Upper Solomon River Subbasin

2007 Field Analysis Summary

Subbasin Water Resource Management Program

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I. Introduction

The Solomon River Basin is divided into three sections: Upper Forks, Lower Forks and Mainstem. This field summary will cover the Upper Forks section. The Upper Forks include both a North and South stem of the river. The Upper North Fork begins in Thomas County and continues through Sheridan, Decatur and Norton counties. It flows into Kirwin Reservoir in Phillips County. Bow Creek is a tributary to the North Fork and eventually flows into Kirwin Reservoir also. The Upper South Fork headwaters are in Sherman County. It travels west to east through Thomas, Sheridan, Graham and Rooks Counties where it enters Webster Reservoir.

The Upper North Fork, Upper South Fork and Bow Creek headwaters all originate in the Northwest Kansas Groundwater Management District #4 (GMD 4). GMD 4 was formed on March 1, 1976 pursuant to the Groundwater Management District Act. More information about GMD 4 is available at their website, www.gmd4.org.

As mentioned above, Webster and Kirwin Reservoirs separate the upper forks from the lower forks. Both were constructed and are operated by the U.S. Department of the Interior, Bureau of Reclamation. Kirwin on the north fork was completed in 1955 while Webster on the south fork was finished in 1956. The reservoirs provide flood control and irrigation storage for the area.

The upper forks of the Solomon River flow mainly through the High Plains physiographic region. The topography is characterized by flat to gently rolling hills with narrow, shallow valleys. Sand, gravel and porous rock, called mortar bed, cover the region. The Smoky Hills physiographic region begins in Rooks County and continues eastward. The western edge of the Smoky Hills is characterized by steep chalk bluffs that can be found south of the Solomon River.

Figure 1 is a map of the entire Solomon basin.

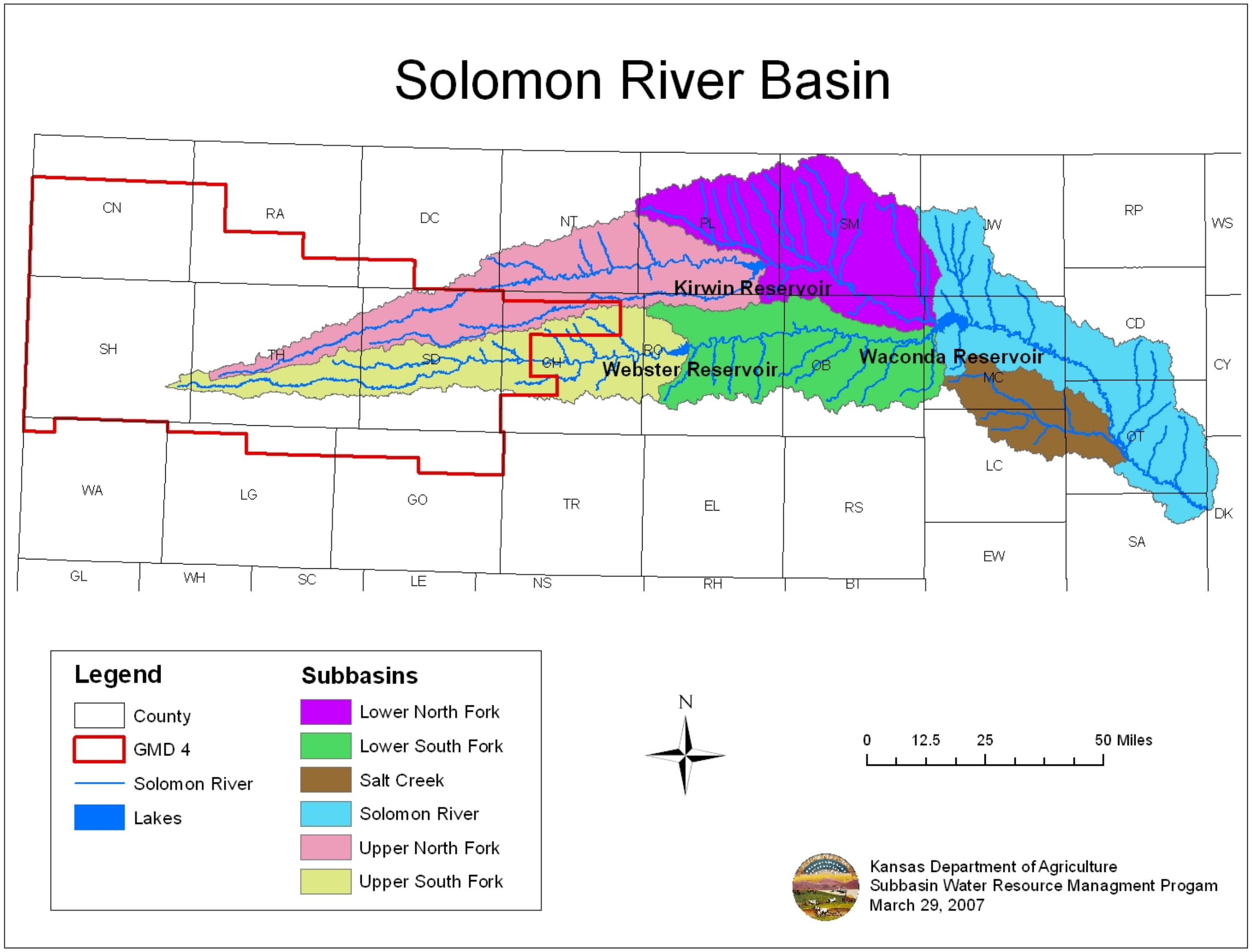

Figure 1: Solomon River Basin divided into subbasins

II. Precipitation

Precipitation in the Upper Solomon subbasin averages 21.29 inches (in.) since 1939. Figure 2 shows the annual variation in precipitation. Both precipitation charts are derived from various National Climatic Data Center (NCDC) stations including Studley in Sheridan County, Densmore in Norton County, Lenora in Norton County, Norton in Norton County, Rexford in Thomas County, Damar in Rooks County, Hill City in Graham County, Hoxie in Sheridan County, Logan in Phillips County and Mingo in Thomas County. The data is downloaded then averaged to create the following charts. The highest precipitation totals occurred in 1993 with 33.31 in. and the lowest in 2002 with 10.97 in. Annual precipitation data for these NCDC stations is currently available through 2006.

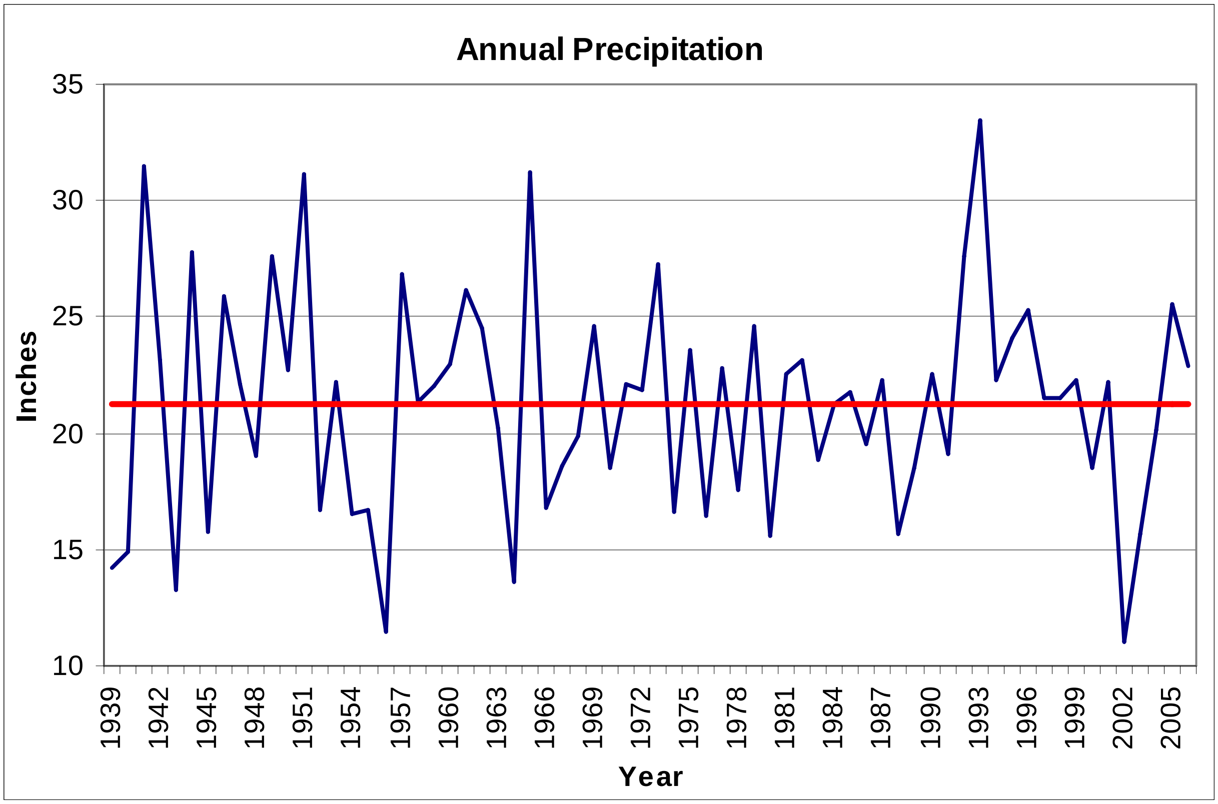

Figure 2: Upper Solomon Subbasin precipitation 1939-2006

Figure 3 shows precipitation measurements for January, 2007 to October, 2007. November and December data are not currently available. With these measurements the subbasin experienced a total of 17.72 in. of precipitation during the first 10 months in 2007. July had the most precipitation with 2.99 in. and February had the least with 0.28 in.

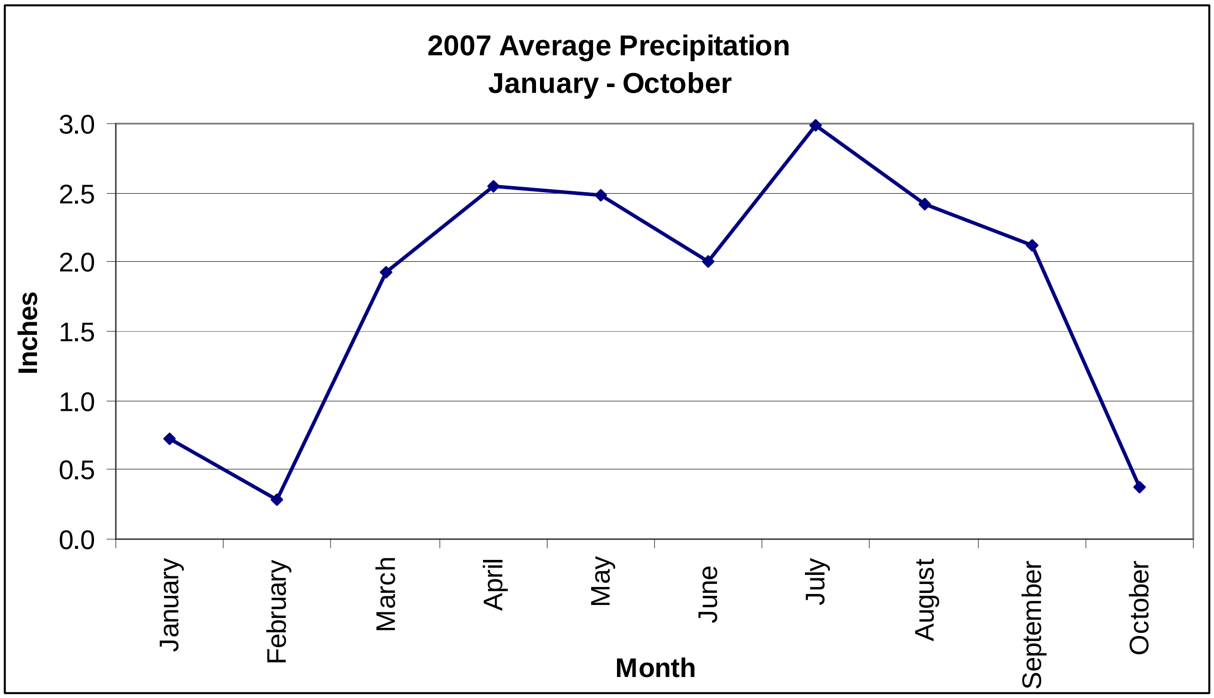

Figure 3: 2007 Monthly Average Precipitation (November and December data not available)

III. Surface Water

The Upper Solomon subbasin has three United States Geological Survey (USGS) streamflow gages. The Upper North Fork has a gage at Glade. It has been in operation since October 1, 1952. The Stockton gage is on Bow Creek which is a tributary to the North Fork Solomon River. It has been in service since November 20, 1950. The third gage is above Webster Reservoir on the Upper South Fork. It has been in operation the longest beginning January 8, 1945 (Figure 4).

The average flows over the period of record at these three gages were 25.26 cfs at Glade, 14.33 cfs at Bow Creek, and 49.49 cfs above Webster. During most of the 1990s, streamflow maintained higher levels at these gages, averaging 38.63 cfs at Glade, 16.84 cfs at Bow Creek and 55.30 cfs above Webster. Significantly reduced flows occurred in the 2000s, averaging 5.91 cfs at Glade, 4.6 cfs at Bow Creek, and 11.26 cfs above Webster (Figure 5). Flows started off strong for 2007, but faded as the year went on (Figure 6). Western Kansas had a significant snowstorm during the winter of 2007. This provided substantial runoff during late-February through early-March.

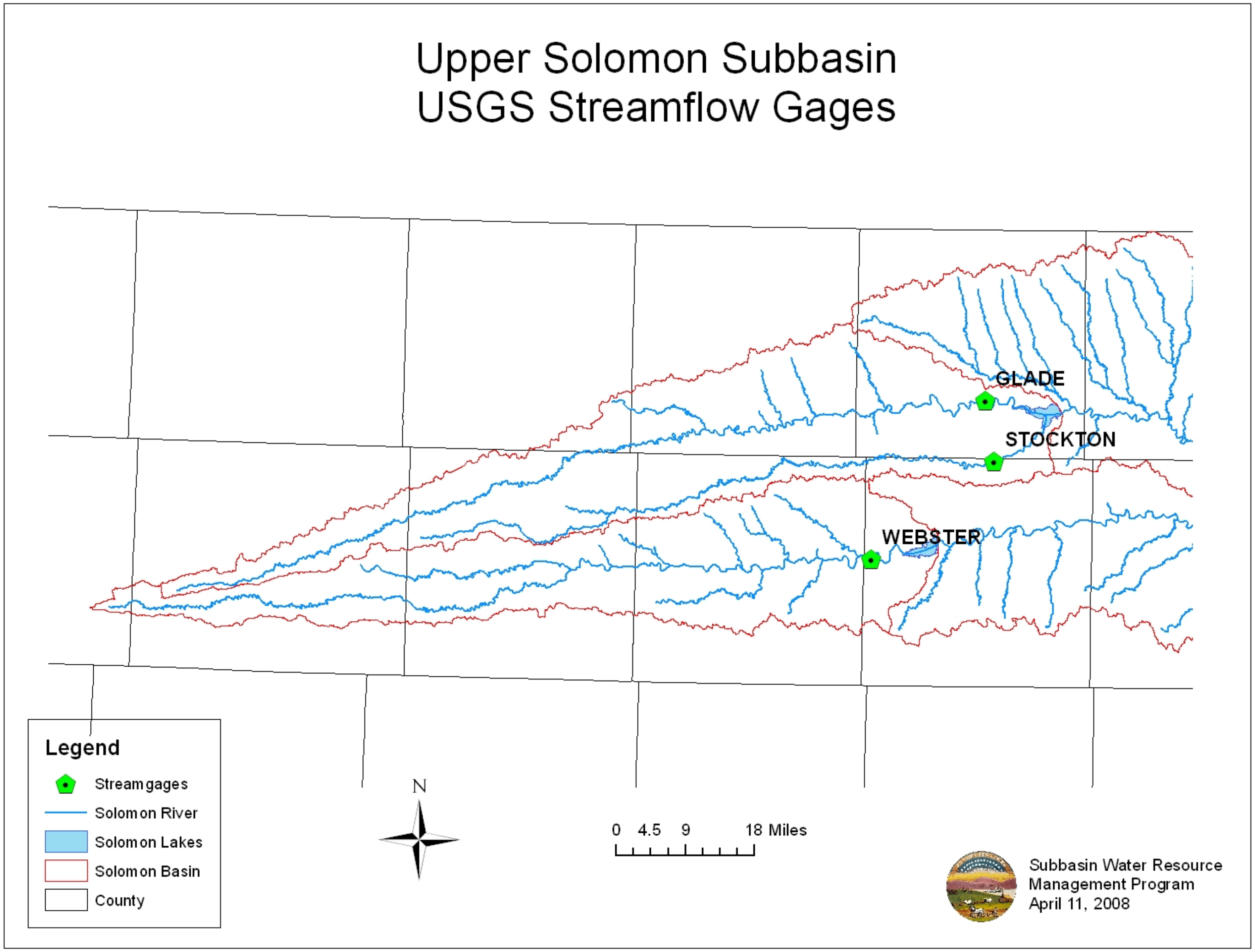

Figure 4: Upper Solomon Subbasin USGS Streamflow Gages

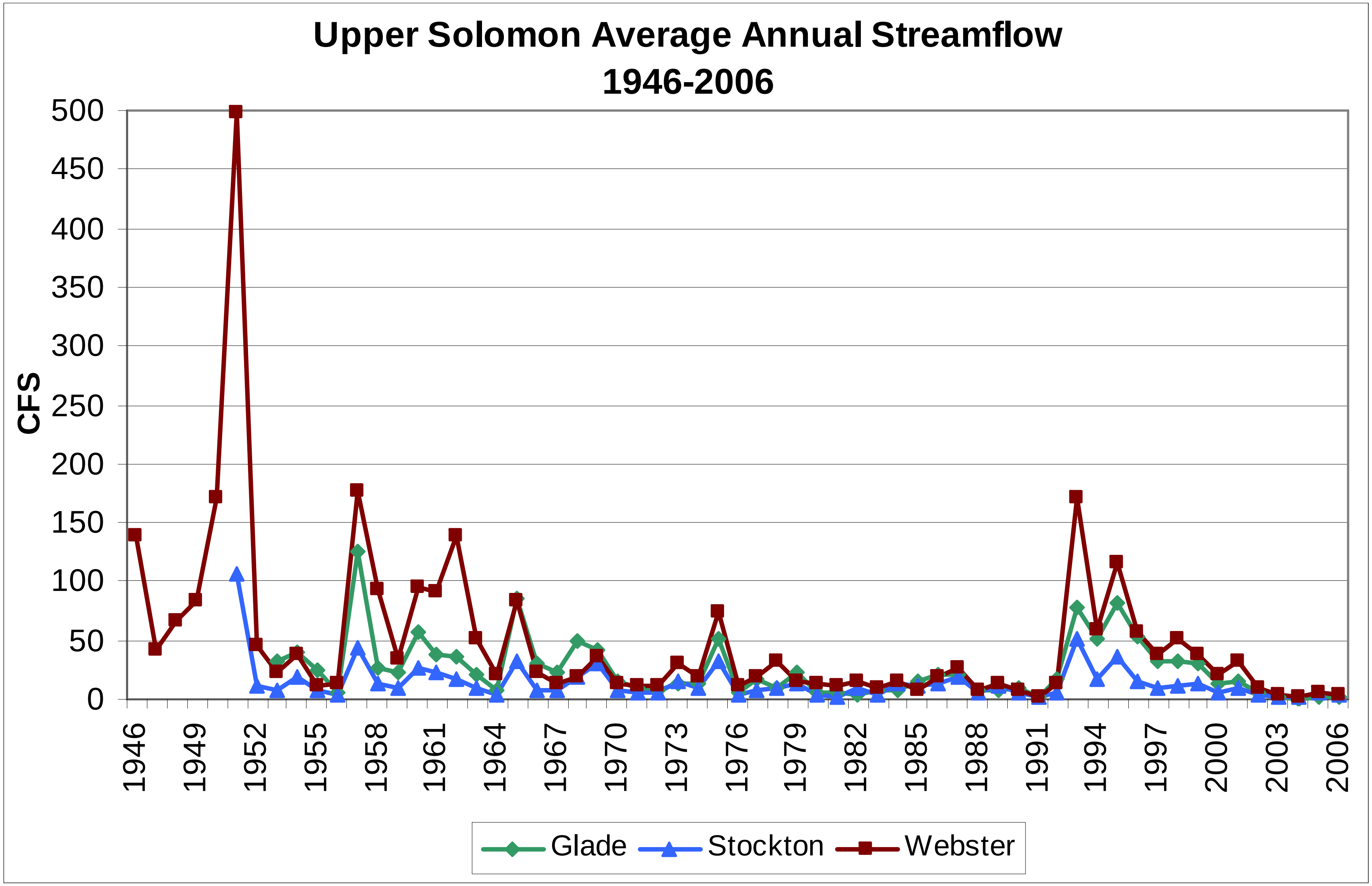

Figure 5: Average Annual Streamflow, 1946-2006

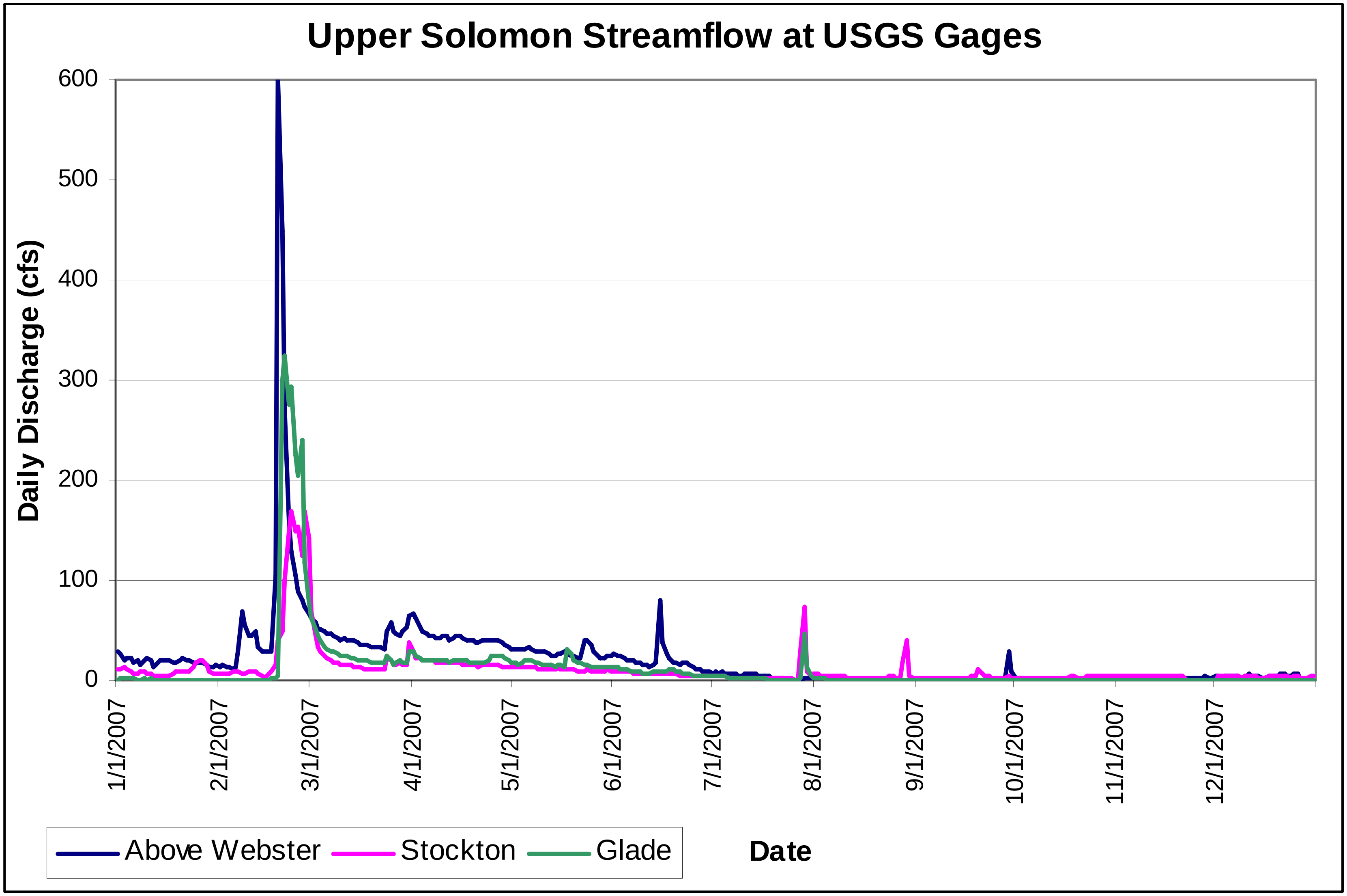

Figure 6: Daily Streamflow for 2007

IV. Groundwater

The upper reaches of the Upper North and South Forks of the Solomon River subbasin are situated over the Ogallala portion of the High Plains Aquifer (Figure 7). The Kansas Geological Survey (KGS) and the Kansas Department of Agriculture's Division of Water Resources (KDA-DWR) cooperatively measures groundwater levels in the Upper North and South Forks of the Solomon River subbasin annually. There are additional wells monitored through the Subbasin Water Resource Management Program (SWRMP). There are a total of 110 monitoring wells used for these measurements. The monitoring wells were drilled in two aquifer systems, the Ogallala-High Plains and the alluvial aquifers, and are plotted separately on the hydrologic charts (Figure 8 through Figure 19). The wells are monitored on a tri-annual basis in the winter, spring and fall. Only the winter measurements (December, January and February) are used for this analysis because those are considered to be the least affected by groundwater pumping. The following figures chart groundwater levels in all the monitoring wells (legal descriptions are available in the appendix) and also the five-year rolling averages. The y-axis is labeled as depth below land surface (DBLS) measured in feet.

Several of the monitoring wells have been measured since the early to mid-1960s. In the 1980s a number of wells were added to the monitoring network as well as when the SWRMP started in the basin in 2000. Ongoing observation of water levels is critical to understanding the fluctuations that may occur over time. Historical records can provide a hydrologic outlook on the long-term sustainability or decline of an area.

Groundwater levels in the Ogallala-High Plains can be affected by climatic conditions and well pumping. After the irrigation season, water levels tend to recover rapidly, but may take up to six months or more to fully recover to static water level conditions. During drought conditions water levels may not fully recover before the next irrigation season begins. Positive long-term trends in water levels generally occur where recharge exceeds withdrawals from the aquifer. Declining trends in alluvial aquifer water levels may be a result of reduced discharge to streams from the Ogallala-High Plains aquifer as groundwater levels decline in this aquifer system.

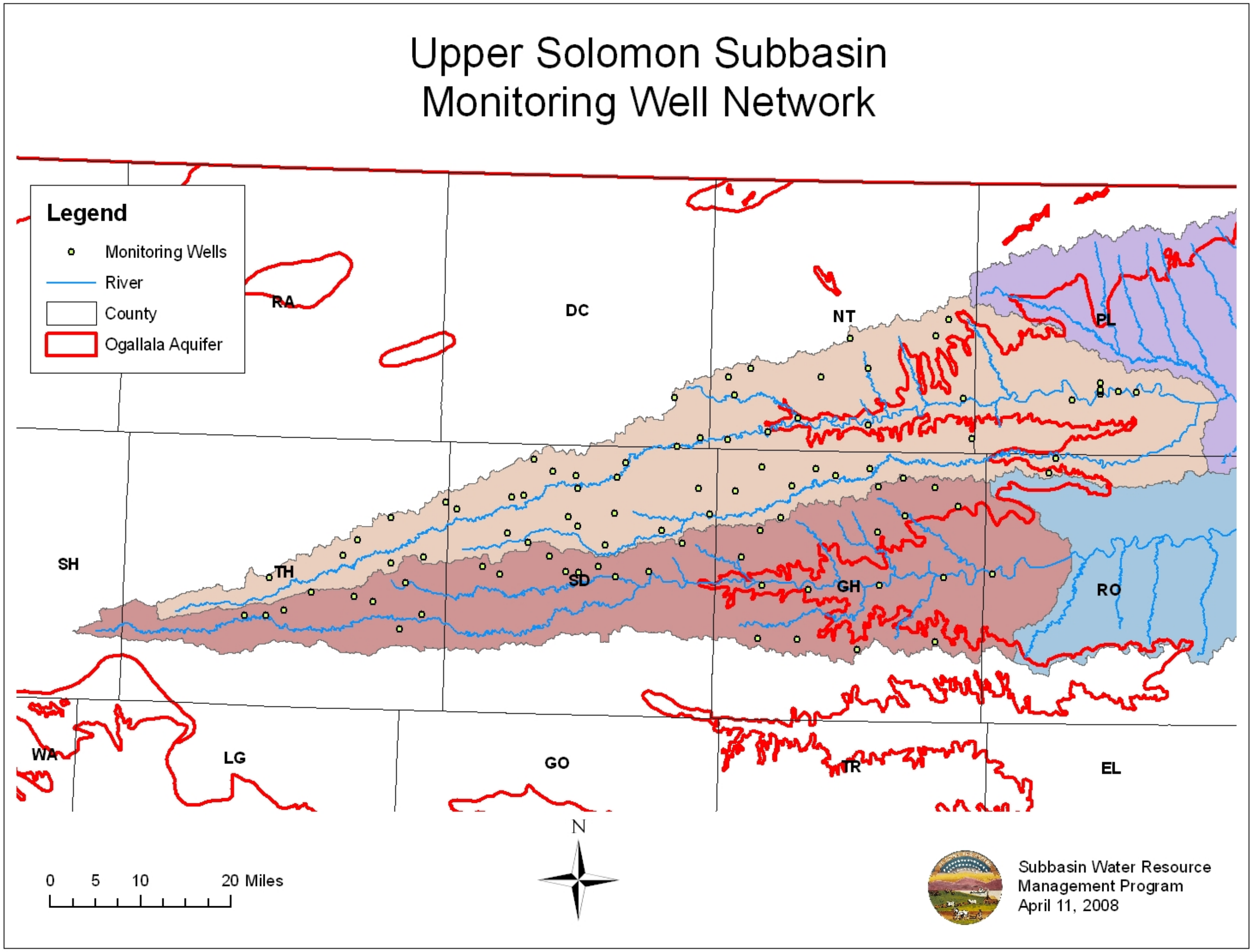

Figure 7: Upper Solomon Subbasin Monitoring Wells

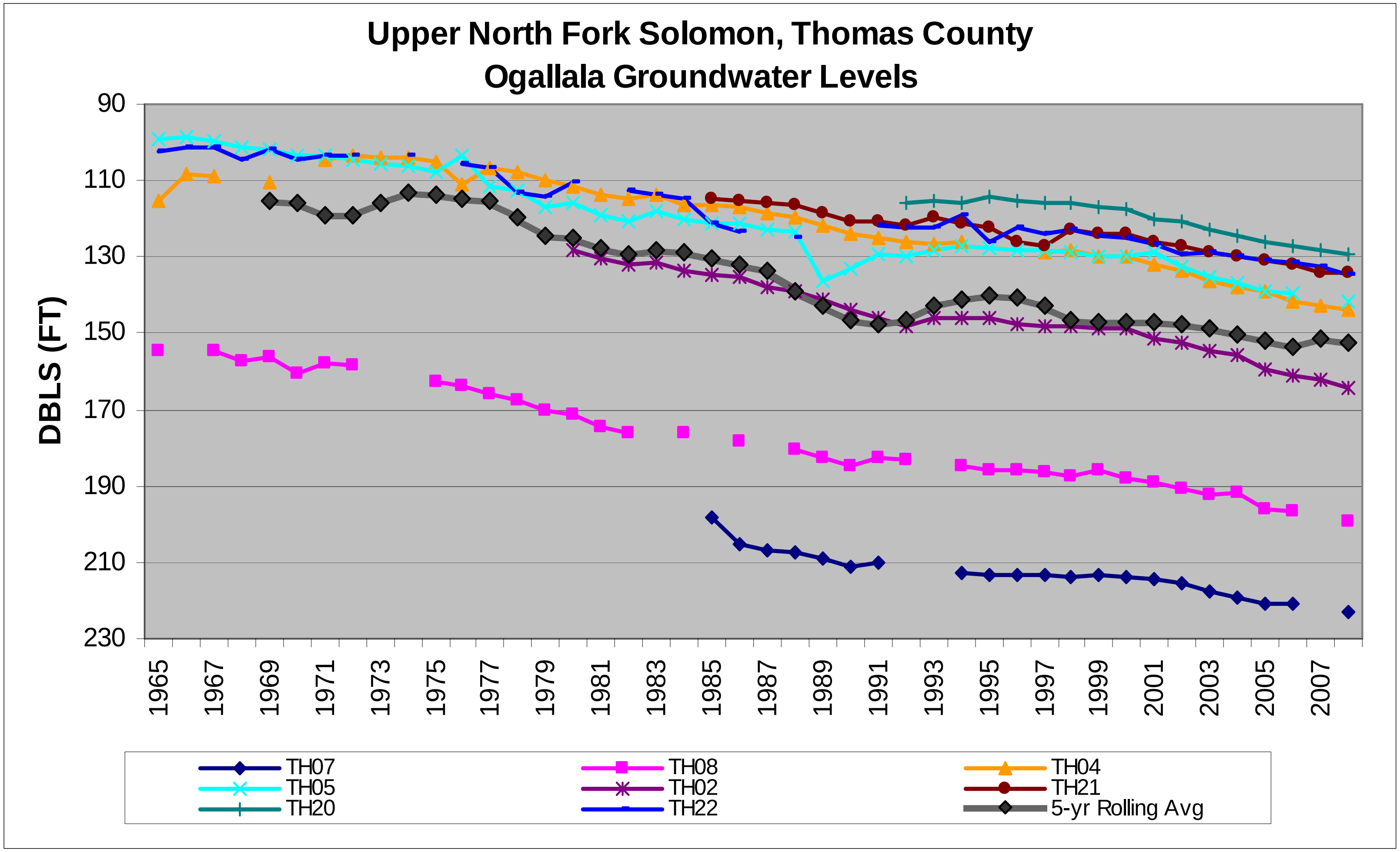

Figure 8: Ogallala-High Plains monitoring well levels, Upper North Fork in Thomas County

In the Upper North Fork of the Solomon River, the eight Ogallala-High Plains wells have declined on average 1.40 ft from January 2007 to January 2008 (Figure 8). The change in water levels ranged from a decline of 2.32 ft (TH22) to an increase of 0.08 ft (TH21). There are a number of wells with historic data that show a net decline in water levels ranging from 28.78 ft (TH04) to 44.65 ft (TH08). The five-year rolling average shows a net decline in water levels of 37.62 ft since 1969.

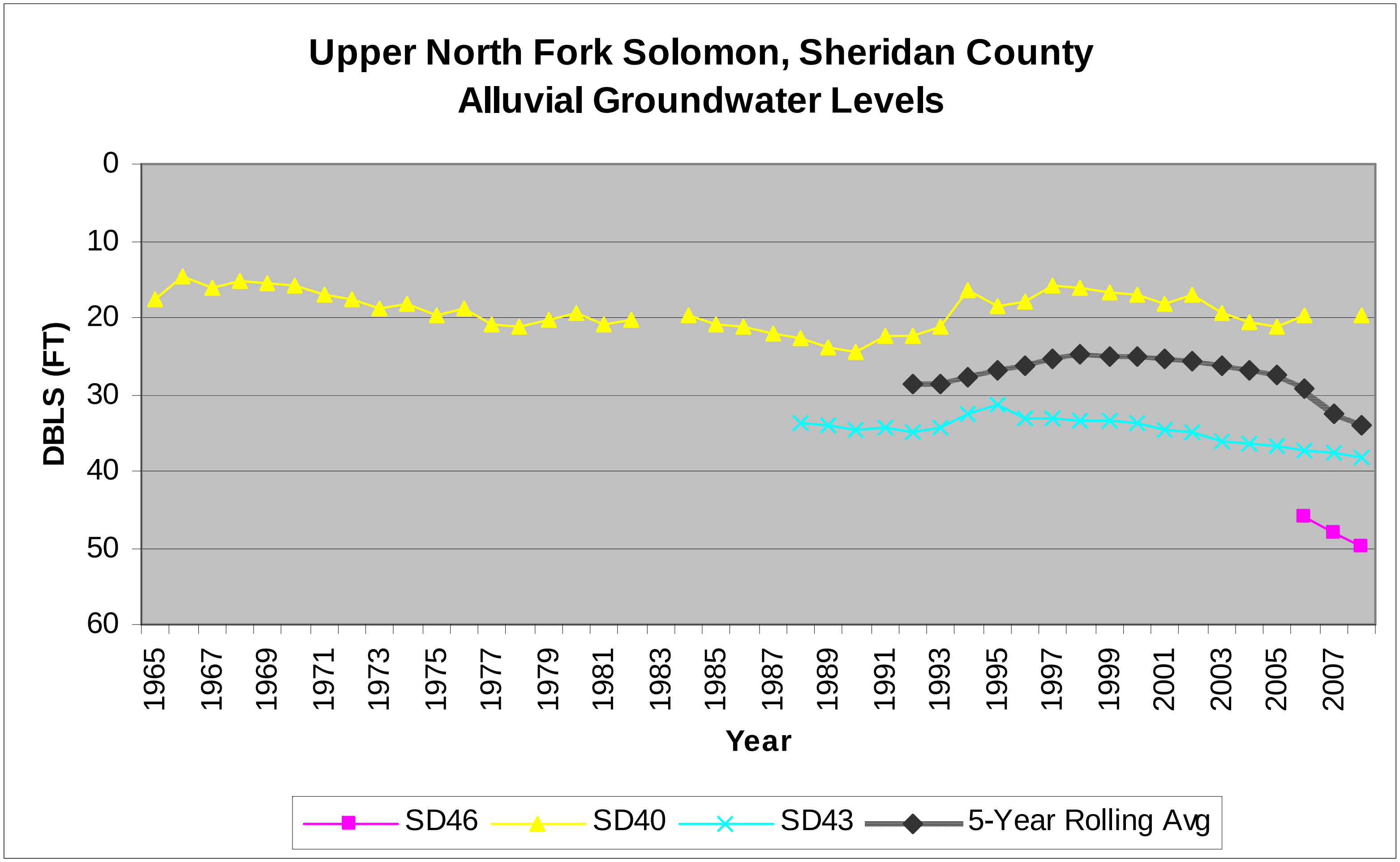

Figure 9: Alluvial monitoring well levels, Upper North Fork in Sheridan County

Wells located in Sheridan County on the Upper North Fork Solomon are drilled in the alluvial and Ogallala-High Plains aquifer. Figure 9 represents the alluvial wells in Sheridan County. There are three wells measured, one with historic data (SD 40). The average change in water levels in the last year are -1.26 ft, with water level changes ranging from -0.75 ft (SD43) to a -1.77 ft (SD46). SD 40 has data dating back to 1965 and has shown a net decline of 1.97 ft, whereas SD 43 that has only been measured since 1988 is showing a net decline of 4.50 ft in water levels. The five-year rolling average shows an increase in water levels during the mid-1990s and then a declining trend in the last 10 years.

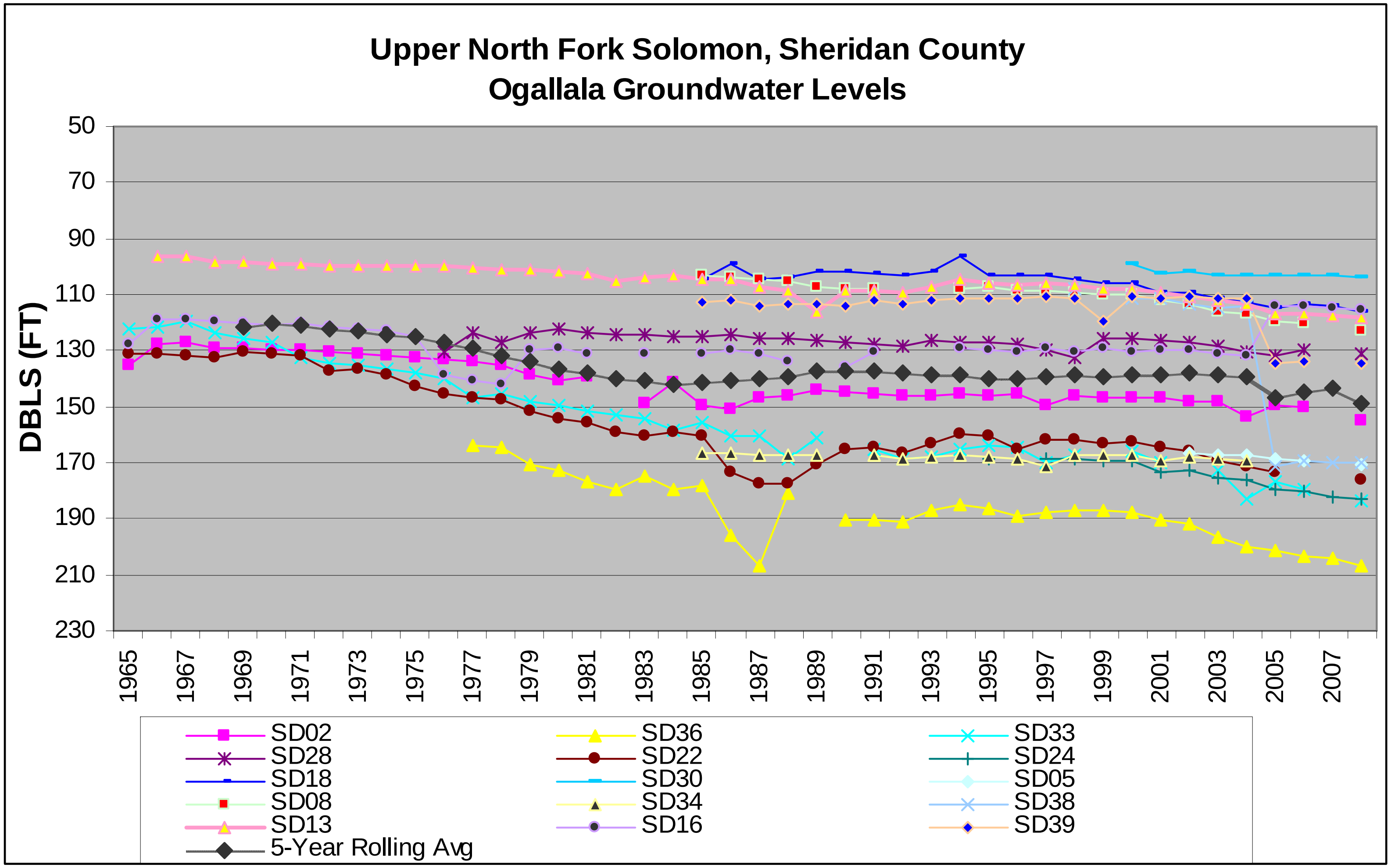

Figure 10: Ogallala-High Plains wells in the Upper North Fork, Sheridan County.

There are 15 wells monitored in the Ogallala-High Plains in the Upper North Fork, Sheridan County (Figure 10). From 2007 to 2008 the average these wells have declined is 1.20 ft, with water level declines ranging from 2.74 ft (SD36) to 0.08 ft (SD34). Monitoring of some of these wells started in 1965, and shows a decline in the water table ranging from 20.08 ft (SD02) to 61.40 ft (SD33). The five-year rolling average shows an overall declining trend in water levels with a net decline of 27.55 ft.

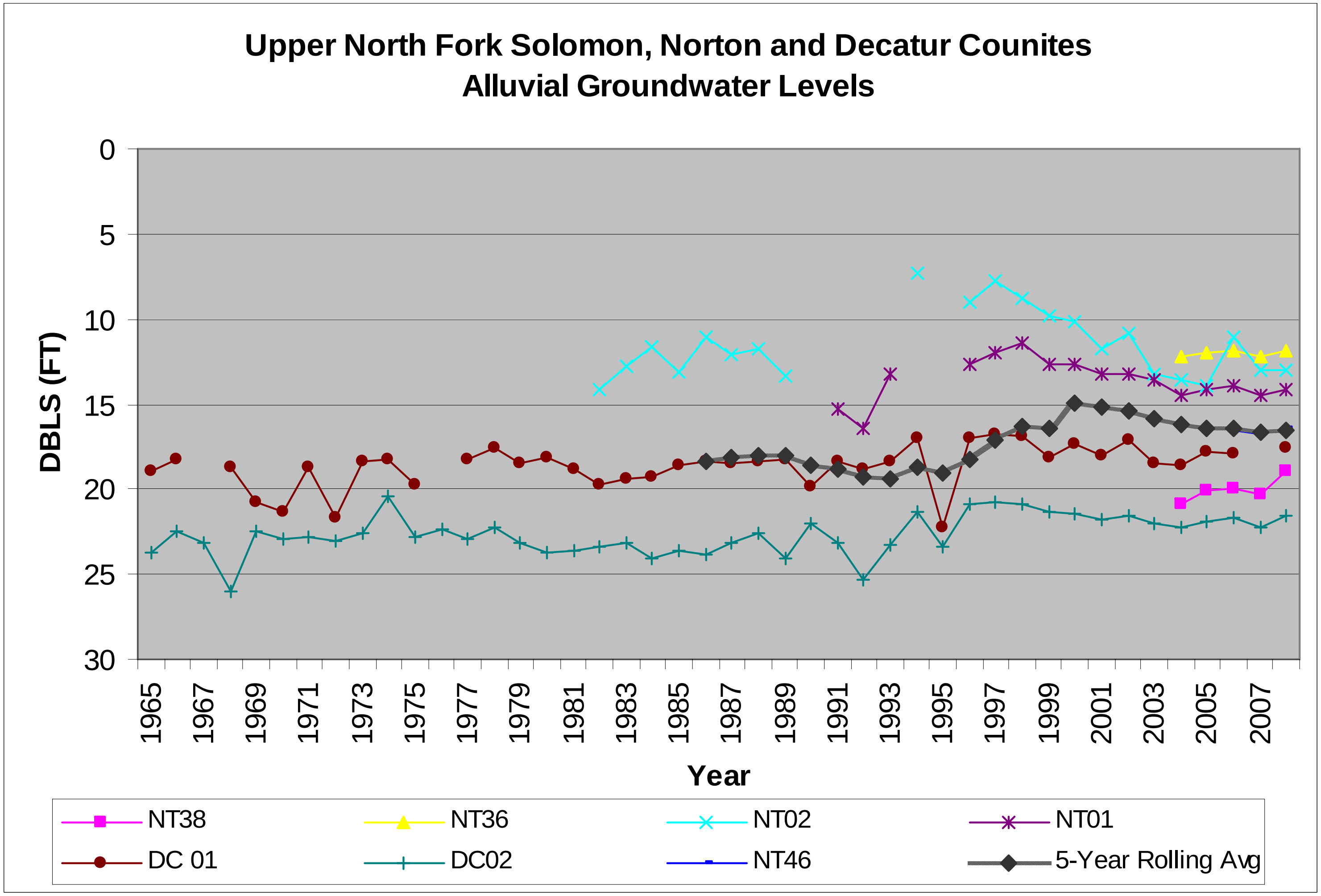

Figure 11: Alluvial monitoring well levels, Upper North Fork in Norton and Decatur Counties

In Norton and Decatur Counties of the Upper North Fork Solomon, both alluvial and Ogallala-High Plains wells are measured. There are seven alluvial wells, five in Norton County and two in Decatur County (Figure 11). The average change in water levels showed an increase of 0.52 ft in these counties. The change in water levels ranged from 1.39 ft (NT 8) to 0.01 ft (NT02). DC01 and DC02 were first measured in 1965. Since 1965, the water table has increased 1.35 ft (DC01) and 2.12 ft (DC02). The five-year rolling average shows a slight decrease in the water table since 2000.

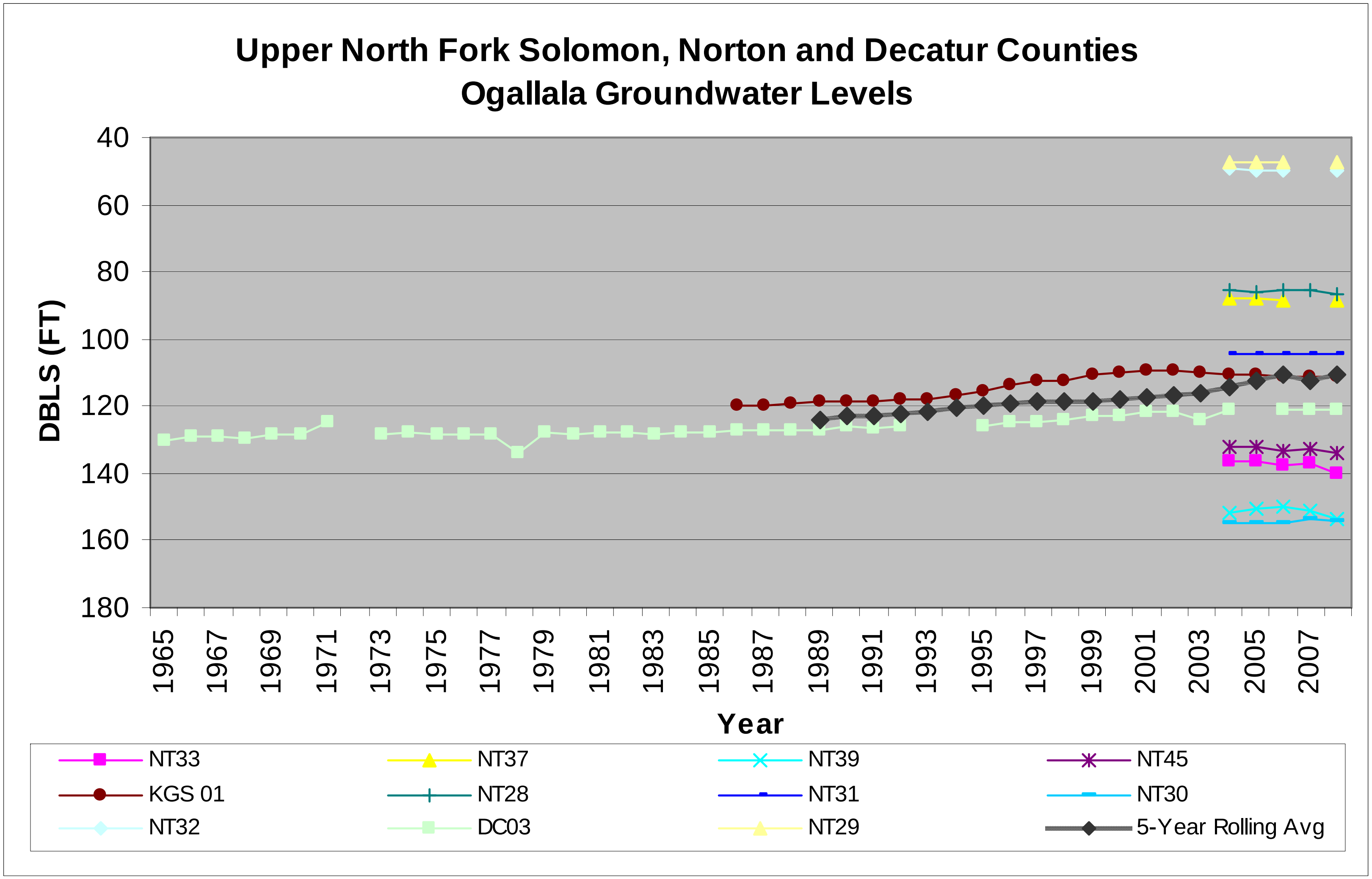

Figure 12: Ogallala-High Plains monitoring wells in the Upper North Fork, Norton and Decatur Counties.

The 11 Ogallala-High Plains wells in Norton and Decatur Counties in Figure 12 have shown an overall decline in water levels of 1.10ft. The range in the water level changes are 0 ft (NT31) to -3.40 ft (NT33). DC03 has been measured since 1965 and shows a net increase in the water table of 9.34 ft. KGS01, measured since 1986, is also showing a net increase in the water table of 8.98 ft. The five-year rolling average shows a net increase in the water table over time.

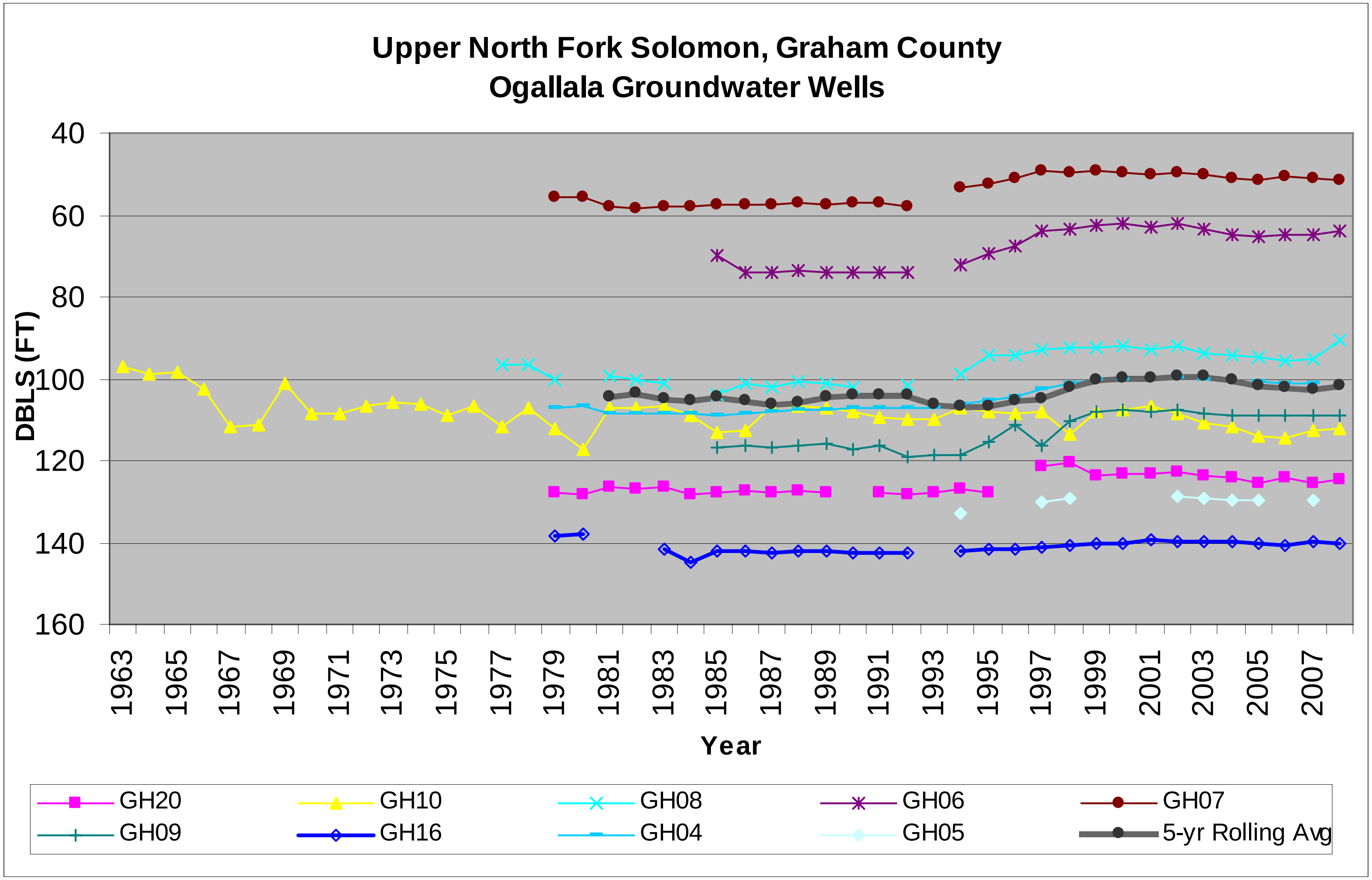

Figure 13: Ogallala-High Plains monitoring well levels, Upper North Fork in Graham County

There are nine monitoring wells in Graham County in the Upper North Fork Solomon (Figure 13) located in the Ogallala-High Plains aquifer. The average change in the water table in 2008 was an increase of 0.89 ft. The changes in the water table ranged from 4.80 ft (GH08) to -0.33 ft (GH16). GH10 has been measured since 1963 and shows a net decline in the water table of 15.25 ft, whereas GH08 measured since 1977 shows a net increase of 5.88 ft. The five-year rolling average shows fairly consistent water levels since 1998.

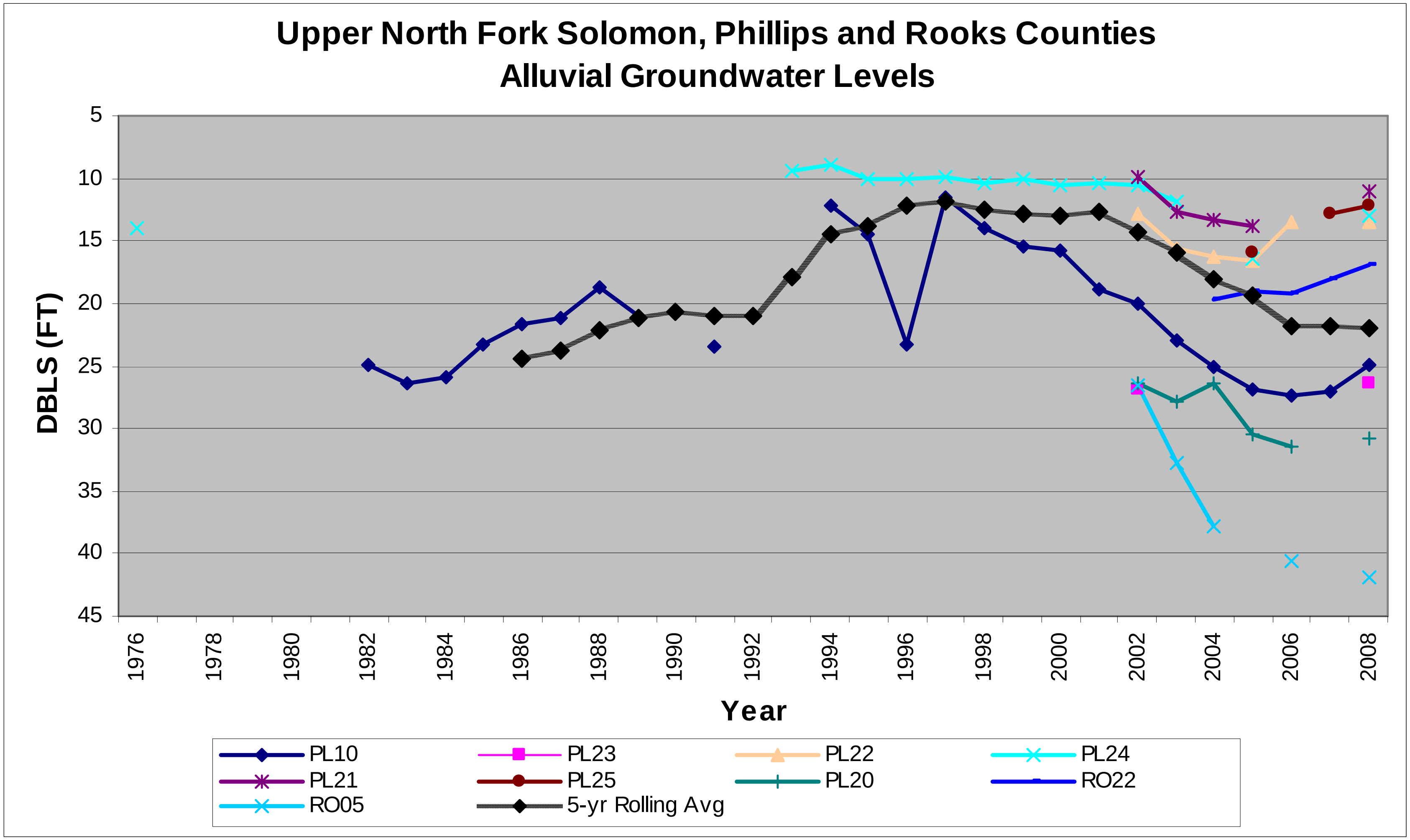

Figure 14: Alluvial monitoring well levels, Upper North Fork in Phillips and Rooks Counties

In Phillips and Rooks Counties there are nine alluvial wells monitored in the Upper North Fork Solomon (Figure 14). The average change in water levels from 2007 to 2008 shows an increase of 1.32 ft. The change in the water levels ranged from 0.62 ft (PL25) to 2.06 ft (PL10). PL24 has been measured since 1976 and shows a net increase in the water table of 0.94 ft, whereas PL10, measured since 1982, shows a slight net decline of 0.05 ft. The five-year rolling average shows an increasing or stable water table until 2001 when it started to decline.

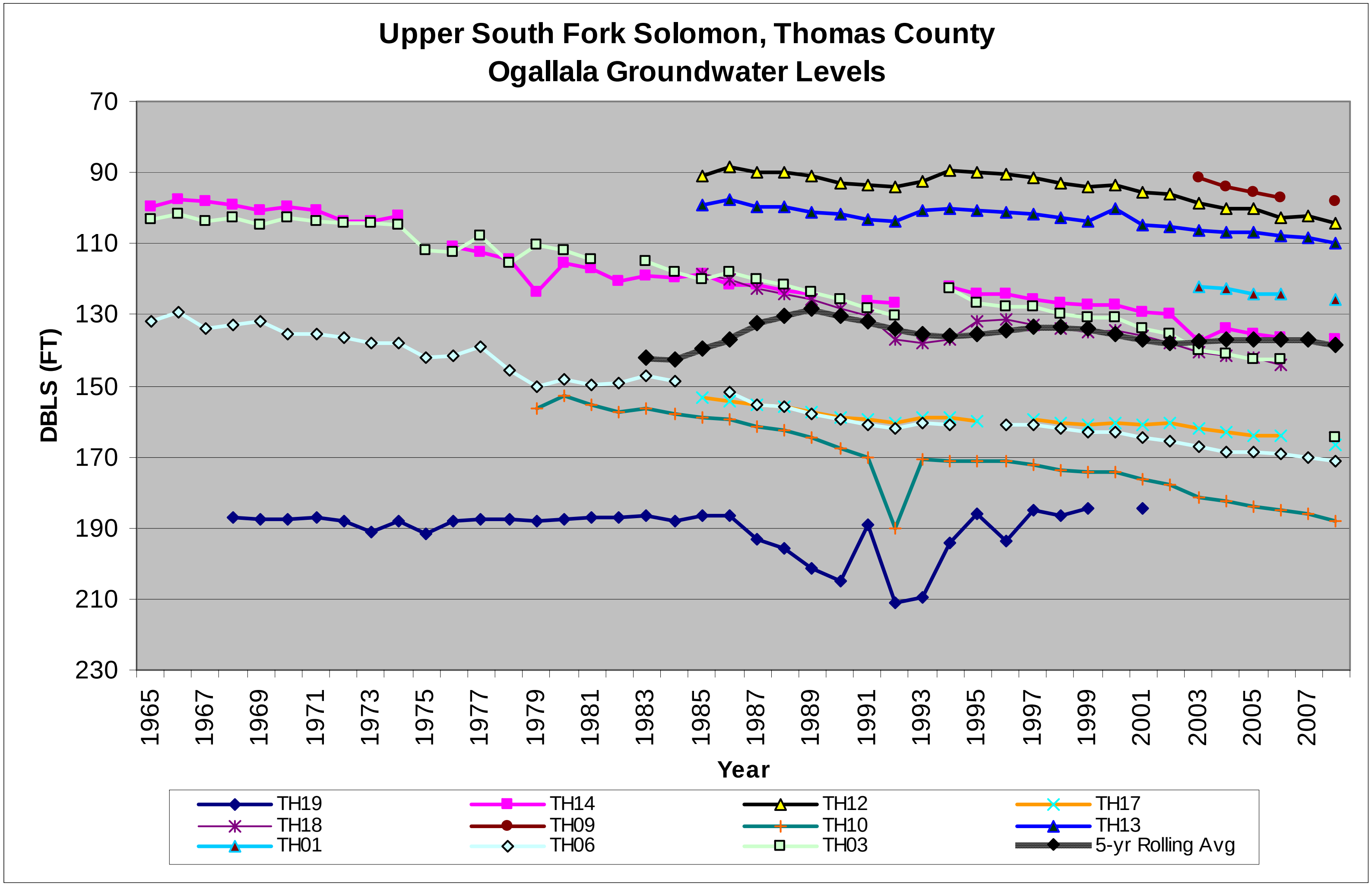

Figure 15: Ogallala-High Plains monitoring well levels, Upper South Fork in Thomas County

The Upper South Fork Solomon in Thomas County has 11 Ogallala-High Plains wells monitored. The average change in the water table is a decline of 1.73 ft and ranging from -0.69 ft (TH06) to -2.33 ft (TH12) from 2007 to 2008. Two wells, TH06 and TH03, have been measured since 1965. TH06 has a net decline of 39.38 ft since 1965 and TH03 has a net decline of 61.13 ft. The five-year rolling average shows an increase in the water table in the early 1980s and generally declining from the late 1980s to present.

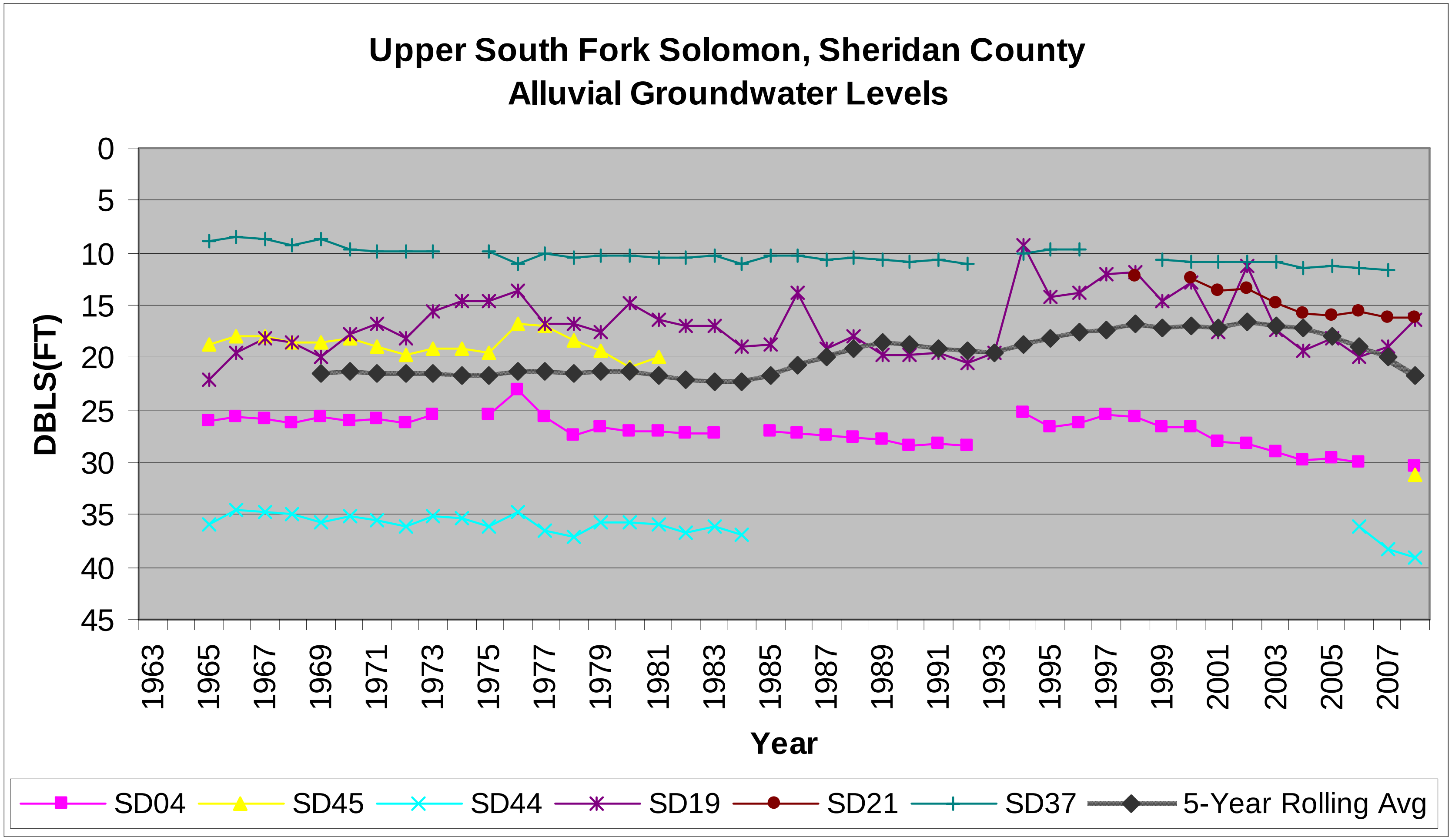

Figure 16: Alluvial monitoring wells in the Upper South Fork Solomon, Sheridan County

There are six alluvial monitoring wells in the Upper South Fork Solomon in Sheridan County (Figure 16). The average change in water levels was an increase of 0.63 ft. From 2007 to 2008 the change in the water table ranged from an increase of 2.66 ft (SD19) to a decline of 0.73 ft (SD44). There are a number of wells with historical data dating back to 1965. SD19 over time has a net increase of 5.88 ft, whereas SD45 declined a net of 12.32 ft. The five-year rolling average shows a declining trend since 2003. Prior to 2003 the water table was steady and increasing.

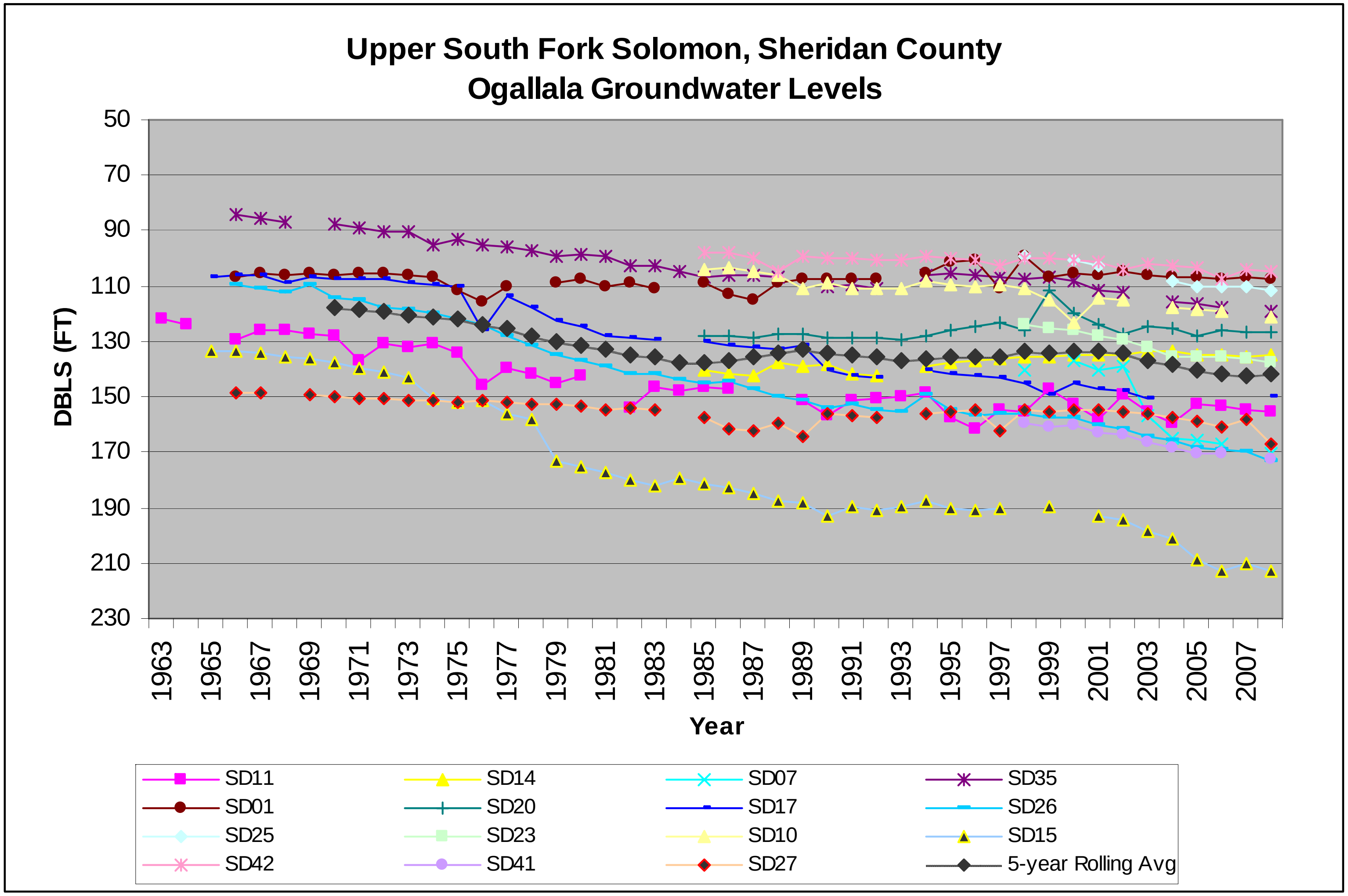

Figure 17: Ogallala-High Plains monitoring well levels, Upper South Fork in Sheridan County

There are 15 Ogallala-High Plains monitoring wells located in the Upper South Fork in Sheridan County (Figure 17). The Ogallala-High Plains wells have measurements dating back to 1965 same as the alluvial wells. The average change in the water table for these wells is a decline of 1.89 ft in 2008. The change in the water levels ranged from a decline of 8.77 ft (SD27) to an increase of 0.45 ft (SD20). Since 1963, SD11 has a net decline of 33.38 ft and SD27 has decline a net of 18.42 ft. The five-year rolling average reflects this declining trend.

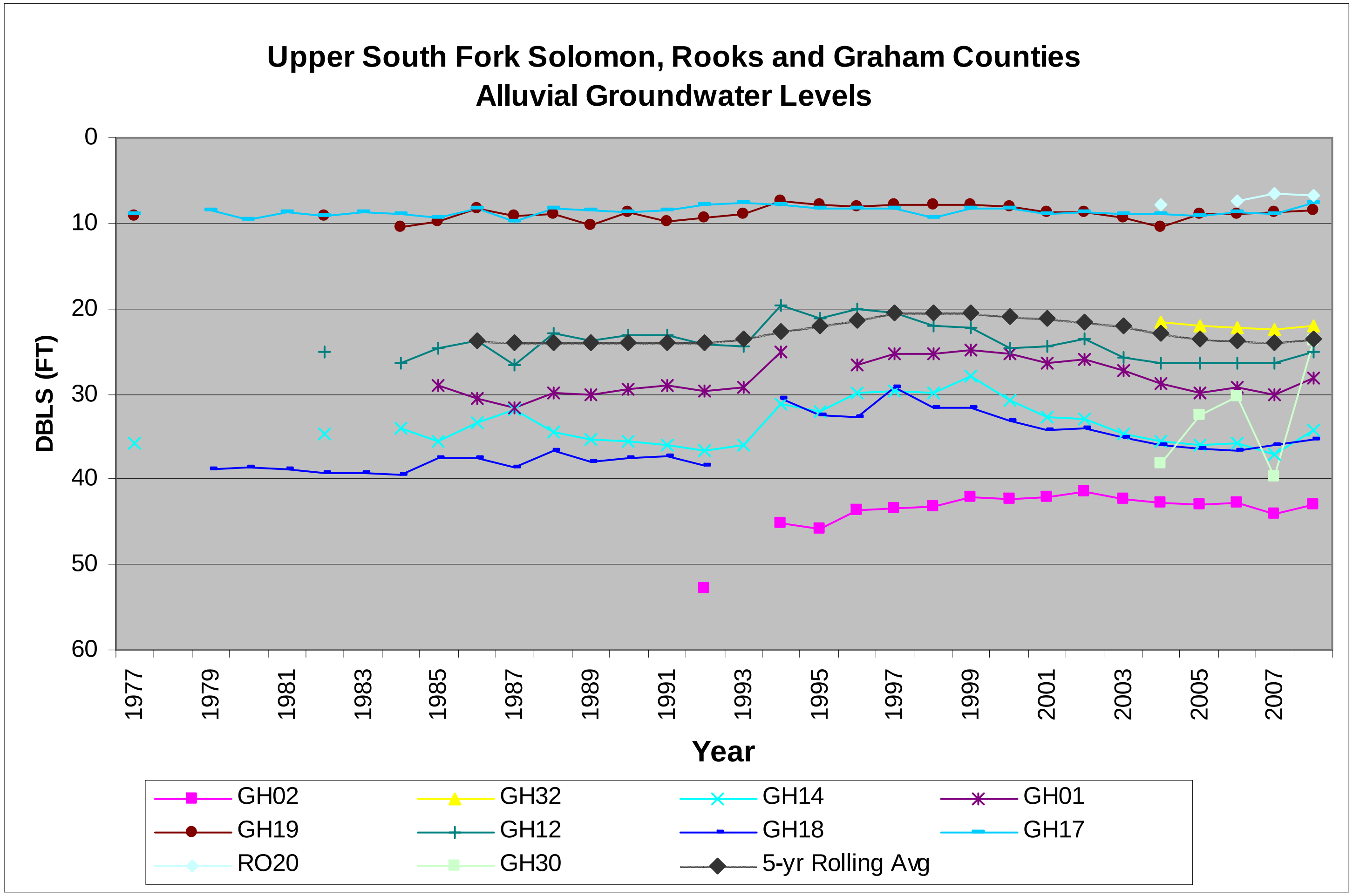

Figure 18: Alluvial monitoring well levels, Upper South Fork in Graham and Rooks Counties

Figure 18 shows the 10 alluvial monitoring wells located in the Upper South Fork in Graham and Rooks counties. The average change in the alluvial water levels is an increase of 2.54 ft. The change in the water levels ranged from a decrease of 0.17 ft (RO20) to an increase of 15.99 ft (GH30). GH14 has been measured since 1977 and has had a net increase of 1.55 ft. The trend for this area is increasing with GH18 and RO20 showing a net increase of 3.51 ft and 1.15 ft, respectively. The five-year rolling average shows a generally stable water table.

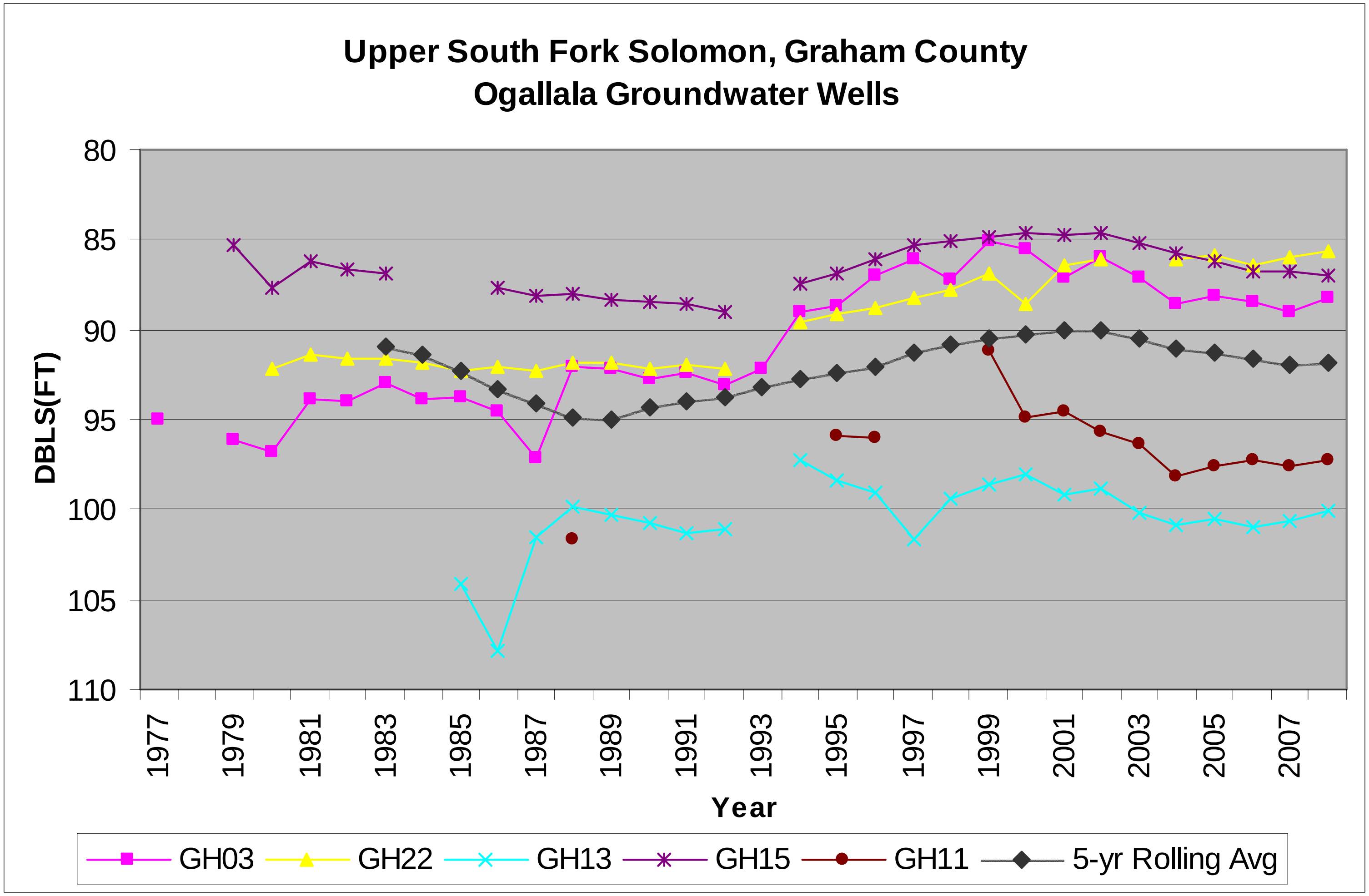

Figure 19: Ogallala-High Plains monitoring well levels, Upper South Fork in Graham County

There are five Ogallala-High Plains monitoring wells located in the Upper South Fork Graham County (Figure 19). The average change in the water levels for the Ogallala-High Plains wells is an increase of 0.38 ft in 2008. The change in the water table ranged from a decline of 0.18 ft (GH15) to an increase of 0.79 ft (GH03). Data for this area dates back to 1977. Since 1977, GH03 increased a net of 6.74 ft whereas GH15 has had a net decline of 1.62 ft. The five-year rolling average shows that overall the water levels have declined moderately since 2002.

V. Water Use

The Upper Solomon subbasin has a total of 1,158 water rights. The total authorized quantity of these water rights is 282,466.11 acre-feet per year. Most of the water rights and authorized quantities are appropriated groundwater rights (Table 1).

Table 1: Water Rights in the Upper Solomon Subbasin

Type	Source	Number of Rights	Authorized Quantity
Vested	Surface Water	5	561.78
Appropriated	Surface Water	19	28,826.00
Vested	Groundwater	19	1,000.03
Appropriated	Groundwater	1115	252,078.30

The water use ranges from 246,868 acre-feet in 1988 to 66,461 acre-feet in 1993. The average water use for the subbasin from 1987-2006 was 147,003.97 acre-feet. Water use in 2006 was 132,968 acre-feet. This was up from 2005 but still below the subbasin average (Figure 20).

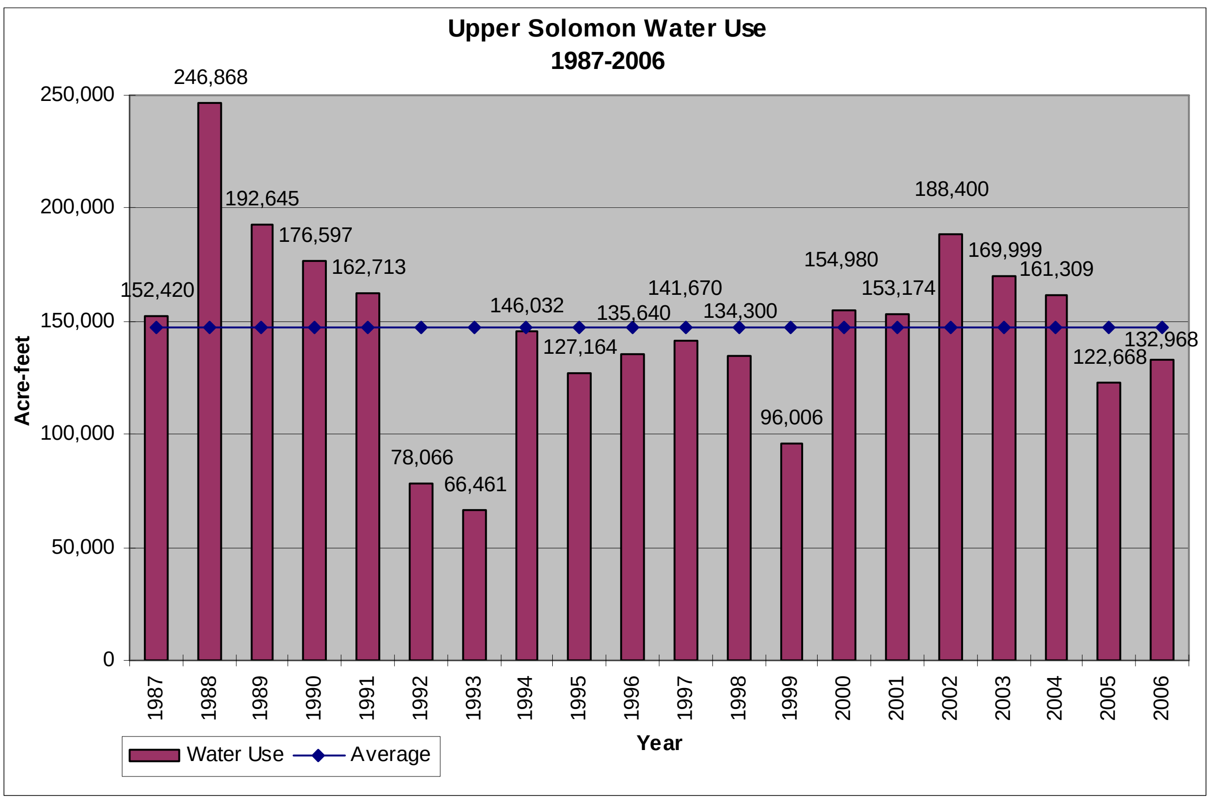

Figure 20: Ground and Surface Water use by year

VI. Conclusions

Even though the subbasin did see some significant precipitation events during 2007, there were still declines in some water levels. The streamflows started off average to well above average at the beginning of the year but declined significantly by the end of the year. Evaluating this change in hydrologic response to streamflow is an indication why it is so important to continue to study this basin at the current level to determine the long term effects of current water usage on this basin and existing property rights. It is equally important to understand how fast the system recovers after a recharge event as it is to understand the impacts of pumping and other factors on the hydrologic system.

VII. Appendix

Monitoring Well ID	Legal Description	Subbasin
DC03	05S 26W 05 NESESE	High Plains
GH03	09 24W 22 NWNENE	High Plains
GH04	06S 22W 19 SWSWSW	High Plains
GH05	06S 22W 16 SESWSW	High Plains
GH06	06 23W 17 SWSWNE	High Plains
GH07	06 23W 13 NWNWNW	High Plains
GH08	06 24W 28 NWNENW	High Plains
GH09	06 24W 14 NENENE	High Plains
GH10	06 25W 28 SWNWSW	High Plains
GH11	06S 21W 19 SWSESW 02	High Plains
GH13	07 25W 33 SESESE	High Plains
GH15	07 25W 24 NWNWNW	High Plains
GH16	06 25W 12 SWSWSW	High Plains
GH20	07 24W 08 SWNWNE	High Plains
GH22	09 25W 14 SESESE	High Plains
KGS01	04S 25W 13 SWSWSW	High Plains
NT28	03S 23W 34 NESESE	High Plains
NT29	04S 22W 18 SWNWSW	High Plains
NT30	03S 22W 20 SESESE	High Plains
NT31	03S 21W 29 SESWSW	High Plains
NT32	03S 21W 21 NENESE	High Plains
NT33	05S 21W 25 NESESW	High Plains
NT37	04S 25W 34 SWSESW	High Plains
NT39	04S 25W 28 NWNENE	High Plains
NT45	04S 23W 19 SESENW	High Plains
SD01	09 27W 12 SWSWSW	High Plains
SD02	07 28W 36 NENWNE	High Plains
SD05	07 27W 07 NE	High Plains
SD07	09 28W 15 SWNWNE	High Plains
SD08	07 29W 05 NWNWNW	High Plains
SD10	09 29W 03 NENENE	High Plains
SD11	09 30W 35 NWNWNW	High Plains
SD13	06 29W 24 NENWNW	High Plains
SD14	09 26W 22 NWNWNW	High Plains
SD15	08 30W 11 SWNWSW	High Plains
SD16	06 29W 10 SENWSW	High Plains
SD17	08 30W 30 NENWSW	High Plains
SD18	07 30W 08 SWSWNW	High Plains
SD20	08 27W 35 SWNWNW	High Plains
SD22	07 28W 21 NENWNW	High Plains
SD23	08 28W 17 NWNESE	High Plains

SD24	07 28W 08 SESWSW	High Plains
SD25	08 28W 16 NENESW	High Plains
SD26	08 30W 13 SENENE	High Plains
SD27	07 26W 28 SWNENW	High Plains
SD28	07 26W 19 NWNWSW	High Plains
SD30	07 26W 12 NWSENW	High Plains
SD33	07 29W 30 NENWNE	High Plains
SD34	06 26W 26 SWNWNW	High Plains
SD35	09 29W 17 NWNENW	High Plains
SD36	07 29W 27 SWSWSW	High Plains
SD38	06 28W 21 NWSWSE	High Plains
SD39	06 27W 05 SWNWNW	High Plains
SD41	08 29W 01 NWSESE	High Plains
SD42	08 28W 11 SENENE	High Plains
TH01	08 32W 32 SENENE	High Plains
TH02	08 31W 03 SWSESE	High Plains
TH03	08 31W 20 SWSESE	High Plains
TH04	08 32W 12 SENWSW	High Plains
TH05	08 32W 07 NWNENE	High Plains
TH06	08 33W 34 NWNWSW	High Plains
TH07	08 34W 29 SWSWSW	High Plains
TH08	08 34W 23 SWNWSE	High Plains
TH09	09 31W 10 NWSESE	High Plains
TH10	09 34W 12 NESENE	High Plains
TH12	09 31W 17 SWSWSW	High Plains
TH13	09 32W 03 NENENE	High Plains
TH14	09 32W 27 NWSWSE	High Plains
TH17	09 34W 17 NENWNE	High Plains
TH18	09 34W 11 SWSWSW	High Plains
TH19	09 35W 32 SENENE	High Plains
TH20	07 32W 13 SENWSE	High Plains
TH21	07 32W 33 NWSWNW	High Plains
TH22	07 31W 01 SESWNE	High Plains
DC01	05 26W 33 SESWSW 1	Upper North Fork
DC02	05 26W 26 SESENE 1	Upper North Fork
NT01	05 04W 14 NWSESW 1	Upper North Fork
NT02	05 22W 18 SWSWSE 1	Upper North Fork
NT36	05S 24W 20 SWSWSW	Upper North Fork
NT38	05S 25W 28 SESWSW	Upper North Fork
NT46	04S 21W 35 SESESW	Upper North Fork
PL10	04 19W 35 SESESE	Upper North Fork
PL20	04S 18W 28 NWNWNW	Upper North Fork
PL21	04S 18W 28 SWSWNW	Upper North Fork
PL22	04S 18W 28 SWSWSW	Upper North Fork
PL23	04S 18W 33 NWSWNE	Upper North Fork
PL24	04S 18W 34 NENENE	Upper North Fork
PL25	04S 17W 30 SWSWSW	Upper North Fork
RO05	06S 19W 05 SENENW	Upper North Fork

RO22	06S 19W 17 NWNWNW	Upper North Fork
SD40	06 27W 08 SESWNE 1	Upper North Fork
SD43	06 27W 19 NESESW 1	Upper North Fork
SD46	06S 28W 28 SWSENE	Upper North Fork
GH01	08 25W 24 NWNENW 1	Upper South Fork
GH02	09 23W 26 NWNENE	Upper South Fork
GH12	08 21W 17 NENWNW 1	Upper South Fork
GH14	08 24W 23 NESWSW 1	Upper South Fork
GH17	07 22W 10 NWNWSW	Upper South Fork
GH18	07 22W 19 NWNWNW	Upper South Fork
GH19	08 22W 18 SWSESW 1	Upper South Fork
GH30	06S 21W 33 SESESE	Upper South Fork
GH32	09S 21W 19 NENENW	Upper South Fork
RO20	08S 20W 07 NESESE	Upper South Fork
SD04	09 28W 04 NWSWSW 1	Upper South Fork
SD19	08 26W 14 SENENE 1	Upper South Fork
SD21	08 27W 18 SENENE	Upper South Fork
SD37	08 27W 11 SESWSE 1	Upper South Fork
SD44	08S 26W 16 SWSWSE	Upper South Fork
SD45	08S 27W33 NWNWSE	Upper South Fork