NRC/PSEG Public Meeting

Hazards Evaluations and Probable Maximum Flood Determination

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Aircraft Hazards Analysis

NRC Public Meeting

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Agenda

- Regulatory Drivers
- PSEG Site
- Discussion of FAA Data
- Approach and Assumption of Aircraft Analysis
- Summary

Regulatory Drivers

NRC Regulations

- 10 CFR 100.20, Factors to be Considered when Evaluating Sites.
- 10 CFR 100.21, Non-Seismic Siting Criteria.
- 10 CFR 52.17, Contents of Applications, Technical Information.

NRC Guidance

- Regulatory Guide 1.206, C.I.3.5.1.6.
- NUREG-0800, SRP 3.5.1.6.

Regulatory Guide 1.206 and SRP 3.5.1.6

An aircraft hazards analysis is required for each of the following:

- All airports located within 8.05 km (5 statute miles)
- Airports with projected operations greater than:
  - $193d^2$ ($500d^2$) movements per year located within 16.10 km (10 statute miles)
  - $386d^2$ ($1000d^2$) outside 16.10 km (10 statute miles)
- Federal holding patterns or approach patterns within 3.22 km (2 miles)
- Military installations or any airspace usage that might present a hazard to the site (for some uses, such as practice bombing ranges, it may be necessary to evaluate uses as far as 32.19 km (20 statute miles) from the site).

Regulatory Guide 1.206 and SRP 3.5.1.6 (cont'd)

- Federal airways within 3.22 km (2 miles)

SRP 3.5.1.6 further requires an aircraft hazards analysis for:

- The plant is at least 5 statute miles from the nearest edge of military training routes, including low-level training routes, except for those associated with usage greater than 1000 flights per year, or where activities (such as practice bombing) may create an unusual stress situation.

PSEG Site

- No airports within 5 miles of PSEG Site.
- Airport operations criteria is not exceeded.
- No holding or approach patterns within 2 miles of the site (Closest approach pattern is 4.3 miles from PSEG Site).
- Dover Air Force Base 23.8 miles away.
- Nearest edge of military training routes not within 5 miles (VR1709, 36.7 miles from PSEG Site).

PSEG Site (cont'd)

- Airways – There are four airways where the edge of the airway is within 2 miles of the PSEG Site:
  - V123-312
  - V29
  - J42-150
  - V157

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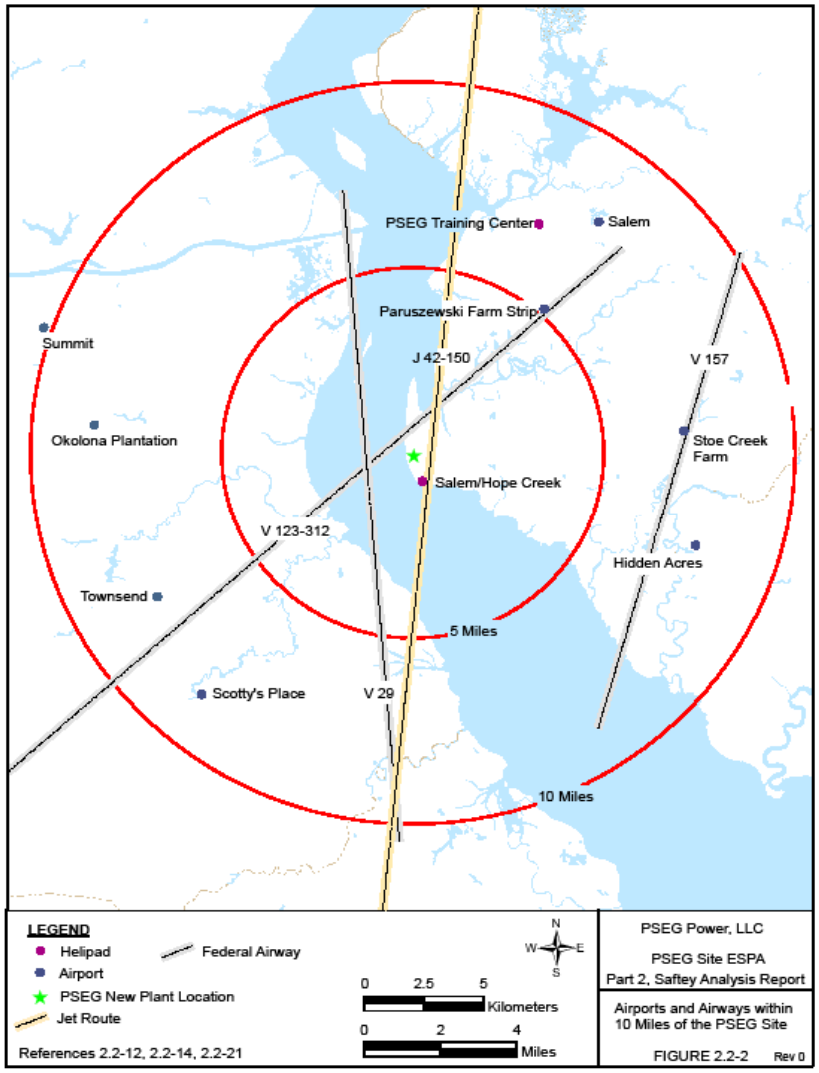
PSEG Site (cont'd)

Width of airway:

- V – route 8 nautical miles (9.2 statute miles)
- J – route 10 nautical miles (11.5 statute miles)



FAA Data

Requested the following data from FAA April 28, 2009:

- Number of operations per year with aircraft types (i.e., general, military, and commercial)
  - Flight plan data files and Radar hit data (lat/long/altitude) on the following airways:
    - V123-312
    - V29
    - V157
    - J42-150
- Confirmation that the number of flights per year on Military Route VR1709 does not exceed 1000.

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FAA data received August 13, 2009

- Flight plan data was not complete
  - Airway V123-312 had only 42 flights
  - Airway J42-150 had less than 200 flights.
  - This was discussed with the FAA
- Radar hit data (within 20 nautical miles of the proposed plant location) could not be sorted into separate airways due to the close proximity.
- Unable to provide data on military operations because the Enhanced Traffic Management System (ETMS) database filters out the military aircraft.

Options for Approach to Aircraft Hazards Analysis

- Option 1 – Use the SRP 3.5.1.6 methodology to calculate probability per year of an aircraft crashing into a plant.
- Option 2 – Use Hope Creek probability of crash and increase probability for growth in air traffic.
- Option 3 – Use the methodology in DOE Standard DOE-STD-3014-96, "Accident Analysis for Aircraft Crash into Hazardous Facilities" for determination of crash probabilities.

Note: For Options 1 and 3 the DOE Standard DOE-STD-3014-96 is used to calculate the effective area of the seismic Category I structures

Option 1 – SRP Methodology

- Use the methodology in SRP 3.5.1.6 to calculate probability per year of an aircraft crashing into a plant.
  - Option 1A – Use FAA data
  - Option 1B – Use Hope Creek UFSAR Table 3.5-8 annual flight data and adjust for growth of airway traffic

Approach and Assumption of Aircraft Analysis (cont'd)

Option 1 – SRP Methodology (cont'd)

- SRP 3.5.1.6 calculation

  Item III.2 of SRP 3.5.1.6 provides the following formula for calculation of probability of crash into plant from an airway:

$$P_{FA} = C \times N \times \frac{A}{W}$$

P_{FA} = Probability of crash from the airway on the plant per year

C = in-flight crash rate per mile for aircraft type using the airway

C = 4E-10 per aircraft mile for commercial aircraft.

No guidance for other types (i.e., general and military)

N = number of flights per year along the airway.

W = width of airway (plus twice the distance from the airway edge to the site when the site is outside the airway) in miles.

A = effective area of plant in square miles.

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Option 1 – SRP Methodology (cont'd)

- Issues with this methodology
  - Option 1A
    - N-value for each airway can't be determined
    - N-value for military aircraft can't be determined
    - C-value for military and general aviation aircraft not provided.
  - Option 1B
    - Growth rate for air traffic data not available (civilian and military)
    - C-value for military and general aviation aircraft not provided.

Approach and Assumption of Aircraft Analysis (cont'd)

Option 1 – SRP Methodology (cont'd)

- ESP or COL applicants that used this methodology
  - North Anna ESPA
    - Airway annual flight operations data available.
  - Vogtle ESPA
    - Did not have airway annual flight operations data, used Augusta Airport annual operations data as proxy for airway traffic data.
  - Clinton ESPA
    - Clinton Power Station FSAR flight data projected for increased air traffic.
  - STP 3 & 4 and V. C. Summer 2 & 3 COLAs
    - Did not have airway annual flight operations data, used local airport annual operations data as proxy for airway traffic data.

Option 2 – Hope Creek Methodology.

- Use Hope Creek probability of crash and increase probability for growth in air traffic.
- Issues with this methodology
  - Growth rate for flight data not available
  - Methodology for determining probability has changed since Hope Creek was licensed.

Option 3 – DOE Methodology

- Use the methodology in DOE-STD-3014-96, to calculate crash probabilities
- DOE standard provides values for crashes per square mile per year for different aircraft types for specific DOE facilities around the country and an average for the continental U. S.
- We plan to use the continental U. S. average.
- COL applicants that used this methodology
  - Bell Bend COLA
    - Continental US average for crash probabilities by aircraft type.
  - Calvert Cliffs COLA
    - Continental US average for crash probabilities by aircraft type.

Summary

Detailed Flight Data Unavailable

Alternate Calculation Method Employed

- DOE Standard DOE-STD-3014-96
- CONUS Average
- Acceptable Method to Determine Aircraft Crash Probability

Consequences Determined from Technology Specific Evaluation

Waterborne Hazards on the Delaware River

NRC Public Meeting

Tuesday, December 8, 2009

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Outline

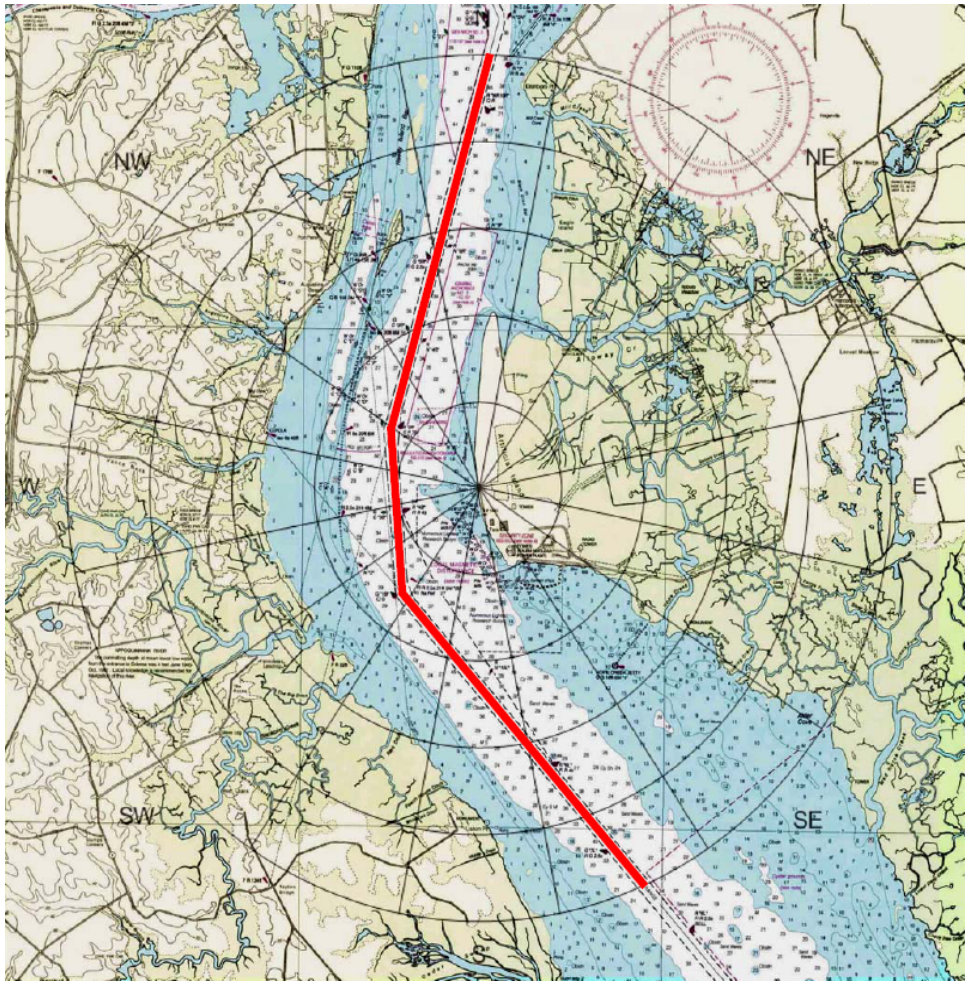
Challenges

Regulatory Guidance

Approach

Results of Analysis

Conclusions



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Incomplete vessel data sources

- Several partial data sets
  - Specific chemicals are unknown
  - Number of trips of each chemical are unknown

SRP Section 2.2 (NUREG-0800), Reg. Guide 1.70 used to identify hazards

Reg. Guide 1.91 (Explosive Chemicals)

- Also has probability equation: $r = n \cdot f \cdot s$
  - r = exposure rate, n = explosion rate, f = frequency of shipment, s = exposure distance

Reg. Guide 1.78 (Toxic Chemicals)

- Used with NUREG-0570 for dispersion, used to determine if concentration at site is explosive

Acceptance Criteria for Analysis

Deterministic Analysis

- Pressure at site safety related buildings < 1 psid
- Concentration of vapor cloud < LEL
- Concentration in control room < IDLH
  - Control room habitability analysis performed for COLA
- Wall temperature increase from a fire < 200ºF

Probabilistic Analysis

- Rate of hazards < 10^{-6} hazards per year with conservative estimates
  - A hazard is a condition where a deterministic criteria is exceeded

Available Vessel Data Sources

U.S. Coast Guard (2001-07)

- MISLE Database includes vessel accidents, commodity, spill size, if incident caused fire/explosion
- Only includes spills, **no shipment data**

Army Corps of Engineers (2003-07)

- Total tonnage, Registered Tonnage of boats by 4-digit commodity
- **Does not have number of shipments** of each chemical

Maritime Exchange for Delaware River & Bay (2003-09)

- Specific vessels: 2-digit commodity tonnage
- **Not all shipments identified** (compared with USACE)

USACE Example Data

Shipments of "Benzene & Toluene" in 2003

- Foreign vessels not binned by vessel dimensions
- 271,440 tons not transported on one vessel

DIRECTION	TTYPE	VTYPE	REG TONS	CAP TONS	OVER LENGTH	OVER BREADTH	ACTUAL DRAFT	LOAD DRAFT	LIGHT DRAFT	H_F POINT	CONTAIN ERIZED	PUB GROUP	TONS
Downbound	**Foreign**	**02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3212**	**65478**
Upbound	**Foreign**	**01**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**3212**	**49**
Downbound	**Foreign**	**01**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**3212**	**17**
Upbound	Foreign	02	0	0	0	0	0	0	0	0	0	3212	271440
Downbound	**Domestic**	**05**	**3146**	**9438**	**320**	**66**	**17**	**21**	**3**	**38**	**0**	**3212**	**5266**
Downbound	**Domestic**	**02**	**15701**	**51869**	**699.8**	**99.1**	**28**	**37.9**	**22**	**142**	**0**	**3212**	**10352**
Downbound	**Domestic**	**02**	**15701**	**51869**	**699.8**	**99.1**	**25**	**37.9**	**22**	**142**	**0**	**3212**	**5949**

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Types of Hazards

Vapor Cloud Explosions

Solid Material Explosions

Liquid / Vapor Explosions

Fires

Toxic Vapor Clouds

Chemical Vapor Cloud Explosions (VCE)

Liquid or gaseous chemical release disperses as wind blows toward the site

- If above the LEL near an ignition source, explosion could occur

Mitigating factors:

- Plume meander (Reg. Guide 1.145)
- Plume rise – unconfined vapor clouds will not explode per NUREG-0014, the SER for Hartsfield Nuclear Plants (SRP 2.2.1-2.2.2)

VCE Probabilistic Analysis – Probability Equation

Step 1: Determine hazard of single vessel

- $R_{haz} = P_{spill} \cdot R_{accident} \cdot P_{weather} \cdot D_{trip}$
  - R_{haz} = Rate of hazards per vessel trip
  - P_{spill} = Probability of spill, dependent on amount released (spills/accident)
  - $R_{accident}$ = Rate of vessel accidents per mile
  - $P_{weather}$ = Adverse wind direction probability (hazardous conditions at the site/spill)
  - D_{trip} = Hazardous vessel miles per trip

Step 2: Determine allowable number of trips

- $T_{allowable} = 10^{-6} / R_{haz}$
  - Estimated trips must be less than allowable trips

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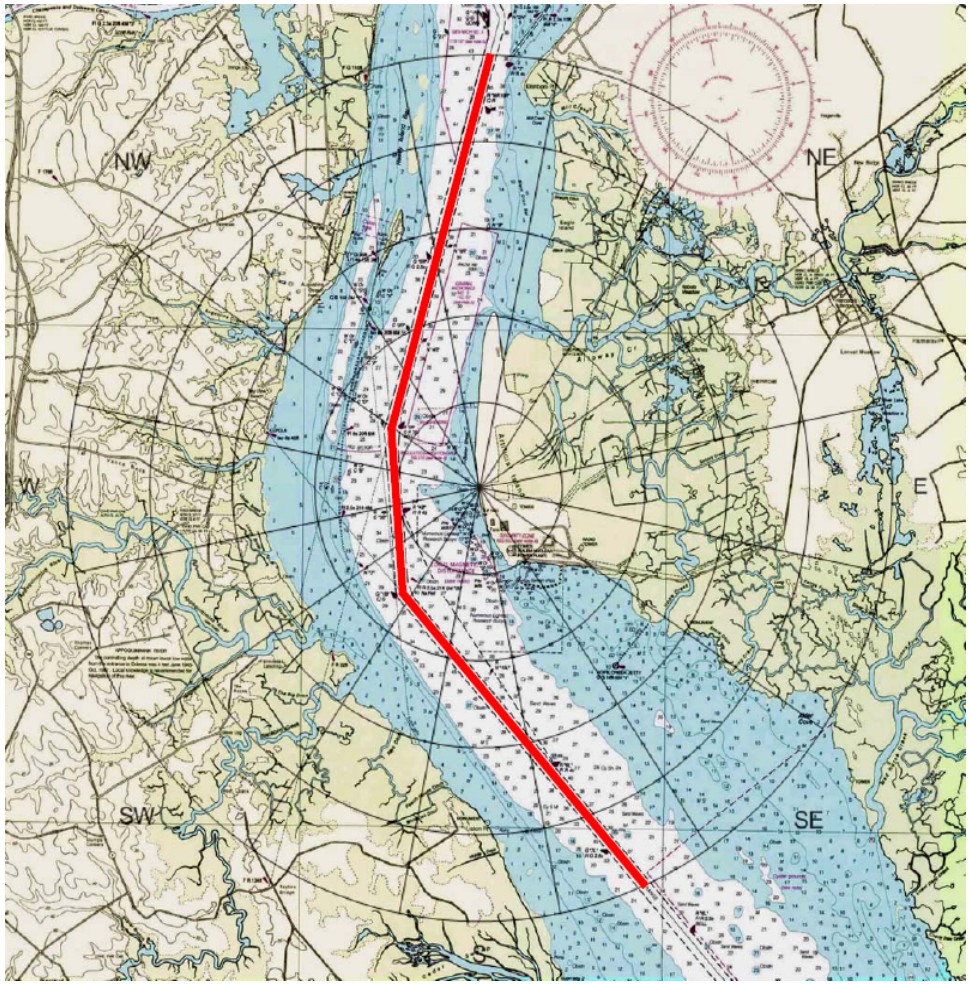
Spill and Accident Rate for VCE Analysis

U.S. Coast Guard MISLE Database

- Used for conditional spill size probability
- Multiplied by vessel incident rate 1.8×10^{-6} per mile
  - From NUREG/CR-6624

Spill Size	Occurrences	Probability	Spills per Vessel Mile
0-100 gallons	9260	0.9341	1.68×10^{-6}
100-1000 gallons	494	0.0498	8.97×10^{-8}
1000-2000 gallons	58	0.0059	1.05×10^{-8}
2000-10,000 gallons	61	0.0062	1.11×10^{-8}
10,000-50,000 gallons	27	0.0027	4.90×10^{-9}
50,000-322,000 gallons	12	0.0012	2.18×10^{-9}
>322,000 gallons	1	0.0001	1.82×10^{-10}
All Spills	9913	1	1.8×10^{-6}

Wind Direction and Trip Length for VCE Analysis



- Case is spill size, wind speed, stability class
- Deterministic model determines standoff distance
- Only wind from spill to site can be hazardous
- Direction probability from ESPA Section 2.3
- Miles within standoff distance are trip length

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Sample Results for Propane VCE

Spill Volume (gallons)	Weather (Stability)	Standoff Miles	Trip Length	Directions	Worst Direction	Worst Direction Frequency	Spill Rate	Total Hazard
2,000	G	<0.9	0	-	-	0	1.05E-08	0
10,000	G	1.8	4	S-NNW	S	0.51%	1.11E-08	2.26E-10
10,000	F	1.1	1.2	WSW-WNW	WSW	0.69%	1.11E-08	9.19E-11
10,000	E	<0.9	0	-	-	0	1.11E-08	0
50,000	G	3.4	7.7	SSE-N	N	0.69%	4.90E-09	2.60E-10
50,000	F	2.0	4.3	S-NNW	NNW	1.17%	4.90E-09	2.47E-10
50,000	E	1.2	1.7	SW-NW	NW	4.14%	4.90E-09	3.45E-10
322,000	G	5.0	11	SSE-N	N	0.69%	2.18E-09	1.65E-10
322,000	F	4.3	9.7	SSE-N	N	1.19%	2.18E-09	2.52E-10
322,000	E	2.5	5.5	S-NNW	NW	4.14%	2.18E-09	4.96E-10
322,000	D	1.7	3.8	SSW-NNW	NW	2.63%	2.18E-09	2.18E-10
322,000	C	<0.9	0	-	-	0	2.18E-09	0
>322,000	All	5.0	11	SSE-N	NW	10.79%	1.82E-10	2.16E-10
						Total		2.52E-09
						Allowable Shipments		397

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VCE Analysis: Allowable Number of Trips

Each chemical analyzed similar to propane

- Propane is most bounding VCE

Chemical	Allowable Number of Trips
Propane	**397**
Gasoline	**3753**
Benzene	**9131**
Ammonia	**4629**
Naphtha	**3753**
Methane	**708**
Acetone	**3753**
Vinyl Chloride	**520**

Estimated Number of Trips

Estimated number of trips must be less than allowable number of trips

Bounding chemicals selected for each commodity (USACE)

- Propane is bounding for explosions of acyclic hydrocarbons, petro. prod. NEC, unknown...
- Total tons for all “propane” commodities used

Transported Commodities and Bounding Chemicals

USACE 4 Digit Commodity	Chemical Analyzed for each Types of Hazard
Acyclic Hydrocarbons	Propane for both VCE and toxicity
Alcohols	Methanol and ethanol for both VCE and toxicity
Ammonia	Ammonia for both VCE and toxicity
Benzene & Toluene	Benzene for both VCE and toxicity
Carboxylic Acids	Acetic acid for VCE, formic acid for toxicity
Chem. Products NEC	Ammonia for both VCE and toxicity
Chemical Additives	No hazard – Low vapor pressure
Explosives	TNT for a stationary explosion
Fert. & Mixes NEC	Ammonium nitrate for a stationary explosion
Gasoline	Gasoline for both VCE and toxicity
Hydrocarbon & Petrol Gases, Liquefied and Gaseous	Methane for both VCE and toxicity
Inorganic Chem. NEC	Ammonium nitrate for a stationary explosion, hydrogen peroxide for toxicity
Naphtha & Solvents	Naphtha for both VCE and toxicity
Nitrogen Func. Comp.	Ammonium nitrate for a stationary explosion, ammonia for both VCE and toxicity
Nitrogenous Fert.	Ammonium nitrate for a stationary explosion
Ordnance & Access.	TNT for a stationary explosion
Organic Comp. NEC	Acetone for both VCE and toxicity
Organo - Inorg. Comp.	Propane for a VCE, ammonia for toxicity
Other Hydrocarbons	Vinyl chloride for a VCE, ethylene dichloride for toxicity
Pesticides	Herbicide and insecticide for toxicity
Petro. Products NEC	Propane for both VCE and toxicity
Unknown or NEC	Propane for a VCE, ammonia for toxicity

USACE 4 digit commodities listed are potentially hazardous

- Navigation Data Center User's Guide shows chemicals in each commodity
- If unknown, propane used for explosion, ammonia used for toxicity

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VCE Analysis: Estimated Number of Trips

USACE & Maritime Exchange data used for average & minimum shipment size (2003-07)

- Minimum shipment used (except propane & gasoline)

Chemical	USACE Maximum Total Tons per Year	USACE Average Reg Tons	USACE Minimum Reg Tons	Maritime Exchange Average Shipment Tons	Maritime Exchange Minimum Shipment Tons	Tons per Vessel Used in this Analysis	Estimated Number of Trips
Propane	**514,839**	**7238**	**2307**	**7592**	**1269**	**4000**	**129**
Gasoline	**4,044,285**	**5062**	**614**	**14,922**	**10,400**	**4000**	**1102**
Benzene	**358,551**	**10,424**	823	**5234**	**2351**	**800**	**449**
Ammonia	**140,636**	**9035**	**4272**	**8109**	829	**800**	**176**
Naphtha	**731,221**	**5375**	1347	**11,280**	**4527**	**1000**	**732**
Methane	**398,585**	**1999**	1999	**-**	**-**	**1000**	**399**
Acetone	**1,102,373**	**15,276**	**8815**	**7512**	829	**800**	**1378**
Vinyl Chloride	**182,955**	**11,411**	1922	**-**	**-**	**1900**	**97**

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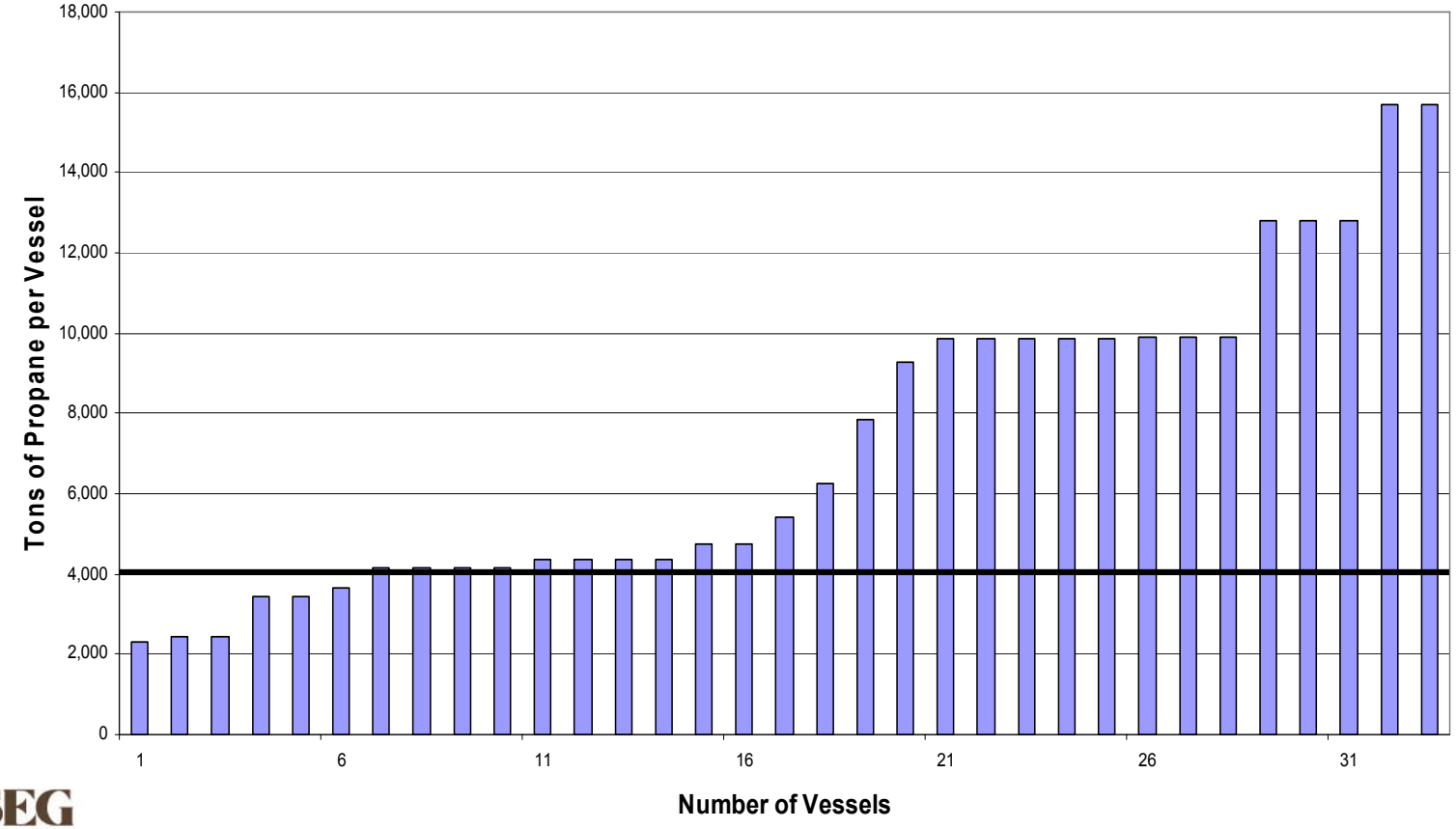
Propane Vessel Size

Plot of vessels in Maritime Exchange data shows two common vessel sizes, 4,000 tons & 10,000 tons

- 4,000 tons of propane used as min. ship size



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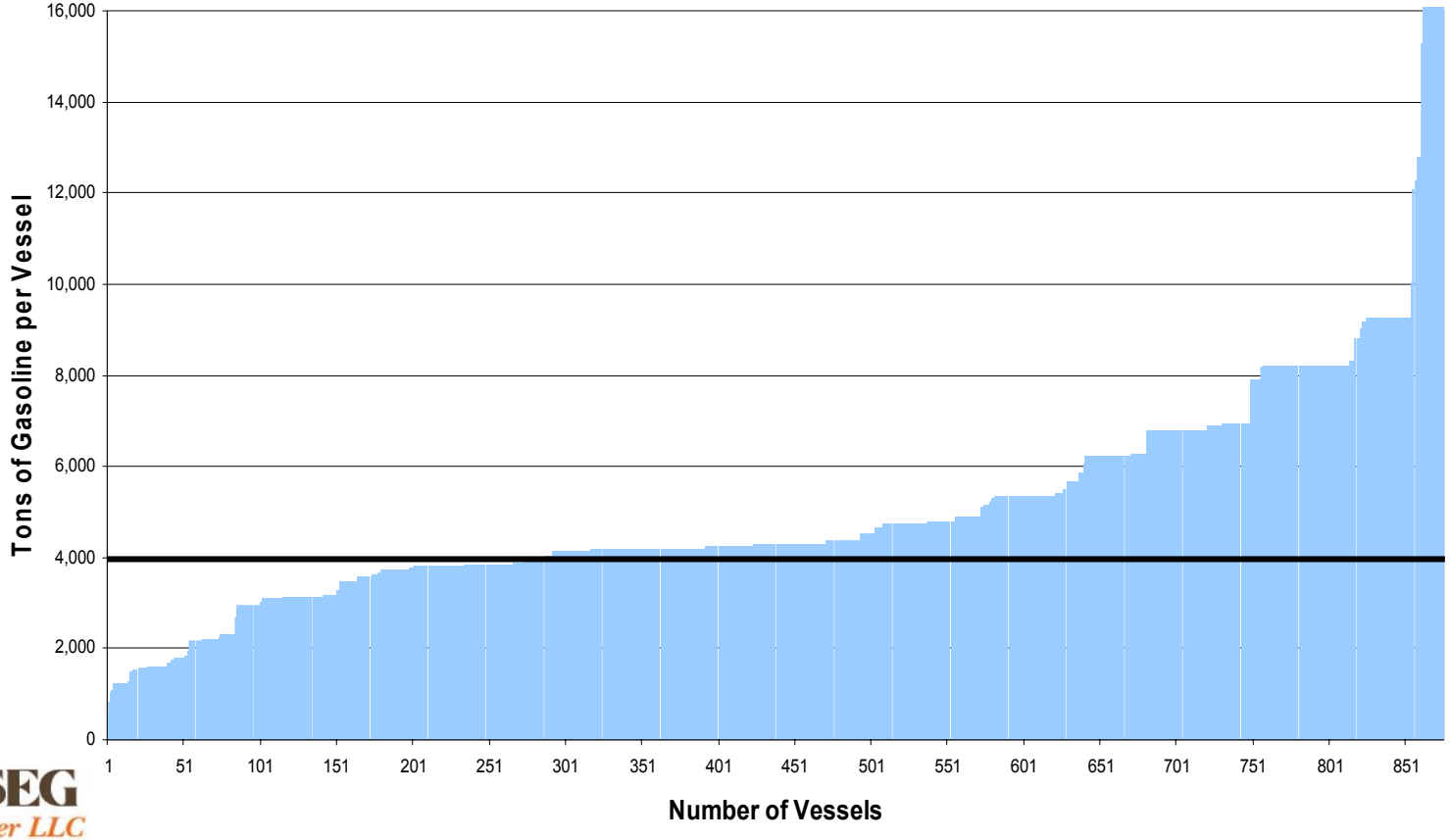
Gasoline Vessel Size

Plot of vessels in Maritime Exchange data shows most vessels around 4,000 tons

- Valero Refinery reported typical shipment ~6,000 tons
- 4,000 tons of gasoline used as min. ship size



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Chemical Vapor Cloud Explosions - Conclusion

Conservative input used to determine allowable shipments

Existing data used to determine estimated number of shipments

Chemical	Allowable Number of Trips	Estimated Number of Trips
Propane	**397**	**129**
Gasoline	**3753**	**1102**
Benzene	**9131**	**449**
Ammonia	**4629**	**176**
Naphtha	**3753**	**732**
Methane	**708**	**399**
Acetone	**3753**	**1378**
Vinyl Chloride	**520**	**97**

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Solid Chemical Explosions

Largest explosions on vessels: Texas City Disaster (1947), Halifax Explosion (1917)

- Both involved ~2300 tons of solid explosive

Ammonium Nitrate and Explosives/ Ordinance are most likely shipped

Probability used with a maximum solid explosion size of 2500 tons

Solid Chemical Explosions

Standoff distance for 2500 tons of explosive is 1.46 miles → 2.5 miles of waterway

From MISLE data, 0.01 explosions per spill

From NUREG/CR-6624, 1.8×10^{-6} incidents per mile and 0.025 spills per incident

Hazards per trip = $2.5 \times 0.01 \times 1.8 \times 10^{-6} \times 0.025$

Hazards per trip = 1.125×10^{-9}

Allowable number of trips = $10^{-6} / 1.125 \times 10^{-9}$

A total of 888 allowable trips per year

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Solid Chemical Explosions

Allowable mass @ closest approach (0.9 mi) = 589 tons (shipments smaller than 589 tons are acceptable)

- 888 trips/year x 589 tons/trip= 523,032 tons per year (total allowable mass)

Per USACE (2003-07)

- Largest total annual amount of explosives/ordinance = 610 tons/year
- Largest total annual amount of ammonium nitrate or other fertilizers = 165,412 tons/year

Solid explosives are acceptable

Liquid / Vapor Chemical Explosions

Largest explosion in MISLE is Bow Mariner

- MTBE vapor, equivalent of 116 tons of TNT
- Ethyl Alcohol from adjacent tanks did not explode
- An explosion up to 6 times greater is acceptable using deterministic only

Liquids/vapors much less explosive than solids

- Chemical vapors more likely to explode than liquids

Chemical Fires

Three types of fires

- BLEVE Fireball - Short duration, high heat load
- Pool Fire - Long duration, low heat load
- Jet Fire - Medium duration, medium heat load

ACI Standard: a concrete wall can tolerate a short term increase of 200ºF

ALOHA used

- 5,000 ton release, temperature rise of 173ºF
- 322,000 gal (655 tons) release temperature rise of 37ºF
  - 322,000 gal is second largest release reported in MISLE

Conclusions

Vapor cloud explosions

- Estimated number of trips per year, based on conservative use of existing data < Allowable trips using probabilistic & deterministic analyses

Solid explosions

- Actual yearly tonnage < Allowable yearly tonnage using probabilistic & deterministic analysis

Liquid/vapor explosion

- Overpressure at 6x the largest historical release < 1 psid

Fire

- Maximum temperature increase < 200ºF

Determination of Design Water Level Associated with the Probable Maximum Hurricane Surge

NRC Public Meeting

Tuesday, December 8, 2009

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Regulatory Requirements: 10 CFR 50 Appendix A

Criterion 2—Design bases for protection against natural phenomena.

Structures, systems, and components **important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect:**

(1) Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated,

(2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena and

(3) the importance of the safety functions to be performed.

Determination of Probable Maximum Surge Flooding

Per Regulatory Guide 1.59 and ANS2.8 – Consider combined effects of:

- Surge from the Open Coast
- Propagated to the site
- With Coincident 10% exceedance High Tide
- With Coincident wind setup

= PMS Stillwater Level

- PMS Stillwater Level
- With Coincident Wave Runup
- With Sea Level Rise

= Design Water Level

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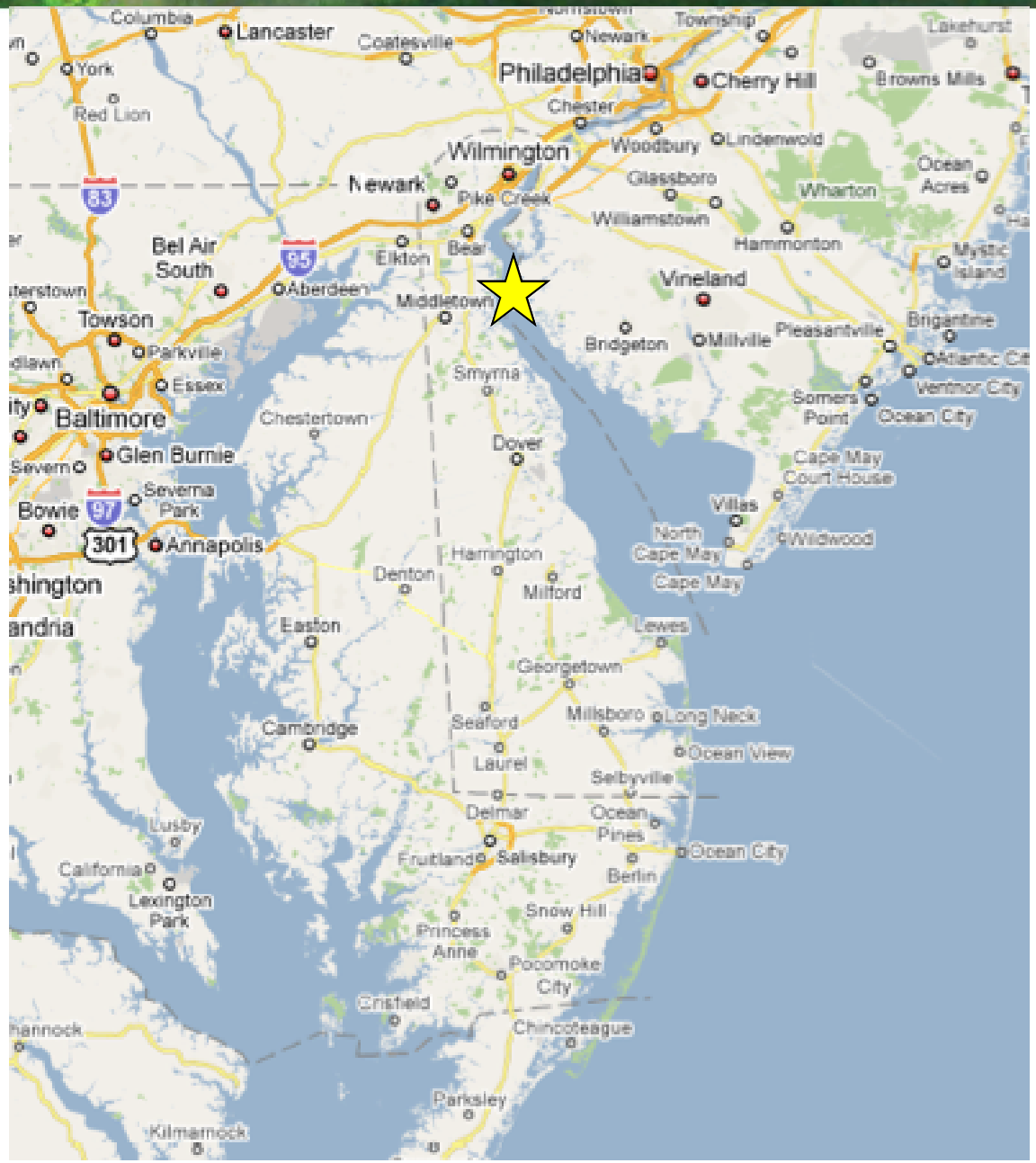
Site Location Relative to Delaware River and Bay



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Begin with the Maximum Surge at the Open Coast

Analysis starts with large scale processes and proceeds sequentially to processes operating locally at the site

1. **Surge at open coast (scale ≈ 500 n.mi)**

Storms That Produced Significant Surges in Delaware Bay					
Name	Year	Category	Nearest Approach to Site (n.mi)	Surge at Mouth (ft)	Surge at Philadelphia (ft)
Unnamed	1933	1	70	3.8	7.1
Hazel	1954	4	98	NA	9.4
Connie	1955	4	98	NA	5.0
Floyd	1999	1	70	2.6	4.0
Isabel	2000	1	163	3.1	5.4

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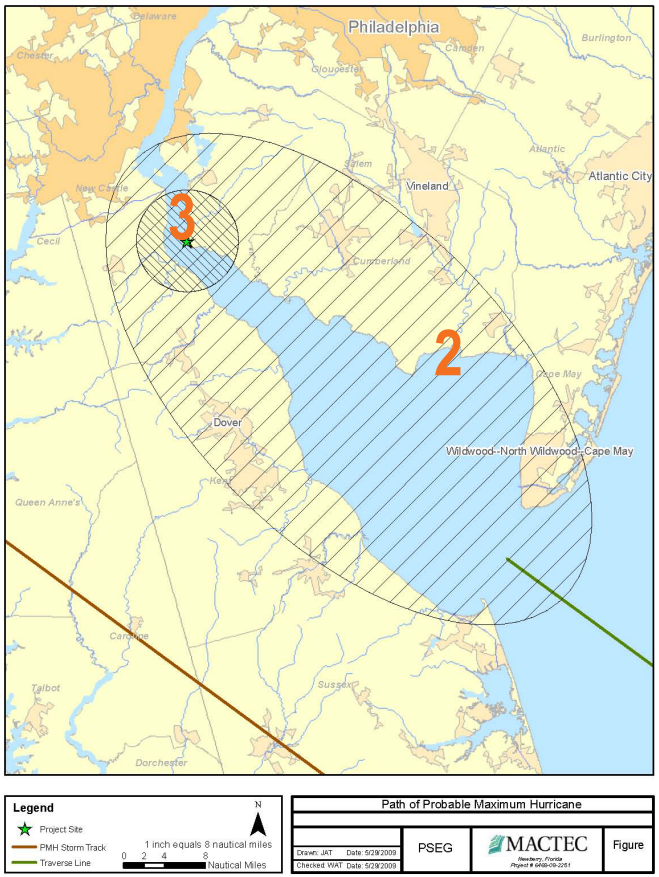
Move from the Open Coast to the Impact at the Site

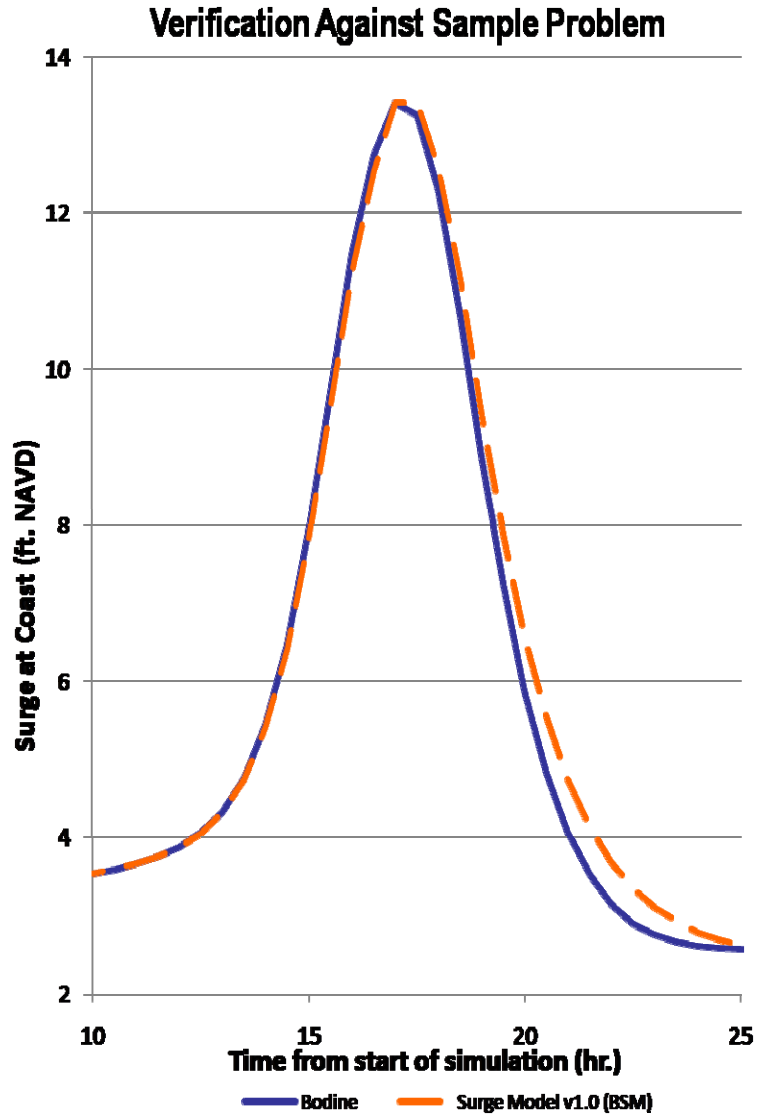
Analysis starts with large scale processes and proceeds sequentially to processes operating locally at the site

1. Surge at open coast (scale ≈ 500 n.mi)
2. Propagation of surge and setup of Delaware Bay (scale ≈ 50 n.mi)
3. Wave Runup (scale ≈ 5 n.mi.)



Determination of Surge at Open Coast

- Method of Bodine (1971)
  - Cited in RG 1.59 and ANS 2.8
  - Used for South Texas Project COL
- Verified against Bodine sample problem
- Compared to SLOSH Display Model and RG 1.59



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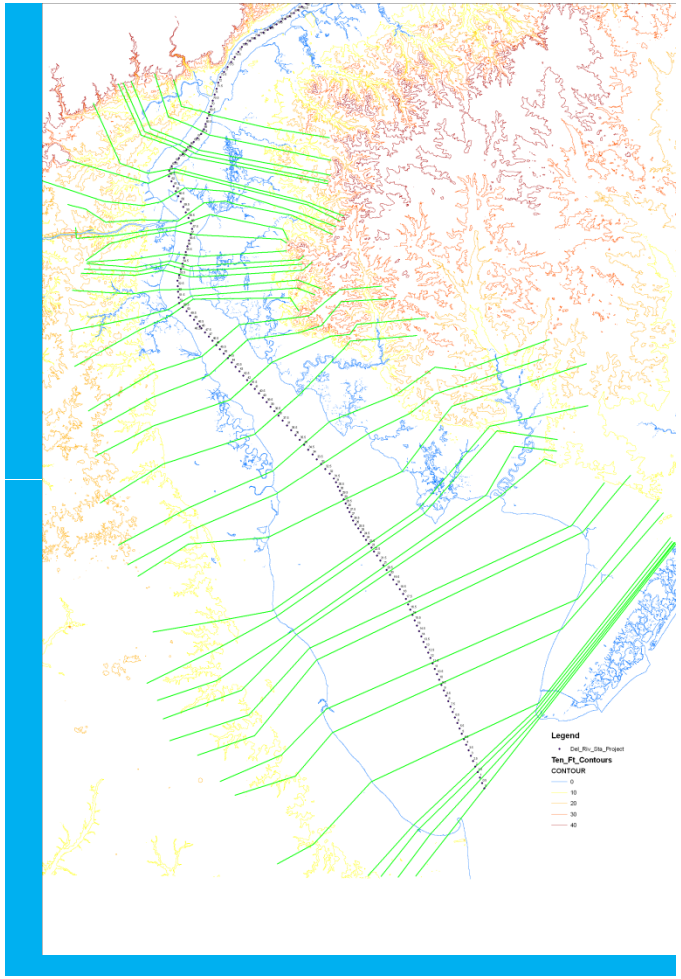
Propagation of Surge Through the Delaware Bay

Used HEC-RAS to Propagate Surge

- Developed by the US Army Corps of Engineers
- Accepted per NUREG-0800
- Used for PMS on South Texas Project COL
- Model calibrated against normal tide data



Cross-sections used in HEC-RAS to simulate Delaware Bay and lower estuary

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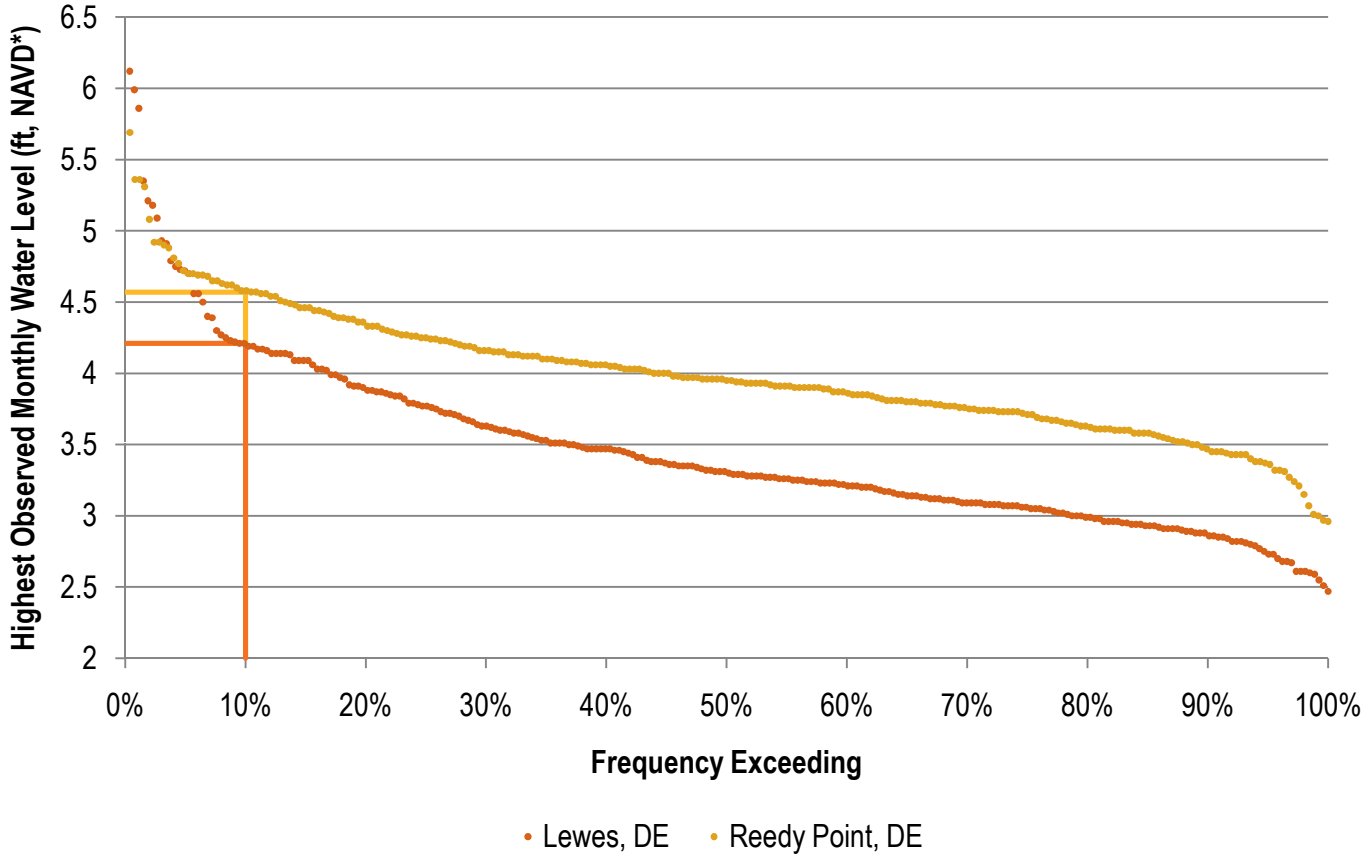
Derivation of 10% Exceedance High Tide

Based on 21 years of Observed Monthly Maxima



***NAVD - North American Vertical Datum, 1988**

data values represent the monthly maximum water levels during the period 1987-2008

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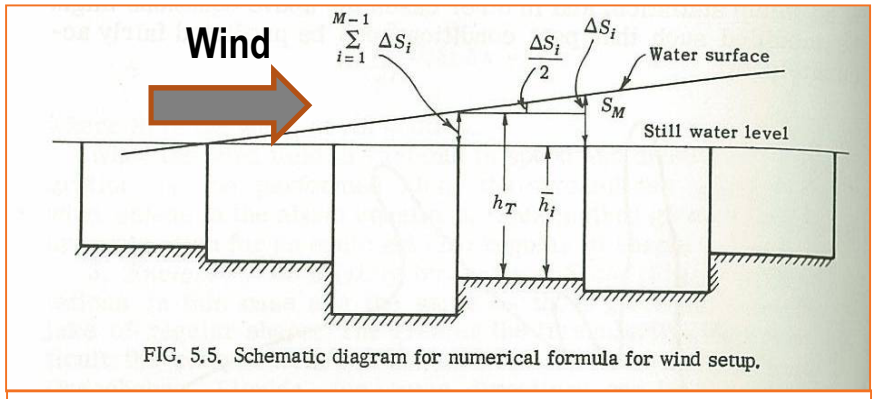
Account for the Wind Setup Effect

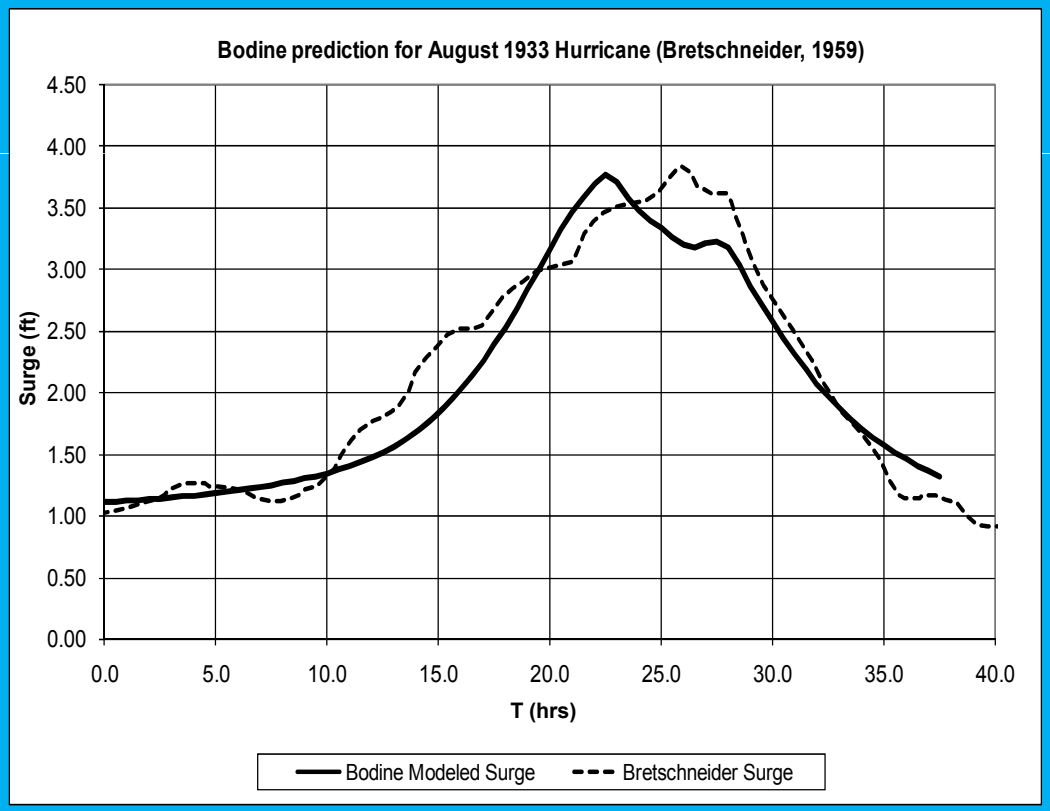
- Accounts for the effect of Wind on the open water in the Bay
- Used Kamphuis (2000) Wind Setup procedure
  - No specific NRC guidance for methodology
  - Used for PMS on South Texas Project COL



Schematic Diagram for Kamphuis Procedure

Validation of Surge Modeling Method

- The 1933 hurricane described by Bretschneider (1959) was used to validate the procedure for estimating the PMS Stillwater Level
- The Bodine procedure replicated surge at mouth of Delaware Bay



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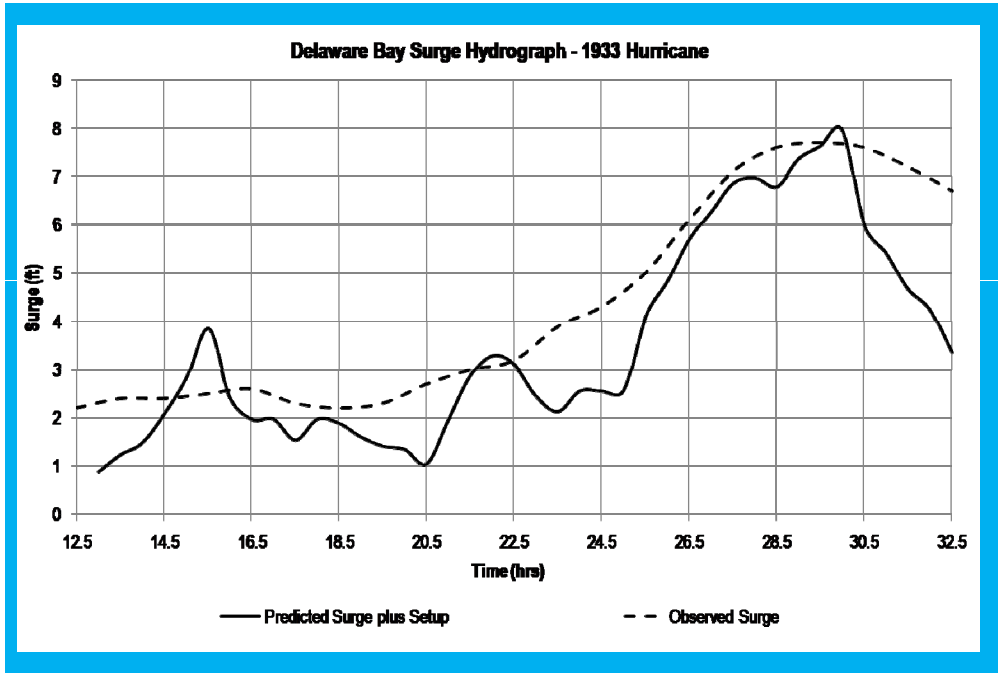
Validation of Propagation Modeling Method

HEC-RAS simulation with observed discharge at Trenton + Bodine-estimated tide and surge at the mouth of Delaware Bay

- HEC-RAS surge + Kamphuis wind setup adequately simulated observed surge at Reedy Point
- Model overestimated peak surge (water level minus tide) by 4%
  - Actual surge 7.6 ft
  - Estimated surge 7.9 ft



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Determination of Probable Maximum Surge Flooding

Per Regulatory Guide 1.59 and ANS2.8 – Consider combined effects of:

- Surge from the Open Coast
- Propagated to the site
- With Coincident 10% exceedance High Tide
- With Coincident wind setup

= PMS Stillwater Level

- PMS Stillwater Level
- With Coincident Wave Runup
- With Sea Level Rise

= Design Water Level

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PMS Associated with Probable Maximum Hurricane

PMH (NUREG 0800) is the Probable Maximum Hurricane that causes the Probable Maximum Surge

- **Most sensitive PMH variables that affect PMS are**
  - Radius of Maximum Winds, R - at mouth of Delaware Bay the PMH R may range from 11 to 28 n.mi.
  - Forward Speed, T – at mouth of Delaware Bay PMH T may range from 26 to 42 kts.
- **A factorial design approach was used, simulating all possible combination of large, medium, and small Radius and Speed**

R →

T ↑

	11 n.mi	20 n.mi	28 n.mi
42 kt	R 11 T42	R20 T42	R28 T42
34 kt	R 11 T34	R20 T34	R28 T34
26 kt	R 11 T26	R20 T26	R28 T26

Highest at Site

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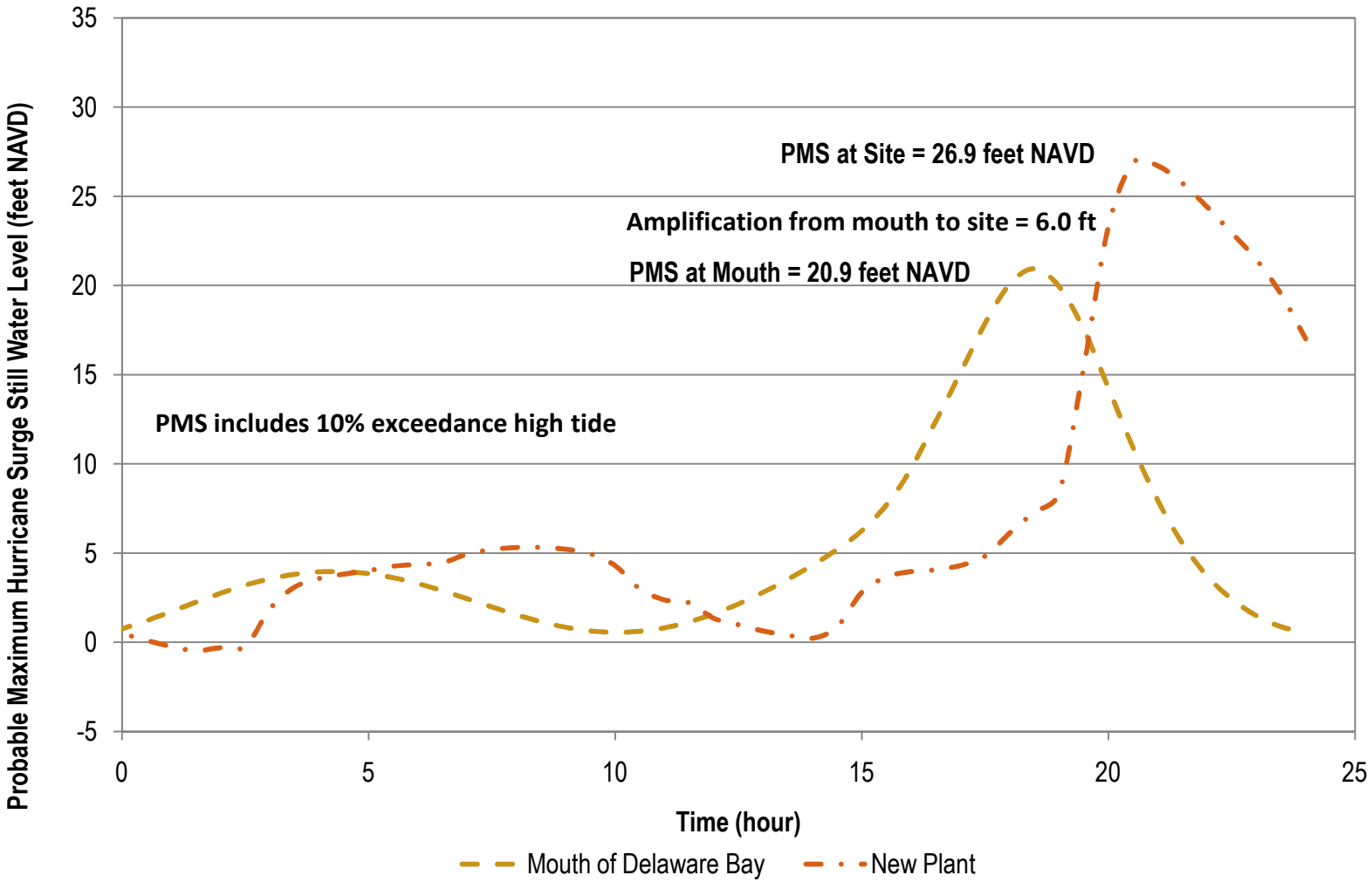
PMS Stillwater Level Associated with PMH



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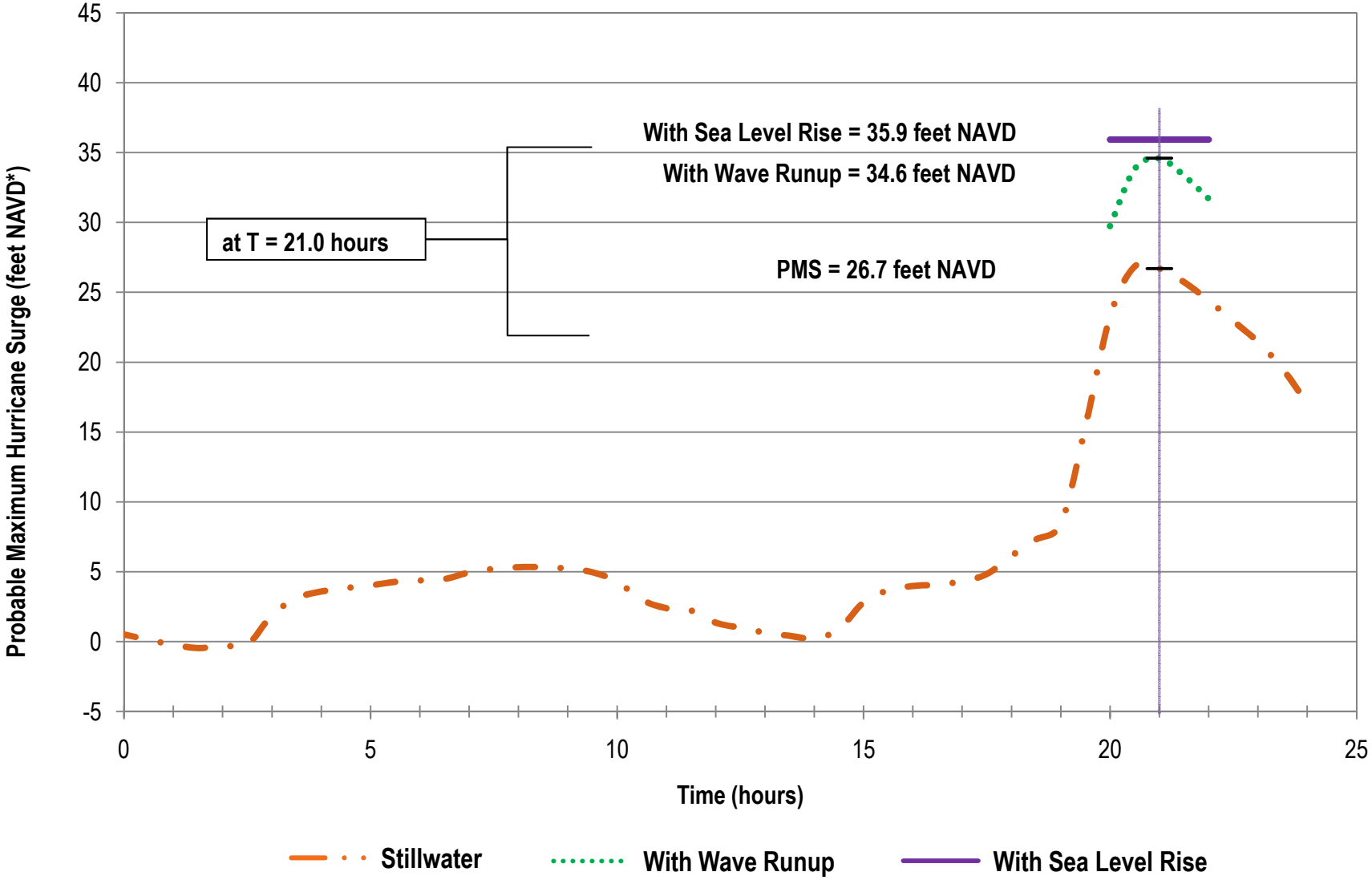
Coincident Wave Runup

- **Wave Runup estimated using USACE Coastal Engineering Manual (CEM) method**
  - Replaces Shore Protection Manual cited by RG 1.59
  - Accepted by NUREG 0800
  - Used for PMS on South Texas Project COL
- **Inputs include bathymetry, water levels, and winds at the site**
- **The wave field is duration- and fetch-limited**
- **Assumed critical site facilities will be on fill with a 3:1 slope, protected by rip-rap**

Sea Level Rise is the upper 95% confidence limit sea level rise over 100 years

- Monthly mean sea level trends at NOAA Reedy Point Tidal Gage Station from 1956 through 2006
- The monthly sea level trend over this 50 year period is +1.14 feet/century
- The upper 95% confidence limit estimated by NOAA by extrapolation of sea level trends is +1.35 ft/century
- The Analysis uses +1.35 ft to conservatively account for change over 60 year plant life

Probable Maximum Surge – with all coincident effects



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