

BRIDGETON-NOCKAMIXON-TINICUM
GROUNDWATER MANAGEMENT COMMITTEE

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Groundwater Level Monitoring of the
Aquifer in the Neighborhood of Palisades Schools, Nockamixon
December 29, 2008

Summary

A yearlong study of the Palisades High School well and a number of wells in the neighborhood, strongly suggests that the aquifer supplying these wells is seriously stressed. The year-to-year decline in the water level of 25 feet from 2007 to 2008, during a normal rainfall season, suggests that the content of the aquifer is a declining resource with a risk of running out at the current rate of withdrawal.

It is also apparent that

- The variation of the aquifer was recorded as being about 50 ft, significantly greater than any other aquifer being monitored in the area.
- The anecdotal history of the area confirms that the decline in the water table is man made, and that neither the Palisades School District nor the homes in the area are alone responsible for this draw down.
- There is strong evidence that a seasonal nocturnal water user from May to September significantly tips the balance between a rising and falling aquifer.
- Without community remedial action, there could be serious consequences for the residents and the school district in the event of a drought such as the area experienced in the mid-1960s.
- To illustrate the severity of the situation: This summer (2008) at least two wells on nearby Buck Road needed to be re-drilled or deepened.¹ Another well needs to be replaced this summer.² These are not isolated incidents without a common causative factor.

1 Anthony Buck at 51 Buck Road deepened their well from 223 ft to 413 feet, Linda and Joseph Gaibler at 93 Buck Road drilled a replacement well to a depth of 460 feet.

2 Robert Hippauf at 46 Buck Road faces imminent replacement of his well. When it was drilled to some 180 feet fifteen years ago, it produced 32 gallons per minute, last summer it was found to be inadequate.

- It needs to be pointed out that the strategy of drilling deeper wells is not a viable solution for finding new water. It only causes a race to see who can have the deepest well, so they can be the last to run out of water. The solution is to not take out more water out of the aquifer than goes into it; indeed, the withdrawal must only be a fraction of the recharge.

Discussion

The Bridgeton-Nockamixon-Tinicum Groundwater Management Committee (BNT GWMC) is a three municipal advisory committee that was formed in 1999 to conduct technical studies, provide information for the residents and to recommend regulations about local water resources to the three townships. The region is largely rural with significant forested land, farming and low-density villages. There is only modest industry in the townships. The only outstanding industrial operation that impacts groundwater near the school district is a quarry that does not impact this particular study³. One of the committee's projects has been the long term monitoring of water levels at 12 locations that we felt were or would be important to health of the residents' on-lot water supply⁴.

In the fall of 2007, the school district was performing maintenance and discovered that the high school well static water level (SWL) was much lower than they had remembered it to be when it was last measured. Namely, they thought it should be in the neighborhood of -130 feet, but found it to be -170 feet.

Members of the committee suggested that by installing a well data logger we could gather the information that might

1. Evaluate the seriousness of the problem
2. Possibly identify the source of the problem
3. Suggest a solution

There are three school building within 1000 foot radius – a high, middle and elementary schools along with the district administrative offices. Nominally, there are 1500 students and staff in these buildings when classes are in session. From aerial photographs we have determined that there are about 34 houses that could be considered to be a part of this aquifer. There is a nursery (Bucks Country Nursery) some 1800 feet south of the high school well.

The schools sit on a ridge that peaks over 600 feet above Mean Sea Level (MSL) in the complex. The geography slopes to the Delaware River, approximately 120 feet MSL to the east and to Lake Nockamixon to the southwest at 395 feet MSL. Figure 1 is a Graphical Information System (GIS) image showing the composite aerial photographs of the area, the contours and monitoring locations.

In the early 1900s, the USGS conducted a survey of groundwater in Northern Bucks County⁵. One of the conclusions of that study is that the underling geology of the region of diabase, layered

3 The quarry is some 2.4 miles from the study area and in a direction roughly perpendicular to the fracture strikes in the region of the PHS. Static water levels between the regions of the PHS and the quarry are much higher than those of this study.

4 All household water supplies in the townships are from on-lot wells.

5 *Hydrogeology and Ground-water Quality of Northern Bucks County, Pennsylvania*, RA Sloto and CL Schreffler, USGS Report 94-4109

Lokatong and Brunswick fractured rock, which has poor transmissivity⁶ and storage capacity.⁷ The geology under high school is Lokatong shale.

A Global Water WL16 Water Level Data Logger with a 275 foot cable and 120 foot range set to record levels every 30 minutes was installed in the High School well on October 27th 2007. Item A in Figure 1. As part of the maintenance mentioned above, logging water meters were installed and since February 2008, daily usage data has been recorded for each of the three buildings. The data has been downloaded and analyzed monthly since it was installed. In addition to the individual school usage data, rainfall has been collected in the high school quadrangle for 4½ years.

In late August 2008 a second logger became available and was installed in a resident's well that is a little more than a quarter mile to the south.⁸ The location of this logger is shown as item B in Figure 1. This logger is in a development that was built in the 1950-60s. The data from this logger, when adjusted for the difference in elevation, normally tracks the high school water level hour by hour and by a difference of less than 2 feet.⁹ See Figure 6. We therefore conclude this evidence shows these two wells share the same aquifer.

Figure 2 the black curve represents the recorded water level, filtered by choosing the maximum reading in a 3.5 hr window.¹⁰ The green curve is the daily water use in gallons use by the three buildings. The red curve is the cumulative rainfall for the year. Note that the seasonal maximum SWL occurs in late April. What is curious is the dramatic drop of 9 feet from April 22nd to April 26th. There were many other drops of 6-8 feet during May and June when the school district use was low. This anomalous behavior was particularly apparent in late June and July. The school district was watering newly laid sod on its practice field, using upwards of 10,000 gpd on a number occasions during the summer. These waterings did not cause close to this magnitude of depression.

As part of the study, several residents' wells in the neighborhood have been spot checked with a sonic water level meter on a roughly monthly basis. See Table 2.

Table 1 records the spot measurements taken during the study period. Several wells in the SSW to NNE direction can also be seen to track the logged wells. Wells perpendicular to this strike in another study around the quarry tend to follow with a few days delay. They tend to show an asymptotic approach to each other after rain events.

6 Transmissivity is a hydrogeological term that characterizes the ability of water to pass through porous rock.

7 "Whereas the low infiltration capacity, thin, poorly permeable clayey soils, and low ground-water storage of the Lokatong and Brunswick Formations favor rapid surface-water runoff" *Geohydrology of Southeastern Pennsylvania*, D Low, D Hippe, D Yannacci, USGR Report 00-4166

8 1508±30 ft @ 186° from north.

9 On one occasion when the levels did not track each other, the owner of the second well reported to have been filling his hot tub.

10 This filtering has been found to faithfully follow the static water level, yet filter out the depression due to a normal pumping cycle. Generally for wells with good yield, a 1.5 hour to 3.5 hour window is adequate.

Table 1
Estimated Nominal Water Consumption

Water Consumption	Housing Units	gallons per day (gpd)
Palisades School District	---	8000
Mountain View Subdivision	32	9120
School Road	13	3705
Agricultural Use	---	Unknown
Total	---	20825 +

Where:

Palisades Schools water use is approximately 7.5 gpd per person when school is in session

Mountain View Subdivision has approximately 32 houses

School Road has approximately 13 houses

Housing Units usage was calculated at 285 gpd per housing unit

It should be noted that during a previous study, state loggers had been installed on the well pumps of the three schools. A significant portion of the well pump activity was between 11:00AM and 2:00PM coincident with lunchroom activity. An analysis of the water use records gives an estimate that the per capita usage is about 7.5 gpd¹¹.

The recharge rates have not been estimated. However, it must be noted that

- All residences have on-lot septic systems and
- The school district exports its wastewater to a package plant 2.5 miles to the ESE in Kintnersville on the Nockamixon Creek.
- Rainfall has been normal during the 2007-2008 period. The summer was noted for dry periods followed by intense rainfall that produce an average summer.
- The well owner at 5 Mountain View Road shared with the author, that his well and most of the other wells in the subdivision had to be re-drilled in the summer 1997, some 35 years after the subdivision was completed.¹²
- Palisades Middle School was completed about 1991. A household well behind Palisades Middle School would overflow in the spring; now it is at -70 feet SWL.
- Several owners remembered that “many years ago” when the subdivision was new, basements flooded in the spring and that they installed sump pumps. The pumps have not been active for “many years”.
- In the summer of 2008 three wells on Buck Road went dry.

¹¹ The median use is approximately 7.1 gpd when school is in session; and the overall annual average use is approximately 5 gpd.

¹² Ken Kerstner is reported to have been the well driller for many in the subdivision. His business is in Easton, PA

Observations

There was also another curious phenomenon, namely the disappearance of the weekday variation prominent in the fall data. From October 2007 through April, it is apparent when school was in session. Figure 3 illustrates the month of December. During the week, there is a foot or so daily variation that is not present over the weekend. When the Christmas break occurs on the 23rd, there is a smooth rise until the New Year.

However, during May and June that behavior is not clearly visible. Figure 4. In September the phenomena reappears.

A sophisticated Fourier Transform of the data designed to quantify periodic behavior, clearly shows the daily one cycle per day (1/day) in the October to April data. Figure 5a. There is also the twice (2/day) peak very common in household data, breakfast and evening use. For the May-September data this signature is no longer a sharp peak and it almost disappears. Figure 5b.

The disappearance of the daily cycling is speculated to be due to a matching nocturnal water use that roughly matches the daytime withdrawal. The matching withdrawal patterns could cancel each other and result in no daily variation. The increased use shows up instead as a steady steep decline in water table over months. If the matching use was indeed the cause of the change, that use would suggest a withdrawal rate of perhaps 10,000 to 25,000 gpd.

Residents, high school maintenance staff and the authors can testify that in the spring and summer from sundown to 5:00 AM, the spray system at the Bucks County Nursery is usually operating and that the road surface on State Route 412 is frequently wet from the excess spray.

Appendix A

Table 2	Spot Static Water Level (SWL) measurements around the School Complexes
Figure 1	Aerial View of Palisades Area
Figure 2	PHS Well Showing Rainfall and School District Water Use from Fall 2007 through Fall 2008
Figure 3	PHS Well Showing Rainfall and School District Water Use from Fall 2007 through Winter 2008
Figure 4	PHS Well Showing Rainfall and School District Water Use from Spring 2008 through Summer 2008
Figure 5a	Fourier Transform of Fall and Winter 2007-08 Data
Figure 5b	Fourier Transform of Summer 2008 Data
Figure 6	PHS well overlaid with the residence at 5 Mountain View Road

Table 2
Spot Static Water Level (SWL) measurements around the School Complexes

Address	Date	SWL	Δ HS	Latitude	Longitude
29 School Dr.	10/30/2007	331.8		40.52532	-75.19520
33 School Dr.	10/30/2007	340.8		40.52613	-75.19555
"35 School Dr.	10/30/2007	405.3	-8.6	40.52400	-75.19700
"35 School Dr.	3/21/2008	426.0	-9.6	40.52400	-75.19700
"35 School Dr.	5/9/2008	416.5	-8.7	40.52412	-75.19703
"35 School Dr.	6/30/2008	397.2	-9.4	40.52412	-75.19703
"107 School Dr.	10/30/2007	417.1		40.52452	-75.19747
"119 School Dr.	10/30/2007	397.2		40.52498	-75.19803
"141 School Dr.	10/30/2007	421.8		40.52763	-75.19678
"212 School Dr.	10/30/2007	307.4		40.53053	-75.20075
"226 School Dr.	10/30/2007	326.4		40.53050	-75.19895
"233 School Dr.	10/31/2007	300.0		40.52927	-75.19552
"46 Buck Dr.	10/30/2007	391.6		40.51830	-75.19468
"51 Buck Dr.	10/30/2007	370.0		40.51888	-75.19462
"128 School Dr.	10/30/2007			40.52518	-75.19927
"120 School Dr		362.8		40.52407	-75.19907
"High School"		410.0		40.52123	-75.19800
"DN school		410.0		40.52327	-75.19893
"DN school	8/5/2008	390.3		40.52327	-75.19893
"PALMS	10/31/2007	414.8	0.6	40.52203	-75.20587
"PALMS	5/4/2008	427.8	-1.2	40.52203	-75.20587
"PALMS	6/30/2008	405.6	-1.0	40.52203	-75.20587
"PALMS	8/5/2008	394.2		40.52203	-75.20587
"216 Meginnes Rd.		511.0	97.1	40.52175	-75.20743
"216 Meginnes Rd.	7/8/2008	511.0	97.1	40.52175	-75.20743

Table 2 Continued

Address	Date	SWL	Δ HS	Latitude	Longitude
"4659 Rt. 412"		473.8		40.51965	-75.20000
"4659 Rt. 412"	5/9/2007	478.0	52.3	40.51965	-75.20000
"387 Frogtown Rd	1/27/2008	399.4		40.52328	-75.18543
5 Mt View	11/10/2007	414.0	-3.3	40.51645	-75.19997
5 Mt View	12/20/2007	426.5	0.5	40.51645	-75.19997
5 Mt View	1/28/2008	433.8	1.5	40.51645	-75.19997
5 Mt View	2/25/2008	436.6	-0.3	40.51645	-75.19997
5 Mt View	3/21/2008	436.8	1.2	40.51645	-75.19997
5 Mt View	5/1/2008	426.0	0.2	40.51645	-75.19997
5 Mt View	6/30/2008	407.6	1.0	40.51645	-75.19997
5 Mt View	8/5/2008	396.5	2.8	40.51645	-75.19997
5 Mt View	8/5/2008	392.5	2.8	40.51645	-75.19997
34 Haycock Dr	1/28/2007	437.5	5.2	40.51850	-75.20113
34 Haycock Dr	2/25/2008	441.8	4.9	40.51850	-75.20113
34 Haycock Dr	3/21/2008	442.3	6.7	40.51850	-75.20113
34 Haycock Dr	5/1/2008	432.5	6.7	40.51850	-75.20113
34 Haycock Dr	6/30/2008	414.6	8.0	40.51850	-75.20113
34 Haycock Dr	8/5/2008	405.8		40.51850	-75.20113
29 School Dr.	10/30/2007	331.8		40.52532	-75.19520
33 School Dr.	10/30/2007	340.8		40.52613	-75.19555
"35 School Dr.	10/30/2007	405.3	-8.6	40.52400	-75.19700
"35 School Dr.	3/21/2008	426.0	-9.6	40.52400	-75.19700
"35 School Dr.	5/9/2008	416.5	-8.7	40.52412	-75.19703
"35 School Dr.	6/30/2008	397.2	-9.4	40.52412	-75.19703
"107 School Dr.	10/30/2007	417.1		40.52452	-75.19747
"119 School Dr.	10/30/2007	397.2		40.52498	-75.19803
"141 School Dr.	10/30/2007	421.8		40.52763	-75.19678
"212 School Dr.	10/30/2007	307.4		40.53053	-75.20075
"226 School Dr.	10/30/2007	326.4		40.53050	-75.19895

These table entries represent individual spot measurements taken from time-to-time with a Global Water Sonic water level monitor. The objective was to find those wells in the neighborhood of the High School that tracked (followed) within a few feet the variations observed in the High School water level (Δ HS). Those wells that tracked the High School are assumed to be all drawing from the same aquifer.

Aerial View of Palisades Area

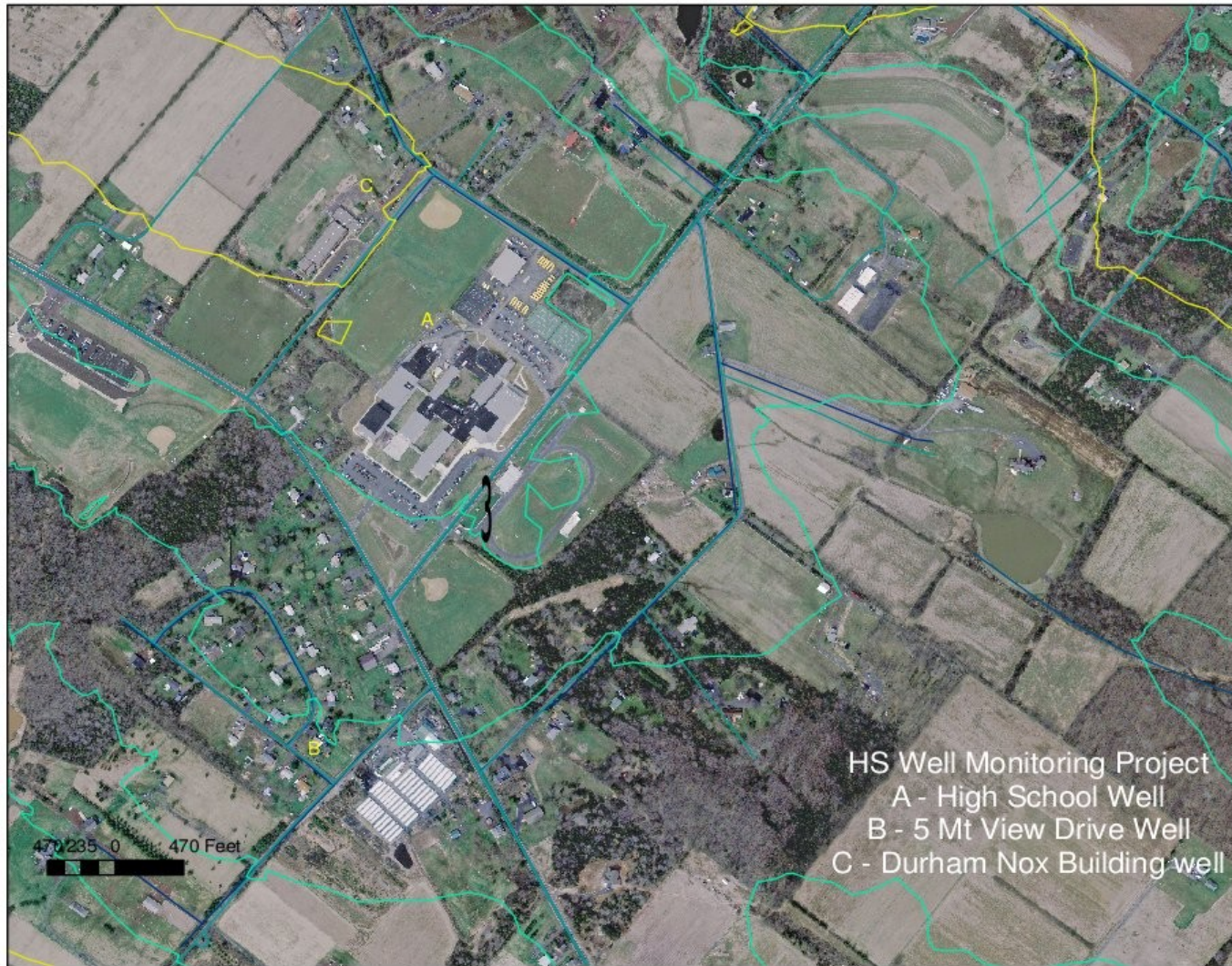


Figure 1
Palisade High School Well
Showing Rainfall and School District Water Use from Fall 2007 through Fall 2008

High School Well
@ 40 31.273N 75 11.883W
BNT Water Resources Cmte

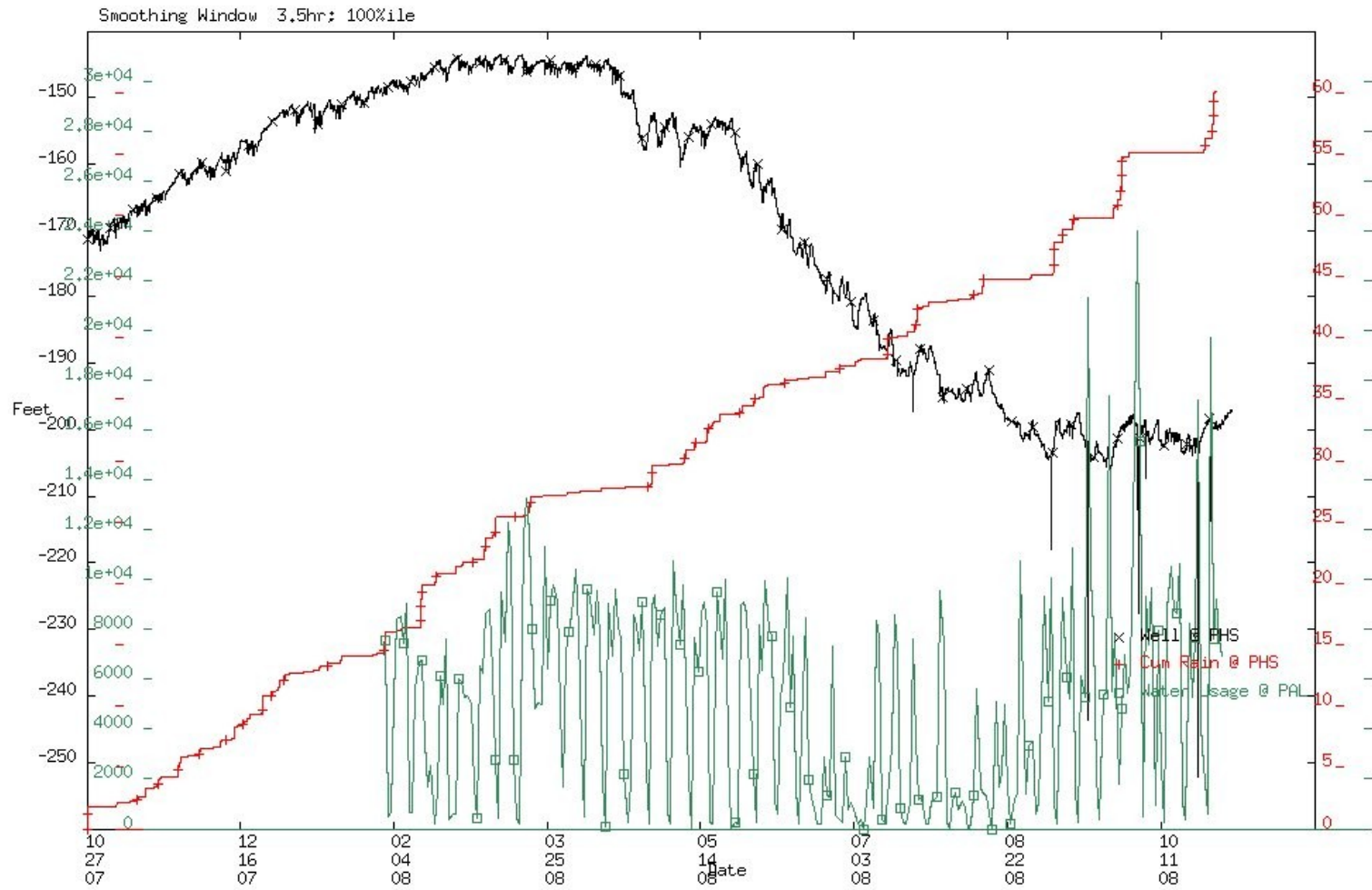


Figure 2

Palisade High School Well

Showing Rainfall and School District Water Use from Fall 2007 through Winter 2008

High School Well
 @ 40 31.273N 75 11.883W
 BNT Water Resources Cmte

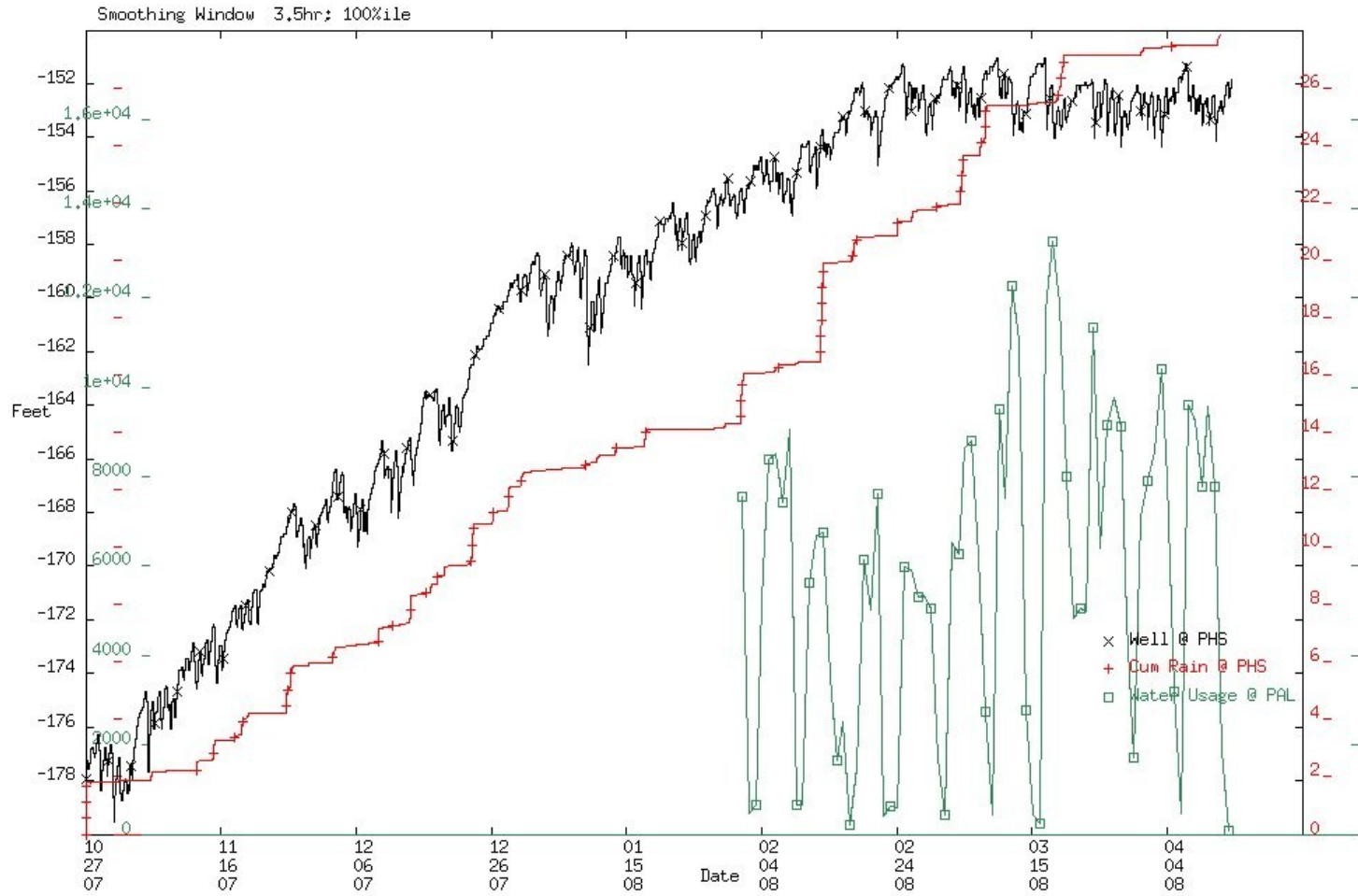


Figure 3

Palisade High School Well

Showing Rainfall and School District Water Use from Spring 2008 through Summer 2008

High School Well
 @ 40 31.273N 75 11.883W
 BNT Water Resources Cmte

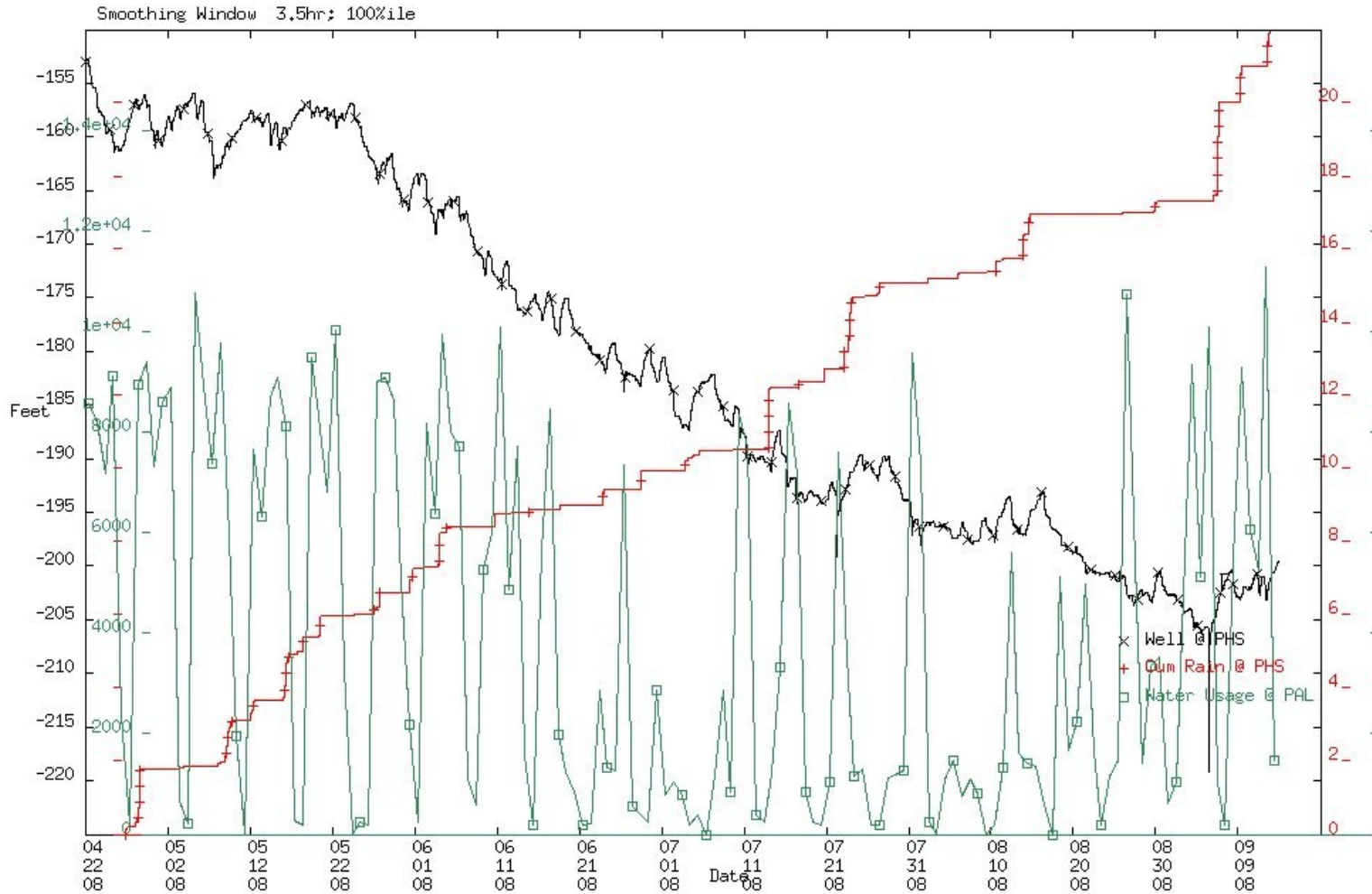


Figure 4

Fourier Transform of Fall and Winter 2007-08 Data
Showing a once and a minor twice a day time signature
[A Fourier transform changes the time domain into a frequency domain]

Transformed Data
HS_fall11_100_fft.csv

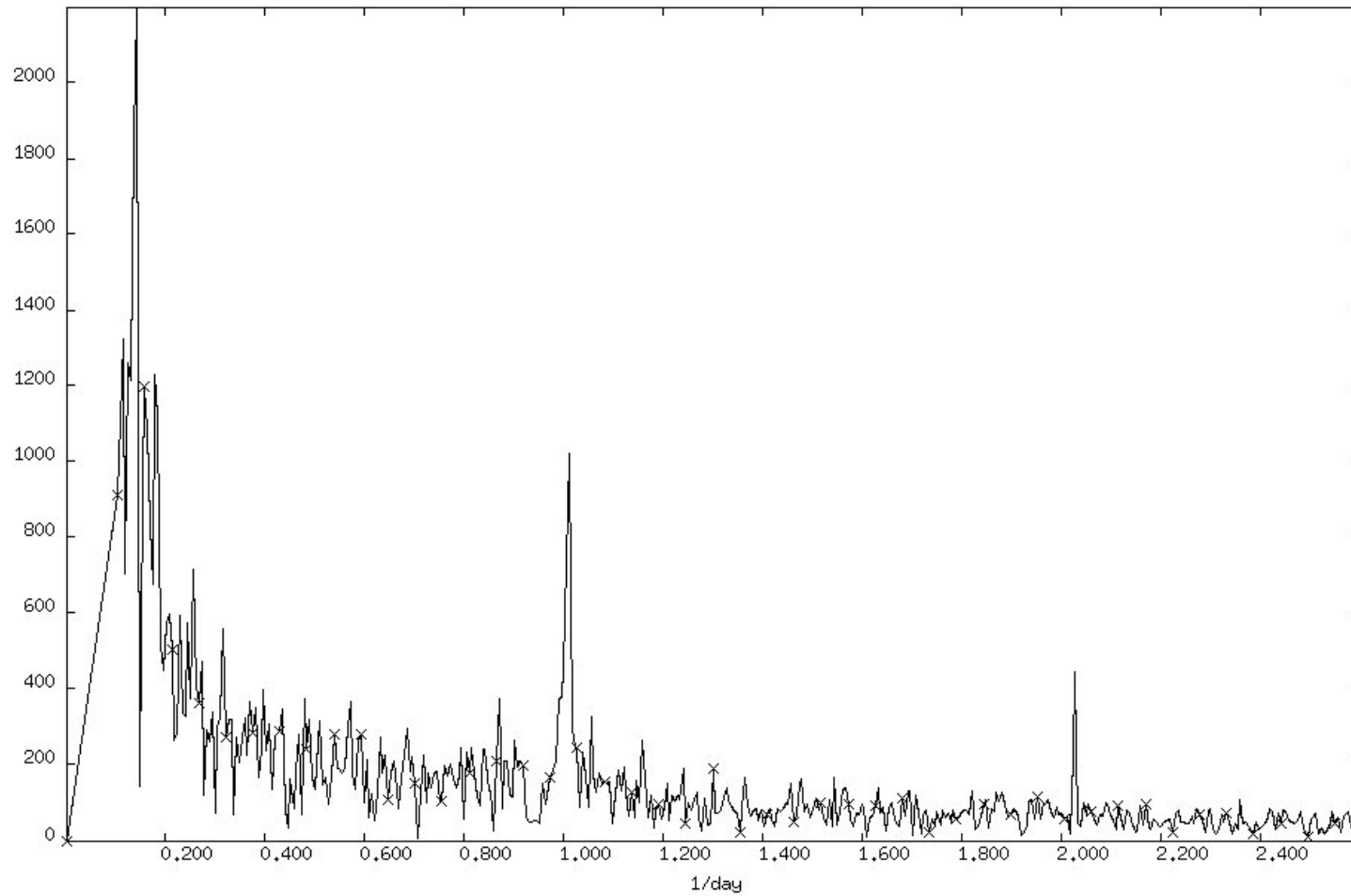


Figure 5a

Fourier Transform of summer 2008 Data
Showing no once and twice a day time signatures

Transformed Data
HS_summer_100_fft.csv

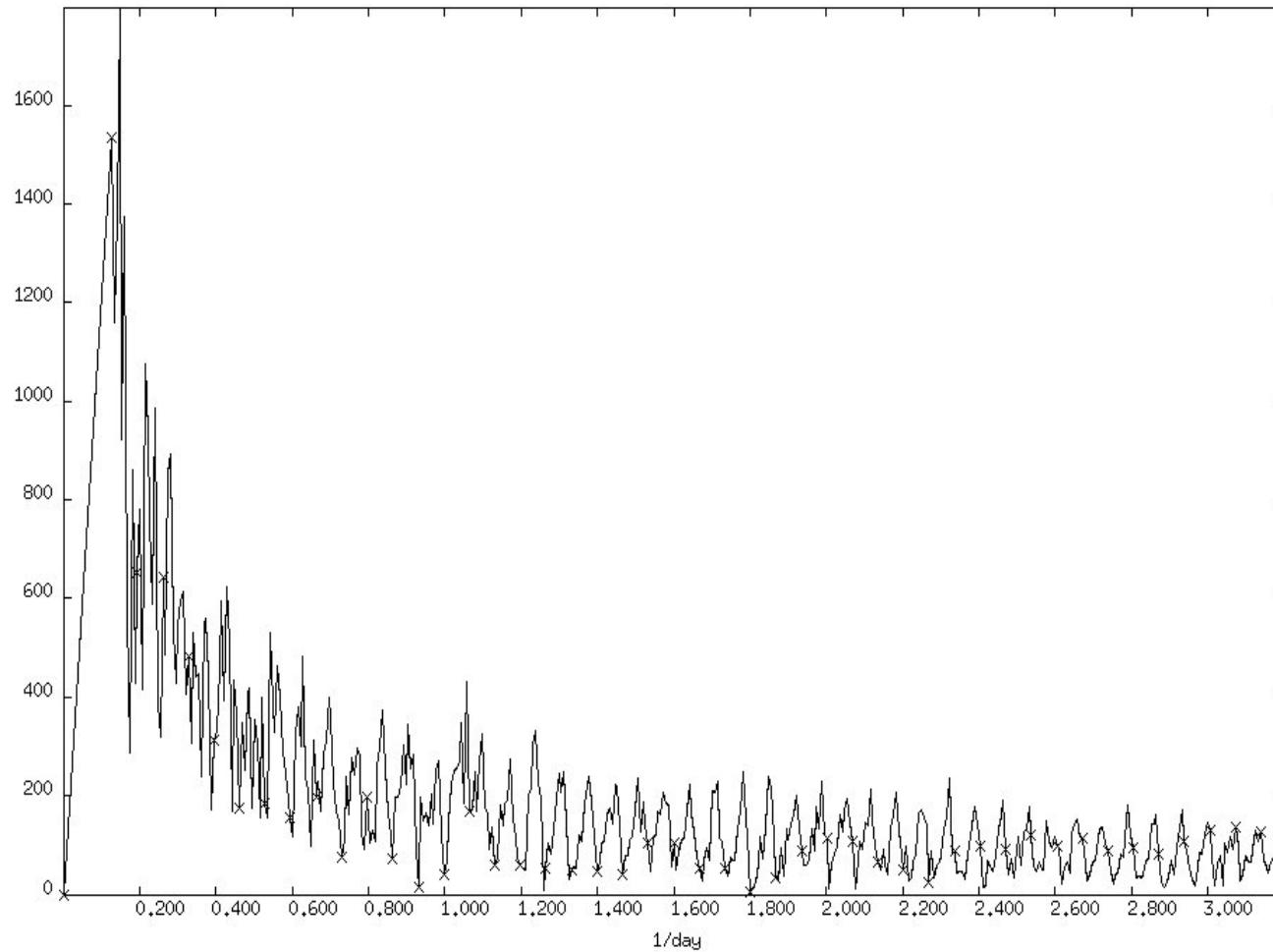


Figure 5b
Palisade High School well overlaid with the residence at 5 Mountain View Road

This shows a virtually completely identical response
[March 2008 through October 2008]

High School Well
@ 40 31.273N 75 11.883W
BNT Water Resources Cmte

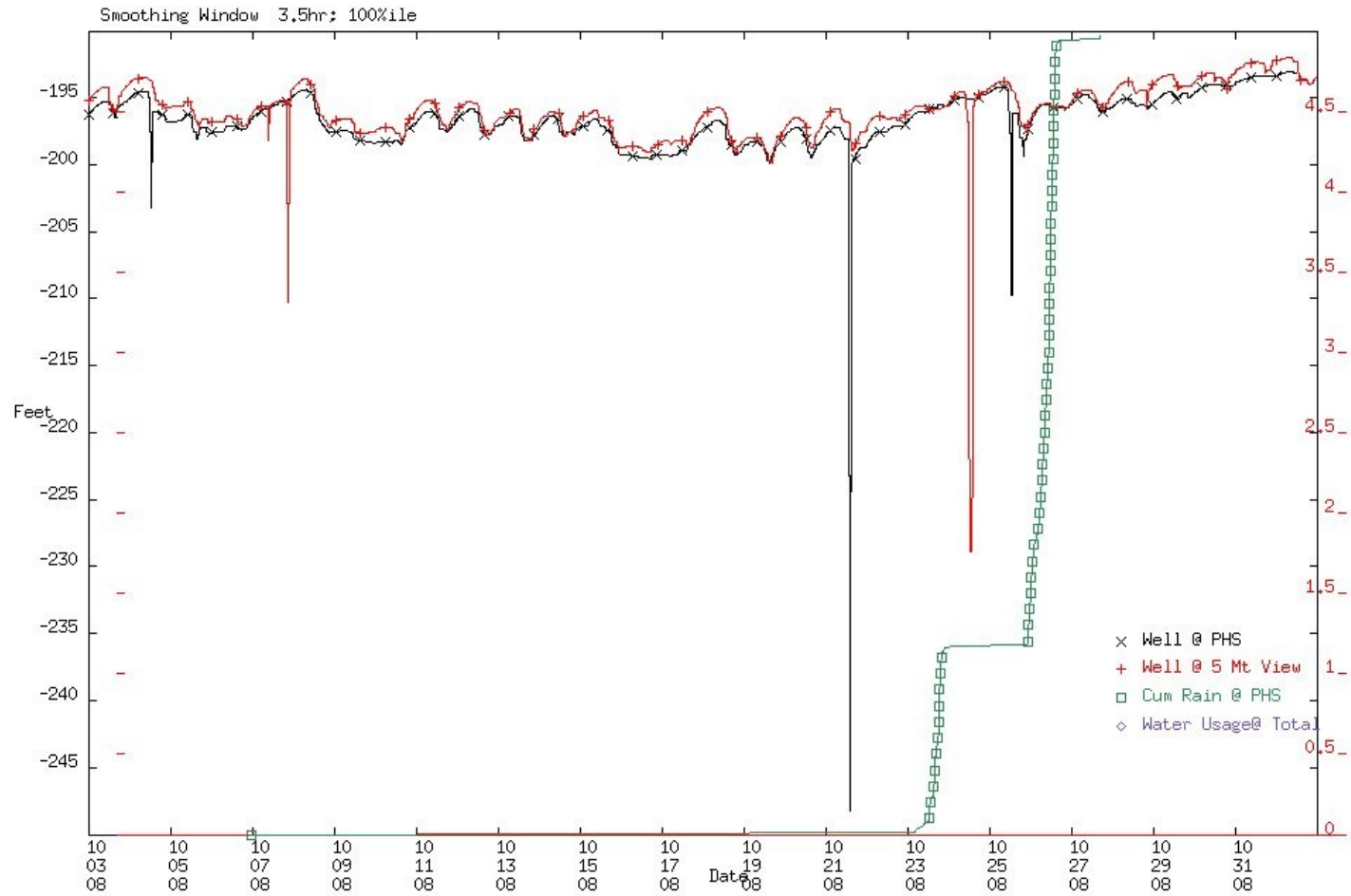


Figure 6