Idaho Department of Water Resources
Open-File Report

Summary of Ground Water Level Data and Trends in the Lindsay Creek Ground Water Management Area and the Tammany Creek Area, 2012

By
Kenneth W. Neely
Technical Hydrogeologist

July 2, 2012

Table of Contents

Executive Summary 1

Purpose and Scope 2

Geographic Setting 2

Hydrogeologic Setting 3

Status of the Monitoring Network 4

Summary of Water Level Data 6

Overall Observations 6

Lindsay Creek GWMA 7

Tammany Creek Area 10

Water Level Changes, 2006-2011 13

Conclusions 15

Recommendations 16

Acknowledgements 17

References 18

APPENDIX A 20

List of Figures

Figure 1. General location Map for Lewiston Area 4

Figure 2 Map showing the 12 wells that are currently being monitored in the Lindsay Creek GWMA, Tammany Creek area, and downtown Lewiston area. Table 1 lists the attributes of these wells. 6

Figure 3. Water levels for four Lindsay Creek Ground Water Management Area wells. . 8

Figure 4. Top-of-aquifer elevations (feet above sea level) for the Lindsay Creek GWMA wells. 9

Figure 5. Water levels for seven Tammany Creek area monitoring wells. 11

Figure 6. Water level elevation contour map for the Tammany Creek Area. April 2011 (Well 7 is not included in the analysis because it is completed in a deeper aquifer than the other six wells). 12

Figure 7. Top-of-aquifer elevations for the Tammany Creek wells. 13

Figure 8. Maximum water level changes between spring 2006 and spring 2011. 14

Figure 9. Minimum water level changes between fall 2006 and fall 2011. 15

List of Tables

Table 1. List of the wells currently being monitored for ground water levels in the Lindsay Creek GWMA, Tammany Creek area, and downtown Lewiston area. 7
Table 2. Changes in the maximum and minimum water levels between 2006 and 2011 14

Executive Summary

The Idaho Department of Water Resources (IDWR) manages a ground water level monitoring network in an area east and southeast of the City of Lewiston in Nez Perce County, Idaho. This area contains two subbasins: the Lindsay Creek Ground Water Management Area (GWMA), and the Tammany Creek area. The Lindsay Creek GWMA was designated on March 5, 1992 by the Idaho Department of Water Resources (IDWR, 1992) because it appeared that the conditions in the shallow basalt aquifer in the Lindsay Creek drainage were approaching those of a Critical Ground Water Area. The justification for the designation was based on "reports of well owners, impending land use changes, review of well driller's reports of wells drilled in the area, knowledge of the hydrogeology of the Lewiston area and separate reports completed by a consulting geologist and a Department Hydrogeologist" (IDWR, 1992). At the time of the designation, there was concern that additional ground water pumping might affect the availability of water for existing wells and senior water rights.

The hydrogeology of the Lewiston area consists of two aquifer systems: 1) a deep regional basalt aquifer in the Grande Ronde Formation that extends at least 10 miles to the south and east of Lewiston, and 2) a series of shallow perched aquifers in the basalt flows and sedimentary interbeds of the Wanapum and Saddle Mountain Formations that exist throughout most of the area. Hydraulic communication between wells completed in the regional aquifer is very good, and water levels have not declined in this aquifer despite extensive usage by the three major water suppliers in the area (City of Lewiston, Lewiston Orchards Irrigation District, and Asotin Public Utilities Department). However, wells completed in the aquifers of the Wanapum and Saddle Mountain Formations have experienced water level declines.

The record of ground water level monitoring for the Lewiston area was sporadic from 1992 to 1999, and most of the wells that were measured during that time period are no longer active monitoring sites. In 1999 and 2000, several wells were added to the network, and by 2006, the network had 11 wells. Currently, the monitoring network consists of 12 wells that are measured by IDWR using a calibrated electric tape on a quarterly (once every three months) basis. Four of the wells are associated with the Lindsay Creek GWMA, seven wells are in the Tammany Creek area, and one infrequently-used public supply well is located in downtown Lewiston. The Lewiston well has a pressure transducer deployed in it which records instantaneous water level and temperature readings twice a day. The Lewiston well is completed in the regional aquifer; the other 11 wells are completed in the perched basalt aquifers of the Wanapum and Saddle Mountain Formations.

Declining water level trends indicate that the shallow basalt aquifers in the Lindsay Creek and Tammany Creek Areas continue to be stressed. The time period from 2006 to 2011 was analyzed in detail for this report because it contains the most complete record of water level data for most of the wells. Water levels in the four Lindsay Creek GWMA wells declined an average of 6.9 feet from 2006 to 2011, which equates to 1.4 feet per

year. The seven Tammany Creek wells had an average decline of 7.4 feet in the same time period, which is 1.5 feet per year.

Although the 11 wells monitored in the Lindsay Creek GWMA and Tammany Creek area have exhibited ground water level declines, the differences in the magnitude of the declines, the variability in seasonal water levels cycles, the varying individual responses to pumping, and the differences in water level elevations and top-of-aquifer elevations indicate that the wells are completed in several separate shallow aquifers that have limited water availability and receive limited recharge. Ralston (personal communication, 2012) believes that the shallow system is a series of perched aquifers that exist primarily because of infiltration from surface irrigation related to decades of water applied in the Lewiston Orchards area. Some of these shallow aquifers may also be recharged naturally by surface flow in streams located to the south of Tammany Creek, such as Sweetwater Creek. However, recharge from the Lewiston Orchards is not significant today, and recharge from Sweetwater Creek is believed to be relatively minor. As a result, the shallow aquifers are water-limited and water levels are declining. Moreover, at least 40 new domestic wells have been drilled in the general vicinity of the Lindsay Creek and Tammany Creek areas since 2003, causing additional stress on these limited resources.

Quarterly monitoring by calibrated electrical tape will continue for the 12 wells in the monitoring network. The transducer in the Lewiston well will remain deployed until at least the end of 2013. Up to six additional monitoring wells are proposed to be added to the Lindsay Creek network in an effort to better understand the hydrogeology. Two of these wells will be on the southern edge of the Lindsay Creek GWMA, which will also provide useful data for the Tammany Creek area. The new wells will be selected from existing well driller's reports at IDWR.

The information from this study was presented to the Nez Perce County Commissioners in 2012. Other future activities may include the development of a management plan for the area and the formation of an advisory committee.

Purpose and Scope

The purpose of this report is to summarize the hydrologic conditions and trends in the Lindsay Creek Ground Water Management Area (GWMA) and the Tammany Creek area in Nez Perce County, Idaho. The report also proposes potential actions to improve the understanding of the local hydrogeology and to protect the shallow ground water resources in both areas.

Geographic Setting

The general area of interest is located in northwestern Nez Perce County (Figure 1). The area is east and southeast of the City of Lewiston, which is located at the confluence of the Clearwater and Snake Rivers. The area is characterized by flat lowlands in downtown Lewiston near the rivers, north-facing and west-facing slopes that rise away

from the lowlands, narrow canyons in the Lindsay Creek area, plateaus in the Lewiston Orchards and in the central to eastern portions of the Lindsay Creek GWMA, and a relatively wide and flat stream channel bordering Tammany Creek. The main population centers are the downtown Lewiston area and the Lewiston Orchards located south of the downtown area. The Lindsay Creek GWMA and Tammany Creek area are sparsely populated with farms, small ranches, individual homes on small acreage, and rural subdivisions.

Hydrogeologic Setting

The Grande Ronde is the oldest formation in the Lewiston area that is an important ground water resource. The Grande Ronde is the lowermost formation in the Yakima Subgroup, which is in the upper part of the Columbia River Group (Cohen and Ralston, 1980). The Grande Ronde Formation is comprised of basalt flows with few soil interbeds, and with a total thickness of up to 2,800 feet (Cohen and Ralston, 1980). The Grande Ronde Formation is overlain by the Wanapum Formation which, in the Lewiston area, consists primarily of the two flows of the Priest Rapids member with a total thickness of about 150 feet (Cohen and Ralston, 1980). The Saddle Mountains Formation overlies the Wanapum, and consists of a series of flows and interbeds. Cohen and Ralston (1980) describe the Saddle Mountain Formation stratigraphy as eight basalt flows, which are underlain by the Sweetwater Creek interbed at the base of the formation. Swanson and others (1977) identified seven unconformities in the Wanapum and Saddle Mountain Formations.

The regional aquifer is in the upper part of the Grande Ronde Formation. Cohen and Ralston (1980) classified the upper 800 feet of the Grande Ronde Formation as the Russell Aquifer. Wells producing from this aquifer typically yield 2,000 gallons per minute or more. Recharge sources for the Russell Aquifer are Lapwai Creek to the east of Lewiston, the Clearwater River to the north and east of Lewiston, and at an area to the south of Lewiston near the confluence of Asotin Creek with the Snake River where natural recharge from these two sources occurs. The Russell Aquifer discharges to the Snake River downstream of Lewiston near Chief Timothy Park.

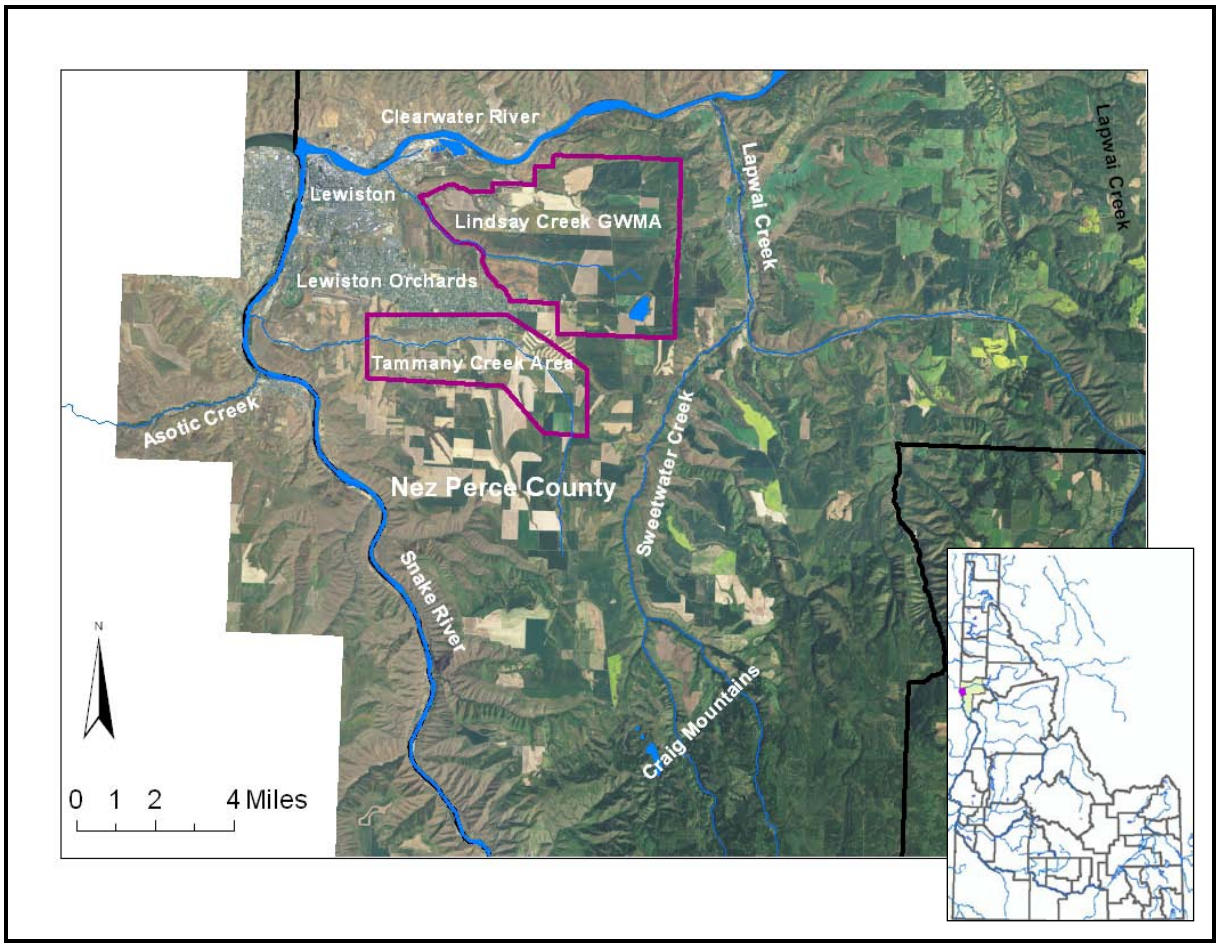


Figure 1. General location Map for Lewiston Area

The Wanapum and Saddle Mountain Formations occur throughout the Lindsay Creek GWMA and the Tammany Creek area. The formations contain several shallow perched aquifers that exist because of recharge associated with leakage from surface irrigation in the Lewiston Orchards area in the 20th century, and from natural recharge coming from Sweetwater Creek to the southeast of the Tammany Creek area. Ralston (personal communication, 2012) described how the downward movement of water from the surface has probably resulted in progressively more water-limited aquifers with depth (i.e, the shallowest aquifers are the first to capture the surface water and fill, leaving less water available to leak downward into the deeper aquifers).

Status of the Monitoring Network

The oldest record of ground water level measurements for the two areas dates back to 1980 for a well that was measured until 2003. One well in the Tammany Creek area has been measured regularly since 1985.

In 1992, the monitoring network for the Lindsay Creek GWMA and Tammany Creek area came into existence when the U.S. Geological Survey (USGS) began measuring five

wells as part of the IDWR/USGS Cooperative Program. Unfortunately, measurements at three of these wells were discontinued during the subsequent 12 years. IDWR added nine wells to the monitoring network in 1999 and 2000; however, three of these wells are no longer measured. IDWR added two replacement wells and a third new well in the mid 2000's. In 2009, IDWR assumed responsibility for the two wells measured by the USGS.

Currently, 11 wells in the Lindsay Creek GWMA and Tammany Creek area are being measured on a quarterly basis by IDWR using a calibrated electric tape. A 12th well, which is located in the downtown Lewiston area, was added to the monitoring program in 2011. In addition to being measured quarterly with an electric tape, the Lewiston well has a transducer deployed in it which records instantaneous water level and temperature readings twice a day. The 11 wells in the Lindsay Creek GWMA and Tammany Creek area are completed in the Wanapum and Saddle Mountain Formations; the Lewiston well is completed in the Russell Aquifer of the Grande Ronde Formation. The 12 wells are shown in Figure 2 and listed in Table 1.

Water level measurements can usually be accomplished on the quarterly field visits. However, sometimes a well is being pumped at the time of the site visit. In most cases, the pumping ceases during the site visit; however, the recovery of water levels in some of the wells is very slow, which results in a less-than-ideal measurement. In this situation, the measurement is recorded with an accompanying field note of "recovering". Pumping and recovering water level measurements are less representative of water level conditions and trends than non-pumping measurements, but they still have value.

Several wells have posed specific challenges when attempting to measure the water level:

1. Well 2 (35N 05W 04ABC1) – The tape has hung around 300 feet on occasion, and required numerous attempts to get it below this level.
2. Well 4 (35N 05W 02CCB1) – The well has been pumping on arrival, or has been pumped very recently. Water levels recover very slowly.
3. Well 6 (35N 05W 12CDB1) – In 2010, the tape got stuck about 6 feet below the top of the well casing at the pitless adaptor. It was successfully removed in 2011. During another measuring event, the tape stuck briefly just above the water level.
4. Well 7 (35N 05W 27BAB1) – The well is difficult to measure in the summer and fall when the water levels are significantly lower than in the winter and spring. The tape has hung around 300 feet on occasion, and required numerous attempts to get it below this level.
5. Well 8 (35N 05W 27BAB2) – The well has been pumping on arrival, or has been pumped very recently. Water levels recover very slowly.
6. Well 10 (35N 05W 23DDB1) – The well has been pumping on arrival, or has been pumped very recently. Water levels recover very slowly.

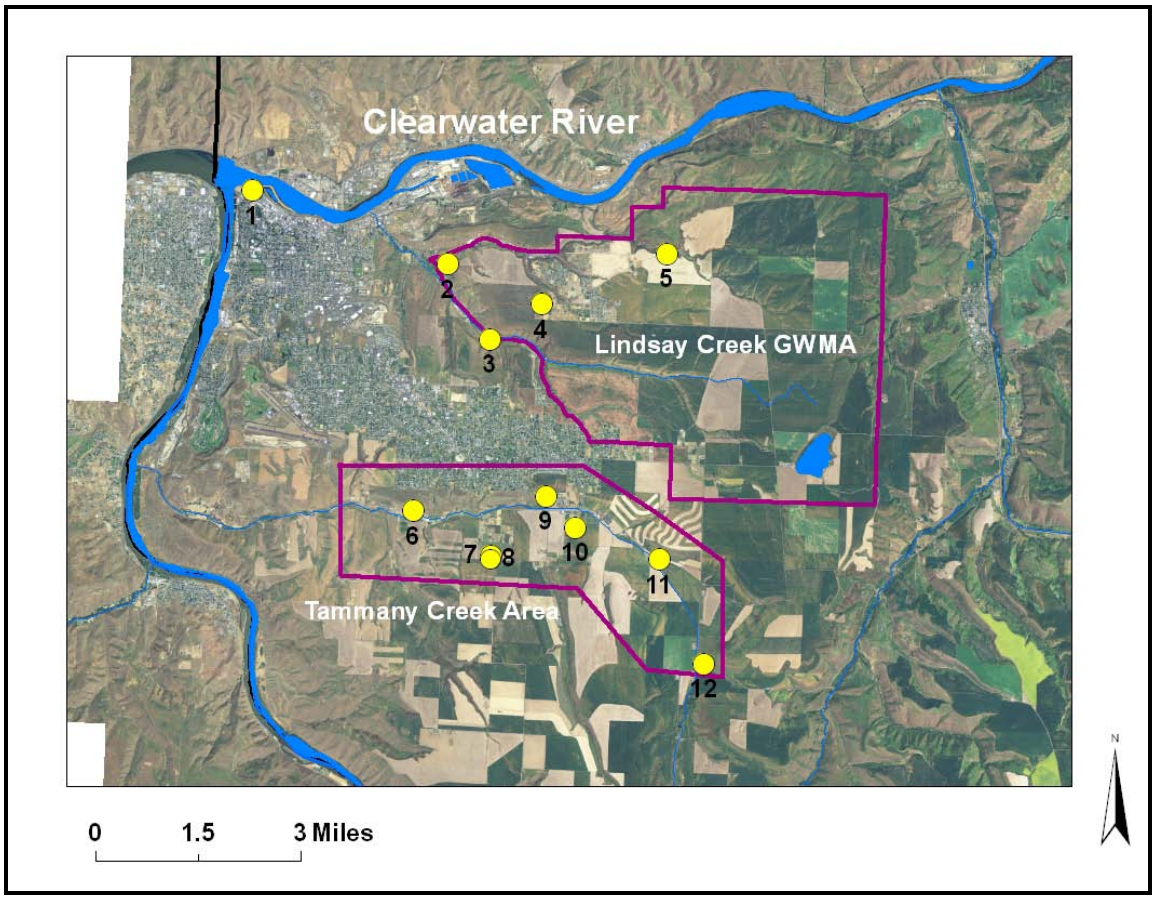


Figure 2 Map showing the 12 wells that are currently being monitored in the Lindsay Creek GWMA, Tammany Creek area, and downtown Lewiston area. Table 1 lists the attributes of these wells.

Summary of Water Level Data

Overall Observations

A review of the monitoring data for 11 wells in the Lindsay Creek GWMA and Tammany Creek area indicates that all have observable water level declines since 2006. However, two wells (one in each area) have exhibited only slight declines (1-3 feet), and both showed recovery in 2011 and early 2012. The maximum (spring) and minimum (fall) water level values were analyzed for changes from 2006 to 2011 because this was the most complete time period of data collection for the wells. The four Lindsay Creek wells had average declines of 3.4 feet and 10.3 feet for the maximum and minimum values, respectively, over the five year period. The seven Tammany Creek wells had average declines of 3.2 feet and 11.7 feet for the maximum and minimum water levels, respectively.

Table 1. List of the wells currently being monitored for ground water levels in the Lindsay Creek GWMA, Tammany Creek area, and downtown Lewiston area.

Well Number[1]	Station Name	Year Drilled	Well Depth (feet)	Open Interval[2] (feet)	Period of Monitoring Data[3]
1	36N 06W 36ADB1	1960	735	190-503 (P), 505-735 (O)	2011-2012
2	35N 05W 04ABC1	2003	600	560-600(P)	2004-2012
3	35N 05W 10BCA1	2005	350	310-350 (P)	2006-2012
4	35N 05W 02CCB1	1991	243	190-230 (P)	2005-2012
5	35N 05W 01AAB1	1987	285	120-140 (P), 160-180 (P), 203-285 (O)	2000-2012
6	35N 05W 21CDB1	1975	190	88-190 (O)	2006-2012
7	35N 05W 27BAB1	1994	448	147-448 (O)	1999-2012
8	35N 05W 27BAB2	1997	323	153-323 (O)	1999-2012
9	35N 05W 23CAC1	1990	279	177-279 (O)	1999-2012
10	35N 05W 23DDB1	1992	355	78-355 (O)	1999-2012
11	35N 05W 25ADD1	1979	585	333-585 (O)	1985-2012
12	35N 04W 31DCCA1	2006	290	270-290 (P)	2007-2012

[1]Well Number as shown on Figure 2.
[2] P = Perforations; O = Open Hole;
[3] Includes measurements made by the USGS and IDWR, but does not include the initial water level reported by the well driller.

Lindsay Creek GWMA

Four wells are currently being monitored for water levels for the Lindsay Creek GWMA (Figure 2). Three of the wells are within the GWMA's boundaries, and one well is just outside the boundary. All of the wells are completed in the shallow perched aquifer system (Wanapum and Saddle Mountain Formations).

Wells 2 and 3 are located along the western edge of the GWMA. Water level measurements in these two wells have shown similar overall declines with minor seasonal cycles (Appendix A). However, the decline in Well 2 is not as steep as Well 3 (Well 2 has been monitored for seven years and has declined about seven feet; Well 3 has been monitored for six years and has declined about 11 feet). Neither well has been visited while being pumped, and none of the measurements have shown large drawdowns in the fall which have occurred in some of the other wells being monitored. Water levels in Well 2 are consistently lower than the levels in Well 3 by about 110 feet, suggesting that the wells may be completed in the same aquifer (Figure 3). Despite the similarities in water level trends between the two wells, the top-of-aquifer elevations more strongly suggest that Well 2 is completed in a deeper aquifer than Well 3 (Figure 4). Furthermore, both wells are completed in deeper aquifers than Well 4 and Well 5 to the east. The similarities in water level trends may simply indicate that Well 2 and Well 3 are both experiencing approximately the same degree of declines even though they are probably completed in separate aquifers.

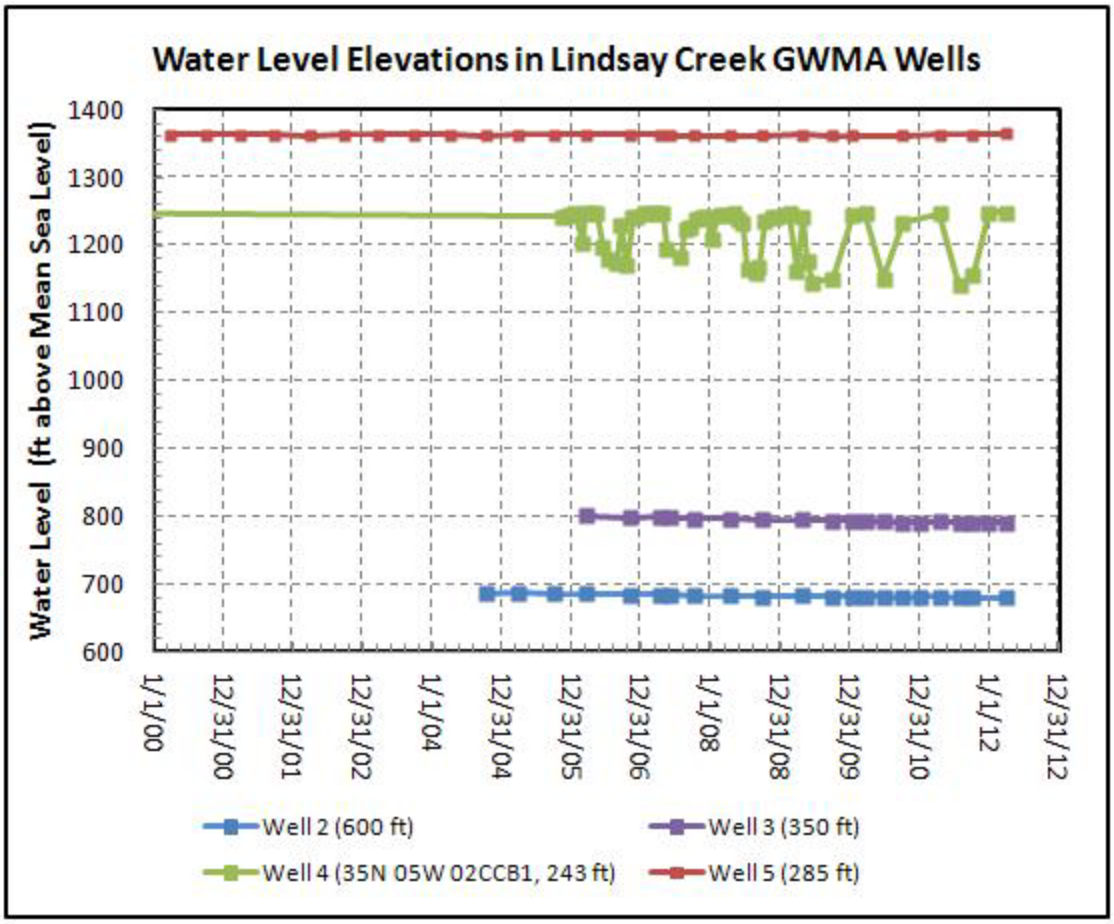


Figure 3. Water levels for four Lindsay Creek Ground Water Management Area wells.

Wells 4 and 5 are located on the plateau to the east and northeast of Wells 2 and 3, and are 300 to 500 feet higher in land surface elevations. The water level elevations for Wells 4 and 5 are also considerably higher than the elevations for Wells 2 and 3 (Figure 3).

Well 4 has a water level trend that is significantly differently than the other three Lindsay Creek GWMA wells (Figure 3 and Appendix A). Maximum water levels have declined less than 0.2 feet since 2006. However, minimum water levels have shown significant declines. Well 4 has been visited several times during pumping or as it is recovering from pumping; at these visits, large drawdowns (about 100 feet) have been observed. Based on the hydrograph (Figure 3), the minimum water levels representing pumping and recovery measurements have declined almost 30 feet since 2006. Furthermore, the difference in maximum water level elevations from Well 4 to Well 3 is about 450 feet, which is a significantly greater than the difference between Wells 2 and 3. Based on the differences in water level elevations and water level trends between Wells 2 and 3, and Well 4, it appears that Well 4 is completed in a perched aquifer that is shallower than the aquifers of Wells 2 and 3.

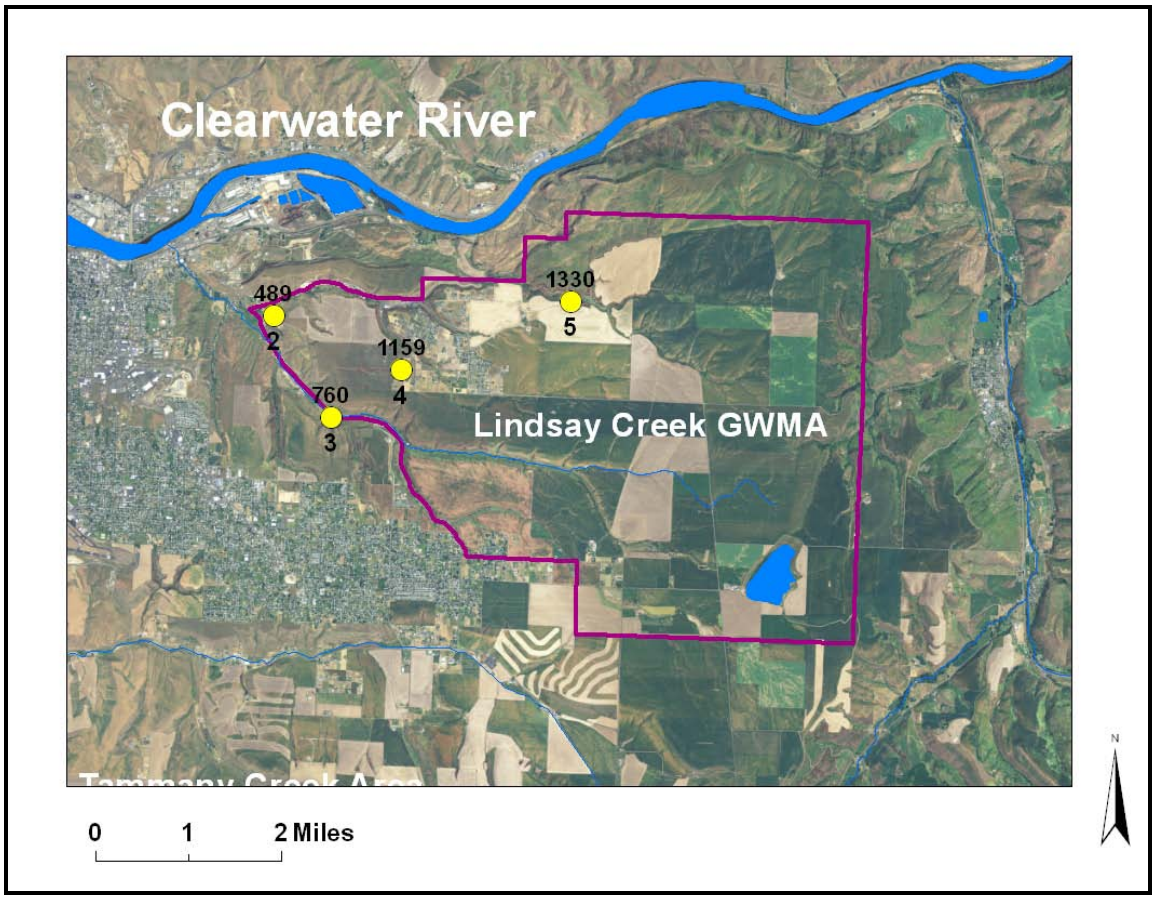


Figure 4. Top-of-aquifer elevations (feet above sea level) for the Lindsay Creek GWMA wells.

Well 5 is located two miles to the northeast of Well 4. Well 5 is unused and about ½ mile from the nearest well in use. Well 5 shows the smallest water level change of the four Lindsay Creek GWMA wells (Appendix A). The water level for Well 5 declined about 1.5 feet from 2000 to 2010, and has risen over 2 feet since early 2011. Based on the water level trends and the top-of-aquifer elevations, it is probable that Well 5 is completed in a shallower aquifer than Well 4.

In summary, the four wells currently monitored for the Lindsay Creek GWMA are producing water from the Wanapum and Saddle Mountain Formations. All four wells have exhibited water level declines since 2006; however, these declines vary in magnitude, and water levels in Well 5 have been recovering since early 2011. Wells 2 and 3 have very similar water level trends, and both have distinct seasonal fluctuations with water levels being highest in the spring and lowest in the fall. Well 4 appears to have some similar seasonal fluctuations as Wells 2 and 3, but it exhibits significant pumping effects which make water level trend analyses less certain. Moreover, maximum water levels in Well 4 have not declined like those of Wells 2 and 3. Well 5 shows very subtle seasonal variations. All four wells have significantly different top-of-aquifer elevations. Based on available data (water level trends, water level elevations, well completion intervals, and top-of-aquifer elevations), it seems probable that all four

wells are completed in separate aquifers with Well 5 completed in the shallowest perched aquifer and each well to the west completed in progressively deeper perched aquifers.

Tammany Creek Area

The Tammany Creek area lies south of the Lindsay Creek GWMA (Figure 1). Tammany Creek originates about three miles south of Well 12, flows north until about a mile north of Well 12, bends to the northwest near Well 11, and then flows almost due west from Well 10 for about 7 miles until it drains into the Snake River (Figure 2). Seven wells are currently being monitored in the Tammany Creek area (Figure 2). Six of the wells have been monitored since at least 1999.

Well 6 is the westernmost well in the Tammany Creek area, and it has had a water level decline of almost 30 feet since 1999 (about 2.3 feet per year) (Appendix A). Well 6 is a community well that services several homes. Seven wells have been drilled or deepened within a mile of Well 6 since 2000, and these wells appear to be completed in the same aquifer.

Wells 7 and 8 have very different water level trends from each other even though they only 150 feet apart, and their total depths differ by only 125 feet (448 feet for Well 7 and 323 feet for Well 8). The maximum level for Well 8 declined 3.55 feet since 2006, and the minimum levels have been occasionally impacted by pumping. Well 7 had only 0.12 feet of decline in the maximum level since 2006, but the minimum level has declined over 42 feet, which is the greatest decline for all of the wells monitored in both the Tammany Creek and Lindsay Creek areas (Appendix A). Well 7 also had seasonal fluctuations of over 150 feet from the maximum to minimum water levels. Unlike some of the other wells, the seasonal minimums for Well 7 do not seem to be related to pumping of the well since it has never been pumping on arrival. Well 8 encountered the shallow aquifer at an elevation of 1,096 feet above mean sea level (amsl). Well 7 encountered the shallow aquifer at an elevation of 1,084 feet amsl and a deeper aquifer at an elevation of 911 feet amsl. The two wells have very different water level elevations and they vary over the course of a year. In the spring, the difference between Wells 7 and 8 is about 210 feet; in the fall, the difference has been up to about 360 feet (Figure 5). Well 8 appears to be in good hydraulic communication with the other Tammany Creek wells based on similarities in the water level elevations and the top-of-aquifer elevations (Figures 6 and 7). However, the water level trends and water level elevations in Well 7 indicate that it is mostly influenced by the conditions of the deeper aquifer. Seven wells have been drilled within ½ mile of Wells 7 and 8 since 2003; three are completed in the shallower aquifer and four are completed in the deeper aquifer.

Well 9 has a water level trend that is slightly different than most of the other wells in the Tammany Creek area. The minimum water level actually increased about seven feet from 2002 to 2006, while the maximum level stayed about the same. Since 2007, both the maximum and minimum have declined abruptly, about 10 and 20 feet, respectively. Furthermore, the difference between the maximum and minimum values in the annual cycle has increased over the last couple years. One new well has been drilled within ¼

mile of Well 9 since 2003, and it produces from the same aquifer. Several new wells have been drilled since 2000 to the northeast of Well 9 at a distance of about 1.25 miles.

Well 10 had a decline in the maximum value of 10.5 feet from 1999 to 2011, which equates to 0.8 feet per year. The water level in this well is significantly affected by pumping. Water levels taken during the recovery phase after pumping are 50 to 110 feet lower than non-pumping levels.

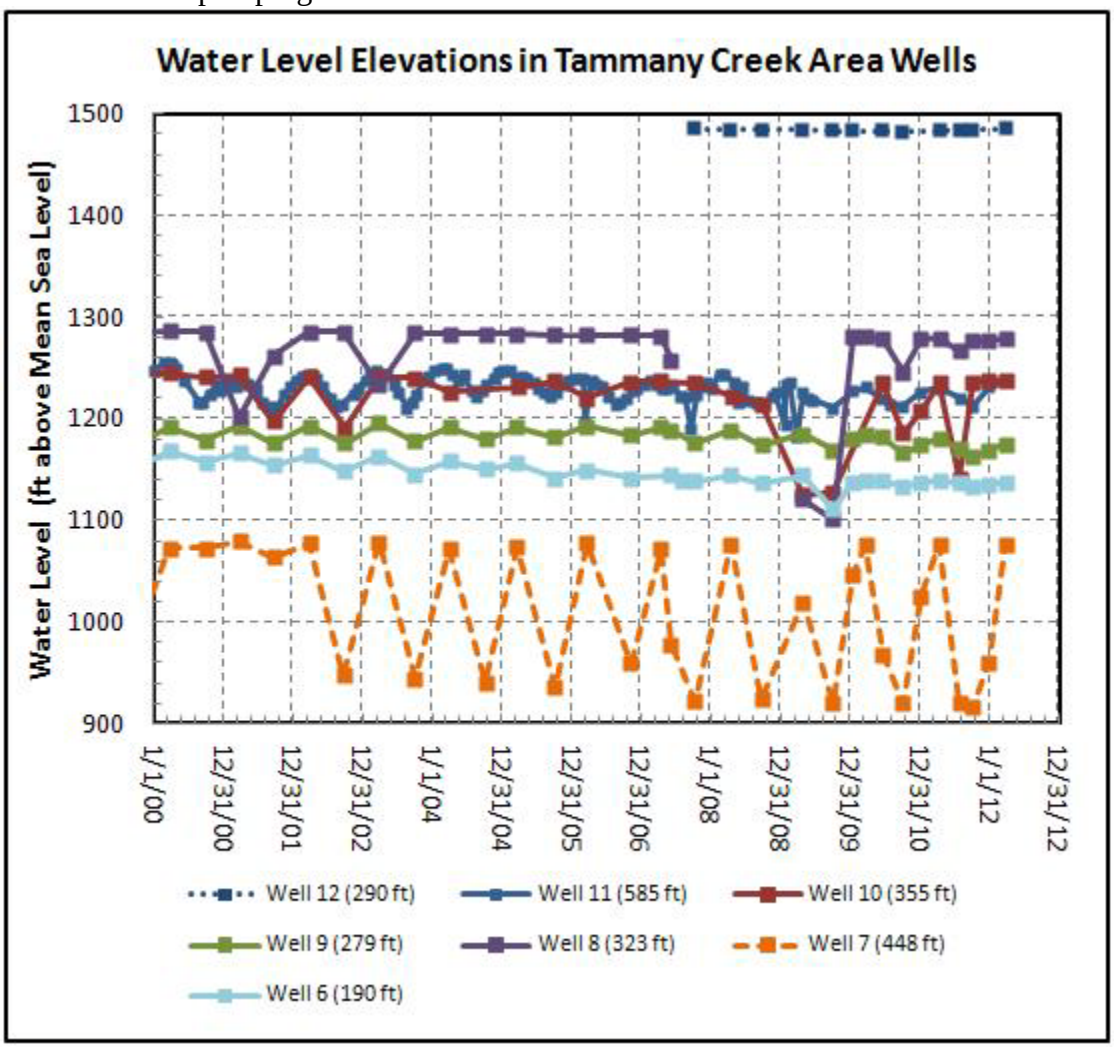


Figure 5. Water levels for seven Tammany Creek area monitoring wells.

Well 11 was measured by the USGS on an irregular basis from 1985 to 1999, and then on a monthly basis as part of the IDWR/USGS Cooperative Water Level Measuring Program until 2009 when IDWR assumed the measurement responsibilities. The water level declined about 100 feet from 1985 to 1999. Beginning in 1999, the water levels increased for a few years, then began gradually decreasing in 2005. This pattern shows some similarities to Well 9.

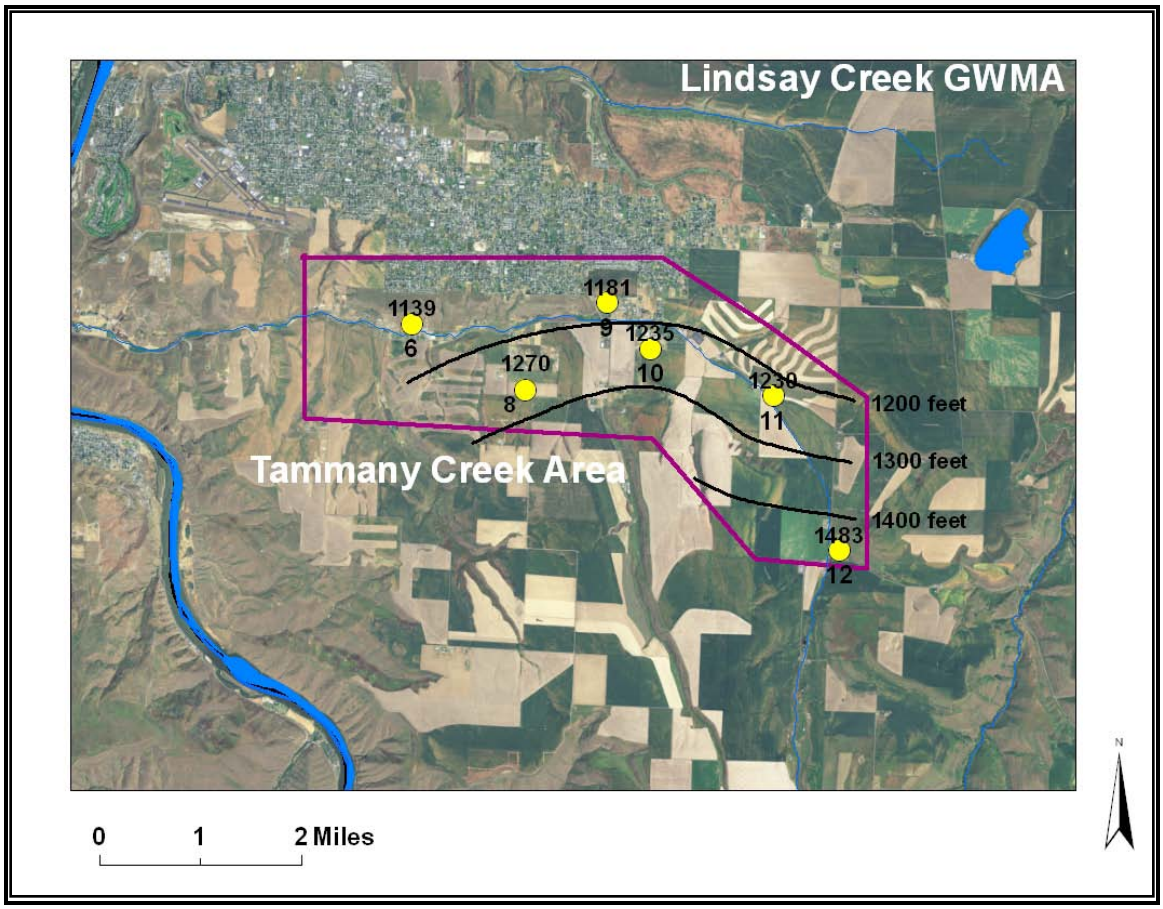


Figure 6. Water level elevation contour map for the Tammany Creek Area. April 2011 (Well 7 is not included in the analysis because it is completed in a deeper aquifer than the other six wells).

Well 12 was drilled in 2006 and has been monitored since late 2007. Water levels declined a little more than 2 feet from 2007 to late 2010. Since early 2011, water levels have risen, and by early 2012, the levels were actually higher than in 2007. The water level elevation is considerably higher than all of the other Tammany Creek monitoring wells. However, contouring all of the Tammany Creek wells (except Well 7) produces a relatively continuous water-table surface (Figure 6) suggesting that Well 12 is in the same aquifer. However, the top-of-aquifer elevation for Well 12 is about 375 feet higher than the other wells (Figure 7). Based on the top-of-aquifer elevation, it seems likely that Well 12 is completed in a shallower aquifer than the other Tammany Creek monitoring wells. Few other wells exist near Well 12, and only one new well has been drilled within a mile of it since 2006.

In summary, all of the Tammany Creek monitoring wells have shown varying declines in water levels, with one well exhibiting recovery in water levels since early 2011. Based on three pieces of evidence (similarities in water level trends (Figure 5), water level elevation contouring (Figure 6), and similarities in top-of-aquifer elevations (Figure 7), it appears that five of the wells (6, 8, 9, 10, and 11) are in good hydraulic communication and probably completed in the same aquifer. However, well 12 is most likely completed

in a shallower aquifer and Well 7 is open to the same aquifer as the five wells and a deeper aquifer.

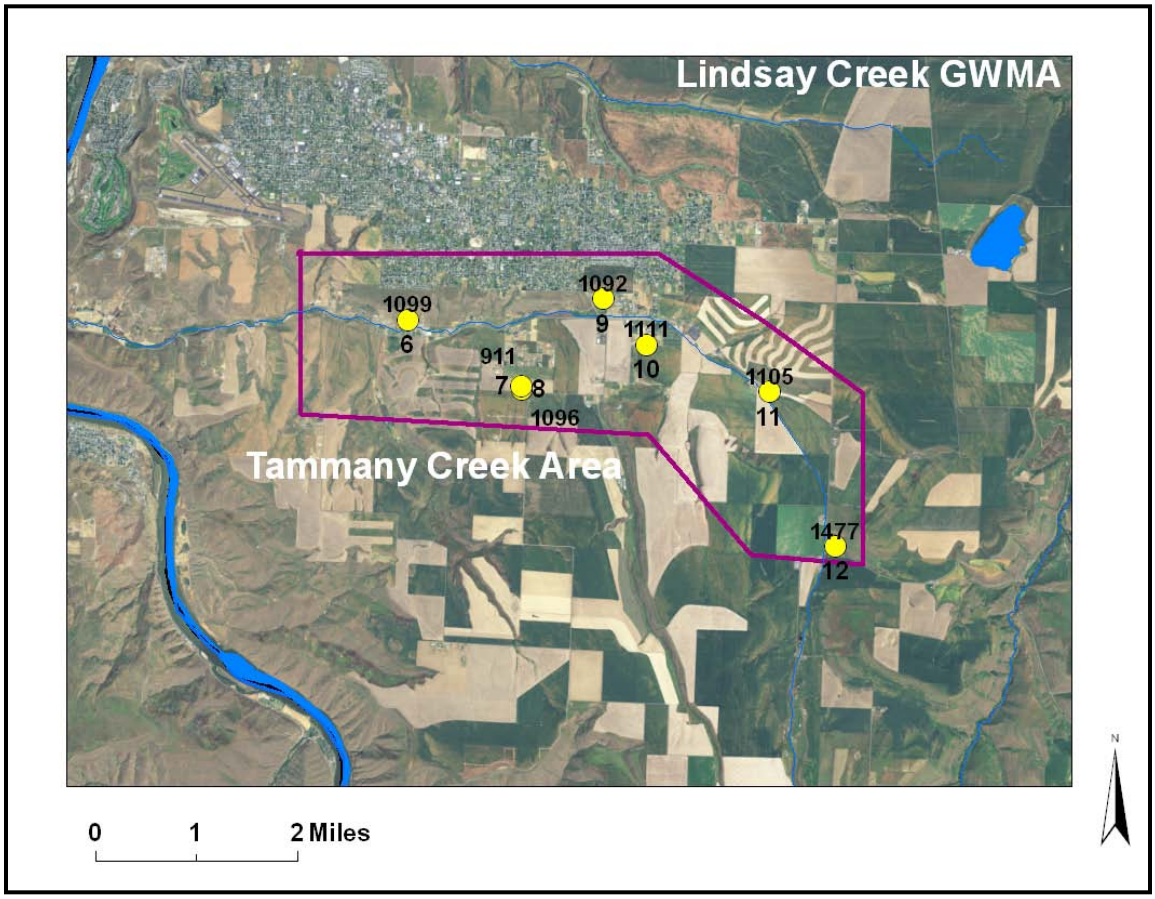


Figure 7. Top-of-aquifer elevations for the Tammany Creek wells.

Water Level Changes, 2006-2011

An analysis of the data collected from 2006 to 2011 was conducted to evaluate changes in water levels at the 11 wells monitored for the Lindsay Creek GWMA and Tammany Creek area. This time interval was selected because it has the most complete record for the majority of the wells. Well 1 is not included in this analysis because it has been monitored for less than one year. The data used for Well 12 are between 2008 and 2011 because monitoring did not begin until the fall of 2007.

The maximum water level in the Lindsay Creek and Tammany Creek wells typically occurs in the spring each year, and the minimum water level occurs in the fall. Table 2 shows the changes in the maximum and minimum values for the wells in the Lindsay Creek and Tammany Creek areas. Nineteen of the 22 changes were declines in water levels, with 13 declines greater than 3 feet. For the Lindsay Creek GWMA, the average decline in the maximum for the four wells was 3.4 feet, and the average decline in the minimum was 10.3 feet. In the Tammany Creek area, the average decline in the maximum for the seven wells was 3.2 feet, and the average decline in the minimum was

11.7 feet. Figures 8 and 9 show the changes in the maximum and minimum values. In some cases, the observed changes between nearby wells are comparable, such as Wells 2 and 3, and Wells 6 and 9. However, the rest of the observations vary greatly from well to well. These variabilities are probably attributable to local pumping effects at individual wells and to the fact that the wells are completed in several different perched aquifers.

Table 2. Changes in the maximum and minimum water levels between 2006 and 2011.

Well Number	Station Name	Change in Maximum (feet)	Change in Minimum (feet)
2	35N 05W 04ABC1	-4.50	-4.05
3	35N 05W 10BCA1	-9.26	-7.90
4	35N 05W 02CCB1	-0.15	-29.70
5	35N 05W 01AAB1	0.20	0.52
6	35N 05W 21CDB1	-9.97	-9.26
7	35N 05W 27BAB1	-0.12	-42.60
8	35N 05W 27BAB2	-3.55	-6.06
9	35N 05W 23CAC1	-11.6	-20.98
10	35N 05W 23DDB1	15.34	-0.59
11	35N 05W 25ADD1	-10.51	-1.53
12	35N 04W 31DCCA1	-1.75	-0.62

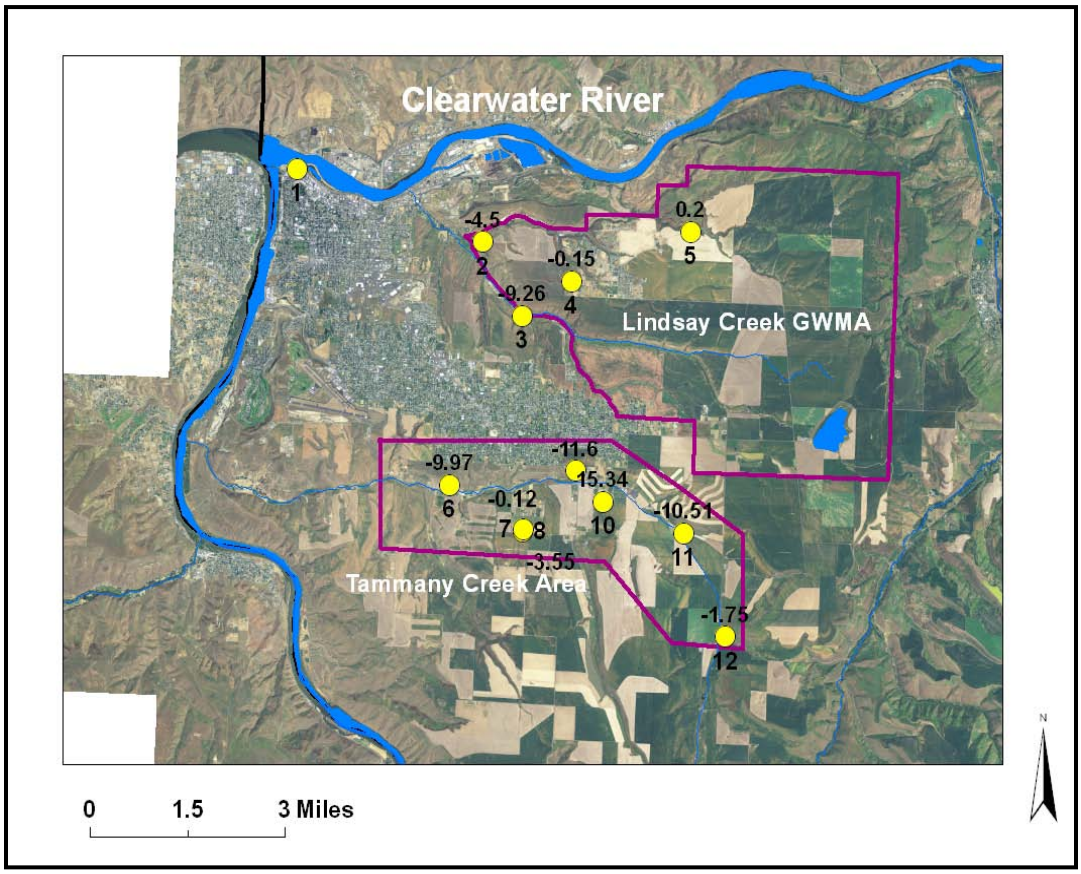


Figure 8. Maximum water level changes between spring 2006 and spring 2011.

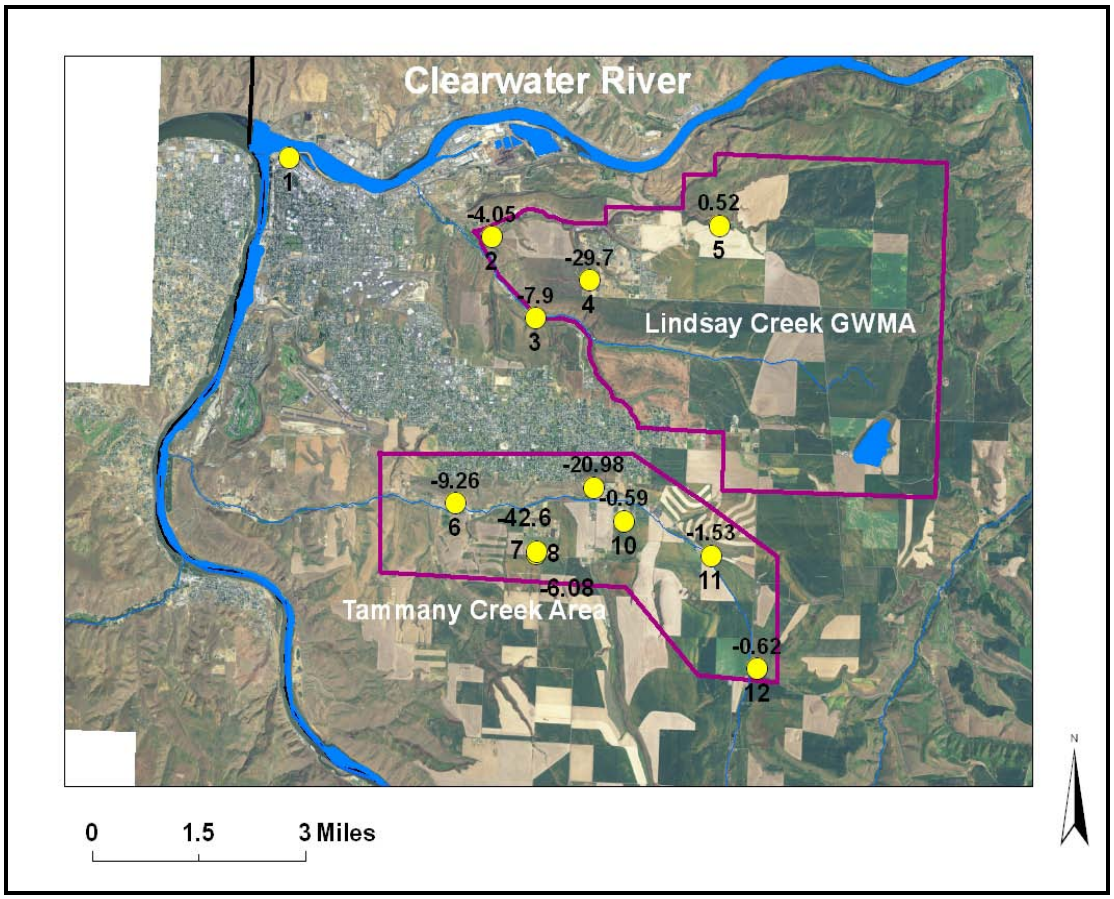


Figure 9. Minimum water level changes between fall 2006 and fall 2011.

Conclusions

Ground water level monitoring in the Lindsay Creek GWMA and the Tammany Creek area indicates that the shallow perched aquifers of the Wanapum and Saddle Mountains Formations have experienced declines in water levels since at least 2000. The largest water level declines are in locations where at least 40 new domestic wells that have been drilled since 2003. The eastern part of the Lindsay Creek GWMA and the southeastern part of the Tammany Creek area have shown lesser declines and have actually had water level recoveries since late 2010. These locations are characterized by very low densities of nearby wells, and few new well constructions in the last 10 years.

The shallow aquifer system in these two areas is a sequence of perched aquifers that probably become progressively more water-limited with depth. The four Lindsay Creek monitoring wells may be completed in four separate perched aquifers, with the shallowest aquifer in the easternmost well, and the aquifers getting progressively deeper to the west. In Tammany Creek, it is likely that the seven monitoring wells are completed in three different aquifers, with Well 12 completed in the shallowest aquifer, Wells 6, 8, 9, 10,

and 11 completed in the main perched aquifer, and Well 7 completed in both the main perched aquifer and a deeper aquifer. Well 7 had the largest decline in minimum water levels which supports the hypothesis that the deeper aquifers are more water-limited, at least at this location.

The complex nature of the shallow perched aquifer system in the Lindsay Creek and Tammany Creek areas warrants additional monitoring wells. If several strategically-located wells are added to the network, the result may be a better understanding of the water level declines observed thus far. Ultimately, this may help determine whether additional management policies are needed to protect these ground water resources.

Recommendations

1. Continue water level measurements at all 12 wells on a quarterly basis.

2. Maintain the pressure transducer in Well 1 until at least December 2013.

3. Add up to six wells to the monitoring network. Potential locations for these wells are:

    a. Two wells near Well 2. Thirteen wells have been drilled within ¾ mile of Well 2 from 2002 to 2011. A well to the northeast of Well 2 would be a good addition to the network. Two wells with depths of 230 feet and 405 feet are the top choices. Another well between Wells 2 and 3 could be added. The top choices are a 352-foot well and a 275-foot well.

    b. One or two wells near Well 4. There are over a dozen wells in the area drilled before 2002 with total depths ranging from 220 feet to 475 feet. Since the wells are older and owner changes may have occurred since they were drilled, it may be challenging to find and identify them in the field. Two wells have been drilled within ¼ mile of Well 4 since 2002, but both are considerably deeper than Well 4 (890 feet and 981 feet). These wells are probably completed in the base of the Wanapum Formation, whereas Well 4 is most likely completed in the Saddle Mountains Formation. Two other deep (875 feet and 1,200 feet) wells are to the northeast and east of Well 4. It may be beneficial to add one of these four deeper wells to the network because they could be in hydraulic communication with the aquifers of Well 2 or Well 3.

    c. Two wells northeast of Well 9 and slightly south of the Lindsay Creek GWMA boundary. There are at least 12 wells with depths ranging from 165 feet to 275 feet, with most of the depths being around 200-225 feet.

These wells were drilled from 1998 to 2003, and most were drilled in 1999. There are also eight wells with depths ranging from 703 feet to 950 feet. These wells are probably completed in the base of the Wanapum Formation; however, it is possible that they reached the top of the Grande Ronde Formation, and thus are producing from the regional aquifer. Adding both a shallow and a deep well to the network is recommended.

4. Investigate options for developing a management plan for the area, and for the formation of an advisory committee.

5. Repeat this analysis and complete a new status report in five years (2017).

Acknowledgements

I extend sincere thanks to the report's technical reviewers: Rick Raymondi, Sean Vincent, and Mike McVay, all employees at the Idaho Department of Water Resources. Appreciation is also expressed to Dr. Dale Ralston for the time he provided to discuss the Lewiston hydrology with me.

References

Bond, J. G. and D. R. Ralston, 1977, Lewiston Orchards Groundwater Potential and Well Site Location Study: Unpublished Consulting Report, Moscow, Idaho, 17 p.

Castelin, PM., 1976, Reconnaissance of the Water Resources of the Clearwater Plateau, Nez Perce, Lewis and Northern Idaho Counties, Idaho: Idaho Department of Water Resources, Water Information Bulletin No. 41. (http://www.idwr.idaho.gov/WaterInformation/Publications/wib/wib41-clearwater_plateau.pdf)

City of Lewiston, 2010. Drinking Water Source Protection Plan for the City of Lewiston & Lewiston Orchards Irrigation District. City of Lewiston in collaboration with the Asotin County Public Utility District, Clarkston, WA, 123 p. (http://www.cityoflewiston.org/DocumentView.aspx?DID=1488)

Cohen, P.L., and Ralston, D., 1980. Reconnaissance study of the "Russell" Basalt aquifer in the Lewiston basin of Idaho and Washington, Idaho. Water Resources Research Institute Research Technical Completion Report, submitted to Idaho Department of Water Resources and Idaho Department of Health and Welfare, Division of Environment, 165 p. (http://pbadupws.nrc.gov/docs/ML0326/ML032680737.pdf)

Crosthwaite, E.G. 1989. Results of Testing Exploratory Wells, Nez Perce Reservation, ID. Contractor (P.G.) report.

Douglas, A., Winter, G., Baldwin, J., and Brackney, K., 2005. Isotopic Age Dating of Municipal Water Wells in the Lewiston Basin, Idaho Nez Perce Tribe. Idaho Department of Environmental Quality, Lewiston Regional Office, Ground Water Quality Technical Report 24, 31 p. (http://www.deq.idaho.gov/media/470695-_water_data_reports_ground_water_isotopic_age_dating_lewiston_basin_24.pdf)

Eliason, J. R., 1997. Hydrogeologic Analysis of the Lewiston Orchards Irrigation District #3 Well. Wyatt-Jaykim Engineers.

EPA; 1988; Support Document for Designation of the Lewiston Basin Aquifer as a Sole Source Aquifer. Office of Groundwater. EPA 910/0-88-194.

Harrington, H., and Bendixsen, S., 1999. Groundwater Management Areas in Idaho: Overview as of 1998. Idaho Department of Water Resources Open-File Report, 66 p. (http://www.idwr.idaho.gov/WaterInformation/Publications/ofr/ofr-gwma_rpt.pdf)

Hooper, P.R., Webster, G.D., and Camp, V.E., 1985. Geologic map of the Clarkston 15-minute quadrangle, Washington and Idaho. Washington Division of Geology and Earth Resources Geologic Map GM-31, 48 p., and 1 sheet.

Hydrology Program; 1984; Analysis of Aquifer Test Data from the Grande Ronde Formation, Clarkston, Washington, and Lewiston Idaho. Department of Geology and Geological Engineering, University of Idaho, Moscow, Idaho 83843.

Idaho Department of Water Resources, 1992. Order in the Matter of Designating the Lindsay Creek Management Area. Idaho Department of Water Resources, 7 p. (http://www.idwr.idaho.gov/WaterInformation/GroundWaterManagement/LindsayCreek/PDFs/lc_gwma-order_create.pdf)

Melton, W., 1997. Russell Sole Source Aquifer Ground Water Monitoring. Idaho Department of Environmental Quality, Lewiston Regional Office, Ground Water Quality Technical Report 9,19 p. (http://www.deq.idaho.gov/media/470627-_water_data_reports_ground_water_russell_sole_source_aquifer.pdf)

Ralston, D., 2011. Evaluation of Ground Water Development Potential for LOID Irrigation Water from the Regional Aquifer in the Lewiston Basin, Idaho.

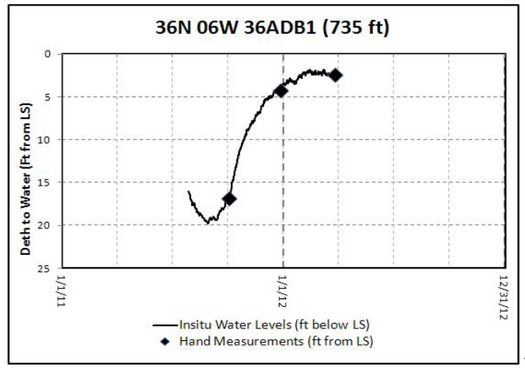
Stevens, G.R., 1994. Evaluation of the Groundwater Resources within the Lewiston Basin, M.S. Thesis, University of Idaho, Moscow, Idaho.

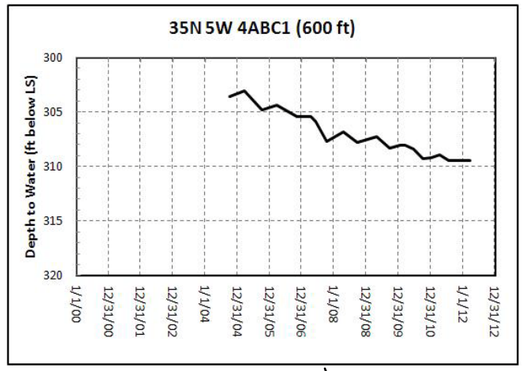
Williams, B.R., Nimmer, R., Osiensky, J., Owen, M., and McKenna, J., 2001. Clearwater Basin Source Water Assessment Report. Prepared for Idaho Water Resources Institute; submitted to DEQ by the Lewiston Regional Office.

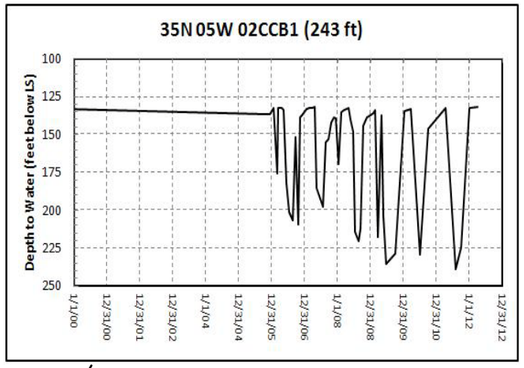
Wyatt, D. R., Bond, J., Elaison, J., Ralston, D., and Stevens, G.R., 1994. Lewiston Basin Deep Aquifer Study. Wyatt-Jaykim Engineers. Lewiston, Idaho. 177 p.

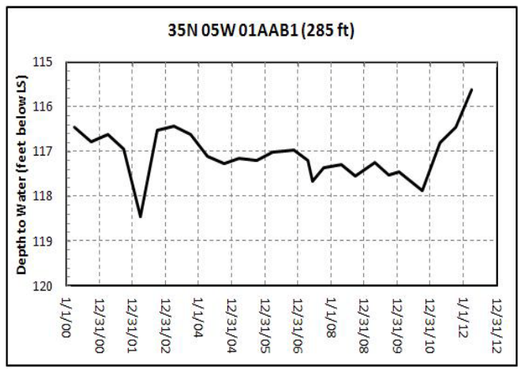
APPENDIX A

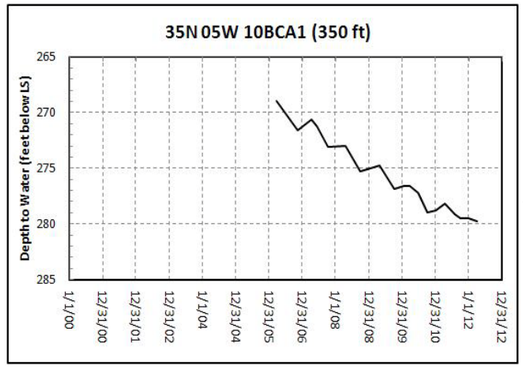
HYDROGRAPHS OF LINDSAY CREEK AND TAMMANY CREEK GROUND WATER LEVEL MONITORING NETWORK

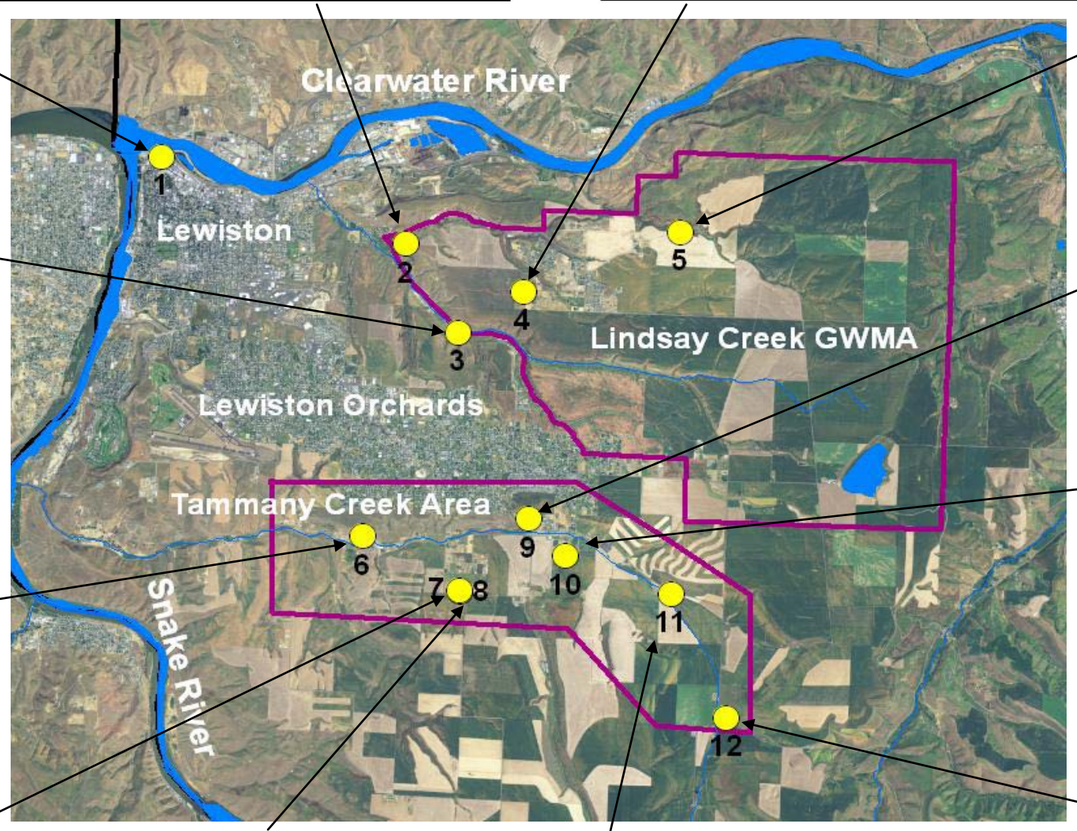

36N 06W 36ADB1 (735 ft)
Deth to Water (Ft from LS)
Insitu Water Levels (ft below LS)
Hand Measurements (ft from LS)

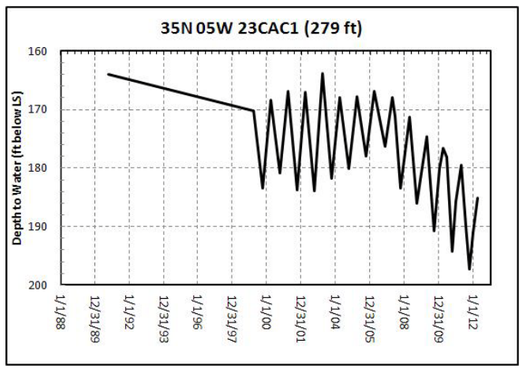

35N 5W 4ABC1 (600 ft)
Depth to Water (ft below LS)

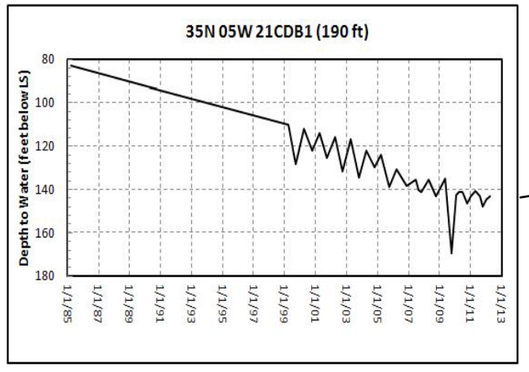

35N 05W 02CCB1 (243 ft)
Depth to Water (feet below LS)

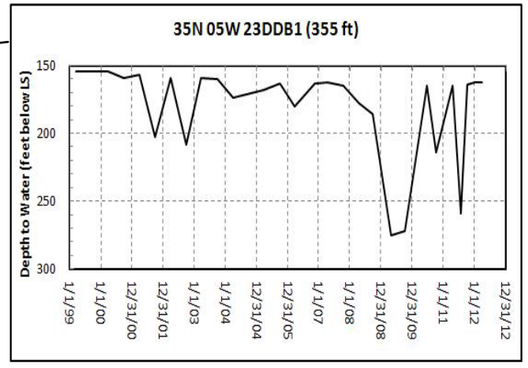

35N 05W 01AAB1 (285 ft)
Depth to Water (feet below LS)

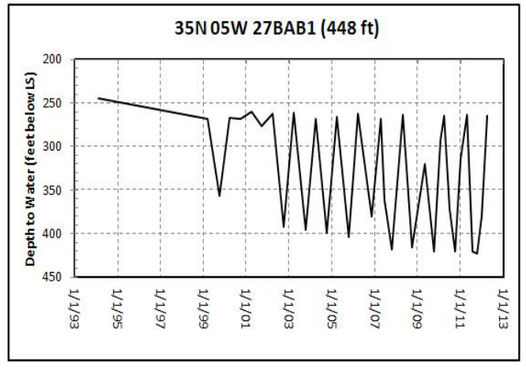

35N 05W 10BCA1 (350 ft)
Depth to Water (feet below LS)

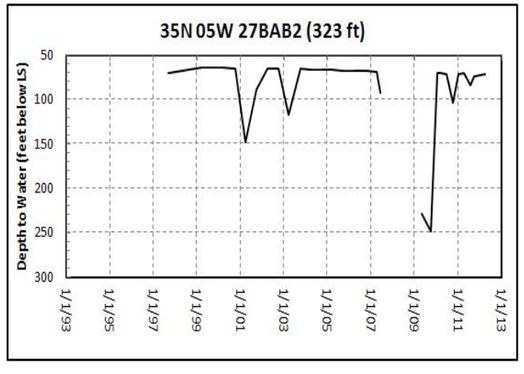

Clearwater River
Lewiston
Lewiston Orchards
Tammany Creek Area
Lindsay Creek GWMA
Snake River
1
2
3
4
5
6
7
8
9
10
11
12

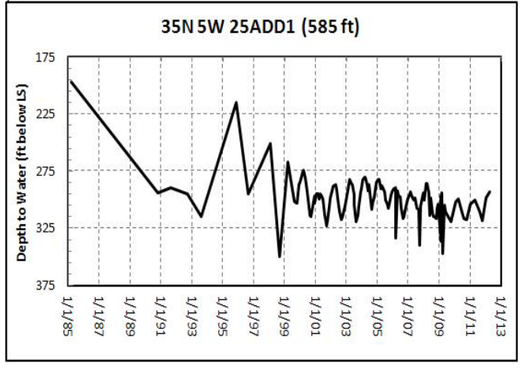

35N 05W 23CAC1 (279 ft)
Depth to Water (ft below LS)

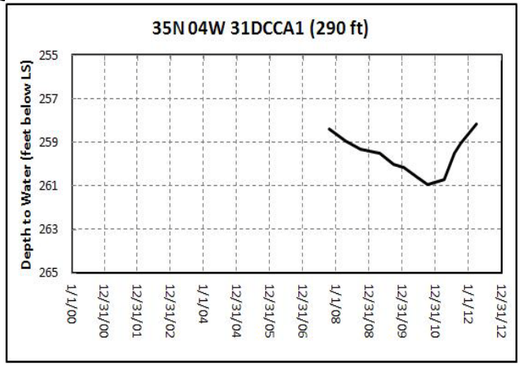

35N 05W 21CDB1 (190 ft)
Depth to Water (feet below LS)


35N 05W 23DDB1 (355 ft)
Depth to Water (feet below LS)


35N 05W 27BAB1 (448 ft)
Depth to Water (feet below LS)


35N 05W 27BAB2 (323 ft)
Depth to Water (feet below LS)


35N 5W 25ADD1 (585 ft)
Depth to Water (ft below LS)


35N 04W 31DCCA1 (290 ft)
Depth to Water (feet below LS)