Mine Pool Prediction & Validation Oversight Study

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SMCRA = Science-based permitting

1. **PERMIT APPLICATION:**

   Baseline data monitoring (30 CFR 780.21(b)) (Applicant)

   Probable Hydrologic Consequences (780.21(f)) (Applicant)

   Hydrologic Reclamation Plan (780.21(h)) (Applicant)

   Cumulative Hydrologic Impact Assessment: (780.21(g)) (Regulatory Authority)

2. **PERMIT ISSUANCE:**
   Material Damage Finding: (773.15(e))

3. **MINING PHASE:**
   Quarterly Monitoring (780.21(i))

4. **BOND RELEASE:**
   Hydrologic Evaluation (800.40(b))

Probable Hydrologic Consequences: **Surface Mine** on Acidic Seam

* Probable Hydrologic Consequence of developing a **Surface Mine** into an **acidic Coal seam**?
  - Prediction: Low pH Water with elevated Aluminum & Iron

* Hydrologic Reclamation Plan to "minimize disturbances to hydrologic balance"?
  - Alkaline addition & special handling plan of acid forming materials to control the formation and evolution of AMD

Probable Hydrologic Consequences: **Underground Mine** on Acidic Seam

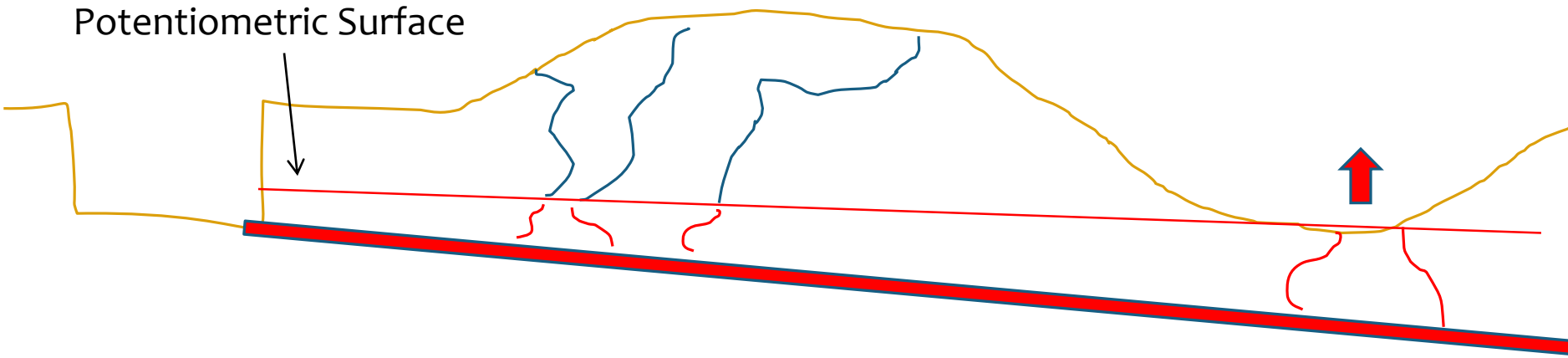
* Probable Hydrologic Consequence of developing an **underground mine** into an **acidic Coal seam**?
  - Flooded Mine Pool will be circumneutral pH, elevated Iron, net acidic or net alkaline

* Hydrologic Reclamation Plan to "minimize disturbances to hydrologic balance"
  - Design a mine plan that promotes inundation and prevent a point source discharge from the mine pool
    - Requires a prediction of the post-mining pool elevation

Mine Pool Predictions

* Potentiometric Surface of the mine pool defines where water can and cannot flow and defines flooding extent

* In part, Mining plans are evaluated based on whether the post-mining potentiometric surface will be > than land surface overtop and adjacent to the mine



8.5 Prediction of Hydrologic Consequences/Protection of Hydrologic Balance.

a) For underground mining activities -

1) Describe the quality and volume of mine drainage which is anticipated at the end of the 5-year permit period and upon complete development of the planned mine. Describe the methodology and/or calculations used to estimate the drainage characteristics.

Based on the past experience in the underground mining, the mine workings will generate an estimated 0.5 gpm of drainage for each acre of mine workings. It is anticipated that 120 acres will be mined on a yearly basis. Using the information provided, the volume of the mine drainage anticipated at the end of the 5-year period as follows:

(5 years x 120 acres) x 0.5gpm = 300 gpm

and, upon complete development:

1281 acres x 0.5gpm = 640.5 gpm

It should be understood that these volume rates are approximate and may be affected by numerous variables throughout the life of the operation, including the placement of internal water seals, unmineable areas, etc. Mine water discharge associated with existing underground mines on the Upper Freeport coal seam exhibit good quality.

See Pages 8.5a-1 through 8.5a-3 for the expected volume of water that the pit will produce while active. The study was performed at the Darmac No. 2 box cut. Darmac No. 2 is also in the Upper Freeport seam and is similar in size to the proposed pit.

2) Estimate the postmining pool level, and indicate the basis for this estimate.

The postmining pool level is estimated to crest at 950. The basis for this estimate is that 950 will be the highest point of coal elevation encountered during the mining operation.

3) Describe the barrier pillars which will be left around the perimeter of the mine to promote flooding, and the basis for the barrier design. Barrier pillar design must be customized to fit site conditions. Provide data gathered at the site which confirms assumptions regarding barrier width and integrity.

Programmatic Oversight Study

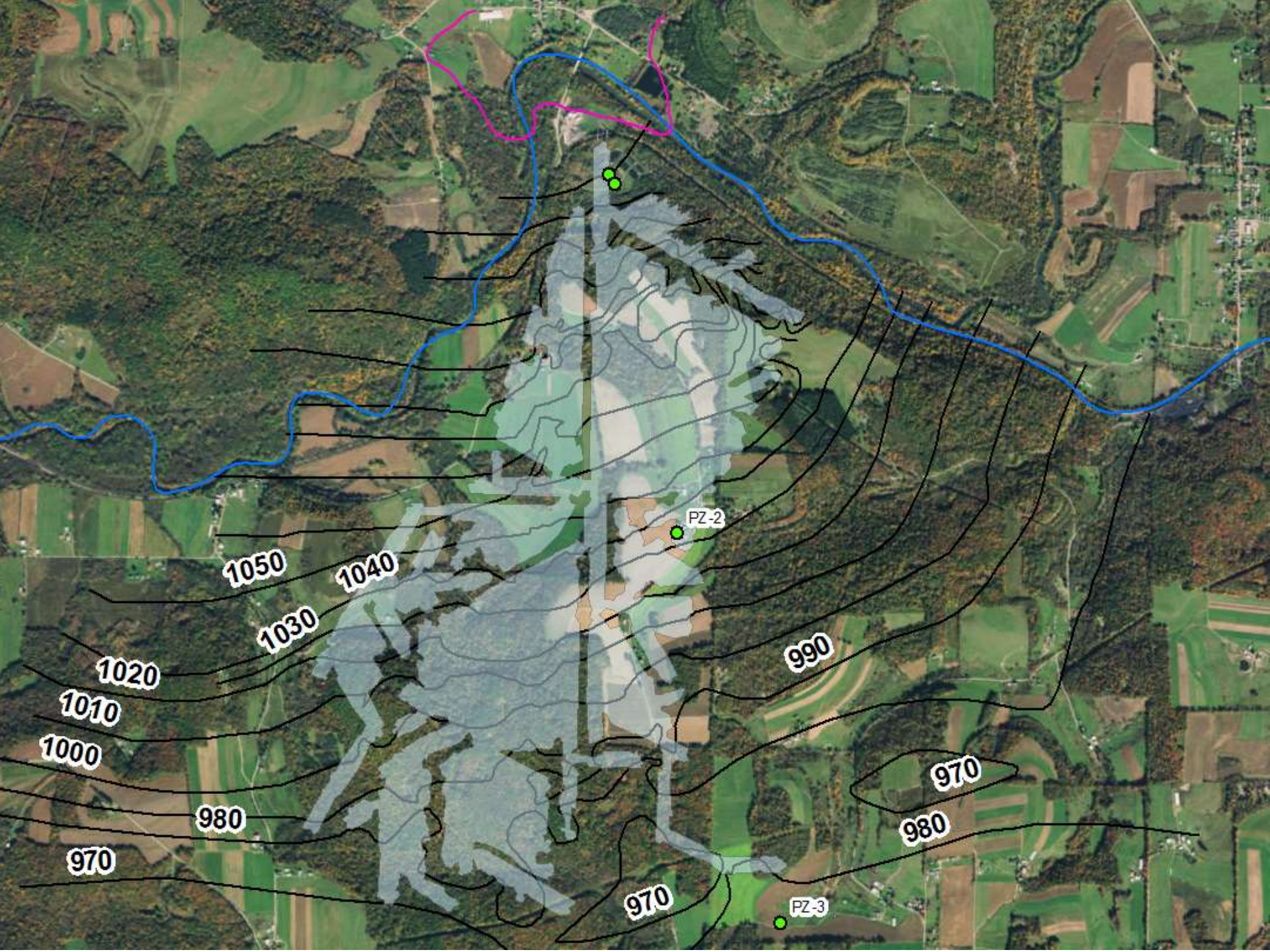
* Compare Predicted Pool Elevations to Actual Pool Elevations
* Quantify the "discharge risk" caused by actual vs predicted discrepancy
* Attempt to identify any existing data that would have resulted in an improved prediction
* Conduct site inspections in areas where mine pool elevation > land surface to ensure pollutional discharges aren't occurring

** Discharge Risk = Area where piezometric surface of mine pool > land surface (note overburden thickness)

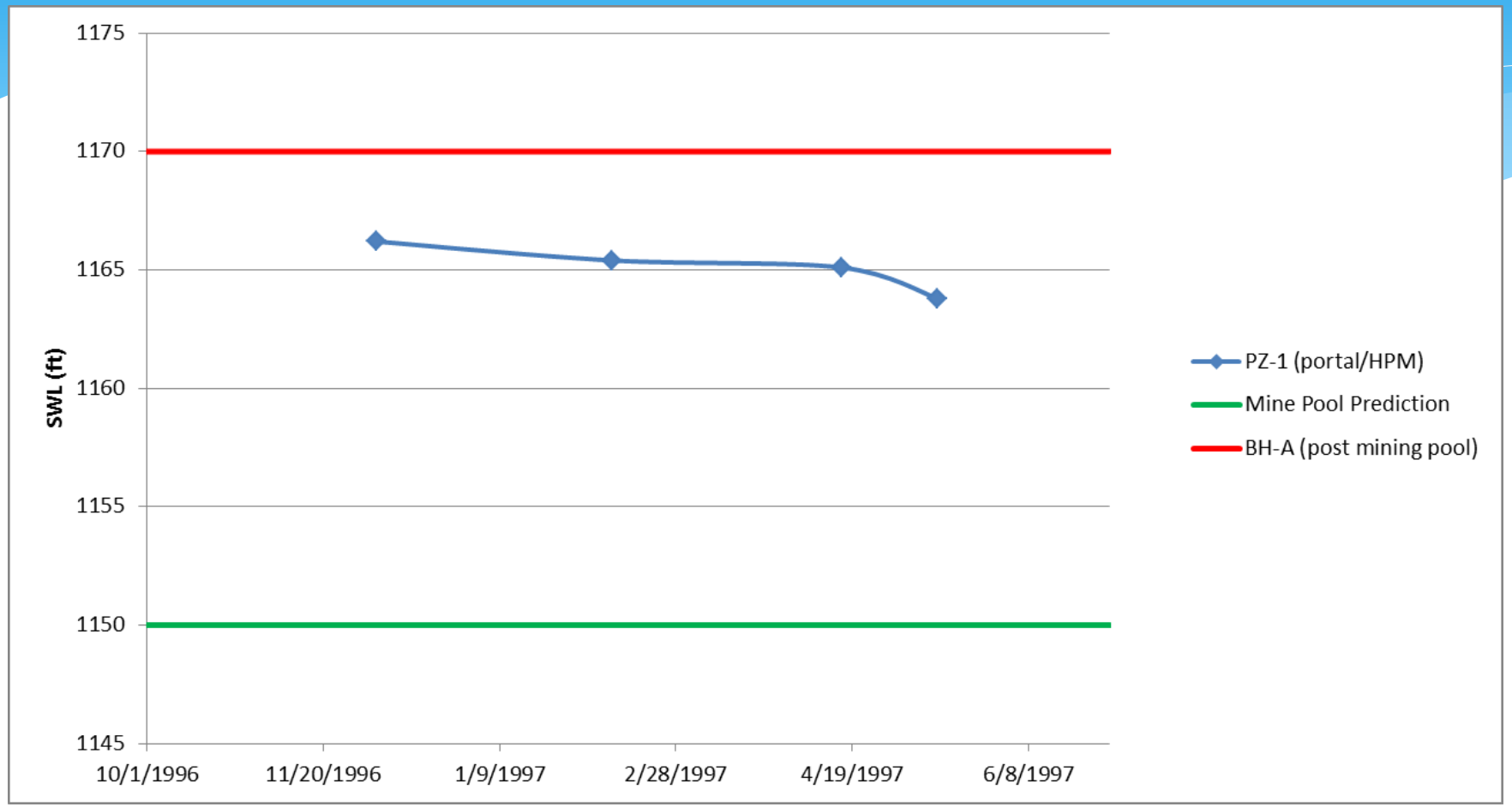
Validation Results

Mine	Prediction (ft)	Actual (ft)	Discrepancy (ft)	Basis
Mine 1	968	1002	+34	HPM

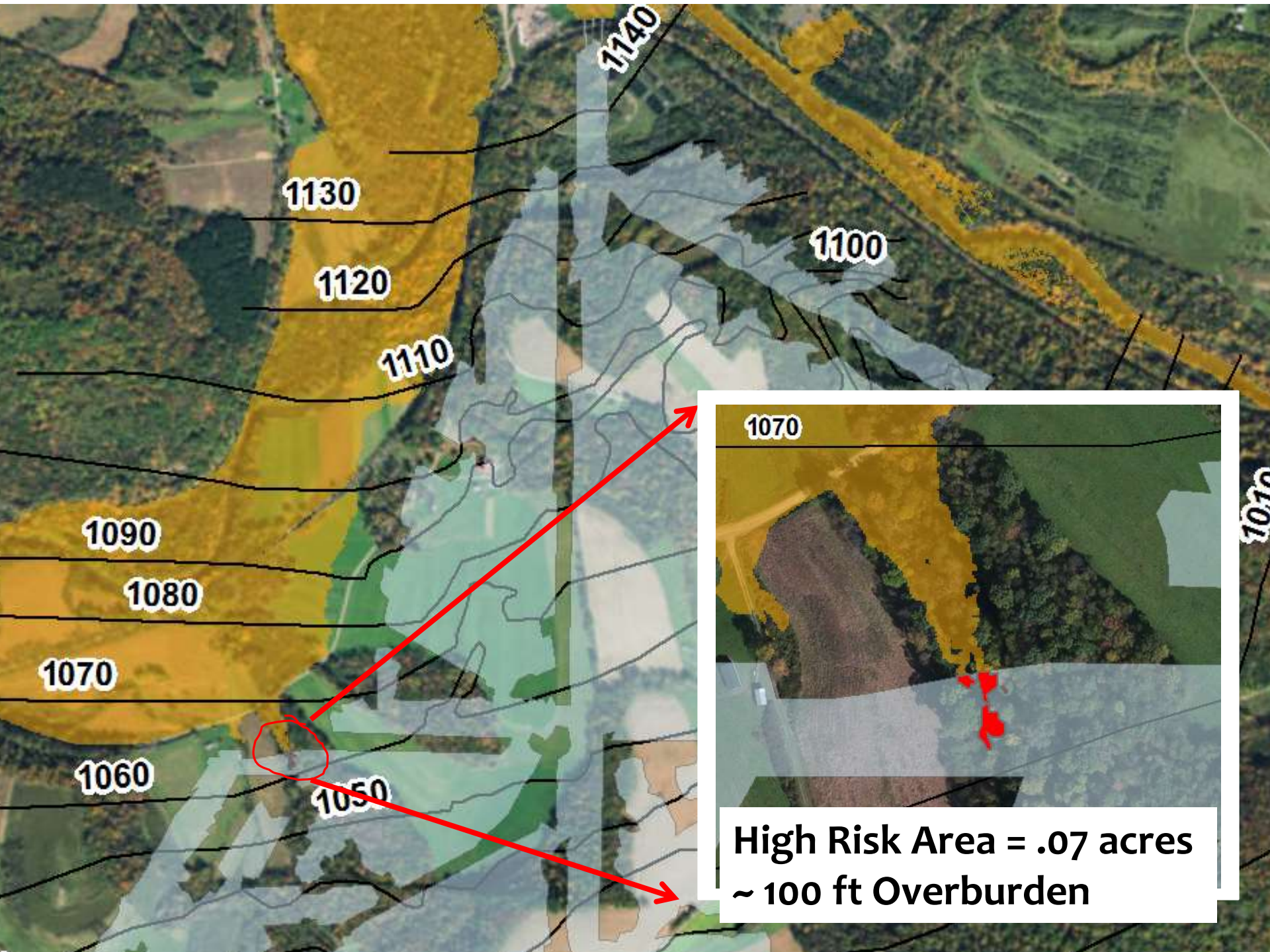
HPM = High Point of Mining

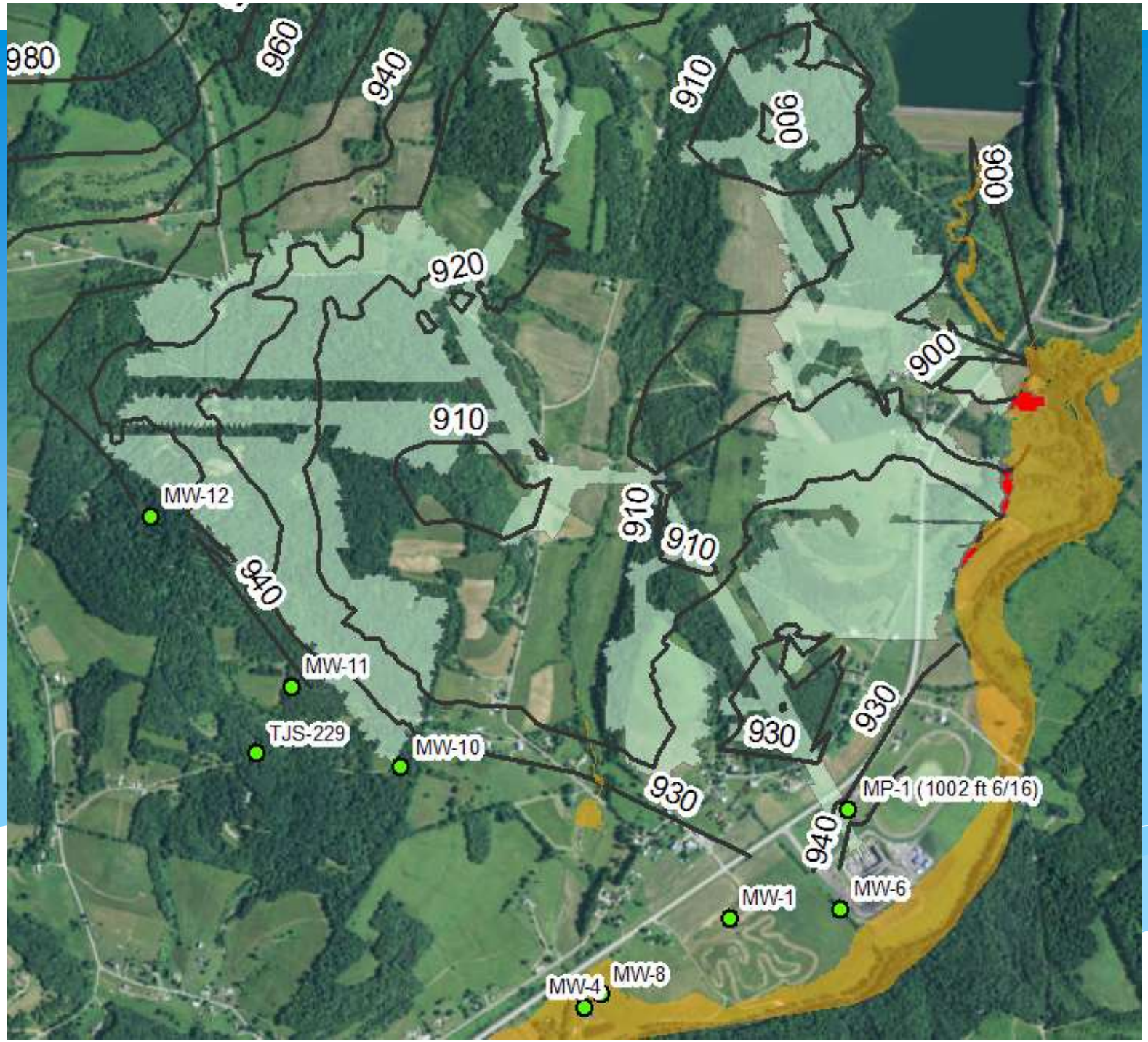

PZ -2
PZ -3
1050
1040
1030
1020
1010
1000
990
980
970
980
970
970

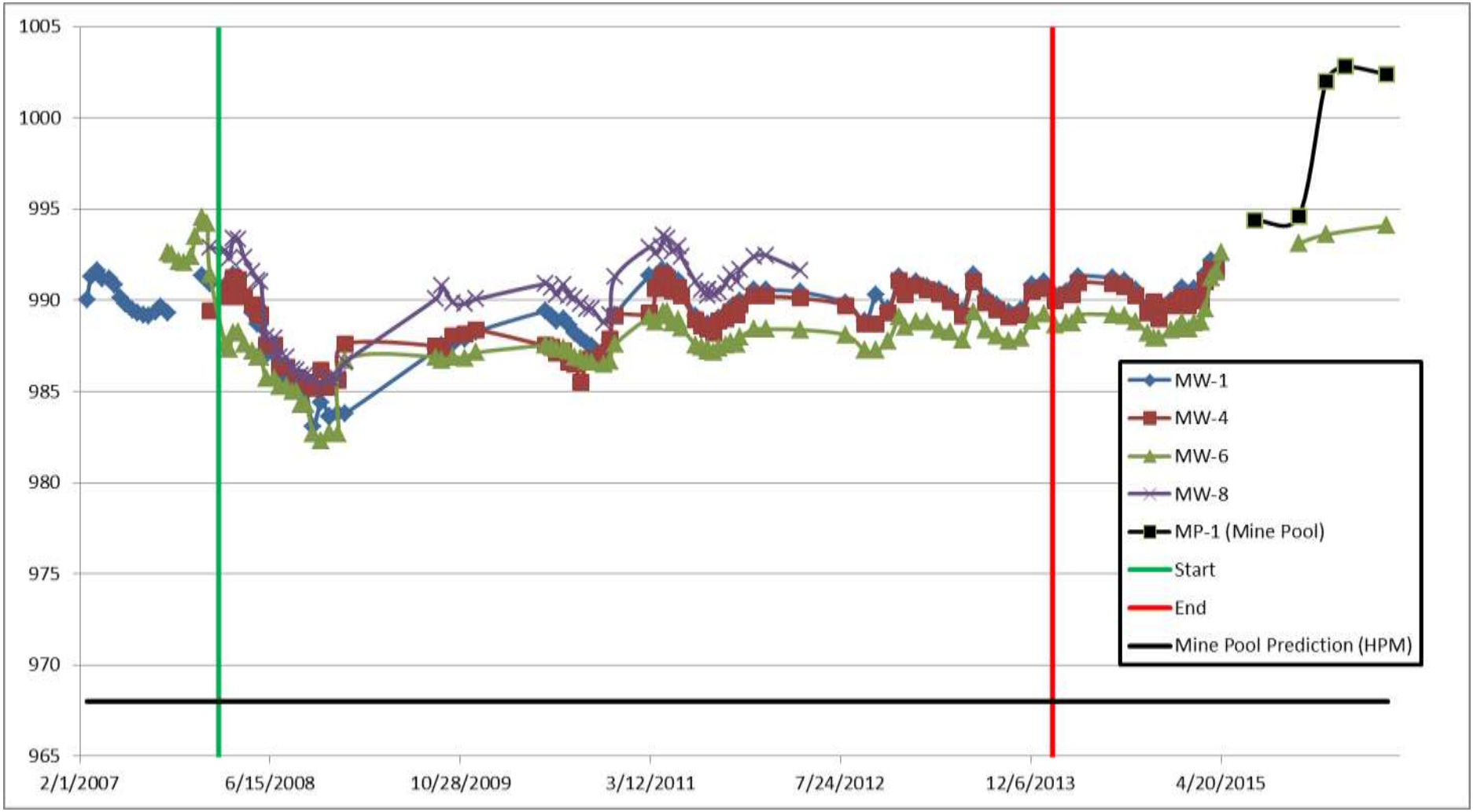
Prediction Validation

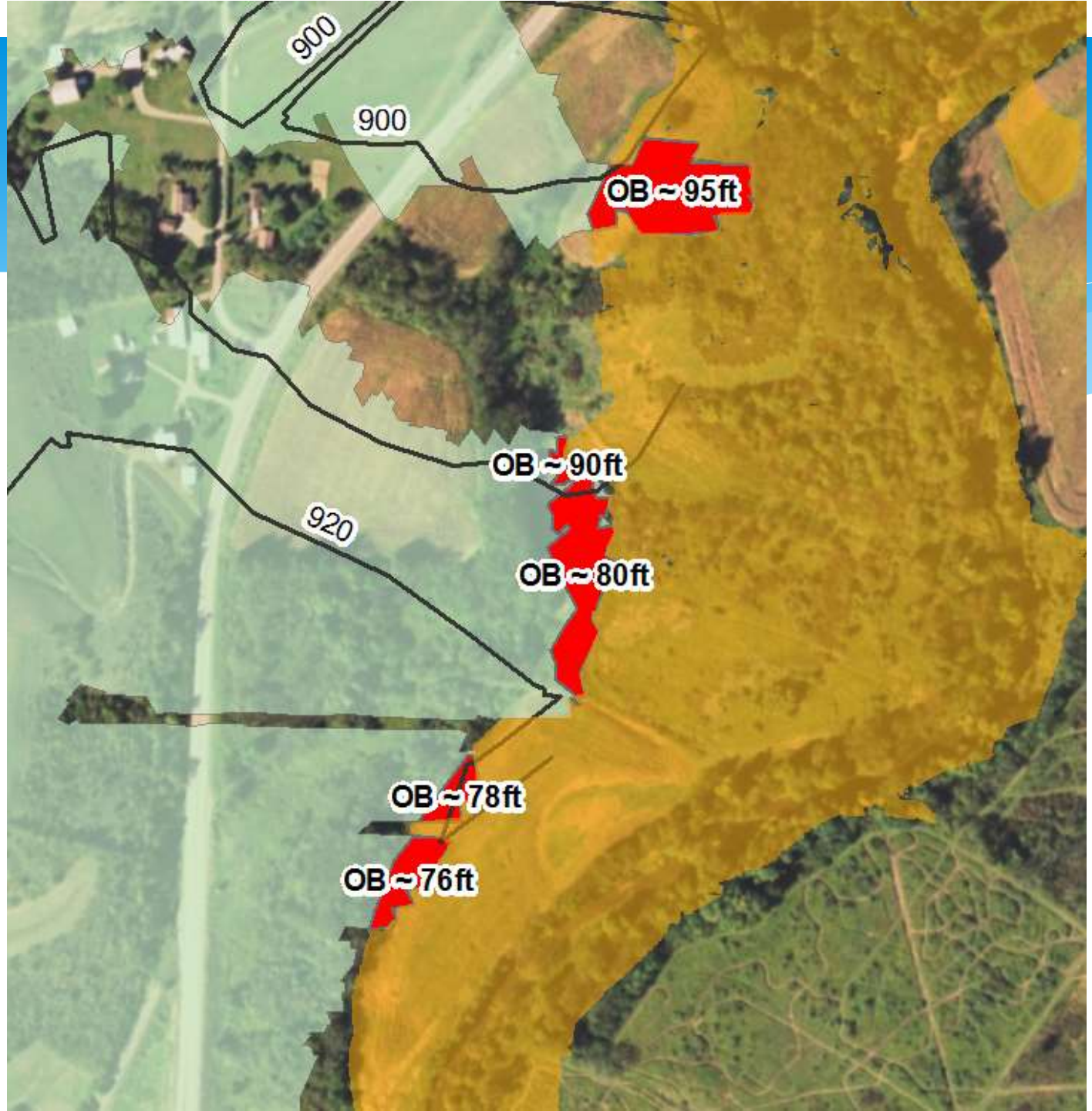


** Note post-mining head is slightly higher

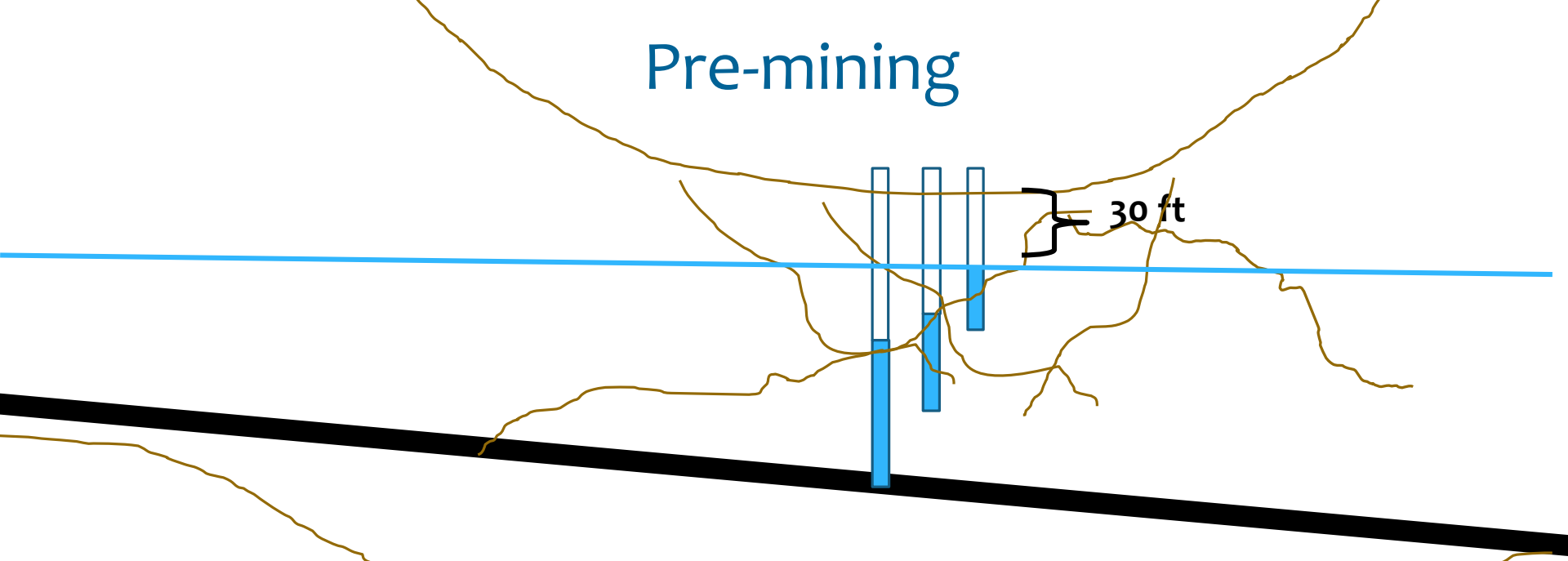

1140
1130
1100
1120
1110
1090
1080
1070
1060
1050
1070
High Risk Area = .07 acres
~ 100 ft Overburden


980
960
940
910
900
900
920
910
900
910
910
910
940
MW-12
MW-11
TJS-229
MW-10
930
930
930
MP-1 (1002 ft 6/16)
940
MW-1
MW-6
MW-4
MW-8


1005
1000
995
990
985
980
975
970
965
2/1/2007
6/15/2008
10/28/2009
3/12/2011
7/24/2012
12/6/2013
4/20/2015
MW-1
MW-4
MW-6
MW-8
MP-1 (Mine Pool)
Start
End
Mine Pool Prediction (HPM)

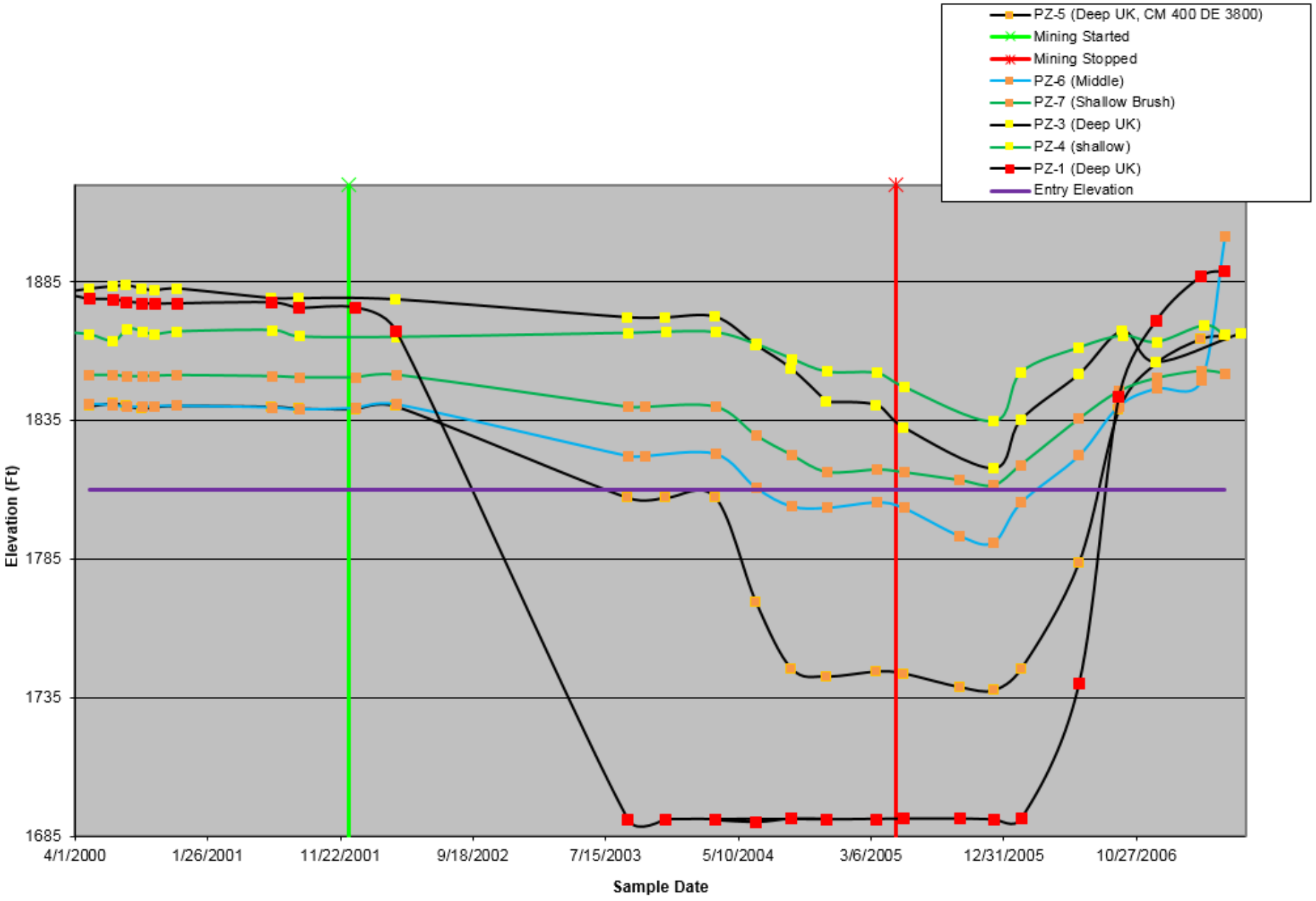

900
900
OB ~ 95ft
OB ~ 90ft
920
OB ~ 80ft
OB ~ 78ft
OB ~ 76ft

Pre-mining



Post-mining

Question: How will removing coal (affect K/T) change post-mining head for entire system


PZ-5 (Deep UK, CM 400 DE 3800)
Mining Started
Mining Stopped
PZ-6 (Middle)
PZ-7 (Shallow Brush)
PZ-3 (Deep UK)
PZ-4 (shallow)
PZ-1 (Deep UK)
Entry Elevation
Elevation (Ft)
1885
1835
1785
1735
1685
4/1/2000
1/26/2001
11/22/2001
9/18/2002
7/15/2003
5/10/2004
3/6/2005
12/31/2005
10/27/2006
Sample Date

Summary Results

Mine	Prediction Based on HPM* (ft)	Actual (ft)	Discrepancy (ft)	Prediction using Pre Mining PZ	Discrepancy (ft)
Mine 1	968	1002	+34	996	+6
Mine 2	1150	1170	+20	1166	+4
Mine 3	1180	1225	+45	1249	-24 ft
Mine 4	1810	1897	+87	1877	+20

* HPM = High point of mining

Summary

* A reliable cost-effective prediction method for UG mines is needed, similar to ABA for surface mines ;
* ~ 40 UG mines (7 BF) treatment liability of ~ $250 Million
* Using pre-mining piezometer data from the coal seam near the HPM is a better predictive tool than High Point of Mining
* Developing/Optimizing a predictive method would be a great applied-science project or student thesis