3. AFFECTED ENVIRONMENT

This section addresses the elements of the environment that could potentially be affected by the Proposed Action and the alternatives. The section is divided into two major areas: 1) the regional area, including the six-county region surrounding Cape Canaveral Air Station (CCAS) (formerly Cape Canaveral Air Force Station [CCAFS]) arid Kennedy Space Center (KSC) and 2) the global area. A brief discussion of plutonium levels in the global environment is included to provide a perspective of the types, sources, and levels of plutonium that exist in the environment on a broad scale.

The affected environment has been discussed in detail in previous (Tier 2) Environmental Impact Statements (EISs) for the Galileo (NASA 1989b) and Ulysses missions (NASA 1990). Much of the material has been updated for this document with sources such as the October 1994 *Kennedy Space Center Environmental Resource Document* (NASA 1994). Additional information, including information specific to CCAS, was taken from the *Air Force Environmental Assessment for the Titan IV/Solid Rocket Motor Upgrade Program* (USAF 1990).

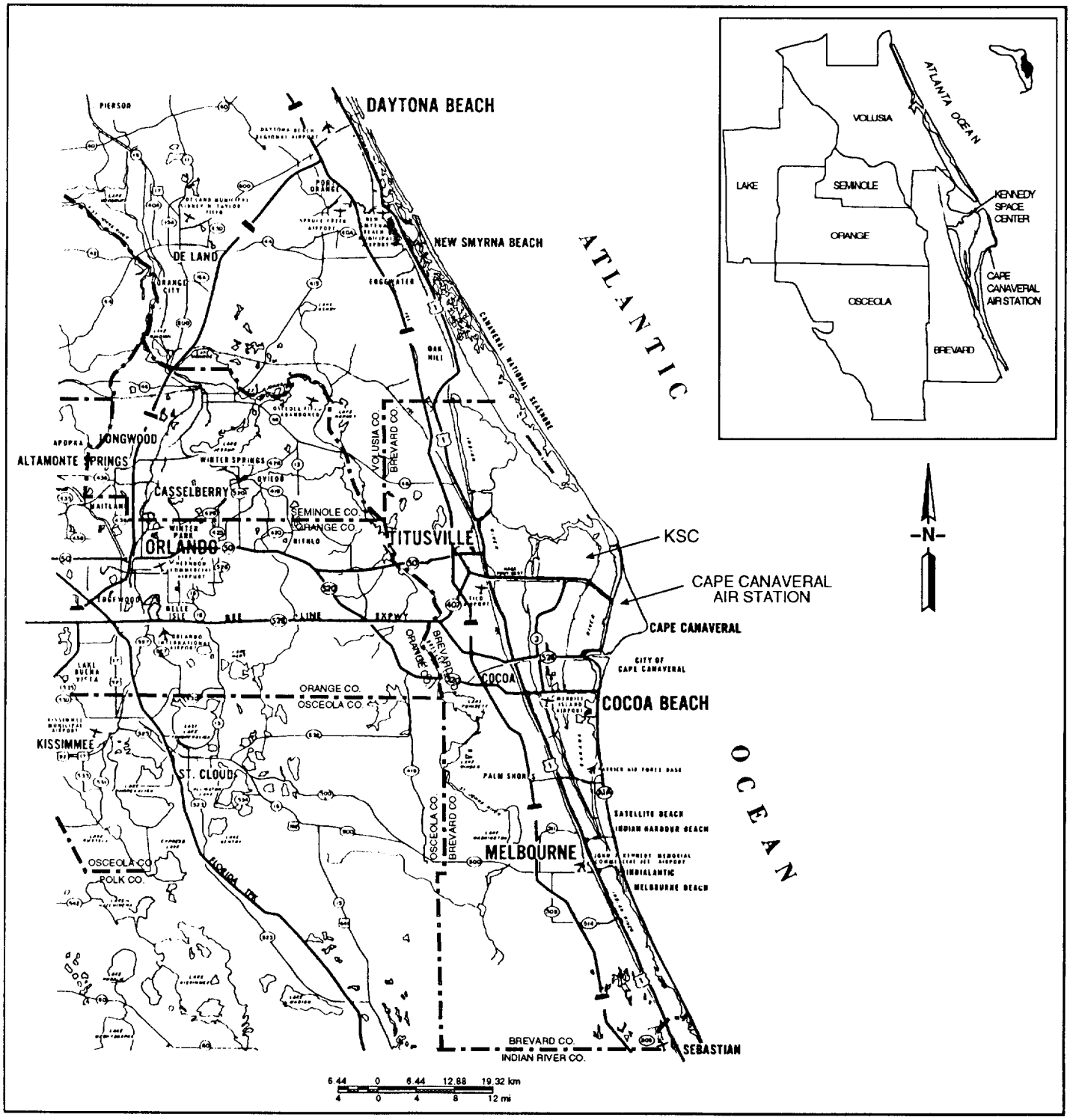
3.1 REGIONAL AREA

For the purpose of this document, the region of interest consists of the six counties-Volusia, Seminole, Lake, Orange, Osceola, and Brevard counties-shown in Figure 3-1.

CCAS is located on the east coast of Florida in Brevard County near the city of Cocoa Beach, approximately 24 km (15 mi) north of Patrick Air Force Base. The station is adjacent to the NASA KSC, Merritt Island, Florida. The station is bounded by KSC on the north, the Atlantic Ocean on the east, the city of Cape Canaveral on the south, and the Banana River and KSC/Merritt Island National Wildlife Refuge on the west. KSC is located in the northeast coastal section of Brevard County, Florida and the southern part of Volusia County, Florida. It is bounded on the north by uninhabited marsh land, on the east by the Atlantic Ocean, on the south by CCAS and on the west by the shallow tidal Indian River. Figure 3-2 illustrates the location of CCAS and KSC relative to Brevard and Volusia Counties.

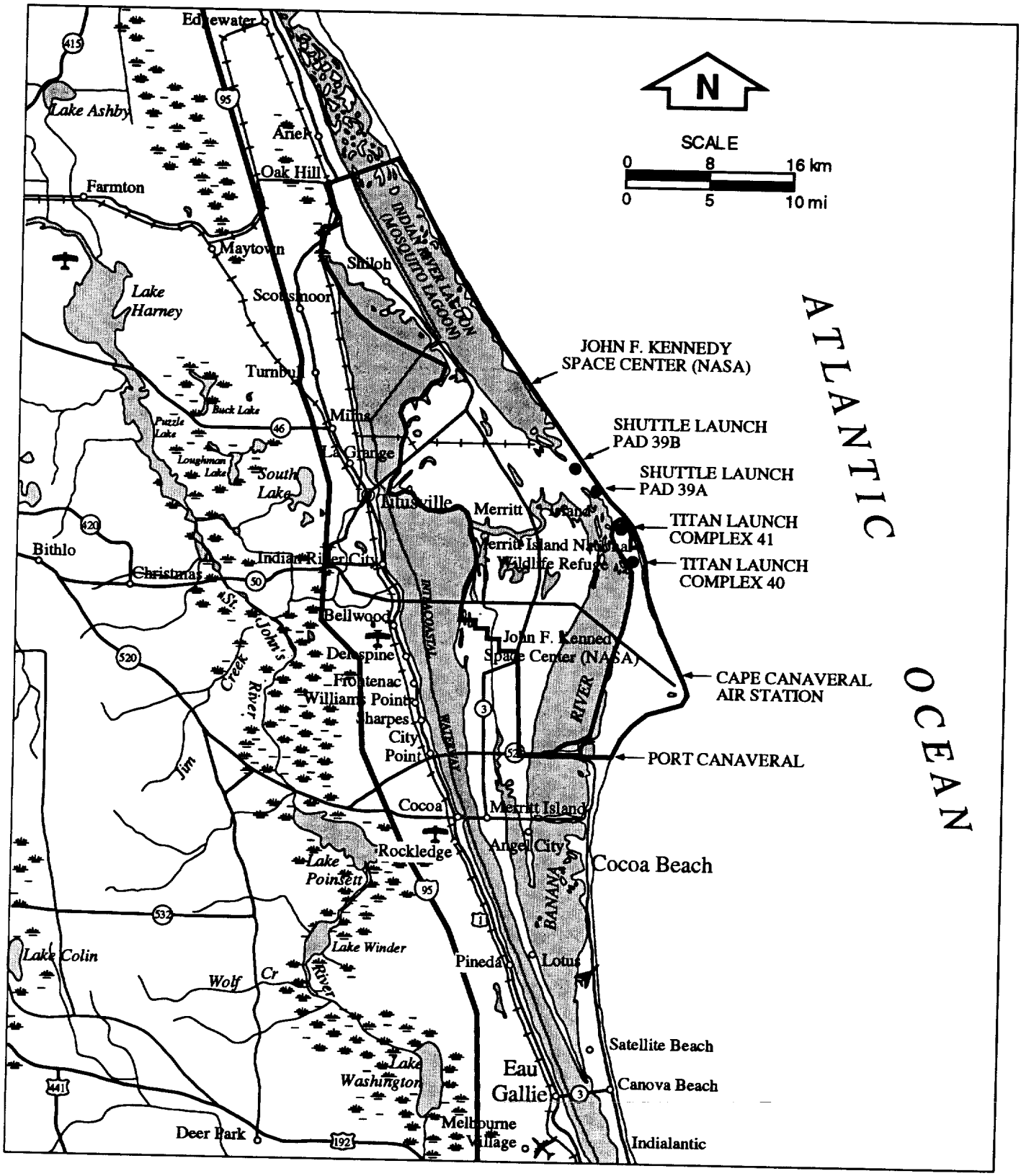
3.1.1 Land Use

About 8 percent (132,742 ha; 328,000 acres) of the total region (1.7 million ha; 4.1 million acres) is urbanized (ECFRPC 1992a), with the largest concentrations of people occurring in three metropolitan areas: 1) Orlando in Orange County, with expansions into the Lake Mary and Sanford areas of Seminole County to the north and into the Kissimmee and St. Cloud areas of Osceola County to the south, 2) the coastal area of Volusia County, including Daytona Beach, Port Orange, Ormond Beach, and New Smyrna Beach, and 3) along the Indian River Lagoon and coastal area of Brevard County, specifically the cities of Titusville, Melbourne, and Palm Bay. Approximately 85 percent of the region's population lives in urban areas.



Source: NASA 1986

FIGURE 3-1. REGIONAL AREA OF INTEREST



Source: NASA 1986, NASA 1994

FIGURE 3-2. LOCATION OF CCAS RELATIVE TO THE REGION

The majority of the region is considered rural, which includes agricultural lands and associated trade and service areas, conservation and recreation lands, and undeveloped areas. Agricultural areas include citrus groves, winter vegetable farms, pasture land and livestock, foliage nurseries, sod farms, and dairy land. With more than 5,000 farms, nurseries, and ranches in the region, about 35 percent (566,580 ha; 1.4 million acres) of the regional area is devoted to agriculture.

Conservation and recreation lands account for almost 25 percent of the total acreage in the region, or slightly more than 404,700 ha (1 million acres) (ECFRPC Undated-a). The region also contains about 2,185 ha (5,400 acres) of saltwater beaches and more than 80 acres of archaeological and historic sites (DOI 1991). Numerous areas within the region have special status land use designations. These include a portion of the Ocala National Forest, the Canaveral National Seashore adjacent to KSC, five State preserves or reserves, seven State wildlife management areas, and three national wildlife refuges, including the Merritt Island National Wildlife Refuge at KSC.

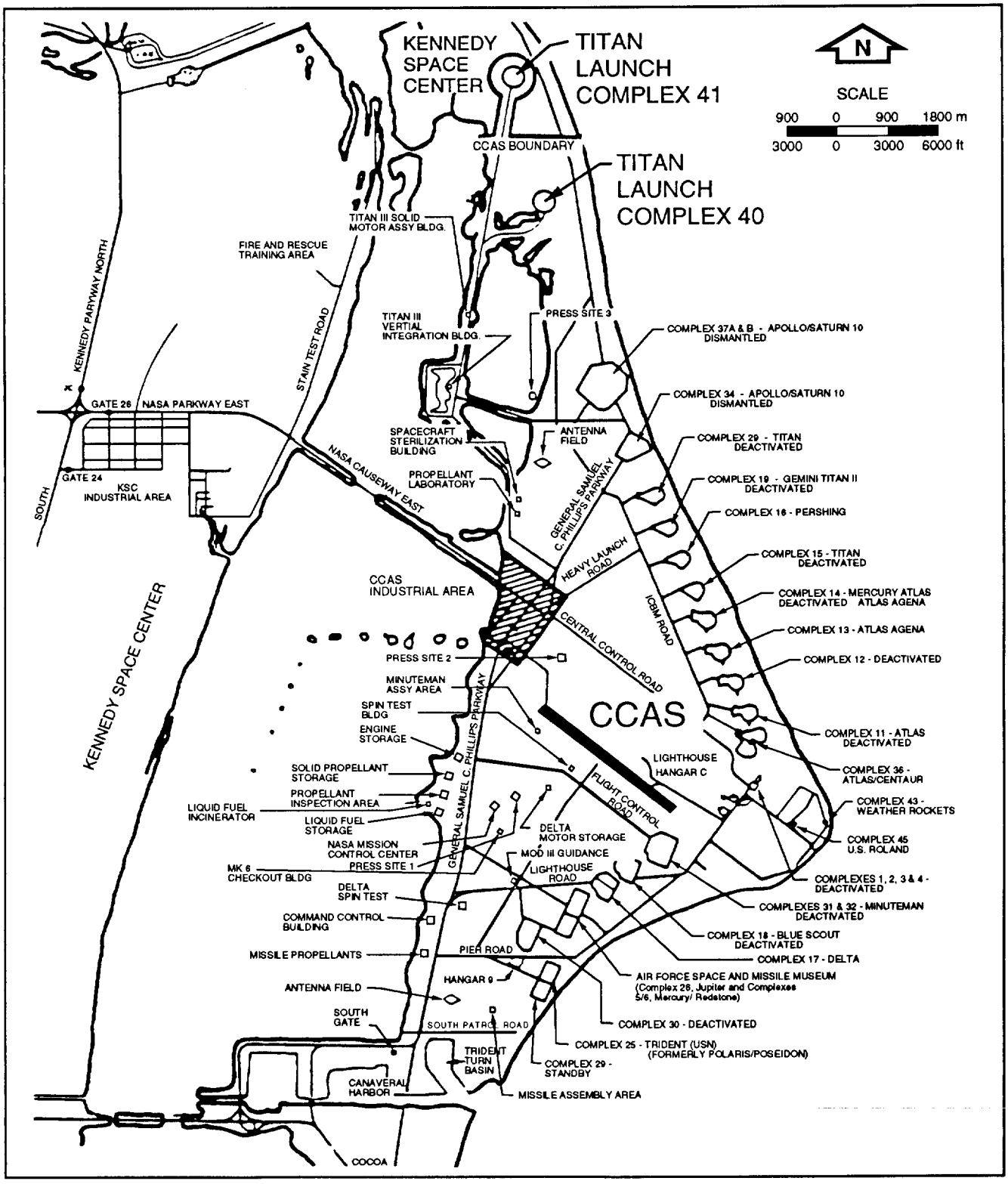
CCAS

CCAS occupies approximately 6,394 ha (15,800 acres) (roughly 64.75 km^2 or 25 mi^2) of the barrier island that also contains the city of Cape Canaveral (see Figure 3-3). Approximately 1,880 ha (4,700 acres) or 30 percent of the station is developed, consisting of more than 40 launch complexes and support facilities, many of which have been dismantled or deactivated (USAF 1990). The remaining 70 percent (about 4,440 ha; 11,100 acres) is unimproved land (USAF 1990). The Titan IV Launch Complexes 40 and 41 are located in the northernmost section of CCAS. Launch Complex 40 has been operational since 1 964. Launch Complex 41 was previously used from 1964 to 1 977 for test flights of the Titan III A and Titan III C. Subsequently, it was reactivated in 1986 and renovated to support Titan IV launches (USAF 1 990).

Launch Complex 40 and 41 (see Figure 3-4) each consist of a launch pad, Mobile Service Tower (MST), Umbilical Tower (UT), Aerospace Ground Equipment (AGE) building, air conditioning shelter, gas storage area, propellant holding areas, and miscellaneous service facilities. Launch Complex 41, as well as Launch Complex 40 to the southeast, has been strengthened and upgraded to accommodate Titan IV launches using the larger and more powerful solid rocket motor upgrade (SRMU) (USAF 1990).

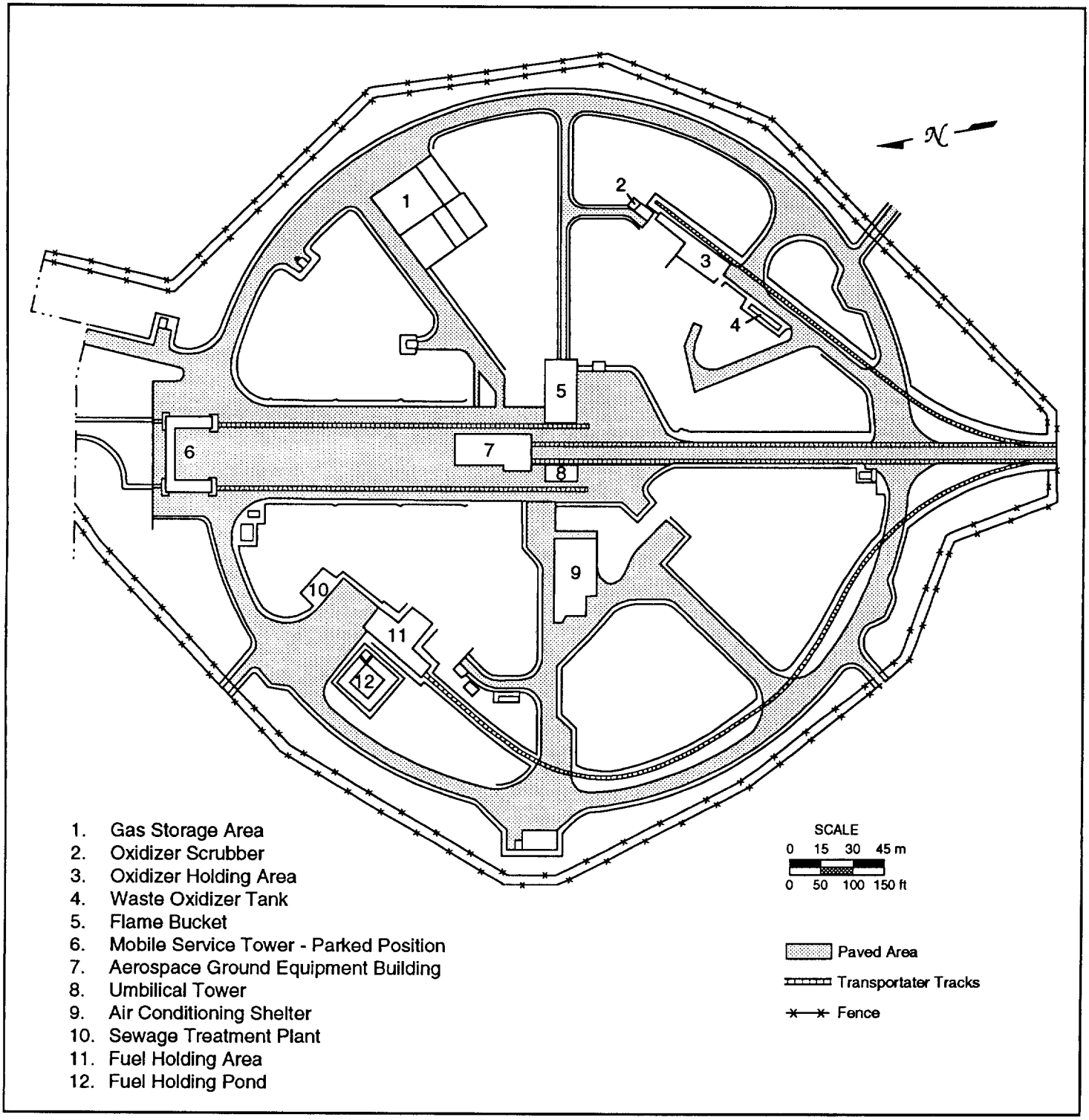
The launch pad is a concrete deck with fixed foundations to support the launch transporter with the mounted Titan IV/Centaur launch vehicle, the MST, and the UT (Martin Marietta 1992). The launch pad deck is 7 m (23 ft) above mean sea level and approximately 4.3 m (14 ft) above the surrounding complex finish grade. Rails for the MST and transporter are nested flush with the deck surface.

A concrete exhaust duct with an opening of 5.5 to 17.7 m (18 to 58 ft), an integral part of the launch pad, deflects solid rocket motor exhaust gases away from the launch pad to reduce the noise (acoustic) and shock wave (overpressure) that result from ignition of the solid rocket motors. The launch complex includes a water deluge system and an overpressure suppression system, which sprays high-pressure water directly into the solid



Source: USAF 1986

FIGURE 3-3. EXISTING LAND USE AT CCAS



Source: USAF 1990

FIGURE 3-4. LAYOUT OF LAUNCH COMPLEXES 40 AND 41 AT CAPE CANAVERAL AIR STATION, FLORIDA

rocket motor upgrade (SRMU) exhaust plume to reduce acoustic loads on the vehicle and the overpressure from the SRMUs.

The MST provides facilities for mating the Centaur and the spacecraft to the Titan IV and for servicing and inspecting the complete integrated flight vehicle. Just prior to launch, the MST is moved from its service position to its park position, north of the launch pad.

The UT is a steel-frame structure anchored to the launch pad that extends approximately 52 m (170 ft) above the top of the launch pad. It provides connections for propellants, pressurization gases, and conditioned air to both the launch vehicle and to the payload fairing. Installations on the tower accommodate both manual and launch-disconnected umbilicals.

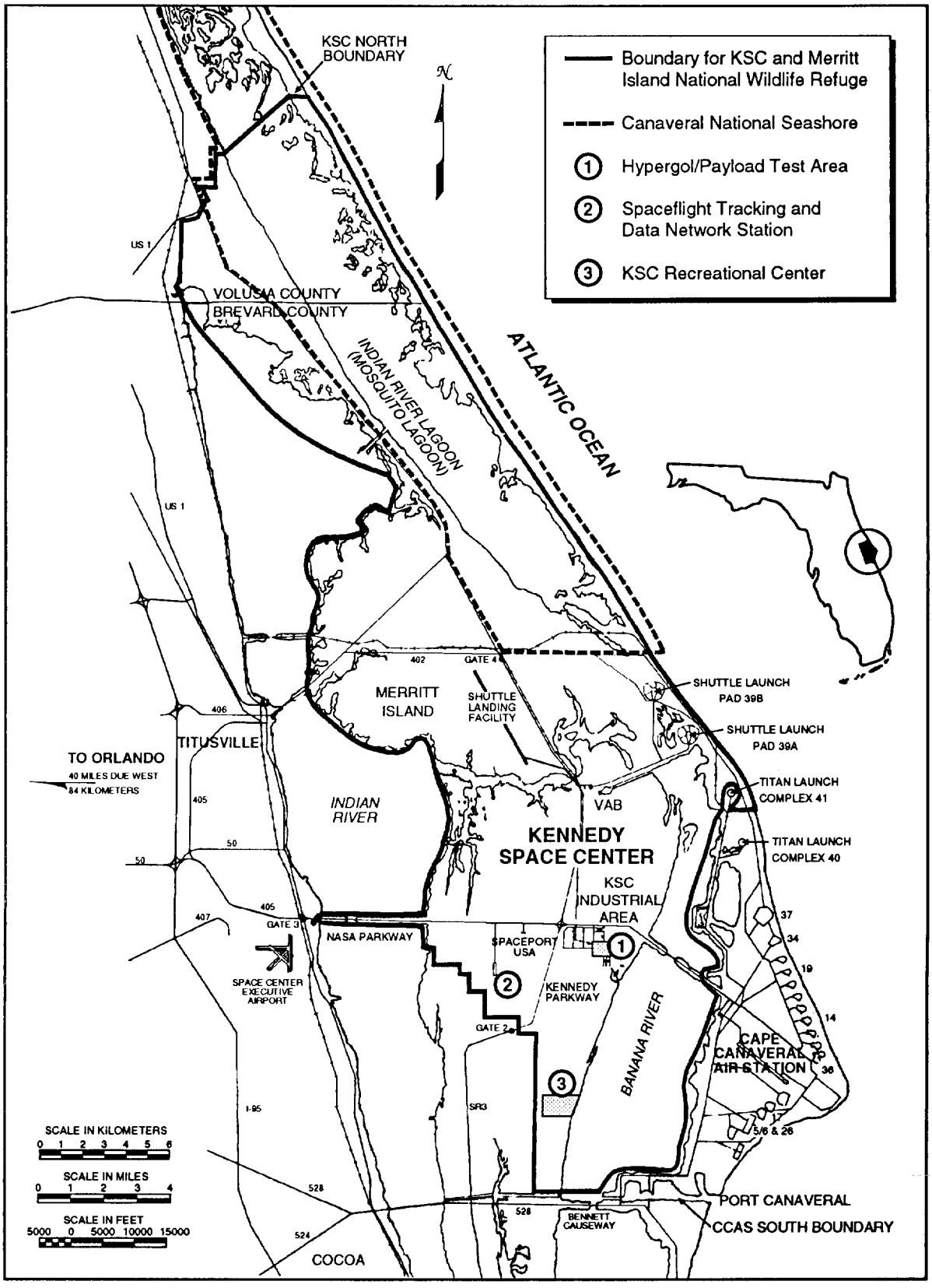
The AGE building is a two-story, reinforced concrete structure located between the MST rails and adjacent to the launch pad. The upper level (first level or level A) houses the two Titan AGE vans and has provisions for two additional vans for either the Centaur or spacecraft AGE. The lower level (second level or level B) contains a rack room and a facility power and air conditioning equipment room, as well as the propellant transfer and pressurization control set, used to control and monitor propellant loading, unloading, and tank pressurization. The building is constructed to withstand exposure to the thermal and acoustical environment produced by the vehicle engine exhaust and is maintained at an air pressure above atmospheric pressure to reduce the possibility of equipment contamination in the building. To ensure a source of uncontaminated air, there are two interchangeable intakes, one located approximately 152 m (500 ft) north and the other approximately 152 m (500 ft) south of the building.

The gas storage area contains storage vessels for high-pressure nitrogen and helium. Separate holding areas contain facilities to store, transfer, and unload propellants for the launch vehicle (unsymmetrical dimethylhydrazine and nitrogen tetroxide) and for the Centaur (liquid hydrogen and liquid oxygen).

A lightning mitigation system has been constructed at both Launch Complexes 40 and 41. This system consists of four towers located at the four corners of the launch pad wired to ground lightning flashes. The towers are more than 91.5 m (300 ft) tall and will secure the area for continued pad activities when thunderstorms are in the area.

KSC

KSC occupies approximately 56,452 ha (139,490 acres) (see Figure 3-5). Approximately 2,148 ha (5,308 acres) or 4 percent of the Center is developed, of which 2,406 ha (5,945 acres) is under NASA operational control. The remaining 54,303 ha (134,182 acres) is undeveloped land (NASA 1994). Nearly 40 percent of KSC consists of open water areas. The Shuttle Launch Complexes 39A and 39B are located in the northeast portion of KSC. Launch Complexes 39A and B have been operational since the



Source: NASA 1990

FIGURE 3-5. EXISTING LAND USE ON KSC

1970s and consist of facilities to support launch of the Shuttle (i.e., Space Transportation System [STS]). Figure 3-6 illustrates the layout of Launch Complexes 39A and 39B.

KSC is the major NASA installation for launch operations and related programs in support of manned space missions. Present and near-future mission plans call for the launching of manned vehicles into low Earth orbit for conducting scientific experimentation. To accomplish these goals, the Shuttle provides the capability to support a wide range of scientific applications (NASA 1994).

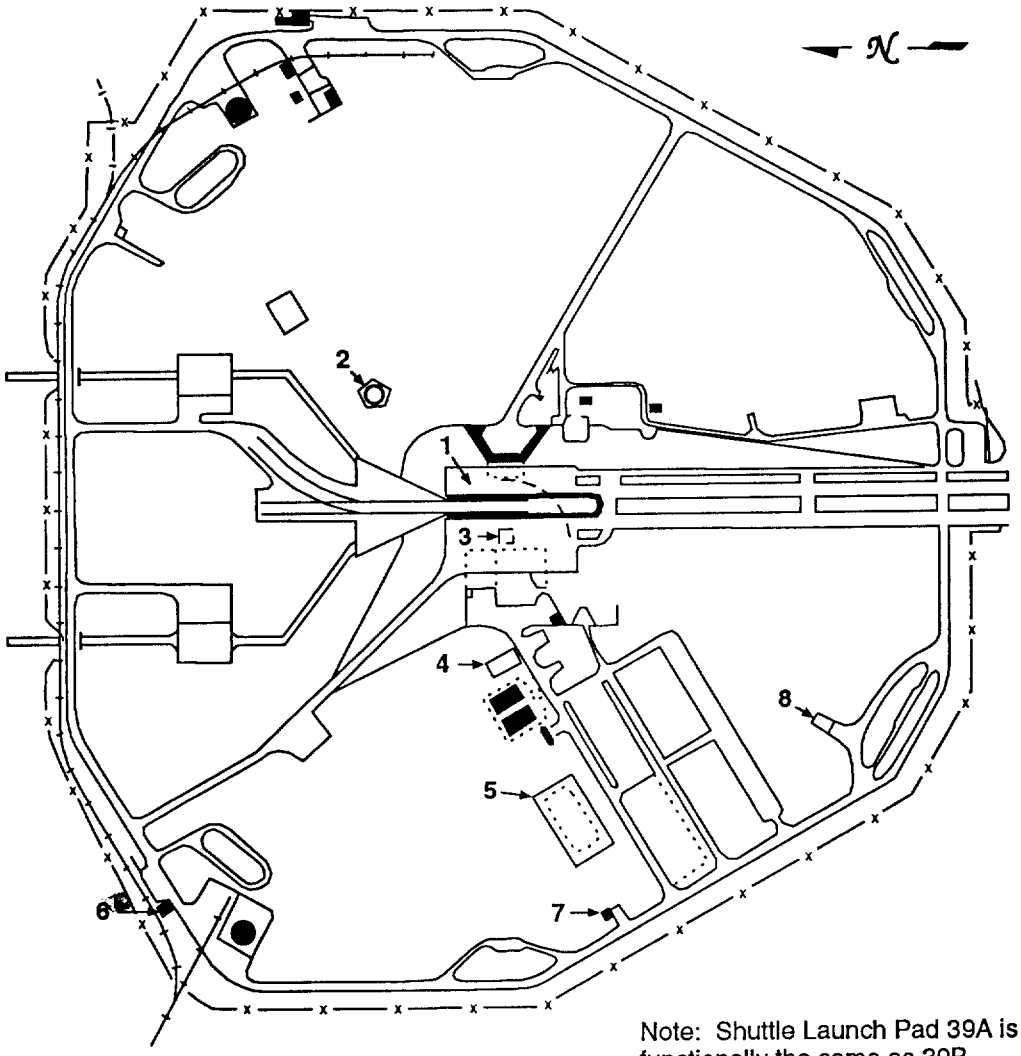
3.1.2 Atmospheric Environment

The structure of the atmosphere can be classified in a number of ways, using either temperature, density, or chemical composition. From the standpoint of the dispersion of atmospheric pollutants, however, a temperature classification scheme is most important. Essentially, the Cassini launch would cause its greatest potential environmental impacts in the lower layers of the atmosphere: the troposphere and the stratosphere. The primary concerns associated with the troposphere are potential violations of the National Ambient Air Quality Standards (NAAQS) developed under the Clean Air Act (CAA) by the U.S. Environmental Protection Agency (EPA) and global warming issues. The principal concern within the stratosphere is ozone depletion.

3.1.2.1 Atmospheric Layers

The troposphere is the atmospheric layer closest to the Earth's surface. All life exists and virtually all weather occurs within this layer. Additionally, this layer accounts for more than 80 percent of the mass and essentially all of the water vapor, clouds, and precipitation contained in the Earth's atmosphere. The troposphere varies from an altitude of 10 km (32,808 ft) at the poles to 15 km (49,200 ft) at the equator. In this layer, the temperature decreases with height at the nominal rate of approximately 6.5°C/km (about 3.57°F/1,000 ft). In addition, vertical convection tends to maintain a well-mixed atmospheric environment in this layer; however, stagnations do occur. As a result of the mixing and scavenging by precipitation, the mean residence time for tropospheric aerosols is short (ranging from a few days to a few weeks). The troposphere and the stratosphere are separated by a narrow region called the tropopause.

The stratosphere extends from the tropopause up to an altitude of approximately 50 km (164,050 ft). In general, vertical mixing is limited within the stratosphere, providing little transport between the layers above and below. Thus, the relatively dry, ozone-rich stratospheric air does not easily mix with the lower, moist ozone-poor tropospheric air. In addition, the lack of vertical mixing and exchange between atmospheric layers provides for extremely long residence times, allowing the stratosphere to often act as a "reservoir" for certain types of atmospheric pollution. The temperature is relatively constant in the lower stratosphere and gradually increases with altitude, reaching approximately 3°C (37.5°F) at the top of the layer. The temperature increase is caused primarily to the adsorption of short-wave radiation by ozone molecules.



Source: INSRP 1989a

FIGURE 3-6. SHUTTLE LAUNCH PAD 39B AT KSC

3.1.2.2 Meteorology

The climate of the region is subtropical with two definite seasons: long, warm, humid summers and short, mild, and dry winters (NASA 1994). Rainfall amounts vary both seasonally and yearly. The average rainfall is about 130 cm (51 in.), with about 70 percent falling during the wet season (May to October). These rainfall fluctuations result in frequent, although usually not severe, episodes of flooding and drought. The temperature is more constant than precipitation; prolonged cold spells and heat waves are rare. Tropical storms, tropical depressions, and hurricanes, all of which can produce large amounts of rainfall and high winds, occasionally strike the region. Hail falls occasionally during thunderstorms, but hailstones are usually small and seldom cause much damage. Snow is rare.

Figure 3-7 provides wind roses indicating the seasonal wind directions at CCAS and KSC. The winds in September through November occur predominantly from the east to northeast. Winds typically occur from the north to northwest in December through February; from the southeast in March through May and from the south in June through August. Sea breeze (onshore winds) and land breeze (offshore winds) phenomena occur commonly over a 24-hour day due to unequal solar heating of the air over land and ocean. Land breeze (toward the sea) occurs at night when air over land has cooled to a lower temperature than that over the sea; sea breeze (toward the land) occurs during the day when air temperatures are lower over the sea. Temperature inversions occur infrequently (approximately 2 percent of the time).

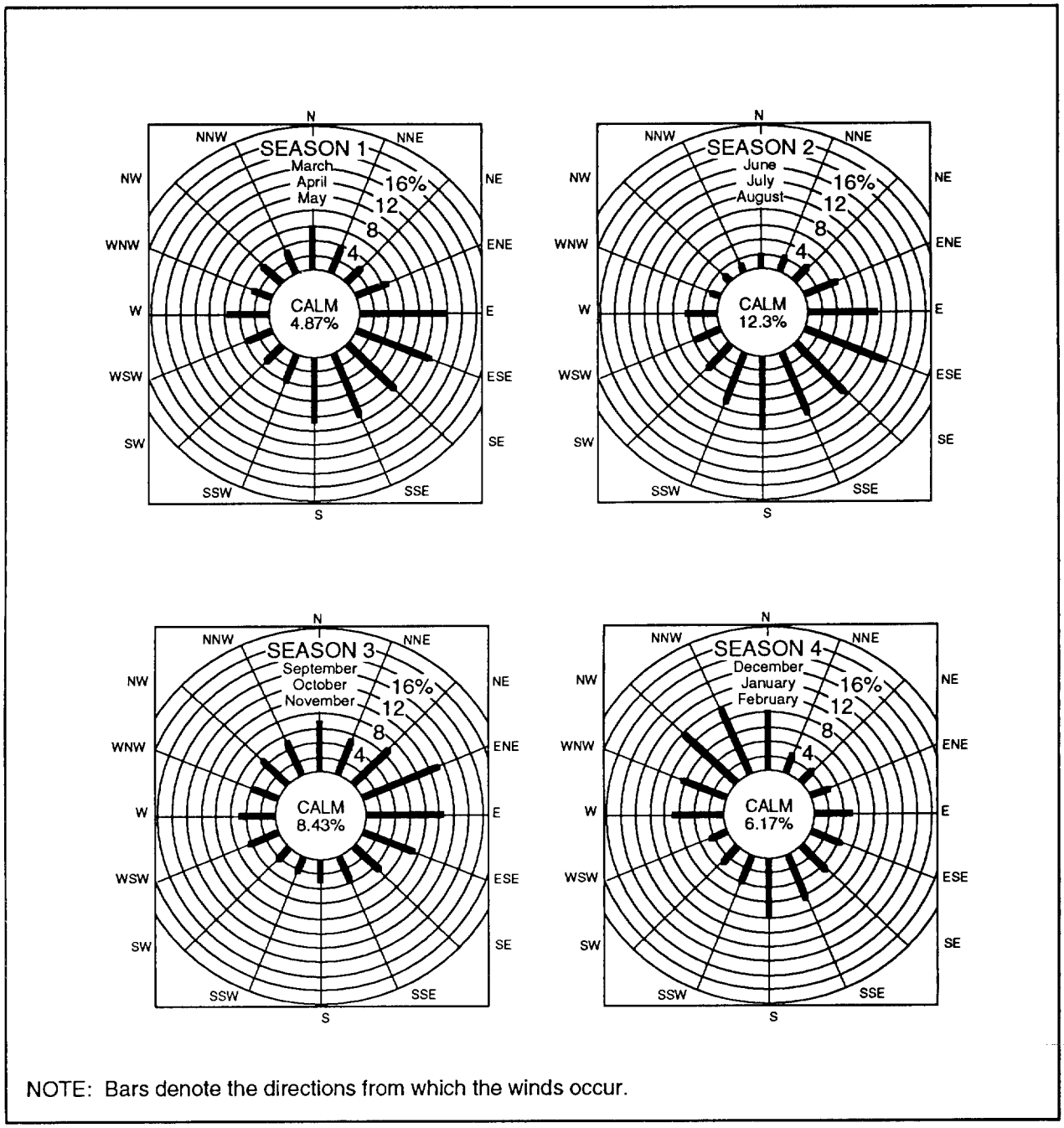
Tornadoes may occur but are rare. The U.S. Air Force (USAF 1986) cited a study that concluded that the probability of a tornado hitting a point within the Cape Canaveral area in any given year is 0.00074, with a return frequency of approximately once every 1,300 years. Tornadoes are rare and damage has been minimal (NASA 1994).

Tropical depressions and hurricanes occur mainly in the months of August through November in Florida. Less than 30 hurricanes have passed within 185 km (100 nautical miles) of the CCAS regional area since 1887 (NASA 1994). Hurricane David (which paralleled the coast in September 1981), Hurricane Hugo (September 1 989), and Hurricane Andrew (August 1992) were the last hurricanes to affect the CCAS/KSC area.

Eighty percent of the thunderstorms occurring in this area occur from May through September, with a maximum of 16 thunderstorm days on average in July (NASA 1994). Lightning detection systems indicate that on the average there are 1,400 cloud to ground strikes per month in the summer months within the 350 km^2 (135 mi^2) KSC area (Bionetics Corporation 1990).

3.1.2.3 Air Quality

Air quality at CCAS is considered good, primarily because of the distance of the station from major sources of pollution. There are no Class I or nonattainment areas for NAAQS criteria pollutants (i.e., ozone, nitrogen oxides, sulfur dioxide, lead, carbon monoxide, and particulates) within about 96 km (60 mi) of CCAS. Orange County, to the west of CCAS, was a nonattainment area for ozone until 1987 when it was redesignated



NOTE: Bars denote the directions from which the winds occur.

Source: NASA 1986

FIGURE 3-7. WIND ROSES INDICATING SEASONAL WIND DIRECTIONS - LOWER ATMOSPHERIC CONDITIONS: CAPE CANAVERAL/MERRITT ISLAND LAND MASS

as an ozone attainment area (NASA 1994). Orange County is currently designated as an air quality maintenance area (State of Florida 1991a). Under Section 176(c) of the CAA, the general conformity rules require a Federal action to conform to the applicable State Implementation Plan. The general conformity rules apply to nonattainment areas and to maintenance areas (e.g., Orange County). Because Brevard County, CCAS/KSC and its vicinity are considered to be "in attainment" or "unclassifiable" with respect to NAAQS for criteria pollutants (USAF 1990), these rules do not apply to CCAS/KSC or to the Cassini mission.

Ambient air quality at KSC is monitored by a single permanent air monitoring station (PAMS) (Busacca et al. 1991). The PAMS is located approximately 0.4 km (0.25 mi) southeast of the Environmental Health Facility (Building L7-1557). Six exceedances of the standard were observed at the PAMS site since 1988 (NASA 1994). Historically, ozone levels can reach peak concentrations during any of the spring and fall months (Busacca et al. 1991). Table 3-1 provides ambient air quality data for 1993.

3.1.3 Noise

Monitoring of ambient noise levels at CCAS has not been performed (USAF 1990). The 24-hour average ambient noise level at KSC is appreciably lower than the EPA recommended upper level of 70 decibels (dBA). This is on a scale ranging from approximately 10 dBA for the rustling of grass or leaves to 115 dBA, the unprotected hearing upper limit for exposure on a missile or space launch. The backwoods and National Wildlife Refuge areas of KSC are exposed to relatively low ambient noise levels, in the range of 35 to 40 dBA (NASA 1994).

Noise generated at CCAS, however, is expected to include sources from day-to-day operations, launches of space vehicles, industrial operations, construction, aircraft operating in the vicinity, boats, and vehicular traffic. The noise caused by the day-to-day operations at CCAS and KSC probably approximates that of any urban industrial area reaching levels of 60 to 80 dBA (USAF 1990). The launch of a space vehicle generates intense, but relatively short-duration noise levels at low frequencies. At the launch pad, the maximum sound pressure can exceed 160 dBA (NASA 1994). Peak noise levels from industrial and construction activities from mechanical equipment, such as diesel locomotives, cranes, and rail cars, could range from approximately 89 to 111 dBA. Vehicular traffic noise ranges from 85 dBA for a passenger automobile to 110 dBA for a motorcycle (NASA 1994). (As enforced by the Occupational Safety and Health Administration [OSHA], continuous exposure for longer than 8 hours per day to noise levels above 85 dBA requires monitoring for hearing damage; the maximum short-term [15 minute] occupational exposure level is 115 dBA.)

3.1.4 Geology and Soils

The region of interest is underlain by a series of limestone formations, with a total thickness of several thousand feet. The lower formations (the Avon Park and Ocala) contain the Upper Floridan Aquifer, which is under artesian pressure in the vicinity of CCAS/KSC. At CCAS/KSC, the Upper Floridan Aquifer commences at a depth of about

TABLE 3-1. SUMMARY AIR QUALITY DATA FROM KSC (1993)

Criteria Pollutant	Federal and State Standard[a]	January	February	March	April	May	June
Ozone (ppb)	120 (hr-avg)[b]	18 (99.9%)	32 (100.0%)	35 (99.9%)	35 (82.1%)	32 (89.0%)	22 (62.1%)
Sulfur Dioxide (ppb)	140(24-hr)[c,d] 500 (3-hr)[d]	1 1 (98.0%)	1 1 (72.1%)	1 1 (99.3%)	1 1 (85.4%)	1 1 (88.4%)	1 2 (62.1%)
Nitrogen Dioxide (ppb)	(max. value) (10-min avg) 50 (annual-avg)[d]	26 17 13 (100.0%)	23 22 16 (100.0%)	41 24 13 (100.0%)	35 22 8 (85.4%)	32 29 11 (89.0%)	35 32 20 (62.1%)
Carbon Monoxide (ppm)	35 (hr-avg)[b] 9 (8-hr)[c]	1.615 1.365 (99.6%)	0.497 0.465 (99.9%)	0.801 0.737 (99.9%)	0.548 0.434 (86.4%)	0.569 0.394 (89.0%)	1.282 0.925 (62.1%)
Criteria Pollutant	**Federal and State Standard[a]**	**July**	**August**	**September**	**October**	**November**	**December**
Ozone (ppb)	120 (hr-avg)[b]	74 (96.2%)	75 (73.9%)	35 (69.9%)	36 (99.9%0	16 (100.0%)	17 (100.0%)
Sulfur Dioxide (ppb)	140(24-hr)[c,d] 500 (3-hr)[d]	4 17 (96.2%)	3 19 (76.3%)	1 1 (69.9%)	1 1 (99.7%)	1 2 (94%)	1 1 (8.5%)
Nitrogen Dioxide (ppb)	(max. value) (10-min avg) 50 (annual-avg)[d]	10 10 33 (96.2%)	16 15 18 (76.3%)	24 19 10 (69.9%)	- - 12 (100.0%)	- - 10 (100.0%)	- - 11 (100.0%)
Carbon Monoxide (ppm)	35 (hr-avg)[b] 9 (8-hr)[c]	0.731 0.379 (96.2%)	2.057 1.544 (76.2%)	1.8 0.614 (69.9%)	0.994 0.492 (99.9%)	0.853 0.727 (99.7%)	1.439 1.262 (100.0%)

Source: NASA 1994

a. Federal and State standards are identical except for sulfur dioxide; State of Florida 24-hr standard is 100 ppb.
b. Maximum hourly average concentration (not to be exceeded more than once per year).
c. Maximum time-period average concentration (not to be exceeded more than once per year).
d. Annual arithmetic mean cannot be exceeded.

NOTE: 21 days are required to yield a valid month. (%) =Percent of valid data for the month.

80 m (260 ft) and is about 110 m (360 ft) thick (USAF 1990). Beds of sandy clay, shells, and clays of the Hawthorn formation overlie the Floridan Aquifer, forming the principal confining beds for that aquifer (i.e., the Hawthorn formation isolates the Floridan Aquifer from the shallower aquifers). The Hawthorn formation lies at a depth of about 30 m (100 ft) at CCAS/KSC and is up to 50 m (1160 ft) thick. Overlying the Hawthorn formation are Upper Miocene, Pliocene, Pleistocene, and Recent deposits, which form secondary semi-confined aquifers and the surficial aquifer lying at depths up to about 30 m (100 ft) at CCAS/KSC. CCAS and KSC are located on a barrier island composed of relict beach ridges.

The U.S. Department of Agriculture's Soil Conservation Service has mapped the soils in the CCAS/KSC area and has identified five major soil associations. (The locations of the major soils associations are given in *Kennedy Space Center Environmental Resource Document [NASA* 1994]). The principal soils in the vicinity of Launch Complexes 40 and 41 are highly drained, sandy soils (percolation rate greater than 51 cm [20 in.] per hour) on level or moderately sloping topography (USAF 1990). The soils near Launch Complexes 39A and 39B are marshy, very poorly drained, and saline on nearly level terrain (NASA 1994).

3.1.5 Hydrology and Water Quality

3.1.5.1 Surface Waters

The major surface water resources in the region are the upper St. Johns River basin, the Indian River Lagoon system, the Banana River, and a portion of the Kissimmee River along the western border of Osceola County. The St. Johns River and its tributaries in the region are classified by the State as Class I surface water (potable water supply) and serve as the source of potable water for the city of Melbourne and for much of the surrounding population (State of Florida 1991c).

Major inland water bodies in the CCAS/KSC area are the Indian River, Banana River, and Mosquito Lagoon (see Figure 3-2). These water bodies are shallow estuarine lagoons with average water depths of 0.6 to 0.9 m (2 to 3 ft), except for the portions maintained as part of the Intercoastal Waterway, between Jacksonville to the north and Miami to the south. The Indian and Banana Rivers join at Port Canaveral and form a combined area of 60,000 ha (150,000 acres) in Brevard County. This area receives drainage from 218,500 ha (540,000 acres) of surrounding area (USAF 1990). Launch Complexes 39A, 39B, 40 and 41 are located on the barrier island between the Atlantic Ocean and the Banana River. Most precipitation at the complex infiltrates directly into the soils with any surface runoff flowing toward the Banana River (USAF 1990). The Banana River and Indian River were historically connected by Banana Creek. This connection was severed in 1964 with the construction of the Launch Complex 39 crawlerway at KSC. Navigation locks within Port Canaveral virtually eliminate any significant oceanic influence on the Banana River. Public navigation is prohibited within the manatee refuge portion of the Banana River north of State Road 528 (see Section 3.1.6.4 for a discussion of endangered and threatened species).

3.1.5.2 Surface Water Quality

The major surface water resources in the region include the St. Johns River and associated tributaries, the Indian River Lagoon system, the Banana River, and, along the western edge of the region, a portion of the Kissimmee River, which forms part of the border of Osceola County. The St. Johns River system serves as a source of potable water for parts of the region, including the city of Melbourne (State of Florida 1991c).

The State of Florida has adopted water quality standards, as required under the Federal Clean Water Act of 1977, and has designated each surface water resource as one of five classes (Class I through Class V), based upon potential use and value. (Class I waters are subject to the most stringent standards, reflecting their value as potable water sources; Class V waters have much less stringent standards, reflecting their potential value for navigation, utility, and industrial use.) Within the region, the St. Johns River and its tributaries have been designated as Class I (i.e., potable water supply) by the State (State of Florida 1991c). In the immediate vicinity of CCAS and KSC (Figure 3-8), Mosquito Lagoon has been designated by the State as Class II (i.e., shellfish propagation and harvesting), as has the northern-most segment of the Indian River extending from the NASA railway spur crossing and a second segment of Indian River south of Merritt Island (NASA 1994). The remaining of the surface waters in the immediate vicinity of CCAS and KSC (i.e., Banana Creek, Banana River, and the Indian River south of Titusville) have been designated as Class III waters (i.e., recreation and fish and wildlife management).

Florida's Aquatic Preserve Act of 1975 facilitated the designation of certain state-owned submerged lands and associated coastal waters as Aquatic Preserves (NASA 1994). Aquatic Preserves have exceptional biological, aesthetic, and scientific values, and such activities as oil and gas drilling, dredging, and effluent discharges are substantially restricted. In the vicinity of KSC, Aquatic Preserves include the entire Mosquito Lagoon and a portion of the Banana River south of State Road 528 (Figure 3-8).

A special designation, Outstanding Florida Waters (OFW), has been established for certain water bodies within the State that demonstrate recreational or ecological significance. This designation constitutes the highest level of protection afforded surface waters in the State. The OFW designation can apply to waters within State or national parks, wildlife refuges, aquatic preserves, and other State and Federal areas. Within the region, 38 water bodies are designated OFW (State of Florida 1991d). In the vicinity of CCAS, the surface waters adjacent to Merritt Island National Wildlife Refuge, Mosquito Lagoon, and Canaveral National Seashore, as well as the Banana River Aquatic Preserve and portions of the Indian River near Sebastian Inlet State Recreation Area about 68 km (42 mi) south of Launch Complex 41, are designated OFW (Figure 3-9).

The Indian River Lagoon has been selected as an Estuary of National Significance through U.S. EPA's National Estuary Program. The goal of this program is to balance conflicting uses of the Nation's estuaries while restoring or maintaining their natural character (NASA 1994).

Surface water quality near CCAS and KSC is monitored at 11 long-term monitoring stations that are maintained by NASA. These stations are located in Mosquito Lagoon, the

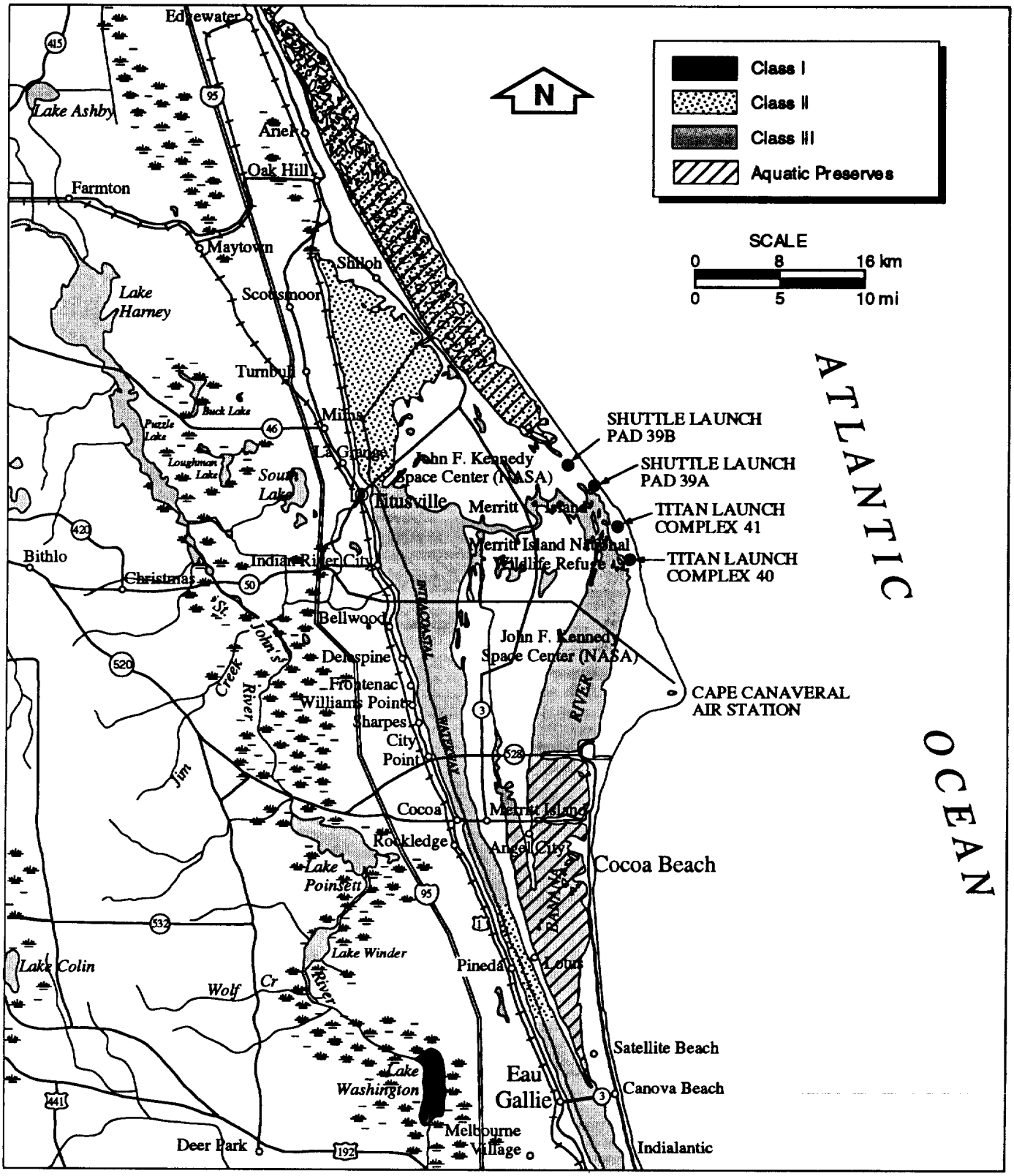


FIGURE 3-8. CCAS/KSC SURFACE WATER CLASSIFICATIONS AND AQUATIC PRESERVES

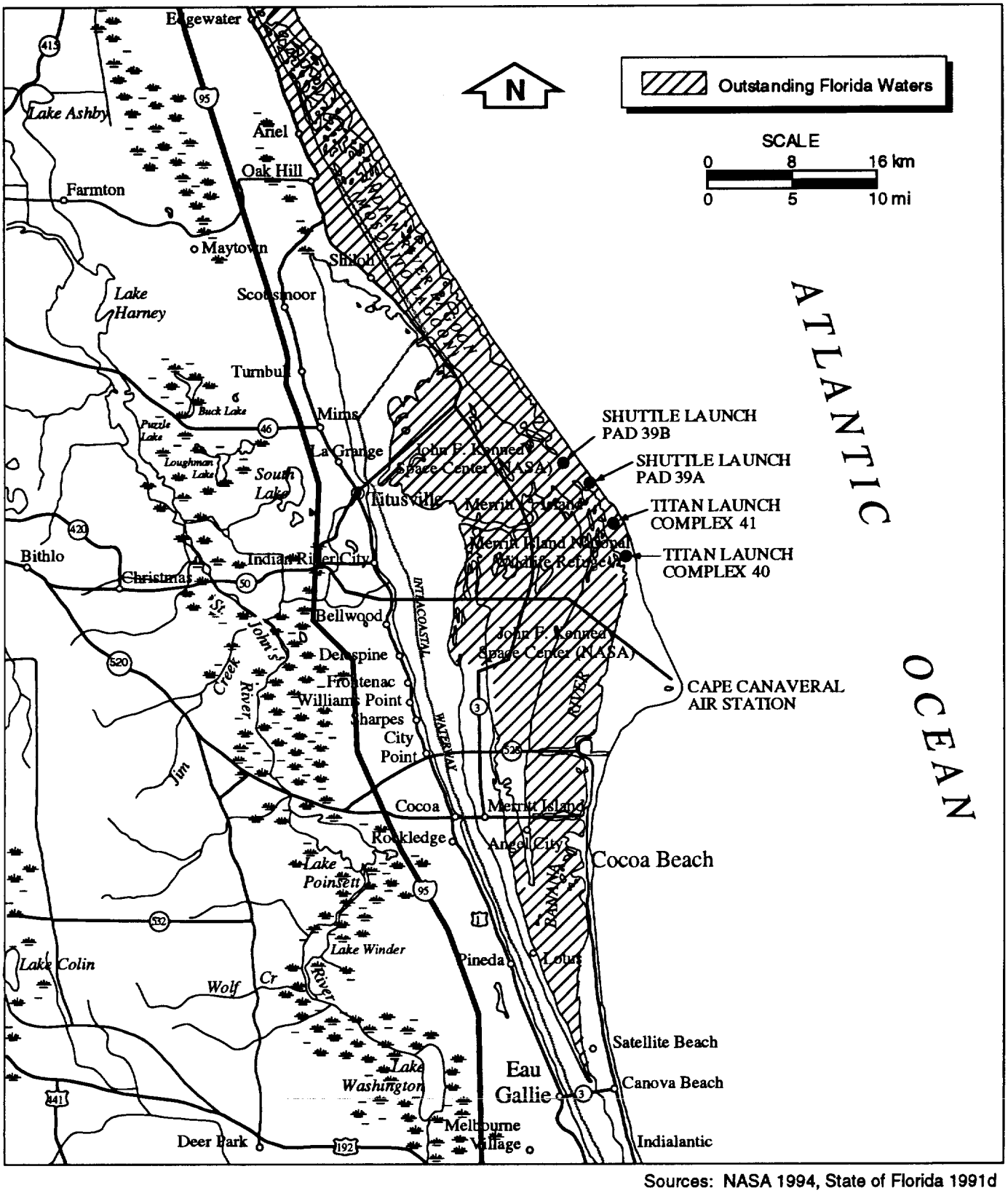


FIGURE 3-9. OUTSTANDING FLORIDA WATERS

Banana River, Banana Creek, and at other locations on and near KSC. Other monitoring stations in the general area are maintained by Brevard County, the U.S. Fish and Wildlife Service (FWS), and the Florida Department of Environmental Protection (FDEP) (NASA 1994). In general, the water quality in the monitored surface waters has been characterized as good, although data from a recent study of water quality monitoring programs prepared for NASA indicate that certain parameters (i.e., primarily phenols and silver) consistently exceed State water quality criteria with pH, iron and aluminum occasionally exceeding criteria. Nutrients and metals, when detected, have generally been below the Class II standards. The Banana River segment to the north of NASA Parkway East is subject to stormwater runoff from the Titan IV assembly and launch areas. Because of the runoff, the salinity of the northern segment of the river tends to be somewhat lower than that of the southern segment, although both segments tend to be brackish to saline (15 to 36 parts per thousand salinity at NASA Causeway East [USAF 1990]). Recent water quality data from the northern segment of the Banana River, given in Table 3-2, indicate the trends noted above for phenols, aluminum, iron, zinc, and silver. Because of the relatively high salinity of the river, Class III marine standards are cited where appropriate.

3.1.5.3 Groundwater

Three principal geohydrologic units underlie the area. In order of descending depth, these units are a surficial aquifer, secondary semi-confined aquifers (found below confining layers but above and within the Hawthorn formation), and the Floridan Aquifer (NASA 1994, USAF 1990).

The surficial aquifer (an unconfined hydrogeologic unit) is contiguous with the land surface and is recharged by rainfall along the coastal ridges and dunes, with little recharge occurring in the low swampy areas. Figure 3-10 illustrates the recharge area in the vicinity of CCAS and KSC for the surficial aquifer. Major discharge points for the surficial aquifer are the estuary lagoons, shallow seepage occurring to troughs and swales, and evapotranspiration. Inland fresh surface waters are primarily derived from surficial groundwater.

Wells that tap the surficial unconfined aquifer are largely used for non-potable or individual domestic uses, although this source is also used for some municipal public supply systems (e.g., the cities of Mims and Titusville, which are about 16 km [10 mi] northwest of the CCAS/KSC launch sites, and Palm Bay, located about 64 km [40 mi] south of the CCAS/KSC launch sites in Brevard County).

Groundwaters under artesian and semi-confined conditions in the secondary aquifers and Floridan Aquifer near CCAS/KSC have upward flow potentials. Recharge to the secondary aquifers is minor and depends on leakage through the surrounding lower permeability beds. Because of the thickness (55 m [160 ft]) and the relatively impermeable nature of the confining units of the Hawthorn formation, however, it is thought that, in general, no significant natural inter-aquifer leakage is occurring from the Floridan Aquifer into the more shallow aquifers (NASA 1994). Because of recharge characteristics, the more shallow aquifers, and the surficial aquifer in particular, are more pertinent to launch vehicle operations than the deeper, isolated Floridan Aquifer.

TABLE 3-2. SUMMARY OF WATER QUALITY MONITORING DATA FOR NORTH BANANA RIVER, PEPPER FLATS, SAMPLED IN 1991

Parameters	Average	Range	FDEP Class III Standards
Conductivity (µmhos/cm)	34,200	12,300 - 58,000	Varies
Total Suspended Solids (mg/1)	33.3	4.0 - 145.0	No Standard
Turbidity NTU	2.7	0.1 - 7.1	29 NTU Above Background
Oil and Grease (mg/l)	0.6	<0.2 - 6.7	< 5.0; No Taste or Odor
Phenols (µg/1)	137	6 - 822	1.0, varies
Alkalinity (mg/1)	163.2	97.6 - 408.0	>20 (fresh)
pH	8.3	7.5 - 9.3	6.5 - 8.5 (marine)
Total Kjeldahl Nitrogen (mg/1)	2.34	< 0.02 - 8.70	No Standard
Nitrate Nitrogen (mg/1)	0.05	<0.02 - 0.3	No Standard
Ortho Phosphate (mg/1)	0.032	<0.025 - 0.20	No Standard (marine)
Chlorophyll A (mg/m^3)	5.6	<0.5 - 36.7	No Standard
Biological Oxygen Demand(mg/1)	3.5	<1.0 - 16.0	[a]
Chemical Oxygen Demand (mg/1)	660	180 - 1570	No Standard
Dissolved Oxygen (mg/1)	6.2	4.8 - 8.8	>4 (marine)
Total Organic Carbon (mg/1)	6.6	1.9 - 50.1	No Standard
Aluminum (mg/1)	0.65	<0.10 - 6.33	< 1.5 (marine)
Cadmium (µg/l)	0.21	<0.01 - 3.60	9.3 (marine)
Chromium (mg/1)	0.018	<0.001 - .05	0.05 (Cr^{+6}) (marine)
Iron (mg/1)	0.29	<0.04 - 0.98	<0.3 (marine)
Zinc (µg/1)	50	<10 - 170	86 (marine)
Silver (µg/1)	16.59	<0.05 - 68.40	<0.05 (marine)

Sources: Bionetics Corporation 1991, NASA 1994, State of Florida 1991c

a. Based on dissolved oxygen limits.

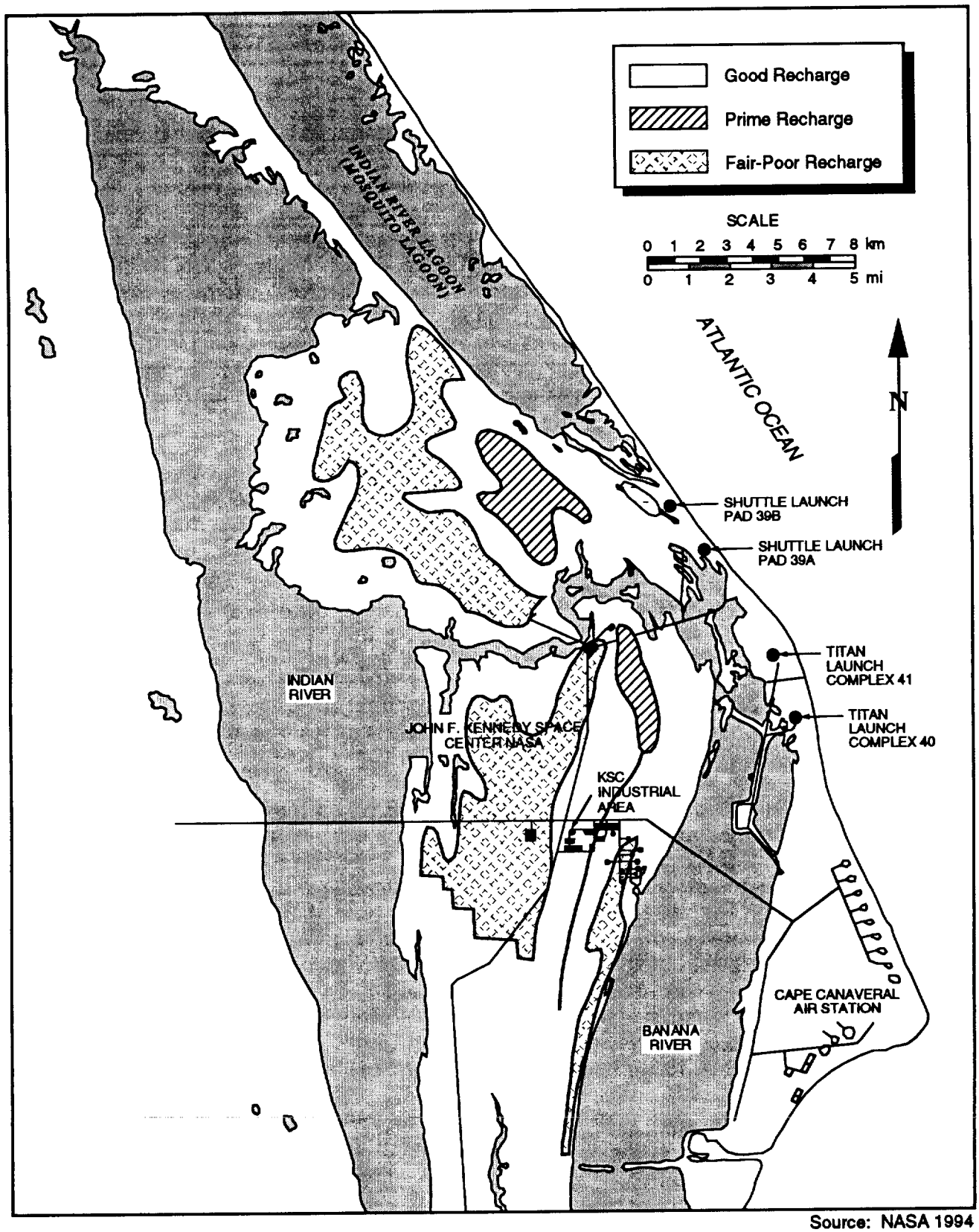


FIGURE 3-10. POTENTIAL RECHARGE FOR SURFICIAL AQUIFER

3.1.5.4 Quality of Groundwater

Almost all (89 percent) of the freshwater used in the region is drawn from groundwater supplies, principally the Floridan Aquifer (ECFRPC 1992a). The Floridan Aquifer covers 212,000 km^2 (82,000 mi^2) of Florida and is 610 m (2,000 ft) thick in some areas (FSU 1984). In portions of the region, such as at CCAS and KSC (where the Floridan Aquifer is under artesian pressure) and in an area bordering the St. Johns River, the Floridan Aquifer is considered too saline for potable water use (ECFRPC 1992a). CCAS obtains its potable water from the city of Cocoa, which in turn, draws its water from non-brackish areas of the Floridan Aquifer (USAF 1990). KSC also receives its water from a permitted public supply utility within the St. Johns River Water Management District (NASA 1994). The region contains some effective recharge areas for the Floridan Aquifer. These areas are located primarily in the upland portions of Lake, Orange, Seminole, Osceola, and Volusia Counties and comprise very porous, sandy soils, where up to 30 percent of the total annual rainfall enters the Floridan Aquifer.

Groundwater in the State of Florida has been established as four classes: Class G-I (i.e., potable water; total dissolved solids less than 3,000 mg/I) through G-IV (i.e., nonpotable water; total dissolved solids [TDS] of 10,000 mg/I or more). The majority of the State's groundwaters, including the groundwater underlying CCAS and KSC, are classified as G-II (i.e., potable water use; total dissolved solids less than 10,000 mg/I) (State of Florida 1991b).

Overall, water in the surficial unconfined aquifer in the vicinity of CCAS and KSC meets State of Florida Class II groundwater secondary quality standards for potable water use with the general exception of chloride, iron, and/or total dissolved solids (NASA 1994, USAF 1990). The concentrations of these parameters are considered to be elevated because of the influence of adjacent saline surface waters.

Tables 3-3 and 3-4 summarize groundwater quality data from shallow groundwater wells installed within and around the perimeter of Launch Complexes 40 and 41. These data indicate that the shallow groundwater is generally of good quality. However, wells at both complexes contained concentrations of TDS and iron above the Florida Secondary Drinking Water Standards. In addition, orthophosphate, total phosphate, sulfate, ammonia, chloride, magnesium, and boron were found at somewhat elevated concentrations in the local vicinity when compared to the water quality in background wells. Previous investigations of groundwater near Launch Complexes 40 and 41 found cadmium, chloride, iron, manganese, and/or TDS above Florida Drinking Water Standards. In addition, some samples had traces of 1, 1, 1-trichloroethane, benzene, and dimethyl-hydrazine (USAF 1990, Reagan 1993, Reagan 1995).

Initial groundwater studies at Launch Complexes 39A and 39B indicated minor groundwater contamination of aluminum (Al), cadmium (Cd), chromium (Cr), iron (Fe), and lead (Pb) with trace and periodic detection of volatile organic compounds (NASA 1994).

The groundwater of the secondary semi-confined aquifer ranges from moderately brackish to brackish, primarily because of very slow, upward leakage from the Floridan

TABLE 3-3. GROUNDWATER MONITORING DATA FOR LAUNCH COMPLEX 40, SAMPLED ON NOVEMBER 4,1994

Parameter Monitored (mg/l)[a]	MW-1[b]	MW-2	MW-3	MW-4	MW-5	Florida Drinking Water Standards[c]
Ortho Phosphate	0.02	0.06	0.04	0.02	<0.02	No Listing
TP	0.03	0.09	0.09	0.08	0.09	No Listing
Sulfate	5.0	17.0	17.0	32.0	90.0	250.0
Zinc	<0.01	0.31	<0.01	<0.01	<0.01	5.0
Surfactants	<0.125	<0.063	<0.063	<0.063	<0.063	0.5[d]
pH (standard units)	7.41	7.05	7.13	6.99	7.01	6.5-8.5
TDS	194.0	310.0	706.0	618	816	500.0[e]
Aluminum	<0.05	0.05	<0.05	<0.05	<0.05	0.2
Ammonia	<0.02	0.03	1.61	8.09	2.38	No Listing
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005	0.005
Chloride	4.61	16.7	240	79.7	165	250.0
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	0.10
Copper	<0.01	<0.01	<0.01	<0.01	<0.01	1.0
Iron	<0.02	<0.02	0.53	<0.02	<0.02	0.3
Lead	<0.015	<0.015	<0.015	<0.015	<0.015	0.015
Nickel	<0.005	<0.005	<0.005	<0.005	<0.005	0.1
Nitrate	0.51	0.18	<0.01	<0.01	<0.01	10.0
Magnesium	3.68	4.43	6.68	34.2	20.9	No Listing
Boron (µg/l)	<50.0	<50.0	50.0	290.0	110.0	No Listing
MMH (µg/l)	<5.0	<5.0	<5.0	<5.0	<5.0	No Listing
UDMH (µg/l)	<10.0	<10.0	<10.0	<10.0	<10.0	No Listing

Source: Reagan 1995

a. Units are measured in mg/l except where noted.
b. Background Monitoring well.
c. Florida Drinking Water Standards, Florida Administrative Code, Title 17, Chapter 17-550.
d. Standard for foaming agents was used for surfactants.
e. The TDS standard may be greater that 500 mg/l if no other standard is exceeded.

TABLE 3-4. GROUNDWATER MONITORING DATA FOR LAUNCH COMPLEX 41, SAMPLED ON NOVEMBER 7, 1994

Parameter Monitored (mg/l)[a]	MW-1[b]	MW-2	MW-3	MW-4	MW-5	Florida Drinking Water Standards[c]
Ortho Phosphate	<0.02	<0.02	0.77	2.45	0.58	No Listing
TP	0.06	1.76	0.82	0.05	0.62	No Listing
Sulfate	2.5	37.0	1.2	6.60	176	250.0
Zinc	<0.01	<0.01	0.01	<0.01	<0.01	5.0
Surfactants	<0.125	<0.063	<0.063	<0.063	<0.025	0.5[d]
pH (standard units)	6.99	7.26	6.87	6.68	6.81	6.5-8.5
TDS	294.0	372.0	442.0	428.0	922.0	500.0[e]
Aluminum	<0.05	<0.05	<0.05	0.07	<0.05	0.2
Ammonia	0.02	0.93	0.36	0.03	1.78	No Listing
Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005	0.005
Chloride	12.7	46.8	88.6	22.3	36.1	250.0
Iron	0.864	<0.02	0.94	5.11	0.74	0.3
Lead	0.015	<0.015	<0.015	<0.015	<0.015	0.015
Nickel	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
Nitrate	0.93	<0.01	<0.01	0.01	0.01	10.0
Magnesium	3.64	6.35	3.43	7.96	38.2	No Listing
Boron (µg/l)	<50.0	64.0	120.0	<50.0	240.0	No LIsting
MMH (µg/l)	<5.0	<5.0	<5.0	<5.0	<5.0	No Listing
UDMH (µg/l)	<10.0	<10.0	<10.0	<10.0	<10.0	No LIsting

Source: Reagan 1995

a. Units are measured in mg/I except where noted.
b. Background monitoring well.
c. Florida Drinking Water Standards, Florida Administrative Code, Title 17, Chapter 17-550.

d. Standard for foaming agents was used for surfactants.
e. The TDS standard may be greater than 500 mg/I if no other standard is exceeded.

Aquifer (NASA 1 994). Water from the Floridan Aquifer in the vicinity of CCAS and KSC is highly mineralized (principally chlorides) primarily because of the natural and induced (due to pumping) lateral seawater intrusion and a lack of flushing due to the distant recharge areas (e.g., Polk and Orange Counties) (NASA 1 994). The Floridan Aquifer in the vicinity of CCAS and KSC has been ranked as having a low potential for well field acceptability.

3.1.5.5 Offshore Environment

The offshore environment of the Atlantic Ocean at KSC/CCAS can be described by its bottom topography and characteristics of ocean circulation in the area.

Out to depths of approximately 18.3 m (60 ft), sandy shoals dominate the underwater topography. The sea floor continues to deepen out to about 100 km (62 mi) from the coastline, where the bank slopes down to depths of 732 to 914 m (2,400 to 3,000 ft) to the Blake Plateau. The Blake Plateau extends out to about 370 km (230 mi) from the shore at KSC/CCAS. Figure 3-11 shows the bathymetry of the offshore areas.

Offshore currents usually reflect the general northern flow of the Gulf Stream, as illustrated in Figure 3-1 2 (National Oceanic and Atmospheric Administration [NOAA] 1 980). Studies of water movements in the area indicate a shoreward direction of the current for the entire depth, surface to bottom, in the region out to depths of 18 *m* (60 ft) (about 33 km [20.5 mil offshore) at speeds of several miles per day. Wind-driven currents generally determine the current flow at the surface. During the autumn (September through November), the prevailing winds are out of the northeast, with occasional winds out of the south. The prevailing winds transport surface waters toward the shore, with an offshore component in shallow bottom waters that diminishes rapidly with distance offshore (INSRP 1 989c). The net effect is that material suspended in the water column tends to be confined to the area near the coast, and heavier material (e.g., sand) is deposited in this area.

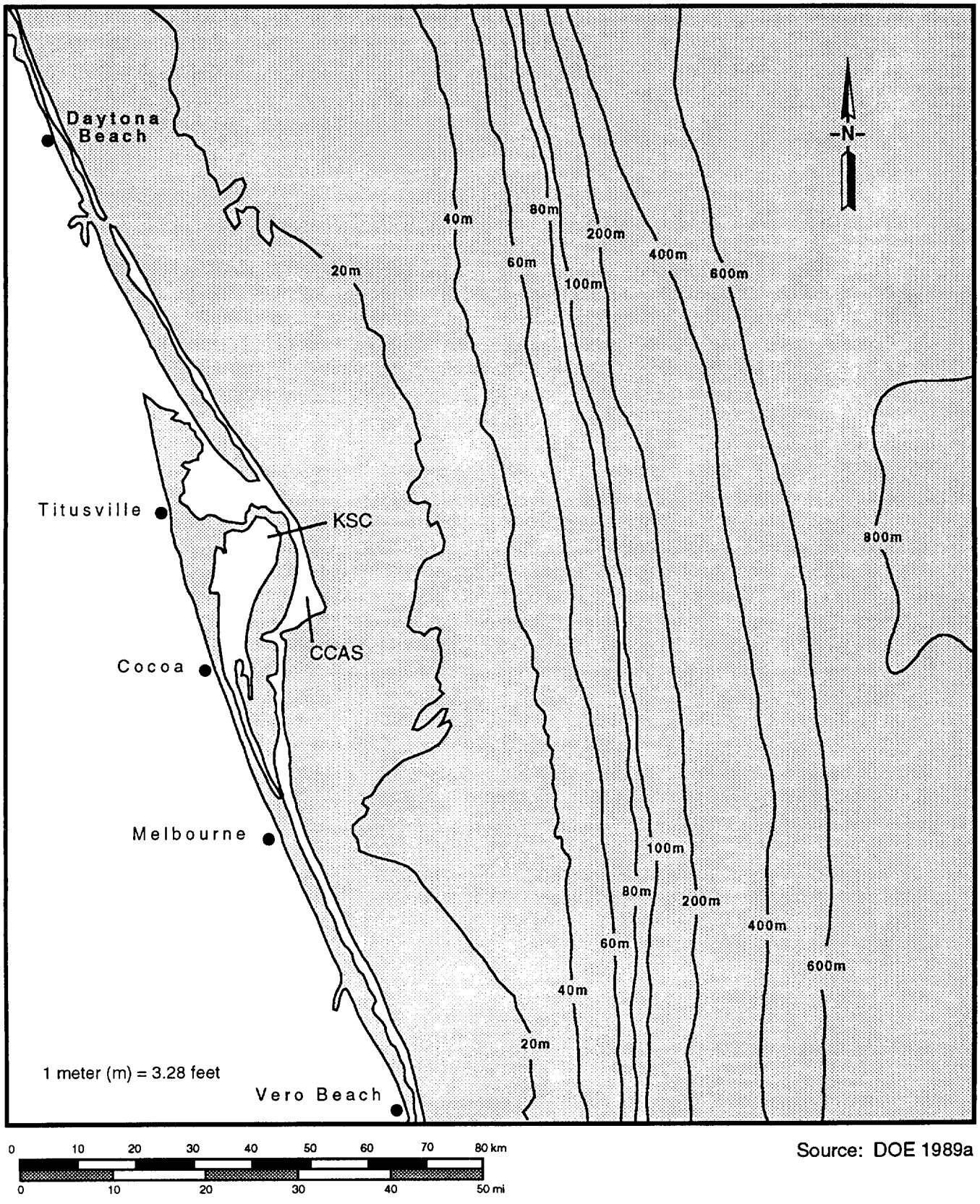
The occasional northward winds result in a net movement of surface waters offshore, with an inshore movement of the higher density bottom waters. Materials suspended in the surface waters are transported in an offshore direction, with the heavier bottom materials moving in shore.

In the region out to the sloping bank (100 km [62 mil), the flow is slightly to the north and tends to move eastward when the winds blow to the south. Water over the Blake Plateau flows to the north most of the time and is known as the Florida current of the Gulf Stream (AEC 1 975).

3.1.6 Biological Resources

3.1.6.1 Floodplains and Wetlands

Titan IV Launch Complexes 40 and 41 are located on a greater than 500-yr floodplain (NASA 1 994). Wetlands near the launch area consist largely of mixed salt-tolerant grasses and mangroves. Wetlands in the CCAS/KSC area include freshwater ponds and canals, brackish impoundments, tidal lagoons, bays, rivers, vegetated marshes, and mangrove swamps. These wetlands provide resources for vast numbers of marine organisms, waterfowl, and terrestrial wildlife. Many of the wetlands within the Merritt



Source: DOE 1989a

FIGURE 3-11. OFFSHORE WATER DEPTH NEAR CCAS/KSC REGION

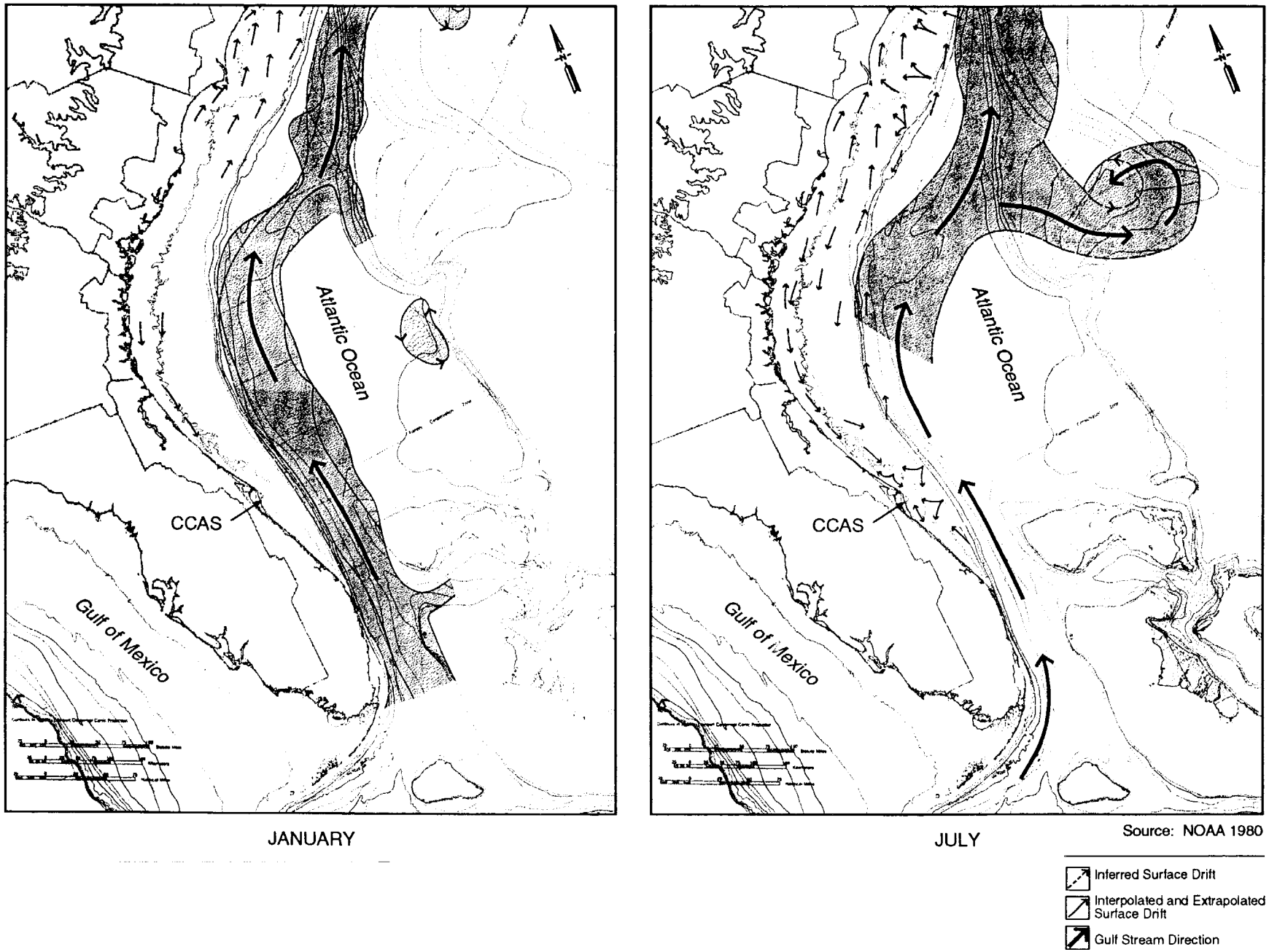


FIGURE 3-12. OCEAN CURRENTS AND WATER MASSES OFFSHORE OF CCAS/KSC FOR JANUARY AND JULY

Island National Wildlife Refuge are managed for overwintering waterfowl habitat and host about 200,000 waterfowl each year.

The wetlands adjacent to Launch Complex 41 are mixed, consisting of salt-tolerant grass marsh with some black mangrove and sea oxeye vegetation areas. The wetlands at Launch Complex 40, which are separated from the complex by a narrow band of wax myrtle/Brazilian pepper vegetation to the west, consist of white/mixed mangrove with scattered areas of mixed salt-tolerant grass marsh areas interspersed (USAF 1990).

Shuttle Launch Complexes 39A and 39B are surrounded by 100 year floodplain (NASA 1994). Wetlands on KSC comprise approximately 35 percent of the land area. Sensitive coastal mangrove communities and aquatic preserves are present next to Launch Complexes 39A and 39B (NASA 1979).

3.1.6.2 Terrestrial Resources

The region has several terrestrial and aquatic conservation and special designation areas (e.g., wildlife management areas and aquatic preserves), which serve as wildlife habitat and comprise about 25 percent (about 404,700 ha [1 million acres]) of the total land and water acreage within the region (about 1.7 million ha [4.1 million acres]).

Table 3-5 provides an overview of the 11 general land cover types throughout the 6-county region. Freshwater and coastal wetlands comprise about 23 percent of the total area of the 6-county region, followed by xeric grassland (21 percent), scrub and shrub (17 percent), water (12 percent), and hardwood/pine forest (11 percent) (ECFRPC 1988).

Important terrestrial wildlife species in the region include migratory and native waterfowl (e.g., ringneck, pintail, and baldpate ducks), as well as turkey, squirrel, whitetailed deer, and wild hogs. Black bear also exist in the region. The St. Johns River basin is an important waterfowl hunting area. The seven State wildlife management areas in the region are hunted for small game, turkey, hogs, and deer.

The majority of the land surrounding Launch Complexes 39A, 39B, 40 and 41, including KSC/Merritt Island National Wildlife Refuge and the Mosquito Lagoon/Cape Canaveral National Seashore areas, is undeveloped and in a near-natural state. These areas host a variety of vegetative communities, ranging from mangrove swamps and salt marshes to freshwater wetlands and coastal dunes and beaches. Sixty-eight reptile and amphibian species; more than 300 bird species, including 8 to 9 rookeries of nesting birds; and more than 25 mammal species use these communities (NASA 1994). A bird rookery is located about 0.5 km (0.3 mi) south of Launch Complex 39A and 2.5 km (1.3 mi) north of Launch Complex 41.

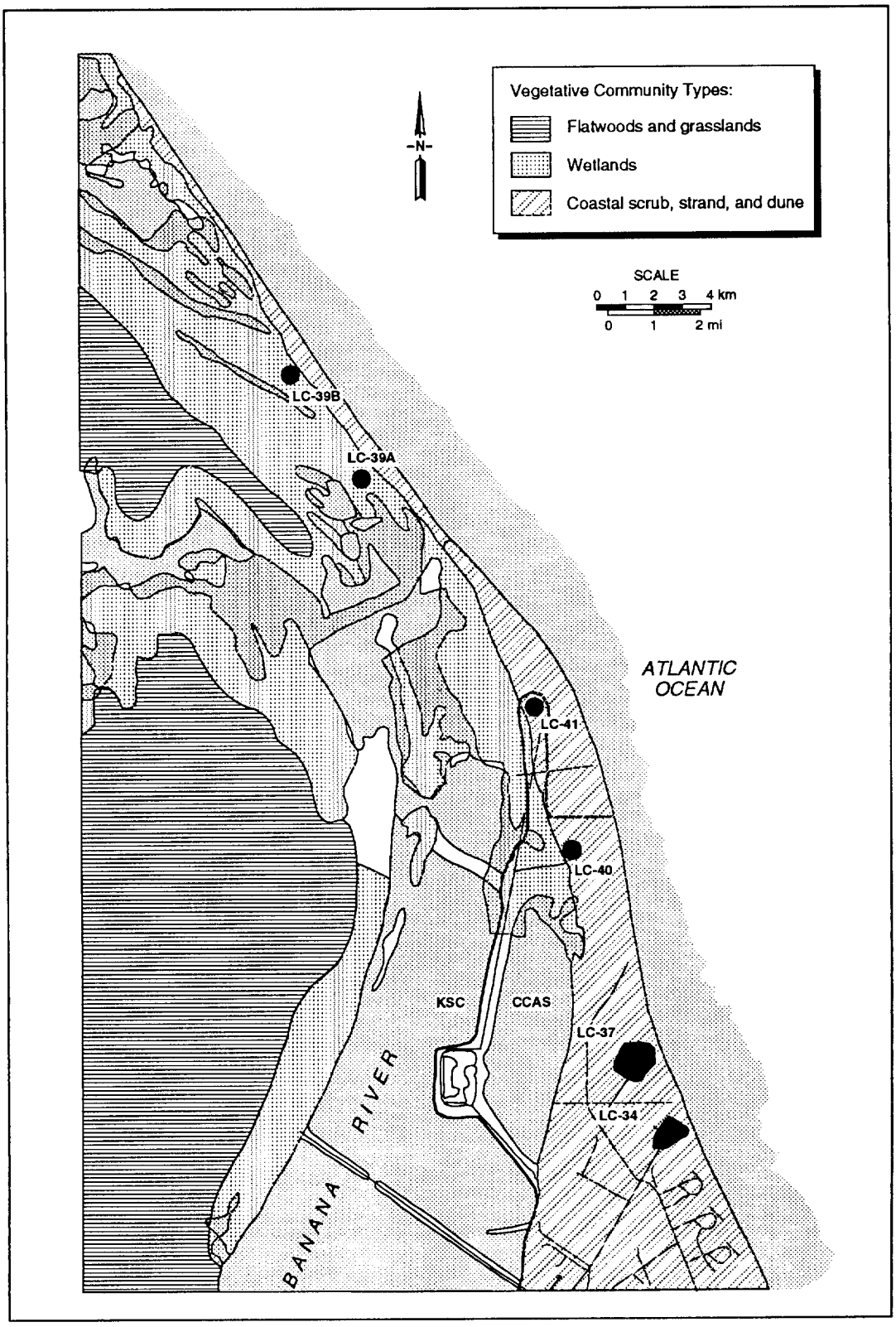
Approximately 70 percent (4,400 ha [11,100 acres]) of the total acreage (6,394 ha [15,800 acres]) at CCAS is undeveloped and dominated by three principal vegetative communities (Figure 3-13). The coastal dune community is the smallest (320 ha; 800 acres), extending from the high tide line of the Atlantic Ocean across the beach into the dunes along the coastal perimeter of CCAS (USAF 1990). Inland from the coastal

TABLE 3-5. MAJOR LAND COVER TYPES WITHIN THE REGION, BY COUNTY (ACREAGE[a] AND PERCENT)[b]

Types of Land Cover	Brevard County		Lake County		Orange County		Osceola County		Seminole County		Volusia County		Region Total	
	Acreage	%	Acreage	%	Acreage	%	Acreage	%	Acreage	%	Acreage	%	Acreage	%
Coastal Strand	1,050	0.13	0	0.00	0	0.00	0	0.00	0	0.00	657	0.08	1,707	0.04
Xeric Grassland	108,457	13.51	89,604	12.08	139,117	21.66	434,402	46.01	45,937	21.55	76,856	9.48	894,486	21.53
Hardwood/Pine Forest	73,492	9.16	59,617	8.04	87,415	13.61	60,308	6.39	17,204	8.07	182,406	22.50	480,488	11.57
Scrub/Shrub	102,363	12.75	218,044	29.40	119,224	18.56	79,970	8.47	33,053	15.50	155,060	19.13	707,799	17.04
Hardwood Hammock	23,312	2.90	45,587	6.15	34,588	5.38	13,706	1.45	23,191	10.88	60,621	7.48	201,031	4.84
Coastal Wetland	22,129	2.76	0	0.00	0	0.00	0	0.00	0	0.00	17,846	2.20	39,978	0.96
Freshwater Swamp	185,636	23.13	176,512	23.80	104,830	16.32	238,997	25.31	38,949	18.27	162,584	20.06	907,614	21.85
Water	175,268	21.83	83,751	11.29	57,851	9.01	77,598	8.22	21,186	9.94	93,134	11.49	508,849	12.25
Urban/Bare Ground	90,203	11.24	68,563	9.24	99,359	15.47	39,236	4.16	33,692	15.80	60,401	7.45	391,509	9.43
Citrus Orchard	19,305	2.40	0	0.00	0	0.00	0	0.00	0	0.00	1,040	0.13	20,347	0.49
Other Agriculture	1,520	0.19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
TOTAL	802,733	100.00	741,677	100.00	642,384	100.0	944,215	100.0	213,212	100.0	810,605	100.0	4,153,807	100.0

Source: ECFRPC 1988

a. One acre equals 0.40 hectares.
b. The data for this table were compiled directly from the computer data base referenced. The level of precision implied by the numbers is an artifact of the computer compilation process; therefore, data should be viewed only as approximate acreages and approximate percentages.



Source: NASA 1979

FIGURE 3-13. MAJOR VEGETATION COMMUNITIES NEAR CCAS/KSC LAUNCH SITES

dune community is the coastal strand community, covering about 920 ha (2,300 acres) of CCAS. Further inland is the coastal scrub community, which occupies the largest portion of the undeveloped area of CCAS (3,760 ha; 9,400 acres). Three other ecologically important communities exist at CCAS, although in smaller amounts (Figure 3-13). Mangrove swamp (180 ha [450 acres]) is the largest community of the three, followed by salt marsh (56 ha [140 acres]) and freshwater wetland (80 ha 120 acres]). Mangrove and salt water swamps surround Launch Complexes 39A and 39B at KSC.

Coastal strand and dune communities are marked by extremes in temperature and prolonged periods of drought (NASA 1990). Vegetation on the dunes is dominated by sea oats. Other grasses, such as slender cordgrass and beach grass, also occur. Shrubs, such as beach berry and marsh elder, occur in the dune community, along with herbs, including beach sunflower and camphorweed. The beach areas, while largely unvegetated, still provide significant wildlife resources. The tidal zone supports a large number of several species of marine invertebrates, as well as small fish that are food for many shore birds. Several species of gulls, terns, sandpipers, and other birds use the beaches of the Cape Canaveral area. In addition, research indicates that these beaches are important to nesting sea turtles (USAF 1990).

Strand occurs between the coastal scrub community and the salt spray zone of the dune system. The growth characteristics of strand vegetation produce a low profile that is maintained by nearly constant winds. Plants that can tolerate strand conditions are saw palmetto, wax myrtle, tough buckthorn, cabbage palm, partridge pea, prickly pear, and various grasses. The white-tailed deer, raccoon, mice, 14 species of birds, such as red-tailed hawk and the red-headed woodpecker, and only 2 species of reptile (i.e., gopher tortoise and eastern diamondback rattlesnake), among others, use this community (USAF 1990).

The coastal scrub association is characterized by xeric tree species, including scrub oak, live oak and sand live oak, and myrtle oak. The scrub community is a harsh environment limited by low soil moisture conditions. Herbaceous and shrub vegetation is sparse and includes wire grass, saw palmetto, tar flower, lantana, wax myrtle, greenbriar, prickly pear, gopher apple, and others. Ten species of mammals, including white-tailed deer, armadillo, feral hogs, and bobcat use this habitat type at CCAS. In addition, 14 species of birds (similar to those inhabiting the coastal strand) and 5 species of reptiles use the scrub community.

3.1.6.3 Aquatic Biota

The coastline from Daytona south to Melbourne and extending seaward to a depth of 100 fathoms is one of the most productive marine fishery areas along the southern Atlantic coast. The inshore waters support an important sea trout and redfish sport fishery. The lagoons and rivers support commercial fishery operations for blue crab and black mullet.

A total of 141 species of freshwater, estuarine, and marine fish have been documented within the northern portions of the Indian River Lagoon near KSC/CCAS (ECFRPC 1988). Of these, 65 species are considered commercial fish and 85 are sport fish and/or are fished commercially. One species known to inhabit the river, the rainwater killifish *(Lucania parva),* while not on the Federal or State threatened or endangered lists,

has been listed by the Florida Committee on Rare and Endangered Plants and Animals, a group consisting largely of research biologists, as a "species of special concern," and by the Florida Natural Areas Inventory as "imperiled statewide" (ECFRPC 1991a).

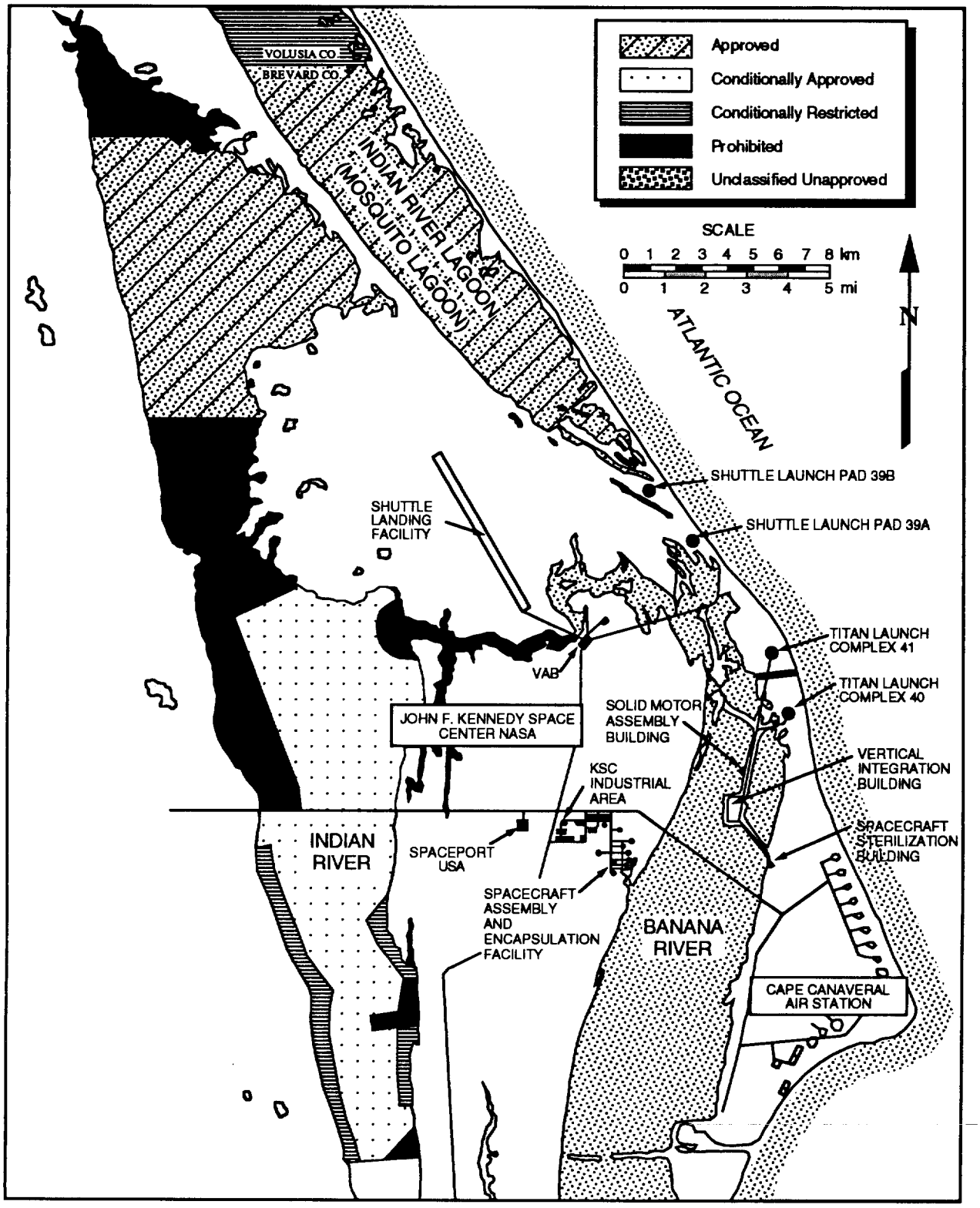
Shellfishing is an important component of the commercial and recreational fishing effort. In 1990, Brevard County produced 100 percent of the Florida east coast landings of calico scallops 392,656 kg (872,568 lb). Furthermore, Brevard County landings of clams accounted for 81.6 percent of the Florida east coast clam harvest. Volusia County accounted for 3.25 percent of clam landings off the Florida east coast (State of Florida 1990). Clams are taken primarily from tidal mud flat areas. Commercial fishing is an important economic asset to the region. Brevard County and Volusia County ranked second and fourth respectively, among the 12 east coast Florida counties in terms of 1990 finfish landings. Brevard ranked second in invertebrate landings (e.g., crab, clams, and oysters) and first in shrimp landings, with Volusia fifth in both categories (State of Florida 1990). Mosquito Lagoon is considered among the best oyster and clam harvesting areas on the east coast (NASA 1994). Figure 3-14 illustrates the shellfish harvesting areas in the vicinity of KSC/CCAS.

3.1.6.4 Endangered and Threatened Species

The Federal Government's Threatened or Endangered Species List, prepared by the U.S. FWS, currently recognizes 29 endangered or threatened species in this region. Another 63 species, including 30 plants, are being reviewed for possible listing. The State of Florida's list includes 53 species considered endangered or threatened. The Florida Committee on Rare and Endangered Plants and Animals gives endangered or threatened status to 60 species. The Florida Natural Areas Inventory includes 57 species in its top two most endangered categories. Roughly half of all the endangered and threatened species identified by these lists occurs in wetlands, principally estuarine environments; the other half depends on upland habitats (ECFRPC 1991b). No federally designated flora exist at CCAS, although coastal vervain *(Verbena maritima),* a dune species, has been reported on both CCAS and KSC and is being evaluated for listing as threatened. Prickly-apple cactus *(Cereus gracilis),* which is being considered for threatened status, may occur at KSC. Other species which have been reported at KSC and are being evaluated for listing as threatened include Curtiss reedgrass *(Calamovilfa curtissii)* which has been reported in the southern and central regions of KSC, and tampa vervain *(Verbena tampensis)* which occurs in disturbed areas adjacent to hardwood hammocks (NASA 1994).

Table 3-6 lists 21 federally protected wildlife species known to occur in the vicinity of CCAS/KSC. Table 3-6 contains seven endangered species, nine threatened species, and five that may be listed as threatened (NASA 1994). Table 3-6 also indicates the status of each of the federally listed species at CCAS/KSC (USAF 1990).

About 15 percent of the total U.S. population of the West Indian Manatee *(Trichechus manatus latirostris)* occurs in the waters bordering CCAS and KSC (NASA 1994). The following areas at CCAS/KSC have been designated as critical habitat for manatee by the FWS (see Figure 3-6): the entire inland section of the Indian River, the entire inland section of the Banana River, and all waterways between the Indian and Banana Rivers (exclusive of those existing manmade structures or settlements that are not necessary to



Source: NASA 1994

FIGURE 3-14. SHELLFISH HARVESTING AREAS NEAR CCAS/KSC

TABLE 3-6. FEDERALLY LISTED THREATENED AND ENDANGERED FAUNA OCCURRING NEAR CCAS AND KSC

Common Name	Scientific Name	FWS	FGFW FC	FCR EPA	Status at CCAS	Status at KSC
West Indian Manatee	*Trichechus manatus latirostris*	E	E	T	Re	Re
Southeastern Beach Mouse	*Peromyscus polionotus niveiventris*	T	T	NL	Re	Re
Florida Mouse	*Peromyscus floridanus*	C2	SSC	T	Re	Re
Round-Tailed Muskrat	*Neofiber alleni*	C2	NL	SSC	Re-possible	U
Bald Eagle	*Haliaeetus Ieucocephalus*	E	T	T	V	Re/Tr
Arctic Peregrine Falcon	*Falco Peregrinus tundrius*	T	E	E	Tr	Tr
Wood Stork	*Mycteria americana*	E	E	E	Re	Re
Roseate Tern[a]	*Sterna dougallii*	T	T	T	N/O	R
Piping Plover	*Charadrius melodus*	T	T	SSC	V	V
Florida Scrub Jay	*Aphelocoma coerulescens coerulescens*	T	T	T	Re	Re
Bachman's Sparrow	*Aimophila aestivalis*	C2	NL	NL	V	R
Reddish Egret[b]	*Egretta rufescens*	C2	SSC	R	V	N
Atlantic Ridley Sea Turtle	*Lepidochelys kempi*	E	E	E	O/NN	O/NN
Loggerhead Sea Turtle	*Caretta caretta caretta*	T	T	T	O/N	O/N
Leatherback Sea Turtle	*Dermochelys coriacea coriacea*	E	E	R	O/N	O/N
Hawksbill Sea Turtle	*Eretmochelys imbricata imbricata*	E	E	E	O/NN	O/NN
Atlantic Green Sea Turtle	*Chelonia mydas mydas*	E	E	E	O/NN	O/NN
American Alligator	*Alligator mississippiensis*	T/(S/A)	SSC	SSC	Re	Re
Eastern Indigo Snake	*Drymarchon corais couperi*	T	T	SSC	Re	Re
Atlantic Salt Marsh Snake	*Nerodia fasciata taeniata*	T	T	E	N/O	Re
Gopher Tortoise	*Gopherus polyphemus*	C2	SSC	T	Re	Re

Sources: NASA 1994, USAF 1990

a. Rare migrant observed at KSC only.
b. KSC a major nesting area.

KEY:

FWS: U.S. Fish and Wildlife Service
FGFWFC: Florida Game and Freshwater Fish Commission
FCREPA: Florida Commission on Rare and Endangered Plants and Animals

E: Endangered
T: Threatened
T/(S/A): Threatened/similarity of appearance
SSC: Species of Special Concern
R: Rare
NL: Not listed
Re: Resident year-round
C2: Proposed listing as threatened
V: Visitor; does not nest at CCAS
Tr: Transient; occurs seasonally
N: Nesting
O/N: Occurs on beach or offshore; nests
O/NN: Occurs on beach or offshore; no nests
N/O: Not observed
U: Status undetermined

the normal needs of the survival of the species). On March 11, 1990, FWS established the waters of the Banana River from State Road 528 north to the NASA Parkway East causeway as a manatee refuge.

Loggerhead *(Caretta caretta caretta)*, Atlantic green *(Chelonia mydas mydas)*, and leatherback *(Dermochelys coriacea coriacea)* turtles use the beach areas at CCAS and KSC as nesting habitat. Nesting typically occurs between May and October (USAF 1990).

Populations of the southeastern beach mouse *(Peromyscus polionotus niveiventris)* are high at CCAS largely because of the amount of dune grassland habitat at the station (USAF 1990). Population studies in 1989 determined the beach mice population to be between 11,000 and 15,000 for all desirable habitats at CCAS. On KSC, the beach mice habitat narrows and the population density decreases (USAF 1990).

Arctic peregrine falcons *(Falco peregrinus tundrus)* use the dune habitat at CCAS for overwintering. In addition, a wood stork *(Mycteria americana)* rookery is located about 2 km (1.4 mi) northwest of Launch Complex 41 and about 4 km (2.8 mi) from Launch Complex 40 (USAF 1990). This rookery was abandoned in 1991. Florida scrub jays *(Aphelocoma coerulescens coerulescens)* use the scrub habitat in the vicinity of the complexes; nests have been observed 201 m (660 feet) away from Launch Complex 41. A 1988 survey estimated the entire CCAS scrub jay population to be between 900 and 1,800 birds, with a maximum of about 200 of these within a 0.6 km (0.4 mi) radius of Launch Complexes 40 and 41. Scrub jay populations at the Merritt Island National Wildlife Refuge appear to have declined in recent years, according to a recent survey that located about 3,600 birds versus 10,000 in earlier surveys (NASA 1994).

Approximately 20 nesting locations used by bald eagles *(Haliaeetus leucocephalus)* have been located at KSC. The nest area nearest to CCAS Launch Complexes 40 and 41 is about 10 km (6 miles) to the west, near the KSC industrial area (NASA 1994). Bald eagles are visitors at CCAS and do not nest year-round. In 1990, eight sites at KSC were active, and five eaglets were fledged. In 1991, five nests were active, and four eaglets were fledged (Busacca et al. 1991).

Osprey *(Pandion haliaetus)*, listed by the Convention on International Trade in Endangered Species of Wild Flora and Fauna, were thought to be actively using 25 out of 54 possible nesting sites near KSC (NASA 1994). Eleven of the active nests were located on manmade structures. Between 1988 and 1990, the number of Osprey young produced on KSC ranged from 35 to 44 individuals (Busacca et al. 1991). The closest known nesting site is about 5 km (3.1 mi) south of Launch Complex 41.

Bobcats *(Lynx rufus)* are also listed by the convention on International Trade in Endangered Species of Wild Flora and Fauna. Bobcats are reportedly common in scrub, strand, and ruderal grass habitats at KSC (NASA 1994).

In addition to the 21 species listed in Table 3-6, FWS lists 5 species of whale as endangered:

- Finback *(Balaeroptera physalus)*
- Humpback *(Megaptera novaeangliae)*
- Northern right *(Eubalaena glacialis)*
- Sei *(Baeaenoptera borealis)*
- Sperm *(Physeter catodon)*

These whales occur in the coastal waters near CCAS. The National Marine Fisheries Services under the National Oceanic and Atmospheric Administration is proposing to designate a critical habitat area for the northern right whale *(Eubalaena glacialis)* pursuant to the Endangered Species Act. The habitat proposed for designation involves the water adjacent to the coast of Georgia and Florida, which includes the Cape Canaveral area (58 FR 29186).

3.1.7 Socioeconomics

3.1.7.1 Population

Major population centers within 97 km (60 mi) of KSC/CCAS include Orlando, Daytona Beach, Titusville, and Melbourne (see Figure 3-1).

The U.S. Census Bureau has designated three Metropolitan Statistical Areas (MSAs) within the region-Orlando MSA (Orange, Osceola, and Seminole Counties), the Daytona Beach MSA (Volusia County), and the Melbourne-Titusville-Palm Bay MSA (Brevard County) (ECFRPC 1991a). The population in Lake County, although growing faster than the State average, is split between many small- to medium-sized municipalities and rural areas.

The regional population grew at a faster rate from 1980 to 1990 than the State. The region grew by 49 percent (1,336,495 to 1,994,542); the State only grew by 32.7 percent (9,746,324 to 12,937,926). By the year 2000, it is anticipated that 2,575,400 people will be living in the region (a 29. 1 -percent increase) (ECFRPC 1991a). The population in Brevard County (the location of CCAS) for 1990 was 398,978, a 46.2-percent increase since 1980.

All counties are expected to experience population increases through the year 2000. Orange County is expected to remain the most populated county, growing to 843,600 in the year 2000 (a 24.5-percent increase from 1990), followed by Brevard County, with an increase to 533,600 (a 33.7-percent increase) (ECFRPC 1991a).

Of the approximately 2 million people in the region in 1990, about 86 percent were white, 11 percent black, 2 percent Native American/Eskimo/Aleut/Pacific Islander/Asian, and the remaining 1 percent not falling into any of the above racial categories (ECFRPC 1992b). About 6 percent of the total 1990 population was of hispanic origin (across all

races). About 9 percent of the regional population (about 189,000 people) lived within 32 km (20 mi) of the Titan IV and Shuttle launch complexes at CCAS/KSC. The racial composition reflected the overall regional population as 88 percent white, 10 percent black and 2 percent falling into the remaining two categories. Hispanic representation was about 6 percent across all races. The uncontrolled population area nearest the launch complexes is about 16 km (10 mi) to the southeast, and contained less than 2 percent of the total regional population. Racial composition was approximately 97.5 percent white, 1.0 percent black and 2 percent divided amongst the remaining two categories; about 2 percent were of hispanic origin (across all races).

3.1.7.2 Economy

The region's economic base is tourism and manufacturing. Regional tourism now attracts more than 20 million visitors annually. Walt Disney World and Sea World, near Orlando, along with KSC, are among the most popular tourist attractions in the State (ECFRPC 1992a).

Economic sectors providing significant employment include services, with 301,300 employees (34.9 percent of total non-agricultural employment); retail trade, with 183,900 (21.3 percent); government, with 113,800 (13.1 percent); manufacturing, with 94,200 (10.9 percent); construction, with 48,300 (5.6 percent); finance and real estate, with 43,000 (5.0 percent); wholesale trade, with 41,200 (4.8 percent); and transportation and public utilities, with 38,000 (4.4 percent) (ECFRPC 1991a).

At the beginning of 1991, 984,434 people were employed in the region (863,800 non-agricultural and 120,634 agricultural). A total of 593,796 people were employed in Orange, Seminole, and Osceola Counties, 180,491 in Brevard, 153,720 in Volusia, and 56,427 in Lake (ECFRPC 1991a). The unemployment rate for the region at the beginning of 1991 was 6.6 percent (a 22-percent increase from the 1990 rate of 5.3 percent), with Lake County (8.2 percent) having the highest unemployment rate of the six counties within the region (ECFRPC 1991a).

The current employment pool at CCAS comprises military and civilian personnel, all associated with the U.S. Air Force. Military personnel are assigned to Patrick Air Force Base (PAFB), approximately 15 miles away from the duties they perform at CCAS. Most people employed on base are contractor personnel from companies associated with the missile testing and space launch operations. As of September 30, 1990, the total economic impact of PAFB on the region within a 50-mile radius of the base was estimated at $590,103,976. In addition, as of September 30, 1990, 4,281 secondary jobs were created within the region, and local employment, supported by annual expenditures to operate PAFB, was estimated at 16,425 (PAFB 1990).

At the end of September 1993, 18,253 personnel were employed at KSC. This population included contractor, construction, tenant, and permanent civil service employees (NASA 1994).

The 1990 median annual household income across the six-county region ranged from $7,237 to $76,232, with both ends of the range occurring in Orange County (ECFRPC Undated-b). Within 32 km (20 mi) of the launch complexes, the median income ranged from $10,940 to $55,606 with most of the census tracts within this area

recording median incomes in excess of $25,000. At the nearest uncontrolled population area (16 km [10 mi]) from the launch complexes, the median income was $34,000.

3.1.7.3 Transportation

The region's road network includes five major limited access highways: Interstate 4, Interstate 95, Florida's Turnpike, the Spessard L. Holland East-West Expressway, and the Martin L. Andersen Beeline Expressway. In addition, numerous Federal, State, and county roads are located in the region (ECFRPC 1992a). Primary highways serving CCAS include Interstate 95, US-1, State Route (SR)-A1A, and SR-520. CCAS is linked to the highway system by the south gate via SR-A1A, NASA Causeway, and General Samuel C. Phillips Parkway (see Figure 3-3). Road access to KSC is from SR-3 and Phillips Parkway from the south, NASA Causeway (SR-405) and the Beach Road (SR-406) from the west, and Kennedy Parkway from the north. All roads to KSC have control access points which are manned 24 hours per day, seven days a week (NASA 1994).

Rail service for freight is available in all six counties, although passenger service is limited. Rail transportation in the KSC/CCAS area is provided by Florida East Coast Railway. A mainline traverses the cities of Titusville, Cocoa, and Melbourne. Launch Complexes 40 and 41 are serviced by a branch line from Titusville through KSC (see Figure 3-2).

The region has three major airports: Orlando International Airport, already the 43rd busiest airport in the world in number of passengers, Daytona Beach Regional, and Melbourne Regional (ECFRPC 1992a). Melbourne Regional Airport, the closest air transportation facility of the three, is located 48 km (30 mi) south of CCAS (see Figure 3-2). CCAS contains a skid strip used for Government aircraft and delivery of launch vehicles. Any air freight associated with the operation of Launch Complexes 40 and 41 arrives at the CCAS skid strip.

Port Canaveral, the nearest navigable seaport, has approximately 480 m (1600 ft) of dockage available at existing wharf facilities.

3.1.7.4 Public and Emergency Services

A mutual agreement exists among the city of Cape Canaveral, KSC, and the range contractor at CCAS for reciprocal support in the event of an emergency or disaster (USAF 1990).

Health care in the region is provided at 28 general hospitals (6,600 beds total), 3 psychiatric hospitals, and 2 specialized hospitals. Medical services for CCAS are provided primarily at the Air Force Space Command Hospital at Patrick Air Force Base and at Wuesthoff Hospital and the Parrish Medical Center, which are both located outside of CCAS in the vicinity of Cocoa Beach. The two offsite hospitals have a total of 458 beds. CCAS is also equipped with a dispensary, which is located in the industrial area. The medical personnel at the dispensary are employed by a private company, under contract to NASA (USAF 1990). Medical services are provided at KSC by an occupational health facility and an emergency aid clinic.

Recreational facilities in the CCAS, which are for base personnel only, are located in the industrial and port areas and include a fitness center, softball field, picnic pavilion, a U.S. Navy service club, and a naval recreation facility. Cultural facilities on station include the Air Force Space and Missile Museum and the original NASA mission control, which are all located at the southern portion of the base. Off-base military and civilian personnel use recreational and cultural facilities available within the Communities. A Visitor Information Center is located in the southwest portion of KSC. No public school facilities are present on CCAS/KSC (USAF 1990).

Nearly 90 percent of the people in the six-county region rely on public systems for potable water. CCAS obtains its potable water from the city of Cocoa water system under a contract and uses 11.3 million liters (3 million gallons) per day (USAF 1990). The Cocoa water system draws its supplies from the Floridan Aquifer. The onsite water distribution systems are sized to accommodate the short-term high-volume flows required by the launch deluge system. To support launches, the distribution system at CCAS was constructed to provide up to 30,000 gal/min for 10 min (USAF 1990). During a Titan IV launch, about 1.5 million liters (400,000 gal) of water are used by the deluge system, the OVSS, and pad washdown. In comparison, approximately 3.3 million liters (863,000 gal) of water are used for each Shuttle launch.

3.1.7.5 Historic/Archaeologic Resources

There are 81 sites within the region that are listed on the National Register of Historic Places (DOI 1991), 2 on the National Registry of Historic Landmarks, and 1 area (Emeralda Marsh) on the National Registry of Natural Landmarks (48 FR 8686).

An archaeological/historical survey of CCAS conducted in 1982 determined that Cape Canaveral has been inhabited for 4,000 to 5,000 years (USAF 1986). The survey located 32 prehistoric and historic sites and several uninvestigated historic localities. A midden site (Br 79) is located near the eastern edge of Launch Complex 39A (NASA 1979). All other recorded archaeological sites are located more than 2 km (1.2 mi) away from any of the launch sites under consideration. The initial results of the field survey indicated that many of the archaeological resources had been severely damaged by the construction of roads, launch complexes, powerlines, drainage ditches, and other excavation. Launch Pads 5, 6, 13, 14, 19, 26, 34, the mission control center at CCAS, and Launch Pads 39A and 39B at KSC are all listed on the National Register of Historic Places (DOI 1991).

3.2 GLOBAL ENVIRONMENT

This section provides a general overview of the global environment, including population distribution and density, general climatological characteristics, and surface type (i.e., ocean, rock, soil) and also briefly discusses the global atmospheric inventory of plutonium. The information provided for global demographics was extracted primarily from the *World Demographic Update Through 1990 for Space Nuclear System Safety Analysis,* prepared for the U.S. Department of Energy (Halliburton NUS 1992). This document used worldwide population statistics and other information compiled into 720 cells of equal size. The cells were derived by dividing the entire Earth from pole to pole into 20 latitude bands of equal area. Each latitude band was then segmented into 36 equal size cells for a total

of 720 cells. Each of the cells covered an area of the Earth equal to 708,438 km^2 (273,528 mi^2).

3.2.1 Population Distribution and Density

Table 3-7 lists the distribution of the Earth's population across each of the 20 equal area latitude bands. Figure 3-15 illustrates the land-adjusted population densities within the latitude bands. These exhibits show that, with the exception of the four more southern latitude bands, the total population among the bands varies by about one order of magnitude. The greatest population densities (see Figure 3-13) occur in a relatively narrow grouping of the four northern bands between latitudes 17 and 44 degrees north (bands 4 through 7).

3.2.2 Climatology

Figure 3-16 illustrates the worldwide climatic types, which range from the perpetual frost of the polar climates to the dry desert climates.

3.2.3 Surface Types

The worldwide distribution of surface types is an important characteristic in considering the potential consequences of accident scenarios analyzed for the Cassini mission. Table 3-7 provides a breakdown of the total land fraction for each of the 20 equal area latitude bands noted previously. The total land fraction was further subdivided by the fraction consisting of soil cover and rock cover. For the most densely populated bands (bands 4 through 7), the land fraction varies from about 33 percent (band 7) to about 45 percent (band 4), with the soil fraction dominating (75 percent in band 4 to 92 percent in band 7).

3.2.4 Worldwide Plutonium Levels

Plutonium (Pu-238), used in the primary fuel for the Cassini spacecraft radioisotope thermoelectric generators (RTGs), already exists in the environment as a result of atmospheric testing of nuclear weapons and a 1964 launch accident. The following paragraphs describe the worldwide levels of plutonium in the environment. This information provides a perspective against which to compare the scope of postulated incremental releases of plutonium into the environment that could result from a Cassini mission accident.

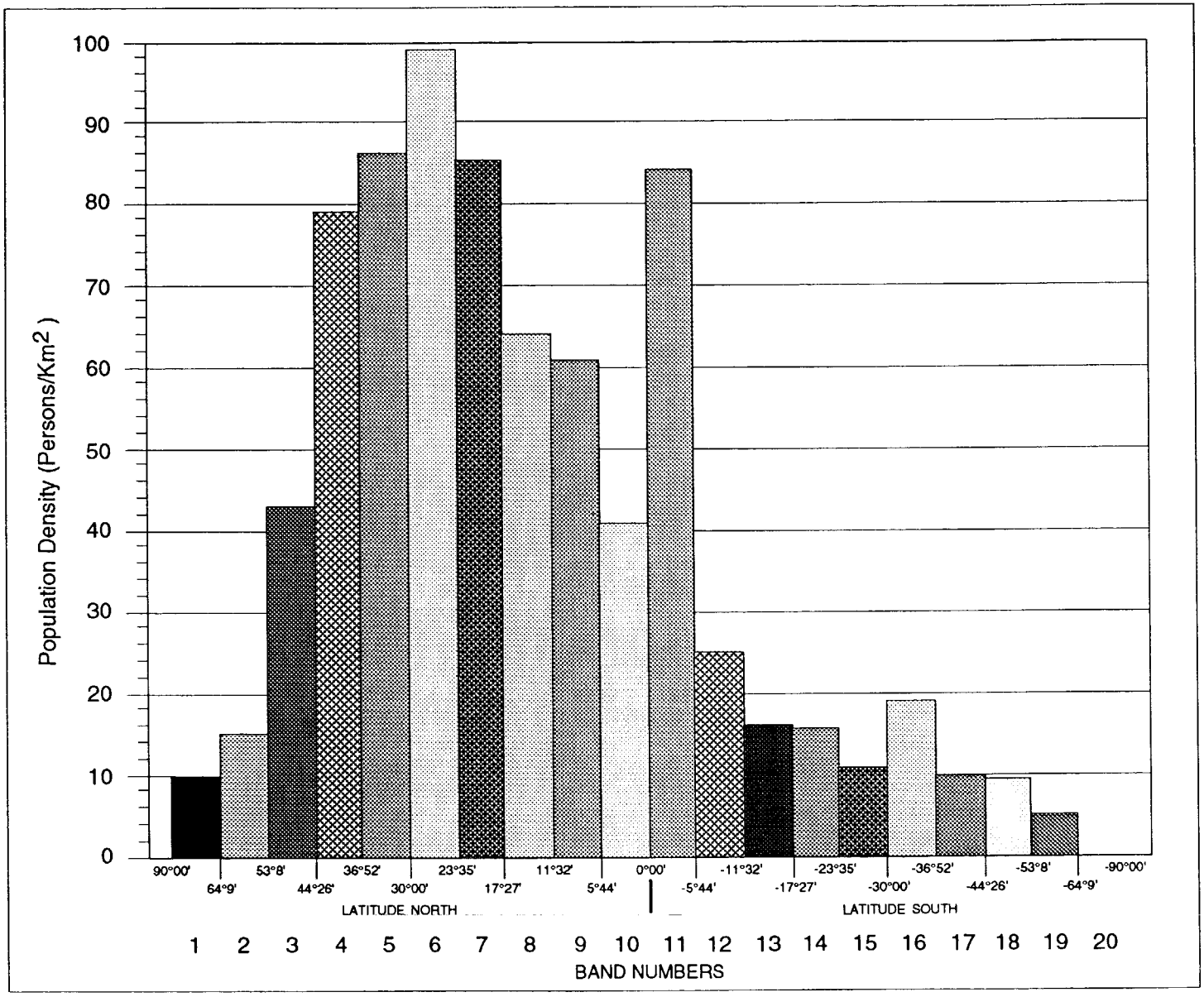
During the period 1945 through 1974, above-ground nuclear weapons tests produced about 1.63×10^{16} Becquerels (Bq) (440,000 curies [Ci]) of plutonium in the environment (EPA 1977, AEC 1974). About 97 percent (about 1.59×10^{16} Bq [430,000 Ci]) of this plutonium was Pu-239 and Pu-240, which are essentially identical, both chemically and with respect to their radiological emission energies. The remainder (about 3.7×10^{14} Bq [10,000 Ci]) consisted primarily of Pu-238 (about 3.3×10^{14} Bq [9,000 Ci]), along with Pu-241 and Pu-242. (Some of the Pu-238 and -241 has decayed since the time of release.) Consequently, above-ground nuclear testing is the major source of worldwide plutonium distribution in the environment.

TABLE 3-7. LATITUDE BAND POPULATION AND SURFACE CHARACTERISTICS

Latitude Band	Band Population[a]	Population Density,[b] Persons/km^2 (Persons/mi^2)	Band Surface Fractions			
			Water	Land	Land Rock Fraction	Land Soil Fraction
1	6.07×10^7	10.0 (3.86)	0.7332	0.2668	1.00[c]	0.0[c]
2	2.02×10^8	15.1 (5.83)	0.4085	0.5915	1.00[c]	0.0[c]
3	5.37×10^8	42.7 (16.49)	0.4456	0.5544	0.251[c]	0.749[c]
4	7.99×10^8	78.7 (30.39)	0.5522	0.4478	0.251	0.749
5	8.37×10^8	86.2 (33.28)	0.5718	0.4282	0.153	0.847
6	8.81×10^8	98.7 (38.11)	0.6064	0.3936	0.088	0.912
7	6.33×10^8	84.9 (32.78)	0.6710	0.3290	0.076	0.924
8	3.60×10^8	63.9 (24.67)	0.7514	0.2486	0.058	0.924
9	3.31×10^8	60.6 (23.90)	0.7592	0.2408	0.077	0.923
10	1.99×10^8	40.9 (15.79)	0.7854	0.2146	0.084	0.916
11	1.99×10^8	84.0 (32.43)	0.7630	0.2370	0.044	0.956
12	1.23×10^8	24.8 (9.58)	0.7815	0.2185	0.055	0.945
13	8.15×10^7	16.3 (6.29)	0.7799	0.2201	0.085	0.915
14	8.53×10^7	15.5 (5.98)	0.7574	0.2426	0.089	0.911
15	5.40×10^7	10.8 (4.17)	0.7796	0.2204	0.092	0.980
16	5.76×10^7	18.8 (7.26)	0.8646	0.1354	0.112	0.888
17	1.03×10^7	9.8 (3.78)	0.9538	0.0462	0.296	0.704
18	4.62×10^6	9.4(3.63)	0.9784	0.0216	0.296[c]	0.704[c]
19	7.45×10^5	4.7 (1.81)	0.9930	0.0070	1.00[c]	0.0[c]
20	$<10^3$	<0.1 (<.04)	0.3863	0.6137	1.00[c]	0.0[c]

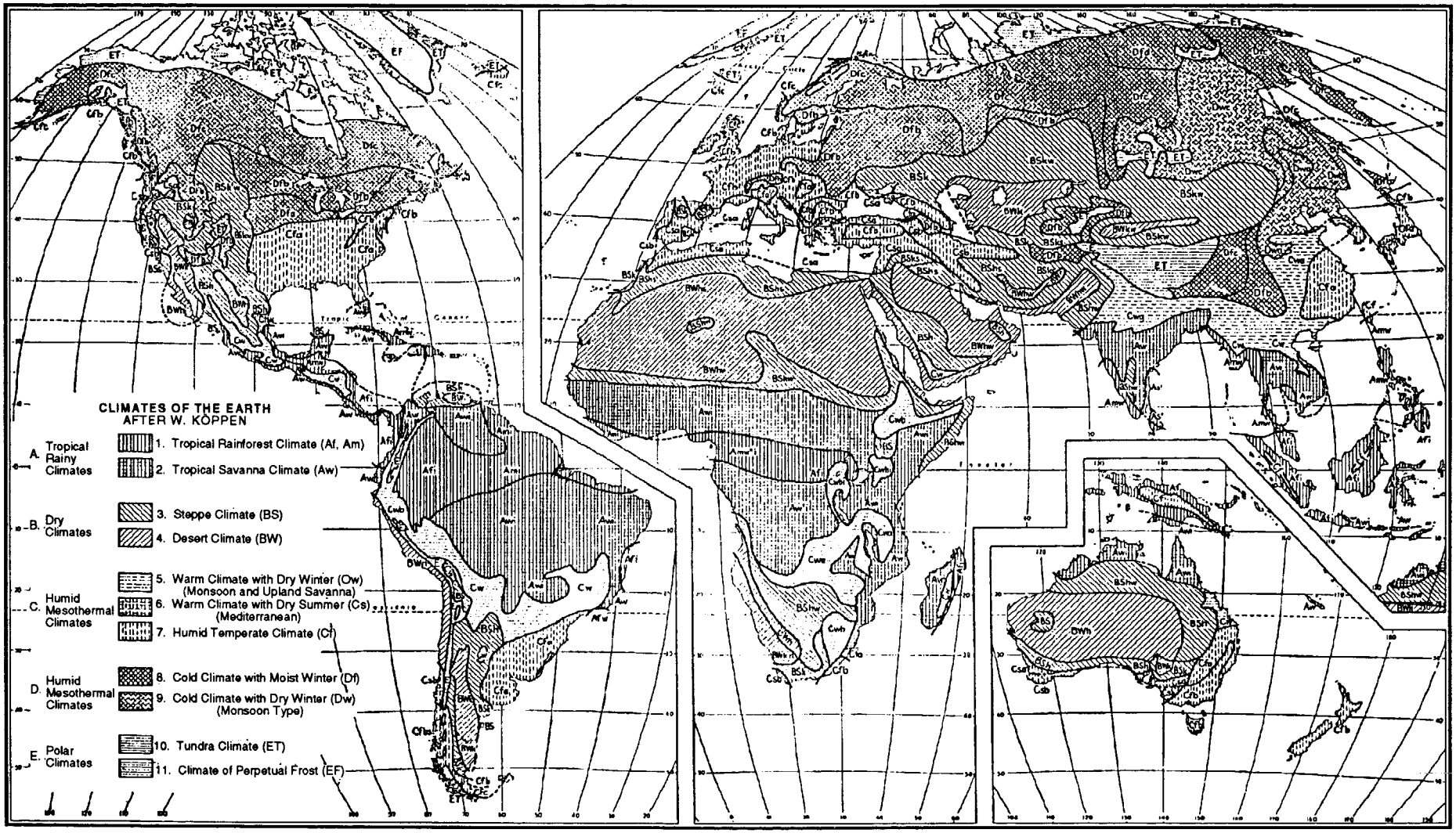
Source: Halliburton NUS 1994a

a. Represents 1990 level (Halliburton 1992).
b. Population density on land fraction (Halliburton NUS 1994a).
c. Assumed values.



Source: Halliburton NUS 1994a

FIGURE 3-15. WORLD POPULATION (BAND LAND AREA) DENSITY BY LATITUDE BANDS



Source: NUS 1982

FIGURE 3-16. WORLDWIDE CLIMATES

Table 3-8 indicates that the Pu-238 in the atmosphere from weapons tests (about 3.3 x 10^{14} Bq [9,000 Ci]) was increased by the 1964 reentry and burnup of a Systems for Nuclear Auxiliary Power (SNAP)-9A RTG, which released 6.3 x 10^{14} Bq (17,000 Ci). This release into the atmosphere was consistent with the RTG design philosophy of the time. (Subsequent RTGs, including the RTGs on the Cassini spacecraft, have been designed to contain the Pu-238 fuel to the maximum extent possible, recognizing that there are mass and configuration requirements relative to the spacecraft and its mission that must be considered with the design and configuration of the power source and its related safety requirements.) Since 1964, essentially all of the SNAP-9A release has been deposited on the Earth's surface (AEC 1974). About 25 percent (approximately 1.5 x 10^{14} Bq [4,000 Ci]) of that release was deposited in the northern latitudes, with the remaining 75 percent settling in the southern hemisphere. In April 1986, approximately 3.7 x 10^{19} Bq (100,000,000 Ci) of various radioisotopes were released to the environment from the Chernobyl accident (NRC 1987). Approximately 3.0 x 10^{13} Bq (810 Ci) were Pu-238.

The heat source for the SNAP-27 RTG released from the Apollo 13 spacecraft during reentry survived impact and has been resting in one of the deepest areas of the Pacific Ocean, the Tonga Trench, with no evidence of any radioactive release (see Section 2.2.4.2).

The total plutonium released to the ocean environment by overseas nuclear reprocessing plants between 1967 and 1987 is approximately 7.4 x 10^{14} Bq (20,000 Ci) (IAEA 1976, NCRP 1987, UNSCEAR 1988). Assuming that 15 percent of the total was Pu-238 (based upon the 1980-85 fraction in Britain's Sellafield releases), about 1.1 X 10^{14} Bq (3,000 Ci) of Pu-238 have been added from these sources, bringing the total of Pu-238 dispersed into the environment up to about 1.1 x 10^{15} Bq (29,810 Ci).

TABLE 3-8. MAJOR SOURCES AND APPROXIMATE AMOUNTS OF PLUTONIUM-238 DISTRIBUTED WORLDWIDE

Sources	Amount (Becquerels [curies])
Atmospheric Testing 1945-74 Deposited near testing sites and worldwide	3.3 x 10^{14} (9,000)
Space Nuclear - SNAP-9A, 1964	6.3 x 10^{14} (17,000)
Overseas Nuclear Reprocessing Plants, 1967 - 1987	1.1 x 10^{14} (3,000) (estimated; see text)
Chernobyl Nuclear Power Station, 1986	3.0 x 10^{13} (810)
Total[a]	1.1 x 10^{15} (29,810)

a. The heat source for the SNAP-27 RTG from Apollo 1 3 landed intact in the Tonga Trench of the Pacific Ocean. The inventory of this RTG has not been included in the worldwide total because there have been no indications of release from this RTG; hence, it is considered unavailable to the biosphere (DOE 1980).