BUCKINGHAM TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

ANNUAL GROUNDWATER WITHDRAWAL AND MONITORING REPORT

FOR 2014

Prepared For:

Buckingham Township
4613 Hughesian Drive
P.O. Box 413
Buckingham, PA 18912

Prepared By:

INTEX Environmental Group, Inc.
6907A Easton Road
Pipersville, PA 18947-1025
Ph: 215.766.7230 ▪ Fax: 215.766.9730

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Buckingham Township
Annual Groundwater Withdrawal and Monitoring Report for 2014

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1.0 Introduction and Summary

1.1 Introduction

Buckingham Township is located in the Ground Water Protected Area of the Delaware River Basin. Buckingham Township provides water to many of its residents from the aquifers within the Township. In order to comply with the requirements of the Delaware River Basin Commission (DRBC), Buckingham must provide an annual hydrogeologic report. The report should evaluate the ground water production from a group of pumping wells, establish any effect of groundwater production on the aquifers present within the Township and describe the hydrologic and geologic impacts on the aquifers in the Ground Water Protected Area. The purpose of this report is to satisfy the DRBC requirements for the year 2014. Although the Lahaska wells (L-1 and L-2) are on the Buckingham Township Docket, they are owned and controlled by the Peddlers Village Partnership. The Mill Creek Wells (FG-1 and FG-2), formerly known as the Forest Grove Wells, came on-line this year.

1.2 Summary

Buckingham Township produced 260,606,390 gallons of water from seventeen 17 of 20 Township-operated production wells during 2014, and 232,838,000 gallons from the same production wells in 2013. This is an increase of 27,768,390 gallons (11.9%) from 2013 to 2014 and an increase of 33,409,390 gallons (14.7%) from 2010 to 2014. Although, disregarding the production from the Lahaska wells (L-1 and L-2), which are not owned by the Township, Buckingham Township produced a total of 241,030,000 gallons of water during 2014. This is an increase of 8,192,000 gallons (3.5%) from 2013 to 2014. The total monthly production for the years 2007-2014 from Buckingham's production wells is shown in Figure 1. Figure 1 shows that seasonal variation in production continues to be the most significant variable for all seven years. From 2007 through 2014, production has been highest in the late spring, summer and early fall and lowest in the cold, shortest month of February. In July of 2010, groundwater production in Buckingham Township exceeded 25,000,000 gallons for the first time. In July of 2011, groundwater production exceeded 30,000,000 gallons for the first time. For July 2013 and 2014, production was 22,969,000 and 25,344,600 gallons.

The total annual ground water production from 1997 through 2014 is shown in Figure 2. The most production (236,219,680 gallons) was in 2012, until 2014, when 260,606,390 gallons of water were produced. A comparison of the production from the BV (Buckingham Village) wells, the CS (Cold Spring) wells and the FS (Fieldstone) wells between 2005 and 2014 can be seen in Figures 3, 4 and 5. The Furlong wells, which had limited production before 2003, are illustrated in Figure 6. One of these wells, F-6, has since been dropped from the Furlong production well system because of poor performance.

A new well in 2010, F-9 is reserved as an emergency backup well and was not used at all in 2014. F-9 is temporarily piped to the Furlong System. The piping remains mostly in place in case the well needs to be reactivated during a water shortage emergency. All of the F-9 treatment systems remain in place and are ready if needed. The other newest well, F-8, is connected to the Furlong System and has been operational since June of 2011.

The Buckingham Village, Cold Spring and Fieldstone wells are believed to be producing from the Stockton Formation. However, wells BV-1 and BV-2 are located very close, approximately 750 feet, to the surface contact with the underlying Paleozoic carbonate rocks. The contact between the Stockton and the limestone is an erosional unconformity with associated karst features that commonly store significant amounts of groundwater. There is evidence that the Buckingham Village wells penetrate carbonate rocks at their lowest depths. It is very likely that some of the water being produced from BV-1 and BV-2 is coming from the underlying carbonate rocks. Furlong wells F-1 through 7 produce mainly from the Brunswick Formation with some intermixed Lockatong facies. However, there is also evidence that wells F-1 and F-3, drilled in close proximity to the Furlong-Flemington Fault, may have penetrated into the underlying carbonate rocks. Wells F-8 and F-9 are developed in the Allentown and Leithsville Formations, respectively. Both of these formations are carbonate and are located within the Buckingham Valley.

Forty-one (41) observation wells, one pond, and one stream gauge are monitored on a regular (monthly) basis to evaluate potential impacts of the production wells in Buckingham Township on the aquifers (see Table 1). Nine (9) of these wells are in addition to the originally established network. These observation wells serve the area of the Buckingham Village wells, the Cold Spring wells, the Fieldstone wells, the Forest Grove wells, and the Furlong production wells. Since March 2005, several additional wells have been added to monitor the Furlong wells. The behavior of these observation points is illustrated in Figures 9 through 13, and 15.

Two wells on the Buckingham Township docket, Lahaska wells L-1 and L-2, are owned and operated by Peddlers Village Partnership. These two wells produced a total of 19,576,390 gallons in 2014 a slight decrease from the 20,986,010 gallons in 2013. Buckingham Township monitors six wells in the Lahaska area. LM-1, 5, 7 and 8 have been removed from the network because of access problems or requests by the homeowners over the years. The depth-to-water in the six Lahaska observation wells is shown in Figure 14.These production wells in the past have not been included in the total production for the year, however, this year they are being accounted for. This explains the large increase in production for the current year.

2.0 Regional Geology

The majority of Buckingham Township is located in the Triassic Lowlands Physiographic Province of southeastern Pennsylvania. The Triassic Lowlands Province covers a large portion of southeastern Pennsylvania and is composed of continental sedimentary rocks and associated igneous rocks of the Newark Supergroup. The ages of the Newark rocks are believed to span the late Triassic through early Jurassic (Olsen, 1980).

Rocks of the Triassic Period in Bucks County were formed by deposition in the Newark-Gettysburg Basin, which is one of a series of 20 disconnected, major and minor basins between Nova Scotia and Georgia. The Newark-Gettysburg Basin is the largest of the Triassic Basins exposed above sea level. It covers an area of 7,770 square kilometers (Tappert, 1986). The outcrop belt of the Triassic rocks in the Newark-Gettysburg Basin is widest in Bucks County (>50 km.). Red and gray clastics (shales, siltstones and argillites) are the dominant sediments and the igneous rocks include diabase dikes, sills and basalt flows. These rocks have been divided into the Stockton, Lockatong and Brunswick (Passaic) Formations.

The rocks in the basin are severed by several normal faults, such as the Furlong-Flemington and Chalfont Faults, and the fault blocks have been tilted toward the northwest between 5 and 25 degrees. The average dip of the bedding planes is approximately 14 degrees towards the northwest, although there is considerable variation to the strike and dip. Joints are common and along with bedding planes and fractures, provides much of the secondary porosity that acts as aquifer storage. The discontinuities also result in the aquifer being classified as "leaky" for purposes of analysis.

The most reliable aquifer in Buckingham Township is the Stockton Formation. The Stockton is divisible into three members (Rima, Meisler and Longwell, 1962). The three members are: (1) the lower arkosic member, (2) the middle finer arkose and (3) the upper shale member. In general, wells developed in the course, arkosic facies are most dependable.

Lower Paleozoic quartzite and limestone are exposed on Buckingham Mountain and in the limestone valley northwest of the mountain. The Furlong-Flemington Fault is a normal fault that exposes these lower Paleozoic rocks on the upthrown side of the fault (Faill, 1973).

3.0 Production Wells

3.1 Introduction

During 2014, groundwater was pumped from 17 wells operated by Buckingham Township, identified as BV-1, BV-2, CS-1, CS-2, CS-3, CS-4, FS-1, FS-2, F-1, F-2, F-3, F-4, F-5, F-7, F-8, FG-1 and FG-2, and from two wells owned and operated by Peddlers Village Partnership, identified as L-1 and L-2. The locations of the wells that were producing in 2014 (as well as F-9, a well relegated to emergency use and not used in 2014) are shown on the map inside the back cover of this report. The Township's Consolidated Docket (D2003-13 CP-6, dated March 6, 2013) covers these 19 wells, and includes un-used well F-6 and idle well F-9 in the Furlong system, and Cold Spring system idle well.

The locations of the 17 active wells, their docketed allocations, and networks of observation wells and gauge station are summarized in Table 1. The production from the 19 wells (17 operated by Buckingham Township and the two Lahaska wells) for 2014 is summarized in Table 2, along with the Docket limits. None of the wells exceeded their docket limits during 2014, and the system total monthly and annual docket limits were not exceeded during 2014.

3.2 Buckingham Village (BV) Wells

The maximum monthly production from the two Buckingham Village (BV) wells for 2014 was 1,212,000 gallons in July, which is approximately 26.68% of the allowable limit permitted in the docket. The data presented in Figure 3 reveal that groundwater production from the BV wells was somewhat greater than expected during the months of June, July, August and September in 2011. This was likely the result of a major leak that was repaired in September 2011. The quantity of the loss resulting from the June through September leak is not known. The productions from the two BV wells since the year 2005 along with the allowable limits are illustrated in Figure 3.

3.3 Cold Spring (CS) Wells

Wells CS-1, CS-2, CS-3, and CS-4 combined to produce a monthly maximum of 11,286,000 gallons in August 2014, or 58.72% of the permitted monthly allocation. The production data for wells CS-1, CS-2, CS-3, and CS-4 (since 2005) are shown in Figure 4. Well CS-5 is planned to supplement the existing four wells serving the Cold Spring system in the future.

3.4 Fieldstone (FS) Wells

Fieldstone wells FS-1 and FS-2 are consistent producers; however, their production is always well below their permit limits. In 2014 the maximum combined production occurred in January at 569,000 gallons, which is 30.59% of the docket limit. Figure 5 shows that these wells produce consistently through the years with very little change until May of 2011 through the end of 2012, when Fieldstone production reached its highest. This was likely the result of replacing an errant water meter on May 11, 2011. The degree of the error resulting from the replaced meter was not known; however, production from the Fieldstone wells was significantly higher in 2012 relative to other years, including 2014.

3.5 Furlong (F) Wells

The maximum production from Furlong system wells F-1, F-3, F-4 and F-5 occurred in July at 3.019, 0.682, 1.188, and 0.801 mg. These maximums are 62.16%, 41.51%, 33.32%, and 44.80% of the wells' monthly docket limits. The maximum production from wells F-2, F-7, and F-8 occurred in July, March, and October at 0.373, 0.481, and 5.165 mg. These maximums are 31.11%, 21.55%, 94.13% of the wells' monthly docket limits. Figure 6 shows that these wells production have been consistent through the years, however, the amount produced in 2014 is slightly higher than it has been in past years.

Well F-9 will continue to be held out as an emergency water source for the Furlong area, although it remained inactive throughout 2014. Figure 6 shows the combined production from the Furlong area wells.

3.6 Mill Creek Wells (Former Forest Grove (FG) Wells)

The Estates of Mill Creek (Forest Grove) Development has two wells completed in the Brunswick (Passaic) Formation that are close to the Chalfont Fault. These wells are now in production and the PA DEP permit was renewed in July of 2010 by the developer. The monitoring program is still in effect as of the writing of this report, at the request and expense of the developer. The wells began operating in June of 2014. The maximum production from the Mill Creek (Forest Grove) System Wells FG-1 and FG-2 occurred in September at 0.293 and 0.116 mg. These maximums are 28.36 and 11.23 percent of the wells' monthly docket limits. Figure 7 shows that these wells' production have been consistent through the years, although, the amount produced in 2014 is slightly higher than it has been in past years. Figure 7 shows the combined production from the Mill Creek wells.

3.7 Lahaska (L-1 & L-2) Wells

The maximum production from the Lahaska wells L1 & L2 occurred in August at 0.709 and 1.617 mg. These maximums are 21.44 and 65.87 percent of the wells' monthly docket limits. Figure 8 shows that these wells productions remain below the DRBC limit for the entire year. Figure 8 shows the combined production from the Lahaska wells.

4.0 Water Levels – Production and Monitoring Wells

4.1 Introduction

A network of thirty six (36) observation wells and one (1) stream gauging station are maintained to monitor the impact of the Buckingham Township production wells that were in service in 2014. The observation wells are identified by the name of the owner or a conspicuous geographic location, including the monitoring well number. The observation well in the vicinity of Buckingham Village is the Clymer well (BVM-1). The observation well in the vicinity of the Fieldstone wells is the Bouton well (FSM-1). Those observation stations near the Cold Spring wells are Hohmann (CSM-2), Gronendahl (CSM-3), Simone (CSM-4), Cahalin (CSM-5) and the Pine Run stream gauge station. The observation wells close to the Furlong wells are Yerkes (FM-4 and FM-5), Kimball or Bound (FM-2) Slack (FM-3 and FM-3A), Deschamps (FM-8), Swayze (FM-9 and FM-9A), Collie (FM-13), Green (FM-11), Nicholas (FM-10), Hearns (FM-12), Yavoroski (FM-15), Giangrande (FM-14), Sinclair (FM-16) and Coles/Orleans (FM-7). Through the years, some of the observation wells have changed, been dropped, or added. In 2011 there were 16 Furlong observation wells (FM-2 through FM-5 and FM-7 through FM-16) being monitored. Several additional wells are being monitored for reference purposes only. The locations of the observation stations are shown on the map inside the back cover of this report.

Six (6) additional observation wells currently monitored in the vicinity of the Lahaska production wells. These Lahaska observation wells are: Picciotti (LM-2), John's Metal Shop (LM-3), Elizabeth James Realty (LM-4), Hugo (LM-6), Tota (LM-9) and Fox Briar (LMW-11). An access-related problem prevented monitoring LM-8 (Yates) since 2010. Four Lahaska monitoring wells have been removed over the years from the original list, but those remaining provide adequate information.

4.2 BV-1 and BV-2 Production Wells and their Observation Well

Depth to water measurements for non-pumping water levels at well BV-1 varied from 44 feet to 65 feet below the measuring point in 2014. Measurements at BV-2 also ranged from 45 to 66 feet. The highest water levels for both wells were in April and May, and the deepest levels in October. The depth-to-water levels in the Clymer observation well (BVM-1) fluctuated about 7.88 feet throughout the year which is about 4.35 feet less than the case in the previous year. We believe the fluctuation in static water level for the Clymer well is partly the result of domestic use rather than from an impact from the production wells. The variations in static water levels in the Buckingham Village wells and their observation well are illustrated in Figure 9. There is very clear correlation between the production wells and their water levels; in fact, they are nearly identical as they had been in earlier years. There is a relatively good correlation in water levels (where data is available) between the observation well and the production wells.

4.3 Cold Spring Production Wells, Observation Wells and Pine Run Gauging Station

Depth to non-pumping water levels in well CS-1 ranged from 3 feet in March to 21 feet in November 2014. Depth-to-water in well CS-2 ranged from 7 feet in March to 47 feet in November 2014. Well CS-3 showed the shallowest water level from 4 feet in April and July; the deepest measurement of 14 feet was recorded in October 2014. Depth-to-water in well CS-4 ranged from 18 feet in April to 32 feet in October. Depth-to-water in well CS-5 ranged from 18 feet in May to 27 feet in October and November. None of the Cold Spring pumping wells showed clear correlation between the pumping wells (CS-1 through CS-4) and their monitoring wells.

There is no clear indication that pumping from any of the Cold Spring wells affected stream flow in Pine Run. The variations in static water levels in wells CS-1, CS-2, CS-3, and CS-4 and the Pine Run observation station for 2014 are shown in Figure 10.

Wells CS-3 and CS-4 are located within the Hearthstone residential subdivision. Well CS-4 is located several hundred feet upstream of the pond known as the Brandon Way and Cold Spring Creamery Road, HOA Pond #3, and well #3 is located immediately adjacent to the pond. In October 2014 the HOA (Home Owners Association) notified Buckingham Township that the Pond #3 water level appeared to be historically low. The Township proactively took wells CS-3 and CS-4 out of service, and from the end of October into the first week of December, measured the pond water levels, local precipitation, and water levels in wells CS-3 and CS-4. The study was conducted to assess the relationship between the pond's water levels, precipitation, and

pumpage and water levels at wells CS-3 and CS-4. The study concluded that the pond's low water levels occurred in response to the large precipitation deficit that occurred during the summer and early fall (see Section 5.0 of this report). When precipitation returned to normal during the course of the study, the pond's water level returned to normal. The study was summarized in a report submitted to the DRBC and Pennsylvania Department of Environmental protection.

4.4 Fieldstone Production Wells and Observation Well FSM-1

Depth to non-pumping water levels for the production wells FS-1 and FS-2 show good correlation between each other as they did during previous years. The highest water levels below the measurement point for FS-1 and FS-2 were both in May, at 33 feet (FS-1) and 36 feet (FS-2). The deepest recorded measurement were both in October at 58 feet (FS-1) and 60 feet (FS-2). The observation well (Bouton) shows a muted correlation with the water levels in the production wells. Figure 11 shows the variation in static water levels for the Fieldstone production wells and the Fieldstone observation well during 2014.

4.5 Furlong Production and Monitoring Wells

Seven Furlong production wells (F-1 through F-5, F-7 and F-8) had monthly production ranging from a low of 7,000,000 gallons in February to a high of 10,326,000 gallons in July 2014. During 2014, water use in Furlong was at a level similar to the previous year (Figure 6). The wells or ponds that have been impacted in the past (i.e., Sinclair, Collie, Giangrande, Black, Kocis, Green, Nicholas, Deschampes, Swayze, and Bound) continue to be monitored for any potential impacts that may be occurring.

All things considered, it would appear that precipitation amounts have a greater impact on water levels in the monitoring wells in the F-4 and F-5 vicinity than does the operation of production wells F-4 and F-5. Figure 12 shows a number of monitoring wells in the North Furlong Area (Deschamps, Coles, Rawes, Schroeder and Swayze) plotted against precipitation from 2008 through 2014. Wells F-4 and F-5 were being pumped continuously during most of that time frame with restrictions on their discharge from May 6, 2009 through September 24, 2010. We know from the results of the aquifer stress test in 2002 that F-4 had a greater impact on domestic wells north and east of F-4. F-5 only had a noticeable impact on the Rawes and Deschamps wells. F-4 and F-5 apparently derive their water from two different sets of fracture systems, as either well was only affected by less than 2 feet when the other well was being pumped. In examining Figure 12 the magnitude of the change in water level with time appears to be related to the distance separating the well from either F-4 or F-5. The Coles/Orleans well (FM-7) is the closest to F-4 and has the largest change in water level over the course of a year. The Swayze well is farther than the Coles well from F-4 and has a lower magnitude of water level change than does the Coles well. The Deschamps well is closest to F-5 and has the larger water level change when compared to the Rawes or Schroeder wells. These three wells have shown less magnitude of water level variation than the Coles and Swayze wells and were less affected from F-4 pumping than when F-5 was pumping. After April 2009, it is evident that even with F-4 and

F-5 pumping, albeit with some DRBC restrictions, there is not a lot of effect, other than that from precipitation, on water levels in these wells.

Well F-8 was brought on line and started contributing to the system on June 1, 2011.

4.5.1 Furlong System - General

Recent operations, including the drought-like conditions during the summer of 2006, indicate that wells F-1 through F-7 can be expected to yield approximately 345,600 gallons per day (gpd) in the longer term. The Developers, with the cooperation of the Township, investigated the possibility of increasing production from F-7 and F-3 as well as developing new wells in the area. Unfortunately, F-3 and F-7 did not offer up any additional yield following their hydraulic stimulation through hydrofracturing.

Figure 13 shows the non-pumping water levels of the Furlong wells along with several of the key monitoring wells. The production wells (except F-7) and some of the monitoring wells that have been impacted in the past have static levels similar to the last several years except in the fall 2011 when water levels were somewhat higher as a result of the inordinate amounts of precipitation experienced in August and September. As for F-7, the Township will continue to monitor its performance. It is currently unknown what the reason is for continued erratic behavior of its water levels.

4.5.2 Effects on Domestic Wells and Ponds

Water levels continue to be monitored monthly at a number of domestic wells and ponds where there has been an impact on their operating water levels in the past. These wells are; Sinclair, Collie, Giangrande, Black, Boros, Swayze and Deschampes. Some of the recent actions taken in regard to domestic wells and ponds are: The Township and Developer reimbursed the Buckley family for redrilling their well in 2009 which closed out the last issue in the area where there had been an impact on a domestic well from the operation of F-7. The Collie family, thought to have been impacted by the operation of F-7 as well, has not yet connected to the system. There are three families on Edgehill Drive (off Upper Mountain Road), the Hartwigs, Eisenbergs and Fonashes that may have been impacted by wells F-4 and F-5. They have yet to decide whether or not to connect to the Township system although the Fonashes, who have adequate water volume but sporadic sediment, made an inquiry in October of 2013 and we have been trying to get the Developer, Orleans, through their well depletion agreement involved with a possible connection. The Zazula family, who also live on Edgehill Drive, complained about their well to the Township but it was found that their well likely penetrates the Chickies Quartzite, which is a Paleozoic formation on the other side of the Furlong-Flemington Fault. This fault separates the Zazula well from F-4 and F-5. There is likely another reason than the pumping of wells F-4 and F-5 that has created the presumed water quality concern with the Zazula well. Since an inspection of their well site In January 2011, there have been no further complaints about sediment in their well water.

The Schroeder case, pond water elevation matter, has been resolved wherein the DRBC has accepted the Township's mitigation proposal to provide a continuous source of clean water from an existing Township well into the drainage swale that eventually empties into the Schroeder ornamental pond. This source must be provided between June 1 and November 1 and keep the Schroeder pond at an "adequate level", as described in their September 24, 2010, letter to the Township's attorney. The Schroeder Pond is no longer being monitored. The Schroeder's contacted both the Township and the DRBC in 2012 concerning his pond, but there was nothing beyond the initial contact.

4.6 Lahaska Observation Wells

Some of the Lahaska observation wells are quite shallow such as LM-9 (the Tota well). In this well the depth-to-water varied from 8.99 feet in March to13.80 feet in August. Other wells are quite deep, such as Picciotti's well (LM-2). Depth-to-water measurements in this well were between 103.67 feet in May and 140.14 feet in November, during 2014. With the exception of the Piccioti well, the Lahaska wells share generally similar trends in water levels during 2014.

The results of the depth-to-water measurements for the Lahaska Observation wells are shown in Figure 14.

4.7 Mill Creek Observation Wells (Former Forest Grove (FG) Observation Wells)

Depth to water measurements for non-pumping water levels at well FG-1 varied from 15 feet to 27 feet below the measuring point in 2014. Measurements at FG-2 ranged from 11 to 22 feet. The shallowest water levels for both wells were in April, and the deepest levels in September. The depth-to-water levels in the Black observation well (DW-1) fluctuated about 21.37 feet throughout the year. The depth-to-water levels in the Black observation well (DW-2) fluctuated about 10.11 feet throughout the year. The depth-to-water levels in the Choi observation well fluctuated about 9.51 feet throughout the year. The depth-to-water levels in the Morrison observation well fluctuated about 11.44 feet throughout the year. The depth-to-water levels in OW-1, OW-2, OW-3, OW-4, OW-5, OW-6, OW-7, and OW-8 fluctuated about 12.73, 12.58, 12.15, 2, 6.24, 63.46, 11.22, and 17.39 feet, respectively. We believe the fluctuation in static water level for the system is the result of domestic use rather than from an impact from the production wells. The variations in static water levels in the Mill Creek (FG) wells and their observation well are illustrated in Figure 15. There is a relatively good correlation in water levels (where data is available) between the observation well and the production wells.

5.0 Precipitation

Precipitation is the single most important climatic factor involved in bringing recharge to the aquifers in Buckingham Township. In fact, with no appreciable imported water and negligible underflow from neighboring communities, precipitation, along with several installed spray irrigation systems and numerous residential on-lot disposal systems, is the only source of ground water recharge/recycling within the Township.

Buckingham received 46.61 inches of rain in 2014 based on unofficial readings taken at six sites in the Township. This is roughly 3.54 inches greater than the historical average of 43.07 inches. Figure 16 shows a nearly continuous record of annual rainfall since 1963 with a range of 42.35 inches between maximum and minimum values for that fifty one- (51) year period. Also shown on Figure 16 is a linear trend line for the local data that demonstrates the general increase in precipitation, on average, over that time frame.

2011 (72.55 inches) has been the wettest year since 1963, with 1996 previously having the highest annual precipitation at 66.4 inches.

Annual rainfall cannot always show the severity of droughts or floods because rain can be concentrated in a few days and, under these circumstances, much of it can and sometimes does, leave the basin as surface runoff providing little recharge to the aquifers.

Monthly precipitation for the years 2010 through 2014 are shown in Figure 17. The monthly ranges from one basin inch (March 2012) to more than fifteen basin inches in both August and September of 2011. It is clear that drought to flood conditions can change quite rapidly. The monthly average (blue line) shows a smoother variation (made more severe by the extreme precipitation of August and September 2011) of 8.54 basin inches, yet even the "average" values show significant variation.

6.0 Surface Water – Pine Run Watershed

A stream gauging station is located on an unnamed tributary to Pine Run, which crosses Landisville Road between Burnt House Hill Road and Bergstrom Road. The data, which are presented in Figure 18, are in feet below a measuring point. A low value means that the elevation of the water is high so the discharge is high; a high value means that the elevation of the water is low so the discharge is low. For 2010, the water level in Pine Run showed a drop-off to 14.7 feet below the measuring point because of two months of below average precipitation in August and September. Water levels rebounded in October 2010, roughly 0.9 feet, as precipitation was at almost 8 inches for the month. In 2011, the Pine Run responded to the unusually heavy (±32 inches) rainfall in August and September, which raised the water level in Pine Run to a measurement of 13.4 feet. In 2012, the Pine Run water levels, as in past years, generally follow a delayed response to precipitation. In 2013, the Pine Run water level ended the year 0.22 feet higher than in the beginning of the year. In 2014, the Pine Run water level ended the year 0.08 feet lower than in the beginning of the year, and as in past years, followed a delayed response to precipitation.

7.0 Conclusions

Buckingham Township produced 260,606,390 gallons of water from seventeen 17 of 20 Township-operated production wells during 2014, and 232,838,000 gallons from the same production wells in 2013. This is an increase of 27,768,390 gallons (11.9%) from 2013 to 2014 and an increase of 33,409,390 gallons (14.7%) from 2010 to 2014.

When the production is disregarded from the Lahaska wells (L-1 and L-2), which are not owned by the Township, Buckingham Township produced a total of 241,030,000 gallons of water during 2014. This is an increase of 8,192,000 gallons (3.5%) from 2013 to 2014.

None of the wells exceeded their permit allocations.

A total of forty two (42) observation wells and a stream gauge were monitored during the year to evaluate the effects, if any, of the production wells on the various aquifers penetrated by the wells. Although Furlong wells F-1, F-2 and F-3 have not been operated at their docketed limits, it appears that their long-term sustainable yields will be less than their allowable maximum. Wells F-4 and F-5 were brought on line in 2006 followed by wells F-6 and F-7 in 2007. Well F-6 has subsequently been out of service since the summer of 2008 as it was operating too inefficiently to provide a reliable source of water. Impacts from the operation of well F-7 have lessened somewhat from 2007 and may be related to putting F-6 out of service as well as increased precipitation amounts in 2009 through 2011. The Township has connected one of the F-7 impacted homeowners (Black) to their water system and another family, the Boros', drilled a new well and the Township reimbursed them for the cost of replacing their well. The Buckleys were reimbursed by the Township in 2009 for their new well. The Collie family has been given the opportunity to connect to the Township Water System but has yet to do so. The Sinclair well, the Giangrande well and the Collie well are continuing to be monitored by the Township and this will continue for the foreseeable future. The Township, the Schroeders and the DRBC have agreed on a resolution to the alleged impact on the Schroeder pond from operating wells F-4 and F-5. The Township has provided a clean reliable source of water to the pond from a well adjacent to the drainage swale that empties into the Schroeder pond during the time period of June 1 through November 1 of each year in sufficient quantity to keep the pond at an "adequate level". With this agreement, the DRBC approved the plan in their September 24, 2010, letter and subsequently lifted the interim limits on the discharge from wells F-4 and F-5. The Developer responsible for F-4 and 5 effects, Orleans Homebuilders, ran a water line part way up Edgehill Drive with 6 homes currently connected and three more possible. The Bounds (home and four apartments) on Forest Grove Road were apparently impacted by F-3 and were connected through an easement to the Furlong water distribution pipe in Buckingham Forest in 2007.

Well F-8 is connected to the Furlong System and started producing on June 1, 2011. Well F-9 is connected to the Furlong system, as an emergency water supply, should unusual demand require it. Well F-9 was not used at all during 2014.

Cold Spring system well CS-4 came on-line in July, 2014.

The low water levels that occurred in Brandon Way and Cold Spring Creamery Road HOA Pond #3 were the result of the large summer/fall precipitation deficit, rather than withdrawals at wells CS-3 and CS-4.

Mill Creek system wells FG-1 and FG-2 came on-line in June and September 2014, respectively.

8.0 References

Faill, R. T., 1973, Tectonic Development of the Triassic Newark-Gettysburg Basin in Pennsylvania. Geol. Soc. America Bull., v.84, p. 725 – 740

Olsen, P. E., 1980, The Latest Triassic and Early Jurassic Formations of the Newark Basin (Eastern North America, Newark Supergroup) Stratigraphy, Structure and Correlation, New Jersey Academy of Science Bulletin, vol. 25, no. 2, pp. 25 - 45.

Rima, D., R.., Meisler, H. and Longwill, S., 1962 Geology and Hydrology of the Stockton Formation in southeastern Pennsylvania: PA Geological Survey Bulletin W-14.

Tappert, Stephen, 1986, Hydrologic Evaluation of the Core Creek Watershed, Bucks County, Pennsylvania.

Table 1

Production Well Monitoring in Buckingham Township (Inlcudes Lahaska and Forest Grove Wells)

Domestic Wells

Owner	Well ID#		System Name
Black	DW-1	Farm	Forest Grove
Black	DW-2	House	Forest Grove
Choi	DW-3		Forest Grove
Morrison	DW-4A		Forest Grove

Observation Wells

Owner	Well ID#	
Toll Brothers	OW-1	Forest Grove
	OW-2	Forest Grove
	OW-3	Forest Grove
	OW-4	Forest Grove
	OW-5	Forest Grove
	OW-6	Forest Grove
	OW-7	Forest Grove
	OW-8	Forest Grove

Table 1 (Cont'd)

Production Well Monitoring in Buckingham Township (Inlcudes Lahaska and Forest Grove Wells)

Name	Well No.	System Name
Bouton	FSM-1	Fieldstone
Trinity	8	
Clymer	BVM-1	B. Village
Gronedahl	CSM-3	Cold Spring
Simone	CSM-4	Cold Spring
Cahalin	CSM-5	Cold Spring
Hohmann	CSM-2	Cold Spring
4747 CSC Road		Cold Spring
4001 Durham Rd DJ office		Cold Spring
H'stone pond well		Cold Spring

Name	Well No.	
Slack	FM-3a	Furlong
Bound	FM-2	Furlong

Table 1 (Cont'd)

Production Well Monitoring in Buckingham Township (Inlcudes Lahaska and Forest Grove Wells)

Name	Well No.		System Name
Yerkes	FM-4		Furlong
Deschampes	FM-8		Furlong
Swayze	FM-9	House	Furlong
Swayze	FM-9a	Pond	Furlong
Collie	FM-13		Furlong
Green	FM-11		Furlong
Nicholas	FM-10		Furlong
Hearns	FM-12		Furlong
Yavoroski	FM-15		Furlong
Giangrandes	FM-14		Furlong
Sinclair	FM-16		Furlong
Coles/Orleans	FM-7		Furlong

Pine Run Stream	Cold Spring

Name	Well No.	
Picciotti	LM-2	Lahaska
John's Metal Shop	LM-3	Lahaska
Eliz. James Realty	LM-4	Lahaska
Hugo	LM-6	Lahaska
Tota	LM-9	Lahaska
Fox Briar - estate well	LM-11	Lahaska

TABLE 2
Monthly Groundwater Production in Buckingham Township
2014

Month	Wells BV1 & BV2 Gallons*	Well CS-1 Gallons	Well CS-2 Gallons	Well CS-3 Gallons	Well CS-4 Gallons	Well CS-5 Gallons	Wells FS1 & FS2 Gallons*	Well F-1 Gallons	Well F-2 Gallons	Well F-3 Gallons	Well F-4 Gallons	Well F-5 Gallons	Well F-7 Gallons	Well F-8 Gallons	Well F-9 Gallons	Well FG-1	Well FG-2	L-1	L-2
Jan	745,000	1,924,000	5,122,000	3,106,000	0	0	569,000	1,737,000	304,000	415,000	640,000	253,000	472,000	3,763,000	0	0	0	619800	661900
Feb	776,000	1,342,000	4,574,000	2,684,000	0	0	497,000	1,749,000	304,000	419,000	644,000	199,000	430,000	3,255,000	0	0	0	816600	237100
Mar	794,000	1,614,000	7,080,000	1,204,000	0	0	554,000	1,812,000	309,000	431,000	659,000	178,000	481,000	3,877,000	0	0	0	1017200	0
Apr	717,000	2,415,000	7,188,000	0	0	0	517,000	1,649,000	276,000	392,000	595,000	231,000	464,000	3,900,000	0	0	0	1354400	0
May	821,000	2,872,000	7,822,000	0	0	0	500,000	2,069,000	347,000	496,000	754,000	506,000	480,000	3,759,000	0	0	0	715300	599390
Jun	1,070,000	2,811,000	7,830,000	0	0	0	514,000	2,668,000	357,000	632,000	965,000	650,000	440,000	3,601,000	0	46,000	0	695600	897200
Jul	1,212,000	2,526,000	7,807,000	823,000	17,000	0	507,000	3,019,000	373,000	682,000	1,188,000	801,000	462,000	3,801,000	0	163,000	0	700100	1263500
Aug	890,000	1,610,000	4,887,000	2,827,000	1,962,000	0	510,000	2,653,000	330,000	573,000	1,079,000	725,000	407,000	4,411,000	0	510,000	0	709400	1616600
Sep	843,000	1,535,000	4,365,000	1,572,000	3,362,000	0	520,000	2,433,000	306,000	513,000	1,013,000	347,000	60,000	4,704,000	0	293,000	116,000	821000	1336500
Oct	924,000	1,342,000	3,557,000	1,461,000	3,133,000	0	489,000	1,712,000	202,000	352,000	488,000	310,000	171,000	5,165,000	0	83,000	78,000	326700	1353000
Nov	721,000	2,393,000	6,813,000	1,000	1,000	0	486,000	2,266,000	263,000	469,000	905,000	610,000	439,000	2,823,000	0	48,000	58,000	186500	1423300
Dec	813,000	1,480,000	4,154,000	1,091,000	3,058,000	0	507,000	2,319,000	247,000	528,000	862,000	585,000	476,000	3,034,000	0	59,000	47,000	718900	1506400
Totals	10,326,000	23,864,000	71,199,000	14,769,000	11,533,000	0	6,170,000	26,086,000	3,618,000	5,902,000	9,792,000	5,395,000	4,782,000	46,093,000	0	1,202,000	299,000	8,681,500	10,894,890

Water Year 2014 Total = 260,606,390 Gallons

* Wells BV-1 & BV-2 and FS-1 & FS-2 are read through common water meters and cannot be differentiated as to individual wells

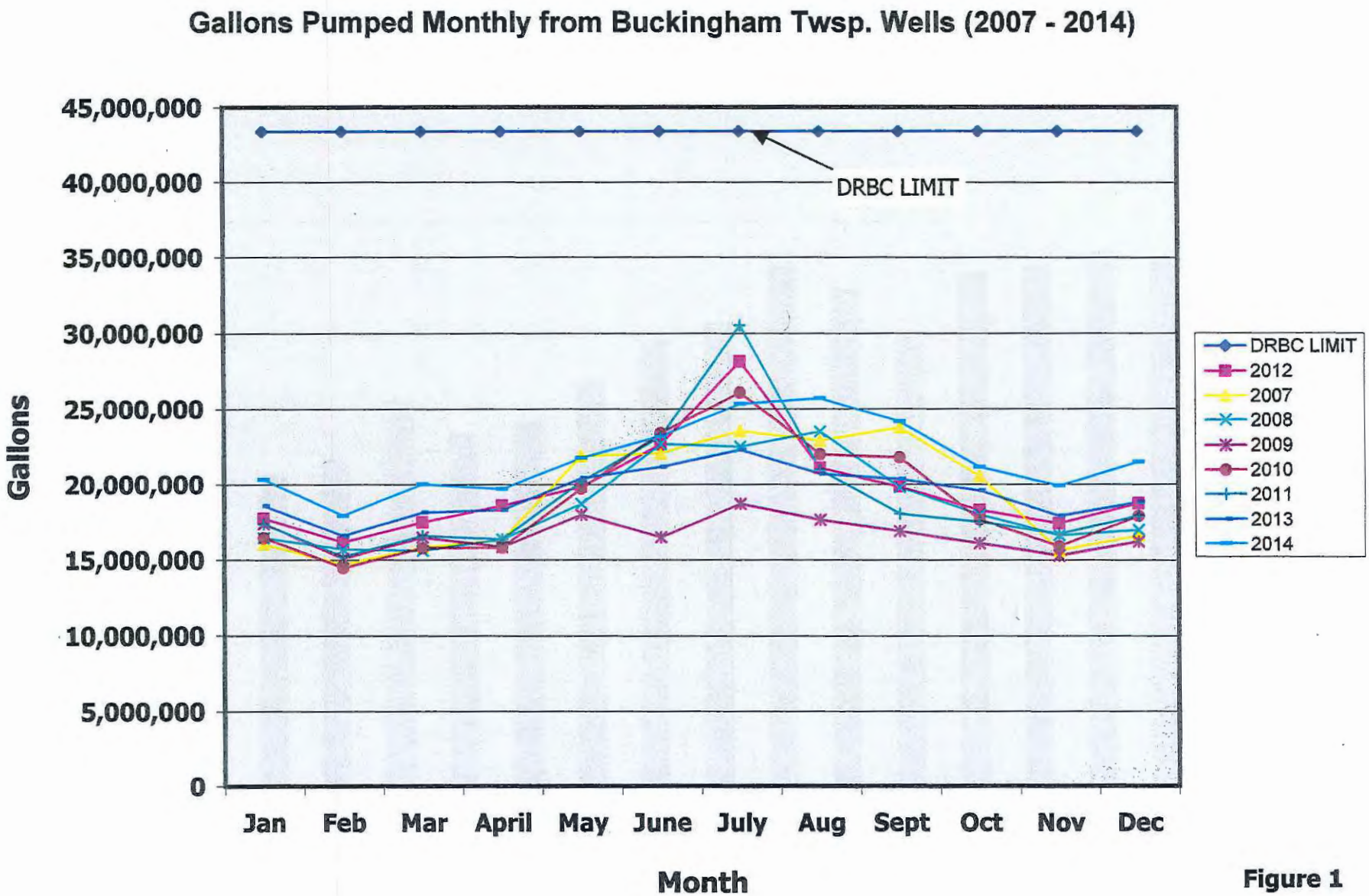

Gallons Pumped Monthly from Buckingham Twsp. Wells (2007 - 2014)
45,000,000
40,000,000
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
Gallons
DRBC LIMIT
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month
DRBC LIMIT
2012
2007
2008
2009
2010
2011
2013
2014

Figure 1

Groundwater Production - Buckingham Township Wells 1997 - 2014

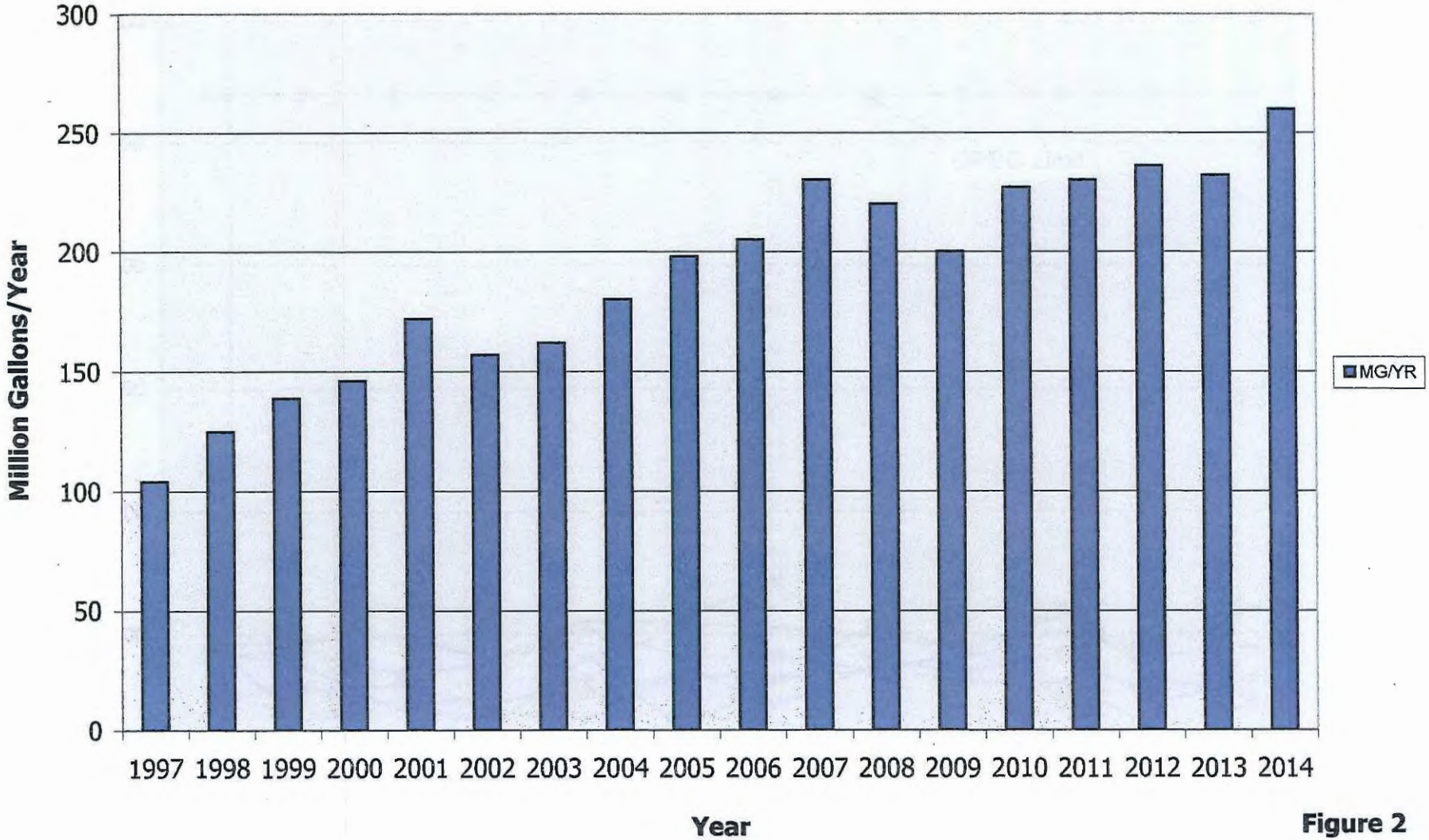


Figure 2

Groundwater Production from Buckingham Village Wells 2005-2014

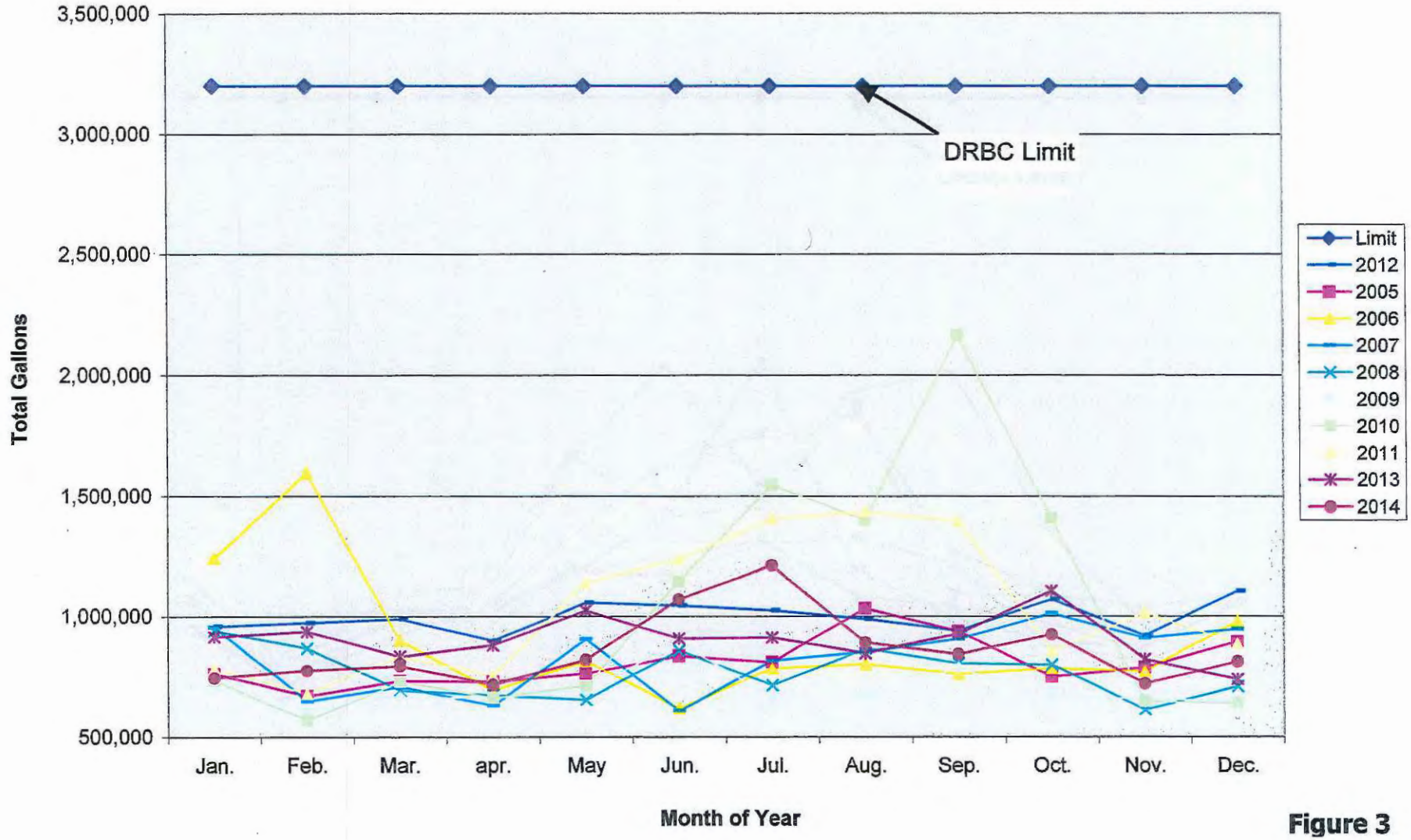


Figure 3

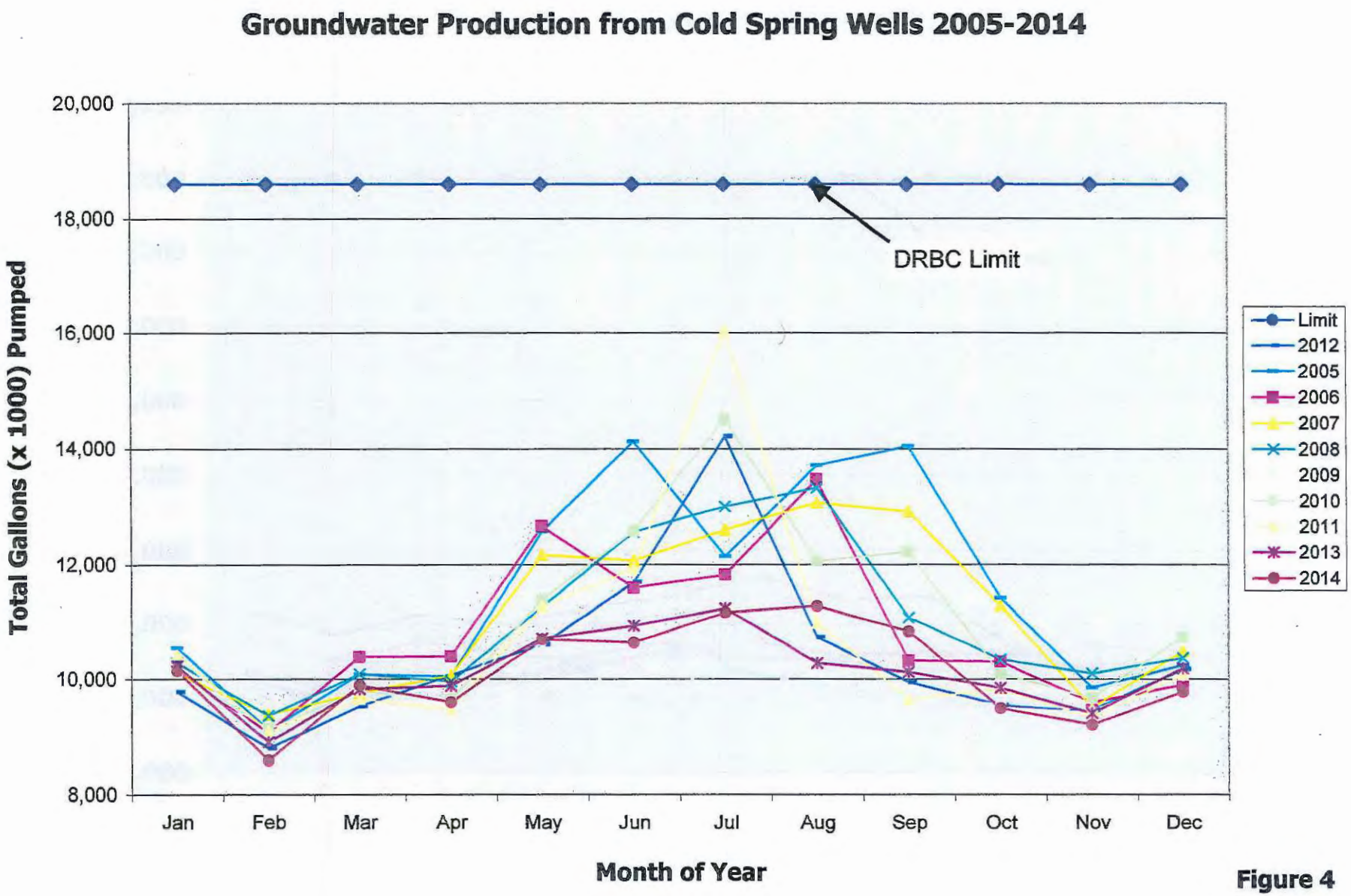

Groundwater Production from Cold Spring Wells 2005-2014
20,000
18,000
16,000
14,000
12,000
10,000
8,000
Total Gallons (x 1000) Pumped
DRBC Limit
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of Year
Limit
2012
2005
2006
2007
2008
2009
2010
2011
2013
2014

Figure 4

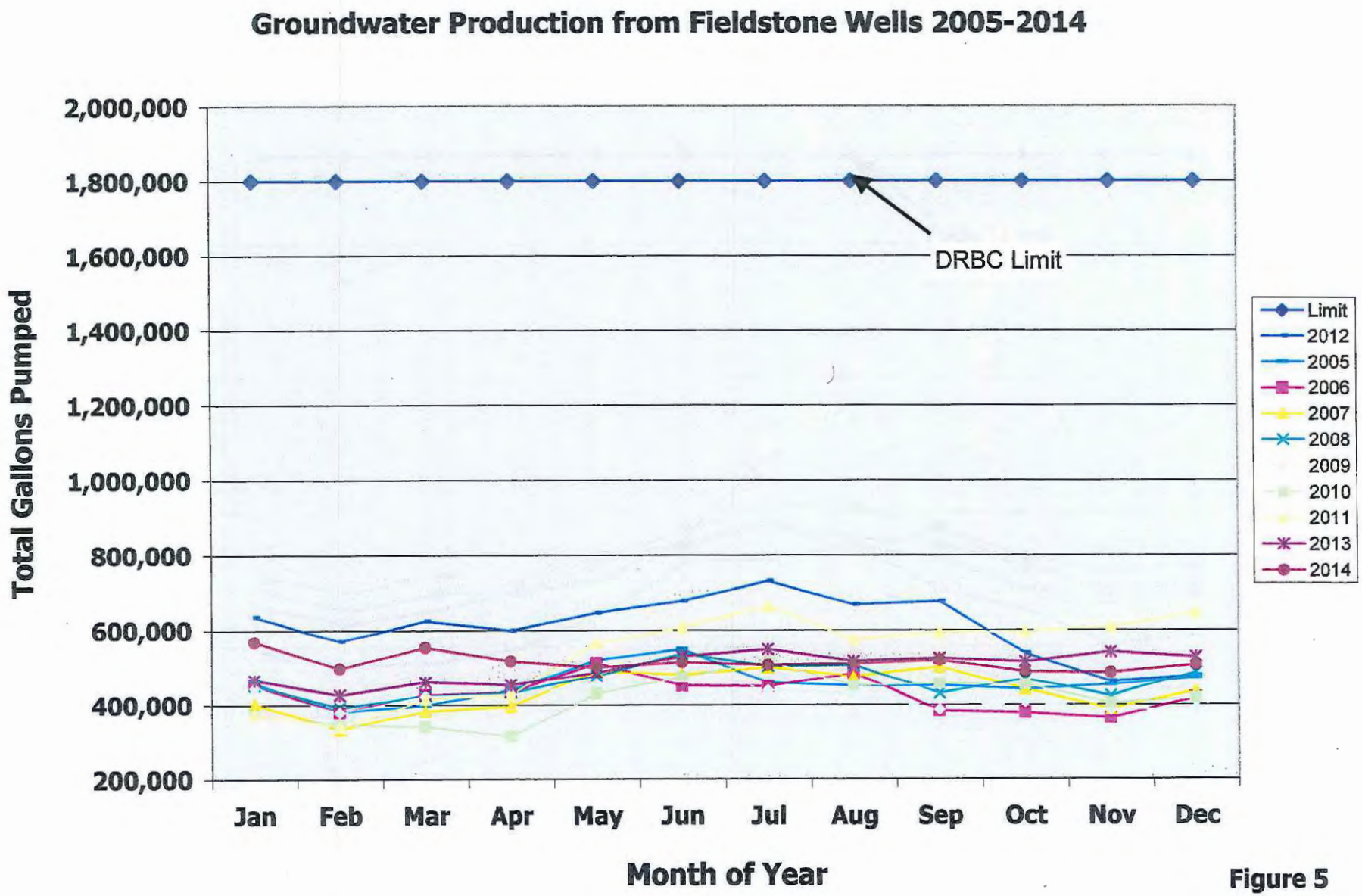

Groundwater Production from Fieldstone Wells 2005-2014
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
Total Gallons Pumped
DRBC Limit
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of Year
Limit
2012
2005
2006
2007
2008
2009
2010
2011
2013
2014

Figure 5

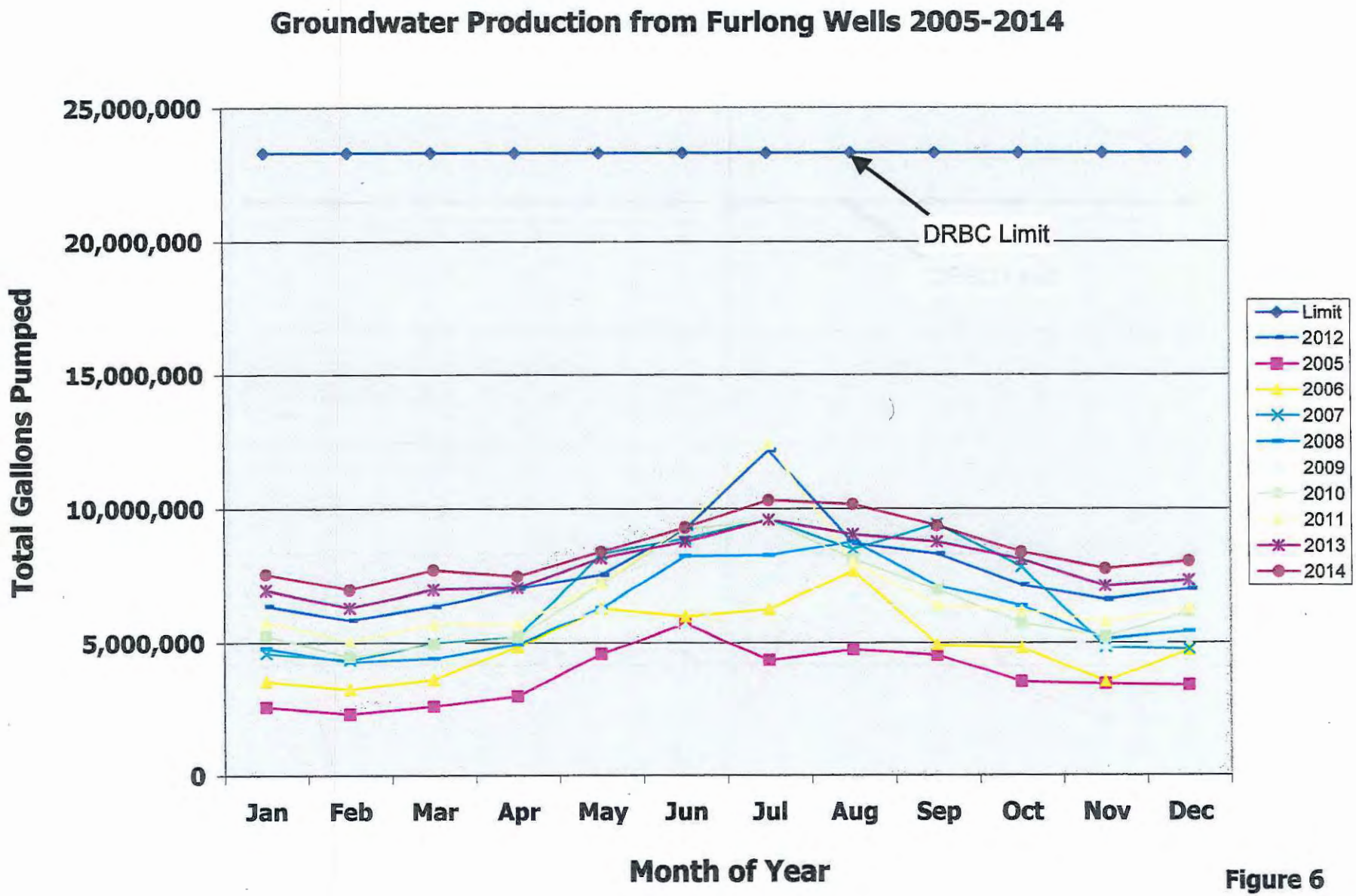

Groundwater Production from Furlong Wells 2005-2014
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
Total Gallons Pumped
DRBC Limit
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of Year
Limit
2012
2005
2006
2007
2008
2009
2010
2011
2013
2014

Figure 6

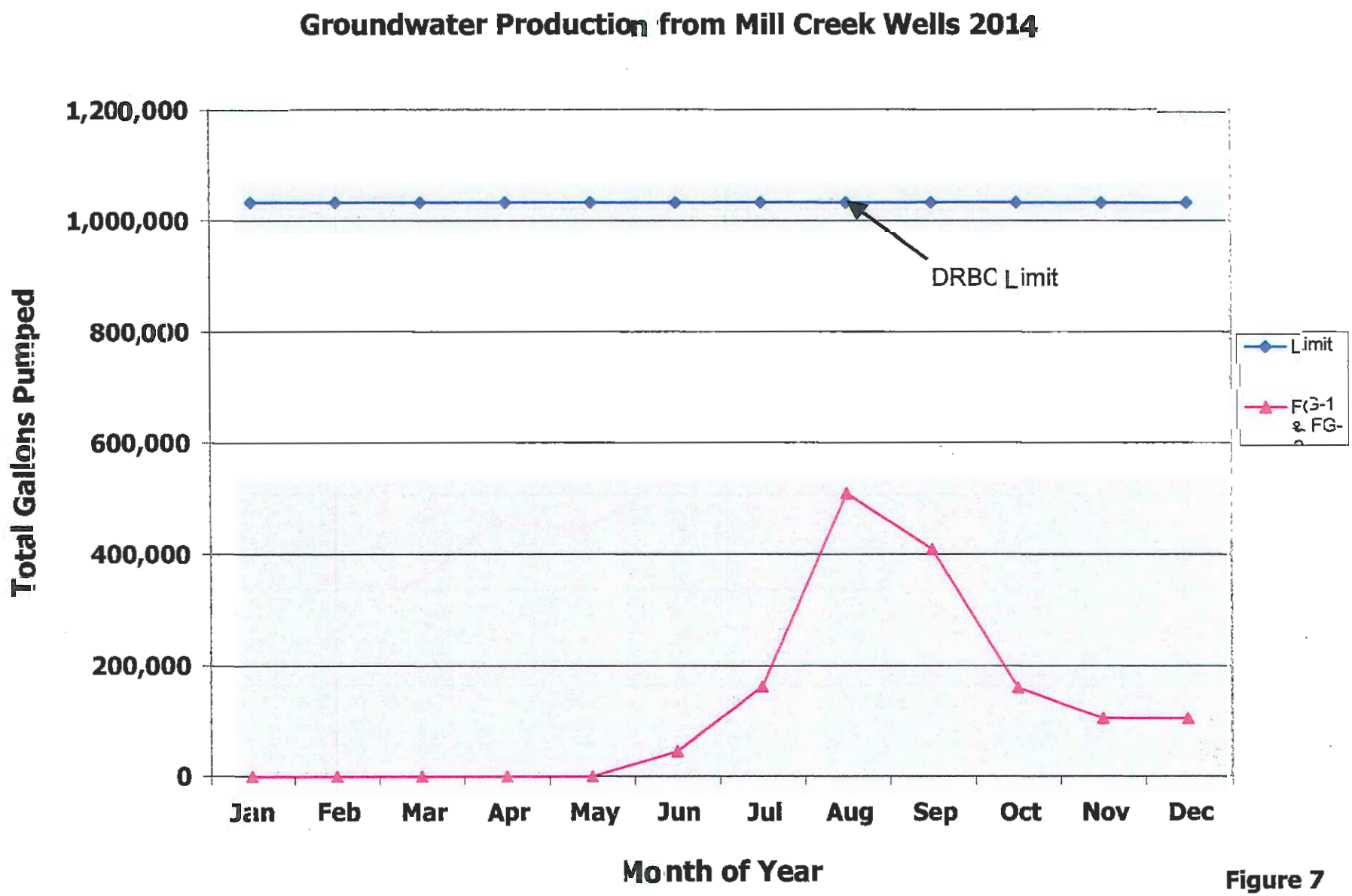

Groundwater Production from Mill Creek Wells 2014
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Total Gallons Pumped
DRBC Limit
Limit
FG-1 & FG-
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of Year

Figure 7

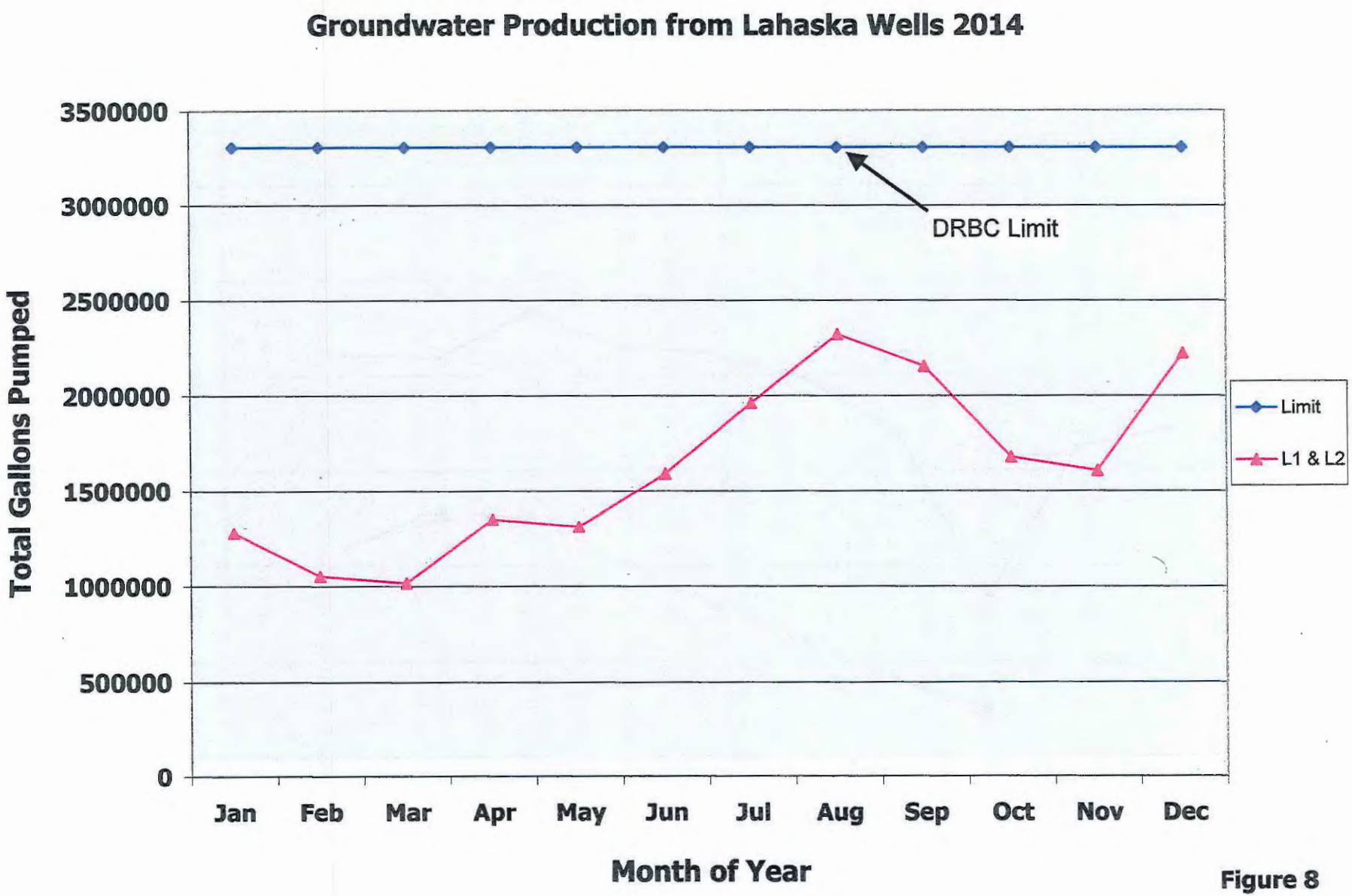

Groundwater Production from Lahaska Wells 2014
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
Total Gallons Pumped
DRBC Limit
Limit
L1 & L2
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of Year

Figure 8

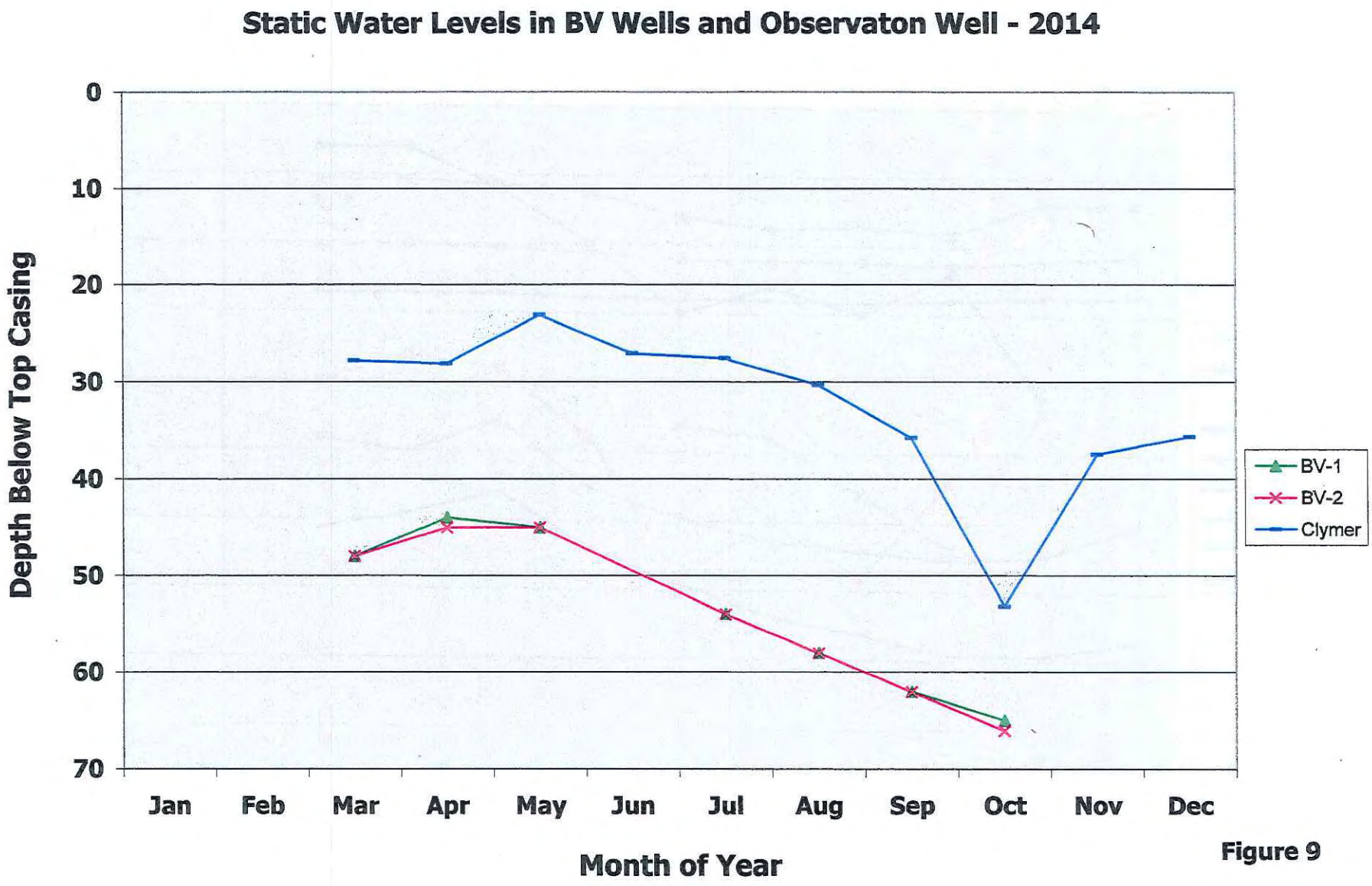

Static Water Levels in BV Wells and Observaton Well - 2014
Depth Below Top Casing
0
10
20
30
40
50
60
70
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of Year
BV-1
BV-2
Clymer

Figure 9

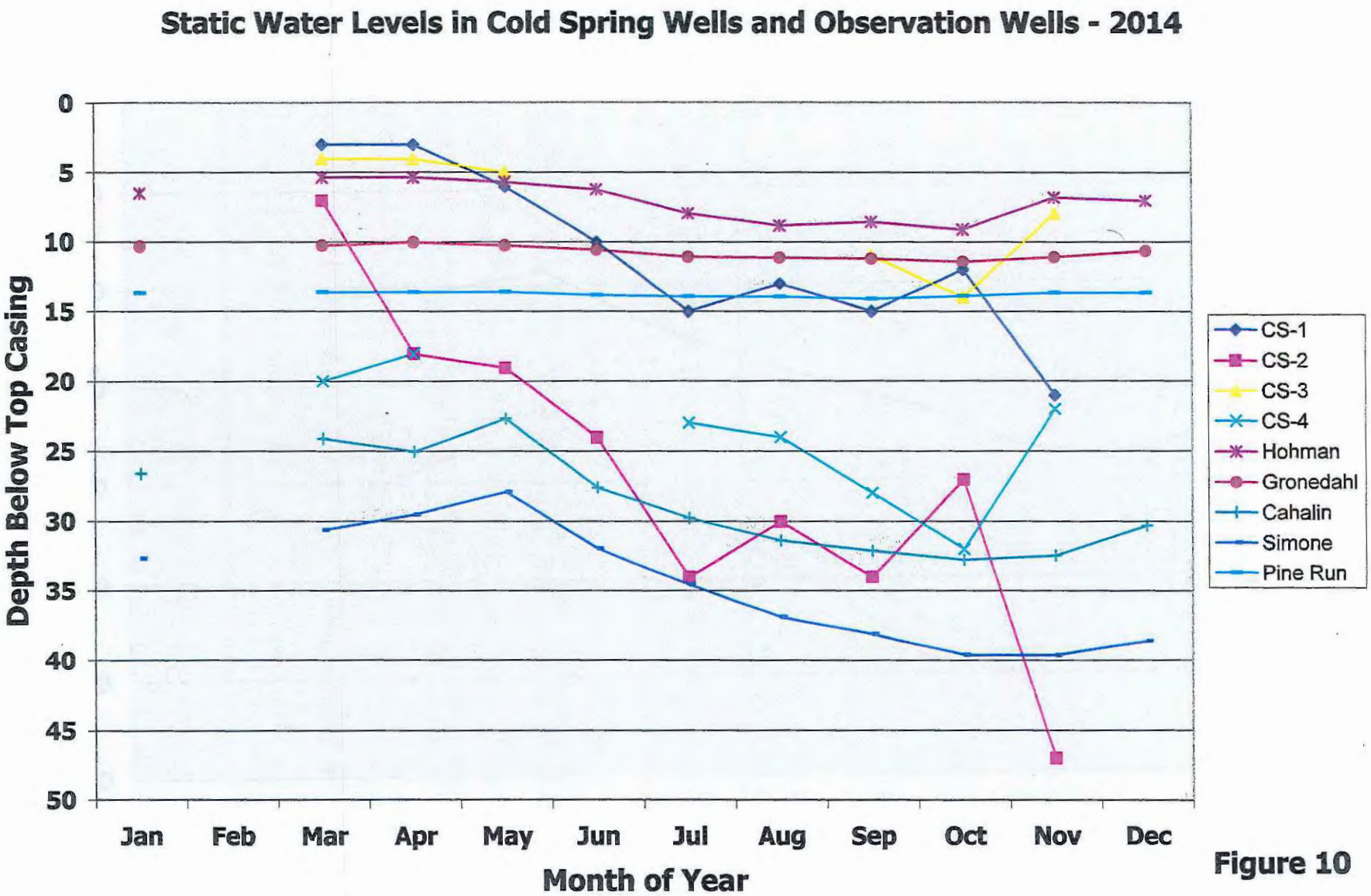

Static Water Levels in Cold Spring Wells and Observation Wells - 2014
Depth Below Top Casing
0
5
10
15
20
25
30
35
40
45
50
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of Year
CS-1
CS-2
CS-3
CS-4
Hohman
Gronedahl
Cahalin
Simone
Pine Run

Figure 10

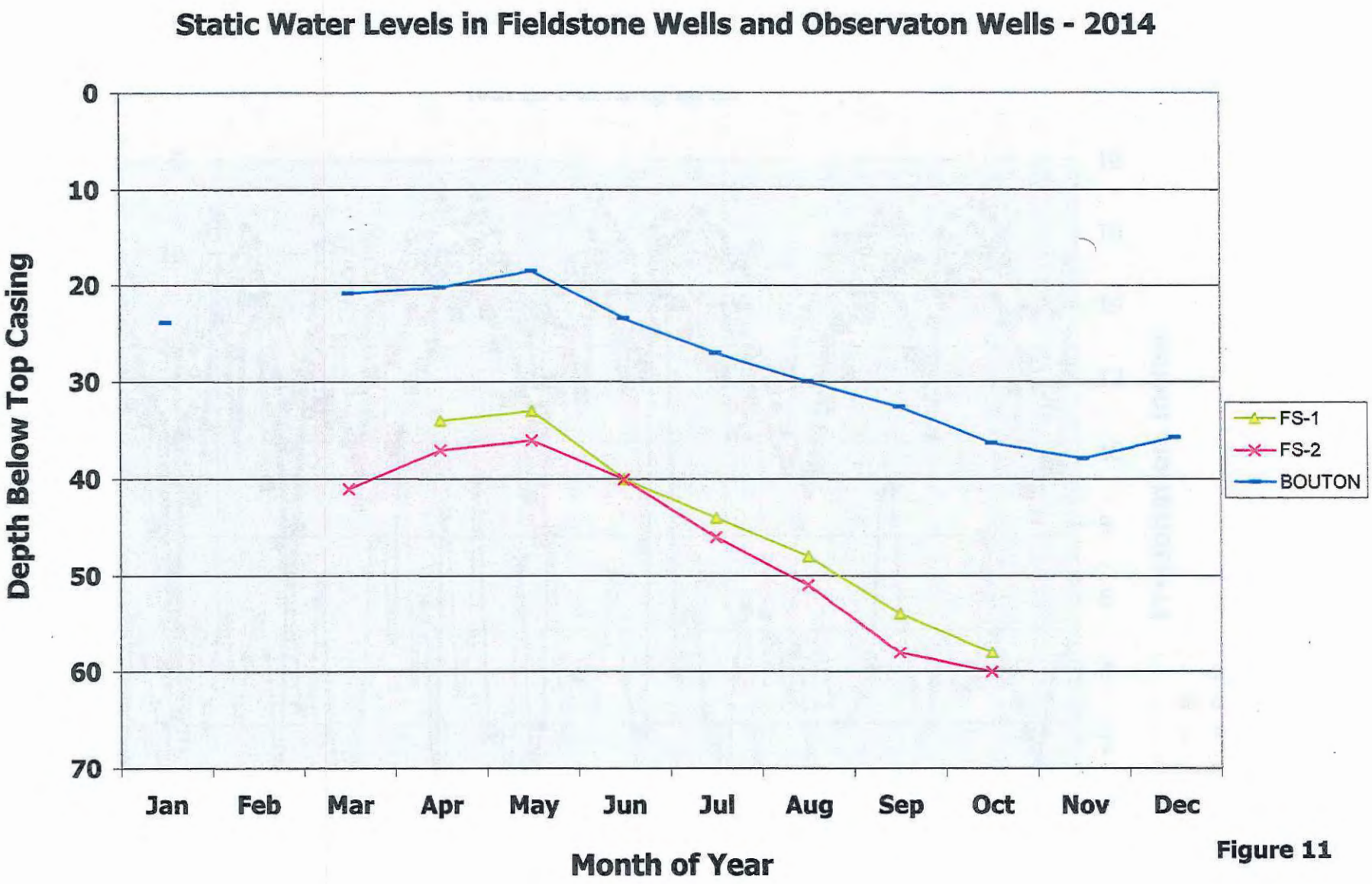

Static Water Levels in Fieldstone Wells and Observaton Wells - 2014
Depth Below Top Casing
0
10
20
30
40
50
60
70
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of Year
FS-1
FS-2
BOUTON

Figure 11

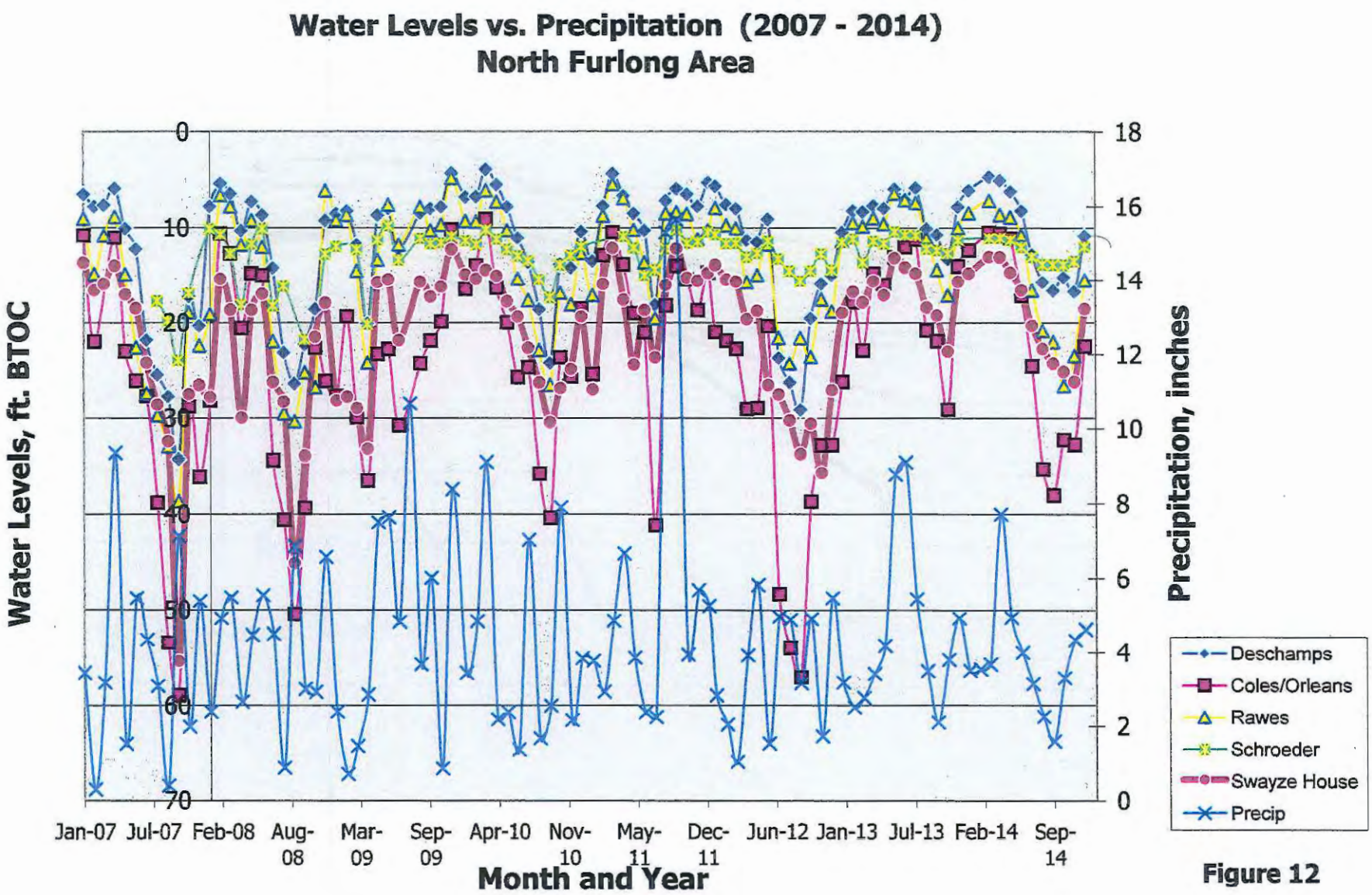

Water Levels vs. Precipitation (2007 - 2014)
North Furlong Area
Water Levels, ft. BTOC
Precipitation, inches
0
10
20
30
40
50
60
70
18
16
14
12
10
8
6
4
2
0
Jan-07
Jul-07
Feb-08
Aug-08
Mar-09
Sep-09
Apr-10
Nov-10
May-11
Dec-11
Jun-12
Jan-13
Jul-13
Feb-14
Sep-14
Month and Year
Deschamps
Coles/Orleans
Rawes
Schroeder
Swayze House
Precip

Figure 12

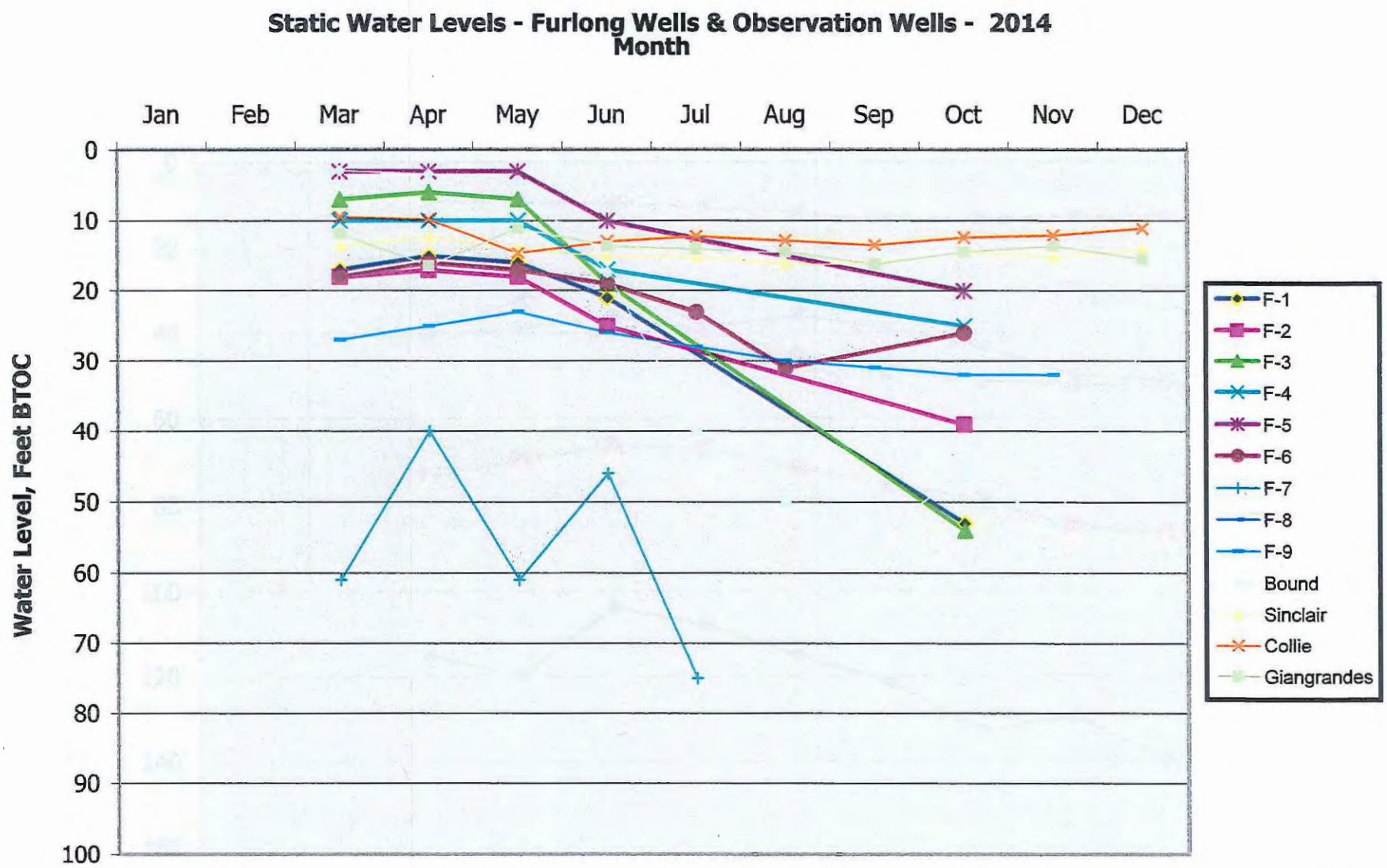

Static Water Levels - Furlong Wells & Observation Wells - 2014
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Water Level, Feet BTOC
0
10
20
30
40
50
60
70
80
90
100
F-1
F-2
F-3
F-4
F-5
F-6
F-7
F-8
F-9
Bound
Sinclair
Collie
Giangrandes

Figure 13

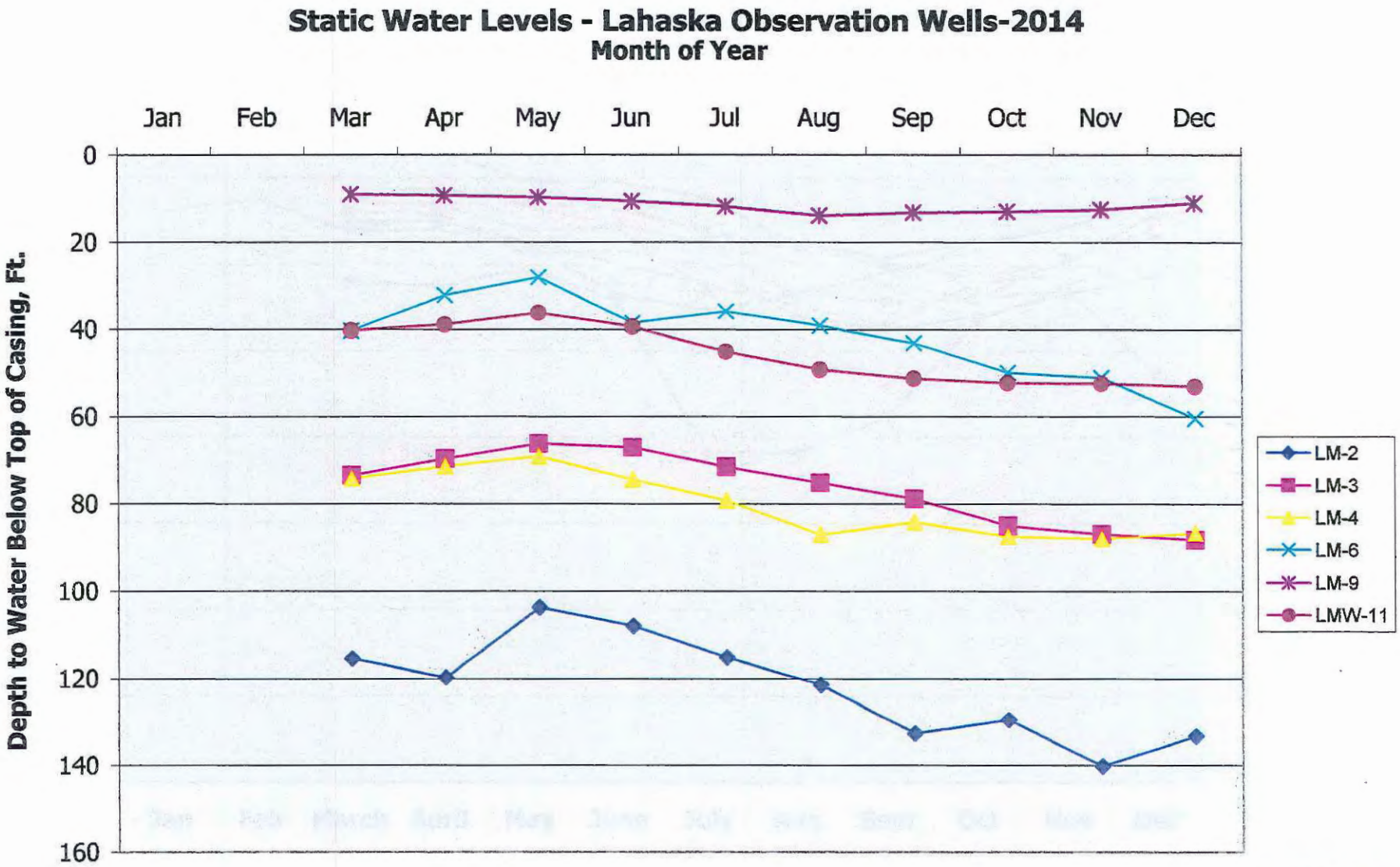

Static Water Levels - Lahaska Observation Wells-2014
Month of Year
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
0
20
40
60
80
100
120
140
160
Depth to Water Below Top of Casing, Ft.
LM-2
LM-3
LM-4
LM-6
LM-9
LMW-11

Figure 14

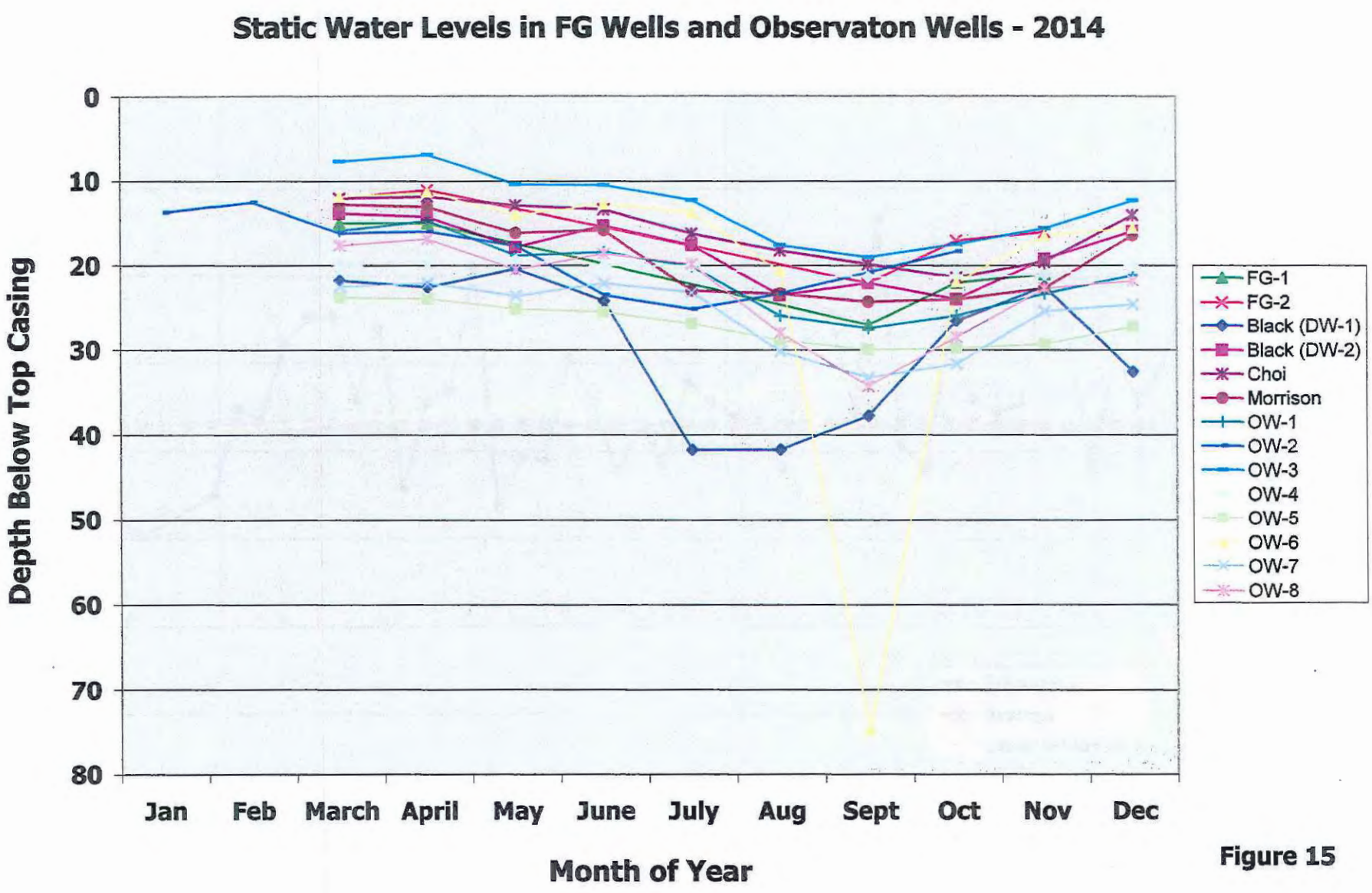

Static Water Levels in FG Wells and Observaton Wells - 2014
Depth Below Top Casing
0
10
20
30
40
50
60
70
80
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month of Year
FG-1
FG-2
Black (DW-1)
Black (DW-2)
Choi
Morrison
OW-1
OW-2
OW-3
OW-4
OW-5
OW-6
OW-7
OW-8

Figure 15

Precipitation vs. Average Rainfall, 1963 - 2014

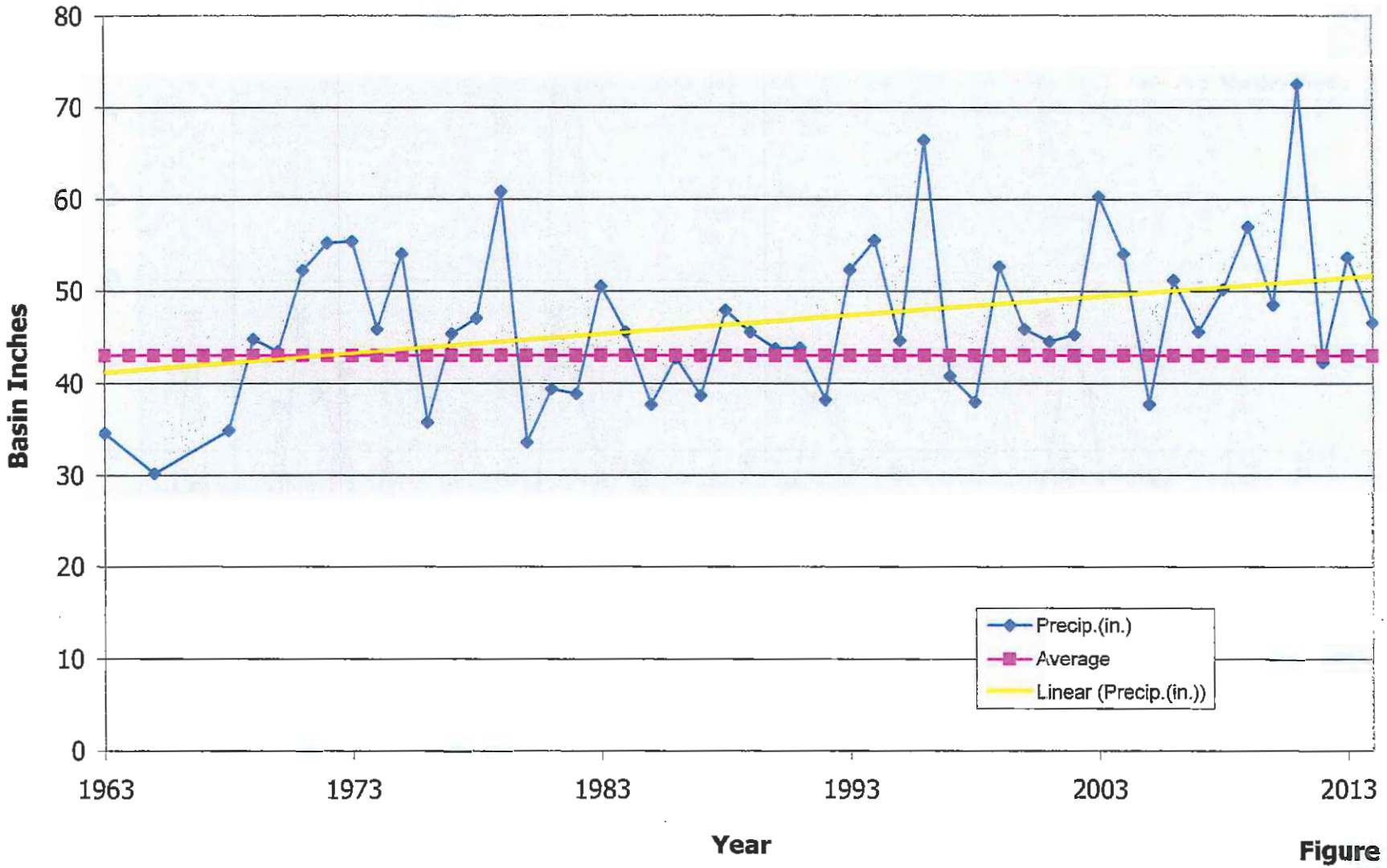


Figure 16

Monthly Avg. Precip. Compared to Monthly Precip. - 2010-2014

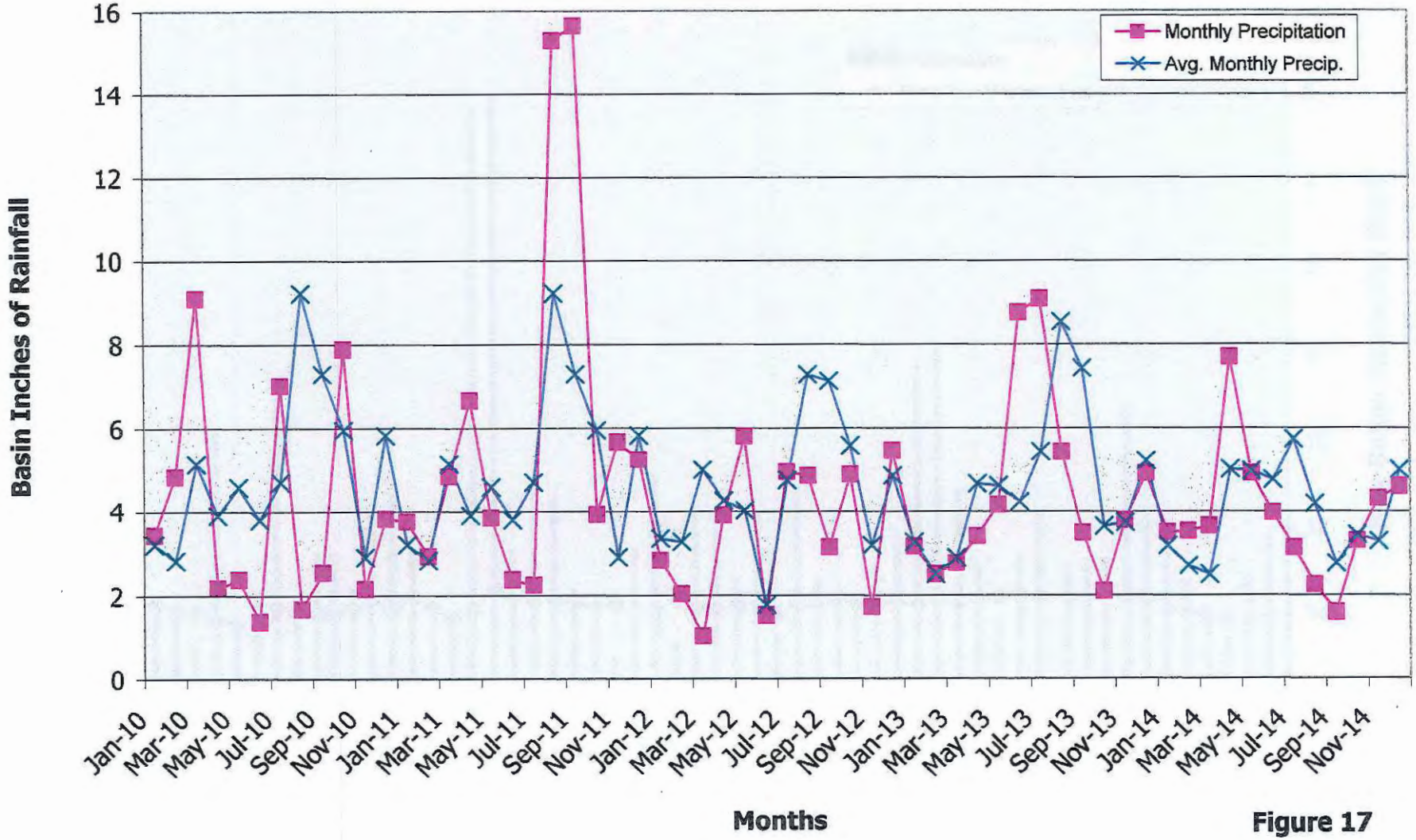


Figure 17

Correlation of Rainfall to Water Level in Pine Run, 2010-2014

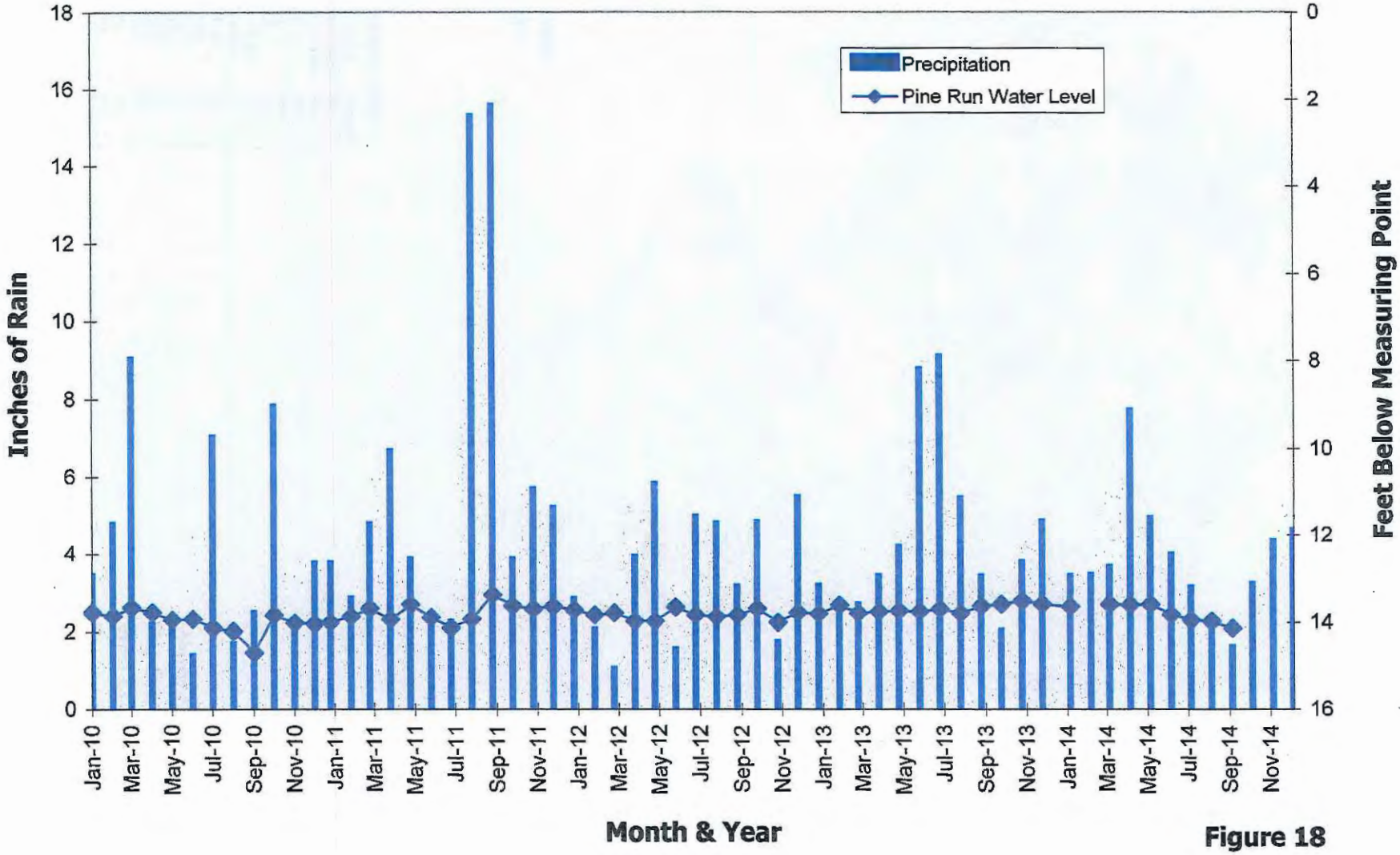
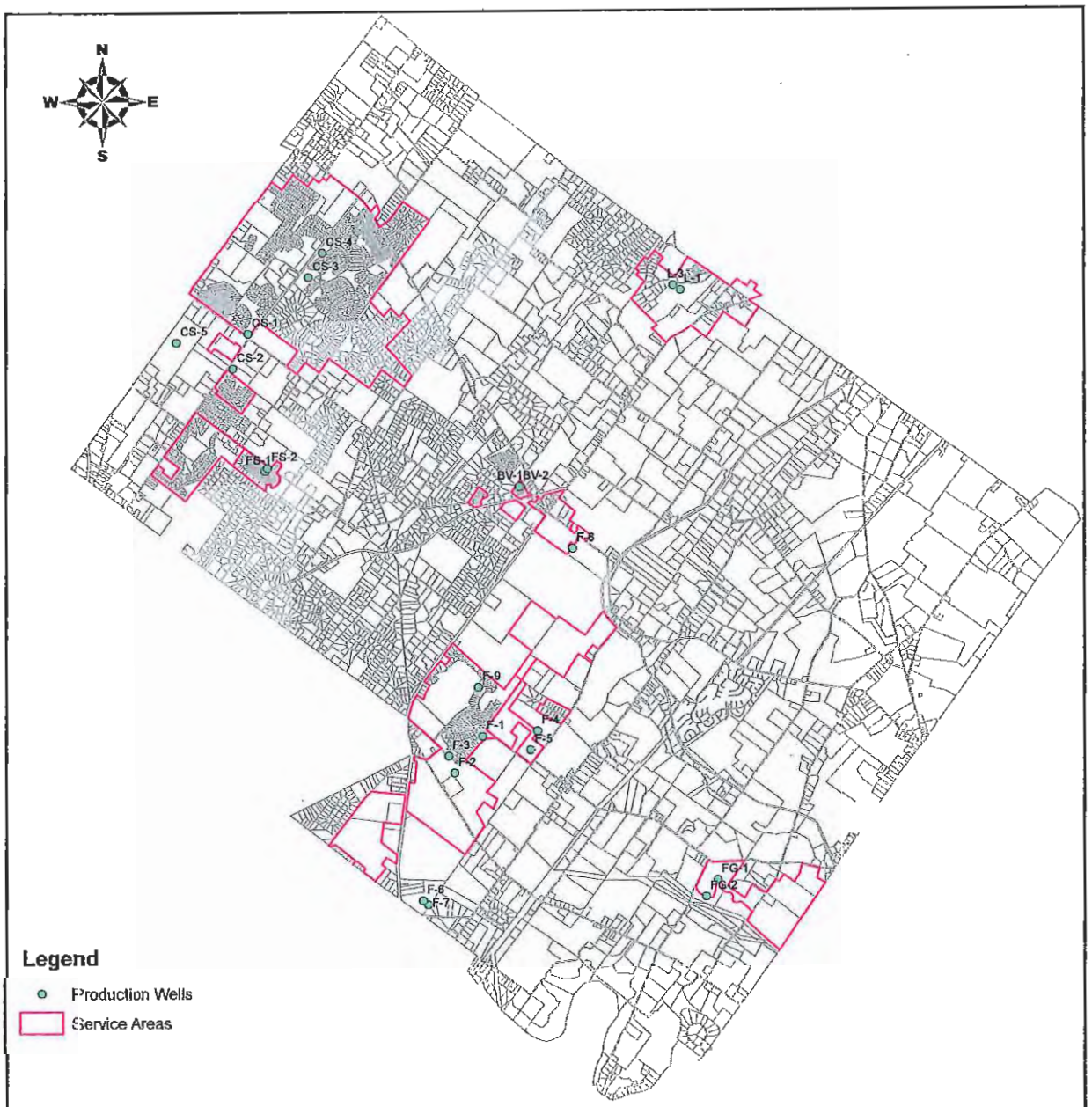


Figure 18



Production Wells

WELLNAME	DRBCNO
Buckingham Village	BV-1
Buckingham Village	BV-2
Fieldstone	FS-1
Fieldstone	FS-2
Cold Spring	CS-3
Peddlers Village	L-3
Peddlers Village	L-1
Furlong Water	F-2
Furlong Water	F-1
Furlong Water	F-4
Furlong Water	F-5
Furlong Water	F-7
Furlong Water	F-6
Cold Spring	CS-5
Cold Spring	CS-4
Cold Spring	CS-1
Cold Spring	CS-2
Furlong Water	F-3
Furlong Water	F-8
Furlong Water	F-9
Mill Creek	FG-1
Mill Creek	FG-2

0 0.375 0.75 1.5 Miles

Water Supply Production Well Locations

Buckingham Township

Bucks County, Pennsylvania

October 2012