From: Gary L. Smith [gls@wright-pierce.com]
Sent: Monday, February 05, 2007 9:11 AM
To: Neil P. Cheseldine (npc@wright-pierce.com)
Subject: FW: Wolfeboro

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/600.pdf>

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/springs.map>

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/ks.pdf>

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/miscsurvey.map>

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/600hikspdf.pdf>

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/bedrock.map>

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/higherks.pdf>

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/wolfe6.hds>

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/wolfe5.hds>

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/wolfe5.gwv>

<file://V:/Email Attachment Archive/Npc/Wolfeboro NH/wolfe6.gwv>

here ya go.

———

From: Jesse Schwalbaum [mailto:schwalbaum@comcast.net]
Sent: Sunday, February 04, 2007 12:27 PM
To: Gary Smith; Peter J. Wilson
Subject: Wolfeboro

Howdy Boys:

Here's where we stand on Wolfeboro.

My latest version of the model, which includes conservative K values, is attached as Wolfe5.gwv (the base maps are also attached). The pre-discharge groudwater levels calibrate well to observed water levels. With 600,000 gpd the mound under the discharge area looks fine, but there appears to be a little bit of "break out" in the southeast - just west of the power line and the southern extent of sand and gravel.

I would feel a lot better if everything looked good on the most conservative run but this is the real world. I could make this breakout go away by opening up the drains, increasing the K values, or reducing the discharge. But we should put our heads together and figure out what how far out on a limb we want to go and what makes the most sense.

I've also included a run with slightly higher K values (wolfe6). There is still a very small area indicating breakout but I don't know how real that is. For all we know there could be springs there already or the bedrock could be lower. I just don't think we have much data there.

So look these over and lets talk on Monday on where to go from here.

Jesse

From: Peter C. Atherton [pca@wright-pierce.com]
Sent: Wednesday, February 07, 2007 2:38 PM
To: 'Neil P. Cheseldine'
Subject: FW: Wolf- Elevation Survey Error

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From: Gary L. Smith [mailto:gls@wright-pierce.com]
Sent: Wednesday, February 07, 2007 2:34 PM
To: 'Peter C. Atherton'
Subject: RE: Wolf- Elevation Survey Error

All this assumes I am coming back from Dominica!!

I plan to review draft report and figures the week (Feb 19th)I come back from vacation. I would say we could get together the end of that week Thurs. and discuss the draft. Then have draft out to Town the following week, receive comments and incorporate edits then schedule presentation to whomever.
Yes RIB could go east of power line as well as wicks. Wicks not recommended given effluent quality. Will not crowded on west side. I would recommend we shoot for a loading rate from NHDES greater than N. Conway so we can be highest in the country!!! Soils can handle it fine.

Not only can I smell the salt air but I can taste the "Bahama Mama's" as I right this verbose e-mail. In fact I can see the bronze bodies walking on the beach..... Oh shit it is a CDM salesmen. There everywhere.
See you soon.

From: Peter C. Atherton [mailto:pca@wright-pierce.com]
Sent: Wednesday, February 07, 2007 11:40 AM
To: 'Gary L. Smith'
Cc: 'Neil P. Cheseldine'; 'Melissa Hamkins'
Subject: RE: Wolf- Elevation Survey Error

Hi Gary - I need to update the project status memo for Dave Ford....w/r/t the Phase III report updated with the model results...when can I say it will be available for him? When are you available to meet at the Town to review and present the Phase III results and answer questions, etc?

Can any of the RIBs (or possibly a wick or 2 or 3) be placed on the east side of the power lines? Can we place an RIB or 2 on the east side if things get too crowded on the west side?

ahh...I can smell the salty air now (or is that an airport?)....

Peter C. Atherton, P.E.

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From: Gary L. Smith [mailto:gls@wright-pierce.com]
Sent: Wednesday, February 07, 2007 7:07 AM
To: Neil P. Cheseldine (npc@wright-pierce.com); Peter C. Atherton (PCA@wright-pierce.com); Peter J. Wilson (pjw@wright-pierce.com)
Subject: Wolf- Elevation Survey Error

Neil,
Attached is a site plan showing the location of B-9 MW 7 and the survey (top of pvc) elevation provided by the surveyor Don Voltz. The location of MW 7 indicates the ground elevation should be approximately 663 where Voltz's elevation puts the ground at approximately 642. The topo checks out with the rest of the monitoring well surveyed elevations so I suspect Voltz's elevation survey is the problem for MW 7. I picked up earlier errors with his survey and had him correct the mistakes so it is not out of the question that there is another error.

Neil, if you and Pete concur, would you have either Voltz or internal WP staff reshoot MW 7. I do not want to have this discrepancy picked up by reviewers and have it raise questions on the accuracy of the model and its results.
Gary

From: Peter C. Atherton [pca@wright-pierce.com]
Sent: Thursday, February 08, 2007 2:50 PM
To: 'David Ford'
Subject: RE: Disposal status report

Hi Dave - The model results indicate that the site can take up to 600,000 gpd. The actual site rating will need to be approved by DES as part of their review of the Phase III report and model results, etc. The Phase III report will be completed over the next 1 to 2 weeks. We would like to set up a meeting with you to discuss your review of the Draft report the week of February 26th. We would also like to review the preliminary design results for the disposal facilities that day. Are there any days the week of the 26th that are better for you than others? Pete

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From: David Ford [mailto:wolfdpw@metrocast.net]
Sent: Thursday, February 08, 2007 12:16 PM
To: 'Peter C. Atherton'
Subject: RE: Disposal status report

Pete,

Did we get any results from computer model on long term capacity of site?

Dave

From: Peter C. Atherton [mailto:pca@wright-pierce.com]
Sent: Thursday, February 08, 2007 6:52 AM
To: 'David Ford'
Subject: Disposal status report

Hi Dave - I was working through a few items yesterday on the project before Gary went on vaca...I plan to have status completed today. Pete

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From: Peter C. Atherton [pca@wright-pierce.com]
Sent: Wednesday, February 14, 2007 6:13 PM
To: 'Neil P. Cheseldine'
Cc: 'Peter J. Wilson'; 'Gary L. Smith'
Subject: RE: new prelim model results

Wow, that's great. Question...do we have any concerns about what DES will or won't call a mode of failure? What happened to get us here?...survey bust...just working the model?

I did let Dave know some things are up on the FTP and more would come later in the week (with a completed draft report end of day Monday, etc). Pete

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From: Neil P. Cheseldine [mailto:npc@wright-pierce.com]
Sent: Wednesday, February 14, 2007 4:34 PM
To: 'Peter C. Atherton'
Cc: 'Peter J. Wilson'
Subject: FW: WW Disposal - Laura Ames Call - Confidential

Pete,

Pete Wilson has uploaded a number of Appendices (i.e. figures, boring/well logs, etc.) that are complete and ready for Dave Ford consumption. I have not reviewed them yet, but I would not be concerned about Dave looking them over at this point in time if you would like to let him know that he can access this info on the FTP site

Pete also said he is working through text portions and hopes to mostly complete tomorrow. He also expects final model results tomorrow, which he will also write in. Jesse has verbally indicated that the site capacity is.....(drum role) at or above 1 mgd. There is no dramatic failure mode - instead the existing wetland "drains" have more flow out. I would hold off on telling Dave any specifics until we have written info from Jesse, but you can tell him that modeling results continue to look pretty good.

I am in Claremont tomorrow. Available to review report progress on Friday and formulate a game plan for next week and also consider releasing available report text sections to Dave.

Neil

Neil Cheseldine, P.E.
Wright-Pierce

From: Neil P. Cheseldine [npc@wright-pierce.com]
Sent: Tuesday, February 20, 2007 10:34 AM
To: 'David Ford'
Cc: 'Peter C. Atherton'; 'Peter J. Wilson'; 'Melissa Hamkins'; 'Gary L. Smith'; 'Richard N. Davee'
Subject: Wolfeboro - Phase 3 Hydrogeo report status

Dave,

The groundwater flow modeling is complete and still looks good in terms of site capacity accommodating the future annual average design flow of 600,000 gpd. We are assembling the draft Phase 3 hydrogeo report. There is some uncertainty regarding the schedule to complete the Phase 3 report because Gary Smith had a snowmobiling mishap on Sunday. I am not sure of all the details except that he was involved in some kind of collision and is presently in the hospital hoping to be released later today - preliminary report is broken ribs and other assorted cuts and bruises (not how I would choose to follow up a vacation in the tropics...). As our lead hydrogeologist, we need to get Gary's input on the Phase 3 report and hopefully he will be feeling better soon - we will keep you posted. We will be prepared to discuss the hydrogeo issues at the meeting on Thursday. Please feel free to contact us with any questions you may have prior to meeting on Thursday.

Neil C.

Neil Cheseldine, P.E.
Wright-Pierce
(802) 434-4944
(802) 434-6076 fax
(802) 272-6745 mobile

From: Gary L. Smith [gls@wright-pierce.com]
Sent: Wednesday, March 07, 2007 7:57 AM
To: 'Peter C. Atherton'
Cc: Neil P. Cheseldine (npc@wright-pierce.com)
Subject: RE: Wolf Report

The model cannot simulate what you are asking for. It is to variable. The only way would be to make a statement based upon professional judgment. At this time I do not believe we could pass the straight face test if we try to overstate the sites capability without the modeling results to support this.
The only way this could be done would be the following:

1. reduce the I I .
2. Use the storage lagoon for buffer (best option in my opinion)
3. lower flows occurring the month before the 800k flows
4. collect more data and rerun the model--- may increase or decrease conclusions
5. take a wait and see position after the flows start going into the site

I am open to any suggestions as I know how important this is.

From: Peter C. Atherton [mailto:pca@wright-pierce.com]
Sent: Wednesday, March 07, 2007 4:03 AM
To: 'Gary L. Smith'; 'Neil P. Cheseldine (npc@wright-pierce.com)'; 'Peter J. Wilson (pjw@wright-pierce.com)'
Subject: RE: Wolf Report

Gary - Thank you for your review.

How does this affect our ability to discharge an "annual average" flow of 600,000 gpd...I understand the model loads at 600,000 gpd constant loading until steady state...can we with confidence have a statement in the text of the report of what the modeling is but have this be interpreted/be assumed to be equivalent to a 600,000 annual average were there may be a a month or two with flows say up to 800k and a few months down below 4/500k?

This will be important, as we would love to have the site rated for the max month condition (approx 800,000 gpd).

At this time, it is likely not critical for the Town, as the effluent storage pond is to remain in the mix....but in the future it could gone.

I don't want to push the limits and want to be on solid groud, but, with the above the goal, and the science the science, how best to proceed?

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From: Gary L. Smith [mailto:gls@wright-pierce.com]
Sent: Tuesday, March 06, 2007 6:10 PM

To: Neil P. Cheseldine (npc@wright-pierce.com); Peter C. Atherton (PCA@wright-pierce.com); Peter J. Wilson (pjw@wright-pierce.com); Mellisa A. Sherlin (mas@wright-pierce.com)
Subject: Wolf Report

To All:
We are not to send the report out until we receive from Jesse are revised memo containing the following discussion and information:

1. A determination of the mound height(s) beneath the modeled portion of the RIB.
2. Peter W. and myself disagree with Jesse's memo that stated "Similarly no "breakout" is expected from the higher discharge scenarios. *It is our opinion the modeling does show breakout will occur in the vicinity of B-7 at flows of 800,000 and 1,000,000 gpd. The memo and Section 9.5 of our report needs to be changed to reflect this finding.*
3. Jesse must provide a clear and understandable statement on the time of travel value for the particle track between the modeled RIB and the closest segment of the unnamed brook, closest wetland and RIB, and Nineteenmile Brook and the RIB.

Peter W. said he will send e-mail request to Jesse today for info. and Peter W. please call Jesse in early AM to emphasize that we need the data ASAP.

Gary

From: Peter C. Atherton [pca@wright-pierce.com]
Sent: Wednesday, March 07, 2007 4:03 AM
To: 'Gary L. Smith'; 'Neil P. Cheseldine (npc@wright-pierce.com)'; 'Peter J. Wilson (pjw@wright-pierce.com)'
Subject: RE: Wolf Report

Gary - Thank you for your review.

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From: Gary L. Smith [mailto:gls@wright-pierce.com]
Sent: Tuesday, March 06, 2007 6:10 PM
To: Neil P. Cheseldine (npc@wright-pierce.com); Peter C. Atherton (PCA@wright-pierce.com); Peter J. Wilson (pjw@wright-pierce.com); Mellisa A. Sherlin (mas@wright-pierce.com)
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Peter W. said he will send e-mail request to Jesse today for info. and Peter W. please call Jesse in early AM to emphasize that we need the data ASAP.

Gary

From: Peter J. Wilson [pjw@wright-pierce.com]
Sent: Wednesday, March 07, 2007 10:19 AM
To: 'Neil P. Cheseldine'
Cc: 'Gary L. Smith'
Subject: FW: Wolfie
Attachments: wolfe model mem.doc

From: Jesse Schwalbaum [mailto:schwalbaum@comcast.net]
Sent: Wednesday, March 07, 2007 10:02 AM
To: Peter J. Wilson
Subject: Re: Wolfie

Pete:

Attached is a revised memo noting potential breakout at discharges above 800,000 gpd.

Jesse
----- Original Message -----

From: Peter J. Wilson
To: 'Jesse Schwalbaum'
Sent: Wednesday, March 07, 2007 9:46 AM
Subject: RE: Wolfie

Thanks Jesse. I will use the max heights for the mounding. I thought you said you did not do a 400,000 gpd run.

Breakout appears in the vicinity of B-7 towards the unnamed brook and along the 600' and lower contours in both the 800 and 1 mgd runs

From: Jesse Schwalbaum [mailto:schwalbaum@comcast.net]
Sent: Wednesday, March 07, 2007 9:40 AM
To: Peter J. Wilson
Subject: Re: Wolfie

Pete:

The groundwater mounds beneath the discharge area have wide ranges depending on where you look, but below is a summary. Highest mounds are at southern extent of discharge area, lowest to the north.

400,000	600,000	800,000	1MGD
5-22 ft	8-26 ft	15 - 32 ft.	16-35 ft.

Minimum groundwater travel time to the unnamed brook is about one month. Minimum travel time to wetland is also one month (the furthest wetland to the west). Minimum travel tie to 19 Mile Brook is 3 months.

I don't see the "breakout" area you are referring to. You'll have to tell me which run and precisely where.

Jesse

----- Original Message -----
From: Peter J. Wilson
To: 'Jesse Schwalbaum'
Cc: 'Gary L. Smith'
Sent: Tuesday, March 06, 2007 5:47 PM
Subject: RE: Wolfie

Jesse,

I confirmed with Gary that we do need the actual numbers for each scenario, just like what was done for Raymond. As far as the travel time we would like to know the shortest travel time to the unnamed brook (to the east of B-7) and also the closest wetland. We need this for the design and regulatory purposes.

Also it appears that there is some break out in the area along the steep slope south of the discharge in the area of B-7. Could you verify our finding and make note in your memo if you concur.

We are submitting the report to NH DES tomorrow.

Please call with any questions.

Thanks,

Pete

From: Jesse Schwalbaum [mailto:schwalbaum@comcast.net]
Sent: Tuesday, March 06, 2007 1:48 PM
To: Peter J. Wilson
Subject: Re: Wolfie

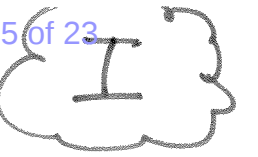
Pete:

Initial responses to your questions...

1. What are the actually mound heights at the different discharge rates. It is essentially the difference between the mound height and bedrock elevation. I can get those numbers for you but the whole idea of a "mound height" is not as straightforward or as useful a concept as it would be for a relatively flat water table because there is no water table before the discharge.

2. Page 7, first paragraph, first sentence states simulation of 400,000 gpd. Is this correct? No, 600,000. Corrected.

3. Same page second paragraph paticle tracking discussion talks about wetlands and seeps. What about travel time to unnamed and Nineteenmile brooks? I calculated the travel times to the springs because they would be the shortest travel times to discharge. Travel time to the brooks will be longer. So between about six months and two years, depending where you are on the brook. I can't really narrow it down much more than that unless you want to specify a particular location in the brook.



WRIGHT-PIERCE
Engineering a Better Environment

MEMORANDUM

TO:	WP Wolfeboro Team	DATE:	June 16, 2009
FROM:	Jesse Schwalbaum	PROJECT NO.:	10922
SUBJECT:	Additional Wolfeboro Modeling		

The Mission

As requested, I have conducted some additional runs on the Wolfeboro groundwater model. There were two primary goals of this second round of modeling: 1) to compile all of the new and pertinent data from the site (e.g., water levels, borings, response to loading, discharge data, locations of seeps and slumps), 2) to re-calibrate the model in transient mode to the new data and the March/April loading of the RIBs and 3) to attempt to use the model as a tool for confirming the maximum potential loading rate and aid in the development of operating procedures that will minimize potential seeping and slumps.

It is important to note at the outset that this type of ad hoc model re-calibration is far from ideal. In early February I was asked to put together a budget for collecting data at the site specifically for re-calibrating the model to discharge conditions. I'm sure there were budgetary or other practical reasons for not implementing that scope of work. The point is that instead of implementing a scope of work intended to re-calibrate the model to observed conditions in a meaningful way, the decision was made to collect a more limited set of data. Now I have been asked to re-calibrate the model with this limited data and the results are, predictably, limited.

The Limitations: Data and Assumptions

Although I have, over the course of five days and many, many model runs, managed to do something akin to re-calibrating the Wolfeboro model, the results are not very satisfactory. There is a problem. If the problem were just a model problem I would be able to fix it. I am a very experienced modeler with a lot of tools at my disposal. However, after a good deal of effort I have come to the conclusion that the calibration problem is due to one or both of the following: 1) some of the data is contradictory or erroneous or 2) there are structural problems with the conceptual model of this aquifer. A "conceptual model" is the basic hydrogeologic understanding of how an aquifer works and forms the framework of the numerical model.

With respect to the first conclusion, the data that I am having the most difficulty with are the pre-discharge water levels. Initially, the model was calibrated to water levels obtained in December of 2006. According to data from nearby USGS long-term monitoring wells, December 2006 was a time of relatively high groundwater levels. The assumption was that if water levels were relatively high in this region of New Hampshire in December of 2006 than chances were good that that they were also relatively high at this site. We are not talking about maximum potential groundwater levels, but relatively high, or what we generally call "seasonal high" groundwater levels. This represents a typical spring season groundwater level.

Now in 2009 we have some new groundwater levels at the site. Unfortunately, I'm having a difficult time making sense of some of these data. We have two sets of new water level data: 1) sporadic readings and transducer data collected by Wright-Pierce early this year and 2) semi-regular water level readings obtained from Woodard & Curran.

The Wright-Pierce data includes transducer readings taken at a few wells before and during the March and April discharges. Unfortunately, readings were only taken at two of the wells that were originally used to calibrate the model – MW-8 and MW-15. The other wells, PMW-1, PMW-2, MW-16 and MW-19, were installed more recently and I have been unable to find any survey data for these wells. So we have only two wells with which to compare the previous steady state pre-discharge model calibration. The water level recorded for MW-15 on February 20, 2009 was within a few inches of the December 2006 water level, indicating that these were comparable high groundwater conditions. But the water level in MW-8 was almost three feet higher in February of 2009 than in December of 2006. This is a big change. There were some short term discharges at the RIBs in February but not enough is known about these discharges to determine if they could have resulted in significantly higher water levels at MW-8. This means that the data collected by WP this year is of limited usefulness in establishing or comparing the pre-discharge groundwater levels assumed in the model. It is difficult to calibrate to or make predictions regarding discharge conditions without a reasonable starting point.

I was hoping that the W&C water level data would be helpful. That data is reproduced in Table 1, below. It should be noted that the W&C data were apparently measured from the top of casing (TOC) rather than the top of PVC (TOP). It would be nice to know the differences between these two measurements, but that difference should only be a few of inches at most.

There is something else odd about the W&C data. The table contains two columns of data, one labeled "Depth, Feet" and the other labeled "DTW, Feet." I assume that "DTW" stands for "depth to water" and, in fact, the numbers in this column are at least in the ballpark of the depths to water in Gary's table. The "Depth, Feet" is a bit of a mystery. Is this depth to the bottom of the well? Then why would they change over time? And how could the measured depth of MW-1 (16 to 20 feet) be deeper than the well itself (about 12 feet according to the log that I have)?

These oddities aside, the W&C water level data just does not seem to make sense. Was the highest water level in MW-1 really in August of 2008, the driest time of the year? Why would this be different from the other wells? And why are the water levels taken by W&C on February

20, 2009 so different from the levels taken by Gary on the same day (see the Wolfeboro RIB Water Level Data)? Something does not look right here.

Table 1: Woodard & Curran Water Level Data

Date	Well Location	Depth Feet	DTW Feet
5/13/09	MW-1	19.58	6.92
2/20/09	MW-1	18.17	5.58
11/5/08	MW-1	16.88	4.08
8/7/08	MW-1	16.46	4.00
5/14/08	MW-1	16.33	4.08
5/13/09	MW-2	13.42	3.29
2/20/09	MW-2	12.17	6.33
11/5/08	MW-2	11.08	5.17
8/7/08	MW-2	10.88	4.38
5/14/08	MW-2	10.92	3.17
5/13/09	MW-6	55.08	42.58
11/5/08	MW-6	54.92	53.25
8/7/08	MW-6	NA	dry
5/14/08	MW-6	48.58	20.17
4/18/08	MW-6	NA	dry
5/13/09	MW-8	62.17	25.67
11/5/08	MW-8	59.58	38.08
8/7/08	MW-8	59.79	36.75
5/14/08	MW-8	61.08	35.17
4/18/08	MW-8	60.83	40.50
5/13/09	MW-15	26.33	5.02
2/20/09	MW-15	25.17	3.92
11/5/08	MW-15	23.92	3.67
8/7/08	MW-15	24.75	3.00
5/15/08	MW-15	24.42	2.83
4/18/08	MW-15	24.83	3.08
11/5/08	MW-16	NA	Damaged
8/7/08	MW-16	NA	NA
5/14/08	MW-16	50.75	42.58
5/13/09	MW-16B	49.42	45.83
5/13/09	MW-19	55.03	46.17
11/5/08	MW-19	56.00	dry

If the W&C water levels are taken at face value than we have some very high pre-discharge groundwater levels that the model will not be able to match without making major structural changes to the model.

This brings us to the second possible conclusion (back in paragraph 3). The primary parameters within the model are hydraulic conductivity (K) and recharge. I have not yet been able to find a combination of K and recharge that provides a good match for the observed starting water levels, the observed mound and the observed seeps. And this is by no means a hit-or- miss process, as in the old days. I have a calibration program that tweaks all of the model parameters systematically and compares the results to observed conditions over and over again for hundreds of model runs. This is why I've actually been able to get other work done this week. But the fact that this program has not been able to come up with a close match suggests that there is something structural in our conceptual model of the aquifer that does not match reality. By structural, I mean that either: 1) the assumed bedrock elevations are off in significant areas of the model, 2) there is channeling of water on or in the bedrock, 3) there is channeling of water through coarse gravel deposits or 4) there is till and bedrock in areas that the model assumes is sand and gravel. The calibration program that I have been using suggests that the latter is one likely candidate because it is insisting that the K values in some areas (in the southeast region of the model) should be below 1 ft/day. This is a value more representative of till than sand.

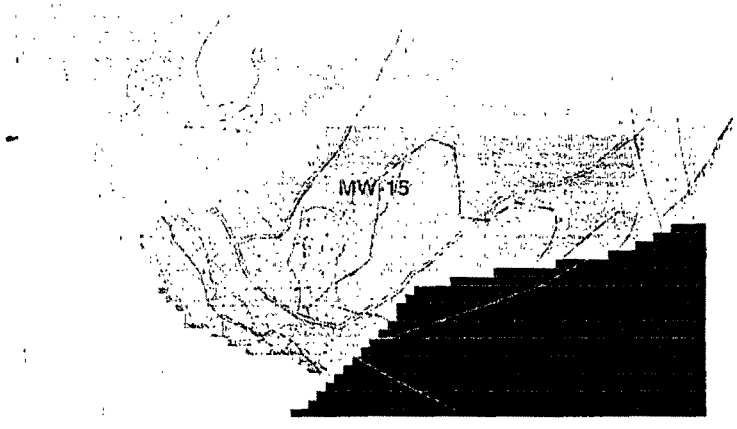
In other words, our conception of how groundwater moves through this aquifer is incomplete and no amount of modeling is going to be able to fill the gap in a satisfactory way. I think it is safe to assume that there are reasons that these seeps have occurred. But the model is not providing us with all of those reasons because there is something about that aquifer that we do not know. We do not even know if these seeps are an unusual occurrence. In many areas, groundwater seeps on steep slopes are a normal occurrence in wet springs.

Model Re-Calibration

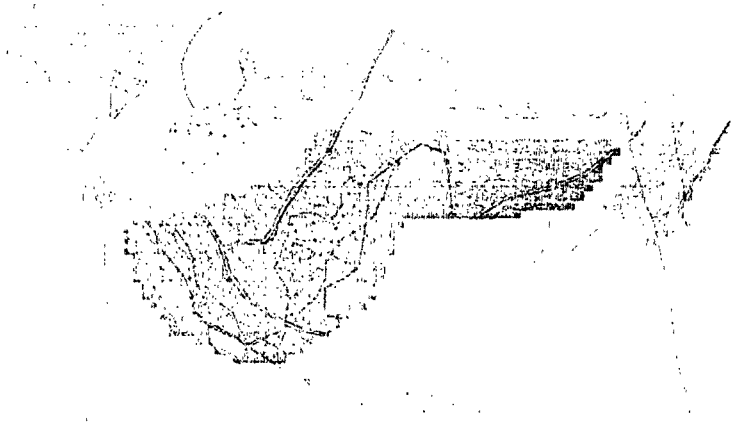
Now that I've discussed the data problems, I can go on to discuss the model runs. I have been running the model in steady state mode to calibrate the non-discharging seasonal high groundwater levels and then switching to transient model to calibrate to the observed mound and seeps. For the seeps, I am assuming that the seeps occur because the groundwater levels are coming to the ground surface. Therefore in these calibration runs I assume that the water levels reach the ground surface in those areas.

The K values are grouped into several zones. I was not able to make much headway calibrating to the mound and seeps using the original zonation – some areas would inevitably have water levels that were too high and some areas would be too low no matter what K values the program used. So I added another K zone in the southeast region of the model – near Nineteen Mile Brook and the access road along the slope of the hill. This gave better results but there are clearly complexities in the aquifer that are not represented in the model. The old and new K zonations are shown below.

New Zonation



Old Zonation



When re-calibrating to the observed water levels and seeps under discharge conditions, what the calibration routine keeps trying to do is have higher Ks near the top of the hill and some portions of the slope and then lower Ks near the southeastern area of Nineteen Mile Brook. I set a lower limit of 1 ft/day for this area but the model wants to go lower. This could either mean that the soils are tighter or that bedrock gets shallow in this area.

It has been clear since the early phases of modeling this site that the groundwater flow is controlled to a great deal by the bedrock. We made some assumptions early on with respect to depths to bedrock and the bedrock surface but we have limited data.

The bottom line is that although this re-calibration process has shed some light on how the model may differ from the actual aquifer conditions in the field, the model is not going to be a lot of help in coming up with a solution because we don't know what precisely is causing the seeps to occur. Is it a bedrock channeling issue? Preferential flow through gravel zones? Is there till where we assumed there was sand and gravel? Do the seeps occur every time there is a wet spring? Is our water level data accurate? Did the high discharge rate this March cause the seeps to gauge deeper into the soils thus perpetuating the seeps? There are just too many unknowns.

Summary

The model has been re-calibrated with respect to the new data and observations obtained at the this spring but: 1) the calibration targets (the water levels and flows), have a high degree of uncertainty that propagates through the model, 2) the calibration is statistically mediocre, 3) the calibration cannot be made better without significantly more (and better) data and 4) the model results suggest that we do not have enough data to fully characterize this aquifer.

Even if we were to assume that all of the observed data that we are trying to calibrate to was perfectly accurate, I would need to arbitrarily change our conceptual model of the aquifer in order to match those conditions. Unfortunately, there are many, many ways to structurally change the model in order to make the observed data fit but if we do not choose the real one, then the model is not going to be very helpful in solving the problem.

The original purpose of the model was to evaluate the potential groundwater mound, address nitrogen loading to the wetlands and brook and determine the potential for seeps along the slope. This is what the model was designed to do and in spite of the data uncertainties and model limitations, the model seems to have functioned fairly well. The predicted groundwater mound beneath the loading beds was pretty close to observed conditions and the model did predict that a discharge greater than 600,000 gpd could result in groundwater seeps along the slope. Now the groundwater model is being asked answer questions it was not designed for – how short term RIB rotations might impact flows and seeps, how greater loading rates and greater than expected discharges might cause slumps and seeps. For most of the aquifers and models that I have worked on over the years these kinds of short term and small scale questions may have been posed with a limited amount of model changes. But not this one. There are simply too many unknowns.

WRIGHT-PIERCE
Engineering a Better Environment

MEMORANDUM

TO:	Dave Ford	DATE:	11 June 2009
FROM:	Melissa Hamkins	PROJECT NO.:	10922H
SUBJECT:	Action Plan for addressing RIB site Start up and Operational Issues		

Based on our discussion at the working session on June 10, 2009, we propose the following action plan:

Slump/Sand Release Area

1. Coordinate with NHSC determine whether the recent sand release has entered the wetlands area and if so to what extent. We have coordinated having NHSC on-site on June 11, 2009 to inspect the site. Based on their assessment we will refine the action plan for moving forward.
2. Coordinate with SWCole to investigate the slump, sink, and sand release area to identify why they happened, will it happen again, and what can be done to prevent it.
3. Based on results of both NHSC and SWCole evaluations develop a plan for next steps. Develop a memorandum presenting recommended next steps.

Seeps

1. Recalibrate groundwater model based on applied flows, locations of seeps and groundwater levels in monitoring wells. This will allow the model results to more accurately reflect the conditions on the ground and will result in better predictive capability of the model. Use recalibrated model to determine overall capacity of site and, if appropriate, what actions will maintain the capacity of the site.
2. Develop a memorandum report for item 1.

RIB Surface

1. At the meeting we developed a plan for operations of the RIB to address algae and operating surface infiltration rates. Wright-Pierce will document this in the meeting notes and develop a specific memorandum outlining the plan for this summer.

Meetings/Workshops

We anticipate 3 meetings to discuss the results of the above actions with the Town and or DES.

Given the importance of this work, the Town may want the results of these efforts to be peer-reviewed to add an additional perspective to the discussion.

Melissa A. Hamkins

From: William J. Schwalbaum [wjs@wright-pierce.com]

Sent: Friday, June 12, 2009 11:08 AM

To: Peter C. Atherton (PCA@wright-pierce.com); Melissa A. Hamkins (mah@wright-pierce.com); Gary L. Smith (gls@wright-pierce.com)

Cc: Richard N. Davee (RND@wright-pierce.com)

Subject: Wolfeboro Modeling

Wolfeboro Team:

I am just writing to summarize the modeling tasks that have been assigned to me yesterday so that we are all on the same page. I have not yet done any runs yet but I have reviewed the chronology, some of the new data and how this new data may or may not change the model assumptions. I am still waiting for the W&C water levels which I think will help us evaluate our assumptions regarding seasonal high groundwater levels at the site.

Basically, the goal of the modeling is to take all of the new and pertinent data from the site (e.g., water levels, borings, response to loading, discharge data, locations of seeps and slumps) and to re-calibrate the model as best as possible to the new data and the results of the March/April loading. Once that is done, we will try to use the model as a tool for confirming the maximum potential loading rate and aid in the development of operating procedures that will minimize potential seeping and slumps.

That said, there are three things to keep in mind with respect to this endeavor. The first is that a similar scope of work (without the operational aspect) conducted in early 2007 took me about two weeks. So this is a stretch. The results that we will talk about on Tuesday afternoon will be preliminary and given the sensitivity of what is happening in Wolfeboro, I do not believe that we should immediately be providing the client with results that are not thoroughly considered, reviewed and presented.

The second point is that the new data that we have is sporadic, incomplete and, in some cases, inconsistent. Hopefully this data will provide us with more insight into how the aquifer system works under stress, but this is not a certainty. This is forensic hydrogeology we are doing.

Finally, the groundwater model will be of limited usefulness with respect to dealing with the seeps and slumps. A groundwater flow model is intended to predict flows in the ground and at specific boundary conditions. If the flow model predicts that water levels will come above the ground surface, this is an indication that there will be seepage at the ground surface - the water has to go somewhere- but the model does not see these seeps and slumps. Seeps and slumps follow a different set of rules than groundwater flow and are effected by small scale structures in the soils and on the slopes that cannot be simulated in a groundwater flow model. As a matter of principle, if a groundwater flow model indicates that under a given set of conditions, the water levels will be significantly above the ground surface (except in the vicinity of existing wetlands where groundwater already seeps to the ground surface) than we would not recommend implementing that scenario, precisely because it could result in consequences (seeps and slumps) that cannot be evaluated with a groundwater flow model. So once we are in a seep and slump condition, the groundwater model is of limited usefulness in evaluating that scenario other than indicating that these things might happen in a given area.

Enough said. Back to coffee and computer.

Jesse

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