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Water 2020: Water Supply Planning

Summary Report on Groundwater Modeling Subgroups for Areas I, II, and V

St. Johns River Water Management District
Palatka, Florida

St. Johns River Water Management District
Palatka, Florida

Water 2020: Water Supply Planning

Summary Report on Groundwater Modeling Subgroups for Areas I, II, and V

Charles H. Tibbals

September 1999

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INTRODUCTION

The St. Johns River Water Management District (SJRWMD) Water 2020 process is an ambitious regional water supply planning initiative. It involves estimation of future water supply needs for one of the fastest growing regions in the State of Florida. It involves development of environmental, hydrologic, and water quality criteria to define natural system needs, and the development and evaluation of complex water supply management alternatives. All planning activities are conducted with public involvement and the participation of all affected and interested parties is actively solicited.

Because of the magnitude and complexity of the task at hand several tools have been developed to assist in the planning process, these include the following:

- Groundwater flow models
- Groundwater allocation models
- Economic optimization and decision models

Each of these models is designed to help define and evaluate the nearly limitless number of options and alternatives available within the planning area. The groundwater flow models provide a particularly important function. These models estimate the hydrologic and water quality response of the aquifer system to groundwater withdrawals and provide the basic foundation for all other planning tools.

During the first of the District's public Workgroup meetings used to introduce the Water 2020 plan, it was recognized that the groundwater flow models were, in effect, the foundations upon which the allocation and optimization models were to be built. Three of the six area Workgroups decided there was a specific need for a smaller groups of interested parties to focus more detailed attention on the groundwater flow models. To that end, modeling subgroups were established for Workgroup Areas I, II, and V.

PURPOSE AND SCOPE

The purpose of this report is to document the process, activities, and results of the modeling subgroups in Workgroup Areas I, II, and V. The enclosed documentation includes the Minutes of the subgroup meetings (Appendix A), model peer review comments and recommendations (Appendix B), and results of the modeling subgroup process.

ACKNOWLEDGMENTS

The District wishes to thank all of the individual participants that attended the modeling subgroup meetings and model peer review meetings. Special thanks go to Orlando Utilities Commission, Volusian Water Alliance, and St. Johns County Board of Commissioners for allowing the District to use their meeting rooms and technical facilities in order to accommodate the modeling subgroups.

BACKGROUND

The first Workgroup meetings introduced the notion of groundwater modeling to achieve predictions of year 2020 groundwater levels, spring flows and wetlands water levels. The concept of computer modeling of groundwater flow was met with open skepticism. The reasons for that skepticism probably included less-than-complete explanations of the modeling process by the District; the public's lack of familiarity with what is involved in computer modeling; and a certain amount of general suspicion of the entire notion of computer modeling.

Because of the large and varied makeup of the Workgroups, it was decided by the Workgroups in Areas I, II, and V to create modeling subgroups and to convene a series of meetings where interested parties could receive detailed modeling presentations and ask questions to gain a better understanding of how groundwater flow modeling is conducted. The District contracted with Charles Tibbals, retired hydrologist formerly with the U.S. Geological Survey (USGS), to Chair and to moderate the modeling subgroup meetings.

SUBGROUP PROCESS

At least 3 subgroup meetings were held for each area. Attendance was typically in the range of 6-10 people in addition to District personnel. The modeling familiarity of the subgroup members ranged from fair to nonexistent but all were interested in satisfying themselves that the process was legitimate.

The first subgroup meeting in each area tended to be somewhat contentious but, after an initial venting, the attendees became more comfortable with the notion of computer modeling as they became more informed about the legitimacy of the process and, especially, of the tools.

The first major milestone occurred when the attendees realized that the models were not "home-brewed black boxes" created by the District but were long established, peer-reviewed, published and available model codes such as the MODFLOW (1988) code authored by USGS researchers Mike McDonald and James Harbaugh. The subgroups learned that the model codes were essentially "kits" that provide the framework into which local hydrologic data and stresses are input in order to craft a groundwater flow model that represents the local flow system.

The subgroups became comfortable with the legitimacy of the model codes but they still wanted to be assured that the local models were properly constructed from a valid conceptual model; that appropriate modeling assumptions were made; appropriate boundary conditions were imposed; and that the models were properly run, calibrated, and interpreted. However, they realized that the technical expertise necessary to make those determinations was not contained in the subgroup membership. Therefore, it was decided to convene technical peer review panels comprised of qualified modelers and these panels would examine, in detail, the District's models from conception through execution and interpretation. It was felt that it was important to have a lead reviewer that was totally removed from the Water 2020 process, that had no previous ties to the District, and that was intimately familiar with groundwater flow models and Florida groundwater hydrology. The District contracted with Robert E. (Bob) Faye, P.E., retired USGS Groundwater Specialist for the Southeast Region. Bob Faye was the lead reviewer and Charles Tibbals was co-lead reviewer. The technical qualifications of Bob Faye and Charles Tibbals are noted in Appendix C.1. From time-to-time, other private consultants, modelers, and interested citizens with a technical background sat in and participated in the reviews of models that dealt with their particular areas. Bob Faye and Charles Tibbals sat on all of the peer panels. The reviews were open to all observers that wished to attend and they could ask questions directly or through the reviewers. Two rounds of reviews were conducted for each groundwater flow model.

The first round of reviews was completed in late July 1998, and the review results were written-up and distributed to interested parties by late August. At this point, the subgroups were fairly at ease with the overall validity of the groundwater flow models.

Soon after the completion of the first round of peer reviews was completed, it became apparent from the initial results of the optimization and decision modeling conducted by District contract consultants at the University of Florida, that wetlands water-level declines (rather than declining spring flows or salt-water intrusion) were driving the Decision Model results in terms of determining locations of water-supply deficit areas and the size of the deficits. Charles Tibbals wrote a letter (Appendix C.3) to Barbara Vergara, Director of the Division of Water Supply Planning, SJRWMD, expressing concern that the models may not be entirely capable of the required degree of accuracy in determining declines in wetland water levels in response to pumping. For example, projected wetlands declines of 0.35' or more in a specific area would signal an unacceptable level of wetlands drawdown for that area. Tibbals felt like it was problematic as to whether the groundwater flow models were capable of accurately computing such a small change in water level in the surficial aquifer, especially projected 20 years in time.

The District then decided that the aspect of "uncertainty" in groundwater flow model results should be explored and that methodologies should be developed to incorporate that uncertainty into the Decision model results. The issue of model uncertainty is addressed in a separate report prepared by District consultants, CH2Mhill, Gainesville, FL.

RESULTS

The Subgroup process allowed the District to present its groundwater flow models in a public forum yet in a more focused and detailed fashion than could be accomplished in the Workgroups. The attendees of the Subgroup meetings were able to participate in the meetings and were able to directly question the District modelers in order to gain a better understanding of the models. A second result of the Subgroup process was the enabling of the technical peer review process to more accurately determine if the models were properly constructed, operated, and interpreted. Thirdly, the process gave rise to the notion of incorporating "uncertainty" in the results and interpretation of the models. Finally, and most importantly, the Subgroup process helped engender more public confidence in the use of groundwater flow models to predict the effects of future pumping on the hydrology of modeled areas. It is fair to say that not everyone came away from the process totally convinced. However, it is believed that almost everyone is more comfortable with the legitimacy of the models and with their potential efficacy in predicting future hydrologic effects.

APPENDIX A: MINUTES OF MODELING SUBGROUPS

Appendix A.1: Area I – East-Central Florida model area

Appendix A.1.a. -- Minutes of meeting of February 4, 1998

February 10, 1998

Charles H. Tibbals
297 E. Lakeview St.
Umatilla, FL 32784

Barbara Vergara, Director
Division of Needs and Sources
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H207: **Summary of 2-04-98 Area I Groundwater Modeling Subgroup Meeting**

Dear Barbara:

Please find enclosed the Minutes of the Area I Groundwater Modeling Subgroup Meeting of February 4, 1998, held in the conference room of Orlando Utilities Commission, 3800 Gardenia Avenue, Orlando, Florida, and chaired by me.

The Minutes contain the substance of the meeting; a listing of concerns later submitted to me by the attendees; and my comments and suggestions as to how to resolve those concerns.

The meeting was called to order at 2:00 PM and the attendees (listing attached) introduced themselves. I briefly explained my hydrologic experience and that I was recently retired from the U.S. Geological Survey and under contract with the District. I distributed blank comment sheets to each attendee and asked that they list their comments, concerns, and general impressions. Those sheets are included as enclosures here and I would suggest that copies of those sheets and the agenda be included when the Minutes are later sent to the attendees.

I reviewed my notes and the written concerns submitted by some of the attendees and was able to discern several common threads of thought. Those concerns and my comments are shown in the Minutes. In some cases only the concern is noted. My lack of comment on a concern does not, in any way, diminish its importance or utility. Rather, it simply means that the concern relates to District policy and is not addressable by me.

The meeting was adjourned at 5:30 PM.

If you have any questions regarding the meeting or this summary, please do not hesitate to contact me. Thank you.

Sincerely,

/S/

Attachments

cc: Doug Munch, Director, Division of Groundwater Programs, SJRWMD

MINUTES OF MEETING

St. Johns River Water Management District
Area I Work Group
Groundwater Modeling Subgroup
Chairman, Charles Tibbals

February 4, 1998

Conference Room
Orlando Utilities Commission
3800 Gardenia Avenue
Orlando Florida

The meeting was called to order at 2:00 PM.

The attendees (listing attached) were each asked to introduce themselves. Charles Tibbals, Chair, briefly described his hydrologic experience and explained that he was recently retired from the U.S. Geological Survey and was now under contract with the District to give technical support to the District's water resources assessments and water resources planning activities.

Comment sheets were given to each attendee and they were asked to list their comments, concerns, and general impressions that resulted from the meeting. Those sheets are included as an attachment along with a copy of the agenda.

Mr. Tibbals gave a brief presentation of the general groundwater hydrology of the East-Central Florida area and then gave an overview of the concepts of groundwater modeling.

Paula Presley gave a presentation on the status and history of regional groundwater model development in East-Central Florida.

Brian McGurk followed with a presentation of his work in developing the District's East-Central Florida Model.

Thoughtful questions were posed from the floor throughout all of the presentations and there was lively give-and-take. All of the comments were constructive in nature.

The next meeting will be at the same location, 2:00 PM, March 4, 1998.

The meeting was adjourned at 5:00 PM.

FOLLOWUP

The verbal and written concerns submitted by some of the attendees were later reviewed by the Chair. Several common threads of concern were identified. Those concerns and the Chair's comments are listed below. In some cases only the concern is noted. Lack of Chair's comment on a concern does not, in any way, diminish its importance or utility. Rather, it simply means that the concern relates to District policy and is not addressable by the Chair.

CONCERNS

(1) There was general discomfort that the models might be used in the Consumptive Use Permitting (CUP) process without sufficient proven verification of their accuracy and ability to predict future Floridan aquifer potentiometric heads and Floridan spring flows.

Comment: There was general agreement that more work needed to be done in order to instill confidence in the model results. That should include "verification" calibrations of at least one period that is drier than the original calibration period and another such verification of a period that is wetter. This seems like a reasonable course of action.

During the meeting, I explained the extreme difficulty in replicating an entire well hydrograph for its period of record because of the fluctuations caused by rainfall/recharge variations and the general lack of reliable historical pumping data in all categories except that for the large public suppliers. I believe that all parties will support short-term calibrations if the individual calibrations are for a sufficiently wide range of conditions.

Another effort that could help support confidence in the models would be to use time-series analyses at those locations where long-term water-level and springflow data are available. Such locations are few but a few wells (Orange 47, Alamana, Bithlo 1, Cocoa A, Seminole 125) and springs (Blue, Wekiva, and Rock) come to mind. Silver Spring is out of the area but it has over 60 years of continuous record and might be used to develop curves of relation for other springs with discontinuous or intermittent record.

(2) There was some concern expressed when I stated that model results were generally accurate to within about 20%.

Comment: I should have been more explicit by saying that the drawdowns simulated are generally accurate to within plus or minus 10%. Brian McGurk did a better job of this by describing drawdown error in terms of standard deviation. I did go on to say that, when spring flows were replicated as part of the calibration, the calibration is greatly enhanced. It was also made clear that the modeling calibration process makes every effort to remove all nonrandom error (bias) so that only random error remains and even that is sought to be minimized.

(3) "Why is it that we say the models compute can compute a reasonably accurate predicted change in head but the computed potentiometric surface is not necessarily as accurate?"

Comment: I explained that, although the computed potentiometric "change" map in head caused by future pumping scenarios is everywhere summed algebraically with the "starting" potentiometric surface in order to generate a resultant potentiometric map, there is no way to predict what effect future climatic conditions will also be superimposed as a stress. Therefore, the "shape" of the predicted potentiometric surface will be reasonably accurate even though its absolute altitude may be above or below that which is computed from the change and starting potentiometric head maps.

(4) "Consider using proscribed drawdown (and springflow) conditions to compute the amount and distribution of allowable pumping stresses."

Comment: The person who made this suggestion claims to have no particular experience or training in groundwater hydrology or ground- water flow modeling but he would have made a fine hydrologist!

The suggestion here is to solve the "inverse" problem -- that is, input the desired result and let the model compute the stresses that would cause that result. This is actually "Optimization and Decision modeling" and is harder than would first appear but it does raise the interesting possibility of an additional form of verification.

Why not sketch out acceptable potentiometric map and springflow conditions and then adjust the pumping distribution and amounts to conform? This would take a considerable amount of modeling effort and, if the predicted pumping amounts are left unchanged from the earlier projections, it would probably result in pumping distributions that would be uneconomical to incorporate within the existing infrastructure. Even so, it might be worth the exercise just to see what changes in pumping configurations would have to be made in order to accommodate the desired spring flows and potentiometric heads.

(4) "Let's increase the recharge to the drainage well zone in the Upper Floridan in order to create a 'water bank' and thereby increase potentiometric head ... the inflow water could be treated."

Comment: The rate at which inflow water would have to be treated during storm events would preclude such treatment but the notion of increasing the use of the drainage well zone has been discussed off and on for several years. The hydraulics of the matter are favorable but the water quality issues are, at this time, intractable within existing environmental regulations.

(5) A hydrograph was presented by one of the attendees that, at first glance, appeared to show a "leveling-off" of the decline in ground- water levels in recent years in spite of increased supply well construction and overall increases in pumping.

Comment: I think the important thing to note is that the apparent "leveling-off" was shown to have occurred only over the past 3-4 years, a period marked by annual rainfall that, in general, has typically exceeded that which has occurred in most of the preceding 35 years. Whether recent rainfalls represent "return-to-normal" conditions or some other statistical representation is not important. What is important is that, over the past few years, we have been experiencing "wetter-than-usual" conditions.

It is probable that, over the past few years, total pumping for public supplies may have increased because of population growth, especially in newer neighborhoods. Wetter conditions have probably caused decreased water use in most established areas. Areas of growth have, of course, resulted in new water demands. Therefore, a hydrograph of groundwater levels in selected observation wells near pumping centers that serve established areas might show an apparent leveling-off of water levels because those particular pumping centers may not be pumping as much water as in years past. Also, wetter conditions have certainly caused decreases in agricultural water demands, plus some population growth has probably occurred on what used to be irrigated agricultural lands.

(6) "Conduct peer reviews of the models."

Comment: Although the District's models undergo extensive internal review, the suggestion to conduct external peer reviews is certainly worthy of consideration and would probably enhance confidence in the modeling process as well as in the model results.

(7) "Add roads and other geographic locators to the model output maps."

Comment: I agree. This would appear to be a minor comment but it has important implications with regard to the reader being able to determine exactly where modeled pumping stresses are input and where drawdown occurs in relation to those stresses.

(8) There was concern for diminished water levels in lakes, streams and wetlands as a result of groundwater pumping.

(9) There was objection to the use of surface water from Lake Griffin as a source for public supply.

(10) "Lake County's lakes and springs are being left out of the District's Minimum Flows and Levels determinations."

(11) "To have a final plan by the end of 1999 might be rushing the process."

(12) There was concern that agriculture might be given low priority in the permitting of future groundwater pumping.

These Minutes were prepared by Charles H. Tibbals, 2-10-98.

Appendix A.1.b. -- Minutes of meeting of March 4, 1998

March 9, 1998

Charles H. Tibbals
297 E. Lakeview St.
Umatilla, FL 32784

Barbara Vergara, Director
Division of Needs and Sources
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H207: **Summary of 3-04-98 Area I Groundwater Modeling Subgroup Meeting**

Dear Barbara:

Please find enclosed the Minutes of the Area I Groundwater Modeling Subgroup Meeting of March 4, 1998, held in the conference room of Orlando Utilities Commission, 3800 Gardenia Avenue, Orlando, Florida.

At the February 4 meeting, I explained my USGS hydrologic experience and that, in spite of being under contract to SJRWMD, I was commissioned to continue playing a neutral role with regard to District policies and groundwater models. I did not repeat that information at the March 4 meeting because of the continuing nature of these meetings. However, I probably should have done so because there were one or two new members that had not attended the previous meeting.

I distributed blank comment sheets to each attendee and asked that they list their comments, concerns, and general impressions and to send or fax them to me by Friday, March 6. As of this writing, I have received only 3 comment sheets, which, I suppose, can be interpreted as the group being generally satisfied with the direction of the meetings. Those sheets are included herein. I suggest that copies of the sheets and the agenda be included when the Minutes are later sent to the attendees.

I reviewed my notes and the written concerns submitted by some of the attendees. Where appropriate, I address those concerns directly in the Minutes. Lack of comment on a concern does not, in any way, diminish its importance or utility. Rather, it simply means that the concern relates to District policy.

The meeting was adjourned at 5:30 PM.

If you have any questions regarding the meeting or this summary, please do not hesitate to contact me. Thank you.

Sincerely,

/S/

Attachments

cc: Doug Munch, Director, Division of Groundwater Programs, SJRWMD

MINUTES OF MEETING

St. Johns River Water Management District
Area I Work Group
Groundwater Modeling Subgroup
Chairman, Charles Tibbals

March 4, 1998

Conference Room
Orlando Utilities Commission
3800 Gardenia Avenue
Orlando Florida

The meeting was called to order at 2:00 PM.

The attendees (listing attached) were each asked to introduce themselves.

Comment sheets were given to each attendee and they were asked to list their comments, concerns, and general impressions that resulted from the meeting and to send or fax them to the Chair by Friday, March 6. Those sheets are included as an attachment along with a copy of the agenda.

Charles Tibbals, Chair, presented the following draft statement of the goal of the Modeling Subgroup and asked the group for suggested changes.

GOAL: Obtain and convey a better understanding of the computer modeling process as a tool to predict the effects of current and future groundwater pumping on the groundwater resource (drawdowns, springflow, potential salt-water intrusion – lateral and vertical); lake and wetland water levels and hydroperiod; and on vegetation.

It was explained that current modeling technology allows hydrologic determinations, which, in terms of accuracy and ability to directly simulate, are ranked in the order in which they are presented in the statement of goal.

There were no suggested changes to the draft goal.

Bill Osburn presented the results of his sample trend and time-series analyses on selected wells, springs, and rainfall stations. It was shown by double-mass analyses that rainfall at Orlando was in good annual relationship with rainfall stations at Lake Alfred and at Sanford and thus, the Orlando rainfall station can, for the purposes of this sample trend analyses, be used in the local trend and time-series analyses. Simple hydrograph representations showed Upper and Lower Floridan potentiomentric levels, Rock and Wekiva springflow, and Orlando rainfall all enjoying an upward trend since 1991. However, when long-term potentiomentric levels in the Upper and Lower Floridan wells at Lake Adair were double-massed against long-term Orlando rainfall, the results showed that, in spite of wetter weather and relatively stable pumpage from the nearby Highland well field, potentiometric levels in the wells were actually declining. Similar results were shown for the Orange 47 Upper Floridan well near Orlovista. It was emphasized that

double-mass analyses must be carefully applied and cautiously interpreted and that the results are entirely qualitative.
Brian McGurk presented a summary of changes in his current East-Central Florida model from an earlier version. Most of the changes had to do with the expansion of the modeled area and the treatment of the lateral salt-water interface.

During the group discussion of groundwater flow models, Tibbals noted that the models are not "homebrewed." Rather, they are constructed from fully documented and peer-reviewed computer codes that are in use throughout the Nation to simulate groundwater flow. The model codes are used to process hydrologic input data that are unique to the particular area being modeled. It was further noted that:

o The calibration process seeks to reproduce an observable set of hydrologic conditions, typically Floridan potentiomentric heads and spring flows.

o Model "sensitivity analyses are deliberate perturbations of a calibrated model by making global changes in a single model parameter (such as transmissivity) and, with all other parameters and stresses held constant, noting the changes in model results. Sensitivity analyses help the modeler determine which model parameters are the most important and where and to what degree errors in those parameters are likely to adversely affect model results.

o Model "verifications" are actually additional independent calibration steps in which a calibrated model is used to simulate additional sets of hydrologic conditions with no model changes other than pumping scenarios and, perhaps, starting heads including Floridan and water table heads that are reflective of the period being verified.

o The existence and discharge of Croaker Hole Spring and Island Spring were predicted during calibration of the old RASA model and later verified in the field by confirming their locations and measuring their discharges. It was noted that this particular success built confidence in the model's ability to accurately simulate the Floridan groundwater flow system in the east-central Florida area.

o Modeling is the best way to make a quantitative evaluation of the effects of current and future pumping stresses on the groundwater system. Other options would be to (1) do nothing – that is, abandon the modeling effort and perform no predictive analyses or (2) retreat to a type of qualitative analyses such as trend and time series analyses which have very limited ability to predict the effects of future distributed pumping stresses in nonhomogenous aquifer systems that cover large areas.

There was general agreement that Brian McGurk should seek to perform 2 additional verification calibrations using input data reflective of (1) a recent wet period, say, 1994-95, and (2) a relatively recent dry period, say, 1990. These calibrations would be in addition to his non-steady-state, or transient, calibration that has not yet been conducted. It was also agreed that trend and time-series analyses be continued and expanded as an independent corroboration of the model. Roy Silberstein offered to work with Bill Osburn to help extend Bill's work by employing additional analyses at additional hydrologic stations.

The group was asked to suggest the makeup of a possible external technical peer panel to review the East-Central Model including model assumptions, modeled hydrologic framework, boundary conditions, input data, and model application, results, and interpretations.

Unfortunately there was no clear consensus as to whether a peer review should be conducted and, if it was, just who should sit on the panel. The group did agree, however, that the groundwater model must yield reasonably accurate results in predicting the effects of projected pumping stresses for the year 2020.

It is the opinion of Chair that a technical peer review be performed sooner rather than later so that any problems that are identified can be resolved before Brian McGurk gets too much further along in the modeling process.

Chuck Drake offered to sit on a technical peer panel. Lawrence Pearson suggested that a modeler from SFWMD might also sit on the panel. Rob Teegarden suggested David McIntyre as a reviewer. Tibbals suggested that Robert Faye might be on the panel. Mr. Faye is recently retired as Groundwater Specialist for the USGS Southeast Region. He is very familiar with Florida hydrology and reviewed all groundwater flow models prepared by the USGS in the Southeast.

In the absence of consensus, the Chair recommends that a technical peer panel be convened and staffed by Robert Faye, Chuck Drake, David McIntyre, and an experienced groundwater modeler from SFWMD.

The date of the next meeting was not decided but the location will remain at the OUC Gardenia Avenue facility and the start time of the meeting will be at 2:00 PM.

These Minutes were prepared by Charles Tibbals, March 9, 1998.

Appendix A.1.c. -- Minutes of meeting of October 26, 1998

October 27, 1998

Charles H. Tibbals
297 E. Lakeview St.
Umatilla, FL 32784

Barbara Vergara, Director
Division of Water Supply Management
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H207: **Summary of 10-26-98 Area I Groundwater Modeling Subgroup Meeting**

Dear Ms. Vergara:

Please find enclosed the Minutes of the Area I Groundwater Modeling Subgroup Meeting of October 26, 1998, held in the conference room of Orlando Utilities Commission, 3800 Gardenia Avenue, Orlando, Florida. Also included is the list of attendees.

I distributed blank comment sheets to each attendee and asked that they list their comments, concerns, and general impressions and to send or fax them to me. As of this writing, I have not received any comment sheets, which, I suppose, can be interpreted as the group being generally satisfied with the direction of the meetings.

The subgroup decided to meet again in late January or early February 1999 after the second round of peer reviews.

If you have any questions regarding the meeting or this summary, please do not hesitate to contact me. Thank you.

Sincerely,

/S/

Attachments

cc: Doug Munch, Director, Division of Groundwater Programs, SJRWMD

MINUTES OF MEETING

St. Johns River Water Management District
Area I Work Group
Groundwater Modeling Subgroup
Chairman, Charles Tibbals

October 26, 1998

Conference Room
Orlando Utilities Commission
3800 Gardenia Avenue
Orlando Florida

The meeting was called to order at 1:30 PM.

The attendees (listing attached) were each asked to introduce themselves.

Comment sheets were given to each attendee and they were asked to list their comments, concerns, and general impressions that resulted from the meeting and to send or fax them to the Chair as soon as possible.

Charles Tibbals, Chair, presented a brief synopsis of the results of the peer review (the Review) of Brian McGurk's and Paula Presley's East-Central Florida groundwater flow model. The Review's summary comment is that no major or fatal flaws were found in the model. Other comments were reported as follows:

o The Review found that the model was properly vertically discretized.

o Recharge to the surficial aquifer system needs to be further refined in terms of recharge that results from septic systems, agricultural irrigation, rapid infiltration basins (RIBs), and spray fields.

It was noted by the Chair that such refinement is most critical to model results in the high-rate Floridan recharge areas where confining beds between the surficial and Upper Floridan aquifers are thin or permeable.

o The MODFLOW "River" package should be used to help quantify Floridan upward leakage into lakes and rivers in areas of artesian flow.

o Projected year 2020 increases in agricultural pumping are primarily due to anticipated increases in pumping for golf courses, ferneries and tree and plant nurseries.

o The Chair believes that his originally published extinction depth for evapotranspiration is believed to be too deep at 12-13 feet and that it should be revised to say, 6-8 feet for use in the District's models.

o It was strongly suggested that model-computed spring flows at the larger springs should be more closely calibrated than at present.

o The most important peer comment (since rescinded) is that the west boundary of the model be moved eastward from east Sumter County to mid-Lake County.

Note: If this were to be done, the Leesburg area and Bugg Spring areas would have been excluded from the model area. Subsequent conversations between the Chair and Bob Faye, lead reviewer, caused later reconsideration and rescinding of that comment.

Brian McGurk distributed copies of his response to the Review which stated his intentions to comply with almost all of the suggestions, the primary exception being the suggestion to move the west boundary of the model. Paula gave a brief report on the status of projected year 2020 water use data. The data for the SFWMD area is not yet forthcoming so the SJRWMD estimates will be used instead.

Brian stated that his planned completion date for his model is still early January 1999, and that he and Paula are preparing a SJRWMD Technical Memorandum on the steady-state model and on the conceptual model used in the formulation of the steady-state model. He said that the final model documentation report will be prepared for review and publication by September 1999. That report will include the results of the transient model.

David McIntyre asked about how the model might be able to account for interconnected wetlands and inflow to wetlands from uplands. The consensus was that MODFLOW cannot account for routing of wetland flow. Charles Tibbals indicated that MODFE, a finite-element model is much better equipped for such types of determinations.

Tibbals also stated that, in high-rate recharge areas or in areas where the confining beds are thin or permeable, drawdown in the surficial aquifer and in wetlands might occur more or less contemporaneously with that in the Floridan in response to year 2020 pumping. However, in areas where confining beds are thick or slowly permeable, wetlands response will lag that in the Floridan, perhaps by several years. Thus, the wetlands constraints that trigger deficit areas may be overly conservative especially in areas where confining beds are thick or less permeable. That, combined with problematic surficial aquifer calibration, caused the subgroup to suggest that surficial aquifer water levels and wetlands be more closely monitored to acquire actual water-level data and that, in the initial rendering, less emphasis be given to model results in wetland areas in terms of triggering deficit areas.

Roy Silberstein presented the results of his pilot study to identify suitable hydrologic sites in east and west Orange County that could furnish adequate data for long-term statistical analyses so that the effects of groundwater pumping could be separated from the effects of rainfall. He stressed that there was strong colinearity between rainfall and pumping because the absence of rainfall tends to cause more water to be pumped for agricultural and turf irrigation and by public supplies for lawn, garden, and other uses. Silberstein identified several long-term observation wells, rainfall stations, and was able to recover good historical pumping information from the Cocoa Well Field in east Orange County and from the OUC Pine Hills and the Orange County Oak Meadows wellfields in west Orange County. He showed long-term raw plots of rainfall, water levels in well OR-47, and well-field pumping. These plots showed an apparent

cause-and-effect relation between pumping and levels in OR-47. These data were not analyzed because it was beyond the scope of Silberstein's pilot study. A follow up study that would include such analyses is anticipated. Tibbals noted that water levels in OR-47 reflected heads in the Upper Floridan aquifer whereas the Pine Hills and Oak Meadows supply wells pump from the Lower Floridan, thus water level declines in OR-47 tend to understate the effects of Lower Floridan pumping.
The subgroup decided to meet after the next model peer review is accomplished, probably some time in late January or early February 1999.

The meeting was adjourned at 4:00 PM.

These Minutes were prepared by Charles Tibbals, October 27, 1998.

Appendix A.2: Area II – Volusia County model area

Appendix A.2.a. -- Minutes of meeting of March 19, 1998

March 23, 1998

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P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H207: **Summary of 3-19-98 Area II Groundwater Modeling Subgroup Meeting**

Dear Barbara:

Please find enclosed the Minutes of the Area II Groundwater Modeling Subgroup Meeting of March 19, 1998, held at the Volusian Water Alliance Headquarters in Daytona Beach, Florida. Also attached is a copy of the meeting agenda and a listing of the attendees.

I explained my USGS hydrologic experience and that, in spite of being under contract to SJRWMD, I was commissioned to continue playing a neutral role with regard to District policies. I further stated that, although I was neutral in terms of any specific groundwater model constructed by the District, that I was in favor of the use of groundwater models as predictive, quantitative tools.

I distributed blank comment sheets to each attendee and asked that they list their comments, concerns, and general impressions and to send or fax them to me by Friday, March 20.

Stan Williams' modeling presentation was preempted by questions from several of the Subgroup members. Basically, the Subgroup was more interested in just what questions the model is going to answer and when will the answers be available than in how the model is constructed. Reflecting back on our experiences in the Area I Modeling Subgroup meetings, this is the type of information they, too, wanted.

I have reluctantly come to the conclusion that the District should consider changing its approach to the modeling presentations. The current method is entirely adequate if the presentations were before a technical group of other modelers. However, the members of the Modeling Subgroups are, for the most part, unfamiliar with even the basic concepts of groundwater flow modeling and really are not interested in the nuts and bolts of model construction. In other words, a discussion of boundary conditions is not what they came to hear.

I recommend that the District modelers get together and develop a standard outline of a presentation that they might give to, say, a group of interested citizens. Listed below is a rough listing of items that might be included:

o Discussion of "Just what is a model?"

o "These are the types of models we use."

o Listing of what a model can and cannot directly do.

o Listing of what a model can indirectly do and how you would have the model do it.

Note: An example of direct versus indirect modeling might be the effects of a lowered water table cause by drainage rather than direct simulation of the drainage system itself.

o Listing of the District's model objectives.

o Timeline to accomplish the objectives. Be prepared to expand upon every facet of the timeline, if necessary.

o Emphasize that "real-world" results can, in fact, be determined in terms of future (and past) changes to the system. Give an example of each.

o Discuss how the District's modeling results will be used by the District in its water supply planning process including consumptive use permitting. This information was probably was given to the Area Workgroups but it bears repeating here.

o Show the model and model grid as a "sandwich" of data (see fig. 43, PP1403, p.54) that represent the combined model layers.

o Show how the model layers are abstractions of the hydrogeology (see fig.8, PP1403E, p. 12)

o Show some model results.

o From here on, you would discuss hard-core modeling stuff (calibration, verification, etc.) if the group shows such an appetite.

As you can see, the contents of the presentation are not appreciably different from a typical modeling presentation but they are addressed in a somewhat different order and with emphasis in different places.

I would also suggest that an additional experienced District modeler attend the meetings to give the featured presenter a little backup when needed.

If you have any questions regarding the meeting or this summary, please do not hesitate to contact me. Thank you.

Sincerely,

/S/

Attachments

cc: Doug Munch, Director, Division of Groundwater Programs, SJRWMD

MINUTES OF MEETING

St. Johns River Water Management District
Area II Work Group
Groundwater Modeling Subgroup
Chairman, Charles Tibbals

March 19, 1998

Conference Room
Volusian Water Alliance Headquarters
Daytona Beach, Florida

The meeting was called to order at 2:00 PM.

The attendees (listing attached) were each asked to introduce themselves.

Comment sheets were given to each attendee and they were asked to list their comments, concerns, and general impressions that resulted from the meeting and to send or fax them to the Chair by Friday, March 19. Those sheets are included as an attachment along with a copy of the agenda.

Charles Tibbals, Chair, explained his USGS hydrologic experience and that, in spite of being under contract to SJRWMD, he was commissioned to continue playing a neutral role with regard to District policies. He further stated that, although he was neutral in terms of any specific groundwater model constructed by the District, that he was in favor of the use of groundwater models as predictive, quantitative tools.

Tibbals then presented the following draft statement of the goal of the Modeling Subgroup and asked the group for suggested changes.

GOAL: Obtain and convey a better understanding of the computer modeling process as a tool to predict the effects of current and future groundwater pumping on the groundwater resource (drawdowns, springflow, potential salt-water intrusion – lateral and vertical); lake and wetland water levels and hydroperiod; and on vegetation.

Tibbals explained that current modeling technology allows hydrologic determinations which, in terms of accuracy and ability to directly simulate, are ranked in the order in which they are presented in the statement of goal.

There were no suggested changes to the draft goal.

Tibbals gave a presentation on the hydrogeology of East-Central Florida with particular emphasis on Volusia County in terms of directions of groundwater flow; recharge and discharge areas; occurrence of brackish groundwater; and evapotranspiration.

Tibbals followed with a brief discussion on the concepts of groundwater flow modeling and explained that the District's models are not "homebrewed." Rather, they are constructed from fully documented and peer-reviewed computer codes that are in use throughout the Nation to simulate groundwater flow. The model codes are used to process hydrologic input data that are unique to the particular area being modeled.

Stan Williams, SJRWMD, discussed the history of regional flow model development in the Volusia Groundwater Basin and then began his second presentation – an overview of his Volusia Groundwater Flow Model. At this point, questions began to flow from several members of the Subgroup to the extent that Williams' presentation was effectively preempted.

Most of the questions centered on the capabilities of the model:

o What will the model be expected to do and when will it be completed?

o Will the model assess the effects of stresses other than pumping?

o What will be the effects of long-term pumping on vegetative changes?

o Can the model be used to assess the effects of previous surface drainage; construction of Rapid Infiltration Basins; and construction (or removal) of surface-water control structures?

o Can the model simulate the effects of and current and future groundwater pumping?

o What is the typical radius of effect of pumping?

o Can the model simulate the effects of previous and future pumping on lateral and vertical (upconing) salt-water intrusion?

o To what depth does pumping affect lateral salt-water intrusion?

o Can the model predict the effects of drought?

o To what extent has development affected the groundwater resource including springflows, wetlands, recharge, and water quality?

o To what extent is the model sensitive to rainfall, pumpage, impervious surfaces; and canals?

o Is Gemini Spring now intermittent?

o Is Ponce DeLeon Springs projected to become intermittent or cease flow?

o How much rainfall is needed to keep the aquifer potentiometric surface unchanged?

o What would be the effects of deep well injection of effluent at Port Orange?

o What would be the effects of Daytona Beach effluent returned to Tiger Bay?

o What would be the effects of plugging Tiger Bay Canal?

o What are the model input parameters?

o How is the model calibrated? Verified?

Stan Williams could have addressed many of the above-listed questions if he had been able to complete his presentation.

It was generally agreed that the District should, for each of its models, develop a timeline of model capabilities and completion dates. The timeline would not be considered to be a series of deadlines. Rather, it would serve to keep the Subgroup informed as to the model's status in terms of progress and capabilities.

Bill Osburn presented the results of his sample trend and time-series analyses on selected wells, springs, and rainfall stations. It was shown by double-mass analyses that, beginning in about 1980, rainfall at DeLand was not in good annual relationship with rainfall stations at Sanford and thus, the DeLand rainfall station should not be used as a "stand-alone" index to historical rainfall conditions in Volusia County. Rather it should be incorporated into rainfall data from several surrounding stations that have more reliable records.

Osburn showed time-series data for the Upper Floridan well at Alamana and for Blue Spring. Double-mass graphs were presented that showed declines in aquifer head and springflow that were more than could be attributed to deficient rainfall. It was emphasized that double-mass analyses must be carefully applied and cautiously interpreted and that the results are entirely qualitative.

The date of the next meeting is Wednesday, April 15, at Volusian Water Alliance Headquarters in Daytona Beach. The start time of the meeting will be at 2:00 PM.

The meeting was adjourned at 5:30 PM.

These Minutes were prepared by Charles Tibbals, March 23, 1998.

Appendix A.2.b. -- Minutes of meeting of April 23, 1998

April 29, 1998

Charles H. Tibbals
297 E. Lakeview St.
Umatilla, FL 32784

Barbara Vergara, Director
Division of Needs and Sources
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H207: **Summary of 4-23-98 Area II Groundwater Modeling Subgroup Meeting**

Dear Ms. Vergara:

Please find enclosed the Minutes of the Area II Groundwater Modeling Subgroup Meeting of March 23, 1998, held at the Volusian Water Alliance Headquarters in Daytona Beach, Florida. Also attached is a copy of the meeting agenda and a listing of the attendees.

For the benefit of the new attendees, I reiterated my USGS hydrologic experience and that, in spite of being under contract to SJRWMD, I was commissioned to continue playing a neutral role with regard to District policies. I further stated that, although I was neutral in terms of any specific groundwater model constructed by the District, that I was in favor of the use of groundwater models as predictive, quantitative tools.

I distributed blank comment sheets to each attendee and asked that they list their comments, concerns, and general impressions and to send or fax them to me by April 26.

I apologized to the Subgroup and to Stan Williams for letting the last meeting stray to the extent that Stan was unable to finish his presentation. I explained that I intentionally let the meeting ramble because, in any kick-off meeting there is a certain amount of venting that needs to occur. Unfortunately, I misgauged the extent and duration of such venting.

At this meeting, the attendees were much more receptive to the meeting agenda and respectful of the presenters.

Doug Munch and Stan Williams gave outstanding presentations. Stan's reworked format seemed to satisfy everyone's curiosity about just what a groundwater model is and what questions it can and cannot answer explicitly or implicitly. The written comments I received were quite flattering of both Doug and Stan. I believe we're back on track to the extent that this group is probably ahead of Area I.

I strongly recommend that Doug's and Stan's presentations be given at the Area V kickoff Subgroup meeting and at the next Area I Subgroup meeting as well. Stan would not necessarily have to be the presenter but his format could be followed almost in its entirety. Doug's presentation would best be given by Doug.

Even considering the success of this meeting, I believe there ultimately will be a need for a peer review panel to review Stan's model. After talking with Doug, it is my recommendation that an Area II model peer review panel be convened that would be structured like the one being formulated for Area I, with Bob Faye as the lead reviewer. The other members (2?) could be nominated by the Subgroup. In fact, it would be a good idea if the District planned to convene an Area V model peer review panel also. Bob Faye could provide the objective technical expertise and the continuity and commonality among the review panels.

As Doug explained to me and to the Subgroup, the groundwater flow model is the linchpin for the entire optimization/decision modeling process. That being the case, it is absolutely essential that the District models not only be correct and defensible to the District's satisfaction, but to everyone else's as well.

I would continue to suggest that an additional experienced District modeler attend the meetings to give the featured presenter a little backup when needed. I can do it for most matters of clarification, but in matters of model defense, it would be inappropriate for me to comment.

I believe that the Subgroup now has a sufficient feel for the structure and capabilities of the model, at least in general terms. In looking over the comments received after the meeting, I noticed several convergent themes that would warrant special discussion as agenda items at subsequent meetings:

(1) Conceptually, just how does the model incorporate springs, what parameters are input, and how are the results presented?

(2) How can say, 30 mgd of pumping in a spring basin not result in a 30 mgd reduction in springflow (District needs to explain induced recharge, decreased diffuse upward leakage and decreased aquifer through-flow)?

(3) A timeline should be developed for the "what-if" simulations.

(4) Exactly how might the model implicitly or explicitly evaluate:

- Saltwater intrusion
- "East-side" effluent piped back to west for Ag use
- Effects of paving on recharge
- Effects of ditches, canals, and drains on area hydrology
- Effects of RIBs or land application of effluent
- Impacts on wetlands (water level and hydroperiod)
- Tracking of pollutant flow in aquifer (say, particle tracking) resulting from surface spills

(5) There was a suggestion that the 1935-55 period be used as the base reference for determining impacts.

If you have any questions regarding the meeting or this summary, please do not hesitate to contact me. Thank you.

Sincerely,

/S/Attachments

cc: Doug Munch, Director, Division of Groundwater Programs, SJRWMD

MINUTES OF MEETING

St. Johns River Water Management District
Area II Work Group
Groundwater Modeling Subgroup
Chairman, Charles Tibbals

April 23, 1998

Conference Room
Volusian Water Alliance Headquarters
Daytona Beach, Florida

The meeting was called to order at 2:00 PM.

The attendees (listing attached) were each asked to introduce themselves.

Comment sheets were given to each attendee and they were asked to list their comments, concerns, and general impressions that resulted from the meeting and to send or fax them to the Chair by April 26. Those sheets are included as an attachment along with a copy of the agenda.

Charles Tibbals, Chair, reiterated his USGS hydrologic experience and that, in spite of being under contract to SJRWMD, he was commissioned to continue playing a neutral role with regard to District policies. He further stated that, although he was neutral in terms of any specific groundwater model constructed by the District, that he was in favor of the use of groundwater models as predictive, quantitative tools.

Tibbals reminded the attendees of the goal of the Subgroup:

GOAL: Obtain and convey a better understanding of the computer modeling process as a tool to predict the effects of current and future groundwater pumping on the groundwater resource (drawdowns, springflow, potential salt-water intrusion – lateral and vertical); lake and wetland water levels and hydroperiod; and on vegetation.

Tibbals explained that current modeling technology allows hydrologic determinations, which, in terms of accuracy and ability to directly simulate, are ranked in the order in which they are presented in the statement of goal.

At this point, Tibbals apologized to the Subgroup and to Stan Williams for letting the last meeting stray to the extent that Stan was unable to finish his presentation. Tibbals explained that, in any kick-off meeting there is a certain amount of venting that needs to occur. Tibbals asked that, in light of the last meeting, the attendees try to hold their questions until each presentation was complete.

Doug Munch gave a presentation of the structure of the District's Optimization and Decision Modeling Process to develop the Water 2020 Supply Plan. He emphasized that the groundwater flow models are the linchpin models that provide input to the optimization models along with their constraint parameters:

(1) Aquifer level responses due to pumping; (2) Projected water demands; and (3) Environmental hydrologic constraints. The optimization models, after they are resolved, then feed the decision models and their constraint parameters: (1) Water service area deficits; (2) Strategy for relaxing constraints; (3) New and/or alternative sources; and (4) Technical, economic, political, and social constraints.

Munch also explained that, in sequence and together, the groundwater flow models, optimization models, and decision models all contribute to the development of the Water Supply Plan Strategies (with costs) which, when resolved, result in the final Water 2020 Supply Plans. He emphasized that it is the groundwater flow model that must first be accurately developed before any action can take place in optimization and decision modeling.

Stan Williams, SJRWMD, discussed the history of regional flow model development in the Volusia Groundwater Basin and then began his second presentation – an overview of his Volusia Groundwater Flow Model. He discussed the model objectives, modeling definitions, model versions (evolution of the model), and model capabilities and incapabilities.

The model's objectives are:
(1) explore water supply alternatives
(2) evaluate hydrologic impacts of pumping
(3) evaluate Consumptive Use Permits
(4) facilitate hydrologic system understanding
(5) investigate "what if" questions

Williams explained that sometimes modelers confuse matters by using the term "model" when referring to both their own work and to the general model computer code the modeler uses to ultimately construct the groundwater flow models that are unique to a given area by the inputting of the area's relevant hydrologic data. He also explained that the model code used is not a "homebrewed" code. Rather, it is MODFLOW -- a published, long-accepted, peer-reviewed set of computer coded instructions authored by Michael McDonald and Arlen Harbaugh (U.S. Geological Survey) that has been used throughout the Nation for more than 10 years. Williams said that a groundwater flow model is a mathematical representation of a complex system and consists of equations built into a computer program. The hydrologic parameters that describe the "real" system are applied within the framework of the model code.

Williams described the differences in his model versions (1994 vs 1999) in terms of:
(1) level of calibration
(2) calibration periods and durations:
- predevelopment and average 1995
- monthly: Jan 1995 through Dec 1995
- dry monthly: Jan 1990 through Dec 1990
- verification to 1997 conditions

(3) improvements in characterization:
- surficial recharge
- evapotranspiration
- leakance of upper confining unit
- hydraulic conductivity of Upper Floridan
- stratigraphy of aquifer systems

– spring sensitivity

Williams went on to discuss model capabilities in terms of:
(1) Impact Assessment:
- groundwater levels: surficial and Floridan
- spring flows
- recharge and discharge
- ***potential*** for saltwater intrusion

(2) Planning
- evaluation of alternative water supply scenarios
- conservation and reuse
- Consumptive Use Permit assessment
– conflicts among existing users
– impacts due to allocation

(3) Hypothesis-testing
- wet/dry period impacts
- surface drainage impacts: canals, control structures, RIBs
- injection or land application of treated wastewater
- impacts of development

He further described the model's incapabilities
to solve for:
(1) assessment of vegetation changes

(2) depth, degree of saltwater intrusion

(3) impacts of development to water quality

(4) site-specific evaluations

Williams delved a little deeper into the actual construction of the groundwater flow model by briefly describing:
(1) Model input parameters:
- starting heads of each aquifer simulated
- leakance of confining beds
- hydraulic conductivity/transmissivity of aquifers
- storativity of each aquifer layer
- recharge distribution
- evapotranspiration
- boundary conditions

(2) Modeling process
- system conceptualization
- calibration
- sensitivity analyses
- future projections

(3) Sensitivity analyses

The model tends to be <u>more sensitive</u> to:

- recharge to Upper Floridan (leakance of Upper Floridan confining unit)
- hydraulic conductivity of Upper Floridan
- recharge to surficial aquifer
- extinction depth for evapotranspiration

and <u>less sensitive</u> to:

- surficial and Lower Floridan hydraulic conductivities
- leakance of middle semi-confining unit

Williams said that, at this point, his findings were limited to a determination of:
- projected Surficial aquifer drawdowns
- projected Upper Floridan aquifer drawdowns
- projected spring flows

Williams went on to list some of the potential undesirable conditions that might result from projected increases in groundwater pumping in some areas:
- reduction of freshwater storage
- lateral or vertical saltwater intrusion
- decreased amount or viability of wetlands
- reductions in spring flow

At the previous meeting it was generally agreed that the District should develop a timeline of model capabilities and completion dates. The timeline would not be considered to be a series of deadlines. Rather, it would serve to keep the Subgroup informed as to the model's status in terms of progress and capabilities.

Williams presented the following timeline for the Volusia model:

(1) Calibrations and predictions
- Predevelopment conditions: Dec 1997
- Average 1995 conditions: April 1998

- 1997 verification: July 1998; Dec 1998
- Monthly 1995: Sept 1998
- Monthly 1990: Dec 1998
- 2020 projections: May 1998; Jan 1999

(2) “What if...” simulations

- effects of canals and/or plugging
- changes to Tiger Bay control structure
- quantitative effects of injection or application of effluent
- effects of Rapid Infiltration Basins (RIBs)

The date of the next meeting is Thursday, June 4, at Volusian Water Alliance Headquarters in Daytona Beach. The start time of the meeting will be at 1:30 PM.

The meeting was adjourned at 5:00 PM.

These Minutes were prepared by Charles Tibbals, April 29, 1998.

Appendix A.2.c. -- Minutes of meeting of June 4, 1998

June 9, 1998

Charles H. Tibbals
297 E. Lakeview St.
Umatilla, FL 32784

Ms. Barbara Vergara, Director
Division of Needs and Sources
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H207: **Summary of 6-04-98 Area II Groundwater Modeling Subgroup Meeting**

Dear Ms. Vergara:

Please find enclosed the Minutes of the Area II Groundwater Modeling Subgroup Meeting of June 4, 1998, held at the Volusian Water Alliance Headquarters in Daytona Beach, Florida. Also attached is a copy of the meeting agenda and a listing of the attendees.

I distributed blank comment sheets to the attendees and asked that they list their comments, concerns, and general impressions and to send or fax them to me by June 5.

The questions posed by the attendees were fewer than in earlier meetings and only 3 comment sheets were received. My interpretation is that the earlier questions have been answered.

One of the attendees suggested that Doppler rainfall estimates be placed in a database for "real-time" simulations. Perhaps Stan or Doug (or I) should mention that "real-time" aquifer simulation is not necessary because (1) we already have data acquisition in the form of observation wells and spring-flow measurements and (2) because the primary purpose of the model is to provide information on how projected increases in pumping in the year 2020 will affect the aquifers.

Stan showed a table that included model mass balances under several sets of conditions. That table illustrated how fluxes respond to pumping stresses. Stan's table showed the mass balance for the entire model in bulk but it did not show the balances on layer-by-layer basis. I suggested that a more detailed mass balance would help the Subgroup understand the model a little better.

We set a date for the next meeting but the Subgroup would be better served if the meeting occurred after the first phase of Bob Faye's review of Stan's model.

Doug Munch and I agreed that, in setting the review times, that Bob Faye would first consult with Doug as to the availability of the modelers. When the dates are firm, the Subgroup members will be notified as to time and place so that they, or their representatives or reviewers can attend. This is probably the best way to proceed for Areas I and V also.

I discussed the make-up of the peer review panel. I emphasized that the at-large reviewers would be only those who were qualified to do so. In other words, they must have groundwater modeling experience. It may be that Bob Faye is the only reviewer.

To not have what might appear to be a closed review, I offered to make room for observers of the process. When the review kicks off, I'll set the ground rules by asking the observers to strictly limit their input to items of a relevant technical nature and to submit their questions through one of the reviewers during breaks. That will allow the reviewers to screen the questions.

If you have any questions regarding the meeting or this summary, please do not hesitate to contact me. Thank you.

Sincerely,

/S/

Attachments

cc: Doug Munch, Director, Division of Groundwater Programs, SJRWMD

MINUTES OF MEETING

St. Johns River Water Management District
Area II Work Group
Groundwater Modeling Subgroup
Chairman, Charles Tibbals

June 4, 1998

Conference Room
Volusian Water Alliance Headquarters
Daytona Beach, Florida

The meeting was called to order at 1:30 PM.

The attendees (listing attached) were each asked to introduce themselves.

Comment sheets were given to each attendee and they were asked to list their comments, concerns, and general impressions that resulted from the meeting and to send or fax them to the Chair by June 5. Those sheets are included as an attachment along with a copy of the agenda.

Charles Tibbals, Chair, reminded the attendees of the goal of the Subgroup:

GOAL: Obtain and convey a better understanding of the computer modeling process as a tool to predict the effects of current and future groundwater pumping on the groundwater resource (drawdowns, springflow, potential salt-water intrusion – lateral and vertical); lake and wetland water levels and hydroperiod; and on vegetation.

Stan Williams gave a progress report on the status of the Volusia groundwater model. He said that he was near completion in his compilation of the projected 2020 water-use projections and would have them ready for model data entry by June 21. He said that he had intended to present some preliminary model results but that he was not entirely comfortable with them and that he wanted to check them further. Williams showed a "computed-vs-observed" potentiometric map for predevelopment (1935) conditions. He said that he was reasonably satisfied with the match except in the area around Blue Spring, along the Crescent City Ridge, and in a small area just east of the DeLand Ridge in central Volusia. Tibbals said not to be overly concerned about small mismatches because the construction of the "1935 predevelopment map" was an estimate based on only a few water level measurements in unleveled wells and that those water levels were applied to a more modern-day potentiometric "shape." Tibbals said he knew this to be the case because he, personally, drew that portion of the predevelopment map back during the RASA project in the early 1980's.

Williams discussed how springs were simulated in the model. He discussed how the spring "conductance" was determined by dividing the spring discharge by the head difference between the Floridan aquifer and the spring pool elevation. It was asked if this relationship was linear. Williams said that it is acknowledged that there is turbulent flow in and around the spring vent but that, within the observed and computed range of flow of the spring, the relationship is believed to be reasonably linear to the extent that a linear relationship could be used in the modeling effort.

It was asked if faults allowed connection between the Upper and Lower Floridan aquifer in the vicinity of Blue Spring. Tibbals said that the brackish water that discharges from Blue Spring indicates that deeper, poor quality water enters the spring. Tibbals further stated that, in order to achieve calibration of his RASA model of the early 1980's, he had to allow for increased upward leakage from the Lower Floridan. Williams said he had also allowed for such an improved connection. Asked if such a connection was due to faulting, Tibbals replied that expert geologists (which, Tibbals said, he is not) remain locked in argument as to the presence of Floridan faults and that such geologic structure can also be explained by ancient erosional features on the top of the limestone or by ancient, buried sinkholes.

Williams showed a table of model mass balances under several sets of conditions. The table illustrated how fluxes changed in response to pumping stresses. Williams' table showed the mass balance for the entire model in bulk but it did not show the balances on layer-by-layer basis. Tibbals suggested that a more detailed mass balance would help the Subgroup understand the model a little better. Even so, Williams was able to demonstrate how increased pumping in a spring basin did not necessarily result in a gallon-for-gallon reduction in spring flow. In his simulation, only about 30%-40% of the increase in pumping was derived from a reduction in springflow. The remainder was derived from increased downward leakage in recharge areas; decreased diffuse upward leakage in discharge areas; increases in boundary inflow in some areas; and decreases in boundary outflow in other areas. He also showed that some of the increase in recharge from the surficial aquifer was offset by a reduction in evapotranspiration caused by the lowering of the surficial aquifer's water table. Tibbals noted that the actual locations of the pumping stresses in a spring basin dictate how the spring would react. For example, if all of the pumping came from wells located a few tens of feet from the spring itself, it would be reasonable to expect that the spring's discharge would be reduced much more than if the pumping took place in areas farther from the spring.

A suggestion was made that the effects of "post-" predevelopment canals and ditches be incorporated into the model by having a lower surficial aquifer head in the areas where the drainage network was dense. It was agreed that this seemed to be a reasonable course of action. In addition, it was agreed that a test of the effects of plugging the canals could be incorporated into a "sensitivity" analysis of the effects of wide-spread changes in water table altitude.

It was suggested that dye studies might be conducted to determine the extent of "conduit" flow in the aquifer system. Tibbals said that dye studies conducted by the USGS showed only that they were inconclusive at best. He said that if anyone was further interested, Trudy Phelps (USGS –Altamonte Springs) could be contacted at (407)865-7575.

A date was set for the next meeting but Tibbals explained that the Subgroup would be better served if the meeting occurred after the first phase of the peer review of Williams' model.

Tibbals said that, in setting the review times, Bob Faye, ex-USGS Groundwater Specialist, would first consult with Doug Munch as to the availability of the modelers. When the date is firm, the Subgroup members will be notified as to time and place so that they, or their representatives/reviewers can attend.

Tibbals discussed the make-up of the peer review panel, in addition to Bob Faye. He emphasized that the at-large reviewers would be only those who were qualified to do so. In other words, they must have groundwater modeling experience. Tibbals acknowledged that Bob Faye may well be the only reviewer.

Tibbals said that, to not have what might appear to be a closed review, room would be made for observers of the process. He said the observers should strictly limit their input to items of a relevant, technical nature and to submit their questions through one of the reviewers during breaks. The reviewers would then screen the questions.

The date of the next meeting is Thursday, July 9, at Volusian Water Alliance Headquarters in Daytona Beach. The start time of the meeting will be at 1:30 PM.

The meeting was adjourned at 4:30 PM.

These Minutes were prepared by Charles Tibbals, June 9, 1998.

Appendix A.2.d. -- Minutes of meeting of October 29, 1998

November 3, 1998

Ms. Barbara Vergara, Director
Division of Water Supply Management
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H207: **Summary of 10-29-98 Area II Groundwater Modeling Subgroup Meeting**

Dear Ms. Vergara:

Please find enclosed the Minutes of the Area II Groundwater Modeling Subgroup Meeting of October 29, 1998, held at the Volusian Water Alliance Headquarters in Daytona Beach, Florida. Also attached are a copy of the meeting agenda, a listing of the attendees, and a copy of one comment sheet

I distributed blank comment sheets to the attendees and asked that they list their comments, concerns, and general impressions and to send or fax them to me. as of this writing, only one comment sheet has been received.

It was agreed by the subgroup that the next meeting be held after the next round of peer reviews. This might be in late January or early February 1999.

If you have any questions regarding the meeting or this summary, please do not hesitate to contact me. Thank you.

Sincerely,

/S/

Attachments

cc: Doug Munch, Director, Division of Groundwater Programs, SJRWMD

MINUTES OF MEETING

St. Johns River Water Management District
Area II Work Group
Groundwater Modeling Subgroup
Chairman, Charles Tibbals

October 29, 1998

Conference Room
Volusian Water Alliance Headquarters
Daytona Beach, Florida

The meeting was called to order at 1:30 PM.

The attendees (listing attached) were each asked to introduce themselves.

Comment sheets were given to each attendee and they were asked to list their comments, concerns, and general impressions that resulted from the meeting and to send or fax them to the Chair. Those sheets are included as an attachment along with a copy of the agenda.

Charles Tibbals, Chair, presented a brief synopsis of the results of the peer review (the Review) of Stan Williams' Volusia Basin groundwater flow model. The Review's summary comment is that no major or fatal flaws were found in the model. Other comments were reported as follows:

o The Review found that the model was properly vertically discretized.

o Particular attention should be given to the calibration of Blue Spring. It was noted that a substantial portion of the Blue Spring groundwater basin occurs outside the Volusia model and that proper model southwest boundary inflows should be such that the flow from Blue Spring can be satisfied.

o The Volusia model overlaps Durden's N.E. Florida Model to the north and McGurk's and Presley's East-Central Model to the south. It was noted by the peer reviewers that, in order to maintain credibility, it is imperative that the models be in agreement in the overlapped active areas to the extent that the models yield almost identical results due to pumping in those areas.

o Recharge to the surficial aquifer system needs to be further refined in terms of recharge that results from septic systems, agricultural irrigation, rapid infiltration basins (RIBs), and sprayfields.

It was noted by the Chair that such refinement is most critical to model results in the high-rate Floridan recharge areas where confining beds between the surficial and Upper Floridan aquifers are thin or permeable.

o The MODFLOW "River" package should be used to help quantify Floridan upward leakage into lakes and rivers in areas of artesian flow.

- o Projected year 2020 increases in agricultural pumping are primarily due to anticipated increases in pumping for golf courses, ferneries and tree and plant nurseries rather than for citrus.

- o Charles Tibbals believes that his originally published extinction depth for evapotranspiration is believed to be too deep at 12-13 feet and that it should be revised to say, 6-8 feet for use in the District's models.

Stan Williams stated his intentions to comply with almost all of the Review suggestions. His major concern was with the potential problem with the overlapped model areas to the north and south.

Williams gave a presentation of the current status of his model including transmissivity distributions, leakance distributions, locations of springs, and other important input items.

Stan showed how he had normalized aquifer test results for different pumping depths so that useable transmissivities could be obtained. He also showed how he had developed Theissen polygons to distribute rainfall data over the model area, paying particular attention to the apparently anomalously disparate rainfall data from two rainfall stations in close proximity.

Don Feaster asked how the model would account for the effects of ditched and drained areas. Charles Tibbals explained that, though MODFLOW cannot account for routing of wetland flow, it can account for the lowered water table by simply imposing such a lowered water table as an input model condition. Charles Tibbals indicated that MODFE, a finite-element model is much better equipped for such types of determinations and that he had recommended that the District construct, or have constructed, a small-scale MODFE test model in the Tiger Bay drainage basin in central Volusia County.

As to the ability of the Volusia and other District models to predict drawdown in wetlands, Tibbals stated that, in high-rate recharge areas or in areas where the confining beds are thin or permeable, drawdown in the surficial aquifer and in wetlands might occur more or less contemporaneously with that in the Floridan in response to year 2020 pumping. However, in areas where confining beds are thick or slowly permeable, wetlands response will lag that in the Floridan, perhaps by several years. Thus, the wetlands constraints that trigger deficit areas may be overly conservative especially in areas where confining beds are thick or less permeable. That, combined with problematic surficial aquifer calibration, caused the subgroup to suggest that surficial aquifer water levels and wetlands be more closely monitored to acquire actual water-level data and that, in the initial rendering, less emphasis be given to model results in wetland areas in terms of triggering deficit areas.

The date for the next meeting was not determined. It was generally agreed that we should wait until late January or early February 1999, after the next round of peer reviews. The location of the meeting will be at Volusian Water Alliance Headquarters in Daytona Beach. The start time of the meeting will be at 1:30 PM.

The meeting was adjourned at 4:30 PM.

These Minutes were prepared by Charles Tibbals, November 3, 1998.

Appendix A.3: Area V – Northeast Florida model areas

Appendix A.3.a. -- Minutes of meeting of May 14, 1998

May 18, 1998

Charles H. Tibbals
297 E. Lakeview St.
Umatilla, FL 32784

Ms. Barbara Vergara, Director
Division of Needs and Sources
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H207: **Summary of 5-14-98 Area V Groundwater Modeling Subgroup Meeting**

Dear Ms. Vergara:

Please find enclosed the Minutes of the Area V Groundwater Modeling Subgroup Meeting of May 14, 1998, held at the Agricultural Center in St. Augustine, FL. Also attached is a copy of the meeting agenda and a listing of the attendees.

By way of introducing myself, I told the attendees of my USGS hydrologic experience and that, in spite of being under contract to SJRWMD, I was commissioned to continue playing a neutral role with regard to District policies. I further stated that, although I was neutral in terms of any specific groundwater model constructed by the District, that I was in favor of the use of groundwater models as predictive, quantitative tools.

I distributed blank comment sheets to each attendee and asked that they list their comments, concerns, and general impressions and to send or fax them to me by May 15.

Doug Munch gave an even more polished version of the Water 2020 model development strategy than he did at the last Area II meeting. Doug Durden and David Toth gave excellent presentations but Durden tended to stray from the successful "upside down" format [(1) results first, (2) what a model can and cannot do, and, finally, (3) how you got there] that was used so effectively by Stan Williams. Consequently, many of the attendees were somewhat intimidated at the outset by Durden's lead-off that stressed the technical aspects of model development.

I strongly recommend that Stan personally give his presentation at the next Area V Subgroup meeting and at the next Area I Subgroup meeting as well.

I believe there ultimately will be a need for a peer review panel to review Durden's model and Toth's analytical techniques. After talking with Doug Munch, it is my recommendation that an Area V model peer review panel be convened that would be structured like the ones being formulated for Areas I & II, with Bob Faye as the lead reviewer. Bob Faye could provide the objective technical expertise and the continuity and commonality among the review panels.

Because the groundwater flow model is the linchpin for the entire optimization/decision modeling process in all of the Water 2020 areas, it is absolutely essential that the District's models not only be correct and defensible to the District's satisfaction, but to everyone else's as well.

I would continue to suggest that an additional experienced District modeler attend the meetings to give the featured presenter a little backup when needed. I can do it for most matters of clarification, but in matters of model defense, it would be inappropriate for me to comment.

In looking over the comments received after the meeting, I noticed a couple of items that would warrant special discussion as agenda items at subsequent meetings:

(1) Durden's freshwater/saltwater interface model and its potential use was not fully conveyed to the Subgroup. Trudy Phelps noted that, in some areas of NE Florida, upward movement of brackish water apparently takes place upward along buried karst or other structural or solution features and that interface movement is not believed to be the source of elevated chlorides in most wells. The Subgroup picked up on this as an apparent contradiction between the hydrogeology and the simulated hydrogeology.

(2) Two members of the Subgroup expressed concern that Doug Durden was having to spend so much time on assembling pumping data.

(3) One member thought that David Toth's analytical model had too many limitations to be able to contend with a transient water table aquifer with leakage, variable recharge, and variable withdrawals. I'm not sure if the limitations make it fatally flawed, though. David's analytical model is really a hybrid analytical/numerical model that incorporates many aspects of a numerical model such as MODFLOW. In relatively low-transmissivity, nonartesian aquifers, cones of depression do not extend as far as they do in high-transmissivity, artesian systems so it would seem that a county-wide numerical model based on MODFLOW would be a form of overkill. Further, the lack of data and few monitoring wells would also seem to speak against the use of such a model. The important thing here, is that David needs to emphasize all these points at the next meeting

If you have any questions regarding the meeting or this summary, please do not hesitate to contact me. Thank you.

Sincerely,

/S/

Attachments

cc: Doug Munch, Director, Division of Groundwater Programs, SJRWMD

MINUTES OF MEETING

St. Johns River Water Management District
Area V Work Group
Groundwater Modeling Subgroup
Chairman, Charles Tibbals

May 14, 1998

Conference Room
St. Johns Agricultural Center
3125 Agricultural Center Drive
St. Augustine, Florida

The meeting was called to order at 1:30 PM.

The attendees (listing attached) were each asked to introduce themselves.

Comment sheets were given to each attendee and they were asked to list their comments, concerns, and general impressions that resulted from the meeting and to send or fax them to the Chair by May 15. Those sheets are included as an attachment along with a copy of the agenda.

Charles Tibbals, Chair, reiterated his USGS hydrologic experience and that, in spite of being under contract to SJRWMD, he was commissioned to continue playing a neutral role with regard to District policies. He further stated that, although he was neutral in terms of any specific groundwater model constructed by the District, that he was in favor of the use of groundwater models as predictive, quantitative tools.

Tibbals discussed goal of the Subgroup:

GOAL: Obtain and convey a better understanding of the computer modeling process as a tool to predict the effects of current and future groundwater pumping on the groundwater resource (drawdowns, springflow, potential salt-water intrusion – lateral and vertical); lake and wetland water levels and hydroperiod; and on vegetation.

Tibbals explained that current modeling technology allows hydrologic determinations which, in terms of accuracy and ability to directly simulate, are ranked in the order in which they are presented in the statement of goal.

Tibbals explained that sometimes modelers confuse matters by using the term "model" when referring to both their own work and to the general model computer code the modeler uses to ultimately construct the groundwater flow models that are unique to a given area by the inputting of the area's relevant hydrologic data. He also explained that the model code used is not a "homebrewed" code. Rather, it is MODFLOW -- a published, long-accepted, peer-reviewed set of computer coded instructions authored by Michael McDonald and Arlen Harbaugh (U.S. Geological Survey) that has been used throughout the Nation for more than 10 years.

Doug Munch gave a presentation of the structure of the District's Optimization and Decision Modeling Process to develop the Water 2020 Supply Plan. He emphasized that the groundwater flow models are the linchpin models that provide input to the optimization models along with their constraint parameters: (1) Aquifer level responses due to pumping; (2) Projected water demands; and (3) Environmental hydrologic constraints. The optimization models, after they are resolved, then feed the decision models and their constraint parameters: (1) Water service area deficits; (2) Strategy for relaxing constraints; (3) New and/or alternative sources; and (4) Technical, economic, political, and social constraints.

Munch also explained that, in sequence and together, the groundwater flow models, optimization models, and decision models all contribute to the development of the Water Supply Plan Strategies (with costs) which, when resolved, result in the final Water 2020 Supply Plans. He emphasized that it is the groundwater flow model that must first be accurately developed before any action can take place in optimization and decision modeling. He also said that the groundwater flow models would be revisited every 5 years in order to incorporate new and better input data.

Trudy Phelps, guest speaker from the U.S. Geological Survey office in Altamonte springs, gave a brief presentation that described the hydrogeology of northeast Florida and that summarized the results of numerous previous hydrologic studies that have been conducted in the area. Trudy said that one of the most notable findings in recent years is the increasing amount of evidence to suggest that the seemingly hit-or-miss occurrences of elevated chlorides in Upper Floridan aquifer wells can be explained by upward movement of brackish water that apparently takes place upward along buried karst or other structural or solution features and that interface movement is not believed to be the source of elevated chlorides in most instances.

Doug Durden, SJRWMD, discussed the history of regional flow model development in the northeast Florida area. Durden then gave an overview of his 1994 Northeast Florida Groundwater Flow Model. He stressed that his current model was assembled in 1994 and was originally intended to predict projected 2010 stresses rather than 2015 stresses and that he was still assembling pumping data.

The 1994 model consists of 4 aquifer layers and 3 semi-confining unit layers. The aquifers represented are, from top to bottom, the surficial aquifer system, Upper Floridan aquifer, Lower Floridan aquifer, and the Fernandina permeable zone.

Durden listed the following limiting features of the model:

(1) The surficial aquifer system is represented as a constant-head source-sink bed.

(2) The Floridan system is simulated as steady-state.

(3) The model area is too small -- pumping effects extend to the edge of the model boundaries.

Durden said the results of his 1994 model run with projected 2010 pumping rates showed that, in most of the study area, 2010 drawdowns were predicted to be an additional 0-5 feet; in the south half of the area, drawdowns would be an additional 5-20 feet; and, in the Fernandina Beach area, 2010 heads are projected to actually rise 0-10 feet due to decreased pumping.

Durden then discussed his 1994 Northeast Florida Regional Sharp-Interface model. He said that the model configuration was the same as the flow model and had the following limitations:

(1) The surficial aquifer system is represented as a constant-head source-sink bed.

(2) The model area is too small to the extent that pumping effects extend to the edge of the model boundaries.

(3) Constants w/respect to time: withdrawals, lateral boundary conditions, and surficial aquifer water levels.

(4) Freshwater/saltwater transition zone represented as a sharp interface.

(5) Preferential flowpaths (for upward saltwater movement) are not represented explicitly.

Durden said the results of the sharp interface model showed that:

(1) Significant movements of the saltwater interface take place over 1000's of years.

(2) **But** there is relatively high **potential** for saltwater intrusion via preferential paths. The areas likely to be most affected are in the south grid area and in the beaches areas of Duval and St. Johns Counties.

Durden said he plans to rework the 1994 model and construct the **1999** Northeast Florida Regional Groundwater Flow Model. Its primary objectives are to:

(1) Predict aquifer heads in response to changes in pumping between 1995 and 2015.

(2) Predict changes in spring discharge.

(3) Evaluate effects of cumulative pumping impacts in analyses of Consumptive Use Permit (CUP) applications.

(4) Provide basis for optimization modeling to enable analyses of minimum flows and levels.

(5) Evaluate "what-if" groundwater withdrawal scenarios.

(6) Provide basis for new salt-water intrusion model.

Durden said there would be numerous improvements in the 1999 model:

(1) The model domain will be expanded to the west and south so that boundary effects can be reduced and the "lakes" area to the west can be included in the modeled area.

(2) The surficial aquifer will be active.

(3) Floridan and surficial aquifer systems will be simulated as transient systems.

(4) Model grid will be nested within the USGS "megamodel."

The 1999 steady-state model will be calibrated to Spring 1995 conditions and the transient version will be calibrated to the period May 1995 – September 1995 conditions using monthly stress periods.

Durden says his water-use study is currently underway and that he's about 30% complete for public supplies and about 10% for agriculture-irrigation.

Durden presented the following timeline for the 1999 Northeast Florida Model:

(1) Completion of assembly of 1995 and projected 2020 pumping data	August 1998
(2) Complete predevelopment model	October 1998
(3) Complete steady-state 1995 calibration	December 1998
(4) Simulate 2020 drawdown simulations	January 1999
(5) Activate steady-state version of active surficial aquifer system	March 1999
(6) Complete transient May-September 1995 version of model	August 1999

David Toth presented an overview of his analytical model of the St Johns County and St. Augustine wellfields. Toth's analytical model is really a hybrid analytical/numerical, coupled-aquifer model that incorporates many aspects of a numerical model such as MODFLOW. For example, the model area can be gridded, and multiple pumping wells can be simulated. Leakage between aquifer layers can also be simulated. Toth indicated that, in relatively low-transmissivity, nonartesian aquifers, cones of depression do not extend as far as they do in high-transmissivity, artesian systems so it would seem that a county-wide numerical model based on MODFLOW would be a form of overkill. Further, the lack of data and lack of monitoring wells would also seem to speak against the use of such a model. Toth believes that, in spite of the limitations of his model (must assume uniform transmissivity, leakance, and storativity), that it will yield useable results.

It was generally agreed that the groundwater models should be subjected to outside technical peer review so that all parties could be assured that the models are properly constructed, calibrated, verified, and applied; have the correct input data and boundary conditions; and that the model results are properly interpreted. Tibbals agreed to make such a recommendation to the District.

The date of the next meeting is Thursday, June 18, at the St. Johns Agricultural Center in St. Augustine. The start time of the meeting will be at 1:30 PM.

The meeting was adjourned at 5:15 PM.

These Minutes were prepared by Charles Tibbals, May 18, 1998.

Appendix A.3.b. -- Minutes of meeting of June 18, 1998

June 24, 1998

Charles H. Tibbals
297 E. Lakeview St.
Umatilla, FL 32784

Ms. Barbara Vergara, Director
Division of Needs and Sources
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H207: **Summary of 6-18-98 Area V Groundwater Modeling Subgroup Meeting**

Dear Ms. Vergara:

Please find enclosed the Minutes of the Area V Groundwater Modeling Subgroup Meeting of June 18, 1998, held at the Agricultural Center in St. Augustine, FL. Also attached is a copy of the meeting agenda, a listing of the attendees, and comment sheets.

I distributed blank comment sheets to each attendee and asked that they list their comments, concerns, and general impressions and to send or fax them to me by June 19.

The meeting was much better attended than the first meeting. There were numerous questions posed from the floor but only 1 comment sheet was turned in. I believe the Area V Subgroup is waiting for the results of the peer review before pursuing the issues any further.

If you have any questions regarding the meeting or this summary, please do not hesitate to contact me. Thank you.

Sincerely,

/S/

Attachments

cc: Doug Munch, Director, Division of Groundwater Programs, SJRWMD

MINUTES OF MEETING

St. Johns River Water Management District
Area V Work Group
Groundwater Modeling Subgroup
Chairman, Charles Tibbals

June 18, 1998

Conference Room
St. Johns Agricultural Center
3125 Agricultural Center Drive
St. Augustine, Florida

The meeting was called to order at 1:30 PM.

The attendees (listing attached) were each asked to introduce themselves.

Comment sheets were given to each attendee and they were asked to list their comments, concerns, and general impressions that resulted from the meeting and to send or fax them to the Chair by June 19. Those sheets are included as an attachment along with a copy of the agenda.

Charles Tibbals, Chair, reminded the Subgroup of its goal:

GOAL: Obtain and convey a better understanding of the computer modeling process as a tool to predict the effects of current and future groundwater pumping on the groundwater resource (drawdowns, springflow, potential salt-water intrusion – lateral and vertical); lake and wetland water levels and hydroperiod; and on vegetation.

Tibbals reiterated that current modeling technology allows hydrologic determinations which, in terms of accuracy and ability to directly simulate, are ranked in the order in which they are presented in the statement of goal.

Doug Durden, SJRWMD, presented an update on his progress in reworking his earlier, smaller (1994 version) Northeast Florida Groundwater Flow Model. He stressed that the 1994 version was originally intended to predict projected 2010 stresses rather than 2015 stresses and that the modeled area was too small because pumping effects extended to the edge of the model boundaries.

In answer to a question posed after the May 14 meeting, Durden explained that the SHARP Interface Model (by Hydrogeologic, Inc.) predicts saltwater interface movement but does not explicitly take into account saltwater movement along joints, faults, or buried sinkholes that might allow preferential flow from deeper, salty aquifer layers. However, he went on to say that if the SHARP model showed high potential for interface movement in an area, then it could be assumed that, if a preferential flowpath existed, then high potential for flow along that path would also exist. The confining beds that overlay the Floridan system are thick and tend to mask the surface expression of buried karst features. Thus the locations of preferential flowpaths are, for the most part, unknown although recent seismic analyses showed the existence of what appeared to be at least one buried sinkhole or collapse feature in the St. Johns River in Duval County. The areas likely to be most affected are in the south grid area, in the beaches areas of Duval and St. Johns Counties, and, generally, along the thread of the St. Johns River.

Durden presented results of mass balance determinations as output by his 1994 model which showed that, in response to modern-day pumping stresses, changes in predevelopment flows caused by lowered Upper Floridan heads due to pumping were:

(1) Increased downward leakage to the Upper Floridan in recharge areas and decreased upward leakage in discharge areas.

(2) Increased upward leakage from the Lower Floridan.

(3) Increased boundary inflow from the west and south, not much change from the north, and decreased boundary outflow to the east (seaward).

Durden presented similar results for the Lower Floridan and Fernandina Permeable Zone. The upper part of the Lower Floridan is used for water supply in some areas but not to the degree of the Upper Floridan. Durden said the Lower Floridan is recharged by downward leakage from the Upper Floridan, lateral inflow from the west boundary, and upward leakage from the Fernandina Permeable Zone. The Lower Floridan discharges to pumping wells, upward leakage to the Upper Floridan, and seaward flow to the east boundary.

The Fernandina Permeable Zone is recharged from downward leakage from the Lower Floridan and it discharges by upward leakage to the Lower Floridan and seaward flow to the east boundary. When asked if the Fernandina Permeable Zone had ever been used for water supply, Durden said that, in 1945, a paper company attempted to use the zone (at about 2200') but the well salted up in about a year.

Durden presented some of his results in the form of gridded data which showed ranges of flow rates in and out of the Upper Floridan through the overlying confining beds. Higher upward leakage rates along the thread of the St. Johns River were thought to be the result of buried karst features that might allow for enhanced upward leakage through the confining beds.

Durden said the expanded (from 1994 model) **1999** Northeast Florida Regional Groundwater Flow Model is on schedule and is awaiting final resolution and entry of the pumping data which is almost complete.

Durden restated the 1999 model's list of improvements over the 1994 model:

(5) The model domain will be expanded to the west and south so that boundary effects can be reduced and the "lakes" area to the west can be included in the modeled area.

(6) The surficial aquifer will be active.

(7) Floridan and surficial aquifer systems will be simulated as transient systems.

(8) Model grid will be nested within the USGS “megamodel.”

The 1999 steady-state model will be calibrated to Spring 1995 conditions and the transient version will be calibrated to the period May 1995 – September 1995 conditions using monthly stress periods.

The following timeline for the 1999 Northeast Florida Model is repeated from the Minutes of the previous meeting:

(1) Completion of assembly of 1995 and projected 2020 pumping data	August 1998
(2) Complete predevelopment model	October 1998
(3) Complete steady-state 1995 calibration	December 1998
(4) Simulate 2020 drawdown simulations	January 1999
(5) Activate steady-state version of active surficial aquifer system	March 1999
(6) Complete transient May-September 1995 version of model	August 1999

David Toth presented some results from areal drawdown models of the Tillman Ridge and the St. Augustine surficial aquifer system wellfields. In his models, Toth represents the surficial system as being comprised of an upper, unconfined aquifer separated from a lower, confined aquifer by a semiconfining bed that is partly comprised of a dense layer of "blue marl clay." The confined surficial is, in turn, underlain by the Hawthorn Formation and then by the Upper Floridan aquifer. The Hawthorn acts as an underlying semiconfining bed for the confined surficial and as an overlying semiconfining bed for the Upper Floridan.

All simulated pumping from the surficial aquifer system is from the <u>confined</u> surficial layer. Pumping from the Upper Floridan was also simulated. The current (1995) and future predicted 2020 drawdowns were shown in tabular format for the <u>confined</u> surficial at the grid cells in which pumping wells were located. Drawdowns induced in the <u>unconfined</u> surficial were shown in the form of drawdown contour maps over the entire modeled area.

One of the attendees felt that water in the unconfined surficial could not leak downward through the "blue marl" semiconfining bed and into the confined surficial in response to pumping there. Tibbals said that, although he had not seen the particular marl in question, that he was familiar with that type of material in his own neighborhood in Lake County. He further said that such materials often contain some sand and that the "clay" may also be more silt than clay. Tibbals said that a simple, empirical way of determining if the marl is impermeable is to place a chunk of it out in the open and see if it dries. If it dries, then it is not impermeable because, in order for the chunk to dry, water must move from the inside to the outside where it can evaporate.

Toth then presented the results of his wellfield models:

The Tillman Ridge wellfield model showed 1995 unconfined surficial drawdowns of 0.5' – 2.5' whereas, using projected 2020 pumping rates, the drawdowns were 0.5' – 5.0' but over an area that is 2.5 times larger in area. In 1995, the Upper Floridan supplied about 37% of the pumping whereas in 2020, the Floridan is anticipated to provide only about 28%.
Toth showed tables of current and projected pumping levels in Tillman Ridge grid cells of the confined surficial that are occupied by pumping wells. The 1995 drawdowns averaged about 14' in the 7 simulated grid cells. The projected 2020 drawdowns averaged about 23' in 17 cells.

Tibbals noted that, due to screen entrance losses and friction losses in the well-bores, drawdowns in the pumped wells are always greater than in the aquifer immediately adjacent to the pumping wells.

The St. Augustine wellfield model showed 1995 unconfined surficial drawdowns of 0.3' – 1.3'. Using projected 2020 pumping rates, the drawdowns were essentially unchanged in magnitude and in affected area. This is because most of the projected increase in pumping in 2020 is estimated to be from the Upper Floridan aquifer. In 1995, the Upper Floridan supplied about 28% of the pumping whereas in 2020, the Floridan is anticipated to provide about 41%.

Toth showed tables of current and projected pumping levels in St. Augustine wellfield grid cells of the confined surficial that are occupied by pumping wells. The 1995 drawdowns averaged about 4' in the 7 simulated grid cells. The projected 2020 drawdowns averaged about 4.4' in 12 cells.

At the previous meeting, May 14, it was generally agreed that the groundwater models should be subjected to outside technical peer review so that all parties could be assured that the models are properly constructed, calibrated, verified, and applied; have the correct input data and boundary conditions; and that the model results are properly interpreted.

Tibbals informed the group that the District had arranged to contract with Robert Faye, recently retired USGS Groundwater Specialist, to act as lead reviewer in the peer review process.

Tibbals explained that additional qualified reviewers are welcome to attend the reviews and to ask questions but that a qualified reviewer is one that has had actual hands-on experience with groundwater flow modeling and has published the results of such modeling. Tibbals went on to explain that, in order to have an "open" review, observers of the review would be welcome.

Observers would be able to pose questions to the reviewers during breaks and the reviewers would screen those questions for relevance before introducing them into the actual review.

Tibbals said that the dates of the reviews would be made known to the subgroup members so they could arrange to attend or have their designated reviewers or observers attend.

No date was set for the next meeting. It was agreed that the first round of peer review should take place before meeting again. However, the location of the next meeting will still be the St. Johns Agricultural Center in St. Augustine and the start time of the meeting will be at 1:30 PM.

The meeting was adjourned at 4:30 PM.

These Minutes were prepared by Charles Tibbals, June 24, 1998.

Appendix A.3.c. -- Minutes of meeting of October 28, 1998

November 2, 1998

Charles H. Tibbals
297 E. Lakeview St.
Umatilla, FL 32784

Ms. Barbara Vergara, Director
Division of Water Supply Management
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H207: **Summary of 10-28-98 Area V Groundwater Modeling Subgroup Meeting**

Dear Ms. Vergara:

Please find enclosed the Minutes of the Area V Groundwater Modeling Subgroup Meeting of October 8, 1998, held at the St. Johns County Auditorium in St. Augustine, FL. Also attached is a copy of the meeting agenda. Al Canepa has the listing of the attendees.

I distributed blank comment sheets to each attendee and asked that they list their comments, concerns, and general impressions and to send or fax them to me. As of this date, none have been received. The meeting was poorly attended. I suggested that no further meetings be held until after the next round of model peer reviews. It is anticipated that the next meeting will be in late January or early February 1999.

If you have any questions regarding the meeting or this summary, please do not hesitate to contact me. Thank you.

Sincerely,

/S/

Attachments

cc: Doug Munch, Director, Division of Groundwater Programs, SJRWMD

MINUTES OF MEETING

St. Johns River Water Management District
Area V Work Group
Groundwater Modeling Subgroup
Chairman, Charles Tibbals

October 28, 1998

St. Johns County Auditorium
4020 Lewis Speedway
St. Augustine, Florida

The meeting was called to order at 1:30 PM.

The attendees (listing attached) were each asked to introduce themselves.

Comment sheets were given to each attendee and they were asked to list their comments, concerns, and general impressions that resulted from the meeting and to send or fax them to the Chair.

Charles Tibbals, Chair, presented a brief synopsis of the results of the peer review (the Review) of Doug Durden's Northeast Florida groundwater flow model. The Review's summary comment is that no major or fatal flaws were found in the model. Other comments were reported as follows:

o The Review found that the model was properly vertically discretized.

o Recharge to the surficial aquifer system needs to be further refined in terms of recharge that results from septic systems, agricultural irrigation, rapid infiltration basins (RIBs), and sprayfields.

It was noted by the Chair that such refinement is most critical to model results in the high-rate Floridan recharge areas where confining beds between the surficial and Upper Floridan aquifers are thin or permeable.

o Until Durden's large-scale model is finalized, his current model will be linked to Motz's Keystone Heights model by imposing outfluxes from that model as influxes to Durden's current model.

o Similarly, stresses from the proposed Cecil Field wellfield will be evaluated with SURFDOWN or another analytical model and its influxes will be imposed as outfluxes on Durden's current MODFLOW model.

o The MODFLOW "River" package could be used to help quantify Floridan upward leakage into lakes and rivers in areas of artesian flow.

o The Keystone Heights potentiometric high can be the result of low transmissivities on its flanks in addition to recharge in the interior of the high.

o The most important peer comment (since rescinded) is that the west boundary of the large-scale model be moved eastward from its current position to a line from Keystone Heights to St. Marys.

Note: If this were to be done, part of the Keystone Heights area would have been excluded from the model area. Subsequent conversations between the Chair and Bob Faye, lead reviewer, caused later reconsideration and rescinding of that comment.

Doug Durden stated his intentions to consider almost all of the suggestions, the primary exception being the suggestion to move the west boundary of the model. He also discussed his regression model to determine water-table altitudes as a function of land-surface altitude. He indicated that correlation coefficients were better for the entire suite of data than for either the low-altitude or the high-altitude data taken separately. (*In a side-bar discussion with Durden, Charles Tibbals explained why this could be the case and still cause the full-suite model to yield more inaccurate results than either the low- or high-altitude models.)*

Durden presented the results of several scenario modeling runs. The purpose was to show the drawdown effects of pumping:

(1) in the S.E. grid area including that in the beaches area.
(2) by all of the JEA wells including those proposed for the Cecil Field wellfield.
(3) hypothetical pumping from Upper/Lower Floridan wells back-plugged to the Upper Floridan.
(4) in the proposed Cecil Field area.
(5) by all public supply, commercial, and industrial wells including the beaches and at the proposed Cecil Field wellfield.

Scenario pumping results showed that JEA doesn't cause very much drawdown at the beaches and that the proposed Cecil Field wellfield would cause even less. Also, back-plugging of Upper/Lower Floridan wells would not cause much additional drawdown even if all of the pumping was from the Upper Floridan.

Charles Tibbals, Chair, presented a brief synopsis of the results of the peer review (the Review) of David Toth's St. Augustine and Tillman Ridge SURFDOWN analytical groundwater flow models. The Review's summary comment is that no major or fatal flaws were found in the Tillman Ridge model and that the method for dealing with contrasting transmissivities in the St. Augustine model may or may not be problematical. If so, a MODFLOW model could easily be constructed to cope with the contrasting transmissivities.

Other comments were reported as follows:

(1) If 2-stage test pumping is conducted in the St. Augustine wellfield as offered by John Regan, Utilities Director, drawdowns in the unconfined surficial may take days, rather than hours, to equilibrate. For that reason, only the heads in the confined surficial (pumped zone) will be meaningful. Such pumping will determine if the transmissivity contrast in the confined surficial will necessitate a MODFLOW model to replace the SURFDOWN model for the

well field.

(2) A sensitivity test should be performed on the "ET factor" for both well field models.

(3) The matrix of the SURFDOWN models should be enlarged.
David Toth stated his intentions to consider all of the review comments. He wanted to wait until the St. Augustine test pumping was completed before firming plans to construct a MODFLOW model.

Toth presented the results of his "ET factor" sensitivity analyses and the results of enlarging the SURFDOWN model matrices. The analyses showed that the model results were insensitive to the ET factor and to the model matrix..

No date was set for the next meeting. It was agreed that the second round of peer review should take place before meeting again.

The meeting was adjourned at 3:30 PM.

These Minutes were prepared by Charles Tibbals, November 2, 1998.

APPENDIX B: PEER REVIEW COMMENTS ON GROUNDWATER FLOW MODELS

Appendix B.1: Area I – East-Central Florida model area

Appendix B.1.a. -- Peer review of July 21, 1998

July 28, 1998

Robert E. Faye
3468 Larch Pine Drive
Duluth, GA 30096

Doug Munch, Director
Division of Groundwater Programs
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H283: Summary of Peer Review of the East-Central Florida model/project (Area I); July 21, 1998

Dear Doug:

Enclosed is the Summary of the Peer Review of the East-Central Florida model/project conducted at the SJRWMD Groundwater Programs meeting room during July 21, 1998. The meeting was chaired by Robert Faye and was called to order about 0830. Attendees at the meeting numbered seven and are listed by name and affiliation by Attachment to the Summary. Based on our discussions of Friday, July 24, 1998, during the exit interview, SJRWMD Groundwater Programs will solicit comments from selected attendees and those comments received will be attached to and distributed with the formally accepted Summary.

After calling the meeting to order, Robert Faye briefly explained the purpose of the Peer Review and emphasized the informal nature of the discussions. All attendees were urged to actively participate in the discussions. Although many attendees offered comments and suggestions, the bulk of the technical questions and suggestions were offered by Robert Faye and Charles Tibbals. Following is a summary of the highlights of the Peer Review discussions including the significant comments and recommendations made by the Review Attendees. Because the order of discussion of the Peer Review was left largely to the discretion of the Groundwater Programs staff responsible for the presentation, the Review did not necessarily follow the previously prepared daily meeting agenda. The Peer Review Summary also reflects more the order of discussion at the meeting than that of the formal agenda.

Please call me at 770-476-3815 if you wish to discuss any part or aspect of the enclosed Summary or the related meeting or review process.

Sincerely,

Robert E. Faye, P. E.

Enclosures/Attachments

cc: Barbara Vergara, Director, Division of Needs and Sources, SJRWMD
Charles H. Tibbals

SUMMARY OF PEER REVIEW MEETING
EAST-CENTRAL FLORIDA MODEL/PROJECT
JULY 21, 1998

Brian McGurk and Paula Presley were well-prepared for the Peer Review. Their presentation to the Review Attendees was detailed and logical and focused on those elements of the Floridan and Surficial aquifer systems and model development necessary for an appropriate understanding of model calibration and application. Many of the visual aids used by Brian and Paula were excellent and could easily serve as prototypes for other projects and models that will undergo future peer reviews.

Unless otherwise noted, the comments and recommendations summarized below were made by Robert Faye and/or Charles Tibbals. Comments, suggestions, conclusions, and recommendations attributed herein to the Review are also those of Robert Faye and/or Charles Tibbals.

1. The review began with a detailed presentation of the conceptual flow system and aquifer system hydrogeology. McGurk described recent interpretations that indicate an extension of the Boulder Zone into south Orange County and that the Lower Floridan aquifer in the study area may be more heterogeneous than previously thought. He indicated the occurrence of a "second" Middle Semi-confining Unit within the Lower Floridan aquifer in the southwestern part of the study area and noted that highly mineralized water in the eastern part of the Lower Floridan aquifer was not considered a part of the groundwater flow system for modeling purposes. McGurk also described a highly permeable zone at the base of the Upper Floridan aquifer that had previously been mapped by Miller (1986) at or near the top of the Middle Semi-confining Unit. This unit comprises most or all of the defined Lower Zone of the Upper Floridan aquifer which is represented by layer three in the updated East-Central Florida flow model. The vertical discretization of the East-Central Florida flow model, as described by McGurk and Presley, is excellent, particularly considering the Water 2020 focus on conditions in the Surficial and Upper Floridan aquifers and the subdivision of the Upper Floridan aquifer into upper and lower zones for simulation purposes.

2. Considerable discussion ensued regarding the algorithm used by McGurk and Presley to compute cell-by-cell recharge to the active model layer that represents the Surficial aquifer and related recharge results. David MacIntyre questioned the utility of the resulting map that shows the areal distribution of total recharge, particularly in the western parts of the model area along the Mt. Dora and Lake Wales ridges. Much of the concern was expressed regarding the term Ru (surface runoff), which McGurk computed using the SCS curve number method. MacIntyre apparently believes that the Ru values computed for a particular watershed should be compared to streamflow data measured at gaging stations. Faye objected to this interpretation indicating that the algorithm used by McGurk was strictly a mass balance of vertical flows and that considering lateral flow from cell to cell (represented by Ru) was an inappropriate extension of the methodology. Tibbals suggested that Ru in the ridge areas should be zero or very small and asked McGurk to check the actual computed net recharge rates (rather than show a range) for the disputed areas.

Subsequent presentation of the simulated net recharge to the Upper Floridan aquifer showed a high degree of sensitivity to topography and land use, which indicates that the algorithm and method used by McGurk is at least reasonable. The Review recommends that simulated arrays of predevelopment and 1995 recharge rates be compared and differences described as part of the discussion of model calibration .

3. MacIntyre and Faye reiterated the advantages of using appropriate elements of the groundwater budget as model calibration parameters (conditions). Budget considerations can be both qualitative and quantitative from the viewpoint of establishing the validity of a calibration. With respect to the East-Central Florida flow model area, a number of river reaches should be given strong consideration for use in model calibration where flow gradients in the Upper Floridan aquifer are predominantly upward, including parts of the St. Johns River, Reedy Creek, Econlockhatchee River, Wekiva River, and perhaps others. Dredging of the St. Johns River by the Corps of Engineers in the 1930's may have enhanced the hydraulic connection between the river and the Upper Floridan aquifer between Lake George and Lake Harney. The Review recommends that RIVER cells be used with MODFLOW to simulate Upper Floridan aquifer discharge to the rivers. A useful baseflow computation method that can be applied to the streamflow record of area streams is HYSEP, developed by Ron Sloto of the USGS in Malvern, PA.

4. The Review recommends that a transient analysis be used to simulate the conjunctive decay of groundwater levels and streamflow during the period December 1994 (a very wet period) through May 1995. Successful simulation of both receding groundwater levels and baseflow along selected river reaches will provide a strong, positive indication of model calibration.

5. Paula Presley described the water-use data base for the model area and maps were shown of the distributions of various wells based on water use, including consumptive use permitted wells, free flowing wells, agricultural wells, etc. The bulk of the wells are permitted wells and McGurk assumes that the number of unpermitted wells with significant pumpage is small. Substantial discussion of water use and methods of computing water use ensued among the Attendees. Chuck De Gerlande inquired about the status of the efforts to plug free-flowing wells. Apparently many will be fitted with valves to control the discharge. De Gerlande also asked about the locations of historical wells and whether or not the locations were well known. He also inquired about the location of the "wastewater well" (Sand Lake Road test well at Sand Lake Road Wastewater Treatment Plant). Apparently, data obtained during the drilling of this well will affect interpretations of the thickness of the freshwater part of the Lower Floridan aquifer, indicating a thinner section than previously thought. David MacIntyre wanted to know what agricultural activity was "driving" the increases in agricultural pumpage projected to year 2020. The increases were based largely on projected increases in the acreage allocated to nurseries. The Review emphasizes that the various methods used to compute water use, particularly agricultural water use, be discussed and appropriately qualified, either in the report that summarizes the model development and results or in a separate document.

6. The discussion of ET and the application of the "ET package" to MODFLOW was straightforward, with the exception of the assignment of extinction depths. Charles Tibbals suggested that his published curve relating evapotranspiration to water level (Tibbals, 1990) may indicate an unreasonably deep extinction depth. The map showing rates of simulated ET appeared reasonable, with respect to the correlation of rates to topography.

7. The presentation of simulated heads and flux was somewhat hampered by the use of maps showing ranges of potentiometric levels rather than specific contours. Illustrations showing the distribution of simulated flux at the boundaries for the various model layers also were not available at the time of the Review but were later provided to Bob Faye. Graphs showing the relation of simulated heads in the Surficial and Upper Floridan aquifers to 1995 observed heads at "target" wells were presented to demonstrate the quality of model calibration. Comparisons were excellent; however, similar comparisons at all wells with 1995 water levels, not just at the "target" wells, would provide additional insight into the overall calibration and were recommended by the Review . Model calibration was also indicated by the comparison of simulated spring discharge to observed spring discharge. With several

exceptions, including Apopka, Palm and Sanlando, Starbuck, and Bug Springs, the simulated discharges for both predevelopment and year 1995 conditions appear reasonable. However, David MacIntyre stated that inaccuracies in the simulation of predevelopment and 1995 spring flows will be a " a significant source of debate". The Review recommends that the model be subjected to additional calibration to improve the simulation of spring discharge at the springs named above.

8. Probably the most critical recommendation of the Review is in regard to the western boundary of the East-Central Florida flow model. The western boundary was extended westward to a poorly posed (hydraulically) limit in order to include the areas of Leesburg and Bugg Springs. Simulations of future pumping would thus include simulated responses in these areas. Without this consideration, the western boundary could be located along a north-northwest trending flowline in the Upper Floridan aquifer that corresponds to topographically high northwest trending ridges in west Polk and east Lake counties. Such a boundary is highly defensible as a no-flow boundary and its use would probably facilitate model calibration. Future simulations at Leesburg and Bugg Springs could perhaps be accommodated by using a local well field model or by applying appropriate analytical models.

9. Boundaries applied to various layers of the East-Central Florida flow model were also a topic of considerable discussion. General-head conditions were applied to all boundaries of the layers representing the Surficial and Floridan aquifers. No-flow conditions were applied to the western boundary of the model layer that represents the Lower Floridan aquifer. The Review recommends that general-head boundaries be used for all layers except where the boundary occurs at a freshwater/saltwater interface, where no-flow conditions probably prevail. In addition, the sensitivity analysis of the calibrated model should include tests of the specified heads used to define the general-head boundaries as well as the locations of the boundaries. Testing boundary locations generally includes moving the boundary several columns away from the main area of study. Simulated flux at the various boundaries (quantity and direction) should also be determined for the calibrated model and presented in the summary report.

10. The results of the Peer Review of the East-Central Florida flow model indicate that the model has progressed substantially toward final calibration. Acknowledging and implementing the several recommendations discussed above should provide a well calibrated and appropriately documented model.

LIST OF ATTENDEES
PEER REVIEW OF THE EAST-CENTRAL FLORIDA MODEL/PROJECT
JULY 21, 1998

Name	Affiliation	Phone number/email
Robert Faye	Reviewer/Consultant	770-476-3815 refaye@mindspring.com
Chuck DeGerlande	Orange County Utilities	407-836-6859 Fax 407-836-6859
Charles Tibbals	Reviewer/Consultant	352-669-4703 ctibbals@cde.com
Rick Coleman	Orlando Utilities Commission	407-649-4416 rcoleman@ouc.com
Paula Presley	SJRWMD	904-329-4143
Brian McGurk	SJRWMD	904-329-4245
David MacIntyre	PB Water	407-875-3337 ext.228 macintyre@pbworld.com

Appendix B.1.b. -- Peer review of May 4, 1999

May 13, 1999

Robert E. Faye
P.O. Box 43
Blairsville, GA 30514

Doug Munch, Director
Division of Groundwater Programs
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H283 Summary of second Peer Review of East-Central model/project (Area I), May 4, 1999.

Dear Doug:

Enclosed is the summary of the second Peer Review of the East-Central Florida model/ project. The meeting was held at the SJRWMD Groundwater Programs meeting room during May 4, 1999. The meeting was chaired by Robert Faye and was called to order at about 0915. Attendees at the meeting numbered six and are listed by name and affiliation in an Attachment to this Summary. All attendees were urged to actively participate in the review discussions; however, most of the technical comments and suggestions were made by Robert Faye and Charles Tibbals.

Please call me at 706-745-7105 if you wish to discuss any part of the enclosed summary or the related meeting or review process.

Sincerely,

Robert E Faye

Robert E. Faye, P.E.

Enclosures/Attachments

cc: Barbara Vergara, Director, Division of Needs and Sources, SJRWMD
Charles H. Tibbals

SUMMARY OF PEER REVIEW MEETING
EAST-CENTRAL FLORIDA MODEL/PROJECT
MAY 4, 1999

The technical discussions opened with a short review of suggestions and recommendations made during the first Peer Review in July 1998 (memo to Doug Munch, July 28, 1998), and which of these suggestions had been applied to the current model. With the exceptions of the transient analysis and a thorough test of the eastern boundary at the presumed location of the freshwater/saltwater interface, all previous suggestions and recommendations had been implemented.

Although not specifically addressed during the July 1998 Peer Review of the East-Central Florida model, the Review Team has repeatedly urged, subsequently, that recharge, hydraulic characteristic, and all other arrays and coverages in areas common to the East-Central and Volusia County flow models be compared in detail and all differences completely reconciled. Although some efforts to reconcile known differences between the models have occurred, particularly with respect to methods to simulate recharge, differences in hydraulic characteristic arrays, among others, remain unresolved. The Review Team strongly believes that until this reconciliation is completed, the calibration of both models must be considered incomplete and perhaps inadequate to simulate future conditions. Following are comments, suggestions, and conclusions based on the review of May 4, 1999.

1. Model calibration is comprehensive and generally excellent. Calibration to 1995 conditions includes comparison of simulated potentiometric levels to 202 observed water levels in the Upper Floridan aquifer (layer 2), comparison of simulated potentiometric levels to observed water levels at 117 lakes and wells completed in the surficial aquifer (layer 1), comparison of simulated spring flows to observed flows at 23 first and second magnitude springs (layer 2), and comparison of simulated total runoff to reported total annual runoff at 43 gaged streamflow sites (layers 1 and 2).

A total water budget, including areally distributed estimates of evapotranspiration (ET) and precipitation, were used to compute recharge to the surficial aquifer. A minimum ET of 27 in/yr from the unsaturated zone is assigned to the entire model area. Computed ET (by MODFLOW) varies according to land cover and soil type. Depth to water varies according to soil type. Extinction depths assigned to the model are 6 ft and 10 ft. Initial extinction depths were assigned by soil type and later refined during calibration. Other budget components are applied irrigation water, water applied to rapid infiltration basins, and streamflow. Applied water rates are assigned to the flow model and are not computed by MODFLOW. Total streamflow includes both assigned (runoff) and computed (baseflow) components. Overland runoff is computed using SCS curve numbers correlated to land use and soil type coverages. Baseflow is computed using the River Package of MODFLOW. Self- supplied domestic water supplies totaled about 40 MGD in the study area during 1995 but were not included in the water-budget computation. The Review Team recommends that an appropriate percentage of this water be assigned to the model representing return flow from septic tank effluents. Return flow should occur in unsewered areas characterized by relatively high occupation densities.

Simulated 1995 conditions were generally biased low for several budget components, including springflow and total streamflow, and for potentiometric levels in layer 2 (Upper Floridan aquifer). In addition, simulated predevelopment conditions in layers 3 and 4 (lower part of the Upper Floridan and lower Floridan aquifers) indicated landward flow across the general-head boundaries representing the freshwater/saltwater interface. Such results probably indicate a general deficiency of water supplied to the model and the Review Team recommends that applied recharge be increased accordingly. Perhaps this can most effectively be achieved by lowering the minimum ET rate assigned to the model in conjunction with selective adjustment of confining unit leakance between layers. The application of return flows from septic tanks may also offset or partially offset the current recharge deficiency.

2. Following additional calibration of the model to 1995 conditions (per suggestions above), the direction and quantity of simulated predevelopment flow across the general-head boundaries representing the freshwater/saltwater interface in layers 3 and 4 should be noted. If flow directions are still generally landward, then additional model calibration and tests of the boundary are recommended. A useful test was described during the recent review of the Northeast Florida flow model and may also be applicable to the East-Central flow model (See letter to Doug Munch, April 14, 1999; Item #4).

3. Conceptual as well as model sensitivity analyses indicate that perhaps only a single extinction depth be assigned to MODFLOW to simulate discharge to ET. A depth between 6 and 10 ft may be appropriate and can be tested through sensitivity analysis. A sensitivity test should also be performed on the assigned minimum ET rate.

4. Simulated local ET rates are high (perhaps excessively high) at several sites and may approach accepted rates of maximum possible ET, equal to free water-surface evaporation. The calibration to 1995 conditions with additional recharge, as suggested above, may exacerbate the locally high ET conditions. The Review Team recommends that all such sites be identified and evaluated for contributing factors such as soil type, land use, applied irrigation water, etc. If trends are noted, then perhaps uniform, consistent corrections can be made throughout the model domain.

5. Pumping from multiaquifer wells in east-central Polk County is simulated by the model but the distribution of total pumpage between aquifers is unknown. The Review Team suggests collecting flow log data at these wells or ascertaining if similar data exist in nearby similar wells. The Southwest Florida Water Management District may have acquired such data.

6. Sensitivity analysis of drain parameters at springs was conducted only for those springs for which minimum flows and levels had been assigned. The Review Team recommends that the sensitivity analysis be inclusive of all first magnitude springs.

7. Simulated discharge to the Wekiva River may be excessive, based on seepage run data published by Tibbals in USGS Professional Paper 1403-E. The Review Team recommends that simulated and published results be compared and additional calibration be performed to reasonably minimize differences between simulated and published streamflows.

8. Residuals between simulated and observed heads at drainage wells indicate that potentiometric levels at drainage wells are generally simulated higher than observed. This bias could be the result of excessive recharge assigned to drainage well cells. The Review Team recommends that recharge rates to drainage wells be further evaluated and

possibly reduced, while being careful not to contradict valid field data or other useful studies that report drainage well recharge rates.

LIST OF ATTENDEES
SECOND PEER REVIEW OF THE EAST-CENTRAL FLORIDA MODEL/PROJECT
MAY 4, 1999

Name	Affiliation	Phone number/email
Robert E. Faye	Reviewer/Consultant	706-745-7105 refaye@stc.net
Carol Demas	University of Florida	904-312-2345 demas@district.sjrwmd.state.fl.us
Doug Munch	SJRWMD	904-329-4173 doug_munch@district.sjrwmd.state.fl.us
Paula Presley	SJRWMD	904-448-7909
Charles H. Tibbals	Consultant/SJRWMD/Reviewer	352-669-4703 ctibbals@cde.com
Karl Kurka	DEP-OWP	850-488-0784

Appendix B.2: Area II – Volusia County model area

Appendix B.2.a. -- Peer review of July 22, 1998

July 29, 1998

Robert E. Faye
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Doug Munch, Director
Division of Groundwater Programs
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H283: Summary of Peer Review of the Volusia Florida GWB model/project (Area II); July 22, 1998

Dear Doug:

Enclosed is the Summary of the Peer Review of the Volusia Florida GWB model/project conducted at the SJRWMD Groundwater Programs meeting room during July 22, 1998. The meeting was chaired by Robert Faye and was called to order about 0830. Attendees at the meeting numbered seven and are listed by name and affiliation by Attachment to the Summary. Based on our discussions of Friday, July 24, 1998, during the exit interview, SJRWMD Groundwater Programs will solicit comments from selected attendees and those comments received will be attached to and distributed with the formally accepted Summary.

After calling the meeting to order, Robert Faye briefly explained the purpose of the Peer Review and emphasized the informal nature of the discussions. All attendees were urged to actively participate in the discussions. Although many attendees offered comments and suggestions, the bulk of the technical questions and suggestions were offered by Robert Faye and Charles Tibbals. The enclosed Summary begins with a brief description of the major points of discussion followed by comments and recommendations regarding the current technical status of the Volusia GWB flow model and its application to achieve Water 2020 objectives. Following the general comments and recommendations are listed specific topical comments and recommendations. Because the order of discussion of the Peer Review was left largely to the discretion of the Groundwater Programs staff responsible for the presentation, the Review did not necessarily follow the previously prepared daily meeting agenda. The Peer Review Summary also reflects more the order of discussion at the meeting than that of the formal agenda.

Please call me at 770-476-3815 if you wish to discuss any part or aspect of the enclosed Summary or the related meeting or review process.

Sincerely,

Robert E. Faye, P. E.

Enclosures/Attachments

cc: Barbara Vergara, Director, Division of Needs and Sources, SJRWMD
Charles H. Tibbals

SUMMARY OF PEER REVIEW MEETING
VOLUSIA FLORIDA GWB MODEL/PROJECT
JULY 22, 1998

Little or no information regarding simulation results based on the Volusia Florida GWB flow model now under development were presented to Attendees during this Peer Review. Lacking, in particular, were any descriptions of calibration results, including simulations of predevelopment, modern or future potentiometric levels, or simulated budget results. Also lacking, to a large degree, were any descriptions of model development or construction such as maps showing layer by layer boundary conditions or the thickness and areal extent of critical hydrogeologic units. Accordingly, the Peer Review Meeting Summary immediately below and the following list of specific Recommendations address mostly data to be used in model development and calibration and a number of "what if" conditions that may or may not ultimately affect model development. Recommendations and comments made herein may ultimately prove to be of little consequence to model development and calibration. Because of the lack of descriptions of model calibration and simulation results cited above, the Review could only address most topics in a general and highly conditional manner.

Unless otherwise noted, the comments and recommendations summarized below were made by Robert Faye and/or Charles Tibbals. Comments, suggestions, conclusions, and recommendations attributed herein to the Review are also those of Robert Faye and/or Charles Tibbals.

1. The meeting began with Stan Williams describing the improvements in the Volusia GWB flow model currently under development, compared to the model described in Williams (1995). Improvements are to include (a) detailed calibration of springflow; (b) active simulation of additional surface-water features, particularly lake levels; (c) detailed evaluation of the transmissivity array in the model layer that corresponds to the Upper Floridan aquifer; and (d) simulation of specific groundwater budget components such as recharge, ET, baseflow, etc. Grid spacing will be uniform with square cells representing 2,500 ft. per side. The model used in Williams (1995) incorporated variable grid spacing. Williams does not intend to subdivide the Upper Floridan aquifer into upper and lower zones, which is somewhat different from the approach used by McGurk and Presley in designing the East-Central Florida flow model. Williams also plans to use a uniform rather than areally distributed leakance array for the Middle Semi-confining unit (5 x 10**-5/d), except in the vicinity of Blue springs. The Review recommends that maps be developed showing the thickness of the various confining units over the study area and that appropriate values of vertical hydraulic conductivity be applied to the thickness arrays to evaluate VCONT (leakance). A similar approach may be necessary to evaluate the transmissivity of the Lower Floridan aquifer, following a determination of the extent and thickness of the salt water "wedge" in the eastern and western parts of the model area. Williams emphasized that little or no data are available to determine either heads or other hydrogeologic features of the Lower Floridan aquifer and that he intends to consider the entire Lower Floridan in the model area as a freshwater source. Bob Ahlert expressed concern regarding the nature and surface of the Middle Semi-confining unit. He believes that the confining unit is "breached", characteristically, and that "breached" zones provide direct connection between the Upper and Lower Floridan aquifers. The possibility of a local breach in the Middle Semi-

confining Unit is suggested by Tibbals (1990, USGS Professional Paper 1403-E) in the vicinity of Blue Springs. The Review is not aware of any field data or other interpretations of hydrologic or geophysical data that suggest that "breaching" of the Middle Semi-confining Unit occurs at all, let alone commonly or characteristically. Until such data or interpretations are available, a characteristically "breached" Middle Semi-confining Unit must be considered implausible.

2. Williams plans to use a thickness map of the Upper Floridan aquifer and estimates of lateral hydraulic conductivity to develop the transmissivity array for the corresponding model layer. Estimates of lateral hydraulic conductivity used by Williams were based on aquifer-test results and the entire thickness of the Upper Floridan aquifer at the test sites (Miller, 1986). This approach is flawed. Only the depth of penetration of the well into the aquifer should be used to estimate lateral conductivity, not the entire aquifer thickness. Accordingly, Williams' estimates of conductivity are biased low and the Review recommends that he recompute conductivity using depth of penetration. The Review also recommends that a flownet analysis, using an appropriate potentiometric surface map of the Upper Floridan aquifer, be applied to the vicinity of Blue and other large springs to evaluate the transmissivity and the extent of the area contributing to the springs.

3. Water-use data to be applied as pumping arrays to the Volusia Florida GWB flow model were discussed in considerable detail. Ahlert emphasized that data sources and data density be carefully considered and believes that domestic withdrawals from the Upper Floridan aquifer are inconsequential from a resource management viewpoint. Major pumpage apparently is related to agricultural and municipal use and Williams plans to use St. Johns River WMD permit and other data to determine same for model calibration. Bob Haviland indicated that a "freshwater lens" in the Surficial aquifer along Barrier Beach in east Volusia County had been depleted by pumping, which had caused additional withdrawals from the Upper Floridan aquifer in the area of the lens. This lens apparently exists in highland recharge areas of offshore barrier islands. Discussions with Trudy Phelps (USGS, Altamonte Springs) following the Review indicates that chloride concentrations in the Surficial aquifer are highly variable along the barrier islands (25 to 15,000 mg/l; USGS WRIR 90-4069) and that the highest concentrations occur where the islands are narrow or where the sampled well is in close proximity to either the ocean or the intracoastal waterway. No substantial or credible scientific evidence of depletion was found. In fact, Volusia county apparently continues to permit wells in the Surficial aquifer on the barrier islands, further indicating that freshwater is still readily available. The Review believes that freshwater is still available from the Surficial aquifer in these highland areas. Concerns regarding depletion may perhaps be substantially overstated and do not seem to be based on known field data or hydrologic investigation.

4. Williams apparently plans to simulate net recharge to the Surficial aquifer by areally distributing average annual rainfall to the uppermost model layer and removing water from this layer using the "ET package" of MODFLOW. Charles Tibbals indicated that an extinction depth of 13 ft. applied to the "ET Package" was probably excessive and recommended a depth ranging from 6 ft. to 10 ft. An anomalously low annual rainfall (42 in) was measured during the intended calibration year over an area of major recharge to the Upper Floridan aquifer and has caused a calibration dilemma. The area of influence of the low rainfall is unknown; however, unreported rainfall

data are apparently available from nearby sites. The Review recommends that the unreported data be collected and used to restrict the area of low rainfall to the smallest reasonable extent using Thiessen polygons or a similar approach. Bob Morrell expressed concern that recharge in the coastal areas would not be appropriately accounted for and cited the apparently well known variability of recharge in such areas. The Review recommends that Williams consider the algorithm used by McGurk and Presley to compute net recharge to the East-Central Florida flow model. Application of this algorithm has demonstrated a substantial sensitivity of distributed recharge rates to topography and land use, including irrigated land use. Haviland urged that Williams take an additional look at recharge from wetlands and the replenishment of wetlands using reclaimed wastewater. Recharge to the surficial aquifer from septic tanks is an issue in the model area but estimates of total contribution and affected area are yet to be determined. Several Attendees suggested that the total contribution, when distributed over the affected area, would be relatively small and within the error limits of other components of the recharge budget. Regardless, the Review recommends that an estimate for recharge from septic tanks be developed as soon as possible.

5. Surface-water and surface drainage features applied to the flow model were also discussed. Haviland expressed concern that the effects of drainage canals on surface features such as wetlands could not be accurately accounted for. The actual significance of such canals to discharge from the Surficial aquifer was not well understood by the Attendees and the Review recommends that, at least, all of the model cells that contain drainage canals be identified and appropriately "flagged" for additional emphasis when evaluating calibration results. Drain cells probably should be applied to those cells where the canals are a dominant feature and be used as calibration features where supporting data are available. Once calibrated, the sensitivity of model simulations to drainage features imposed on the Surficial aquifer can be tested by artificially raising and lowering the base level at the drain cells used to simulate the feature.

6. The Review also recommends that much additional consideration be given to using groundwater budget components as calibration parameters. In particular, the St. Johns River between Lake George and Lake Dexter should be simulated using RIVER cells assigned to both the Upper Floridan and Surficial aquifers. This reach is a known zone of artesian discharge. Tibbals indicated that dredging of the St. Johns River channel in parts of this reach may have enhanced discharge to the river from the Upper Floridan aquifer.

7. Williams plans to assign general-head conditions to much of the perimeter of the model for all layers. No-flow conditions will be assigned to the remainder of the boundaries. Appropriate maps or other illustrations were not available to further evaluate boundary conditions. The Review recommends that particular attention be paid to the eastern boundaries of the Upper and Lower Floridan aquifer. For the calibrated model, eastward flow in both aquifers should be entirely lost to diffuse upward leakage before reaching the assigned boundary. If this condition is not met, then the boundary should be moved eastward until this condition is satisfied or a general-head condition should be imposed.

Other Recommendations

Peer Review of the Volusia Florida GWB model/project
July 22, 1998

Recommendations below largely refer to Review comments regarding report content and the presentation and description of simulation results. The items below are not a complete list of necessary topics or illustrations but refer largely to those items discussed during the Peer Review.

1. Maps showing simulated head differences between various model layers should be included in the final report for each simulation period - predevelopment, modern, future. Similar maps showing simulated head differences for the same layer during different periods are equally valuable.

2. Model boundary conditions should be clearly illustrated and explained, by layer. Simulated flux across various boundaries should be determined and illustrated on maps or listed in tables. Simulated boundary flux should be compared by layer for all major simulation periods.

3. A table showing simulated and observed spring flows for various simulation periods should be included in the report.

4. Simulated potentiometric surfaces for each layer and each simulation period should be shown. Maps showing simulated drawdown by layer and period are equally useful.

5. The simulated mass balance for each major simulation period should be illustrated or tabulated. Each simulated budget component should be presented or listed as a part of the mass balance summary.

6. A table or hydrogeologic column should be used to compare the geologic and hydrogeologic units in the model area to model layers and zones of leakance or VCONT.

LIST OF ATTENDEES
Peer Review of the Volusia Florida GWB Model/Project
July 22, 1998

Name	Affiliation	Phone number/email
Robert Faye	Reviewer/Consultant	770-476-3815 refaye@mindspring.com
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Roy Silberstein	PBSJ/Vol. Water Alliance	407-644-1579
Bob Morrell	PBSJ/Vol. Water Alliance	407-647-7275 ramorrell@pbsj.com

Appendix B.2b. -- Peer review of August 26, 1998

September 1, 1998

Robert E. Faye
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Doug Munch, Director
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St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H283: Summary of the second Peer Review of the Volusia Florida GWB model/ project (Area II); August 26, 1998

Dear Doug:

Enclosed is the Summary of the second Peer Review of the Volusia Florida GWB model/ project conducted at the SJRWMD Groundwater Programs meeting room during August 26, 1998. The meeting was chaired by Robert Faye and was called to order about 0930. Attendees at the meeting numbered five and are listed by name and affiliation by Attachment to the Summary. The progress of the meeting was deliberate and straightforward. Stan Williams was well prepared and covered most of the critical features of model design and calibration during his presentation. All attendees were urged to actively participate in the discussions and a lively dialog occurred regarding several model topics and features, particularly the method of computing net recharge to the Surficial aquifer. The enclosed Summary begins with a brief description of the major concerns addressed during the Peer Review followed by specific topical comments and recommendations. The order of the Review discussions did not necessarily follow the previously prepared agenda. The Peer Review Summary also reflects more the order of discussion than that of the formal agenda.

Please call me at 770-476-3815 if you wish to discuss any part or aspect of the enclosed Summary or the related meeting or review process.

Sincerely,

Robert E. Faye, P.E.

Enclosures/Attachments

cc: Barbara Vergara, Director, Division of Needs and Sources, SJRWMD

Charles H. Tibbals

SUMMARY OF PEER REVIEW MEETING
VOLUSIA FLORIDA GWB MODEL/PROJECT
AUGUST 26, 1998

Major Concerns:

The north, south, and west boundaries selected for the Volusia GWB model are somewhat troublesome because of the proximity of the boundaries to major springs and the projected locations of major pumping wells or well fields. Alexander Springs exists just beyond the midpart of the western boundary. Rock, Seminole, and other smaller springs are located just beyond or just within the western and central parts of the southern boundary of the Volusia GWB model. Proximate to the northern boundary are the proposed Palm Coast and Flagler Beach well fields, projected to withdraw between 6 and 10 MGD by year 2020 from the Upper Floridan aquifer. Such points of high discharge so close to model boundaries frequently distort simulation results at the boundaries and require the application of highly unique boundary features to affect model calibration. Such unique features often cannot be accurately projected into the future, resulting in highly suspect results when the model is used to simulate future conditions. Because spring discharges are a critical feature of year 2020 simulations, extraordinary means will be required to assure the appropriate simulation of future spring discharges that occur near the southern and western Volusia GWB model boundaries. Similarly, the effects of future withdrawals at the Palm Coast and Flagler Beach well fields on the head and flux distributions near the northern boundary will have to be determined in order to appropriately apply the Volusia GWB model to the simulation of year 2020 conditions.

Paralleling the discussions of Volusia GWB model boundaries were descriptions of corresponding boundaries of the East-Central Florida (ECF) model and the current Northeast Florida (NEF) model. Apparently, a portion of the northern part of the ECF model overlaps the southern part of the Volusia GWB model. Similarly, the southernmost part of the current NEF model overlaps the northern part of the Volusia GWB model. Accordingly, most or all the southern boundary of the NEF model and the northern boundary of the ECF model are internal to the Volusia GWB model and corresponding boundaries of the Volusia GWB model are internal, respectively, to the ECF and NEF models. Such overlapping of boundaries will require that boundary fluxes, head distributions, and hydraulic characteristic arrays all be consistent in the overlapped areas of the three models before final calibration is achieved for any of the models. In addition, model arrays that represent groundwater budget components, such as pumping and recharge, must be consistent in the overlapped areas when calibration represents the same period in time, such as 1995. Because the springs and well fields that are immediately adjacent to the boundaries of the Volusia GWB model (see discussion above) are internal to either the ECF or NEF model. the Review recommends that simulation of future conditions at these locations be achieved using either the NEF or ECF model, whichever is appropriate.

Other Comments, Concerns, and Recommendations:

1. All major streams, rivers, and lakes in the study area are simulated in the current

Volusia GWB model. Lakes currently included in the model are those larger than 500 acres. Application of the model to the simulation of future conditions may require that a finer grid resolution be utilized in areas of high lake density, in order to accommodate lakes smaller than 500 acres. Prior to final calibration, a GIS coverage of drainage features, including canals, will be developed and used to select the final array of such features incorporated into the model. The Review believes that illustrations and data published in USGS WRIR 84-4206 will be useful in creating this array. In addition, the Review recommends that selection criteria, such as length, location, section geometry, and discharge, be established beforehand and used to select the drainage canals and canal reaches necessary to reasonably simulate drainage from the Surficial aquifer.

Lakes currently included in the Volusia GWB model are Lake Woodruff, Spring Garden Lake, Lake Norris, Lake Harney, Lake Ashby, Lake George, Lake Monroe, Lake Jesup, and Lake Crescent. Lakes are simulated using adjacent general-head boundary cells with a high conductance value between cells, which, in effect, maintains a nearly constant head at the lake cells.

Streams currently included in the Volusia GWB model include the St. Johns River, Spruce Creek, the Tomoka and Little Tomoka Rivers, the Wekiva River, Haw and Middle Haw Creeks, Little Haw Creek, Deep Creek, Alexander Springs Creek, and the Lake Ashby Canal. Stream reaches are simulated using the MODFLOW River Package with cells assigned to the Surficial and Upper Floridan aquifers, as appropriate. Simulated results of aquifer discharge (whether Surficial or Upper Floridan) to these streams were not presented. For final calibration, the Review recommends that model discharge to all stream reaches be determined and compared to independently determined rates of baseflow for the same reaches, wherever possible. HYSEP is recommended as an appropriate computer code for separating stream discharge hydrograph data into baseflow and surface runoff.

2. Springs of major interest to the Volusia GWB model are Ponce de Leon, Blue, Green, Messant, Droty, Island, and Gemini Springs. Spring discharges are simulated using the Drain Package of MODFLOW. Simulated 1995 discharges at these springs presented during the Review compare favorably to observed discharges (7 percent or less), except at Droty Springs where the difference is about 28 percent. However, the observed discharge at Droty Springs is only about 1 cfs.

A depression in the potentiometric surface of the Upper Floridan aquifer at Ormond Beach is consistently represented on maps by a partially closed contour interval (5 ft.). This depression cannot be satisfactorily explained by pumping in the vicinity of Ormond Beach or by nearby pumping. The Review recommends that discharge from the Upper Floridan aquifer to unknown springs hypothetically placed near but offshore of Ormond Beach be simulated using the Volusia GWB model. Such discharge accompanied by modifications to the appropriate hydraulic characteristic arrays in the vicinity of Ormond Beach may provide a reasonable simulation of the observed depression. The accuracy of the measuring point altitudes at wells at and near Ormond Beach used to construct the Upper Floridan aquifer potentiometric surface maps should also be checked and compared to the National Geodeditc Vertical Datum (Mean Sea Level Datum). Poorly assigned measuring point altitudes, in terms of the Geodedtic Datum, could contribute to the appearance of a depression when none exists or accentuate a slight existing depression.

3. The geohydrologic framework of the Upper Floridan aquifer and related confining units was portrayed using east-west and north-south trending section lines showing natural gamma logs at control points. The Upper Floridan aquifer in the Volusia GWB is not subdivided into two distinct water-bearing units, as in the ECF model area. However, the Middle Semiconfining Unit is modeled as a water-bearing unit (active layer) and both lateral and vertical flows are simulated within and across this unit in the Volusia GWB model. The designation of the Middle Semiconfining Unit as an active layer was based on geohydrologic analysis and requirements to simulate highly specific discharges at major springs, particularly Blue Springs. The base of the Middle Semiconfining Unit in the Volusia GWB is defined as the top of highly mineralized water characterized by a chloride concentration of 5,000 mg/l (unpublished map) or the base of the unit as formally mapped by Miller (1986), whichever is higher.

The base of the Lower Floridan aquifer was also modified for this project from the formal representations by Miller (1986). Where highly mineralized water occurs, the base of the aquifer was raised to a level in the water column characterized by a chloride concentration of 5,000 mg/l. (unpublished map). Where "freshwater" occurs, the base of the aquifer is the same as that mapped by Miller (1986).

The Review recommends that contour maps showing the thickness of the Middle Semiconfining and Upper confining units, as applied to the Volusia GWB model, be developed and included in future representations of the Volusia GWB model and model results. Leakance arrays representing these units in the model were developed by combining the respective thickness arrays to corresponding distributions of vertical hydraulic conductivity.

Contour maps showing altitude at the top of the aquifer units defined in the Volusia GWB should also be developed along with respective maps showing aquifer thickness.

The Review also expresses caution in the application of unpublished maps and any other unpublished interpretive resources to this and other ongoing simulation-based projects. Unpublished interpretive resources that are frequently utilized should be peer reviewed and published. Alternatively, maps and other unpublished interpretive information can be published in the reports that summarize the results of model investigations, along with appropriate explanations of respective methods and approaches.

4. Lateral boundary conditions assigned to the layer of the Volusia GWB model that represents the Surficial aquifer are no-flow to the north, east, and south and mostly general-head

to the west. Corresponding conditions for the layers representing the Upper Floridan aquifer and the Middle Semiconfining Unit are general-head along the entire west and south boundaries and part of the north boundary. Conditions along the remainder of the north boundary are no-flow. A general-head condition is assigned to the eastern boundary of both layers at a distance offshore arbitrarily determined as the line where most simulated eastward flow is lost to diffuse upward leakage. Where the lateral boundaries of the layer representing the Lower Floridan aquifer juxtapose highly mineralized water, no-flow conditions are assigned. General-head conditions are assigned to the remaining boundary cells. The source-head for the general-head condition for all layers is considered the average 1995 head at a distance of 2 cell widths (4,800 ft.) from the boundary.

The Review considers the assigned boundary conditions to be reasonable but cautions that conditions along these boundaries may necessarily change prior to final calibration because of overlapping model areas and other considerations described in **Major Concerns**.

5. The array that represents transmissivity of the Upper Floridan aquifer in the Volusia GWB model is largely based on calibration, such that selected values of lateral hydraulic conductivity, within a specific range of conductivities, were iteratively assigned to the respective thickness array of the aquifer until a satisfactory calibration was achieved. The range of hydraulic conductivities used in this approach (25 to 6,000 ft./day) is based on values determined from the results of aquifer tests. Aquifer tests chosen for analyses were selected based on the interval of surface casing (greater than 100 ft.), the test discharge, and whether or not observation well data were collected during the test. Conductivities were computed from the test transmissivity and the interval of the well open to the Upper Floridan aquifer and were corrected for partial penetration. A lateral hydraulic conductivity of 6,000 ft./day is exceedingly large and probably should only be applied in the vicinity of large springs. Similar approaches were used to develop the transmissivity arrays for the layers representing the Surficial aquifer, the Lower Floridan aquifer, and the Middle Semiconfining Unit. Lateral hydraulic conductivities currently assigned to these layers are 10 to 100 ft./day, 30 ft./day, and 1 ft./day, respectively. Aquifer-test results are not generally available for these units and calibrated hydraulic characteristic arrays are based largely on trial and error calibration. Accordingly, assigned values may change prior to final calibration.

6. Potential (or net) recharge to the Surficial aquifer is computed using an algorithm similar to that applied to the ECF model:

Potential recharge = Rainfall - minimum ET - Overland Runoff + Agriculture application + Septic Tank leakage + a percent of Public Supply.

The specific elements and adjustment factors related to this algorithm are still in various stages of development. The Review strongly recommends that all District scientists currently using a version of this algorithm keep one another well informed regarding algorithm modifications and corresponding changes in simulation results.

Rainfall for 1995 is considered to be 53 inches over the entire Surficial aquifer, the average of data collected at 40 stations within and adjacent to the Volusia GWB. Rainfall at these stations ranged from 42 to 68 inches during 1995. For preliminary calibration, overland runoff is estimated to be 35 percent of total runoff and minimum ET is estimated at

27 inches/year. Maximum ET is considered to be about 46 inches/year. The percentage of public-supply water use applied to the computation of potential recharge ranges from 20 to 50 percent and is considered to represent infiltration to the water table from landscape application, such as yards and golf courses, and system losses from leaking pipes and drains. Rates of water application for agricultural purposes are obtained from the SJRWMD Water Supply Management Division for various crops. Leakage from septic tanks has not been estimated but is currently considered small, compared to other components of the recharge algorithm. The land use at individual model cells is determined using appropriate GIS coverages and is area weighted by cell, to determine the representative land use category within a cell area.

Ultimately, overland runoff will be calculated using area weighted land use in conjunction with appropriate SCS curves, a method similar to that applied to the ECF model. The Review recommends that rates of overland runoff determined in this manner be compared to the rates of surface runoff determined from the hydrograph separation analyses using HYSEP.

The ET Package of MODFLOW is used in the Volusia GWB model to compute excess ET over the minimum rate. A total excess of 19 inches is allowed (27" + 19" = 46"). Extinction depths applied to MODFLOW range from 4 to 8 ft.

For final calibration, rainfall rates for 1995 will vary over the model area to better represent observed rainfall variability. The method of areal distribution has not yet been determined.

7. Calibration results were presented largely in terms of simulated head distributions for the Upper Floridan aquifer and simulated discharges at major springs (discussed above). The comparison of observed to simulated 1995 heads is generally good to excellent. Subsequent to the Review, Stan Williams provided Robert Faye a graph of observed and simulated heads and a table of corresponding residuals at target wells. These data also reflect an appropriate calibration for the model layer representing the Upper Floridan aquifer. Maps of simulated potentiometric surfaces for the Lower Floridan aquifer, the Middle Semiconfining Unit, and the Surficial aquifer were also shown to Robert Faye following the Review but were only briefly examined and discussed. Considering the preliminary nature of the calibration, these results appear reasonable. With the exceptions of simulated spring discharges and the eastward (offshore) discharge from the Upper Floridan aquifer, other features of the groundwater budget useful for calibration were not discussed in detail. The Review strongly recommends that the results of final calibration include a complete, layer-by-layer description of boundary fluxes and comparisons of simulated discharges to rivers and streams to independently determined rates of baseflow, where possible.

LIST OF ATTENDEES
Second Peer Review of the Volusia GWB Model/Project
August 26, 1998

Name	Affiliation	Phone number/email
Robert E. Faye	Reviewer/Consultant	770-476-3815 refaye@mindspring.com
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Appendix B.2.c. -- Peer review of May 5, 1999

May 14, 1999

Robert E. Faye
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Doug Munch, Director
Division of Groundwater Programs
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H283 Summary of third Peer Review of Volusia Florida GWB model/project (Area II), May 5, 1999.

Dear Doug:

Enclosed is the summary of the third Peer Review of the Volusia Florida GWB model/ project. The meeting was held at the SJRWMD Groundwater Programs meeting room during May 5, 1999. The Review was chaired by Robert Faye and was called to order at about 0930. Attendees at the meeting numbered eight and are listed by name and affiliation in an Attachment to this Summary. All attendees were urged to actively participate in the review discussions. Robert Faye, Charles Tibbals, Brad Pekas, David Gore and Bob Haviland were active participants.

Please call me at 706-745-7105 if you wish to discuss any part of the enclosed summary or the related meeting or review process.

Sincerely,

Robert E. Faye, P.E.

Enclosures/Attachments

cc: Barbara Vergara, Director, Division of Needs and Sources, SJRWMD
Charles H. Tibbals

SUMMARY OF PEER REVIEW MEETING
VOLUSIA FLORIDA GWB MODEL/PROJECT
MAY 5, 1999

The technical discussions opened with a short review of suggestions and recommendations made during the second Peer Review in August 1998 (memo to Doug Munch, September 1, 1998) and which of these suggestions had been applied to the current model. With the exception of resolving differences in those parts of the Volusia Florida GWB model common to either the Northeast or East-Central Florida flow models, all previous major suggestions and recommendations had been implemented. Some effort also has been made to resolve differences regarding the computation of recharge to the surficial aquifer and the approaches now applied to the East-Central and Volusia GWB flow models are similar. No such effort has apparently been made with respect to the Northeast flow model. Similarly, no efforts have apparently been made to resolve differences in hydraulic characteristic arrays, pumpage distributions or other coverages in areas common to the three models. Resolving such differences is especially critical for the Volusia GWB model because a major percentage of the model domain is common either to the Northeast or East-Central flow model. Accordingly, even relatively modest changes in critical arrays within the common (or overlap) areas could effectively negate much of the current calibration of the Volusia GWB model, because those changes would affect much if not most of the model domain.

1. The Review Team strongly recommends that every effort be made as quickly as possible to discover, articulate, describe, explain and resolve all differences in all model arrays and other critical coverages used in model calibration (land use, soils, rainfall, overland runoff, etc.) relative to areas common to the domains of the Volusia Florida GWB, Northeast Florida, and East-Central Florida flow models. The results of these efforts should be model arrays with similar or same values in areas common to each of the three models. **Until these differences are resolved, leading to the final calibration of each model, the Review Team cautions that application of any of these models to the simulation of 2020 or other future year conditions is accompanied with considerable risk and uncertainty relative to defending the validity of the simulated results.**

2. Subsequent to the second Peer Review of the Volusia Florida GWB model, Stan Williams has expended considerable effort in refining and improving the hydrogeologic and hydrologic descriptions of the surficial aquifer and using these results to refine the calibration of the Volusia Florida GWB model. Currently, more than 1000 control points, including lake levels and water levels in wells, are used to describe the calibration of the surficial aquifer. In addition, simulated stream discharges compare excellently with observed 1995 discharges at gaging stations. The Review Team commends these efforts because the simulation of flow and heads in the surficial aquifer substantially influences the simulation results for the underlying model layers and calibrated results of simulated heads and springflows in the Upper Floridan aquifer are excellent. Several of these efforts, however, probably have extended far beyond the ability of the principal investigator to rationalize and defend, particularly the model arrays that describe the distribution of lateral hydraulic conductivity and evapotranspiration (ET) extinction depth for the surficial aquifer (layer 1). The current areal distribution of values in each of these arrays now closely resembles the corresponding array of land surface altitude. While such relationships are not impossible (particularly with respect to hydraulic conductivity) and may be related to depositional environments, the distributions in the current Volusia GWB model suggest an excessive reliance on simulation results to calibrate at the expense of

conceptual realizations or field data that support such results. Accordingly, the Review Team recommends that each of these arrays be reevaluated and revised to a level that can be reasonably defended and explained by field data and/or valid conceptual descriptions. In particular, the Review Team recommends that every effort be made to limit applied ET extinction depth to one value or two at the most. In addition the final calibrated distribution of lateral hydraulic conductivity should probably be less detailed and control points showing computed values based on aquifer tests should be shown on the distribution map. Hydraulic conductivity data published by the USGS for Volusia and adjacent counties may be helpful in this regard (Phelps, G. C., 1990, USGS WRIR 90-4069).

A thickness map of the surficial aquifer was not shown during the Review but would be a helpful adjunct to the hydrogeologic description of the aquifer.

3. The limits of several areas contributing to gaging stations were questioned during the Review. The Review Team recommends that maps of an appropriate scale be sent to Howard George of the USGS at Altamonte Springs and request a confirmation of the area boundaries and station lines. The methods used to delineate the areas should be described in the final report that summarizes the results of the study.

4. A line showing a possible canal or stream reach is shown on several coverages crossing the southern part of Lake Monroe. This line is probably a coverage error and should be corrected.

5. The Theissen polygon distribution used to areally distribute average rainfall intrudes eastward (Ashby gage) and perhaps distorts the rainfall coverage. This intrusion may be caused by a relative lack of data to the east and near the coast. A check of calibrated head residuals in the surficial and Upper Floridan aquifer in this area may indicate distorted recharge if residuals are generally biased high or low. The Review Team also recommends that all gages used in the development of the polygon distribution be shown on the appropriate illustration and that the agency affiliated with each gage be noted (SJRWMD, NOAA, etc.).

6. Contour maps are generally easier than color distribution maps for the reader or reviewer to interpret. In addition, all maps or illustrations from published sources or modified from published sources should contain the appropriate citation for the source of the information.

7. The constant head used to define several lakes may need to be adjusted. The Review Team suggests that the current heads used at Lakes Disston, George, Crescent, and Daugharty be checked.

8. A simulated flux of 90 cfs crosses the western boundary of the model. This flux probably represents discharge to Seminole Springs. Because of the proximity to model boundaries, a previous review had recommended removing several springs from the model (including Seminole Springs) and simulating just the spring discharges in the interior of the model. The current application of general head boundaries to the model obviates that recommendation and several of the first or second magnitude springs that were removed can be returned to the model, possibly including Seminole Springs. Care should be exercised, however, regarding the placement of the boundary fixed head to include the approximate contributing area of the spring or springs that occur outside the model boundary.

Also, all large springs in the model domain should be labeled on appropriate illustrations and described in corresponding tables or texts. Those not used in the model should be identified and explanations provided for their model status.

A simulated flux of 62.7 cfs crosses the southern boundary of the model and must discharge somewhere in Seminole County. Probably must of this flux is lost as simulated diffuse leakage to the Wekiva River. Tibbals, in USGS 1403-E, reports seepage run data for the Wekiva River indicating that the source of nearly all of the river discharge is from known springs and, consequently, little or no streamflow gain occurs along the stream channel as leakage. This condition is common also to the East-Central flow model and the Review Team recommends collaboration with Brian McGurk to calibrate both the Volusia GWB and the East-Central flow models to conform as closely as possible to the distribution and quantity of the published Wekiva River flows.

Because of dredging, several reaches of the St. Johns River may be directly connected to the top of the Upper Floridan aquifer. Dredging may have occurred upstream to and across Lake Harney. The connection of cells representing these streams in the model should be checked and connections made to the Upper Floridan aquifer where appropriate.

9. Simulated eastward discharge offshore in the Upper Floridan aquifer (layer 2) is lost entirely to diffuse upward leakage to layer one. Such results probably conform closely to actual aquifer conditions. Transmissivity of layer two in offshore areas appears excessively high, however, ranging from 250,000 to 1,000,000 ft^2/d. Following recalibration of the model per Item#1 above, the sensitivity of this transmissivity array should be tested and lowered, if test results support such an approach. In addition, Joides and other hydrogeologic data pertinent to the Upper Floridan aquifer in offshore areas should be evaluated to support and defend the final calibrated transmissivity distribution.

10. In the algorithm used to compute recharge to the surficial aquifer, reapplication of agriculture waters, landscape irrigation, septic tank returns, water applied to rapid infiltration basins, etc. are all combined in the “reuse” parameter. This is different than Brian McGurk’s approach which separates the water applied to rapid infiltration basins from other secondary applications. Such differences in approach will probably cause unnecessary difficulties when attempts are made to reconcile differences in the areas common to the Volusia GWB and East-Central flow models. The Review Team considers the algorithm that separately accounts for the water applied to rapid infiltration basins as the better approach and recommends that both models conform to this approach.

11. The calibrated transmissivity distribution of the Middle Semi-confining Unit is unusual in the northern part of the study area. The maximum transmissivity shown is only about 300 ft^2/d, which is small for any water-bearing unit. The Review Team is aware that the Middle Semi-confining Unit is simulated as an active layer to provide additional water to the Blue Springs area; however, probably only a single value for transmissivity can be justified for the calibrated model.

12. Simulated 1995 leakage from layer 1 (surficial aquifer) to layer 2 (Upper Floridan aquifer) locally ranges from 36 to 60 in/yr. Corresponding rates for the simulated predevelopment condition at the same cells should be determined and compared to 1995 conditions. Differences should be explained and justified. Simulated leakage rates of 60 in/yr for 1995 probably are not reasonable except in areas characterized by high areal densities of pot holes or sink holes.

13. A table that summarizes the simulated water budget for each model layer and period

should be included in the description of model calibration.

LIST OF ATTENDEES
THIRD PEER REVIEW OF THE VOLUSIA FLORIDA GWB MODEL/PROJECT
MAY 5, 1999

Name	Affiliation	Phone number/email
Robert E. Faye	Reviewer/Consultant	706-745-7105 refaye@stc.net
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Appendix B.3: -- Northeast Florida model areas

Appendix B.3.a. -- Northeast Florida model

Appendix B.3.a.(1) -- Peer review of July 23, 1998

July 27, 1998

Robert E. Faye
3468 Larch Pine Drive
Duluth, GA 30096

Doug Munch, Director
Division of Groundwater Programs
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H283: Summary of Peer Review of the Northeast Florida model/project (Area V); July 23, 1998

Dear Doug:

Enclosed is the Summary of the Peer Review of the Northeast Florida model/project conducted at the SJRWMD Groundwater Programs meeting room during July 23, 1998. The meeting was chaired by Robert Faye and was called to order about 0830. Attendees at the meeting numbered nine and are listed by name and affiliation by Attachment to the Summary. Based on our discussions of Friday, July 24, 1998, during the exit interview, SJRWMD Groundwater Programs will solicit comments from selected attendees and those comments received will be attached to and distributed with the formally accepted Summary.

After calling the meeting to order, Robert Faye briefly explained the purpose of the Peer Review and emphasized the informal nature of the discussions. All attendees were urged to actively participate in the discussions. Although many attendees offered comments and suggestions, the bulk of the technical questions and suggestions were offered by Robert Faye and Charles Tibbals. The enclosed Summary begins with a brief description of the major points of discussion followed by comments and recommendations regarding the current technical status of the model and its application to achieve Water 2020 objectives.

Following the general comments and recommendations are listed specific topical comments and recommendations. Because the order of discussion of the Peer Review was left largely to the discretion of the Groundwater Programs staff responsible for the presentation, the Review did not necessarily follow the previously prepared daily meeting agenda. The Peer Review Summary also reflects more the order of discussion at the meeting than that of the formal agenda.

Please call me at 770-476-3815 if you wish to discuss any part or aspect of the enclosed Summary or the related meeting or review process.

Sincerely,

Robert E. Faye, P. E.

Enclosures/Attachments

cc: Barbara Vergara, Director, Division of Needs and Sources, SJRWMD
Charles H. Tibbals

SUMMARY OF PEER REVIEW MEETING
NORTHEAST FLORIDA MODEL/PROJECT
JULY 23, 1998

The technical discussions opened with Doug Durden describing the status of current numerical groundwater flow models applied to the northeast Florida area and his efforts to combine several models into a single tool to predict future potentiometric levels in the Floridan and Surficial aquifers. Three models were described: (1) A steady-state regional groundwater flow model developed by Motz, et. al. (1995) which simulates conditions in the Floridan aquifer during predevelopment and in 1985; (2) A comprehensive and highly detailed groundwater flow model by Durden (1997) that simulates flow in the Floridan aquifer and in the Fernandina permeable zone during predevelopment, 1985, and 2010 throughout most of northeast Florida and Camden County, Georgia; and (3) A large-area model, that combines many of the features from models (1) and (2) and includes, as well, a larger area of northeast Florida, particularly western parts of Nassau, Duval, and Clay counties as well as parts of Putnam, St. Johns, Flagler, Bradford and Alachua counties. A detailed description of the model by Motz, et. al. (1985) was provided by Durden. This model will form much of the basis for the southwestern part of the large-area model.

The model by Durden (1997) was discussed in the context of its suitability, with and without modification, to predict year 2020 drawdowns based on specified water-use projections. The arrays from this model are intended to form a large part of the input data for the large-area model for the areas represented by Nassau, Duval and Clay counties, Florida and Camden county, Georgia. The large-area model is currently in the initial stages of development and was only briefly and generally discussed. Durden emphasized the rapidly approaching deadlines by which year 2020 drawdowns in the Floridan and Surficial aquifers are to be simulated and provided to SJRWMD contractors and customers. He emphasized the importance of simulating the effects of future withdrawals at a proposed Cecil Field well field on future Floridan and Surficial aquifer water levels as well as future water-level conditions at Keystone Heights, which apparently are affected by pumping at a variety of sources, including Gainesville, Orange Park, Palatka, Jacksonville, and a Georgia Pacific pulp and paper mill near Palatka. The Review concludes that the current Northeast Florida model by Durden (1997) should not be used to predict year 2020 conditions without modification to the boundaries assigned to various layers and some additional recalibration.

With respect to the Keystone Heights concerns, the Review recommends that the model by Motz, et al. (1995) be used to test the drawdown from predevelopment conditions at Keystone Heights caused by the various pumping sources. With the exception of Jacksonville, each pumping source listed above can be separately evaluated to determine its direct contribution to drawdown in the Floridan aquifer at Keystone heights by 1985.

Numerous other highly specific suggestions and recommendations were made by the attendees and reviewers within the context of the discussions summarized above. These comments are summarized below along with appropriate background information that is provided when the context of the discussions may not be readily apparent. Unless otherwise noted the Comments and Recommendations summarized below were made by Robert Faye and/or Charles Tibbals.
Comments, suggestions, conclusions, and recommendations attributed herein to the Review are also those of Robert Faye and/or Charles Tibbals.

Comments and Recommendations
Peer Review of the Northeast Florida Model/Project
July 23, 1998

1. Determine that the currently available version of the Motz, et. al. (1995) model code and input arrays duplicate exactly the code and related arrays reported as the calibrated version. Run the available model with the supposed calibrated arrays and closely check the results against those reported by Motz, et. al. (1995). If these comparisons fail, then additional efforts should be made to bring the model simulations into complete conformance with reported results. Also examine closely the simulated results and flow conditions (features) that are not explained or only casually discussed in the summary report.

2. Regarding the regression analysis of water-table altitudes plotted against land-surface altitudes, the fundamental physical condition that allows this approach to be successful is the lack of extreme, seasonal variation in Surficial aquifer water levels. This point should be clearly established and demonstrated using continuous-record hydrograph data before further refinements of the basic regression approach are attempted. The high-altitude water levels (>90 ft.) used in the original regression were questioned and are perhaps of a different population than the lower-level data. A new regression model should be computed using paired data without the high-altitude water levels and applied to the surficial aquifer. A regression model using only the high-altitude water levels should also be computed, and if suitable, applied to appropriate parts of the Surficial aquifer.

3. Several additional illustrations or modifications to current illustrations were suggested. A column showing the geologic and hydrogeologic frameworks and related active and VCONT model layers should be included in future reports, including the report that summarizes the results of the large-area model. Areas of artesian flow should be outlined on a dedicated illustration or, preferably, on a map showing an Upper Floridan potentiometric surface and boundary conditions.

4. Al Aikens questioned whether or not the vertical discretization (layering scheme) proposed for the large-area model was sufficient to address all of the proposed Water 2020 questions. He suggested that recent USGS work by Phelps and Spechler, that utilizes borehole logs to evaluate zones of high and low transmissivity, be considered in future refinements of the layering scheme for the Northeast Florida flow model.

5. Warren Leve questioned the thickness of the Fernandina permeable zone used by Durden in the current flow model (Durden, 1997). Leve believes the zone as used in the model is too thick. Durden indicated that the thickness is based on maps and data shown by Miller (1986). Faye reiterated that Miller's work is the current hydrogeologic standard for the Floridan aquifer in the study area, but if Leve had additional or contradictory data, he should compare it to Miller's interpretations and document any differences in writing. Durden wants to use Miller's hydrogeologic framework until that work is substantially superseded. Durden's approach is entirely appropriate.

6. The zone of compressed (high gradient) potentiometric contours in the Upper Floridan aquifer southeast of Keystone Heights was a topic of considerable discussion relative to the results of the Motz, et. al. (1995) flow model. Motz, et. al. (1995) was able to simulate the appropriate potentiometric configuration by introducing a line of relatively low transmissivity downgradient of the zone in the Upper Floridan aquifer. Simulating a relatively concentrated recharge to the zone (perhaps from the Lower Floridan aquifer) will also provide a similar result. Durden should carefully examine these possibilities when he considers the results of the Motz, et. al. (1995) model simulations per # 1 above.

7. Several recommendations were made regarding modifications and improvements to the current Northeast Florida flow model (Durden, 1997). The conditions assigned at the boundaries of the layers representing the Upper and Lower Floridan aquifers and the Fernandina permeable zone should conform to the current and most defensible concept of these boundaries and the boundaries must be similar for both predevelopment and 1985 simulations. Accordingly, general-head boundaries should be used in all layers. Where specified heads beyond the boundaries have changed between predevelopment and modern times, and modern heads are largely unknown, the predevelopment gradient across the boundaries should be maintained to assign the modern heads. A special case is the boundary at the freshwater/saltwater interface assigned to the eastern part of the Fernandina permeable zone. A no-flow boundary is probably most appropriate for the predevelopment condition, but modern heads at the boundary may be lower than predevelopment heads because of pumping at St. Marys, Georgia and at Jacksonville. To evaluate the head decline at the boundary, a transient analysis is advised using the recalibrated Northeast Florida model. Realistic pumpage rates at Jacksonville and St. Marys (and elsewhere as necessary) and storativity values should be assigned to the model and run for an appropriate period to determine if water-level declines at the boundary could occur following predevelopment and by how much. A similar approach could be used during calibration of the large-area model and for projecting boundary heads forward to year 2020 conditions. If the transient analysis determines that modern pumping conditions have probably lowered predevelopment heads at or near the specified location of the interface, then iterative tests should be made using alternate runs of the transient model and substituting general-head conditions for no-flow conditions along affected lengths of the interface until remaining no-flow cells (from the predevelopment simulation) are no longer affected. The Review understands that such an approach is approximate, at best, but strongly suggests, as well, that some effort should be made to attempt to evaluate head change at the freshwater/saltwater interface. Ultimately, the head conditions and possible movement of the interface can best be evaluated by applying a variable-density flow model to the study area.

The sensitivity analysis of the current Northeast Florida model (Durden, 1997) is flawed and should be changed for the recalibration as well as for the large-area model when it is calibrated. Several suggestions regarding appropriate changes in the reported approach to sensitivity analysis were made during the Review.

The calibration strategy used for the current Northeast Florida model (Durden, 1997) may also be somewhat flawed. The physical bases for a steady-state calibration are essentially (1) a high aquifer diffusivity, whereby the aquifer equilibrates rapidly to changes in stress, and (2) a demonstrated lack of extreme or frequent changes in head during the selected calibration period. Given the observed values of transmissivity and storativity for the Floridan aquifer in the study area, a high to very high diffusivity can be safely presumed. However, no demonstration or discussion of head changes during and somewhat prior to September 1985 was provided in the summary report or during the Peer Review. Continuous-record hydrographs should be analyzed and used to demonstrate that selected calibration periods are periods of substantially unchanging conditions in the Floridan aquifer. If such conditions cannnot be demonstrated, then an alternative calibration strategy should be considered. If a calibration strategy based on steady-state conditions is maintained, then calibrating to a relatively short (one or two months) "wet" or "dry" condition should be considered and then calibrating again to the alternative condition for the same or following year. Pumping rates used in the calibration should be the average for an appropriate period (several months) prior to the selected calibration period. Appropriate qualification of the calibration strategy should be part of the description of the calibration and related results. Some additional use of groundwater budget components in model calibration is highly recommended. For the current Northeast Florida model, such components could include estimated discharge from the Upper Floridan and Surficial aquifers to the St. Johns River. Use of the "river package" in MODFLOW could facilitate this approach. Dredging of the St. Johns River to maintain a channel for barges may not have enhanced leakage to the river because of the thickness of the underlying confining unit. Calibrating to the measured discharge of large springs should also be considered, if such springs occur in the study area. The approach used by Brian McGurk and Paula Presley to compute net recharge to the East-Central Florida model is recommended to Durden as a reasonable approach to compute net recharge to the large-area model.

8. Al Aikens recommended using a long flow line in the western part of the study area that extends from the area of Keystone Heights to the vicinity of St. Marys and Jacksonville as the western boundary of the large-area model. Such a boundary is highly defensible and would greatly facilitate model development and calibration. Durden strongly objected to this approach citing a lack of areal coverage and related pumping centers necessary to evaluate conditions at Keystone Heights. Faye suggested that the model developed by Motz, et. al. (1995) could be used to relate specific pumping sources to conditions at Keystone Heights, thus maintaining the advantages of the western boundary suggested by Aikens. The response to pumping at Jacksonville at Keystone Heights can be indirectly evaluated at the model boundary using simulations from the recalibrated current Northeast Florida model. Durden further objected citing unknown conditions at the boundaries of the Motz, et. al. (1995) model. Such conditions can be evaluated using a thorough sensitivity analysis, relating changes at the boundaries to responses of heads at Keystone Heights.

Another objection cited by Durden regarding the use of the western flow line as a large-area model boundary was the necessity of evaluating the regional response of the Floridan aquifer to pumping at the proposed Cecil Field well field. The proposed location is outside the boundaries of both the Motz, et. al. (1995) model and the current Northeast Florida model (Durden, 1997). A "well-field" model can be developed centered on the proposed Cecil Field well field location and responses to anticipated pumping can be evaluated at locations that correspond to the near boundary of the current Northeast Florida model (Durden, 1997). Accordingly, flux computed by the well-field model into the Cecil Field well field at the Northeast Florida model boundary can be treated as a specified discharge from the Northeast Florida model, when it is used to predict year 2020 conditions.

Use of the western flow line as a boundary for the large-area model is advantageous from the points of view of both improving the timeliness of calibration and the technical quality of the final model. Objections raised by Durden regarding evaluating the response of potentiometric levels at Keystone Heights to various sources of pumping and the regional response of potentiometric levels to pumping at the proposed Cecil Field well field probably can be overcome without resorting to a large area model, as originally proposed by Durden.

LIST OF ATTENDEES
PEER REVIEW OF THE NORTHEAST FLORIDA MODEL/PROJECT
JULY 23, 1998

Name	Affiliation	Phone number/ email
Robert Faye refaye@mindspring.com	Reviewer/Consultant	770-476-3815
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Al Aikens aaikens@ch2m.com	CH2MHILL	407-423-0030
Charles Tibbals ctibbals@cde.com	Reviewer/Consultant	352-669-4703
Don Beatie beattie@aug.com	SJC Audubon	904-287-6322
Roger Van Ghent rogervg@aug.com	SJC Audubon	904-797-5997

Appendix B.3.a.(2) -- Peer review of April 6, 1999

April 14, 1999

Robert E. Faye
P.O. Box 43
Blairsville, GA 30514

Doug Munch, Director
Division of Groundwater Programs
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL. 32178-1429

Re: SJRWMD Contract #98H283: Summary of second Peer Review of the Northeast Florida model/project (Area V). Model simulations of expected year 2020 drawdowns caused by industrial, commercial and municipal pumping from the Floridan aquifer.

Summary of Peer Review of analytical model results. Model analysis of relative contribution to regional drawdown in the Floridan aquifer caused by groundwater withdrawals for potato irrigation, paper production, and thermo-electric power production.

Dear Doug:

Enclosed are summaries of Peer Reviews of simulation results conducted at the SJRWMD Groundwater Programs meeting room during April 6, 1999. The meeting was chaired by Robert Faye and called to order about 0915. Attendees at the meeting numbered eight and are listed by name and affiliation by Attachment to the summaries. All attendees were urged to actively participate in the discussions; however, the bulk of the technical comments and suggestions were offered by Robert Faye and Charles Tibbals. The order of presentation of topics in the Peer Review summaries reflects the order of discussion at the meeting.

Please call me at 706-745-7105 if you wish to discuss any part of the enclosed summaries or the related meeting or review process.

Sincerely,

Robert E. Faye, P.E.

Enclosures/Attachments

cc: Barbara Vergara, Director, Division of Needs and Sources, SJRWMD
Charles H. Tibbals

SUMMARY OF PEER REVIEW MEETING
EXPECTED YEAR 2020 DRAWDOWNS
NORTHEAST FLORIDA

APRIL 6, 1999

The technical discussions opened with a short review of modifications to the Northeast Florida flow model that resulted from the first Peer Review conducted in July 1998. The no-flow boundary used to simulate the freshwater/saltwater interface in the Fernandina permeable zone was revisited, as were the concerns expressed regarding the area of overlap between the Northeast Florida and Volusia County models. The Review Team again suggests that a test be conducted to evaluate whether or not simulated drawdown occurs at the assigned location of the freshwater/saltwater interface. Details of this suggestion are described below. Doug Durden acknowledged the importance and usefulness of addressing the overlap issues and will do so when he undertakes the development of the "new" Northeast Florida flow model. He has dedicated considerable time and effort to the compilation and verification of water-use data to be used for year 2020 drawdown simulations and has not been able to meaningfully consider other model issues.

Robert Faye briefly discussed the advantages of applying a new code SEAWAT to the simulation of variable density flow. The code can be applied as a module to MODFLOW and can deterministically locate the freshwater/saltwater interface offshore using available RASA or other models. A document describing the SEAWAT program, solution approach, and input data was distributed to Attendees. The Review Team also reemphasized that interpretive products developed by the Groundwater Program Staff and used as bases for model or other studies be peer reviewed and published.

Discussions of the "Drawdown Model" and related simulations began with considerable explanation by Doug Durden of the additional layer added to the modified Northeast Florida flow model to accommodate the computation of evapotranspiration (ET) from the surficial aquifer. (For this Review, the term "modified" is used in conjunction with the northeast Florida flow model to denote that changes to the model described in Durden (1997) were made to accommodate several of the suggestions and recommendations forthcoming from the Peer Review conducted in July 1998.) The additional layer is analogous to a leakance layer but is populated, instead, with ET rate reduction factors. A source-sink layer of specified heads is assigned as a model array (model layer 1) to provide a base for computing the head difference necessary to complete the computation of ET reduction caused by head declines in the surficial aquifer. The model constructed with these additional arrays effectively duplicates the conditions of the coupled unpumped water-table and pumped artesian aquifers, described by Motz (1978), where increases in pumpage are exactly balanced by reductions in ET caused by drawdowns in the water-table aquifer.

The approach by Durden to compute drawdowns in the Floridan aquifer expected for the year 2020 is essentially to apply the principles of superposition using the modified Northeast Florida flow model, partly balancing expected changes in future pumpage with reductions in ET from the surficial aquifer. Modifications to the original Northeast Florida flow model of significance to this review were changes in the assigned boundary conditions of several layers from no-flow to general head. To accommodate superposition, all initial head and boundary head arrays are assigned a zero value. All other model arrays, except pumpage, are exactly those of the modified Northeast Florida flow model described previously. Pumpages assigned to the model represent the expected changes in pumpage (increases or decreases) between years 1995 and 2020. The Review Team believes this approach is technically appropriate and will adequately address the project objectives of evaluating head changes in the Floridan aquifer caused by expected changes in future pumpage. This approach, however, probably will not result in accurate or reasonable descriptions of actual drawdown in the surficial aquifer. The Review Team strongly recommends that only general areas of simulated drawdown in the surficial aquifer be identified and referred to as areas of possible future drawdown. Under no circumstances should simulated values of drawdown be assigned to the surficial aquifer. Other suggestions, comments, and recommendations made by the Review Team are listed below:

1. The term "superposition" is probably more technically accurate and precise than "drawdown", when used in conjunction with the simulation approach described previously. The Review Team suggests using the terms "superposition model" to describe same.

2. The organization of the draft report can be significantly improved by discussing the advantages of the superposition approach in the Methods section. The discussion of the source heads assigned to general head boundaries also appeared out of logical order. At least eight different modifiers were used to describe two or possibly three different models. Such a proliferation of terms is highly confusing to the reader and should be corrected. Whether or not pumpage is assigned to a particular model layer should be indicated on the schematic diagram showing the configuration of model layers. The modifier "changes" should be used in association with "withdrawals", where appropriate, to indicate that the superposition approach is based on differences in pumpage, not actual pumpage.

3. Future pumpage at the proposed Cecil Field well field was located right at the western boundary of the model. Although the assigned boundary condition is general head, the source head is assigned only about four miles from the boundary. Simulated drawdowns in the Upper Floridan aquifer caused by future Cecil Field pumpage appeared to project into the model domain at least eight miles. Given the apparent symmetry of the simulated drawdown configuration associated with this pumpage, the Review Team recommends that the source head be assigned at least ten miles from the current boundary.

4. The most troublesome technical issue raised by the review team was the assignment of no-flow boundary conditions to represent the freshwater/saltwater interface in the Fernandina permeable zone (model layer 5). The concerns raised by the Review Team were essentially the same as those raised in the first Peer Review in July 1998; that is, the boundary is arbitrary and should be tested relative to its influence on simulated results. Accordingly, the Review Team again recommends that such tests be accomplished. Essentially the recommendation is to test the possible extremes at the boundary and evaluate same in conjunction with the corresponding simulated results. An appropriate test can be accomplished by assigning a no-flow condition and specified head condition at the boundary. With the no-flow condition in place,

the simulated results should be checked to determine if drawdown occurs at the adjacent landward cells and the amount of this drawdown compared to the assumed (i.e. assigned) head at the boundary. All other model conditions and arrays should correspond to the calibrated model. If simulated drawdown at the boundary is significant, then the boundary should be converted to a specified head, using those heads considered most representative of actual conditions. The simulated results should then be evaluated by determining the simulated flow across the specified head cells. The algebraic sum of this flow should be compared to the total pumpage from model layers 3 and 4. If a significant percentage of this pumpage is satisfied by flow across the assumed freshwater/saltwater interface, then strong consideration should be given to further evaluation of the boundary, including relocation.

LIST OF ATTENDEES
PEER REVIEW OF EXPECTED YEAR 2020 DRAWDOWNS
NORTHEAST FLORIDA

APRIL 6, 1999

Name	Affiliation	Phone number/email
Robert E. Faye	Reviewer/Consultant	706-745-7105 refaye@stc.net
Charles H. Tibbals	Consultant/SJRWMD	352-669-4703 352-669-6183 (fax) ctibbals@cde.com
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Gordon Grimes	United Water, FL	721-4601 x4610

Appendix B.3.b: – St. Augustine and Tillman Ridge wellfield models

Appendix B.3.b.(1) -- Peer review of July 24, 1998

July 30, 1998

Robert E. Faye
3468 Larch Pine Drive
Duluth, GA 30096

Doug Munch, Director
Division of Groundwater Programs
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H283: Summary of Peer Review of the Tillman Ridge and City of St. Augustine wellfield models, St. Johns County Florida, July 24, 1998

Dear Doug:

Enclosed is the Summary of the Peer Review of the wellfield models/projects conducted at the SJRWMD Groundwater Programs meeting room during July 24, 1998. The meeting was chaired by Robert Faye and was called to order about 0830. Attendees at the meeting numbered fourteen and are listed by name and affiliation by Attachment to the Summary. Based on our discussions of Friday, July 24, 1998, during the exit interview, SJRWMD Groundwater Programs will solicit comments from selected attendees and those comments received will be attached to and distributed with the formally accepted Summary.

After calling the meeting to order, Robert Faye briefly explained the purpose of the Peer Review and emphasized the informal nature of the discussions. All attendees were urged to actively participate in the discussions. Although many attendees offered comments and suggestions, the bulk of the technical questions and suggestions were offered by Robert Faye and Charles Tibbals. The enclosed Summary begins with a brief description of the major points of discussion followed by specific comments and recommendations.
Because the order of discussion of the Peer Review was left largely to the discretion of the Groundwater Programs staff responsible for the presentation, the Review did not necessarily follow the previously prepared daily meeting agenda. The Peer Review Summary also reflects more the order of discussion at the meeting than that of the formal agenda.

Please call me at 770-476-3815 if you wish to discuss any part or aspect of the enclosed Summary or the related meeting or review process.

Sincerely,

Robert E. Faye, P. E.

Enclosures/Attachments

cc: Barbara Vergara, Director, Division of Needs and Sources, SJRWMD

Charles H. Tibbals

SUMMARY OF PEER REVIEW MEETING
TILLMAN RIDGE AND CITY OF ST. AUGUSTINE WELLFIELD MODELS
JULY 24, 1998

David Toth opened the meeting with an excellent presentation describing the local hydrogeology at the St. Augustine wellfield and explaining the analytical model and approaches used to evaluate year 2020 drawdowns caused by pumping at the wellfield. Maps showing computed drawdowns in confined and unconfined parts of the Surficial aquifer and in the Upper Floridan aquifer were presented over same-scale maps of the well field and vicinity in order to evaluate the distributed effects of future pumping, particularly at wetlands. Similar presentations were made regarding the Tillman Ridge wellfield. Observed and computed drawdowns at the Tillman Ridge site were particularly close.

Some considerable discussion ensued regarding the application of MODFLOW to the wellfield areas to evaluate drawdowns caused by future pumping. Several opinions were expressed pro and con. Bob Faye stated that, given the quantity and spatial distribution of the hydraulic characteristic and water-level data available at the wellfield sites, an analytical approach was reasonable, if not actually preferable; that all model results, whether from analytical or numerical tools, ultimately must be judged with respect to the quantity and quality of the data available for input and for comparison of output.

Unless otherwise noted, the Comments and Recommendations summarized below were made by Robert Faye and/or Charles Tibbals. Comments, suggestions, conclusions, and recommendations attributed herein to the Review are also those of Robert Faye and/or Charles Tibbals.

Comments and Recommendations
Peer Review of the Tillman Ridge and City of St. Augustine Wellfield Models
July 24, 1998

1. To improve the calibration of models used at the City of St. Augustine wellfield (whether analytical or numerical) John Regan offered to conduct a capacity test simultaneously at all wells. Such a test is logistically complex and water levels at all wells must be recovered or nearly recovered for the test to be successful. Because the water-level response in the unconfined Surficial aquifer is critical in determining the effects of pumping on wetlands, recovery and drawdown in the unconfined Surficial aquifer should be accurately measured over much of the area of influence of the pumping wells. Recovery of water levels in the unconfined Surficial aquifer must also be complete prior to the onset of the capacity test. Otherwise, water levels measured at the end of the test may be excessively low, when compared to similar drawdowns measured from a completely recovered water-table surface.

The diffusivity (T/S) of the unconfned Surficial aquifer should also be accounted for when when estimating total recovery time. Because the storativity of the unconfined aquifer probably is one hundred or more times greater than the storativity of the confined part of the Surficial aquifer, water-level recovery to an equilibrium condition in the unconfined aquifer will require considerably more time than similar recoveries in the confined Surficial aquifer. Whereas recovery in the confined part of the Surficial aquifer might be complete or nearly complete in two or three hours, recovery in the unconfined part of the aquifer might take two or three hundred hours.

2. The classical analytical approach to evaluating interference at wells caused by pumping at nearby wells is based on superposition (a linear system) and the condition that all wells of interest penetrate the same homogeneous and isotropic aquifer. Accordingly, the use of two transmissivity values (one for the north wellfield and one for the south wellfield) in SURFDOWN to evaluate drawdowns at the City of St. Augustine wellfield is inappropriate. The Review recommends using MODFLOW to evaluate wellfield conditions, with all input and hydraulic characteristic data the same as that used in SURFDOWN with the exception of transmissivity, which is areally distributed.

3. A test of the sensitivity of computed results to the "ET factor" is recommended. The Tillman Ridge well field model is suggested as a prototype for the test because of the good calibration of the model and the otherwise appropriate application of SURFDOWN.

4. Consider enlarging the matrix dimensions in the SURFDOWN source code and recompiling the code. Thus greater model grid resolution will be available for future applications.

List of Attendees
Peer Review of the Tillman Ridge and City of St. Augustine Wellfield Models
July 24, 1998

Name	Affiliation	Phone number/email
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Bill Young	St. Johns County	904-471-2161
John Regan	City of St. Augustine	904-825-1040

Appendix B.3.b.(2) -- Peer review of April 7, 1999

April 15, 1999

Robert E. Faye
P.O. Box 43
Blairsville, GA 30512

Doug Munch, Director
Division of Groundwater Programs
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H283: Summary of second Peer Review of the Tillman Ridge and City of St. Augustine wellfield models, St. Johns County, FL. Application of the wellfield models to compute expected year 2020 drawdowns in the surficial aquifer at and near the wellfields.

Dear Doug:

Enclosed is the summary of the Peer Review of simulation results obtained from the application of the Tillman Ridge and City of St. Augustine wellfield models to compute drawdowns in the surficial aquifer expected for the year 2020. The Review was held in the Groundwater Programs meeting room during April 7, 1999. The meeting was chaired by Robert Faye and called to order about 0930. The Review was divided into morning and afternoon sessions; however, as a practical matter, both sessions merged into detailed discussions of the suitability of the analytical model applied to the analysis of year 2020 drawdowns and of strategies to meet project objectives if the analytical model proved to be unsuitable. Attendees at the sessions numbered five and four, respectively. All attendees were urged to actively participate in the discussions; however, the bulk of the technical comments and suggestions were made by Robert Faye and Charles Tibbals. Attendees are listed by name and affiliation in Attachments to this summary.

Please call me at 706-745-7105 if you wish to discuss any part of the enclosed summary or the related meeting or review process.

Sincerely,

Robert E. Faye, P.E.

Enclosures/Attachments

cc: Barbara Vergara, Director, Division of Needs and Sources, SJRWMD
Charles H. Tibbals

SUMMARY OF PEER REVIEW MEETING
EXPECTED YEAR 2020 DRAWDOWNS
TILLMAN RIDGE AND CITY OF ST. AUGUSTINE WELLFIELDS
ST. JOHNS COUNTY FLORIDA

APRIL 7, 1999

The main objective of simulation investigations at the Tillman Ridge and City of Augustine wellfields is to estimate year 2020 water levels and drawdowns in the surficial aquifer system at projected rates of year 2020 pumping. The surficial aquifer at these sites consists of an unconfined upper unit and a confined lower unit. Pumping is from the confined unit and from the underlying Upper Floridan aquifer. Pumping, particularly from the confined part of the surficial aquifer, induces drawdown in the overlying unconfined unit by leakage through a semiconfining unit.

Proposed methods of simulation use the codes MLTLAY, an unpublished code developed at the SJRWMD, and SURFDOWN, a FORTRAN version of the analytical model described by Motz (1978). The SURFDOWN code simulates a coupled unconfined - confined aquifer system, where pumping from the confined aquifer is exactly balanced by a reduction in evapotranspiration (ET) from the overlying unconfined aquifer. MLTLAY is also a FORTRAN version of an analytical model that describes a multilayered leaky artesian aquifer system. MLTLAY is applied to compute drawdown in the Upper Floridan aquifer and confined part of the surficial aquifer. These drawdowns are then applied to SURFDOWN to compute corresponding drawdowns in the unconfined part of the surficial aquifer. Both models assume isotropic and homogeneous conditions and simulate only the steady-state condition. Transmissivity and leakance values are assigned to the aquifers and confining units based on the results of local aquifer test analyses or other best available data. A recent comprehensive test of the surficial aquifer at Tillman Ridge (Camp Dresser & McKee, 1998) provided transmissivity information for the confined part of the surficial aquifer, a computed leakance for the intervening confining unit, and distributed drawdown data in the confined and unconfined parts of the surficial aquifer. Unpublished results from a similar test recently completed at the City of St. Augustine wellfield will probably provide similar results when analyses are complete (oral communication, Jim Humphries, April 7, 1999). Model calibration at both wellfields consists of adjusting the ET reduction factor to match observed drawdowns in the confined part of the surficial aquifer under specified pumping conditions.

Simulation results and discussions during the Review indicated a pronounced lack of sensitivity of drawdown in the unconfined part of the surficial aquifer to transmissivity of the aquifer. Much if not most of this insensitivity is due to the formulation of the Motz (1978) model, which attempts to exactly balance pumpage from the lower confined aquifer with reductions in ET from the overlying unconfined aquifer. Hence, the vast majority of water transfer computed by the model is vertical rather than lateral, which explains why leakance and the ET reduction factor are the obvious calibration parameters. In fact, wellfield model results appeared to be sensitive only to confining unit leakance and especially to the ET reduction factor. Manipulation of ET rates appears to be the major factor controlling simulated drawdown in the unconfined aquifer and other major hydrologic

processes, such as recharge from rainfall and streamflow and lateral flow from boundaries, are largely unaccounted for. Thus the Motz (1978) model, along with its various derivatives, appears to be a poor choice to apply to the simulation of future conditions in the unconfined part of the surficial aquifer. This model may, however, be a useful screening tool to qualitatively evaluate future conditions.

Because year 2020 drawdowns at the wellfields are focused particularly on conditions in the unconfined part of the surficial aquifer and because the models currently in use seem to be insensitive to the hydraulic characteristics and other hydrologic features of the unconfined aquifer, the Review Team recommends abandoning the current simulation approach in favor of a distributed parameter model, MODFLOW. A MODFLOW model of the wellfields can be constructed with the same configuration of aquifers and confining units used in MLTLAY and SURFDOWN, with the added advantage that all pertinent units can be accommodated in a single model. Where appropriate, single values of leakance and transmissivity can be applied to the MODFLOW wellfield models, mimicking the application of the analytical models. Calibration of the MODFLOW models should consist of an adequate simulation of the comprehensive aquifer tests described previously. This is a transient application and will require application of representative values of storativity and specific yield to appropriate confined and unconfined aquifers. The essential result of the calibration will be a single value or distributed values of transmissivity for the unconfined part of the surficial aquifer. Calibration should be followed with a comprehensive sensitivity analysis, related particularly to the surficial aquifer.

LIST OF ATTENDEES

PEER REVIEW OF EXPECTED YEAR 2020 DRAWDOWNS
AT TILLMAN RIDGE AND CITY OF ST. AUGUSTINE WELLFIELDS
ST. JOHNS COUNTY, NORTHEAST FLORIDA

APRIL 7, 1999

Name	Affiliation	Phone number/email
Robert E. Faye	Reviewer/Consultant	706-745-7105 refaye@stc.net
Charles H. Tibbals	SJRWMD	352-669-4703 352-669-6183 (fax) ctibbals@cde.com
Doug Durden	SJRWMD	ddurden@sjrwmd.state.fl.us
Don Summerfield	City of Jacksonville	904-630-4900 summer@coj.net
David Toth	SJRWMD	david_toth@sjrwmd.state.fl.us
Jim Humphries	City of St. Augustine	904-825-1040 904-825-1051 (fax) fad@aug.com

Appendix B.3.c: -- North-central model

Appendix B.3.c.(1) – Peer review of May 6, 1999

May 16, 1999

Robert E. Faye
P.O. Box 43
Blairsville, GA 30514

Doug Munch, Director
Division of Groundwater Programs
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Re: SJRWMD Contract #98H283 Summary of Peer Review of Revised North-Central Florida model/project , May 6, 1999.

Dear Doug:

Enclosed is the summary of the first Peer Review of the Revised North-Central Florida flow model/project. The meeting was held at the SJRWMD Groundwater Programs meeting room during May 6, 1999. The Review was chaired by Robert Faye and was called to order at about 0930. Attendees at the meeting numbered six and are listed by name and affiliation in an Attachment to this Summary. All attendees actively participated in the review discussions. The illustrations presented to the Review Team were excellent.

Please call me at 706-745-7105 if you wish to discuss any part of the enclosed summary or the related meeting or review process.

Sincerely,

Robert E Faye

Robert E. Faye, P.E.

Enclosures/Attachments

cc: Barbara Vergara, Director, Division of Needs and Sources, SJRWMD
Charles H. Tibbals

SUMMARY OF PEER REVIEW MEETING
REVISED NORTH-CENTRAL FLOW MODEL
MAY 6, 1999

The technical discussions began with a short review of project history and objectives. The study area and boundaries of a previous model (Motz and others, 1995) were enlarged to include most of Marion county, including Silver Springs and the Ocala area. The western boundary of the revised model generally conforms to the drainage boundary of the Silver Springs contributing area. The southeastern boundary generally conforms to the St. Johns River. Flow simulation is accomplished using the MODFLOW code. Boundaries applied to the MODFLOW model are all General Head Boundaries. The model domain comprises about 4313 square miles, approximately one third of which is the area contributing discharge to Silver Springs.

The calibration year for the original model was 1985; the revised model will be calibrated to 1995 conditions. Conditions observed during May 1995 are considered representative of average conditions for the year. The compilation of 1995 water use data has been troublesome and time consuming because of the large number of wells and permits to review and compile. Estimates of groundwater pumped for agricultural use in 1995 are highly uncertain. Total May 1995 pumpage is estimated at 244 million gallons per day (MGD), of which, about 90 MGD is estimated for agricultural purposes. The water use compilation was barely completed at the time of the Review and some revision of the data base may be necessary. For example, wells in western Marion county may not be represented in the model. These data probably can be obtained from the Southwest Florida WMD. Note that pumpage values applied to the model are not average 1995 rates but May 1995 rates. The Review Team noted that self-supplied (unpermitted) domestic use comprises a substantial part of total groundwater use in the area represented by the East-Central flow model and suggested that similar conditions may prevail in the area of the Revised North-Central flow model. The Review Team recommends that self-supplied groundwater pumping from the Floridan aquifer system for domestic purposes (as estimated) be evaluated and , if greater than 7 MGD, be applied to the model, possibly as uniformly distributed pumpage.

The Review Team suggested that the final table showing May 1995 water use indicate those counties where only partial areas were considered for the water use compilation. Also recommended was the use of realistic significant figures when presenting water use rates.

Project objectives are to calibrate the revised model to 1995 conditions and apply the calibrated model to simulate year 2010, 2015, and 2020 conditions in the Floridan aquifer, given future rates and distributions of pumping.

The revised MODFLOW model is discretized areally into 148 rows and 130 columns. Model cells are square representing 2500ft per side. Grid orientation and spacing conform to the corresponding features of the Volusia Florida GWB, East-Central Florida, and Northeast Florida models as well as the “megamodel” being developed by the USGS. Vertically, the model comprises three layers representing, top to bottom, the surficial (layer 1), Upper Floridan (layer 2), and Lower Floridan (layer 3) aquifers. Each layer is separated by a leakance array. The surficial aquifer is represented as a specified head array (source-sink layer). Approaches to the simulation of direct recharge and evapotranspiration were not discussed in detail during the Review but were represented as being similar to those described in Motz and others (1995). Accordingly, direct recharge is probably applied to layer 2 in areas where the Upper Floridan aquifer is unconfined. (Review of the draft of this Summary by Dr. Motz provided information regarding direct recharge to the unconfined parts of the aquifer. Accordingly, direct recharge of 11.6 inches per year is applied to the contributing area of Silver Springs. The water table is well below land surface where the Upper Floridan aquifer is unconfined and the ET package of MODFLOW was not utilized.) The water table surface is estimated based on regression analyses described in Motz and others (1995), by which depth to water in the surficial aquifer is a function of land surface altitude. The hydrologic basis for this method is the "dynamic equilibrium" of the water table, whereby water levels change seasonally over a small range but average annual water levels are little changed. At least one hydrograph of water levels in the surficial aquifer published in Motz and others (1995, pg. 85) shows the condition of "dynamic equilibrium" and supports the application of the regression methodology. On the other hand, depths to water at relatively high altitudes may comprise a statistically different population than corresponding depths measured at lower altitudes in the study area. Perhaps where sufficient data are available for high altitude areas, this hypothesis can be tested.

Preliminary calibration of the model is complete and appears to be excellent. The calibration strategy is based on a preliminary calibration of predevelopment conditions, later refined by calibrating to known year 1995 conditions. Simulated discharges from Layer 2 at 27 springs match "observed" discharges almost exactly for both predevelopment and 1995 conditions. Springs are represented in the flow model as drain cells. The Review Team asked that spring discharges used in the Revised North-Central flow model be compared to corresponding discharges now used in other SJRWMD models to make certain that consistent data are being applied. Simulated baseflow to streams was not compared to 1995 conditions. The Review Team believes that simulated leakage from the Upper Floridan aquifer to the lower Oklawaha River and Goose Creek are also possible calibration parameters and recommends that such comparisons be made if appropriate gaging station data are available. Baseflow data for the lower Oklawaha River are published in an Appendix of USGS Professional Paper 1403-E and may be useful for model calibration. These data also indicate that the filling of Rodman Reservoir raised groundwater levels in the reservoir vicinity and subsequently lowered prereservoir rates of groundwater discharge to the river. Simulated heads for both predevelopment and 1995 conditions were compared to distributed head arrays interpreted from published maps representing, for the most part, potentiometric levels of the Upper Floridan aquifer. Comparisons of simulated heads to water levels at target wells were not shown nor were areally distributed head residuals. Accordingly, the Review Team could not determine any trends or bias in simulated head arrays upon which to base any suggestions for calibration improvement. The Review Team strongly recommends that future representations of calibrated model results include comparisons of simulated heads to corresponding 1995 measured heads and an areal distribution of related calibrated head residuals. In his reply to the draft of this Summary, Dr. Lou Motz indicated that May 1995 potentiometric levels at 214 wells will be compared to simulated potentiometric levels and the results described in the final report.) Also recommended is a table or chart that completely describes the simulated budget, by component and layer, including, particularly, boundary flows and leakage between layers.

Part of the domain of the Revised North-Central flow model apparently overlaps the domain of the Northeast Florida flow model. Accordingly, the Review Team strongly recommends that arrays from both models be compared as quickly as possible and differences in arrays within the common area or areas be reconciled to a common set of values used in both models.

LIST OF ATTENDEES
PEER REVIEW OF REVISED NORTH-CENTRAL FLOW MODEL
MAY 6, 1999

Name	Affiliation	Phone number/email
Dr. Louis H. Motz	University of Florida	352-392-0952 lmotz@ce.ufl.edu
Robert E. Faye	Reviewer/Consultant	706-745-7105 refaye@stc.net
Doug Munch	SJRWMD	904-329-4173 doug_munch@district.sjrwmd.state.fl.us
Charles H. Tibbals	Consultant/SJRWMD/Reviewer	352-669-4703 ctibbals@cde.com
Todd Eller	SJRWMD	904-329-4210
Brain McGurk	SJRWMD	904-329-4245

Appendix B.3.d. Tri-County Potato Farming Area

Appendix B.3.d.(1) -- Peer review of April 6, 1999

SUMMARY OF PEER REVIEW MEETING
REGIONAL DRAWDOWNS CAUSED BY POTATO IRRIGATION
NORTHEAST FLORIDA

APRIL 6, 1999

The objective of this project is to determine the relative contribution to regional drawdown caused by (1) regionally distributed pumping for potato irrigation, mostly in Putnam and St. Johns counties, (2) pumping for paper production at the Georgia Pacific Mill in Palatka in Putnam County, and (3) pumping for steam generation at the Seminole Electric Cooperative near Palatka. All pumping is from the Floridan aquifer system. Pumping for irrigation is seasonal; whereas other pumping is variable but constant.

The approach of study is to apply distributed pumping over the area of interest using an analytical model that represents coupled aquifers under steady-state conditions (Motz, 1978). The uppermost aquifer is unconfined. The lower aquifer is confined and is separated from the overlying unconfined aquifer by a confining unit, characterized by leakance. Pumping is only from the confined aquifer from fully penetrating wells. For this investigation the confined aquifer corresponds to the Upper Floridan aquifer and the unconfined aquifer is the surficial aquifer. Total pumpage applied to the model for potato irrigation is 129 million gallons per day, which is regionally distributed at 727 sites.
All pumpage for irrigation was assumed to be from the Upper Floridan aquifer. Total pumpage for paper production varies but the maximum known rate of 22.1 mgd was used. This pumpage is distributed between the Upper and Lower Floridan aquifers based on respective open intervals in the production wells. Accordingly, a pumping rate of 13.1 mgd was assigned to the model, representing pumpage from the Upper Floridan aquifer. Pumpage for steam generation is estimated at about 0.5 mgd and is derived from the Upper Floridan aquifer. Transmissivity of the Upper Floridan aquifer was assigned at 60,000 feet squared per day. Assigned transmissivity of the surficial aquifer was 1000 feet squared per day. Following some trial and error, a leakance of 1 X 10-4 per day was assigned to the confining unit.

Maximum computed drawdowns caused by the withdrawals for potato irrigation are about 27ft. Drawdown occurs over most of St. Johns and northeast Putnam counties, southeast Clay county and northwest Flagler County. Drawdowns caused by pumpage for paper production range to a maximum of about 9 ft and occur in northern Putnam and southern Clay counties. Maximum drawdown associated with electric power production is about 0.5 ft and occurs in northeast Putnam county.

The Review Team believes that the approach and implementation of this study are appropriate and commend Doug Durden for a job well done. The simulated results appear highly reasonable, particularly taking into account the respective distributions and quantities of pumpage. A relatively large regional drawdown caused by potato irrigation should be expected. The Review Team recommends that an additonal simulation be implemented to include the maximum known pumpage at the Georgia Pacific paper mill, 22.1 mgd from the Upper Floridan aquifer.

APPENDIX C: OTHER REPORTS

Appendix C.1: -- Qualifications of lead technical peer reviewers

Robert E (Bob) Faye, P.E.

Bob is recently retired from the U.S. Geological Survey after having accumulated 27 years of experience in the groundwater discipline. For 12 years, until December 1997, Bob served as the Groundwater Specialist for the Southeast Region including Puerto Rico and the U.S. Virgin Islands. He was responsible for providing technical oversight to all USGS groundwater studies in the Region including groundwater flow models, aquifer hydraulic testing, geophysical studies including surface and bore-hole logging, and general groundwater investigations. About 50% of Bob's USGS technical reviews were on Florida studies. Bob has an extensive bibliography having authored or co-authored 27 technical publications including USGS reports and refereed journal articles on ground- and surface-water studies. He has a B.S. in Civil Engineering from California State University at Sacramento and a M.S. in Civil Engineering from Georgia Institute of Technology. He is a registered Professional Engineer in Colorado and is a member of the American Society of Civil Engineering and the American Society of Testing Materials.

Charles H. Tibbals

Charles is recently retired from the U.S. Geological Survey after having accumulated 29 years of experience in the groundwater discipline, all but 3 months of which was acquired in central Florida. From 1991-97, Charles served as Subdistrict Chief for the Orlando Subdistrict which includes the approximate 20,000 sq-mi. area of east-central, northeast, and south-central Florida. He was responsible for the overall supervision of 53 employees including 14 Hydrologists and 21 Hydrologic Technicians directly engaged in hydrologic studies. From 1990-91, he was Supervisor of the Groundwater Studies Section and was Groundwater Specialist for the Orlando Subdistrict. From 1978-90, he was Groundwater Specialist and groundwater project leader on studies which included the Regional Aquifer Sysytem Systems analysis (RASA) for east-central Florida. Charles has senior-authored 10 peer-reviewed technical reports and co-authored 2 such reports. He has a B.S. in Agricultural Engineering form the University of Georgia and attended the Graduate School at Clemson University. He is a member of the American Institute of Hydrology as a registered Professional Hydrogeologist.

Appendix C.2: -- 2. Elements of groundwater model reviews

ELEMENTS OF GROUNDWATER MODEL REVIEWS

by
Robert E. Faye, P.E.

Modelers: Please be prepared to discuss the following elements and to describe in appropriate detail:

1. Conceptual model of the groundwater flow system and aquifer domain

Hydrologic setting
Hydrogeologic framework
Flow sources and sinks (flow directions)
Flow boundaries (types, internal and external)
History of resource development and related aquifer response (water-level changes, subsidence, salt (saline) water intrusion, etc.)

Compare the elements of the conceptual model to actual field data and field conditions and argue convincingly that the conceptual and actual systems are sufficiently similar.

2. Project objectives and scope

Anticipated applications of the calibrated model that satisfy project objectives
Minimally required complexity of investigation (1D, 2D or 3D approach)
Scale of investigation (regional, intermediate, and/or local flow regimes)
Project area
Areal extent of the aquifer(s) of interest
Model grid and lateral boundaries (grid resolution)
Data requirements

Compare the data requirements to the available data and indicate critical deficiencies.

Defend the selection of the model area and grid resolution using arguments based on the conceptual model, project objectives and scope, the anticipated scale of investigation, and the availability of data.

Explain and defend the rationale for selecting the required level of complexity.

3. Groundwater budget (independent of model results)

Time domain (daily, monthly, drought periods, etc.)
Aquifer domain (surficial aquifer, confined aquifers, etc.)
Budget elements by domain (recharge, spring discharge, baseflow, etc.)
Methods and approaches to budget analysis (hydrograph separation, residual analysis, etc.)

List the budget elements quantitatively and indicate appropriate temporal and aquifer domains.

Defend the methods and approaches used to develop the groundwater budget. Compare alternative approaches and related results where appropriate.

Relate results of budget analysis to project objectives and identify major deficiencies and discrepancies.

4. Numerical model selection and construction

Numerical code selection
Vertical discretization (number of layers)
Treatment of confining units (discrete layer(s) or quasi-3D)
Boundary conditions (lateral, internal, base, at water table)
Input data (hydraulic properties, stresses, etc.)

Compare the assigned boundary conditions to the boundary conditions identified in the conceptual model and defend and explain any major differences or gross approximations.

Explain the rationale for selecting the model code and approach to model construction.

Compare the features of the conceptual model to the corresponding features of the numerical model and explain major differences or approximations.

Identify the attributes of the numerical model that will facilitate and accomplish meeting the project objectives. Explain and defend major discrepancies or deficiencies.

5. Model calibration

Calibration strategy (targets)
- transient or steady-state approach
- calibrate to point-in-time condition or average conditions
- match heads or match heads and fluxes

Trial-and-error approach or inverse solution
Initial conditions
Time-stepping procedure
Assigned stresses (quantities; areal, vertical, and temporal distributions)

Calibration results:
- Mass balance computation
- Simulation results (gradients, heads, fluxes)
- Other (aquifer-test results, well hydrographs, etc.)

Compare corresponding simulated results to observed heads, measured or estimated budget elements, and other calibration features. Identify and explain major differences.

Provide a convincing argument that the numerical model is a plausible and reasonable representation of the conceptual (actual) groundwater flow system.

6. Sensitivity analysis

   Identify those input parameters that, when varied, cause significant changes in simulated results.

7. Model applications (scenario analysis)

   Compare the project objectives to the planned applications of the numerical model. Identify the objectives not met or only partially met by the recognized capabilities of the calibrated model and explain these deficiencies. Is the level of complexity of the calibrated model appropriate for its intended use? If not, then explain.

   Compare the spatial distribution and quantities of scenario stresses to calibrated conditions. Pay particular attention to scenario stresses in close proximity to model boundaries. Identify major differences between calibrated and scenario conditions and justify application of the calibrated model to the scenario conditions.

8. Model documentation/disposition (quality assurance)

   Model updates (additional data, post-calibration changes to input arrays)
   Source code modifications (documentation)
   Post audits (documentation)
   Disposition of "vanilla" code and original input arrays

   Describe any modifications of the original model source code and documentation of same. Present the "paper trail" of code modifications.

   Describe updates to model input arrays based on data made available following calibration. Explain corresponding changes (improvements?) to simulated results. Are these changes and subsequent results adequately documented?

   Describe the results of any post audits of the calibrated model. Are such audits adequately documented?

Appendix C.3: -- Issues of uncertainty in the modeling process

November 30, 1998

Charles H. Tibbals
297 E. Lakeview St.
Umatilla, FL 32784

Mr. Doug Munch, Director
Division of Groundwater Programs
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Subject: Contract #98H207: Model uncertainties with respect to prediction of water levels in wetlands, lakes, and the surficial aquifer system.

Dear Doug:

On several occasions, I have expressed some concern that the District may possibly be asking more of the modelers and of the groundwater flow models than either can deliver with any reasonable degree of certainty. At last week's Area I Workgroup meeting, you asked if I would put my thoughts down on paper so that you, Barbara Vergara, Hal Wilkening, and the modelers could examine my concerns and determine if the District might want to consider some alternative strategies or remedies. Herein are my observations.

The technical peer reviews of the East-Central, Volusia, and Northeast Florida groundwater flow models conducted in July 1998 found no major errors in model construction, assumptions, or execution and, generally, only minor improvements were suggested. Bob Faye (lead reviewer) and I made those determinations and, in recent conversations with him, we still believe those findings to be the case. However, we based our findings primarily on the way the models would be able to predict aquifer responses in the Upper and Lower Floridan aquifers – the pumped aquifers.

We discussed the surficial aquifer system and how net recharge to the surficial might be computed. We did not discuss in any detail how accurately the models would simulate drawdown in the surficial so I guess you could say that the focus of the peer review was primarily upon the Floridan aquifer system.

Bob and I were not fully aware of how critical the surficial aquifer response would be in terms of the Decision Models' determinations of "deficit areas" based upon projected water level declines in wetlands. After learning that a 0.4' wetlands decline projected for the year 2020 would trigger a deficit area, I became concerned that the models simply were not capable of accurately computing such a small change in water level in the surficial aquifer, especially projected that far out in time. I conferred with Bob and he expressed the same reservations.

For the purpose of this discussion "wetlands" also includes lakes, not just swampy areas.
The following items are discussed in numbered sequence for ease of future reference:

(1) The models will do a good job of predicting 2020 <u>Floridan</u> aquifer drawdowns and springflows and will do a reasonably good job of identifying potential Floridan QW trouble spots.

However, the models' abilities to accurately predict 2020 drawdown in the surficial aquifer and in wetlands is hampered by limitations inherent in MODFLOW and uncertainties in aquifer and confining bed parameters, in particular, and even in some of the other types of input data such as Floridan springflow, rainfall, land-surface altitudes, and potentiometric surfaces.

(2) In general, the District's models are constrained by the limiting capabilities of the model codes and equations. MODFLOW's governing equations accurately describe the groundwater hydrology but only the Floridan springflow and evapotranspiration (ET) portions of the surface-water hydrology can be explicitly computed in a reasonably straight-forward manner.

(3) MODFLOW allows some "capture" of water due to reduced Floridan springflows caused by drawdown in the Floridan. Similarly, MODFLOW allows capture of water due to reduced ET as a result of water-table drawdown in the surficial aquifer. ET capture tends to offset water-table drawdown as does surface-water capture (see below).

(4) MODFLOW's equations do not adequately describe "capture" of SW runoff (surface and subsurface) in response to drawdown in the surficial aquifer caused by changes in leakage rates through the confining beds that overlie the Upper Floridan aquifer. MODFLOW's DRAIN or RIVER functions can compute changes in discharge from the surficial, but only if a composite "fixed head" and a composite "drain or river coefficient" can be determined on a nodal basis. Those parameters are difficult, if not impossible to determine, especially in nodes that contain more than one ditch- or river-bed altitude.

(5) MODFLOW does not account for connectivity of wetlands with other wetlands, streams, or with upland drainage, where such connectivity exists. Hence surface-water routing is not simulated or quantified from one node to another. This factor alone causes MODFLOW to overestimate drawdown in the surficial because it doesn't allow for surface-water inflow to help offset the effects of local drawdown caused by increased downward leakage. MODFLOW's inability to adequately describe surface-water capture (see 5) exacerbates the problem.

(6) Model grid discretization is large (2500') with respect to the size of many wetlands. Many wetlands are elongate and coast-parallel, and, in many cases, their narrow dimensions are considerably smaller than 2500'. The geometry of wetlands (size, shape, nodal overlap) cannot be explicitly described in MODFLOW. Storage coefficients for the surficial aquifer must therefore be a composite value of that part of the node that is for free-water surfaces and that which represents <u>non</u>-free-water surfaces. This will not affect the steady-state models but it will have an effect on the transient simulations.

(7) The accuracy of USGS measured springflows are typically rated as "good," meaning the gaging technician believes the measurement is accurate to within 10%. In recent years, springs in the District have been measured from 6 to 12 times per year. Prior to that time, most springs were measured only twice per year with Blue Spring (8 times/yr) and Silver Spring (8 times/yr <u>and</u> computed daily discharge) being the exceptions. The errors in discharge measurements are random errors and are not bias error. Therefore, over a period of a year which contains 8 time-weighted discharge measurements, the random errors should tend to balance out and thus leave a reasonably accurate determination of the average discharge for that year. Computed average discharges for longer periods are even more accurate.

(8) Rainfall in Florida is highly variable, both temporally and spatially. The District has no choice but to assume that the gaged rainfall data are accurate and to construct Theissen polygons or use some other method to interpolate between stations.

(9) Land-surface altitudes are gleaned from USGS topographic maps or from the USGS topographic databases. In either case, those data might be considered the "gold" standard for data derived by indirect means such as photogrammetry augmented by known control points such as surveyed benchmarks. Even so, the USGS rates their interpolated topographic data as accurate to within plus or minus one-half a contour interval (+- 2.5 feet for 1:24,000, 7.5' quadrangle map sheets). I believe that the USGS understates the accuracy. Nevertheless, some error exists even here.

(10) Potentiometric map data points are fixed in space but represent only a "snapshot" in time. Further, the data at the data points are interpolated in space by either an experienced hydrologist or mechanically by a computer. Regardless of which does the best job, there is error inherent in the potentiometric maps.

(11) Floridan aquifer transmissivity (T) and confining bed leakance (L) are typically first rough-estimated using available data and are then fine-tuned as part of the iterative calibration process. This process is aided in spring basins where the actual groundwater flux is known in terms of gaged springflow. Calibrated T's and L's are each believed to be within +- 20% to 30%.

(12) Floridan drawdown is a bit more sensitive to Floridan T than to L, but in models with relatively large node sizes such as the District's, surficial drawdown caused by pumping in the Floridan is more sensitive to L than to surficial T's or to Floridan T's.

(13) The calibration process yields non-unique "working" grid-cell combinations of T & L that yield calibrated Floridan aquifer responses within a few percent even though the individual T's and L's may be less accurate. This is adequate for predicting aquifer responses in the Floridan but the errors in L directly affect the leakage rates to and from the surficial and, hence, can cause errors in the computed drawdowns in the surficial.

(14) Models are considered calibrated if the computed Floridan aquifer heads match the observed heads within, say, +- 2' whereas the triggering wetlands drawdown constraint is only 0.4'. It would be a hard sell that the wetlands drawdown accuracy in the essentially uncalibrated surficial exceeds the calibration criterion for the Floridan where fluxes are reasonably well known.

(15) There may be considerable lag between the time that 2020 drawdowns are seen in the Upper Floridan and when they are seen in the surficial aquifer. Where Upper Floridan confining beds are thin or permeable, drawdowns in the surficial will be reasonably contemporaneous with those in the Upper Floridan. Where confining beds are thick or less permeable, drawdowns in the surficial can lag those in the Upper Floridan by several years. The steady-state versions of the models will not account for lag but the transient versions can.

What to do?

(16) The District might consider testing the Decision Model's sensitivity to the wetland drawdown constraint by relaxing the 0.4' triggering value in, say, 1' increments and see how the deficit areas change. *(This had been done as of the 11-24-98 meeting of the Area I Workgroup.)*

(17) The modelers might consider varying (globally) L in increments of + and -10% and see how projected surficial drawdowns vary. This can be done independently of the testing of the Decision Model, but the testing of both lends perspective to the Decision Model results.

(18) Quantify the wetlands drawdown lag period in the various types of hydrogeologic regimes by running the models in transient mode so that the effects of confining bed thickness and storage (hydraulic diffusivity), can be taken into account.

(19) Using the District's GIS coverages, various wetland regimes could be categorized as to their likely sensitivity to Floridan drawdown. Potential errors in surficial drawdown in areas known not to be sensitive to Floridan drawdown could be discounted in terms of triggered deficits. An example of such an area would be one where confining beds between the Upper Floridan and surficial aquifers are thick or slowly permeable such as in southeast Orange County. Also, wetlands in some (not all) areas of artesian flow would be relatively insensitive to Floridan drawdown. Areas of artesian flow that have thin or permeable confining beds can contain wetlands that are sensitive to Floridan drawdown.

When the sensitivity and error analyses are finalized and evaluated, decisions can be made on how to proceed in terms of qualifying wetland's drawdown results.

Finite-Element rather than Finite-Difference models?

(20) Typically, MODFE (MODular Finite-Element) models are best for modeling small areas in great detail or large areas in much, much less detail but they allow the simulation of interconnected SW drainage as part of a groundwater flow model. Because of the importance of surficial aquifer and wetlands response, some sort of test evaluation might be considered so that decisions can be made with regard to possible large-scale implementation during the next 5-year modeling "window."

(21) Consider constructing a small-scale, finite-element, MODFE groundwater flow model in the Tiger Bay surface-water basin to test the efficacy of a coupled, groundwater-surface-water model.

I have listed and discussed my concerns. I believe that I have rendered a complete listing but I am not so sure that my discussions are totally complete. At some point we probably should have a pure technical meeting of the modelers so that everyone can have a chance to discuss everything with everyone else.

If you have any questions, please call me.

Sincerely,

/S/

cc: Mr. Hal Wilkening, Assistant Director, Department of Resource Management
Ms. Barbara Vergara, Director, Division of Water Supply Planning