Why Watershed Management?

By Ted Tietjen

Nov 18, 2017

To: The Republican River Stakeholders
From Ted Tietjen

Why Watershed Management?

The Republican River Basin is trying to manage a basin that is suffering from the “Tragedy of The Commons”; where water demands exceed what’s available and to comply with the Republican River Compact. It appears the Republican River Compact Administration has come up with a plan that should keep NE in compliance for a number of years. Unfortunately, the compact does not address the challenges we face in the state of NE. If during the growing season we would normally receive 30 plus inches rain per year, there would be no reason to meet as the availability would exceed demand.

The Natural Resource Districts where approved in 1969 by the NE Legislature and then implemented in 1972. The 23 districts were designed to represent watersheds as much possible along county lines. Correlative Rights relating to ground water management are also put in place. “Share and share alike” is the standard that can be used to further the “Tragedy of the Commons” or to use it as a tool to help solve some the challenges in over appropriated watersheds.

At the last stakeholders meeting in Aug a proposal was made to conduct a 4 to 5 year research project on a small Hydrologic Unit Code (HUC 12) to analyze the value in using water balance as a management tool. The committee requested that more detailed information be provided and then report back to the group for further consideration. Some of the concepts and opportunities this research could help identify and quantify are listed in the following bullets.

- Over the long term, the total average annual water supply or less is a limit and could be managed for consumption at similar to native consumption rates
- Anticipated water consumption amount distributions, per field, can be managed through crop selection to maximize land productivity.
- Each landowner determines how much water to consume on each of their fields based on their long-term average annual water supply
- Both surface and groundwater irrigation would be protected to help recapture and retime the average annual water supply in its most effective manner
- Irrigation can be used to maintain the expected consumption on only a portion of the land adequate to maintain a consumption verses supply balance
- Irrigation helps produce maximum benefits and address the variability of high and low precipitation periods
- This concept offers the opportunity to bring the local hydrologic system back to a native historic balance where sustainable aquifers and working streams can coexist
- Based on the landowner’s specific production and conservation goals, any extra water conserved could either be further consumed by them or traded to other water interests

A HU12 located in Perkins County, NE was selected (number 10250006043) and comprises 33,459 acres. What is unique about this watershed is that it is an enclosed watershed. That means no water comes in or goes out of the watershed other than precipitation and a small amount of ground water flux at the boundary. This eliminated a lot of variables such as streams flowing in or out, large dams with a large surface water area and canals. Flood plains or riparian areas are not in the project either.

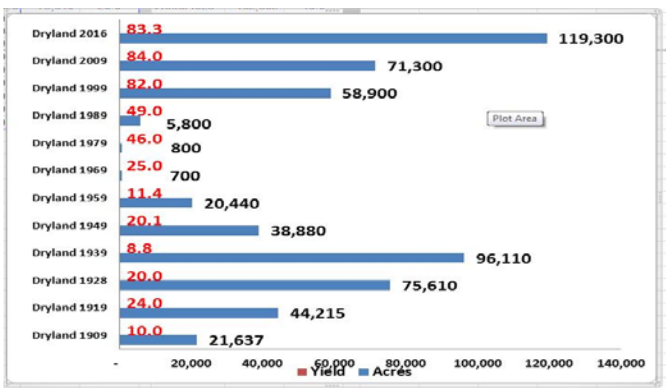
One of the challenges is that the underground aquifer does not follow the watershed. Since the aquifer water movement is very slow it isn't that hard to measure. This ground water flux could be assumed to be zero because it can operate in opposing directions in different parts of the boundary or it could be quantified with the model. The local NRD has enough information to measure it accurately so it should not present a problem.

One of the R & D objectives would be to identify recharge opportunities when the soil profile is already full and the area gets additional precipitation. Another opportunity would be when precipitation events exceed the water intake rate of the soil. These opportunities coupled with better residue management to reduce evaporation, elimination of undesirable vegetation and using cropping systems options to establish a baseline. Once the aquifer recharge baseline has been quantified and becomes measurable, ground water allocations and educational programs can be adjusted to meet the watersheds budgetary goals.

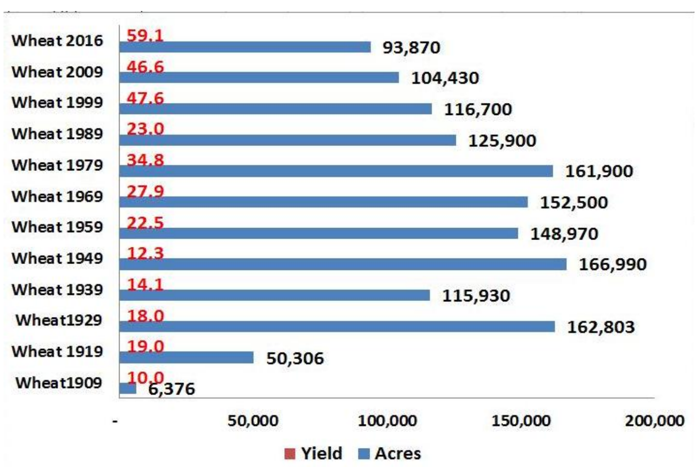
HUC 12 # 102500060403 in Perkins County, NE

As the data was being gathered for the presentation it became clear there was another strong factor influencing cropping systems that was driving water management was economics. It became very clear that economics was the factor and had a greater impact on what was happening and took precedence over everything else. Each grower's behavior also affected management strategies relating to their farming practices.

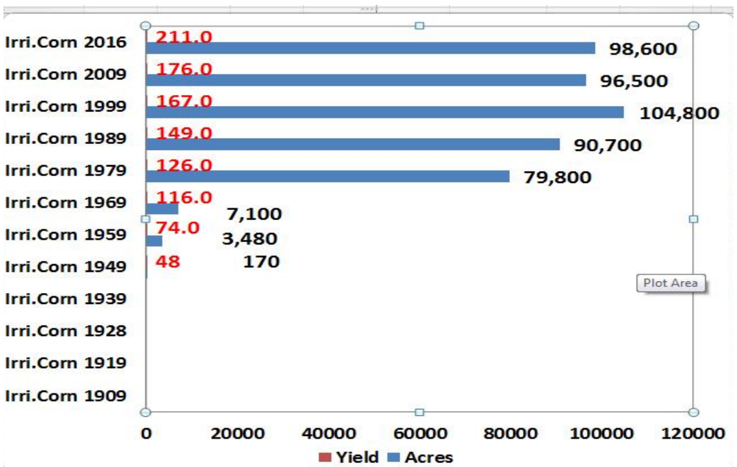
Before laying out the details for the HUC 12 in the R & D project it was decided to look at the cropping history in Perkins County from 1909 to 2016 for three crops, corn, wheat and soybeans. The information was derived from the NE Dept. of Ag Statistics



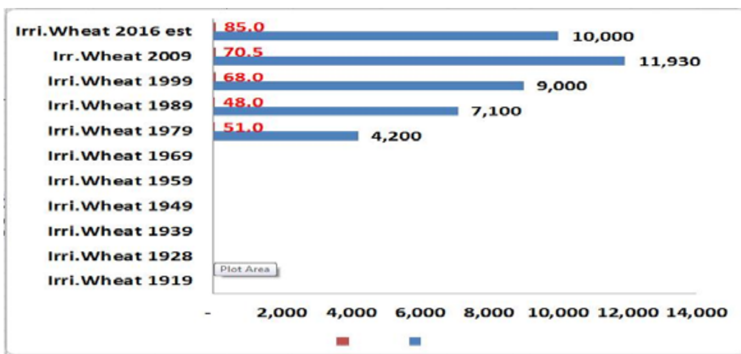
The bar graphs show how the corn cropping system changed. From 1909 to 1939 much of the corn was grown for the livestock. Then starting in the late forties summer fallowing before planting wheat became the norm and lasted until the early 90's when eco-fallow became more common. These eco-fallow acres were then planted to dryland corn rather than wheat as it produced more income due to higher yields and price. By 2016 Perkins County had more acres in dryland corn than wheat.



Wheat acres in 1909 were low because only 15% of the land had been broken out and the price was not attractive. By 1919 the acres jumped partly because of WWI and many more acres were being farmed. By 1928, 65 % of the acres in Perkins County were farmed and wheat became a major crop that surpassed the dryland corn acres. Summer fallow acres increased in the late 1940's as it increased yields and lasted till growers started using eco-fallow to save moisture and then switched to corn. New high yielding varieties came along in the 1990's and
Continued to increase, where 70 to 110Bu/A yields are not uncommon today.



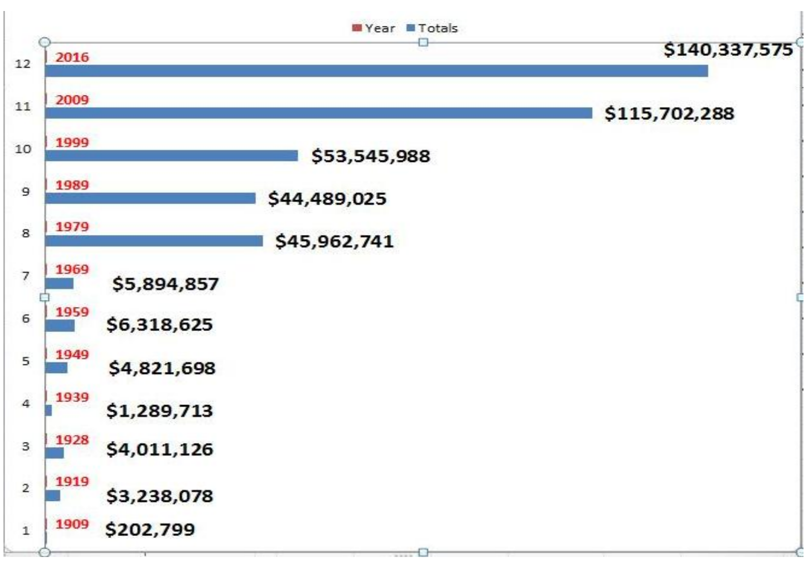
Irrigated corn acres came to the county in the 1950's with yields in the 75 to 80 Bu/A range. Center pivots became popular in the 1970's. At the same time hybrid corn varieties were increasing yields to 125 Bu/A. By **2016 the irrigate corn yields reached an average of 211 Bu/A. Irrigated corn acres kept increasing until a** moratorium on drilling irrigation wells was implemented in the 1970's.



Some growers started irrigating wheat in the 1970's as center pivots became more common. New high yield varieties are still being grown in the crop rotations where yields above 80 Bu/A are common.

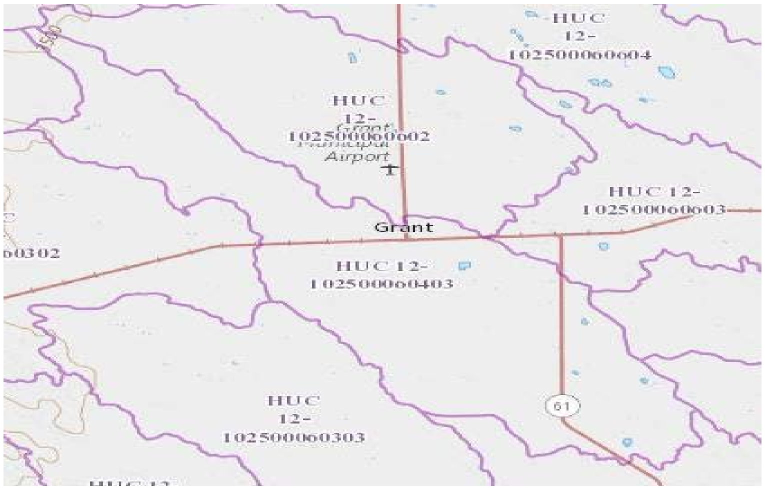
Soybean production under irrigation started

in the 1970's and has grown because it fit well into the crop rotation. Yields have also increased from 30 to 70 Bu/A making it an income producing crop as well.



One can easily see how yield and price increases changed the revenue stream and how they impacted the decision making process. In 1909 when only 15 % of the land was broken out of sod only produced $202,799. WWI prices encouraged farmers to plant more acres. Steam engines and other innovations helped growers to expand their farmable acres in a very short period of time. Revenue from wheat and corn increased 160 % or $3,238,078 by 1919. By 1928 65% of the land in Perkins County was being farmed and increase wealth by another $773,048.

Increased revenue did not really take off until center pivot irrigation development took place. By 1979 the revenue from corn and wheat increased to $45,962,741. In 2016 corn, wheat and soybeans had a cash value of $140,337,575. We did not include other crops and livestock as the data was not available. It is not hard to see why economics is the driver and how we manage our resources.



We need to explain how USGS's Hydrologic Unit Code (HUC) 12, **#102500060403** units came about:
The numbers designate the following:
First two digits: **10** is in the Missouri River Basin
The Next two digits are: **1025**: designates the Republican River Basin
The next 4 digits are: **10250006**: Designates the Stinking Water.
The next 4 digits are: # **102500060403** and is the HUC 12 recommended for the project.

How was the data collected?

Both USGS: https://water.usgs.gov/GIS/huc/html or https://viewer.nationalmap.govadvanced-viewer and NRCS websites: https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx were used in the data gathering process.

Actual NRCS map with acres and crops grown in 2017 in **Section 11 & 12-10-38,** which includes part of **Grant**.

The watershed boundary is color coded in **Red.**
Irrigated land is **Yellow.**
Dry land is **Gray.**
Buildings and waste land is **Orange**

Acres of each crop grown in the HUC 12 in 2017 are as follows:

Irrigated crop acres

Corn	Wheat	Soybeans	Pinto’s	Sudan	Irrigated Acres
6555	292	2592	393	195	10.027

Rain fed acres

Corn	Wheat	soybeans	sunflowers	Milo	Sudan	J Millet	Millet	Fallow	Rain fed Acres
7261	2608	98	207	186	913	530	262	3410	15,475

Pasture, buildings, roads and wasteland acres

Pasture	Grass	CRP	Shelter belts	Buildings/City	Roads/waste	Other Acres
5181	452	135	127	572	1629	7,957

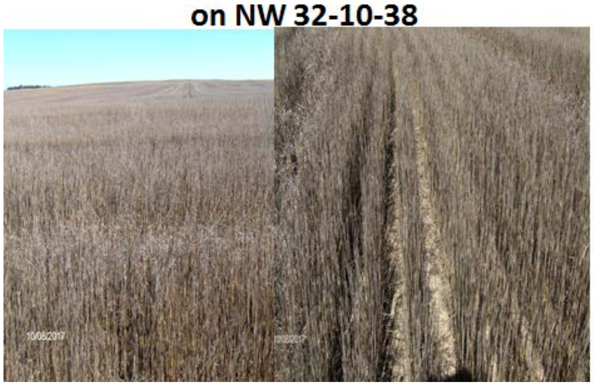
The acres in the HUC 12 watershed are: **Total Acres 33,459**

What did the crops look like?

Irrigated Corn 1n 2017
on E ½ 18-10-38

Irrigated Soybeans in 2017
on NE 19-10-38

Stripper Head Wheat Stubble in 2017
on NW 32-10-38

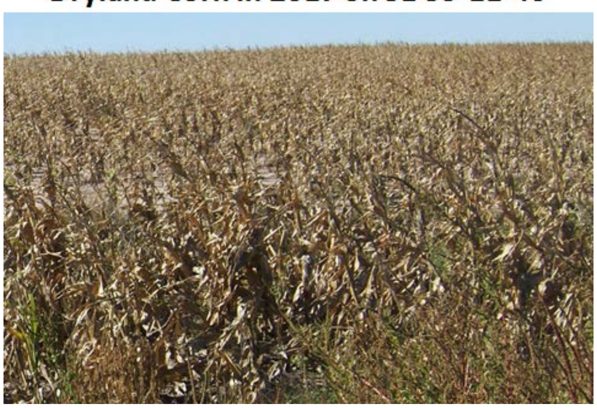


Tilled Dryland Summer Fallow in 2017
on NW 5-10-39

Chemical Fallow in 2017 on 14-11-40

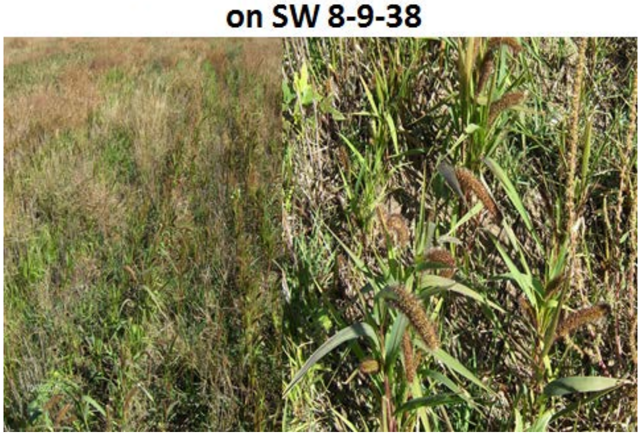
Dryland Corn planted in Wheat stubble in 2017 on SW-5-10-39

Dryland Corn in 2017 on SE 35-11-40



Dryland Sunflowers in 2017 on SE-25-11-40

Dryland Japanese Millet in 2017 on SW 8-9-38



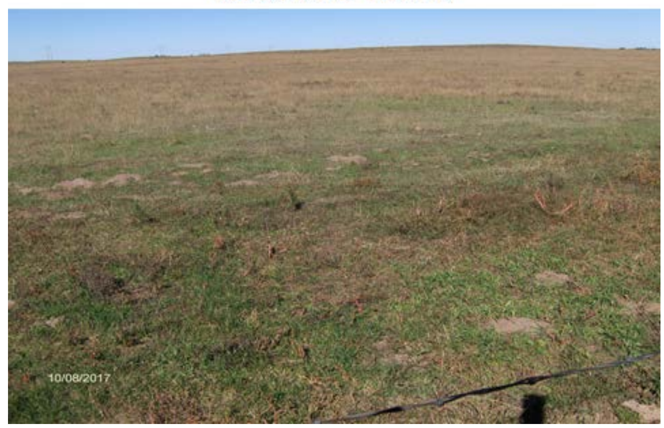
Dryland Sorghum Sudan 1n 2017 on NE-6-10-39

Dryland Sudan Bailed & planted to Wheat in 2017 on SE 25-9-39

Bailed Sudan in 2017 on SEC 36-11-40

Irrigated Sudan after wheat in 2017 on NW 12-9-39

Native Dryland Pasture in 2017 on SW 36-10-39



CRP Field in 2017 on SE 30-11-39

Center Pivot Corners in 2017 including CRP and Shelter Belts

Some observations

The soil moisture conditions in the fall of 2016 where very dry to a depth of five feet. Precipitation during the off season was very low and going into the spring the soil was still very dry prior to planting. The fields that were probed only had moisture to less than a foot. The April rains filled the soil from 3 ½ ft. to 4 ½ ft. depending on the WHC. Corn planted on soils with little residue ran out of moisture before the late July and early Aug rains came had a devastating effect on the yield potential. The September rains filled the soil profile. So we are starting with the soil profile that is full before off season precipitation. That means precipitation received during the off season will help recharge the aquifer provided it doesn't run off.

Fields that had the residue baled in 2016 and then planted to corn in 2017 had yields in the range of 20 to 40 Bu/A. Fields that had been corn in 2016 and then planted back to corn yielded in the 60-to 80 Bu range. Fields that were in wheat in 2016 and planted to corn yielded from 110 to 140 Bu/A.

Most of the fields that were summer fallowed in 2017 were tilled as chemical resistant weeds became such a problem.

What was learned?

Each field in the watershed showed that consumptive water use was quite different with each grower as their cropping systems management had different objectives. The previous year's residue management also played a major role in the following year's production, especially on dryland. Implementing watershed management will require getting a better understanding of why growers make the decisions they do. Real time data from an adequate weather station network, satellite consumptive water use, residue measurement, good information on soil texture and water holding capacity (WHC) in the top five feet and cropping plans that include Growing Degree Days (GDD) will be useful. The information can then be used in developing advanced watershed management strategies.

The first year would be used to develop a base line. In the second year, the project would start to implement what was learned. The third and fourth year would be used to measure the results. Hopefully the information could then be transferred to larger sub-basins. Sub-basins that have riparian areas with undesirable vegetation, dams and streams flowing in and out plus canal systems will require additional management strategies to maximize the beneficial use of water.

What are some of the benefits of watershed management?

There is enough data already to encourage better residue management; cutting three foot trenches in flat terraces and putting wood chips in them for aquifer recharge are already proven. The same concept works for storm water drainage systems and lagoons in fields. Unfortunately, some of the lagoon areas in farm fields may be classified as a wetland and the penalties for modification are very high.

Storm water study in Grant between the Railroad tracks and Highway in 2010

The proposed management model would embrace the concept that each landowner should quantify consumed water on his land, like native consumption, based on the average annual precipitation supply. Over time this concept could bring the hydrologic system back to a natural balance where sustainable aquifers and working streams can coexist. Both surface and groundwater irrigation would be protected to help retime the available water supply to maintain the expected consumption on portions of the property for maximum benefit and address the variability of high and low precipitation periods.

The consumptive use template used here came from earlier work by Frank Kwapnioski. The process demonstrated is currently workable but the consumption data and other assumptions will need better quantification that can be produced by and verified with this proposed research project.

Attached are two consumptive use tables showing water consumption in the HUC 12 with and without residue management. The 3.50-inch credit is based on information from an August 23, 2017 NE Farmer article, "Crop Residue Helps Prevent Unnecessary Water Losses" by Tyler Harris, where he quotes Steve Melvin on UNL research. The third sample of consumptive use is from the LT Farm on the E ½ 18-10-38 Acres, which includes each crop grown in 2017 and the defined 3.50-inch residue credit:

12-Nov-17			HUC 12 crops 2017			
Average Rainfall 2017	20.84	Inches	Precipitation in 2017			
Used LT Farm rain gauge	0	Residue benefit				
HUC 12, #102500060403	20.84					Growing
		Inches	Inches		Growing	Season
CROP	Acres	Consumption	Depletion	Acre/Inches	Season	Precip
Irrigated Corn (95 Rmor GDD)	0	23.2	-4.4	0	April - Sept.	16.5
Irrigated Corn (100 RM or GDD)	0	24.4	-5.6	0	April - Sept.	16.5
Irrigated Corn (105 RM or GDD)	0	25.6	-6.8	0	April - Sept.	16.5
Irrigated Corn (110 RM or GDD)	6555	26.8	-8.0	-52,728	April - Sept.	16.5
Irrigated Corn (115 RM or GDD)	0	28.0	-9.2	0	April - Sept.	16.5
Irr. Sugar Beets ("x" ton/ac)	0	32.7	-13.9	0	April - Sept.	16.5
Irr. Soybeans (50 bu/ac)	0	23.0	-4.2	0	May - Sept.	14.3
Irr. Soybeans (60 bu/ac)	2592	24.0	-5.2	-13,592	May - Sept.	14.3
Irr. Soybeans (70 bu/ac)	0	25.8	-7.0	0	May - Sept.	14.3
Irr. Sorghum ("x" bu/ac)	195	23.0	-4.2	-828	May - Sept.	14.3
Irr. Dry Edible Beans ("x" lbs/ac)	393	22.0	-3.2	-1,275		
Irr. Potatoes ("x" tons/ac)	0	29.0	-10.2			
Irrigated Alfalfa ("x" tons/ac)	0	40.6	-21.8	0		
Irr. Sunflowers ("x" lbs/ac)	0	23.5	-4.7			
Irrigated Wheat ("x" bu/ac)	293	26.6	-7.8	-2,298	August - June	9.4
Irr. Small Grains (other)	0	26.6	-7.8	0		
Dryland Corn (100 bu/ac)	7261	17.8	1.0	6,942	April - Sept.	16.5
Dryland Soybeans (45 bu/ac)	98	16.7	2.1	201	May - Sept.	14.3
Dryland Milo, Sudan & J Millet	1629	17.6	1.2	1,883	April - Sept.	16.5
Wheat/Corn/Soybean/Wheat	0	17.5	1.3	0		
Dryland Edible Beans	0	11.4	7.3	0	May - Sept.	14.3
Dryland Alfalfa	0	19.2	-0.4	0	March - Nov.	18.4
Dryland Wheat	2608	5.7	13.1	34,144	August - June	9.4
Summer Fallow Wheat	3410	15.6	3.2	10,762	August - June	9.4
Summer Fallow Wheat/Corn	0	7.8	10.9	0		
Dryland Small Grains (Oats/Millet	262	18.0	0.8	198		
Conservation Reserve(CRP)	135	21.1	-2.3			
Other AG. Lands, Sunflowers	207	16.6	2.2	446		
Range, Pasture, Grasses	5633	16.2	2.6	14,601	March - Oct.	18.0
Riparian Forest & Woodlands	127	47.0	-28.2	-3,587	March - Oct.	18.0
Wetlands	0	57.0	-38.2	0	Feb. - Oct.	18.0
Open Water	0	48.0	-29.2	0	Precipitation use is based	
Waste Land		19.0	-0.2		on no runoff	
Buildings & Building Sites	572	16.6	2.2	1,233	Representative Equivalent Net	
Urban Land & towns	0	19.7	-0.9	0	-4262	Acre inches
Rural Roads (Unsurfaced)	1490	19.0	-0.2	-364	-355	Acre feet
Totals	33,460			-4262		

12-Nov-17			**HUC 12 crops 2017 # 102500060403**			
Average Rainfall 2017	**20.84**	Inches	**Precipitation in 2017**			
Used LT Farm Rain Gauge	**3.50**	Residue benefit	**Based on WCR&E data**			
HUC 12, #102500060403	**24.34**					**Growing**
		Inches	**Inches**		**Growing**	**Season**
CROP	**Acres**	**Consumption**	**Depletion**	**Acre/Inches**	**Season**	**Precip**
Irrigated Corn (95 RM or GDD)	0	23.2	-1.3	0	April - Sept.	16.5
Irrigted Corn (100 RM or GDD)	0	24.4	-2.5	0	April - Sept.	16.5
Irrigated Corn (105 RM or GDD)	0	25.6	-3.7	0	April - Sept.	16.5
Irrigated Corn (110 RM or GDD)	6555	26.8	-4.9	**-32,080**	April - Sept.	16.5
Irrigated Corn (115 RM or GDD)	0	28.0	-6.1	0	April - Sept.	16.5
Irr. Sugar Beets ("x" ton/ac)	0	32.7	-10.8	0	April - Sept.	16.5
Irr. Soybeans (50 bu/ac)	0	23.0	-1.1	0	May - Sept.	14.3
Irr. Soybeans (60 bu/ac)	2592	24.0	-2.1	**-5,428**	May - Sept.	14.3
Irr. Soybeans (70 bu/ac)	0	25.8	-3.9	0	May - Sept.	14.3
Irr. Sorghum ("x" bu/ac)	195	23.0	-1.1	**-213**	May - Sept.	14.3
Irr. Dry Edible Beans ("x" lbs/ac)	393	22.0	-0.1	**-37**		
Irr. Potatoes ("x" tons/ac)	0	29.0	-7.1			
Irrigated Alfalfa ("x" tons/ac)	0	40.6	-18.7	0		
Irr. Sunflowers ("x" lbs/ac)	0	23.5	-1.6			
Irrigated Wheat ("x" bu/ac)	293	26.6	-4.7	**-1,375**	August - June	9.4
Irr. Small Grains (other)	0	26.6	-4.7	0		
Dryland Corn (100 bu/ac)	7261	17.8	4.1	**29,814**	April - Sept.	16.5
Dryland Soybeans (45 bu/ac)	98	16.7	5.2	**510**	May - Sept.	14.3
Dryland Milo, Sudan & J Millet	1629	17.6	4.3	**7,014**	April - Sept.	16.5
Wheat/Corn/Soybean/Wheat	0	17.5	4.4	0		
Dryland Edible Beans	0	11.4	10.5	0	May - Sept.	14.3
Dryland Alfalfa	0	19.2	2.7	0	March - Nov.	18.4
Dryland Wheat	2608	5.7	16.2	**42,359**	August - June	9.4
Summer Fallow Wheat	3410	15.6	6.3	**21,503**	August - June	9.4
Summer Fallow Wheat/Corn	0	7.8	14.1	0		
Dryland Small Grains (Oats/Millet	262	18.0	3.9	**1,023**		
Conservation Reserve(CRP)	135	21.1	-2.3	**-316**		
Other AG. Lands, Sunflowers	207	16.6	5.3	**1,098**		
Range, Pasture, Grasses	5633	16.2	2.6	**14,601**	March - Oct.	18.0
Riparian Forest & Woodlands	127	47.0	-28.2	**-3,587**	March - Oct.	18.0
Wetlands	0	57.0	-38.2	0	Feb. - Oct.	18.0
Open Water	0	48.0	-29.2	0	**Preciptation use is based**	
Waste Land		19.0	-0.2		**on no runoff**	
Buildings & Building Sites	572	16.6	2.2	**1,233**	**Representative**	**Equivalent Net**
Urban Land & towns	0	19.7	-0.9	0	75756	**Acre inches**
Rural Roads (Unsurfaced)	1490	19.0	-0.2	**-364**	6313	**Acre feet**
Totals	**33,460**			**75,756**		

Revised 11-12-17		**LT Farms 2017 crop year**			Field #: **18-1 through 18-5**	
LT Farm weather station		20.84	**rainfall for 2017**			
Residue Management credit		3.5	Residue benefit, **Based on WCR&E data**			
		24.3				**Growing**
		Inches	**Inches**		**Growing**	**Season**
CROP	**Acres**	**Consumption**	**Depletion**	**Acre/Inches**	**Season**	**Precip**
Irrigated Corn (95 RM)	-	23.2	-1.3	0	April - Sept.	16.5
Irrigated Corn (100 RM)		24.4	-2.5	0	April - Sept.	16.5
Irrigated Corn (105 RM)	-	25.6	-3.7	0	April - Sept.	16.5
Irrigated Corn (110 RM)	**120**	26.8	-4.9	**-589**	April - Sept.	16.5
Irrigated Corn (115 RM)		28.0	-6.1	0	April - Sept.	16.5
Irr. Sugar Beets ("x" ton/ac)	-	32.7	-10.8	0	April - Sept.	16.5
Irr. Soybeans (50 bu/ac)	-	23.0	-1.1	0	May - Sept.	14.3
Irr. Soybeans (60 bu/ac)	-	24.0	-2.1	0	May - Sept.	14.3
Irr. Soybeans (70 bu/ac)	-	25.8	-3.9	0	May - Sept.	14.3
Irr. Sorghum ("x" bu/ac)	-	23.0	-1.1	0	May - Sept.	14.3
Irr. Dry Edible Beans ("x" lbs/ac)	-	22.0	-0.1	0		
Irr. Potatoes ("x" tons/ac)	-	29.0	-7.1	0		
Irrigated Alfalfa ("x" tons/ac)	-	40.6	-18.7	0		
Irr. Sunflowers ("x" lbs/ac)	-	23.5	-1.6	0		
Irrigated Wheat ("x" bu/ac)	-	26.6	-4.7	0	August - June	7.6
Irr. Small Grains (Millet/Oats)	-	26.6	-4.7	0		
Dryland Corn (100 bu/ac)	-	17.8	4.1	**0**	April - Sept.	16.5
Dryland Soybeans (45 bu/ac)	-	16.7	5.2	0	May - Sept.	14.3
Dryland Sorghum	-	17.6	4.3	0	April - Sept.	16.5
Dryland Sunflowers	-	17.5	4.4	0	April - Sept.	16.5
Dryland Edible Beans	-	11.4	10.5	0	May - Sept.	14.3
Dryland Alfalfa	-	19.2	2.7	0	March - Nov.	18.0
Dryland Wheat	-	4.5	17.4	0	August - June	7.6
Summer Fallow Wheat	-	15.6	6.3	0	August - June	7.6
Summer Fallow	**81**	7.4	14.5	**1,171**		
Dryland Small Grains (Millet/Oats	-	18.0	3.9	0		
Conservation Reserve(CRP)	-	21.1	0.8	0		
Other Ag Land	-	16.6	5.3	0		
Range, Pasture, Grasses	-	16.2	5.7	0	March - Oct.	18.0
Riparian Forest & Woodlands	-	47.0	-25.1	0	March - Oct.	18.0
Wetlands	-	57.0	-35.1	0	Feb. - Oct.	18.0
Open Water	-	48.0	-26.1	0	**Precipitation used based**	
Waste Land	3	19.0	2.9	**9**	**on no run off**	
Buildings & Building Sites	5	16.6	5.3	**27**	**Representative**	**Equivalent Net**
Urban Land & towns	-	19.7	2.2	0	**617**	**Acre inches**
Rural Roads (Unsurfaced)	-	19.0	2.9	0	**51**	**Acre feet**
Totals	**209**			**617**		

The first two spreadsheets above demonstrate how this concept can be applied to quantify the 2017 watershed precipitation verses consumption balance both without and with residue management. The remaining spreadsheet represents how the concept can be used to quantify precipitation verses consumption balance on an individual producer basis with adequate residue retention.

These examples apparently indicated that 2017 levels of irrigation could be sustainably implemented in this area with 2017 levels of precipitation, proper cropping and land use management. The total 2017 precipitation was about 58 KAF and the balance remainder for the watershed with total residue management is equal to 6.3 KAF or about 11% of surplus. A slightly larger remainder value of about 14% is calculated for the individual landowner example. However, all the values and assumption used in the above examples are based on current best understandings that should be further developed, improved and verified through this project.

This proposed management model provides tools (tables) so that each landowner can quantify the water consumed on their land based on their cropping patterns and their average annual precipitation supply. Sustainable aquifers and working streams would be possible based on approximating a native hydrologic system. Both surface and groundwater irrigation will be protected to help retime the available water supply and maintain the expected consumption on sustainable portions of the property for maximum benefit and also to address the variability of high and low precipitation periods.

I ask that the Republican River Stakeholders give serious consideration to this project and that it be approved. The next step would be to identify the base line in a watershed and then develop budgets to meet the desired goals and objectives. These goals and objectives would be developed in cooperation and input from the local NRD's, NE Department of Natural Resources, UNL and other interested parties.

Thank you for consideration.