

AFFIDAVIT OF MARK A. QUARLES

BEFORE ME, the undersigned authority, personally came and appeared, Mark A. Quarles, who, after being duly sworn, did depose and say:

Qualifications

1. My name is Mark A. Quarles. I am an expert in the field of investigating planned and accidental releases of environmental pollutants to the environment and evaluating the risks associated with those releases.
2. I have specific education and experience performing environmental investigations in fractured sedimentary bedrock such as limestone and have specific education and experience in karst geologic bedrock conditions.
3. An accurate copy of my curriculum vitae is attached to this Affidavit.
4. I have reviewed and assessed certain sections of the Environmental Report, Turkey Point Plant, Units 6 and 7, Revision 3 (ER) prepared by Florida Power & Light Company (FP&L) relative to the potential for wastewater injection operations to contaminate the groundwater and drinking water aquifers.
5. This Affidavit contains my expert opinions, which I hold to a reasonable degree of scientific certainty. My opinions are based on my application of professional judgment and expertise to sufficient facts or data, consisting specifically of documents related to this matter. These are facts and data typically and reasonably relied upon by experts in my field.
6. In my expert opinion, FP&L has not adequately analyzed and discussed the site conditions, the risks associated with wastewater injection activities, and the potential of certain constituents – including heptachlor, ethylbenzene, toluene, selenium, thallium, and tetrachloroethylene – to contaminate underground aquifers. FP&L concluded in their ER that the potential impact to the groundwater quality in both the underground source of drinking water (USDW) and the Boulder Zone injection formation beneath the Turkey Point plant is “SMALL”. ER, Section 5.2.3.2.4 at 5.2-25. This determination relied upon incomplete, inaccurate, and unsupported data.

Summary of Opinions

Heptachlor, ethylbenzene, toluene, selenium, thallium, and tetrachloroethylene are present in the reclaimed wastewater at unknown or unverified concentrations.

7. FP&L intends to inject reclaimed wastewater via underground injection wells at the Turkey Point Nuclear Facility. ER at 5.2-10.

8. In Revision 3 of the ER, FP&L added ethylbenzene, toluene, selenium, thallium, and tetrachloroethylene to the list of constituents in the wastewater injectate. *See* Table 3.6-2. FP&L asserts that these new constituents and concentrations “have now been evaluated using recent data.” ER Table 3.6-2 at note (b). No explanation was provided regarding the new data or the evaluation process. Indeed, FP&L did not even attempt to describe the source of the constituent list and concentrations. No information was given to determine the date of sample(s), which plant(s) were used to develop the list, whether or not the concentrations were based on a single sampling event, when the sample(s) were collected, if the values represent arithmetic or geometric means, or the maximum/minimum concentrations of the constituents.
9. Constituent concentrations for selenium, thallium, heptachlor, ethylbenzene, toluene, and tetrachloroethylene set forth in Table 3.6-2 differ from the concentrations for these constituents in the wastewater produced from the Dade County wastewater treatment plants and reported by the Environmental Protection Agency (EPA Risk Assessment, Appendix 1 at A1 – 11), thus indicating that the wastewater constituent concentrations are highly variable. Given this variability, a comprehensive sampling plan using more frequent monitoring of long-term data is required to accurately determine constituent concentrations. *See* EPA, NPDES Permit Writer’s Manual at 8-5. Without such a study, the concentrations of the constituents and their resulting environmental impacts cannot be accurately determined. Because FP&L provided no information regarding how it calculated constituent concentrations, it is impossible to verify the accuracy of those concentrations.

Deep well injection at sites with similar geological conditions to the Turkey Point site have caused contamination of groundwater and drinking water aquifers.

10. In my expert opinion, wastewater injected via deep well injection into the Boulder Zone at the Turkey Point site may migrate into the Upper Floridan Aquifer, contaminating the groundwater with six constituents -- selenium, thallium, heptachlor, ethylbenzene, toluene, and tetrachloroethylene. Three independent studies support this conclusion. Information to the contrary, found in FP&L’s ER, is based on generalized data and assumed values, as opposed to actual geological subsurface data from the Turkey Point site.
11. The primary source of the wastewater injectate is the Miami-Dade Water and Sewer Department (MDWASD) South District Wastewater Treatment Plant located approximately 9 miles north of the Turkey Point plant. ER at 2.3-47. Lessons learned from studies of the deep well injection program at the South District Wastewater Treatment plant site, other contaminated sites identified by the US EPA, and risks associated with deep well injection at the Turkey Point site are relevant.
12. First, a study funded by the MDWASD for the South District Wastewater Treatment Plant and its deep well injection program (published in February 2010) concluded that deep well injection operations into the Boulder Zone had contaminated upper portions of the Floridan Aquifer. Contamination at the South District plant, the planned source of

makeup water for Units 6 and 7 at Turkey Point, was due to unintended vertical and horizontal migration of municipal wastewater into the Floridan Aquifer from nine (9) injection wells. Walsh and Price at 1.

13. According to the MDWASD study, contamination of the Floridan Aquifer at the South District plant occurred because of the vertical buoyant transport of wastewater into the subsurface and the occurrence of vertical fractures (or joints) in the lower aquifers. Specifically, the study concluded that “the injectate may first have migrated upwards through discrete vertical pathways from the Boulder Zone to the Middle Confining Unit, with the freshwater injectate migrating upwards through saline water as a chemically distinct water body”. Further, four (4) different plumes were identified at the plant, indicating widespread contamination. The study further concluded that once the contaminated wastewater reached the higher aquifer intervals, the transport mechanism was horizontal flow. Walsh and Price at 14 and 15.
14. According to the MDWASD study, previous studies at the South District plant “raised doubts regarding the efficacy of the (middle) confining unit and the resultant water quality impact of overlying aquifers”. Until contamination of the drinking water formation occurred, the Boulder Zone was believed to be hydrologically separate from the overlying aquifer by a 335-meter thick confining layer – which is the same assumption made by FP&L in the ER. Walsh and Price at 2. In light of the MDWASD study, any conclusion in the ER that the middle confining unit will protect the overlying Floridan Aquifer (without specific Turkey Point data to prove those on-site conditions) may be inaccurate.
15. Second, a study completed for the South District deep well injection site by the Idaho National Engineering and Environmental Laboratory (2001) at the request of the US EPA Region 4 determined that the deep well injection program led to contamination of the Upper Floridan Aquifer. Idaho Lab at 38. In fact, the report concluded that “based upon the hydrogeologic data reviewed, widespread contamination of the Upper Floridan Aquifer would be expected”. That report also concluded that “spatial patterns of contamination suggest that upward migration occurs along localized pathways such as wells that are not adequately sealed or natural conduits” in the bedrock. The study also concluded that the middle confining unit at the South District site “is not a competent confining layer” and recommended that an extensive investigation be completed to properly characterize the site geology and hydrogeology. Idaho Lab at iv.
16. Third, a Risk Assessment published by the EPA in 2003 concluded that 18 deep well injection activities in Florida have resulted in unintended contamination of aquifers by fluid migration from the injection zone. The EPA concluded that contamination at the South District MDWASD was one of the confirmed sites that contaminated an underground source of drinking water. EPA, Risk Assessment at 4-14. According to the EPA, 17 deep injection wells at the South District plant (only 13 of which were permitted at the time of the study to inject partially treated wastewater into the Boulder Zone) resulted in contamination. EPA, Risk Assessment at 4-14 and 15.

17. The fact that the EPA concluded that 18 deep well injection well sites in Florida have already contaminated USDWs underscores the importance of conducting a thorough subsurface investigation at a site *before* deep well injection begins to collect actual site-specific data to determine true site risks.
18. The EPA Risk Assessment concluded that preferential flow paths and substantial data gaps exist at injection well sites in Florida and that the contamination transport model used by the EPA was limited in its ability to predict deep well contamination migration. EPA, Risk Assessment at 4-40. Published reports mentioned by the EPA dating to 1977 “indicate that potential (migration) pathways may exist and that these pathways may short-circuit flow paths associated with conventional flow through porous media” – meaning that preferential pathways along such bedrock features as vertical joints and bedding planes can result in unintended groundwater contamination. EPA, Risk Assessment at 4-40.
19. FP&L has not conducted an investigation for the Turkey Point facility that negates the findings of these three studies. The study conducted by FP&L and referenced in the ER fails to investigate the geologic and hydrogeologic conditions at the Turkey Point site at a depth sufficient to determine aquifer conditions, confining layer characteristics, influence on tidal conditions associated with the Straight of Florida connection to the Boulder Zone, or the occurrence of a circular flow pattern in the deep groundwater.¹
20. FP&L relies upon the existence of a nearly impenetrable middle confining unit layer at the Turkey Point site. As noted above, this conclusion is contradicted by the Idaho National Engineering and Environmental Laboratory (2001) study and the MDWASD (2010) study, both of which found that the middle confining unit of the Floridan Aquifer did not prohibit upward migration. Rather, migration could occur.
21. Further, FP&L’s calculation of migration flow rates and direction are based upon generalized information rather than actual conditions at the injection site. ER at 2.3-13 through 39. For example, FP&L assumed that the bedrock is homogeneous and that injected wastewater would exhibit equidistant radial flow in a circular manner. ER at 5.2-11. Those assumptions are incorrect because fractured sedimentary bedrock is heterogeneous and groundwater flows along preferential pathways – particularly in the underlying karst conditions of the Boulder Zone and the overlying bedrock. As a result,

¹ Although borings and wells were drilled (prior to submitting the initial application, not in association with Revision 3 to the ER), they were only related to the shallow Biscayne aquifer and its ability to supply make-up water. The deepest wells and borings drilled by FP&L were 615 feet below ground surface. ER, at 2.3-16 and 19. The anticipated depth to the top of the Boulder Zone at the site, as estimated by FP&L, is approximately 2,800 feet below ground surface. As such, little is known about critical bedrock and chemical fate and transport mechanisms necessary to adequately determine risks to drinking water supplies. None of the 95 geotechnical borings, 4 cone penetrometer tests, 2 test pits, 22 groundwater observation wells, or 2 surface water sampling locations completed in 2008 by FP&L were designed to understand on-site hydrogeologic conditions in the wastewater injection zone or the nearest overlying bedrock formations. FP&L failed to collect the information necessary to ensure protection of groundwater supplies, design the injection well in terms of casings and depths, or accurately predict vertical or horizontal flow rates and directions.

the estimated migration rate and direction of flow in the ER may underestimate the actual horizontal migration distance and contamination risks to the aquifer.

22. Moreover, without actual subsurface data regarding subsurface conditions, FP&L cannot rule out the existence of large vertical joints in and between the bedrock layers, which would dramatically increase vertical migration flow rates. FP&L estimated that the vertical hydraulic conductivity of the important middle confining unit ranged between 1.3×10^{-4} to no more than 0.24 feet per day (around 3 inches). ER at 2.3-33. That estimate was based upon generalized data for southern Florida, not from the specific site in question. Further, that estimate would be a gross underestimate of the vertical migration rate where vertical joints in the bedrock are present. FP&L has estimated that the horizontal hydraulic conductivity in the middle confining unit (based on data from the South District Plant 9 miles away) is up to 3 feet per day. ER at 2.3-33. That horizontal flow rate can provide a quick connection to a series of vertical joints that may exist over the Turkey Point site.
23. Increases in the vertical and horizontal migration flow rate in the absence of confining layers make contamination of aquifers due to upward migration more likely to occur. EPA's assessment of the Lower Floridan Aquifer supports the existence of vertical joints and high rates of migration flow in the planned Boulder Zone injection formation, which it describes as a "highly developed and complex fracture zone" with "extensive cavernous pores, fractures, and widened joints that allow channelized groundwater flow, sometimes at extremely rapid rates". EPA, Risk Assessment at ES-11.
24. The complex, cavernous nature of the bedrock in the Boulder Zone means that large amounts of water from interconnected bedrock above that zone have historically resulted in large solution-enlarged channels. Solution-enlarged vertical or near vertical joints in the bedrock above the Boulder Zone most typically acted as the conduit to supply that large amount of water - creating the cavernous characteristics of prolific karst zones such as the Boulder Zone. The MDWASD, the Idaho Lab, and EPA Risk Assessment all concluded that large joints are the likely contaminant pathway to the upper aquifer, yet no studies have been performed at the Turkey Point site to identify and map those joints above the Boulder Zone.

FP&L's conclusion that the impacts of upward migration into the Floridan Aquifer would be SMALL is unjustified.

25. Despite the presence of selenium, thallium, heptachlor, ethylbenzene, toluene, and tetrachloroethylene within the wastewater injectate, and the likelihood for upward migration of this injectate into drinking water aquifers, FP&L has conducted no studies regarding the potential impact of this migration. FP&L relies on no expert analysis or study in determining that the environmental impact of the injectate does not need to be modified in light of the presence of these six constituents. Instead, FP&L provides, without any authority or expert opinion, that the impact will remain SMALL. ER at 5.2-13. In my expert opinion, this conclusion is unsupported and may underestimate potential impacts.

26. First, FP&L failed to conduct any studies that would allow it to accurately estimate the risk of aquifer contamination. FP&L has conducted no actual investigation into the hydrological and geological conditions at the deep well injection site. As noted above, without actual subsurface data, FP&L cannot conclude that the middle confining layer will prevent upward migration of wastewater injectate or accurately calculate the rate and direction of flow of the injectate with a reasonable degree of certainty. Thus, any conclusion by FP&L's about the impact of contamination is based on inaccurate and incomplete data.
27. Second, FP&L failed to consider the carcinogenic nature of the constituents found in the injectate and the dangers posed by these constituents to human health and the environment. For example, the EPA banned commercial sale of heptachlor in 1988 because it is a possible human carcinogen. ATSDR Profile Heptachlor at 1 and 13. A breakdown constituent of heptachlor, heptachlor epoxide, is also a probable carcinogen, and it is even more dangerous – having an even lower safe drinking water concentration (0.0002 mg/L, compared to 0.0004 mg/L for heptachlor). FP&L did not take into account the carcinogenic nature of heptachlor and failed to consider heptachlor epoxide altogether.
28. Table 3.6-2 provides that tetrachloroethylene (also known as perchloroethene or perchloroethylene), a probable human carcinogen, is in the wastewater. Tetrachloroethylene breaks down (or degrades) in the environment to other compounds that are known or probable human carcinogens - trichloroethylene and vinyl chloride. Tox FAQ trichloroethylene and vinyl chloride. Vinyl chloride can cause cancer at an even lower concentration (0.002 mg/L, compared to 0.005 mg/L for tetrachloroethylene). FP&L did not take into account the carcinogenic nature of tetrachloroethylene and failed to consider trichloroethene and vinyl chloride altogether.
29. FP&L intends to inject 90 million gallons a day of wastewater containing hazardous chemicals into the Boulder Zone in an area that relies on groundwater to supply potable water to the public. ER at 2-8. The EPA has established Maximum Contaminant Levels (MCLs) for some metal and organic constituents to protect public health by limiting concentrations in drinking water. Any concentration above a MCL is considered to be unsafe for human ingestion. The concentration for each MCL is usually expressed as a "part per million" or a milligram per liter (mg/L) unit of measure.
30. The thallium and tetrachloroethylene concentrations estimated by FP&L to be in the wastewater set forth in Table 3.6-2 (ER, Table 3.6-2) exceed the EPA MCL, and the concentration for selenium nearly exceeds the MCL.

Constituent	FP&L ER (mg/L)	EPA Risk Assessment North / Central Dade County (Maximum) wastewater (mg/L)	EPA Maximum Contaminant Level (mg/L)
Selenium	0.0359	0.00091	0.05
Thallium	0.00620	0.039	0.002
Heptachlor	0.000023	0.000183	0.0004
Ethylbenzene	0.001045	0.0005	0.7
Toluene	0.00174	0.00214	1.0
Tetrachloroethylene	0.00359	0.006 (based on Central Dade plant)	0.005

31. Moreover, the six constituents estimated by FP&L to be in the wastewater are harmful to humans at minute concentrations, as described below. *See ATSDR Tox FAQs for selenium, thallium, heptachlor, ethylbenzene, toluene, and tetrachloroethylene.*
- Selenium – nausea, vomiting, diarrhea, hair loss, nail brittleness, and numbness.
 - Thallium – vomiting, diarrhea, hair loss, and effects on the nervous system, lungs, heart, liver, and kidneys.
 - Heptachlor – possible human carcinogen, and immune and nervous system effects.
 - Ethylbenzene – possible human carcinogen and kidney damage.
 - Toluene – nausea and effects on the nervous system.
 - Tetrachloroethylene – probable human carcinogen, nausea, liver damage, impaired heart function, and death.
32. FP&L's determination that the impact to groundwater from deep well injection would be SMALL is not based on a thorough evaluation of either the wastewater characteristics or the actual subsurface geologic conditions. Unless a thorough investigation of the constituents in cooling intake water and their variable maximum, minimum, and average concentrations over time is performed, along with a consideration of the impacts of these constituents on human health and the environment, and until detailed geologic and hydrogeologic conditions based on actual site data are known, FP&L's determination that the impact to groundwater would be SMALL is unsupported and may underestimate the actual impacts.

Sources:

1. Environmental Report, Revision 3, Part 3, COL Application, Turkey Point Plant, Units 6 & 7, Florida Power and Light Company.
2. *Determination of vertical and horizontal pathways of injected fresh wastewater into a deep saline aquifer (Florida, USA) using natural chemical traces*, Hydrogeology Journal, by Walsh, Virginia and Price, Rene, published online February 2010.
3. *Evaluation of Confining Layer Integrity Beneath the South District Wastewater Treatment Plant, Miami-Dade Water and Sewer Department, Dade County, Florida*, by the Idaho

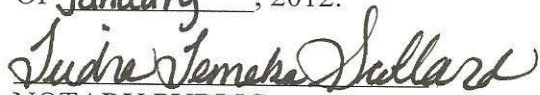
National Engineering and Environmental Laboratory, INEEL / EXT-01-00046, February 2001.

4. *NPDES Permit Writer's Manual*, US EPA, EPA-833-K-10-001, September 2010.
5. *Relative Risk Assessment of Management Options for Treated Wastewater in South Florida*, US EPA Office of Water, EPA 816-R-03-010, April 2003.
6. *Toxicological Profile for Heptachlor and Heptachlor Epoxide*, Agency for Toxic Substances and Disease Registry, November 2007.
7. *Tox FAQ, Ethylbenzene*, Agency for Toxic Substances and Disease Registry, September 2007.
8. *Tox FAQ, Heptachlor and Heptachlor Epoxide*, Agency for Toxic Substances and Disease Registry, August 2007.
9. *Tox FAQ, Toluene*, Agency for Toxic Substances and Disease Registry, February 2001.
10. *Tox FAQ, Tetrachloroethylene*, Agency for Toxic Substances and Disease Registry, September 1997.
11. *Tox FAQ, Trichloroethylene*, Agency for Toxic Substances and Disease Registry, July 2003.
12. *Tox FAQ, Thallium*, Agency for Toxic Substances and Disease Registry, September 1995.
13. *Tox FAQ, Selenium*, Agency for Toxic Substances and Disease Registry, September 2003.
14. *Tox FAQ, Vinyl Chloride*, Agency for Toxic Substances and Disease Registry, July 2006.

Dated: January 23, 2012


MARK A. QUARLES

SWORN TO AND ASCRIBED
BEFORE ME, THIS 23rd DAY
OF January, 2012.


NOTARY PUBLIC

