BACCHUS EXHIBIT C
Description and Maps of Affected Area/Vicinity for Proposed LNP

EXHIBIT C -1
Excerpts from Ch. 2. Site Characteristics
LNP Units 1 and 2, COL Application, Part 2, Final Safety Analysis Report (FSAR)

FROM: LNP Units 1 and 2, COL Application, Part 2, Final Safety Analysis Report (FSAR), Chapter 2. Site Characteristics, 1006 pp.

Figure 2.5.1-238 Sinkhole Types and a Sinkhole Risk Map

2.3-2 dry spring, dry fall…

Figures 2.4.1-204 and 2.4.1-205 provide topographic maps of the site with existing conditions and proposed changes to the natural drainage features. FSAR 2.4-2

Stormwater from the retention ponds will be pumped to the cooling water tower basins, If the drainage system becomes blocked, the LNP site can be drained by overland flow directly to the Lower Withlacoochee River or the Gulf of Mexico. FSAR p.2.4-3

Runoff from the site is primarily overland, with storage provided by wetlands. The general direction of overland flow is to the southwest toward the Lower Withlacoochee River and the Gulf of Mexico (Reference 2.4.1-203). FSAR p.2.4-3

The Withlacoochee River Drainage Basin also encompasses a number of small intermittent streams, connected lakes and wetlands, sinkholes,and tributaries. FSAR 2.4-25

A series of wetlands exist on-site, mainly associated with existing cypress tree growth areas. These wetlands and cypress "domes" provide preferential recharge to both the surficial and Floridan aquifers, and may be associated with increased karst feature development in the Avon Park Formation limestones underlying the Quaternary deposits (Reference 2.4.12-203). FSAR p. 2.4-66

As summarized in Table 2.4.12-201, the surface soils present at the LNP site are undifferentiated Quaternary sands of the Smyrna-Immokalee-Basinger (S1547) Series, described as a loamy fine silica sand and fine silty sand, and are poorly to very poorly drained (Reference 2.4.12-207). FSAR p2.4-66-67

Water table data collected in 2007 indicates that the water table ranges in depth at LNP 1 and LNP 2 areas from less than 0.3 m (1 ft.) below ground surface during rainy periods to approximately 1.5 m (5 ft.) bgs during drier periods. FSAR 2.4-67

The second case examines the Lower Withlacoochee River, although there are no identified users of this surface water. The focus of this evaluation is groundwater that moves downgradient from LNP 1 and 2 and resurfaces within the Lower Withlacoochee River, a distance of approximately 7 km (4.3 mi.). The Lower Withlacoochee River flows to the Gulf of Mexico with freshwater supplied from the Inglis Bypass Channel. Minimum flow into the Lower Withlacoochee River from the Inglis Bypass Channel is 22.4 m3/s (790 cfs) based on monthly averages from 1990 – 2006 (Reference 2.4.13-201). FSAR 2.4-79

In this region the water flows along meandering paths through the pores and around grains of soil or rock while some is trapped in microscopic voids.FSAR 2.4-80

Although there are no recognized sinkholes in the State of Florida sinkhole database within 2 km (1.28 mi.) of the LNP site and no sinkholes at the land surface were observed during site investigations and reconnaissance within the LNP site, the presence of deep, infilled zones identified in some borings suggests that paleo-sinks such as those developed on the barren mature epikarst surface are locally present at the site. FSAR 2-5-4

The only geologic hazard identified in the LNP site area is potential surface deformation related to carbonate dissolution and collapse or subsidence related to the occurrence of karst FSAR 2-5-4

Typical landforms include small sinkholes on nearly planar karst platforms in the Coastal Lowlands; rolling hills and sinkholes on the ridges, such as the Brooksville Ridge and Lake Wales Ridge in north-central Florida; and isolated collapse sinkholes in buried karst and newly developing karstic uplands. (Reference 2.5.1-214) FSAR 2.5-17

Pride et al (1966). Located approximately 89 km (55 mi.) southeast of the LNP site at closest distance is an area of faulting along the Lake Whales Ridge area identified by Pride et al. (Reference 2.5.1-264). The faults trend approximately northwest. The faults likely originated in post-Oligocene time and subsequent movement along the fault zones may have occurred over a long period of time. The later movements probably are associated primarily with subsidence and sinkhole collapse along the solution-widened zones. (Reference 2.5.1-264) FSAR 2.5-41

Karst features form when the flow of water is concentrated along well-defined conduits. Such conduits include joints or fractures, faults, and bedding planes in the rock, enlarged by rock dissolution. Dissolution of limestone in Florida appears to occur preferentially in recharge areas and near the saltwater/freshwater coastal mixing zones; recharge areas are the more important of these two environments of sinkhole development. FSAR 2.5-62-63

Anthropogenic factors include over-pumping of groundwater that reduces the shear-strength of the near-surface materials, and causes higher intergranular stress and a resulting reduction in the load carrying capacity of the soils, as well as the placement of structures over geologic features that have the potential for sinkhole activity. These factors often trigger sinkhole activity and ground subsidence. (Reference 2.5.1-315 FSAR p. 2.5-63

The unit mapped at the site consists of sand, silt, and smectitic-clay decomposition residuum (zp), which is generally 1 – 2 m (3.2 – 6.5 ft.) thick. The map unit includes areas of eolian sand and locally derived colluvium and alluvium. Sinkholes and other karst phenomena associated with the underlying limestone bedrock are common. FSAR 2.5-74

Also mapped within the site vicinity is a unit of sandy solution residuum (re) that is generally 1 – 3 m (3.2 – 10 ft.) thick. It is composed chiefly of quartz sand or calcareous sand on soft sandy limestone and shell-hash limestone. It is limonitic in some areas and includes some eolian sand and colluvium. Clay-filled sinkholes and other karst phenomena are common. FSAR 2.5-75

Thomas M. Scott, Ph.D., P.G., Assistant State
Geologist from the Florida Geological Survey (personal communication, e-mail dated August 31, 2007).
Vernon [Reference 2.5.1-262] postulated several faults in the Citrus-Levy County area of west-central Florida. One of these, the Inverness Fault, is of interest due its proximity to the proposed nuclear power plant site in Levy County. Vernon mapped the area using the limited number of wells that were available and the few accessible outcrops. The limestone surface is karstified and very irregular, making it extremely difficult to map in detail. I know of no investigations subsequent to Vernon that provided support for the existence of the faults. My own investigations of faults (proposed by Vernon) exposed in quarries in Citrus County did not validate the proposed faults. Instead, I found karst-related features that included slickensides and tilted bedding. FSAR 2.5-78

The surface morphology is characterized by dolines (shallow depressions above sinks or paleosinks) varying in size from relatively small, (less than 50 m [164 ft.] in diameter) well-defined circular depressions to large (600 m [2000 ft.] wide) irregular, broad, shallow depressions that are more widespread in the western half of the site location. Many of the circular depressions, which are generally less than 1 to 2 m (2 to 6 ft.) deep, are coincident with cypress domes that are visible in both 1949 black and white (pre-extensive logging) and 2007 aerial photographs. The rectilinear pattern and linear margins of higher areas observed in the topography are consistent with regional joint trends. (See lineament analysis described in FSAR Subsection 2.5.3.2.1.1.)

The morphology is very similar to that of the present coastline in the northern part of Citrus County, which consists of rock-cored marsh islands, broad embayments, and joint-controlled tidal creeks that locally connect a series of circular sinkholes (Figure 2.5.1-236).

This supports the conclusions of previous researchers that the site area is underlain by older, karstified marine terrace surfaces mantled by a thin veneer of Quaternary sediment (i.e., Reference 2.5.1-308; Reference 2.5.1-213; Reference 2.5.1-201; Reference 2.5.1-235).

The rectilinear pattern is more apparent in the terrain above an elevation of about 12.8 m (42 ft.) NAVD88. One possible explanation of the variable surface morphology is that the terrain to the west of the LNP units, which may be underlain by a younger (lower elevation) marine terrace, may have experienced a different erosional history. Alternatively, the variation in geomorphic expression across the site location may reflect shallower groundwater and a generally eastward increase in the thickness of Quaternary cover sand that was deposited against the Brooksville Ridge to the east of the site. The lack of well data for the undeveloped areas beyond the LNP site precludes identification of paleoshorelines and detailed mapping of the thickness of Quaternary cover that could be used to differentiate between these two hypotheses. FSAR p. 2.5 -79 to 80

The LNP site stratigraphy and surface morphology are consistent with expected characteristics of a developed paleokarst landscape mantled by several meters of sand (i.e., a mantled epikarst subsurface) (Figure 2.5.1-244). Although there are no recognized sinkholes in the State of Florida sinkhole database within 2 km (1.28 mi.) of the LNP site (Figure 2.5.1-244), and no sinkholes at the land surface were observed during site investigations and reconnaissance within the LNP site, the presence of deep, infilled zones identified in some borings suggests that paleosinks, such as those developed on the barren mature epikarst surface depicted in Figure 2.5.1-239, are locally present at the site FSAR 2.5-83

[Site Location Karst Development begins on FSAR p 2.5-82]

Surface morphology and subsurface data indicate that there has been a long period of karst development in the site location (FSAR Subsection 2.5.1.2.1.3). The LNP site surface morphology is consistent with that of a more developed, older (paleo) karst landscape mantled by several feet to tens of feet of sand (i.e., a mantled epikarst subsurface formed over a denuded karst). With the exception of a small surface sinkhole that formed in response to drilling at one borehole, no sinkholes at the land surface were observed during site investigations and reconnaissance within the LNP site. The presence of deep, infilled zones identified in some site borings suggests that paleosinks are locally present at the LNP site 2.5-178

Man-caused changes on the natural environment is an important factor indeveloping and triggering collapse. Two of the most common collapse-precipitating activities are the withdrawal of groundwater for residential and industrial use (groundwater pumping) and the concentration of surface runoff or change in surface runoff patterns resulting from the construction and development activities. (Reference 2.5.3-214) Modified drainage and diverted surface water commonly accompany construction activities and can lead to focused infiltration of surface runoff, flooding, and erosion of sinkhole-prone earth materials. (Reference 2.5.3-215) Though many variables contribute to the ultimate cause of collapse, a singular event usually acts as the final triggering mechanism. (Reference 2.5.3-214) FSAR 2.5-184

FSAR 2.5-184

As described in FSAR Subsection 2.5.1.2.5, there is no record that human activities, such as mining, have been performed in soil or rock near the vicinity of the LNP site, and hence there is no risk associated with mine subsidence or collapse. FSAR 2.5-187

The potential for subsidence or collapse pertaining to future solution activity of the LNP subsurface is described in this section, as well as the potential for uplift. FSAR 2.5-187

Nonsafety-related structures will be supported on drilled shaft foundations. Considering the soil conditions at the site and the anticipated structural loads, shallow foundations will not provide adequate bearing capacity within permissible settlement and differential settlement requirements, and soil improvement techniques are not recommended due to the high water table and wetland conditions at the site. The specific design of these drilled shafts will be finalized prior to construction. Foundation concepts under nonsafety-related structures are shown on Figures 2.5.4.5-201A, 2.5.4.5-201B, 2.5.4.5-202A, and 2.5.4.5-202B. FSAR 2.5-287

The gross permeability of the diaphragm wall is taken as 10-6 cm/sec (0.002835 ft/day). Potential leakage through "windows," as mentioned above, may necessitate greater than expected pumping rates in order to maintain dry working conditions within the excavation. FSAR 2.5-296

The total flow that must be accommodated with sumps and shallow wells is conservatively determined to be in the range of 1136 to 1893 lpm (300 to 500 gpm) at steady-state conditions during construction, based on the site hydraulic conductivity characteristics summarized in Table 2.5.4.6-201 and the hydrogeological conditions at the site, as described in FSAR Subsection 2.4.12.

FSAR 2.5-296

Randazzo, A.F., and D.L. Smith, "Subsidence-Induced Foundation Failures in Florida's Karst Terrain," in Beck, B.F., ed., "Sinkholes and the Engineering and Environmental Impacts of Karst," Proceedings of the Ninth Multidisciplinary Conference, Huntsville, Alabama, September 6-10, 2003, pp. 82 – 94.

Sinclair, W.C., and J.W. Stewart, "Sinkhole Type, Development, and Distribution in Florida," Map Series 110, Florida Geological Survey, 1985.

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Tihansky, A.B., "Sinkholes, West-Central Florida: A Link between Surface Water and Ground Water," excerpted from Galloway, D., D.R. Jones, and S.E. Ingebritsen, *Land Subsidence in the United States*, U.S. Geological Survey
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