PMTurkeyCOLPEm Resource

From: Orthen, Richard <Richard.Orthen@fpl.com>
Sent: Wednesday, May 25, 2016 6:58 AM
To: Williamson, Alicia
Subject: [External_Sender] FPL - MDC DERM CA Progress
Attachments: May 16, 2016 Supplemental Information.pdf; MDC_presentation_IDOP.pdf; MDC_presentation_model_051316 (1).pdf; MDC_RWS_05162016(2).pdf

Alicia,

Attached FYI is information on CA-related GW modeling FPL shared with MDC DERM this month.

Rick

Hearing Identifier: TurkeyPoint_COL_Public
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Subject: [External_Sender] FPL - MDC DERM CA Progress
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From: Orthen, Richard

Created By: Richard.Orthen@fpl.com

Recipients:
"Williamson, Alicia" <Alicia.Williamson@nrc.gov>
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MESSAGE	111	5/25/2016 6:59:02 AM
May 16, 2016 Supplemental Information.pdf	995788	
MDC_presentation_IDOP.pdf	329955	
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MDC_RWS_05162016(2).pdf	3506506	

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May 23, 2016

Wilbur Mayorga
Chief
Miami-Dade County Department of Regulatory and Economic
Division of Environmental Resources Management
701 N.W. 1st Court 6th Floor
Miami, FL 33136-3912

Dear Mr. Mayorga:

On May 16, 2016 Florida Power & Light Company (FPL) met with Miami-Dade County Division of Environmental Resources Management (DERM) staff, representatives from the Florida Department of Environmental Protection (FDEP), and the South Florida Water Management District (SFWMD) to present models, reports, and data associated with the requirements of paragraphs 17 b.i., d. iii, and d. iv., of the Consent Agreement between MDC DERM and FPL (Agreement). FPL presented 1) a discussion of the three-dimensional groundwater model, 2) a proposal for a Recovery Well System based on the model results, and 3) a review and recommendation for near term Interceptor Ditch Operation.

The submittals were contained on digital media (thumb drives and hard drives) due to the size of the information provided. Recognizing the complexity of the submittal and in order to provide documentation of the discussions which ensued, FPL is providing the attached supplemental document to summarize FPL's proposals.

Please contact me at 561-691-2808 (Matthew.Raffenberg@fpl.com) or Scott Burns at 561-694-4633 (Scott.Burns@fpl.com) if you have any questions.

Sincerely,

Matthew J. Raffenberg
Sr. Director of Environmental Licensing and Permitting

Attachment: Supplemental Information in Support of the May 16, 2016 Submittal to Miami-Dade County DERM

CC: Lee Hefty/DERM, John Truitt/FDEP, Paula Cobb/FDEP, Jon Shaw/SFWMD

Supplemental Information in Support of the May 16, 2016 Submittal to Miami-Dade County RER-DERM

May 23, 2016

Background: On May 16, 2016, Florida Power & Light Company (FPL) met with representatives of the Miami-Dade County Division of Environmental Resources Management (DERM), the Florida Department of Environmental Protection (FDEP) and the South Florida Water Management District (SFWMD) to present models, reports and data associated with the requirements of paragraphs 17 b.i., d. iii, and d. iv., of the Consent Agreement between MDC DERM and FPL (Agreement). FPL presented:

1) a discussion of the three-dimensional groundwater model;

2) a proposal for a recovery well system based on the model results; and

3) a review and recommendation for near-term Interceptor Ditch operation.

The submittals were contained on digital media (thumb drives and hard drives) due to the size of the information provided. Recognizing the complexity of the submittal and in order to provide documentation of the discussions which ensued, FPL is providing this supplemental document to summarize FPL's proposals.

Groundwater Model

General Description: Pursuant to the terms of the Agreement, FPL has developed a three-dimensional, density dependent, transient groundwater flow and transport model (Model) sufficient to support the design of a groundwater recovery well system (RWS) to intercept, capture, contain and retract hypersaline groundwater (groundwater with a chloride concentration of greater than 19,000 mg/L) west and north of the Turkey Point Cooling Canal System (CCS). The Model covers groundwater and surface water features over a 276 square-mile study area and has the capability to calculate water level and salinity occurrence and movement on a monthly basis over a range of varying historic hydrologic conditions. The model was calibrated to existing historic data and then used to evaluate a series of 16 different salinity management/remediation alternatives, which were ranked against a series of environmental and social performance criteria in order to identify a best-performing recommended alternative.

The Model is very large (approximately 890,000 cells with each individual cell size ranging from 200 to 500 feet), complex (solving for flow, salt, and heat transport across six faces per cell, resulting in nearly 16,000,000 simultaneous equations being solved per time step) and is being calibrated against a vast amount of historic data (approximately 9,800 data targets to match). As a result, the Model's run times are lengthy (approximately 12 hours per run) and the number of alternatives evaluated significant. A model of this size and complexity typically performs at various levels across the model domain due to variations in aquifer properties that cannot be practically measured in the field or reproduced in a model. As such, these types of models undergo extended calibration and sensitivity analysis to improve the response across all areas of the model domain. Likewise, at the time of this submittal, there are some areas in the Model that do not represent the measured data as well as the modeling team would prefer. To that end, and consistent with the intent of the Agreement, FPL's modeling team is continuing to reduce the uncertainty of the Model in those areas.

Data Sources: Sources of data used to inform the development of the Model included surface water and groundwater elevation data, salinity, aquifer performance test, topography, and climate. The Model was calibrated over three distinct time periods: 1968 pre-CCS steady state; 1969 to 2010 seasonal transient; and 2010 through 2015 monthly transient. The availability of the data varied among the three calibration periods. For the steady state 1968 pre-CCS condition, water level data consists of USGS water level maps and a small number of static water level measurements, while the position and orientation of salt water was compared against a series of test wells drilled and tested from 1970 to 1973 as part of the design study for the Turkey Point CCS as described in reports by Golder, 2011. Water level and salinity data used in the seasonal transient calibration period was taken from USGS monitoring wells and FPL's G and L series monitoring wells associated with IDOP monitoring. Monitoring data from the Extended Uprate Monitoring Plan (SFWMD, 2009) was used for water levels and salinity calibration targets. Data from these sources are included in the data drives provided to the Agencies on May 16, 2016.

Groundwater salinity data beneath the Model Lands area has been limited by accessibility in the wetlands and accordingly there has been a high degree of uncertainty. To address this data bias and to provide a basis for spatial assessment of remedial actions on the location and orientation of the hypersaline groundwater plume, FPL conducted three dimensional Continuous Surface Electromagnetic Mapping (CSEM) of the hypersaline groundwater plume north and west of the CCS. The CSEM methods data analysis and results are summarized in a May 11, 2011 presentation made to MDC DERM and in a report by ENERCON Inc., entitled "PTN Cooling Canal System Electromagnetic Conductance Geophysical Survey," May 2016. These data were available for and used in the assessment of model calibration.

Aquifer characteristic data for the model were derived from two aquifer performance tests conducted at Turkey Point and regional aquifer characteristics as reported in USGS reports (Klein and Stewart, 1996; Fish and Stewart, 1991; Langevin, 2001). The onsite aquifer performance tests were conducted in support of a site license for Units 6 and 7 (HDR, 2009) and, more recently, at the northwest corner of the CCS (ENERCON, 2016) as required in the Agreement. Aquifer characteristics data from both on-site tests identified lower than regional permeabilities for the Biscayne Aquifer, which could be related to clastics encountered in the Ft Thompson at these sites.

Regional canal characteristics were informed from data compiled by the SFWMD and stored on their publicly available hydrologic database, DBHydro. Canal bottom hydraulics were developed with satellite-based topographic and bathymetric data and were generally consistent with information in the USGS regional model provided by the MDC Water and Sewer Department. Similarly, net recharge in the FPL model was derived using algorithms developed for the USGS regional model. Transient water conditions used to represent the CCS canals and the Interceptor Ditch were based on monthly water budget results contained in the Turkey Point Annual Extended Uprate Monitoring Plan reports.

Model Development and Calibration: a description of the model development and calibration is included in the presentation entitled, "Variable Density Ground Water Model Analysis and Results; Model use, design, calibration and description of alternatives," May 16, 2016 by Andersen and Ross.

The sequence of calibration and predictive models simulate the key hydrologic processes in the study area. Groundwater flow from the surficial aquifer to Biscayne Bay (or vice versa) is simulated using a time-variant, specified head boundary condition. Specified head values in Biscayne Bay are based upon water level measurements collected continuously at two stations (TPBBSW-3B and TPBBSW-10B) between 2010 and 2015.

Groundwater recharge is simulated as net recharge (i.e. rainfall less evapotranspiration and runoff) using the standard MODFLOW Recharge Package. The base recharge rates—which were rescaled during calibration using domain-wide multipliers—were calculated using NEXRAD data freely available from SFWMD and a methodology based upon the one developed for a USGS modeling study and presented by Hughes and White (2014). Climate conditions during the overlapping period of NEXRAD rainfall and evapotranspiration data (1996-2014) were assumed to be representative of conditions during the Models' full temporal domain: 1940 through the future. Long-term averages of the net recharge rates calculated using these data is assumed to represent steady-state conditions during the 1940-1968 period. Similarly, seasonal (i.e. May-October and November-April) averages of these rates were assumed for the period from 1968-1995, after which the data-based net recharge rates were used directly through 2014. The average monthly net recharge rates from 2008-2014 (i.e., the applicable period for the 2008 LULC data) were used to define net recharge in 2015.

Groundwater extraction is simulated using MODFLOW's Well Package and includes municipal, industrial and agricultural groundwater pumping. The initiation of pumping from municipal and industrial extraction wells begins at the date of installation (if known) and pumping rates from these wells were based on recorded extraction data wherever possible. Gaps in these data were filled using patterns in the recorded values and/or reasonable assumptions based on the modelers' professional judgment. Septic system return flow was assumed to offset groundwater extraction for private water supply wells and recreational irrigation losses (e.g. the component of lawn irrigation which does not recharge the surficial aquifer); none of these components of the groundwater budget were modeled.

Agricultural areas were identified using the 1995 and 2008 Land Use/Land Cover (LULC) data available from SFWMD (http://www.sfwmd.gov/gis/). Agricultural extraction rates were estimated for all agricultural areas based on the net recharge calculations (above); when the NEXRAD-based (crop-specific) maximum evapotranspiration (ET) rate exceeded the recharge rate, this ET deficit was assumed to have been met by groundwater extraction from the surficial aquifer. Lacking any earlier geospatial coverages, all areas classified as agricultural in the 1995 LULC dataset were assumed to be agricultural from the beginning of the models' time-domain (1940) through 2007. The 2008 LULC coverage was assumed to represent the agricultural areas in 2008 and beyond.

Interactions between the groundwater system, canals, and the CCS are represented using MODFLOW's River and Drain packages. The CCS and primary canals (e.g. the perimeter canals, C-103 and C-111) are represented using the River Package; all secondary canals are modeled as drains. The base river and drain conductances were calculated using the appropriate layer hydraulic conductivities and either the GIS-based surface area of the surface water feature (for the canal bottoms) or the lateral exposed area (for the vertical canal-aquifer interfaces). The heads assigned to each river cell in the CCS are based on a north-to-south interpolation between five water level measurement stations: three south of the plant outfall on the western/discharge side (CCS-1, CCS-2 and CCS-4) and two on the eastern/intake side (CCS-5 and CCS-6).

Water levels in both perimeter canals (C-103 and C-111), L-31E and C-111E were based on linear spatial interpolations of water levels between the paired "headwater" (e.g. S179-H) and "tailwater" (e.g. S179-T) water level measurement stations. Water levels in the remaining canals were based on either water levels in adjacent, connected canals (e.g. C-113, C-110, C103S) or surface topographic patterns (e.g. the North, Florida City and Card Sound Road canals).

Groundwater flow across the model's lateral boundaries (i.e., under the canals forming the Model's perimeter) was simulated using a General Head boundary condition (GHB). These GHBs extend from the bottom of the perimeter canals to the base of the surficial aquifer. Boundary conductances were based upon the lateral area and hydraulic conductivity of each cell. The boundary heads assigned to each GHB cell are equal to either the Biscayne Bay head (for GHBs beneath the bay) or the River Package heads in the overlying canal (which, as noted above, are all based on measured water levels).

High-flow zones were present in some—but not all—of the well boring logs analyzed when developing the model layering. An upper and lower high flow zone were assumed to be continuous throughout the entire model domain.

Aquifer Performance Tests: Aquifer characteristics used in the development of the model were initially driven by the results of the two Turkey Point aquifer performance test results. Due to the model's size and complexities, initial run times were between 24 and 36 hours per run. This, combined with a constrained model development schedule, made it impractical to use automated parameter optimization estimator software to calibrate the model. Instead, the model was calibrated using a conventional best professional judgment iterative process. Discussions with the developer of the SEAWAT code identified some tradeoffs between closure criteria and longer time steps to reduce model run time to 12 hours. Initial calibration efforts achieved the calibration statistics identified and agreed to in meetings with MDC DERM and produced good fits with water level and salinity data trends beneath and within 2 miles of the CCS.

Calibration Results: The initial calibration produced two areas where improvements are warranted; 1) the rate at which the saltwater interface moved to the west through three key historic monitoring wells (G-28, G-21 and TPGW-7D) was underestimated by the Model, and 2) the vertical profile of salinity distributions in the Model did not reflect the CSEM profiles in two specific strata: the base of the aquifer and the middle preferential flow zones. The FPL modeling team began a parallel process of continuing to work on improvements to the calibration while using the initial calibrated model to assess RWS alternatives

performance in meeting the goals and objectives of the Agreement. Improvements to the Model's performance in matching the historic westward movement of the saltwater interface were achieved by increasing aquifer permeability in the high-flow zones in the model to match the regional aquifer permeability found elsewhere in the region.

The increased permeability assumptions that improved the Model's predictive ability for the SWI migration in the western extreme of the model domain, also result in impacts closer to the CCS. The modeled movement of hypersaline water in the bottom layers (10, 11) extend beyond where the plume has been mapped using the CSEM technique in the revised model. When the alternatives were analyzed using the revised calibrated model, there was minimal retraction of the hypersaline plume in layers 10 and 11. Full retraction was observed in all other layers.

The salinity profiles generated by the initial calibrated model resemble a classic wedge shaped profile of hypersaline water moving in the aquifer with the farthest westward extent occurring in the deepest model layer. This results in an overstatement of the volume and extent of the hypersaline plume when compared to the CSEM profiles. CSEM data indicates the maximum westward extent of hypersaline water occurs in the middle high flow zone with the edge of the plume closer to the CCS at the base of the aquifer.

Next Steps: Despite the improvements made in regard to the historic westward movement discussed above, there remain opportunities for model improvement and further calibration enhancements. FPL is continuing to pursue the following improvements now:

- Address layer 10/11 response.
- Confirm SWI rate of movement response, in parallel with above work.
- Comprehensive review and validation of general model results to the full data set.

FPL will review implementation of the automated parameter optimization estimator software following the above activities, those identified in regulatory review and a revised calibration of the Model is conducted.

Recovery Well System (RWS)

Development and Evaluation of Alternatives: A total of 16 RWS alternatives were developed and evaluated using a series of environmental criteria aligned with the goals of capturing arresting and retracting hypersaline groundwater west and north of the CCS. These alternatives and the ranking criteria are summarized in the May 16th presentation entitled "Variable Density Ground Water Model Analysis and Results: Remedial Alternatives Modeling Evaluations and Selected Alternative" (Ross and Andersen, 2016). The criteria and ranking is provided below in Figure 1.

The RWS design alternatives focused on the hypersaline plume and containment of the CCS with the objective of retracting the hypersaline plume to the L-31E canal. Evaluation of these alternatives using the initially calibrated model, and further analysis with the revised calibrated model, identified that Alternative 3D (Figure 2) produced superior extraction performance through the base of the aquifer with acceptable

wetland drawdown (Figure 3). Alternative 3D provides for a 15 MGD (total) withdrawal via ten wells. In general, the east-west location of the well line established the point of extraction. Any locations west of the CCS boundary had the undesirable effect of drawing hypersaline water outside the CCS boundary prior to its extraction, which is contradictory to the overall goal. Utilization of the northeast to southwest alignment provided by the western boundary of the CCS offered upland locations that resulted in the broadest coverage for accomplishing retraction of the hypersaline groundwater to the west and east. It also provides the function of interception and containment of hypersaline groundwater to the east.

Criteria	Desciption	Score	Alternative 2	Alternative 3	Alternative 3 B	Alternative 3 C	Alternative 3 D	Alternative 4	Alternative 5	Alternative 5B	Alternative 5C	Alternative 6	Alternative 6B	Alternative 7A	Alternative 7B	Alternative 7C	Alternative 8
1	HS Cell Reduction (1 to 5 years)	>50% = 5; 40-49% = 4; 30-39% =3; 20-29% =2; 10-19% = 1	1	4	4	4	4	4	4	4	4	1	2	2	2	2	4
	HS Cell Reduction (6 to 10 years)	>80% = 5; 70-79% = 4; 60-69% = 3; 50-59% = 2; 40-49% = 1	0	2	2	3	3	2	2	2	2	0	0	0	0	0	2
2	HS Mass Reduction (1 to 5 years)	>50% = 5; 40-49% = 4; 30-39% =3; 20-29% =2; 10-19% = 1	1	3	3	3	3	4	3	3	3	1	1	1	1	1	3
	HS Mass Reduction (1 to 5 years)	>80% = 5; 70-79% = 4; 60-69% = 3; 50-59% = 2; 40-49% = 1	0	1	2	2	2	2	1	2	2	0	0	0	0	0	2
3	HS Interface Movement (5 years)	>50% = 5; 40-49% = 4; 30-39% =3; 20-29% =2; 10-19% = 1	2	4	4	4	4	4	3	3	3	2	2	2	2	2	4
	HS Interface Movement (10 years)	>80% = 5; 70-79% = 4; 60-69% = 3; 50-59% = 2; 40-49% = 1	0	2	2	2	2	2	2	2	1	0	0	0	0	0	2
4	SW Interface Movement (5 years)	>50% = 5; 40-49% = 4; 30-39% =3; 20-29% =2; 10-19% = 1	0	3	3	2	2	3	4	4	3	5	4	3	3	3	3
	SW Interface Movement (10 years)	>80% = 5; 70-79% = 4; 60-69% = 3; 50-59% = 2; 40-49% = 1	0	1	1	1	1	1	2	2	2	3	2	2	3	3	1
5	Wetland impacts	3= no cells w/ DD>0.2 ft 0= no cells >0.5 ft -1 = 1-10 cells > 0.5 ft -2 = 11-44 cells >0.5 ft -3= >45 cells > 0.5	3	-2	-2	-2	-2	-2	-3	-2	-3	-3	-3	3	3	3	-1
6	Surface water seepage	-5 if more than 50% is from surface water canals; 0 if 30 to 50% and +5 if less than 30%	5	0	0	0	0	0	0	0	0	5	5	5	5	5	0
7	Time to Implement	ESTIMATED:-3= > 2 yr, 0= 1.5 - 2 yr, 3= 0<1.5 yr	3	3	3	3	3	0	-3	-3	-3	0	0	0	0	0	3
8	Permits	3 permitting <0.5 year; 0 permitting .6 to 1 year; -3 permitting >1 yr	3	3	3	3	3	0	0	-3	-3	0	0	-3	-3	-3	-3
9	Legal Control	use 3 if on FPL land: -3 if project is on non FPL land	3	3	3	3	3	3	3	3	3	-3	-3	-3	-3	-3	-3
10	Retracts hypersaline plume	0 = not back to L-31 5 = fully back to L-31	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
		scores															
		TOTAL HYDRAULIC (rows 1- 6)	12	18	19	19	19	20	18	20	17	14	13	18	19	19	20
		TOTAL MANAGEMENT (rows 7-10)	9	9	9	9	14	3	0	-3	-3	-3	-3	-6	-6	-6	-3
		TOTAL	**21**	**27**	**28**	**28**	**33**	**23**	**18**	**17**	**14**	**11**	**10**	**12**	**13**	**13**	**17**

FIGURE 1: Alternative Evaluation Matrix. Note criteria 1 – 6 focus on technical merit, while criteria 7-10 focus on execution merit.

The western extraction alternatives showed limited impacts on the position of the edge of the saltwater-freshwater interface (SWI) miles to the west of the CCS. For this reason, a series of additional alternatives (Alt 6 and 7 series) were developed and evaluated. These alternatives involve injection and/or extraction of water near the SWI and do not directly or indirectly address the hypersaline plume west of the CCS. An alternative (7C) that involved injection of approximately 2 MGD (total) distributed over 8 injection locations for three years provided the best impact to the location of the SWI. Again, any extraction west of the CCS boundary had the undesirable impact of potentially pulling groundwater to the west.

Additionally, a combined alternative 8 (consisting of Alt 3D extraction and Alt 7C injection) was developed and modeled using the initial calibrated model. The results showed the retraction of the hypersaline plume west and north of the CCS was achieved and the SWI was more effectively moved back to the east.

The revised calibrated version of the Model was used to model the 16 alternative arrangements. The revised calibrated model showed improvements in the salinity in the western portion of the model domain which was achieved by increasing the permeability assumptions in the Model, described above.

FIGURE 2: Alternative 3D Recovery Well System site layout. Design includes 10 extraction wells with a total extraction of 15 mgd drawn from the lower layers of the aquifer (-70 to -90 feet bls).

As identified earlier, the increased permeability assumptions that improved the ability to match the observed SWI migration in the western extreme of the model domain also result in modeling impacts closer to the CCS. The modeled movement of hypersaline water in the bottom layers (10, 11) extend beyond where the plume has been mapped using the CSEM technique in the revised model. When the alternatives

were analyzed using the revised calibrated model, there was minimal retraction of the hypersaline plume in layers 10 and 11. Full retraction was observed in all other layers.

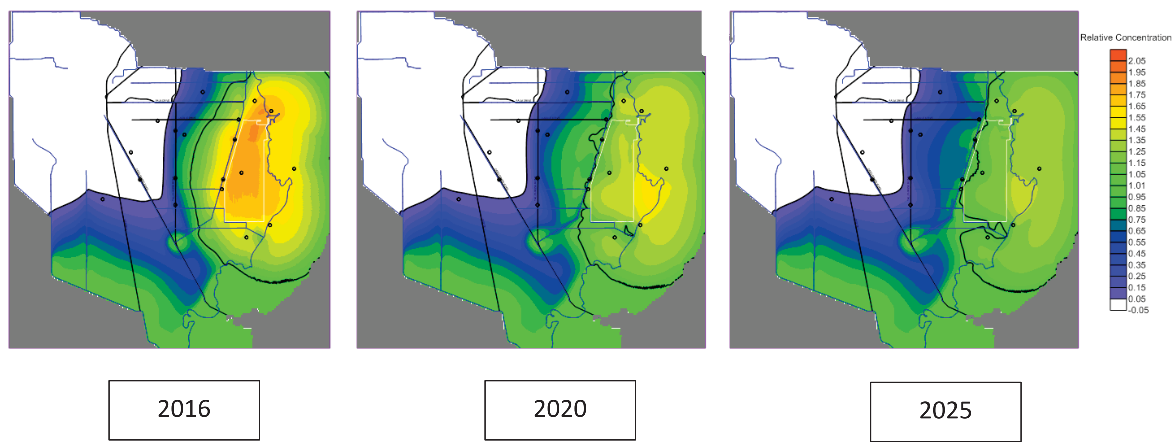


FIGURE 3: Model results in Layer 8 (approximately 50 ft bgs) showing 2016, 2020 and 2025 results where the hypersaline plume is retracted to the CCS western boundary and significant salinity reduction is achieved below the CCS.

Conclusion of Alternative Evaluation: The groundwater model provides an adequate tool to evaluate different alternatives for the Recovery Well System required and described in the Consent Agreement. The CSEM data provide additional perspective regarding the actual location and elevation of the hypersaline plume west and north of the CCS. Alternative 3D successfully complies with the objectives stated in paragraph 17, 17.b and 17.b.i of the Consent Agreement. Further improvements to the model assumptions and model calibration will produce a better match to the CSEM and groundwater monitoring data based plume orientation.

Interceptor Ditch Operation Plan (IDOP)

The operation of the Interceptor Ditch (ID) was reviewed to determine the impacts of current operations and potential for that operation to be modified. Model runs were conducted with the recommended RWS alternative (Alt 3D) with and without the Interceptor Ditch pumping using the groundwater model and the water balance model developed for the Uprate Monitoring program. The analysis concluded that 1) the current Interceptor Ditch operations are effective in preventing migration of hypersaline groundwater to the west in the upper layers of the aquifer, 2) the RWS will be effective at reversing and containing migration of hypersaline groundwater in the middle and lower layers of the aquifer (> 55 ft., and 3) the ID operations do play a minor role in maintaining low salinity in the CCS, most predominantly in years where drought conditions are present.

FPL recommends that significant modification of the ID or the IDOP is premature, and will be better informed by observations and measurements made following installation and operation of the proposed RWS. Re-evaluation of the IDOP within two years of RWS operation is recommended.

Variable Density Ground Water Model Analysis and Results

Modification to the Interceptor Ditch Operations Plan (IDOP)

Pete Andersen, P.E. and James Ross Ph.D.

Tetra Tech

May 16, 2016

Introduction

- Current ID operating procedure:
  - Pumping when hydraulic conditions suggest the potential for westward migration of CCS water into L31-E.
  - Pumping is continued until it appears likely that an eastward flow has been established
- The purpose of this task is to review Interceptor Ditch (ID) Operations and identify potential improvements accounting for the proposed remedial alternative.
- Evaluate the efficacy of:
  - Elimination of ID pumping
  - Continuing existing protocols,
  - Modification of existing protocols,

3D Model Procedure & Results

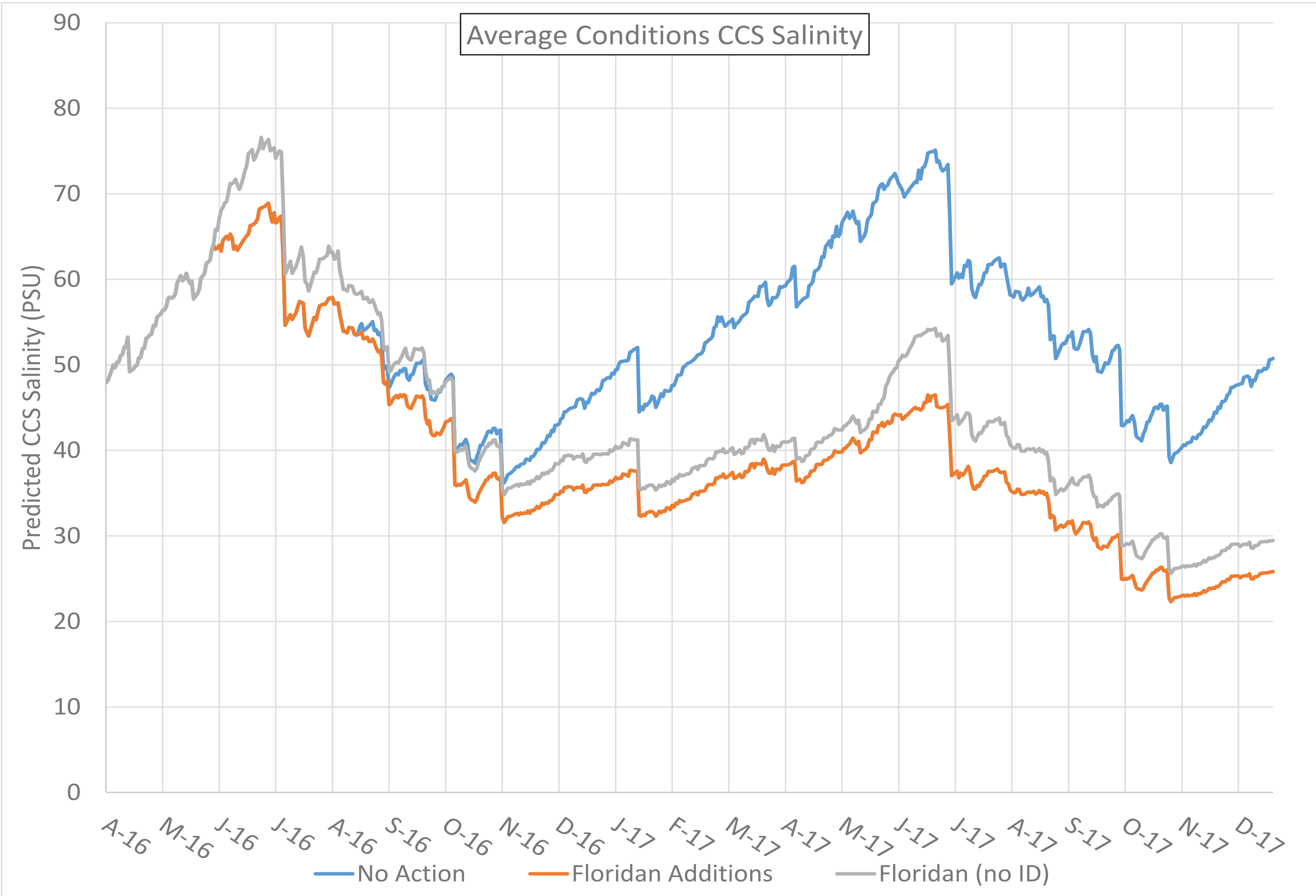
- Run model with proposed RWS and current ID operating procedures
- Run model with proposed RWS and no ID operation
- Compare results (Alt 3D, Alt 3D_no_ID)
  - Migration of hypersaline and saline fronts
  - L31-E protection
  - Efficiency of proposed remedial alternative
- Modeled salinities indicate ID effective at maintaining low salinity east of L-31E in shallow part aquifer
- RWS alternative effective at reducing salinity in deeper part of aquifer

Interceptor Ditch Operations on CCS Salinity

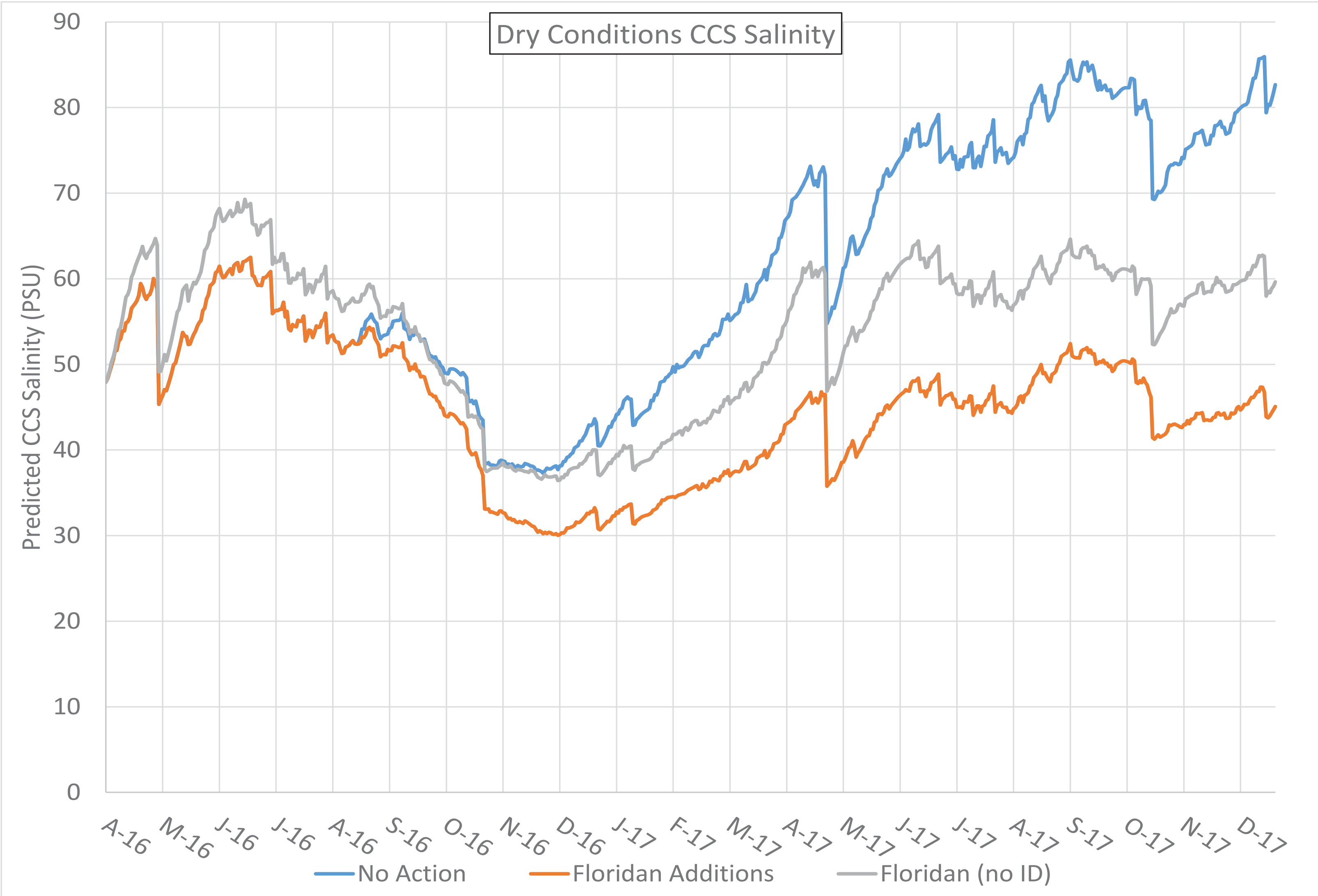
- IDOP is not a freshening strategy
- Analyses of salt budget and freshening projections included IDOP operations as part of Baseline conditions
- Analysis conducted using salt budget model developed for Uprate Monitoring Plan to determine impact of discontinuing IDOP on ability of FAS wells to maintain an average annual salinity of 34 psu
- Results suggest during average years (and by implication, wet years) CCS salinity targets should be achievable with or without IDOP
- Depending on drought severity, salinity targets without IDOP may be challenging

FPL

CCS Simulated Salinity with and without IDOP



CCS Simulated Salinity with and without IDOP



Conclusions

- The current IDOP is effective in preventing westward migration of CCS saline water in the upper portion of the Biscayne aquifer
  - ID and RWS address different depths of the aquifer
  - ID: capture/contain westward migration of CCS water in upper 20-25 ft.
  - RWS: remove hypersaline water in deep >55 ft. of aquifer
- RWS may not be efficient at containing shallow migration
  - Anisotropy
  - High flow zones
- Recommend continued operation of ID while RWS is being implemented
  - Re-evaluate and modify according to effects of abatement and RWS after operational
  - Consider elimination / wholesale modification based on monitoring

FPL.

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Variable Density Ground Water Model Analysis and Results

Model use, design, calibration and description of alternatives

Pete Andersen, P.E. and James Ross Ph.D.

Tetra Tech

May 16, 2016

Presentation Outline

Groundwater flow and transport model

- Model objectives and applications
- Design of the model
- Calibration
- Overview of alternatives

Recovery Well System /IDOP analyses

- Description of RWS alternatives
- RWS alternatives modeling results
- IDOP evaluation approach

FPL

Executive Summary

- FPL has developed a 3D, density dependent, transient groundwater flow and saltwater transport model to evaluate various abatement and remediation alternatives
- FPL followed standard model development procedures and used publically available software
- The model was calibrated to nearly 50 years of water level and salinity data from the Biscayne aquifer in the vicinity of the Turkey Point cooling canal system
- The calibrated model meets or exceeds accepted metrics for calibration
- Model is ready for use as an engineering tool that contributes to decision-making and conceptual design

Model Objectives

Develop a modeling tool that meets the following objectives:

- Three-dimensional, coupled, transient flow and transport to represent variable density conditions as a function of space and time (compute hydraulic head and concentration)
- Utilizes existing aquifer data informed by recent APT results
- Calibrates to past groundwater conditions from pre-CCS to present
- Reasonable (1/2 day maximum) computer run times
  - Balance spatial model resolution between practical and most desirable
  - Consider important elements of conceptual model
- Open source, public domain software for simulation and pre-, post-processing
- An engineering tool that contributes to decision-making and conceptual design

Model Applications

- To assess impacts of abatement (CCS freshening) on the existing location and extent of hypersaline groundwater
- To assess remediation wellfield system (RWS) design alternatives in terms of:
  - Effect on reducing the salt mass and volumetric extent of hypersaline groundwater west and north of FPL's property
  - Impacts to wetland hydroperiod west and north of FPL's property
  - Identification of a preferred alternative RWS design and operational plan
- To evaluate current Interceptor Ditch Operation Procedures (IDOP) in relation to abatement and RWS operations to determine if revisions to the IDOP are warranted

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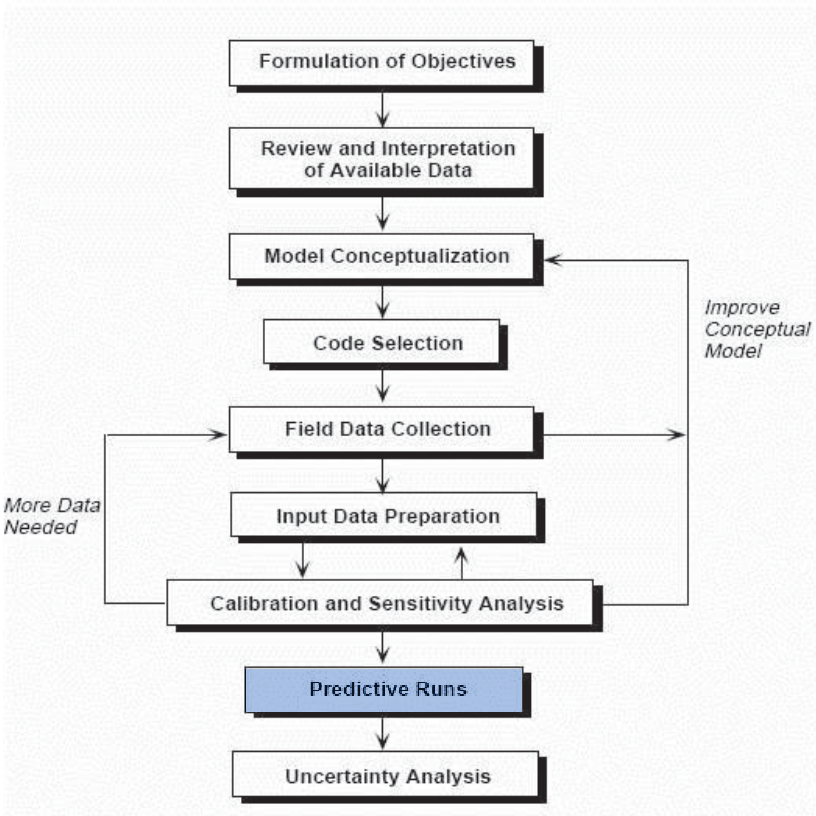
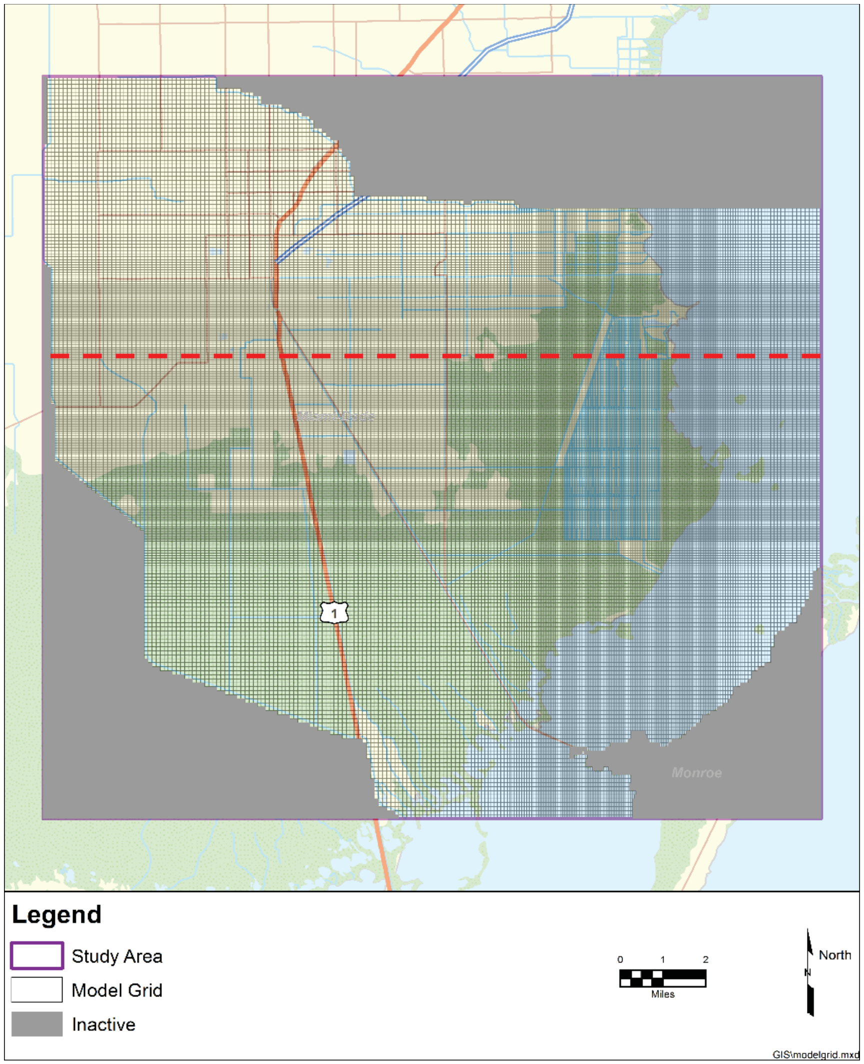
Model Application Process



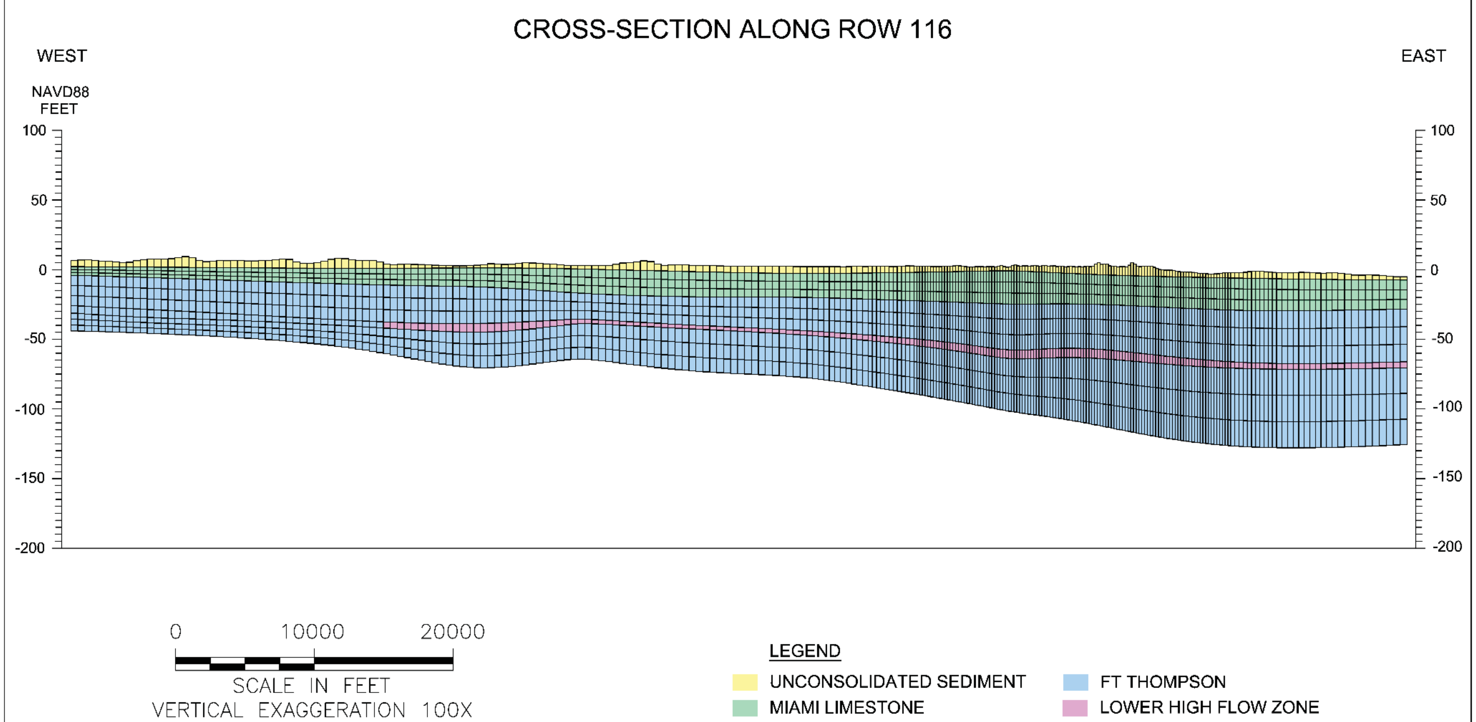
- Significant up-front work to get to evaluation of alternatives
- Follows a logical process
- Model calibration:
  - Adjust model parameters to achieve match to observed conditions
  - Belief that model can "predict" effect of remedial alternatives hinges on ability to replicate past conditions
- Remedial alternatives = "Predictive Runs"

Study Area / Model Domain



- 276 square miles areally
- Biscayne aquifer and surface waters
- Extent is a balance between maintaining hydrologic boundary conditions and detail required near CCS
- 295 rows, 274 columns
- 200 to 500 foot grid spacing
- Oriented N-S
- 11 layers
- Model code = SEAWAT
  - Public domain (USGS)
  - FPL and MDC familiarity
  - Can represent conceptual model
  - Efficient numerically

Model Layering Superimposed on Hydrostratigraphy along Typical Cross-Section



* Key Largo included as zones in Miami Limestone

Goals of Calibration

- **Satisfy calibration statistical criteria**
  - Maintain low overall error in model
  - Match magnitude of observed water levels and salinity
- **Best fit to data trends**
  - Simulate temporal and spatial trends
    - -- Seasonal fluctuations in groundwater levels
    - -- Breakthrough of saltwater and hypersaline front at distal wells

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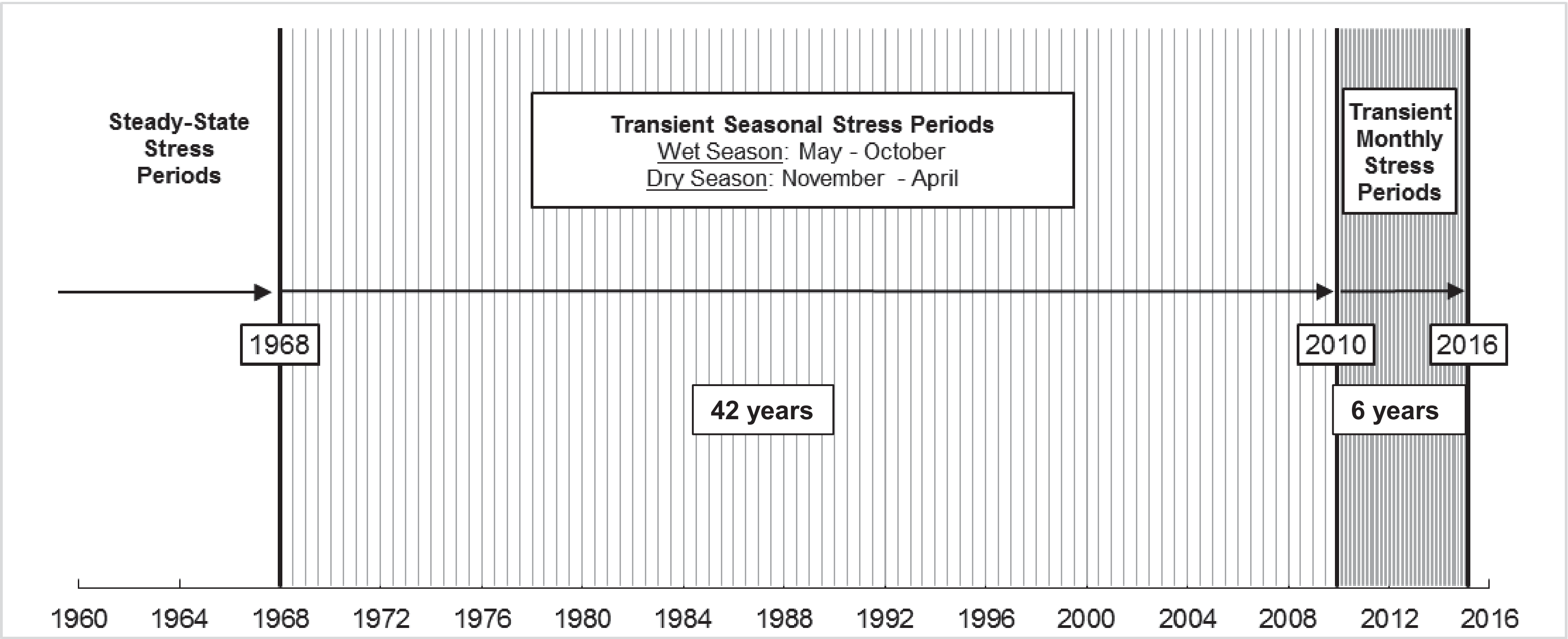
Three Calibration Periods to Present

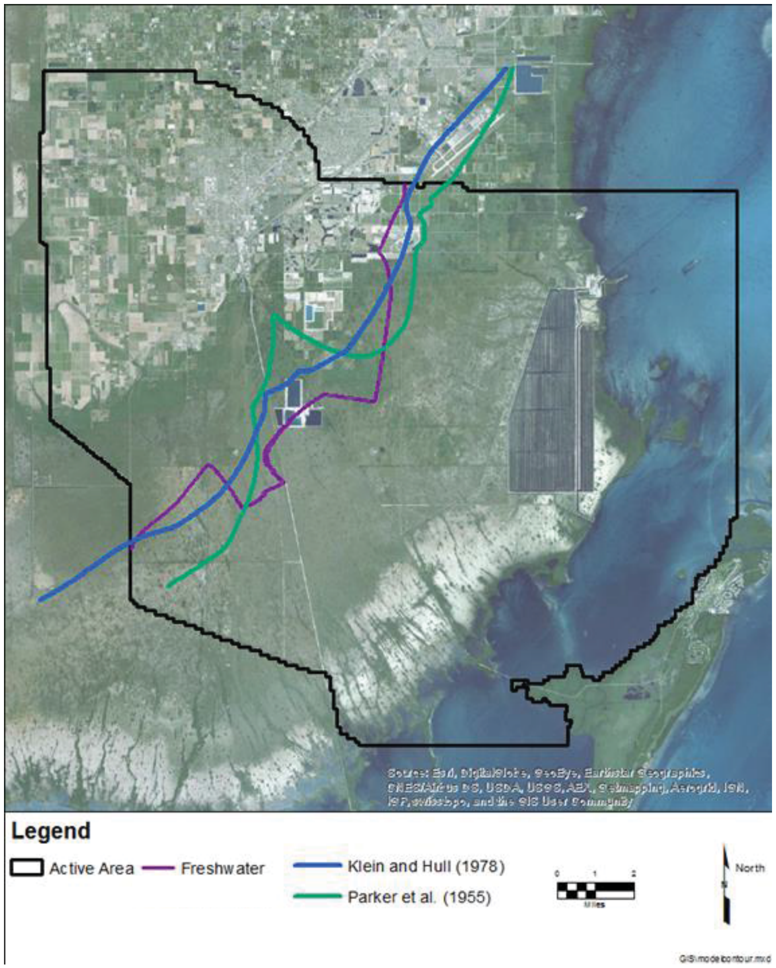


Establish physically based initial condition

Limited data; long term saline interface movement

Detailed and reliable data

Comparison of Location of Pre-CCS Fresh/Saline Interface



- Initial calibration
- 1 PSU salinity (1000 mg/L TDS)
- “steady-state” equilibrium
- 1968
- Initial condition for transient simulations to present day

Calibration Statistics (Initial)

Metric	Mean Error (ft)	Mean Absolute Error (ft)	MAE / Range (percent)	Number of Targets
Seasonal Salinity	0.042	0.19	9.6	2979
Seasonal Heads	0.058	0.45	6.6	839
Monthly Salinity	-0.004	0.19	10.9	2482
Monthly Heads	-0.09	0.37	7.2	3476

- **Numerical measures of calibration**
- **Mean Error:**
  - = $\frac{1}{n}\sum_{i=1}^{n}(h_m - h_s)_i$
  - A measure of bias
  - Want to be close to 0.0
- **Mean Absolute Error:**
  - = $\frac{1}{n}\sum_{i=1}^{n}\left|(h_m - h_s)_i\right|$
  - A measure of error without regard to +/-
  - Want to be 5-10% of the range of observations

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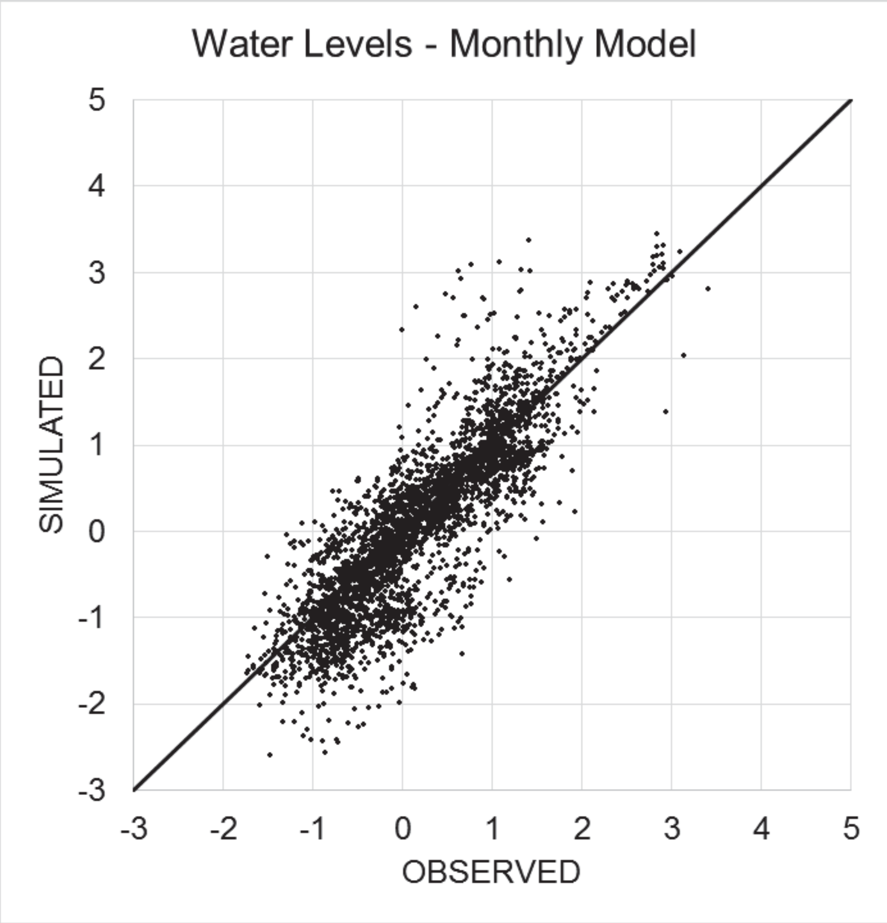
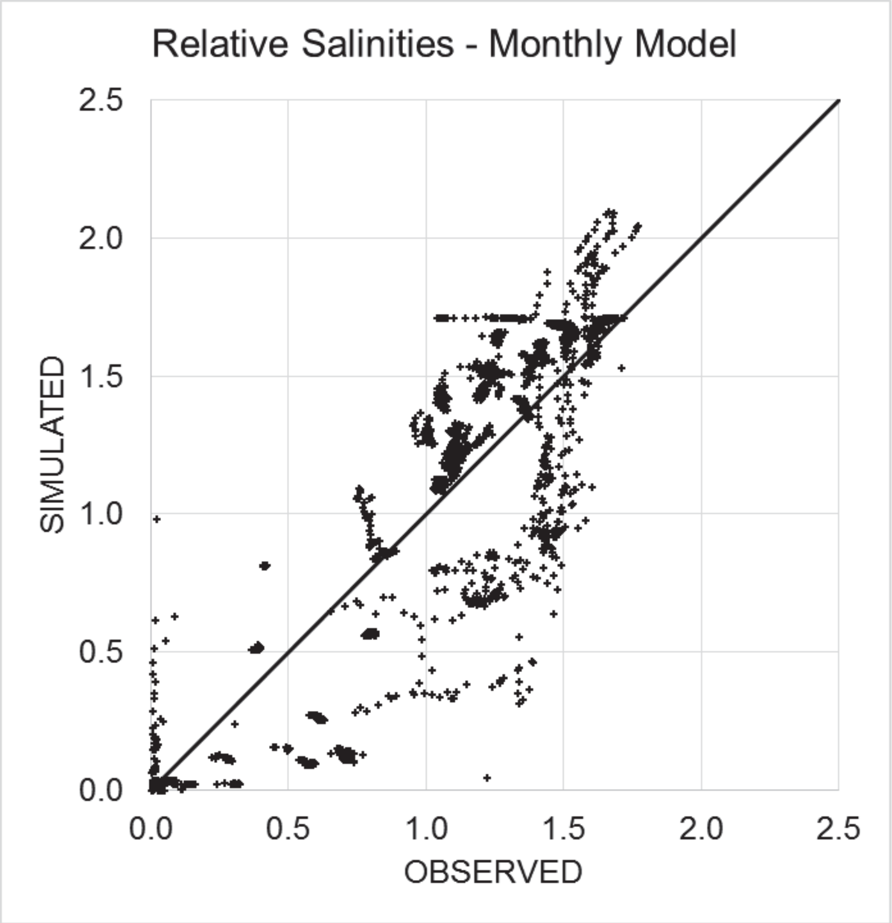
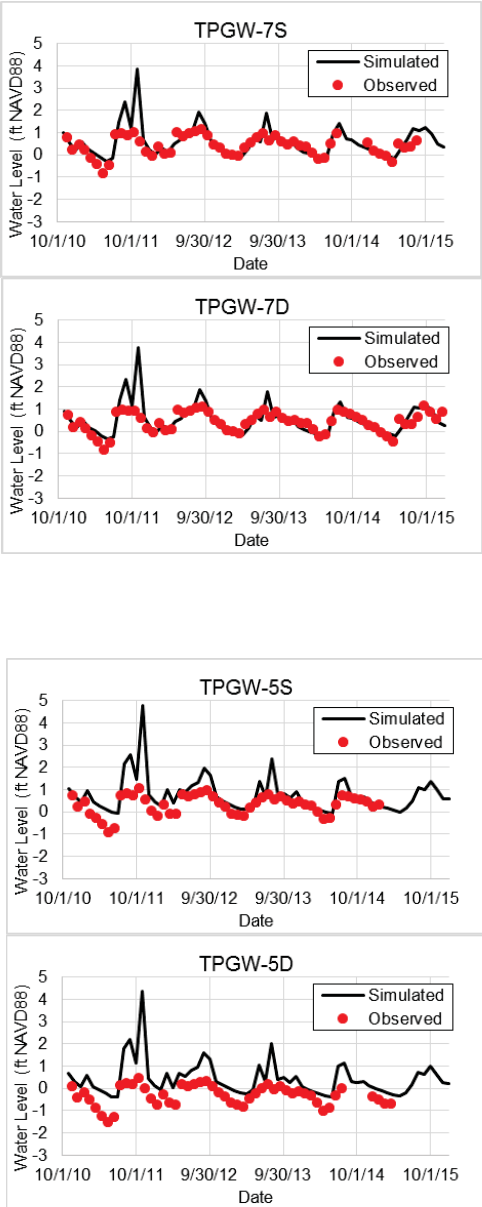
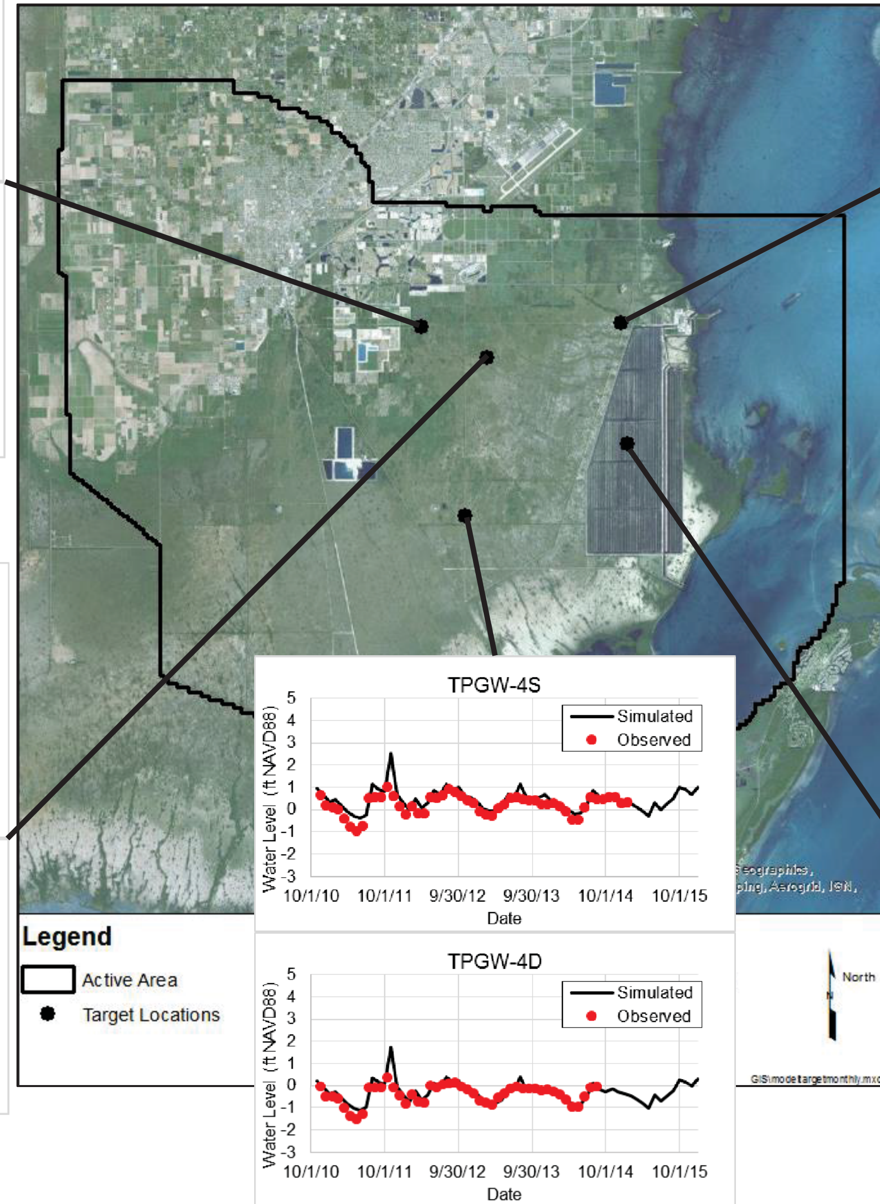
Simulated vs Observed (Initial)

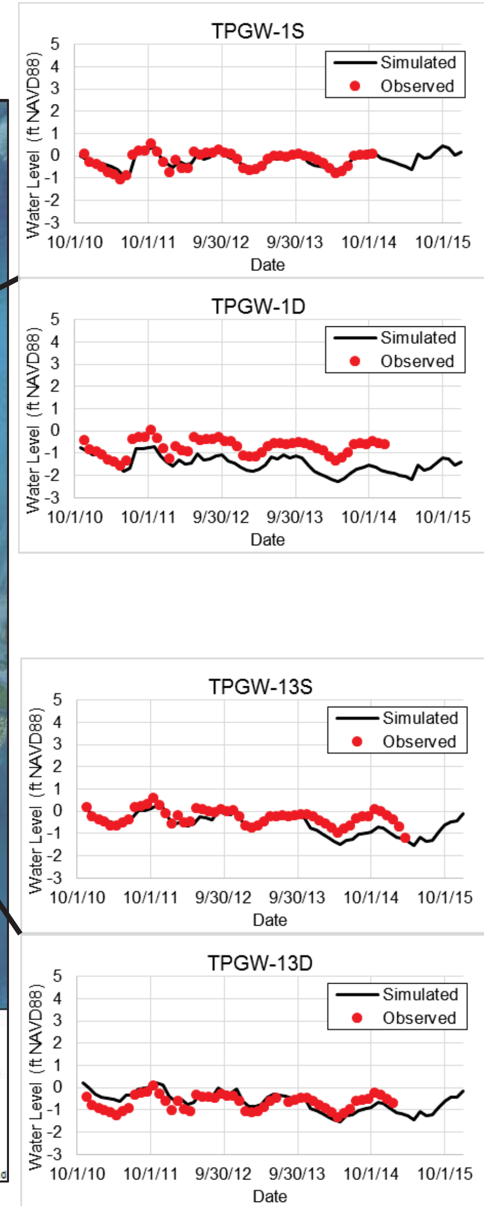




Monthly Model Water Level (Initial)







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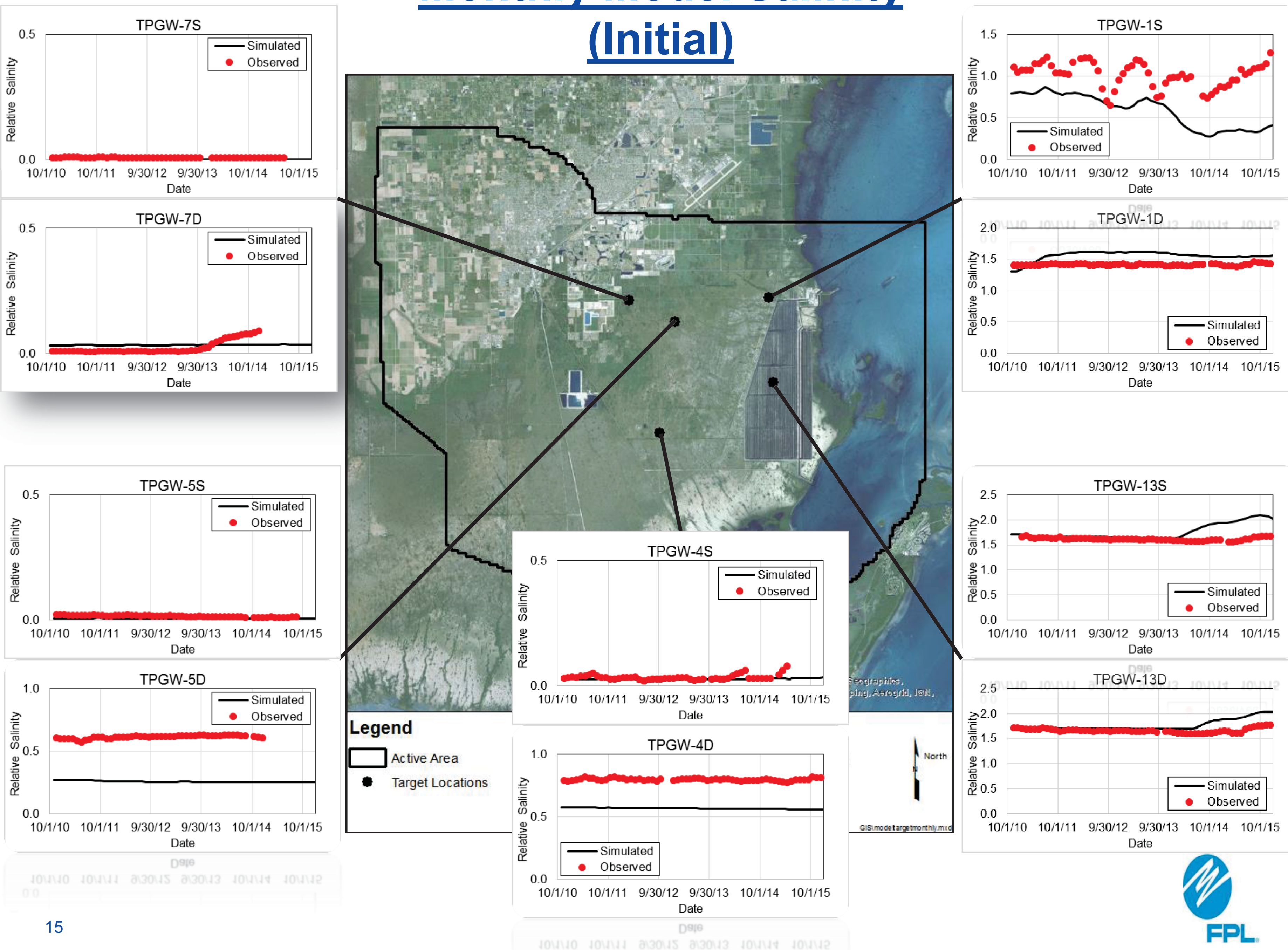
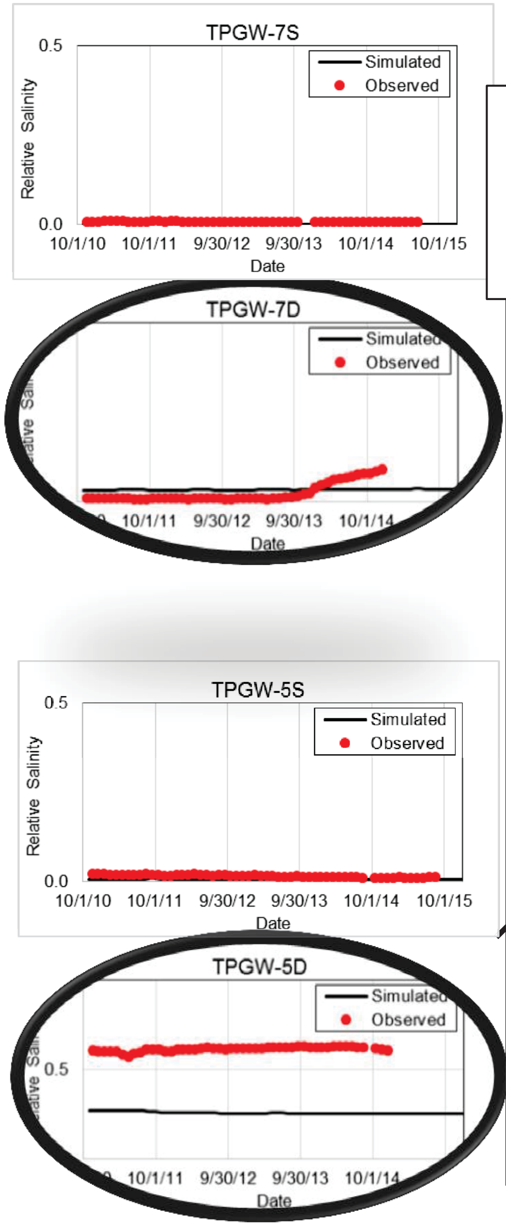
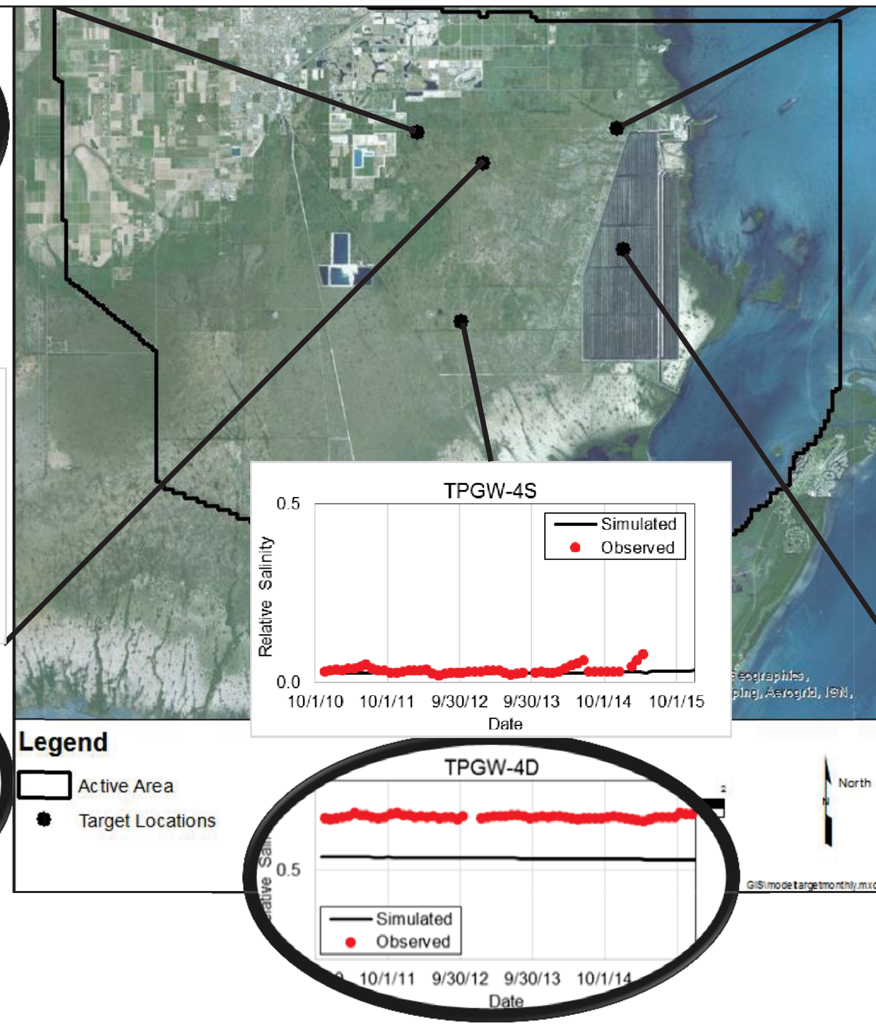
Monthly Model Salinity (Initial)

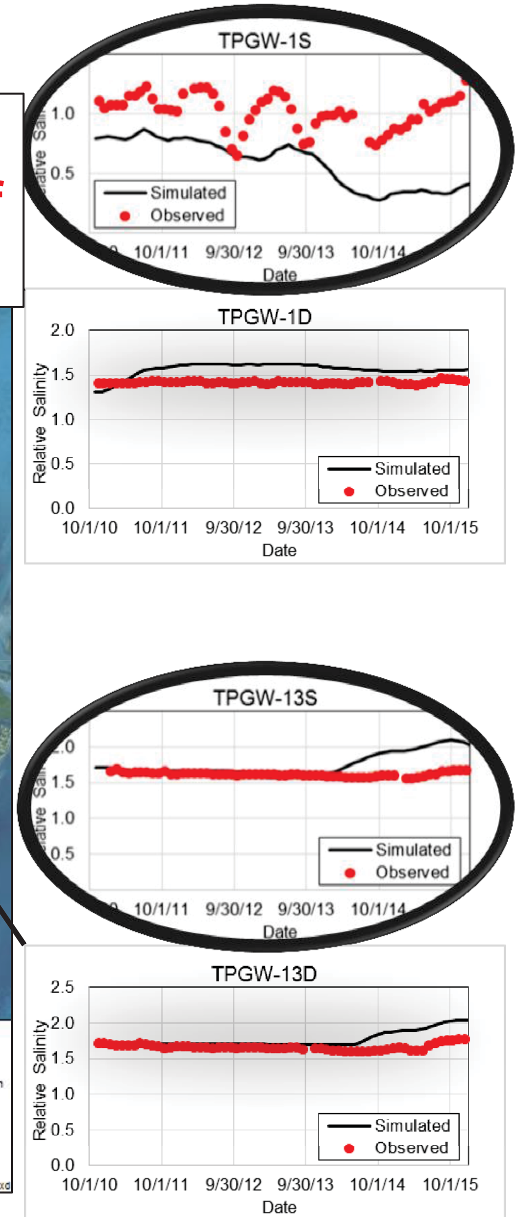


Monthly Model Salinity (Initial)

Model consistently underestimates salinity to west of CCS







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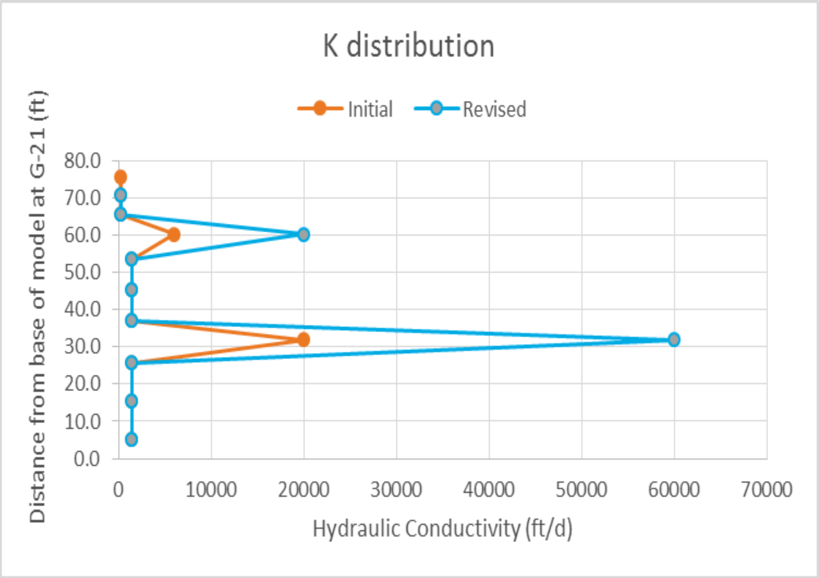
Hydraulic Conductivity Revision

- Initial objective: utilize existing aquifer data informed by recent APT results
- Calibration results point to need to increase hydraulic conductivity (K):
  - Distal saline water breakthrough (G-21, G-28, TPGW-7) is not matched
  - APT K / transmissivity (T) is low with respect to other APTs and regional models
- Decision to raise K
  - Consistent with scale dependence of localized test vs regional models
  - Double T
  - Increase K of high flow zones



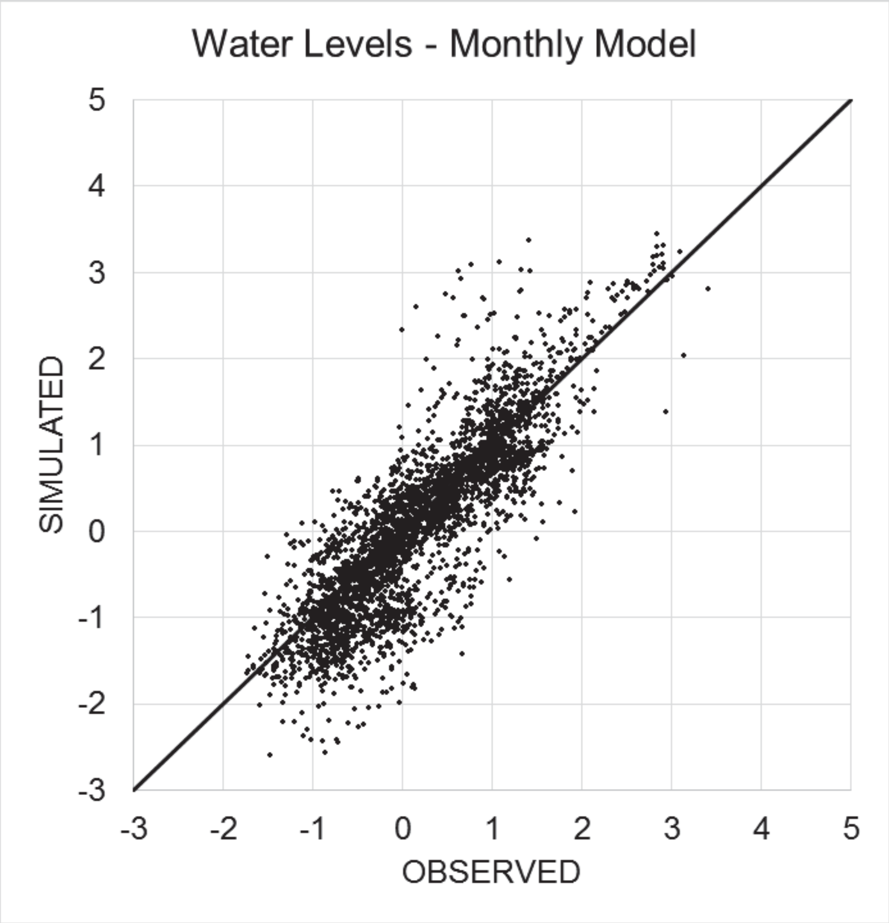
Calibration Statistics (Revised)

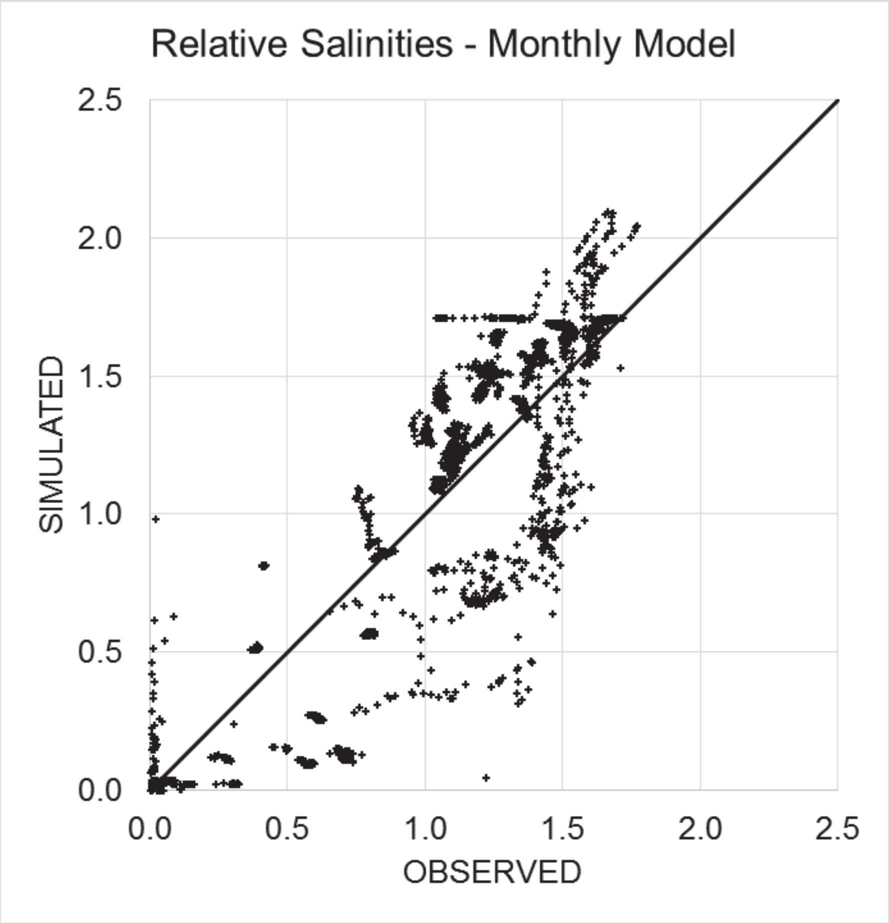
Metric	Mean Error (ft)	Mean Absolute Error (ft)	MAE / Range (percent)	Number of Targets
Seasonal Salinity	0.171	0.229	11.4	2979
Seasonal Heads	0.007	0.464	6.8	839
Monthly Salinity	0.095	0.161	9.1	2482
Monthly Heads	-0.035	0.356	6.9	3476

Monthly model heads and salinity improved with little change to seasonal statistics

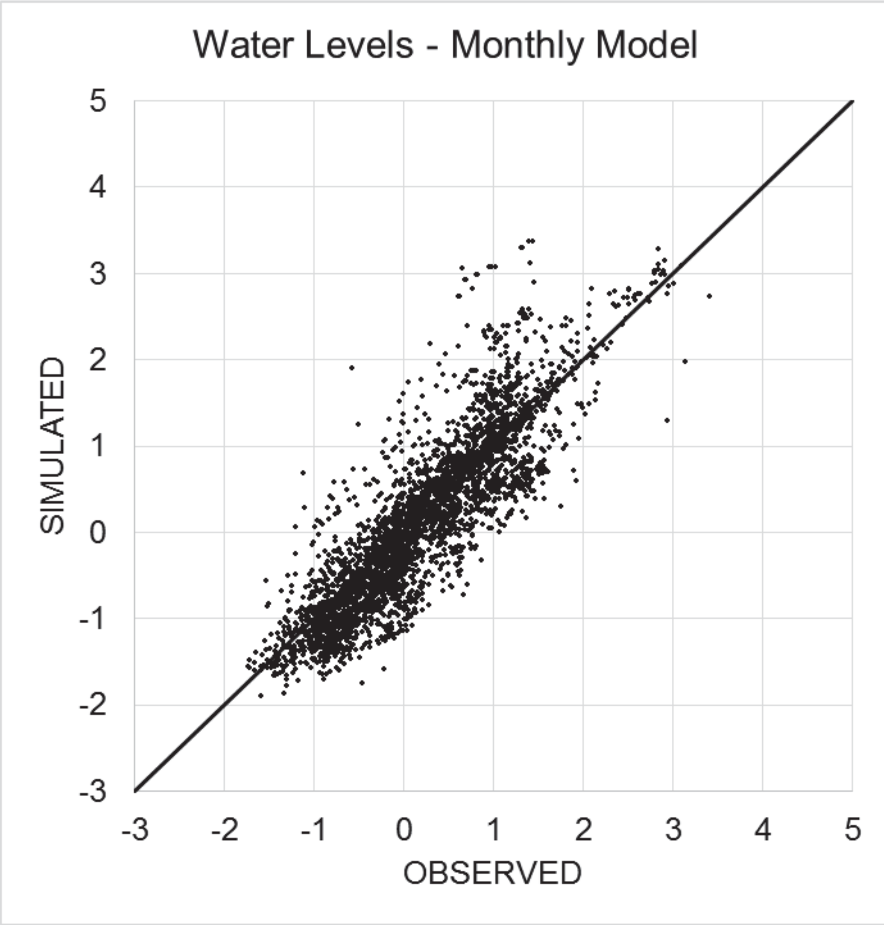
- **Numerical measures of calibration**
- **Mean Error:**
  - $= \frac{1}{n}\sum_{i=1}^{n}(h_m - h_s)_i$
  - A measure of bias
  - Want to be close to 0.0
- **Mean Absolute Error:**
  - $= \frac{1}{n}\sum_{i=1}^{n}\left|(h_m - h_s)_i\right|$
  - A measure of error without regard to +/-
  - Want to be 5-10% of the range of observations

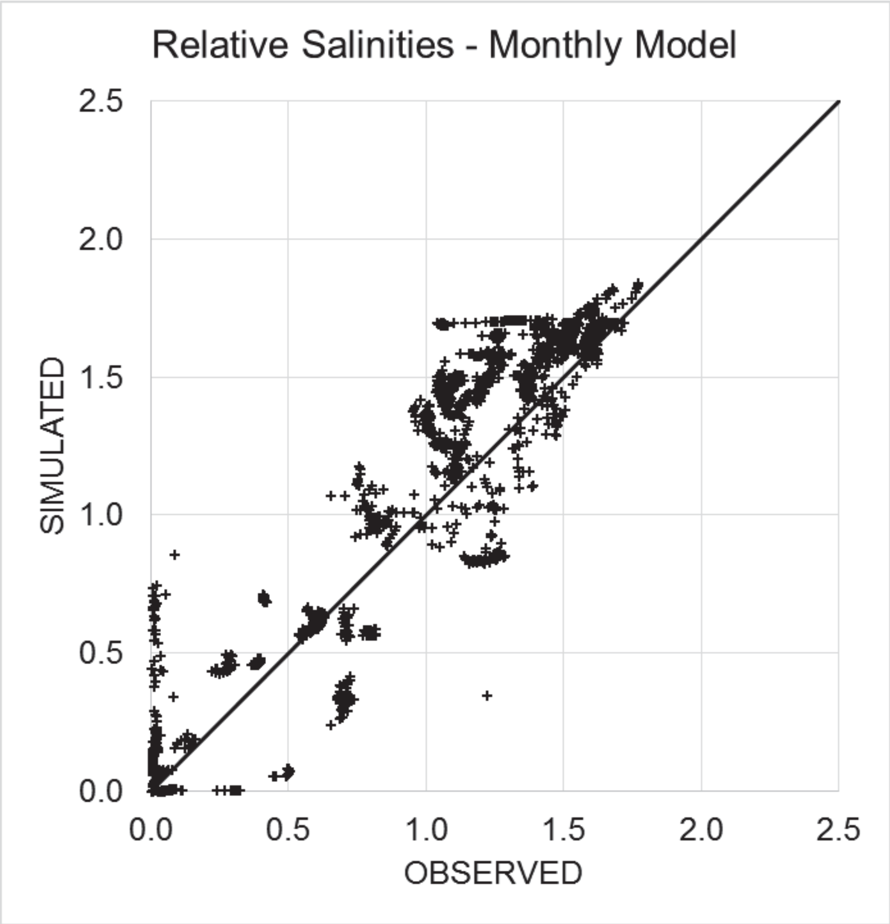
Simulated vs Observed (Initial)





Simulated vs Observed (Revised)





Significant improvement in match to water level and salinity targets in revised model

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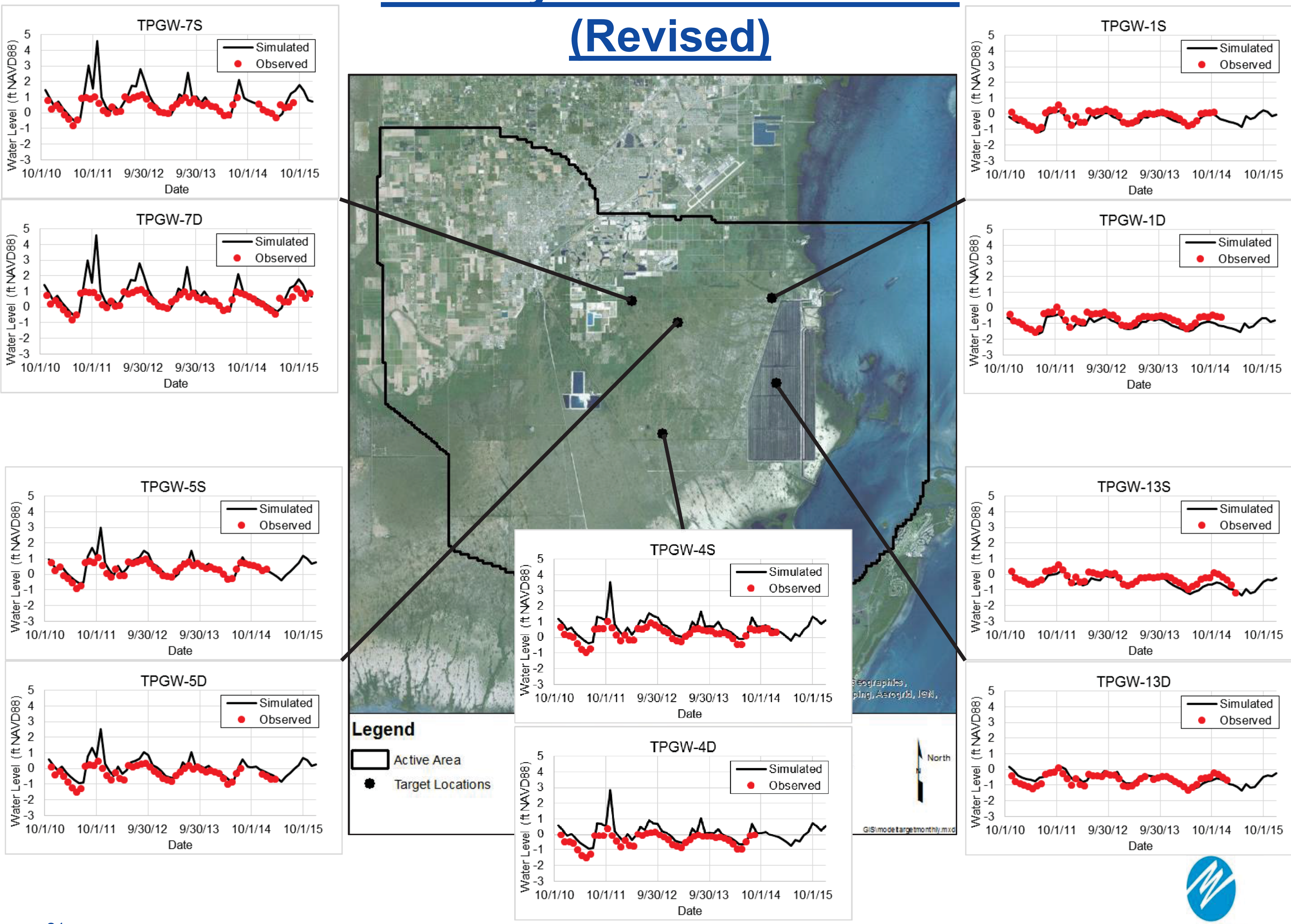
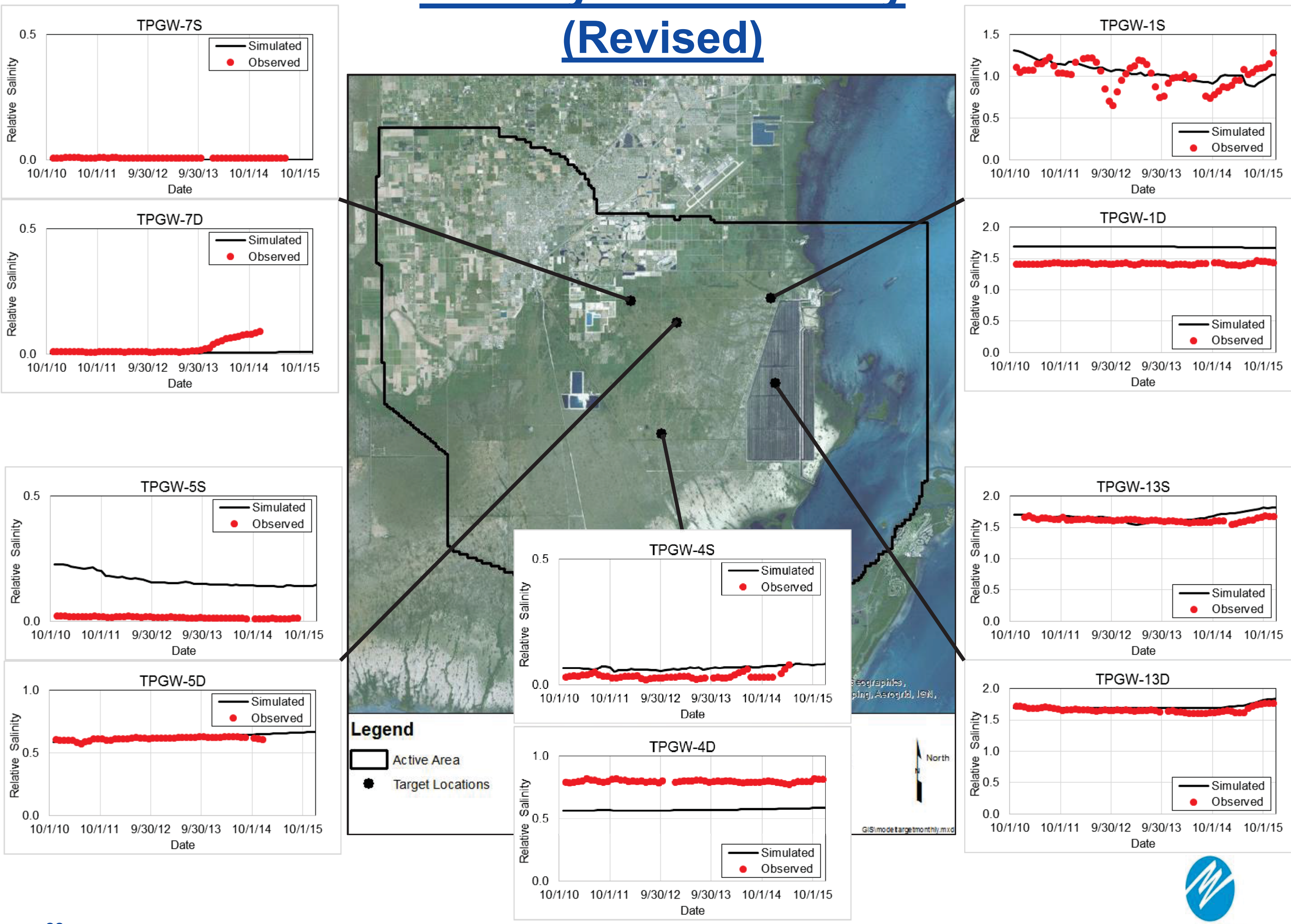
Monthly Model Water Level (Revised)



Monthly Model Salinity (Revised)



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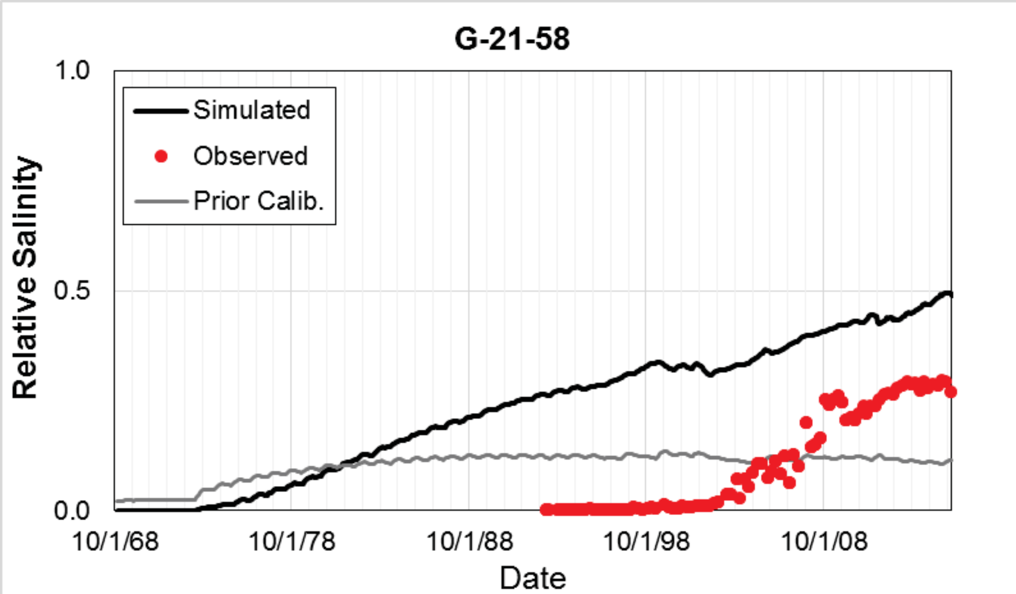
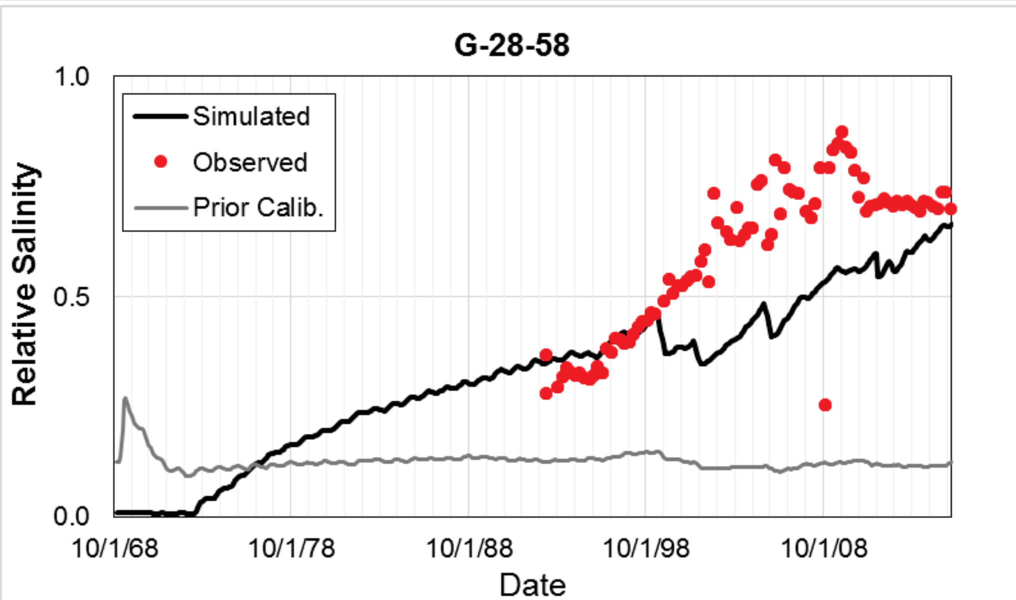
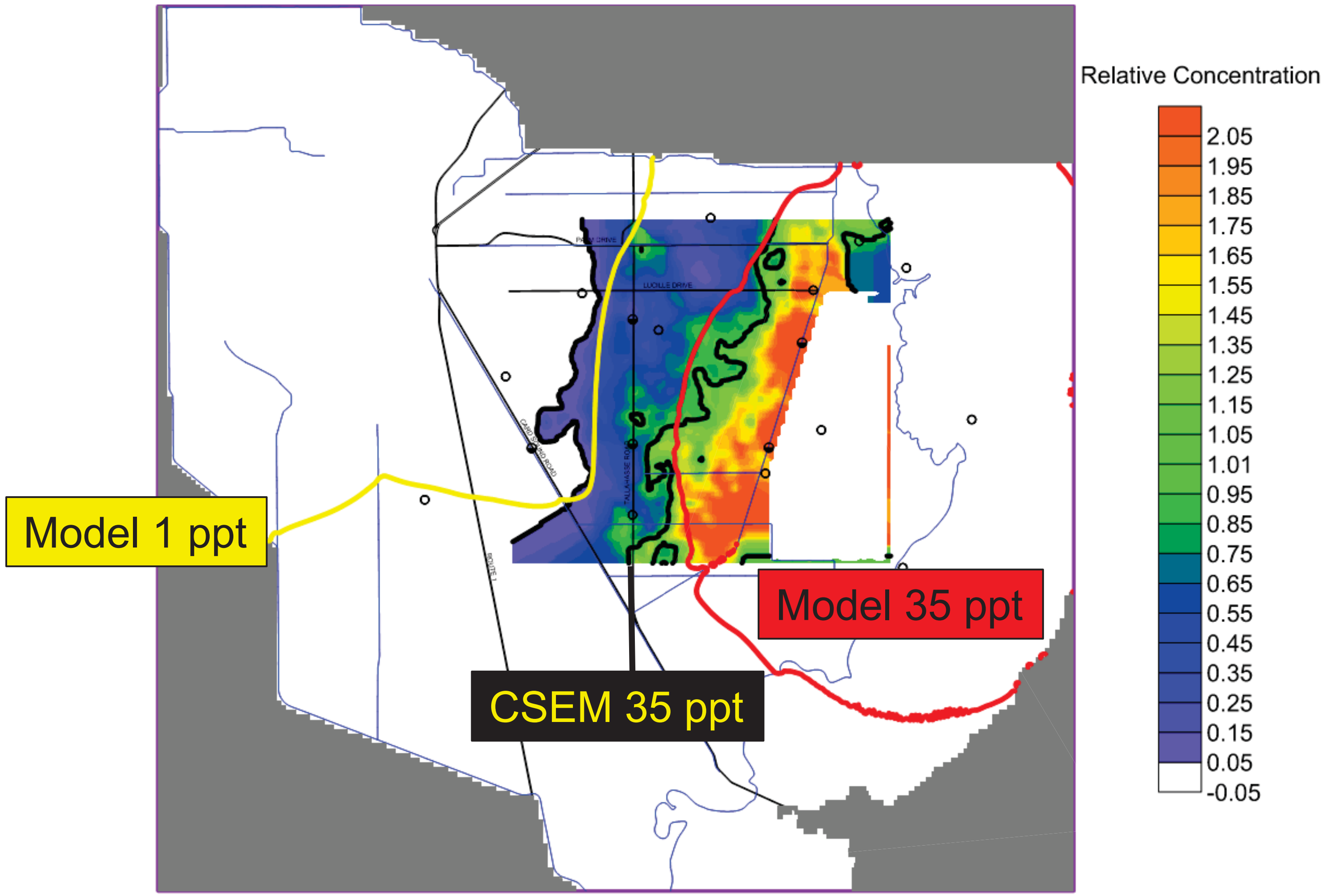
Salinity at Distal Wells





Revised model better simulates breakthrough at G-wells

CSEM / Model Comparison for 2016

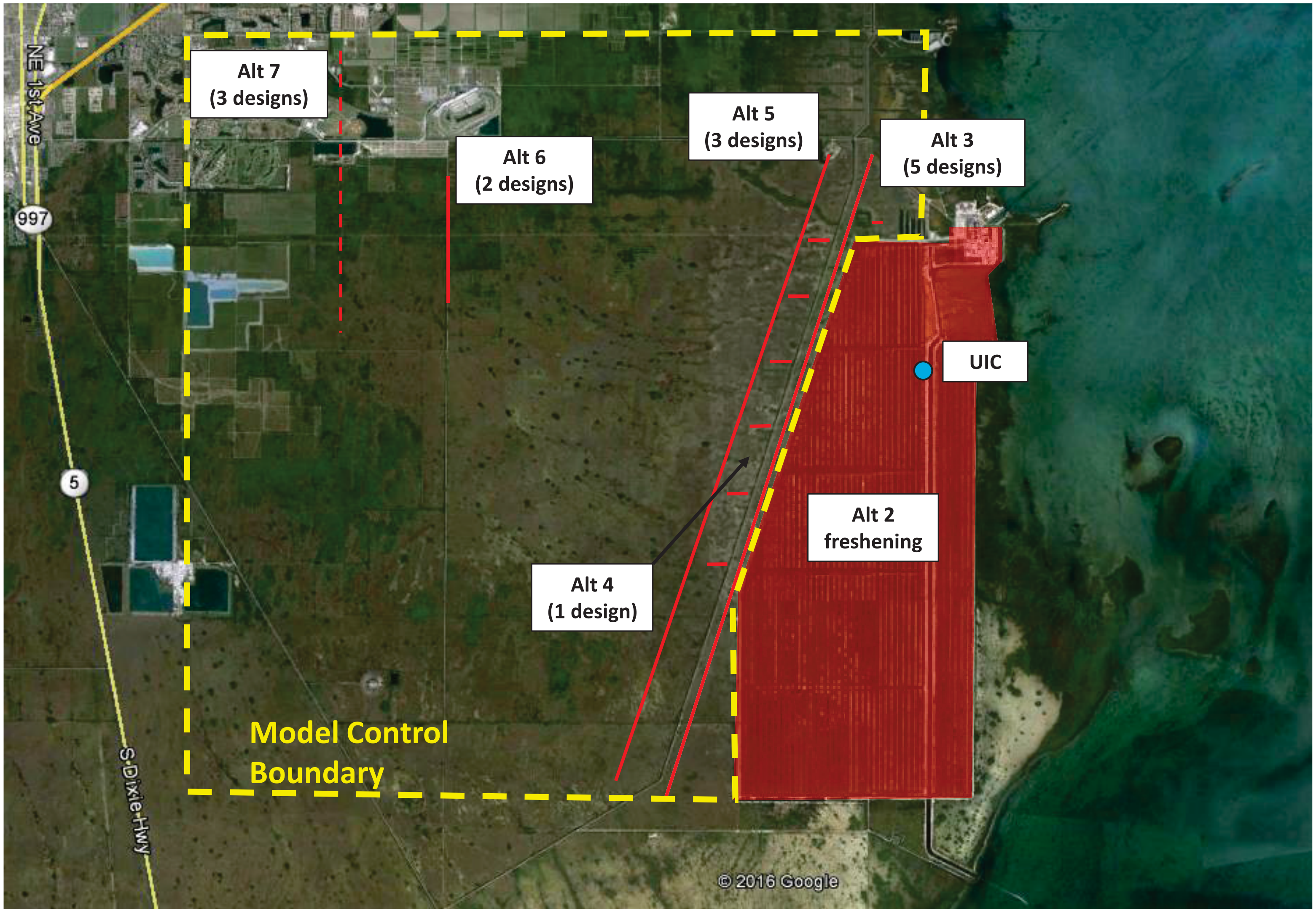


Note: CSEM data at -55 ft; model 35 ppt line in layer 8, 1 ppt line in layer 11

Model Deemed Calibrated and Ready for Simulation of RWS Scenarios

- Meets calibration guidance of:
  - Distal saline water breakthrough (G-21, G-28) is reasonably matched
  - ME close to 0.0 in monthly simulation of head and salinity
  - MAE less than 10% of range of head and salinity
  - CSEM data reasonably matched
- Model ready for use as an engineering tool that contributes to decision-making and conceptual design
- The two simulated K distributions provide *sensitivity analysis on predictions*

RWS Alternatives That Were Simulated



Note: 32 scenarios simulated (16 designs (including no action) x 2 K distributions)

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Variable Density Ground Water Model Analysis and Results

Remedial Alternatives Modeling Evaluations and Selected Alternative

James Ross Ph.D. and Pete Andersen, P.E.

Tetra Tech

May 16, 2016

Presentation Outline

- Review abatement and remedial alternatives
- Ranking criteria for recovery well system (RWS) alternatives
- Selected alternative and results
- Conclusions and schedule

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RWS Alternative Categories

- **Hypersaline Plume RWS Alternatives**
  - Objectives; Address provisions of the Consent Agreement
    - -- Intercept, capture, contain, and ultimately retract the hypersaline plume
    - -- Demonstrate that it will not create adverse impacts to groundwater, wetland, or other environmental resources
- **Saltwater Interface RWS Alternatives**
  - Objectives
    - -- Evaluate options to stabilize or retract the toe of saltwater at the base of the Biscayne aquifer

RWS Alternatives

- **Near-source RWS Alternatives**
  - Alternative 1 – Baseline condition (if no action were to be taken)
  - Alternative 2 – CCS Salinity Abatement
  - Alternative 3 – Vertical well extraction (7 wells, 15 MGD) west of ID (on FPL property)
  - Alternative 4 – Horizontal well extraction (6 wells, 15 MGD) west of L-31E (on FPL property)
- **Freshwater-saltwater toe RWS Alternatives**
  - Alternative 5 – Vertical well extraction (7 to 16 wells, 15 MGD) further west of L-31E
  - Alternative 6 – Vertical well extraction (6 wells, 12 MGD) on SW 137th Ave
  - Alternative 7 – Vertical well injection (4 to 8 wells, 1 to 5 MGD) Along theoretical SW 147th Ave

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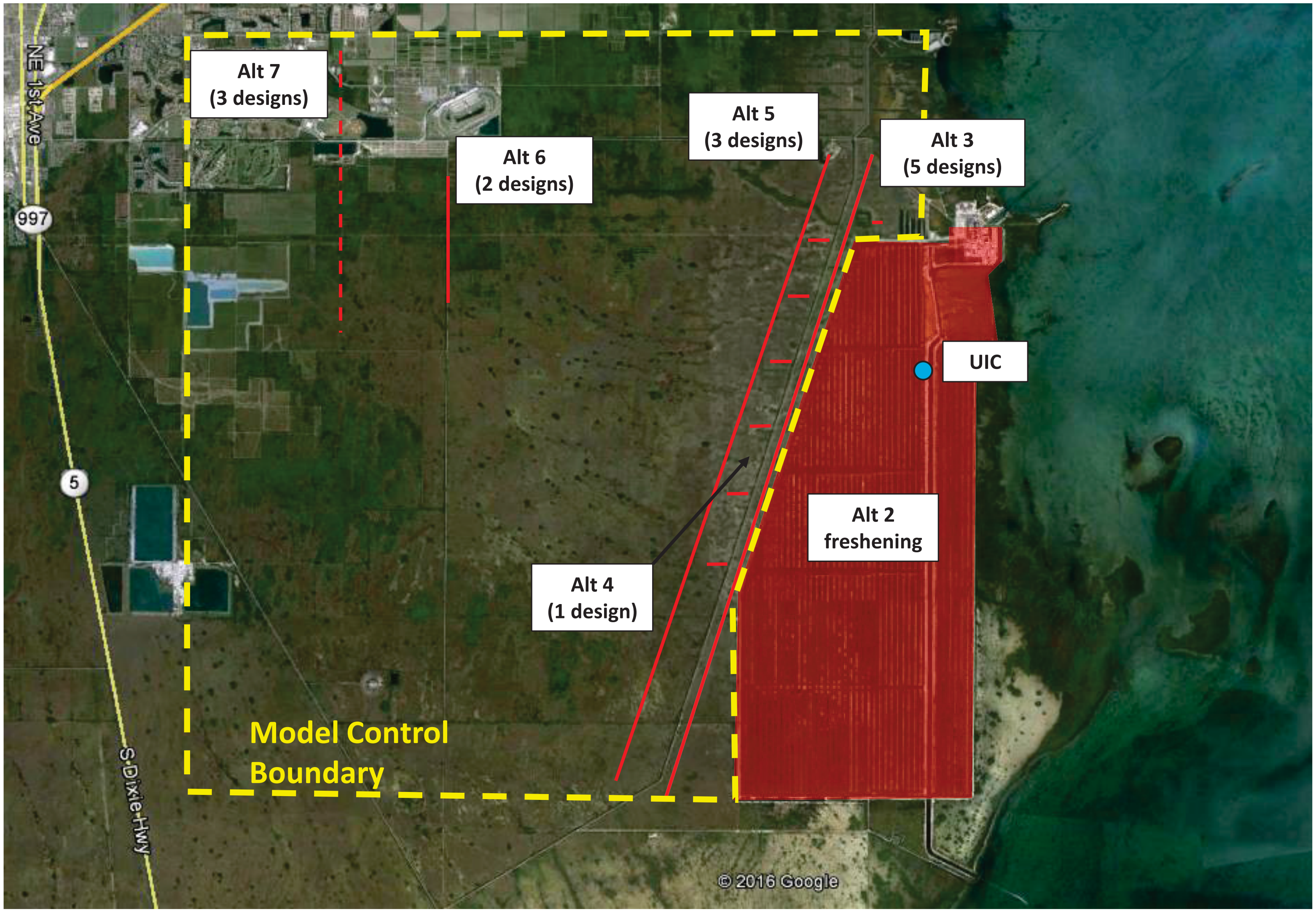
RWS Alternatives



Applications Simulations: Selection Criteria

Criteria	Metric	Score
Reduction of hypersaline cells relative to initial condition (after 5 and 10 yrs of operation)	Number of model cells changed within Compliance Zone	1 to 5 based on % of cells reduced from HS to S
Mass reduction in hypersaline cells (after 5 and 10 yrs of operation)	Mass reduced from initial hypersaline condition	1 to 5 based on % reduction from Initial Condition
Movement of edge of hypersaline water (5 and 10 year evaluation)	Number of model rows where hypersaline interface is pulled back to model control boundary	1 to 5 based on % of rows with interface pull back
Degree of retreat of 'toe' of salt water interface (5 and 10 year evaluation)	Number of model rows near ACI and Newton where toe retreats	1 to 5 based on % of rows with interface retreat
Wetland impacts	Number of wetland cells with drawdown in layer 1 compared to base case	-3 to 3 based on # of cells exceeding 0.2 and 0.5 ft. of drawdown
Surface water seepage	Percentage of withdrawal from SW seepage	-5 to 5 based on surface water flows from less than 30% to greater than 50%

Applications Simulations: Selection Criteria

Criteria	Metric	Score
Time to Implement	months	-3 to 3
Permits	Number and complexity	-3 to 3 best professional judgment
Legal Control	Degree project component depend on non FPL lands	-3 to 3: yes/no combined with magnitude
Public perception/relations	Best professional judgment	1-3; 3 = public benefit 2 = neutral 1 = negative perception
Retracts hypersaline plume to the L-31 E in 10 years	Model responses to high flow zones	0 = no 5 = yes

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Applications Simulations: Ranking Matrix

Criteria	Desciption	Score	Alternative 2	Alternative 3	Alternative 3 B	Alternative 3 C	Alternative 3 D	Alternative 4	Alternative 5	Alternative 5B	Alternative 5C	Alternative 6	Alternative 6B	Alternative 7A	Alternative 7B	Alternative 7C	Alternative 8
1	HS Cell Reduction (1 to 5 years)	>50% = 5; 40-49% = 4; 30-39% =3; 20-29% =2; 10-19% = 1	1	4	4	4	4	4	4	4	4	1	2	2	2	2	4
	HS Cell Reduction (6 to 10 years)	>80% = 5; 70-79% = 4; 60-69% = 3; 50-59% = 2; 40-49% = 1	0	2	2	3	3	2	2	2	2	0	0	0	0	0	2
2	HS Mass Reduction (1 to 5 years)	>50% = 5; 40-49% = 4; 30-39% =3; 20-29% =2; 10-19% = 1	1	3	3	3	3	4	3	3	3	1	1	1	1	1	3
	HS Mass Reduction (1 to 5 years)	>80% = 5; 70-79% = 4; 60-69% = 3; 50-59% = 2; 40-49% = 1	0	1	2	2	2	2	1	2	2	0	0	0	0	0	2
3	HS Interface Movement (5 years)	>50% = 5; 40-49% = 4; 30-39% =3; 20-29% =2; 10-19% = 1	2	4	4	4	4	4	3	3	3	2	2	2	2	2	4
	HS Interface Movement (10 years)	>80% = 5; 70-79% = 4; 60-69% = 3; 50-59% = 2; 40-49% = 1	0	2	2	2	2	2	2	2	1	0	0	0	0	0	2
4	SW Interface Movement (5 years)	>50% = 5; 40-49% = 4; 30-39% =3; 20-29% =2; 10-19% = 1	0	3	3	2	2	3	4	4	3	5	4	3	3	3	3
	SW Interface Movement (10 years)	>80% = 5; 70-79% = 4; 60-69% = 3; 50-59% = 2; 40-49% = 1	0	1	1	1	1	1	2	2	2	3	2	2	3	3	1
5	Wetland impacts	3= no cells w/ DD>0.2 ft 0= no cells >0.5 ft -1 = 1-10 cells > 0.5 ft -2 = 11-44 cells >0.5 ft -3= >45 cells > 0.5	3	-2	-2	-2	-2	-2	-3	-2	-3	-3	-3	3	3	3	-1
6	Surface water seepage	-5 if more than 50% is from surface water canals; 0 if 30 to 50% and +5 if less than 30%	5	0	0	0	0	0	0	0	0	5	5	5	5	5	0
7	Time to Implement	ESTIMATED:-3= > 2 yr, 0= 1.5 - 2 yr, 3= 0<1.5 yr	3	3	3	3	3	0	-3	-3	-3	0	0	0	0	0	3
8	Permits	3 permitting <0.5 year; 0 permitting .6 to 1 year; -3 permitting >1 yr	3	3	3	3	3	0	0	-3	-3	0	0	-3	-3	-3	-3
9	Legal Control	use 3 if on FPL land: -3 if project is on non FPL land	3	3	3	3	3	3	3	3	3	-3	-3	-3	-3	-3	-3
10	Retracts hypersaline plume	0 = not back to L-31 5 = fully back to L-31	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
		scores															
		TOTAL HYDRAULIC (rows 1- 6)	12	18	19	19	19	20	18	20	17	14	13	18	19	19	20
		TOTAL MANAGEMENT (rows 7-10)	9	9	9	9	14	3	0	-3	-3	-3	-3	-6	-6	-6	-3
		TOTAL	**21**	**27**	**28**	**28**	**33**	**23**	**18**	**17**	**14**	**11**	**10**	**12**	**13**	**13**	**17**

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Selected Alternative

- **FPL identified Alternative 3 configurations B, C, D as the superior alternatives**
  - Configurations vary in length of north-to-south transect of extraction wells
- **Of these configurations, Alternative 3D wells are located along greatest N-S transect (north of CCS to southern CCS edge)**
- **This alternative performed well for:**
  - Maximizing N-S retraction of the hypersaline plume
  - Reducing hypersaline mass in aquifer
  - Moderating drawdown impacts to wetlands
  - Minimizing off-site activities and environmental impacts
  - One year implementation, straight forward permitting path
  - FPL control of project lands (extraction, disposal, transmission)

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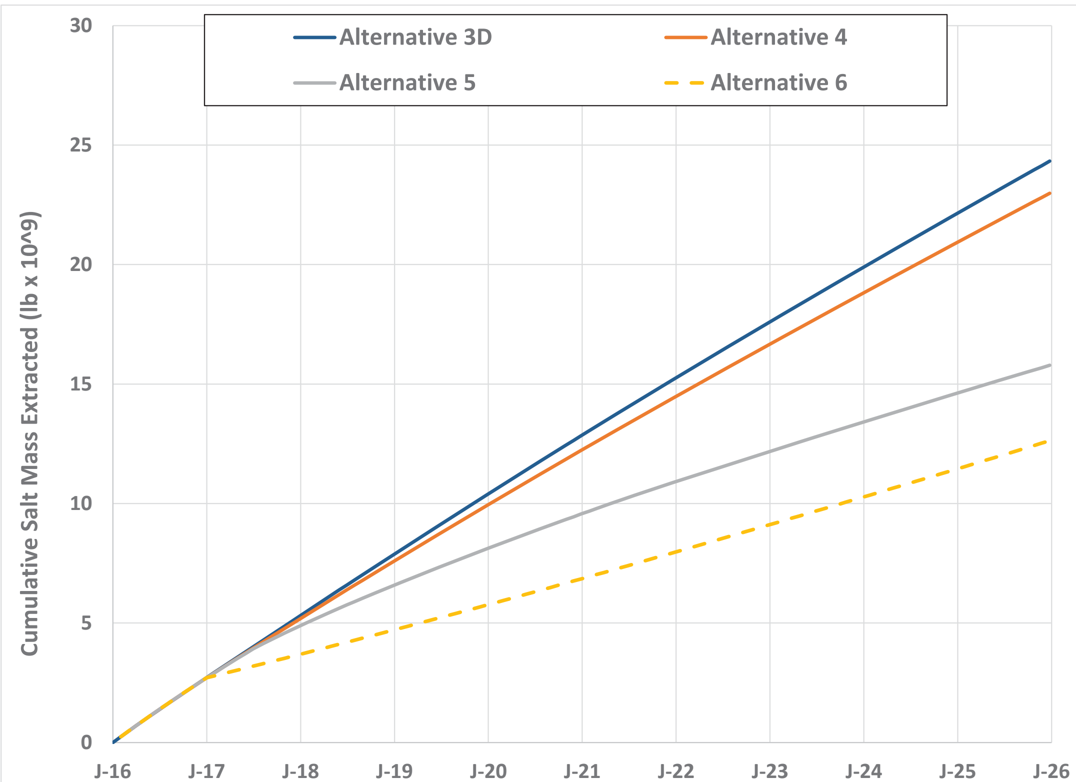
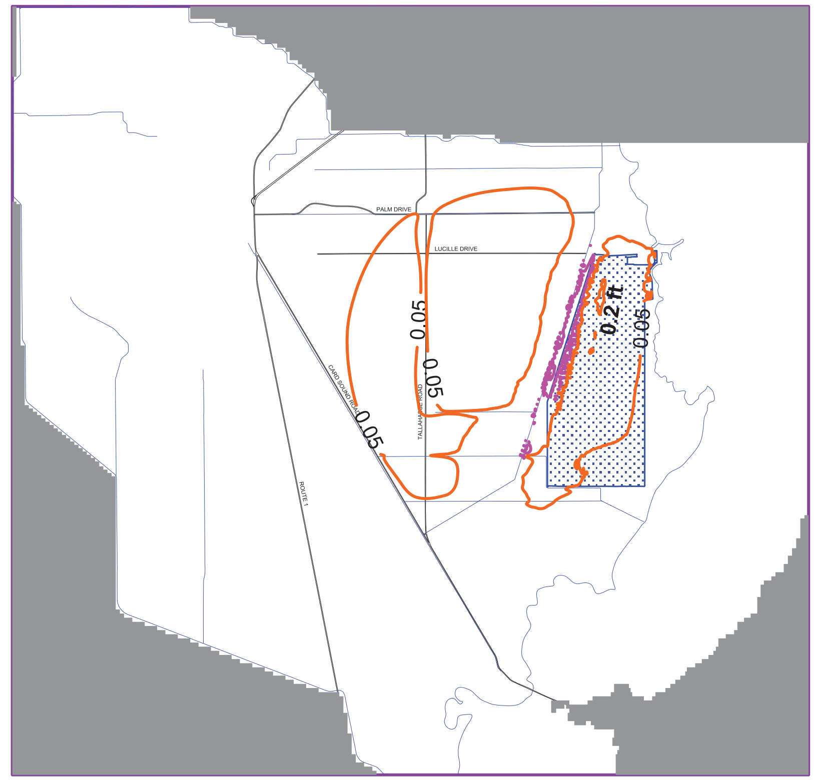
Alternative 3D Impacts

Cumulative Salt Mass Extracted



Impacts to Wetlands



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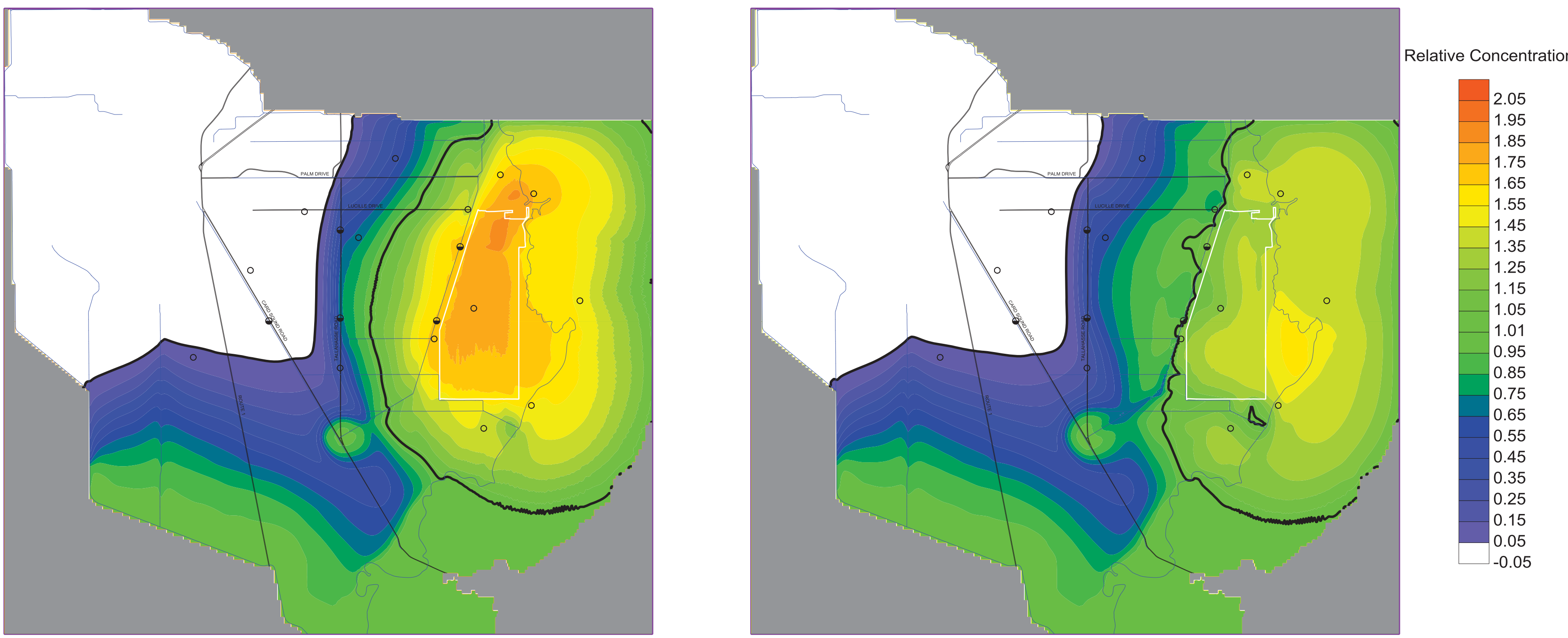
Shallow to Mid-Aquifer Saltwater Wedge Movement

Year 1 - 2016 | Year 5 - 2020

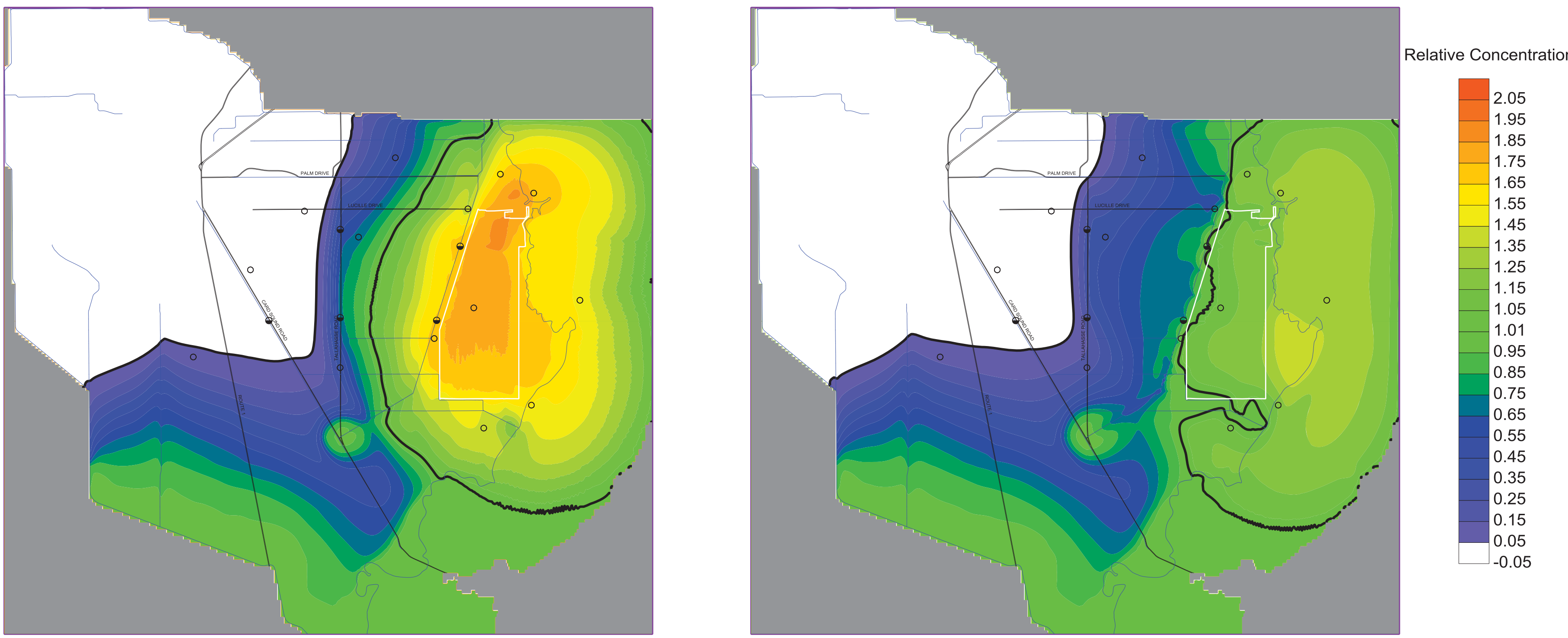


Black contour line west of the CCS represents landward location of hypersaline groundwater (>19,000 mg/L chloride)

Shallow to Mid-Aquifer Saltwater Wedge Movement

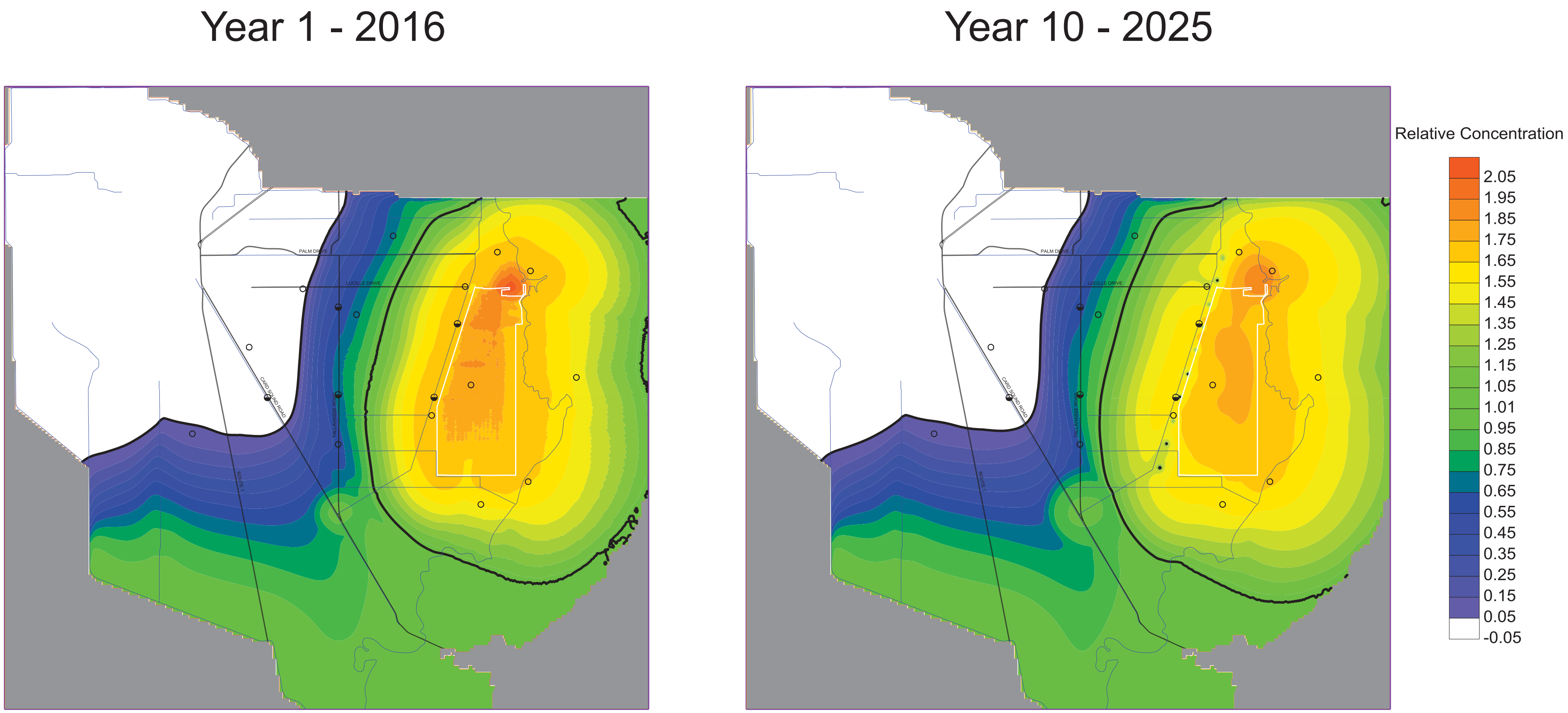
Year 1 - 2016

Year 10 - 2025



Black contour line west of the CCS represents landward location of hypersaline groundwater (>19,000 mg/L chloride)

Deep Aquifer Saltwater Wedge Movement



Black contour line west of the CCS represents landward location of hypersaline groundwater (>19,000 mg/L chloride)

Conclusions

- **Model in it's current state of development is sufficient to evaluate performance of remediation alternatives**
  - Model simulates hypersaline groundwater at the base of the aquifer farther west than is represented in the CSEM results
    - -- Over-simulation of mass in deep samples of G-28
  - Model potentially underestimates capture of hypersaline groundwater along the base of the aquifer west of the CCS
  - Additional refinements to the salinity distribution and rate of migration could be made in the western part of the model domain
  - Continued refinement of the model will proceed as prescribed in the Consent Agreement

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Conclusions

- Extensive and multi-faceted evaluation of myriad alternatives produced a recommended Recovery Well System alternative
- Recommended alternative Alt 3D, pulls hypersaline interface back to compliance boundary within first 5 years
- Continued improvement in terms of saline and hypersaline reduction expected over years 6 to 10
- No single extraction alternative was capable of both retracting the hypersaline plume west and north of the CCS to the L-31E canal AND retracting the saltwater interface
- Alternative 7C involving recharge of the Biscayne Aquifer at rates of 2 mgd along theoretical SW 147th Ave appear effective in stopping westward migration of the interface and possibly pushing the toe further east

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Schedule

- Formulation of Objectives (complete)
- Data Review (complete)
- Model Design (complete)
- Calibration (complete)
- Finalize ranking of alternatives (complete)
- Internal Vetting (complete)
- ID Operations Review (complete)
- Prepare Datasets and Presentation to MDC (complete)
- **Meeting with MDC (today) to present:**
  - ID operations review
  - Selected RWS alternative
- **Miami Dade DERM review and approval**

Schedule

- **Miami Dade DERM review and approval**
- **Approved alternative action items**
  - permitting, monitoring well construction
  - engineering design,
  - Construction contracting,
  - Construction
  - Operational testing
  - Operations, monitoring and reporting