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PERFORMANCE-BASED GROUNDWATER MONITORING REPORT: HYDROLOGIC SUMMARY

FORMER SINCLAIR REFINERY SITE WELLSVILLE, NEW YORK

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Acronyms

ft^3/s	cubic feet per second
ft msl	feet mean sea level
gpm	gallons per minute
GWCT	Groundwater Collection Trench
NYSDEC	New York State Department of Environmental Conservation
PBGM	Performance-based Groundwater Monitoring Plan
Q90	stream baseflow conditions
river	Genesee River
Site	OU-2
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
URS	URS Corporation
WLCB	Water Level Control Berm

This report is a continuation of the groundwater collection trench (GWCT) evaluation program and summarizes the hydrological characteristics based on monthly synoptic water surveys conducted in 2010 and 2011, long-term continuous groundwater elevation trend data, and the operation of the GWCT (pumping rates, manhole pumping level changes, etc.). In addition, this report describes the effects the Water Level Control Berm (WLCB), which was installed in the Main Drainage Swale, had on mitigating the groundwater seep located near Manhole G.

Evaluation

Based on the January 2010 to July 2011 hydrologic results, the following key conclusions are reached:

- The cumulative groundwater capture induced by a system of seven pumping manholes (Manhole A to G) within a GWCT is an effective means to reduce the impact of the glacial drift aquifer groundwater from reaching the Genesee River. The January 2010 to July 2011 data are consistent with observations made in previous years (2008 and 2009).
- Therefore, the GWCT pumping system achieves the performance criteria outlined in the Performance-Based Groundwater Monitoring Plan (PBGM).
- Conditions when groundwater capture was not attained at localized areas occurred:
    - When the GWCT total pumping fell below the required rates that are compatible with river flows; and
    - During storm events when high river flows are sustained for an extended period of time. These conditions are characterized by river flows approaching and exceeding 1,000 ft^3/s for more than 1 to 2 weeks.
- Based on 38 years of historical river flows, the GWCT system is effective in capturing groundwater at least 90 percent of anticipated river flows (up to mean daily flow of 1,000 ft^3/s) – barring major storm events.
- The WLCB was installed in October 2010 to mitigate a groundwater seep that had developed in the upper reach of the Main Drainage Swale, near Manhole G. The WLCB reversed the local hydraulic gradient between the WLCB pool and the GWCT (water flowing from the WLCB pool to the GWCT). In this hydraulic setting, the former seep can no longer discharge.
- These conclusions have verified the previous observations made in the January 2010 report titled "Evaluation of the Groundwater Collection Trench Hydraulics and Groundwater Capture Efficiency Report" (URS, 2010).

Recommendations

The following recommendations are based on this data review and historical GWCT performance data presented in previous reports (URS, 2010):

Barrier Wall

Based on two and one-half years of GWCT performance monitoring data (October 2008 through July 2011) and numerical modeling efforts, it is determined that groundwater capture and mitigation of groundwater discharge to the Genesee River by pumping the GWCT alone is effective and sustainable into the foreseeable future. On this basis, a barrier wall (i.e., slurry wall) installed between the trench system and the Genesee River is not needed to facilitate or enhance groundwater capture.

Water Level Control Berm

The WLCB that has been installed in the Main Drainage Swale has provided a reliable method to continuously raise the water level in the southern end of the Main Drainage Swale, thereby creating a reversal in groundwater flow direction toward the GWCT. This flow direction reversal has effectively mitigated seeps along the western site boundary and, therefore, no other remedial actions are necessary to mitigate the former seep located in upper reach of the Main Drainage Swale.

GWCT Operations and Monitoring

The following operation and monitoring procedures are recommended:

- Pump Manholes A through G (Manhole H off).
- Reduce electronic groundwater monitoring program. Conduct continuous monitoring in Manholes A through G only. Terminate the use of LevelTROLL data loggers in piezometers TPZ-01 through TPZ-09, and piezometer/monitoring wells T-1, MW-55R, PW-4, PZ-7, PZ-8, SP-1E, SP-1W, SP-2E, T-08, T-11, T-12, T-18 and T-28 as well as swale staff gauge SG-07.
- Reduce monthly groundwater elevation monitoring program from a site-wide synoptic (all site wells) to manholes and piezometers/wells located in the trench or downgradient of the trench. **Table 2** presents the proposed revised groundwater elevation survey program.
- Implement a GWCT operation management plan focused on maintaining groundwater capture on critical areas of the Site during high river flow conditions and minimizing excessive flow loading to the wetlands treatment system in order to maintain the treatment system efficiency. The following is proposed:

    1. If Genesee River flow is >1,000 ft^3/s, then turn off pumps for Manholes E, F and G. Resume pumping of Manholes E, F and G when the river flow is <1,000 ft^3/s. Note that based on a 39-year history of the Genesee River mean daily flows

(USGS Gage 04221000), it is anticipated that the shutdown criteria will occur approximately 15 days per year (annual 4%); and

2. If Genesee River flow is >5,000 ft^3/s, then turn off all GWCT pumps. Resume pumping of Manhole A, B, C, D, E, F and G when river flow is <1,000 ft^3/s. Note that based on a 39-year history of the Genesee River mean daily flows (USGS Gage 04221000), it is anticipated that the shutdown criteria will occur approximately 2 days per year (annual <1%).

1.0 INTRODUCTION

1.1 Background

A summary report of the groundwater collection trench (GWCT) performance was submitted to the United States Environmental Protection Agency (USEPA) in January 2010 which presented the results of the GWCT long-term monitoring from December 2008 through December 2009, the results of numerical groundwater flow modeling analyses focused on evaluating the effectiveness of the GWCT to capture Site groundwater, and a preliminary evaluation of a groundwater seep located in the headwaters of the Main Drainage Swale. Data presented in the January 2010 report confirmed that the GWCT can provide Site-wide groundwater capture by pumping the GWCT from six manholes (Manholes A through F; URS, 2008). Site-wide capture was possible from pumping manholes, preferential pathways in the GWCT and a groundwater deflection zone caused by losing river reaches.

The GWCT performance was evaluated using three independent means: 1) potentiometric surface evaluation from synoptic field measurements; 2) numerical analysis from a recalibrated groundwater model; and 3) long-term continuous hydraulic data from pressure transducers installed at the pumping Manholes and selective piezometers within and outside the GWCT.

- The first method was based on a potentiometric surface evaluation from synoptic field measurements. These results present insights to seasonal instances of groundwater conditions representing a snapshot of a transient hydrologic environment.
- The second method was based on numerical analysis from a calibrated groundwater model. The modeling results present insights to groundwater conditions that are less constrained by limitations of the monitoring network because the model solves the continuity equation governed by flow dynamics.
- The third method provides insights to the temporal relationship between groundwater pumping and river flow conditions – especially regarding pump settings to maintain groundwater capture at different hydroperiods and extreme climatic conditions where groundwater pumping becomes impractical.

Based on supporting results from these three technical approaches, pumping Manholes A through G will provide 100% Site groundwater capture at the site boundary (from piezometer T-1 to the CELA, approximately 3,300 feet).

The recommendations made in the January 2010 report were:

- Adjust manhole pump switch settings to attain maximum groundwater drawdown efficiency;
- Conduct monthly Site-wide synoptic groundwater elevation measurements from the entire monitoring network and collect continuous water level data from the manholes and selected piezometers for the next 12 months;

- Install a Water Level Control Berm in the upper reach of the Main Drainage Swale to reduce or eliminate the groundwater seep located adjacent to Manhole G. The benefit of reducing or eliminating the groundwater seep is to mitigate potential bank soil erosion caused by the seep;
- Install the Midslope Sheet Pile Wall; and
- Refine the performance criteria in the Performance-based Groundwater Monitoring Plan (PBGM).

This report is a continuation of the GWCT evaluation program and summarizes the hydrological characteristics based on monthly synoptic water surveys conducted in 2010 and 2011, long-term continuous groundwater elevation trend data, and the operation of the GWCT (pumping rates, manhole pumping level changes, etc.). In addition, this report describes the effects the Water Level Control Berm (WLCB), which was installed in the Main Drainage Swale, had on mitigating the groundwater seep located near Manhole G and the effect it had on the groundwater flow regime in this area.

1.2 Remedial Goal

The overall remedial goal for the Former Sinclair Refinery Operable Unit 2 (OU-2; Site) is to reduce the flow of glacial drift aquifer groundwater to the Genesee River (river). Currently this goal is achieved by capturing Site groundwater by extracting (pumping) the groundwater from a 3,300 feet (ft)-long GWCT. The GWCT has eight extraction points or manholes. The GWCT was constructed in such a fashion that it is feasible to intercept groundwater flow and hydraulically capture groundwater prior to discharging to the Genesee River.

As described in the PBGM (URS, 2008), the performance criterion for evaluating the overall performance of the GWCT is as follows:

> ”At a minimum, a groundwater divide between the GWCT and river must be maintained. Achieving this criterion demonstrates that the groundwater gradient between the GWCT and the Genesee River has been reversed (gradient sloping towards the GWCT) and that groundwater flow is not occurring across the GWCT.”

Synoptic Site-wide groundwater elevation measurements collected from the GWCT (manholes and piezometers), the Site monitoring well network, and river staff gages were evaluated to assess the effectiveness of the GWCT in capturing Site groundwater. The evaluation discussed in this report also included the review of long-term continuous groundwater elevation trend data monitored from each manhole and trench piezometer and manhole pumping rates.

2.0 HYDROLOGIC CONDITIONS IN 2010 AND 2011

Site-wide synoptic water level measurements (surveys) were conducted from January 2010 to July 2011. The monitoring network comprised of 132 monitoring wells/piezometers, 13 Genesee River gages, 8 manholes, 9 piezometers in the GWCT and 3 surface water gages in the Main Drainage Swale (**Figure 1**). The water levels collected in the synoptic surveys represented a relatively wide range of hydrologic conditions for the area.

Figure 2 presents the water survey dates and the hydrograph of the Genesee River mean daily streamflows since the PBGM program began in June 2008. Additionally, it presents the mean daily flow statistic based on 41 years of historical flows. Barring storm events, the hydrologic conditions between 2008 and summer of 2010 were generally drier than normal conditions (based on past 41 years of daily flow statistics published by the U.S. Geological Survey; USGS). Starting in the fall of 2010, the river flows approached relatively closer to normal flows excluding the flood conditions on December 1, 2010.

River flows during spring 2011 exhibited unusually high flows that greatly exceeded normal conditions, including mean daily flows that frequently exceeded 1,000 cubic feet per second (ft^3/s). These seasonally high flows were never experienced in the Genesee River since it was altered in the early 1970s for flood control purposes. The unique event is also underscored by the number of days when spring season mean daily flows exceeded 1,000 ft^3/s from 1973 to 2011 (**Figure 2 Inset**). The number of days when mean daily flows exceeded 1,000 ft^3/s between March and May in 2011 was almost twice (60 days) as previously experienced in the four highest event days during the 38 year history: 2004 (30 days), 1993 (32 days), 1984 (30 days) and 1978 (32 days).

The synoptic water level survey events for the 2010 and 2011 period occurred when the Genesee River mean daily streamflows at the USGS gage in Wellsville ranged from 31 ft^3/s (September 23, 2010) to 1,830 ft^3/s (March 22, 2011). **Figure 3** displays the flow duration curve of the Genesee River based on mean daily streamflows between October 1972 and July 2011 (USGS National Water Inventory System) and the Site hydrologic surveys conducted from January 2010 through July 2011.

Generally, streamflows that occur between 40 percent and 60 percent of the flow duration can be considered as normal average conditions as illustrated on **Figure 3**. Streamflows that occur less than 40 percent are characteristic of wetter conditions and greater than 60 percent, drier conditions. Stream baseflow (Q90) is estimated to be less than 40 ft^3/s.

The streamflows that were observed during each of the synoptic water level survey events in 2010 and 2011 are plotted to show the range of hydrologic conditions evaluated for the GWCT performance. The hydrologic conditions represented in the synoptic events ranged from extremely dry conditions below the Q90 baseflow (September 23, 2010; river flow 31 ft^3/s) to very wet conditions (March 22, 2011; river flow 1,830 ft^3/s). Therefore, this hydrologic evaluation adequately represents a wide range of climatic conditions anticipated at the Site based on river conditions observed in the previous 38 years – including a unique spring condition that was never experienced in the hydrologic record since 1973. It is also noted that the region experienced flood conditions on December 1, 2010 when the Genesee River streamflow was measured at 11,300 ft^3/s (USGS Gage 04221000).

3.0 REMEDIAL SYSTEM UPGRADES

In order to maintain bank stability during sediment remediation activities conducted along the Genesee River bank and channel, a mid-slope sheet pile wall was constructed on June 15, 2010, at the riverbank between manholes B and C, just below the Genesee River lower drop structure. The mid-slope sheet pile wall affected local groundwater flow in the vicinity of Manholes B and C – primarily by reducing aquifer connectivity to the river. The hydrologic effects are described in the following section for the month of June.

A Water Level Control Berm (WLCB) was constructed in October 2010 and became operational on November 5, 2010 in the headwater of the Main Drainage Swale and adjacent to the Genesee River upper drop structure. The purpose of the WLCB was to mitigate a groundwater seep discharging to the Main Drainage Swale by reversing the hydraulic gradient between the swale and groundwater. The hydrologic effect of the WLCB was successful in mitigating the seep and enhancing the hydraulic capture between the WLCB and Manhole G. The hydraulic loading to the aquifer caused by the WLCB pool water is discussed in **Section 4.0** for the month of November, December 2010 and February 2011.

In December 2010, following the record flood conditions of the Genesee River (11,300 ft^3/s), it was observed that the discharge pipe in the berm showed signs of piping and water loss. Repairs to the WLCB were performed in January 2011, which included construction of a concrete anti-seep collar and concrete spillway.

4.0 SYNOPSIS OF GROUNDWATER CAPTURE

The following sections provide an overview of the groundwater capture conditions observed during the past 18 months (January 2010 through July 2011). Potentiometric surface maps discussed in this section are presented on a CD and included in **Appendix A**. Only selected maps (**Figure 8**, **Figure 16**, **Figure 17** and **Figure 21**) are provided in paper format and presented in the Figure section of this report.

4.1 January 2010

Water levels measured on January 21, 2010 represented wet conditions in the Genesee River (streamflow 355 ft^3/s). The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 133 gallons per minute (gpm).

The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system in the vicinity of Manholes A; and C through H (**Figure 4 – see CD in Appendix A**). The exception is in the vicinity of Manhole B where it was being pumped at a reduced average rate of approximately 3 gpm (drawdown of 1.6 ft from static conditions). The areas where capture was not achieved are located between the manhole and flanking mid-trench piezometers TPZ-02 and TPZ-03. Groundwater capture does occur in the immediate vicinity of Manhole B. The pumping rate at Manhole B was deliberately reduced in order to evaluate the total contaminant loading to the wetland treatment system which had not fully matured yet. In the subsequent months, Manhole B pumping rate was increased in a step-wise schedule to further assess the loading effects to the wetland treatment system.

In the Main Drainage Swale, surface water elevations have consistently been above 1487 feet mean sea level (ft msl) since the swale was monitored at gage SG-06 (installed November 2009). These readings make the swale the highest water body between Manhole D and the upper drop structure in the Genesee River – contributing to a groundwater divide underneath the swale. This feature was consistent throughout the year. East of the swale, groundwater flows to the Genesee River. West of the swale, groundwater flows to the GWCT. The higher surface water elevations at the swale appear to be sustained by increased discharge from the GWCT/wetlands treatment system relative to the previous year and possibly by the temporary berm next to gage SG-06.

4.2 February 2010

Water levels were measured on February 23, 2010. The hydrologic conditions of the Genesee River were unknown for this date because the USGS gauging station was iced up. The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 114 gpm.

The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system in the vicinity of Manholes A; and C through H (**Figure 5 – see CD in Appendix A**). The exception is in the vicinity of Manhole B where it was being pumped at a reduced average rate of approximately 4 gpm (drawdown of 1.6 ft from static conditions). The areas where capture was not achieved are located between the manhole and flanking mid-trench piezometers TPZ-02 and TPZ-03. Groundwater capture does occur in the immediate vicinity of Manhole B. As discussed earlier, the pumping rate at Manhole B was deliberately reduced in order to evaluate the total contaminant loading to the wetland treatment system which had not fully matured yet.

4.3 March 2010

Water levels measured on March 19, 2010 represented very wet conditions in the Genesee River. The mean daily streamflow was 925 ft^3/s, which was the third highest flow condition observed during the synoptic water level measurement survey program (June 2008 through June 2011). Based on the flow duration evaluation (**Figure 3**), this flow represents approximately 8 percent of the total flows observed in the past 38 years. (This also means that 92 percent of mean daily flows at the river in the past 38 years were lower than 925 ft^3/s.) The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 179 gpm.

The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system in the vicinity of Manholes A; and C through H (**Figure 6 – see CD in Appendix A**). The exception is in the vicinity of Manhole B where it was being pumped at a reduced average rate of approximately 6 gpm as part of the contaminant loading evaluation to the wetland treatment system (drawdown of 0.2 ft from static conditions). The areas where capture was not achieved are located between the manhole and flanking mid-trench piezometers TPZ-02 and TPZ-03.

4.4 April 2010

Water levels measured on April 15, 2010 represented normal average conditions in the Genesee River (streamflow 190 ft^3/s). The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 129 gpm.

The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system in the vicinity of Manholes A; and C through H (**Figure 7 – see CD in Appendix A**). The exception is in the vicinity of Manhole B where it was being pumped at a reduced average rate of approximately 5 gpm as part of the contaminant loading evaluation to the wetland treatment system (drawdown of 1.3 ft from static conditions). The areas where capture was not achieved are located between the manhole and flanking mid-trench piezometers TPZ-02 and TPZ-03.

4.5 May 2010

Water levels measured on May 24, 2010 represented normal average conditions in the Genesee River (streamflow 246 ft^3/s). The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 152 gpm.

The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system in Manholes A through H (**Figure 8**). It is also noted groundwater capture was attained in the vicinity of Manhole B, which was pumping at approximately 21 gpm with a groundwater elevation of 1476.78 ft msl (drawdown of 6.3 ft from static conditions).

4.6 June 2010

Water levels measured on June 18, 2010 represented normal average conditions in the Genesee River (streamflow 171 ft^3/s). The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 132 gpm.

The mid-slope sheet pile wall was completed on June 15, 2010 in the vicinity of Manhole C. The mid-slope sheet pile wall reduced the aquifer connectivity to the Genesee River in this region – similar to a no-flow boundary condition. With a reduced down-gradient source of water to the pumping center, the mid-slope sheet pile wall contributed to drawdown effects that extended laterally within the GWCT. This resulted in a more efficient groundwater capture for the area although Manhole C was pumping at a relatively low rate of 3 gpm. The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system in Manholes A through H (**Figure 9 – see CD in Appendix A**).

4.7 July 2010

Water levels measured in July 28, 2010 represented normal average conditions in the Genesee River (streamflow 169 ft^3/s) similar to the previous month. The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 129 gpm. The potentiometric surface contours show that Site groundwater is captured by the GWCT pumping system in Manholes A through H (**Figure 10 – see CD in Appendix A**).

4.8 August 2010

Water levels measured in August 31, 2010 represented very dry conditions in the Genesee River (streamflow 52 ft^3/s). The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 112 gpm. The potentiometric surface contours show that Site groundwater is captured by the GWCT pumping system in Manholes A through H (**Figure 11 – see CD in Appendix A**).

4.9 September 2010

Water levels measured in September 23, 2010 represented the driest period evaluated for the year. The Genesee River streamflow was 31 ft^3/s, which is below the Q90 baseflow. The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 90 gpm. The potentiometric surface contours show that Site groundwater is captured by the GWCT pumping system in Manholes A through H (**Figure 12 – see CD in Appendix A**).

4.10 October 2010

Water levels measured in October 28, 2010 represented very wet conditions in the Genesee River (streamflow 456 ft^3/s). The GWCT was pumped at Manholes B through F at a total average pumping rate of approximately 73 gpm. The GWCT system pumpage was reduced because Manholes A and G were not pumping on the day the survey was conducted. Manhole A pump malfunctioned during the synoptic data event. Manhole G was deliberately shut down to collect static water levels as baseline prior to the installation of the WLCB – primarily to measure the natural hydraulic gradient between the WLCB pool and Manhole G under static conditions.

The potentiometric surface contours show that Site groundwater is captured by the GWCT pumping system in Manholes B through F (**Figure 13 – see CD in Appendix A**). However, in the vicinity of Manholes A and G, groundwater levels recovered to almost static conditions.

4.11 November 2010

Water levels measured in November 19, 2010 represented very wet conditions in the Genesee River (streamflow 520 ft^3/s). The survey was conducted when the river was still in recession after a storm on November 17, 2010. The GWCT was pumped at Manholes A through F at a total average pumping rate of approximately 103 gpm. Manhole G was not pumping due to the recent construction of the WLCB in the swale (completed November 5, 2010) and the need to acquire static water levels as baseline.

The potentiometric surface contours show that Site groundwater is captured by the GWCT pumping system in Manholes A through F (**Figure 14 – see CD in Appendix A**). In the vicinity of the WLCB the following characteristics apply:

- The surface water elevation of the WLCB pool was greater than groundwater elevations near the berm – indicating the pool is losing water to the aquifer.
- On this basis, the seep, which was previously discharging to the swale can no longer discharge groundwater to the swale.
- Without Manhole G pumping, Manhole F could not sustain enough drawdown to maintain groundwater capture – part of which is attributed to high river conditions that necessitate increased pumping.

4.12 December 2010

Water levels were measured on December 21, 2010. The hydrologic conditions of the Genesee River were unknown for this date because the USGS gauging station was iced. The GWCT was pumped at Manholes A through F at a total average pumping rate of approximately 119 gpm.

The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system in the vicinity of Manholes A through F (**Figure 15 – see CD in Appendix A**). Based on water levels and hydraulic gradients, it appears that groundwater may leave the GWCT towards the Main Drainage Swale in the vicinity of mid-trench piezometer TPZ-07 – midway between manholes F and G. The primary reasons may be high streamflow conditions due to the December 1, 2010 flood event, no pumping at Manhole G and additional water entering the GWCT from the WLCB pool – all contributing to greater head in the GWCT relative to down-gradient region near piezometer TPZ-07. Additionally, the surface water at the Main Drainage Swale had the lowest elevation (1487.62 ft msl as measured at gage SG-06) relative to adjacent groundwater (T-08, 1487.94 ft msl; TPZ-07, 1488.61 ft msl).

Capture at Manhole G was enhanced by the hydrologic effects of the WLCB surface water pool (note Manhole G was not pumping during this synoptic event).The WLCB surface water pool reversed the groundwater flow so that the pool is losing water about half the extent of the western bank (from the berm southward) and flowing toward the trench. Without Manhole G pumping, capture at Manhole G only extends south to approximately piezometer T-27. Therefore, groundwater in the vicinity of Manhole H flows towards the headwater region of the Main Drainage Swale.

4.13 January 2011

No synoptic water level measurements were conducted for the month.

4.14 February 2011

Water levels were measured on February 3, 2011. The hydrologic conditions of the Genesee River were unknown for this date because the USGS gauging station was iced. It is believed water levels measured on February 3, 2011 represent normal average conditions in the Genesee River (streamflow less than 300 ft^3/s). This is based on similar groundwater elevations at background monitoring well MW-99 compared to the June 18, 2010 water data. On February 3, 2011, the groundwater elevation at monitoring well MW-99 was 1495.44 ft msl and on June 18, 2010, 1495.90 ft msl when the river streamflow was 171 ft^3/s . The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 132 gpm. The potentiometric surface contours show that Site groundwater is captured by the GWCT pumping system in Manholes A through H (**Figure 16**).

The groundwater elevation data suggests that the hydrologic effect of the WLCB pool enhances the GWCT groundwater capture from Manhole F to Manhole H. Additionally, the WLCB is effective in mitigating the former seep in the headwater of the swale. **Figure 16** displays the potentiometric surface contours in the vicinity of the WLCB. The following features are observed:

- The WLCB surface water pool elevation was 3.24 ft higher than groundwater elevation at Manhole G, which is relatively significant (hydraulic gradient 0.034 ft/ft).
- Additionally, the WLCB surface pool elevation was higher than groundwater elevations observed between the pool and trench at piezometers MW-55R, PZ-07 and PZ-08.
- Therefore, the WLCB surface water pool is losing water throughout the extent of its western bank and flowing toward the trench. On the eastern bank, the Genesee River is flowing into the WLCB pool.
- On this basis, the seep, which was previously discharging to the swale can no longer function due to the reversal of the hydraulic gradient.
- Pumping at Manhole G (35 gpm) created drawdown of 3 ft facilitating groundwater capture at Manhole H.
- Downgradient from Manhole G, efficient pumping at Manhole F (22 gpm) is maintaining groundwater capture.

4.15 March 2011

Water levels measured on March 22, 2011 represented very wet conditions in the Genesee River. The mean daily streamflow was 1,830 ft^3/s, which was the highest flow condition observed to date since synoptic water level measurements were made. Based on the flow duration evaluation (**Figure 3**), this flow represents approximately 3 percent of the total flows observed in the past 38 years. The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 155 gpm during this period. Prior to March 22, 2011, the Genesee River was flowing at greater than 1,000 ft^3/s for 18 days with peak flow of 5,640 ft^3/s on March 6, 2011. These flow rates caused the GWCT pumps to operate at maximum capacity at a combined rate of 220 to 230 gpm. The wetland treatment system is designed to treat a maximum sustained flow rate of 150 gpm. Long-term pumping of the GWCT at rates greater than 150 gpm is not beneficial to the effective operation of the wetland treatment system. Therefore, the manhole pumping rates were reduced in March by approximately 34 % from a total of 228 gpm (February 28, 2011) to 150 gpm (March 8, 2011). Reducing the flow rate limited the drawdown efficiency the GWCT during the extreme high streamflow conditions.

The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system at Manhole A, between Manholes B through F and at Manhole G (**Figure 17**). The exception is in the regions between Manhole A and B, between Manhole F and G and in the vicinity of Manhole H where the high river condition contributed to less drawdown in the GWCT. The primary reason is attributed to the unusually high river condition contributing surface water bank flow to the groundwater system and the limitation of the GWCT system to maintain adequate drawdown at the prescribed pumping rates.

4.16 April 2011

Water levels measured on April 11, 2011 also represented very wet conditions in the Genesee River. The mean daily streamflow was 1,220 ft^3/s, which was the second highest flow condition observed to date since synoptic water level measurements were made. The synoptic survey was made during the recession period from a storm event when peak flow was 4,660 ft^3/s on April 6, 2011. Based on the flow duration evaluation (**Figure 3**), this flow represents approximately 6 percent of the total flows observed in the past 38 years. The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 153 gpm during this period.

The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system at Manhole A, between Manholes B through E and at Manholes F, G and H (**Figure 18 – see CD in Appendix A**). The exception is in the regions between Manhole A and B, between Manhole E and F, and between Manholes F and G. Similar to the previous month, the primary reason is attributed to the unusually high river condition contributing water to the groundwater system and the limitation of the GWCT system to maintain adequate drawdown at the prescribed pumping rates. In addition the high rainfall in the vicinity of the Site resulted in increased infiltration and locally elevated groundwater condition at the site.

4.17 May 2011

Water levels measured on May 23, 2011 represented very wet conditions in the Genesee River. The mean daily streamflow was 898 ft^3/s, which was the fourth highest flow condition observed to date when synoptic when synoptic measurements were made. The synoptic survey was made during the recession period from a storm event when peak flow was 1,750 ft^3/s on May 20, 2011. Based on the flow duration evaluation (**Figure 3**), this flow represents approximately 9 percent of the total flows observed in the past 39 years. The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 135 gpm during this period.

The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system between Manholes B through E, at Manholes F and between Manholes G and H (**Figure 19 – see CD in Appendix A**). The exception is in the regions between Manhole A and B and between Manholes F and G. The primary reason is attributed to the unusually high river condition contributing water to the groundwater system and particularly the reduced pumpage at Manhole A (10 gpm).

4.18 June 2011

Three synoptic water level measurements were conducted in June: 1) June 1, 2011 under pumping conditions (Manholes A, B, C, D, F and G pumping); 2) June 17, 2011 under non-pumping conditions (static); and 3) June 29, 2011 under pumping conditions (Manholes A, B, C, D, F and G pumping). The following discusses the synoptic survey results during GWCT pumping only (June 1, 2011 and June 29, 2011).

June 1, 2011

Water levels measured on June 1, 2011 represented close to very wet conditions in the Genesee River (approximately 12 percent of the total flows observed in the past 38 years; **Figure 3**). The mean daily streamflow was 811 ft^3/s. The synoptic survey was made during the recession period from a storm event when peak flow was 2,540 ft^3/s on May 30, 2011. The GWCT was pumped at Manholes A through D and at Manholes F and G. Manhole E was shut down. The total average pumping rate was approximately 193 gpm during this period.

The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system between Manholes A through F and between Manholes G and H (**Figure 20 – see CD in Appendix A**). The sole exception is in the mid-region between Manhole F and G. In the vicinity of piezometer TPZ-07 (between Manhole F and G), the surface water of the Main Drainage Swale had the lowest elevation (1487.64 ft msl at SG-06). Therefore, groundwater may leave the GWCT locally and discharge into the Main Drainage Swale. Although the river conditions were relatively wet during this month, the high GWCT system pumpage demonstrates that groundwater capture can be attained in most of the targeted regions except in the localized area between Manholes F and G. This area is also downgradient from water leaving the WLCB due the reversed hydraulic gradient between the WLCB pool and groundwater in the vicinity of Manhole G. Based on static water levels alone, it is possible that the additional water contribution from the WLCB pool into the GWCT may contribute to the elevated groundwater head observed at mid-trench piezometer TPZ-07 in the region between Manholes F and G.

Of note is that inland groundwater does not leave the GWCT in the vicinity of Manhole E despite any groundwater withdrawals occurring in this area. Therefore, groundwater intercepting the GWCT is being captured by the drawdown induced by Manhole D pumping.

June 29, 2011

Water levels were measured on June 29, 2011 to further evaluate the hydraulic relationship between the WLCB pool, groundwater conditions at the GWCT and recent seepage that had developed in the Main Drainage Swale immediately north of the WLCB. As part of this effort, a surface water gage (SG-08) was installed in the Main Drainage Swale just north (below) the WLCB to compare the surface water elevation to groundwater in the vicinity (mid-trench piezometer TPZ-07 area between Manholes F and G). Additionally, Manhole E had been shut down since the June 1, 2011 period.

The water levels measured on June 29, 2011 represented dry conditions (**Figure 3**) when the Genesee River flow was 101 ft^3/s. The GWCT was pumped at Manholes A through D and Manholes F and G at a total average pumping rate of approximately 142 gpm during this period.

The potentiometric surface contours are shown in **Figure 22**. The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system between Manholes A through H (**Figure 21**). Between Manhole F and G, groundwater is being captured by Manhole F pumping. This observation is made primarily due to the surface water elevation of the Main Drainage Swale (SG-08; 1487.59 ft msl) that is higher than adjacent groundwater: T-08, 1487.18 ft msl; T-37, 1487.41 ft msl; and TPZ-07, 1487.58 ft msl.

4.19 July 2011

The water levels measured on July 13, 2011 represented dry and baseflow conditions (**Figure 3**) when the Genesee River flow was 42 ft^3/s. The GWCT was pumped at Manholes A through G at a total average pumping rate of approximately 154 gpm during this period.

The potentiometric surface contours are shown in **Figure 22**. The potentiometric surface contours show that Site groundwater was captured by the GWCT pumping system between Manholes A through H (**Figure 22**).

5.0 GWCT OPERATIONS

5.1 January 2010 through December 2010

The GWCT was continuously operated during 2010 with pumping of Manholes A through G. Manhole H was not operated in 2010. The GWCT was shut down for two weeks from June 23, 2010 through July 6, 2010 for routine maintenance of the GWCT and the treatment system ponds. From October 28, 2010 through December 31, 2010, Manhole G was not pumped because it was turned off to facilitate a study of the WLCB and its effects on the hydraulic loading of the aquifer in the vicinity of Manhole G.

Based on review of the long-term continuous groundwater level elevation trend data (January 1, 2010 through December 17, 2010) collected from each manhole and trench piezometer and manhole pumping rates, the following was observed. These observations are based on the groundwater elevation trend data and pumping rates presented in **Figures 23** through **41**.

- The GWCT (Manholes A through F) was operational for more the 91% of the time during 2010. Manhole G was in operation for 76% of the time (note Manhole G was off from November through December to facilitate a study on the effect of the WLCB on groundwater flow). A summary of the operational run time is provided below:

Manhole ID	Run Days	Off Days	Run Time
MH-A	331	34	91%
MH-B	351	14	96%
MH-C	351	14	96%
MH-D	351	14	96%
MH-E	351	14	96%
MH-F	351	14	96%
MH-G	279	86	76%
MH-H	0	365	0%

- The pumps in the GWCT are configured to maintain a specific groundwater drawdown in the manholes. The float switch settings and average drawdown maintained during the 4th quarter of 2010 in the manholes is summarized below:

Manhole ID	Pump High Level Switch Setting (ft msl)	Pump Low Level Switch Setting (ft msl)	Average Groundwater Drawdown Elevation (ft msl)	Pump Cycle Amplitude (ft)	Average Groundwater Drawdown (ft) (note 1)
A	1478.3	1477.0	1477.7	1.3	5.5
B	1478.0	1475.8	1476.9	2.2	6.1
C	1479.0	1477.3	1478.2	1.7	4.0
D	1483.0	1481.6	1482.3	1.4	3.8
E	1483.5	1483.3	1483.4	0.2	3.8
F	1483.5	1482.2	1482.9	1.3	4.9
G	1488.6	1486.7	1487.7	1.9	1.7
H	na	na	na	na	na

na = not applicable
msl = mean sea level
Note 1: Based on static water level conditions observed on July 7, 2010

- Manhole pumps A, B, C, D, E, F and G successfully lowered groundwater elevations to pump float switch set points and the pumps cycled. Manhole pump cycle patterns and significant operation events for Manholes A through G are illustrated on **Figures 23** through **41**.
- Pumping rates for GWCT varies with the change in the Genesee River streamflow with higher pumping rates observed during higher streamflow conditions (see Section 5.3).
- From April through September, potential sporadic loss of groundwater capture was observed in the vicinity of Manhole E and mid-trench piezometer TPZ-05. During this time period Manhole E pumping rate was held constant at rates ranging from 25 to 30 gpm. These rates resulted in marginal drawdown differential of approximately <0.5 ft between Manhole E and trench mid-trench piezometer TPZ-05. Synoptic groundwater elevation measurement events demonstrate that groundwater capture was achieved during those time frames; however, the continuous groundwater elevation data shows that due to low pumping rates, minimal groundwater drawdown was achieved in this area potentially reducing effectiveness of GWCT to sustain groundwater capture. **Figure 34** and **Figure 35** compare the groundwater elevation trends for Manhole E and piezometer TPZ-05 and illustrated the small drawdown differential between the two monitoring points.

5.2 January 2011 through July 2011

The GWCT was continuously operated during the first half of 2011 with pumping of Manholes A through G. Manhole H was not operated in 2011. The GWCT was shut down for two weeks from June 3, 2011 through June 17, 2011 for routine maintenance of the GWCT and the treatment system ponds. From January 1, 2011 through January 31, 2011, Manhole G was not pumped because it was turned off to facilitate a study of the WLCB and its effects on the hydraulic loading of the aquifer in the vicinity of Manhole G. From May 26 through June 3, 2011 and June 17, 2011 to July 5, 2011, Manhole E was turned off to assess the effectiveness of Manholes D and F in capturing groundwater along Manhole E's trench system (from trench mid-trench piezometer TPZ-05 to trench mid-trench piezometer TPZ-06).

Based on review of the continuous groundwater level elevation trend data (January 1, 2011 through June 30, 2011) collected from each manhole and trench piezometer and the manhole pumping rates, the following was observed. These observations are based on the groundwater elevation trend data and pumping rates presented on **Figures 23** through **41**.

- The GWCT (Manholes A, B, C, D and F) was operational for more the 92% of the time during first half of 2011. Due to various hydraulic studies performed on the GWCT system, Manholes E and G were in operation 88% and 75% of the time, respectively. Manhole E was off in late May and late June to assess the effects Manholes D and F have on capturing groundwater along Manhole E's trench system. Manhole G was off in January to facilitate a study on the effect of the WLCB on groundwater flow. A summary of the operational run time is provided below:

Manhole ID	Run Days	Off Days	Run Time
MH-A	167	14	92%
MH-B	167	14	92%
MH-C	167	14	92%
MH-D	167	14	92%
MH-E	159	22	88%
MH-F	167	14	92%
MH-G	136	45	75%
MH-H	0	181	0%

- The pumps in the GWCT are configured to maintain a specific groundwater drawdown in the manholes. The float switch settings and average drawdown maintained at the end of the 2nd quarter of 2011 in the manholes are summarized below:

Manhole ID	Pump High Level Switch Setting (ft msl)	Pump Low Level Switch Setting (ft msl)	Average Groundwater Drawdown Elevation (ft msl)	Pump Cycle Amplitude (ft)	Average Groundwater Drawdown (ft) (note 1)
A	1478.7	1478.0	1478.4	0.7	4.8
B	1479.0	1478.0	1478.5	1.0	4.5
C	1479.0	1477.3	1478.2	1.7	1.4
D	1484.5	1483.5	1484.0	1.0	2.1
E	1485.0	1484.0	1484.5	1.0	2.8
F	1484.5	1482.5	1483.5	2.0	4.2
G	1488.6	1486.7	1487.7	1.9	1.6
H	na	na	na	na	na

na = not applicable
msl = mean sea level
Note 1: Based on static water level conditions observed on July 7, 2010

- Manhole pumps A, B, C, D, E, F and G successfully lowered groundwater elevations to pump float switch set points and the pumps cycled. Manhole pump cycle patterns and significant operation events for Manholes A through G are illustrated on **Figures 23** through **41**.
- Pumping rates for GWCT vary with the change in the Genesee River streamflow, with higher pumping rates observed during higher streamflow conditions (see Section 5.3).

From March through May 2011, historically high spring river flow influenced the water table elevation throughout the Site and caused the water table to rise 3 to 4 ft while the GWCT was pumping. During the first week of the high river flow event all manhole pumps were operating at 100% maximum capacity at a total combined rate of 206 to 238 gpm. These rates are approximately 150% higher than the design capacity of the wetland treatment system. On March 8, 2011, due to concerns of maintaining the treatment system discharge criteria, the flow rates for Manholes A, B, D, E, F and G were reduced by closing their discharge values to restrict flow while still maintaining aggressive pumping during the high river flow event. Subsequently, due to reduced instantaneous flow rates coupled with the high river flow the GWCT could not dewater the aquifer system to the pre-set drawdown levels. The reduced pumping capacity resulted in marginal drawdown differentials along the GWCT system. Synoptic groundwater elevation measurement events (March – May 2011) demonstrate that groundwater capture was achieved along a majority of the GWCT system during this period; however, the continuous groundwater elevation data show that due to restricted pumping rates and historically high river flow, minimal groundwater drawdown was achieved, potentially reducing effectiveness of the GWCT to sustain groundwater capture during the extreme high river flow periods.

5.3 GWCT Pumping Rates vs. River Flow

The spring season of 2011 was characterized by unusually high and sustained river conditions, with 60 days of mean daily flows exceeding 1,000 ft^3/s. When river flows approach 1,000 ft^3/s (storm events), the GWCT pumping system may generally require greater than 180 gpm to maintain Site-wide groundwater capture (based on observations made March 19, 2010 and June 1, 2011). On this basis, limited groundwater capture observed between certain pumping manholes in March, April and May 2011 is attributed to total pumpage (less than 180 gpm) and when river flows were very high (approaching or greater than 1,000 ft^3/s).

The empirically derived relationship between the GWCT system pumpage, river flows and the groundwater capture efficiency is presented on **Figure 42**. The figure displays three groups of data relationships.

- The first group (symbolized in yellow) represents synoptic water level measurement events that demonstrate when Site-wide or near Site-wide capture was attained from January 2010 to July 2011. The best-fit trend line (dashed) represents the general total pumping rates that contributed to full groundwater capture at different river flow conditions. For instance, during normal average conditions, the GWCT total pumpage ranged between 140 to 160 gpm to maintain Site-wide groundwater capture – which also represents the optimal design capacity of the wetlands treatment system for long-term management and operation.
- Partial groundwater capture was observed when the GWCT total pumpage fell below the 140 to 160 gpm range (below the dashed line) relative to river flows. This is evidenced by the second group of synoptic events (symbolized in blue) when partial groundwater capture was observed primarily due to reduced pumping (or no pumping) at certain manholes during normal average or wet conditions. It is noted that all of these events occurred when Manhole B or G pumping rates were deliberately reduced or shut down as part of this study, respectively. The exception was a pump malfunction at Manhole A during the October 28, 2011 survey.
- The final group (symbolized in red) belongs to synoptic water level measurement events when partial capture was observed due to reduced pumping during very high and sustained river flows (mostly in the spring months of 2011).

The empirical relationship demonstrates that full groundwater capture is attainable when the GWCT total pumping rates are compatible with river conditions. During very wet conditions typical of storm events, the pumping requirement exceeds 200 gpm, which is not feasible to sustain for long periods because the wetlands treatment system is only designed to treat an average flow rate of approximately 150 gpm.

6.0 GROUNDWATER MODEL FLOW ANALYSIS AND WATER LEVEL CONTROL BERM

6.1 Groundwater Model Flow Analyses

Three groundwater flow simulations were conducted utilizing the calibrated numerical groundwater flow model developed for this project (URS, 2010; Michael Planert April 2011 personal communication). The objectives of the simulation are: 1) assess various GWCT pumping scenarios to determine the effects the pumping scheme has on creating hydraulic capture of Site groundwater flowing to the Main Drainage Swale/river from Manhole D to Manhole H; 2) model the May 23, 2011 GWCT pumping configuration and Genesee River flow conditions to assess the hydraulic capture of the trench during very wet river flow conditions (e.g., 898 ft^3/s on May 23, 2011; previous 24 hour flow 977 ft^3/s; peak 1,750 ft^3/s on May 20, 2011) (**Figure 3**); and 3) model the groundwater flow in the vicinity of the WLCB and determine the groundwater flow paths between the WLCB and the GWCT. The model used to conduct these simulations is the URS 2010 model (URS, 2010) updated to include: 1) WLCB constructed in the headwater of the Main Drainage Swale; and 2) Mid-slope sheet pile wall constructed along the riverbank between Manholes B and C. Presented below is a summary of the model simulations results.

6.1.1 Sensitivity Analysis of the GWCT Pumping Scenarios

Model simulations were conducted to evaluate four GWCT pumping scenarios to determine the effects the pumping scheme has on creating hydraulic capture of Site groundwater flowing to the Main Drainage Swale/river from Manhole D to Manhole H. The assumptions used in the model simulations were set to resemble the October 23, 2010 river flow conditions and the pumping of Manholes A through G. Below is the model parameters used in the simulations:

- Genesee River discharge rate at 456 ft^3/s; and
- Manhole pumping rates (total flow at 139 gpm): MH-A at 16 gpm, MH-B at 19 gpm, MH-C at 4 gpm, MH-D at 13 gpm, MH-E at 25 gpm, MH-F at 27 gpm, MH-G at 35 gpm and MH-H was off (0 gpm).

Presented below are the results of the four model simulations:

- Manholes A through G pumping (baseline) (total flow 139 gpm): Complete groundwater capture along entire length of GWCT (**Figure 43**).
- Manholes A, B, C, D, F and G pumping (total flow 114 gpm): Complete groundwater capture along entire length of GWCT, even with Manhole E off (**Figure 44**).
- Manholes A, B, C, D and G pumping (total flow 87 gpm): No groundwater capture between Manholes E and F (**Figure 45**).
- Manholes A, B, C and D pumping (total flow 52 gpm): No groundwater capture between Manholes E and F and Manholes F and G (**Figure 46**).

6.1.2 May 23, 2011 GWCT Pumping Scheme and Genesee River Flow

A groundwater flow model simulation was conducted for the May 23, 2011 GWCT pumping scheme and Genesee River flow conditions to assess the hydraulic capture of the trench during wet river flow conditions. The assumptions used in the model simulation were set to reflect the May 23, 2011 field conditions such as river flow and GWCT pumping rates. The field conditions are:

- Genesee River discharge rate at 898 ft^3/s; and
- Manhole pumping rates (total flow at 129 gpm): MH-A at 10 gpm, MH-B at 25 gpm, MH-C at 6 gpm, MH-D at 21 gpm, MH-E at 20 gpm, MH-F at 24 gpm, MH-G at 23 gpm and MH-H was off (0 gpm).

The model results showing the potentiometric surface and groundwater flow pathlines are presented in **Figure 47** (Site-wide view) and **Figure 48** (view of Manhole D to Manhole G). The results indicate the GWCT system captures Site groundwater along the entire length of the trench system when pumping the trench at a total rate of 129 gpm with very wet river flow conditions (898 ft^3/s).

6.1.3 WLCB Groundwater Flow Paths

Model assumptions discussed in Section 6.1.2 above were used to assess the groundwater flow paths in the vicinity of the WLCB**.** **Figure 49** shows the modeled groundwater flow paths in the vicinity of the WLCB. The groundwater flow paths flow from the pool water around the western end of the berm and discharges downgradient of the WLCB into the Main Drainage Swale. The approximate length of the seepage face, as predicted by the model, along the Main Drainage Swale west bank is about 70 ft as measured from the berm northward. Prior to the startup of the GWCT on June 15, 2011, water seeps were observed on the west bank of the Main Drainage Swale from the berm to approximately 60 ft downstream of the berm. This field observation confirms the model predicted seepage face shown on **Figure 49**.

6.2 Water Level Control Berm

The WLCB was constructed in October 2010, as part of the recommendations to mitigate groundwater seeps in the southern end of the Main Drainage Swale. As described in this report, excessive precipitation and subsequent increased river discharge in the Genesee River have occurred during the spring 2011. As a result, during the spring 2011, several areas of new seepage were observed approximately 20 to 60 ft north of the WLCB on the western site boundary and eastern flood control berm located adjacent to the Genesee River.

On June 3, 2011, pumping from the GWCT was temporarily halted, in order to clean out the sludge from the Sedimentation Pond and transfer the material to the sludge drying beds. The maintenance event was planned to last a total of two weeks until June 17, 2011. During the week of June 13, 2011, URS personnel were onsite and observed several seeps (4-5) along the western bank of the Main Drainage Swale. In order to attempt to observe and quantify the nature of the seeps, URS excavated small depressions at the base of each seep and measured the flow rate in liters/ second each day. A total of seven seeps were evaluated: three seeps on the eastern bank of the Main Drainage Swale on the Genesee River flood control berm (seeps XE-1, XE-2 and XE-3); and four seeps on the western bank of the Main Drainage Swale (seeps XW-1, XW-2, XW-3 and XW-4). The locations of the seeps evaluated in this study are shown on **Figure 50**.

Seepage flow measurements were initiated on Thursday, June 16, 2010. The GWCT became operational on Friday, June 17, 2011 at 2:00 PM. On Saturday, June 18, 2011, it was observed that 3 of the 4 seeps along the western site boundary were no longer active and one seep remained active (XW-2). All the seeps on the eastern flood control berm remained active. On June 22, 2011, it was observed that the seeps on the western site boundary were no longer active and were not discharging water. The seeps on the eastern flood control berm remained active. **Figure 51** is a graph showing the seepage rate (liters/second) for seeps observed north of the WLCB on the western side of the Main Drainage Swale and eastern flood control berm.

On July 13, 2011, URS personnel along with USEPA and New York State Department of Environmental Conservation (NYSDEC) walked the area to observe sampling locations. During this visit, it was observed that the four seep locations on the western site boundary were dry and no flow was observed. The seeps on the eastern flood control berm were active; however, no evidence of siltation or piping was observed.

Based on the observations of seep areas following startup of the GWCT, it can be concluded that continued operation of the GWCT at Manhole G and maintaining elevated surface water levels in the Main Drainage Swale south of the WLCB are effective methods to mitigate groundwater seepage in this area.

7.0 SUMMARY AND CONCLUSIONS

7.1 Summary

The monthly synoptic surveys conducted from January 2010 to July 2011 evaluated groundwater conditions in a wide range of climatic conditions, including very high seasonal flows that have never been observed in the hydrologic record dating back to 1973. The hydrologic observations confirm previous conclusions (based on 2009 data) that river conditions affect groundwater. The required system pumpage to maintain Site-wide groundwater capture ranges widely between wet and dry climatic conditions. **Table 1** summarizes the groundwater capture characteristics, the total GWCT system pumpage, river conditions and causes when groundwater capture was not attained in specific areas.

7.1.1 January 2010 through December 2010

In 2010, groundwater capture was not attained in the vicinity of Manhole B during field surveys conducted in January, February, March and April. The primary cause is due to reduced pumping at Manhole B (less than 7 gpm). The pumping rate at Manhole B was deliberately reduced in order to evaluate the total contaminant loading to the wetland treatment system which had not fully matured yet. In the subsequent months, Manhole B pumping rate was increased in a step-wise schedule to further assess the loading effects to the wetland treatment system. This is an operational issue that can be mitigated by allowing the pumps to operate at maximum capacity and depress the water table to the designed drawdown levels.

The March 19, 2010 data are important because river conditions were very high (925 ft^3/s), which represent approximately 8 percent in the flow duration curve (**Figure 3**). Based on the flow duration curve presented on **Figure 3**, the March 19, 2010 event occurred during very wet conditions. The 925 ft^3/s streamflow occurred in less than 8 percent of the mean daily flows observed in the past 39 years. These very wet river flows are attributed to major storm events. It also means that for 92 percent of the time in the past 39 years, river flows were less than 925 ft^3/s. Even in this extreme climatic condition, groundwater capture was attained throughout the extent of the GWCT except at Manhole B (only because Manhole B was pumping at reduced rates). This suggests that:

- The GWCT system is capable of maintaining full groundwater capture if the manholes are operating at their optimal settings;
- The likely maximum threshold, regardless of pumping rates, for sustaining groundwater capture is when river flows generally approach 1,000 ft^3/s; and
- Groundwater capture was not attained in Manholes A, G and H (October 28, 2010) primarily because the manholes were not pumping during high river conditions. Manhole A pump malfunctioned during the synoptic data event. Manhole G was deliberately shut down to collect static water levels as baseline prior to the installation of the WLCB – primarily to measure the natural hydraulic gradient between the WLCB pool and Manhole G under static conditions. Therefore, the total GWCT system pumpage was 73 gpm when the river flow was 456 ft^3/s. As a comparison, the GWCT system total

pumpage was approximately 152 gpm to maintain full Site-wide groundwater capture when the river flow was 246 ft^3/s (May 24, 2010). A similar observation is made for the November 19, 2010 event, when river flow was relatively high (520 ft^3/s) but total GWCT pumpage was at a reduced rate of 103 gpm. In this case, groundwater capture was not observed in the area between Manholes F and G and south of mid-trench piezometer TPZ-08 / Manhole H due to Manhole G being shut down.

- The synoptic survey results for the November 19, 2010 and the December 21, 2010 presents hydrologic conditions when the WLCB was constructed and Manhole G was not pumping. In both events, the hydraulic gradient was reversed between the WLCB pool and groundwater, facilitating surface water recharge (mostly treated water from the wetlands treatment system) to the glacial aquifer. This phenomenon effectively eliminated the former seep in the now WLCB pool area.
- Although the WLCB effectively mitigated a seep within the former pool area, without Manhole G pumping, groundwater capture between Manhole F and G and in the Manhole H area may be variable depending on river flow conditions.

7.1.2 January 2011 through July 2011

The spring season of 2011 was characterized by unusually high and sustained river conditions with 60 days of mean daily flows exceeding 1,000 ft^3/s. The sustained high river flow condition observed in March, April and May was a unique event that can be associated with extreme wet climatic conditions observed elsewhere in the nation – such as the regional Mississippi River floods during the same time period that had not occurred since the mid-1930s. However, based on the past 38 years of daily flows, the cumulative frequency evaluation shows that the Genesee River flow exceeding 1,000 ft^3/s occurred approximately 8 percent of the recorded duration and is representative of heavy rain/storm events. The difference is that in spring 2011, these high flows were sustained over a longer period of time than the typical recession time after a storm (typically less than 2 weeks).

When river flows approach 1,000 ft^3/s, the GWCT pumping system may require greater than approximately 180 gpm to maintain Site-wide groundwater capture (based on observations made on March 19, 2010 and June 1, 2011). On this basis, the relatively lower total pumpage (less than 180 gpm) when river flows were very high (approaching or greater than 1,000 ft^3/s) in March, April and May2011, is attributed to limited groundwater capture between certain pumping manholes.

The June 1, 2011 data (**Table 1**) indicate Site-wide groundwater capture with the possible exception at a localized area between Manholes F and G. This area is downgradient from the WLCB and the treated discharge water entering the aquifer from the WLCB pool may contribute to elevated heads within the GWCT. Based on static groundwater elevations alone, there is a positive gradient to the Main Drainage Swale indicating a possibility of localized groundwater discharge to the swale just north of the WLCB (June 1, 2011 data). On June 29, 2011 as well July 13, 2011, the surface water elevation of the Main Drainage Swale in this area was higher than groundwater – indicating a reversed gradient towards the GWCT. In this case, groundwater is captured by Manhole F pumping.

All synoptic survey results in 2011 (February to July) showed a reversal of the hydraulic gradient between the upper reach of the former Main Drainage Swale (now the WLCB pool) and groundwater in the Manhole G area within a wide range of river flow conditions (42 ft^3/s – July 13, 2011 to 1,830 ft^3/s – March 22, 2011). **Figure 52** displays the water table profiles from three synoptic surveys based on pre-WLCB water elevations measured on October 19, 2009 (river flow 252 ft^3/s) and post-WLCB water elevations measured on May 23, 2011 (river flow 898 ft^3/s) and on June 29, 2011 (river flow 101 ft^3/s).

The transect in **Figure 52** represents the water table between the Manhole G region, the WLCB pool and the Genesee River. In the pre-WLCB period, pumping at Manhole G induced a drawdown that generally extended to monitoring well MW-55R but did not intersect the Main Drainage Swale. As the result, groundwater, downgradient from the GWCT, that was not captured by Manhole G naturally discharged to the Main Drainage Swale. As part of this natural discharge, a seep developed with flow rates as high as approximately 200 gpm during wet seasons.

The WLCB raised the surface water elevation in the former Main Drainage Swale by maintaining pool storage. As the result, the pool elevation is consistently higher than adjacent groundwater west of the WLCB (even without Manhole G pumping). By reversing the hydraulic gradient between the former Main Drainage Swale and groundwater, the WLCB mitigated the former seep. **Figure 52** presents the water table profiles (hydraulic gradients) when Manhole G was pumping at two different river flow conditions. As shown, the drawdowns from the pumping Manhole G intercept the WLCB pool that facilitates water flow from the WLCB pool to Manhole G.

7.2 Conclusions

Based on the January 2010 to July 2011 hydrologic results, the following conclusions are indicated:

- The GWCT pumping system has achieved the performance criteria outlined in the Performance-Based Groundwater Monitoring Plan (PBGM);
- The GWCT pumping rates to achieve Site-wide groundwater capture are not static. They vary widely according to the Genesee River flow conditions;
- Conditions when groundwater capture was not attained at localized areas occurred:
  - When the GWCT total pumping fell below the required rates that are compatible with river flows; and
  - During sustained high river conditions (river flows approaching and exceeding 1,000 ft^3/s for more than 1 to 2 weeks);
- When the manhole pumping is maintained within the operational thresholds, groundwater capture was attained throughout the extent of the GWCT;
- In instances where groundwater capture was not observed, the primary cause was reduction in the manhole pumping rates or nonpumping conditions;
- Climatic conditions (river flows) affect the total GWCT system pumpage required to sustain groundwater capture. The GWCT system may be effective in capturing

groundwater during 90 percent of river discharge (up to mean daily flow of 1,000 ft^3/s) – barring major storm events;

- The WLCB reversed local hydraulic gradient between the swale (above the berm) and the GWCT (water flowing from the swale to the GWCT). In this setting, the former seep cannot discharge to the swale; and
- These conclusions have verified the previous observations made in the January 2010 report titled “Evaluation of the Groundwater Collection Trench Hydraulics and Groundwater Capture Efficiency Report” (URS, 2010).

8.0 RECOMMENDATIONS

Long-term continuous groundwater level elevation trend data collected from each manhole and trench piezometer (January 2010 through July 2011), monthly synoptic site-wide groundwater elevation measurements (January 2010 through July 2011) and manhole pumping rates were reviewed. The following recommendations are based on this data review and historical GWCT performance data presented in previous reports (URS, 2010):

Barrier Wall

Based on two and one-half years of GWCT performance monitoring data (October 2008 through July 2011) and numerical modeling efforts, it is determined that groundwater capture and mitigation of groundwater discharge to the Genesee River by pumping the GWCT alone is effective and sustainable. On this basis, a barrier wall (i.e., slurry wall) installed between the trench system and the Genesee River is not required. This is supported by three independent means:

1. Based on 22 monthly potentiometric surface evaluations generated from Site-wide synoptic groundwater elevation measurements, the result of the potentiometric surface analyses clearly demonstrates that the GWCT can maintain groundwater capture without the aid of a downgradient barrier wall. An overview of when groundwater capture was attained and the trench pumping conditions is provided in **Table 3**.
2. Long-term continuous groundwater elevation data collected from Manholes A through G that demonstrates drawdowns necessary to maintain groundwater capture.
3. A numerical groundwater flow model analysis using various modeling scenarios clearly demonstrates that the GWCT can maintain groundwater capture without the aid of a downgradient barrier wall.

Water Level Control Berm

The WLCB that has been installed in the Main Drainage Swale has provided a reliable method to continuously raise the water level in the southern end of the Main Drainage Swale, thereby creating a reversal in groundwater flow direction toward the GWCT. This flow direction reversal has effectively mitigated seeps along the western site boundary and no other remedial actions are necessary to mitigate the former seep located in upper reach of the Main Drainage Swale.

GWCT Operations and Monitoring

- Pump Manholes A through G (Manhole H off).
- Reduce electronic groundwater monitoring program. Conduct continuous monitoring in Manholes A through G only. Terminate the use of LevelTROLL data loggers in piezometers TPZ-01 through TPZ-09, and piezometer/monitoring wells T-1, MW-55R, PW-4, PZ-7, PZ-8, SP-1E, SP-1W, SP-2E, T-08, T-11, T-12, T-18 and T-28 as well as swale staff gauge SG-07.

- Reduce monthly groundwater elevation monitoring program from a site-wide synoptic (all site wells) to manholes and piezometers/wells located in the trench or downgradient of the trench. **Table 2** presents the proposed revised groundwater elevation survey program.
- Implement a GWCT operation management plan focused on maintaining groundwater capture on critical areas of the Site during high river flow conditions and minimizing excessive flow loading to the wetlands treatment system in order to maintain the treatment system efficiency. The following is proposed:
    1. If Genesee River flow is >1,000 ft^3/s, then turn off pumps for Manholes E, F and G. Resume pumping of Manholes E, F and G when the river flow is <1,000 ft^3/s. Note that based on a 39-year history of the Genesee River mean daily flows (USGS Gage 04221000), it is anticipated that the shutdown criteria will occur approximately 15 days per year (annual 4%); and
    2. If Genesee River flow is >5,000 ft^3/s, then turn off all GWCT pumps. Resume pumping of Manhole A, B, C, D, E, F and G when river flow is <1,000 ft^3/s. Note that based on a 39-year history of the Genesee River mean daily flows (USGS Gage 04221000), it is anticipated that the shutdown criteria will occur approximately 2 days per year (annual <1%).

9.0 REFERENCES

Planert, Michael, April 2011. Personal communication.

URS, 2008. Revised Appendix 13 – Performance Based Groundwater Monitoring Plan, Final (100%) Design Report Phase II-2 Remediation at Operable Unit 2; Former Sinclair Refinery Site, Wellsville, NY: Presentation to US Environmental Protection Agency, Region 2 and New York State Department of Environmental Conservation, July 2008.

URS, 2010. Evaluation of the Groundwater Collection Trench Hydraulics and Groundwater Capture Efficiency Report. Former Sinclair Refinery Site, Wellsville, NY. Prepared for Atlantic Richfield Company (a BP affiliated Company), Prepared by URS Corporation, Cleveland, Ohio.

Date	Genesee River Streamflow (ft^3/s)	GWCT Total Pumpage (gpm)	Groundwater Capture Not Attained	Causes (GWCT Pumping Operations)	Causes (Natural Conditions)
January 21, 2010	355	133	Manhole B	Reduced pumping at Manhole B	
February 23, 2010	Ice	114	Manhole B	Reduced pumping at Manhole B	
March 19, 2010	925	179	Manhole B	Reduced pumping at Manhole B	Storm event high flow (past 24 hr flow 1,090 ft^3/s; peak flow 4,120 ft^3/s on March 14)
April 15, 2010	190	129	Manhole B	Reduced pumping at Manhole B	
May 24, 2010	246	152	*		
June 18, 2010	171	132	*		
July 28, 2010	169	129	*		
August 31, 2010	52	112	*		
September 23, 2010	31	90	*		
October 28, 2010	456	73	Manholes A, G and H	No pumping at Manholes A and G	
November 19, 2010	520	103	Manhole H and between Manholes F and G	No pumping at Manhole G	
December 21, 2010	Ice	119	Manhole H and between Manholes F and G	No pumping at Manhole G	
January 2011	Ice			WLCB repair work. No synoptic water levels measured.	
February 3, 2011	Ice	132	*		
March 22, 2011	1,830	155	Manhole H; between Manholes F and G; between Manholes A and B		Unusually high river conditions (past 24 hr flow 2,500 ft^3/s; 18 days of sustained flow greater than 1,000 ft^3/s; peak flow 5,640 ft^3/s on March 6)
April 11, 2011	1,220	153	Between Manholes F and G; between Manholes E and F; between Manholes A and B		Storm event high flow (past 24 hr flow 1,210 ft^3/s; peak 4,660 ft^3/s on April 6)
May 23, 2011	898	135	Between Manholes F and G; between Manholes A and B	Reduced pumping at Manhole A	Storm event high flow (past 24 hr flow 977 ft^3/s; peak 1,750 ft^3/s on May 20)
June 1, 2011	811	193	Between Manholes F and G		Storm event high flow (past 24 hr 1,110 ft^3/s; peak 2,540 ft^3/s on May 30)
June 29, 2011	101	142	*		
July 13, 2011	42	154	*		

* Full groundwater capture from Manholes A – H

WELLSVILLE,
NEW YORK

July, 2011

Summary of Groundwater Capture Based on Monthly Synoptic Groundwater Elevation Measurements January 2010 – June 2011

TABLE 1

Table 2

Proposed Groundwater Elevation Monitoring Points for the GWCT Performance Monitoring Program

Location	Type
MW-11	Monitoring Well
MW-25	Monitoring Well
MW-27	Monitoring Well
MW-50	Monitoring Well
MW-53	Monitoring Well
MW-55R	Monitoring Well
MW-56	Monitoring Well
MW-57	Monitoring Well
MW-68A	Monitoring Well
MW-68B	Monitoring Well
MW-69A	Monitoring Well
MW-69B	Monitoring Well
MW-70	Monitoring Well
MW-71	Monitoring Well
MW-78	Monitoring Well
MW-79	Monitoring Well
MW-88	Monitoring Well
MW-94	Monitoring Well
MW-95	Monitoring Well
MW-97	Monitoring Well
MW-101	Monitoring Well
MWR-01	Monitoring Well
MWR-02	Monitoring Well
OW-01	Monitoring Well
OW-02	Monitoring Well
OW-03	Monitoring Well
OW-04	Monitoring Well
OW-07	Monitoring Well
OW-08	Monitoring Well
OW-09	Monitoring Well
OW-10	Monitoring Well
PW-02	Monitoring Well
PW-04	Monitoring Well
PZ-07	Monitoring Well
PZ-08	Monitoring Well
RW-01	Monitoring Well
RW-02	Monitoring Well
RW-03	Monitoring Well
TPZ-01	Piezometer
TPZ-02	Piezometer
TPZ-03	Piezometer
TPZ-04	Piezometer
TPZ-05	Piezometer

Location	Type
TPZ-06	Piezometer
TPZ-07	Piezometer
TPZ-08	Piezometer
TPZ-09	Piezometer
SP-1E	Piezometer
SP-1W	Piezometer
SP-2E	Piezometer
SP-3E	Piezometer
SP-4E	Piezometer
SP-5W	Piezometer
DP-1	Piezometer
DP-2	Piezometer
MH-A	Manhole
MH-B	Manhole
MH-C	Manhole
MH-D	Manhole
MH-E	Manhole
MH-F	Manhole
MH-G	Manhole
MH-H	Manhole
SG-05	MSD Staff Gage
SG-06R	MSD Staff Gage
SG-07	MSD Staff Gage
SG-08	MSD Staff Gage
T-01	Piezometer
T-03	Piezometer
T-04	Piezometer
T-05	Piezometer
T-06	Piezometer
T-07	Piezometer
T-08	Piezometer
T-09	Piezometer
T-10	Piezometer
T-11	Piezometer
T-12	Piezometer
T-13	Piezometer
T-16	Piezometer
T-17	Piezometer
T-18	Piezometer
T-20	Piezometer
T-21	Piezometer
T-22	Piezometer
T-23	Piezometer

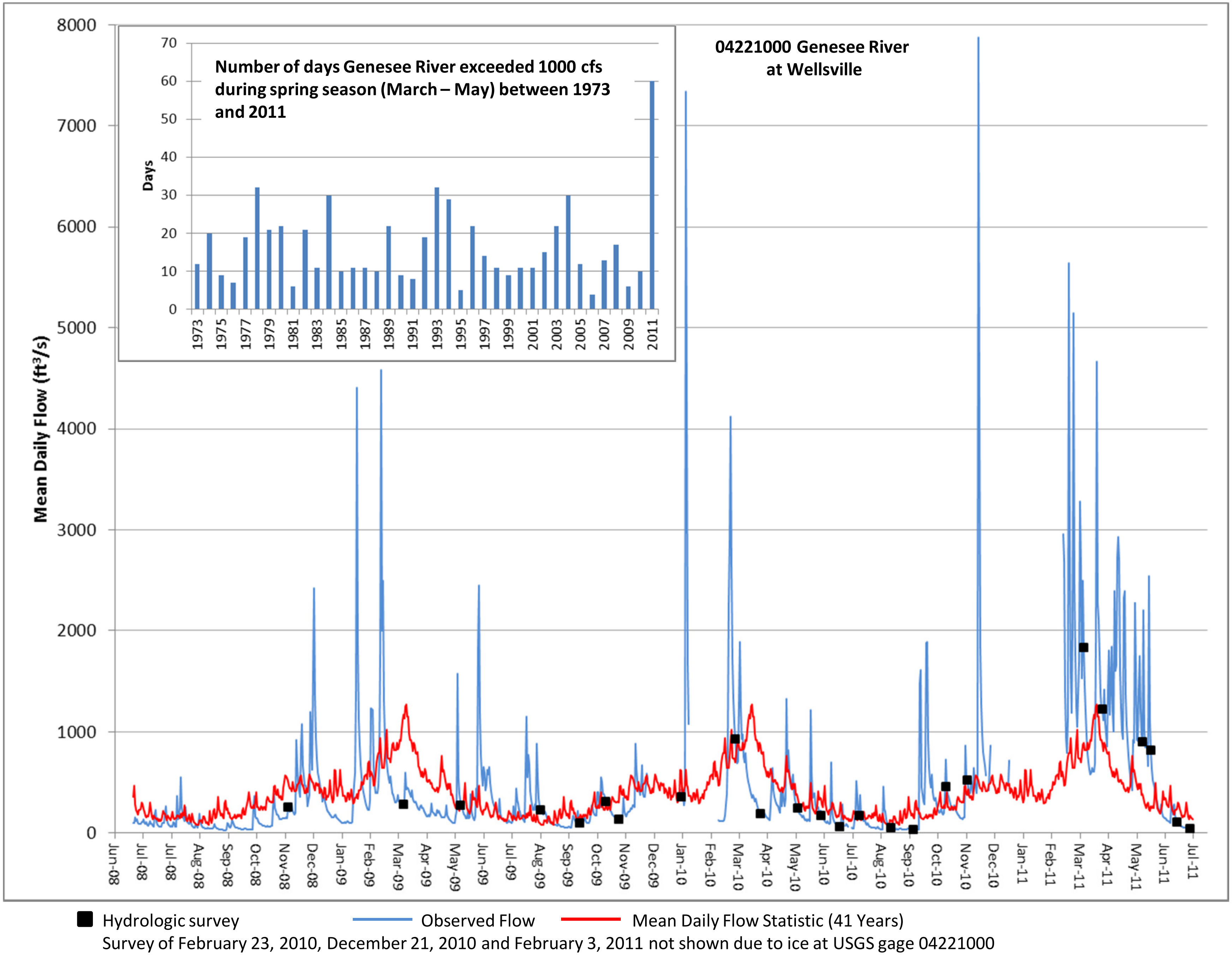
Location	Type
T-24	Piezometer
T-25	Piezometer
T-26	Piezometer
T-27	Piezometer
T-28	Piezometer
T-29	Piezometer
T-30	Piezometer
T-31	Piezometer
T-32	Piezometer
T-33	Piezometer
T-34	Piezometer
T-35	Piezometer
T-36	Piezometer
T-37	Piezometer
T-38	Piezometer
T-39	Piezometer
T-40	Piezometer

HYDROLOGIC MONITORING NETWORK
2011

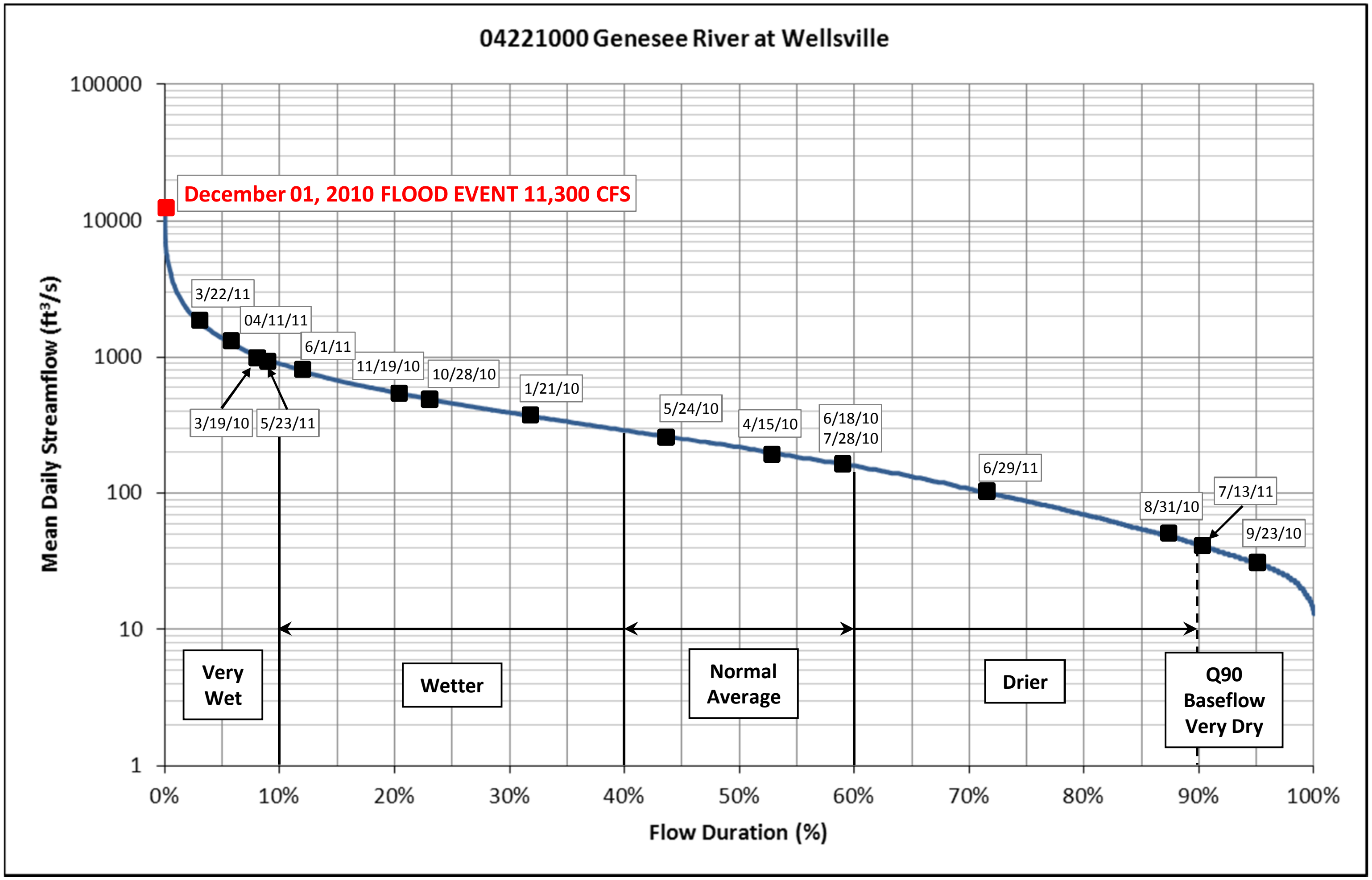
WELLSVILLE, NY

URS

FIGURE 1



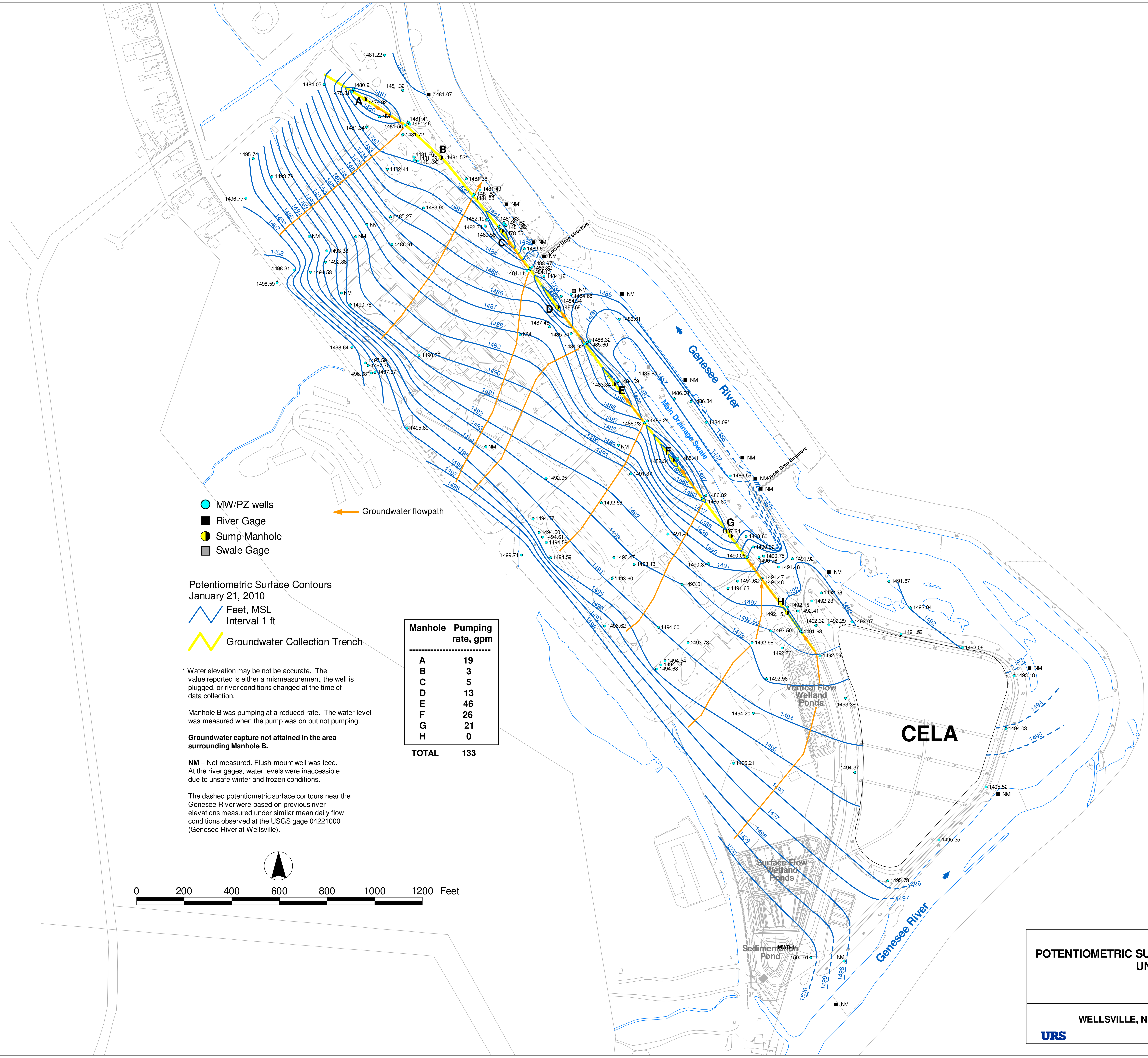
WELLSVILLE, NEW YORK *July, 2011*	**Genesee River Hydrograph and Site Hydrologic Surveys June 2008 – July 2011**	**FIGURE 2**



Flow duration evaluation based on 14,012 mean daily streamflows measured from October 1, 1972 to July 4, 2011.

■ Hydrologic survey
Survey of February 23, 2010 and December 21, 2010 not shown due to ice at USGS gage 04221000

WELLSVILLE, NEW YORK *July, 2011*	**Genesee River Flow Duration and Site Hydrologic Surveys January 2010 – July 2011**	**FIGURE 3**



Manhole	Pumping rate, gpm
A	19
B	3
C	5
D	13
E	46
F	26
G	21
H	0
TOTAL	133

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

Manhole B was pumping at a reduced rate. The water level was measured when the pump was on but not pumping.

Groundwater capture not attained in the area surrounding Manhole B.

NM – Not measured. Flush-mount well was iced. At the river gages, water levels were inaccessible due to unsafe winter and frozen conditions.

The dashed potentiometric surface contours near the Genesee River were based on previous river elevations measured under similar mean daily flow conditions observed at the USGS gage 04221000 (Genesee River at Wellsville).

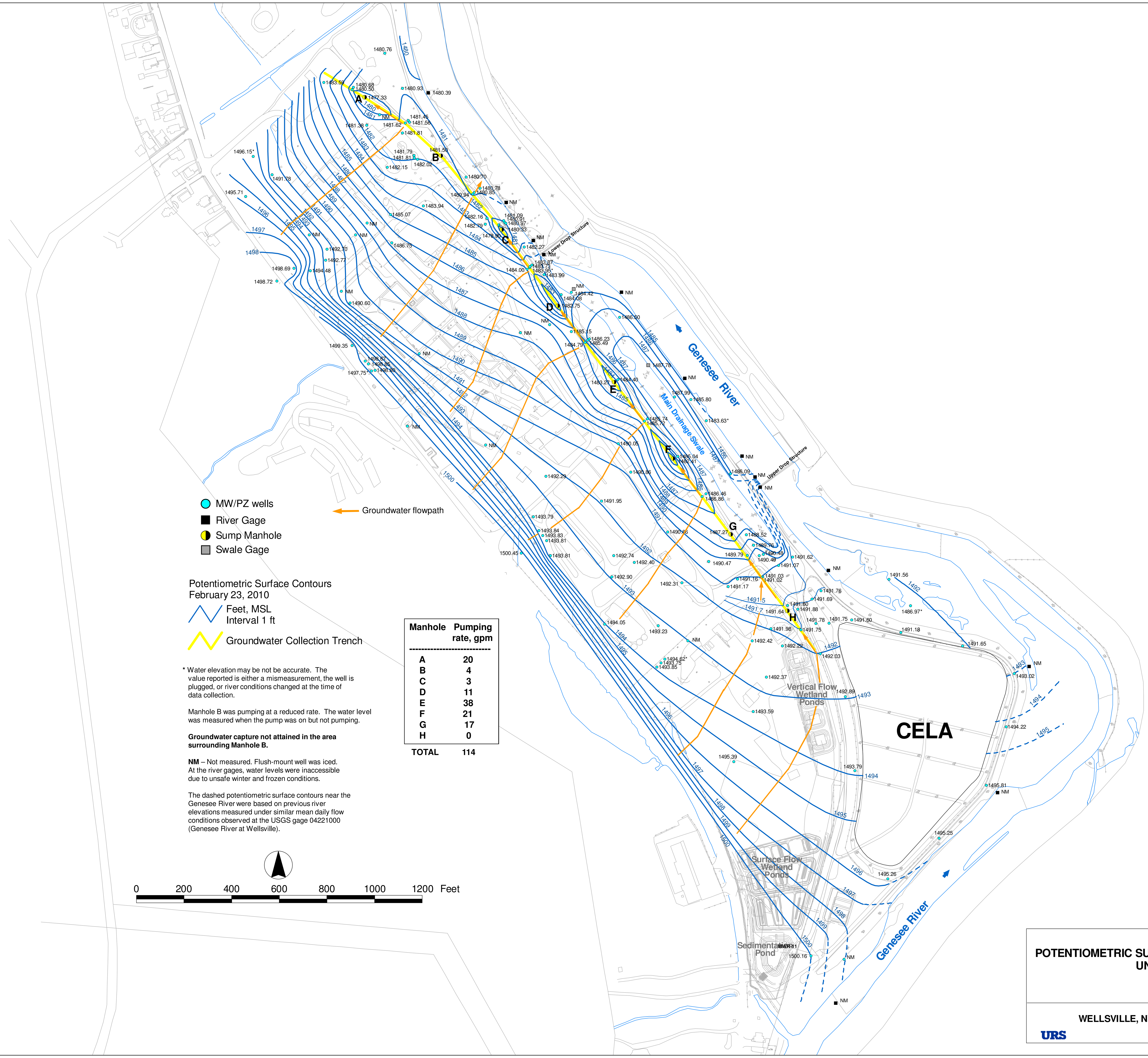
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS JANUARY 21, 2010

WELLSVILLE, NY

URS

April 2010

FIGURE 4



Manhole	Pumping rate, gpm
A	20
B	4
C	3
D	11
E	38
F	21
G	17
H	0
TOTAL	114

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

Manhole B was pumping at a reduced rate. The water level was measured when the pump was on but not pumping.

Groundwater capture not attained in the area surrounding Manhole B.

NM – Not measured. Flush-mount well was iced. At the river gages, water levels were inaccessible due to unsafe winter and frozen conditions.

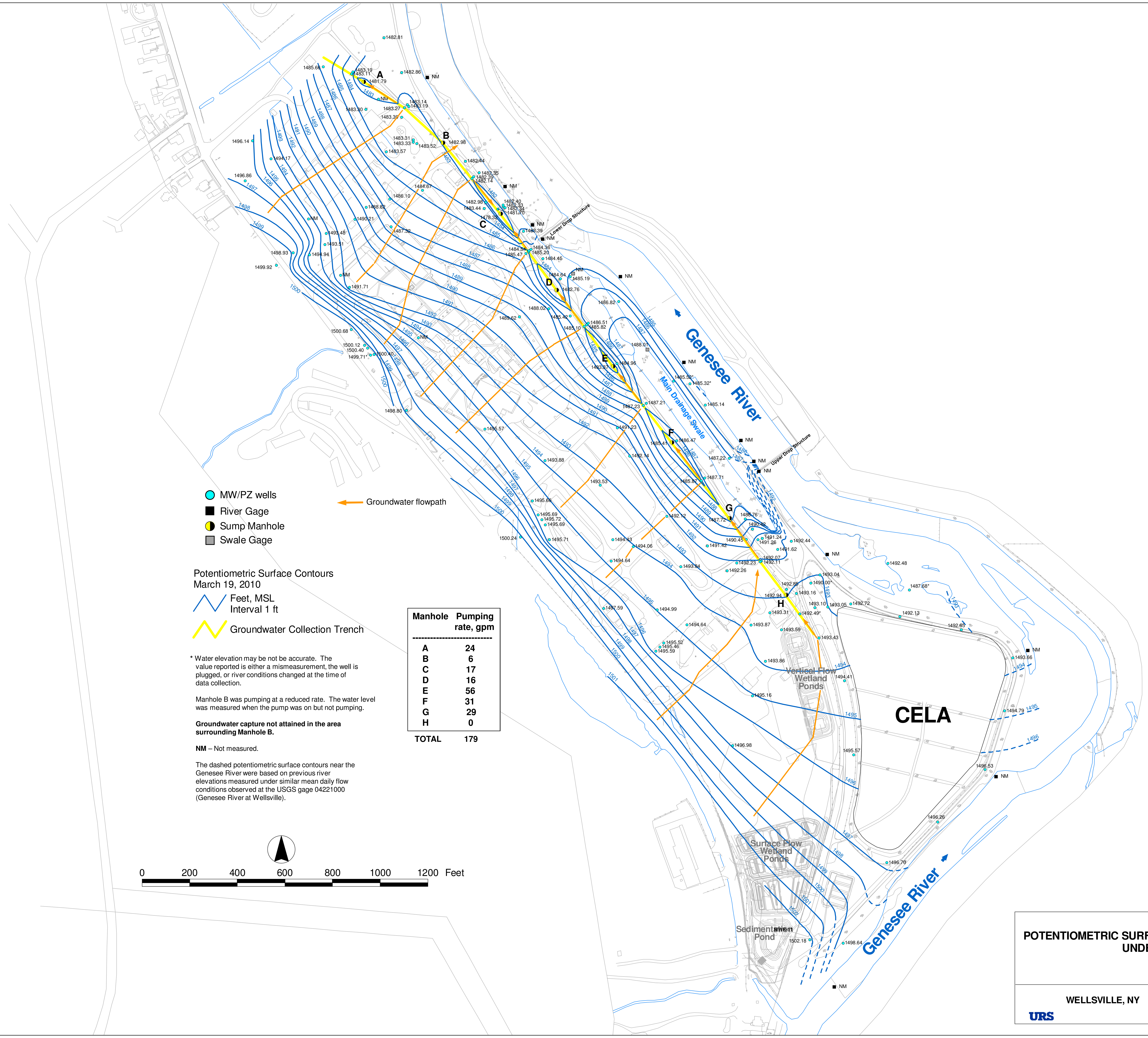
The dashed potentiometric surface contours near the Genesee River were based on previous river elevations measured under similar mean daily flow conditions observed at the USGS gage 04221000 (Genesee River at Wellsville).

POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS FEBRUARY 23, 2010

WELLSVILLE, NY

URS April 2010

FIGURE 5



* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

Manhole B was pumping at a reduced rate. The water level was measured when the pump was on but not pumping.

Groundwater capture not attained in the area surrounding Manhole B.

NM – Not measured.

The dashed potentiometric surface contours near the Genesee River were based on previous river elevations measured under similar mean daily flow conditions observed at the USGS gage 04221000 (Genesee River at Wellsville).

Manhole	Pumping rate, gpm
A	24
B	6
C	17
D	16
E	56
F	31
G	29
H	0
TOTAL	179

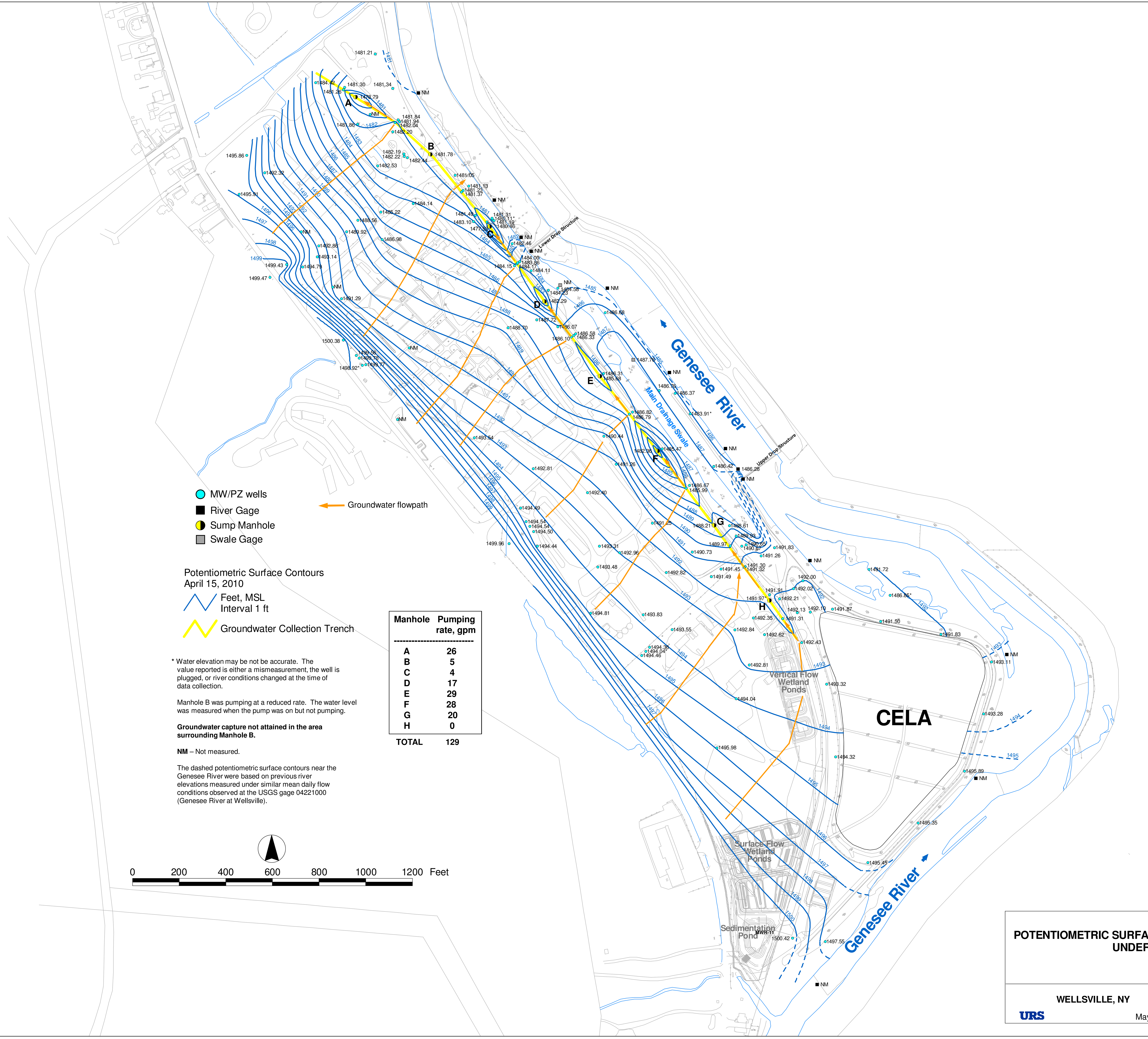
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS MARCH 19, 2010

WELLSVILLE, NY

URS

June 2010

FIGURE 6



Manhole	Pumping rate, gpm
A	26
B	5
C	4
D	17
E	29
F	28
G	20
H	0
TOTAL	129

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

Manhole B was pumping at a reduced rate. The water level was measured when the pump was on but not pumping.

Groundwater capture not attained in the area surrounding Manhole B.

NM – Not measured.

The dashed potentiometric surface contours near the Genesee River were based on previous river elevations measured under similar mean daily flow conditions observed at the USGS gage 04221000 (Genesee River at Wellsville).

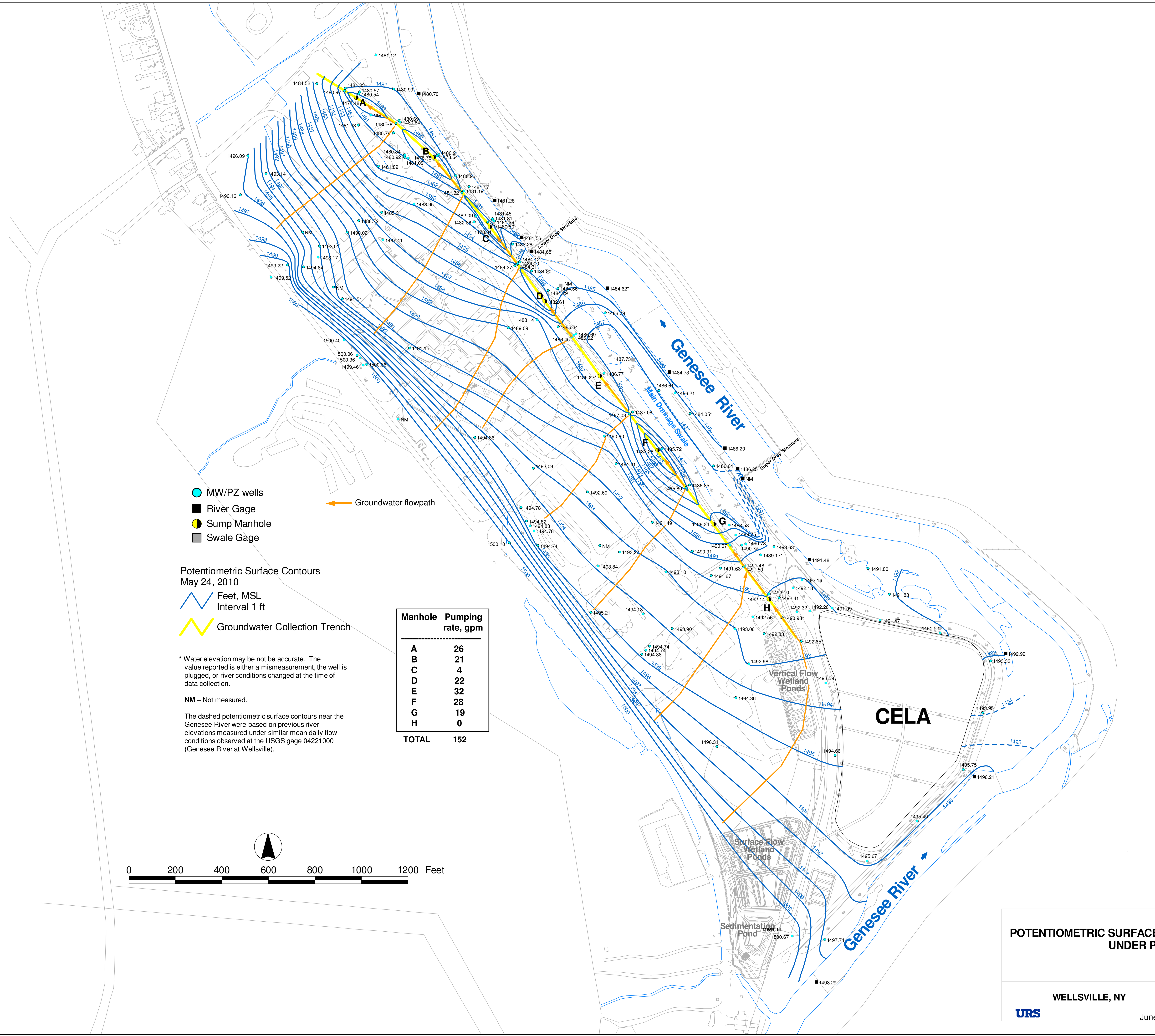
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS APRIL 15, 2010

WELLSVILLE, NY

URS

May 2010

FIGURE 7



Manhole	Pumping rate, gpm
A	26
B	21
C	4
D	22
E	32
F	28
G	19
H	0
TOTAL	152

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

The dashed potentiometric surface contours near the Genesee River were based on previous river elevations measured under similar mean daily flow conditions observed at the USGS gage 04221000 (Genesee River at Wellsville).

POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS
MAY 24, 2010

WELLSVILLE, NY

URS

June 2010

FIGURE 8

Manhole	Pumping rate, gpm
A	22
B	19
C	3
D	19
E	27
F	26
G	16
H	0
TOTAL	132

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

The dashed potentiometric surface contours near the Genesee River were based on previous river elevations measured under similar mean daily flow conditions observed at the USGS gage 04221000 (Genesee River at Wellsville).

Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

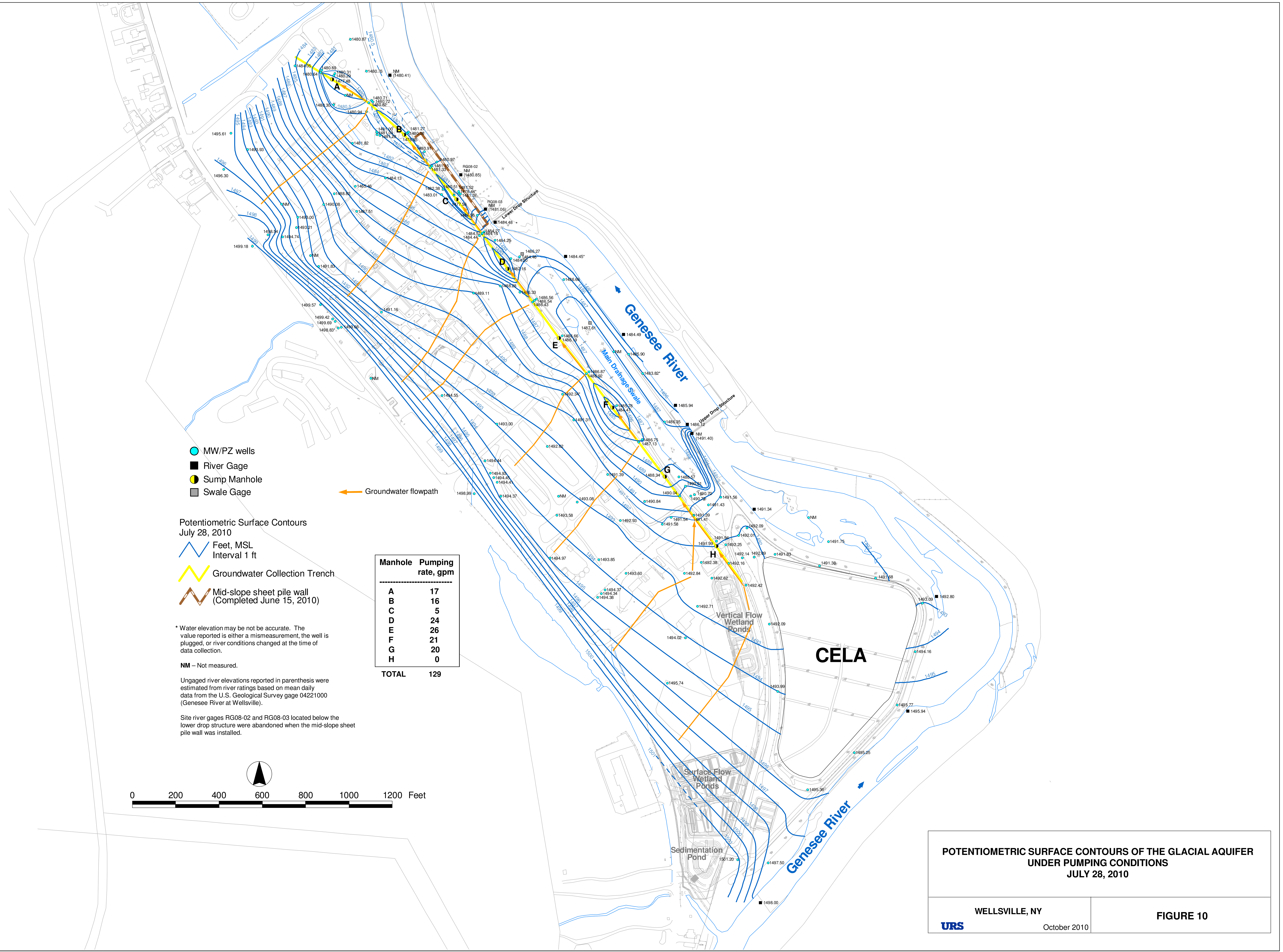
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS JUNE 18, 2010

WELLSVILLE, NY

URS

June 2010

FIGURE 9



MW/PZ wells
River Gage
Sump Manhole
Swale Gage

Groundwater flowpath

Potentiometric Surface Contours
July 28, 2010

Feet, MSL
Interval 1 ft

Groundwater Collection Trench

Mid-slope sheet pile wall
(Completed June 15, 2010)

Manhole	Pumping rate, gpm
A	17
B	16
C	5
D	24
E	26
F	21
G	20
H	0
TOTAL	129

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

Ungaged river elevations reported in parenthesis were estimated from river ratings based on mean daily data from the U.S. Geological Survey gage 04221000 (Genesee River at Wellsville).

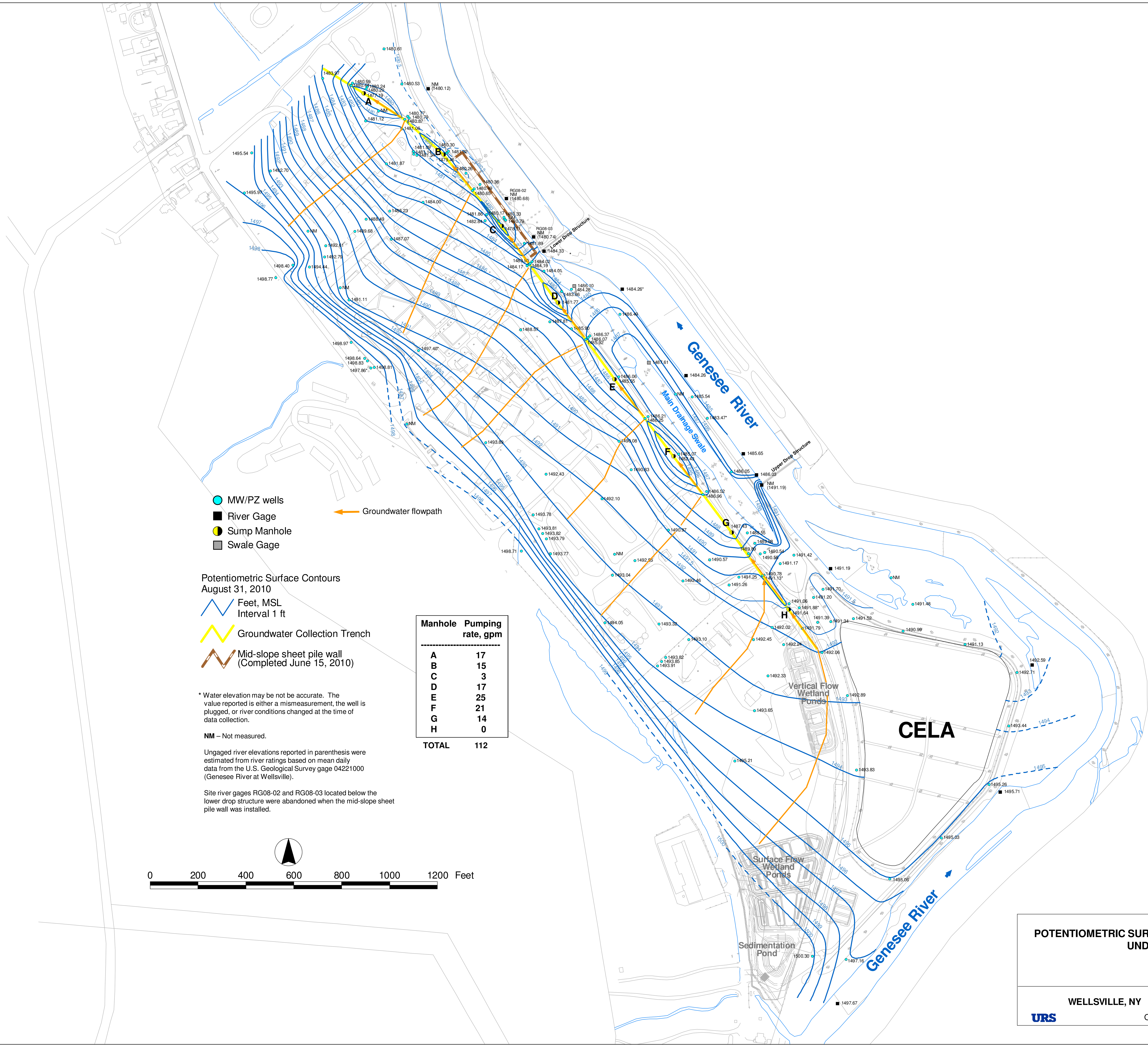
Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS JULY 28, 2010

WELLSVILLE, NY

URS October 2010

FIGURE 10



Manhole	Pumping rate, gpm
A	17
B	15
C	3
D	17
E	25
F	21
G	14
H	0
TOTAL	112

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

Ungaged river elevations reported in parenthesis were estimated from river ratings based on mean daily data from the U.S. Geological Survey gage 04221000 (Genesee River at Wellsville).

Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

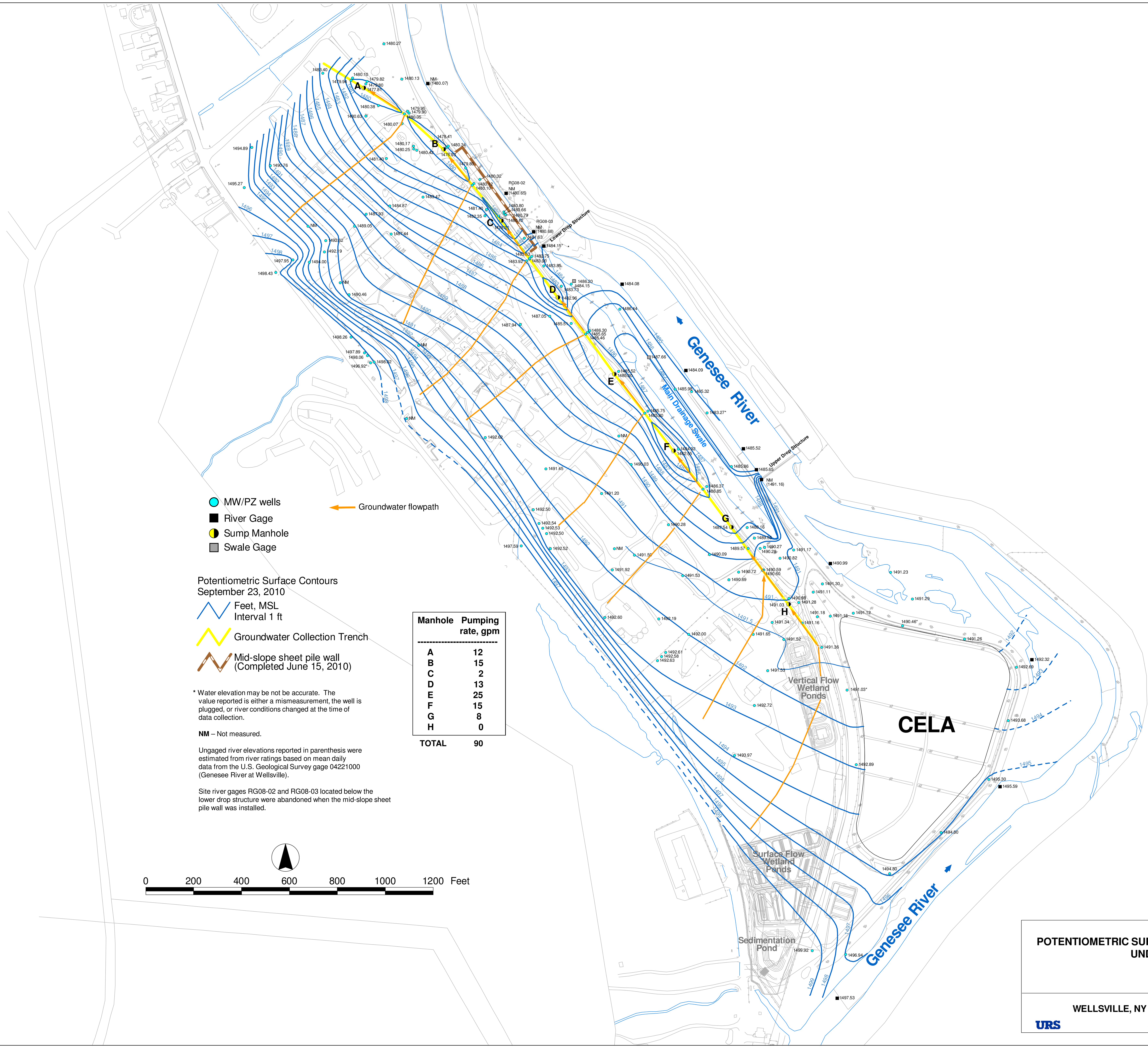
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS AUGUST 31, 2010

WELLSVILLE, NY

URS

October 2010

FIGURE 11



Manhole	Pumping rate, gpm
A	12
B	15
C	2
D	13
E	25
F	15
G	8
H	0
TOTAL	90

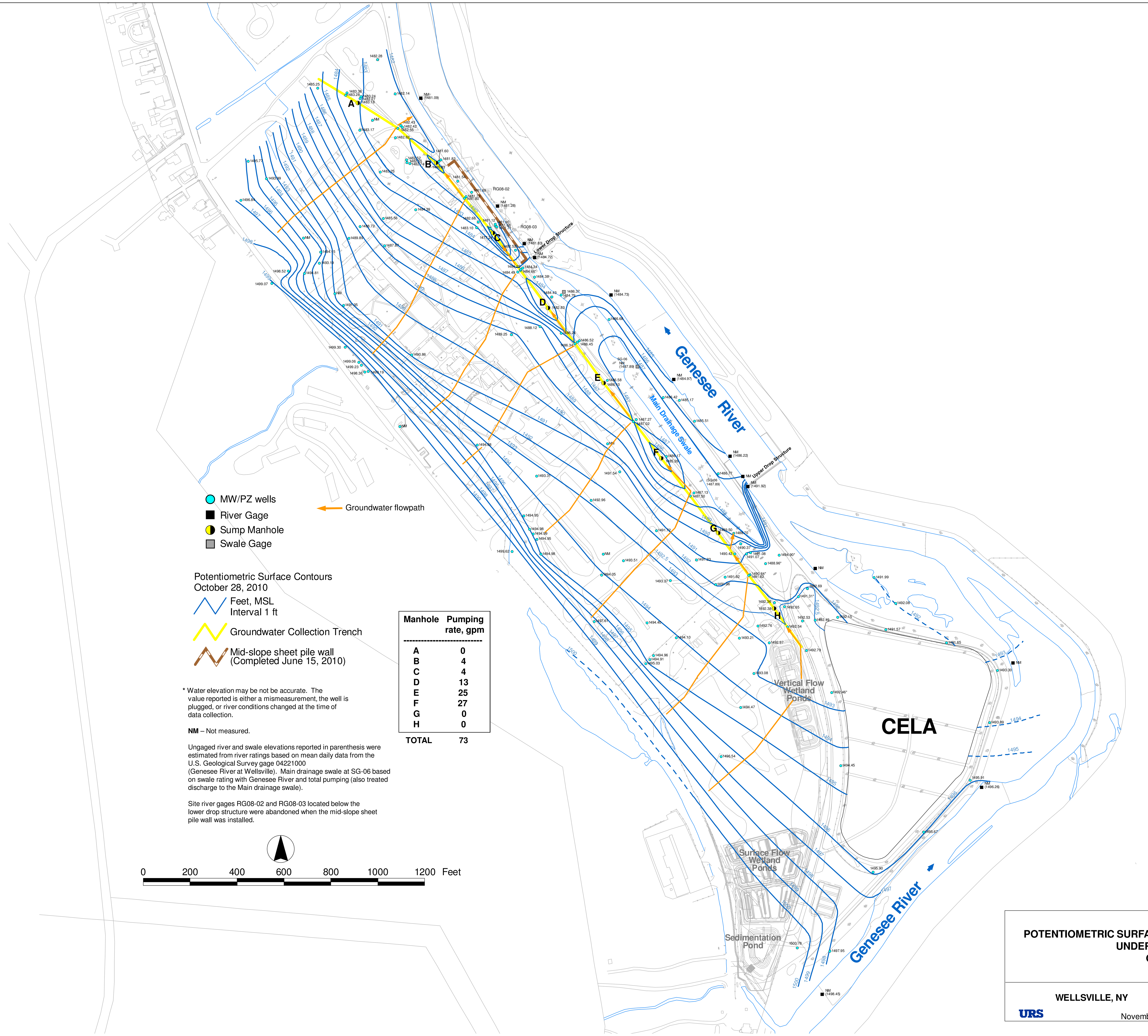
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS SEPTEMBER 23, 2010

WELLSVILLE, NY

URS

October 2010

FIGURE 12



Manhole	Pumping rate, gpm
A	0
B	4
C	4
D	13
E	25
F	27
G	0
H	0
TOTAL	73

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

Ungaged river and swale elevations reported in parenthesis were estimated from river ratings based on mean daily data from the U.S. Geological Survey gage 04221000 (Genesee River at Wellsville). Main drainage swale at SG-06 based on swale rating with Genesee River and total pumping (also treated discharge to the Main drainage swale).

Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS OCTOBER 28, 2010

WELLSVILLE, NY

URS

November 2010

FIGURE 13

Manhole	Pumping rate, gpm
A	19
B	17
C	4
D	11
E	24
F	28
G	0
H	0
TOTAL	103

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

Ungaged river and swale elevations reported in parenthesis were estimated from river ratings based on mean daily data from the U.S. Geological Survey gage 04221000 (Genesee River at Wellsville).

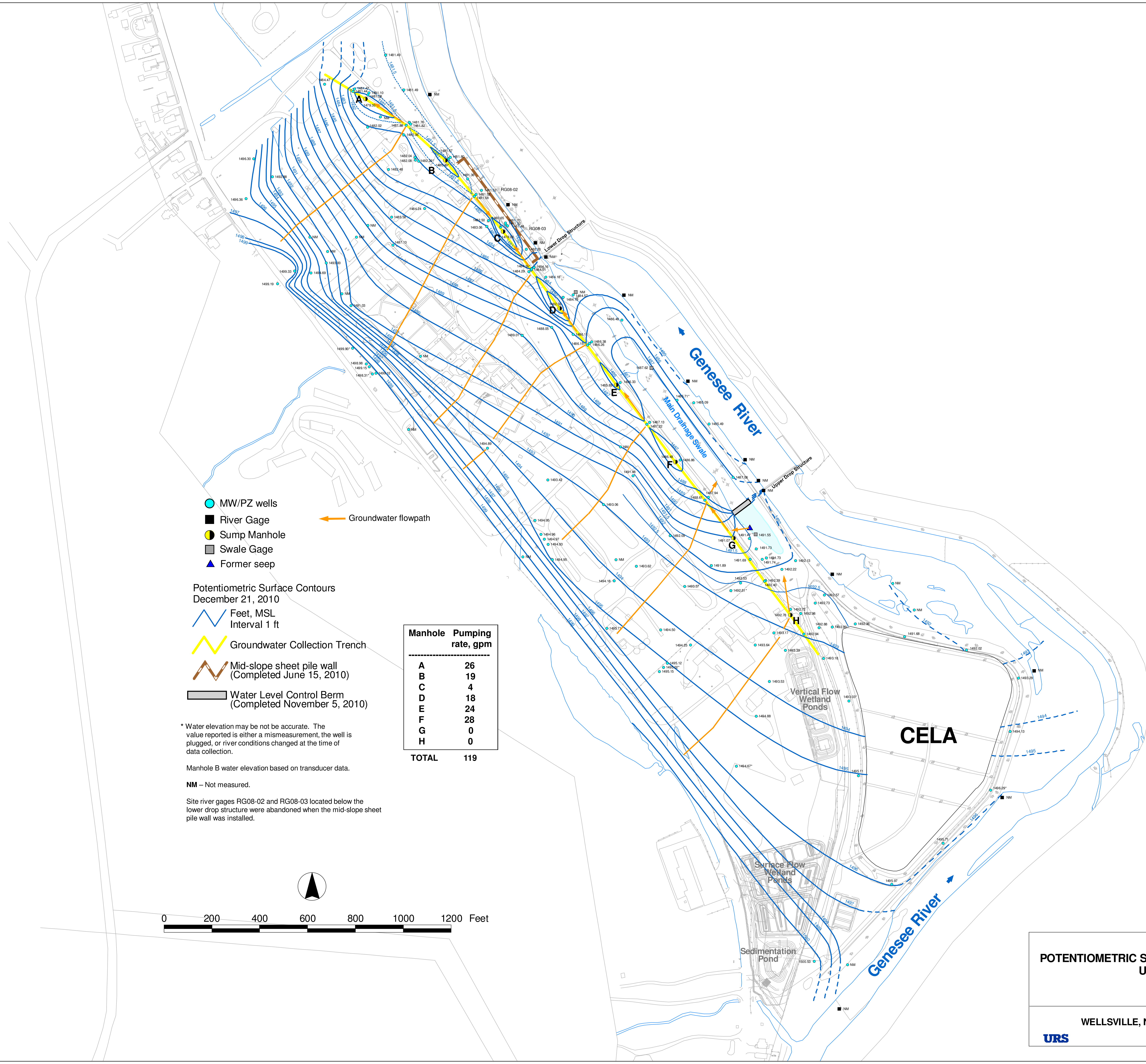
Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

WATER ELEVATIONS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS NOVEMBER 19, 2010

WELLSVILLE, NY

URS November 2010

FIGURE 14



- MW/PZ wells
- River Gage
- Sump Manhole
- Swale Gage
- Former seep
- Groundwater flowpath

Potentiometric Surface Contours
December 21, 2010

- Feet, MSL Interval 1 ft
- Groundwater Collection Trench
- Mid-slope sheet pile wall (Completed June 15, 2010)
- Water Level Control Berm (Completed November 5, 2010)

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

Manhole B water elevation based on transducer data.

NM – Not measured.

Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

Manhole	Pumping rate, gpm
A	26
B	19
C	4
D	18
E	24
F	28
G	0
H	0
TOTAL	119

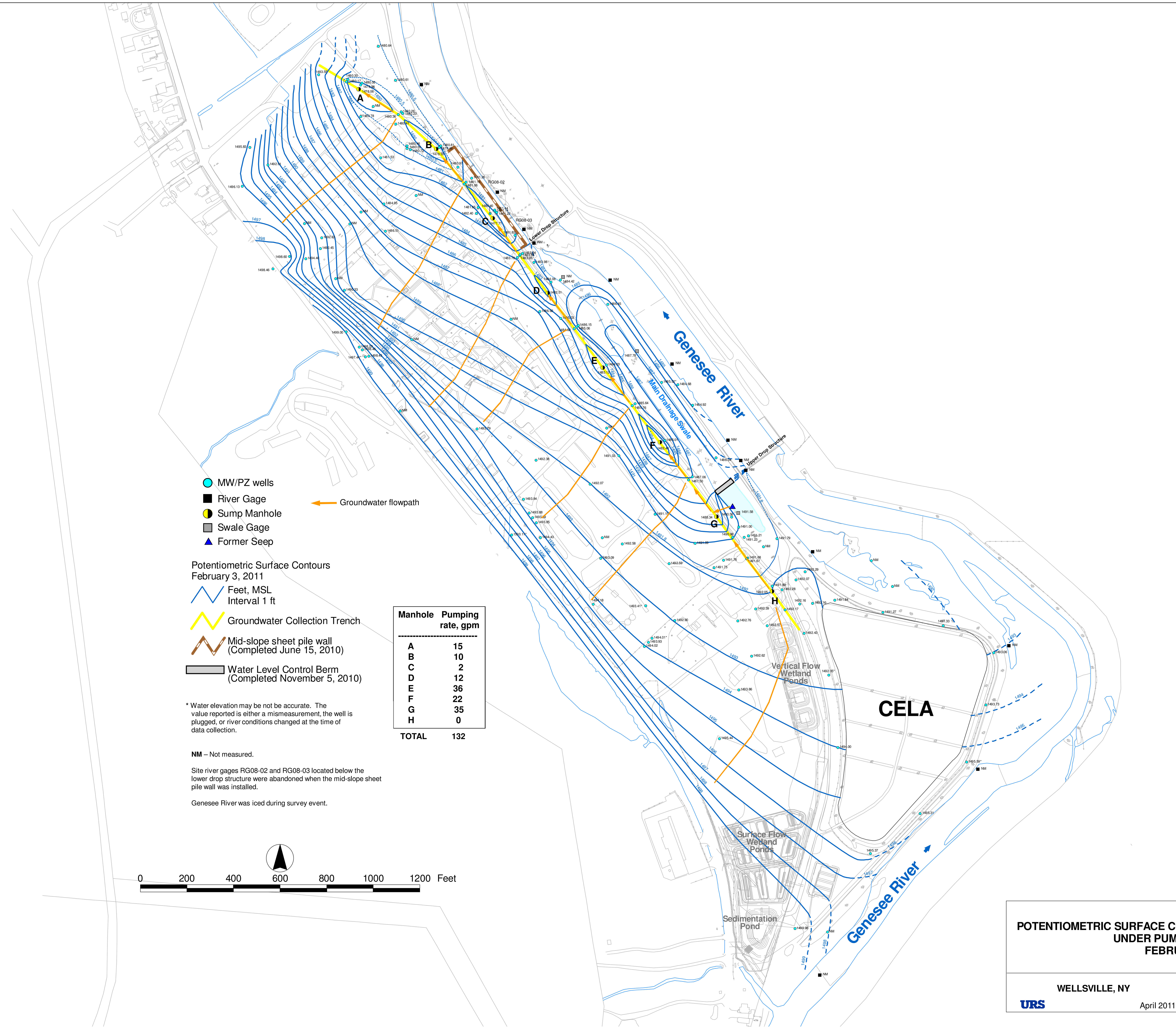
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS DECEMBER 21, 2010

WELLSVILLE, NY

URS

April 2011

FIGURE 15



Manhole	Pumping rate, gpm
A	15
B	10
C	2
D	12
E	36
F	22
G	35
H	0
TOTAL	132

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

Genesee River was iced during survey event.

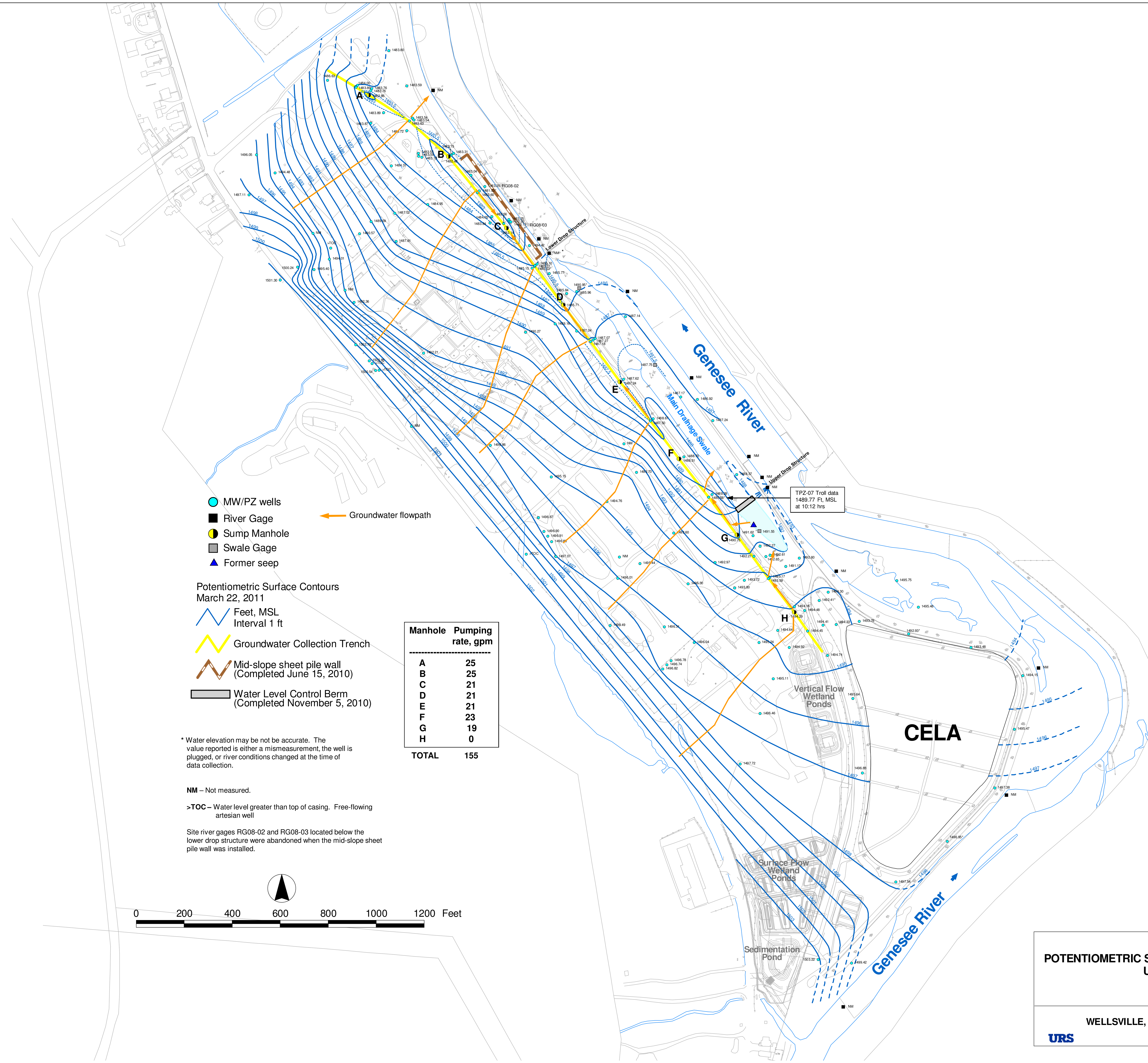
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS FEBRUARY 3, 2011

WELLSVILLE, NY

URS

April 2011

FIGURE 16



Manhole	Pumping rate, gpm
A	25
B	25
C	21
D	21
E	21
F	23
G	19
H	0
TOTAL	155

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

>TOC – Water level greater than top of casing. Free-flowing artesian well

Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

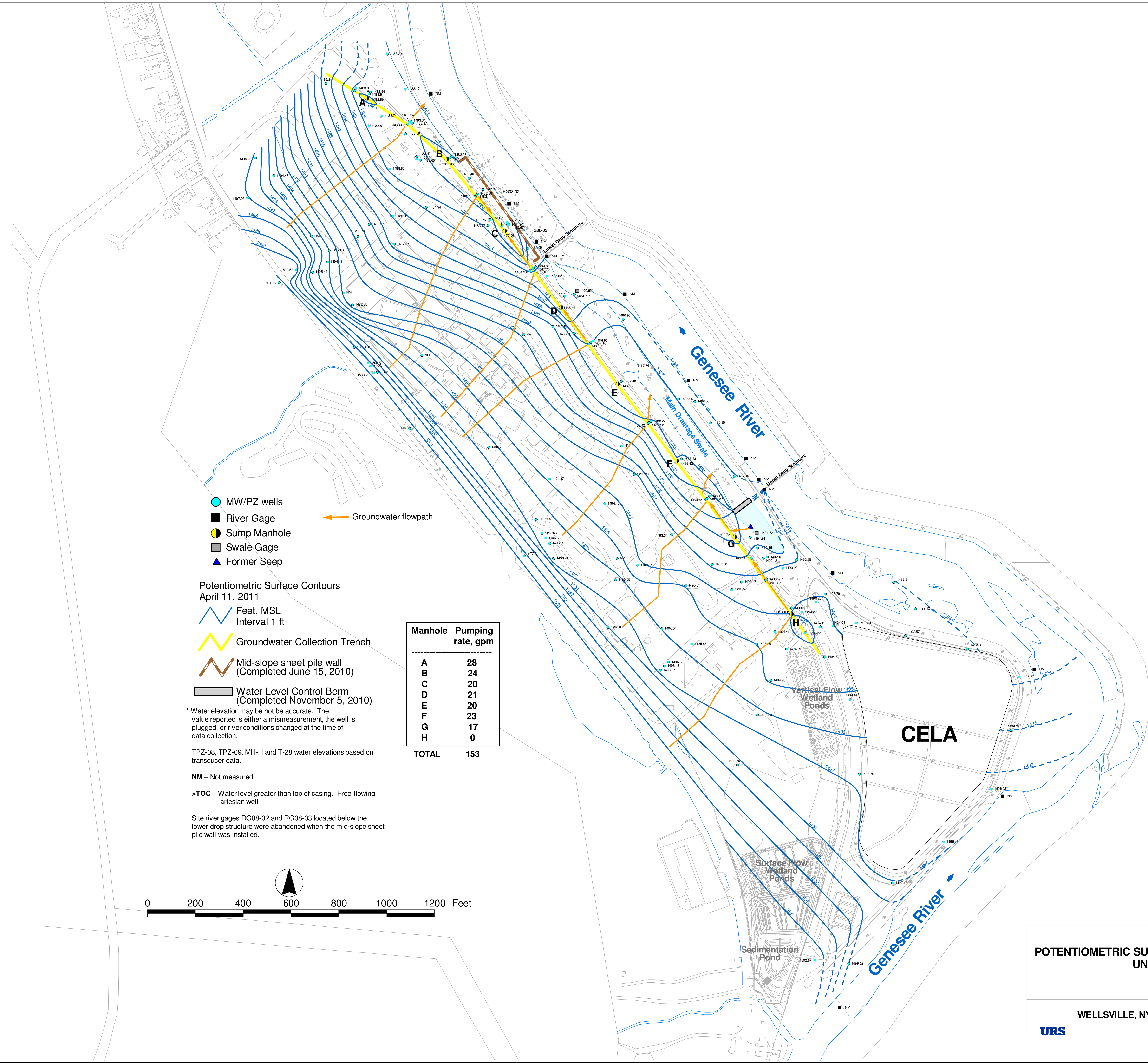
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS MARCH 22, 2011

WELLSVILLE, NY

URS

April 2011

FIGURE 17



Manhole	Pumping rate, gpm
A	28
B	24
C	20
D	21
E	20
F	23
G	17
H	0
TOTAL	153

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

TPZ-08, TPZ-09, MH-H and T-28 water elevations based on transducer data.

NM – Not measured.

>TOC – Water level greater than top of casing. Free-flowing artesian well

Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

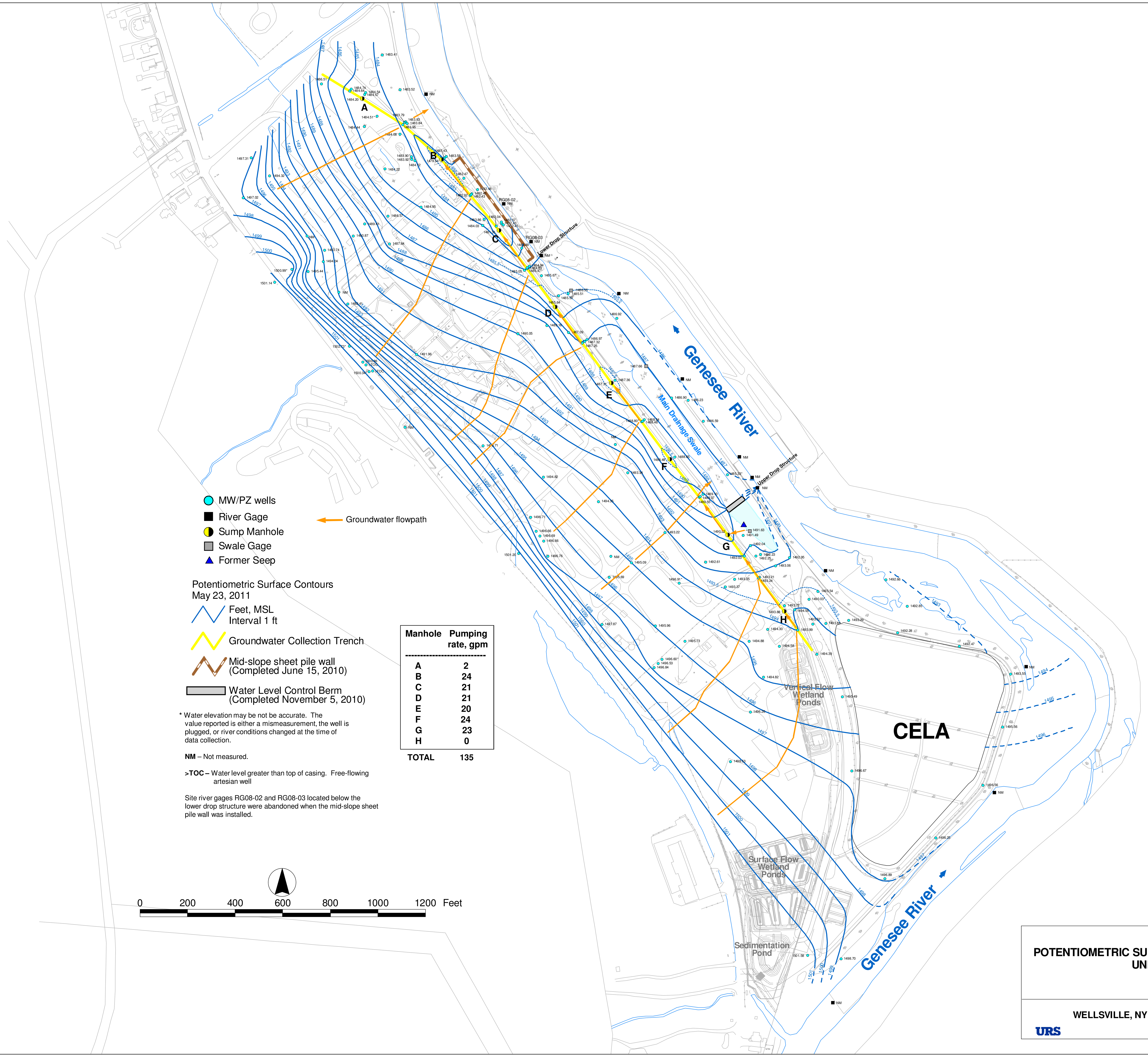
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS APRIL 11, 2011

WELLSVILLE, NY

URS

April 2011

FIGURE 18



Manhole	Pumping rate, gpm
A	2
B	24
C	21
D	21
E	20
F	24
G	23
H	0
TOTAL	135

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

>TOC – Water level greater than top of casing. Free-flowing artesian well

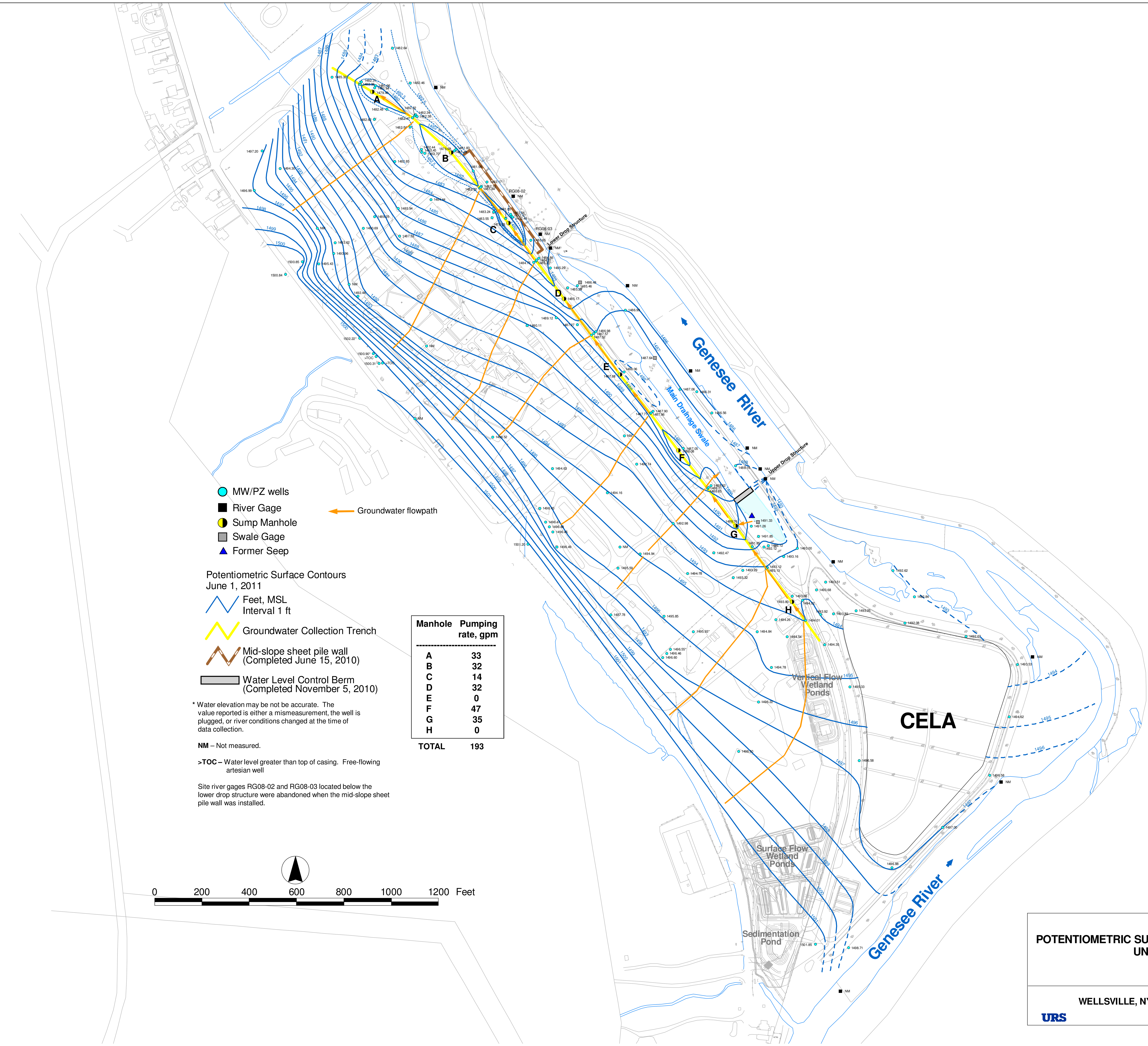
Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS MAY 23, 2011

WELLSVILLE, NY

URS June 2011

FIGURE 19



Manhole	Pumping rate, gpm
A	33
B	32
C	14
D	32
E	0
F	47
G	35
H	0
TOTAL	193

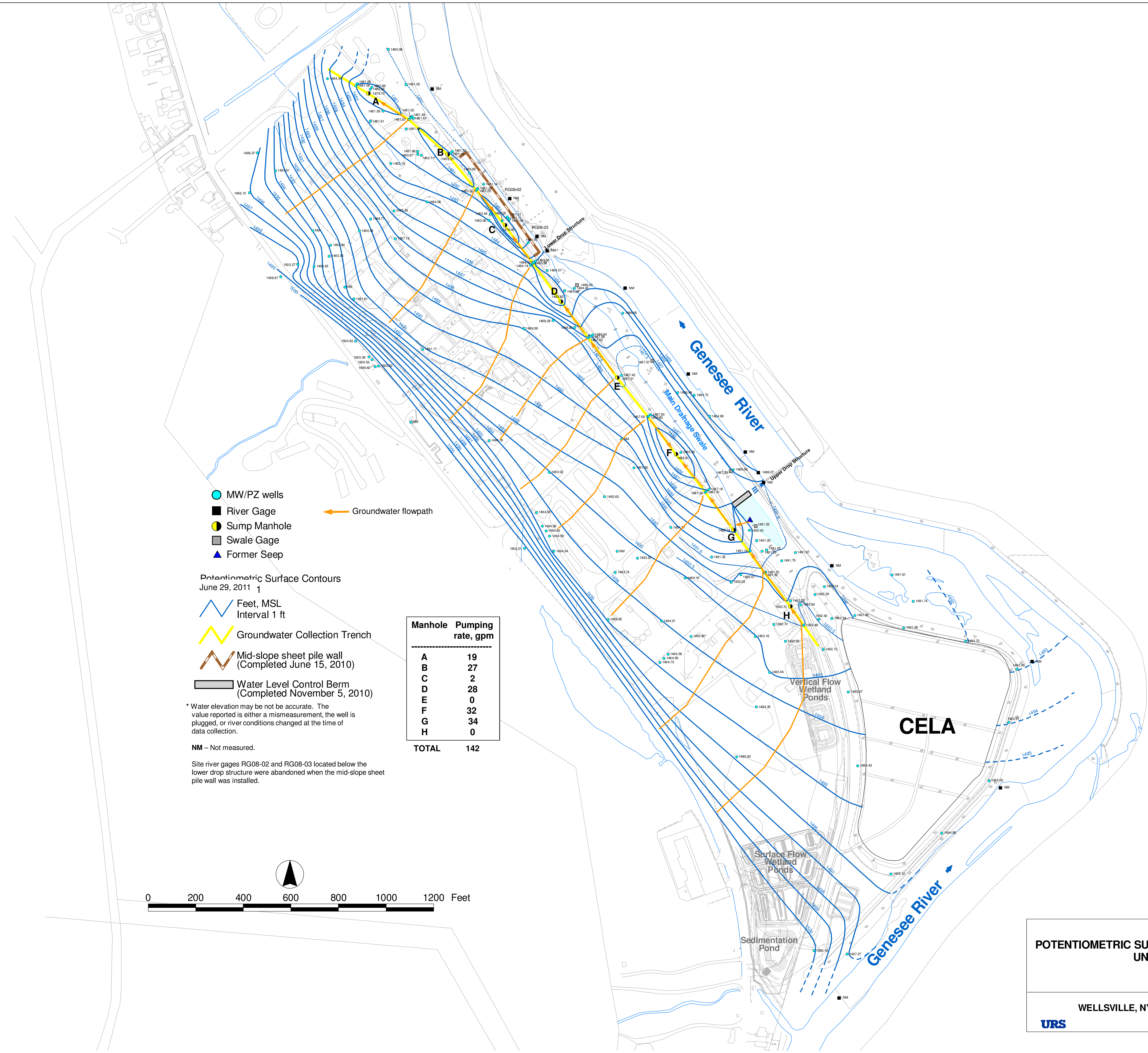
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS JUNE 1, 2011

WELLSVILLE, NY

URS

June 2011

FIGURE 20



MW/PZ wells
River Gage
Sump Manhole
Swale Gage
Former Seep
Groundwater flowpath

Potentiometric Surface Contours
June 29, 2011 1

Feet, MSL
Interval 1 ft

Groundwater Collection Trench

Mid-slope sheet pile wall
(Completed June 15, 2010)

Water Level Control Berm
(Completed November 5, 2010)

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

Manhole	Pumping rate, gpm
A	19
B	27
C	2
D	28
E	0
F	32
G	34
H	0
TOTAL	142

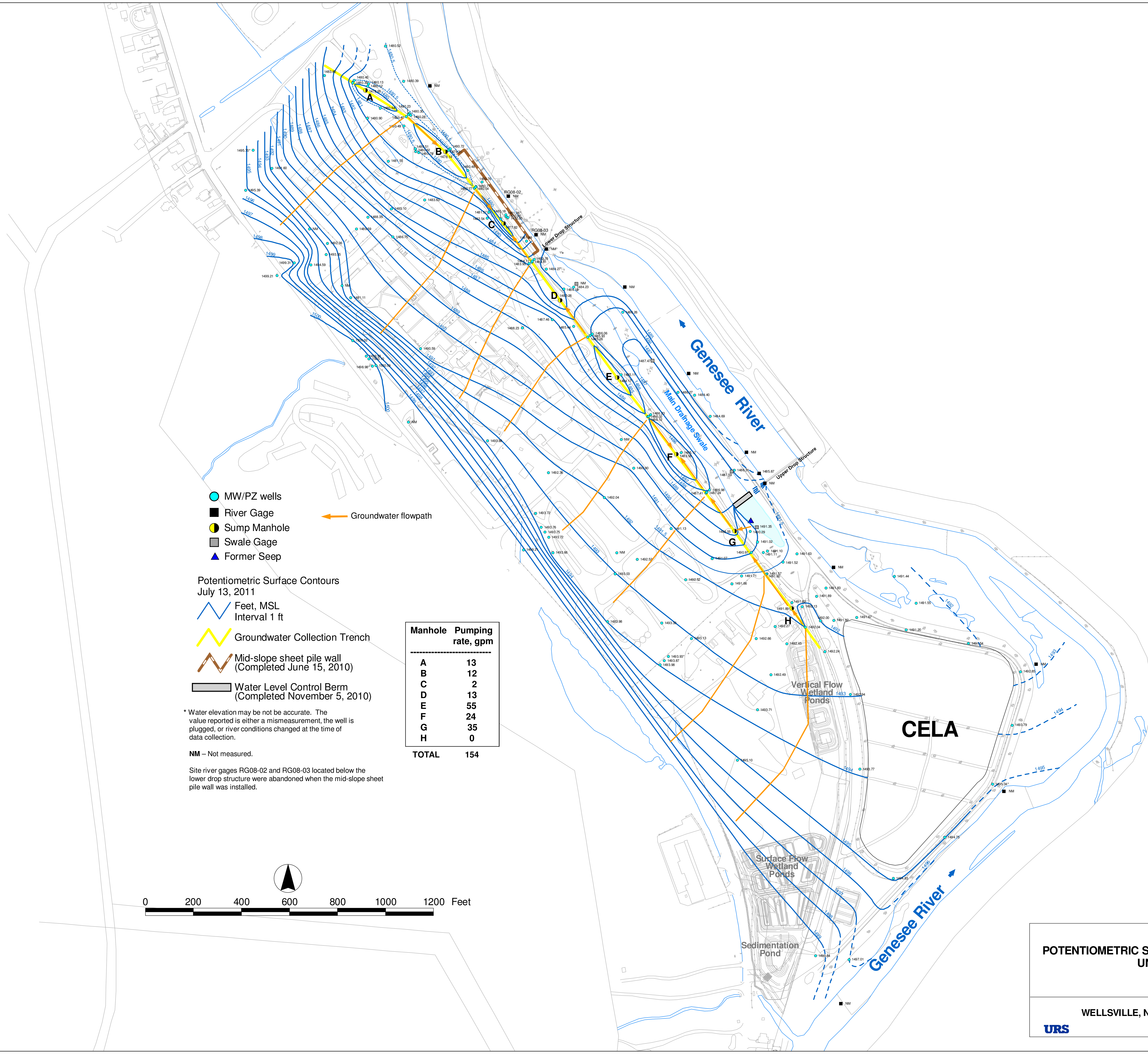
POTENTIOMETRIC SURFACE CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS JUNE 29, 2011

WELLSVILLE, NY

URS

July 2011

FIGURE 21



Manhole	Pumping rate, gpm
A	13
B	12
C	2
D	13
E	55
F	24
G	35
H	0
TOTAL	154

* Water elevation may be not be accurate. The value reported is either a mismeasurement, the well is plugged, or river conditions changed at the time of data collection.

NM – Not measured.

Site river gages RG08-02 and RG08-03 located below the lower drop structure were abandoned when the mid-slope sheet pile wall was installed.

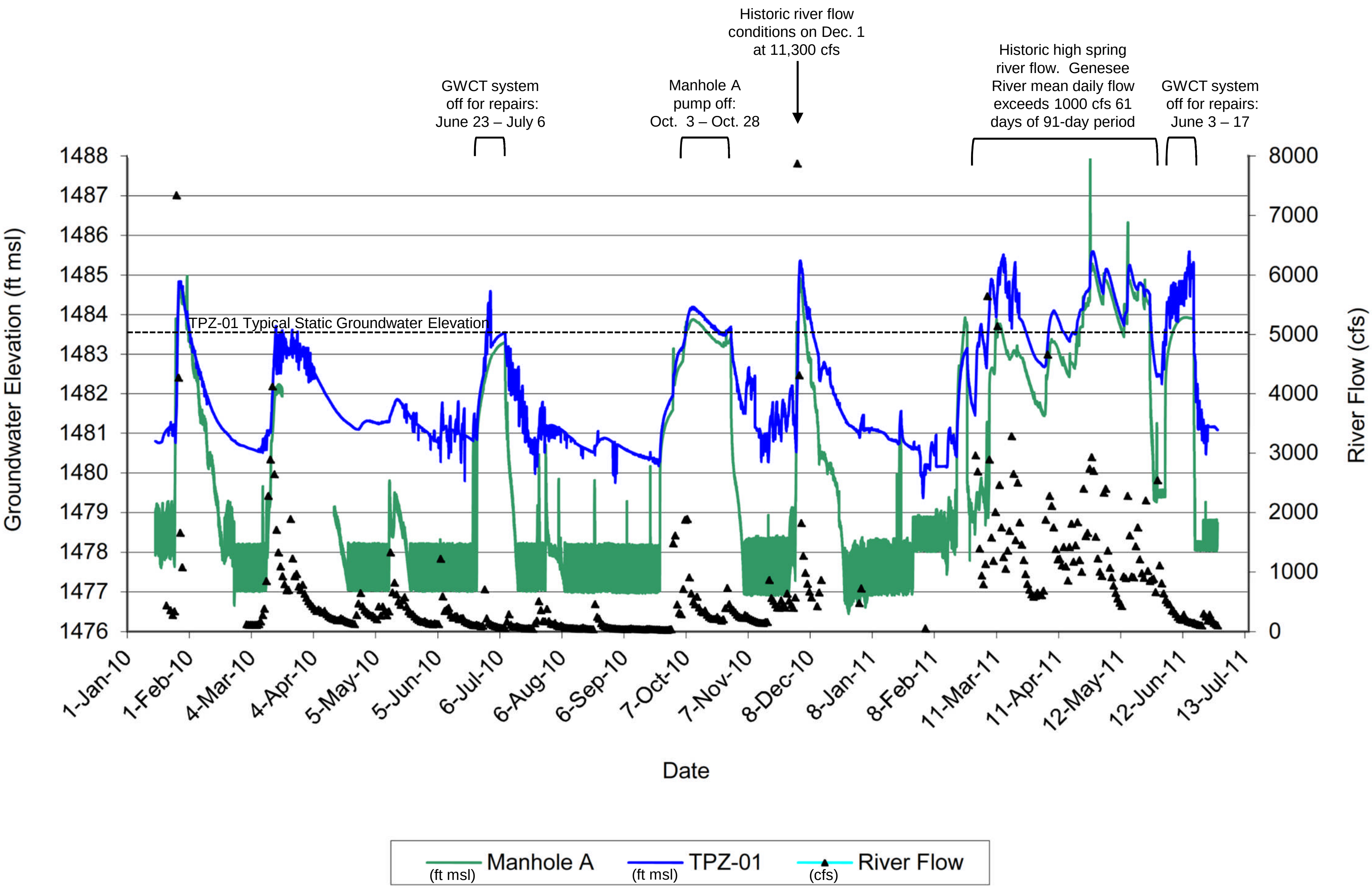
POTENTIOMETRIC SURFAC CONTOURS OF THE GLACIAL AQUIFER UNDER PUMPING CONDITIONS JULY 13, 2011

WELLSVILLE, NY

URS

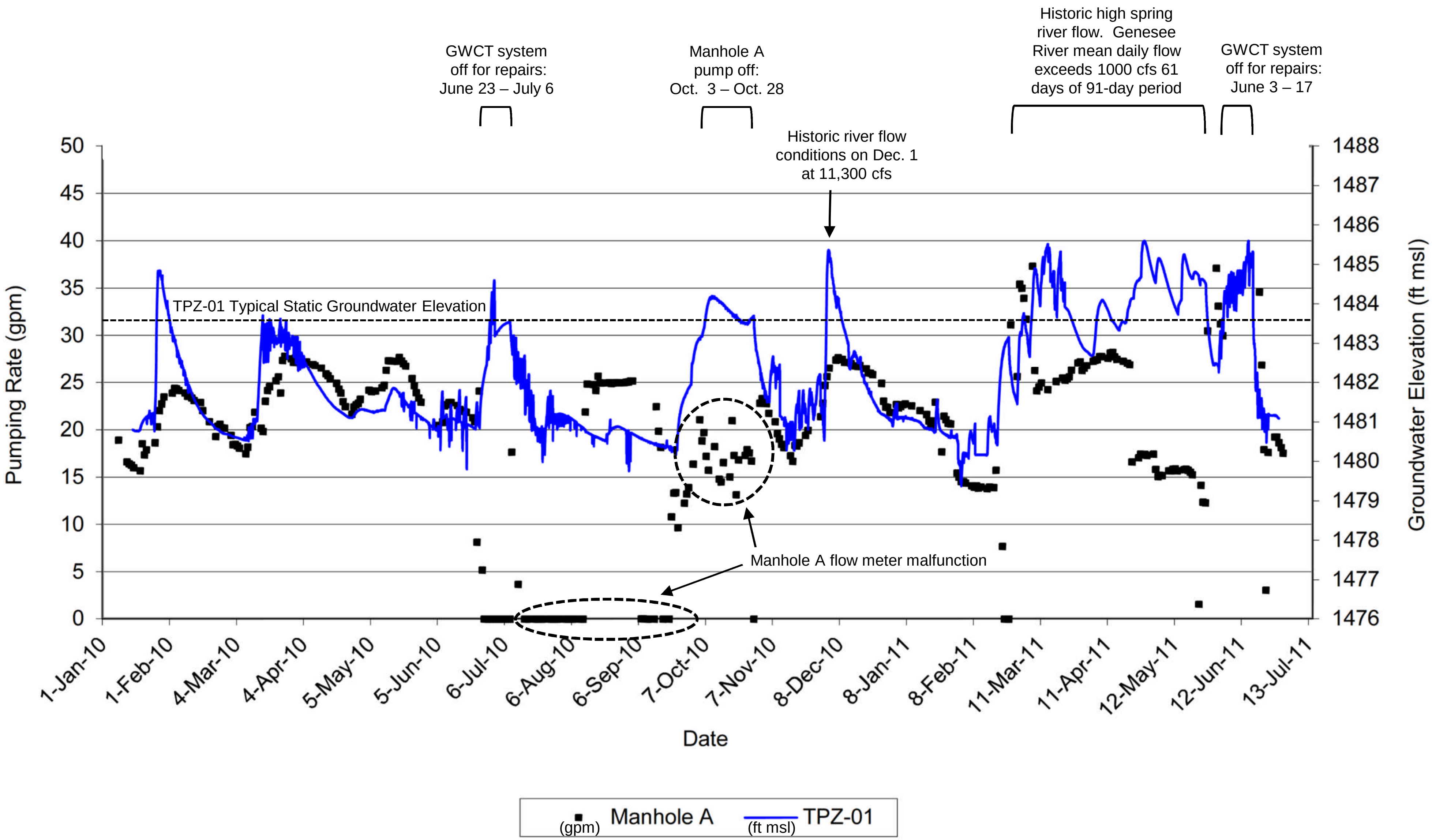
July 2011

FIGURE 22

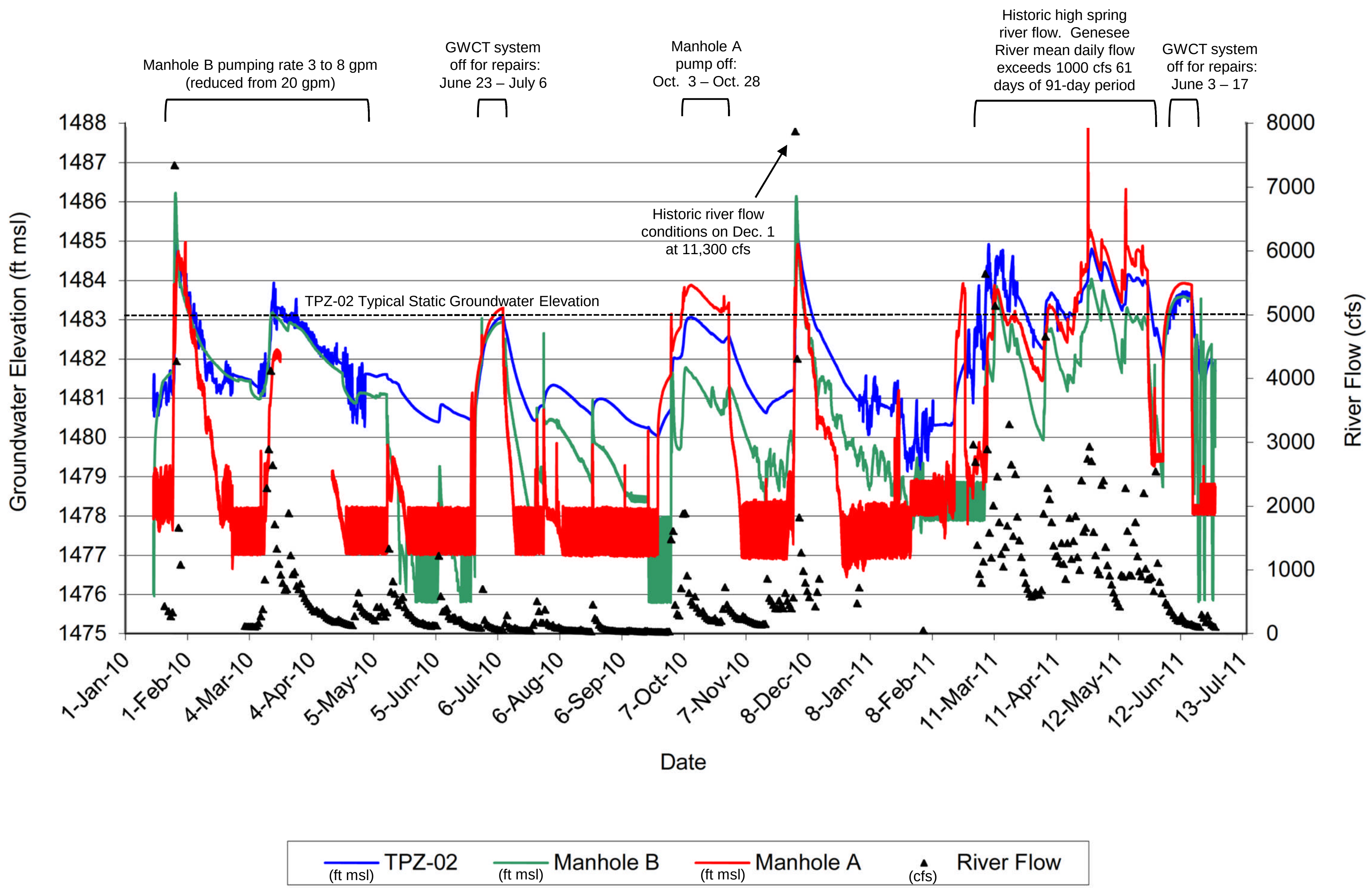


Note: Genesee River flow is observed mean daily flow measured at USGS Gage 0422100 located at Wellsville, NY.

WELLSVILLE, NEW YORK *July, 2011*	**TPZ-01 and Manhole A Groundwater Elevation Trends**	**FIGURE 23**

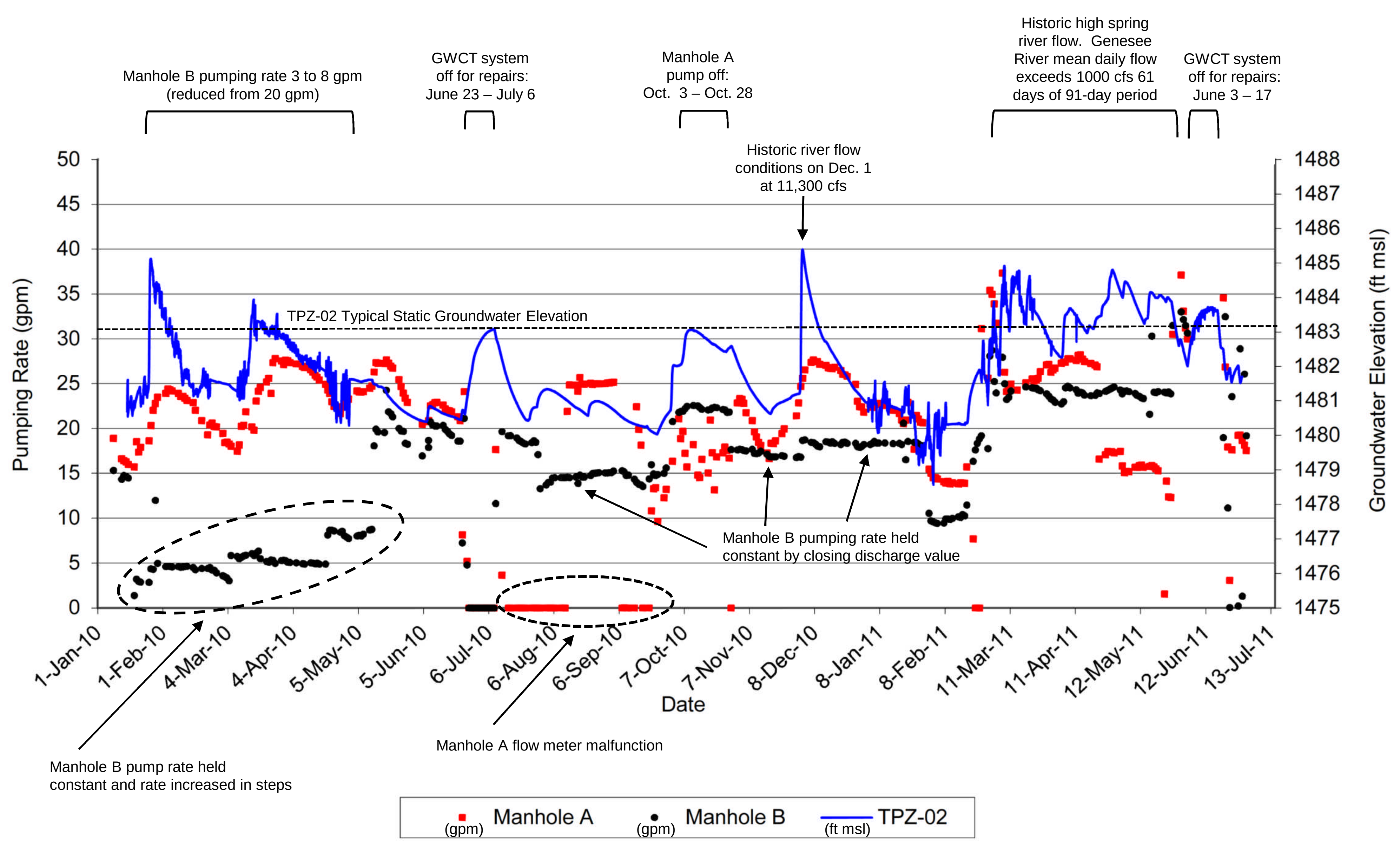


WELLSVILLE, NEW YORK *July, 2011*	**TPZ-01 Groundwater Elevation Compared to Manhole A Pumping Rate**	**FIGURE 24**

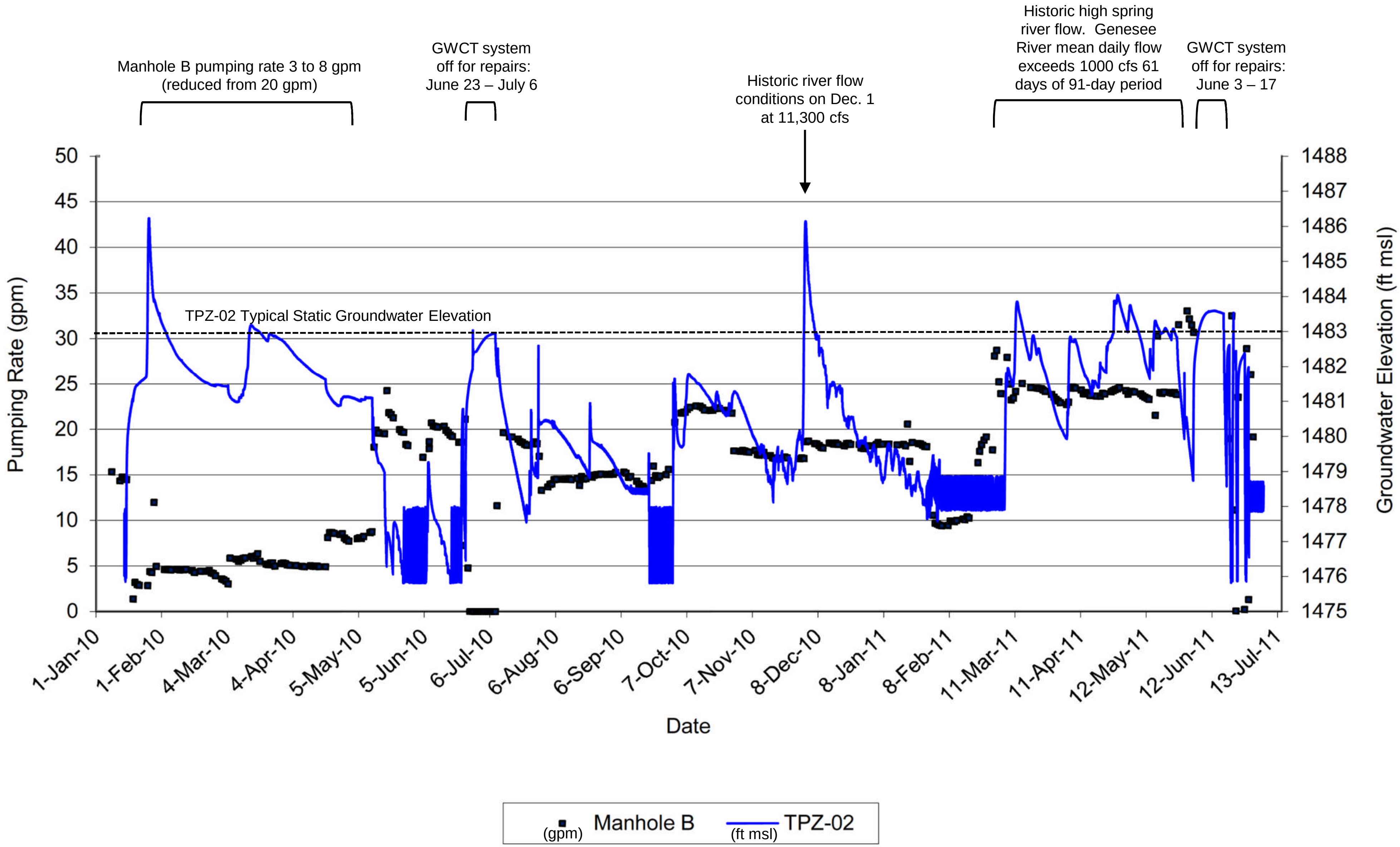


Note: Genesee River flow is observed mean daily flow measured at USGS Gage 0422100 located at Wellsville, NY.

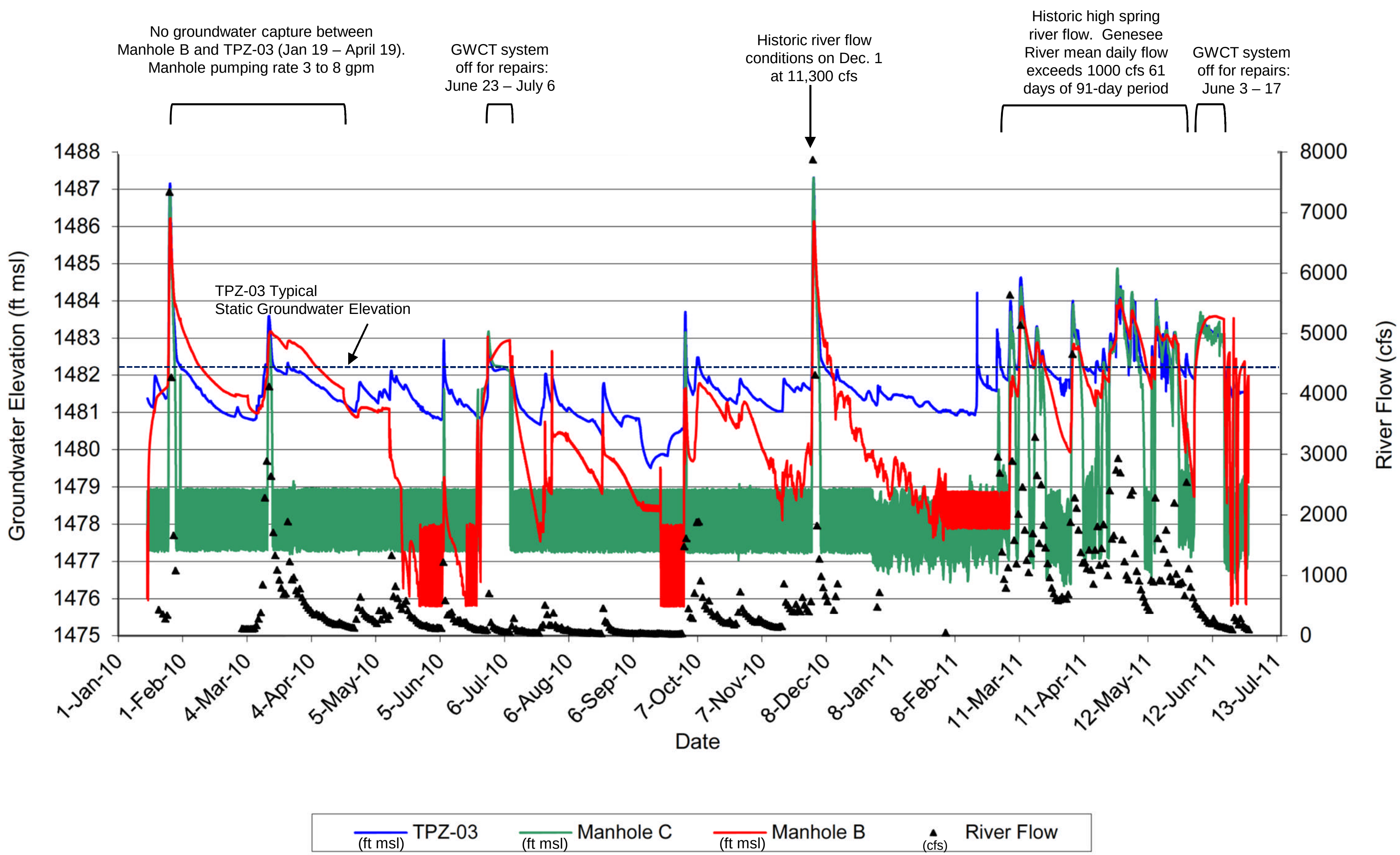
WELLSVILLE, NEW YORK *July, 2011*	**Manhole A, TPZ-02 and Manhole B Groundwater Elevation Trends**	**FIGURE 25**



WELLSVILLE, NEW YORK *July, 2011*	**TPZ-02 Groundwater Elevation Compared to Manhole A and Manhole B Pumping Rates**	**FIGURE 26**

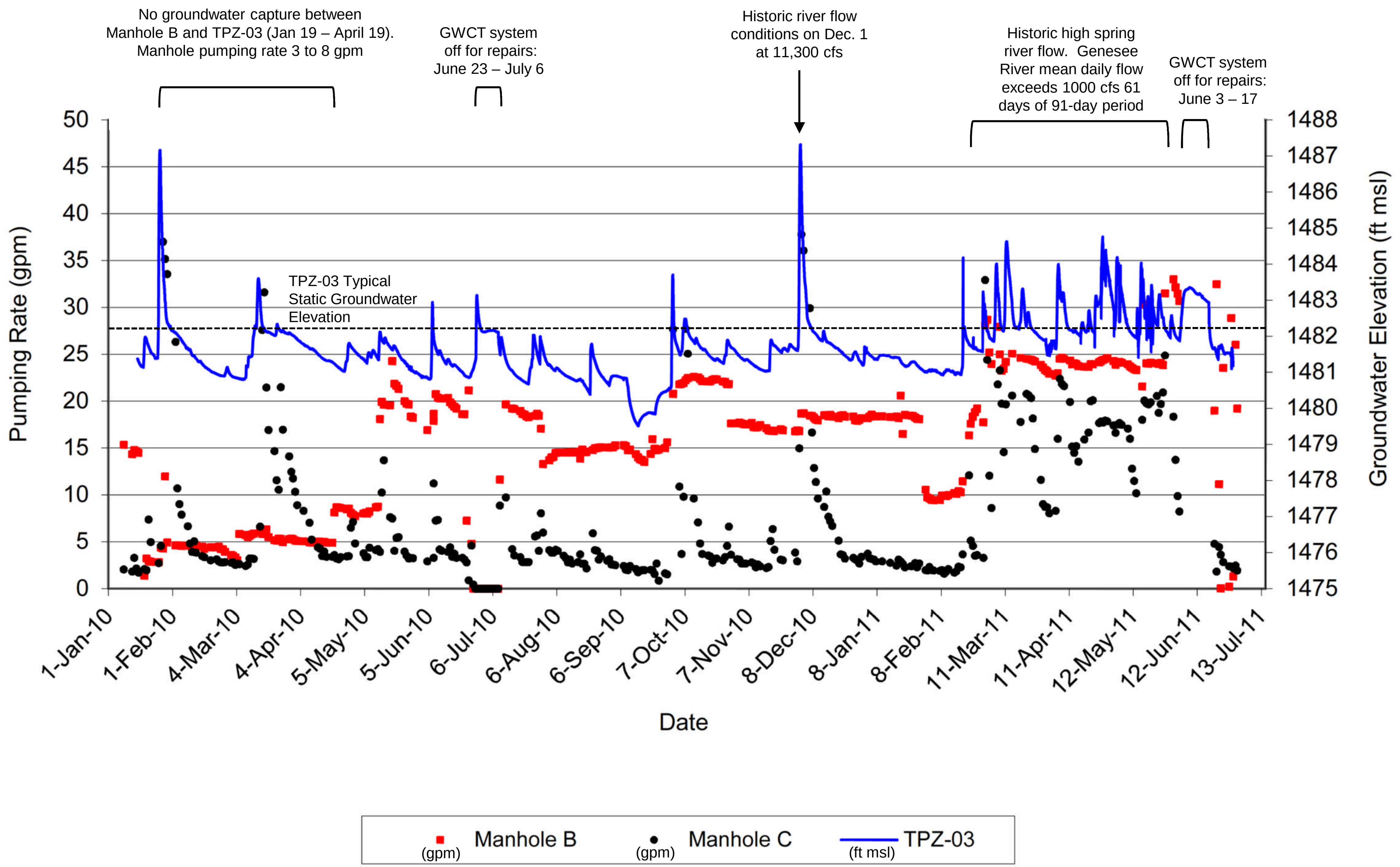


WELLSVILLE, NEW YORK *July, 2011*	**TPZ-02 Groundwater Elevation Compared to Manhole B Pumping Rate**	**FIGURE 27**

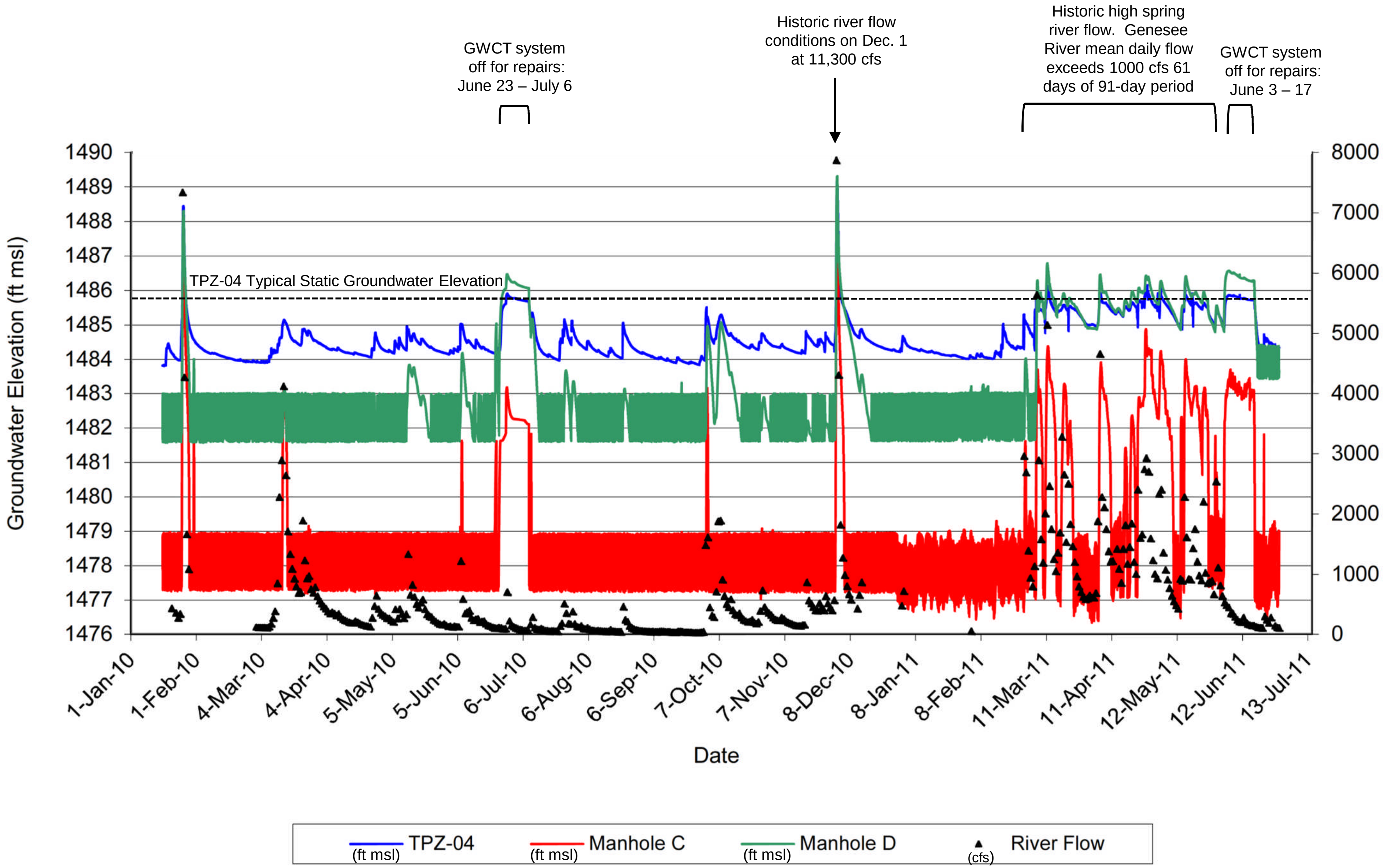


Note: Genesee River flow is observed mean daily flow measured at USGS Gage 0422100 located at Wellsville, NY.

WELLSVILLE, NEW YORK *July, 2011*	**Manhole B, TPZ-03 and Manhole C Groundwater Elevation Trends**	**FIGURE 28**

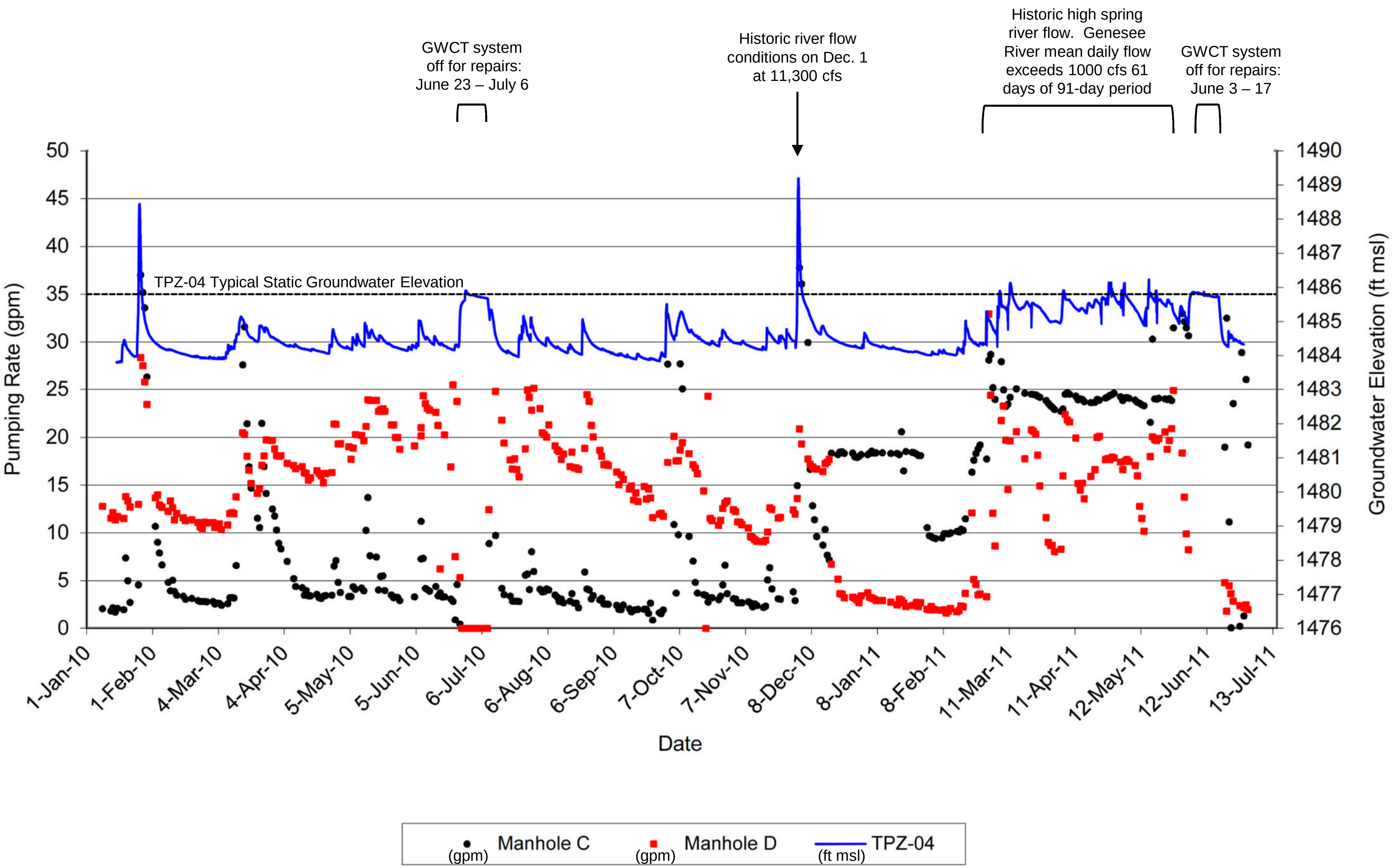


WELLSVILLE, NEW YORK *July, 2011*	**TPZ-03 Groundwater Elevation Compared to Manhole B and Manhole C Pumping Rates**	**FIGURE 29**

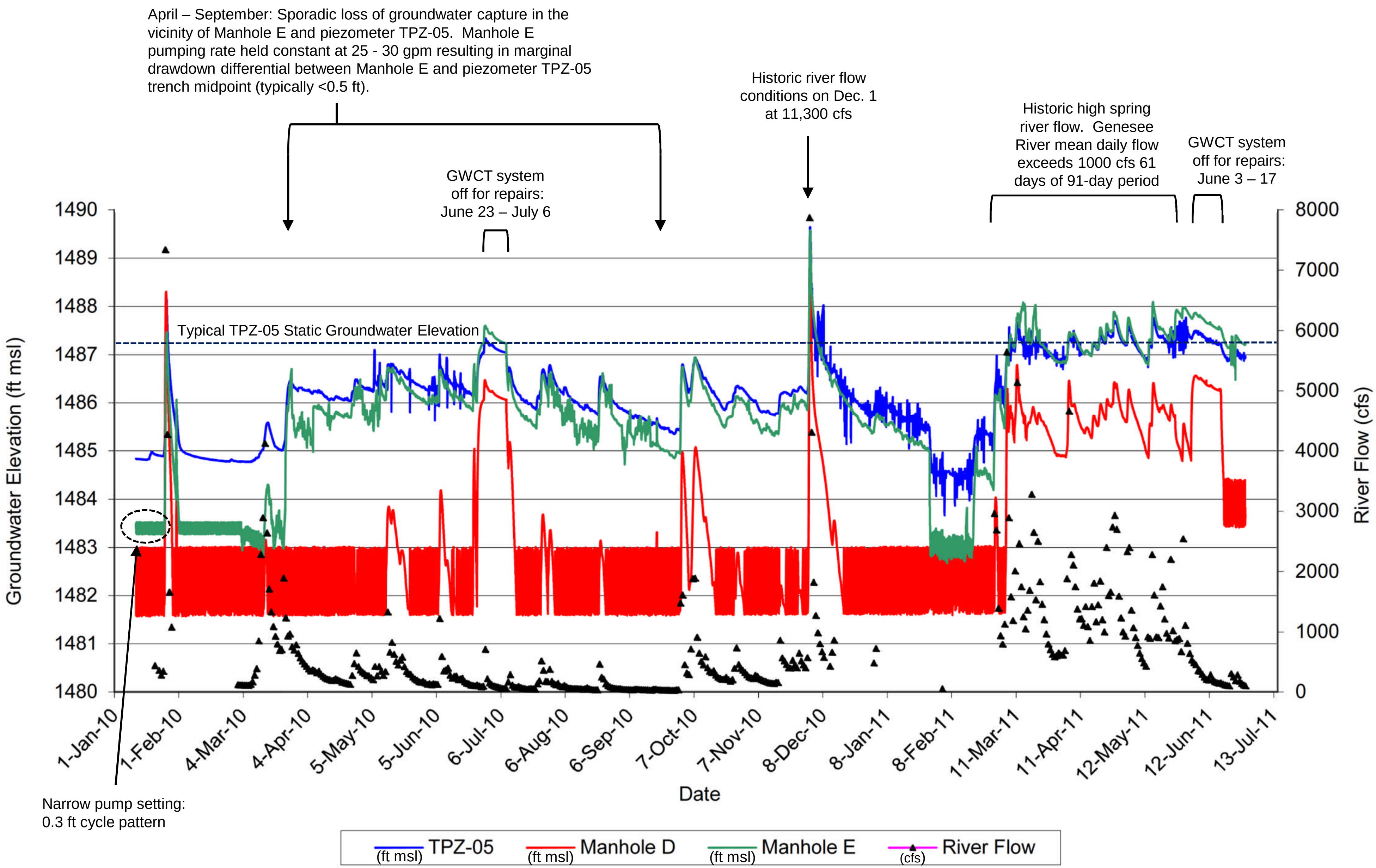


Note: Genesee River flow is observed mean daily flow measured at USGS Gage 0422100 located at Wellsville, NY.

WELLSVILLE, NEW YORK *July, 2011*	**Manhole C, TPZ-04 and Manhole D Groundwater Elevation Trends**	**FIGURE 30**

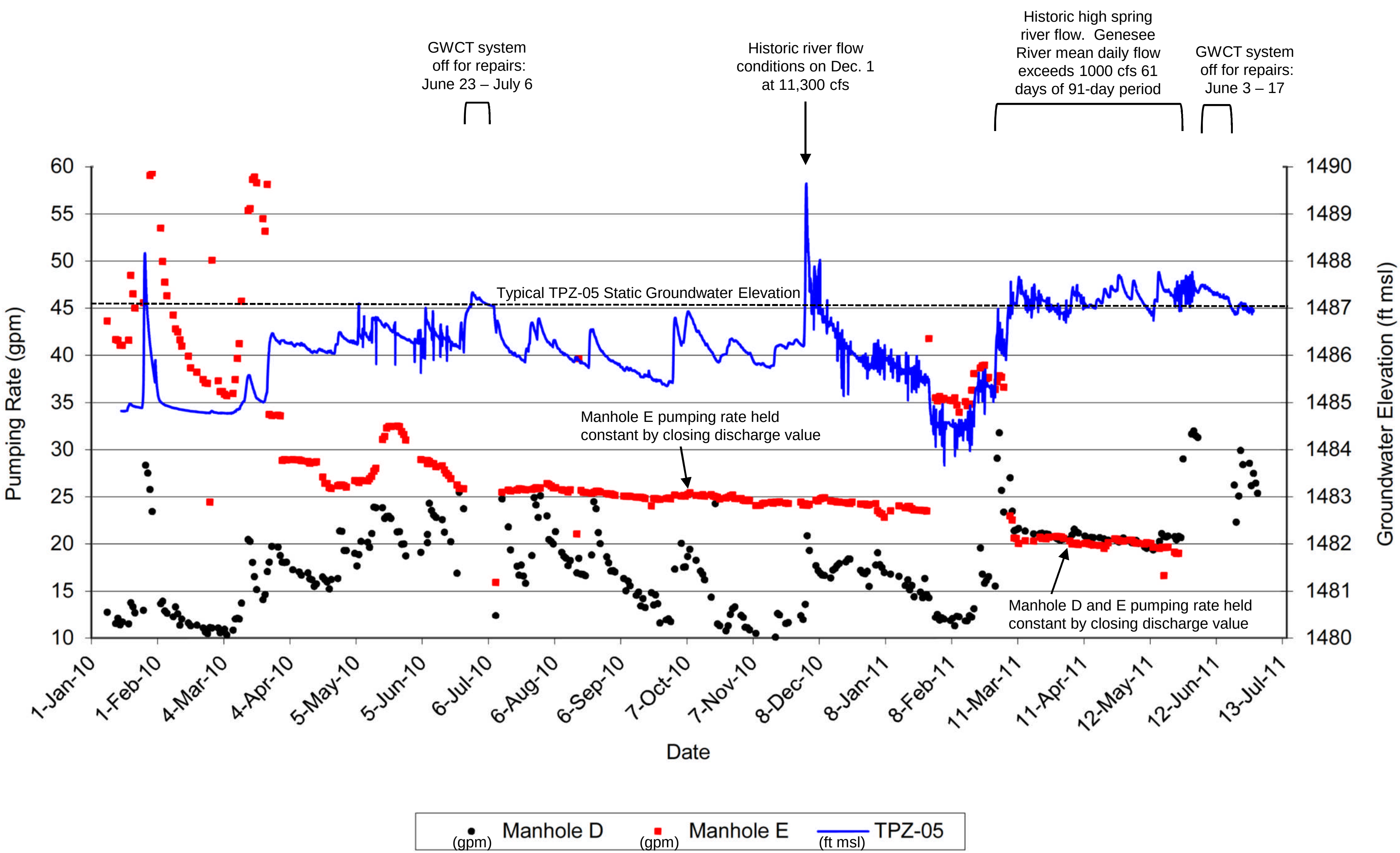


WELLSVILLE, NEW YORK *July, 2011*	**TPZ-04 Groundwater Elevation Compared to Manhole C and Manhole D Pumping Rates**	**FIGURE 31**

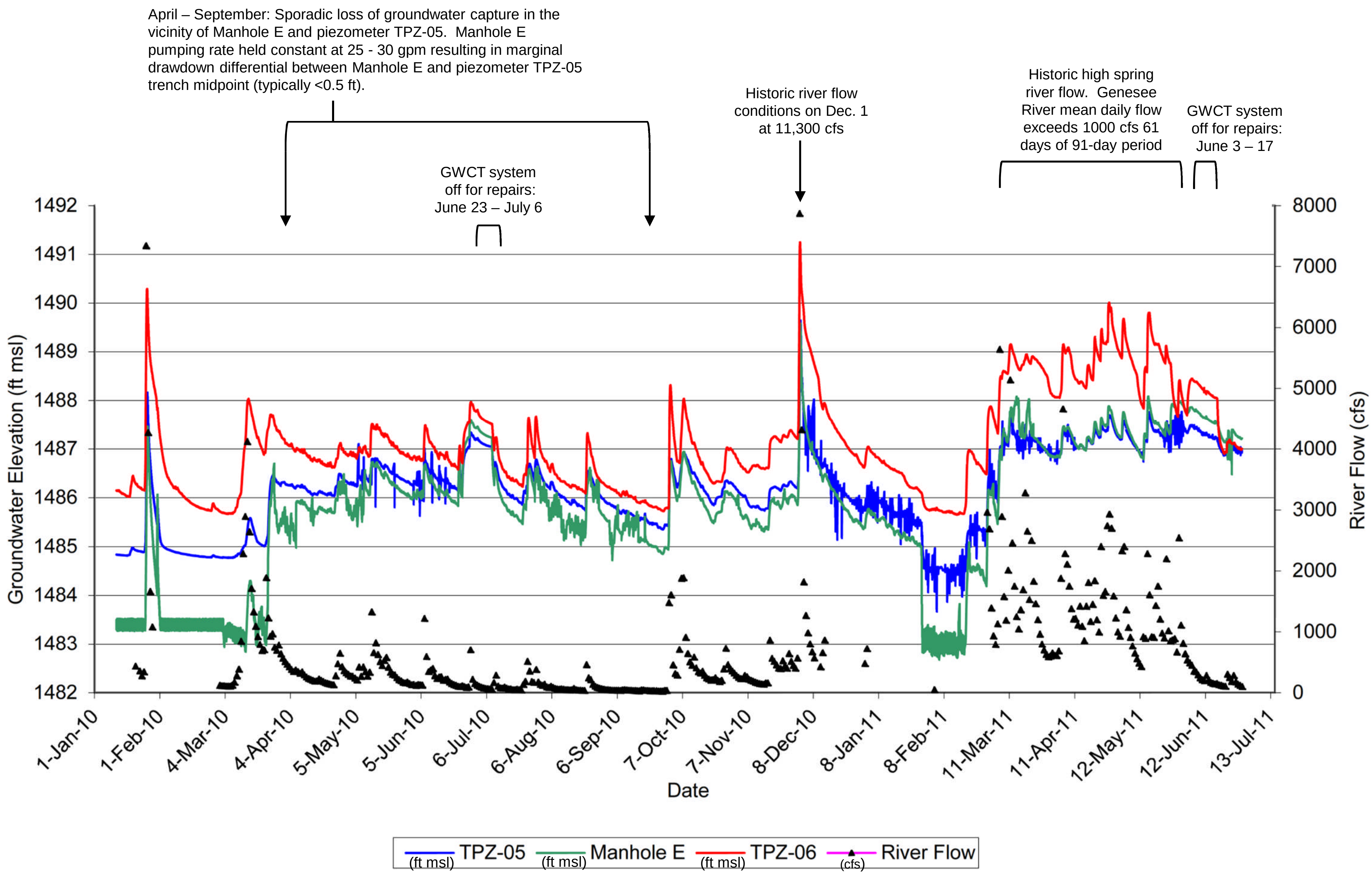


Note: Genesee River flow is observed mean daily flow measured at USGS Gage 0422100 located at Wellsville, NY.

WELLSVILLE, NEW YORK *July, 2011*	**Manhole D, TPZ-05 and Manhole E Groundwater Elevation Trends**	**FIGURE 32**

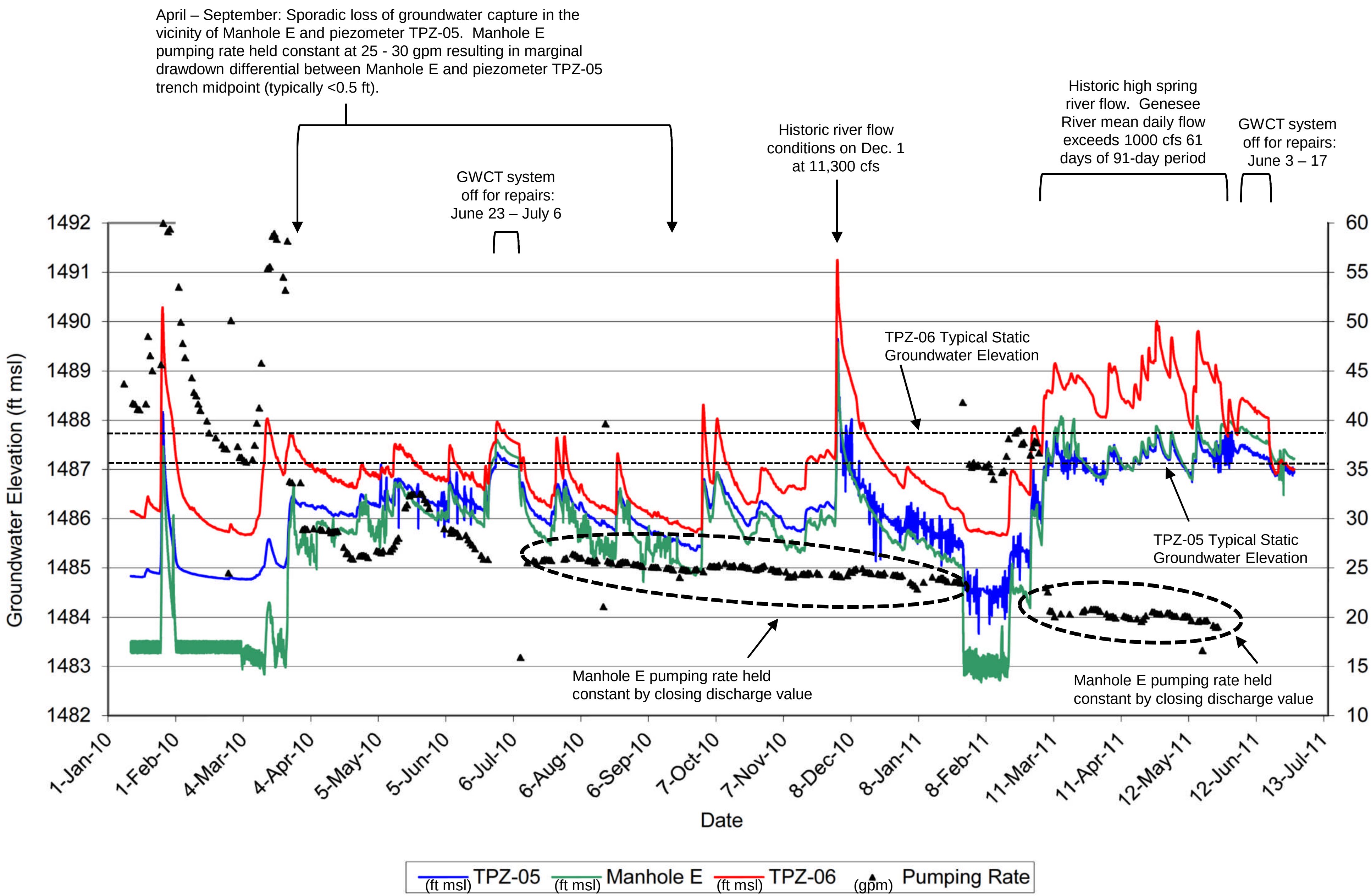


WELLSVILLE, NEW YORK *July, 2011*	**TPZ-05 Groundwater Elevation Compared to Manhole D and Manhole E Pumping Rates**	**FIGURE 33**



Note: Genesee River flow is observed mean daily flow measured at USGS Gage 0422100 located at Wellsville, NY.

WELLSVILLE, NEW YORK *July, 2011*	**TPZ-05, Manhole E and TPZ-06 Groundwater Elevation Trends**	**FIGURE 34**

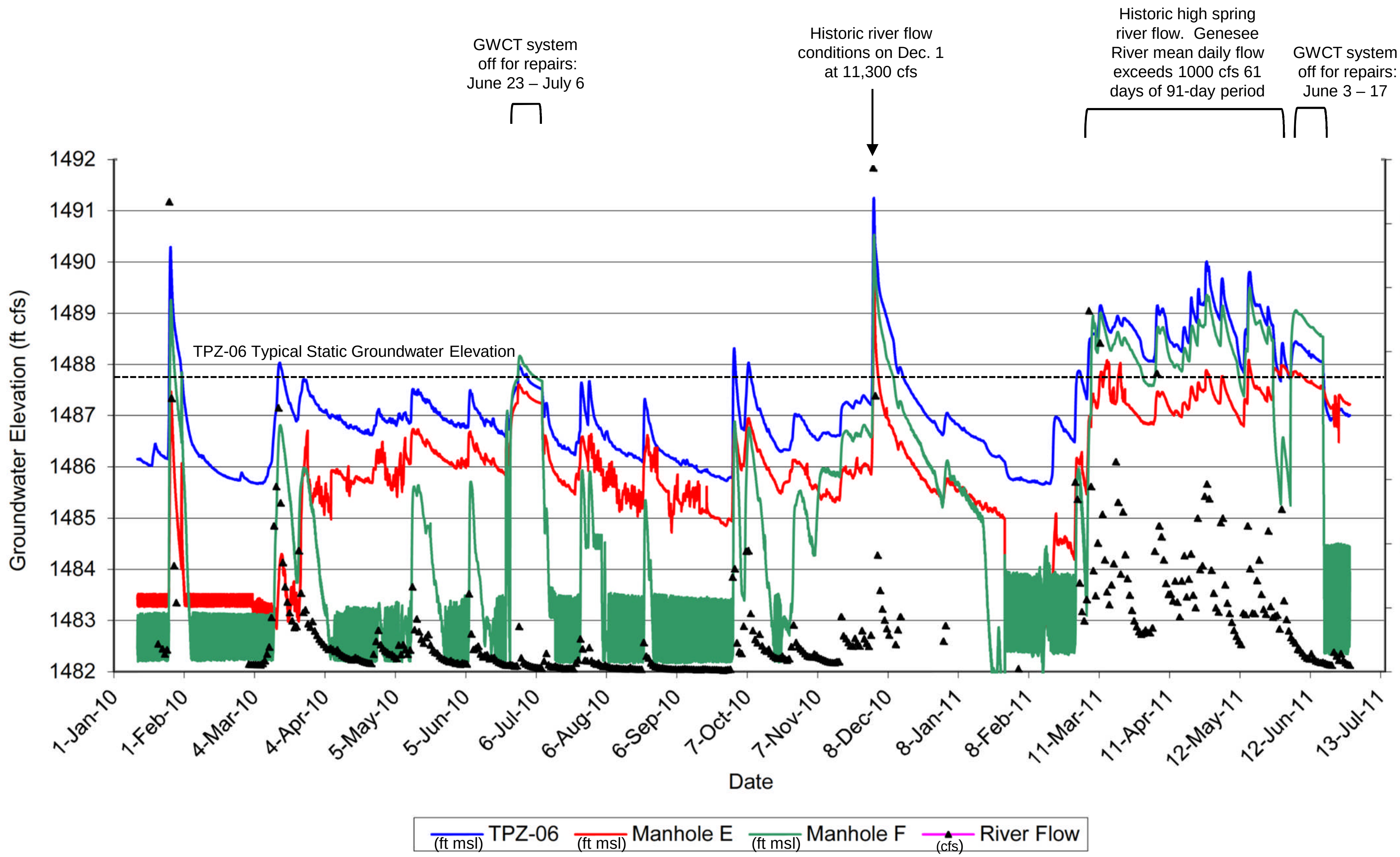


WELLSVILLE, NEW YORK

July, 2011

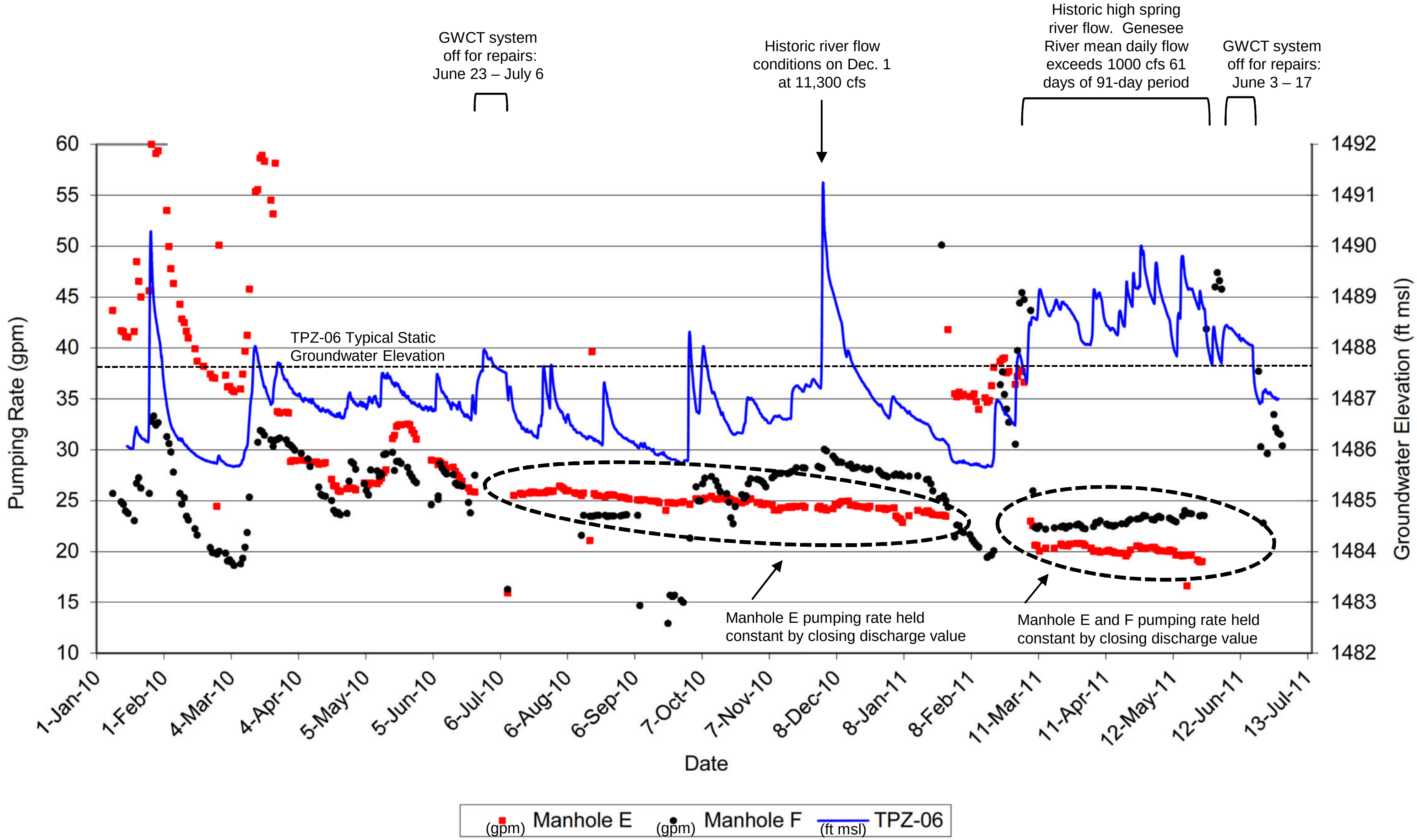
TPZ-05, Manhole E and TPZ-06 Groundwater Elevation Trends Compared to Manhole E Pumping Rate

FIGURE 35

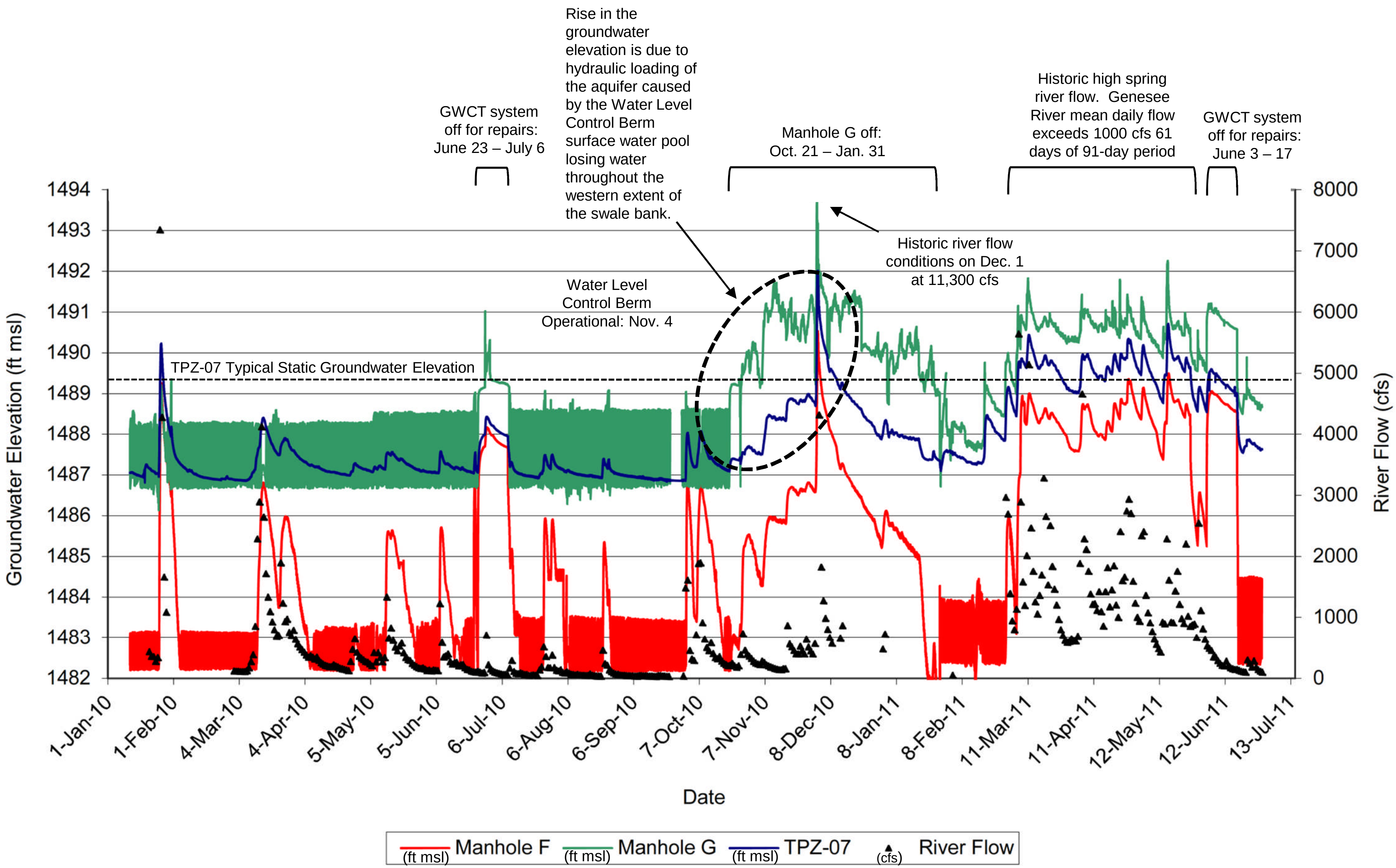


Note: Genesee River flow is observed mean daily flow measured at USGS Gage 0422100 located at Wellsville, NY.

WELLSVILLE, NEW YORK *July, 2011*	**Manhole E, TPZ-06 and Manhole F Groundwater Elevation Trends**	**FIGURE 36**

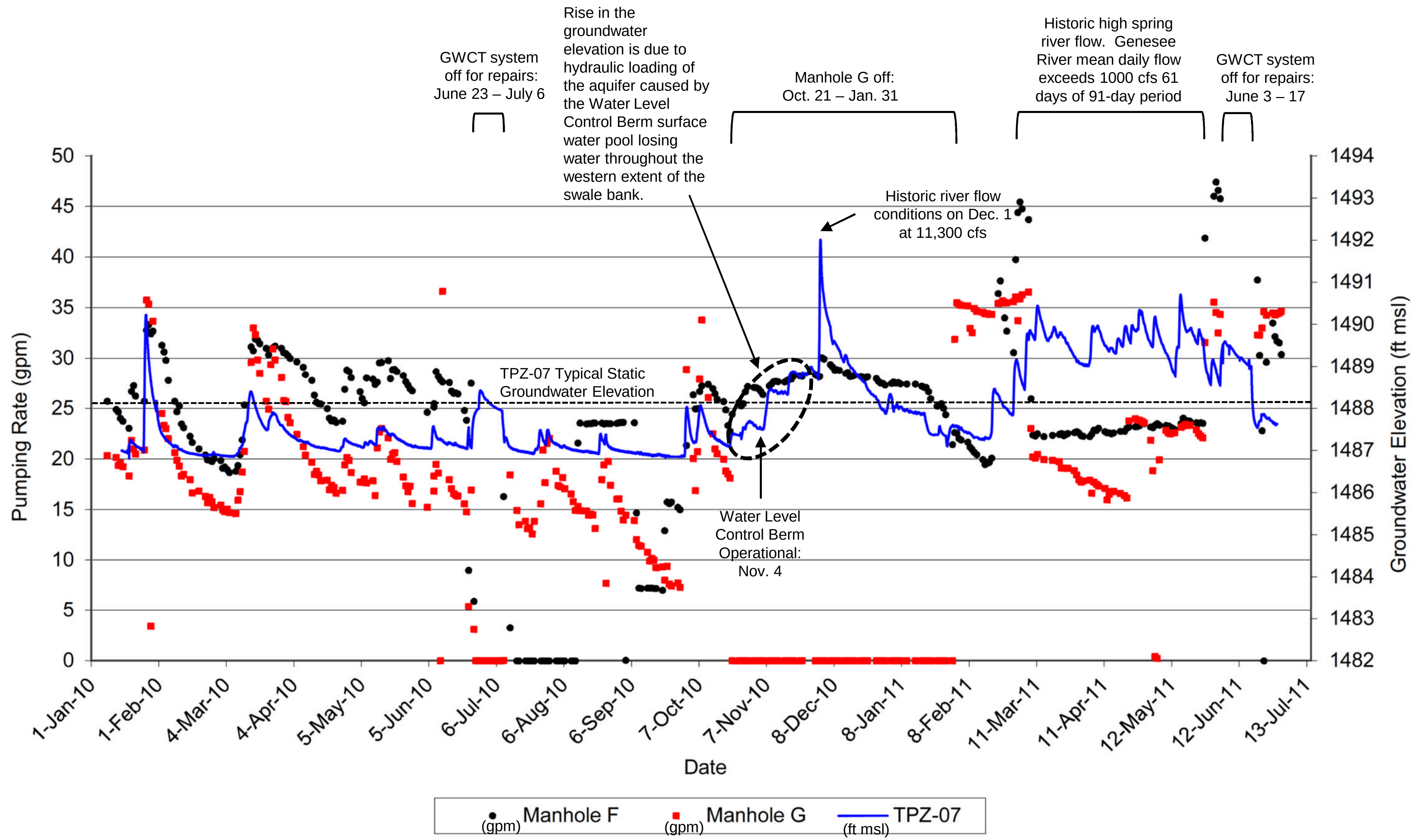


WELLSVILLE, NEW YORK *July, 2011*	**TPZ-06 Groundwater Elevation Compared to Manhole E and Manhole F Pumping Rates**	**FIGURE 37**

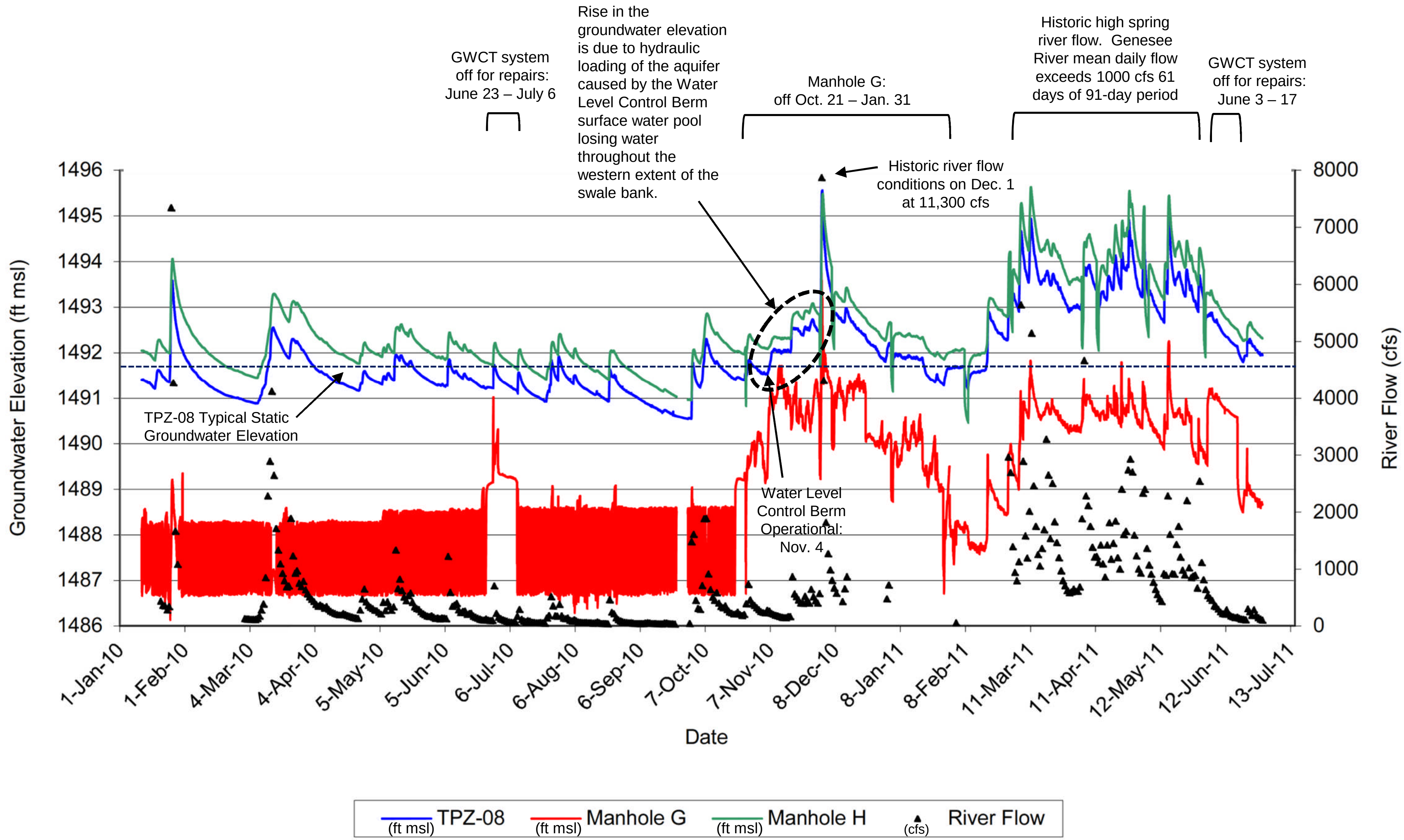


Note: Genesee River flow is observed mean daily flow measured at USGS Gage 0422100 located at Wellsville, NY.

WELLSVILLE, NEW YORK *July, 2011*	**Manhole F, TPZ-07 and Manhole G Groundwater Elevation Trends**	**FIGURE 38**

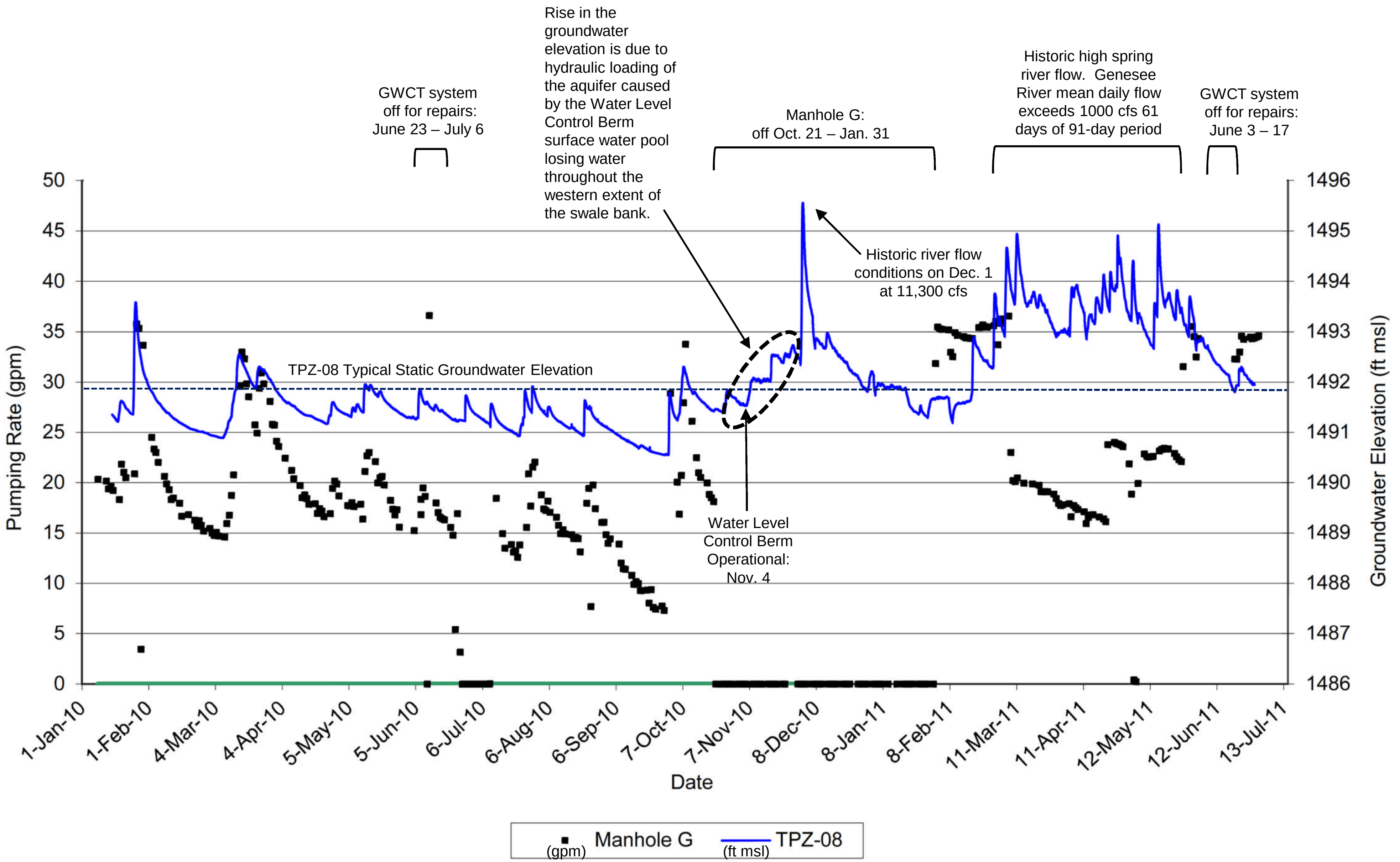


WELLSVILLE, NEW YORK *July, 2011*	**TPZ-07 Groundwater Elevation Compared to Manhole F and Manhole G Pumping Rates**	**FIGURE 39**

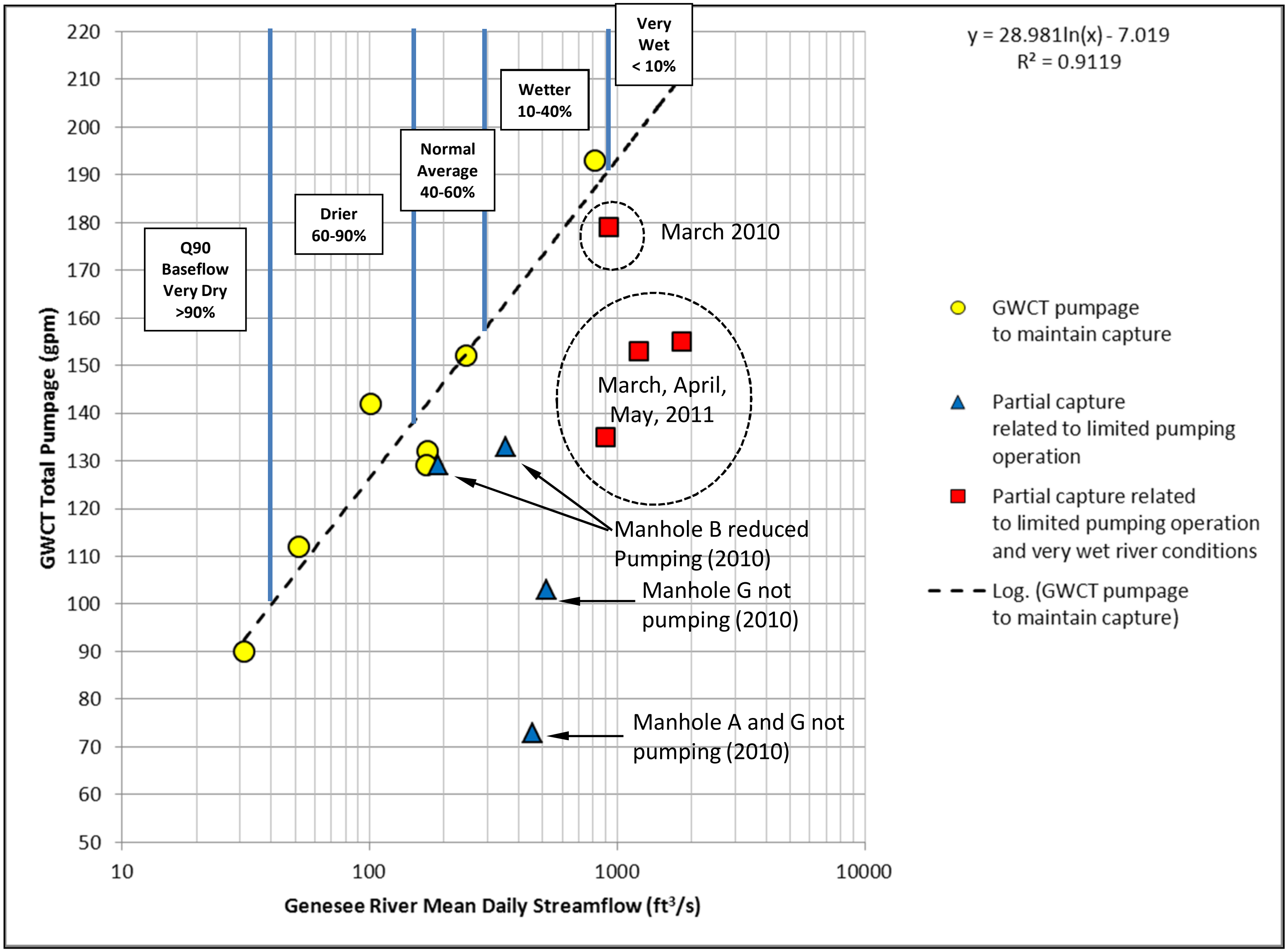


Note: Genesee River flow is observed mean daily flow measured at USGS Gage 0422100 located at Wellsville, NY.

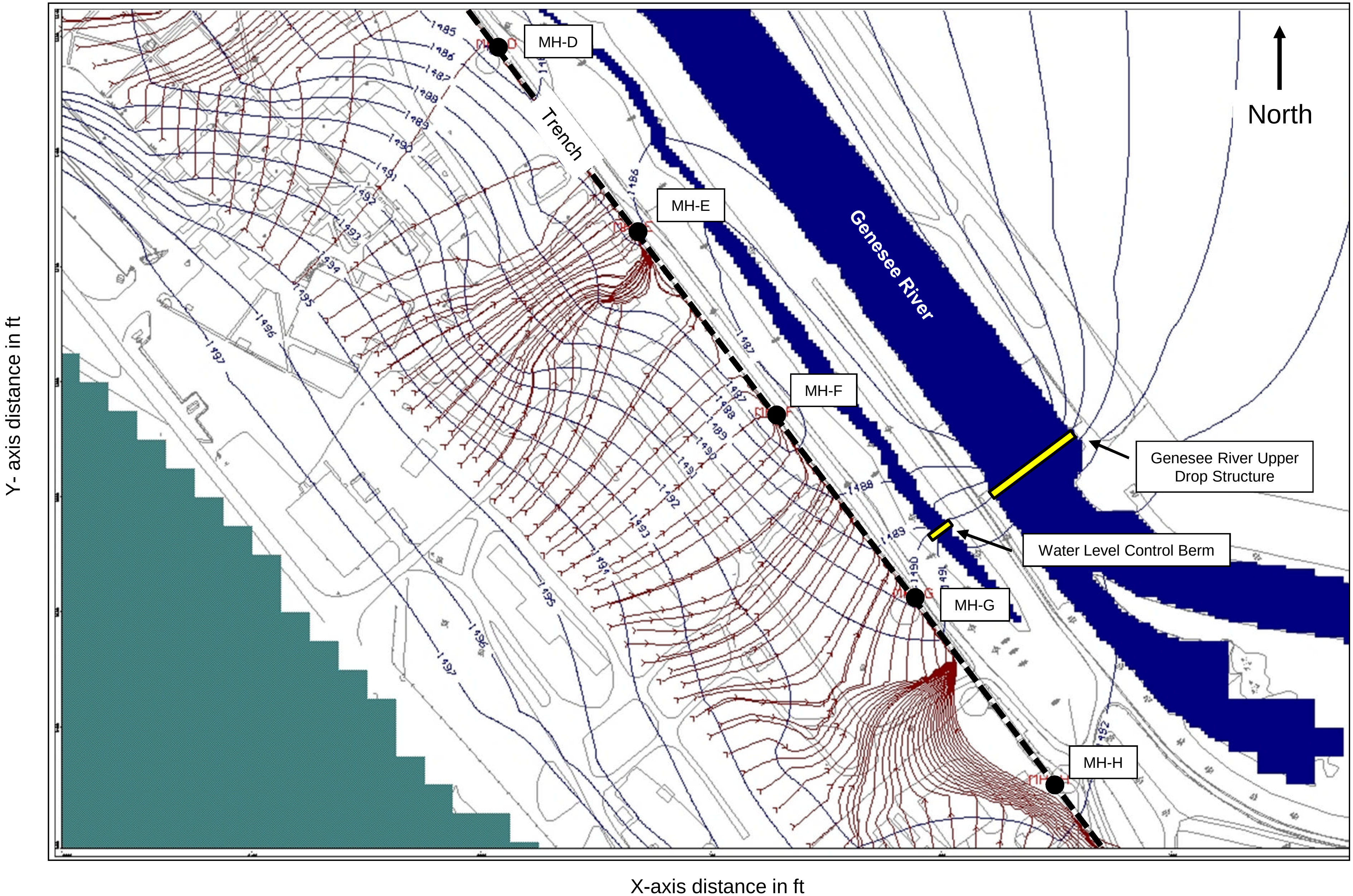
WELLSVILLE, NEW YORK *July, 2011*	**Manhole G, TPZ-08 and Manhole H Groundwater Elevation Trends**	**FIGURE 40**



WELLSVILLE, NEW YORK *July, 2011*	**TPZ-08 Groundwater Elevation Compared to Manhole G Pumping Rate**	**FIGURE 41**



WELLSVILLE, NEW YORK July, 2011	**Relationship Between Total GWCT System Pumping, Genesee River Mean Daily Streamflow and Site-wide Groundwater Capture (January 2010 – July 2011)**	**FIGURE 42**



WELLSVILLE, NEW YORK

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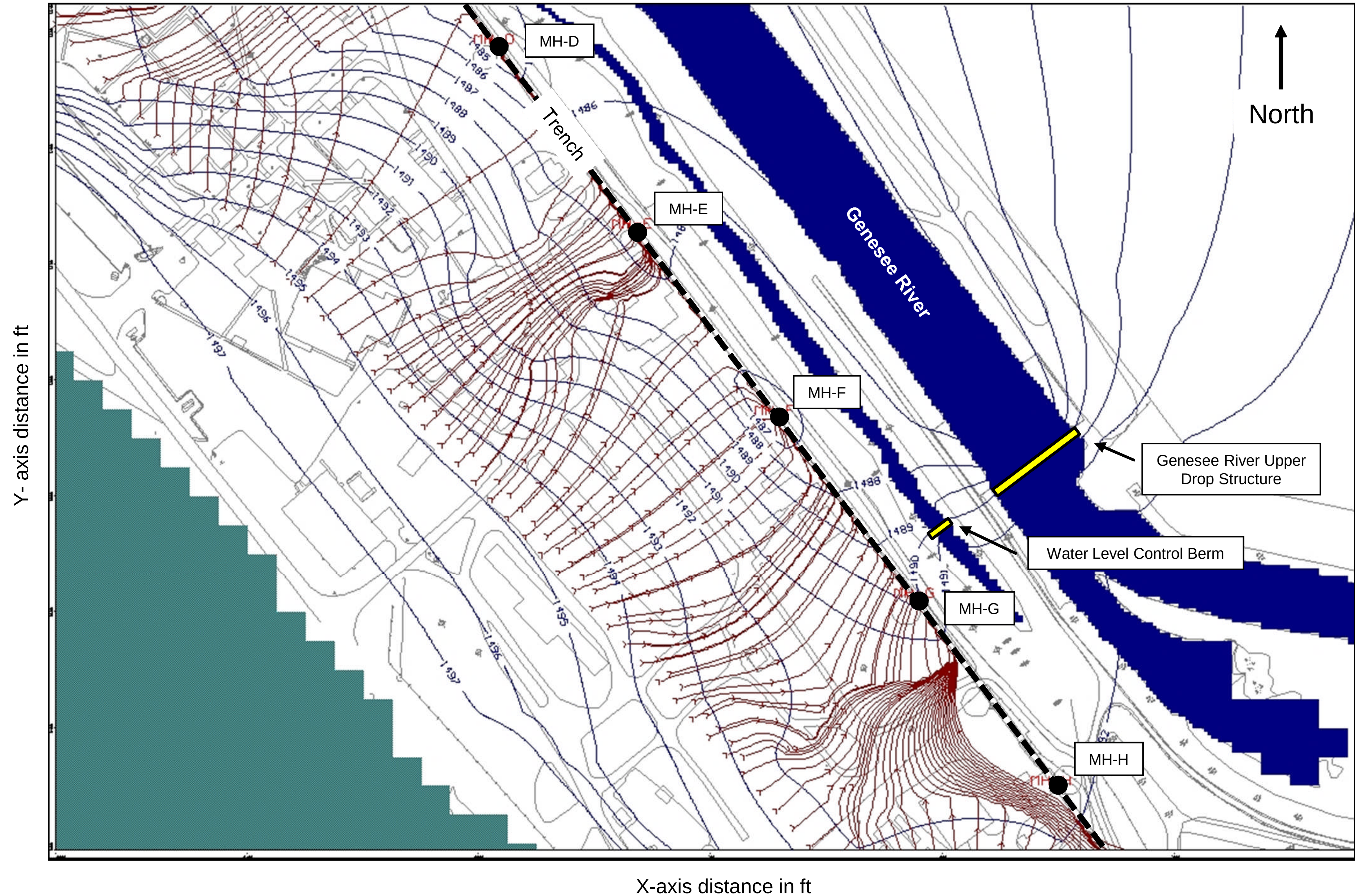
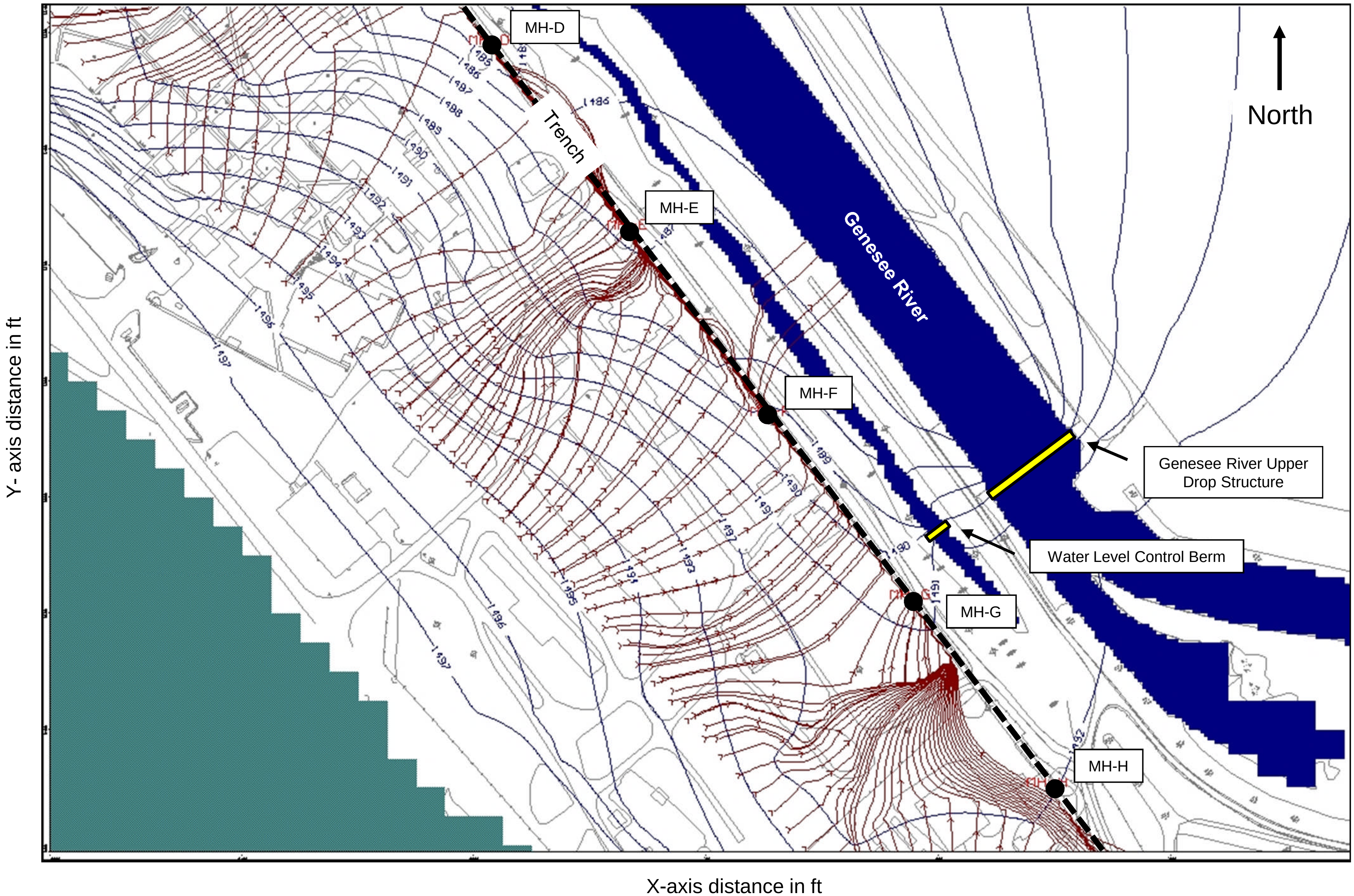
Model Simulation Results: Manholes A through G Pumping (Baseline), Total Flow 139 gpm

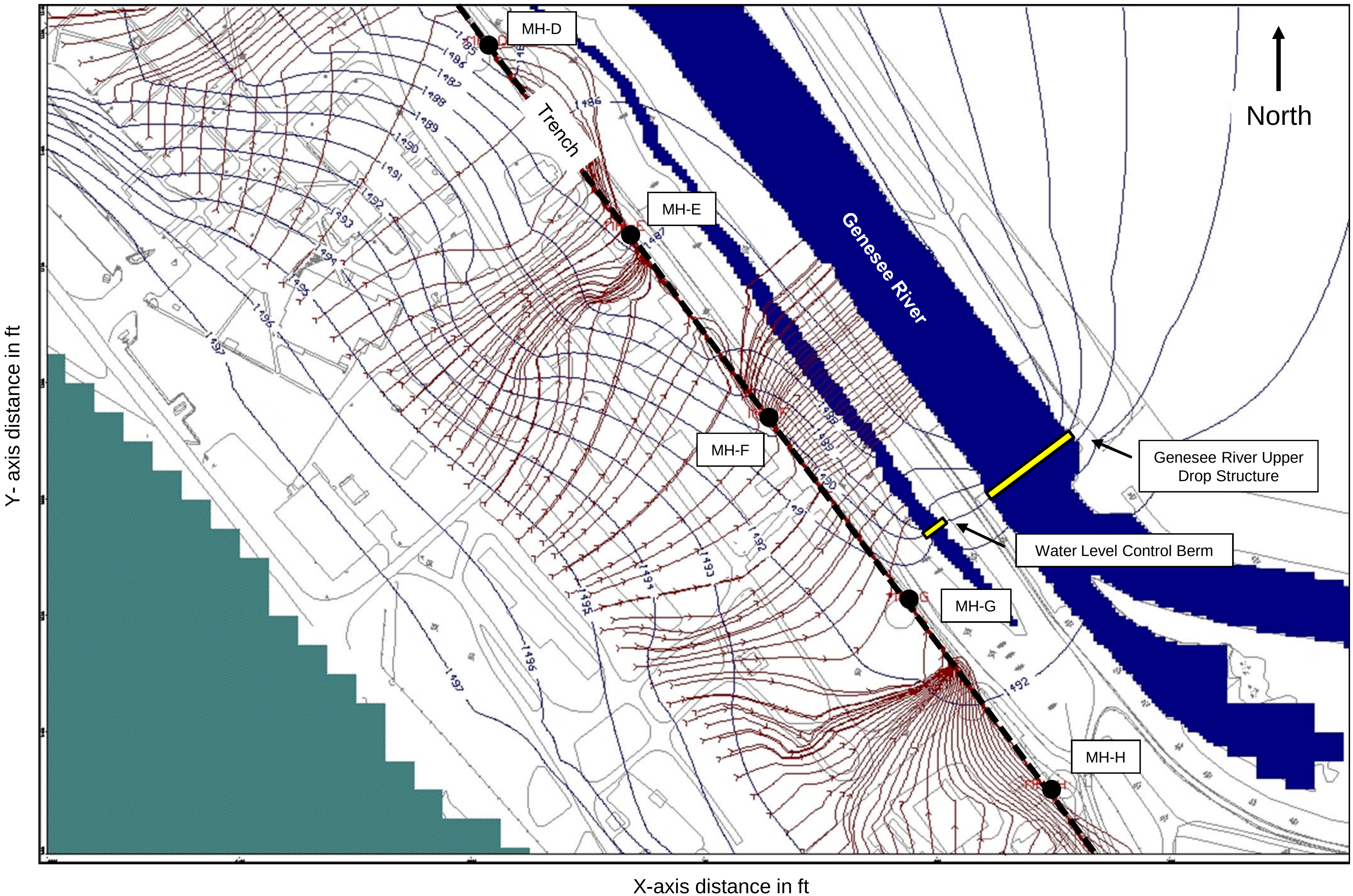
FIGURE 43



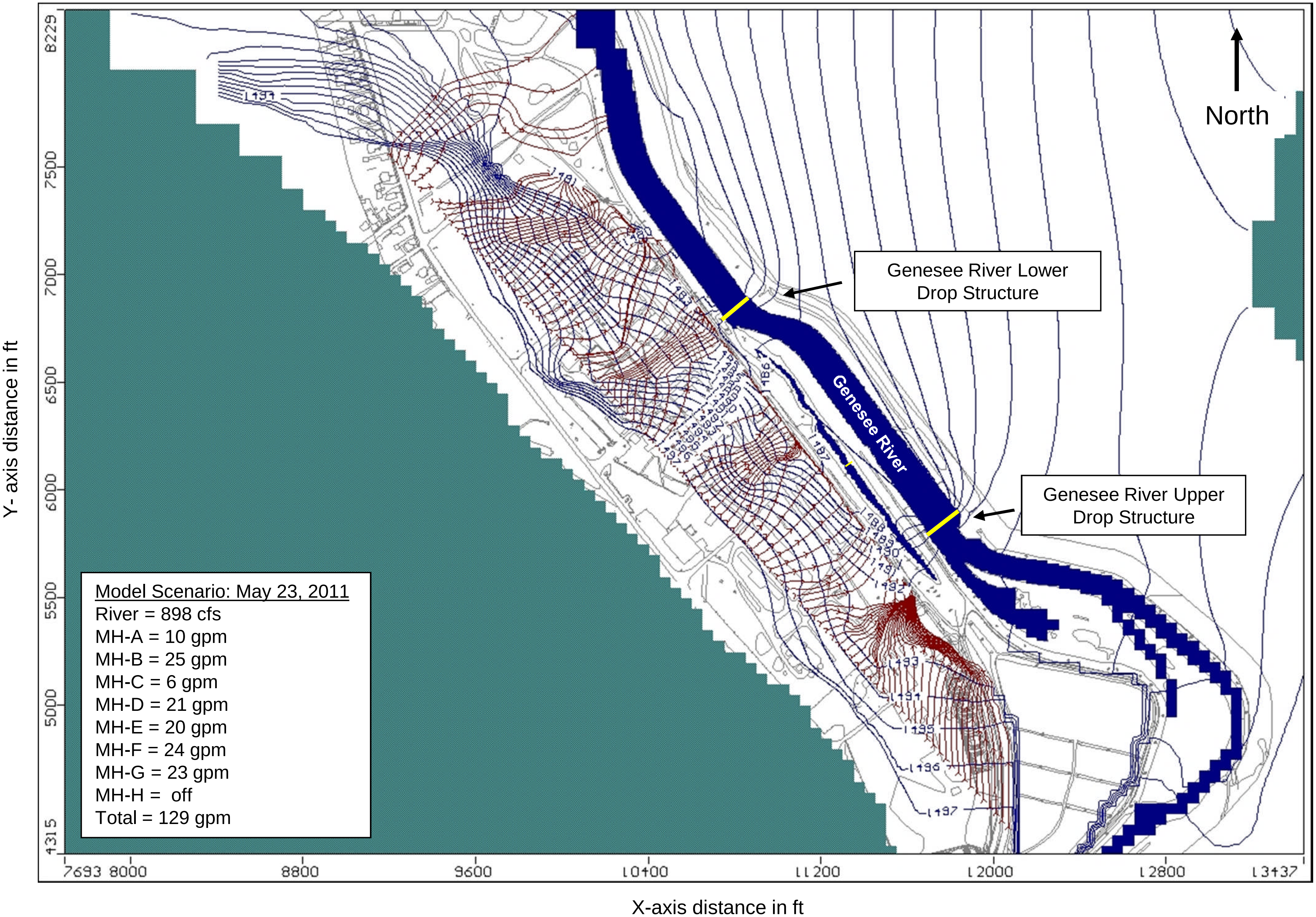
WELLSVILLE, NEW YORK *July, 2011*	**Model Simulation Results: Manholes A, B, C, D, F and G Pumping, Total Flow 114 pgm**	**FIGURE 44**



WELLSVILLE, NEW YORK *July, 2011*	**Model Simulation Results: Manholes A, B, C, D and G Pumping, Total Flow 87 gpm**	**FIGURE 45**

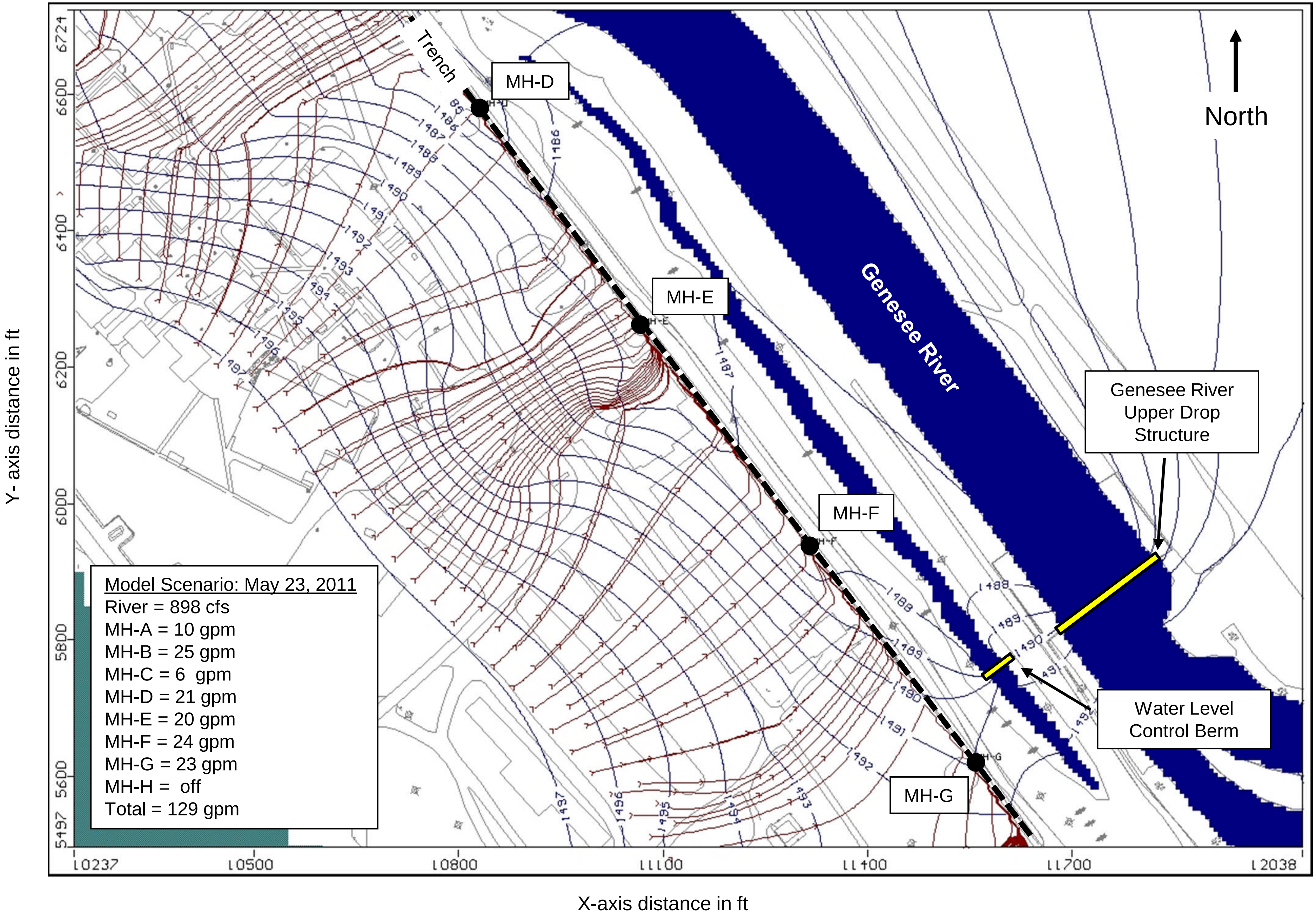


WELLSVILLE, NEW YORK *July, 2011*	**Model Simulation Results: Manholes A, B, C and D Pumping, Total Flow 52 gpm**	**FIGURE 46**

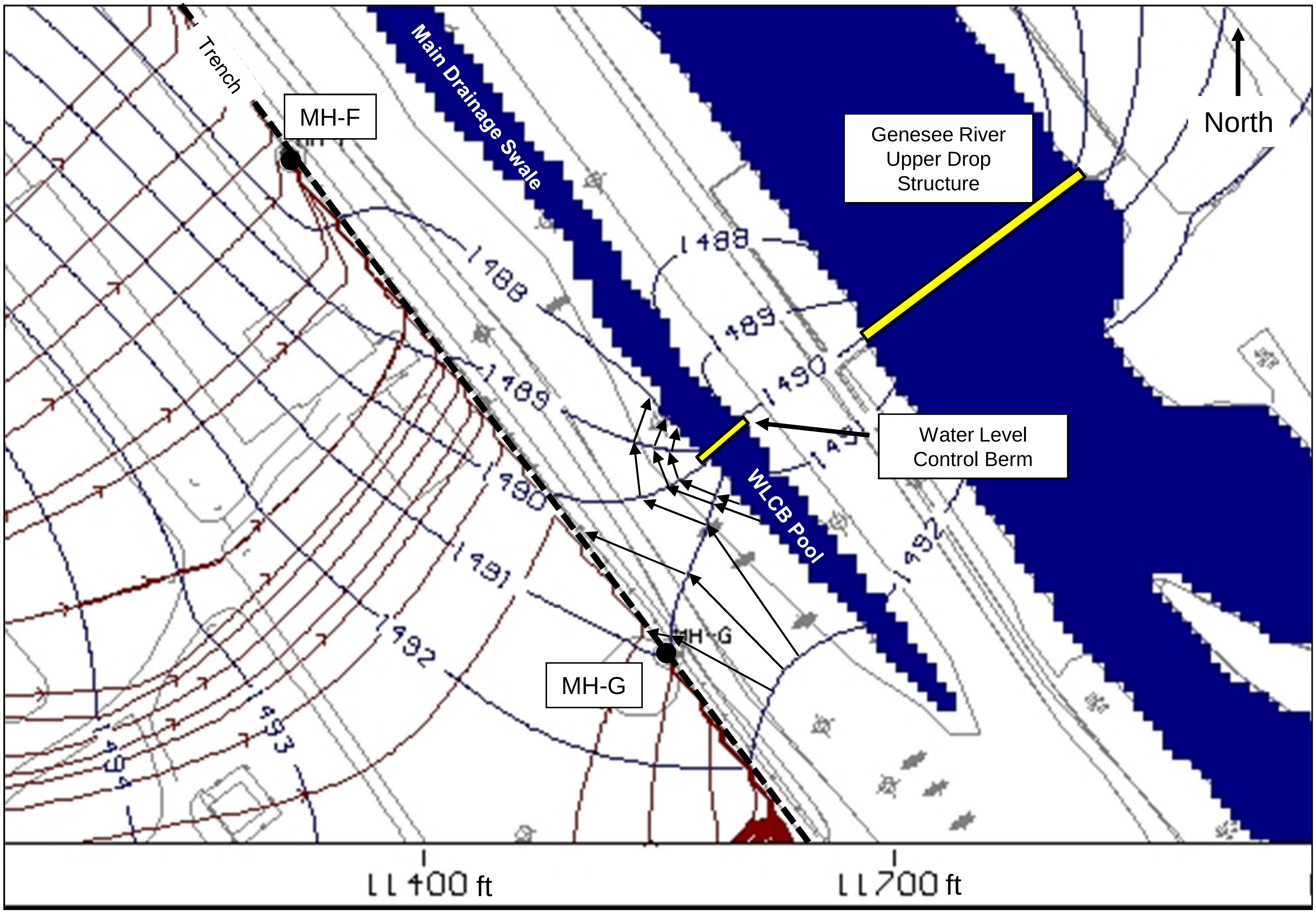


Model Simulation Results: Site-wide View of Potentiometric Surface and Groundwater Flow Pathlines for May 23, 2011 GWCT Pumping Scheme and River Flow Conditions

FIGURE 47



WELLSVILLE, NEW YORK *July, 2011*	**Model Simulation Results: Manhole D to Manhole G Potentiometric Surface and Groundwater Flow Pathlines for May 23, 2011 GWCT Pumping Scheme and River Flow Conditions**	**FIGURE 48**



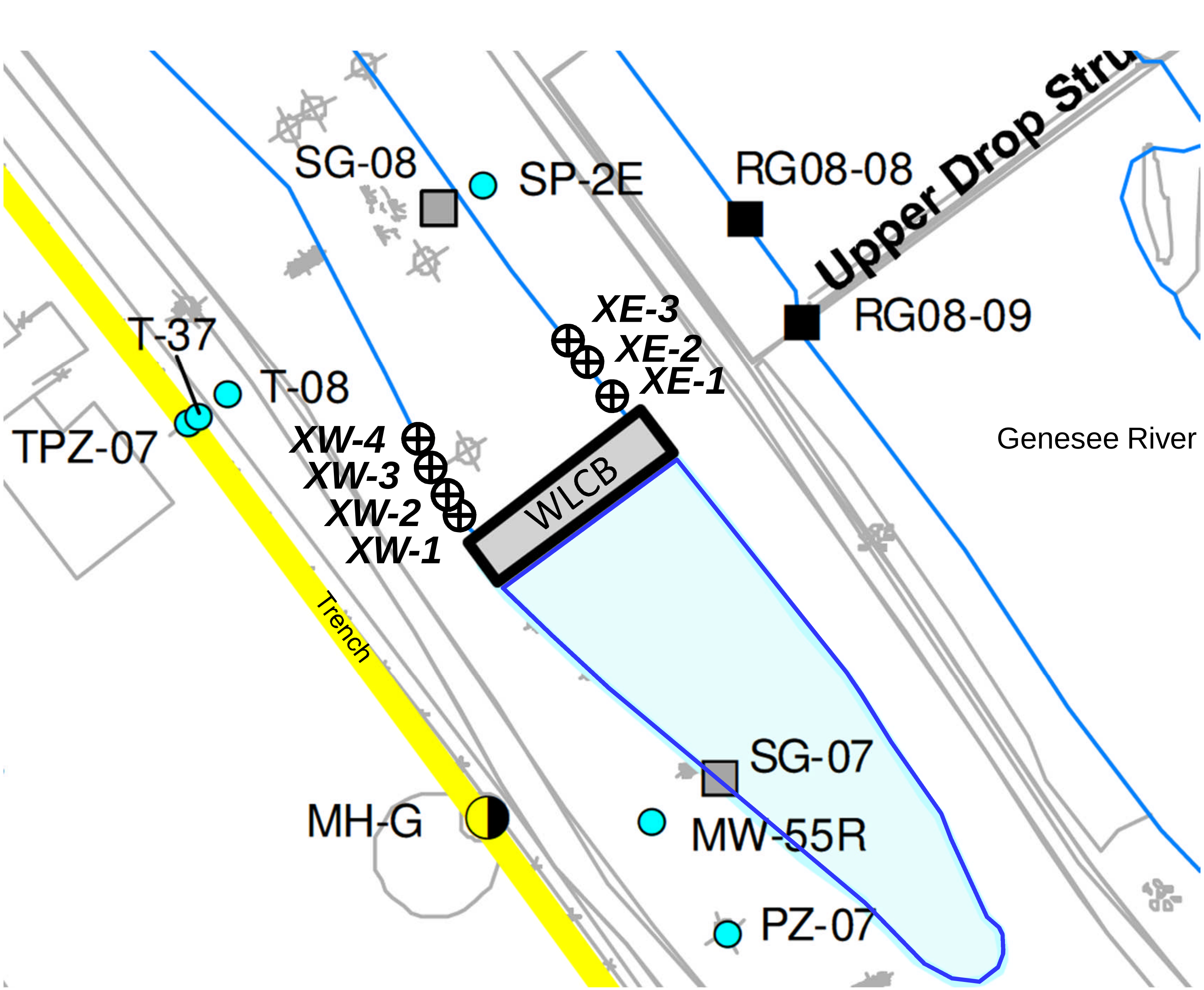
WELLSVILLE, NEW YORK

July, 2011

Model Simulation Results: Vicinity of the WLCB Showing Potentiometric Surface and Groundwater Flow Pathlines for May 23, 2011 GWCT Pumping Scheme and River Flow Conditions

FIGURE 49

North



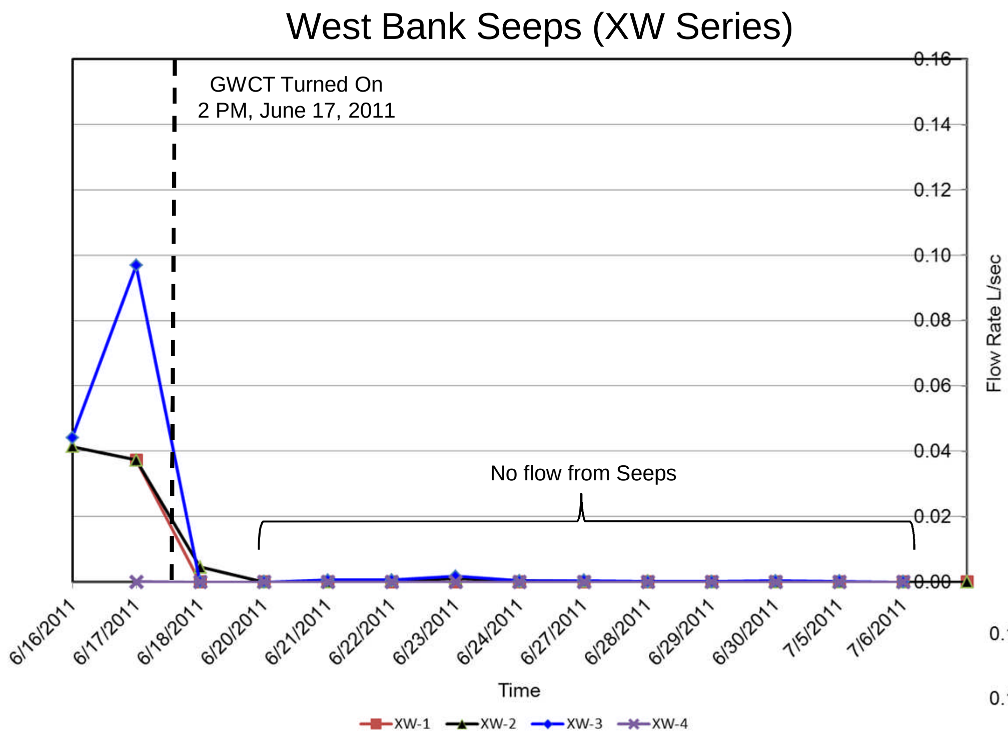
Seep Location Distance from Center Line of <u>WLCB (approximate)</u>

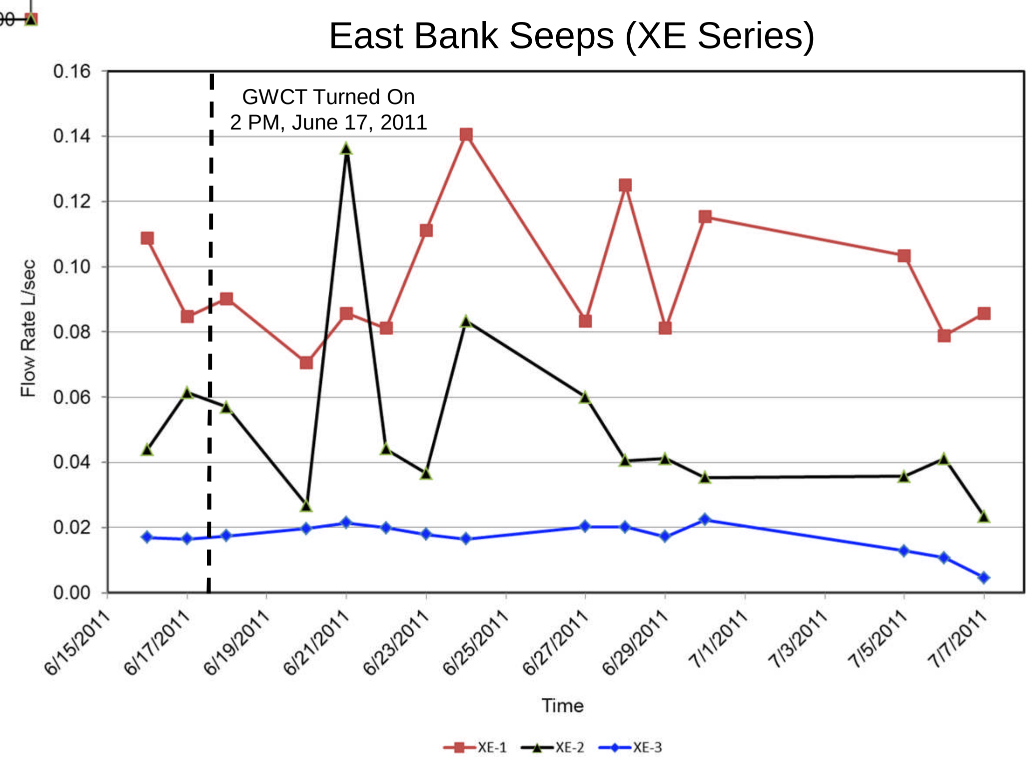
XE-1 = 25 ft
XE-2 = 42 ft
XE-3 = 54 ft
XW-1 = 26 ft
XW-2 = 34 ft
XW-3 = 46 ft
XW-4 = 58 ft

⊕ Seep location

Note: Scale not shown

WELLSVILLE, NEW YORK *July, 2011*	**Groundwater Seep Locations North of the Water Level Control Berm: June – July 2011**	**FIGURE 50**





WELLSVILLE, NEW YORK

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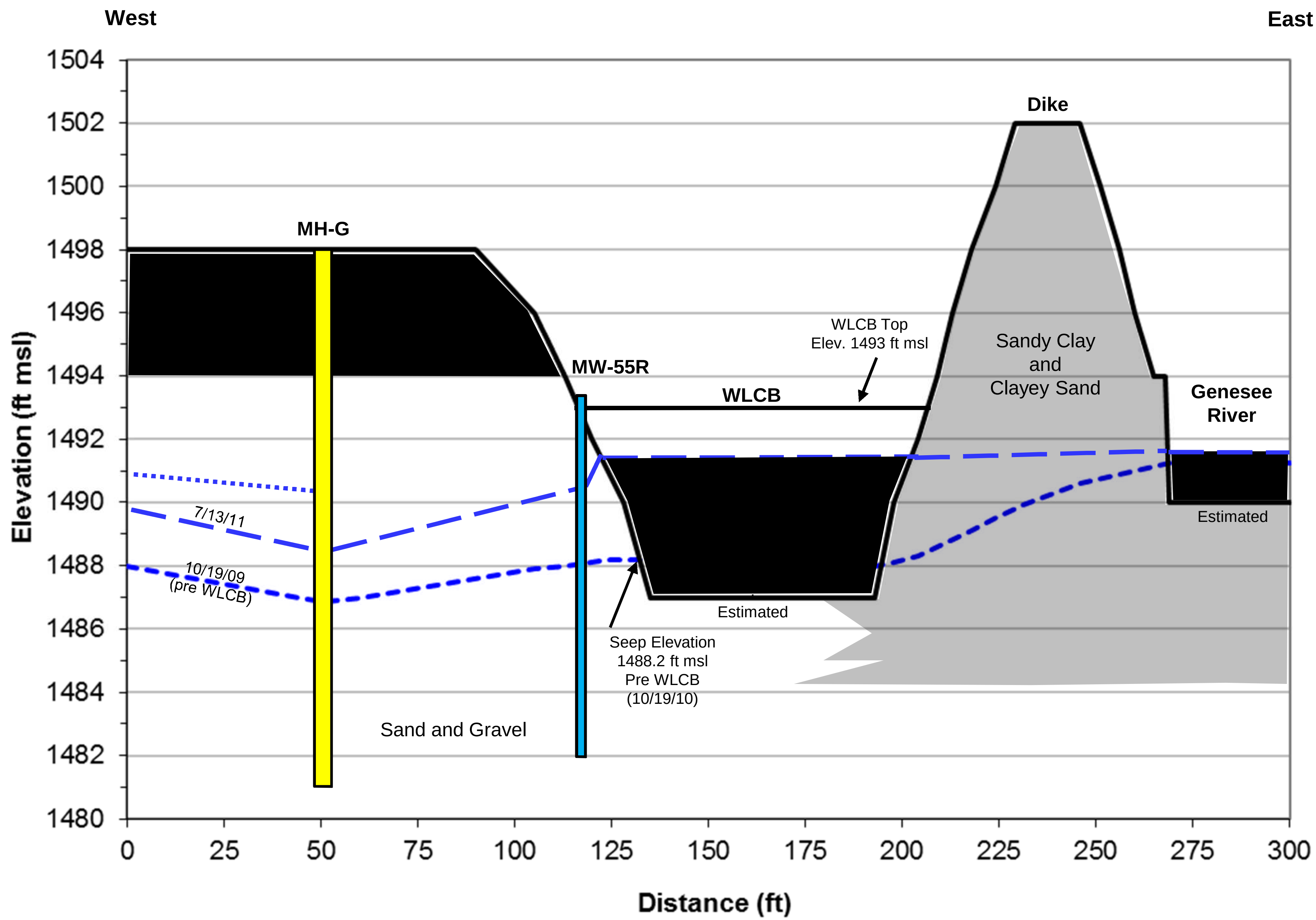
Groundwater Seep Flow Data: June 16 – July 12, 2011

FIGURE 51



WELLSVILLE, NEW YORK *July, 2011*	**Water Table Profile Between Manhole G and the Genesee River**	**FIGURE 52**