Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

margin caves includes large, globular chambers, bedrock spans, thin bedrock partitions between chambers, tubular passages that end abruptly, and curvilinear phreatic dissolution surfaces. The flank margin caves are not conduits, but rather mixing chambers (Figure 2.5.1-362). They receive freshwater from the fresh groundwater lens in the island interior as diffuse flow, and discharge that water, after mixing, as diffuse flow to the sea. The caves develop without an external opening to the sea or the land. Current entry is possible due to surface erosion breaching into the cave (Reference 263). Examples of flank margin caves are Lighthouse Cave, San Salvador Island Bahamas and Salt Pond Cave, Long Island, Bahamas (Reference 263).

In addition to flank margin caves, there are banana holes in the Bahamas (Figure 2.5.1-362). Banana holes form inland from the flank margin caves at the top of the fresh groundwater lens where the vadose and phreatic freshwaters mix. They are smaller phreatic dissolution voids that form due to collapse of a relatively thin bedrock roof resulting in a broad, vertical-walled depression up to 10 meters (33 feet) across (Reference 263). Both the flank margin caves and banana holes are found in the Bahamas at elevations of 1 to 6 meters (3.3 to 20 feet) above sea level. These caves formed during a ~~glacio-eustatic~~ glacioeustatic sea level high stand that reached elevations above modern sea level. According to Mylroie and Carew (Reference 263), these caves formed approximately 125,000 years ago. The duration of this high stand above modern sea level lasted about 15,000 years, during which time the Bahamas consisted of islands even smaller than today because all land below 6 meters (20 feet) in elevation was below sea level. Therefore, these phreatic caves formed in small freshwater lenses in as little as 15,000 years (Reference 263).

The process of shoreline flow that formed the flank margin caves may be active in the Bahamas today, but at an elevation closer to modern sea level. However, similar processes are not likely to be active currently at the Turkey Point Units 6 & 7 site because of the absence of fresh groundwater shoreline flow near the site. The position of the freshwater/saltwater interface is approximately ~~6 miles (~~9.6 kilometers~~)~~ (6 miles) inland from the site (Figure 2.4.12-207), groundwater at the site is saline (Tables 2.4.12-210 and 2.4.12-211), and the long term sea level rise trend at Miami Beach, Florida, as estimated based on data from 1931 to 1981, is ~~0.78 foot (~~0.2 meter~~)~~ (0.78 foot) per century (~~Reference 2.4.5-206~~Subsection 2.4.5). Therefore, a freshwater/saltwater mixing zone that would promote carbonate dissolution at the site does not now exist.

Karst development on the Yucatan Peninsula, Quintana Roo, Mexico

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

The Yucatan Peninsula is outside of the 200-mile radius "site region" but karst development there provides evidence of shoreline flow and, therefore, is discussed here. In the Yucatan Peninsula, dissolution features intermediate in size between flank margin and epigenetic continental caves form along the margin of the discharging fresh groundwater lens as a result of freshwater/saltwater mixing. Fresh groundwater discharges are very substantial on the Yucatan carbonate platform, as they are fed by a large volume of allogenic recharge (i.e., recharge of the groundwater from an outside location) from the Yucatan interior (Reference 965). Smart et al. (Reference 965) believe that the Quintana Roo caves (Figure 2.5.1-363) represent a new cave type intermediate in size between flank-margin and epigenetic continental systems. The Quintana Roo caves located several kilometers interior from the coast may display elements of a dendritic tributary pattern (typical of epigenetic continental caves). Downstream, this drainage passes into an extended zone characterized by a cross-linked anastomosing passage pattern that extends inland from the coast for maximum distances of 8 to 12 kilometers (5 to 7.5 miles) (Reference 965). Large isolated mixing chambers characteristic of the flank margin type caves are absent. Instead, large chambers occur as an element in the anastomosing zone and are generally associated with collapse. Rectilinear maze patterns are generally absent from the caves located in the interior; however, they do appear to be characteristic of some of the coastal caves where fractures have developed parallel to the flank margin (Reference 965).

The passage types in the Quintana Roo caves are horizontal elliptical tubes and canyon-shaped passages and are extensively modified by collapse, but many retain dissolutional wall morphology. The caves are actively enlarging because of undersaturation with respect to calcium carbonate, resulting from the mixing of fresh and saline water. However, according to Smart et al. (Reference 965), many caves in the interior are above the present mixing zone and are characterized by collapse and infill with surface-derived clays, speleothem deposits, and calcite raft sands. Cave sediment fill, speleothem, and ceiling-level data indicate multiple phases of cave development. These multiple phases are associated with glacio- eustatic changes in sea level, and alternate in individual passages between active phreatic enlargement and vadose incision and sedimentation. Due to the continued accretion of carbonate rocks along the coast during the Pleistocene, caves that are now located in the interior of the Yucatan Peninsula were formerly closer to the coast, and have gone through multiple phases of cave development. Collapse of the cave roofs is extensive and ubiquitous, which results in the development of crown-collapse surface cenotes. Collapse is a result of the large roof spans caused by lateral expansion of passages at the level of the mixing zone, the low strength of the poorly cemented Pleistocene limestones, and the withdrawal of buoyant support during ~~sea-level~~ sea level low stands (Reference 965).

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Two critical conditions that control the development of multiphase Quintana Roo caves following ~~glacio-eustatic~~ glacioeustatic variations in sea level are:

1. **When the passage segments remain connected to the underlying deep cave systems and are occupied by the present mixing zone, substantial inflow of saline water maintains the rate of mixing-driven carbonate dissolution, and the predominantly carbonate rock is removed, allowing active passage enlargement to continue.**
2. **When the links between cave passages are absent, rates of dissolution are low, and passage enlargement ceases (Reference 965).**

If the flow of freshwater through a passage is maintained by tributaries, the velocity may be sufficient to prevent accumulation of further sediments or to flush uncemented sediments from the passage and the cave void will remain open. If such freshwater flows are limited or absent due to blockage of the feeders, the passage segment will gradually become occluded by infill and roof collapse (Reference 965).

The greater topographic relief of the cenotes terrane of the Yucatan Peninsula provides a stark contrast with the flat topography seen at the Turkey Point Units 6 & 7 site and in the available bathymetric data for the near-site area of Biscayne Bay. The apparent origin of the greater topographic relief and a much more developed karst regime in the cenotes terrane relative to the Turkey Point Units 6 & 7 site and its vicinity is the relatively high rate of fresh groundwater discharge from a large inland watershed in the Yucatan that produces a more robust mixing

zone and more carbonate dissolution (Reference 965). The absence of a more developed karst topography or an active mixing zone near the site (because of the location of the freshwater/ saltwater interface as shown in Figure 2.4.12-207 and the presence of saline groundwater at the site as demonstrated by Tables 2.4.12-210 and 2.4.12-211) suggests that the process of shoreline flow that is instrumental in forming the caves on the Yucatan Peninsula is not a mechanism that is likely to produce cavernous limestone with the potential for collapse at the site.

Deep Pore Water Upwelling

~~Deep Pore Water Upwelling (~~DPU~~)~~ **takes place beyond the shoreline on the continental shelf through advection of water through deeper, confined permeable shelf sediments and rocks driven by buoyancy and pressure gradients. Evidence of DPU is provided by the existence of offshore submarine springs. In this case, the flow may be driven by an inland hydraulic head through highly permeable confined aquifers or by the large-scale cyclic movement of water due to thermal gradients (Reference 946). Examples of deep pore water upwelling are:**

- **Submarine paleokarst sinkholes beneath Biscayne Bay (approximately ~~8 miles [~~13 kilometers~~]~~ [8 miles] northeast of the site)**
- **Crescent Beach Spring and Red Snapper Sink, both off the coast of Crescent Beach, Florida (approximately ~~200 miles [~~320 kilometers~~]~~ [200 miles] north of the site)**

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Submarine Paleokarst Sinkholes Beneath Biscayne Bay

Cunningham and Walker (References 958 and 989) conducted a study east of the Miami Terrace using high-resolution, multichannel seismic-reflection data (Figure 2.5.1-356). The data exhibit disturbances in parallel seismic reflections that correspond to the carbonate rocks of the Floridan Aquifer system and the lower part of the overlying intermediate confining unit (Figure 2.5.1-357). The disturbances in the seismic reflections are indicative of deformation in carbonate rocks of Eocene to middle Miocene age. This deformation is interpreted to be related to collapsed paleocaves or collapsed paleocave systems, and includes fractures, faults, and seismic-sag structural systems (Figure 2.5.1-358) (References 958 and 989).

In general, the seismic-sag structural systems exhibit one or more zones of vertically stacked, concave-upward arrangements of generally parallel seismic-reflection patterns (Figure 2.5.1-358) (References 958 and 989). Twelve seismic sag structural systems have been delineated on the seismic profiles of Cunningham and Walker (Reference 958). Two types of seismic-sag structural systems they have identified are "narrow" and "broad". The type of system is defined based on the measured differences in the inner sag width of the

deformed seismic reflectors. The inner sag width is defined as "the distance between inflection points (i.e., where the shape of the subsidence profile changes from concave to convex) on both sides of the structural trough" (Reference 958).

Collapse related to the "narrow", seismic-sag structural systems is multistoried as shown in Figure 2.5.1-358 (Reference 958). The uppermost termination of zones of concave upward reflections displayed in many of the narrow sag structures may correspond to paleotopographic expression of the upper surface of paleosinkholes, since many are filled in with onlapping reflections. The onlapping reflections indicate passive sedimentary fill at the top of sagging reflections. This relationship is shown in zones 2 and 3 in the N1 profile in Figure 2.5.1-358. These two zones are indicative of cave collapse and suprastratal deformation during the Eocene. Cunningham and Walker (Reference 958) hypothesize that the association of narrow, seismic-sag structural systems with a possible single fault, in some cases, likely indicates a structural fabric and associated fracture/fault permeability. Although the more recent work by Cunningham and Walker confirms the existence of the seismic-sag structural systems in Biscayne Bay, the authors indicate that both faults and karst collapse systems that might cause disruption in confinement have only been imaged in the middle Eocene to Oligocene part of the Floridan Aquifer system (Reference 989). These faults may have a substantial control on the geographic distribution of some of the narrow seismic sag structural systems (References 958 and 989).

A major collapse event associated with the "broad", seismic-sag structural system is shown in Figure 2.5.1-359. This collapse event occurred in the Eocene based on the deformation of seismic-reflection stratigraphic layer 8 (SS8) reflections which are assigned to Eocene-age rocks. These SS8 reflectors appear to have downlapping relations onto the upper surface of the zone 2 sag structures and truncate reflectors at the top of the zone 2 structure (Reference 958).

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

There are three possible mechanisms for the formation of the seismic sag structures: (1) "corrosion" or dissolution by an Eocene mixed freshwater/saltwater zone associated with regional groundwater flow, (2) upward groundwater flow during the Eocene driven by Kohout convection (the circulation of relatively warm saline groundwater deep in carbonate platforms and subsequent mixing with meteoric water as it rises), and (3) upward ascension of hydrogen sulfide-charged groundwater, with the hydrogen sulfide derived from the dissolution and reduction of calcium sulfates in the deeper Eocene or Paleocene rocks (Reference 958). The potential link between the seismic sags and submarine paleosinkholes suggests the seafloor sinkholes began to form as early as the Eocene.

Regardless of the mechanism of formation, the geophysical data indicate the absence of deformation in rocks younger than middle Miocene (Figures 2.5.1-357, 2.5.1-358, and 2.5.1-359). This finding suggests that if the same mechanism had been active at the Turkey Point Units 6 & 7 site during the Eocene, none of the strata younger than middle Miocene would be deformed. These younger strata include the Miami Limestone, Key Largo Limestone, Fort Thompson Formation, Tamiami Formation and Peace River Formation. The total thickness of this section at the site is approximately ~~450 feet (~~137.2 meters~~)~~ (450 feet) (Figure 2.5.1-332). Deformation of rocks below this depth is not likely to pose a threat of surface collapse at the site.

Crescent Beach Spring and Red Snapper Sink, off the coast of Northeast Florida

Crescent Beach Spring and Red Snapper Sink are located outside of the 200-mile radius ~~"site region"~~ site region, but the spring and sink are evidence of deep pore water upwelling and warrant discussion here. Crescent Beach Spring, a freshwater spring, is located approximately 4 kilometers (2.5 miles) east of Crescent Beach, Florida (Figure 2.5.1-364) and is considered a first-order magnitude spring with a flow rate of greater than 40 ~~meters^3/second~~ cubic meters/second (greater than1400 ~~feet^3/second~~ cubic feet/second) (Reference 946). The spring is located at a depth of 18 meters (59 feet) in the Atlantic Ocean and erosion of confining strata to a depth of 38 meters (125 feet) at the mouth of the vent has enabled direct hydrologic communication of confined groundwater in the Floridan Aquifer with coastal bottom waters (Reference 946).

The Red Snapper Sink (Figure 2.5.1-364) is located approximately 42 kilometers (26 miles) off Crescent Beach and is incised approximately 127 meters (417 feet) into the continental shelf at a water depth of 28 meters (99 feet). Divers investigating the site observed that seawater was flowing into small caves at the base of the hole, indicating possible recharge of the Floridan Aquifer, and that the water in the bottom of the hole was similar in salinity and sulfate content to ambient seawater. According to Moore (Reference 946), Red Snapper Sink was similar to Crescent Beach Spring before the piezometric head was lowered along the coast, and preservation of the feature suggests that a freshwater spring was active at this site in the recent past.

The existence of Crescent Beach Spring and, by inference, Red Snapper Sink indicates the presence of abundant fresh groundwater within confined aquifers on the continental shelf. Breaching of the confining layer overlying such aquifers by erosional or tectonic mechanisms has the potential to create similar submarine springs on the shelf off southern Florida. No capable faults that could induce a

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

breach of the confining layer have been identified in the site vicinity (~~FSAR~~ Subsection 2.5.3.6). Groundwater in the Biscayne Aquifer (the surficial aquifer) is saline (Table~~s~~ 2.4.12-210 and 2.4.12-211). Therefore, dissolution of carbonate rocks in the vicinity of deep pore water upwelling from this aquifer into

the overlying ocean is not probable. At the site, the underlying Tamiami Formation and Hawthorne Group combined comprise more than approximately ~~500 feet (~~152 meters~~)~~ (500 feet) of low-permeability rocks and sediments that overlie and confine the Floridan Aquifer (Figures 2.4.12-202 and 2.4.12-204). Deep pore water upwelling generally occurs well off shore, where the slope of the shelf is steeper and erosion of this thickness of confining sediments is more likely. For this reason, carbonate dissolution associated with deep pore water upwelling from the Floridan Aquifer is not likely to pose a threat of surface collapse or sinkhole hazard at the site.

The following revised text in the last paragraph of FSAR Subsection 2.5.1.2.2, Site Area Stratigraphy, and additional paragraphs will be included in a future revision of the COLA.

Four geologic cross sections, two isopach (thickness) maps, ~~one~~**two** structure contour map**s**, and a site geologic map were prepared from the information obtained from the site subsurface investigation (Figure 2.5.1-33~~6~~**4**). Geologic cross section A-A' (Figure**s** 2.5.1-338 **and 2.5.1-386**) extends east-west through the power blocks and eight borings, including the two deepest borings B-601 and B-701. Cross section B-B' (Figure**s** 2.5.1- 339 **and 2.5.1-387**) extends west-east through the southern edge of the site and includes eight borings, the deepest at 153 feet (46.6 meters) bgs. Cross section C-C' (Figure**s** 2.5.1-340 **and 2.5.1-388**) extends diagonally northwest-southeast through the entire site and passes through the western power block. Cross section C-C' includes seven borings including the deepest boring, B-701(DH), at a depth of 615.5 feet (187.6 meters) bgs. Cross section D-D' (Figure**s** 2.5.1-341 **and 2.5.1-389**) also extends diagonally northwest- southeast through the entire site but passes through the eastern power block. Cross section D-D' includes six borings; the deepest at a depth of 215 feet (66 meters) bgs.

The locations of the surface traces of the cross sections are shown on Figures 2.5.1-342 and 2.5.1-344 (isopach maps of the Key Largo Limestone and the Fort Thompson Formation, respectively) and Figures 2.5.1-349, and 2.5.1-343 (structure contour maps of the top of the Key Largo Limestone and the Fort Thompson Formation, respectively). Two versions of each of the four cross- sections are provided. Cross-sections in the first set (Figures 2.5.1-338, 2.5.1-339, 2.5.1-340, and 2.5.1-341) are truncated at the elevation of ~~-200 feet (~~-61 meters~~)~~ (-200 feet) NAVD88 and depict the subsurface stratigraphy with a vertical exaggeration of 12 to 1. Figures 2.5.1-386, ~~-387,~~ 2.5.1-388, and 2.5.1-389 depict a thicker section of the subsurface stratigraphy on the same cross-sections with a vertical exaggeration of only 4 to 1.

The cross sections indicate that geologic contacts beneath the site are relatively flat and undeformed. This **stratigraphy** reflects the environment of deposition and subsequent erosion of the paleosurface. ~~This is represented by~~ **The flat and undeformed nature of**

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

the geologic contacts is reflected in the isopach maps of the Key Largo Limestone (Figure 2.5.1-342) and the Fort Thompson Formation (Figure 2.5.1-344) that indicate a relatively uniform thickness across the site with no abrupt changes. ~~A~~**The** structure contour map**s** of the top of the **Key Largo Limestone (Figure 2.5.1-349) and the** Fort Thompson Formation **(Figure 2.5.1-343)** show a relatively flat paleosurface ~~(Figure 2.5.1-343)~~. Boring logs and descriptions of the lithology are included in the geotechnical data report in References 708 **and 995**. **Section 5.3 of Appendix 2.5AA provides a discussion of the isopach and structure contour maps and reasons for concluding that they provide no strong evidence for the presence of large collapse features in the Key Largo Limestone or Fort Thompson Formation at the site.**

The following revised text will be included in a future COLA revision to replace paragraphs 7 through 14 of FSAR Subsection 2.5.1.2.4, Site Geologic Hazards.

Seventh paragraph and onward:

An FGS investigation (Reference 724) concludes that most of Miami-Dade County is underlain by limestone containing solution cavities. ~~It indicates that a few localities in the Homestead/Turkey Point area may be underlain by open and sand-filled cavities in a zone occurring between depths of about 18 to 31 feet (5 to 9 meters). Information collected during the course of Units 6 & 7 subsurface investigations include rod drops, loss of drill fluid circulation, rock recovery, and Rock Quality Designation (RQD).~~
~~Analysis of this information indicates that, while individual boreholes showed variation, data collected during the drilling of boreholes qualitatively points towards the existence of two preferential secondary porosity flow zones in the areas beneath and in the immediate vicinity of the Units 6 & 7 site:~~

- ~~An upper zone from approximately -25 feet to -35 feet NAVD 88 located predominantly within the Key Largo limestone (the start of this zone correlates roughly with the boundary between the overlying Miami Limestone and the underlying Key Largo Limestone).~~

- ~~A lower zone from approximately -65 feet to -75 feet NAVD 88 that correlates with a sandy zone within the Fort Thompson Formation.~~

~~Analysis of the caliper, suspension velocity, and acoustic televiewer data collected from 10 borings during the Units 6 & 7 subsurface investigation provides additional evidence supporting the existence of these secondary porosity flow zones beneath Units 6 & 7. As stated in the MACTEC site subsurface investigation report (Reference 708), the location of cavities and weathered zones on the televiewer logs correspond precisely with increases in caliper log diameter and suspension P- and S-wave velocity drops. Study of the downhole geophysical data logs confirms that such cavities and weathered zones are commonly observed within the elevation ranges proposed for the upper and lower secondary porosity flow zones. A downhole video~~

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

~~survey conducted in pilot hole MW-1, located on the Turkey Point Peninsula, also supports the existence of these secondary porosity zones. The downhole video shows evidence of highly permeable zones containing interconnected vugs between the elevations of approximately -21 feet to -43 feet NAVD 88 and -62 feet to -72 feet NAVD 88.~~

Zones of secondary porosity have formed in limestone beneath the site where micro-karst features have developed (FSAR Subsections 2.4.12.3.1 and 2.5.1.2.4). These zones of secondary porosity provide areas of preferential groundwater flow. The micro-karst features are thought to have formed by solution enlargement of sedimentary structures when fresh groundwater formerly flowed from inland areas, mixed with sea water, and facilitated dissolution as it flowed through the zone to the sea. The zones of secondary porosity can be subdivided into two categories: touching-vug porosity and moldic porosity.

The two zones of secondary porosity were identified at the site following review of the geophysical logs, the geotechnical boring logs, and the shear wave velocity logs. In general, the zones of secondary porosity were identified based on increases in borehole diameter on the caliper logs, darkened areas on the acoustic televiewer images, typically lower P-S wave velocity values, rod drops, and in the case of touching-vug porosity, loss of drilling fluid ~~circulatilon~~ circulation**. Figures 2.5.1-351, 2.5.1-352, and 2.5.1-353 show the approximate locations of the two zones of secondary porosity on three example-boring logs, B-604 (DH), B-608 (DH), and B-710 G (DH) and their locations at the Turkey Point Units 6 & 7 site are shown on Figure 2.5.1-228 and Figure 2.5.4-202. Figures 2.5.1-351, 2.5.1-352, and 2.5.1-353 were compiled using the lithology, caliper, natural gamma, acoustic televiewer, and velocity (Vs and Vp) logs.**

Recent studies by Cunningham et al. (References 404 and 723) suggest vuggy porosity is common within the Biscayne Aquifer (Miami Limestone, Key Largo Limestone, and Fort Thompson Formation) and that typical solution features associated with the touching-vug porosity include solution-enlarged fossil molds up to pebble size, molds of burrows or roots, irregular vugs surrounding casts of burrows or roots, and bedding plane vugs. Cunningham et al. (Reference 404) show images of vugs in the Miami Limestone and Fort Thompson Formation, with cavernous vugs approximately 4 feet in height (Figure 2.5.1-385). The results of extensive site investigation for Turkey Point Units 6 & 7 (Subsections 2.5.1.2.2 and 2.5.4.2.2, and Reference 708) offer no evidence that karstification of the area has developed cavernous limestone with the potential for collapse and formation of sinkholes.

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Touching-vug porosity occurs on the site within the approximate depth interval of 20 to 35 feet (Figures 2.5.1-351, 2.5.1-352, and 2.5.1-353) near the contact of the Miami Limestone and Key Largo Limestone (the "Upper Zone" of secondary porosity discussed in ~~FSAR~~ Subsection 2.4.12.1.4). Because the elevation of ground surface at the site is approximately 0 feet NAVD88 (Reference 708), this depth interval corresponds approximately to -20 to -35 feet NAVD88. The origin of this porosity is solution enlargement of burrows, inter-burrow vugs, moldic fossils, root molds, and vugs between root casts (References 404, 723 and 969). These structures are sufficiently numerous and closely spaced so as to form a laterally continuous zone of interconnected voids. Results of drilling and coring within the zone of touching-vug porosity during the site subsurface investigation have shown the feature to be laterally persistent, generally of centimeter scale, with very few indications of possible larger voids such as a rod drop.

**Moldic porosity occurs in pockets within the approximate depth interval of 60 to 75 feet (-60 to -75 feet NAVD88) (Figures 2.5.1-351, 2.5.1-352, and 2.5.1-353) in the Fort Thompson Formation and forms the "Lower Zone" of secondary porosity discussed in FSAR Subsection 2.4.12.1.4. The origin of this feature is preferential dissolution of fossil shells and other organic structures rather than the matrix rock within which they are contained, resulting in void spaces of generally centimeter scale within molds of the structures (References 404, 723 and 969).
Results of drilling and coring within the zone of moldic porosity during the site subsurface investigation have shown the feature not to be laterally persistent but occurring in isolated sandy pockets with very few indications of possible larger voids such as a rod drop.**

As seen from the cores taken during the subsurface investigation and photos of the cores (References 708 and 995), the potential origin of the touching-vug porosity within the upper zone is associated with original reef structure and, based on Cunningham et al. (References 404 and 723), solution enlargement. ~~The "cavities" described in the MACTEC report (Reference 708) are considered to represent both touching-vug porosity and moldic porosity. The potential origin of touching-vug porosity within the upper zone of secondary porosity is solution enlargement and original reef structure.~~ The potential origin of the lower zone of secondary porosity is moldic porosity resulting from dissolution on in situ bivalve shells.~~Recent studies by Cunningham et al. (References 404 and 723) suggest vuggy porosity is common in the Biscayne Aquifer (Miami and Key Largo Limestones and Fort Thompson Formation) and that typical solution features associated with the touching-vug porosity include solution-enlarged fossil molds up to pebble size, molds of burrows or roots, irregular vugs surrounding casts of burrows or roots, and bedding plane vugs.~~

As further discussed in Appendix 2.5AA, dissolution of the limestone in the upper zone of secondary porosity likely occurred during the Wisconsinan glacial stage of the Pleistocene Epoch when sea level was lower than during the preceding interglacial stages when the Miami Limestone and Key Largo Limestone were

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

formed (Figures 2.5.1-372 and 2.5.1-373) and fresh groundwater from the Everglades mixed with seawater and discharged through the zone to the sea. The coralline vugs within the Key Largo Limestone typically exhibit evidence of precipitation of secondary minerals such as calcite (~~FSAR~~ Subsection 2.5.1.2.2).
This finding suggests that the environment within the Upper Zone of secondary porosity is currently one dominated by deposition rather than solution. The position of the freshwater/saltwater interface is approximately 6 miles (9.6 kilometers) inland from the site (Figure 2.4.12-207), groundwater within the zone of touching-vug porosity is saline (Tables 2.4.12-210 and 2.4.12-211), the long term sea level rise trend at Miami Beach, Florida, as estimated based on data from 1931 to 1981, is 0.78 foot (0.2 meter) per century (~~Reference 2.4.5-206~~Subsection 2.4.5), and there is no freshwater shoreline flow near the site. Therefore, a freshwater/saltwater mixing zone that would promote further dissolution of the limestone within the zone of ~~toucing-vug~~ touching-vug porosity does not now exist and development of large underground caverns with the potential for collapse is not likely within this Upper Zone of secondary porosity. Further, this zone will be completely removed during excavation of the nuclear island foundations (~~FSAR~~ Subsection 2.5.4.5.1).

Dissolution of the limestone in this zone of secondary porosity likely occurred during the early to mid-Pleistocene Epoch when sea level fluctuated to a level lower than when the Fort Thompson Limestone was formed and fresh groundwater from inland areas discharged through the formation toward the sea. As noted previously, the position of the freshwater/saltwater interface is approximately 6 miles (9.6 kilometers) inland from the site (Figure 2.4.12-207), groundwater within the zone of moldic porosity is saline (Tables 2.4.12-210 and 2.4.12-211), the long-term sea level rise trend at Miami Beach, Florida, as estimated based on data from 1931 to 1981, is 0.78 foot (0.2 meter) per century (~~Reference 2.4.5-206~~Subsection 2.4.5), and there is no freshwater shoreline flow near the site. Therefore, a freshwater/saltwater mixing zone that would promote further dissolution of the limestone within the zone of moldic porosity does not now exist and development of large underground caverns with the potential for collapse is not likely within this Lower Zone of secondary porosity.

While touching-vug and moldic porosity similar to that noted by Cunningham et al. (References 404 and 723) and Lucia (Reference 969) occur at the Turkey Point Units 6 & 7 site, it should be noted that only occasional small rod drops were noted during the site investigation (References 708 and 995)~~in 6 out of the 88 boreholes and approximately 9,000 feet (2,745 meters) 2745 meters (9000 feet) of rock coring (Subsections 2.5.1.2.4, 2.5.4.1.2.1 and 2.5.4.4.5.5) (Table 2.5.1-208)~~. A "rod drop" occurs when, while drilling, the bit encounters a relatively soft zone or void and the drill head and rod string suddenly advances at a rate much faster than the rate when drilling the overlying more competent material. A rod drop can also occur during an SPT when the weight of the string of drill rods is sufficient to advance the

SPT sampler at the bottom of the borehole without additional blows of the sampling hammer. The occurrence of a rod drop indicates the presence of very soft or very loose material, which can be interpreted as void or cavity infill or as inter-bedded materials with substantially different hardness or compactness. Alternatively, a rod drop could indicate that the drill or sampler might have penetrated a cavity that is only partially filled with soft or loose material.

Groundwater levels monitored in onsite observation wells indicate a consistent site-wide upward vertical flow potential within the Biscayne Aquifer (Table 2.4.12- 204). The geotechnical logs of the boreholes in which the rod drops occurred indicate that, except for the two drops that occurred in the Miami Limestone, the drops occurred as the drill or sampler advanced from relatively competent rock into a more sandy zone. In this situation, the upward hydrostatic head within the aquifer may have caused an upward blowout of the sand into the borehole when the confining layer above the sand was breached. The rod drops may have occurred not because the drill or sampler encountered very soft or very loose material indicative of void infill, but because liquefaction of the sand in the blowout zone reduced its bearing capacity to less than the down-pressure on the drill or the weight of the rod string.

Despite the presence of the aforementioned upper and lower zones of secondary porosity, the number and magnitude of rod drops that occurred during drilling were negligible, as described in Subsection 2.5.4.1.2.1. **It can be noted that each of the 88 geotechnical borings drilled in support of the detailed site subsurface investigation was advanced to a minimum depth of ~~100 feet (~~30.5 meters~~)~~ (100 feet), with many drilled to ~~150 feet (~~45.7 meters~~)~~ (150 feet) or more, and none encountered large paleokarst sinkholes or large open voids. Boring logs (Reference 708) indicate the:**

- **0.9-meter (3-foot) drop in B-805 occurred within the Miami Limestone.**
- **0.6-meter (2-foot) drop in B-637 occurred within the Miami Limestone.**
- **One rod drop in each of borings B-738, B-811 and B-814 occurred in sandy zones in the Fort Thompson Formation.**
- **0.3-meter (1-foot) drop in B-714 occurred at the base of the Fort Thompson Formation immediately before penetrating the sands of the Tamiami Formation.**

~~**No rod drops occurred in the nuclear island footprint of either Unit 6 or Unit 7. Two of the rod drops occurred within the Miami Limestone (B-637 and B-805), which will be completely removed beneath the nuclear islands. Boring B-714 is located in the footprint of the Unit 7 annex building and the rod drop in this boring might have been due to the process of drilling from the hard limestone of the Fort Thompson Formation into the underlying silty sand of the Tamiami Formation (Table 2.5.1-210, Figure 2.5.1-378)**~~ **The evaluation of all data (References 708 and 995) indicate that outside the vegetated depressions and drainages (in vertical borings), a total of 20.1 feet of interpreted tool drops (due to voids and/or voids filled with soft sediments) are observed, in a total of 7918.4 feet cored, for a 0.3 percent of the total cored in 93 borings. Individual drops in the vertical borings range from 0.4 feet to 4 feet (1.5 feet max within the Unit 6 & 7 building footprints). Results from the site investigations (References 708 and 995), show that interpreted tool drops are found more often under the vegetated depressions and drainages. In the three inclined borings, a total**

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

of 15.2 feet of tool drops are observed, in a total of 356.4 feet cored, for a 4.3 percent of the total cored length. Individual drops in the inclined borings range from 0.3 feet to 2.5 feet. Boring locations with interpreted tool drops, among all sampling locations, are shown in Figure 2.5.1-378. The maximum length of interpreted tool drop (due to voids and/or voids filled with soft sediments) is limited to 1.5 feet within the Unit 6 & 7 building footprints, and the frequency of encountering an interpreted tool drop is less than 0.5 percent site-wide. These statistics are based on the drilling conducted during both, the initial and supplemental site investigations (References 708 and 995).

Cavities observed during rock core operations were relatively small. The overall data collected during the Units 6 & 7 subsurface investigations are consistent with a communication with the FGS, which indicates that dissolution present in the site area is generally considered to be ~~micro-karst~~ **microkarst** with numerous small cavities. **This information is consistent with investigations by Cunningham (References 404 and 723) in the Biscayne Aquifer in southeastern Florida.**

An investigation of small surface depressions identified within the site (Figure 2.5.1-333) and site area is discussed in Subsection 2.5.3. The UFSAR for Turkey Point Units 3 & 4 concludes that "[s]uch depressions are not sinkholes associated with collapse above an underground solution channel, but rather potholes, which are surficial erosion or solution features" (Reference 712~~, p. 2.9-3~~). These solution potholes are not expected to form large voids beneath the surface that would pose a hazard to the site (Reference 264).

An integrated geophysical survey focused on the Units 6 & 7 power block area and the small surface depressions identified within the site is discussed in Subsection 2.5.4.4.5. Based on ~~all of the site characterization data collected from the site~~ **an integrated interpretation of the boring data (Subsection 2.5.4.1.2.1) and the integrated site geophysical survey data,** there is no **apparent** evidence for sinkhole hazards or for the potential of surface collapse due to the presence of large underground openings.
The origin and significance of the surface depressions, as well as the interpretation of the geophysical survey data are discussed further in Appendix 2.5AA. The locations of the vegetated depressions correlate well with results of the geophysical surveys (Figures 2.5.4-223 and 2.5.4-228). The presence of peat within the vegetated depressions, as well as the s~~S~~oft zones within the Miami Limestone indicated by relatively low SPT "N" values recorded in logs of soil borings drilled on the geophysical survey lines correlate well with low-gravity anomalies, suggesting that the gravity anomalies identify areas of soft rock rather than large subsurface voids.

The **MASW data indicate that the vegetated depressions at the site are underlain by continuous Key Largo Formation (Figures 2.5.4-227 and 2.5.4-241). These two figures show MASW data along survey lines 9 and 10 that intersect at a prominent vegetated depression. Within the limits of survey resolution, the microgravity data do not indicate the presence of large subsurface voids. To address uncertainties in the resolution of the geophysical data away from survey lines and at depth beneath the foundation, a microgravity survey will be conducted at the base of the Unit 6 and Unit 7 nuclear island excavations (Subsection 2.5.4.4.5.5).**

What can be interpreted as karst, or sinkhole-like features similar to the small surface depressions on site have been noted in aerial photographs of the nearby portion of Biscayne Bay (Appendix 2.5AA~~, Section 2.2~~). The Bay has been modified and dredged

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

and has an average water depth that ranges from 6 to 13 feet (Reference 991). Assuming the water level in the bay is 0 feet NAVD 88 ~~NAVD88~~, the bottom of the bay ranges in elevation from approximately -6 to -13 feet NAVD 88 ~~(NAVD88)~~. According to Reich et al. (Reference 992), sediments overlying bedrock in the bay range in thickness from less than 6 inches to 30 feet. Using this information and the elevations

of the bottom of the bay, the elevation of the bedrock surface within which the "karst/sinkhole-like features" occur on the floor of the bay (or alternatively the "vegetated depressions", "local depressions" and "potholes" described in ~~FSAR~~ Subsection 2.5.3) ranges from -6.5 to -43 feet NAVD 88 ~~NAVD88~~. The Upper Zone of secondary porosity within the Biscayne Aquifer is located near the contact of the Miami Limestone and Key Largo Limestone at an approximate elevation of -28 feet NAVD 88 ~~NAVD88~~ (~~FSAR~~ Subsection 2.5.1.2.4). The Lower Zone of secondary porosity is located within the Fort Thompson Formation at an approximate elevation of -65 feet NAVD 88 ~~NAVD88~~ (~~FSAR~~ Subsection 2.5.1.2.4). Based on site stratigraphic data (~~FSAR~~ Subsection 2.5.1.2.2), the units are relatively flat and it appears that the Upper Zone of secondary porosity at the Turkey Point Units 6 & 7 site occurs within the stratigraphic interval within which the "karst/sinkhole- like features" occur on the floor of Biscayne Bay. That level is the stratigraphic interval of the Miami Limestone and Key Largo Limestone (Figure 2.5.1-332). Results of the site subsurface investigation (References 708, 995, and 996) have demonstrated the absence of large solution cavities at this stratigraphic interval on the site.

While the touching-vug porosity exhibited in the Upper Zone of secondary porosity and the "karst/sinkhole-like features" on the bottom of Biscayne Bay may be in the same stratigraphic interval, the formation of these dissolution features is somewhat different. Dissolution features such as vugs are typically post-depositional features that occur in a freshwater phreatic system in which groundwater has filled open spaces and causes dissolution. The "karst/sinkhole- like features" on the bottom of the bay appear to be paleo-dissolution features that formed during the Wisconsinan (most recent) glacial stage of the Pleistocene when sea level was approximately 100 meters (328 feet) lower than the modern ocean (Reference 262) and at an elevation favorable for dissolution by rainwater of subaerial limestone in what is now the bay. More information on the development of the "karst/sinkhole-like features" on the bottom of Biscayne Bay is provided in ~~FSAR~~ Appendix 2.5AA and in the following paragraph, together with a summary of the evolution of the bay.

The process of limestone deposition in Florida was variable during the Pleistocene Epoch due to fluctuations in glacial runoff and the corresponding sea level The Sangamon interglacial corresponds to the Q5e interglacial stage that occurred between approximately 125,000 and 75,000 thousand years ago (Reference 928). During this time, sea level rose globally and in Florida resulted in an increase in marine carbonate deposition. Sea level was approximately 20 feet higher than today (References 993 and 994) and covered the entire Florida peninsula south of Lake

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Okeechobee (Reference 994). The marine sediments (i.e. the Miami Limestone and Key Largo Limestone) that accumulated during the Sangamon and the previous interglacial high sea level stands (Reference 928) were lithified and their depositional morphology preserved. Two elongated sediment ridges that formed the Key Largo Ridge and the Atlantic Coastal Ridge resulted in the limestone basin that is now filled by Biscayne Bay, Card Sound, and Barnes Sound.

During lower sea level stands of the Wisconsinan glacial stage, the Florida platform became emergent (sea level was approximately 100 meters (328 feet) lower than today) and the sea floor of Biscayne Bay was exposed (Reference 262). The exposed sea floor of the Bay was altered by rainwater. Dissolution, re- precipitation, and vegetative soil formation cemented the calcareous surface and slowly produced a very hard reddish limestone "soil crust" over the surface.
Carbonate dissolution resulting from infiltration of rain water produced solution holes and pipes into the underlying limestone and solution-hole drainage, in particular dendritic drainage patterns, developed on the limestone of Biscayne Bay and its vicinity, including the Turkey Point Units 6 & 7 site. This process of surface dissolution ended in Biscayne Bay when sea level rose and flooded the Bay but continued on emergent areas, including the Turkey Point Units 6 & 7 site. The depositional morphology and paleo-dissolution morphology resulting from the Sangamon interglacial high sea level stand and Wisconsinan glacial low sea level stand are preserved on the sea floor of Biscayne Bay (References 993 and 994).

The position of the fresh water/salt water interface is approximately 6 miles inland from the bay in the vicinity of the site (Figure 2.4.12-207), groundwater beneath the site is saline (Tables 2.4.12-210 and 2.4.12-211), sea level is rising (Subsection 2.4.5.2.2.1), and there is no fresh groundwater shoreline flow near the site. Therefore, a ~~fresh water/ salt water~~ freshwater/saltwater mixing zone that would promote further dissolution of the limestone underlying the Turkey Point Units 6 & 7 site or the dissolution features on the floor of Biscayne Bay does not exist. These features on the floor of Biscayne Bay do not appear to have the capacity for development of large underground caverns with the potential for collapse and formation of sinkholes.

The following text in FSAR Subsection 2.5.3.8.2.1, Potential Sources of Non-Tectonic, Geologic Deformation, last paragraph, will be revised in a future revision of the COLA.

Geologic reconnaissance and aerial photo analysis identified numerous ellipsoidal or circular features. These features consist of vegetation and water-filled areas that are generally less than 1 foot lower in elevation than the surrounding areas within the site and site area. Many of these surficial depressions observed on preconstruction photographs have been obliterated by construction of the Turkey Point Units 3 & 4 cooling canals (Figures 2.5.1-333 and 2.5.3-202). The underlying Miami Limestone is covered by recent deposits of-peat and-organic~~-rich mud and~~ silt-approximately ~~2 to 6 feet~~ ~~**(0.6 to 1.8 meters)**~~ ~~**(2 to 6 feet** thick)~~ **0.6 to 3.41.8 meters (2 to 11 feet thick)**

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

(Subsection 2.5.1.2.2). In vegetated field and geotechnical work investigations **(References 248, 249, and 250)** have confirmed that the deposits of ~~mud~~ **peat** ~~and silt~~ reach thicknesses exceeding ~~6 feet (~~**1.8 meters**~~)~~ **(6 feet)** and appear to **remain** wetter than the surrounding areas. These karst features were formed after the deposition of the Pleistocene Miami Limestone, but their exact timing is not known. The formation and significance of the vegetated depressions are discussed further in Appendix 2.5AA.

The Florida Geological Survey generally ~~assesses~~ **assigns** a low hazard to karst features that form when limestone is exposed at the surface or beneath a thin veneer of permeable sediment, as is the case within the site area (Reference 229) (Figure 2.5.1-222). In these cases, such solution potholes are generally expected to be shallow and broad, and to develop gradually, rather than in a single, sudden collapse event. Additionally, these solution potholes are not expected to form large voids beneath the surface that would pose a hazard to the site (Reference 229). Based on information developed in this subsection and in Subsection 2.5.1.2.5.2, the possibility of dissolution features similar to the one reported southeast of Key Largo (Reference 228) **existing at at depth beneath this site area is unlikely** ~~existing at depth beneath this site area is unlikely are unlikely beneath the site area~~ (Subsection 2.5.4.4.5). No collapse or settlement problems associated with karst-type dissolution of underlying limestones have been associated with Turkey Point Units 3 & 4 (Reference 209). An integrated geophysical survey focused on the Units 6 & 7 power block area and several of the surficial depressions identified within the site was conducted as part of this application and is discussed in Subsection 2.5.4.4.5 ~~and Appendix 2.5AA~~. **Although subject to spatial resolution and detection limits inherent in a subsurface investigation, the** ~~Based upon~~ available **borehole and geophysical** data~~,~~ **indicate** there is minimal hazard posed by sinkholes and no evidence for potential surface collapse due to the presence of large underground openings **at the site**.

The following references will be added to FSAR Subsection 2.5.1.3 in a future COLA revision.

969 Lucia, F., *Rock-Fabric/Petrophysical Classification of Carbonate Pore Space for Reservoir Characterization,* AAPG Bulletin, Vol. 79, No. 9, pp. 1275–1300, September 1995.

989 Cunningham, K.~~J.~~, C. Walker~~, C.~~, and R. Westcott~~, R.L.~~, *Near-Surface, Marine Seismic-Reflection Data Define Potential Hydrogeologic Confinement Bypass in the Carbonate Floridan Aquifer System,* Southeastern Florida, SEG Las Vegas 2012 Annual Meeting, 2012.~~, available at: http://dx.doi.org/10.1190/segam2012-0638.1~~

990 Perkins, R.~~D.~~, *Depositional Framework of Pleistocene Rocks in South Florida*, ~~In: Enos, P. and Perkins, R.D. (eds.),~~ Quaternary Sedimentation in South Florida, Enos, P. and R. Perkins, (eds.), Geological Society of America Memoir 147, pp. 131- 197, 1977.

991 Cantillo, A.~~Y.~~, (editor) 1983 Biscayne Bay Hydrocarbon Study, NOAA National Ocean Service, USDC, February~~,~~ 2005.

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

992 Reich, C., R. Halley~~, R.B.~~, T. Hickey, ~~T.,~~ and P. Swarzenski, ~~P.,~~ *Groundwater Characterization and Assessment of Contaminants in Marine Areas of Biscayne National Park, U.S. Department of the Interior,* National Park Service Technical Report NPS/NRWRD/NRTR-2006/356, ~~163 p.,~~ 2006.

993 Reich, C. ~~D.~~, T. Hickey~~, T. D.~~, K. DeLong, ~~K. L.,~~ R. Poore, ~~R. Z.,~~ and J. Brock, ~~J. C.,~~ *Holocene Core Logs and Site Statistics for Modern Patch-Reef Cores: Biscayne National Park, Florida,* USGS Open-File Report 2009-1246, ~~26 p.,~~ 2009.

994 Wanless, H., *Geologic Setting and Recent Sediments of the Biscayne Bay Region*, Florida in Biscayne Bay: Past/Present/Future, A. Thorhaug, ~~A.~~ and A. Volker~~, A.~~ (editors). A Symposium presented by the University of Miami April 2-3, 1976.

995. Paul C. Rizzo Associates, Inc., *Supplemental Field Investigation Data Report, Turkey Point Nuclear Power Plant Units 6 & 7*, Revision 2, RIZZO, Pittsburgh, Pennsylvania, April 15, 2014.

996. Paul C. Rizzo Associates, Inc., *Surficial Muck Deposits Field and Laboratory Investigation Data Report, Turkey Point Nuclear Power Plant Units 6 & 7*, Revision 1, RIZZO, Pittsburgh, Pennsylvania, April 3, 2014.

997. Willard and Bernhart, *Impacts of Past Climate and Sea Level Change on Everglades Wetlands: Placing a Century of Anthropogenic Change in to a late-Holocene Context*, Climatic Change, Willard, Debra A., and Bernhart, Christopher E., Volume 107, DOI10.1007/s10584-011-0078-9, pp. 59-80, 2011.

998. Robles et al., *Condition of the Natural Resources of Florida Bay, Everglades National Park*, A State of the Parks Technical Report, Robles, M.D., M.R. Lara, D.L. Jones, and M.J. Butler, NatureServe, Arlington, Virginia, pp. 102, 2005.

The following revised figures will be included in FSAR Subsection 2.5.1 in a future COLA revision:

Figure 2.5.1-338 Cross-Section A-A' Truncated (Vertical exaggeration = 12:1)

Figure 2.5.1-339 Cross-Section B-B' Truncated (Vertical exaggeration = 12:1)

Figure 2.5.1-340 Cross-Section C-C' Truncated (Vertical exaggeration = 12:1)

Figure 2.5.1-341 Cross-Section D-D' Truncated (Vertical exaggeration = 12:1)

Figure 2.5.1-342 Isopach Map of the Key Largo Limestone

Figure 2.5.1-343 Structure Contour Map: Top of the Fort Thompson Formation

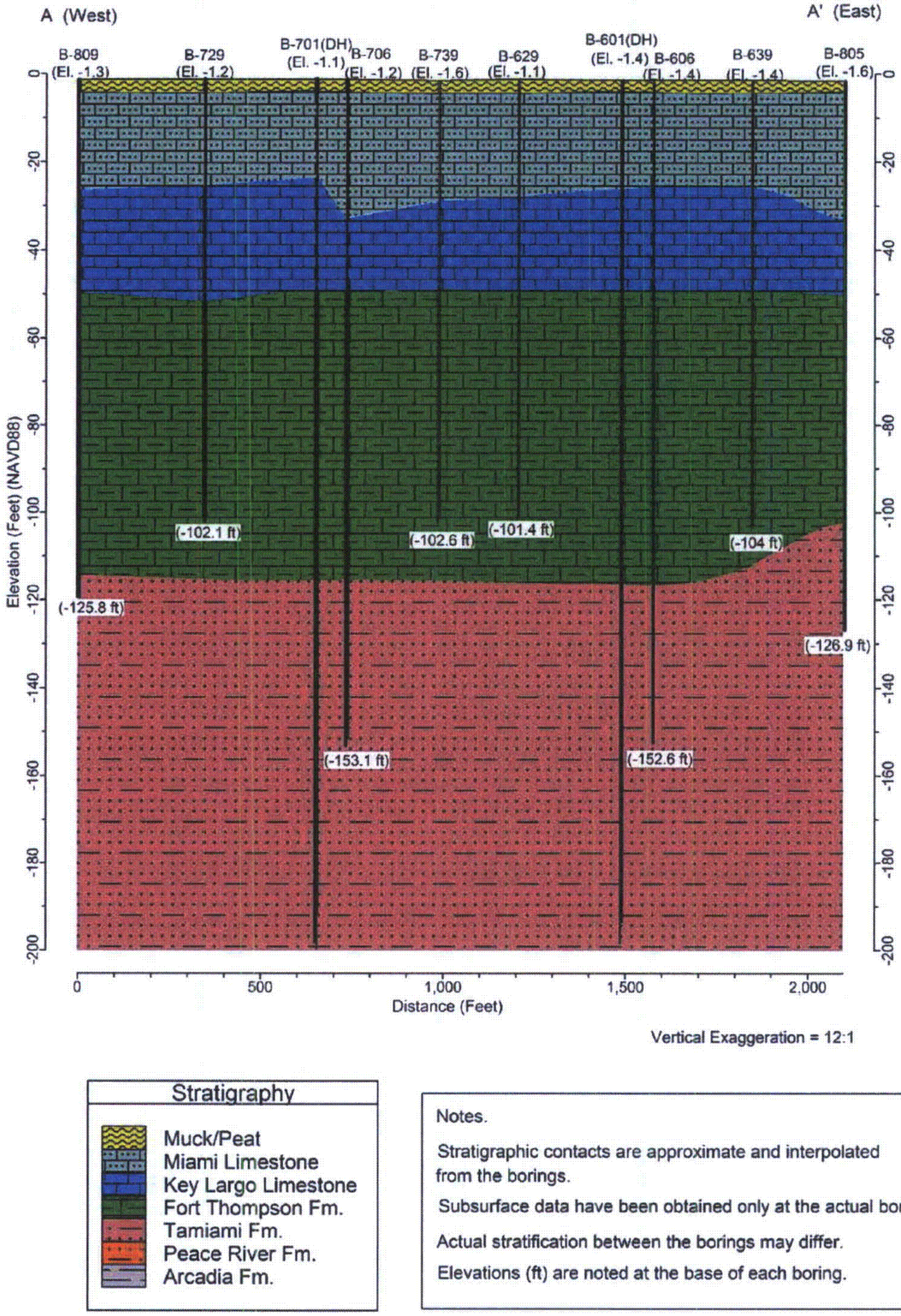
Figure 2.5.1-344 Isopach Map of the Fort Thompson Formation

Figure 2.5.1-349 Structure Contour Map: Top of the Key Largo Limestone

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-338 Cross-Section A-A′ Truncated (Vertical Exaggeration = 12:1)

This figure appears in Appendix 2.5AA as Figure 2.5AA-211



Notes.

Stratigraphic contacts are approximate and interpolated from the borings.

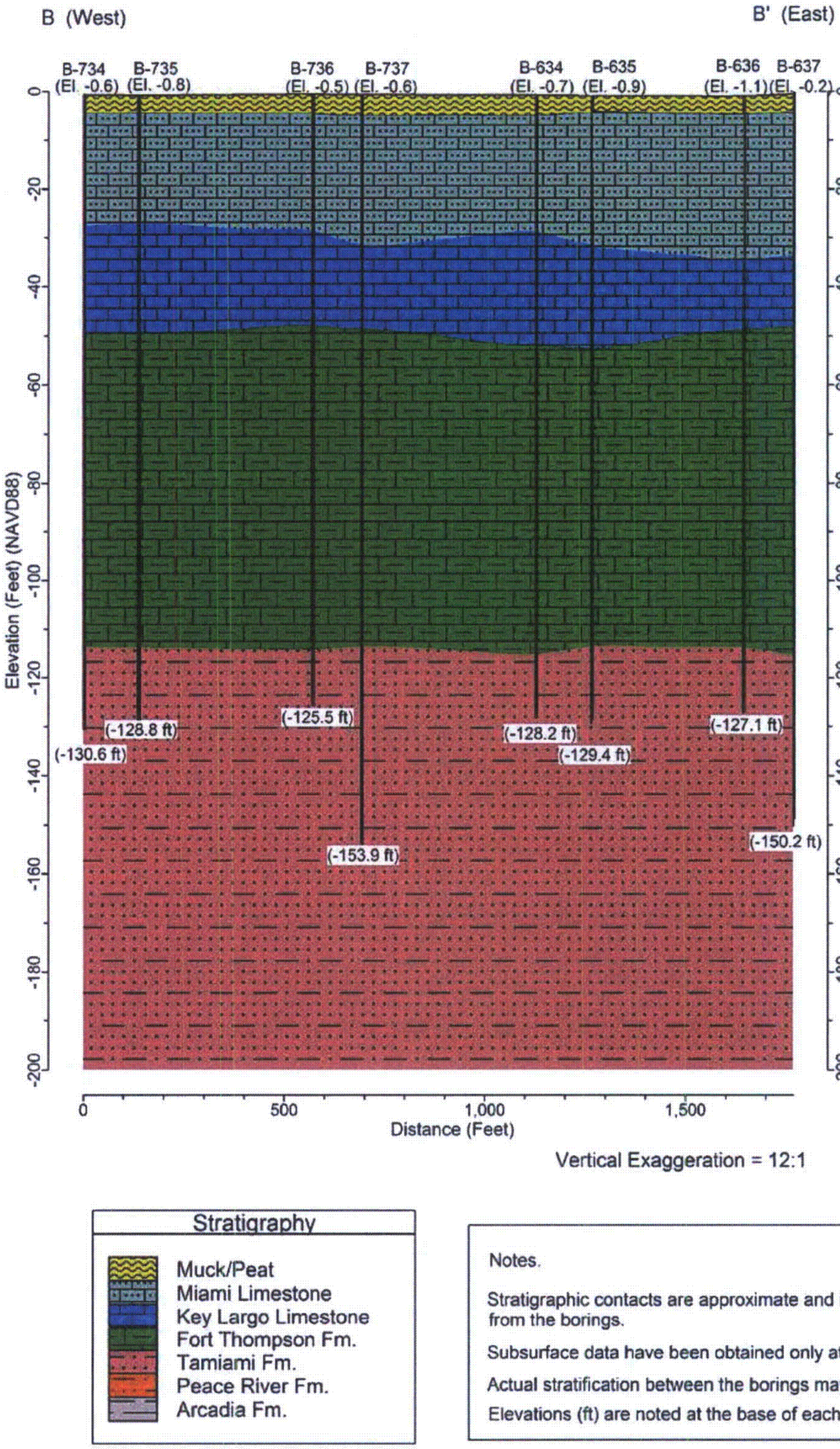
Subsurface data have been obtained only at the actual boring locations.

Actual stratification between the borings may differ.

Elevations (ft) are noted at the base of each boring.

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-339 Cross-Section B-B′ Truncated (Vertical Exaggeration = 12:1)
This figure appears in Appendix 2.5AA as Figure 2.5AA-212



Notes.

Stratigraphic contacts are approximate and interpolated from the borings.

Subsurface data have been obtained only at the actual boring locations.

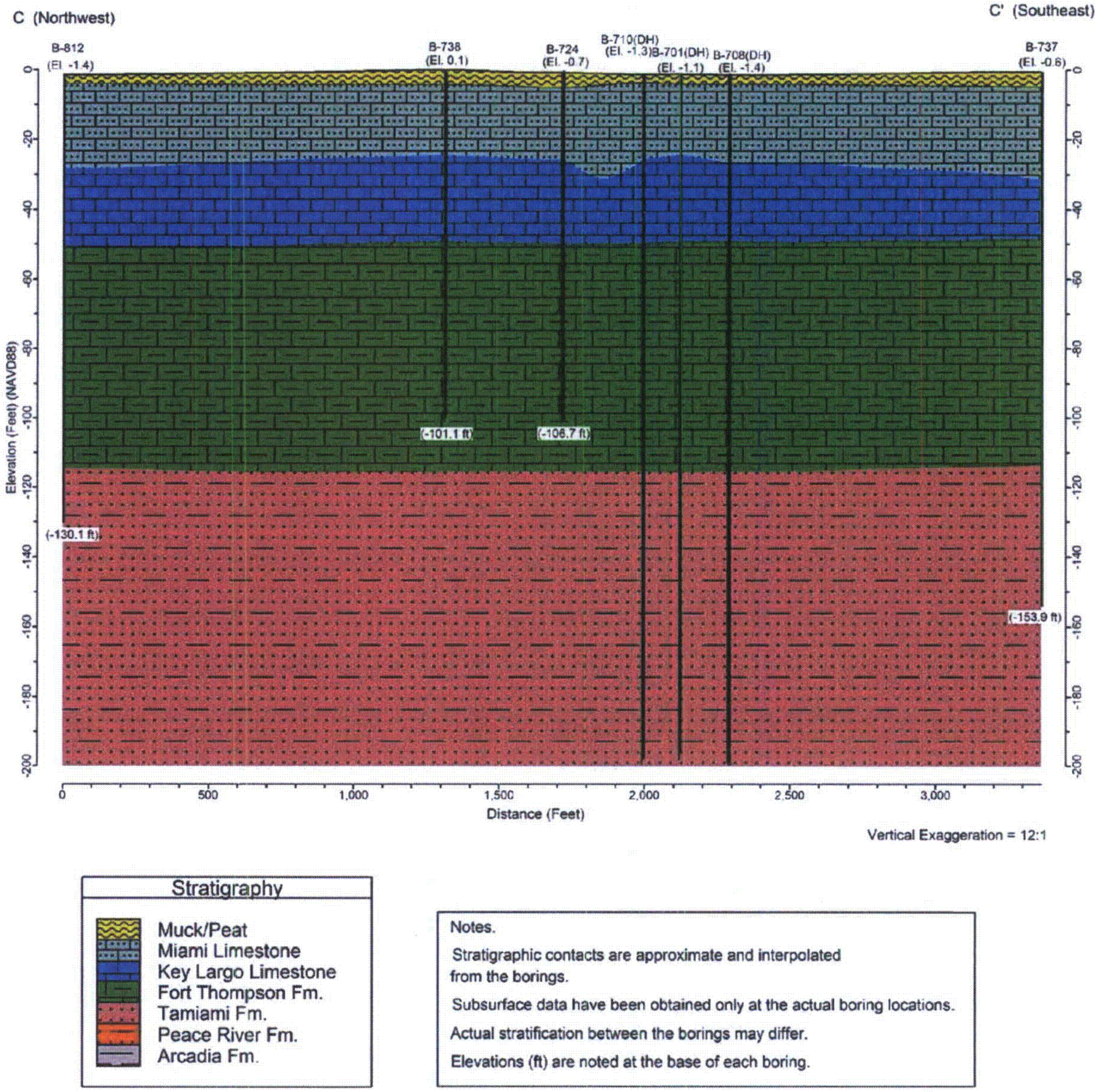
Actual stratification between the borings may differ.

Elevations (ft) are noted at the base of each boring.

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-340 Cross-Section C-C′ Truncated (Vertical Exaggeration = 12:1)

This figure appears in Appendix 2.5AA as Figure 2.5AA-213



Notes.

Stratigraphic contacts are approximate and interpolated from the borings.

Subsurface data have been obtained only at the actual boring locations.

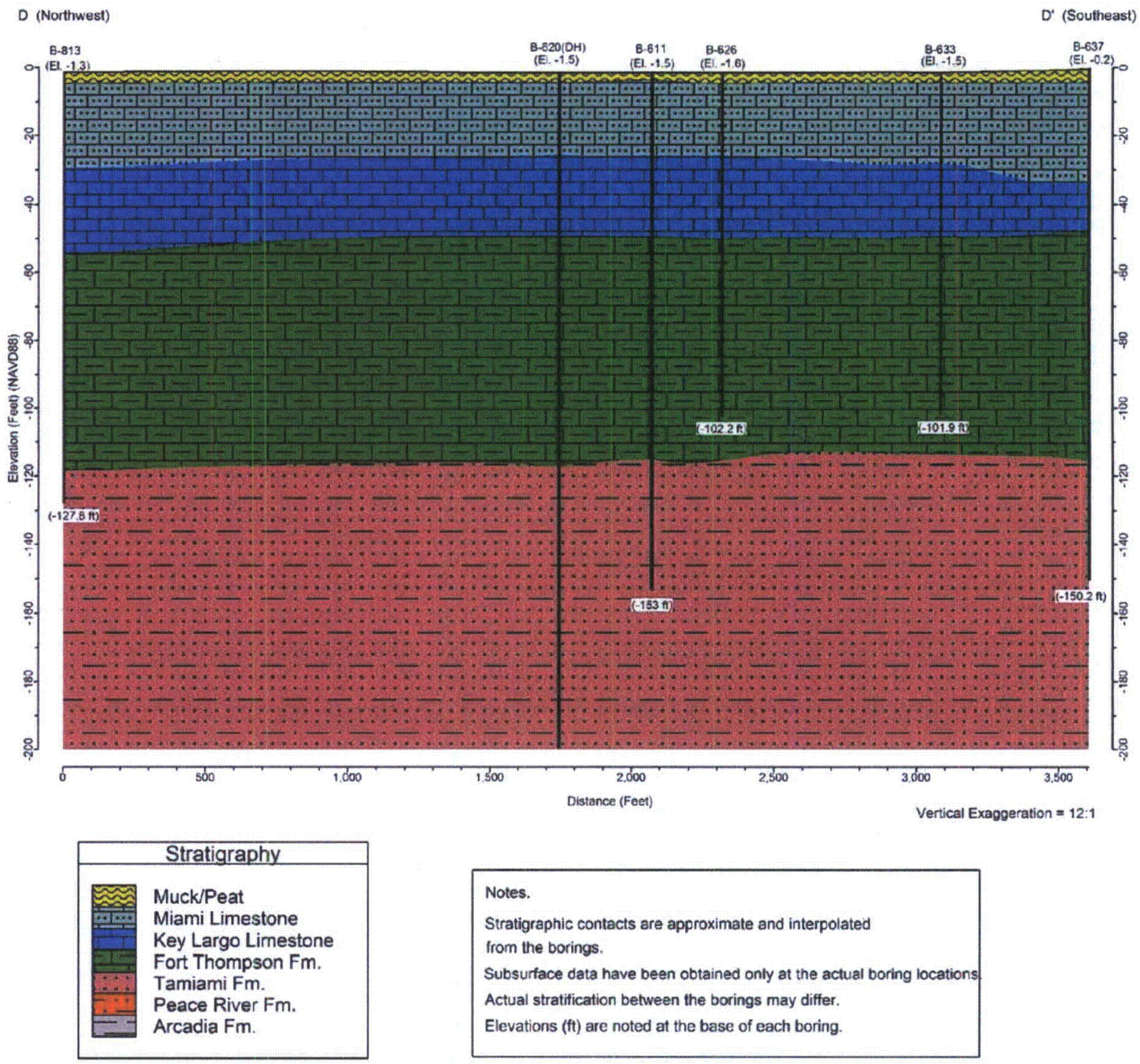
Actual stratification between the borings may differ.

Elevations (ft) are noted at the base of each boring.

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

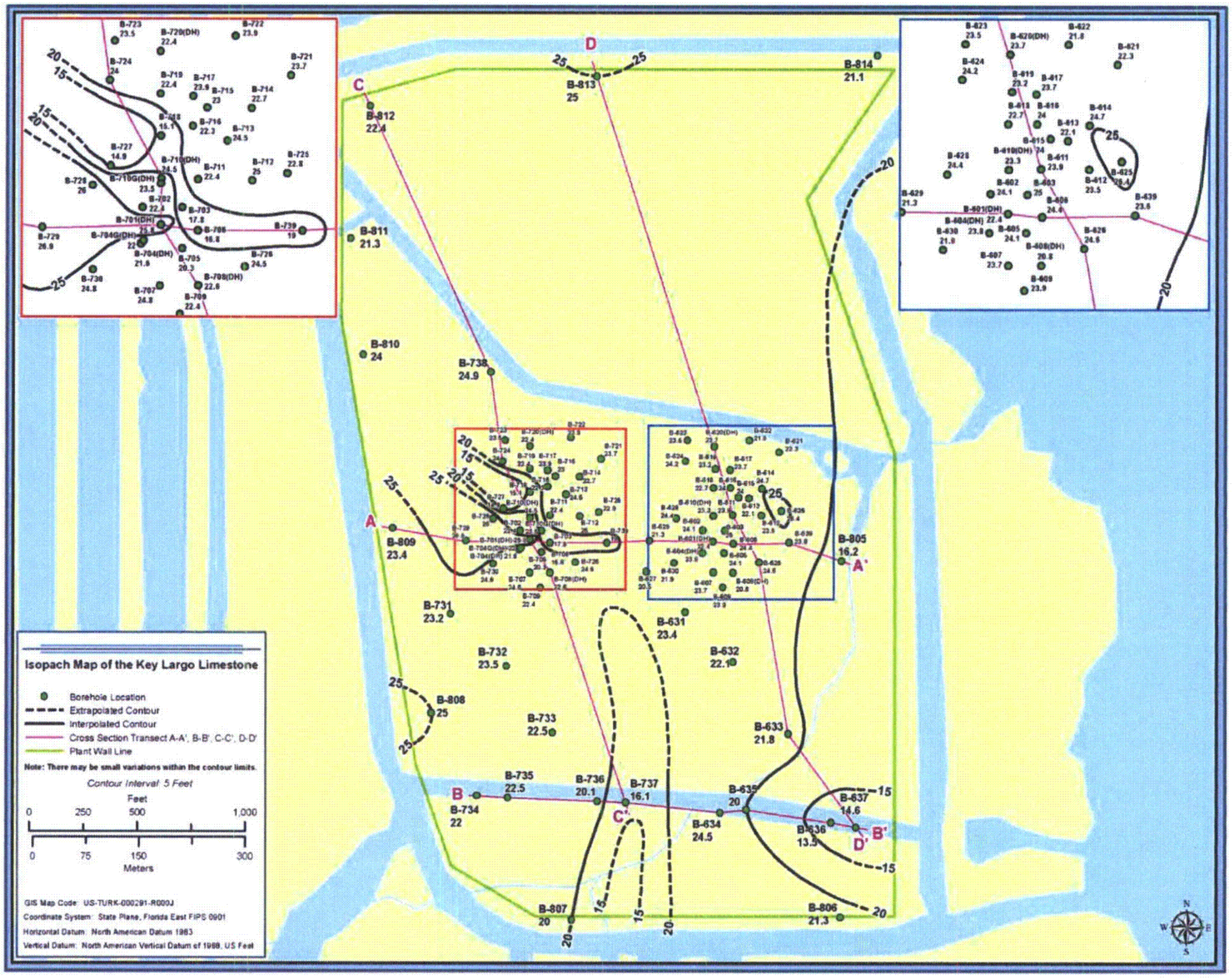
Figure 2.5.1-341 Cross-Section D-D' Truncated ~~D-D` Truncated'~~ (Vertical Exaggeration = 12:1)

This figure appears in Appendix 2.5AA as Figure 2.5AA-214



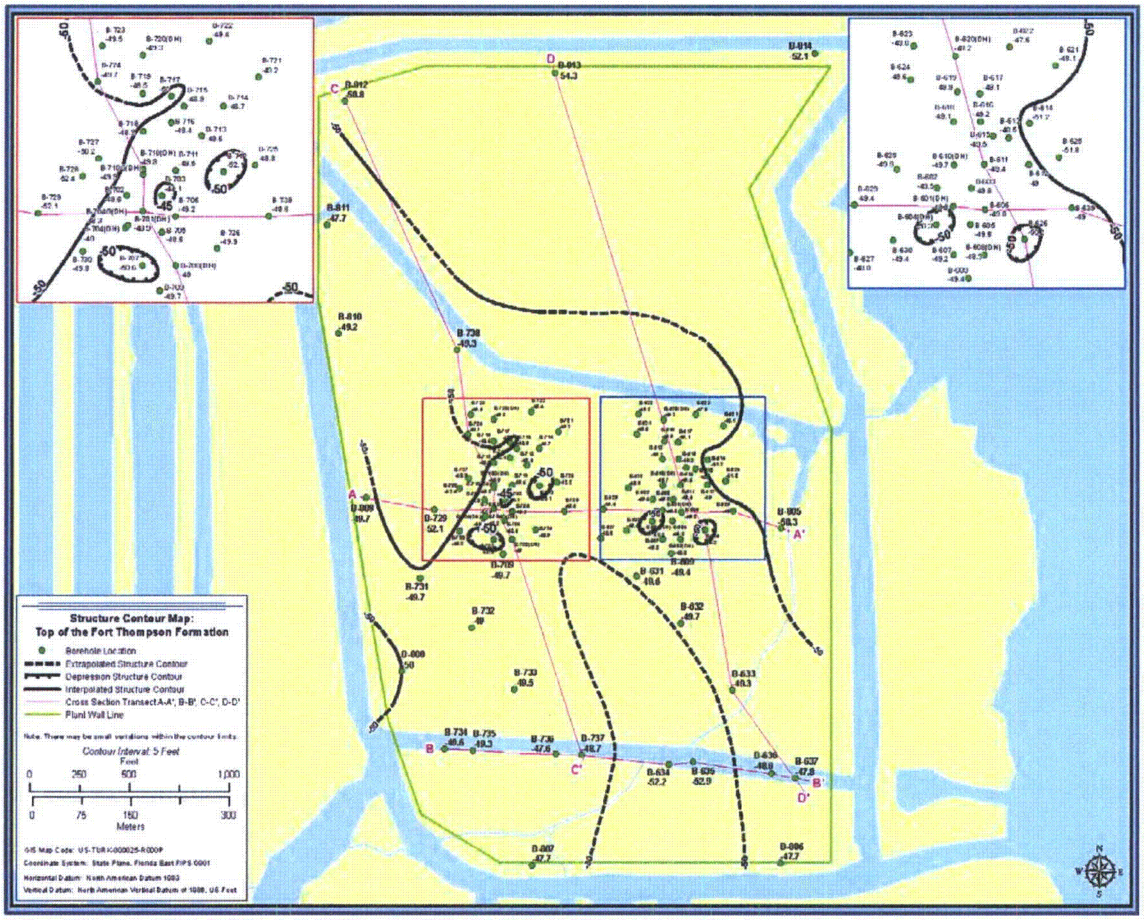
Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-342 Isopach Map of the Key Largo Limestone
This figure appears in Appendix 2.5AA as Figure 2.5AA-207



Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

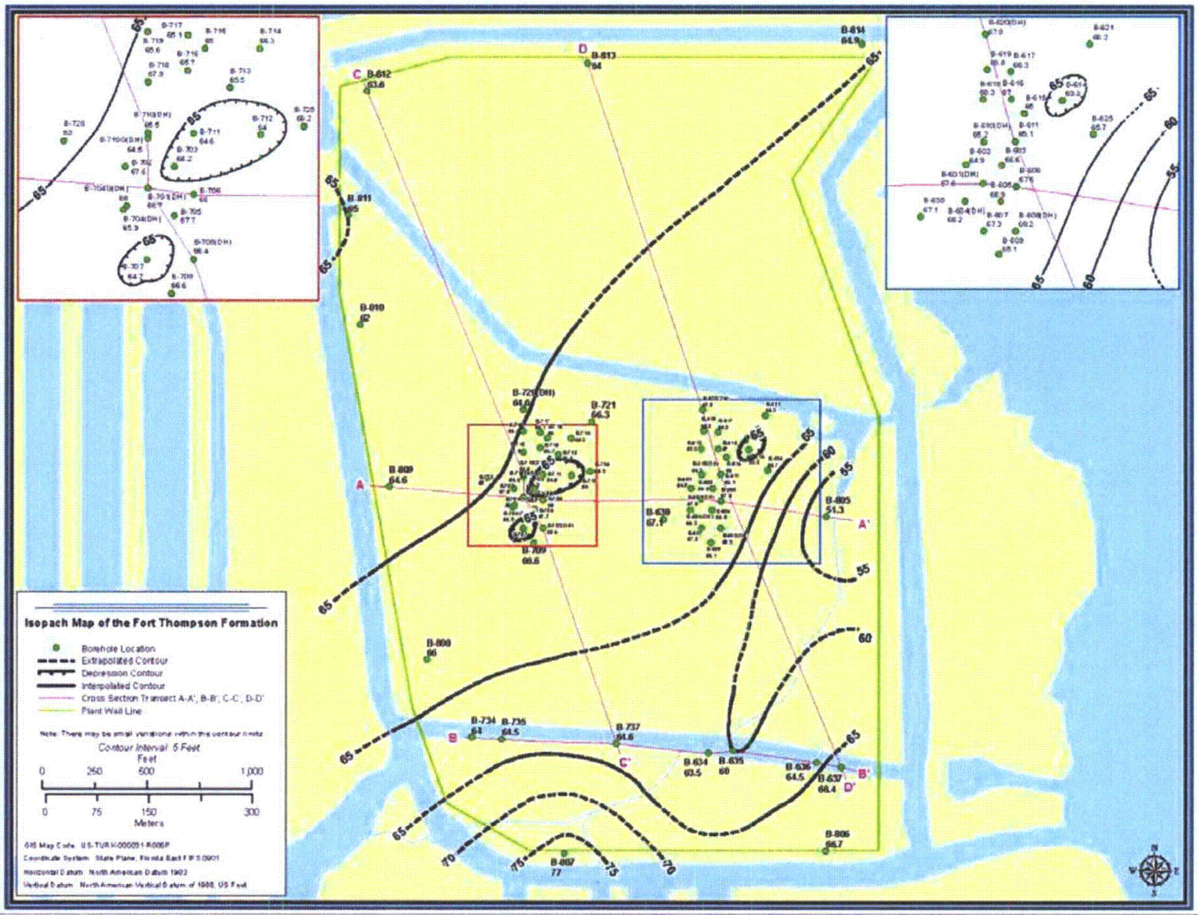
Figure 2.5.1-343 Structure Contour Map of the Top of the Fort Thompson Formation
This figure appears in Appendix 2.5AA as Figure 2.5AA-208



Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

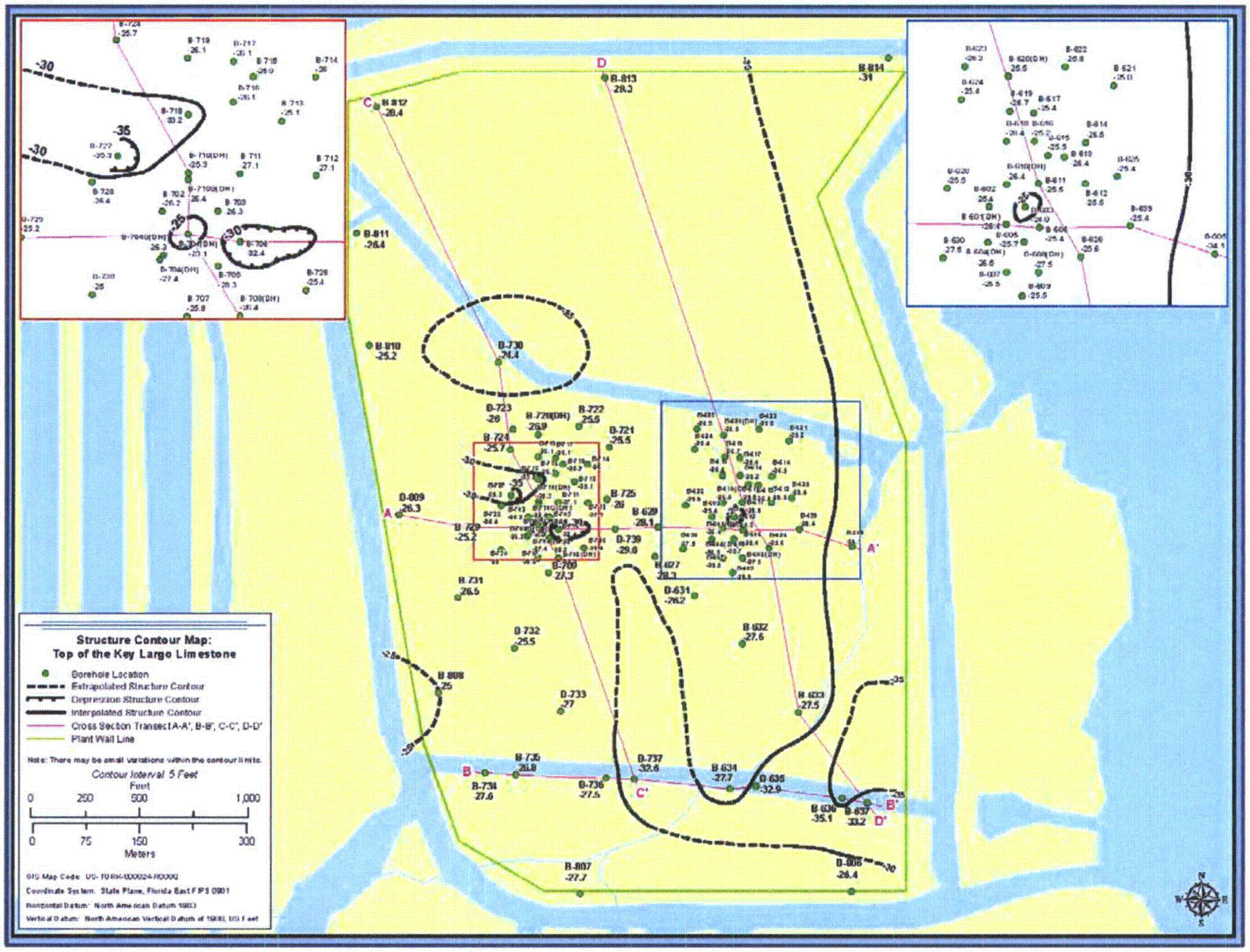
Figure 2.5.1-344 Isopach Map of the Fort Thompson Formation

This figure appears in Appendix 2.5AA as Figure 2.5AA-21



Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-349 Structure Contour Map of the Top of the Key Largo Limestone
This figure appears in Appendix 2.5AA as Figure 2.5AA-209



Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

The following new figures will be included in FSAR Subsection 2.5.1 in a future COLA revision:

Figure 2.5.1-351 The two zones of secondary porosity on B-604 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (3 pages)

Figure 2.5.1-352 The two zones of secondary porosity on B-608 (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (5 pages)

Figure 2.5.1-353 The two zones of secondary porosity on B-710 G (DH) showing the lithology, caliper, natural gamma, velocity (Vs and Vp) and acoustic televiewer logs (5 pages)

Figure 2.5.1-385 Relation between Touching-Vug Porosity and Conduit Porosity for the Fort Thompson Formation and Miami Limestone of the Biscayne Aquifer in Cunningham et al. Study Area

Figure 2.5.1-386 Cross-Section A-A' (Vertical Exaggeration = 4:1)

Figure 2.5.1-387 Cross-Section B-B' (Vertical Exaggeration = 4:1)

Figure 2.5.1-388 Cross-Section C-C' (Vertical Exaggeration = 4:1)

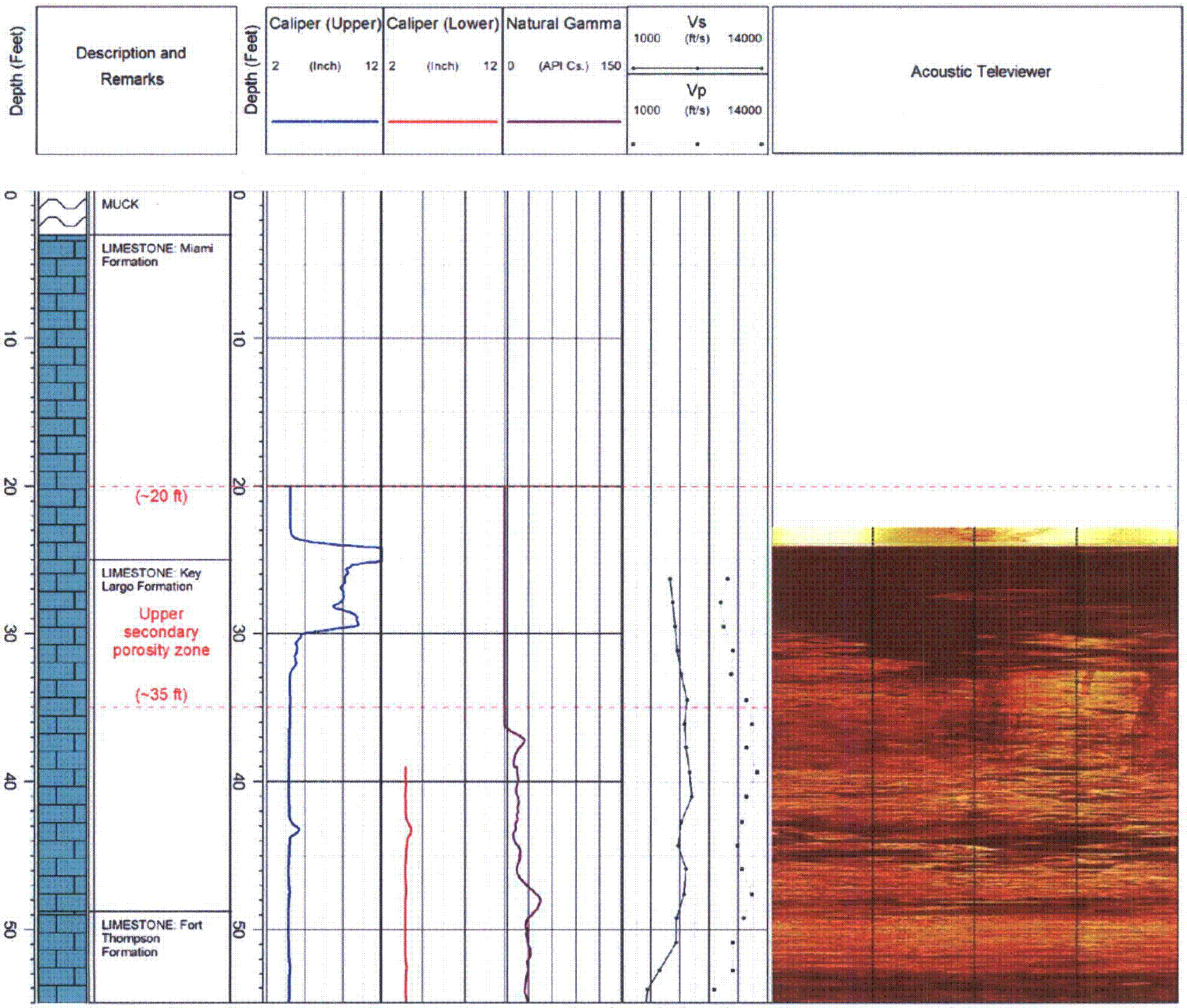
Figure 2.5.1-389 Cross-Section D-D' (Vertical Exaggeration = 4:1)

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-351 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-604 (DH) S~~s~~howing the L~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 1 of 3)

Log ID: **B-604 (DH)**
Total Depth: **165 ft**
Northing: **396,916 (NAD83/90)**
Easting: **876,592 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 29.0 ft; 4" from 29.0 to 165.0 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/19/08 Completed 3/23/08**
Drilled By: **P. Pitts / R. Landeros**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 20.05 to 105 feet bgs.
Caliper (lower section) from 39.05 to 157 feet bgs.
Natural Gamma (lower and upper sections) from 20.05 to 157 feet bgs.
Reciever to reciever Vs and Vp from 26.3 to 150.9 feet bgs.
Acoustic Televiewer from 22.78 to 120.65 feet bgs.

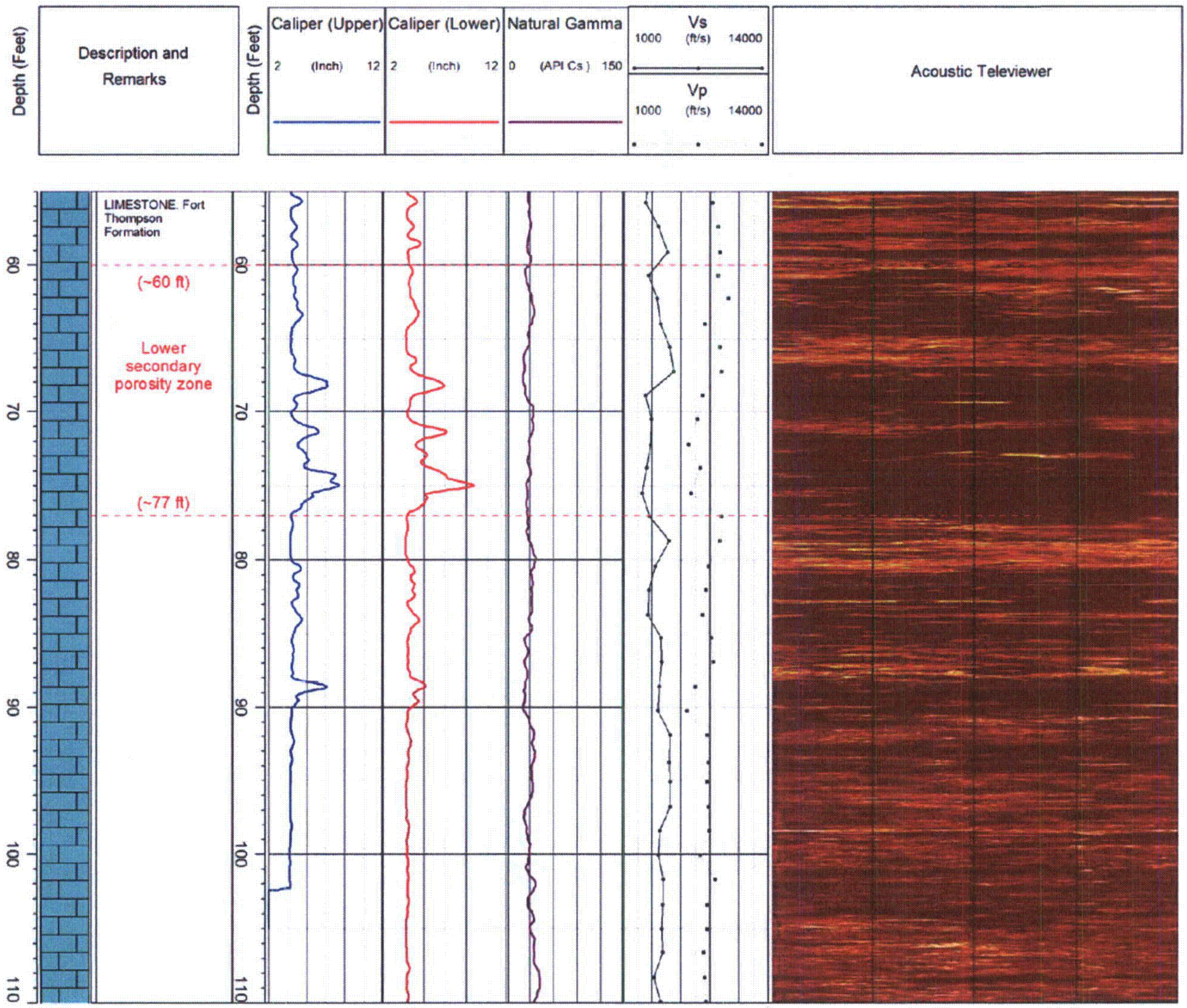


Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-351 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-604 (DH) S~~s~~howing the L~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 2 of 3)

Log ID: **B-604 (DH)**
Total Depth: **165 ft**
Northing: **396,916 (NAD83/90)**
Easting: **876,592 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 29.0 ft; 4" from 29.0 to 165.0 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/19/08 Completed 3/23/08**
Drilled By: **P. Pitts / R. Landeros**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 20.05 to 105 feet bgs.
Caliper (lower section) from 39.05 to 157 feet bgs.
Natural Gamma (lower and upper sections) from 20.05 to 157 feet bgs.
Reciever to reciever Vs and Vp from 26.3 to 150.9 feet bgs.
Acoustic Televiewer from 22.78 to 120.65 feet bgs.

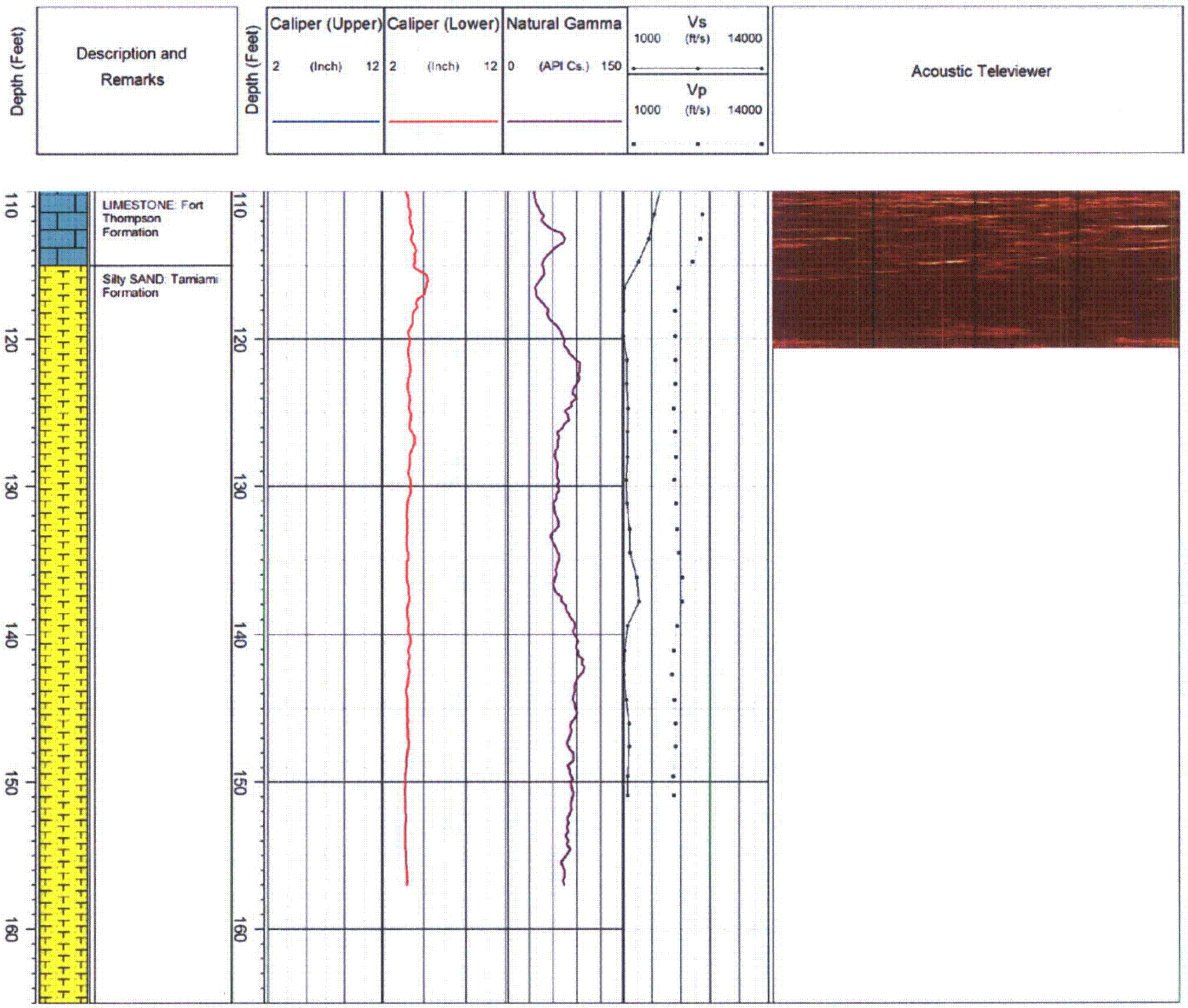


Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-351 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-604 (DH) S~~s~~howing the L ~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 3 of 3)

Log ID: **B-604 (DH)**
Total Depth: **165 ft**
Northing: **396,916 (NAD83/90)**
Easting: **876,592 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 29.0 ft; 4" from 29.0 to 165.0 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/19/08 Completed 3/23/08**
Drilled By: **P. Pitts / R. Landeros**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 20.05 to 105 feet bgs.
Caliper (lower section) from 39.05 to 157 feet bgs.
Natural Gamma (lower and upper sections) from 20.05 to 157 feet bgs.
Reciever to reciever Vs and Vp from 26.3 to 150.9 feet bgs.
Acoustic Televiewer from 22.78 to 120.65 feet bgs.



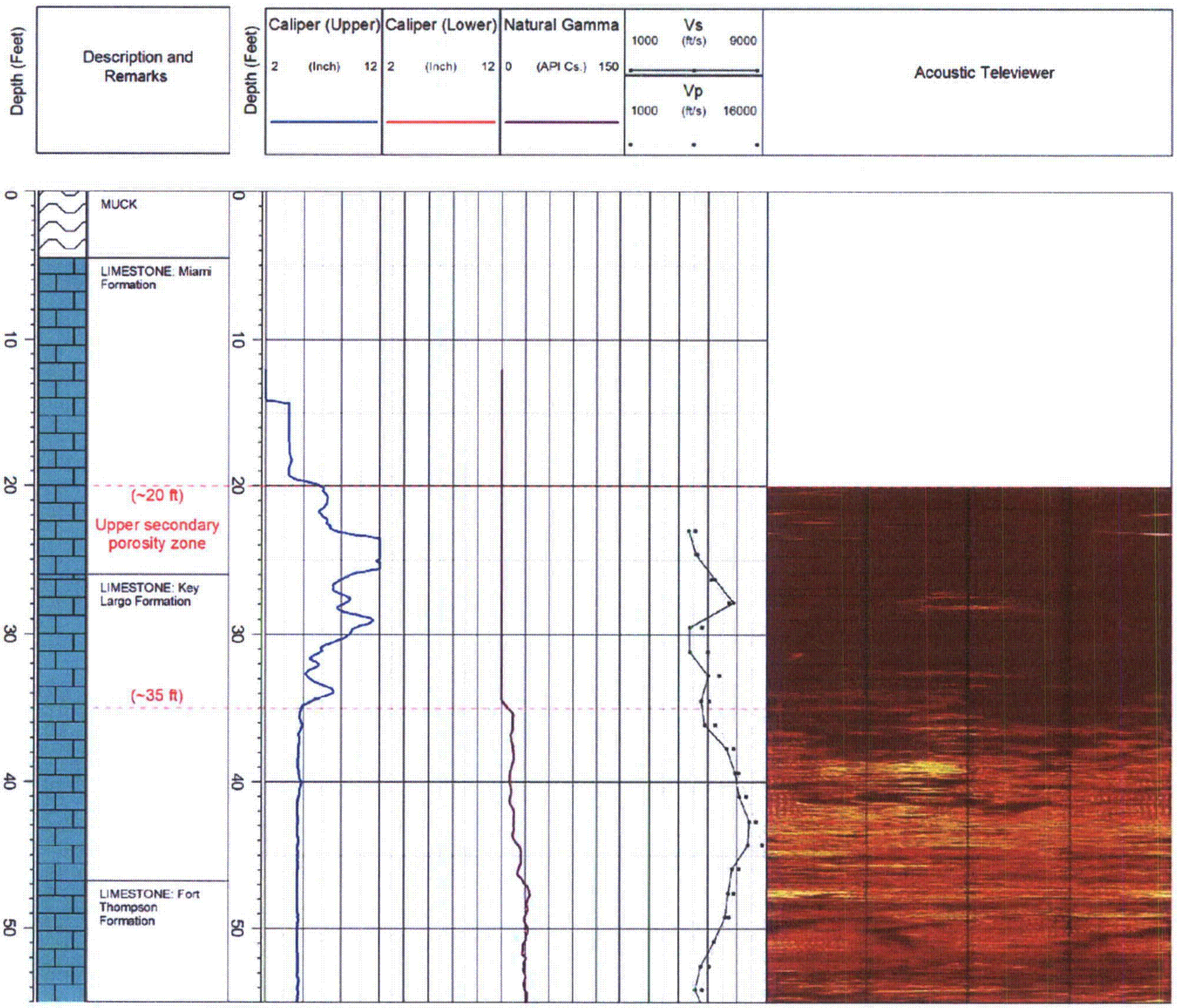
~~**Source: Subsection 2.5.1 Reference 708**~~

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-352 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-608 (DH) S~~s~~howing the L~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 1 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
Natural Gamma (lower and upper sections) from 12.05 to 255 feet bgs
Reciever to reciever Vs and Vp from 23 to 249.3 feet bgs.
Acoustic televiewer from 20 to 120.2 feet bgs.

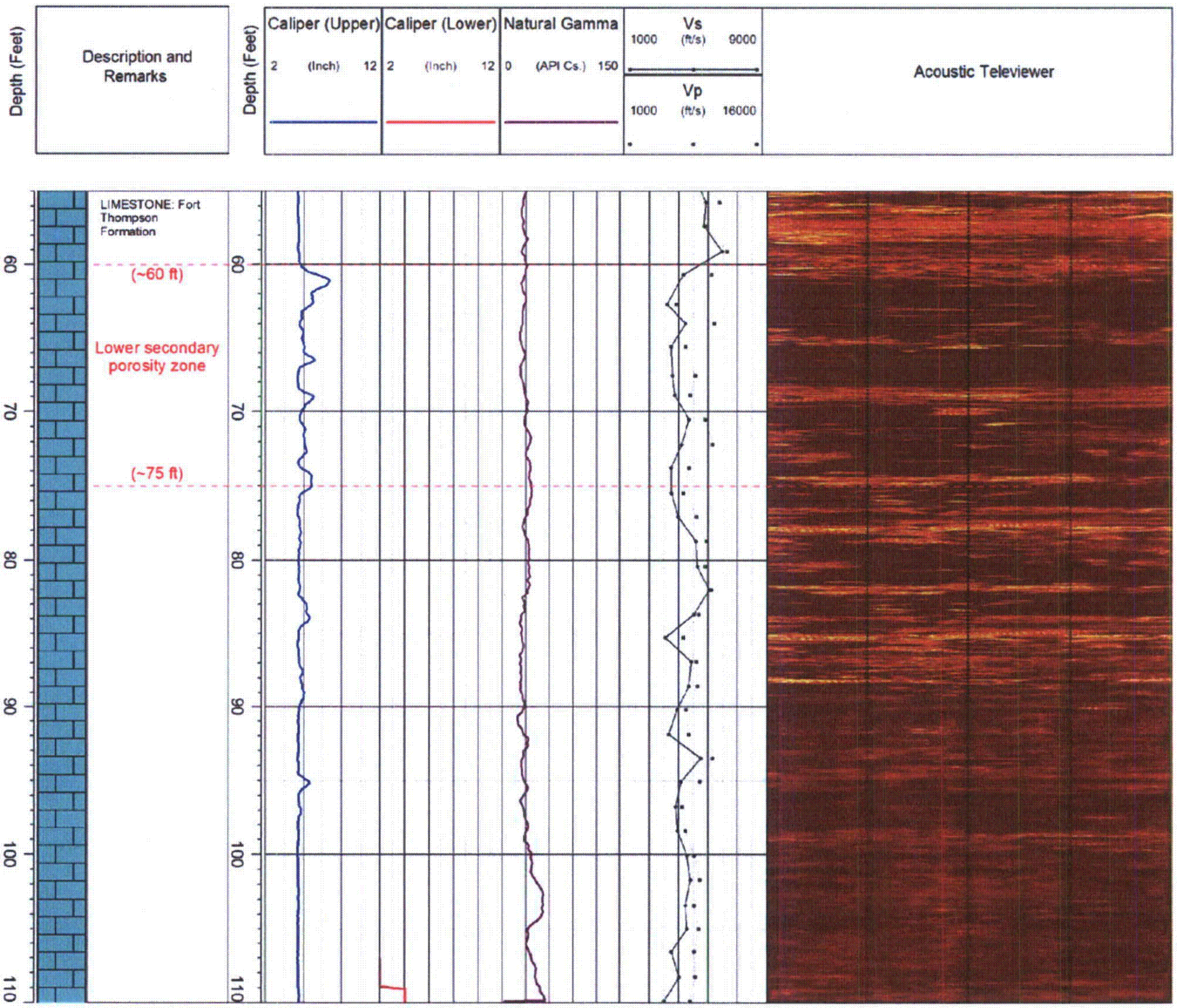


Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-352 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-608 (DH) S~~s~~howing the L~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 2 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
Natural Gamma (lower and upper sections) from 12.05 to 255 feet bgs
Reciever to reciever Vs and Vp from 23 to 249.3 feet bgs.
Acoustic televiewer from 20 to 120.2 feet bgs.

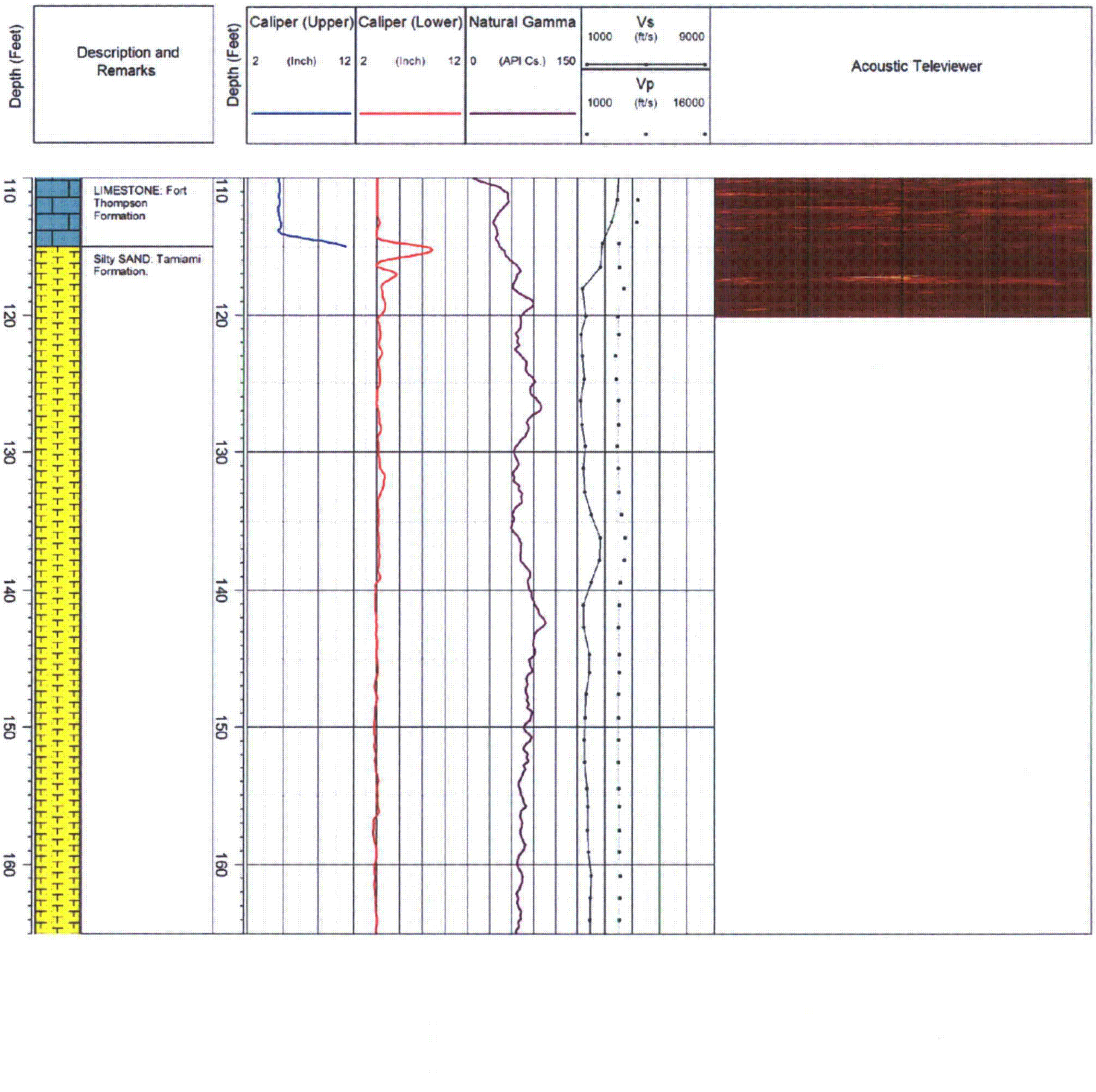


Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-352 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-608 (DH) S~~s~~howing the L ~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 3 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
Natural Gamma (lower and upper sections) from 12.05 to 255 feet bgs
Reciever to reciever Vs and Vp from 23 to 249.3 feet bgs.
Acoustic televiewer from 20 to 120.2 feet bgs.

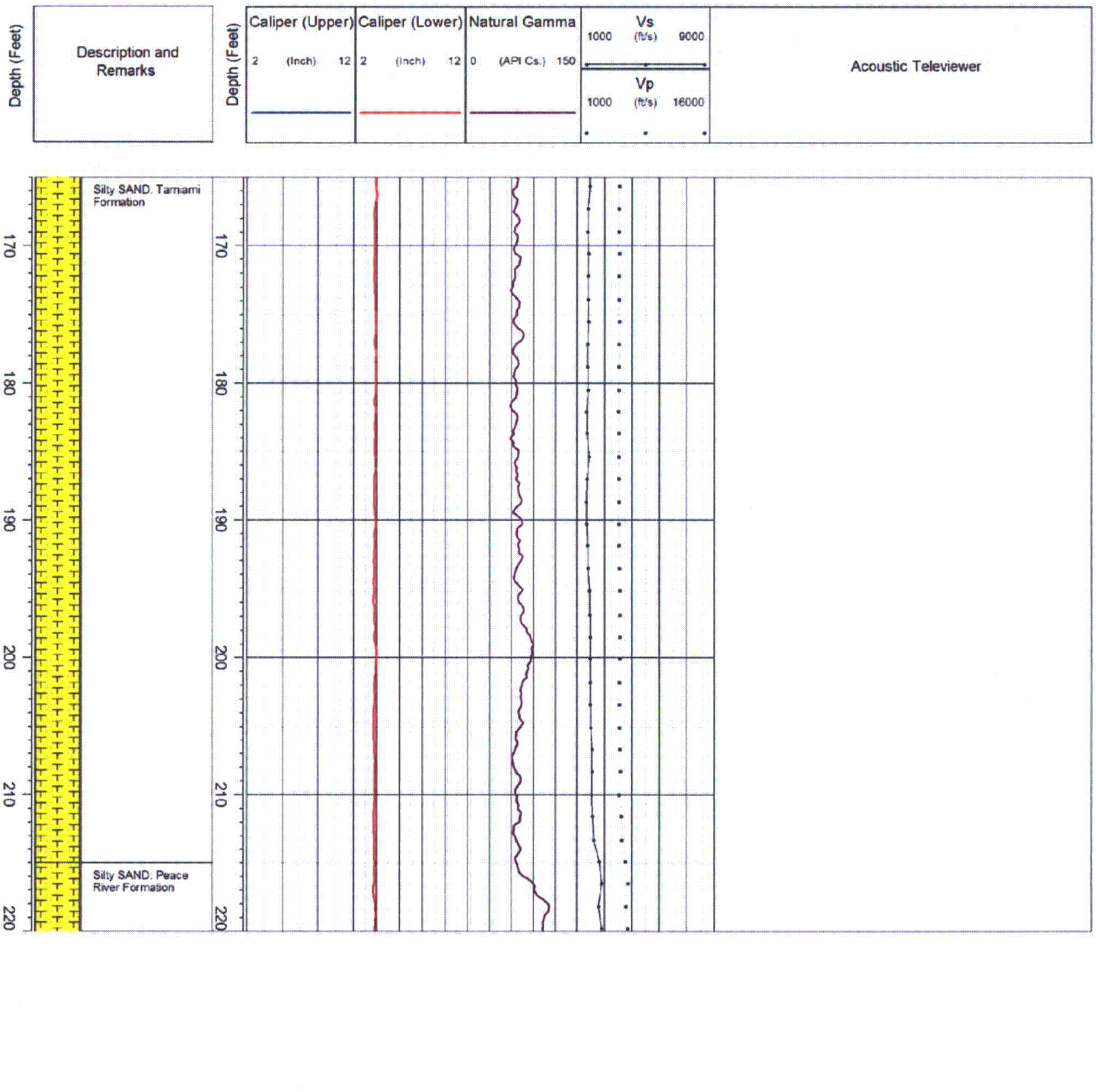


Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-352 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-608 (DH) S~~s~~howing the L~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 4 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
Natural Gamma (lower and upper sections) from 12.05 to 255 feet bgs
Reciever to reciever Vs and Vp from 23 to 249.3 feet bgs.
Acoustic televiewer from 20 to 120.2 feet bgs.

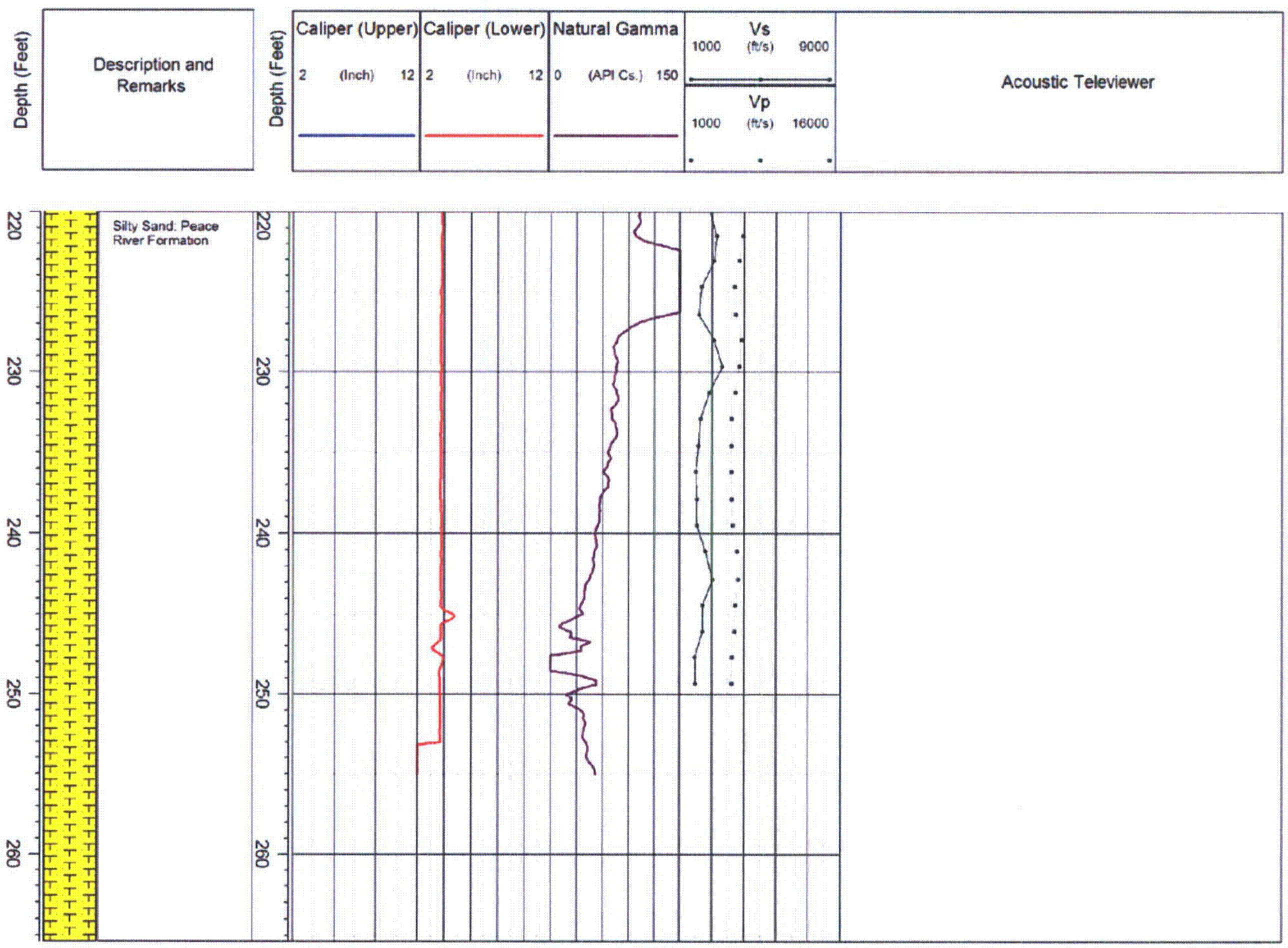


Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-352 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-608 (DH) S~~s~~howing the L ~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 5 of 5)

Log ID: **B-608 (DH)**
Total Depth: **265.4 ft**
Northing: **396,830 (NAD83/90)**
Easting: **876,736 (NAD83/90)**
Hole Diameter: **5" from 0.0 to 34.0 ft; 4" from 34.0 to 265.4 ft.**
Elevation (Ground Surface): **-1.5 ft**
Drilling Date: **Started 3/25/08 Completed 4/2/08**
Drilled By: **R. Landeros/N. Rodriguez (MACTEC)**
Lithology Logged By: **S. Woodman/B. Taylor (MACTEC)**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 12.05 to 115 feet bgs.
Caliper (lower section) from 107.05 to 255 feet bgs.
Natural Gamma (lower and upper sections) from 12.05 to 255 feet bgs
Reciever to reciever Vs and Vp from 23 to 249.3 feet bgs.
Acoustic televiewer from 20 to 120.2 feet bgs.

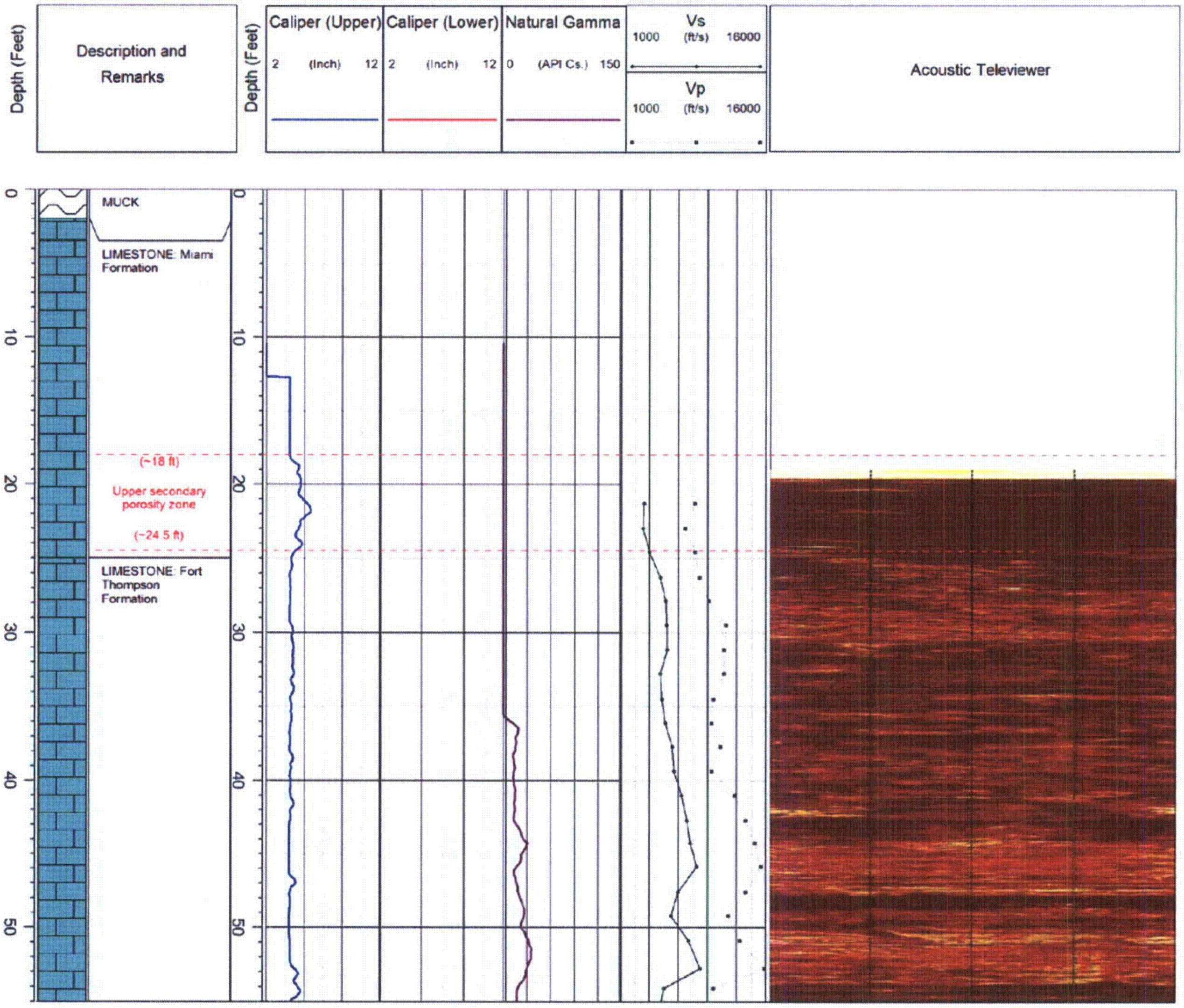


Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-353 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-710 G (DH) S~~s~~howing the L~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 1 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.

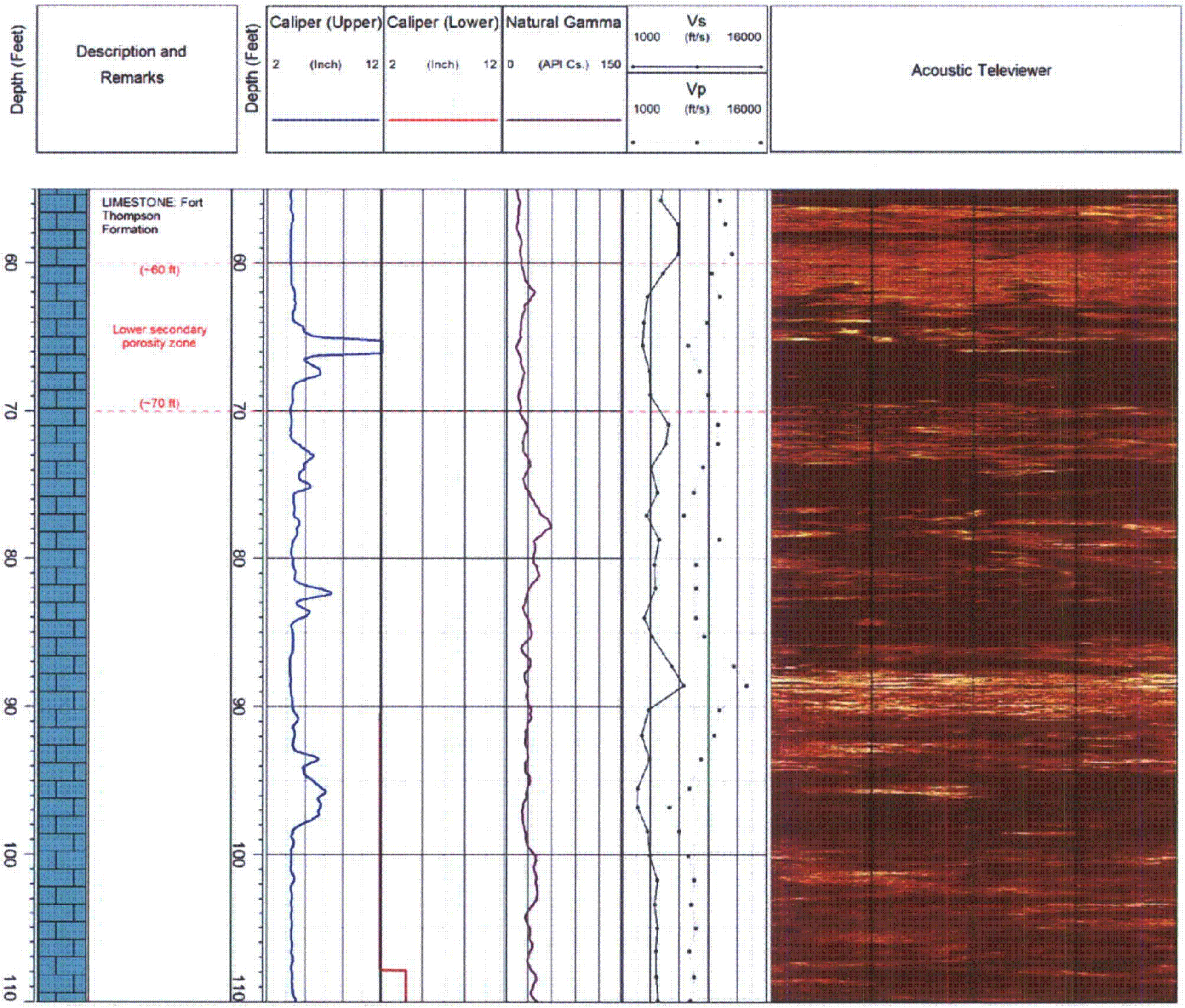


Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-353 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-710 G (DH) S~~s~~howing the L ~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 2 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.

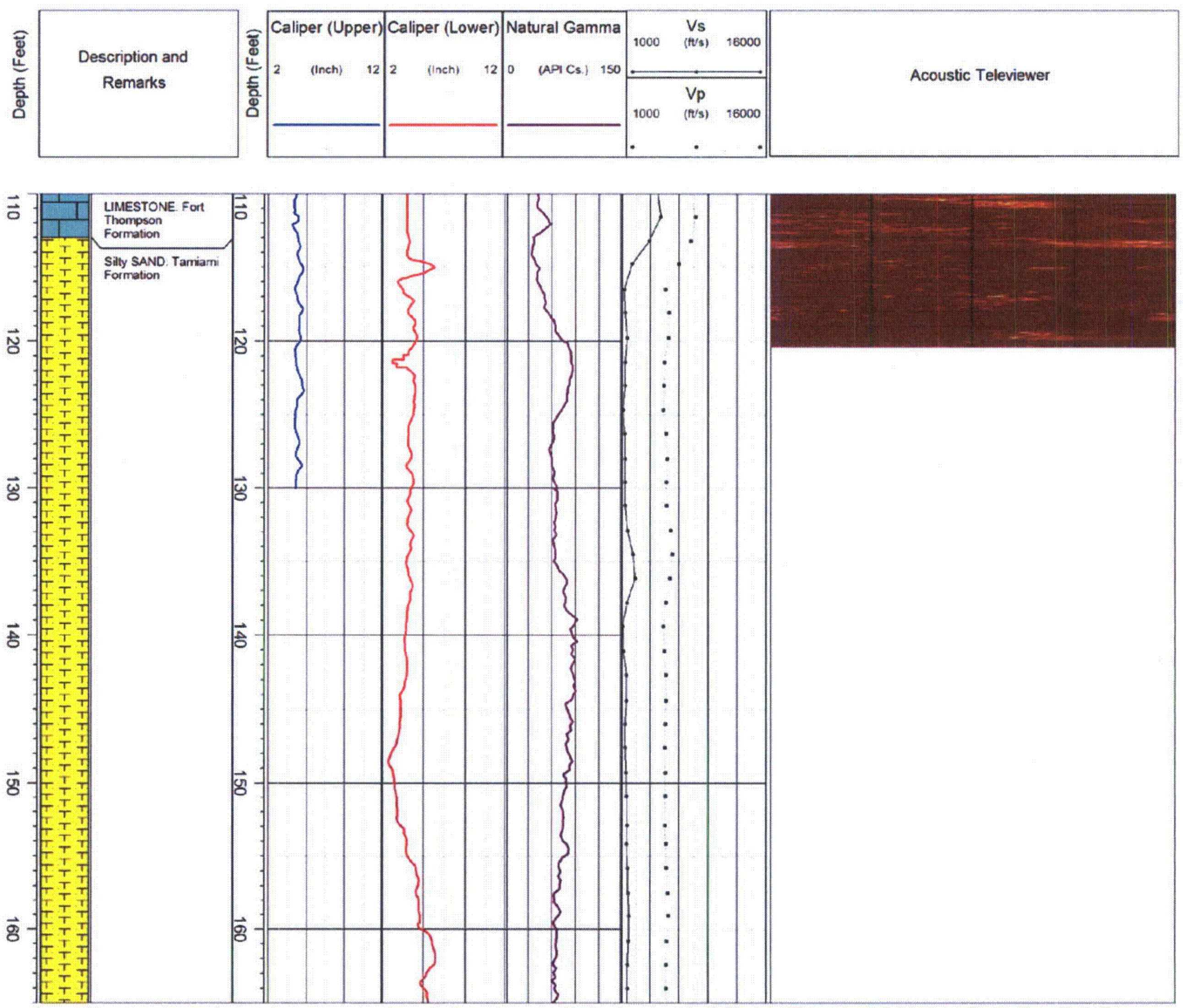


Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-353 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-710 G (DH) S~~s~~howing the L~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 3 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.



Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-353 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-710 G (DH) S~~s~~howing the L~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 4 of 5)

Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.

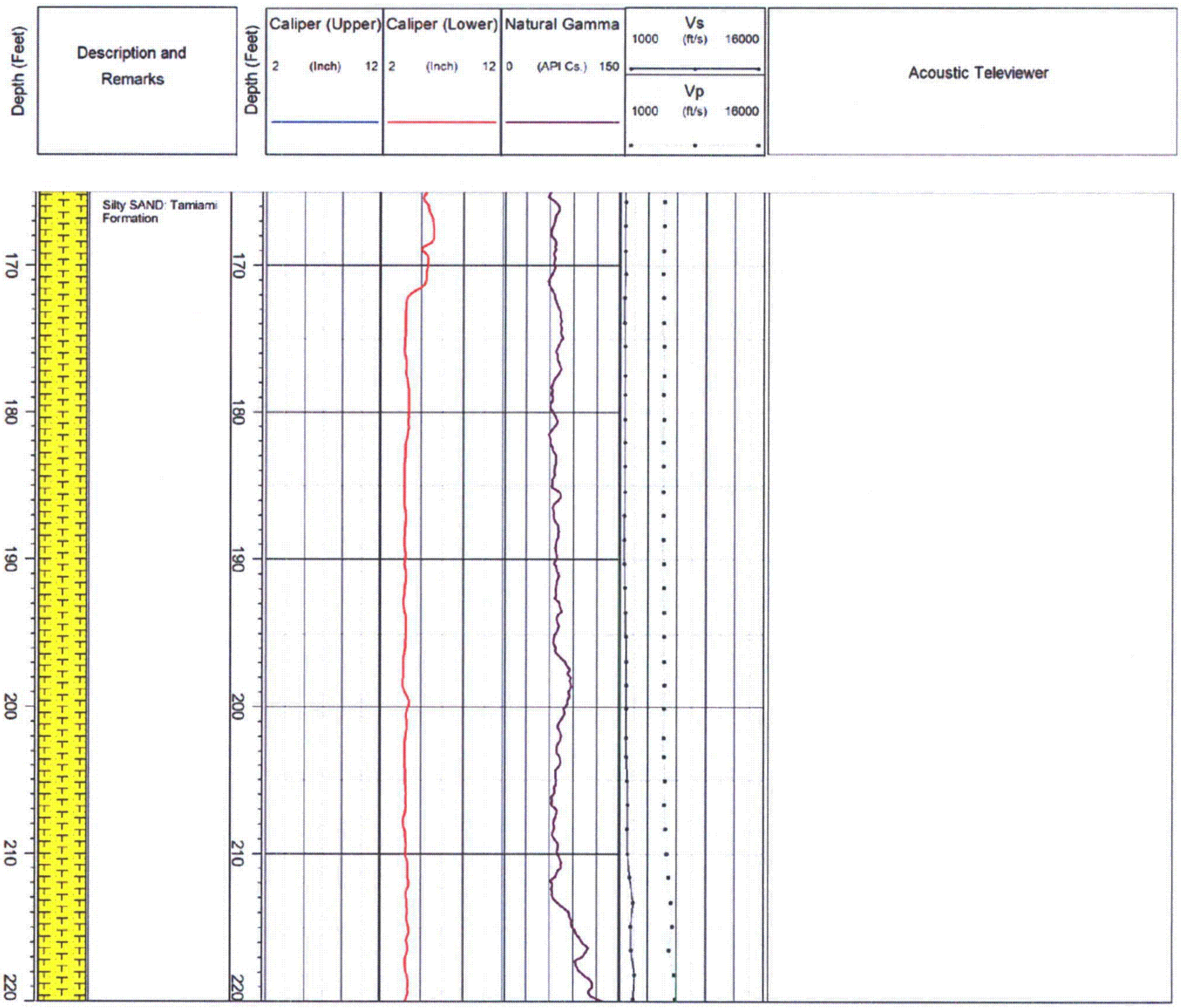
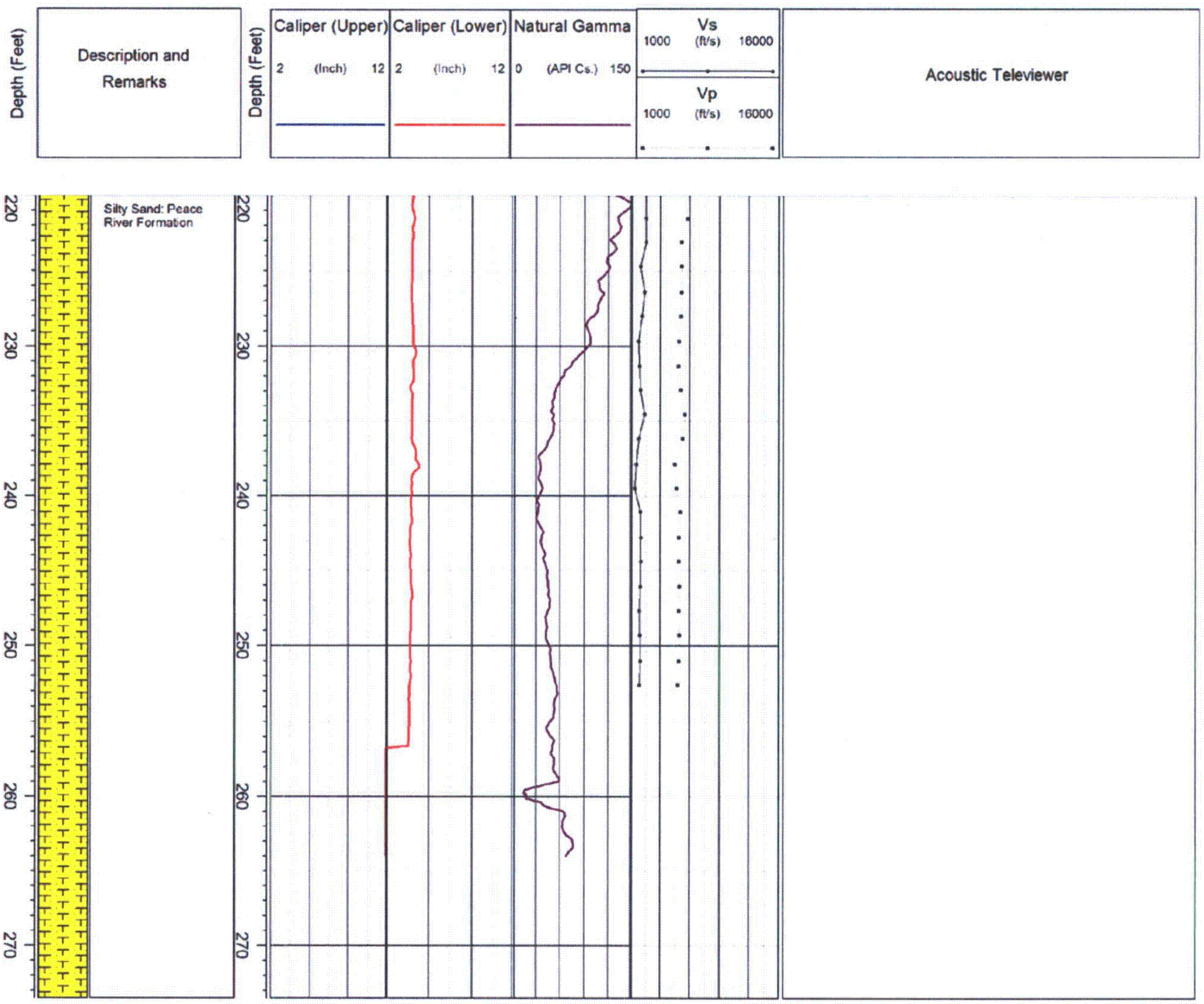


Figure 2.5.1-353 The T~~t~~wo Z~~z~~ones of S~~s~~econdary P~~p~~orosity on B-710 G (DH) S~~s~~howing the L ~~l~~ithology, C~~c~~aliper, N~~n~~atural G~~g~~amma, V~~v~~elocity (Vs and Vp) and A~~a~~coustic T~~t~~eleviewer L~~l~~ogs (Sheet 5 of 5)

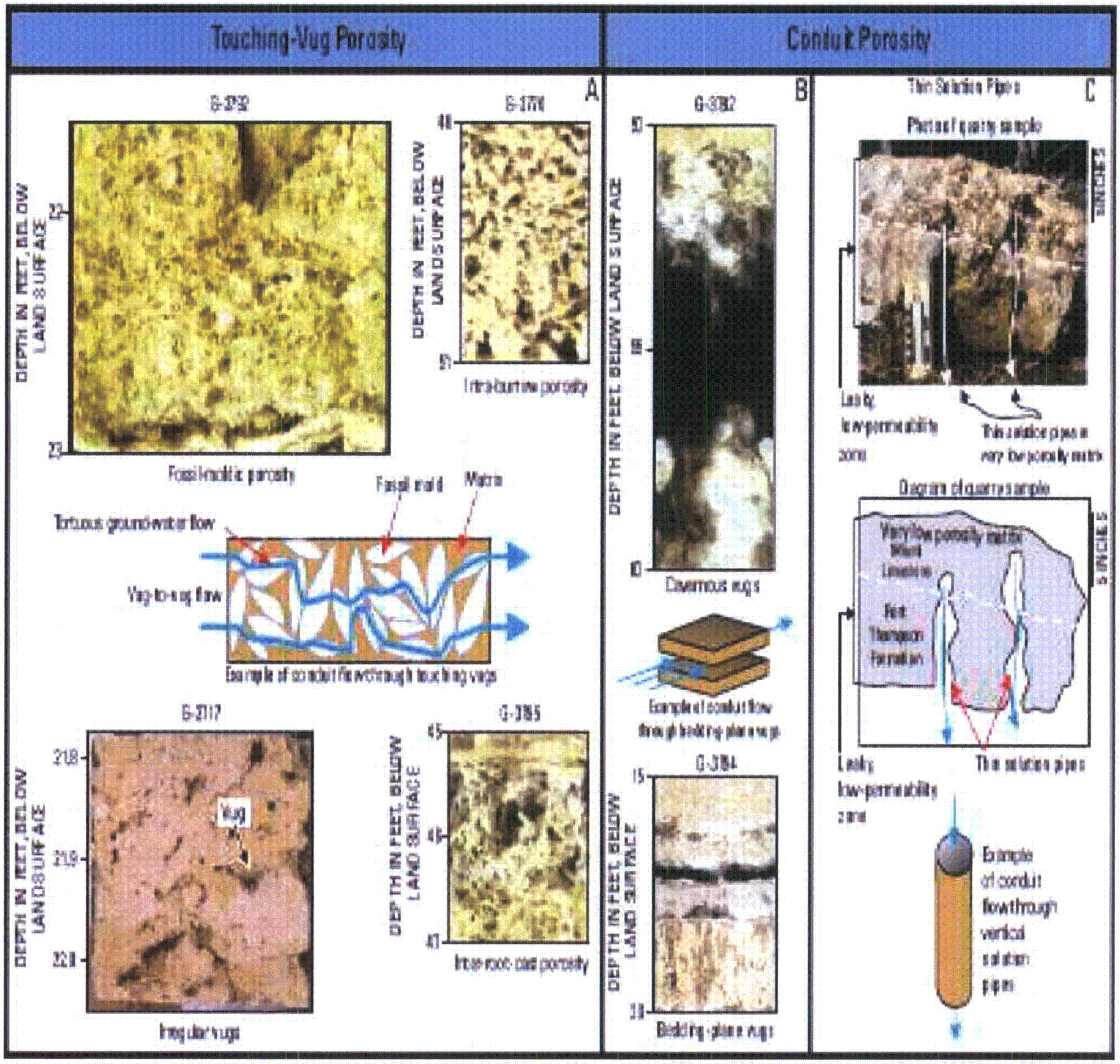
Log ID: **B-710G(DH)**
Total Depth: **273.5 ft**
Northing: **397,075 (NAD83/90)**
Easting: **875,792 (NAD83/90)**
Hole Diameter: **4" from 0.0 to 273.5 ft**
Elevation (Ground Surface): **-1.4 ft**
Drilling Date: **Started 3/10/08 Completed 3/13/08**
Drilled By: **R. Landeros / N. Rodriguez**
Lithology Logged By: **S. Woodham**
Geophysical Log Operator: **GEOVision Geophysical Services**

Note:
Caliper (upper section) from 10.4 to 130 feet bgs.
Caliper (lower section) from 90.4 to 264 feet bgs.
Natural Gamma (lower and upper sections) from 10.4 to 264 feet bgs.
Reciever to reciever Vs and Vp from 26.2 to 257.5 feet bgs.
Acoustic Televiewer from 19 to 120.4 feet bgs.



Source: ~~Subsection 2.5.1~~ Reference 708

Figure 2.5.1-385 Relation between Touching-Vug Porosity and Conduit Porosity for the Fort Thompson Formation and Miami Limestone of the Biscayne Aquifer in Cunningham et al. Study Area

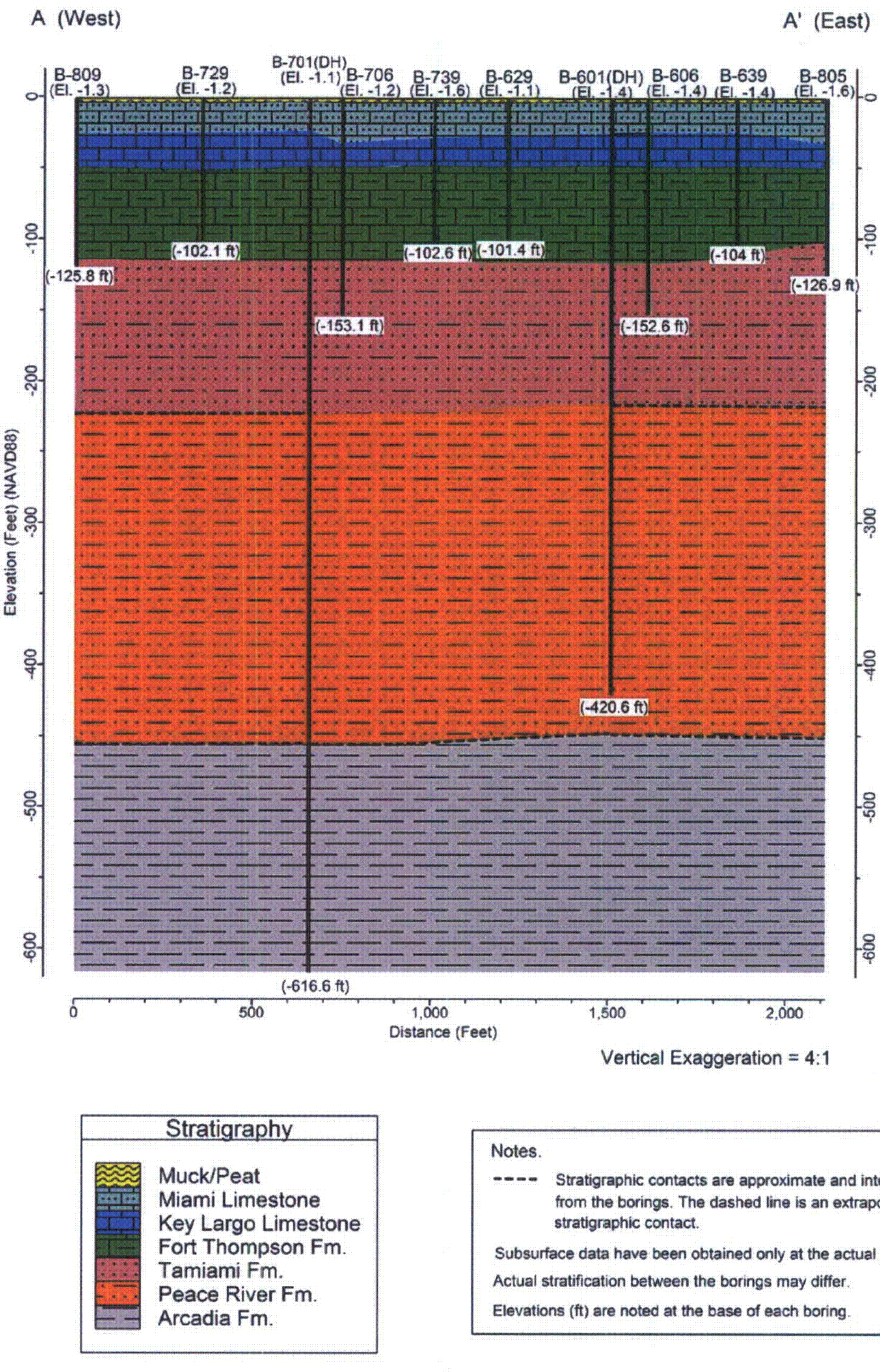


Source: modified from ~~Subsection 2.5.1~~ Reference 404

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-386 Cross-Section A-A′ (Vertical Exaggeration = 4:1)

This figure appears in Appendix 2.5AA as Figure 2.5AA-215



Notes.

---- Stratigraphic contacts are approximate and interpolated from the borings. The dashed line is an extrapolated stratigraphic contact.

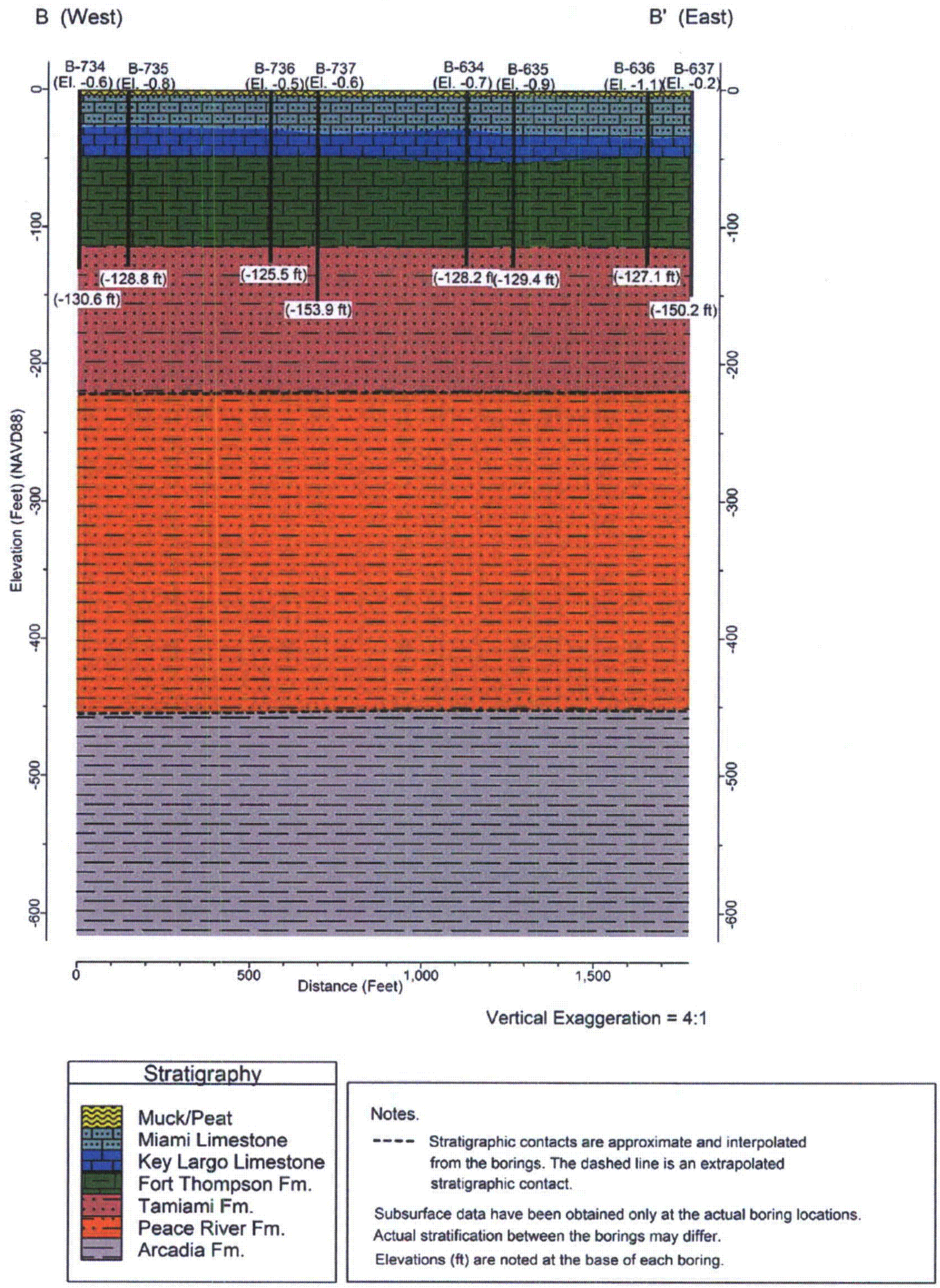
Subsurface data have been obtained only at the actual boring locations.

Actual stratification between the borings may differ.

Elevations (ft) are noted at the base of each boring.

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

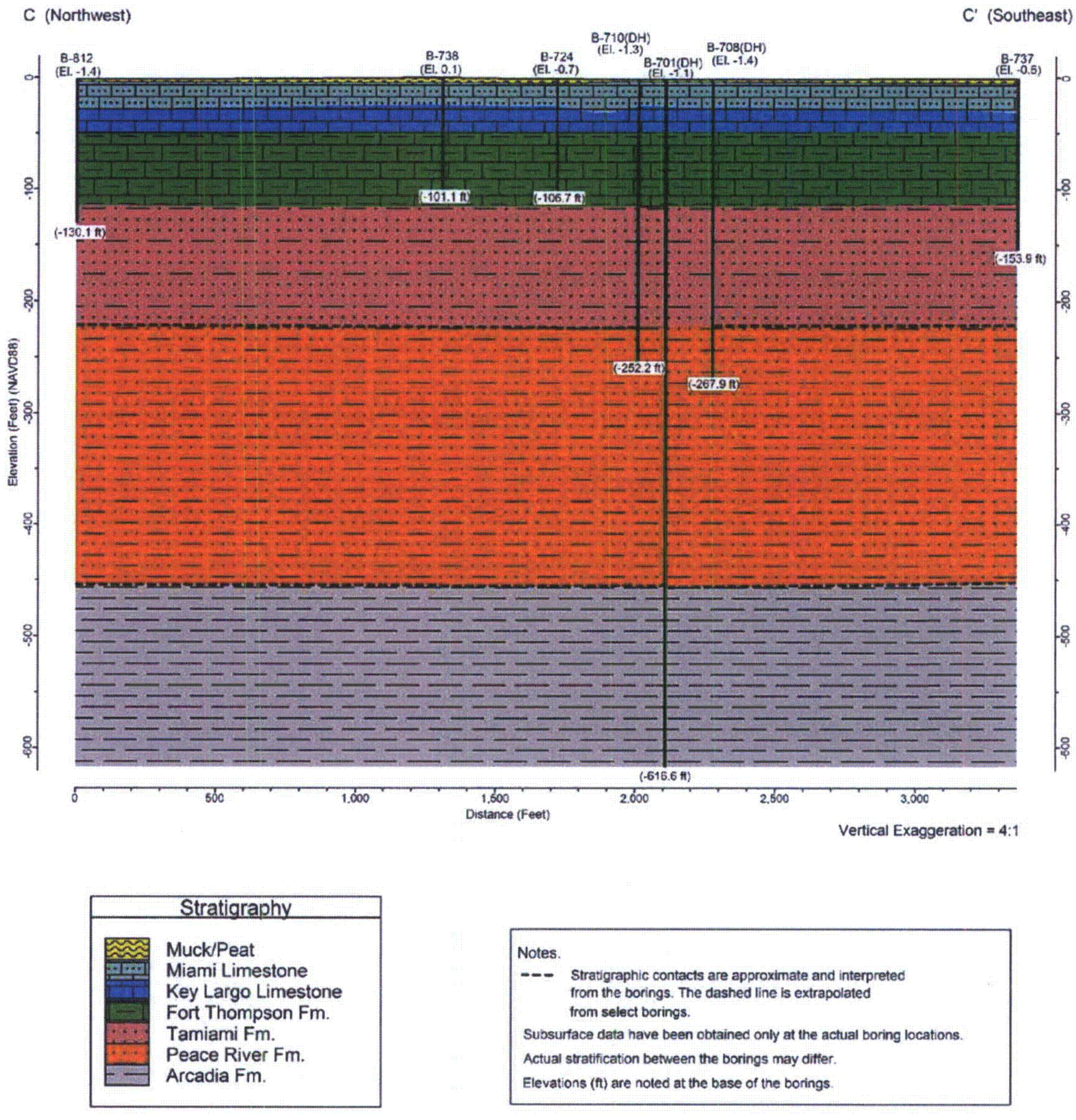
Figure 2.5.1-387 Cross-Section B-B′ (Vertical Exaggeration = 4:1)
This figure appears in Appendix 2.5AA as Figure 2.5AA-216



Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

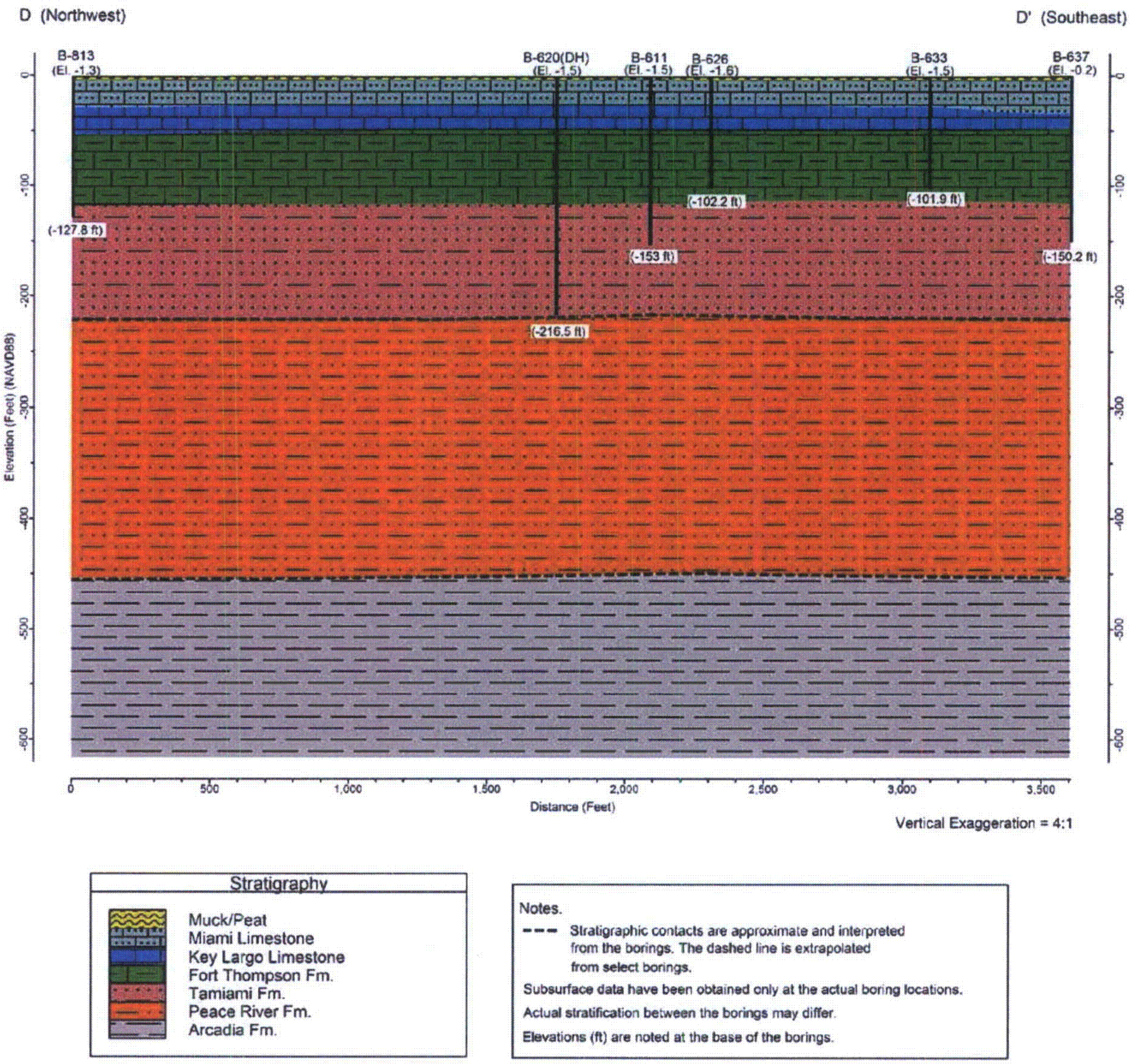
Figure 2.5.1-388 Cross-Section C-C′ (Vertical Exaggeration = 4:1)

This figure appears in Appendix 2.5AA as Figure 2.5AA-217



Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Figure 2.5.1-389 Cross-Section D-D′ (Vertical Exaggeration = 4:1)
This figure appears in Appendix 2.5AA as Figure 2.5AA-201



Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

The following Appendix 2.5AA, Potential for Carbonate Dissolution and Karst Development at the Turkey Point Units 6 & 7 Site, will be included in a future revision of the COLA.

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

~~Appendix~~ APPENDIX 2.5AA

POTENTIAL FOR CARBONATE DISSOLUTION AND KARST DEVELOPMENT AT THE TURKEY POINT UNITS 6 & 7 SITE

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

TABLE OF CONTENTS

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

LIST OF TABLES

LIST OF FIGURES

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Executive Summary

Karstification resulting from dissolution of carbonate rock can lead to the creation of subsurface voids from which sinkholes might develop when the process occurs at or near the earth's surface. However, based ~~upon~~ **on** investigations completed to date, including review of published reports pertaining to karst development in south Florida, geologic field reconnaissance, and a detailed subsurface geotechnical investigation, it is concluded that formation of large subsurface voids with the potential for collapse and development of sinkholes is not likely at the Turkey Point Units 6 & 7 site.

Two types of features related to dissolution of carbonate rock have been identified at the site: (1) vegetated depressions at and near the ground surface and (2) zones of secondary porosity within the underlying limestone. The vegetated depressions are thought to be the result of a subaerial, epigenic, gradual process of carbonate dissolution caused by downward seepage of slightly acidic meteoric water following fractures, joints and bedding planes in the near-surface rock. These features have formed either currently (onsite) or during the Wisconsinan glacial stage (on the floor of Biscayne Bay) when continental glaciation had lowered sea level approximately 100 meters and exposed the limestone on the floor of Biscayne Bay to subaerial weathering and dissolution. The vegetated depressions are surficial dissolution features that are not subject to collapse into an underground solution cavity.

Because seawater saturated with calcium carbonate contains far less calcium carbonate than fresh water saturated with calcium carbonate, the combined fluids become under-saturated with respect to calcium carbonate, and dissolution of carbonate rocks (limestone) occurs within the mixing zone at the freshwater/saltwater interface of the two fluids (~~FSAR~~ Reference 2.5.1-945). Carbonate dissolution in paleo-mixing zones of freshwater and saltwater has formed a second type of feature on the site: zones of secondary porosity. These zones of secondary porosity have formed **microkarst** ~~micro-karst~~ features of generally centimeter scale in limestone beneath the site and provide pathways of preferential groundwater flow. The **microkarst** ~~micro-karst~~ features are thought to have formed by solution enlargement of sedimentary structures in the rock near the contact of the Miami Limestone and Key Largo Limestone and within the Fort Thompson Formation. The zones of secondary porosity were formed during the Pleistocene, -when periods of continental glaciation lowered **the** sea level and allowed mixing of fresh**water** and saltwater within the stratigraphic intervals of the zones. During these periods, fresh groundwater flowed from inland areas, mixed with seawater near the shoreline, and facilitated dissolution as it flowed through the zones to the sea.

The zones of secondary porosity have developed by solution enlargement of two types of sedimentary structures- ~~:~~ "touching-vug porosity" and "moldic porosity" (~~FSAR~~ Subsection 2.5.1.2.4). Touching-vug porosity forms the ~~"Upper Zone"~~ **Upper Zone** of secondary porosity on the site that occurs near the contact of the Miami Limestone and the underlying Key Largo Limestone, within the approximate depth interval of ~~**20 to 35 feet (**~~6.1 to 10.7 meters~~)~~ **(20 to 35 feet)** below the current land surface (~~FSAR~~ Figures 2.5.1-351, **2.5.1**-352, and **2.5.1**-353). Because the current land surface elevation at the site is approximately ~~0 feet (~~0 meters~~)~~ **(0 feet)** NAVD88, this depth interval is also the approximate elevation interval of ~~-20 to -35 feet (~~-6.1 to -10.7 meters~~)~~ **(-20 to -35 feet)** NAVD88. This zone will be removed completely during excavation of the nuclear island foundations.

Moldic porosity forms the ~~"Lower Zone"~~ **Lower Zone** of secondary porosity on the site and occurs in pockets within the approximate depth interval of ~~60 to 75 feet (-60 to -75 feet, or~~ -18.3 to -22.9 meters **(-60 to -75 feet)** NAVD88~~)~~ in the Fort Thompson Formation. While both the Upper and Lower zones of secondary porosity formed in ~~paleo-mixing~~ **paleomixing** zones of fresh groundwater and seawater, groundwater in these zones now is saline (~~FSAR~~ Tables 2.4.12-210 and 2.4.12-211) and not conducive to further dissolution of the limestone host rock.

Marked-up Revised Response
to NRC RAI No. 02.05.01-17 (eRAI 6024)

Mixing zones can occur in both surface water as point source discharge and in groundwater as submarine groundwater discharge. An instance of a point source discharge in the vicinity of Turkey Point Units 6 & 7 is the outfall of a drainage canal into Biscayne Bay. Because the closest outfall is more than ~~one~~ **1** mile from the site (~~FSAR~~ Figure 2.4.1-203), dissolution of carbonate rocks at the site due to point source discharge is not likely.

Submarine groundwater discharge occurs as shoreline flow or further ~~off shore~~ **offshore** as deep pore water upwelling. The zones of secondary porosity in limestone at the site are thought to have formed in the past by the process of shoreline flow. Evidence that this process is active or was **active** in the past at several other areas within the site region and why it is not likely to pose a sinkhole hazard at the site is discussed in ~~FSAR~~ Subsection 2.5.1.1.1.1.1.1. These areas include a submarine paleokarst sinkhole in the Key Largo National Marine Sanctuary, flank margin caves in the Bahamas, and the cenotes terrain of the Yucatan, Mexico, where shoreline flow was the formative process for karstification. Because groundwater at the site is currently saline (~~FSAR~~ Tables 2.4.12-210 and 2.4.12-211), the freshwater/saltwater interface is approximately ~~6 miles (~~9.6 kilometers~~)~~ **(6 miles)** inland from the site (~~FSAR~~ Figure 2.4.12-207), and the long-term sea level rise trend at Miami Beach, Florida, as estimated based on data from 1931 to 1981, is ~~0.78 foot (~~0.2 meter~~)~~ **(0.78 foot)** per century (Reference 2.4.5-206), carbonate dissolution in a fresh groundwater/saltwater mixing zone by the process of shoreline flow is not likely to develop large underground voids with the potential for collapse and formation of sinkholes at the site.

Evidence of deep pore water upwelling in or near the site region is also discussed in ~~FSAR~~ Subsection 2.5.1.1.1.1.1.1. This process occurs ~~within~~ **in** the ~~sea bed~~ **seabed** on the ~~off-shore~~ **offshore** continental shelf where a layer of relatively impermeable rocks or sediments overlying a confined aquifer is breached by erosion or tectonic action, allowing upwelling of fresh groundwater into the ocean. At the site, the underlying Tamiami Formation and Hawthorne Group combined comprise more than approximately ~~500 feet (~~152 meters~~)~~ **(500 feet)** of low-permeability rocks and sediments that overlie and confine the Floridan Aquifer (~~FSAR~~ Figures 2.4.12-202 and 2.4.12-204). Deep pore water upwelling generally occurs well ~~off shore~~ **offshore**, where the slope of the shelf is steeper and erosion of this thickness of confining sediments more likely. For this reason, carbonate dissolution associated with deep pore water upwelling is not likely to pose a threat of surface collapse or sinkhole hazard at the site.

Data from the extensive site geotechnical subsurface investigation for Turkey Point Units 6 & 7 described in ~~FSAR~~ Reference 2.5.1-708 including a multi-method surface geophysical survey designed to detect subsurface cavities, offer**s** no evidence that karstification of the area has developed cavernous limestone with the potential for collapse and formation of sinkholes (within the limits of the geophysical survey imposed by diminishing resolution with increasing depth, decreasing cavity size, and increasing offset from survey lines). Structure contour and isopach maps for the Key Largo Limestone and Fort Thompson Formation and cross-sections prepared with data from the site subsurface investigation do not suggest the existence of large underground caverns or sinkholes.

The effects of potential changes in sea level and groundwater level during the life of the Turkey Point Units 6 & 7 plant have little potential to induce formation of large underground cavities or sinkholes at the site. Because of the planned method of groundwater control during site construction**,** no significant change in groundwater level or associated hydrodynamic stress that might lead to formation of sinkholes is anticipated.

1. ~~Introduction~~ INTRODUCTION

This appendix summarizes information previously provided in the FSAR and in the responses to various requests for additional information by the NRC**,** and provides additional information pertaining to the potential for carbonate dissolution and karst development at the Turkey Point Units 6 & 7 site. This summary outlines the extent to which karst features have developed on and adjacent to the site, the processes by which they were formed, and the improbability of contemporary carbonate dissolution resulting in the formation of large subsurface voids with the potential for collapse. Based ~~upon~~ **on** investigations completed to date, including review of published reports pertaining to karst development in south Florida and a detailed site subsurface geotechnical investigation, two types of features related to carbonate dissolution have been identified on the site: vegetated depressions at and near the ground surface and zones of secondary porosity within the underlying limestone. The vegetated depressions have formed by a surficial dissolution mechanism, as discussed further in Section 2. The zones of secondary porosity have formed by a subsurface mechanism of solution enlargement of sedimentary structures in the carbonate rock, as discussed further in Section 3. Neither of these features is believed to pose a hazard of sinkhole development or foundation instability at the site, as detailed in the discussions in Sections 2 and 3.

Chemical disequilibrium with respect to carbonate saturation in a freshwater/saltwater mixing zone provides an important mechanism for carbonate dissolution, several examples of which are provided in Section 4 along with a discussion of the potential for formation of cavernous limestone susceptible to collapse in a mixing zone on or near the site. Section 5 provides clarification of issues related to interpretation of the data from the detailed site subsurface geotechnical investigation~~, as they~~ **as it** pertain**s** to carbonate dissolution and formation of karst features on the site.

The fresh groundwater/saltwater interface within the surficial aquifer that underlies the site is currently located approximately ~~6 miles (~~9.6 kilometers~~)~~ **(6 miles)** inland from the site (~~FSAR~~ Figure 2.4.12-207). Groundwater in the aquifer is saline at the site (~~FSAR~~ Tables 2.4.12-210 and 2.4.12-211), and the long-term sea level rise trend at Miami Beach, Florida, as estimated based on data from 1931 to 1981, is ~~0.78 foot (~~0.2 meter~~)~~ **(0.78 foot)** per century (Reference 2.4.5-206). Therefore, a fresh groundwater/saltwater mixing zone that would promote carbonate dissolution does not exist, and there does not appear to be a potential for development of large underground caverns with the potential for collapse at the site.

2. ~~Surficial Dissolution Features (FSAR Subsections 2.5.1.2.4 and 2.5.3.8.2.1)~~ SURFICIAL DISSOLUTION FEATURES

Karstification resulting from dissolution of carbonate rock can lead to creation of sinkholes when the process occurs at or near the earth**'s** surface. As further discussed in ~~FSAR~~ Subsection 2.5.1.1.1.1.1.1, the U.S. Geological Survey has identified three main types of sinkholes in Florida (~~FSAR~~ Reference 2.5.1-264), and the Florida Geological Survey has classified four **area** type**s** ~~areas~~ of sinkhole occurrences throughout the state (~~FSAR~~ Figure 2.5.1-222). The Turkey Point Units 6 & 7 site is located within Area I where, if they occur, sinkholes are typically surface-solution sinkholes. In this type of sinkhole, limestone is exposed at the ground surface or under a thin mantle of overburden and subject to subaerial dissolution by slightly acidic surface water. Dissolution is concentrated at the surface and along fractures, joints, and other openings in the rock.

The Florida Geological Survey generally assigns a low hazard to karst features that form when limestone is exposed at the surface or beneath a thin veneer of permeable sediment, as is the case within the site area. In these cases, such solution potholes are generally expected to be shallow, broad, and to develop gradually rather than in a sudden collapse event (~~FSAR~~ Subsection 2.5.3.8.2.1, ~~FSAR~~ Reference 2.5.3-229). Development of surface-solution features proceeds with a slow decline of the ground surface that results in the formation of a generally bowl-shaped depression commonly filled with organic-rich sediments. This process is thought to be currently active on the site and has formed the vegetated depressions that serve as sediment traps and contain an accumulation of ~~H~~**h**olocene sediments known as muck (a mixture of decomposed organic matter and silt). The vegetated depressions are surficial solution features and are not subject to collapse into an underground solution cavity.