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# NUCLEAR REGULATORY COMMISSION

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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ADVANCED BOILING WATER REACTOR SUBCOMMITTEE

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WEDNESDAY

APRIL 24, 2013

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ROCKVILLE, MARYLAND

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., Michael Corradini, Chairman, presiding.

SUBCOMMITTEE MEMBERS:

MICHAEL CORRADINI, Chairman

J. SAM ARMIJO, Member

DENNIS C. BLEY, Member

HAROLD B. RAY, Member

MICHAEL T. RYAN, Member

STEPHEN P. SCHULTZ, Member

WILLIAM J. SHACK, Member

JOHN W. STETKAR, Member

ACRS CONSULTANTS PRESENT:

WILLIAM HINZE

NRC STAFF PRESENT:

QUYNH NGUYEN, Designated Federal Official

HOSUNG AHN, NRO/DSEA/RHMB

NILESH CHOKSHI, NRO/DSEA

CHRISTOPHER COOK, NRO/DSEA/RHMB

TEKIA GOVAN, NRO/DNRL/LB3

BRAD HARVEY, NRO/DSEA/RHMB

HENRY JONES, NRO/DSEA/RHMB

REBECCA KARAS, NRO/DSEA/RGS1

FRANKIE VEGA, NRO/DSEA/RGS1

GEORGE WUNDER, NRO/DNRL/LB3

ALSO PRESENT:

RICHARD BENSE, NINA

LYLE HIBLER, PNNL

PAUL JENSEN, Atkins North America

PATRICK LYNETT, University of Southern California

SCOTT HEAD, NINA

RAJIV PRASAD, PNNL

T-A-B-L-E O-F C-O-N-T-E-N-T-S

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P R O C E E D I N G S

8:14 a.m.

CHAIR CORRADINI: The meeting will come to order. This is a meeting of the Advanced Boiling Water Reactor or ABWR Subcommittee for the ACRS. My name is Mike Corradini. I'm chairman of the subcommittee. ACRS Members currently in attendance are Bill Shack, Mike Ryan, Sam Armijo and Harold Ray and Dennis Bley, as well as our consultant, Dr. Bill Hinze.

We also have Mr. Quynh Nguyen as our Designated Federal Official for the meeting. As announced in the Federal Register on April 8th, the subject of today's briefing is Chapter 2, Site Characteristics of the COL application submitted by Nuclear Innovation of North America or NINA for the South Texas Project Units 3 and 4 and resolution of some action items from previous briefings on the subject.

Sections 2.1 through 2.4 will be discussed today. The remaining section, 2.5, will be presented at a future meeting, to be determined, we'll get back to you on that. Last time the subcommittee was briefed on Chapter 2 was in November, was on November 30th of 2010. I'm sure you have that firmly entrenched in your minds.

MR. HEAD: Yes, sir, we do.

CHAIR CORRADINI: The rules for participation in today's meeting were announced in the Federal Register notice for the, for an open or closed meeting, however we expect this meeting will be mostly open to the public. I am asking the NRC staff and the applicant to verify only people with required clearance and a need to know are present if we enter into a closed session of the discussion.

We have a telephone bridge line for the public and stakeholders to hear the deliberations. This line will not carry any signal from this end if we need to enter into a closed meeting. Also to minimize disturbances, the line will be kept in the listen in only mode until the end of the meeting where we'll allot a few minutes for allocated or we'll allot a few minutes that have been allocated for public comment.

At that time any member of the public attending this meeting in person or through the bridge line can make a statement or provide comments as desired. We'll check on that as we get close to the end line to see if there are any folks on line.

As the meeting is transcribed I request

that participants in this meeting use the microphones located throughout the room when addressing the subcommittee. Participants should first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

And then, as we do on airplanes, please silence all cell phones, pagers, iPhones, iPads and all appropriate appliances. We'll now proceed with the meeting. And I call upon Mr. George Wunder of NRO to begin the presentation. George.

MR. WUNDER: Thank you, Mr. Chairman. We're delighted to be here after kind of a long wait on Chapter 2. But thanks to your most thorough introduction we have nothing to add.

CHAIR CORRADINI: So, great, I didn't even have a chance to take off my glasses you were so fast. So we'll turn to NINA. Scott, are you going to lead us off on some, I think responses on action items primarily.

MR. HEAD: Yes, sir, well, a couple things. Our agenda for today, we do want to talk about two interesting changes that have taken place since the last time we met. And then we do have an action item Number 65 that we want to close today, or excuse me to present to you today and hopefully, and close that action.

Attendees, the team that's here, the attendees, you want to go ahead and --

MR. BENSE: My name is Dick Bense.

MR. HEAD: No, I want you to move to the, Dr. Bob Bailey briefed you on the ADCIRC, our ADCIRC work that we had presented last time and Dr. Paul Jensen had briefed you on the MCR breach work from last time. The topics for discussions, I should say the first topic is, next slide please.

Okay, first off as background, I thought we would go ahead and show this slide. We've shown this slide before and it portrays most of what we'll be talking about today. Down at the bottom, obviously, is the Gulf of Mexico with the Barrier Islands.

You see the prominent feature to the upper left is the Main Coolant Reservoir which Unit 1 and 2 is using right now and obviously Unit 3 and 4 will be using once we're licensed. It's a little harder to see, but to the right of the Main Cooling Reservoir is the Colorado River. The Colorado River is what's used to actually fill the Main Cooling Reservoir. I'd say distance from Units 3 and 4 to the Barrier Islands is about 15 miles.

CHAIR CORRADINI: So from the little white patch, I was going to ask that question, from the little white patch at the top to the Barrier Island is 15 miles?

MR. HEAD: Yes, sir. The South Texas and we'll show you another picture in a second with respect to the location of Units 3 and 4 versus 1 and 2. Okay. So with respect to a couple of interesting items that have transpired in the intervening time frame. NRC issued Reg Guide 1.221, which concerned design-basis hurricane and hurricane missiles for nuclear power plants in October of 2011.

You know, based on the nature of the changes, STP 3 and 4 committed to this Reg Guide and that ended up was changing the maximum hurricane wind speeds and more importantly the hurricane generator missile spectrum was changed. We went through an analysis and NRC went through a review and we confirmed that the ABWR DCD buildings and the site specific buildings can withstand these new requirements.

You'll see more detail on that hopefully in July, when we brief you on 3738. Okay? The next interesting change is, as a result of Fukushima and the lessons learned we created an Appendix 1E and added it to our COLA to describe our position and what we've done to address the post-Fukushima recommendations.

As part of the discussion with the NRC on the cliff edge effect or the physical margin for flooding, we made some decisions regarding a number of doors that allowed us to determine if the cliff edge was really at 51 feet. And that information is included in 1E and the results of that you see down below, it's 11 feet above a design-basis flood, 12.8 feet above the maximum flood level from the NRC briefs and 17 feet above nominal site grade.

At this point in time this was a paper change regarding, involving some doors and so we thought it was the appropriate thing to do. And you'll see that in 1E when we have that briefing on --

MEMBER ARMIJO: Scott, that MCR breach delta is dependent on the size of the breach and how much comes out and all that. We're going to talk about that later today.

MR. HEAD: Yes, sir. I'm going to just brief you on a follow-up item related to that and then the rest of the briefing will be by NRC. Okay so here's the promised slide. There's 1 and 2 with respect to the MCR breach b~~riefs~~.

This lower water you see down at the bottom is the essential cooling pond and that's a below grade feature. Three and 4 we located to the right side back in that area and so the distance between the Main Cooling Reservoir and 3 and 4 is a little bit further, obviously than where 1 and 2 is located right now.

That's a picture for perspective. This is to head towards closing this follow-up item that we committed to do. A picture of, another picture you've seen before of the embankment. You'll see this picture a couple more times today I'm sure. The distance from the, from toe to toe is around 300 feet.

So with respect to the follow-up item we went back and looked and said did we, were we really clear last time with respect to what we were trying to describe? And so with respect to the breach, there's a number of things that go into the calculations because the breach is an intermediate step. The actual goal is the flood elevation at the buildings.

And so what's needed is a breach location, picking one that's basically oriented towards, you know, the either 3, Unit 3 or Unit 4. The breach width is important, obviously. And the timing with respect to how quick that breach opens because how quick it opens also impacts how fast the Main Cooling Reservoir empties.

As you noted in the first picture, the contents of the Main Cooling Reservoir is finite. It's not a lake, it's not a river. It's what's there is all that will be there except for we allow some rain to take place, basically a foot of rain. But that's the starting point.

The breach width is based on the Froehlich equation. That's an empirical regression that has a number of features in terms of width and timing. And we use that for the breach width. The breach opening speed was based on MacDonald Langridge equation. That's another equation that has features to it that could be used.

And so those two features, the, or three features, the location, the breach width and the breach opening speed, are all placed into FLDWAV, which is, actually calculates the discharge from the MCR. That amount, that quantity is input in RMA-2 and that's used ~~the~~ to predict the actual flood levels at the buildings. So this is, by the way this is a new slide. We didn't include that two years ago, so.

CHAIR CORRADINI: And just so I'm clear, the upper left box, the only place where it creates an issue is facing north towards the planned Unit 3 and 4 locations. A breach anywhere else doesn't --

MR. HEAD: Yes, sir, that, we believe this is clearly bounding aimed right at, if anything that, obviously anything that happens outside of that, you know, the plants would be shut down and there would be consequences and everything because we would lose our cooling source. But the safety, we only, we believe that the safety aspects are only for anything that's headed north towards the plants.

On the left side you'll see, I was alluding to as part of a confirmatory analysis these, the breach width and the breach timing are all based on empirical regression equations that are developed based on previous dam breaches. The BREACH model is an actual model that used hydrological principles, soil mechanics and other aspects to actually model a breach.

And we ran that as a confirmatory

analysis to, just like I say, to confirm, you know, the results that we were getting from our, our what we're calling the FLDWAV model.

MEMBER ARMIJO: Are these the same models that were used for Units 1 and 2 when you did that or were they different?

MR. HEAD: No, sir. Well there has been, I'll say there's been some post-Fukushima work on 1 and 2 that would have used FLDWAV or breach.

DR. JENSEN: RMA-2 and the hydrograph from breach.

MR. HEAD: All right. But when 1 and 2 was licensed they used an instantaneous removal of 2,000 feet of the reservoir for their flood, to determine their flood levels.

MEMBER ARMIJO: So that was just arbitrary, 2,000 feet? Did you pick it out of the air?

MR. HEAD: No, it wasn't arbitrary, at least based on what I've seen. What was done is you find the elevation or the breach width that creates the maximum flood level. If you take away the whole north embankment it goes out and so you, and so there's a level that creates the worst case. And so that's what 1 and 2 did back in the 80's.

MEMBER ARMIJO: Okay.

MR. HEAD: Okay. This is clearly a different approach. So here's the slide that caused some of the questions that occurred. The FLDWAV is basically the STP model and you see the discharge growing up to a maximum point.

And that maximum point is the maximum breach that the Froehlich equation would say the embankment would reach. The time involved to do that is the time that the MacDonald equation would say would occur.

CHAIR CORRADINI: So when you say, I read this but just to make sure I got it right. For all intents and purposes FLDWAV is just being driven by the two correlations of size and time speed.

MR. HEAD: Yes, sir. That's exactly correct.

CHAIR CORRADINI: Okay, thank you.

MR. HEAD: The red curve is our confirmatory analysis. That is the BREACH model results and I'm sure we will discuss that some more today. But this is our results with the STP FLDWAV model and the BREACH model. And so we went back again and looked at what, you know, how we had described that and next slide.

And so here is the open item, which was how does the MCR breach width, derived from the Froehlich's equation used in the FLDWAV model, compare with the value used in the confirmatory breach model?

All right. So the FLDWAV model is the STP COLA model and the width is 417 feet. So at that point the width would be 417 feet.

The BREACH model, the second one down, the width at the peak flow is 398 feet. Now recall this is a model. So at 398 feet, it continues to grow to 485 feet. But in the intervening six hours, the Main Cooling Reservoir has lowered and therefore at that final width it's no longer peak flow.

And so that's why at 398, at six hours is peak flow and yet the final width is 485 feet with breach since there's nothing to, you know, we don't cause it to stop. It just keeps growing until the physics say it stops growing.

Now what we've added below is one aspect of the Froehlich equations. There is an equation that Froehlich used that, based on the height of our reservoir and the volume of our reservoir, you put into a calculation and you would get 62,600 CFS using the Froehlich equation.

And I'm going to show you the results of other aspects of that here in a second. So here again, here is the blue and the red are from the previous slides, is what we've presented before. You see the maximum peak at 417, you see the breach results.

But we've added another aspect of the Froehlich equations. If you put information into FLDWAV regarding the breach growth rate and time and width, you'll get the green curve. And so what this shows, we think, is some idea of the conservatism that we have in our analysis right now.

CHAIR CORRADINI: So this is kind of like emptying a bucket but the target that you're looking at, the blue line then causes a much larger max flood height than the red line?

MR. HEAD: Yes, sir, which is what we were after. You know, and not only, it causes the 38.2 feet flood elevation of which then we added about a 25 percent margin out at the plant to come up with ultimately 40 foot flood elevation.

CHAIR CORRADINI: Okay.

MR. HEAD: So if you'll back up just a couple of slides. The 417 and the 398 and the 485, I think answer or that's what we believed was the questions with respect to the follow-up items.

CHAIR CORRADINI: Okay, questions from the committee? Okay. Thank you for the follow-up items. I think we'll now turn to staff. So a new team will assemble with new tents. Tekia, are you going to be our leader today?

MS. GOVAN: Yes.

CHAIR CORRADINI: Okay. So, Ms. Govan, Govan?

MS. GOVAN: Govan.

CHAIR CORRADINI: Govan. I thought you were French so. The other two suspects look familiar. The person on the left will remain nameless until identified. Clarity and volume in your voice. Tekia, go ahead.

MS. GOVAN: Good morning. My name is Tekia Govan. I am the project manager for the review of Chapter 2, entitled Site Characteristics as this chapter is contained in the South Texas Project Units 3 and 4 COL application.

Today the staff is here to present the findings of their review for Phase 4, which has resulted in a safety evaluation report with no open items. The staff review team for Chapter 2 consists of George Wunder, lead PM; myself and David

Misenhimer as chapter PM's; and the technical staff from the Radiation Protection and Accident Consequence branch where Michael McCoppin is branch chief and the Hydrology and Meteorology branch where Christopher Cook is the branch chief.

The staff last presented our Chapter 2 to the ACRS Subcommittee in 2010 where we discussed our safety evaluation with open items. During that meeting we discussed our findings in the areas of 2.1, geography and demography; 2.2, nearby industrial transportation and military facilities; 2.3 meteorology; 2.4, hydrology; and 2.5, geology, seismology and geotechnical engineering.

We were able to conclude our review and make acceptable findings, acceptable safety findings with no open items in Sections 2.1 and 2.2. However, we left the 2010 ACRS meeting with open items and/or ACRS action items in the areas of 2.3, 2.4 and 2.5. Today's presentation will focus on the closure of open items and ACRS action items for Sections 2.3 and 2.4.

Section 2.4 is notable in that the staff was required to disposition a non-concurrence of the safety evaluation prior to making the final, the document final. The resolution of the non-concurrence will be discussed in detail during the second portion of this meeting.

As stated earlier, 2.5 will be presented to the ACRS Subcommittee at a later date as it is still being reviewed by the staff in connection with a Fukushima recommendation 2.1. At this time I will turn the presentation over to Mr. Brad Harvey, who is our technical reviewer and today's presenter for 2.3, meteorology.

MR. HARVEY: Again, my name is Brad Harvey. I'm the meteorological reviewer for the South Texas Project, COLA. Since the ACRS Subcommittee meeting on STP COLA last reviewed FSAR Chapter 2.3 during its meeting on November 30, 2010, the staff issued Regulatory Guide 1.221 related to defining design-basis hurricane wind speeds and missiles for sites located along the Gulf and Atlantic coasts.

Reg Guide 1.221 defines a design-basis hurricane as having the same $10^{-7}$ per year exceedance frequency as a design-basis tornado. The staff subsequently issued RAI 02.03.01-24, requesting that the applicant identify design-basis hurricane wind speed and missile spectrum for the STP site.

RAI 02.03.01-24, also asked the

applicant to confirm that the ABWR standard plant and the STP site-specific structure, systems and components important to safety, are designed to protect against the combined effects of hurricane winds and missiles. The applicant's response to RAI 02.03.01-24, identified an STP site-specific design-basis hurricane wind speed of 210 miles an hour or three second gust wind speed based on the guidance in Regulatory Guide 1.221.

To ensure that the STP Unit's 3 and 4 design reflects the guidance in Regulatory Guide 1.221, the applicant revised FSAR Tier 2, Table 2.0-2 to include 210 miles an hour as a site-characteristic hurricane wind speed for STP Units 3 and 4.

MEMBER SHACK: Brad, just, that Reg Guide, those hurricane wind speeds are really, I think based on the NUREG-7005 where you have the probabilistic models now for hurricanes.

MR. HARVEY: That's correct.

MEMBER SHACK: So we use a probabilistic model to deduce the winds, but we still use a deterministic model to determine surge. Is that where we're at?

DR. JONES: Well, we actually were

allowed to do probabilistic and also deterministic. Our new ISG and the way we're going forward now with the post-Fukushima. Sure, you could do probabilistic. They've always had the option to do probabilistic surge.

MEMBER SHACK: Okay, so I guess that's the answer is that they could do either one. They've chosen, they've done deterministic.

DR. JONES: Exactly.

CHAIR CORRADINI: Simply because it's easier to do and potentially bounding at the time when they did it?

DR. JONES: Exactly, exactly.

MEMBER SHACK: Well bounding is the --

CHAIR CORRADINI: Bounding in some sense of the word. But back to I guess Bill's question, it can be inconsistent based on the choice of how they want to choose each of the --

DR. JONES: Well one thing we have to remember too, what will bring your maximum winds at a site is different than would bring your maximum surge, two different phenomena. So you can have a plant in the middle of a valley and the hurricane that would bring your surge there might have light winds because it's coming from a certain direction.

So you have to keep that in mind. They're two different, you know --

MEMBER SHACK: But you do have a probabilistic models for the hurricanes that you could --

DR. JONES: Yes, and we have them also for whenever you want to do surge.

CHAIR CORRADINI: Okay, thank you.

MR. HARVEY: The staff confirmed that the applicant's 202 mile-an-hour site-specific design-basis hurricane wind speed derived from Regulatory Guide 1.221 is correct. Therefore, the staff considers RAI 02.03.01-24 to be resolved and closed with regards to Chapter 2.

The staff is also confirming as part of its review of FSAR Chapter 3, that the ABWR standard plant and STP site-specific SSCs important to safety are designed to be protected against hurricane winds and missiles. The staff --

MEMBER SHACK: Again, is this the limiting wind speed for the site, is it the hurricane wind speed rather than the tornado?

MR. HARVEY: For site characteristics, that's correct. I believe 200 miles an hour was the tornado site characteristic value and 210 is the hurricane. At the $10^{-7}$ for your probability level. The staff will report its conclusion on the issue regarding protection against hurricane winds and missiles in a subsequent ACRS meeting on Chapter 3.

I will now address ACRS Action Items 91 and 92, both of which concern how portions of the FSAR and SER address global climate change. I will start with a response to Action Item 92, which concerns a generic issue of using global climate change projections to evaluate the impact of natural phenomenon at a site. This will be followed by a response to Action Item 91, which concerns an apparent inconsistency in the treatment of climate change effects and characterizing the STP site.

In Action Item 92, the ACRS asked what criteria will be used to initiate the use of global climate change predictions in revising analysis of the impact of natural phenomenon on the STP site? The staff does not currently have a formal mechanism in place for initiating the use of global climate change predictions and analyzing the impact of changing natural phenomenon at a COL site.

In developing the climatological characteristics of the STP site, the staff relied on General Design Criteria 2 to Appendix A to 10 CFR

Part 50, which states structure, systems and components important to safety shall be designed to withstand the effects of natural phenomenon such as earthquakes, tsunamis, hurricanes, floods, tornadoes and seiches without loss of capacity to perform their safety functions.

The design-basis for these SSCs shall reflect in part appropriate consideration of the most severe of the natural phenomenon 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 historic data have been accumulated.

DR. HINZE: Will these be gradients that you will be looking at or absolute values or percentages? How do you see this developing?

MR. HARVEY: Well basically we've been using, for instance tornadoes and hurricanes the design-basis for them are $10^{-7}$ per year in terms of, based on historic --

DR. HINZE: Right but in terms of the change from climate change, would these be based upon absolute values then?

MR. HARVEY: Well we haven't really --

DR. HINZE: Have a position on that?

MR. HARVEY: We don't have our position yet on that.

DR. HINZE: I see, okay.

MEMBER ARMIJO: The models on these climate change are simply that, models. And the data don't support the models. Temperatures aren't rising.

CHAIR CORRADINI: I'm going to limit this discussion just so --

MEMBER ARMIJO: I just want to make sure that we don't, we go at least somewhere on the record there's some question about whether there's any value in trying to incorporate unproven models and hypotheses.

MR. HARVEY: Further on in my presentation, I think I touched on that.

CHAIR CORRADINI: Keep on going.

MR. HARVEY: Okay. Although GDC-2 emphasizes the use of historic data to define the design-basis, the staff acknowledges in SER Section 2.3S.1.4.7, on climate change, long-term climate change resulting from human or natural causes may introduce changes into the most severe natural phenomenon reported for the site.

However, no conclusive evidence or

consensus of opinion is available on the speed or nature of such changes. There is a level of uncertainty in projecting future conditions because, among other reasons, the assumptions regarding a future level of emissions of heat trapping gases, depends on projections of population, economic activity and choice of energy technologies.

Further uncertainty is introduced in attempting to downscale average global climate change predictions to regional predictions of changes and extreme meteorological conditions. If it becomes evident that long-term climate change is influencing the most severe natural phenomenon reported at a site, the COL holders have a continuing obligation to ensure that their plants continue to operate safely. 10 CFR Part 50, Appendix B, Criteria 16, entitled Corrective Actions, requires licensees to promptly identify and correct conditions adverse to quality.

Operation of the plant outside the FSAR specifications constitutes a non-conforming condition and a condition adverse to quality. This means licensees should be identifying when ambient conditions such as extreme temperatures are outside design specifications and evaluate this adverse condition in a timely manner.

The NRC inspection program includes a procedure to verify a licensee's design features and the implementation of procedures to protect mitigating systems from adverse weather effects. This procedure has been used in the past to identify situations when ambient temperatures were outside the FSAR specified design-basis conditions.

The NRC's Near-Term Task Force review of insights from the Fukushima accident, recommended that the staff initiate rulemaking to require licensees to confirm seismic and flooding hazards every 10 years, address any new and significant information and if necessary update the design-basis for SSCs important to safety to protect against the updated hazards. This Near-Term Task Force recommendation identified as recommendation 2.2, is classified as a Tier 3 activity.

The staff intends to include other natural, man-related hazards such as meteorological phenomenon within the scope of this rulemaking. This potential rulemaking provides an opportunity to address concerns related to climate change.

For example, this potential new rule may cause licensees and the staff to periodically review recent trends and extreme meteorological conditions and the latest information on global and regional climate change predictions and analyzing the impact of changing natural phenomenon at all plant sites. Any questions regarding our response to Action Item 92?

MEMBER SCHULTZ: Well, Brad, just your use of a conditional phrase. It may cause the staff and licensees, that is if it is implemented is what you're saying?

MR. HARVEY: I expect, yes.

MEMBER SCHULTZ: If it's implemented every 10 years, it will be done.

MR. HARVEY: Yes, well we, the rule has not, the confines of the rule have not been obvious.

MEMBER SCHULTZ: So that's why you phrased it that way?

MR. HARVEY: That's correct.

MEMBER SCHULTZ: Thank you.

MR. HARVEY: Action Item 91. In Action Item 91, ACRS stated that there is an inconsistency in the treatment of climate change effects for natural phenomenon and characterizing the STP site. In particular the FSAR and SER both addressed the impact of sea level rise from global climate change in the next century on the potential maximum tsunami.

But neither the FSAR or SER mentioned a potential increase in wind and rain accompanying future hurricanes. The FSAR and SER projections for sea level rise during the next 100 years are based on trends derived from historic data and do not take into consideration potential increases derived from projections of future changes and global or local climate change.

This is the same approach used to evaluate wind and rain accompanying future hurricanes. With respect to addressing sea level rise from global climate change, the applicant evaluated a maximum flood level for the probable maximum tsunami at the STP site assuming a long-term sea level rise of 1.43 feet during the next 100 years as provided by NOAA's Center for Operational Oceanographic Products and Services.

This long-term sea level rise projection is based on tide gauge measurements made at nearby Freeport, Texas, during the 53 year period, 1954 to 2006. However, future changes in sea level experienced at any particular location along the coast depend not only on the increase in the global average sea level, but also on changes in regional currents and winds, proximity to mass and melting ice sheets, vertical motions of the land to geological forces.

The long-term sea level rise projection used by the applicant to identify the potential maximum tsunami, is based on historic measurements and does not consider future predictions and sea level rise from such items as expansion of the ocean volume due to warming and the melting of glaciers and ice sheets.

Regarding the potential increase in wind and rain accompanying future hurricanes, SER Section 2.3S.1 references the U.S. Global Change Research Program as a source of information regarding the impacts of climate change on the United States, including the force and frequency of Atlantic hurricanes. The USGCRP reports that the force and frequency of Atlantic hurricanes have increased substantially in recent decades, but the number of North American main line hurricanes reaching land does not appear to have increased in the past century.

The USGCRP reports that likely changes in the future for the United States in surrounding coastal waters will include more intense hurricanes with related increases in wind and rain, but not necessarily an increase in the number of storms that make landfall.

The applicant states in FSAR Section 2.3S.1, that the currents of all tropical cyclones within a 100 nautical mile radius of the STP site have been somewhat cyclical during the available period of record, which is 1851 through 2006 with a peak occurring in the 1940's and a secondary peak in the 1880's. Therefore, quantifying potential increases in wind and rain accompanying future hurricanes is uncertain at best.

In conclusion, projected sea level rise during the next 100 years is based on trends derived from historic data and does not take into consideration potential increases derived from projections of future changes in the global or local climate. This is the same approach used to evaluate wind and rain accompanying future hurricanes. Any questions regarding our response to Action Item 91?

CHAIR CORRADINI: Committee, no. Go ahead.

MR. HARVEY: This last slide of my presentation summarizes the conclusions and status of SER Section 2.3. First the FSAR meets the regulatory requirements to address regional and local climatic information and presents appropriate information on the atmospheric dispersion characteristics of the site.

Second, all COL items were adequately addressed by the applicant. And third, there are no open or confirmatory items. This concludes my presentation.

CHAIR CORRADINI: Thank you. Dr. Jones is next.

DR. JONES: I'm Dr. Henry Jones. I'm the lead hydrologist for the South Texas project. And the reviewers that actually participated are Dr. Nebiyu Tiruneh and Dr. Hosung Ahn.

I'm going to address first the open items and then after that followed by the action items. Open Item 02.04.4-1, this was about the Main Cooling Reservoir, embankment, breach, flood analysis which was briefed by the applicant earlier. And it was, needed to be updated by describing the process in selecting the plausible breach widths and the breach time.

The applicant did provide the response and satisfied our requirements. They described the use of a Dam Safety Officer, the characterization of the breach, applied the BREACH model as you saw earlier this morning and compared the results to historical database of dam failures.

And based on independent confirmatory analysis by the staff, we have determined that the applicant's estimated breach flood discharge is reasonable and conservative and the staff closed this open item based on confirmatory analysis. Any questions on this open item?

Open Item 2.4.5-1, and this has to do with the storm surge which they also briefed earlier. The applicant has not shown, we said that they did not show that the model results accounted for a conservative, plausible, probable maximum hurricane scenario. And we wanted them to describe in more detail how they used their model in the FSAR.

And in response they provided additional information. Through their response we actually had a second audit out there where they actually presented their findings. And in RAI 2.4.5-11, they fully described how they used the ADCIRC model, how they set it up. They actually, based on our recommendation, used the probable maximum hurricane scenarios that was used in the SLOSH model.

We wanted it to be almost similar so there wouldn't be any questions about there was a difference in the input and the meteorological parameters. They did sensitivity runs for the storm parameters using the five, you know, radius, forward speed, track direction, landfall, location of the storm.

We determined that the applicant had selected the conservative scenarios and this was based on the scenarios that we had used ourselves in the SLOSH model and that their estimate for the PS, the probable maximum at the site was conservative. We determined that they had selected the appropriate model, ADCIRC is the state of the art model used by civil engineering firms across the United States also for Katrina and the Corp of Engineers. And the staff concluded that the applicant's ADCIRC simulations for determining the surge at the site were adequate. And we closed this open item. Any questions on this one?

Next Open Item 2.4.10-1, this is for flood protection. The applicant, we said the applicant didn't provide an analysis to show whether or not a hurricane storm surge could erode the toe of the Main Cooling Reservoir. And we also will touch on this this afternoon in ~~MCP~~ NCP brief too. A lot of this is overlapping.

The action, the applicant provided the staff, reviewed the responses. They described the use of the ADCIRC model. And essentially what happened is that due to the high resolution of the ADCIRC model it was able to see the levees and the rock piles there which the SLOSH or the model used by Resio which was ADCIRC, it didn't have the same resolution. So what happened is you wind up with a level of about 29 feet, which is equal to the grade level for the MCR.

And we determined that this would not lead to a breach because it was at the same level as the base of the MCR. It wouldn't be there only about 80 minutes and wouldn't have the velocities. Your winds are coming directly out of the south throughout which actually pushes the waves and current away from the northern embankment.

So you have no erosional forces through the wave action or currents on the north face whatsoever. It's just physically implausible that you could do it under this scenario. So the staff determined that the applicant's design and flood characteristics and measures were acceptable and we closed this item.

MEMBER SHACK: Just to go back on the ADCIRC model, there was a frictional term added to that right that describes the, as you're rolling along the friction?

DR. JONES: You might have mixed it, tsunami we had this kind of, when we get to our tsunami we had an issue about --

MEMBER SHACK: That's in tsunami?

DR. JONES: -- frictional, that's tsunami I think you're talking about. We do have frictional terms in there, realistic ones. But that's you know the modeling of it, that's a whole different scenario. But we didn't add anything. The model has realistic frictional terms to it.

MEMBER SHACK: But what is the realistic frictional term that was used?

DR. JONES: No, it was Manning's throughout, you know, the model you have for bathymetry, you have it for over the bottom, you have the topography when it comes in. I think you're thinking of the tsunami action item which is coming up later.

MEMBER SHACK: Okay, yes I --

CHAIR CORRADINI: There was a discussion about the --

DR. JONES: Yes, there was a discussion about that where specific Manning's frictional coefficients were used.

MEMBER SHACK: Okay, but do you have to use the same frictional coefficients in the, for the surge?

DR. JONES: Not necessarily. And the model is different, it's totally different. ADCIRC, you could have frictional coefficients, realistic over the wide range of the whole area. Then you could have different Manning's coefficients on land. And we have Patrick Lynett here who did the tsunami modeling.

He could explain to you how he used it for tsunami is different in his modeling because he could do a 1D. This is a 2D, 3D model ADCIRC. 1D model you can specify one coefficient and send it in and then specify another one and then send it in because you're only in one dimension. Then you could span to two dimensional which you'll see in tsunami.

With ADCIRC multiple coefficients depending on what the topography is. So you wouldn't have one. You would have it based on --

CHAIR CORRADINI: Whether there's trees or rocks --

DR. JONES: -- trees or rocks or coral reefs or buildings.

MEMBER SHACK: I guess I was --

DR. JONES: You're thinking of the tsunami. I guarantee you were thinking of the tsunami scenario.

MEMBER SHACK: But I still need a friction, I still have a frictional term to describe the roll up over the, to the site in the ADCIRC model --

DR. JONES: Terms, there's multiple, there's multiple terms.

MR. HEAD: Is it assuming that it's grass? Is it scrub?

DR. JONES: It's based on what it actually is. You actually can tune it to what is actually there. There actually are coefficients.

CHAIR CORRADINI: I think all Bill is asking is when they did the tuning, what did they assume the terrain was relative --

DR. JONES: There's actually brush and scrub there.

MEMBER SHACK: Okay and so it has to remain brush and scrub for the model to remain valid I guess is --

DR. JONES: We were trying to be as realistic as possible.

MEMBER BLEY: He only means in 15 years.

DR. JONES: Well in 15 years it still wouldn't change. It wouldn't change.

MEMBER SHACK: Did you do a sensitivity run with no friction?

DR. JONES: That's in tsunami situation.

MEMBER SHACK: You don't do that in --

DR. JONES: We did that with the tsunami.

MEMBER SHACK: We don't do that with surge?

MEMBER ARMIJO: Are surge and tsunamis two different things? And that's why I think one surge is just a flooding, a sea level rise. Tsunami is a wave and --

DR. JONES: It's a wind wave. You have extra water being pushed to shore. Very slow acting, that's why you see reporters there on the shore. They can sit there with their thumbs up, rising slowly. Whereas a tsunami you wouldn't have a reporter there. He would be gone. It's a totally different phenomenon. You do it in 2D not 1D.

It's just like you're, you do it in 2D with different coefficients are put in. You don't do sensitivity analysis of frictional coefficients, I mean you can. They've done studies of that.

MEMBER BLEY: I think the question is not what do you do, but it's do you have any way to look at the impact --

DR. JONES: Well sure. In the core.

MEMBER BLEY: -- of changes in the future and do you do any sensitivity studies to try to bound that now before the plant is there?

DR. JONES: We saw no changes in our analysis.

MEMBER BLEY: You did sensitivity studies for different --

DR. JONES: Not for the frictional coefficients because there was no changes seen there except for the topographic features whether you have maybe, like in this case a levee there or rock or buildings.

MEMBER SHACK: Okay, so you're arguing based on experience that if you did the sensitivity studies you wouldn't have seen much because everything is so slow and the frictional terms are relatively less important.

DR. JONES: Exactly.

MEMBER BLEY: Okay.

CHAIR CORRADINI: Keep on going.

DR. JONES: Okay, Open Item 2.4.12-1, the applicant needed to clarify the potential for groundwater mounding in the Lower Shallow Aquifer and for a west-southwest directed pathway. We issued a few RAIs to address this issue above.

The applicant provided responses to these RAIs, including a revised groundwater modeling document. The staff reviewed the responses. We also performed an independent confirmatory analysis and the staff review included the evaluation of an improved alternative groundwater model, particle tracking showing all the pathways are to east or to the south east. And sensitivity cases involving ranges of post-construction infiltration rates and excavation backfill conductivity values.

And the staff concluded that these alternative pathways were plausible and acceptable. And we closed this open item.

CHAIR CORRADINI: I was trying to understand, sorry to sound that I don't understand, but I don't understand the open item. In other words, you're looking at where the groundwater is and how that would impact whatever comes above it and how it filters through?

DR. JONES: Well when you have the construction, and I'm not a groundwater specialist, but you have the construction, you have the pre-construction, you have the fill in there. And it changes the direction of where the water flow is going to be. And a lot of times we send RAIs out, say well look at what you're going to have after you build the plant. How does it change your groundwater path flow?

CHAIR CORRADINI: But the impact is on off-site transport for radionuclides.

DR. JONES: Yes, that's a fill in. It actually goes over into Section 13, Subsection 13.

CHAIR CORRADINI: I think we've, I don't think we have any more questions on that.

(Off microphone comment)

DR. JONES: All right. This is for the maximum groundwater level. This is also a carryover the ~~MCP~~ NCP that you will see later on. The applicant provided a response. We asked them to clarify their basis for determining the maximum groundwater level. They provided a response. We reviewed the response and provided independent confirmatory analysis.

And then we reviewed the field observations 34-year record, the site characteristic data. We did some modeling, post-construction groundwater levels. We did a combination of field observation and modeling results. And we did confirmation of the groundwater depression at existing STP Units 1 and 2.

And the staff found that the site characteristics of maximum groundwater level of 28 feet above mean sea level is technically defensible and acceptable. And that was our conclusion, that was the maximum groundwater, 28 feet. And then we closed it. Any questions?

In summary, the staff reviewed various flooding mechanisms including rain, hurricanes, tsunamis, surge, dam breach, et cetera to determine the site-specific design, flood basic characteristics and the required flood protection. The applicant identified the flood caused by the breach of the Main Cooling Reservoir embankment as the design-basis flood.

The staff also reviewed the groundwater

area to identify characteristics of maximum groundwater level and accidental release of radioactive liquid effluents. The staff identified four open items which we have discussed and they are all closed.

Open Item 2.4.4-2 was made obsolete due to the applicant's modification of the analytical tools used to estimate erosion and deposition in the area of the safety related facilities. There are no confirmatory items. Any questions?

MALE PARTICIPANT: Why did you say there were four in the slides, there's five?

DR. JONES: Didn't I say five, okay, five, yes. Sorry about that. Any questions on that? Okay, now I proceed to the action items. Action Item 93, ACRS requests information on the probable maximum tsunami site impact if the roughness coefficient, and this is what you were speaking to, coefficient is modified significantly. For example, destruction of vegetation by fire.

No vegetation scenario modeled in 1D and 2D using rough, so seriously what it is, is there is low friction, there's never, you never have zero friction. And the low friction is like having a parking lot paved over, okay. And then what you do is you have moderate friction. Then you have what's realistic friction for the site.

And then the real values you think are going to be there. What you do is you do 1D analysis, which is extremely conservative because, you know, the world is 2D, 3D. And so you do that and you do it for the three scenarios of friction. And then you do a 2D run for the three scenarios of the friction.

And what he came up with in the 1D case, you know, when you have low, yes, it might reach the site. But once you go to a 2D, no matter what friction you use, it never reaches the site. No matter what friction, low, medium, high. It doesn't reach the site because of the spread and it's, you know, 13 miles inland. It just doesn't reach the site.

And so in the 1D cases once you add some friction to it, it doesn't reach the site. So 1D cases did not include lateral dissipation or radial spreading because it's one dimensional. And we assumed that the bottom with no friction, no bottom loss when it was coming in and a time ~~skill~~ scale extremely conservative.

If you had actually a submarine

landslide it would start to slide and it would be a certain time that it would slide. We assumed in the model, instantaneous. That's not going to happen, instantaneous or a hot start. And so we got them and we took the maximum submarine landslide dimensions that you could.

Next, so what we did then is we modeled it and we came to the conclusion that it was safe from tsunami. Any questions on that? I mean it's extremely, we've done the most conservative of any group I've seen in the literature. I mean 1D with low friction with the most massive submarine landslide you can picture. You can't get any more conservative than it.

MEMBER SHACK: Okay, my recollection is simply that, is that even with the 2D model you had to have some friction. If you put zero friction in --

DR. JONES: There was no zero, low friction.

MEMBER SHACK: Yes, low, well the comparison is with the Levy site where in fact you did the 2D model with low friction.

DR. JONES: We did the same thing.

MEMBER SHACK: You did zero friction,

low friction.

DR. JONES: Pat, if you can address that. MEMBER SHACK: At least I think my memory is correct.

DR. LYNETT: When you do --

CHAIR CORRADINI: Please identify yourself.

DR. LYNETT: Patrick Lynett, University of Southern California. I've been working with Henry in the NRC to do some of the tsunami analysis. When you have onshore flow you have to have some type of friction. So usually a very small value like we use here for the low friction. It doesn't do that much. But you have to include some measure of physical friction.

CHAIR CORRADINI: What you have to have is a no slip boundary if that's what you're really saying. With some frictional just computed.

DR. LYNETT: Well so what happens, the reason you have to include something small, so if you have very mild slips like we have in a lot of these places, if you have no friction at all the water will just keep going and going and going and going and going, pretty much forever because there's nothing to dissipate it. So you have to include some measure of small friction in the analysis.

CHAIR CORRADINI: So back to Dr. Jones' analogies, so the friction you chose was a parking lot friction?

DR. JONES: Yes. So imagine everything paved over by concrete.

MEMBER SCHULTZ: And your phrase, excuse me, the phrase it doesn't do much means there was no difference in the site impact or little difference in the site impact.

DR. LYNETT: Between which and which?

MEMBER SCHULTZ: Well you had said low friction versus the brush case, I guess.

DR. LYNETT: Okay, so if we look at these three different scenarios, low friction which is parking lot, mid friction which is grass and high friction which is brush, there is a moderate difference between the low friction and the mid friction. And there is a very significant difference between the mid friction and the high friction, which the high friction is the realistic friction.

CHAIR CORRADINI: Keep on going. Thank you.

DR. JONES: Action Item 94, the ACRS

requests information of what arrangements have been made for replenishing the ultimate heat sink water. There is a separate ultimate heat sink for each Unit 3 and 4 that is configured with a dedicated water basin and it is sized to provide cooling water for 30 days.

On site wells provide the makeup water for these basins. The Main Cooling Reservoir is the secondary source of the makeup water. And as it was mentioned earlier today is the Colorado River is the makeup water for the MCR. So the surface and groundwater sources are not safety related because the basins have their own capacity 30 days supply. The 30 day supply is provided by groundwater backup of the MCR, which has a backup of the Colorado River.

Action Item 95, ACRS requests information on the impact of removing groundwater, this is related to the previous item, to replenish the ultimate heat sink. And so what we have here is we're saying groundwater is used for potable and sanitary supply, production of the mineralized water, fire protection and makeup water for the ultimate heat sink. The annual usage they haven't exceeded the, for 1 and 2, and 3 and 4 would not exceed this limit.

The STP permit has not been fully used to date. And the production wells for existing plants have caused a reversal somewhat of the flow pattern. But the radial inflow of the wells and surrounding aquifer were nothing that has a safety impact. Any questions on that?

The estimated land-surface subsidence, as you will see this again maybe in the ~~MCP~~ NCP discussion, the estimated land-surface subsidence since 1900 over the most of the county has been less than one foot. Okay so from 1900 to now, less than one foot. Where you do have subsident exceedance of one foot is in the northwest portion of Matagorda County.

And it's attributed to the exploration of petroleum and sulfur mining. So you know, there's no safety impact of subsidence at the site. In addition, they have a groundwater monitoring programs for 3 and 4 based on what they have at 1 and 2. And this will include subsidence monitoring to ensure structural stability. So there's no safety issue here.

MEMBER ARMIJO: I don't remember what these basins, how they were constructed. Are they the same kind of structures as the Main Cooling Reservoir?

DR. JONES: No.

MEMBER ARMIJO: So what are they?

DR. JONES: I think they're just your typical reservoir basins.

CHAIR CORRADINI: The applicant can answer.

MR. HEAD: Scott Head. They're a huge concrete tank, basically with cooling towers on the top that contain the 30 days of supply.

MEMBER ARMIJO: Thank you.

DR. HINZE: The makeup water from the subsurface is from the deep aquifer?

DR. JONES: From the wells?

DR. HINZE: Yes, which aquifer is it from? Is it the deep?

CHAIR CORRADINI: Back to the applicant.

MR. HEAD: Yes, this is Scott Head again. It's the deep aquifer.

DR. HINZE: Thank you.

CHAIR CORRADINI: Any other questions from the committee? Okay. So we'll let part of you go and we'll continue because we're going to start our non-concurrence discussion. Tekia, you're going to present something to us to get us properly oriented. Is that correct?

MS. GOVAN: Right. Before we close out Chapter 2, I didn't hear any ACRS action items so we are to assume --

CHAIR CORRADINI: No, you're right. You didn't hear any.

MS. GOVAN: -- action items that we presented are closed.

CHAIR CORRADINI: Yes.

MS. GOVAN: Okay, perfect. So we'll transition to the non-concurrence. Mr. or Dr. Ahn.

CHAIR CORRADINI: Yes, Dr. Ahn is going to join us. But you have something you want to tell us ahead of time, right?

MS. GOVAN: Yes, I do, yes.

CHAIR CORRADINI: Okay.

(Off the record comments)

MS. GOVAN: Okay, good morning again. I'm Tekia Govan, Chapter 2 PM for the South Texas Units 3 and 4 COL application. As stated in my remarks earlier, Section 2.4 of this review is notable in that the staff was required to disposition a non-concurrence for the safety evaluation prior to making the document final.

I would like to give a brief overview of the non-concurrence process prior to the presenters presenting their findings for the non-concurrence. The US Nuclear Regulatory Commission strives to establish and maintain an environment that encourages all employees and NRC contractors to promptly raise concerns and differing views without fear of reprisal.

Individuals are expected to promptly raise concerns and discuss their views with their immediate supervisors on a regular and ongoing basis. If informal discussions do not resolve concerns, individuals have various mechanisms for expressing and having their concerns and differing views heard and considered by management.

The non-concurrence process allows employees to document their differing views and concerns early in the decision making process, have them responded to and attach them to documents moving through a management approval chain. On June 8, 2011, Dr. Hosung Ahn submitted to his supervisor Section A of the non-concurrence form stating three issues with Chapter 2.4 entitled Hydrological Engineering contained in the proposed South Texas Project Units 3 and 4 safety evaluation report.

The first issue was the Main Cooling Reservoir breach flood analysis in SER Section 2.4.4. The second issue was flood analysis of hurricane and MCR breach combination, in SER 2.4.5. And the third issue was maximum groundwater level in SER Section 2.4.12.

Upon the recommendation of the Office of New Reactor Management, six technical experts in the area of dam breach analysis and hurricane storm surge were selected through the Office of Nuclear Regulatory Research, to independently review the applicant's FSAR, the staff's SER and the non-concurrence to provide their expert opinion on the issues raised by Dr. Ahn.

Upon completion of this review, upon completion and review of the expert analysis, on December 6, 2011, Dr. Ahn's supervisor provided written documentation of his analysis of the non-concurrence in Section B of the non-concurrence form. The non-concurrence of Dr. Ahn and his supervisor's recommendation which included the six expert analysis, were forwarded to the division management in the Division of Site Safety and Environmental Analysis for resolution of the issue.

On October 15, 2012, the division

management documented their final resolution of these issues in Section C of the non-concurrence form. The documentation of this non-concurrence has been requested by Dr. Ahn to be made publicly available and can be found in ADAMS.

At this time I would turn to Dr. Corradini, who will provide remarks regarding ACRS's expectations, followed by Dr. Ahn who will present his non-concurrence. Then Dr. Henry Jones and Dr. Rajiv Prasad will follow with the staff's finding and resolution of the non-concurrence.

CHAIR CORRADINI: So just to remind everybody, we want to make sure we ensure equal and appropriate time to hear both perspectives of the non-concurrence. So I'll ask the members to focus their questions primarily on the presenters and their comments during the allocated time. We have an hour for each. And then we can discuss it after the fact. So first I'll call on Dr. Ahn for your presentation.

DR. AHN: Good morning, everybody. My name is Hosung Ahn, hydrologist in the hydrology and meteorology branch. I filed this non-concurrence in June 2011. And management concluded last year with revising SER substantially. So I've reviewed this revised SER as well as reviewed comment from the external peer review and I decided I will not concur the final, I mean the revised SER.

So this morning I am presenting why I am not concurring on the revised SER. So first let's cope with the site review from my original non-concurrence issue. But I say that the basic issue remained the same about this question and the justification is slightly different from the original non-concurrence.

MEMBER BLEY: And you said at this time you do concur with the revised.

CHAIR CORRADINI: No, do not.

MEMBER BLEY: You do not, okay.

DR. AHN: There are three independent issue. One is the, three independent issue and I do not concur all three of them. So as was already said there are three non-concurrence issues. I am focusing my presentation on the first issue, the shell damage issue because that's the most important and critical issue for the safety and for the structural part of Chapter 3.

So on that first issue, I have four main concerns. There was interest on how they analyze the dam breach for the MCR. They used the empirical equation to predict the breach parameter. Breach parameter means the breach width, breach time and peak breach outflow. But peak outflow is simulated by the model.

So empirical equation, I claim that when they estimate breach width, breach time is not that sensitive but breach width is the most sensitive parameter. When they estimate the breach parameter they used one selective equation, Froehlich equation. That does not produce the conservative estimate.

I confirm that equation with the existing actual breach data from the Florida cases and I found that equation underestimate the breach width significantly. So I introduced that in detail. So that empirical equation method is the primary method. But they also used the NWS-BREACH model. That's the physical model for simulating breach process.

But it's also depending on how you define the model. I found that there are three issues. The first one is that STP used the low value. That resulted in the underestimation of the breach process as well as the flow process. Also the staff used unrealistically small tailwater section compared to the expected breach. So I'll explain that in detail.

The last one is that both staff and STP never considered a scouring hole. If you look at the breach there are big scour hole. And I'll explain that too. So let's begin with STP already attributes the site layout and some structure of future -- and I add some that could be related to the breach analysis.

STP complete the MCR construction in 1983. And they did the filling tests. That means that they filled the reservoir sequentially then they measured the seepage and whether there are problems or are there or not. They did filling tests up to 45 feet. And they observed some sliding on the system.

So they said that they determined national normal operating level would be 45 feet. Now they're going to add two more units and they're going to raise their operating level to 49 feet. So my concern is that with that higher water level, seepage volume will increase. Then it could induce the piping failure. So that's basic concern on the breach analysis.

MEMBER ARMIJO: Where is the seepage

actually occurring? Where is it being detected in these wells or?

DR. AHN: Everywhere.

MEMBER ARMIJO: So all around this dike or levee or whatever you want to call it.

CHAIR CORRADINI: But I guess Sam's question is the cross hash region is where they -- is it the yellow or the cross hash region where they determine what's seeping?

DR. AHN: It's actually seeping on the valve embankment and then it's through the foundation. In the foundation there are two sand layers. I will show them.

CHAIR CORRADINI: Okay.

DR. AHN: Seepage will cut through them. So the location of the breach is the applicant STP and I concur that the location is the closest from the site. That's on the northern embankment. And during the breach they have the cement block on the interior side of the embankment. That cement block could have fall into the bottom of the breach. That could increase the roughness quotient. We call them MSM.

That really induce more wide a breach and more breach were induced. So that should be considered by applicant and the Staff never considered that effect.

And when we defined the breach, redefined the erosion of the embankment and when we defined the scouring here we defined the erosion of the foundation is defined as scouring. The bottom elevation is 29 feet and below we consider that scouring but STP and staff never considered the scouring of the foundation.

So next four pages of, yes, in general when we do the dam breach or levee breach analysis in Chapter 2 safety analysis, we have a regulatory framework of Part 50 GDC-2 that was already introduced. It clearly said that we should consider the most severe event with a sufficient margin. I believe that STP didn't do that when they estimated, especially the breach width.

Was the Part ~~100.20~~8 100.20(c)(2) that we should use the maximum probable event for the rain or wind. Why don't we use the same approach for the dam breaches? That's my concern. And we have the guidance in SRP, RG 1.206 and ANS 2.8, that's the industry guidelines. However, the issue on general dam breach problem is that we don't have a detailed, technical guidance for the dam breach analysis.

Second, we have some dam breach historical data. However, especially for the larger dam, you don't have sufficient data. So all of our, the guessing game and we have a lot of uncertainty in breach analysis due to the data gather and uncertainty on those factors.

And applied conservatism similar to the other flood causing mechanism, that's another issue. For example, in rain input in the storm we use the probable maximum approach it, like for the probable maximum precipitation, we use the envelope approach to, use what is the envelope for the record of the rainfall on top of that we used the moisture maximization through adding more margin on there.

That's what we do to PMP and also some hurricanes we use the PMH approach for hurricane. That is really a bounding approach. We should, my opinion is that we should use the similar conservatism applied to the dam breach analysis. I'll explain that, explain a little bit more on that.

CHAIR CORRADINI: Can I ask one, just clarification?

DR. AHN: Yes.

CHAIR CORRADINI: So when the two additional units are added the mean depth would be four feet larger.

DR. AHN: Higher.

CHAIR CORRADINI: Higher, sorry, higher. And is that the major difference that causes your concern? I'm trying to understand. I understand the modeling differences. But I guess I'm, you start off by saying there was a difference in the operational level. So is that the source of it if it stayed at 45 would there be an issue?

DR. AHN: They did the filling test for 45. But they never did a filling test for 49.

CHAIR CORRADINI: Okay. But if they stayed at 45, would there be an issue?

DR. AHN: I don't think so. Yes.

CHAIR CORRADINI: There still would be an issue. I'm trying to understand. I'm just doing a relative comparison. They're at 45 now and operating. And now they choose to go to 49 with the two additional units. Is it the difference in inventory of those four feet that caused the concern?

DR. AHN: I think that's a concern. But I need to explain this way. Applicant used the deterministic approach. And they just postulate breach scenario without field condition or a field data. No matter what operating concern, whatever, they just postulate the breach scenario, then they estimate the maximum flood level.

And they, that level exceeded the design-based flood level. So they used that information for structure design. That's what they did. So whether operating level is higher or lower, I think that doesn't matter.

CHAIR CORRADINI: It doesn't matter. Okay.

DR. AHN: They just postulate the scenario, breach scenario. But my concern is that raising that level the potential of dam breach could increase. But that information is not used in any of the MRCs.

CHAIR CORRADINI: Okay.

DR. AHN: So I introduced the general issue on there. And to simulate the dam breach we should use, we should simulate the erosion and the flow process together. The process is reservoir, breach outflow and tailwater. We have no physical model that could handle all of this together.

And the NWS-BREACH model can handle

reservoir and erosion process and breach outflow. But it has some limitation on the tailwater routing. So how applicant did that is that they used the combined approach. First they used an empirical equation to create the breach parameter. Breach parameter, again means the breach width and breach time.

Then they used a numerical model. Plus they used a FLDWAV model to simulate breach outflow. Then they used an RMA-2 model to simulate the tailwater routing. Then they used the NWS-BREACH model to validate their estimation. So staff used a similar approach but they used the BREACH model as a primary tool. Then they used the historical model and entered equation to validate their estimation.

I used a similar approach to the STP. But instead of the RMA-2 model, I used the FLO2D model. That simulates tailwater spreading on the tailwater. But the result are same, the basic issue is that how we define the parameter and how we define the empirical equation. That's the key point in here.

So again, what empirical regression equations, that's the simple regression equation to predict the breach parameter. Based on the reservoir size. The reservoir size means the height of the head of the reservoir and the storage bottom of the reservoir. It's a very simple equation. But it produced some bad results, some uncertainty in there.

So next slide, I'm going to introduce the, why STP's breach width estimation is not conservative or why their estimate is not, why they underestimate the breach width. STP breach parameter estimation also relies on the first part of the left side of the part. As they introduced their breach is 417 feet and that's based on the Froehlich, best fit equation. I emphasize best fit. This is not the bounding equation.

And they used the MLM bounding equation to get 1.7 breach timing. And using the Froehlich equation they and the peak flow rate of 63,000 cfs, then they used the American model for the wave. For the wave they used the 417 feet breach width and the 1.7 hour breach time, then they simulate a breach peak outflow, that's 130.

I used the MLM breach width equation. That's, resulting in much more conservative result. And based on some sort of a scouring hole, breach width would be 700 feet to 1,700 feet. That's almost two or three times wider than what applicant estimated. Using that breach width, I simulate FLDWAV model and it ended up 280 kcfs. That's almost two times larger than what applicant estimated.

I also used the BREACH, NWS-BREACH model with conservative roughness coefficient and realistic tailwater section. That end up about 260, so again two times larger than what applicant estimated at peak flow.

So my issue is that STP's breach width estimation is not conservative. I think they underestimated breach. The main reason is that they just keep the Froehlich best fit equation, based upon region and they just ignore the MLM equation. When they justify why they don't use the MLM equation they said, I think one of the RAIs they said that MLM equation is not for the bridge width. But that's not correct.

I have a lot of paper. They actually classify that MLM erosion volume equation, that equation can be used to predict breach width. So I think the applicant's justification is incorrect on that. And also use of the best fit equation, that's another concern and I explained that in further detail.

So to predict a breach parameter, that means breach width and breach time, there are four determining equations. USBR had one equation. Von Thun and Gillette has another equation. Then Froehlich's one equation and MLM is another equation. What guidance said, all the agent's guidance all the federal agency or state guidance said, what they said is that we should use all equation to make engineering determination.

Engineering determination means what is the construction condition and what is the current condition of the dam already? And how an actual breach could occur. So we should do that. But they just picked the Froehlich equation and that's it. That's what they said.

And also in terms of the breach peak flow, there are over, more than ten equations. However, the applicant used just Froehlich breach equation and they ignored the other equation. The other equation actually end up much higher breach volume than, the peak flow volume than Froehlich equation. So that's another concern on that. So on the next page I made a --

MEMBER ARMIJO: Before you leave that

chart, could you go back to, you also cite that the breach for STP Units 1 and 2 is 2,000 feet and that was determined, pretty much deterministic that they just said --

DR. AHN: That's the same determinist approach. But on the UFSA they never clearly state how they end up 2,000. But they just assume the 2,000 and instantaneous failure.

MEMBER ARMIJO: And that was, did not create problems for the flooding of the units.

DR. AHN: Yes, Units 1 and 2, they are designed for these 51 feet. So I don't see any problem with it.

MEMBER ARMIJO: So Unit 3 and 4 --

DR. AHN: Unit 3 and 4, their flood is 40 feet. That's much lower.

MEMBER ARMIJO: Okay. So that's a main issue. So your approach would have predicted a breach similar to their 2,000 feet closer.

DR. AHN: Actually it's less than that. I said it's about 700 feet to 1700 feet, less than 2,000.

MEMBER ARMIJO: Yes, it would be less than 2,000. But much greater than 417.

DR. AHN: That's right.

MEMBER ARMIJO: Okay. I don't understand what the problem is.

DR. AHN: This one, UFSAR used in the Victoria ESP, that's actually withdrawn. But they used about 2,000, it is similar conditions, but they assumed the 2,000. I don't know exactly how they estimated 2,000. But they did that.

And the initial version of the Units 3 and 4 FSAR, they assume the 4,700 feet. Now they change that to 417. That's our basic concern raised. And for the Martin Cooling Pond in Florida, that reservoir size is quite similar, about 700, I mean 7,000, acre area with some similar head. But actual breach was 600 feet. So that's why I say this 417 feet is not conservative. And this is small. Next page.

MEMBER SCHULTZ: Excuse me, go back again please. Why are the latter two -- in your notes you indicate the latter two approaches are not applicable to MCR, why is that? Is that your conclusion or?

DR. AHN: The two equation, they rely only on the breach head, not the breach volume. So if you use that equation it underestimate breach width.

MEMBER SCHULTZ: For each of them. Thank you.

DR. AHN: So I made a position analysis for the MCR breach size to know the potential size of the breach width. What I did is from the two papers that Xu and Zhang and the Froehlich paper, that is 2008, that's different from what I say the Froehlich equations. I pulled the basic data from that paper and I plot that on the graph. On x axis it shows the breach volume and the y axis is the breach head.

So if you look at that the data is really scattered. That means it introduce high uncertainty estimation, whatever your estimation is. Then I plot the position of the MCR, MCP, Martin Cooling Pond as well as Teton. The applicant chose the Teton as a showcase for MCR. I believe that's incorrect because Teton dam is very high. It's about 270 feet high. And the storage volume is a little bit higher than MCR.

But it reached the 419 feet breach. But because that is the high then it cannot be the showcase for the MCR. A better choice is the Martin Cooling Pond in Florida. And staff chose there, but after the, when they analyze the data it's a little bit different way they did it. So what I am saying is that MCR is the largest dam based on the clarification of that dam even by the State of Colorado or international definition.

MCR is the largest dam and it has a low head, but high volume. So breach width could be higher or wider. That's my presumption on this. And that's true for the, I proved that for the Martin Cooling Pond cases. And based on the size of the MCR, which showcases the Martin Cooling Pond breach that happened in 1979, in November. So that's my observation throughout this position.

CHAIR CORRADINI: Can I ask one clarifying question just so I remember? In the non-concurrence report with the appendices, you are in agreement with the other experts that it's a pipe break that would be the initiating event. Am I correct?

DR. AHN: Yes.

CHAIR CORRADINI: So it would be, so the pipe would break, I'm still trying to understand this. The pipe would break through the embankment and then would cause erosion and it would just erode to some size. Now we're talking about how big of a size it erodes to. And that's dynamically considered in both cases? In other words you start with a little hole.

DR. AHN: Yes, starting from the small piping hole.

CHAIR CORRADINI: But I guess the reason I'm asking that question is in what I thought was the assumption was it kind of rises up quickly versus erodes slowly. But is the rise up quickly still a dynamic erosion of a hole? That's what I'm confused about.

DR. AHN: In the NWS-BREACH model the vertical erosion and the horizontal erosion that is --

CHAIR CORRADINI: Well, it's coming from a pipe break. Okay.

DR. AHN: Yes, it's starting from one pipe break.

CHAIR CORRADINI: Okay, thank you.

DR. AHN: Yes, Martin Cooling Pond where piping started is from the foundation, not the embankment itself. Similar thing could happen on MCR breach.

CHAIR CORRADINI: Okay, so this is a different initiation for the Martin Cooling Pond. It initiated differently in your MCP.

DR. AHN: Yes, you said, that's a good point.

CHAIR CORRADINI: I just wanted to understand.

DR. AHN: When the breach modeling, we assume that piping started from the embankment. I tested piping starting from the foundation and it has same effect.

CHAIR CORRADINI: Okay.

DR. AHN: So in terms of the conservatism, I put some historical dam breach or levee breach cases because I make for the case for dam breach or a levee breach because when I look at the levee breach width of the breach is much wider than dam breach. So those data come from the different source of the data.

But problems on the levee breach data is that we don't have extensive or comprehensive database. So I used some limited report or paper. But my conclusion on there is levee breach wider than dam. So what all the difference between the dam and levee?

The dam has solely the foundation and it has a raised embankment on the side. But levee system doesn't have it. MCR doesn't have any treatment -- they have some treatment on the foundation. But they have no sea barrier or any solely the foundation on theirs. That's why I believe that MCR will breach wider. And it will -- scouring will happen on the MCR breach. That's my opinion.

STP estimates breach width of 417 feet. They have the scatter data, then they developed a best to fit deviation equation. And they just used it without the margin. So what this mean 417?

In an actual case about 50 percent of a chance the breach width could exceed that barrier. That's why I claim that this is not conservative. So I said that rough STP it is, again it's for GDC-2 condition. And Froehlich equation does not provide the bounding equation.

However, while Froehlich provided confidence interval, offered confidence interval or lower confidence interval based on the standard deviation from the mean of the friction error. So we can use that upper bounding equation as a, I mean upper confidence interval as a bounding equation. So tools are available, but applicant never used them.

Next page. So here I said we have four candidate equations to predict breach width and breach time. First three equation, USBR and von Thun and Gillette equation cannot applicable because that is based only on the breach head. So the only candidate is the Froehlich equation and the MLM equation. Which choice is better?

Staff said that the Froehlich equation is the better because its prediction error is smaller. Froehlich equation is .43 and MLM equation is .83. So Froehlich equation is better in this case. I disagree with that because that Froehlich prediction error is just the error in breach lengths, breach width.

However, MLM equation prediction error of .83, is the breach volume error. This is a different dimension. You cannot compare one to the other. Then I think that Dr. Head also commented that MLM equation, actually that's for the breach width. MLM equation, best fit equation, produced higher R squared error compared to the bounding.

I think that's slightly, we cannot compare one to the other. Best fit equation we can define R squared. However, for the bounding equation we cannot define R squared because the procedure are different. So that justification is also, I think it not correct. CHAIR CORRADINI: Can I ask you to repeat that because I read our consultant's report and it was persuasive to me. So I am trying to understand your explanation, your counter argument. Can you just repeat it please?

DR. AHN: Okay. Actually two external reviewer say this. Froehlich prediction equation, prediction errors one of them MLM prediction equation. The USBR hydrologic engineer, he actually wrote his paper in 1992. He estimate the prediction error for these three equation.

And he said that Froehlich prediction equation is smaller, so it's more, it's better equation for MCR breach equation. I said that's incorrect because they are two different dimensions.

CHAIR CORRADINI: They have two different what, I'm sorry?

DR. AHN: Dimensions.

CHAIR CORRADINI: Okay.

DR. AHN: Yes, Froehlich equation is for the breach width. MLM equation is for the breach erosion volume. It has much more intrinsic error and it has literally higher error. So that's different. That's one thing.

Then historical breach data used in the MLM is much -- the range of the data is more, much, much smaller than MLM equation. That's shown on this, on Page 8. So we chose to verify MLM, definitely this graph say that MLM equation is better because the data reference, MLM is superior.

CHAIR CORRADINI: Okay, thank you.

DR. AHN: That's my argument. So based on Martin Cooling Pond cases, that's the historical data. I evaluate those three equations and I conclude that the MLM and the, MLM equation or the bounding Froehlich equation is better.

So for MCR because the MCR and the MCP are same condition, similar condition. So that's my conclusion of this specific sub-topic. And the next one I'll explain the roughness coefficient.

CHAIR CORRADINI: We need to conclude in about 30 minutes, just so, time check.

DR. AHN: I go fast. Roughness coefficient. In the BREACH model, roughness coefficient is the most important parameter, among others. And Manning's equation originally developed for the flow, but when we apply that then it's the roughness coefficient in breach, it could have a slightly different meaning.

The issue is the STP used a non-conservative n-value. However, the staff used the n-value of .75, that's quite, I mean much more conservative than what applicant has made. So I agree with this the staff's value and I do not agree with applicant's value. And I just, I explained that on the next page.

So why the breach n-value should be higher than Froehlich n-value. It's explained on there. Basically the reason is that breach create more flow, that create more resistance. But that's why they should use the higher n-value. And the State of New Jersey, they defined the probable maximum n-value and they also defined the probable maximum breach width.

But they always concentrate their commentary on the higher value. The breach manual provide for low n-value cases and the Staff used that to justify the, justify the applicant's n-value, .05 is reasonable and acceptable. But the other study used really higher n-values. Sometimes they used more than, greater than .1 value.

Next page. So I put all different meanings and values from different sources. The first two I already explained as applicant used .05.

Staff used the .075. And the Handbook of Hydrology, that's the most widely referenced group, they used n-value for China as a .04 to .1. And Chow, he also reached the extensive n-value and he said the n-value is .035 to .1.

So the high end is really high. And the next two Fenton and Trieste and Jarrett paper, and their n-value is really high, especially for Trieste and Jarrett said the breach head barrier, the n-value is much higher than, it should be two times higher than what is based on the field flow condition.

Then they should, they said you should use a higher value, two times higher than that. So the next one there is like .225. That's really high. And the last two I estimate n-value based on the Chow method. And also calibrate n-value using the Martin Cooling Pond. And it's about, it's over .75. So what I concluded is that the staff choosing an n-value of .75 is reasonable.

It's not that really conservative. That's my conclusion. So what I am saying is that applicant's n-value of .05 is small. One expert peer review said the n-value of .025 is reasonable. But I disagree with that because if you use the n-value of .025, breach width is less than a hundred feet.

It's much smaller. Breach volume is like less than a 100. It's also small. Even .05, that's not working on this case.

MEMBER SCHULTZ: But your bottom line conclusion is that the .075, which was used in the staff SER analysis, is appropriate?

DR. AHN: Acceptable, yes. I agree. The next one is the tailwater section. BREACH model used one dimensional flow out on the breach section as well as tailwater. On tailwater, the units specify only one cross section. That's more than limitation but is acceptable based on our tests and our analysis.

I claim that the staff used an unrealistically small cross section compared to the expected breach width. Breach width is about 400 or 500 feet. Bottom tailwater section they used the 600 feet. That substantially decreased the breach process. So that's the issue I raised on there.

And the applicant used a similar approach for their sensitivity analysis. But when they used a simulation of the BREACH model, they used the .05 and that is not a, small breach section, tailwater section is not impacted on there. So my opinion, I disagree on that.

And the issue is the wide, the bridge width because the reality of the tailwater section is that it's more than one mile wide, width and it has slightly upslope. So tailwater section is very critical in this simulation.

CHAIR CORRADINI: So I don't understand what a tailwater is. Are you saying it's, is that your next figure? Are you going to show, okay, fine thank you. Thank you.

DR. AHN: Next figure show what is the tailwater sections. Let's look at first the bottom left figure. I used the FLO2D model and applicant used a similar approach using the RMA-2 model. We simulate two dimensional flow on the tailwater section down. The tailwater section down means the downstream of the breach section. That's another part of the breach section.

I observed that there, the tailwater flow is really widely deposited. So if we use the small section it creates a head, initial tailwater head dramatically. If you look at the top left picture, I compare the staff's tailwater section and my tailwater section on the bottom and top. That is the imaginary section, that section, that does not exist on the field.

But they used a small section, that constrict breach process. That's what I said on there. And on the top right hand corner, that actually is the scale of the staff's breach section and my section. I used the 3,000 breach. On the side I put some barrier. But that does not effect final simulation.

CHAIR CORRADINI: So, I'm sorry that I'm still not following. It would seem to me with a larger tailwater section the water would disperse away from the unit. What am I missing?

DR. AHN: That's a good point.

CHAIR CORRADINI: I mean if I make it a 1,000 feet it's not going to go just that way. It's going to go that way. So am I missing something?

DR. AHN: Yes, lots of people ask the same question.

CHAIR CORRADINI: Okay.

DR. AHN: That tailwater is only near the breach section. So if here is that small tailwater section, breach for outflow of water will be smaller. So if that transfers to the site, actual flooding head will be lower even though tailwater head near the bridge section is higher. There are some compensation effect.

CHAIR CORRADINI: Okay. All right.

DR. AHN: So if I use the wider, wide tailwater breach section, it create wider breach width. Then it creates much more flow. That transfer higher flooding at the site.

CHAIR CORRADINI: And your simulation is what we're looking at, at the lower left? It's your simulation that we're looking at the lower left?

DR. AHN: No, no, for the BREACH, NWS-BREACH model, I used the wider breach section on there. I used that outflow on my two dimensional flow model, that's the lower left.

CHAIR CORRADINI: Fine, that's all I was asking.

DR. AHN: Two different models.

CHAIR CORRADINI: Okay. Thank you.

DR. AHN: So my, before that, the staff did the sensitivity analysis of the tailwater section. However, in their sensitivity analysis they used an n-value of .05 and on the blue line. So what that mean? They choose the n-value of .075 but they did sensitivity analysis with n-value of .05.

Then they concurred that tailwater section is not a limiting factor. I disagree with that. I did same sensitivity analysis with n-value of .075. And I end up the red line. This is very sensitive. Even in SER they conclude that tailwater section is not contributing factor.

But I disagree based on my simulation. Then they used the n-value of .075 in their simulation and they conclude that maximum outflow will be about 170. So applicant's breach scenario is acceptable. If I used the n-value of .75 with wider breach width, that's 3,000 feet, it end up much higher outflow and flooding river. So I think that's simply modeling error.

MEMBER SCHULTZ: Is there something in the equations that explain the graph that you show, the results that you show on the graphs that for an n of .05 it's going to be rising and then flatten at a particular?

DR. AHN: That's on my reanalysis report. I include my sensitivity analysis paper on there and clearly say that this is showing the same thing as yours on there. And the the report also show this graph. So all the data are there.

MEMBER SCHULTZ: Okay. I'll take a look

at that more carefully. It looks like the equations provide some unusual results with that sensitivity.

DR. AHN: No, we use the same model and same, only the difference is the Manning's value of the tailwater section. So through the sensitivity analysis I verified that. Next.

So far I explained the tailwater section. We did the sensitivity analysis by STP, staff and I, myself. And I plot them on there. So all the basic data are on the report, on the report. And I just plot this. And at Manning's n-value of .075, we have a deep, deep difference between my estimation and the staff's and the STP. Why that happen?

That's because of the small tailwater section. That's the clear result of the model. And why is there a difference between the staff and the STP? That's because they used different soil property. And I tabulate that on there.

Next page. Scouring hole issue. I said staff and STP never used a scouring hole. And in the external peer review they unanimously conclude that scouring hole will not occur. I disagree on that. When they, when external peer review look at the soil property, I think they misinterpret the actual soil property. So I'll explain that later.

But, so my issue is that scouring will happen in MCR based on field data. And I explain that even more.

CHAIR CORRADINI: Can I just say back to you after reading the non-concurrence, when you say scouring you mean erosion due to turbulence? When you scour that means I'm, I have some sort of turbulent action that's essentially taking up soil and eroding.

DR. AHN: It's same as the breach. But I defined that scouring is below the embankment and breaching is on the embankment.

CHAIR CORRADINI: Okay, fine.

DR. AHN: Erosion process are the same.

CHAIR CORRADINI: Okay.

DR. AHN: Next, please. I brought some Martin Cooling Pond breach case in here. They used about 600 feet of the breach and in their breach scouring hole is very wide and extensive. And their depth is maximum 30 feet, about 30 feet, 29 feet.

And average is about 16 feet. That's why I assume that, I assume that probably from scouring holes scenarios. Zero depth, ten feet depth, 15 feet depth and 20 feet depth. And that's the range of this, I got that value from this.

What scouring hole impact, I mean what's the meaning of the scouring hole? It creates the wider breach volume compared to just a breach itself. And it produces more outflow and it induce more flooding, that's the basic concern on there. Next, please.

MEMBER ARMIJO: Without scouring you would just have the initial breach of the levee or the dam and it would pretty much remain the same throughout the drainage, it wouldn't widen? If you don't have scarring does that, a breach just --

DR. AHN: It's condensing. When, if you simulate the breach in water without scouring hole, breach width will actually be wider, about more than a 1,000 feet. If we use the scouring hole, breach width will be lower. But actual volume is, remain the same.

MEMBER BLEY: So you're saying the cross section stays the same.

DR. AHN: Cross section is same, yes.

MEMBER BLEY: In either case.

DR. AHN: Yes. So if I use the ten feet scouring hole, breach outflow volume is about 270 something. If I use the 20 feet, actual breach volume is slightly lower than that but still nearly the same.

Next page I show the -- there are the sand layers and what, how piping could occur. I'll jump to the next page. And other thing that, currently they have five groundwater pumping wells. And they're going to add one more well. The other MCR leg system.

If they continuously pumping groundwater from there, there could be land subsidence, currently they never observed. They will induce significant drawdown and at the southern point it could induce land subsidence and that could create breaching and scouring. That's my basic opinion on there.

This one is the soil property from the UFSAR report. And I found that about a few weeks ago and I include that on there. But two external peer review said that scouring will not occur because cohesion value, c-value, first the green color is really high, a 1,000 or 2,000 pound per square feet.

So the clay layer scouring hole will not occur. However, they missed the next page on there. They measure the soil property after filling the reservoir. What are the difference between the construction end of the construction and after construction? End of the construction that clay layer is really compacted.

So the soil is really stiff and it has a higher cohesion value, more than 1,000. However, after filling water, clay layer is soaked and saturated and c-value is dramatically reduced. Like that, there are some pipe on the second, on the red column, the fourth red column, I used the bar as the missing data. But I checked the actual UFSAR report and it's not missing value.

That means there is local washout on the clay layer. And during the '83 to '84 they measure and have a cohesion value and it's about 350 pound foot, cubic feet. So --

MEMBER BLEY: Where are they measuring this?

DR. AHN: Just taking sample and they measure this area from the left.

MEMBER BLEY: Right outside of the levee area.

DR. AHN: No, no the embankment. They took samples from the --

MEMBER BLEY: Right through the

embankment down.

DR. AHN: Embankment and the clay layer, that's all foundation.

MEMBER BLEY: And this is down near the bottom.

DR. AHN: Yes, exactly. They took the sample and they made up a value, that's the value.

MEMBER BLEY: If I read your equation right though, it looks like the shear strength is going up in general because your fee ($\Phi$) is going up.

DR. AHN: That's true.

MEMBER BLEY: So the shear strength is getting better even though it's less compacted?

DR. AHN: You say blue column, I mean the green column?

MEMBER BLEY: Your degrees.

DR. AHN: Degrees, yes.

MEMBER BLEY: The equation says the shear strength is going up because that shear angle is going up.

DR. AHN: In the BREACH model figure, the angle is not that sensitive. Most sensitive area is the seabed. But what external peer review said is that c-value is really high. So scouring will not occur. I disagree with that based on the data actual c-values really decreased.

So the staff and the STP really used actually 300 feet or 400 feet in our BREACH model. But external peer review, they missed this fact and they said that scouring will not occur.

MEMBER BLEY: 1984 is the most recent sample they have?

DR. AHN: I believe, yes.

MEMBER BLEY: So we don't know what it is right now?

DR. AHN: Right now, we don't know, no. Next page is, I just summarized my simulation of the breach process and the final breach width and the further, and I end up over about 45 feet. That's five feet greater than what applicant estimates. So my conclusion is that STP should use the conservative equation or realistic breach parameter.

And next, the hurricane storm surge.

CHAIR CORRADINI: If I might just do a, I'm sorry to, but we started about an hour ago. You said you want to deal with issue one. This is now onto issue two. Do you want to deal with this because I think we were going to need about an hour for the staff too? So I wanted to ask your opinion here.

DR. AHN: It's up to you. I can skip.

CHAIR CORRADINI: Well when you started you said you wanted to definitely present issue one, so --

DR. AHN: Yes, I finished the issue one.

CHAIR CORRADINI: Okay, okay, so we're into issue two. Do you want to, you have just, as I see this it's just a few slides. So you want to continue please?

MEMBER ARMIJO: But before you do that, back on slide 20 in the final analysis after all of these issues that you've raised the fundamental, the final difference that is on this chart that the STP flood level would be six feet or should be six feet higher than what they currently estimate.

DR. AHN: No, no. STP's flood level is about 6 feet in depth. But that means plant grade is 34 feet meets the river and they estimate 40 feet. What I estimate is about 45 feet, that's five feet higher than what applicant estimated.

MEMBER ARMIJO: Yes, that's what, I think we were saying the same thing. At least I'm trying to say the same thing. So they, your 44.6 after all of these differences and they're at 38.8.

DR. AHN: 38.8, but they decided 40 feet including some margin.

MEMBER ARMIJO: So they, 40, so there's about a five foot difference in flood level.

DR. AHN: Between them and mine, yes. On hurricane storm surge issue, number two, Page 21, STP storm surge, storm scenario, hurricane scenario is not conservative that's what an external peer review commented. However, their wind speed is unrealistically high.

The air estimated is over 184 feet, miles per hour, that's much higher than what's estimate on US Army Corps of Engineer estimated. However, the storm surge is much lower than what is Army Corps of Engineer estimated. Their storm surge is over 30 feet. But Army Corps is over and they end up over 40 feet, so very big difference. Why they end up different is your, I think applicant should answer these questions. That's basically my issue.

Next, please. This issue is more like the processing issue. Staff identified that maximum groundwater level is exceeding the DCD maximum level. So that is clear departure. However, on the site parameter table and departure report it never addressed and subsequent structure analysis. Some they incorporate this new maximum groundwater level and some they are not. So that is the basic issue on there. So that's my presentation.

CHAIR CORRADINI: Okay.

DR. AHN: Any questions?

CHAIR CORRADINI: Questions from the committee?

MEMBER ARMIJO: A lot of questions. But I, you know, basically, you know, this is a lot of detail that is not our, certainly not my area. But it seems that the experience with this Martin Cooling Pond is very relevant to the MCR.

DR. AHN: Yes.

MEMBER ARMIJO: And there you have data from a natural event and your analysis would be consistent with that data, your analytical approach. And if you apply that same analytical approach to the cooling reservoir, you get a much bigger breach.

DR. AHN: That's right.

MEMBER ARMIJO: And so, you know, I'll be asking the staff, you know, what is, what's wrong with that approach? I mean we all believe in data. And this is a, maybe there's better examples of something similar to the Main Cooling Reservoir.

But this looks pretty reasonable so, but it seems to me that's your experimental basis, if you will, for your, to support your analysis and your claims.

DR. AHN: If you look at the position, NRC's, on Page 6, it clearly say that Martin Cooling Pond could have been the best showcase for the MCR. But the difference between that and MCR is that MCR is like a clay and silt embankment. However, this, the Martin Cooling Pond describes that, that's the fine sand or the silt material. So sand material has a lower corrosive strength.

However, I look at the Martin Cooling Pond breach report and their cohesive value is even higher than what STP's value. So that argument is nullified.

MEMBER ARMIJO: Well you have your backup slide, slides 36 and 37 where there's a lot of similarities between those two things. But there's also differences.

DR. AHN: That's right.

MEMBER ARMIJO: For example, the MCRs have relief wells and sand core blankets, a variety of things to control seepage that are, seem to be significant. But so later, you know, that's what I'll be looking for is, you know, why is the MCR not a good representation of what, is not, that the MCP is not representative of the MCR. What are the differences that basically counter your argument?

DR. AHN: Somebody may argue that way. But what is the better candidate? There is no case.

MEMBER ARMIJO: Well that's what I'm saying. Is there anything better? And are there any features in the MCR that say well, yes, you have a good example. But what we've got is we've got these wells or we've got other features that protect us against these wide breaches.

DR. AHN: That's the positive side, but there was the negative side. One negative side is that the actual breach head of the Martin Cooling Pond is much lower than MCR. That's the one thing.

CHAIR CORRADINI: Say it again, I'm sorry.

DR. AHN: Actual breach head.

MALE PARTICIPANT: There's 16 and seven.

DR. AHN: He said 16, but if you look at the table condition it's about 20.

(Off microphone comment)

MEMBER BLEY: If you get that low it's likely you have a lot more head compression.

DR. AHN: And basically in this the 600

feet breach area, that's why I claim that MCR could be wider than 600 feet.

CHAIR CORRADINI: Other questions?

MEMBER BLEY: I have a few. I've read your analysis a while back and I don't remember the details now. I'm being refreshed. I have a few things that aren't quite hanging together. You originally, calculation said you get a breach width between 700 and 1,700 feet.

Then you've shown us some pictures where you're using a 600 foot wide breach with scouring. And I thought you had 600 foot without scouring. What is the, is this picture the one that you've actually based your final calculations on, 600 feet wide with scouring?

DR. AHN: I did that.

MEMBER BLEY: Well you did a lot of things. But the one that leads to the 45 foot, 44.8 feet, is that this cross section?

DR. AHN: No, no, this is the Martin Cooling Pond cross section. This is not --

MEMBER BLEY: Which one is the one that leads to your 44 feet? Is it the wide one that's very, without scouring?

DR. AHN: Wide one, yes. No, no, ten

feet scouring hole and 1,000 feet.

MEMBER BLEY: And a 1,000 feet wide. Okay.

DR. AHN: If I used the 20 feet scouring hole it's over 700 feet.

CHAIR CORRADINI: Okay. A couple of other questions just to help me out. And you did a lot of calculations so I don't know if you've been able to separate these things. Out of the areas where you think they've been conservative, roughly how important are scouring versus not accounting for the uncertainties and the, you know, not setting an upper bound on the equation that they used.

And you used something different. But if they had used their equation with --

DR. AHN: Let's go back --

CHAIR CORRADINI: -- the bounding calculations.

DR. AHN: -- to the applicant's analysis. They used positive when they estimate the breach parameter, they used the empirical equation. On there, only issue is whether it's conservative or not. When we used the breach parameter and the BREACH model, we have several different factor. So let's think of that later. First the empirical equation. Whether they used a conservative or not, I think that's the only issue.

CHAIR CORRADINI: And I have a little trouble deciding whether it's conservative enough. You know and you say they're not conservative but maybe they're not conservative enough, in your opinion. You think they're just actually not conservative, that they're optimistic compared to the real world.

DR. AHN: But you cannot use the best fit equation because ten percent chance of a time it will it will exceed, structure is there it will always, actual flooding will always exceed that estimate. Whether you use the one standard deviation or two standard deviation the result of the equation. But we should use the conservatism on there, margin.

CHAIR CORRADINI: Other questions? Okay. Why don't we take a break now and come back at 10:35 and staff will come back for the, I think, details on the non-concurrence review. Okay, 10:35, we start again.

(Whereupon, the foregoing matter went off the record at 10:22 a.m. and went back on the record at 10:35 a.m.) CHAIR CORRADINI:

Let's come back into session. Tekia, you're back.

MS. GOVAN: We're back, and we're ready for the staff to present their findings for the non-concurrence. At the table we have Dr. Henry Jones, Dr. Rajiv Prasad, from PNNL, who is one of our contractors, and Dr. Lyle Hibler also from PNNL, and he's a contractor.

Henry Jones and Dr. Rajiv Prasad will be giving the presentations, and I'll turn it over to Dr. Henry Jones.

DR. JONES: And this is the presentation of the staff NCP. Just to qualify this, in a normal NCP process we usually don't have six experts weigh in on this. But we thought that in this case with the issues confronting us that we would have six experts, three who are experts in dam breach and three in the storm surge that they review our SER.

And actually, it has resulted in us actually strengthening the SER, a lot of what we learned from the panel members in this instance we actually incorporated into the SER itself. And so --

CHAIR CORRADINI: Can I ask you a question since you opened the door?

DR. JONES: Yes.

CHAIR CORRADINI: So is the standard review plan in need of revising based on what you've gone through?

DR. JONES: No. We have everything that we need in the SER.

CHAIR CORRADINI: Okay. So it's more a matter of the completeness of how you looked at what was there based on your review.

DR. JONES: Yes, you bet. All right.

MS. GOVAN: Completeness and clarification, right?

DR. JONES: Yes. Okay, what we have here is going to be the three issues that were raised. One was the staff's MCR breach flood analysis was not conservative, and the Froehlich equation was not applicable, you can read that.

The staff's NWS BREACH, the Manning values, the comparison to the Martin cooling pond. The use of the NWS BREACH model was inappropriate, and the staff did not consider scouring, and you've heard that from Dr. Ahn.

And the second one was the hurricane storm surge and MCR embankment breach. There actually was a part where can you actually have a breach of the MCR caused by storm surge, and also was the NWS 23 scenarios conservative, and the review of the ADCIRC model.

And finally, the SER, did it improperly identify the maximum groundwater level, was there a need for a DCD departure. And so now I'm going to turn this over to Dr. Rajiv to deal with Issue 1.

DR. PRASAD: Good morning. My name is Rajiv Prasad, and I am from PNNL as stated previously. We are a contractor to the NRC for performing the STP surface water and groundwater reviews for the FSAR.

As stated before, the NRC contracted six independent experts. Let's move to the next slide. They contracted six independent experts to review the staff's SER, the applicant's Final Safety Analysis Report, and the NCP issues. Three of these experts reviewed the documents related to NCP Issue Number 1, which is related to the dam breach described in SER Section 2.4.4.

Just a brief introduction about these experts. Mr. Tony Wahl is a hydraulic engineer at the Bureau of Reclamation. He is an expert in the canal and embankment breach research. His research includes uncertainty in prediction of embankment breach parameters, examination of the empirical methods and numerical models to predict embankment breach parameters, characterization of erodibility of cohesive soils, stability of the spillway channels, and headcut erosions in spillway channels.

Expert Number 2, Dr. Baecher is a professor of civil engineering at the University of Maryland. He works primarily on the assessment and management of risks associated with water resources infrastructure, flood and coastal protection, and dam safety. He's the author of four books on risk, safety, and protection to civil infrastructure, and is a member of the U.S. National Academy of Engineering. Mr. Robert Patev is a regional technical specialist in the North Atlantic Division of the Army Corps of Engineers New England District. He is an expert in probabilistic evaluation of potential loadings from hurricanes, reliability analysis of hurricane protection, assessment of economic and loss-of-life consequences due to possible failures, and systematic integration of these factors into risk assessments.

Three experts listed as Item Number 2 reviewed NCP Issue Number 2 related to the PMH storm surge. Dr. Jennifer Irish is an expert in the coastal physics response due to extreme events like hurricanes. Dr. Irish has expertise in storm surge dynamics, storm morphodynamics, vegetative effects, coastal hazard risk assessment, and coastal engineering.

Dr. Irish has 28 papers in peer review journals, and more than 30 publications in professional conferences. Dr. Irish currently leads research on hurricane storm surge parameterization; extreme-value and forecast statistics; vegetation, breach and barrier interactions and responses to storms; and impacts of climate change on coastal flooding and damages.

Expert Number 2, Dr. Luettich, serves as the director University of North Carolina's Institute of Marine Sciences, and as a director of UNC Center for Natural Hazards and Disasters. He is the lead PI on the Department of Homeland Security Center for Excellence in Natural Disasters, Coastal Infrastructure and Emergency Management.

He is one of the principal developers of the ADCIRC model and has overseen ADCIRC's applications, both in hindcasts and forecast modes to storm surge and inundation scenarios.

Expert Number 3, Dr. Resio is a professor of ocean engineering and the director of the Taylor Engineering Research Institute at the University of North Florida. Previously, Dr. Resio served as the senior technologist for the U.S. Army Corps of Engineers Coastal and Hydraulics Lab from 1994 to 2011.

He served as a co-leader of the post Katrina interagency forensics study, and subsequently became the leader of the risk analysis team for the South Louisiana Hurricane Protection Project. He has been developing a new technical approach for hurricane risk assessment now being used along all U.S. coastlines. His new approach is also being extended by the NRC for new licensing guidelines at coastal sites. Next slide, please.

Now I will describe the resolution of the first NCP issue related to SER Section 2.4.4. The applicant's analysis of the MCR embankment breach is described in FSAR Section 2.4S.4. The staff performed an independent review and evaluated the empirical methods and physically based modeling used by the applicant.

The staff's independent review included confirmatory analysis, that for independent, and employed both empirical methods as well as physically based approaches. One of the specific

NCP criticisms of the applicant's selection of the Froehlich empirical equation and the staff's independent review and acceptance of this approach, was that the Froehlich equation is not applicable to breach widths exceeding 164 feet.

The independent review by the experts concluded that Froehlich equation is indeed applicable to breach widths exceeding 164 feet. The independent review also concluded that Froehlich equation's breach width prediction has less uncertainty compared to other approaches.

This was one of the issues also raised by Dr. Ahn in his presentation earlier. The independent review also stated that Froehlich equation is the most appropriate for estimation of the peak discharges from a dam breach.

MEMBER BLEY: Can you tell us, or are you going to come to it later, that the best fit equation, Mr. Prasad --

DR. PRASAD: Yes.

MEMBER BLEY: -- how the uncertainty is accounted for in your analyses?

DR. PRASAD: Well, the way we use the empirical equation is to get at an estimated breach width.

MEMBER BLEY: Right.

DR. PRASAD: Then what we do is, the guidelines call for us to use the best method and these are all deterministic, and then try to look at what margins would be available.

The margins come from our sensitivity analysis that we conducted on top of the best case scenario. That best case scenario began in the staff's independent assessment. The first thing we did was to look at if the empirical equations and the predictions from those were acceptable or not, and if the approach would be okay. So we verified that.

And then in our independent confirmation we actually used the breach, NWS BREACH model to look at sensitivity of the breach parameters, and try to look at how sensitive these estimations of the breach parameters are, which ultimately lead to the design basis flood estimation which is the quantity we want --

MEMBER BLEY: Since you start with the best fit equation that has uncertainty, there's uncertainty in the data around that, you never quite account for that or try to bound it or account for, you know, how far away from that best estimate fit the data are. So I just don't quite understand why not.

CHAIR CORRADINI: Can I ask Dennis's question differently?

MEMBER BLEY: Yes.

CHAIR CORRADINI: Is the Froehlich model or the MLM model a best estimate fit or some sort of bound on it? Because the breach calculation is always lower. In other words, going back to Slide 12 of the applicant's presentation, the red line is substantially below the blue bump.

That tells me that the blue bump with the fit is inherently conservative compared to what I would compute based on some more complex model where I could run the numbers and crank through the what-ifs about the various model parameters. And instead of getting one red line I would get a range of red lines to address Dennis's issue. Am I off base?

DR. PRASAD: Let me answer it this way.

CHAIR CORRADINI: Feel free.

DR. PRASAD: Thank you.

MEMBER BLEY: But before you do, just one last thing. If you start with the best fit experience data, you know, you haven't seen all the experience, so further data, some of it, will be well within the bounds we've already seen and some are going to be outside of that.

So you need some way to account for the spread in the data that's already there and for what we might not have seen as yet, so from that point go ahead.

DR. PRASAD: Right. Okay, so you have historical cases where they have, dams have breached. So you have parameters that could be ascertained or estimated the best that you can tell. There's the Dam Safety Office database that lists these parameters. And those parameters are basically what are used by these different empirical equations to come up with a predictive equation.

If you look in the literature, what has happened when the individual investigators were developing these equations was that they were purposely biasing those equations. They were not using the best fit, they were purposely biasing these equations to actually end up on the higher side of the scatter, not on the lower side.

That was one thing that the investigators intentionally did to account for some of the uncertainty. They always knew that based on only those measured predictive values and just one or two independent parameters that you want to base your empirical equations on, that there is going to be a lot more factors, like for example, construction of the dam, the detailed soil, what soil conditions are there, site specific scenarios, like do you have conditions that are more amenable to piping and stuff like that.

Those are not explicitly accounted for by the independent variables in those equations. So they always taught that any time they come up with an equation, a predictive equation that should be applied in practice, that they bias it on the higher side.

MEMBER BLEY: Now does that apply to the Froehlich equation?

DR. PRASAD: That applies to all of the equations.

MEMBER BLEY: So the plat that we saw that shows that as the best fit inside all the data isn't actually the Froehlich equation?

DR. PRASAD: I don't know how that equation was, how Dr. Ahn created that slide I'm not aware of.

MEMBER BLEY: Okay.

DR. PRASAD: So I can't tell whether that line that goes through, which is described as the Froehlich equation, is actually the Froehlich equation or not. But --

MEMBER BLEY: It's certainly about a best fit to the --

DR. PRASAD: It looks like the scatter is probably evenly distributed on either side, so I tend with that assessment, yes. But what the history tells us about development of these methods is that they're biased towards the higher end. So there is some account of the uncertainty, if you will, or the bias towards the higher end in terms of prediction.

Now let me go back and explain one more thing. In terms of the uncertainly itself, the data show a large amount of scatter. Now if you were to say that I would like to use a bounding equation on enveloping equation, what you're saying is that you want to go in history and look at the worst case scenario without actually accounting for all the factors that contributed to that severe an event, which may or may not be proof for your specific case that you're applying it to.

So those are some of the things that we

need to keep in mind. So when we apply these equations there is an implicit understanding that they're biased towards the higher end.

MEMBER ARMIJO: I'd like a couple of questions. Is the Froehlich equation applied to all kinds of dams whether it's a concrete dam or earth-filled dam or a levy? Is it a general use or is it unique to these kinds of things, dams such as the cooling reservoir?

DR. HIBLER: My understanding is it's generally.

MEMBER ARMIJO: Okay, that seems like it would be hard to generalize with such different structures. But the other thing is, the way the independent analysis used the Froehlich equation, did you use that same approach to predict what actually happened with the Martin cooling pond, and did you predict the breach with -- I'm just saying, if the independent analysis said this is okay, then did you validate it by saying, and it compares well to the data when you use the equation our way?

DR. PRASAD: By independent analysis, you mean the staff's independent analysis?

MEMBER ARMIJO: Well, either the staff's independent analysis, but the independent review didn't actually do any analysis, they just reviewed?

DR. PRASAD: My understanding is that they did not do any additional analysis.

MEMBER ARMIJO: Okay, well, maybe --

DR. PRASAD: They looked at the analysis that the staff presented and the NCP presented.

MEMBER ARMIJO: Yes.

MEMBER SCHULTZ: So your question, Sam's question then, it focuses on the staff's analysis.

MEMBER ARMIJO: Yes.

DR. PRASAD: Okay.

DR. HIBLER: We didn't do a calibration to the MCP.

DR. PRASAD: No. The way we used the MCP case was when we were doing the analysis both based on empirical equations as well as based on the NWS BREACH physically based model, was we wanted to know if these results that we were getting were reasonable, were biased towards the higher end, or whether we were for some reason underpredicting.

So one thing you do when you do prediction is to go back in history and look at what are the comparable cases that I can find and whether there has been an instance where there is significant difference between what we are seeing in our estimation versus what has already occurred.

So the Dam Safety database was actually sorted based on specifically looking at a few parameters of the storage reservoir itself, like for volume and the head. And when you do that sorting, we ended up with Martin cooling pond actually as the only case that matched closely to the MCR.

Then we went back and looked at, at that point we did not know what this Martin cooling pond case was. We went back and looked at it, and lo and behold, it's also an embankment constructed on existing grade level which includes a cooling pond.

So it was pretty analogous to the way the MCR behaves, but there are significant differences between how the MCR was constructed versus how the Martin cooling pond was constructed, the way they fail, the materials in the embankment they are completely different.

MEMBER ARMIJO: Yes, and that's what I'd like to get understood, a little more detail on exactly why those differences make it distinct.

DR. PRASAD: Right, and Dr. Ahn was also showing in his slides, do you remember one slide where the material embankments were mentioned, and for the MCP it is sand and silt versus for the MCR it is silt and clay. That's what he mentioned. It's actually compacted clay, which is much more cohesive and much more, well, less erodable I'd say.

CHAIR CORRADINI: Okay, thank you.

DR. PRASAD: So continuing with this slide, I had already described the Froehlich we got into question there. There's also this issue about the Manning's n, and let me explain that a little bit more in terms of what the staff's choices were about Manning's n.

And a little bit of history at this point is probably also important in the sense that in the National Weather Service Breach model, which is a physically based model, goes from a piping initiation to collapse of that, both of that pipe, collapse of that pipe with the overburden, and then expanding that breach or growing that breach into a regular trapezoidal section.

In NWS BREACH, what they do is they use Manning's n in two different ways, and actually in the input files there are two places where you specify these Manning's n values. And these two are meant to be two different Manning's n values to control two different things.

One is the Manning's n value in the

traditional way we understand it about channel roughness. The other one is actually a surrogate for the erodibility of the embankment material itself.

And that Manning's n is actually the recommendation in the breach manuals as well as in literature is to pick a Manning's n value that fits the bare earth medium, not to confuse it with the channel flow properties.

CHAIR CORRADINI: Can you say that one more time, please, for the uninitiated?

DR. PRASAD: Okay. Simply --

CHAIR CORRADINI: Simply's good.

DR. PRASAD: There are two Manning's n values specified in the breach model. One is in the traditional sense that we understand about the channel roughness, the other one is a surrogate for the erodibility of the soil.

The surrogate part is the value that is responsible for most of the uncertainty in the prediction or the sensitivity of the prediction of breach parameters that you see. Now when we picked our Manning's n values, we based it on the base case that the applicant had started with, which is 0.05, and then we went back and saw how NWS BREACH model actually says you should estimate these parameters.

And when we did that we found that 0.05 was actually a very conservative value. We did a sensitivity analysis on top of that both decreasing that value and increasing that value. So if you look in the SER there will be cases described with Manning's n value at 0.025 going up to 0.075, plus or minus 50 percent that we did.

MEMBER BLEY: And this is for the case where it's used a surrogate?

DR. PRASAD: Yes. This is the Manning's n value that is used as a surrogate. In all of these instances, the Manning's n value that is for the tailwater section is set at 0.06, still pretty conservative in terms of what you would see in terms of the channel roughness with the littering and effects going on once the dam breaches and then the material falls out.

MEMBER SCHULTZ: So in the two applications, from what you've just said, there's not a wide range of variability on the Manning's n value, even though you need to select one for one piece of the application and another for the other?

DR. PRASAD: Yes. With the understanding that these values that we use for the erodibility part of it are very, very conservative. That was actually demonstrated by Mr. Wahl in his independent review.

MEMBER SCHULTZ: The values that the staff has selected.

DR. PRASAD: That the staff has selected. That the applicant selected to begin with at 0.05, and the staff ran a sensitivity analysis reducing and increasing that value.

MEMBER SCHULTZ: Was it intentional to select it as very conservative or did it just turn out in review that it was very conservative? Were two values selected? That's my first question.

DR. PRASAD: It turned out to be conservative in review.

MEMBER SCHULTZ: Okay. All right.

DR. PRASAD: So when we did our reviews --

MEMBER SCHULTZ: Value was selected.

DR. PRASAD: Right.

MEMBER SCHULTZ: They were. There were two different values that were used for these two --

DR. PRASAD: There were two different values selected for independent analysis.

MEMBER SCHULTZ: -- approaches.

DR. PRASAD: And they turned out to be pretty conservative.

MEMBER ARMIJO: What is the physical reason that justifies your statement that 0.075 is not credible under Item C?

DR. PRASAD: That actually comes from --

DR. HIBLER: The independent reviewers, that's consistent with what the independent reviewers stated as well. Based on the documentation and the NWS BREACH description of that parameter, 0.075 is huge. It should be, you know, half that value or something like that.

CHAIR CORRADINI: But I think what Sam's after is --

MEMBER ARMIJO: A physical reason.

CHAIR CORRADINI: Yes.

DR. PRASAD: Well, the physical reason is that, remember, these are roughness values. And roughness to flow is determined by what material you have over which the flow takes place. The bigger the material, the higher the resistance to flow.

So basically if you look in the dam breach manuals and the literature, there's a surrogate to grain size, of medium grain size, and the Manning's n value. The bigger the medium grain size, the bigger the Manning's n value because you expect the water to be resisted more by these bigger blocks of material. MEMBER ARMIJO: But Dr. Ahn, in his review he said that, you know, you have this concrete soil material on the liner or whatever that is, and when that breaks up it goes through the breach and that's going to make it, you have to take that into consideration.

DR. PRASAD: Sure. But that is the part where we specify Manning's n in the second part with the traditional channel roughness part of it. That's not the erodibility part of it. The erodibility part is based mainly on, I keep calling it a surrogate, which is to say that we need to get some measure of the stresses that are impacted on those soil materials to erode them away to make the opening.

MEMBER SHACK: I'm looking at Wahl's report, and he's getting these values from what he calls the Strickler equation. And now are those the erodibility values?

DR. PRASAD: Those are the erodibility values, yes.

MEMBER SHACK: Okay, so when he says of then, of 0.04, he's talking about boulder size range.

DR. PRASAD: That is correct.

MALE PARTICIPANT: Three-foot chunks.

CHAIR CORRADINI: This is basically you're taking an erosion, at least if I understand this correctly, you're taking an erosion value or you're trying to estimate an erosion based on some roughness value of an eroding pipe with some length scale that gives you a roughness.

DR. PRASAD: Right. You're trying to figure out if that pipe, what are the stresses --

CHAIR CORRADINI: On an eroding channel, I should say, excuse me.

DR. PRASAD: Right. On that note, beginning with the pipe then going into a channel, what is the stresses that would be impacted on those particles to basically detach them from the physical embankment and move them away?

So that is where this notion of erodibility of the embankment medium grain size comes into the picture and not the boulders that are actually obstructing the flow. So those are two physically different concepts.

DR. HIBLER: Some of the standard engineering practices, too, have a Manning's n be set as a sum of different ends of the flow features or environmental features, the first part would be on the grain size. How rough is the soil that the flow is occurring over, and then you would add on to that different terms to account for vegetation, buildings, tortuosity of the channel and so on.

In the first case that Rajiv was talking about where erodibility is concerned, that summation is cut off after the first term. But when you go downstream, those other terms come into play and that's why there's two different values used.

MEMBER SHACK: And that's why it's as high as 0.06 then in the tailwater is that I'm talking about trees and --

DR. PRASAD: Yes, basically big lots of say the soil cement that would come out and would line the tailwater section as the flow moves out. So that's the channel bottom which is going to be, you have a specified Manning's n for that in the breach model itself.

MEMBER SHACK: But I have a hard time understanding why in the erodibility a large value of n is conservative. I would have thought that the erodibility thing, small would have been the conservative way. It would erode faster.

DR. PRASAD: Yes, I think Mr. Wahl also touched on that point in his report a little bit. It goes back to the stress equation that he used in the NWS BREACH and how the model was set up. And it's a non-linear equation and --

MEMBER SHACK: It's counterintuitive to me.

DR. PRASAD: Yes. But the way the equation is set up, there are multiple factors that effect how that stress would come out based on how you specify your Manning's n value. But that's the effect you see.

And when you end up increasing these Manning's n values, which is the erodibility part in the NWS BREACH, you start seeing these embankments that really lose their strength, metaphorically speaking, very quickly, and then the breach sort of exponentially goes as the increase of Manning's n values.

So that's the sensitivity part that you're seeing in the breach analysis. But going back to the recommendation that it is actually the medium grain size that you should be basing these on, because that's where the stress is coming from that detach those particles, that Manning's n values of 0.05 is very conservative, 0.075 is not credible and actually should have been in the region of about 0.025 to 0.04.

But there's also this relationship that if you don't change anything and just reduce those Manning's n values down, then the flow coming out from NWS BREACH becomes smaller and the breach becomes smaller also.

So in our review, the objective was to basically figure out if the applicant's analysis was conservative enough. And in our review we found that when once we factored in all of these things, that although we may not agree that that Manning's n value presents the medium grain size of the embankment that it is giving us a value that is conservative.

And that's where our review stops, saying that even if you pick a Manning's n value of 0.075 the breach width that we get is pretty comparable to what they got. We got our free flow not quite going up to what they did. I think they were at about 130,000 cfs, and our report indicated it was about 127,000 cfs. That's at Manning's n value of 0.075.

And from that point on it was pretty

clear that we could not get the flow and the width to go any bigger in a conservative sense. So only review part after that was to basically see how you specify this outflow coming out of the embankment breach into a two-dimensional model which spreads it out near the stipulated structures that we are concerned about and how high the water gets.

MEMBER SHACK: Okay.

MEMBER SCHULTZ: Before we leave that slide, can you help me resolve the statements b and c, where b says it would have been useful to examine the n value of 0.075 and c says 0.075 is not credible?

DR. PRASAD: Right. This is about the tailwater section. One of the things that you see is the breach becomes larger and larger as you raise your Manning's n value up. Our sensitivity analysis began with basically its value of 0.05 for the Manning's n. Now eventually to get to the water surface elevation at the SSCs, we used the scenario from NWS BREACH which had a Manning's n value of 0.075, although the sensitivity analysis for the tailwater section was done at 0.05.

Our position is that 0.05 being an extremely conservative value for Manning's n that there is no reason to believe that you need to do a tailwater sensitivity analysis at 0.075 which is not a credible value.

So we did our sensitivity analysis of the tailwater section at 0.05, and what that demonstrated was that in NWS BREACH it's specified the biggest section that you think the tailwater is going to attain.

CHAIR CORRADINI: Tailwater is the last bit of water out?

DR. PRASAD: Well, it's a cross section. It's a cross section the way it is set up in -- do you want to take that one?

DR. HIBLER: Sure. Downstream of the breach the shape of the topography needs to be specified, and the shape of that topography can influence --

CHAIR CORRADINI: Oh, okay. Got it. Thank you.

MEMBER SCHULTZ: I have it, thank you.

MEMBER SHACK: Now where do you hand this off to the flooding model?

MEMBER ARMIJO: We get water out of there.

DR. HIBLER: A breach simulation yields

discharge outflow from the breach as a function of time, and that's a boundary condition to the RMA-2 model that --

MEMBER SHACK: Yes, but the tailwater somehow, that's what I'm sort of looking at is that if you take the, you know, changing that tailwater dimension, how does that impact the flooding analysis that you're going to be doing --

CHAIR CORRADINI: That's the size of the pipe you're going to tell it to flow out of, I assume. DR. HIBLER: We tell it that discharge is a function of time and the 2-D flow model determines the shape of that, the spreading of that over the realistic topography, which is the --

MEMBER SHACK: So it's not really so much the size of the tailwater as the overall flow that really is the input to the flood model?

DR. HIBLER: Yes.

CHAIR CORRADINI: Oh, I thought you had to give it both the area as well as the volumetric flow. You just give it the volumetric flow rate. We just give it the volumetric flow rate.

MEMBER SHACK: But the volumetric flow rate is affected then by your tailwater geometry.

DR. HIBLER: Right. And in the case for

the 2-D flow that tailwater concept is replaced with realistic topography.

CHAIR CORRADINI: Got it. Okay, thank you. Now you can go on.

DR. PRASAD: Okay, next slide. So our independent review found that -- okay, one note about NWS BREACH. It's an old model, but that it is used in standard engineering practice for dam breaches if you want to use a physically based approach rather than an empirical approach.

So these models are, well, NWS BREACH is the only model that is going to be available. The Agricultural Research Service and the Bureau of Reclamation are partnering with universities and they are trying to develop new approaches, but they're still in development phase and testing phases.

There might be one new model that has become recently available, like in the last month or so, but that's not really used in standard engineering practice. So for our analysis and review we would limit that to using what is available and used widely. That's one note.

Just a note about the scour hole. In our review, we do not do at PNNL, as the NRC's contractor, any geotechnical review. That said, there was this concern that we needed to understand the geotechnical properties of the MCR and how that related to breaching.

And so in that case what we have done, awhile ago, I think this is from two or three years ago, that we have contacted some of the NRC staff in the geotechnical branch to get their opinion on what they felt about the construction quality of the embankment, how erosion could take place, what are the strength properties.

You saw some of the cohesive strength properties that Dr. Ahn was showing you his table and those properties. And the NRC staff basically came up with a determination that the foundation of the embankment is compacted clay, which is not really amenable to a deep scour hole formation.

If you look at the independent reviewer's comments on the scour hole, it's also clear that when they base their opinions on the soil properties and the geotech properties of the embankment, that they feel that even if it was plausible that the scour hole was formulated it would not be significant. It would not be significant. It would not be significantly enough to change any of the conclusions that we draw in the SER.

MEMBER BLEY: It wouldn't change the levels that you see over at the --

DR. PRASAD: If it's not significant I wouldn't expect it to change much.

DR. HIBLER: I would just distinguish, when they said significant they weren't saying significant if there was a scour hole of the dimensions that's been previously described. What they say is the scouring depths would not be significant. So it's probably less severe than what you might be envisioning.

MEMBER BLEY: Now Dr. Ahn told us, and I didn't go back and double check the reviewers, that they base that on compaction data right after construction and not what was found later. Can you say anything about that?

DR. PRASAD: Well, honestly, I don't know.

MEMBER BLEY: That seems like that could be a significant point.

MS. GOVAN: We have someone coming up from geotechnical who can address your question.

MEMBER BLEY: Okay.

(Off the record comments)

DR. CHOKSHI: I think we'll have one of our geotechnical engineer. Originally the staff -- he died, but you explained what the --

MALE PARTICIPANT: Are you going to resurrect him or something?

MS. KARAS: This is Becky Karas. I'm chief of the geosciences and geotechnical engineering area. We've had two reviewers on this project since the beginning. The geotechnical area is a distinct discipline and there's a lot of analyses that's looked at for the subsurface of the site in general.

We had two different reviewers on this project. One of them has recently retired subsequent to performing this review, Mr. Wayne Bieganousky who had 30, 35 years-plus experience between the Army Corps and the U.S. NRC. Frankie Vega of my staff has been following the review also since the beginning. I think he can talk a little bit about the parameters --

MR. VEGA: Hi, this is Frankie Vega. For the stability analysis that was provided in Section 2.5 of the FSAR, for cohesion properties, drain cohesion properties and of constructions, a

300-pound per square feet was used.

MEMBER BLEY: 300?

MR. VEGA: 300, yes.

MEMBER BLEY: Not thousands.

MR. VEGA: Not 3,000, no. That's the drain and of construction, a cohesion that was used for the stability of that as a slope stability. And for the MCR, a liquifaction analysis was done too, based on these types of properties.

MEMBER BLEY: And you concluded based on those parameters that scouring was not an issue?

MR. VEGA: We didn't look at scouring, but we looked at the slope stability itself.

MEMBER BLEY: What about the question --

MR. VEGA: For scouring, it's important to say that the foundation of the soil was prepared in a way that the low strength soils were removed and replaced by higher strength clays. I think that wasn't mentioned before.

MEMBER BLEY: I think that the question I had asked was, your expert reviewers, at least according to Dr. Ahn, when they dismissed scouring, did it based on compaction of 1,000 or more psi, and would it have made a difference to them if they knew that the compaction wasn't that great now?

MR. VEGA: I'm not familiar with that conclusion.

MEMBER BLEY: Okay, thanks.

DR. PRASAD: Just one point. I think the SER was available to the independent reviewers. And in the SER we had mentioned, plus the sensitivity analysis report that we did for NWS BREACH, both used cohesive strength values of 300 pounds per square feet or less, and those were available to the independent reviewers.

MEMBER BLEY: Okay, thanks.

DR. PRASAD: Okay, one more note I'd like to make about scour. We did not consider, or did not determine that the foundation beneath the embankment itself would be amenable to scouring. But as you get beyond the dam when the flow is coming out, the native soils are still the uncompacted soils on the side and it's possible that there could be a scour hole formation there because of these flows.

And that scour hole was initially postulated by STP, and the staff reviewed it, and we also took account for the fact that the material coming out of that scour hole could get deposited and could result in an elevation of the water surface elevation at the safety related SSCs.

So that was one analysis where we did consider the scour hole formation, and not only a scour hole formation but the effects of that on the safety related structures.

So with that note, the technical aspects of NCP Issue Number 1 were resolved because the staff's literature review determined that the empirical equations were applicable to the MCR. The staff's NWS-BREACH modeling did not suggest that tailwater cross section was a dominant factor.

This was what we meant when we did our sensitivity analysis in development of the conservative breach parameters. The staff determined that the applicant's Manning's n value is reasonable and conservative.

The staff's search of the Dam Safety Office database of historical dam failures showed that Martin Cooling Pond failure was the closest, and as it turned out only analog. And the staff used NWS BREACH model because it is accepted in standard engineering practice.

And the staff also determined that the scour hole would not form directly below the MCR embankment and its foundation, but there is the possibility it would have formed beyond the toe of the embankment and we did account for that.

That concludes my presentation on Issue Number 1. Dr. Jones will continue with Issue --

MEMBER SHACK: Well, let me just, both the staff and the non-concurrents seem to ~~argue~~ agree that the Martin cooling pond supports their case.

MEMBER ARMIJO: But they came to different conclusions.

MEMBER SHACK: And they come to different conclusions. Can PNNL and the staff sort of explain why they think Martin cooling pond supports their view?

DR. HIBLER: Well, for the two parameters that were searched in the DSO, Dam Safety Office database, they're similar in terms of the volume of water that's assumed to spill, and the difference between the pool elevation, initial pool elevation, and the base of the breach. And only those two parameters are the, at least in those two parameters the Martin cooling pond and MCR are similar.

That database wasn't searched or developed to incorporate other factors. So if the focus is on other factors like construction methods, materials and so on, those two cases are distinct.

MEMBER SHACK: Okay, so the answer seems to be that there really is no comparison. I mean it's the right height and volume but we don't know anything about the rest of it.

DR. PRASAD: Yes. In any empirical comparison you run into those issues. What are the site-specific issues that we don't know about or are different that are not accounted for in a, for example, integration equation.

MEMBER ARMIJO: The cooling pond seems to me just to be telling you that it's got a lower head than the MCR, about the same area, similar volume. It's built different. That's where the explanation has to be, but we haven't heard it other than, oh, it's built different.

I haven't heard any real good argument that says the reason we won't have a wide breach is because we have relief wells or we have this feature or some other feature. I haven't heard any of that except yes, it's different.

DR. PRASAD: Yes, I think I mentioned that before. And actually, Dr. Ahn presented in his table about the construction being silt and clay, really compacted clay for the MCR embankment was this silt and sand, which are more less strong cohesive soils and much more erodable soils.

So it's not surprising in our minds that it would lead to a wider embankment breach even with a lower head, and also because the soils, native soils there are probably different than what the MCR is, MCR foundation is with the compacted clay layer that you see the scouring going through the foundation.

MEMBER ARMIJO: So is the silt clay the salvation of the MCR? Is that the main difference, or is it, I don't even know what relief wells are. Does that help, or does a sand core blanket, those features, do they help? I'm looking for a really good engineering argument that says this is why the MCR is superior construction to the MCP.

DR. HIBLER: We reviewed the report that South Florida Water Management District put forth after the Martin cooling pond failure occurred, and there's a couple things in there. I'm not a geotechnical person, but what I pulled from there was the Martin cooling pond embankment was newer and therefore not as, didn't develop a history of performance and corrective actions that other structures might have had.

There were some filtering of water out of the Martin cooling pond that were noted on the SEP, and some corrective actions that were supposed to have taken place that hadn't taken place at the time of the failure.

Now I think that the active maintenance of the main cooling reservoir with its existing wells and drainage blankets make it a distinct case.

MEMBER SHACK: I mean one of the reviewers quotes that some guy who reviewed the failure and, you know, he does claim that it was sand and silty sand for the Martin cooling pond. Then they quote some laboratory test results that get three orders of magnitude in head rate advance and breach widening between clay type things and silty soil type things.

MEMBER ARMIJO: Very, very strong effect.

MEMBER SHACK: At least from the laboratory tests it's a fairly significant effect, and we do seem to have some confirmation that, in fact, it is sand and silty sand from someone who's knowledgeable of it.

DR. HINZE: You have to consider the

start of the breach as well as the expansion of the breach, and that the expansion of the breach is what is really being of concern here, not the start. And the silt and sandy is really going to be very detrimental to the MCP.

CHAIR CORRADINI: So to get back to Sam's original question, it is the construction or it is the materials of construction is one major factor, and the fact that as you were saying this has, essentially, I don't want to call it relief wells, but I call it seepage detection.

DR. HINZE: And it's also the subsurface that underlies the entire area. There's a lot more sand in that area than there is in the MCR. That's very critical.

CHAIR CORRADINI: Okay. Proceed.

DR. CHOKSHI: Before we go to the next, may I make a comment?

CHAIR CORRADINI: Sure.

DR. CHOKSHI: This is Nilesh Chokshi from the NRC. I just wanted to make sure that the whole resolve on next slide is properly characterized. We have gone through the whole non-concurrence process and made a decision, and that is the issue to our satisfaction. But it's not resolved in the sense that non-concurring Dr. Ahn agrees with what --

CHAIR CORRADINI: No.

DR. CHOKSHI: I just wanted to make it clear.

CHAIR CORRADINI: Yes, we understand that, right.

DR. CHOKSHI: And at this public meeting I thought I'd better make it --

CHAIR CORRADINI: No, that's fine. That's perfectly fine.

MS. GOVAN: And that'll be the same for all of the --

CHAIR CORRADINI: Yes, for all the three issues you're going to go over.

Go ahead.

DR. PRASAD: So that concludes Issue 1 presentation, and Dr. Jones will continue with Issue Number 2.

DR. JONES: Okay, this is the Number 2, hurricane storm surge and MCR embankment breach. I think I can sum this up in many ways. The ADCIRC model, when we first started, most of the applicant's six years ago first used the 1-D and we came out and said no, you need to use a 2-D. SLOSH was made available by NOAA. We had the SLOSH, PNNL did their analysis with SLOSH.

The best model out there was ADCIRC, but it's, you know, very expensive to run. Many simulations on that. But the applicant went beyond what we called for. They actually went to using the ADCIRC. They had an expert on the ADCIRC.

We had a second audit, actually, in 2009, in which we went down and they explained to us in detail what they did. We gave them feedback. We wanted them to use the ADCIRC, but we wanted them to use the same met input from the NWS 23 that they used in the staff's SLOSH, so that we can have a comparison, so there wouldn't be any issues that we had something different. And they ran that model.

But the unique thing was that they used very proprietary, I guess, high, very high resolution topography and bathymetry, which not only that Dr. Resio didn't have for his ADCIRC model but we didn't have our SLOSH model.

And if you know numerical modeling that is critical, because if you don't see the feature it's not there. So why you see the SLOSH model in this case, even though it's a low resolution, it's a warning model, it has the same output as the ADCIRC model by Dr. Resio.

The only conclusion you can raise, and then you see in their slides, especially when we had the second audit, and also I have it in my back-up slides, and you see that they have a, they can see the levy which is there at Matagorda. And you can see the rock piles. It's very clear.

And if something hits that, and that's what Carla, I guess Hurricane Carla did. It hit that levy back then and saved Matagorda. The highest surge they had, it was 15 feet, the levy is 25 feet, blocked it. Never got over it.

So that is physically what happens. That's what ADCIRC was designed to do, and that's why it was used in the Katrina -- Dr. Lynett, actually, though he does tsunami, actually does surge too. They used that in the Katrina study, the presidential study.

And you can see the resolution. You can get down to only a few meters with ADCIRC and see these features. And so the applicant by doing that what they did, they wound up with 29 feet, which is highly credible if you know you got the blockage with the levy and stuff.

So what would happen if you didn't have

the levy or the rock pile? Well, you would get that 39 feet that you have on the SLOSH and the Resio ADCIRC. But what it proves though with Dr. Resio, his research said that you get a peak.

Some areas where you can expand the storm until you get to the point where you can't expand it any more, you get no difference in your surge. And you look at all his storms, 10 to the 8, 10 to the negative 13, probably -- this stops at like 39 feet.

You don't get any higher, maybe 40 at the most. Because what happens is that's your fetch. A wave needs intensity, duration and fetch. By expanding the storm wider you get a bigger fetch. But after awhile you got it on, part of it's on land, and you've got the outer barrier to the point you're not getting any more fetch out of that.

Now to address Dr. Ahn about the 184, basic meteorology. Delta p, isobar here, isobar here. That's your delta p. If you move it wider apart you get less wind because now you don't have the gradient any more. Move it closer, you get higher wind.

So in the case of the Resio ADCIRC and also the case of the PNNL, they had actually wider, well, actually the applicant had a wider storm. They actually used a wider storm than we did on the staff. And Resio used a whole bunch of wider storms.

But the thing it comes down to is that bathymetry. Now 29 feet was 29 feet. That's one foot above Katrina, which is the record for the United States. What's 39 feet? That's one foot below the world record which has only happened once, in the Indian Ocean in the 1970s. Okay, that's what you're talking about in rarity.

So conservatism, 29 feet, yes. That's very conservative, one foot above what we have recorded in Katrina. And he was talking about the PMH. On one hand he said that it provides a bounding, but on the other hand he says it's questionable because it has been updated.

Well, the NWS 23 covers the period from 1871 to 1978. If you look at it, only 18.5 percent of the storms occurred outside of that period. All Category 4 hurricanes impacting Texas, they've never seen a Category 5, and what the applicant had was a Category 6 which doesn't exist. We don't have that category.

And as it occurred within the NWS

reporting period, you heard the applicant report that we had periods of peaks in the '70s and the '40s. And so for the United States itself only 17 percent of all hurricanes that impacted the United States occurred outside the NWS 23 reporting period, and among the 12 most intense hurricanes to hit the country, only three occurred outside of the NWS reporting period.

Matter of fact, right now while we're doing this review, and I have warned the applicants, well, the operators, of this that we actually, in most all cases the storm surge on the new reactors exceeded the storm surge on the old operating reactors.

You remember most of these were licensed before '79, and NWS 23 came out in '79. So none of these plants ever used NWS 23 for their design basis. And they're finding it's very conservative to the point that one has decided to go back and do the probability storm surge and use the JPM.

MEMBER SHACK: Yes, but you've just convinced me that NWS 23 doesn't give me anything like a 10 to the minus 4 or 10 to the minus 5 storm.

DR. JONES: Well, actually, if you look at Texas, you look at this case here. Here you have the SLOSH model by the staff, they got 39 feet. Then you have Resio with his storms which actually went up to 10 nega 13, and he had the same level. So, you know, we've got the same conservativism, you know, using NWS 23, and he used JPM method, the joint probability method.

Or you could take the real database, the most current database from NOAA, load it in, do your Monte Carlo and you get simulated storms. And he came up with the same thing. So it's always going to be site by site difference. In some cases you'll have --

MEMBER SHACK: No, but I mean he's getting a different storm. He's picking up something from something, I mean you can't guarantee this is always going to work out that way.

DR. JONES: Exactly. If you go the other way you actually in some cases, like they were going to use ADCIRC until they actually find out it's going to lower the surge which actually saved them money. Went on to one applicant, they said that at the beginning. They said they would love to use ADCIRC because they were hoping that it actually lowered the level. Sometimes it might be a higher level, because it depends on what feature it's going to see.

In the case of STP, the levy and the rock pile --

MEMBER SHACK: But as you point out, I mean ADCIRC's as good as your bathymetry.

DR. JONES: And that's all numerical models.

MEMBER SHACK: Yes, that's true.

DR. JONES: But some have better physics, and then ADCIRC has better physics than, and NOAA admits that. Matter of fact, NOAA now uses ADCIRC in conjunction with FEMA, okay. So NOAA never objected to, they always admitted that the SLOSH was only for warning purposes. You don't have time to do detailed analysis when you have to evacuate people.

ADCIRC is made for engineering purposes for exactly what we're using it for, for design, and that's what the applicant in this case used ADCIRC to get precise detail to be precise. And actually Reg Guide 1.59 says in it that the applicants can use more detailed bathymetry and topography and get a less conservative result.

We said that in the 1977 1.59, and it said that, even then when we changed it we said we will accept less conservative results for more realism. So that's part of our Regulatory Guidance. Next, please.

DR. HINZE: How did you treat the decrease in intensity over the land?

DR. JONES: Well, actually the applicant was extreme in this. Not only did they have a 184 mile per hour storm, they didn't decay it.

DR. HINZE: Didn't decay it.

DR. JONES: They just hit it and just kept going.

DR. HINZE: That's additional conservatism piled onto this.

DR. JONES: Exactly. And so we found that the independent reviewers, yes, they say, well, maybe you could have used a larger storm which, actually, applicant used a larger storm than the staff. But when you took off the balance between intensity, 184 miles per hour versus something bigger, Dr. Resio says it was a wash. It was good. It was sound. It was conservative. It was acceptable analysis.

And so they suggested a review, perform ADCIRC, but Dr. Resio did that. We incorporated that into the SER, his results. Next, please.

MEMBER SHACK: Now the 184 is some ten-minute average wind?

DR. JONES: Yes, at 30 feet.

MEMBER SHACK: Which is why it's lower than the 210 gusts that you do --

DR. JONES: Oh, gusts. Yes, gusts is different. Yes, and so it's sustained. It's sustained. And they also did a stationary, fast, and slow moving. And so another thing to -- the bottom line is this. The applicant, back in the 2009 second audit said, we're going to do this. We're not going to use our analysis, we're going to use the staff's analysis to prove that nothing's going to happen to the MCR.

They took our analysis, used our winds, and then they said, we're going to go and do the implausible. Because if you look at the storm that produces the surge for all three scenarios, the wind is out of the south. It goes over the MCR and blows everything away from the MCR.

So there's no wave action, no current. You're only talking about 11 feet of water, and currents are not made instantaneously in the real world. I mean the gulf stream is seven feet per second and it takes a long time, days, hours, to generate currents at those speeds.

So there's a lot of conservatism. I took the 184 miles per hour and used my oceanographic experience and came up with everything below what you can use to rate below clay. Never made it to it. And that's assuming that you have instantaneous currents. But you're never going to get them because the winds are blowing physically away from this area.

So anything that we break would be what, the south side or on the east side, which would not impact the plant at all. And you see my velocities there, the equation I came up. And actually, even on the MCR breach they came up with only, in 1.7 hours they only came up with six feet per second, which was below the erodibility for clay in the area, breach area. So if you're talking about scour, you know, that falls within the range I had.

DR. HINZE: I'm just trying to connect the dots between on Page 7G and H, and then what you've just described on the following slide. Is what you're describing in J and K the reanalysis that the staff did in response to the applicant's recommendations?

DR. JONES: Yes. What you did is you

have, the literature you have, the Corps of Engineers figures for what you can do to erode compacted clay. And what you did is a bounding analysis. You take the winds because that's what's going to generate your currents. It doesn't matter how deep it is. That's irrelevant.

You just take, say I assume that these currents are going to exist from the surface, from the top to 11 feet down, have 184 miles per hour. What would be the surface period if it instantaneously happened right there at the breach which only lasts for, you know, 80 minutes, this event.

And what you get there is a maximum current of four feet per second, maybe five feet per second. And that falls well within the literature for not eroding compacted clay or grass line, actually, for grass line. It wasn't affected at the grass line. But remember, that's assuming that it was aligned the way that you could have erosion, and we know physically that is implausible the way the hurricane is and the winds that you're never going to get those currents or the wave action, ever. It's not plausible.

Actually, to get those type of winds you actually had to push the surge back the other way. So the bottom line is that they have a model that is acceptable, that's a state-of-the-art. They used the most, higher resolution than either the staff or Dr. Resio.

That based on the literature that the most likely difference is that the high resolution that the ADCIRC model saw the levy at Matagorda, saw the rock pile and was blocked. That you have 29 feet, which is equal to the MCR grade level, so therefore that alone you're not going to have erosion or simultaneous, the surge eroding MCR and then have a combination of it breaking at that point. It's one foot above Katrina. And even with the staff's 39 feet there's all below the MCR breach of 40, so there's no safety issue there. Any questions on the Issue 2? Next.

And this is concerning the maximum ground water level for the ABWR maximum ground water level. DCD Tier 1 limit is two feet below the plant grade. The non-concurrence states that the FSAR site characteristic is 28 feet. This is correct.

The surface water departure was implemented, not a ground water, but a surface water departure was implemented for the two proposed units in accordance with the DCD limit. A surface water departure was required for the ABWR if the DBF is shown to exist at a level equal to or higher than one foot below plant grade, and that's of course at 40 feet it does that.

For the proposed units, the surface water departure equated to 33 feet msl. The NRO Division of Engineering evaluated it. They assumed that these conditions, that the underground was saturated at design basis flood. So they assumed that that level was saturated, then on top of that they put the water level for design basis flood, and then they did their calculations for the hydrodynamic/dynamic forces, then put it into their seismic and other force design. And the hydrodynamic forces were just very small compared to everything else.

So they also evaluated the design basis flood 40 and they said there were no deficiencies noted. And in the summary, the non-concurrence incorrectly puts the DCD term "maximum groundwater level" in the wrong context, because the maximum groundwater level is, you take in account all the seasonal fluctuations, everything, and you get the 28 feet.

The question is, could possibly a design basis flood do something, but that was never analyzed by either the staff or by him. That's a design basis flood incident, and when they did the safety analysis had no impact.

Well, I'll let Dr. Chokshi, if he wants to add something to it.

DR. CHOKSHI: I'll wait for the question.

DR. JONES: If there's a question.

DR. CHOKSHI: But maybe let me just, in the DCD there are two water levels. The one is the one that's called maximum groundwater level, and there is a groundwater level associated with the design basis flood.

The standard designs are not designed for substrate flooding, so the basic of these two cohorts, they're just conditioned that my design basis flood is actually below ground level. So now in the South Texas is you have to take a departure because the design basis flood.

So any parameters that are associated with a design basis floods are automatically, have to consider is that a part of a departure. So you don't need to separate departure for that groundwater level which is associated with the design basis flood, because it automatically is a part of the design basis flood.

That comes into the play, into the engineering analysis. How do you combine my, if you go to 3.8 sections, structural sections, they were never designed, the load combinations associated with the design basis flood. In that case is you have to account for the ground saturation at all the substrates, hydrostatic loads, et cetera. So they're all accounted for.

So I think it's just a process issue. But I think they are taking a departure.

DR. JONES: Okay. And the staff's, this resolution, this is a summary. The staff's MCR breach flood analysis is not conservative. As discussed above, the technical issues were resolved. Changes to the SER Section were made.

The staff added text to explain the staff's review of the applicant's use of the empirical methods, and the staff added text to explain the tailwater sensitivity analysis. And the staff's conclusions in SER Section 2.4.4 did not change. So it didn't change our findings, but we did add more detail.

On Issue Number 2, a hurricane storm surge and MCR embankment breach as discussed above, they were resolved. We did make changes to Section 2.4.5 were made. The staff added text explaining how the probable maximum hurricane is appropriately conservative. Then we added, the staff added sensitivity analysis used storms less intense but larger than the probable maximum hurricane, and our conclusions there did not change.

And in Item Number 3, management concluded that all necessary departures had been requested and there were no changes to the SER, and there's no change to the staff's conclusion in the SER Section 2.4.12. That's the end of my discussion. Any questions?

CHAIR CORRADINI: Questions from the committee? So we're at the end of this part of Chapter 2 of 2.1 through 2.4. So any general questions or comments from the committee? Otherwise, I was going to turn to members of the public either here or on the phone line, but if there's something, go around the table. Bill?

DR. HINZE: Well, I stand by the details and the conclusions I reached on my report to you.

CHAIR CORRADINI: Which we all have.

DR. HINZE: I believe that the STP and the staff have come up with very reasonable parameters, and verging on being too conservative in my view. One of the things that I think that we have accomplished here is we've approved the document with Dr. Ahn's NCP.

I think that one of the things that I mentioned in the report that needs to be emphasized is that the uncertainties in all these processes, which have a great deal of uncertainty, were not emphasized sufficiently and their impact was not truly considered. And I think that that's a lesson that we should take from this exercise.

CHAIR CORRADINI: Steve?

MEMBER SCHULTZ: I too appreciate the discussions this morning. The applicants set the stage, and I think Dr. Ahn has done an excellent job of his presentation of the issues that he had identified. And he's explained his concerns well to the committee, just as to the staff's response and the consultants they have used in preparing that response have been very deliberate in their reevaluation of the concerns that Dr. Ahn has raised. And that the modifications to the SER have been appropriately conducted and achieved.

CHAIR CORRADINI: Dennis?

MEMBER BLEY: And I appreciated all the discussion today and thought it was very helpful. I have no real questions left except I need to pursue a little on my own understanding how the uncertainty was addressed in all of this. And I see conflicts that I haven't been able to resolve yet, so I'm going to have to dig into that a little.

CHAIR CORRADINI: Harold?

MR. RAY: Well, echoing what Bill and, I guess, Dennis said here as well, I don't think it should be a part of this applicant's review, but I do think there ought to be some lessons learned here. I don't know what they are or how exactly we're going to try and derive them, but we shouldn't go through this sort of an exercise only when somebody raises an objection, as was done in this case.

Even though the outcome affirms the original conclusions, it's much sounder, I think, than existed originally, and I'm therefore thinking that there needs, I don't know whether we're talking about input to the staff's review plan or Reg Guides or what it is, but there's something that ought to be learned from this it seems to me or derived from this, not learned from it maybe, that provides us the kind of review that we've gotten here now without there having to have been this exercise take place.

But like I say, it shouldn't become a part of this application's review. It's something we need to figure out how to do separately.

CHAIR CORRADINI: Sam?

MEMBER ARMIJO: Yes, I thought the presentations were excellent both from the staff and from Dr. Ahn. I do have one kind of summary question is after all is said and done on the breach issues, we wind up with the STP saying they're designing or they'll, a flood level of 40 feet.

And Dr. Ahn's analyses of the various analysis he did comes up with 44.6 feet, so a difference of about five feet. And my question is to the staff and to the applicant is, is that the end of the world? I mean it really was 45 feet instead of 40 feet.

DR. JONES: Well, 40 feet is what they came up with, but we heard this morning -- and someone correct me -- that they said that they're going to have it waterproofed to a height of 51 feet.

MEMBER ARMIJO: They've just got plenty of margin.

DR. JONES: Exactly.

MEMBER ARMIJO: But basically I appreciated this presentation. Plowing through this stuff, I think I learned a little bit, but I think I didn't hear enough of in was that the engineering of this MCR is a very different structure than the Martin cooling pond.

And with some discussion of that I think it would have been put to bed a lot easier, because it looks like it's a very detailed engineered structure and the pond was pretty much a pile of dirt. And so it's not as good an example as it appeared to be when you first read about it.

DR. JONES: Made for two different purposes.

MEMBER ARMIJO: Yes. Thank you.

CHAIR CORRADINI: Mike?

MR. HEAD: Mr. Chairman, can I interject just for a second, please?

CHAIR CORRADINI: Well, I was going to call on you eventually, but feel free to interject now to help --

MR. HEAD: He was at this point, and

then since I raised it I feel like I have to -- the 40 feet --

CHAIR CORRADINI: And you are?

MR. HEAD: I'm Scott Head, okay.

CHAIR CORRADINI: Still.

MR. HEAD: The 40 feet is a design basis number used in design basis calculations. The 51 feet is a flood elevation and has not been used in the design basis calculation. So there is a difference. It's subtle, but I think it's worth knowing that we're not changing the design basis to 51 feet, okay. We're leaving it at 40 feet, and believe that that's what it should be. But we've been able, by selecting doors, in essence, raise the inundation level to 51 feet.

MEMBER ARMIJO: Which is really the main objective was to keep --

MR. HEAD: Well, it's certainly, in light of recent events it is important.

MEMBER ARMIJO: Yes.

CHAIR CORRADINI: Well, thank you, sir. I thought you had something else you were going to --

MR. HEAD: No, that's --

CHAIR CORRADINI: This is -- okay.

MEMBER RYAN: No additional comments, thank you.

CHAIR CORRADINI: Dr. Shack?

MEMBER SHACK: Well, these processes are always very enlightening. You get a chance to read a lot of things that are very interesting. I concur with Bill. I think, you know, that there's a great deal of uncertainty here that sort of is not treated very well, and I'm not sure that piling conservatism upon conservatism at every correlation that you use is the answer.

But you do have to have some better appreciation that, okay, you used the best fit for the width. You used the conservative one for the top line. You can use the conservative estimate for the tailwater, and what do I really end up with? And it's, you know, you're left with a little bit of, it takes almost engineering judgment to decide that you've really done it. And a little better treatment of that and a few more sensitivity studies, I think, would be helpful in putting some of these things to rest.

But as I said, very interesting reading. I'm just glad to see too that people sort of pushed them out there to do some probabilistic hurricane studies. I mean that NUREG was sitting there, and there it was. Just when you needed it there was an ADCIRC calculation 10 to the minus 13. Good for research.

DR. JONES: That goes back to what Dr. Ray was saying. We actually are addressing this. We have the probabilistic hydrology workshop to address the ACRS concerns to try to update in the ISG that you saw, the tsunami surge.

We went over probabilistic and uncertainties, Dr. Resio, and also, and this was very helpful, I think, for the dam failure part of the ongoing 50.54. I think if we hadn't have had this, then I don't think we would have been as prepared to deal with the issues for that. So this was very helpful.

CHAIR CORRADINI: So before I end this, are there members, people in the audience that have comments?

DR. CHOKSHI: Dr. Corradini, may I?

CHAIR CORRADINI: Oh, I'm sorry.

DR. CHOKSHI: This is Nilesh Chokshi again. I think, first of all, I think I want to say that this process, I think, you know, the issues of this by Dr. Ahn, I think they were significant issues, and that was one of the reasons why we thought we need a -- a lot of judgments are involved in this process.

So that way we wanted also an independent set of five to look at this because it comes down to, you know, every step you can add things, but is that appropriate? The second thing I think that this may be enhanced and I think they can still enhance the basis of our, you know, the decisions. We will better explain to you

In fact, what we're having versus developing the ISG for the dam analysis, and I think Dr. Ahn mentioned that there is a need for guidance in this area because it's in the process, and I think from what I heard, and that question about uncertainty -- and I think, thinking about this, you've all done a good job explaining how the uncertainties are there, you know, accounted for. So I think we are doing, and I think this is all very useful, and that this is helping us in coming up with ISG which will be used for the 2.1.

It is a significant issues, and I think we have to do it in a proper way. I don't think, you know, very thoughtful because it's the way, because there's so much judgment and other things involved. So I think the comments I've heard, I think it's pretty much along the line we are we are also thinking, and I think the are the issues we need to address. So thank you.

MEMBER SCHULTZ: Excuse me, Mike. Nilesh, can you explain the schedule associated with that effort in 2.1, when we'll have a chance to see that?

DR. CHOKSHI: Yes, actually I'll let Chris Cook explain more detail.

MR. COOK: Hi, I'm Christopher Cook. I'm chief of the hydrology and meteorology branch. The Interim Staff Guidance on the dam assessment should have gone out into the Federal Register this week for a comment period that will be going through --

(Simultaneous speaking.)

MR. COOK: So approximately just a little bit under 30 days as we had targeted, so it's up there now.

For the public comment period, we're going to be having a public meeting on May the 2nd. We're also then, also having other meetings with the Interagency Committee on Dam Safety, at the federal level, talking to our federal partners and what have you, I believe that fell on the 9th, to discuss the ISG with the different methods that were used at looking at both dam failure as well as routing of the flood wave once it leaves. So that's all incorporated into the ISG. Like I said, it's out for comment now.

CHAIR CORRADINI: Okay. Any other comments from folks in the room? The bridge line should be open. Are there comments from those listening in? I think it's been unmuted. Is anybody out there making noise?

MALE PARTICIPANT: I'm out here but I have no questions.

CHAIR CORRADINI: All right. So let me conclude by thanking the staff and the applicant. I guess there's a few things, a couple of them generic and one specific, I guess, that I wanted. So I wanted to thank everybody for their contributions, Dr. Ahn for taking the time to explain his issues, and the staff for explaining how they resolved it relative to the other staff conclusions as well as the independent reviewers.

But I had three things. One is, I think that Bill said it and Harold emphasized it, is that if there's a lesson learned here relative to explain the uncertainties or in the standard review plan in this sort of area of review, I guess we'd like to know about it so that we don't necessarily do this every time. So that's kind of takeaway 1. Don't write it down as an action item, anybody, but I assume the staff will remember this because we won't forget it.

The second thing is that I do think it's important that we understand, at least in this area I'm technically, I was going to use the word "at the mercy," but I guess it's good to be at the mercy of the consultant. But I listen to Bill a lot because he's very expert in this area.

But I do think there is one thing that I'd like to see, and I asked Quynh about this. I think there is probably an RAI, it kind of goes to Slide Number 12 of the applicant. I'm sure there's an RAI where the breach model with one calculation in the red is there, but I assume there's a series of them. I'll call them sensitivity studies, so I can see the spread of how the prediction looks as a function of that.

I think that would address a lot of the questions that, or at least some of the questions, potentially, that Dennis was asking about what-ifs, and how those what-ifs relative to the detailed model span out and kind of interact with what I thought was the conservative blue line on top. All right.

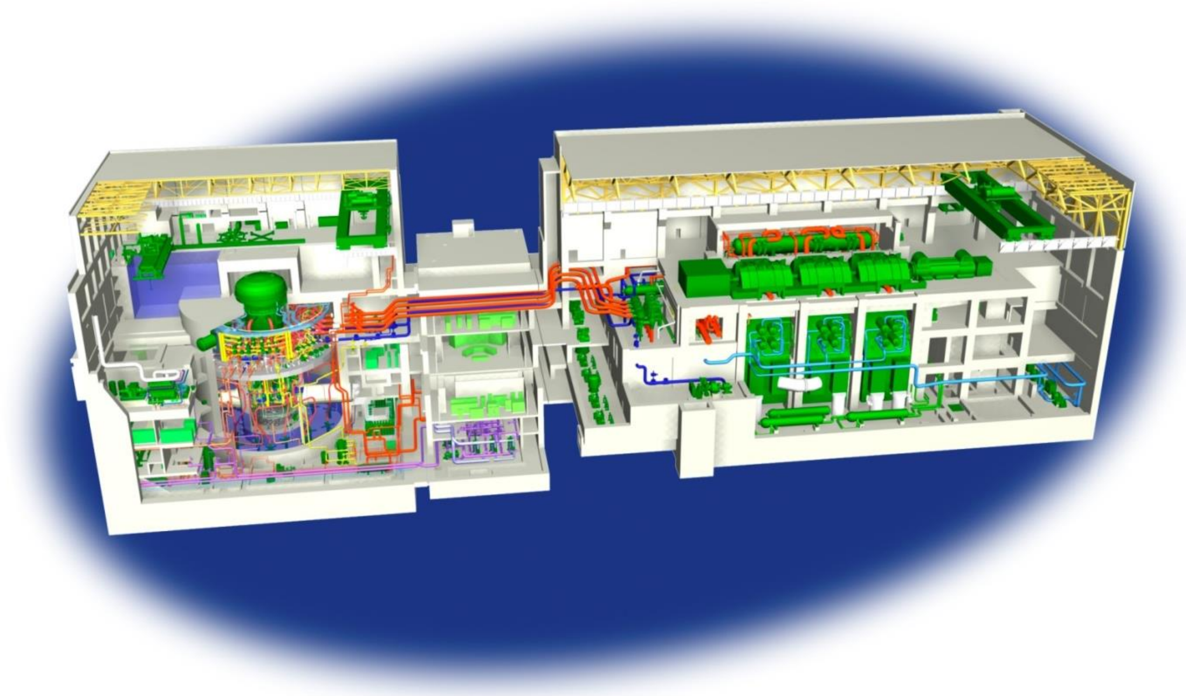
But I think it kind of goes back again to the generic issues that we're always asking for, what are the uncertainties and what drives the calculation that we eventually have to make a judgment on. So I think if the applicant or the staff could point Quynh to the specific RAI, maybe the committee can have that in the back of our pockets just so we can look at it. That might help Dennis.

With that though, I thank everybody, and unless there's more questions we're adjourned.

(Whereupon, the foregoing matter went off the record at 11:59 a.m.)

# South Texas Project Units 3&4
# Presentation to ACRS ABWR Subcommittee:

# Chapter 2  Site Characteristics



# Agenda

- Introduction and Agenda
- Attendees
- Topics for Discussion:
  - COLA Changes since 11/30/2010 ACRS Meeting
  - ACRS Action Item 65
- Comments and Questions

# Attendees

| | |
|---|---|
| Scott Head | Manager, Regulatory Affairs, STP 3&4 |
| Steve Thomas | Manager, Engineering, STP 3&4 |
| Dick Bense | Regulatory Affairs, STP 3&4 |
| Dr. Bob Bailey | Exponent Engineering and Scientific Consulting |
| Dr. Paul Jensen | Atkins Global |

# Chapter 2 Site Description – Summary

## South Texas Project site is located near the Gulf of Mexico:


- Large site, 12,200 acres
- Main Cooling Reservoir sized for four units, 7000 acres
- Infrastructure in place
  - ✓ Road and barge access
  - ✓ Transmission corridor
- Low population density nearby
- Existing State, County and Site Emergency Plans
- Strong community support

# COLA Changes since 11/30/2010 ACRS Meeting

**Regulatory Guide 1.221**, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," Rev. 0, October 2011, incorporated:

- Maximum hurricane wind speed for STP Site revised to meet RG 1.221.
- Hurricane generated missile spectrum revised to meet RG 1.221.

Existing design met RG 1.221 requirements:

- ABWR DCD buildings; and,
- Site specific buildings.

# COLA Changes since 11/30/2010 ACRS Meeting (continued)

COLA Revision 8 added new Appendix 1E:
Response to NRC Post-Fukushima Recommendations, included:

**Available Physical Margin for Flooding (i.e.,** the **Cliff Edge)**:

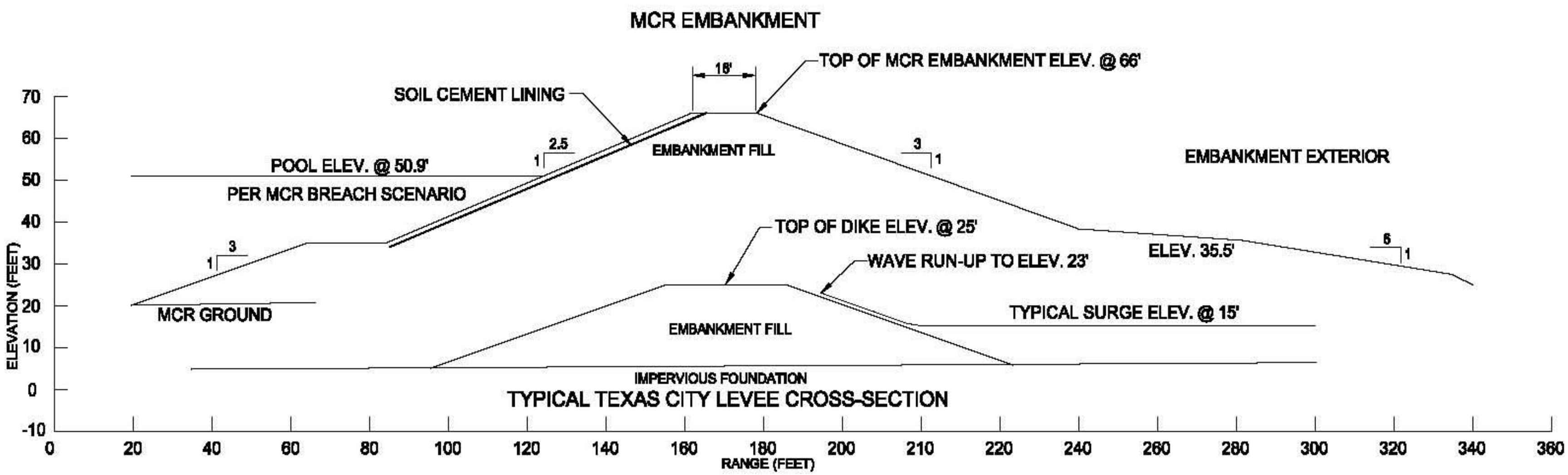
STP 3 & 4 maintains ability to cool the core until flood water level exceeds 51 feet MSL.

- 17 feet above nominal site grade;
- 12.8 feet above maximum flood level (MCR breach); and
- 11 feet above the design basis flood of 40 feet MSL.

# Main Cooling Reservoir Embankment Breach

- MCR formed by 12.4-mile-long embankment enclosing a 7000 acre reservoir.
- Constructed above natural ground
- Minimum embankment crest elevation is 65.8 feet MSL.
  Normal max operating level is 49 feet MSL.
- Toe of embankment is approximately 29 feet MSL at the north end.

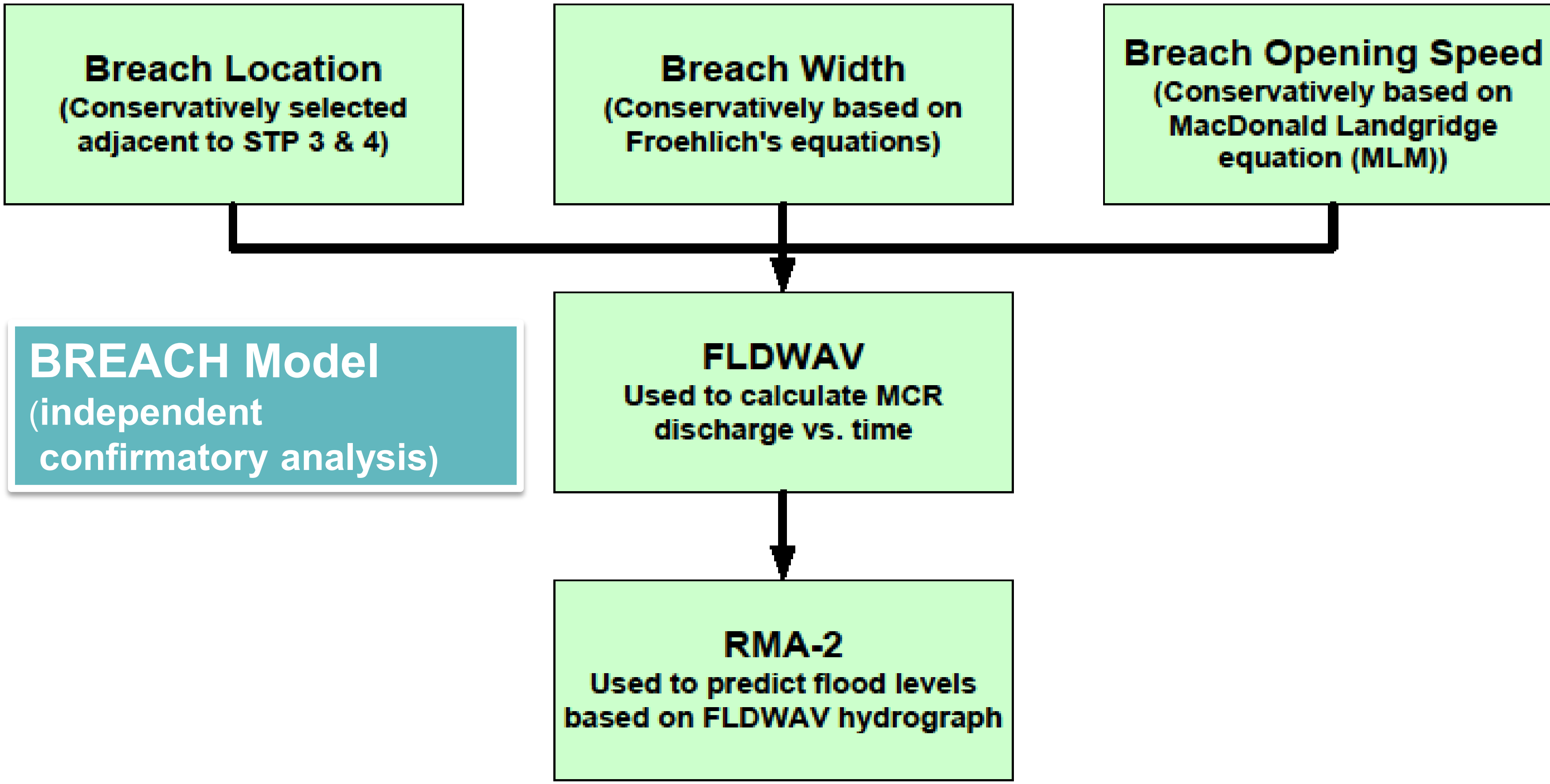
# Main Cooling Reservoir Embankment Breach (continued)




## MCR Embankment Cross Section

(superimposed with cross section of  typical Texas City Hurricane Storm Levee)

# Main Cooling Reservoir Embankment Breach (continued)



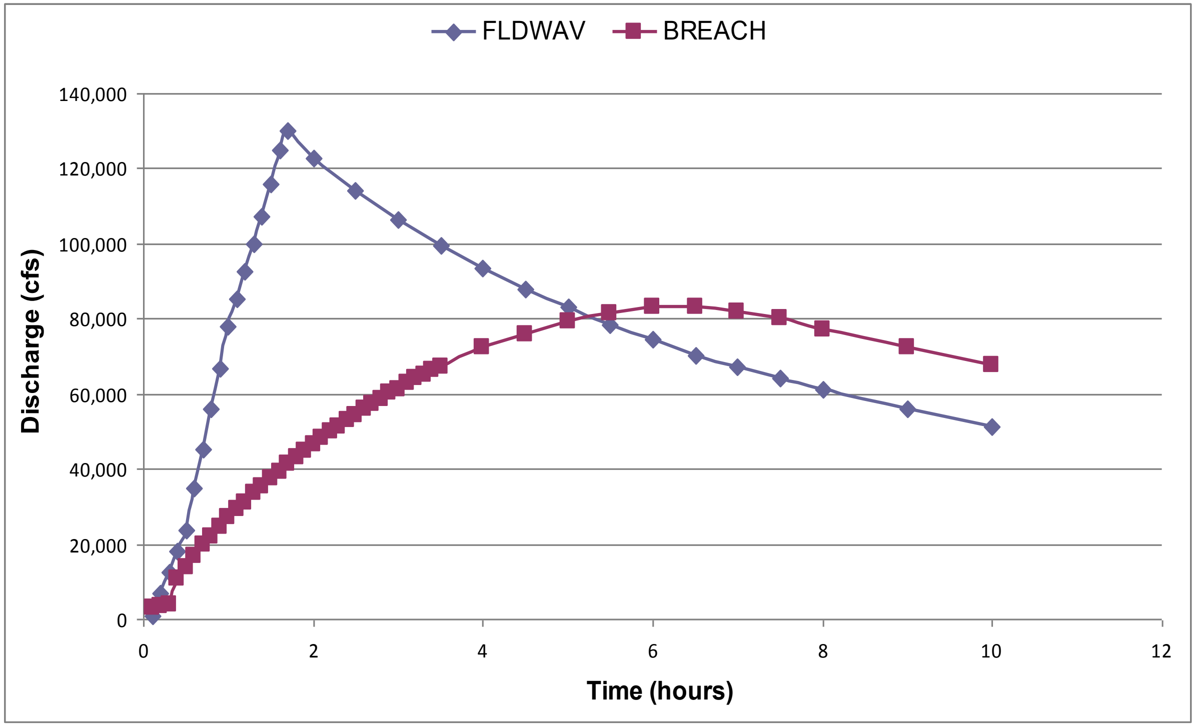
# Main Cooling Reservoir Embankment Breach (continued)

## MCR Breach Flow:

### FLDWAV (STP COLA Model using Froehlich width and MLM time)

compared to

### BREACH Model (independent confirmatory analysis)




**FSAR Figure 2.4S.4-13c:**
Comparison of BREACH and FLDWAV Outflow Hydrographs

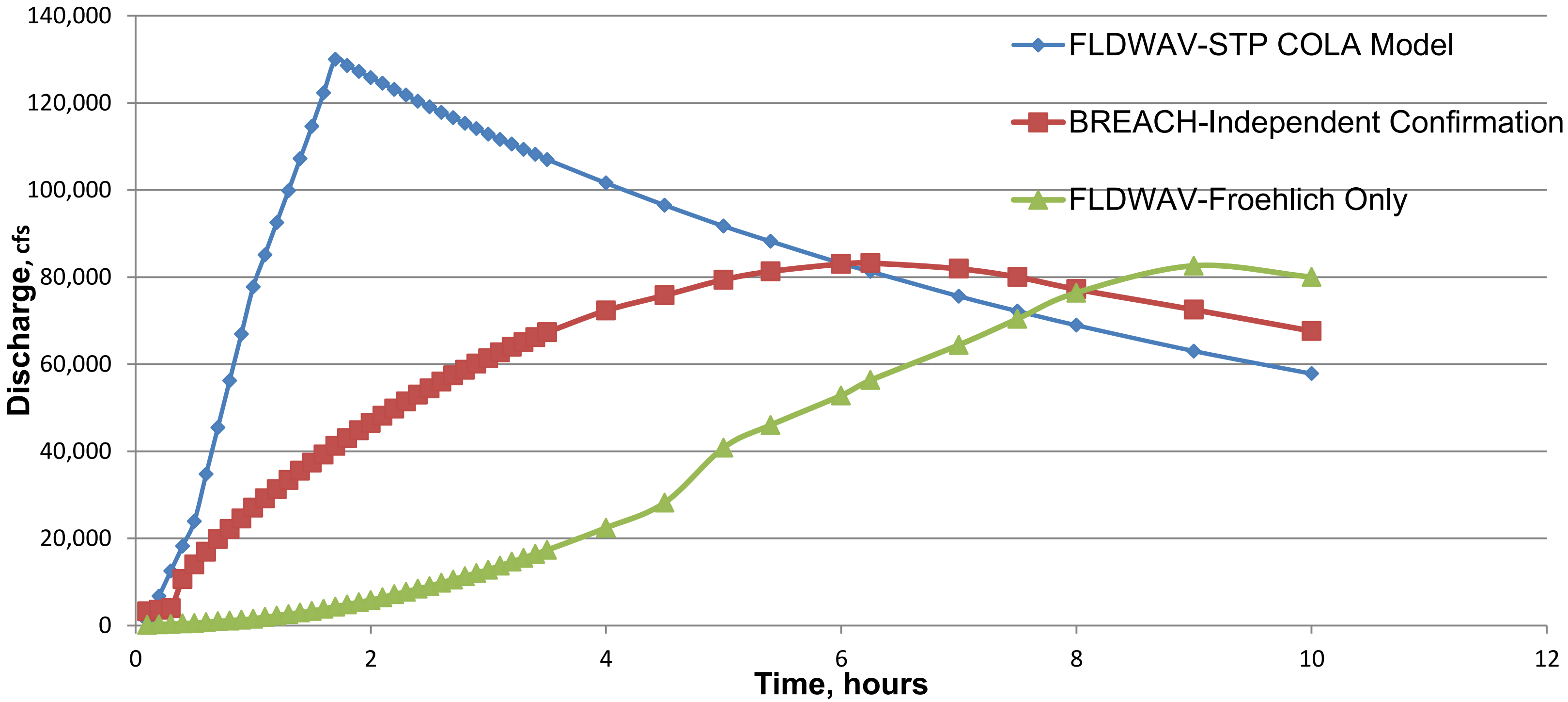
# Main Cooling Reservoir Embankment Breach
**(ACRS Action Item 65)**

**How does MCR breach width derived from Froehlich's equation used in the FLDWAV model compare with value used in confirmatory BREACH Model?**

| | PEAK FLOW | | | Final |
|---|---|---|---|---|
| | Flow | Time | Width | Width |
| | (cfs) | (Hours) | (feet) | (feet) |
| FLDWAV-STP COLA Model | 130,000 | 1.7 | 417 | 417 |
| BREACH-STP | 83,000 | 6.25 | 398 | 485 |
| Froehlich Equations | 62,600 | 10.6 | | 417 |

# Main Cooling Reservoir Embankment Breach
**(ACRS Action Item 65)**

**FLDWAV Model** (STP COLA Model using Froehlich width and MLM time)
**BREACH Model** (Independent Confirmation)
**FLDWAV Model** (Froehlich Width only)



# Questions and Comments

United States Nuclear Regulatory Commission
*Protecting People and the Environment*

# Presentation to the ACRS Subcommittee

**South Texas Project Units 3 and 4**
**COL Application Review**

**STP Chapter 2**
**SER with no OIs**
**"Site Characteristics"**

**April 24, 2013**

# ACRS Subcommittee Presentation
# STP Chapter 2 SER with no OIs

## Staff Review Team

- **Project Managers**
  - George Wunder
  - Tekia Govan, David Misenhimer
- **Technical Staff**
  - RPAC, Chief, Michael McCoppin
  - RHMB, Chief, Christopher Cook

# Summary of Staff Review

*2.1 - Geography and Demography*

*2.2 - Nearby Industrial, Transportation, and Military Facilities*

**2.3 - Meteorology**

**2.4 - Hydrology**

*2.5 - Geology, Seismology, and Geotechnical Engineering*

# STP COL Chapter 2.3 Meteorology

**NRC Reviewer/Presenter:**
**Brad Harvey**

# New RAI 02.03.01-24
## Design-Basis Hurricane Winds and Missiles

- New RG 1.221 (Oct 2011)
  - Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants
  - $10^{-7}$ per year exceedance frequency
- RAI 02.03.01-24
  - Applicant identified design-basis hurricane wind speed and missiles for the STP site
  - Applicant confirmed ABWR standard plant and STP site-specific SSCs are protected against hurricane winds and missiles

# Action Item 92

- ACRS asked what criteria will be used to initiate use of global climate change predictions and revise analysis of impact of natural phenomena on the STP site
- GDC 2: Design basis for SSCs shall reflect 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

# Action Item 92 (cont'd)

- SER Section 2.3S.1.4.7: Climate Changes
  - NRC staff acknowledges that long-term climatic change resulting from human or natural causes may introduce changes into the most severe natural phenomena reported for the site
  - There is a level of uncertainty in projecting future conditions
  - If it becomes evident that long-term climatic change is influencing the most severe natural phenomena reported at a site, the COL holders have a continuing obligation to ensure that their plants continue to operate safely
- NTTF Recommendation 2.2: Program for Periodic Confirmation of Seismic and Flooding Hazards (Tier 3)
  - SECY-12-0095: The staff includes seismic, flooding, and other natural and man-related external hazards within the scope of this rulemaking
  - This rulemaking could provide a potential opportunity to address global climate change

# Action Item 91

- ACRS noted an “inconsistency” in climate change effects treatment for natural phenomenon in characterizing the STP site
  - Potential maximum tsunami address sea level rise from global climate change in the next century, but no mention of the potential increase in wind and rain accompanying future hurricanes
- Both sea level rise and hurricane wind/rain data are based on either historical or deterministic data: future changes resulting from climate change are uncertain
  - Sea Level Rise: NOAA CO-OPS
    - 1.43-ft rise/100-yr projection based on locally measured trends
  - Hurricane Winds and Rain: USGCRP
    - More intense hurricanes with related increases in wind and rain likely
    - May not be an increase in the number of storms that make landfall

# Summary of Review

- **Conclusions and Status of SER Section 2.3 – Meteorology**

  - FSAR met regulatory requirements
  - All COL items adequately addressed
  - No open or confirmatory items

# STP COL Chapter 2.4 Hydrology

**NRC Reviewers:**
**Dr. Henry Jones**
**Dr. Nebiyu Tiruneh**
**Dr. Hosung Ahn**

**Presenters:**
**Dr. Henry Jones**
**Dr. Nebiyu Tiruneh**

# Open Item 02.04.04-1

**Open Item 02.04.04-1:** The main cooling reservoir embankment breach flood analysis needed to be updated by describing the process of selecting the plausible breach widths and breach time parameters for determining the flood characteristics.

- **Staff's Review**

  **Action**: The applicant provided and staff reviewed the responses to RAIs 02.04.02-3, 02.04.04-14 and 02.04.04-15. The applicant did the following to close the open item:

  - described the use Dam Safety Office for characterization of the breach,
  - applied the BREACH model, including a sensitivity analysis,
  - and compared results to a historical database of dam failures.

  Based on an independent confirmatory analysis, the staff determined that the applicant-estimated breach flood discharge is reasonable and conservative. The staff closed the open item based on its confirmatory analyses.

# Open Item 02.04.05-1

**Open Item 02.04.05-1**: The applicant has not shown that the ADCIRC model results account for the most conservative plausible PMH scenario. The description and results of these models are also missing from the FSAR.

- **Staff's Review**
  - **Actions:**
    - STP provided additional information through the response of RAI 02.04.05-11 to more fully describe ADCIRC and to clarify the ADCIRC model set-up, PMH scenario, sensitivity runs for storm parameters (e.g., radius, forward speed, track direction, and landfall location) of storm.
    - Staff determined that the applicant has selected conservative PMH scenarios for estimating the PMSS at the STP site. The staff also determined that the applicant has selected an appropriate model supported by site-specific information. The staff concluded that the applicant's ADCIRC simulations for determining the PMSS at the STP site are adequate.
    - Staff determined that the response is acceptable, thus closed the open item.

# Open Item 02.04.10-1

**Open Item 02.04.10-1**: The applicant did not provide an analysis to show whether or not a hurricane storm surge could erode the toe of the main cooling reservoir northern embankment during the PMSS.

- **Staff's Review:**

  **Action**: The applicant provided and the staff reviewed the responses to RAI 02.04.05-11.

  - The applicant described the use of the ADCIRC model and determined the PMSS maximum flood elevation including wave action.
  - The applicant determined that the PMSS would exceed the elevation of the embankment toe but not for an length of time or with such a current to erode the toe of the embankment.
  - Staff determined one scenario that could have led to a breach of the main cooling reservoir embankment. That was the storm surge could wet the toe of the embankment during the PMSS leading to erosion of toe. Staff determined that  was unlikely to occur.
  - Staff determined that applicant's estimate of the design basis flood characteristics and proposed flood protection measures are acceptable, thus **closed this open item**.

# Open Item 02.04.12-1

**Open item 02.04.12-1:** The applicant needed to clarify the potential for groundwater mounding in the Lower Shallow Aquifer, and for a west-southwest directed pathway during post-construction period

- **Staff's Review**

  **Open Item 02.04.12-1**: The staff issued RAIs 02.04.12-46, 02.04.12-48, 02.04.12-50, and 02.04.12-51 to address the above issue.

  **Actions**:

  - The applicant provided responses to the RAIs including a revised groundwater modeling document
  - Staff reviewed RAI responses and performed independent confirmatory analyses. Staff's review included evaluation of:
    - An improved alternative groundwater model
    - Particle tracking showing all pathways are to east-southeast
    - Sensitivity cases involving ranges of post-construction infiltration rates and excavation backfill hydraulic conductivity values
  - Staff concluded that plausible alternative pathways are analyzed, and exclusion of a west-southwest pathway in the Lower Shallow Aquifer is technically defensible
  - This part of Open Item 02.04.12-1 is closed.

# Open Item 02.04.12-1 (cont.)

- **Open Item 02.04.12-1:** The applicant needed to clarify the technical basis for the site characteristic of maximum groundwater level
- **Staff's Review**

**Open Item 02.04.12-1**: The staff issued RAI 02.04.12-49 to address the above issue.

**Actions**:

- The applicant provided a revised response to RAI 02.04.12-49.
- Staff reviewed the RAI response and performed an independent confirmatory analysis. Staff's review included evaluation of:
    - Field observations: 34-yr record, piezometer 602A, site characterization data
    - Modeling: post-construction groundwater levels
    - Combinations of field observations and modeling results
    - Confirmation of groundwater depression at existing STP Units 1 and 2
- Staff found that the site characteristic for maximum groundwater level of 28 ft above MSL is technically defensible and acceptable under normal and extreme conditions excluding the maximum flood level

# Open Item 02.04.12-1 (cont.)

- Staff found the groundwater level could reach plant grade (34 ft MSL) during the design basis flood (maximum flood level = 40 ft above MSL).
  - This groundwater condition during the maximum flood level is included in the engineering evaluation in SER Section 3.8.
- This part of Open Item 02.04.12-1 is closed thus closing this OI completely.

# Summary of Review

- The staff reviewed various flooding mechanisms (rain, hurricane, tsunami, dam breach, etc.) to determine site-specific design basis flood characteristics and required flood protection.
- The applicant identified the flood caused by a breach of the Main Cooling Reservoir embankment as the design basis flood.
- The staff also reviewed the groundwater area to identify the characteristics of the maximum groundwater level and accidental release of radioactive liquid effluents.
- The staff identified 5 open items and they are all closed.
- Open Item 02.04.04-2 was made obsolete due to applicant's modification of analytical tools used to estimate erosion and deposition in the area of the safety-related facilities.
- There are no confirmatory items.

# Action Item 93

- ACRS requested information on the PMT site impact if the roughness coefficient is modified significantly. For example, destruction of the vegetation by fire.
  - "No vegetation" scenario modeled in 1D and 2D simulations using a roughness characteristic of grass/turf.
  - 1D tsunami wave front slowed significantly. Maximum water elevation 10 m at a distance of 10 km from the site. Site elevation ~ 10 m.
  - 2D tsunami wave front is 10 m at the shoreline (i.e.,1/2 of 1D case).

  Conservative assumptions:
  - 1D case does not include lateral dissipation (radial spreading).
  - Offshore regions are assumed to be without bottom friction (no energy loss).
  - Time scale of submarine landslide motion is small (i.e., instantaneous displacement of the sea surface).
  - Maximum submarine landslide dimensions.

# Action Item 94

- ACRS requested information on what arrangements have been made for replenishing the UHS water.
  - There is a separate UHS for each STP Unit 3 & 4 that is configured with a dedicated water basin sized to provide cooling for 30 days.
  - Onsite wells primarily provide makeup water to the UHS basins.
  - The main cooling reservoir is the secondary source of makeup water. The Colorado River is the source of makeup water for the main cooling reservoir.
  - The surface and groundwater sources are not safety-related because UHS basins of each unit as sufficient capacity to provide a 30-day cooling water supply to the UHS without the need for any makeup or blowdown.

# Action Item 95

- ACRS requested information on the impact of removing ground water to replenish UHS. Would this change the local groundwater flow and lead to surface subsidence that could impact STP Units 3 & 4?
  - Groundwater will be used for the potable and sanitary supply, the production of demineralized water, fire protection, and makeup water for the UHS.
  - Annual groundwater usage at STP Units 1 and 2 is 1.59 M $m^3$/yr (1,288 ac-ft/yr). The normal groundwater consumption rate for the STP units 3 and 4 is 1.94 M $m^3$/yr (1,575 ac-ft/yr).
  - The STP permit limit has not been fully used to date. The estimated groundwater permit is 3.7 M $m^3$/yr (3,000 ac-ft/yr).
  - Production wells for existing plants have caused the Deep Aquifer to exhibit a local reversal of the flow pattern. This results in a radial flow toward the production wells from the surrounding aquifer.

# Action Item 95 (cont'd)

- The estimated land-surface subsidence since 1900 over most of Matagorda County to be less than 1 ft .
- Where land-surface subsidence exceeds 1 ft in northwest Matagorda County, it is attributed to groundwater withdrawals associated with
- gas/petroleum exploration and sulfur mining.
- During construction and through operation in 1993 of STP Units 1 and 2, a subsidence rate of less than 0.1 in. to about 0.2 in. per year was observed.
- Groundwater monitoring for STP Units 3 and 4 will be similar to existing reporting requirements for STP Units 1 and 2. **Considerations will include subsidence monitoring to ensure structural stability.**

**ACRS Subcommittee Presentation**
**SER with no OIs Chapter 2**

# Questions

## ACRS Subcommittee Presentation
## SER with no OIs Chapter 2

# *Back up Slides*

# Backup Slide
## (Action Item 91)

- Hurricane Wind Loads
  - $10^{-2}$ per year value of 139 mph (ASCE/SEI 7-05)
  - $10^{-7}$ per year value of 210 mph (RG 1.221)
- Local Intense Precipitation (PMP, HMR 51 & 52)
  - 5-minute probable max precipitation depth: 6.4 inches
  - 1-hour probable max precipitation depth: 19.8 inches
  - Maximum power block water level due to local PMP storm: 36.6 ft MSL
- Probable Maximum Surge (PMH, NOAA Tech Report NWS 23)
  - Probable maximum storm surge water level: 31.1 ft MSL

# Presentation to the ACRS Subcommittee

**Overview of the Non-Concurrence Process**

**STP Chapter 2**
**SER with no OIs**
**“Site Characteristics”**

**April 24, 2013**

# Overview of the Non-Concurrence Process

- The non-concurrence process (NCP)
- Documentation of the Non-Concurrence
  - The non-concurrence (Section A)
    - Issue #1: Main Cooling Reservoir (MCR) Breach Flood Analysis in SER Section 2.4.4
    - Issue #2: Flood Analysis of Hurricane and MCR Breach Combination in SER Section 2.4.5
    - Issue #3: Maximum Groundwater Level in SER Section 2.4.12
  - Supervisor's Review and Recommendation (Section B)
  - Management's Resolution of the issue (Section C)
- This non-concurrence is captured as NCP-2011-14 and can be found in ADAMS (Accession number – ML12348A249)

# South Texas Project Units 3 and 4 COLA Review
# SER Chapter 2.4 Hydrology: Non-Concurrence


**Presentation to the ACRS Subcommittee**
**Presenter: Hosung Ahn, Ph.D., P.E.**
**NRO/DSEA/RHMB**


**April 24, 2013**

# Hydrology Non-concurrence Issues

- #1 Main Cooling Reservoir (MCR) Levee Breach (FSAR Sec. 2.4.4)
  - 1.1 Breach width estimated by the Froehlich equation is not conservative.

    The breach parameters and flows estimated by the numerical model (NWS-BREACH, or just BREACH) were underestimated by:
  - 1.2 STP used a small breach roughness value.
  - 1.3 The staff specified unrealistically small tailwater section.
  - 1.4 STP and the staff do not consider scouring of the levee foundation.

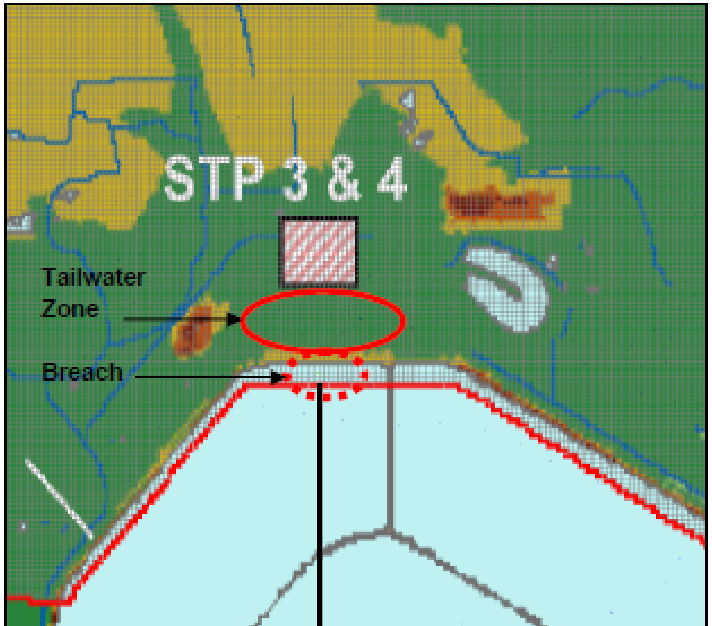
- #2 Probable Maximum Storm Surge (FSAR Sec. 2.4.5):

  Conservatism of parameters and accuracy of wind and surge models used in STP's storm surge analyses are of concern.

- #3 Maximum Groundwater Level (FSAR Sec. 2.4.12):

  The departure of the maximum groundwater level (ABWR DCD Tier 1 Site Parameters) is not addressed in subsequent structural analyses.

# #1 Main Cooling Reservoir (MCR) Levee Breach



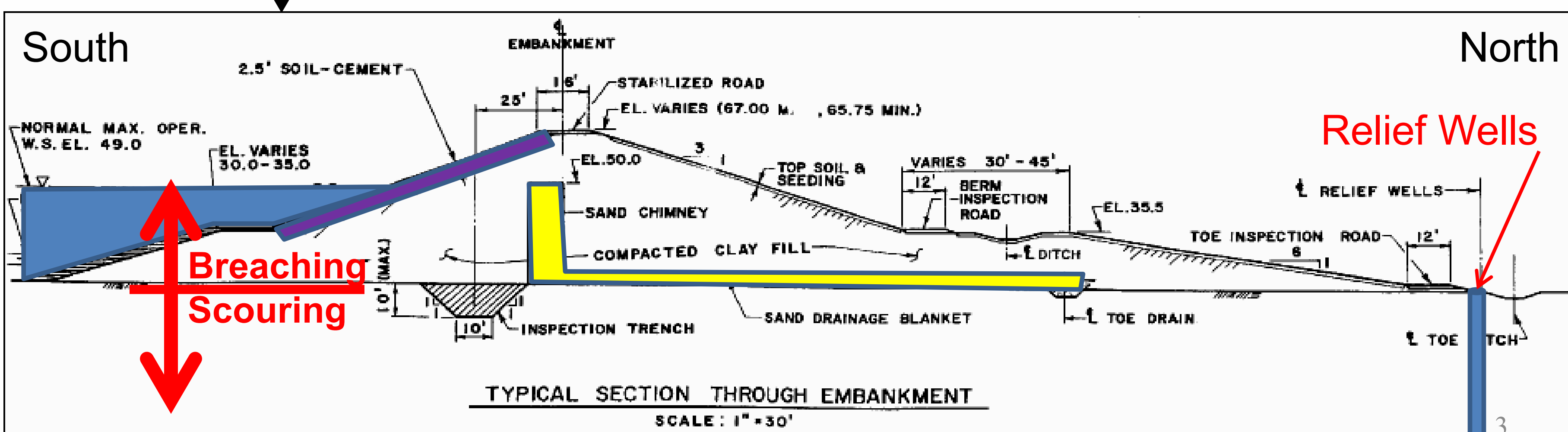

**MCR**

- Area=7000 acres; Levee length: 12.4 miles
- Construction completed in 1983
- Filling test (45 ft msl) from 1983 to 1989
- Proposed the MCR water level to 49 ft msl.

**Breach & Tailwater Condition**

- North levee: 4200 ft
- Elevation: 29~32 ft msl (upslope)
- Breach bottom roughness will be increased by broken cement blocks.

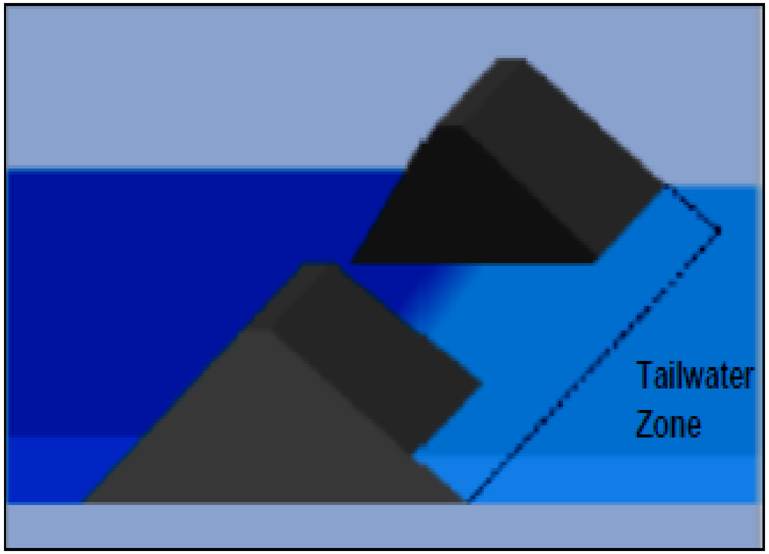
Note: msl=mean sea level



# Dam/Levee Breach Flood Analysis

<u>Regulatory Framework</u>

- Part 50 GDC 2: 'considering the most severe events with sufficient margin.'
- Part 100.20(c )(2): 'using the maximum probable events'
- Guidance provided in SRP, RG 1.206, and ANS 2.8.




<u>Issues in General</u>

- No detailed technical guide available
- Lack of historical data, and uncertainty.
- Applying a conservatism similar to other flooding events (e.g., rain, storm, etc.)
- No single numerical model available to simulate erosion and flow together.

<u>Approach:</u> We used a combined approach.

✓ <u>STP</u>: empirical equations+ numerical models(BREACH,FLDWAW, RMA2). (p. 24)

✓ <u>The staff</u>: numerical models (BREACH, RMA2)+ historical data.

✓ <u>My re-analysis:</u> similar to STP's, but used FLO2D

Note: Empirical regression equations are used to predict breach parameters (width, time, peak flow) using breach head and storage volume.

# 1.1 Breach Parameter Estimates Using Regression Equations

- **STP's Breach Parameter Estimates**:

  Breach width: 417 ft by Froehlich
  Breach time: 1.7 hr by MLM
  Peak flow: 63 kcfs by Froehlich
  83 kcfs by BREACH
  130 kcfs by FLDWAV

- **My Re-analysis**:

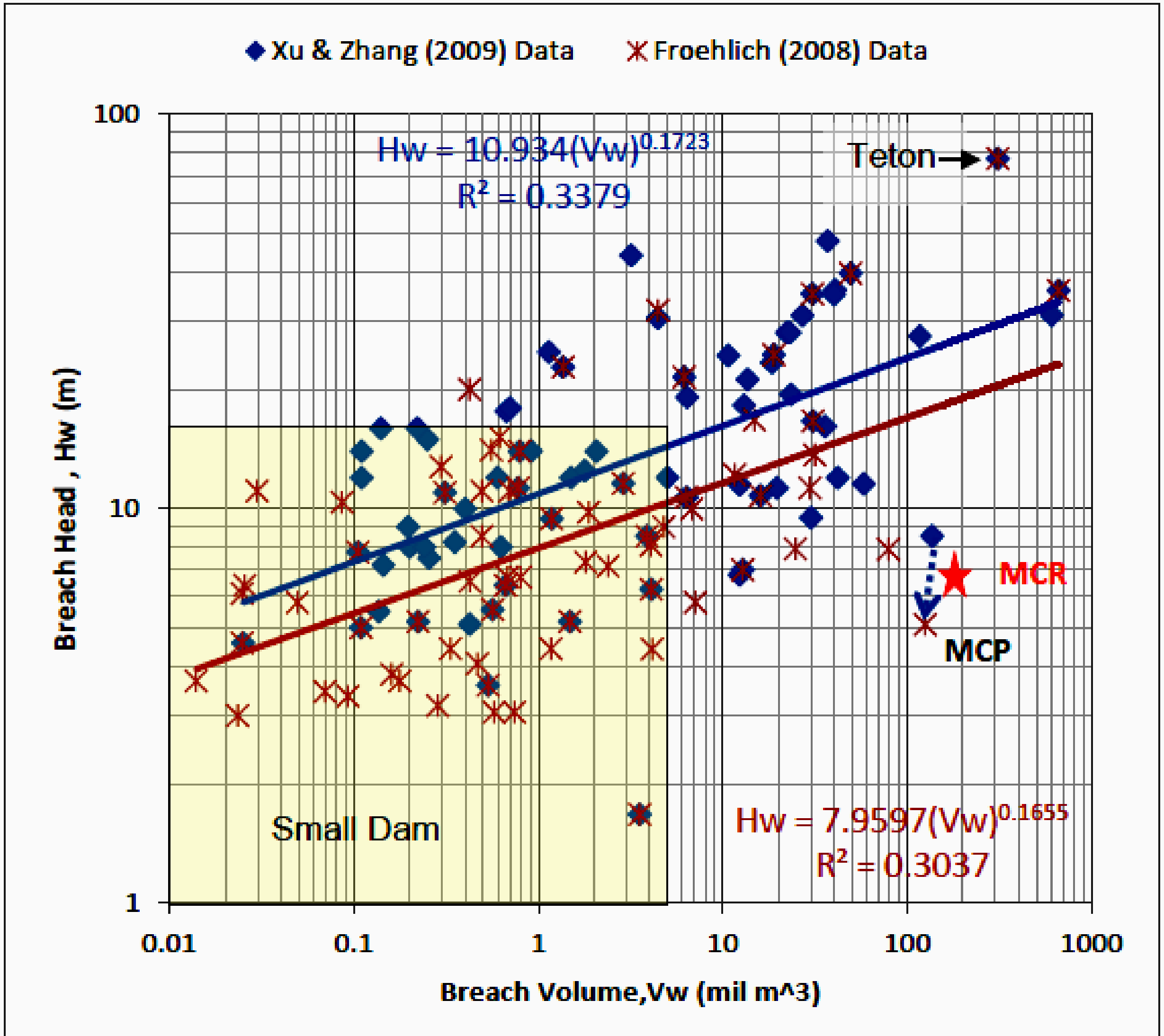
  MLM breach width: 745~1738 ft
  Peak flow: 251 kcfs by 10 equations
  269 kcfs by BREACH
  280 kcfs by FLDWAV

- **Non-concurrence Issues**:
  - STP's breach width estimate is not conservative compared to other similar cases:
    - ✓ 2000 ft for STP Units 1&2
    - ✓ 2034 ft for Victoria ESP
    - ✓ 4757 ft for STP FSAR v. 0&1
    - ✓ 600 ft on the Martin Cooling Pond breach.
  - Other government guides (USBR, USACE, etc.) recommend to '**use all equations, then make an engineering judgment.**' However, STP did not use the MLM breach width equation as well as many breach peak flow equations, resulting in non-conservative parameter estimates (see my re-analysys).

**Notes:**

- **kcfs**=1000 cubic feet per second; **MLM**=MacDonald and Langridge-Monopolis equation (1984).
- Froehlich, MLM, USBR, and von Thun and Gillette provide both breach width and time equations, but later two are not applicable to MCR.

# Position Analysis for Main Cooling Reservoir Breach




Discussions:

- By the State of Colorado dam classification, MCR is a large dam.
- MCR which has low head and large storage volume could breach widely.
- Based on the reservoir size (head and volume), suitable example for MCR is not the Teton (B=495 ft) but the Martin Cooling Pond (MCP) breach (B=600 ft).

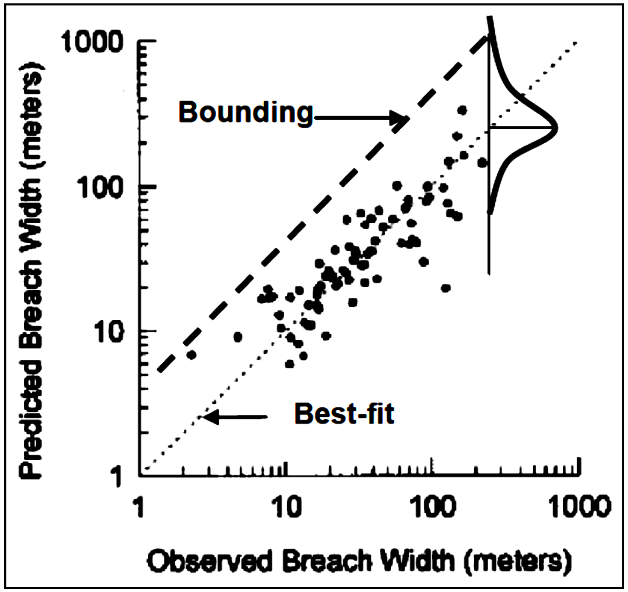
Note: B=breach width

# Historical Maximum and Envelope for Breach Widths

Record of Extreme Breach Widths:

- Dam: USBR database: 738 ft, 610ft , 551 ft ,…
  Worldwide: 5800 ft in India
- Levee: Europe (Nagy, 2006): 8000 ft, 1300 ft, 1000 ft, … from 39 cases
  California Delta Levee: 1018 ft , 950 ft, 926 ft, …… from 14 cases
- STP's MCR breach width: 417 ft (It is just a mean value for a given reservoir size without margin.)

Note: The above data indicates that levees tend to breach wider than dams.

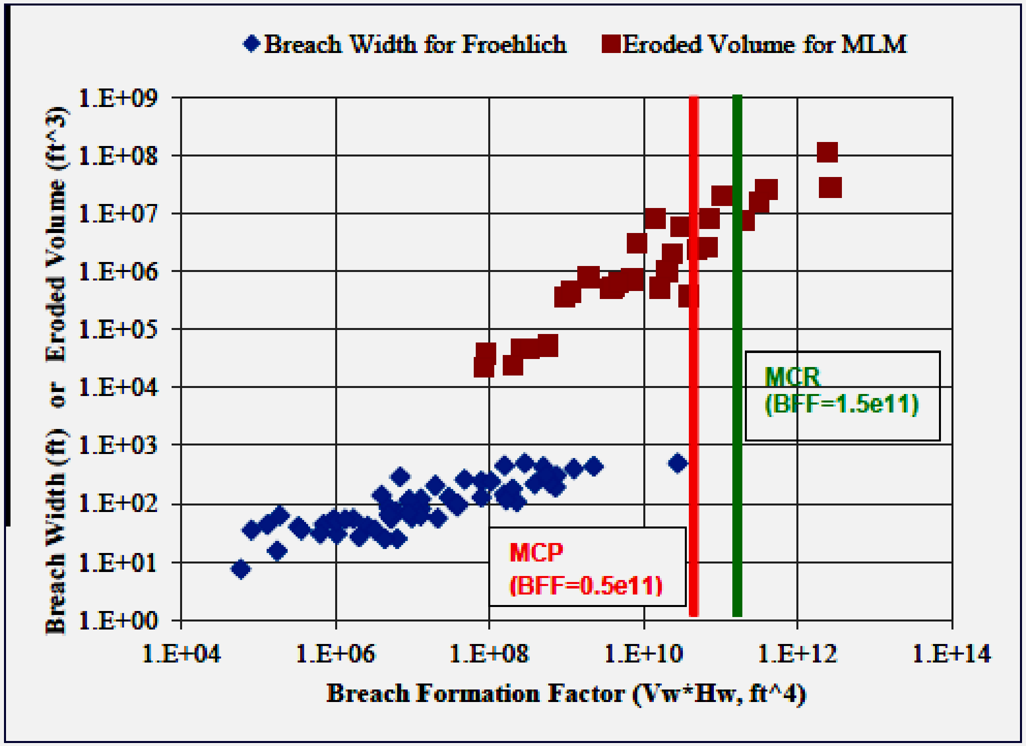



Conservatism

- To meet the GDC 2 requirements, STP should use a bounding breach width equation to address uncertainties in data and models.
- Froehlich (1995) does not provide bounding equations, but an upper confidence limit of a best-fit equation (Wahl, 2004) could be used alternatively.

Note: USBR=U.S. Bureau of Reclamation

# Better Breach Width Equation for MCR Levee




USBR: $B=2h_w$; von Thun & G: $B=2.5h_w+C_b$
Froehlich : $B = 0.1803\ V_w^{0.32}\ h_w^{0.19}$
MLM : $B = 0.0261\ (V_w\ h_w)^{0.769}\ /A$

Notes: B=breach width, $h_w$=head (m), $V_w$=storage volume ($m^3$), Cb=storage factor, A=cross section area ($m^2$). MLM=MacDonald and Langridge-Monopolis equation (1984)

The staff asserted that Froehlich's breach width equation is better because its prediction error (0.43) is smaller than the MLM error (0.82).

**My Conclusions:**

- The above assertion is not valid because the two errors have different dimensions (length vs. volume).
- The MLM equation is better because the sizes of MCR and MCP data are within the range of MLM data.
- The Martin Cooling Pond (MCP) breach shows that the MLM or bounding Froehlich equations are good for MCP, thus for MCR (see the backup slides p.37).

# 1.2 Breach Bottom Roughness Coefficient (n-value)

<u>Issue:</u> STP used non-conservative n-value (0.05) in the BREACH model. However, the staff chose n-value of 0.075 in the SER.

<u>My Opinions:</u>

- I agree with the staff, but not with the applicant.

- Breach n-value should be higher than flow n-value because eroded materials create mud flow with high resistance. The State of New Jersey Dam Breach Guide (2011) states that "n-value at the dam breach should be assumed to be larger than the maximum field n-value to account for uncertainties of high energy losses" – They used the term "probable maximum n-value."

- The BREACH manual (1991) provides four low n-value examples (<0.035), while other dam breach studies used high n-values (>0.1).

Notes: 1) Manning's Equation: $V=1.49R^{2/3}S^{1/2}/n$, where V=velocity, R=hydraulic radius, S=slope, n=Manning's n-value, in English units.

2) n-value is the most sensitive parameter in MCR BREACH runs.

# Referenced and Verified n-values Applicable to MCR

| Source | Selected n | Range of n's |
|---|---|---|
| STP FSAR | 0.05 | 0.025~0.08 |
| SER & My Re-analysis | 0.075 | 0.025~0.075 |
| Handbook of Hydrology (Maidment, 1993): boulder) | - | 0.04~0.1 |
| Chow (1959) – for major rough stream (W>100ft) | - | 0.035~0.1 |
| Fenton, et al. (2006) – Dam Breach (p.29) | 0.1 | |
| Trieste and Jarrett (1987) - Dam Breach (p.30) | | 0.05~0.225 |
| **My Estimates Using the Chow Method (p.31)** | **0.0775** | **0.07~0.085** |
| **Calibrated n with the 1979 MCP Breach (p.38)** | **0.09** | **0.06~0.12** |

**Note: Page numbers refer to backup slides.**

Conclusions:

- Trieste and Jarrett (1987) concluded that verified breach n-values would be about 210% greater than respective field n-values (Backup slide p.30).
- MCR breach n-value should consider a composite of clay, sand, and broken cement blocks (p.31).
- The n-values in bold are site-specific MCR values, thus credible.
- Therefore, the staff's selection of n=0.075 is reasonable and conservative.

# 1.3 Tailwater Section in the BREACH Model

**Issues**:

- The staff used an unrealistically small tailwater section (width of 600 ft) compared to the anticipated breach width (The same is true in FSAR Table 2.4.4-6b). Then the staff concluded that tailwater section is not critical in breach and that a small tailwater section is realistic.

**My Opinions (see Ahn, 2012a):**

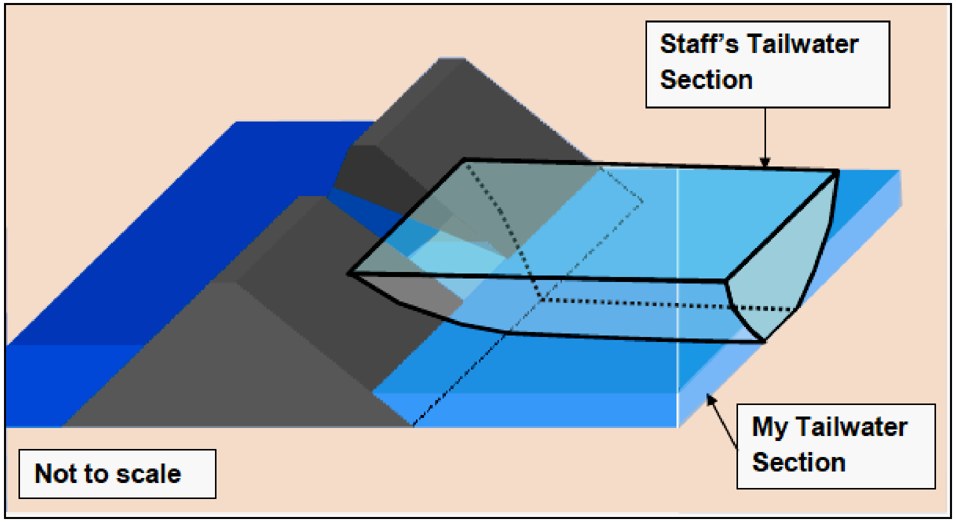
- I disagree. The MCR breach tailwater zone is wide (>1 mile) overland plain with mild upslope to the North (4 ft to 1 mi), so that the tailwater spreads quickly and widely to the lateral directions - A wide tailwater section is realistic.

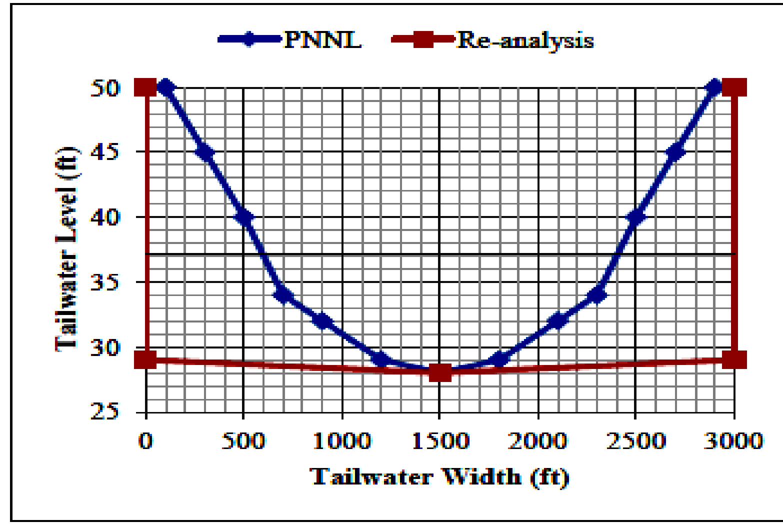
- My re-analysis shows that small tailwater section produces high tailwater level at the beginning of breach, resulting in reducing breach head and resulting breach width significantly. My sensitivity analysis also shows that tailwater section is very critical in breach.

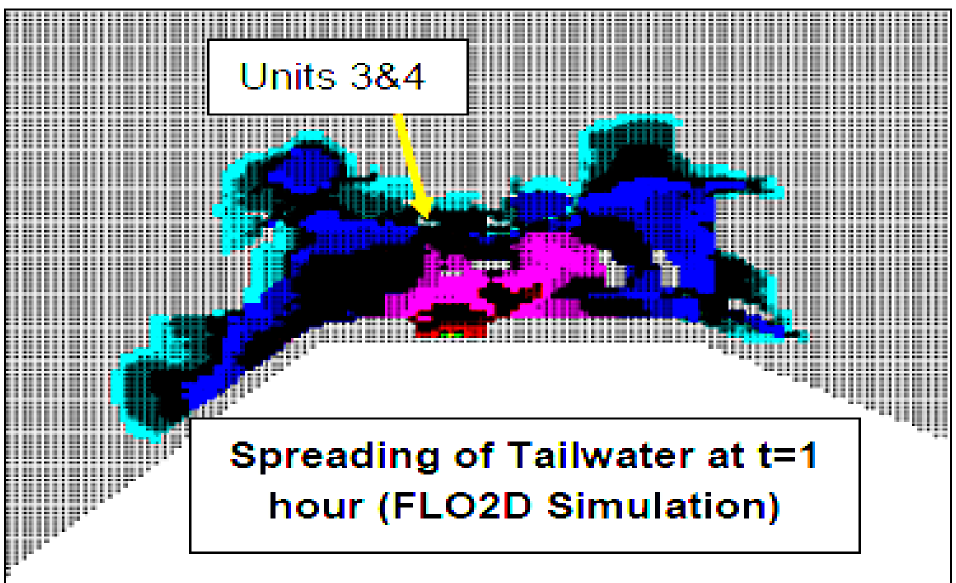
Note: NWS-BREACH performs an 1-dimentional routing of breach outflow and tailwater with only one representative cross section as input – It is a limitation of the model but acceptable.

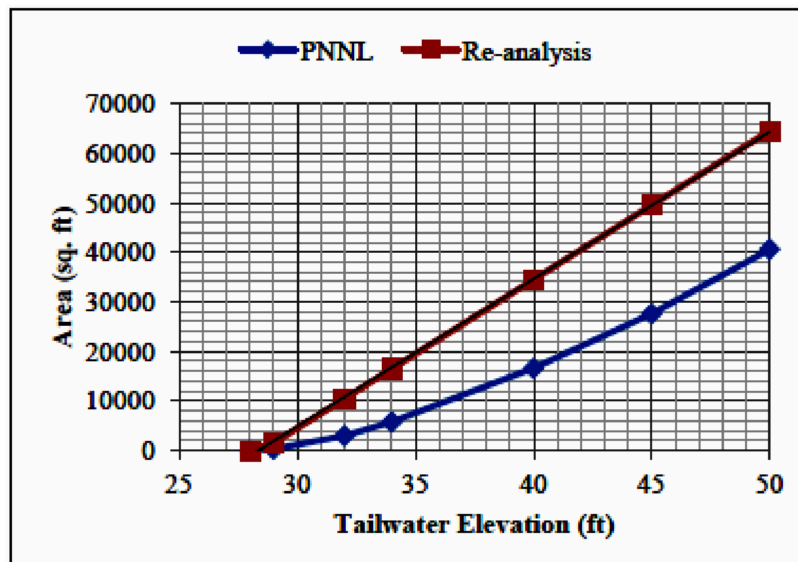
# The Staff Used an Unrealistically Small Tailwater Section

(Staff: 600 ft at bottom, 2800 ft at top; Re-Analysis: 3000 ft)

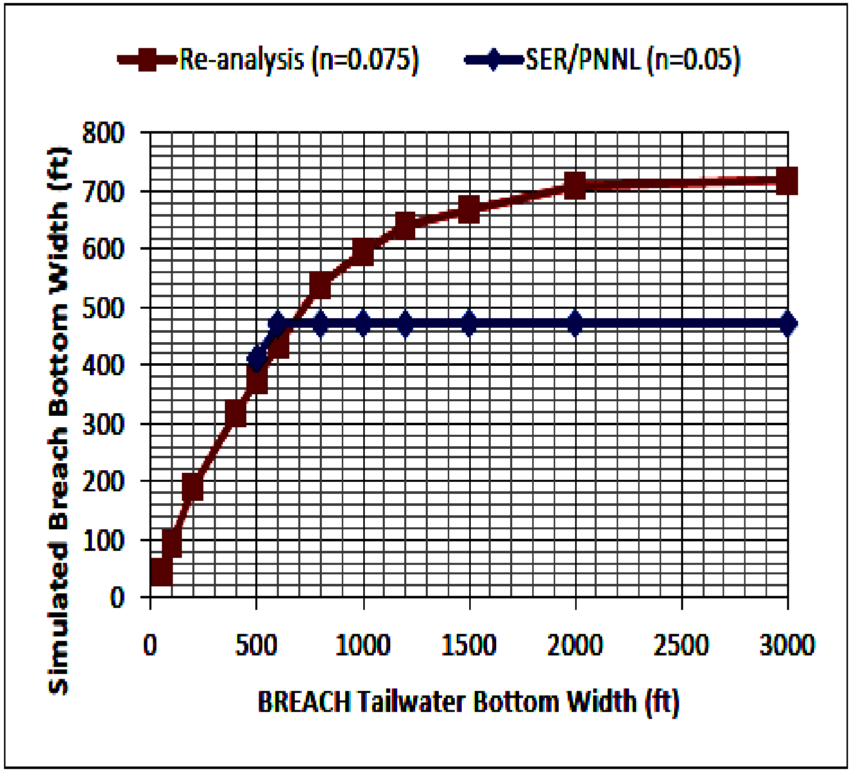


# BREACH: Tailwater Section Width vs. Breach Width



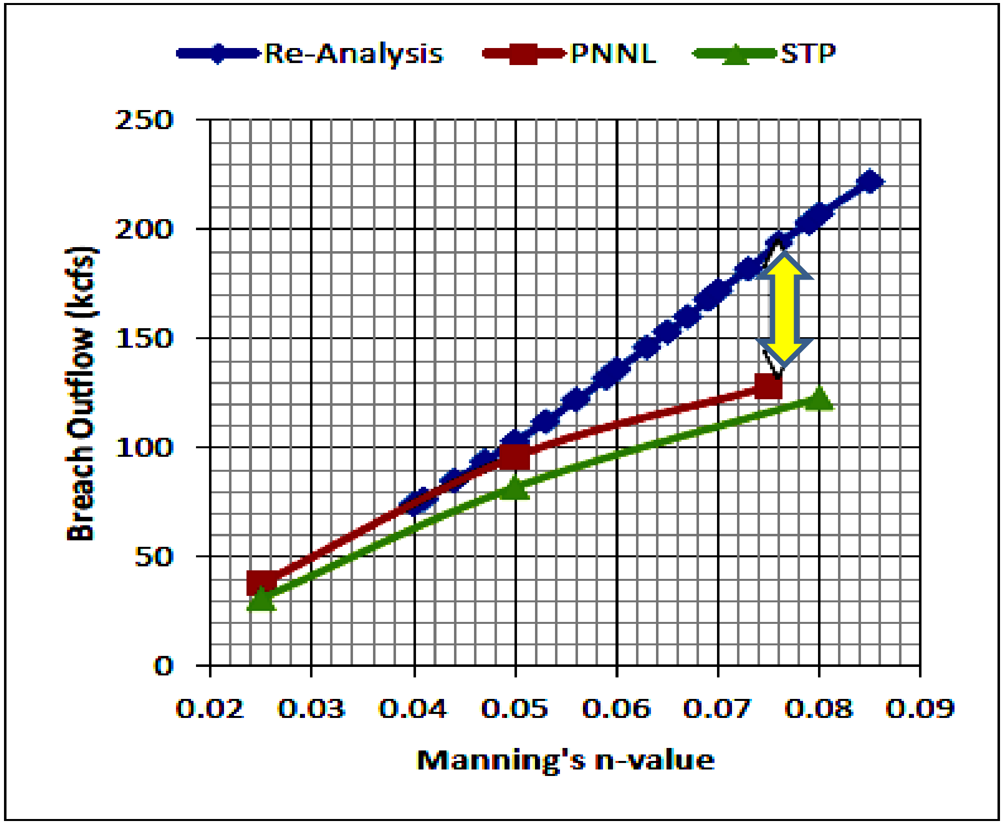

**<u>My Re-analysis Findings</u>**

- The staff/PNNL selected n=0.075. However, they performed a tailwater section sensitivity analysis with n=0.05, then concluded that the tailwater section is not a limiting factor. (SER p. 51) – This conclusion is incorrect as my re-analysis shows that tailwater section is very sensitive in breach.

- The staff obtained peak flow of 130 kcfs using BREACH with n=0.075 and a small tailwater section, then concluded that STP's breach estimate is acceptable – The model is flawed.

- In my re-analysis, I used a width of 3000 ft, but a tailwater width greater than 2000 ft is acceptable (see Ahn, 2012a).

# Sensitivity of Two Breach Parameters (n-value and Tailwater Section)




Notes: W=tailwater bottom width; c=cohesion of soils; $\phi$=friction angle.

Discussions:

- The differences in outflows are due to width of the tailwater section and soil properties.

| | W (ft) | c(lb/ft²) | $\phi$(°) |
|---|---|---|---|
| STP | 600 | 300 | 20 |
| Staff | 600 | 200 | 15 |
| Re-an. | 3000 | 300 | 20 |
| All assumed no scour hole. | | | |

- It is clear from the figure that the staff underestimated breach outflows by using a small tailwater section.
- 

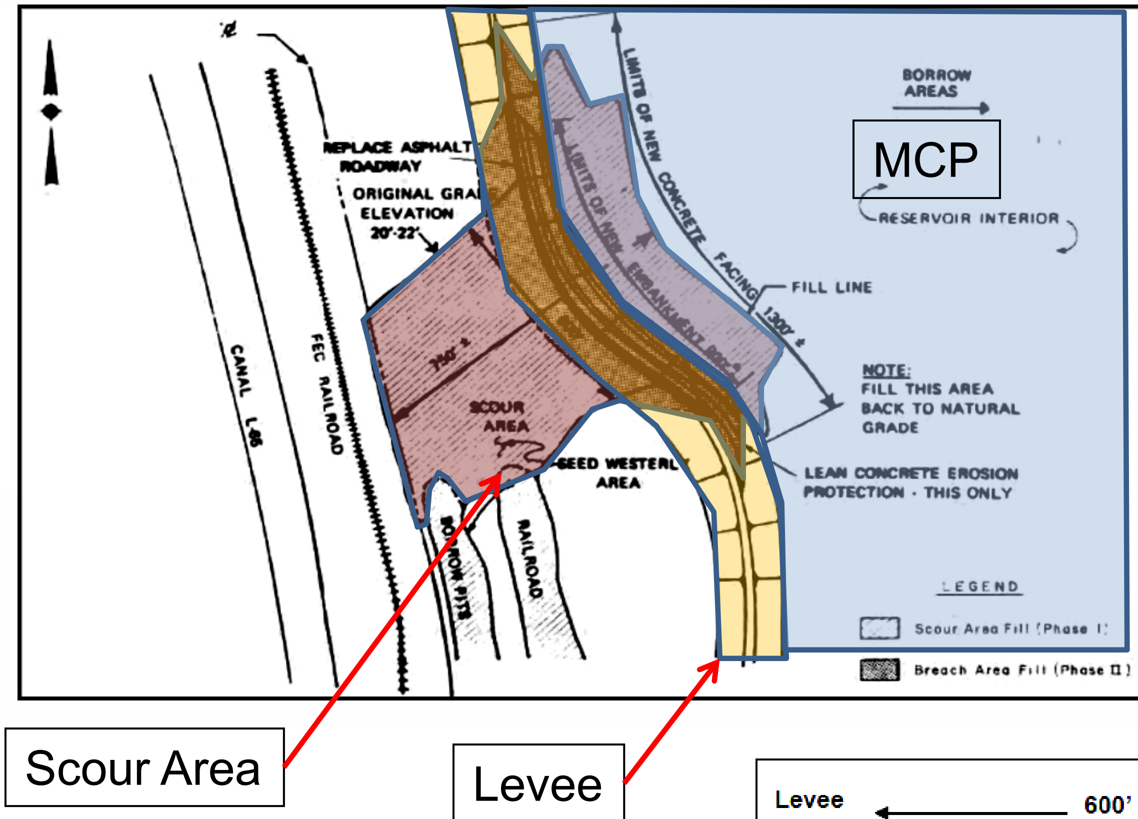
# 1.4 Scour Hole Issues

- STP and the staff did not consider the potential of foundation scouring.

- <u>External Reviews:</u>
  - Three reviewers concluded that a scour hole will not be formed: however they interpreted the field data incorrectly (see slide p.19).
  - Mr. Wahl asserted that the result of scour hole analysis in re-analysis must be discounted because the modeling and the results are not clearly documented: However he never reviewed the input and result of the model in my report.
  - Dr. Baecher stated that the staff should investigate the scouring possibility thoroughly.

- <u>Non-concurrence Issues:</u>
  - Scour holes are very common in levee breaches (e.g., Martin Cooling Pond, p.16). Scouring process in breach has been studied and modeled extensively.
  - The foundation of the MCR levee was not designed to prevent piping or scouring. Instead, UFSAR states that the foundation treatments were done by "removing trees and vegetation, scarifying and replacing the surface soil up to 9 inches with clay, then compacting."
  - The foundation could be scoured by piping through sand layers in foundation or by land subsidence from groundwater pumping (see p. 17 & 18).
  - STP and the staff forced not to occur scouring in BREACH. However, I relaxed the constraint, resulting in a deep scour hole.

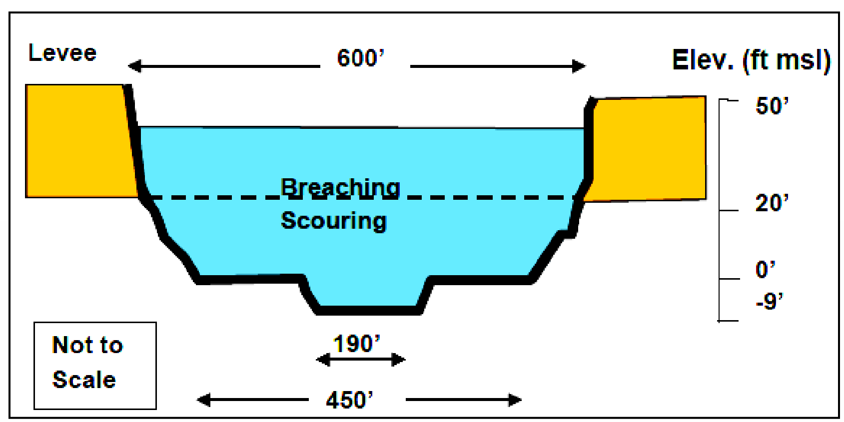
# 1979 Martin Cooling Pond Breach with Scour Hole




- <u>Levee Breach</u>
  width: 600 ft

- <u>Scour Hole</u>
  - Piping started through foundation sand layers.
  - Width: 450 ft
  - Length: 700 ft
  - Max. depth: 29 ft

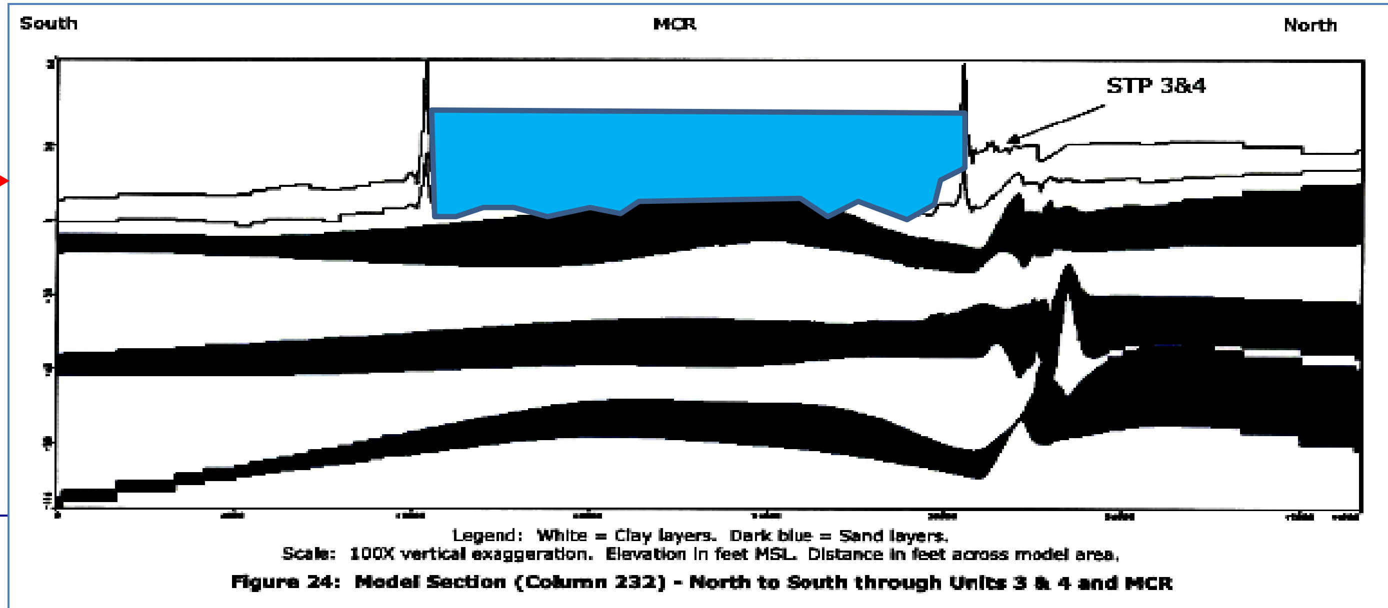
  (~16 ft on average)

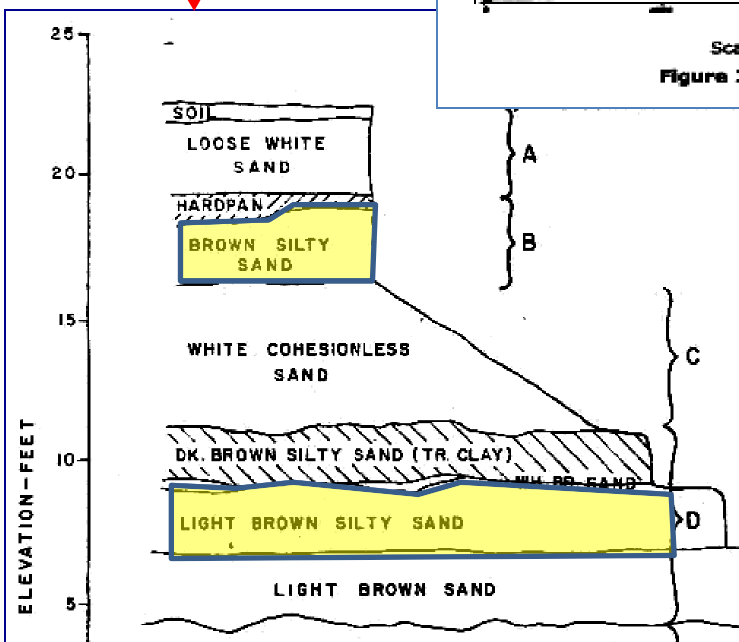


# Sand Layers below MCR and MCP Levees

MCR

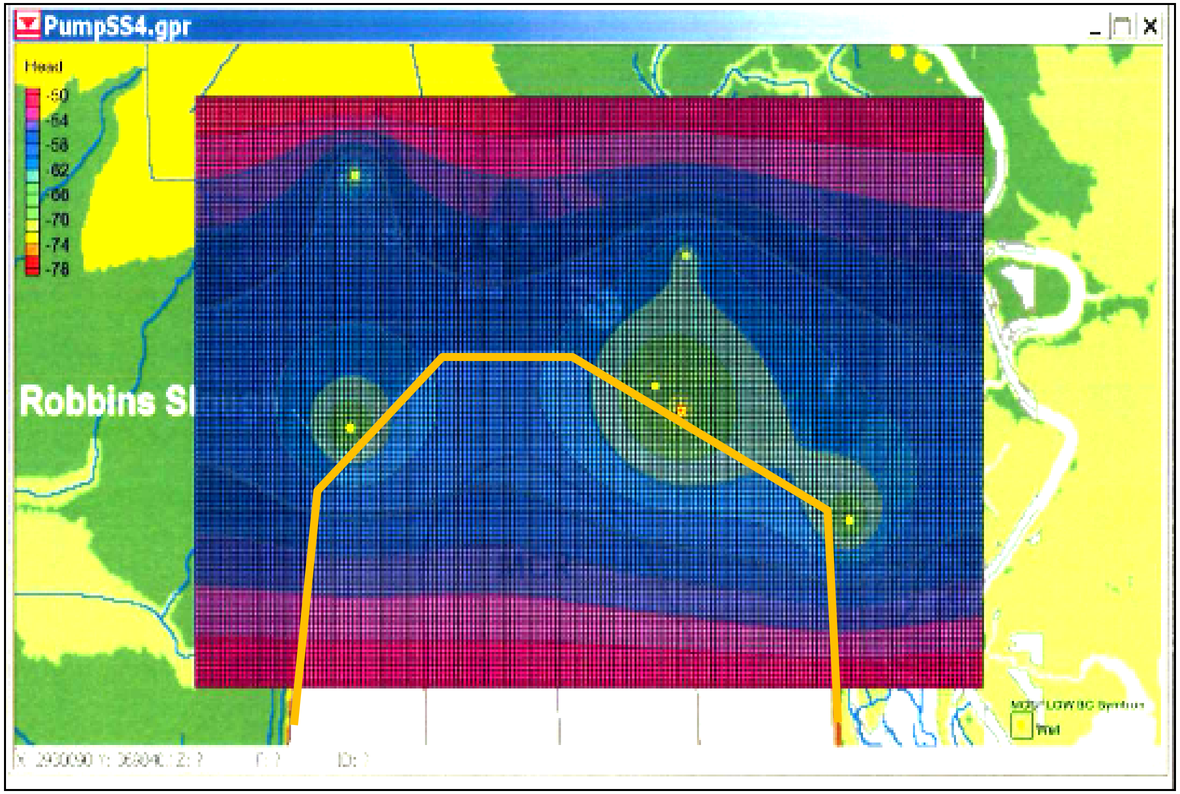
MCP




- Both MCR (black) and MCP (yellow) have sand layers, through which seepages have been occurred.
- Using a 3-D groundwater model, STP estimated a post-construction seepage rate of 2600 gpm along the 12.4-mi levee, mostly through sand layers.

# Potential Land Subsidence from On-site Groundwater Pumping




- The south Texas area has been experiencing severe land subsidence (max. 2m).
- STP plans to pump groundwater from the Chicot Aquifer using 6 wells (5 existing +1 proposed) at a total rate of 1860 gpm.
- I estimated long-term groundwater drawdown of about 30~40 ft near the wells, which could induce land subsidence that may trigger piping and scouring.



Note: gpm: gallons per minute

# Soil Properties Before and After the Construction of MCR

| Layer | Thick-ness (ft ) | End of MCR Construction | | After MCR Construction | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1975~1983 | | 1983~1984 | |
| | | c (psf) | $\phi$ (º) | c (psf) | $\phi$ (º) | c (psf) | $\phi$ (º) |
| Embankment | 36 | 1100 | 5 | 150 | 20 | 300 | 20 |
| Clay Layer 1a | 6~8 | 1000 | - | - | 20 | 350 | 17 |
| Clay Layer 1b | 4~24 | 2000 | 20 | - | 20 | 350 | 17 |
| Sand Layer 2 | 20~30 | - | 30 | 0 | 30 | 0 | 35 |
| Clay Layer 3 | 15~25 | 2000 | 20 | - | 20 | 350 | 17 |
| Sand Layer 4 | 25~50 | - | 30 | 0 | 30 | 0 | 35 |
| **Sources: STP UFSAR Rev. 13, Section 2.5.6.1.1 & Table 2.5.6-2&5** | | | | | | | |

SER: The staff and external reviewers concluded that scour hole is not likely because c-values of the clay are high (>1000 psf).

Notes: $\tau = c+\sigma \tan(\phi)$, where $\tau$=shear strength, $\sigma$ =stress, c=cohesion, $\phi$= friction angle; psf=pound per square feet

My Opinions:

- I disagree. The c-values reduced substantially after filling the MCR (changing the soil properties from compacted to saturated), but they failed to recognize this.
- I used the post-construction c-value (c=300 psf) that induces scouring of the foundation.

# Re-analysis: Comparison of MCR Breach Flood Estimations

| Run ID | Scour Hole (ft) | Breach Width (ft) | Model Used to Get Peak | Peak Flow (kcfs) | Peak Time (hr) | Flood Level (ft msl) |
|---|---|---|---|---|---|---|
| MLM-D10 | 10 | 1047 | FLDWAV | 309 | 1.9 | 44.6 |
| MLM-D20 | 20 | 745 | FLDWAV | 280 | 2.1 | 44.1 |
| MLM Qp &Tf | 0 | - | | 217 | 2.5 | 43.0 |
| Avg Qp, MLM Tf | 0 | - | | 251 | 2.5 | 43.6 |
| RUN1 | 0 | 934 | BREACH | 194 | 3.3 | 42.6 |
| RUN2 (base) | 10 | 633 | BREACH | 269 | 2.1 | 43.9 |
| RUN23 | 15 | 516 | BREACH | 271 | 1.8 | 44.0 |
| RUN24 | 20 | 433 | BREACH | 267 | 1.6 | 43.9 |
| STP Values | 0 | 417 | FLDWAV | 130 | 1.7 | 38.8 |

Conclusions: STP should use conservative breach equations. They should consider (1) reasonable n-value, (2) realistic tailwater section, and (3) scour hole.

Note: Qp: peak flow, Tf: breach time; Re-analysis used n of 0.075

# #2 Hurricane Storm Surge Flooding

Issue: Conservatism of storm parameters and accuracy of wind and surge models used in STP's storm surge analyses are of concern.

My Comments on the Revised SER:

- The objectives of storm surge analysis are (1) to determine the level and magnitude of flooding caused by storm surge and (2) to determine site inundation for emergency plans. However, the staff's review focused only on the first objective.
- STP's probable maximum hurricane scenarios are not conservative but their wind speeds are unrealistically high (184 mph vs. 134 mph by USACE; see backup slide p.39 & p.40).
- The staff concluded that the STP's estimate is reasonable and conservative. However, STP's surge estimate of 29.3 ft msl is much lower than two other estimates (39.8 ft msl by USACE's ADCIRC and 39.6 ft msl by PNNL's SLOSH).

Note: msl: mean sea level

# #3 Maximum Groundwater Level

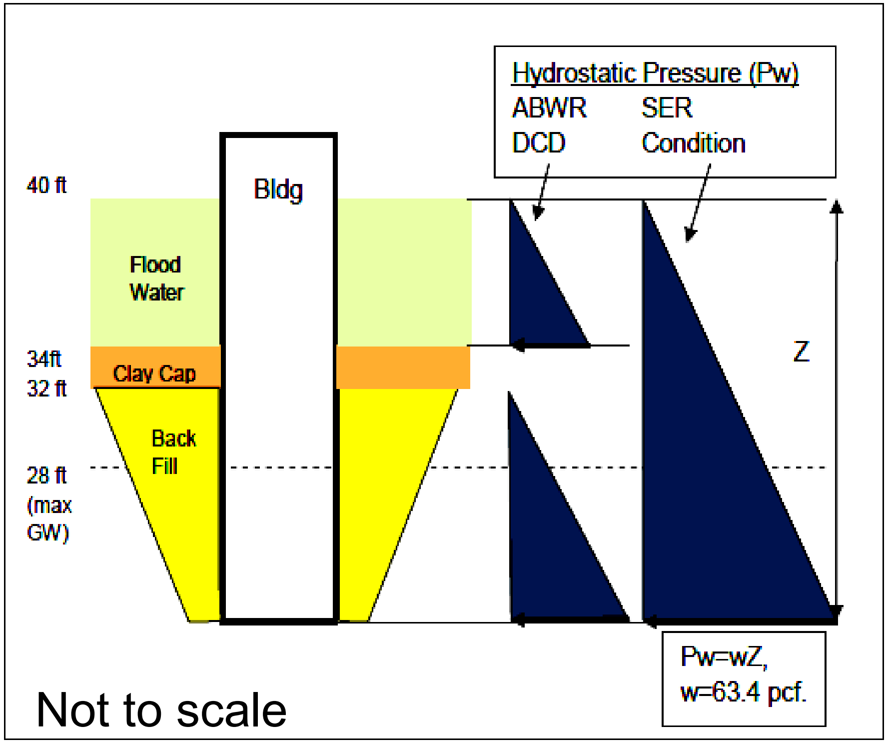
Issue: The departure of the maximum groundwater level (ABWR DCD Tier 1 Site Parameters) is not addressed in subsequent structural analyses.

Maximum Groundwater Level:

- DCD requirement: 32 ft msl
- STP estimate: 28 ft msl
- Staff estimate: 34 ft msl (It is only a 2 ft departure, however it increases static water pressure significantly.

10 CFR Part 52 App. A Requirements:

The DCD Tier 1 contains approved and certified parameters, so any departure from Tier 1 should be reported and addressed.




My Finding: The SER states that "all departure conditions have been requested." However I found that the departure is not addressed on:

- ✓ COLA Part 7, Departures
- ✓ FSAR Tier 1 Table 5.0 (Site Parameters)
- ✓ Flood protection and structural analyses (e.g., RAI 03.08.04-39)

# BACKUP SLIDES

BACKUP 1: MCR  Levee Breach Analysis

BACKUP 2: 1979 Martin Cooling Pond Breach

BACKUP 3: Hurricane Storm Surge

BACKUP 4: List of References

# BACKUP 1 Approaches for MCR Breach Flood Analysis

STP's Approach

- $[V_w, H_w] \rightarrow$ Empirical Equ's $\rightarrow$ [B, Tf] $\rightarrow$ FLDWAV $\rightarrow$ Q(t) $\rightarrow$ RMA2 $\rightarrow$ h(t)
- Use the BREACH model to validate empirical estimates of [B, Tf].

Staff/PNNL's Approach

- BREACH ----------------------------------------------$\rightarrow$ Q(t) $\rightarrow$ RMA2 $\rightarrow$ h(t)
- Use historical records to validate BREACH estimates of [B, Tf].

My Re-analysis Approach

- $[V_w, H_w] \rightarrow$ Empirical Equ's $\rightarrow$ [B, Tf] $\rightarrow$ FLDWAV $\rightarrow$ Q(t) $\rightarrow$ FLO-2D $\rightarrow$ h(t)
- BREACH----------------------------------------------$\rightarrow$ Q(t) $\rightarrow$ FLO-2D $\rightarrow$ h(t)

Notes

- $V_w$=volume, $H_w$=head, B & Tf=breach width and time, Q(t)= breach outflow at time t, h(t)=hydrograph.
- BREACH is 1-dimensional numerical breach and flow simulation model. FLDWAV is 1-D breach flow simulation model. Both RMA2 and FLO2D are 2-D flow model used to simulate MCR breach flooding.

# B1 Prediction Errors for Empirical Breach Equations

## Prediction Errors (Wahl, 2004)

- Assume that the errors (predicted minus observed) are a normal, independent, and identically distributed random variable.
- The mean prediction error on the best-fit regression equation is given by two standard division of prediciton errors (~ 97.5% exceedance probability).

## Froehlich Breach Width (B) Error

- Denoting V[x]=variance and Cov[xy] = covariance of rv's (x,y), the variance of breach widths is:

  $V[B_o]=V[B_p+\varepsilon_B]=V[B_p^2]+V[\varepsilon_B^2]+Cov[B_p{}^*\varepsilon_B]$

- From which, $S_\varepsilon(B)$ is estimated as:

  $S_\varepsilon(B)=(V[\varepsilon_B^2])^{1/2}$

  $=( V[B_o]- V[B_p^2]- Cov[B_p\varepsilon_B])^{1/2}$

## MLM Breach Volume (V=AB) Error

- The variance of the MLM breach volumes is expressed as:

  $V[V_o] = V[A_oB_o]$

  $=V[(A_p+\varepsilon_A)(B_p+\varepsilon_B)]$

  $=V[A_pB_p+A_p\varepsilon_B+\varepsilon_A B_p+\varepsilon_A\varepsilon_B]$

  $=V[\varepsilon_B^2](\sim)+V[\varepsilon_B](\sim)+Cov[\varepsilon_B.(\sim)](\sim) +...$

  (e.g., 12 terms on RHS).

- The term $S_\varepsilon(B)=[V(\varepsilon_B^2)]^{1/2}$ is obtained from the last expression implicitly. However, these error terms are not defined in Wahl (2004).

## Conclusions:

It is clear that the MLM breach volume error ($S_\varepsilon(V)$) is much larger than that of the Froehlich breach width ($S_\varepsilon(B)$) due to (1) errors in breach section area estimates and (2) the dependence between a variable and its error. However, Mr. Wahl and Dr. Baecher compared two entities erroneously.

# B1 BREACH Model

- BREACH was developed by Dr. Fread in NOAA in 1993 and updated in 2000. The model it is no longer supported by NOAA, but has been used widely in practice.
- BREACH simulates a coupling of breach erosion and flow processes in a 1-dimensional domain. Output of theBREACH include erosion rates (size and shape) and outflows in time.
- Because BREACH output are very sensitive to uncertain input parameters (e.g., n-value), the author of BREACH recommended using the model for an auxiliary purpose only.

**BREACH Input**

1.Reservoir: storage-head relation, initial pool level, bottom elevation, inflows, spills, etc.

2.Dam geometry: height, lengths, slope, core, bottom elev., spillway, etc.

3.Dam materials: grain size, porosity, weight, fraction angle, cohesive strength, n-value, etc.

4.Tailwater: cross section, slope, n-value, etc.

5.Model: time step, convergence criteria, etc.

# B1 Structure of the BREACH Model

- Breach flow: Piping orifice: $Q_o = 0.98(2g)^{0.5}Ab(H\text{-}H_p)^{0.5}$,or
  Submerged broad-crested weir: $Q_o = 3B_o(H\text{-}H_c)^{1.5}$

- Tailwater flow: get $Y_t$ from $Q_t=1.49S^{0.5}A^{1.67}/(nP^{0.67})$

- Submergence correction: $Q_b=S_bQ_o$, $S_b=1-[(Y_t-H_c)/(H-H_c)-0.67]^3$

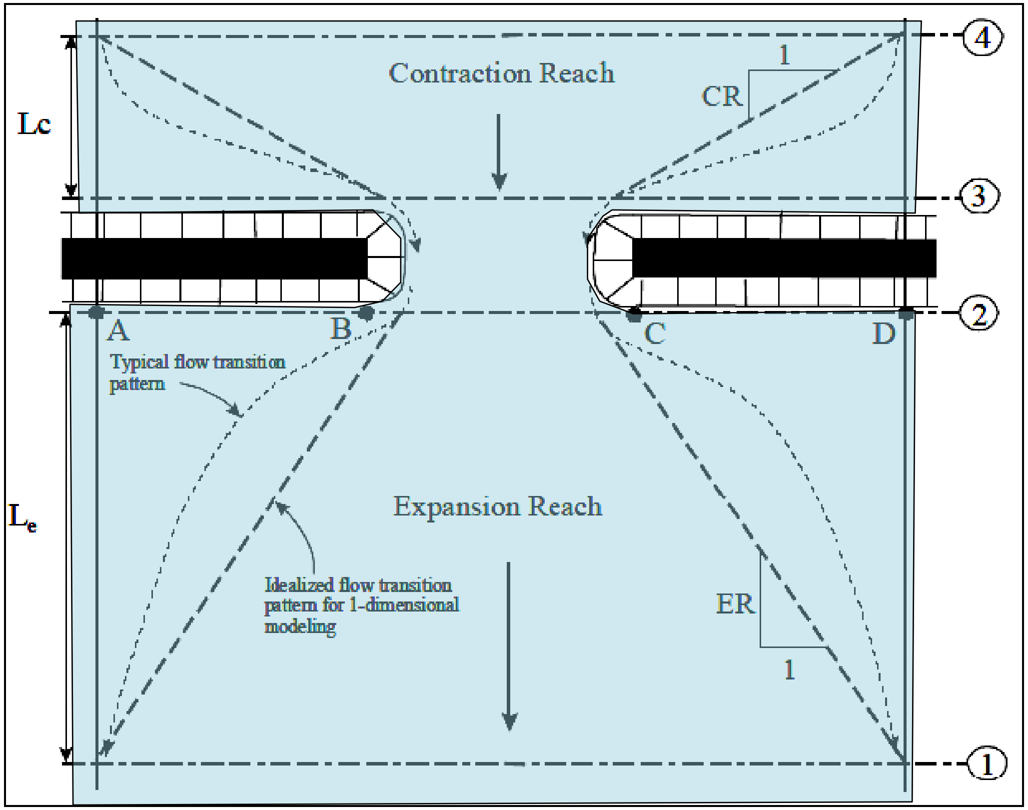
- Erosion by the modified Meyer-Peter & Muller equation:
  $Q_s = aP(SR-t_c)^{1.5}$ , $S=n^2Q_b^{\,2}/(2.21A^2R^{1.33})$

- Iterate the above calculations till $Q_o$ matches $Q_b$.

where Qb=breach outflow, A=breach area, $(H\text{-}H_p)$=piping head, $(H\text{-}H_c)$=weir head, S=slope, P=perimeter $Y_t$=tailwater depth, D=particle size, R=hydraulic radius, a=27.5 , and $\tau_c$=critical share stress.

# B1 Breach Tailwater Section and Energy Losses:

## For bridge encroachment (HEC,2010, HEC-RAS Manual)




Note: HEC-RAS is an 1-dimensional steady and unsteady hydraulic simulation model used to simulate rivers/channel flows with various hydraulic structures.

- The left figure depicts a bridge encroachment in a plain view (similar to levee breaches).
- Expansion Ratio (ER): 1.4-3.6 (for b/B=0.1, S=1 ft/mile) – That is, the MCR tailwater section in BREACH should be far enough from the levee to account for tailwater spreading.
- Head Loss Coefficient:

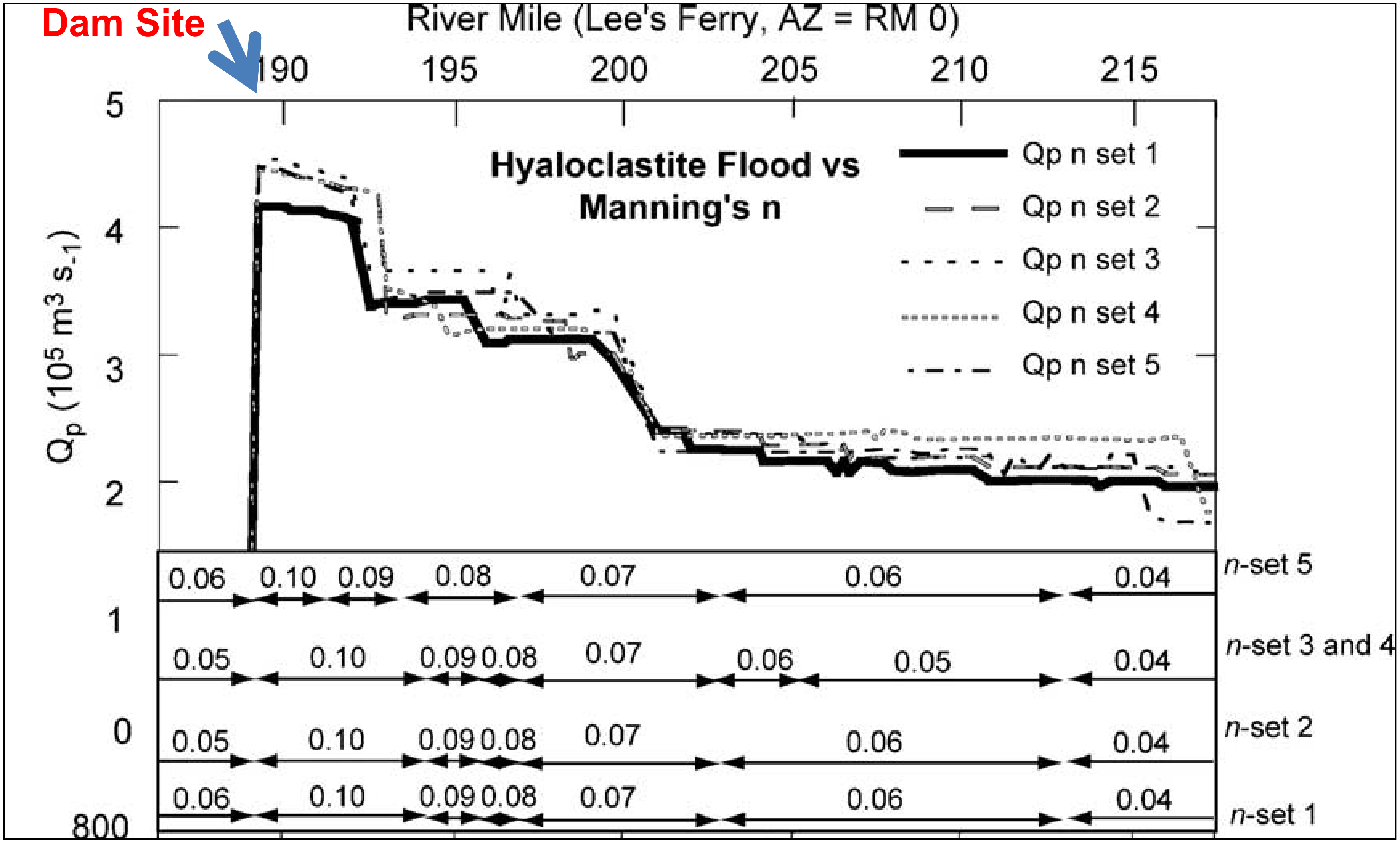
  $h_L = h_{enterance} + h_{friction} + h_{exit}$

  Coeff. for entering=0.3~0.6

  Coeff. for exiting =0.5~0.8
- Similarly, STP should use high n-value to account for the effects entering and exiting head losses.

# B1 Example of Setting Dam Breach n-values

(From Fenton et al., 2006)



# B1 Example Breach n-values (Trieste and Jarrett,1987)

| Study | Field n-value | Verified n-value |
|---|---|---|
| Jarrett and Coasta (1985) | 0.035 ~ 0.125 | 0.10 ~ 0.22 |
| Blanton (1977) | 0.03 ~ 0.047 | 0.07 ~ 0.15 |
| Fread (1977) | 0.04 | 0.07 |
| Leutheusser and Chisholm (1973) | 0.175 | 0.225 |
| Wilson (1973) | 0.02 ~ 0.03 | 0.05 ~ 0.07 |

Comments:

- In each case, author(s) obtained the verified n-values from a calibration of numerical hydrodynamic models with historical breach data.
- Trieste and Jarrett (1987) concluded that verified n-values would be about 210% greater than the respective field n-values.
- Dr. Fread, the author of BREACH, also used n=0.07 in a breach study.

# B1 MCR Breach n-values Estimated in the Re-analysis:

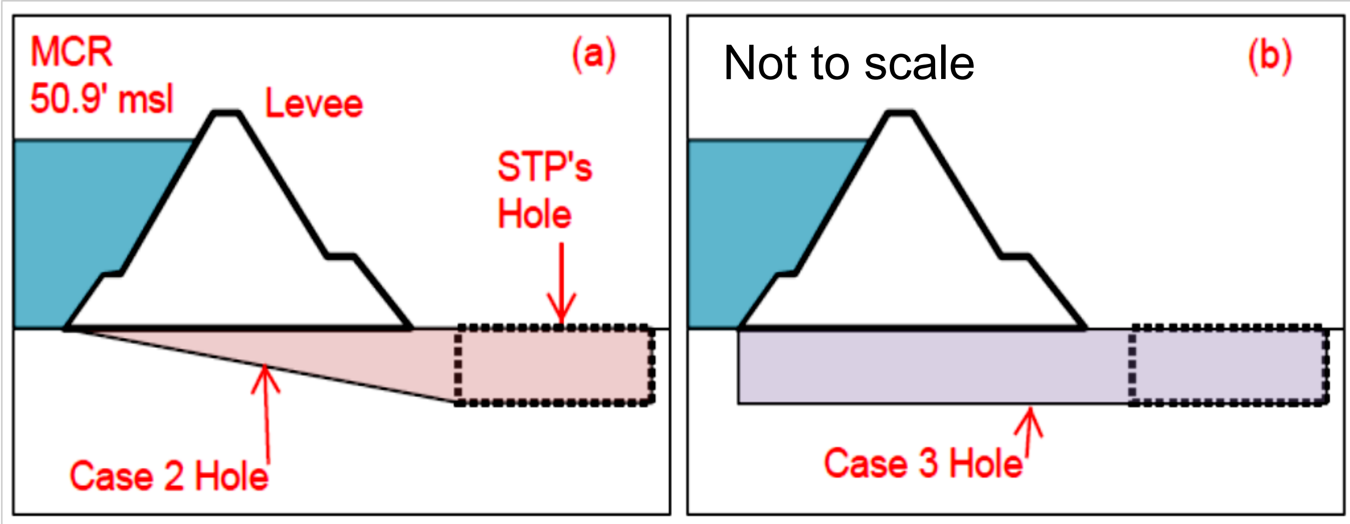
## Using the Chow Method (1959): $n=n_b+n_1+n_2+n_3+n_4$

| Factor | Breach n-Value | Conditions Used in Re-analysis |
|---|---|---|
| Base n-value ($n_b$) | 0.02 | Earth (sand) bed materials |
| Irregularly ($n_1$) | 0.015 | Moderate/severe channel (max. 0.02) |
| Cross-section ($n_2$) | 0.01~0.015 | Contraction & expansion |
| Obstruction ($n_3$) | 0.02~0.03 | 40% covered by broken cement blocks |
| Vegetation ($n_4$) | 0.005 | Small (max. 0.01, outer levee only) |
| Final n-value (sum) | 0.07~0.085 | Average of 0.775 |

Comments:

- SFWMD (1980) reports that large cement blocks (size of 6'x6'x6") were found on the bottom of the MCP breach – This is similar to a boulder channel, and thus for MCR breach.
- Substantial contraction and expansion of breach flow occur before and after water passing the breach zone, resulting in a significant head loss.
- The staff also got a tailwater n-value of 0.056 using the same Chow method.

# B1 Postulating Scour Hole in Re-analysis




- STP postulated a scour hole (W=380 ft, L=203 ft, D=20 ft) at the downstream toe of the embankment,  but not on the levee foundation – I disagree. Scouring of the foundation is highly likely.

- Re-analysis postulated and tested three scouring scenarios: hole depths of 0ft, 10 ft, and 20 ft below the levee. The corresponding peak breach outflows are 194 kcfs, 269 kcfs, and 267 kcfs, respectively.

# B1 My Comments on Mr. Wahl's Review on the BREACH

- Value of n=0.025 is conservative and reasonable; n=0.05 is extremely conservative; and n=0.075 or larger is not credible.
  Comment: This assertion is based on a faulty application of the Strickler's equation. Value of n=0.025 results in B=183 ft and Qp=30 kcfs, which are too small for MCR.

- The Strickler equation or other methods that estimate n-values should be used.
  Comment: The Strickler's equation was developed for a small immovable sand channel, thus it cannot be use for large bank materials. STP and the staff did not use this equation as BREACH uses the equation only for n<0.001. ( Ahn, 2012a,b,c)

- BREACH should use n-value related to embankment materials only.
  Comment: This statement is incorrect because bottom roughness for a composite materials is driven mainly by large size materials.

- Cement blocks would not have a bearing on n-value because breach outflow has enough dynamic energy to remove any cement block.
  Comment: This assertion is against the field observation at the Martin Cooling Pond breach where broken cement blocks littered on the breach bottom (SFWMD, 1980).

- Use of Chow (1959) method to incorporate effects of obstructions, vegetation, channel variability and other factor is inappropriate.
  Comment: This is not true as the Chow method is one of a few methods that can incorporate such effects, therefore the method is widely used in practice.

# B1 My Comments on Dr. Patev's Review of MCR Breach

Dr. Patev focused his review on the geotechnical aspects of MCR breach, then concluded that a wide breach with scour hole is highly unlikely. However many of his assertions are speculative or not factual as:

- Seepage failure is highly unlikely because of compacted silt-clay, seepage control system (e.g., relief wells, sand chimney, berms, etc.), and low permeability ($10^{-5}$ cm/sec). Foundation materials consist with two different clays. – Comment: He failed to recognize sand layers in foundation, through which seepage has been observed.

- The seepage control system has been working well. There is no evidence of continued seepage problem. There are no reports of significant water discharges or boils. – Comment: This is not factual. STP has been observed seepage.

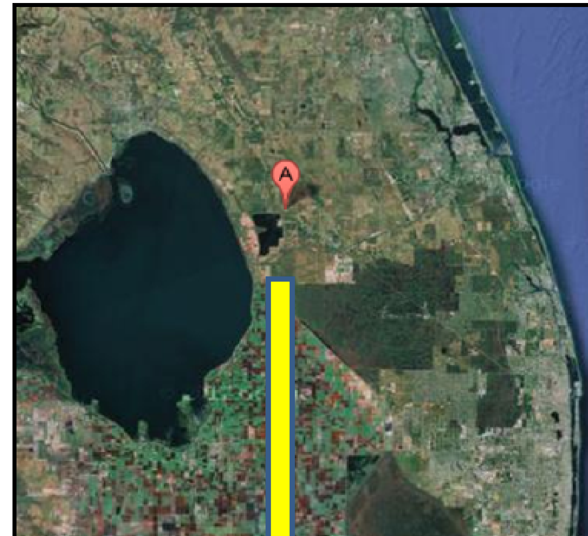
- Inclusion of a scour hole is not recommended due to the foundation soils that has a cohesive share strength of 2000 psf, it is "unlike to see erosion in the foundation" – Comment: He missed the fact that the strength of the clay in embankment and foundation has been decreased substantially after construction (from 2000 psf to <300 psf). He also failed to recognize piping potentials through sand layer or land subsidence. Piping through the MCR foundation will easily lead a deep scour hole.

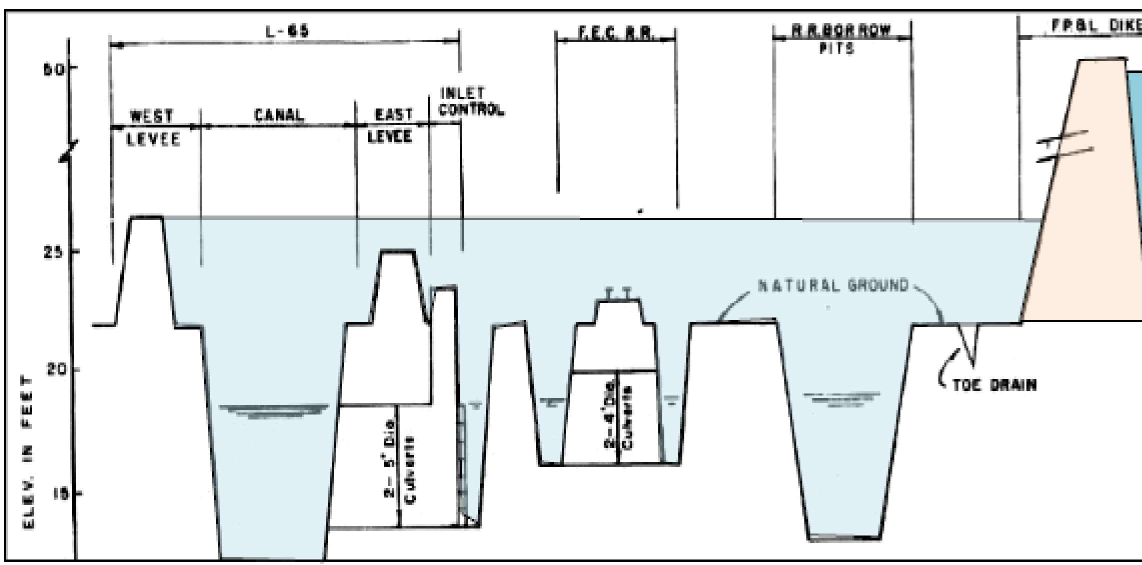
- "MCR is like a failed dam because it lose its containment very quickly." – Comment: This is not true. My BREACH runs shows that breach process lasts more than a day due to a large storage volume, incuring a large breach width.

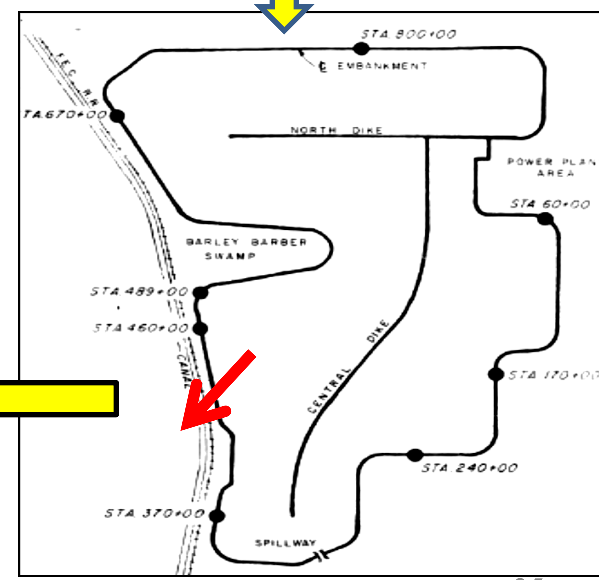
# B2 1979 Martin Cooling Pond Breach

<u>Breach Conditions:</u>

- Fine silt-sand in levee and foundation
- Initiated by a foundation piping failure
- Breach head is 17 ft, which is lower than that of MCR (about 22 ft).
- Actual breach head is about 12 ft due to the obstruction of tailwater flow by railroad and L-65 levee.





# B2 Comparison of MCR and MCP Embankments

| Area | Parameter | MCR | MCP |
|---|---|---|---|
| Geometry | Reservoir Area (ac) | 7000 | 6600 |
| | Breach Head (ft) | 21.9 | 16.74 |
| | Storage Volume ($ft^3$) | $6.6x10^9$ | $3.0x10^9$ |
| | BFF ($ft^4$) | $1.44x10^{11}$ | $0.5x10^{11}$ |
| Levee/ Foundation | Main Materials | silt-clay | silt-sand |
| | Cohesion ($lbs/ft^2$) | 200 | 0 |
| | Friction Angle ($^o$) | 15 | 38 |
| Seepage Control | Sand Core/Blanket | Yes | No |
| | Abutments | Yes | Yes |
| | Relief Wells | 774 | No |

Note: BFF=breach formation factor (head x storage volume).

# B2 Estimation of Breach Widths using Empirical Equations

| Empirical Equation | Breach Width (ft) | |
|---|---|---|
| | MCR | MCP |
| USBR | 66 | 44 |
| Von Thun and Gillette | 235 | 217 |
| Froehlich (upper bounding) | 417 (1001) | 306 (682) |
| MLM | 745 | 537 |
| Recorded | - | **610** |

Comments:

- The upper bounding of the Froehlich equation is based on the best-fit estimation plus an upper 2 standard deviation of prediction errors.
- The result indicates that the bounding Froehlich breach width or MLM breach volume equations are adequate for MCP, thus for MCR.

Note: **USBR**=U.S. Bureau of Reclamation; **MLM**=MacDonald and Langridge-Monopolis equation

# B2 Calibration of an Optimal MCP n-value by BREACH

| N-value | Qp(kcfs) | Tp (hr) | B(ft) |
|---|---|---|---|
| 0.025 | 21 | 18.8 | 179 |
| 0.03 | 29 | 14.9 | 225 |
| 0.04 | 44 | 10.6 | 338 |
| 0.05 | 62 | 8.0 | 468 |
| 0.06 | 82 | 6.4 | 617 |
| 0.07 | 105 | 5.3 | 780 |
| 0.075 | 117 | 4.7 | 851 |
| 0.08 | 127 | 4.0 | 884 |

Notes: Qp=peak outflow, Tp=peak time, B=average breach width.
**MCP**=Martin Cooling Pond in Florida
**USBR**=U.S. Bureau of Reclamation

Recorded MCP Breach Parameters:

- B=600 ft (610 ft by USBR)
- Qp=98 kcfs (110 kcfs by USBR)
- Tp=4 hours.

Comments:

- The calibration show that optimal MCP n-values range from 0.06 to 0.08 without scour hole, or from 0.08 to 0.12 with a scour hole.
- Therefore, n-value of 0.075 is reasonable, if not highly conservative, for both MCP and MCR.

# BACKUP 3 Comparison of Hurricane Scenarios

| Parameter | STP | NRC/PNNL | USACE |
|---|---|---|---|
| Storm Scenario | NWS 23 | NWS 23 | MPI |
| Center Pressure (mb) | 887 | 887 | 880 |
| Radius (nm) | 21 | 21 | 30~42 |
| Moving Speed (mph) | 23 | 22 | 6~13 |
| Wind & Pressure Profiles | NWS 48 | NWS 48 | TC96 |
| Max. Wind Speed (mph) | 184 | 150 | 134 |

Notes:

- **NWS**: National Weather Service of NOAA
- **MPI**: maximum possible intensity
- **TC96**: Thompson & Cardone paper in 1996
- mb=milibar; nm=nautical mile; mph=mile per hour
- Wind speed is a function of pressure gradient and radius.

# B3 Surge Estimates in SER

| Parameter | STP | Staff/PNNL | USACE |
|---|---|---|---|
| Wind Model<br>Surge Models | SWAN,<br>ADCIRC | <br>SLOSH | WAN, STWAVE,<br>ADCIRC |
| a. Initial Condition Total (ft)<br>-10% high tide (ft)<br>- Initial rise (ft)<br>- Sea level rise (ft)<br>- Model uncertainty (ft) | 4.9<br>3.5<br>-<br>1.4<br>- | 6.0<br>2.2<br>2.4<br>1.4<br>- | 9.7 (add after)<br>2.2<br>2.6<br>1.9<br>3.0 |
| b. Surge (ft msl) | 29.3 | 39.6 | 30.1 |
| PMSS (ft msl) (a+b) | 29.3 | 39.6 | 39.8 |

Comments:

Dr. Resio said that STP's storm radius is small (not-conservative) but the storm intensity after landing is high (conservative) so that the STP's surge estimate of 29 ft msl is acceptable. However, he failed to recognize that STP and staff/PNNL set an initial condition before surge modeling, while USACE added the initial condition after surge modeling.

Note: msl=mean sea level; PMSS=probable maximum storm surge; WAN is a off-shore wave model; STWAVE is a near-shore wave model; ADCIRD and SLOAH are a storm surge model.

# B3 Comments on Staff's Hurricane Surge Evaluation

The staff: Concluded that the STP's ADCIRC surge estimate which is much lower than the USACE's estimate is acceptable because STP uses a finer model grid size and the topographic features of the Matagorda levee and dredge pile.

My Opinions: I disagree with the above conclusion because:

- The STP's hurricane intensity is lower than the maximum potential intensity (MPI) of hurricanes, but their maximum wind speed is unrealistically high.
- The STP's ADCIRC was not validated as two external reviewers pointed out.
- Conservative surge scenario is to run the surge model without two topographic features that could be washed out by hurricane surges.
- The exceedance probabilities of storms ($10^{-7}$~$10^{-12}$) in SER Table 2.4S.5-4 are too low compared to others ($10^{-4}$~$10^{-5}$).
- STP did not account for the uncertainty in data and models.

# BACKUP 4 List of References


*Ahn, H, 2012a, Reasons for Non-Concurring the Management Decision on the Hydrology Issues for the STP COLA, NRC, (ML12312A102).

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*Trieste D.J., and R.D. Jarrett, 1987, Roughness Coefficients of Large Floods, Specialty Conference on "Irrigation Systems for the 21st Century", Proc., p. 32-40, Portland, OR.(ML12311A127).

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Note: (*) indicates ADAMS's internal documents.

# Presentation to the ACRS Subcommittee

**South Texas Project Units 3 and 4**
**COL Application Review**

**NCP STP**
**Chapter 2.4 Hydrology**

**Presenters:**
**Dr. Henry Jones, NRC**
**Dr. Rajiv Prasad, PNNL**

**April 24, 2013**

# Non-Concurrence Process (NCP) Issues

The NCP raised three issues:

1. **The Staff's MCR breach flood analysis is not conservative** (SER Section 2.4.4)
    a. The Froehlich equation is not applicable to the MCR
    b. The Staff's NWS BREACH modeling incorrectly specified a tailwater cross-section
    c. Manning's n values could be greater than 0.075
    d. The Staff's comparison of MCR breach to that of Martin Cooling Pond is inappropriate
    e. The Staff's use of NWS BREACH model is inappropriate
    f. The Staff did not consider scouring of the MCR embankment foundation

2. **Hurricane storm surge and MCR embankment breach** (SER Section 2.4.5)
    a. NWS 23 PMH scenarios are not conservative
    b. The Staff should review the applicant's ADCIRC model

3. **The SER inappropriately identified the maximum groundwater level** (SER Section 2.4.12)
    a. Erosion of the clay cap and stone layer could result in saturation of the soil profile
    b. Therefore, a departure from DCD occurs

# Independent Review of NCP Issues

1. **Independent reviewers for dam breach related issues** (SER Section 2.4.4)
    1. Tony L. Wahl, PE, Hydraulic Engineer, Hydraulic Investigations and Laboratory Services Group, Bureau of Reclamation
    2. Gregory B. Baecher, PhD, Professor, Civil and Environmental Engineering, University of Maryland
    3. Robert C. Patev, Senior Risk Advisor, Risk Management Center, USACE

2. **Independent reviewers for PMH surge issues** (SER Section 2.4.5)
    1. Jennifer L. Irish, PhD, PE, D.CE, Associate Professor, Virginia Polytechnic Institute and State University
    2. Rick Luettich, PhD, Director of Institute of Marine Science, University of North Carolina at Chapel Hill
    3. Donald P. Resio, PhD, Director Taylor Engineering Research Institute, College of Computing, Engineering and Construction, University of North Florida (previously of USACE Engineer Research Development Center Coastal and Hydraulics Laboratory)

3. **No external review for groundwater level issues; NRC Staff determination** (SER Section 2.4.12)

# Resolution of NCP Issues

1. **The Staff's MCR breach flood analysis is not conservative** (SER Section 2.4.4)

    a. The independent review states that Froehlich equation is applicable to breach widths exceeding 164 ft; and concludes that Froehlich equation has less uncertainty than other approaches and maintains an appropriate amount of conservatism

    b. The independent review states that the Staff's independent NWS-BREACH analysis specified a realistic tailwater cross section and while additional sensitivity runs at Manning's n value of 0.075 would have been useful, the Staff's conclusions would remain unaltered

    c. The independent review finds Manning's n value of 0.05 is extremely conservative; 0.075 is not credible

    d. The independent review states that the staff's comparison of MCR breach to Martin Cooling Pond failure is appropriate; and states that piping failure of MCR embankment would not result in a wide breach as in riverine levees; and states that piping is most likely failure mode

# Resolution of NCP Issues

1. **The Staff's MCR breach flood analysis is not conservative** (SER Section 2.4.4) (continued)

    e. The independent review found the Staff's use of NWS-BREACH acceptable

    f. The independent review states that effects of a scouring hole formed directly under the MCR embankment are unproven; and states that geotechnical conditions at the site mitigate against scour; and states that the clays in the MCR embankment are moderately to very stiff, making erosion of the foundation highly unlikely; and recommends that a scour hole in the breach analysis be not included

**As discussed, the Staff has resolved NCP Issue #1**

# Resolution of NCP Issues

2. **Hurricane storm surge and MCR embankment breach** (SER Section 2.4.5)

   a. The applicant's ADCIRC PMSS is below site grade (10.4 m [34 ft]) and is equal to the main cooling reservoir north embankment grade level (8.8 m [29 ft]), thus the main cooling reservoir embankment is safe against erosion
   b. The independent review states that PMH from NWS 23 is smaller in size compared to a few storms that have occurred in the Gulf of Mexico during the past few decades
   c. The independent review performed an estimate of expected changes to applicant-estimated PMSS water surface elevation if a storm larger than the PMH but with decaying intensity during landward approach were used based on a suite of ADCIRC runs that used rare and large hurricanes near Matagorda Bay
   d. The independent review estimated that the relative magnitudes of changes to maximum surge water surface elevation—an increase because of larger size and a decrease because of decaying intensity—would approximately cancel each other

# Resolution of NCP Issues

2. **Hurricane storm surge and MCR embankment breach** (SER Section 2.4.5) (cont'd)

   e. The independent review concluded for the STP site that using larger, strong, but decaying storms would not change staff's conclusions in the SER The independent review agreed that ADCIRC model is appropriate

   f. The independent review agreed that the staff's review of ADCIRC model and applicant's simulations is reasonable and acceptable

   g. The independent review suggested that a recalibrated ADCIRC addressing rare and large hurricanes near Matagorda Bay by Resio should be used

   h. The independent review suggested that staff should perform ADCIRC runs to estimate surge from extremely large but moderately strong hurricanes

# Resolution of NCP Issues

**2. Hurricane storm surge and MCR embankment breach (SER Section 2.4.5) (cont'd)**

i. No wave/significant current action on north face of MCR – Winds from the north would oppose surge or current development.

j. The staff calculated maximum current velocities of 1.2 m/s (4 ft/s) to 1.6 m/s (5 ft/s) for the NRC SLOSH and USACE ADCIRC storm surges. Flow duration is 80 minutes.

k. For this duration, Hewlett et al.(1987) state that depending on the quality of the grass cover, grass-lined channels can sustain velocities of 2.7 to 4.3 m/s (9 to 14 ft/s).

l. The predicted velocities fall below 2.7 to 4.3 m/s (9 to 14 ft/s). This suggests that the grass cover would be able to withstand this level of a hydraulic attack.

# Resolution of NCP Issues

2. **Hurricane storm surge and MCR embankment breach** (SER Section 2.4.5) (cont'd)

   m. These ADCIRC runs were completed by the USACE under NRC contract in 2011 and modified to reflect site specific characteristics. PMSS below MCR breach flooding level using storms with exceedance probabilities of $10^{-8}$ to $10^{-13}$.
   n. Even if the grass cover were damaged within this time frame, the clay content of the underlying zone B materials (clay with a liquid limit ≥ 30) suggests that these materials would have at least a moderate resistance to erosion.
   o. The maximum mean current velocities that are considered to be safe against erosion are 1.2 to 1.5 m/s (4 to 5 ft/s) for stiff clay soil and ordinary gravel[2].which falls within the staff's current velocity calculations.

**As discussed, the Staff has resolved NCP Issue #2**

[2]Fortier and Scobey, 1926; Connecticut Council for Soil and Water Conservation, 1985

# Resolution of NCP Issues

3. **The SER process for identifying maximum groundwater level is inappropriate (SER Section 2.4.12)**

   a. For the ABWR maximum groundwater level, the DCD Tier 1 limit is two feet below plant grade. The non-concurrence states that the FSAR site characteristic is 28 ft msl for groundwater. This is correct. A surface water departure was implemented for the two proposed units in accordance to the DCD limit. A surface water departure us required for the ABWR if a DBF is shown to exist at a level equal to or higher than 1 foot below plant grade.

   b. For the proposed STP units, the surface water departure equated to 33 ft msl. The NRO Division of Engineering evaluated saturated conditions from 28 ft to 33 ft msl. They also evaluated the design basis flood impacts from 34 ft to 40 ft msl – no safety deficiencies were noted.

   c. In summary, the non-concurrence incorrectly puts the DCD term “maximum groundwater level” in the wrong context by failing recognize that his requirement is valid only during a non-design basis flood event. Regarding this third topic, no further actions are recommended.

# Resolution of NCP Issues

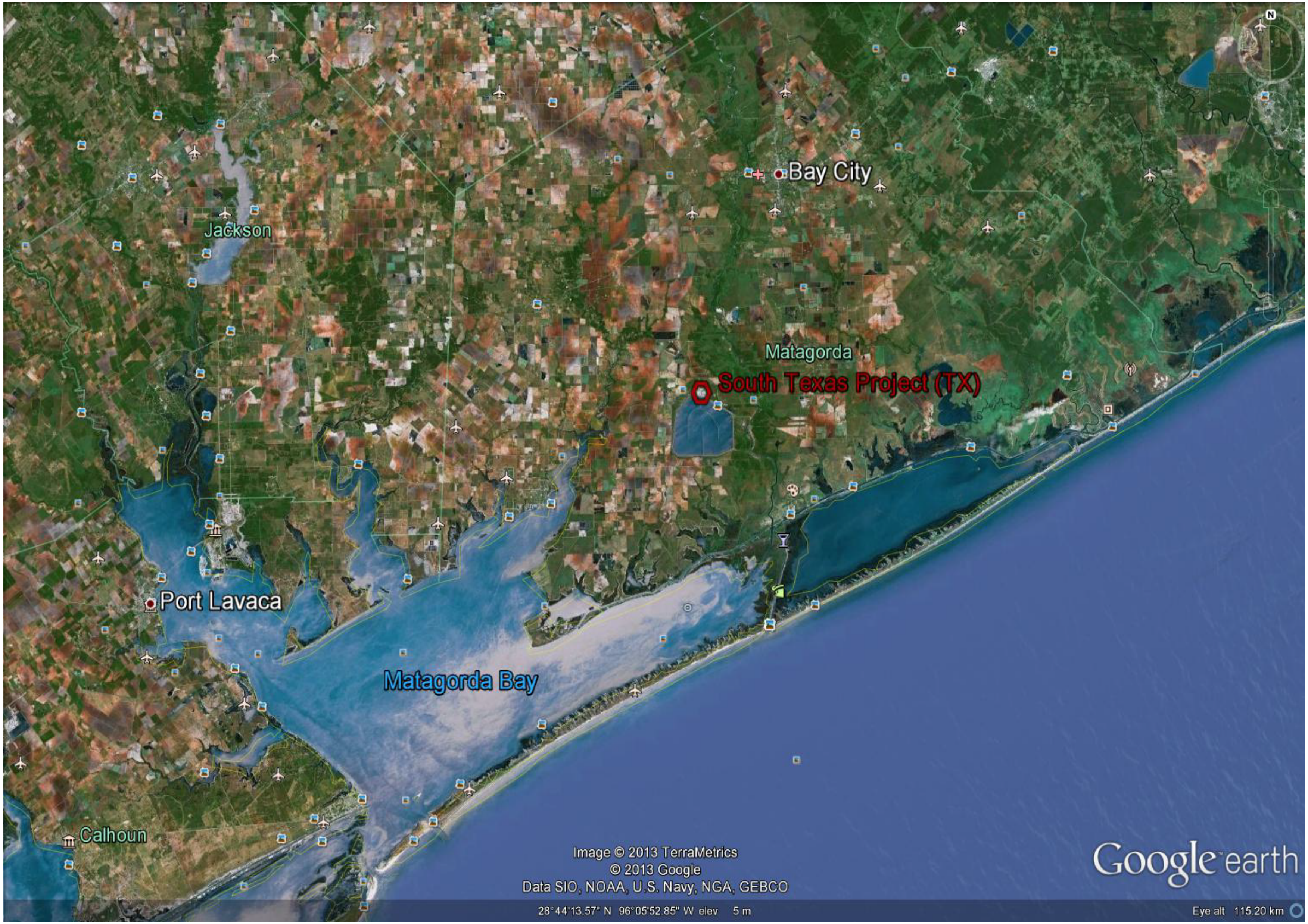
1. **The Staff's MCR breach flood analysis is not conservative** (SER Section 2.4.4)
   a. As discussed above, the technical issues were resolved
   b. Changes to the SER Section 2.4.4 were made
      i. The Staff added text to explain the Staff's review of the applicant's use of empirical methods
      ii. The Staff added text to explain the tailwater sensitivity analysis
   c. The Staff's conclusions in SER Section 2.4.4 did not change
2. **Hurricane storm surge and MCR embankment breach** (SER Section 2.4.5)
   a. As discussed above, the technical issues were resolved
   b. Changes to the SER Section 2.4.5 were made
      i. The Staff added text to explain that the PMH is appropriately conservative
      ii. The Staff added a sensitivity analysis that used storms less intense but larger than the PMH
   c. The Staff's conclusions in SER Section 2.4.5 did not change
3. **The SER inappropriately identified the maximum groundwater level** (SER Section 2.4.12)
   a. DSEA management concludes that all necessary departures have been requested
   b. No changes to the SER; No change to Staff's conclusions in SER Section 2.4.12

**ACRS Subcommittee Presentation**
**SER with no OIs Chapter 2**

# *Discussion/Committee Questions*

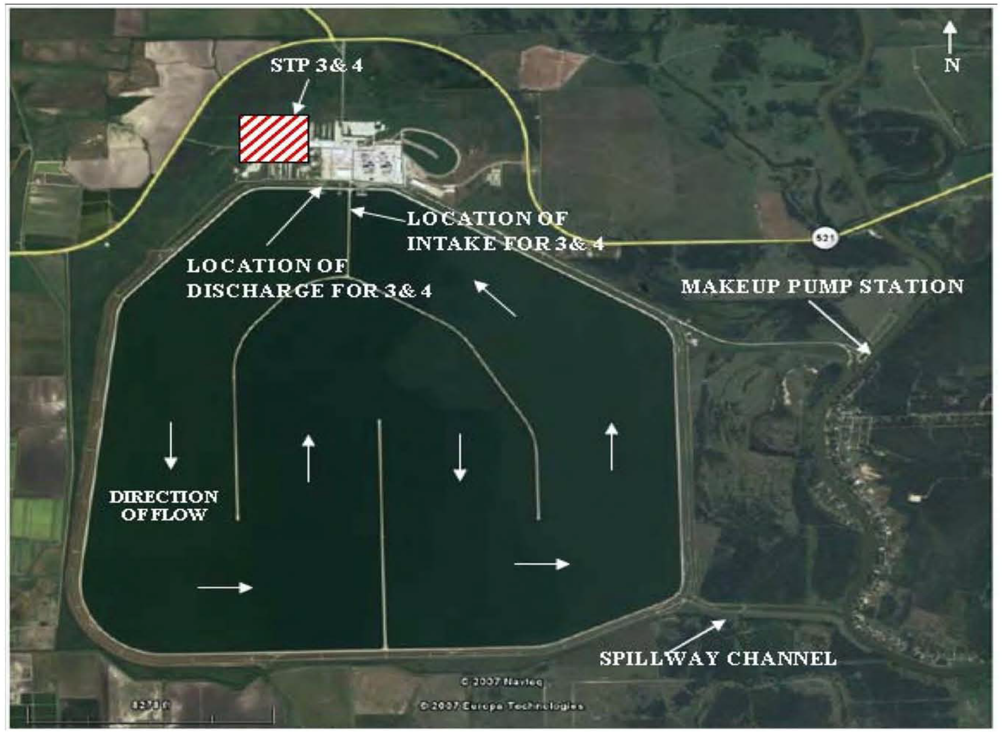
## ACRS Subcommittee Presentation
## SER with no OIs Chapter 2

*Back up Slides*


Bay City
Jackson
Matagorda
South Texas Project (TX)
Port Lavaca
Matagorda Bay
Calhoun
Image © 2013 TerraMetrics
© 2013 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
28°44'13.57" N 96°05'52.85" W elev 5 m
Google earth
Eye alt 115.20 km

# Chapter 2 – Site Description (Continued)

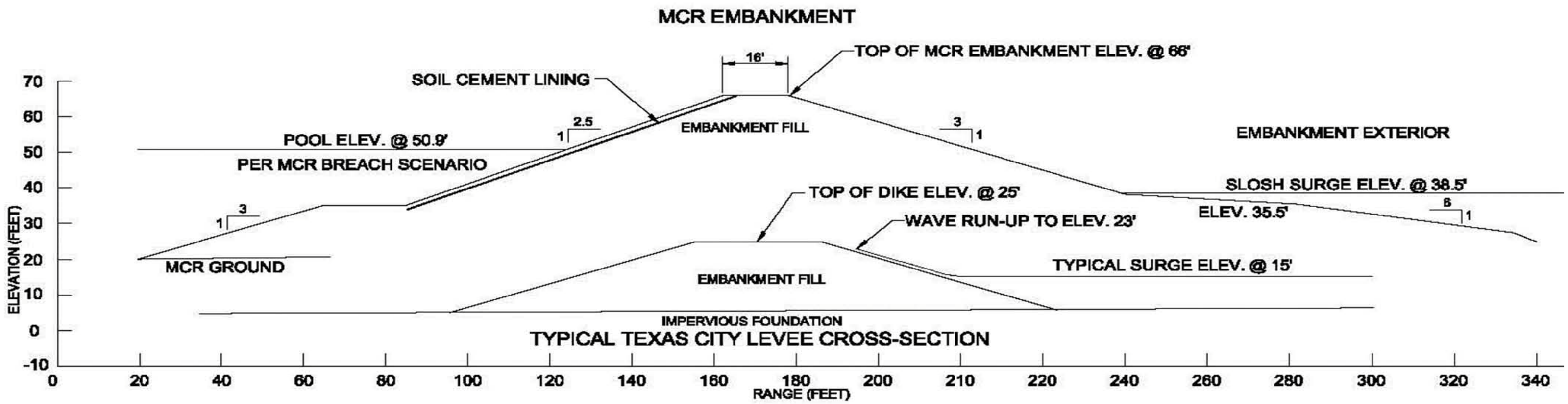
Site layout showing Main Cooling Reservoir (MCR) and locations of STP Units 1 & 2 and STP Units 3 & 4:



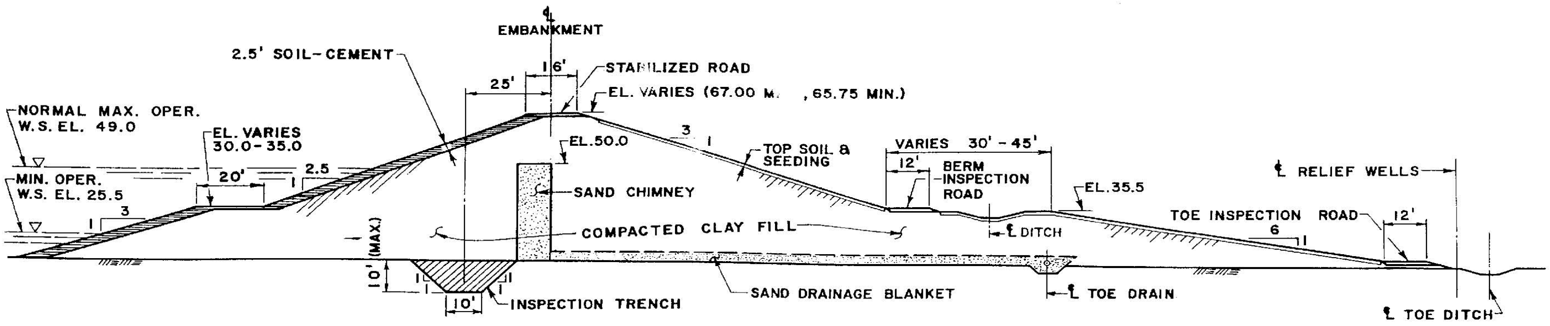

South Texas Project (TX)
© 2013 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 INEGI
Google earth
Imagery Date: 1/26/2011
1979
28°46'51.07" N 96°02'51.38" W elev 12 m
Eye alt 2.02 km

# Probable Maximum Storm Surge (Continued)

- PMSS potential threat to MCR Embankment (RAI 02.04.05-10)
  - SLOSH models do exceed 34 ft. In "worst case" the flood level is ≥ 34 ft for < 80 minutes. No wind waves and only moderate current.
  - There is no threat to MCR Embankment.



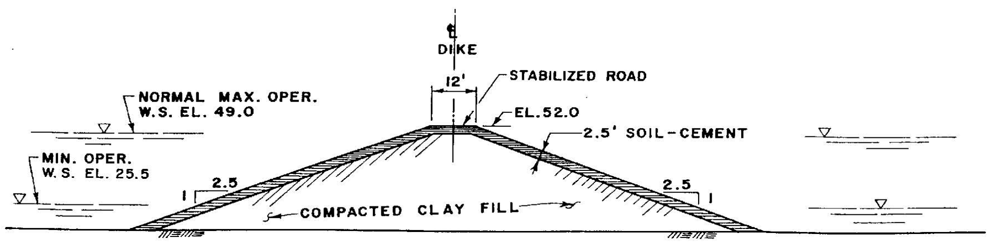

MCR Embankment Cross Section with superimposed cross section of Texas City Hurricane Storm Levee




TYPICAL SECTION THROUGH EMBANKMENT

SCALE: 1" = 30'

NOTE: SECTION SHOWN REPRESENTS TYPICAL SECTION. SAND DRAINAGE BLANKET AND TOE DRAIN APPLIES TO APPROXIMATELY 6 % OF EMBANKMENT PERIMETER. FOR MORE DETAILS OF VARIATIONS IN THIS CROSSECTION SEE F.S.A.R. SECTION 2.5.6.



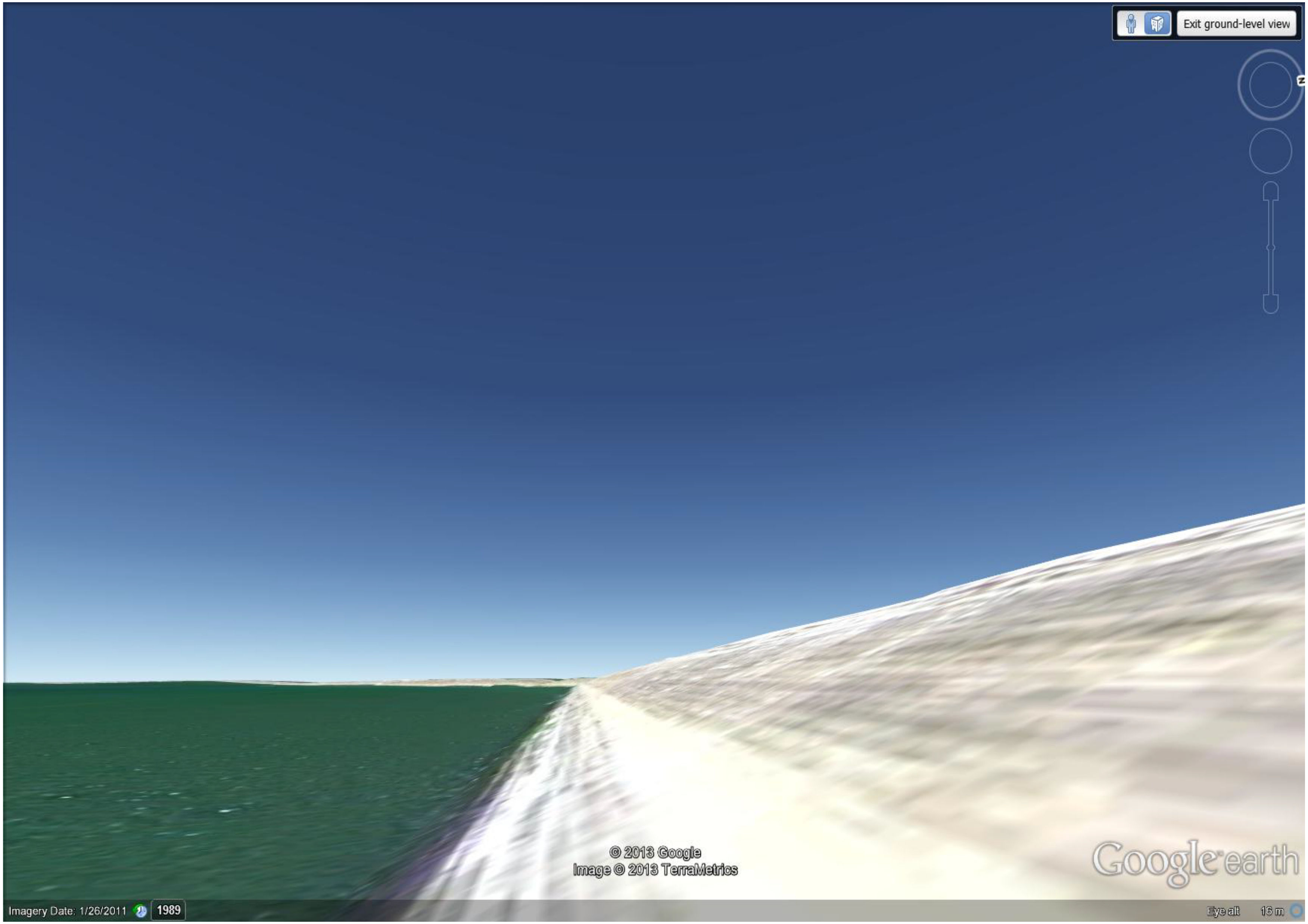

TYPICAL SECTION THROUGH DIKE

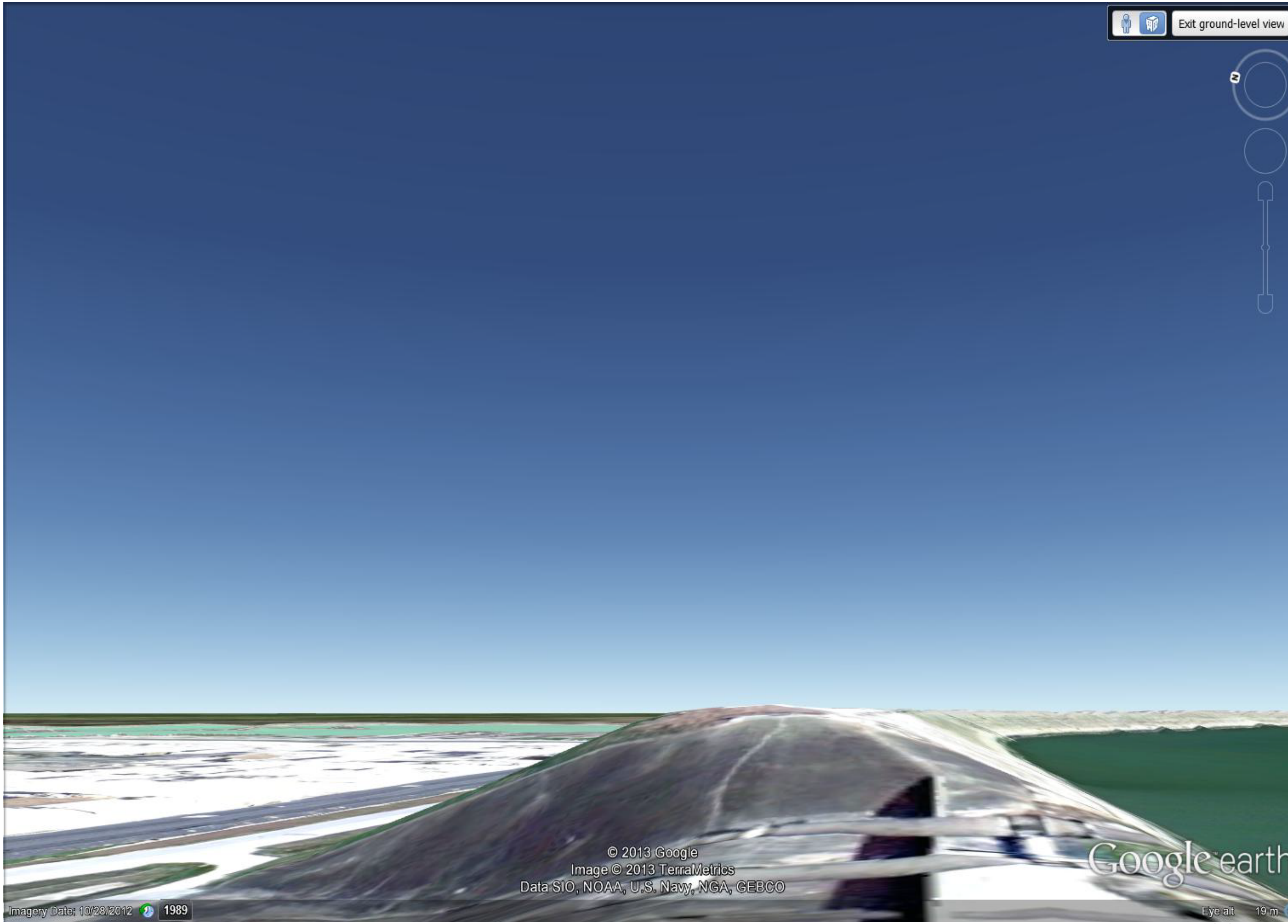
SCALE: 1" = 30'

SOUTH TEXAS PROJECT
UNITS 1 & 2

COOLING RESERVOIR EMBANKMENT AND INTERIOR DIKES TYPICAL SECTIONS

Figure 2.4.8-3 Revision 0


Exit ground-level view
© 2013 Google
Image © 2013 TerraMetrics
Google earth
Imagery Date: 1/26/2011
1989
Eye alt
16 m


Exit ground-level view
© 2013 Google
Image © 2013 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
Imagery Date: 10/28/2012
1989
Eye alt 19 m


Exit ground-level view
N
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 INEGI
© 2013 Google
Google earth
Imagery Date: 1/26/2011
2005
Eye alt
10 m

# Model Comparison – Differences

- **Grid Resolution**
- **Terrain Features (City of Matagorda Levee)**
- **Wind Model**
- **Friction Coefficients**
  - Bottom
  - Surface
- **Pressure Differential**
  - SLOSH: 133 Mb
  - ADCIRC: 123 Mb to 126 Mb

Page 75, Paragraph 4
Page 83, Paragraph 2
Page 86, Paragraphs 2 & 3
Page 88
Pages 96-97 (Conclusion)

# Features

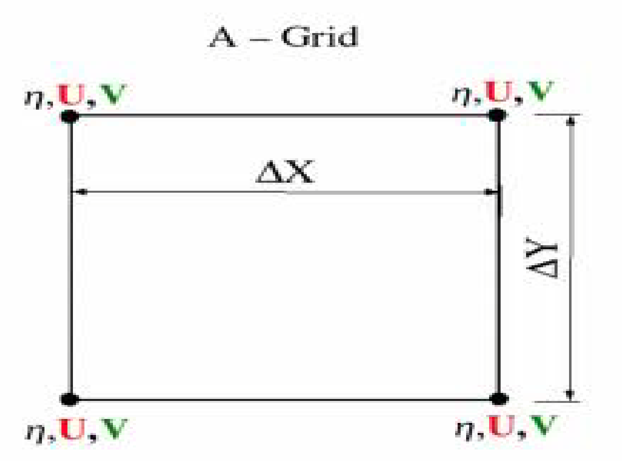
## SLOSH

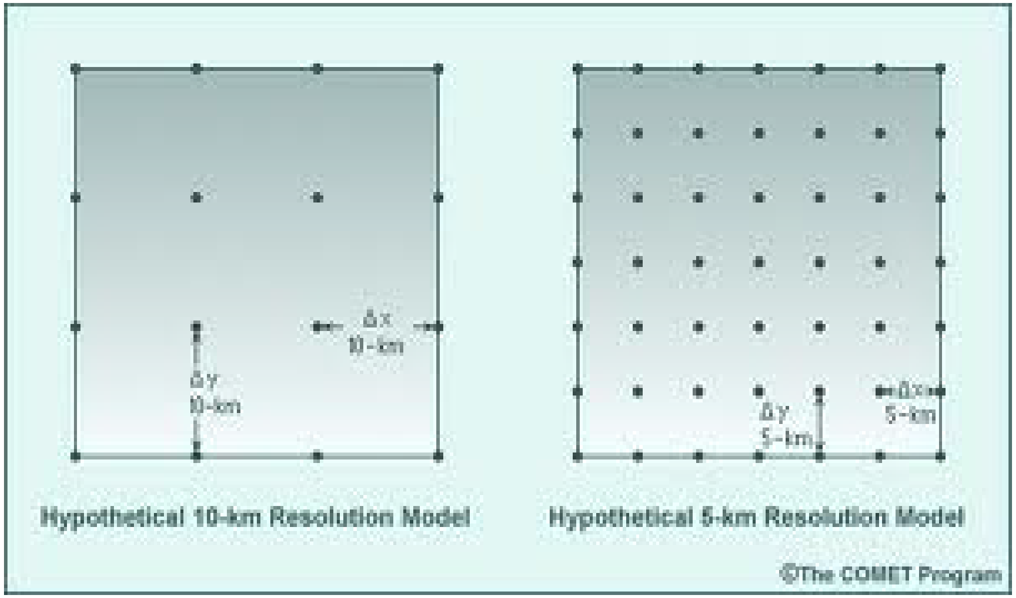
- Incorporating
  - SLOSH surface wind fields as wind stress
  - Overtopping of barrier systems, levees, and roads
  - Inland inundation using wet and dry
  - Sub-grid size events, flow through barrier gaps, adverse river flow, and deep passes between bodies of water via simple (1-d) hydraulic procedures
- Not incorporating
  - Upstream river flow and rain
  - Wind-generated waves
  - Astronomical tides

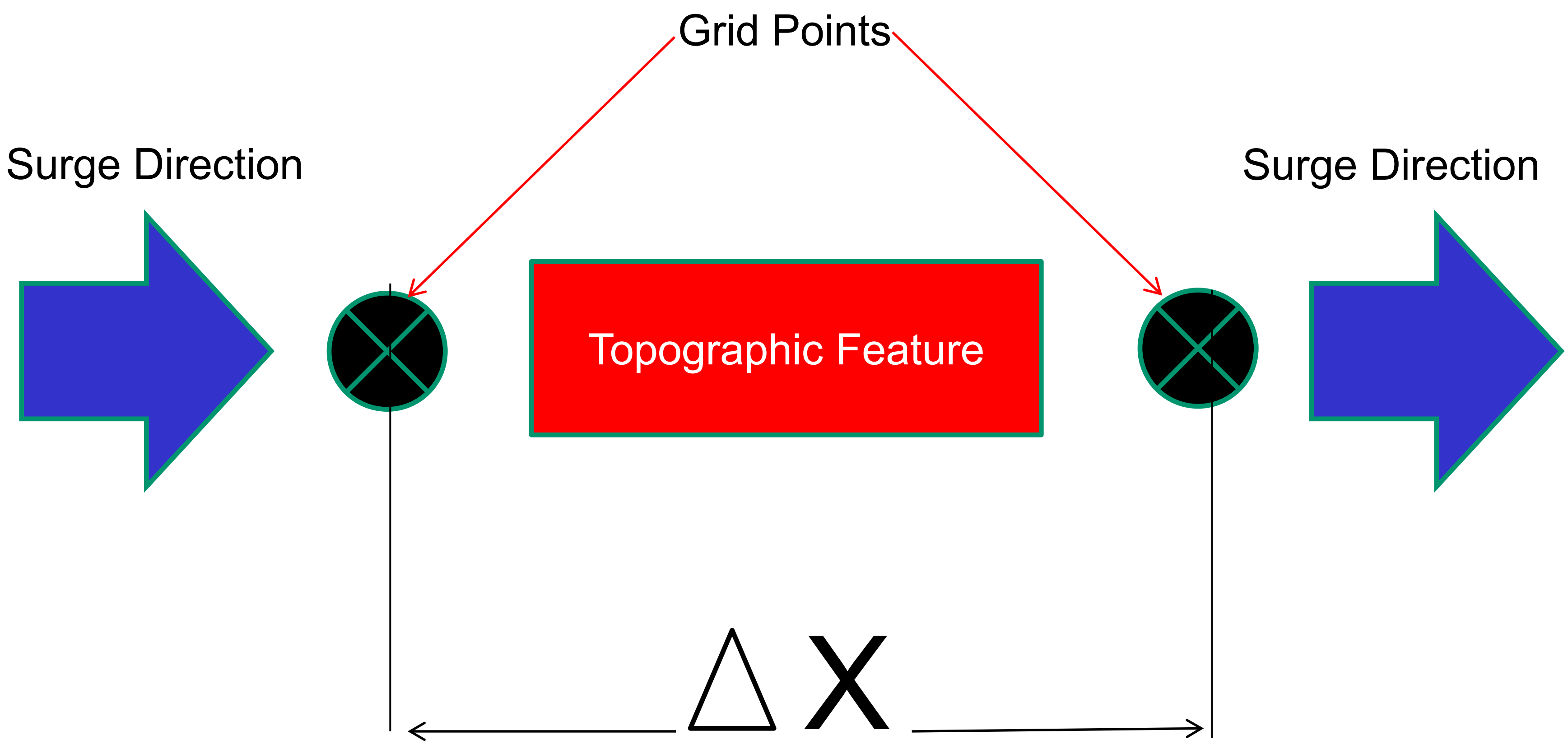
## ADCIRC

- Incorporating
  - Overtopping of barrier systems, levees, and roads
  - Upstream river flow and Inland inundation using wet and dry
  - Astronomical tides
- Incorporating as options
  - Meteorological forcings (i.e., surface winds and pressures)
  - Wind-generated waves as the gradient of wave radiation stresses
  - Spatially variable bottom frictions
  - Surface wind roughness and canopy

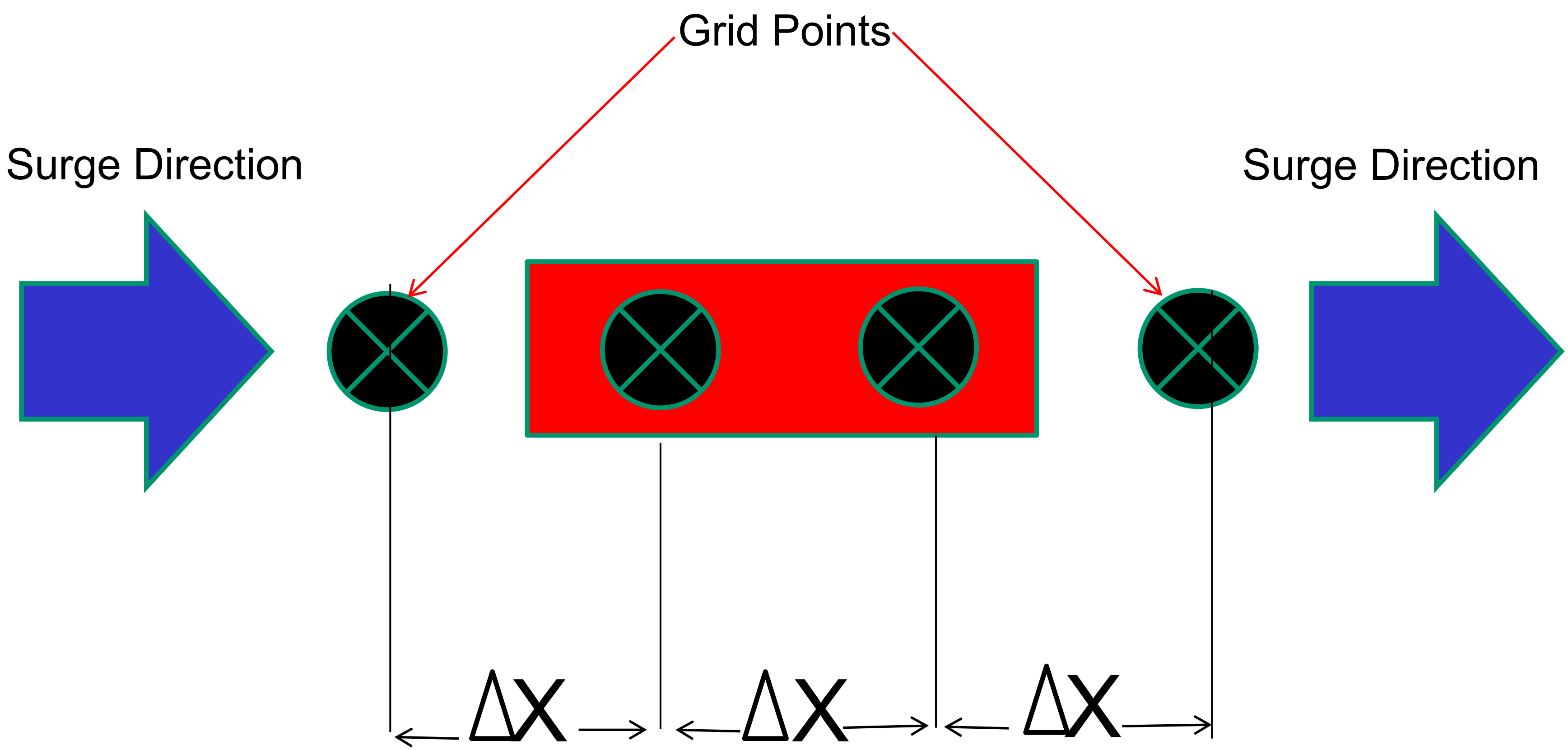
# Numerical Model Grids





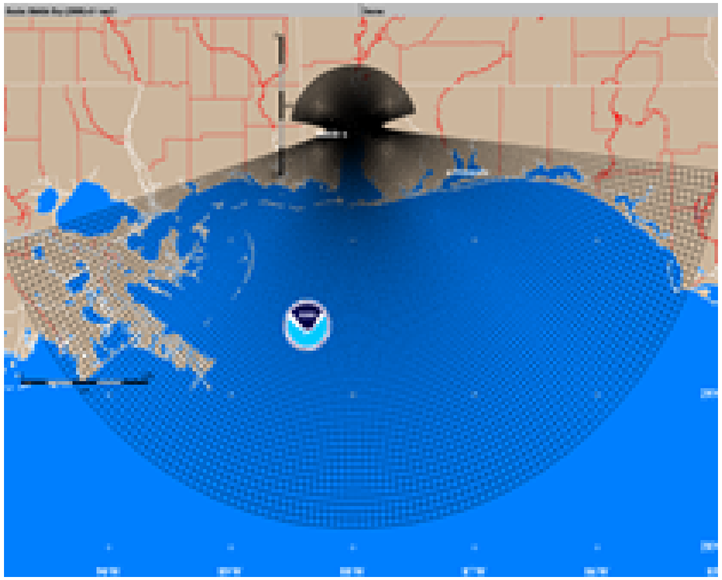

Model will not "see" the feature (e.g. Levee) due to low spacial resolution (e.g., SLOSH)




Model will "see" the feature (e.g., Levee)
due to high spacial resolution (e.g., ADCIRC)

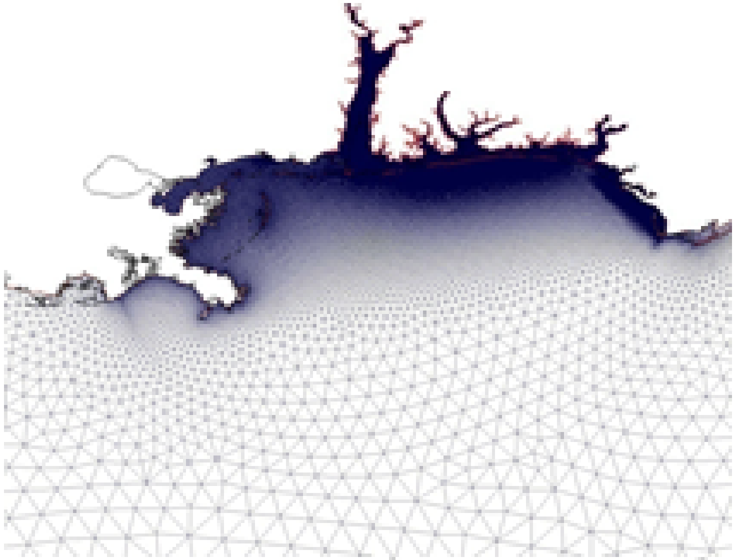
# Example Grid

## SLOSH (emo2)



- App. 100 basin grids along the east coast of United States
- emo2: Mobile Bay (2008) v3
- App. 31,000 points

## ADCIRC

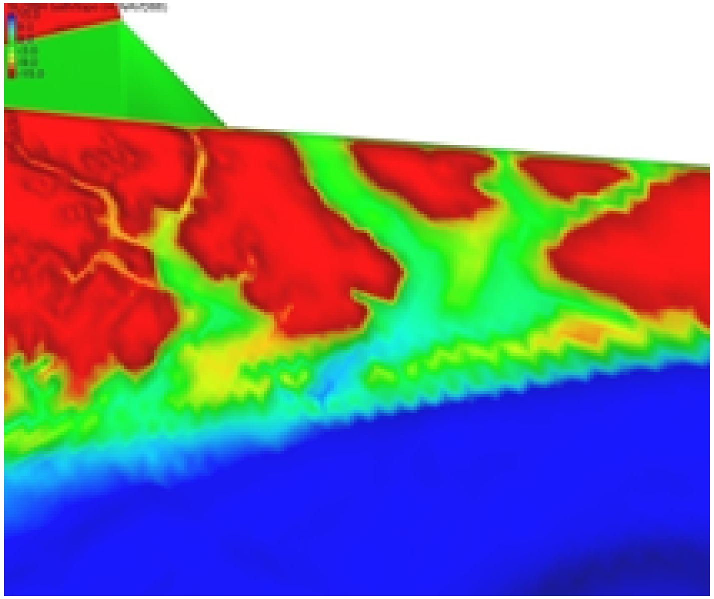


- Based on EC95 mesh (nodes: app. 31,000 )
- Unstructured grids (Mobile Bay to St Andrew Bay)
- App. 450,000 nodes

Example

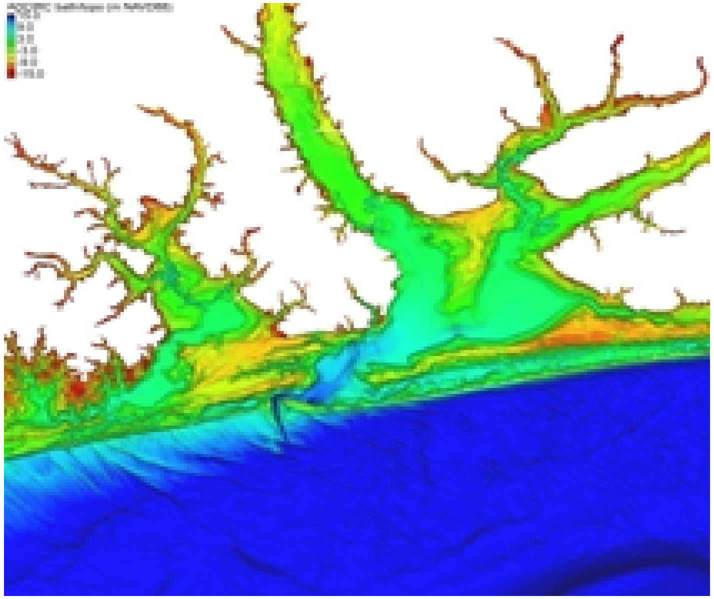
# Bathymetry/Topography

**SLOSH (emo2)**



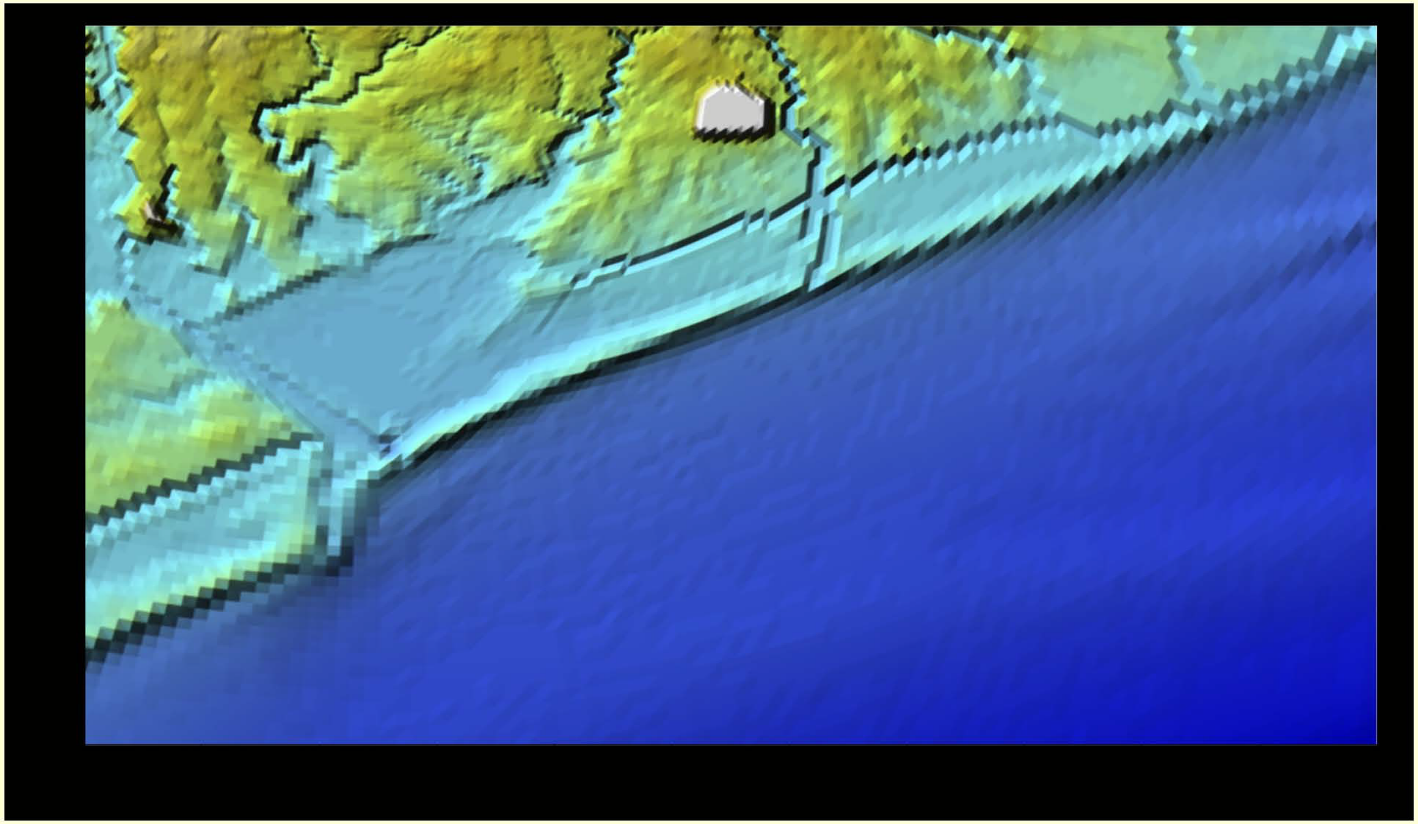
- Datum: NAVD 88
- Bathymetry: GEODAS (GEOphysical Data System)
- Topography: USGS (U.S. Geological Survey) topographic maps

**ADCIRC**

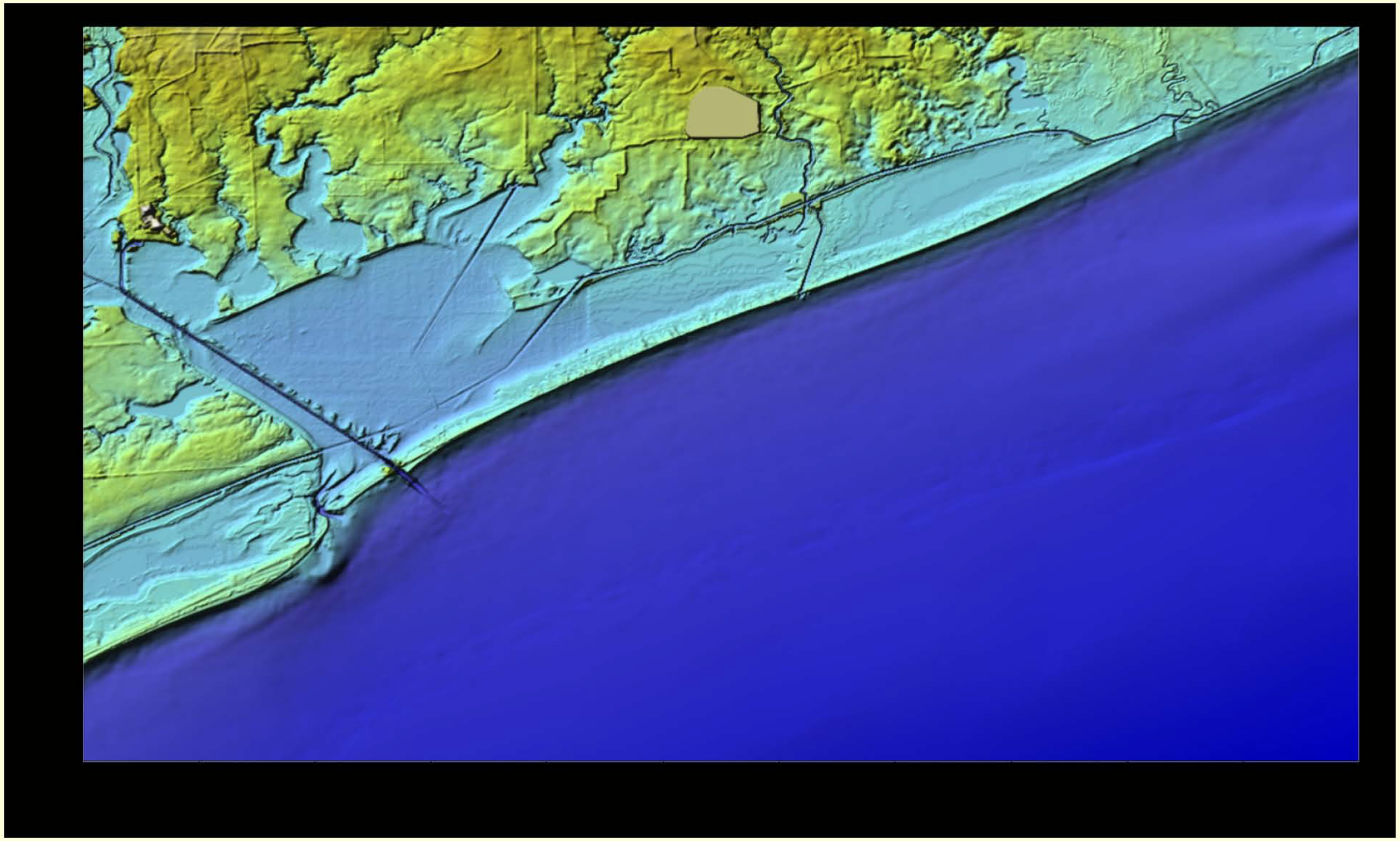


- Datum: NAVD 88
- Bathymetry: GEODAS + EC2001 (East Coast 2001 ADICRC grid)
- Topography: Bare-earth LIDAR data by county + USGS NED (National Elevation Dataset)

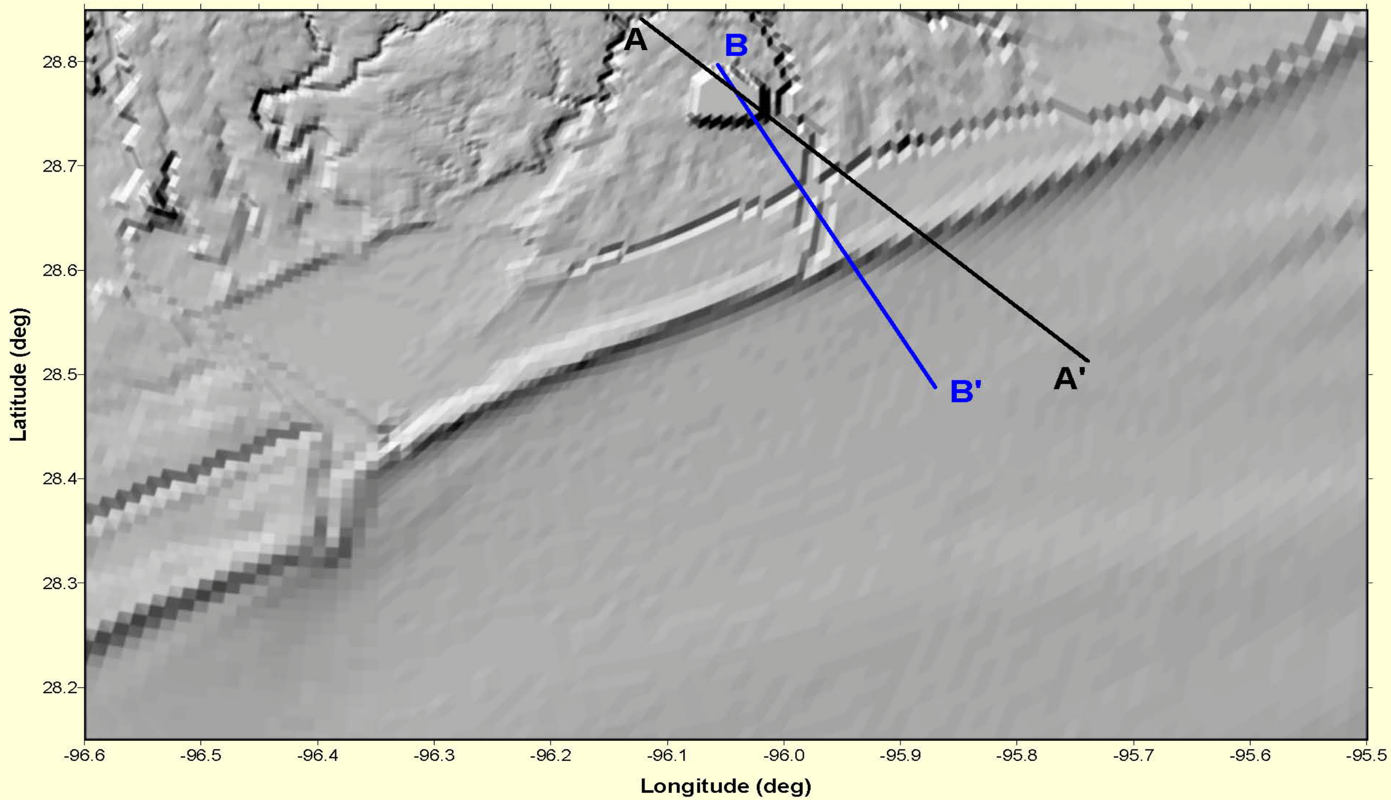
# Topographic Data – SLOSH



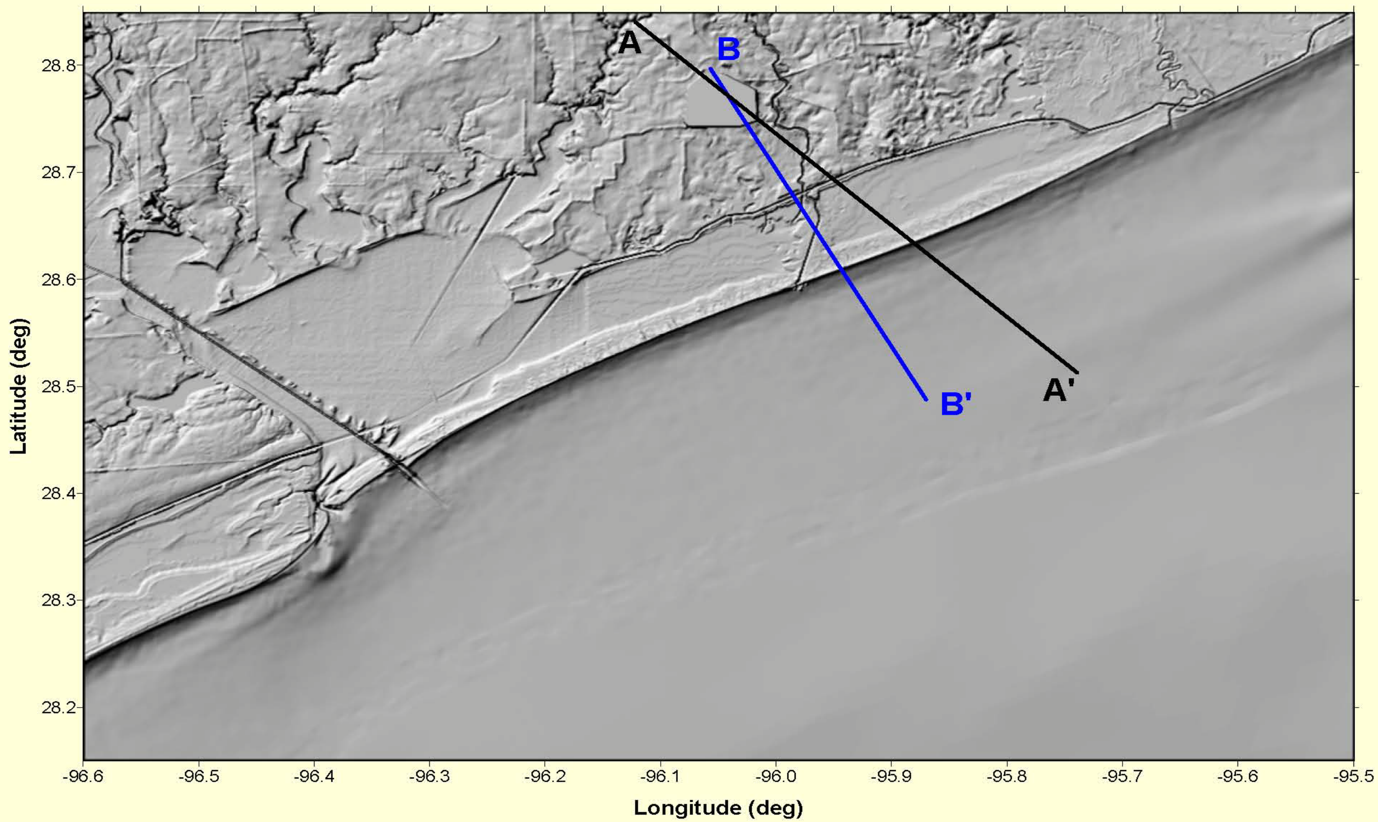
# Topographic Data – ADCIRC



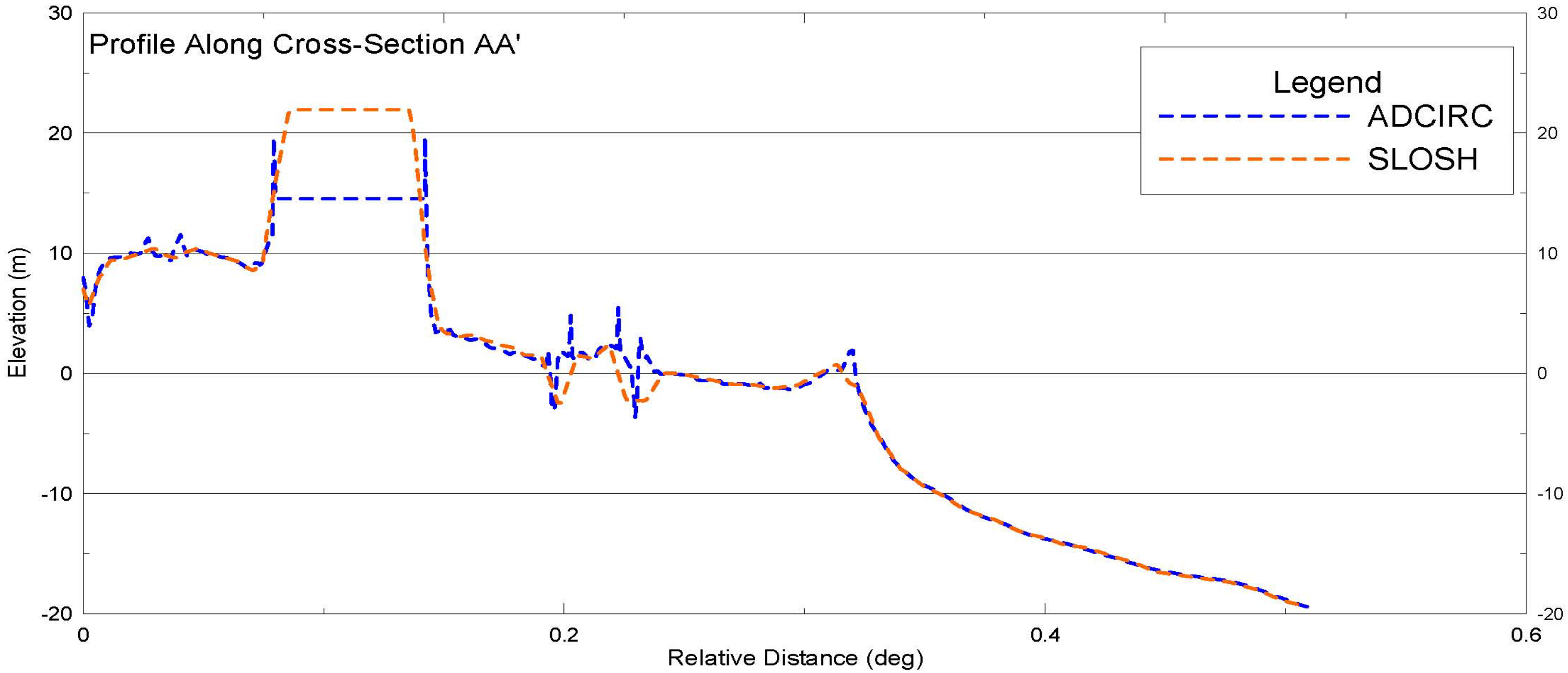
# Cross Sections AA' and BB' for SLOSH



# Cross Sections AA' and BB' for ADCIRC



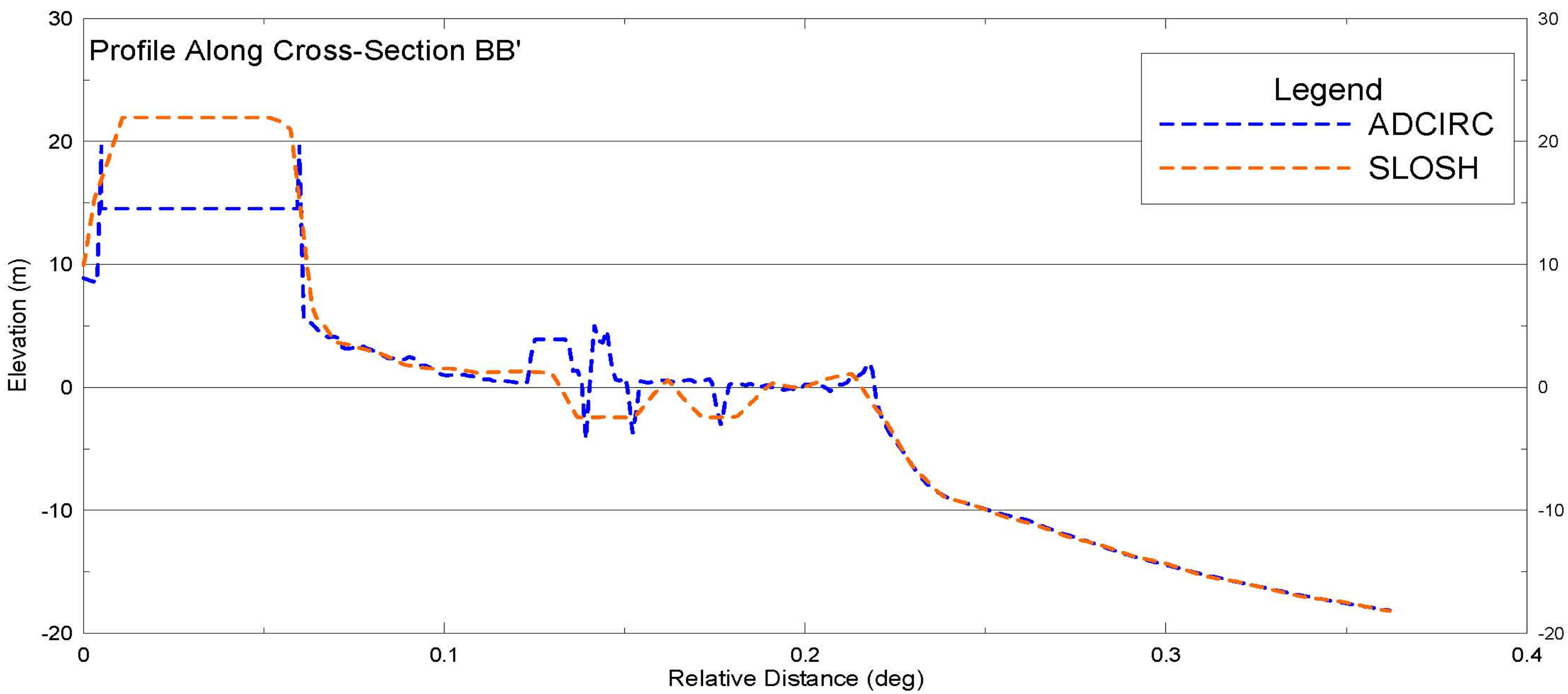
# Cross Section A-A' for SLOSH and ADCIRC

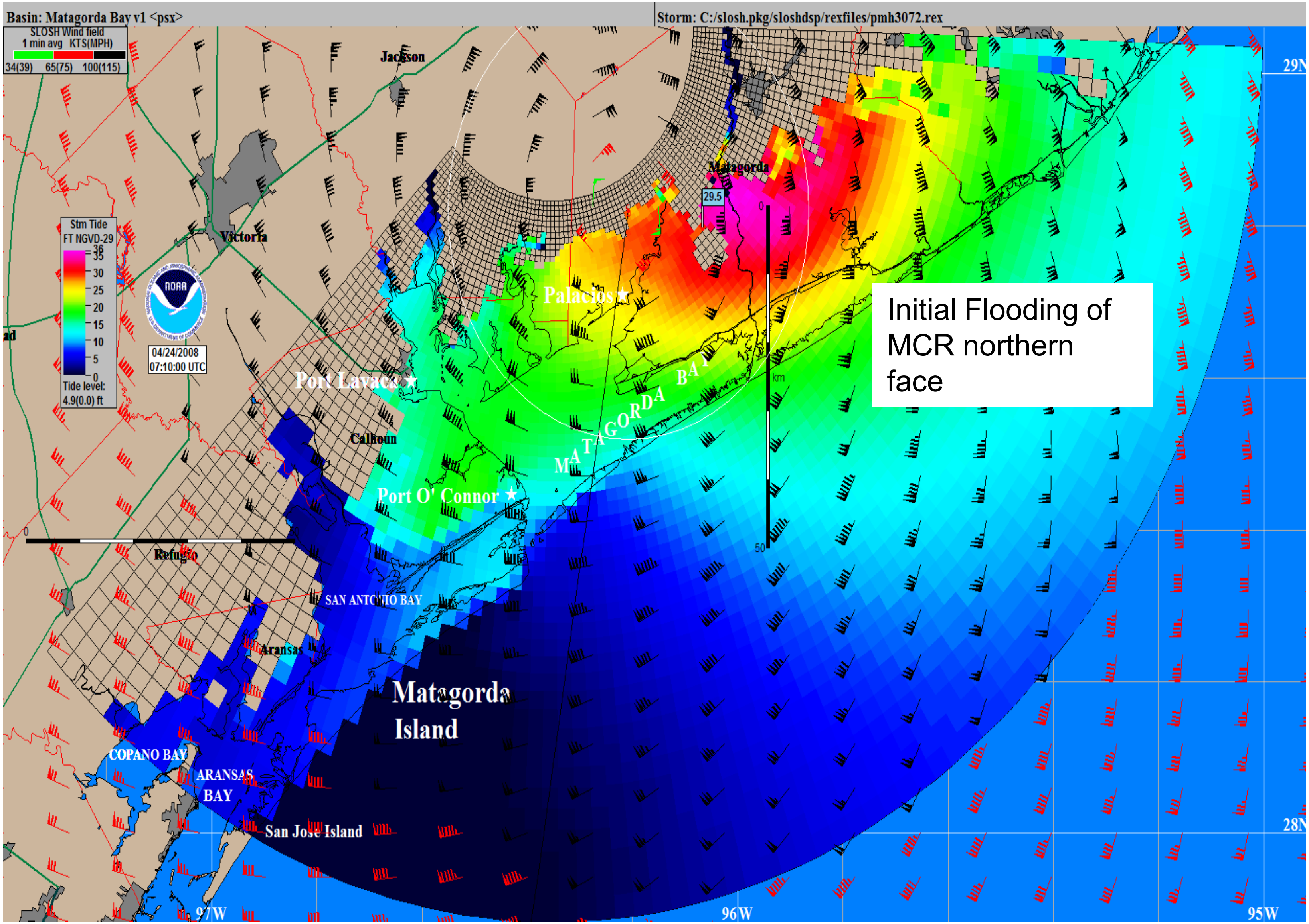


Exponent



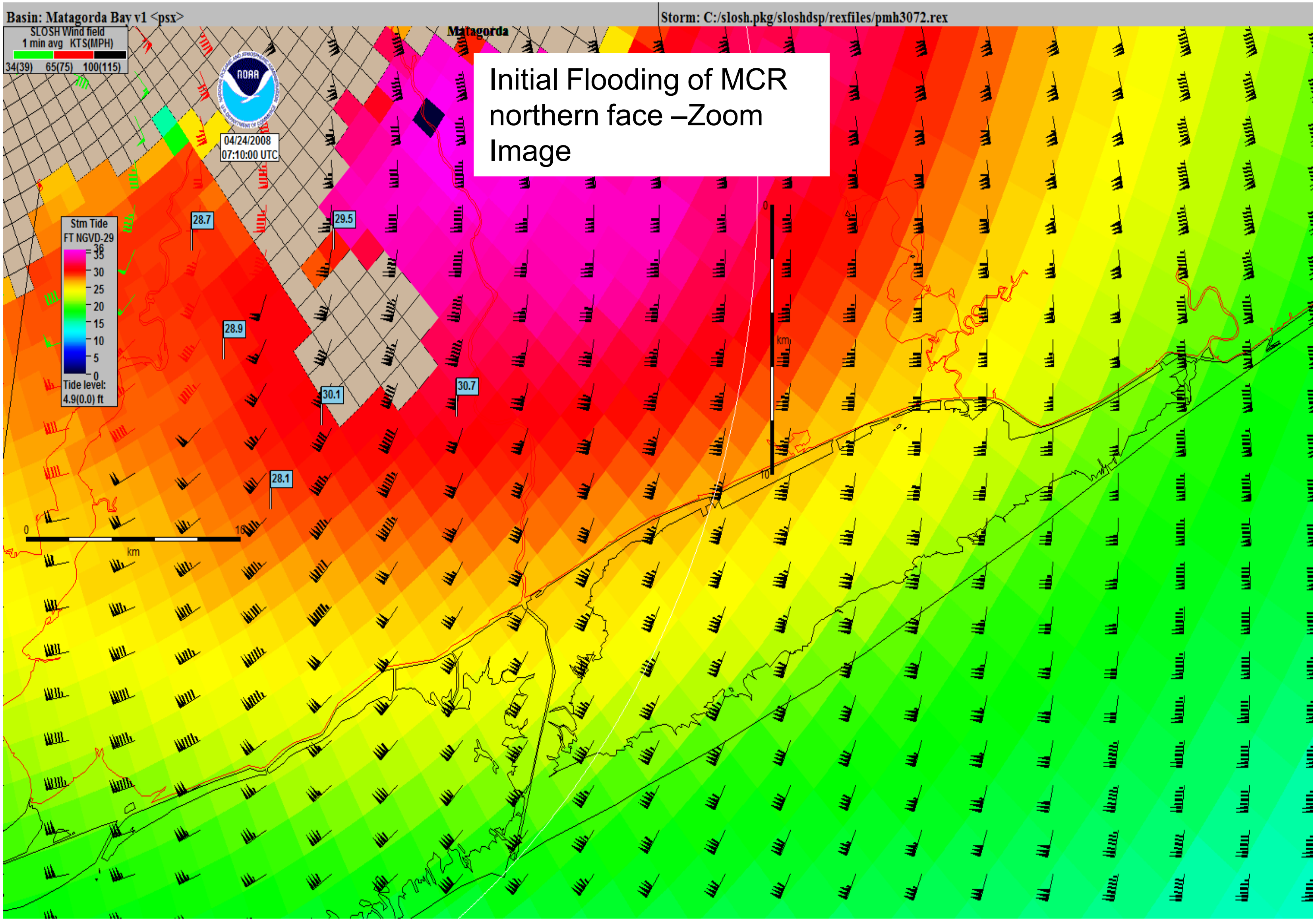
# Cross Section B-B' for SLOSH and ADCIRC

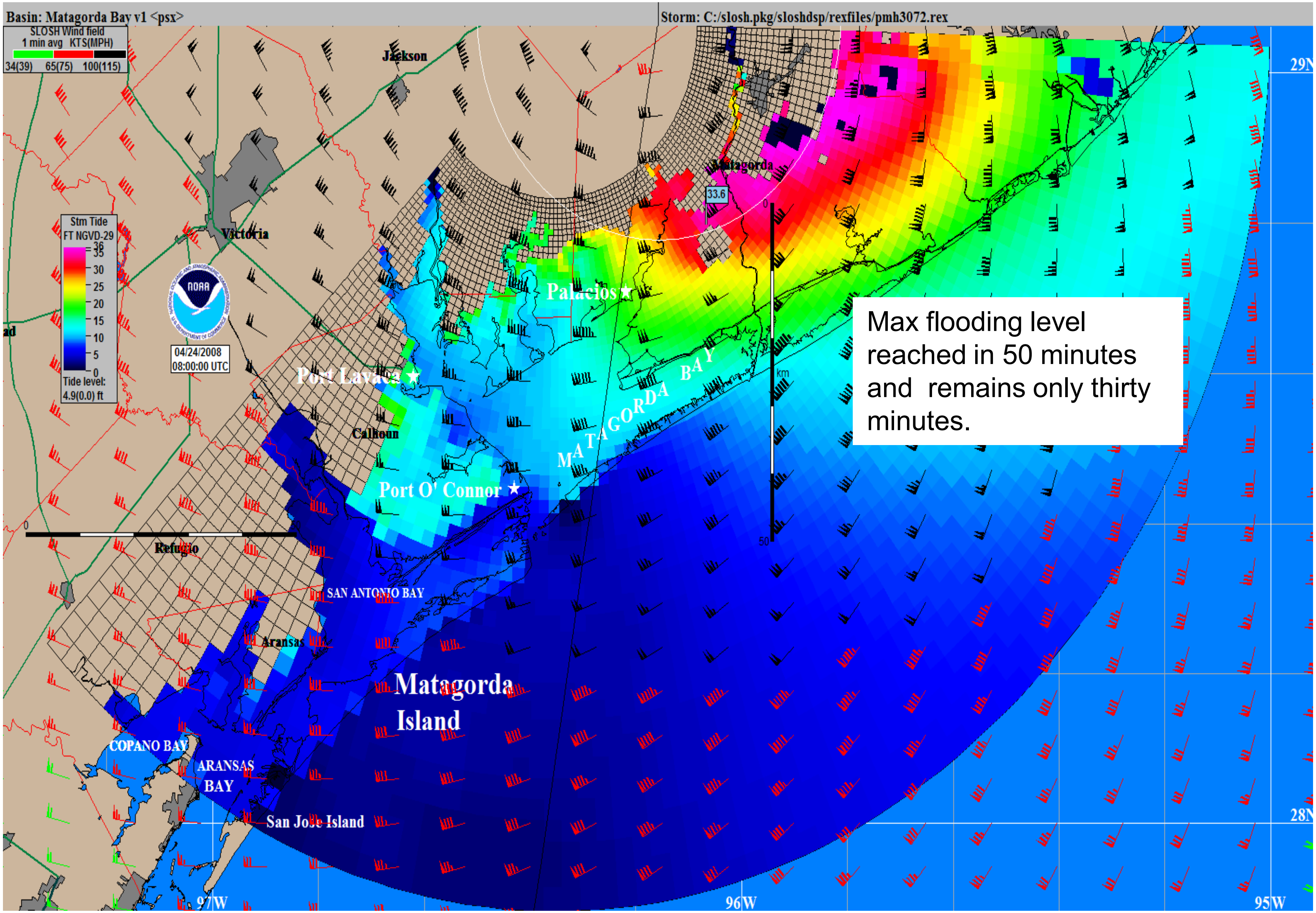




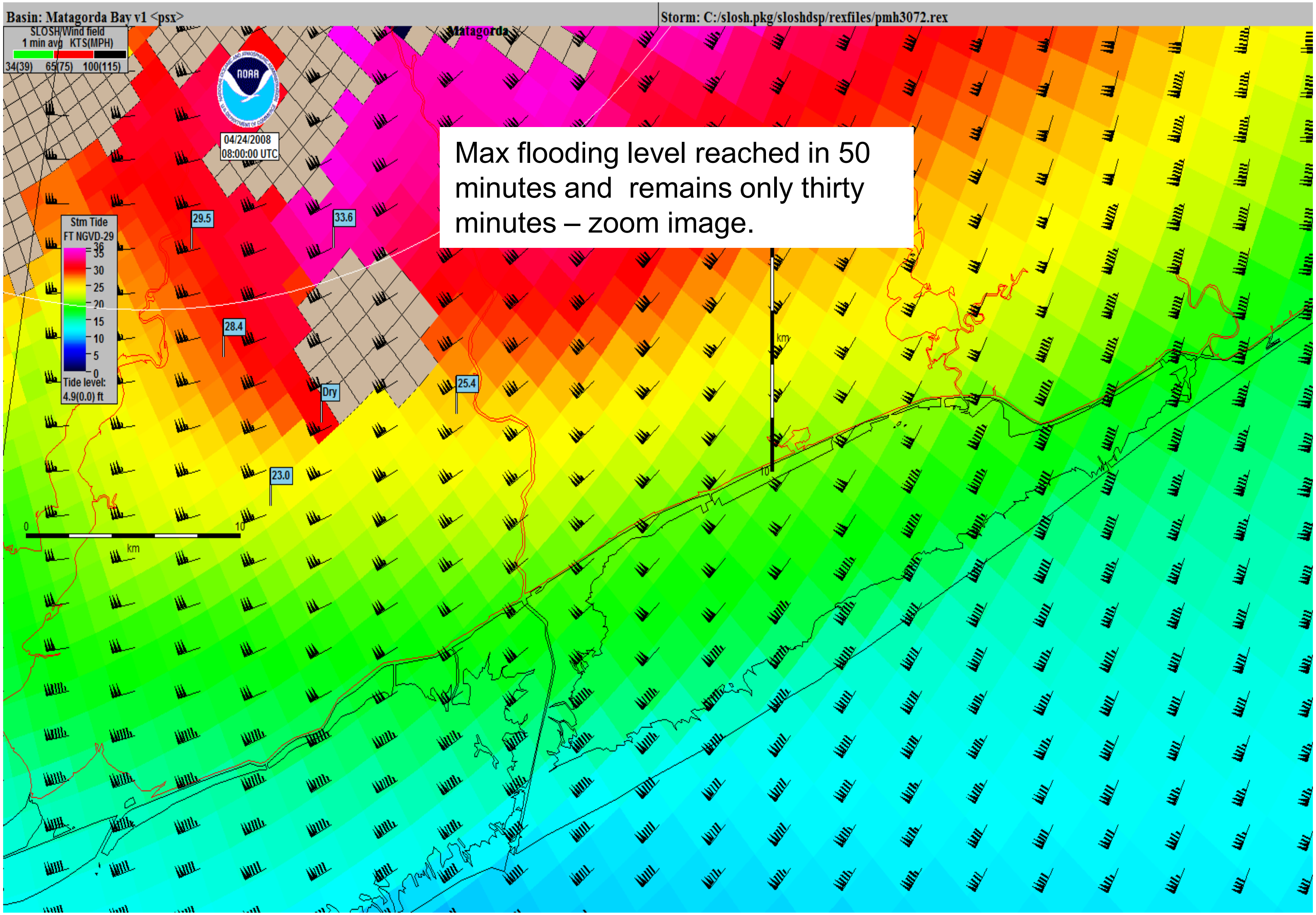

Initial Flooding of MCR northern face

# Initial Flooding of MCR northern face –Zoom Image






Max flooding level reached in 50 minutes and remains only thirty minutes.




Max flooding level reached in 50 minutes and remains only thirty minutes – zoom image.

# Maximum Groundwater Level (Action Item 58)

ABWR DCD limit and STP Site Characteristic for max groundwater level:
"61.0 cm (2.0 feet) below grade" (Table 2.0-1)

Site Characteristic limit as function of site grade required individual evaluation and engineering judgment for each application because:

- STP site grade varies from 36.6 feet MSL at the center of the power block to 32 feet MSL at the corners of the powerblock with a nominal power block elevation of approximately 34 feet MSL.