PSEG Early Site Permit
Advisory Committee on Reactor Safeguards
Subcommittee Meeting
SSAR Section 2.4

June 9, 2015

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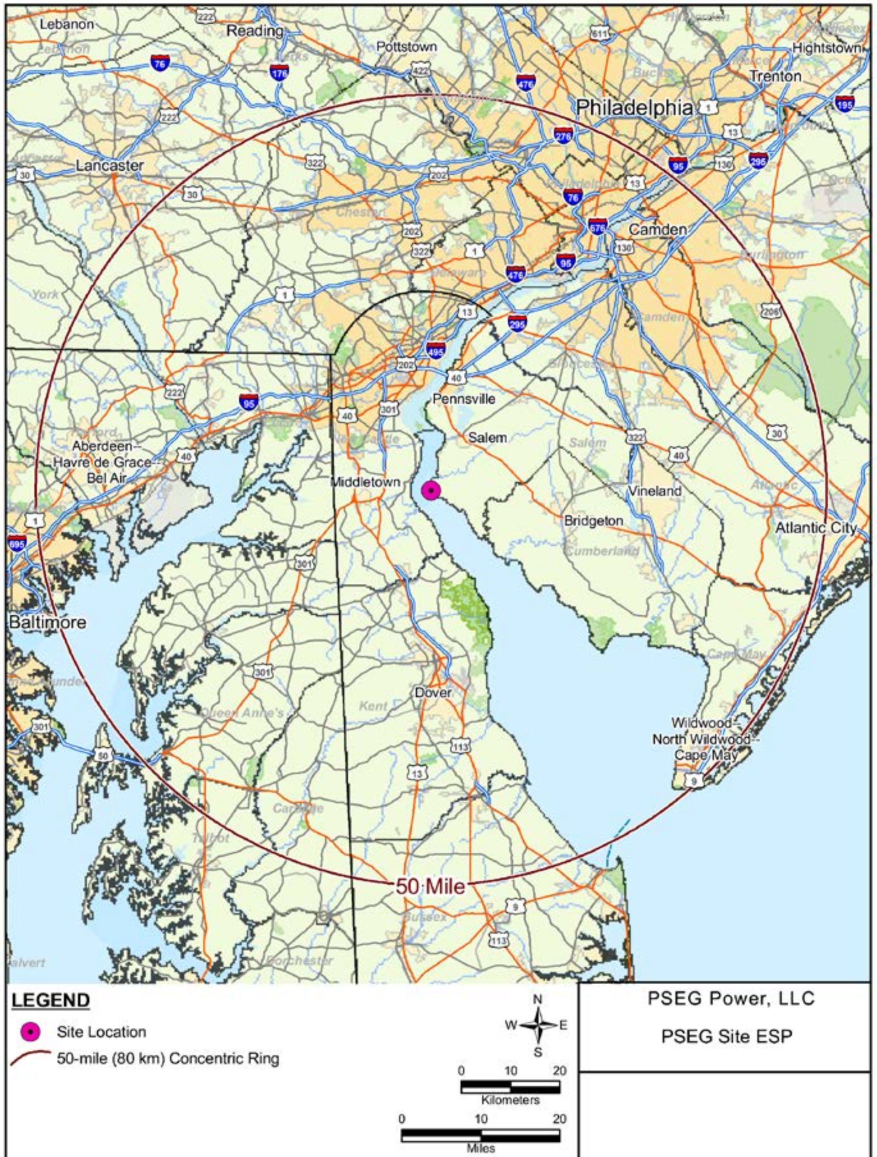
Chapter 2 – Section 2.4
Hydrologic Engineering

Areas covered in ESP same as for COLA

- RS-002 outlines NRC review approach
- Regulatory Guidance
  - RG 1.27
  - RG 1.29
  - RG 1.59
  - RG 1.102
  - RG 1.206
- NUREG/CR-7046
- NUREG/CR-6966
- QA requirements apply – 10 CFR 50 Appendix B

2.4.1 Hydrologic Description



PSEG Site

- 52 river miles (RM) upstream of the mouth of Delaware Bay.
  - 17 RM downstream of the Delaware Memorial Bridge (RM69)
  - 40 RM southwest of Philadelphia, Pennsylvania (RM 92)
- Head of the Delaware Bay (RM 48)
- Chesapeake and Delaware (C&D) Canal channel entrance (RM 59).

2.4.1 Hydrologic Description

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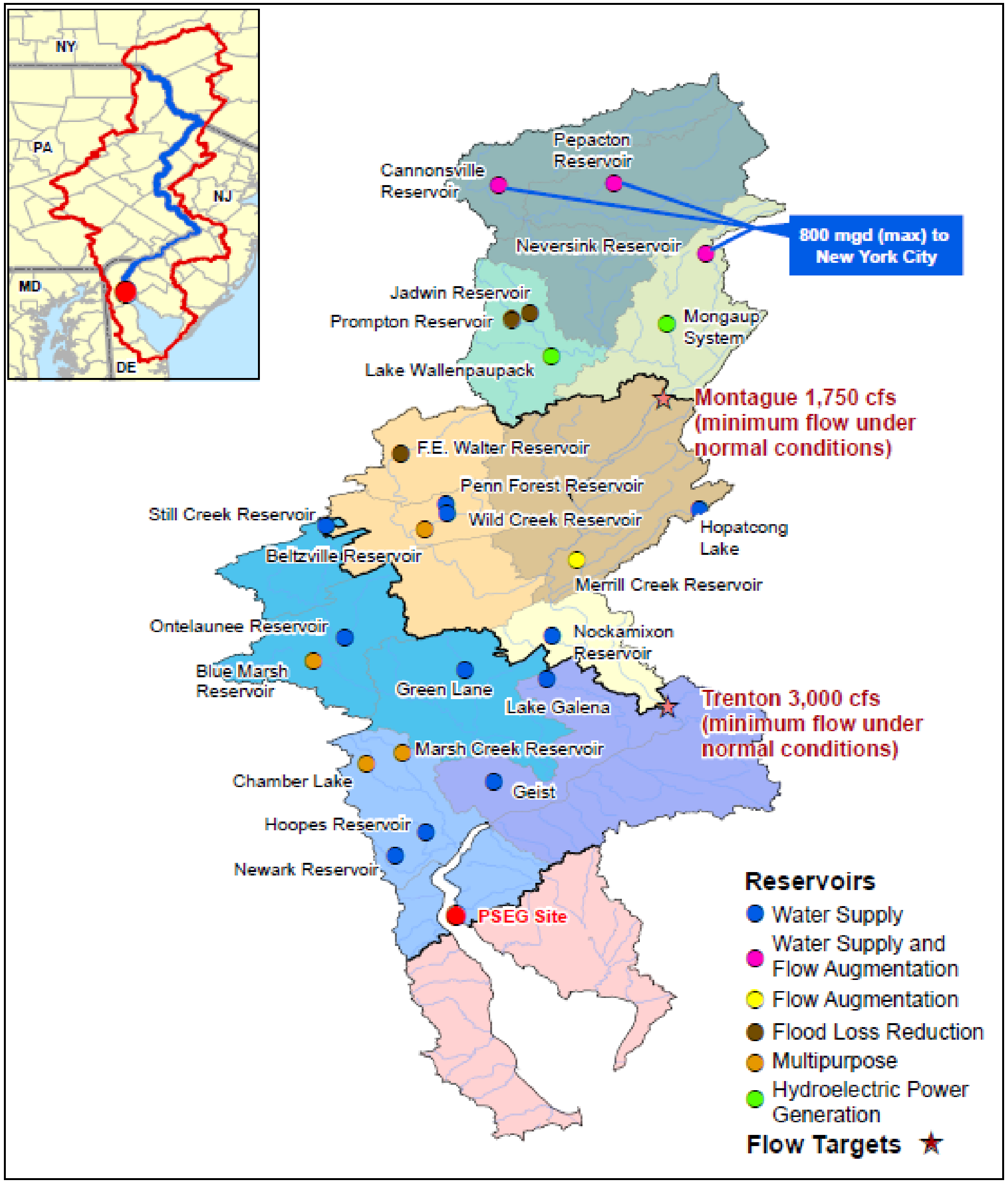
2.4.1 Hydrologic Description

- Delaware River Basin covers 13,600 square miles (sq. mi.)
- Tidal flow ranges from 400,000 cubic feet per second (cfs) to 472,000 cfs
- Freshwater flow is approximately 15,000 cfs
- Delaware River is the longest undammed river east of the Mississippi River



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2.4.2 Floods

Historical records show highest flood events recorded near mouth of Delaware River and within Delaware Bay are caused by storm surge

Events Resulting in Storm Surges in the Delaware River near the PSEG Site

Storm Event	Year	Estimated Storm Surge, ft.[a]	
		Reedy Point	Philadelphia
Hurricane of 1878	1878	5 to 8	5 to 8
Chesapeake-Potomac Hurricane	1933	7.7	7.1
Hurricane Hazel	1954	n.a.[b]	9.4
Hurricane Connie	1955	n.a.[b]	5.0
Hurricane Floyd	1999	2.9	4.0
Hurricane Isabel	2003	5.0	5.4

a) surge above predicted tide
b) n.a. = not available

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2.4.2 Floods

Flooding scenarios investigated for the site include:

- Local Intense Precipitation
- PMF on rivers and streams
- Potential dam failures
- Maximum surge and seiche flooding
- Probable maximum tsunami
- Ice effect flooding
- Channel diversions

2.4.2 Floods (Cont.)

Local Intense Precipitation

- NOAA Hydrometeorological Reports
- HEC-HMS is used to simulate the precipitation-runoff processes in watershed systems to determine peak discharge
- The resulting peak flows are used to determine the maximum WSEL resulting from the PMP event
- Analysis can be refined once a technology is selected and site grading and drainage systems are designed
- Site will be designed to ensure PMP event will not cause flooding events or operational problems

2.4.3 Probable Maximum Flood on Streams and Rivers

Methodology and Inputs

- USACE HEC-HMS and HEC-RAS Model developed and validated for the Delaware River System upstream of the PSEG Site
- Two probable maximum precipitation events considered
  - 15,000 sq. mi. storm centered over Doylestown, PA
  - 2150 sq. mi. storm centered over Philadelphia, PA

Results

- Maximum WSEL is 21.0 ft. NAVD due to PMF combined with 10% exceedance high tide, worst regional surge, and wave runup
- PMF at site is not expected to cause flooding events or operational problems

2.4.4 Potential Dam Failures

Methodology and Inputs

- Screening of dams and regional combinations developed for failure scenarios
- Seismic failure of dams assumed for immediate breach
    - Dam failures are sequenced, such that flood waters converged at the DE River at the same time

Results

- Failure of Cannonsville and Pepacton Reservoirs produces greatest WSEL of 0.3 ft. NAVD
- Combined events of 10% exceedance high tide, 500 year flood, and wave runup produces a WSEL of 9.4 ft. NAVD
- Dam failure runup at site is not expected to cause flooding events or operational problems

2.4.6 Probable Maximum Tsunami Flooding

Historical Tsunami Record

- Documented seismic events (Puerto Rico, Lisbon 1755)
- Documented landslide events (Grand Banks, 1929)
- Landslide events in geologic record (Currituck, Cape Fear, other sites along east coast continental margin)
- Volcanic cone collapse events in geologic record (Canary Islands)

Modeling Approach MOST (Method of Splitting Tsunami)

- Solves nonlinear shallow water equations
- Used extensively in tsunami forecasting and inundation studies

Probable Maximum Tsunami events

- La Palma Landslide in Canary Islands
- Hispaniola Trench
- Currituck Landslide

2.4.6 Probable Maximum Tsunami Flooding (Cont.)

La Palma Landslide in Canary Islands

- Usual worst case scenario for most coastal areas in the Northeast
- Impact inside Delaware Bay reduced by refraction of incident waves to areas north and south of bay entrance

Hispaniola Trench

- Largest subduction zone in Atlantic Ocean
- Plausible tsunamigenic region based on geological processes and history of events
- Results show slightly larger impact than La Palma case, with more wave penetration into Bay

2.4.6 Probable Maximum Tsunami Flooding (Cont.)

Currituck Landslide

- Representative of large East Coast slide events found in geological record
- Sensitivity tests show wave conditions in Delaware bay are largely insensitive to shifts in assumed slide location along continental shelf margin
- Represents the PMT event for the PSEG site

Model results:

- All tsunami-generated runups and drawdowns at site are not expected to cause flooding events or operational problems
- Maximum runup with 10% exceedance high tide is 1.15 ft. (5.65 ft. NAVD)
- Maximum drawdown with 90% exceedance low tide is -1.16 ft. (-6.16 ft. NAVD)
- Tsunami-induced velocities at site are not large compared to maximum observed tidal currents

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2.4.7 Ice Effects

- Historical ice jam information review and model simulation of a major historic ice jam event
  - Flooding potential from historic ice jam discharge is elevation 8.1 ft. NAVD
- Intake structure will be designed to address ice effects, including surface ice, frazil ice, and other dynamic forces and blockages associated with ice effects
- Ice effects at site are not expected to cause flooding events or operational problems

2.4.8 Cooling Water Canals and Reservoirs

- These features are not present at PSEG Site

2.4.9 Channel Diversions

- Shoreline near PSEG Site is flat and low and neither a seismic nor severe weather event result in a major shoreline collapse

2.4.11 Low Water Considerations

- 20-year low flow conditions with 90% exceedance low tide simulated in HEC-RAS model result in a WSEL of -5.0 ft. NAVD
- Negative surge from hurricane reduces WSEL in vicinity of the PSEG Site by 10.9 ft.
- Coincident with a 20-year low flow in the Delaware River at Trenton and 90% exceedance low tide, WSEL could be as low as -15.9 ft. NAVD
- A safety-related intake structure designed to operate during low water conditions identified
- Low water conditions at site are not expected to cause operational problems

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Chapter 2 – Section 2.4.5
Probable Maximum Surge and Seiche Flooding

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2.4.5 Probable Maximum Surge and Seiche Flooding

Probable Maximum Hurricane (PMH) Storm Meteorological Parameters based on NWS 23

- Central pressure, P_0 = 26.65 inches of mercury (Hg)
- Pressure drop, delta-P = 3.5 in. of Hg
- Radius of maximum winds, R = from 11 to 28 nautical miles (NM)
- Forward speed, T = from 26 to 42 knots (kt)
- Coefficient related to density of air, K = 68
- Track direction, from 138 degrees (moving northwest)

PSEG ESPA Storm Surge Screening

- Modeled with Bodine storm surge method
- Coupled with HEC-RAS; Kamphuis wind setup method; and Coastal Engineering Manual wave runup method
- Parameters Resulting from Screening: R = 28 NM; T = 26 kt
- Produces total Water Surface Elevation (WSEL) of 42.4 ft. NAVD

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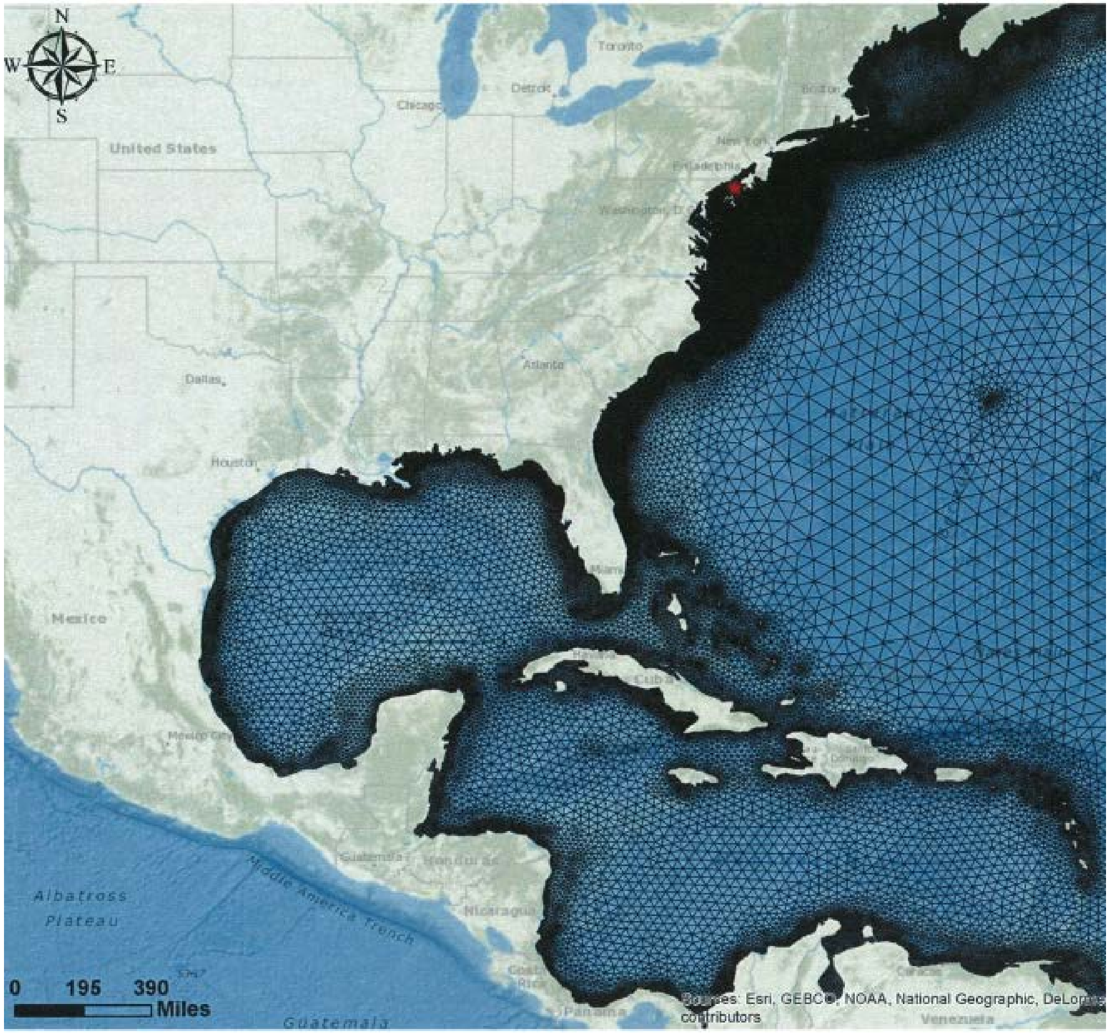
2.4.5 Probable Maximum Surge and Seiche Flooding (Cont.)

PSEG developed a high resolution 2-D storm surge model (ADCIRC+SWAN) to support development of the response to RAI No. 67

- 2-D models are recognized as a more accurate storm surge modeling tool
- FEMA Region III coastal flood study



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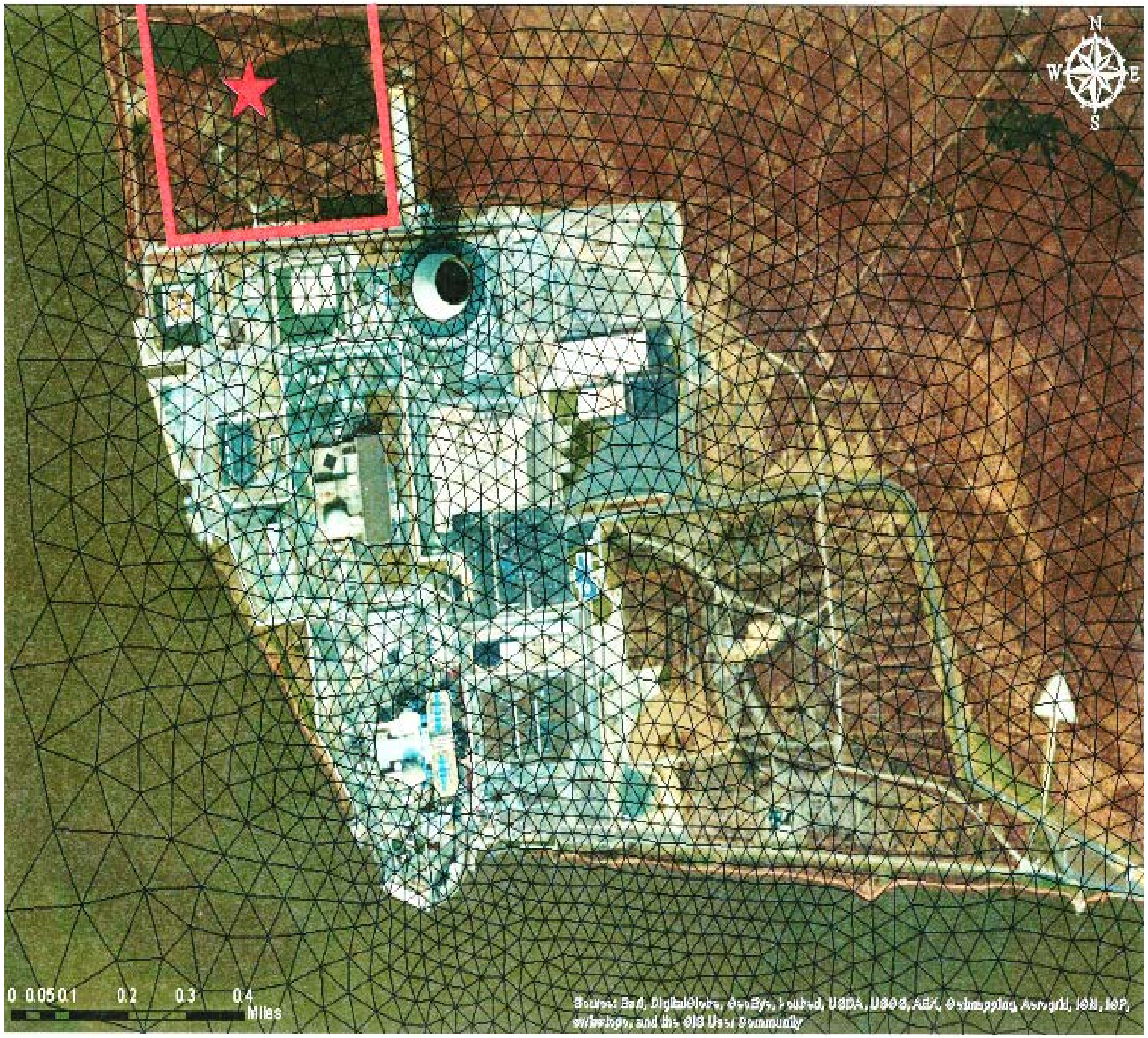
2.4.5 Probable Maximum Surge and Seiche Flooding (Cont.)

Use high resolution ADCIRC+SWAN Model to determine total design basis WSEL for the selected PMH storm

Finite element mesh refined at project site



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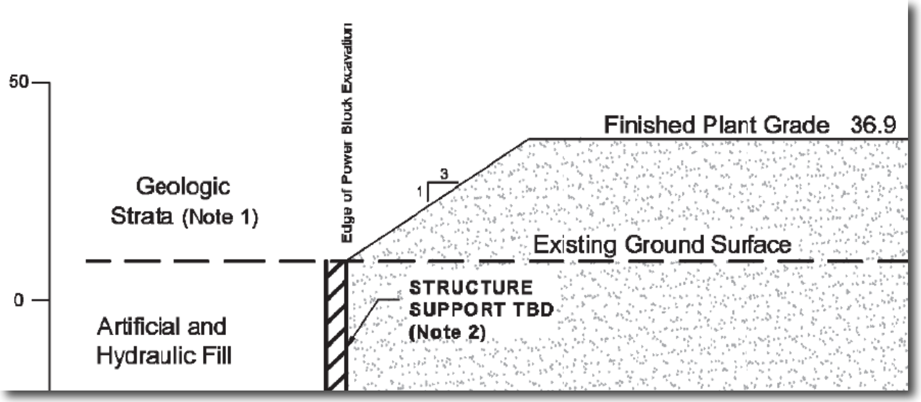
2.4.5 Probable Maximum Surge and Seiche Flooding (Cont.)

Wave runup determined using USACE Coastal Engineering Manual (CEM) Methodologies

Output from ADCIRC+SWAN Model evaluated at four points around powerblock



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2.4.5 Probable Maximum Surge and Seiche Flooding (Cont.)

PMH Maximum Total Water Surface Elevation

- 2-D ADCIRC+SWAN Model Results:
  - Antecedent Water Level 1.35 ft.
  - Maximum Still Water Level 20.2 ft. NAVD
  - Wave Runup 7.4 ft.
  - 10% Exceedance High Tide 4.5 ft.
  - Maximum Total Water Surface Elevation 32.1 ft. NAVD

Design Basis Flood Total WSEL is 32.1 ft. NAVD

2.4.10 Flooding Protection Requirements

- All safety-related SSC (with exception of intake structure) for new plant will be constructed at least one foot higher than DBF

- New plant site grade is established at 36.9 ft. NAVD. This meets requirements of a dry site as defined in NRC RG 1.102

- Riprap protection will be provided on the slopes of the site to provide protection from wave runup

Section 2.4.12 Groundwater and Section 2.4.13 Accidental Release of Radioactive Liquid Effluents

2.4.12 Groundwater

Regional Hydrogeology and Groundwater Use

- Regional hydrogeologic units are characterized as permeable coarse-grained materials separated by less permeable fine-grained materials within NJ Coastal Plain
- PSEG Site lies outside two Critical Water-Supply Management Areas designated in NJ
- PRM aquifer system (about 400 to over 1000 ft. below grade) provides majority of potable water for region and PSEG site
- Nearest off-site public water supply well is located more than 3.5 miles west of PSEG Site, across Delaware River, in DE

Regional Hydrogeology- Hydrostratigraphic Classification

Site Stratigraphic Unit	Hydrogeological Characteristics
Artificial & Hydraulic Fill	Leaky confining units.
Alluvium	Upper portion is a water-bearing zone; lower silts and clays, when present, act as a leaky confining unit.
Kirkwood Formation (upper)	Leaky confining unit.
Kirkwood Formation (lower)	Water-bearing zone; part of the Vincentown Aquifer.
Vincentown Formation	Water-bearing zone.
Hornerstown Formation (upper)	Upper portion is a water-bearing zone and part of the Vincentown Aquifer.
Hornerstown Formation (lower)	Lower portion, along with the Navesink Formation act as a leaky confining unit.
Navesink Formation	Leaky confining unit.
Mount Laurel Formation	Water-bearing zone, with the Wenonah Formation comprises the Wenonah-Mt. Laurel Aquifer.
Wenonah Formation	Water-bearing zone.
Marshalltown Formation	Confining unit.
Englishtown Formation	Water-bearing zone.
Woodbury Formation	Confining unit.
Merchantville Formation	Confining unit.
Magothy Formation	Water-bearing zone.
Raritan Formation	Confining unit.
Potomac Formation	Water Bearing Unit.

2.4.12 Groundwater (Cont.)

Local Hydrogeology and Groundwater Use

- The deeper PRM aquifer has sufficient capacity to provide potable groundwater to support new plant construction and future operations without inducing saline intrusion
- Investigations characterized shallower hydrogeologic units at new plant location to support construction and accidental release evaluations
- Shallow aquifers in vicinity of site are saline and tidally-influenced and not potable water sources
- In new plant area, predominant groundwater flow direction in shallower units (Alluvium and Vincentown aquifers) is westerly toward Delaware River

Local Hydrogeology

Average Groundwater Elevations (ft. NAVD) in Alluvium

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2.4.12 Groundwater (Cont.)

Site Groundwater Modeling

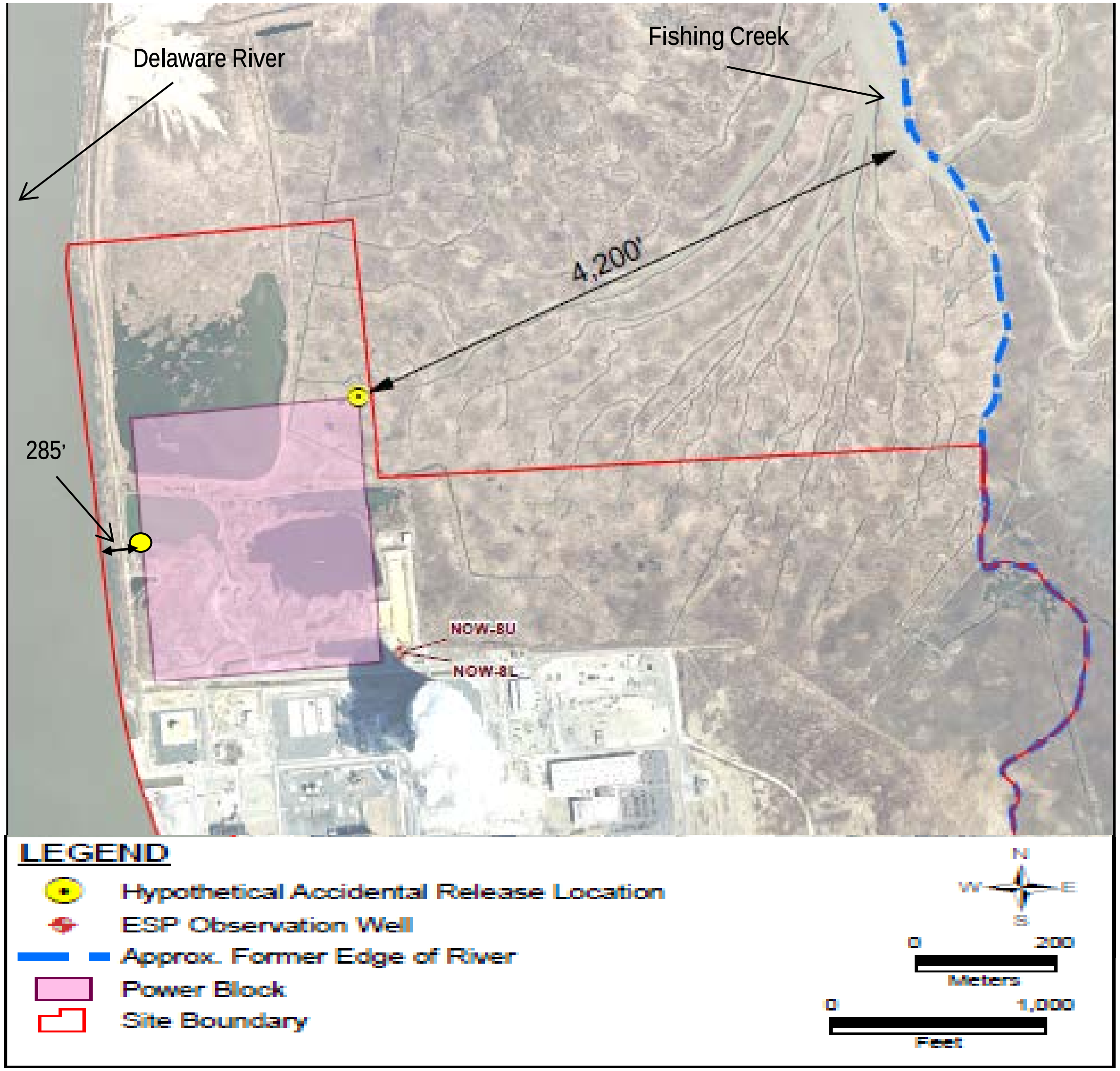
- Site-wide groundwater model developed, based on the PPE, to assess:
  - Dewatering requirements during construction
  - Effects of dewatering on shallow aquifers
  - Post-construction hydrostatic loading
- Site Groundwater modeling results:
  - Dewatering requirements consistent with HCGS construction
  - Groundwater levels in the shallow aquifer will return to a natural condition, which will be only slightly higher than preconstruction
  - Local mounding in shallow aquifers is possible due to soil retention wall placement
- Groundwater model will be refined once a reactor technology has been selected

Accidental Release in Groundwater

- Two accidental release locations are hypothesized at the edge of Power Block:
    - At western edge of Power Block assuming migration west toward the Delaware River
    - At northeast corner of Power Block, assuming migration northeast toward a Delaware River tributary named Fishing Creek
- Conservative hydrogeologic parameter values are used in the evaluation, as are minimum distances to two potential receptor locations
- Shortest transport pathway is taken as through shallowest unit (Alluvium)

2.4.13 Accidental Release of Radioactive Liquid Effluents in Groundwater and Surface Water (Cont.)

Accidental Release in Groundwater – Hypothetical Flow Paths



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Accidental Release in Groundwater

- Exposure point concentrations compared to Effluent Concentration Levels (ECLs) defined in 10 CFR Part 20
- Assuming maximum groundwater velocities, and solely advective transport with decay, some radionuclides would exceed ECLs for each release scenario
- Factoring in dilution results in levels up to several orders of magnitude below ECLs and Unity Rule is met for each release scenario

Accidental Release to Surface Water

- No potable surface water bodies located downgradient of the PSEG Site
- Outdoor tanks containing radionuclides will have secondary containment to prevent catastrophic release of liquid effluent directly to surface water
- Controlled release points will be established for systems that could be in contact with radioactive liquids to prevent unmonitored discharges to surface water