UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	
	)	
FLORIDA POWER & LIGHT COMPANY	)	Docket No. 50-250-SLR
	)	Docket No. 50-251-SLR
(Turkey Point Nuclear Generating Station, Unit Nos. 3 and 4)	)	June 24, 2019
	)	

EXPERT REPORT OF WILLIAM NUTTLE, PH.D, PEng (Ontario)

I have been retained by the Intervenors in this matter to offer expert testimony. The following is my written report.

My opinions are based on data on hydrogeology, hydrology, hydraulics, and water quality of both surface water and groundwater available to me as of June 23, 2019. In particular, I have compiled data related to the water and salt budgets for the CCS. Florida Power and Light (FPL) conducts monitoring and reports these data annually under an agreement with the South Florida Water Management District, which acts as a point of distribution to other agencies and the public. . I compiled daily values for components of the water budget from spreadsheet files that I obtained through this pathway. The spreadsheet files cover separate but overlapping periods of

time: September 2010 through November 2015,[1] June 2015 through November 2016,[2] Jun 2016 through May 2017,[3] and June 2017 through May 2018,[4] Figure 1.

OPINIONS

Opinion 1:

New information provided by Miami-Dade County points to material and significant changes to the hydrology of the Turkey Point region as the result of water management decisions since Florida Power & Light (FPL) submitted its Environmental Report,[5] on January 2018.

On June 28, 2018, the Florida Department of Environmental Protection issued a permit modification[6] with a stipulation that FPL set and maintain the 40 EMB weirs at 1.8 feet NGVD. This action was challenged by Miami-Dade County (County) with the claim that, in the words of

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[1] File contents are identified by this title on the "README" tab, "Water and Salt Balance Model of the Florida Power & light Cooling Canal System (CCS)," and this statement on the "Key" tab: "This model is based on the previously calibrated balance model (September 2010 through May2015) saved with filename Water&Salt_Balance_Thru_May2015_report.xlsx." The author of the file is identified as James Ross.

[2] File contents are identified by this title on the "README" tab, "Water and Salt Balance Model of the Florida Power & light Cooling Canal System (CCS)," and this statement on the "Key" tab: "This model is based on the previously calibrated balance model (September 2010 through May 2016) saved with filename Balance_Model_May2016_draftfinal_v2.xlsx." The author of the file is identified as James Ross.

[3] File contents are identified by this title on the "README" tab, "Water and Salt Balance Model of the Florida Power & light Cooling Canal System (CCS)," and this statement on the "Key" tab: "This model is based on the previously calibrated balance model (September 2010 through May 2016) saved with filename Balance_Model_May2016_draftfinal_v2.xlsx." The author of the file is identified as James Ross.

[4] File contents are identified by this title on the "README" tab, "Water and Salt Balance Model of the Florida Power & light Cooling Canal System (CCS)," and this statement on the "Key" tab: "This model is based on the previously calibrated balance model (June 2015 through May 2017) saved with filename Balance_Model_May2017_v3_draftfinal.xlsx" The author of the file is identified as James Ross.

[5]Applicant's Environmental Report – Subsequent Operating License Renewal Stage – Turkey Point Nuclear Plant Units 3 and 4." January 2018. 762 p. ADAMS Accession No. ML18037A836.

[6] Florida Power and Light Permit No. 0193232-182, Everglades Mitigation Bank Phase II Modification and Credit Release.

the County, the permit modification "may adversely impact water resources," "is not sustainable over the long term," and "interferes with protecting water quality in the L-31E canal from chloride contamination and addressing the existing inland migration of the salt intrusion front [from the cooling canal system] in this area."[7] Further, the County noted that the permit modification "may exacerbate the existing water quality violations that FPL is otherwise working to abate and remediate, thus hindering the progress of those efforts and harming wetlands . . . ."

At issue is the amount of fresh water discharged as surface water from the freshwater wetlands, known as the Model Lands Basin, which bound the Turkey Point cooling canal system (CCS) to the west. The Model Lands Basin comprises about 21,000 acres of wetlands fully enclosed by SW 344 Street (and the associated Florida City canal) to the north, the L-31E canal and levee to the east and southeast, Card Sound Road (and associated canal) to the southwest, and Florida City (US Route 1) to the west. Surface water drains out of the Model Lands Basin through a series of culverts (the EBM culverts) located along the L-31E canal, south of the CCS. The inflow of fresh water to the Model Lands Basin is limited by rainfall; essentially no surface water flows into the basin and inflow of groundwater is small relative to rainfall. Outflow is regulated by adjusting the height of weirs set in the culverts.

Lowering the elevation of the weirs increases the discharge of freshwater from the Model Lands Basin, and this has benefits for freshwater wetlands south and east of the L-31E canal and levee, i.e. outside of the Model Lands Basin. FPL manages the area outside the basin as a wetland mitigation bank, for which it receives credits from FDEP. The freshwater wetlands east and south of the L-31E are exposed to periodic inundation and by saline water from Biscayne Bay, during periods of extreme tides and storm surge, as well as the chronic encroachment by saline water driven by sea level rise. The input of fresh water discharged from the Model Lands Basin mitigates the negative impact of salt water on the fresh water vegetation.

[7] Letter from Miami-Dade County DERM to Florida DEP dated July 18, 2018. (RE: Request for an Extension of Time in accordance with Section 120.57, …)

The benefits to the wetlands outside the basin of increased discharge through the weirs come at the expense of direct negative consequences within the Model Lands Basin for hydrological conditions needed to sustain the freshwater wetlands and water supplies for communities adjacent to the basin. The letter from DERM to FDEP documents the technical and scientific basis for concern that these consequences are being realized as a result of FDEP's stipulations in the recent permit modification.

Lowering the elevation of the weirs drains water out of the basin, which has the effect of lowering the watertable throughout the basin. Lowering the watertable directly impacts the wetlands in the basin, degrading their ecological functioning. Lowering the watertable indirectly impacts the wetland by opening pathways for the infiltration of saline groundwater into the L-31E canal. From here, the saline water can move throughout the basin through the network of interconnected drainage canals, which threatens the freshwater wetlands with further degradation. Lowering the watertable also reduces the natural hydraulic barrier against the intrusion of saltwater into the basin through the Biscayne aquifer from Biscayne Bay and water discharged into the aquifer from the CCS. Salt water intrusion threatens to degrade water supply wells adjacent to the Model Lands Basin.

Opinion 2

FPL's compliance with this modified permit exacerbates impacts from operating the CCS on groundwater, surface water, and ecological resources in the Model Lands Basin.

Decreased water levels in the Model Lands Basin exacerbate impacts in the basin from the CCS in two ways. First, decreased water levels reduces the seaward gradient in hydraulic head that provides a barrier to the intrusion of salt water into the aquifer. Second, decreased water levels open a pathway for the vertical movement of CCS water into the L-31E canal and thus throughout the basin through the network of drainage canals that connect to the L-31E canal. The first mechanism, related to the horizontal movement of saline water into the aquifer, appears to be generally recognized. However, the second mechanism is not; therefore, the following is a brief discussion of the principles involved and an analysis to demonstrate that it feasible under the conditions present at the CCS.

Stable density stratification in a coastal aquifer involves stability against vertical flow as well as horizontal flow. Water in the Biscayne aquifer west of the CCS is stratified. A layer of freshwater, fed by rainfall and groundwater flow from the west, overlies the plume of hypersaline water fed by flow out of the CCS. This plume extends west beneath the ID and the L-31E canal.

The stability of the interface between the freshwater and salt water in a coastal aquifer implies that the watertable above the freshwater in the aquifer occurs above mean sea level. The Ghyben-Herzberg relationship[8] estimates the depth to the interface between freshwater and salt water, z, as the height of the freshwater water-table above sea level, h, multiplied by a factor computed from the densities of freshwater (nominally 1000 kg/m^3) and seawater (1025 kg/m^3);

$z = \frac{\rho_f}{(\rho_s - \rho_f)} h$. For freshwater and sea water the multiplier is 40. In the situation of the L-31E canal and the hypersaline plume from the CCS, water level in the CCS plays the role of sea level. The water level in the L-31E canal is, on average, 0.3 feet above the level of the CCS; therefore the depth to the interface below the canal is computed to be 12 feet. However, the density of hypersaline water in the CSS and its plume can be higher than that of sea water; density of water with a salinity of 60 psu, roughly the long-term average for the CCS, is 1042 kg/m^3. Using this higher density, the multiplier is 24, and the estimated depth to the interface below the L-31E canal is 7 feet.

The interval 7 to 12 feet coincides exactly with the depth of the L-31E canal.[9] Therefore, conditions exist for the upper portion of the CCS plume to intersect with the bottom of the L-31E canal.

[8] https://en.wikipedia.org/wiki/Saltwater_intrusion#Ghyben%E2%80%93Herzberg_relation

[9] "The depth of the L-31E canal is around 9 feet." Janzen, J., and S. Krupa, 2011. Water Quality Characterization of Southern Miami-Dade Nearby FPL Turkey Point Power Plant. Technical Publication WS-31, South Florida Water Management District, July 2011.

Operation of the ID exacerbates the infiltration of CCS water into the L-31E. Water is pumped out of the ID for the purpose of maintaining a hydraulic barrier to westward movement of CCS water in the shallow groundwater. Pumping lowers the water level in the ID and in the wetlands immediately adjacent to it. This decreases the height of the water-table in the freshwater lens, which also decreases the depth to the freshwater/salt water interface. Therefore, by lowering the watertable, ID operations also promote the vertical flow of the CCS water in the hypersaline plume upward into the upper area of the Biscayne aquifer.[10]

Operation of the ID represents a large, undocumented demand on the water budget of the Model Lands Basin. Water pumped out of the ID is a mixture of saline water discharged from the CCS and fresh groundwater flow from the west. The amount of freshwater withdrawn by ID operations can be estimated from the ID pumping rate and salinity data collected for the ID and the L-31E canal. The impact of pumping on the water table in the wetlands west of the CCS is exacerbated by the fact that pumping from the ID occurs predominantly during the dry season, January through May. This is when the amount of freshwater in the aquifer is at its seasonal low, and hydraulic gradients conducive for flow from the CCS into the L-31E canal exist.

On any single day, the amount of water pumped from the ID, Q_{ID}, is the sum of an amount of water that has entered the ID from the west, from Q_{L31}, and an amount of water recycled from the CCS, Q_{RW};

$$Q_{ID} = Q_{L31} + Q_{RW}. \qquad \text{Equation 3}$$

Similarly, the amount of salt in the water pumped from the ID is the sum of an amount carried into the ID in groundwater flow from the west and in the flow of recycled water from the CCS;

[10] The July 18, 2018 letter from DERM to FDEP presents evidence for the influence of ID pumping on water level in the L-31E canal and for groundwater inflow as the cause of salinization of the L-31E, especially in recent years. Evidence for vertical migration of the plume was discussed at a meeting at the South Florida Water Management District in February 2017; PowerPoint presentation by Jonathon Shaw, Turkey Point Power Plant Interceptor Ditch Operations, Joint Agency Meeting – SFWMD/DEP/DERM, February 9, 2017.

$$Q_{ID}S_{ID} = Q_{RW}S_{CCS} + Q_{L31}S_{L31}. \quad \text{Equation 4}$$

From these two equations, one can derive the following formula to calculate the portion of the total daily ID pumping that is fed by groundwater flow from the west:

$$Q_{L31} = Q_{ID}[(S_{CCS} - S_{ID}) / (S_{CCS} - S_{L31})] \quad \text{Equation 5}$$

The daily rate of pumping from the ID, Q_{ID}, and the salinity of water in the ID, S_{ID} , are measured. The salinity measured in the L-31E canal can be taken as representative of the salinity of water flowing into the ID from the west. Shallow groundwater west of the CCS is not totally fresh, as a consequence of infrequent flooding of the wetlands there by water from Biscayne Bay. The salinity of water below the CCS is taken to be 60 gm/l, which reflects the long-term, stable average of salinity measured in a shallow well in the center of the CCS.[11]

Based on these data, calculations reveal that ID pumping removes about 3.5 mgd of mostly fresh groundwater from the Biscayne aquifer west of the CCS. This is the average of the amount of freshwater extracted calculated using Equation 5 applied with daily values of pumping rate and salinity. The pumping rate varies from day to day, and salinity in the ID tends to be higher on days with higher rates of pumping.

This rate of extraction is large relative to other withdrawals from the aquifer. Nearby well fields operated by public water utilities[12] withdraw 2 mgd (Florida City), 11 mgd (Homestead), and 17 mgd (FKAA). The withdrawal of freshwater as a consequence of ID operations is not documented in current regional water supply plans.

The recovery well system began operation in June 2018, and it is likely that the recovery well system will have a similar effect stimulating the infiltration of CCS water into the L-31E canal. The recovery well system (RWS) removes around 14 mgd of water from the aquifer, about half

[11] TPGW-13

[12] Water use figures from Table A-8, 2013 Lower East Coast Water Supply Plan Update: Appendices, October 10, 2013.

of this amount is groundwater removed from the Model Lands Basin. This is hypersaline groundwater removed from the base of the aquifer, but the removal of this water from the aquifer impacts the freshwater water budget of the basin because the groundwater removed at depth must be replaced by infiltration from above.

The County estimates that the amount of water removed from the basin annually by the RWS is equivalent to one foot of surface water, about 20% of the annual input from rainfall, across the wetlands of the entire basin. According to information provided by the County, the impact of water removed by the RWS on the freshwater balance of the Model Lands Basin is similar to the reduction in weir elevation that is the subject of the County's challenge to FDEP.

Opinion 3

New information on mechanisms of drought in south Florida provides evidence that "more favorable climatic conditions" that are being relying on to meet salinity targets in the CCS are unlikely to occur.

Under the terms of the Consent Order,[13] FPL must "maintain average salinity in the CCS at or below 34 psu." To achieve this, FPL has adopted the strategy of adding about 14 mgd of low-salinity water from the Upper Floridan aquifer on a continuous basis to augment rainfall, the major source of freshwater. Confidence in this strategy is provided by simulation modeling[14] based on the same models that have proven successful in calculating components of the water and salt budgets, which constitute part of the annual report from the monitoring program. The proof of concept is a plot showing salinity being reduced over a 12-month period from about 60 psu down to about 35 psu, and then from 35 psu to 25 psu after a second year of water additions.

[13] Consent Order 2016. State of Florida Department of Environmental Protection v. Florida Power & Light Company, OGC File No. 16-0241.

[14] Tetra Tech, May 9, 2014, Evaluation of Required Floridan Water for Salinity Reduction in the Cooling Canal System – Technical Memorandum; and Tetra Tech, March 13, 2015, Evaluation of L-31E Water Addition Impacts on CCS Salinity Reduction – Technical Memorandum.

The reductions in salinity achieved from actually adding fresh water to the CCS have, so far, not been able to replicate the results of the model simulation. The freshening program of adding 14 mgd of Floridan water on a continuous basis began on November 28, 2016; however, water additions, using various amounts from a variety of other sources, for the purpose of reducing salinity were first made in response to a spike in salinity in 2014, Table 1. During the period beginning in 2014, in only one year has the reduction in salinity matched the results of the model. This occurred during calendar year 2015, when salinity dropped from about 70 psu on January 1 to about 35 psu at the end of December, Figure 1. However, the amount of additional water required to achieve this result was about double the prescribed 14 mgd, Table 1.

Table 1: Average water balance fluxes by calendar year compiled from the FPL's annual monitoring reports. Inflow from "other sources" includes smaller amounts pumped from the interceptor ditch, plant blowdown in all years, and larger volumes added to reduce salinity in 2014, 2015, 2016 (briefly) and 2017. In 2017, the amount from other sources includes input from storm surge during Hurricane Irma.

	Inflow (mgd)		**Outflow (mgd)**	
Year	Rainfall	Other sources	Evaporation	Net Discharge to Groundwater
2011	19.4	7.6	36.0	-9.0
2012	23.4	4.5	32.5	-4.8
2013	21.0	4.9	38.2	-12.8
2014	14.8	9.9	41.9	-17.5
2015	25.0	36.0	41.4	15.0
2016	21.3	4.4	36.6	-5.8
2017	22.2	28.0	38.0	12.3

In the DSEIS,[15] NRC staff review the analysis of the CCS's response to freshening by FPL's modelers. The discussion offered by FPL's modelers focuses on the variability in rainfall as the main confounding factor. From this, NRC staff draw that conclusion, "The modelers anticipate that under more favorable climatic conditions (e.g., less severe dry seasons), the addition of Upper Floridan aquifer water should help to reduce CCS water salinities to 34 PSU."

[15] Generic Environmental Impact Statement for License Renewal of Nuclear Plants, 4 Supplement 5, Second Renewal, Regarding Subsequent License Renewal for Turkey Point 5 Nuclear Generating Unit Nos. 3 and 4, Draft Report for Comment (NUREG–1437).

I have reviewed the model calculations that lead to selecting 14 mgd of Floridan water as the preferred design.[16] These calculations were based on climatic conditions measured by the monitoring program during the period November 2010 through October 2014. Within this period, the modelers refer to the period November 2010 through October 2012 as reflecting "normal weather patterns," and the period November 2013 through October 2014 as reflecting "dry weather patterns," but no justification is given for these characterizations.

A new study,[17] published in May 2019, investigates the occurrence of wet periods and drought in south Florida. The authors examined monthly regional rainfall data from 1906 to 2016, and they draw the following conclusion: "Historical drought evaluated in different time windows indicated that there is a wet and dry cycle in the regional hydrology, where the area is currently in the wet phase of the fluctuation since 1995 with some drought years in between." "Overall, the long-term rainfall variability in the [south Florida] region is strongly associated with AMO [Atlantic Multidecadal Oscillation]. However, the emergence of a negative phase of AMO has been reported. As a result, the current wet phase of the hydrologic regime could gradually decline to below average.

In other words, considering the historical pattern of rainfall drought and surplus, one should anticipate that the years ahead will be dryer than recent years and not expect a return to the "normal weather patterns" on which FPL's strategy for salinity reduction appears to depend.

Opinion 4

The ongoing dispute between the County and FDEP over setting the elevation of the weirs along the L-31E canal is evidence that achieving compliance with requirements for remediation

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[16] Tetra Tech, March 13, 2015, Evaluation of L-31E Water Addition Impacts on CCS Salinity Reduction – Technical Memorandum; and its application in Golder and Associates, March 29, 2106, Water Supply Alternatives Analysis; Report for Florida Power & Light Company

[17] Anteneh Z. A., A. M. Melesse, and W. Abtew, 2019. Teleconnection of Regional Drought to ENSO, PDO, and AMO: Southern Florida and the Everglades. Atmosphere 10(6) DOI: 10.3390/atmos10060295

established by DERM and FDEP[18][19] does not reliably predict future compliance with state and local water quality requirements.

Section 4.5.1.2 of the current DSEIS reads, in part, "NRC staff has concluded that the site-specific impacts for this issue at the Turkey Point site are MODERATE for current operations [due to the presence of hypersaline water from the CCS in the aquifer], but will be SMALL during the subsequent license renewal term as a result of ongoing remediation measures and State and county oversight, now in place at Turkey Point." However, the State and county are in dispute over a matter that critically affects FPL's remediation measures.

The County has filed a Petition for Administrative Hearing[20] (MDC 2018a [petition for administrative hearing]) challenging the FDEP's permit modification requiring FPL to lower the weirs. The outcome of this dispute will affect the impact that the operation of the CCS will have both on the groundwater, surface water and ecological resources in the Model Lands Basin and on the efficacy of FPL's efforts to remediate the CCS groundwater plume and to protect potable water supply wells. But, this will not be the last such dispute.

Hydrologic conditions in the Model Lands Basin in general, and the elevation of the weirs along the L-31E canal in particular, are at the nexus of overlapping goals and responsibilities of several federal, state, and county agencies. In some cases, these goals conflict. For example, the permit modification issued by FDEP reverses one of the actions prescribed in the consent agreement between the County and FPL for remediation at Turkey Point, required FPL to raise the elevation of the weirs. The County's letter to FDEP identifies other ways in which FDEP's recent action

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[18] Consent Agreement Concerning Water Quality Impacts Associated with the Cooling Canal System at Turkey Point Power Plant. October 6, 2015. ADAMS Accession No. ML15286A366

[19] Consent Order, OGC File Number 16-0241, between the State of Florida Department of Environmental Protection and Florida Power & Light Company regarding settlement of Matters at Issue [Westward Migration of Hypersaline Water from the Turkey Point Facility and Potential Releases to Deep Channels on the Eastern and Southern Side of the Facility]." June 20, 2016. ADAMS Accession No. ML16216A216.

[20] Petition for Administrative Hearing before the State of Florida Department of Environmental Protection filed by Miami-Dade County vs Department of Environmental Protection on September 17, 2018.

conflicts with goals for management of hydrologic conditions in the Model Lands Basin established for projects of the U.S. Army Corps of Engineers and by FDEP, itself.

Therefore, NRC staff should reassess their conclusion that cooperation of between FDEP and DERM will shepherd FPL's remediation measures to a successful result.

QUALIFICATIONS

My resume is attached hereto as Exhibit B and contains my qualifications and a list of all publications that I have authored.

SIGNATURE

William K. Nuttle
June 23, 2019

Figure 1: Daily values of the components of the CCS water budget reported from FPL's monitoring program for the period September 2010 through November 2017. Upper panel: average salinity in CCS. Bottom panel: daily values of rainfall and water inputs from other sources.