b. Are NRD pumping records used in the Model, or are power records used? What are the pros and cons of using each?

Power records were used in the model when metered pumping records were not available. Now that metered pumping records are available for all three NRDs, these will be used in the model (metered data has been used since 2001 in the URNRD). The advantage of power record data is that it is available for years when no metered pumping records exist. However, it is an estimate rather than a direct measurement. Metered pumping records are the preferred source of pumping data as they are a direct measurement. However, ~~this~~ these data is not available for every well in the basin for most of the period of time they have been in use.

c. What portion of the base flows used by the Model occur within 20 days of a precipitation event?

will talk to Jim, add comment to answer, we need more detail? Is this model of a smaller area

There are no precipitation "events" in the model. A groundwater model does not use precipitation as a direct input. The Republican model takes the annual precipitation data for the official gauges and interpolates these values to every model grid cell. Then a series of curves are used to determine the recharge to that cell, based on the precipitation, the soil type, and whether or not the cell is irrigated. The Republican model uses monthly stress periods, meaning the stresses (e.g. recharge, pumping) can only be changed on a monthly basis. The annual recharge for each cell is apportioned to each monthly stress period using a fixed monthly distribution. See http://www.republicanrivercompact.org/v12p/html/ch04.html for more information.

7. System Design

a. The Model used for the Republican River Basin uses 1 aquifer layer. The Platte River Model uses multiple levels. What are the resultant differences?

It is very difficult to assess the impact of the multiple layers in the Platte River model because there are so many other differences between the two models. The Platte River model may yield different results for the Republican River tributaries in that model area, but this may have nothing to do with the multiple layers. Also, it is important to note that the Republican River is simply a boundary condition to the Platte River model. The focus of the Platte River model is on the Platte River; therefore, much less attention was given to the area of the Republican River in the Platte River model.

b. There is a significant amount of overlap between the Platte and Republican Models. Has there been a comparison between the two Models? Do the two Models show similar results? What end result differences are there?

DNR is currently conducting a study to compare the inputs to the two models in the area in which they overlap. While there are numerous, small scale and minor variability's in the model parameters, there do not appear to be any significant differences. The analysis of the model results (e.g. predicted heads and baseflows) is not complete at this time.

moves back in time toward 1935, to account for the gradual increase in phreatophytes from then until the present day. As groundwater pumping developed in the basin, the water extracted for irrigation came from several sources, including reduced riparian ET (this is known as ET salvage). Because of this phenomenon, riparian ET in the model during 2001 to 2005 is less than it was during the 1950's (average of approximately 500 kAF per year in the 1950's to approximately 420 kAF per year in 2001-2005).

b. What does the Model show consumptive use by vegetation to have been in 1920, 1960, and 2006?

The following values are presented as multiyear averages in order to smooth out the short term variability and highlight the long term variability. The values are for the entire model domain, not just for Nebraska. In the 1920's, average annual riparian ET was approximately 480 kAF in the model. In the 1960's this had increased to approximately 540 kAF in the model. For the years 2001-2005 (the 2006 model run has not been finalized) the average annual riparian ET was approximately 420 kAF in the model.

c. Does the Model show vegetation water usage to vary depending on how much water is pumped by irrigation wells?

Yes, ET decreases when streamflow decreases, because the water is not as available to the plants. This is a primary reason that riparian ET is so much lower in 2001-2005 when compared to the 1960's. The recent drought has also contributed to the lower riparian ET values. However, even during the 1990's, average annual riparian ET was approximately 470 kAF, significantly lower than during the 1960's despite the wet conditions.

3. Stream / Aquifer Relationship

Join to 3a

a. Once a stream permanently stops flowing, it is said to have disconnected from the aquifer. According to the Model, do irrigation wells "above" a disconnected stream affect stream flow? Is it easier for Nebraska to comply with the Kansas agreement if the streams are dry?

The groundwater computed beneficial consumptive use is calculated by running the model under two scenarios, with groundwater pumping on and with groundwater pumping off. Any stream that is flowing with groundwater pumping off can potentially be impacted when the groundwater wells are turned on. If groundwater pumping causes an otherwise wet stream to go dry, it is obviously affecting stream flow. Once a stream goes dry, no additional impacts are possible. However, the difference between the streamflow with no groundwater pumping and the streamflow with groundwater pumping (in the case of a dry stream this is zero flow) still yields the impacts to that stream. In short, once pumping has caused a stream to become dry, no additional impacts are possible, but there are always impacts to the stream unless it naturally dries up under the no pumping condition.

It is therefore not easier for Nebraska to comply with the Compact if the streams are dry. The annual accounting to determine the computed water

supply (of which Nebraska can consumptively use approximately half) essentially contains two components, gauged streamflows and consumptive use (both surface and groundwater). If Nebraska's streams were dry (i.e. virtually zero streamflow at the stream gauges) then the only component of virgin water supply in Nebraska would be the consumptive use. Put another way, Nebraska's consumptive use would be 100% of the water supply within Nebraska. Under the Compact Nebraska is not allowed to use 100% of the water supply within Nebraska. Dry streams always make it harder for Nebraska to comply with the Compact because less water flows into Kansas. Finally, dry streams would result in no Imported Water Supply Credit since that is based on the mound water measured at the stream gauges.

b. What is the relationship of the aquifer level to the stream flow? If the aquifer goes down, does the stream flow also go down? If the aquifer level stays level, does the stream also stay the same?

In the groundwater model, every stream cell contains a stream bed elevation. The model also calculates the stage in the river for that cell if there is any water in the river at that time. Then, if the aquifer level is greater than the stream stage, water will move from the aquifer to the stream. If the aquifer level is below the stream stage, water will move from the stream to the aquifer (until the stream dries up). The greater the difference between the aquifer level and stream stage, the more water will move between the aquifer and stream.

The rate of flow between the stream and aquifer is also dependant on the streambed conductance, a constant that is determined during calibration ~~and~~ that never changes during future simulations. The streambed conductance is a property of the width and thickness of the streambed, the length of the stream in the model cell, and the hydraulic properties of the streambed (how readily water moves through the materials).

Large changes in aquifer levels are not required for the baseflows to the stream to change significantly. Typical values for streambed conductance in the Republican mainstem are approximately 1 ft^2/s (~~these values are lower in the tributaries due to narrower streams and finer streambed materials~~). This is multiplied by the water level difference to compute the flow between the aquifer and stream (e.g. a 1 foot water level difference would result in a baseflow of 1 ft^3/s for that model grid). The grid size in the Republican model is 1 mi^2, so baseflow to each model grid roughly represents the baseflow for each river mile. Therefore, a change in water levels of 1 foot would reduce baseflows (or increase stream losses) by about 1 ft^3/s (or ~724 ac-ft/yr) per river mile.

As an example, let's consider the Republican River mainstem in the Lower Republican NRD. The portion of the Republican River in the Lower Republican NRD is approximately 100 miles long. The LRNRD portion of the annual groundwater pumping impacts to streamflow has been approximately 45,000 acre-feet in recent years. Based on the numbers above, these

impacts would occur with an approximately 6 inch lowering of the aquifer on average within Republican River stream cells in the LRNRD.

4. Precipitation

a. What percent of normal has precipitation been in the Republican River Basin each year for the last decade?

This would obviously depend on what is meant by *normal.* We will assume that normal is referring to the long term average (and not the more recent, above average rains of the 1980's and 1990's). The following table presents the percentile (the 50th percentile is the median value, which for precipitation data is usually very close to the mean) for annual rainfall based on the official compact gauges. Data are presented for the gauges in Nebraska only, and for all of the Compact gauges.

Year	NE Only	All Stations
1996	94%	93%
1997	54%	56%
1998	39%	53%
1999	69%	72%
2000	34%	29%
2001	63%	66%
2002	2%	3%
2003	33%	26%
2004	70%	71%
2005	48%	61%

b. Is precipitation the primary factor determining Nebraska's allocation? If so, what percentage of the allocation does precipitation contribute to the allocation as compared to base flow on a year-to-year basis? Is there a significant variation in this percentage each year?

Precipitation is the only source of the Compact Virgin Water Supply. Precipitation that reaches the stream, either through runoff or as baseflow, during the year that it fell, contributes to the NE allocation for that year. However, much of a given years precipitation (or lack of), will affect baseflow for many subsequent years. It appears that this question is really asking; how much of each year's allocation is the result of precipitation during that year, versus baseflows resulting from previous year's precipitation?

This is very difficult to assess. DNR is currently studying the baseflow and runoff patterns in the basin. Preliminary results suggest that most of the

streams in the basin are baseflow-dominated most of the time. This would suggest that the allocation would depend heavily on previous year's precipitation. However, during any given heavy precipitation year (such as 1993), the majority of the streams in the basin were clearly runoff-dominated. ~~That allocation in 1993 was heavily dependant on the current year's precipitation. So there can be a significant year-to-year variation in the primary source of NE allocation for each year.~~

Simply put, during dry to moderate precipitation years, there is probably very little runoff contribution to streamflow, so the NE allocation would be much more dependant on precipitation from past years. During wet years, runoff is more dominant, and the allocation is primarily determined by the precipitation from that year.

c. Does the Model use precipitation inputs from just the official gages, or does the system use input from other locations, such as the NERain project? Would the Model benefit from additional input and measurement locations?

The model uses the official Compact gauges only. It is possible that the model would benefit from additional precipitation stations, though stations with a short period of record are not very useful for model calibration.

5. Dams and Reservoirs

a. Has the placement of the dams in the Basin caused a change in base flow or stream flow?

The construction of dams decreases peak flood flows. However, the overall effect cannot be known without completion of a calibrated rainfall-runoff model.

b. Has the construction of dams caused an increase in the number of trees in the Basin?

~~This is unknown.~~

6. Model Inputs

a. Have there been any significant modifications to the data going into the Model since what was released to the public on the RRCA web site in 2005? Specifically, has there been any revision of historical pumping data or any other changes? If so, please detail those changes.

There have been no significant changes to model input data for the model runs for 2005 and previous years. For 2006, DNR will be using the metered pumping data collected by the LRNRD and the MRNRD (meters have been used for URNRD pumping since 2001). For the previous years, the pumping in the LRNRD and the MRNRD was estimated using power records. DNR will continue to calculate the power record estimated pumping, and compare this to pumping as measured by meters. At the current time there is not sufficient data to draw any conclusions regarding the power record method used in the past, so it would be premature to modify the past pumping data at this time.

[Ann, I don't know how you want to answer this one.]

c. If water is imported into the Basin via Spring Creek, where is it measured at?

The first Compact gauge below Spring Creek is at Guide Rock.

d. What is the difference in credit to Nebraska if the stream is augmented from outside the Republican River Basin as compared to from within?

If the augmentation being considered is from groundwater wells, current Compact accounting procedures would result in no difference. However, the DNR has discovered a flaw in the accounting procedures (not in the model itself), and if NE can get the Compact Administration to agree to its proposed changes, there would be a difference. Then a well outside the surface water basin (but within the model) would not count as consumptive use of virgin water supply, and Nebraska's allocation would increase by approximately 50% of any imported water that made it to a compact gauge. Under current accounting procedures, the consumptive use of the well would count against Nebraska, reducing the net benefit.

Current Nebraska law prohibits interbasin transfers of surface water, so augmentation from none-groundwater sources would not be possible.

8. Mound

a. The mound credit Nebraska has received each year from the Platte has decreased? Is this because of a decrease in the amount of water coming from the Platte, or is it because more water is failing to get to the stream once it is in the Republican River Basin? If it is the latter, is it drought, pumping, or conservation that is causing the problem? If a combination, what are the percentages attributed to each cause?

The mound credit has been reduced from nearly 20 kAF in 2000 to less than 10 kAF in 2003, though it has increased slightly since then. ~~This is primarily due to more water not making it to the stream once it gets to the basin, and has been almost unaffected by changes in water coming from the Platte. Groundwater pumping (primarily in the Tri-Basin and Lower Republican NRDs) accounts for most of the water that gets into the Republican Basin but does not make it to an accounting point in the stream.~~ To a much lesser extant, the reduction in recharge during the recent drought has also prevented mound water from making it to accounting points in the stream.

b. If the amount of mound water coming from the Platte is increased, will it be easier for Nebraska to stay in compliance? How can Nebraska increase this credit, according to the Model?

An increase in imported water supply reaching the compact gauges would make it easier for NE to stay in compliance because the Mound Credit would increase. This could happen ~~in the model~~ in two ways. A reduction in pumping in the area of the mound (~~and the areas between the mound and the river~~) would allow more of the mound water to reach the stream, increasing the mound credit. Alternatively, a significant increase in the amount of

answer 1d + 1e first

Model Questions

1. Conservation

a. Are the effects of conservation in the Model?

Yes and No. First it must be recognized that the RRCA gw model only models groundwater flow. The model does not include a surface water component, and therefore any impact of conservation practices on SW supply are not specifically addressed in the model. (3) the conservation effects are not ~~explicitly~~ input into the model. However, the effects of conservation are implicitly taken into account due to model calibration. Although there are no inputs to the groundwater model that specifically represent conservation measures, ~~However~~, the model is calibrated to observed heads and baseflows. If conservation measures have had an effect on groundwater levels and stream baseflows, the model does account for this, ~~in some way (i.e. something else in the model accounts for the impact of conservation measures on water levels and baseflows).~~ (3) If conservation measures have an effect on total streamflow through a change in runoff, it would be impossible for the groundwater model to account for this (i.e. ~~runoff and total streamflow are not modeled by MODFLOW, a separate *rainfall-runoff model* would be needed for this~~). To account for this impact a separate rainfall model would be needed.

but it does not answer the impact to any specific portion

b. If not, why were they excluded?

As stated in manner to 1d, At the time of the Final Settlement Stipulation (FSS), there was a lack of data regarding the effect conservation measures have on recharge to the aquifer, as well as the spatial and temporal distribution of conservation measures in the basin. Therefore, the RRCA Conservation Committee was created in order to answer these types of questions. The Conservation Committee provides an annual report to the RRCA.

c. If the effects of conservation were in the Model, would it change the depletions to the stream that the Model says are caused by groundwater irrigation?

It is possible that specifically factoring in the change in recharge to the aquifer in locations where conservation measures have been implemented would change the model-calculated depletions in stream baseflow due to groundwater pumping. However, as indicated in the response to 1a, the currently used method for distributing recharge in the model provides for simulated baseflows and water levels that reasonably match observations. The method of distributing recharge could be changed to incorporate the effect of conservation measures on recharge, if a method could be devised that results in a match of model-predicted and observed baseflows and water levels that is at least as good as the current calibration does. However, it is very difficult to predict what type of effect this would have on the resulting model-calculated stream depletions due to groundwater pumping, if any. The difference in depletions would likely vary both spatially and temporally, and be both greater and less than depletions calculated with the model as currently used over space and time. The net difference for the basin as a whole may or may not be significant.

d. What is the estimated depletion of the stream in the Republican River Basin that is caused by conservation?

It also must be noted that conservation practices, particularly the use of min tillage practices, reduce the need for supplimental irrigation and therefore reduce the need for gw pumping. This reduction reduces N's Consumptive use from irrigation and helps with compact compliance.

1 d.

By conserv. act we assume you mean such farming practices as: installing farm ponds & terraces and using minimum tillage and modern crop practices. The impact of the practices are b -

~~This is~~ not currently well understood. The RRCA Conservation Committee is conducting a study of the effects of terraces and small ponds. The Principle Investigators for the study are Derrel Martin of the University of Nebraska and James Koelliker of Kansas State University.

Preliminary results suggest that modern cropping and tilling practices are the primary cause of decreasing runoff over the past fifty years; the effect of modern crop management may be 10 times that of terraces. Combined with modern crop management practices, terraces reduce runoff from the field to almost zero.

However, the modeling also shows that most of the water lost to runoff is not lost to evaporation, but instead recharges the aquifer. This would simply ~~be~~ a retiming of streamflow, ~~unless groundwater pumping intercepts the extra recharge before it becomes baseflow to a stream.~~

e. Does the amount of conservation vary from State to State as a percent of each watershed?

The only information available on distribution of conservation measures is for terraces. The inventory completed by the Compact conservation study shows a total of about 2.3 million acres of terraced fields in the Republican River Basin. Of these, approximately 220 thousand are in Colorado, 900 thousand are in Kansas, and 1.2 million are in Nebraska.

The Republican River Compact Administration (RRCA) Engineering committee is in the process of creating an inventory of dams and small reservoirs that need to be tracked according to the Final Settlement Stipulation. This inventory is nearly complete for Nebraska, but not for Colorado or Kansas.

2. Vegetation

a. Does the Model show a change in the amount of water used by riparian vegetation each year or each decade? Has there been an increase in vegetation water usage in the Model since the 1950s? If so, how much has the change been?

The model does show a change in riparian evapotranspiration (ET), both on a year to year basis and over the long term. A monthly maximum ET for every model cell is calculated each year based on climate data collected at three stations (McCook, Akron, and Red Cloud). This results in short term (monthly to annual) variability in the riparian ET in the model. There is also a long term trend in the total riparian ET in the model. This reflects both the gradual re-emergence of phreatophytes in the basin following the 1935 flood (increase in total annual ET with time) and the build-up of groundwater pumping (decreasing total annual ET with time). The re-emergence of phreatophytes is dealt with in the model by a series of sub-basin ET area factors (see http://www.republicanrivercompact.org/v12p/html/factors.html). These curves adjust the present day distribution of ET areas, mostly downward as one

Although quantified stream and canal flows across the state are included in the Annual Hydrographic Report by DNR, limited information on individual diversions is available except in the Republican basin. As of Oct., 2005 there were approximately 6,800 diversions operating in Nebraska outside of fully and over appropriated areas. If the Committee chooses to mandate use of flow meters in all river basins as a result of LR 198, we wish to present information from our experience so far to aid the decision.

Deleted: i.e. for the Blue, Niobrara, Nemaha, Missouri Tributaries, and lower Platte basins

Recommendations

A determination of the state's interest in the overall level of accuracy required in reporting of water used and acres irrigated should govern whether to require flow meters universally or just in limited areas. Universal use of flow meters would aid water administration, but implementing an effective and universal flow metering system requires increased expenditures for personnel, technology, and maintenance. If required by law, flow meters may be a cost to users who will weigh the cost against the irrigation value and increased information available for agricultural management. Start up costs for broadcast reporting flow meters average about $1000 per unit, with additional maintenance/replacement costs to be expected. Some kind of rudimentary flume placed recorder is necessary for most of Nebraska because of gravity systems on relatively flat terrain, but even they can be equipped with dial up modems for remote monitoring. Historically, many variations on "metering" have been used with some success; i.e calibration of existing pump power usage with water volume pumped has been used for both ground water and surface water. A variety or patchwork of volume monitoring devices typically exists in basins requiring metering. Detail differences Platte & Republican, including volumes, residual riparian rights, ranching and crop orientations. Ron this last isn't a sentence and I am not sure what point is.

Insuring meters are properly installed, accurately working, and read requires more staff than DNR has available currently. Estimates needed vary according to the current staffing patterns, geographical distances, and numbers of diversions in the particular water divisions. (We have estimates from all divisions- untabulated - 300-400 man hours for an additional end of year reading for Cambridge; for a reading at every diversion point, 40 (should this be 4? They have far less individual appropriations than any one else other than Brad) more personnel for Bridgeport [currently using 7 persons for 120 recorders/200 pumpers, or roughly 4,000 water discharge measures/year]; Ord estimates 8 more personnel; 10 FTE for the 2,200 permits in Lincoln F.O. area; Norfolk estimates one additional FTE) There may be other variations in personnel needs depending upon the number of readings or calibrations required, and the choice of instruments, i.e. remote or manual reporting/recording.

operations formerly relying solely on surface irrigation from canals is the rule of thumb if ground water is available.

DNR operates 70 continuous stream and reservoir gages, eight partial year gages, 94 canal and canal return flow gages, and makes spot measurements or observations of stage at 42 sites operated by other agencies or districts. Twelve other gages are operated in cooperation with the U.S. Geological Survey. The Hydrographic Summary of reports from these gauges is produced annually, coordinated with USGS reporting, and is on the DNR website.

Limitations to currently available DNR information

Statewide, approximately 5 of every 6 natural flow permits (approximately 6,500 total) are pump diversions, amenable to metering. ~~Preceding statement is not true.~~ The Director has discretionary authority to require flow meters for all appropriations for investigatory and enforcement purposes. Local investigations or conditions may merit discretionary monitoring with local record keeping of water volumes.

Deleted: Flow metering statewide is typically limited to head gates of irrigation district diversions. Individual diversion data is less available and usually limited to investigations and areas required by order of the Department.

Deleted: ~~Every diversion is examined~~ at least annually by field staff.

Statutory authority under § 46-209 (general authority), 46- 261, and 46-256 (as condition of water use) enable DNR to require installation of a measuring device for surface water uses. Some permits require a measuring device routinely, i.e. at head gates of irrigation district and canal company projects, and for conduct water permits; otherwise the requirement is ancillary to an appropriation's location or circumstances.[1] Some orders apply to individual diversions and are not time limited. Such orders have historically been issued following several years of requests for administration. Examples:

Deleted: taking in stream flow

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Table 1: Standing Orders to Install Measuring Device

1. Dec. 1, 1981, Keya Paha R.; Ord Field Office
2. Sept. 4, 1981, Big Blue R. above the mouth of the West Fork (for irrigation only, not storage, during water administration for the Blue Compact,)
3. (date), Division 2-C (Niobrara R., WY to Sheridan Co. line) Bridgeport F. O., includes approximately 20 appropriations
4. Feb. 8, 1993, Platte R. below McConaughy and above the mouth of the Loup R.. Agreement was reached with natural resources districts to allow timing devices once the NRD certified the maximum pumping of the facility. However, DNR reserved the right to require meters if the timing devices were unsatisfactory.
5. May 23, 1991, Republican R. (Harlan Lake to Guide Rock diversion) Cambridge F.O., on all individual diversions for administration purposes; see attached order
6. May 1, 2000, entire Republican R., Cambridge F.O., for RRCA purposes; see attached order

[1] . Division 1-A (N. Platte R., WY to G.I.), Bridgeport Field Office, uses 70 data loggers on flumes usually at headgates of canals; most canals in upper Platte have 40-50 years published data. Some irrigation districts (Loup PPID) have required their customers to have flow meters as a condition of delivery contracts. [1]

DNR will present written testimony to the Natural Resources Committee for use in the hearings in North Platte on July 31. This request is specific to LR 198:

Introduced by Louden, 49;
PURPOSE: To examine the benefits, costs, and data collection from flow meters installed to measure ground water use and surface water use, and to determine whether use of flow meters should be mandated in all river basins.

Incidental questions to be answered for the Committee for their determination are: where does the water go; how much; and how does each user (GW/SW) get just the allocation?

Overview

DNR has authority over surface water appropriations (and some groundwater transfers- municipal, industrial, out of state, etc). NRDs have authority over ground water, and may monitor amounts pumped from individual wells as required by law. The focus for DNR testimony is on surface water.

Surface and ground water flow meters and monitoring required by LB 962 are in place. For surface water meters, this means in the Republican basin, but this does not include fully appropriated basins in the rest of the state or the part of the state not fully appropriated. (see map handout) For ground water flow meters, this means in the Republican and in all fully appropriated areas. Additional funding by the state for water metering (Natural Resources Cash Fund, LB 962) facilitated compliance with LB 962 requirements.

NDNR has had general regulatory authority to require evidence of actual surface water uses from the beginning of the appropriation system but has not always used flow meters to get this information, many times relying instead on the number of acres irrigated. Appropriations specify which lands may be irrigated and state a maximum amount which may be removed from the stream to do it. However, since the early 1900s, when called upon for water administration on a frequent basis, the Department has required metering devices on canals and large diversions. With the introduction of smaller surface water diversions through individual pumping facilities, measuring of such diversions was difficult until recent advancements in individual meters. Ron, you could state, "Technology has improved over the years and as budget has allowed, the Department has taken advantage of such advancements. Technology is now available to remotely monitor and record flows, but is not widely in use mostly because of monitary considerations.

Hydrographic data

Surface irrigation is unevenly used in Nebraska. It is generally more common in the west where irrigation began and irrigation projects are very large. The West has more canal gages and flumes for measurement, although individual pump projects exist all around the state. In the east, there are many smaller individual diversions and flow meters would be necessary to record amounts diverted. Increased use of "supplemental" wells in

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Deleted: Throughout its history, barring complaints from other appropriators, DNR regulation has generally focused on ensuring the specified location of the permitted acres for irrigation, and relied upon the rebuttable presumption that no more water shall be applied than good husbandry indicates so the quantity limit expressed in the appropriation will be adhered to. Measurement of water for irrigation at head gates of canal systems rather than at individual user diversions from a canal or stream has been the rule until the onset of modern concerns for full and over appropriation in some basins.

Deleted: Generally, technology in the field remains 1890's primitive and requires a person to gather and record the data.

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go to (2)

surface water-induced recharge in the area of the mound ~~might eventually~~ would increase the amount of mound water reaching the stream. ~~This would depend on future well development in the area of the mound.~~ However, this could ~~also~~ take a significant amount of time to cause any appreciable change, as the mound has formed over many decades and groundwater movement is generally very slow. ~~The most effective way to~~ increase the mound credit would be to limit pumping in the area of the mound and between the mound and the river. ~~Limiting pumping for~~ would be a faster way of

9. Surface Water

a. Is there any surface water still available to purchase in the Republican River Basin? If so, how much is there and who owes it?

There is no significant source of additional surface water in the basin. Existing water rights may be available for dry-year leasing on an occasional basis.

b. What are the effects on the Model when surface water is put in the stream instead of the canals and fields?

Recharge to the aquifer from canal seepage and surface water irrigation is a significant input of water to the model. When less water is used for surface water irrigation, there will be less recharge in the model. This has the potential to increase the model calculated impact to streamflow.