Williams, Jim

From: Schellpeper, Jennifer
Sent: Thursday, October 25, 2007 10:16 AM
To: Jim Williams (jwilliams@dnr.ne.gov)
Subject: by the way
Attachments: DRAFT Agenda for 20071025.doc

Jim,
Jason, Steve and I are meeting with Derrel Martin on East Campus this afternoon, 3:30 pm to discuss the RR ET study. You are welcome to join or if you have additional items we need to cover let me know. I've attached our agenda for you to review.

Jen

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Agenda for 10/25/2007 meeting with Derrel Martin on Task Order #10

1. Goal for today's meeting: Develop "Phase II" of the study.

2. Specify Project Goals
   a. Determine if the removal of invasive species will result in a reduction of long-term ET.
   b. Develop a method using remote sensed data to estimate annual/monthly riparian vegetation ET throughout the RR Basin (tie to GW monitoring levels and use to improve model inputs)

3. Methodologies
   a. Develop discussion of how GW monitoring will be tied to ET measurements. Ultimate goal to use data to compare to current GW model and improve the inputs
   b. Vegetation Classification – details on how we do this for remote sensing and how monitored/catalogued at each site (Riparian Ecologist/Botanist)

4. Work Product & Report Deadlines
   a. Quarterly status reports – 1 page, email acceptable [beginning 12/07]
   b. Annual reports – 12/31 each year [beginning 2007 or 2008]
   c. Draft report – [6 months after final data is collected]
   d. Final report – [1 year after final data is collected]
   e. Develop a matrix showing the timeline of activities
   f. Add required presentations?

5. Discussion of Implementation, Personnel and Management

6. Revised budget with FY noted at top

7. Secondary Goal for today's meeting – Discuss how this proposal will work with Durelle Scott's proposal.

8. How does this work overlap or build on the Panhandle METRIC study ($359,351) and the Central Platte NRD study ($639,064) with Suat?

9. Add discussion of overlap/cooperation with the 3 other studies that are occurring

10. Schedule follow-up meeting with entire team

NPDC

1. Triangle GW Survey and Trib. Diverter Survey – any major holes?
2. Remote Sensing Proposal – approved at minimum level, 7 images for $55,000
3. Weather Station – any way to quantify potential difference in data at the current and possible sites?

DRAFT
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PRELIMINARY WORK PLAN AND SCOPE OF WORK

Improving the Representation of Phreatophytes in the Republican River Basin Groundwater Model, Nebraska

HDR Engineering, Inc.
June 30, 2006

Introduction

Since the Settlement on the Republican River Basin Compact in 2003, streamflows have continued to diminish. Some individuals and organizations are saying that much or all of the declining streamflows can be attributed to vegetation (phreatophytes) along the streams and to watershed and farm conservation practices. This preliminary work plan and scope of work has been prepared to address this concern. The primary purposes of document are to provide (1) an assessment for improving the evapotranspiration (ET) estimates in groundwater model, and (2) a preliminary work plan and scope of work for the development, testing, and application of an improved representation of ET in the model.

Review of the Method used in the Groundwater Model

An overview of the representation of phreatophytes in the Republican River basin groundwater model (RRCGWM), is provided in the document titled: Republican River Compact Administration Groundwater Model, Jun 30, 2003, page 11. Conceptually, the method uses the traditional MODFLOW Evapotranspiration Package. The following table very briefly describes the application of this package in the RRCGWM.

Parameter	Value	Comment
Maximum ET	A monthly value is calculated using the Hargreaves method and weather data at Akron, McCook, and Red Cloud climate stations	No adjustment is made for the type of vegetation.
Depth at Maximum ET	*Cells with streams:* Value is set to average ground surface minus 5 ft to account of stream incision. *Cell without streams:* Value is set to average ground surface.	No adjustment is made for the size or location of stream.
Depth at Extinction (ET ceases)	Universally set to 10 ft.	No adjustment for the type of vegetation.
Phreatophyte coverage	Acreage calculated for model cells with phreatophytes.	If the phreatophytes covers parts of cells, a proportional adjustment is applied to the maximum ET rate. No adjustment is made for density of phreatophytes.

Using 2004 model results as an example, the annual maximum potential ET loss for the model area was about 1,400,000 ac-ft. The model calculated ET was about 392,000 ac-ft, which is 28 percent of the maximum. The model-wide average rate of ET loss for the delineated phreatophyte areas is about 12 inches of water. This indicates that the phreatophytes were getting some of their water from the aquifer and some from unsaturated zone, or were not getting all the water that they could use.

A Review of Methods Used to Represent Phreatophytes in MODFLOW

Original ET Package

The original ET package in MODFLOW, as presented by McDonald and Harbaugh[1] assumes the ET in a cell is calculated on the basis of the simulated water level and the depths where ET is at a maximum and where ET becomes extinct (ceases). The model assumes that when the water table is:

1. at or above the maximum ET depth, the ET occurs at the maximum rate;
2. at or below the extinction ET depth, ET does not occur; and
3. between the maximum and extinction depths, ET is proportional between the two limits.

This method was used in the RRCGWM.

This package has the advantages of simplicity and common use. However, for relatively large model cells (one square mile) such as the RRCGWM, making a precise calculation of a representative land surface elevation and depths at maximum and extinction ET are difficult or impossible. As a result, the modeler often has to resort to determining the values by calibration.

ETS1 ET Package

The USGS[2] has prepared an alternative ET package (ETS1) by subdividing the linear relationship between extinction and maximum ET depths into two or more linear segments. It has the advantage of defining a rather complicated relationship between ET and depth to the water table and is the method recommended for the development of Groundwater Availability Models (GAM) in Texas[3]. It has a disadvantage of having to define soil and plant rooting depths which becomes problematic for relatively large model cells.

Net Recharge

Some groundwater modelers indirectly adjust for ET of an aquifer system by removing an estimate of the ET from their estimate of total recharge. For example, in areas of the model where the water table is substantially below the land surface and no ET is

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[1] McDonald, M.G. and Harbaugh, A.W., 1988, A modular three-dimensional finite difference ground-water flow model: U.S. Geological Survey Techniques of Water Resources Investigations, 06-A1.

[2] Banta, E.R., 2000, MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model—Documentation on packages for simulating evapotranspiration with a segmented function (ETS1) and drainges with return flow (DRT1), U. S. Geological Survey Open-File Report 00-466.

[3] Scanlon, B, Keese, K, Bonal, N., Deeds, N, Kelley, V, and Litvak, M., 2005, Evapotranspiration estimates with emphasis on groundwater evapotranspiration in Texas, Prepared by Texas Water Development Board (http://www.twdb.state.tx.us/gam/resources/resources.htm)

expected, net recharge would be set equal to total recharge. However, in areas with a relatively shallow water table and where ET is expected, total recharge would be reduced to net value to account for the portion of recharge that would be lost to ET. Such an approach does not provide a direct accounting of the loss of water to ET in the model's water budget. The advantage of this approach is simplicity when net recharge is determined directly by calibration. It has the disadvantage of poorly defining an aquifer system by leaving out a major water budget component ET.

Independent Calculation of ET

Another approach is to calculate water losses from ET outside of the model, then inputing these losses directly to the model which parallels the representation of well pumpage in the model. This approach provides an opportunity to be very rigorous in utilizing precise climatic data, delineating the coverage and type of phreatophytes, applying selective crop coefficients, and estimating the amount of the water being derived from the unsaturated zone. Westenburg, Harper, and DeMeo[4] used this in the Lower Colorado River Accounting System (LCRAS) in Arizona. The approach could be taken a step further by applying the ET losses directly to the RRCGWM.

Recommended Method for Republican River Compact Groundwater Model (RRCGWM)

Based on this review and various constraints in the Republican River Basin, there does not appear to be justification for replacing the ET Package (original) that is being used in the model. This assessment is based primarily on:

- complexity of having to partition the water uptake by plants between the aquifer and the unsaturated zone,
- variability of the physiographic and hydrologic setting within a square mile model cell,
- having to calibrate the model to baseflow in the streams, and
- having to update the model each year.

A Review of Parameters Used to the Original ET Package as they Relate to the RRCGWM and Potential for Improvements

Land Surface Elevation

The land surface elevation in a sense becomes the datum that links the elevation of the simulated water table to the losses of water to ET. As commonly done by most modelers, the land surface elevation of cell in the RRCGWM is calculated as an average from a GIS coverage. Because there may be not be a non-uniform distribution of land surface elevations in a model cell, the average of the land surface elevations may not be a representative value for modeling purposes. This would be most noticeable in the vicinity of streams and in the rolling hills area where there are considerable topographic changes within a model cell.

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[4] Westenburg, C.L., Harper, D.P., and DeMeo, G.A., 2006, Evapotraspiration of phreatopyhtes along the Lower Colorado River at Havasu National Wildlife Refuge, Arizona: U.S. Geological Survey Scientific Investigations Report 2006-5043.

Even though the representation may not be as precise as possible, a more rigorous means of calculating a representative land surface elevation within each model cell probably has very limit potential for improving the ET representation in RRCGWM.

Maximum and Extinction ET Depths

These two parameters are very sensitive in the resulting water table elevation near Republican River basin streams and in partitioning the discharge of groundwater to either ET or streams.

A comprehensive study[5] that compiled and analyzed data from 11 sites in Nevada and California with the purpose of developing equations for estimating ground-water evapotranspiraton as a function of phreatophyte cover and/or as depth to groundwater is of considerable interest to the Republican River Basin. Their analysis shows that the ET equation for plant coverage has an exponential form. It shows ET increasing rapidly for up 25 percent of plant coverage, and very little increase in ET rate when the plant coverage is greater than 50 percent. The equation for ET as a function of depth to the water table is linear with the slope varying by season. These curves show extinction depths ranging from approximately 15 feet in the winter to 50 feet in the summer.

Along the Republican River in Nebraska, the extinction depth appears to be too small on the basis of wide-spread plant coverage and the variability of plant types. Thus, some improvement in accuracy seems possible with a more refined delineation and representation of these two parameters.

Maximum ET Rate

The Bowen-ratio and Hargreaves methods are commonly used for estimating the maximum ET which is based on research on water consumption by crops and the application of coefficients to adjust for a specific crop or types of plants. Because the Hargreaves method relies on readily available climatic data, it has rather common use and is the method used in the RRCGWM. In the RRCGWM, the maximum ET is calculated at three stations (Akron, McCook and Red Cloud) for a single plant type.

As with the ET extinction depth, a single maximum ET rate does not seem to capture the variability of potential ET losses. Thus, some improvement in accuracy seems reasonable with a more refined delineation and representation.

Phreatophyte Coverage

In the development of the RRCGWM, satellite images during the early 1990's were the basis for recent phreatophyte coverage in Nebraska. These data coupled with site investigations provided a general subdividing the plants into grasses, shrubs and trees. However, in the final design of the model, a single plant coverage was used throughout the model. To adjust for partial phreatophyte coverage in a cell and to accommodate the limits of MODFLOW, the maximum ET rate was adjusted in proportion to the coverage of phreatophytes within a cell.

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[5] Nichols, W.D., 2000, Regional Ground-water evapotranspiration and ground-water budgets, Great Basin, Nevada: U.S. Geological Survey Professional Paper 1628.

In Nebraska, an improvement in the confidence of the ET losses can be gained by updating the phreatophyte coverage with the latest available satellite data and possibly with field surveys on plant types.

A Suggested Work Plan and Scope of Work

Study Topics

In advancing the confidence and accuracy of the ET losses in the RRCGWM in Nebraska, the suggested studies are directed toward:

- updating the phreatophyte coverage,
- subdividing the phreatophytes into about three plant types, such as grasses, shrubs, and trees, and
- reassessing the ET extinction depth.

Approach

The suggested approach is to divide the study into two phases. The first phase (Phase I) is a pilot study to determine the level of improvement or change that can be expected with an update of the phreatophyte coverage and a more detailed representation of maximum ET rates and ET extinction depths. Then, if the results indicate substantial improvements can be achieved, the second phase would be a study for the entire Republican River basin in Nebraska.

Tasks (Phase 1 Only)

Select Test Areas: In Nebraska, select about six cross sections of the Republican River and major tributaries. The locations and sizes of the cross sections would vary from about a mile wide on tributaries to several miles wide in heavily vegetated parts of the Republican River.

Phreatophyte Coverage: For each test area, study the satellite data and delineate the total phreatophyte coverage. On a case by case basis, either utilize existing data or field surveys to subdivide the total phreatophyte coverage into three types (grasses, shrubs and trees).

Maximum ET Rate (Crop/Plant coefficient): Conduct literature review to estimate a representative crop coefficient for each of the three types of plants.

ET Extinction Depth: Along each of the cross sections, prepare a detailed depth to water table map below land surface and relate the depth to the water table to the types of phreatophytes. Emphasis will be placed on the fringes of the cross sections where phreatophytes fade out. From these data, select a representative ET extinction depth for each plant type.

Extrapolate for Complete Coverage: Develop and apply an approximating method to extrapolate the ET parameters from the cross sections to other areas in the model. This method probably would be indexed to 1990s data and statistical methods.

Code the Pilot ET data into RRCGWM and Run: The testing with the RRCGWM will be limited to a period from 1995 to 2004. The starting heads, pumping and recharge in the model would come from the current RRCGWM data set.

Comparison of Model with Revised ET with current RRCGWM Results: Model calculated water budget for ET and baseflow would be compiled from the model with the revised ET definition and compared with the current RRCGWM results.

Assessment of Improvement and Confidence in Model Results: The first assessment will be simply to determine if there is a significant difference in the ET and stream discharge between the two models. If there is, then a comparison with baseflow targets will be assessed to determine if there is an improvement in the model's accuracy with the revised ET method.

Study Participants

The suggested pilot study can be conducted by the current team of consultants which includes Flatwater, McDonald and Morrissey, and HDR.

Schedule and Estimated Costs

If the pilot study can be conducted with limit field surveys, it is estimated to take about six months to complete and cost about $75,000 to $100,000.

Larry Land, P.E.