CITY OF RALEIGH
PUBLIC WORKS DEPARTMENT
CONSTRUCTION MANAGEMENT DIVISION

WILDERS GROVE SERVICE CENTER
SOLID WASTE SERVICES FACILITY
630 Beacon Lake Drive
Raleigh, NC 27610

FINAL REPORT
DEPARTMENT OF ENERGY
DOE GRANT EE0002808

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APPENDICES

A. BACKGROUND

On October 30, 2009, the U.S. Department of Energy provided notice of intent to award the City of Raleigh a $1.3 million grant for a geothermal heating and cooling system at the new Wilders Grove Solid Waste Service (SWS) Center. The grant award was for technology demonstration of geothermal energy systems. Final award and Notice to Proceed with Recovery Act Grant EE-0002808 was issued January 29, 2010. Design of the facility was completed, the project was bid and construction began March 29, 2010 with substantial completion attained in April 2012. The state-of-the-art center was built on the site of the City's now closed Wilder Grove's Landfill, off of New Bern Avenue in east Raleigh.

The $1.3 million federal grant covered about half of the estimated $2.6 million cost of the geothermal heating and cooling system for the Wilders Grove SWS Center. City funds were used to cover the rest of the system cost. Installation of the geothermal heating and cooling system followed the City Council's adopted policy of using renewable energy in municipal buildings to enhance energy efficiency. Furthermore, the geothermal unit will help the City achieve its goal of reducing its use of fossil fuels by 20 percent over five years.

The total design and construction cost of the Wilders Grove SWS Center was approximately $20M. The SWS Center is the first of five planned remote operations facilities to be built by the City of Raleigh to make City services more convenient to residents. The 24,000-square-foot facility sits on 20 acres and houses all of the City's Solid Waste Services Department staff and vehicles. It replaced an old Solid Waste Services' headquarters facility location at 400 W. Peace St, near the center of downtown Raleigh.

The City of Raleigh worked with the U. S. Department of Energy (DOE) and other members of the grant teams under the DOE grant program to establish the protocols for data collection under the grant and to outline various methods and equipment to measure, monitor, and report energy usage at the Wilders Grove Solid Waste Service (SWS) Center Remote Operations Site constructed by the City. Personnel from CDH Energy and Oak Ridge National Lab were also involved in the geothermal grant project to manage and verify data collection and analysis and provide other technical assistance.

One of the major objectives identified for the demonstration portion of the DOE Grant Program was to prove the viability of Ground Source Heat Pump (GSHP) systems in significantly reducing energy usage of HVAC and Domestic Water Heating systems (greater than 30%) compared to traditional HVAC systems. It was desired to demonstrate that these GSHP systems can be installed at a reasonable return on investment for these and other types of buildings when compared to traditional HVAC systems.

Another major objective of the Grant Program has been to fund the ability to significantly monitor and trend well field, outdoor air and space temperatures and energy end use of all system components to verify how these systems actually perform compared to predicted computer models and other empirical data. The objective has been to accurately monitor and trend detailed energy end use data and other variables for an extended post occupancy period.

During grant meetings and in subsequent memorandum, DOE requested that the site energy usage be quantified and measured for all energy end use systems in the facility. This data would continue to be collected post occupancy until the end of 2014. Of special interest to the Department of Energy (DOE) is the energy consumption of the various components of the Ground Source Heat Pump Systems (GSHP), including the compressor energy used to heat the building, the compressor energy used to cool the building, the fan distribution energy consumption, and the energy used by the ground source loop pumps. Also of interest is the performance of the well field as a heat sink for the building heating and cooling loads.

DOE also requested Energy End Use be trended for ventilation and domestic water heating systems. In this case, a Ground Source Heat pump is used to provide Domestic Hot Water for the facility and a Ground Source Heat pump Dedicated Outdoor Air System (DOAS) with energy recovery is being used to provide Ventilation Air to the facility.

The DOE also requested the report include all other electrical energy end use consumption categories including exterior and interior lighting energy, plug load energy and other miscellaneous energy consumers. Also requested was that a comparison be made on the energy usage in monthly intervals with other appropriate parameters including OA temperatures, interior space temperatures, occupied and unoccupied scheduled periods, and ground source supply and return water temperatures as well as ground loop flow rates.

Also requested was that a comparison be made between the actual energy usage of the current GSHP, lighting and other energy end uses to the projected modeled baseline energy usage of traditional systems and the modeled Baseline for the actually installed systems. This comparison will verify if the savings projected by the Energy modeling is being realized during real performance.

The energy information requested has been provided in both a numerical format and graphical format in intervals of 15 minutes, hourly, daily and monthly. All data will be archived for future reference by hour, day and month. Data is being transmitted automatically from the building automation system to CDH Energy.

B. EXECUTIVE SUMMARY

The Objectives of the DOE Grant program have been successfully achieved and the City of Raleigh and the SWS Division are very pleased with the comfort, performance, and energy efficiency of the GSHP system. The City of Raleigh would positively evaluate using this type of system on other upcoming City Operations Facility or service building projects where the conditions would be favorable for this type of installation.

This project has well demonstrated that these systems are financially viable with a reasonable incremental ROI and payback period compared to the installation costs and energy usage of traditional HVAC systems for these types of office and service buildings.

As noted in Table 2 of Section C, the total actual measured energy consumption for the SWS facility is 375,541 KWH annually. For the building size, this results in an energy use intensity usage (EUI) of 53,405 BTU/SF/YEAR. This compares to an anticipated EUI usage of 105,470 BTU/SF/YEAR for a traditional VAV reheat system with electric heat. The DOE Commercial Building Benchmarking Data would anticipate a EUI energy usage for this building of 92,900 BTUH/SF/YEAR. Our current consumption is a 42.5 % improvement over a typical building of this type.

The result of the comparison between the modeled energy usage for the Traditional VAV reheat system and lighting controls represented by Table 3 in Section C and the actual measured electrical usage of our facility represented by Table 5 in Section 3 is 366,114 KWH. The result of this comparison is that SWS facility has a 49.4 % reduction in energy usage for our building, using both GSHP systems and improved lighting control.

The HVAC systems themselves are only using 26.5% of the annual energy consumption compared to the model of the traditional HVAC systems. The annual operating costs for the SWS building are only $41,300 annually, as compared to an estimated $82,280 annually (TABLE 3 – Section C) if traditional systems would have been used.

To more easily illustrate the economics of the GSHP system, a simple payback period analysis was performed. Here, the return to the investment consists of reduced operating costs or energy savings from the system. The period of time required to recoup the funds expended in an investment, or to reach the break-even point, is the payback period. Payback period intuitively measures how long something takes to "pay for itself."

The total "additional' cost for the alternative GSHP systems was approximately $440,000 as compared to traditional HVAC systems, with this $400,000 in extra costs being primarily for the well field

construction costs. The annual savings in energy costs using the baseline HVAC system from the original design and the actual GSHP system are $41,300; resulting in a 10.6 year payback ($400,000 / $41,400 savings per yr. = 10.6 yr.).

This payback period recognizes that there are some system inefficiencies and oversizing that occurred with the original system design; however, this was not realized until after the construction was complete and the performance and operation could be examined. In hindsight, construction costs could have reduced by a more robust and less conservative design which would further reduce payback period. This comparison also does not assume any inflation in energy costs. As energy costs increase, the payback period is reduced even further. The payback is also well before equipment replacement cycles and the life of the well field is estimated to be at 50 years. The geothermal system and well field is a very beneficial and efficient system that will likely provide cost effective service for the life of the facility.

Building Energy information is further discussed in Section C of this report. The process involved in setting up and validating the Energy reporting and monitoring implementation is discussed in Sections D and F of the report. The well field construction and monitoring of well field and weather data is discussed in Section E. Detailed discussions of the costs for different components of the Traditional systems and the GSHP systems are discussed in Section G of the report. The Objectives for the project from the City of Raleigh's perspective have all been met and are discussed further in Section H. Lessons Learned and information that can be carried over for other applications are summarized in Section I. A few lessons learned which would improve first cost and energy performance of these in building systems were the following:

- Design for the dedicated outdoor air supply (DOAS) to only operate during building occupied periods or to control humidity levels and to have stages for variability. Design and operate the DOAS to minimize simultaneous cooling and reheating.

- Similarly, design the ground source loop pumps to only operate during building occupied periods except if several heat pumps call for system operation.

Based on the operational changes as recently implemented resulting from discussions with Oak Ridge National Lab Building Technology Research personnel, it is estimated that the changes made to the DOAS schedules and the Ground Source Pumping schedules will save an additional 19,200 KWH and $2115 annually. Therefore, the annual savings is now estimated to be $43,095 for a new simple payback of 10.2 years. Additional investigation and sequence of operation revisions are still being made to reduce DOAS Heating and Cooling and pumping usage even further.

- Another important lesson learned in the evaluation of the ROI for implementing these new technologies is that it is important to be realistic in the usage predictions for the systems to avoid oversizing the systems. Review of different usage scenarios will produce savings adequate to maintain an acceptable payback.

- The same rigor should be applied to the well field sizing to make sure the well field has comfortable safety factors, but it not oversized with respect to the overall average annual heating and cooling loads for the facility. Make sure proper diversity of loads are accounted for in the calculations.

- Implementation of multiple zones in the Wilders Grove facility has verified that a GSHP system can be adequately designed and controlled for a multi-use facility as each zone can represent separate space use, such as separate small buildings, classrooms or even separate retail spaces.

The DOE grant has allowed the City to construct an exemplary facility that has attained a level of performance above that originally anticipated. The facility will be used as a model for further development in the City.

The facility has also been recognized for several performance and sustainability awards, not only locally but nationally as well. Some of the more significant awards and recognition have consisted of the following:

- 2013 USGBC LEED Platinum Certification. At the time of certification, this was the first such solid waste facility recognized by the USGBC.

- 2013 Solid Waste Association of North America (SWANNA) Project of the Year Winner. Excellence award for landfill reuse and sustainability.

- 2013 NC Public Works Association Nominee for Project of the Year

- City of Raleigh Sir Walter Raleigh Award Winner for Excellence & Sustainability

C. BUILDING ENERGY SUMMARY

The implementation of the energy usage data collection process has also been successfully accomplished over the last two years and we believe it is now accurate for all the various energy end uses and total building energy consumption.

The energy end uses and total building energy consumption for September 2012-August 2013 are illustrated for all equipment and systems in Appendices A1-F1 at the end of the report and in Table 1 of this Executive Summary. The energy end uses and total building energy consumption for September 2013-August 2014 are illustrated for all equipment and systems in Appendices A2-F2 and in Table 2 of this Energy Summary.

Table 3 notes the non-geothermal baseline facility energy usage. This design was proposed in the schematic design process as an alternate to purse in addition to the design of the geothermal system. A baseline design is also required to be used in life cycle cost analysis.

Table 4 notes the modeled energy consumption of the actual building construction, using the final GSHP system, pumping system, lighting controls and hot water generation system. The actual use of the HVAC and lighting energy uses compares overall very favorably with the modeled building energy use data as discussed in and illustrated in Tables 4 and 5 in this Energy Summary.

The total measured energy usage of the GSHP's for heating energy, cooling energy, fan energy and ground loop pumps is 124,645 kWh annually versus a predicted use of 144,770 kWh annually in the energy modeling. The lower usage is a reflection of some decisions made by the City to operate the equipment in a more energy efficient manner based on some review with the DOE.

The total measured energy usage of the DHW GSHP is 10,133 kWh annually versus a predicted annual usage of 18,780 kWh annually. This usage is substantially less than anticipated in the original design. The difference is due to a much reduced use of showers and other DHW consumption compared to that predicted by Solid Waste Management when the original design parameters were established. This portion of the project did not result in as attractive a payback since the actual demand was much less than projected.

TABLE 1

CITY OF RALEIGH WILDERS GROVE SERVICE CENTER
ELECTRICAL ENERGY CONSUMPTION (KWH)
PERFORMANCE CRITERIA
SEPTEMBER 1, 2012 – AUGUST 31, 2013

	9/2012	10/2012	11/2012	12/2012	1/2013	2/2013	3/2013	4/2013	5/2013	6/2013	7/2013	8/2013	TOTAL
GSHP 1-27 Cooling	1965	1445	675	495	345	385	290	1065	1765	2085	3360	3165	17040
GSHP 1-27 Heating	455	1155	3780	3525	4980	4695	5060	1520	630	135	355	105	26395
GSHP 1-27 Fan	1075	1155	1045	970	1195	910	915	1095	1145	1545	1240	1100	13390
GSHP-28 Cooling/Heating	5230	5040	5050	5090	5110	4630	2335	760	1100	4380	5690	3210	47625
GSHP-28 Fan	2160	2200	2110	2220	1960	1540	1210	950	880	1410	1690	1180	19510
GSHP-29 DHW Heating	690	790	890	1040	1100	880	980	845	810	420	470	440	9355
Domestic Water Circulation Pumps	160	160	160	165	170	150	170	160	180	90	80	80	1725
Ground Loop Pumps	240	250	250	260	260	240	250	235	250	240	250	230	2955
Interior Lighting	0	0	0	0	0	0	0	0	0	2650	2670	2620	7940
Exterior Lighting	0	0	0	0	0	0	0	0	0	3870	4300	4200	12370
SUBTOTAL	11975	12195	13960	13765	15120	13430	11210	6630	6760	16825	20105	16330	158305
Net Metered Utility Consumption	0	0	0	0	0	33480	31360	20235	19630	23830	28590	25900	
Solar Energy Production	0	0	0	0	0	3900	5720	6500	6790	6420	6060	6120	
Building Total Usage	0	0	0	0	0	37380	37080	26735	26420	30250	34650	32020	
Miscellaneous Electrical Usage	0	0	0	0	0	0	0	0	0	13425	14545	15690	
Average Outdoor Temp (°F)	70.8	60.4	46.7	49.2	44.7	42.9	46.2	61.6	67.5	75.8	78.8	76.3	
Average Well Field Supply Temp (°F)	71.9	69.4	66.2	65.5	64.3	63.9	63.8	66	67.9	71.2	73.2	73.2	
Average Building Return Temp (°F)	73.9	70.3	65.7	65	63.7	63.2	63.2	66.3	68.9	73.5	75.9	75.3	
Average Loop Flow Rate (GPM)	343	343	344	344	344	344	344	343	344	344	345	345	

TABLE 2

CITY OF RALEIGH WILDERS GROVE SERVICE CENTER
ELECTRICAL ENERGY CONSUMPTION (KWH)
PERFORMANCE CRITERIA
SEPTEMBER 1, 2013 – AUGUST 31, 2014

	9/2013	10/2013	11/2013	12/2013	1/2014	2/2014	3/2014	4/2014	5/2014	6/2014	7/2014	8/2014	TOTAL
GSHP 1-27 Cooling	2544	1119	8516	322	290	287	343	933	2701	4290	4302	3799	29446
GSHP 1-27 Heating	10	841	3127	4647	6188	4477	3665	759	112	20	11	17	23874
GSHP 1-27 Fan	1177	1271	1167	1308	1417	1070	1092	1337	1250	1091	1699	1076	14955
GSHP-28 Cooling/Heating	2439	3979	4480	4062	2615	1443	1666	1589	1779	1897	2513	2164	30626
GSHP-28 Fan	970	1465	1650	1615	902	528	593	694	696	677	748	666	11204
GSHP-29 DHW Heating	556	794	873	950	980	855	1012	976	991	859	609	678	10133
Domestic Water Circulation Pumps	109	168	165	170	170	152	168	163	171	164	219	162	1981
Ground Loop Pumps	1152	1132	1152	1250	1302	1117	1204	1087	1210	1297	1382	1258	14543
Interior Lighting	2703	2514	2406	2596	2574	2290	2393	2385	2355	2491	2824	2733	30264
Exterior Lighting	4330	4665	4786	4948	4896	4022	4078	3744	3624	3512	3846	3771	50222
SUBTOTAL	15990	17948	28322	21868	21334	16241	16214	13667	14889	16298	18153	16324	217248
Net Metered Utility Consumption	22223	26893	31250	31250	35637	28950	28463	20053	20121	21336	24134	22773	313083
Solar Energy Production	6129	3807	4056	3079	3604	3486	5299	6265	7373	7092	6637	5631	62458
Building Total Usage	28352	30700	35306	34329	39241	32436	33762	26318	27494	28428	30771	28404	375541
Miscellaneous Electrical Usage	12362	12752	6984`	12461	17907	16195	17548	12651	12605	12130	12618	12080	158293
Average Outdoor Temp (°F)													
Average Well Field Supply Temp (°F)													
Average Building Return Temp (°F)													
Average Loop Flow Rate (GPM)													

TABLE 3 – BASELINE FACILITY MODELED ENERGY USAGE

The energy usage for the Baseline facility HVAC systems was modeled based on the use of Variable Air Volume type Air Handling systems with variable volume electric reheat terminal units instead of the installed system of Ground Source Heat Pumps.

The energy usage for the Baseline facility lighting systems was modeled based on the use of energy efficient lighting fixtures without the benefit of motion detection and day-lighting control systems which are installed in the current actual building construction.

The modeled energy usage for the Baseline Domestic Water Heating systems was based on electric resistance DHW heating systems instead of the GSHP DHW heating system actually installed for the building.

The modeled **Baseline Energy Consumption** and annual utility costs were estimated to be the following:

	ANNUAL KWH CONSUPTION	ANNUAL COSTS
LIGHTING (INTERIOR)	49,000 KWH	$5390 ANNUALLY
HEATING	240,290 KWH	$26,430 ANNUALLY
COOLING	125,900 KWH	$13,850 ANNUALLY
FANS	105,180 KWH	$11,570 ANNUALLY
DHW HEATING	59,485 KWH	$6580 ANNUALLY
MISC. LOADS	71,700 KWH	$7880 ANNUALLY
LIGHTING (SITE)	97,090 KWH	$10,680 ANNUALLY
TOTALS	741,655 KWH	$82,380 ANNUALLY
TOTALS	2530 MMBTU ANNUALLY	105,470 BTU/SF/YR ANNUALLY

TABLE 4 – MODELED BUILDING ENERGY CONSUMPTION WITH GSHP

The annual Modeled Building Energy Consumption and utility costs for the **actually constructed** building using the GSHP system and improved lighting controls was estimated to be the following:

	ANNUAL KWH CONSUPTION	ANNUAL COSTS
LIGHTING (INTERIOR)	**48,530 KWH**	**$5335 ANNUALLY**
HEATING	**33,400 KWH**	**$3675 ANNUALLY**
COOLING	**51,660 KWH**	**$5680 ANNUALLY**
FANS	**40,810 KWH**	**$4480 ANNUALLY**
DHW HEATING	**18,780 KWH**	**$2065 ANNUALLY**
MISC. LOADS	**71,700 KWH**	**$7885 ANNUALLY**
LIGHTING (SITE)	**29,160 KWH**	**$3205 ANNUALLY**
PUMPS	**18,900 KWH**	**$2080 ANNUALLY**
TOTALS	**312,940 KWH**	**$34405 ANNUALLY**
TOTALS	**1070 MMBTU ANNUALLY**	**44,500 BTU/SF/YR ANNUALLY**

The modeled improvement in energy consumption and costs of using the GSHP system and improved lighting controls was estimated to reduce energy consumption by 1460 MMBTU annually and save $47,975 annually in utility expenditures. The improvements in the systems were estimated to reduce the energy use intensity of the building from the Traditional System prediction of 105,470 BTU/ square foot/year to the GSHP prediction of 44,500 BTU/square foot /year.

HVAC LOADS	Consumption
HEATING	33,400 KWN
COOLING	51,660 KWN
FANS	40,810 KWN
	125,870 KWH
DHW HEATING	59,485 KWH

TABLE 5 – ACTUAL MEASURED ANNUAL ENERGY END USE

The current actually measured energy end use data and costs for the facility are illustrated in this Table and are shown in the Appendices for each GSHP and piece of equipment as well as lighting systems and DHW Heating systems.

	ANNUAL KWH CONSUMPTION	ANNUAL COSTS
LIGHTING (INTERIOR)	30,264 KWH	$3,325 ANNUALLY
GSHP-1-27		
HEATING/FAN	23,874 KWH	$2,625 ANNUALLY
COOLING/FAN	29,446 KWH	$3,240 ANNUALLY
FAN ONLY	14,955 KWH	$1,645 ANNUALLY
GSHP-28		
HEATING	10,000 KWH	$1,100 ANNUALLY
COOLING	20,626 KWH	$2,270 ANNUALLY
FAN	11,204 KWH	$1,230 ANNUALLY
GSHP-29		
DHW HEATING	10,133 KWH	$1,115 ANNUALLY
DHW PUMPS	1981 KWH	$ 215 ANNUALLY
GROUND SOURCE LOOP PUMPS	14,543 KWH	$1,600 ANNUALLY
MISC ELECTRIC	158,293 KWH	$17,410 ANNUALLY
SITE LIGHTING	50,222 KWH	$5,525 ANNUALLY
TOTALS	375,541 KWH	$41,300 ANNUALLY
TOTALS	1281 MMBTU ANNUALLY	53,405 BTU/SF/YR

D. PROJECT OBJECTIVES

Project Objective I: Provide demonstration of Wilders Grove Solid Waste Service Center Geothermal Heat Pumps viability on energy usage for future Service Centers planned by the City of Raleigh and for other similar cooling dominated facilities in the southeast.

- Effective Cooling of 24,000 SF Administration Building
- Minimum 30% Energy Cost Savings compared with conventional HVAC Systems
- Size Well Loop System to meet current and future heating and cooling demand based on thermal conductivity of ground reservoir
- The ground source heat pump well field is designed to accommodate a 100 ton HVAC cooling load and is expandable to include an additional 25 tons.
- Well field design based on Thermal Conductivity testing on site
- Thermal Conductivity = 1.45 to 1.55 Btu / hr-ft-SF

Project Objective II: Reuse rejected heat from Heat Pumps to reduce return water heat content to well field and, in turn, generate hot water for domestic use.

- Minimize long term heat transfer to ground reservoir
- Reduce power cost for domestic hot water generation
- Recover heat before being discharged back to well field
- Evaluate whether system reduces well field return water temperature by 10ºF to 20ºF when system is operating

Additional Project Objectives:

- Provide demonstration of Geothermal Heat Pumps viability on energy usage for future Service Centers planned by the City of Raleigh and for other similar use facilities in the southeast.

- Provide hot water and building load applications:
  - Evaluate pre-heating of hot water for use with vehicle washing system.
  - Evaluate evaporative cooling system for building cooling loads.
- Prove viability for high demand, sporadic cooling loads throughout the year, without significantly raising the temperature of the well field to the point of lost viability.
- Evaluate use of a multi zoned geothermal heating and cooling system for multiple room or facility space applications (The Wilders Grove facility has 27 different building zones. This system will be controlled with a building management system).
- Provide means to monitor temperature trends of heat pump system, excess heat rejection systems, and the well field by using the Facility Management Control System.
- Obtain and monitor temperatures for the GSHP well field with depth and location within and outside the well field.
- Monitor energy use and performance of the GSHP system. Establish performance metrics and reporting formats from GSHP control points and compare to predicted usage.
- Achieve Minimum Energy Savings of 30%. Establish and verify economic performance of the system.
- Provide educational outreach.

E. ENERGY REPORTING IMPLEMENTATION SUMMARY

During the Spring and Summer of 2012 and through the Summer of 2014, Jacobs Engineering, City of Raleigh personnel, the Enterprise software developer, the BAS provider, and several of the project Construction subcontractors worked to get all the energy end use monitoring devices properly connected and reporting properly through the Building Automation Systems. We also worked to make sure the Periscope Enterprise reporting system for data assimilation and report creation was reporting values properly. The reporting of the energy use and energy end use for the facility has been now reported in two full calendar years – September of 2012- August of 2013 and September of 2013 – August of 2014. Samples of the Periscope Enterprise reporting system architecture are included in the Appendix.

The Energy End Use Data for the space GSHP's 1-27, GSHP-28, GSHP-29 and the Ground Loop Pumps have been reporting since September of 2012. With the assistance of Oak Ridge Research personnel, it was discovered this year that the Ground Loop Pump reporting was inaccurate for the 2012 -2013 reporting period. The error was caused by an inaccurate conversion used in the monitoring system, but this situation was corrected for the 2013-2014 period. Total energy use was correct, but the portion being assigned to this particular unit was inaccurate.

The energy end use data for the interior and exterior lighting energy usage also took longer to work out as there were communication issues with the Watt Stopper digital data controller that had to be resolved with the manufacturer. It was discovered that the data was only accurately being reporting to the building automation system over the last three months of the 2012-2013 trending period. The exterior lighting system was connected to sub-metering in late 2013. However, the 2013-2014 trending information should have completely accurate representations of the lighting consumption use.

Oak Ridge personnel also assisted in providing several operational control revisions to the loop pumping system, hot water system production and direct outdoor air supply (DOAS) unit to further reduce energy costs.

The Solar Energy production data and total net utility metered data from the utility were properly connected and programmed to receive accurate data the last few months of the 2012-2013 trending year. This data was extrapolated into annual energy usage for the 2012-2013 trending year, but is providing accurate data for the 2013-2014 year.

The miscellaneous electrical and plug loads energy is not sub-metered and is calculated by subtracting all the sub-metered loads from the total energy consumption metered for the building and the energy produced by solar photovoltaic panels. The miscellaneous electrical energy component comprises a wide variety of energy consumption from the Wilders Grove main building panel. These uses involve ice machine production for the entire field staff, numerous vending machines for the lunch and break area, roll up bleachers for staff briefings, multiple building and site access and security gates, cameras and card reader security access systems, radio communications and miscellaneous unit heaters in addition to the network, plug and computer load circuits.

The Energy End Use Data collection continues to be provided to CDH Energy in daily batch transmissions. This data transmission is scheduled to continue throughout the remainder of 2014 and beyond as may be desired by the DOE.

F. WELL FIELD AND WEATHER DATA

1. Well Field and Temperature Data

a. Well Field

Preliminary design by the A-E for construction had indicated 60-400 feet deep wells were required for the building loads. The well field was designed for 6 circuits with 10 wells on each circuit, a total of 60 wells. Third party ground thermal conductivity testing was performed on 2-test wells by Geothermal Resource Technologies in mid-2010. The conductivity test information resulted in the geothermal well depths being revised to 335 feet.

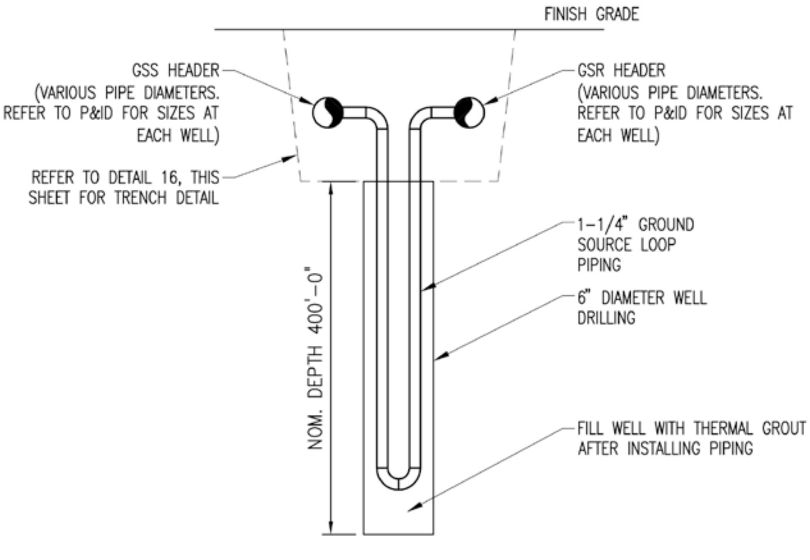
Well drilling records, as well as periodic time cycle information on the well construction process, was collected. An average duration cycle for the well drilling information is summarized for various steps in the well construction, well loop install, and the grouting process in Appendix G. Information pertaining to actual well field layout and construction durations is contained in Appendix G.

In future operational research, the number of ground loop circuits in use can be varied and results evaluated.

A closed loop system was installed for this facility as compared to an open loop system. In a closed loop system, the water within the tubes never physically contacts the groundwater and groundwater is not withdrawn from or recharged to the aquifer. The water within the tubes is simply circulated between the boreholes and the building's heat exchange device.

For this project, the ground loops used to facilitate the transfer of excess heat to or from the building consist of a series of 6 circuits with 10 wells on each circuit, a total of 60 wells. Each well is a 335 foot deep vertical well, spaced at 25-feet on centers. The wells are located beneath a parking lot, which allows for long term performance monitoring and expansion of the system as the facility grows or expands as necessary. Each well has a pair of continuous 11/4-inch HDPE pipes connected at the base with a "U" fitting that provides circulation of water and transfer of heat to or from the Granite bedrock beneath the facility.

The horizontal portion of the well field piping connecting the circuit piping was connected with a thermal weld process to ensure long lasting connections. The loop circuits were each flushed and pressure tested prior to the well field being put into use. Each well was filled with thermally enhanced grout for increased conductivity and heat transfer. A typical detail of the well construction is noted below.



TYPICAL WELL DETAIL

Well loop circuits are controlled using valves located in a buried geothermal control circuit vault located outside the building and adjacent to the well field in the parking lot. There are 6 well field loop circuits with 10 wells on each circuit.

Pumps located in the building mechanical room constantly convey water through the building heat pumps, heat exchangers and the vertical well field circuit loops. Pressure gages monitor the difference between the supply and return piping. Flow is monitored on the loop piping in the upstairs mezzanine. Temperature gages are also installed to monitor supply and return temperatures.

Well Field Loop Pumps

General Photos of the well field construction follow:

Well Drilling

Well Drilling

Well Loop Install

Well Head Loop & Grouting

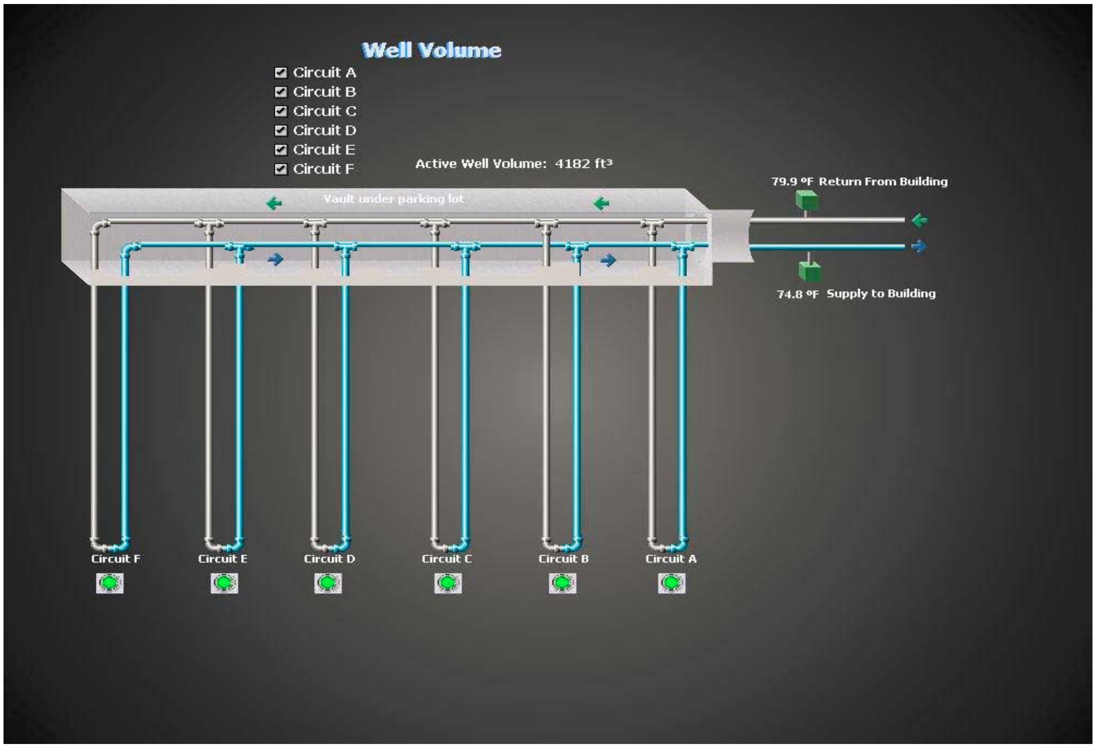
Well Grouting Equipment

Well Field Vault

Header Pipe Thermal Welding

Well Head Connections

The final well field circuit layout is depicted in the building automation system in the below screen shot. Temperatures to and from the well field are recorded in the administration building mechanical room as they enter and leave the building. The well field vault has valves installed on each circuit to allow circuits to be opened and closed. The vault piping also has taps installed to allow temperature probes to be inserted in each circuit to manually monitor temperatures if this data is desired.



Well Volume

☑ Circuit A
☑ Circuit B
☑ Circuit C
☑ Circuit D
☑ Circuit E
☑ Circuit F

Active Well Volume: 4182 ft^3

79.9 ºF Return From Building

74.8 ºF Supply to Building

b. Temperature Wells

Actual well field temperatures are being obtained in four well bores (1 well is up gradient of the well field, 2 wells are within the well field, 1 well is down gradient of the well field). The temperature data is being down-loaded from the probes and reported monthly. The below site plan layout depicts the location and orientation of the four temperature wells in the well field.

The temperature wells are 335 feet deep to match the geothermal well depth. Temperature probes are installed at depths of 60, 146, 233 and 320 feet within the temperature well. The probes are small diameter devices and all four devices were suspended from the top of each well at the correct elevation and communicated thru connected data cables. Little temperature variation has been recorded to date at the well field during the operation of the geothermal system. This bodes well for long term use of the well field.

Well Field Data Logger

c. Well Field Performance

The well field performance was evaluated by the system design engineer in report of October, 2013. Performance data was provided by the City of Raleigh from the Building Management System installed at the Wilders Grove Facility. This data was charted on line graphs for June 9, 2013 through June 30, 2013, July, 2013, August, 2013, September 2013, and October 1, 2013 through October 9, 2013.

The data shows that the circulation pump varied in flow between 300 and 370 gallons per minute. The maximum load observed was approximately 80 tons (the original design was a peak load of 100 tons). This maximum load is as expected since most buildings operate with a 20% load diversity. Reviewing the trend data clearly shows when the facility is not occupied, daily peak loads and when the system is operating in a heating mode (negative loads). The supply and return temperature differences range between 0 (when the heat pumps are shut down) to 4 degrees. The system tonnage was calculated using the basic formula:

$$Q=500xgpmx\Delta T \text{ (Temp in – Temp out).}$$

The operational data to date indicates that the well field is operating correctly. It was reported that the well field temperature monitoring sensors have not indicated any significant increase in temperatures.

Temperature difference between the well field and the supply loop holds at a difference of around 10ºF. This was expected by the AE when designed due to a lack of significant ground water and the well field being constructed essentially in solid granite. The quantity of wells, flows and layouts appear to be meeting the design intent. With an observed 80 ton load, the well field is operating at the intended capacity. Some additional load could potentially be added to the system if the flow rates are reduced. The current well field could probably handle an additional 20 ton HVAC load when accounting for system operational diversity.

2. Solar and Weather Data

a. Solar Data

Solar PV is installed on the Wilders Grove facility to provide a minimum of 12.5% of the building's energy consumption. The system designed for the Solid Waste Services Building has a nominal rating of 49.35 KW (DC). Solar intensity from the local weather station is provided in Appendix F1 for February 1, 2013 to September 30, 2013 and Appendix F2 for September 1, 2013 to August 31, 2014. The contribution of the solar energy production to the buildings energy consumption is a consideration in the total energy consumption of the facility.

b. Weather Data

A local weather station was installed at the facility to monitor typical weather information such as rainfall, temperatures, wind speed and direction, barometric pressure and humidity. The station also includes two additional sensors that monitor UV and solar radiation. The station has an interface with the City local and system network to log and report weather data.

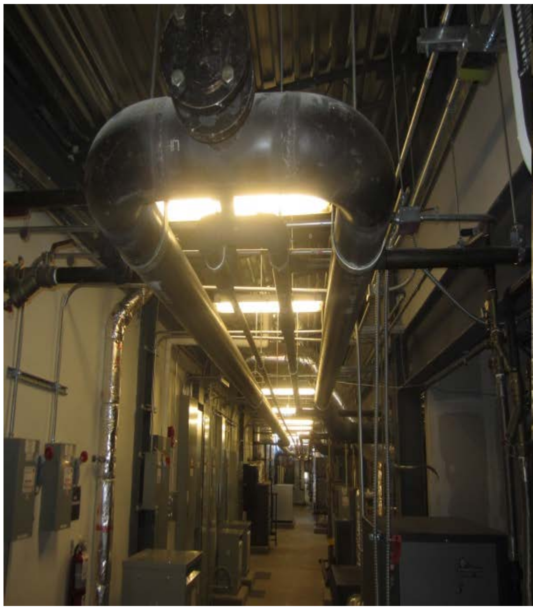
G. BUILDING SYSTEMS DESCRIPTIONS AND ENERGY CONSUMPTION

The implementation of the energy usage data collection was accomplished in the following manner:

1. Ground Source Heat Pump System Energy Usage

a. System Description

Cooling and heating for the facility is provided by 27 water to water ground source heat pumps connected to a condenser water well field and pumped by two condenser water circulating pumps. The system utilizes direct expansion geothermal ground water source heat pumps with supply air fans and filters. A total of 27 ground source heat pump units of various sizes are installed. Spaces in the building are zoned based on heat load profiles. The installed system modifies the HVAC operation to follow the actual building occupancy. Utilizing zoned heat pumps allows these systems to shut-off when portions of the building are not occupied while the remainder of the facility continues to operate, un-interrupted with no disruption in comfort levels. A general layout of these heat pump units in the building are noted in the following photos:



GSHP Loop Connection

Supply/Return Loop Connection

Temperature control for the building zones or spaces are regulated by space temperature sensors controlling each heat pump. Rooms that have similar occupancies and exposures are grouped together and supplied by one heat pump. One of these spaces, deemed the more critical, will have the wall mounted space temperature sensor. The design of the building automation and control system is based on a web based direct digital control system. All override functions will be through buttons on the wall mounted temperature sensors. The required interface protocol for all equipment shall be BACNET or LON.

On demand ventilation air flow is monitored by duct mounted air flow stations. A fixed air flow will be supplied to low occupancy areas. Densely occupied spaces will utilize a flow control device to vary outside air flows. As a space becomes occupied and carbon dioxide levels increase, carbon dioxide sensors in the rooms will increase outside air flows to maintain constant levels 400 ppm or less (equivalent of outdoor air) per ASHRAE 62.1-2004.

Air Flow Station

For outdoor air and ventilation, a Ground Source Heat Pump DOAS unit is installed in the mezzanine of the SWS Facility to supply ventilation to the entire SWS Facility. The Dedicated Outdoor Air System (DOAS) directs outdoor ventilation air for the facility required for occupant and exhaust.

The capacity of the DOAS was designed to provide a minimum of 20 CFM of outdoor air per building occupant. The outside air quantities for the air handling system will be provided in accordance with the latest ASHRAE Standards and the North Carolina State Building Code. The DOAS includes a heat recovery section to recovery energy from the combination exhaust / relief air from the building and use it to temper the required minimum amount of outdoor air for the building. The energy recovery is by means of an air to air rotating enthalpy wheel. This unit is referenced as GSHP 28.

GSHP 28 Dedicated Outdoor Air Supply Unit

GSHP 28 Dedicated Outdoor Air Supply Unit

b. GSHP Compressor Heating Mode and Fan Energy Consumption in kWh

This data was collected by the Verius electric sub-metering equipment and is reported to the Periscope Enterprise software system during periods when the BAS system indicates the individual space heat pumps (GSHP 1-27) are in the Heating mode.

The Periscope system is a configurable, web-based dashboard application that provides rapid identification of real-time and historical trends in key attributes of multi-facility operation, including energy use, operational efficiencies and critical metrics. The system is capable of reducing volumes of data from disparate systems into visual knowledge, Periscope by Activelogix gives the user the ability to quickly identify issues and assess relationships and take action in rapidly changing environments in order to optimize resource efficiencies and sustainability. The architecture, network layout and control system component information is included in the Appendix with system schematics.

The energy was measured with current transducers and measurements of voltage and power factor from which Kw and kWh is calculated continuously. The Verius metering device was installed in panels adjacent to the electrical panels for the circuits being monitoring such that short connections to the panel circuits could be provided. The Verius device connects to the JACE for communication to the City's network and Periscope System.

Verius Panel Connections to Electrical Panel Circuits

The Periscope System has provided this data electronically since September of 2012 to CDH Energy / DOE in 15 minute intervals and archived the data to be presented in any time frame format desired. GSHP Fan energy is included in this data since it cannot be isolated from the compressor energy usage. This data is summed into monthly and annual energy consumption and is detailed in Appendix A1 for September 1, 2012 to August 31, 2013 and Appendix A2 for September 1, 2013 to August 31, 2014.

c. GSHP Compressor Cooling Mode Energy Consumption in kWh

This data was s collected by the Verius electric sub-metering equipment and reported to the Periscope Enterprise software system during periods when the BAS system indicates the individual space heat pumps (GSHP 1-27) are in the Cooling mode. The energy was measured with current transducers and measurements of voltage and power factor from which Kw and kWh was calculated continuously. The Periscope System provided this data electronically since September of 2012 to CDH Energy / DOE in 15 minute intervals and archived the data to be presented in any time frame format desired. GSHP Fan energy is included in this data since it cannot be isolated from the compressor energy usage. This data is summed into monthly and annual energy consumption and is detailed in Appendix A1 for September 1, 2012 to August 31, 2013 and Appendix A2 for September 1, 2013 to August 31, 2014.

d. GSHP Total Energy Consumption in kWh

This data was collected by the Verius electric sub-metering equipment and reported to the Periscope Enterprise software system during all periods when the BAS system indicates the individual space heat pumps (GSHP 1-27) are operating. The energy was measured with current transducers and measurements of voltage and power factor from which Kw and kWh and was calculated continuously.

This total energy usage data for GSHP’s 1-27 gives the total energy usage for each GSHP throughout the given time interval. The difference between this data and either of the previous two data sets will account for energy consumption of the GSHP Ventilation fans during periods when the compressors are not operating for either heating or cooling; but the fans are still operating during the building occupied periods. Similar data was also reported for the Dedicated OA Ventilation GSHP-28. Outdoor ventilation heat Pump GSHP-28 has sub-metered data available for fan energy usage and total energy usage, but data is not directly available for compressor energy. Compressor energy is determined by subtracting the measured fan energy from the total sub-metered energy. It is also not possible to determine if the heat pump is in cooling or heating mode. It is assumed to be in cooling or dehumidification mode most months except for the main winter months.

The Periscope System provided this data electronically since September of 2012 to CDH Energy / DOE in 15 minute intervals and archived the data to be presented in any time frame format desired. This data is summed into monthly and annual energy consumption for GSHP’s 1-27 and is detailed in Appendix A1 for September 1, 2012 to August 31, 2013 and Appendix A2 for September 1, 2013 to August 31, 2014.

The Data for GSHP-28 is detailed in Appendix B1 for September 1, 2012 to August 31, 2013 and Appendix B2 for September 1, 2013 to August 31, 2014.

e. Comparison Data

Additionally, the following information was provided on a monthly basis for each of the GSHP's to compare how these parameters effect the energy consumption of the GSHP's. The Periscope System provided this data electronically since September of 2012 to CDH Energy / DOE in 15 minute intervals and archived the data to be presented in any time frame format desired. This data is presented for each GSHP in Appendix A1 for September 1, 2012 to August 31, 2013 and Appendix A2 for September 1, 2013 to August 31, 2014 as averages for each month.

(1) Measurement of OA Temperature and comparison versus energy consumption using temperature sensors and the Building Automation System (BAS).

(2) Measurement of Space Zone Temperature and comparison versus energy consumption using temperature sensors and the Building Automation System (BAS).

Additionally, in Appendix E1 for September 2012 to August 31, 2013 and Appendix E2 for September 1, 2013 to August 31, 2014, the following comparison data is provided:

(1) Measurement of ground loop entering and leaving temperatures to and from the system using temperature sensors and flow rates using an ultrasonic flow meter.

(2) Measurement of ground source well field pumping energy through use of current transducers and measurement of voltage and power factor from which Kw and kWh can be calculated at the same intervals. This data will be summed into annual energy consumption.

2. Lighting Energy Consumption

Interior lighting energy consumption has been monitored and recorded at each lighting panel with current transducers and measurement of voltage and power factor from which Kw and kWh can be calculated for each interval. Indications are also provided concerning which spaces are occupied and unoccupied during given intervals through tracking of occupancy sensors and where lighting is not required due to lighting provided by natural sources. This data has been summed into monthly energy consumption for only 3 months during the 2012-2013 trending year due to lack of accurate data before that period. During the 2013- 2014 trending year the data should be completely accurate.

Exterior parking and site lighting energy consumption was s also provided on a monthly basis for only 3 months during the 2012- 2013 trending year, but is accurate for the entire 2013-2014 trending year.

The Periscope System provided this data electronically since July of 2012 to DOE in 15 minute intervals and archived the data to be presented in any time frame format desired. This data is presented in Appendix D1 for September 2012 to August 2013 and Appendix D2 for September 1, 2013 to August 31, 2014 as averages for each month.

3. Domestic Hot Water Heating Energy Consumption

Domestic Water Heating Energy consumption was monitored and recorded for GSHP-29 and for the domestic water pumping energy use with current transducers and measurement of voltage and power factor from which Kw and kWh is calculated for each interval. This data was summed into monthly and annual energy consumption.

The unit for generating domestic hot water was a Heat Harvester domestic water source 10 HP single scroll compressor.

Heat Harvester

Heat Harvester

Hot water for domestic use was generated and stored on site. The unit was initially programmed to generate hot water at night during non-peak times. After further review with DOE personnel and City personnel, the generation period was changed to a shorter early morning non-peak time. This allowed the unit to be operated for shorter periods and coincide with the DOAS operation, also resulting in shorter pumping durations and reduced energy costs. A back up electric heat element was provided in the storage tank as illustrated in the attached photo.

The Periscope System provided the hot water data system electronically since September of 2012 to DOE in 15 minute intervals and archived the data to be presented in any time frame format desired. This data is summed into monthly and annual energy consumption and is detailed in Appendix C1 for September 1, 2012 to August 31, 2013 and in Appendix C2 for September 1, 2013 to August 31, 2014.

Hot Water Tank

4. Plug Load and Miscellaneous Energy Consumption

Miscellaneous energy consumption is calculated for each interval by subtracting the measured energy end use measure quantities from the total net metered data for the building plus the amount provided by solar photovoltaic panels. The miscellaneous end plug load energy end use is not separately sub- metered.

The miscellaneous electrical energy component comprises a wide variety of energy consumption from the Wilders Grove main building panel. These uses involve ice machine, vending machines, bleachers, multiple building and site gates, cameras and security access systems, and unit heaters in addition to the network, plug and computer load circuits. Some exhaust fans are also not separately metered.

5. Total Energy Consumption

Total Energy Usage Consumption summed for each time interval and summarized monthly is based on the building's net electric energy usage meter and the metered data for electrical energy production for the solar photovoltaic system. This data was only reliable over a few months during the 2012-2013 trending year due to errors in the meter variables for the utility meter and the data from the solar photovoltaic data requiring further verification. This data is detailed in Appendix F1 for February 1, 2013 to August 31, 2013 and Appendix F2 for September 1, 2013 to August 31, 2014.

H. GEOTHERMAL SYSTEM AND COMPONENT COSTS

Actual component cost for the geothermal system construction were tabulated and provided by the construction contractor, T.A. Loving, Inc. of Goldsboro, NC and is included in the Appendix. During the design development process, and as part of the City's decision analysis, a conventional system cost estimate was provided by the Designer. The conventional system estimate did not have a detailed design for a plan estimate take-off other than the general zone layout noted on the plans and the designers experience with such systems and costs from prior design. This conventional system estimate was used for comparison with other system designs for selection of the final preferred design option. This cost estimate was also used for comparison with the GSHP system design estimate. Due to the anticipated favorable payback period, the GSHP system was selected for construction. A cost table outlining these two estimates with major cost element items is included at the end of the section. A brief summary of the main components is included in the discussion below:

1. General Conditions

This GSHP general conditions costs was provided from the construction contractor as part of the bid item breakdown. The original design estimate for the base system included an overhead and profit amount that was greater than the amount provided by the construction contractor for a similar cost system. The same general condition overhead and profit costs for the conventional building were reduced based on a pro rata costs for the building size at the time of the design estimate. There is relatively little to no difference for this element, similar cost would be encountered regardless of the type of system installed.

2. Well Field and Loop Pumping System

$18.33 / SF for 24,000 SF facility

This was determined to be the main cost delta for an analysis of energy savings vs. extra system cost for the payback analysis. Well field costs and the costs of the loop pumping systems were determined to be the main or extra cost premium for the GSHP system above a conventional system cost.

3. Building Equipment Cost

Due to the variety of spaces and types of use in the Wilders Grove facility, and the desire by SWS staff to have numerous zoned spaces with more individual control, the Wilders Grove facility also has more heat pumps in the facility than would a "typical" commercial facility where they may have larger areas (such as classrooms, store space, etc.) that would have fewer heat pumps. This is a reason that the conventional HVAC system cost for the Wilders Grove facility may be skewed slightly higher than a commercial facility.

- Conventional System Cost Estimate Prepared during design development.

Conventional Heat Pump HVAC System	$ 34.01/SF
Conventional Hot Water System	$ 2.26/SF
	$ 36.27/SF

- Actual GSHP HVAC Construction Cost from construction

Geothermal Heat Pump HVAC System	$35.17/SF
Hot Water Mechanical System	$3.51/SF
	$38.68/SF

- Delta for System Cost – ($38.68 - $36.27 = $2.61/ SF). The extra cost for the building HVAC was $1.16/ SF and was $1.25/ SF for the hot water geothermal system, for a total system delta of $2.41 / SF. This small delta for difference between the systems was assumed to be essentially $0 as summarized in the Note below.

NOTE: The HVAC and hot water Systems cost difference is likely much closer as no detailed system design was done for the conventional system cost estimate. The original estimate also did not include any detailed design for the duct heating units which would likely have been installed in the facility. This would have increased the conventional building costs. Also, the original building size for the conventional design estimate was ~2,700 sf smaller than the final facility design. Prorating the costs for a slightly larger building would make this cost difference go away. The original building would likely have used electric duct heating to supplement heat pumps in heating season which would also close the difference in cost. The Assumption is that the "in building" costs for the conventional and GSHP systems are essentially the same. The main difference for system costs evaluation and analysis would be for cost of the well field and pumping system.

4. Control System, System Enhancements and Grant Administration

The City originally required basic BAS system controls for the original facility design. The base design estimate included a cost estimate for basic control system points for the zone system. However, the basic control system was substantially enhanced to provide power and energy monitoring of the controls and systems for grant reporting and to automatically report data every 15 minutes on a 24/7 basis.

Another addition was for the construction of four (4) well field temperature wells. Temperature monitoring was provided in the well field with data loggers installed inside each temperature wells. The wells were drilled to the same depth as the loop field wells and were used to measure temperature effects with depth. Temperature was recorded at four different elevations in each temperature well.

Flow meters were also added and provided on the well loop and hot water loops to monitor pump flow thru the system.

There was also added cost for grant administration and reports provided by the contractor, and for compliance with Davis Bacon and Buy American Act and associated reporting.

- This extra system cost - ($12.68 / SF GSHP control cost vs. $7.12 / SF conventional HVAC) = $5.56 / SF extra. It is noted that all this cost was extra and would be attributed to data collection and admin costs, all relative to the grant. This additional cost would also not be considered an extra cost typical of a geothermal system as it was entirely grant related costs.

5. Permit Cost / Other Issues

- The new facility site was located on a closed City of Raleigh solid waste landfill under NC Division of Solid Waste closure permit jurisdiction. Permission had to be obtained from State of NC to construct the initial Solid Waste Facility. Approval resulted in modification of permit to recognize the Solid Waste Facility. There was no additional cost other than design costs to pursue this issue with the regulatory authority. Minor permit fee modification costs were incurred for the facility; however, none of these costs were directly attributable to the geothermal system.

- A closed loop well field system was used for construction. An open loop would have been a permit issue with NC Division of Water Quality due to groundwater contamination potential and was not pursued.
- The building permit was not an issue for construction. Inspections personnel were made aware of the GSHP operation in a training class by the manufacturer and subcontractor so they were aware of equipment operation and well field connections.
- As a closed loop system was designed, no NC Department of Natural Resources water quality permits were required. Geothermal well construction permits were also not required except that a NC Licensed Well Driller was required for the actual well construction. Well construction drilling reports were provided to State of NC as records of construction.

None of these potential additional costs were able to be identified or quantified. It was assumed there was not any additional costs above that which would be anticipated in a conventional system.

5. Cost of Grant Administration to Construction Cost / Other Soft Costs

- As noted, the administrative cost from the general contractor to comply with the DOE grant is included mainly in the instrumentation and control costs and indirectly in his GC Overhead costs.
- Cost to comply with Davis Bacon for labor standards for the DOE grant monitoring was minimized. The additional

cost for the City resulting from Davis Bacon was reduced as the GC contractor and subs were already paying at or above Dept. of Labor prevailing wage rates. Additional monies were included in the contractors overhead for monthly payroll reporting and cost updating.

- There was additional cost for compliance with Buy American requirements; however, the cost to comply with the Buy American Act was also not that significant as it was determined from the submittal review that the contractor was already obtaining a majority of American Made products in original bid.
- Other Soft Costs: Design and commissioning costs from the design team and commissioning agent were likely higher due to “new” system technology used for GSHP system; however, this was not able to be quantified. More experience with these systems will only serve to reduce these costs. As they become more widespread, costs may actually reduce as the systems are supposed to be more robust and have fewer system mechanical issues.
- It was noted that the design team did not have significant experience with GSHP systems and this likely resulted in a more conservative design that a design from a more experienced team.

6. Summary

The Wilders Grove bid and construction costs were established in 2009 - 2010. The approximately $1.8 M total are actual bid and construction costs provided by the construction contractor and would be much more accurate for comparisons than would costs from estimating manuals. At the time of bid, large commercial geothermal systems were a little more unknown in our geographic area; prices for such systems were likely much higher than similar work for systems that may have been designed and built in later years.

Using sample 2010 Mean’s cost data (examples include in the Appendix), the range for conventional mechanical systems for a variety of similar type buildings to Wilders Grove is very wide; ranging from $17 to over $50/SF. None of these examples include geothermal systems, they are all for convention HVAC and Plumbing systems.

From the few samples of the 2010Means cost data included in the Appendix, you could note that a mean HVAC system cost average is $35.25/ SF and a range for a typical 2010 Mechanical system by itself is going to be on the order of $23.50 - $47/ SF. But again, this delta depends on such factors as building complexity, energy code compliance, LEED standards applicable for which the building is designed and the building occupancy or how it is being managed for the users. Again, this HVAC system cost from Means does not include the well field and pumping system. The Wilders Grove project also included a solar PV system and also attained LEED Platinum status; so we would expect it to be on the higher end of the cost curve in lieu of the bottom. The actual bid cost for the geothermal HVAC and hot water plumbing system at Wilders Grove was $38.60/SF, not that much different than the average system cost from Means.

It is important to note that, since Wilders Grove is likely a smaller building in SF space than a more conventional industrial or commercial building, the well field cost would thus tend to be more costly per SF than it would say for a 50,000-150,000 SF high school building or commercial retail space. Both $/SF and Tons/SF comparisons are much reduced as the building size increases.

Granted, as has been determined during operation, the Wilders Grove facility has some additional capacity in the well field as only approximately 80 Tons of cooling is being utilized. In hindsight, you can infer from this that the original design was conservative and the City spent more on the well field than an optimal well field design would dictate. From the designers view, and using the models available at the time of design, their design objective was to provide the City with a system that was fully functional and provide for the building out of the facility.

In comment to this, part of the purpose of the grant was to enable design models to be enhanced so that more cost efficient designs could be performed. On the other hand, a benefit for the City is that there is additional capacity for building and facility expansion and the life of the well field should be extended.

A good analysis or comparison outcome of this study and the grant may be to show what kind of system parameters would the “new” well field and system design models resulting from the grant research provide for our facility. Would the new design models provide a well field and GSHP system that was 10%, 20% smaller or more in size? This would significantly reduce the cost delta between the conventional and geothermal system. Are there new well tube designs that have been developed that would reduce the number of wells required, or their final depth, to provide the same amount of heat rejection? The development of better design information and models were an original objective of the grant. Another major objective was to also demonstrate the technologies worked in a cost effective manner for conventional facilities.

It was noted that the costs for the equipment in the building were approximately the same for a conventional heat pump system as for a GSHP system. The extra costs were mainly the cost of the well field and pumping system. The additional cost for the ground source heat pump system, compared to the conventional system, for the well field was $440,000.

The additional cost for the GSHP system for the well field construction was thus $18.31 per square foot for the facility. Due to conservative design of the well field and other systems, these well field costs have now been determined to include some additional built in capacity for the future growth of the facility or for expansion to include another building. This was not realized as being that significant at the time of design and construction; however, a smaller well field construction costs would realize a much lower payback period. The advantage after the fact is that the project can take advantage of these costs in the future facility expansion.

The following table summarizes the bid costs for the geothermal system and compares these costs to the conventional system estimate that was prepared during the design development:

City of Raleigh, Wilders Grove SWS Facility		**ACTUAL GEOTHERMAL HVAC BID COSTS**			**DESIGN PHASE ESTIMATE FOR CONVENTIONAL HVAC SYSTEM (for smaller size building when performed)**			**Extra Costs Delta**
		24000	SF		**21000**	SF		
Summary Cost Estimates		A			B			
Item	Description	Geothermal GSHP Bid Costs	**Cost / SF**		Base HVAC System Estimate Cost	**Cost / SF**		
1	General Conditions	$ 86,682.50	$ 3.61		$73,680.13	$ 3.51		$ 0.10
2	Architectural	$ -						
3	Structural	$ -						
4	Civil	$ -						
5	Wells and Loop Piping	$ 439,398.16	$ 18.31			$ 0.00		$ 18.31
6	Plumbing / Hot Water	$ 84,312.68	$ 3.51		$47,505.00	$ 2.26		
6	Mechanical	$ 844,146.00	$ 35.17	$38.6	$714,124.00	$ 34.01	$36.2	$ 2.42
7	Electrical	$ 48,776.00	$ 2.03		$41,459.60	$ 1.97		
8	Monitoring and Controls (includes grant admin costs)	$ 304,435.00	$ 12.68		$149,600.00	$ 7.12		$ 5.56
	TOTALS	$ 1,807,750.34	$ 75.32		$1,026,368.73	$ 48.87		$ 26.45
	Building Cost	$ 6,274,697.00	$ 261.45					

Conventional system cost provided by the Designer during design development for comparison with GSHP system. This design was used in the base building energy model for comparison with the GSHP system.

I. OBJECTIVE RESULTS

The project has clearly obtained the Objectives of the DOE Grant. Related to Objective #1:

1. CO2 Emissions and Greenhouse Gas Reduction

The annual carbon emissions reduction equivalent for the reduced kWh is 278 Metric Tons of carbon equivalent or similar to the greenhouse gas emissions of 58 vehicles annually or energy of 25.3 homes annually.

2. Energy Savings

The Energy Savings for the HVAC systems through use of the GSHP systems compared was very significant. The original modeled data anticipated an annual energy use of 471.370 kWh annually for heating , cooling, reheating, and fan energy for the building using a traditional VAV reheat system providing required OA for ventilation.

The modeled energy annual energy consumption for the GSHP system using GSHP 's for the space heating and cooling loads and a GSHP DOAS with an energy recovery wheel for conditioning OA for ventilation was anticipated to use 144,770 kwh annually . A significant amount of the savings was related to a reduced amount of reheating and reduced energy consumption for heating and cooling ventilation outdoor air due to heat reclaim and reduction of OA based on CO2 demand control.

The actual measured energy usage is 116,650 kWh for the HVAC systems. This may be a little less than could be anticipated, probably due to weather differences, sequence of controls and occupancy differences. Importantly, this is overall an almost 75% reduction in energy usage for the HVAC systems. This is much greater than the original goal of a 30% reduction in energy usage.

Related to Objective # 2:

a. Minimize Long Term Heat Transfer to Reservoir and reduce cost for Domestic Water Heating

The Wilders Grove project reused rejected heat from Heat Pumps to reduce return water heat content to well field and, in turn, generate hot water for domestic use. The Rejected Heat from the heat pumps in cooling during the winter is being used to heat other parts of the building, also reducing temperatures going back to the well field.

The DHW is being heated by the Heat Harvester, reducing the temperature going back to the well field by several degrees. The DHW electric resistance heating systems were anticipated to use 59,485 KWH annually and the GSHP DHW systems were anticipated to use 18,780 KWH based on the anticipated gallons of DHW needed and number of showers etc. The actual usage has been measured at 10,135 KWH annually, much less than anticipated based on less use of the showers and other DHW needs than originally thought during the design development. The technology works. The original design could have benefited from a phased approach to hot water generation to allow demand to materialize and incrementally expand the system.

Related to Additional Objectives:

a. Improved Work Function, Indoor Air Quality and Comfort

The building design provided for both and an Administrative and an Operations portion within the building. The Operations portion included a gathering area, break room, toilet and locker room areas, mud room, and crew supervisor's offices. The Operations area was designed to accommodate up to 250 employees going through the building in a typical work day. The gathering area will include a retractable bleacher system to accommodate the entire SWS staff for weekly and monthly meetings. Adequate shower, locker and restroom space was provided to accommodate the entire projected staff to change before and after daily routes. Locker spaces shall be provided for both wet and dry clothes for each employee.

The Administrative portion of the building includes individual office, modular office, conference rooms and work space for the SWS administration staff. The Administrative portion also included four classroom / training areas designed to accommodate work crews that vary from 10-50 people. The class room and training spaces also open to a larger area to support larger functions and community events. The building was designed to allow for staggered meetings of crews to go out in the morning to facilitate efficiency of time with crew supervisors and to allow for staggered fueling functions and vehicle wash functions.

Due to the wide array of multi-functional uses planned for the building, and with a large part of the building being unoccupied during large portions of the day, the HVAC system was designed with 27 zones. The zones were established to accommodate the wide variety of uses that occur within the building and to ensure that occupant load exists. Carbon dioxide sensors (CO2) were also provided in the large group areas of the building to control the larger HVAC zones so that heat pumps were only used during periods of actual demand. The building occupants are very comfortable with 27 zones of local temperature control. Zone loads vary for such areas as general administration, individual offices, conference rooms, training rooms, class rooms, crew rooms, locker rooms, break rooms, mud rooms, storage, etc.

The occupants are also assured of good indoor air quality with each zone receiving dedicated fresh air through local terminal units controlled by the CO2 sensors. Air quality surveys performed for LEED indicate almost 100% occupant satisfaction with indoor comfort.

b. Reduced Maintenance Requirements

Maintenance requirements will be reduced in the longer term due to no need to maintain central systems equipment like boilers, cooling towers, and chiller or spray coolers.

All the units are indoors on an upper mezzanine level, are not subject to the outdoor environment and are very easy to maintain.

Maintenance will also be reduced due to expected longer heat pump life due to less lift on the compressors. Maintenance is also easier as units are enclosed, indoor, and are easily accessible.

The well field is underground in the vehicle parking lot and well protected. The well field life is estimated to be 50 years. To date, temperature monitoring in the well field indicates little effect of the building loads. Supply and return water from the well field are typically both below 80 degrees F and indicate at least a

5-7 degree temperature difference.

c. Reliance to Harsh Weather

The heat pump systems work with relatively constant water supply temperatures for their heat source and heat sink and are thus not affected by higher than normal summer temperatures or lower than normal winter air temperatures as would a traditional external heat pump system might be, or as a airside system with central cooling and heating plants might be.

The multitude and number of heat pump zones also provides a safety factor in harsh weather compared to more centralized systems in that, if one heat pump fails, only a very small portion of the building is affected as compared to larger centralized systems where perhaps 50% or 100% of the building might be out of service if a unit goes down.

d. Evaporative Cooler Implementation

Based on the energy model and economic analysis of installing an evaporative cooler vs. adding additional geothermal wells, several conclusions were made:

- Adding an evaporative cooler at this time, after construction completion, would not provide any significant benefit to the building operation when compared to the increase in energy and water costs to operate the equipment.

- Adding additional geothermal wells, either to the existing field or as a separate field, would be prudent if significantly expanding the facility would be expected within the next two or three years.

- Adding an evaporative cooler to off-set temperature rises within the well field “preemptively” would only be feasible if temperature rises would indicate premature failure of the well field, i.e. in less than the 20+ year life span.

- An evaporative cooler would be feasible and the only cost effective alternative to support an expansion of the Service Center.

- An evaporative cooler in conjunction with the well field expansion could be used to serve an expanded facility and/or additional buildings while preserving the flexibility of terminal heat pump HVAC systems.

e. Building Information Systems

Trending has been designed to collect temperature, energy consumption, and performance data every 15 minutes.

This data is summed every day, every week, and every month. Data can be compared against any grouping of weather or well field variables for analysis and against occupied and unoccupied periods and space temperatures.

On site weather conditions are being used in operational control of systems and for use in analysis of weather trends.

Data can be compared against modeled and predicted usage and performance data to validate current performance claims.

Data can be summed hourly, daily, weekly, monthly and annually to compare year on year performance. Trending data is also collected and maintained.

f. Education

A Kiosk monitor has been installed in the lobby of the Solid Waste Facility that provides current building performance information from the City's enterprise management system. Geothermal heat pump units, hot water production, pumping, lighting, electric vehicle charging, geothermal well field, and solar performance are a few of the displays on the kiosk. SWS staff use the Kiosk and display to conduct educational tours thru the facility and demonstrate the various building energy efficient components. This display also serves to provide a visual reminder to all SWS staff for energy consumption and management as they go about their daily tasks in the building.

J. LESSONS LEARNED / AREAS OF IMPROVEMENT

- For our application, and based on conversations and reports from other facilities, it can be stated that the “additional” cost for the geothermal systems greater than the conventional systems is basically the cost for the well field; the in building costs are not significantly different from conventional systems and can be a bit less since no additional HVAC heating source is needed. Lowering this well field cost is a key element to making GSHP system more viable.

  As the additional cost delta for a GSHP system is mainly the cost of the well field or other type of heat sink construction, more research needs to be provided to minimize the well field and heat sink costs by better design and construction. The DOE grant provided an opportunity for further development of new design models and construction of new applications and new materials and equipment development.

  The City plans a phase 2 development at Wilders Grove for a future maintenance facility. An expansion of the existing geothermal well field or new well field construction will be evaluated during the design and new design and construction techniques will be incorporated. The new facility may also incorporate the addition of the evaporative cooler that was considered as part of this projects grant research and evaluation process.

- Well field pumps for the City of Raleigh geothermal system were originally designed to operate 24/7 and operated on a pressure differential of 10 PSI. Based on review of the pumping sequence of operations with the DOE research team and internal review by the City’s team, this sequence of operation has now been reduced such that the well field pumps only run during occupied hours only, with several heat pumps now required to call for heating or cooling during unoccupied periods before the circulating GSHP pumps are commanded to turn on.

  Controlling and lowering pumping costs can significantly affect the energy efficiency of the system. This is a significant design element that needs to be accurately considered in the design of the GSHP system.

- Based on review with the DOE research team and interview review by the City’s team, it was determined that the original anticipated design load demands for the designed dedicated outdoor air (OA) unit was too conservative and not as robust or functional a unit as could have been provided.

The sizing of these OA systems should be carefully evaluated to avoid oversizing of equipment and increase capital cost. A different sized unit with more functional controls could have been selected that could have more capability to adjust to varying building demands.

Our unit was sized based on a much larger occupancy population than what is actually present at any time in the building. Much more diversity could be assumed for the number of occupied people and outdoor air required. It would have been beneficial to investigate how much turndown the dedicated outdoor air heat pump could do before it has to become a constant volume unit in order to continue operating. Our unit selection had a limited amount of turndown in airflow capability and little variability in operation of the dual compressors.

- Reduce the size of the domestic geothermal hot water system to better reflect the actual demand of the building. During system operation, it was determined that the initial user requests and subsequent demand analysis for the hot water system was oversized to reflect more showers being taken and much more usage than has actually been encountered.

  Much greater diversity could have been assumed in the domestic hot water demand and a system design that could be expanded as demand was actually encountered. Providing a design to allow add on hot water units as demand was realized would have been much more cost effective.

  Since the DHW system at Wilders Grove has significant additional capacity to serve other DHW needs, the City of Raleigh is evaluating the possibility of using the additional capacity to provide the DHW needs of the Vehicle Wash facility and for domestic hot water and radiant floor heating applications in the future Phase 2 Solid Waste Maintenance Facility.

- Analyze number of cooling and heating zones actually needed to reduce the initial capital construction cost.

  The Wilders Grove project could have been provided with fewer HVAC zones and still have provided the level of control and comfort within the building. Fewer HVAC zones would have reduced indoor GSHP equipment costs.

  However, implementation of multiple zones in the Wilders Grove has verified that a GSHP system can be adequately designed and controlled for a multi-use facility. In this regard, each zone could represent separate space use, such as a small building or a classroom or even a separate retail space. This would translate into a larger well field being very applicable for HVAC in a larger commercial space, such as a shopping center or mall with separate retail spaces, a school with multiple class rooms or even separate small building spaces.

- Dedicated OA systems on this project were designed to operate 24/7 to avoid infiltration into the building, keep it pressurized and avoid potential moisture and condensation (southeastern climate) in the duct system. The installed unit has been using a lot of energy during unoccupied periods (over 100 hours weekly).

  Further investigation with the DOE research team and the City's team has shown this dedicated outdoor air unit does not need to operate during these unoccupied periods. The unit is now scheduled to be off on the equipment schedule unless wet bulb ambient temperature and humidity conditions are very high. Humidity levels are monitored thru the weather station on-site and alerts are provided to maintenance staff when, or if, high humidity levels are encountered. This revision in the sequence of operation and control will significantly reduce energy costs over time and likely further extend the life of the unit as it is running much less.

- END OF REPORT -

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Public Release: This report, including attachments, is approved for public release.

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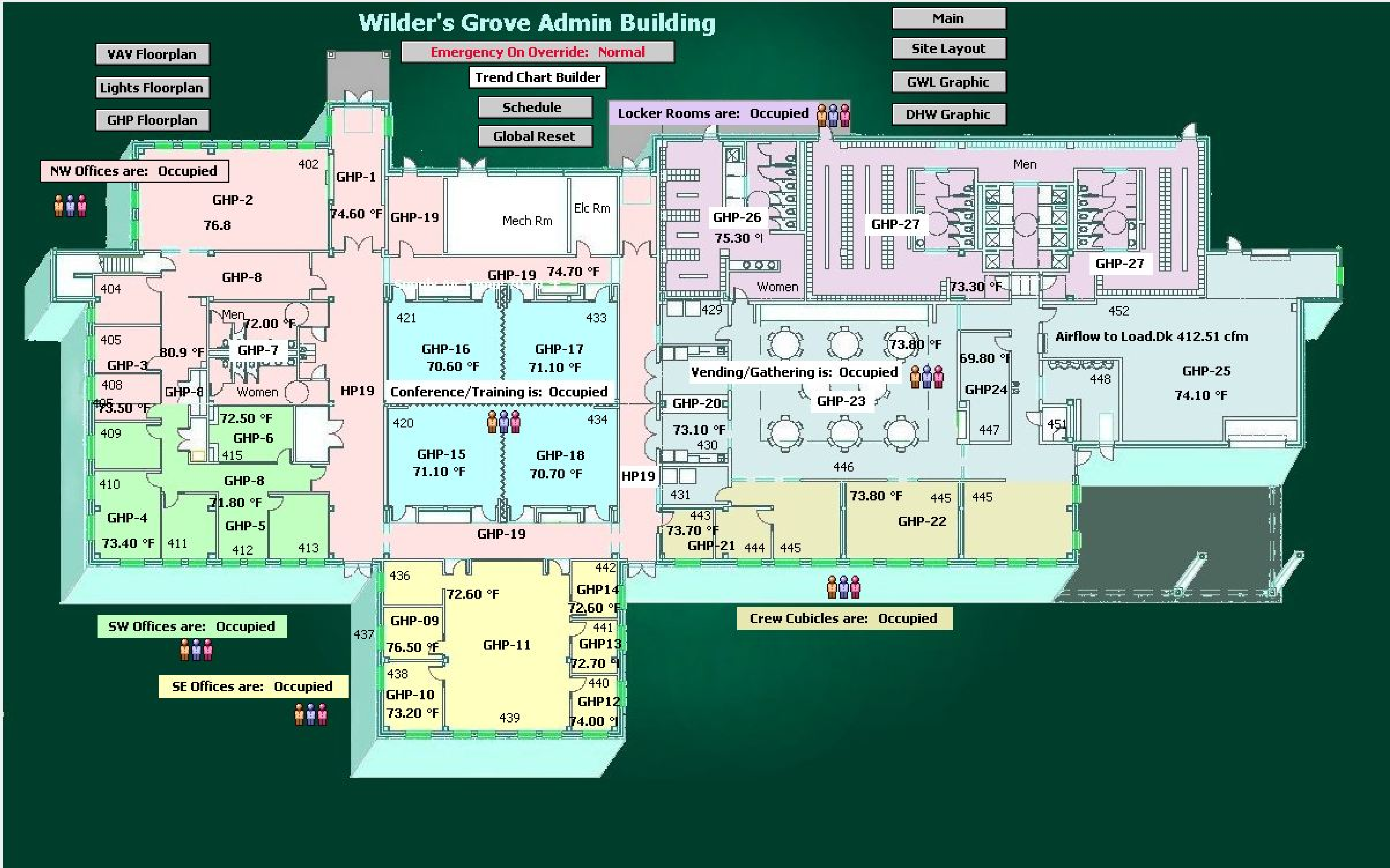
APPENDICES

JACOBS

CITY OF RALEIGH
NORTH CAROLINA

APPENDIX A1

- MONTHLY ELECTRICAL ENERGY CONSUMPTION
- MONTHLY AVERAGE OUTDOOR & ZONE TEMPERATURES
- GROUND SOURCE HEAT PUMPS GSHP 1-27
- SEPTEMBER 1, 2012 – AUGUST 31, 2013



Wilder's Grove Admin Building

Emergency On Override: Normal

Locker Rooms are: Occupied

NW Offices are: Occupied

Conference/Training is: Occupied

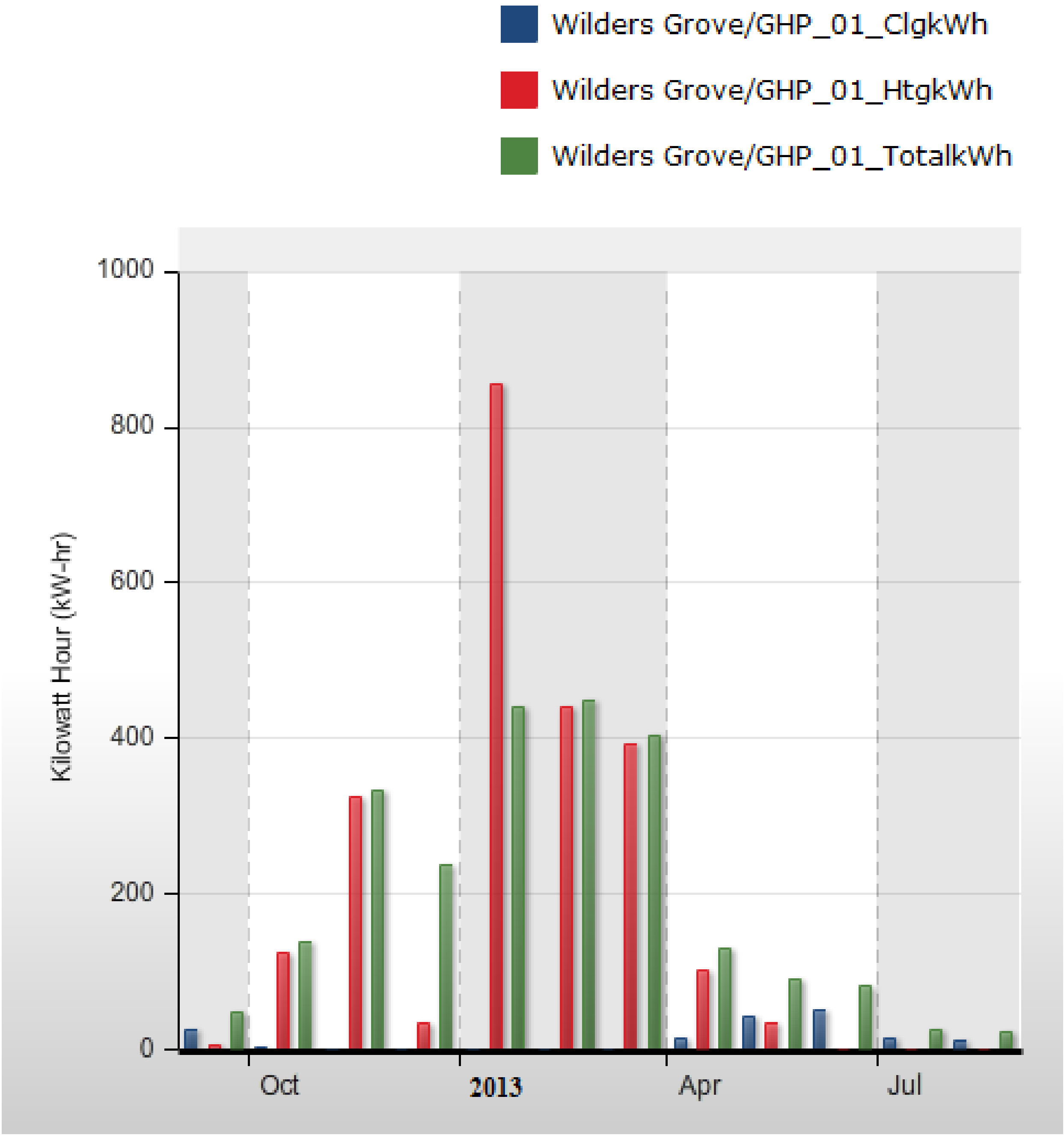
Vending/Gathering is: Occupied

Airflow to Load.Dk 412.51 cfm

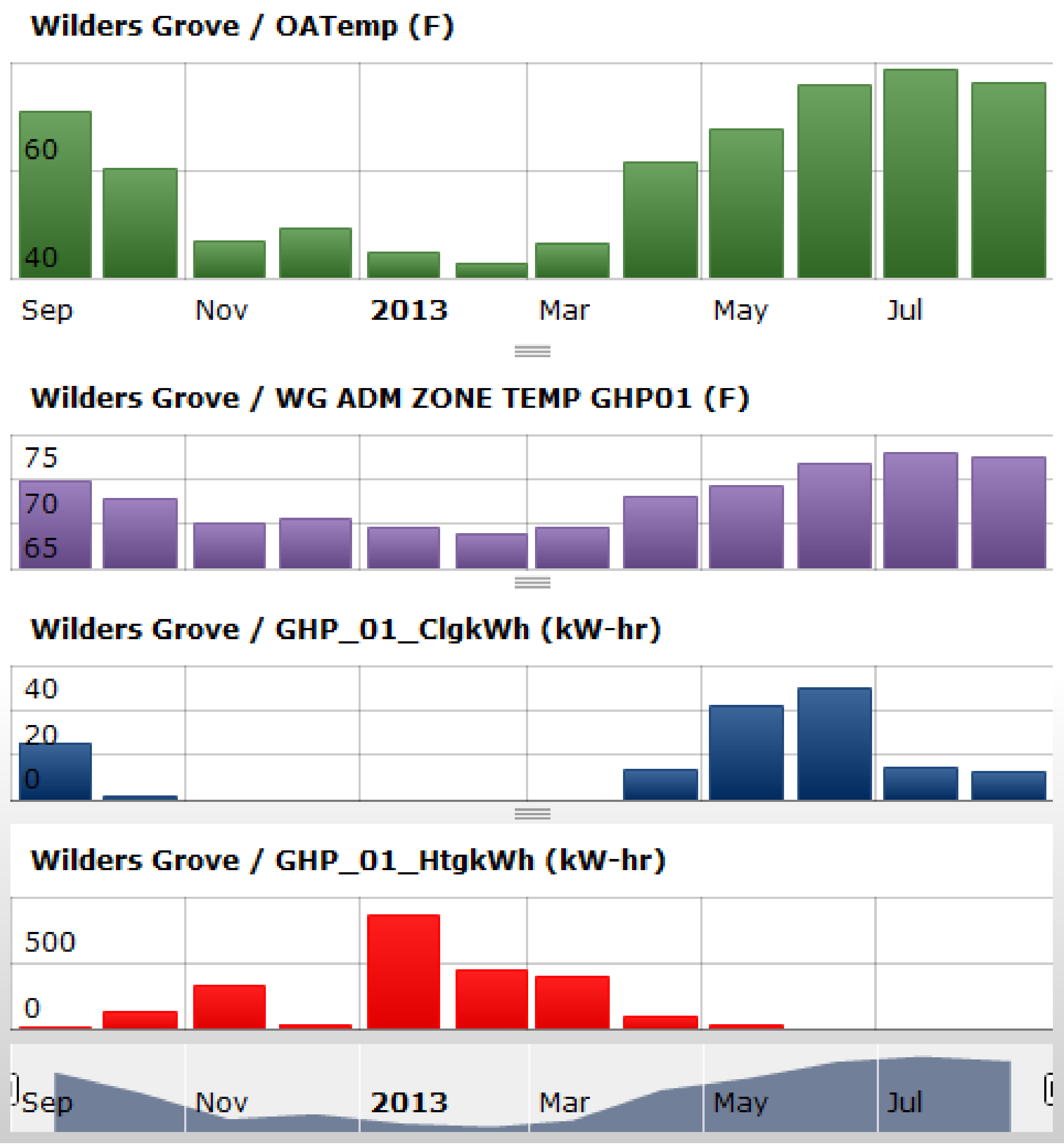
SW Offices are: Occupied

SE Offices are: Occupied

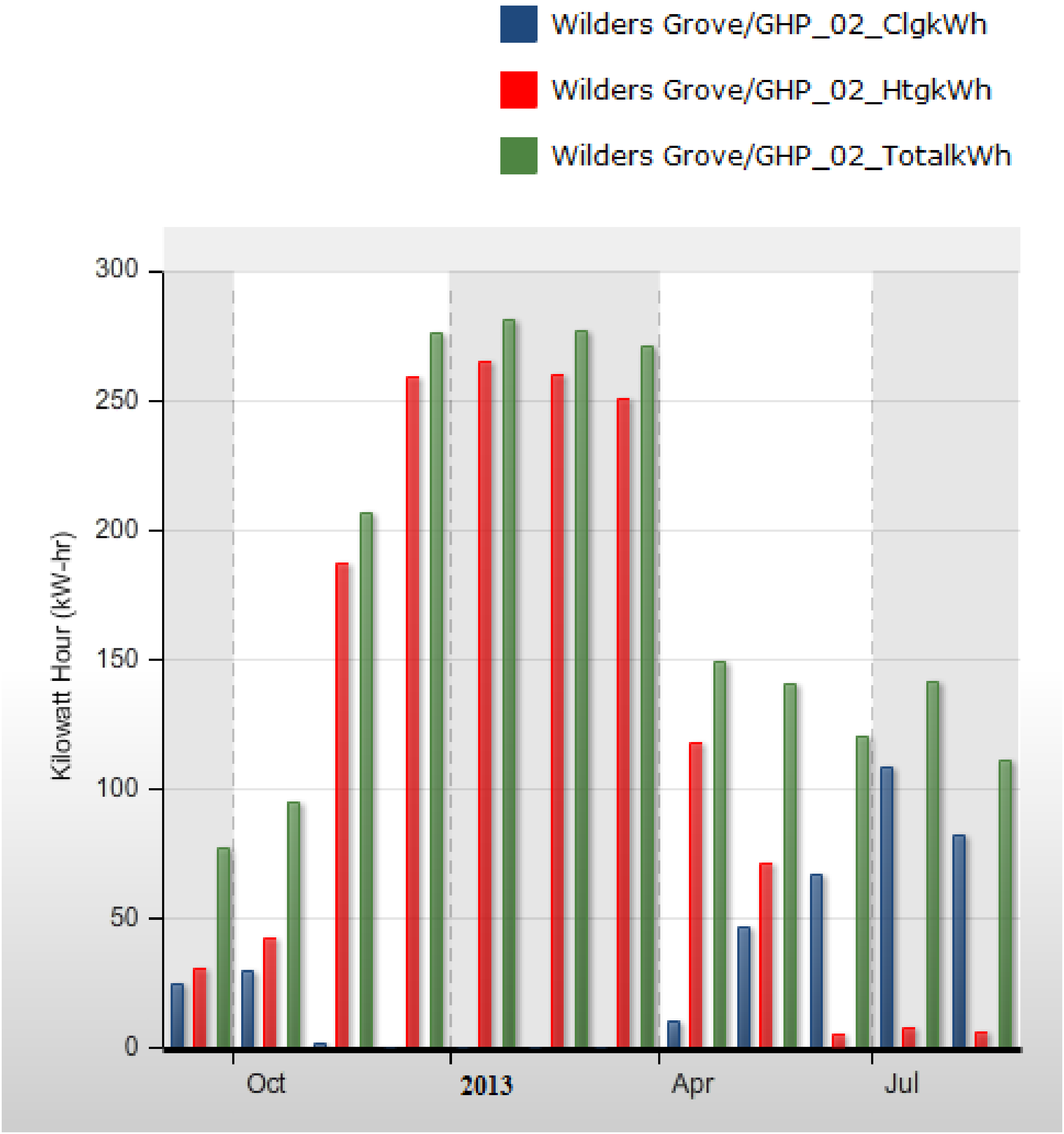
Crew Cubicles are: Occupied


Wilders Grove/GHP_01_ClgkWh
Wilders Grove/GHP_01_HtgkWh
Wilders Grove/GHP_01_TotalkWh
Kilowatt Hour (kW-hr)
1000
800
600
400
200
0
Oct
2013
Apr
Jul

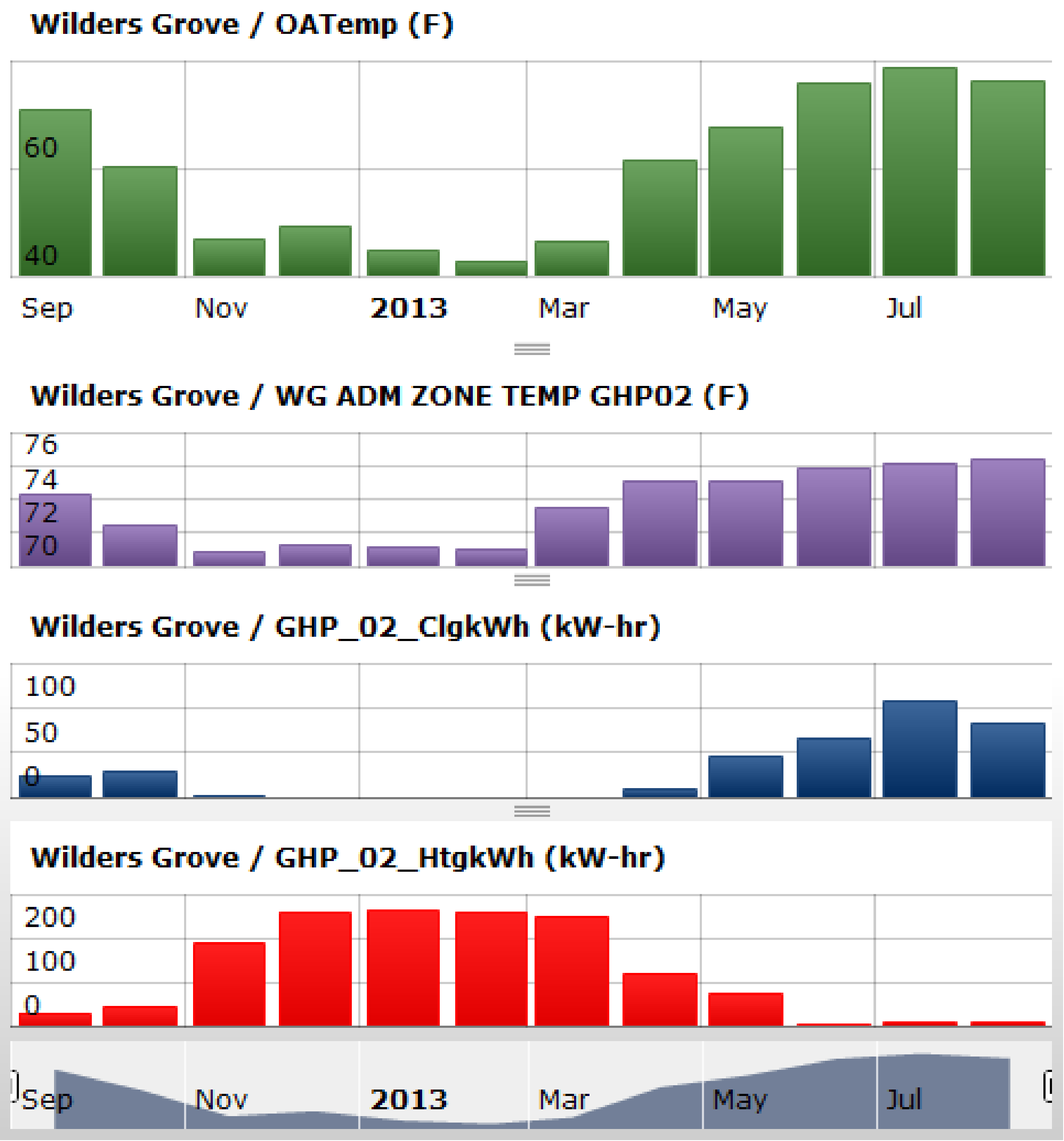
Timestamp	Wilders Grove/GHP_01_ClgkWh (kW-hr)	Wilders Grove/GHP_01_HtgkWh (kW-hr)	Wilders Grove/GHP_01_TotalkWh (kW-hr)
Sep 2012	25.478	7.047	49.173
Oct 2012	2.007	124.349	139.181
Nov 2012	0	323.592	333.264
Dec 2012	0	34.162	235.981
Jan 2013	0	855.536	439.729
Feb 2013	0	441.718	449.58
Mar 2013	0	393.326	402.769
Apr 2013	13.221	101.273	129.678
May 2013	42.317	33.334	92.036
Jun 2013	49.994	0	81.392
Jul 2013	14.15	0	25.586
Aug 2013	12.273	0	22.91


Wilders Grove / OATemp (F)
60
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP01 (F)
75
70
65
Wilders Grove / GHP_01_ClgkWh (kW-hr)
40
20
0
Wilders Grove / GHP_01_HtgkWh (kW-hr)
500
0
Sep
Nov
2013
Mar
May
Jul

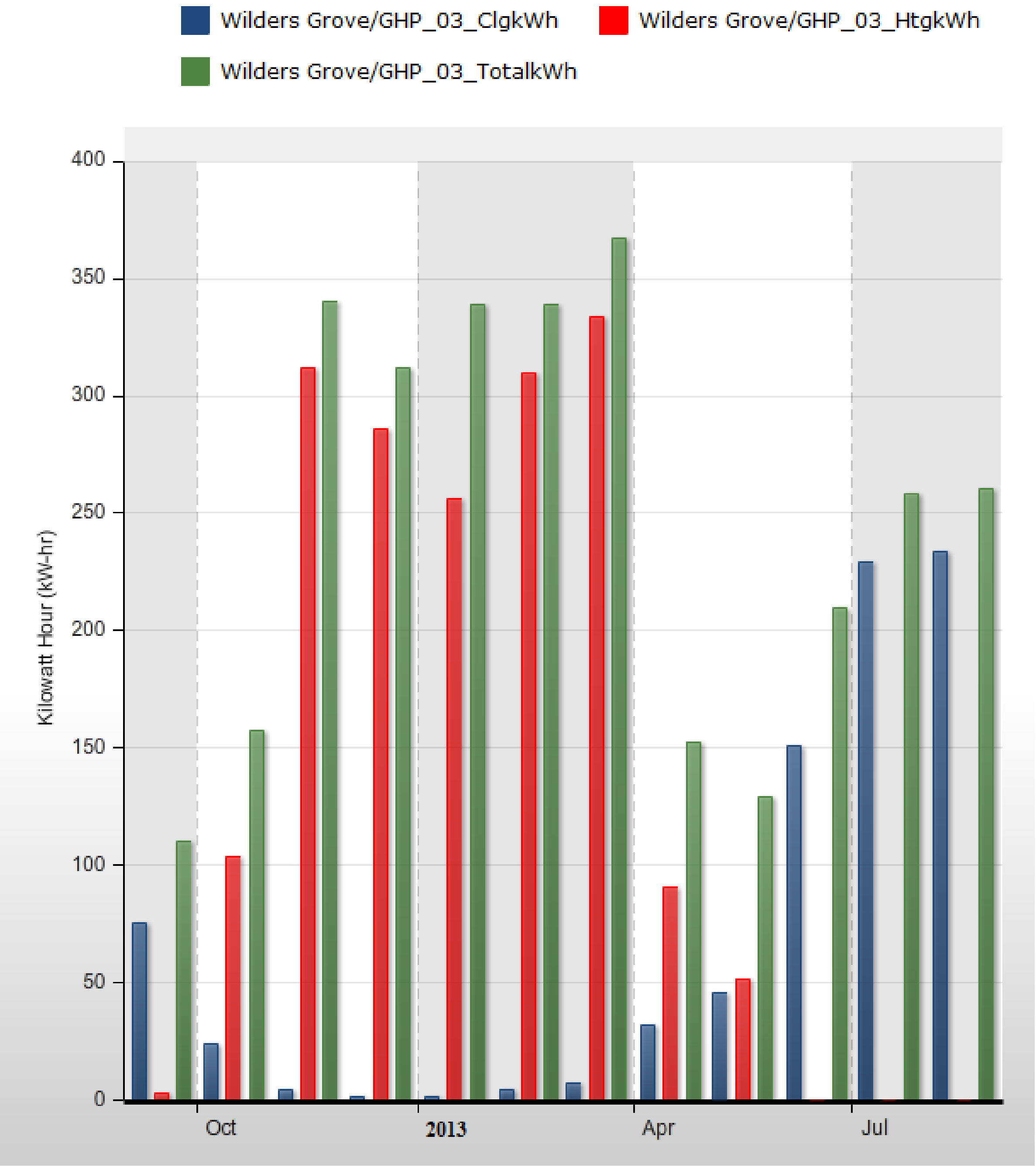
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP01 (F)	Wilders Grove / GHP_01_ClgkWh (kW-hr)	Wilders Grove / GHP_01_HtgkWh (kW-hr)	Events
Sep 2012	70.75	74.852	25.478	7.047	
Oct 2012	60.363	72.747	2.007	124.349	
Nov 2012	46.686	70.031	0	323.592	
Dec 2012	49.184	70.542	0	34.162	
Jan 2013	44.667	69.492	0	855.536	
Feb 2013	42.867	68.965	0	441.718	
Mar 2013	46.195	69.653	0	393.326	
Apr 2013	61.57	72.911	13.221	101.273	
May 2013	67.548	74.377	42.317	33.334	
Jun 2013	75.839	76.652	49.994	0	
Jul 2013	78.833	77.91	14.15	0	


Wilders Grove/GHP_02_ClgkWh
Wilders Grove/GHP_02_HtgkWh
Wilders Grove/GHP_02_TotalkWh
Kilowatt Hour (kW-hr)
300
250
200
150
100
50
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_02_ClgkWh (kW-hr)	Wilders Grove/GHP_02_HtgkWh (kW-hr)	Wilders Grove/GHP_02_TotalkWh (kW-hr)
Sep 2012	24.808	30.221	77.289
Oct 2012	29.374	42.357	95.089
Nov 2012	1.777	187.084	206.291
Dec 2012	0	259.21	275.9
Jan 2013	0.105	265.329	280.997
Feb 2013	0	259.768	276.564
Mar 2013	0	250.538	270.667
Apr 2013	9.94	118.05	148.918
May 2013	46.518	71.099	140.637
Jun 2013	66.672	5.388	120.639
Jul 2013	108.399	7.838	141.845
Aug 2013	81.954	5.891	110.627


Wilders Grove / OATemp (F)
60
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP02 (F)
76
74
72
70
Wilders Grove / GHP_02_ClgkWh (kW-hr)
100
50
0
Wilders Grove / GHP_02_HtgkWh (kW-hr)
200
100
0
Sep
Nov
2013
Mar
May
Jul

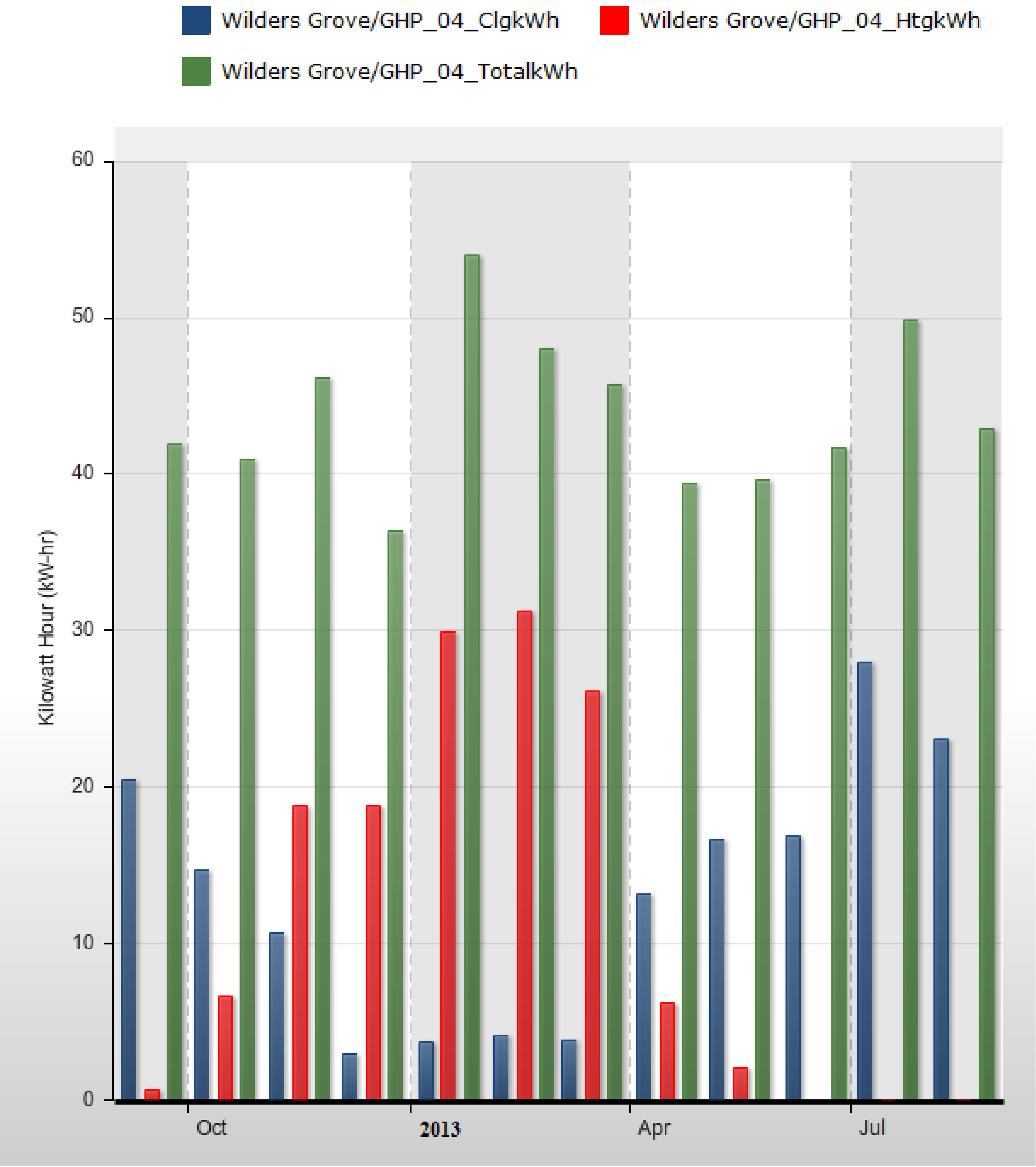
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP02 (F)	Wilders Grove / GHP_02_ClgkWh (kW-hr)	Wilders Grove / GHP_02_HtgkWh (kW-hr)	Events
Sep 2012	70.75	74.248	24.808	30.221	
Oct 2012	60.363	72.422	29.374	42.357	
Nov 2012	46.686	70.86	1.777	187.084	
Dec 2012	49.184	71.301	0	259.21	
Jan 2013	44.667	71.196	0.105	265.329	
Feb 2013	42.867	71.025	0	259.768	
Mar 2013	46.195	73.497	0	250.538	
Apr 2013	61.57	75.067	9.94	118.05	
May 2013	67.548	75.071	46.518	71.099	
Jun 2013	75.839	75.795	66.672	5.388	
Jul 2013	78.833	76.114	108.399	7.838	


Wilders Grove/GHP_03_ClgkWh
Wilders Grove/GHP_03_HtgkWh
Wilders Grove/GHP_03_TotalkWh
Kilowatt Hour (kW-hr)
400
350
300
250
200
150
100
50
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_03_ClgkWh (kW-hr)	Wilders Grove/GHP_03_HtgkWh (kW-hr)	Wilders Grove/GHP_03_TotalkWh (kW-hr)
Sep 2012	75.485	2.894	110.298
Oct 2012	23.687	103.581	157.322
Nov 2012	4.499	311.679	340.296
Dec 2012	1.655	285.797	312.266
Jan 2013	1.582	256.465	339.117
Feb 2013	4.788	309.901	338.61
Mar 2013	7.362	333.526	367.22
Apr 2013	31.906	90.784	152.631
May 2013	45.648	51.874	129.459
Jun 2013	151.215	0	209.625
Jul 2013	229.229	0	258.365
Aug 2013	233.941	0	260.338


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP03 (F)
74
73
72
71
Wilders Grove / GHP_03_ClgkWh (kW-hr)
200
100
0
Wilders Grove / GHP_03_HtgkWh (kW-hr)
200
0
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP03 (F)	Wilders Grove / GHP_03_ClgkWh (kW-hr)	Wilders Grove / GHP_03_HtgkWh (kW-hr)	Events
Sep 2012	70.75	73.095	75.485	2.894	
Oct 2012	60.363	72.409	23.687	103.581	
Nov 2012	46.686	72.057	4.499	311.679	
Dec 2012	49.184	72.057	1.655	285.797	
Jan 2013	44.667	72.028	1.582	256.465	
Feb 2013	42.867	72.007	4.788	309.901	
Mar 2013	46.195	73.173	7.362	333.526	
Apr 2013	61.57	74.092	31.906	90.784	
May 2013	67.548	74.234	45.648	51.874	
Jun 2013	75.839	72.842	151.215	0	
Jul 2013	78.833	72.066	229.229	0	
Aug 2013	76.345	72.398	233.941	0	


Wilders Grove/GHP_04_ClgkWh
Wilders Grove/GHP_04_HtgkWh
Wilders Grove/GHP_04_TotalkWh
Kilowatt Hour (kW-hr)
0
10
20
30
40
50
60
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_04_ClgkWh (kW-hr)	Wilders Grove/GHP_04_HtgkWh (kW-hr)	Wilders Grove/GHP_04_TotalkWh (kW-hr)
Sep 2012	20.485	0.644	41.937
Oct 2012	14.684	6.624	40.906
Nov 2012	10.701	18.863	46.174
Dec 2012	3.002	18.852	36.402
Jan 2013	3.744	29.927	54
Feb 2013	4.101	31.198	47.943
Mar 2013	3.829	26.111	45.729
Apr 2013	13.171	6.184	39.431
May 2013	16.638	2.084	39.645
Jun 2013	16.922	0.056	41.724
Jul 2013	28.023	0	49.807
Aug 2013	23.057	0.042	42.845

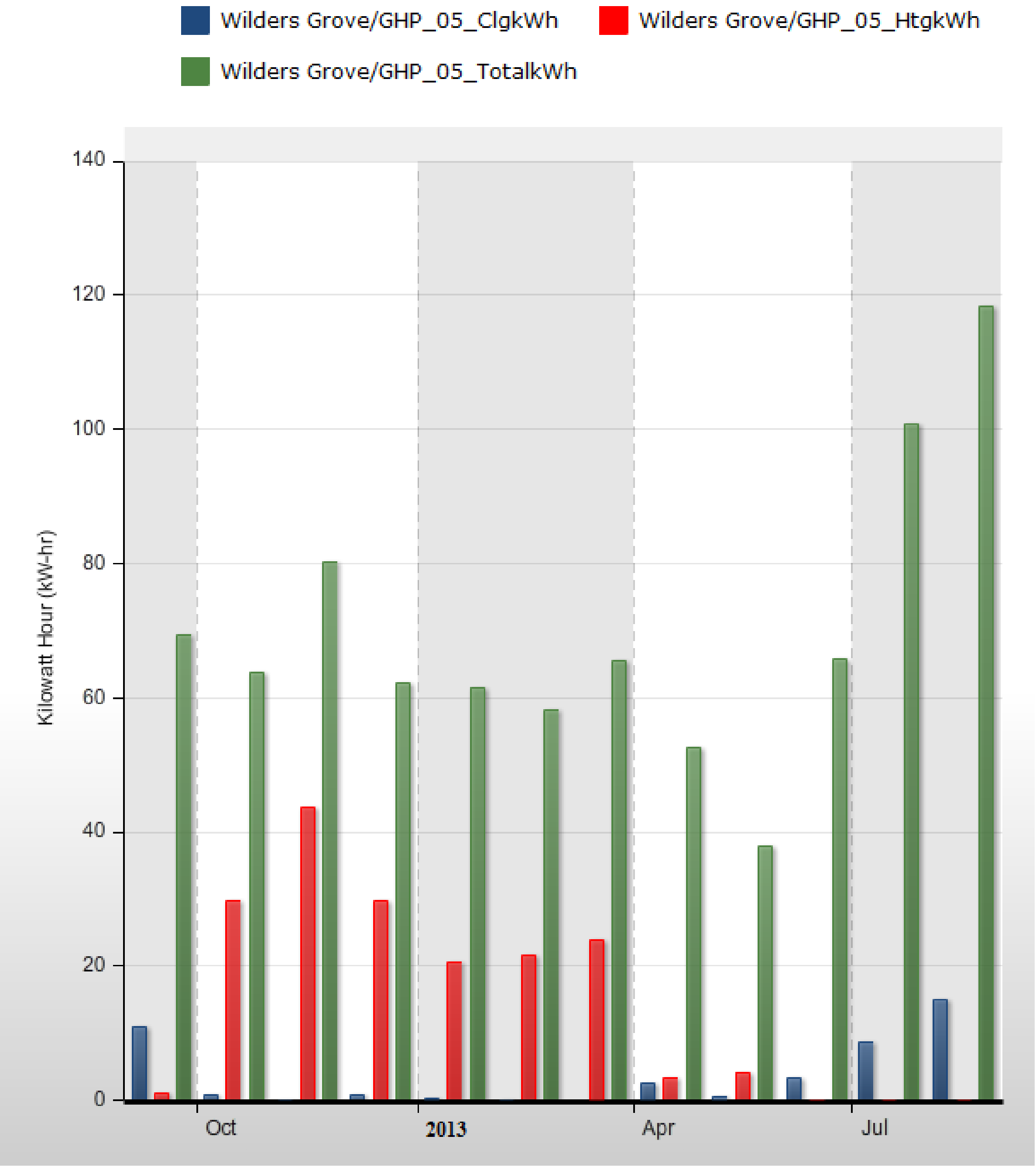
Wilders Grove / OATemp (F)

Wilders Grove / WG ADM ZONE TEMP GHP04 (F)

Wilders Grove / GHP_04_ClgkWh (kW-hr)

Wilders Grove / GHP_04_HtgkWh (kW-hr)

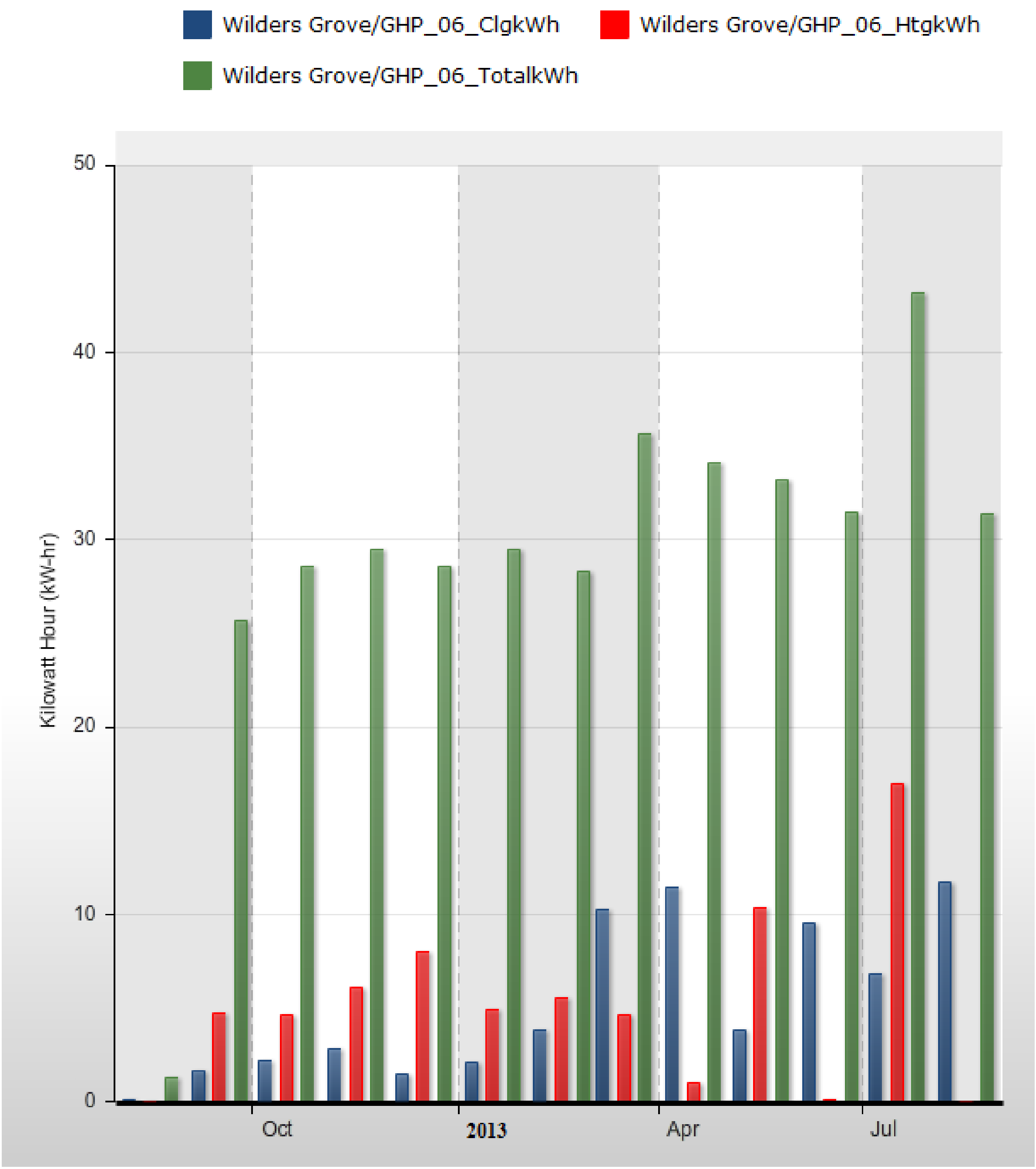
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP04 (F)	Wilders Grove / GHP_04_ClgkWh (kW-hr)	Wilders Grove / GHP_04_HtgkWh (kW-hr)	Events
Sep 2012	70.75	75.124	20.485	0.644	
Oct 2012	60.363	72.635	14.684	6.624	
Nov 2012	46.686	69.929	10.701	18.863	
Dec 2012	49.184	69.642	3.002	18.852	
Jan 2013	44.667	69.327	3.744	29.927	
Feb 2013	42.867	68.876	4.101	31.198	
Mar 2013	46.195	69.985	3.829	26.111	
Apr 2013	61.57	73.442	13.171	6.184	
May 2013	67.548	74.264	16.638	2.084	
Jun 2013	75.839	76.082	16.922	0.056	
Jul 2013	78.833	76.118	28.023	0	
Aug 2013	76.345	76.113	23.057	0.042	


Wilders Grove/GHP_05_ClgkWh
Wilders Grove/GHP_05_HtgkWh
Wilders Grove/GHP_05_TotalkWh
Kilowatt Hour (kW-hr)
140
120
100
80
60
40
20
0
Oct
2013
Apr
Jul

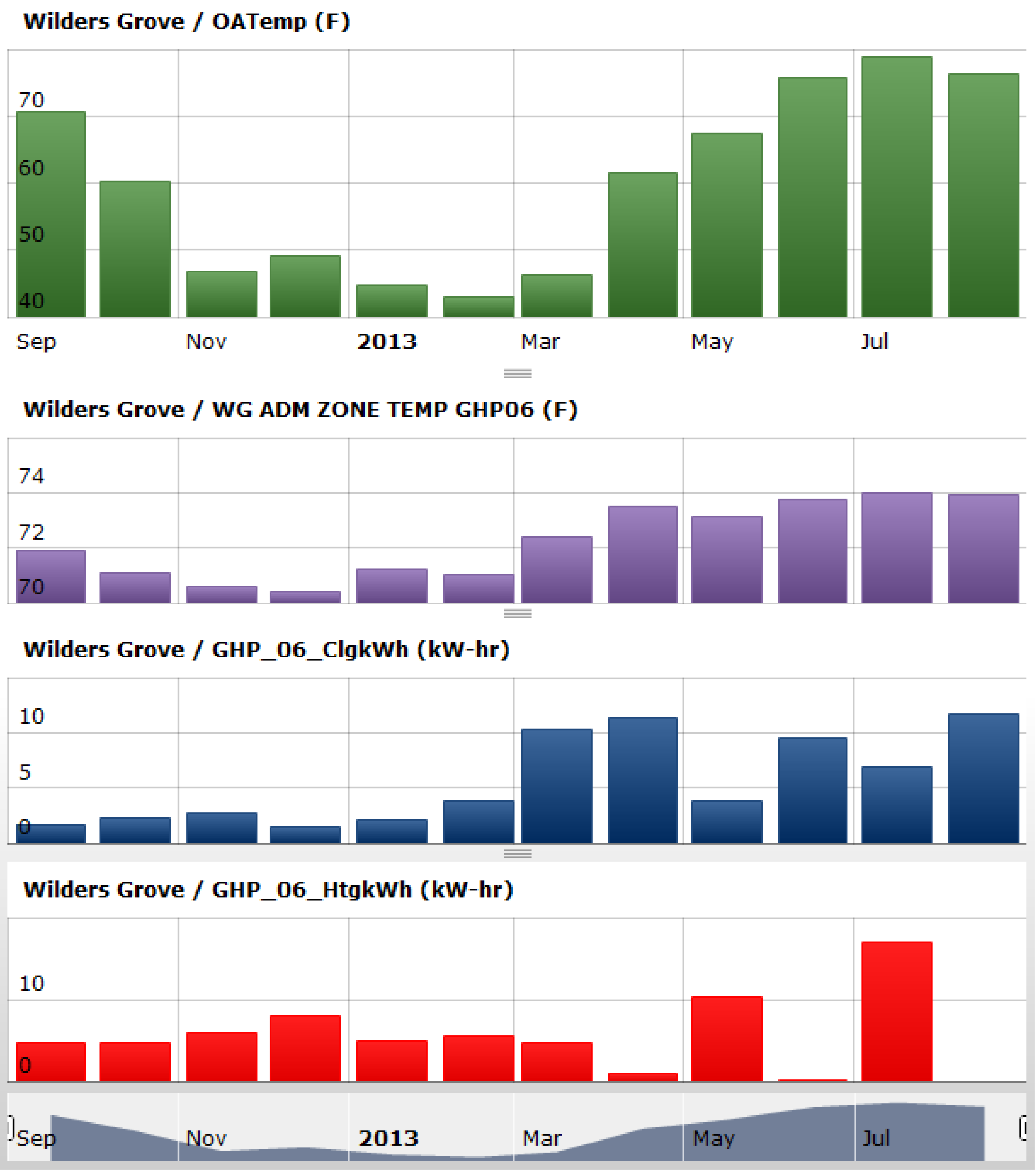
Timestamp	Wilders Grove/GHP_05_ClgkWh (kW-hr)	Wilders Grove/GHP_05_HtgkWh (kW-hr)	Wilders Grove/GHP_05_TotalkWh (kW-hr)
Sep 2012	10.979	0.96	69.287
Oct 2012	0.816	29.729	63.798
Nov 2012	0.092	43.576	80.237
Dec 2012	0.763	29.626	62.302
Jan 2013	0.227	20.621	61.575
Feb 2013	0.101	21.497	58.222
Mar 2013	0.136	23.962	65.555
Apr 2013	2.635	3.375	52.562
May 2013	0.479	4.217	37.751
Jun 2013	3.315	0	65.673
Jul 2013	8.687	0	100.941
Aug 2013	15.019	0	118.23


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP05 (F)
74
72
70
68
Wilders Grove / GHP_05_ClgkWh (kW-hr)
10
0
Wilders Grove / GHP_05_HtgkWh (kW-hr)
40
20
0
Sep
Nov
2013
Mar
May
Jul

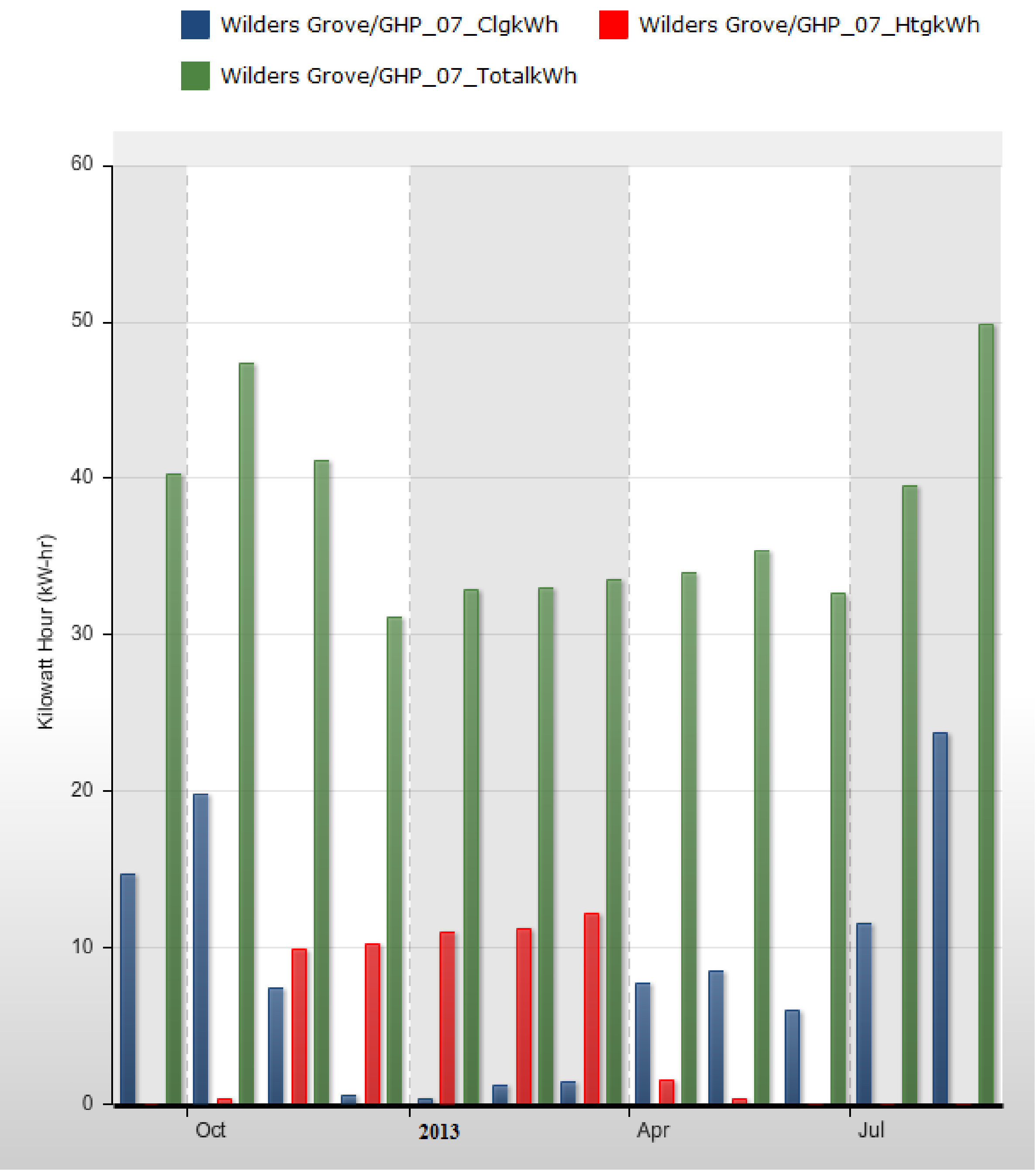
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP05 (F)	Wilders Grove / GHP_05_ClgkWh (kW-hr)	Wilders Grove / GHP_05_HtgkWh (kW-hr)	Events
Sep 2012	70.75	72.034	10.979	0.96	
Oct 2012	60.363	70.791	0.816	29.729	
Nov 2012	46.686	69.349	0.092	43.576	
Dec 2012	49.184	69.952	0.763	29.626	
Jan 2013	44.667	70.737	0.227	20.621	
Feb 2013	42.867	70.396	0.101	21.497	
Mar 2013	46.195	71.875	0.136	23.962	
Apr 2013	61.57	73.815	2.635	3.375	
May 2013	67.548	72.852	0.479	4.217	
Jun 2013	75.839	74.347	3.315	0	
Jul 2013	78.833	74.138	8.687	0	
Aug 2013	76.345	74.222	15.019	0	


Wilders Grove/GHP_06_ClgkWh
Wilders Grove/GHP_06_HtgkWh
Wilders Grove/GHP_06_TotalkWh
Kilowatt Hour (kW-hr)
50
40
30
20
10
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_06_ClgkWh (kW-hr)	Wilders Grove/GHP_06_HtgkWh (kW-hr)	Wilders Grove/GHP_06_TotalkWh (kW-hr)
Aug 2012	0.118	0.033	1.281
Sep 2012	1.69	4.723	25.714
Oct 2012	2.214	4.636	28.584
Nov 2012	2.789	6.07	29.468
Dec 2012	1.443	7.988	28.587
Jan 2013	2.066	4.917	29.506
Feb 2013	3.846	5.506	28.292
Mar 2013	10.259	4.623	35.608
Apr 2013	11.403	0.972	34.088
May 2013	3.784	10.365	33.22
Jun 2013	9.525	0.106	31.516
Jul 2013	6.831	16.962	43.213
Aug 2013	11.715	0	31.38

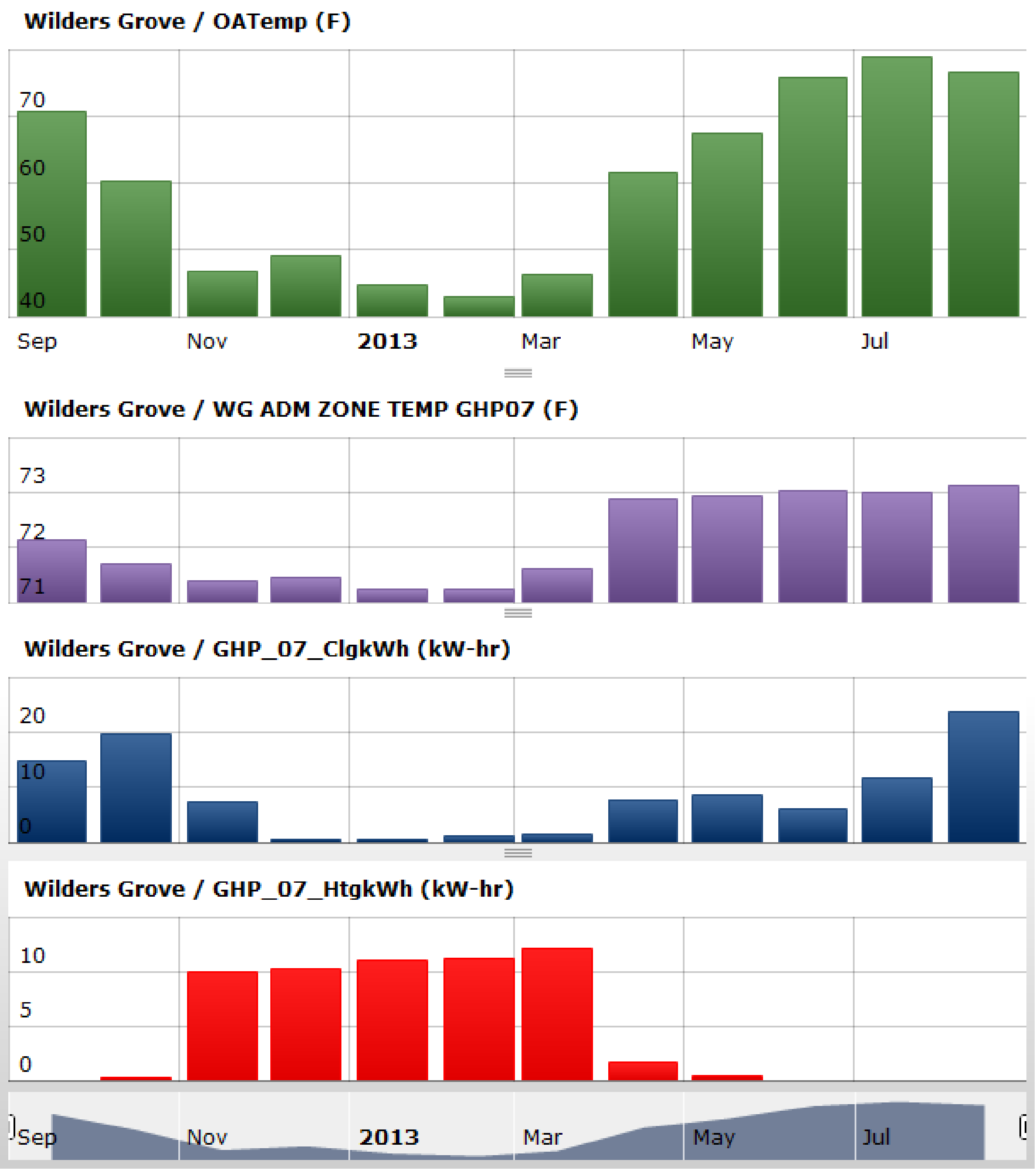

Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP06 (F)
74
72
70
Wilders Grove / GHP_06_ClgkWh (kW-hr)
10
5
0
Wilders Grove / GHP_06_HtgkWh (kW-hr)
10
0
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP06 (F)	Wilders Grove / GHP_06_ClgkWh (kW-hr)	Wilders Grove / GHP_06_HtgkWh (kW-hr)	Events
Sep 2012	70.75	71.923	1.69	4.723	
Oct 2012	60.363	71.117	2.214	4.636	
Nov 2012	46.686	70.61	2.789	6.07	
Dec 2012	49.184	70.415	1.443	7.988	
Jan 2013	44.667	71.236	2.066	4.917	
Feb 2013	42.867	71.027	3.846	5.506	
Mar 2013	46.195	72.37	10.259	4.623	
Apr 2013	61.57	73.479	11.403	0.972	
May 2013	67.548	73.115	3.784	10.365	
Jun 2013	75.839	73.766	9.525	0.106	
Jul 2013	78.833	73.971	6.831	16.962	
Aug 2013	76.345	73.959	11.715	0	

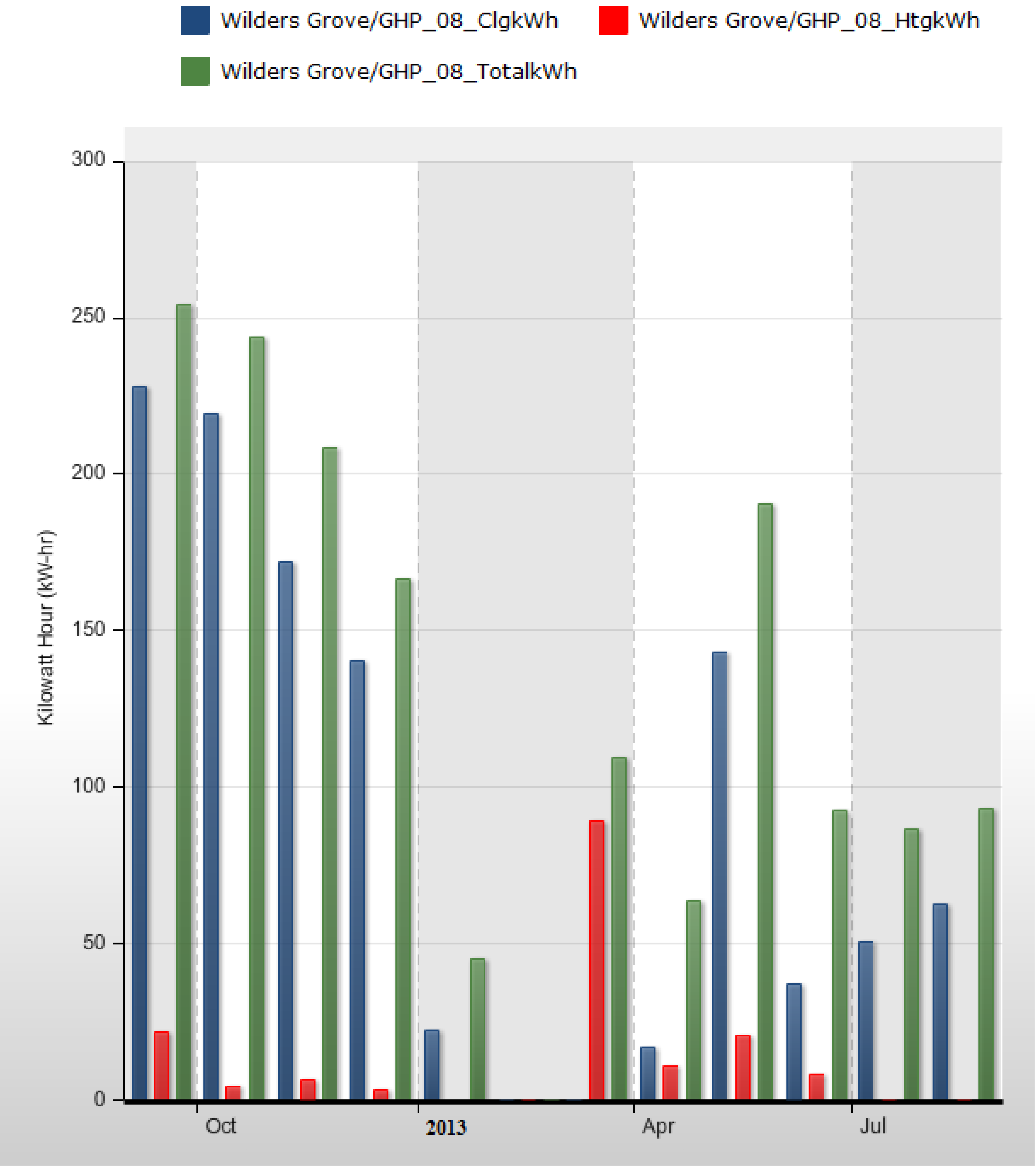


Wilders Grove/GHP_07_ClgkWh
Wilders Grove/GHP_07_HtgkWh
Wilders Grove/GHP_07_TotalkWh
Kilowatt Hour (kW-hr)
60
50
40
30
20
10
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_07_ClgkWh (kW-hr)	Wilders Grove/GHP_07_HtgkWh (kW-hr)	Wilders Grove/GHP_07_TotalkWh (kW-hr)
Sep 2012	14.66	0	40.302
Oct 2012	19.786	0.331	47.393
Nov 2012	7.403	9.97	41.116
Dec 2012	0.592	10.276	31.164
Jan 2013	0.364	11.034	32.848
Feb 2013	1.178	11.173	32.983
Mar 2013	1.47	12.182	33.529
Apr 2013	7.72	1.592	34.01
May 2013	8.515	0.337	35.348
Jun 2013	5.96	0	32.635
Jul 2013	11.499	0	39.487
Aug 2013	23.761	0	49.793


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP07 (F)
73
72
71
Wilders Grove / GHP_07_ClgkWh (kW-hr)
20
10
0
Wilders Grove / GHP_07_HtgkWh (kW-hr)
10
5
0
Sep
Nov
2013
Mar
May
Jul

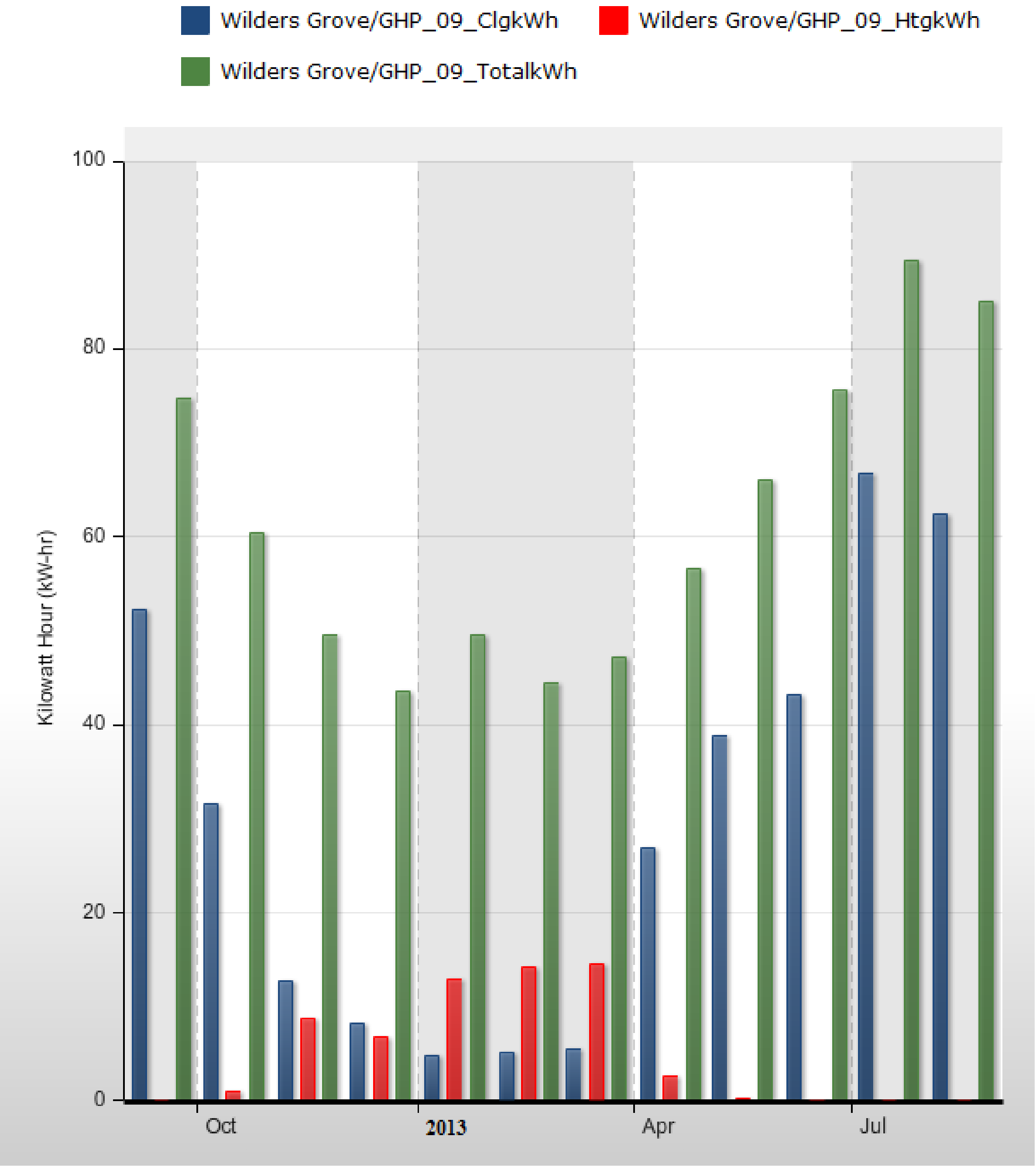
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP07 (F)	Wilders Grove / GHP_07_ClgkWh (kW-hr)	Wilders Grove / GHP_07_HtgkWh (kW-hr)	Events
Sep 2012	70.75	72.133	14.66	0	
Oct 2012	60.363	71.689	19.786	0.331	
Nov 2012	46.686	71.396	7.403	9.97	
Dec 2012	49.184	71.443	0.592	10.276	
Jan 2013	44.667	71.233	0.364	11.034	
Feb 2013	42.867	71.223	1.178	11.173	
Mar 2013	46.195	71.604	1.47	12.182	
Apr 2013	61.57	72.869	7.72	1.592	
May 2013	67.548	72.924	8.515	0.337	
Jun 2013	75.839	73.028	5.96	0	
Jul 2013	78.833	73.006	11.499	0	


Wilders Grove/GHP_08_ClgkWh
Wilders Grove/GHP_08_HtgkWh
Wilders Grove/GHP_08_TotalkWh
Kilowatt Hour (kW-hr)
300
250
200
150
100
50
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_08_ClgkWh (kW-hr)	Wilders Grove/GHP_08_HtgkWh (kW-hr)	Wilders Grove/GHP_08_TotalkWh (kW-hr)
Sep 2012	227.909	21.772	254.178
Oct 2012	219.502	4.678	244.016
Nov 2012	171.839	6.729	208.676
Dec 2012	140.387	3.144	166.578
Jan 2013	22.146	0.336	45.396
Feb 2013	0	0	0
Mar 2013	0	89.527	109.516
Apr 2013	16.847	10.964	63.653
May 2013	143.162	20.985	190.3
Jun 2013	36.927	8.023	92.33
Jul 2013	50.867	0	86.77
Aug 2013	62.742	0	93.159

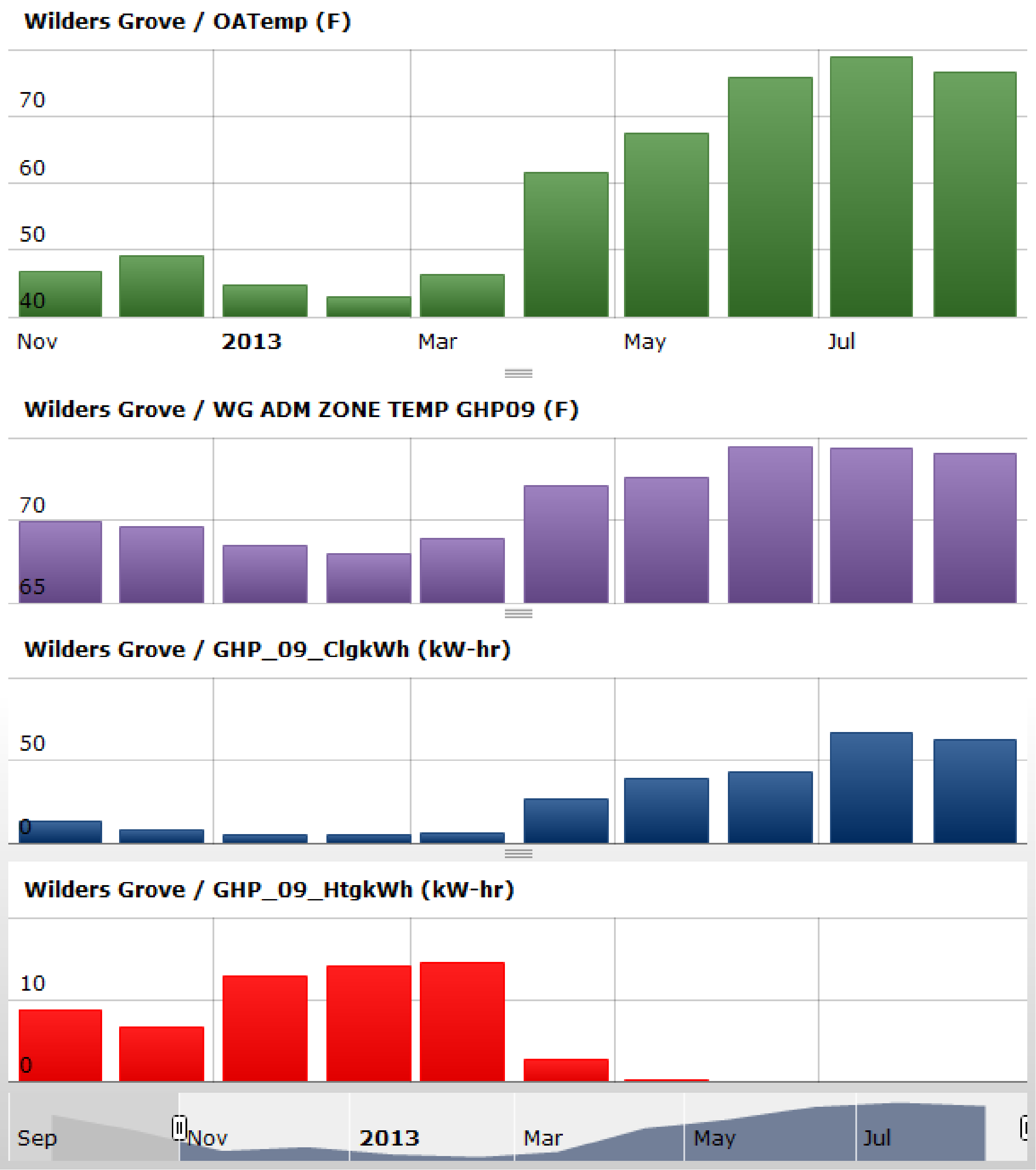

Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP08 (F)
50
0
Wilders Grove / GHP_08_ClgkWh (kW-hr)
200
100
0
Wilders Grove / GHP_08_HtgkWh (kW-hr)
50
0
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP08 (F)	Wilders Grove / GHP_08_ClgkWh (kW-hr)	Wilders Grove / GHP_08_HtgkWh (kW-hr)	Events
Sep 2012	70.75	79.915	227.909	21.772	
Oct 2012	60.363	81.486	219.502	4.678	
Nov 2012	46.686	80.461	171.839	6.729	
Dec 2012	49.184	80.673	140.387	3.144	
Jan 2013	44.667	81.065	22.146	0.336	
Feb 2013	42.867	0	0	0	
Mar 2013	46.195	68.324	0	89.527	
Apr 2013	61.57	69.162	16.847	10.964	
May 2013	67.548	80.766	143.162	20.985	
Jun 2013	75.839	72.173	36.927	8.023	
Jul 2013	78.833	73.467	50.867	0	

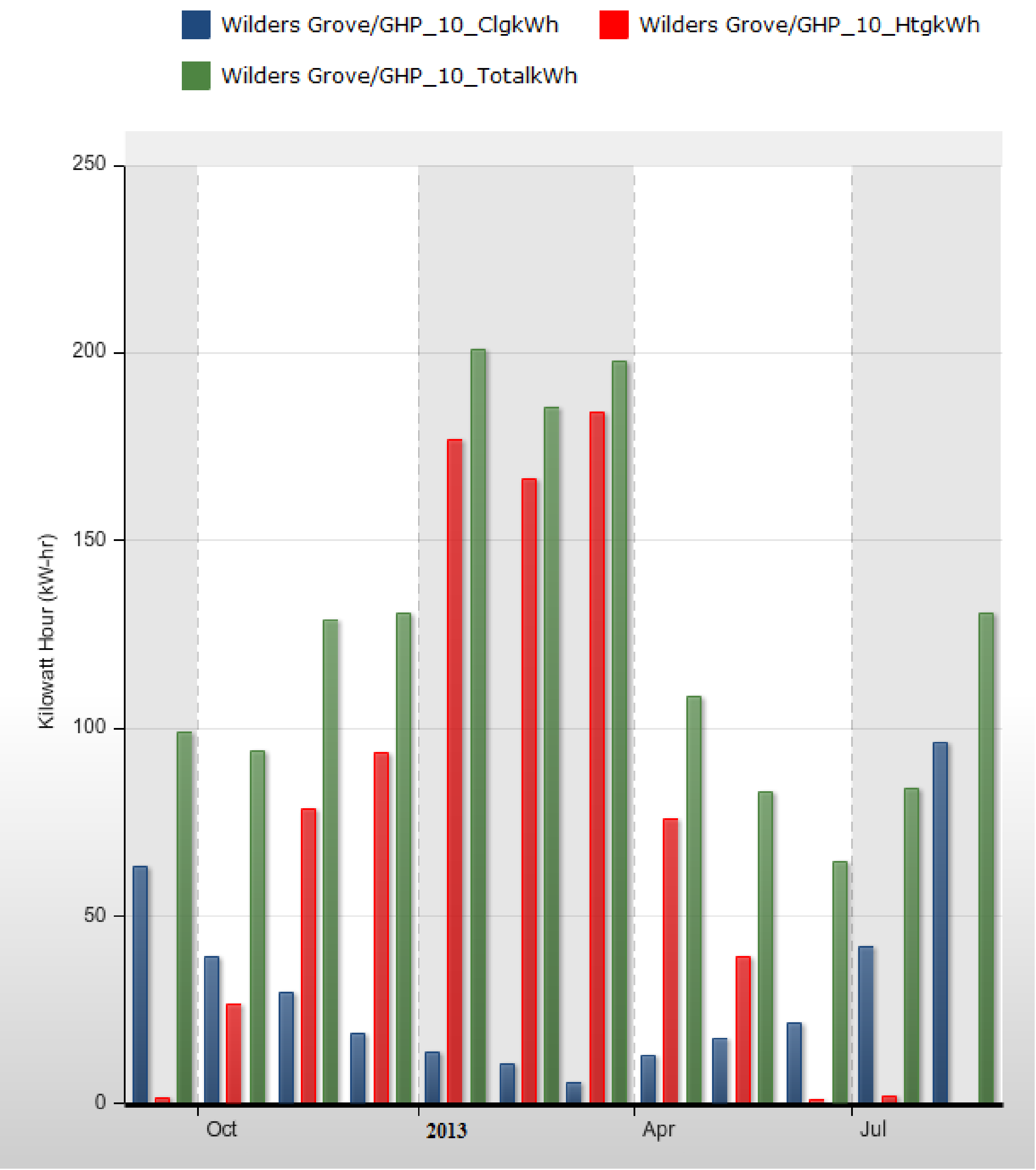


Wilders Grove/GHP_09_ClgkWh
Wilders Grove/GHP_09_HtgkWh
Wilders Grove/GHP_09_TotalkWh
Kilowatt Hour (kW-hr)
100
80
60
40
20
0
Oct
2013
Apr
Jul

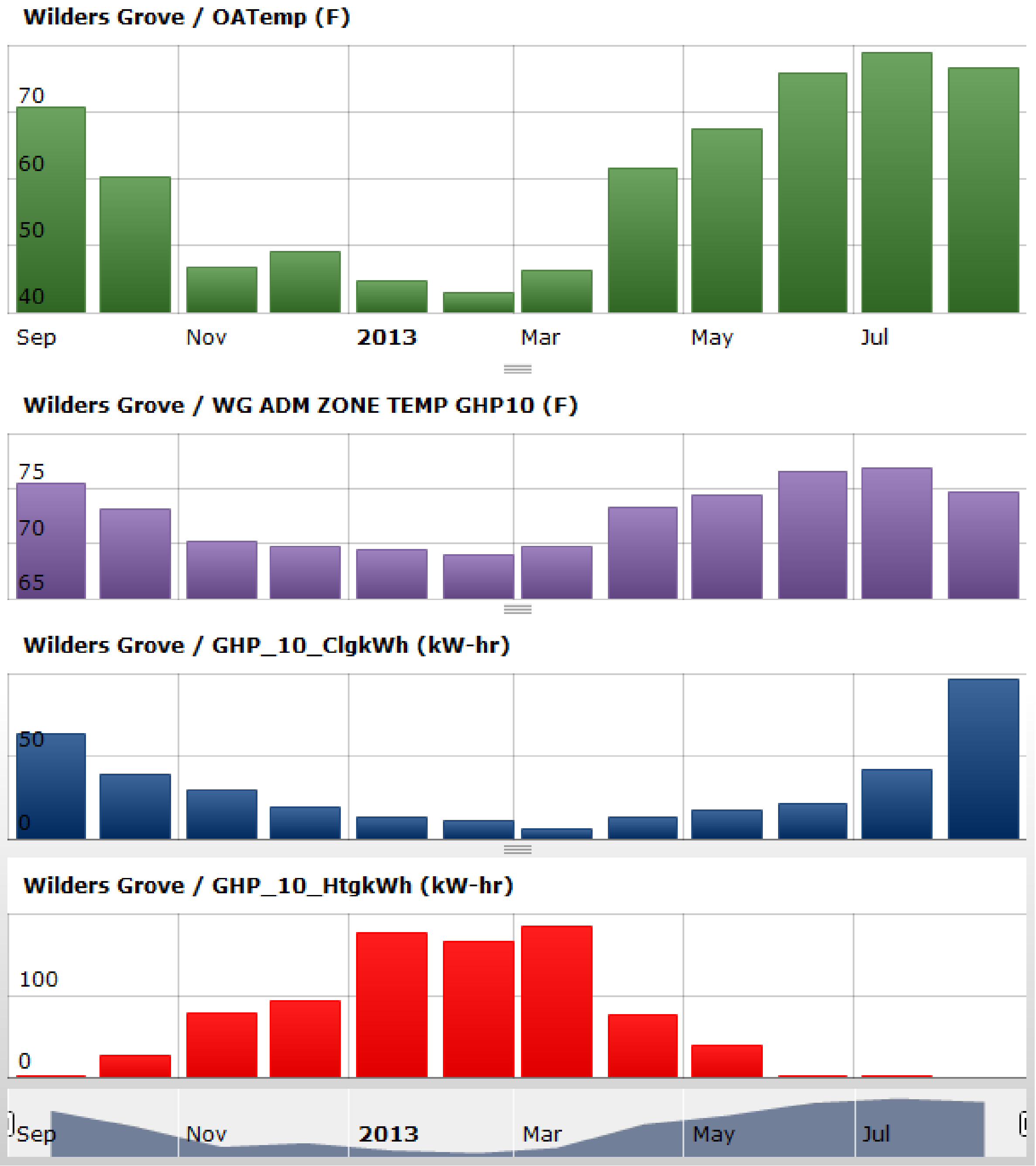
Timestamp	Wilders Grove/GHP_09_ClgkWh (kW-hr)	Wilders Grove/GHP_09_HtgkWh (kW-hr)	Wilders Grove/GHP_09_TotalkWh (kW-hr)
Sep 2012	52.265	0	74.795
Oct 2012	31.497	0.942	60.331
Nov 2012	12.796	8.723	49.594
Dec 2012	8.253	6.661	43.635
Jan 2013	4.711	12.926	49.568
Feb 2013	5.06	14.087	44.463
Mar 2013	5.554	14.48	47.229
Apr 2013	26.896	2.631	56.582
May 2013	38.846	0.14	66.056
Jun 2013	43.101	0	75.584
Jul 2013	66.741	0	89.416
Aug 2013	62.458	0	85.026


Wilders Grove / OATemp (F)
70
60
50
40
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP09 (F)
70
65
Wilders Grove / GHP_09_ClgkWh (kW-hr)
50
0
Wilders Grove / GHP_09_HtgkWh (kW-hr)
10
0
Sep
Nov
2013
Mar
May
Jul

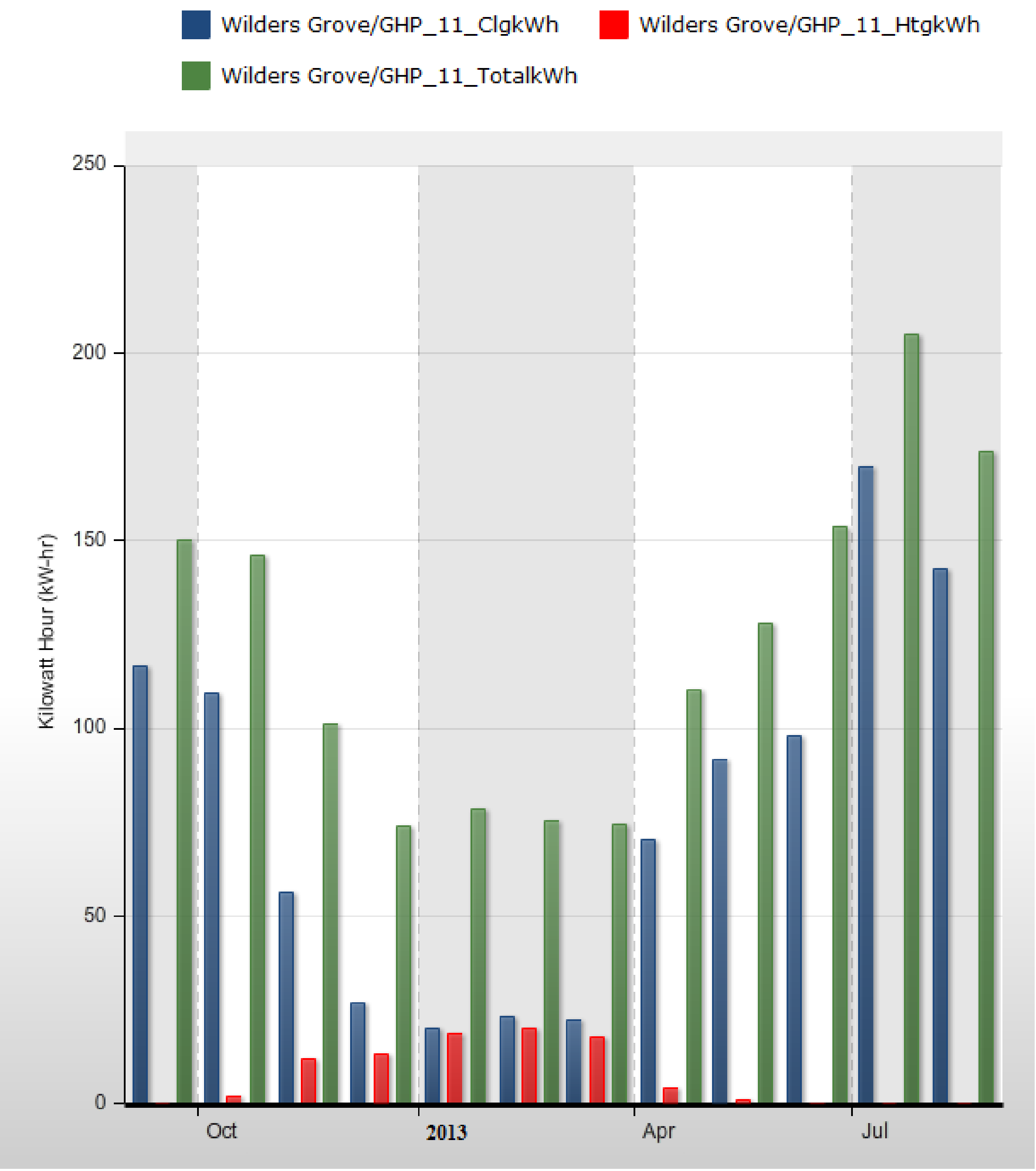
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP09 (F)	Wilders Grove / GHP_09_ClgkWh (kW-hr)	Wilders Grove / GHP_09_HtgkWh (kW-hr)	Events
Dec 2012	49.184	69.62	8.253	6.661	
Jan 2013	44.667	68.468	4.711	12.926	
Feb 2013	42.867	67.918	5.06	14.087	
Mar 2013	46.195	68.857	5.554	14.48	
Apr 2013	61.57	72.048	26.896	2.631	
May 2013	67.548	72.641	38.846	0.14	
Jun 2013	75.839	74.446	43.101	0	
Jul 2013	78.833	74.333	66.741	0	
Aug 2013	76.49	74.051	62.458	0	


Wilders Grove/GHP_10_ClgkWh
Wilders Grove/GHP_10_HtgkWh
Wilders Grove/GHP_10_TotalkWh
Kilowatt Hour (kW-hr)
250
200
150
100
50
0
Oct
2013
Apr
Jul

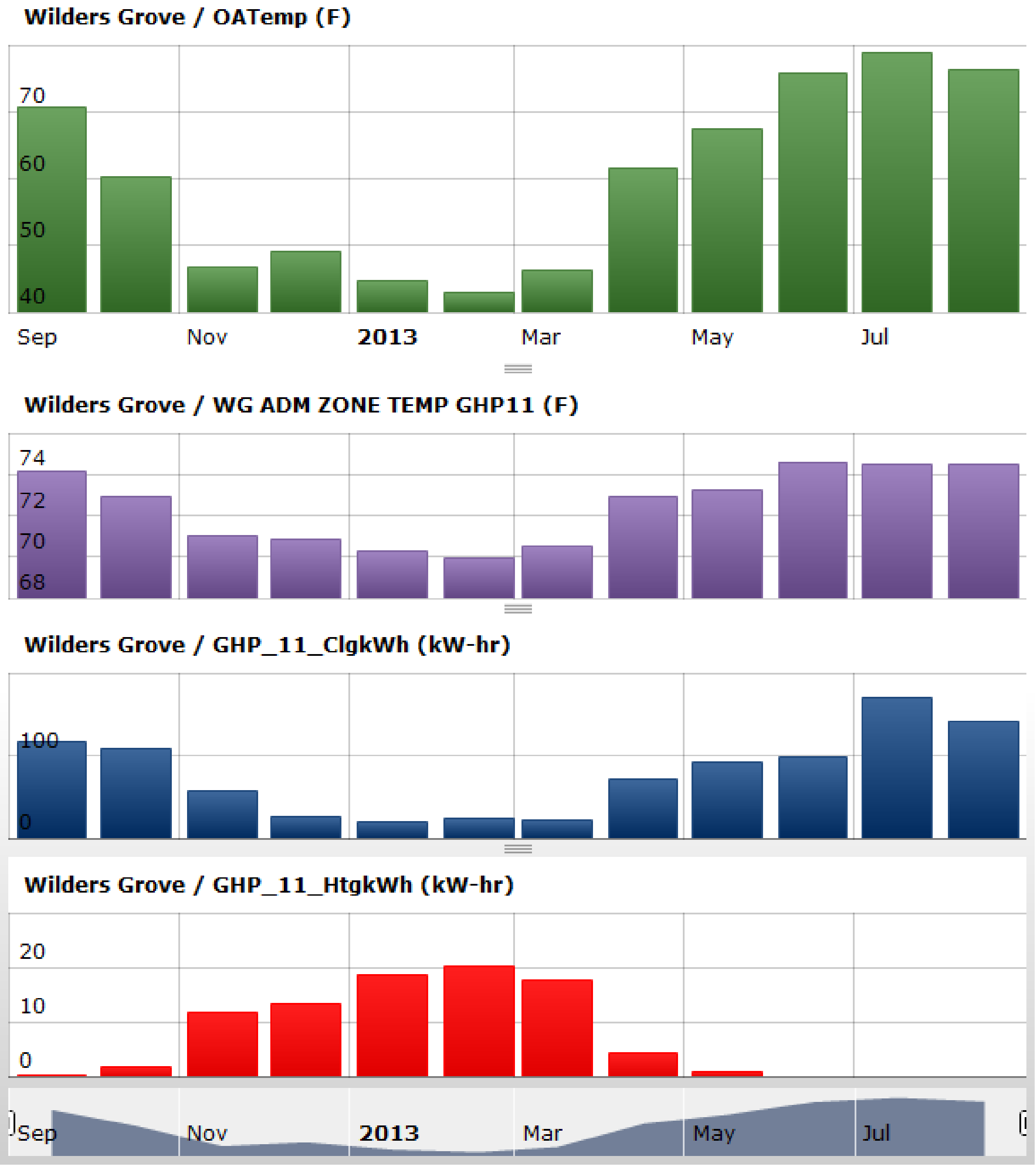
Timestamp	Wilders Grove/GHP_10_ClgkWh (kW-hr)	Wilders Grove/GHP_10_HtgkWh (kW-hr)	Wilders Grove/GHP_10_TotalkWh (kW-hr)
Sep 2012	63.052	1.447	98.775
Oct 2012	39.054	26.493	93.793
Nov 2012	29.413	78.691	128.644
Dec 2012	18.777	93.516	130.56
Jan 2013	13.528	176.846	200.858
Feb 2013	10.527	166.383	185.389
Mar 2013	5.726	184.234	197.809
Apr 2013	12.545	75.954	108.208
May 2013	17.388	39.109	83.003
Jun 2013	21.189	0.92	64.333
Jul 2013	41.926	1.869	83.966
Aug 2013	96.154	0.104	130.419


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP10 (F)
75
70
65
Wilders Grove / GHP_10_ClgkWh (kW-hr)
50
0
Wilders Grove / GHP_10_HtgkWh (kW-hr)
100
0
Sep
Nov
2013
Mar
May
Jul

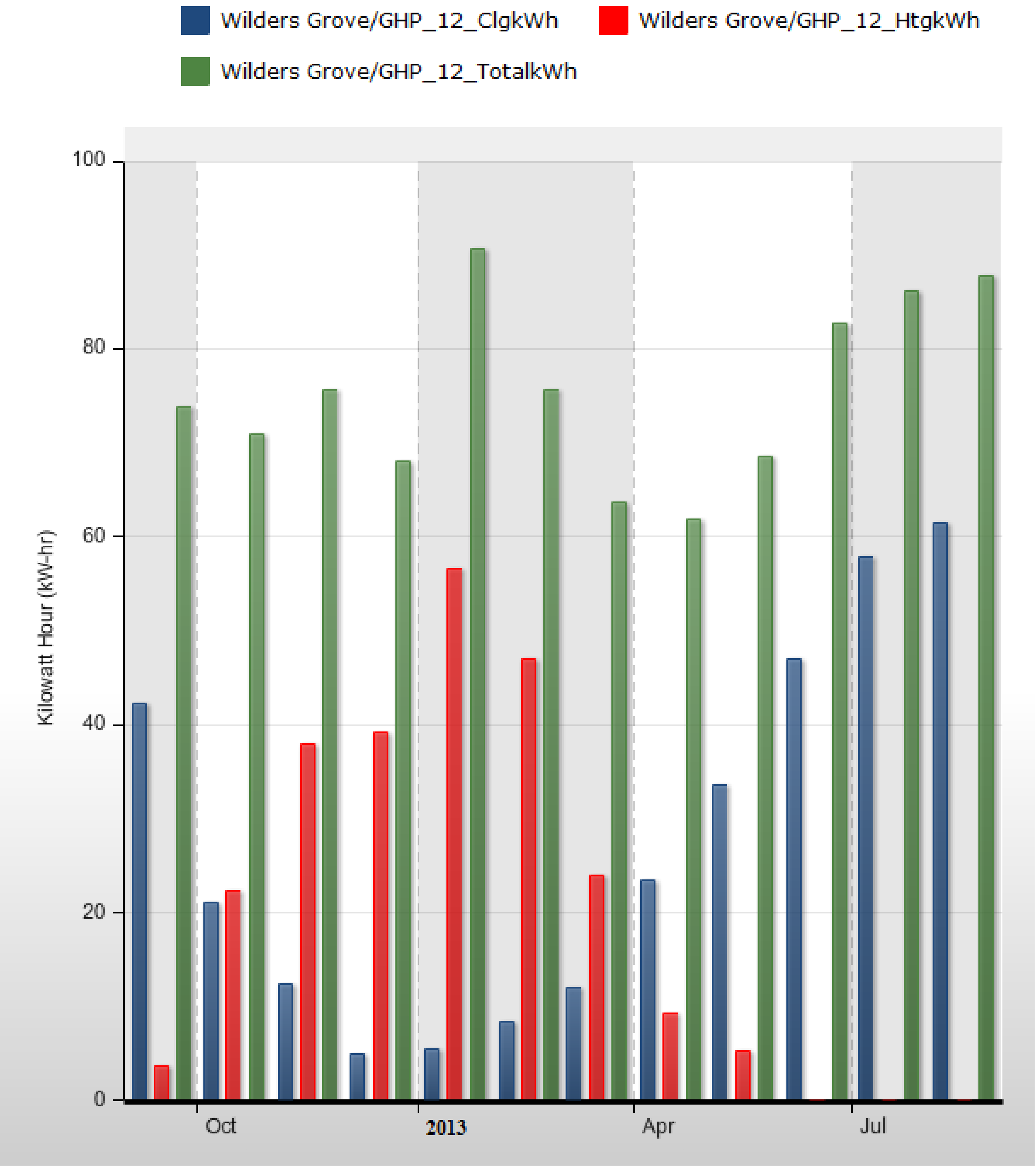
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP10 (F)	Wilders Grove / GHP_10_ClgkWh (kW-hr)	Wilders Grove / GHP_10_HtgkWh (kW-hr)	Events
Sep 2012	70.75	75.449	63.052	1.447	
Oct 2012	60.363	73.089	39.054	26.493	
Nov 2012	46.686	70.141	29.413	78.691	
Dec 2012	49.184	69.791	18.777	93.516	
Jan 2013	44.667	69.426	13.528	176.846	
Feb 2013	42.867	68.996	10.527	166.383	
Mar 2013	46.195	69.782	5.726	184.234	
Apr 2013	61.57	73.289	12.545	75.954	
May 2013	67.548	74.417	17.388	39.109	
Jun 2013	75.839	76.583	21.189	0.92	
Jul 2013	78.833	76.776	41.926	1.869	


Wilders Grove/GHP_11_ClgkWh
Wilders Grove/GHP_11_HtgkWh
Wilders Grove/GHP_11_TotalkWh
Kilowatt Hour (kW-hr)
250
200
150
100
50
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_11_ClgkWh (kW-hr)	Wilders Grove/GHP_11_HtgkWh (kW-hr)	Wilders Grove/GHP_11_TotalkWh (kW-hr)
Sep 2012	116.701	0.17	150.293
Oct 2012	109.142	1.698	145.821
Nov 2012	56.097	11.766	101.207
Dec 2012	26.99	13.31	74.022
Jan 2013	20.097	18.732	78.523
Feb 2013	23.364	20.188	75.242
Mar 2013	22.476	17.696	74.497
Apr 2013	70.527	4.26	110.113
May 2013	91.747	0.86	128.054
Jun 2013	97.79	0	153.912
Jul 2013	169.571	0	204.909
Aug 2013	142.552	0	173.815


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP11 (F)
74
72
70
68
Wilders Grove / GHP_11_ClgkWh (kW-hr)
100
0
Wilders Grove / GHP_11_HtgkWh (kW-hr)
20
10
0
Sep
Nov
2013
Mar
May
Jul

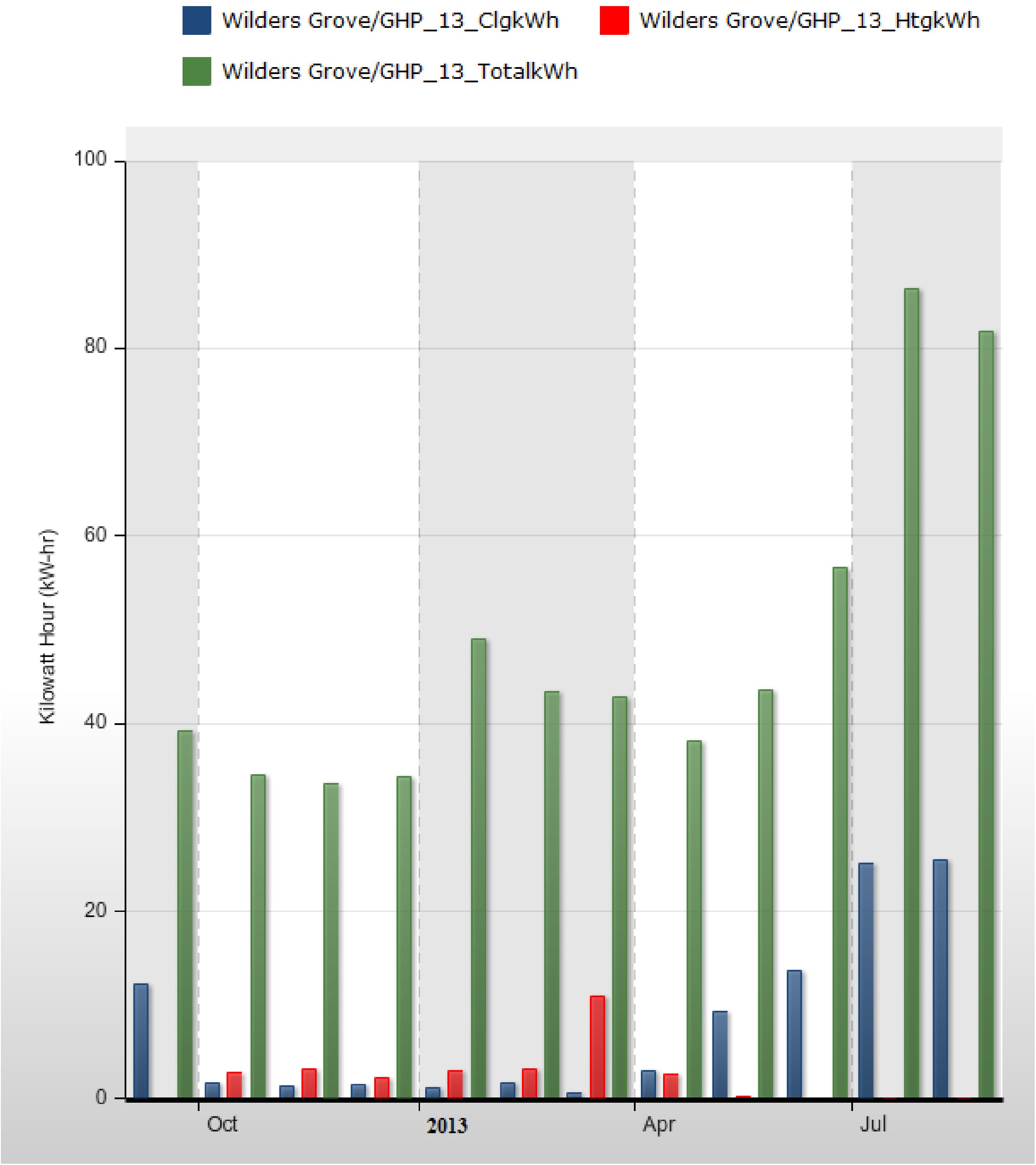
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP11 (F)	Wilders Grove / GHP_11_ClgkWh (kW-hr)	Wilders Grove / GHP_11_HtgkWh (kW-hr)	Events
Sep 2012	70.75	74.124	116.701	0.17	
Oct 2012	60.363	72.894	109.142	1.698	
Nov 2012	46.686	71.055	56.097	11.766	
Dec 2012	49.184	70.859	26.99	13.31	
Jan 2013	44.667	70.248	20.097	18.732	
Feb 2013	42.867	69.958	23.364	20.188	
Mar 2013	46.195	70.493	22.476	17.696	
Apr 2013	61.57	72.907	70.527	4.26	
May 2013	67.548	73.241	91.747	0.86	
Jun 2013	75.839	74.592	97.79	0	
Jul 2013	78.833	74.457	169.571	0	
Aug 2013	76.345	74.488	142.552	0	


Wilders Grove/GHP_12_ClgkWh
Wilders Grove/GHP_12_HtgkWh
Wilders Grove/GHP_12_TotalkWh
Kilowatt Hour (kW-hr)
100
80
60
40
20
0
Oct
2013
Apr
Jul

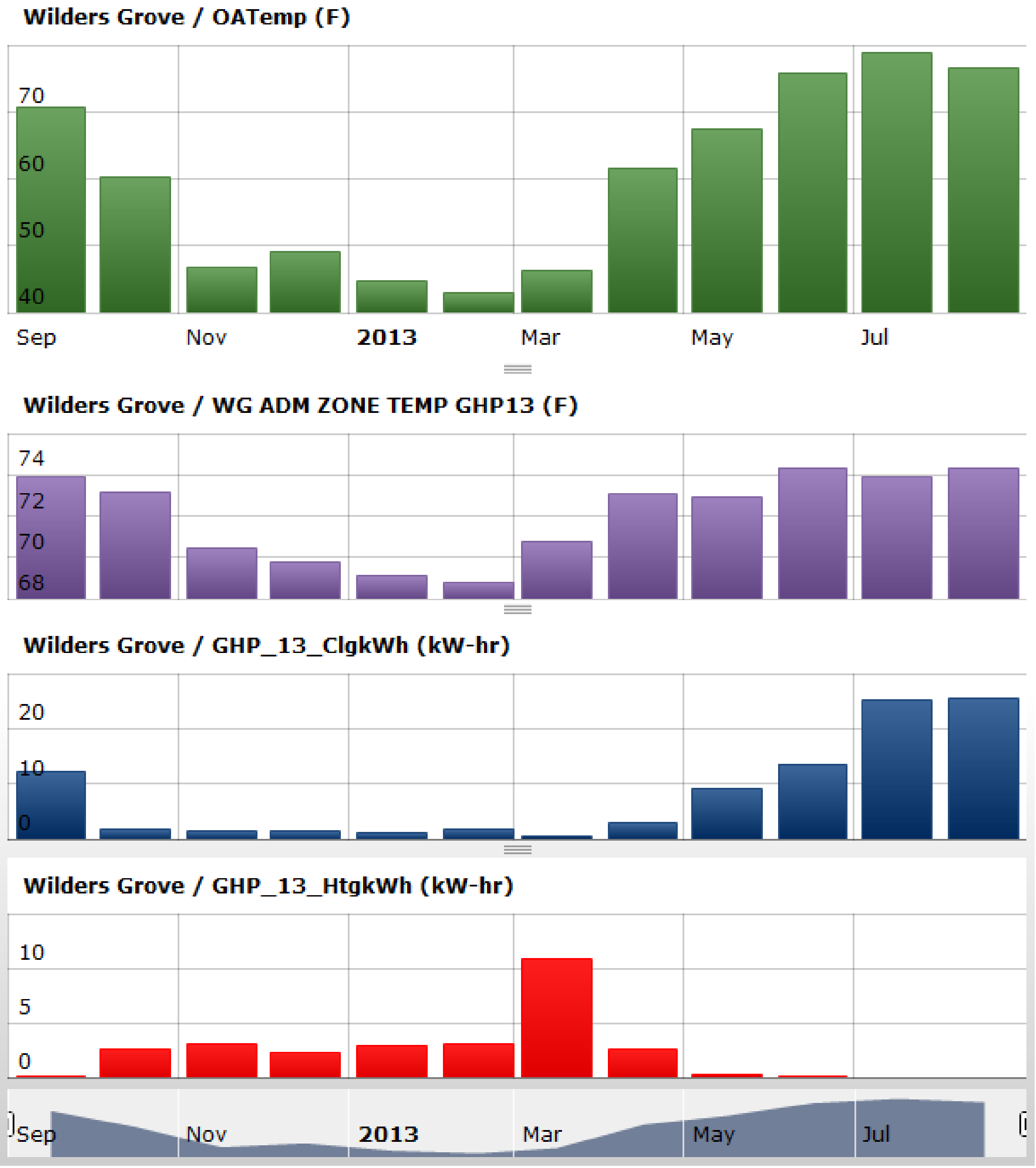
Timestamp	Wilders Grove/GHP_12_ClgkWh (kW-hr)	Wilders Grove/GHP_12_HtgkWh (kW-hr)	Wilders Grove/GHP_12_TotalkWh (kW-hr)
Sep 2012	42.262	3.719	73.883
Oct 2012	21.049	22.354	70.906
Nov 2012	12.409	37.956	75.615
Dec 2012	5.005	39.106	68.049
Jan 2013	5.417	56.585	90.675
Feb 2013	8.359	46.938	75.649
Mar 2013	11.956	23.884	63.686
Apr 2013	23.429	9.271	61.862
May 2013	33.581	5.286	68.491
Jun 2013	46.92	0	82.779
Jul 2013	57.941	0	86.152
Aug 2013	61.566	0	87.784


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP12 (F)
75
70
65
Wilders Grove / GHP_12_ClgkWh (kW-hr)
60
40
20
0
Wilders Grove / GHP_12_HtgkWh (kW-hr)
40
20
0
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP12 (F)	Wilders Grove / GHP_12_ClgkWh (kW-hr)	Wilders Grove / GHP_12_HtgkWh (kW-hr)	Events
Sep 2012	70.75	75.49	42.262	3.719	
Oct 2012	60.363	73.729	21.049	22.354	
Nov 2012	46.686	70.917	12.409	37.956	
Dec 2012	49.184	70.477	5.005	39.106	
Jan 2013	44.667	69.828	5.417	56.585	
Feb 2013	42.867	69.303	8.359	46.938	
Mar 2013	46.195	69.351	11.956	23.884	
Apr 2013	61.57	72.988	23.429	9.271	
May 2013	67.548	73.636	33.581	5.286	
Jun 2013	75.839	75.092	46.92	0	
Jul 2013	78.833	75.531	57.941	0	


Wilders Grove/GHP_13_ClgkWh
Wilders Grove/GHP_13_HtgkWh
Wilders Grove/GHP_13_TotalkWh
Kilowatt Hour (kW-hr)
100
80
60
40
20
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_13_ClgkWh (kW-hr)	Wilders Grove/GHP_13_HtgkWh (kW-hr)	Wilders Grove/GHP_13_TotalkWh (kW-hr)
Sep 2012	12.22	0.039	39.226
Oct 2012	1.726	2.667	34.422
Nov 2012	1.359	3.127	33.53
Dec 2012	1.406	2.247	34.249
Jan 2013	1.063	2.971	48.967
Feb 2013	1.679	3.027	43.304
Mar 2013	0.54	10.943	42.846
Apr 2013	2.868	2.551	38.049
May 2013	9.31	0.281	43.512
Jun 2013	13.562	0.034	56.639
Jul 2013	25.104	0.022	86.37
Aug 2013	25.426	0.023	81.826



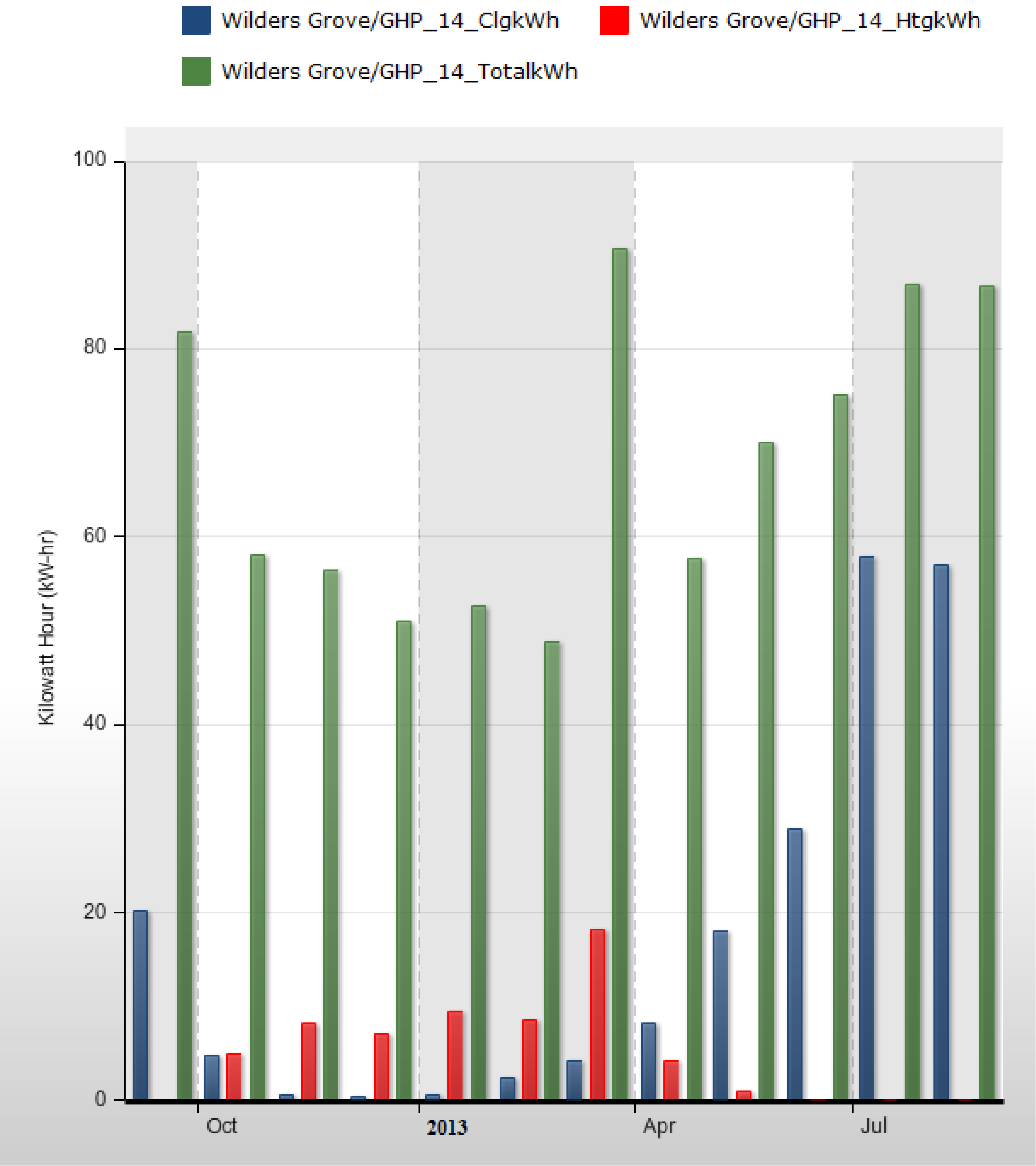
Wilders Grove / OATemp (F)

Wilders Grove / WG ADM ZONE TEMP GHP13 (F)

Wilders Grove / GHP_13_ClgkWh (kW-hr)

Wilders Grove / GHP_13_HtgkWh (kW-hr)

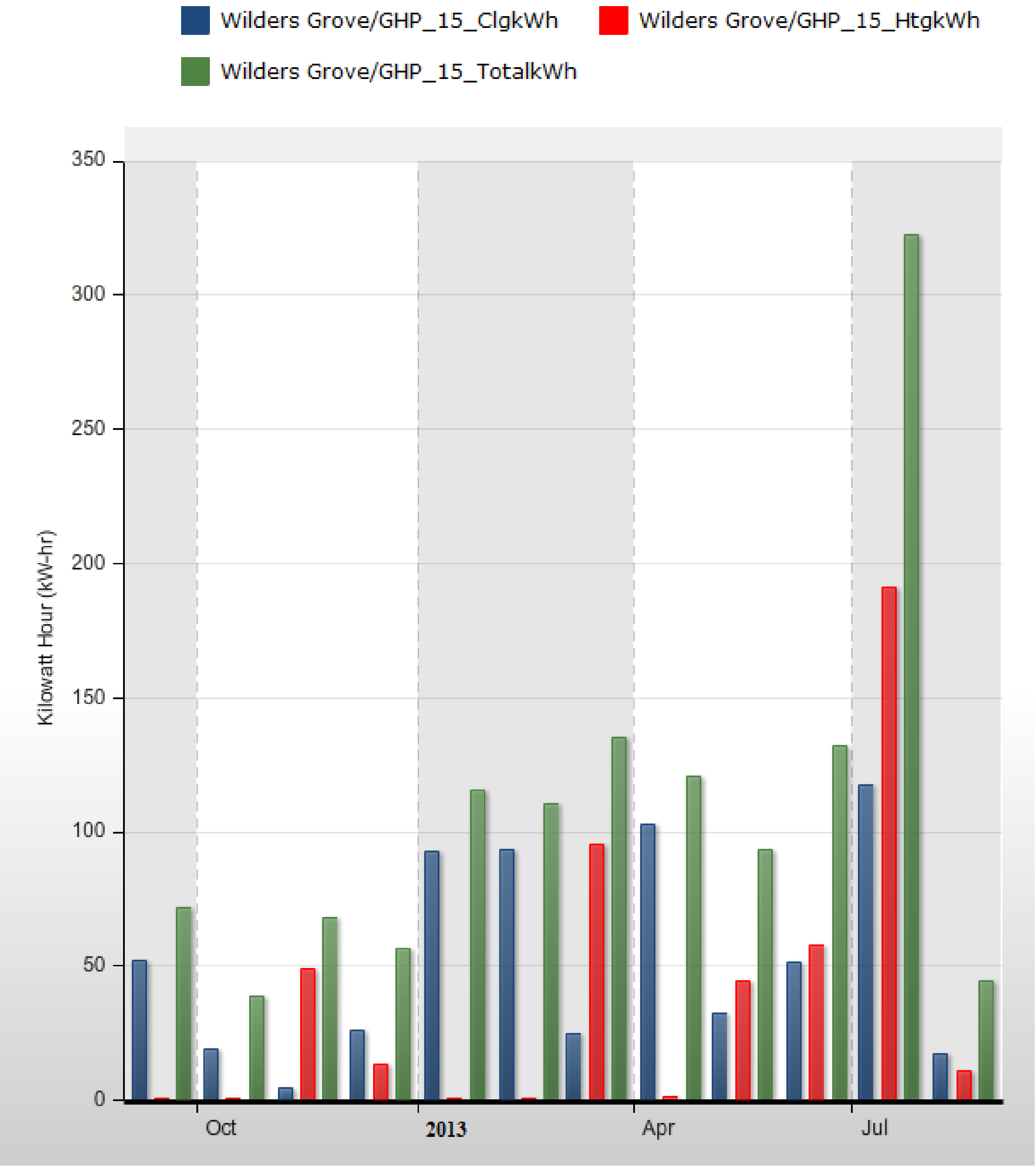
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP13 (F)	Wilders Grove / GHP_13_ClgkWh (kW-hr)	Wilders Grove / GHP_13_HtgkWh (kW-hr)	Events
Sep 2012	70.75	73.874	12.22	0.039	
Oct 2012	60.363	73.147	1.726	2.667	
Nov 2012	46.686	70.414	1.359	3.127	
Dec 2012	49.184	69.785	1.406	2.247	
Jan 2013	44.667	69.122	1.063	2.971	
Feb 2013	42.867	68.809	1.679	3.027	
Mar 2013	46.195	70.767	0.54	10.943	
Apr 2013	61.57	73.083	2.868	2.551	
May 2013	67.548	72.887	9.31	0.281	
Jun 2013	75.839	74.34	13.562	0.034	
Jul 2013	78.833	73.942	25.104	0.022	


Wilders Grove/GHP_14_ClgkWh
Wilders Grove/GHP_14_HtgkWh
Wilders Grove/GHP_14_TotalkWh
Kilowatt Hour (kW-hr)
100
80
60
40
20
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_14_ClgkWh (kW-hr)	Wilders Grove/GHP_14_HtgkWh (kW-hr)	Wilders Grove/GHP_14_TotalkWh (kW-hr)
Sep 2012	20.127	0.114	81.829
Oct 2012	4.732	4.897	58.029
Nov 2012	0.654	8.189	56.431
Dec 2012	0.431	7.17	50.909
Jan 2013	0.519	9.443	52.521
Feb 2013	2.356	8.637	48.778
Mar 2013	4.251	18.22	90.735
Apr 2013	8.276	4.184	57.697
May 2013	18.015	0.915	70.046
Jun 2013	28.859	0	75.15
Jul 2013	57.831	0	86.898
Aug 2013	57.025	0	86.652

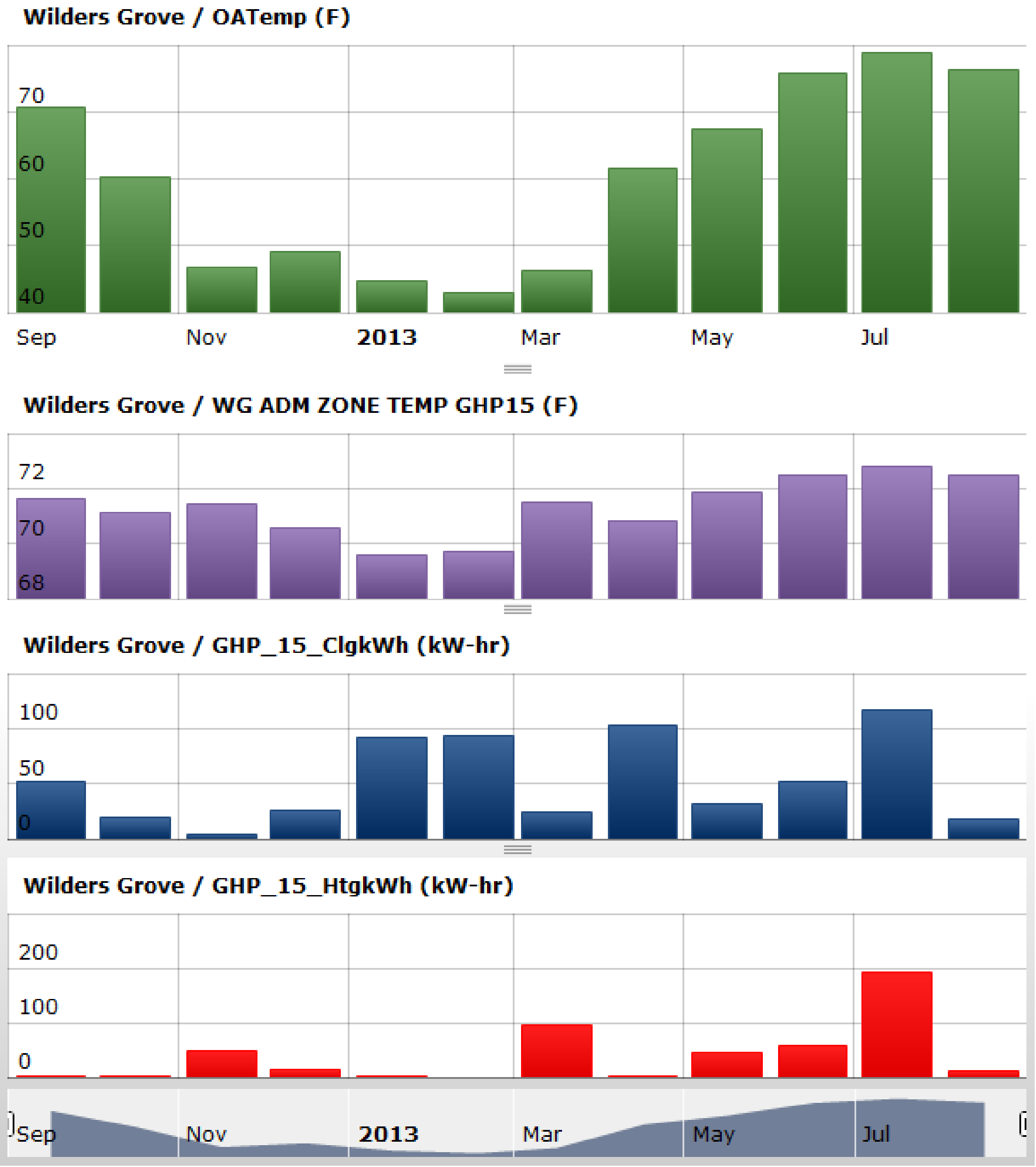

Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP14 (F)
75
70
65
Wilders Grove / GHP_14_ClgkWh (kW-hr)
40
20
0
Wilders Grove / GHP_14_HtgkWh (kW-hr)
10
0
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP14 (F)	Wilders Grove / GHP_14_ClgkWh (kW-hr)	Wilders Grove / GHP_14_HtgkWh (kW-hr)	Events
Sep 2012	70.75	75.638	20.127	0.114	
Oct 2012	60.363	73.433	4.732	4.897	
Nov 2012	46.686	70.652	0.654	8.189	
Dec 2012	49.184	70.215	0.431	7.17	
Jan 2013	44.667	69.934	0.519	9.443	
Feb 2013	42.867	69.938	2.356	8.637	
Mar 2013	46.195	70.595	4.251	18.22	
Apr 2013	61.57	73.698	8.276	4.184	
May 2013	67.548	74.624	18.015	0.915	
Jun 2013	75.839	75.789	28.859	0	
Jul 2013	78.833	74.787	57.831	0	

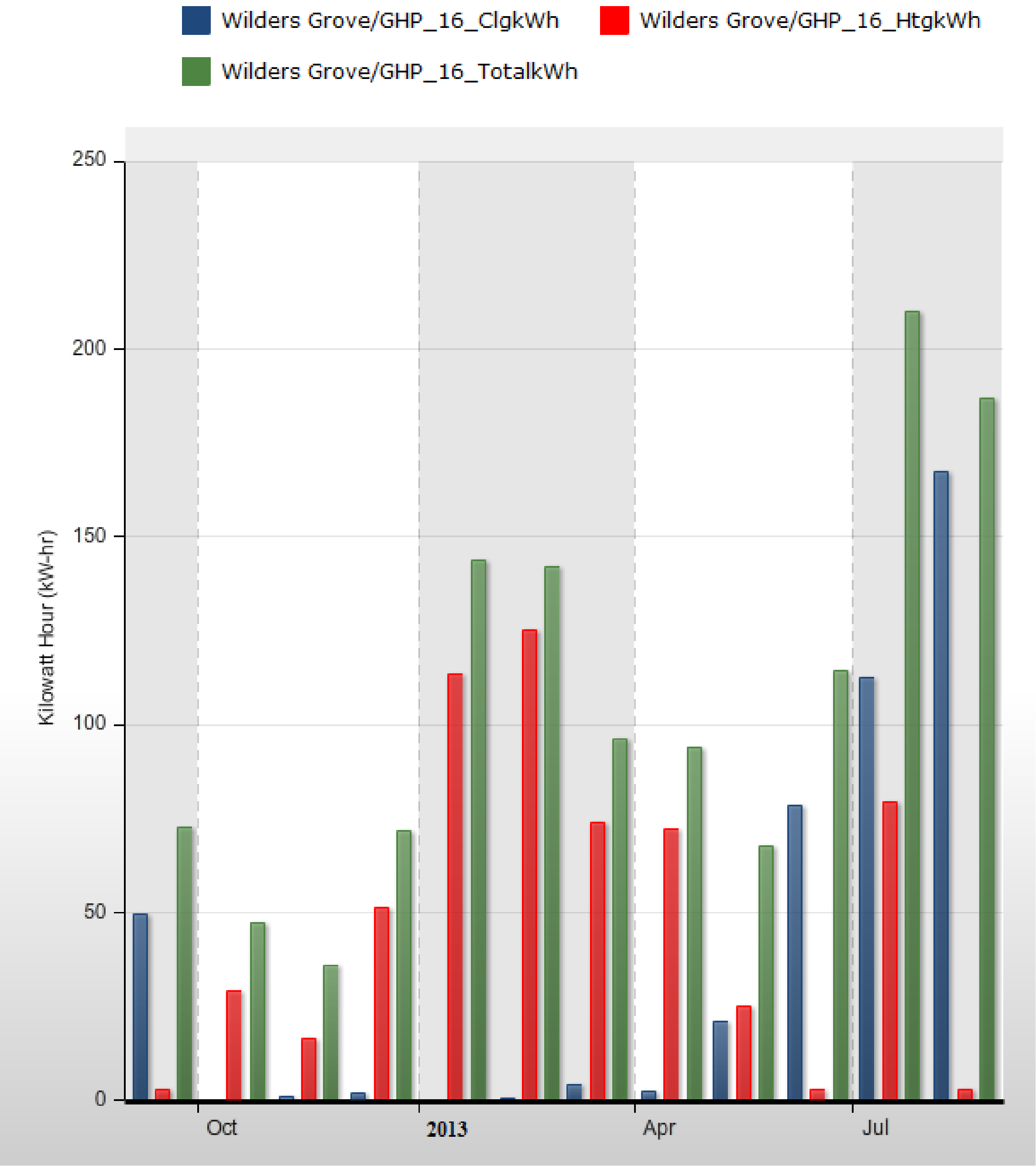


Wilders Grove/GHP_15_ClgkWh
Wilders Grove/GHP_15_HtgkWh
Wilders Grove/GHP_15_TotalkWh
Kilowatt Hour (kW-hr)
350
300
250
200
150
100
50
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_15_ClgkWh (kW-hr)	Wilders Grove/GHP_15_HtgkWh (kW-hr)	Wilders Grove/GHP_15_TotalkWh (kW-hr)
Sep 2012	52.259	0.928	71.68
Oct 2012	19.071	0.474	39.003
Nov 2012	4.399	49.054	68.063
Dec 2012	25.808	13.553	56.408
Jan 2013	92.621	0.69	115.596
Feb 2013	93.543	0.42	110.44
Mar 2013	24.766	95.006	135.42
Apr 2013	103.07	1.092	120.791
May 2013	32.151	44.703	93.416
Jun 2013	51.32	57.683	131.927
Jul 2013	117.244	191.371	322.422
Aug 2013	17.456	11.002	44.316


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP15 (F)
72
70
68
Wilders Grove / GHP_15_ClgkWh (kW-hr)
100
50
0
Wilders Grove / GHP_15_HtgkWh (kW-hr)
200
100
0
Sep
Nov
2013
Mar
May
Jul

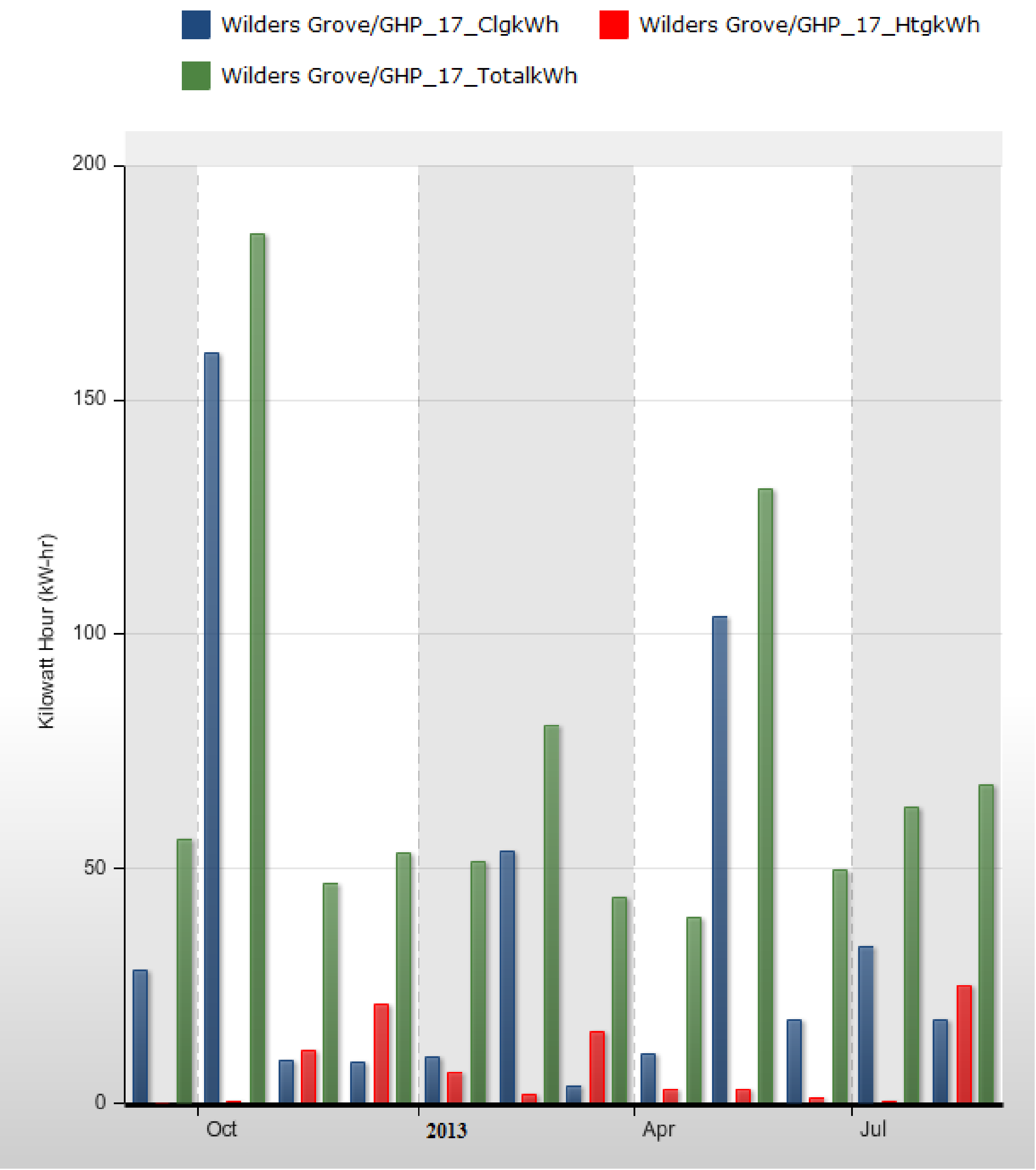
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP15 (F)	Wilders Grove / GHP_15_ClgkWh (kW-hr)	Wilders Grove / GHP_15_HtgkWh (kW-hr)	Events
Sep 2012	70.75	71.627	52.259	0.928	
Oct 2012	60.363	71.147	19.071	0.474	
Nov 2012	46.686	71.446	4.399	49.054	
Dec 2012	49.184	70.554	25.808	13.553	
Jan 2013	44.667	69.607	92.621	0.69	
Feb 2013	42.867	69.703	93.543	0.42	
Mar 2013	46.195	71.486	24.766	95.006	
Apr 2013	61.57	70.854	103.07	1.092	
May 2013	67.548	71.882	32.151	44.703	
Jun 2013	75.839	72.51	51.32	57.683	
Jul 2013	78.833	72.792	117.244	191.371	


Wilders Grove/GHP_16_ClgkWh
Wilders Grove/GHP_16_HtgkWh
Wilders Grove/GHP_16_TotalkWh
Kilowatt Hour (kW-hr)
250
200
150
100
50
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_16_ClgkWh (kW-hr)	Wilders Grove/GHP_16_HtgkWh (kW-hr)	Wilders Grove/GHP_16_TotalkWh (kW-hr)
Sep 2012	49.551	2.776	72.777
Oct 2012	0.235	28.945	47.398
Nov 2012	0.793	16.352	35.809
Dec 2012	1.979	51.322	71.497
Jan 2013	0.11	113.603	143.636
Feb 2013	0.439	125.314	141.835
Mar 2013	3.99	73.964	96.243
Apr 2013	2.159	72.211	94.041
May 2013	20.985	24.809	67.472
Jun 2013	78.337	2.69	114.098
Jul 2013	112.623	79.429	209.925
Aug 2013	167.181	2.779	186.619


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP16 (F)
73
72
71
Wilders Grove / GHP_16_ClgkWh (kW-hr)
100
0
Wilders Grove / GHP_16_HtgkWh (kW-hr)
100
50
0
Sep
Nov
2013
Mar
May
Jul

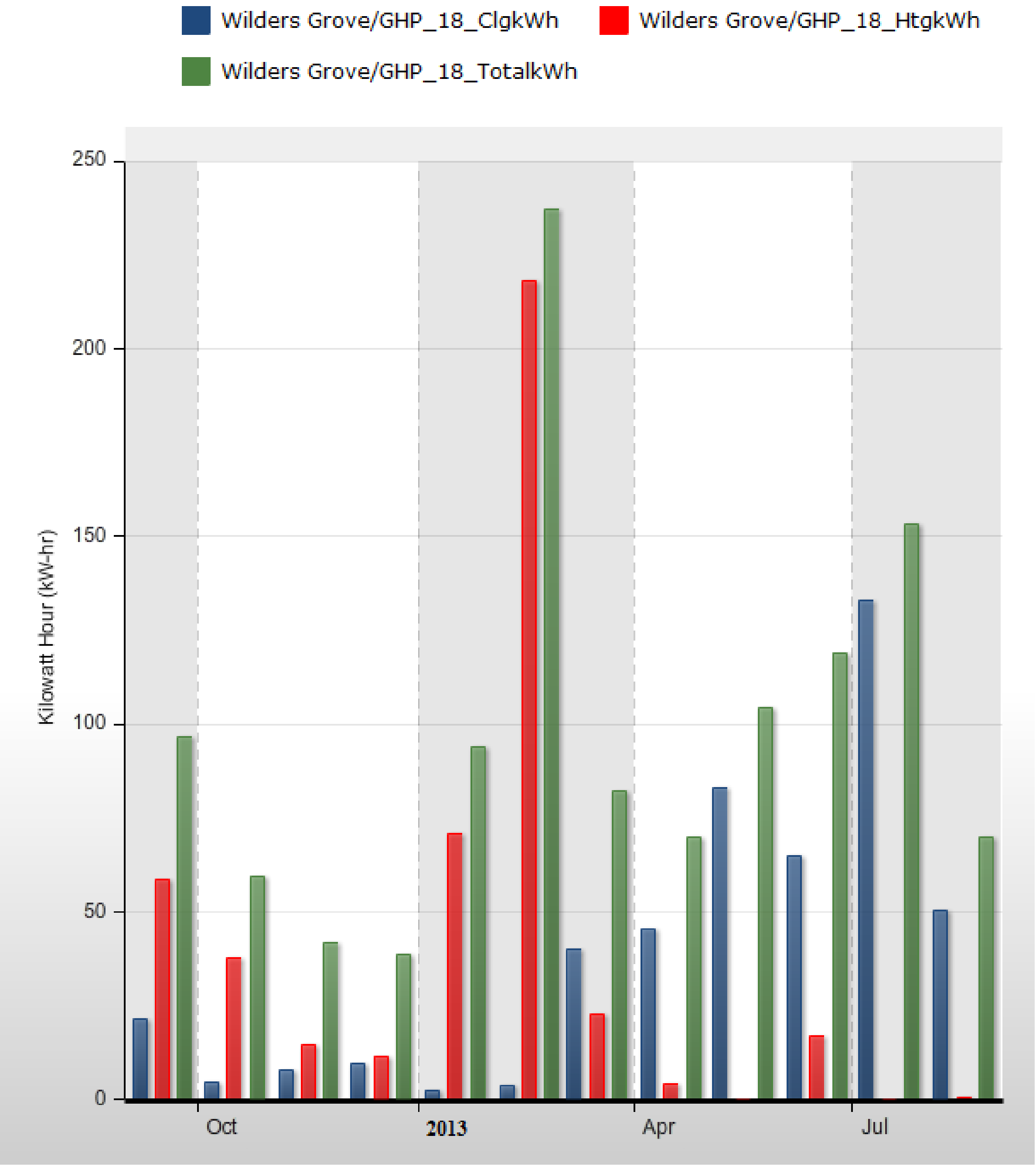
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP16 (F)	Wilders Grove / GHP_16_ClgkWh (kW-hr)	Wilders Grove / GHP_16_HtgkWh (kW-hr)	Events
Sep 2012	70.75	71.948	49.551	2.776	
Oct 2012	60.363	71.876	0.235	28.945	
Nov 2012	46.686	71.521	0.793	16.352	
Dec 2012	49.184	71.511	1.979	51.322	
Jan 2013	44.667	71.281	0.11	113.603	
Feb 2013	42.867	71.323	0.439	125.314	
Mar 2013	46.195	71.857	3.99	73.964	
Apr 2013	61.57	72.847	2.159	72.211	
May 2013	67.548	72.298	20.985	24.809	
Jun 2013	75.839	72.637	78.337	2.69	
Jul 2013	78.833	73.216	112.623	79.429	
Aug 2013	76.345	72.332	167.181	2.779	


Wilders Grove/GHP_17_ClgkWh
Wilders Grove/GHP_17_HtgkWh
Wilders Grove/GHP_17_TotalkWh
Kilowatt Hour (kW-hr)
200
150
100
50
0
Oct
2013
Apr
Jul

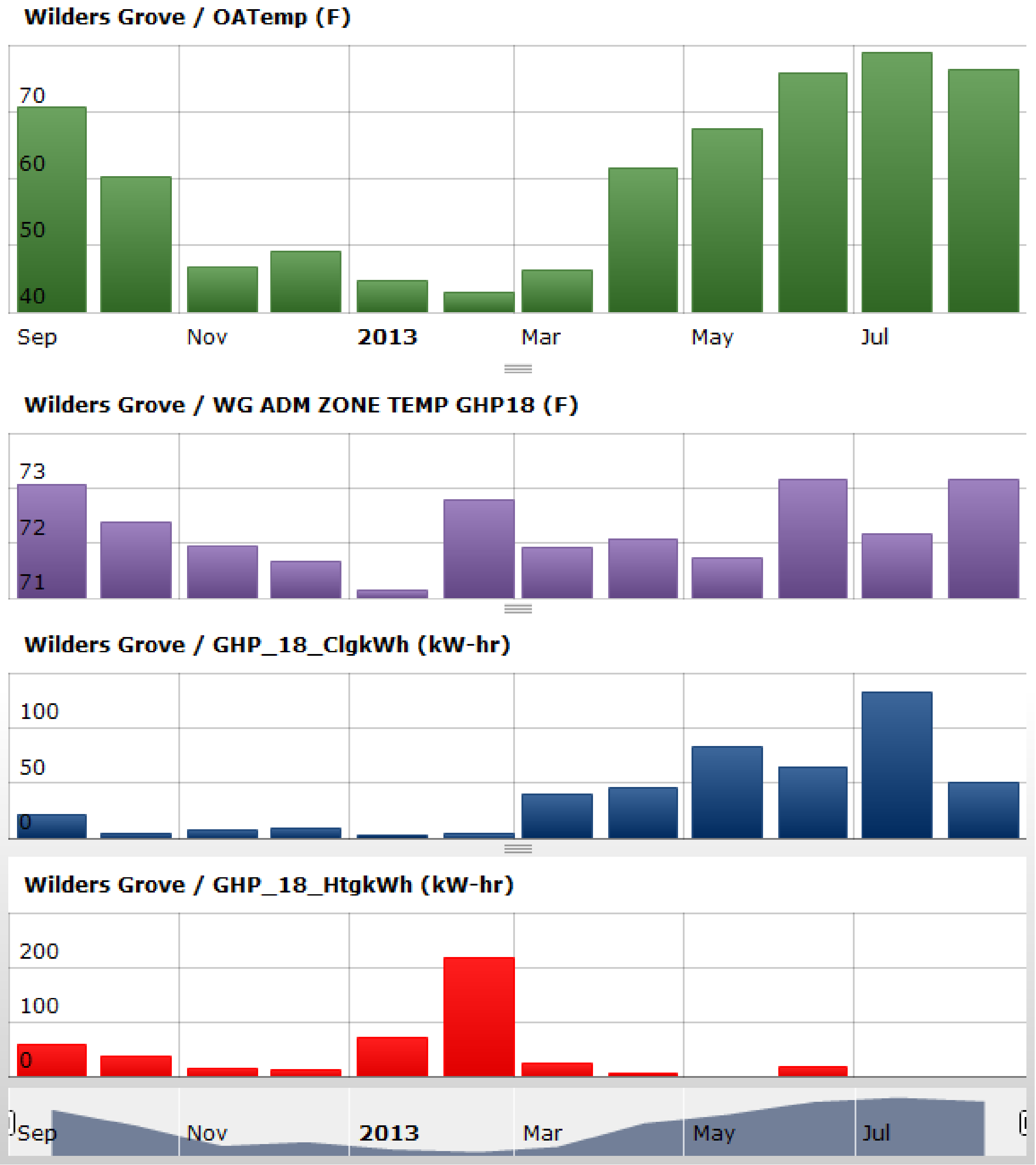
Timestamp	Wilders Grove/GHP_17_ClgkWh (kW-hr)	Wilders Grove/GHP_17_HtgkWh (kW-hr)	Wilders Grove/GHP_17_TotalkWh (kW-hr)
Sep 2012	28.205	0	56.339
Oct 2012	160.111	0.387	185.525
Nov 2012	9.274	11.156	46.805
Dec 2012	8.792	21.058	53.243
Jan 2013	9.677	6.59	51.51
Feb 2013	53.746	1.714	80.731
Mar 2013	3.79	15.121	43.769
Apr 2013	10.501	3.104	39.63
May 2013	103.729	3.067	131.086
Jun 2013	17.924	1.109	49.776
Jul 2013	33.319	0.253	63.188
Aug 2013	17.645	25.246	67.874


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP17 (F)
73
72
71
70
Wilders Grove / GHP_17_ClgkWh (kW-hr)
100
0
Wilders Grove / GHP_17_HtgkWh (kW-hr)
20
10
0
Sep
Nov
2013
Mar
May
Jul

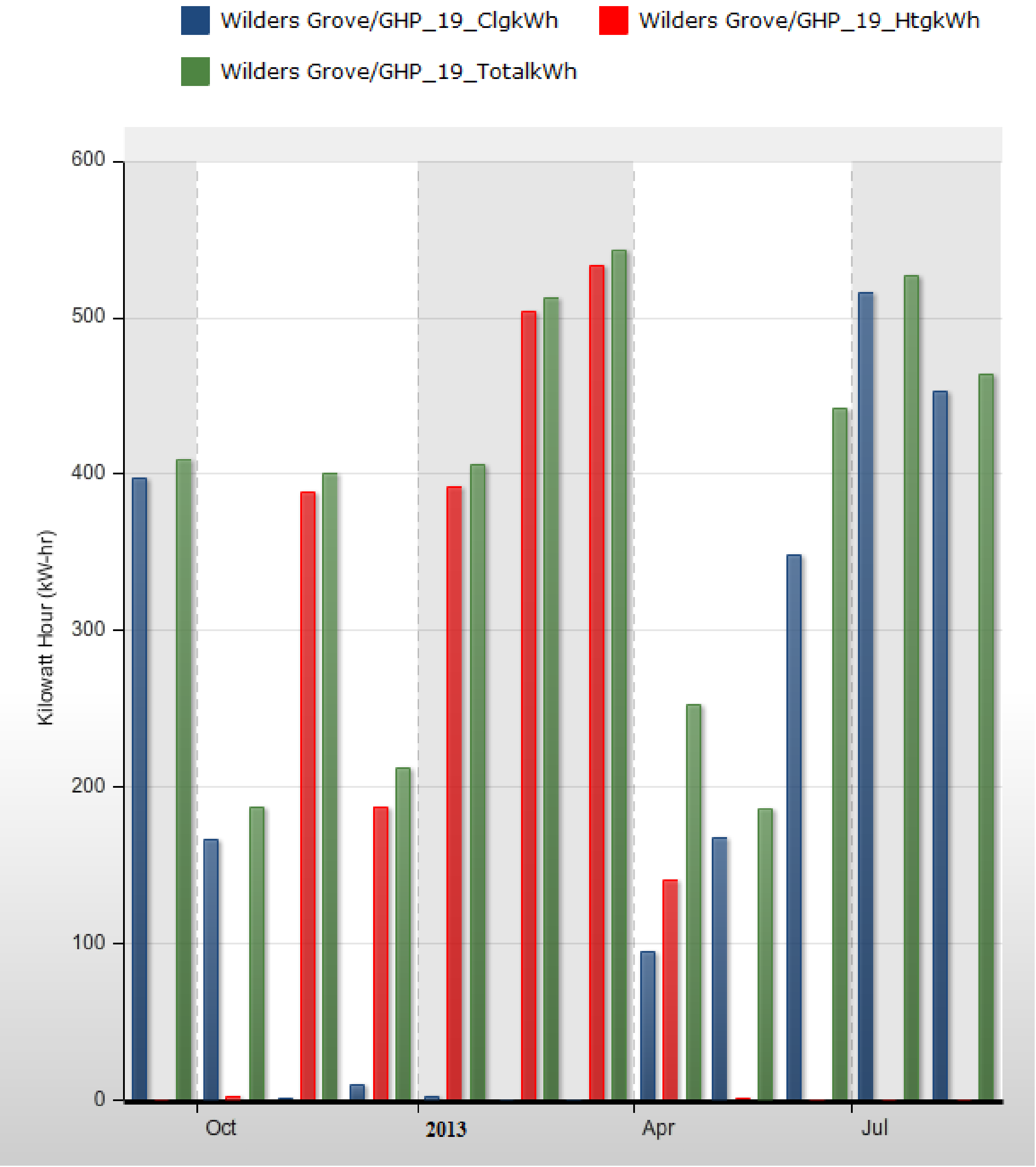
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP17 (F)	Wilders Grove / GHP_17_ClgkWh (kW-hr)	Wilders Grove / GHP_17_HtgkWh (kW-hr)	Events
Sep 2012	70.75	73.402	28.205	0	
Oct 2012	60.363	71.861	160.111	0.387	
Nov 2012	46.686	71.678	9.274	11.156	
Dec 2012	49.184	71.491	8.792	21.058	
Jan 2013	44.667	70.96	9.677	6.59	
Feb 2013	42.867	71.058	53.746	1.714	
Mar 2013	46.195	71.759	3.79	15.121	
Apr 2013	61.57	72.746	10.501	3.104	
May 2013	67.548	71.902	103.729	3.067	
Jun 2013	75.839	73.393	17.924	1.109	
Jul 2013	78.833	72.948	33.319	0.253	


Wilders Grove/GHP_18_ClgkWh
Wilders Grove/GHP_18_HtgkWh
Wilders Grove/GHP_18_TotalkWh
Kilowatt Hour (kW-hr)
250
200
150
100
50
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_18_ClgkWh (kW-hr)	Wilders Grove/GHP_18_HtgkWh (kW-hr)	Wilders Grove/GHP_18_TotalkWh (kW-hr)
Sep 2012	21.178	58.714	96.806
Oct 2012	4.817	37.767	59.546
Nov 2012	7.786	14.77	41.612
Dec 2012	9.451	11.526	38.71
Jan 2013	2.495	70.954	93.924
Feb 2013	3.544	218.311	237.027
Mar 2013	40.088	22.693	81.899
Apr 2013	45.535	4.059	69.791
May 2013	82.942	0.062	104.202
Jun 2013	64.921	16.894	119.005
Jul 2013	132.936	0	153.338
Aug 2013	50.478	0.37	70.038


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP18 (F)
73
72
71
Wilders Grove / GHP_18_ClgkWh (kW-hr)
100
50
0
Wilders Grove / GHP_18_HtgkWh (kW-hr)
200
100
0
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP18 (F)	Wilders Grove / GHP_18_ClgkWh (kW-hr)	Wilders Grove / GHP_18_HtgkWh (kW-hr)	Events
Sep 2012	70.75	73.076	21.178	58.714	
Oct 2012	60.363	72.366	4.817	37.767	
Nov 2012	46.686	71.958	7.786	14.77	
Dec 2012	49.184	71.661	9.451	11.526	
Jan 2013	44.667	71.139	2.495	70.954	
Feb 2013	42.867	72.798	3.544	218.311	
Mar 2013	46.195	71.916	40.088	22.693	
Apr 2013	61.57	72.082	45.535	4.059	
May 2013	67.548	71.716	82.942	0.062	
Jun 2013	75.839	73.141	64.921	16.894	
Jul 2013	78.833	72.161	132.936	0	
Aug 2013	76.345	73.159	50.478	0.37	


Wilders Grove/GHP_19_ClgkWh
Wilders Grove/GHP_19_HtgkWh
Wilders Grove/GHP_19_TotalkWh
Kilowatt Hour (kW-hr)
600
500
400
300
200
100
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_19_ClgkWh (kW-hr)	Wilders Grove/GHP_19_HtgkWh (kW-hr)	Wilders Grove/GHP_19_TotalkWh (kW-hr)
Sep 2012	397.289	0	409.11
Oct 2012	166.841	2.078	186.816
Nov 2012	0.713	388.103	400.083
Dec 2012	9.597	187.812	212.185
Jan 2013	2.559	392.362	405.927
Feb 2013	0	503.707	512.179
Mar 2013	0	533.073	542.531
Apr 2013	95.355	140.467	252.165
May 2013	167.458	1.048	185.953
Jun 2013	348.108	0	441.679
Jul 2013	515.527	0	526.762
Aug 2013	452.934	0	463.241

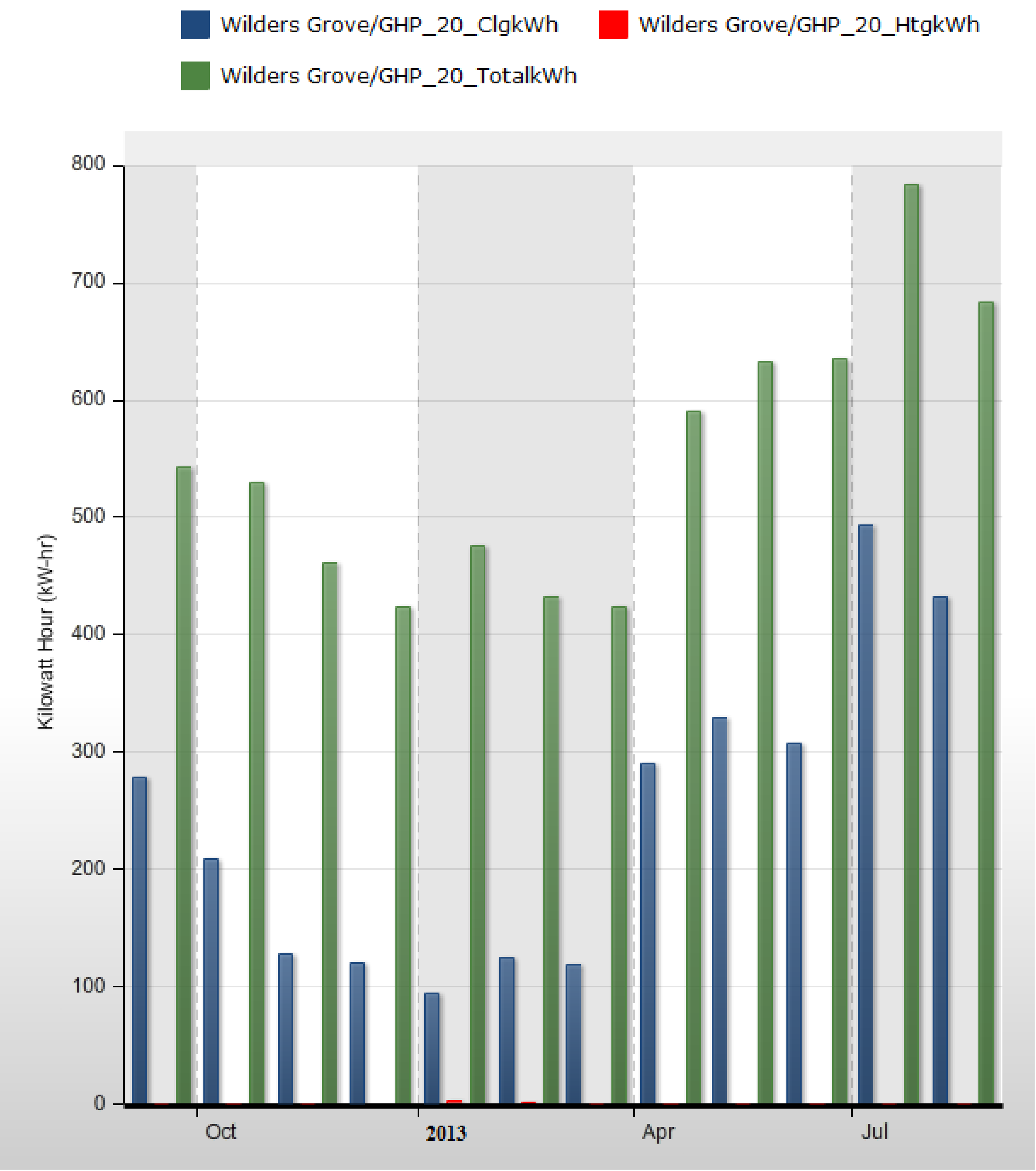
Wilders Grove / OATemp (F)

Wilders Grove / WG ADM ZONE TEMP GHP19 (F)

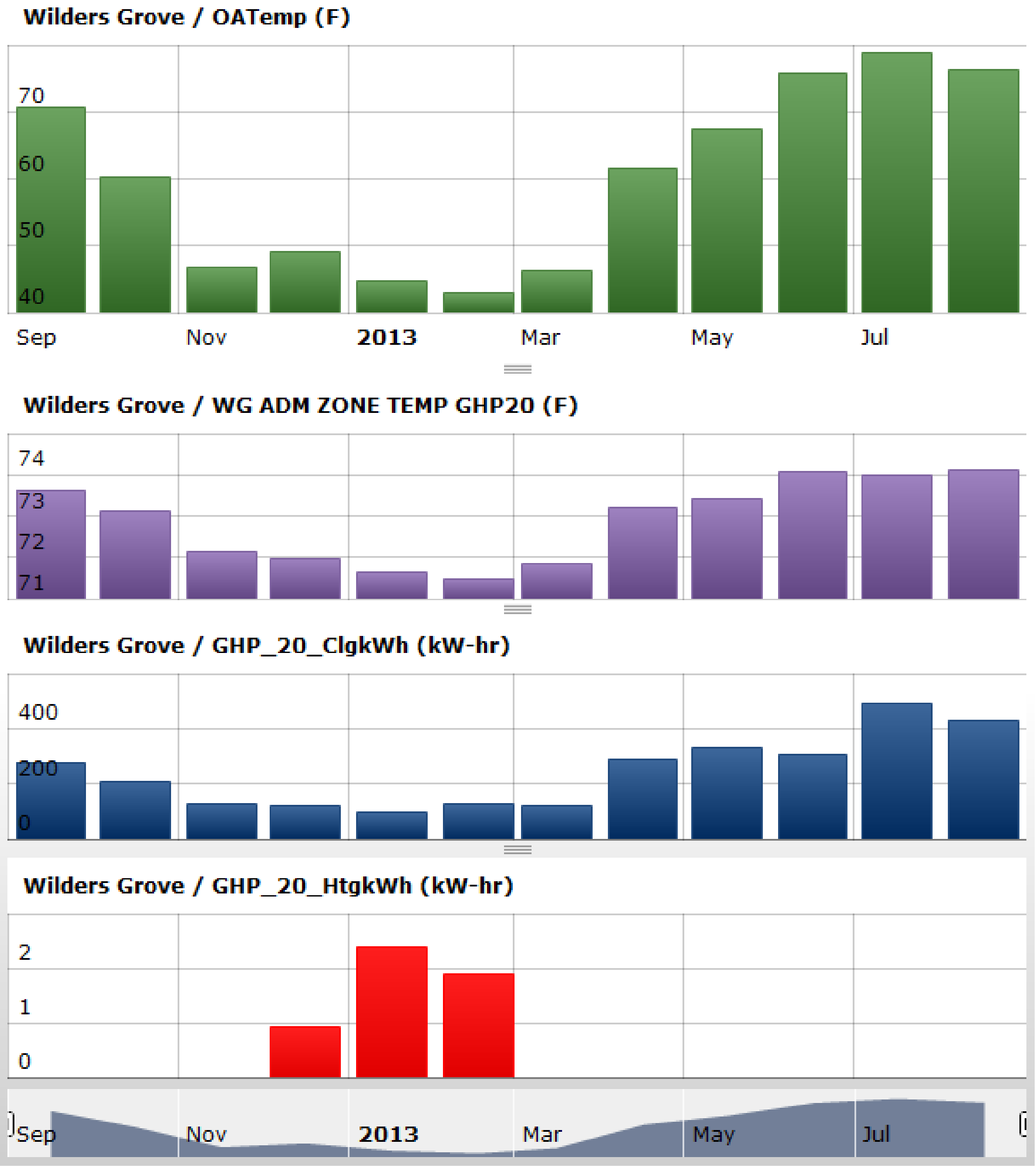
Wilders Grove / GHP_19_ClgkWh (kW-hr)

Wilders Grove / GHP_19_HtgkWh (kW-hr)

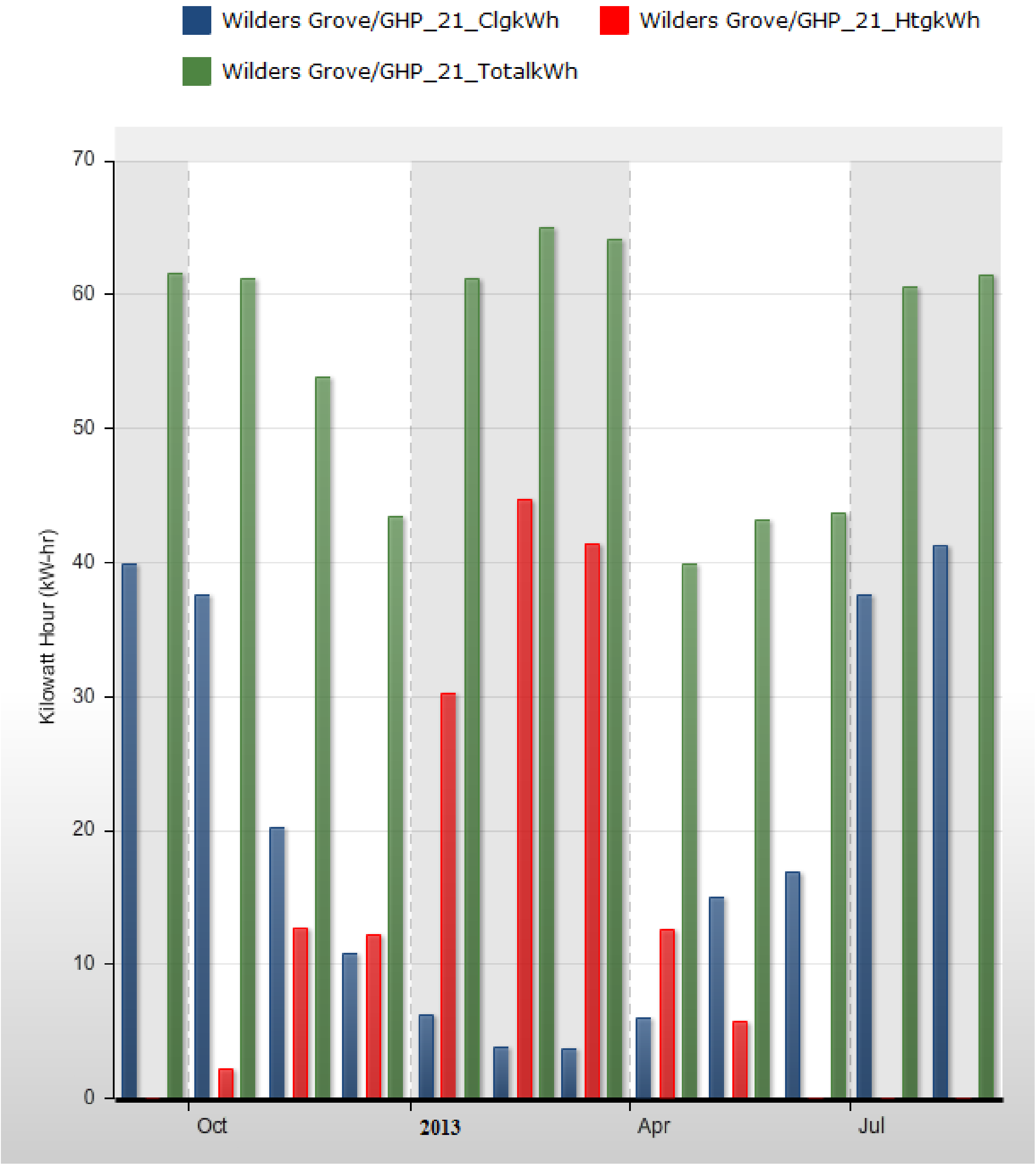
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP19 (F)	Wilders Grove / GHP_19_ClgkWh (kW-hr)	Wilders Grove / GHP_19_HtgkWh (kW-hr)	Events
Sep 2012	70.75	75.356	397.289	0	
Oct 2012	60.363	74.018	166.841	2.078	
Nov 2012	46.686	70.953	0.713	388.103	
Dec 2012	49.184	71.621	9.597	187.812	
Jan 2013	44.667	70.411	2.559	392.362	
Feb 2013	42.867	69.726	0	503.707	
Mar 2013	46.195	70.168	0	533.073	
Apr 2013	61.57	72.966	95.355	140.467	
May 2013	67.548	73.969	167.458	1.048	
Jun 2013	75.839	75.888	348.108	0	
Jul 2013	78.833	76.233	515.527	0	
Aug 2013	76.345	75.947	452.934	0	


Wilders Grove/GHP_20_ClgkWh
Wilders Grove/GHP_20_HtgkWh
Wilders Grove/GHP_20_TotalkWh
Kilowatt Hour (kW-hr)
800
700
600
500
400
300
200
100
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_20_ClgkWh (kW-hr)	Wilders Grove/GHP_20_HtgkWh (kW-hr)	Wilders Grove/GHP_20_TotalkWh (kW-hr)
Sep 2012	278.574	0	542.929
Oct 2012	208.993	0	529.41
Nov 2012	128.176	0	461.853
Dec 2012	120.293	0.931	423.519
Jan 2013	94.852	2.407	475.464
Feb 2013	125.677	1.885	432.071
Mar 2013	119.873	0	423.386
Apr 2013	289.699	0	590.856
May 2013	329.341	0	632.201
Jun 2013	308.239	0	635.86
Jul 2013	494.078	0	783.93
Aug 2013	432.817	0	683.358


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP20 (F)
74
73
72
71
Wilders Grove / GHP_20_ClgkWh (kW-hr)
400
200
0
Wilders Grove / GHP_20_HtgkWh (kW-hr)
2
1
0
Sep
Nov
2013
Mar
May
Jul

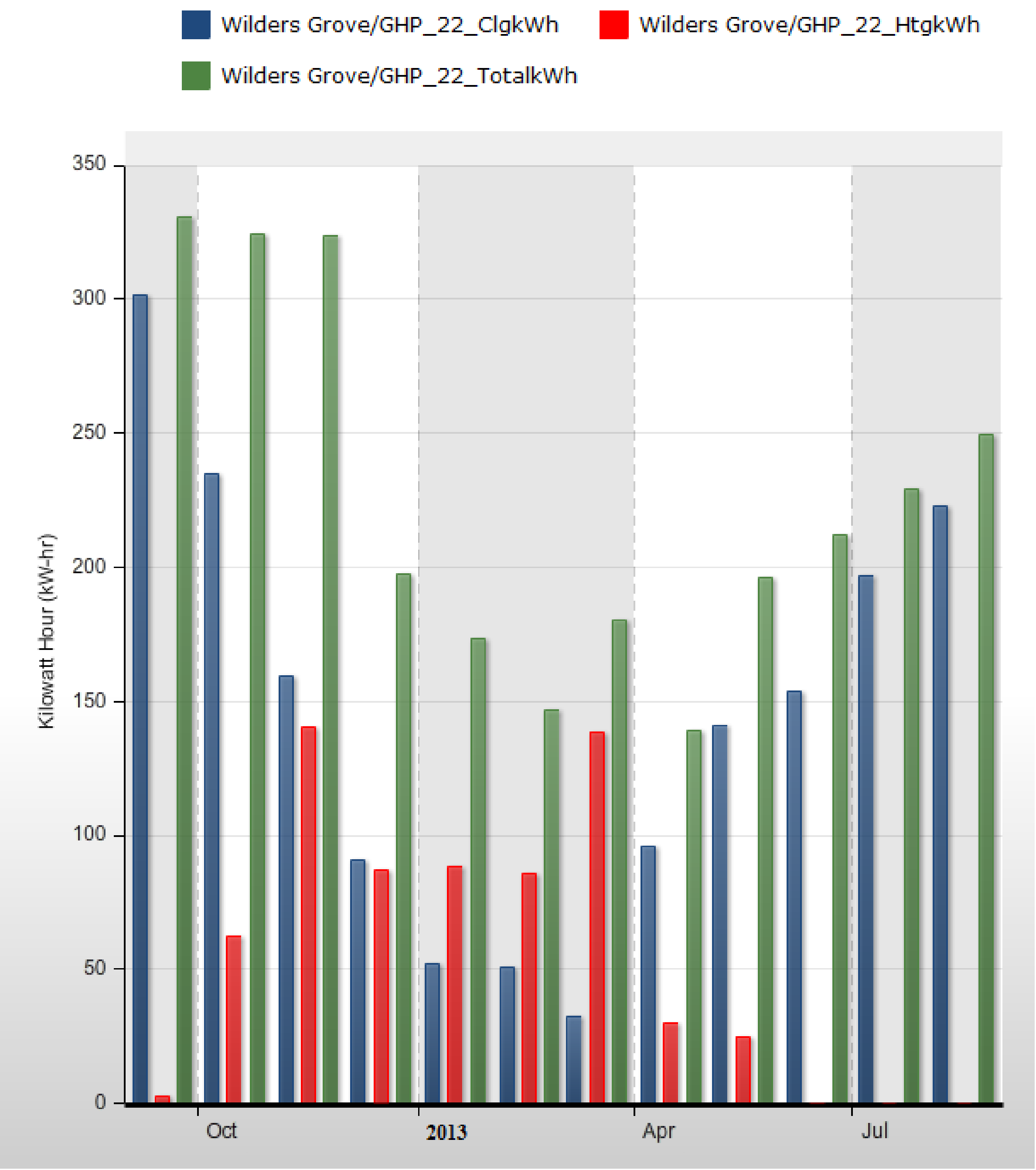
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP20 (F)	Wilders Grove / GHP_20_ClgkWh (kW-hr)	Wilders Grove / GHP_20_HtgkWh (kW-hr)	Events
Sep 2012	70.75	73.643	278.574	0	
Oct 2012	60.363	73.111	208.993	0	
Nov 2012	46.686	72.129	128.176	0	
Dec 2012	49.184	71.991	120.293	0.931	
Jan 2013	44.667	71.65	94.852	2.407	
Feb 2013	42.867	71.497	125.677	1.885	
Mar 2013	46.195	71.855	119.873	0	
Apr 2013	61.57	73.206	289.699	0	
May 2013	67.548	73.435	329.341	0	
Jun 2013	75.839	74.062	308.239	0	
Jul 2013	78.833	73.987	494.078	0	
Aug 2013	76.345	74.119	432.817	0	


Wilders Grove/GHP_21_ClgkWh
Wilders Grove/GHP_21_HtgkWh
Wilders Grove/GHP_21_TotalkWh
Kilowatt Hour (kW-hr)
70
60
50
40
30
20
10
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_21_ClgkWh (kW-hr)	Wilders Grove/GHP_21_HtgkWh (kW-hr)	Wilders Grove/GHP_21_TotalkWh (kW-hr)
Sep 2012	39.906	0	61.573
Oct 2012	37.557	2.153	61.22
Nov 2012	20.189	12.774	53.854
Dec 2012	10.79	12.248	43.399
Jan 2013	6.218	30.235	61.217
Feb 2013	3.802	44.751	65.034
Mar 2013	3.704	41.448	64.086
Apr 2013	5.95	12.611	39.87
May 2013	14.981	5.716	43.157
Jun 2013	16.947	0	43.735
Jul 2013	37.528	0	60.584
Aug 2013	41.306	0	61.493


Wilders Grove / OATemp (F)
70
60
50
40
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP21 (F)
74
72
70
Wilders Grove / GHP_21_ClgkWh (kW-hr)
40
20
0
Wilders Grove / GHP_21_HtgkWh (kW-hr)
40
20
0
Sep
Nov
2013
Mar
May
Jul

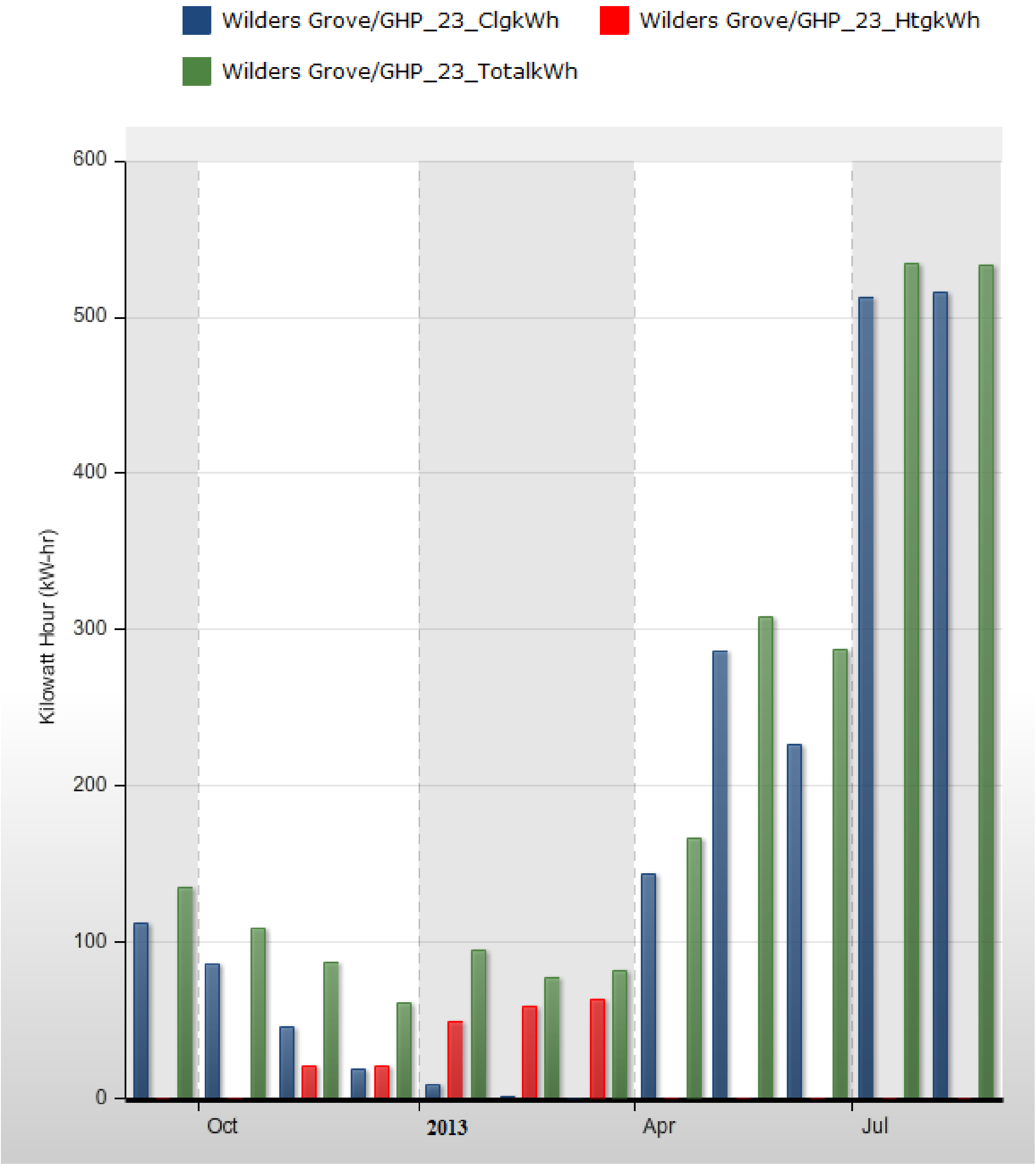
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP21 (F)	Wilders Grove / GHP_21_ClgkWh (kW-hr)	Wilders Grove / GHP_21_HtgkWh (kW-hr)	Events
Jan 2013	44.667	71.59	6.218	30.235	
Feb 2013	42.867	72.11	3.802	44.751	
Mar 2013	46.195	72.722	3.704	41.448	
Apr 2013	61.57	74.771	5.95	12.611	
May 2013	67.548	74.748	14.981	5.716	
Jun 2013	75.839	75.507	16.947	0	
Jul 2013	78.833	75.633	37.528	0	
Aug 2013	76.345	75.806	41.306	0	


Wilders Grove/GHP_22_ClgkWh
Wilders Grove/GHP_22_HtgkWh
Wilders Grove/GHP_22_TotalkWh
Kilowatt Hour (kW-hr)
350
300
250
200
150
100
50
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_22_ClgkWh (kW-hr)	Wilders Grove/GHP_22_HtgkWh (kW-hr)	Wilders Grove/GHP_22_TotalkWh (kW-hr)
Sep 2012	301.792	2.694	330.719
Oct 2012	234.798	62.327	324.344
Nov 2012	159.452	140.112	323.75
Dec 2012	90.885	86.858	197.69
Jan 2013	52.386	88.26	173.537
Feb 2013	50.574	86.036	146.446
Mar 2013	32.34	138.577	180.614
Apr 2013	96.119	30.025	139.058
May 2013	141.06	25.053	196.021
Jun 2013	153.978	0	212.079
Jul 2013	196.981	0	229.28
Aug 2013	222.711	0	249.542


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP22 (F)
74
72
70
Wilders Grove / GHP_22_ClgkWh (kW-hr)
300
200
100
0
Wilders Grove / GHP_22_HtgkWh (kW-hr)
100
0
Sep
Nov
2013
Mar
May
Jul

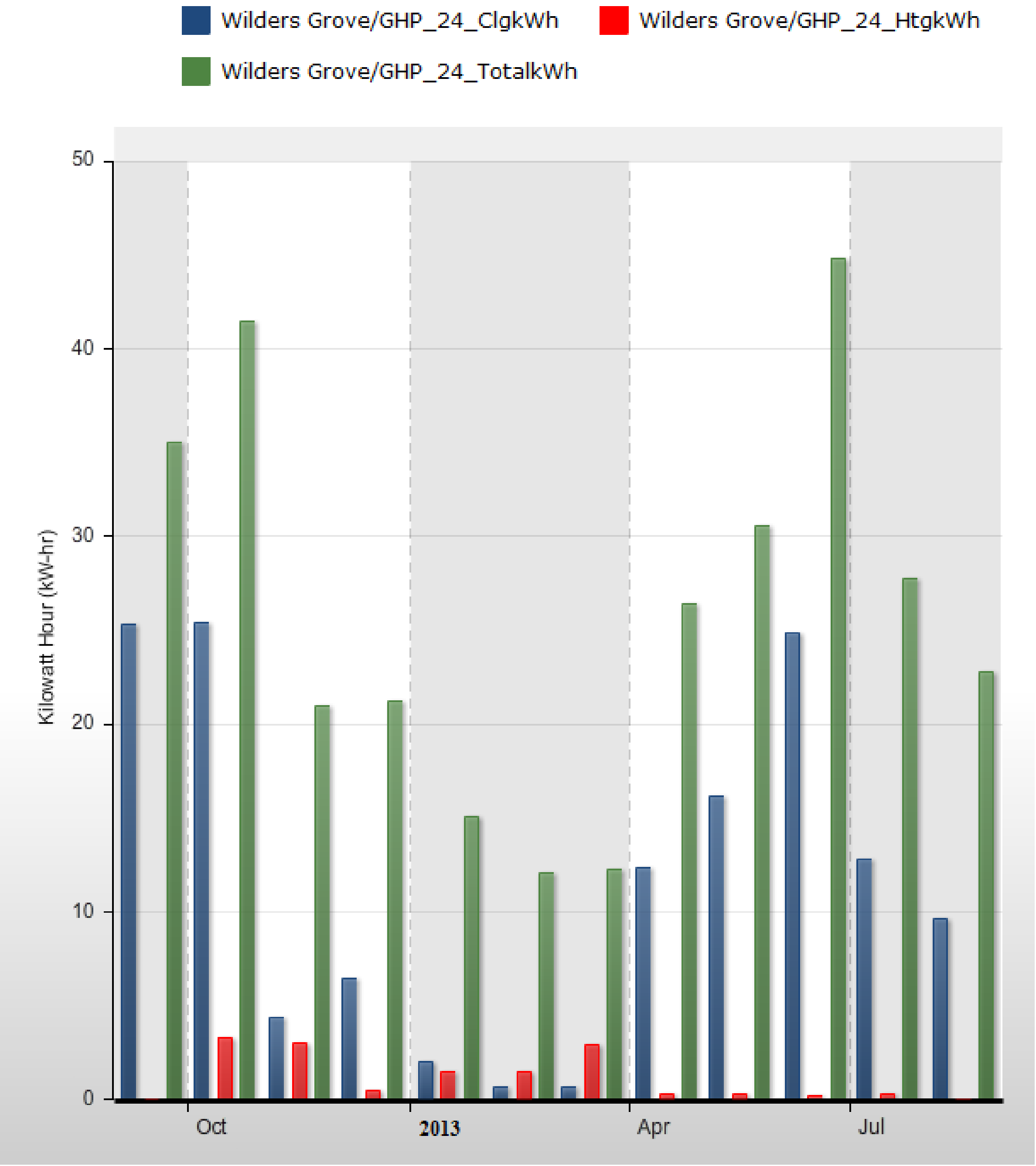
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP22 (F)	Wilders Grove / GHP_22_ClgkWh (kW-hr)	Wilders Grove / GHP_22_HtgkWh (kW-hr)	Events
Sep 2012	70.75	74.433	301.792	2.694	
Oct 2012	60.363	73.324	234.798	62.327	
Nov 2012	46.686	71.873	159.452	140.112	
Dec 2012	49.184	71.675	90.885	86.858	
Jan 2013	44.667	71.044	52.386	88.26	
Feb 2013	42.867	70.729	50.574	86.036	
Mar 2013	46.195	71.059	32.34	138.577	
Apr 2013	61.57	73.495	96.119	30.025	
May 2013	67.548	73.906	141.06	25.053	
Jun 2013	75.839	74.808	153.978	0	
Jul 2013	78.833	74.879	196.981	0	
Aug 2013	76.345	75.117	222.711	0	


Wilders Grove/GHP_23_ClgkWh
Wilders Grove/GHP_23_HtgkWh
Wilders Grove/GHP_23_TotalkWh
Kilowatt Hour (kW-hr)
600
500
400
300
200
100
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_23_ClgkWh (kW-hr)	Wilders Grove/GHP_23_HtgkWh (kW-hr)	Wilders Grove/GHP_23_TotalkWh (kW-hr)
Sep 2012	112.19	0	135.12
Oct 2012	86.145	0	108.539
Nov 2012	45.818	20.775	87.675
Dec 2012	19.185	20.717	61.623
Jan 2013	8.789	49.087	94.668
Feb 2013	1.218	58.91	76.938
Mar 2013	0.145	63.518	81.983
Apr 2013	143.924	0	166.347
May 2013	285.819	0	308.172
Jun 2013	226.503	0	287.505
Jul 2013	512.133	0	533.972
Aug 2013	515.519	0	533.439


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP23 (F)
74
72
70
Wilders Grove / GHP_23_ClgkWh (kW-hr)
400
200
0
Wilders Grove / GHP_23_HtgkWh (kW-hr)
50
0
Sep
Nov
2013
Mar
May
Jul

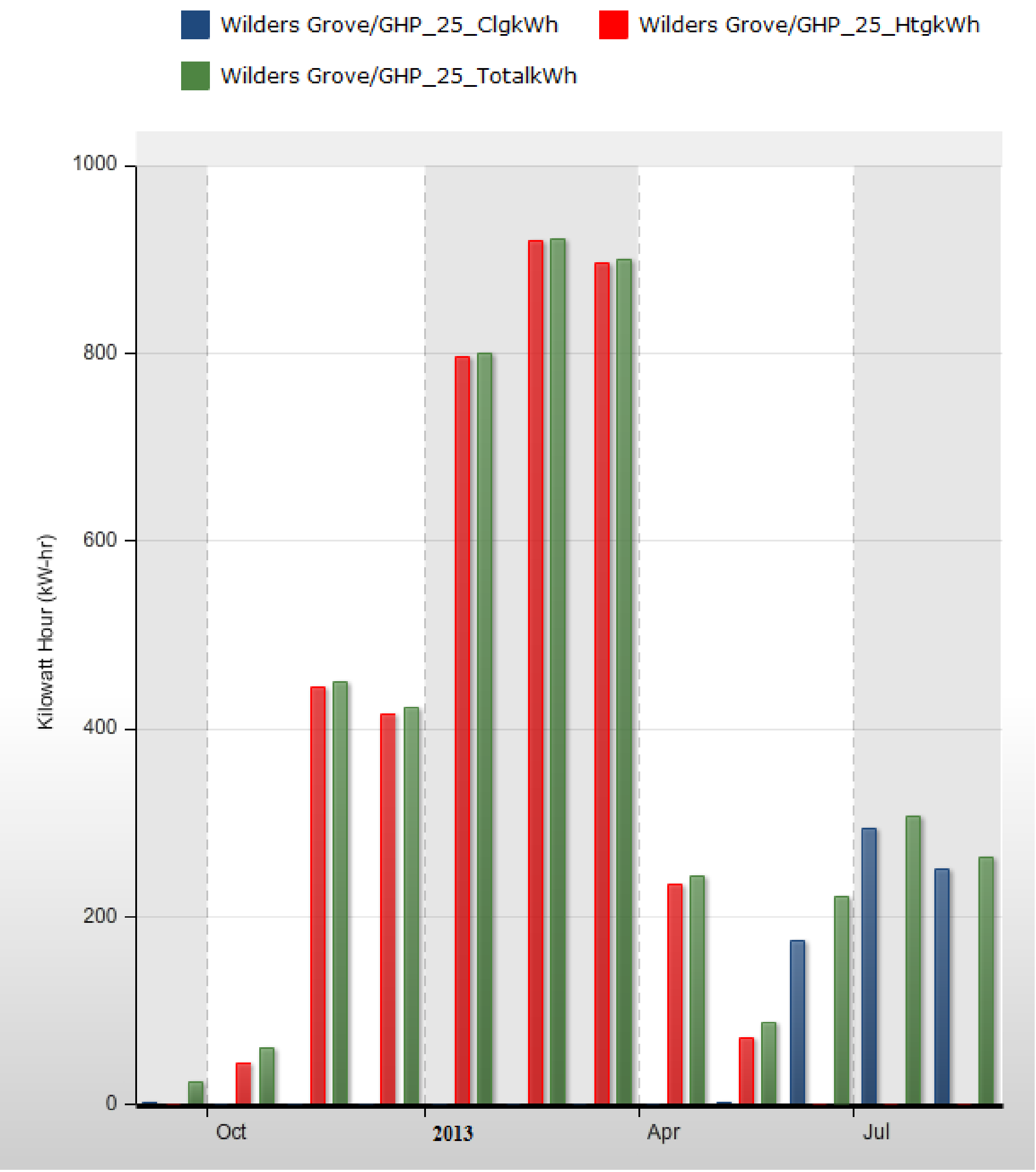
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP23 (F)	Wilders Grove / GHP_23_ClgkWh (kW-hr)	Wilders Grove / GHP_23_HtgkWh (kW-hr)	Events
Sep 2012	70.75	73.737	112.19	0	
Oct 2012	60.363	72.579	86.145	0	
Nov 2012	46.686	71.584	45.818	20.775	
Dec 2012	49.184	71.646	19.185	20.717	
Jan 2013	44.667	71.14	8.789	49.087	
Feb 2013	42.867	70.884	1.218	58.91	
Mar 2013	46.195	71.091	0.145	63.518	
Apr 2013	61.57	72.954	143.924	0	
May 2013	67.548	73.405	285.819	0	
Jun 2013	75.839	73.936	226.503	0	
Jul 2013	78.833	73.955	512.133	0	
Aug 2013	76.345	74.197	515.519	0	


Wilders Grove/GHP_24_ClgkWh
Wilders Grove/GHP_24_HtgkWh
Wilders Grove/GHP_24_TotalkWh
Kilowatt Hour (kW-hr)
50
40
30
20
10
0
Oct
2013
Apr
Jul

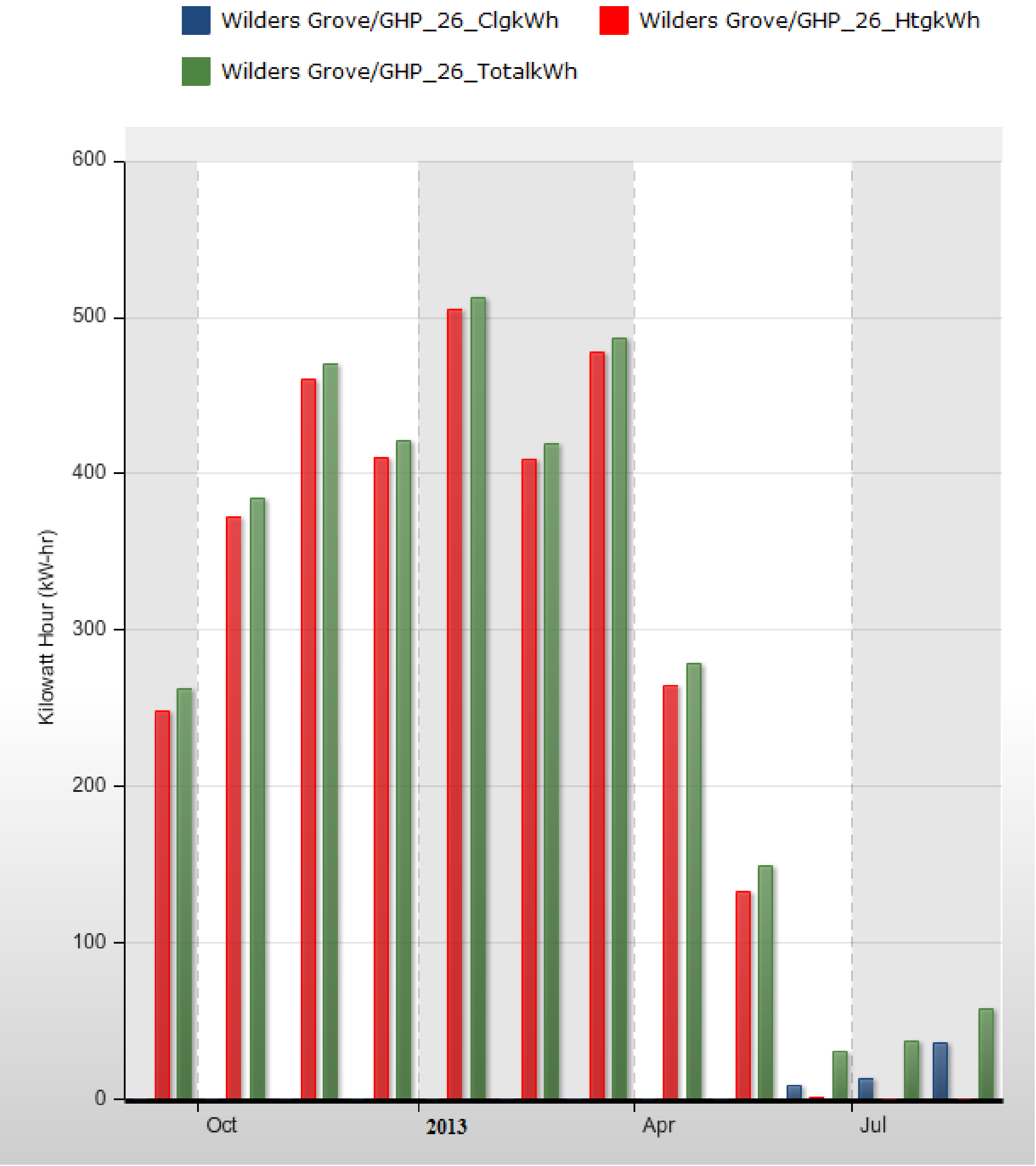
Timestamp	Wilders Grove/GHP_24_ClgkWh (kW-hr)	Wilders Grove/GHP_24_HtgkWh (kW-hr)	Wilders Grove/GHP_24_TotalkWh (kW-hr)
Sep 2012	25.298	0	34.981
Oct 2012	25.438	3.306	41.436
Nov 2012	4.358	3.006	20.934
Dec 2012	6.481	0.485	21.266
Jan 2013	2.035	1.426	15.05
Feb 2013	0.615	1.484	12.059
Mar 2013	0.636	2.878	12.285
Apr 2013	12.358	0.264	26.385
May 2013	16.158	0.304	30.596
Jun 2013	24.894	0.156	44.819
Jul 2013	12.827	0.258	27.741
Aug 2013	9.592	0	22.81


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP24 (F)
74
72
70
Wilders Grove / GHP_24_ClgkWh (kW-hr)
20
10
0
Wilders Grove / GHP_24_HtgkWh (kW-hr)
2
0
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP24 (F)	Wilders Grove / GHP_24_ClgkWh (kW-hr)	Wilders Grove / GHP_24_HtgkWh (kW-hr)	Events
Sep 2012	**70.75**	**73.254**	**25.298**	**0**	
Oct 2012	**60.363**	**72.012**	**25.438**	**3.306**	
Nov 2012	**46.686**	**71.569**	**4.358**	**3.006**	
Dec 2012	**49.184**	**71.499**	**6.481**	**0.485**	
Jan 2013	**44.667**	**71.125**	**2.035**	**1.426**	
Feb 2013	**42.867**	**70.977**	**0.615**	**1.484**	
Mar 2013	**46.195**	**71.22**	**0.636**	**2.878**	
Apr 2013	**61.57**	**72.672**	**12.358**	**0.264**	
May 2013	**67.548**	**73.006**	**16.158**	**0.304**	
Jun 2013	**75.839**	**72.844**	**24.894**	**0.156**	
Jul 2013	**78.833**	**73.549**	**12.827**	**0.258**	
Aug 2013	**76.345**	**74.028**	**9.592**	**0**	


Wilders Grove/GHP_25_ClgkWh
Wilders Grove/GHP_25_HtgkWh
Wilders Grove/GHP_25_TotalkWh
Kilowatt Hour (kW-hr)
1000
800
600
400
200
0
Oct
2013
Apr
Jul

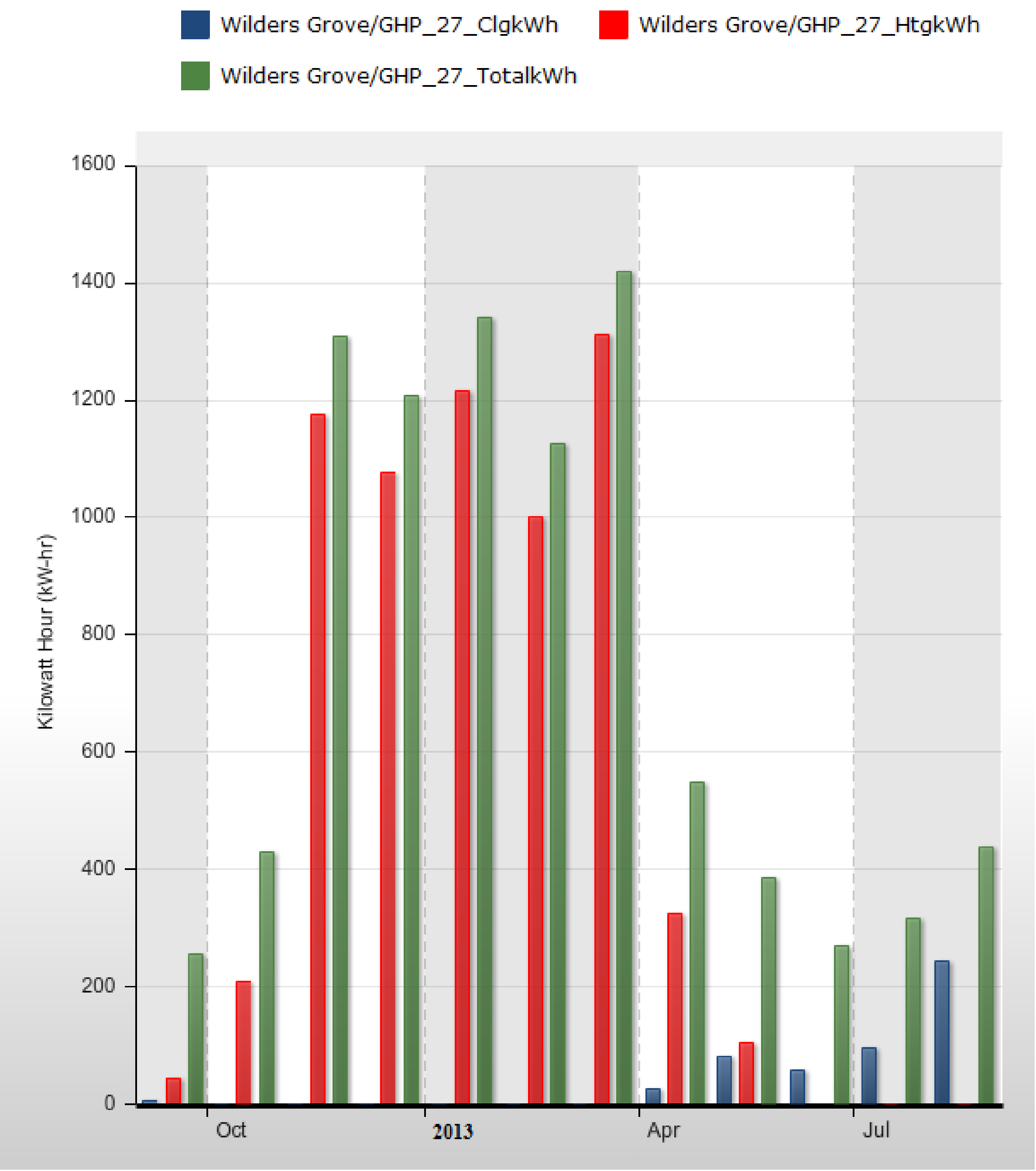
Timestamp	Wilders Grove/GHP_25_ClgkWh (kW-hr)	Wilders Grove/GHP_25_HtgkWh (kW-hr)	Wilders Grove/GHP_25_TotalkWh (kW-hr)
Sep 2012	1.215	0	23.727
Oct 2012	0	44.454	60.748
Nov 2012	0	444.029	450.306
Dec 2012	0	414.678	422.39
Jan 2013	0	795.778	799.328
Feb 2013	0	920.048	922.286
Mar 2013	0	895.918	899.347
Apr 2013	0	233.319	243.972
May 2013	2.764	70.852	87.189
Jun 2013	173.533	0	221.942
Jul 2013	293.287	0	306.576
Aug 2013	250.423	0	262.951


Wilders Grove/GHP_26_ClgkWh
Wilders Grove/GHP_26_HtgkWh
Wilders Grove/GHP_26_TotalkWh
Kilowatt Hour (kW-hr)
600
500
400
300
200
100
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_26_ClgkWh (kW-hr)	Wilders Grove/GHP_26_HtgkWh (kW-hr)	Wilders Grove/GHP_26_TotalkWh (kW-hr)
Sep 2012	0	248.461	261.903
Oct 2012	0	371.933	384.048
Nov 2012	0	460.33	469.694
Dec 2012	0	410.767	421.354
Jan 2013	0	504.443	512.611
Feb 2013	0	409.715	419.314
Mar 2013	0	477.668	486.949
Apr 2013	0	263.999	278.237
May 2013	0	132.403	149.192
Jun 2013	8.759	0.834	30.995
Jul 2013	13.591	0	37.228
Aug 2013	35.967	0	57.886


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP26 (F)
74
72
70
Wilders Grove / GHP_26_ClgkWh (kW-hr)
20
0
Wilders Grove / GHP_26_HtgkWh (kW-hr)
400
200
0
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP26 (F)	Wilders Grove / GHP_26_ClgkWh (kW-hr)	Wilders Grove / GHP_26_HtgkWh (kW-hr)	Events
Sep 2012	70.75	73.701	0	248.461	
Oct 2012	60.363	73.628	0	371.933	
Nov 2012	46.686	72.372	0	460.33	
Dec 2012	49.184	72.3	0	410.767	
Jan 2013	44.667	72.114	0	504.443	
Feb 2013	42.867	71.914	0	409.715	
Mar 2013	46.195	72.246	0	477.668	
Apr 2013	61.57	74.524	0	263.999	
May 2013	67.548	74.846	0	132.403	
Jun 2013	75.839	73.504	8.759	0.834	
Jul 2013	78.833	73.425	13.591	0	


Wilders Grove/GHP_27_ClgkWh
Wilders Grove/GHP_27_HtgkWh
Wilders Grove/GHP_27_TotalkWh
Kilowatt Hour (kW-hr)
1600
1400
1200
1000
800
600
400
200
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_27_ClgkWh (kW-hr)	Wilders Grove/GHP_27_HtgkWh (kW-hr)	Wilders Grove/GHP_27_TotalkWh (kW-hr)
Sep 2012	4.99	44.89	254.812
Oct 2012	0	210.13	429.502
Nov 2012	0	1175.68	1307.495
Dec 2012	0	1077.91	1207.438
Jan 2013	0	1214.95	1341.044
Feb 2013	0	1002.73	1125.544
Mar 2013	0	1311.48	1419.876
Apr 2013	27.57	326.63	548.561
May 2013	80.22	106.09	385.535
Jun 2013	59.15	1.86	269.565
Jul 2013	95.32	0	316.564
Aug 2013	245.4	0	439.009


Wilders Grove / OATemp (F)

Wilders Grove / WG ADM ZONE TEMP GHP27 (F)

Wilders Grove / GHP_27_ClgkWh (kW-hr)

Wilders Grove / GHP_27_HtgkWh (kW-hr)

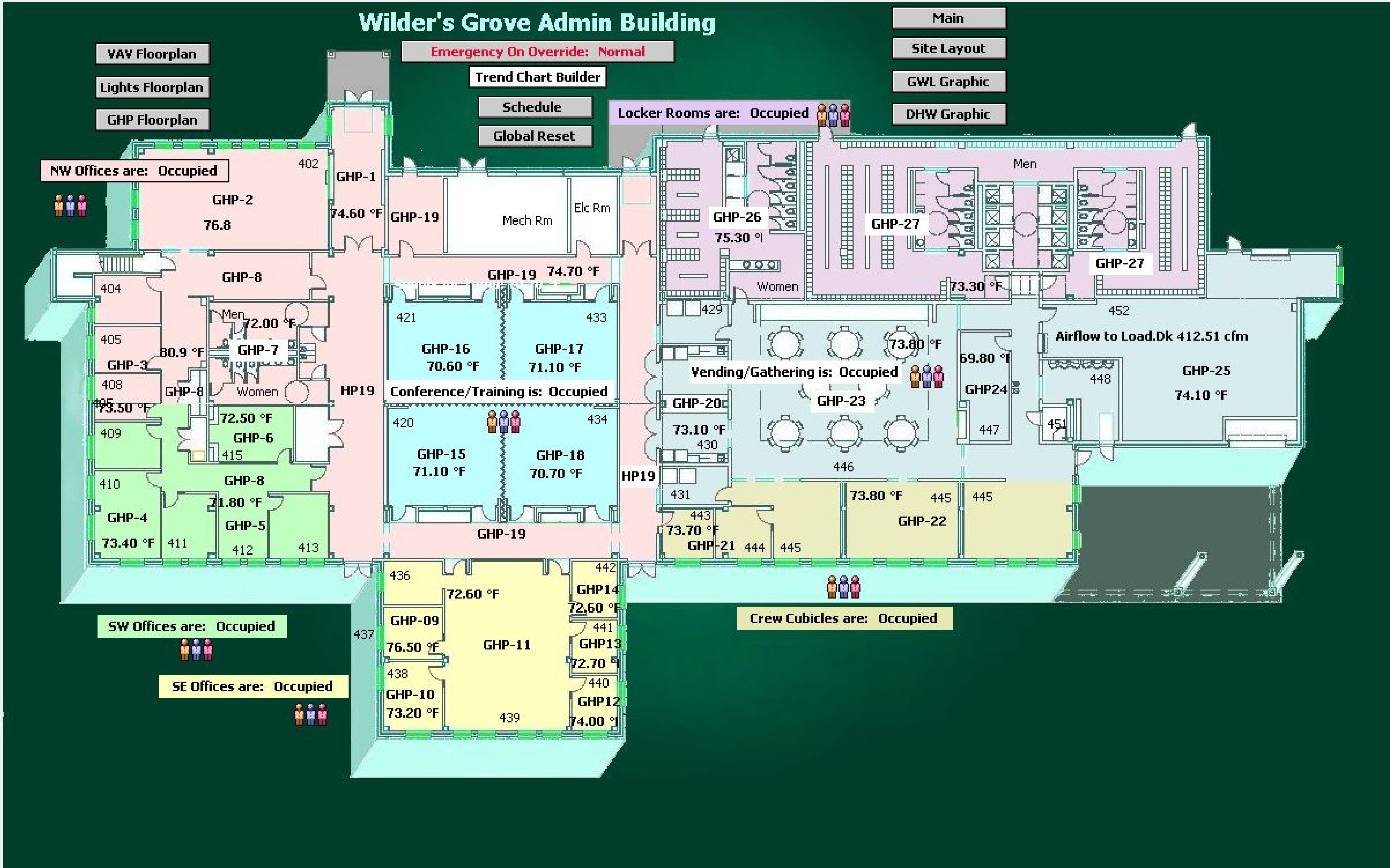
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP27 (F)	Wilders Grove / GHP_27_ClgkWh (kW-hr)	Wilders Grove / GHP_27_HtgkWh (kW-hr)	Events
Sep 2012	70.75	71.775	4.99	44.89	
Oct 2012	60.363	71.219	0	210.13	
Nov 2012	46.686	71.131	0	1175.68	
Dec 2012	49.184	71.367	0	1077.91	
Jan 2013	44.667	70.879	0	1214.95	
Feb 2013	42.867	70.718	0	1002.73	
Mar 2013	46.195	71.134	0	1311.48	
Apr 2013	61.57	72.793	27.57	326.63	
May 2013	67.548	73.163	80.22	106.09	
Jun 2013	75.839	73.572	59.15	1.86	
Jul 2013	78.833	73.839	95.32	0	

JACOBS

CITY OF RALEIGH
NORTH CAROLINA

APPENDIX A2

- MONTHLY ELECTRICAL ENERGY CONSUMPTION
- MONTHLY AVERAGE OUTDOOR & ZONE TEMPERATURES
- GROUND SOURCE HEAT PUMPS GSHP 1-27
- SEPTEMBER 1, 2013 – AUGUST 31, 2014



Wilder's Grove Admin Building

Emergency On Override: Normal

Locker Rooms are: Occupied

NW Offices are: Occupied

Conference/Training is: Occupied

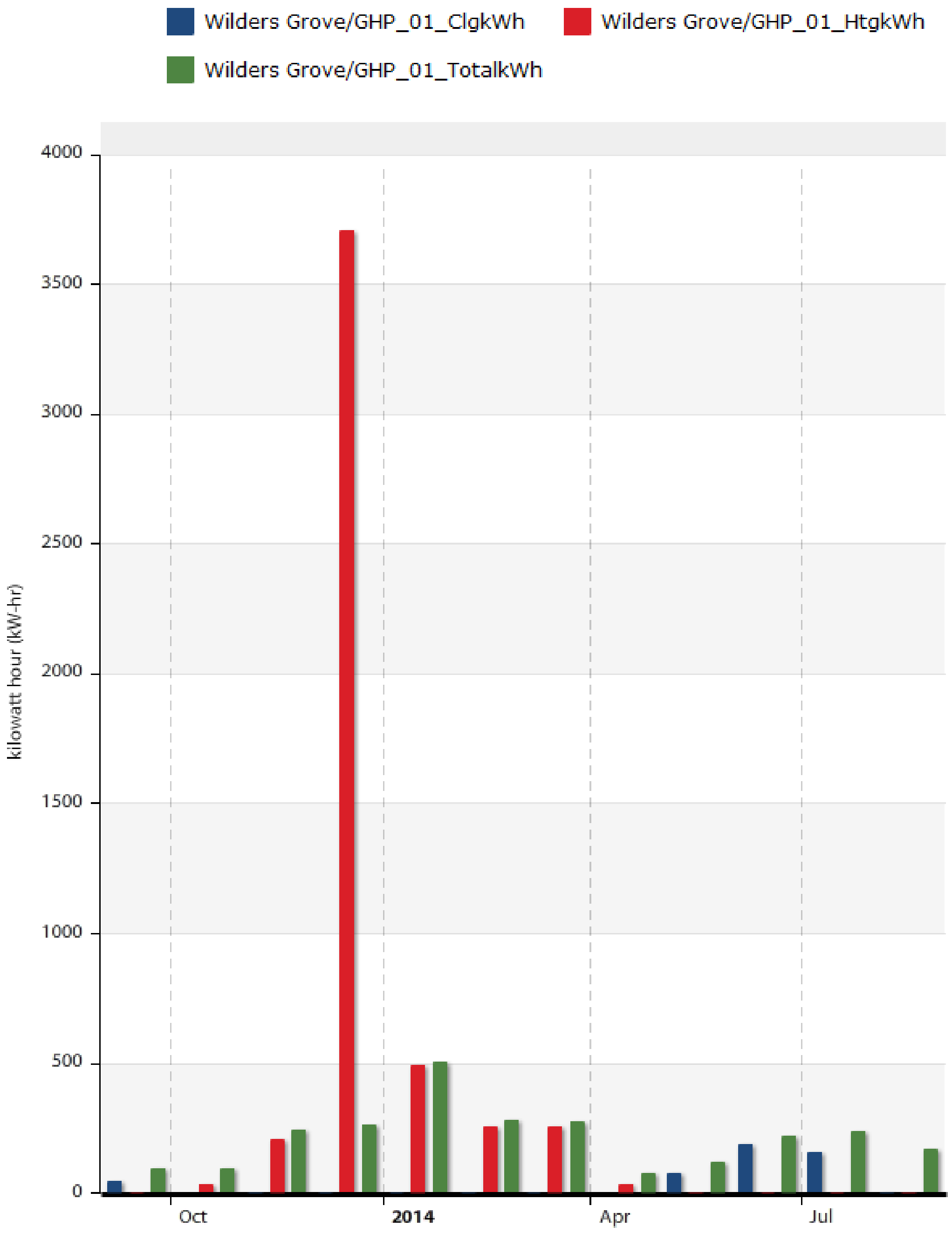
Vending/Gathering is: Occupied

Airflow to Load.Dk 412.51 cfm

SW Offices are: Occupied

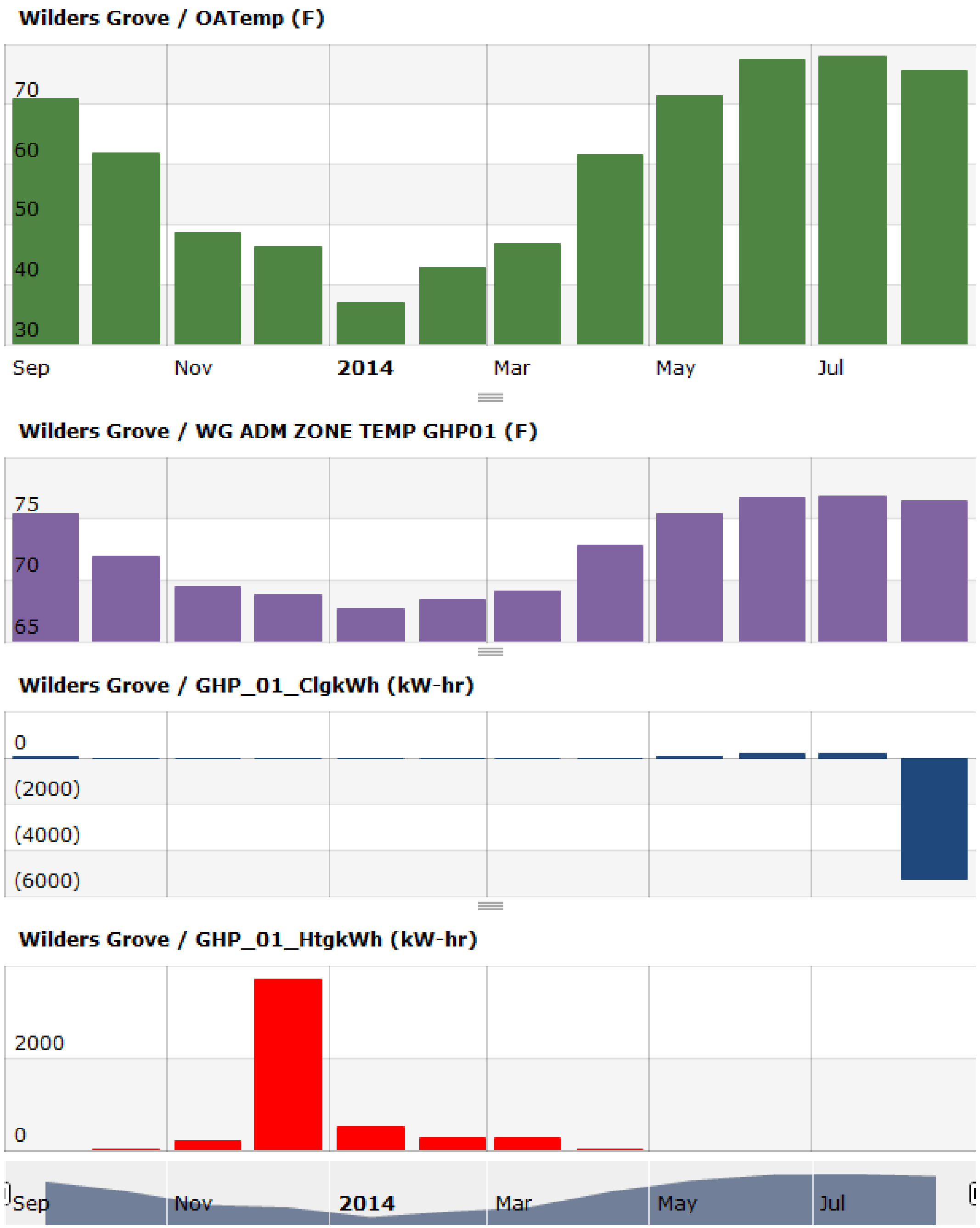
SE Offices are: Occupied

Crew Cubicles are: Occupied

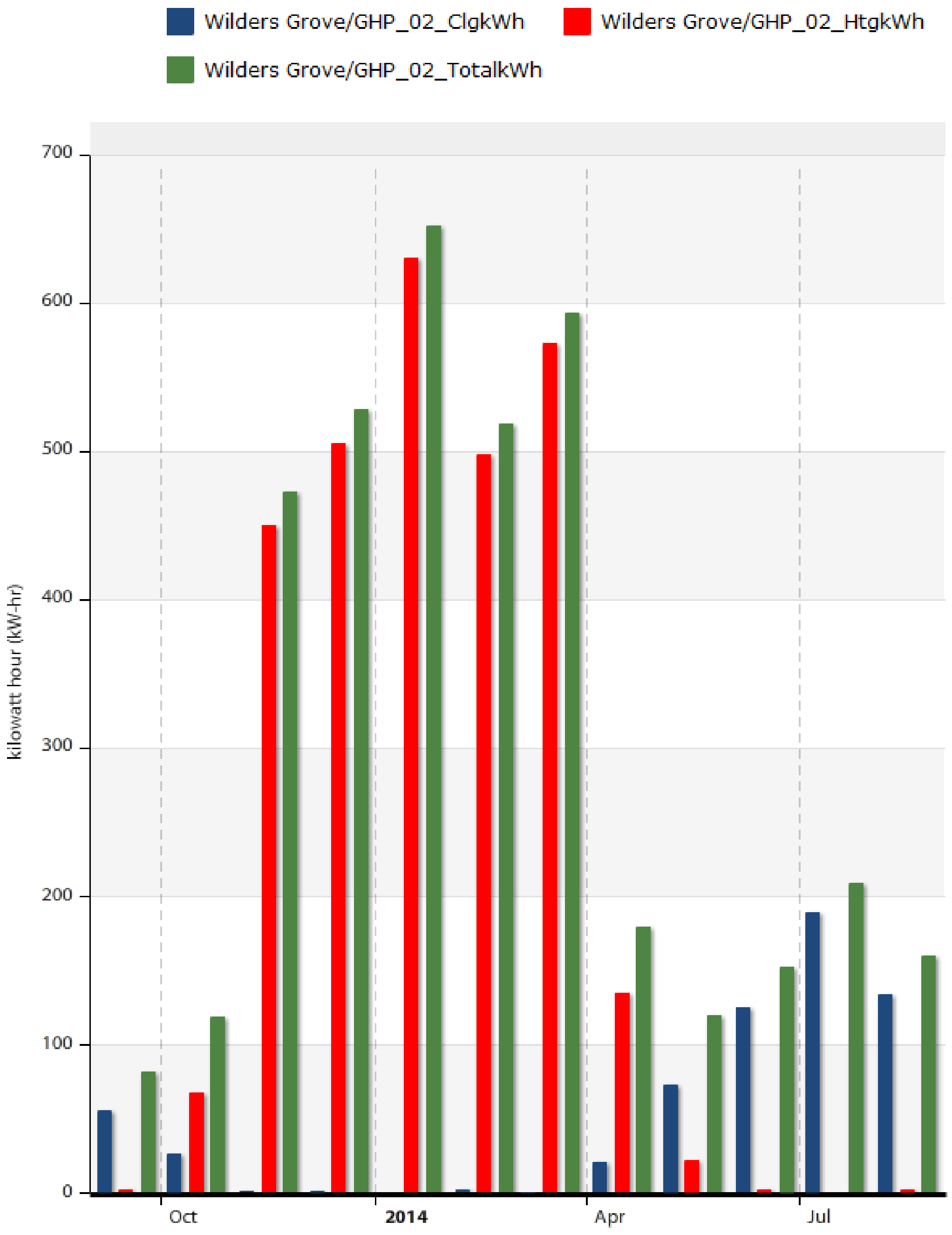


Wilders Grove/GHP_01_ClgkWh
Wilders Grove/GHP_01_HtgkWh
Wilders Grove/GHP_01_TotalkWh
kilowatt hour (kW-hr)
4000
3500
3000
2500
2000
1500
1000
500
0
Oct
2014
Apr
Jul

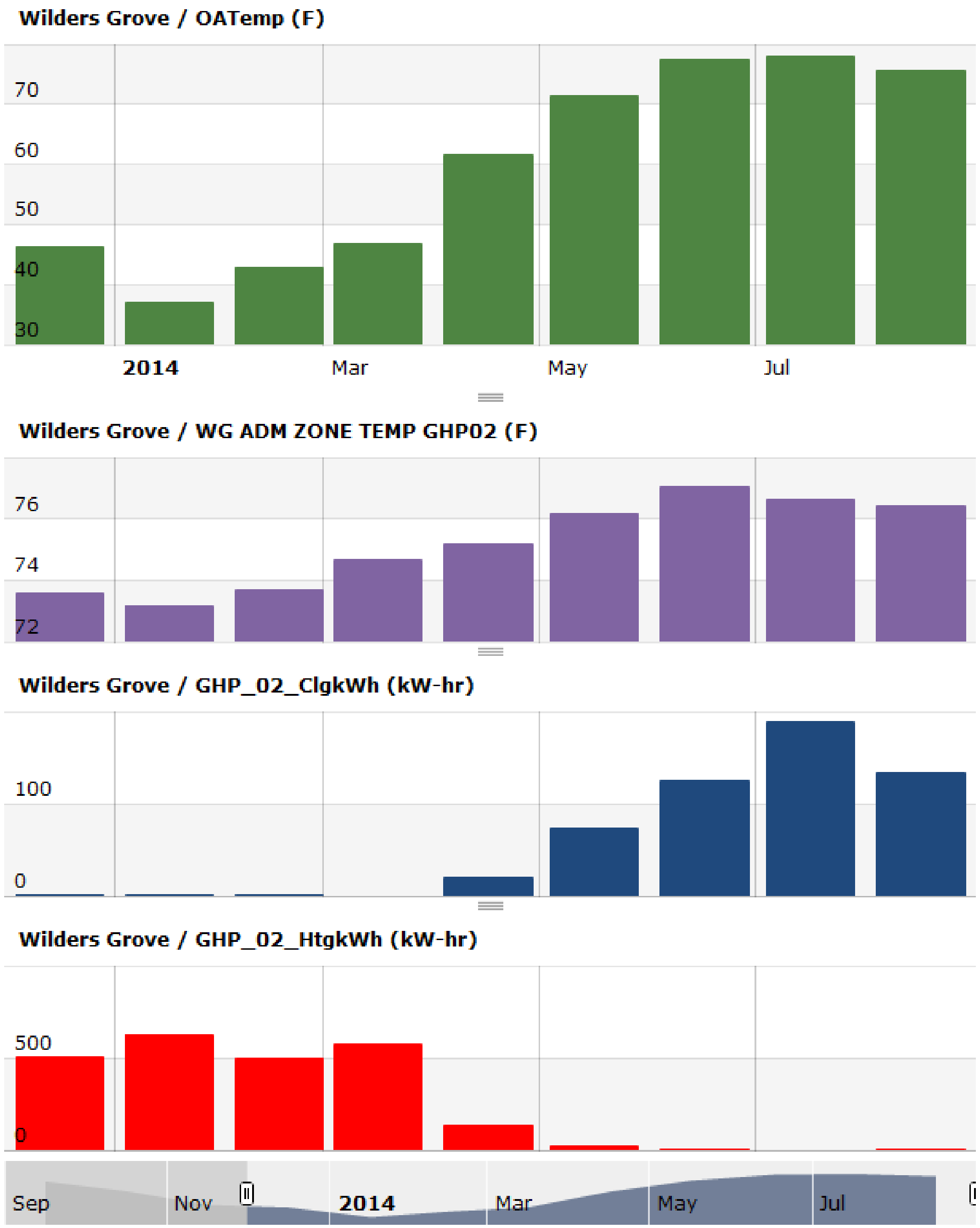
Timestamp	Wilders Grove/GHP_01_ClgkWh (kW-hr)	Wilders Grove/GHP_01_HtgkWh (kW-hr)	Wilders Grove/GHP_01_TotalkWh (kW-hr)
Sep 2013	45.849	0	92.864
Oct 2013	3.845	35.023	97.106
Nov 2013	0	203.123	240.167
Dec 2013	0	3706.809	263.533
Jan 2014	0	489.671	505.634
Feb 2014	0	257.267	277.418
Mar 2014	0	253.435	277.022
Apr 2014	3.218	29.979	74.212
May 2014	75.057	0	115.99
Jun 2014	186.981	0	217.305
Jul 2014	153.214	0	236.773
Aug 2014	-5266.788	0	168.548


Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP01 (F)
75
70
65
Wilders Grove / GHP_01_ClgkWh (kW-hr)
0
(2000)
(4000)
(6000)
Wilders Grove / GHP_01_HtgkWh (kW-hr)
2000
0
Sep
Nov
2014
Mar
May
Jul

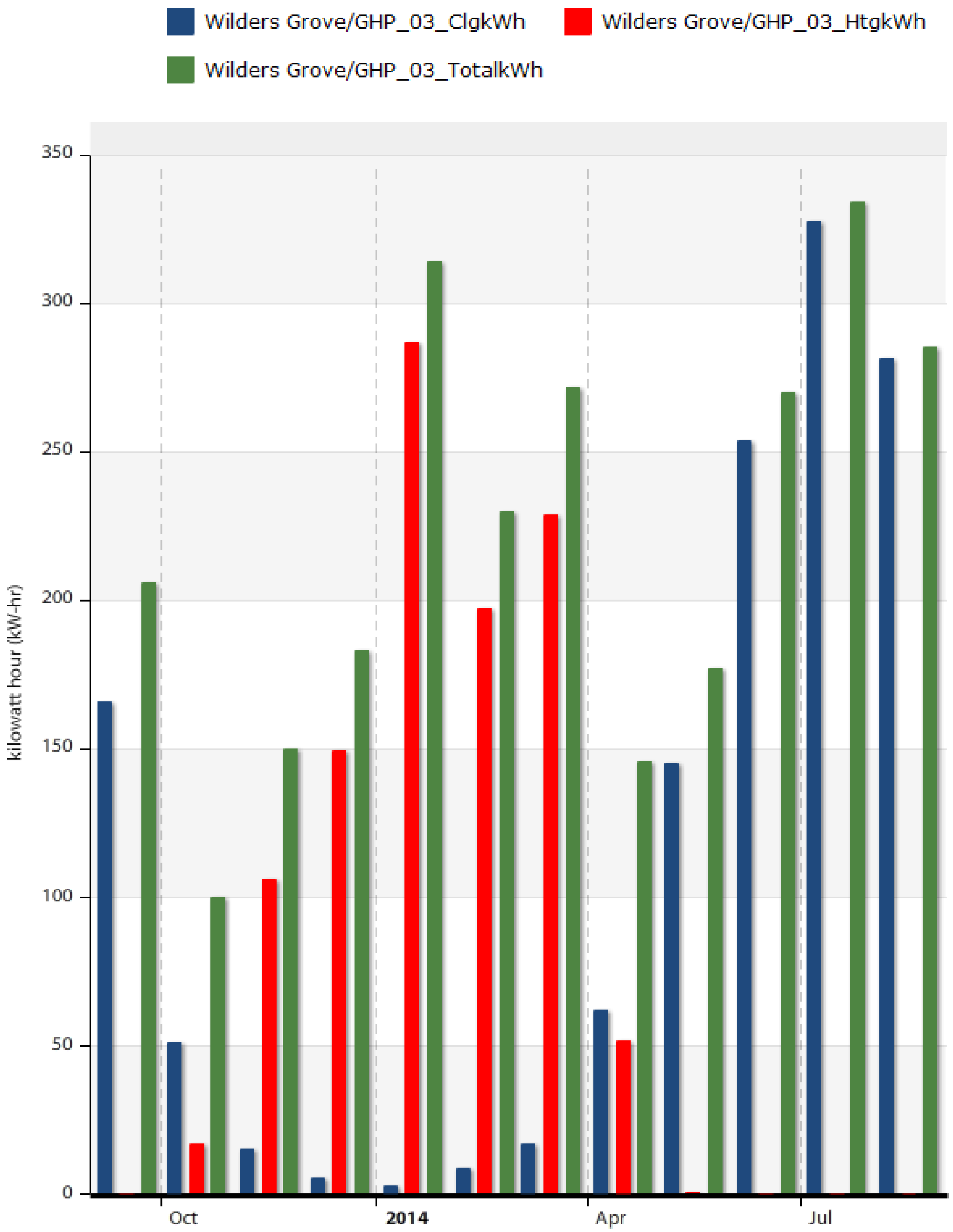
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP01 (F)	Wilders Grove / GHP_01_ClgkWh (kW-hr)	Wilders Grove / GHP_01_HtgkWh (kW-hr)	Events
Sep 2013	70.866	75.375	45.849	0	
Oct 2013	61.964	71.985	3.845	35.023	
Nov 2013	48.77	69.447	0	203.123	
Dec 2013	46.33	68.89	0	3706.809	
Jan 2014	37.04	67.657	0	489.671	
Feb 2014	42.946	68.404	0	257.267	
Mar 2014	46.722	69.153	0	253.435	
Apr 2014	61.693	72.835	3.218	29.979	
May 2014	71.501	75.421	75.057	0	
Jun 2014	77.411	76.757	186.981	0	
Jul 2014	77.992	76.854	153.214	0	
Aug 2014	75.579	76.422	-5266.788	0	


Wilders Grove/GHP_02_ClgkWh
Wilders Grove/GHP_02_HtgkWh
Wilders Grove/GHP_02_TotalkWh
kilowatt hour (kW-hr)
700
600
500
400
300
200
100
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_02_ClgkWh (kW-hr)	Wilders Grove/GHP_02_HtgkWh (kW-hr)	Wilders Grove/GHP_02_TotalkWh (kW-hr)
Sep 2013	55.318	2.487	81.502
Oct 2013	26.006	68.027	118.11
Nov 2013	1.605	450.171	472.163
Dec 2013	1.481	504.752	527.906
Jan 2014	0.62	629.574	651.865
Feb 2014	1.966	497.971	518.585
Mar 2014	0.1	572.585	592.849
Apr 2014	20.806	135.384	179.401
May 2014	72.767	22.147	119.972
Jun 2014	125.519	2.024	151.922
Jul 2014	188.83	0.679	208.669
Aug 2014	134.143	2.052	159.902


Wilders Grove / OATemp (F)
70
60
50
40
30
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP02 (F)
76
74
72
Wilders Grove / GHP_02_ClgkWh (kW-hr)
100
0
Wilders Grove / GHP_02_HtgkWh (kW-hr)
500
0
Sep
Nov
2014
Mar
May
Jul

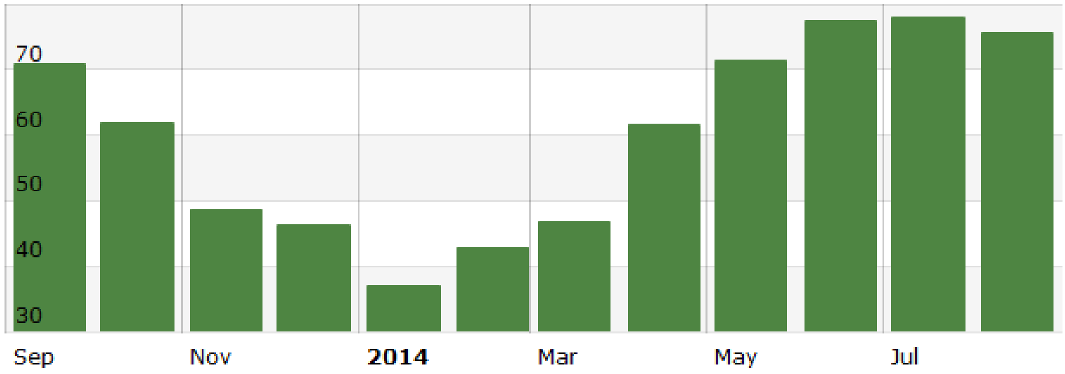
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP02 (F)	Wilders Grove / GHP_02_ClgkWh (kW-hr)	Wilders Grove / GHP_02_HtgkWh (kW-hr)	Events
Dec 2013	46.33	73.581	1.481	504.752	
Jan 2014	37.04	73.182	0.62	629.574	
Feb 2014	42.946	73.663	1.966	497.971	
Mar 2014	46.722	74.661	0.1	572.585	
Apr 2014	61.693	75.176	20.806	135.384	
May 2014	71.501	76.189	72.767	22.147	
Jun 2014	77.411	77.026	125.519	2.024	
Jul 2014	77.992	76.649	188.83	0.679	
Aug 2014	75.579	76.436	134.143	2.052	



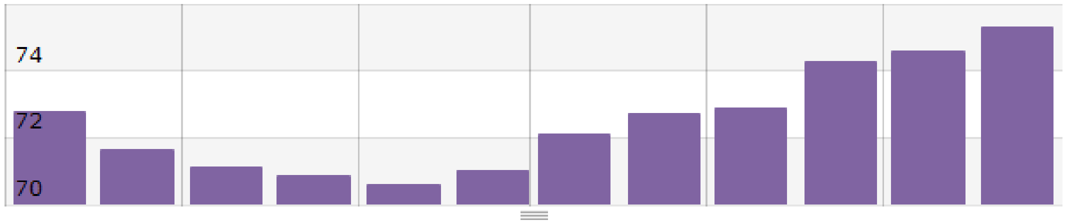
Wilders Grove/GHP_03_ClgkWh
Wilders Grove/GHP_03_HtgkWh
Wilders Grove/GHP_03_TotalkWh
kilowatt hour (kW-hr)
350
300
250
200
150
100
50
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_03_ClgkWh (kW-hr)	Wilders Grove/GHP_03_HtgkWh (kW-hr)	Wilders Grove/GHP_03_TotalkWh (kW-hr)
Sep 2013	165.883	0.072	205.909
Oct 2013	50.969	16.946	100.11
Nov 2013	15.355	106.229	150.042
Dec 2013	5.455	149.374	183.253
Jan 2014	2.627	286.598	314.155
Feb 2014	8.742	197.2	230.053
Mar 2014	16.744	228.724	271.846
Apr 2014	62.12	51.795	145.852
May 2014	145.154	0.859	177.215
Jun 2014	253.433	0.002	269.783
Jul 2014	327.712	0	334.32
Aug 2014	281.34	0	285.009

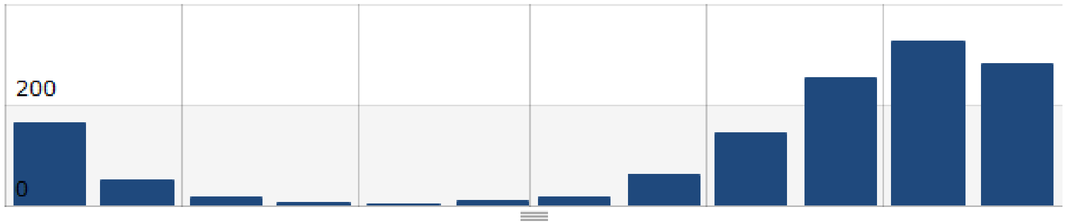
Wilders Grove / OATemp (F)



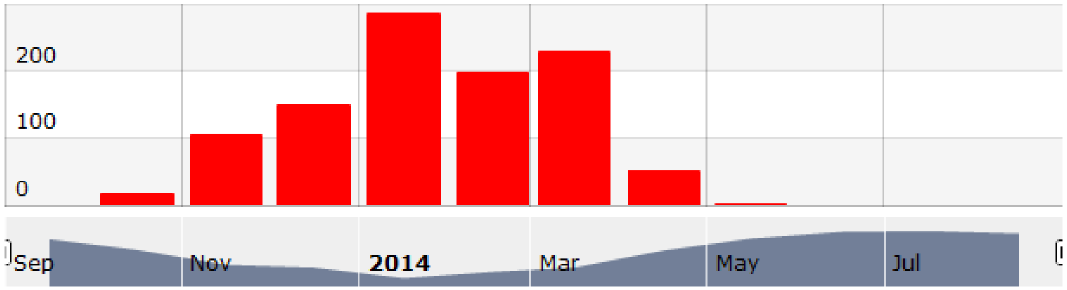
Wilders Grove / WG ADM ZONE TEMP GHP03 (F)



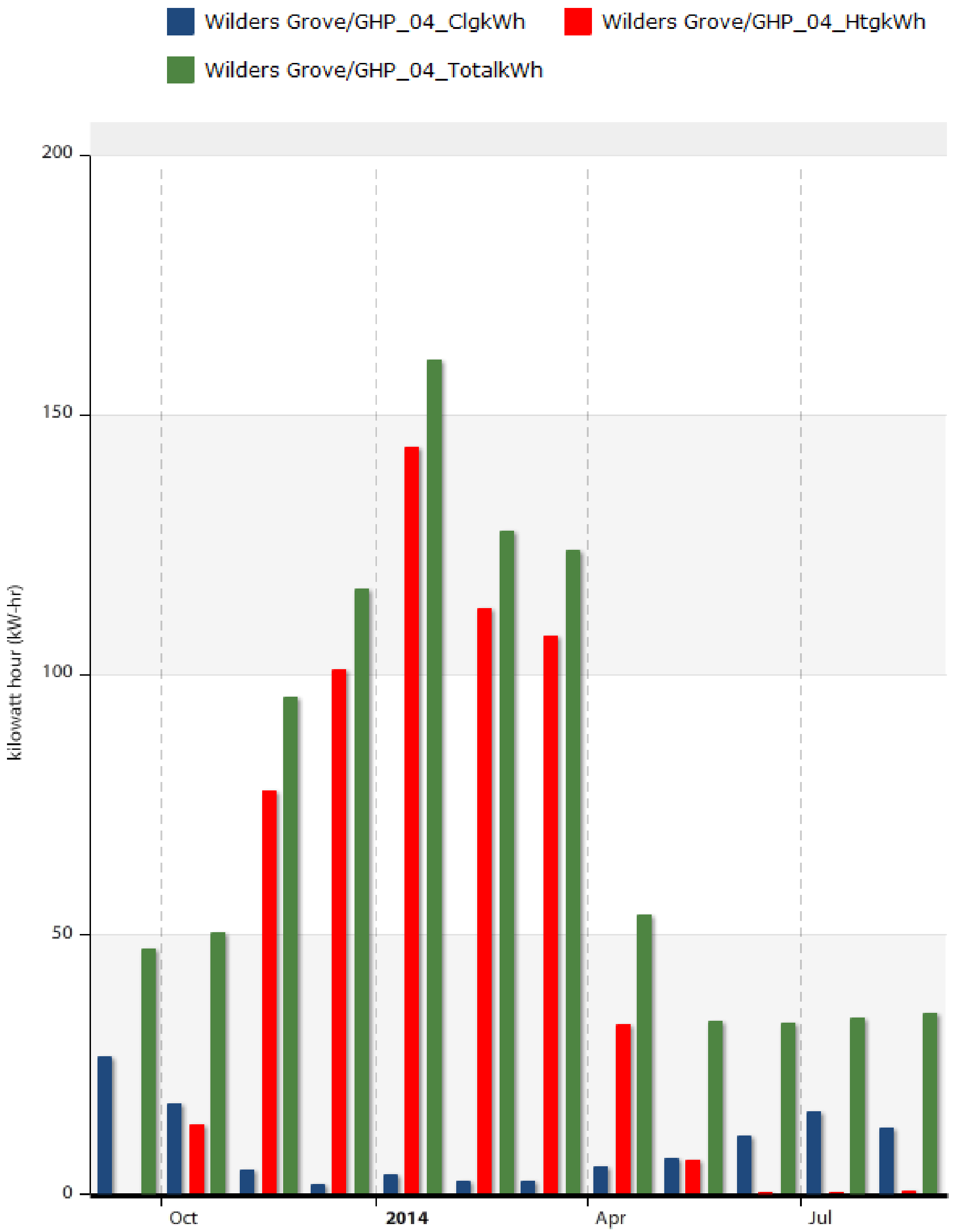
Wilders Grove / GHP_03_ClgkWh (kW-hr)



Wilders Grove / GHP_03_HtgkWh (kW-hr)

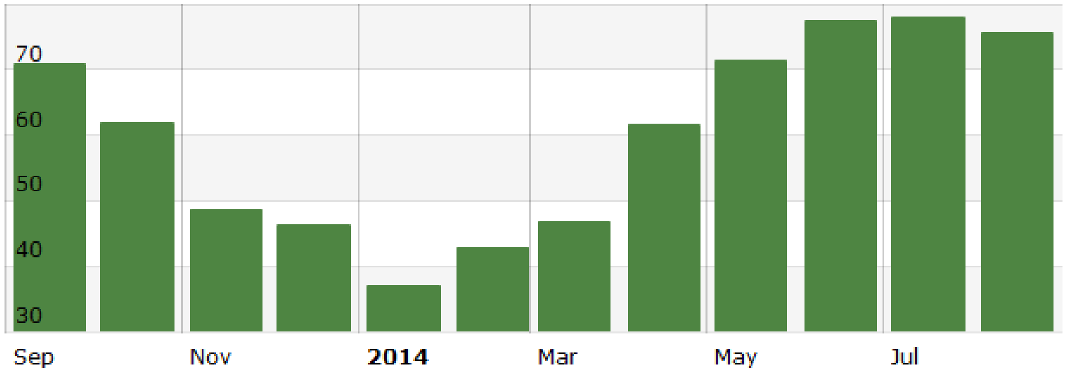


Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP03 (F)	Wilders Grove / GHP_03_ClgkWh (kW-hr)	Wilders Grove / GHP_03_HtgkWh (kW-hr)	Events
Sep 2013	70.866	72.77	165.883	0.072	
Oct 2013	61.964	71.653	50.969	16.946	
Nov 2013	48.77	71.107	15.355	106.229	
Dec 2013	46.33	70.861	5.455	149.374	
Jan 2014	37.04	70.626	2.627	286.598	
Feb 2014	42.946	71.03	8.742	197.2	
Mar 2014	46.722	72.089	16.744	228.724	
Apr 2014	61.693	72.732	62.12	51.795	
May 2014	71.501	72.904	145.154	0.859	
Jun 2014	77.411	74.276	253.433	0.002	
Jul 2014	77.992	74.563	327.712	0	
Aug 2014	75.579	75.317	281.34	0	

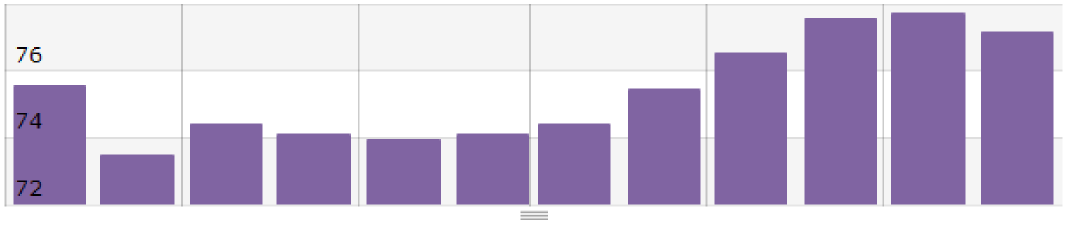

Wilders Grove/GHP_04_ClgkWh
Wilders Grove/GHP_04_HtgkWh
Wilders Grove/GHP_04_TotalkWh
kilowatt hour (kW-hr)
200
150
100
50
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_04_ClgkWh (kW-hr)	Wilders Grove/GHP_04_HtgkWh (kW-hr)	Wilders Grove/GHP_04_TotalkWh (kW-hr)
Sep 2013	26.508	0.092	47.294
Oct 2013	17.332	13.49	50.167
Nov 2013	4.757	77.721	95.489
Dec 2013	1.788	100.81	116.474
Jan 2014	3.67	143.875	160.59
Feb 2014	2.539	112.836	127.644
Mar 2014	2.64	107.548	123.871
Apr 2014	5.374	32.645	53.612
May 2014	6.89	6.703	33.12
Jun 2014	11.161	0.42	32.813
Jul 2014	15.959	0.262	33.945
Aug 2014	12.699	0.551	34.752

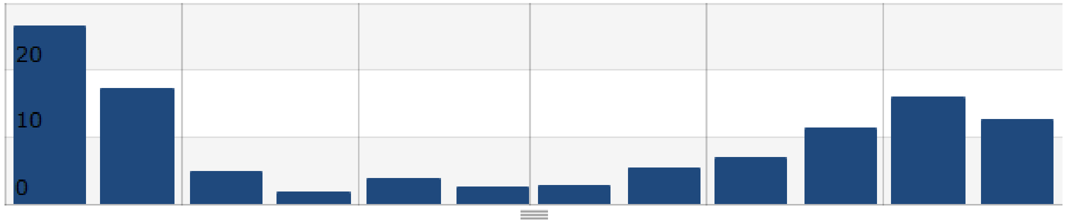
Wilders Grove / OATemp (F)



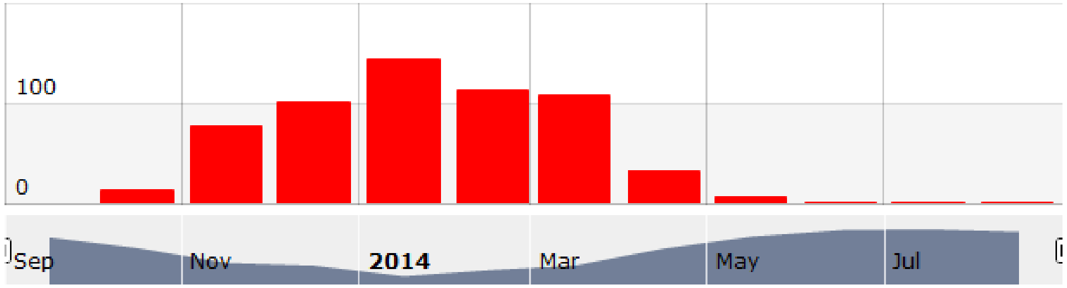
Wilders Grove / WG ADM ZONE TEMP GHP04 (F)



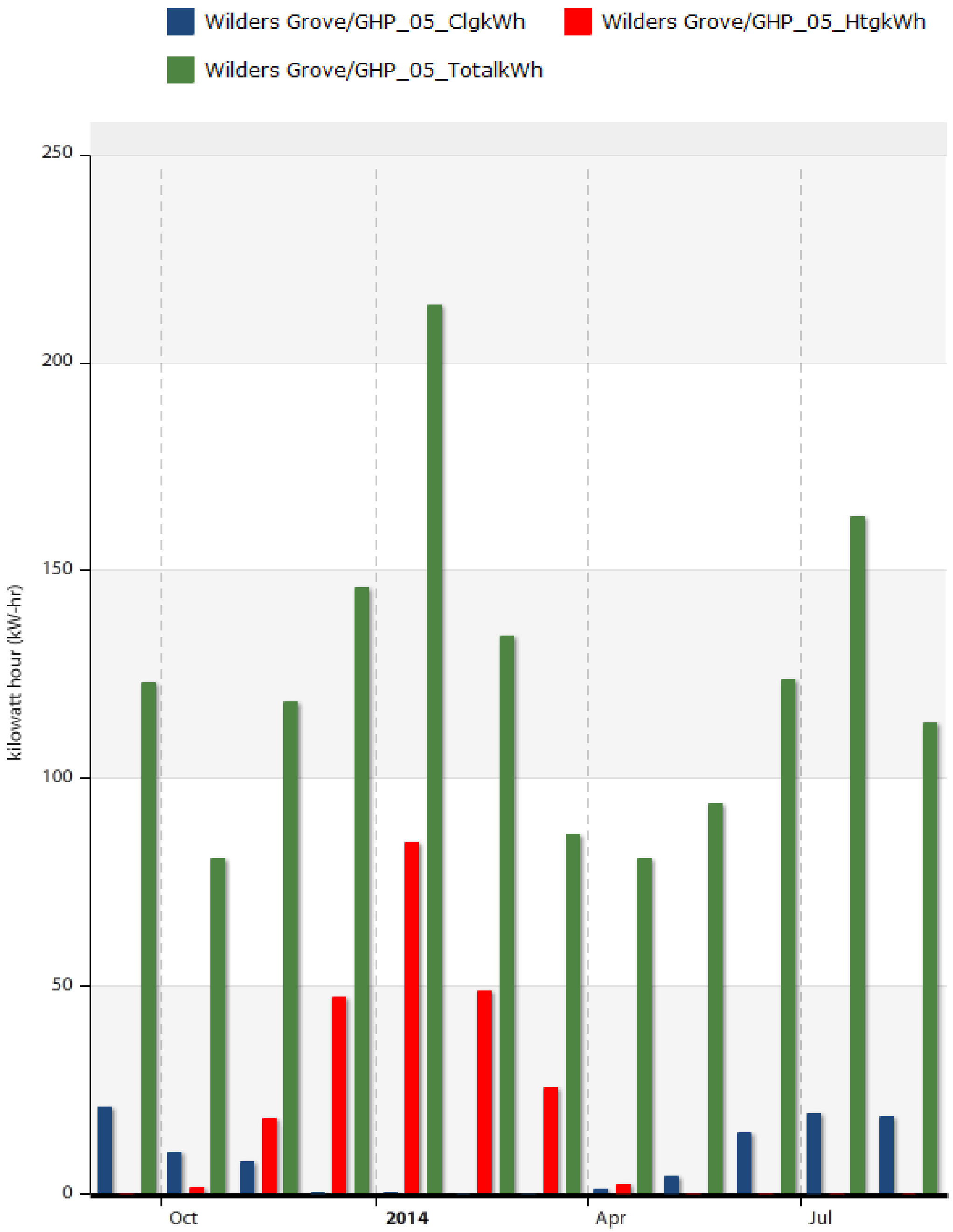
Wilders Grove / GHP_04_ClgkWh (kW-hr)



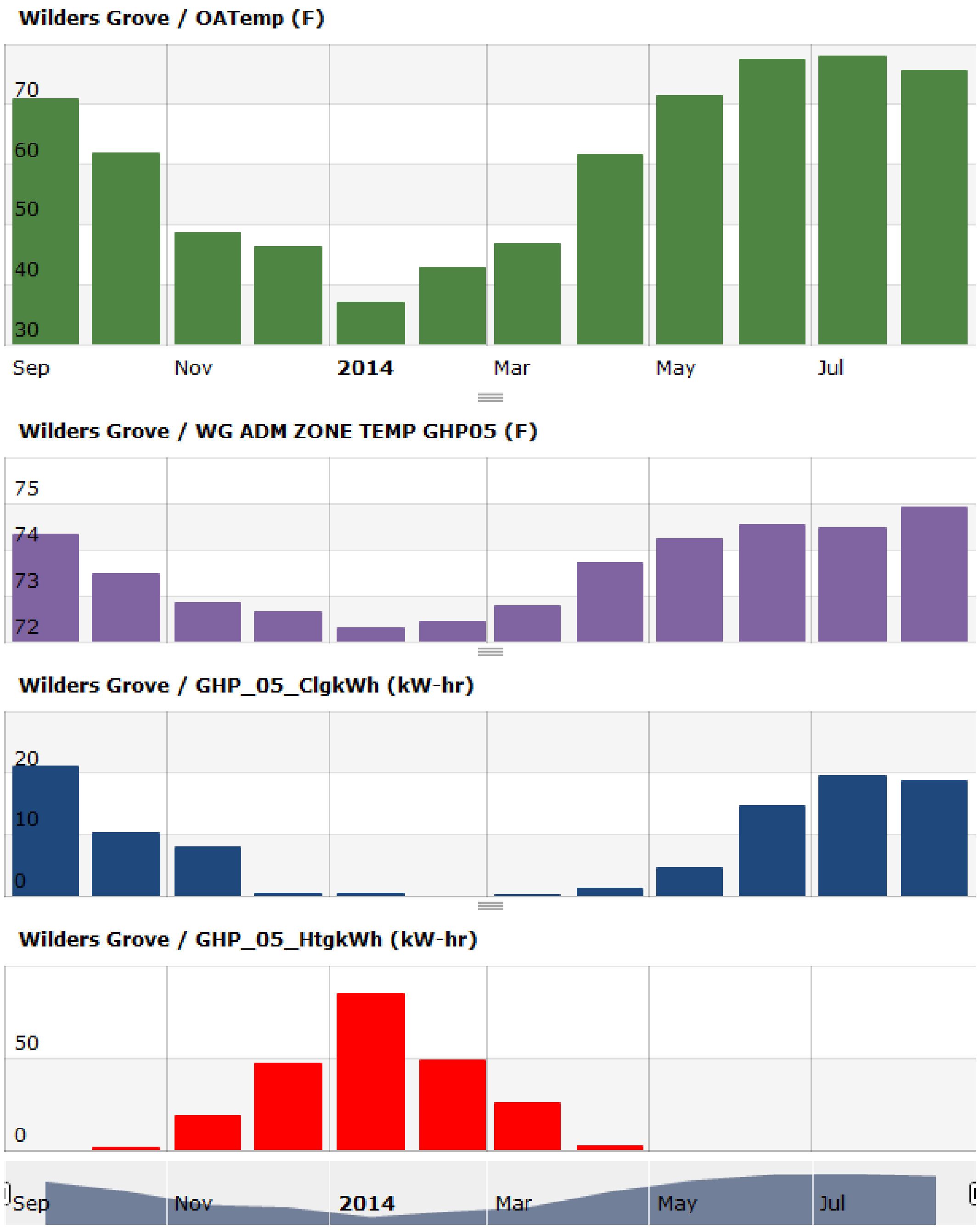
Wilders Grove / GHP_04_HtgkWh (kW-hr)



Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP04 (F)	Wilders Grove / GHP_04_ClgkWh (kW-hr)	Wilders Grove / GHP_04_HtgkWh (kW-hr)	Events
Sep 2013	70.866	75.576	26.508	0.092	
Oct 2013	61.964	73.47	17.332	13.49	
Nov 2013	48.77	74.425	4.757	77.721	
Dec 2013	46.33	74.122	1.788	100.81	
Jan 2014	37.04	73.927	3.67	143.875	
Feb 2014	42.946	74.102	2.539	112.836	
Mar 2014	46.722	74.422	2.64	107.548	
Apr 2014	61.693	75.431	5.374	32.645	
May 2014	71.501	76.549	6.89	6.703	
Jun 2014	77.411	77.579	11.161	0.42	
Jul 2014	77.992	77.706	15.959	0.262	
Aug 2014	75.579	77.17	12.699	0.551	


Wilders Grove/GHP_05_ClgkWh
Wilders Grove/GHP_05_HtgkWh
Wilders Grove/GHP_05_TotalkWh
kilowatt hour (kW-hr)
250
200
150
100
50
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_05_ClgkWh (kW-hr)	Wilders Grove/GHP_05_HtgkWh (kW-hr)	Wilders Grove/GHP_05_TotalkWh (kW-hr)
Sep 2013	21.131	0	122.903
Oct 2013	10.322	1.434	80.883
Nov 2013	7.853	18.241	118.191
Dec 2013	0.334	47.188	145.794
Jan 2014	0.309	84.667	213.667
Feb 2014	0	48.918	134.331
Mar 2014	0.043	25.727	86.697
Apr 2014	1.28	2.5	80.549
May 2014	4.44	0	93.977
Jun 2014	14.652	0	123.756
Jul 2014	19.559	0	162.944
Aug 2014	18.818	0	113.397



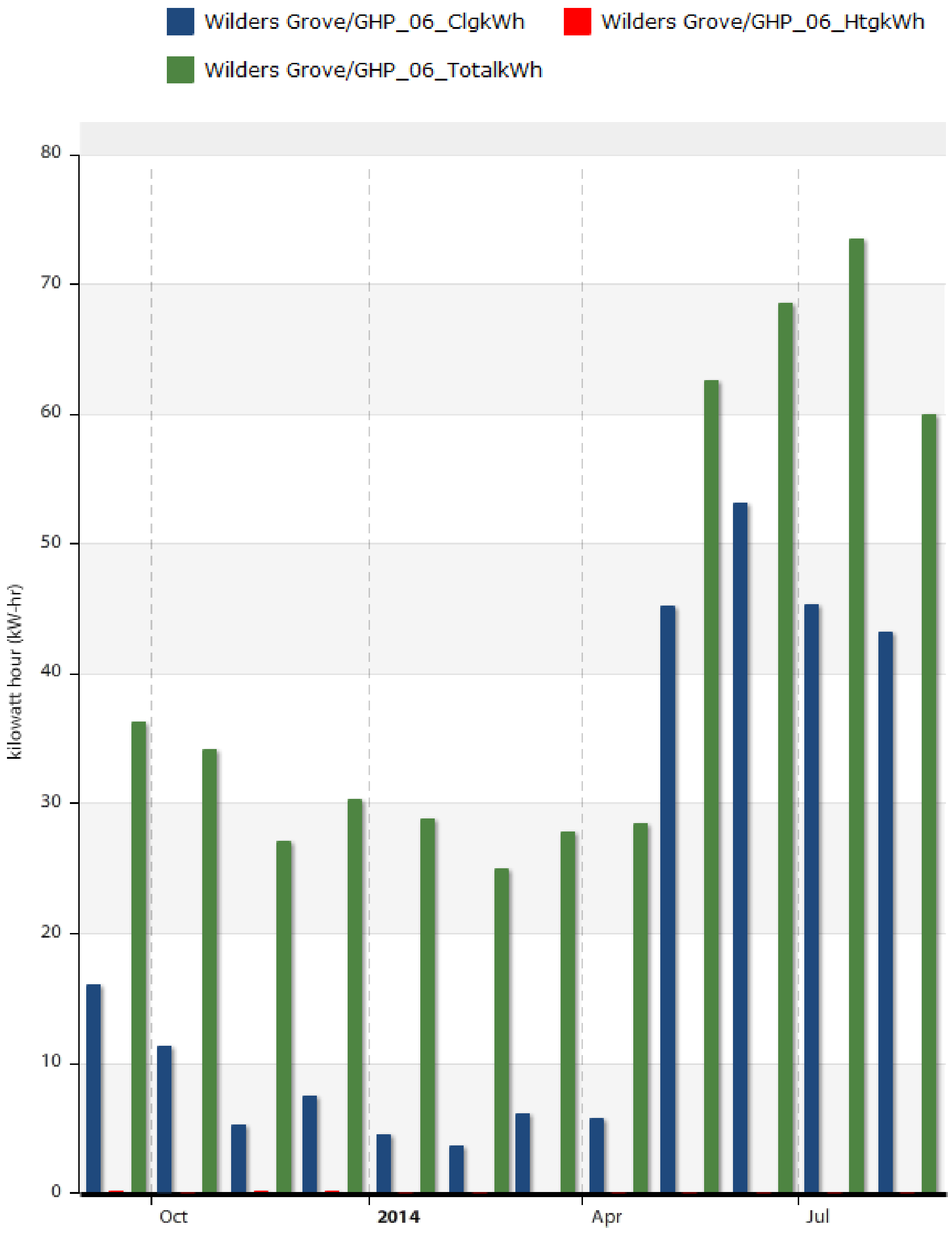
Wilders Grove / OATemp (F)

Wilders Grove / WG ADM ZONE TEMP GHP05 (F)

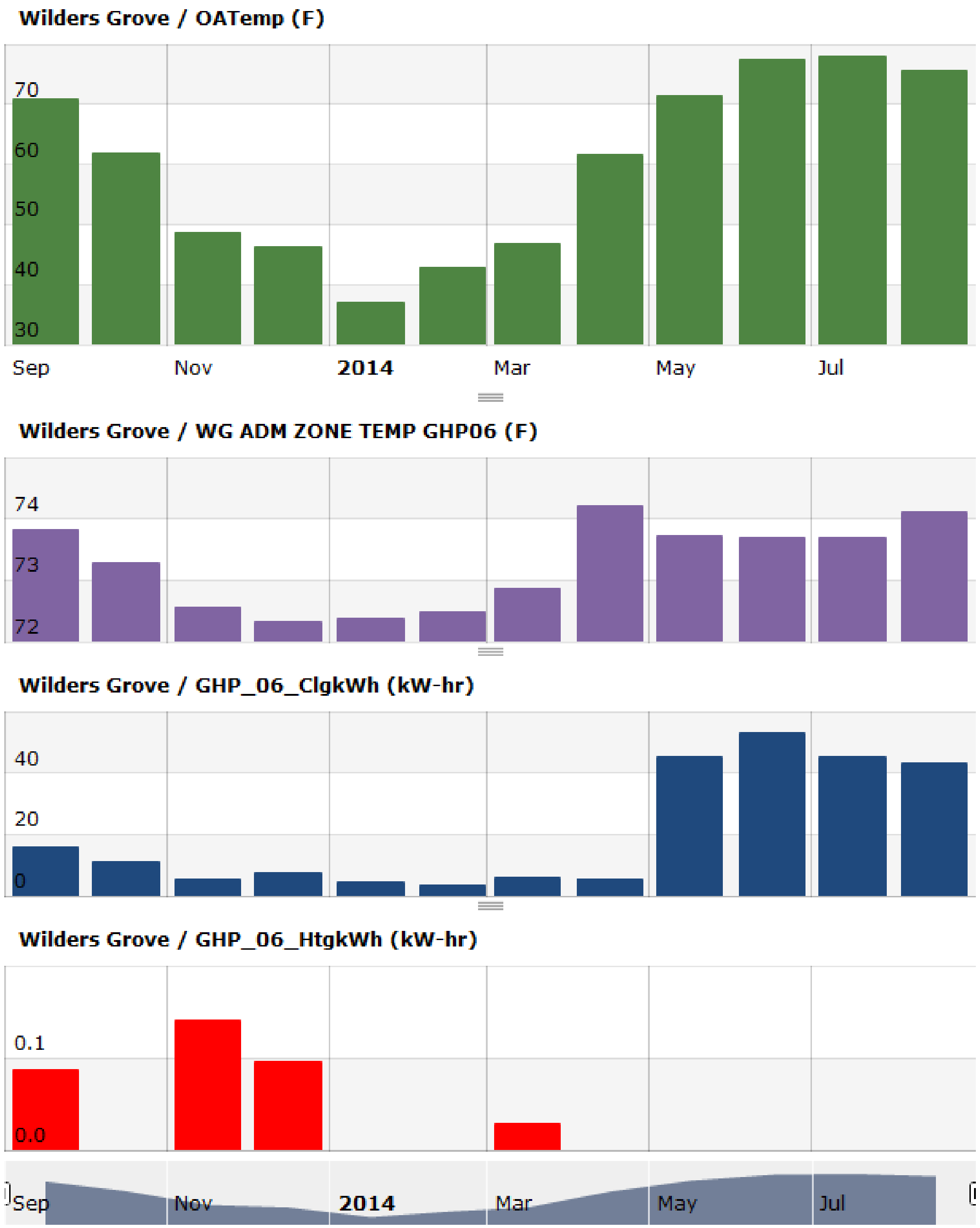
Wilders Grove / GHP_05_ClgkWh (kW-hr)

Wilders Grove / GHP_05_HtgkWh (kW-hr)

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP05 (F)	Wilders Grove / GHP_05_ClgkWh (kW-hr)	Wilders Grove / GHP_05_HtgkWh (kW-hr)	Events
Sep 2013	70.866	74.327	21.131	0	
Oct 2013	61.964	73.464	10.322	1.434	
Nov 2013	48.77	72.845	7.853	18.241	
Dec 2013	46.33	72.648	0.334	47.188	
Jan 2014	37.04	72.315	0.309	84.667	
Feb 2014	42.946	72.444	0	48.918	
Mar 2014	46.722	72.77	0.043	25.727	
Apr 2014	61.693	73.719	1.28	2.5	
May 2014	71.501	74.246	4.44	0	
Jun 2014	77.411	74.525	14.652	0	
Jul 2014	77.992	74.459	19.559	0	
Aug 2014	75.579	74.915	18.818	0	


Wilders Grove/GHP_06_ClgkWh
Wilders Grove/GHP_06_HtgkWh
Wilders Grove/GHP_06_TotalkWh
kilowatt hour (kW-hr)
80
70
60
50
40
30
20
10
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_06_ClgkWh (kW-hr)	Wilders Grove/GHP_06_HtgkWh (kW-hr)	Wilders Grove/GHP_06_TotalkWh (kW-hr)
Sep 2013	15.973	0.087	36.255
Oct 2013	11.35	0	34.15
Nov 2013	5.294	0.14	27.056
Dec 2013	7.443	0.096	30.256
Jan 2014	4.543	0	28.83
Feb 2014	3.662	0	24.916
Mar 2014	6.087	0.028	27.817
Apr 2014	5.736	0	28.453
May 2014	45.207	0	62.581
Jun 2014	53.18	0	68.514
Jul 2014	45.379	0	73.453
Aug 2014	43.239	0	59.951



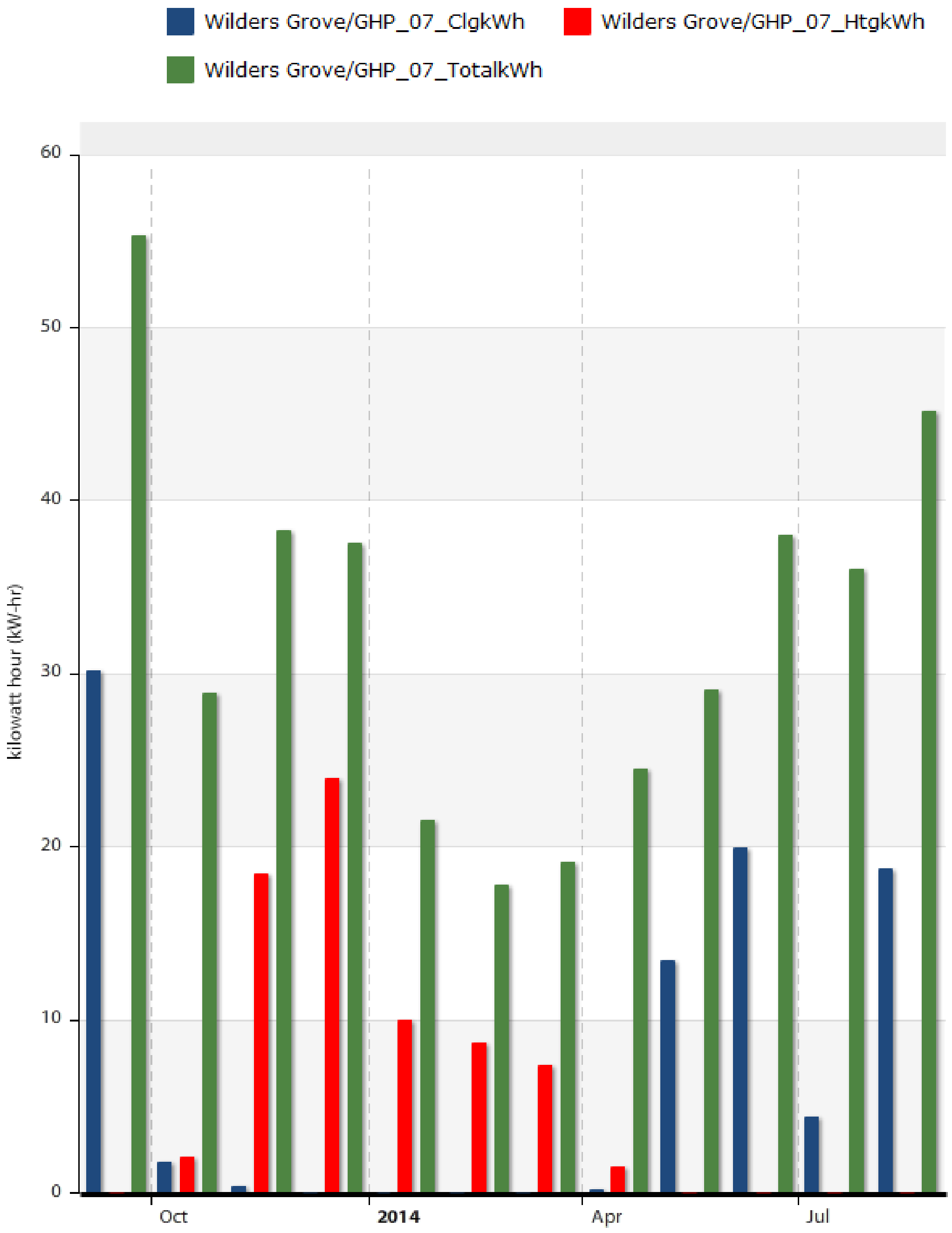
Wilders Grove / OATemp (F)

Wilders Grove / WG ADM ZONE TEMP GHP06 (F)

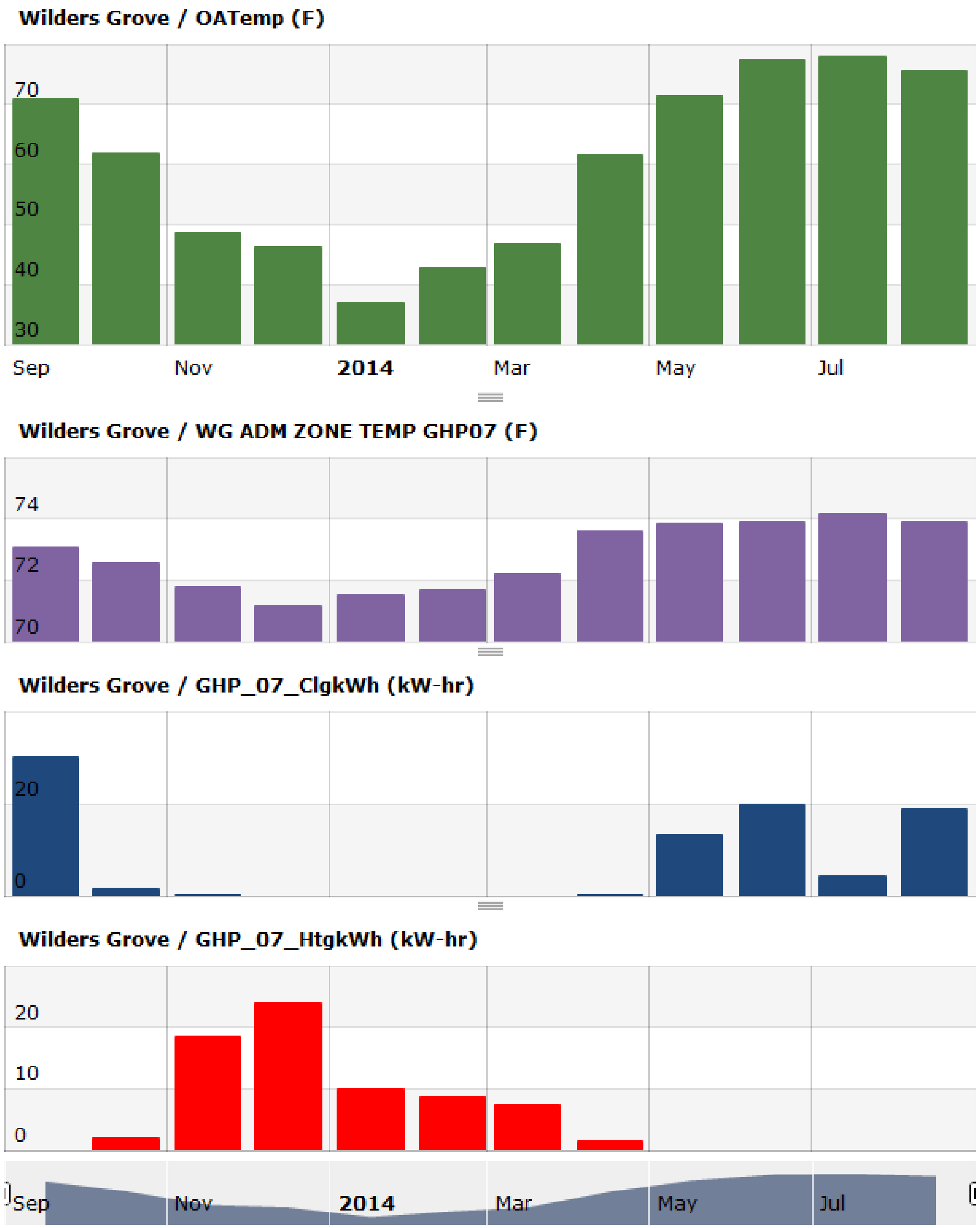
Wilders Grove / GHP_06_ClgkWh (kW-hr)

Wilders Grove / GHP_06_HtgkWh (kW-hr)

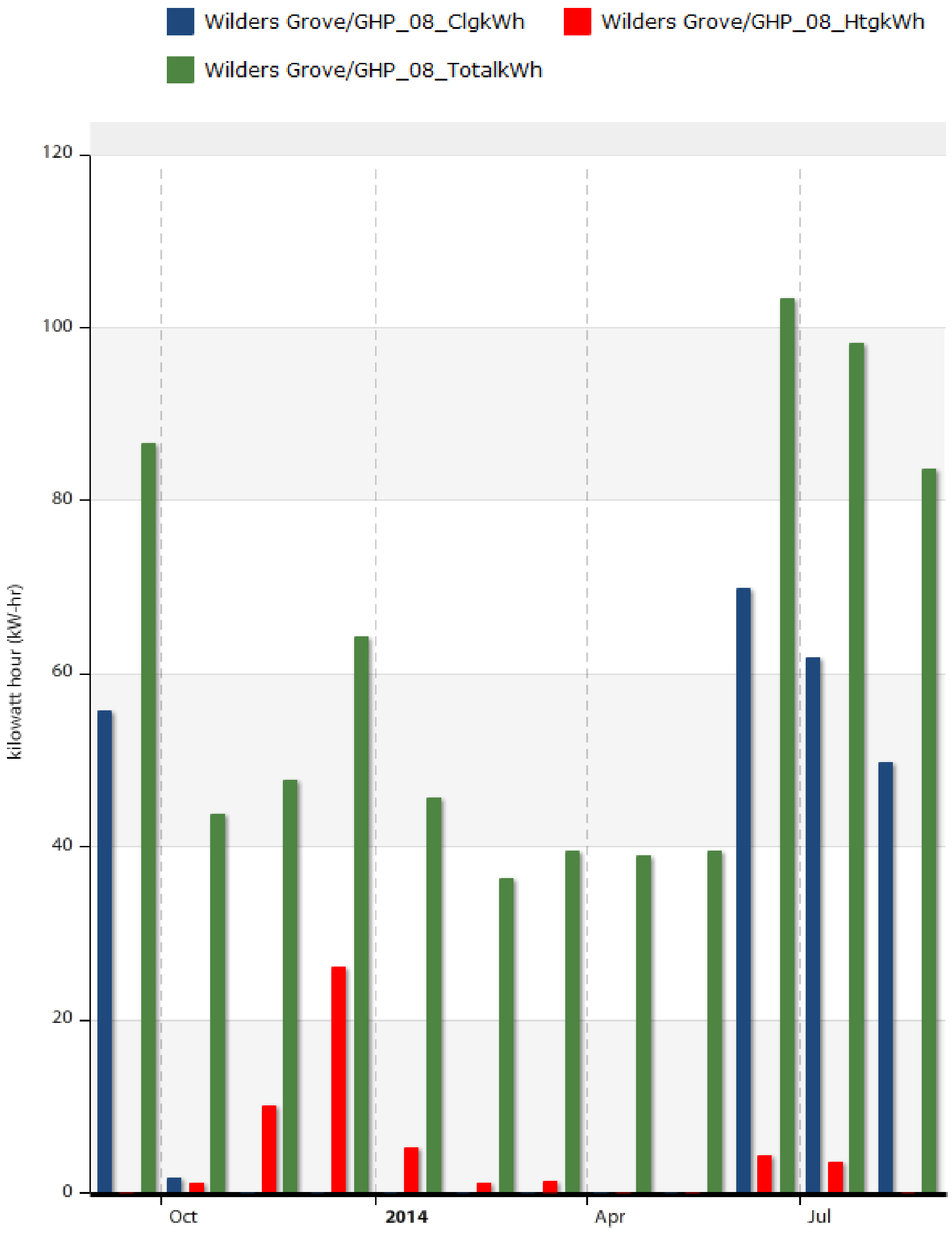
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP06 (F)	Wilders Grove / GHP_06_ClgkWh (kW-hr)	Wilders Grove / GHP_06_HtgkWh (kW-hr)	Events
Sep 2013	70.866	73.834	15.973	0.087	
Oct 2013	61.964	73.283	11.35	0	
Nov 2013	48.77	72.566	5.294	0.14	
Dec 2013	46.33	72.332	7.443	0.096	
Jan 2014	37.04	72.385	4.543	0	
Feb 2014	42.946	72.49	3.662	0	
Mar 2014	46.722	72.878	6.087	0.028	
Apr 2014	61.693	74.212	5.736	0	
May 2014	71.501	73.713	45.207	0	
Jun 2014	77.411	73.697	53.18	0	
Jul 2014	77.992	73.699	45.379	0	
Aug 2014	75.579	74.103	43.239	0	


Wilders Grove/GHP_07_ClgkWh
Wilders Grove/GHP_07_HtgkWh
Wilders Grove/GHP_07_TotalkWh
kilowatt hour (kW-hr)
60
50
40
30
20
10
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_07_ClgkWh (kW-hr)	Wilders Grove/GHP_07_HtgkWh (kW-hr)	Wilders Grove/GHP_07_TotalkWh (kW-hr)
Sep 2013	30.132	0	55.277
Oct 2013	1.772	2.026	28.842
Nov 2013	0.379	18.435	38.274
Dec 2013	0	23.924	37.53
Jan 2014	0	10.02	21.542
Feb 2014	0	8.667	17.788
Mar 2014	0	7.361	19.138
Apr 2014	0.196	1.457	24.52
May 2014	13.387	0	29.014
Jun 2014	19.947	0	38.042
Jul 2014	4.38	0	35.997
Aug 2014	18.713	0	45.148

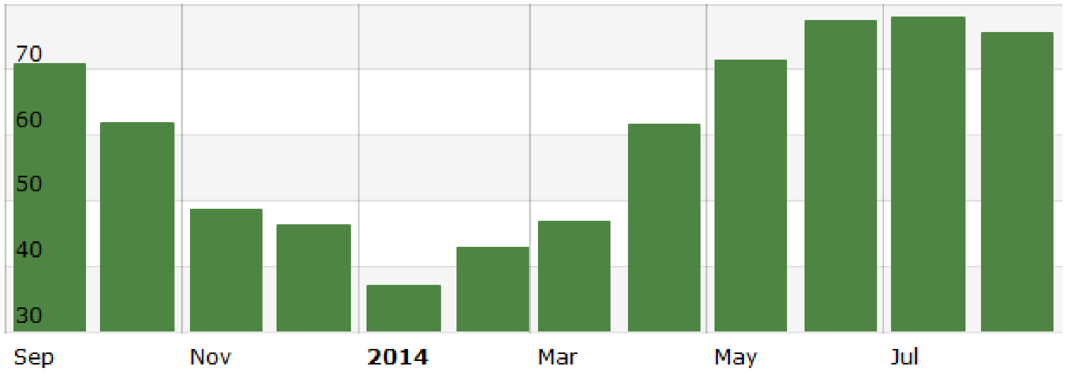

Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP07 (F)
74
72
70
Wilders Grove / GHP_07_ClgkWh (kW-hr)
20
0
Wilders Grove / GHP_07_HtgkWh (kW-hr)
20
10
0
Sep
Nov
2014
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP07 (F)	Wilders Grove / GHP_07_ClgkWh (kW-hr)	Wilders Grove / GHP_07_HtgkWh (kW-hr)	Events
Sep 2013	70.866	73.077	30.132	0	
Oct 2013	61.964	72.582	1.772	2.026	
Nov 2013	48.77	71.796	0.379	18.435	
Dec 2013	46.33	71.154	0	23.924	
Jan 2014	37.04	71.526	0	10.02	
Feb 2014	42.946	71.675	0	8.667	
Mar 2014	46.722	72.23	0	7.361	
Apr 2014	61.693	73.613	0.196	1.457	
May 2014	71.501	73.867	13.387	0	
Jun 2014	77.411	73.895	19.947	0	
Jul 2014	77.992	74.179	4.38	0	
Aug 2014	75.579	73.906	18.713	0	

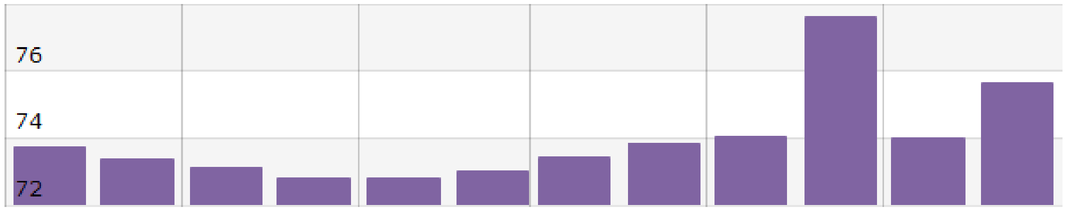

Wilders Grove/GHP_08_ClgkWh
Wilders Grove/GHP_08_HtgkWh
Wilders Grove/GHP_08_TotalkWh
kilowatt hour (kW-hr)
120
100
80
60
40
20
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_08_ClgkWh (kW-hr)	Wilders Grove/GHP_08_HtgkWh (kW-hr)	Wilders Grove/GHP_08_TotalkWh (kW-hr)
Sep 2013	55.722	0	86.585
Oct 2013	1.691	1.057	43.72
Nov 2013	0	10.052	47.633
Dec 2013	0	26.027	64.263
Jan 2014	0	5.321	45.596
Feb 2014	0	1.085	36.344
Mar 2014	0	1.375	39.468
Apr 2014	0	0	38.879
May 2014	0	0	39.497
Jun 2014	69.801	4.233	103.372
Jul 2014	61.794	3.476	98.142
Aug 2014	49.787	0	83.589

Wilders Grove / OATemp (F)

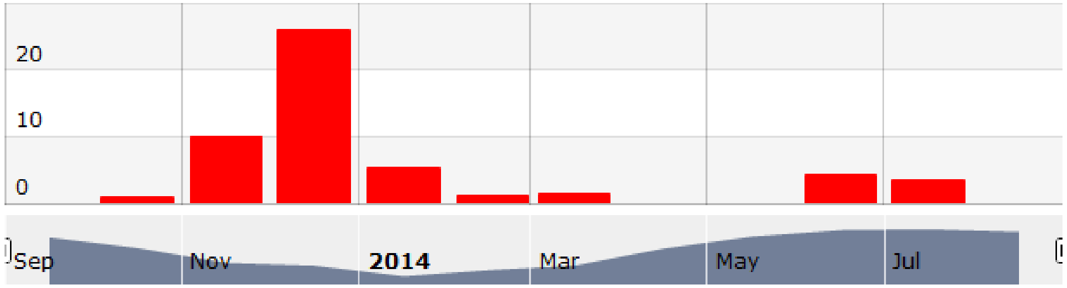


Wilders Grove / WG ADM ZONE TEMP GHP08 (F)

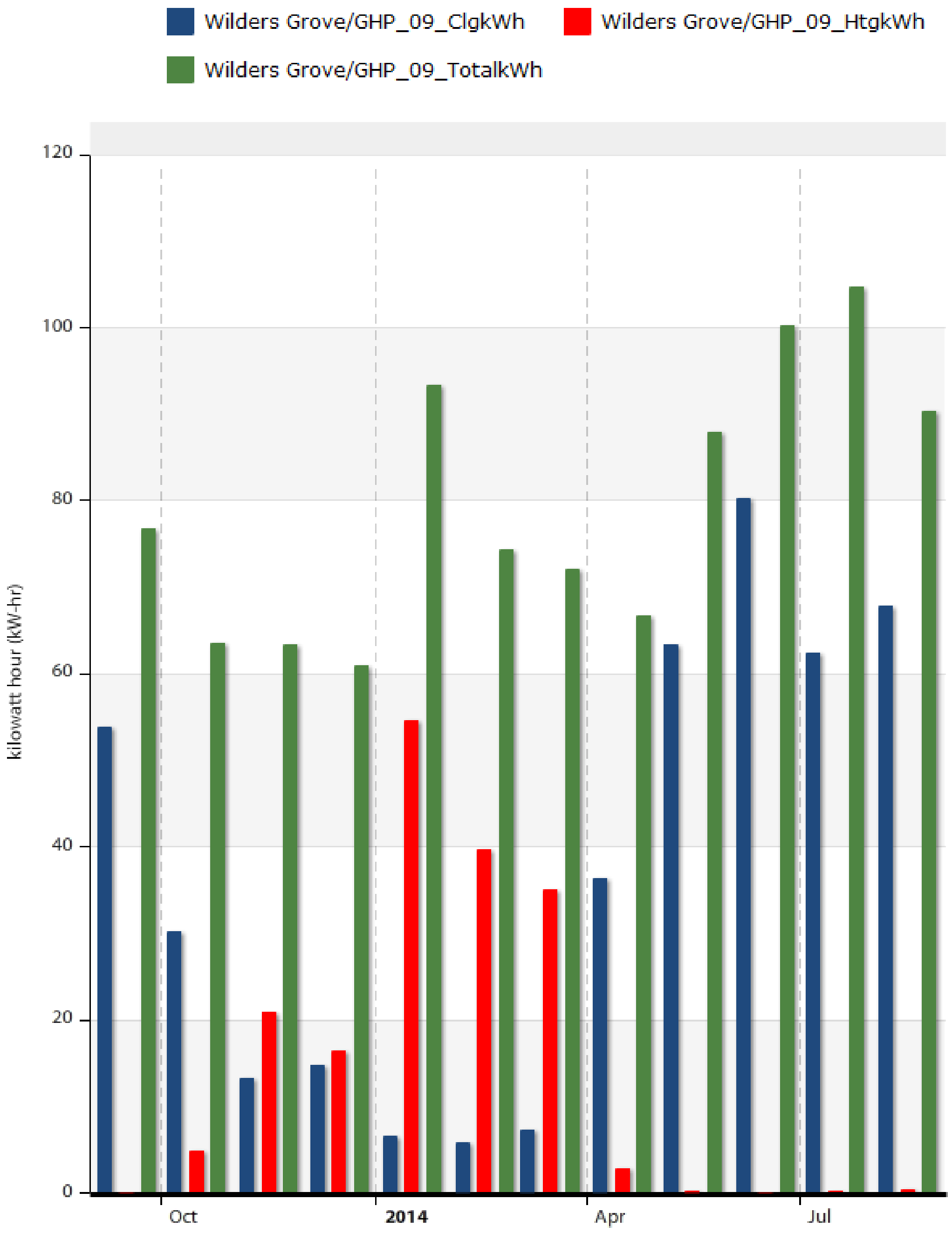


Wilders Grove / GHP_08_ClgkWh (kW-hr)

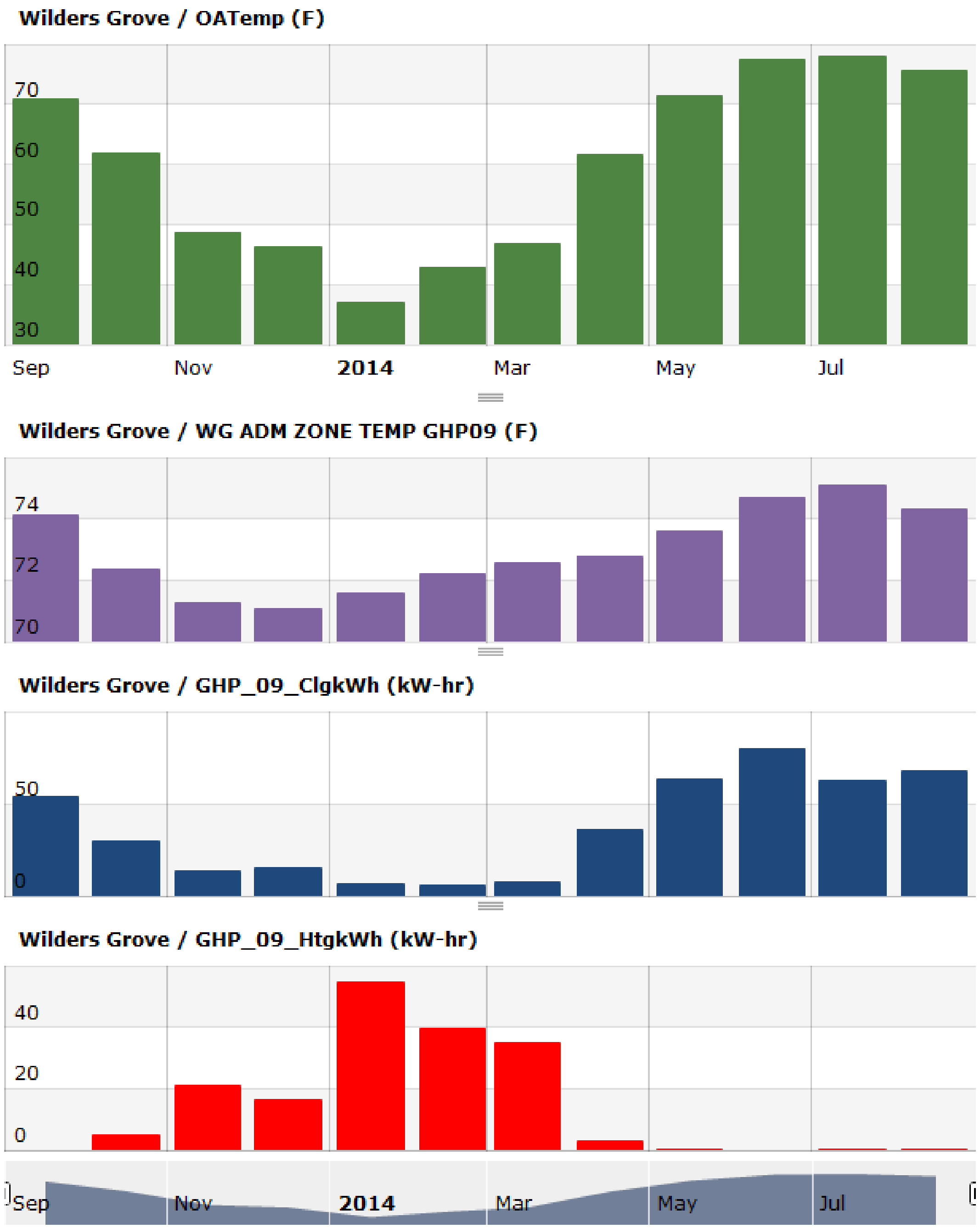
Wilders Grove / GHP_08_HtgkWh (kW-hr)



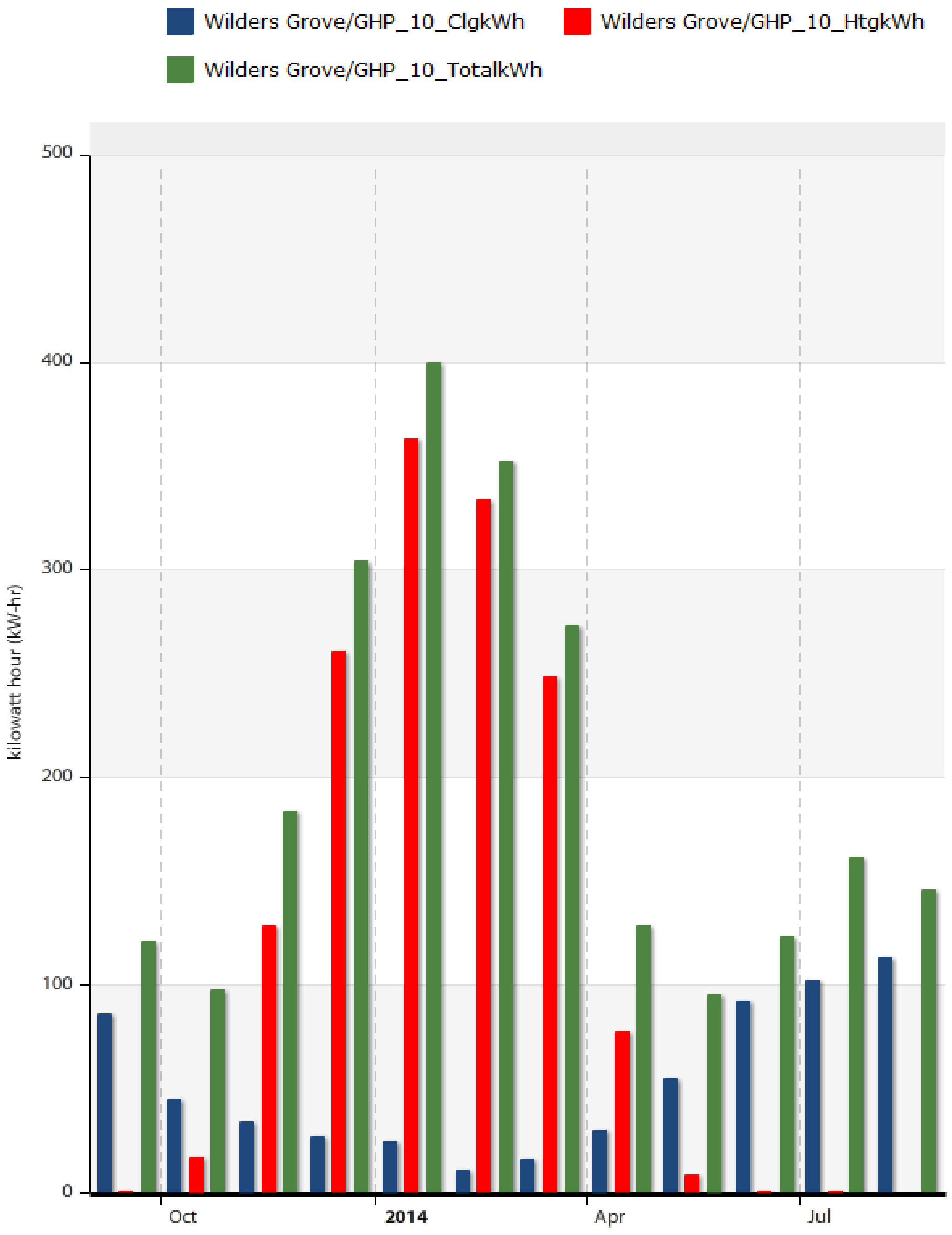
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP08 (F)	Wilders Grove / GHP_08_ClgkWh (kW-hr)	Wilders Grove / GHP_08_HtgkWh (kW-hr)	Events
Sep 2013	70.866	73.754	55.722	0	
Oct 2013	61.964	73.386	1.691	1.057	
Nov 2013	48.77	73.143	0	10.052	
Dec 2013	46.33	72.789	0	26.027	
Jan 2014	37.04	72.805	0	5.321	
Feb 2014	42.946	73.012	0	1.085	
Mar 2014	46.722	73.417	0	1.375	
Apr 2014	61.693	73.869	0	0	
May 2014	71.501	74.044	0	0	
Jun 2014	77.411	77.628	69.801	4.233	
Jul 2014	77.992	73.978	61.794	3.476	
Aug 2014	75.579	75.633	49.787	0	


Wilders Grove/GHP_09_ClgkWh
Wilders Grove/GHP_09_HtgkWh
Wilders Grove/GHP_09_TotalkWh
kilowatt hour (kW-hr)
120
100
80
60
40
20
0
Oct
2014
Apr
Jul

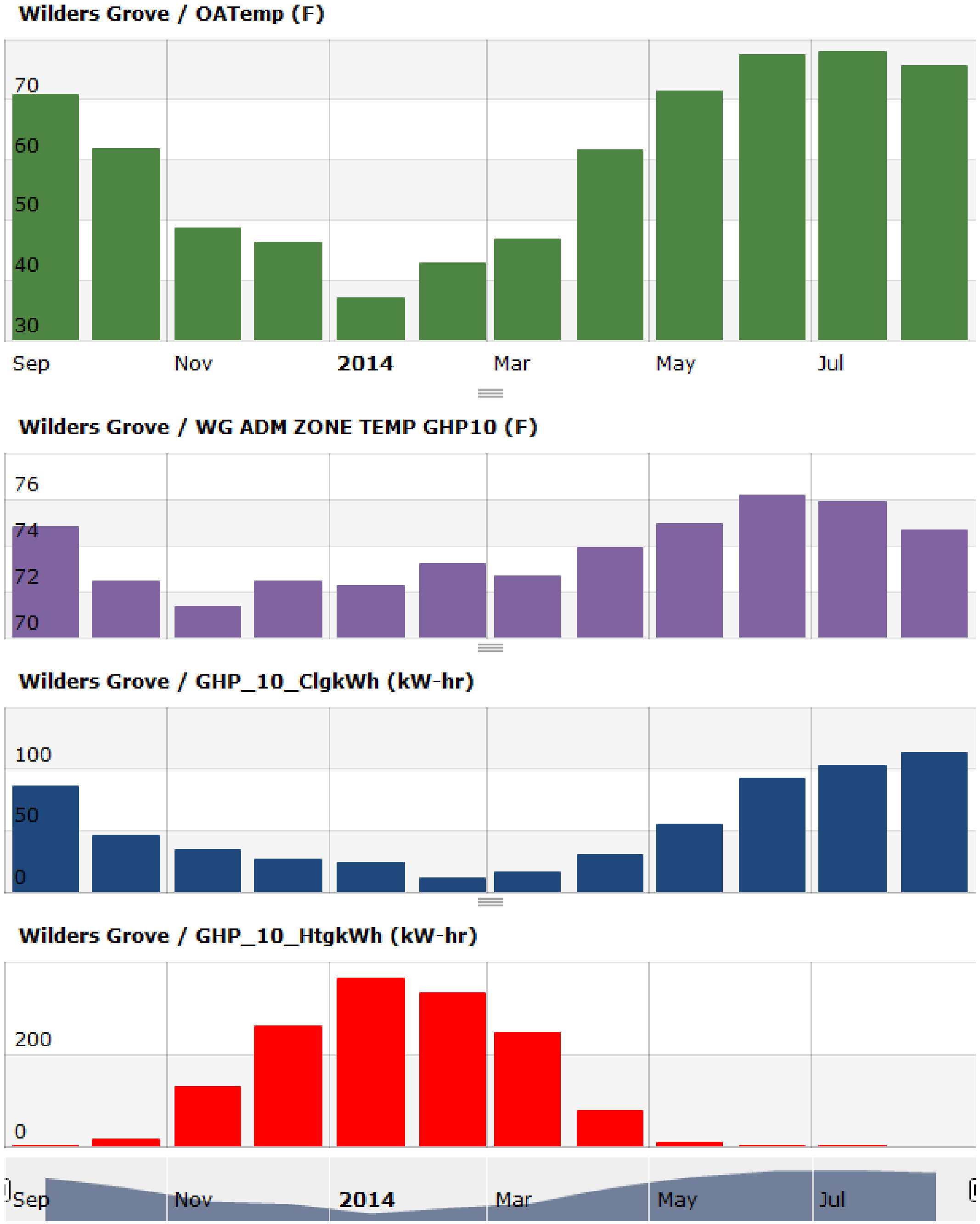
Timestamp	Wilders Grove/GHP_09_ClgkWh (kW-hr)	Wilders Grove/GHP_09_HtgkWh (kW-hr)	Wilders Grove/GHP_09_TotalkWh (kW-hr)
Sep 2013	53.792	0	76.795
Oct 2013	30.197	4.884	63.592
Nov 2013	13.169	20.957	63.359
Dec 2013	14.82	16.429	60.828
Jan 2014	6.469	54.668	93.31
Feb 2014	5.729	39.737	74.342
Mar 2014	7.253	35.03	72.024
Apr 2014	36.283	2.735	66.747
May 2014	63.376	0.26	87.95
Jun 2014	80.19	0	100.172
Jul 2014	62.312	0.122	104.645
Aug 2014	67.887	0.344	90.273


Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP09 (F)
74
72
70
Wilders Grove / GHP_09_ClgkWh (kW-hr)
50
0
Wilders Grove / GHP_09_HtgkWh (kW-hr)
40
20
0
Sep
Nov
2014
Mar
May
Jul

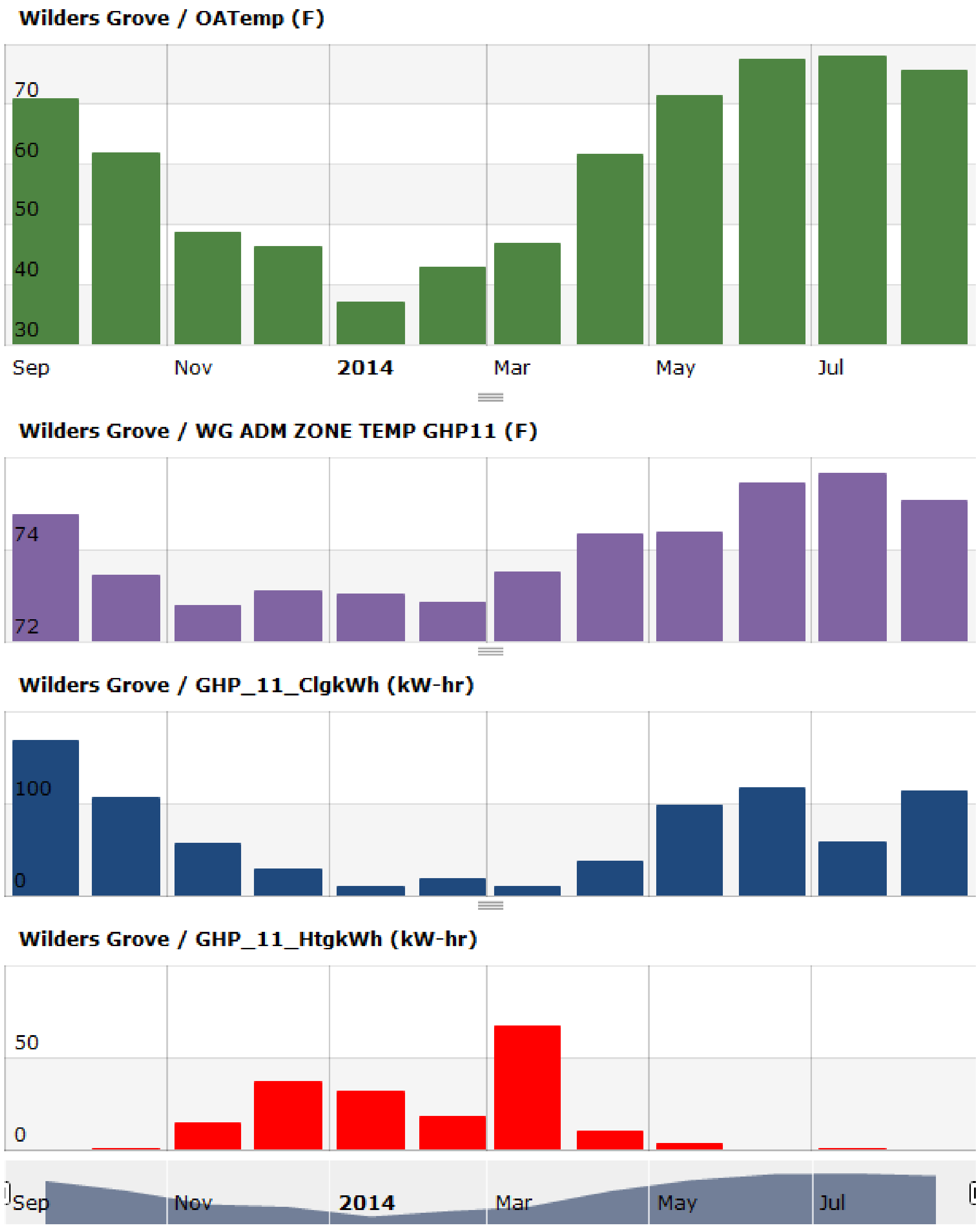
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP09 (F)	Wilders Grove / GHP_09_ClgkWh (kW-hr)	Wilders Grove / GHP_09_HtgkWh (kW-hr)	Events
Sep 2013	70.866	74.107	53.792	0	
Oct 2013	61.964	72.355	30.197	4.884	
Nov 2013	48.77	71.274	13.169	20.957	
Dec 2013	46.33	71.083	14.82	16.429	
Jan 2014	37.04	71.603	6.469	54.668	
Feb 2014	42.946	72.219	5.729	39.737	
Mar 2014	46.722	72.548	7.253	35.03	
Apr 2014	61.693	72.786	36.283	2.735	
May 2014	71.501	73.591	63.376	0.26	
Jun 2014	77.411	74.702	80.19	0	
Jul 2014	77.992	75.11	62.312	0.122	
Aug 2014	75.579	74.308	67.887	0.344	


Wilders Grove/GHP_10_ClgkWh
Wilders Grove/GHP_10_HtgkWh
Wilders Grove/GHP_10_TotalkWh
kilowatt hour (kW-hr)
500
400
300
200
100
0
Oct
2014
Apr
Jul

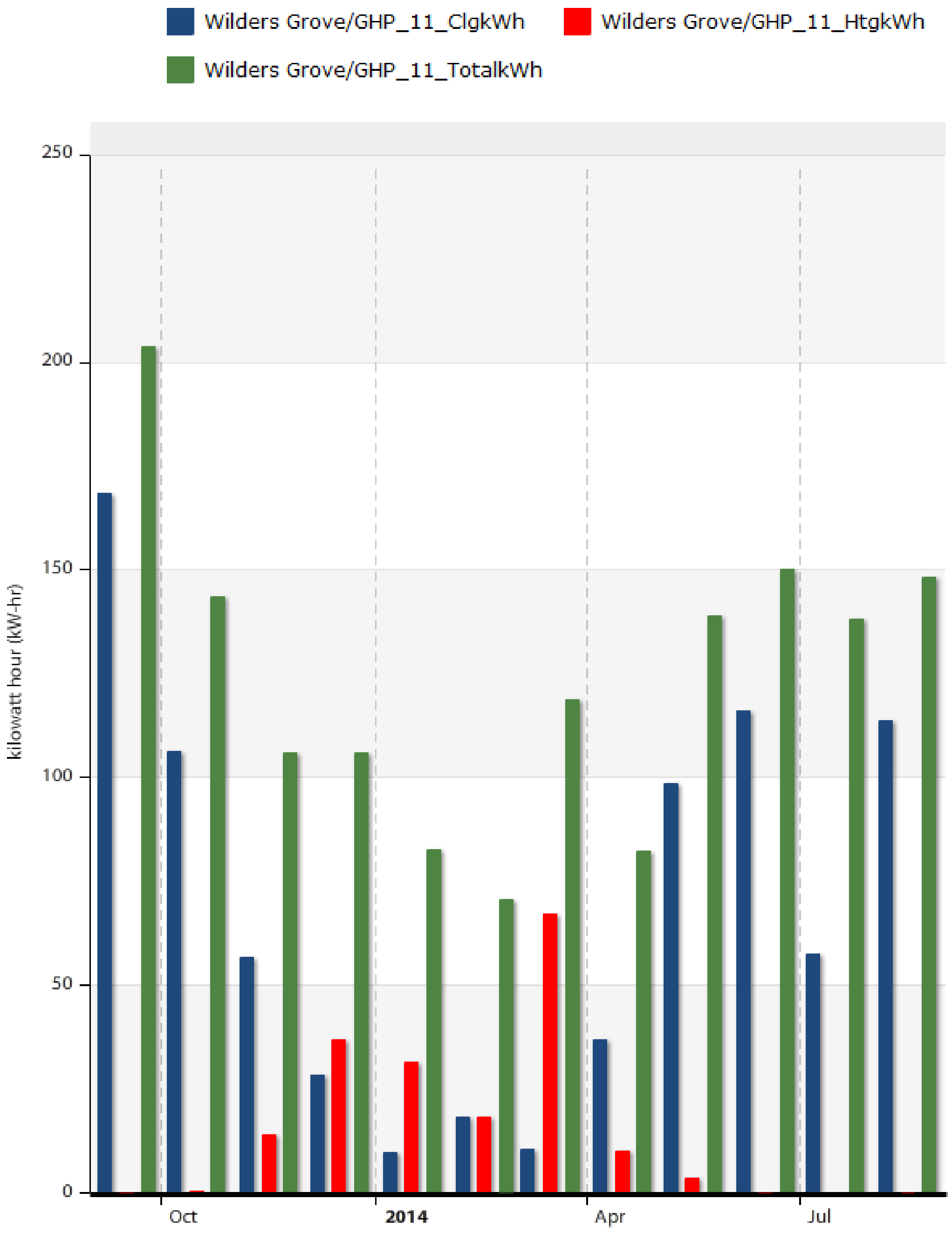
Timestamp	Wilders Grove/GHP_10_ClgkWh (kW-hr)	Wilders Grove/GHP_10_HtgkWh (kW-hr)	Wilders Grove/GHP_10_TotalkWh (kW-hr)
Sep 2013	85.939	0.907	121.181
Oct 2013	45.474	17.517	97.769
Nov 2013	34.052	128.995	183.696
Dec 2013	27.219	260.432	303.913
Jan 2014	24.733	363.18	399.48
Feb 2014	11.164	333.568	352.529
Mar 2014	16.542	248.636	272.958
Apr 2014	30.535	77.439	128.559
May 2014	55.095	8.4	95.32
Jun 2014	92.466	1.091	123.111
Jul 2014	102.637	1.071	161.82
Aug 2014	113.753	0.249	146.039


Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP10 (F)
76
74
72
70
Wilders Grove / GHP_10_ClgkWh (kW-hr)
100
50
0
Wilders Grove / GHP_10_HtgkWh (kW-hr)
200
0
Sep
Nov
2014
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP10 (F)	Wilders Grove / GHP_10_ClgkWh (kW-hr)	Wilders Grove / GHP_10_HtgkWh (kW-hr)	Events
Sep 2013	70.866	74.802	85.939	0.907	
Oct 2013	61.964	72.472	45.474	17.517	
Nov 2013	48.77	71.33	34.052	128.995	
Dec 2013	46.33	72.486	27.219	260.432	
Jan 2014	37.04	72.264	24.733	363.18	
Feb 2014	42.946	73.212	11.164	333.568	
Mar 2014	46.722	72.66	16.542	248.636	
Apr 2014	61.693	73.898	30.535	77.439	
May 2014	71.501	74.943	55.095	8.4	
Jun 2014	77.411	76.185	92.466	1.091	
Jul 2014	77.992	75.897	102.637	1.071	
Aug 2014	75.579	74.682	113.753	0.249	

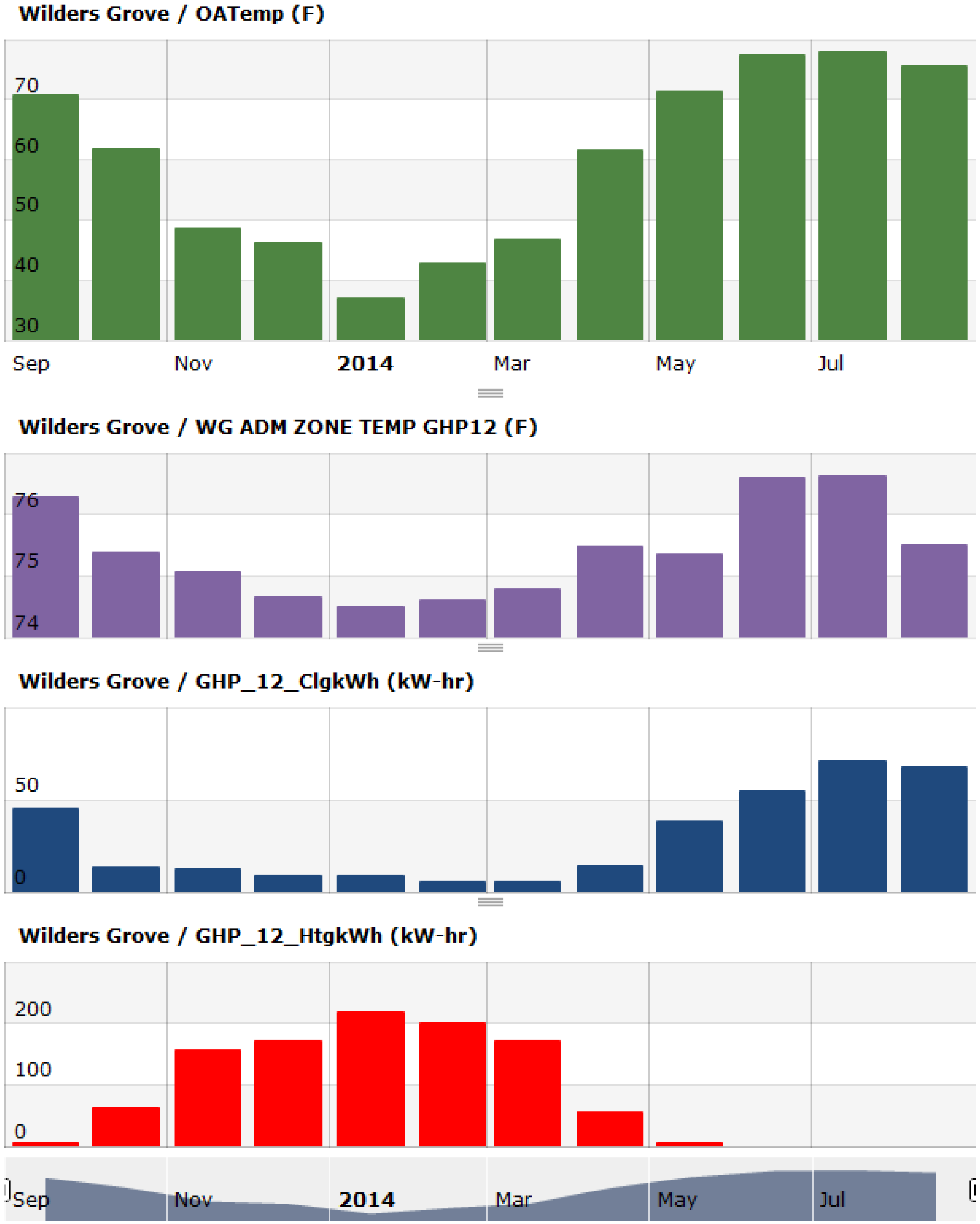

Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP11 (F)
74
72
Wilders Grove / GHP_11_ClgkWh (kW-hr)
100
0
Wilders Grove / GHP_11_HtgkWh (kW-hr)
50
0
Sep
Nov
2014
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP11 (F)	Wilders Grove / GHP_11_ClgkWh (kW-hr)	Wilders Grove / GHP_11_HtgkWh (kW-hr)	Events
Sep 2013	70.866	74.755	168.522	0	
Oct 2013	61.964	73.42	106.536	0.274	
Nov 2013	48.77	72.788	56.567	14.168	
Dec 2013	46.33	73.1	28.554	36.775	
Jan 2014	37.04	73.006	9.568	31.617	
Feb 2014	42.946	72.867	18.29	18.158	
Mar 2014	46.722	73.494	10.386	67.296	
Apr 2014	61.693	74.318	37.056	9.951	
May 2014	71.501	74.351	98.534	3.513	
Jun 2014	77.411	75.421	116.145	0	
Jul 2014	77.992	75.639	57.415	0.209	
Aug 2014	75.579	75.048	113.54	0	

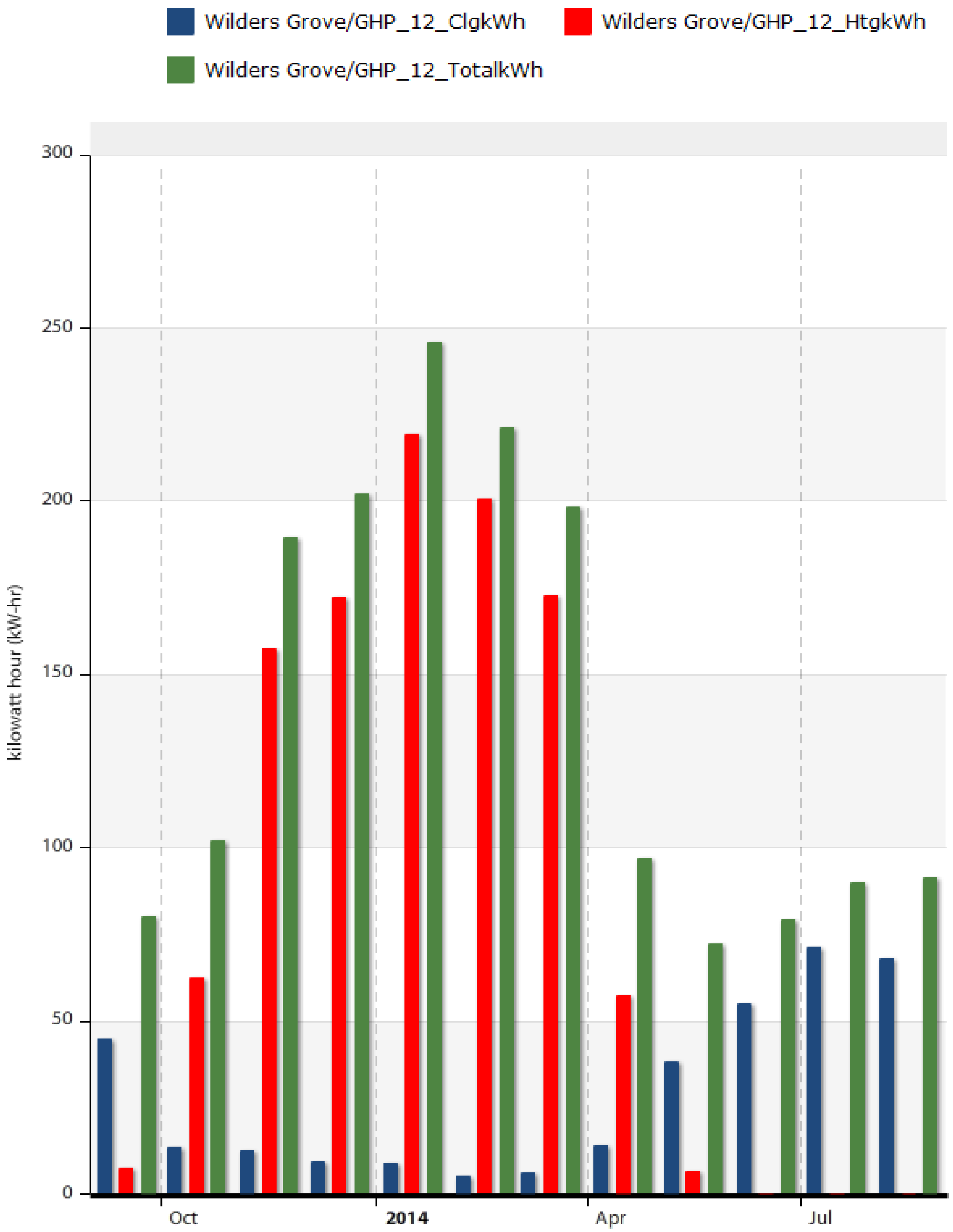


Wilders Grove/GHP_11_ClgkWh
Wilders Grove/GHP_11_HtgkWh
Wilders Grove/GHP_11_TotalkWh
kilowatt hour (kW-hr)
250
200
150
100
50
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_11_ClgkWh (kW-hr)	Wilders Grove/GHP_11_HtgkWh (kW-hr)	Wilders Grove/GHP_11_TotalkWh (kW-hr)
Sep 2013	168.522	0	203.619
Oct 2013	106.536	0.274	143.612
Nov 2013	56.567	14.168	106.065
Dec 2013	28.554	36.775	105.831
Jan 2014	9.568	31.617	82.606
Feb 2014	18.29	18.158	70.748
Mar 2014	10.386	67.296	118.939
Apr 2014	37.056	9.951	82.423
May 2014	98.534	3.513	138.876
Jun 2014	116.145	0	150.275
Jul 2014	57.415	0.209	138.304
Aug 2014	113.54	0	148.271

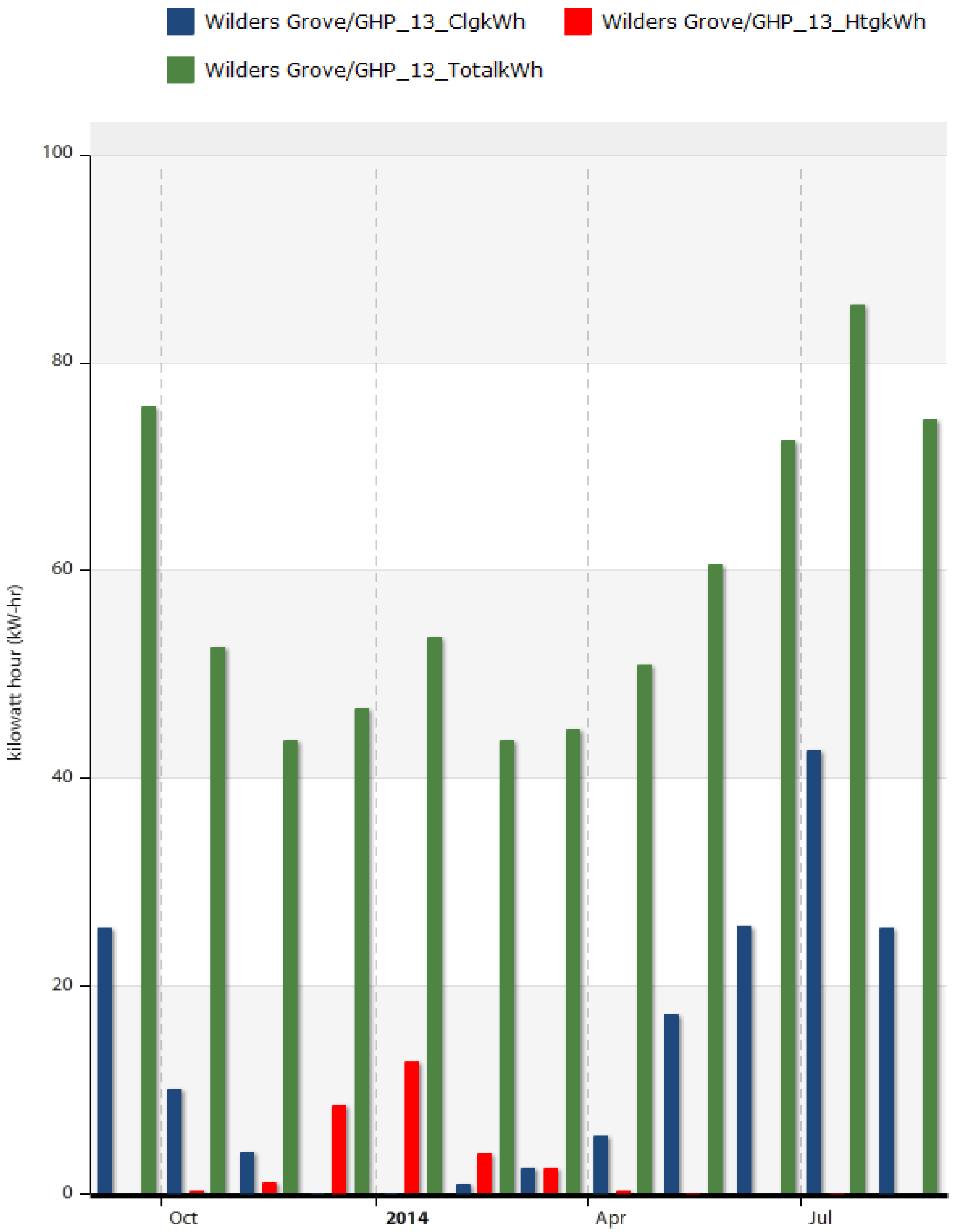

Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP12 (F)
76
75
74
Wilders Grove / GHP_12_ClgkWh (kW-hr)
50
0
Wilders Grove / GHP_12_HtgkWh (kW-hr)
200
100
0
Sep
Nov
2014
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP12 (F)	Wilders Grove / GHP_12_ClgkWh (kW-hr)	Wilders Grove / GHP_12_HtgkWh (kW-hr)	Events
Sep 2013	70.866	76.294	44.96	7.471	
Oct 2013	61.964	75.393	13.524	62.623	
Nov 2013	48.77	75.069	12.771	157.519	
Dec 2013	46.33	74.666	9.194	172.23	
Jan 2014	37.04	74.513	9.118	219.11	
Feb 2014	42.946	74.603	5.386	200.564	
Mar 2014	46.722	74.79	5.959	172.69	
Apr 2014	61.693	75.497	14.192	57.205	
May 2014	71.501	75.369	38.216	6.76	
Jun 2014	77.411	76.597	54.953	0	
Jul 2014	77.992	76.62	71.195	0	
Aug 2014	75.579	75.507	67.821	0	

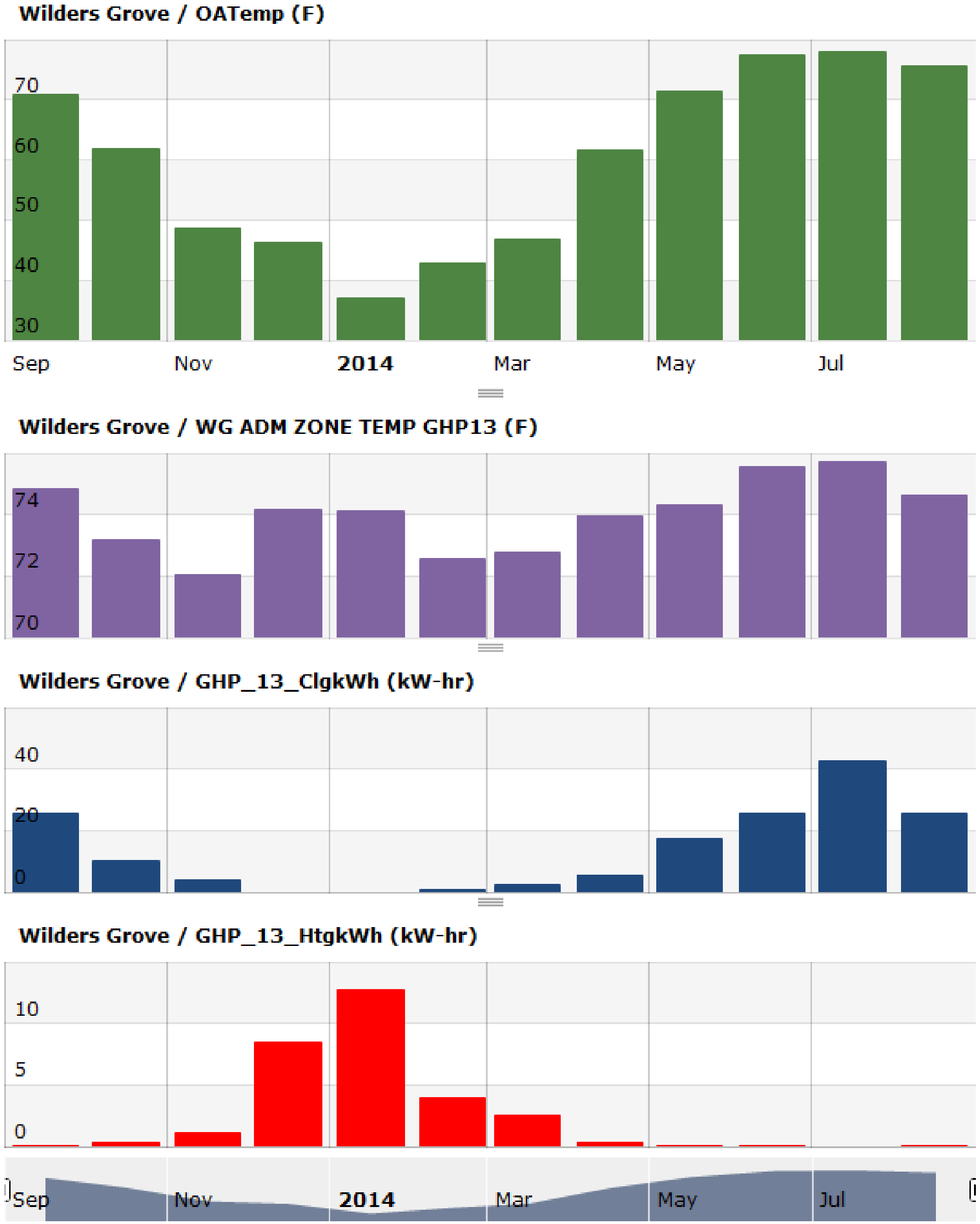


Wilders Grove/GHP_12_ClgkWh
Wilders Grove/GHP_12_HtgkWh
Wilders Grove/GHP_12_TotalkWh
kilowatt hour (kW-hr)
300
250
200
150
100
50
0
Oct
2014
Apr
Jul

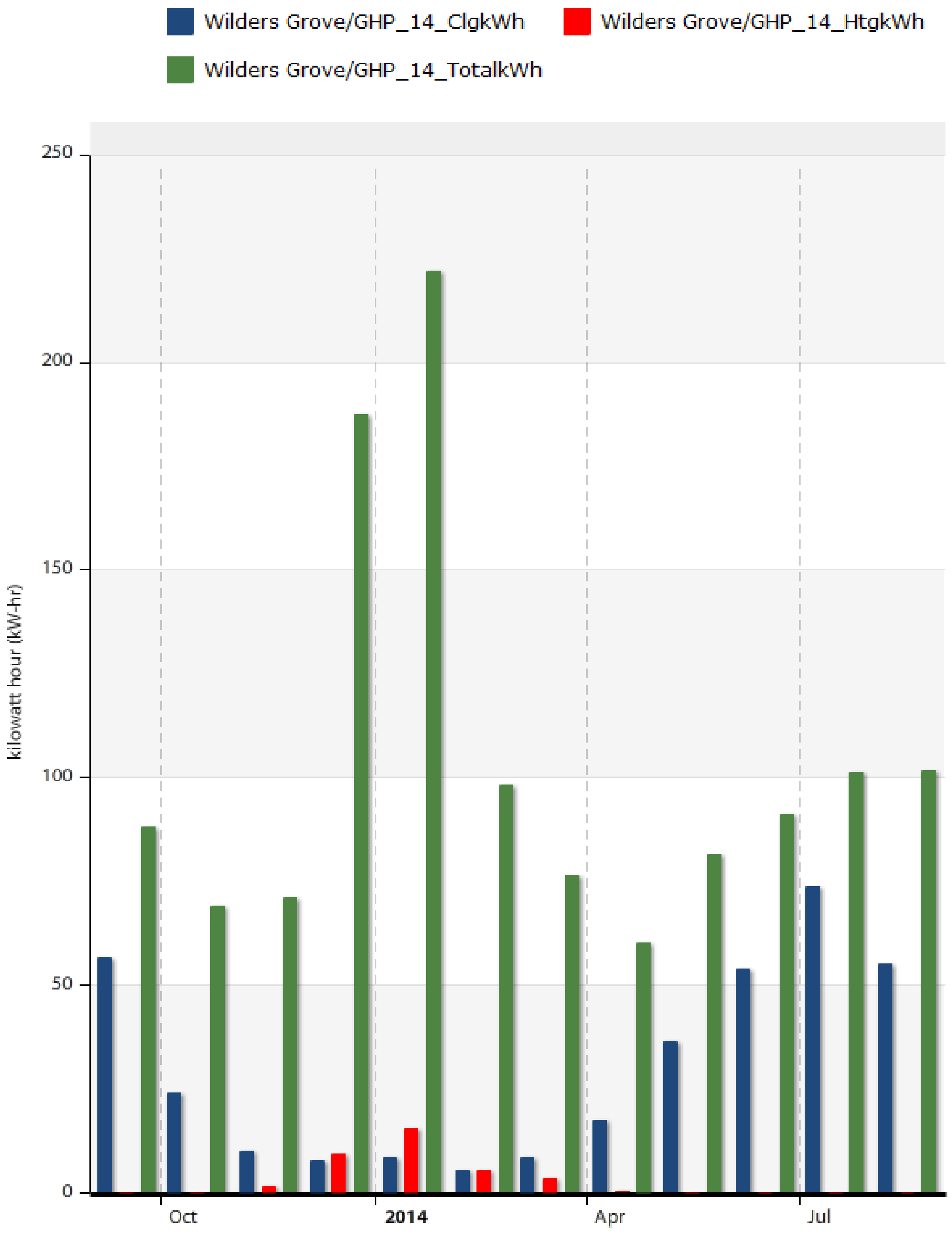
Timestamp	Wilders Grove/GHP_12_ClgkWh (kW-hr)	Wilders Grove/GHP_12_HtgkWh (kW-hr)	Wilders Grove/GHP_12_TotalkWh (kW-hr)
Sep 2013	44.96	7.471	80.007
Oct 2013	13.524	62.623	102.226
Nov 2013	12.771	157.519	189.687
Dec 2013	9.194	172.23	201.983
Jan 2014	9.118	219.11	246.011
Feb 2014	5.386	200.564	221.261
Mar 2014	5.959	172.69	198.364
Apr 2014	14.192	57.205	96.699
May 2014	38.216	6.76	72.018
Jun 2014	54.953	0	79.254
Jul 2014	71.195	0	89.966
Aug 2014	67.821	0	91.424


Wilders Grove/GHP_13_ClgkWh
Wilders Grove/GHP_13_HtgkWh
Wilders Grove/GHP_13_TotalkWh
kilowatt hour (kW-hr)
100
80
60
40
20
0
Oct
2014
Apr
Jul

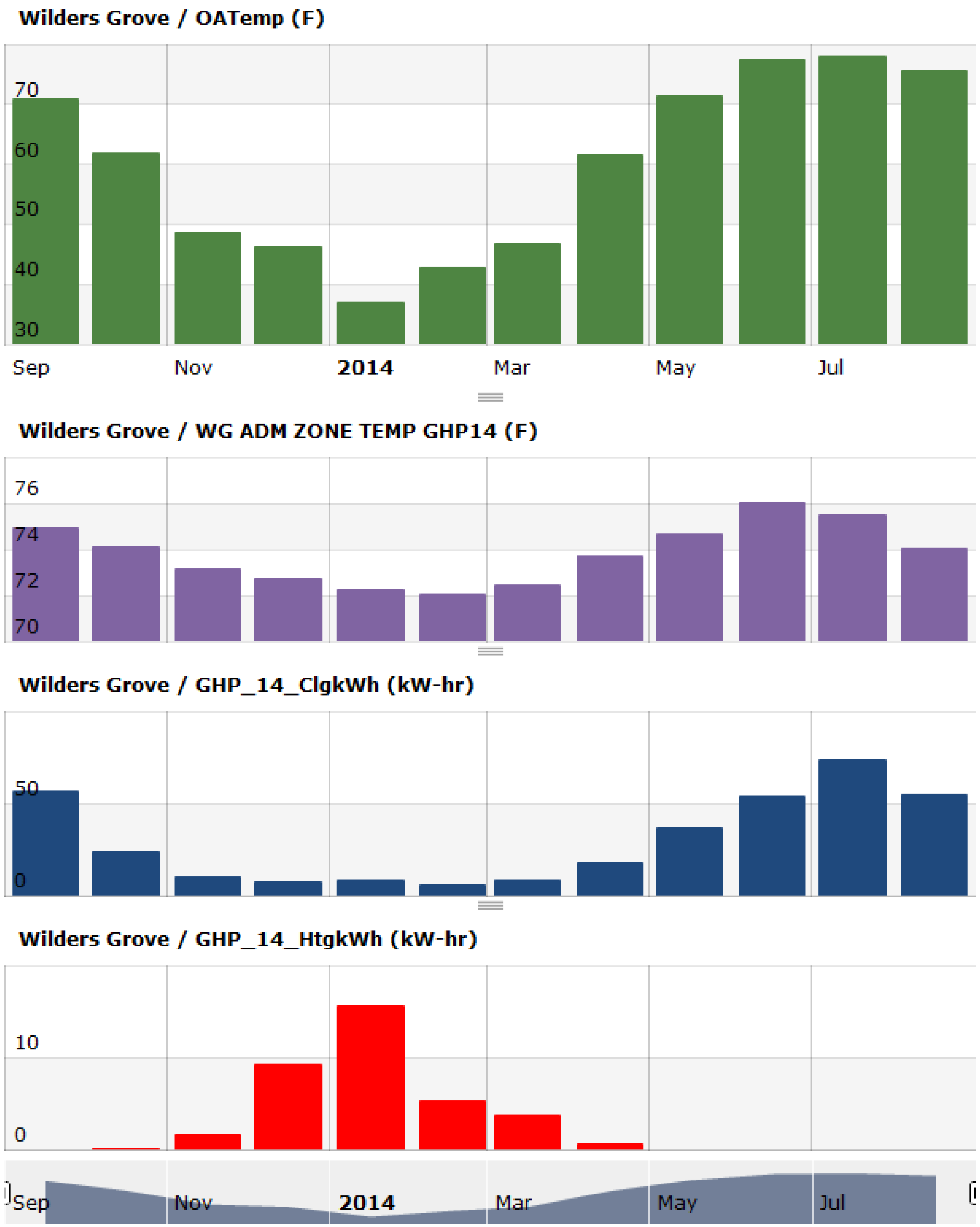
Timestamp	Wilders Grove/GHP_13_ClgkWh (kW-hr)	Wilders Grove/GHP_13_HtgkWh (kW-hr)	Wilders Grove/GHP_13_TotalkWh (kW-hr)
Sep 2013	25.68	0.082	75.802
Oct 2013	10.077	0.279	52.609
Nov 2013	4.021	1.061	43.625
Dec 2013	0	8.483	46.682
Jan 2014	0	12.806	53.548
Feb 2014	0.938	3.96	43.658
Mar 2014	2.442	2.519	44.72
Apr 2014	5.673	0.368	50.962
May 2014	17.302	0.067	60.525
Jun 2014	25.838	0.03	72.508
Jul 2014	42.683	0	85.564
Aug 2014	25.581	0.03	74.478


Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP13 (F)
74
72
70
Wilders Grove / GHP_13_ClgkWh (kW-hr)
40
20
0
Wilders Grove / GHP_13_HtgkWh (kW-hr)
10
5
0
Sep
Nov
2014
Mar
May
Jul

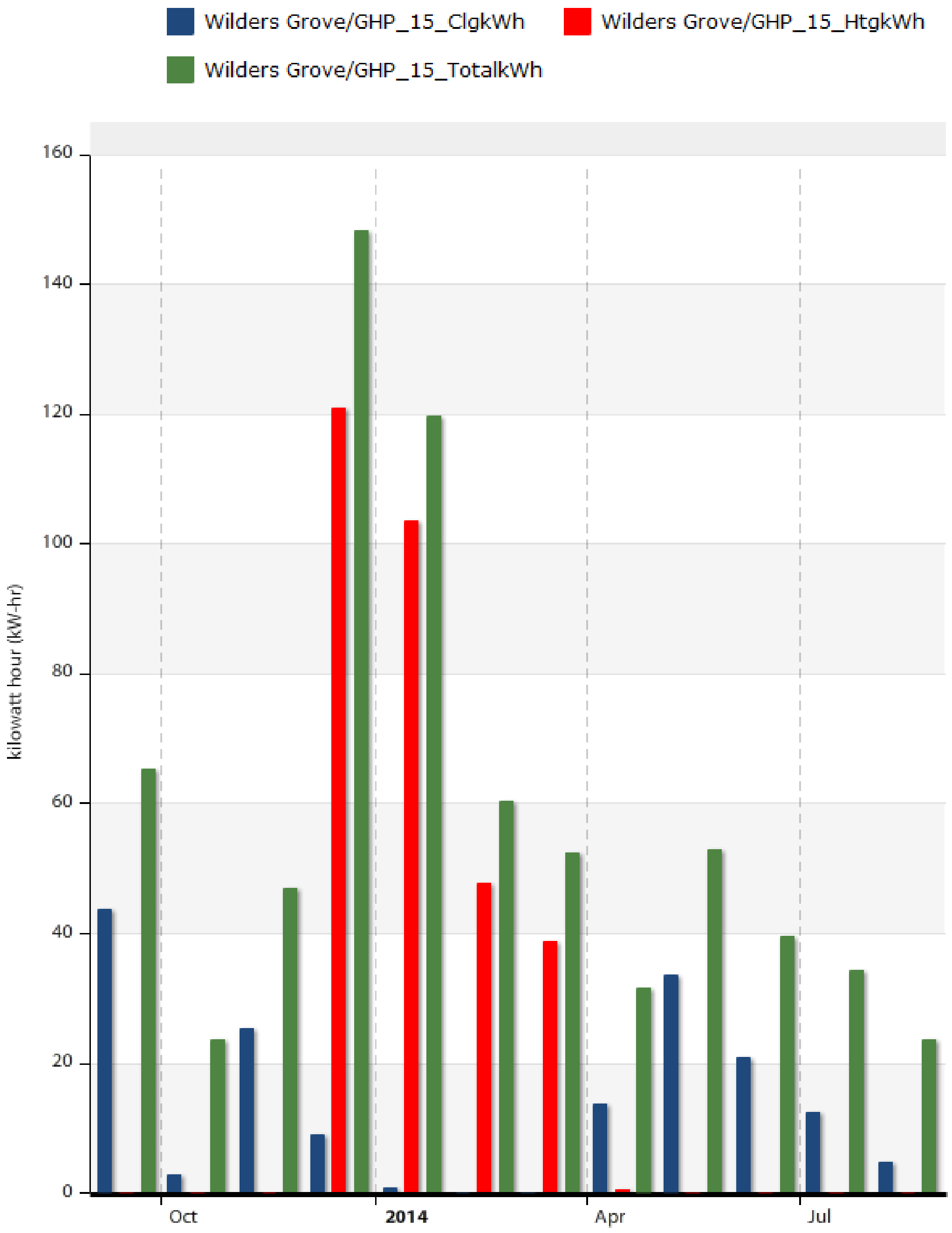
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP13 (F)	Wilders Grove / GHP_13_ClgkWh (kW-hr)	Wilders Grove / GHP_13_HtgkWh (kW-hr)	Events
Sep 2013	70.866	74.85	25.68	0.082	
Oct 2013	61.964	73.165	10.077	0.279	
Nov 2013	48.77	72.065	4.021	1.061	
Dec 2013	46.33	74.158	0	8.483	
Jan 2014	37.04	74.107	0	12.806	
Feb 2014	42.946	72.562	0.938	3.96	
Mar 2014	46.722	72.758	2.442	2.519	
Apr 2014	61.693	73.979	5.673	0.368	
May 2014	71.501	74.327	17.302	0.067	
Jun 2014	77.411	75.569	25.838	0.03	
Jul 2014	77.992	75.706	42.683	0	
Aug 2014	75.579	74.651	25.581	0.03	


Wilders Grove/GHP_14_ClgkWh
Wilders Grove/GHP_14_HtgkWh
Wilders Grove/GHP_14_TotalkWh
kilowatt hour (kW-hr)
250
200
150
100
50
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_14_ClgkWh (kW-hr)	Wilders Grove/GHP_14_HtgkWh (kW-hr)	Wilders Grove/GHP_14_TotalkWh (kW-hr)
Sep 2013	56.505	0.002	87.93
Oct 2013	24.029	0.041	68.931
Nov 2013	10.23	1.604	70.854
Dec 2013	7.641	9.24	187.566
Jan 2014	8.53	15.685	221.75
Feb 2014	5.516	5.328	98.239
Mar 2014	8.554	3.661	76.596
Apr 2014	17.666	0.581	60.102
May 2014	36.583	0.012	81.441
Jun 2014	54.018	0.003	91.101
Jul 2014	73.601	0	101.41
Aug 2014	55.08	0	101.541

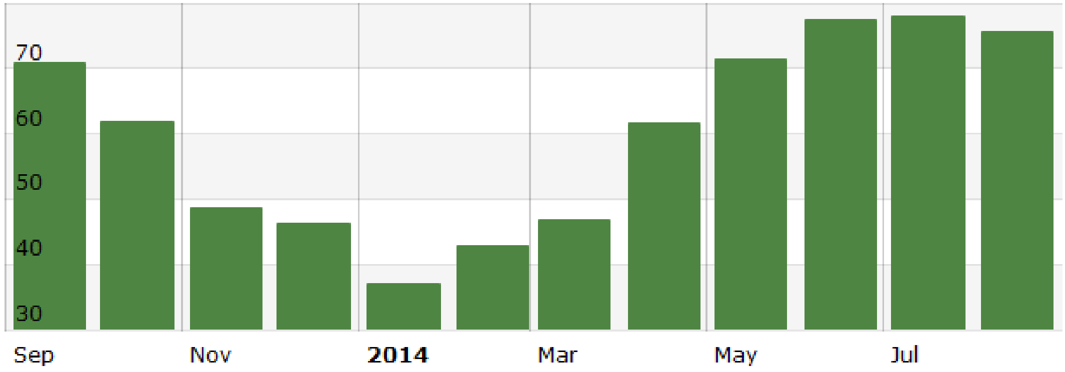

Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP14 (F)
76
74
72
70
Wilders Grove / GHP_14_ClgkWh (kW-hr)
50
0
Wilders Grove / GHP_14_HtgkWh (kW-hr)
10
0
Sep
Nov
2014
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP14 (F)	Wilders Grove / GHP_14_ClgkWh (kW-hr)	Wilders Grove / GHP_14_HtgkWh (kW-hr)	Events
Sep 2013	70.866	74.931	56.505	0.002	
Oct 2013	61.964	74.128	24.029	0.041	
Nov 2013	48.77	73.149	10.23	1.604	
Dec 2013	46.33	72.76	7.641	9.24	
Jan 2014	37.04	72.264	8.53	15.685	
Feb 2014	42.946	72.053	5.516	5.328	
Mar 2014	46.722	72.447	8.554	3.661	
Apr 2014	61.693	73.718	17.666	0.581	
May 2014	71.501	74.696	36.583	0.012	
Jun 2014	77.411	76.017	54.018	0.003	
Jul 2014	77.992	75.47	73.601	0	
Aug 2014	75.579	74.061	55.08	0	

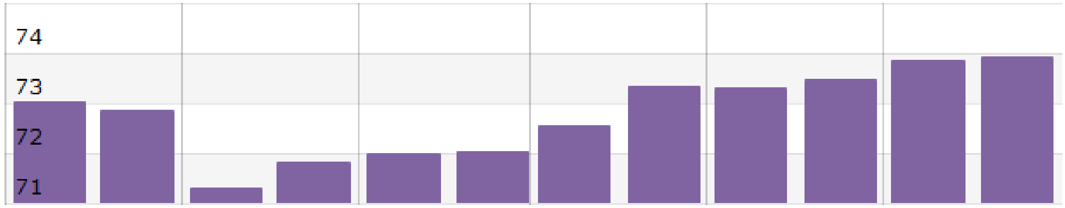

Wilders Grove/GHP_15_ClgkWh
Wilders Grove/GHP_15_HtgkWh
Wilders Grove/GHP_15_TotalkWh
kilowatt hour (kW-hr)
160
140
120
100
80
60
40
20
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_15_ClgkWh (kW-hr)	Wilders Grove/GHP_15_HtgkWh (kW-hr)	Wilders Grove/GHP_15_TotalkWh (kW-hr)
Sep 2013	43.674	0	65.263
Oct 2013	2.648	0	23.725
Nov 2013	25.371	0	46.91
Dec 2013	9.021	120.967	148.35
Jan 2014	0.739	103.485	119.639
Feb 2014	0	47.679	60.351
Mar 2014	0	38.716	52.537
Apr 2014	13.734	0.653	31.513
May 2014	33.493	0	53.018
Jun 2014	20.928	0	39.503
Jul 2014	12.368	0	34.419
Aug 2014	4.669	0	23.546

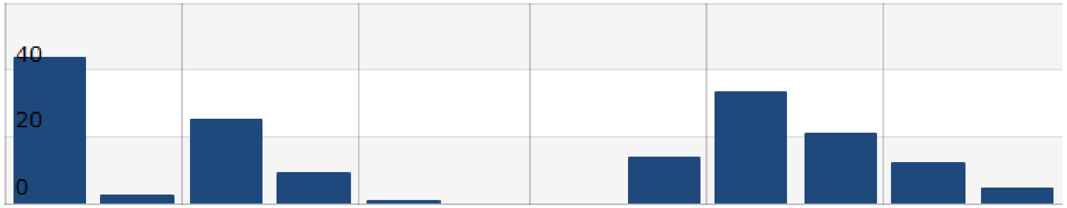
Wilders Grove / OATemp (F)



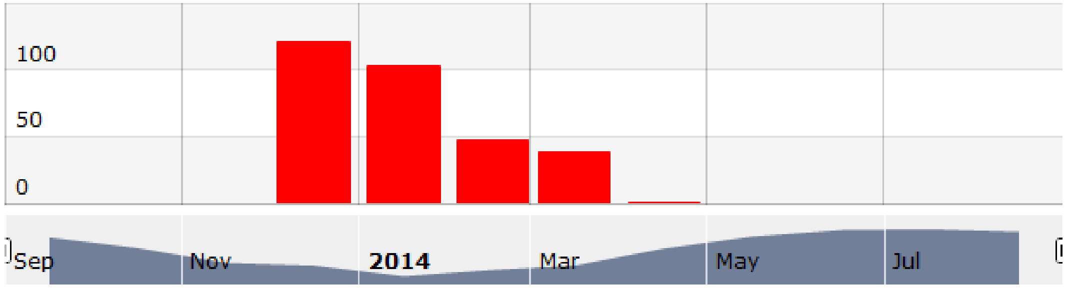
Wilders Grove / WG ADM ZONE TEMP GHP15 (F)



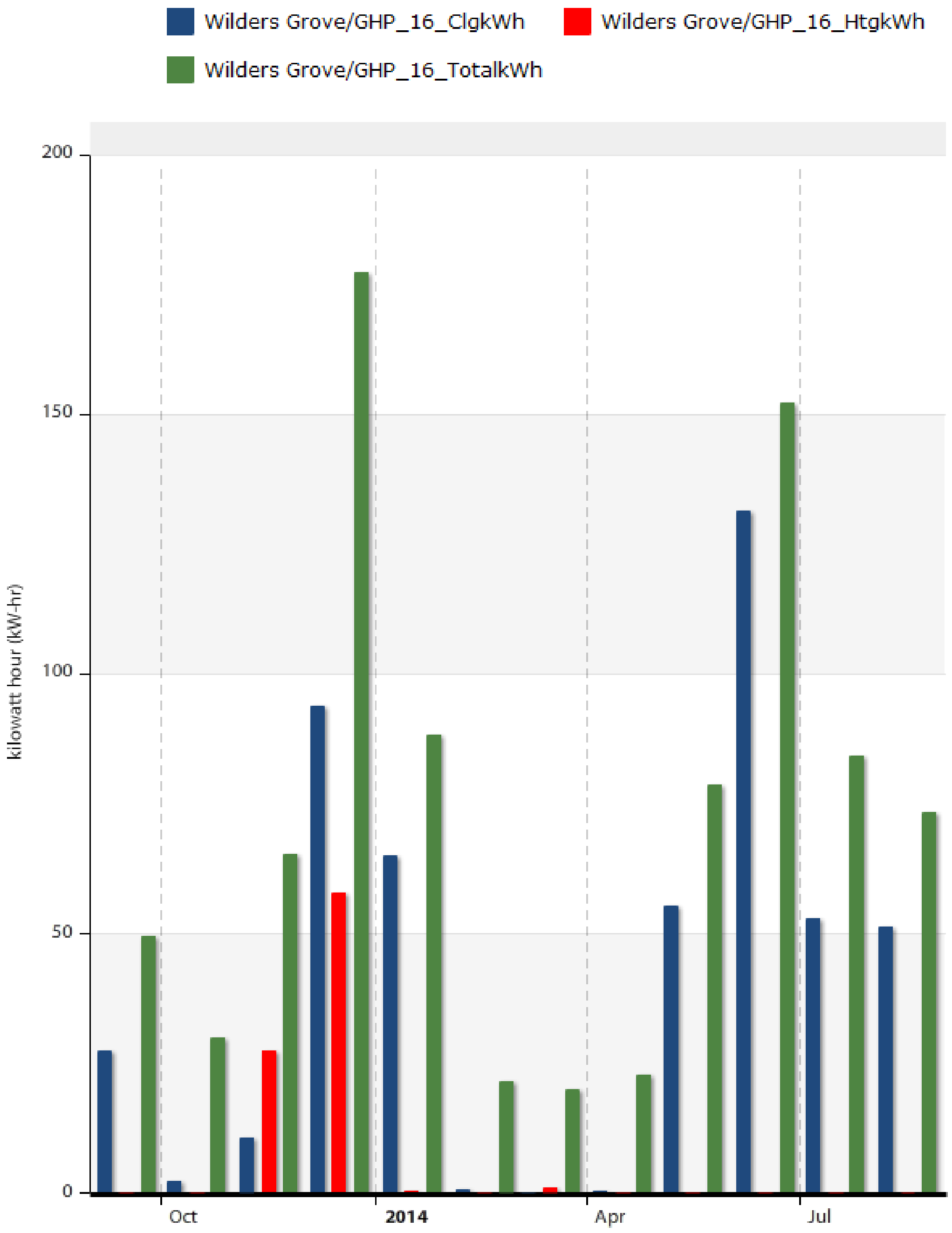
Wilders Grove / GHP_15_ClgkWh (kW-hr)



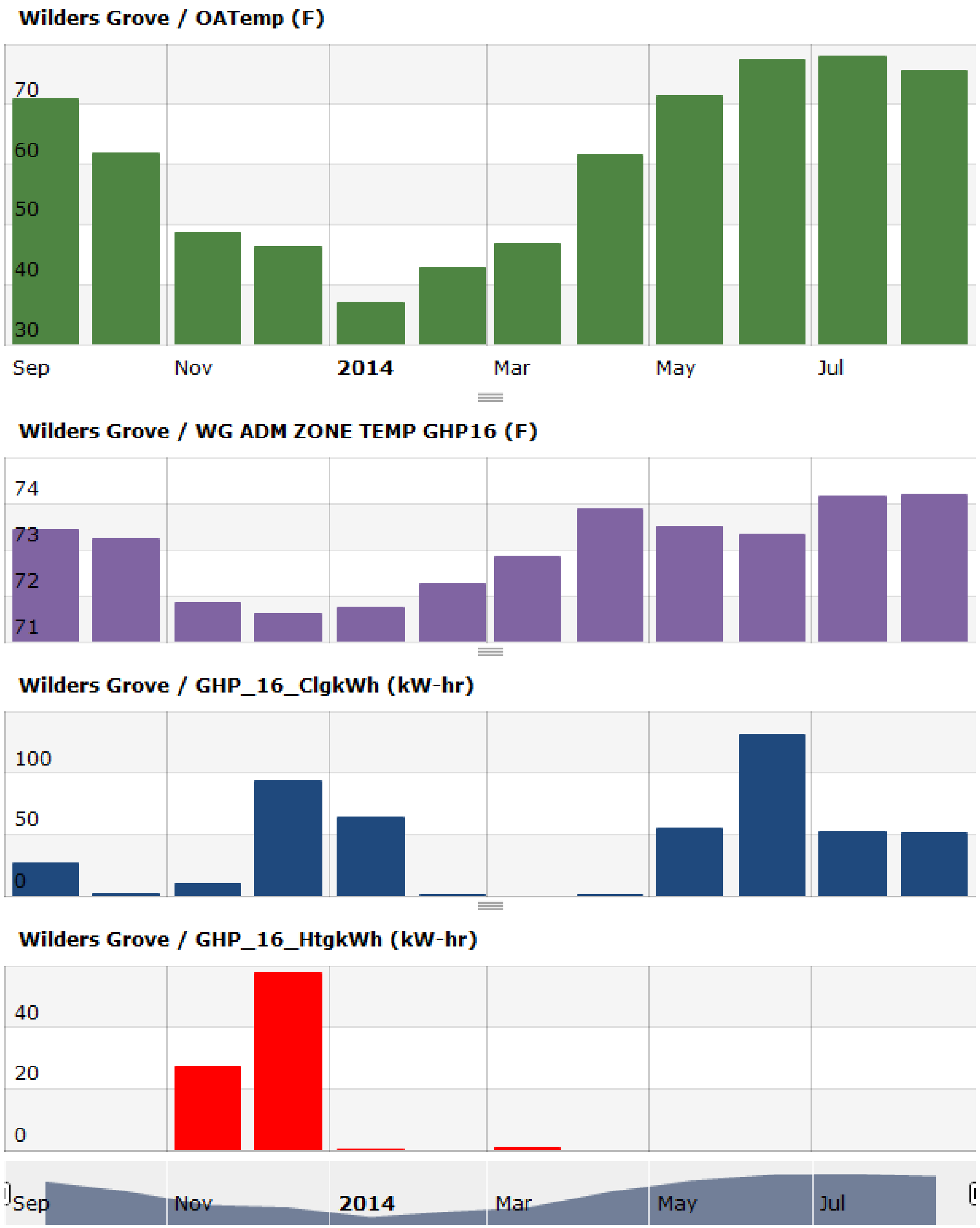
Wilders Grove / GHP_15_HtgkWh (kW-hr)



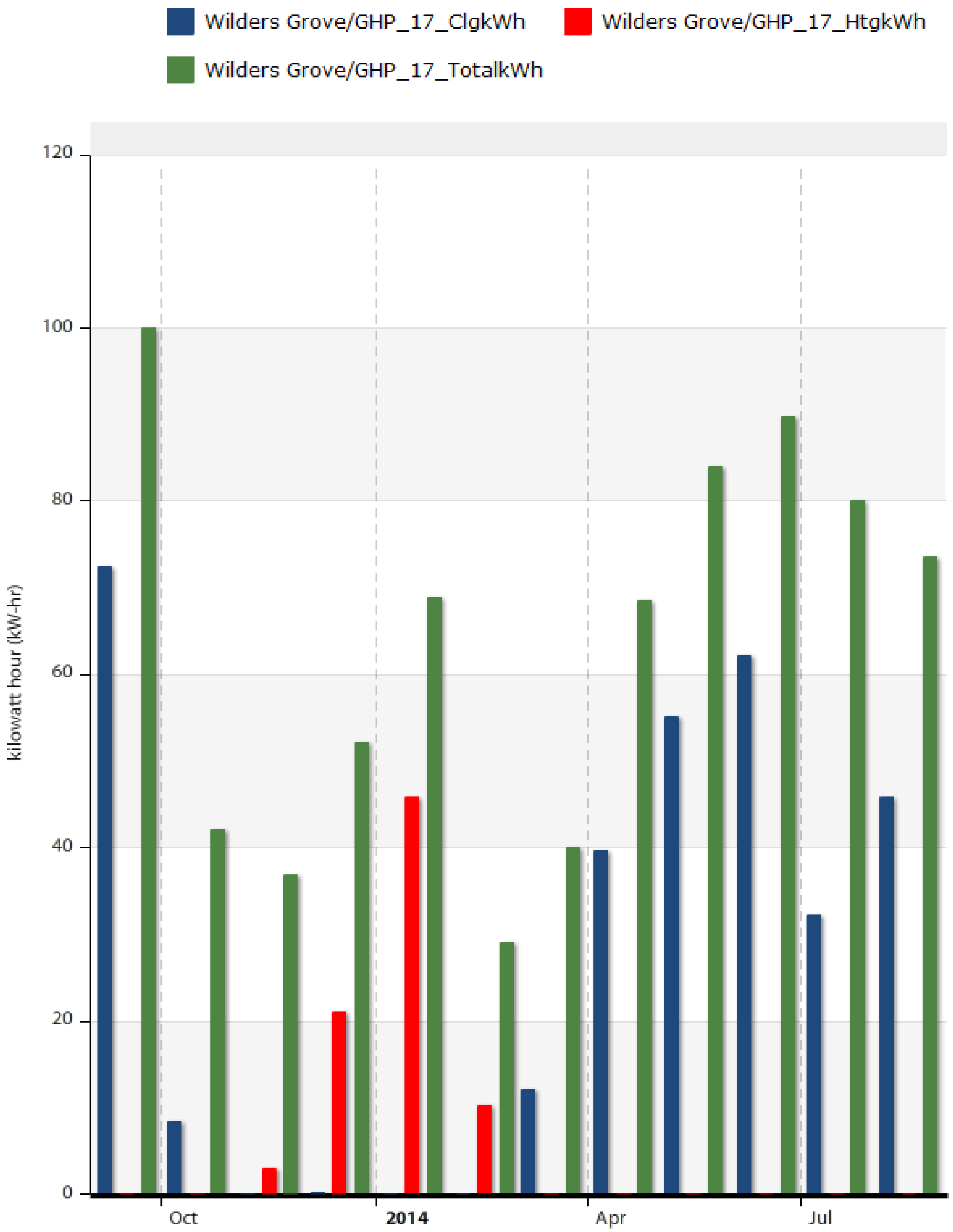
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP15 (F)	Wilders Grove / GHP_15_ClgkWh (kW-hr)	Wilders Grove / GHP_15_HtgkWh (kW-hr)	Events
Sep 2013	70.866	73.033	43.674	0	
Oct 2013	61.964	72.848	2.648	0	
Nov 2013	48.77	71.302	25.371	0	
Dec 2013	46.33	71.805	9.021	120.967	
Jan 2014	37.04	71.997	0.739	103.485	
Feb 2014	42.946	72.037	0	47.679	
Mar 2014	46.722	72.555	0	38.716	
Apr 2014	61.693	73.319	13.734	0.653	
May 2014	71.501	73.294	33.493	0	
Jun 2014	77.411	73.465	20.928	0	
Jul 2014	77.992	73.841	12.368	0	
Aug 2014	75.579	73.912	4.669	0	


Wilders Grove/GHP_16_ClgkWh
Wilders Grove/GHP_16_HtgkWh
Wilders Grove/GHP_16_TotalkWh
kilowatt hour (kW-hr)
200
150
100
50
0
Oct
2014
Apr
Jul

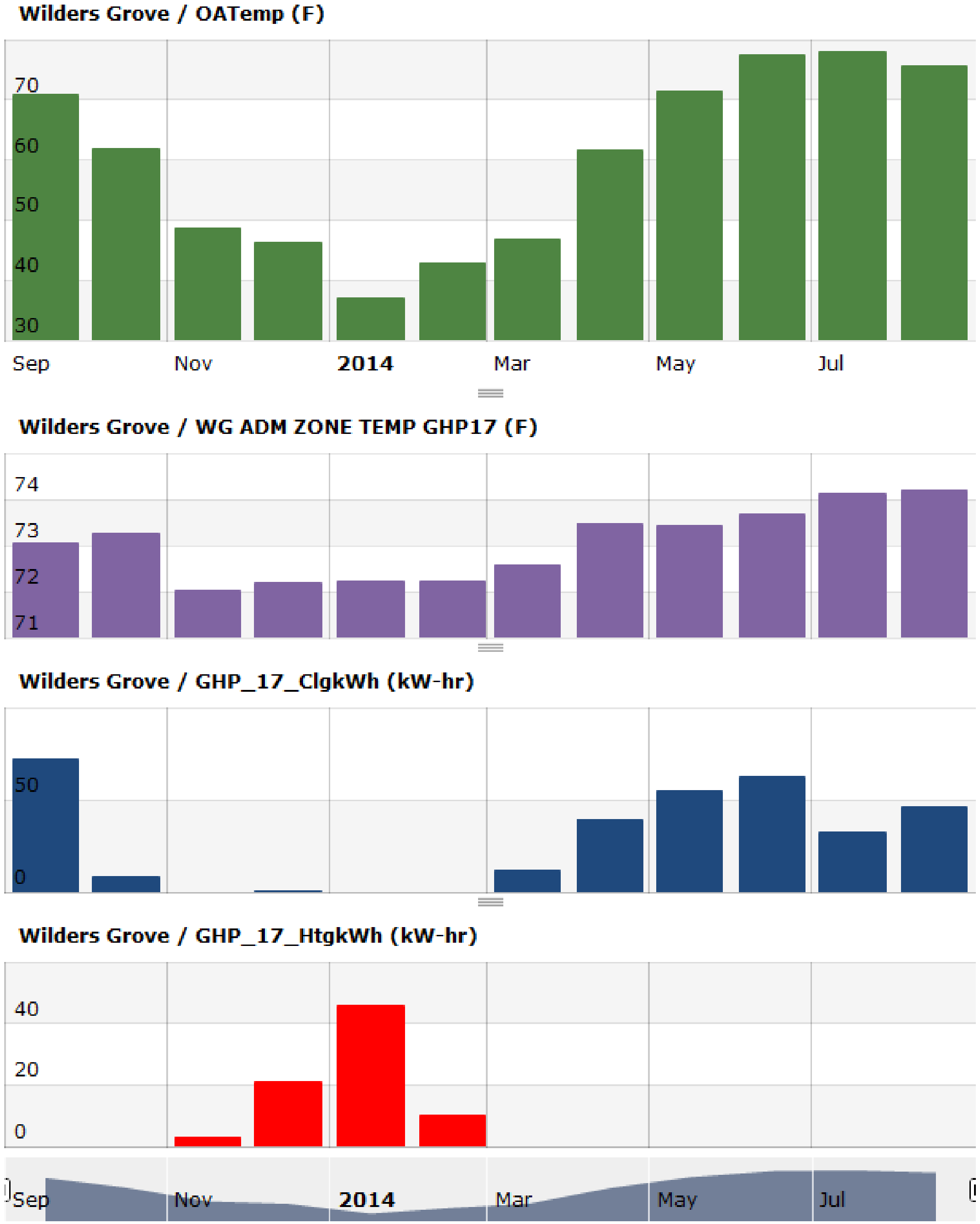
Timestamp	Wilders Grove/GHP_16_ClgkWh (kW-hr)	Wilders Grove/GHP_16_HtgkWh (kW-hr)	Wilders Grove/GHP_16_TotalkWh (kW-hr)
Sep 2013	27.339	0	49.542
Oct 2013	2.372	0	29.981
Nov 2013	10.523	27.465	65.111
Dec 2013	93.774	57.64	177.304
Jan 2014	64.813	0.361	88.153
Feb 2014	0.646	0	21.388
Mar 2014	0	1.04	19.782
Apr 2014	0.237	0	22.735
May 2014	55.266	0	78.531
Jun 2014	131.364	0	152.071
Jul 2014	52.93	0	84.039
Aug 2014	51.286	0	73.178


Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP16 (F)
74
73
72
71
Wilders Grove / GHP_16_ClgkWh (kW-hr)
100
50
0
Wilders Grove / GHP_16_HtgkWh (kW-hr)
40
20
0
Sep
Nov
2014
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP16 (F)	Wilders Grove / GHP_16_ClgkWh (kW-hr)	Wilders Grove / GHP_16_HtgkWh (kW-hr)	Events
Sep 2013	70.866	73.428	27.339	0	
Oct 2013	61.964	73.228	2.372	0	
Nov 2013	48.77	71.847	10.523	27.465	
Dec 2013	46.33	71.621	93.774	57.64	
Jan 2014	37.04	71.745	64.813	0.361	
Feb 2014	42.946	72.281	0.646	0	
Mar 2014	46.722	72.847	0	1.04	
Apr 2014	61.693	73.876	0.237	0	
May 2014	71.501	73.513	55.266	0	
Jun 2014	77.411	73.332	131.364	0	
Jul 2014	77.992	74.151	52.93	0	
Aug 2014	75.579	74.181	51.286	0	


Wilders Grove/GHP_17_ClgkWh
Wilders Grove/GHP_17_HtgkWh
Wilders Grove/GHP_17_TotalkWh
kilowatt hour (kW-hr)
120
100
80
60
40
20
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_17_ClgkWh (kW-hr)	Wilders Grove/GHP_17_HtgkWh (kW-hr)	Wilders Grove/GHP_17_TotalkWh (kW-hr)
Sep 2013	72.463	0	100.099
Oct 2013	8.323	0	42.113
Nov 2013	0	3.046	36.932
Dec 2013	0.259	21.013	52.111
Jan 2014	0	45.871	68.841
Feb 2014	0	10.193	29.001
Mar 2014	12.095	0	40.085
Apr 2014	39.71	0	68.635
May 2014	55.125	0	83.936
Jun 2014	62.226	0	89.76
Jul 2014	32.262	0	80.059
Aug 2014	45.922	0	73.666



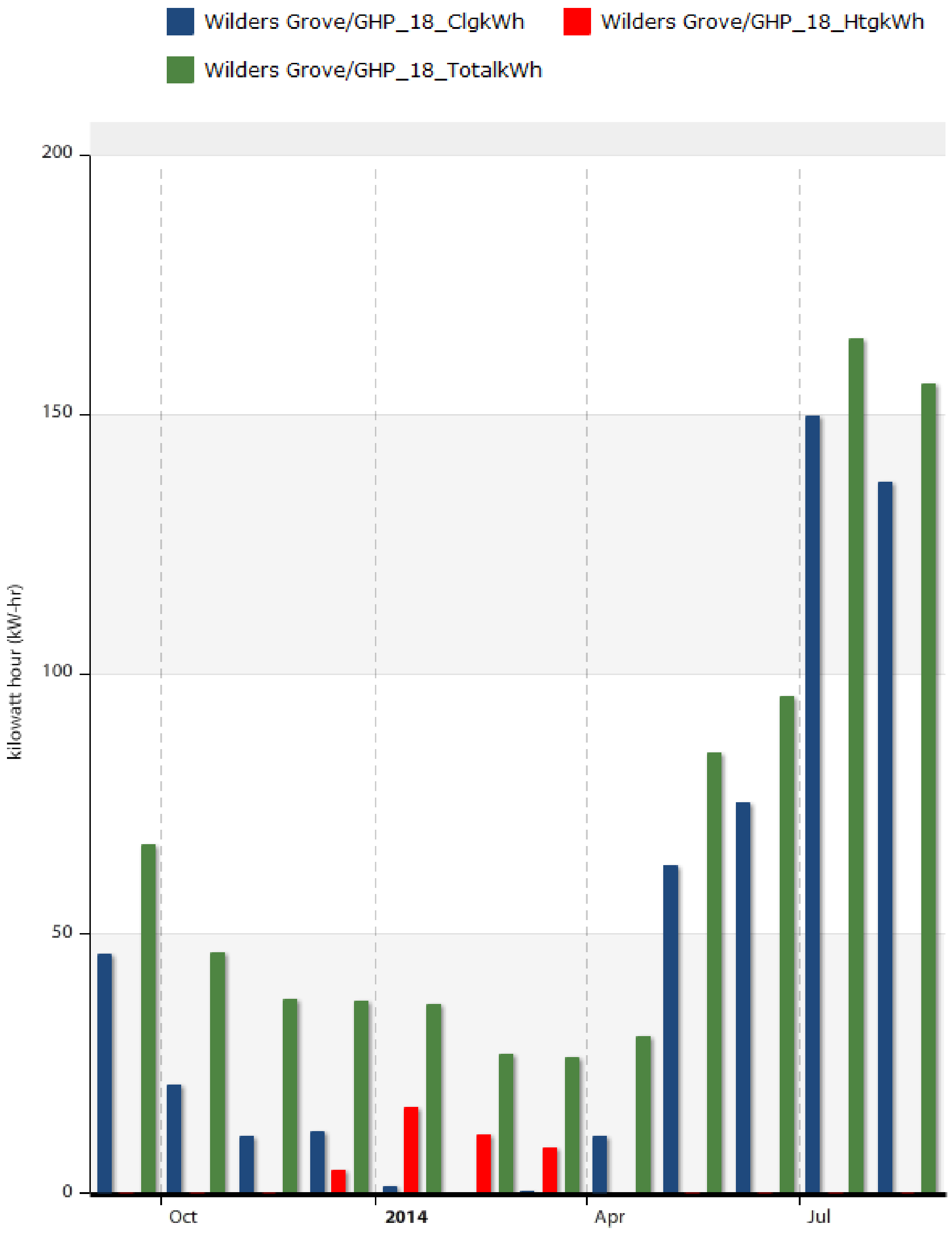
Wilders Grove / OATemp (F)

Wilders Grove / WG ADM ZONE TEMP GHP17 (F)

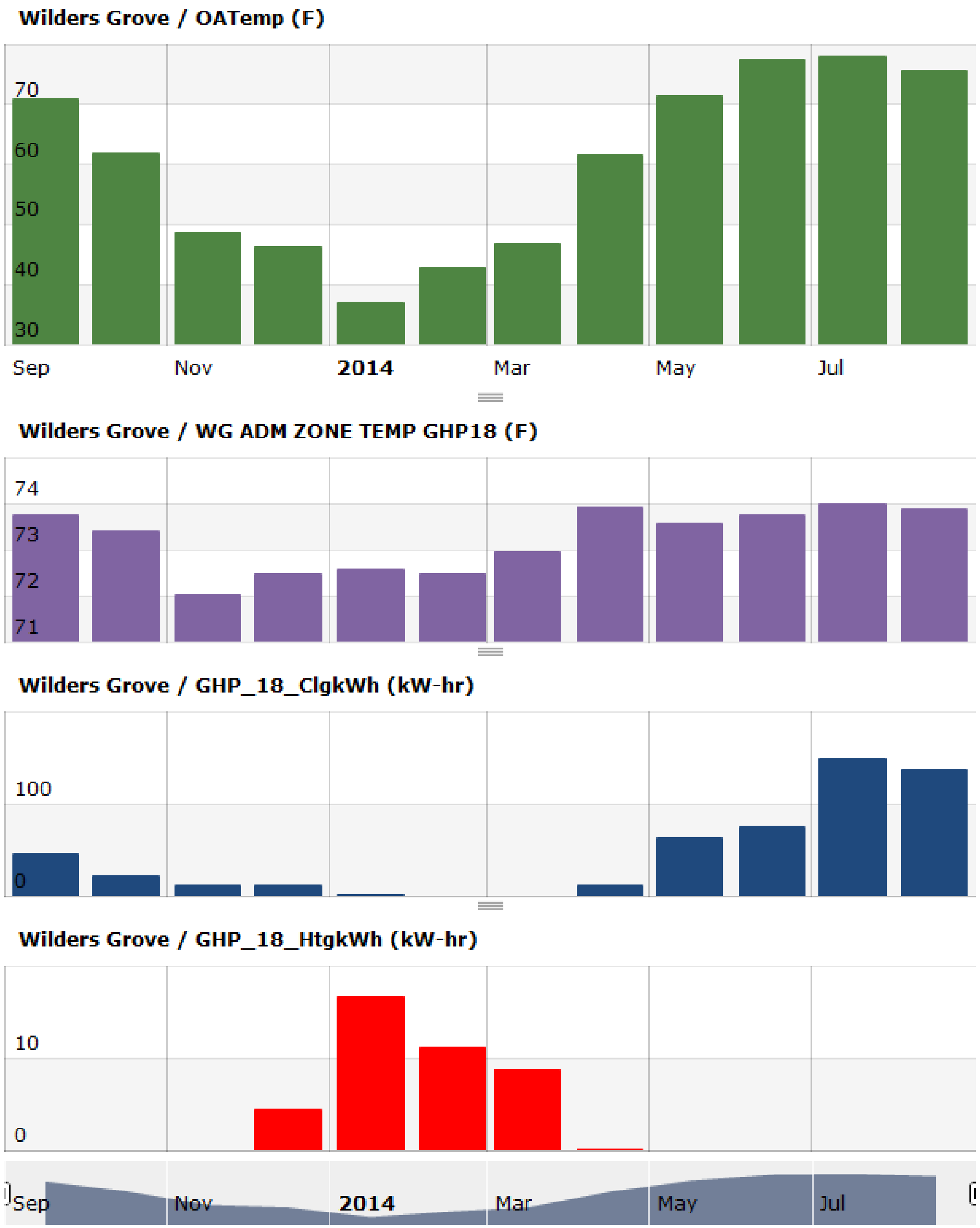
Wilders Grove / GHP_17_ClgkWh (kW-hr)

Wilders Grove / GHP_17_HtgkWh (kW-hr)

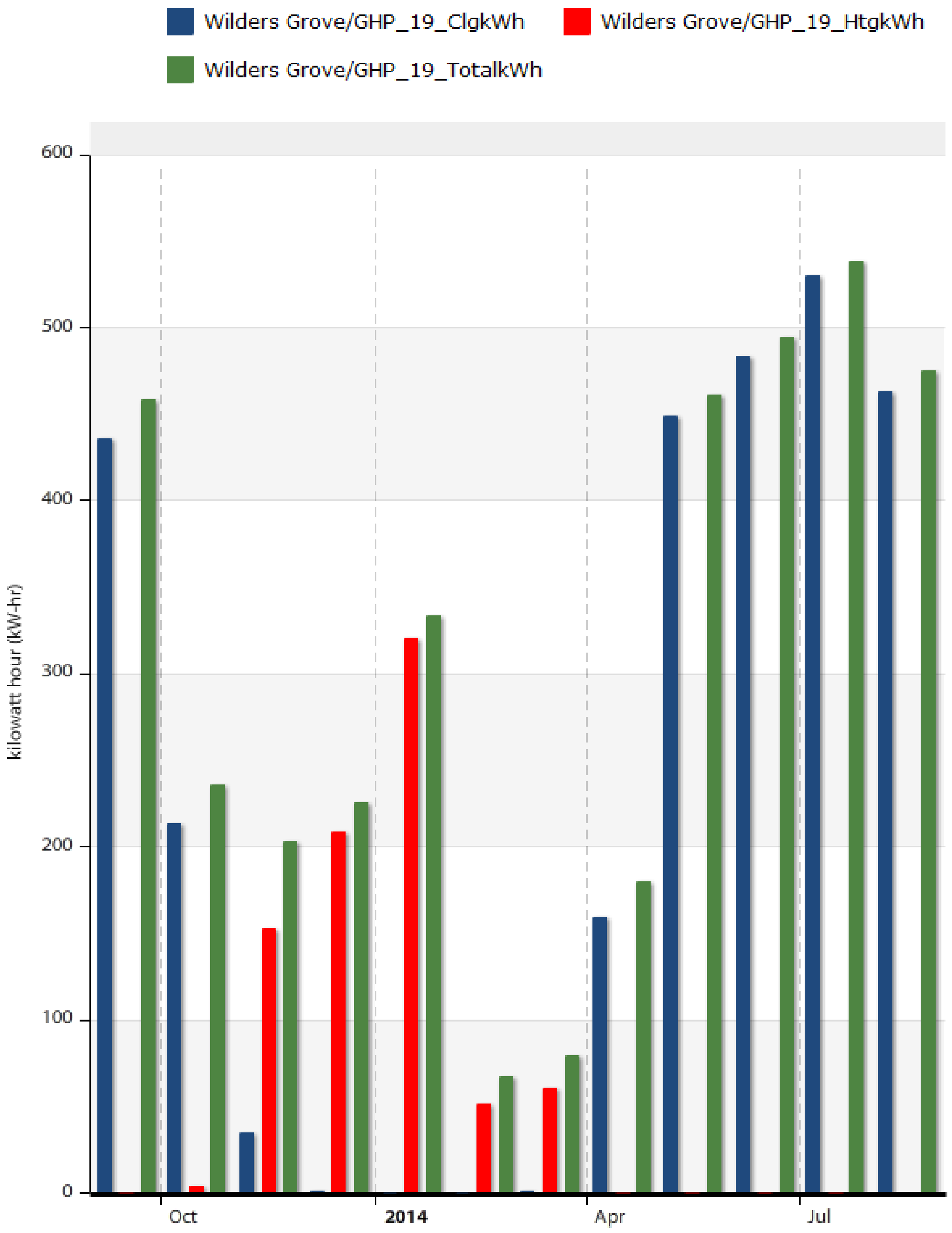
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP17 (F)	Wilders Grove / GHP_17_ClgkWh (kW-hr)	Wilders Grove / GHP_17_HtgkWh (kW-hr)	Events
Sep 2013	70.866	73.051	72.463	0	
Oct 2013	61.964	73.27	8.323	0	
Nov 2013	48.77	72.024	0	3.046	
Dec 2013	46.33	72.189	0.259	21.013	
Jan 2014	37.04	72.236	0	45.871	
Feb 2014	42.946	72.232	0	10.193	
Mar 2014	46.722	72.589	12.095	0	
Apr 2014	61.693	73.487	39.71	0	
May 2014	71.501	73.442	55.125	0	
Jun 2014	77.411	73.663	62.226	0	
Jul 2014	77.992	74.12	32.262	0	
Aug 2014	75.579	74.212	45.922	0	


Wilders Grove/GHP_18_ClgkWh
Wilders Grove/GHP_18_HtgkWh
Wilders Grove/GHP_18_TotalkWh
kilowatt hour (kW-hr)
200
150
100
50
0
Oct
2014
Apr
Jul

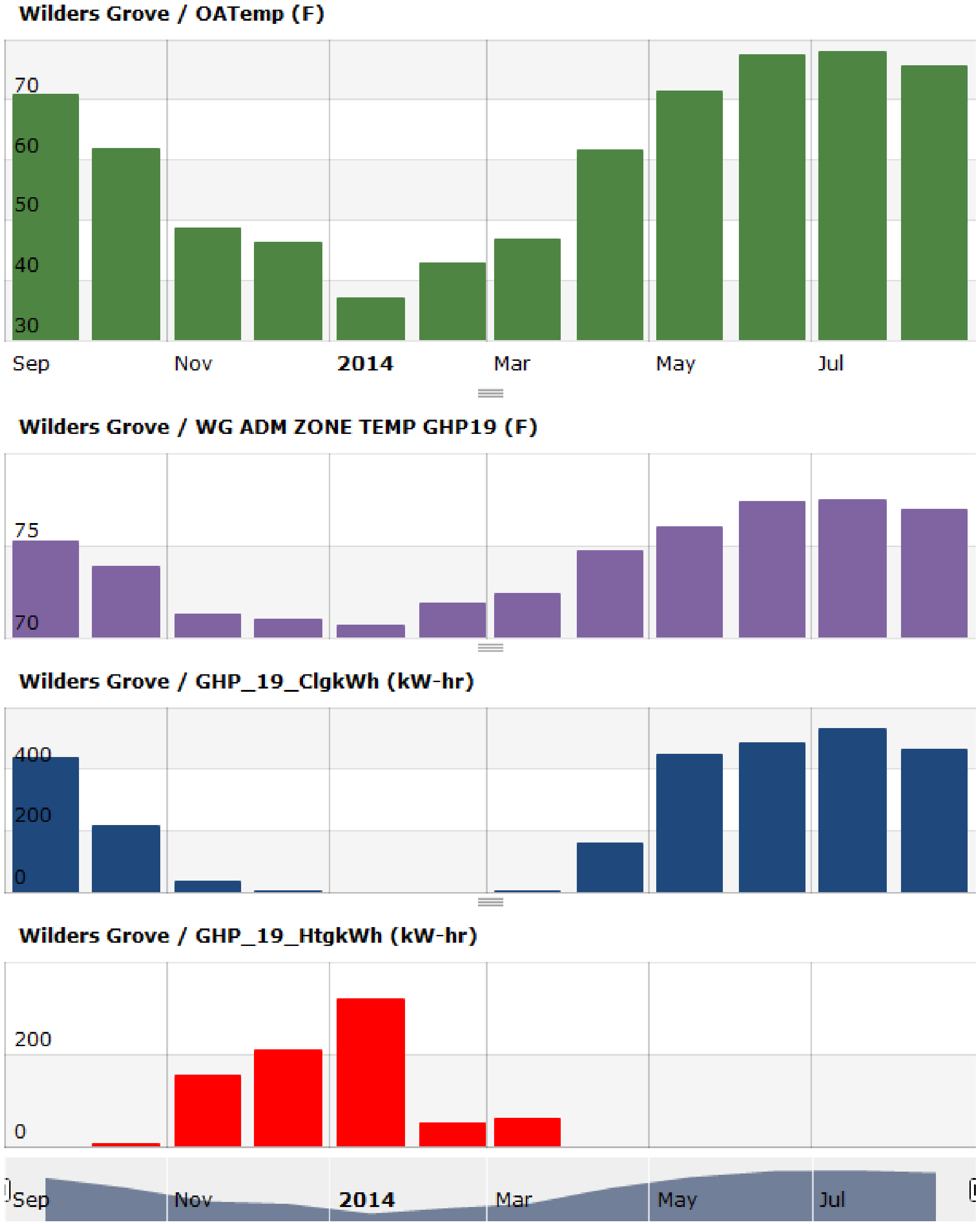
Timestamp	Wilders Grove/GHP_18_ClgkWh (kW-hr)	Wilders Grove/GHP_18_HtgkWh (kW-hr)	Wilders Grove/GHP_18_TotalkWh (kW-hr)
Sep 2013	45.884	0	66.97
Oct 2013	20.964	0	46.311
Nov 2013	11.028	0	37.182
Dec 2013	11.716	4.355	36.989
Jan 2014	1.269	16.618	36.203
Feb 2014	0.187	11.229	26.595
Mar 2014	0.22	8.777	26.123
Apr 2014	10.825	0.176	30.012
May 2014	63.196	0	84.891
Jun 2014	75.255	0	95.598
Jul 2014	149.556	0	164.488
Aug 2014	137.04	0	155.919


Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP18 (F)
74
73
72
71
Wilders Grove / GHP_18_ClgkWh (kW-hr)
100
0
Wilders Grove / GHP_18_HtgkWh (kW-hr)
10
0
Sep
Nov
2014
Mar
May
Jul

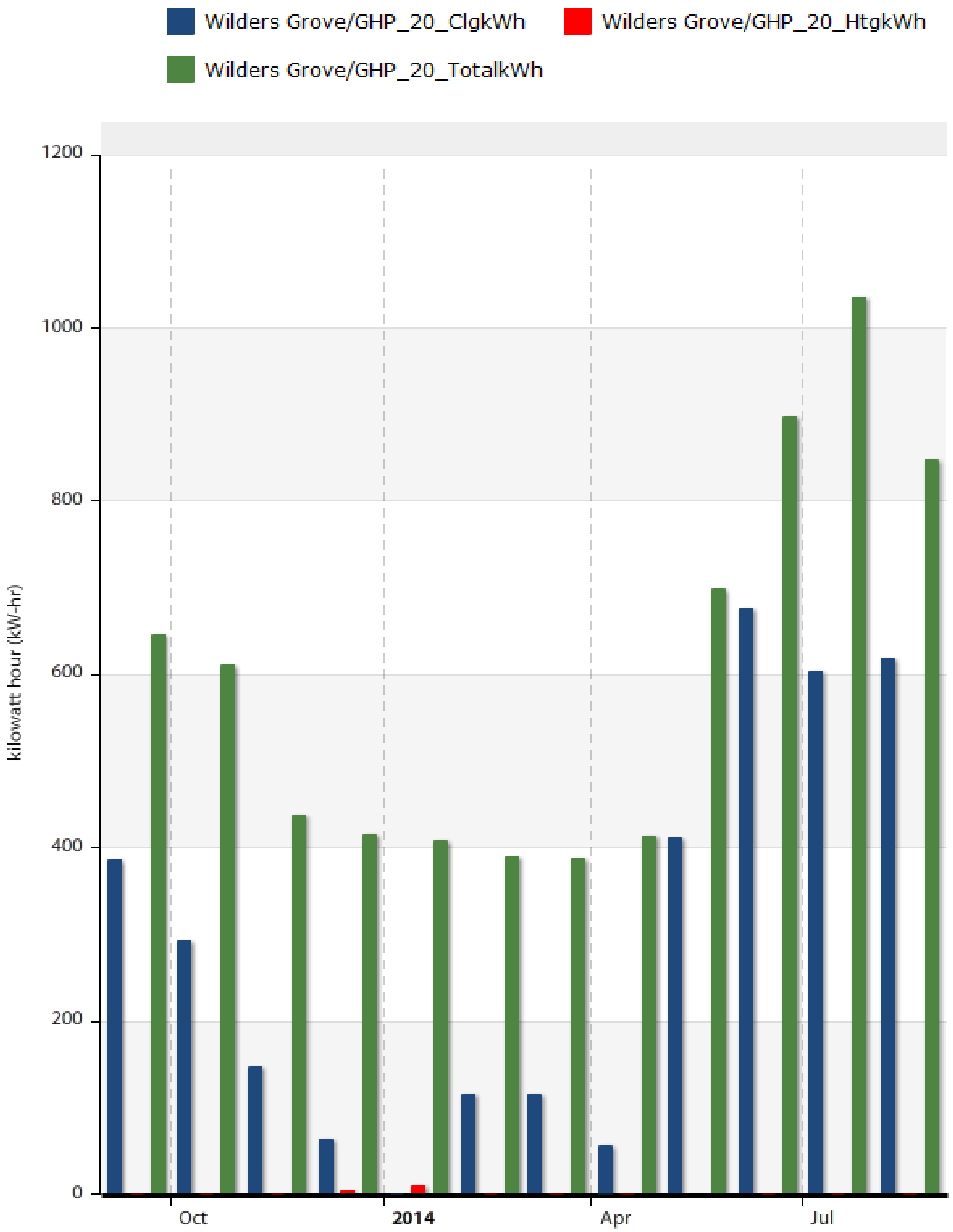
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP18 (F)	Wilders Grove / GHP_18_ClgkWh (kW-hr)	Wilders Grove / GHP_18_HtgkWh (kW-hr)	Events
Sep 2013	70.866	73.733	45.884	0	
Oct 2013	61.964	73.397	20.964	0	
Nov 2013	48.77	72.024	11.028	0	
Dec 2013	46.33	72.487	11.716	4.355	
Jan 2014	37.04	72.566	1.269	16.618	
Feb 2014	42.946	72.483	0.187	11.229	
Mar 2014	46.722	72.958	0.22	8.777	
Apr 2014	61.693	73.931	10.825	0.176	
May 2014	71.501	73.58	63.196	0	
Jun 2014	77.411	73.732	75.255	0	
Jul 2014	77.992	74.002	149.556	0	
Aug 2014	75.579	73.87	137.04	0	


Wilders Grove/GHP_19_ClgkWh
Wilders Grove/GHP_19_HtgkWh
Wilders Grove/GHP_19_TotalkWh
kilowatt hour (kW-hr)
600
500
400
300
200
100
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_19_ClgkWh (kW-hr)	Wilders Grove/GHP_19_HtgkWh (kW-hr)	Wilders Grove/GHP_19_TotalkWh (kW-hr)
Sep 2013	435.77	0	458.332
Oct 2013	213.312	4.184	236.028
Nov 2013	34.166	152.916	203.299
Dec 2013	1.125	208.949	225.212
Jan 2014	0	320.136	333.363
Feb 2014	0.097	51.233	67.318
Mar 2014	1.408	60.837	78.93
Apr 2014	158.947	0	179.997
May 2014	448.837	0	460.896
Jun 2014	483.591	0	494.709
Jul 2014	529.929	0	538.598
Aug 2014	463.057	0.238	474.986

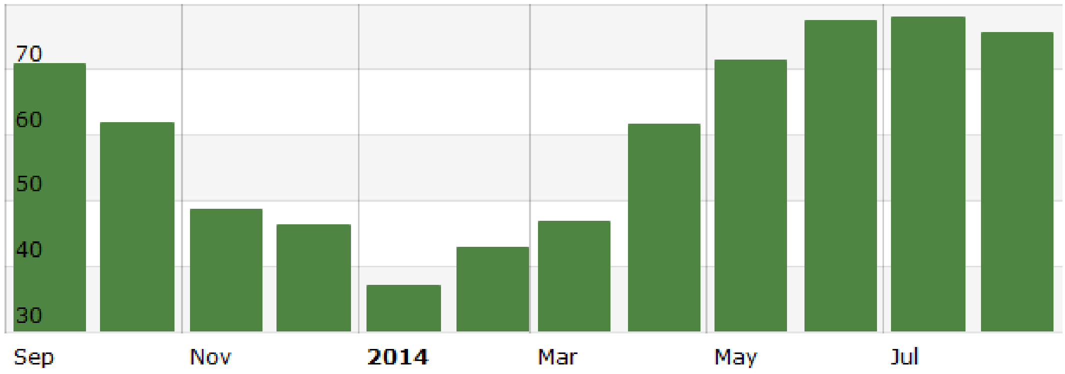

Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP19 (F)
75
70
Wilders Grove / GHP_19_ClgkWh (kW-hr)
400
200
0
Wilders Grove / GHP_19_HtgkWh (kW-hr)
200
0
Sep
Nov
2014
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP19 (F)	Wilders Grove / GHP_19_ClgkWh (kW-hr)	Wilders Grove / GHP_19_HtgkWh (kW-hr)	Events
Sep 2013	70.866	75.269	435.77	0	
Oct 2013	61.964	73.884	213.312	4.184	
Nov 2013	48.77	71.301	34.166	152.916	
Dec 2013	46.33	70.972	1.125	208.949	
Jan 2014	37.04	70.641	0	320.136	
Feb 2014	42.946	71.857	0.097	51.233	
Mar 2014	46.722	72.391	1.408	60.837	
Apr 2014	61.693	74.694	158.947	0	
May 2014	71.501	75.987	448.837	0	
Jun 2014	77.411	77.402	483.591	0	
Jul 2014	77.992	77.483	529.929	0	
Aug 2014	75.579	76.964	463.057	0.238	

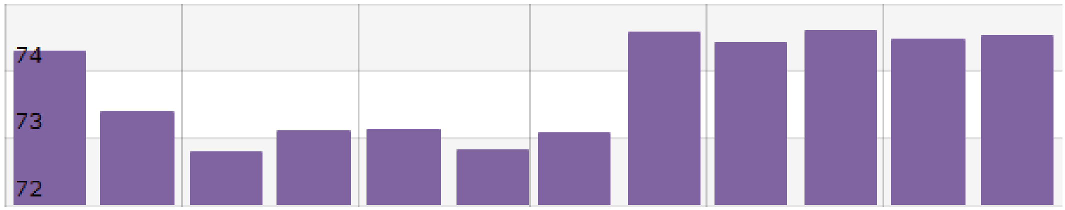

Wilders Grove/GHP_20_ClgkWh
Wilders Grove/GHP_20_HtgkWh
Wilders Grove/GHP_20_TotalkWh
kilowatt hour (kW-hr)
1200
1000
800
600
400
200
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_20_ClgkWh (kW-hr)	Wilders Grove/GHP_20_HtgkWh (kW-hr)	Wilders Grove/GHP_20_TotalkWh (kW-hr)
Sep 2013	386.244	0	645.961
Oct 2013	292.433	0	610.966
Nov 2013	147.425	0	438.732
Dec 2013	64.437	3.341	415.693
Jan 2014	0	8.936	408.815
Feb 2014	116.6	0	389.015
Mar 2014	115.755	0	387.442
Apr 2014	55.698	0	414.186
May 2014	411.695	1.102	699.051
Jun 2014	675.325	0	897.402
Jul 2014	603.884	0	1035.291
Aug 2014	619.007	0	848.3

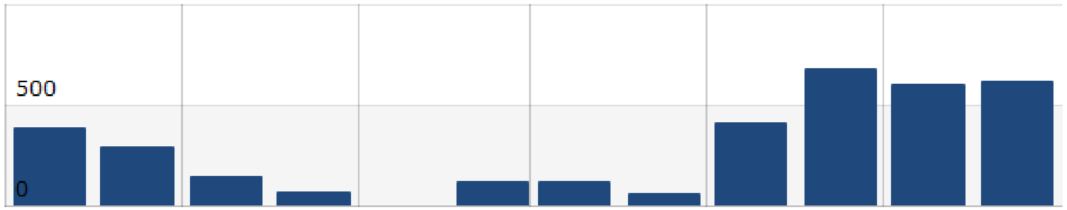
Wilders Grove / OATemp (F)



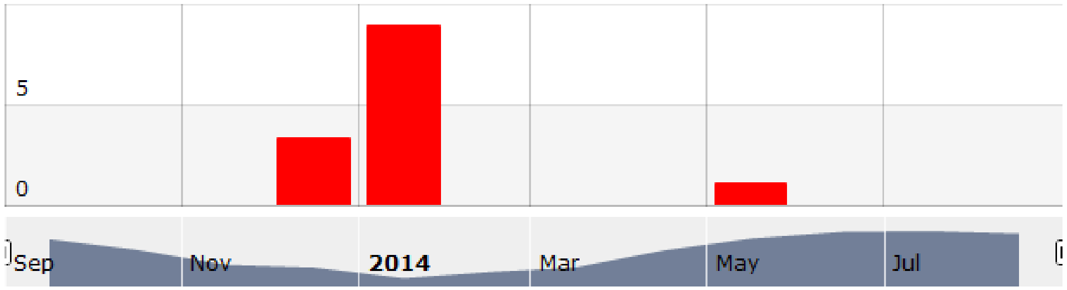
Wilders Grove / WG ADM ZONE TEMP GHP20 (F)



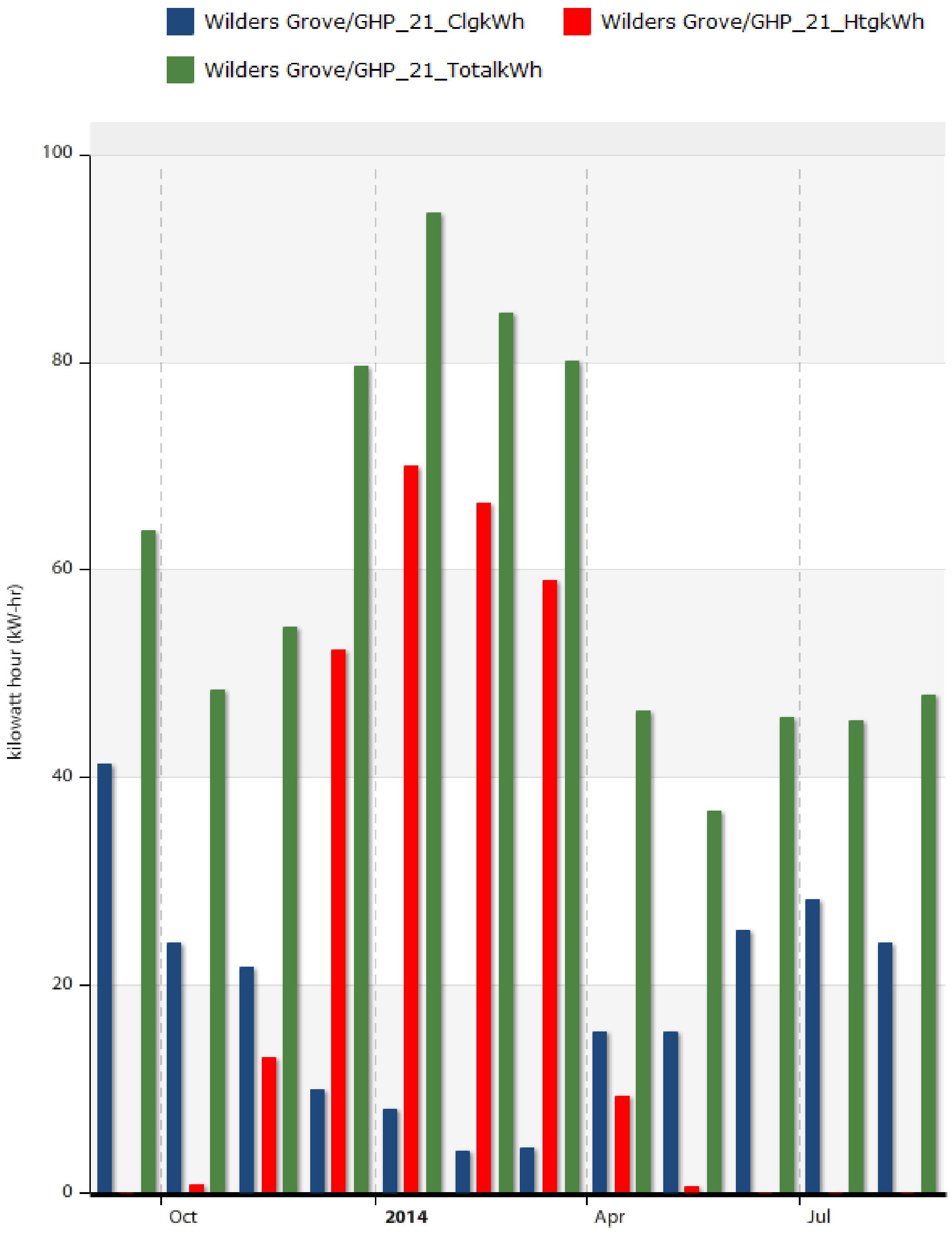
Wilders Grove / GHP_20_ClgkWh (kW-hr)



Wilders Grove / GHP_20_HtgkWh (kW-hr)

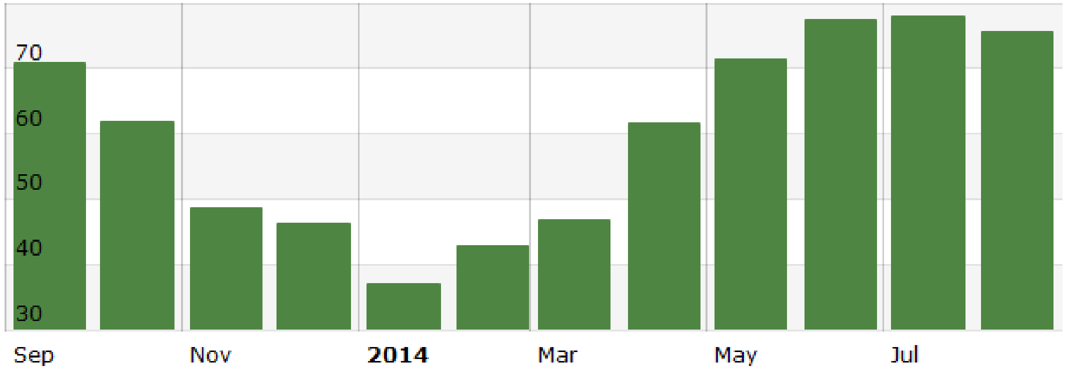


Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP20 (F)	Wilders Grove / GHP_20_ClgkWh (kW-hr)	Wilders Grove / GHP_20_HtgkWh (kW-hr)	Events
Sep 2013	70.866	74.302	386.244	0	
Oct 2013	61.964	73.4	292.433	0	
Nov 2013	48.77	72.789	147.425	0	
Dec 2013	46.33	73.102	64.437	3.341	
Jan 2014	37.04	73.133	0	8.936	
Feb 2014	42.946	72.819	116.6	0	
Mar 2014	46.722	73.073	115.755	0	
Apr 2014	61.693	74.572	55.698	0	
May 2014	71.501	74.434	411.695	1.102	
Jun 2014	77.411	74.601	675.325	0	
Jul 2014	77.992	74.467	603.884	0	
Aug 2014	75.579	74.515	619.007	0	

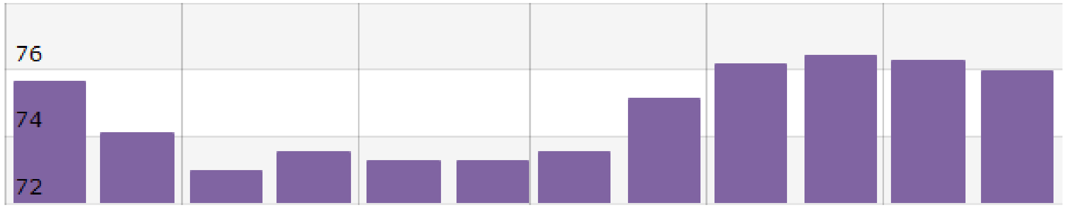

Wilders Grove/GHP_21_ClgkWh
Wilders Grove/GHP_21_HtgkWh
Wilders Grove/GHP_21_TotalkWh
kilowatt hour (kW-hr)
100
80
60
40
20
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_21_ClgkWh (kW-hr)	Wilders Grove/GHP_21_HtgkWh (kW-hr)	Wilders Grove/GHP_21_TotalkWh (kW-hr)
Sep 2013	41.369	0	63.729
Oct 2013	24.096	0.77	48.468
Nov 2013	21.7	13.081	54.558
Dec 2013	10.019	52.282	79.634
Jan 2014	8.038	70.016	94.383
Feb 2014	4.101	66.403	84.756
Mar 2014	4.416	59.019	80.059
Apr 2014	15.598	9.318	46.455
May 2014	15.583	0.6	36.752
Jun 2014	25.327	0	45.721
Jul 2014	28.259	0	45.474
Aug 2014	24.046	0	47.968

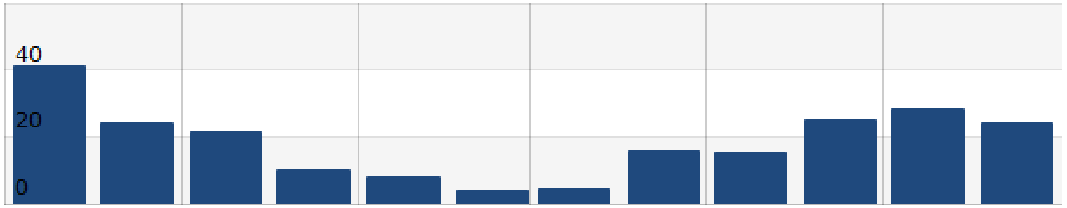
Wilders Grove / OATemp (F)



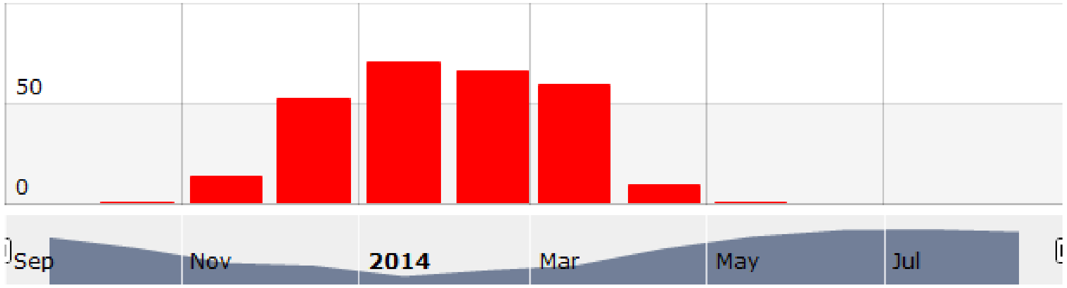
Wilders Grove / WG ADM ZONE TEMP GHP21 (F)



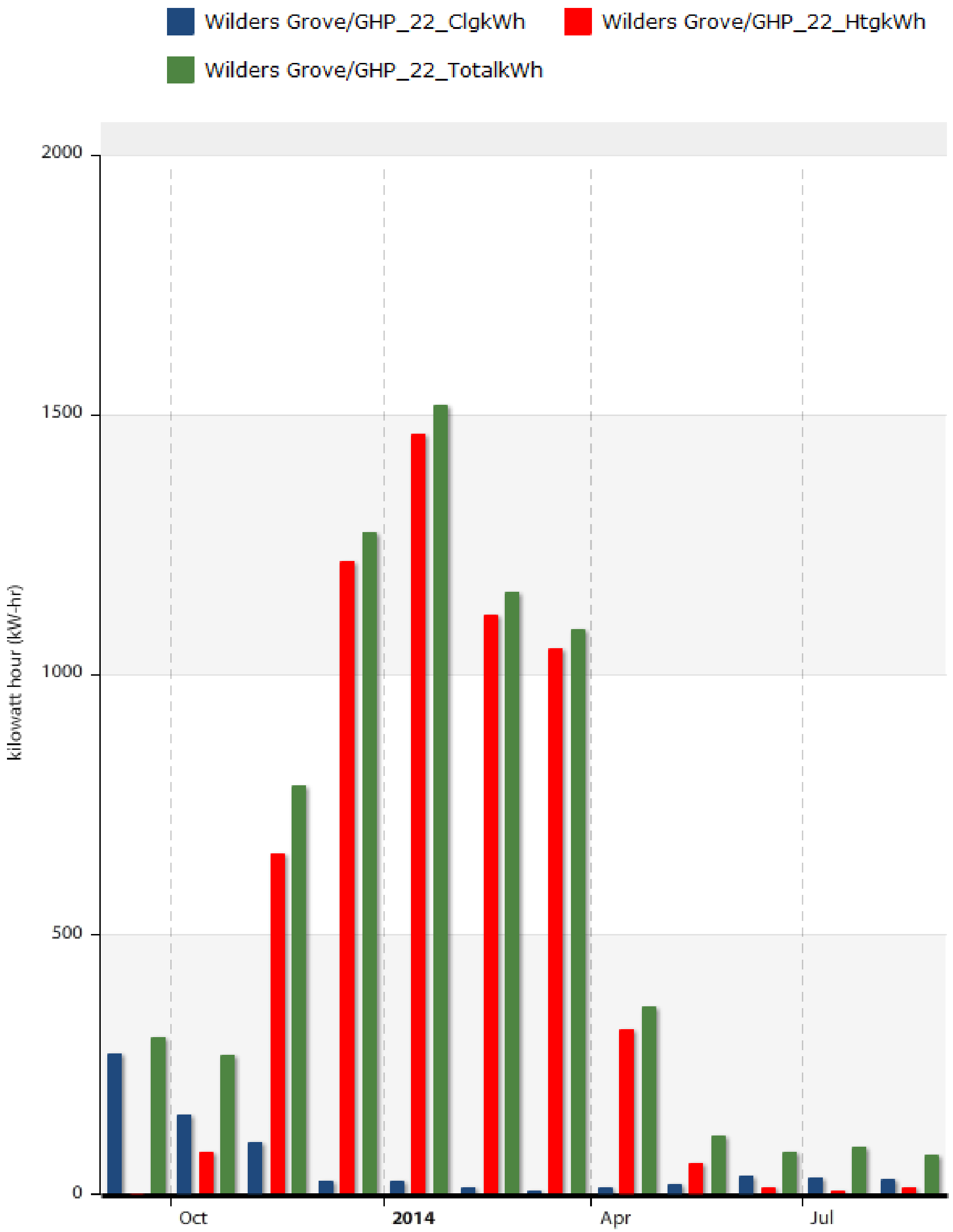
Wilders Grove / GHP_21_ClgkWh (kW-hr)



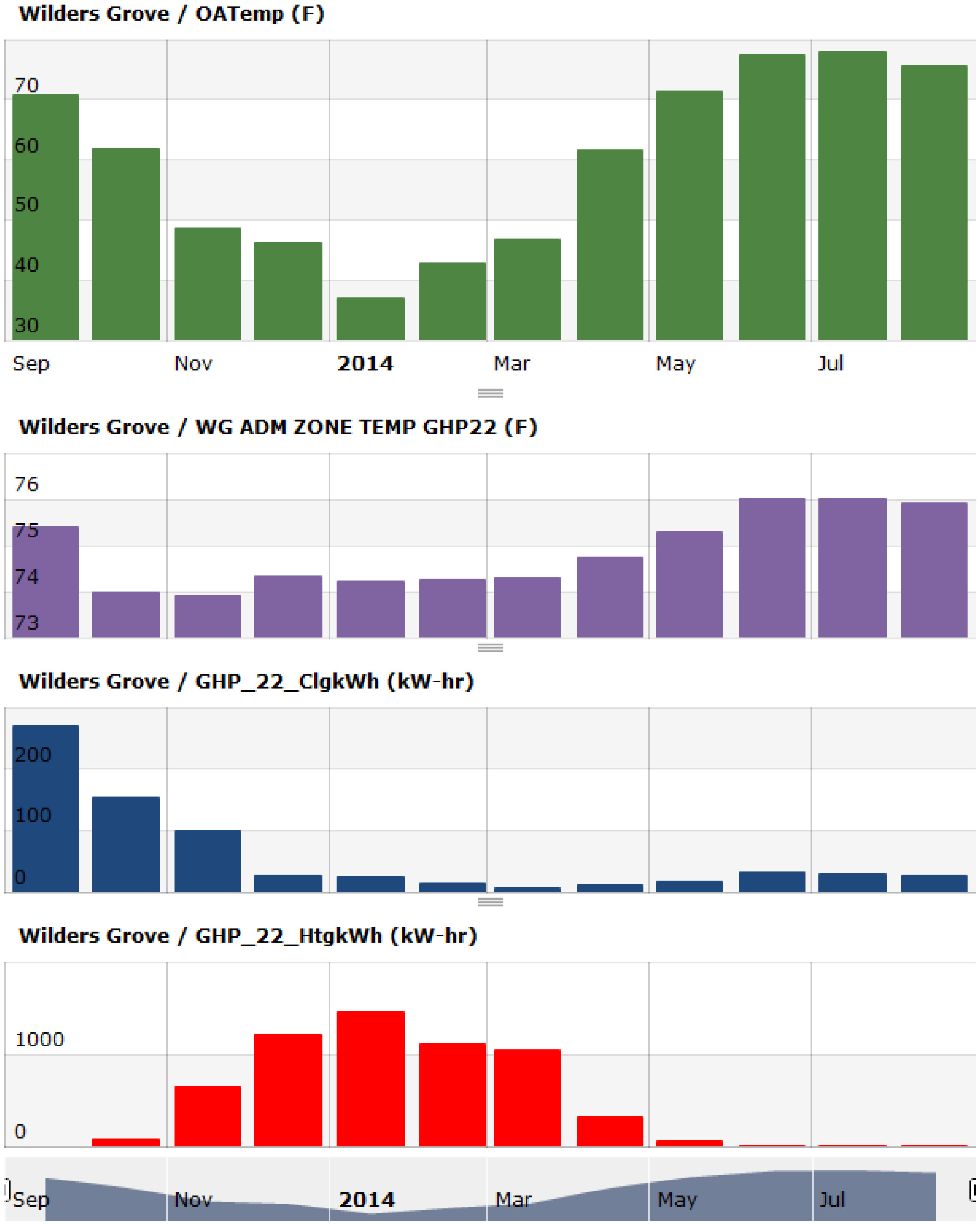
Wilders Grove / GHP_21_HtgkWh (kW-hr)



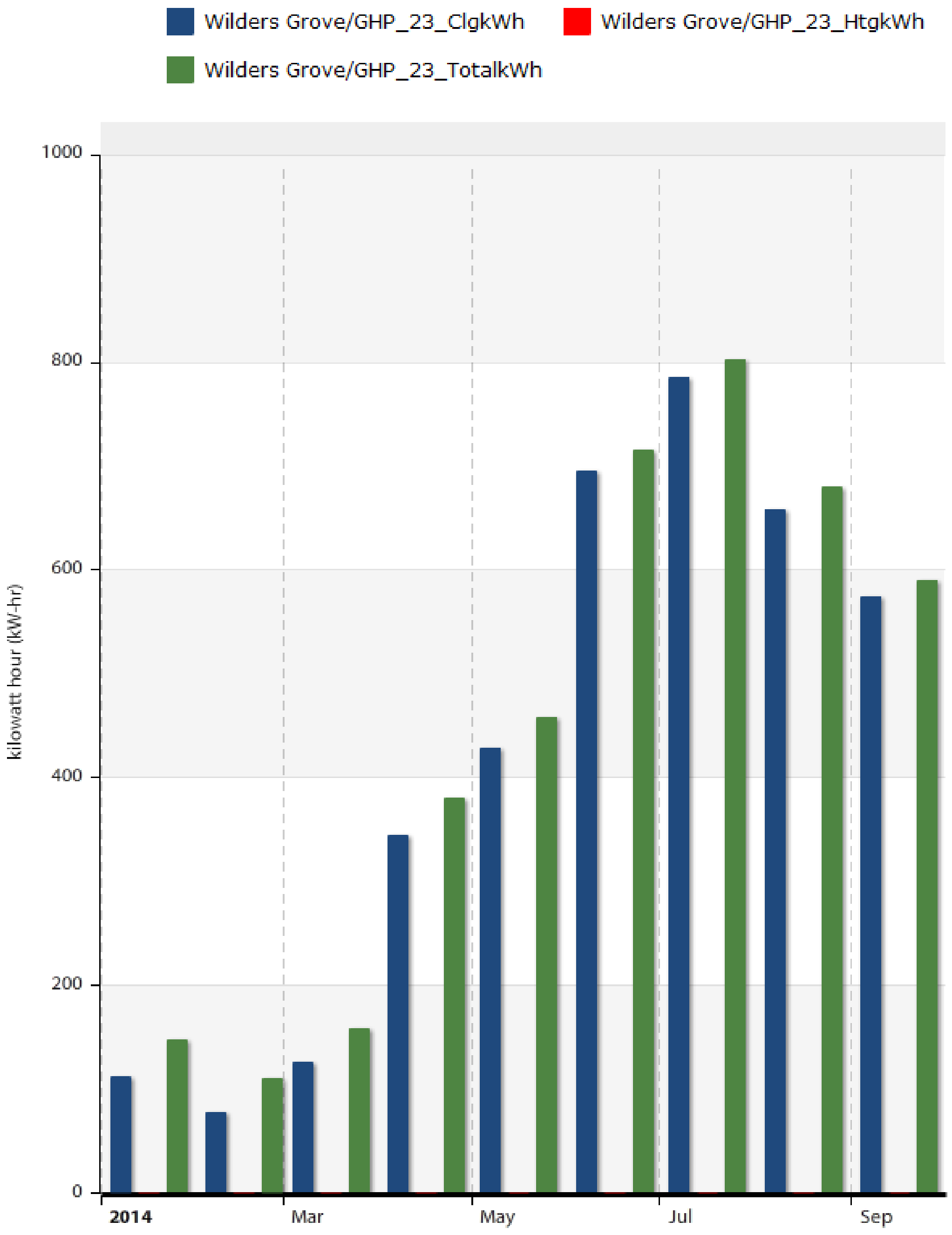
Timestamp	**Wilders Grove / OATemp (F)**	**Wilders Grove / WG ADM ZONE TEMP GHP21 (F)**	**Wilders Grove / GHP_21_ClgkWh (kW-hr)**	**Wilders Grove / GHP_21_HtgkWh (kW-hr)**	**Events**
Sep 2013	70.866	75.652	41.369	0	
Oct 2013	61.964	74.124	24.096	0.77	
Nov 2013	48.77	72.989	21.7	13.081	
Dec 2013	46.33	73.532	10.019	52.282	
Jan 2014	37.04	73.261	8.038	70.016	
Feb 2014	42.946	73.28	4.101	66.403	
Mar 2014	46.722	73.556	4.416	59.019	
Apr 2014	61.693	75.112	15.598	9.318	
May 2014	71.501	76.15	15.583	0.6	
Jun 2014	77.411	76.449	25.327	0	
Jul 2014	77.992	76.273	28.259	0	
Aug 2014	75.579	75.97	24.046	0	


Wilders Grove/GHP_22_ClgkWh
Wilders Grove/GHP_22_HtgkWh
Wilders Grove/GHP_22_TotalkWh
kilowatt hour (kW-hr)
2000
1500
1000
500
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_22_ClgkWh (kW-hr)	Wilders Grove/GHP_22_HtgkWh (kW-hr)	Wilders Grove/GHP_22_TotalkWh (kW-hr)
Sep 2013	269.373	0	301.242
Oct 2013	153.145	81.55	266.004
Nov 2013	100.412	656.695	786.399
Dec 2013	26.274	1215.493	1273.502
Jan 2014	25.333	1461.277	1517.513
Feb 2014	14.014	1114.198	1156.731
Mar 2014	6.114	1048.593	1086.688
Apr 2014	12.138	316.162	361.73
May 2014	18.292	60.298	113.721
Jun 2014	33.868	12.848	81.457
Jul 2014	30.054	6.096	91.66
Aug 2014	26.929	14.126	75.376

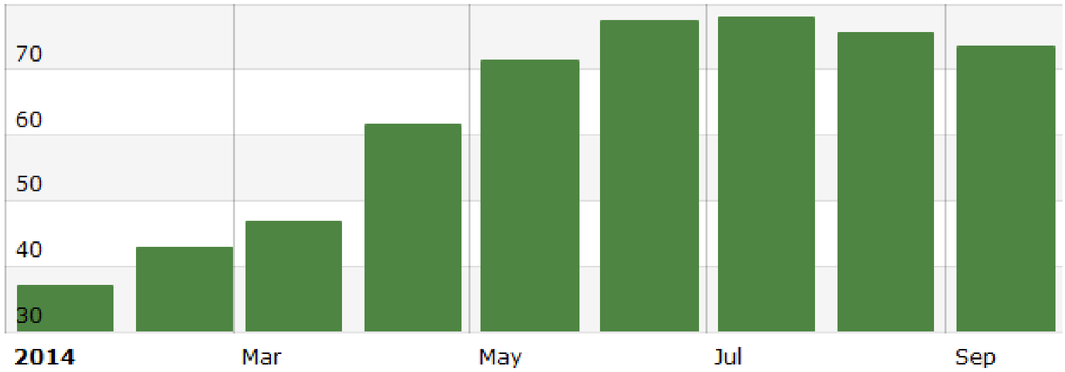

Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP22 (F)
76
75
74
73
Wilders Grove / GHP_22_ClgkWh (kW-hr)
200
100
0
Wilders Grove / GHP_22_HtgkWh (kW-hr)
1000
0
Sep
Nov
2014
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP22 (F)	Wilders Grove / GHP_22_ClgkWh (kW-hr)	Wilders Grove / GHP_22_HtgkWh (kW-hr)	Events
Sep 2013	70.866	75.389	269.373	0	
Oct 2013	61.964	73.988	153.145	81.55	
Nov 2013	48.77	73.926	100.412	656.695	
Dec 2013	46.33	74.32	26.274	1215.493	
Jan 2014	37.04	74.231	25.333	1461.277	
Feb 2014	42.946	74.25	14.014	1114.198	
Mar 2014	46.722	74.31	6.114	1048.593	
Apr 2014	61.693	74.739	12.138	316.162	
May 2014	71.501	75.295	18.292	60.298	
Jun 2014	77.411	76.022	33.868	12.848	
Jul 2014	77.992	76.017	30.054	6.096	
Aug 2014	75.579	75.906	26.929	14.126	

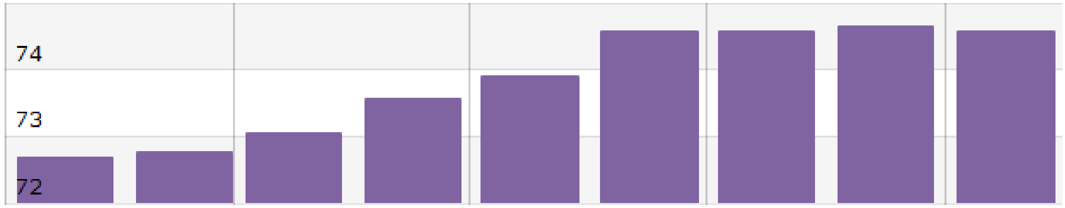

Wilders Grove/GHP_23_ClgkWh
Wilders Grove/GHP_23_HtgkWh
Wilders Grove/GHP_23_TotalkWh
kilowatt hour (kW-hr)
1000
800
600
400
200
0
2014
Mar
May
Jul
Sep

Timestamp	Wilders Grove/GHP_23_ClgkWh (kW-hr)	Wilders Grove/GHP_23_HtgkWh (kW-hr)	Wilders Grove/GHP_23_TotalkWh (kW-hr)
Jan 2014	111.602	0	146.992
Feb 2014	78.535	0	110.06
Mar 2014	126.034	0	158.795
Apr 2014	344.221	0	379.6
May 2014	428.719	0	457.775
Jun 2014	694.934	0	715.263
Jul 2014	785.029	0	801.836
Aug 2014	658.444	0	679.752
Sep 2014	573.856	0	590.09

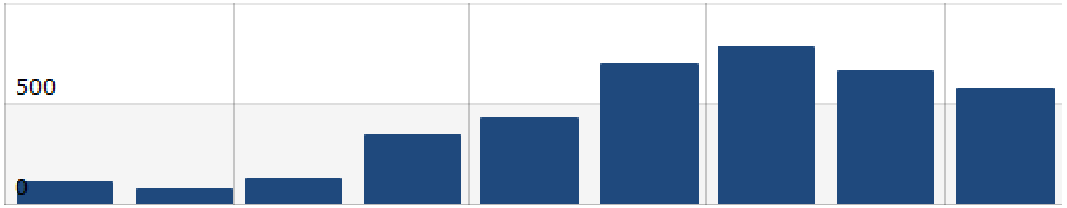
Wilders Grove / OATemp (F)



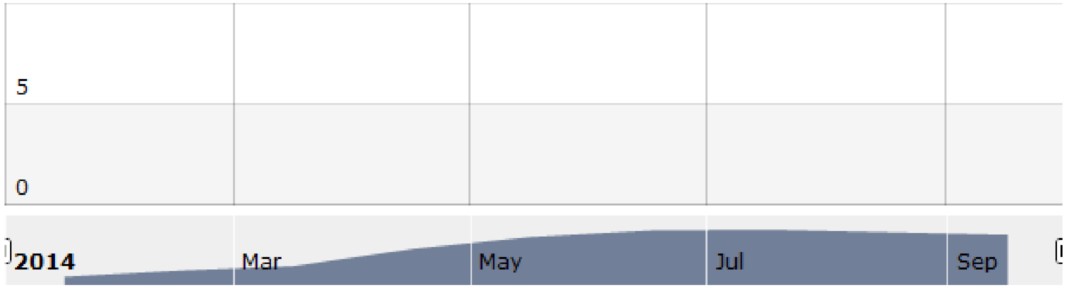
Wilders Grove / WG ADM ZONE TEMP GHP23 (F)



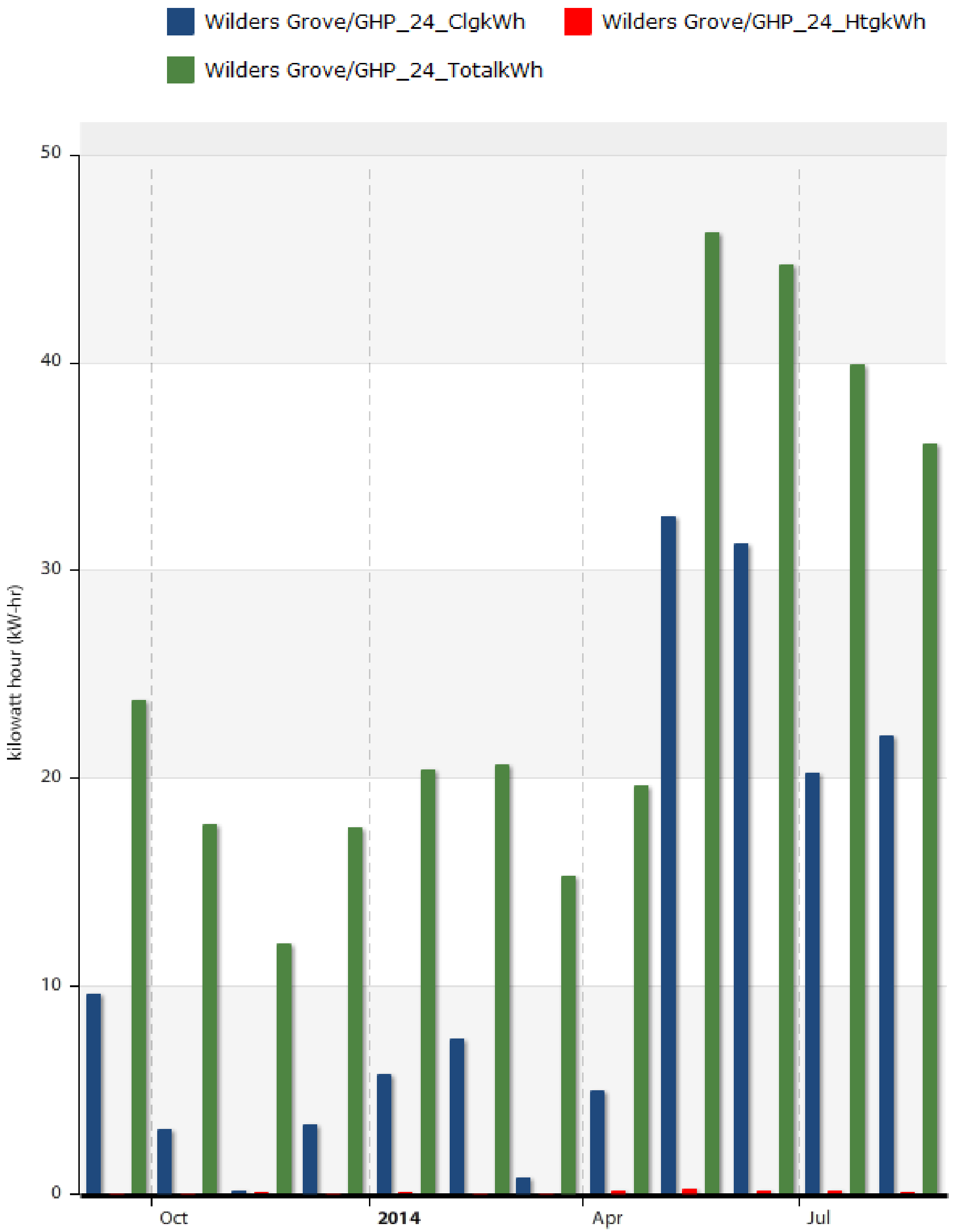
Wilders Grove / GHP_23_ClgkWh (kW-hr)



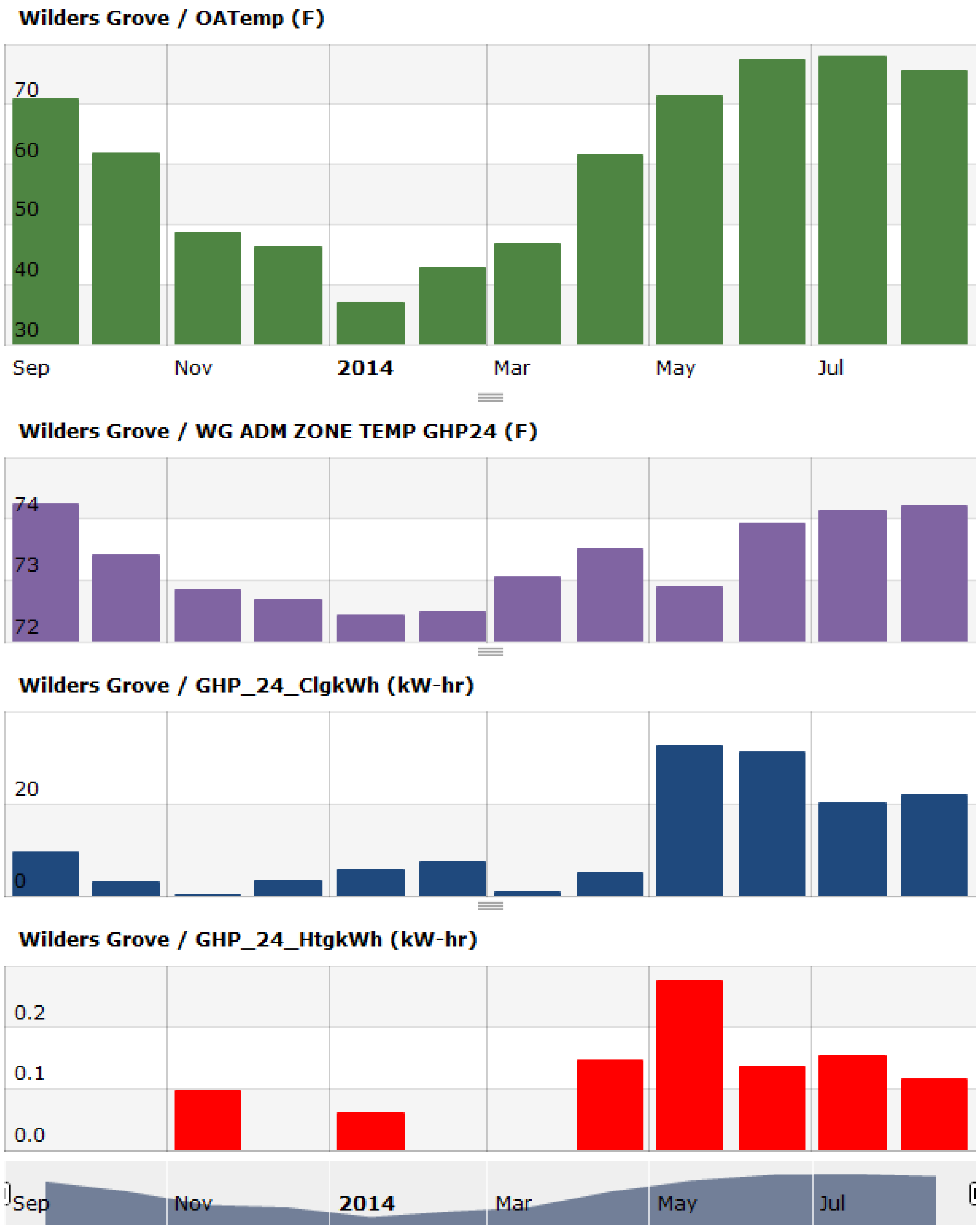
Wilders Grove / GHP_23_HtgkWh (kW-hr)



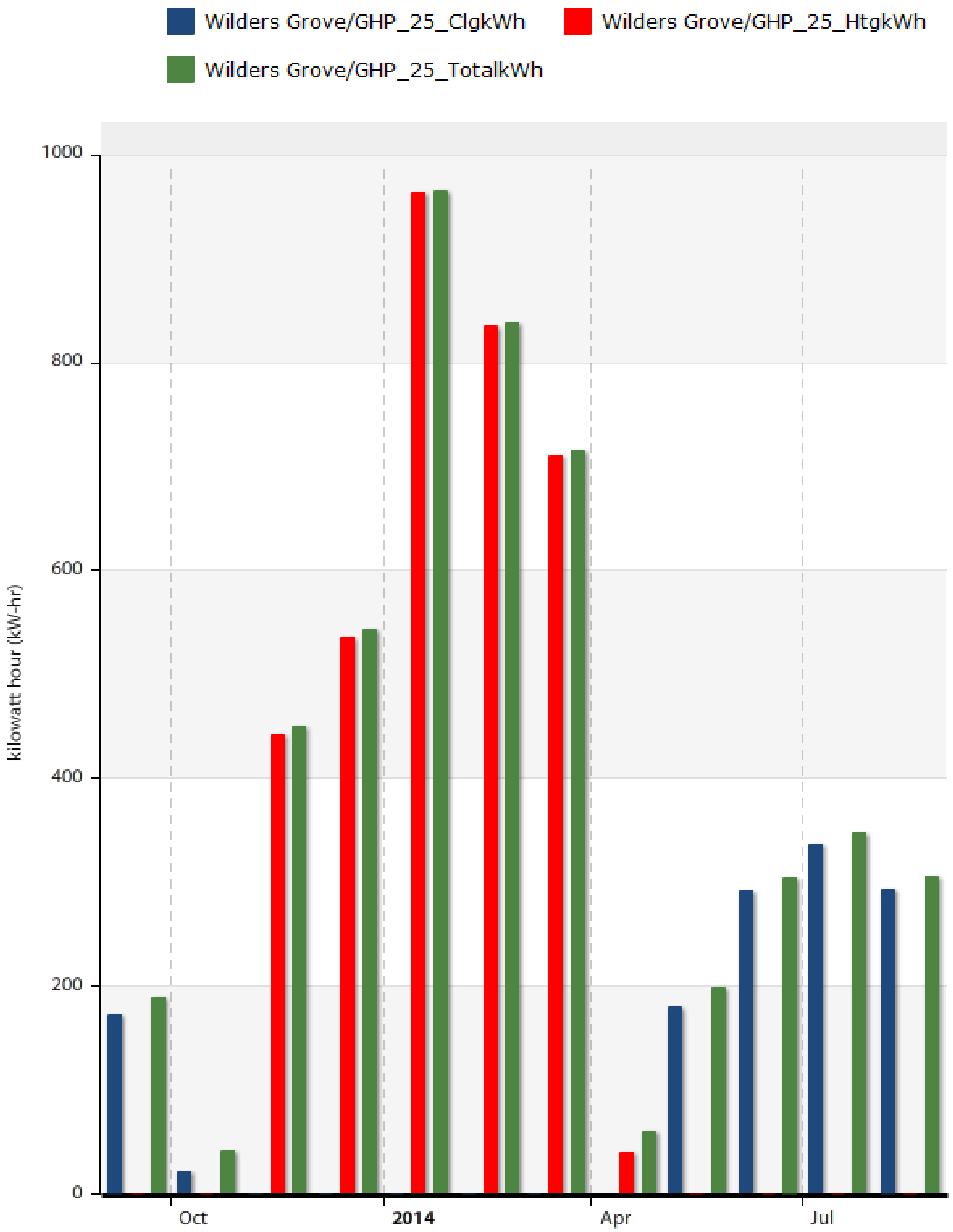
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP23 (F)	Wilders Grove / GHP_23_ClgkWh (kW-hr)	Wilders Grove / GHP_23_HtgkWh (kW-hr)	Events
Jan 2014	37.04	72.684	111.602	0	
Feb 2014	42.946	72.761	78.535	0	
Mar 2014	46.722	73.044	126.034	0	
Apr 2014	61.693	73.558	344.221	0	
May 2014	71.501	73.898	428.719	0	
Jun 2014	77.411	74.579	694.934	0	
Jul 2014	77.992	74.568	785.029	0	
Aug 2014	75.763	74.642	658.444	0	
Sep 2014	73.512	74.567	573.856	0	


Wilders Grove/GHP_24_ClgkWh
Wilders Grove/GHP_24_HtgkWh
Wilders Grove/GHP_24_TotalkWh
kilowatt hour (kW-hr)
50
40
30
20
10
0
Oct
2014
Apr
Jul

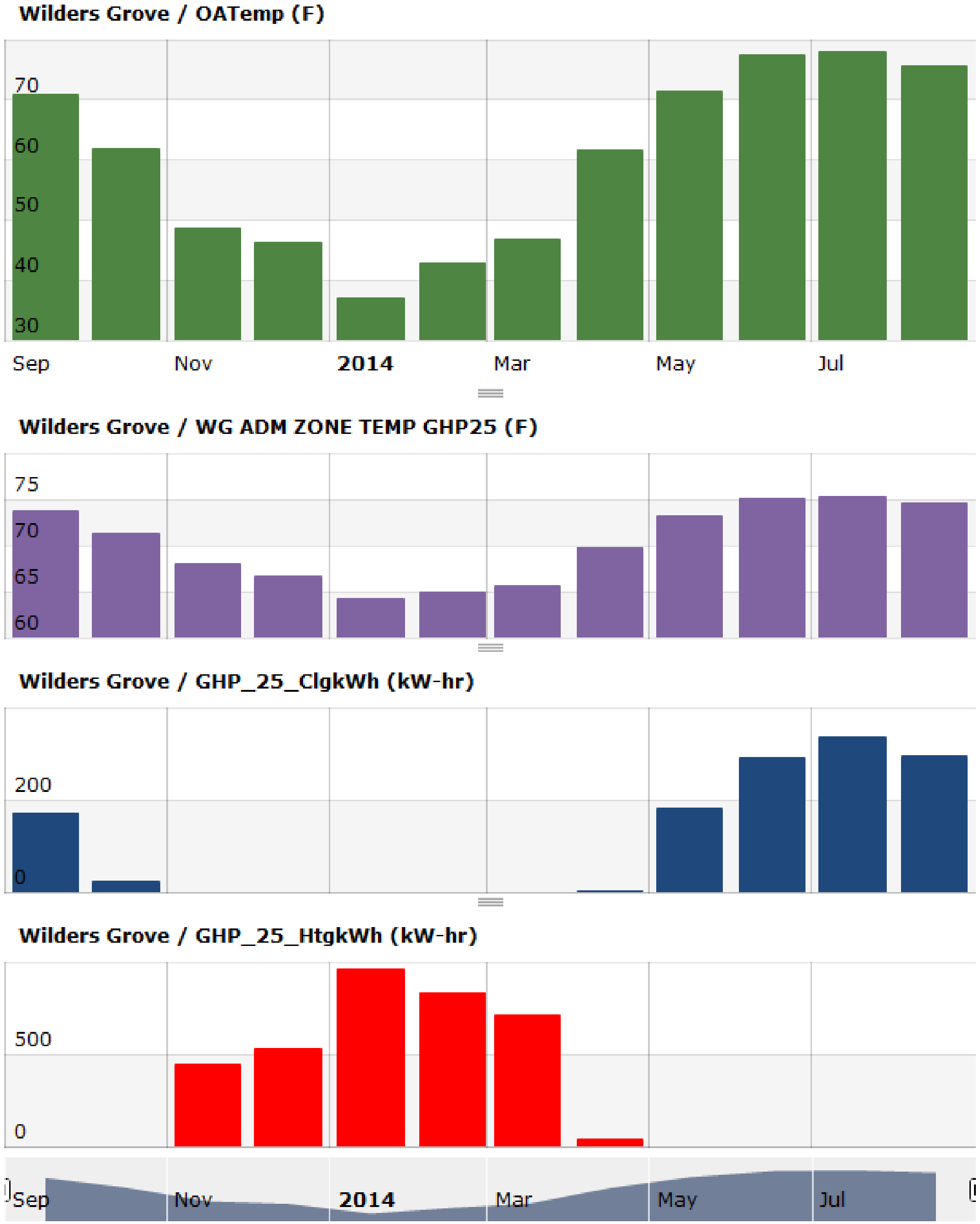
Timestamp	Wilders Grove/GHP_24_ClgkWh (kW-hr)	Wilders Grove/GHP_24_HtgkWh (kW-hr)	Wilders Grove/GHP_24_TotalkWh (kW-hr)
Sep 2013	9.623	0	23.758
Oct 2013	3.095	0	17.762
Nov 2013	0.132	0.097	12.042
Dec 2013	3.331	0	17.658
Jan 2014	5.714	0.06	20.383
Feb 2014	7.474	0	20.614
Mar 2014	0.805	0	15.283
Apr 2014	4.969	0.147	19.667
May 2014	32.633	0.276	46.262
Jun 2014	31.262	0.137	44.694
Jul 2014	20.297	0.155	39.922
Aug 2014	22.039	0.115	36.06


Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP24 (F)
74
73
72
Wilders Grove / GHP_24_ClgkWh (kW-hr)
20
0
Wilders Grove / GHP_24_HtgkWh (kW-hr)
0.2
0.1
0.0
Sep
Nov
2014
Mar
May
Jul

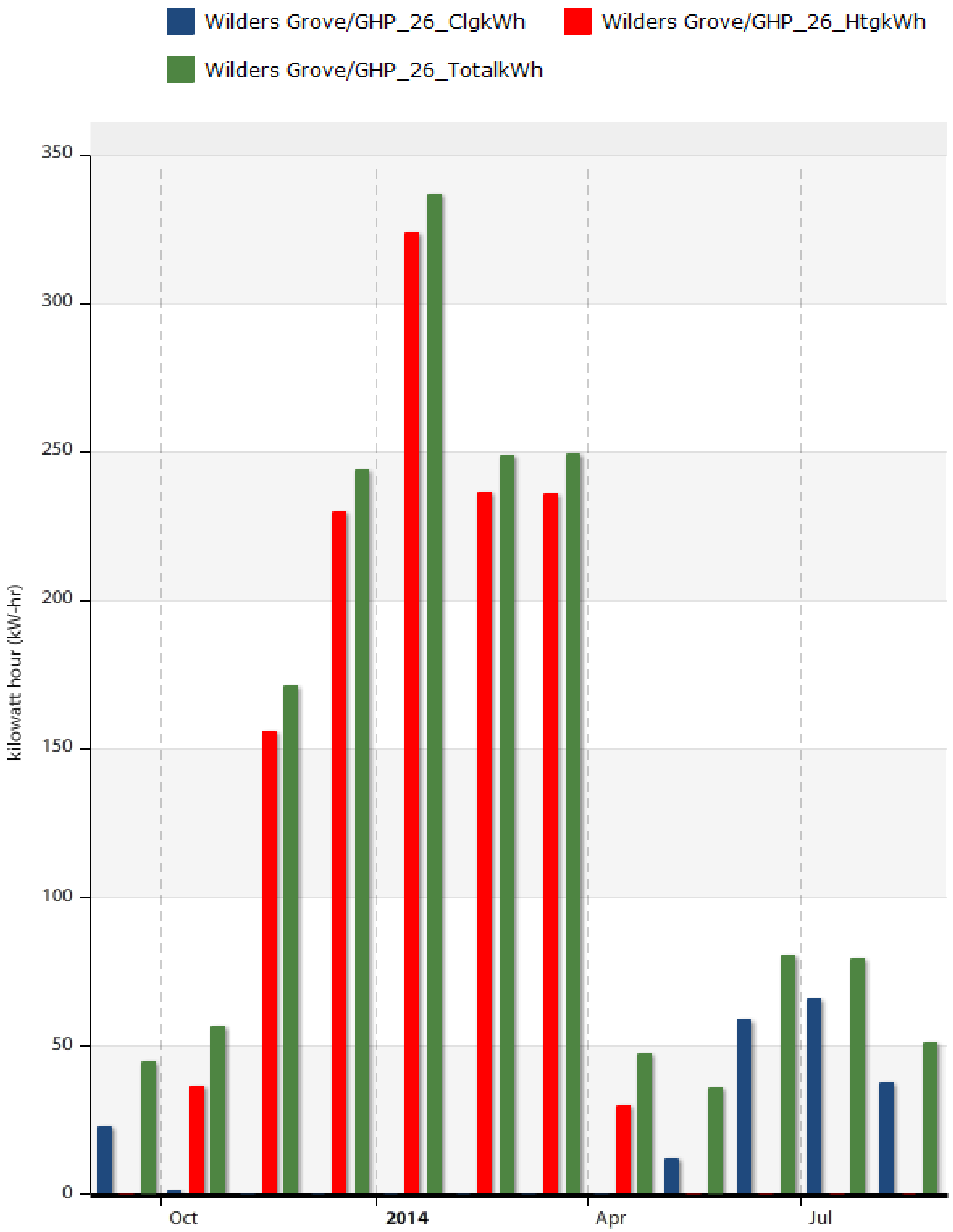
Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP24 (F)	Wilders Grove / GHP_24_ClgkWh (kW-hr)	Wilders Grove / GHP_24_HtgkWh (kW-hr)	Events
Sep 2013	70.866	74.244	9.623	0	
Oct 2013	61.964	73.418	3.095	0	
Nov 2013	48.77	72.857	0.132	0.097	
Dec 2013	46.33	72.678	3.331	0	
Jan 2014	37.04	72.437	5.714	0.06	
Feb 2014	42.946	72.491	7.474	0	
Mar 2014	46.722	73.058	0.805	0	
Apr 2014	61.693	73.519	4.969	0.147	
May 2014	71.501	72.904	32.633	0.276	
Jun 2014	77.411	73.941	31.262	0.137	
Jul 2014	77.992	74.141	20.297	0.155	
Aug 2014	75.579	74.214	22.039	0.115	


Wilders Grove/GHP_25_ClgkWh
Wilders Grove/GHP_25_HtgkWh
Wilders Grove/GHP_25_TotalkWh
1000
800
600
400
200
0
kilowatt hour (kW-hr)
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_25_ClgkWh (kW-hr)	Wilders Grove/GHP_25_HtgkWh (kW-hr)	Wilders Grove/GHP_25_TotalkWh (kW-hr)
Sep 2013	172.84	0	188.893
Oct 2013	22.579	0	41.435
Nov 2013	0	443.191	450.565
Dec 2013	0	535.377	543.229
Jan 2014	0	963.147	965.31
Feb 2014	0	835.108	838.705
Mar 2014	0	710.931	716.164
Apr 2014	0.536	39.935	59.996
May 2014	180.155	0	199.552
Jun 2014	291.254	0	304.146
Jul 2014	337.449	0	347.062
Aug 2014	293.8	0	306.5

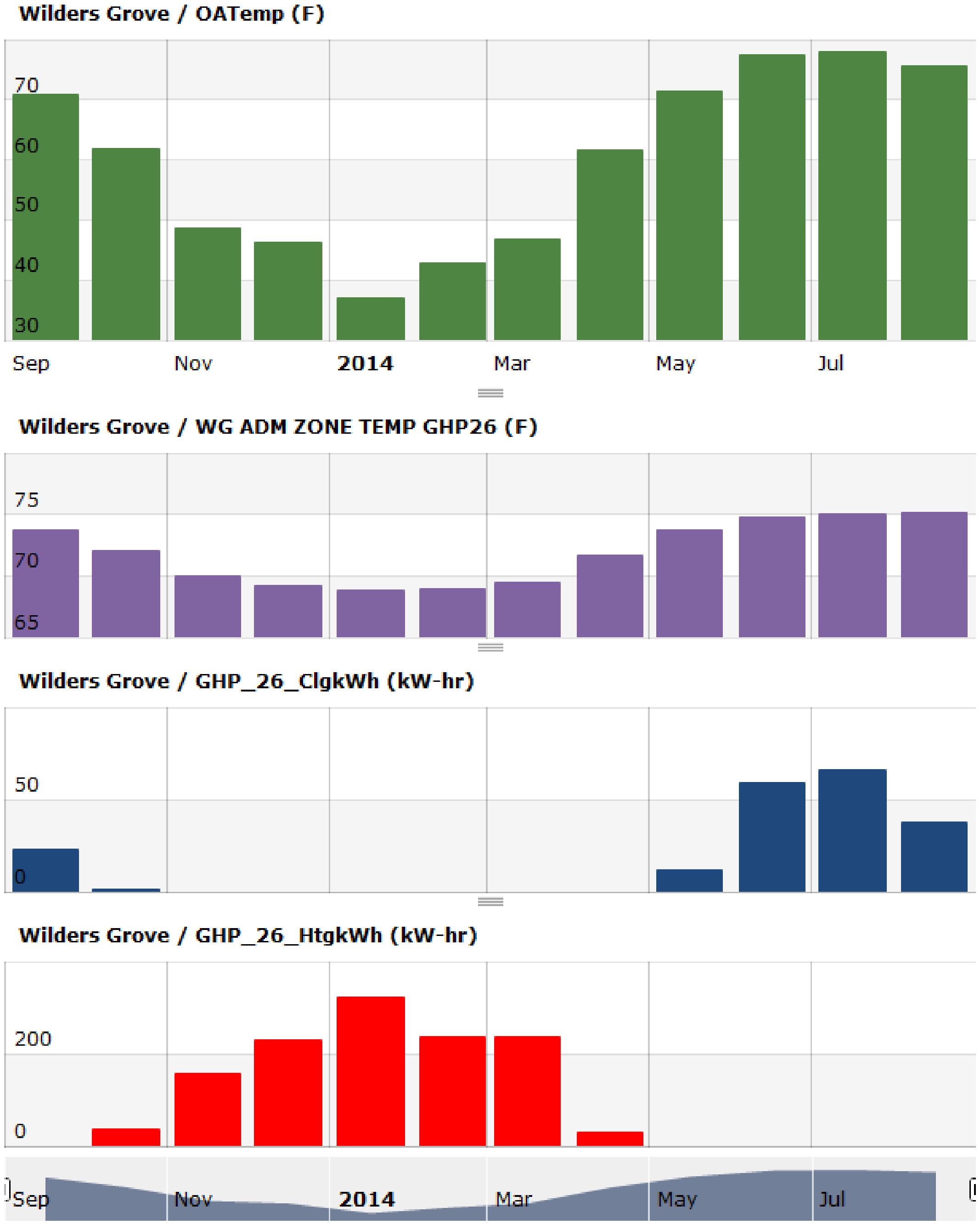

Wilders Grove / OATemp (F)
70
60
50
40
30
Sep
Nov
2014
Mar
May
Jul
Wilders Grove / WG ADM ZONE TEMP GHP25 (F)
75
70
65
60
Wilders Grove / GHP_25_ClgkWh (kW-hr)
200
0
Wilders Grove / GHP_25_HtgkWh (kW-hr)
500
0
Sep
Nov
2014
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP25 (F)	Wilders Grove / GHP_25_ClgkWh (kW-hr)	Wilders Grove / GHP_25_HtgkWh (kW-hr)	Events
Sep 2013	70.866	73.702	172.84	0	
Oct 2013	61.964	71.347	22.579	0	
Nov 2013	48.77	68.035	0	443.191	
Dec 2013	46.33	66.688	0	535.377	
Jan 2014	37.04	64.225	0	963.147	
Feb 2014	42.946	64.955	0	835.108	
Mar 2014	46.722	65.619	0	710.931	
Apr 2014	61.693	69.819	0.536	39.935	
May 2014	71.501	73.226	180.155	0	
Jun 2014	77.411	75.155	291.254	0	
Jul 2014	77.992	75.27	337.449	0	
Aug 2014	75.579	74.678	293.8	0	



Wilders Grove/GHP_26_ClgkWh
Wilders Grove/GHP_26_HtgkWh
Wilders Grove/GHP_26_TotalkWh
kilowatt hour (kW-hr)
350
300
250
200
150
100
50
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_26_ClgkWh (kW-hr)	Wilders Grove/GHP_26_HtgkWh (kW-hr)	Wilders Grove/GHP_26_TotalkWh (kW-hr)
Sep 2013	22.935	0	44.726
Oct 2013	1.389	36.635	56.827
Nov 2013	0	156.115	171.131
Dec 2013	0	229.709	244.006
Jan 2014	0	323.974	336.599
Feb 2014	0	236.447	248.552
Mar 2014	0	235.614	249.289
Apr 2014	0	29.732	47.494
May 2014	11.946	0	36.063
Jun 2014	58.914	0	80.716
Jul 2014	65.966	0	79.154
Aug 2014	37.745	0	51.171



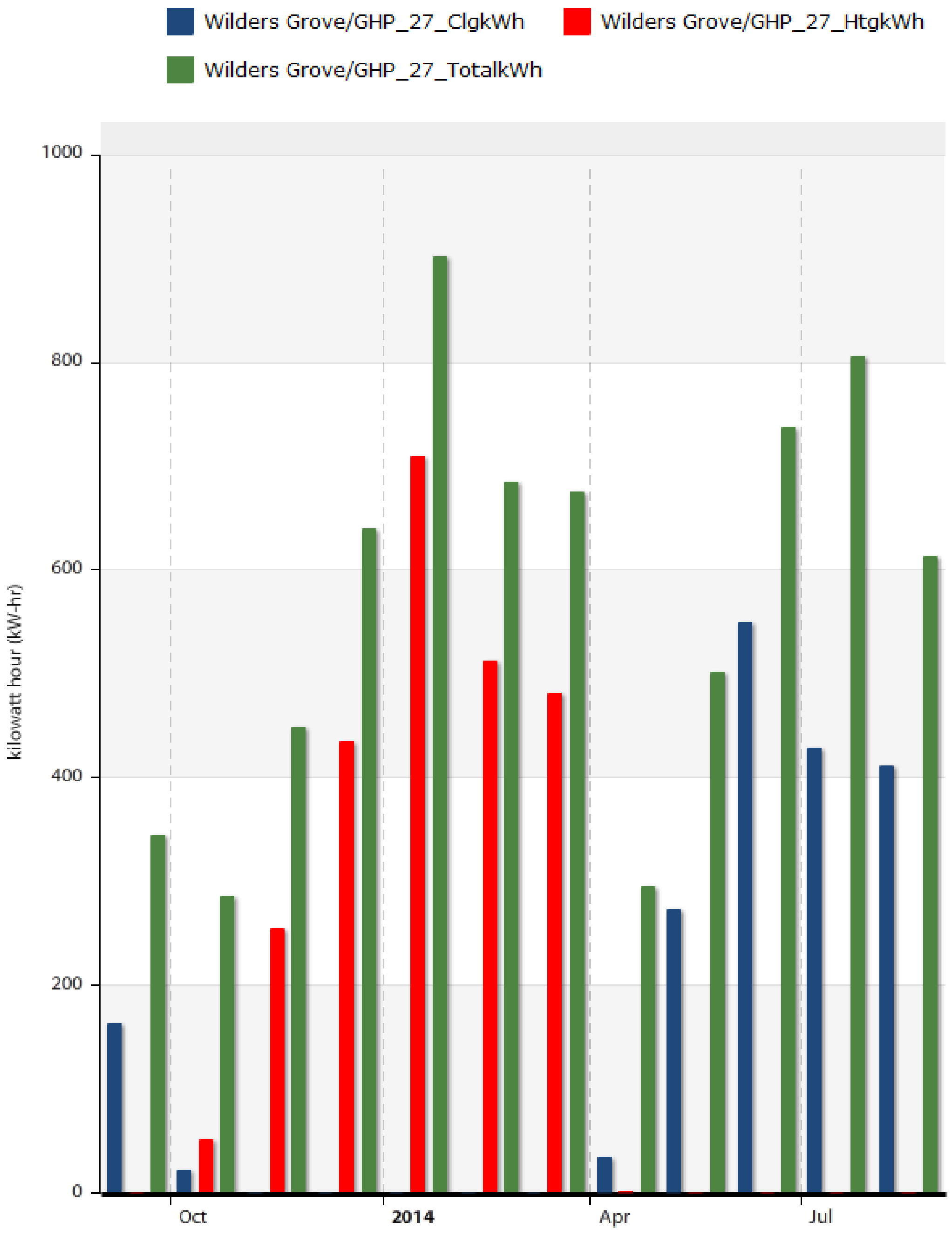
Wilders Grove / OATemp (F)

Wilders Grove / WG ADM ZONE TEMP GHP26 (F)

Wilders Grove / GHP_26_ClgkWh (kW-hr)

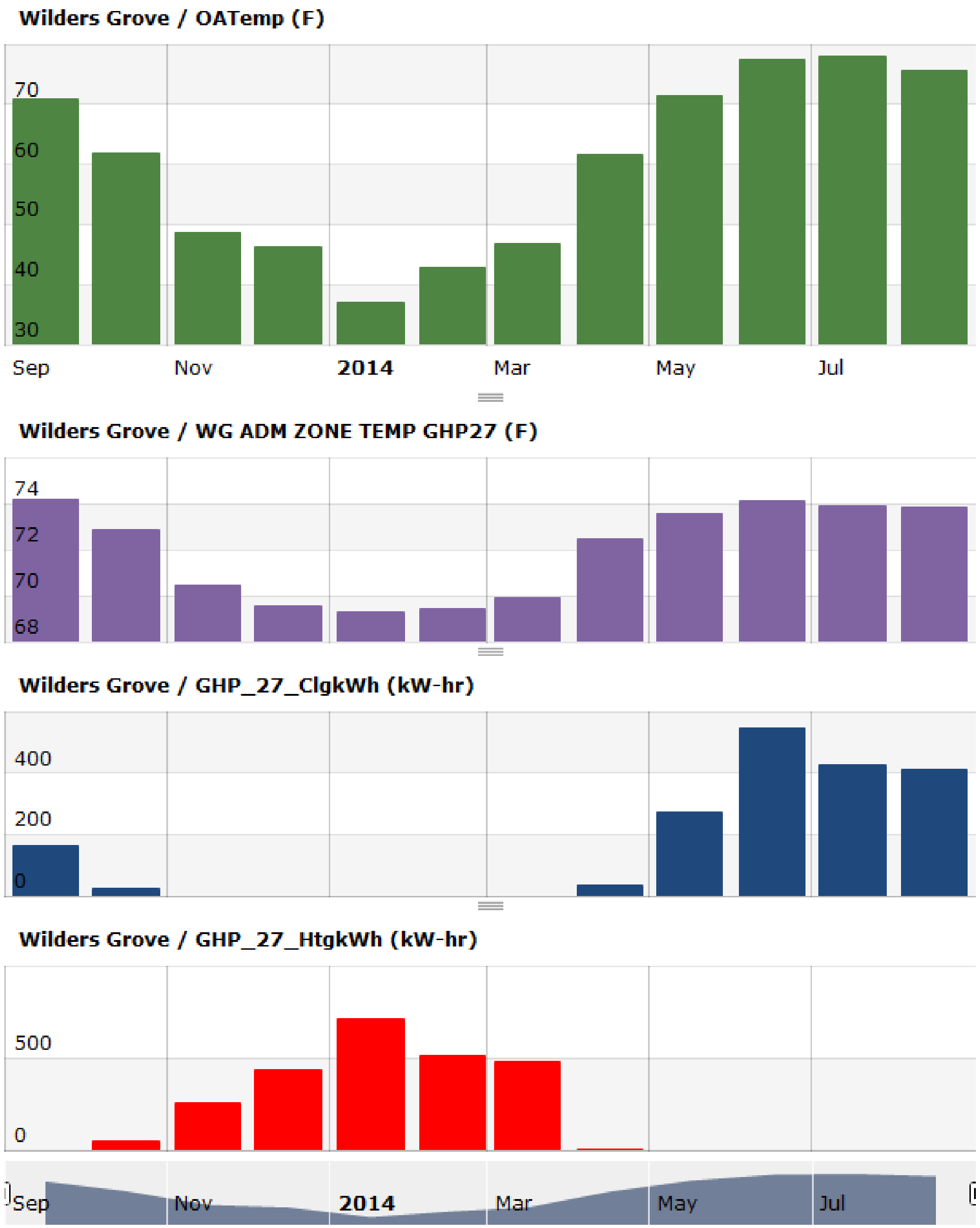
Wilders Grove / GHP_26_HtgkWh (kW-hr)

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP26 (F)	Wilders Grove / GHP_26_ClgkWh (kW-hr)	Wilders Grove / GHP_26_HtgkWh (kW-hr)	Events
Sep 2013	70.866	73.747	22.935	0	
Oct 2013	61.964	72.012	1.389	36.635	
Nov 2013	48.77	69.969	0	156.115	
Dec 2013	46.33	69.208	0	229.709	
Jan 2014	37.04	68.776	0	323.974	
Feb 2014	42.946	68.94	0	236.447	
Mar 2014	46.722	69.47	0	235.614	
Apr 2014	61.693	71.646	0	29.732	
May 2014	71.501	73.785	11.946	0	
Jun 2014	77.411	74.839	58.914	0	
Jul 2014	77.992	75.094	65.966	0	
Aug 2014	75.579	75.207	37.745	0	



Wilders Grove/GHP_27_ClgkWh
Wilders Grove/GHP_27_HtgkWh
Wilders Grove/GHP_27_TotalkWh
kilowatt hour (kW-hr)
1000
800
600
400
200
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_27_ClgkWh (kW-hr)	Wilders Grove/GHP_27_HtgkWh (kW-hr)	Wilders Grove/GHP_27_TotalkWh (kW-hr)
Sep 2013	163.333	0	344.647
Oct 2013	22.661	50.822	286.256
Nov 2013	0	254.043	447.917
Dec 2013	0	435.452	638.959
Jan 2014	0	709.245	900.979
Feb 2014	0	513.013	684.354
Mar 2014	0	480.768	675.566
Apr 2014	34.937	2.13	295.329
May 2014	273.753	0	502.105
Jun 2014	549.007	0	737.05
Jul 2014	428.141	0	805.389
Aug 2014	410.658	0	612.449



Wilders Grove / OATemp (F)

Wilders Grove / WG ADM ZONE TEMP GHP27 (F)

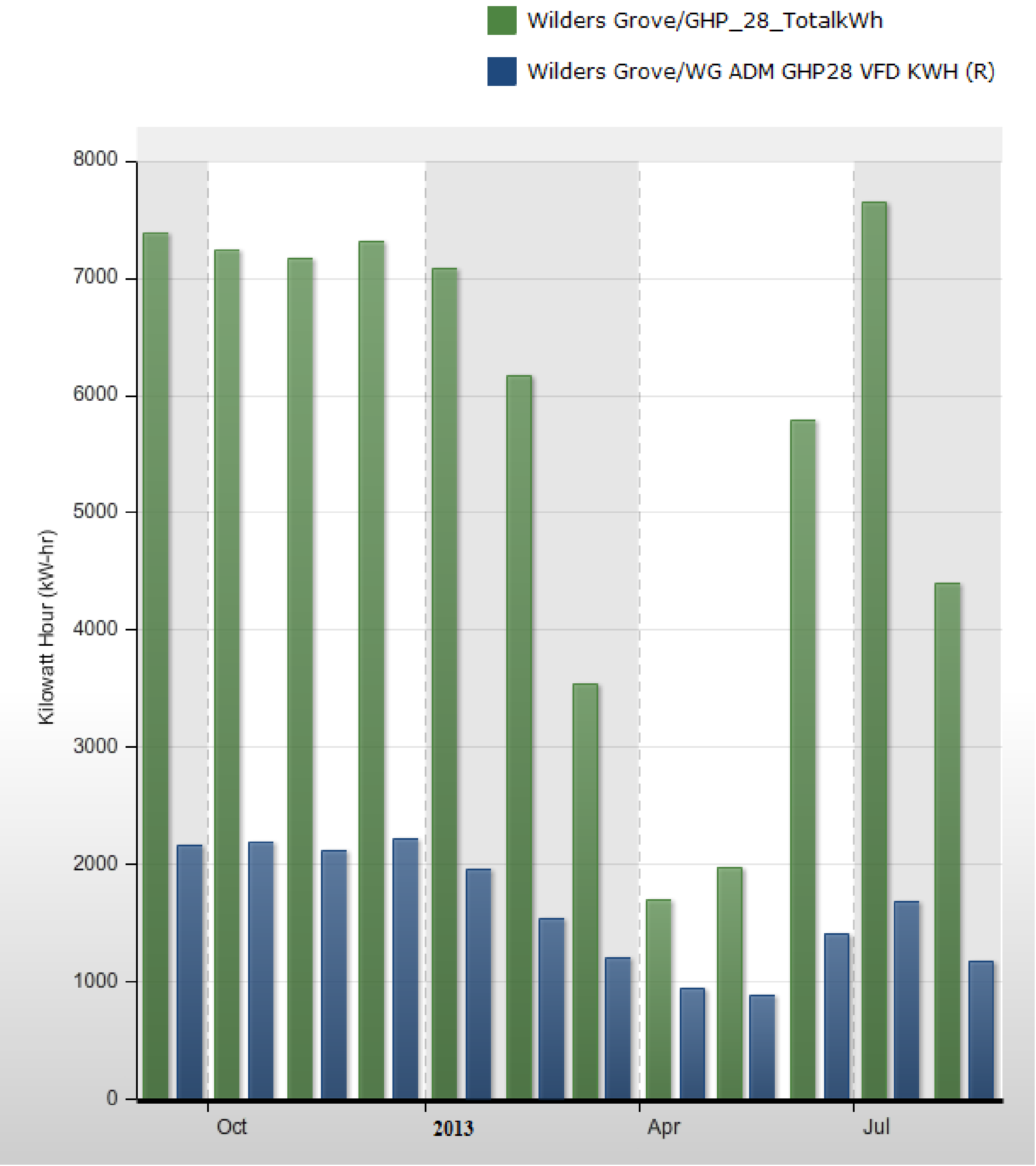
Wilders Grove / GHP_27_ClgkWh (kW-hr)

Wilders Grove / GHP_27_HtgkWh (kW-hr)

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM ZONE TEMP GHP27 (F)	Wilders Grove / GHP_27_ClgkWh (kW-hr)	Wilders Grove / GHP_27_HtgkWh (kW-hr)	Events
Sep 2013	70.866	74.199	163.333	0	
Oct 2013	61.964	72.841	22.661	50.822	
Nov 2013	48.77	70.474	0	254.043	
Dec 2013	46.33	69.551	0	435.452	
Jan 2014	37.04	69.257	0	709.245	
Feb 2014	42.946	69.409	0	513.013	
Mar 2014	46.722	69.932	0	480.768	
Apr 2014	61.693	72.46	34.937	2.13	
May 2014	71.501	73.576	273.753	0	
Jun 2014	77.411	74.116	549.007	0	
Jul 2014	77.992	73.916	428.141	0	
Aug 2014	75.579	73.865	410.658	0	

APPENDIX B1

- MONTHLY ELECTRICAL ENERGY CONSUMPTION
- MONTHLY AVERAGE OUTDOOR AIR & SUPPLY AIR TEMPERATURES
- DEDICATED OUTDOOR AIR GROUND SOURCE HEAT PUMP – 28
- SEPTEMBER 1, 2012 – AUGUST 31, 2013


Wilders Grove/GHP_28_TotalkWh
Wilders Grove/WG ADM GHP28 VFD KWH (R)
Kilowatt Hour (kW-hr)
8000
7000
6000
5000
4000
3000
2000
1000
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GHP_28_TotalkWh (kW-hr)	Wilders Grove/WG ADM GHP28 VFD KWH (R) (kW-hr)
Sep 2012	7386.109	2163
Oct 2012	7243.246	2197
Nov 2012	7167.699	2114
Dec 2012	7316.383	2222
Jan 2013	7077.938	1964
Feb 2013	6168.414	1536
Mar 2013	3545.148	1209
Apr 2013	1705.039	946
May 2013	1979.836	881
Jun 2013	5793.438	1414
Jul 2013	7645.07	1687
Aug 2013	4391.961	1182


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM SA TEMP GHP28 (F)
70
65
Wilders Grove / WG ADM GHP28 VFD KWH (R) (kW-hr)
2000
1000
0
Wilders Grove / GHP_28_TotalkWh (kW-hr)
5000
0
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM SA TEMP GHP28 (F)	Wilders Grove / WG ADM GHP28 VFD KWH (R) (kW-hr)	Wilders Grove / GHP_28_TotalkWh (kW-hr)	Events
Sep 2012	70.75	70.041	2163	7386.109	
Oct 2012	60.363	71.468	2197	7243.246	
Nov 2012	46.686	71.971	2114	7167.699	
Dec 2012	49.184	72.038	2222	7316.383	
Jan 2013	44.667	72.087	1964	7077.938	
Feb 2013	42.867	72.057	1536	6168.414	
Mar 2013	46.195	65.799	1209	3545.148	
Apr 2013	61.57	70.869	946	1705.039	
May 2013	67.548	72.487	881	1979.836	
Jun 2013	75.839	72.866	1414	5793.438	
Jul 2013	78.833	72.07	1687	7645.07	
Aug 2013	76.345	74.438	1182	4391.961	

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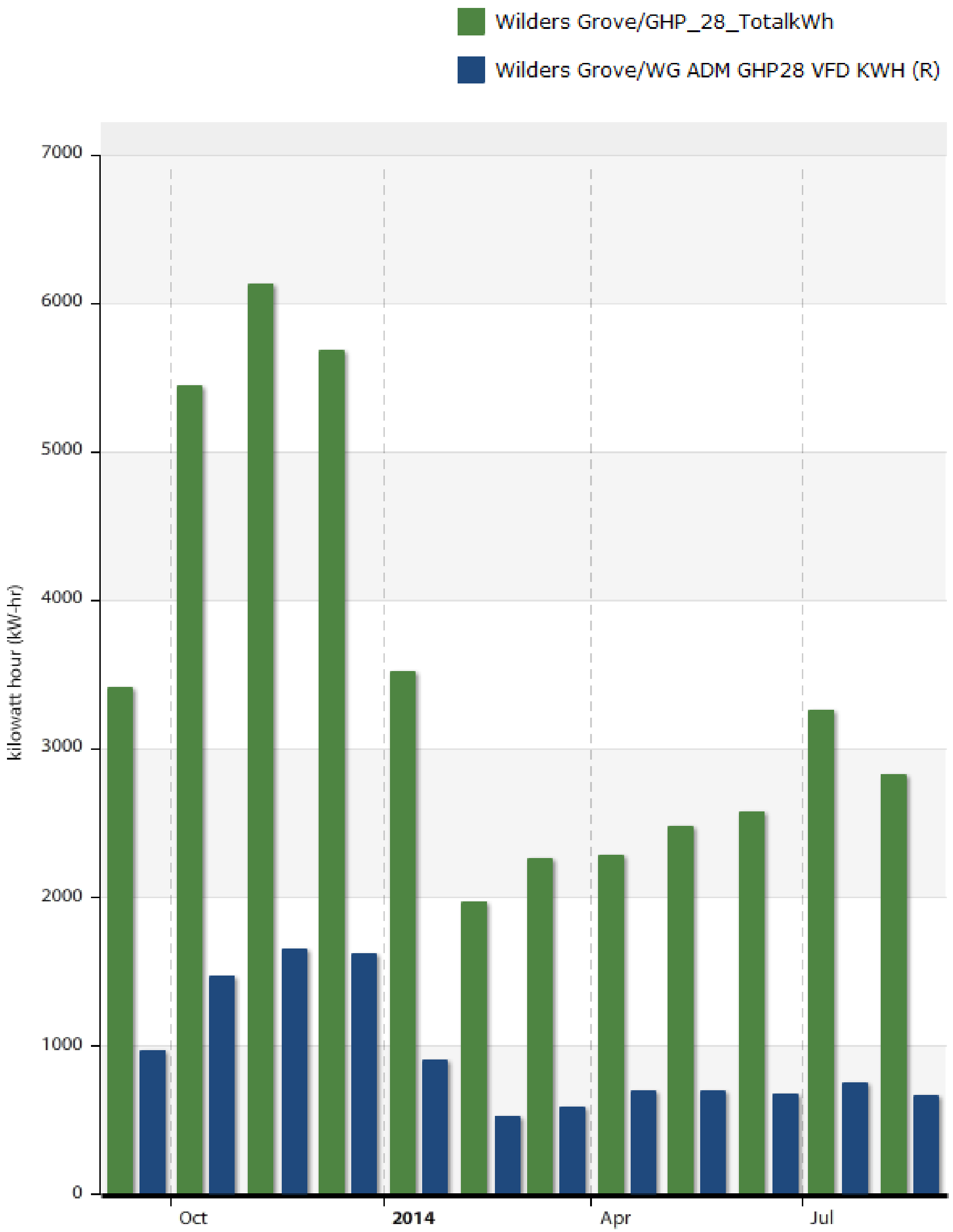
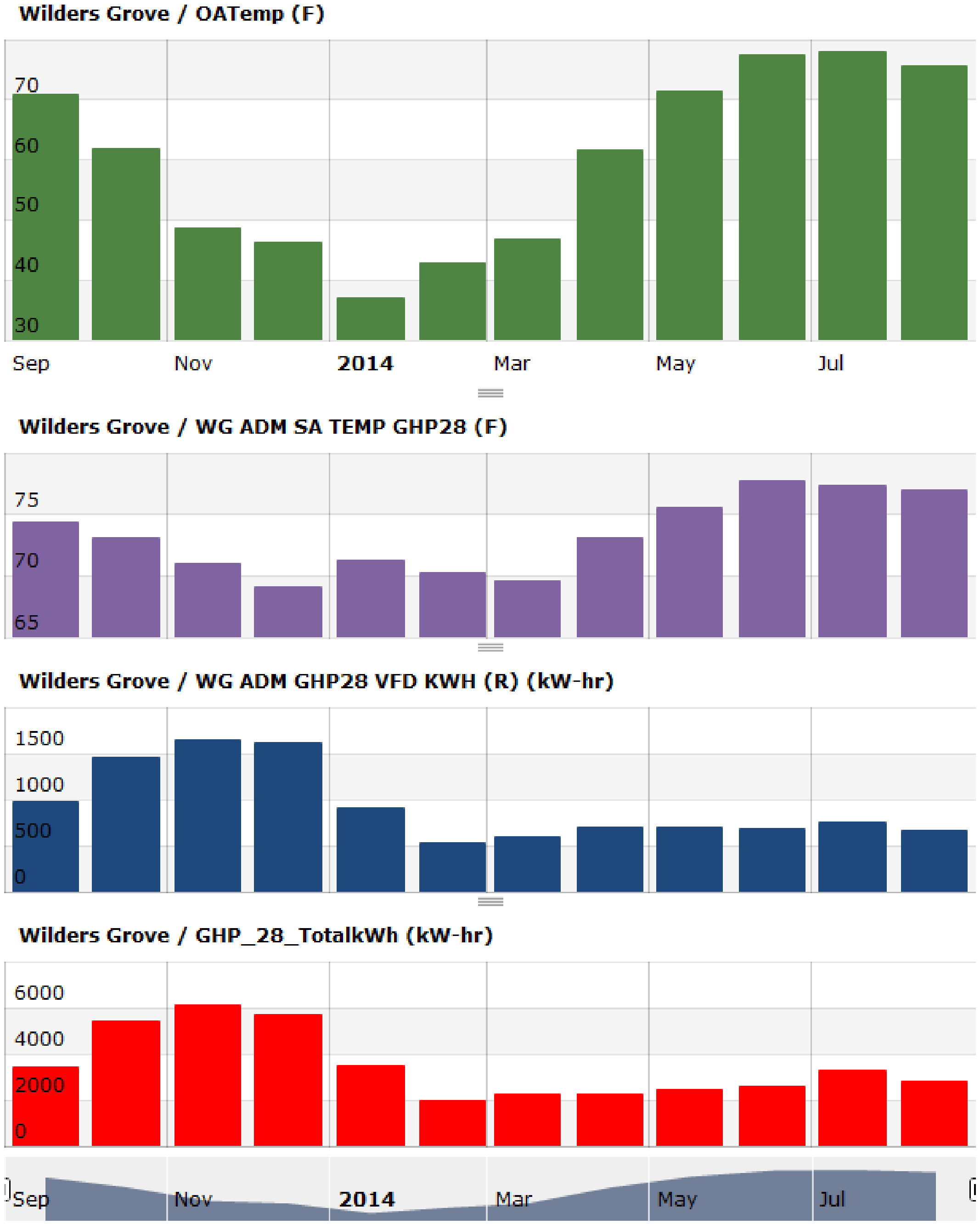
CITY OF RALEIGH NORTH CAROLINA

APPENDIX B2

- MONTHLY ELECTRICAL ENERGY CONSUMPTION
- MONTHLY AVERAGE OUTDOOR AIR & SUPPLY AIR TEMPERATURES
- DEDICATED OUTDOOR AIR GROUND SOURCE HEAT PUMP – 28
- SEPTEMBER 1, 2013 – AUGUST 31, 2014


Wilders Grove/GHP_28_TotalkWh
Wilders Grove/WG ADM GHP28 VFD KWH (R)
kilowatt hour (kW-hr)
7000
6000
5000
4000
3000
2000
1000
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GHP_28_TotalkWh (kW-hr)	Wilders Grove/WG ADM GHP28 VFD KWH (R) (kW-hr)
Sep 2013	3409.383	970
Oct 2013	5443.805	1465
Nov 2013	6130.445	1650
Dec 2013	5677.047	1615
Jan 2014	3516.766	902
Feb 2014	1971.25	528
Mar 2014	2259.141	593
Apr 2014	2282.781	694
May 2014	2475.312	696
Jun 2014	2573.578	677
Jul 2014	3261.125	748
Aug 2014	2829.797	666



Wilders Grove / OATemp (F)

Wilders Grove / WG ADM SA TEMP GHP28 (F)

Wilders Grove / WG ADM GHP28 VFD KWH (R) (kW-hr)

Wilders Grove / GHP_28_TotalkWh (kW-hr)

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM SA TEMP GHP28 (F)	Wilders Grove / WG ADM GHP28 VFD KWH (R) (kW-hr)	Wilders Grove / GHP_28_TotalkWh (kW-hr)	Events
Sep 2013	70.866	74.337	970	3409.383	
Oct 2013	61.964	73.053	1465	5443.805	
Nov 2013	48.77	71.038	1650	6130.445	
Dec 2013	46.33	69.091	1615	5677.047	
Jan 2014	37.04	71.28	902	3516.766	
Feb 2014	42.946	70.202	528	1971.25	
Mar 2014	46.722	69.653	593	2259.141	
Apr 2014	61.693	73.152	694	2282.781	
May 2014	71.501	75.517	696	2475.312	
Jun 2014	77.411	77.739	677	2573.578	
Jul 2014	77.992	77.346	748	3261.125	
Aug 2014	75.579	77.002	666	2829.797	

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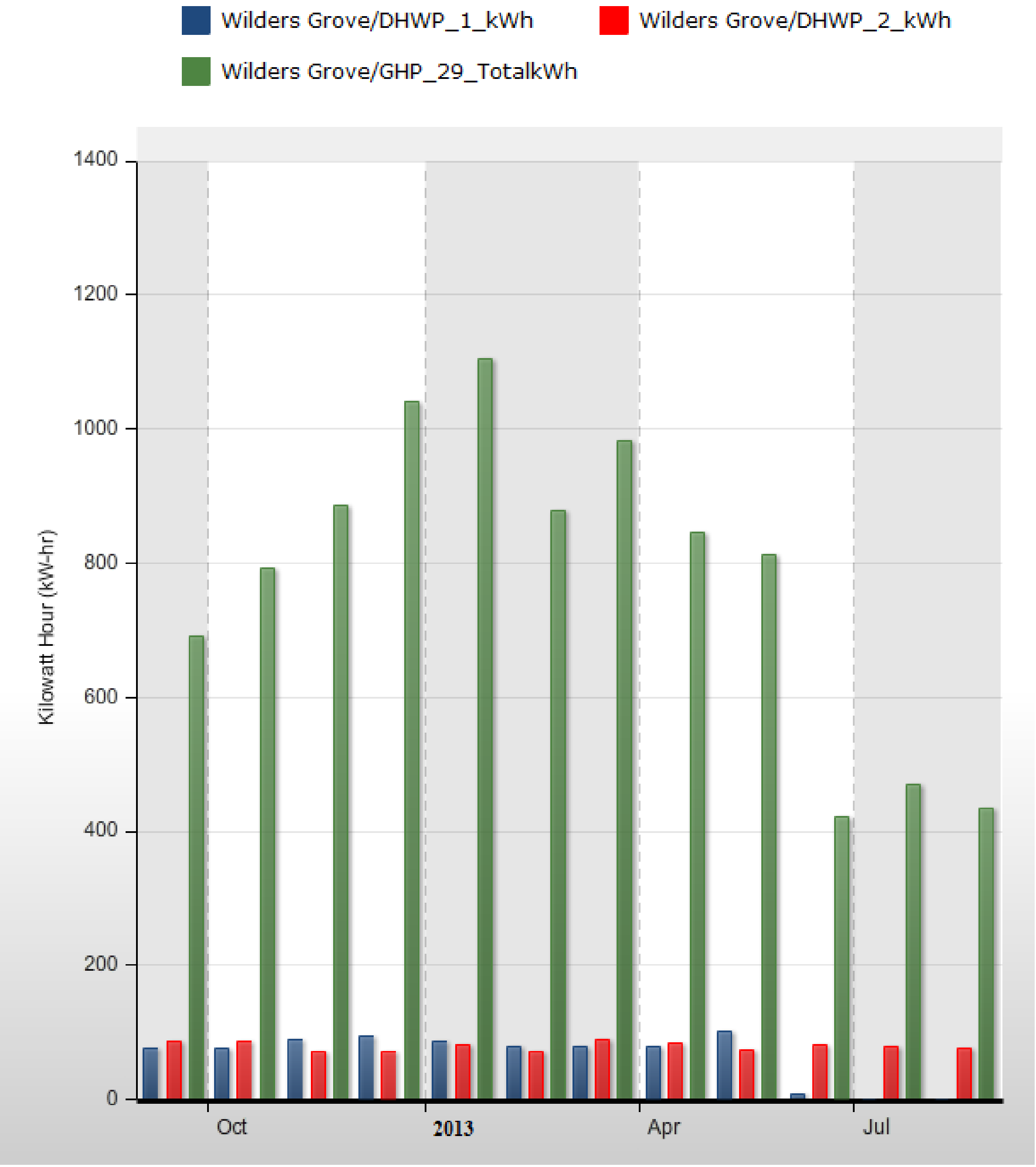
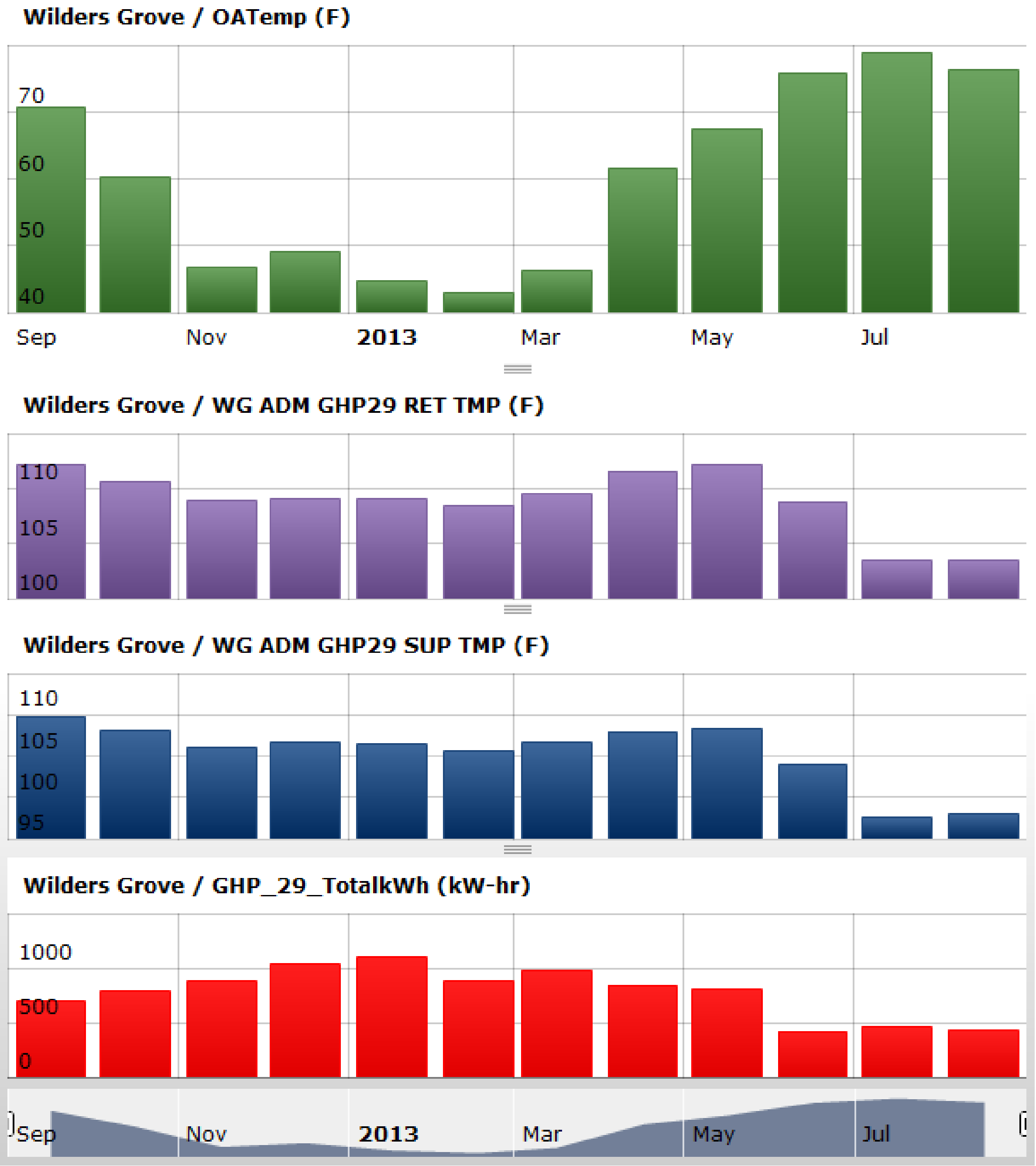
CITY OF RALEIGH NORTH CAROLINA

APPENDIX C1

- MONTHLY ELECTRICAL ENERGY CONSUMPTION
- MONTHLY ENERGY CONSUMPTION – PUMPS
- WATER-TO-WATER GROUND SOURCE HEAT PUMP – 29
- SEPTEMBER 1, 2012 – AUGUST 31, 2013


Wilders Grove/DHWP_1_kWh
Wilders Grove/DHWP_2_kWh
Wilders Grove/GHP_29_TotalkWh
Kilowatt Hour (kW-hr)
1400
1200
1000
800
600
400
200
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/DHWP_1_kWh (kW-hr)	Wilders Grove/DHWP_2_kWh (kW-hr)	Wilders Grove/GHP_29_TotalkWh (kW-hr)
Sep 2012	76.4	87.758	691.738
Oct 2012	77.036	86.405	792.196
Nov 2012	89.599	72.485	885.816
Dec 2012	94.942	71.994	1042.257
Jan 2013	87.821	82.6	1103.709
Feb 2013	78.052	72.589	878.749
Mar 2013	79.19	88.952	983.324
Apr 2013	79.68	83.065	845.375
May 2013	101.251	75.245	811.742
Jun 2013	9.258	80.739	421.166
Jul 2013	0.03	78.592	469.529
Aug 2013	0.001	76.366	435.502


Wilders Grove / OATemp (F)
70
60
50
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM GHP29 RET TMP (F)
110
105
100
Wilders Grove / WG ADM GHP29 SUP TMP (F)
110
105
100
95
Wilders Grove / GHP_29_TotalkWh (kW-hr)
1000
500
0
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM GHP29 RET TMP (F)	Wilders Grove / WG ADM GHP29 SUP TMP (F)	Wilders Grove / GHP_29_TotalkWh (kW-hr)	Events
Sep 2012	70.75	112.121	109.844	691.738	
Oct 2012	60.363	110.683	108.138	792.196	
Nov 2012	46.686	108.847	106.162	885.816	
Dec 2012	49.184	109.084	106.64	1042.257	
Jan 2013	44.667	109.019	106.486	1103.709	
Feb 2013	42.867	108.47	105.685	878.749	
Mar 2013	46.195	109.55	106.621	983.324	
Apr 2013	61.57	111.605	107.993	845.375	
May 2013	67.548	112.233	108.391	811.742	
Jun 2013	75.839	108.814	103.975	421.166	
Jul 2013	78.833	103.452	97.594	469.529	
Aug 2013	76.345	103.578	98.05	435.502	

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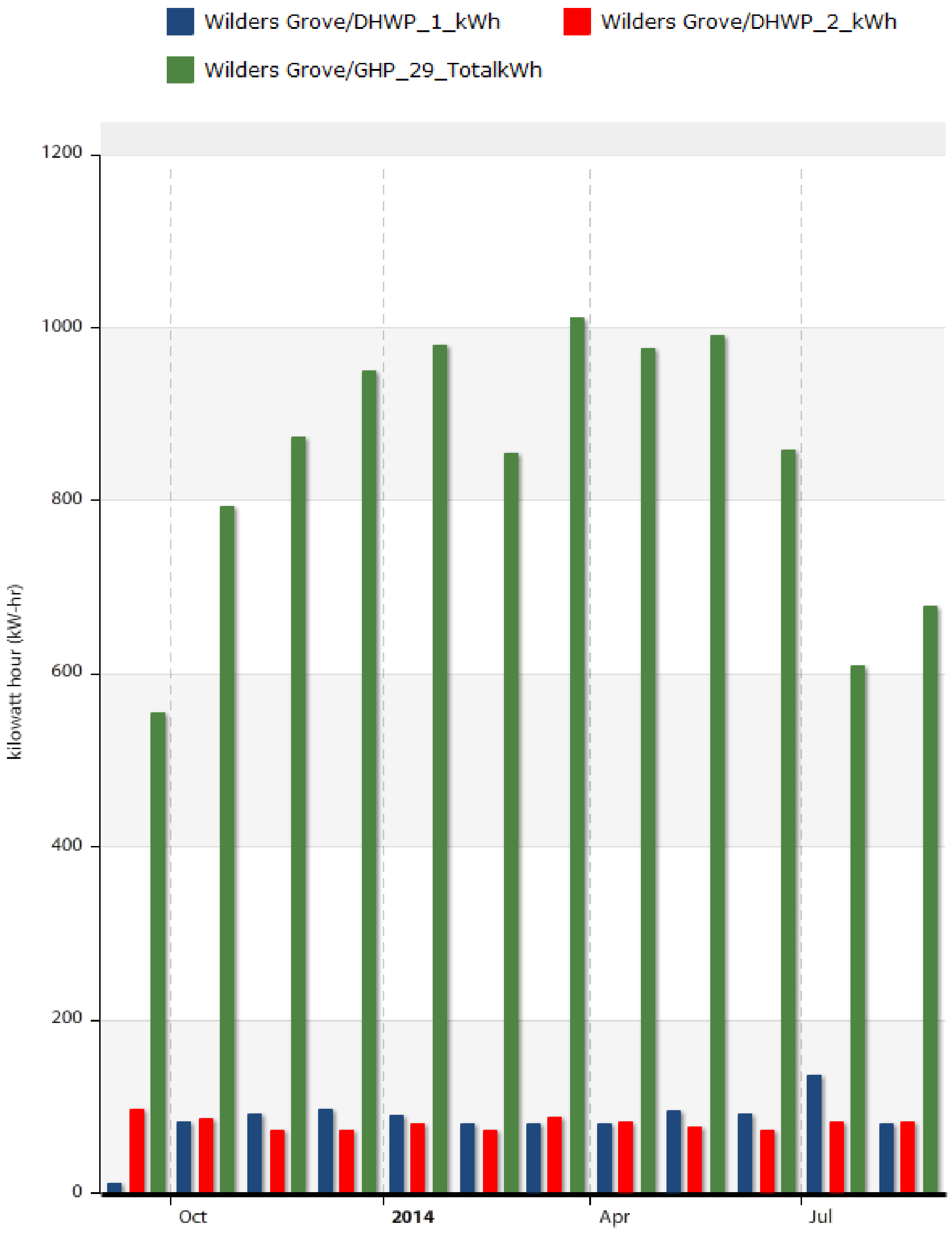
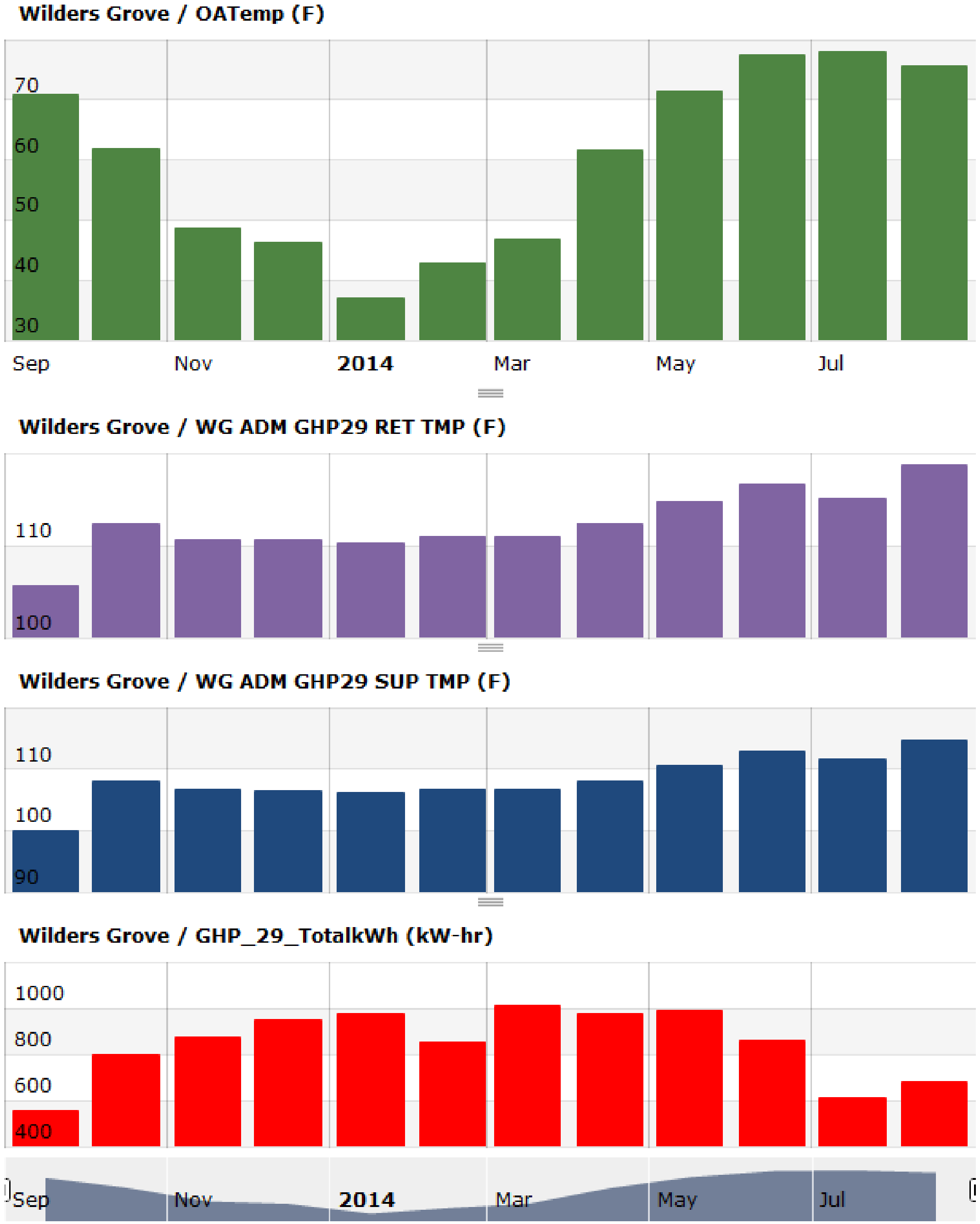
CITY OF RALEIGH • NORTH CAROLINA

APPENDIX C2

- MONTHLY ELECTRICAL ENERGY CONSUMPTION
- MONTHLY ENERGY CONSUMPTION – PUMPS
- WATER-TO-WATER GROUND SOURCE HEAT PUMP – 29
- SEPTEMBER 1, 2013 – AUGUST 31, 2014


Wilders Grove/DHWP_1_kWh
Wilders Grove/DHWP_2_kWh
Wilders Grove/GHP_29_TotalkWh
kilowatt hour (kW-hr)
1200
1000
800
600
400
200
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/DHWP_1_kWh (kW-hr)	Wilders Grove/DHWP_2_kWh (kW-hr)	Wilders Grove/GHP_29_TotalkWh (kW-hr)
Sep 2013	11.547	96.526	556.021
Oct 2013	82.298	86.003	794.248
Nov 2013	92.217	72.912	872.587
Dec 2013	97.307	73.259	949.677
Jan 2014	90.224	80.145	980.185
Feb 2014	80.467	72.247	854.694
Mar 2014	79.896	87.543	1011.996
Apr 2014	80.517	81.815	976.438
May 2014	94.797	76.295	991.533
Jun 2014	92.284	72.484	859.188
Jul 2014	136.434	82.683	609.24
Aug 2014	80.176	82.356	677.863



Wilders Grove / OATemp (F)

Wilders Grove / WG ADM GHP29 RET TMP (F)

Wilders Grove / WG ADM GHP29 SUP TMP (F)

Wilders Grove / GHP_29_TotalkWh (kW-hr)

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM GHP29 RET TMP (F)	Wilders Grove / WG ADM GHP29 SUP TMP (F)	Wilders Grove / GHP_29_TotalkWh (kW-hr)	Events
Sep 2013	70.866	105.7	100.021	556.021	
Oct 2013	61.964	112.342	108.09	794.248	
Nov 2013	48.77	110.64	106.604	872.587	
Dec 2013	46.33	110.557	106.37	949.677	
Jan 2014	37.04	110.256	106.092	980.185	
Feb 2014	42.946	111.02	106.778	854.694	
Mar 2014	46.722	110.984	106.691	1011.996	
Apr 2014	61.693	112.395	107.954	976.438	
May 2014	71.501	114.834	110.552	991.533	
Jun 2014	77.411	116.587	112.826	859.188	
Jul 2014	77.992	115.072	111.685	609.24	
Aug 2014	75.579	118.76	114.63	677.863	

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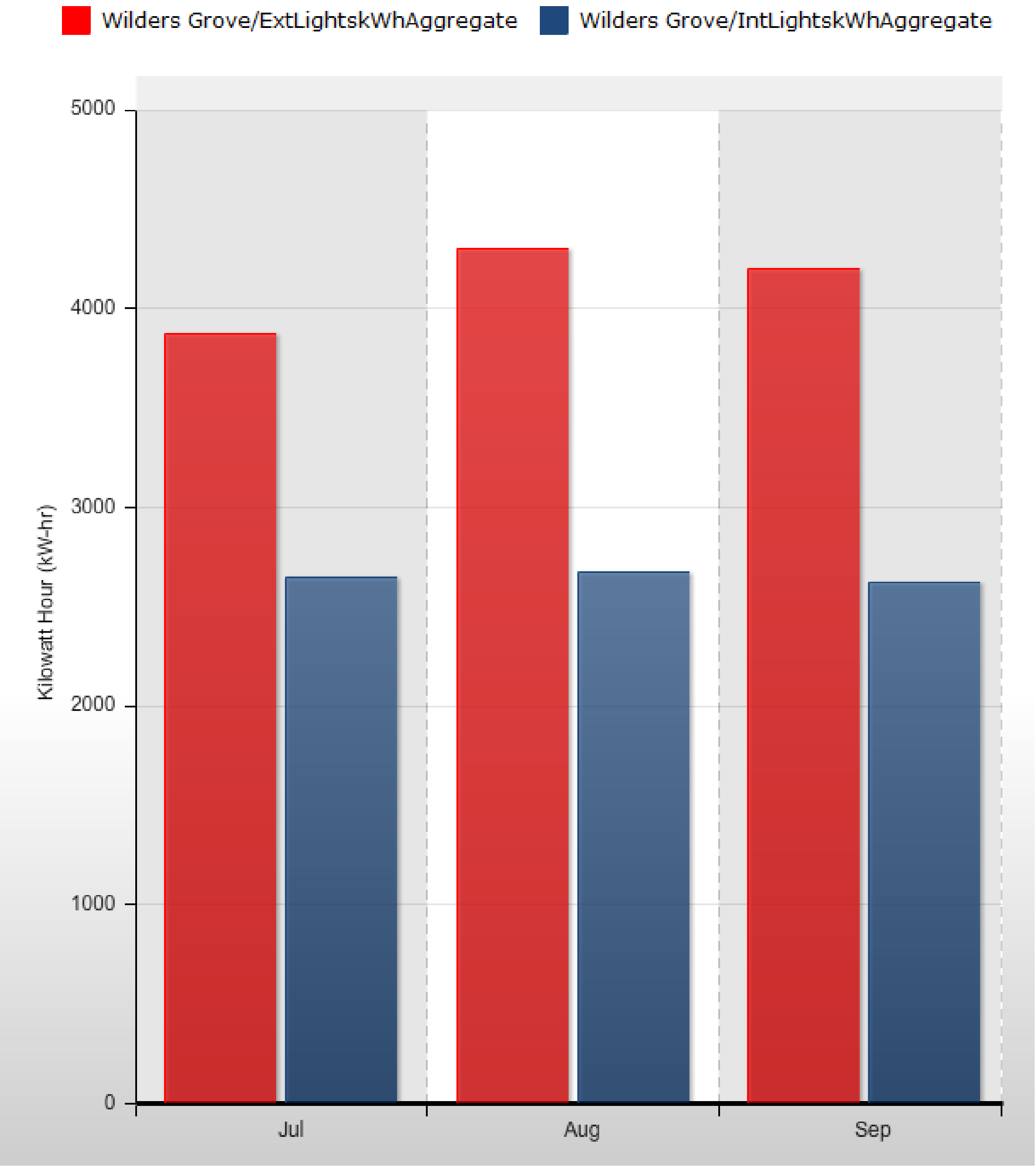
CITY OF RALEIGH
NORTH CAROLINA

APPENDIX D1

- INTERIOR LIGHTING ELECTRICAL ENERGY CONSUMPTION
- EXTERIOR LIGHTING ELECTRICAL ENERGY CONSUMPTION
- JULY 2013 – SEPTEMBER 2013


Wilders Grove/ExtLightskWhAggregate
Wilders Grove/IntLightskWhAggregate
Kilowatt Hour (kW-hr)
5000
4000
3000
2000
1000
0
Jul
Aug
Sep

Timestamp	Wilders Grove/ExtLightskWhAggregate (kW-hr)	Wilders Grove/IntLightskWhAggregate (kW-hr)
Jul 2013	3874.154	2645.324
Aug 2013	4301.715	2669.127
Sep 2013	4202.029	2617.994

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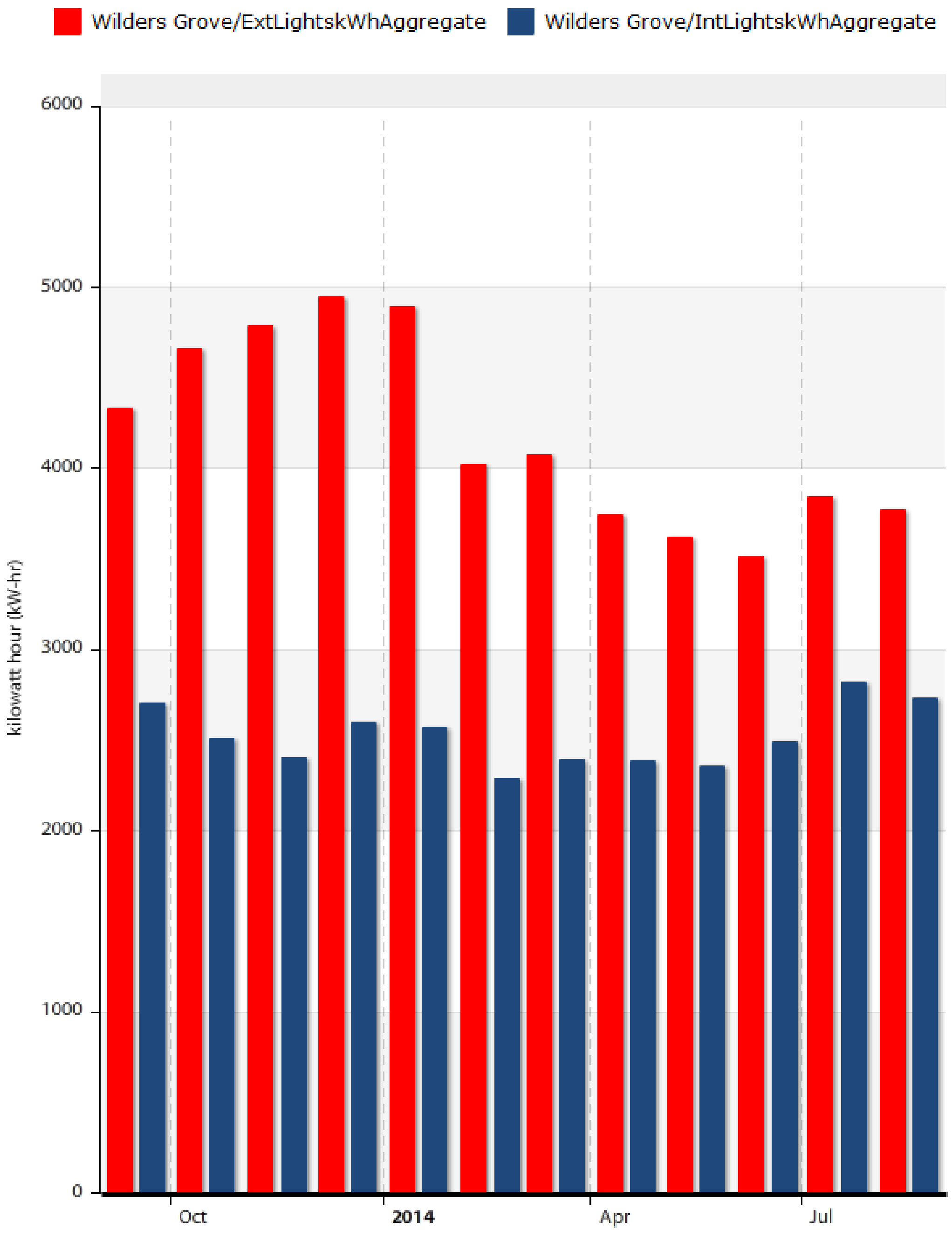
APPENDIX D2

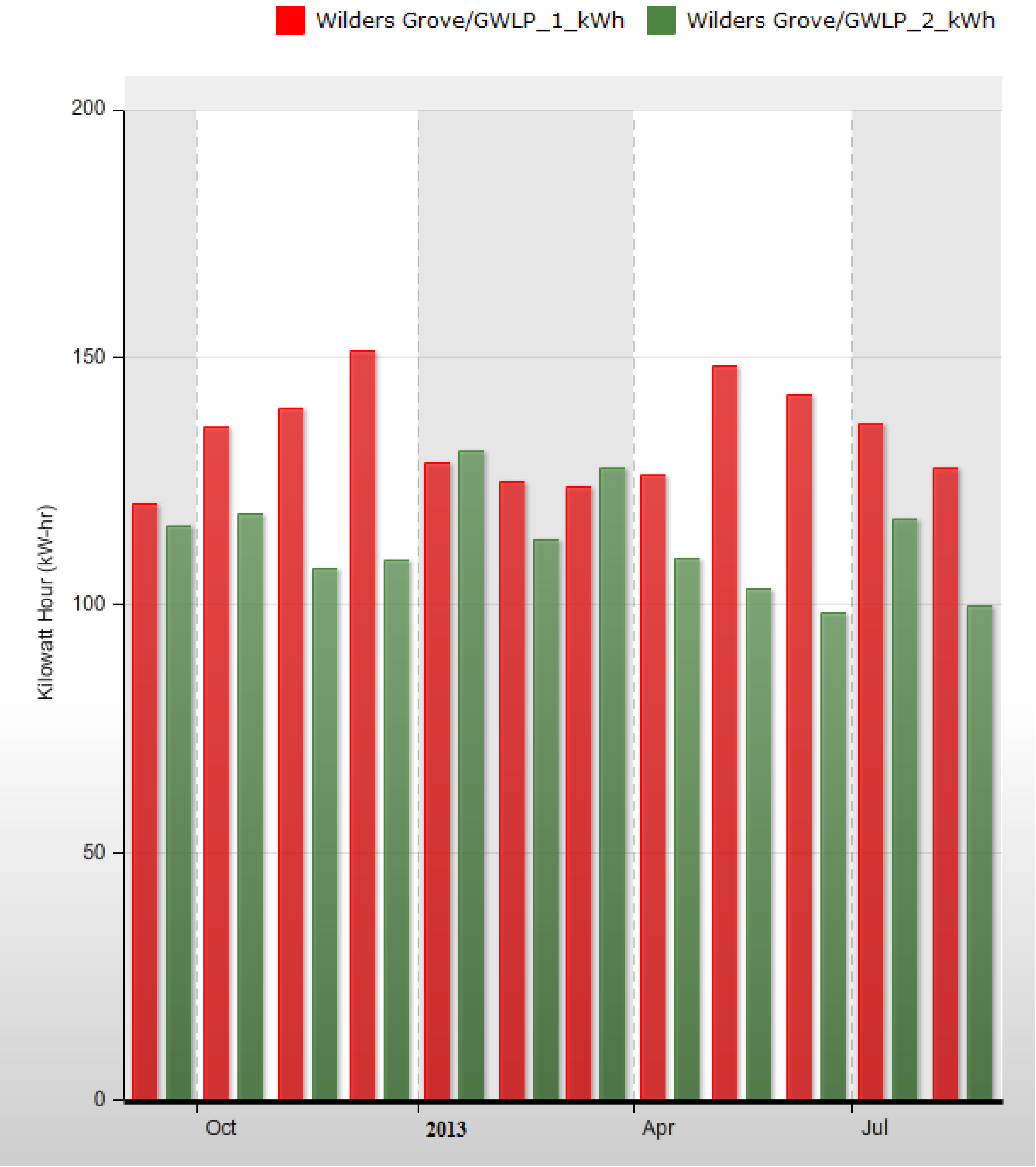
- INTERIOR LIGHTING ELECTRICAL ENERGY CONSUMPTION
- EXTERIOR LIGHTING ELECTRICAL ENERGY CONSUMPTION
- SEPTEMBER 2013 – AUGUST 2014


Wilders Grove/ExtLightskWhAggregate
Wilders Grove/IntLightskWhAggregate
kilowatt hour (kW-hr)
6000
5000
4000
3000
2000
1000
0
Oct
2014
Apr
Jul

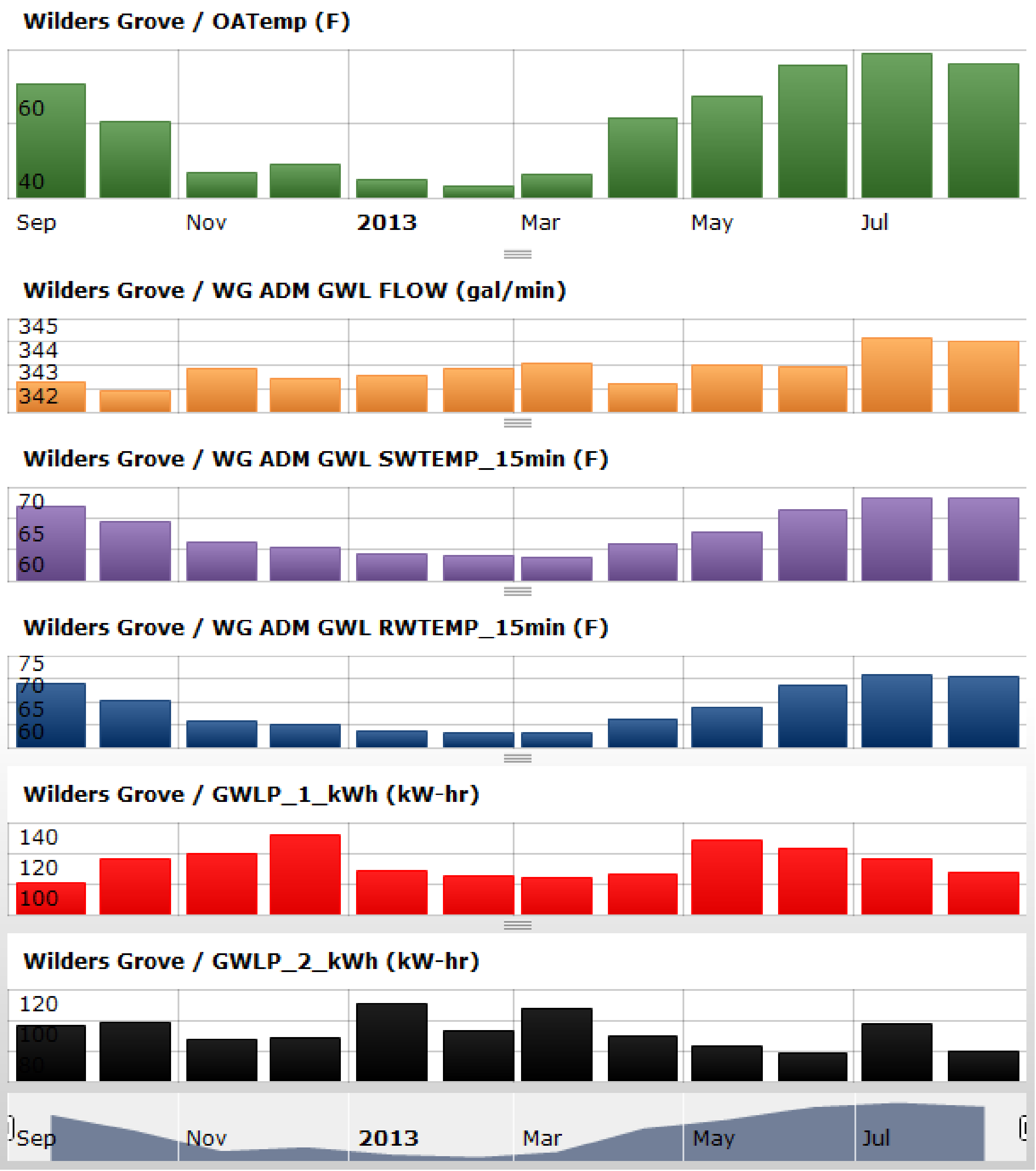
Timestamp	Wilders Grove/ExtLightskWhAggregate (kW-hr)	Wilders Grove/IntLightskWhAggregate (kW-hr)
Sep 2013	4329.887	2702.598
Oct 2013	4665.232	2513.809
Nov 2013	4785.885	2405.682
Dec 2013	4947.65	2595.893
Jan 2014	4896.16	2574.082
Feb 2014	4022.125	2290.07
Mar 2014	4078.051	2392.902
Apr 2014	3743.73	2384.691
May 2014	3623.727	2354.848
Jun 2014	3512.367	2490.883
Jul 2014	3845.84	2823.508
Aug 2014	3771.324	2732.723

APPENDIX E1

- MONTHLY ELECTRICAL ENERGY CONSUMPTION
- MONTHLY AVERAGE LOOP SUPPLY AND RETURN TEMPERATURES AND WATER FLOWS
- GROUND SOURCE LOOP PUMPS
- SEPTEMBER 2012 – AUGUST 31, 2013


Wilders Grove/GWLP_1_kWh
Wilders Grove/GWLP_2_kWh
Kilowatt Hour (kW-hr)
200
150
100
50
0
Oct
2013
Apr
Jul

Timestamp	Wilders Grove/GWLP_1_kWh (kW-hr)	Wilders Grove/GWLP_2_kWh (kW-hr)
Sep 2012	120.478	115.825
Oct 2012	135.979	118.251
Nov 2012	139.62	107.521
Dec 2012	151.404	108.916
Jan 2013	128.72	131.02
Feb 2013	124.853	113.36
Mar 2013	123.815	127.677
Apr 2013	126.126	109.29
May 2013	148.263	103.357
Jun 2013	142.404	98.481
Jul 2013	136.605	117.187
Aug 2013	127.501	99.931


Wilders Grove / OATemp (F)
60
40
Sep
Nov
2013
Mar
May
Jul
Wilders Grove / WG ADM GWL FLOW (gal/min)
345
344
343
342
Wilders Grove / WG ADM GWL SWTEMP_15min (F)
70
65
60
Wilders Grove / WG ADM GWL RWTEMP_15min (F)
75
70
65
60
Wilders Grove / GWLP_1_kWh (kW-hr)
140
120
100
Wilders Grove / GWLP_2_kWh (kW-hr)
120
100
80
Sep
Nov
2013
Mar
May
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM GWL FLOW (gal/min)	Wilders Grove / WG ADM GWL SWTEMP_15min (F)	Wilders Grove / WG ADM GWL RWTEMP_15min (F)	Wilders Grove / GWLP_1_kWh (kW-hr)	Wilders Grove / GWLP_2_kWh (kW-hr)	Events
Sep 2012	70.75	343.308	71.886	73.913	120.478	115.825	
Oct 2012	60.363	342.916	69.488	70.308	135.979	118.251	
Nov 2012	46.686	343.887	66.19	65.668	139.62	107.521	
Dec 2012	49.184	343.459	65.464	65.015	151.404	108.916	
Jan 2013	44.667	343.58	64.338	63.694	128.72	131.02	
Feb 2013	42.867	343.865	63.93	63.234	124.853	113.36	
Mar 2013	46.195	344.088	63.834	63.213	123.815	127.677	
Apr 2013	61.57	343.245	66.031	66.326	126.126	109.29	
May 2013	67.548	344.012	67.899	68.886	148.263	103.357	
Jun 2013	75.839	343.926	71.233	73.553	142.404	98.481	
Jul 2013	78.833	345.165	73.156	75.931	136.605	117.187	
Aug 2013	76.345	345.038	73.166	75.335	127.501	99.931	

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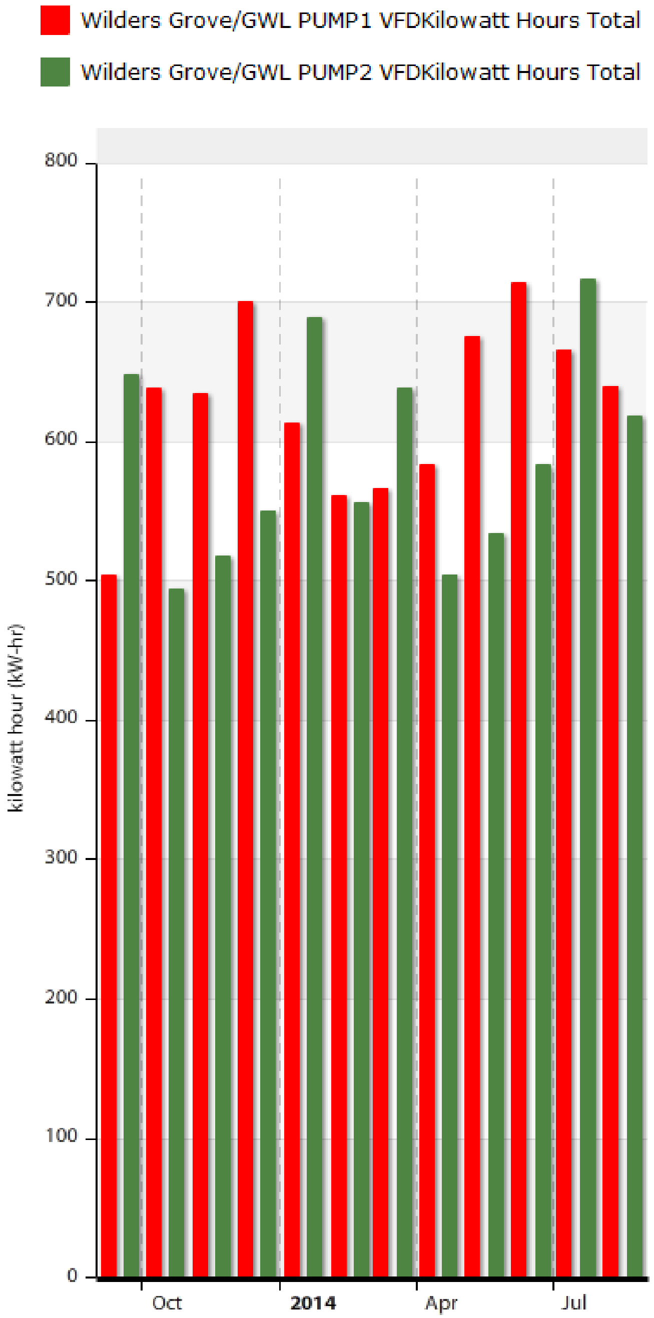
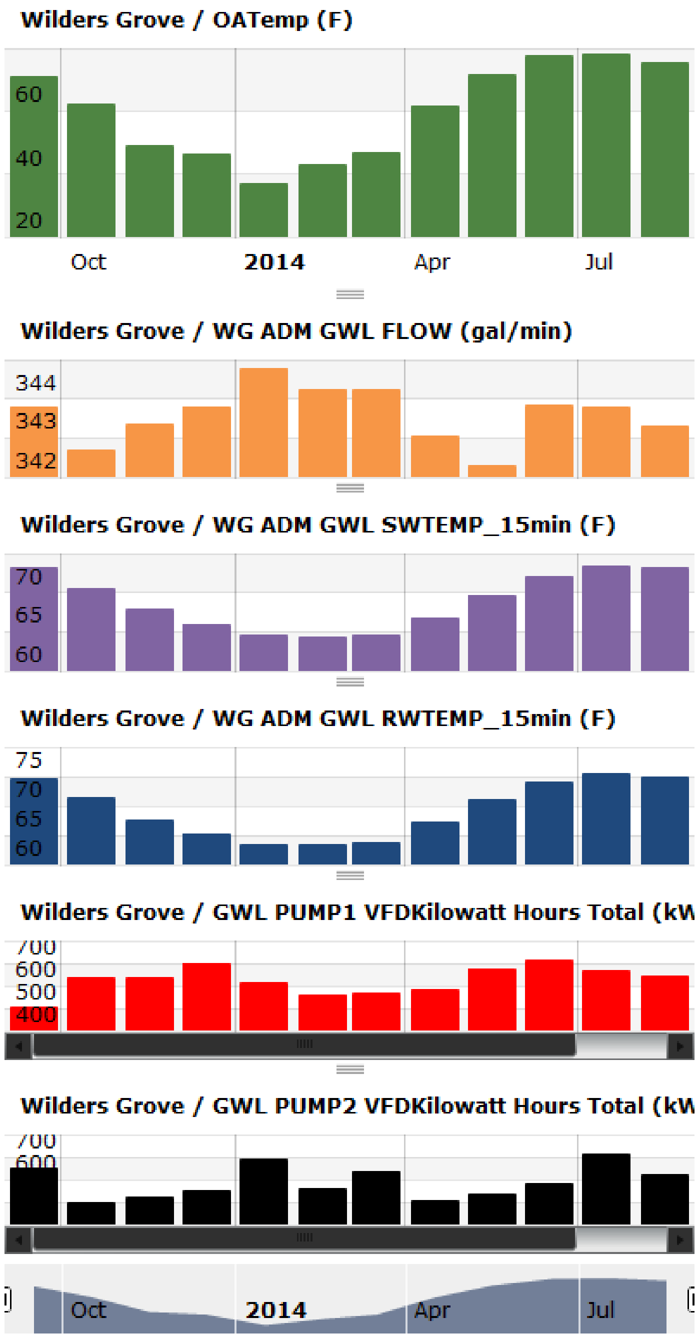
CITY OF RALEIGH · NORTH CAROLINA

APPENDIX E2

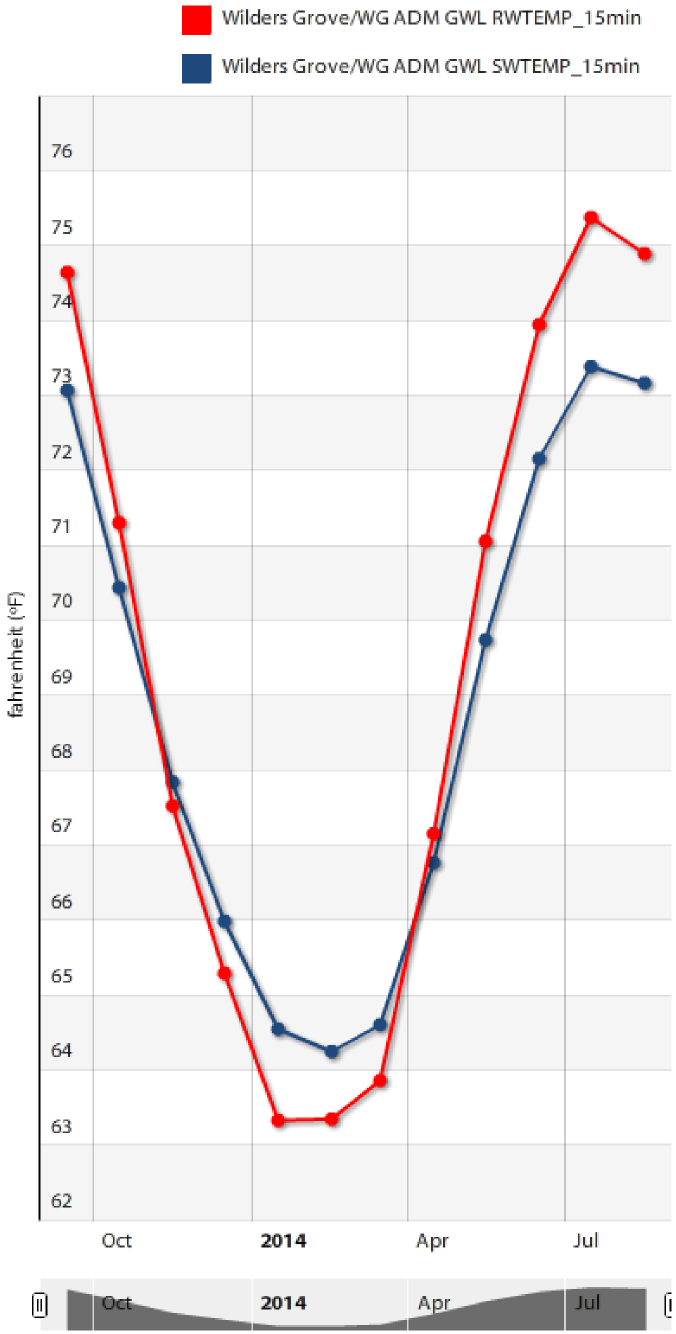
- MONTHLY ELECTRICAL ENERGY CONSUMPTION
- MONTHLY AVERAGE LOOP SUPPLY AND RETURN TEMPERATURES AND WATER FLOWS
- GROUND SOURCE LOOP PUMPS
- SEPTEMBER 2013 – AUGUST 31, 2014


🟥 Wilders Grove/GWL PUMP1 VFDKilowatt Hours Total
🟩 Wilders Grove/GWL PUMP2 VFDKilowatt Hours Total
kilowatt hour (kW-hr)
800
700
600
500
400
300
200
100
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/GWL PUMP1 VFDKilowatt Hours Total (kW-hr)	Wilders Grove/GWL PUMP2 VFDKilowatt Hours Total (kW-hr)
Sep 2013	504	648
Oct 2013	638	494
Nov 2013	634	518
Dec 2013	700	550
Jan 2014	613	689
Feb 2014	561	556
Mar 2014	566	638
Apr 2014	583	504
May 2014	676	534
Jun 2014	714	583
Jul 2014	666	716
Aug 2014	640	618


Wilders Grove / OATemp (F)
60
40
20
Oct
2014
Apr
Jul
Wilders Grove / WG ADM GWL FLOW (gal/min)
344
343
342
Wilders Grove / WG ADM GWL SWTEMP_15min (F)
70
65
60
Wilders Grove / WG ADM GWL RWTEMP_15min (F)
75
70
65
60
Wilders Grove / GWL PUMP1 VFDKilowatt Hours Total (kW
700
600
500
400
Wilders Grove / GWL PUMP2 VFDKilowatt Hours Total (kW
700
600
Oct
2014
Apr
Jul

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM GWL FLOW (gal/min)	Wilders Grove / WG ADM GWL SWTEMP_15min (F)	Wilders Grove / WG ADM GWL RWTEMP_15min (F)	Wilders Grove / GWL PUMP1 VFDKilowatt Hours Total (kW-hr)	Wilders Grove / GWL PUMP2 VFDKilowatt Hours Total (kW-hr)	Events
Sep 2013	70.866	343.81	73.067	74.641	504	648	
Oct 2013	61.964	342.682	70.435	71.303	638	494	
Nov 2013	48.77	343.336	67.841	67.52	634	518	
Dec 2013	46.33	343.815	65.983	65.291	700	550	
Jan 2014	37.04	344.773	64.545	63.324	613	689	
Feb 2014	42.946	344.249	64.243	63.346	561	556	
Mar 2014	46.722	344.222	64.602	63.859	566	638	
Apr 2014	61.693	343.028	66.765	67.151	583	504	
May 2014	71.501	342.305	69.736	71.05	676	534	
Jun 2014	77.411	343.83	72.151	73.945	714	583	
Jul 2014	77.992	343.774	73.383	75.374	666	716	
Aug 2014	75.579	343.319	73.162	74.885	640	618	


Wilders Grove/WG ADM GWL RWTEMP_15min
Wilders Grove/WG ADM GWL SWTEMP_15min
fahrenheit (ºF)
76
75
74
73
72
71
70
69
68
67
66
65
64
63
62
Oct
2014
Apr
Jul
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/WG ADM GWL RWTEMP_15min (ºF)	Wilders Grove/WG ADM GWL SWTEMP_15min (ºF)
Sep 2013	74.641	73.067
Oct 2013	71.303	70.435
Nov 2013	67.52	67.841
Dec 2013	65.291	65.983
Jan 2014	63.324	64.545
Feb 2014	63.346	64.243
Mar 2014	63.859	64.602
Apr 2014	67.151	66.765
May 2014	71.05	69.736
Jun 2014	73.945	72.151
Jul 2014	75.374	73.383
Aug 2014	74.885	73.162

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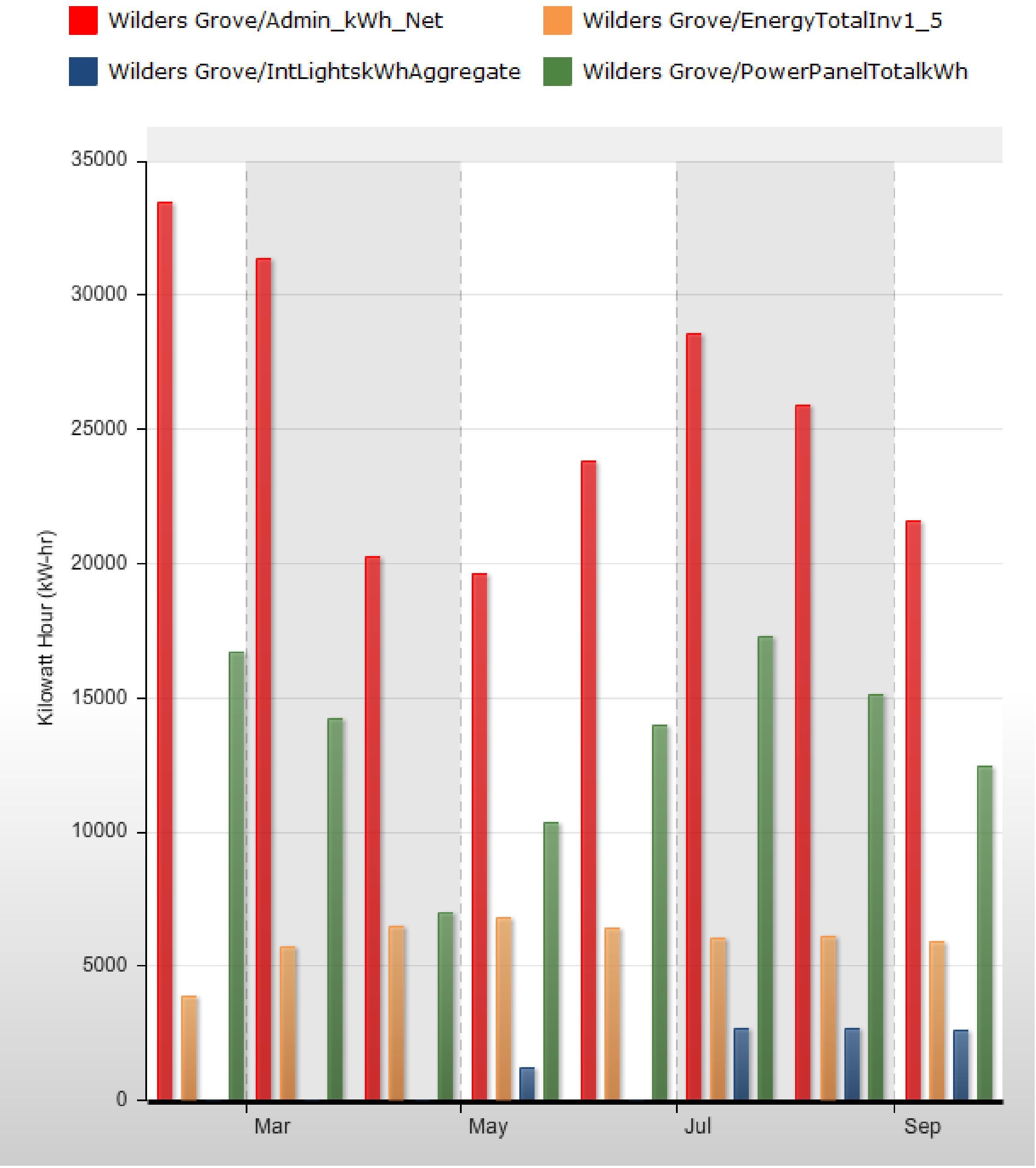
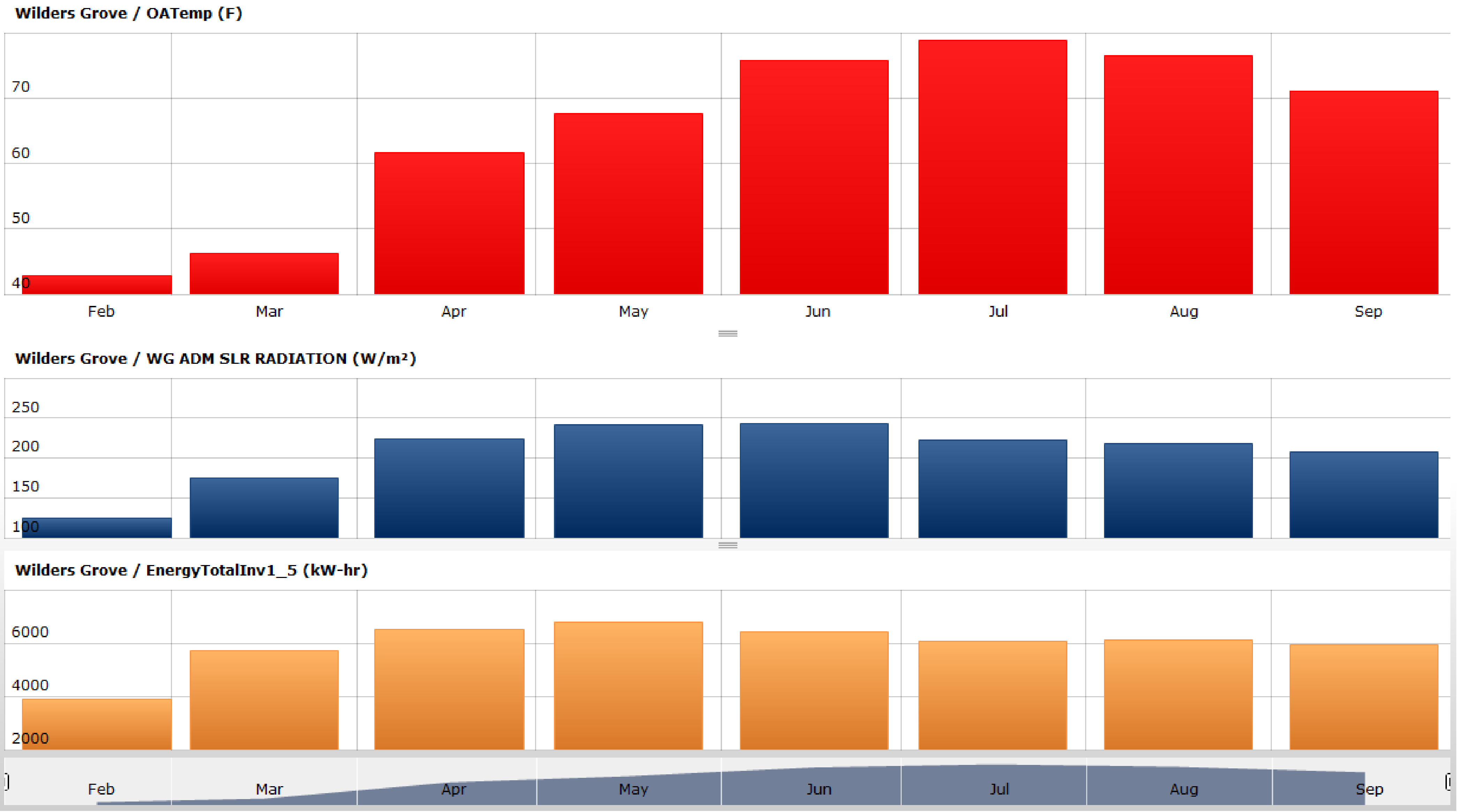
CITY OF RALEIGH
NORTH CAROLINA

APPENDIX F1

- MONTHLY NET METERED ELECTRICAL ENERGY CONSUMPTION
- SOLAR PHOTOVOLTAIC PRODUCTION
- AVERAGE MONTHLY SOLAR IRRADIATION AND TEMPERATURES
- FEBRUARY 1, 2013 – SEPTEMBER 30, 2013


Wilders Grove/Admin_kWh_Net
Wilders Grove/EnergyTotalInv1_5
Wilders Grove/IntLightskWhAggregate
Wilders Grove/PowerPanelTotalkWh
Kilowatt Hour (kW-hr)
35000
30000
25000
20000
15000
10000
5000
0
Mar
May
Jul
Sep

Timestamp	Wilders Grove/Admin_kWh_Net (kW-hr)	Wilders Grove/EnergyTotalInv1_5 (kW-hr)	Wilders Grove/IntLightskWhAggregate (kW-hr)	Wilders Grove/PowerPanelTotalkWh (kW-hr)
Feb 2013	33483.799	3896	0	16698.664
Mar 2013	31361	5720	0	14211.391
Apr 2013	20234.602	6497	0	6987.062
May 2013	19632.898	6787	1214.785	10383.875
Jun 2013	23827.008	6421	-336.158	14001.562
Jul 2013	28593.781	6063	2645.324	17290.75
Aug 2013	25902.531	6116	2669.127	15119.391
Sep 2013	21574	5936	2617.994	12473.328


Wilders Grove / OATemp (F)
70
60
50
40
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Wilders Grove / WG ADM SLR RADIATION (W/m²)
250
200
150
100
Wilders Grove / EnergyTotalInv1_5 (kW-hr)
6000
4000
2000
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM SLR RADIATION (W/m²)	Wilders Grove / EnergyTotalInv1_5 (kW-hr)	Events
Feb 2013	42.867	124.378	3896	
Mar 2013	46.195	175.568	5720	
Apr 2013	61.57	223.785	6497	
May 2013	67.548	241.792	6787	
Jun 2013	75.839	243.101	6421	
Jul 2013	78.833	223.104	6063	
Aug 2013	76.54	217.71	6116	
Sep 2013	71.131	207.42	5936	

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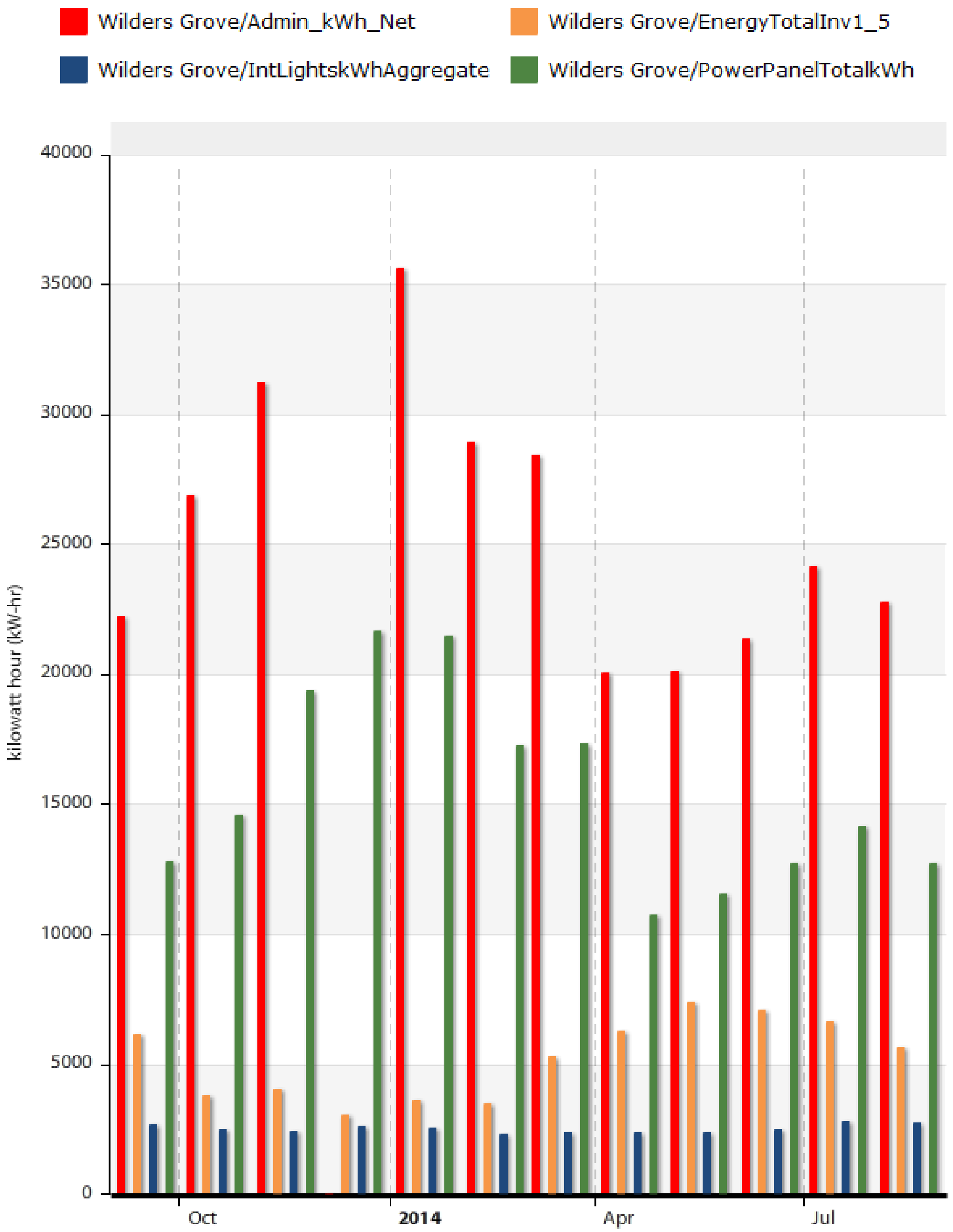
CITY OF RALEIGH • NORTH CAROLINA

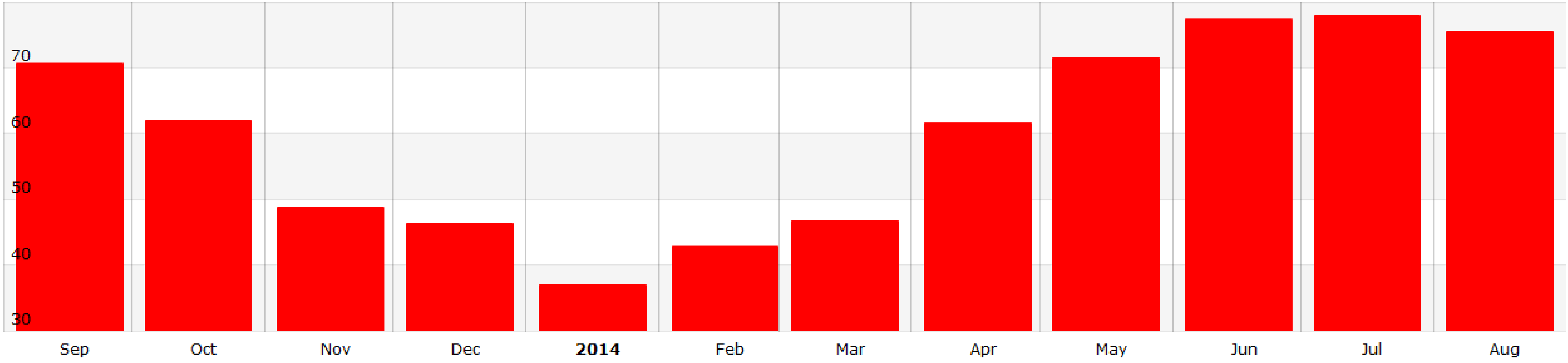
APPENDIX F2

- MONTHLY NET METERED ELECTRICAL ENERGY CONSUMPTION
- SOLAR PHOTOVOLTAIC PRODUCTION
- AVERAGE MONTHLY SOLAR IRRADIATION AND TEMPERATURES
- SEPTEMBER 1, 2013 – AUGUST 31, 2014

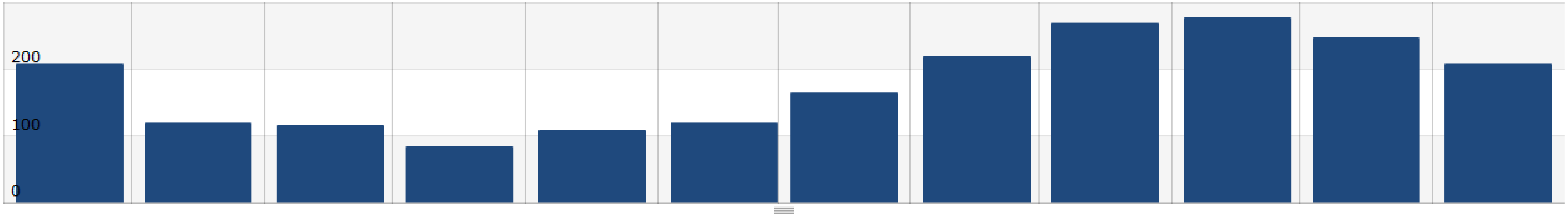

Wilders Grove/Admin_kWh_Net
Wilders Grove/EnergyTotalInv1_5
Wilders Grove/IntLightskWhAggregate
Wilders Grove/PowerPanelTotalkWh
kilowatt hour (kW-hr)
40000
35000
30000
25000
20000
15000
10000
5000
0
Oct
2014
Apr
Jul

Timestamp	Wilders Grove/Admin_kWh_Net (kW-hr)	Wilders Grove/EnergyTotalInv1_5 (kW-hr)	Wilders Grove/IntLightskWhAggregate (kW-hr)	Wilders Grove/PowerPanelTotalkWh (kW-hr)
Sep 2013	22223.031	6129	2702.598	12810.344
Oct 2013	26893.281	3807	2513.809	14565.953
Nov 2013	31249.75	4056	2405.682	19349.688
Dec 2013	-252050.703	3079	2595.893	21641.156
Jan 2014	35637.273	3604	2574.082	21468.344
Feb 2014	28949.906	3486	2290.07	17242.969
Mar 2014	28462.648	5299	2392.902	17344.531
Apr 2014	20053.078	6265	2384.691	10762.406
May 2014	20121.328	7373	2354.848	11538.781
Jun 2014	21335.531	7092	2490.883	12759.094
Jul 2014	24134.328	6637	2823.508	14184.312
Aug 2014	22773.344	5631	2732.723	12701.875

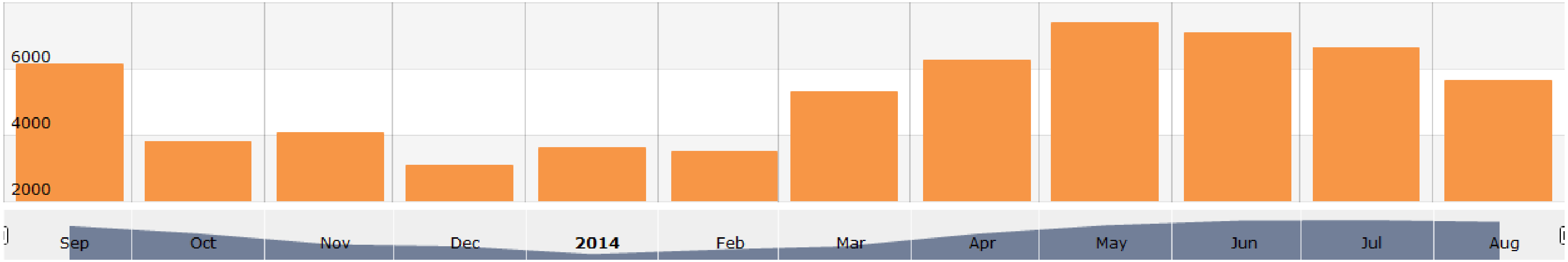
Wilders Grove / OATemp (F)



Wilders Grove / WG ADM SLR RADIATION (W/m²)

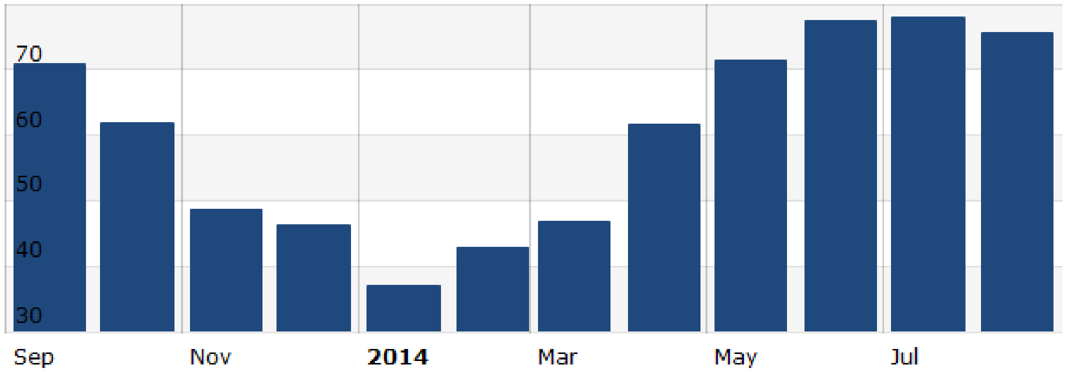


Wilders Grove / EnergyTotalInv1_5 (kW-hr)

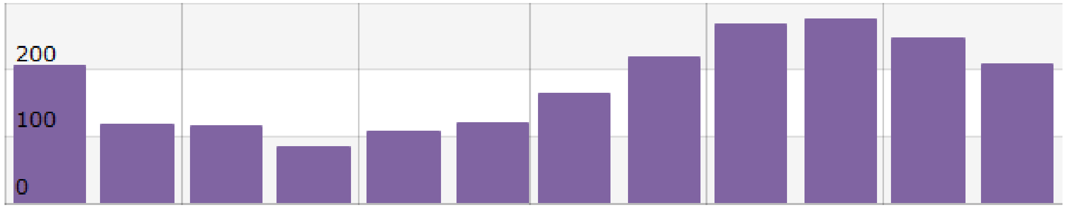


Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM SLR RADIATION (W/m²)	Wilders Grove / EnergyTotalInv1_5 (kW-hr)	Events
Sep 2013	70.866	206.545	6129	
Oct 2013	61.964	118.562	3807	
Nov 2013	48.77	114.849	4056	
Dec 2013	46.33	83.467	3079	
Jan 2014	37.04	107.803	3604	
Feb 2014	42.946	120.029	3486	
Mar 2014	46.722	164.04	5299	
Apr 2014	61.693	219.02	6265	
May 2014	71.501	269.202	7373	
Jun 2014	77.411	276.421	7092	
Jul 2014	77.992	246.472	6637	

Wilders Grove / OATemp (F)

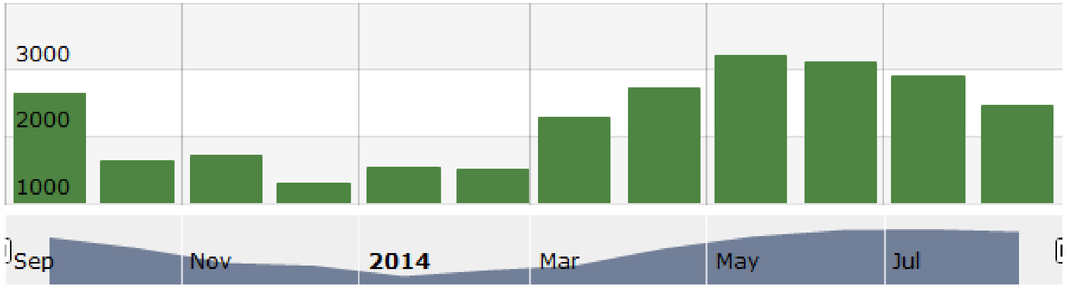


Wilders Grove / WG ADM SLR RADIATION (W/m²)



Wilders Grove / VW_kWh_Net (kW-hr)

Wilders Grove / EnergyTotalInv6_7 (kW-hr)



Timestamp	Wilders Grove / OATemp (F)	Wilders Grove / WG ADM SLR RADIATION (W/m²)	Wilders Grove / VW_kWh_Net (kW-hr)	Wilders Grove / EnergyTotalInv6_7 (kW-hr)	Events
Sep 2013	70.866	206.545	-319.979	2659	
Oct 2013	61.964	118.562	-497.412	1637	
Nov 2013	48.77	114.849	-615.033	1724	
Dec 2013	46.33	83.467	-858.914	1294	
Jan 2014	37.04	107.803	-1071.82	1546	
Feb 2014	42.946	120.029	-887.893	1496	
Mar 2014	46.722	164.04	-579.184	2287	
Apr 2014	61.693	219.02	-414.805	2724	
May 2014	71.501	269.202	-359.884	3213	
Jun 2014	77.411	276.421	-274.718	3117	
Jul 2014	77.992	246.472	-228.593	2909	
Aug 2014	75.579	207.445	-231.654	2461	

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CITY OF RALEIGH
NORTH CAROLINA

APPENDIX G

GROUND LOOP HEAT PUMP PERFORMANCE REPORT
OCTOBER 28, 2013

CITY OF RALEIGH

RALEIGH, NC

WILDERS GROVE SERVICE CENTER
GROUND LOOP HEAT PUMP PERFORMANCE REPORT

HIPP PROJECT # 208077

OCTOBER 28, 2013

Rev	Date	Purpose of Issuance
-	10/28/2013	For Reference Only

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& CONSULTING, INC.

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QUALITY SEAL FOR EVALUATION

Hipp Engineering and Consulting, Inc. is pleased to deliver this Evaluation for your review. The following signature by our technical lead for this project serves as a quality seal on this deliverable.

Harold W Jones

Harold W. Jones, P.E.
Lead Mechanical Engineer
Hipp Engineering & Consulting, Inc.
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ENGINEER
HAROLD W. JONES

Harold W Jones

10-28-2013

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

1.0 GENERAL

Hipp Engineering & Consulting, Inc. (HIPP) was contracted by Hazen and Sawyer in 2008 to prepare a study and engineering detailed design for their Wilders Grove Solid Waste Service Facility. The facility was completed and has been operating for two years. This report is a follow up to regarding the performance of the Ground Loop Heat Pump system that was installed at that facility.

The facility was constructed in the East Raleigh area adjacent to the old landfill site. The facility is a combination of offices, class rooms, meeting spaces, and locker facilities for the entire solid waste department. The requirements for these spaces provided some difficult situations for the HVAC systems to address:

- Locker areas are occupied for approximately 1 hour in the morning and 1 hour in the afternoon. Approximately 300 people occupy this space during these periods.
- Class rooms are used daily to brief work crews for approximately ½ hour each morning. The rooms are used periodically through the day for training activities.
- The dining area is also to be equipped with bleachers for a monthly assembly type meeting where all of the department's employees are present. This monthly meeting would last for about one hour.

The mechanical systems utilize ground source heat pumps, heat / cooling reclamation and on-demand ventilation to address the unique occupancy requirements for the facility. To further enhance energy conservation measures, domestic water is heated using a ground source heat pump system with an electric back-up heating element. The systems (HVAC and plumbing) provide energy savings of approximately 42% over conventional designs and received 10 LEED credits for energy conservation.

The facility received LEED Gold status for its construction and operational performance.

2.0 OVERALL SYSTEM OPERATION

A. Section 3 of this report contains well field performance data that was provided by the City of Raleigh from the Building Management System installed at the Wilders Grove Facility. This data was charted on line graphs for June 9, 2013 through June 30, 2013, July, 2013, August, 2013, September 2013, and October 1, 2013 through October 9, 2013. The data shows that the circulation pump varied in flow between 300 and 370 gpm. The maximum load observed was approximately 80 tons (the original design was a peak load of 100 tons). This maximum load is as expected since most buildings operate with a 20% load diversity. Reviewing the trend data clearly shows when the facility is not occupied, daily peak loads and when the system is operating in a heating mode (negative loads). The supply and return temperature differences range between 0 (when the heat pumps are shut down) to 4 degrees. The system tonnage was calculated using the basic formula $Q=500xgpmx\Delta T$ (Temp in – Temp out).

B. GLHP Water Flows

While the original design called for a constant speed circulation pump, the City of Raleigh opted to upgrade the system to variable speed using a Variable Frequency Drive. The pump speed is controlled based on the differential pressure between the supply and return lines in the facility. From the data it can be seen that even under a no load condition the pump was maintaining flow at 300+ gpm. Due to the high pressure drop through the well field, changes within the building demand are very slight and are not detected by the differential pressure transmitter. Should the City want to modify the operation to reduce the water flow through the system, a differential temperature control scheme could be employed where the pump speed is varied to maintain a differential between supply and return temperatures. The heat pump systems are designed to typically use 80°F supply and 90°F return. The lower flows and lower temperature rises are due to higher water flow rates. Varying the flow rate to obtain higher water loop temperatures can reduce the pump power consumption.

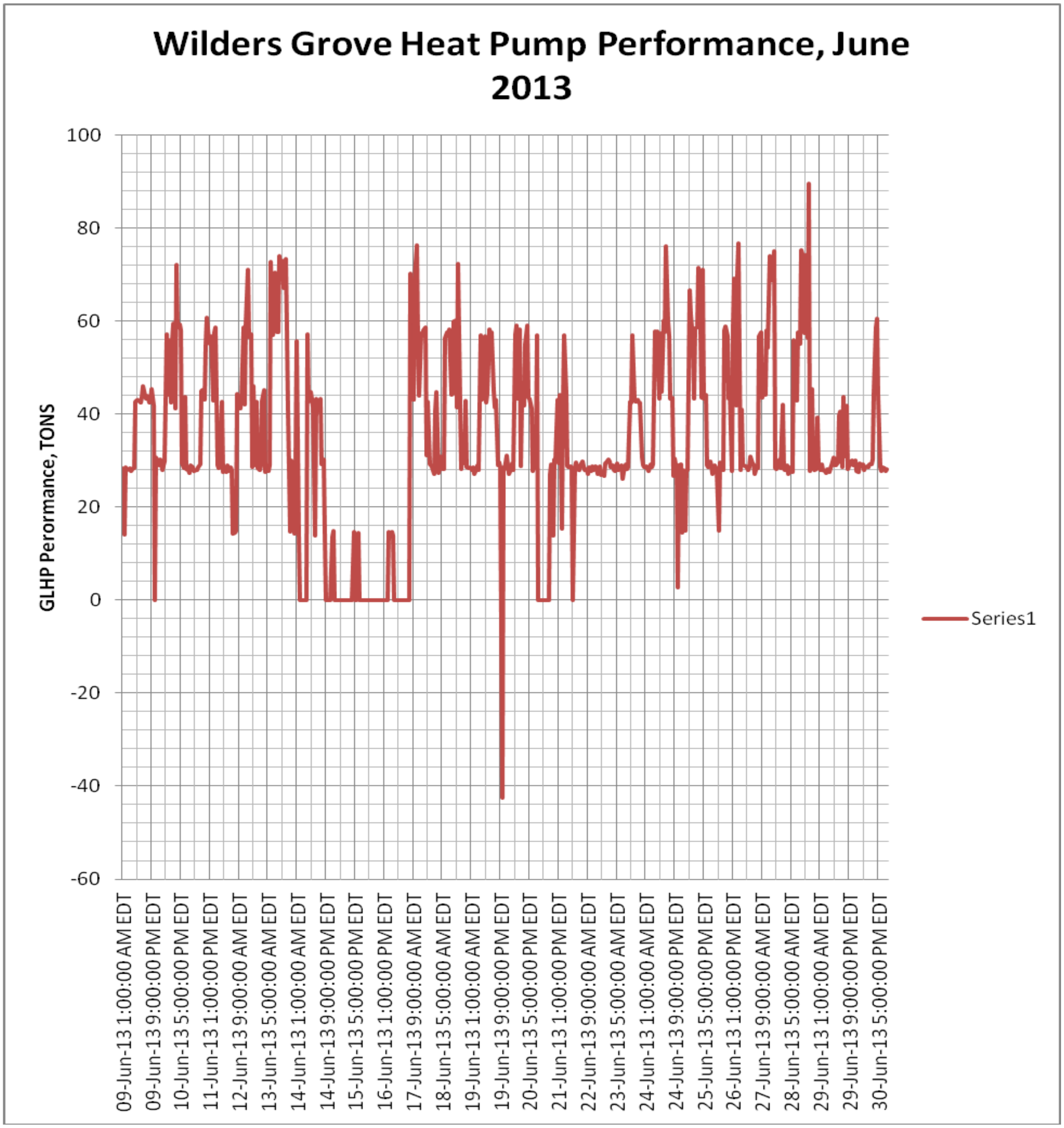
C. Well Field Capacity

The operational data to date indicates that the well field is operating correctly. It was reported to HIPP that the well field monitoring sensors have not indicated any increase in temperatures. Temperature differences between the wellfield and supply loop hold at around 10^o F. This was expected when designed due to a lack of ground water and the well being essentially solid granite. The quantity of wells, flows and layouts appear to be meeting the design intent and with an observed 80 ton load, the well field is operating at the intended capacity. Some additional load could potentially be added to the system if the flow rates are reduced. The current well field could probably handle an additional 20 ton HVAC load when accounting for system operational diversity.

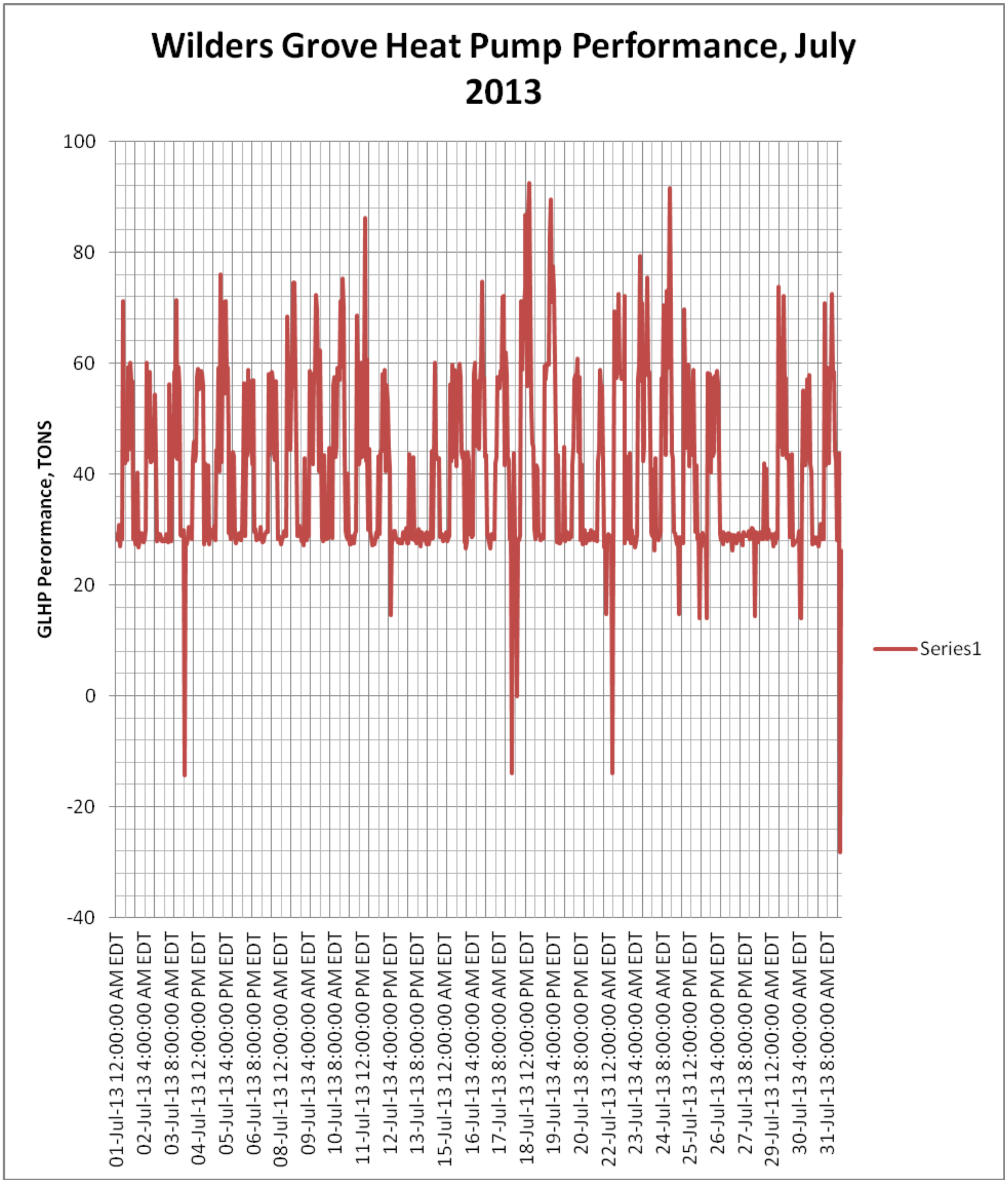
3.0 GRAPHICAL DATA

3.0 GENERAL

The graphical data included in this section is based on actual trend data provided by the City of Raleigh from June 9th to October 9, 2013.



3.0 GRAPHICAL DATA



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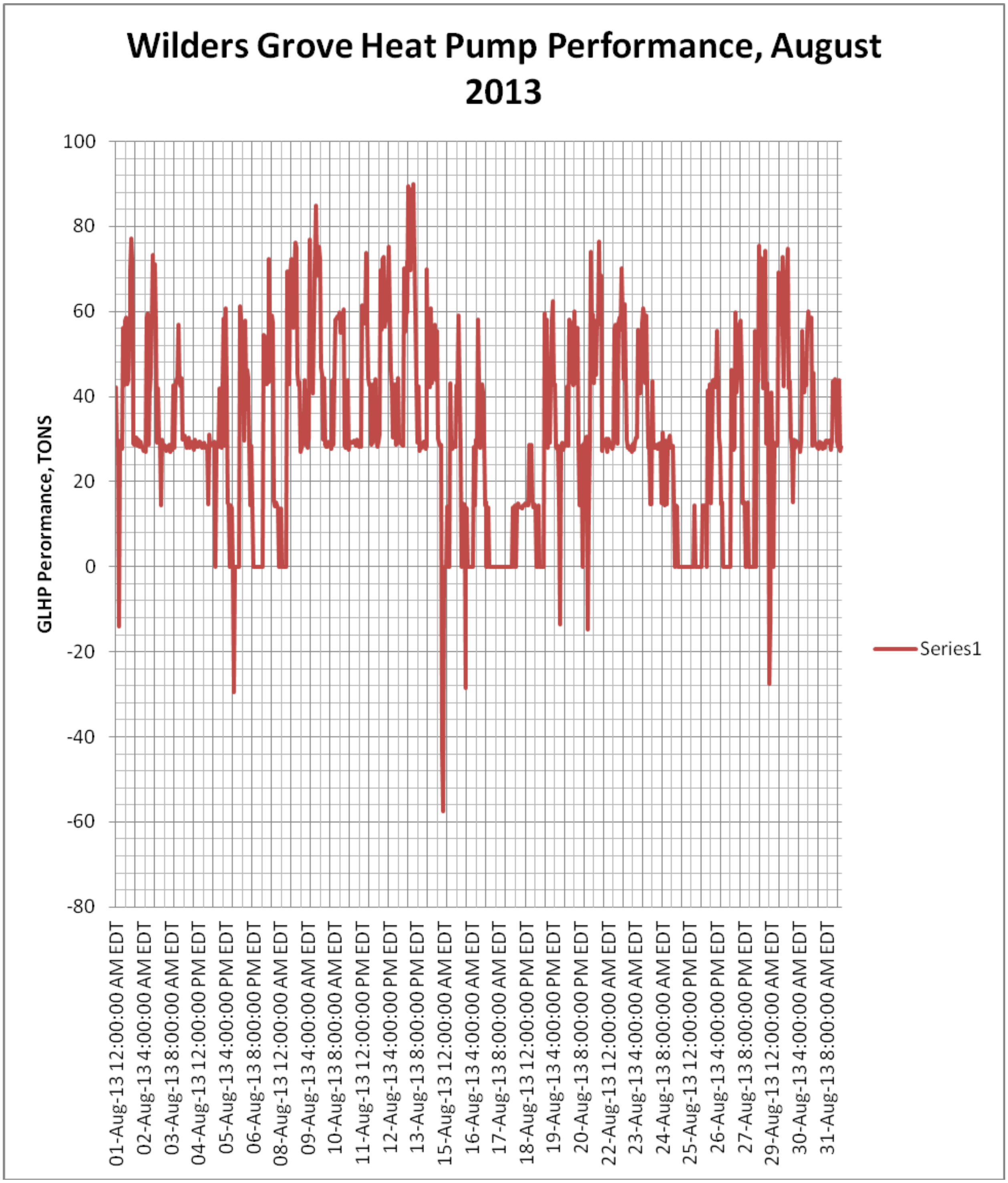

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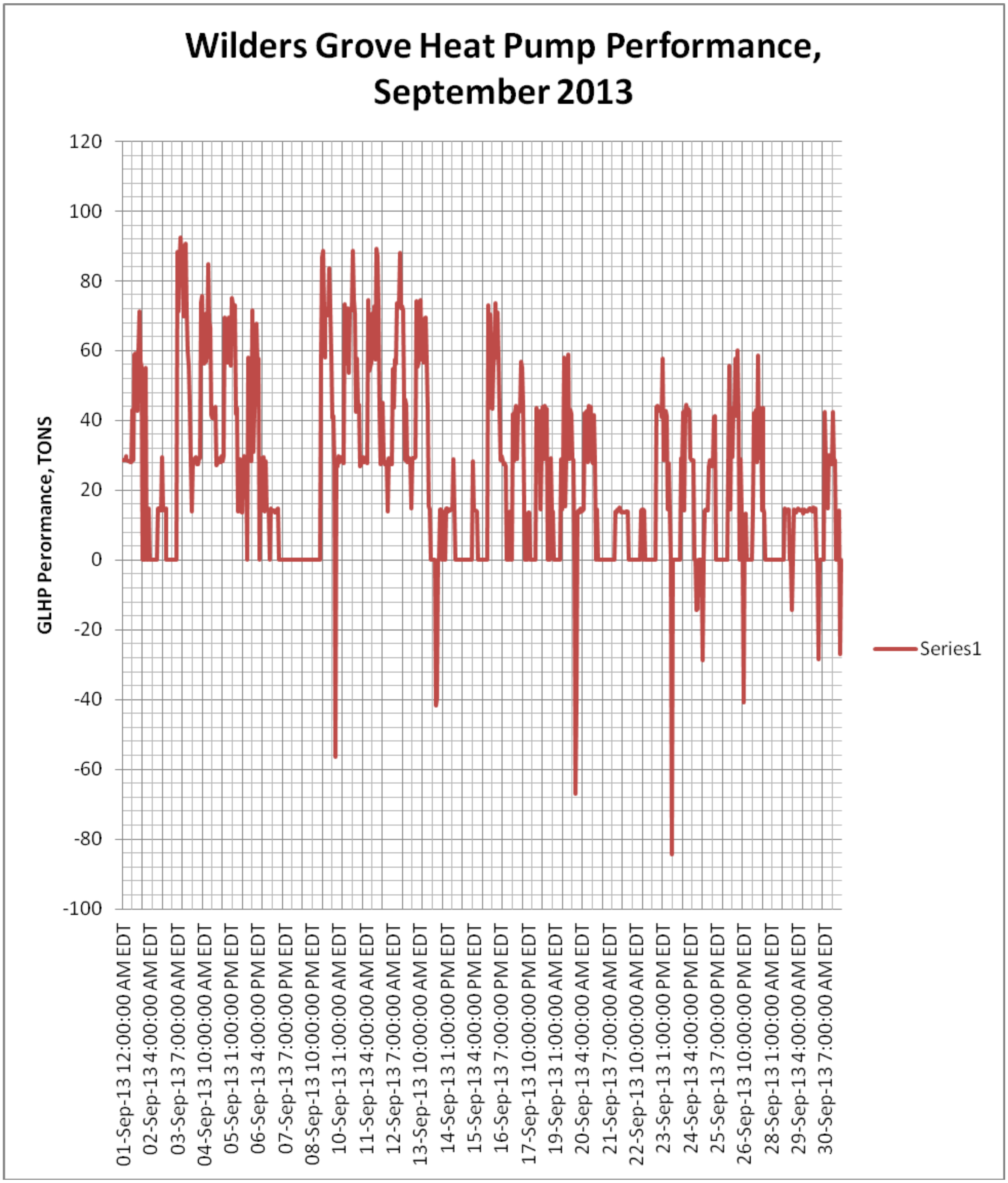
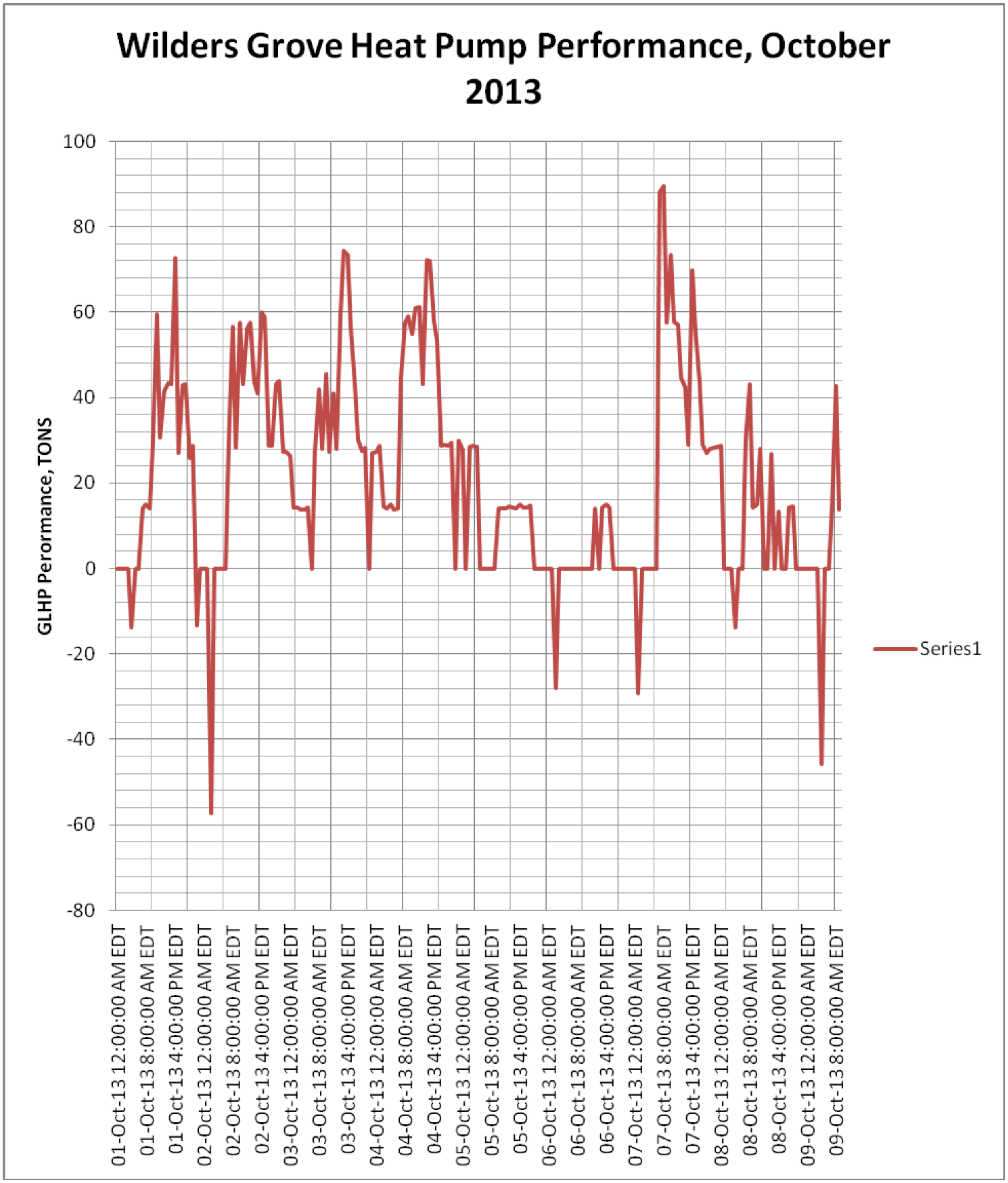


3.0 GRAPHICAL DATA



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CITY OF RALEIGH
NORTH CAROLINA

APPENDIX H

EVAPORATIVE COOLER EVALUATION REPORT

CITY OF RALEIGH

RALEIGH, NC

WILDERS GROVE SERVICE CENTER
EVAPORATIVE COOLER EVALUATION

HIPP JOB # 208077

FEBRUARY 18, 2011

Rev	Date	Purpose of Issuance
A	02/18/2011	Issued For Review

HAZEN AND SAWYER
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EVAPORATIVE COOLER EVALUATION

1.0 EXECUTIVE SUMMARY

1.0 GENERAL

Hipp Engineering was contracted by Hazen & Sawyer to provide an evaluation for adding an evaporative cooler to the current ground coupled heat pump system. This equipment addition will produce a “Hybrid” ground coupled heat pump system that combines the currently installed heat exchange well field with an evaporative cooler or closed circuit cooling tower.

These hybrid systems are typically used to reduce the number of wells or their depth and still provide the cooling capacity needed to operate the facility. In this case the well field has already been installed and sized for the maximum loads within the facility. For this project the evaporative cooler would ultimately be used to prolong the well field life and provide additional capacity should future additions of the administration facility be constructed. Installation of an evaporative cooler at this time would not be recommended until a building expansion is planned.

The following report will describe the current system and associated well field; how it has been modified based on actual test data from the original design. It will also describe how an evaporative cooler can be added into the system and its operation. A comparison of energy models are also included comparing the hybrid system operation to the current design. Finally, an economic analysis is provided that will compare operation of the ground coupled system with the hybrid and the benefit of using the hybrid system in lieu of additional wells for future facility expansions.

2.0 CURRENT GROUND COUPLED HVAC SYSTEM

2.0 GENERAL

A. The ground coupled component or well field of the HVAC system is nothing more than using the Earth as a heat exchanger. In this case, the Earth is a heat sink for rejecting heat energy from the building during the summer and a heat source for absorbing thermal energy during the winter.

B. The current HVAC system design is comprised of unitary terminal units to be installed on the equipment platform level of the facility and utilize direct expansion water source heat pumps and supply fans.

C. The original well field design was based on installing 60 wells to a depth of 400 feet on a 25 ft. x 25 ft. spacing. It was found that the thermal performance of the ground beneath the facility was superior than the assumed values used during th system design. Based on the actual test data, the well field depths were reduced to 335 ft. Reducing the well field depth is purely a cost savings for the facility and does not impact the overall well field performance or longevity of the field.

2.1 PERFORMANCE

A. The well field capacity is based on providing a maximum of 100 refrigeration tons (1,200,000 BTU/HR) of heat rejection from the facility. The cooling water from the well field is used to produce condenser water for the water source heat pumps optimized for a temperature of 85°F supply water. (Operating the well field at lower temperatures will reduce the heat pump equipment life) This load will vary during the year however the facility will have a cooling load throughout the year when the building is occupied.

B. The well field is designed to produce 85°F supply water. During design day summer conditions the evaporative cooler cannot generate supply water less than 85°F. Additionally, the optimum water temperature for constant speed water source heat pumps is 85°F. Operating at this temperature ensures proper compressor oil return, long equipment life and consuming the least amount of electrical energy.

C. The well field also serves as a heat source for building heating. In order to heat the facility, the heat pump units reverse their operation to draw heat from the well field and provide building heating and domestic hot water generation. The heat load however is minimal compared to the cooling load.

2.1 WELL FIELD LIFE

A. It is anticipated that the well field will provide 20 years of service. This life is based on the theory that heat rejected to the well field will accumulate and slowly raise the ground temperature to the point where it is no longer viable. In northern climates (where long term use of ground coupled heat pumps have been observed) this limited life has not been seen. This is due to the balance between heating and cooling loads where heat rejected during the summer is recovered for winter heating. In southern climates (including North Carolina) the cooling season is significantly longer and even during winter months it is not uncommon to require facility cooling. This results in an almost continual heat rejection the well field with little heat recovery.

B. While the calculations indicate that the well field has a limited life, there is no long-term data to support this fact. Ground water, heat conduction and other factors (not addressed by the design calculations) will affect the heat retention of the ground. It can be concluded that the ultimate life of the well field is unknown but should be a minimum of 20 years. As part of a Department of Energy Grant associated with this project, the well field's performance (temperature rise) will be monitored to provide this long term data.

3.0 GENERAL

A hybrid ground coupled HVAC system combines the ground coupled well field with a mechanical cooling device typically an evaporative cooler or closed circuit cooling tower. The well field is sized for the building's heating load and is used for the base cooling load. The evaporative cooler is typically operated to supplement the well field during peak loads. This arrangement reduces the number or depth of well points while meeting the building's cooling loads. For this facility an evaporative cooler is being evaluated to prolong the theoretical life of the well field and provide additional capacity for the eventual expansion of the administration building.

3.1 EVAPORATIVE COOLER

A. An evaporative cooler or cooling tower cools water by a combination of heat and mass transfer. The water to be cooled is distributed in the tower by spray nozzles, splash bars, or film-type fill, which exposes a very large water surface area to atmospheric air. Atmospheric air is circulated by (1) fans, (2) convective currents, (3) natural wind currents, or (4) induction effect from sprays. A portion of the water absorbs heat to change from a liquid to a vapor at constant pressure. This heat of vaporization at atmospheric pressure is transferred from the water remaining in the liquid state into the airstream.

B. The temperature of the water leaving the cooling tower or approach temperature is based on the wet-bulb temperature of the air. The typical approach of a cooling tower is 7 - 10°F. For Raleigh, the design wet-bulb temperature is 75°F resulting in a leaving water temperature of 85°F.

C. The evaporative cooler both are designed to produce 85°F supply water. During design day summer conditions the evaporative cooler cannot generate supply water less than 85°F. Additionally, the optimum water temperature for constant speed water source heat pumps is 85°F. Operating at this temperature ensures proper compressor oil return, long equipment life and consuming the least amount of electrical energy.

D. The cooling tower or evaporative cooler to be used for this project is of the indirect type. An indirect cooling tower has the water to be cooled pass through a heat exchanger. The tower sprays water over the fill and heat exchanger to cool the water loop. Cooling water to the heat pumps is separated from the evaporative cooler.

3.2 AFFECT ON SYSTEM

A. As currently configured, the evaporative cooler would only serve to off-set some of heat rejection from the well field and would not provide a significant benefit to the facility operation.

B. Should the service center be expanded an evaporative cooler would be necessary to provide the additional cooling capacity necessary to meet the increase in HVAC load. This is purely for economic reasons as shown in section 5 and appendix 'D' where the costs are compared for expanding the well field vs. adding the evaporative cooler.

4.0 ENERGY MODEL

4.0 GENERAL

The original energy model prepared for the administration facility compared the operation of the ground coupled heat pump HVAC system to a conventional system using direct expansion central air handling units and electric heat. The ground coupled heat pump system produced energy savings of 57.5% over the conventional system. Using the same heat pump units but with an evaporative cooler, the savings are still 50.2% over the conventional system allowing the facility to receive all 10 LEED points for energy. There are no savings for using the evaporative cooler in lieu of the well field. The evaporative cooler and its additional equipment increases the operational costs of the system compared with the ground loop system itself.

4.1 ENERGY MODEL RESULTS

The energy model results are included in appendix 'B' of this report. The hybrid system's energy model includes the additional tower fan and circulation pump operation. It should also be noted the operation of the evaporative cooler has no affect on the heat pumps within the facility i.e. there is no increase nor decrease in efficiency.

4.1 ITEMS NOT INCLUDED IN ENERGY MODEL

The energy model that was prepared only compares the difference in energy or electrical consumption. There are costs that are not included within the energy model that will need to be addressed in order to understand the impact of adding this type of equipment.

A. Water consumption: An evaporative cooler, by its definition, evaporates water in order to produce a cooling effect. This type of equipment typically evaporates 3 gallons per minute per 100 tons of refrigeration. For a 100 ton load, the evaporation rate is 3 gpm (3 gpm/100 tons x 100 tons). Over the course of an hour, that would be 180 gallons. Additionally, in order to avoid developing high concentrations of dissolved solids and to maintain cooling tower efficiency, a portion of the water flow is bled off as "blow-down". For initial estimates, this value is based on a continuous blow-down to maintain 4 cycles of concentration (amount of solids remaining if the water were evaporated from the tower basin 4 times) the blow-down rate would be approximately 1 gpm. The total make-up for a 100 ton cooling tower operating at full load is therefore 4 gpm or 240 gallons per hour.

B. The cost for the water is based on the City of Raleigh Water rates. The reclaim water that will be used for make-up to the cooler would be sold at $1.56/CCF (100 cubic feet) or 50% of the cost for potable water. 1 CCF = 748 gallons of water. The energy model was able to produce hourly results for the cooling tower operation for the year. With this data, the actual make up water rate (evaporation + blow-down) was calculated and determined to be 154,870 gallons annually. This breaks down to 207 CCF or a cost of $306.43 / year.

C. Finally, maintenance costs are not included for either system. An evaporative cooler does require significant annual maintenance as well as periodic cleaning and overhaul. It should also be noted that the use of reclaim water will increase the periodic system cleaning requirements due to deposits from the water as opposed to systems using potable water. These costs will be outlined in the economic analysis of this report.

D. There are no Installation costs included in the energy model. These costs are where savings are available as the installation of an evaporative cooler is significantly less than boring additional wells. These costs will also be outlined in the economic analysis of this report.

5.0 ECONOMIC ANALYSIS

The economic analysis that is provided in appendix ‘C’ includes operating costs (energy, maintenance and water consumption) and installation costs (equipment, piping and electrical services). The following is a list of operating costs for an evaporative cooler that would not be found with the well field:

Annual maintenance including water testing, $2,000/year
Evaporative Cooler Cleaning, $5,000/3 years
Evaporative Cooler Major Maintenance, $7,500/10 years
Water Make-up, $306.43/year
Electrical Usage, Pump & Fan, $6,573/year

The major difference between the evaporative cooler and well field when comparing lies with the installation costs of the systems, especially in the case of adding 10 additional well points for a future expansion of the facility. In this case, the costs break down as follows:

Evaporative Cooler:	Direct Costs	$95,880
	In-Direct Costs	$17,400
	Total including contingency, overhead & profit	$169,353

Note: Direct costs include extending reclaim water make-up to the evaporative cooler from the Service Center, Routing a sanitary waste line from the evaporative cooler to the site sewer, evaporative cooler package, electrical service from the administration building and control communication interface.

Well Field:	Direct Costs	$211,706
	In-Direct Costs	$9,900
	Total including contingency, overhead & profit	$331,302

Note: Direct costs include removal and replacement of concrete pavement, drilling 10 wells to a depth of 350 feet with costs based on actual bid prices received during current well field installation.

A copy of these cost estimates are included in appendix ‘D’ of this report.

The main cost for adding well field points to the existing system is removal of the concrete pavement, drilling the wells, piping and re-installing the concrete. Engineering is minimal for the well field while the evaporative cooler would require a complete design package for installation. Please note the costs included in the estimates are high level and should only be used for evaluation purposes. A detailed cost estimate would be necessary for securing funding for this project addition.

5.0 ECONOMIC ANALYSIS

The cost analysis included in appendix 'C' shows that there is no pay-back period for using the evaporative cooler to serve a building addition as opposed to attempting to add wells to the well field. A no pay-back period is an indication that the first cost is low for the evaporative cooler when compared to the well field option. The only way that the well field option would even be feasible is if new wells could be installed in a lawn type area as opposed to under the pavement. The end result of this evaluation would be to delay the purchase of an evaporative cooler until a facility expansion is planned, then use the evaporative cooler to serve the additional loads. It would also be recommended that no piping, conduit or other materials be installed unless an expansion to the facility is expected within the next one to two years.

6.0 CONCLUSIONS

Based on the energy model and economic analysis of installing an evaporative cooler vs. adding additional wells, several conclusions can be made.

1. Adding an evaporative cooler at this time will not provide any significant benefit when compared to the increase in energy and water costs to operate the equipment. Adding additional wells would be prudent if expanding the facility would be expected within the next two or three years.
2. Adding an evaporative cooler to off-set temperature rises within the well field "preemptively" would only be feasible if temperature rises would indicate premature failure of the well field i.e. in less than the 20 year life span.
3. An evaporative cooler would be feasible and the only cost effective alternative to support an expansion of the Service Center.
4. An evaporative cooler in conjunction with the well field could be used to serve an expanded facility and/or additional buildings while preserving the flexibility of terminal heat pump HVAC systems.

7.0 APPENDIX 'A'

Appendix 'A'
Evaporative Cooler Catalog Cut Sheets

BAC Closed Circuit Cooling Tower Selection Program

Release 6.5 NA

Program data and calculations are correct as of Feb. 13, 2009.

To:	Hipp Engineering	**Inquiry No.:**	
Attn:	Harold Jones	**Project Name:**	Wilders Grove
From:	Chris Norwood	**Date:**	Jun. 4, 2009

Selection Parameters

Model & Fan Motor

Product Line:	Series FXV
Number of Units:	1
Model:	FXV-L442
Coil Type:	Standard Coil
Standard Total Fan Motor Power Per Unit:	10.0 HP
Fan Motor:	Standard Motor
Total Pump Motor Power Per Unit:	3.0 HP

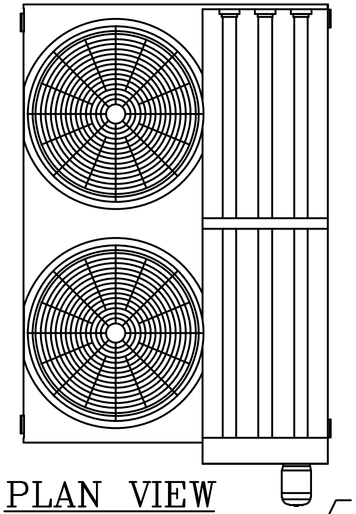
Model Accessories

Unit Intake Option:	(None)
Unit Internal Option:	(None)
Unit Discharge Option:	(None)
Unit Access Option:	(None)

Maximized Capability, Wet Operation

Thermal performance for this selection is certified by the Cooling Technology Institute (CTI).

Flow Rate:	300.00 GPM
Fluid:	Water
Heat Rejection:	1,499,400 BTUH
Fluid Pressure Drop:	4.56 psi
Entering Fluid Temperature:	95.00° F
Leaving Fluid Temperature:	85.00° F
Wet Bulb Temperature:	78.02° F
Range:	10.00° F



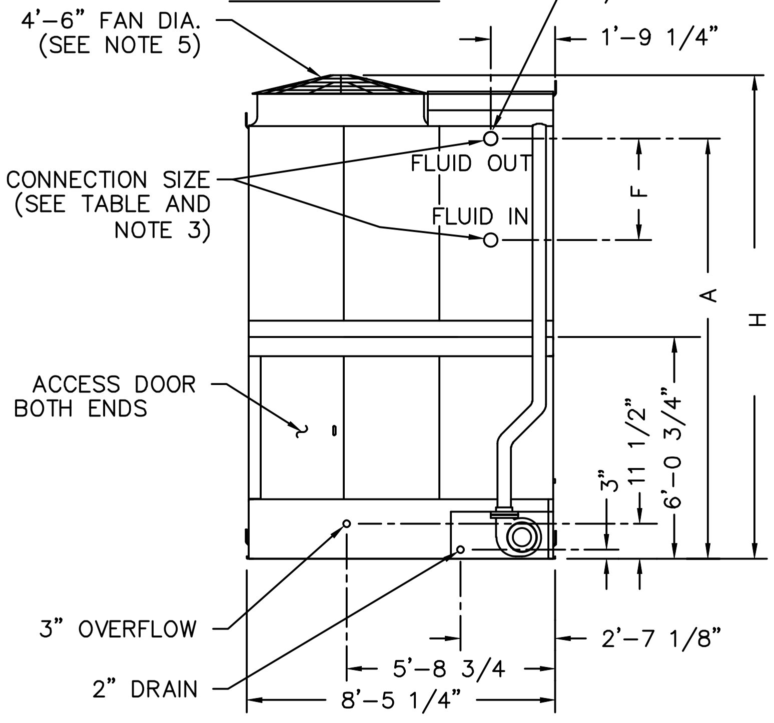
PLAN VIEW

DIMENSION H	
FAN OPTION	H
STD FAN & LOW SOUND FAN	13'-2 3/4"
WHISPER QUIET FAN	13'- 8 1/4"

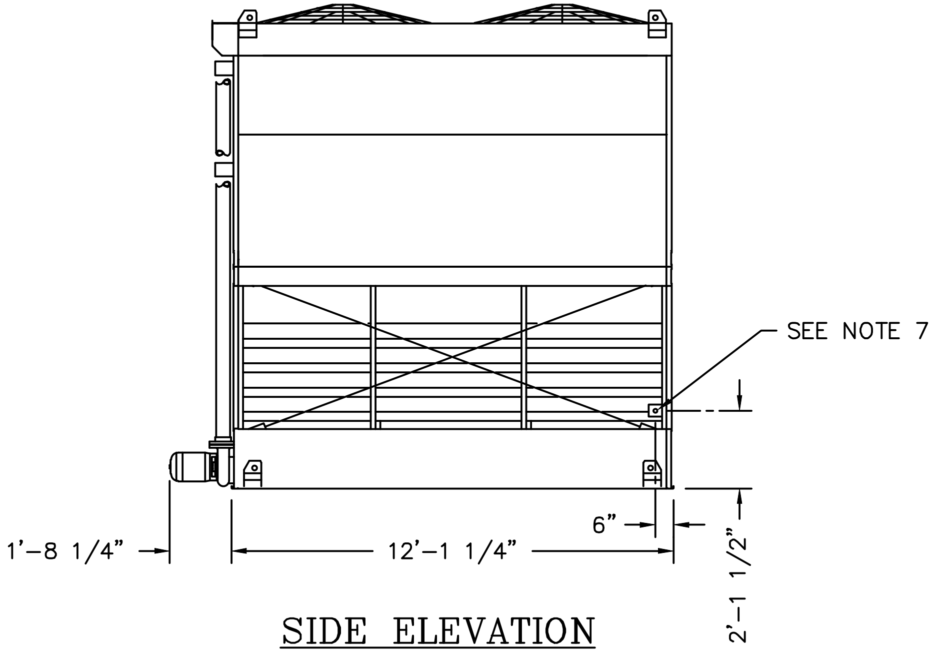
MODEL NUMBER	SHIPPING WEIGHT	OPERATING WEIGHT	HEAVIEST SECTION (UPPER)	CONNECTION SIZE	A	F
FXV- 441	8760	14,220	5120	4"	11'-6"	24"
FXV- 442	9410	15,150	5770	4"	11'-6"	33 1/4"
FXV- 443	10,060	16,080	6420	4"	11'-6"	42 1/2"
FXV- 444	10,770	17,070	7130	4"	11'-6"	51 3/4"
FXV- Q440	9410	15,150	5770	6"	11'-5"	31 3/8"
FXV- Q441	10,770	17,070	7130	6"	11'-5"	49 7/8"

NOTES:

1. ALL DIMENSIONS ARE IN FEET AND INCHES. WEIGHTS ARE IN POUNDS.
2. DIMENSIONS SHOWING LOCATION OF COIL CONNECTIONS ARE APPROXIMATE AND SHOULD NOT BE USED FOR PREFABRICATION OF CONNECTING PIPING.
3. COIL CONNECTIONS ARE IPS BEVELLED FOR WELDING.
4. CONNECTIONS 3" & SMALLER ARE MPT.
5. THE AREA ABOVE THE DISCHARGE OF THE FAN MUST BE UNOBSTRUCTED.
6. FOR WEIGHT LOADING AND SUPPORT REQUIREMENTS REFER TO THE SUGGESTED STEEL SUPPORT DRAWING.
7. MECHANICAL MAKE UP CONNECTION: 1-1/2". FOR ELECTRIC WATER LEVEL CONTROL, SEE ATTACHED DRAWING FOR CONNECTION DETAILS.



END ELEVATION



SIDE ELEVATION

(RH UNIT)

B.A.C.
ORDER NO:

DATE:

BALTIMORE AIRCOIL
COMPANY

SERIES 1500
FLUID COOLER

DRAWING NUMBER:
BAC−17092A

C

8.0 APPENDIX 'B'

Appendix 'B'
Energy Model Results

Annual Cost Summary

208077 Wilders Grove Final Load Calc

02/10/2011
03:50PM

Table 1. Annual Costs

Component	[B000] Base Line ($)	[B090] Base Line ($)	[B180] Base Line ($)	[B270] Base Line ($)	[P] Ground Source Heat Pumps ($)
Air System Fans	20,434	20,390	20,287	20,395	3,203
Cooling	7,449	7,493	7,307	7,508	6,102
Heating	13,045	13,090	12,879	13,045	1,510
Pumps	0	0	0	0	1,447
Cooling Tower Fans	0	0	0	0	0
HVAC Sub-Total	**40,928**	**40,973**	**40,473**	**40,949**	**12,262**
Lights	4,968	4,959	4,966	4,961	3,684
Electric Equipment	6,221	6,210	6,219	6,213	4,611
Misc. Electric	38,174	38,110	38,167	38,126	17,754
Misc. Fuel Use	0	0	0	0	0
Non-HVAC Sub-Total	**49,362**	**49,280**	**49,352**	**49,300**	**26,049**
Grand Total	**90,290**	**90,253**	**89,825**	**90,249**	**38,311**

Table 2. Annual Cost per Unit Floor Area

Component	[B000] Base Line ($/ft²)	[B090] Base Line ($/ft²)	[B180] Base Line ($/ft²)	[B270] Base Line ($/ft²)	[P] Ground Source Heat Pumps ($/ft²)
Air System Fans	0.757	0.755	0.752	0.756	0.119
Cooling	0.276	0.278	0.271	0.278	0.226
Heating	0.483	0.485	0.477	0.483	0.056
Pumps	0.000	0.000	0.000	0.000	0.054
Cooling Tower Fans	0.000	0.000	0.000	0.000	0.000
HVAC Sub-Total	**1.516**	**1.518**	**1.499**	**1.517**	**0.454**
Lights	0.184	0.184	0.184	0.184	0.137
Electric Equipment	0.230	0.230	0.230	0.230	0.171
Misc. Electric	1.414	1.412	1.414	1.412	0.658
Misc. Fuel Use	0.000	0.000	0.000	0.000	0.000
Non-HVAC Sub-Total	**1.829**	**1.826**	**1.828**	**1.826**	**0.965**
Grand Total	**3.345**	**3.344**	**3.328**	**3.343**	**1.419**
Gross Floor Area (ft²)	26994.0	26994.0	26994.0	26994.0	26994.0
Conditioned Floor Area (ft²)	26994.0	26994.0	26994.0	26994.0	26994.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 3. Component Cost as a Percentage of Total Cost

Component	[B000] Base Line (%)	[B090] Base Line (%)	[B180] Base Line (%)	[B270] Base Line (%)	[P] Ground Source Heat Pumps (%)
Air System Fans	22.6	22.6	22.6	22.6	8.4
Cooling	8.3	8.3	8.1	8.3	15.9
Heating	14.4	14.5	14.3	14.5	3.9
Pumps	0.0	0.0	0.0	0.0	3.8
Cooling Tower Fans	0.0	0.0	0.0	0.0	0.0
HVAC Sub-Total	**45.3**	**45.4**	**45.1**	**45.4**	**32.0**
Lights	5.5	5.5	5.5	5.5	9.6
Electric Equipment	6.9	6.9	6.9	6.9	12.0
Misc. Electric	42.3	42.2	42.5	42.2	46.3
Misc. Fuel Use	0.0	0.0	0.0	0.0	0.0
Non-HVAC Sub-Total	**54.7**	**54.6**	**54.9**	**54.6**	**68.0**
Grand Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Annual Cost Summary

208077 Wilders Grove Evap Cooler

02/10/2011
03:34PM

Table 1. Annual Costs

Component	[B000] Base Line ($)	[B090] Base Line ($)	[B180] Base Line ($)	[B270] Base Line ($)	[P] Ground Source Heat Pumps ($)
Air System Fans	20,434	20,390	20,287	20,395	0
Cooling	7,449	7,493	7,307	7,508	5,121
Heating	13,045	13,090	12,879	13,045	3,476
Pumps	0	0	0	0	1,449
Cooling Tower Fans	0	0	0	0	466
HVAC Sub-Total	**40,928**	**40,973**	**40,473**	**40,949**	**10,511**
Lights	4,968	4,959	4,966	4,961	3,546
Electric Equipment	6,221	6,210	6,219	6,213	4,438
Misc. Electric	38,174	38,110	38,167	38,126	26,389
Misc. Fuel Use	0	0	0	0	0
Non-HVAC Sub-Total	**49,362**	**49,280**	**49,352**	**49,300**	**34,373**
Grand Total	**90,290**	**90,253**	**89,825**	**90,249**	**44,884**

Table 2. Annual Cost per Unit Floor Area

Component	[B000] Base Line ($/ft²)	[B090] Base Line ($/ft²)	[B180] Base Line ($/ft²)	[B270] Base Line ($/ft²)	[P] Ground Source Heat Pumps ($/ft²)
Air System Fans	0.757	0.755	0.752	0.756	0.000
Cooling	0.276	0.278	0.271	0.278	0.190
Heating	0.483	0.485	0.477	0.483	0.129
Pumps	0.000	0.000	0.000	0.000	0.054
Cooling Tower Fans	0.000	0.000	0.000	0.000	0.017
HVAC Sub-Total	**1.516**	**1.518**	**1.499**	**1.517**	**0.389**
Lights	0.184	0.184	0.184	0.184	0.131
Electric Equipment	0.230	0.230	0.230	0.230	0.164
Misc. Electric	1.414	1.412	1.414	1.412	0.978
Misc. Fuel Use	0.000	0.000	0.000	0.000	0.000
Non-HVAC Sub-Total	**1.829**	**1.826**	**1.828**	**1.826**	**1.273**
Grand Total	**3.345**	**3.344**	**3.328**	**3.343**	**1.663**
Gross Floor Area (ft²)	26994.0	26994.0	26994.0	26994.0	26994.0
Conditioned Floor Area (ft²)	26994.0	26994.0	26994.0	26994.0	26994.0

Note: Values in this table are calculated using the Gross Floor Area.

Annual Cost Summary

208077 Wilders Grove Evap Cooler

02/10/2011
03:34PM

Table 3. Component Cost as a Percentage of Total Cost

Component	[B000] Base Line (%)	[B090] Base Line (%)	[B180] Base Line (%)	[B270] Base Line (%)	[P] Ground Source Heat Pumps (%)
Air System Fans	22.6	22.6	22.6	22.6	0.0
Cooling	8.3	8.3	8.1	8.3	11.4
Heating	14.4	14.5	14.3	14.5	7.7
Pumps	0.0	0.0	0.0	0.0	3.2
Cooling Tower Fans	0.0	0.0	0.0	0.0	1.0
HVAC Sub-Total	**45.3**	**45.4**	**45.1**	**45.4**	**23.4**
Lights	5.5	5.5	5.5	5.5	7.9
Electric Equipment	6.9	6.9	6.9	6.9	9.9
Misc. Electric	42.3	42.2	42.5	42.2	58.8
Misc. Fuel Use	0.0	0.0	0.0	0.0	0.0
Non-HVAC Sub-Total	**54.7**	**54.6**	**54.9**	**54.6**	**76.6**
Grand Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Appendix 'C'
Economic Analysis

Cash Flow Details

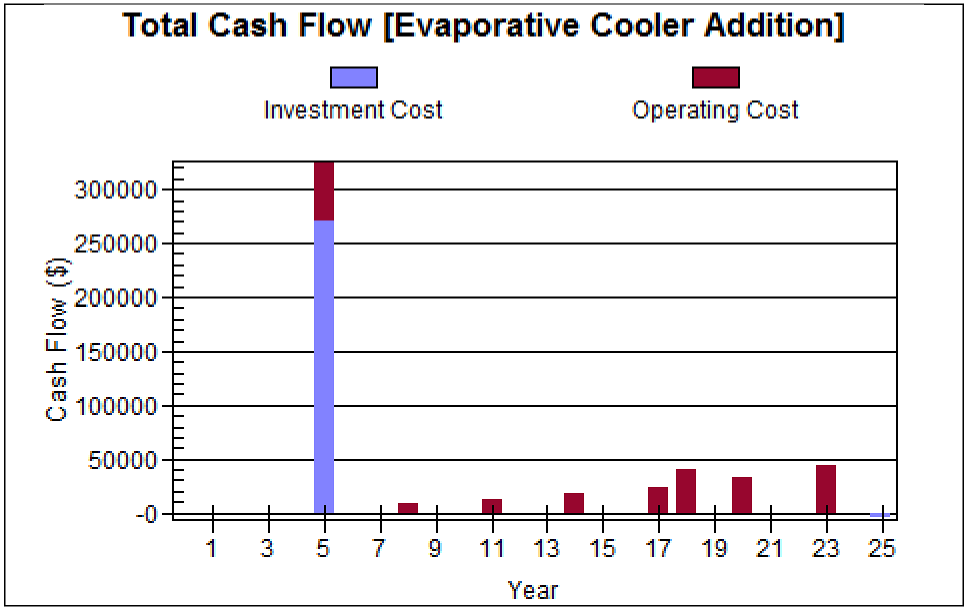
Project: Evaporative Cooler
Prepared By:

2/10/2011
5:37:33 PM

Wilders Grove Evaporative Cooler Option

Feasibility of adding evaporative cooler

Type of Analysis	Private Sector Lifecycle Analysis	
Type of Design Alternatives	Independent	
Length of Analysis	25	yrs
Minimum Attractive Rate of Return	2.00	%
Income Taxes	Not Considered	



1A. Component Cash Flows [Evaporative Cooler Addition], Actual Value

Year	Date	Cash Investment ($)	Loan Principal ($)	Loan Interest ($)	Total Investment Cost ($)	Annual Operating Cost ($)	Non-Annual Operating Cost ($)	Total Operating Cost ($)	Total Cash Flow ($)
0	Initial	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	0	0	0
3	3	0	0	0	0	0	0	0	0
4	4	0	0	0	0	0	0	0	0

Cash Flow Details

Year	Date	Cash Investment ($)	Loan Principal ($)	Loan Interest ($)	Total Investment Cost ($)	Annual Operating Cost ($)	Non-Annual Operating Cost ($)	Total Operating Cost ($)	Total Cash Flow ($)
5	5	272,745	0	0	272,745	76,000	0	76,000	348,745
6	6	0	0	0	0	0	0	0	0
7	7	0	0	0	0	0	0	0	0
8	8	0	0	0	0	0	10,718	10,718	10,718
9	9	0	0	0	0	0	0	0	0
10	10	0	0	0	0	0	0	0	0
11	11	0	0	0	0	0	14,266	14,266	14,266
12	12	0	0	0	0	0	0	0	0
13	13	0	0	0	0	0	0	0	0
14	14	0	0	0	0	0	18,987	18,987	18,987
15	15	0	0	0	0	0	0	0	0
16	16	0	0	0	0	0	0	0	0
17	17	0	0	0	0	0	25,272	25,272	25,272
18	18	0	0	0	0	0	41,699	41,699	41,699
19	19	0	0	0	0	0	0	0	0
20	20	0	0	0	0	0	33,638	33,638	33,638
21	21	0	0	0	0	0	0	0	0
22	22	0	0	0	0	0	0	0	0
23	23	0	0	0	0	0	44,772	44,772	44,772
24	24	0	0	0	0	0	0	0	0
25	25	-5,417	0	0	-5,417	0	0	0	-5,417
Totals		267,328	0	0	267,328	76,000	189,352	265,352	532,680

1B. Present Worth Cash Flows [Evaporative Cooler Addition]

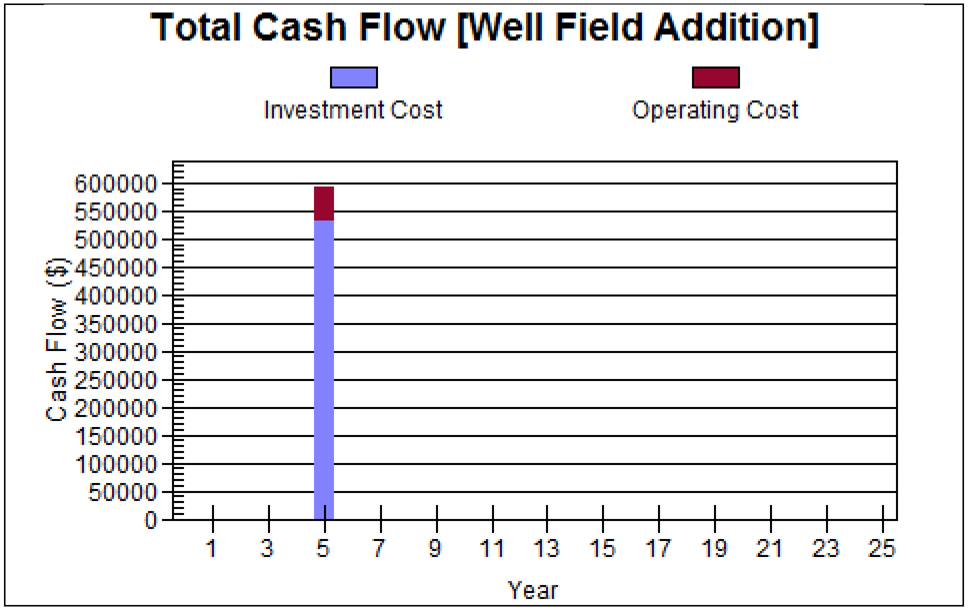
Year	Date	Total Investment Cost ($)	Total Operating Cost ($)	Total Present Worth ($)
0	Initial	0	0	0
1	1	0	0	0
2	2	0	0	0
3	3	0	0	0
4	4	0	0	0
5	5	247,033	68,836	315,869
6	6	0	0	0
7	7	0	0	0
8	8	0	9,148	9,148
9	9	0	0	0
10	10	0	0	0

Cash Flow Details

Project: Evaporative Cooler
Prepared By:

2/10/2011
5:37:33 PM

Year	Date	Total Investment Cost ($)	Total Operating Cost ($)	Total Present Worth ($)
11	11	0	11,473	11,473
12	12	0	0	0
13	13	0	0	0
14	14	0	14,390	14,390
15	15	0	0	0
16	16	0	0	0
17	17	0	18,049	18,049
18	18	0	29,196	29,196
19	19	0	0	0
20	20	0	22,637	22,637
21	21	0	0	0
22	22	0	0	0
23	23	0	28,392	28,392
24	24	0	0	0
25	25	-3,302	0	-3,302
Totals		243,731	202,121	445,852



2A. Component Cash Flows [Well Field Addition], Actual Value

Year	Date	Cash Investment ($)	Loan Principal ($)	Loan Interest ($)	Total Investment Cost ($)	Annual Operating Cost ($)	Non-Annual Operating Cost ($)	Total Operating Cost ($)	Total Cash Flow ($)
0	Initial	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	0	0	0
3	3	0	0	0	0	0	0	0	0
4	4	0	0	0	0	0	0	0	0
5	5	533,564	0	0	533,564	61,700	0	61,700	595,264
6	6	0	0	0	0	0	0	0	0
7	7	0	0	0	0	0	0	0	0
8	8	0	0	0	0	0	0	0	0
9	9	0	0	0	0	0	0	0	0
10	10	0	0	0	0	0	0	0	0
11	11	0	0	0	0	0	0	0	0
12	12	0	0	0	0	0	0	0	0
13	13	0	0	0	0	0	0	0	0

Year	Date	Cash Investment ($)	Loan Principal ($)	Loan Interest ($)	Total Investment Cost ($)	Annual Operating Cost ($)	Non-Annual Operating Cost ($)	Total Operating Cost ($)	Total Cash Flow ($)
14	14	0	0	0	0	0	0	0	0
15	15	0	0	0	0	0	0	0	0
16	16	0	0	0	0	0	0	0	0
17	17	0	0	0	0	0	0	0	0
18	18	0	0	0	0	0	0	0	0
19	19	0	0	0	0	0	0	0	0
20	20	0	0	0	0	0	0	0	0
21	21	0	0	0	0	0	0	0	0
22	22	0	0	0	0	0	0	0	0
23	23	0	0	0	0	0	0	0	0
24	24	0	0	0	0	0	0	0	0
25	25	0	0	0	0	0	0	0	0
Totals		533,564	0	0	533,564	61,700	0	61,700	595,264

2B. Present Worth Cash Flows [Well Field Addition]

Year	Date	Total Investment Cost ($)	Total Operating Cost ($)	Total Present Worth ($)
0	Initial	0	0	0
1	1	0	0	0
2	2	0	0	0
3	3	0	0	0
4	4	0	0	0
5	5	483,265	55,884	539,149
6	6	0	0	0
7	7	0	0	0
8	8	0	0	0
9	9	0	0	0
10	10	0	0	0
11	11	0	0	0
12	12	0	0	0
13	13	0	0	0
14	14	0	0	0
15	15	0	0	0
16	16	0	0	0
17	17	0	0	0
18	18	0	0	0
19	19	0	0	0

Cash Flow Details

Year	Date	Total Investment Cost ($)	Total Operating Cost ($)	Total Present Worth ($)
20	20	0	0	0
21	21	0	0	0
22	22	0	0	0
23	23	0	0	0
24	24	0	0	0
25	25	0	0	0
Totals		483,265	55,884	539,149

Analysis Details

Project: Evaporative Cooler 2/10/2011
Prepared By: 4:45:05 PM

Wilders Grove Evaporative Cooler Option

Feasibility of adding evaporative cooler

Type of Analysis .... Private Sector Lifecycle Analysis
Type of Design Alternatives .... Mutually Exclusive
Length of Analysis .... 25 yrs
Minimum Attractive Rate of Return .... 2.00 %
Income Taxes .... Not Considered

1A. Summary of Results

Base Case **[Winner]**	Evaporative Cooler Addition [EC]
Challenger	Well Field Addition [WF]
[EC] Total Present Worth ($)	$445,852
[WF] Total Present Worth ($)	$539,149
Net Present Worth Savings ($)	$-93,297
Internal Rate of Return	n/a
Payback Period (yrs)	n/a

1B. Comparative Analysis Details

		Cash Flow (Present Worth $)			SIR and Payback Calculation (Present Worth $)				
Year	**Date**	**[EC] Cash Flow ($)**	**[WF] Cash Flow ($)**	**Net Present Worth Savings ($)**	**Operating Cost Savings ($)**	**Cumulative Operating Cost Savings ($)**	**Additional Investment Cost ($)**	**Cumulative Additional Investment Cost ($)**	**Year-End SIR**
0	Initial	0	0	0	0	0	0	0	0.000
1	1	0	0	0	0	0	0	0	0.000
2	2	0	0	0	0	0	0	0	0.000
3	3	0	0	0	0	0	0	0	0.000
4	4	0	0	0	0	0	0	0	0.000
5	5	315,869	539,149	-223,280	12,952	12,952	236,232	236,232	0.055
6	6	0	0	0	0	12,952	0	236,232	0.055
7	7	0	0	0	0	12,952	0	236,232	0.055
8	8	9,148	0	9,148	9,148	22,099	0	236,232	0.094
9	9	0	0	0	0	22,099	0	236,232	0.094
10	10	0	0	0	0	22,099	0	236,232	0.094
11	11	11,473	0	11,473	11,473	33,573	0	236,232	0.142
12	12	0	0	0	0	33,573	0	236,232	0.142
13	13	0	0	0	0	33,573	0	236,232	0.142
14	14	14,390	0	14,390	14,390	47,963	0	236,232	0.203
15	15	0	0	0	0	47,963	0	236,232	0.203
16	16	0	0	0	0	47,963	0	236,232	0.203
17	17	18,049	0	18,049	18,049	66,011	0	236,232	0.279
18	18	29,196	0	29,196	29,196	95,208	0	236,232	0.403
19	19	0	0	0	0	95,208	0	236,232	0.403
20	20	22,637	0	22,637	22,637	117,845	0	236,232	0.499
21	21	0	0	0	0	117,845	0	236,232	0.499
22	22	0	0	0	0	117,845	0	236,232	0.499
23	23	28,392	0	28,392	28,392	146,237	0	236,232	0.619
24	24	0	0	0	0	146,237	0	236,232	0.619
25	25	-3,302	0	-3,302	0	146,237	3,302	239,534	0.611
Totals		445,852	539,149	-93,297	146,237		239,534		

Lifecycle Summary

Project: Evaporative Cooler
Prepared By:

2/10/2011
4:39:32 PM

Wilders Grove Evaporative Cooler Option

Feasibility of adding evaporative cooler

Type of Analysis	Private Sector Lifecycle Analysis	
Type of Design Alternatives	Mutually Exclusive	
Length of Analysis	25	yrs
Minimum Attractive Rate of Return	2.00	%
Income Taxes	Not Considered	

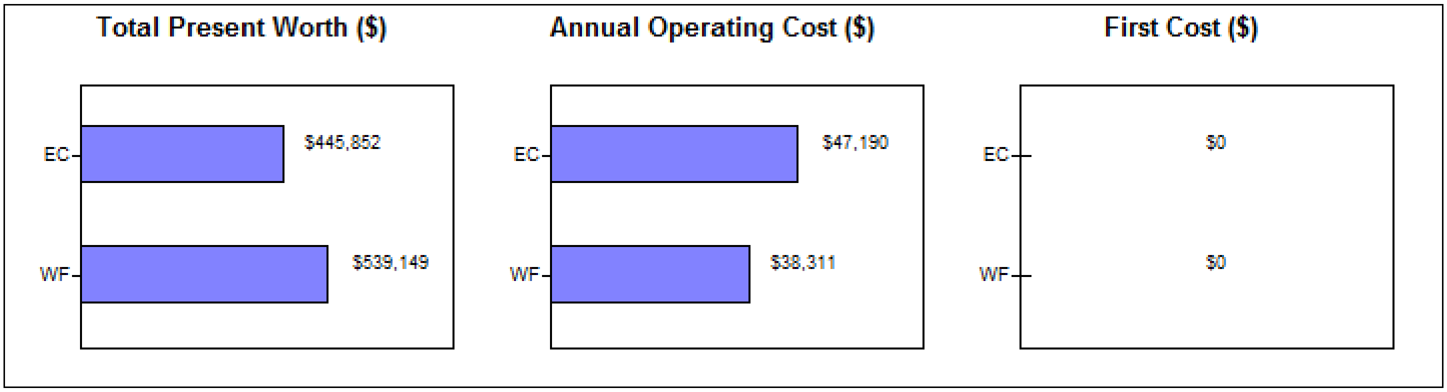


Table 1. Executive Summary

Economic Criteria	Best Design Case for Each Criteria	Value ($)
Incremental NPW Savings Analysis	Evaporative Cooler Addition	-
Lowest Total Present Worth	Evaporative Cooler Addition	$445,852
Lowest Annual Operating Cost	Well Field Addition	$38,311
Lowest First Cost	Evaporative Cooler Addition	$0

Table 2. Design Cases Ranked by First Cost

Design Case Name	Design Case Short Name	Total Present Worth ($)	Annual Operating Cost ($/yr)	First Cost ($)
Evaporative Cooler Addition	EC	$445,852	$47,190	$0
Well Field Addition	WF	$539,149	$38,311	$0

Table 3. Incremental Analysis Data

Challenger	Base Case	Additional First Cost ($)	NPW Savings ($)	IRR (%)	Payback Period (yrs)
WF	EC [Winner]	$0	$-93,297	n/a	n/a

Total Present Worth Profiles

Project: Evaporative Cooler
Prepared By:

2/10/2011
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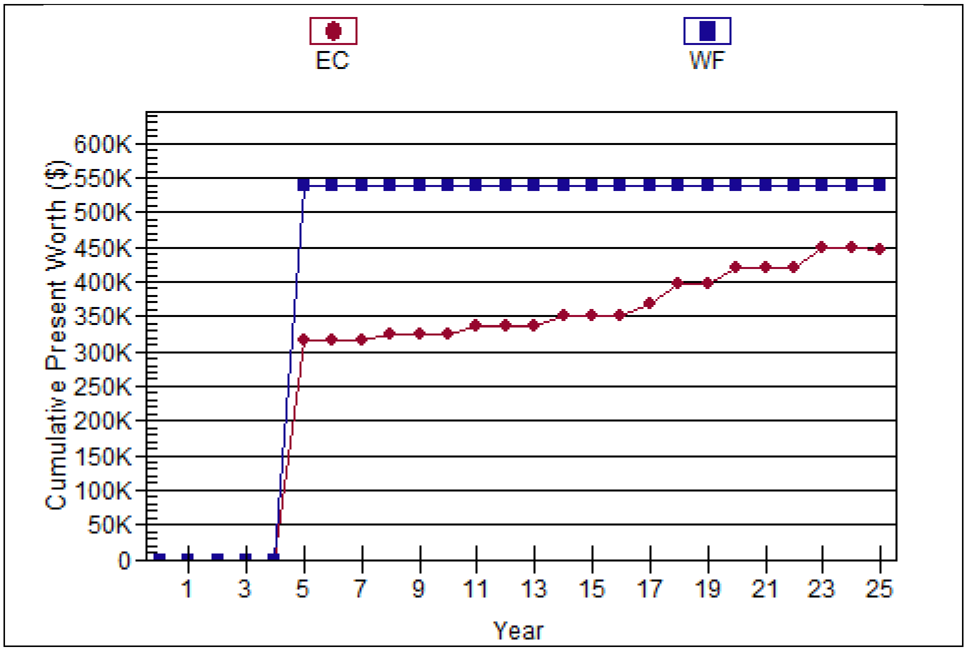
Wilders Grove Evaporative Cooler Option

Feasibility of adding evaporative cooler

Type of Analysis	Private Sector Lifecycle Analysis	
Type of Design Alternatives	Mutually Exclusive	
Length of Analysis	25	yrs
Minimum Attractive Rate of Return	2.00	%
Income Taxes	Not Considered	



Design Cases Ranked by First Cost

Design Case Name	Design Case Short Name	Total Present Worth ($)	Annual Operating Cost ($/yr)	First Cost ($)
Evaporative Cooler Addition	EC	$445,852	$47,190	$0
Well Field Addition	WF	$539,149	$38,311	$0

Appendix 'D'
Cost Estimates

HIPP ENGINEERING
& CONSULTING, INC.

COST ESTIMATING FORM, EVAPORATIVE COOLER

Summary Cost Estimates

GENERAL				MATERIAL	LABOR		TOTAL
Item	**Description**	**Quantity**	**Units**	**Total Material Costs**	**Total Labor Hours**	**Total Labor Cost**	**Total Raw Cost**
Direct Costs							
1	General Conditions			$ -	0.0	$ -	$ -
2	Architectural			$ -	0.0	$ -	$ -
3	Structural			$ -	0.0	$ -	$ -
4	Civil			$ -	0.0	$ -	$ -
5	Process			$ -	0.0	$ -	$ -
6	Mechanical			$ 66,448.13	147.4	$ 7,072.85	$ 73,520.98
7	Electrical			$ 1,756.00	429.2	$ 20,602.90	$ 22,358.90
8	Instrumentation and Controls			$ -	0.0	$ -	$ -
						Sub-Total Direct Costs	$ 95,879.87

In-Direct Costs					
9	Engineering	N/A	150.0	$ 15,000.00	$ 15,000.00
10	Construction Management	N/A	0.0	$ -	$ -
11	Commissioning	N/A	24.0	$ 2,400.00	$ 2,400.00
12	Validation	N/A	0.0	$ -	$ -
				Sub-Total In-Direct Costs	$ 17,400.00

Total Raw Cost	$ 113,279.87
Overhead & Profit, 15%	$ 16,991.98
Total Cost	$ 130,271.86
Contingency, 30%	$ 39,081.56
Grand Total Project	$ 169,353.41

HIPP ENGINEERING
& CONSULTING, INC.

COST ESTIMATING FORM, EVAPORATIVE COOLER

Mechanical, Piping

GENERAL				MATERIAL		LABOR				TOTAL
Item	**Description**	**Quantity**	**Units**	**Material Unit Cost**	**Material Extended Cost**	**Unit MH**	**Extended MH**	**Labor Unit Cost**	**Labor Extended Cost**	**Total Item Cost**
1	Evaporative Cooler	1	Ea	$ 60,000.00	$ 60,000.00	24	24	$ 48.00	$ 1,152.00	$ 61,152.00
3	Foundations (12" Sono-tubes)	2	CY	$ 740.00	$ 1,480.00	16.5	33.03	$ 48.00	$ 1,585.44	$ 3,065.44
4	Rigging into place	1	Lot	$ 1,000.00	$ 1,000.00	32	32	$ 48.00	$ 1,536.00	$ 2,536.00
5	1 1/2" Pipe Insulation	9	LF	$ 3.07	$ 27.63	0.09	0.801	$ 48.00	$ 38.45	$ 66.08
6	Exterior Piping, 1 1/2"	150	LF	$ 2.43	$ 364.50	0.07	9.75	$ 48.00	$ 468.00	$ 832.50
7	Exterior Piping, 6"	60	LF	$ 40.00	$ 2,400.00	0.12	7.32	$ 48.00	$ 351.36	$ 2,751.36
8	1 1/2" Valves	2	Ea	$ 57.00	$ 114.00	0.75	1.5	$ 48.00	$ 72.00	$ 186.00
9	6" Valves	2	Ea	$ 281.00	$ 562.00	4.8	9.6	$ 48.00	$ 460.80	$ 1,022.80
10	Trenching	50	CY	$ -	$ -	0.11	5.35	$ 48.00	$ 256.80	$ 256.80
11	Back-fill	50	CY	$ 10.00	$ 500.00	0.16	8	$ 48.00	$ 384.00	$ 884.00
12	Test & Balance	1	Lot	$ -	$ -	16	16	$ 48.00	$ 768.00	$ 768.00

Sub-total, Material Cost	$ 66,448.13
Sub-total, Labor Hours	147.35
Sub-total Labor Cost	$ 7,072.85
Total Cost	$ 73,520.98

HIPP ENGINEERING & CONSULTING, INC.

COST ESTIMATING FORM, EVAPORATIVE COOLER

Electrical, Power

GENERAL				MATERIAL		LABOR				TOTAL
Item	**Description**	**Quantity**	**Units**	**Material Unit Cost**	**Material Extended Cost**	**Unit MH**	**Extended MH**	**Labor Unit Cost**	**Labor Extended Cost**	**Total Item Cost**
1	Breaker, 10 HP (fan)	1	Ea	$ 268.00	$ 268.00	5	5	$ 48.00	$ 240.00	$ 508.00
2	Breaker, 3 HP (pump)	1	Ea	$ 238.00	$ 238.00	3.5	3.5	$ 48.00	$ 168.00	$ 406.00
3	Conduit & Wire	100	LF	$ 10.50	$ 1,050.00	4.2	420	$ 48.00	$ 20,160.00	$ 21,210.00
8	Grounding	1	Lot	$ 200.00	$ 200.00	0.73	0.727	$ 48.00	$ 34.90	$ 234.90
3				$ -	$ -		0	$ 48.00	$ -	$ -
								Sub-total, Material Cost		$ 1,756.00
								Sub-total, Labor Hours		429.23
								Sub-total Labor Cost		$ 20,602.90
								Total Cost		$ 22,358.90

COST ESTIMATING FORM, WELL FIELD

Summary Cost Estimates

GENERAL				MATERIAL	LABOR		TOTAL
Item	**Description**	**Quantity**	**Units**	**Total Material Costs**	**Total Labor Hours**	**Total Labor Cost**	**Total Raw Cost**
	Direct Costs						
1	General Conditions			$ -	0.0	$ -	$ -
2	Architectural			$ -	0.0	$ -	$ -
3	Structural			$ -	0.0	$ -	$ -
4	Civil			$ -	0.0	$ -	$ -
5	Process			$ -	0.0	$ -	$ -
6	Mechanical			$ 72,659.50	2896.8	$ 139,046.88	$ 211,706.38
7	Electrical			$ -	0.0	$ -	$ -
8	Instrumentation and Controls			$ -	0.0	$ -	$ -
						Sub-Total Direct Costs	$ 211,706.38

	In-Direct Costs				
9	Engineering	N/A	75.0	$ 7,500.00	$ 7,500.00
10	Construction Management	N/A	0.0	$ -	$ -
11	Commissioning	N/A	24.0	$ 2,400.00	$ 2,400.00
12	Validation	N/A	0.0	$ -	$ -
				Sub-Total In-Direct Costs	$ 9,900.00

Total Raw Cost	$ 221,606.38
Overhead & Profit, 15%	$ 33,240.96
Total Cost	$ 254,847.34
Contingency, 30%	$ 76,454.20
Grand Total Project	$ 331,301.54

Mechanical, Piping

GENERAL				MATERIAL		LABOR				TOTAL
Item	Description	Quantity	Units	Material Unit Cost	Material Extended Cost	Unit MH	Extended MH	Labor Unit Cost	Labor Extended Cost	Total Item Cost
1	Exterior Piping, 1 1/2"	50	LF	$ 2.43	$ 121.50	0.07	3.25	$ 48.00	$ 156.00	$ 277.50
2	Exterior Piping, 2"	200	LF	$ 2.69	$ 538.00	0.07	13.2	$ 48.00	$ 633.60	$ 1,171.60
3	Exterior Piping, 2 1/2"	500	LF	$ 5.60	$ 2,800.00	0.08	39	$ 48.00	$ 1,872.00	$ 4,672.00
4	Wells	10	Ea	$ 6,840.00	$ 68,400.00	0	0	$ 48.00	$ -	$ 68,400.00
5	Trenching	80	CY	$ -	$ -	0.11	8.56	$ 48.00	$ 410.88	$ 410.88
6	Back-fill	80	CY	$ 10.00	$ 800.00	0.16	12.8	$ 48.00	$ 614.40	$ 1,414.40
7	Cut Concrete Paving	750	LF	$ -	$ -	2.4	1800	$ 48.00	$ 86,400.00	$ 86,400.00
8	Haul Spoils for disposal	100	CY	$ -	$ -	0.14	14	$ 48.00	$ 672.00	$ 672.00
9	Patch Concrete & rebar	60	CY	$ 740.00	$ -	16.5	990	$ 48.00	$ 47,520.00	$ 47,520.00
10	Test & Balance	1	Lot	$ -	$ -	16	16	$ 48.00	$ 768.00	$ 768.00
									Sub-total, Material Cost	$ 72,659.50
									Sub-total, Labor Hours	2,896.81
									Sub-total Labor Cost	$ 139,046.88
									Total Cost	$ 211,706.38

BAC Closed Circuit Cooling Tower Selection Program

Release 6.5 NA

Program data and calculations are correct as of Feb. 13, 2009.

To: Hipp Engineering
Attn: Harold Jones
From: Chris Norwood

Inquiry No.:
Project Name: Wilders Grove
Date: Jun. 4, 2009

Selection Parameters

Model & Fan Motor

Product Line: Series FXV
Number of Units: 1
Model: FXV-L442
Coil Type: Standard Coil
Standard Total Fan Motor Power Per Unit: 10.0 HP
Fan Motor: Standard Motor
Total Pump Motor Power Per Unit: 3.0 HP

Model Accessories

Unit Intake Option: (None)
Unit Internal Option: (None)
Unit Discharge Option: (None)
Unit Access Option: (None)

Maximized Capability, Wet Operation

Thermal performance for this selection is certified by the Cooling Technology Institute (CTI).

Flow Rate: 300.00 GPM
Fluid: Water
Heat Rejection: 1,499,400 BTUH
Fluid Pressure Drop: 4.56 psi
Entering Fluid Temperature: 95.00° F
Leaving Fluid Temperature: 85.00° F
Wet Bulb Temperature: 78.02° F
Range: 10.00° F

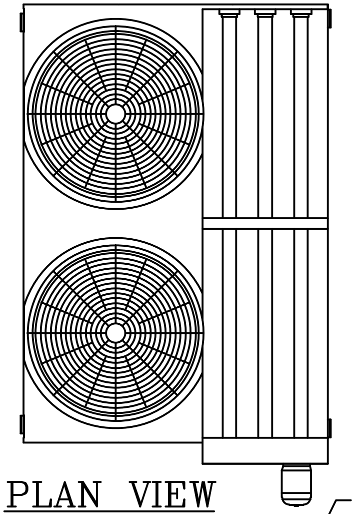
BAC–17092A

DIMENSION H	
FAN OPTION	H
STD FAN & LOW SOUND FAN	13'–2 3/4"
WHISPER QUIET FAN	13'– 8 1/4"

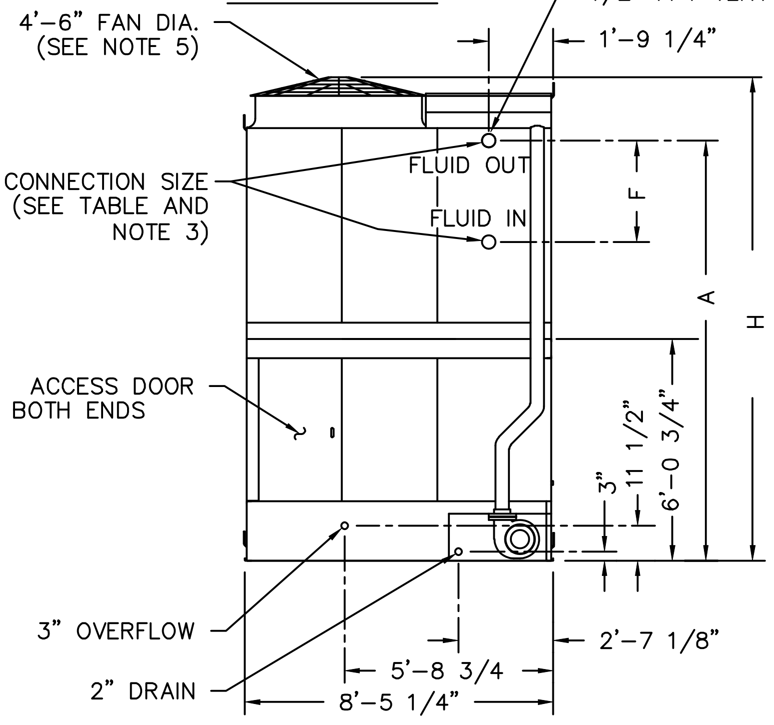
MODEL NUMBER	SHIPPING WEIGHT	OPERATING WEIGHT	HEAVIEST SECTION (UPPER)	CONNECTION SIZE	A	F
FXV– 441	8760	14,220	5120	4"	11'–6"	24"
FXV– 442	9410	15,150	5770	4"	11'–6"	33 1/4"
FXV– 443	10,060	16,080	6420	4"	11'–6"	42 1/2"
FXV– 444	10,770	17,070	7130	4"	11'–6"	51 3/4"
FXV– Q440	9410	15,150	5770	6"	11'–5"	31 3/8"
FXV– Q441	10,770	17,070	7130	6"	11'–5"	49 7/8"

NOTES:

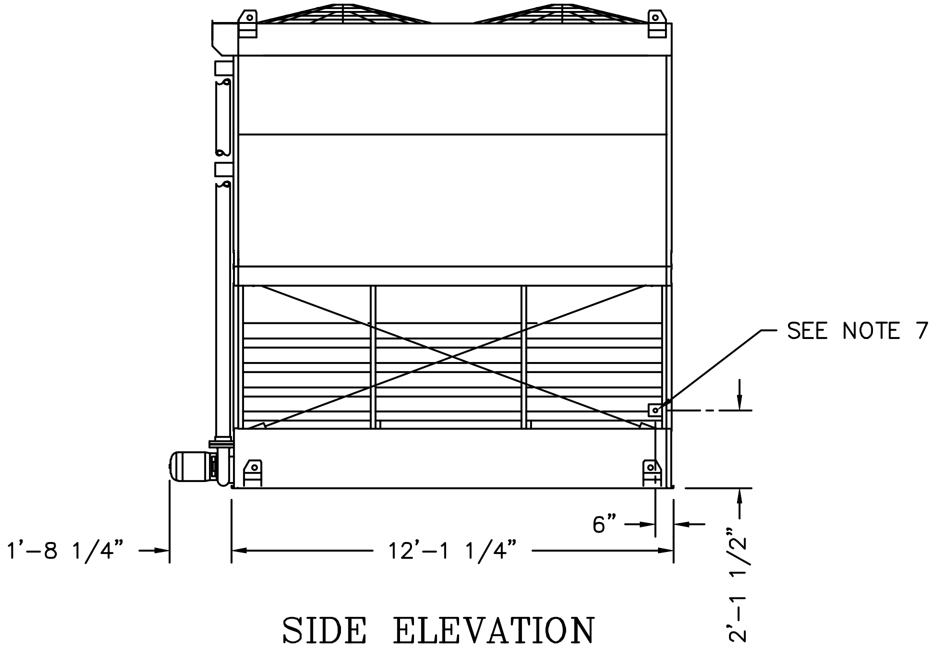
1. ALL DIMENSIONS ARE IN FEET AND INCHES. WEIGHTS ARE IN POUNDS.
2. DIMENSIONS SHOWING LOCATION OF COIL CONNECTIONS ARE APPROXIMATE AND SHOULD NOT BE USED FOR PREFABRICATION OF CONNECTING PIPING.
3. COIL CONNECTIONS ARE IPS BEVELLED FOR WELDING.
4. CONNECTIONS 3" & SMALLER ARE MPT.
5. THE AREA ABOVE THE DISCHARGE OF THE FAN MUST BE UNOBSTRUCTED.
6. FOR WEIGHT LOADING AND SUPPORT REQUIREMENTS REFER TO THE SUGGESTED STEEL SUPPORT DRAWING.
7. MECHANICAL MAKE UP CONNECTION: 1–1/2". FOR ELECTRIC WATER LEVEL CONTROL, SEE ATTACHED DRAWING FOR CONNECTION DETAILS.



PLAN VIEW



END ELEVATION



SIDE ELEVATION

(RH UNIT)

B.A.C.
ORDER NO:

DATE:

BALTIMORE AIRCOIL
COMPANY

SERIES 1500
FLUID COOLER

DRAWING NUMBER:
BAC–17092A

C

Annual Cost Summary

208077 Wilders Grove Final Load Calc

02/10/2011
03:50PM

Table 1. Annual Costs

Component	[B000] Base Line ($)	[B090] Base Line ($)	[B180] Base Line ($)	[B270] Base Line ($)	[P] Ground Source Heat Pumps ($)
Air System Fans	20,434	20,390	20,287	20,395	3,203
Cooling	7,449	7,493	7,307	7,508	6,102
Heating	13,045	13,090	12,879	13,045	1,510
Pumps	0	0	0	0	1,447
Cooling Tower Fans	0	0	0	0	0
HVAC Sub-Total	**40,928**	**40,973**	**40,473**	**40,949**	**12,262**
Lights	4,968	4,959	4,966	4,961	3,684
Electric Equipment	6,221	6,210	6,219	6,213	4,611
Misc. Electric	38,174	38,110	38,167	38,126	17,754
Misc. Fuel Use	0	0	0	0	0
Non-HVAC Sub-Total	**49,362**	**49,280**	**49,352**	**49,300**	**26,049**
Grand Total	**90,290**	**90,253**	**89,825**	**90,249**	**38,311**

Table 2. Annual Cost per Unit Floor Area

Component	[B000] Base Line ($/ft²)	[B090] Base Line ($/ft²)	[B180] Base Line ($/ft²)	[B270] Base Line ($/ft²)	[P] Ground Source Heat Pumps ($/ft²)
Air System Fans	0.757	0.755	0.752	0.756	0.119
Cooling	0.276	0.278	0.271	0.278	0.226
Heating	0.483	0.485	0.477	0.483	0.056
Pumps	0.000	0.000	0.000	0.000	0.054
Cooling Tower Fans	0.000	0.000	0.000	0.000	0.000
HVAC Sub-Total	**1.516**	**1.518**	**1.499**	**1.517**	**0.454**
Lights	0.184	0.184	0.184	0.184	0.137
Electric Equipment	0.230	0.230	0.230	0.230	0.171
Misc. Electric	1.414	1.412	1.414	1.412	0.658
Misc. Fuel Use	0.000	0.000	0.000	0.000	0.000
Non-HVAC Sub-Total	**1.829**	**1.826**	**1.828**	**1.826**	**0.965**
Grand Total	**3.345**	**3.344**	**3.328**	**3.343**	**1.419**
Gross Floor Area (ft²)	26994.0	26994.0	26994.0	26994.0	26994.0
Conditioned Floor Area (ft²)	26994.0	26994.0	26994.0	26994.0	26994.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 3. Component Cost as a Percentage of Total Cost

Component	[B000] Base Line (%)	[B090] Base Line (%)	[B180] Base Line (%)	[B270] Base Line (%)	[P] Ground Source Heat Pumps (%)
Air System Fans	22.6	22.6	22.6	22.6	8.4
Cooling	8.3	8.3	8.1	8.3	15.9
Heating	14.4	14.5	14.3	14.5	3.9
Pumps	0.0	0.0	0.0	0.0	3.8
Cooling Tower Fans	0.0	0.0	0.0	0.0	0.0
HVAC Sub-Total	**45.3**	**45.4**	**45.1**	**45.4**	**32.0**
Lights	5.5	5.5	5.5	5.5	9.6
Electric Equipment	6.9	6.9	6.9	6.9	12.0
Misc. Electric	42.3	42.2	42.5	42.2	46.3
Misc. Fuel Use	0.0	0.0	0.0	0.0	0.0
Non-HVAC Sub-Total	**54.7**	**54.6**	**54.9**	**54.6**	**68.0**
Grand Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Annual Cost Summary

208077 Wilders Grove Evap Cooler

02/10/2011
03:34PM

Table 1. Annual Costs

Component	[B000] Base Line ($)	[B090] Base Line ($)	[B180] Base Line ($)	[B270] Base Line ($)	[P] Ground Source Heat Pumps ($)
Air System Fans	20,434	20,390	20,287	20,395	0
Cooling	7,449	7,493	7,307	7,508	5,121
Heating	13,045	13,090	12,879	13,045	3,476
Pumps	0	0	0	0	1,449
Cooling Tower Fans	0	0	0	0	466
HVAC Sub-Total	**40,928**	**40,973**	**40,473**	**40,949**	**10,511**
Lights	4,968	4,959	4,966	4,961	3,546
Electric Equipment	6,221	6,210	6,219	6,213	4,438
Misc. Electric	38,174	38,110	38,167	38,126	26,389
Misc. Fuel Use	0	0	0	0	0
Non-HVAC Sub-Total	**49,362**	**49,280**	**49,352**	**49,300**	**34,373**
Grand Total	**90,290**	**90,253**	**89,825**	**90,249**	**44,884**

Table 2. Annual Cost per Unit Floor Area

Component	[B000] Base Line ($/ft²)	[B090] Base Line ($/ft²)	[B180] Base Line ($/ft²)	[B270] Base Line ($/ft²)	[P] Ground Source Heat Pumps ($/ft²)
Air System Fans	0.757	0.755	0.752	0.756	0.000
Cooling	0.276	0.278	0.271	0.278	0.190
Heating	0.483	0.485	0.477	0.483	0.129
Pumps	0.000	0.000	0.000	0.000	0.054
Cooling Tower Fans	0.000	0.000	0.000	0.000	0.017
HVAC Sub-Total	**1.516**	**1.518**	**1.499**	**1.517**	**0.389**
Lights	0.184	0.184	0.184	0.184	0.131
Electric Equipment	0.230	0.230	0.230	0.230	0.164
Misc. Electric	1.414	1.412	1.414	1.412	0.978
Misc. Fuel Use	0.000	0.000	0.000	0.000	0.000
Non-HVAC Sub-Total	**1.829**	**1.826**	**1.828**	**1.826**	**1.273**
Grand Total	**3.345**	**3.344**	**3.328**	**3.343**	**1.663**
Gross Floor Area (ft²)	26994.0	26994.0	26994.0	26994.0	26994.0
Conditioned Floor Area (ft²)	26994.0	26994.0	26994.0	26994.0	26994.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 3. Component Cost as a Percentage of Total Cost

Component	[B000] Base Line (%)	[B090] Base Line (%)	[B180] Base Line (%)	[B270] Base Line (%)	[P] Ground Source Heat Pumps (%)
Air System Fans	22.6	22.6	22.6	22.6	0.0
Cooling	8.3	8.3	8.1	8.3	11.4
Heating	14.4	14.5	14.3	14.5	7.7
Pumps	0.0	0.0	0.0	0.0	3.2
Cooling Tower Fans	0.0	0.0	0.0	0.0	1.0
HVAC Sub-Total	**45.3**	**45.4**	**45.1**	**45.4**	**23.4**
Lights	5.5	5.5	5.5	5.5	7.9
Electric Equipment	6.9	6.9	6.9	6.9	9.9
Misc. Electric	42.3	42.2	42.5	42.2	58.8
Misc. Fuel Use	0.0	0.0	0.0	0.0	0.0
Non-HVAC Sub-Total	**54.7**	**54.6**	**54.9**	**54.6**	**76.6**
Grand Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Lifecycle Summary

Project: Evaporative Cooler 2/10/2011
Prepared By: 4:39:32 PM

Wilders Grove Evaporative Cooler Option

Feasibility of adding evaporative cooler

Type of Analysis	Private Sector Lifecycle Analysis	
Type of Design Alternatives	Mutually Exclusive	
Length of Analysis	25	yrs
Minimum Attractive Rate of Return	2.00	%
Income Taxes	Not Considered	

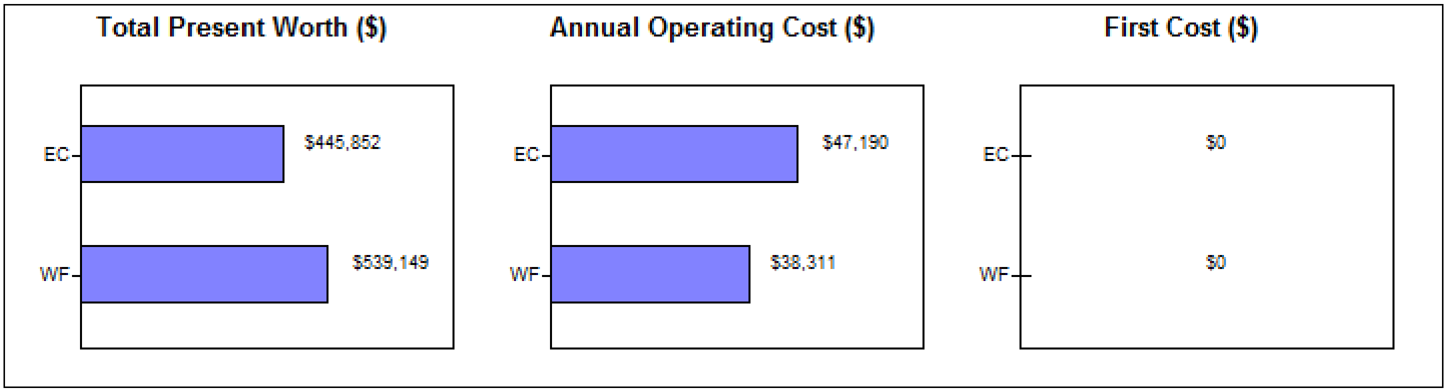


Table 1. Executive Summary

Economic Criteria	Best Design Case for Each Criteria	Value ($)
Incremental NPW Savings Analysis	Evaporative Cooler Addition	-
Lowest Total Present Worth	Evaporative Cooler Addition	$445,852
Lowest Annual Operating Cost	Well Field Addition	$38,311
Lowest First Cost	Evaporative Cooler Addition	$0

Table 2. Design Cases Ranked by First Cost

Design Case Name	Design Case Short Name	Total Present Worth ($)	Annual Operating Cost ($/yr)	First Cost ($)
Evaporative Cooler Addition	EC	$445,852	$47,190	$0
Well Field Addition	WF	$539,149	$38,311	$0

Table 3. Incremental Analysis Data

Challenger	Base Case	Additional First Cost ($)	NPW Savings ($)	IRR (%)	Payback Period (yrs)
WF	EC [Winner]	$0	$-93,297	n/a	n/a

Analysis Details

Project: Evaporative Cooler
Prepared By:

2/10/2011
4:45:05 PM

Wilders Grove Evaporative Cooler Option

Feasibility of adding evaporative cooler

Type of Analysis........Private Sector Lifecycle Analysis
Type of Design Alternatives........Mutually Exclusive
Length of Analysis........25 yrs
Minimum Attractive Rate of Return........2.00 %
Income Taxes........Not Considered

1A. Summary of Results

Base Case **[Winner]**	Evaporative Cooler Addition [EC]
Challenger	Well Field Addition [WF]
[EC] Total Present Worth ($)	$445,852
[WF] Total Present Worth ($)	$539,149
Net Present Worth Savings ($)	$-93,297
Internal Rate of Return	n/a
Payback Period (yrs)	n/a

1B. Comparative Analysis Details

		Cash Flow (Present Worth $)			SIR and Payback Calculation (Present Worth $)				
Year	**Date**	**[EC] Cash Flow ($)**	**[WF] Cash Flow ($)**	**Net Present Worth Savings ($)**	**Operating Cost Savings ($)**	**Cumulative Operating Cost Savings ($)**	**Additional Investment Cost ($)**	**Cumulative Additional Investment Cost ($)**	**Year-End SIR**
0	Initial	0	0	0	0	0	0	0	0.000
1	1	0	0	0	0	0	0	0	0.000
2	2	0	0	0	0	0	0	0	0.000
3	3	0	0	0	0	0	0	0	0.000
4	4	0	0	0	0	0	0	0	0.000
5	5	315,869	539,149	-223,280	12,952	12,952	236,232	236,232	0.055
6	6	0	0	0	0	12,952	0	236,232	0.055
7	7	0	0	0	0	12,952	0	236,232	0.055
8	8	9,148	0	9,148	9,148	22,099	0	236,232	0.094
9	9	0	0	0	0	22,099	0	236,232	0.094
10	10	0	0	0	0	22,099	0	236,232	0.094
11	11	11,473	0	11,473	11,473	33,573	0	236,232	0.142
12	12	0	0	0	0	33,573	0	236,232	0.142
13	13	0	0	0	0	33,573	0	236,232	0.142
14	14	14,390	0	14,390	14,390	47,963	0	236,232	0.203
15	15	0	0	0	0	47,963	0	236,232	0.203
16	16	0	0	0	0	47,963	0	236,232	0.203
17	17	18,049	0	18,049	18,049	66,011	0	236,232	0.279
18	18	29,196	0	29,196	29,196	95,208	0	236,232	0.403
19	19	0	0	0	0	95,208	0	236,232	0.403
20	20	22,637	0	22,637	22,637	117,845	0	236,232	0.499
21	21	0	0	0	0	117,845	0	236,232	0.499
22	22	0	0	0	0	117,845	0	236,232	0.499
23	23	28,392	0	28,392	28,392	146,237	0	236,232	0.619
24	24	0	0	0	0	146,237	0	236,232	0.619
25	25	-3,302	0	-3,302	0	146,237	3,302	239,534	0.611
Totals		445,852	539,149	-93,297	146,237		239,534		

Cash Flow Details

Project: Evaporative Cooler
Prepared By:

2/10/2011
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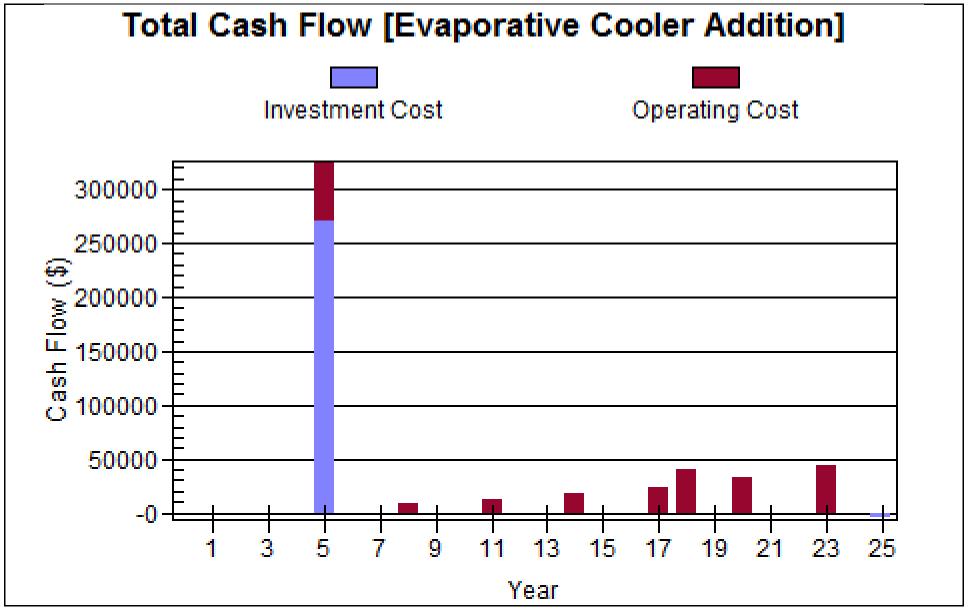
Wilders Grove Evaporative Cooler Option

Feasibility of adding evaporative cooler

Type of Analysis	Private Sector Lifecycle Analysis	
Type of Design Alternatives	Independent	
Length of Analysis	25	yrs
Minimum Attractive Rate of Return	2.00	%
Income Taxes	Not Considered	



1A. Component Cash Flows [Evaporative Cooler Addition], Actual Value

Year	Date	Cash Investment ($)	Loan Principal ($)	Loan Interest ($)	Total Investment Cost ($)	Annual Operating Cost ($)	Non-Annual Operating Cost ($)	Total Operating Cost ($)	Total Cash Flow ($)
0	Initial	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	0	0	0
3	3	0	0	0	0	0	0	0	0
4	4	0	0	0	0	0	0	0	0

Cash Flow Details

Project: Evaporative Cooler
Prepared By:

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Year	Date	Cash Investment ($)	Loan Principal ($)	Loan Interest ($)	Total Investment Cost ($)	Annual Operating Cost ($)	Non-Annual Operating Cost ($)	Total Operating Cost ($)	Total Cash Flow ($)
5	5	272,745	0	0	272,745	76,000	0	76,000	348,745
6	6	0	0	0	0	0	0	0	0
7	7	0	0	0	0	0	0	0	0
8	8	0	0	0	0	0	10,718	10,718	10,718
9	9	0	0	0	0	0	0	0	0
10	10	0	0	0	0	0	0	0	0
11	11	0	0	0	0	0	14,266	14,266	14,266
12	12	0	0	0	0	0	0	0	0
13	13	0	0	0	0	0	0	0	0
14	14	0	0	0	0	0	18,987	18,987	18,987
15	15	0	0	0	0	0	0	0	0
16	16	0	0	0	0	0	0	0	0
17	17	0	0	0	0	0	25,272	25,272	25,272
18	18	0	0	0	0	0	41,699	41,699	41,699
19	19	0	0	0	0	0	0	0	0
20	20	0	0	0	0	0	33,638	33,638	33,638
21	21	0	0	0	0	0	0	0	0
22	22	0	0	0	0	0	0	0	0
23	23	0	0	0	0	0	44,772	44,772	44,772
24	24	0	0	0	0	0	0	0	0
25	25	-5,417	0	0	-5,417	0	0	0	-5,417
Totals		267,328	0	0	267,328	76,000	189,352	265,352	532,680

1B. Present Worth Cash Flows [Evaporative Cooler Addition]

Year	Date	Total Investment Cost ($)	Total Operating Cost ($)	Total Present Worth ($)
0	Initial	0	0	0
1	1	0	0	0
2	2	0	0	0
3	3	0	0	0
4	4	0	0	0
5	5	247,033	68,836	315,869
6	6	0	0	0
7	7	0	0	0
8	8	0	9,148	9,148
9	9	0	0	0
10	10	0	0	0

Cash Flow Details

Project: Evaporative Cooler
Prepared By:

2/10/2011
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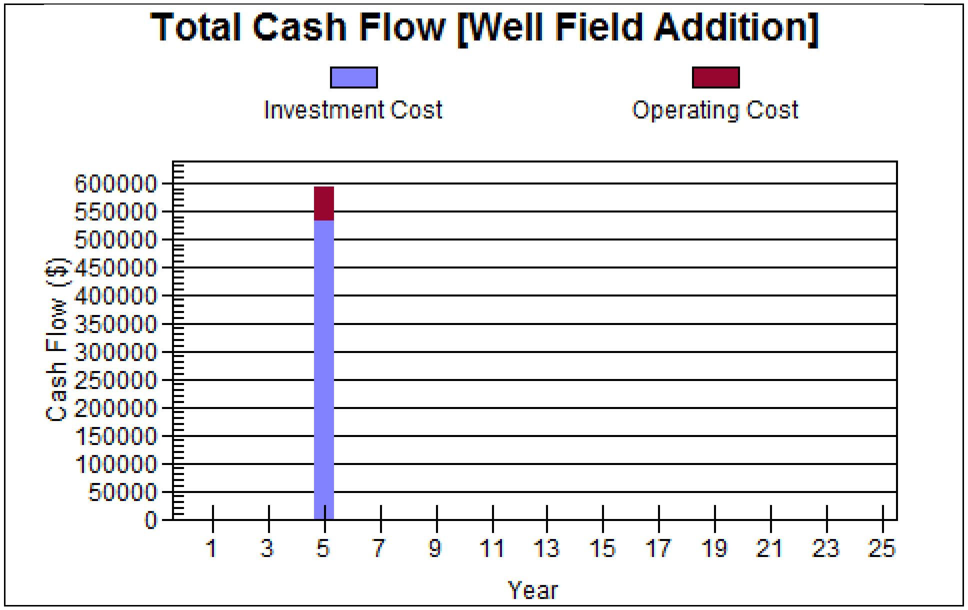
Year	Date	Total Investment Cost ($)	Total Operating Cost ($)	Total Present Worth ($)
11	11	0	11,473	11,473
12	12	0	0	0
13	13	0	0	0
14	14	0	14,390	14,390
15	15	0	0	0
16	16	0	0	0
17	17	0	18,049	18,049
18	18	0	29,196	29,196
19	19	0	0	0
20	20	0	22,637	22,637
21	21	0	0	0
22	22	0	0	0
23	23	0	28,392	28,392
24	24	0	0	0
25	25	-3,302	0	-3,302
Totals		243,731	202,121	445,852

Cash Flow Details



2A. Component Cash Flows [Well Field Addition], Actual Value

Year	Date	Cash Investment ($)	Loan Principal ($)	Loan Interest ($)	Total Investment Cost ($)	Annual Operating Cost ($)	Non-Annual Operating Cost ($)	Total Operating Cost ($)	Total Cash Flow ($)
0	Initial	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	0	0	0
3	3	0	0	0	0	0	0	0	0
4	4	0	0	0	0	0	0	0	0
5	5	533,564	0	0	533,564	61,700	0	61,700	595,264
6	6	0	0	0	0	0	0	0	0
7	7	0	0	0	0	0	0	0	0
8	8	0	0	0	0	0	0	0	0
9	9	0	0	0	0	0	0	0	0
10	10	0	0	0	0	0	0	0	0
11	11	0	0	0	0	0	0	0	0
12	12	0	0	0	0	0	0	0	0
13	13	0	0	0	0	0	0	0	0

Year	Date	Cash Investment ($)	Loan Principal ($)	Loan Interest ($)	Total Investment Cost ($)	Annual Operating Cost ($)	Non-Annual Operating Cost ($)	Total Operating Cost ($)	Total Cash Flow ($)
14	14	0	0	0	0	0	0	0	0
15	15	0	0	0	0	0	0	0	0
16	16	0	0	0	0	0	0	0	0
17	17	0	0	0	0	0	0	0	0
18	18	0	0	0	0	0	0	0	0
19	19	0	0	0	0	0	0	0	0
20	20	0	0	0	0	0	0	0	0
21	21	0	0	0	0	0	0	0	0
22	22	0	0	0	0	0	0	0	0
23	23	0	0	0	0	0	0	0	0
24	24	0	0	0	0	0	0	0	0
25	25	0	0	0	0	0	0	0	0
Totals		533,564	0	0	533,564	61,700	0	61,700	595,264

2B. Present Worth Cash Flows [Well Field Addition]

Year	Date	Total Investment Cost ($)	Total Operating Cost ($)	Total Present Worth ($)
0	Initial	0	0	0
1	1	0	0	0
2	2	0	0	0
3	3	0	0	0
4	4	0	0	0
5	5	483,265	55,884	539,149
6	6	0	0	0
7	7	0	0	0
8	8	0	0	0
9	9	0	0	0
10	10	0	0	0
11	11	0	0	0
12	12	0	0	0
13	13	0	0	0
14	14	0	0	0
15	15	0	0	0
16	16	0	0	0
17	17	0	0	0
18	18	0	0	0
19	19	0	0	0

Cash Flow Details

Project: Evaporative Cooler
Prepared By:

2/10/2011
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Year	Date	Total Investment Cost ($)	Total Operating Cost ($)	Total Present Worth ($)
20	20	0	0	0
21	21	0	0	0
22	22	0	0	0
23	23	0	0	0
24	24	0	0	0
25	25	0	0	0
Totals		483,265	55,884	539,149

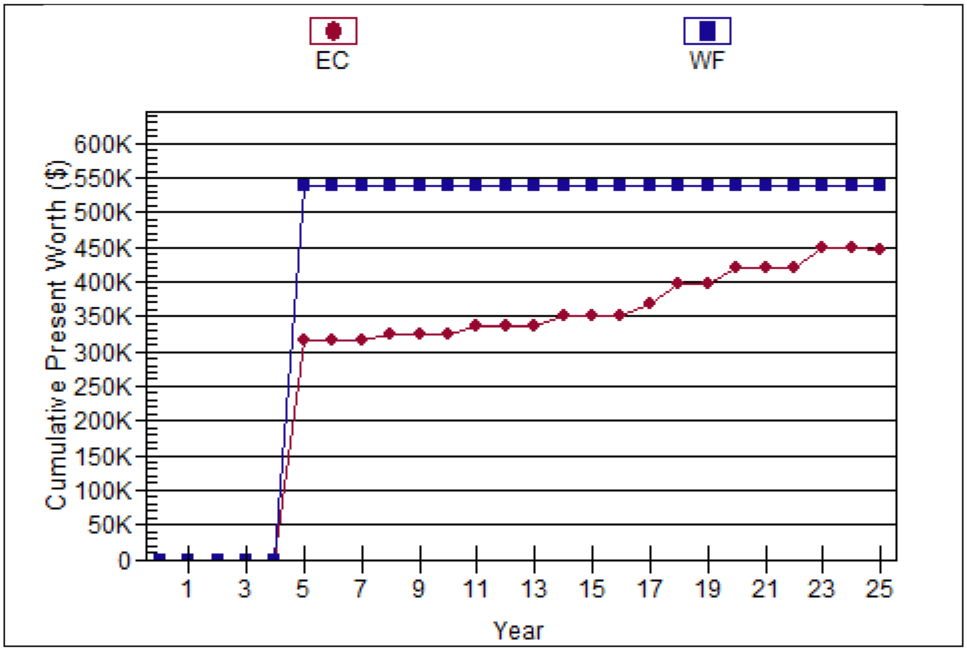
Total Present Worth Profiles

Project: Evaporative Cooler 2/10/2011
Prepared By: 4:57:24 PM

Wilders Grove Evaporative Cooler Option

Feasibility of adding evaporative cooler

Type of Analysis	Private Sector Lifecycle Analysis
Type of Design Alternatives	Mutually Exclusive
Length of Analysis	25 yrs
Minimum Attractive Rate of Return	2.00 %
Income Taxes	Not Considered



Design Cases Ranked by First Cost

Design Case Name	Design Case Short Name	Total Present Worth ($)	Annual Operating Cost ($/yr)	First Cost ($)
Evaporative Cooler Addition	EC	$445,852	$47,190	$0
Well Field Addition	WF	$539,149	$38,311	$0

HIPP ENGINEERING & CONSULTING, INC.

COST ESTIMATING FORM, EVAPORATIVE COOLER

Summary Cost Estimates

GENERAL				MATERIAL	LABOR		TOTAL
Item	**Description**	**Quantity**	**Units**	**Total Material Costs**	**Total Labor Hours**	**Total Labor Cost**	**Total Raw Cost**
	Direct Costs						
1	General Conditions			$ -	0.0	$ -	$ -
2	Architectural			$ -	0.0	$ -	$ -
3	Structural			$ -	0.0	$ -	$ -
4	Civil			$ -	0.0	$ -	$ -
5	Process			$ -	0.0	$ -	$ -
6	Mechanical			$ 66,448.13	147.4	$ 7,072.85	$ 73,520.98
7	Electrical			$ 1,756.00	429.2	$ 20,602.90	$ 22,358.90
8	Instrumentation and Controls			$ -	0.0	$ -	$ -
						Sub-Total Direct Costs	$ 95,879.87

	In-Direct Costs				
9	Engineering	N/A	150.0	$ 15,000.00	$ 15,000.00
10	Construction Management	N/A	0.0	$ -	$ -
11	Commissioning	N/A	24.0	$ 2,400.00	$ 2,400.00
12	Validation	N/A	0.0	$ -	$ -
				Sub-Total In-Direct Costs	$ 17,400.00

Total Raw Cost	$ 113,279.87
Overhead & Profit, 15%	$ 16,991.98
Total Cost	$ 130,271.86
Contingency, 30%	$ 39,081.56
Grand Total Project	$ 169,353.41

HIPP ENGINEERING & CONSULTING, INC.

COST ESTIMATING FORM, EVAPORATIVE COOLER

Mechanical, Piping

GENERAL				MATERIAL		LABOR				TOTAL
Item	**Description**	**Quantity**	**Units**	**Material Unit Cost**	**Material Extended Cost**	**Unit MH**	**Extended MH**	**Labor Unit Cost**	**Labor Extended Cost**	**Total Item Cost**
1	Evaporative Cooler	1	Ea	$ 60,000.00	$ 60,000.00	24	24	$ 48.00	$ 1,152.00	$ 61,152.00
3	Foundations (12" Sono-tubes)	2	CY	$ 740.00	$ 1,480.00	16.5	33.03	$ 48.00	$ 1,585.44	$ 3,065.44
4	Rigging into place	1	Lot	$ 1,000.00	$ 1,000.00	32	32	$ 48.00	$ 1,536.00	$ 2,536.00
5	1 1/2" Pipe Insulation	9	LF	$ 3.07	$ 27.63	0.09	0.801	$ 48.00	$ 38.45	$ 66.08
6	Exterior Piping, 1 1/2"	150	LF	$ 2.43	$ 364.50	0.07	9.75	$ 48.00	$ 468.00	$ 832.50
7	Exterior Piping, 6"	60	LF	$ 40.00	$ 2,400.00	0.12	7.32	$ 48.00	$ 351.36	$ 2,751.36
8	1 1/2" Valves	2	Ea	$ 57.00	$ 114.00	0.75	1.5	$ 48.00	$ 72.00	$ 186.00
9	6" Valves	2	Ea	$ 281.00	$ 562.00	4.8	9.6	$ 48.00	$ 460.80	$ 1,022.80
10	Trenching	50	CY	$ -	$ -	0.11	5.35	$ 48.00	$ 256.80	$ 256.80
11	Back-fill	50	CY	$ 10.00	$ 500.00	0.16	8	$ 48.00	$ 384.00	$ 884.00
12	Test & Balance	1	Lot	$ -	$ -	16	16	$ 48.00	$ 768.00	$ 768.00

Sub-total, Material Cost	$ 66,448.13
Sub-total, Labor Hours	147.35
Sub-total Labor Cost	$ 7,072.85
Total Cost	$ 73,520.98

HIPP ENGINEERING & CONSULTING, INC.

COST ESTIMATING FORM, EVAPORATIVE COOLER

Electrical, Power

GENERAL				MATERIAL		LABOR				TOTAL
Item	**Description**	**Quantity**	**Units**	**Material Unit Cost**	**Material Extended Cost**	**Unit MH**	**Extended MH**	**Labor Unit Cost**	**Labor Extended Cost**	**Total Item Cost**
1	Breaker, 10 HP (fan)	1	Ea	$ 268.00	$ 268.00	5	5	$ 48.00	$ 240.00	$ 508.00
2	Breaker, 3 HP (pump)	1	Ea	$ 238.00	$ 238.00	3.5	3.5	$ 48.00	$ 168.00	$ 406.00
3	Conduit & Wire	100	LF	$ 10.50	$ 1,050.00	4.2	420	$ 48.00	$ 20,160.00	$ 21,210.00
8	Grounding	1	Lot	$ 200.00	$ 200.00	0.73	0.727	$ 48.00	$ 34.90	$ 234.90
3				$ -	$ -		0	$ 48.00	$ -	$ -

Sub-total, Material Cost	$ 1,756.00
Sub-total, Labor Hours	429.23
Sub-total Labor Cost	$ 20,602.90
Total Cost	$ 22,358.90

COST ESTIMATING FORM, WELL FIELD

Summary Cost Estimates

GENERAL				MATERIAL	LABOR		TOTAL
Item	**Description**	**Quantity**	**Units**	**Total Material Costs**	**Total Labor Hours**	**Total Labor Cost**	**Total Raw Cost**
	Direct Costs						
1	General Conditions			$ -	0.0	$ -	$ -
2	Architectural			$ -	0.0	$ -	$ -
3	Structural			$ -	0.0	$ -	$ -
4	Civil			$ -	0.0	$ -	$ -
5	Process			$ -	0.0	$ -	$ -
6	Mechanical			$ 72,659.50	2896.8	$ 139,046.88	$ 211,706.38
7	Electrical			$ -	0.0	$ -	$ -
8	Instrumentation and Controls			$ -	0.0	$ -	$ -
						Sub-Total Direct Costs	$ 211,706.38

	In-Direct Costs				
9	Engineering	N/A	75.0	$ 7,500.00	$ 7,500.00
10	Construction Management	N/A	0.0	$ -	$ -
11	Commissioning	N/A	24.0	$ 2,400.00	$ 2,400.00
12	Validation	N/A	0.0	$ -	$ -
				Sub-Total In-Direct Costs	$ 9,900.00

Total Raw Cost	$ 221,606.38
Overhead & Profit, 15%	$ 33,240.96
Total Cost	$ 254,847.34
Contingency, 30%	$ 76,454.20
Grand Total Project	$ 331,301.54

Mechanical, Piping

GENERAL				MATERIAL		LABOR				TOTAL
Item	Description	Quantity	Units	Material Unit Cost	Material Extended Cost	Unit MH	Extended MH	Labor Unit Cost	Labor Extended Cost	Total Item Cost
1	Exterior Piping, 1 1/2"	50	LF	$ 2.43	$ 121.50	0.07	3.25	$ 48.00	$ 156.00	$ 277.50
2	Exterior Piping, 2"	200	LF	$ 2.69	$ 538.00	0.07	13.2	$ 48.00	$ 633.60	$ 1,171.60
3	Exterior Piping, 2 1/2"	500	LF	$ 5.60	$ 2,800.00	0.08	39	$ 48.00	$ 1,872.00	$ 4,672.00
4	Wells	10	Ea	$ 6,840.00	$ 68,400.00	0	0	$ 48.00	$ -	$ 68,400.00
5	Trenching	80	CY	$ -	$ -	0.11	8.56	$ 48.00	$ 410.88	$ 410.88
6	Back-fill	80	CY	$ 10.00	$ 800.00	0.16	12.8	$ 48.00	$ 614.40	$ 1,414.40
7	Cut Concrete Paving	750	LF	$ -	$ -	2.4	1800	$ 48.00	$ 86,400.00	$ 86,400.00
8	Haul Spoils for disposal	100	CY	$ -	$ -	0.14	14	$ 48.00	$ 672.00	$ 672.00
9	Patch Concrete & rebar	60	CY	$ 740.00	$ -	16.5	990	$ 48.00	$ 47,520.00	$ 47,520.00
10	Test & Balance	1	Lot	$ -	$ -	16	16	$ 48.00	$ 768.00	$ 768.00
								Sub-total, Material Cost		$ 72,659.50
								Sub-total, Labor Hours		2,896.81
								Sub-total Labor Cost		$ 139,046.88
								Total Cost		$ 211,706.38

JACOBS

CITY OF RALEIGH
NORTH CAROLINA

APPENDIX I

CONVENTIONAL VS GEOTHERMAL SYSTEMS COST ESTIMATE

HIPP ENGINEERING & CONSULTING, INC

COST ESTIMATING FORM

Proposed Geo-Thermal Based HVAC and Domestic Hot Water Costs vs. Conventional HVAC and Domestic Hot Water System Costs

Proposed Building

Plumbing, Domestic Hot Water Generation			
Includes DHW Gen. heat pump, storage tank, emergency electric DHW heater, pumps & accessories	**Material Cost**	**Labor Cost**	**Total Line Item Cost**
Ground Source Heat Pump	$ 50,000.00	$ 816.00	$ 50,816.00
Storage Tank / Heat Exchanger	$ 53,181.00	$ 897.60	$ 54,078.60
Pumps and Accessories	$ 5,600.00	$ 633.60	$ 6,233.60
	$ 108,781.00	$ 2,347.20	
Total Domestic Hot Water Generation Cost			$ 111,128.20
Mechanical, HVAC			
Includes heat pumps, ductwork, fans, electric heaters and accessories	**Material Cost**	**Labor Cost**	**Total Line Item Cost**
Ground Source Heat Pumps	$ 191,750.00	$ 13,027.20	$ 204,777.20
Exhaust Fans	$ 4,325.00	$ 1,200.00	$ 5,525.00
Ductwork	$ 97,881.68	$ 226,105.20	$ 323,986.88
Electric Heaters	$ 8,945.00	$ 508.80	$ 9,453.80
Test & Balance	$ -	$ 7,680.00	$ 7,680.00
	$ 302,901.68	$ 248,521.20	
Total HVAC Cost			$ 551,422.88
Mechanical, Piping			
Includes interior & exterior piping, trenching, vaults, pumps, wells and accessories	**Material Cost**	**Labor Cost**	**Total Line Item Cost**
Ground Source Wells	$ 410,400.00	$ -	$ 410,400.00
Ground Source Pumps & Accessories	$ 7,800.00	$ 672.00	$ 8,472.00
Ground Source Interior Piping	$ 35,552.35	$ 41,334.29	$ 76,886.64
Ground Source Exterior Piping	$ 33,025.50	$ 21,922.08	$ 54,947.58
Test & Balance	$ -	$ 2,880.00	$ 2,880.00
	$ 486,777.85	$ 66,808.37	
Total Ground Source Well, Piping and Pump Costs			$ 553,586.22

Conventional Building

Plumbing, Domestic Hot Water Generation			
Includes electric domestic water heater, circulation pump and accessories	**Material Cost**	**Labor Cost**	**Total Line Item Cost**
Water Heater	$ 45,000.00	$ 576.00	$ 45,576.00
Pumps and Accessories	$ 1,680.00	$ 249.60	$ 1,929.60
			$ -
Total Domestic Hot Water Generation Cost			$ 47,505.60
Mechanical, HVAC			
Includes air handling units, vav boxes, fans, electric heaters, ductwork and accessories	**Material Cost**	**Labor Cost**	**Total Line Item Cost**
Air Handling Units	$ 302,613.00	$ 13,488.00	$ 316,101.00
Exhaust Fans	$ 4,325.00	$ 1,200.00	$ 5,525.00
Ductwork	$ 115,967.50	$ 226,708.03	$ 342,675.53
Electric Heaters	$ 39,221.00	$ 2,921.28	$ 42,142.28
Test & Balance	$ -	$ 7,680.00	$ 7,680.00
Total HVAC Cost			$ 714,123.81
Mechanical, Piping			
No mechanical piping required with this type of system. Piping factory installed with AHU equipment.	**Material Cost**	**Labor Cost**	**Total Line Item Cost**
Ground Source Wells	$ -	$ -	$ -
Ground Source Pumps & Accessories	$ -	$ -	$ -
Ground Source Interior Piping	$ -	$ -	$ -
Ground Source Exterior Piping	$ -	$ -	$ -
Test & Balance	$ -	$ -	$ -
Total Mechanical / Hydronic Piping and Pump Costs			$ -

COST ESTIMATING FORM

Proposed Geo-Thermal Based HVAC and Domestic Hot Water Costs vs. Conventional HVAC and Domestic Hot Water System Costs

Subtotal Geo-thermal Based System Costs	$	1,216,137.30

Grand Total Conventional System Costs	$	761,629.41

The items following are enhancements to the well field construction and building control systems monitoring control points to provide for long term monitoring and modeling of the geothermal system.

Well Field Instrumentation

Includes new test / sample wells, well field monitoring devices, testing, estimate	**Material Cost**	**Labor Cost**	**Total Line Item Cost**
Sample / Test Wells	$ 18,000.00	$ 16,128.00	$ 34,128.00
devices, cables to admin	$ 37,000.00	$ 8,500.00	$ 45,500.00
Well Field Testing	$ 15,000.00	$ 5,372.00	$ 20,372.00
	$ 70,000.00	$ 30,000.00	
		Total Well Field Test & Instrumentation Estimate	$ 100,000.00

Building and Well Field Control Points and Modeling

Electronic Control Points	**Material Cost**	**Labor Cost**	**Total Line Item Cost**
200 Points	$ 200,000.00	$ 9,600.00	$ 209,600.00
	$ 200,000.00	$ 9,600.00	
		Total Control Point & Modeling Estimate	$ 209,600.00

Building and Well Field Control Points and Modeling

Electronic Control Points	**Material Cost**	**Labor Cost**	**Total Line Item Cost**
140 Points	$ 140,000.00	$ 9,600.00	$ 149,600.00
	$ 140,000.00	$ 9,600.00	
		Total Control Point & Modeling Estimate	$ 149,600.00

Grand Total Geo-thermal Based System Costs	$	1,525,737.30
15% OH & Profit & 10% Contingency Estimate	$	381,434.32
Total Geothermal System Estimate Estimate	$	1,907,171.62

Grand Total Conventional Based System Costs	$	911,229.41
15% OH & Profit & 10% Contingency Estimate	$	227,807.35
Total Conventional System Estimate	$	1,139,036.77

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CITY OF RALEIGH
NORTH CAROLINA

APPENDIX J

ACTUAL CONSTRUCTION COST OF WILDERS GROVE GEOTHERMALSYSTEM FROM T.A. LOVING CONSTRUCTION COMPANY

Wilders Grove SWS Facility City of Raleigh

GEOTHERMAL ENERGY SYSTEM COST ESTIMATING FORM

PERIOD ENDING:

ESTIMATE #:

				A		B	C	D	E	F	G
Summary Cost Estimates								WORK COMPLETED		MATERIALS	TOTAL
GENERAL				MATERIAL	LABOR		TOTAL	FROM PREVIOUS APPLICATION	THIS PERIOD	PRESENTLY STORED (NOT IN D OR E)	COMPLETED AND STORED TO DATE
Item	Description	Quantity	Units	Total Material Costs	Total Labor Hours	Total Labor Cost	Total Raw Cost				
Direct Costs											
1	General Conditions			$ 68,654.00	180.0	$ 18,028.50	$ 86,682.50				
2	Architectural			$ -	0.0	$ -	$ -				
3	Structural			$ -	0.0	$ -	$ -				
4	Civil			$ -	0.0	$ -	$ -				
5	Wells and Loop Piping			$ 120,326.80	717.3	$ 319,071.36	$ 439,398.16				
6	Plumbing System			$ 63,039.68	652284.5	$ 21,273.00	$ 84,312.68				
6	Mechanical			$ 468,917.99	9015.2	$ 375,228.01	$ 844,146.00				
7	Electrical			$ 15,000.00	687.0	$ 33,776.00	$ 48,776.00				
8	Instrumentation and Controls			$ 226,156.00	0.0	$ 78,279.00	$ 304,435.00				
						Sub-Total Direct Costs	$ 1,807,750.34	$ -	$ -	$ -	$ -
In-Direct Costs											
9	Engineering			N/A	0.0	$ -	$ -	$ -	$ -	$ -	$ -
10	Construction Management			N/A	0.0	$ -	$ -	$ -	$ -	$ -	$ -
11	Commissioning			N/A	0.0	$ -	$ -	$ -	$ -	$ -	$ -
12	Validation			N/A	0.0	$ -	$ -	$ -	$ -	$ -	$ -
						Sub-Total In-Direct Costs	$ 1,807,750.34	$ -	$ -	$ -	$ -
						Total Raw Cost	$ 1,807,750.34	$ -	$ -	$ -	$ -
						Total Cost	$ 1,807,750.34	$ -	$ -	$ -	$ -
						Grand Total Project	$ 1,807,750.34	$ -	$ -	$ -	$ -

Wilders Grove SWS Facility City of Raleigh

GEOTHERMAL ENERGY SYSTEM COST ESTIMATING FORM

PERIOD ENDING:

ESTIMATE #:

General Conditions, All Project Scopes											**WORK COMPLETED**		**MATERIALS**	**TOTAL**
GENERAL				**MATERIAL**		**LABOR**				**TOTAL**	**FROM PREVIOUS APPLICATION**	**THIS PERIOD**	**PRESENTLY STORED (NOT IN D OR E)**	**COMPLETED AND STORED TO DATE**
Item	**Description**	**Quantity**	**Units**	**Material Unit Cost**	**Material Extended Cost**	**Unit MH**	**Extended MH**	**Labor Unit Cost**	**Labor Extended Cost**	**Total Item Cost**				
1	GC Supervision and Management	1	lot	$ 68,654.00	$ 68,654.00		0	$ -	$ -	$ 68,654.00	$ 68,654.00			$ 68,654.00
2	CO 2 DOE Grant Work			$ -	$ -		180	$ -	$ 18,028.50	$ 18,028.50	$ 18,028.50			$ 18,028.50
3														
4														
5														
6				$ -	$ -		0	$ -	$ -	$ -				
7				$ -	$ -		0	$ -	$ -	$ -				
8				$ -	$ -		0	$ -	$ -	$ -				
9				$ -	$ -		0	$ -	$ -	$ -				
10				$ -	$ -		0	$ -	$ -	$ -				
11				$ -	$ -		0	$ -	$ -	$ -				
12				$ -	$ -		0	$ -	$ -	$ -				
13				$ -	$ -		0	$ -	$ -	$ -				
14				$ -	$ -		0	$ -	$ -	$ -				
15				$ -	$ -		0	$ -	$ -	$ -				
16				$ -	$ -		0	$ -	$ -	$ -				
17				$ -	$ -		0	$ -	$ -	$ -				
18				$ -	$ -		0	$ -	$ -	$ -				
19				$ -	$ -		0	$ -	$ -	$ -				
									Sub-total, Material Cost	$ 68,654.00	$ 86,682.50	$ -	$ -	86,682.50
									Sub-total, Labor Hours	180.00	-	-	-	-
									Sub-total Labor Cost	$ 18,028.50	$ -	$ -	$ -	$ -
									Total Cost	$ 86,682.50	$ 86,682.50	$ -	$ -	$ 86,682.50

Wilders Grove SWS Facility City
of Raleigh

GEOTHERMAL ENERGY SYSTEM COST ESTIMATING FORM

PERIOD ENDING:

ESTIMATE #:

Mechanical, Geothermal Desuperheater Hot Water Plumbing System											**WORK COMPLETED**		**MATERIALS**	**TOTAL**
GENERAL				**MATERIAL**		**LABOR**				**TOTAL**	**FROM PREVIOUS APPLICATION**	**THIS PERIOD**	**PRESENTLY STORED (NOT IN D OR E)**	**COMPLETED AND STORED TO DATE**
Item	**Description**	**Quantity**	**Units**	**Material Unit Cost**	**Material Extended Cost**	**Unit MH**	**Extended MH**	**Labor Unit Cost**	**Labor Extended Cost**	**Total Item Cost**				
1	Domestic Hot Water Circulator	1	Ea	$ 319.68	$ 319.68	2	2	$ 31.50	$ 63.00	$ 382.68				
2	DHW Expansion Tank	1	Ea	$ 1,142.64	$ 1,142.64	8	8	$ 31.50	$ 252.00	$ 1,394.64				
3	HW Gen Pump	2	Ea	$ 3,691.44	$ 7,382.88	4	8	$ 31.50	$ 252.00	$ 7,634.88				
4	Heat Exchanger	1	Ea		$ -		0	$ 31.50	$ -	$ -				
5	Electric Back-up DHW Heaters	1	Ea	$ 10,449.00	$ 10,449.00	16	16	$ 31.50	$ 504.00	$ 10,953.00				
6	DHW Storage Tank	1	Ea	$ 34,377.48	$ 34,377.48	36	36	$ 31.50	$ 1,134.00	$ 35,511.48				
7	GHP-29 Ground Source HW Gen	1	Ea	$ 9,368.00	$ 9,368.00	164	164	$ 31.50	$ 5,166.00	$ 14,534.00				
8	Electrical GSHP wiring & conduit	1	Lot		$ -		0	$ 31.50	$ -	$ -				
9	CO 2 DOE Grant Work						50		$ 2,000.00	$ 2,000.00				
10	CO 12 Add flow meter			$ -	$ -		0	$ -	$ 11,902.00	$ 11,902.00		$ 11,902.00		
									Sub-total, Material Cost	$ 63,039.68	$ -	$ -	$ -	$ -
									Sub-total, Labor Hours	284.00	-	-	-	-
									Sub-total Labor Cost	$ 21,273.00	$ -	$ -	$ -	$ -
									Total Cost	$ 84,312.68	$ -	$ -	$ -	$ -

Mechanical, Geothermal Heat Pump HVAC System											**WORK COMPLETED**		**MATERIALS**	**TOTAL**
GENERAL				**MATERIAL**		**LABOR**				**TOTAL**	**FROM PREVIOUS APPLICATION**	**THIS PERIOD**	**PRESENTLY STORED (NOT IN D OR E)**	**COMPLETED AND STORED TO DATE**
Item	**Description**	**Quantity**	**Units**	**Material Unit Cost**	**Material Extended Cost**	**Unit MH**	**Extended MH**	**Labor Unit Cost**	**Labor Extended Cost**	**Total Item Cost**				
1	GHP-01 Ground Source Heat Pump	1	Ea	$ 9,368.00	$ 9,368.00	164	164	$ 38.54	$ 6,320.56	$ 15,688.56				
2	GHP-02 Ground Source Heat Pump	1	Ea	$ 9,369.00	$ 9,369.00	164	164	$ 38.54	$ 6,320.56	$ 15,689.56				
3	GHP-03 Ground Source Heat Pump	1	Ea	$ 9,368.00	$ 9,368.00	164	164	$ 38.54	$ 6,320.56	$ 15,688.56				
4	GHP-04 Ground Source Heat Pump	1	Ea	$ 9,367.00	$ 9,367.00	164	164	$ 38.54	$ 6,320.56	$ 15,687.56				
5	GHP-05 Ground Source Heat Pump	1	Ea	$ 9,366.00	$ 9,366.00	164	164	$ 38.54	$ 6,320.56	$ 15,686.56				
6	GHP-06 Ground Source Heat Pump	1	Ea	$ 9,365.00	$ 9,365.00	164	164	$ 38.54	$ 6,320.56	$ 15,685.56				
7	GHP-07 Ground Source Heat Pump	1	Ea	$ 9,364.00	$ 9,364.00	164	164	$ 38.54	$ 6,320.56	$ 15,684.56				
8	GHP-08 Ground Source Heat Pump	1	Ea	$ 9,363.00	$ 9,363.00	164	164	$ 38.54	$ 6,320.56	$ 15,683.56				
9	GHP-09 Ground Source Heat Pump	1	Ea	$ 9,362.00	$ 9,362.00	164	164	$ 38.54	$ 6,320.56	$ 15,682.56				
10	GHP-10 Ground Source Heat Pump	1	Ea	$ 9,361.00	$ 9,361.00	164	164	$ 38.54	$ 6,320.56	$ 15,681.56				
11	GHP-11 Ground Source Heat Pump	1	Ea	$ 9,360.00	$ 9,360.00	164	164	$ 38.54	$ 6,320.56	$ 15,680.56				
12	GHP-12 Ground Source Heat Pump	1	Ea	$ 9,359.00	$ 9,359.00	164	164	$ 38.54	$ 6,320.56	$ 15,679.56				
13	GHP-13 Ground Source Heat Pump	1	Ea	$ 9,358.00	$ 9,358.00	164	164	$ 38.54	$ 6,320.56	$ 15,678.56				
14	GHP-14 Ground Source Heat Pump	1	Ea	$ 9,357.00	$ 9,357.00	164	164	$ 38.54	$ 6,320.56	$ 15,677.56				
15	GHP-15 Ground Source Heat Pump	1	Ea	$ 9,356.00	$ 9,356.00	164	164	$ 38.54	$ 6,320.56	$ 15,676.56				
16	GHP-16 Ground Source Heat Pump	1	Ea	$ 9,355.00	$ 9,355.00	164	164	$ 38.54	$ 6,320.56	$ 15,675.56				
17	GHP-17 Ground Source Heat Pump	1	Ea	$ 9,354.00	$ 9,354.00	164	164	$ 38.54	$ 6,320.56	$ 15,674.56				
18	GHP-18 Ground Source Heat Pump	1	Ea	$ 9,353.00	$ 9,353.00	164	164	$ 38.54	$ 6,320.56	$ 15,673.56				
19	GHP-19 Ground Source Heat Pump	1	Ea	$ 9,352.00	$ 9,352.00	164	164	$ 38.54	$ 6,320.56	$ 15,672.56				
20	GHP-20 Ground Source Heat Pump	1	Ea	$ 9,351.00	$ 9,351.00	164	164	$ 38.54	$ 6,320.56	$ 15,671.56				
21	GHP-21 Ground Source Heat Pump	1	Ea	$ 9,350.00	$ 9,350.00	164	164	$ 38.54	$ 6,320.56	$ 15,670.56				
22	GHP-22 Ground Source Heat Pump	1	Ea	$ 9,349.00	$ 9,349.00	164	164	$ 38.54	$ 6,320.56	$ 15,669.56				
23	GHP-23 Ground Source Heat Pump	1	Ea	$ 9,348.00	$ 9,348.00	164	164	$ 38.54	$ 6,320.56	$ 15,668.56				
24	GHP-24 Ground Source Heat Pump	1	Ea	$ 9,347.00	$ 9,347.00	164	164	$ 38.54	$ 6,320.56	$ 15,667.56				
25	GHP-25 Ground Source Heat Pump	1	Ea	$ 9,346.00	$ 9,346.00	164	164	$ 38.54	$ 6,320.56	$ 15,666.56				
26	GHP-26 Ground Source Heat Pump	1	Ea	$ 9,345.00	$ 9,345.00	164	164	$ 38.54	$ 6,320.56	$ 15,665.56				
27	GHP-27 Ground Source Heat Pump	1	Ea	$ 9,344.00	$ 9,344.00	164	164	$ 38.54	$ 6,320.56	$ 15,664.56				
33	GHP-28 Ground Source Heat Pump	1	Ea	$ 9,343.00	$ 9,343.00	164	164	$ 38.54	$ 6,320.56	$ 15,663.56				
34	General Exhaust Fan	1	Ea	$ 1,800.00	$ 1,800.00	16	16	$ 38.54	$ 616.64	$ 2,416.64				

Wilders Grove SWS Facility City of Raleigh

GEOTHERMAL ENERGY SYSTEM COST ESTIMATING FORM

PERIOD ENDING:

ESTIMATE #:

35	AHU Ductwork	22366	lbs	$ 0.81	$ 18,071.73	0.027	603.882	$ 38.54	$ 23,273.61	$ 41,345.34				
36	Duct Insulation	30413	SQF	$ 0.81	$ 24,634.53		0	$ 38.54	$ -	$ 24,634.53				
37	OA Louvers	38	SQF	$ 126.00	$ 4,788.00		0	$ 38.54	$ -	$ 4,788.00				
38	Exhaust Fan Mech. Room	1	Ea	$ 2,195.00	$ 2,195.00	8	8	$ 38.54	$ 308.32	$ 2,503.32				
39	Exhaust Fan Electrical Room	1	Ea	$ 2,195.00	$ 2,195.00	8	8	$ 38.54	$ 308.32	$ 2,503.32				
40	Diffusers, 8" neck	24	Ea	$ 22.50	$ 540.00		0	$ 38.54	$ -	$ 540.00				
41	Diffusers, 10" neck	60	Ea	$ 22.50	$ 1,350.00		0	$ 38.54	$ -	$ 1,350.00				
42	Return Grilles	63	Ea	$ 22.50	$ 1,417.50		0	$ 38.54	$ -	$ 1,417.50				
43	Supply Registers	47	Ea	$ 22.50	$ 1,057.50		0	$ 38.54	$ -	$ 1,057.50				
44	Linear Diffusers	37	Ea	$ 57.00	$ 2,109.00		0	$ 38.54	$ -	$ 2,109.00				
45	Linear Returns	8	Ea	$ 57.00	$ 456.00		0	$ 38.54	$ -	$ 456.00				
46	Flexible Duct, 8"	100	LF	$ 2.75	$ 275.00		0	$ 38.54	$ -	$ 275.00				
47	Flexible Duct, 10"	200	LF	$ 3.25	$ 650.00		0	$ 38.54	$ -	$ 650.00				
48	Volume Dampers, 8"	24	Ea	$ 3.00	$ 72.00		0	$ 38.54	$ -	$ 72.00				
49	Volume Dampers, 10"	60	Ea	$ 7.00	$ 420.00		0	$ 38.54	$ -	$ 420.00				
50	Misc. Dampers	24	Ea	$ 5.00	$ 120.00		0	$ 38.54	$ -	$ 120.00				
51	Access Doors	60	Ea	$ 18.50	$ 1,110.00		0	$ 38.54	$ -	$ 1,110.00				
52	Exhaust Ductwork	7000	lbs	$ 0.81	$ 5,670.00	0.027	189	$ 38.54	$ 7,284.06	$ 12,954.06				
53	Exhaust Grilles, 4"	1	Ea	$ 22.50	$ 22.50		0	$ 38.54	$ -	$ 22.50				
54	Exhaust Grilles, 8"	3	Ea	$ 22.50	$ 67.50		0	$ 38.54	$ -	$ 67.50				
55	Exhaust Grilles, 24x24	20	Ea	$ 22.50	$ 450.00		0	$ 38.54	$ -	$ 450.00				
56	Exhaust Volulme Control Box	1	Ea	$ 10,647.00	$ 10,647.00		0	$ 38.54	$ -	$ 10,647.00				
57	Exhaust Dampers	24	Ea	$ 57.00	$ 1,368.00		0	$ 38.54	$ -	$ 1,368.00				
58	Outside Air Ductwork	14000	lbs	$ 0.81	$ 11,340.00	0.027	378	$ 38.54	$ 14,568.12	$ 25,908.12				
59	Outside Air Diffusers, 4" Neck	16	Ea	$ 22.50	$ 360.00		0	$ 38.54	$ -	$ 360.00				
60	Outside Air Diffusers, 6" Neck	10	Ea	$ 22.50	$ 225.00		0	$ 38.54	$ -	$ 225.00				
61	Outside Air Diffusers, 8" Neck	3	Ea	$ 22.50	$ 67.50		0	$ 38.54	$ -	$ 67.50				
62	Outside Air Diffusers, 10" Neck	25	Ea	$ 22.50	$ 562.50		0	$ 38.54	$ -	$ 562.50				
63	Outside Air Flexible Duct, 4"	48	LF	$ 2.75	$ 132.00		0	$ 38.54	$ -	$ 132.00				
64	Outside Air Flexible Duct, 6"	30	LF	$ 2.75	$ 82.50		0	$ 38.54	$ -	$ 82.50				
65	Outside Air Flexible Duct, 8"	9	LF	$ 2.75	$ 24.75		0	$ 38.54	$ -	$ 24.75				
66	Outside Air Flexible Duct, 10"	75	LF	$ 3.25	$ 243.75		0	$ 38.54	$ -	$ 243.75				
57	Outside Air Control Boxes	14	Ea	$ 232.74	$ 3,258.36		0	$ 38.54	$ -	$ 3,258.36				
68	Outside Air Monitors	18	Ea	$ 896.00	$ 16,128.00		0	$ 38.54	$ -	$ 16,128.00				
69	Outside air dampers, 4"	16	Ea	$ 300.00	$ 4,800.00		0	$ 38.54	$ -	$ 4,800.00				
70	Outside Air Dampers, 6"	10	Ea	$ 350.00	$ 3,500.00		0	$ 38.54	$ -	$ 3,500.00				
71	Outside Air Dampers, 8"	3	Ea	$ 400.00	$ 1,200.00		0	$ 38.54	$ -	$ 1,200.00				
72	Outside Air Dampers, 10"	25	Ea	$ 475.00	$ 11,875.00		0	$ 38.54	$ -	$ 11,875.00				
73	Outside Air Dampers, 12"	1	Ea	$ 575.00	$ 575.00		0	$ 38.54	$ -	$ 575.00				
74	Outside Air Dampers, 18"	1	Ea	$ 975.00	$ 975.00		0	$ 38.54	$ -	$ 975.00				
75	Outside Air Dampers, 20"	2	Ea	$ 1,100.00	$ 2,200.00		0	$ 38.54	$ -	$ 2,200.00				
76	Outside Air Dampers, 24"	2	Ea	$ 1,280.00	$ 2,560.00		0	$ 38.54	$ -	$ 2,560.00				
77	Outside Air Duct Insulation	9000	SQF	$ 0.81	$ 7,290.00		0	$ 38.54	$ -	$ 7,290.00				
78	Elect Heating Coils, 100 kw	1	Ea		$ -		0	$ 38.54	$ -	$ -				
79	Unit Heaters	4	Ea	$ 920.00	$ 3,680.00	6	24	$ 38.54	$ 924.96	$ 4,604.96				
80	Electrical GSHP wiring & conduit	1	Lot		$ -		0	$ 38.54	$ -	$ -				
81	Electrical Control Devices	1	Lot		$ -		0	$ 38.54	$ -	$ -				
82	Test & Balance	1	Lot	$ 17,000.00	$ 17,000.00		0	$ 38.54	$ -	$ 17,000.00				
83	Hydronic Systrems	1	Lot	$ 37,372.37	$ 37,372.37	2195	2195	$ 38.54	$ 84,595.30	$ 121,967.67				
84	CO 10 Add VFD to Loop			$ -	$ -		0	$ -	$ 66,373.00	$ 66,373.00		$ 66,373.00		
								Sub-total, Material Cost		$ 468,917.99	$ -	$ -	$ -	$ -
								Sub-total, Labor Hours		8,013.88	-	-	-	-
								Sub-total Labor Cost		$ 375,228.01	$ -	$ -	$ 66,373.00	$ -
								Total Cost		$ 844,146.00	$ -	$ -	$ 66,373.00	$ -

Wilders Grove SWS Facility City of Raleigh

GEOTHERMAL ENERGY SYSTEM COST ESTIMATING FORM

PERIOD ENDING:

ESTIMATE #:

Mechanical, Geothermal Well Field & Ground Loop Piping											WORK COMPLETED		MATERIALS	TOTAL
GENERAL				MATERIAL		LABOR				TOTAL	FROM PREVIOUS APPLICATION	THIS PERIOD	PRESENTLY STORED (NOT IN D OR E)	COMPLETED AND STORED TO DATE
Item	Description	Quantity	Units	Material Unit Cost	Material Extended Cost	Unit MH	Extended MH	Labor Unit Cost	Labor Extended Cost	Total Item Cost				
1	Ground Water Loop Pump	2	Ea		$ -		0		$ -	$ -				
2	Ground Loop Expansion Tank	1	Ea		$ -		0		$ -	$ -				
3	Ground Loop Air Separator	1	Ea		$ -		0		$ -	$ -				
4	Ground Loop Wells, 6"x400 ft deep	60	Ea	$ 915.00	$ 54,900.00	1	60	$ 3,500.00	$ 210,000.00	$ 264,900.00				
5	3/4" Pipe, Cu	731	LF		$ -		0		$ -	$ -				
6	1" Pipe, Cu	12	LF		$ -		0		$ -	$ -				
7	1 1/4" Pipe, Cu	38	LF		$ -		0		$ -	$ -				
8	1 1/2" Pipe, Cu	9	LF		$ -		0		$ -	$ -				
9	2" Pipe, Sch. 40	110	LF		$ -		0		$ -	$ -				
10	2 1/2" Pipe, Sch. 40	52	LF		$ -		0		$ -	$ -				
11	3" Pipe, Sch. 40	92	LF		$ -		0		$ -	$ -				
12	4" Pipe, Sch. 40	217	LF		$ -		0		$ -	$ -				
13	6" Pipe, Sch. 40	497	LF		$ -		0		$ -	$ -				
14	3/4" Pipe Insulation	731	LF		$ -		0		$ -	$ -				
15	1" Pipe Insulation	12	LF		$ -		0		$ -	$ -				
16	1 1/4" Pipe Insulation	38	LF		$ -		0		$ -	$ -				
17	1 1/2" Pipe Insulation	9	LF		$ -		0		$ -	$ -				
18	2" Pipe Insulation	110	LF		$ -		0		$ -	$ -				
19	2 1/2" Pipe Insulation	52	LF		$ -		0		$ -	$ -				
20	3" Pipe Insulation	92	LF		$ -		0		$ -	$ -				
21	4" Pipe Insulation	217	LF		$ -		0		$ -	$ -				
22	6" Pipe Insulation	497	LF		$ -		0		$ -	$ -				
23	Equipment Insulation	500	SQF		$ -		0		$ -	$ -				
24	Exterior Piping, 1"	240	LF	$ 1.20	$ 288.00	0.06	14.4	$ 202.40	$ 2,914.56	$ 3,202.56				
25	Exterior Piping, 1 1/2"	240	LF	$ 1.60	$ 384.00	0.07	16.8	$ 202.40	$ 3,400.32	$ 3,784.32				
26	Exterior Piping, 2"	1500	LF	$ 1.90	$ 2,850.00	0.07	105	$ 90.05	$ 9,455.25	$ 12,305.25				
27	Exterior Piping, 2 1/2"	2100	LF	$ 3.20	$ 6,720.00	0.08	168	$ 80.88	$ 13,587.84	$ 20,307.84				
28	Exterior Piping, 6"	1080	LF	$ 12.86	$ 13,888.80	0.12	129.6	$ 108.96	$ 14,121.22	$ 28,010.02				
29	Valve Vault, 16'x4'x5'	1	Ea	$ 26,856.00	$ 26,856.00	56	56	$ 150.12	$ 8,406.72	$ 35,262.72				
30	3/4" Valves	75	Ea		$ -		0		$ -	$ -				
31	2 1/2" Valves	10	Ea		$ -		0		$ -	$ -				
32	6" Valves	12	Ea		$ -		0		$ -	$ -				
33	Ground Loop Trenching	260	CY		$ -		0		$ -	$ -				
34	Ground Loop Back-fill	722	ton	$ 20.00	$ 14,440.00	0.16	115.52	$ 71.84	$ 8,298.96	$ 22,738.96				
35	Electrical GSHP wiring & conduit	1	Lot		$ -		0		$ -	$ -				
36	Electrical Control Devices	1	Lot		$ -		0		$ -	$ -				
37	Test & Balance	1	Lot		$ -		0		$ -	$ -				
38	CO 2 DOE Grant Work						12		$ 593.50	$ 593.50				
39	CO 5 Temperature Wells						40		$ 48,293.00	$ 48,293.00				
									Sub-total, Material Cost	$ 120,326.80	$ -	$ -	$ -	$ -
									Sub-total, Labor Hours	717.32	-	-	-	-
									Sub-total Labor Cost	$ 319,071.36	$ -	$ -	$ -	$ -
									Total Cost	$ 439,398.16	$ -	$ -	$ -	$ -

Electrical, Power											WORK COMPLETED		MATERIALS	TOTAL
GENERAL				MATERIAL		LABOR				TOTAL	FROM PREVIOUS APPLICATION	THIS PERIOD	PRESENTLY STORED (NOT IN	COMPLETED AND STORED TO DATE
Item	Description	Quantity	Units	Material Unit	Material Extended	Unit MH	Extended MH	Labor Unit	Labor Extended	Total Item				

Wilders Grove SWS Facility City of Raleigh

GEOTHERMAL ENERGY SYSTEM COST ESTIMATING FORM

PERIOD ENDING:

ESTIMATE #:

				Cost	Cost			Cost	Cost	Cost			D OR E)	
1	Material for geothermal systems	1	lot	$ 15,000.00	$ 15,000.00		0	$ -	$ -	$ 15,000.00				
2	Labor for geothermal systems	603	lot	$ -	$ -	1	603	$ 49.00	$ 29,547.00	$ 29,547.00				
3	CO 2 DOE Grant Work			$ -	$ -		84	$ -	$ 4,229.00	$ 4,229.00				
4				$ -	$ -		0	$ -	$ -	$ -				
5				$ -	$ -		0	$ -	$ -	$ -				
6				$ -	$ -		0	$ -	$ -	$ -				
7				$ -	$ -		0	$ -	$ -	$ -				
8				$ -	$ -		0	$ -	$ -	$ -				
9				$ -	$ -		0	$ -	$ -	$ -				
10				$ -	$ -		0	$ -	$ -	$ -				
11				$ -	$ -		0	$ -	$ -	$ -				
12				$ -	$ -		0	$ -	$ -	$ -				
13				$ -	$ -		0	$ -	$ -	$ -				
14				$ -	$ -		0	$ -	$ -	$ -				
15				$ -	$ -		0	$ -	$ -	$ -				
16				$ -	$ -		0	$ -	$ -	$ -				
17				$ -	$ -		0	$ -	$ -	$ -				
18				$ -	$ -		0	$ -	$ -	$ -				
19				$ -	$ -		0	$ -	$ -	$ -				
									Sub-total, Material Cost	$ 15,000.00	$ -	$ -	$ -	$ -
									Sub-total, Labor Hours	687.00	49.00	-	-	-
									Sub-total Labor Cost	$ 33,776.00	$ -	$ -	$ -	$ -
									Total Cost	$ 48,776.00	$ -	$ -	$ -	$ -

Electrical, Instrumenation & Controls, Geothermal System Monitoring and Building Automation Controls											WORK COMPLETED		MATERIALS	TOTAL
GENERAL				MATERIAL		LABOR				TOTAL	FROM PREVIOUS APPLICATION	THIS PERIOD	PRESENTLY STORED (NOT IN D OR E)	COMPLETED AND STORED TO DATE
Item	Description	Quantity	Units	Material Unit Cost	Material Extended Cost	Unit MH	Extended MH	Labor Unit Cost	Labor Extended Cost	Total Item Cost				
1	Electronic Control Points		Ea		$ -	0	0		$ -	$ -				
2	FCMS control Wiring & conduit	1	Lot	$ 218,656.00	$ 218,656.00	0	0		$ -	$ 218,656.00				
3	Backnet & control devices	1	Lot		$ -	0	0		$ -	$ -				
4	GHSP controllers	1	Lot		$ -	0	0		$ -	$ -				
5	FCMS System Integration & training	1	Lot	$ 7,500.00	$ 7,500.00	0	0		$ -	$ 7,500.00				
6	CO 8 Add Power Monitoring CT's			$ -	$ -		0	$ -	$ 78,279.00	$ 78,279.00		$ 78,279.00		
									Sub-total, Material Cost	$ 226,156.00	$ -	$ -	$ -	$ 78,279.00
									Sub-total, Labor Hours	-	-	78,279.00	-	-
									Sub-total Labor Cost	$ 78,279.00	$ -	$ -	$ 78,279.00	$ -
									Total Cost	$ 304,435.00	$ -	$ -	$ 78,279.00	$ 78,279.00

JACOBS

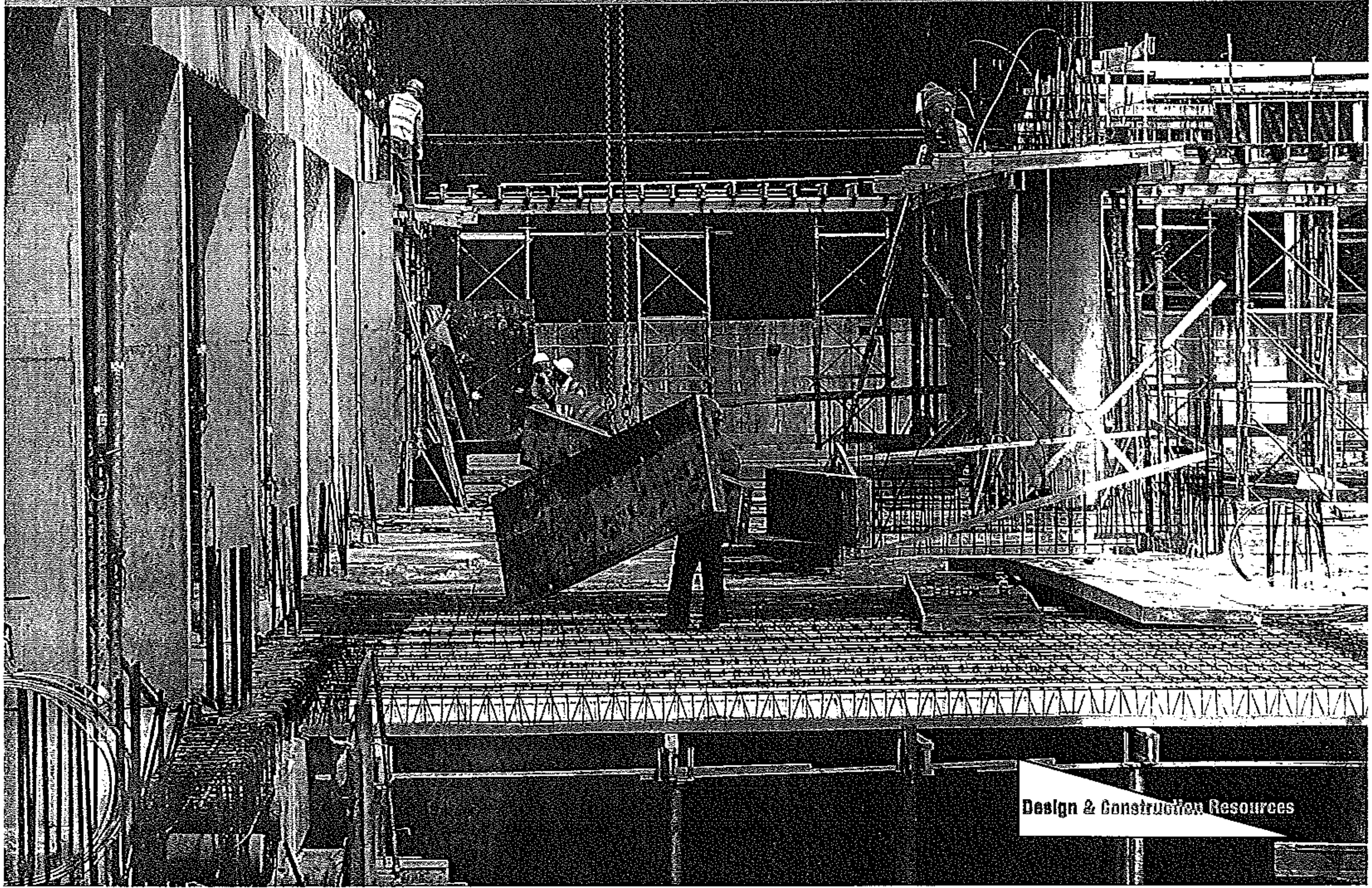
CITY OF RALEIGH
NORTH CAROLINA

APPENDIX K

SAMPLE MEANS 2010 COST DATA

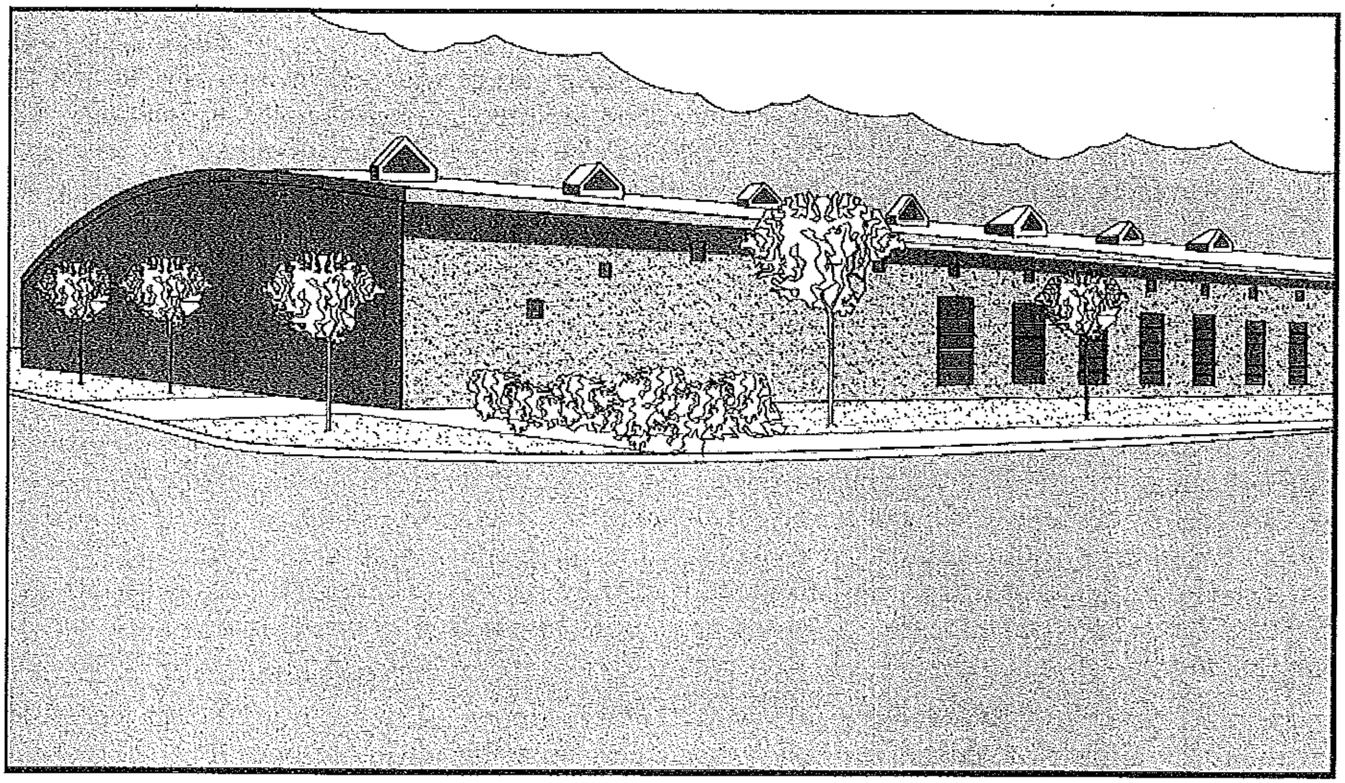
McGraw Hill
CONSTRUCTION

ARCHITECT'S SQUARE FOOT COSTBOOK 2010



Design & Construction Resources

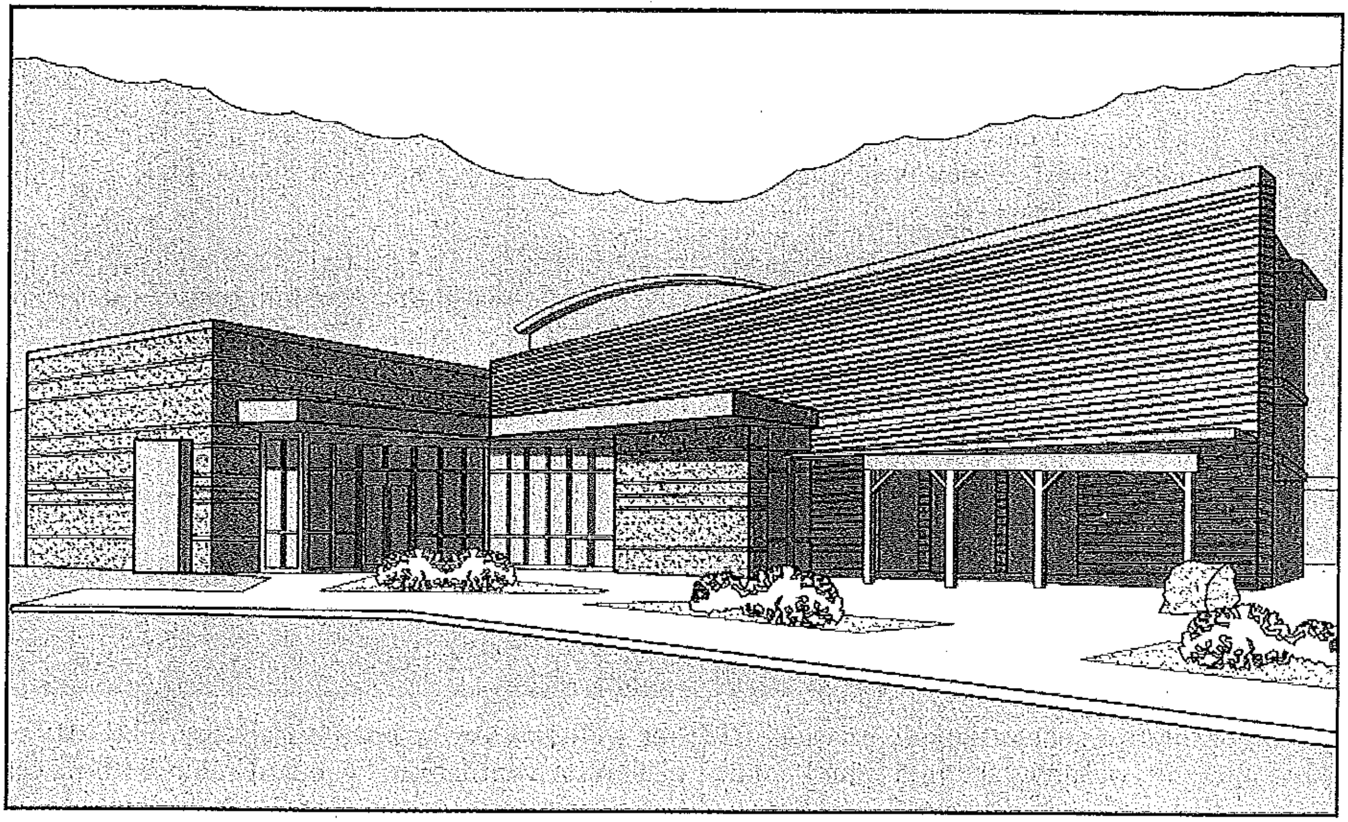
WATER & POWER SERVICE CENTER



Code	Division Name	%	Sq. Ft. Cost	Projected
01	General Requirements	16.87	56.00	1,237,573
03	Concrete	6.77	22.47	496,639
04	Masonry	0.30	1.01	22,218
05	Metals	10.42	34.60	764,563
06	Wood, Plastics, and Composites	0.69	2.31	50,971
07	Thermal and Moisture Protection	14.08	46.72	1,032,487
08	Openings	5.17	17.15	379,014
09	Finishes	14.42	47.84	1,057,319
10	Specialties	1.32	4.38	96,714
11	Equipment	0.57	1.89	41,822
12	Furnishings	0.05	0.18	3,921
22	Plumbing	3.06	10.17	224,795
23	HVAC	10.09	33.47	739,731
26	Electrical	16.18	53.70	1,186,707
	Total Building Costs	100.00	331.88	7,334,473

COST PER SQUARE FOOT = $331.88

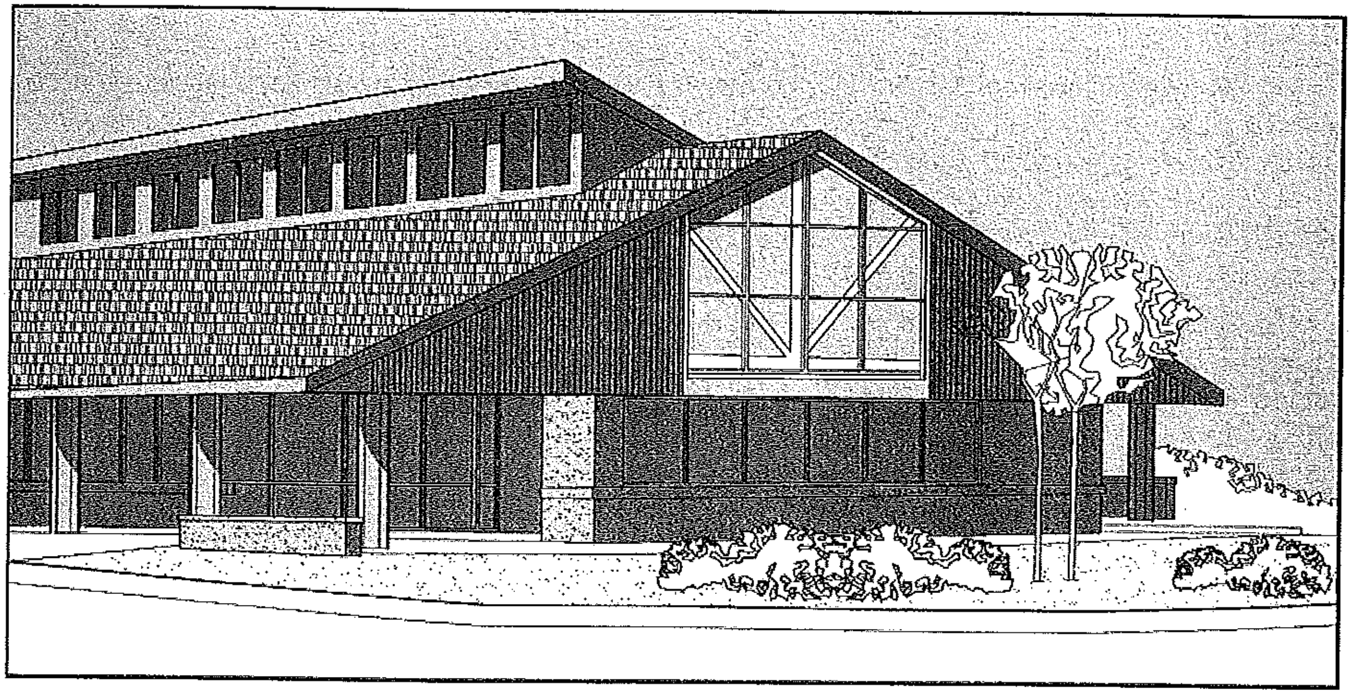
PUBLIC LIBRARY



Code	Division Name	%	Sq. Ft. Cost	Projected
01	General Requirements	15.81	37.22	744,348
03	Concrete	5.35	12.59	251,898
04	Masonry	6.63	15.60	311,914
05	Metals	10.41	24.50	489,931
06	Wood & Plastics	3.41	8.02	160,409
07	Thermal & Moisture Protection	9.31	21.92	438,337
08	Doors & Windows	5.24	12.33	246,504
09	Finishes	10.22	24.06	481,294
10	Specialties	4.42	10.39	207,868
11	Equipment	0.14	0.32	6,424
15	Mechanical	17.31	40.75	815,012
16	Electrical	11.76	27.69	553,701
	Total Building Costs	100.00	235.38	4,707,640

COST PER SQUARE FOOT = $235.38

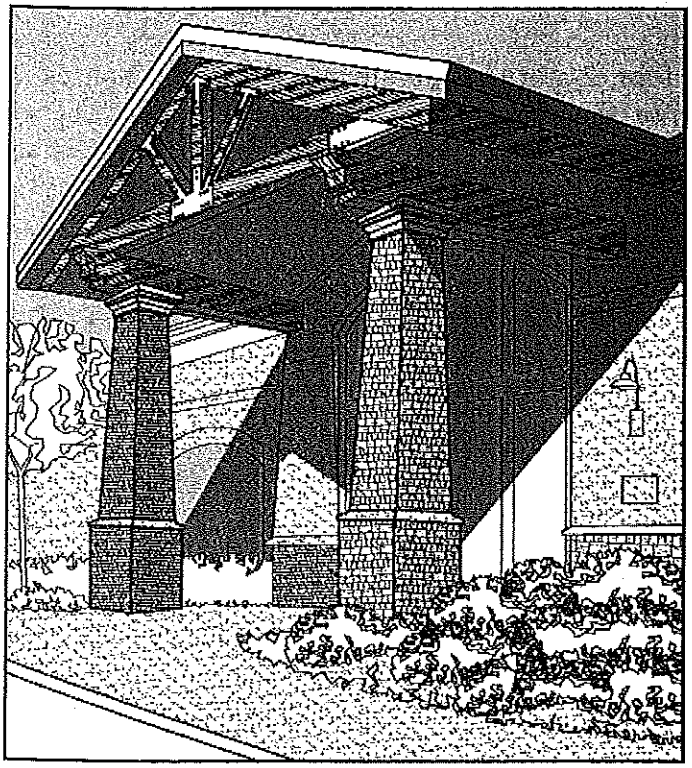
DEPARTMENT OF MOTOR VEHICLES FACILITY



Code	Division Name	%	Sq. Ft. Cost	Projected
01	General Requirements	11.69	32.79	1,291,945
03	Concrete	11.37	31.92	1,257,398
04	Masonry	3.96	11.11	437,678
05	Metals	13.77	38.63	1,521,859
06	Wood & Plastics	2.01	5.65	222,548
07	Thermal & Moisture Protection	8.60	24.14	951,086
08	Doors & Windows	3.49	9.79	385,565
09	Finishes	11.46	32.14	1,266,300
10	Specialties	1.63	4.58	180,259
11	Equipment	1.42	3.99	157,344
12	Furnishings	2.20	6.16	242,808
13	Special Construction	1.33	3.73	146,882
14	Conveying Systems	3.17	8.88	349,877
15	Mechanical	12.94	36.32	1,430,800
16	Electrical	10.96	30.76	1,211,961
	Total Building Costs	100.00	280.60	11,054,310

COST PER SQUARE FOOT = $280.60

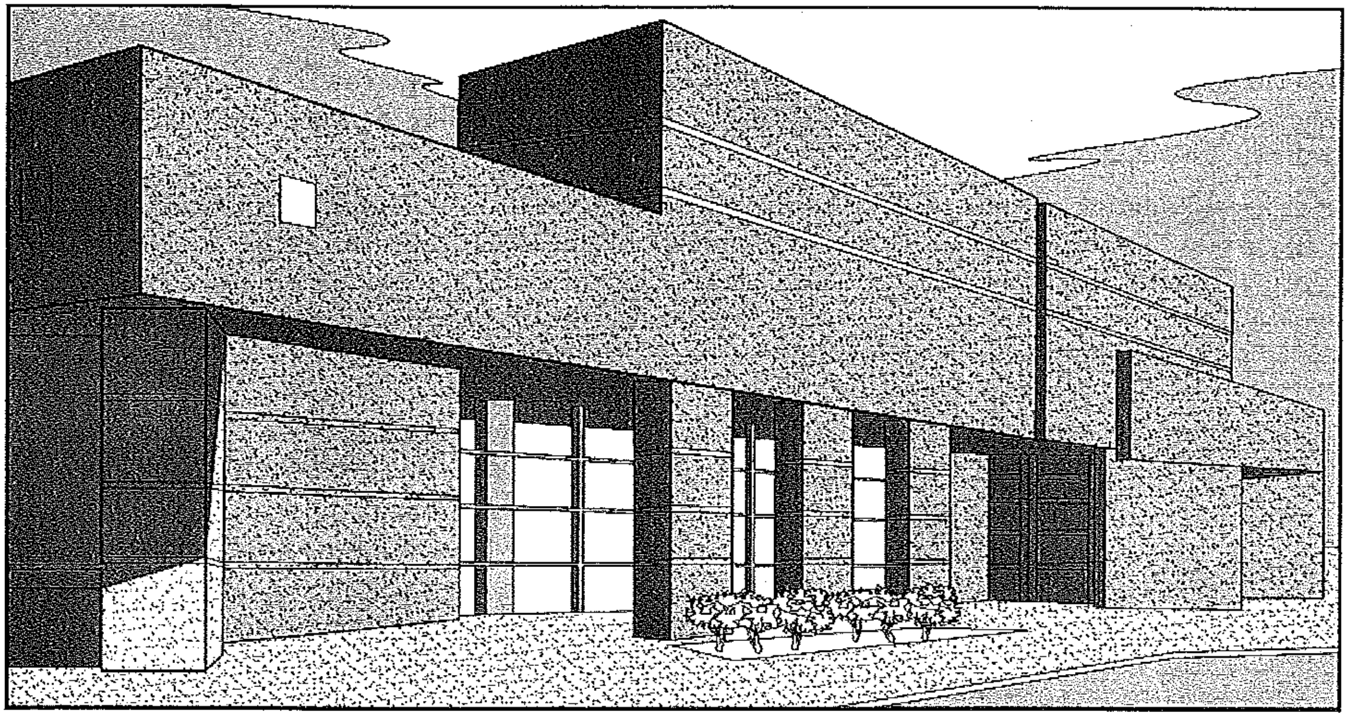
OFFICE BUILDING



Code	Division Name	%	Sq. Ft. Cost	Projected
00	Procurement and Contracting Require	0.51	1.65	32,554
01	General Requirements	10.76	34.69	682,523
03	Concrete	3.05	9.84	193,610
04	Masonry	15.23	49.10	965,982
05	Metals	5.76	18.56	365,161
06	Wood, Plastics, and Composites	8.39	27.05	532,136
07	Thermal and Moisture Protection	7.44	23.99	471,980
08	Openings	8.11	26.15	514,532
09	Finishes	17.83	57.49	1,131,143
10	Specialties	1.36	4.37	86,005
21	Fire Suppression	2.42	7.82	153,814
22	Plumbing	2.93	9.45	185,963
23	HVAC	7.28	23.47	461,761
26	Electrical	8.66	27.91	549,196
27	Communications	0.27	0.88	17,380
	Total Building Costs	100.00	322.43	6,343,738

COST PER SQUARE FOOT = $322.43

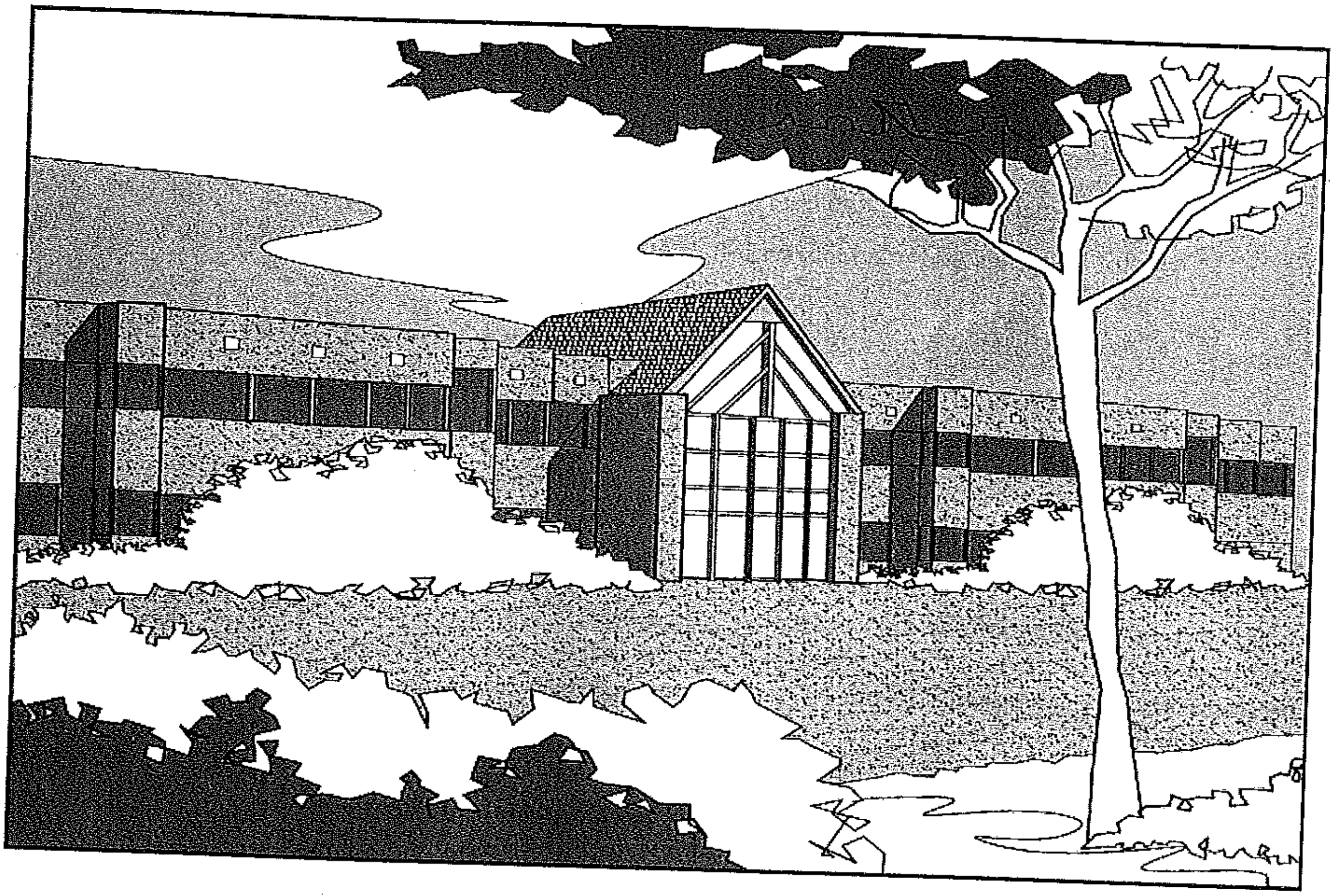
GOVERNMENT OFFICE BUILDING



Code	Division Name	%	Sq. Ft. Cost	Projected
01	General Requirements	3.96	7.97	596,182
03	Concrete	4.70	9.44	706,551
04	Masonry	6.09	12.25	916,661
05	Metals	11.86	23.83	1,783,757
06	Wood & Plastics	2.46	4.95	370,384
07	Thermal & Moisture Protection	7.85	15.77	1,180,088
08	Doors & Windows	5.53	11.12	831,992
09	Finishes	11.63	23.37	1,749,133
10	Specialties	0.92	1.84	137,647
11	Equipment	0.15	0.30	22,518
Ⓧ 15	Mechanical	29.09	58.46	4,375,800
16	Electrical	15.75	31.65	2,369,243
	Total Building Costs	100.00	200.93	15,039,955

COST PER SQUARE FOOT = $200.93

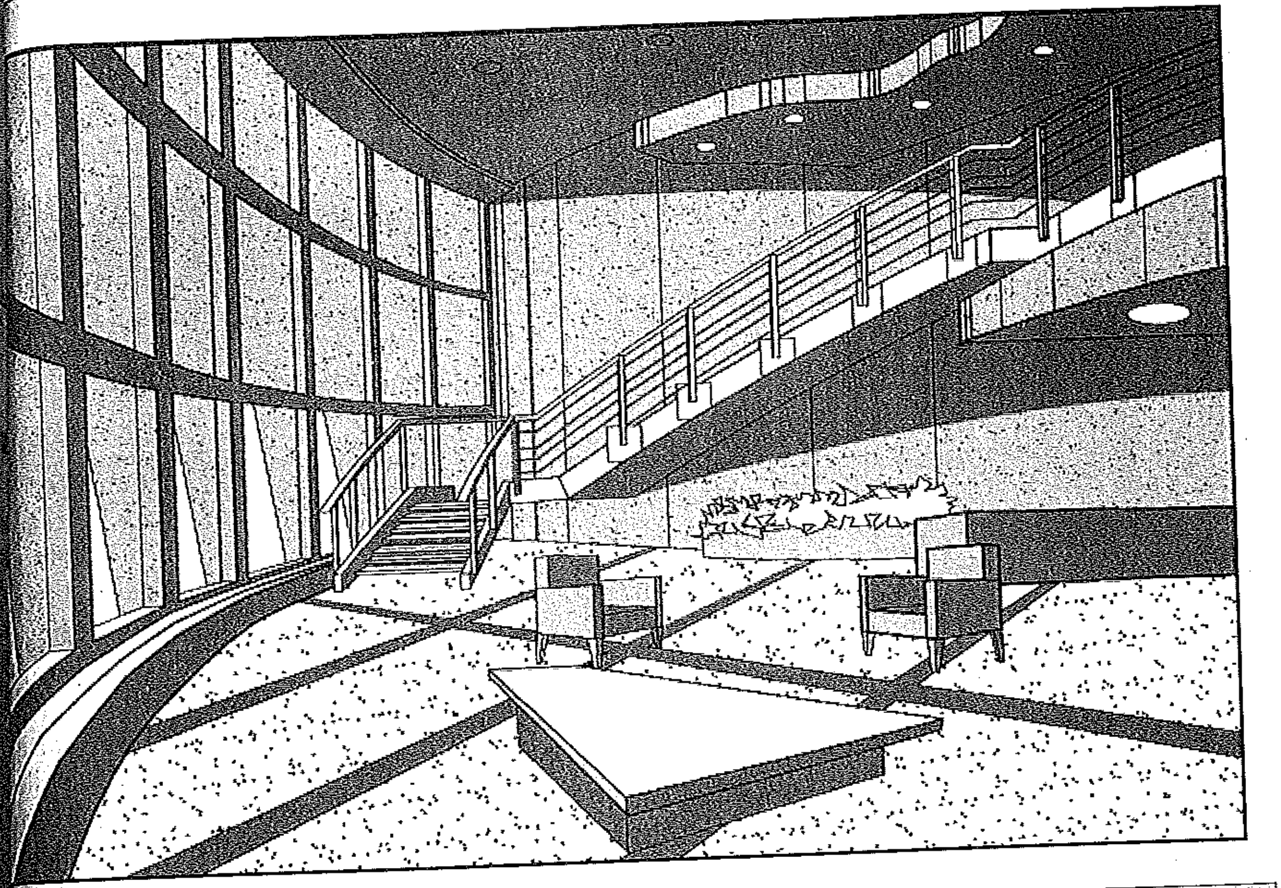
OFFICE BUILDING



Code	Division Name	%	Sq. Ft. Cost	Projected
00	Bidding Requirements	0.68	0.89	18,761
01	General Requirements	0.68	0.89	18,761
03	Concrete	10.17	13.40	281,420
04	Masonry	10.17	13.40	281,420
05	Metals	14.24	18.76	393,988
06	Wood & Plastics	17.63	23.23	487,795
07	Thermal & Moisture Protection	5.09	6.70	140,710
08	Doors & Windows	14.24	18.76	393,988
09	Finishes	1.70	2.23	46,903
10	Specialties	0.81	1.07	22,514
12	Furnishings	0.17	0.22	4,690
14	Conveying Systems	2.37	3.13	65,665
* 15	Mechanical	15.94	20.99	440,891
16	Electrical	6.10	8.04	168,852
	Total Building Costs	100.00	131.73	2,766,359

COST PER SQUARE FOOT = $131.73

For a more in-depth report on this building or additional case studies contact DC&D @ 800-533-5680, or www. DCD. com

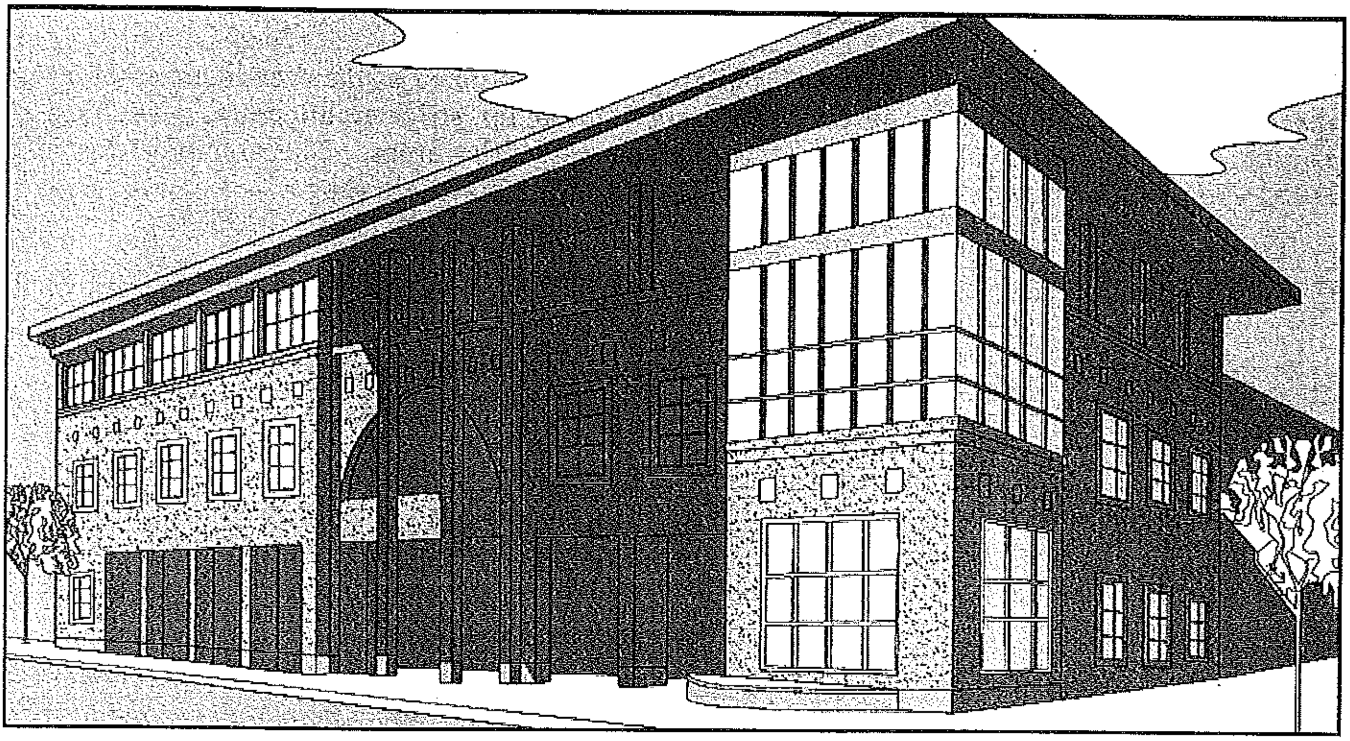


de	Division Name	%	Sq. Ft. Cost	Projected
0	Bidding Requirements	0.80	2.03	81,301
01	General Requirements	8.99	22.73	908,537
03	Concrete	5.23	13.22	528,455
04	Masonry	9.25	23.39	934,959
05	Metals	8.51	21.51	859,756
06	Wood & Plastics	5.63	14.24	569,106
07	Thermal & Moisture Protection	7.44	18.81	752,033
08	Doors & Windows	6.07	15.36	613,821
09	Finishes	11.12	28.12	1,123,984
10	Specialties	3.06	7.73	308,943
11	Equipment	0.12	0.31	12,195
2	Furnishings	8.75	22.12	884,146
14	Conveying Systems	0.80	2.03	81,301
1	Mechanical	15.68	39.66	1,585,366
16	Electrical	8.55	21.61	863,821
	Total Building Costs	100.00	252.85	10,107,724

COST PER SQUARE FOOT = $252.85

For a more in-depth report on this building or additional case studies contact DC&D
@ 800-533-5680, or www. DCD. com

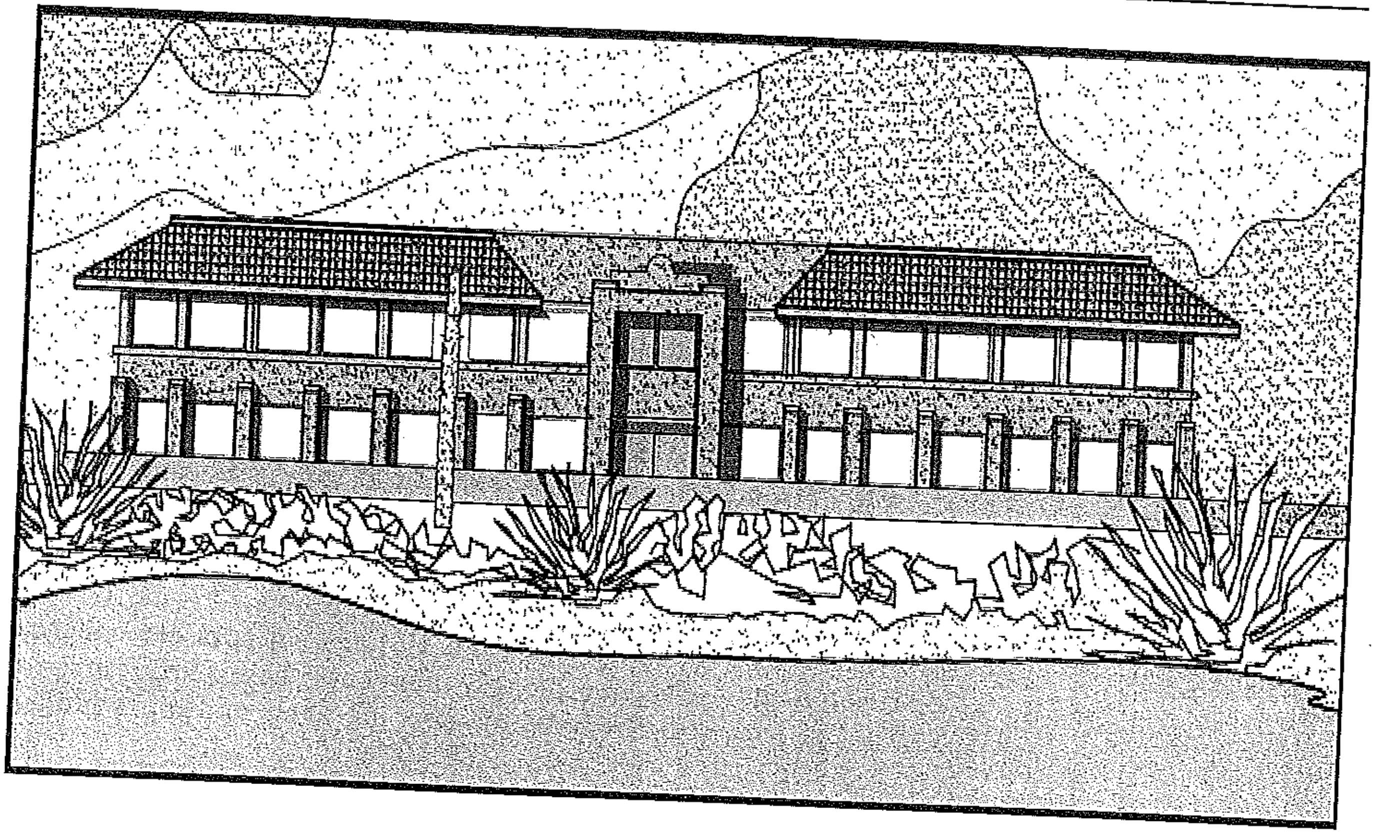
LAW OFFICE BUILDING



Code	Division Name	%	Sq. Ft. Cost	Projected
00	Bidding Requirements	0.27	0.47	17,750
01	General Requirements	16.97	29.28	1,103,934
03	Concrete	6.03	10.41	392,374
04	Masonry	9.26	15.99	602,731
05	Metals	7.06	12.19	459,537
06	Wood & Plastics	7.76	13.39	504,832
07	Thermal & Moisture Protection	4.19	7.23	272,589
08	Doors & Windows	5.17	8.92	336,467
09	Finishes	16.58	28.61	1,078,766
10	Specialties	0.39	0.68	25,653
11	Equipment	0.24	0.41	15,332
12	Furnishings	0.01	0.02	822
14	Conveying Systems	1.43	2.47	93,101
⊛ 15	Mechanical	16.57	28.59	1,077,835
16	Electrical	8.06	13.91	524,602
	Total Building Costs	100.00	172.55	6,506,325

COST PER SQUARE FOOT = $172.55

OFFICE BUILDING - SHELL

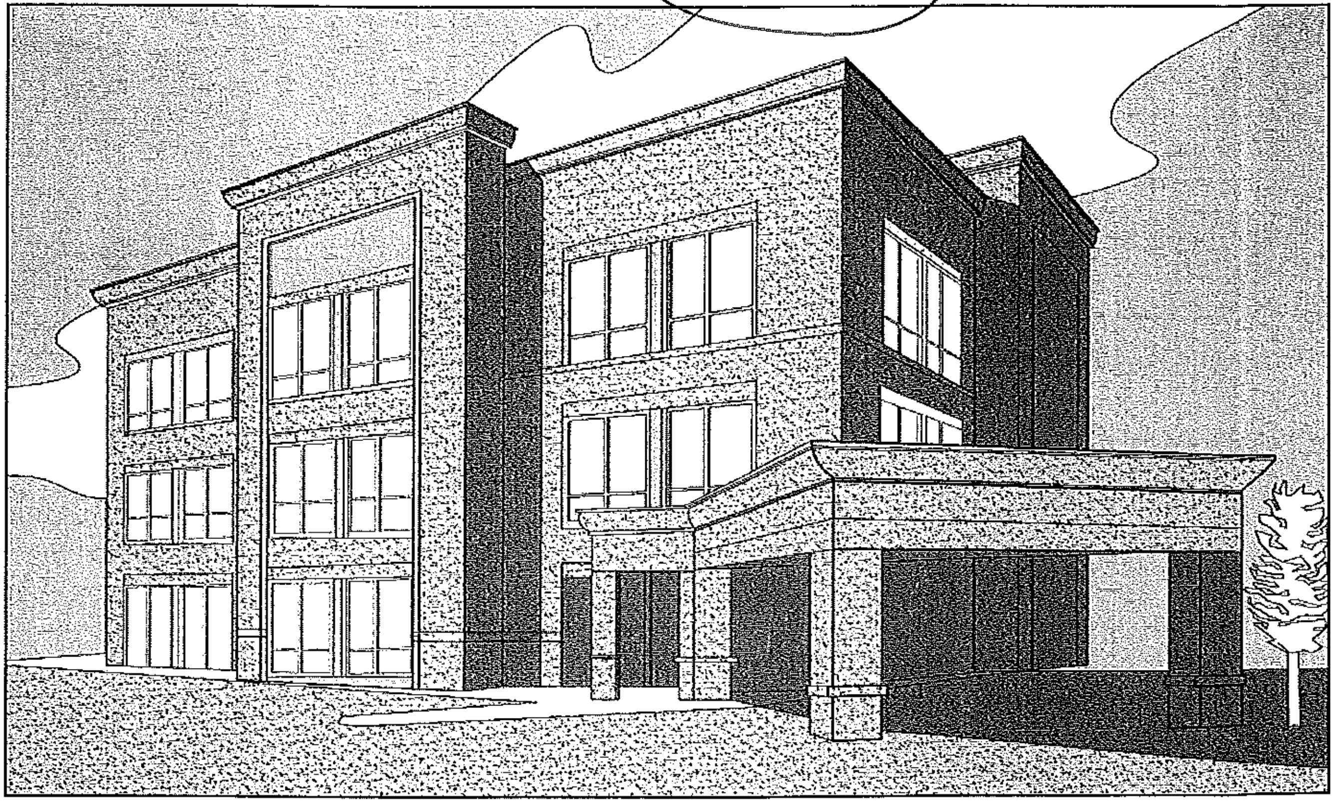


Code	Division Name	%	Sq. Ft. Cost	Projected
00	Bidding Requirements	10.36	13.08	546,099
03	Concrete	10.22	12.91	538,923
04	Masonry	1.23	1.55	64,696
05	Metals	24.42	30.84	1,287,507
06	Wood & Plastics	0.57	0.72	30,264
07	Thermal & Moisture Protection	4.09	5.17	215,716
08	Doors & Windows	7.46	9.42	393,463
09	Finishes	13.42	16.95	707,555
10	Specialties	1.02	1.29	53,982
14	Conveying Systems	1.45	1.83	76,604
15	Mechanical	14.00	17.68	737,961
16	Electrical	11.75	14.84	619,565
	Total Building Costs	100.00	126.28	5,272,335

COST PER SQUARE FOOT = $126.28

For a more in-depth report on this building or additional case studies contact DC&D @ 800-533-5680, or www. DCD. com

OFFICE BUILDING (SHELL ONLY)



Code	Division Name	%	Sq. Ft. Cost	Projected
00	Procurement and Contracting Require	1.98	3.11	74,134
01	General Requirements	21.40	33.58	799,421
03	Concrete	9.00	14.12	336,092
04	Masonry	10.32	16.20	385,721
05	Metals	18.43	28.92	688,631
06	Wood, Plastics, and Composites	0.41	0.64	15,161
07	Thermal and Moisture Protection	4.28	6.71	159,863
08	Openings	4.57	7.18	170,838
09	Finishes	6.78	10.64	253,409
10	Specialties	0.02	0.02	568
12	Furnishings	0.15	0.23	5,585
14	Conveying Systems	4.18	6.55	156,052
21	Fire Suppression	0.89	1.40	33,254
22	Plumbing	2.46	3.87	92,077
23	HVAC	7.04	11.05	263,049
26	Electrical	8.08	12.68	301,957
	Total Building Costs	100.00	156.91	3,735,810

Shell

COST PER SQUARE FOOT = $156.91

For a more in-depth report on this building or additional case studies contact DC&D @ 800-533-5680, or www. DCD. com

CITY OF RALEIGH NORTH CAROLINA

APPENDIX L

CONSTRUCTION PHASE DURATIONS FOR WELL FIELD CONSTRUCTION

Geothermal Well Installation Duration Summary

By: George Douglas

Wilders Grove SWS Facility

	Durations (In Minutes)									
Well Number	**Well Mob & Set Up**	**Casing Install**	**Well Drilling**	**Casing Removal**	**Loop Install**	**Loop Post Test**	**Grout Install**	**2nd Grout**	**Grout Complete**	**Totals**
A1										0
A2									12	12
A3	18	11							12	41
A4						60.00	25	46		131
A5	7	15				60.00	15			97
A6					5		15			20
A7		110.00		8	10	60.00				188
A8				25	28				12	65
A9						62.00	45			107
A10									12	12
B1		10		7	22	60.00	23			122
B2									10	10
B3					14					14
B4		13				60.00			12	85
B5									12	12
B6	8	14					11			33
B7				17	10	60.00				87
B8				65.00	5	60.00	21			151
B9	10	15				60.00	25	17	15	142
B10				9		60.00			12	81
C1								15	60.00	75
C2									12	12
C3						60.00	12	12		84
C4					23	60.00			12	95
C5		32								32
C6										0
C7				10	5					15
C8	15	12	305.00	9		60.00				401
C9	5					60.00				65
C10	15	15			6			12		48

D1					19					19		
D2								12		12		
D3	34	17						12		63		
D4								12		12		
D5	5	15								20		
D6	15	14		7	9					45		
D7								10		10		
D8	15	7	315.00	20	18					375		
D9	19	10	265.00	15	15	72.00	18	10		424		
D10		16	270.00	19					12	317		
E1						60.00	15			75		
E2										0		
E3								15	31	46		
E4	15	20		49						84		
E5		15								15		
E6						60	11			71		
E7	40	20	308.00	11	13	60.00				452		
E8	18	25	398.00	13	5					459		
E9	12	40			16					68		
E10								12		12		
F1										0		
F2	17	72					18	27		134		
F3	22			0:00			15	11		113		
F4			280.00				36	31		347		
F5						60.00				60		
F6							55			55		
F7	55	17	300.00	20		60.00				452		
F8	18	20						12		50		
F9								12		12		
F10										0		
B-10 sister						60.00		12		72		
F-8 sister								12		12		
Sister #										0		
TOTALS - MINUTES	18.2	23.1	305.1	21.7	13.1	60.7	22.5	15.9	16.9	97.2		
TOTALS - HOURS	0.30	0.39	5.09	0.36	0.22	1.01	0.38	0.26	0.28	**8.29**	**say 8 1/2 hours**	
		Summary: Ave Duration for Completion of Well is 8 1/2 hours										
			Individual durations for tasks are summarized above									

JACOBS

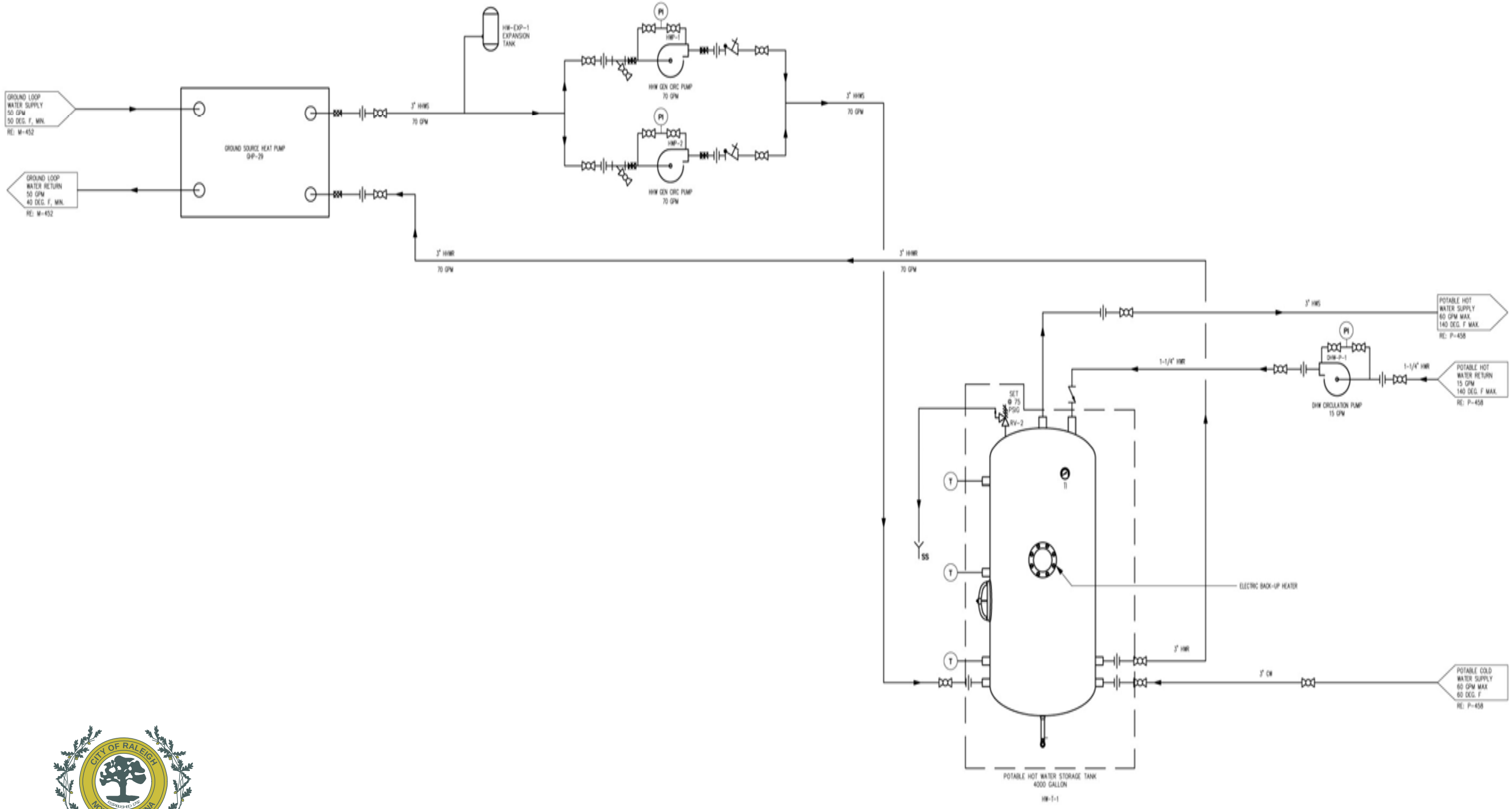
CITY OF RALEIGH
NORTH CAROLINA

APPENDIX M

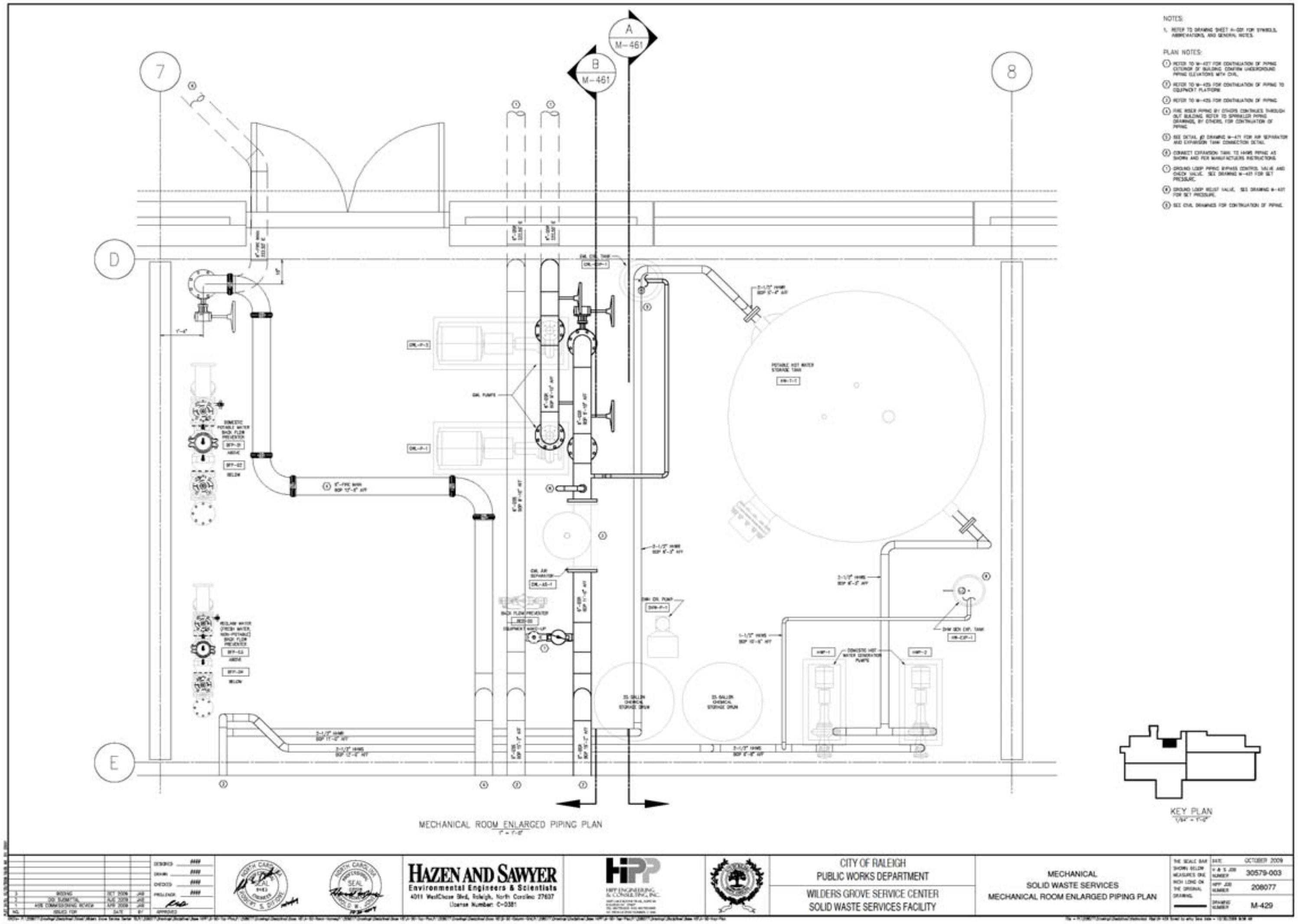
SAMPLE WELL FIELD PHOTOS, SCHEMATIC PLANS FOR GEOTHERMAL SYSTEM, PERISCOPE BUILDING AUTOMATION SYSTEM & SAMPLE HVAC GRAPHICS

Hot Water Generation System Schematic

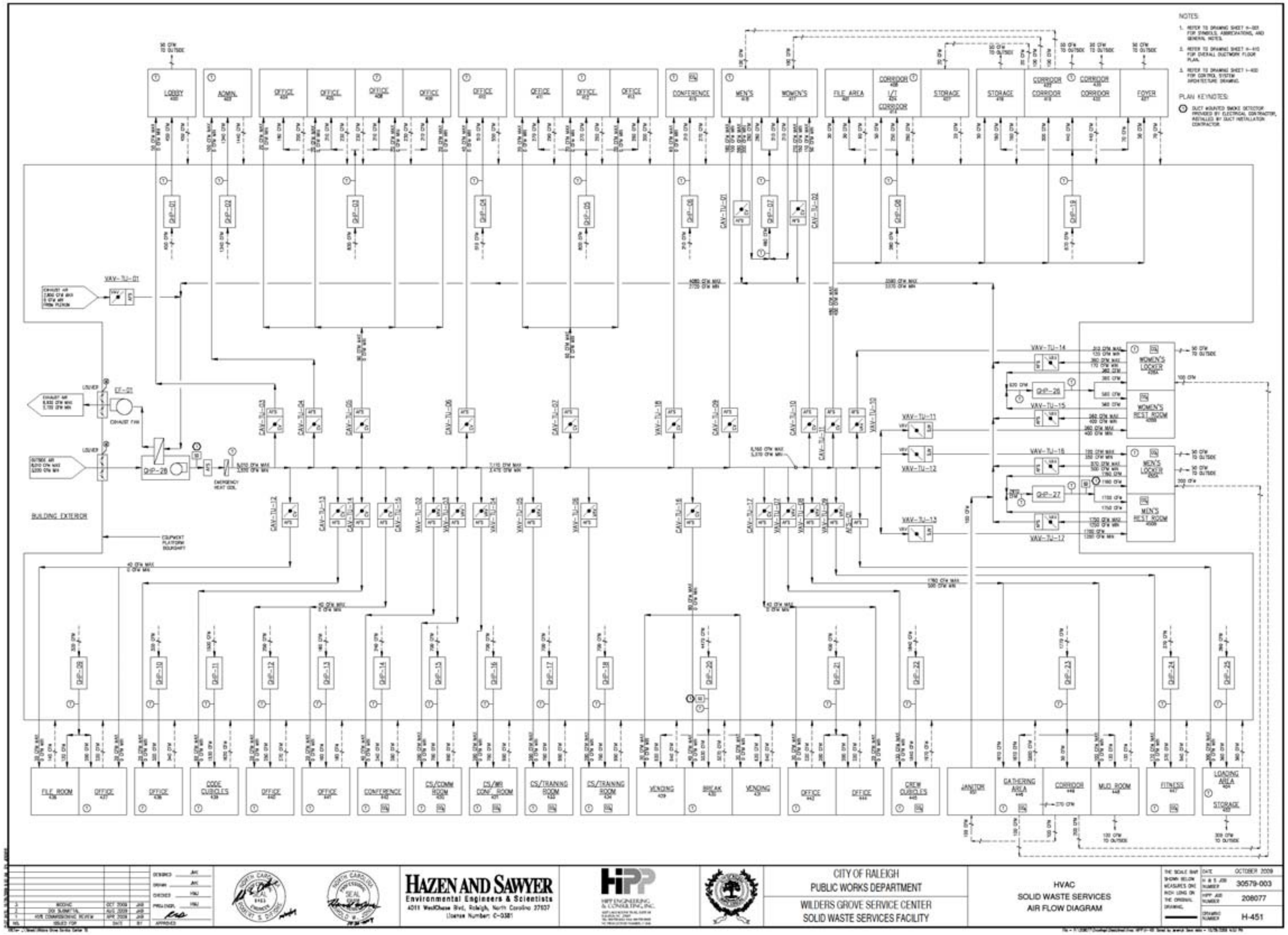
Heat Harvester and Hot Water Generation System



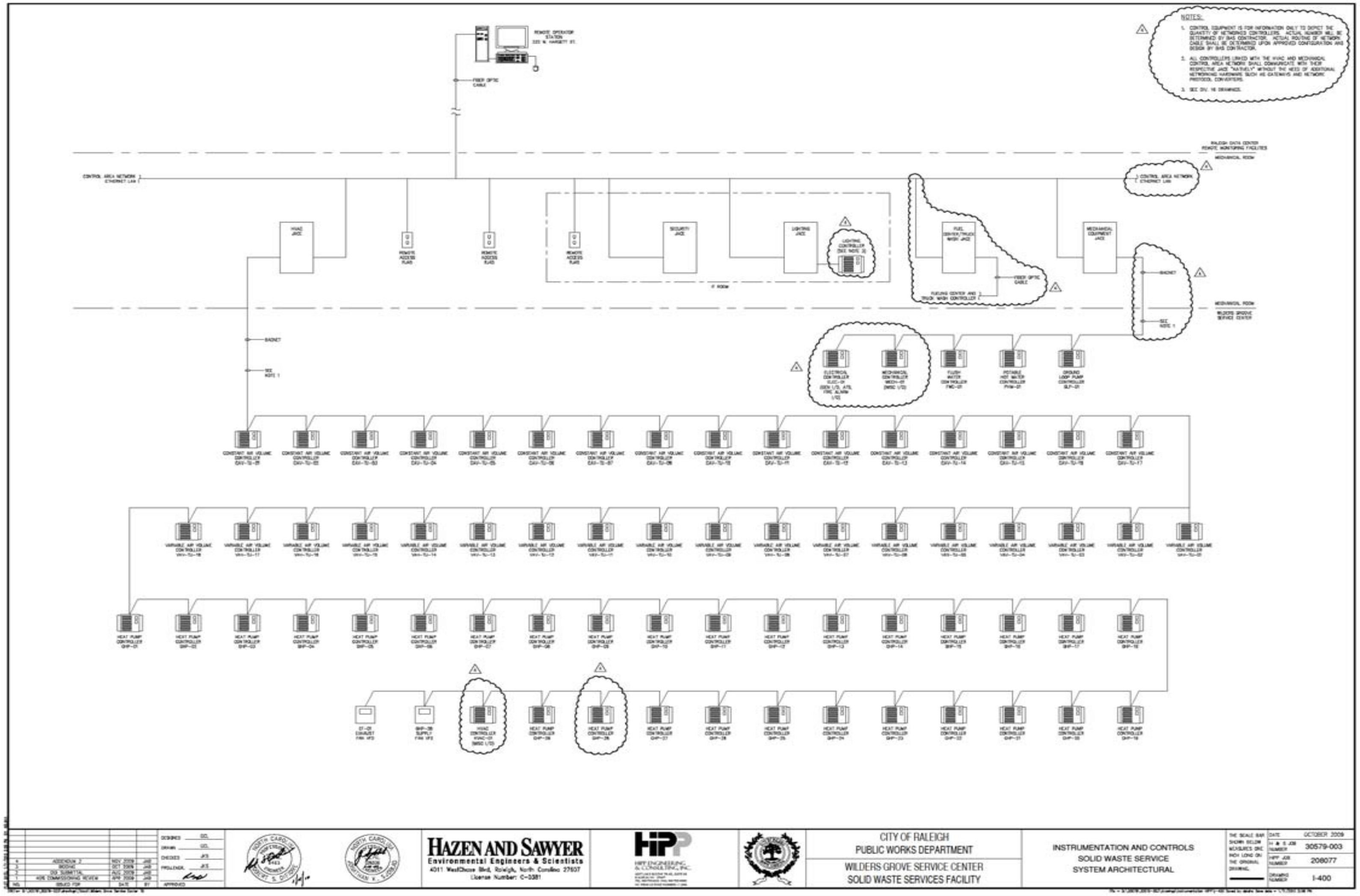
Domestic Hot Water Storage System Schematic



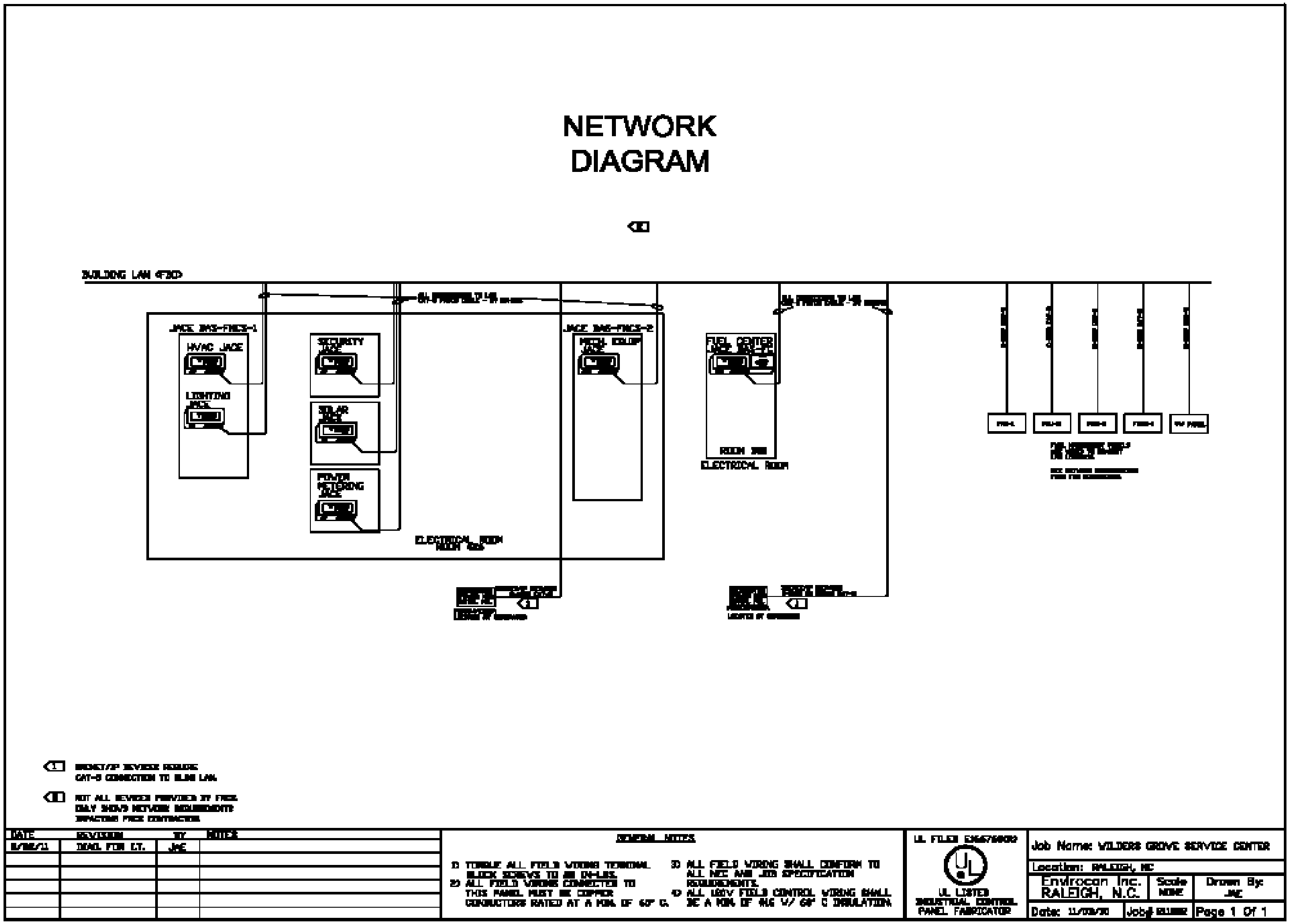
Schematic-Ground Source Heat Pump System For Heating and Cooling of Dedicated Outdoor Air



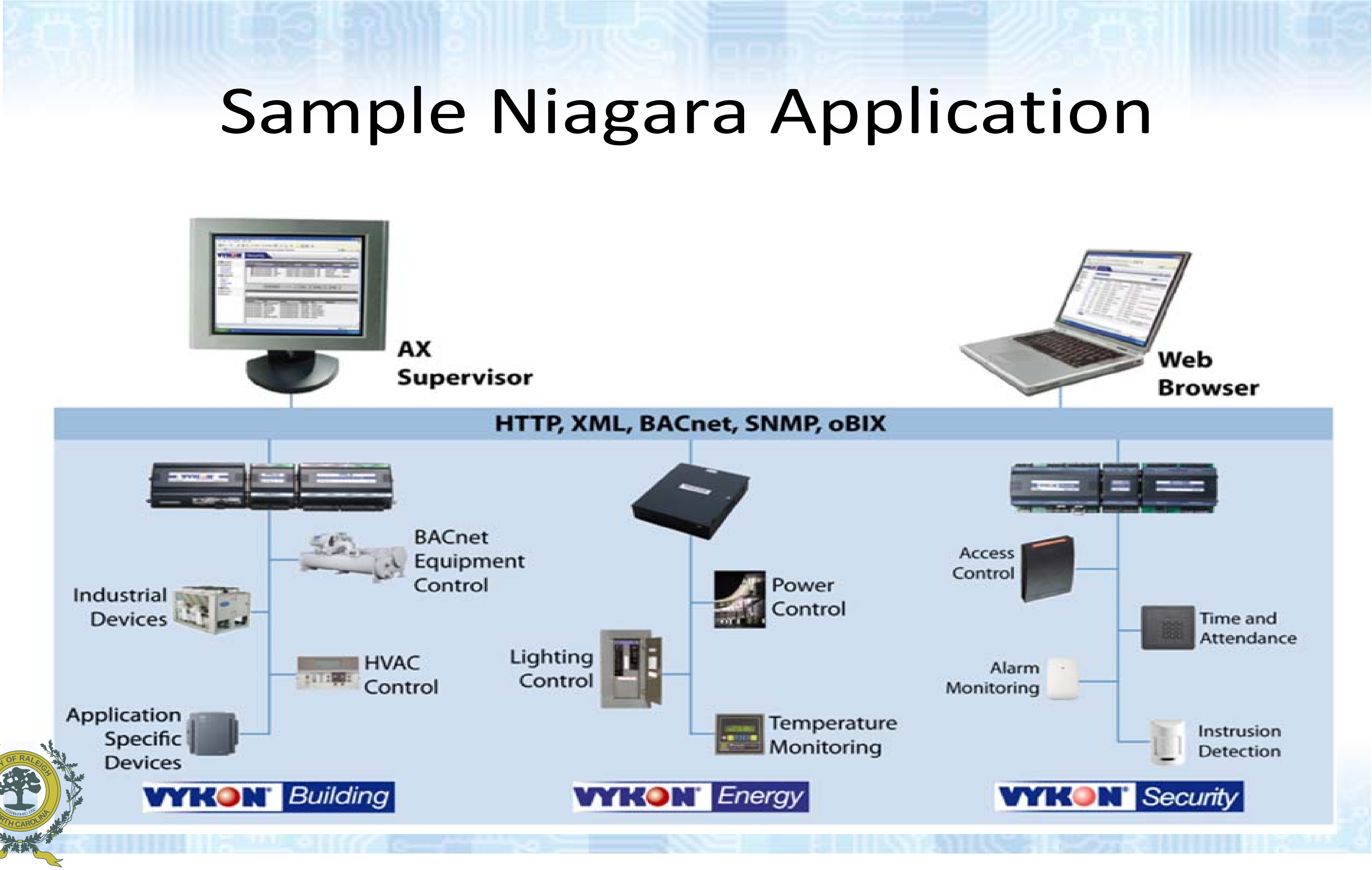
Schematic –Facility Monitoring and Control System



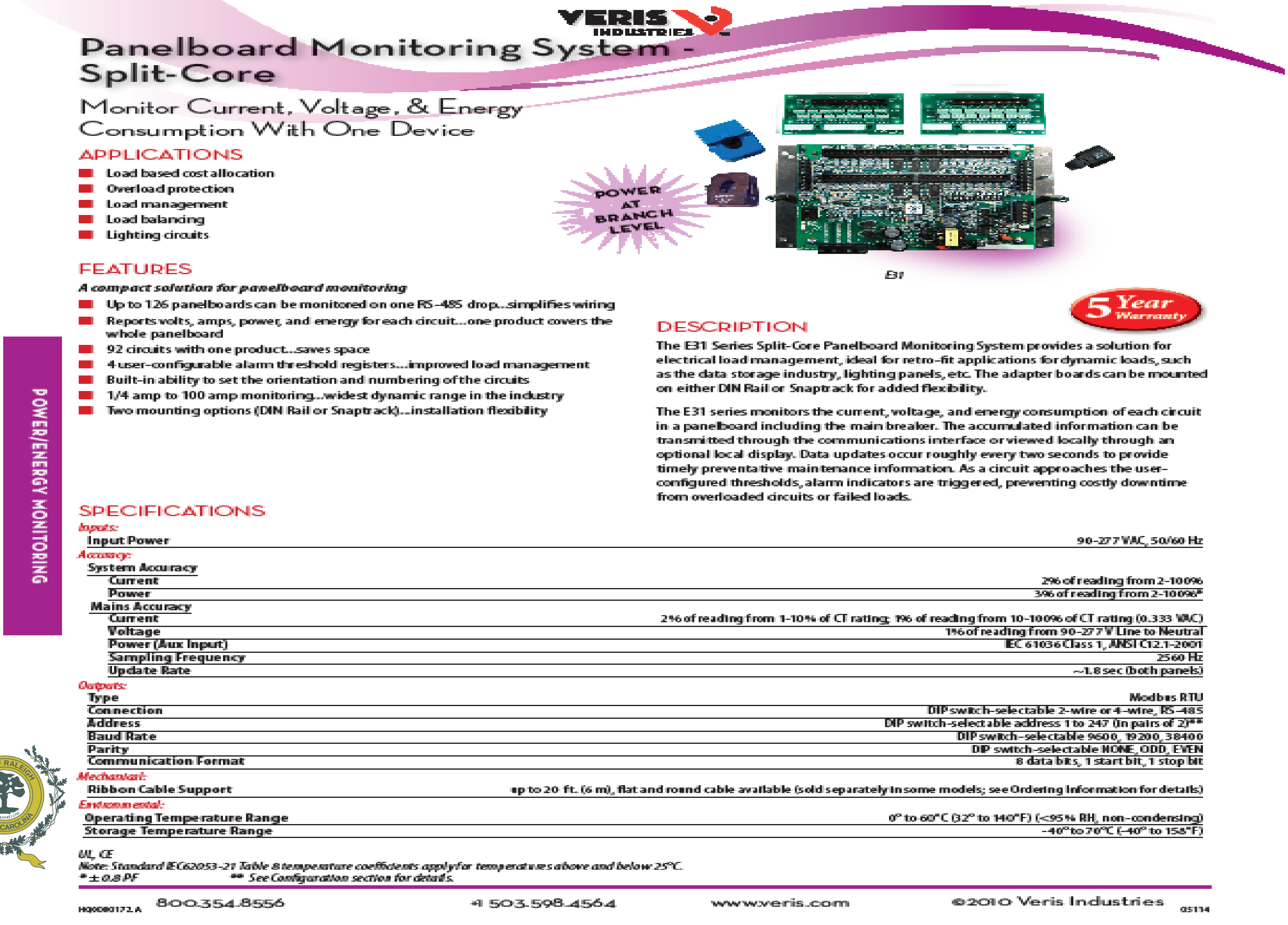
Schematic –Network Control System



Facility Management Monitoring and Control System



Facility Energy and Power Monitoring Control System



VERIS INDUSTRIES

Panelboard Monitoring System - Split-Core

Monitor Current, Voltage, & Energy Consumption With One Device

APPLICATIONS

- Load based cost allocation
- Overload protection
- Load management
- Load balancing
- Lighting circuits

FEATURES

A compact solution for panelboard monitoring

- Up to 126 panelboards can be monitored on one RS-485 drop...simplifies wiring
- Reports volts, amps, power, and energy for each circuit...one product covers the whole panelboard
- 92 circuits with one product...saves space
- 4 user-configurable alarm threshold registers...improved load management
- Built-in ability to set the orientation and numbering of the circuits
- 1/4 amp to 100 amp monitoring...widest dynamic range in the industry
- Two mounting options (DIN Rail or Snaptrack)...installation flexibility

DESCRIPTION

The E31 Series Split-Core Panelboard Monitoring System provides a solution for electrical load management, ideal for retro-fit applications for dynamic loads, such as the data storage industry, lighting panels, etc. The adapter boards can be mounted on either DIN Rail or Snaptrack for added flexibility.

The E31 series monitors the current, voltage, and energy consumption of each circuit in a panelboard including the main breaker. The accumulated information can be transmitted through the communications interface or viewed locally through an optional local display. Data updates occur roughly every two seconds to provide timely preventative maintenance information. As a circuit approaches the user-configured thresholds, alarm indicators are triggered, preventing costly downtime from overloaded circuits or failed loads.

SPECIFICATIONS

Inputs:	
Input Power	90-277 VAC, 50/60 Hz
Accuracy:	
System Accuracy	
Current	2% of reading from 2-100%
Power	3% of reading from 2-100%*
Mains Accuracy	
Current	2% of reading from 1-10% of CT rating; 1% of reading from 10-100% of CT rating (0.333 VAC)
Voltage	1% of reading from 90-277 V Line to Neutral
Power (Aux Input)	IEC 61036 Class 1, ANSI C12.1-2001
Sampling Frequency	2560 Hz
Update Rate	~1.8 sec (both panels)
Outputs:	
Type	Modbus RTU
Connection	DIP switch-selectable 2-wire or 4-wire, RS-485
Address	DIP switch-selectable address 1 to 247 (in pairs of 2)**
Baud Rate	DIP switch-selectable 9600, 19200, 38400
Parity	DIP switch-selectable NONE, ODD, EVEN
Communication Format	8 data bits, 1 start bit, 1 stop bit
Mechanical:	
Ribbon Cable Support	up to 20 ft. (6 m), flat and round cable available (sold separately in some models; see Ordering Information for details)
Environmental:	
Operating Temperature Range	0° to 60°C (32° to 140°F) (<95% RH, non-condensing)
Storage Temperature Range	-40° to 70°C (-40° to 158°F)

UL, CE

Note: Standard IEC62053-21 Table 8 temperature coefficients apply for temperatures above and below 25°C.

** ± 0.8 PF* *** See Configuration section for details.*

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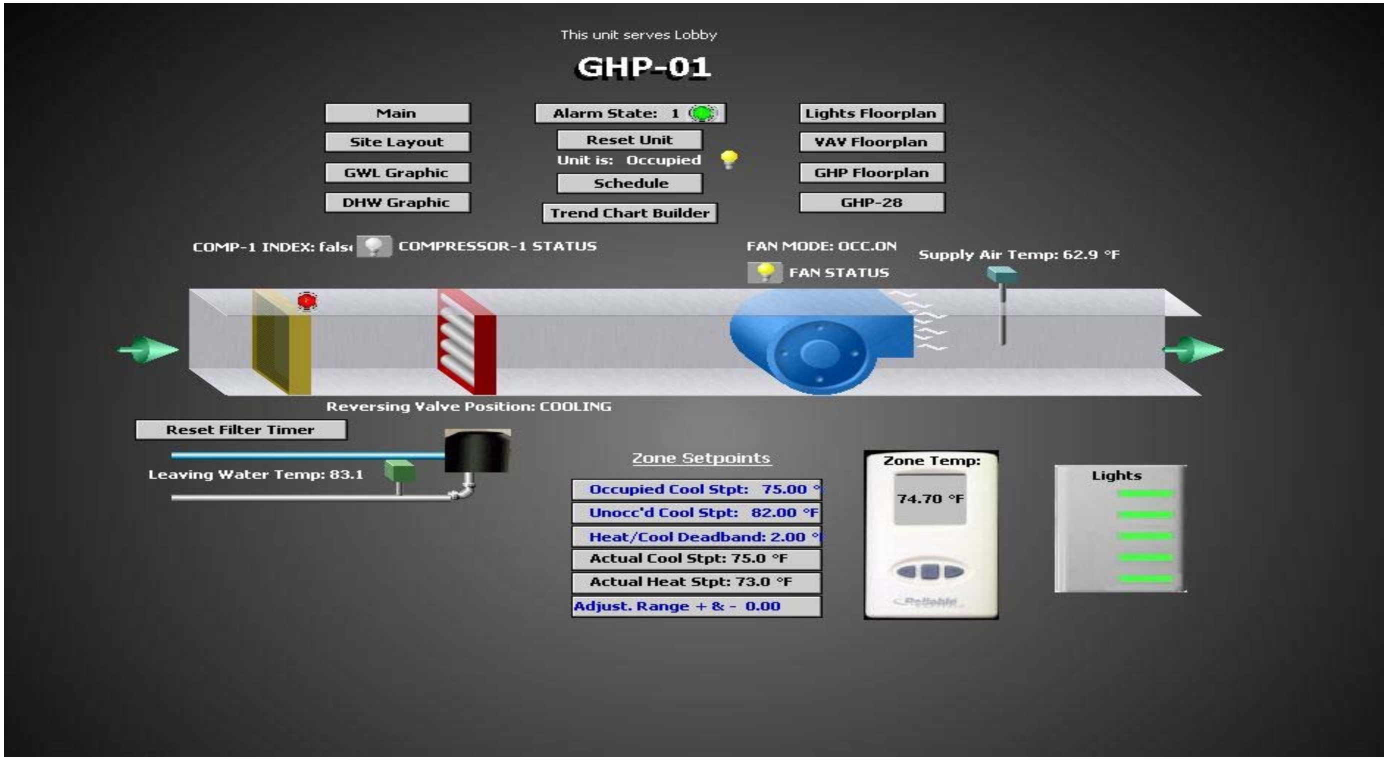
Ground Source Heat Pump System Current and On Going Monitoring

Wilders Grove Solid Waste Service Center

Sample - Mechanical System Monitoring and Controls



This unit serves Lobby

GHP-01

Alarm State: 1

Unit is: Occupied

COMP-1 INDEX: fals

FAN MODE: OCC.ON

Supply Air Temp: 62.9 °F

Reversing Valve Position: COOLING

Leaving Water Temp: 83.1

Occupied Cool Stpt: 75.00 °

Unocc'd Cool Stpt: 82.00 °F

Heat/Cool Deadband: 2.00 °

Actual Cool Stpt: 75.0 °F

Actual Heat Stpt: 73.0 °F

Adjust. Range + & - 0.00

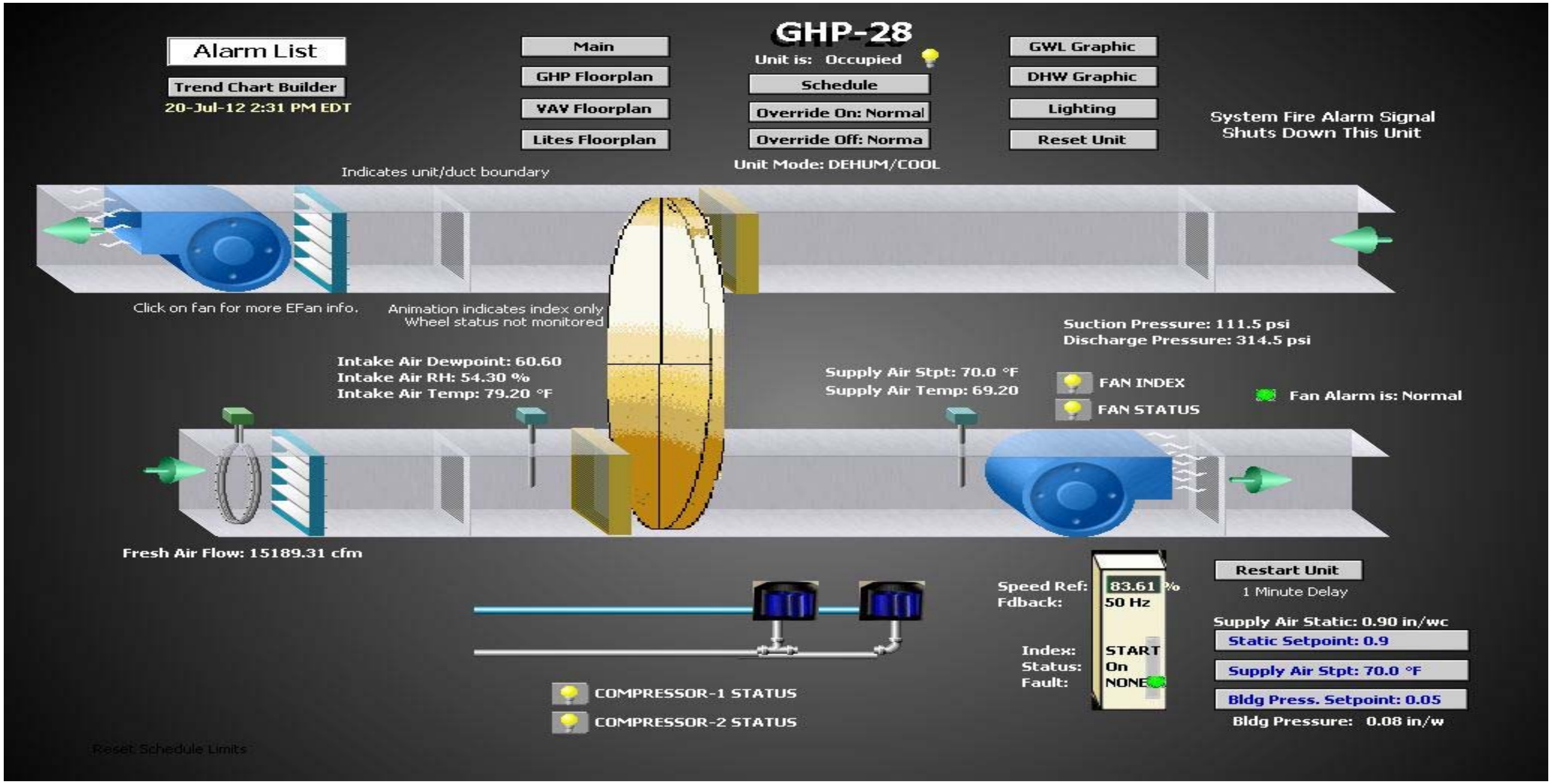
Zone Temp:

74.70 °F

Ground Source Heat Pump System Current and On Going Monitoring

Wilders Grove Solid Waste Service Center

Sample – Data Collection and Trending for Air Handling Equipment



GHP-28

Unit is: Occupied

20-Jul-12 2:31 PM EDT

Unit Mode: DEHUM/COOL

System Fire Alarm Signal Shuts Down This Unit

Indicates unit/duct boundary

Click on fan for more EFan info.

Animation indicates index only
Wheel status not monitored

Suction Pressure: 111.5 psi
Discharge Pressure: 314.5 psi

Intake Air Dewpoint: 60.60
Intake Air RH: 54.30 %
Intake Air Temp: 79.20 °F

Supply Air Stpt: 70.0 °F
Supply Air Temp: 69.20

Fan Alarm is: Normal

Fresh Air Flow: 15189.31 cfm

Speed Ref: 83.61 %
Fdback: 50 Hz

Index: START
Status: On
Fault: NONE

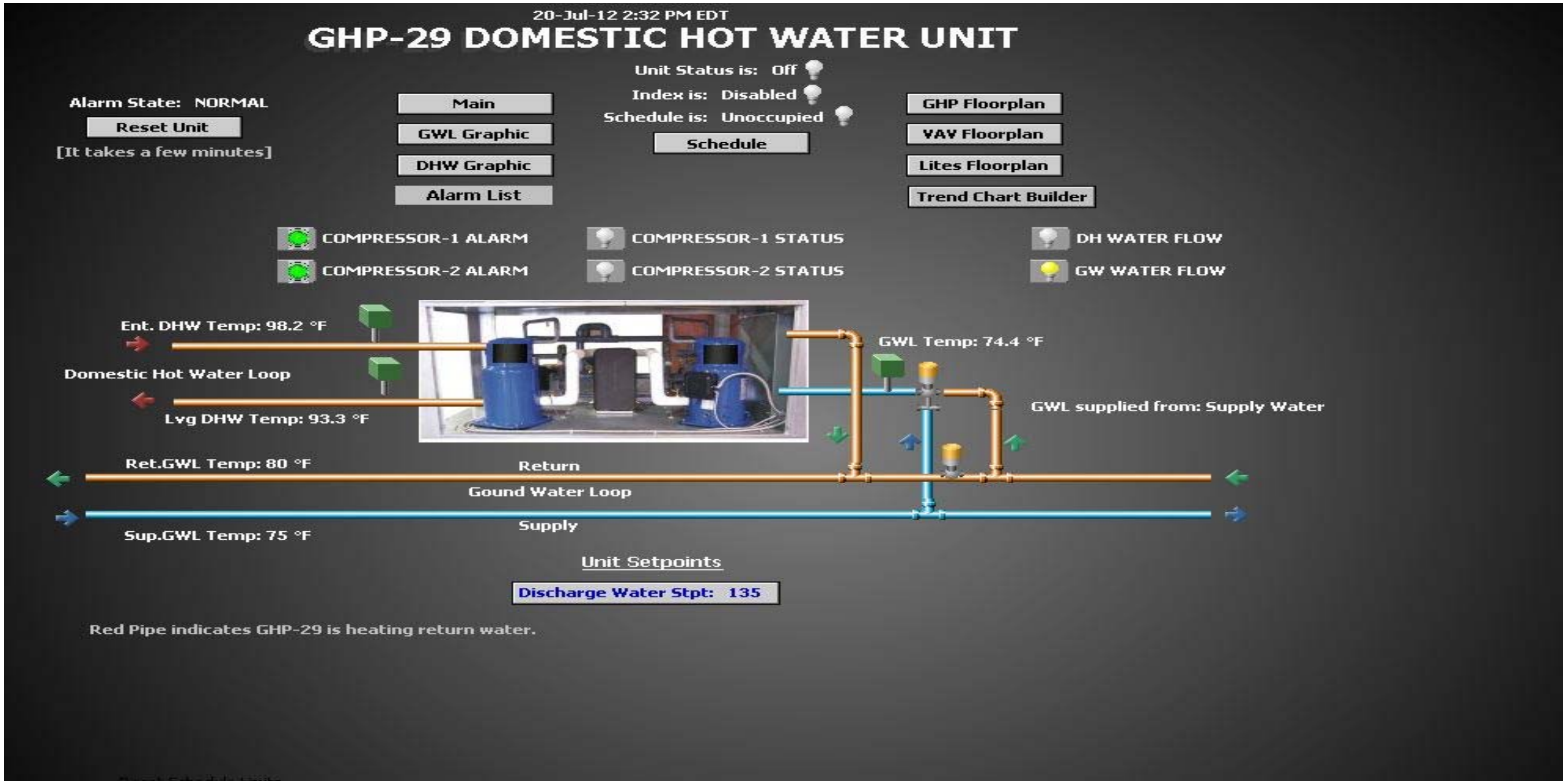
1 Minute Delay

Supply Air Static: 0.90 in/wc
Static Setpoint: 0.9
Supply Air Stpt: 70.0 °F
Bldg Press. Setpoint: 0.05
Bldg Pressure: 0.08 in/w

Ground Source Heat Pump System Current and On Going Monitoring

Wilders Grove Solid Waste Service Center

Sample – Data Collection and Trending for Hot Water Equipment



20-Jul-12 2:32 PM EDT

GHP-29 DOMESTIC HOT WATER UNIT

Unit Status is: Off

Index is: Disabled

Schedule is: Unoccupied

Alarm State: NORMAL

[It takes a few minutes]

Ent. DHW Temp: 98.2 °F

Lvg DHW Temp: 93.3 °F

GWL Temp: 74.4 °F

GWL supplied from: Supply Water

Ret.GWL Temp: 80 °F

Sup.GWL Temp: 75 °F

Discharge Water Stpt: 135

Red Pipe indicates GHP-29 is heating return water.

Well Field Construction Conductivity Testing

Technical Back-Up Slides

Wilders Grove Solid Waste Service Center

Well Field Construction Geothermal Loops

Technical Back-Up Slides

Wilders Grove Solid Waste Service Center

Well Field Construction
Geothermal Loops

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Technical Back-Up Slides

Wilders Grove Solid Waste Service Center

Well Field Construction Loop Circuits and Vault

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Technical Back-Up Slides

Wilders Grove Solid Waste Service Center

Well Field Construction Loop Circuits

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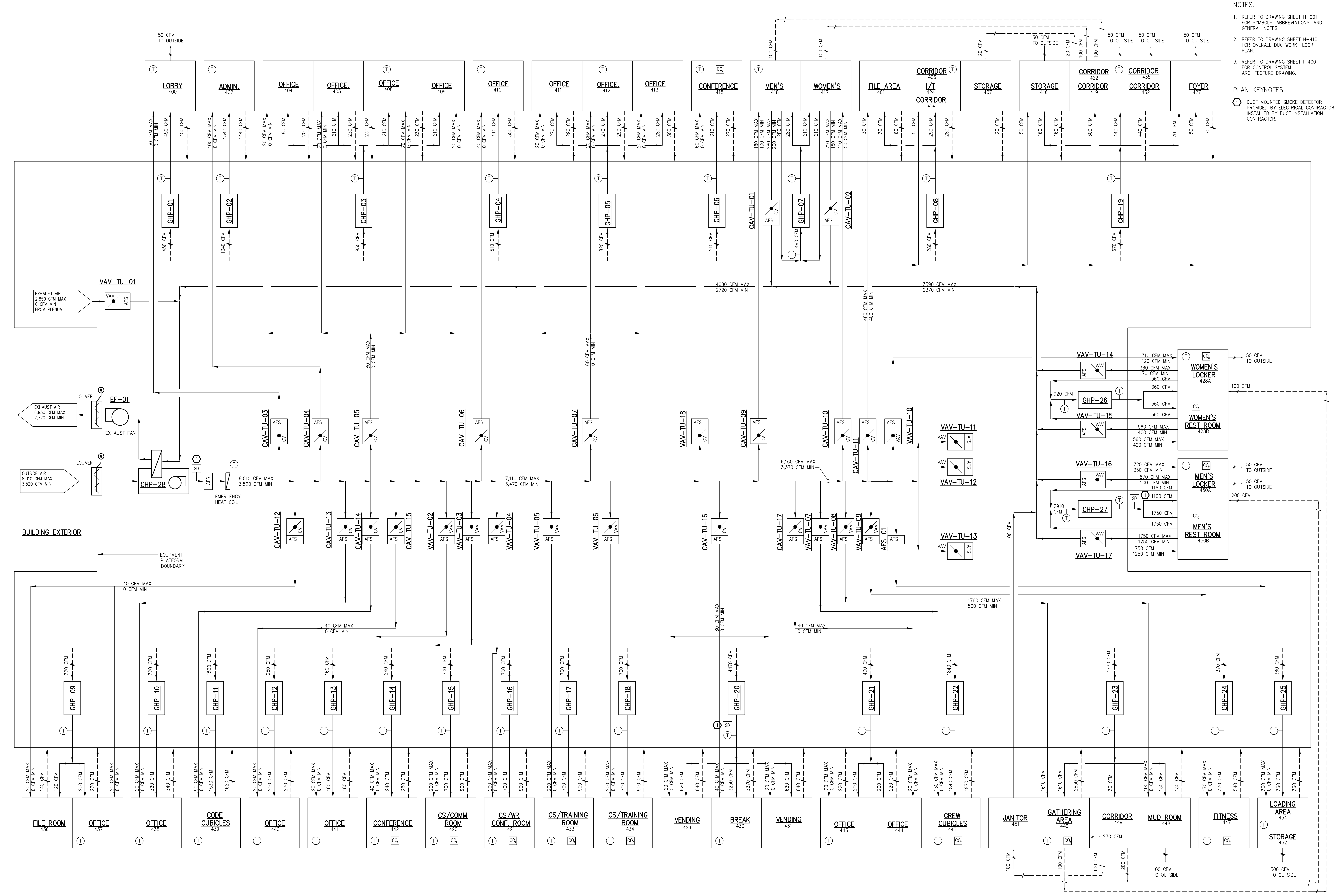
ESTABLISHED 1792
NORTH CAROLINA



NOTES:

1. REFER TO DRAWING SHEET H-001 FOR SYMBOLS, ABBREVIATIONS, AND GENERAL NOTES.
2. REFER TO DRAWING SHEET H-410 FOR OVERALL DUCTWORK FLOOR PLAN.
3. REFER TO DRAWING SHEET I-400 FOR CONTROL SYSTEM ARCHITECTURE DRAWING.

PLAN KEYNOTES:

① DUCT MOUNTED SMOKE DETECTOR PROVIDED BY ELECTRICAL CONTRACTOR, INSTALLED BY DUCT INSTALLATION CONTRACTOR.

PLOT DATE: 10/30/2009 9:05 AM BY: JEREMYK

NO.	ISSUED FOR	DATE	BY
3	BIDDING	OCT 2009	JAB
2	DOI SUBMITTAL	AUG 2009	JAB
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ROBERT S. DiFIORE 9463 10/30/09

HAROLD W. JONES 031518 10-30-2009

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CITY OF RALEIGH
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WILDERS GROVE SERVICE CENTER
SOLID WASTE SERVICES FACILITY

HVAC
SOLID WASTE SERVICES
AIR FLOW DIAGRAM

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	H-451

XREFs= ..\Tblock\Wilders Grove Service Center TB

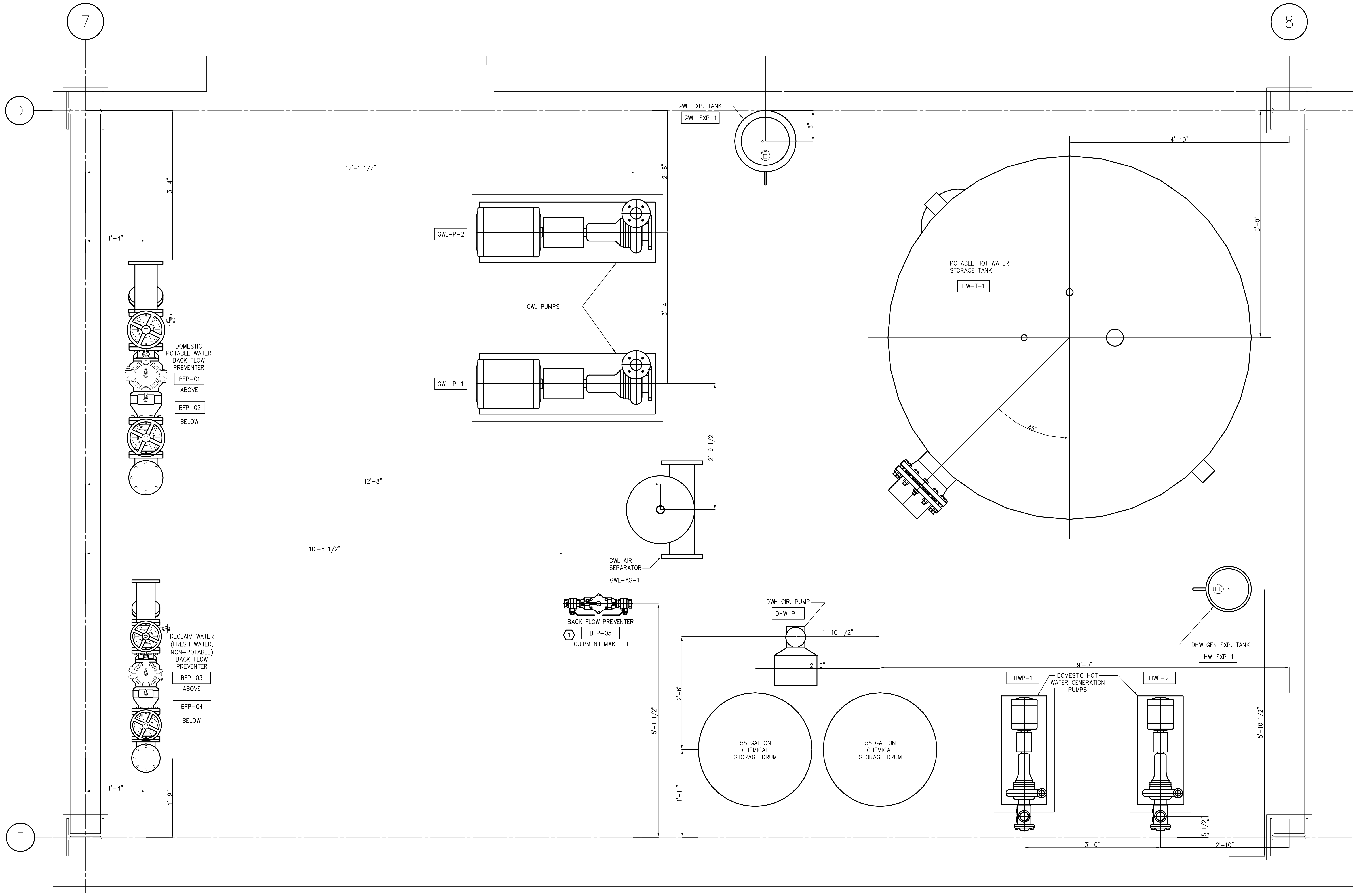
File = P:\208077\Drawings\Disciplines\Hvac HIPP\H-451 Saved by jeremyk Save date = 10/29/2009 4:53 PM

NOTES:

1. THE CONTRACTOR SHALL COORDINATE ALL PIPING AND COMPONENTS WITH EQUIPMENT LAYOUT TO ASSURE REQUIRED ACCESS TO COMPONENTS AND SERVICE AISLES. DIMENSIONS ARE BASED ON PRELIMINARY INFORMATION AND SHALL BE CONFIRMED WITH VENDOR SUBMITTALS.
2. REFER TO STRUCTURAL DRAWINGS FOR EQUIPMENT CONCRETE PADS.

PLAN NOTES:

(1) BACKFLOW PREVENTER MOUNTED INLINE WITH PIPING. SEE P-430FOR PIPING CONNECTION.



MECHANICAL ROOM ENLARGED PLAN
1" = 1'-0"

PLOT DATE: 10/30/2009 9:43 AM BY: ERINY

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3	BIDDING	OCT 2009	JAB
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10/30/09

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10-30-2009

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MECHANICAL
SOLID WASTE SERVICES
GENERAL ARRANGEMENT MECHANICAL ROOM
ENLARGED PLAN

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

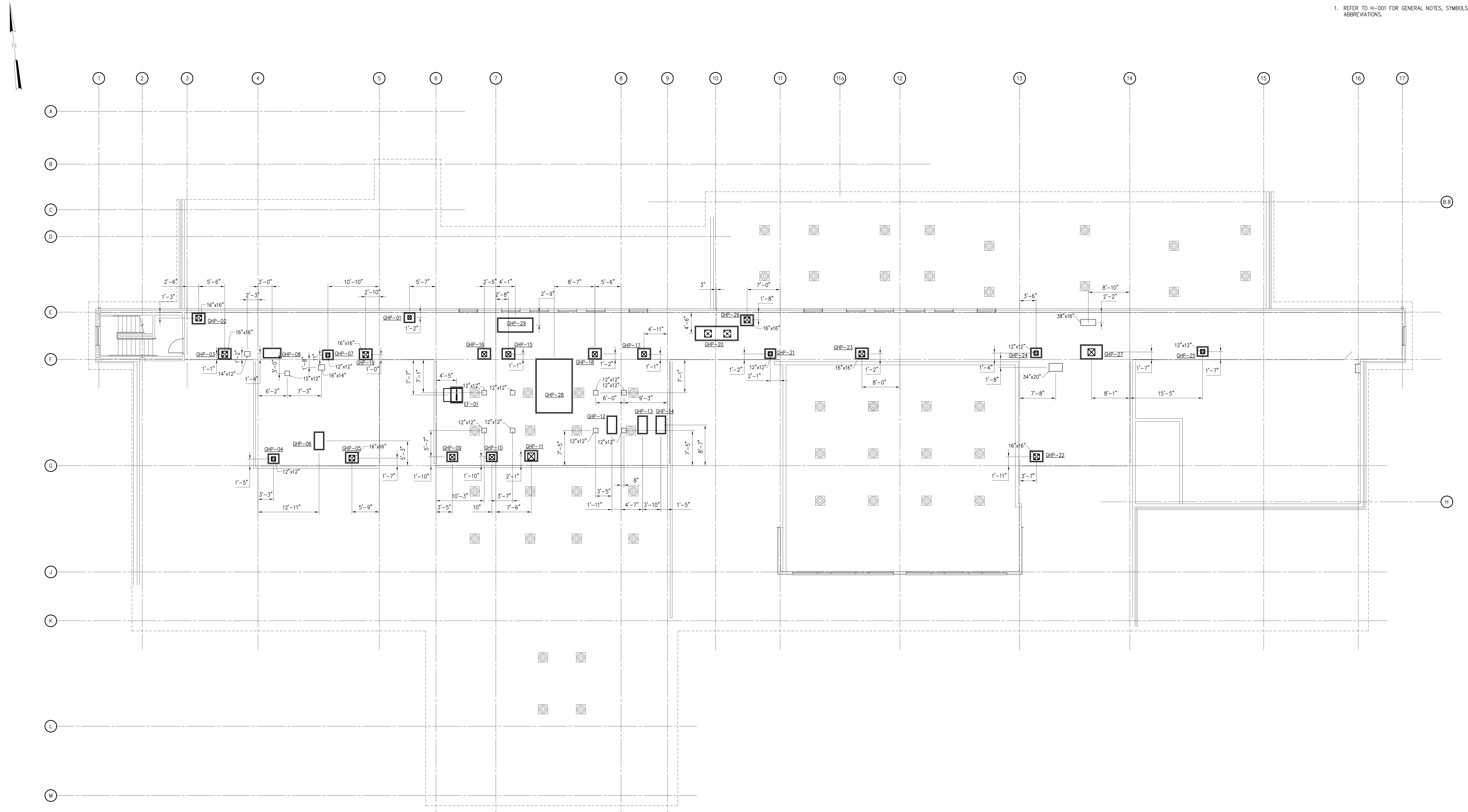
DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	M-411

XREFs= P:\208077\Drawings\Disciplines\Tblock\Wilders Grove Service Center TB,P:\208077\Drawings\Disciplines\Base HIPP\G-SC-Top-Plan,P:\208077\Drawings\Disciplines\Base HS\A-SC-Room-Names,P:\208077\Drawings\Disciplines\Base HS\A-SC-Top-Plan,P:\208077\Drawings\Disciplines\Base HS\S-SC-Column-Grid,P:\208077\Drawings\Disciplines\Base HS\S-SC-Top-Plan

File = P:\208077\Drawings\Disciplines\Mechanical Hipp\M-411 Saved by eriny Save date = 10/30/2009 9:35 AM

NOTES:

1. REFER TO H-001 FOR GENERAL NOTES, SYMBOLS AND ABBREVIATIONS.



EQUIPMENT PLATFORM PLAN

1/8" = 1'-0"

1/8"=1'-0"

8 6 4 2 0 8'

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SOLID WASTE SERVICES FACILITY

MECHANICAL
SOLID WASTE SERVICES
OVERALL GENERAL ARRANGEMENT
EQUIPMENT PLATFORM

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	M-412

PLOT DATE: 10/30/2009 9:43 AM BY: ERINY

XREFs= ..\Tblock\Wilders Grove Service Center TB,..\Base HS\S-SC-Column-Grid,..\Base HS\A-SC-Room-Names,P:\208077\Drawings\Disciplines\Base HIPP\G-SC-Equipment-Platform-Plan,P:\208077\Drawings\Disciplines\Base HS\A-SC-Equipment-Platform-Plan,..\Base HS\A-SC-Key-Plan

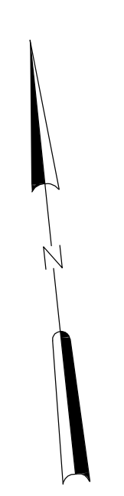
File = P:\208077\Drawings\Disciplines\Mechanical Hipp\M-412 Saved by eriny Save date = 10/30/2009 8:32 AM

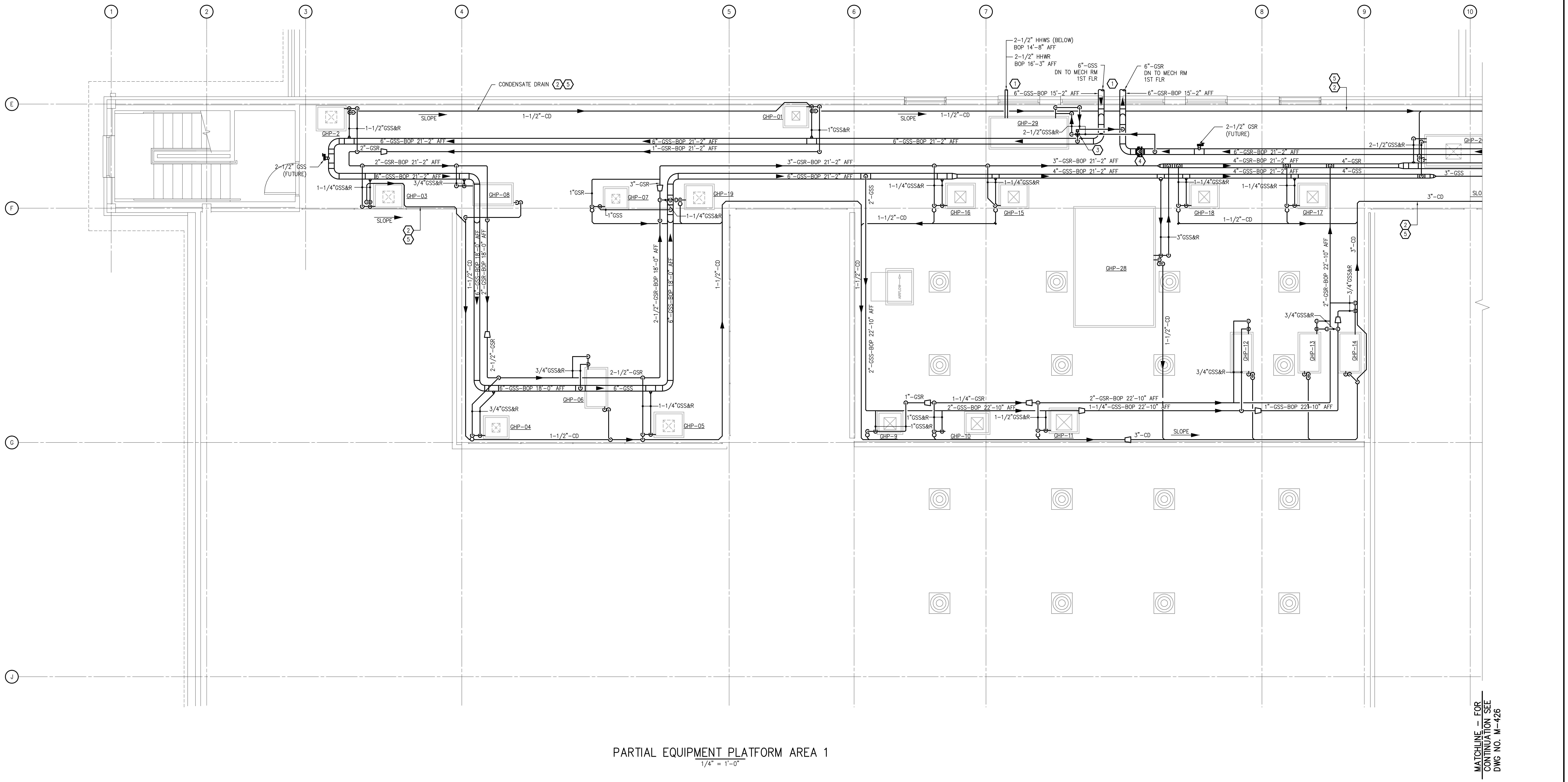
NOTES:

1. SEE DETAIL #1 DRAWING M-471 FOR TYPICAL HEAT PUMP PIPING CONNECTIONS.

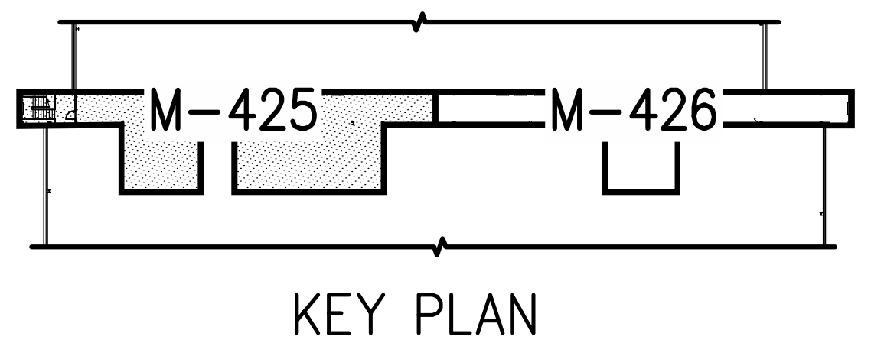
PLAN NOTES:

- ⟨1⟩ REFER TO M-429 FOR CONTINUATION OF PIPING IN MECHANICAL ROOM.
- ⟨2⟩ CONDENSATE SHALL PITCH TOWARDS EAST END OF BUILDING RAINWATER LEADERS.
- ⟨3⟩ THREE WAY CONTROL VALVE AT GHP-29. REFER TO P&ID, M-452, FOR DETAIL OF CONTROL VALVE SIZE AND LOCATION.
- ⟨4⟩ TWO WAY CONTROL VALVE AT GHP-29. REFER TO P&ID, M-452, FOR DETAIL OF CONTROL VALVE SIZE AND LOCATION.
- ⟨5⟩ FIELD ROUTE CONDENSATE DRAIN LINE – AVOID CREATING TRIP HAZARDS WHEREVER POSSIBLE.





PARTIAL EQUIPMENT PLATFORM AREA 1
1/4" = 1'-0"



KEY PLAN
1/64" = 1'-0"

1/4"=1'-0" 1 0 1 2 3 7'

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MECHANICAL
SOLID WASTE SERVICES
PARTIAL MECHANICAL PIPING EQUIPMENT
PLATFORM AREA 1

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	M-425

PLOT DATE: 10/30/2009 9:44 AM BY: ERINY

XREFs= ..\Tblock\Wilders Grove Service Center TB,..\Base HS\S-SC-Column-Grid,P:\208077\Drawings\Disciplines\Base HS\A-SC-Equipment-Platform-Plan,P:\208077\Drawings\Disciplines\Base HIPP\G-SC-Equipment-Platform-Plan,P:\208077\Drawings\Disciplines\Base HIPP\M-SC-Equipment-Platform-Plan,..\Base HS\A-SC-Key-Plan-Equipment-Platform

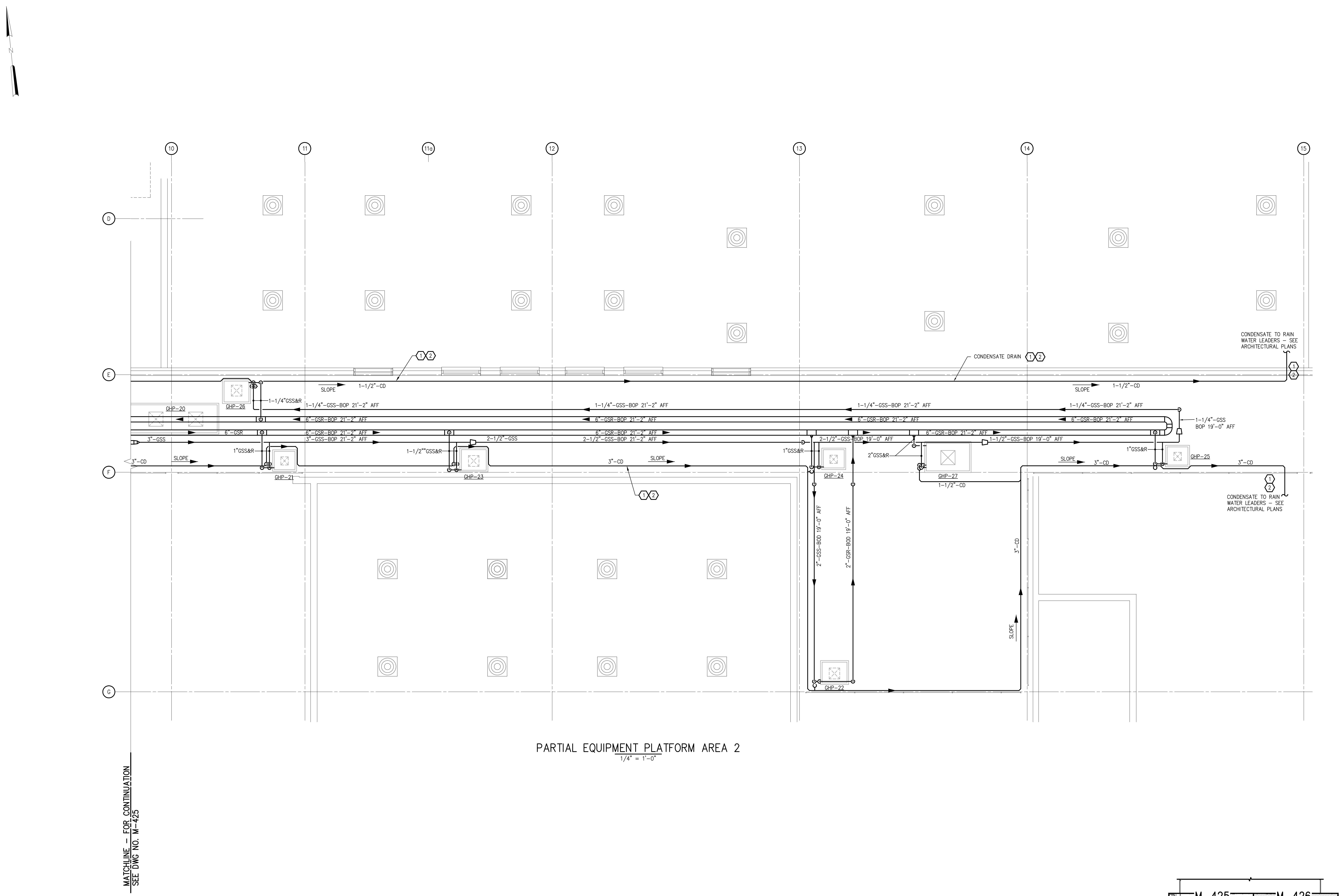
File = P:\208077\Drawings\Disciplines\Mechanical Hipp\M-425 Saved by eriny Save date = 10/30/2009 8:41 AM

NOTES:

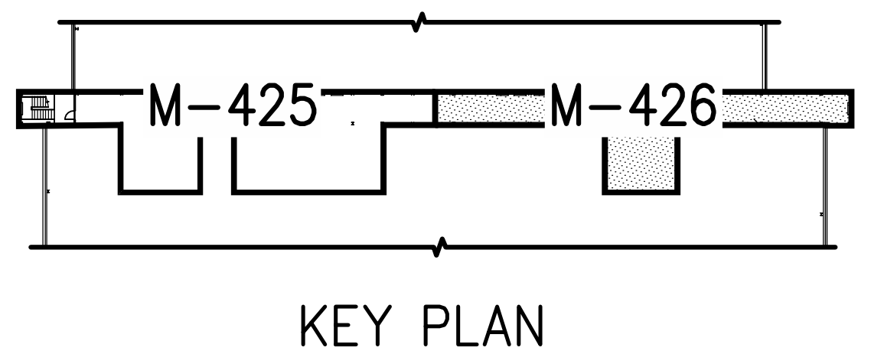
1. SEE DETAIL #1 DRAWING M-471 FOR TYPICAL HEAT PUMP PIPING CONNECTIONS.

PLAN NOTES:

1. CONDENSATE SHALL PITCH TOWARDS EAST END OF BUILDING RAINWATER LEADERS.
2. FIELD ROUTE CONDENSATE DRAIN LINE – AVOID CREATING TRIP HAZARDS WHEREVER POSSIBLE.



PARTIAL EQUIPMENT PLATFORM AREA 2
1/4" = 1'-0"



KEY PLAN
1/64" = 1'-0"

1/4"=1'-0"
1 0 1 2 3 7'

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HAROLD W. JONES 031518 10-30-2009

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MECHANICAL
SOLID WASTE SERVICES
PARTIAL MECHANICAL PIPING EQUIPMENT
PLATFORM AREA 2

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	M-426

PLOT DATE: 10/30/2009 9:44 AM BY: ERINY

XREFs= ..\Tblock\Wilders Grove Service Center TB,..\Base HS\S-SC-Column-Grid,P:\208077\Drawings\Disciplines\Base HIPP\G-SC-Equipment-Platform-Plan,P:\208077\Drawings\Disciplines\Base HS\A-SC-Equipment-Platform-Plan,P:\208077\Drawings\Disciplines\Base HIPP\M-SC-Equipment-Platform-Plan,..\Base HS\A-SC-Key-Plan-Equipment-Platform

File = P:\208077\Drawings\Disciplines\Mechanical Hipp\M-426 Saved by eriny Save date = 10/16/2009 1:27 PM

NOTES:

1. COORDINATE WITH CIVIL FOR PIPING LOCATIONS AND ELEVATIONS.
2. REFER TO P&ID M–451 FOR DETAILS OF PIPE SIZES AND FLOWS.
3. REFER TO M–471 FOR DETAILS.

PLAN NOTES:

① REFER TO M–429 FOR GROUNDWATER PIPING CONTINUATION INSIDE MECHANICAL ROOM.

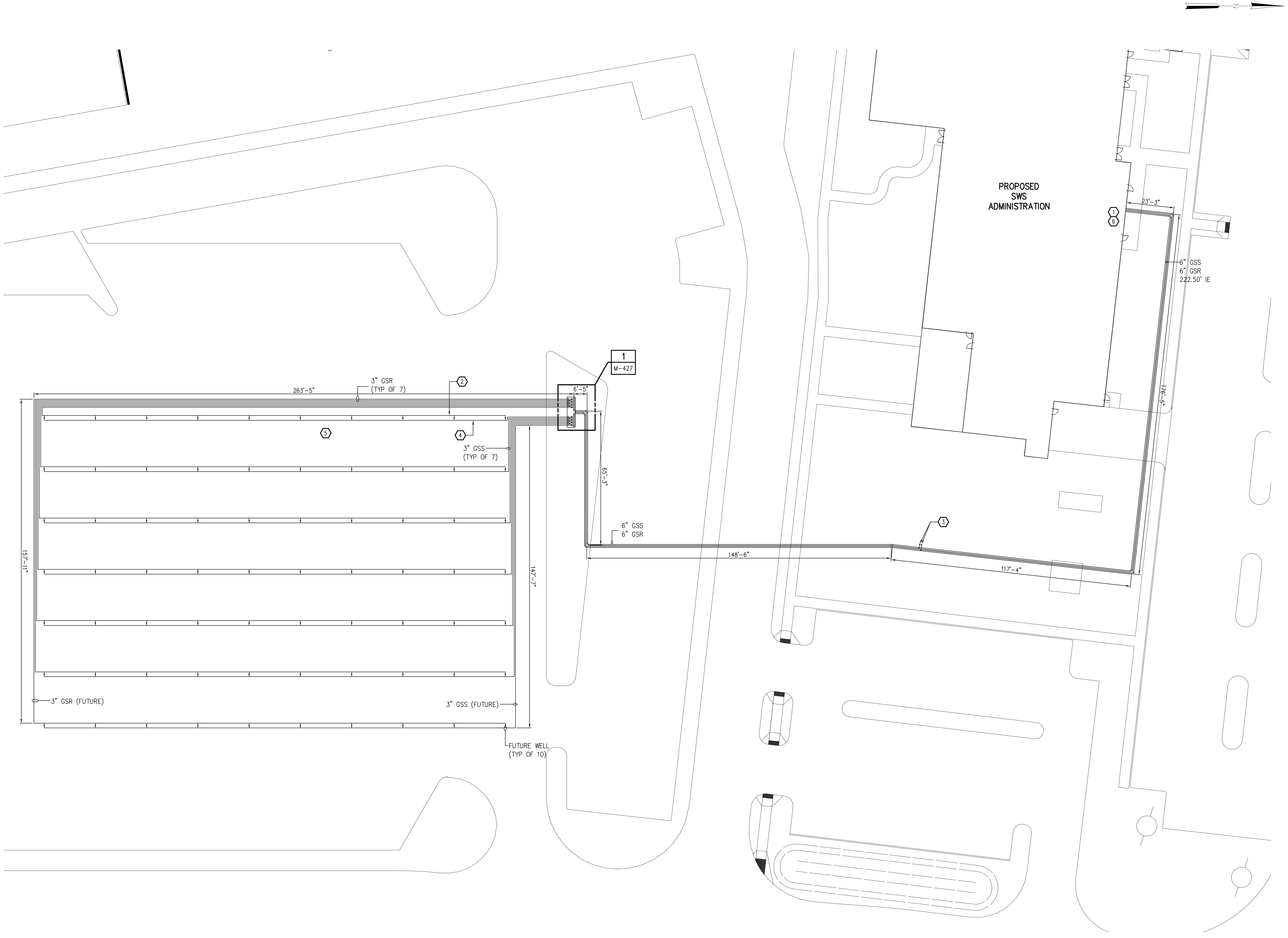
② LOCATION OF WELL SHALL BE COORDINATED WITH CIVIL. TYPICAL OF ALL WELLS.

③ FUTURE EVAPORATIVE COOLER CONNECTIONS, SEE DETAIL #18 DRAWING M–471.

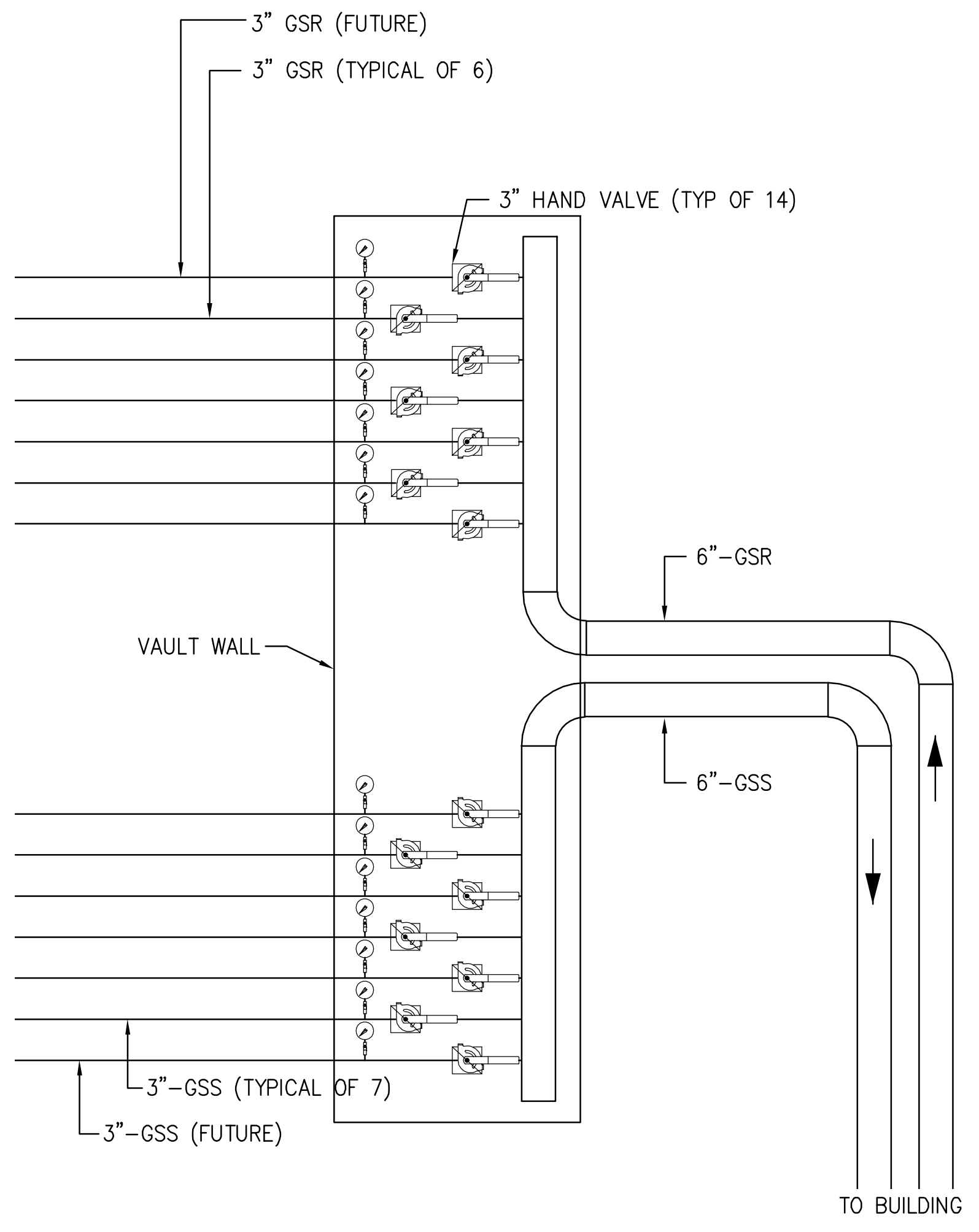
④ SEE DETAIL #15 DRAWING M–471 FOR TYPICAL WELL CONFIGURATIONS.

⑤ SEE DETAIL #16 DRAWING M–471 AND CIVIL DRAWINGS FOR TYPICAL TRENCH AND BACK–FILL REQUIREMENTS.

⑥ SEE DETAIL #17 DRAWING M–471 FOR PIPING MATERIAL TRANSITION DUCTILE IRON TO HPDE.



SITE MECHANICAL PIPING PLAN
3/64" = 1'–0"



UNDERGROUND VALVE BOX

DETAIL 1

NO SCALE

PLOT DATE: 10/30/2009 9:44 AM BY: ERINY

NO.	ISSUED FOR	DATE	BY
3	BIDDING	OCT 2009	JAB
2	DOI SUBMITTAL	AUG 2009	JAB
1	45% COMMISSIONING REVIEW	APR 2009	JAB

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DRAWN ADB/PWS
CHECKED JAB
PROJ.ENGR. JAB
RSD
APPROVED

NORTH CAROLINA PROFESSIONAL SEAL 9463 ENGINEER ROBERT S. DiFIORE 10/30/09

NORTH CAROLINA PROFESSIONAL SEAL 031518 ENGINEER HAROLD W. JONES 10-30-2009

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CITY OF RALEIGH
PUBLIC WORKS DEPARTMENT

WILDERS GROVE SERVICE CENTER
SOLID WASTE SERVICES FACILITY

MECHANICAL
SOLID WASTE SERVICES
MECHANICAL PIPING SITE PLAN

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	M-427

XREFs= ..\Tblock\Wilders Grove Service Center TB,..\Site Bases HS\SP–SITEBASE,..\Base HS\A–VW–Top–Plan,P:\208077\Drawings\Disciplines\Base HIPP\M–Site–Plan

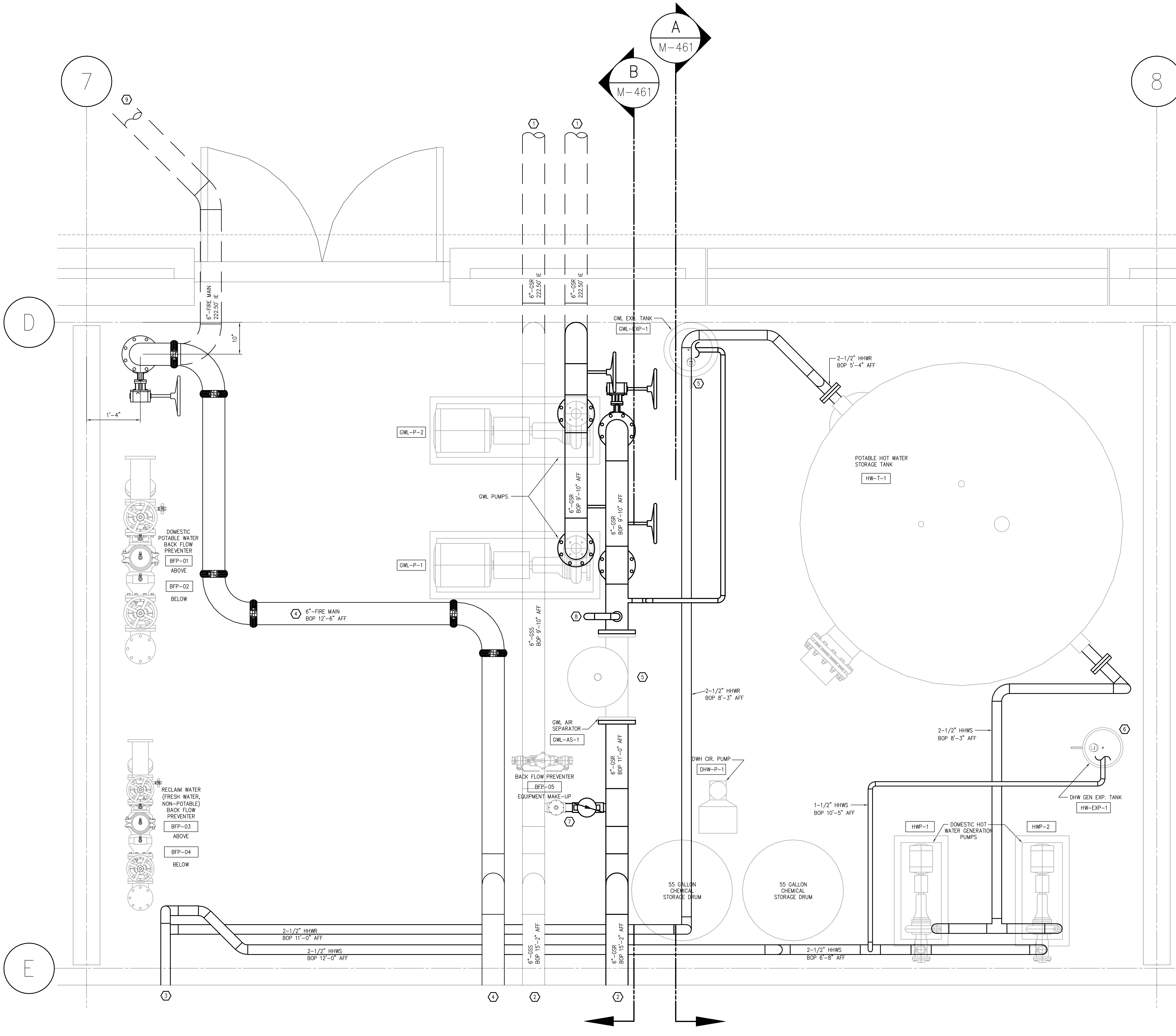
File = P:\208077\Drawings\Disciplines\Mechanical Hipp\M–427 Saved by eriny Save date = 10/30/2009 8:53 AM

NOTES:

1. REFER TO DRAWING SHEET H-001 FOR SYMBOLS, ABBREVIATIONS, AND GENERAL NOTES.

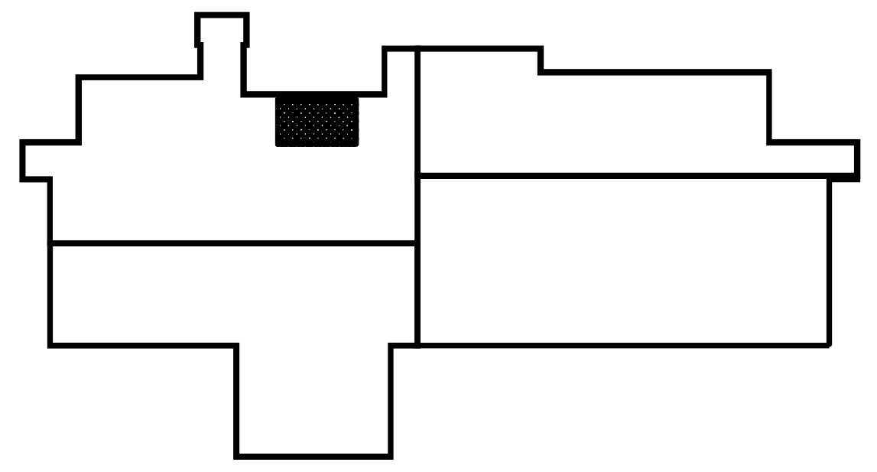
PLAN NOTES:

1. REFER TO M-427 FOR CONTINUATION OF PIPING EXTERIOR OF BUILDING. CONFIRM UNDERGROUND PIPING ELEVATIONS WITH CIVIL.
2. REFER TO M-425 FOR CONTINUATION OF PIPING TO EQUIPMENT PLATFORM.
3. REFER TO M-425 FOR CONTINUATION OF PIPING.
4. FIRE RISER PIPING BY OTHERS CONTINUES THROUGH OUT BUILDING. REFER TO SPRINKLER PIPING DRAWINGS, BY OTHERS, FOR CONTINUATION OF PIPING.
5. SEE DETAIL #2 DRAWING M-471 FOR AIR SEPARATOR AND EXPANSION TANK CONNECTION DETAIL.
6. CONNECT EXPANSION TANK TO HHWS PIPING AS SHOWN AND PER MANUFACTUERS INSTRUCTIONS.
7. GROUND LOOP PIPING BYPASS CONTROL VALVE AND CHECK VALVE. SEE DRAWING M-451 FOR SET PRESSURE.
8. GROUND LOOP RELIEF VALVE. SEE DRAWING M-451 FOR SET PRESSURE.
9. SEE CIVIL DRAWINGS FOR CONTINUATION OF PIPING.



MECHANICAL ROOM ENLARGED PIPING PLAN

1" = 1'-0"



KEY PLAN

1/64" = 1'-0"

NO.	ISSUED FOR	DATE	BY
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2	DOI SUBMITTAL	AUG 2009	JAB
1	45% COMMISSIONING REVIEW	APR 2009	JAB

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RSD
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SEAL 031518 HAROLD W. JONES 10-30-2009

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CITY OF RALEIGH
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WILDERS GROVE SERVICE CENTER
SOLID WASTE SERVICES FACILITY

MECHANICAL
SOLID WASTE SERVICES
MECHANICAL ROOM ENLARGED PIPING PLAN

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	M-429

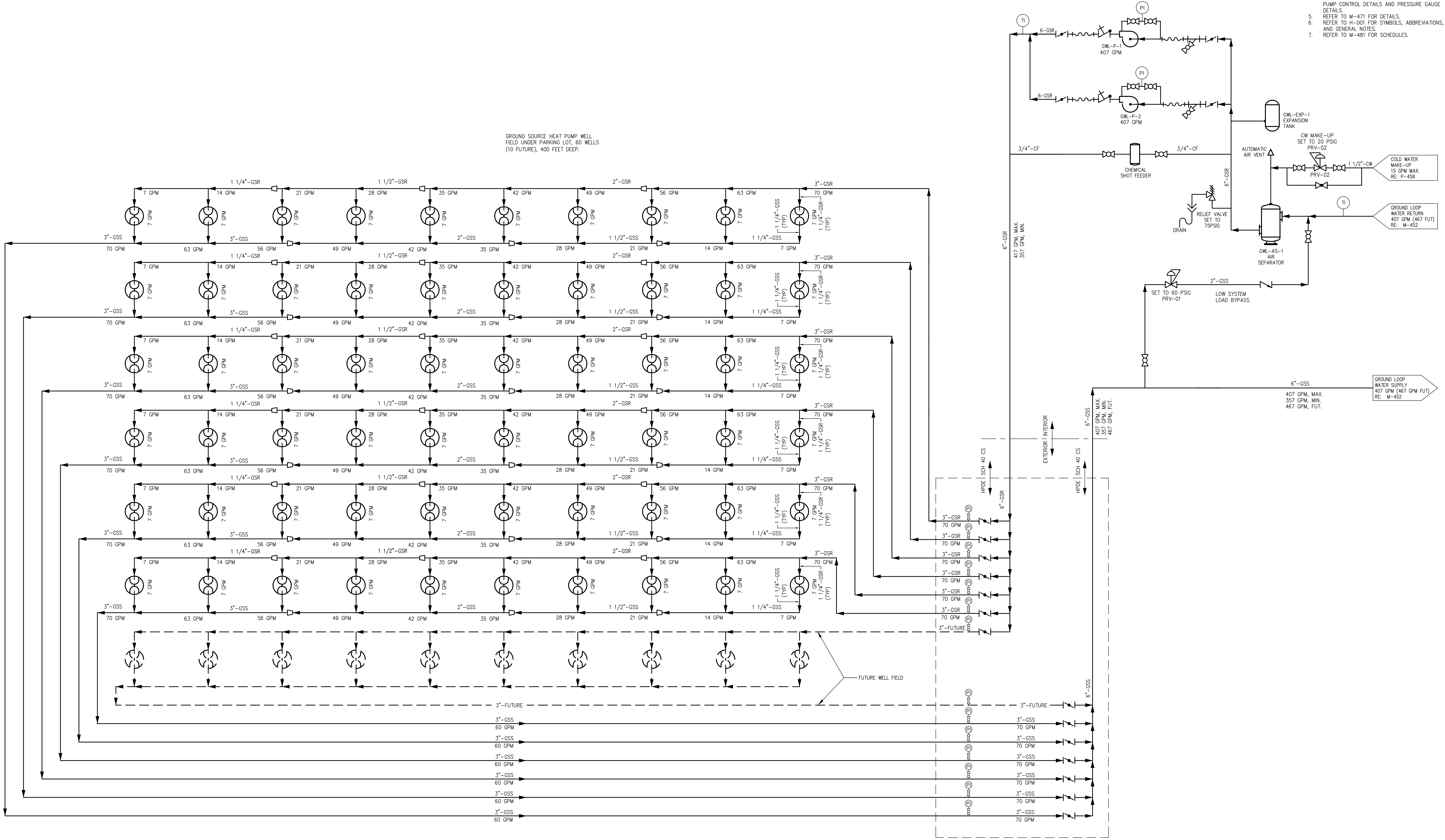
PLOT DATE: 10/30/2009 10:05 AM BY: ERINY

XREFs= P:\208077\Drawings\Disciplines\Tblock\Wilders Grove Service Center TB,P:\208077\Drawings\Disciplines\Base HIPP\G-SC-Top-Plan,P:\208077\Drawings\Disciplines\Base HS\A-SC-Room-Names,P:\208077\Drawings\Disciplines\Base HS\A-SC-Top-Plan,P:\208077\Drawings\Disciplines\Base HS\S-SC-Column-Grid,P:\208077\Drawings\Disciplines\Base HIPP\M-SC-Top-Plan,P:\208077\Drawings\Disciplines\Base HS\A-SC-Key-Plan

File = P:\208077\Drawings\Disciplines\Mechanical Hipp\M-429 Saved by eriny Save date = 10/30/2009 9:56 AM

NOTES:

1. INTERIOR PIPING SCH. 40 CARBON STEEL, INSULATED.
2. EXTERIOR PIPING, HPDE, NON-INSULATED.
3. REFER TO M-427 FOR MECHANICAL PIPING SITE PLAN AND M-429 FOR PIPING IN MECHANICAL ROOM.
4. REFER TO I-401 FOR GROUND SOURCE HEAT PUMP CONTROL DETAILS AND PRESSURE GAUGE DETAILS.
5. REFER TO M-471 FOR DETAILS.
6. REFER TO H-001 FOR SYMBOLS, ABBREVIATIONS, AND GENERAL NOTES.
7. REFER TO M-481 FOR SCHEDULES.



3	BIDDING	OCT 2009	JAB
2	DOI SUBMITTAL	AUG 2009	JAB
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RSD
APPROVED

ROBERT S. DiFIORE 9463
10/30/09

HAROLD W. JONES 031518
10-30-2009

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CITY OF RALEIGH
PUBLIC WORKS DEPARTMENT

WILDERS GROVE SERVICE CENTER
SOLID WASTE SERVICES FACILITY

VALVE MANIFOLD
VAULT

MECHANICAL
SOLID WASTE SERVICES
GROUND SOURCE LOOP GENERATION P&ID

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	M-451

PLOT DATE: 10/30/2009 9:45 AM BY: ERINY

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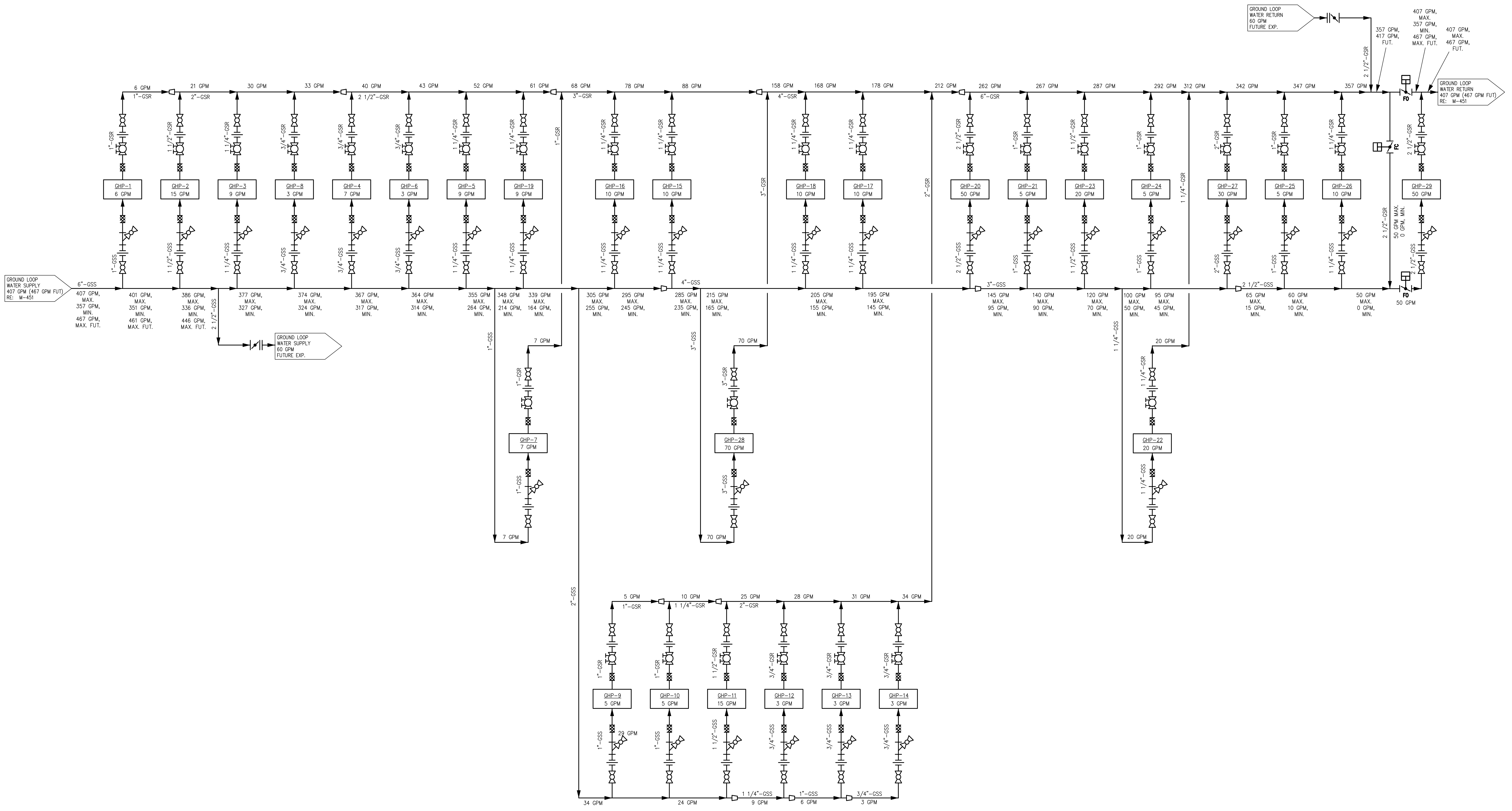
NOTES:

1. REFER TO M-425 AND M-426 FOR PIPING PLAN ON EQUIPMENT PLATFORM.
2. REFER TO I-401 FOR GROUND SOURCE HEAT PUMP CONTROL DETAILS.
3. REFER TO M-471 FOR DETAILS.
4. REFER TO H-001 FOR SYMBOLS, ABBREVIATIONS, AND GENERAL NOTES.



NO.	ISSUED FOR	DATE	BY
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WILDERS GROVE SERVICE CENTER
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MECHANICAL
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GROUND SOURCE LOOP DISTRIBUTION P&ID

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE OCTOBER 2009
H & S JOB NUMBER 30579-003
HIPP JOB NUMBER 208077
DRAWING NUMBER M-452

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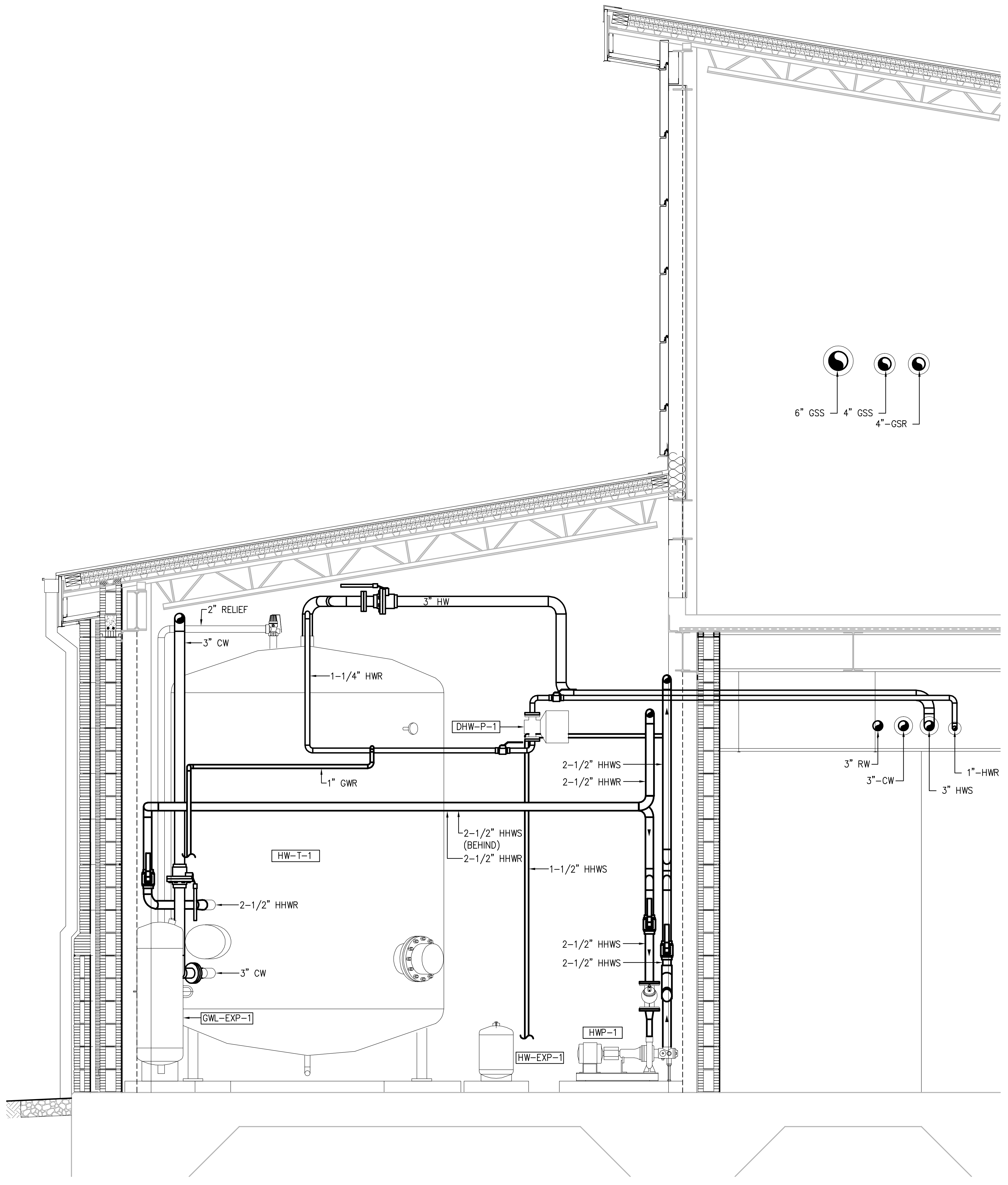
NOTES:

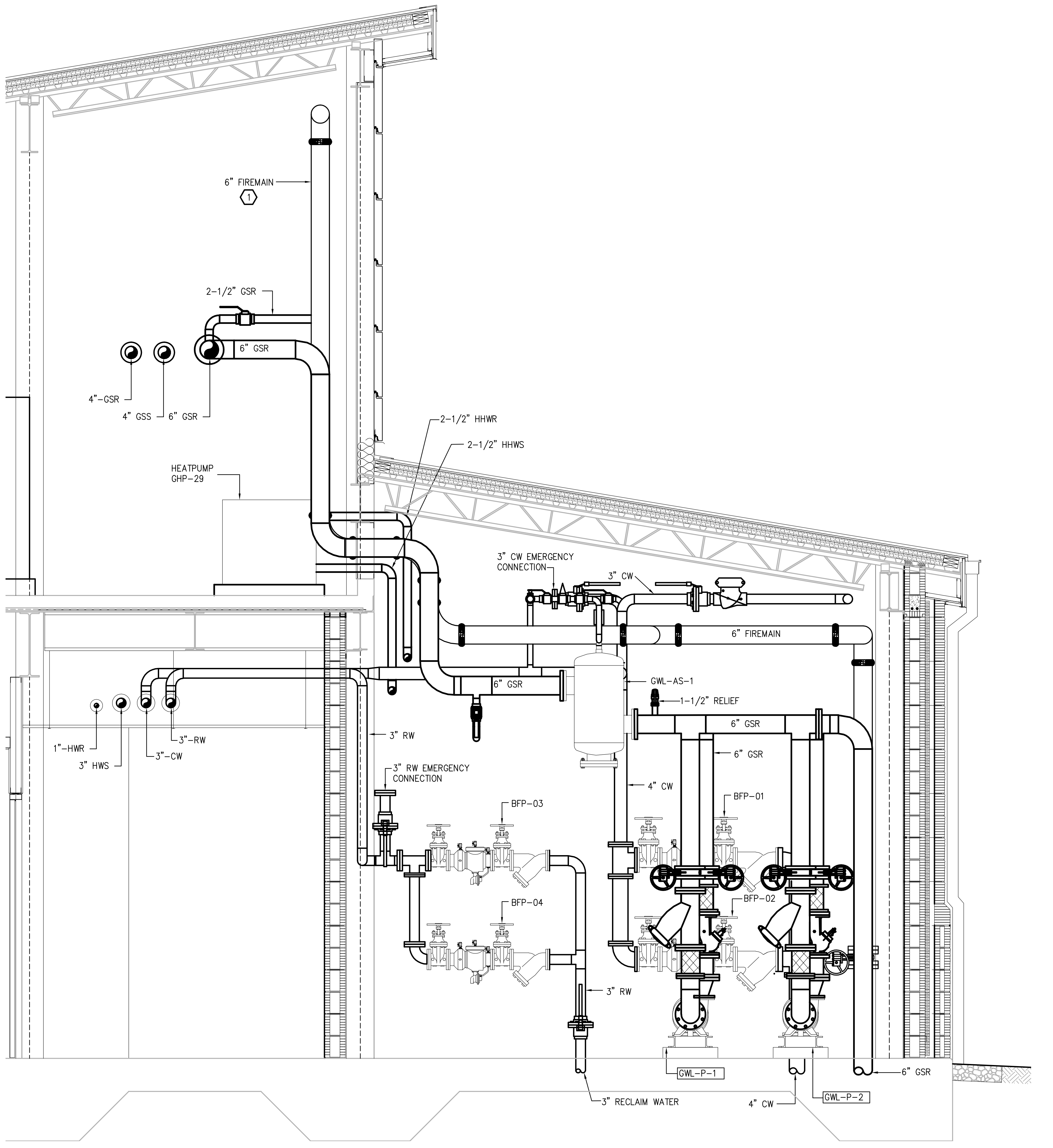
1. REFER TO DRAWING SHEET H-001 FOR SYMBOLS, ABBREVIATIONS, AND GENERAL NOTES.
2. REFER TO DRAWING SHEET M-429 FOR ENLARGED MECHANICAL ROOM PIPING PLAN.
3. REFER TO DRAWING SHEET M-425 AND M-426 FOR EQUIPMENT PLATFORM PIPING PLAN.

PLAN NOTES:

⟨1⟩ FIRE MAIN PIPING SHOWN FOR REFERENCE ONLY. INSTALLATION SHALL BE PERFORMED BY OTHERS.



SECTION (A / M-429)
1/2"=1'-0"



SECTION (B / M-429)
1/2"=1'-0"

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SEAL 9463 ROBERT S. DiFIORE 10/30/09
SEAL 031518 HAROLD W. JONES 10-30-2009

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CITY OF RALEIGH
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WILDERS GROVE SERVICE CENTER
SOLID WASTE SERVICES FACILITY

MECHANICAL
SOLID WASTE SERVICES
MECHANICAL PIPING SECTIONS

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	M-461

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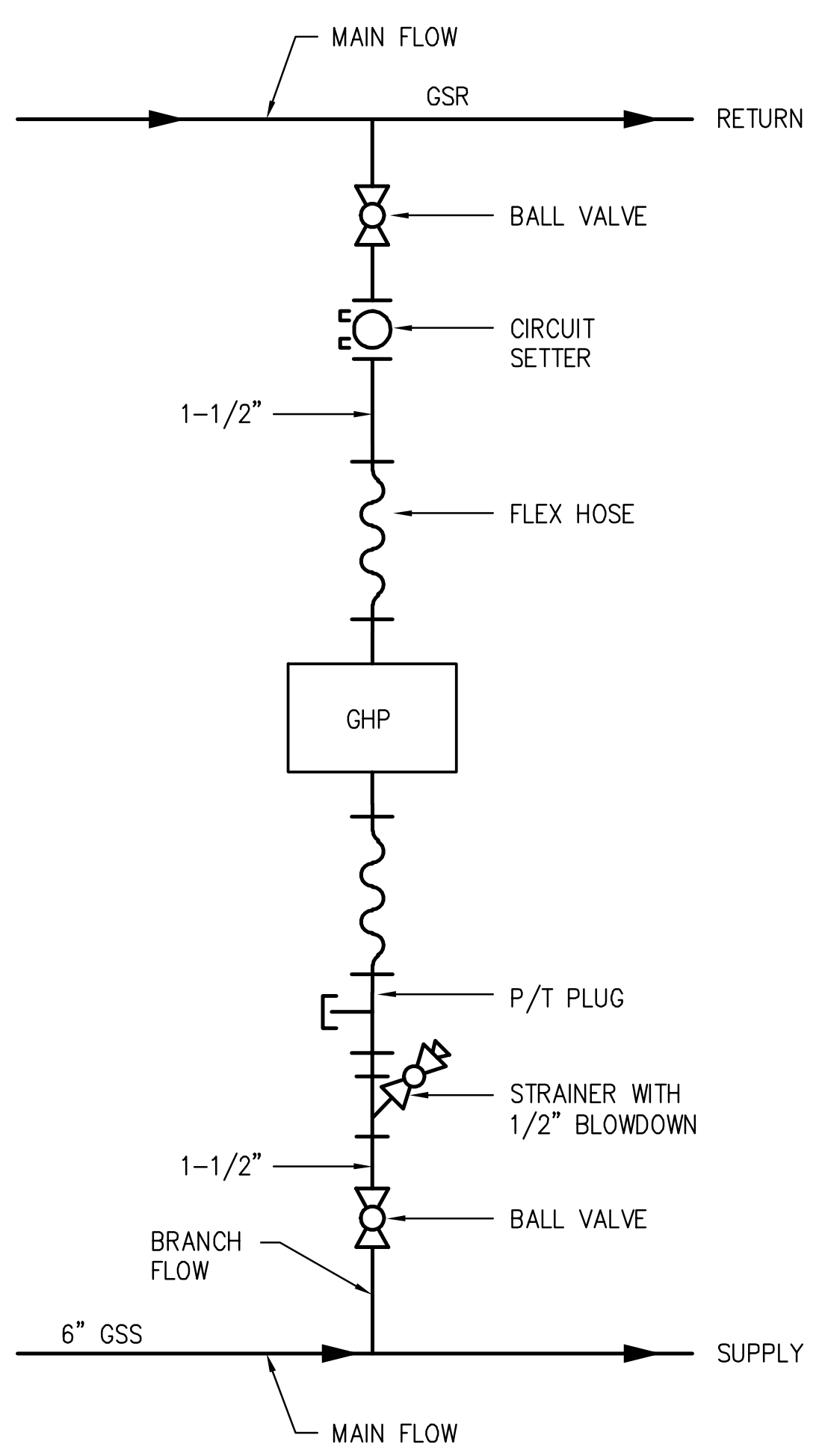
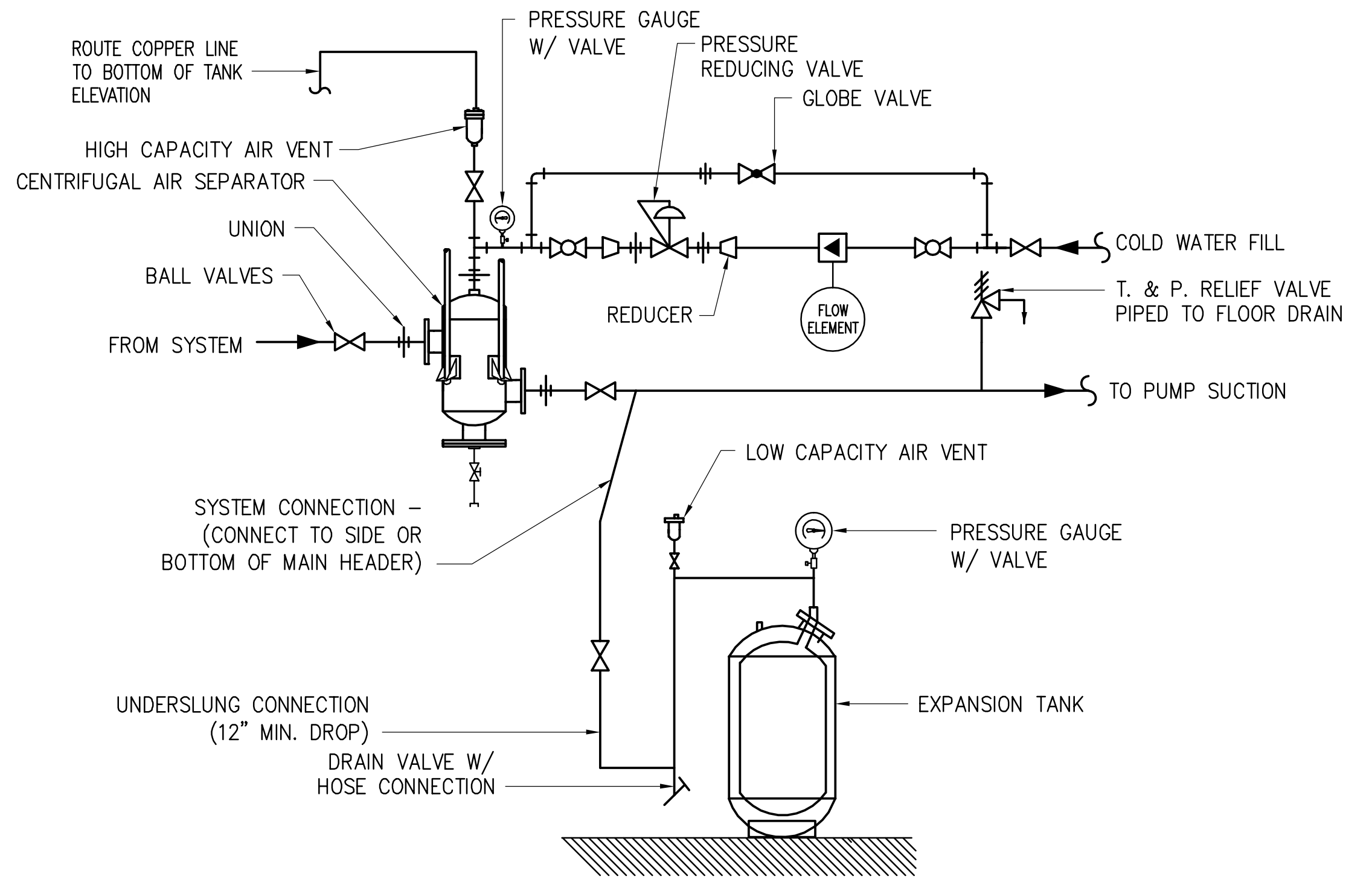


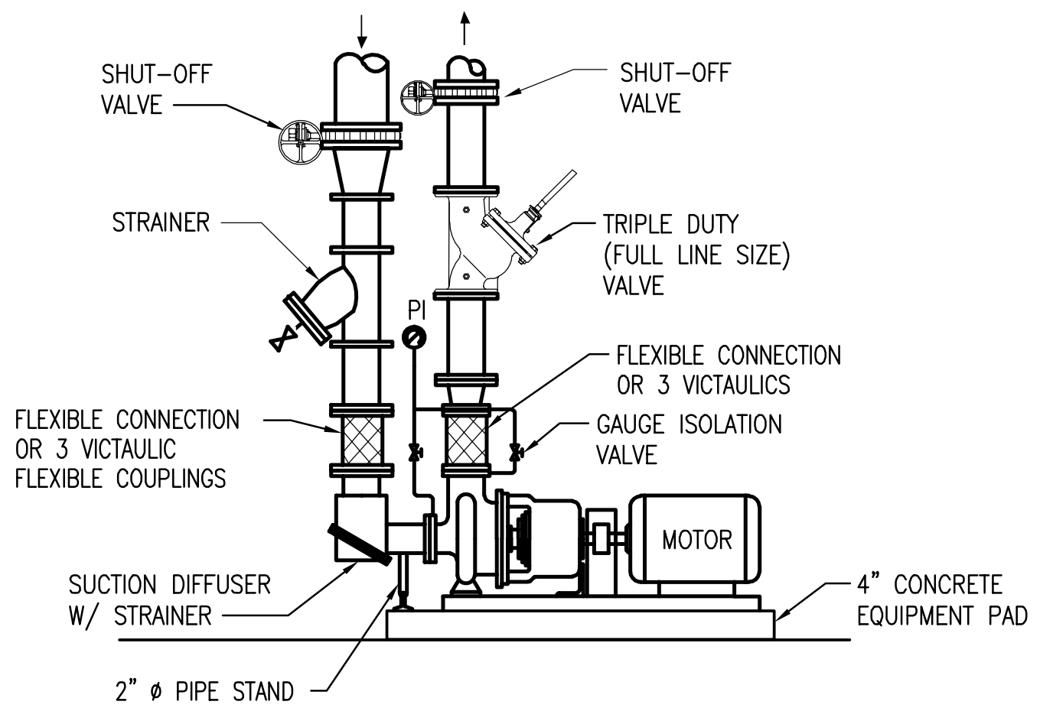
TYPICAL HEAT PUMP CONNECTION DETAIL

DETAIL 1
NO SCALE M-452



AIR SEPARATOR AND EXPANSION TANK

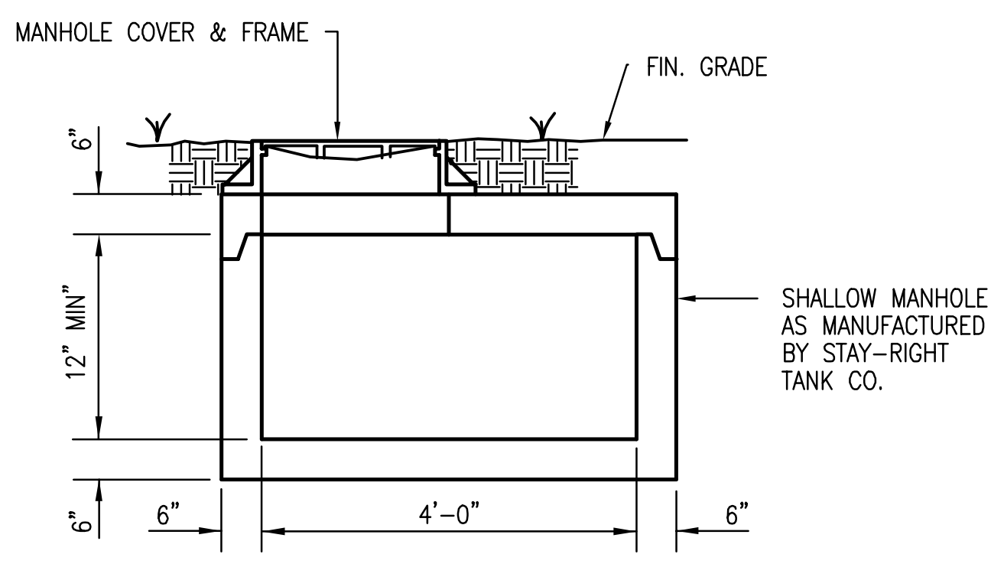
DETAIL 2
NO SCALE M-429



NOTE: THE SUCTION & DISCHARGE PIPING SHALL BE SUPPORTED AND ALIGNED TO ELIMINATE STRESS TO THE FLEXIBLE CONNECTORS.

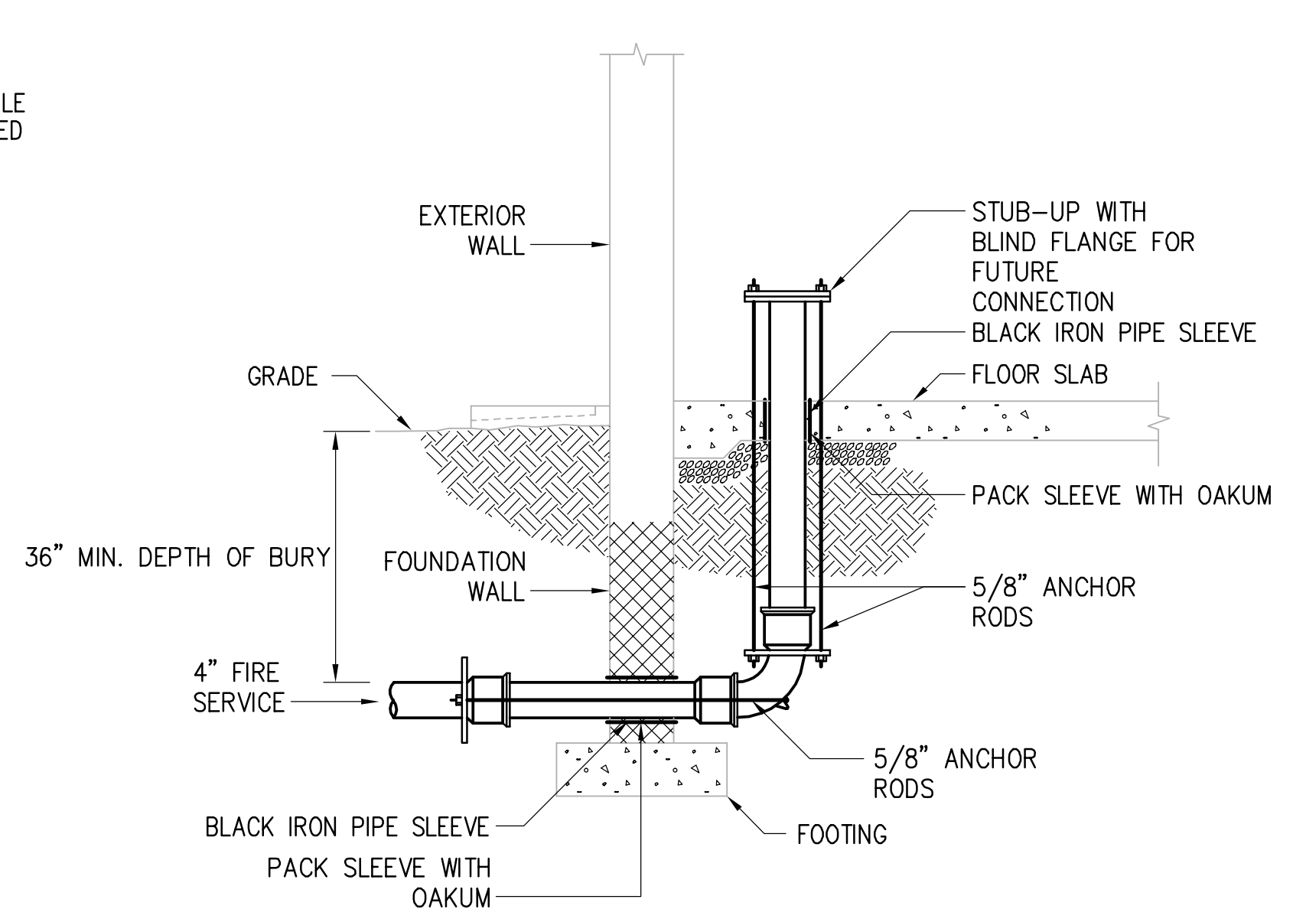
TYPICAL GROUND SOURCE WATER PUMP DETAIL

DETAIL 3
NO SCALE M-429



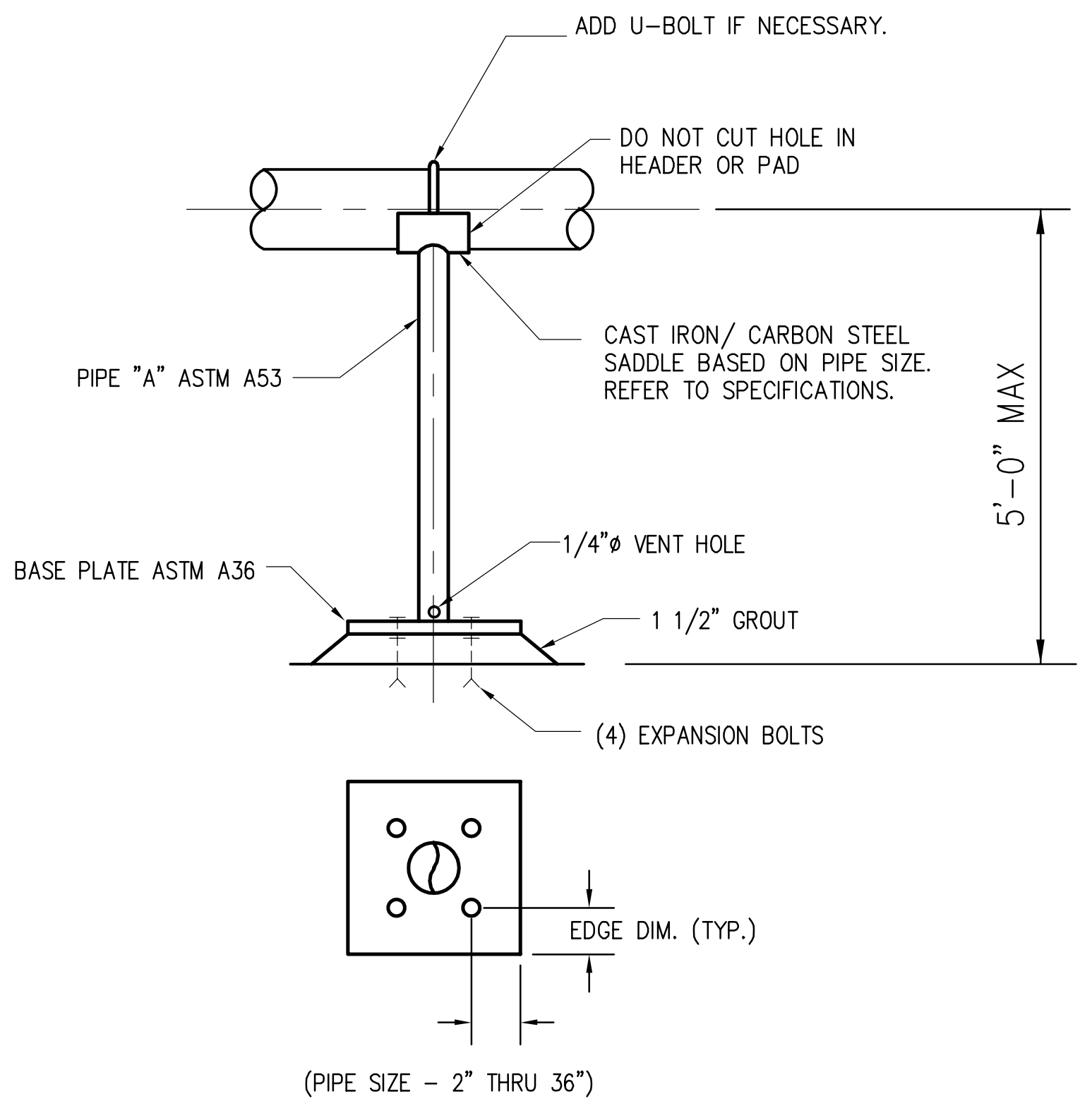
PRECAST SHALLOW MANHOLE DETAIL

DETAIL 4
NO SCALE M-427



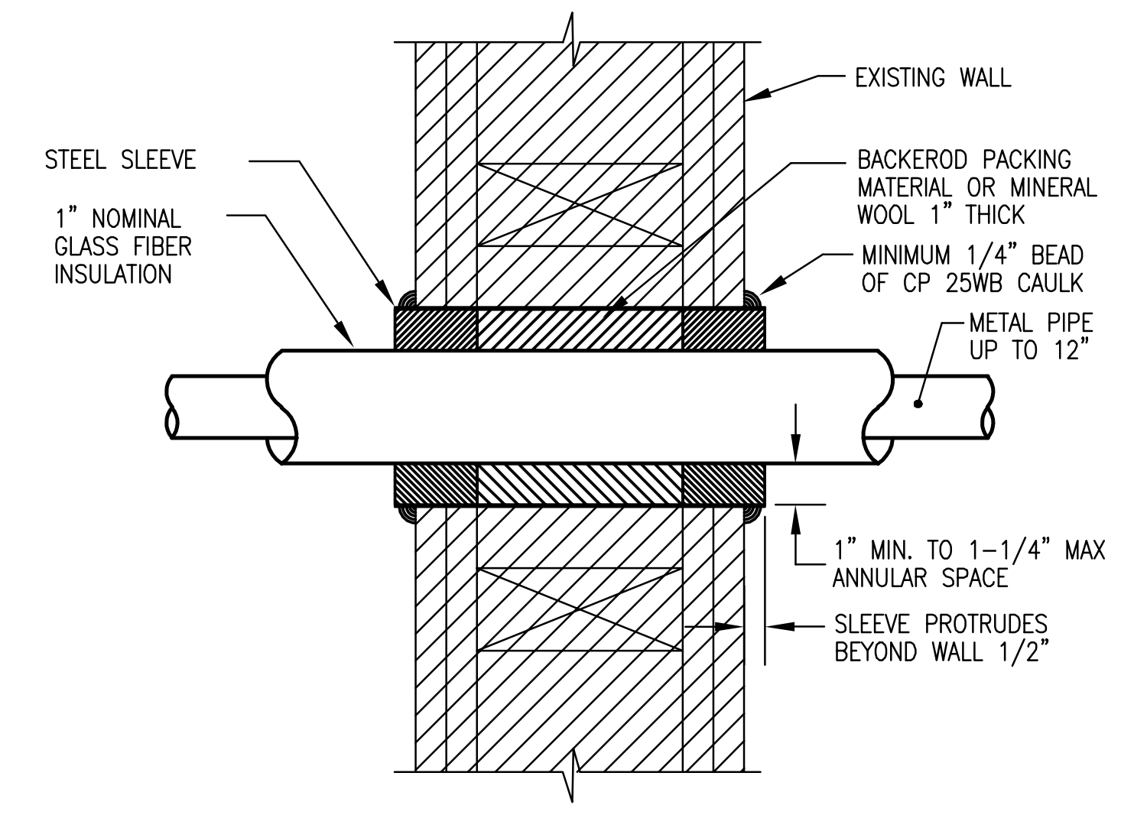
FIRE SERVICE ENTRANCE DETAIL

DETAIL 5
NO SCALE M-429



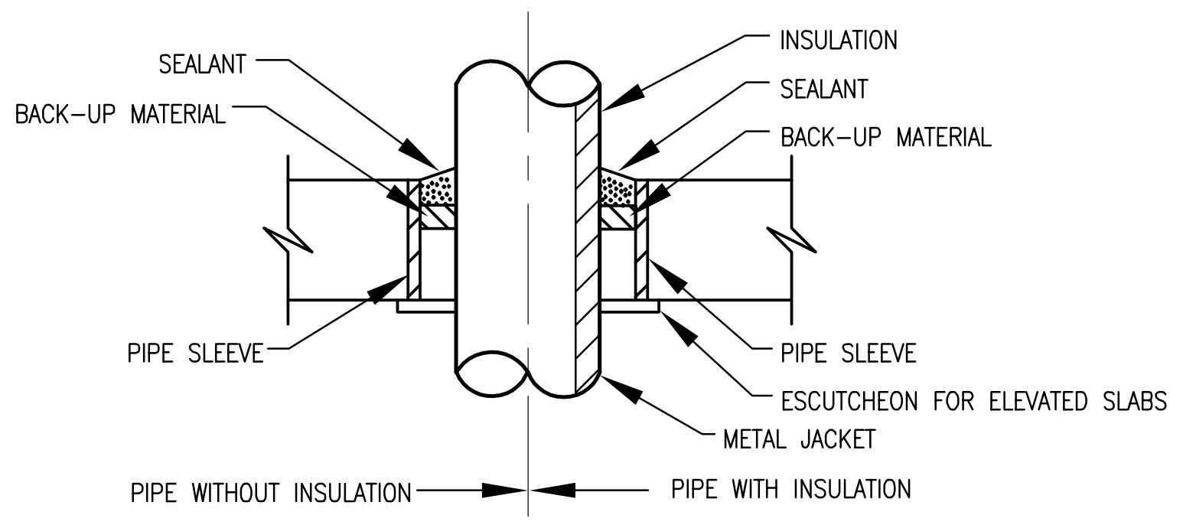
PIPING BASE SUPPORT – RIGID

DETAIL 6
NO SCALE M-429



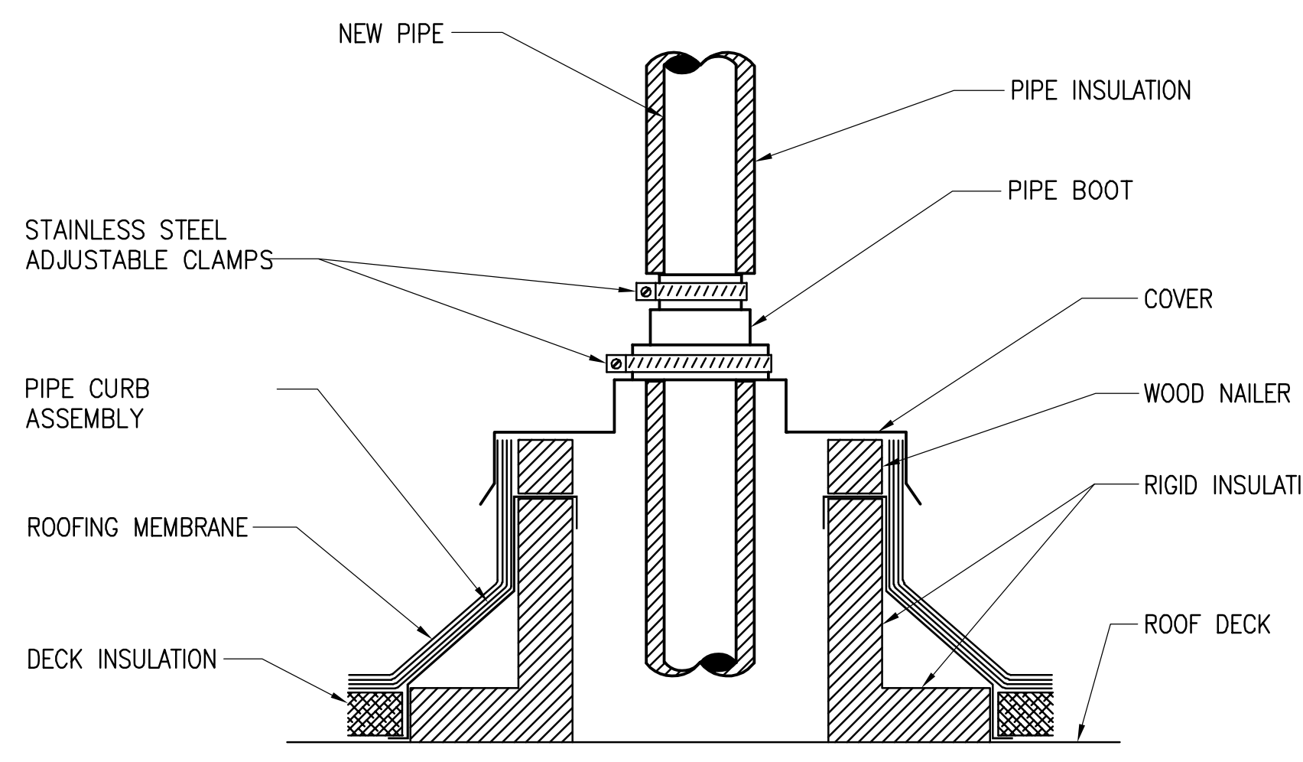
NON-FIRE RATED PIPE PENETRATION DETAIL

DETAIL 7
NO SCALE M-429



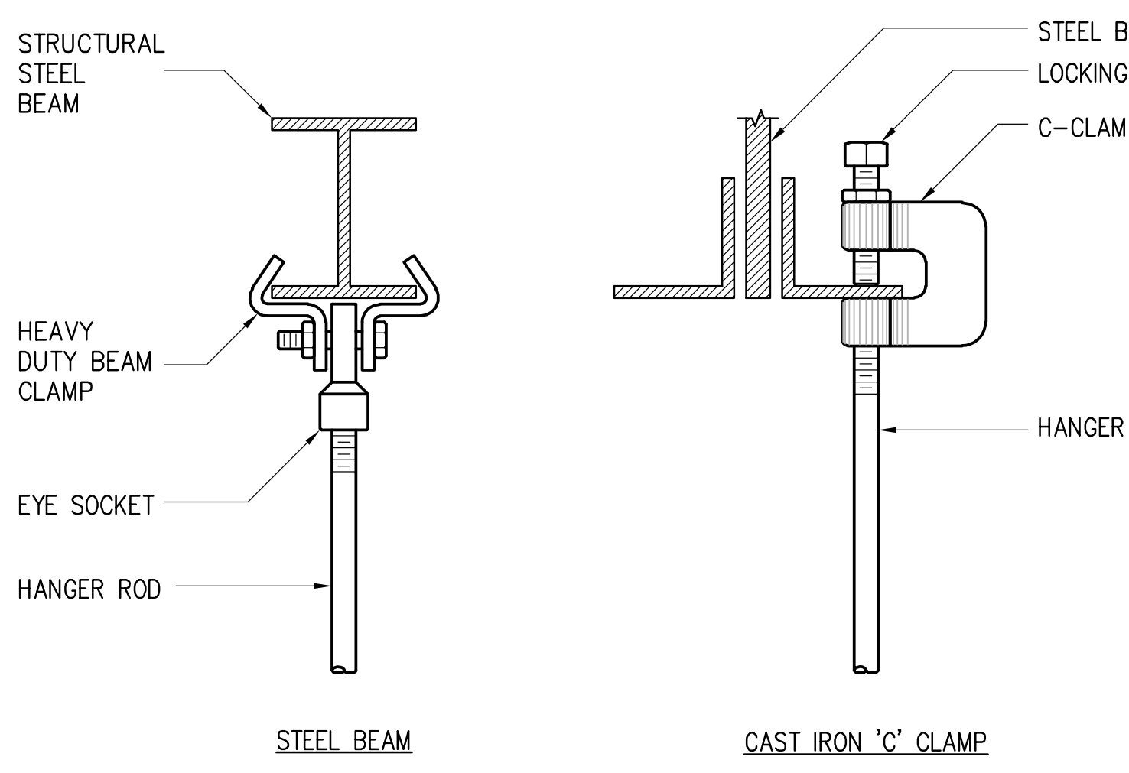
PIPE SLEEVE THROUGH FLOOR

DETAIL 8
NO SCALE M-425



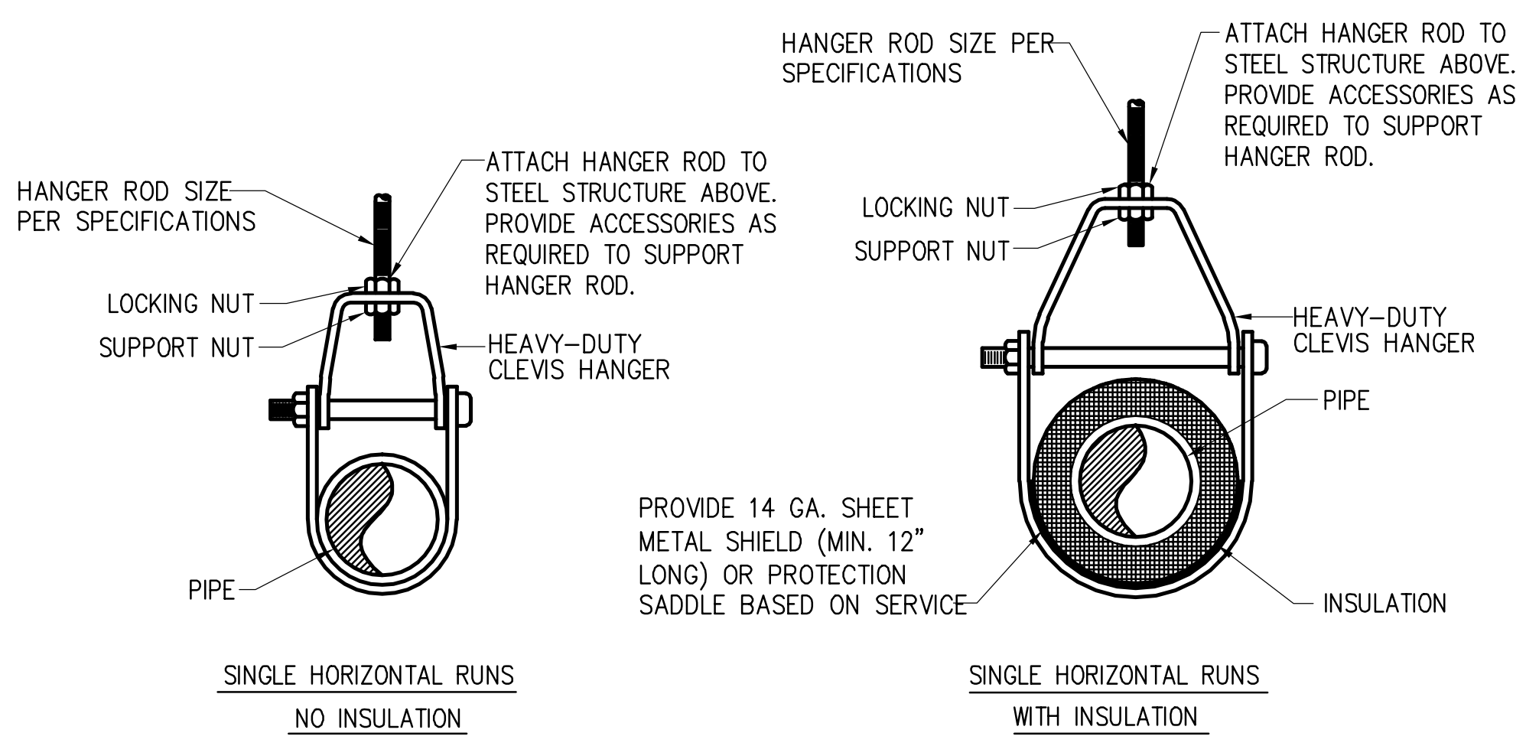
PIPE PENETRATION THRU ROOF DETAIL

DETAIL 9
NO SCALE M-425



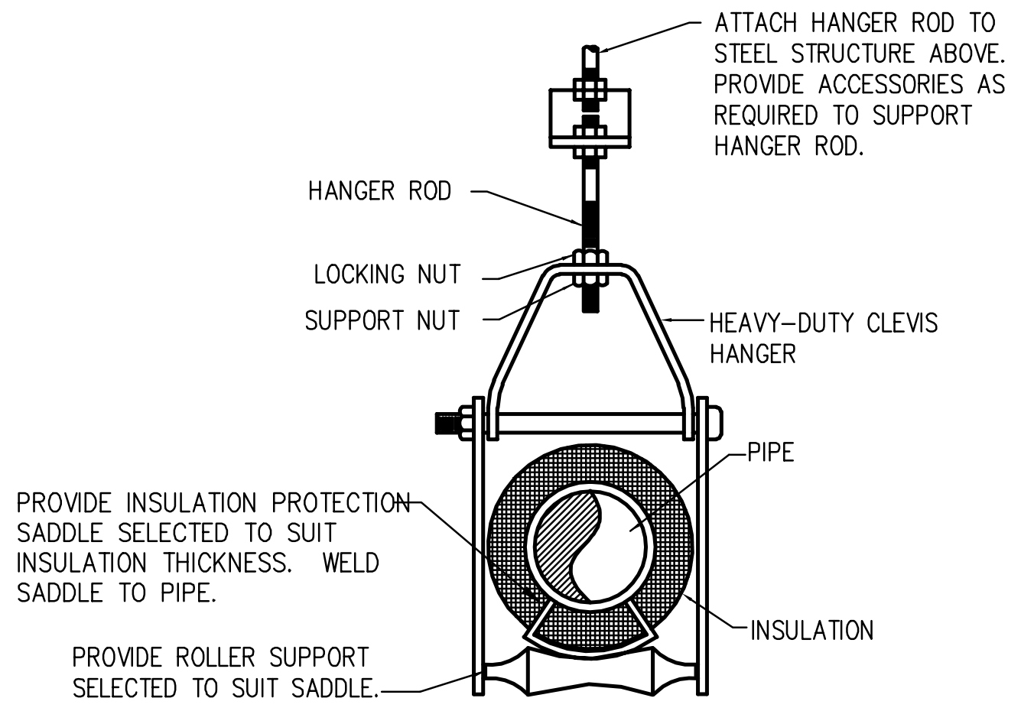
SUPPORT HANGER DETAIL

DETAIL 10
NO SCALE M-425



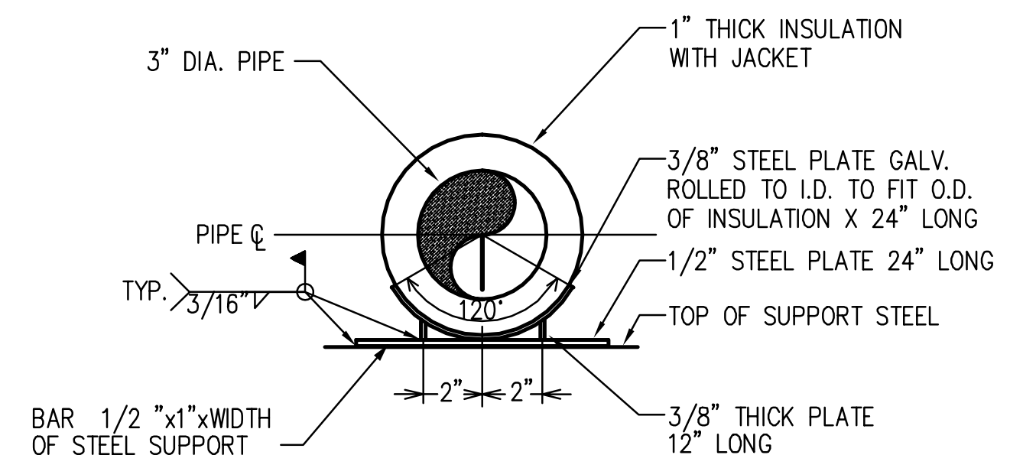
CLEVIS HANGER PIPE SUPPORT DETAIL

DETAIL 11
NO SCALE M-425



PIPE ROLLER SUPPORT WITH INSULATION

DETAIL 12
NO SCALE M-425



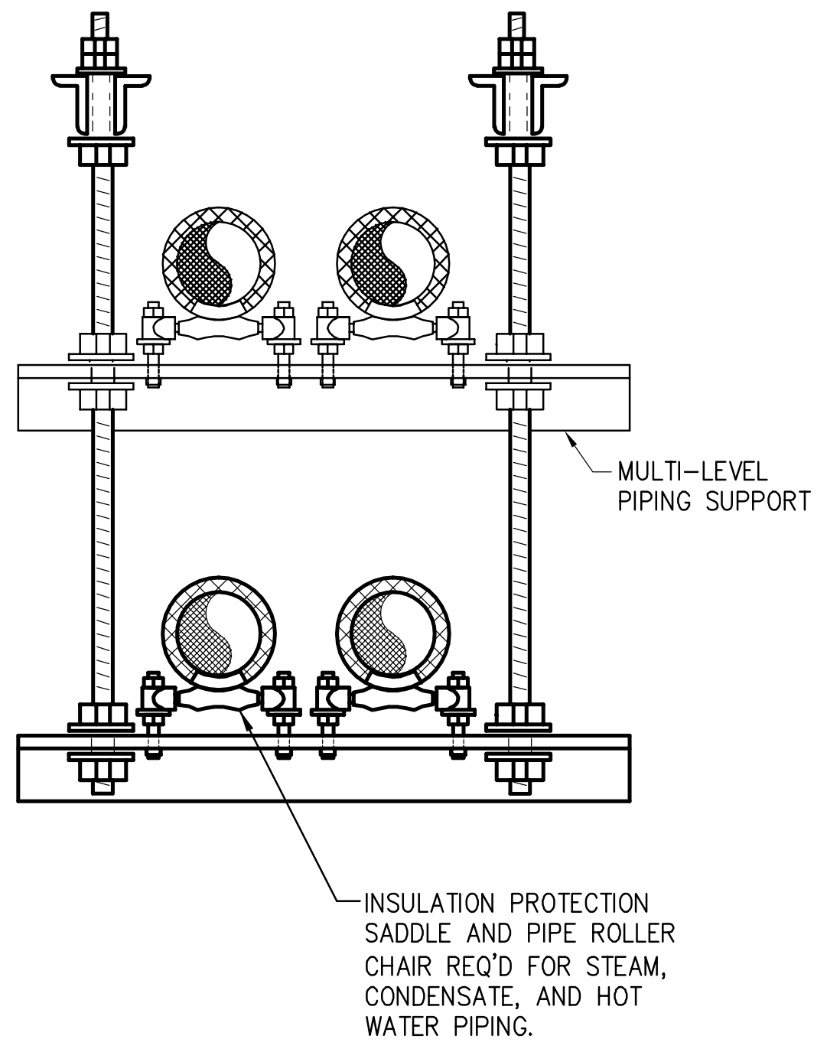
NOTE 1: CONTRACTOR SHALL PROVIDE PIPE SADDLE AND ATTACH TO SUPPORT STEEL.

NOTE 2: CONTRACTOR SHALL SHORTEN 24" LONG SADDLE AS REQUIRED FOR INSTALLATIONS WHERE 24" IS TOO LONG. FIELD VERIFY REQUIRED SADDLE LENGTH.

FOR PIPE RACK INSTALLATION

PIPING SUPPORT DETAIL

DETAIL 13
NO SCALE M-425



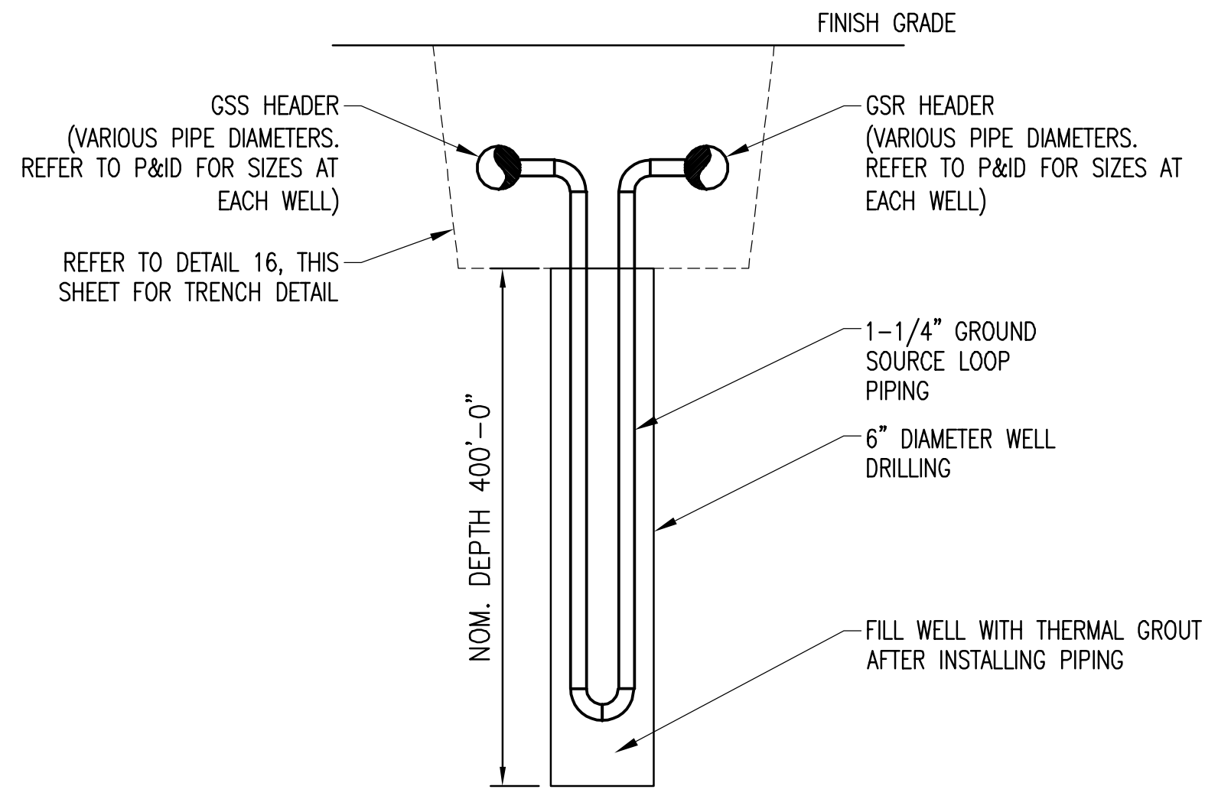
NOTES:

1. SIZE RODS, AND HORIZONTAL MEMBER APPROVED TO SATISFY LOAD REQUIREMENT WITH SAFETY FACTOR OF 5.

2. USE CLEVIS HANGERS IN LIEU OF TRAPEZE SUPPORT WHERE REQUIRED OR WHEN NEEDED TO SLOPE PIPING.

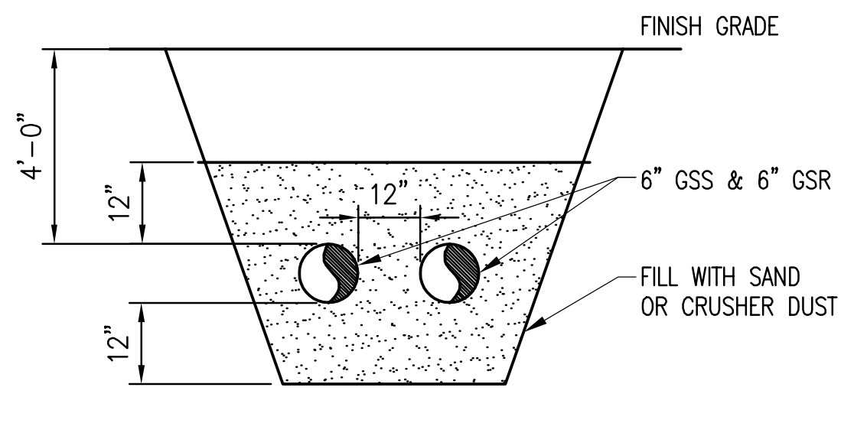
TRAPEZE HANGER PIPING SUPPORT

DETAIL 14
NO SCALE M-425



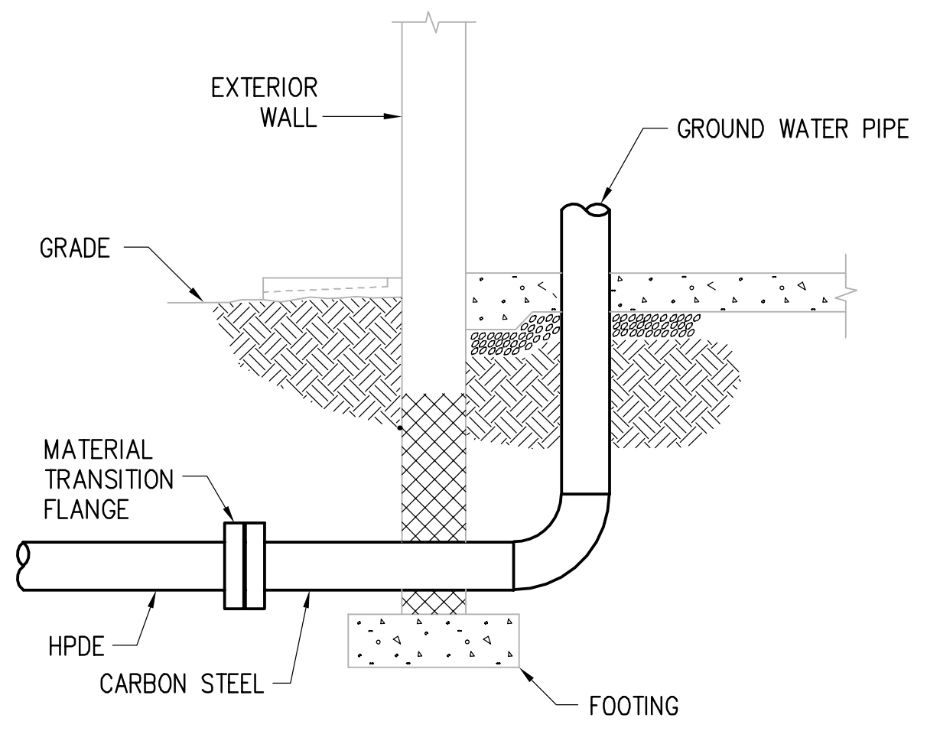
TYPICAL WELL DETAIL

DETAIL 15
NO SCALE M-427



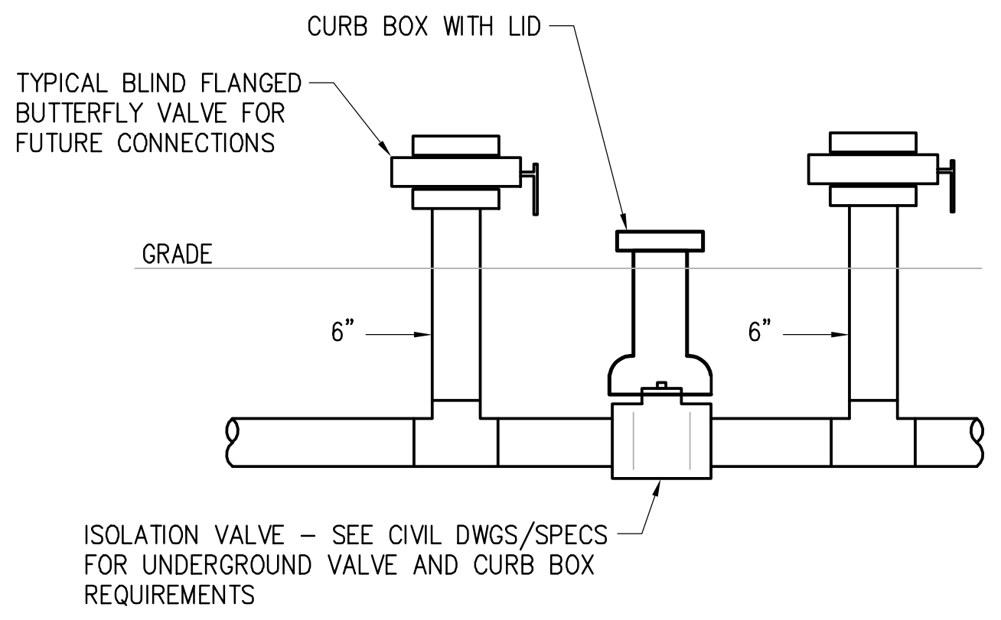
TRENCH DETAIL

DETAIL 16
NO SCALE M-427



MATERIAL TRANSITION DETAIL

DETAIL 17
NO SCALE M-429



EVAPORATIVE COOLER CONNECTION DETAIL

DETAIL 18
NO SCALE M-427

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ROBERT S. DiFIORE 9463
10/30/09

HAROLD W. JONES 031518
10-30-2009

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CITY OF RALEIGH
PUBLIC WORKS DEPARTMENT

WILDERS GROVE SERVICE CENTER
SOLID WASTE SERVICES FACILITY

MECHANICAL
SOLID WASTE SERVICES
MECHANICAL DETAILS

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	M-471

PLOT DATE: 10/30/2009 9:45 AM BY: ERINY

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PUMP SCHEDULE

MARK	SERVES	TYPE	GPM	FEET OF HEAD	MOTORS		MIN EFFIC. %	RPM	TYP. CAT. NUMBER	REMARKS
					MIN HP	VOLTS PH				
GWL-P-1	GROUND WATER LOOP	CENTRIFUGAL	507	90	20	480/3	73	3500	BELL & GOSSETT 1510-3AC	
GWL-P-2	GROUND WATER LOOP	CENTRIFUGAL	507	90	20	480/3	73	3500	BELL & GOSSETT 1510-3AC	

GROUND SOURCE LOOP EQUIPMENT SCHEDULE

TAG	DESCRIPTION	SIZE (GALLONS)	MOUNT (VERTICAL/ HORIZONTAL)	DIMENSIONS (INCHES)	WEIGHT (LBS)	MATERIAL	PRESSURE RATING (PSIG)	TEMPERATURE RATING (DEG F)	MANUFACTURER	MODEL	REMARKS
GWL-EXP-1	GROUND SOURCE LOOP EXPANSION TANK	45	VERTICAL	56 X 16 DIA	517	CARBON STEEL	125	240	BELL & GOSSETT	SERIES D-80V	
GWL-AS-1	GROUND SOURCE LOOP AIR SEPARATOR	34	VERTICAL	26X18X44	579	CARBON STEEL	125	350	BELL & GOSSETT	5360-06F-12-003	

SAFETY RELIEF VALVE SCHEDULE

MARK	MANUFACTURER	MODEL NO.	SIZE	SET PRESSURE (PSIG)	SERVICE	REMARKS
RV-1	WATTS	174A	1-1/2"	75	GROUND LOOP	1,2

COMMENTS

1	ROUTE RELIEF DRAIN TO FLOOR, TERMINATE 6" ABOVE FINISHED FLOOR.
2	SUPPORT RELIEF DRAIN PIPING AS REQUIRED.

PLOT DATE: 10/30/2009 9:46 AM BY: ERINY

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SOLID WASTE SERVICES FACILITY

MECHANICAL
SOLID WASTE SERVICES
MECHANICAL SCHEDULES

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

DATE	OCTOBER 2009
H & S JOB NUMBER	30579-003
HIPP JOB NUMBER	208077
DRAWING NUMBER	M-481

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