

In the Eye of the Hurricane:  
Super Storm Sandy  
PSEG Nuclear  
Preparations, Impacts and Lessons  
Learned

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# Salem and Hope Creek Generating Stations



# Forecast vs. Actual

• **Forecasts** on October 29th at 6 pm called for:

- Additional rainfall of another  $\frac{1}{4}$  -  $\frac{3}{4}$ "
- Winds through midnight will be sustained at 30-45 mph with gusts of 45-65 mph
- Overnight winds will be sustained at 15-30 mph with gusts of 30-50 mph
- Storm surge will be 3-6' and will peak around midnight. Storm surge should recede by mid morning

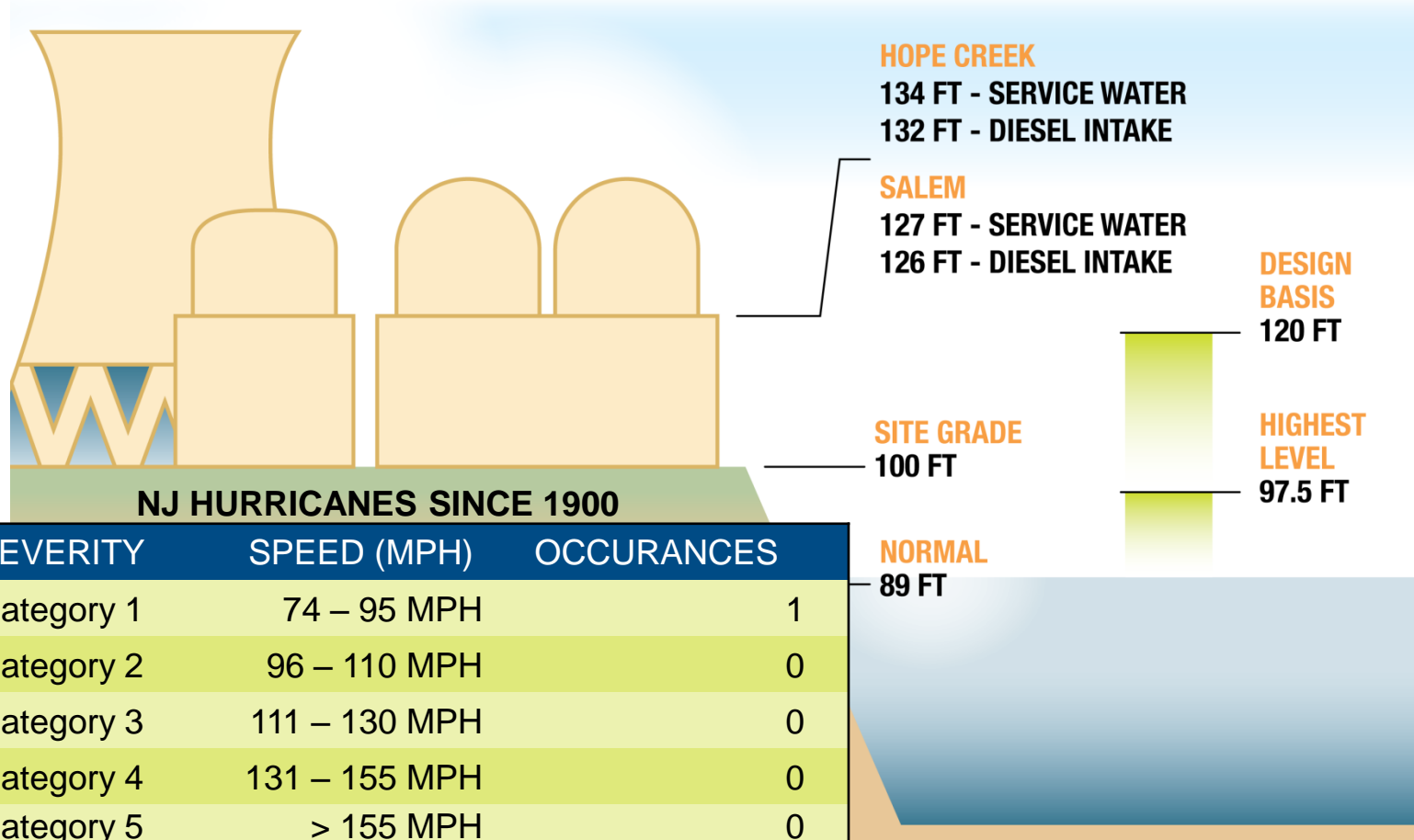
# Forecast vs. Actual

- **Actual** weather from landfall at 8 pm through the early morning
  - Rainfall was consistent with forecast
  - Winds through the evening were 40-60 mph with gusts upon landfall of up to 90 mph
  - Winds were sustained through the night precluding storm restoration to begin until 7 am
  - Storm surge ranged from 11-13.6', causing widespread flooding and devastation to the region

# PSEG Nuclear Unit Status

- Hope Creek - 100% Rated Thermal Power
- Salem Unit 1- 100% Rated Thermal Power
- Salem Unit 2 (two days prior to Sandy's arrival):
  - Defueled, Full Core offload, in Spent Fuel Pool
  - Defueled Mid Loop
  - Single Source of Off-site power
  - Major Equipment OOS
    - 2B Emergency Diesel Generator, 2B Vital Bus OOS
    - 2B 125V DC batteries
    - 21 SW Nuclear Header

# Salem and Hope Creek Flood Design



# Salem and Hope Creek Shutdown Criteria

- IF AT ANY TIME the river level is  $>98.5$  ft, THEN INITIATE actions to place the Unit in Mode 3 within 6 hours and in Mode 5 within the next 30 hours.
- IF hurricane force winds are imminent, THEN **INITIATE** preparations such that the Unit is in Hot Standby (Mode 3) at least two hours prior to the projected arrival of hurricane force winds.

# Salem and Hope Creek Emergency Action Levels (EALs)

- Unusual Event (UE)
  - Delaware River level reaches 99.5 feet at Salem units, 99.5 feet at Hope Creek
  - Average Wind Speed >95 mph for any elevation
- Alert – Escalation with UE conditions
  - Visible damage to Safety Related Structures



# Implementation of Severe Weather Guidelines – Phase 1 (T-3)

- Operations
  - Inspect station blackout equipment
  - Verify remote shutdown panel communications
  - Indication and switch alignment
  - Hope Creek blockhouse sump pump staged

# Implementation of Severe Weather Guidelines – Phase 1 (T-3)

- Maintenance
  - Protect spare equipment required for recovery
  - Inspect/remove/secure outside areas for potential missiles
  - Staging of sump pumps and sandbags
  - Availability of emergency supplies like flashlights, potable water, etc.

# Implementation of Severe Weather Guidelines - Phase 2 (T-2)

- Site walkdowns
- Verifying water tight doors
- Emergency diesel generator availability
- Return Major Plant Equipment for Shutdown Safety
- Ensuring water intakes prepared for severe weather
- Address potential staffing requirement

# Staffing requirements

Only essential personnel req'd to report

- Specific responders from two ERO teams
- Operations Support Center (OSCs)
- Technical Support Center (TSC)
- Emergency Operations Facility (EOF)

# Implementation of Severe Weather Guidelines - Phase 3 (T-0)

- Close watertight doors
- Relocate personnel
- Implement preplanned sandbagging
- Relocate vehicles to shelter
- Establish Fire Protection command post
- Complete various Service Water Bay penetration repairs

# Superstorm Sandy impacts

- Hope Creek - Remained at 100%, HC output greater than demand on PJM
- Salem Unit 1 manually taken offline at 1:09 am (5 day forced outage)
  - Four of the six circulating water pumps no longer available
  - Heavy debris, waves resulted in Travelling water screens stopping
- Non-vital Switching Station lost due to water intrusion
  - Loss of power to several buildings onsite
  - Lost onsite intranet, phones, met tower data to Salem control rooms

# Staffing Requirements

- Suspended Salem Unit 2 refueling outage activities on Sunday evening, October 28
  - All equipment, except SW header, returned to Operations
  - Reactor Cavity flooded up to Refueling level for defense in depth
  - All contractors left site that weekend
  - First time in operating history to suspended refueling outage

# Superstorm Sandy Lessons Learned

- Equipment Issues / Storm Preparations
  - Substation enclosures are susceptible to water intrusion
  - Lack of outage contingencies for loss of building capabilities
  - Lack of adequate sleeping arrangements for essential personnel.
  - Access road monitoring and shoring – extra fill / seawall



# Lessons Learned – Root Cause

- Abnormal Procedure Guidance
  - Inadequate severe weather guidance in Abnormal procedure for wind speed, direction, grassing levels, tide, etc.
  - Decision Making on unit power did not account for wave action effects
  - Severe Weather Guide – No single designated information source for decision-making

# Lessons Learned – Corrective actions

- Previous Shutdown Criteria
  - IF AT ANY TIME river level is >98.5 ft...
    - Maximum Tide was 97.2 feet
  - IF hurricane force winds are imminent...
    - Maximum average wind speed was 59 miles per hour
    - Wind direction shifted 180° in four hours directed at CWIS

# Lessons Learned – Corrective actions

- New Shutdown Criteria
  - CW intake degradation index
    - Uses grassing, tide, wind speed and direction
    - Guidance to shutdown as a composite
  - If hurricane is to pass within 50 miles of site - shutdown