Wetland Hydrology Monitoring Report 2007-2009

NorthMet Project

Prepared for
PolyMet Mining Inc.

March 2010

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Executive Summary

- This report was submitted to the U.S. Army Corps of Engineers (Corps) and the Minnesota Department of Natural Resources in March 2010. It is intended to meet the reporting requirements for pre-project wetland hydrology monitoring. The wetland hydrology monitoring study followed the Corps-approved protocols described in the *Wetland Hydrology Study Plan* (Barr, 2005).
- Documentation is presented in this report for the third, fourth, and fifth years of wetland hydrology monitoring and includes climate, water level, and water elevation data. The data from the first and second years of monitoring were presented in the *Preliminary Wetland Hydrology Study Reports* (Barr, 2006a and 2006b). One partial year (2005) of data and four full years (2006-2009) of baseline wetland hydrology data have been collected for the NorthMet Site.
- Wells were initially installed in 19 wetland monitoring locations in 2005, four of which were electronic wells. At the end of 2007, two wells were removed from the study because they were determined to be within the proposed project footprint. In 2008, one well was relocated within the same wetland complex, two wells were installed in new wetland locations at the NorthMet Site, and two wells were installed in reference wetlands located west of the NorthMet Site that will not be affected by the proposed project. During 2008-2009, there were a total of 21 sites monitored using manual and electronic wells.
- Water levels were recorded in the electronic wells every two to four hours during the 2005-2009 monitoring periods. Manual well data was recorded twice per month in 2005-2007 and once per month in 2008-2009. The electronic well data was collected during November 2005, and throughout the 2006-2009 growing seasons (May 9-October 6) for most locations. Frozen or inundated conditions prevented early installation of some electronic wells.
- The 2005-2009 data show the presence of wetland hydrology in all monitored wetlands. The water table within the wetlands was generally within 12 inches of the ground surface for the majority of each growing season, which meets the minimum technical standard for wetland hydrology (Corps, 2005).
- During the past four water years, the annual precipitation was within or above the normal range. During the 2006-2009 growing seasons, the precipitation was drier than normal in 2006 and 2008, wetter than the normal range in 2007, and within the normal range in 2009.

Daily and monthly precipitation data were compared to WETS precipitation statistics from the National Weather Station in Babbitt, MN to determine climatic normalcy.

- The four full years of monitoring data indicate that the majority of the wetlands on the site have hydrology supported primarily by precipitation, with some localized groundwater contributions. The groundwater flow paths are generally short with recharge areas (uplands) located close to the discharge areas (wetlands). Surface water runoff and local groundwater contributions from uplands can cause increased mineral content within the water in adjacent wetlands. Once the water reaches the wetlands, infiltration through the organic soil is limited by the increased decomposition of organic material with depth, and associated decrease in vertical and horizontal hydraulic conductivity.
- There is a lack of connectivity between the shallow water table in the wetlands and the deeper bedrock aquifer. The depth of soil and till overlying the bedrock ranges up to 33 feet, with bedrock outcrops present that alter local groundwater flow paths. A pumping and isotope test conducted in 2006 indicated that the water within the bedrock is derived from aquifer recharge rather than surface water seepage. The variability of the bedrock and soil surface, along with the location of the surface water divide, create localized, short, surficial groundwater flow paths within the watersheds on the NorthMet site.
- The hydrologic regimes are consistent throughout the large wetland complexes. The maximum water level fluctuation was less than 12 inches in two wetlands (58 and 114) and between 12 to 18 inches in all other wetlands from 2005-2009. Wells located in the southwest and south-central areas show the greatest range of water table fluctuations, while wells in the northwest area show the least fluctuation.
- The wetlands exhibit stable year-to-year water levels and elevations. Water levels in all wells fluctuated in direct response to precipitation events, with the exception of Well 9 in 2008-2009 and Well 7 in 2009. Wells 9 and 7 showed stability indicative of contributing discharge from the larger upstream watersheds.
- The hydrographs in the monitored black spruce and tamarack dominated wetlands (coniferous bogs) exhibited fluctuations indicative of saturated, precipitation-driven hydrology (i.e., rapid response to precipitation with mid-summer drawdown).
- The 2008-2009 data for the reference wetlands provide baseline data for comparison with the black spruce bogs and alder thickets located on the NorthMet Site.

1.0 Objectives

On behalf of PolyMet Mining, Inc., Barr Engineering Company (Barr) is submitting documentation of the third, fourth, and fifth years of wetland hydrology monitoring including hydrology monitoring data, water elevation data, and climatic data for the proposed NorthMet project (Figures 1 and 2). The data from the first and second years of monitoring were presented in the *Preliminary Wetland Hydrology Study Reports* (Barr, 2006a and 2006b). The monitoring study has primarily followed the protocols described in the *Wetland Hydrology Study Plan* (Barr, 2005). The objectives of the study are to:

1. Provide a better understanding of the wetland hydrology at the proposed project site.
2. Collect baseline hydrology data to assess the effect of the proposed project on wetland hydrology.
3. Review the data collected in the hydrogeologic study along with the wetland hydrology data to determine whether specific wetlands have perched water tables or are in direct hydrologic connection with the surficial deposits aquifer.
4. Assist in determining the potential for indirect wetland impacts resulting from the proposed project.

2.0 Methods

2.1 Well Placement

Wetland hydrology was monitored at the proposed NorthMet Site using manual and electronic/recording wells from 2005-2009. Wetland hydrology monitoring wells were initially installed in 19 wetland locations in 2005 (Figure 3). Twenty manual wells were installed on June 28-30, 2005 and October 25, 2005. Manual Wells 4 and 5 were placed near each other in the same wetland location. Four recording wells were installed near manual wells (Wells 1, 4, 7, and 12) on November 9-11, 2005. A total of 11 monitoring locations were situated around the perimeter of the project and are not expected to be impacted by the project. The remaining 8 monitoring locations have the potential to be impacted by the project depending on the final mine and stockpile plans. In 2005, the primary differences from the planned well locations in the *Wetland Hydrology Study Plan* (Barr, 2005) was the relocation of Well 18 to the south, the addition of two wells (Wells 4 and 5) in the northwest corner of the project, and the substitution of Well 4A in the place of the planned locations for Wells 4 and 5. In 2005, the remainder of the wells were installed within the general proximity of the planned locations as presented in the *Wetland Hydrology Study Plan* (Barr, 2005).

In 2006 and 2007, well monitoring was conducted in the same 19 wetland locations as in 2005, with a total of 20 manual wells and 4 recording wells (Figure 3). Two manual monitoring wells (Wells 3 and 17) were removed from the study after the 2007 monitoring period since they were determined to be located within areas that will be directly impacted by the proposed project.

In 2008, 21 wetland locations were monitored with 22 manual wells and 21 recording wells (manual Wells 4 and 5 are both paired with recording Well 4; Figure 4). Fourteen recording wells were installed near 14 existing manual wells on May 21-23, 2008. Recording Well 9 was installed near manual Well 9 on June 27, 2008. On May 22, 2008 a pair of manual and recording wells were installed at two new locations (Wells 21 and 22). Recording Well 1 and manual Well 1 were relocated on May 22, 2008 since it was determined the original location was within an area to be directly impacted by the proposed project. Two pairs of manual and recording wells were installed as reference wells in two reference wetlands located west of the Mine Site on May 21, 2008. The purpose of monitoring the reference wetlands is to document the natural hydrologic fluctuations in wetlands that will not be affected by the proposed project to facilitate interpretation of the project data in relation to climatic fluctuations. The manual well data were used to validate the general trends of the recording well data.

Tables 1 and 2 provide the Universal Transverse Mercator (UTM) coordinates, ground surface elevation, average depth to water, and average water level elevation for the 2005-2009 monitoring wells. Appendices A, B, C, and D provide wetland hydrology and water elevation data for the monitoring wells for 2006, 2007, 2008, and 2009, respectively. Photographs of the well locations are provided in Appendix E. Monitoring of these wells will continue in accordance with the planned study. If it is determined, at some future time, that the wells are not providing useful information, then the monitoring may cease.

2.2 Well Construction and Installation

The manual wells installed in 2005 consisted of an approximately 1.5 to 2.5-foot length of 1.25-inch diameter, 0.01-inch slotted PVC commercial well screen wrapped with a filter sleeve, and threaded to a 1.0 to 2.5-foot riser. The manual wells installed in 2008 consisted of a 2.5-foot length of 1.25-inch diameter, 0.01-inch slot PVC commercial well screen wrapped with a filter sleeve, and threaded to a 2.5-foot solid PVC riser. The well screens were typically installed to a depth of 1.8 to 4.5 feet (14.1 to 44.5 inches) below the ground surface (Table 2).

The recording wells were installed to provide a continuous measurement of water levels during the monitoring period. The recording wells are Ecotone™ WM capacitance water level monitoring instruments manufactured by Remote Data Systems, Inc. The wells consist of a 20-inch (2005 wells) or 32-inch (2008 wells) length of 1.5-inch diameter, 0.01-inch slotted PVC commercial well screen integrated below 14 inches of solid PVC riser. The well screens in 2005 and 2008 were typically installed to a depth of 1.8 to 3.7 feet (21.5 to 44.5 inches) below the ground surface (Table 2).

All wells were backfilled with native soil, which was mounded at the surface to prevent water from preferentially infiltrating the area surrounding the well. None of the wells were installed through a confining soil layer into a more permeable layer below. The soils encountered were typically peats and mucks, however sand, silty loam, and sandy clay were encountered in some wells (Table 1). In situations where mineral soils were present at depth, wells were installed into the mineral layer below the peat since it appeared that the layers were hydraulically connected. Each well was covered with a slip cap and a breather hole was installed near the top of the riser to equalize pressure. A hole was also drilled in the cap at the bottom of each well to allow water to drain out of the well casing. All wells were located with a Global Positioning System (GPS) with 3-meter accuracy immediately after installation. The elevation of the top of the well casing and the ground surface at each well was also surveyed to within approximately 0.1 ft MSL in December 2005, January 2006, December 2007, September 2008, February 2009, and June 2009 using a survey-grade GPS unit.

2.3 Water Level Recording

Typically, the data from the recording wells were downloaded twice per month in 2005-2007 and once per month in 2008 and 2009. The recording wells were set up to collect a water level reading every 2 to 4 hours during the monitoring period, which extended from November 11-23, 2005, April 27-October 25, 2006, April 6-November 26, 2007, May 7-November 26, 2008, and April 28-October 29, 2009. Manual water level measurements were recorded in twice per month in June and October-November 2005, twice per month from April-November in 2006-2007, once per month from May-November in 2008, and once per month from April-October in 2009. During the monitoring period, manual water levels were recorded 5-7 times in 2005, 13 times in 2006, 15 times in 2007, 8 times in 2008, and 7 times in 2009.

Frost action and shrinking and swelling of peat soils along with fluctuation in water levels can affect the elevation of the wells. Therefore, the distance from the top of the well casing to the ground surface was measured during each monitoring event to ensure consistent measurement of the water level below the ground surface. The inserts for the recording wells were removed for the winter on November 24-26, 2007, November 24-26, 2008, and October 28-29, 2009. The casings for the recording and manual wells were generally left in place.

3.0 Wetland Hydrology and Climatic Criteria

3.1 Wetland Hydrology Criteria

The minimum technical standard for an area to meet the technical wetland hydrology criteria in accordance with the *Army Corps of Engineers 1987 Wetland Delineation Manual* (1987 Manual) is to have soil saturation to the ground surface, or to be inundated continuously for 5 percent of the growing season in most years. The growing season dates are determined using the 1987 Manual methods, which allow for estimating the starting and ending dates of the growing season based on the average first and last dates on which the air temperature drops to or rises above 28^0 F based on long-term temperature data. The *Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region* (U.S. Army Corps of Engineers, 2009) more precisely defines the growing season as the period when the soil temperatures exceed 41^o F at a depth of 12 inches or that period in which vegetation is actively growing (for trees and shrubs, after bud break in the spring).

According to the Natural Resources Conservation Service WETS data (statistical climate data for determining wetland hydrology), the normal growing season for the Babbitt area, based on the 1961-1985 climatic record, begins on May 9 and ends October 6, a total of 151 days. Based on the normal growing season in Babbitt, the duration in which soils must be saturated to the surface or be inundated is about 7.6 days (calculated as 151 days x 5 percent = 7.6 days).

3.2 Normal Climatic Conditions

Hydrology monitoring studies that evaluate the presence or absence of wetland hydrology must also consider “climatic normalcy.” The wetland hydrology criteria in the 1987 Manual states that soils must be saturated to the surface “in most years,” which means in more than 50 percent of years. This definition acknowledges that some wetlands will not exhibit wetland hydrology in some years (typically years with below normal precipitation).

To evaluate and understand the wetland hydrology monitoring data; precipitation data during the monitoring period was collected and analyzed. The WETS precipitation statistics from the Babbitt National Weather Service (NWS) station were collected for the normal historic period 1961 to 1985 and used to determine precipitation normalcy during the study period (Table 3). Daily precipitation data was collected from the Babbitt NWS station and compared to the Babbitt NWS WETS averages to determine climate normalcy during the 2005-2009 Water Years (e.g., in 2009 the water year is defined as October 1, 2008 through September 30, 2009). The cumulative 30-day precipitation is shown on Figure 5 in comparison to the long-term range of normal 30-day precipitation.

3.3 Climatic Conditions - Water Years 2005-2009

Prior to the start of the wetland hydrology monitoring in 2005, the prior three water years (2002, 2003, and 2004) were below the normal range for annual precipitation (Table 3). The wetland hydrology monitoring started in late 2005 during a water year that was slightly above the normal range for annual precipitation. The 2006 and 2008 water years were within the normal range for annual precipitation, while annual precipitation during the 2007 water year was above the normal range. Annual precipitation during the 2009 water year was below the normal range. Figure 5 shows multiple periods for Water Years 2005-2009 in which the 30-day cumulative precipitation was both above and below the normal range. The peaks typically occurred after a single large precipitation event (greater than one inch) or after a series of smaller rainfall events over a longer time period (days). The climatic conditions (precipitation, evapotranspiration, etc.) along with the general setting (tree density and type, canopy cover, understory, etc.) influence the water table elevations at the wetland hydrology monitoring sites, as shown in Figures 6-13 and in Appendices A-D.

The precipitation during the normal growing season (May 9- October 6, 151 days) of each year was compared to determine the number of days below the normal range, within the normal range, and above the normal range of annual precipitation (Table 4). While 2005 and 2006 had a similar number of days within the normal range of precipitation, 2005 had 59 days (38 percent) above the normal precipitation range while 2006 only had 20 days (13 percent). In contrast, 2007 and 2008 had similar numbers of days within all three precipitation ranges during the growing season, with precipitation more than one inch below the normal precipitation range during July and August. During the growing season in 2009, there were 114 days within the normal range of precipitation and only 2 days above the normal range of precipitation. In summary, the precipitation during the growing season of 2009 represents normal conditions, 2005 and 2007 were wetter than normal, and 2006 and 2008 represent drier conditions.

The 2005-2009 water years are discussed in more detail as follows:

Water Year 2005

The data show that the 2005 water year was slightly above the normal range for annual precipitation following 3 straight years of annual precipitation below the normal range. The 2005 water year had equal months of precipitation below, within, and above the normal range. The two months during which the majority of the monitoring was conducted both experienced monthly precipitation above the normal range. Due to the long, dry three-year period preceding this study, it was expected that all of the wetlands monitored may not exhibit their normal hydrologic regime.

There were a total of 8 storm events during 2005 with over 1 inch of precipitation, occurring in May, June, September, and October. The largest event was 2.17 inches of rainfall on May 26, 2005.

Water Year 2006

Precipitation during the 2006 water year was at the low end of the normal range, or 2.5 inches below the average annual precipitation. Monthly precipitation during the 2006 water year was below the normal range in June, August, and September, typically months with warm weather and high rates of evapotranspiration, which contributed to lower water levels in the wetlands. Monthly precipitation was above the normal range in three months early in the 2006 water year (November, February, and March), and one month in summer (July).

For most of the 2006 growing season, the 30-day cumulative precipitation fluctuated in and out of the normal range. Precipitation was within the normal range for about 38 percent (57 days) of the growing season (Table 4). During the remainder of the growing season the 30-day cumulative precipitation was:

- Below the normal range: May 9 (1 day),
- Within the normal range: May 10 – May 12 (3 days),
- Above the normal range: May 13 – May 18 (6 days),
- Within the normal range: May 19 – June 5 (18 days),
- Above the normal range: June 6 – June 8 (3days),
- Within the normal range: June 9 – June 11 (3 days),
- Below the normal range: June 12 – July 23 (42 days),
- Within the normal range: July 24 – July 30 (7 days),
- Above the normal range: July 31 – August 1 (2 days),
- Within the normal range: August 2 – August 13 (12 days),
- Above the normal range: August 14 – August 22 (9 days),

- Within the normal range: August 23 – August 29 (7 days),
- Below the normal range: August 30 – September 10 (12 days),
- Within the normal range: September 11 – September 12 (2 days),
- Below the normal range: September 13 – October 1 (19 days),
- Within the normal range: October 2 – October 6 (5 days).

There were also several spikes when precipitation was above the normal range, however, these periods were short-lived and generally resulted from single storm events (Appendix A). There were a total of 4 storm events during 2006 with over 1 inch of precipitation, all occurring between July 3 and August 14. The largest event was 1.76 inches of rainfall on August 13-14, 2006.

Water Year 2007

The 2007 water year was above the normal range for annual precipitation. During the 2007 water year, precipitation was below the normal range for 4 months, within the normal range for 3 months, and above the normal range for 5 months. During the 8 months of wetland hydrology monitoring in 2007, precipitation was below the normal range in July, August, and November; within the normal range in June; and above the normal range in April, May, September, and October. The dry months of July and August contributed to low water levels in the area. In September and October the area received more than 12 inches of precipitation above the average monthly precipitation.

For most of the 2007 growing season, the 30-day cumulative precipitation fluctuated in and out of the normal range. Precipitation was within the normal range for only about 10 percent (15 days) of the growing season (Table 4). During the remainder of the growing season the 30-day cumulative precipitation was:

- Within the normal range: May 9 – May 20 (12 days),
- Above the normal range: May 21 – June 29 (40 days),
- Within the normal range: June 30 – July 2 (3 days),
- Below the normal range: July 3 – September 9 (69 days),
- Above the normal range: September 10 – October 6 (27 days).

There were several spikes when precipitation was above the normal range, with large events occurring in early September (Appendix B). There were a total of 7 storm events during 2007 with over 1 inch of precipitation, occurring in April, May, June, September, and October. The largest event was 8.22 inches of rainfall on September 10, 2007.

Water Year 2008

The data show that the 2008 water year was near the upper end of the normal range for annual precipitation. During the 2008 water year, precipitation was below the normal range for 5 months, within the normal range for 1 month, and above the normal range for 6 months. During the 8 months of wetland hydrology monitoring in 2008, precipitation was below normal in July, August, and November; within the normal range in May and October; and above the normal range in April, June, and September. The dry months of July and August contributed to low water levels in the area.

For the 2008 growing season, the 30-day cumulative precipitation data was within the normal range for about 18 percent (27 days) of the growing season (Table 4). During the remainder of the growing season the 30-day cumulative precipitation was:

- Above the normal range: May 9 – May 25 (17 days),
- Within the normal range: May 26 – June 5 (11 days),
- Above the normal range: June 6 – July 4 (29 days),
- Within the normal range: July 5 (1 day),
- Below the normal range: July 6 – September 11 (68 days),
- Within the normal range: September 12 – September 26 (15 days),
- Above the normal range: September 27 – October 6 (10 days).

There were a total of 5 storm events during 2008 with over 1 inch of precipitation, occurring in April, June, and September (Appendix C). The largest event was during a two-day period with 2.93 inches of rainfall on June 5 and 6, 2008.

Water Year 2009

The data show that the 2009 water year was below the normal range for annual precipitation. During the 2009 water year, precipitation was below the normal range for 5 months, within the normal range for 3 months, and above the normal range for 4 months. During the 7 months of wetland hydrology monitoring in 2009, precipitation was below the normal range in May, June, July, and September; within the normal range in August and October; and above the normal range in April.

For the 2009 growing season, the 30-day cumulative precipitation data was within the normal range for about 76 percent (114 days) of the growing season (Table 4). During the remainder of the growing season the 30-day cumulative precipitation was:

- Within the normal range: May 9 – May 16 (7 days),
- Above the normal range: May 16 – May 17 (2 days),
- Within the normal range: May 18 – May 29 (12 days),
- Below the normal range: May 30 – June 8 (10 days),
- Within the normal range: June 9 – July 8 (30 day),
- Below the normal range: July 9 – July 15 (7 days),
- Within the normal range: July 16 – September 18 (65 days),
- Below the normal range: September 19 – October 6 (18 days).

There were a total of 2 storm events during 2009 with over 1 inch of precipitation, occurring in March and August (Appendix D). The largest event was 1.43 inches of rainfall on August 20, 2009.

4.0 Monitoring Schedule

Monitoring started each year shortly before the beginning of the statistical start of the growing season (May 9), in late April 2006, early April 2007, early May 2008, and late April 2009. After installation, water levels were recorded every two to four hours in the recording wells and the data were typically downloaded once every month. Water levels were typically measured in each manual well once every two weeks from April 25-November 22, 2006, April 6-November 26, 2007 and once every month from May 7-November 26, 2008 and April 28-October 29, 2009.

5.0 Results

5.1 General Site Hydrology

The Partridge River is located to the north, east, and south of the NorthMet site (Figure 2). The proposed Mine Site is located on the north side of the Dunka Road. There is a surface drainage divide oriented generally from southwest to northeast near the northern border of the site (Figure 2). The majority of the Mine Site (80 percent) drains south through culverts under Dunka Road and on to the Partridge River through extensive wetland complexes. The remaining 20 percent of the Mine Site drains north to Hundred Mile Swamp and the Partridge River or northeast to the Partridge River.

The bedrock surface is variable across the site with bedrock exposed at the surface in some locations (Appendix F). The soil/till thickness is also variable ranging from a thin layer over the bedrock to 50-60 feet thick. The bedrock has low primary permeability (Siegel and Ericson, 1980) so groundwater flow within the bedrock is through fractures or other secondary porosity features (Barr, 2008b). Because of the low permeability of the bedrock, the interaction between the surficial deposits and the bedrock aquifers is assumed to be insignificant, according to Siegel and Ericson (1980).

The surficial groundwater flow paths are generally very short on the site with recharge areas (uplands) located very close to the discharge areas (wetlands). In addition, bedrock outcrops cause changes in the local flow patterns (Siegel and Ericson, 1980). The surface water divide is located north of the proposed pit locations with surface water north of this boundary flowing north. South of the proposed pit locations, the soil surface and bedrock surface slope southward past Dunka Road and the railroad. This variability of the bedrock and ground surfaces, along with the location of the surface water divide, limits the length of the surficial groundwater flow paths within the watersheds to short localized flowpaths, rather than long regional flowpaths.

5.2 Hydrogeologic Conditions

A 30-day aquifer performance test (i.e., pumping test) was conducted from October 19, 2006 through November 18, 2006 to assist in understanding the hydrologic connectivity between the wetlands, the surficial deposits aquifer, and the bedrock aquifer. Well and piezometer locations and data are provided in Appendix G. More detailed information and results of the pumping test are provided in the *Phase III Hydrogeologic Investigation* report (Barr, 2007). The distance of each observation well from pumping Well P2 is identified in Appendix G, Table 1 and Figure 1. The hydrographs for the wells and piezometers are shown in Appendix G, Figures 2-5.

Water levels in pumping Well P2, observation wells (Ob2, 2, 12, 20), and piezometers (2P, 12P, and 20P) were monitoring using pressure transducers and data loggers. Additional wetland hydrology monitoring well data was evaluated for this section including Wells 1R, 4R, 7R, and 12R. Pumping Well P2 was located in the Virginia Formation and was installed as an open hole bedrock well from 27 to 610 feet below the ground surface (Appendix G, Table 1). Well Ob2 was located in the Duluth Formation and was installed as an open hole bedrock well from 18-100 feet below the ground surface. Wells 4R, 12, and 20 were shallow wells (2.3 to 3 feet total depth) located in organic soil and screened at a depth of 0.8 to 3 feet below the ground surface. Wells 2P, 12P, and 20P were deeper wells (7.5 feet total depth) located in organic soil and screened at 6.5 to 7.5 feet below the ground surface.

Pumping test Well P2 was located in the upland area located south of Well 2 (Wetland 100; Appendix G, Figure 1). Existing wetland hydrology monitoring wells 4R and 12 were used to evaluate effects of bedrock aquifer drawdown on the surficial aquifer along with an additional well location (Well 20) that was established near the edge of Wetland 100, south of Well 2. Continuous recording data loggers were installed in the wells and piezometers and were began operating approximately 30 days prior to the start of the pumping test and continued for 10 days after pumping ceased (Appendix G, Figures 2-5).

The hydrogeologic investigation found that during the pumping test, pumping Well P2 (located in bedrock) the maximum drawdown was 209 feet (Appendix G, Table 1, Figure 2). During the pumping test, Well Ob2, also located in bedrock, the maximum drawdown was 4.6 feet (Appendix G, Table 1, Figures 2 and 3). The wells and piezometers, installed in the organic soils above the bedrock, had maximum drawdowns of 6.0 and 5.4 inches, respectively (Appendix G, Table 1, Figures 2-5). The precipitation during October 2006 was within the normal range, however it was below the normal range for November 2006 (Table 3; Figures 2-5). During the October 19-November 18 period, the 30-day cumulative precipitation was below the normal range for about 58 percent (18/31 days) during the pumping test.

Piezometers 12P and 20P showed a general decrease in water levels with a maximum drawdown during the pumping test of 0.5 feet (Appendix G, Figure 3). Piezometer 20P was located 145 feet away from pumping Well P2 and 12P was located at a distance of 1,400 feet (0.3 miles). However, the maximum drawdown of wells located 0.7 to 1.9 miles from pumping Well P2 were 0.3 to 0.5 feet during the same time period, which indicates the drawdown of the surficial wells and piezometers during this time period may have been the result of the dry conditions, rather than the pumping test (Appendix G, Table 1).

At the end of pumping test, the water level in Piezometer 20P (installed at a depth of 7.5 feet in organic soil) continues to decrease, while the water level in Well 20 (installed at a depth of 2.4 feet in organic soil) begins to rise. Water levels in other wells and piezometers also continued to generally decrease until rainfall at the end of November. The difference in the response of the Piezometer 20P and Well 20 likely show the lack of hydrologic connectivity between the surficial peat soil and the more decomposed deeper peat soil. Water levels in piezometer 2P fluctuated during the pumping period, but did not display the same overall downward trend as the other wells and piezometers. (Appendix G, Figure 3). The results of the analysis found that with the exception of piezometer 20P, which is the deep piezometer located closest to the pumping well, the decrease in water levels were not attributed to pumping. None of the manual or recording wells monitored for the wetland hydrology study in 2006 showed a response to the pumping test.

Groundwater samples were collected weekly for pumping Well P2 for the duration of the 30-day pumping test. Samples for laboratory analysis of δD, $\delta^{18}O$, tritium, and $\delta^{13}C$ of dissolved organic carbon were collected, filtered, placed into laboratory-supplied containers and submitted for isotope analysis. Water isotope data from pumping Well P2 were plotted with precipitation data from the Marcell Experimental Forest Northern Research Station, located approximately 70 miles west of the Mine Site. The pumping Well P2 data plot very near the inferred meteoric water line. This result suggests the source of the majority of the groundwater that was pumped during the 30-day test was aquifer recharge and not seepage from surface water features, such as the Peter Mitchell Pit or wetlands. Evaporation from open water enriches the water in the heavier isotopes. Groundwater that is derived from seepage from surface water is expected to be enriched in oxygen-18 and deuterium and would not fall on the regional meteoric water line.

5.3 Soil Characteristics

The soils on the site have formed from loamy drift and the underlying dense Rainy lobe till of the Late Wisconsinan glaciation (Natural Resources Conservation Service (NRCS) 2008). The dense underlying till acts as an aquitard that restricts downward water flow, therefore, most of the mineral soils in the depressional and flat-bottom areas of the landscape experience perched water tables during late spring and early summer at depths up to 1 to 3 feet. Mineral soil series present at the NorthMet Site include the very poorly-drained Bugcreek, with the better-drained soils including Babbitt, Eaglenest, Eveleth, and Wahlsten.

The upland soils at the Mine Site typically have high infiltration rates with little runoff and are usually found on bedrock-controlled uplands. The majority of the extensive wetland complexes on and adjacent to the site are mapped as ELT 6-LPN-Lowland Organic Acid to Neutral by the U.S. Forest Service (USDA-USFS 2007), which is equivalent to the Rifle mucky peat and Greenwood peat mapping units in the NRCS soil classification system (Figure 2). These soils are typically characterized by having fibric peat in the upper horizons underlain by mucky peat to a depth of up to 5 feet or more.

An overburden characterization study was conducted in 2008 which provided boring logs for upland and wetland points across the site (Appendix H). The depth to bedrock in the wetland profiles ranged from 11 to 33 feet, with depth to bedrock at the upland points ranging from 2 to 22 feet. The surface horizons of the wetland profiles included varying depths of fibric and hemic peat (1 to 9 ft in depth) overlying mineral soil. The mineral soil textures in the profile included clay with sand, silt, sand, gravel, silty sand (or sandy loam), silty gravel and gravelly silt. The soil borings completed in the uplands (Figure 3) are characterized by mineral soil with textures including silty sand, sand with gravel, and sand with silt. Other geotechnical results for surficial deposits indicate the presence of silty sand, clay and organic soils across the Mine Site (Barr, 2006b).

Because of the lack of interaction between the surficial and bedrock aquifers, the hydrology of the wetlands at the site is primarily supported by direct precipitation and subsurface flow from the relatively small watershed areas with shallow local ground water flow making up a more variable component. Net precipitation (precipitation minus evapotranspiration) is positive for the Partridge River watershed since evapotranspiration is low, which is typical for northern Minnesota due to the cooler climates and a shorter growing season. Lateral subsurface flow within peatland soils on extensive flat peatlands is typically very slow to negligible. Surface runoff from these flat peatlands is also generally negligible except during snowmelt, due to the high water-holding capacity of the peat, the flat slopes, and the surface roughness. Surface runoff from the upland areas to the wetlands is not prevalent due to the loamy soils and healthy forest soil structure, which facilitates infiltration. As indicated in the USFS Ecological Classification System, the upland soils yield water to the lower landscape positions mainly through local groundwater flow.

5.4 Wetland Hydrology

The wetland hydrology data obtained from 2005-2009 represents pre-project conditions. The water level data and the water elevation data, shown in relation to the ground surface and the cumulative precipitation during the past 30 days, are displayed graphically for 2005-2009 in Figures 6-12. The monitoring data for 2005 and 2006 were previously described in the *2005 Preliminary Wetland Hydrology Study Report* (Barr, 2006a) and the *Wetland Hydrology Study Report 2006* (Barr, 2006b). The sources of water supporting the wetland hydrology in these areas are described in the impact evaluation study entitled *Indirect Wetland Impacts at the Mine Site* (Barr, 2008a).

The 2006-2009 data is provided in Appendices A, B, C, and D, respectively. Photographs of each well location are provided in Appendix E. The data for the wells in similar areas of the site are grouped together on each figure. The areas presented include:

1. Northwest Mine Site area including Wells 4, 4A, 5, and 18 (Figure 6).
2. North-central Mine Site area including Wells 2, 10, 11, and 12 (Figure 7).
3. Northeast Mine Site area including Wells 13, 14, and 15 (Figure 8).
4. South-central Mine Site area including Wells 1, 8, 9, 16, 21, and 22 (Figure 9).
5. Southwest Mine Site area including Wells 3, 6, 7, 17, 19 (Figure 10).
6. West of the site, in wetlands located outside of the proposed Mine Site area including reference Wells Ref1 and Ref2 (Figure 11).

5.4.1 General Observations

The monitoring data obtained from 2005-2009 show the presence of wetland hydrology in all wetlands. Continuous water level recording wells were monitored at well locations 1, 4, 7, and 12 from 2006 through 2009 (Well 1 was relocated within the same wetland complex at the beginning of the 2008 monitoring period), with 19 additional recording wells installed in April 2008, including the establishment of monitoring in two reference wetlands. While the recording well data is helpful in understanding the response of wetland hydrology to specific precipitation events at the Mine Site, it is not necessary for documenting whether or not jurisdictional wetland hydrology is present, since it is clearly present in all wetlands monitored.

Figures 6-11 show the range of depth to water over the 2005-2009 monitoring period. The wells located in the south-central and southwest areas of the Mine Site show the greatest range of water level fluctuations (Figures 9 and 10). The wells in the northwest area show the least fluctuation (Figure 7). Water levels in all wells except 4, 4A, and 5 in the northwest part of the Mine Site dropped below the wetland threshold during the July through August drought period in both 2007 and

2008. In addition, Wells 3 and 9 did not drop below the wetland threshold in 2007 and 2007-2008, respectively. Several wells were dry for up to one month during the drought period in 2007 (1, 6, 8, 10, 11, 18, 13, 14, 15, and 19). The water levels in the northwest wells (3, 4, 4A, 5, and 17) decreased 9 to 10 inches during those periods, but maintained water levels within 12 inches of the ground surface. This drop in water level followed a sustained period of over two months with precipitation well below the normal range (Figure 5). Water levels in all wells recovered quickly with over 12 inches of precipitation in early September 2007.

The monitoring data indicate that the hydroperiod remained stable (water levels fluctuating less than 12 inches) within two wetlands throughout the 2006-2009 monitoring period, including Wetland 58 (Well 9R) and Wetland 114 (Well 4M and 5M) (Table 2). The maximum water level fluctuation was between 12 inches and 18 inches during the 2005-2009 monitoring period in Wetland 48 (Wells 1M, 21R, 22M), Wetland 53 (Well 7M, 7R), Wetland 90 (Wells 14M, 14R, 16R), Wetland 83 (Well 15M), Wetland 100 (Wells 2M, 2R, 10R, 11M, 11R, 12M, 12R, 18R), Wetland 103 (Well 3M, 17M), Wetland 114 (Wells 4AM, 4AR), and the wetland with Reference Well Ref1.

The climatic conditions during the last five years include 2 years with annual precipitation within the normal range and 3 years with annual precipitation below the normal range (Table 3). The wetland hydrology monitoring data provided on the figures in Appendices A-D are shown in relation to the cumulative precipitation during the past 30 days. The 30-day cumulative precipitation is also shown in comparison to the long-term range of normal 30-day precipitation. These data provide valuable insight into the observed wetland hydrology because the majority of the monitored wetlands are supported primarily by precipitation. The influence of precipitation on wetland hydrology is typically shown on the graphs as a sharp increase in the rising leg of the hydrograph in response to a precipitation event. In contrast, the influence of groundwater on wetland hydrology is typically shown as a gradual increase in the water table or a gradual sustained water table over longer time periods (such as weeks or months).

The wetland hydrology observed at the Mine Site appears to be indicative of a system primarily supported by precipitation that is sensitive to climatic fluctuations. Water elevations in all wells fluctuated in direct response to precipitation events with the exception of Well 9 in 2008-2009 and Well 7 in 2009. Other than the prolonged drought period in July-August 2007, Wells 9 and 7 showed stability indicative of contributing discharge from upstream watershed wetlands and groundwater discharge. Precipitation patterns during 2005-2009 were highly variable as discussed in Section 3.3.

5.4.2 Northwest Mine Site Area

Wetland 114 (Wells 4, 4A, 5) and Wetland 100 (Well 18) are located in the northwest area of the Mine Site, northwest of the proposed northwest Category 1 stockpile (Figure 2). These wetlands are located north of the surface water divide, with groundwater moving to the north and into One Hundred Mile Swamp. Wetland 114 is contiguous to and on the south edge of One Hundred Mile Swamp, which provides a large contributing watershed area that helps to maintain more stable hydrology throughout this large wetland complex (Figures 3 and 4). Wetland 100 is also contiguous with One Hundred Mile Swamp, although Well 18 is located on the southern boundary (upstream edge) of the wetland; therefore it has a small watershed contributing to maintain its water level. As a result, the water level in this well exhibits greater diurnal and seasonal fluctuations in response to precipitation events compared to Wells 4, 4A, and 5. All of these wells are installed within black spruce bogs (Table 1).

The hydrographs in Figure 6 show that the water level in Wells 4, 4A, and 5 remained 7 to 13 inches higher than Well 18 throughout the 2005-2009 monitoring period, likely because of the influence of the adjacent large wetland complex (One Hundred Mile Swamp). The hydroperiod is similar for both wetlands, with an immediate increase in the water table in response to precipitation events. The water levels in Wells 4, 4A, and 5 remained about 2-13 inches higher than Well 18 throughout 2005-2009. Fluctuations in response to precipitation for recording Well 18 was generally more than 2 inches, while the response for recording Wells 4 and 4A were generally more subdued and less than 2 inches.

The range of the water table fluctuation in Wells 4, 4A, and 5 was 0.2 to 2.0 feet throughout the 2006-2009 monitoring period, which is greater than the range of water table fluctuations for Well 18 (0.9 to 2.0 ft; Table 3). In 2007, 2008, and 2009 there was a drawdown in all wells in response to a dry period during the mid- to late-summer. The water table in Well 18 dropped below the wetland threshold in all monitoring years, but by late summer to early fall the water level always rebounded to within 12 inches of the ground surface. In contrast, the water levels in Wetland 114 (Wells 4, 4A, 5) remained within 12 inches of the ground surface throughout the entire 2005-2009 monitoring period. The well data showed the presence of wetland hydrology for the majority of each growing season in Wetlands 100 and 114.

5.4.3 North-Central Mine Site Area

Wetland 100 (Wells 2, 10, 11, and 12) is located in the north-central area of the Mine Site, north of the proposed Central and East Pit areas (Figure 2). This wetland is located north of the surface water divide, with groundwater moving to the north and into One Hundred Mile Swamp. The north boundary of the watershed for this wetland is Yelp Creek and the Partridge River. The wells are installed within black spruce bogs (Table 1).

The hydrographs in Figure 7 show that the water level in Wells 2, 10, 11, and 12 exhibit a similar response to precipitation events as Well 18, which is also located in Wetland 100. The wells indicate the wetland is generally saturated to the surface, with the data showing brief periods of inundation during the 2005 monitoring period. In response to dry climatic conditions, the water levels in all wells generally dropped below the wetland threshold between mid-June to mid-July 2006, early- to mid-July 2007, early- to mid-August 2008, and early- to mid-September 2009. In 2006, Wells 2, 10, and 11 remained below the wetland threshold for the remainder of the growing season, with only Well 12 rebounding above the wetland threshold by late-July. In 2007, all wells rebounded above the wetland threshold by early September after 1.5 inches of rainfall over a 6-day period. In 2008, the water level in all wells increased abruptly with 0.75 inches of rainfall in a 2-day period, with only the water level in Well 2 remaining above the wetland threshold the remainder of the monitoring period. The other wells recovered to above the wetland threshold by early- to mid-September after multiple rainfall events occurring over a 2-week period. In 2009, the water levels in Wells 2 and 12 were above the wetland threshold by late September, while Wells 10 and 11 took longer to rise and stay above the wetland threshold (3-4 weeks). All of these wells generally responded immediately (within the same day) to rainfall events and showed an immediate response to all rainfall events, which indicates the wetland hydrology is primarily supported by precipitation.

The range of water table fluctuations in Wells 2, 10, 11, and 12 was 0.6 to 1.5 feet throughout the 2006-2009 monitoring period, which is similar to the range of water table fluctuations for Well 18 (0.9 to 2.0 ft; Table 3). The water levels in Wells 2, 10, 11, and 12 remained about 2-12 inches lower than Well 18 throughout the growing season. The water table response to precipitation for Wells 2, 10, 11, and 12 was generally more subdued than Well 18, with water table responses generally less than 2 inches. The well data showed the presence of wetland hydrology for the majority of each growing season in Wetland 100.

5.4.4 Northeast Mine Site Area

Wetland 83 (Well 15), Wetland 84 (Well 13), and Wetland 90 (Well 14) are located east of the two proposed east Category 1 stockpiles (Figure 2). Wetland 83 is located south of the surface water divide, with groundwater moving east towards the Partridge River. Wetlands 84 and 90 are located north of the surface water divide, with groundwater moving to the east/northeast towards the

Partridge River. Well 15 is installed at the downstream and east end of an open bog, while Wells 13 and 14 are installed in black spruce bogs (Table 1).

The hydrographs in Figure 8 show that the water level in Wells 13, 14, and 15 exhibit similar responses to precipitation events as Wells 2, 10, 11, 12, and 18, which are also located in black spruce bogs. The water table in Wells 13, 14, and 15 was generally slightly lower than in Wells 2, 10, 11, 12, and 18 during 2008-2009. The well data indicates that wetlands 83, 84, and 85 are generally saturated to the surface, with only one period of inundation in Well 15 after 2.8 inches of rainfall on June 5-6, 2008.

The range of the water table fluctuation in Wells 13, 14, and 15 was 0.4 to 1.9 feet throughout the 2006-2009 monitoring period, which is similar to the range of water table fluctuations for Wells 2, 10, 11, 12, and 18 (0.6 to 2.0 ft; Table 3). Each year from 2006-2009, there was drawdown in Wells 13, 14, and 15 in response to the dry periods during the mid- to late-summer. All wells eventually rebounded to above the wetland threshold during the growing season, with the exception of Well 14 in 2006. The well data showed the presence of wetland hydrology for the majority of each growing season in wetlands 83, 84, and 90.

5.4.5 South-Central Mine Site Area

Wetland 90 (Well 16) and Wetland 48 (Wells 1, 21, 22) are located south of the proposed East and Central Pit areas, Wetland 106 (Well 8) is located south of the proposed lean ore surge pile, and Wetland 58 (Well 9) is located south of the proposed Category 4 stockpile (Figure 2). All the wells are located south of the surface water divide, with Wells 8 and 9 located south of Dunka Road. Well 1 was located in a cedar swamp during 2005-2007; this well was moved in 2008 to a coniferous bog community dominated by tamarack when it was determined that the original location was in an area directly impacted by the proposed haul roads. Well 22 is located in a coniferous bog dominated by tamarack, Wells 8, 16, and 21 are installed in black spruce bogs, and Well 9 is located in an alder thicket (Table 1). Wetland 106 (Well 8) was previously logged. North of Well 9 and Dunka Road, Wetland 8 is impounded with a continuous stream of water flowing south under Dunka Road and the railroad, through Wetland 10, and discharging into Wetland 58 (Well 9).

The hydrographs in Figure 9 show that the water level in Wells 8, 16, and 21 exhibit a similar response to precipitation events as other wells located in black spruce bogs (Wells 2, 10, 11, 12, 13, 14, and 18). The hydrographs for Wells 1 and 22 also exhibit a similar response to the wells located in black spruce bogs. Well 1 was located in a cedar swamp in 2005-2007 and relocated further east in the same wetland complex to a black spruce bog (Figures 2 and 3). The hydrograph for Well 2 exhibited a similar pattern throughout the 2005-2009 monitoring periods (Figure 13). The water table in Wells 1, 16, 21, and 22 was generally 2 to 8 inches higher than in wetlands 84, 90, and 100 (Wells 2, 10, 11, 12, 13, 14, and 18) throughout the 2006-2009 monitoring period. While the hydrograph for Well 8 is similar to the other wells in black spruce bogs, the water table drawdown during the dry period in August 2008 was at least 10 inches greater. In 2007 and 2008, Well 8 also exhibited higher and lower water levels during the same time periods when compared to the other wells in black spruce bogs. The hydrograph for Well 9 was similar to Wells 8, 16, and 21 in 2006 and 2007. After 2007, the water levels in the wetlands upstream from Wetland 58 (Well 9) have been observed to be inundated year-round with surface water crossing Dunka Road periodically. The constant discharge to Wetland 58 may contribute to the stable water levels recorded for Well 9 in 2008 and 2009. The well data indicates that wetlands 48 and 90 are generally saturated to the surface, with inundated conditions in early June 2006, late September/early October 2007, and early June 2008.

The range of the water table fluctuation in Wells 16 and 21 was 0.4 to 2.8 feet throughout the 2006-2009 monitoring period, which is similar to the range of water table fluctuations for the other wells located in black spruce bogs (0.6 to 2.0 ft). Well 8 is located in a logged black spruce bog and shows a greater range of the water table fluctuation (0.9 to 2.6 feet; Table 3) than the non-logged black spruce bogs. The range of water table fluctuation in Well 9 was 0.2 to 2.0 feet, with a range of only 0.2 to 0.3 feet in 2008 and 2009 because of sustained water levels. In 2006-2009 all wells (except Well 9 in 2008 and 2009) showed a drawdown in water levels in response to dry periods during the mid- to late-summer. All wells eventually rebounded to above the wetland threshold during the growing season. Water levels in Wetland 48, 90, and 101 fell below the wetland threshold periodically in 2007-2009; however, the threshold for wetland hydrology is met each year. The well data showed the presence of wetland hydrology for the majority of each growing season in wetlands 48, 90, and 106.

5.4.6 Southwest Mine Site Area

Wetland 103 (Wells 3, 17), Wetland 53 (Well 7), Wetland 54 (Well 6), and Wetland 15 (Well 19) are located within, south, or southwest of the proposed West Pit (Figure 2). Wells 3 and 17 were monitored from 2005-2007; these wells were removed after 2007 since it was determined that they would be directly impacted by the project. Wells 22 and 3 was installed in a coniferous bog dominated by black spruce. Well 17 was located in a black spruce bog with interspersed areas of alder that also had an understory of sphagnum mat and Labrador tea. Wells 6 and 7 are located in alder thickets, and Well 19 is located in a coniferous bog dominated by black spruce and tamarack (Table 1).

In 2006 and 2007, the hydrographs in Figure 10 show that the water levels in Wells 3, 6, 7, 17, and 19 exhibit a response similar to precipitation events, even though these wells are not all located within the same wetland types. Wells 3 and 17 are located in the same wetland complex and have nearly identical hydrographs. All wells generally respond immediately to precipitation events and this type of hydrograph indicates the wetlands are primarily supported by precipitation. Wells 6 and 19 terminate in sand and as a result, capillarity is reduced so the water table drops quickly with a decrease in precipitation compared to wells installed in soils with higher capillarity or water-holding capacity (e.g., organic soil). With the extended drought in July-September 2007, the water level in all wells except Well 3 decreased below the wetland threshold. The water level in all wells began to increase in late August-early September with 1.8 inches of rainfall (August 28 and September 4). Water tables continued to rise and were maintained near or above the ground surface after an 8-inch rainfall event on September 10.

In 2008 and 2009, the hydrographs show that the water levels in Wells 6 and 19 exhibit a response similar to precipitation events, even though these wells are located within different wetland types. All wells generally respond immediately to precipitation events, although the responses are more subdued for Well 7 than in 2006 and 2007. Well 7 fluctuated more in 2006 (1.5 ft) and 2007 (1.2 ft) than in 2008 (1.1 ft) and 2009 (0.6 ft; Table 3). Just as in 2006 and 2007, Wells 6 and 19 generally exhibited the lowest water elevations in 2008 and 2009. The water level in Wells 6 and 18 dropped below the wetland threshold in 2008 and 2009; however in 2008 the water levels rebounded within 6 inches below the ground surface from September-November. In 2008-2009, only Well 7 remained with 6 inches of the ground surface during the entire monitoring period.

The range of water table fluctuations for the wells in alder thickets (Wells 6, 7) was 0.3 to 2.9 feet throughout the 2006-2009 monitoring period, which is similar to the range of water table fluctuations for Reference Well Ref2 (0.4 to 3.1 ft; Table 3), which is also located in an alder thicket. The hydrographs for Wells 6 and 7 are similar except in the pronounced drawdown during drought periods. The drawdown is more pronounced in Well 6, located in Wetland 54, which is isolated compared to Wetland 53 (Well 7) which has a larger contributing watershed area. Wells 3 and 17 were located in black spruce bogs with the range of water table fluctuation (0.7 to 1.2 ft; Table 3) similar to the other wells in black spruce bogs (0.6 to 2.0 ft). The water table fluctuation was 0.3 to 1.0 feet for Reference Well Ref1, which is also located in a black spruce bog. Well 19 is located in a black spruce bog, but the range of fluctuation was greater (0.6 to 2.6 ft; Table 3) compared to all other wells located in black spruce bogs, this could be partially due to the fact that Well 19 is located near the upstream end of the wetland. All wells showed a drawdown in response to dry periods in mid- to late-summer each year. All wells eventually rebounded above the wetland threshold before the end of the growing season. In 2007-2009, the water levels in most wells were near or above the ground surface except during the drier portions of the year (mid-summer to early-fall). The well data showed the presence of wetland hydrology for the majority of each growing season for wetlands 15, 48, 54, and 103.

5.4.7 Reference Wetlands

Reference Wells Ref1 and Ref2 were installed in April 2008 in wetlands (no identification numbers) located west of the Mine Site (Figure 2). Reference Well Ref1 is installed within a black spruce bog, with an area of cedar located nearby to the west. Reference Well Ref2 is installed in an alder thicket surrounded by a conifer swamp, which is dominated by black spruce and tamarack trees (Table 1).

The hydrographs in Figure 11 show that the water table in Reference Well Ref1 was within 2 inches of the ground surface for most of 2008, dropping to a depth of 11 inches during the drought period from August 3 to September 11. In 2008, Reference Well Ref2 was inundated with up to 7 inches of water, with the exception of August 9 through September 12 when the water table fell below the ground surface. On August 27, 2008 the water table was at more than 17 inches below the ground surface, and after 0.75 inches of rainfall in a 2-day period (August 28-29), the water table rebounded and remained above the ground surface for the remainder of 2008. In 2009, the reference wells exhibited wetland hydrology for the entire monitoring period. Similar to most of the wetlands monitored, the reference wells exhibited a slight decrease in water levels in response to the dry period in late July and August, 2009. The reference wells hydrographs reflect the different climate conditions present in 2008 and 2009.

The water table fluctuation for the reference Wells Ref1 and Ref2 in 2008 was 1.0 and 3.1 feet, respectively (Table 3). In comparison, with a majority of the growing season within the normal range of precipitation in 2009, the range of fluctuation for reference Wells Ref1 and Ref2 was very stable with 0.3 feet and 0.4 feet, respectively. The reference well data showed the presence of wetland hydrology for the majority of each growing season in the reference wetlands.

5.5 Wetland Hydrology Elevations

The average water level elevations recorded in the wetland monitoring wells in 2006-2009, along with the ground elevations at each well, are shown spatially on the figures in Appendices A-D, respectively. The water level elevation data is also shown graphically by project area on the figures in Appendices A-D. The wetland water level elevations are provided in Tables 2 and 3 and Figures 2 and 3.

The average water level elevations for each wetland type from 2005-2009 show the long term hydrologic stability despite varying climatic conditions (Appendix I). Throughout 2007-2009, the lowest average wetland water elevation was at Well 7M, located south of Dunka Road, with values ranging from 1557.4-1558.4 ft. MSL (Figures 3 and 4). The highest average wetland water elevation was at Well 4R, located in the northwest corner of the Mine Site, with values ranging from to 1614.7-1616.1 ft. MSL. The water table gradient throughout the site is very flat, ranging from 0.05 percent to 1.2 percent. The steepest gradient (1.2 percent in 2007-2009) is observed at the edges of the Mine Site and includes transects: between Wells 2 and 12, near the Partridge River; between Wells 19 and 7, in the southwest area; and between Wells 21 and 8. In the headwaters of the Partridge River, between Wells 4 and 4A, the water gradient during 2007-2009 was 0.6 percent, sloped to the northeast. One Hundred Mile Swamp is an extensive flat peatland with an average slope of about 0.2 percent from west to east. The average water table slope between Wells 2, 11, and 18 is about 0.1 percent. In 2007, the average water table slope between Wells 3, 7, 17, and 19 is about 0.8 percent sloping downward to the south (Wells 3 and 17 were removed at the beginning of the 2008 monitoring period).

5.6 Hydrology Results Summary

The monitoring data obtained in 2005-2009 shows the presence of sustained wetland hydrology (within 12 inches of the ground surface) in all of the monitored wetlands throughout 2005-2009 (Figures 6-11). Water levels in all wells except the Wells 4, 4A, and 5 in the northwest part of the Mine Site dropped below the wetland threshold during the July through August drought period in both 2007 and 2008. Several wells throughout the Mine Site were dry for up to one month during the drought period in 2007 (6, 19, 10, 11, 18, 1, 8, 13, 14, and 15). The water levels in the northwest wells (3, 4, 4A, 5, and 17) decreased 9 to 10 inches, but maintained water levels within 12 inches of the ground surface. This drop in water levels followed a sustained period of over two months with precipitation well below the normal range. Water levels in all wells recovered quickly with over 12 inches of precipitation in early September 2007.

Figures 6-11 show the range of depth to water over the five-year monitoring period. The wells located in the southwest and south-central areas of the Mine Site show the greatest range of water levels. The wells in the northwest area, located in Hundred Mile Swamp, show the least fluctuation. Continuous water level recording wells were monitored at well locations 1, 4, 7, and 12 from 2006-2009 (Well 1 was relocated at the beginning of the 2008 monitoring period), with additional wells installed in April 2008. Water levels were recorded once every 2 hours during the 2006-2009 monitoring period. While the recording well data is helpful in understanding the response of wetland hydrology to specific storm events at the Mine Site, it is not necessary for documenting whether or not jurisdictional wetland hydrology is present, since it is clearly present in all wetlands monitored. The recording well data for Wells 4R and 12R, located within the Hundred Mile Swamp complex, indicates very stable hydrology, which is indicative of a large, headwater wetland complex.

On average, wetlands make up 43 percent of the watershed areas within the Mine Site. Within the detailed watersheds shown on Figure 2, wetlands make up 32 percent to 56 percent of the land area within each watershed. The wetland hydrology observed at the Mine Site appears to be indicative of a system primarily supported by precipitation that is sensitive to climatic fluctuations. Precipitation patterns during 2005-2009 were highly variable as discussed in Section 3.3. The large fluctuations in water levels exhibited within the majority of the wetlands are indicative of wetlands supported primarily by precipitation and local surface runoff. The scrub shrub wetlands located near the downstream portion of the project generally show more stable hydrologic regimes due to the upstream contributions and some groundwater component. Without the support of regional ground water systems, the hydrology of these wetlands tends to fluctuate in a pattern that closely mirrors the climatic conditions.

6.0 Future Actions

The wetland hydrology monitoring will continue in 2010 on a monthly basis from approximately early May through late October. A plan to install wetland monitoring wells near the tailings basin is currently under development along with potential modifications to the monitoring plan at the Mine Site. This updated plan will be submitted in March of 2010, with wetland hydrology monitoring beginning in April 2010.

8.0 References

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Tables

Table 1
2005-2009 Wetland monitoring Well Summary
PolyMet Mining
Hoyt Lakes, Minnesota

						2005		2006		2007		2008		2009		UTM Coordinates		2009					
Well ID	PVC ID	Wetland ID	Circ 39 Type	Eggers & Reed Wetland Type	Date Initial Installed	Average Depth to Water[1] (in)	Average Water Elevation (ft MSL)	Average Depth to Water[1] (in)	Average Water Elevation (ft MSL)	Average Depth to Water[1] (in)	Average Water Elevation (ft MSL)	Average Depth to Water[1] (in)	Average Water Elevation (ft MSL)	Average Depth to Water[1] (in)	Average Water Elevation (ft MSL)	X:	Y:	Top of Casing to Ground (in)	Top of Casing Elevation (ft MSL)	Ground Elevation (ft MSL)	Well Length (in)	Below Ground Length (in)	Stratigraphy Notes
Well 1M[3]	---	48	7	Coniferous swamp	6/28/05	0.0	1586.4	-3.4	1586.1	-2.6	1586.2	---	---	---	---	577670	5273982	---	---	---	---	---	4" peat, 16" mucky peat
Well 1M	---	48	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-4.3	1592.0	-1.2	1592.2	577786	5274017	7.9	1593.0	1592.3	28.0	20.1	10" fibric peat, sapric peat to depth of well
Well 1R[3]	A3BF0FE	48	7	Coniferous swamp	11/9/05	-0.5	1586.3	-4.1	1586.1	-3.3	1587.2	---	---	---	---	577670	5273982	---	---	---	---	---	4" peat, 16" mucky peat
Well 1R[3]	A3BF0FE	48	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-4.4	1592.4	-5.86	1592.2	577788	5274017	7.3	1593.3	1592.7	47.5	40.3	10" fibric peat, sapric peat to depth of well
Well 2M	M48-0	100	8	Coniferous bog	6/30/05	11.3	1600.7	14.5	1600.5	7.8	1601.0	-7.8	1600.8	-11.0	1600.8	578291	5275294	23.3	1603.6	1601.7	59.5	36.2	no data
Well 2R	11311992	100	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-5.4	1600.8	-7.84	1600.7	578291	5275286	3.0	1601.5	1601.3	47.5	44.5	peat
Well 3M[2]	M15-8A	103	8	Coniferous bog	6/29/05	0.4	1597.0	1.9	1596.9	2.2	1596.8	---	---	---	---	576018	5274075	---	---	---	---	---	no data
Well 4M	M15-1	114	8	Coniferous bog	6/28/05	-0.9	1615.7	-2.2	1615.4	0.6	1615.5	-0.9	1615.4	0.7	1615.4	574918	5274129	14.1	1616.5	1615.3	28.8	14.6	15" peat
Well 4R[4]	A3BFEE6	114	8	Coniferous bog	11/9/05	-1.4	1615.5	-0.1	1615.6	-5.9	1616.1	-1.7	1615.2	-1.03	1615.5	574920	5274138	6.0	1616.0	1615.5	33.8	27.8	no data
Well 4AM	---	114	8	Coniferous bog	6/29/05	2.7	1597.8	1.0	1598.0	1.5	1597.9	-0.8	1597.7	2.4	1597.9	575669	5274600	13.2	1598.8	1597.7	29.0	15.8	no data
Well 4AR	1130ED9F	114	8	Coniferous bog	5/21/08	---	---	---	---	---	---	-2.0	1597.6	1.22	1597.8	575669	5274600	8.0	1598.4	1597.7	47.5	39.5	fibric peat
Well 5M	M15-2	114	8	Coniferous bog	6/28/05	-1.2	1615.5	-1.4	1615.6	-0.2	1615.5	-0.8	1615.3	-1.1	1615.4	574918	5274129	12.8	1616.6	1615.5	29.0	16.3	15" peat
Well 6M	M48-18	54	6	Alder thicket	6/29/05	1.0	1597.8	0.3	1597.8	5.8	1597.4	-0.6	1597.9	0.0	1597.8	574794	5272347	33.4	1600.5	1597.7	59.5	26.1	3" peat, 25" fine sand
Well 6R	1130E9C3	54	6	Alder thicket	5/23/08	---	---	---	---	---	---	-5.1	1597.6	-1.87	1597.8	574794	5272347	6.3	1598.4	1597.8	47.5	41.3	end of well is in sand
Well 7M	M48-20	53	6	Alder thicket	6/29/05	-1.3	1558.4	2.7	1557.9	-1.5	1558.4	-1.0	1558.2	3.8	1558.2	576323	5272608	31.6	1560.5	1557.9	59.3	27.7	no data
Well 7R	EBDA9E2	53	6	Alder thicket	11/9/05	0.7	1557.9	3.5	1558.0	-9.6	1559.1	-2.4	1558.1	-1.61	1558.4	576312	5272607	7.5	1559.2	1558.5	29.0	21.5	no data
Well 8M	M48-17	106	8	Coniferous bog	6/30/05	0.1	1564.1	4.1	1563.8	6.1	1563.6	-5.0	1563.6	-4.1	1563.8	578657	5273785	31.7	1566.8	1564.2	59.3	27.5	8"peat, 12" fine muck (compacted), 8" sand
Well 8R	10FACBD2	106	8	Coniferous bog	5/23/08	---	---	---	---	---	---	-5.9	1563.7	-3.73	1563.7	578657	5273785	8.5	1564.5	1563.8	47.5	39.0	end of well is in sandy clay
Well 9M	M48-14	58	6	Alder thicket	6/30/05	0.1	1565.8	1.6	1565.7	1.1	1565.8	0.1	1565.5	0.9	1565.8	579257	5274041	27.9	1568.1	1565.7	59.5	31.6	14" peat, 4" muck, 10" sand
Well 9R	1130E1CB	58	6	Alder thicket	6/27/08	---	---	---	---	---	---	-1.0	1565.5	0.27	1565.7	579257	5274041	6.0	1566.2	1565.7	47.5	41.5	muck over sand
Well 10M	EC-1	100	8	Coniferous bog	10/25/05	12.6	1598.3	12.1	1598.4	9.8	1598.6	-11.2	1597.8	-9.9	1598.1	577169	5275313	7.0	1599.5	1598.9	28.8	21.7	mucky peat
Well 10R	11312C31	100	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-6.8	1598.2	-7.88	1598.1	577165	5275315	5.2	1599.0	1598.6	47.5	42.3	fibric peat
Well 11M	M15-9	100	8	Coniferous bog	10/25/05	9.0	1597.4	11.6	1597.2	10.1	1597.3	-7.6	1598.3	-6.4	1598.5	577610	5274975	12.7	1600.1	1599.0	28.8	16.1	mucky peat
Well 11R	1130F7A0	100	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-10.0	1598.4	-11.65	1598.4	577624	5274981	5.2	1599.7	1599.3	47.5	42.3	10" fibric peat, sapric peat to depth of well
Well 12M	M48-1	100	8	Coniferous bog	6/30/05	3.6	1592.4	7.1	1592.1	7.0	1592.1	-5.9	1592.1	-7.8	1591.4	578188	5275487	16.8	1593.5	1592.1	59.5	42.7	14" peat, 4" muck, 10" sand
Well 12R	A3C03B3	100	8	Coniferous bog	11/9/05	-0.40	1591.6	5.25	1591.2	1.02	1591.9	-8.5	1592.0	-6.66	1592.2	578180	5275483	8.5	1593.4	1592.7	33.8	25.3	no data
Well 13M	---	84	8	Coniferous bog	6/29/05	17.5	1578.7	7.3	1579.6	8.7	1579.5	-8.0	1579.4	-7.8	1579.4	580022	5275659	9.2	1580.8	1580.1	29.0	19.8	6" sphagnum peat, 10" mucky peat, 5" mucky silt loam
Well 13R	113137C8	84	8	Coniferous bog	5/23/08	---	---	---	---	---	---	-10.8	1579.2	-9.84	1579.4	580022	5275659	5.5	1580.6	1580.1	47.5	42.0	sapric peat
Well 14M	---	90	8	Coniferous bog	6/29/05	13.9	1574.3	14.3	1574.3	9.5	1574.6	-6.6	1574.9	-9.6	1574.3	580480	5275406	11.2	1576.0	1575.1	29.0	17.8	4" sphagnum peat, 8" black and dark brown muck w/silt loam, 9" reddish peat
Well 14R	10FACBD4	90	8	Coniferous bog	5/23/08	---	---	---	---	---	---	-11.8	1574.4	-12.07	1574.3	580480	5275406	4.0	1575.5	1575.1	47.5	43.5	sapric peat
Well 15M	---	83	8	Coniferous bog	6/29/05	7.5	1572.2	7.5	1572.2	7.3	1572.3	-4.6	1572.0	-5.1	1572.1	580790	5274950	9.1	1573.3	1572.6	29.0	19.9	21" mucky peat w/ some sand, 2+" sand
Well 15R	1131251E	83	8	Coniferous bog	5/23/08	---	---	---	---	---	---	-4.4	1572.1	-3.56	1572.1	580790	5274950	6.0	1572.8	1572.3	47.5	41.5	end of well is in sand
Well 16M	M48-12	90	8	Coniferous bog	6/30/05	3.9	1586.2	3.6	1586.2	2.9	1586.3	-5.1	1586.3	-5.8	1586.0	579201	5274883	28.3	1588.8	1586.5	59.8	31.5	no data
Well 16R	1130EA23	90	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-4.4	1585.8	-4.18	1586.0	579199	5274883	5.4	1586.7	1586.3	47.5	42.1	fibric peat
Well 17M[2]	M15-8	103	8	Coniferous bog	6/29/05	1.8	1599.2	3.3	1599.1	3.5	1599.1	---	---	---	---	575812	5273791	---	---	---	---	---	no data
Well 18M	EC-2	100	8	Coniferous bog	10/25/05	12.7	1595.4	11.1	1595.5	11.7	1595.4	-8.6	1595.9	-8.4	1595.8	577100	5274700	10.0	1597.4	1596.5	28.5	18.5	peat
Well 18R	11312B8A	100	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-7.6	1596.0	-8.54	1595.7	577107	5274695	5.3	1596.8	1596.3	47.5	42.3	fibric peat
Well 19M	M48-7	15	8	Coniferous bog	6/28/05	1.8	1586.4	4.9	1586.1	5.4	1586.1	-1.0	1586.9	-1.4	1585.6	575729	5272919	31.2	1588.3	1585.7	59.7	28.5	8" peat, 18" 10YR6/1 sand
Well 19R	10FAA730	15	8	Coniferous bog	5/21/08	---	---	---	---	---	---	-4.4	1586.0	-1.08	1585.6	575721	5272927	7.0	1586.2	1585.6	47.5	40.5	20" fine sand, fine sandy clay to depth of well
Well 21M	---	48	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-14.3	1589.1	-7.96	1589.6	578590	5274381	5.9	1590.7	1590.2	60.3	54.3	fibric peat
Well 21R	1130F796	48	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-5.8	1589.8	-5.18	1589.5	578593	5274381	6.1	1590.4	1589.9	47.5	41.4	fibric peat
Well 22M	---	48	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-9.2	1598.3	-3.93	1597.8	577270	5274216	11.4	1599.1	1598.1	41.3	29.8	10" fibric peat, 38" fine sandy clay
Well 22R	11313A5D	48	8	Coniferous bog	5/22/08	---	---	---	---	---	---	-5.2	1598.0	-6.16	1597.9	577268	5274214	5.0	1598.7	1598.2	47.5	42.5	10" fibric peat, 18" fine sandy clay, 6" fine sandy clay loam
Well Ref1M	---	---	8	Coniferous bog	5/21/08	---	---	---	---	---	---	0.9	1592.7	-0.08	1592.5	573085	5272649	13.5	1593.6	1592.5	61.0	47.5	fibric peat
Well Ref1R	1130EA3A	---	8	Coniferous bog	5/21/08	---	---	---	---	---	---	-2.6	1592.5	-0.65	1592.4	573085	5272646	7.5	1593.1	1592.5	47.5	40.0	fibric peat
Well Ref2M	---	---	6	Alder thicket	5/21/08	---	---	---	---	---	---	-3.9	1573.6	2.71	1573.6	572981	5270993	15.6	1574.7	1573.4	29.8	14.1	20" fibric peat, sapric peat to depth of well
Well Ref2R	113130E8	---	6	Alder thicket	5/21/08	---	---	---	---	---	---	1.6	1574.0	1.06	1573.7	572979	5270994	9.5	1574.3	1573.5	47.5	38.0	20" fibric peat, sapric peat to depth of well

[1] Positive numbers represent depth below ground and negative numbers represent standing water on the ground surface.

[2] Well was retired from the study after the 2007 monitoring season.

[3] Well 1 was relocated in 2008.

[4] Well 4R is paired with manual Wells 4 and 5.

Bold = Recording wells installed 2008.

"R" refers to recording wells; "M" refers to manual wells

Table 2
2005-2009 Water Elevation Summary
PolyMet Mining
Hoyt Lakes, Minnesota

Date	2005			2006			2007			2008			2009					
Well ID	Average Water Elevation (ft MSL)	n	Range (ft)	Average Water Elevation (ft MSL)	n	Range (ft)	Average Water Elevation (ft MSL)	n	Range (ft)	Average Water Elevation (ft MSL)	n	Range (ft)	TOC Elevation (ft MSL)	Ground Elevation (ft MSL)	Below-ground Length (in)	Average Water Elevation (ft MSL)	n	Range (ft)
1M - removed	1586.4	5.0	0.2	1586.1	14.0	1.6	1586.2	14.0	2.0	---		---		---	---	---	---	---
1M	---		---	---		---	---		---	1592.0	7.0	1.0	1593.0	1592.3	20.1	1592.2	6.0	0.8
1R - removed	1586.3	2.0	0.3	1586.1	14.0	2.0	1587.2	13.0	2.0	---	---	---		---	---	---	---	---
1R	---	---	---	---	---	---	---	---	---	1592.4	---	1.8	1593.3	1592.7	40.3	1592.2	---	1.2
2M	1600.7	6.0	0.5	1600.5	14.0	0.9	1601.0	15.0	1.4	1600.8	7.0	1.5	1603.6	1601.7	36.2	1600.8	6.0	0.6
2R	---	---	---	---	---	---	---	---	---	1600.8	---	1.2	1601.5	1601.3	44.5	1600.7	---	0.7
3M - removed	1597.0	4.0	0.1	1596.9	14.0	0.7	1596.8	14.0	1.1	---	---	---		---	---	---	---	---
4M	1615.7	6.0	0.3	1615.4	13.0	0.7	1615.5	14.0	0.9	1615.4	5.0	0.0	1616.5	1615.3	14.6	1615.4	6.0	0.5
4R	1615.5	2.0	0.1	1615.6	1.0	1.9	1616.1	14.0	1.4	1615.2	---	0.9	1616.0	1615.5	27.8	1615.5	---	0.3
4AM	1597.8	5.0	0.1	1598.0	14.0	0.6	1597.9	14.0	1.2	1597.7	6.0	0.4	1598.8	1597.7	15.8	1597.9	6.0	0.8
4AR	---	---	---	---	---	---	---	---	---	1597.6	---	1.0	1598.4	1597.7	39.5	1597.8	---	0.4
5M	1615.5	6.0	0.3	1615.6	14.0	0.6	1615.5	14.0	0.8	1615.3	5.0	0.2	1616.6	1615.5	16.3	1615.4	6.0	0.3
6M	1597.8	4.0	0.4	1597.8	14.0	1.3	1597.4	14.0	2.7	1597.9	4.0	0.4	1600.5	1597.7	26.1	1597.8	6.0	1.9
6R	---	---	---	---	---	---	---	---	---	1597.6	---	2.9	1598.4	1597.8	41.3	1597.8	---	0.8
7M	1558.4	4.0	0.2	1558.0	14.0	1.2	1558.4	14.0	1.6	1558.2	5.0	0.3	1560.5	1557.9	27.7	1558.2	6.0	0.8
7R	1557.9	2.0	0.1	1557.9	---	0.3	1559.1	14.0	1.2	1558.1	---	1.1	1559.2	1558.5	21.5	1558.4	---	0.6
8M	1564.1	6.0	0.4	1563.8	14.0	0.9	1563.6	14.0	2.6	1563.6	5.0	1.3	1566.8	1564.2	27.5	1563.8	6.0	1.1
8R	---	---	---	---	---	---	---	---	---	1563.7	---	2.5	1564.5	1563.8	39.0	1563.7	---	1.5
9M	1565.8	6.0	0.2	1565.7	14.0	0.8	1565.8	15.0	2.0	1565.5	6.0	0.5	1568.1	1565.7	31.6	1565.8	6.0	0.3
9R	---	---	---	---	---	---	---	---	---	1565.5	---	0.3	1566.2	1565.7	41.5	1565.7	---	0.2
10M	1598.3	4.0	0.9	1598.4	14.0	0.8	1598.6	14.0	1.6	1597.8	6.0	1.1	1599.5	1598.9	21.7	1598.1	6.0	1.1
10R	---	---	---	---	---	---	---	---	---	1598.2	---	1.3	1599.0	1598.6	42.3	1598.1	---	0.7
11M	1597.4	4.0	0.4	1597.2	14.0	0.9	1597.3	14.0	1.1	1598.3	6.0	1.0	1600.1	1599.0	16.1	1598.5	6.0	1.3
11R	---	---	---	---	---	---	---	---	---	1598.4	---	1.5	1599.7	1599.3	42.3	1598.4	---	0.6
12M	1592.4	5.0	0.4	1592.1	14.0	1.0	1592.1	15.0	1.3	1592.1	7.0	1.1	1593.5	1592.1	42.7	1591.4	6.0	0.6
12R	1591.6	1.0	0.0	1591.2	2.0	0.6	1591.9	14.0	1.5	1592.0	---	1.4	1593.4	1592.7	25.3	1592.2	---	0.8
13M	1578.7	6.0	0.7	1579.6	8.0	0.4	1579.5	14.0	1.6	1579.4	6.0	1.2	1580.8	1580.1	19.8	1579.4	6.0	1.3
13R	---	---	---	---	---	---	---	---	---	1579.2	---	1.8	1580.6	1580.1	42.0	1579.4	---	1.1
14M	1574.3	6.0	0.9	1574.3	14.0	1.0	1574.6	14.0	1.5	1574.9	7.0	0.6	1576.0	1575.1	17.8	1574.3	6.0	1.1
14R	---	---	---	---	---	---	---	---	---	1574.4	---	1.5	1575.5	1575.1	43.5	1574.3	---	0.9
15M	1572.2	6.0	0.2	1572.2	14.0	0.7	1572.3	14.0	1.5	1572.0	7.0	0.9	1573.3	1572.6	19.9	1572.1	6.0	1.1
15R	---	---	---	---	---	---	---	---	---	1572.1	---	1.9	1572.8	1572.3	41.5	1572.1	---	0.6
16M	1586.2	6.0	0.4	1586.2	14.0	0.7	1586.3	15.0	1.4	1586.3	7.0	1.7	1588.8	1586.5	31.5	1586.0	6.0	1.3
16R	---	---	---	---	---	---	---	---	---	1585.8	---	1.3	1586.7	1586.3	42.1	1586.0	---	0.7
17M - removed	1599.2	4.0	0.2	1599.1	14.0	0.9	1599.1	14.0	1.2	---	---	---		---	---	---	---	---
18M	1595.4	4.0	1.2	1595.5	14.0	1.0	1595.4	13.0	2.0	1595.9	7.0	1.3	1597.4	1596.5	18.5	1595.8	6.0	1.2
18R	---	---	---	---	---	---	---	---	---	1596.0	---	1.3	1596.8	1596.3	42.3	1595.7	---	0.9
19M	1586.4	7.0	0.4	1586.1	14.0	1.3	1586.1	14.0	2.6	1586.9	7.0	0.8	1588.3	1585.7	28.5	1585.6	---	1.0
19R	---	---	---	---	---	---	---	---	---	1586.0	---	2.3	1586.2	1585.6	40.5	1585.6	---	0.6
21M	---	---	---	---	---	---	---	---	---	1589.1	6.0	2.8	1590.7	1590.2	54.3	1589.6	6.0	0.4
21R	---	---	---	---	---	---	---	---	---	1589.8	---	1.3	1590.4	1589.9	41.4	1589.5	---	0.6
22M	---	---	---	---	---	---	---	---	---	1598.3	5.0	1.5	1599.1	1598.1	29.8	1597.8	---	1.4
22R	---	---	---	---	---	---	---	---	---	1598.0	---	2.2	1598.7	1598.2	42.5	1597.9	---	0.9
Ref1M	---	---	---	---	---	---	---	---	---	1592.7	5.0	1.4	1593.6	1592.5	47.5	1592.5	6.0	0.4
Ref1R	---	---	---	---	---	---	---	---	---	1592.5	---	1.0	1593.1	1592.5	40.0	1592.4	---	0.3
Ref2M	---	---	---	---	---	---	---	---	---	1573.6	5.0	3.1	1574.7	1573.4	14.1	1573.6	6.0	1.2
Ref2R	---	---	---	---	---	---	---	---	---	1574.0	---	2.1	1574.3	1573.5	38.0	1573.7	---	0.4

"R" refers to recording wells; "M" refers to manual wells

Table 3
Precipitation Summary Compared to WETS Data
1999-2009
PolyMet Mining Company
Hoyt Lakes, Minnesota

		30% chance		Babbitt										
	Average	less than	more than	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Inches													
January	0.88	0.52	1.07	0.73	0.55	**1.21**	*0.12*	*0.19*	**1.23**	**2.15**	*0.42*	**1.56**	**0.69**	1.09
February	0.70	0.36	0.86	0.60	0.71	**1.77**	*0.26*	0.44	*0.23*	0.50	**0.88**	*0.34*	*0.17*	**1.13**
March	1.10	0.63	1.34	1.01	1.11	*0.22*	0.96	0.82	0.64	0.95	**1.69**	**2.39**	*0.33*	**2.81**
April	1.96	1.27	2.35	1.70	*0.94*	**5.07**	*0.47*	1.56	1.63	1.91	1.82	**3.56**	**4.46**	**3.36**
May	3.01	1.89	3.63	**5.13**	**3.65**	**6.69**	*1.72*	2.16	**4.53**	**9.01**	3.35	**4.31**	2.77	*1.54*
June	4.29	3.26	5.00	3.96	**5.89**	3.79	4.28	3.36	*1.45*	**5.78**	*1.71*	4.88	**5.58**	*2.30*
July	3.37	2.44	3.96	**13.51**	**4.08**	**4.91**	**5.13**	**5.51**	3.23	*1.42*	**4.92**	*1.22*	*1.31*	*2.38*
August	3.94	2.73	4.70	**4.91**	**5.14**	**9.59**	**4.90**	*1.90*	3.01	*1.77*	*2.10*	*1.05*	*1.07*	3.56
September	3.65	2.44	4.36	**5.33**	*2.23*	*1.41*	3.74	**5.42**	4.04	2.79	*2.13*	**12.75**	**4.87**	*1.12*
October	2.88	1.77	3.48	*1.48*	2.34	**4.07**	2.16	*1.50*	3.08	2.78	1.98	**6.43**	2.28	3.08
November	1.75	1.00	2.13	*0.09*	1.33	2.02	*0.29*	1.49	*0.34*	**3.44**	*0.82*	*0.77*	*0.75*	1.45
December	1.07	0.74	1.27	*0.19*	0.81	*0.67*	*0.50*	0.88	**1.96**	0.90	1.03	**2.21**	**1.92**	**1.38**
Annual	28.60	*25.96*	**30.86**	**38.64**	28.78	**41.42**	*24.53*	*25.23*	*25.37*	**33.40**	*22.85*	**41.47**	*26.20*	*25.20*
Water Year					26.06	**39.14**	28.34	*24.31*	*23.86*	**31.66**	26.14	**35.89**	30.66	*24.24*

The only normal period available for Babbitt is 1961-1985, which is the basis of the data above.

All data is from Babbitt weather station except box shaded gray, which is from Embarrass weather station.

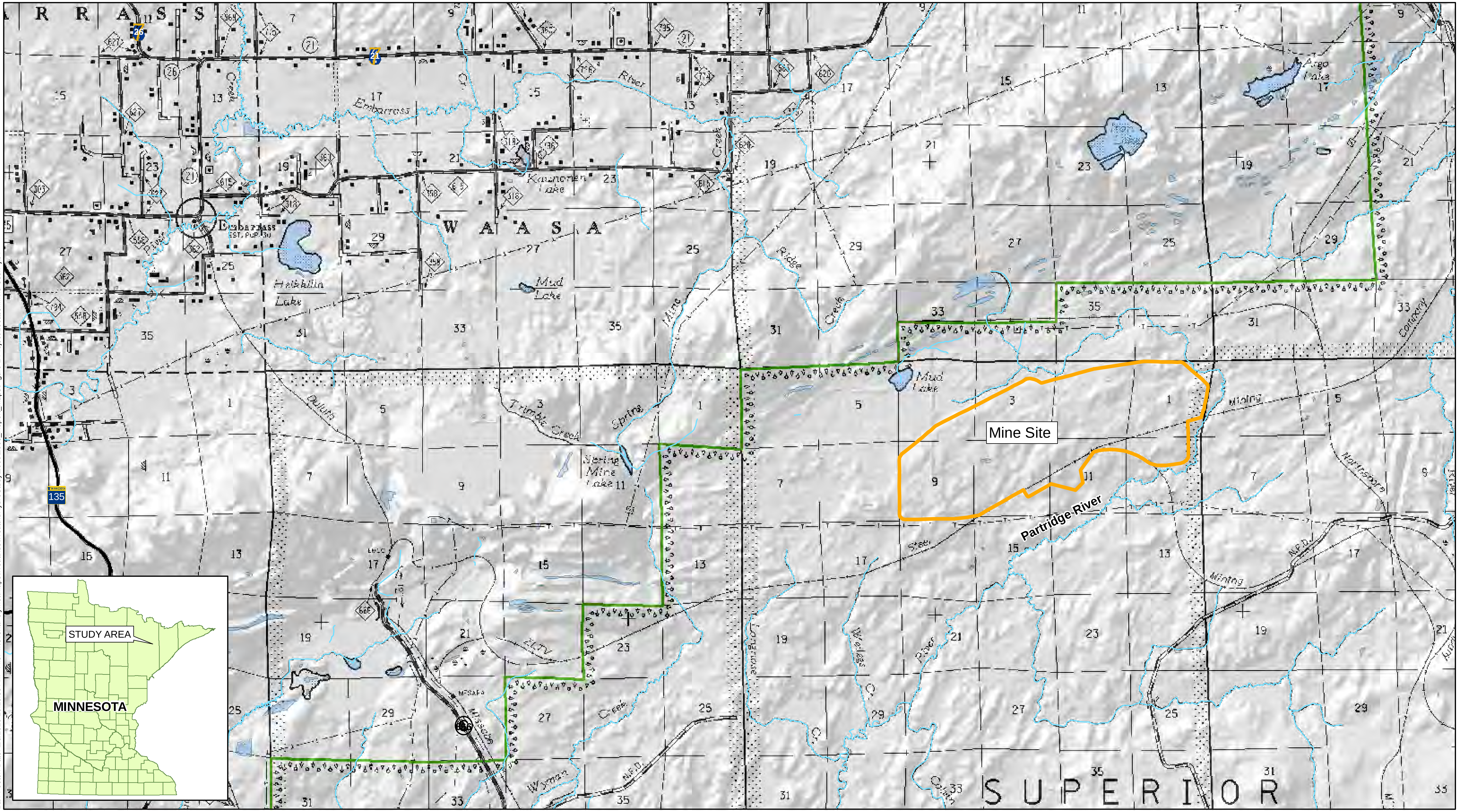
Bold = above the normal range

Italics = below the normal range

Table 4
Precipitation During the Growing Season (May 9-October 6; 151 days)
2005-2009
PolyMet Mining Company
Hoyt Lakes, Minnesota

	Year				
	2005	2006	2007	2008	2009
Days Below Normal Range (percent of total days)	35 (23%)	74 (49%)	69 (46%)	68 (45%)	35 (23%)
Days Within Normal Range (percent of total days)	57 (39%)	57 (38%)	15 (10%)	27 (18%)	114 (76%)
Days Above Normal Range (percent of total days)	59 (38%)	20 (13%)	67 (44%)	56 (37%)	2 (1%)

Figures



Mine Site
National Forest Boundary
Lakes
Streams

1 0.5 0 1
Miles

Figure 1
PROJECT LOCATION
NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, Minnesota

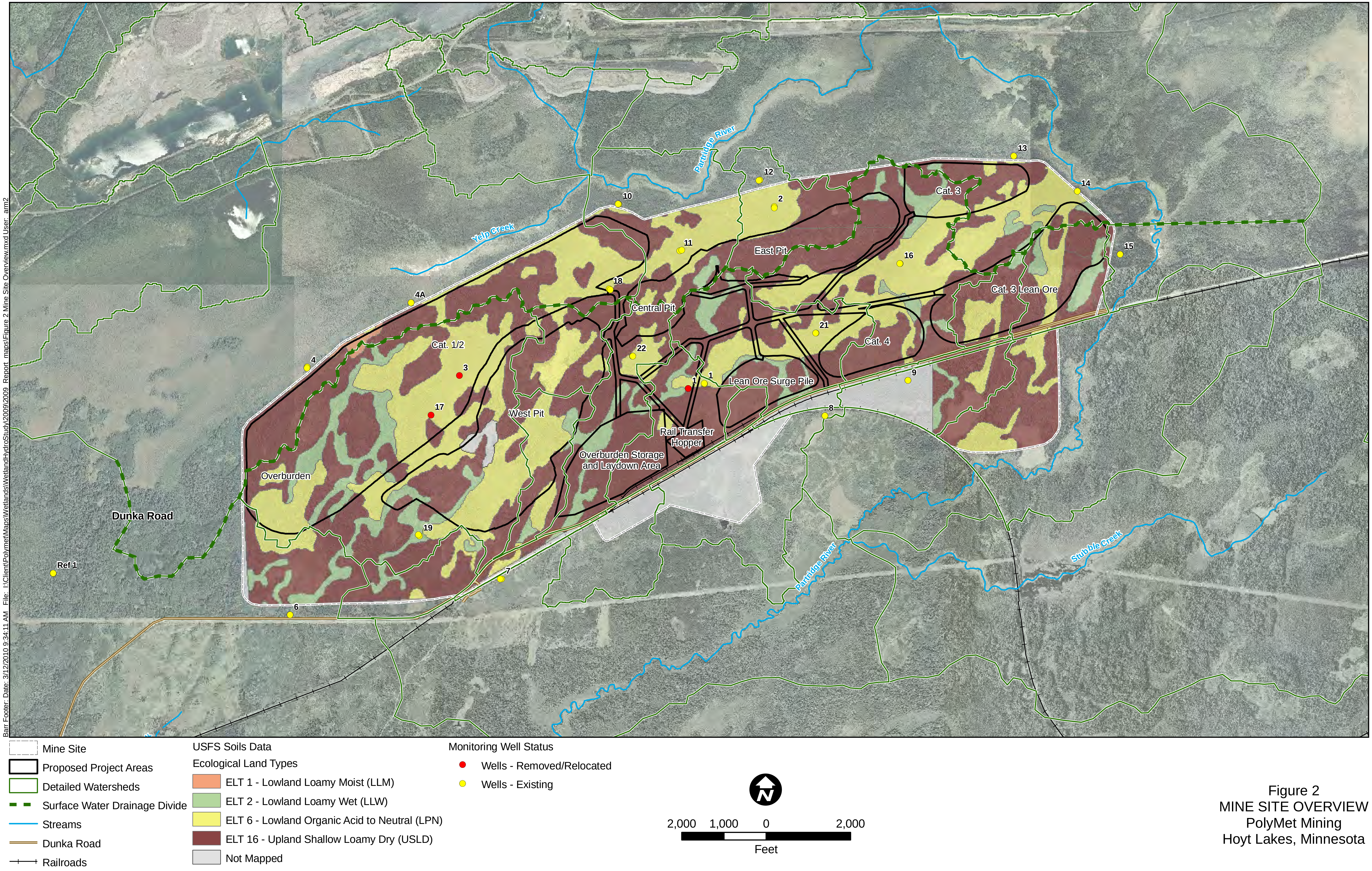
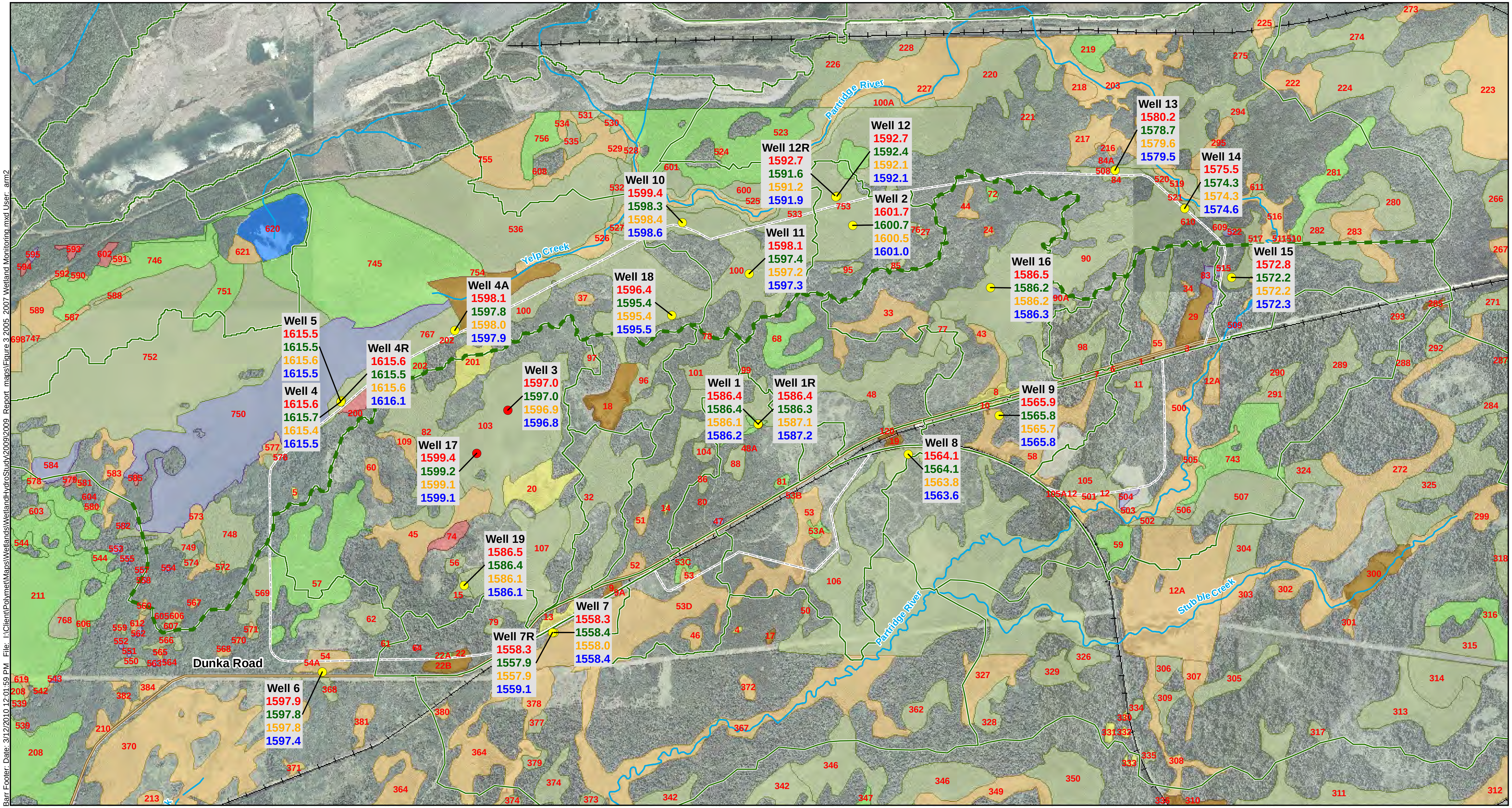


Figure 2
MINE SITE OVERVIEW
PolyMet Mining
Hoyt Lakes, Minnesota



Barr Footer: Date: 3/12/2010 12:01:59 PM File: I:\Client\Polymet\Maps\Wetlands\WetlandHydroStudy\2009\2009_Report_maps\Figure 3 2005_2007 Wetland Monitoring.mxd User: arm2

Mine Site
Detailed Watersheds
Surface Water Drainage Divide
Streams
Dunka Road

Monitoring Well Status
- Wells - Existing
- Wells - Removed/Relocated

Eggers & Reed Wetland Types
- Shrub Swamps (Alder thickets & Shrub-carrs)
- Coniferous bog
- Coniferous swamp
- Deep marsh; Shallow marsh
- Hardwood swamp
- Open water (Shallow, open water & lakes)
- Open bog
- Sedge meadow; Wet meadow

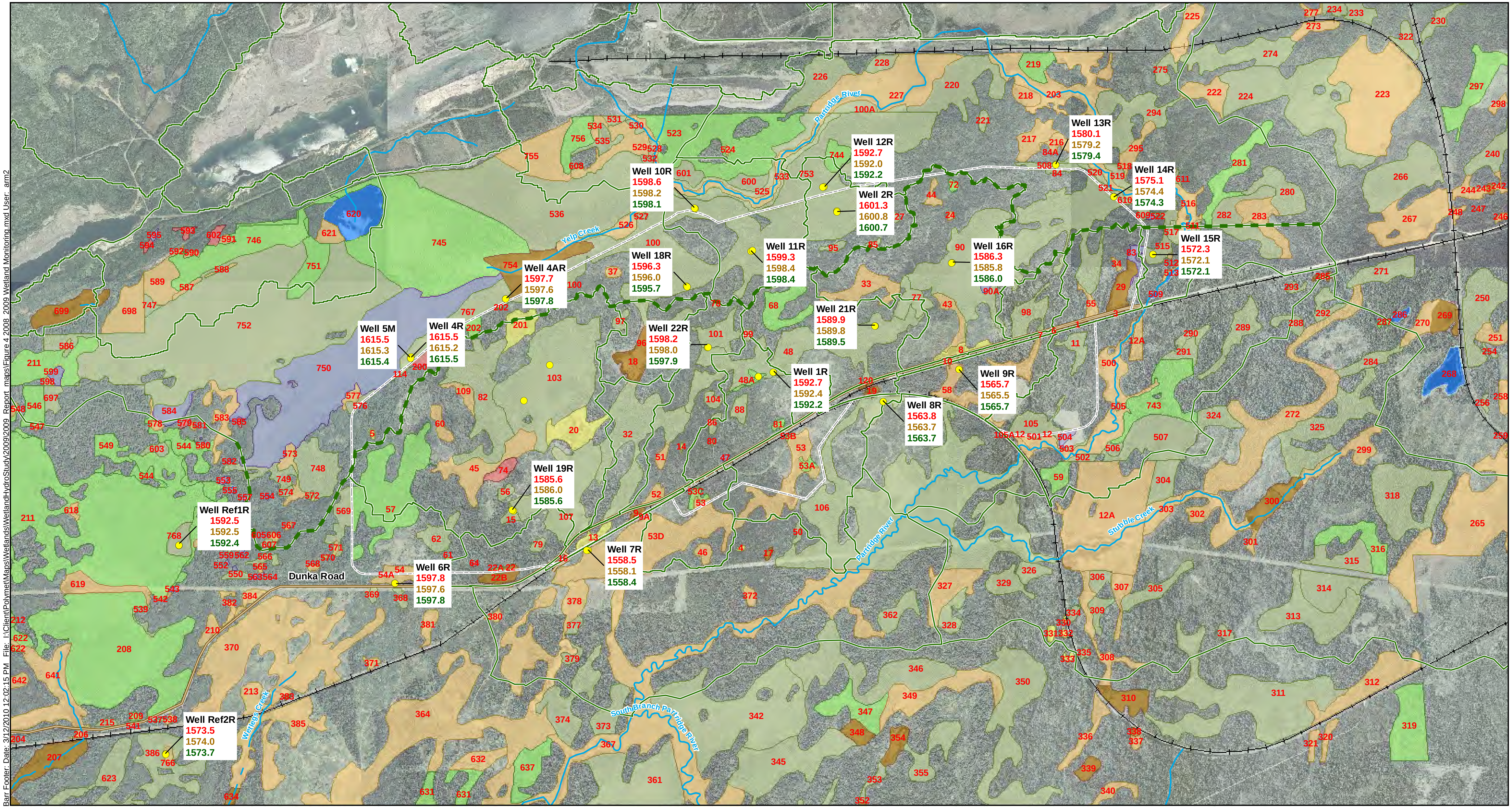
Well Number
- 1587.1 2007 Ground Elevation (ft MSL)
- 1586.2 Average 2005 Water Elevation (ft MSL)
- 1586.2 Average 2006 Water Elevation (ft MSL)
- 1586.2 Average 2007 Water Elevation (ft MSL)

"R" = Recording well

50 Wetland Number

2,000 1,000 0 2,000
Feet

Figure 3
2005-2007 WETLAND MONITORING
GROUND AND WATER LEVEL ELEVATIONS
PolyMet Mining
Hoyt Lakes, Minnesota



Mine Site
Detailed Watersheds
Surface Water Drainage Divide
Streams
Dunka Road
Wetland Hydrology Monitoring Well

Eggers & Reed Wetland Types
Shrub Swamps (Alder thickets & Shrub-carrs)
Coniferous bog
Coniferous swamp
Deep marsh; Shallow marsh
Hardwood swamp
Open water (Shallow, open water & lakes)
Open bog
Sedge meadow; Wet meadow

Well Number
1587.1 2009 Ground Elevation (ft MSL)
1586.2 Average 2008 Water Elevation (ft MSL)
1586.2 Average 2009 Water Elevation (ft MSL)
"R" = Recording well
50 Wetland Number

2,000 1,000 0 2,000
Feet

Figure 4
2008-2009 WETLAND MONITORING
GROUND AND WATER LEVEL ELEVATIONS
PolyMet Mining
Hoyt Lakes, Minnesota

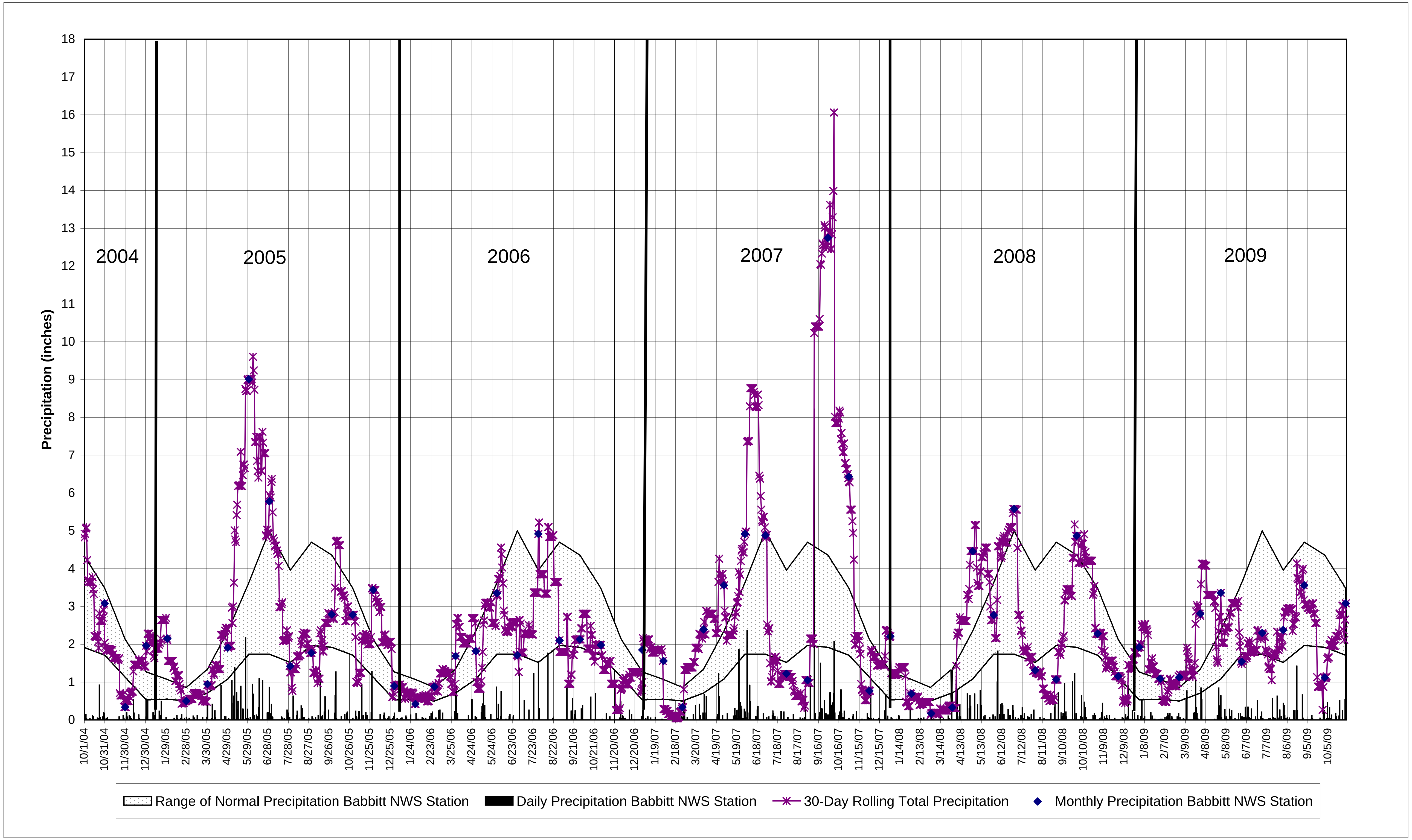
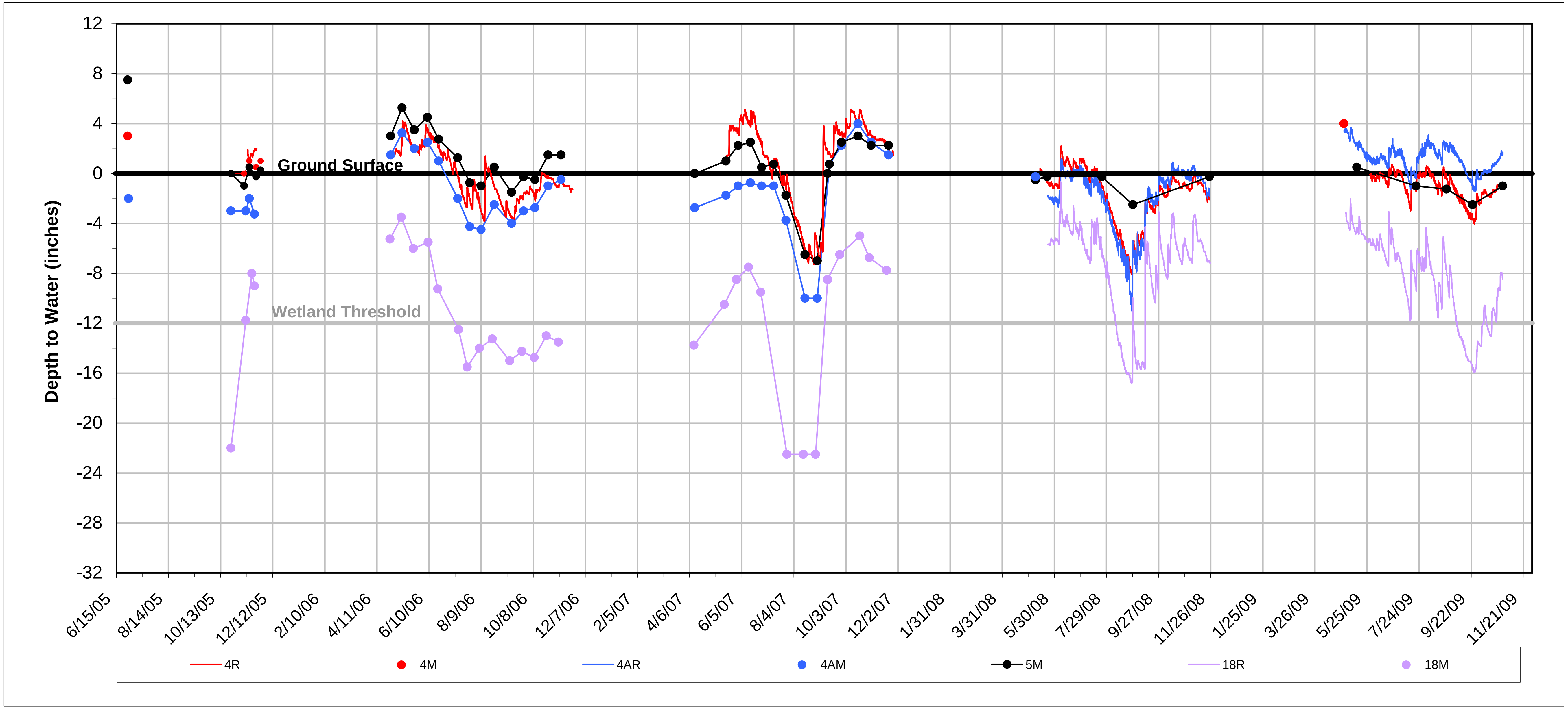
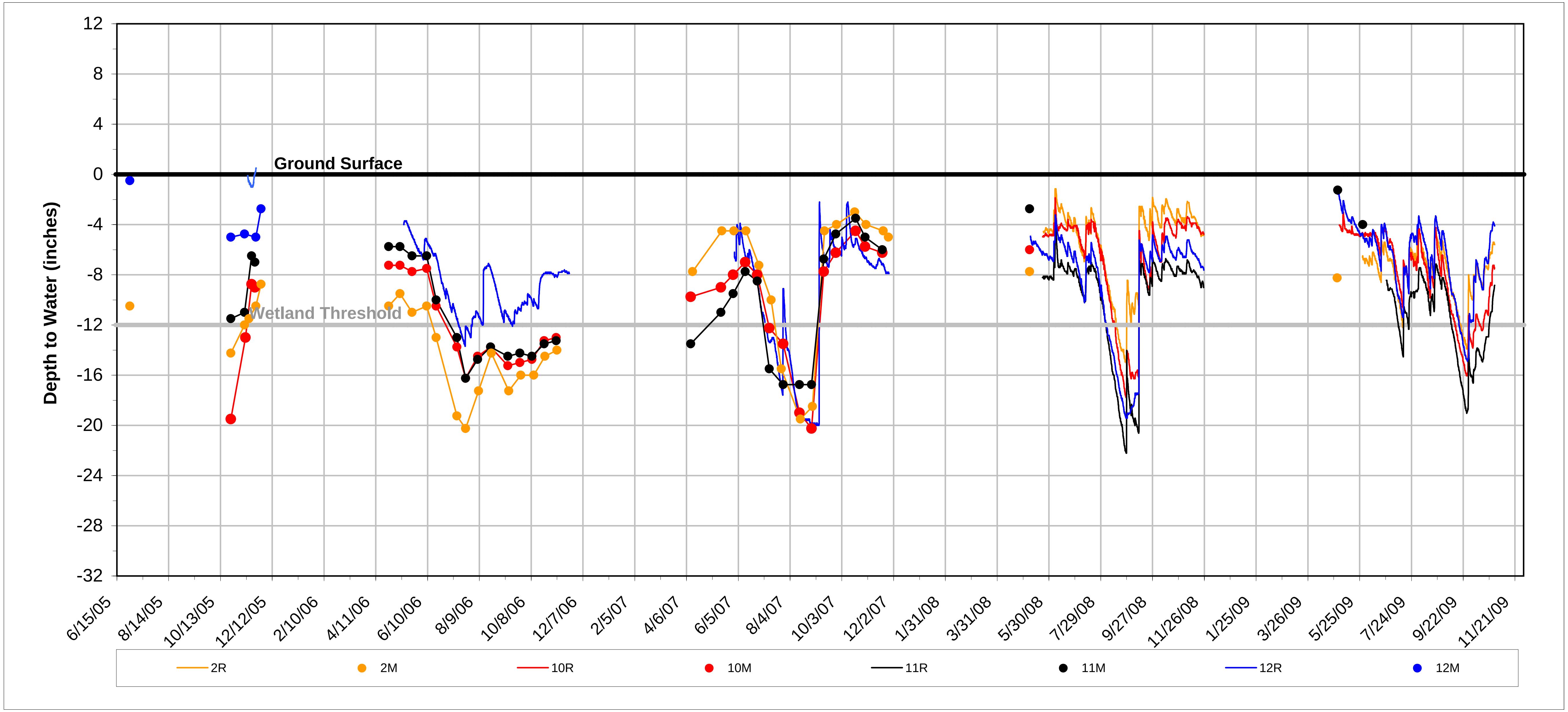


Figure 5
PRECIPITATION STATISTICS FOR
2004-2009 WATER YEARS
PolyMet Mining
Hoyt Lakes, Minnesota



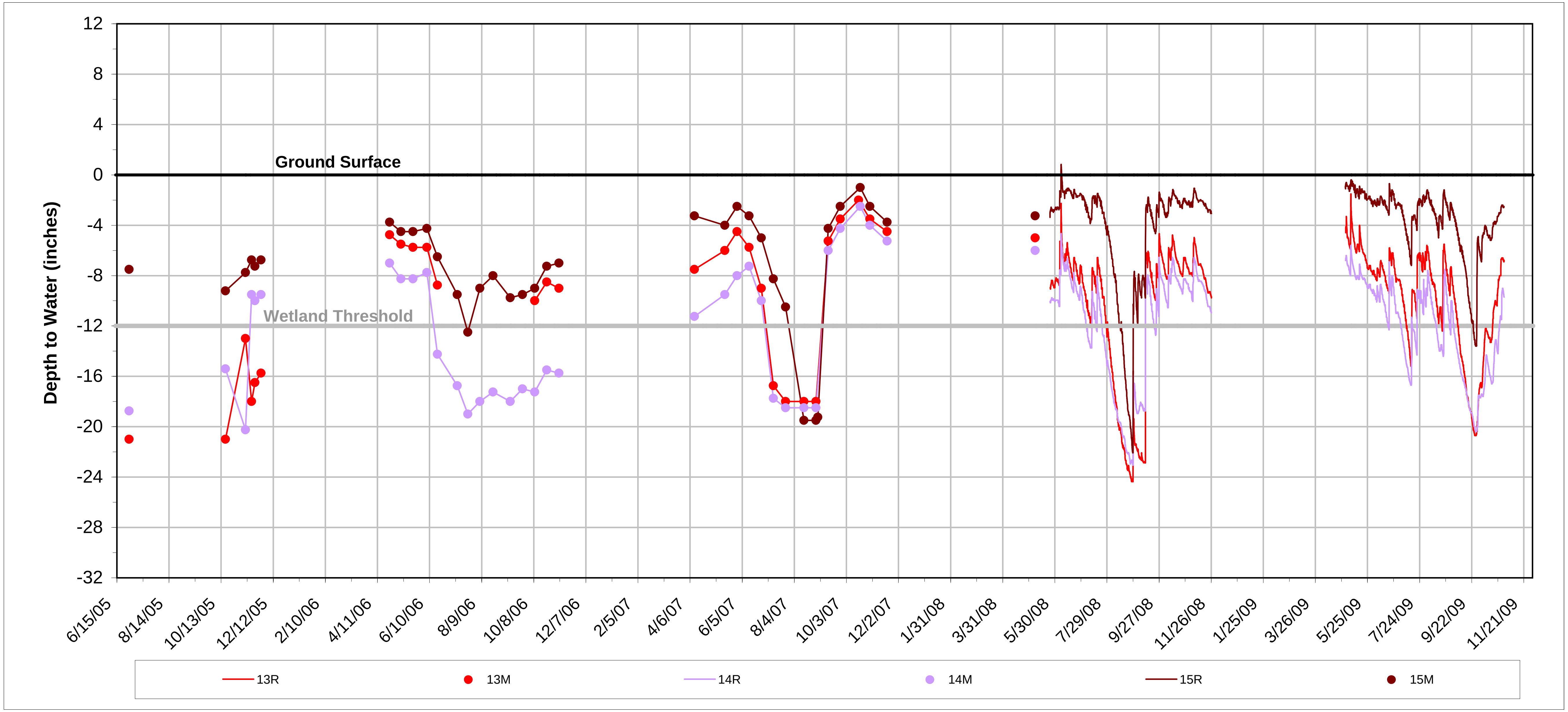
R = Recording well and "M" = Manual well
Continuous lines without points
represent recording wells; lines
with points represent manual wells

Figure 6
2005-2009 WETLAND HYDROLOGY MONITORING DATA
NORTHWEST MINE SITE AREA
PolyMet Mining
Hoyt Lakes, Minnesota



R = Recording well and "M" = Manual well
Continuous lines without points
represent recording wells; lines
with points represent manual wells

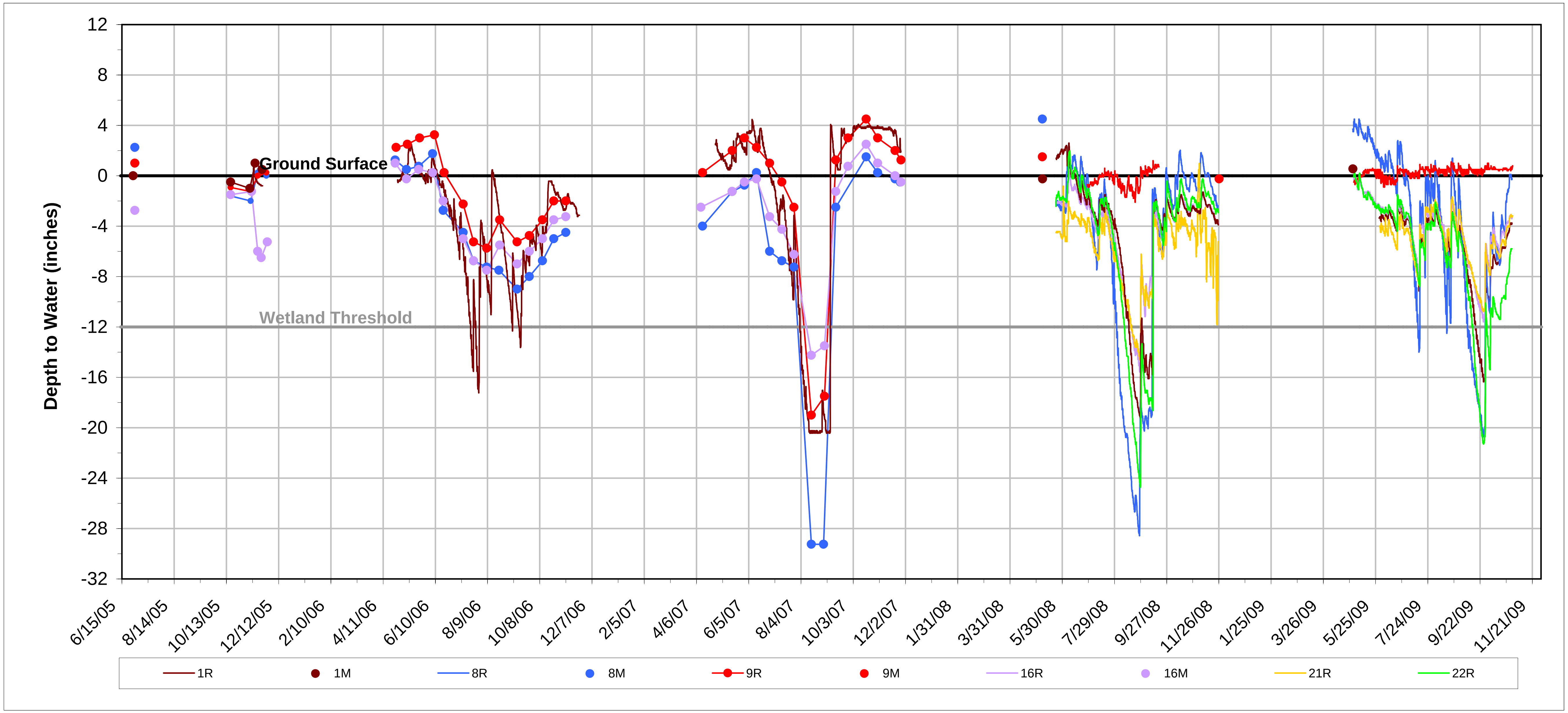
Figure 7
2005-2009 WETLAND HYDROLOGY MONITORING DATA
NORTH-CENTRAL MINE SITE AREA
PolyMet Mining
Hoyt Lakes, Minnesota



R = Recording well and "M" = Manual well
Continuous lines without points
represent recording wells; lines
with points represent manual wells

Figure 8
2005-2009 WETLAND HYDROLOGY MONITORING DATA
NORTHEAST MINE SITE AREA
PolyMet Mining
Hoyt Lakes, Minnesota

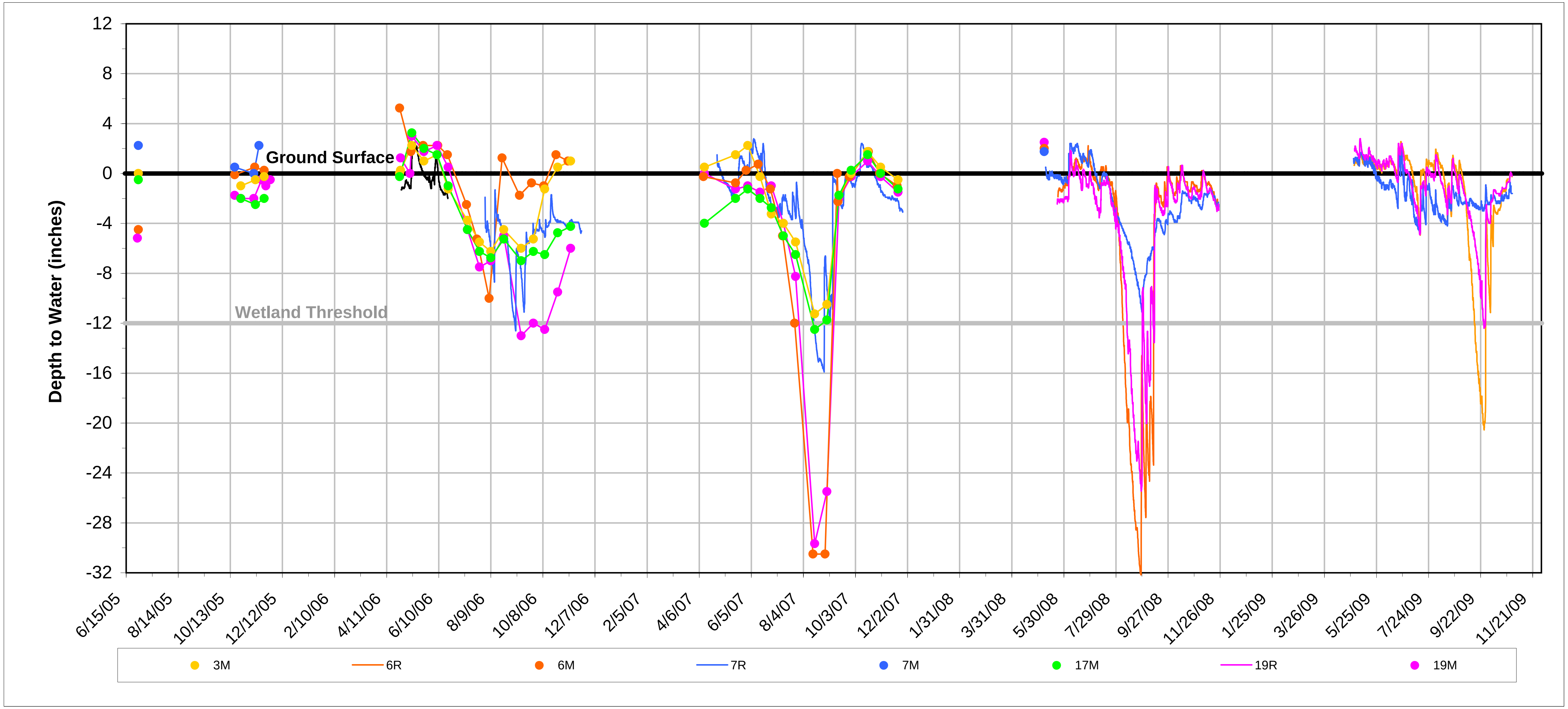
P:\Mpls\23 MN\69\2369862\WorkFiles\WO 008 Corps Wetlands Permit\WetlandHydroStudy\2009Data\2009 PolyMet Well Data\Polymet_Figures_2009



R = Recording well and "M" = Manual well
Continuous lines without points
represent recording wells; lines
with points represent manual wells

Figure 9
2005-2009 WETLAND HYDROLOGY MONITORING DATA
SOUTH-CENTRAL MINE SITE AREA
PolyMet Mining
Hoyt Lakes, Minnesota

P:\Mpls\23 MN\69\2369862\WorkFiles\WO 008 Corps Wetlands Permit\WetlandHydroStudy\2009Data\2009 PolyMet Well Data\Polymet_Figures_2009

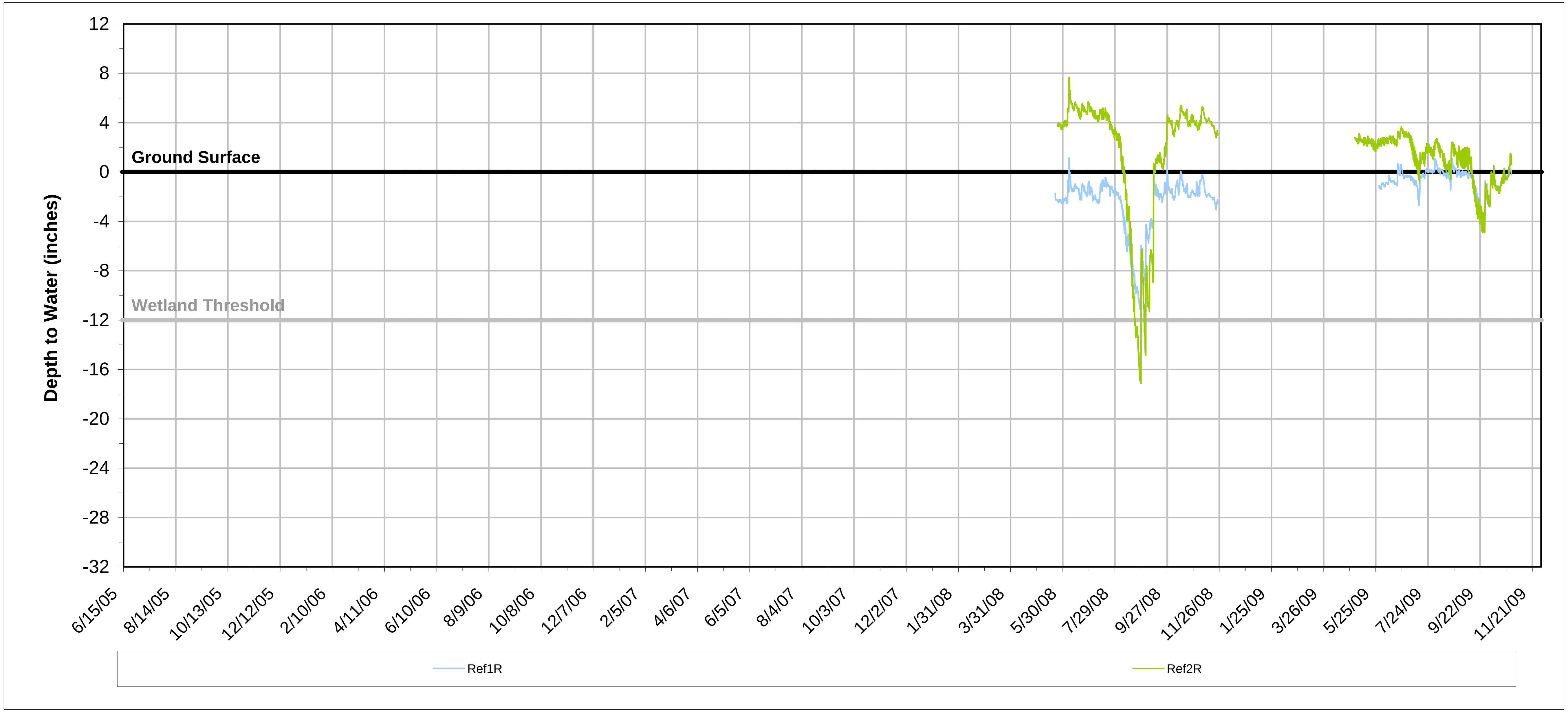


R = Recording well and "M" = Manual well
Continuous lines without points
represent recording wells; lines
with points represent manual wells

Wells 3M and 17M were removed because
they were determined to be within the
project footprint

Figure 10
2005-2009 WETLAND HYDROLOGY MONITORING DATA
SOUTHWEST MINE SITE AREA
PolyMet Mining
Hoyt Lakes, Minnesota

P:\Mpls\23 MN\69\2369862\WorkFiles\WO 008 Corps Wetlands Permit\WetlandHydroStudy\2009Data\2009 PolyMet Well Data\Polymet_Figures_2009



R = Recording well and "M" = Manual well
Continuous lines without points
represent recording wells; lines
with points represent manual wells

Figure 11
2005-2009 WETLAND HYDROLOGY MONITORING DATA
REFERENCE WELLS - WEST OF MINE SITE
PolyMet Mining
Hoyt Lakes, Minnesota

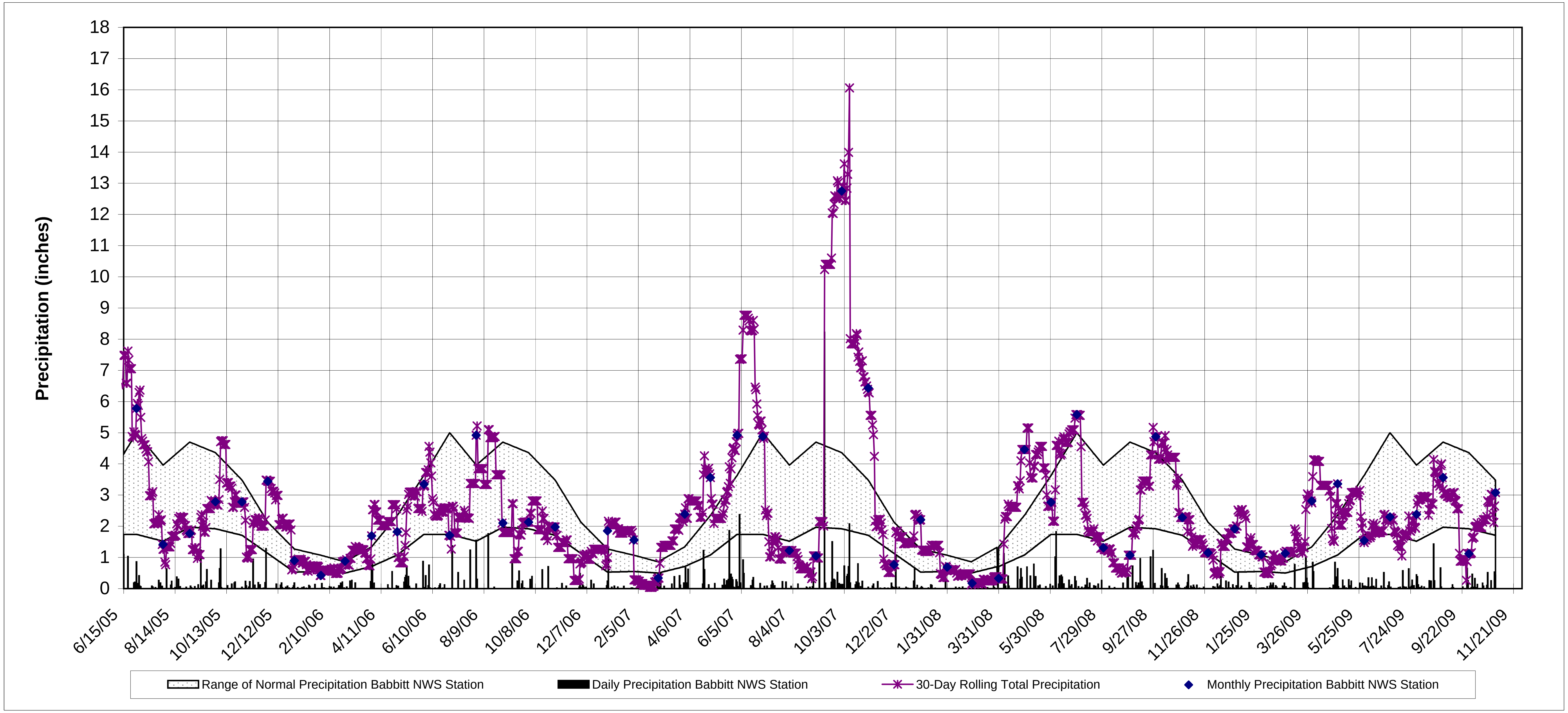
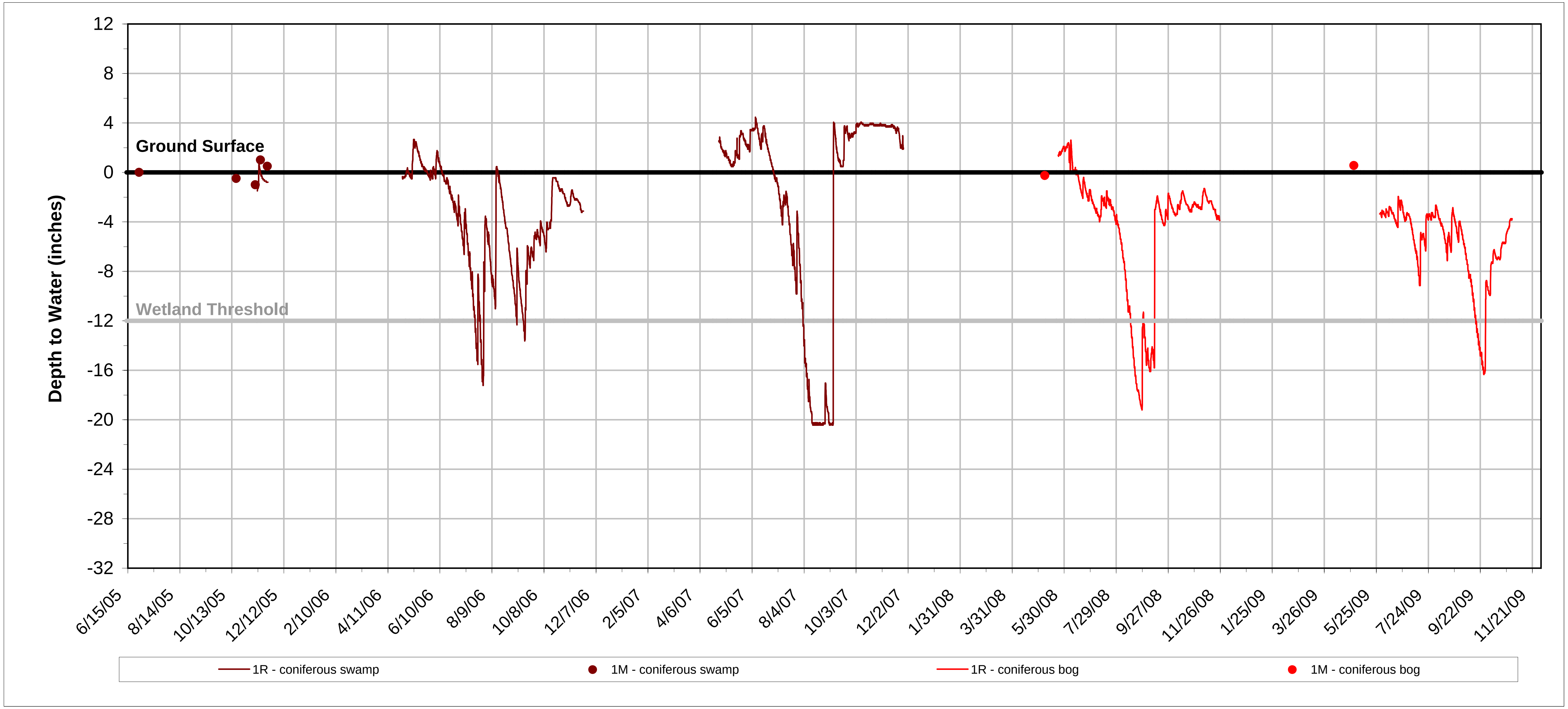


Figure 12
PRECIPITATION SUMMARY 2005-2009
PolyMet Mining
Hoyt Lakes, Minnesota

P:\Mpls\23 MN\69\2369862\WorkFiles\WO 008 Corps Wetlands Permit\WetlandHydroStudy\2009Data\2009 PolyMet Well Data\Water Elevation Summary_2009Fig 12 2005-2009Precip



R = Recording well and "M" = Manual well
Continuous lines without points
represent recording wells; lines
with points represent manual wells

Figure 13
2005-2009 WETLAND HYDROLOGY MONITORING DATA
Well 1
PolyMet Mining
Hoyt Lakes, Minnesota

Appendices

Appendix A

2006 Wetland Hydrology and Water Elevation Data

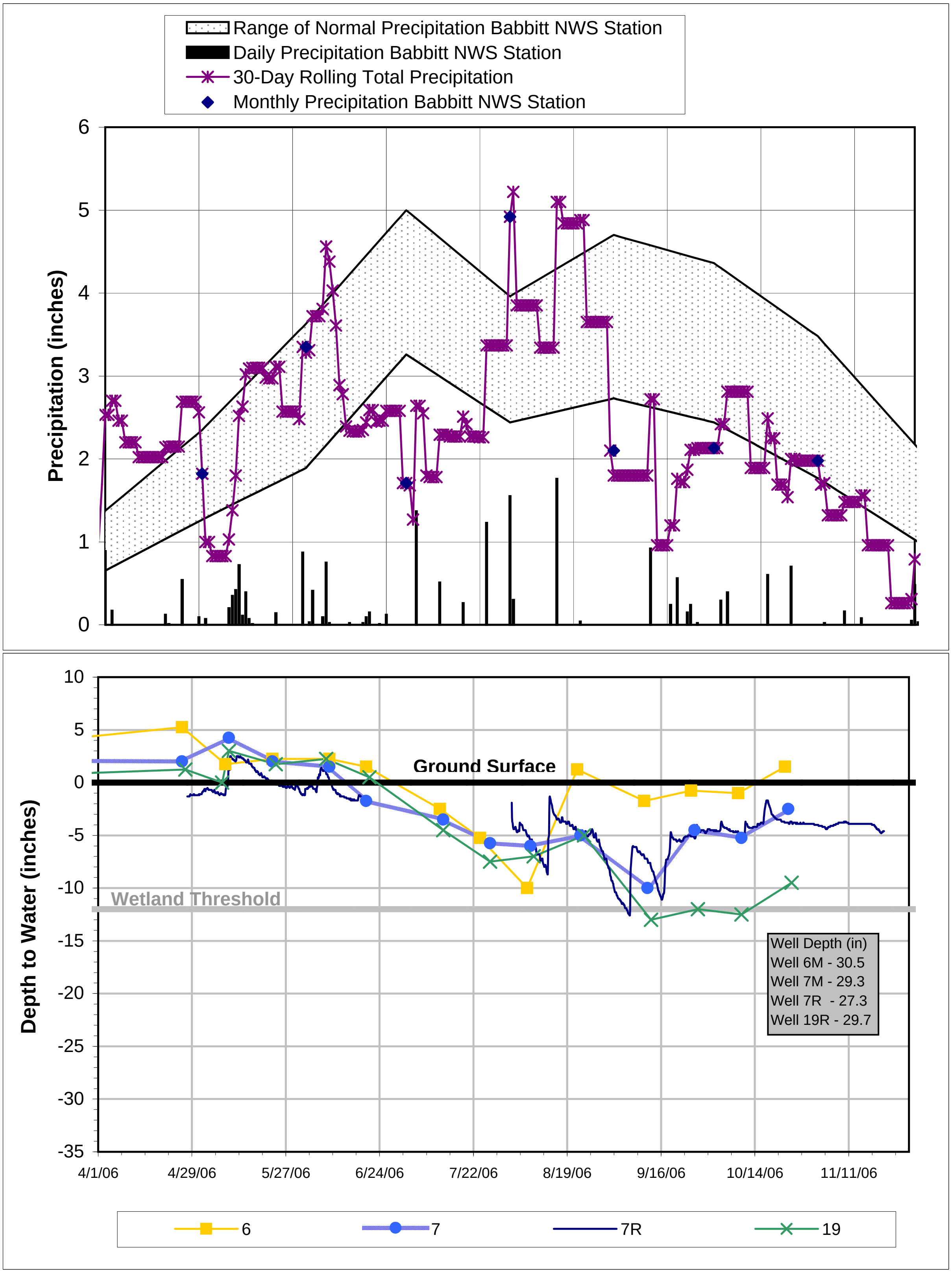


Figure 1
2006 HYDROLOGY MONITORING DATA
Southwest Mine and Stockpile Area
PolyMet Mining
Hoyt Lakes, Minnesota

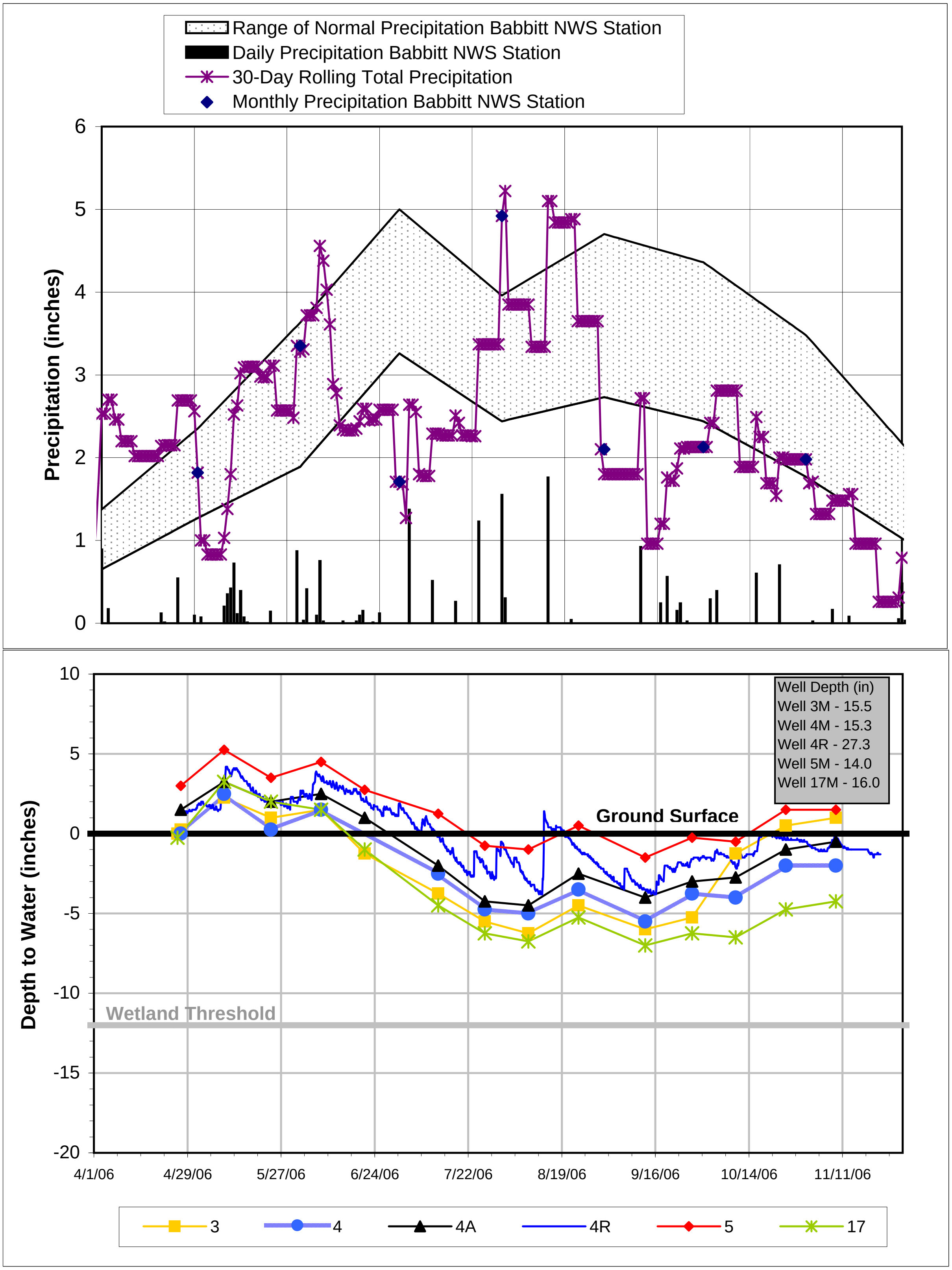


Figure 2
2006 HYDROLOGY MONITORING DATA
Northwest Mine and Stockpile Area
PolyMet Mining
Hoyt Lakes, Minnesota

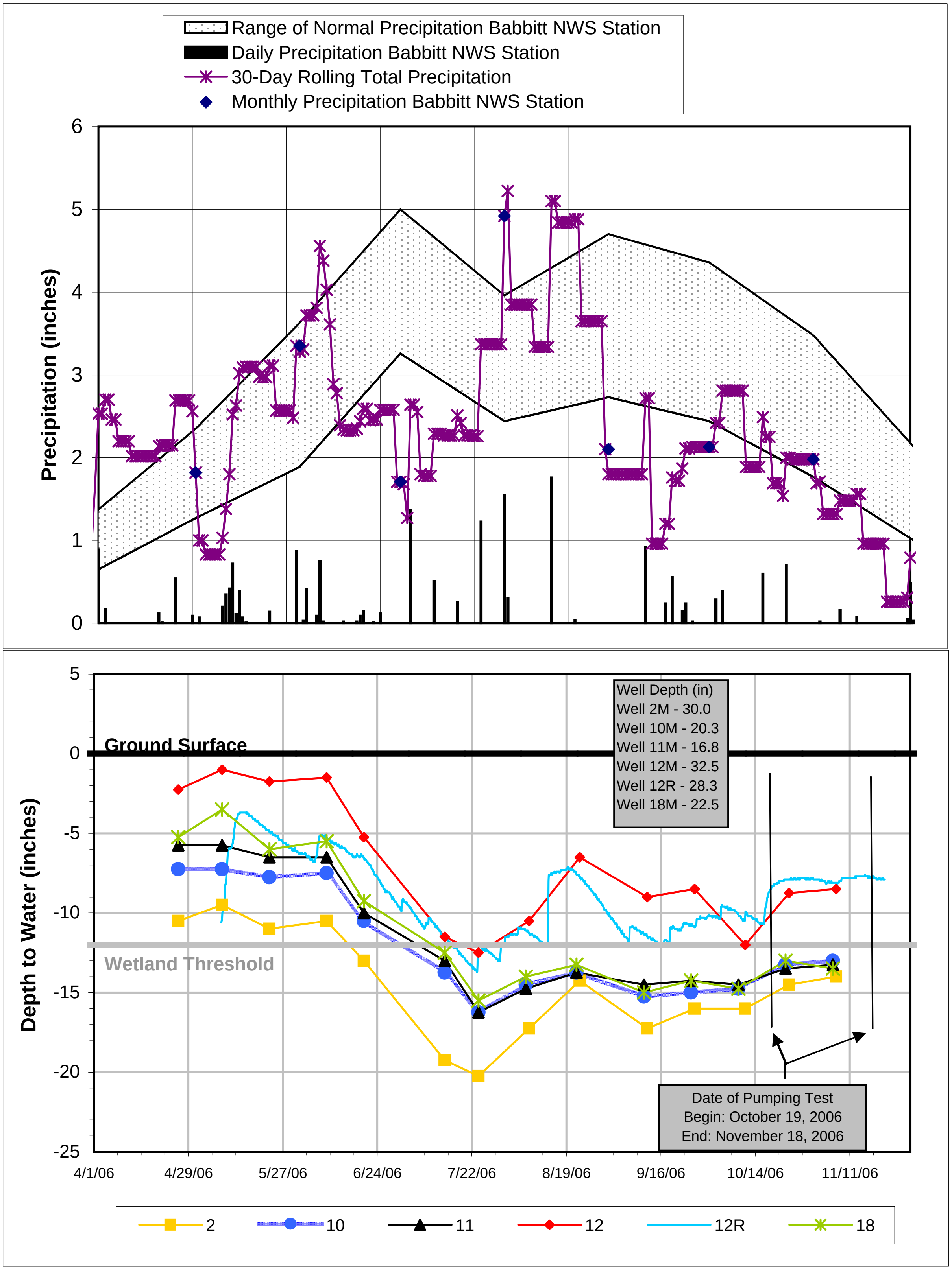


Figure 3
2006 HYDROLOGY MONITORING DATA
North-Central Mine and Stockpile Area
PolyMet Mining
Hoyt Lakes, Minnesota

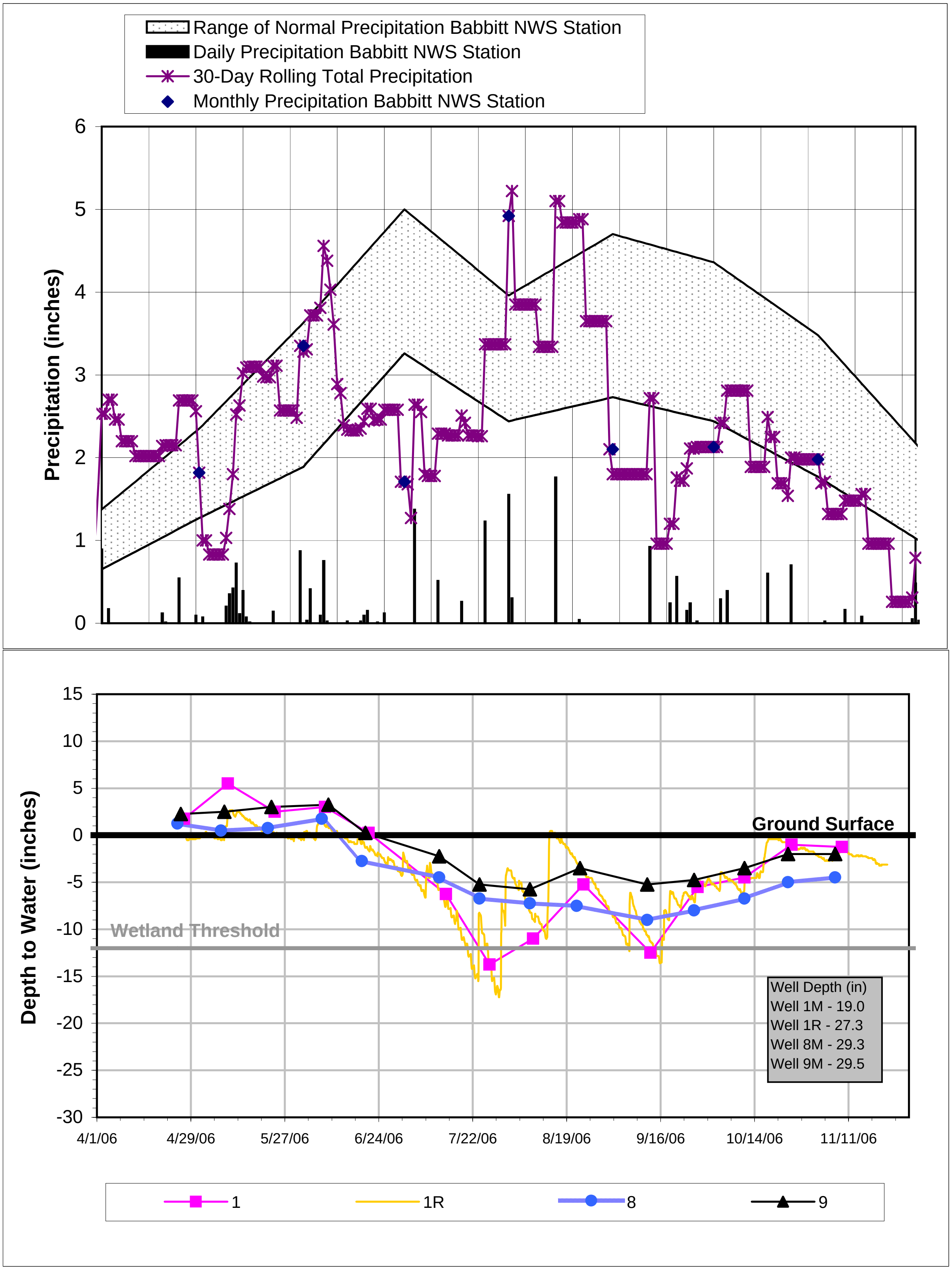


Figure 4
2006 HYDROLOGY MONITORING DATA
South-Central Mine and Stockpile Area
PolyMet Mining
Hoyt Lakes, Minnesota

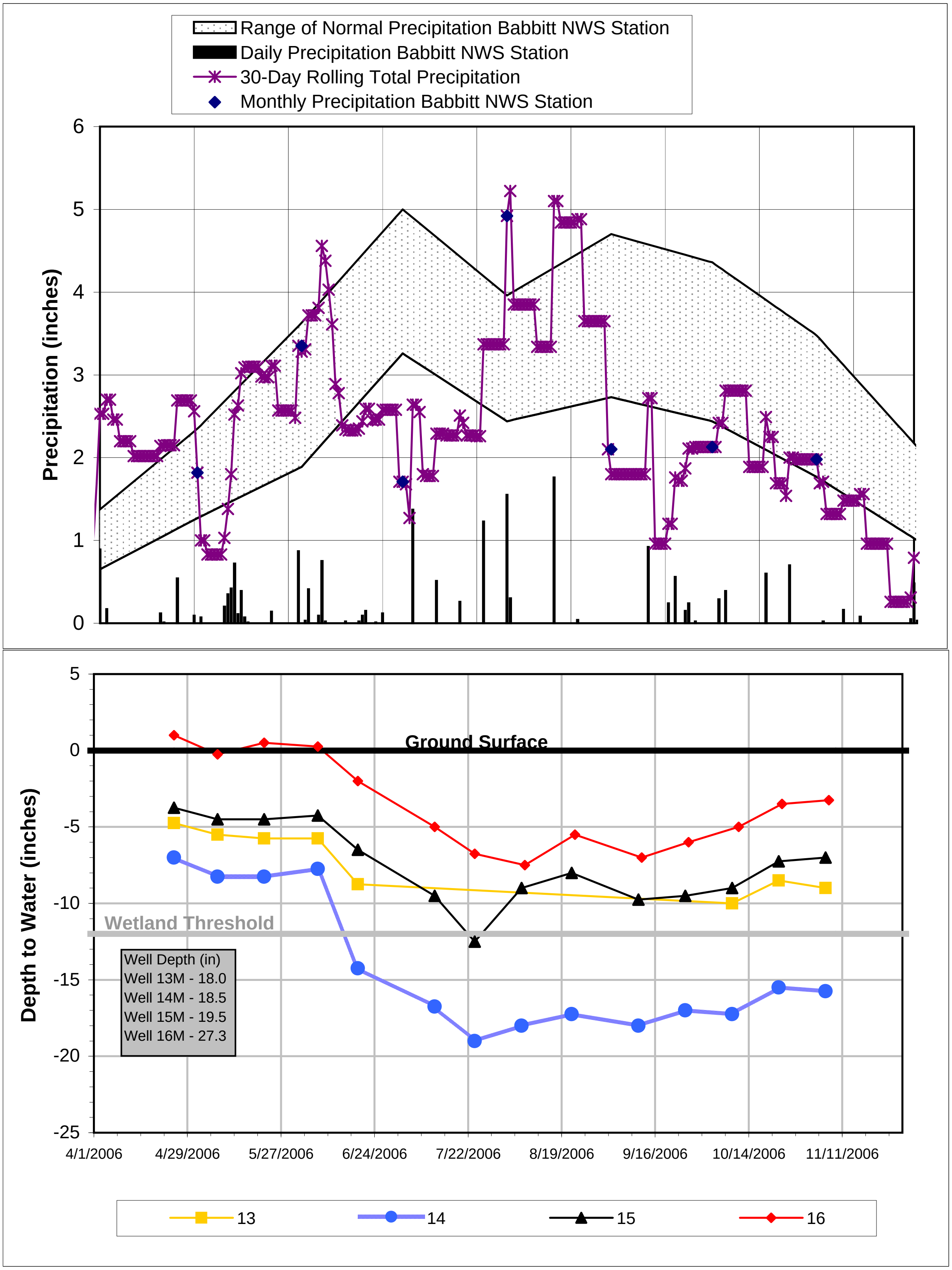


Figure 5
2006 HYDROLOGY MONITORING DATA
Northeast Stockpile Area
PolyMet Mining
Hoyt Lakes, Minnesota

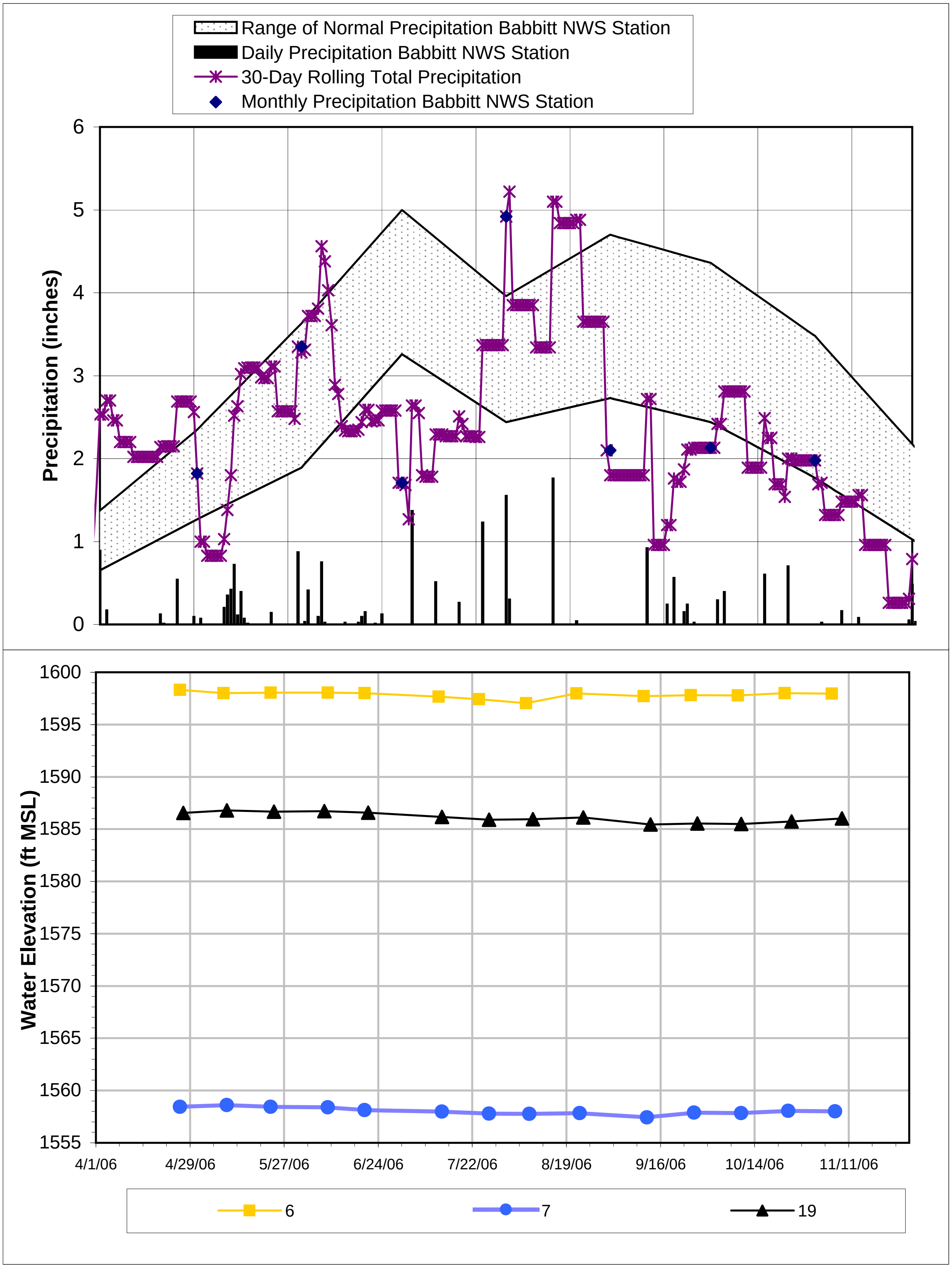


Figure 6
2006 HYDROLOGY MONITORING DATA
Southwest Mine and Stockpile Area
PolyMet Mining
Hoyt Lakes, Minnesota

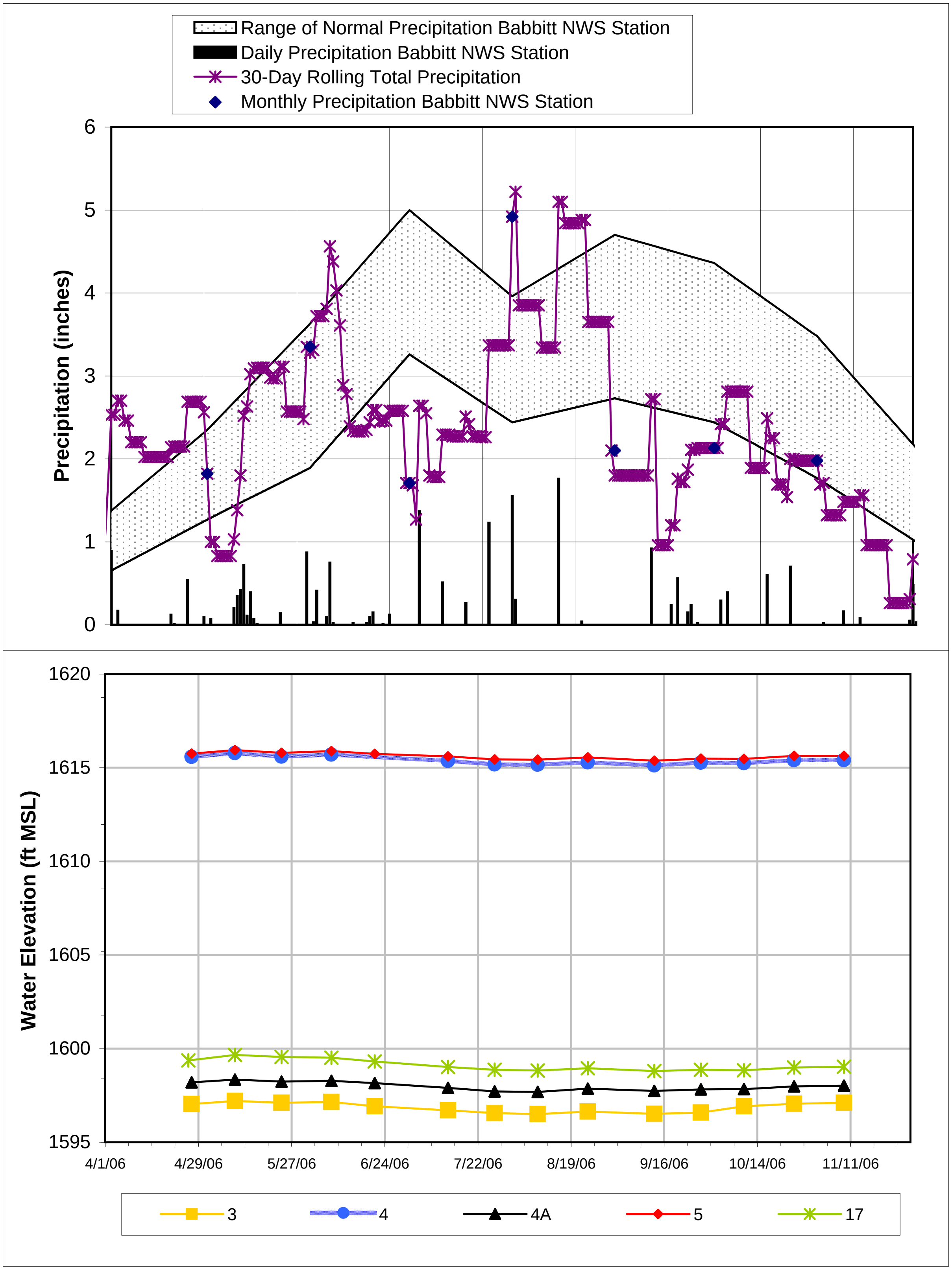


Figure 7
2006 HYDROLOGY MONITORING DATA
Northwest Mine and Stockpile Area
PolyMet Mining
Hoyt Lakes, Minnesota

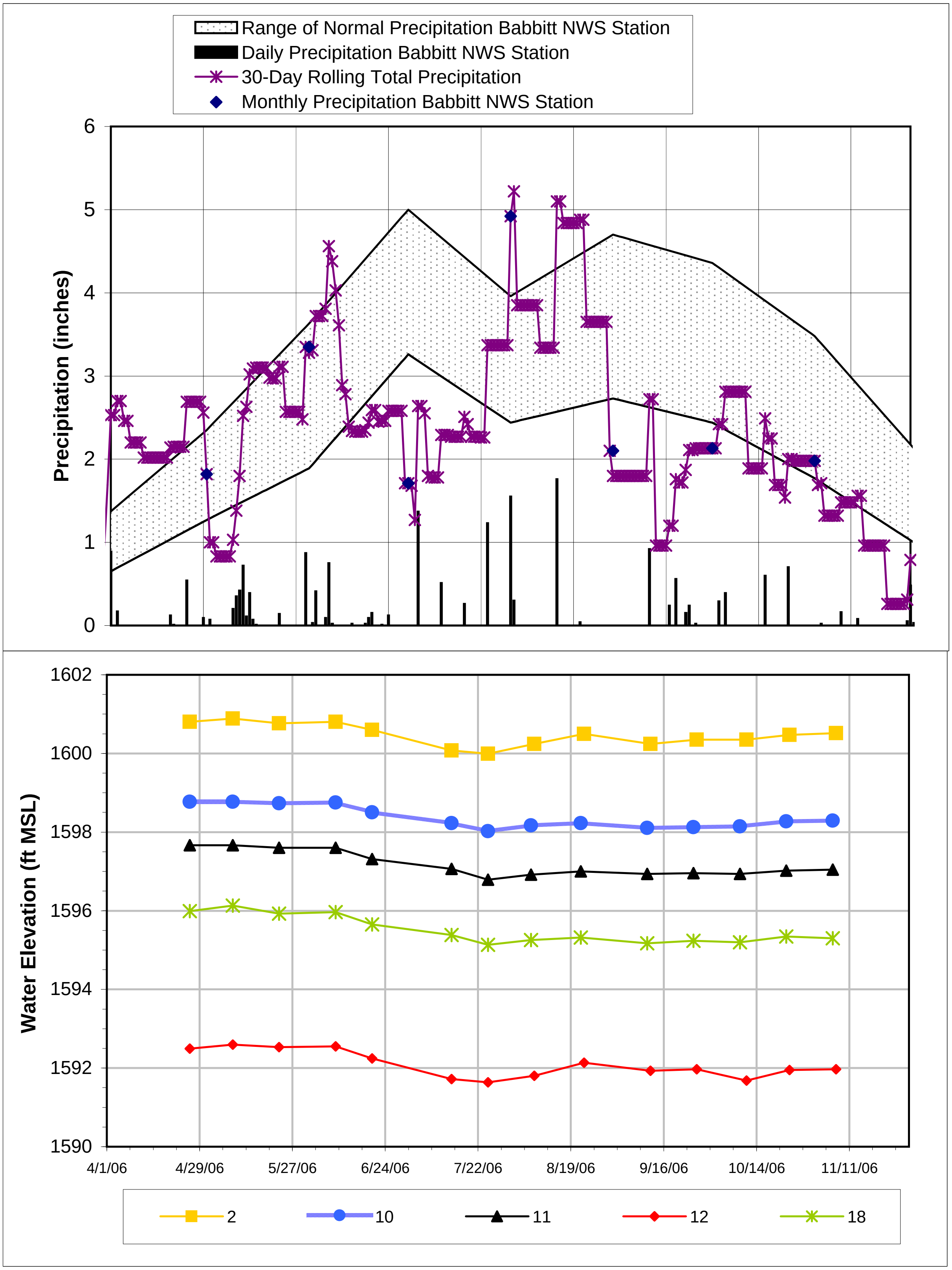
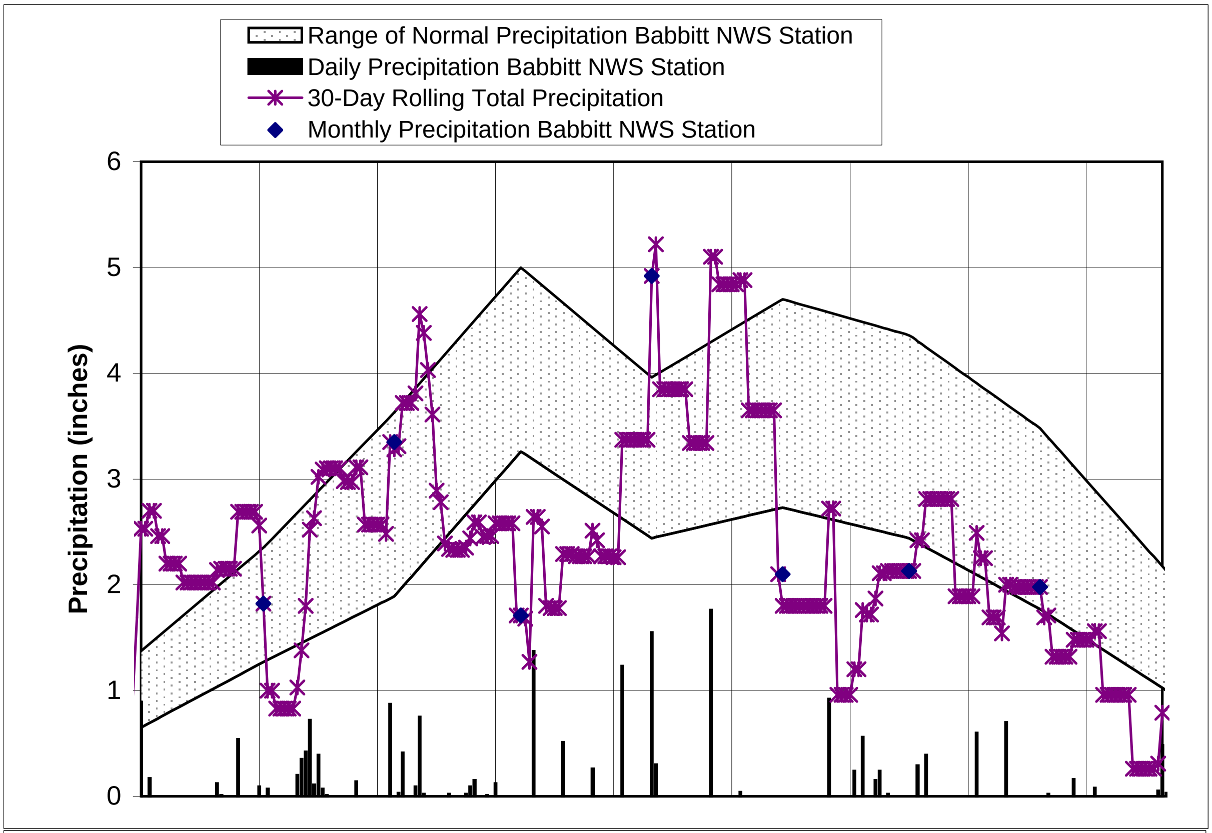


Figure 8
2006 HYDROLOGY MONITORING DATA
North-Central Mine and Stockpile Area
PolyMet Mining
Hoyt Lakes, Minnesota



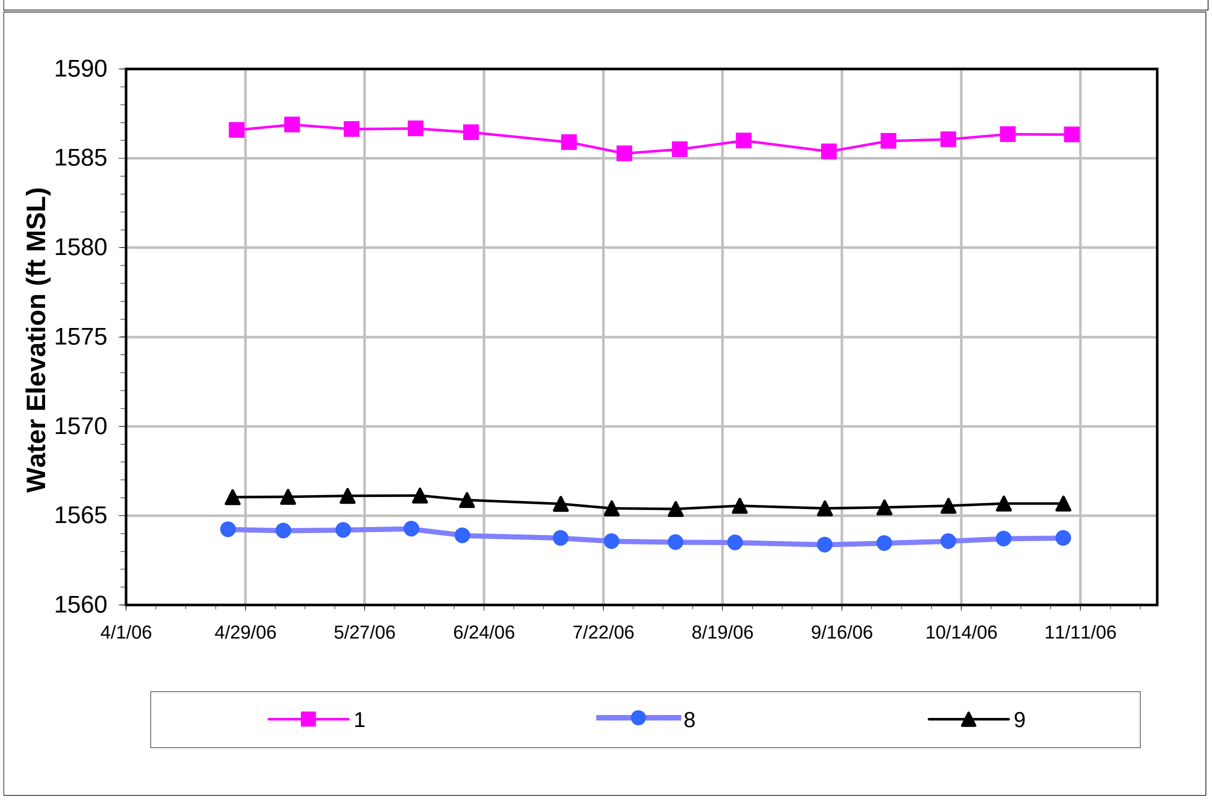


Figure 9
2006 HYDROLOGY MONITORING DATA
South-Central Mine and Stockpile Area
PolyMet Mining
Hoyt Lakes, Minnesota

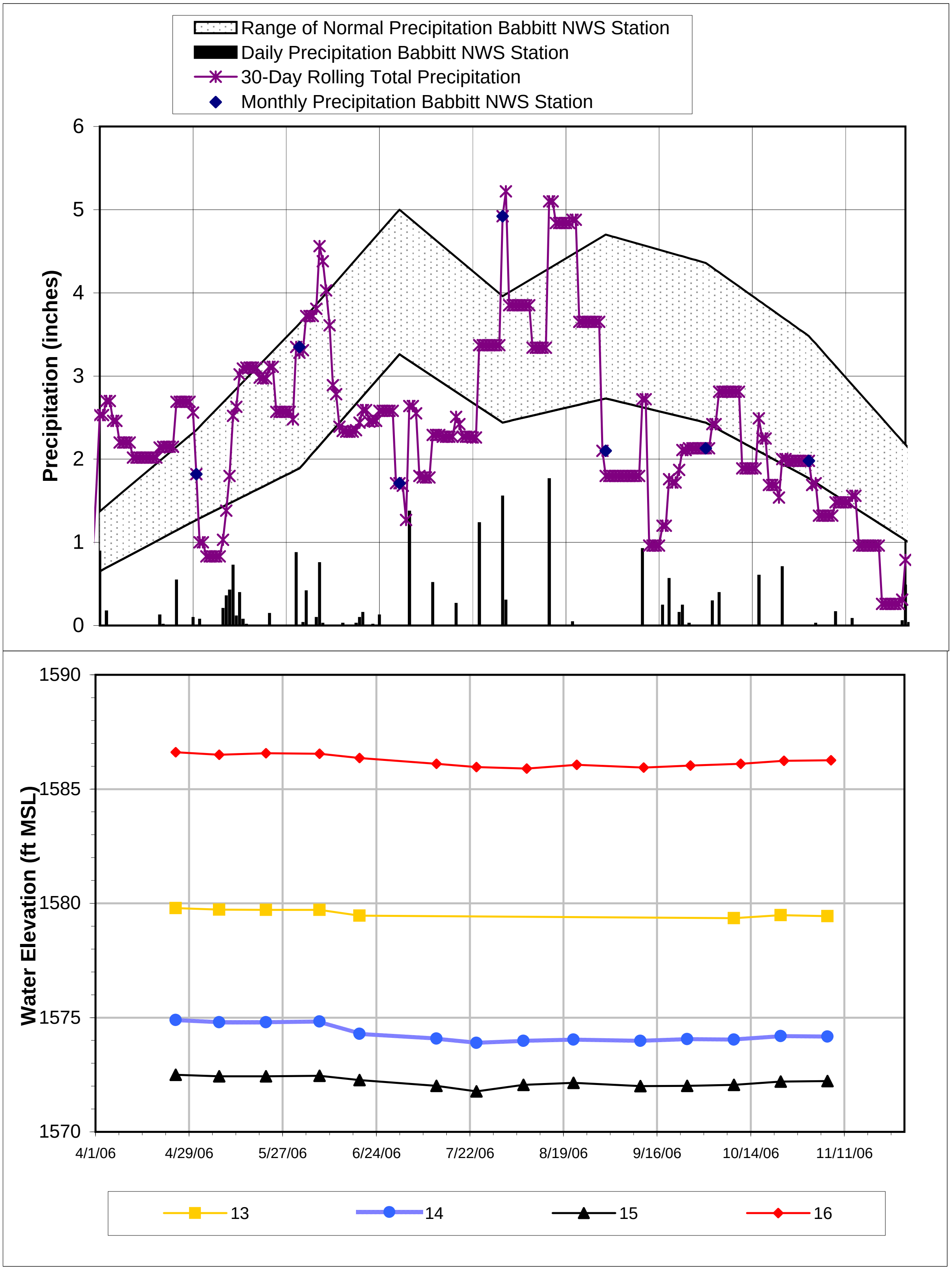
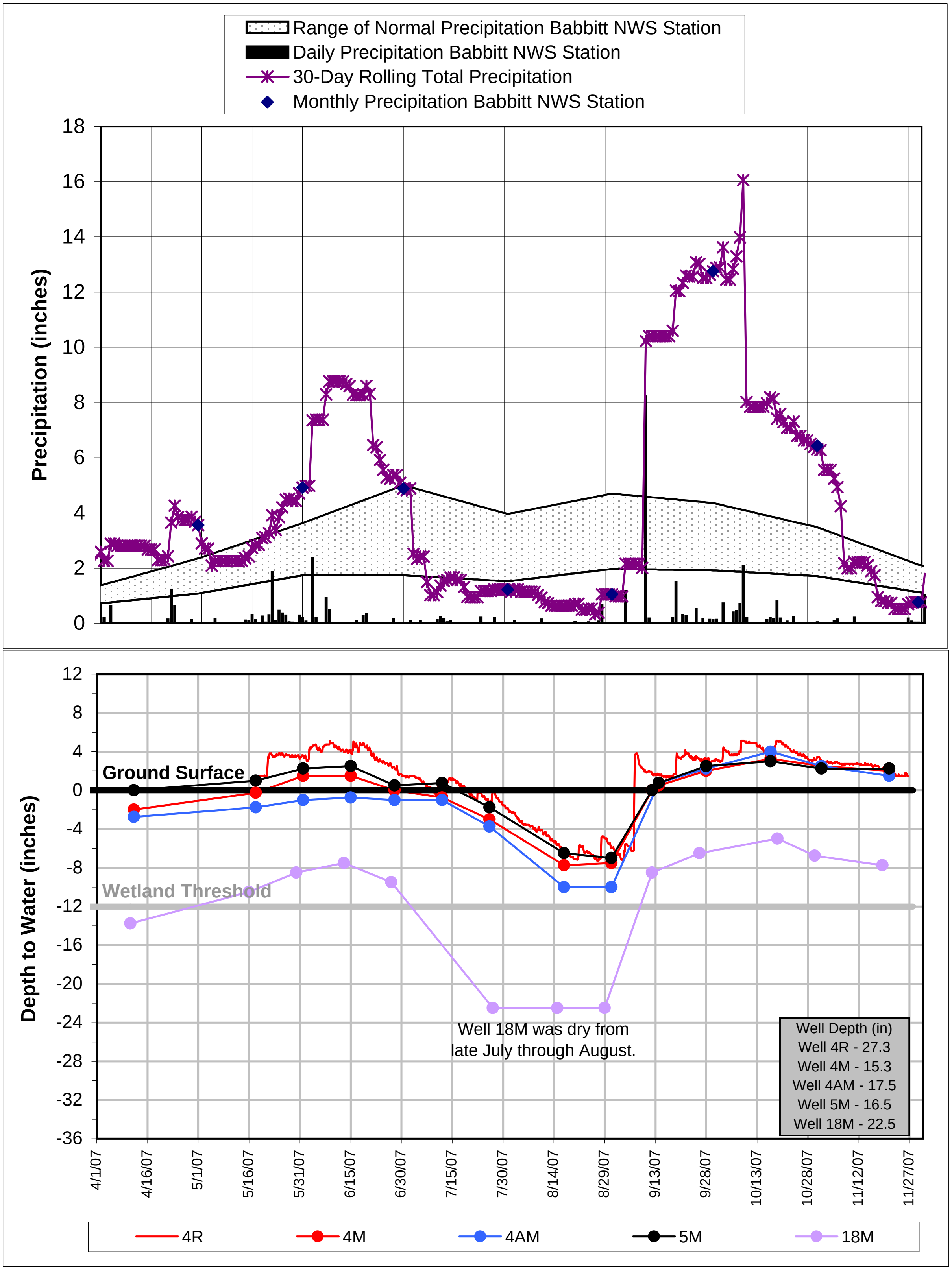


Figure 10
2006 HYDROLOGY MONITORING DATA
Northeast Stockpile Area
PolyMet Mining
Hoyt Lakes, Minnesota

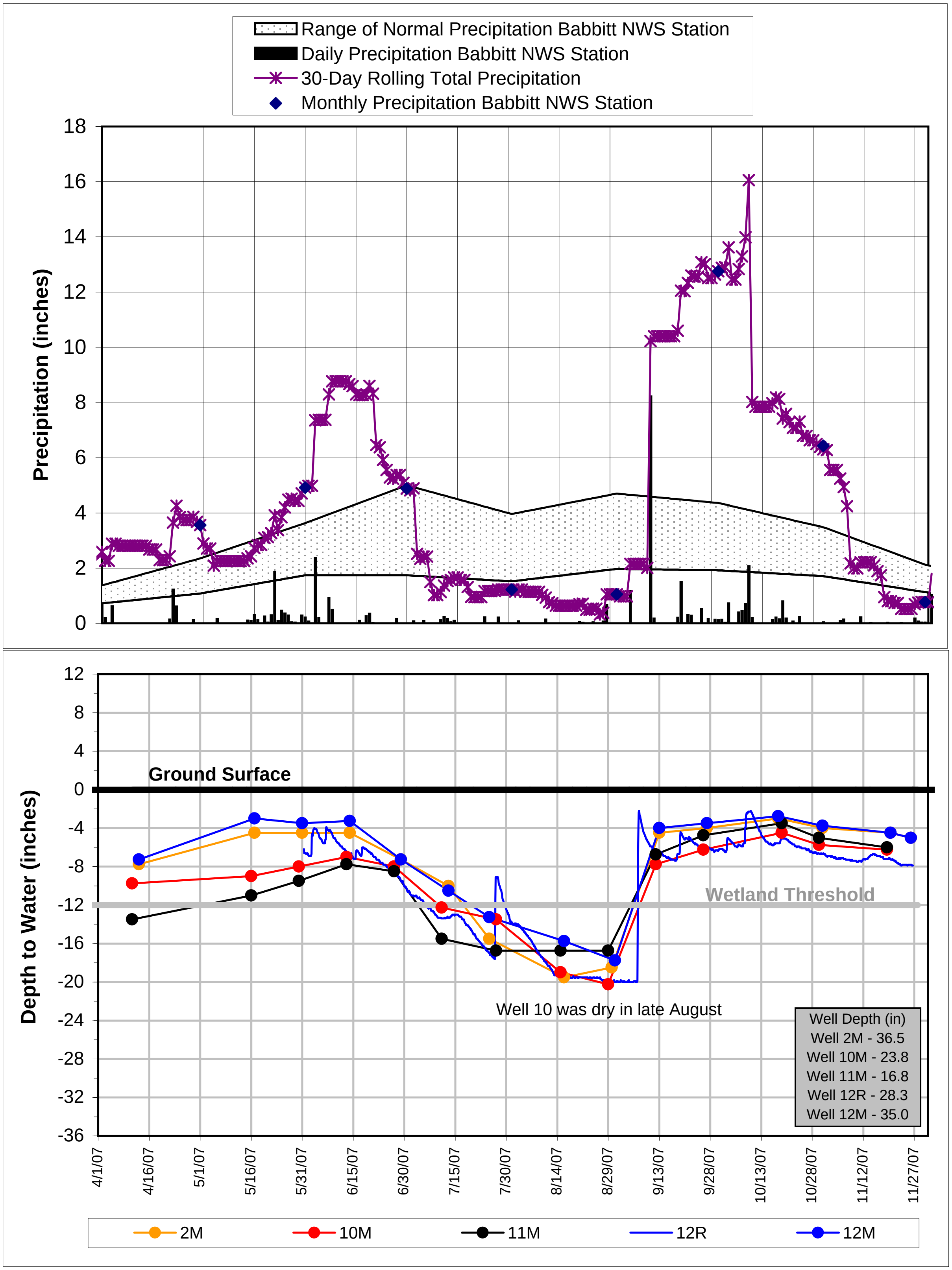
Appendix B

2007 Wetland Hydrology and Water Elevation Data



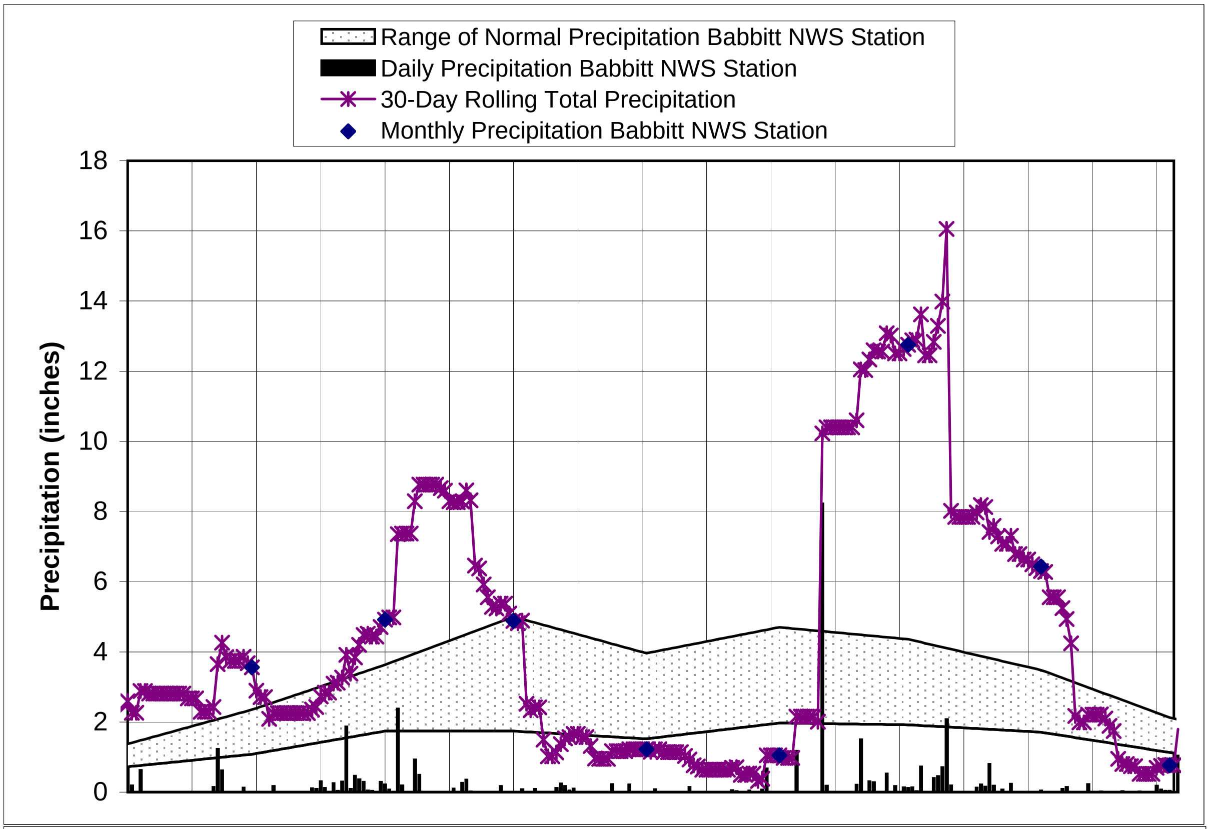
"R" = Recording well and "M" = Manual well

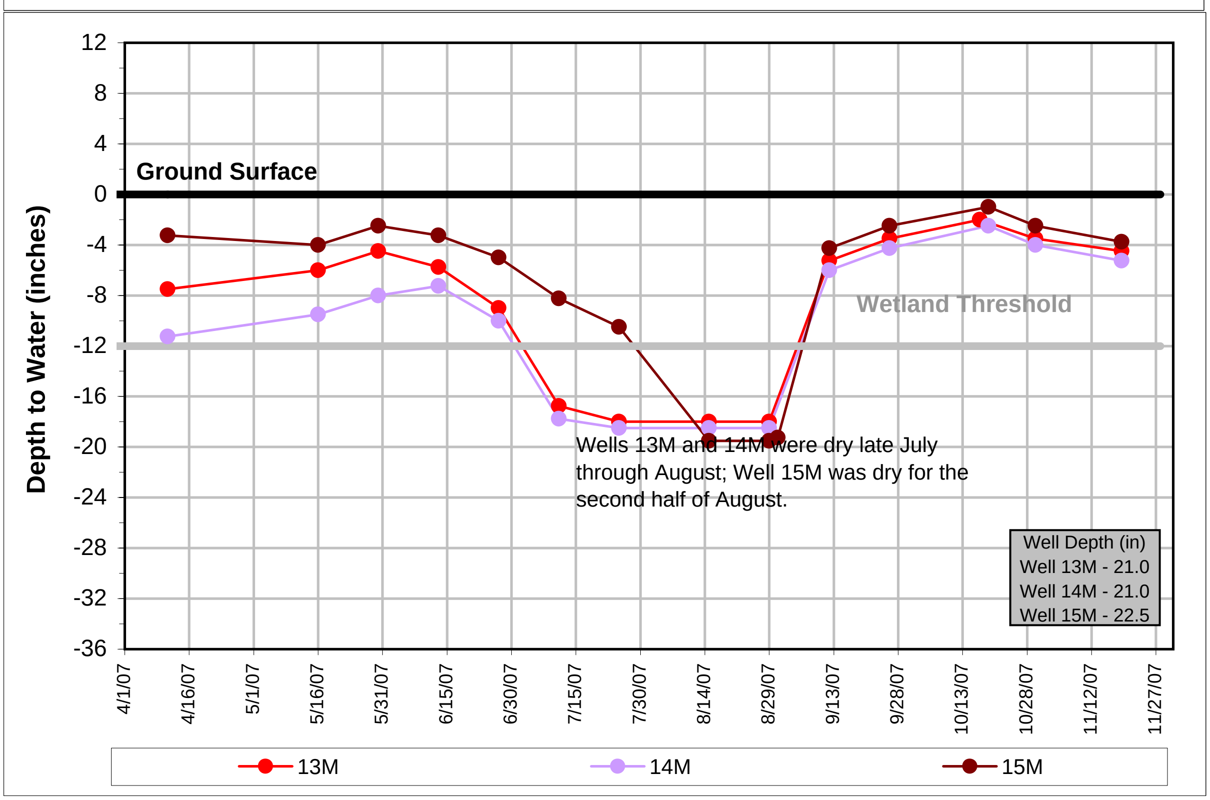
Figure 1
2007 WETLAND HYDROLOGY MONITORING DATA
Northwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



"R" = Recording well and "M" = Manual well

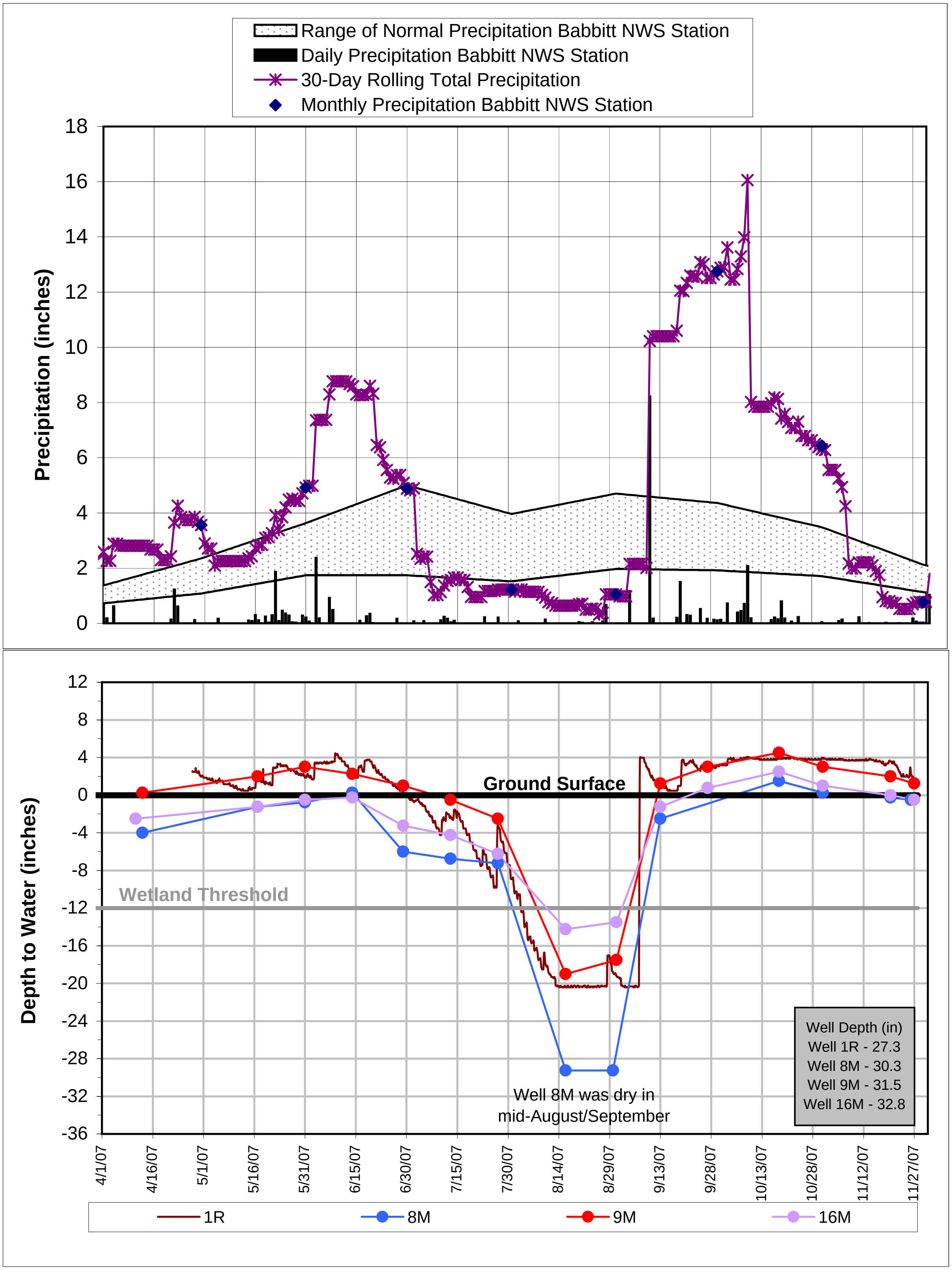
Figure 2
2007 WETLAND HYDROLOGY MONITORING DATA
North-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota





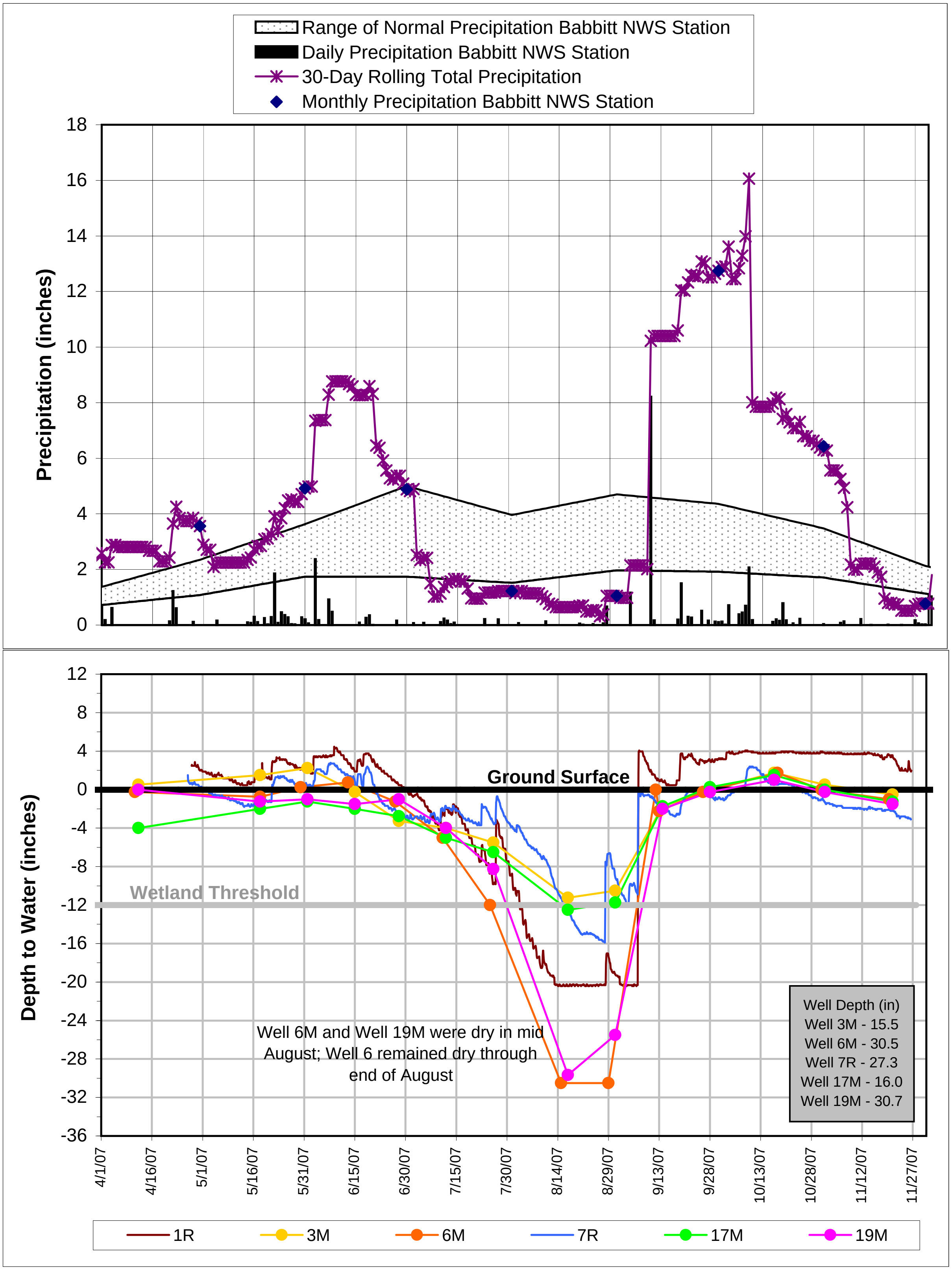
"R" = Recording well and "M" = Manual well

Figure 3
2007 WETLAND HYDROLOGY MONITORING DATA
Northeast Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



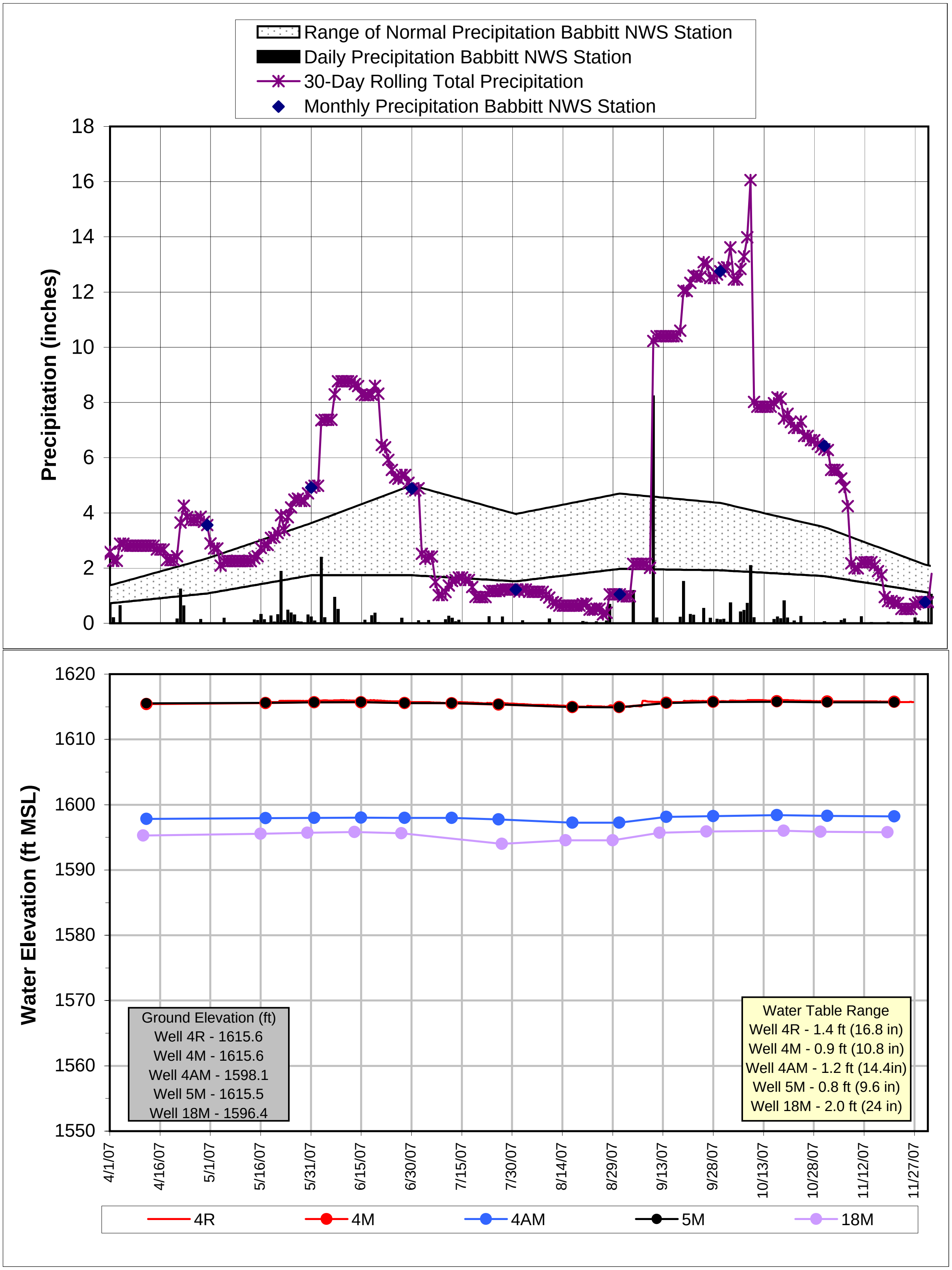
"R" = Recording well and "M" = Manual well

Figure 4
2007 WETLAND HYDROLOGY MONITORING DATA
South-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



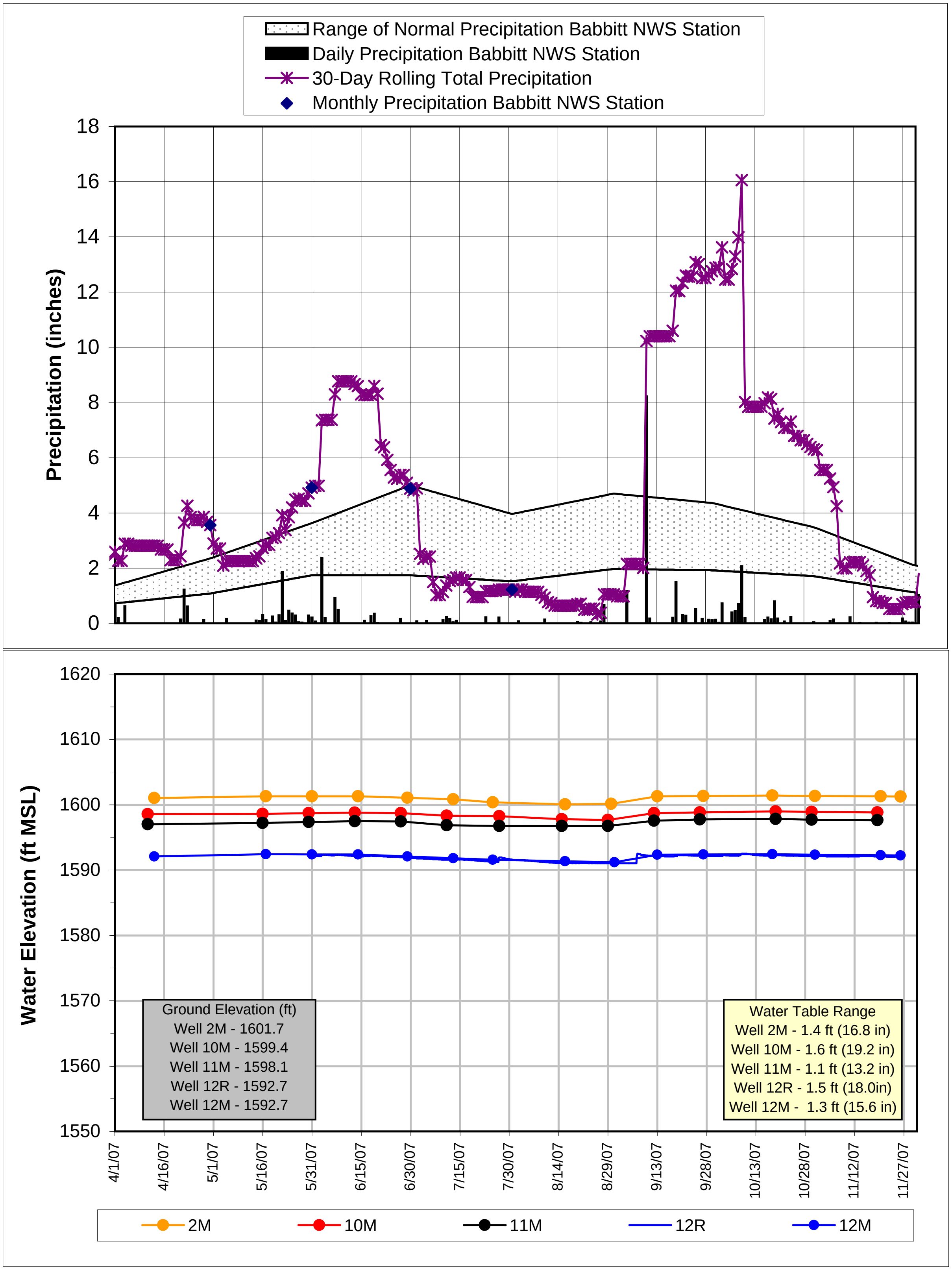
"R" = Recording well and "M" = Manual well

Figure 5
2007 WETLAND HYDROLOGY MONITORING DATA
Southwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



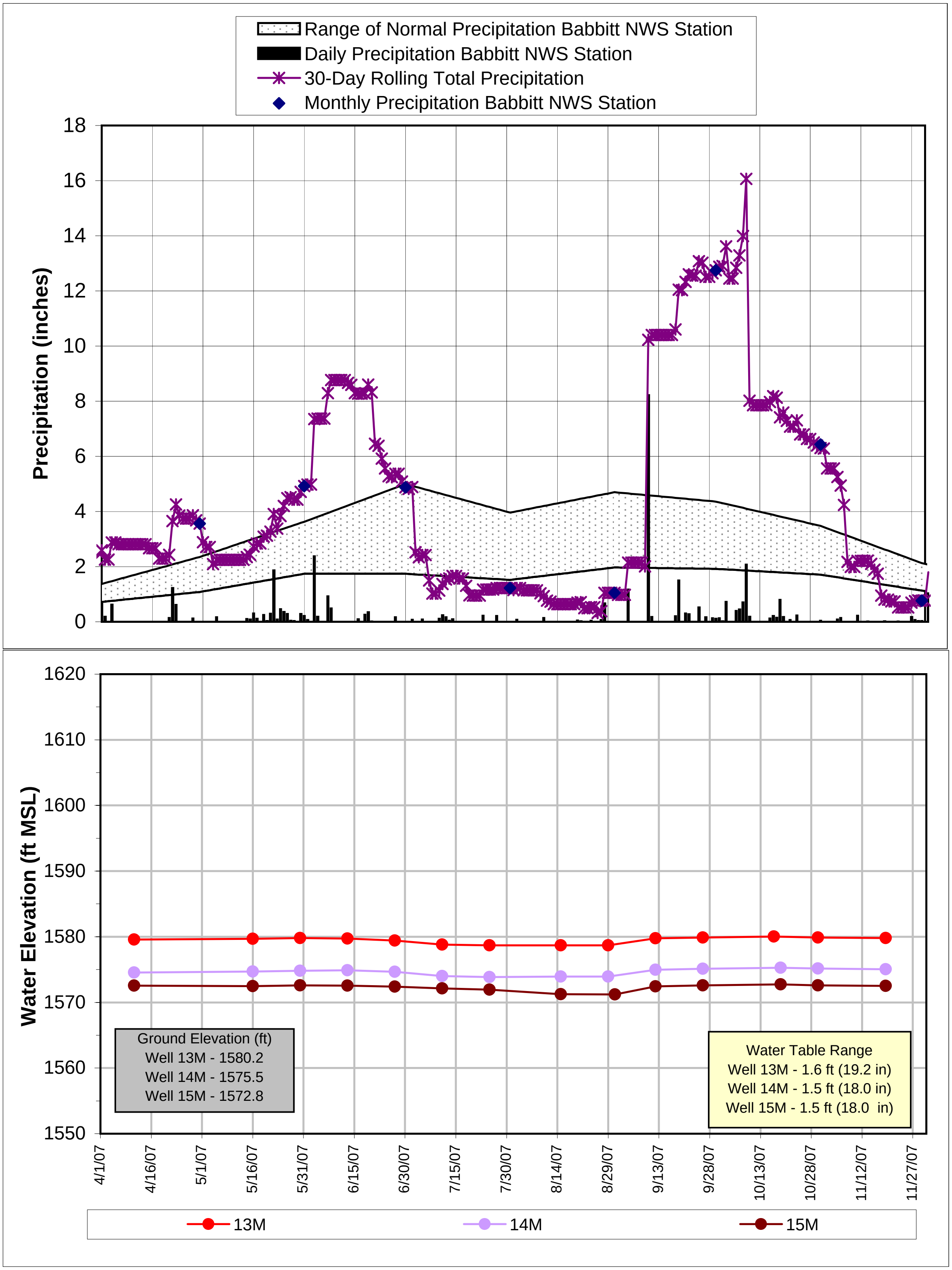
"R" = Recording well and "M" = Manual well

Figure 6
2007 WETLAND WATER ELEVATION DATA
Northwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



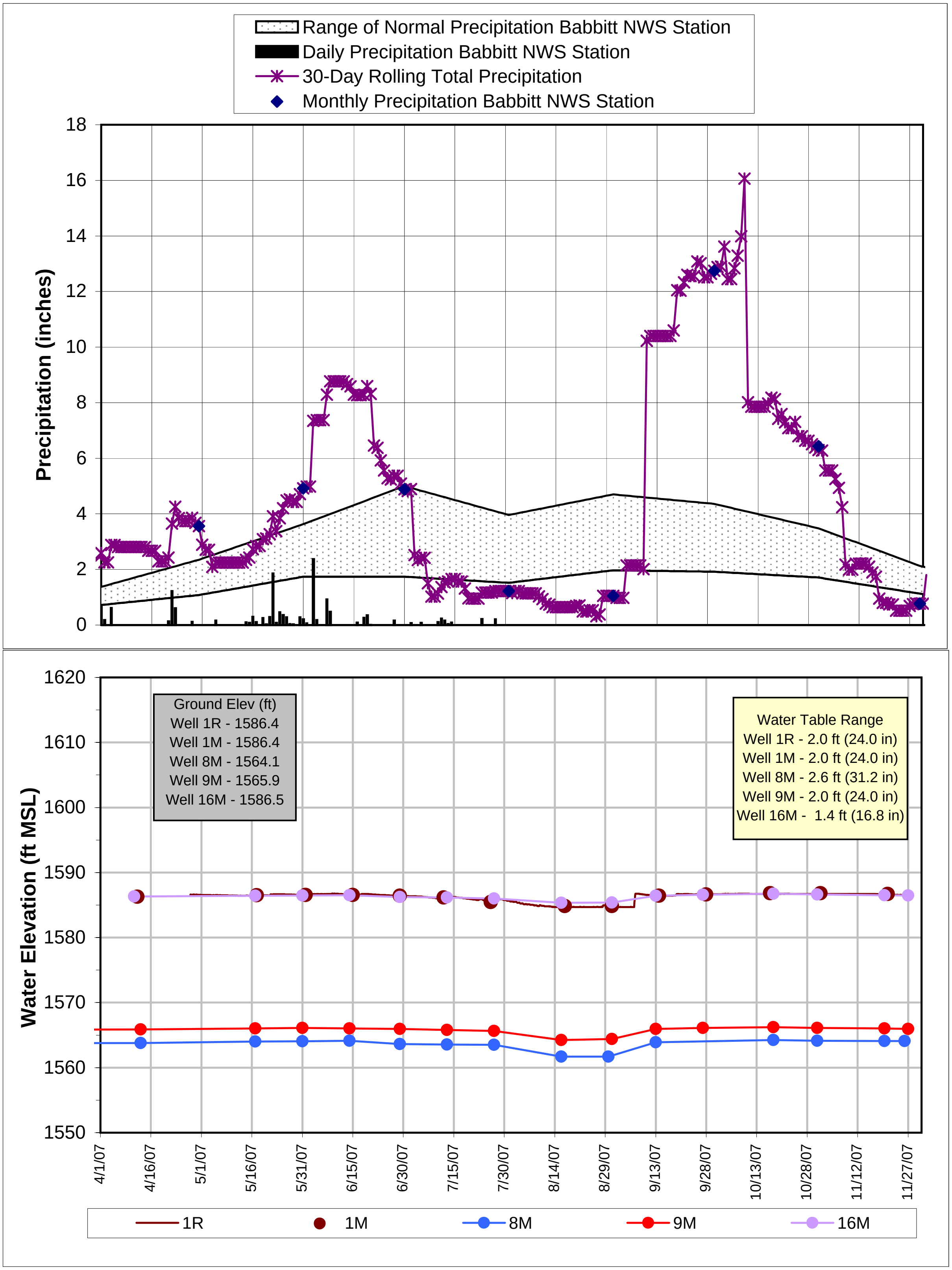
"R" = Recording well and "M" = Manual well

Figure 7
2007 WETLAND WATER ELEVATION DATA
North-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



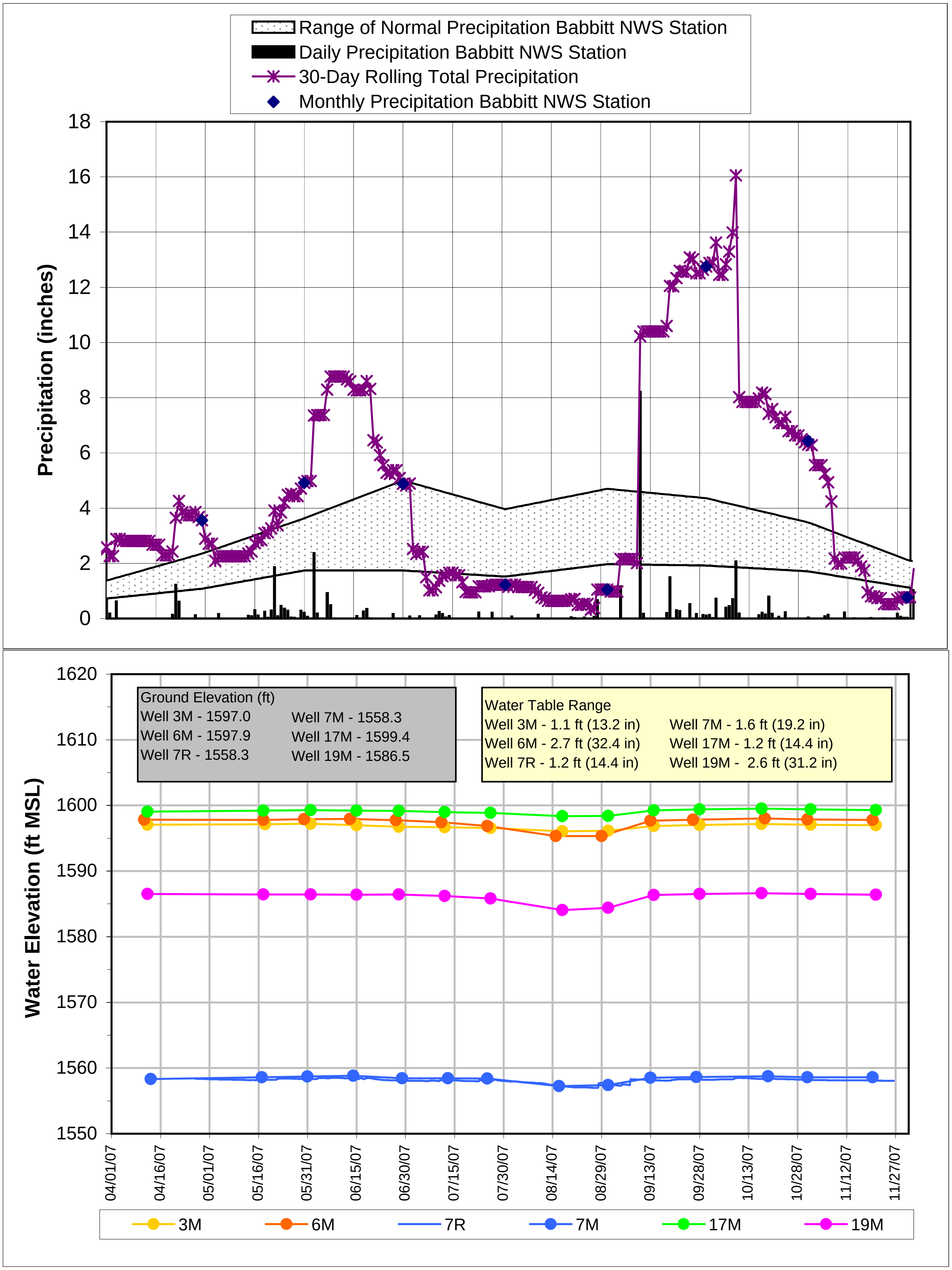
"R" = Recording well and "M" = Manual well

Figure 8
2007 WETLAND WATER ELEVATION DATA
Northeast Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



"R" = Recording well and "M" = Manual well

Figure 9
2007 WETLAND WATER ELEVATION DATA
South-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota

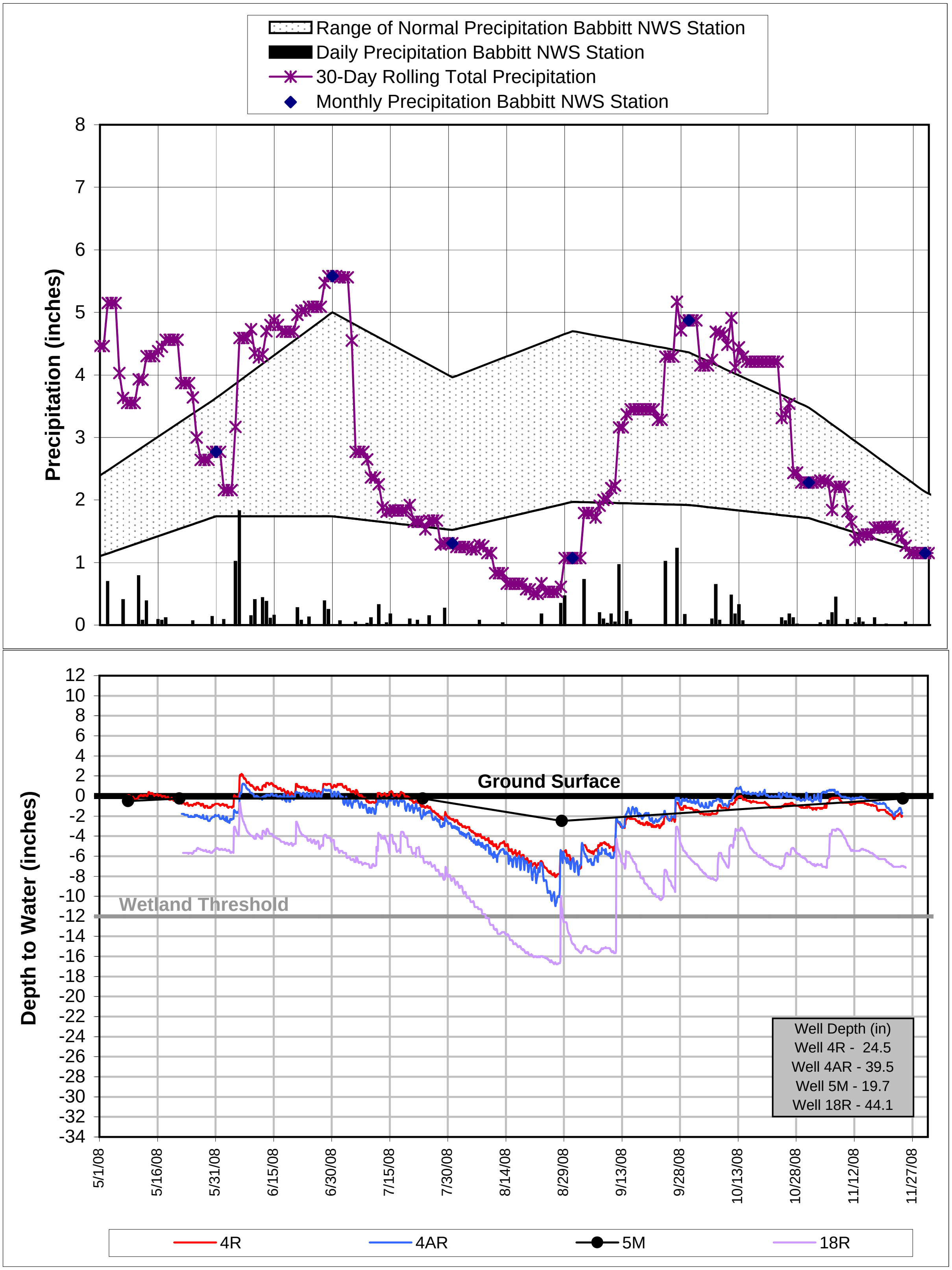


"R" = Recording well and "M" = Manual well

Figure 10
2007 WETLAND WATER ELEVATION DATA
Southwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota

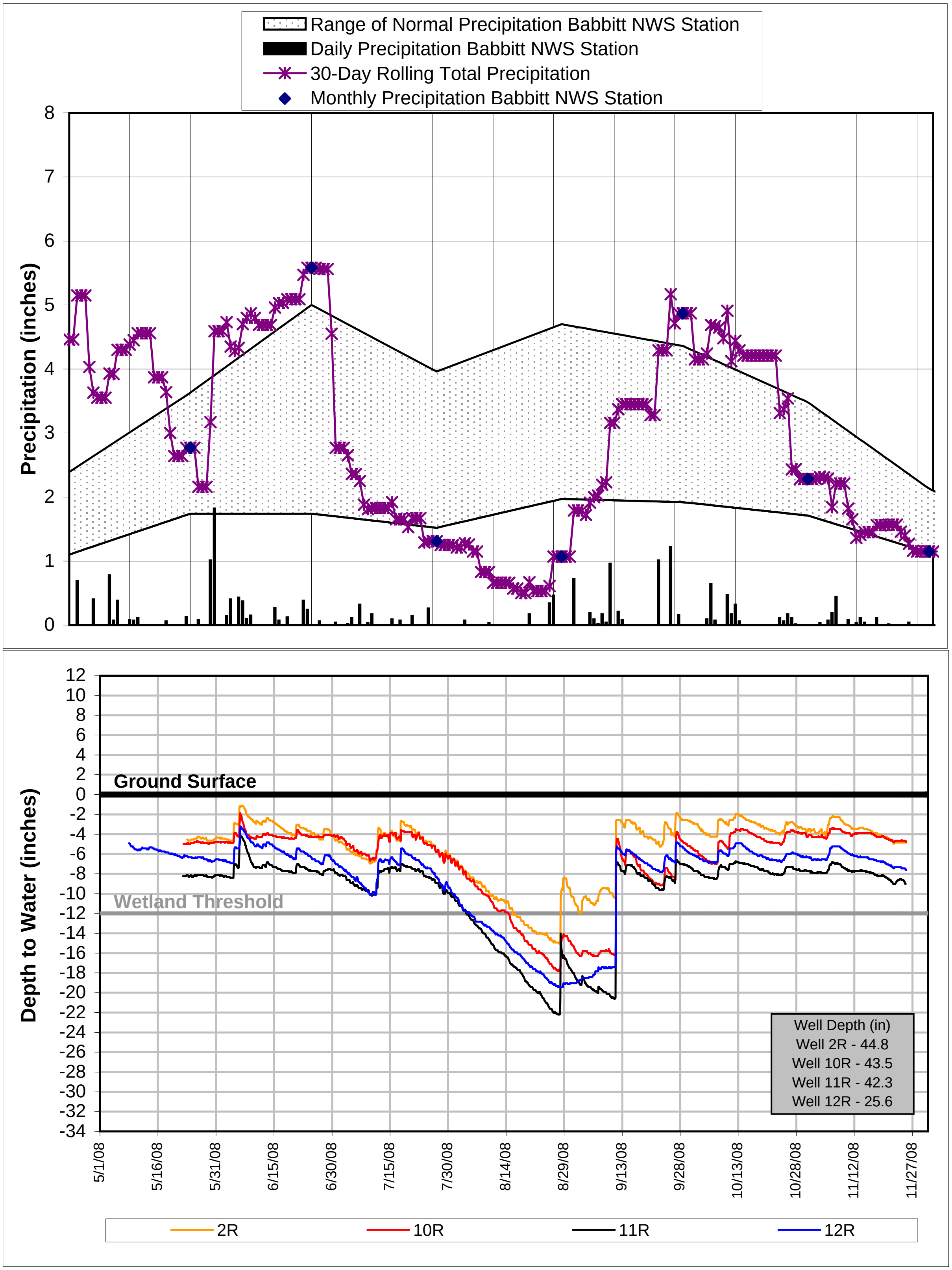
Appendix C

2008 Wetland Hydrology and Water Elevation Data



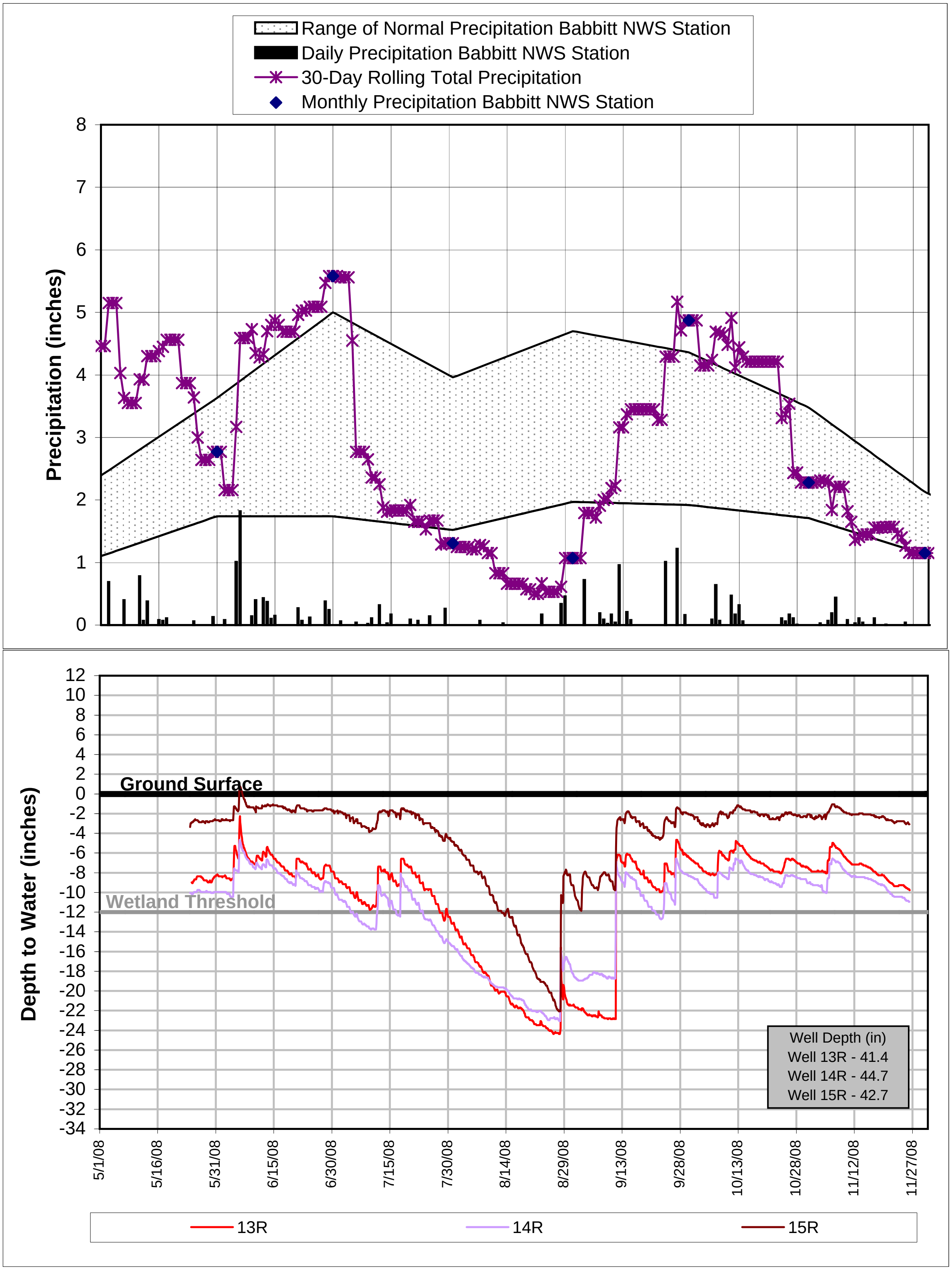
"R" = Recording well and "M" = Manual well

Figure 1
2008 WETLAND HYDROLOGY MONITORING DATA
Northwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



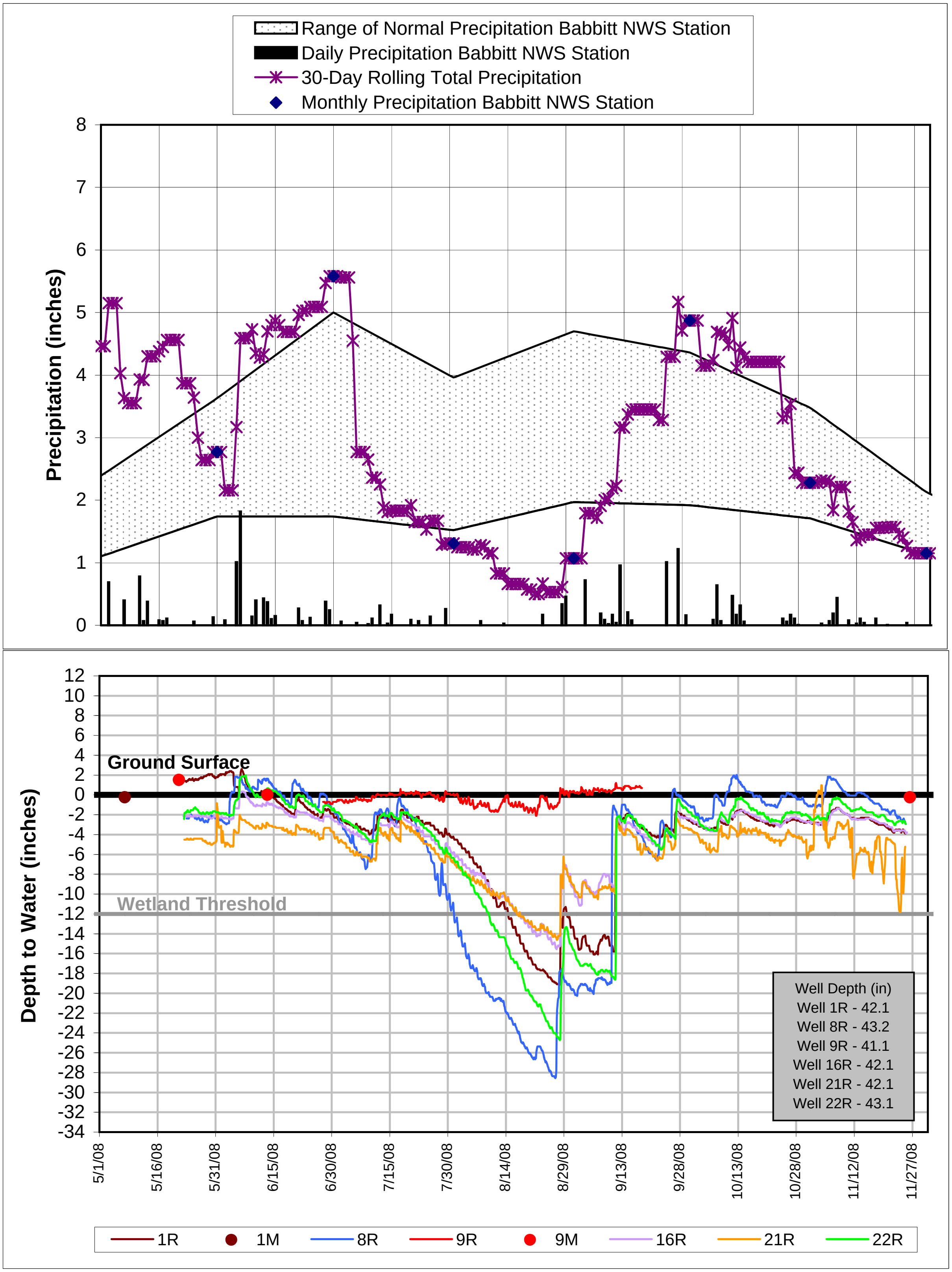
"R" = Recording well and "M" = Manual well

Figure 2
2008 WETLAND HYDROLOGY MONITORING DATA
North-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



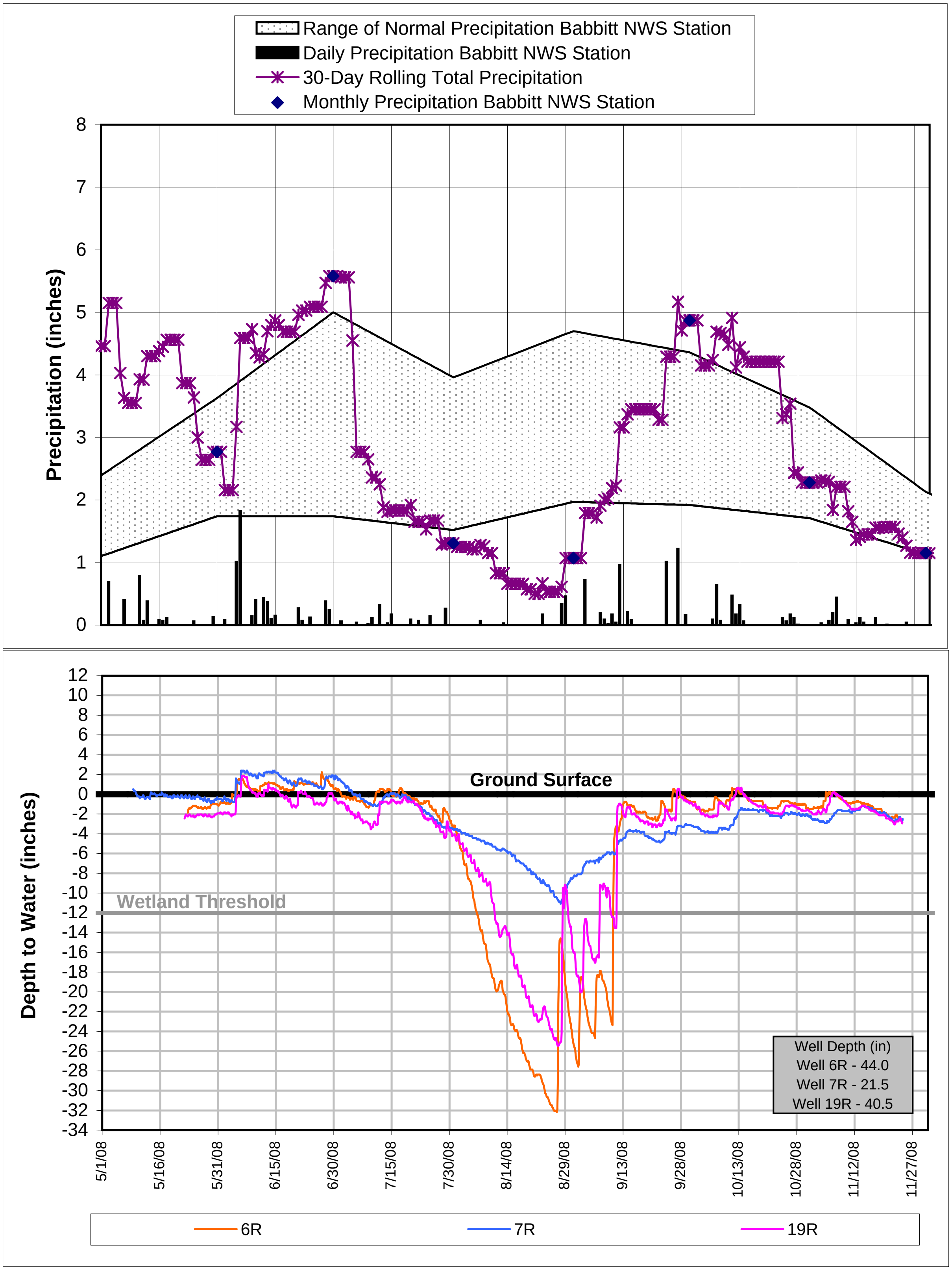
"R" = Recording well and "M" = Manual well

Figure 3
2008 WETLAND HYDROLOGY MONITORING DATA
Northeast Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



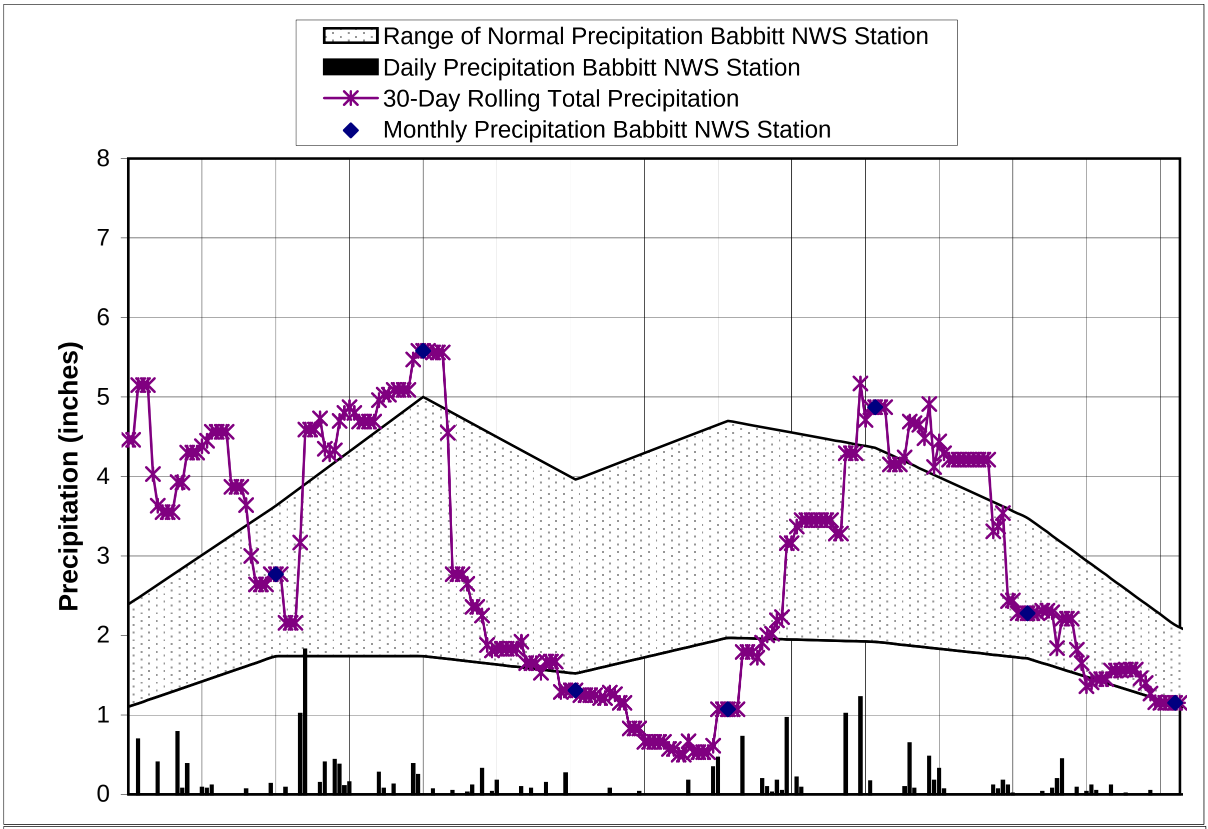
"R" = Recording well and "M" = Manual well

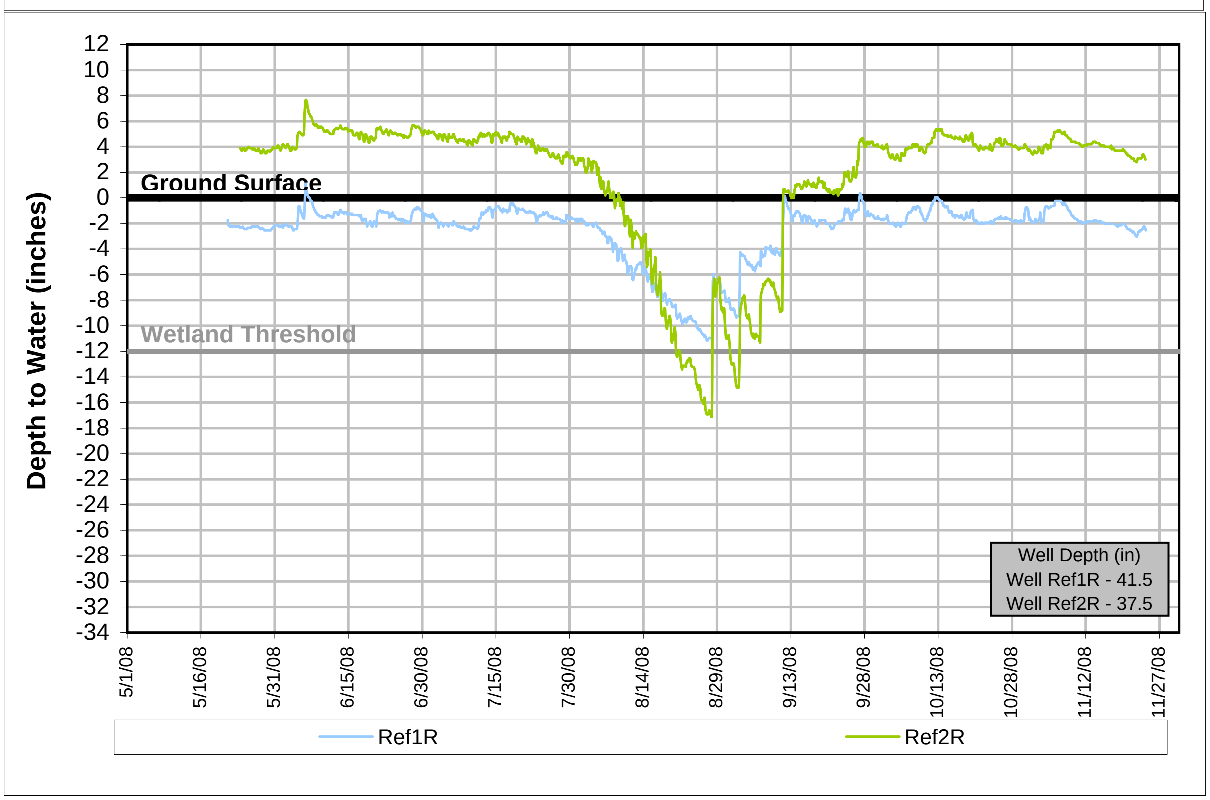
Figure 4
2008 WETLAND HYDROLOGY MONITORING DATA
South-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



"R" = Recording well and "M" = Manual well

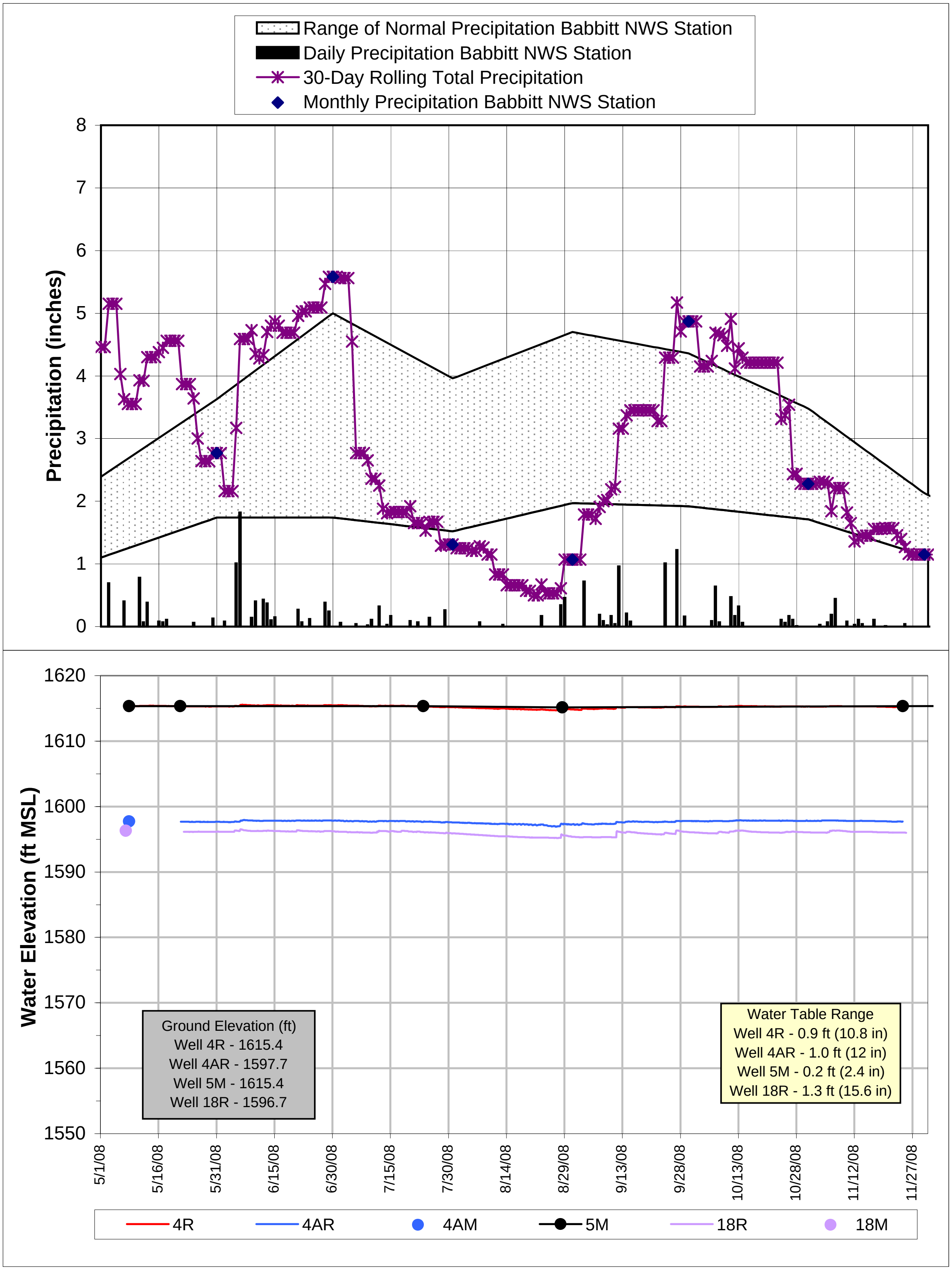
Figure 5
2008 WETLAND HYDROLOGY MONITORING DATA
Southwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota





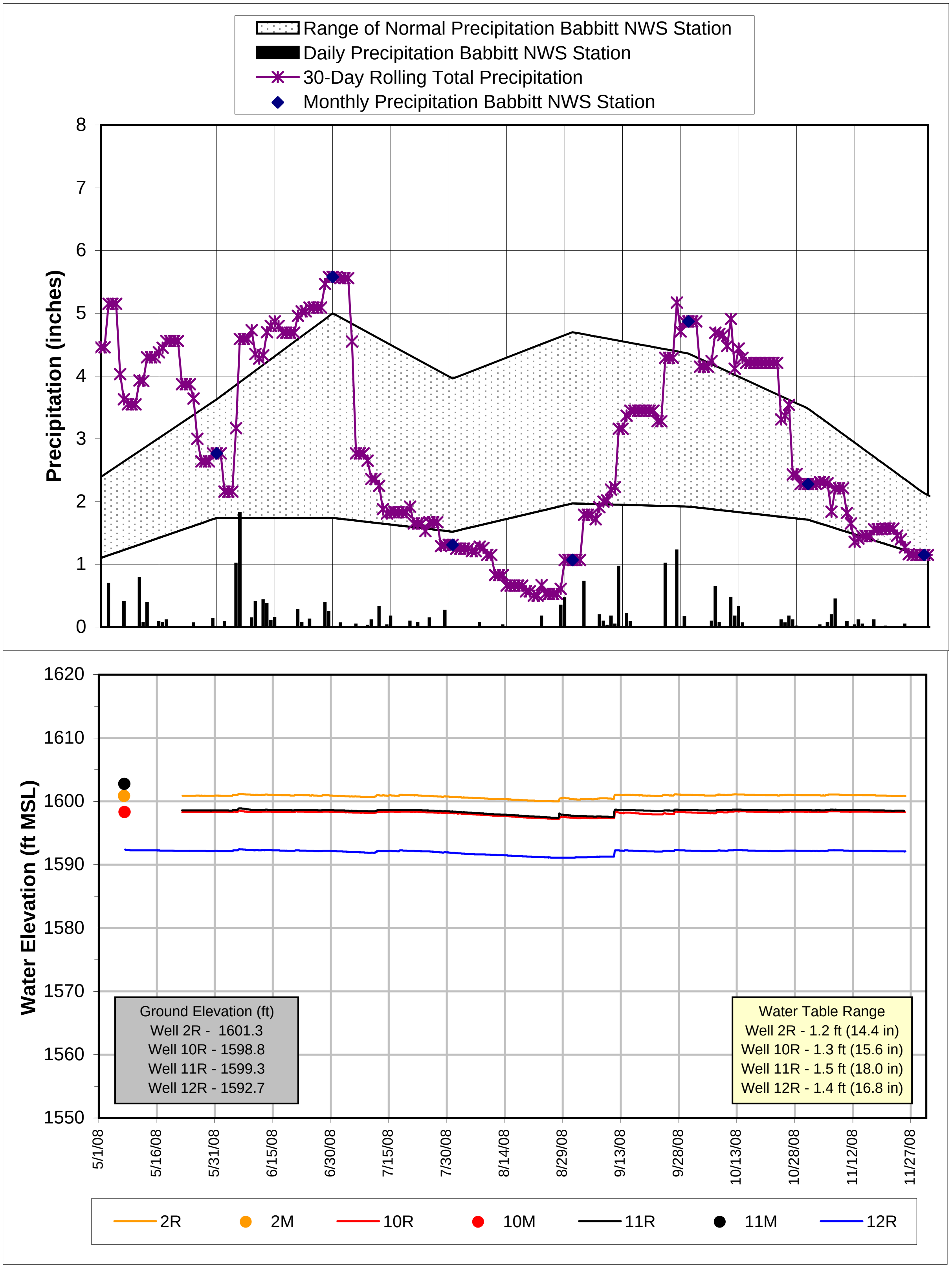
"R" = Recordingwell and "M" = Manual well

Figure 6
2008 WETLAND HYDROLOGY MONITORING DATA
Reference Wells - West of Mine Site
PolyMet Mining
Hoyt Lakes, Minnesota



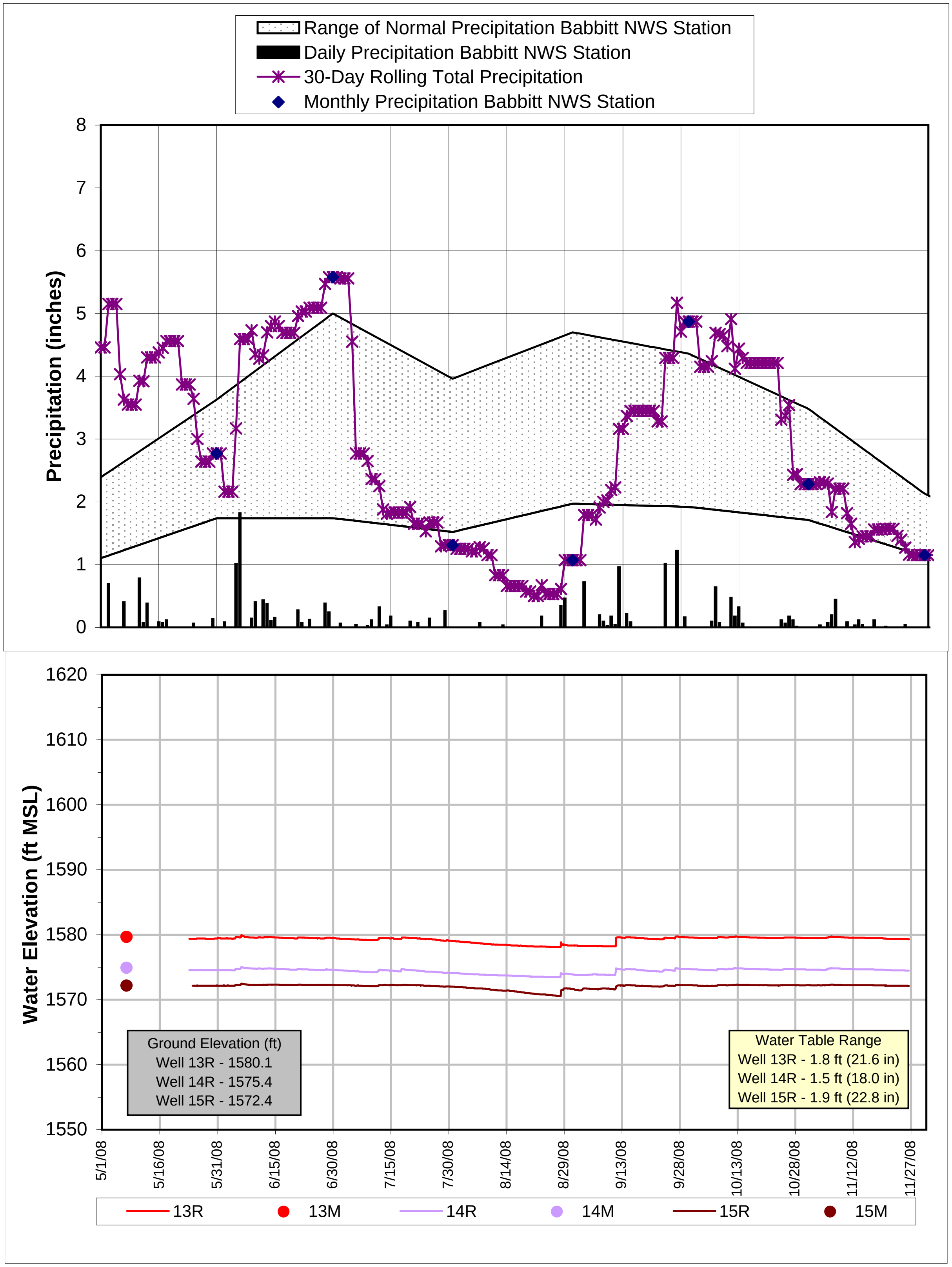
"R" = Recording well and "M" = Manual well

Figure 7
2008 WETLAND WATER ELEVATION DATA
Northwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



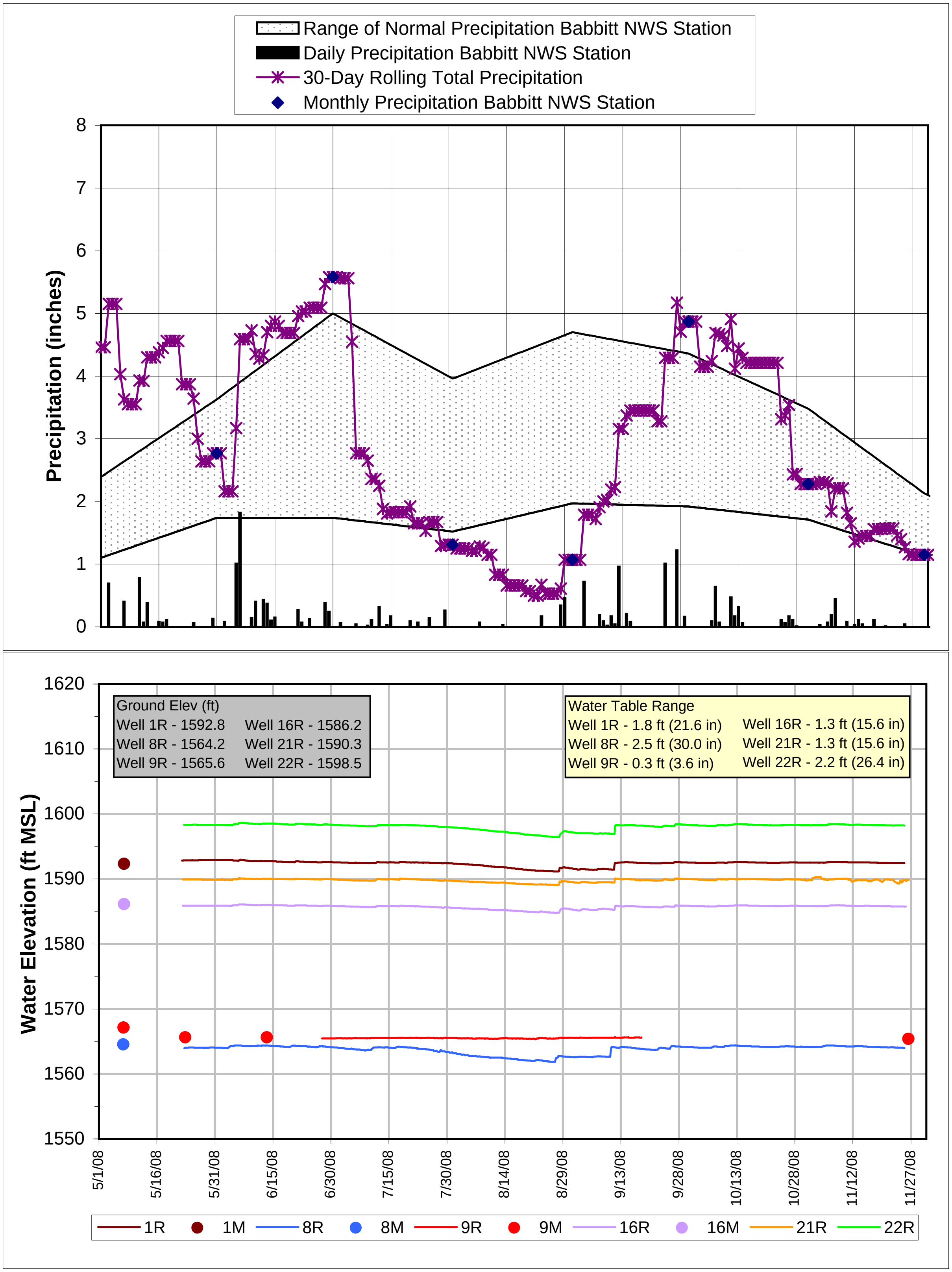
"R" = Recording well and "M" = Manual well

Figure 8
2008 WETLAND WATER ELEVATION DATA
North-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



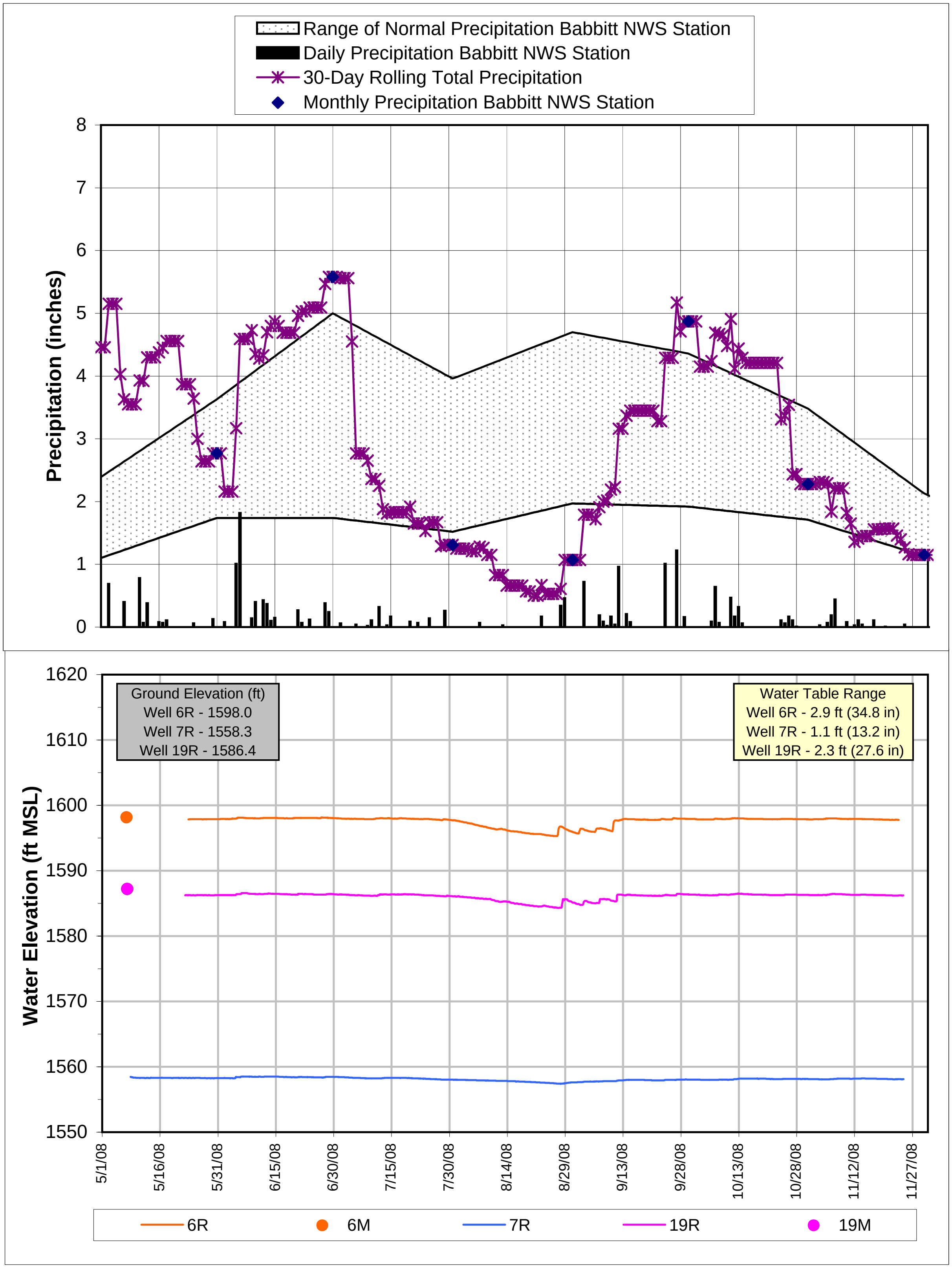
"R" = Recording well and "M" = Manual well

Figure 9
2008 WETLAND WATER ELEVATION DATA
Northeast Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



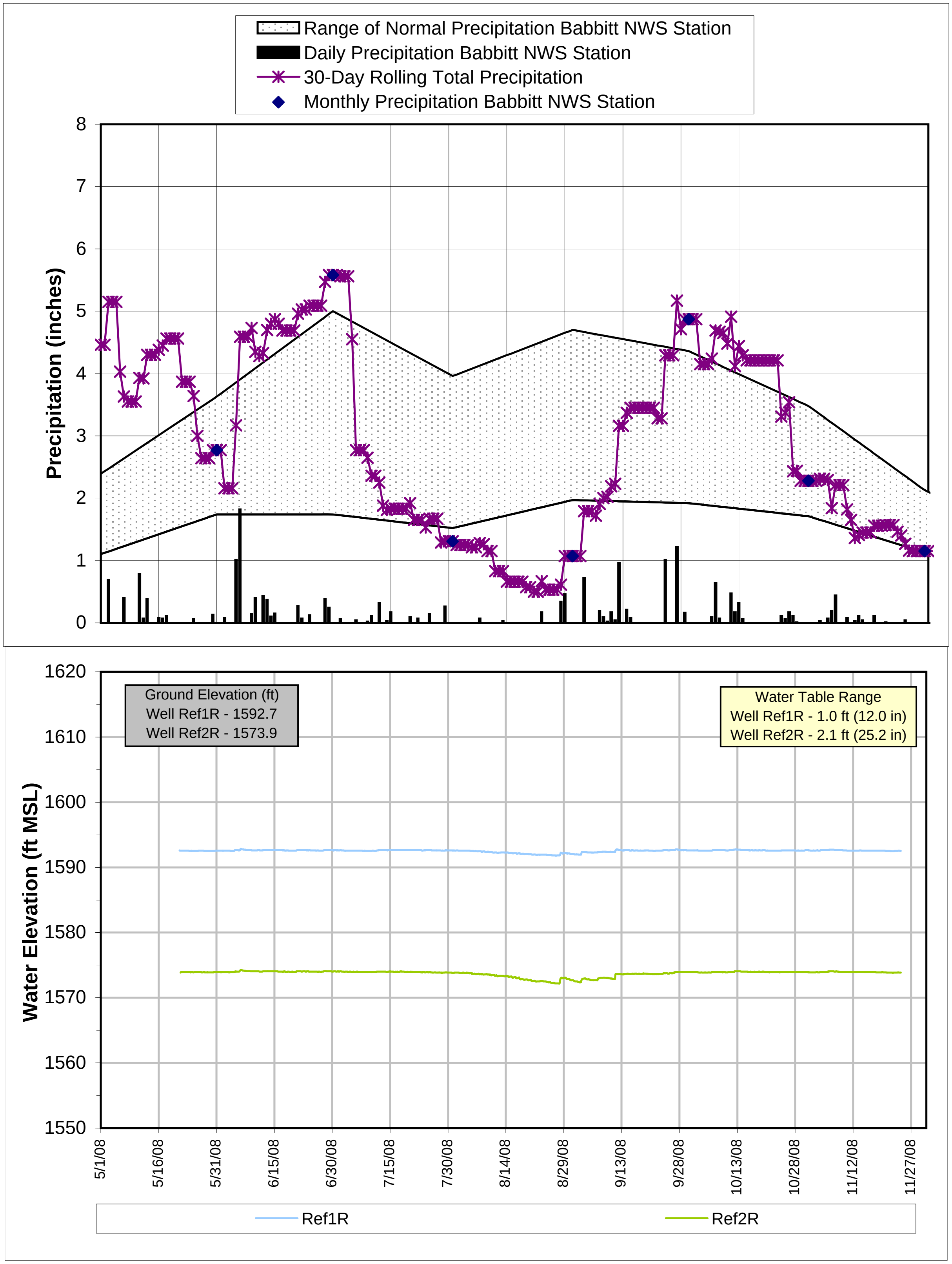
"R" = Recording well and "M" = Manual well

Figure 10
2008 WETLAND WATER ELEVATION DATA
South-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



"R" = Recording well and "M" = Manual well

Figure 11
2008 WETLAND WATER ELEVATION DATA
Southwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota

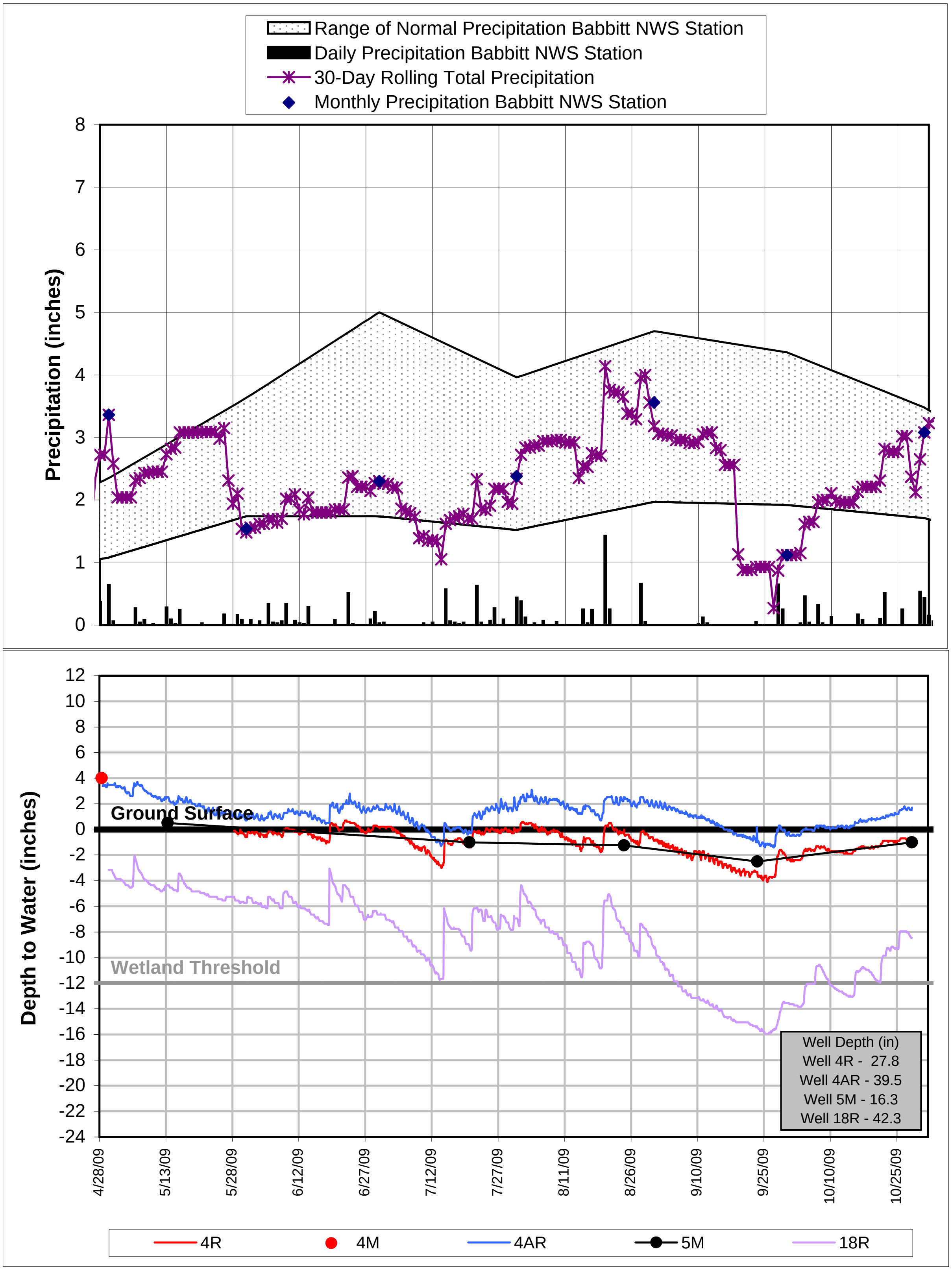


"R" = Recording well and "M" = Manual well

Figure 12
2008 WETLAND WATER ELEVATION DATA
Reference Wells - West of Mine Site
PolyMet Mining
Hoyt Lakes, Minnesota

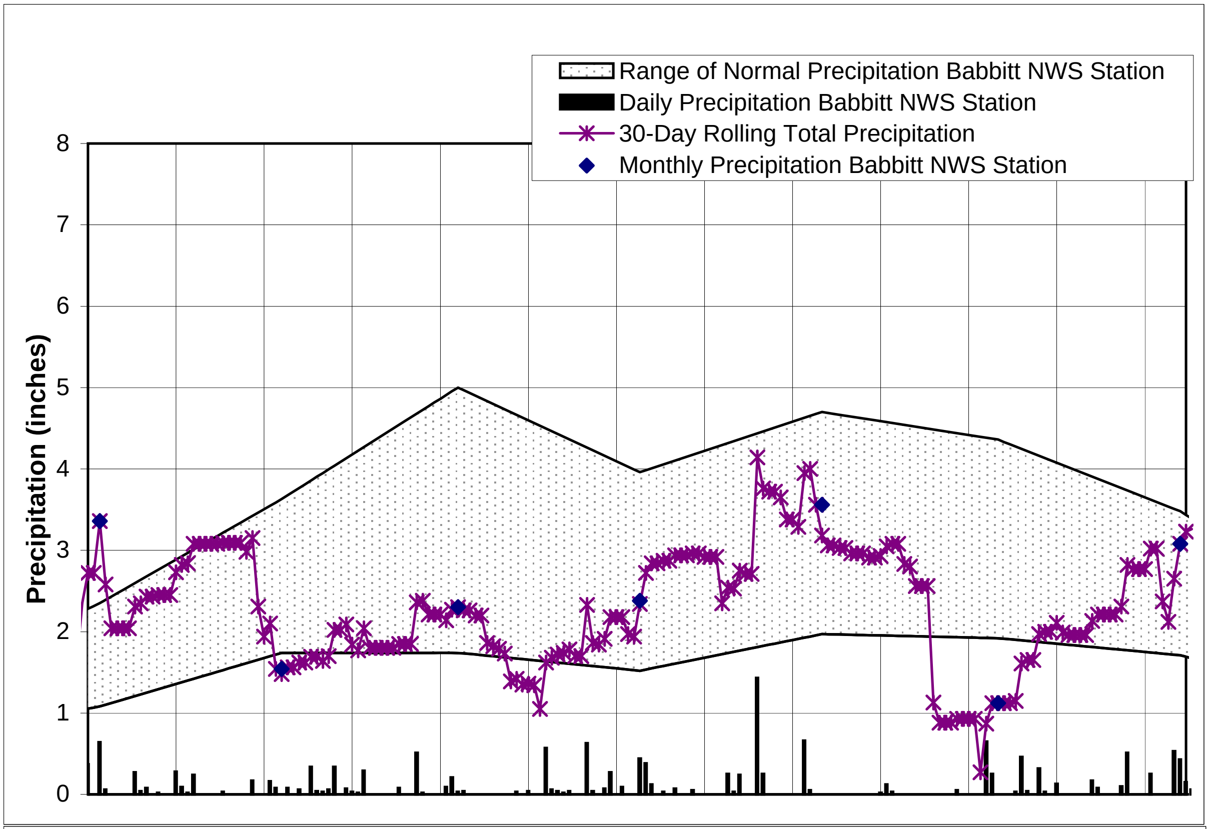
Appendix D

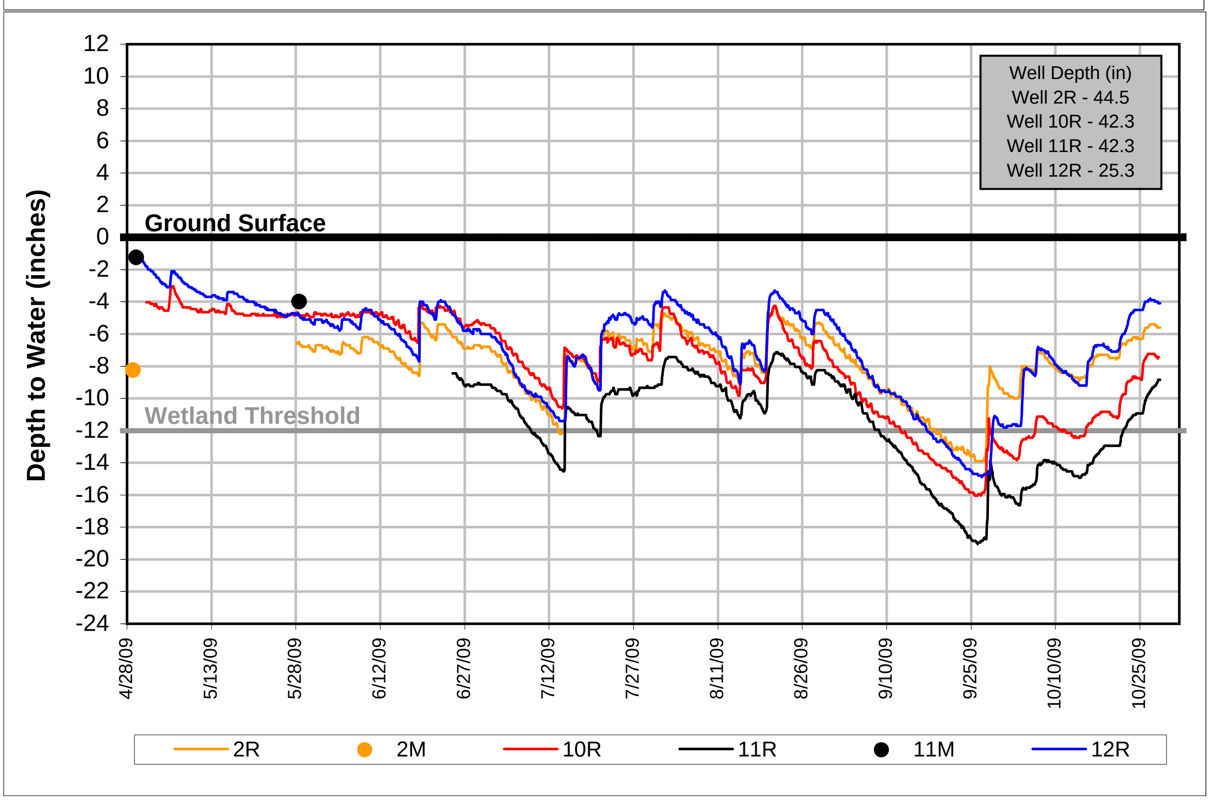
2009 Wetland Hydrology and Water Elevation Data



"R" = Recording well and "M" = Manual well

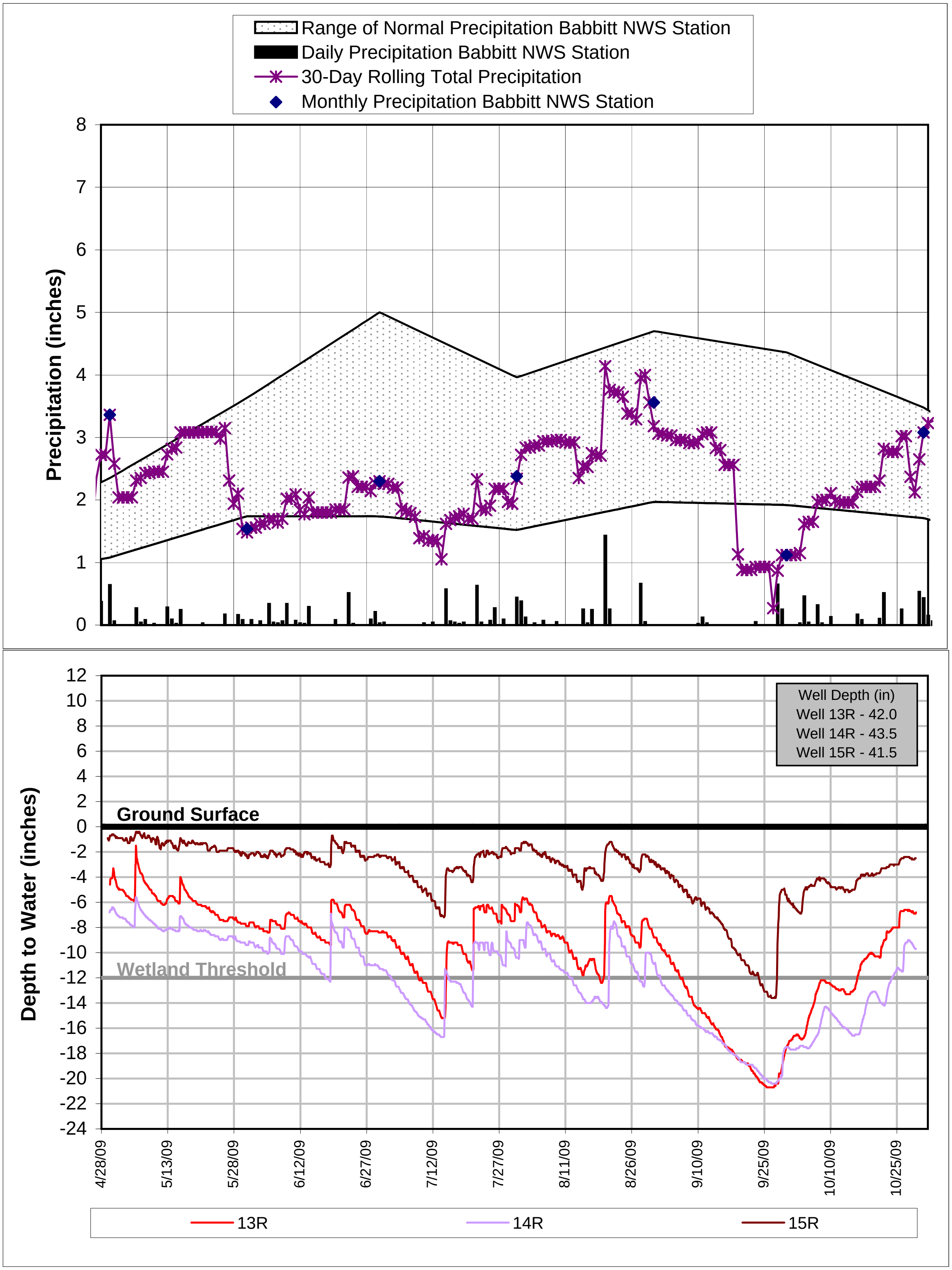
Figure 1
2009 WETLAND HYDROLOGY MONITORING DATA
Northwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota





"R" = Recording well and "M" = Manual well

Figure 2
2009 WETLAND HYDROLOGY MONITORING DATA
North-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota

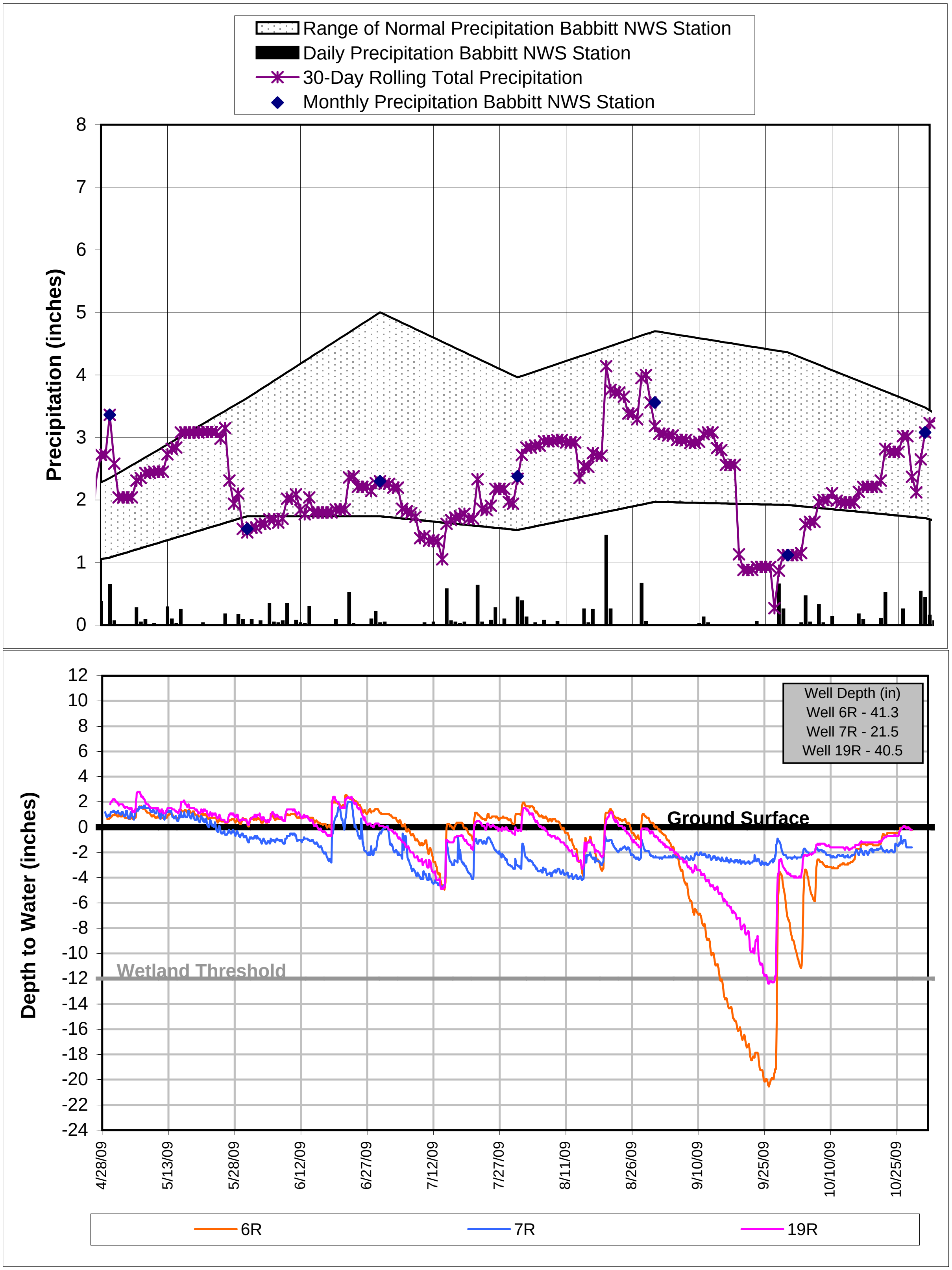


"R" = Recording well and "M" = Manual well

Figure 3
2009 WETLAND HYDROLOGY MONITORING DATA
Northeast Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota

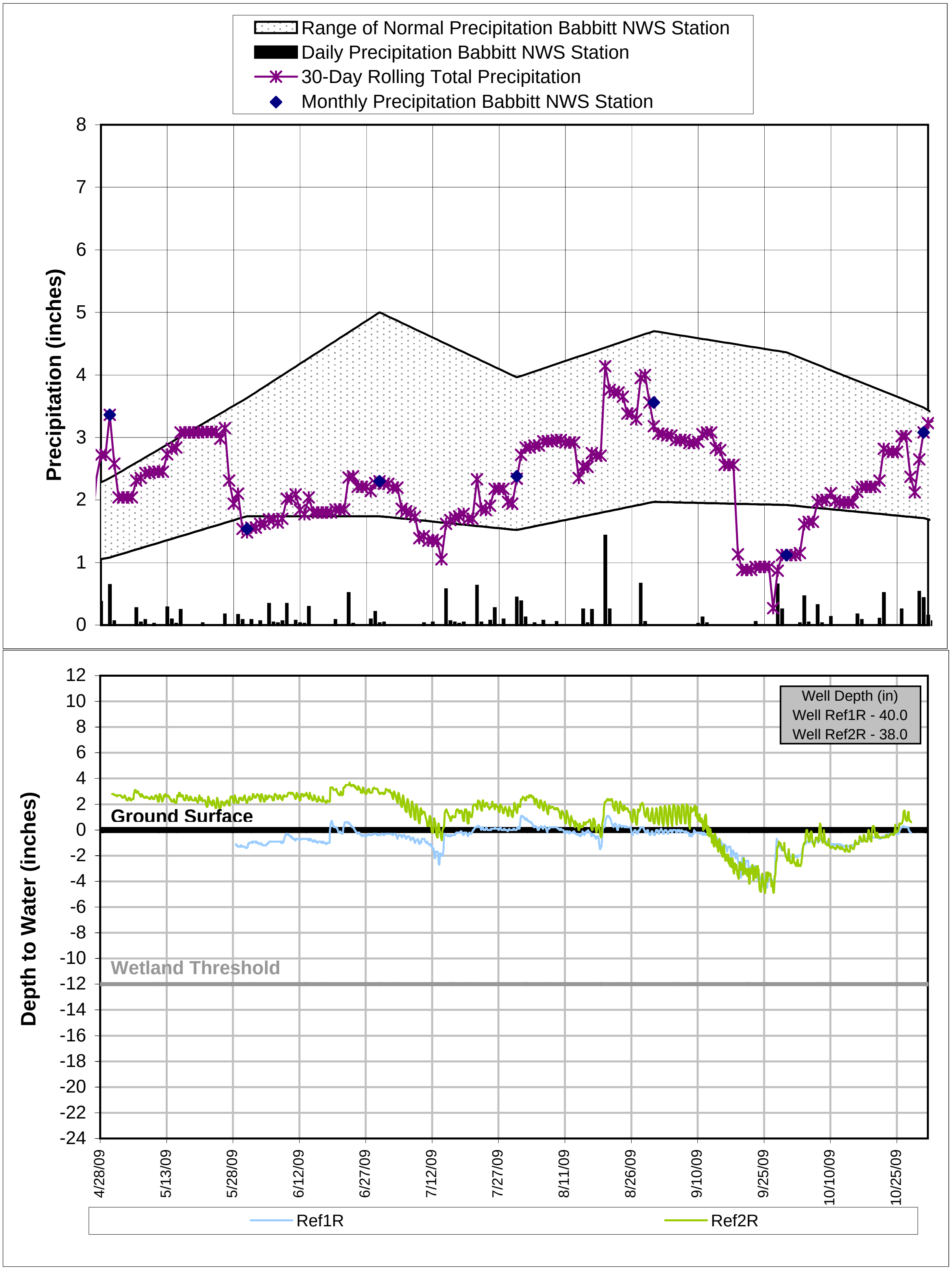
"R" = Recording well and "M" = Manual well

Figure 4
2009 WETLAND HYDROLOGY MONITORING DATA
South-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



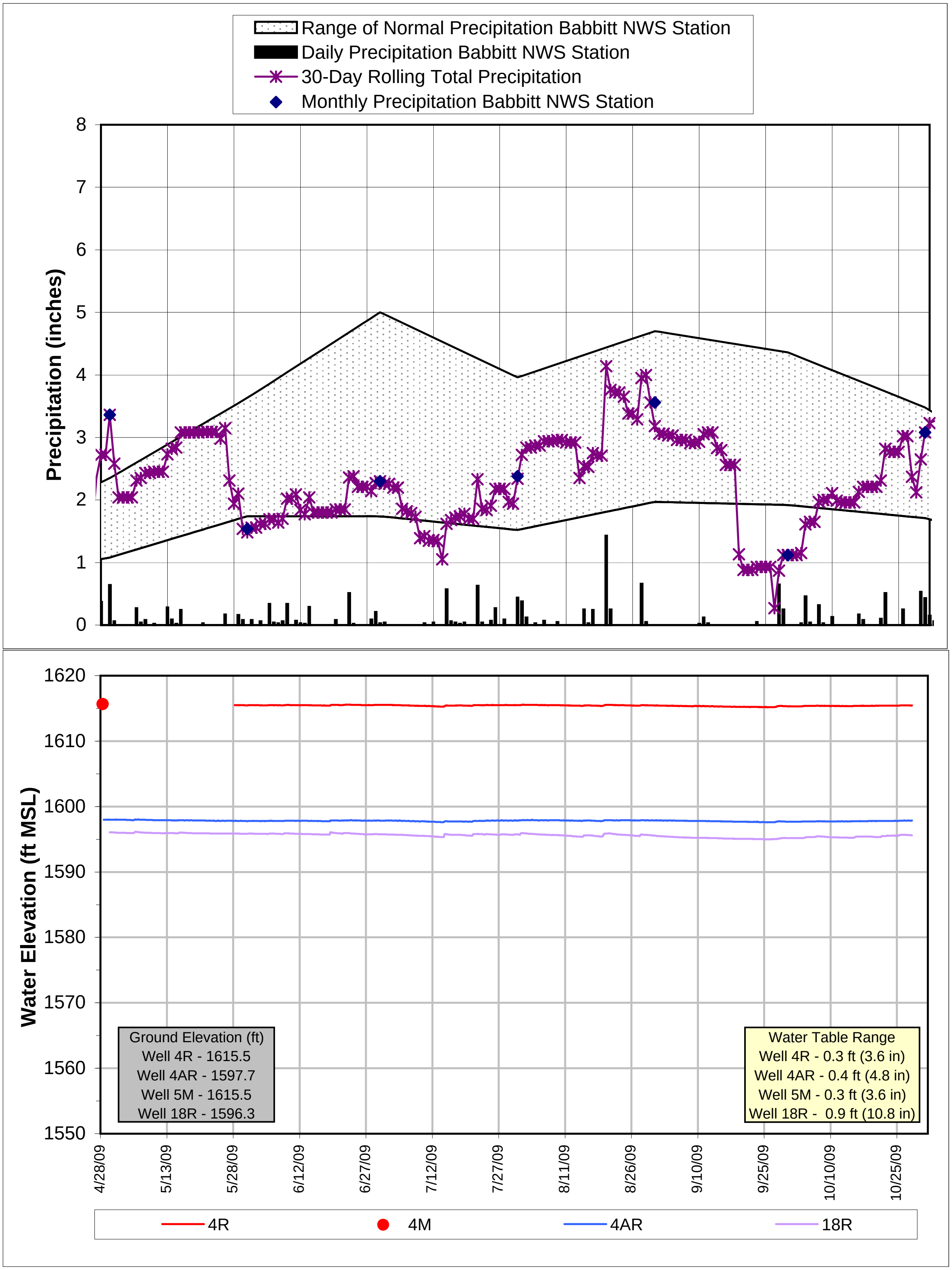
"R" = Recording well and "M" = Manual well

Figure 5
2009 WETLAND HYDROLOGY MONITORING DATA
Southwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



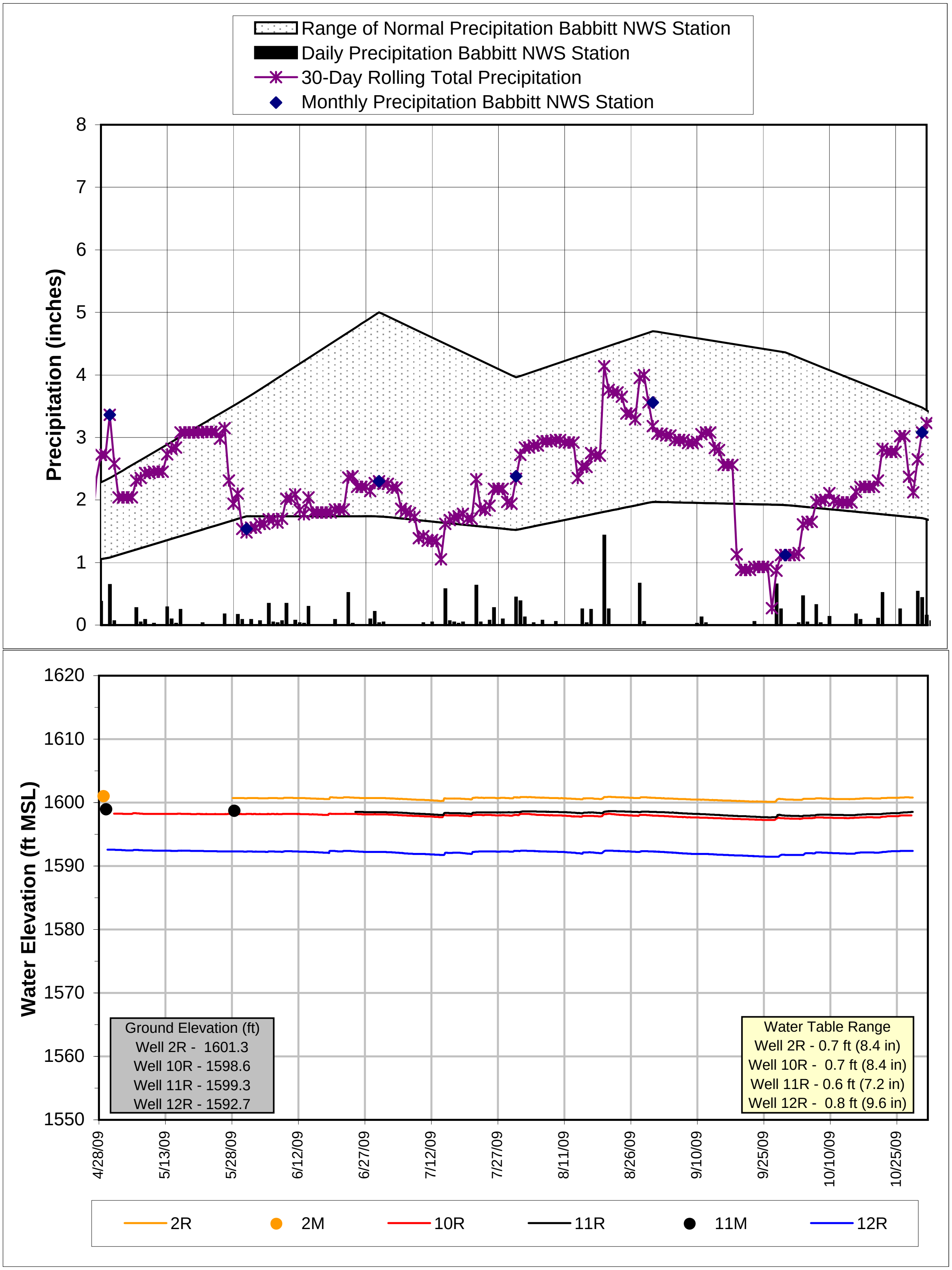
"R" = Recordingwell and "M" = Manual well

Figure 6
2009 WETLAND HYDROLOGY MONITORING DATA
Reference Wells - West of Mine Site
PolyMet Mining
Hoyt Lakes, Minnesota



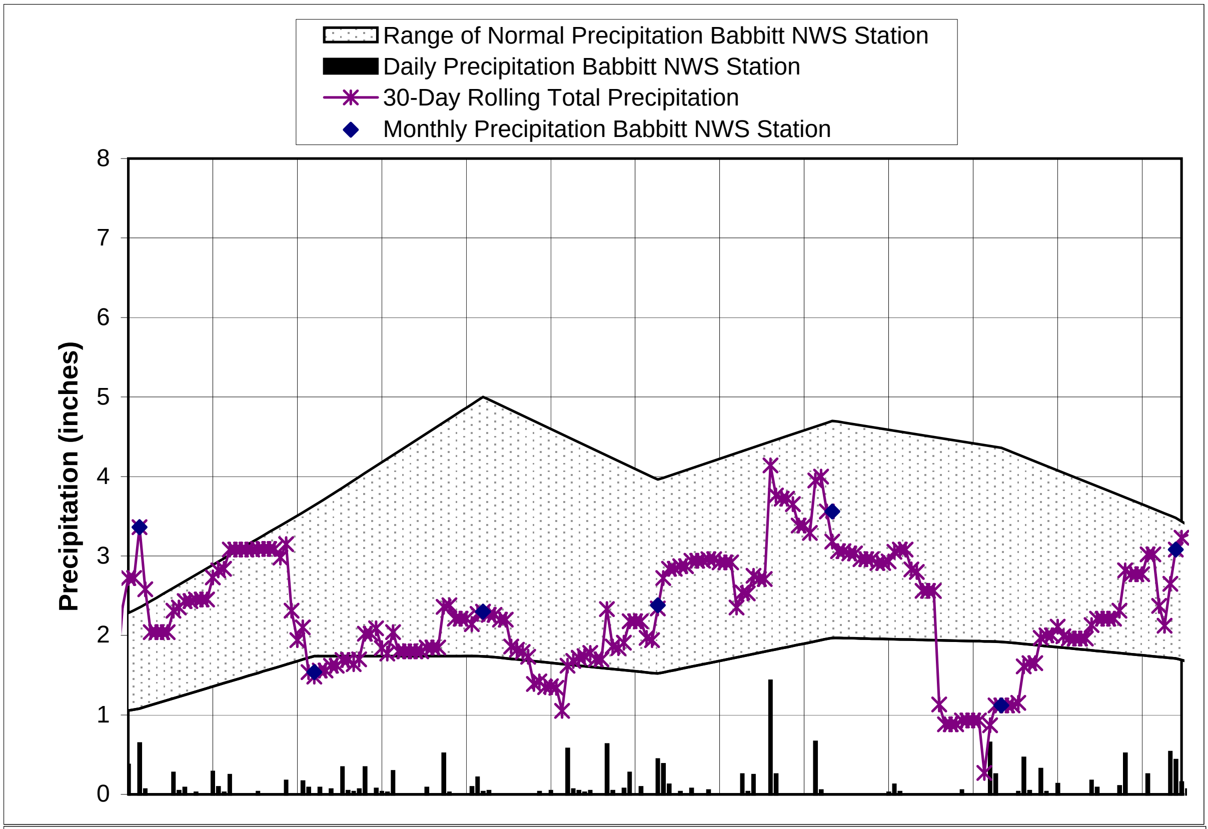
"R" = Recording well and "M" = Manual well

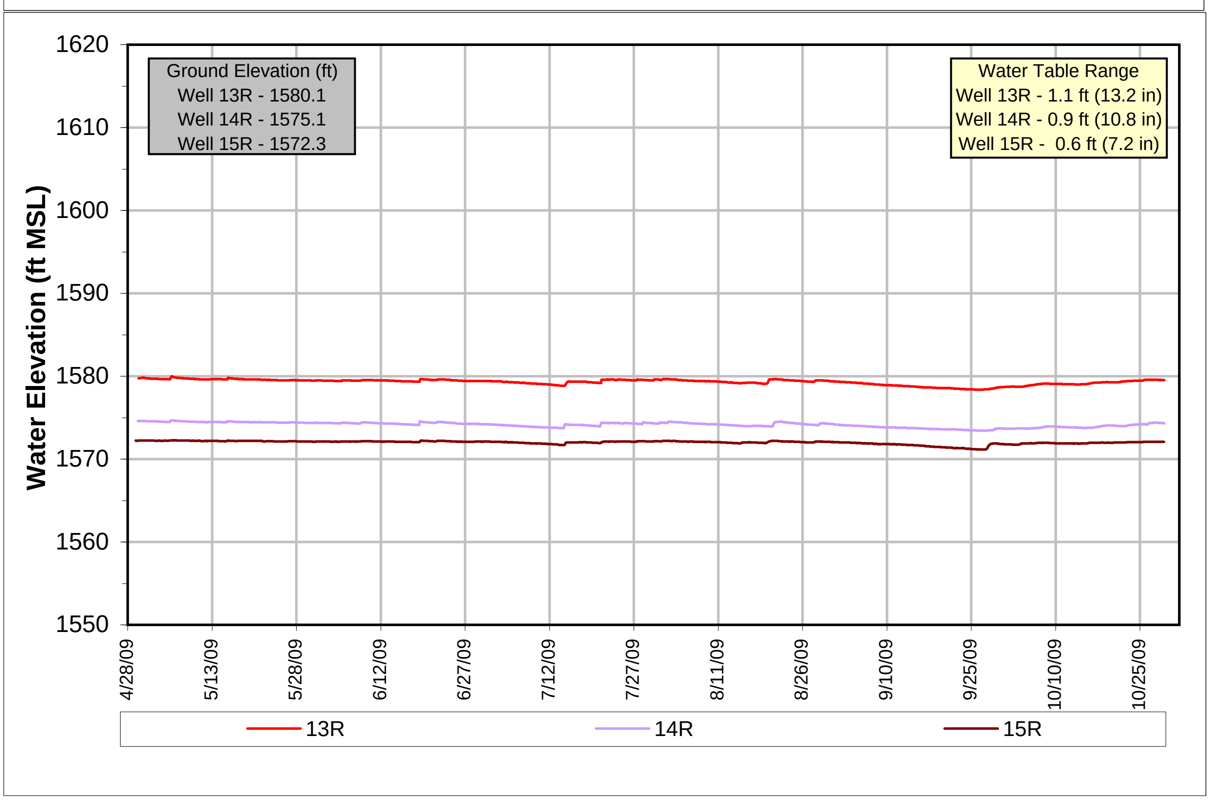
Figure 7
2009 WETLAND WATER ELEVATION DATA
Northwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



"R" = Recording well and "M" = Manual well

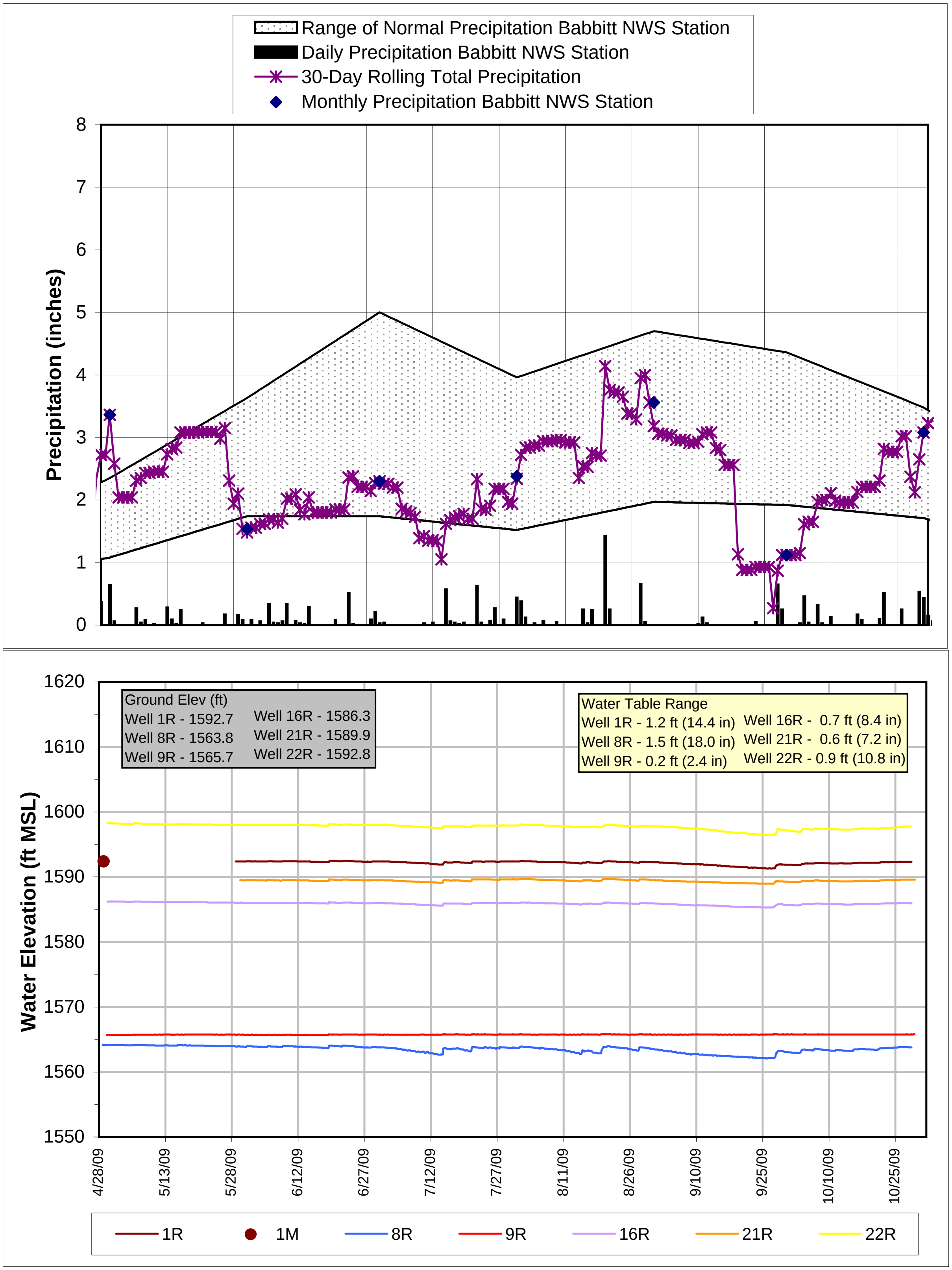
Figure 8
2009 WETLAND WATER ELEVATION DATA
North-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota





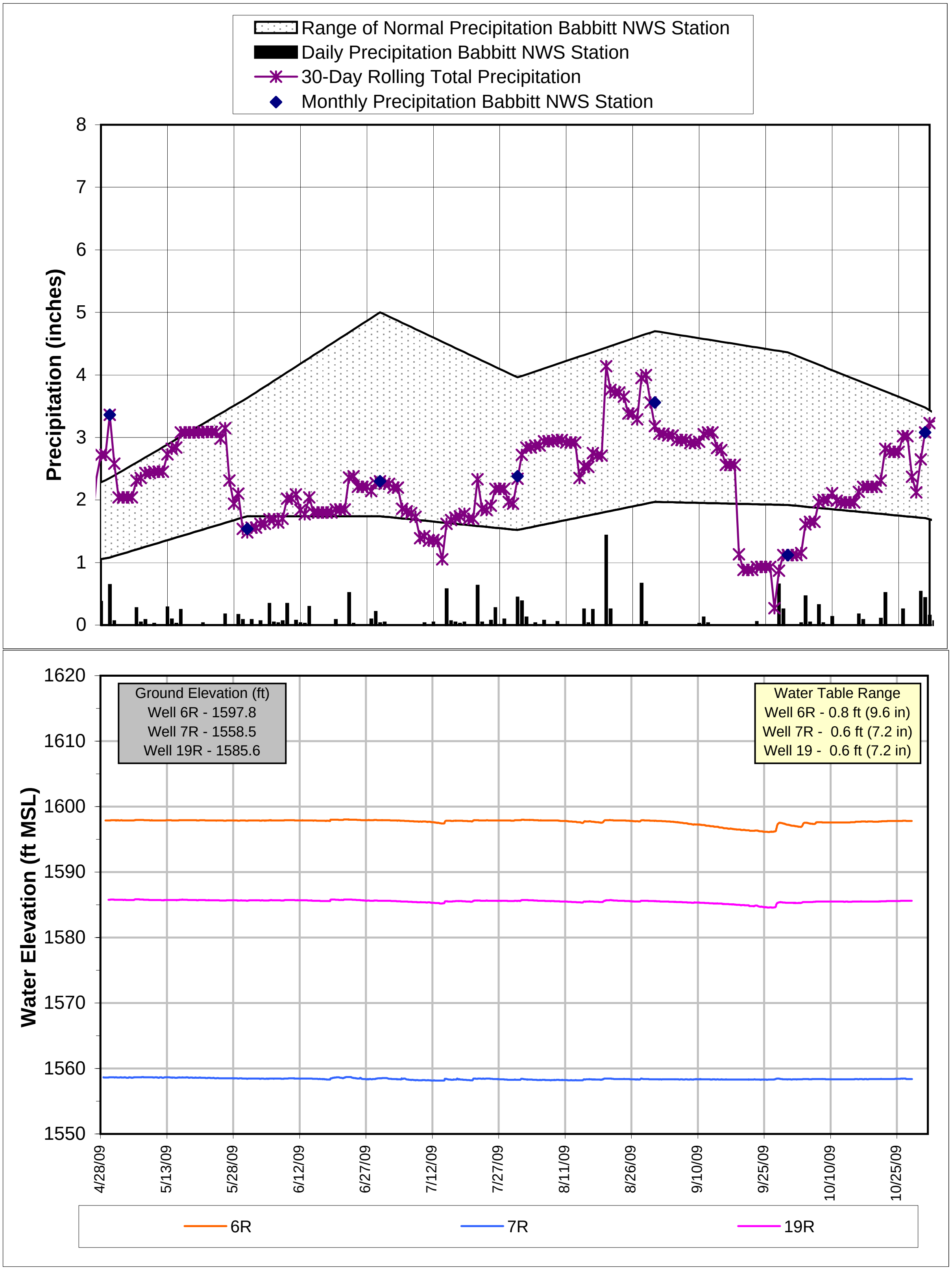
"R" = Recording well and "M" = Manual well

Figure 9
2009 WETLAND WATER ELEVATION DATA
Northeast Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



"R" = Recording well and "M" = Manual well

Figure 10
2009 WETLAND WATER ELEVATION DATA
South-Central Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota



"R" = Recording well and "M" = Manual well

Figure 11
2009 WETLAND WATER ELEVATION DATA
Southwest Mine Site Area
PolyMet Mining
Hoyt Lakes, Minnesota

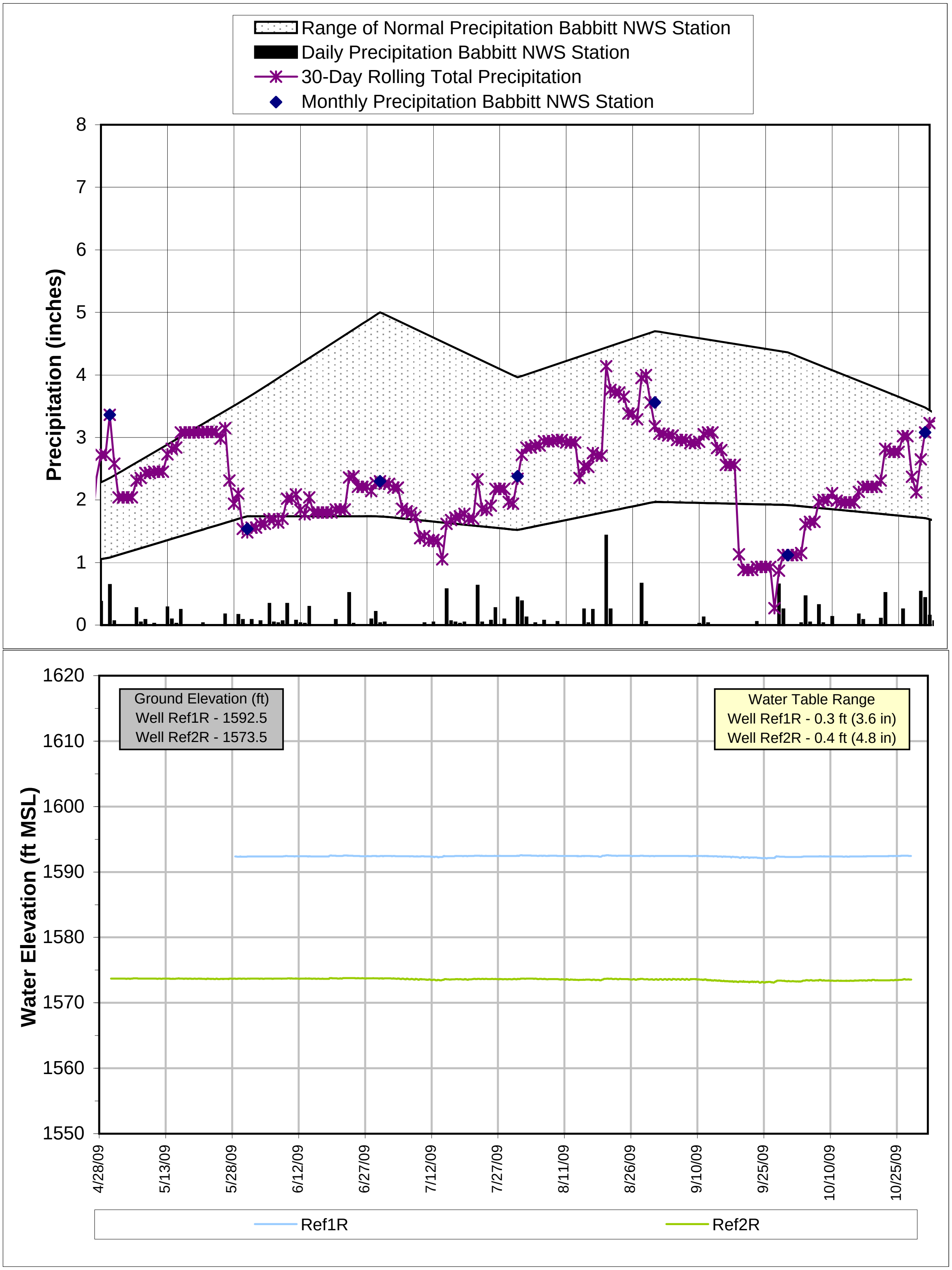


Figure 12
2009 WETLAND WATER ELEVATION DATA
Reference Wells - West of Mine Site
PolyMet Mining
Hoyt Lakes, Minnesota

Appendix E

Well Location Photographs

Date of Photo: June 28, 2005

Well 1 – Removed in 2008
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 1 – Relocated in 2008
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 2
PolyMet Mining Company
Hoyt Lakes, MN

Date of Photo: June 29, 2005

Well 3 – Removed in April 2008
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 4
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 4A
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 5
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 6
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 7
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 8
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 9
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 10
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 11
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 12
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 13
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 14
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 15
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 16
PolyMet Mining Company
Hoyt Lakes, MN

Date of Photo: June 29, 2005

Well 17 – removed in 2008
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 18
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 19
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 21
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Well 22
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

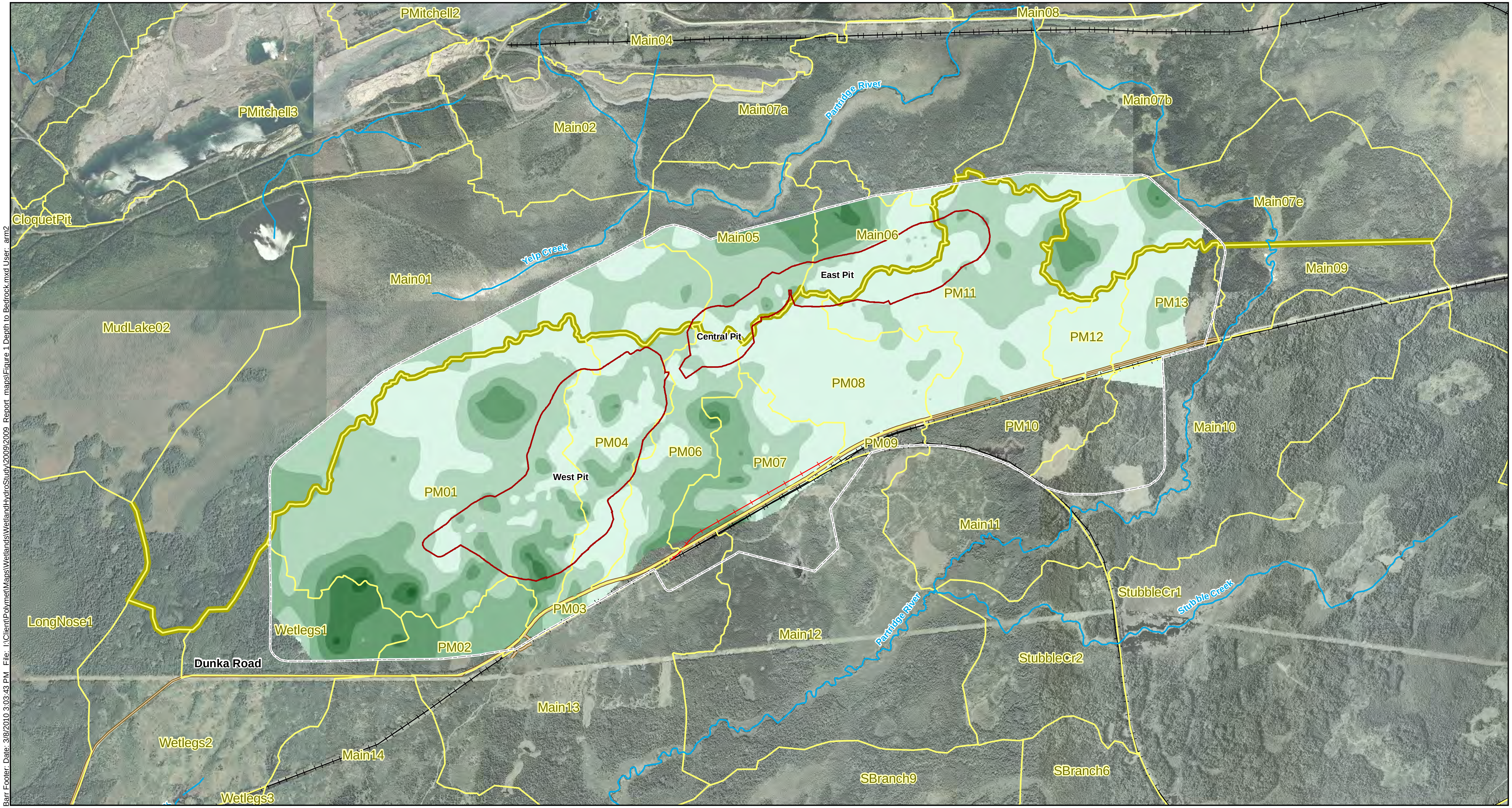
Reference Well 1
PolyMet Mining Company
Hoyt Lakes, MN

Top: June 2009
Bottom: October 2009

Reference Well 2
PolyMet Mining Company
Hoyt Lakes, MN

Appendix F

Depth to Bedrock



Dunka Road
Proposed Railroad
Existing Railroad
Streams
Surface Drainage Divide
Surface Watersheds
Mine Site

Depth to Bedrock (feet)
0 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
50.1 - 58

N

2,000 1,000 0 2,000
Feet

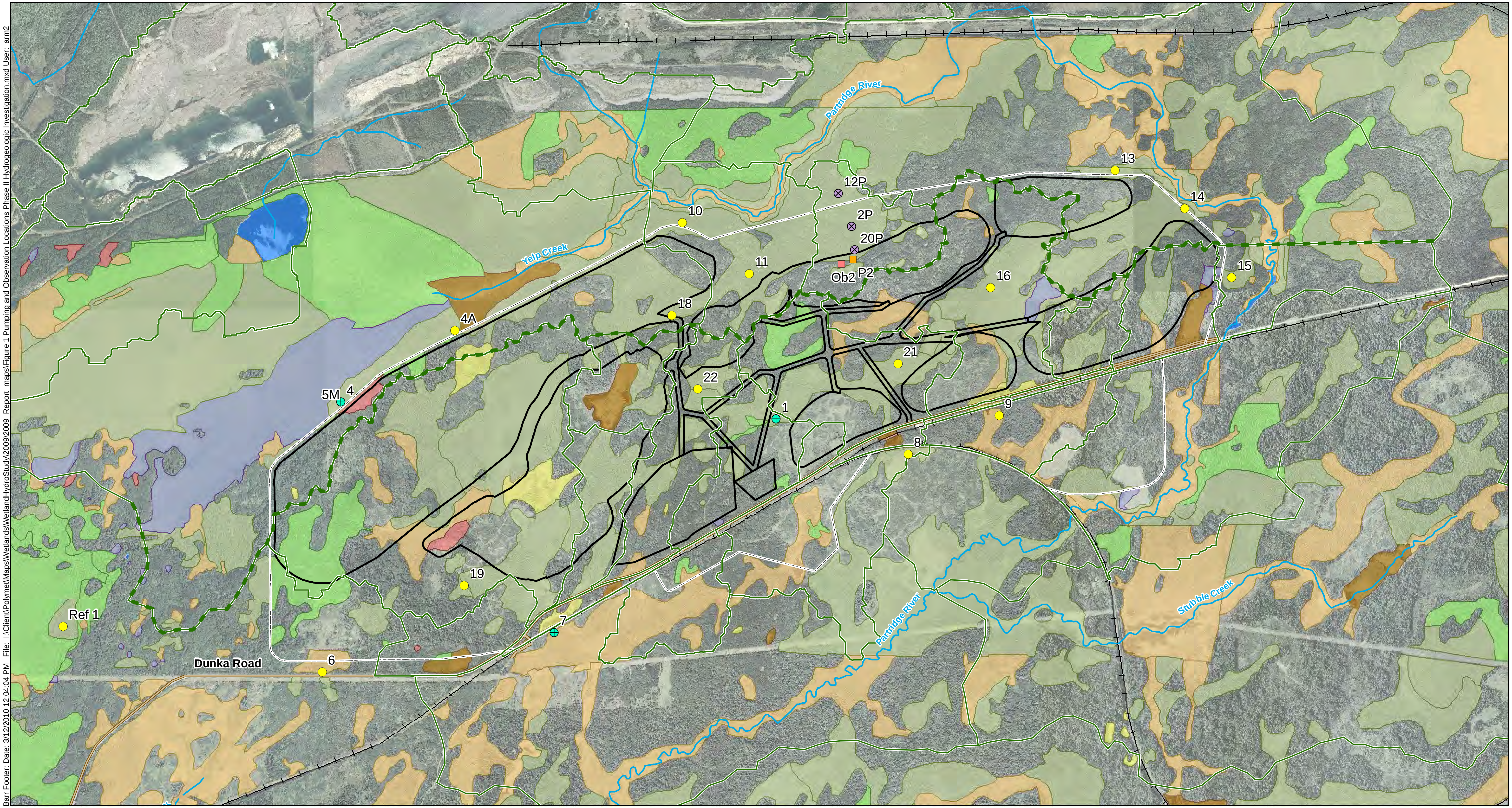
Figure 1
DEPTH TO BEDROCK
PolyMet Mining
Hoyt Lakes, Minnesota

Appendix G

Phase III Hydrogeology Study

Table 1
Pumping Test Summary
2006
PolyMet Mining Company
Hoyt Lakes, Minnesota

ID	Type	Total depth of well/piezometer (ft below ground surface)	Screen Depth (ft below ground surface)	Geologic Deposit	Distance from Pumping Well P2 (ft)	Maximum Drawdown (in)	Maximum Drawdown (ft)
P2	Pumping well - open hole bedrock well	610	None - open from 27 to 610 ft	Virginia Formation	0	2519	209.9
20P	Piezometer	7.5	7.5	Organic Soil	145	5.4	0.5
20	Well	2.4	2.4	Organic Soil	160	5.8	0.5
Ob2	Open hole bedrock well	100	None - open from 18 to 100 ft	Duluth Formation	280	55.7	4.6
2P	Piezometer	7.5	7.5	Organic Soil	750	1.7	0.1
12	Well	3.0	3	Organic Soil	1,400	2.3	0.2
12P	Piezometer	7.5	7.5	Organic Soil	1,400	3.6	0.3
1R	Well	2.3	2.3	Organic Soil	3,800	6.0	0.5
7R	Well	2.3	2.3	Organic Soil	10,300	3.6	0.3
4R	Well	2.3	2.3	Organic Soil	11,500	2.4	0.2



- Pumping Test Piezometer
- Pumping Test Well
- All Other Wetland Monitoring Wells
- Pumping Well (P2)
- Bedrock Observation Well (Ob2)
- Surface Water Drainage Divide
- Detailed Watersheds
- Mine Site
- Streams
- Dunka Road

Proposed Project Areas

Eggers & Reed Wetland Types

- Shrub Swamps (Alder thickets & Shrub-carrs)
- Coniferous bog
- Coniferous swamp
- Deep marsh; Shallow marsh
- Hardwood swamp
- Open water (Shallow, open water & lakes)
- Open bog
- Sedge meadow; Wet meadow

N

2,000 1,000 0 2,000

Feet

Figure 1
PUMPING AND OBSERVATION LOCATIONS
PHASE III HYDROGEOLOGIC INVESTIGATION
PolyMet Mining Inc.
Hoyt Lakes, Minnesota

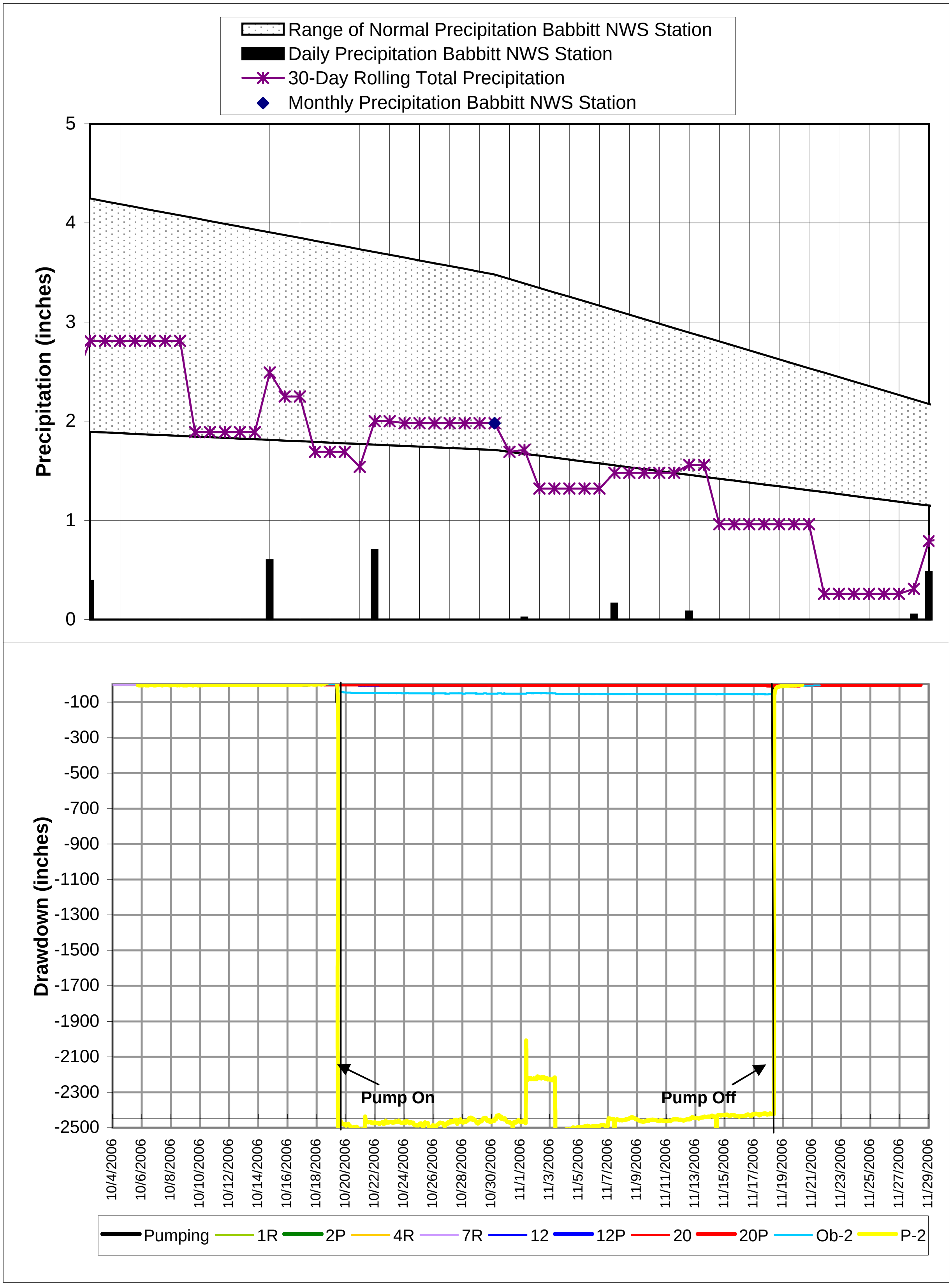


Figure 2
OBSERVED DRAWDOWN AND RECOVERY
PolyMet Mining
Hoyt Lakes, Minnesota

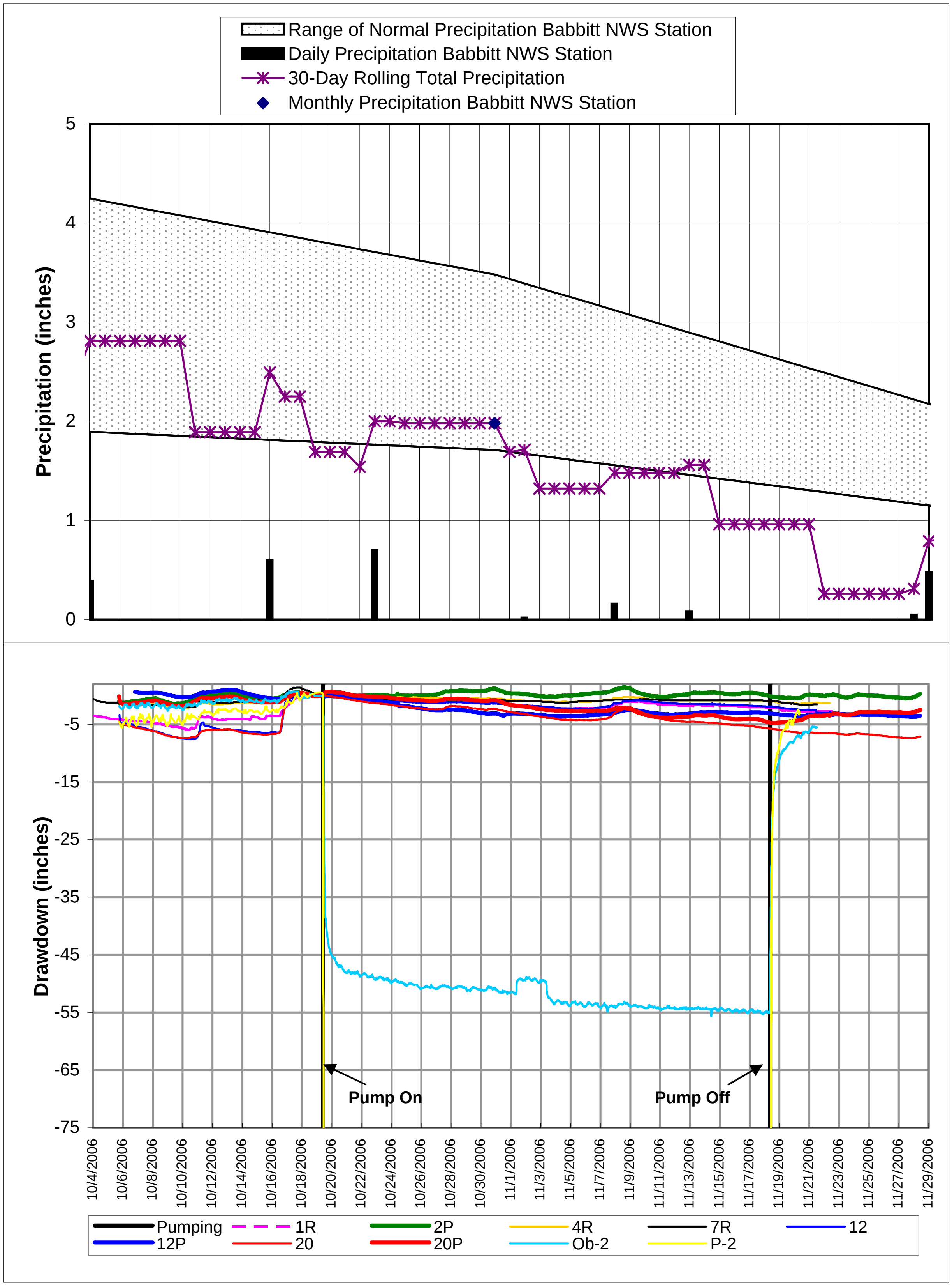


Figure 3
OBSERVED DRAWDOWN AND RECOVERY
PolyMet Mining
Hoyt Lakes, Minnesota

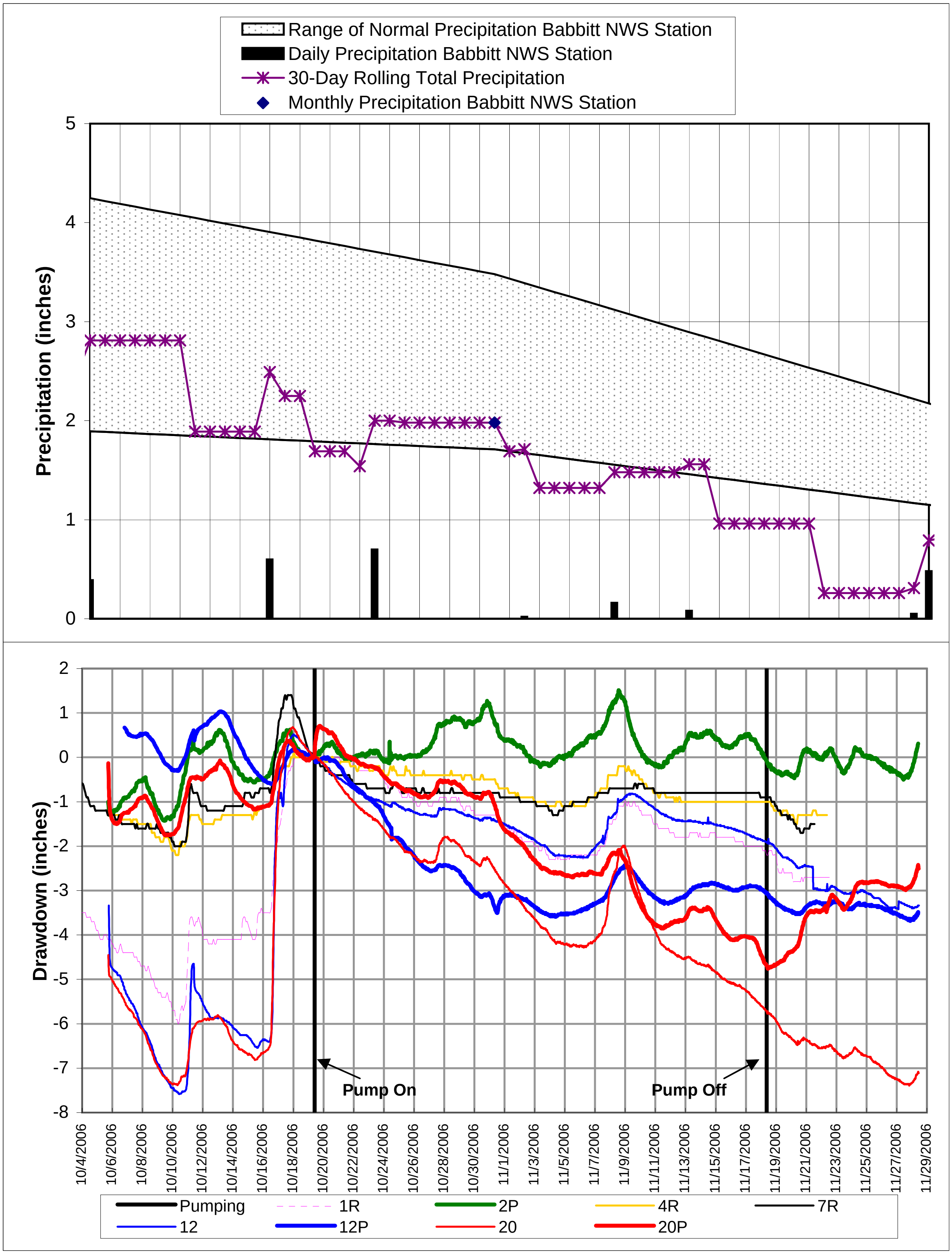


Figure 4
OBSERVED DRAWDOWN AND RECOVERY
PolyMet Mining
Hoyt Lakes, Minnesota

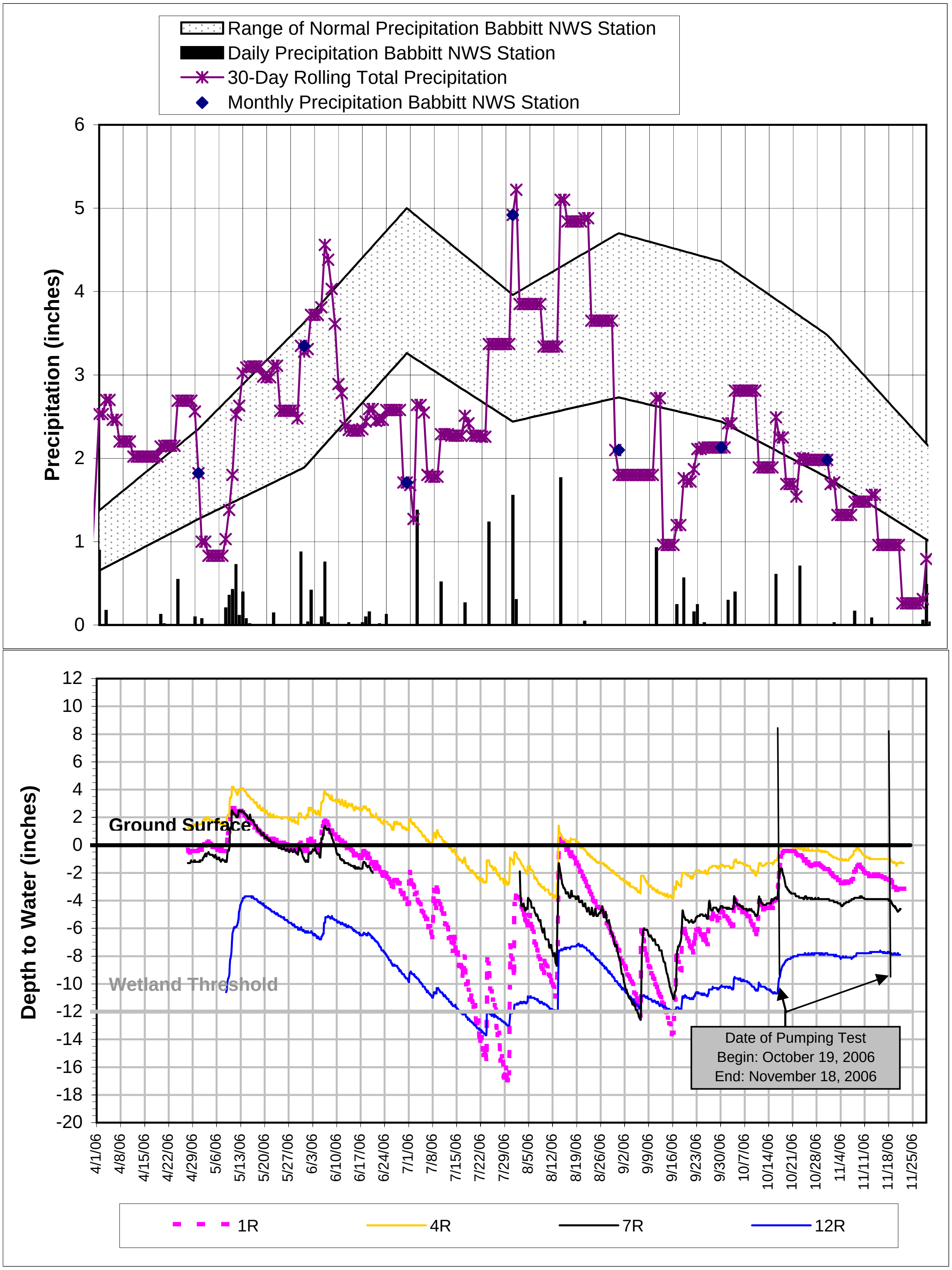
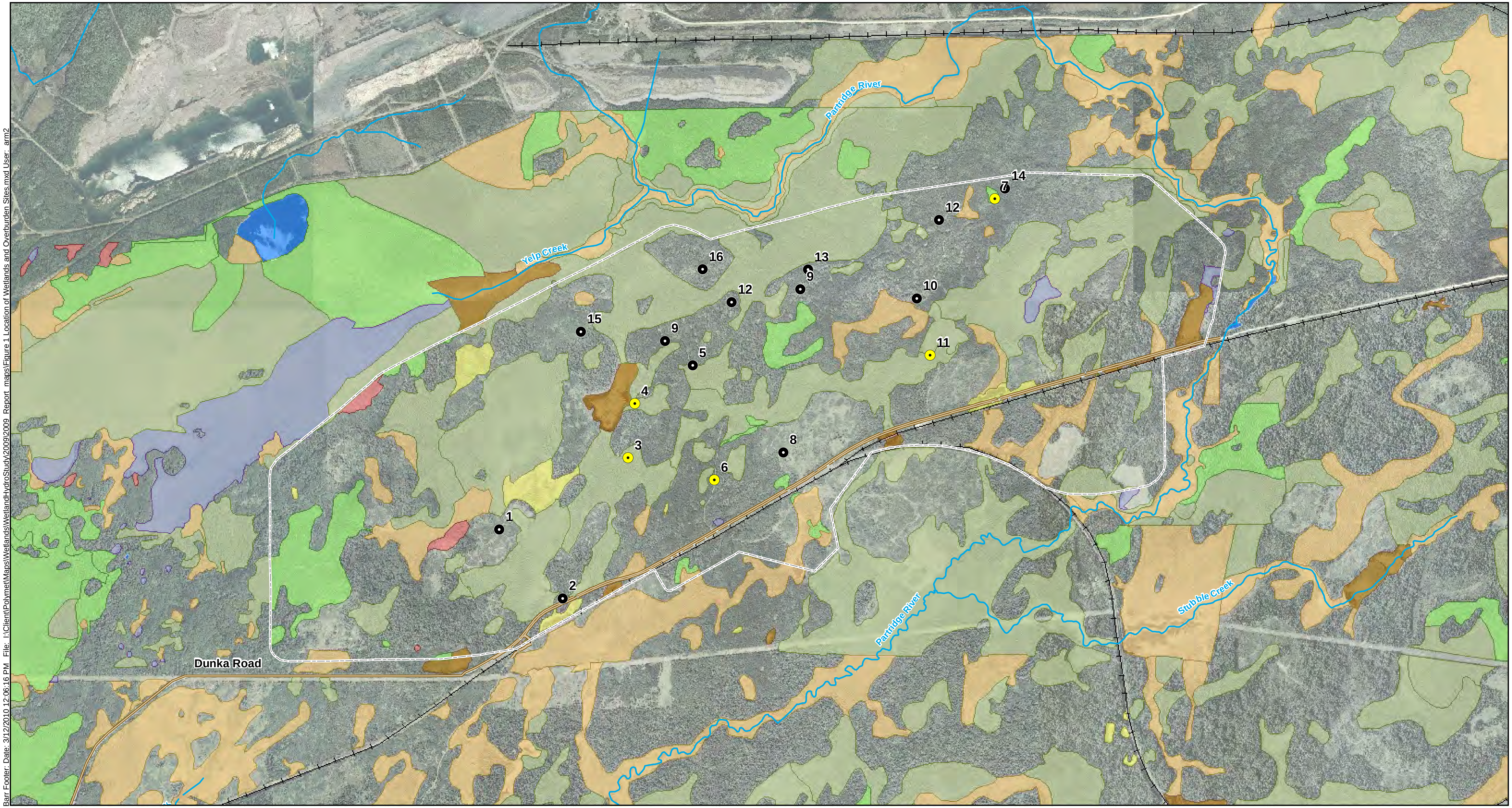


Figure 5
2006 RECORDING WELL MONITORING DATA
PolyMet Mining
Hoyt Lakes, Minnesota

Appendix H

Overburden Boring Logs



Upland Soil Boring Sites
Wetland Soil Boring Sites
Mine Site
Streams
Dunka Road

Eggers & Reed Wetland Types
Shrub Swamps (Alder thickets & Shrub-carrs)
Coniferous bog
Coniferous swamp
Deep marsh; Shallow marsh
Hardwood swamp
Open water (Shallow, open water & lakes)
Open bog
Sedge meadow; Wet meadow

N

2,000 1,000 0 2,000
Feet

Figure 1
LOCATION OF WETLANDS AND OVERBURDEN SITES
PolyMet Mining Inc.
Hoyt Lakes, Minnesota

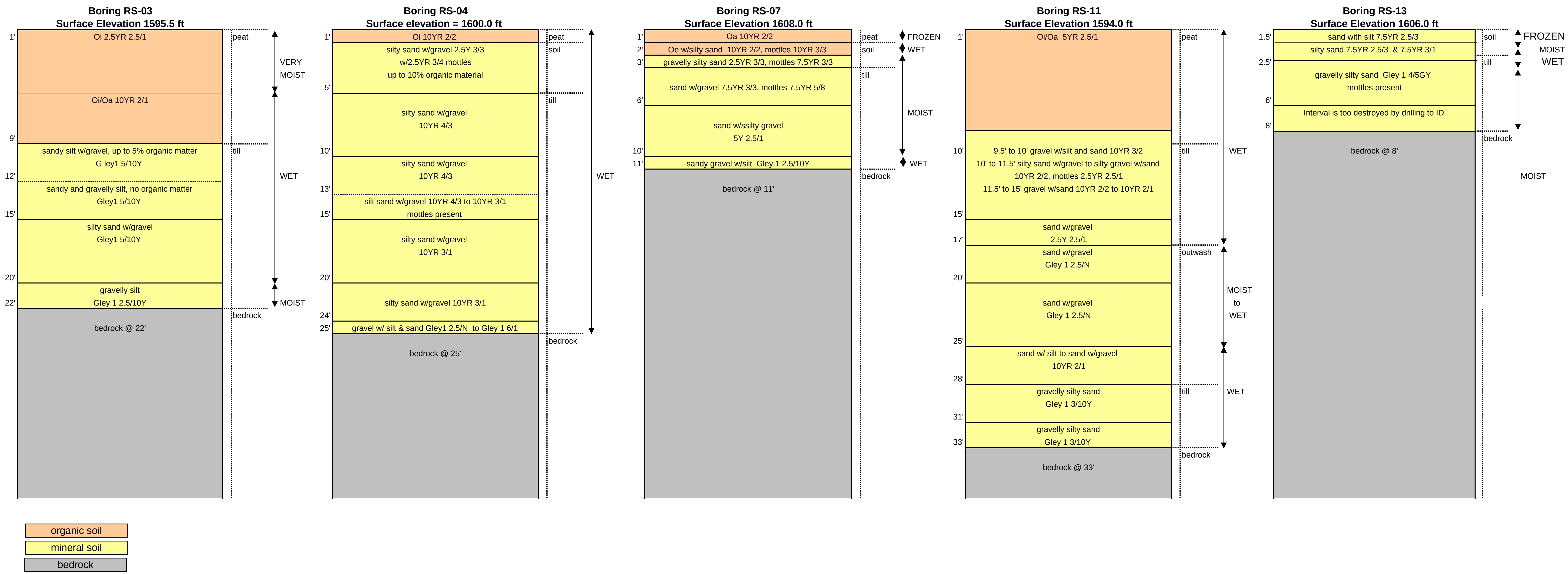


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Figure 2

OVERBURDEN CHARACTERIZATION
PROFILES
PolyMet Mining
Hoyt Lakes, MN

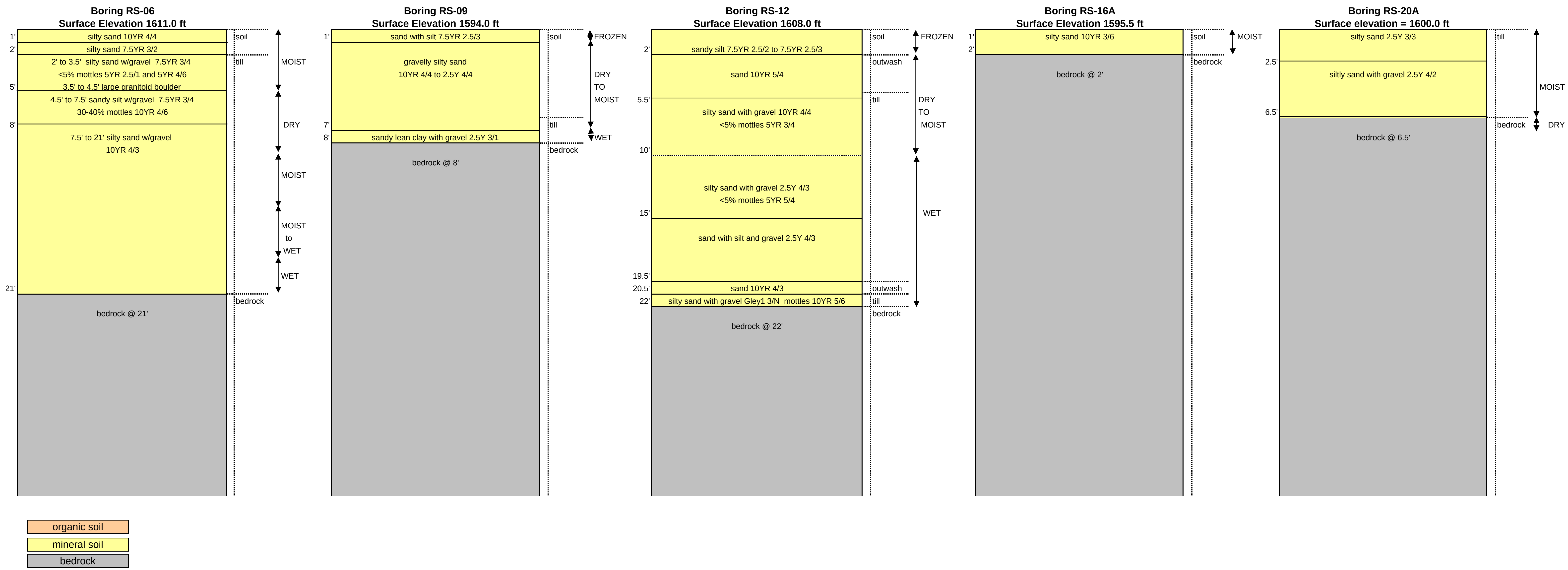

Figure 3

OVERBURDEN CHARACTERIZATION
PROFILES
PolyMet Mining
Hoyt Lakes, MN

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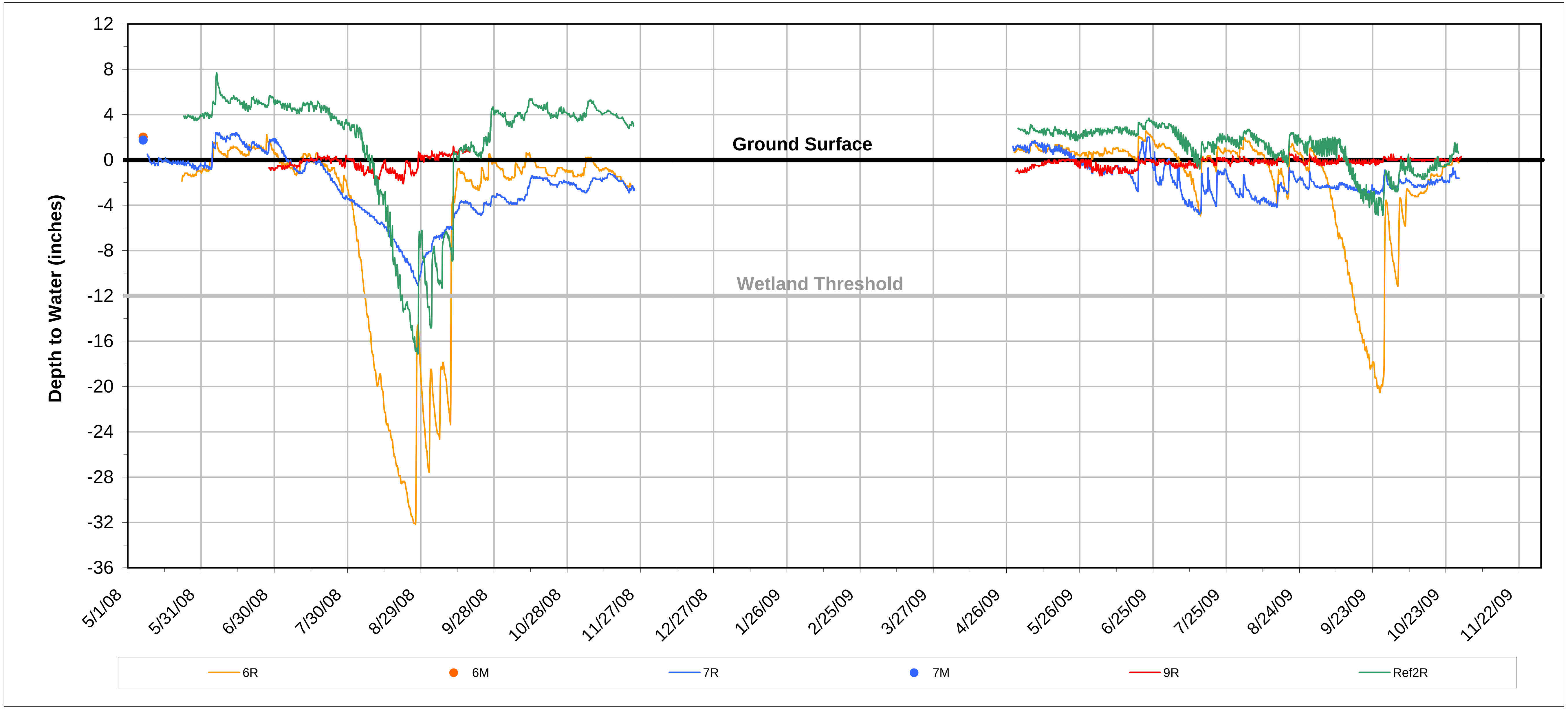
Appendix I

Water Hydrology by Wetland Type

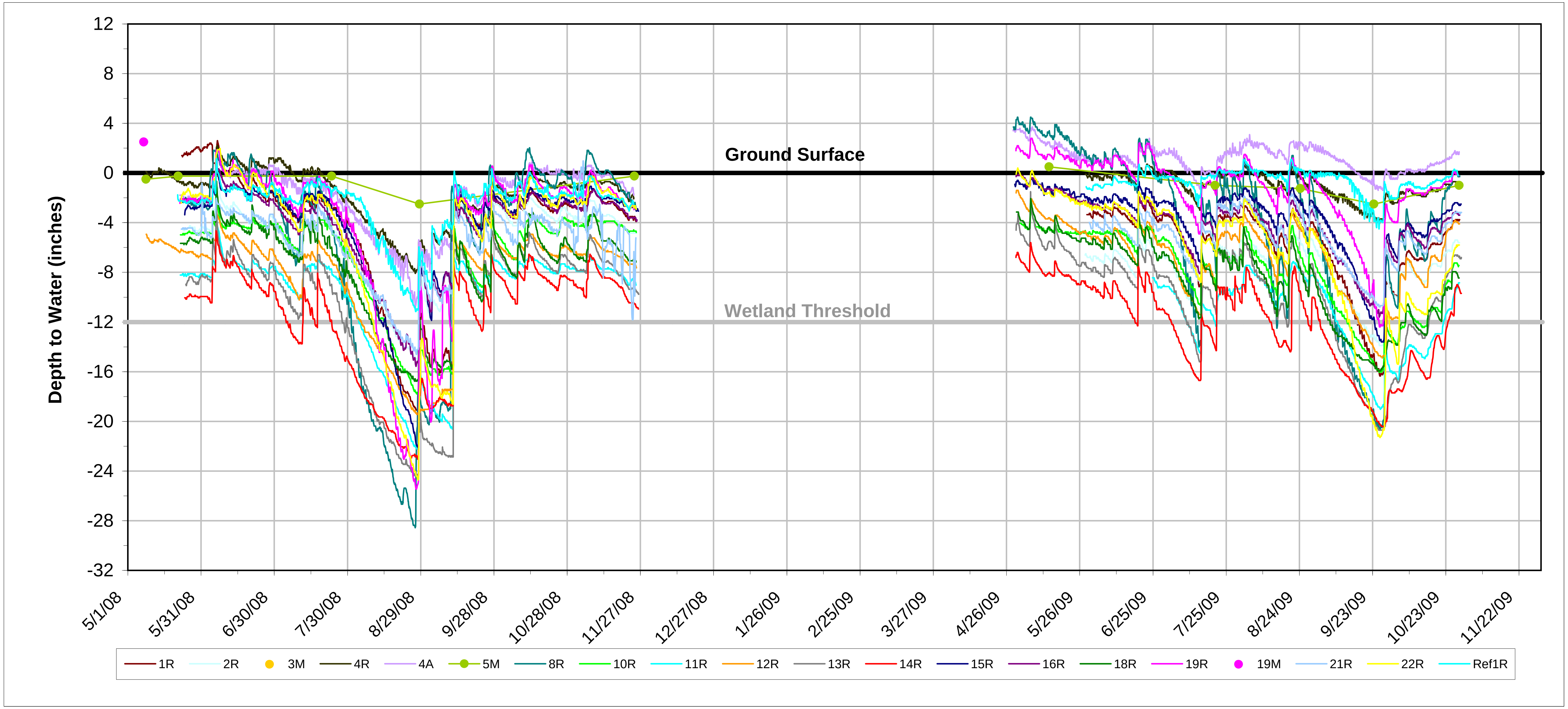
Table 1
2005-2009 Average Water Elevation Data
PolyMet Mining
Hoyt Lakes, Minnesota

Eggers & Reed Wetland Type	Wetland ID	Circular 39 Type	Well ID	Average Water Elevation (ft MSL)				
				2005	2006	2007	2008	2009
Coniferous bog	15	8	Well 19M	1586.4	1586.1	1586.1	1586.9	---
Coniferous bog	15	8	Well 19R	---	---	---	1586.0	1592.2
Coniferous swamp	48	7	Well 1M	1586.4	1586.1	1586.2	---	---
Coniferous swamp	48	7	Well 1R	1586.3	1587.1	1587.2	---	1600.8
Coniferous bog	48	8	Well 1M	---	---	---	1592.0	1592.2
Coniferous bog	48	8	Well 1R	---	---	---	1592.4	1600.7
Coniferous bog	48	8	Well 21M	---	---	---	1589.1	---
Coniferous bog	48	8	Well 21R	---	---	---	1589.8	1615.4
Coniferous bog	48	8	Well 22M	---	---	---	1598.3	1615.5
Coniferous bog	48	8	Well 22R	---	---	---	1598.0	1597.9
Coniferous bog	83	8	Well 15M	1572.2	1572.2	1572.3	1572.0	1563.8
Coniferous bog	83	8	Well 15R	---	---	---	1572.1	1563.7
Coniferous bog	84	8	Well 13M	1578.7	1579.6	1579.5	1579.4	1565.8
Coniferous bog	84	8	Well 13R	---	---	---	1579.2	1565.7
Coniferous bog	90	8	Well 14M	1574.3	1574.3	1574.6	1574.9	1598.1
Coniferous bog	90	8	Well 14R	---	---	---	1574.4	1598.1
Coniferous bog	90	8	Well 16M	1586.2	1586.2	1586.3	1586.3	1598.5
Coniferous bog	90	8	Well 16R	---	---	---	1585.8	1598.4
Coniferous bog	100	8	Well 2M	1600.7	1600.5	1601.0	1600.8	1591.4
Coniferous bog	100	8	Well 2R	---	---	---	1600.8	1592.2
Coniferous bog	100	8	Well 10M	1598.3	1598.4	1598.6	1597.8	1579.4
Coniferous bog	100	8	Well 10R	---	---	---	1598.2	1579.4
Coniferous bog	100	8	Well 11M	1597.4	1597.2	1597.3	1598.3	1574.3
Coniferous bog	100	8	Well 11R	---	---	---	1598.4	1574.3
Coniferous bog	100	8	Well 12M	1592.4	1592.1	1592.1	1592.1	1572.1
Coniferous bog	100	8	Well 12R	1591.6	1591.2	1591.9	1592.0	1572.1
Coniferous bog	100	8	Well 18M	1595.4	1595.5	1595.4	1595.9	1586.0
Coniferous bog	100	8	Well 18R	---	---	---	1596.0	1586.0
Coniferous bog	103	8	Well 3M	1597.0	1596.9	1596.8	---	---
Coniferous bog	103	8	Well 17M	1599.2	1599.1	1599.1	---	1595.8
Coniferous bog	106	8	Well 8M	1564.1	1563.8	1563.6	1563.6	1595.7
Coniferous bog	106	8	Well 8R	---	---	---	1563.7	1585.6
Coniferous bog	114	8	Well 4M	1615.7	1615.4	1615.5	1615.4	1585.6
Coniferous bog	114	8	Well 4R	1615.5	1615.6	1616.1	1615.2	1589.6
Coniferous bog	114	8	Well 4AM	1597.8	1598.0	1597.9	1597.7	1589.5
Coniferous bog	114	8	Well 4AR	---	---	---	1597.6	1597.8
Coniferous bog	114	8	Well 5M	1615.5	1615.6	1615.5	1615.3	1597.9
Coniferous bog	---	8	Well Ref1M	---	---	---	1592.7	1592.5
Coniferous bog	---	8	Well Ref1R	---	---	---	1592.5	1592.4
Alder thicket	53	6	Well 7M	1558.4	1557.9	1558.4	1558.2	1597.8
Alder thicket	53	6	Well 7R	1557.9	1558.0	1559.1	1558.1	1615.4
Alder thicket	54	6	Well 6M	1597.8	1597.8	1597.4	1597.9	1597.8
Alder thicket	54	6	Well 6R	---	---	---	1597.6	1597.8
Alder thicket	58	6	Well 9M	1565.8	1565.7	1565.8	1565.5	1558.2
Alder thicket	58	6	Well 9R	---	---	---	1565.5	1558.4
Alder thicket	---	6	Well Ref2M	---	---	---	1573.6	1573.6
Alder thicket	---	6	Well Ref2R	---	---	---	1574.0	1573.7



R = Recording well and "M" = Manual well
Continuous lines without points
represent recording wells; lines
with points represent manual wells

Figure 1
2008-2009 WETLAND HYDROLOGY MONITORING DATA
WELLS IN ALDER THICKETS
PolyMet Mining
Hoyt Lakes, Minnesota



R = Recording well and "M" = Manual well
Continuous lines without points
represent recording wells; lines
with points represent manual wells

Figure 2
2008-2009 WETLAND HYDROLOGY MONITORING DATA
WELLS IN CONIFEROUS BOGS
PolyMet Mining
Hoyt Lakes, Minnesota

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