species were significantly reduced adjacent to quiet rural roads.	Van der Zande et al., 1980
Habitat		
15	Minimum width to prevent secondary impacts to habitat functions of wetlands.	St. John's River Water Management District, 1999
25	Average width to prevent secondary impacts to habitat functions of wetlands.	
30	Insufficient to protect wetlands.	Miller and Gunsalus, 1997
100	Minimum width necessary to avoid significantly impacting riparian environments.	Ledwith, 1996
300	Sufficient to protect wetland functions from upland development, i.e. 50 percent of wetland-dependent wildlife and water quality from erosion of sands.	Castelle et al., 1994 Miller and Gunsalus, 1997 JEA et al., 2000
	Generally accepted minimum width for wildlife.	Connecticut River Joint Commissions, 2000

TABLE 3.11
(CONTINUED)
EFFECTS OF DEVELOPMENT ON ADJACENT HABITATS

Effect Distance	Effect	Reference
Habitat (Continued)		
322	Buffer to protect saltwater and freshwater marshes in East Central Florida.	Brown et al., 1990
322-732	To protect wetland resources.	
550	Buffer to protect hammock and forested wetlands in East Central Florida.	
Wildlife		
50	Buffer landward from wetlands jurisdictional line to allow semi-aquatic species area to nest/over winter.	Brown and Schaeffer, 1987
164	To support several interior bird species.	Tassone, 1981
164-197	To support hairy and pileated woodpeckers.	
207-584	Recommended setback for 15 species of breeding colonial birds.	Rodgers and Smith, 1995
220-413	Recommended buffer for 16 species of water birds.	Rodgers and Smith, 1997
240	Minimum distance from humans tolerated by snowy egrets.	Klein, 1989
322	Wildlife in salt marsh habitats.	Brown and Orell, 1995
322-550	Wetland-dependent wildlife species in freshwater riverine systems.	
328	Buffer for neotropical migrant birds.	Triquet et al., 1990
328	Width of buffer strips to protect intrinsic wildlife value.	Tassone, 1981
492-574	Buffer for protection of 90-95 percent of bird species.	Spackman and Hughes, 1995
536	Buffer zone for wetland wildlife.	Brown and Schaeffer, 1987
750	Distance of no human activity around bald eagle's nest.	USFWS, 1999
750-1500	Distance of no buildings proximate to bald eagle's nest.	
984-1968	Nest predation into a forest.	Wilcove et al., 1986
Feral Animals		
112 ha	Home range for female cats.	Warner, 1985
228 ha	Home range for male cats.	
4 acres	Home range for dogs.	Beck, 1973
Other		
75	Set-back of septic systems (regulations in VT and NH).	Connecticut River Joint Commissions, 2000

3.12 CARRYING CAPACITY INDICATORS

In the CCIAM, carrying capacity indicators include thresholds, criteria, levels, or standards, which, if exceeded, would result in a significant level of impact or damage to a resource or element. In some cases this level of impact may be sufficient to impair the sustainability of the resource. In the CCIAM, three types of indicators or thresholds have been used to address the carrying capacity limit of a resource (Table 3.12):

TABLE 3.12
CARRYING CAPACITY INDICATORS FOR THE FKCCS

Indicator	Value or definition	Type*	Comments
Population demand for nonresidential uses	Demand is higher than the available nonresidential uses	III	Population demand for retail, services and other nonresidential uses, increases development demand. The user may input further development in the scenario and run model again.
Business demand for employees	Demand is higher than the available local labor force	III	If the business demand for employees surpasses the available local labor force, pressure builds to increase commuting employees.
Per capita government expenditures	Increase in the per capita expenditures as a result of the scenario	III	An increase in per capita government expenditures means that the government will have to seek increased revenues to match increased expenditures. Therefore, it indicates pressure to increase taxes.
LOS of U.S. 1	Median speed. U.S. 1 wide, the threshold speed of 45 mph. Required speed may be different for different segments.	I	Current regulations require the Monroe County maintain an adequate LOS. A failure to maintain the required LOS results in a building moratorium.
Hurricane evacuation clearance time	24 hours – the time required to evacuate the Keys in case of an impending hurricane.	I	Current regulations required that the Keys population evacuate in 24 hours.
Permitted volume of water supply	Daily average: 15.83 MGD Maximum day: 19.19 MGD	I	Per SFWMD permit which expires December 2005.
Minimum patch size for upland Keys forests	13 acres	II	Keys hammocks smaller than 5.9 ha. are considered "all edge," with forest interiors lacking the buffering effects of edge vegetation (Strong and Bancroft 1994).
Lower Keys marsh rabbit habitat	Species is in danger of extinction	II	Species is currently in danger of extinction, mainly due to habitat loss (Forys and Humphrey 1994). Only habitat restoration would be beneficial for the Lower Keys marsh rabbit.
Key deer habitat	Habitat quality classification – Tier 2 and 3.	II	Recent studies (Lopez 2001) have determined habitat needs for Key deer.
Patch size requirement for forest-nesting birds in the Florida Keys	Minimum patch size: Black-whiskered vireo: 0.5 acres; White-eyed vireo: 5 acres; Northern flickers: 7.5 acres; Yellow-billed cuckoo: 16 acres; Mangrove cuckoo: 12.8.	II	Documented in Bancroft et al. (1995), who studied 27 Upper Keys forests ranging in size from 0.5 to 217 acres.
White-crowned pigeon habitat	Fledglings hatch in mangroves but require large (12 acres) hammock patches within 72 hours.	II	Documented in Strong and Bancroft (1994), who studied post-fledging dispersal of white-crowned pigeons in the Florida Keys.

*I = Regulatory, II = Scientific, III = Social (see Section 2.2.1 for further description).

I. Government mandated thresholds are based on quantitative standards mandated by local, state, or federal agencies (e.g., permitted volume of water supply).

II. Environmental thresholds are based on a tolerance range or limit for a resource or species, beyond which it is not sustainable (e.g., Lower Keys marsh rabbit habitat). These thresholds are established in the scientific literature or through consultation with technical experts.

III. Socioeconomic thresholds are based upon a tolerance range for a given socioeconomic measure, which, if exceeded, would degrade quality of life in the Florida Keys (e.g., population demand for nonresidential uses).

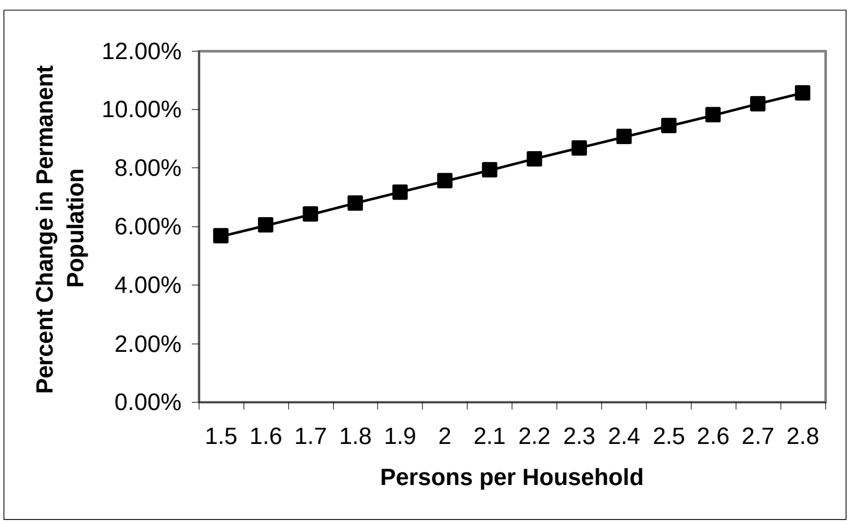
Lack of relevant available data on some topic areas, discussed extensively in previous FKCCS reports, limited the success of attempts to establish carrying capacity thresholds for all environmental parameters. However, carrying capacity indicators exist for several parameters (Table 3.12). Some of these indicators are regulatory and, while currently binding, may be subject to change. Others are documented in the peer-reviewed scientific literature. Together, the carrying capacity indicators provide a framework to explore carrying capacity issues in the Florida Keys.

3.13 SENSITIVITY ANALYSIS

During the development of the CCIAM, the Technical Contractor carried out sensitivity analysis on the model to determine how it reacted to changes in input variables and look-up parameters and coefficients. Sensitivity analyses focused on modules based on numerical calculations, such as Socioeconomics, Fiscal, and Hurricane Evacuation.

All numerical model relationships are linear, resulting from direct multiplication of factors. For example, permanent population is calculated as a multiple of dwelling units. The number of persons per household has varied by less than 0.2 between the 1990 and 2000 Censuses. Changes in the persons per household ratio would affect the magnitude in the percent population change in future scenarios. For example, assume an initial population of 79,589 (per Census 2000) and the construction of 3,000 permanent housing units. The percent permanent population growth would change by 3.8 percent per each additional person per household (Figure 3.13).

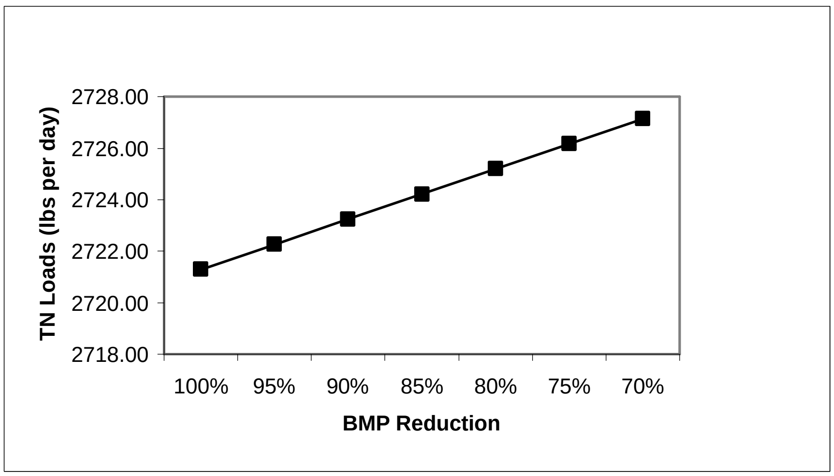
FIGURE 3.13. EFFECT OF PERSONS PER HOUSEHOLD ON PERMANENT POPULATION CHANGE



In the Human Infrastructure Module, median speed on U.S. 1 is estimated using a regression equation, $y = -0.016x + 49.97$, where x is the sum of acres of residential and tourist land uses divided by the length of U.S. 1 in the planning unit, and y is the resulting median speed. In this case, the number of acres of residential and tourist land uses combined, per mile of U.S. 1 in a given planning unit, would have to change by 62.5 acres in order for the median speed to change by 1 mph. None of the scenarios evaluated results in large increases in the acreage of residential or tourist land uses.

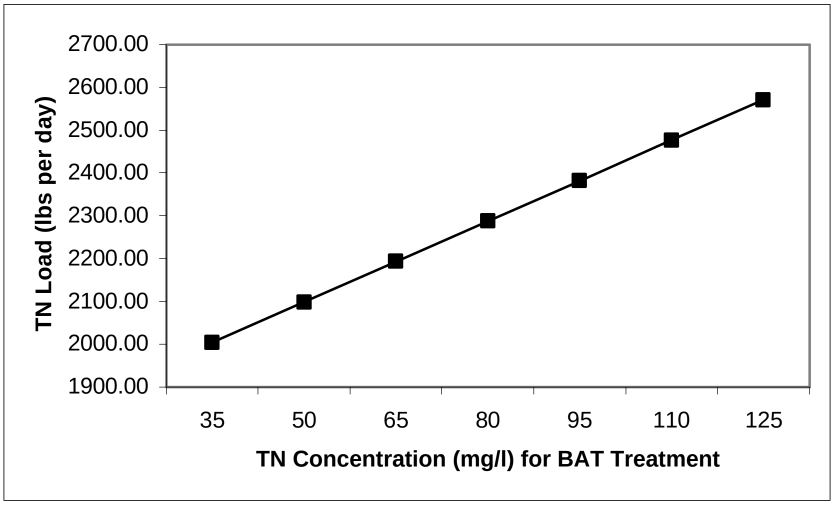
The Stormwater and Wastewater Components of the Integrated Water Module include a series of multiplications (e.g., number of dwelling units times wastewater volume times pollutant concentration times treatment reduction) and additions (e.g., summed over wastesheds, planning units, and entire Keys). Stormwater loads, when summed over the entire study area vary little in response to changes in BMP efficiency. For example, TN loads from stormwater vary only by 1.95 lbs/day with a 10% percent change in BMP efficiency.

FIGURE 3.14. EFFECT OF BMP EFFICIENCY ON TOTAL TN LOADS



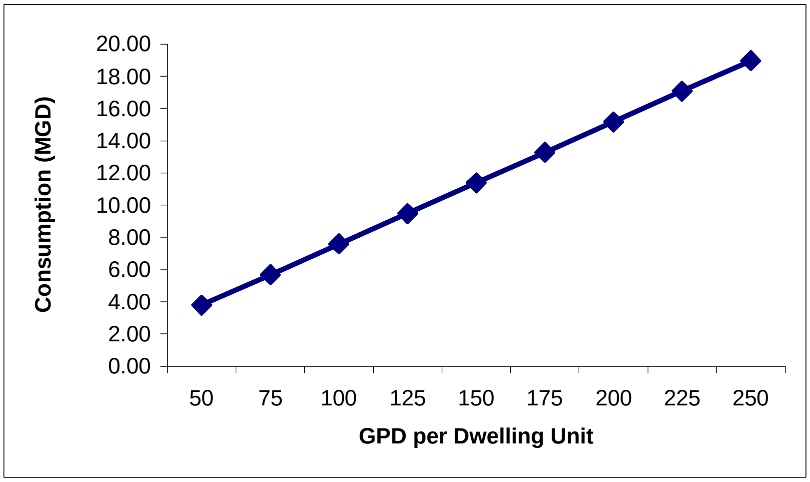
The Wastewater Component is sensitive to changes in effluent characteristics. For example, a change of 15 mg/l of TN for Best Available Technology (BAT) results in almost 100 lbs/day of TN load (Figure 3.15).

FIGURE 3.15. EFFECT OF EFFLUENT CHARACTERISTICS ON WASTEWATER LOADS.



Finally, the Potable Water Component indicates that daily water consumption per dwelling unit has a strong effect on total daily consumption over the entire study area. For example, a reduction of 1 gpd/du (du = dwelling unit) could save approximately 0.8 MGD over the entire Florida Keys (Figure 3.16).

FIGURE 3.16. EFFECT OF WATER CONSUMPTION PER DWELLING UNIT ON TOTAL WATER CONSUMPTION IN THE FLORIDA KEYS.

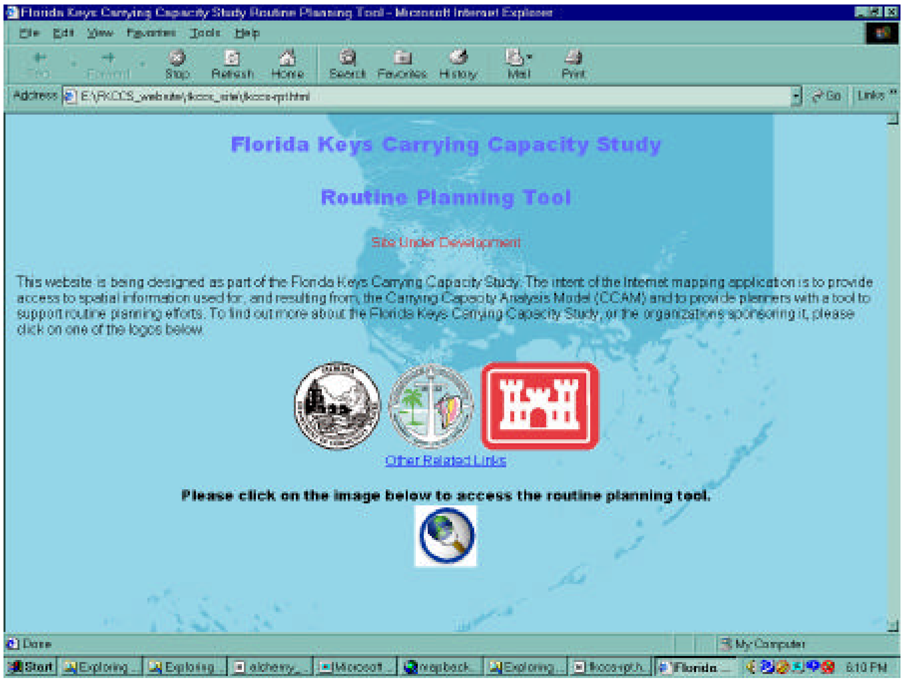


Sensitivity analyses suggest that, overall the CCIAM's sensitivity to changes in model parameters is small and consistent across modules and components. Furthermore, the effect of parameters on model outputs can be easily evaluated and understood, which helps model users understand the limitations and strengths of the model.

3.14 ROUTINE PLANNING SUPPORT TOOL

A by-product of the FKCCS, the RPST is an Internet application, which will allow users to view and query FKCCS data and results, including maps (Figure 3.13).

FIGURE 3.13
RPST HOME PAGE



The RPST will assist local planners in their daily activities. Planners will be able to access the web site using their web browser and access data, such as parcel information, habitat characteristics or presence or absence of species habitat, among others. A key application of this Internet tool will be assisting in making permitting decisions. For example, when reviewing a permit application for development, planners will be able to zoom-in to the subject parcel (Figure 3.14) and perform queries regarding characteristics of the parcels, such as habitat present on the parcel or anticipated wetland impacts. The RPST is a significant value-added benefit of the FKCCS.

FIGURE 3.14
EXAMPLE PARCEL-SPECIFIC QUERIES USING THE RPST