



Hecla

Greens Creek

2010 FWMP Presentation

Tailings Area Fresh Water Monitoring Program



- Comparison against AWQS
- Upgradient / Downgradient comparative graphs for SC, SO₄, Pb, & Zn
- Review of statistical tests for trends
- Continued collection of data from Tributary Creek (Site 9) and Lower Althea (Site 60)

- **Site 58 "MW-T-00-01C"**
 - Up-gradient reference site, located to the northeast of Tailings Area
- **Site 27 "MW-2S"**
 - Down-gradient groundwater site, located south of Tailings Area
- **Site 29 "MW-3S"**
 - Down-gradient groundwater site, located west of Tailings Area
- **Site 32 "MW-5"**
 - Down-gradient groundwater site, located west of Tailings Area

- **Site 59 "MW-T-00-01A"**
 - Up-gradient reference site, located to the northeast of Tailings Area, completed in glacial till
- **Site 28 "MW-2D"**
 - Down-gradient groundwater site, located south of Tailings Area, completed in marine silts/clays

- **Site 9 “Tributary Creek”**
 - Down-gradient surface site, located approximately 1 mile from the tailings pile
- **Site 60 “Lower Althea Creek”**
 - Down-gradient surface site, approximately ¼ mile west of Pond 7

Tailings Area Shallow Wells (PEAT)

- Site 58 "MW-T-00-01C"
- Site 27 "MW-2S"
- Site 29 "MW-3S"
- Site 32 "MW-5"

AWQS Exceedances

| Site | Date | Parameter | Value | Hardness (mg/L) | Standard | Standard Type |
|------|-----------|------------------------|-------|-----------------|----------|-----------------------|
| 58 | 11-May-10 | Alkalinity Total, mg/L | 16.9 | | 20 | Aquatic Life, chronic |
| 58 | 11-May-10 | pH Field, su | 5.12 | | 6.5 | Aquatic Life, chronic |
| 58 | 11-May-10 | pH Lab, su | 6.04 | | 6.5 | Aquatic Life, chronic |
| 58 | 13-Jul-10 | pH Field, su | 5.33 | | 6.5 | Aquatic Life, chronic |
| 58 | 13-Jul-10 | pH Lab, su | 5.3 | | 6.5 | Aquatic Life, chronic |
| 58 | 21-Sep-10 | pH Field, su | 6.18 | | 6.5 | Aquatic Life, chronic |
| 58 | 21-Sep-10 | pH Lab, su | 5.41 | | 6.5 | Aquatic Life, chronic |
| 27 | 11-May-10 | pH Field, su | 5.57 | | 6.5 | Aquatic Life, chronic |
| 27 | 11-May-10 | pH Lab, su | 5.97 | | 6.5 | Aquatic Life, chronic |
| 27 | 13-Jul-10 | pH Field, su | 5.5 | | 6.5 | Aquatic Life, chronic |
| 27 | 13-Jul-10 | pH Lab, su | 5.14 | | 6.5 | Aquatic Life, chronic |
| 27 | 21-Sep-10 | pH Field, su | 6.18 | | 6.5 | Aquatic Life, chronic |
| 27 | 21-Sep-10 | pH Lab, su | 5.48 | | 6.5 | Aquatic Life, chronic |
| 29 | 11-May-10 | Alkalinity Total, mg/L | 8.7 | | 20 | Aquatic Life, chronic |
| 29 | 11-May-10 | pH Field, su | 4.47 | | 6.5 | Aquatic Life, chronic |
| 29 | 11-May-10 | pH Lab, su | 5.27 | | 6.5 | Aquatic Life, chronic |
| 29 | 13-Jul-10 | Alkalinity Total, mg/L | 10.5 | | 20 | Aquatic Life, chronic |
| 29 | 13-Jul-10 | Lead, Dissolved ug/L | 0.679 | 21.9 | 0.54 | Aquatic Life, chronic |
| 29 | 13-Jul-10 | pH Field, su | 4.76 | | 6.5 | Aquatic Life, chronic |
| 29 | 13-Jul-10 | pH Lab, su | 4.6 | | 6.5 | Aquatic Life, chronic |
| 29 | 21-Sep-10 | Alkalinity Total, mg/L | -1 | | 20 | Aquatic Life, chronic |
| 29 | 21-Sep-10 | pH Field, su | 4.93 | | 6.5 | Aquatic Life, chronic |
| 29 | 21-Sep-10 | pH Lab, su | 4.32 | | 6.5 | Aquatic Life, chronic |

AWQS Exceedances (continued)

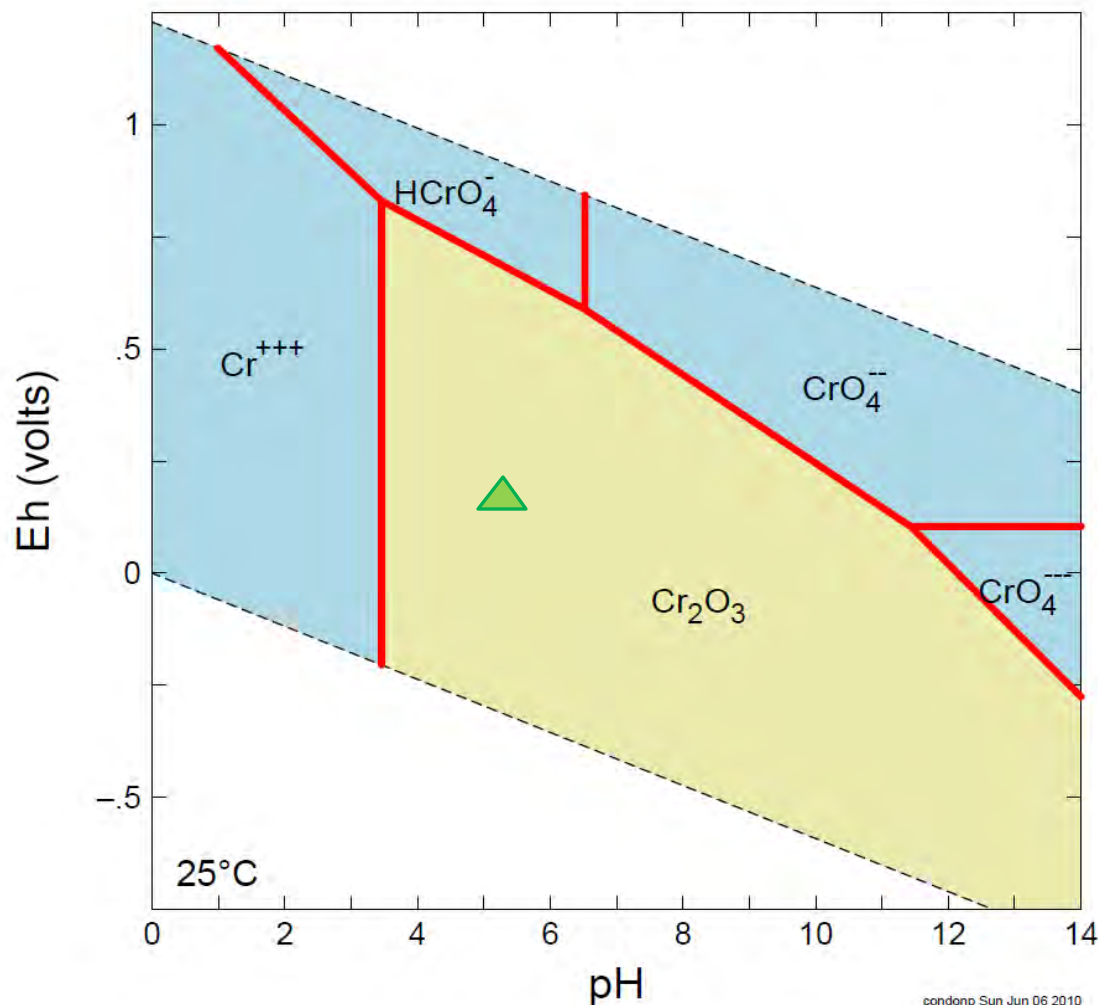
| Site | Date | Parameter | Value | Hardness (mg/L) | Standard | Standard Type |
|------|-----------|--------------------------|-------|-----------------|----------|-----------------------|
| 32 | 11-May-10 | Alkalinity Total, mg/L | 6.4 | | 20 | Aquatic Life, chronic |
| 32 | 11-May-10 | Chromium, Dissolved µg/L | 11.7 | | 11 | Aquatic Life, chronic |
| 32 | 11-May-10 | Lead, Dissolved ug/L | 1.79 | 9.64 | 0.54 | Aquatic Life, chronic |
| 32 | 11-May-10 | pH Field, su | 4.64 | | 6.5 | Aquatic Life, chronic |
| 32 | 11-May-10 | pH Lab, su | 5.23 | | 6.5 | Aquatic Life, chronic |
| 32 | 13-Jul-10 | Alkalinity Total, mg/L | -1 | | 20 | Aquatic Life, chronic |
| 32 | 13-Jul-10 | Lead, Dissolved ug/L | 2.34 | 9.17 | 0.54 | Aquatic Life, chronic |
| 32 | 13-Jul-10 | pH Field, su | 4.75 | | 6.5 | Aquatic Life, chronic |
| 32 | 13-Jul-10 | pH Lab, su | 4.48 | | 6.5 | Aquatic Life, chronic |
| 32 | 21-Sep-10 | Alkalinity Total, mg/L | -1 | | 20 | Aquatic Life, chronic |
| 32 | 21-Sep-10 | Lead, Dissolved ug/L | 1.84 | 8.05 | 0.54 | Aquatic Life, chronic |
| 32 | 21-Sep-10 | pH Field, su | 5.15 | | 6.5 | Aquatic Life, chronic |
| 32 | 21-Sep-10 | pH Lab, su | 4.5 | | 6.5 | Aquatic Life, chronic |


Alaska Water Quality Standards (AWQS) Exceedances



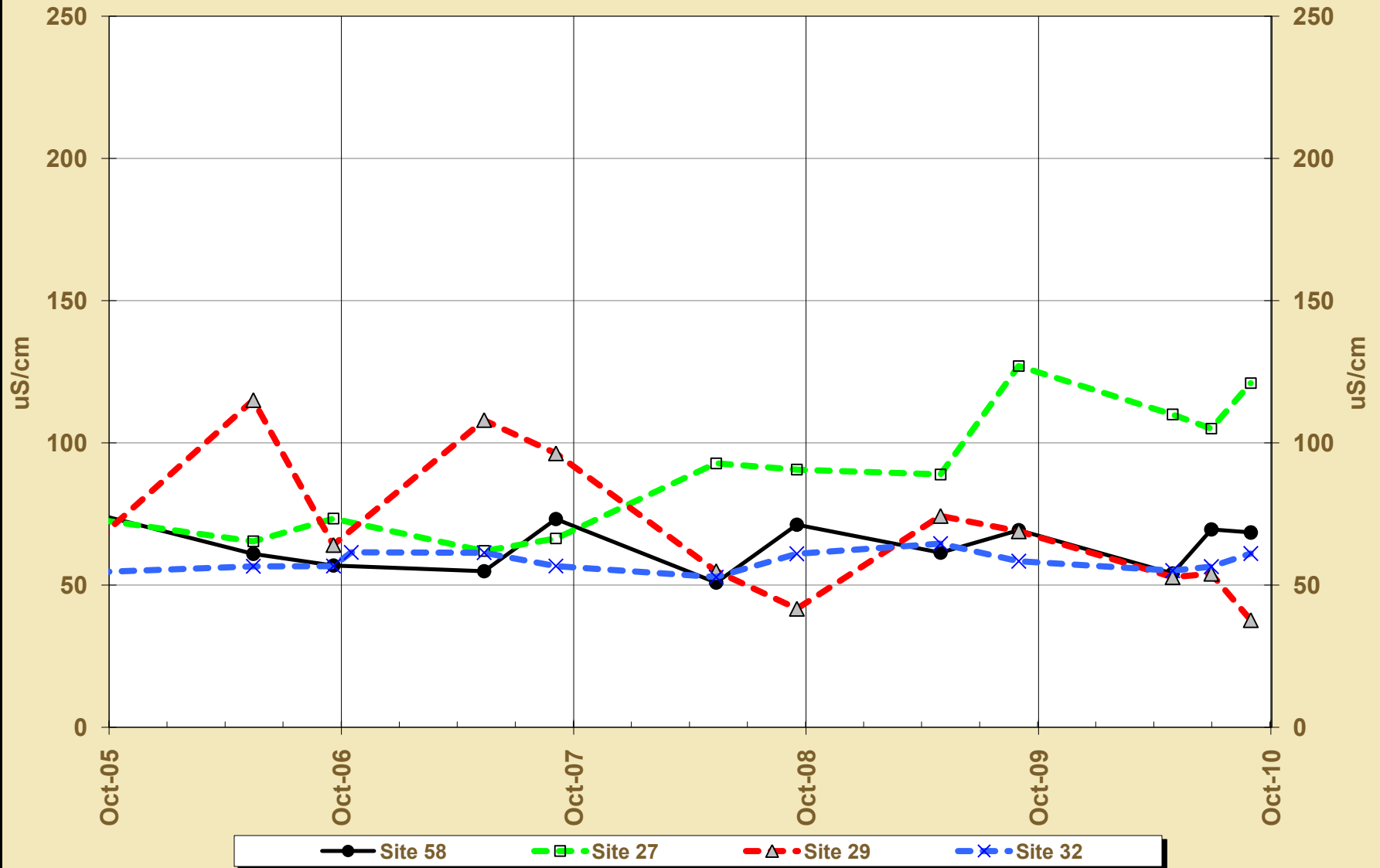
- Shallow wells continue historic trends in low pH, low alkalinity, and elevated lead.
- Shallow well site 32 had exceedances for dissolved chromium during the May sampling. For the May 2011 FWMP sampling, chromium was analyzed for Cr(III) and CR(VI).
- New, lower drinking water standard for arsenic (changed from 50 $\mu\text{g}/\text{l}$ to 10 $\mu\text{g}/\text{l}$) continues to result in exceedances for arsenic at shallow well Site 29.
1988 – present: mean = 17.1 +/- 7.3 $\mu\text{g}/\text{L}$; n=105

Alaska Water Quality Standards (AWQS) Exceedances



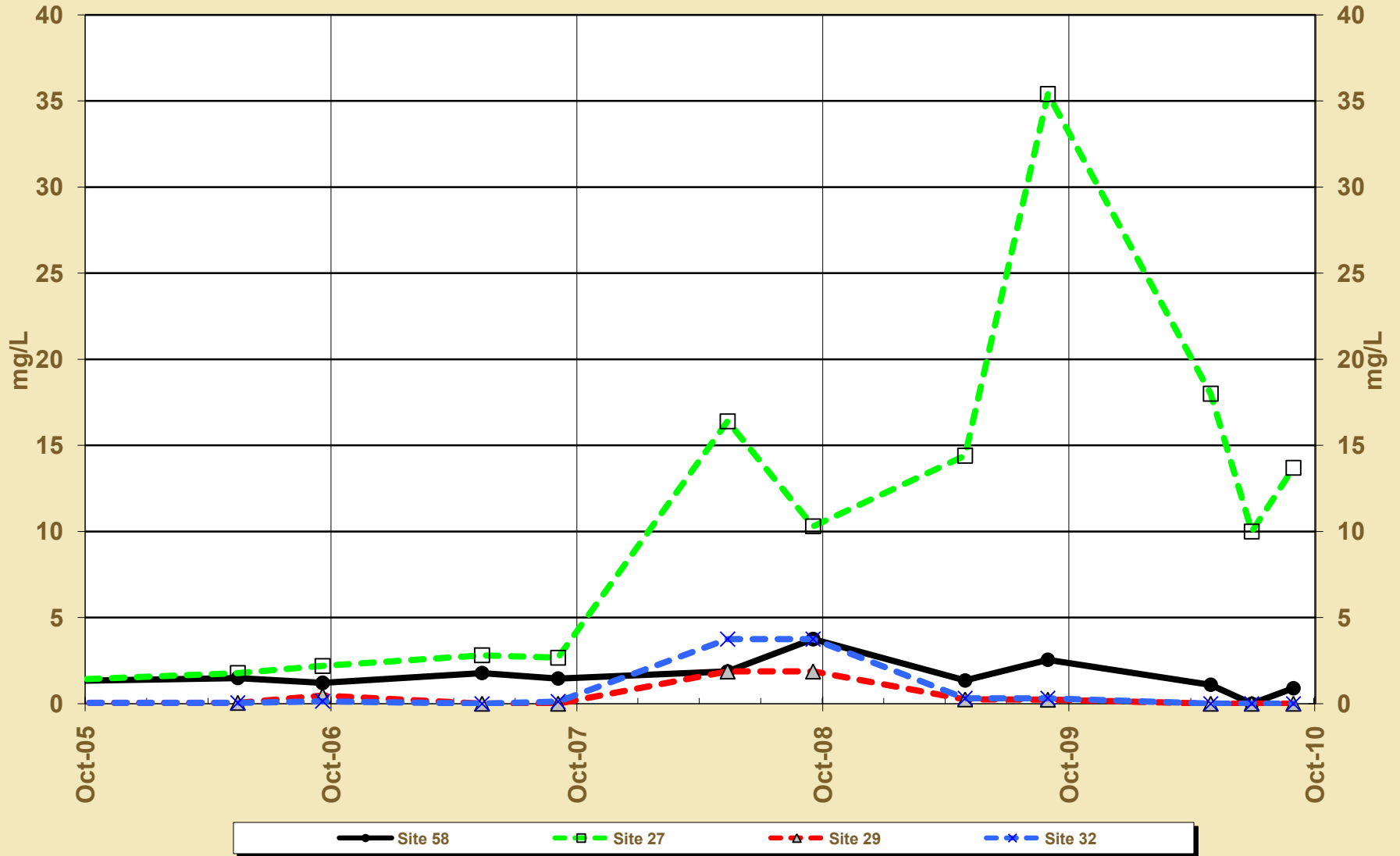
- AWQS is for Cr(VI)
- Analyzed for unspicated dissolved chromium
- Speciation results in Cr existing as Cr(III).
- AWQS for Cr(III) is hardness dependent
- Hardness of 20mg/L results in upper limit of 24 μ g/L.
- May 2011 
 - Eh.18 volts
 - pH = 5.16 s.u.

Tailings (Shallow Wells) - Specific Conductance



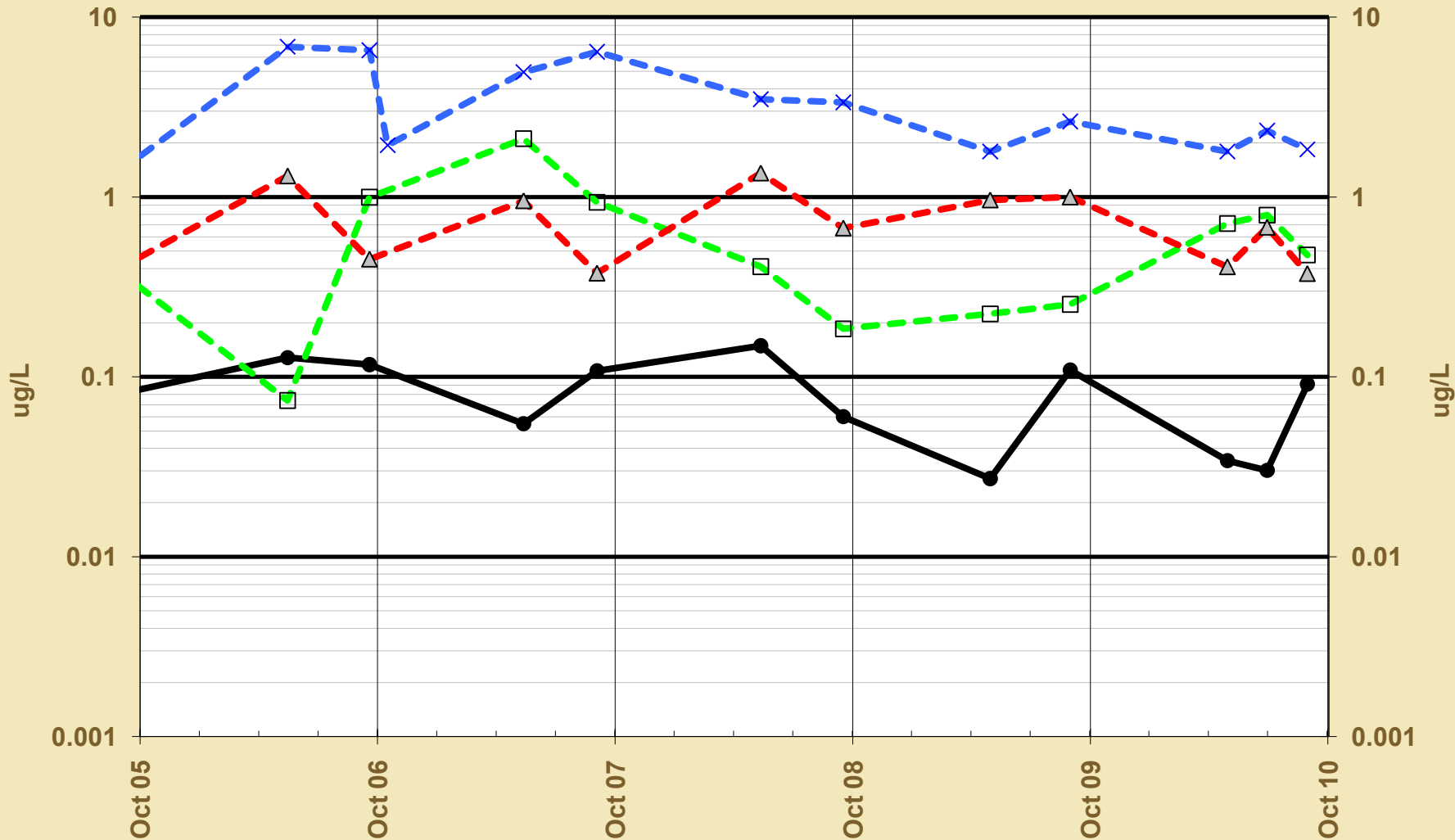
Tailings (Shallow Wells) - Total Sulfate

(Note: Value reports as <MDL plotted at MDL/2)



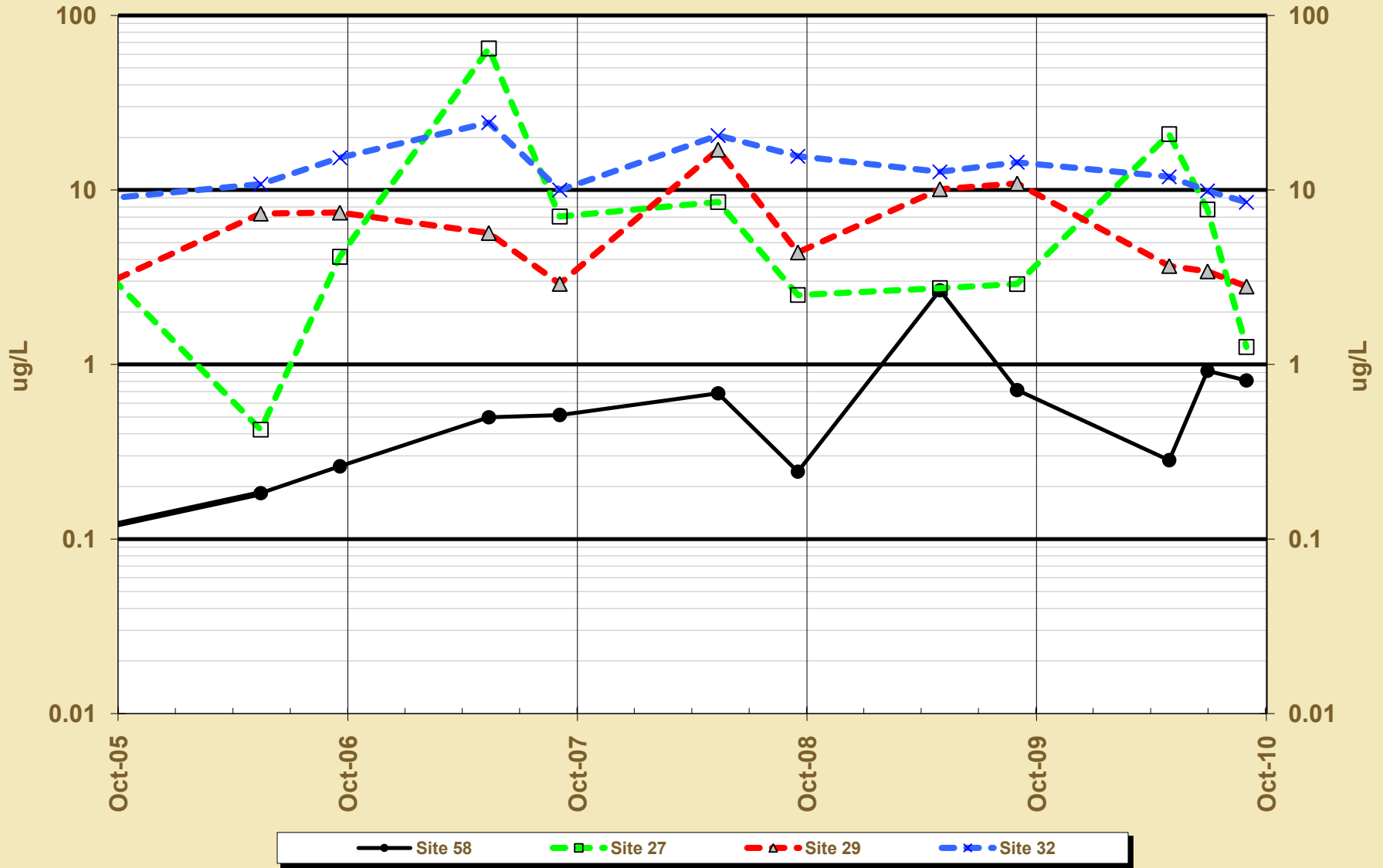
Tailings (Shallow Wells) - Dissolved Lead

(Note: Values reported as <MDL plotted at MDL/2)



Tailings (Shallow Wells) - Dissolved Zinc

(Note: Values reported as <MDL are plotted at 1/2MDL)



Tailings Shallow Wells-Statistical Trends

2010 Water Year

Mann-Kendall Seasonal Trend Test Probabilities

| Site | Cond. | pH | Alkalinity | Sulfate | Diss.-Zinc |
|------|-------------|------|-------------|-------------|------------|
| 58 | 0.04 | 0.15 | 0.07 | 0.12 | 0.93 |
| 27 | 0.98 | 0.82 | 0.18 | 1.00 | 0.45 |
| 29 | 0.04 | 0.18 | 0.02 | * | 0.55 |
| 32 | 0.91 | 0.30 | 0.04 | * | 0.55 |

Sen's slope estimate

| Site | µS/cm/yr | su/yr | mg/L/yr | µg/L/yr | µg/L/yr |
|------|--------------|-------|--------------|--------------|---------|
| 58 | | | | | |
| 27 | +9.10 | | | +3.52 | |
| 29 | | | -6.07 | | |
| 32 | | | | | |

Tailings Area Deep Wells (Glacial / Marine Till)

- Site 59 "MW-T-00-01A"
- Site 28 " MW-2D"

AWQS Exceedances Site 59 & 28



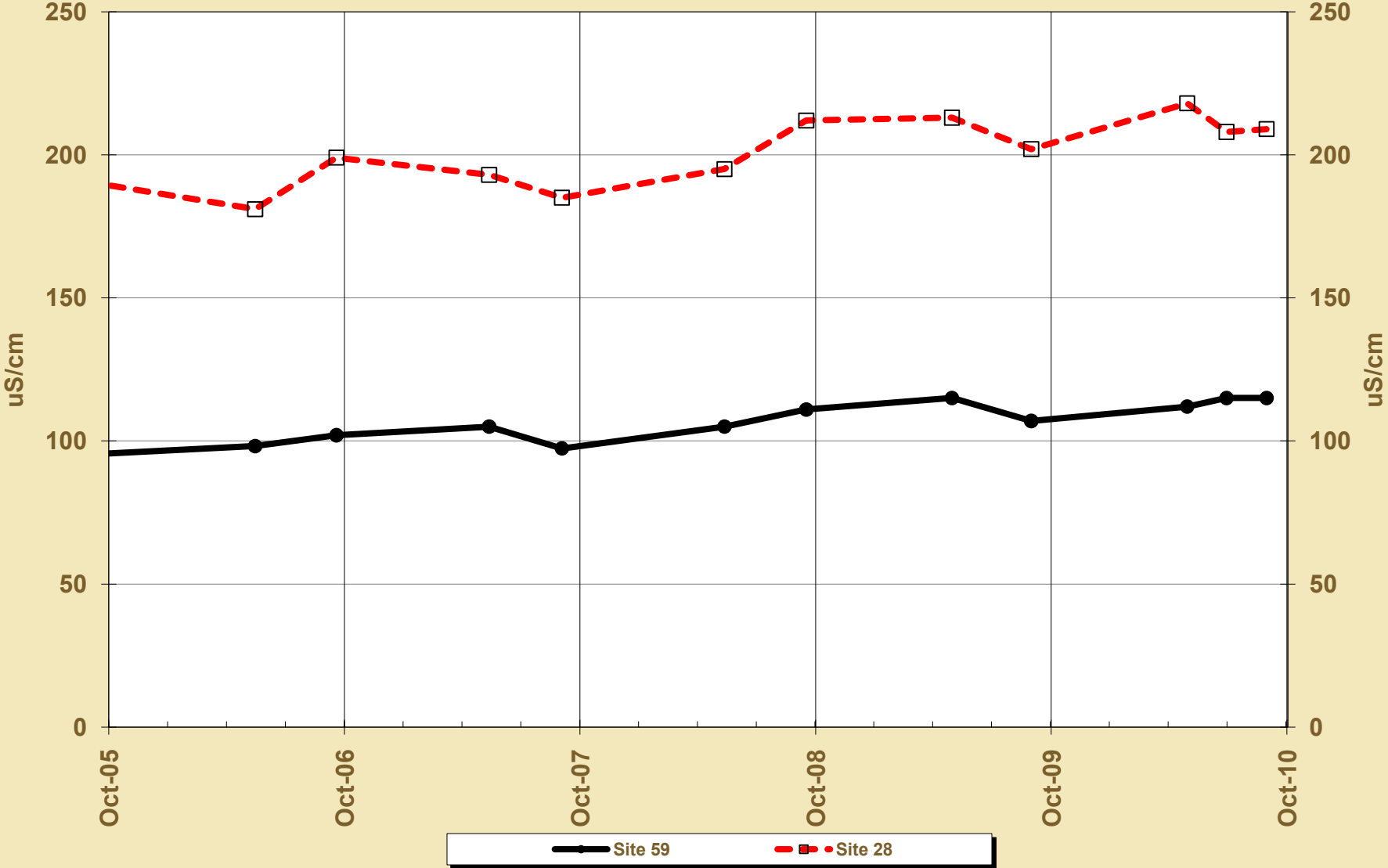
| Site | Date | Parameter | Value | Hardness (mg/L) | Standard | Standard Type |
|------|-----------|------------------------|-------|-----------------|----------|-----------------------|
| 59 | 11-May-10 | pH Field, su | 5.85 | | 6.5 | Aquatic Life, chronic |
| 59 | 13-Jul-10 | pH Field, su | 6.1 | | 6.5 | Aquatic Life, chronic |
| 59 | 13-Jul-10 | pH Lab, su | 6.38 | | 6.5 | Aquatic Life, chronic |
| 59 | 21-Sep-10 | pH Lab, su | 6.11 | | 6.5 | Aquatic Life, chronic |
| 28 | 11-May-10 | Arsenic Dissolved ug/L | 75.1 | | 10 | Aquatic Life, chronic |
| 28 | 13-Jul-10 | Arsenic Dissolved ug/L | 72.8 | | 10 | Aquatic Life, chronic |
| 28 | 21-Sep-10 | pH Field, su | 8.67 | | 8.5 | Aquatic Life, chronic |
| 28 | 21-Sep-10 | Arsenic Dissolved ug/L | 68.5 | | 10 | Aquatic Life, chronic |

The downgradient deep well continues having arsenic levels in exceedance of the AWQS, however these values are similar to the historic measurements.

1988 – present

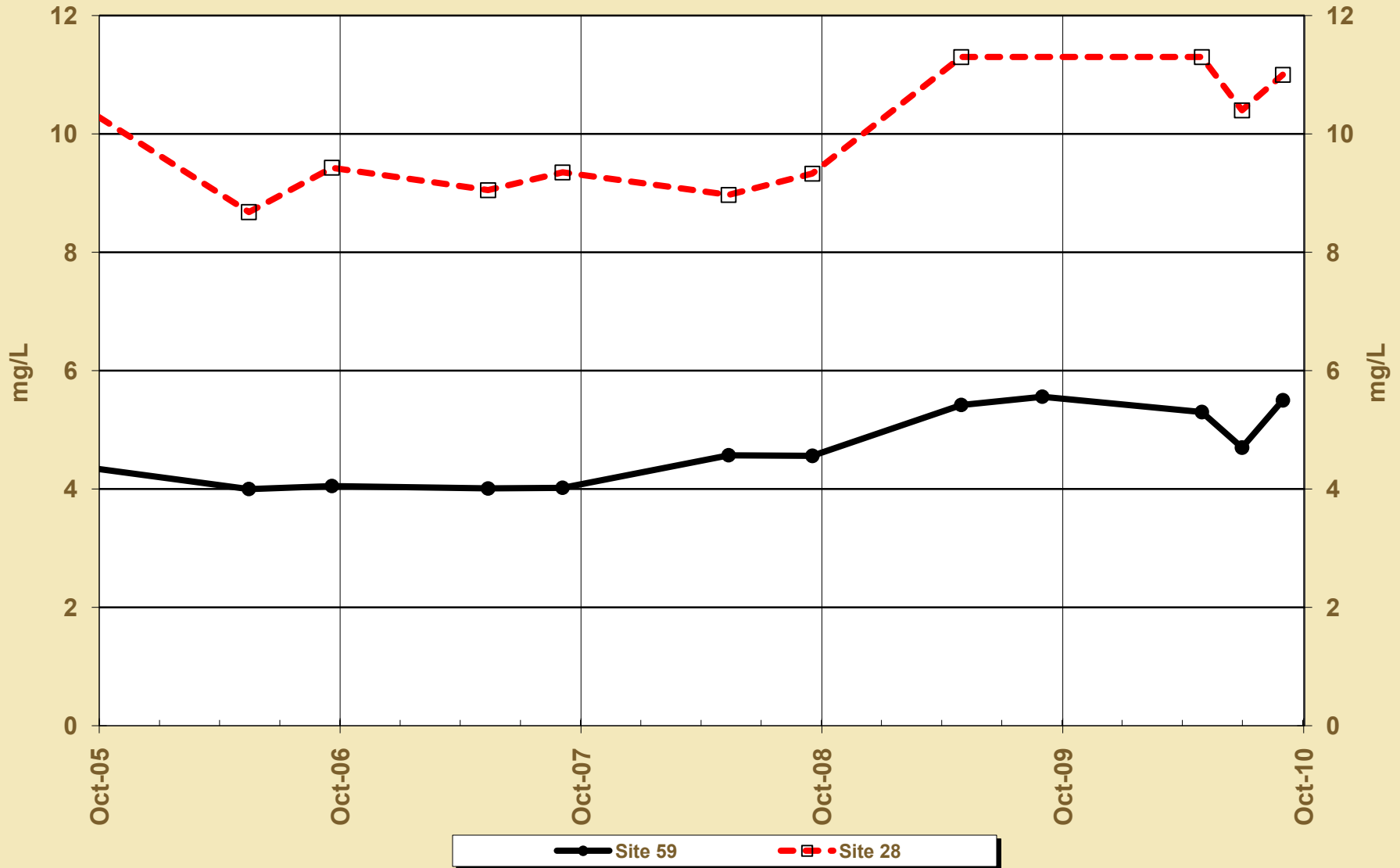
mean = 74.0 +/- 14.6 µg/L; n=115

Tailings (Deep Wells) - Specific Conductance



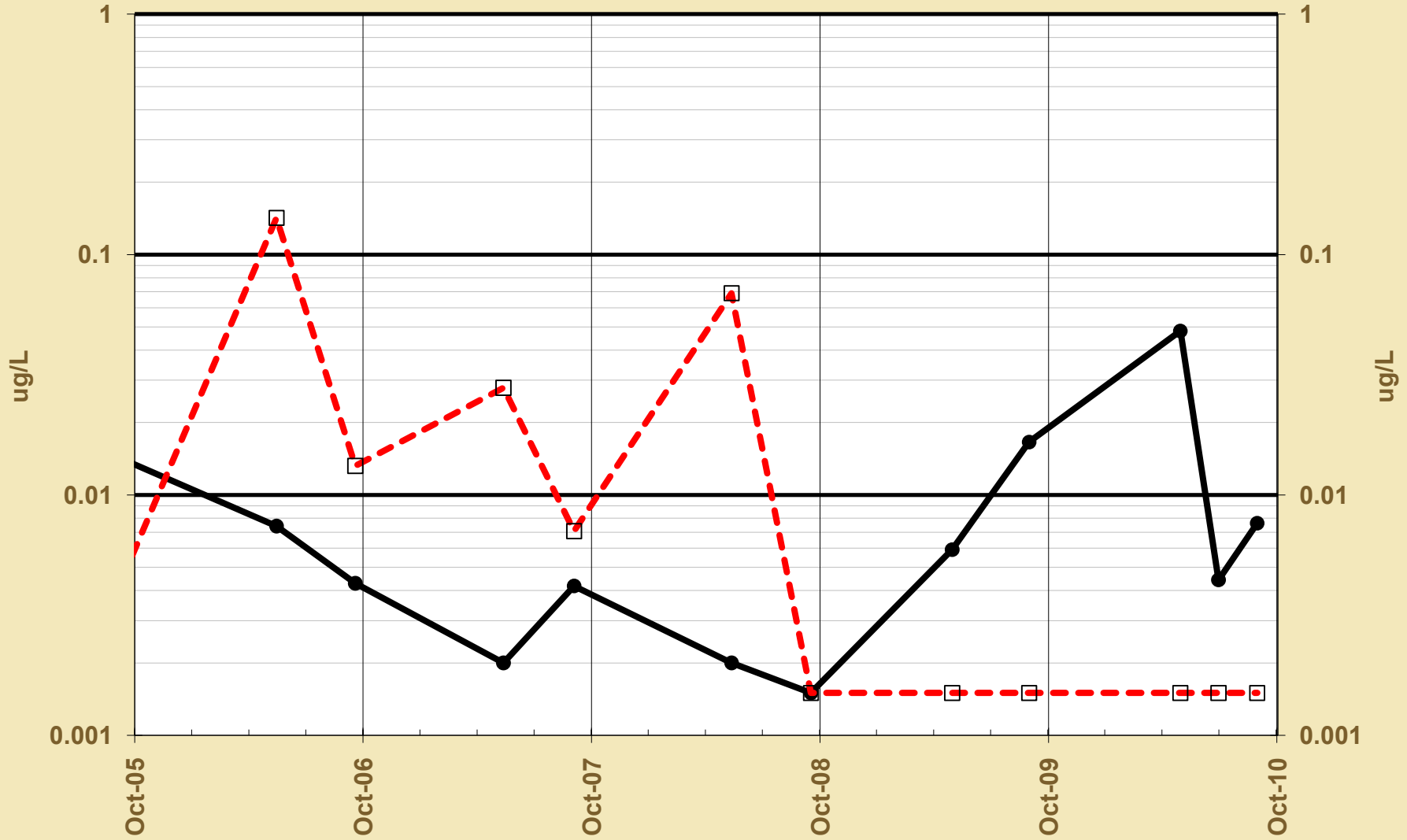
Tailings (Deep Wells) - Total Sulfate

(Note: Value reports as <MDL plotted at MDL/2)



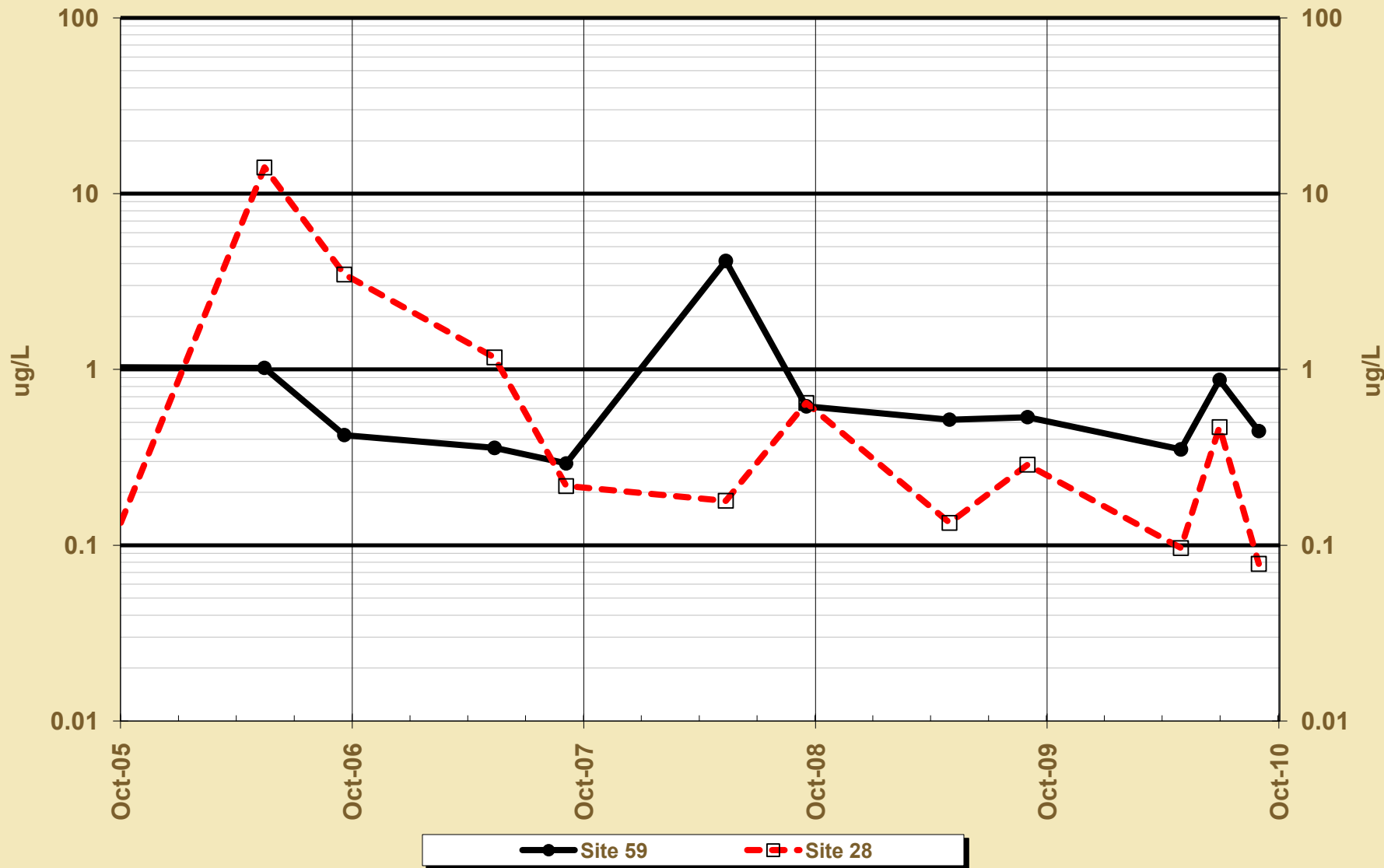
Tailings (Deep Wells) - Dissolved Lead

(Note: Values reported as <MDL plotted at MDL/2)



Tailings (Deep Wells) - Dissolved Zinc

(Note: Values reported as <MDL are plotted at 1/2MDL)



Tailings Deep Wells-Statistical Trends

2010 Water Year

Mann-Kendall Seasonal Trend Test Probabilities

| Site | Cond. | pH | Alkalinity | Sulfate | Diss.-Zinc |
|------|-------------|------|------------|-------------|------------|
| 59 | 1.00 | 0.45 | 0.35 | 0.98 | 0.18 |
| 28 | 0.98 | 0.82 | 0.07 | 0.67 | 0.04 |

Sen's slope estimate

| Site | µS/cm/yr | su/yr | mg/L/yr | µg/L/yr | µg/L/yr |
|------|--------------|-------|---------|--------------|---------|
| 59 | +3.33 | | | +0.29 | |
| 28 | +5.75 | | | | |

Tailings Area Surface Sites

- Site 60 "Lower Althea Creek"
- Site 9 "Tributary Creek"

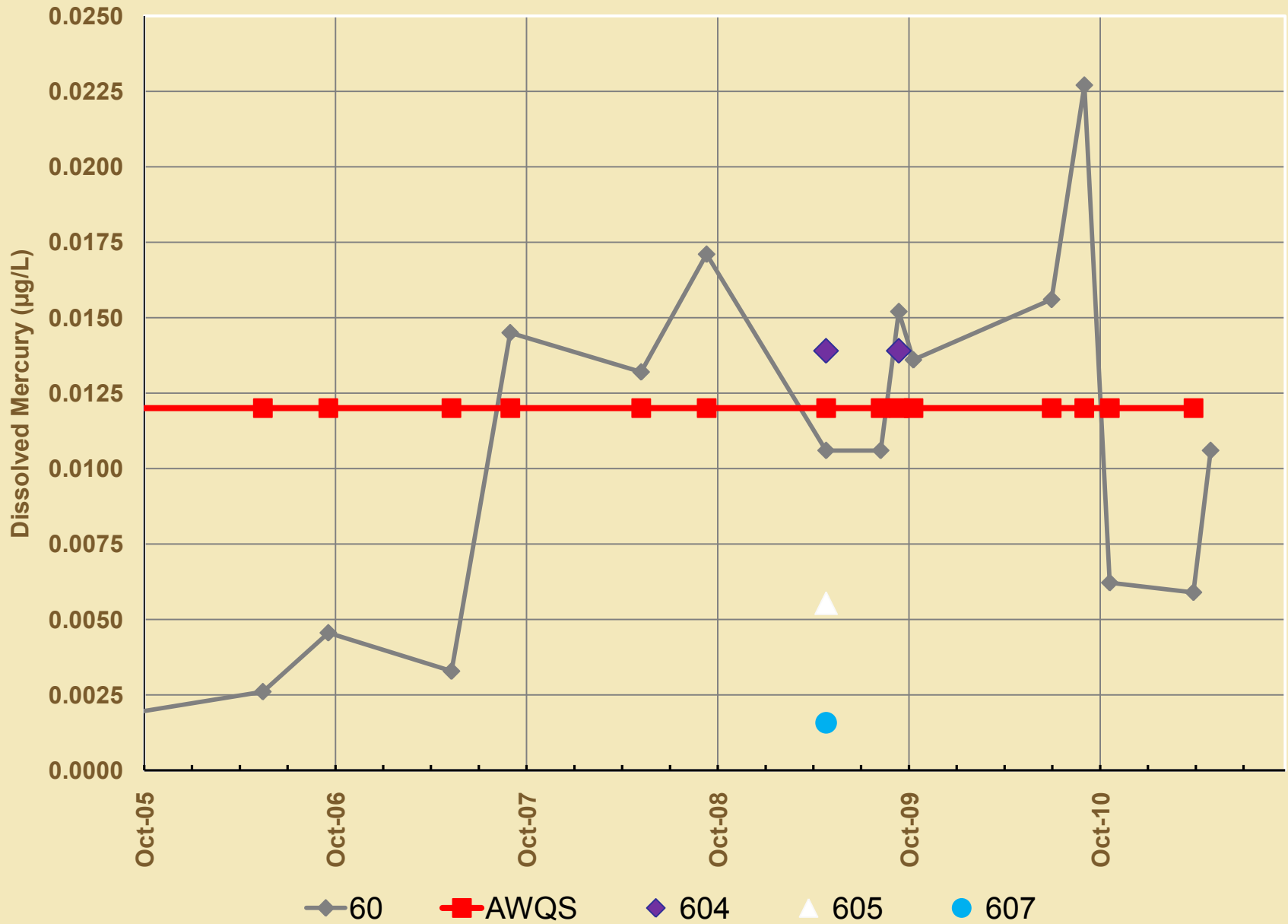
Site 60

- Was added to the FWMP in WY 2006.
- Was added to monitor the impact of Pond 7 on the local watershed.
- Most analytes have returned to pre-disturbance levels.
- Mercury levels decreased below the AWQS during the current water year (2011).

AWQS Exceedances Sites 60

| Site | Date | Parameter | Value | Hardness (mg/L) | Standard | Standard Type |
|------|-----------|-------------------------|--------|-----------------|----------|-----------------------|
| 60 | 13-Jul-10 | Alkalinity Total, mg/L | 11.3 | | 20 | Aquatic Life, chronic |
| 60 | 13-Jul-10 | Mercury, Dissolved µg/L | 0.0156 | | 0.012 | Aquatic Life, chronic |
| 60 | 13-Jul-10 | pH Field, su | 5.5 | | | Aquatic Life, chronic |
| 60 | 13-Jul-10 | pH Lab, su | 5.45 | | | Aquatic Life, chronic |
| 60 | 14-Sep-10 | Alkalinity Total, mg/L | 10.7 | | 20 | Aquatic Life, chronic |
| 60 | 14-Sep-10 | Mercury, Dissolved µg/L | 0.0227 | | 0.012 | Aquatic Life, chronic |
| 60 | 14-Sep-10 | pH Field, su | 6.47 | | | Aquatic Life, chronic |
| 60 | 14-Sep-10 | pH Lab, su | 6.01 | | | Aquatic Life, chronic |

Additional mercury sampling west of tails.



Site 9

- Was originally monitored between 1981 through 1993.
- Was added back into the monitoring plan in 2001 as a biomonitoring site.
- Additional sampling for Suite Q analytes during the months of May, July, and September.
- Continuous monitoring of turbidity, conductivity, and stage (has been problematic).

AWQS Exceedances Sites 9



| Site | Date | Parameter | Value | Hardness (mg/L) | Standard | Standard Type |
|------|-----------|------------------------|-------|-----------------|----------|-----------------------|
| 9 | 11-May-10 | Alkalinity Total, mg/L | 18.2 | | 20 | Aquatic Life, chronic |
| 9 | 11-May-10 | pH Field, su | 6.2 | | 6.5 | Aquatic Life, chronic |
| 9 | 14-Sep-10 | Alkalinity Total, mg/L | 18.7 | | 20 | Aquatic Life, chronic |
| 9 | 14-Sep-10 | pH Lab, su | 6.15 | | 6.5 | Aquatic Life, chronic |

STOP

Greens Creek
&
1350 FWMP Sites

- **Site 48 "Upper Greens Creek"**
 - Up-gradient reference site
- **Site 6 " Middle Greens Creek"**
 - Below the influence from the 1350, 960, 920 Mine/Mill Complex, & Site C
- **Site 54 "Lower Greens Creek"**
 - Referenced to Site 6, below influence of Site 23/D
- **Site 13 "1350 Mine Adit Discharge East"**
 - Monitors the effect of contact water from the eastern portion of the 1350 Waste Rock site.

- **Site 49 "Upper Bruin Creek"**
 - Up-gradient reference site
- **Site 46 " Lower Bruin Creek"**
 - Below influence from Site 23/D
- **Site 57 "MW-23-00-03"**
 - Up-gradient groundwater reference site, located above Site 23
- **Site 56 "MW-D-00-01"**
 - Down-gradient groundwater site, located below Site D

- Comparison against AWQS
- Upgradient / Downgradient comparative graphs for SC, SO₄, Pb, & Zn
- Review of statistical tests for trends and comparison of median values for selected analytes.

Greens Creek & 1350

- Site 48 "Upper Greens Creek"
- Site 06 "Middle Greens Creek"
- Site 54 "Lower Greens Creek"
- Site 13 "1350 Mine Adit Discharge East"

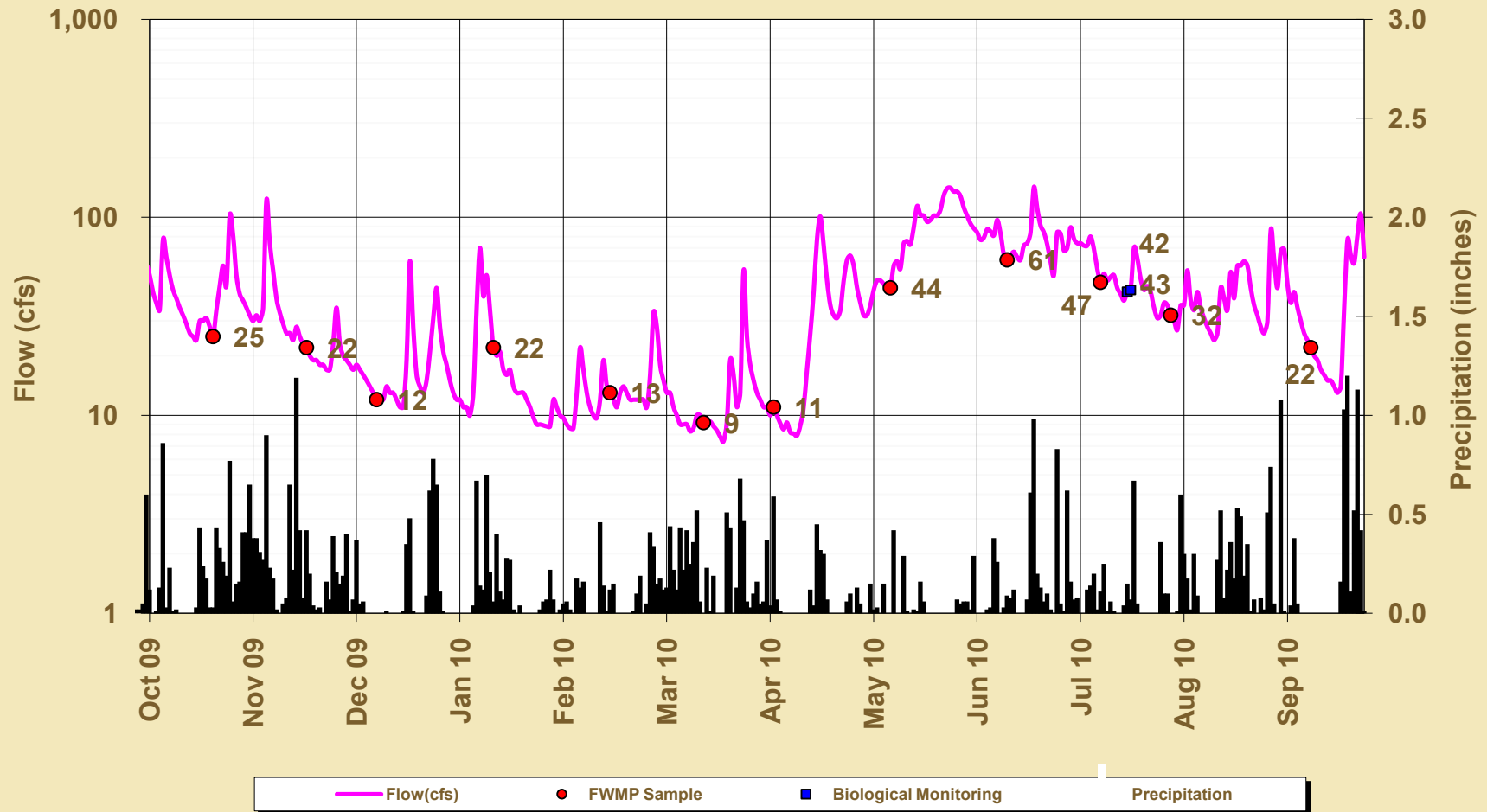
AWQS Exceedances in Greens Creek

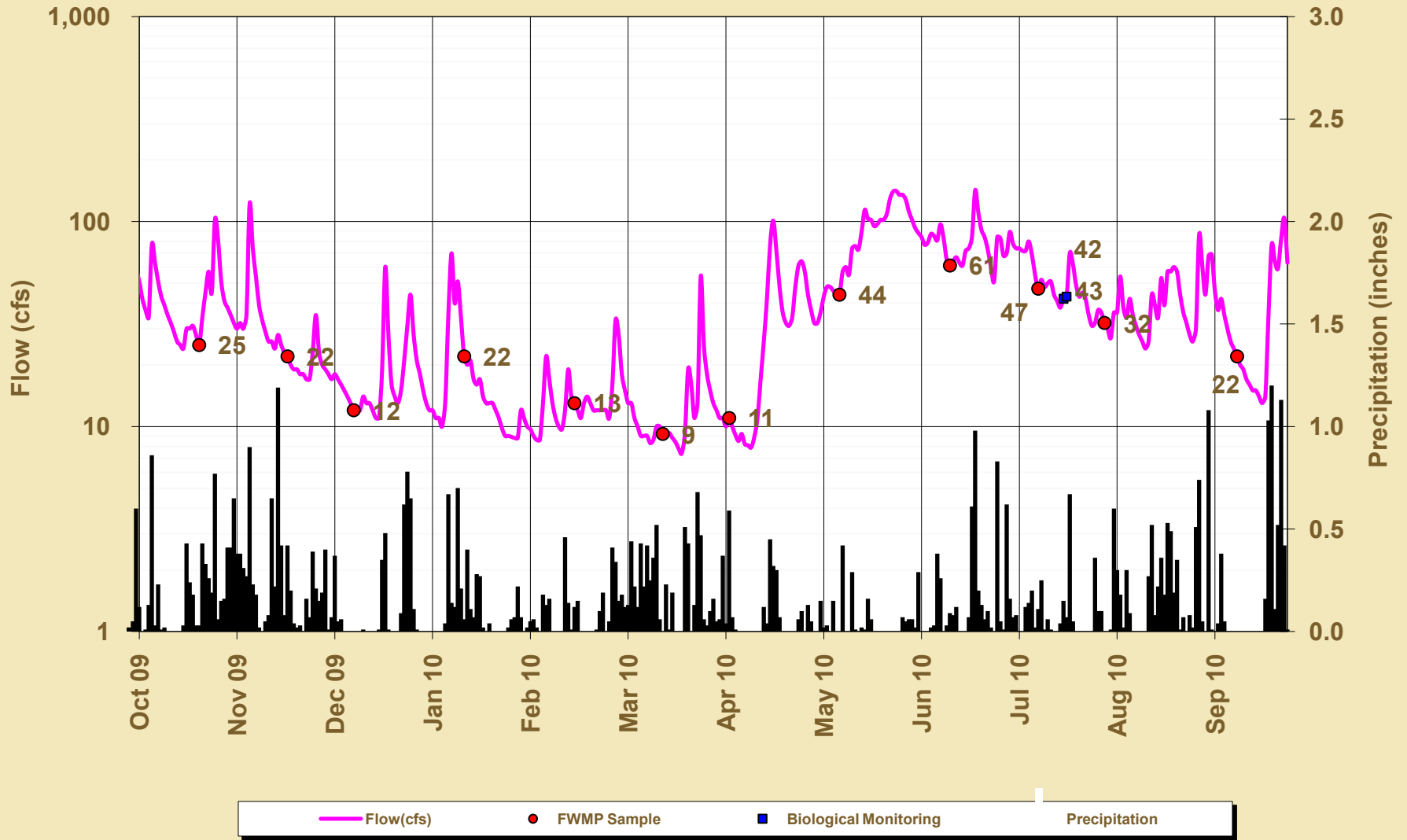


- Sites 48, 6, and 54 exceeded AWQS for pH on several dates.
- Two exceedances were noted for sulfate at site 13.

| Site | Date | Parameter | Value | Hardness (mg/L) | Standard | Standard Type |
|------|-----------|---------------|-------|-----------------|----------|-----------------------|
| 48 | 13-Jul-10 | pH Lab, su | 6.45 | | 6.5 | Aquatic Life, chronic |
| 6 | 12-Jan-10 | pH Field, su | 6.46 | | 6.5 | Aquatic Life, chronic |
| 6 | 16-Feb-10 | pH Lab, su | 6.4 | | 6.5 | Aquatic Life, chronic |
| 6 | 6-Apr-10 | pH Lab, su | 6.48 | | 6.5 | Aquatic Life, chronic |
| 6 | 13-Jul-10 | pH Lab, su | 6.32 | | 6.5 | Aquatic Life, chronic |
| 6 | 14-Sep-10 | pH Lab, su | 6.37 | | 6.5 | Aquatic Life, chronic |
| 54 | 16-Feb-10 | pH Lab, su | 5.94 | | 6.5 | Aquatic Life, chronic |
| 54 | 6-Apr-10 | pH Lab, su | 6.23 | | 6.5 | Aquatic Life, chronic |
| 54 | 13-Jul-10 | pH Lab, su | 5.51 | | 6.5 | Aquatic Life, chronic |
| 54 | 3-Aug-10 | pH Lab, su | 6.25 | | 6.5 | Aquatic Life, chronic |
| 54 | 14-Sep-10 | pH Lab, su | 6.05 | | 6.5 | Aquatic Life, chronic |
| 13 | 20-Oct-09 | SO4 Tot, mg/l | 265 | | 250 | Aquatic Life, chronic |
| 13 | 3-Aug-10 | SO4 Tot, mg/l | 271 | | 250 | Aquatic Life, chronic |

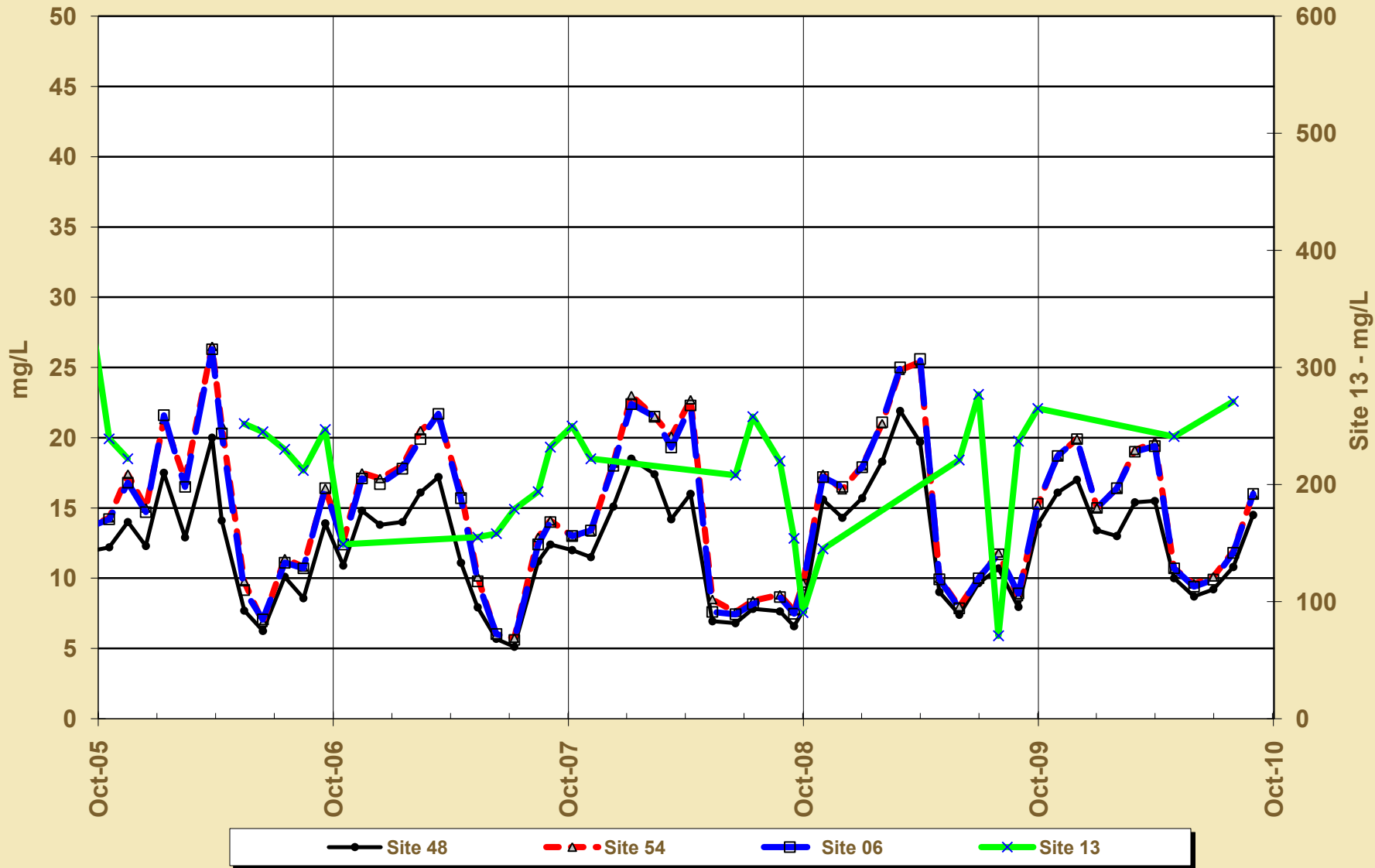
Greens Creek Discharge





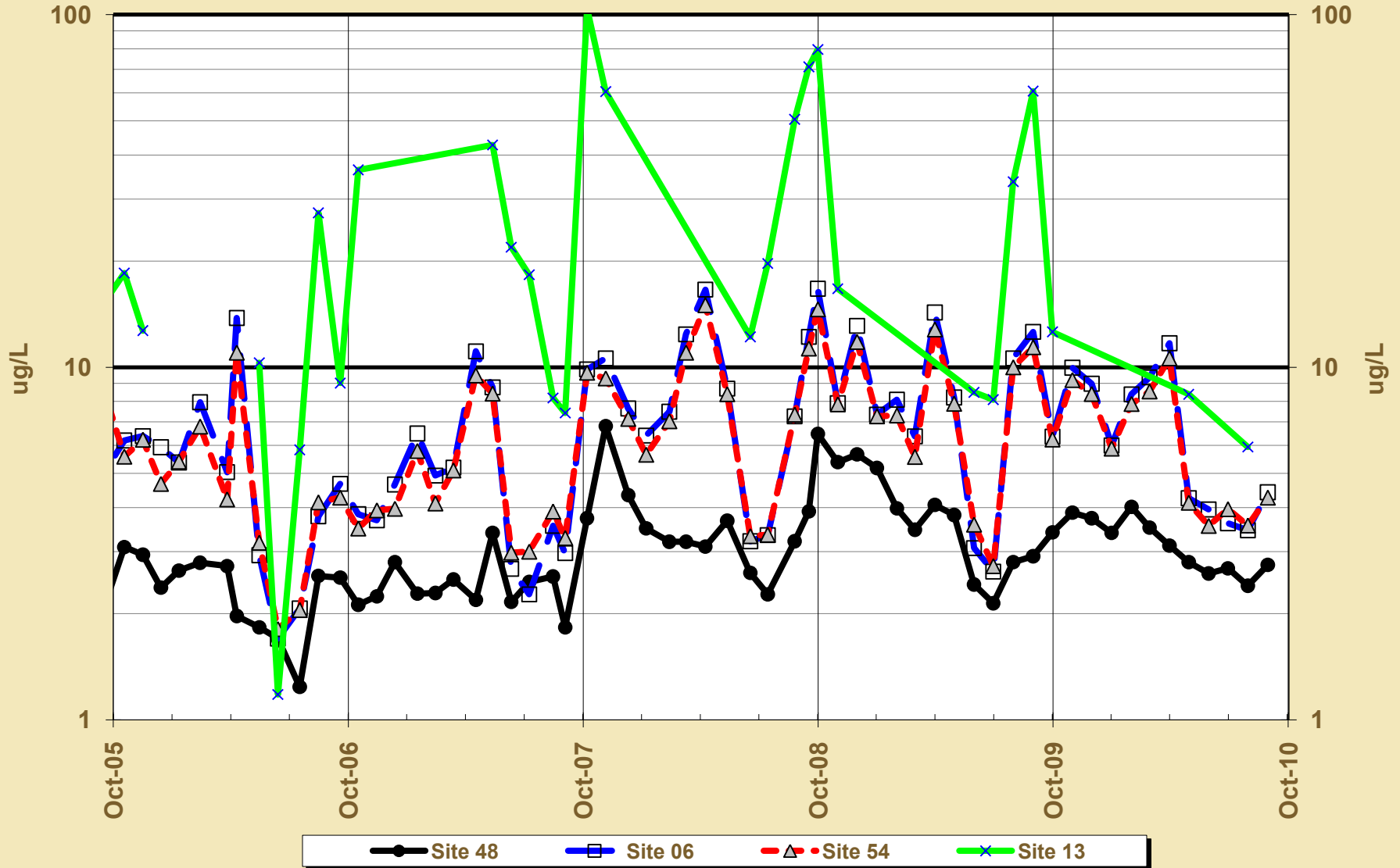
Greens Creek - Total Sulfate

(Note: Value reports as <MDL plotted at MDL/2)



Greens Creek - Dissolved Zinc

(Note: Values reported as <MDL are plotted at 1/2MDL)



2010 Water Year

Mann-Kendall Seasonal Trend Test Probabilities

| Site | Cond. | pH | Alkalinity | Sulfate | Diss.-Zinc |
|------|-------|-------|------------|---------|------------|
| 48 | 0.77 | <0.01 | 0.01 | 0.91 | 1.00 |
| 6 | 0.57 | <0.01 | <0.01 | 0.79 | 1.00 |
| 54 | 0.67 | 0.20 | <0.01 | 0.71 | 1.00 |
| 13 | 0.35 | 0.98 | <0.01 | 0.16 | 0.42 |

Sen's slope estimate

| Site | µS/cm/yr | su/yr | mg/L/yr | µg/L/yr | µg/L/yr |
|------|----------|--------|---------|---------|---------|
| 48 | | -0.06 | -0.83 | | +0.21 |
| 6 | | -0.07 | -1.05 | | +0.39 |
| 54 | | | -0.91 | | +0.32 |
| 13 | | +0.006 | -8.80 | | |

Bruin Creek & Site 23/D Monitoring Wells

- Site 49 "Upper Bruin Creek"
- Site 46 "Lower Bruin Creek"
- Site 57 "MW-23-00-03"
- Site 56 "MW-D-00-01"

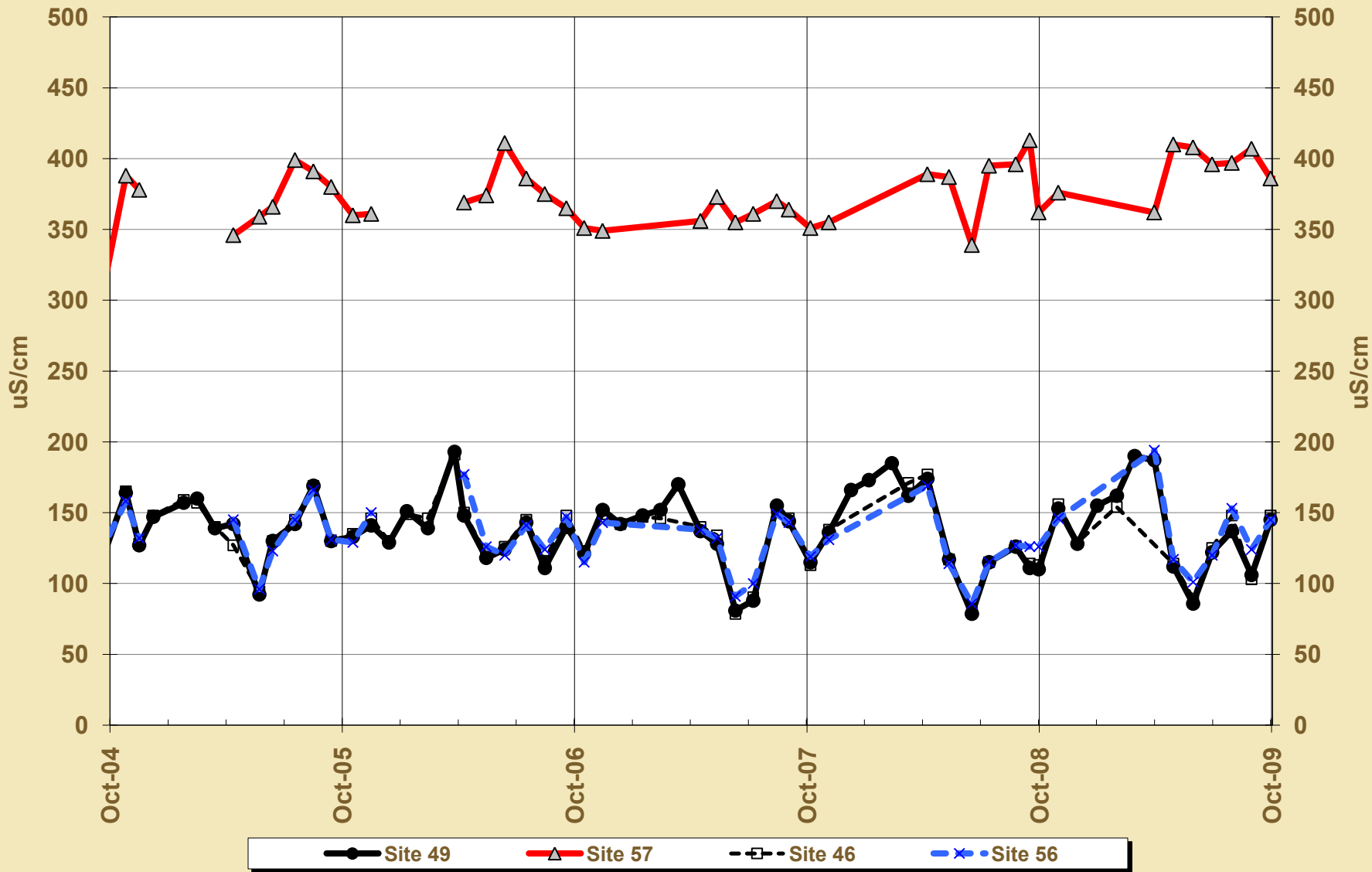
AWQS Exceedances

Bruin Creek & Site 23/D Wells



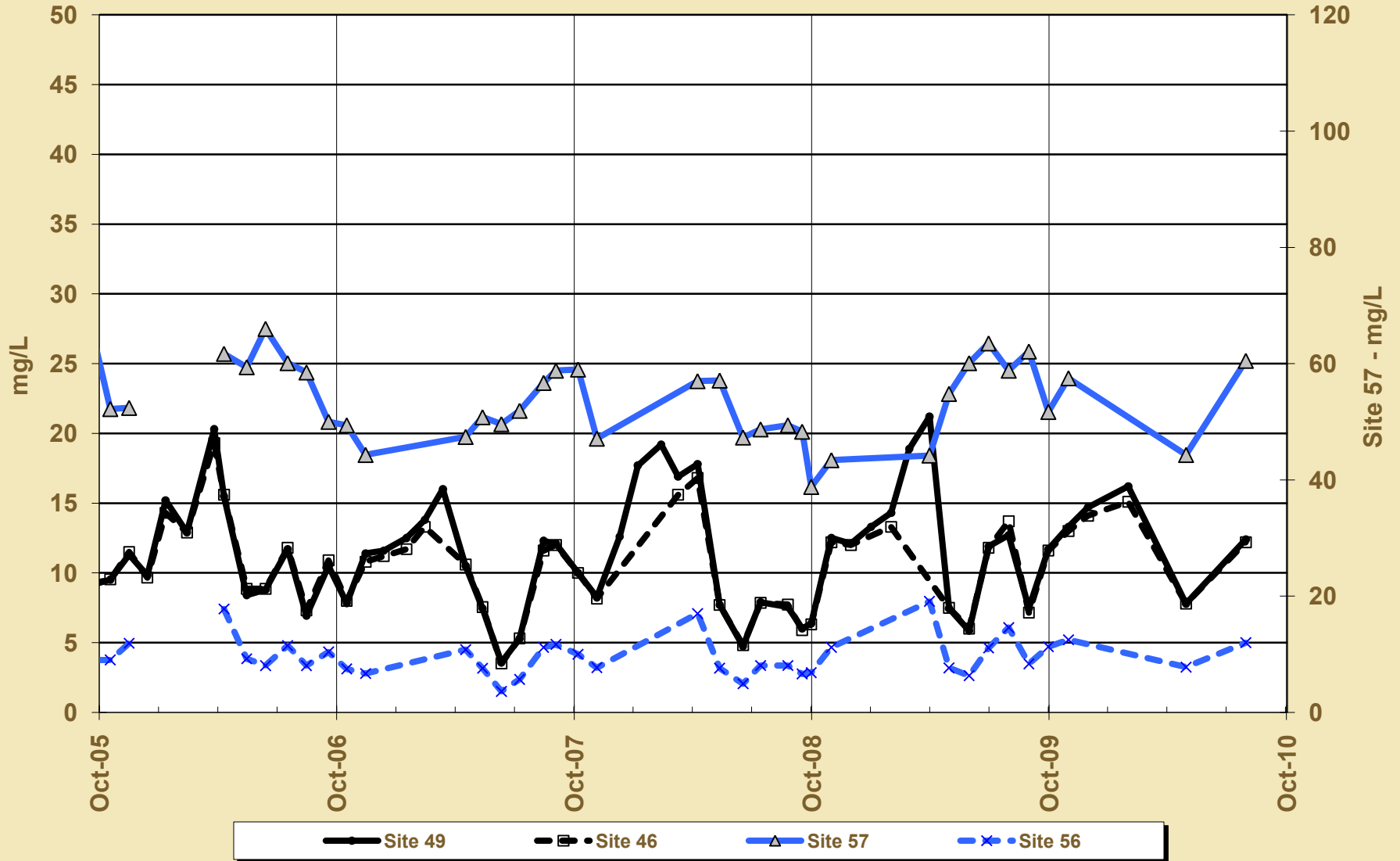
- No measured parameters exceeded AWQS for the Bruin Creek sites (49 & 46) or for the Site 23/D wells (57 & 56).

Site 23 Area - Specific Conductance



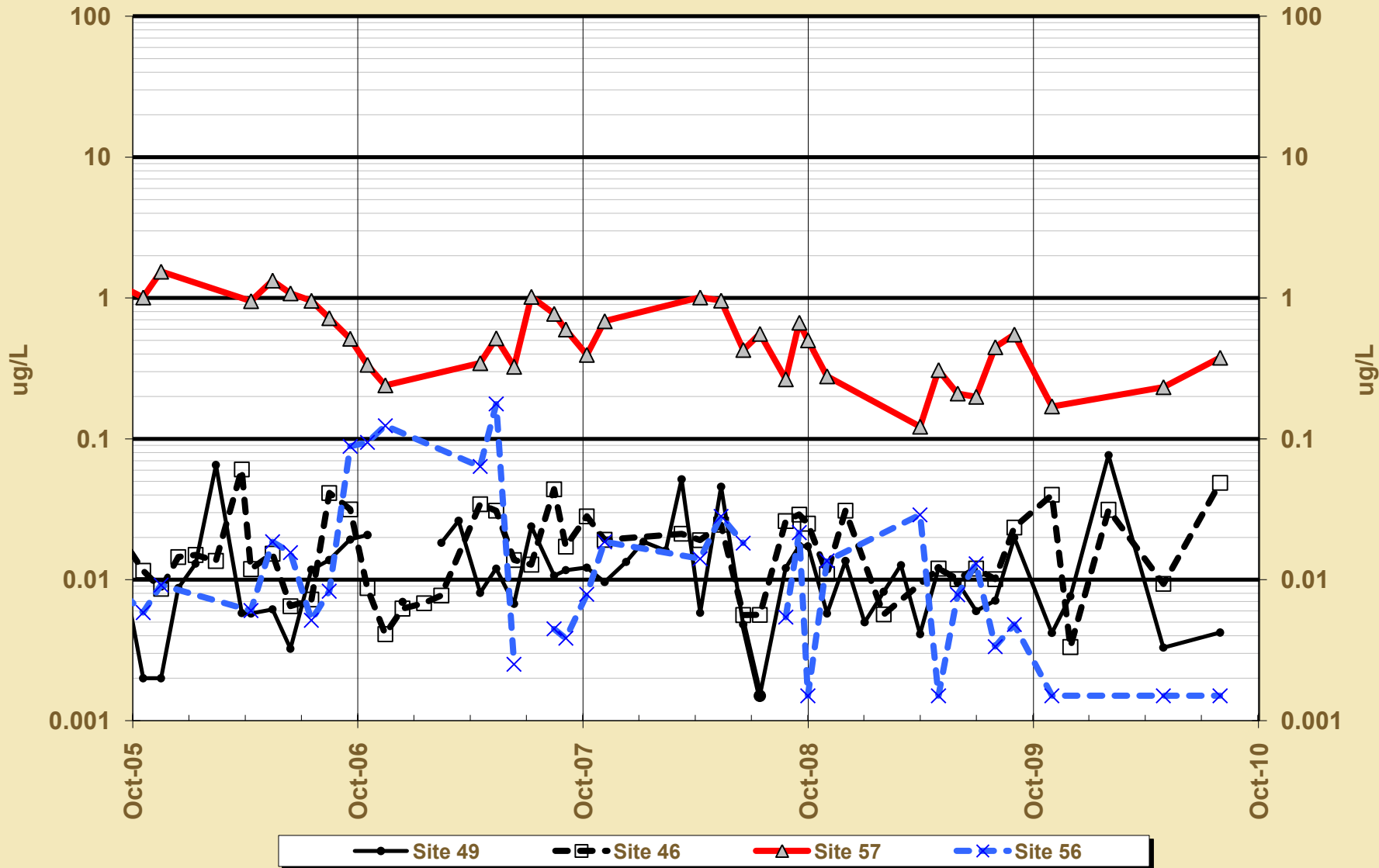
Site 23 Area - Total Sulfate

(Note: Value reports as <MDL plotted at MDL/2)



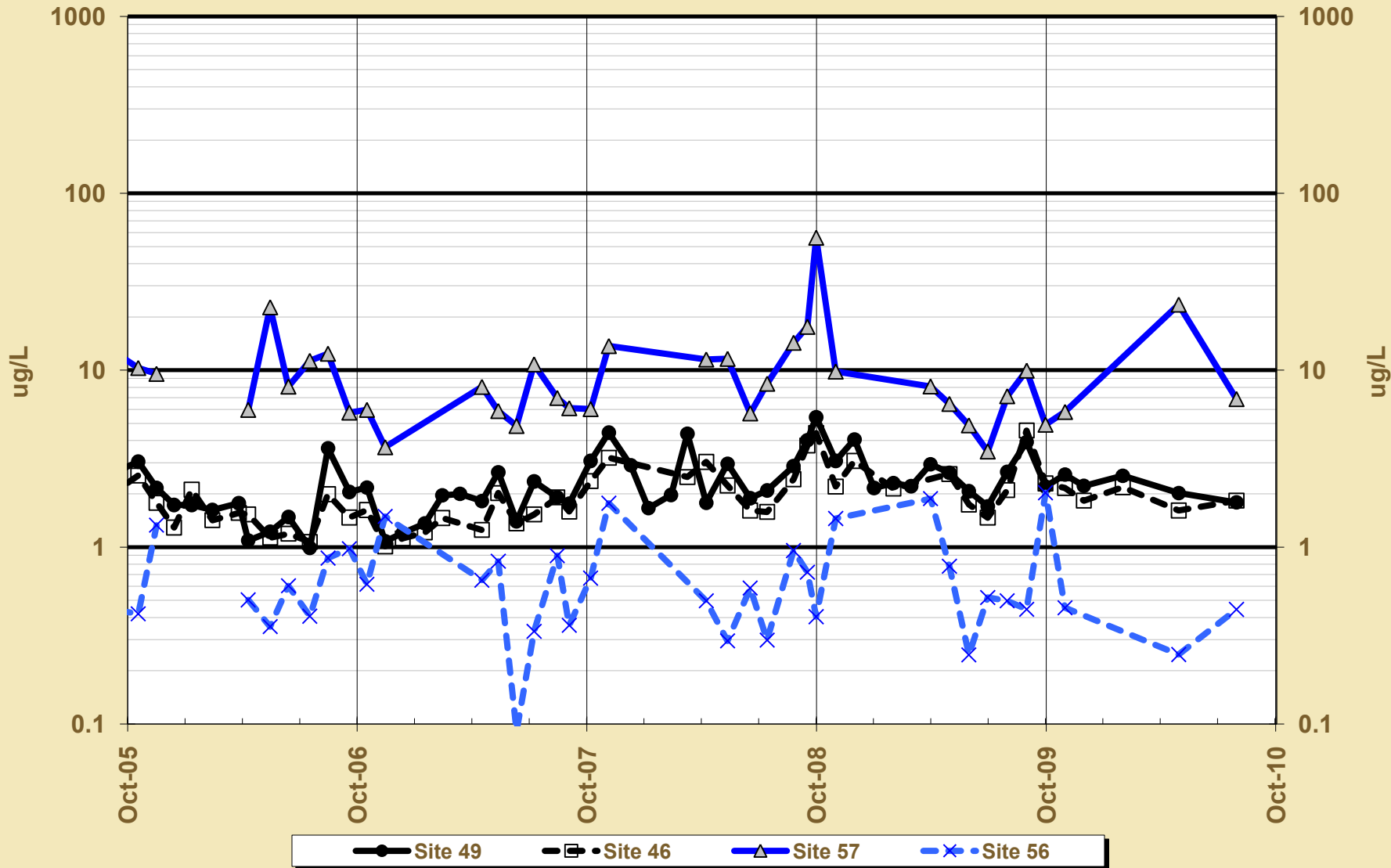
Site 23 Area - Dissolved Lead

(Note: Values reported as <MDL plotted at MDL/2)



Site 23 Area - Dissolved Zinc

(Note: Values reported as <MDL are plotted at 1/2MDL)



Bruin Creek - Site 23 - D Wells

Statistical Testing (pH graphs)

2010 Water Year

Mann-Kendall Seasonal Trend Test Probabilities

| Site | Cond. | pH | Alkalinity | Sulfate | Diss.-Zinc |
|------|-------|------|------------|---------|------------|
| 49 | 0.71 | 0.18 | <0.01 | 0.99 | 0.93 |
| 46 | 0.44 | 0.27 | 0.01 | 0.78 | 0.91 |
| 57 | 0.98 | 0.99 | <0.01 | 0.04 | <0.01 |
| 56 | 0.32 | 0.53 | <0.01 | 0.80 | 0.35 |

Sen's slope estimate

| Site | µS/cm/yr | su/yr | mg/L/yr | µg/L/yr | µg/L/yr |
|------|----------|-------|---------|---------|---------|
| 49 | | | -2.07 | +0.042 | |
| 46 | | | -1.44 | | |
| 57 | +5 | +0.06 | -4.88 | -1.61 | -2.27 |
| 56 | | | -1.79 | | |

Statistical Testing (Comparison of Means)

Assumptions:

- ↑ Conductivity
- ↓ pH
- ↑ Sulfate
- ↓ Alkalinity
- ↑ Dissolved Zinc

Sites Compared:

- downgradient – upgradient
- 06 – 48
- 54 – 06
- 46 – 49
- 56 – 57

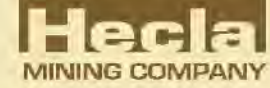
Greens Creek & 920 Area

Statistical Testing (Comparison of Means)

| 2010 Water Year | | | | | |
|---|------------------|------------|----------------------|---------------------------|---------------------|
| Comparison of Medians, Signed-Rank Test Probabilities | | | | | |
| Sites | Cond. | pH | Alkalinity | SO ₄ | Diss-Zinc |
| 6 - 48 | <0.01 | 1.00 | 0.04 | <0.01 | <0.01 |
| 54 - 6 | <0.01 | 1.00 | 0.31 | 0.95 | 1.00 |
| Calculated Medians | | | | | |
| Site | Cond. (uS/cm) | pH (su) | Alkalinity (mg/l) | SO ₄ (mg/l) | Diss-Zinc (ug/l) |
| 48 | 117 | 7.33 | 41.8 | 13.6 | 3.26 |
| 6 | 126 | 6.92 | 44.5 | 15.7 | 6.18 |
| 54 | 128 | 6.67 | 44.3 | 15.6 | 6.06 |

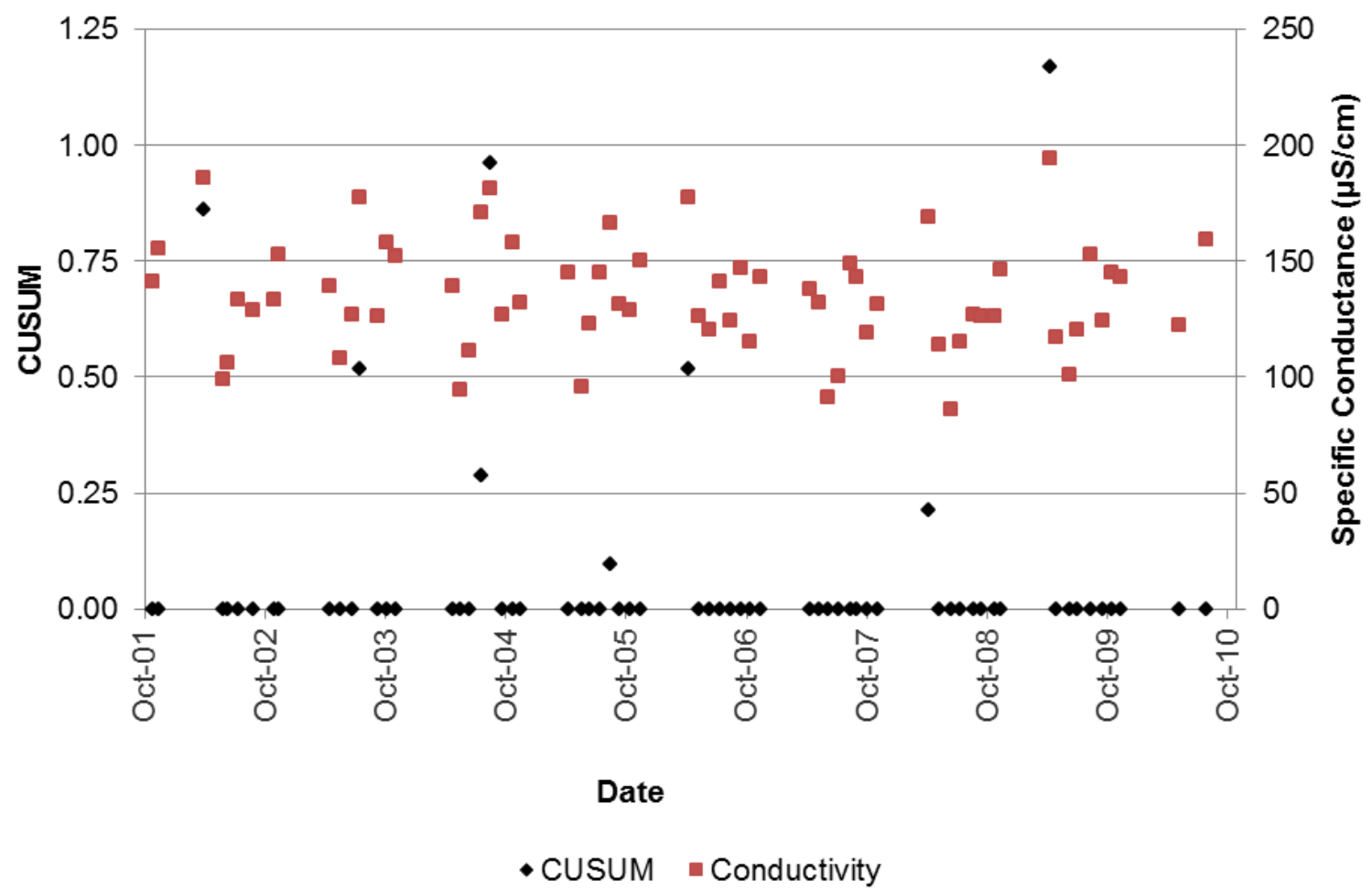
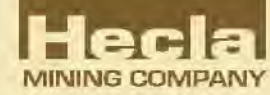
Bruin Creek & Site 23/D Wells

Statistical Testing (Comparison of Means)

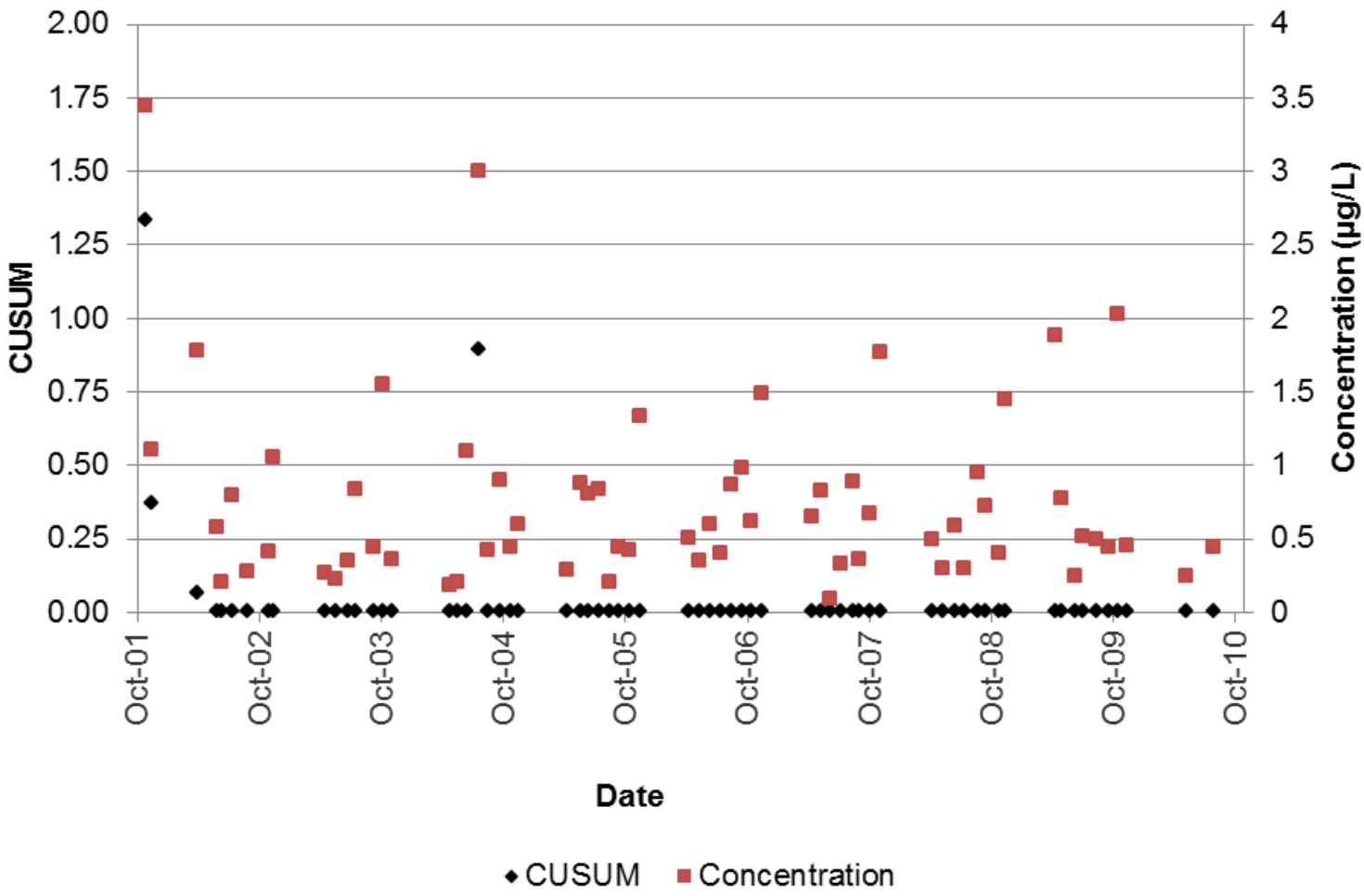
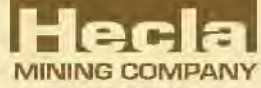


| 2010 Water Year | | | | | |
|---|------------------|-------------|----------------------|---------------------------|---------------------|
| Comparison of Medians, Signed-Rank Test Probabilities | | | | | |
| Sites | Cond. | pH | Alkalinity | SO ₄ | Diss-Zinc |
| 46 - 49 | 0.16 | 0.97 | 0.00 | 1.00 | 0.95 |
| 56 - 57 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Calculated Medians | | | | | |
| Site | Cond. (uS/cm) | pH (su) | Alkalinity (mg/l) | SO ₄ (mg/l) | Diss-Zinc (ug/l) |
| 46 | 152 | 7.74 | 59.8 | 12.9 | 2.21 |
| 49 | 154 | 7.58 | 61.4 | 12.6 | 2.00 |
| 57 | 390 | 7.56 | 139 | 54.6 | 6.34 |
| 56 | 144 | 7.57 | 59.3 | 11.7 | 0.45 |

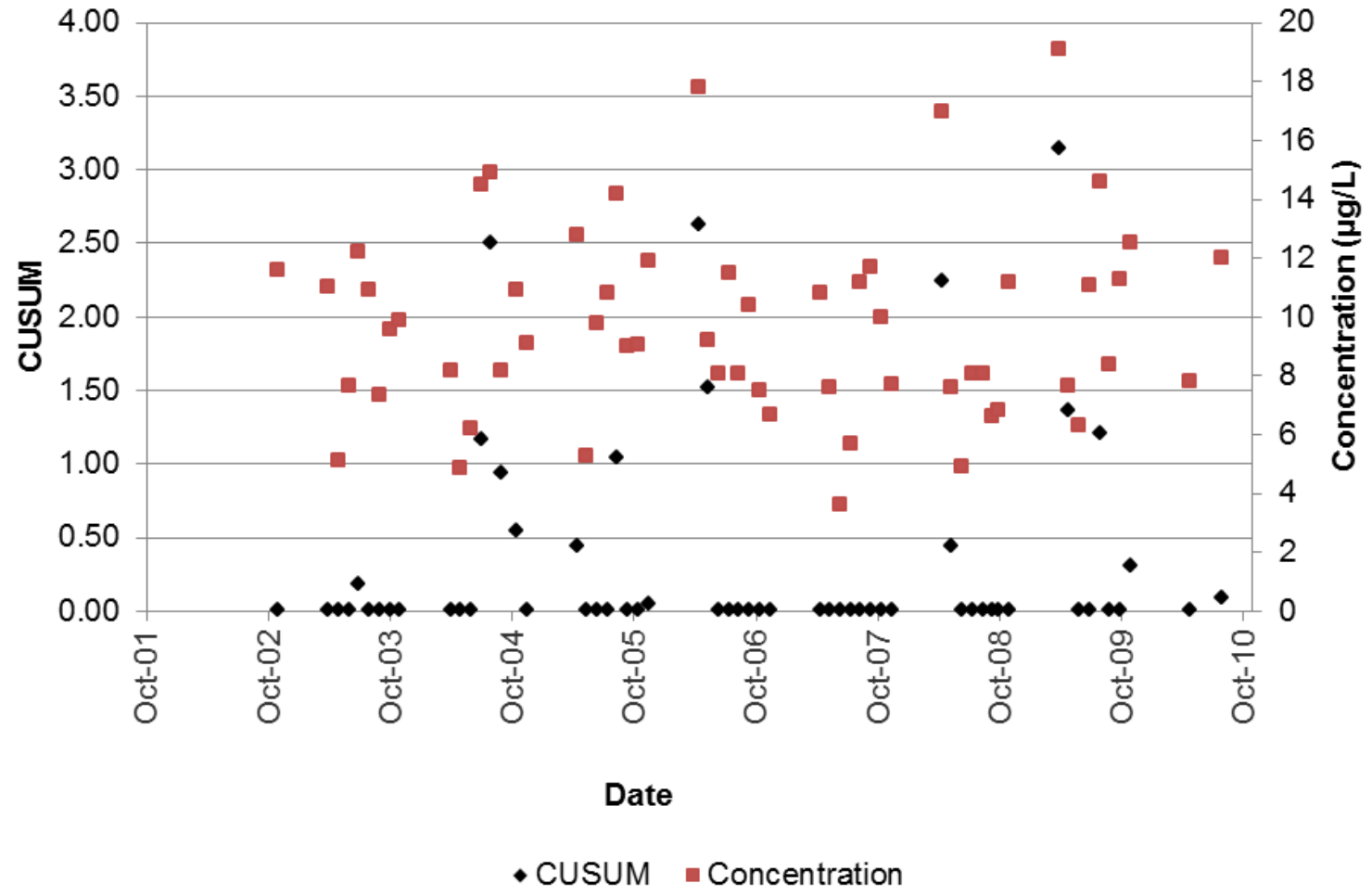
Site 56 Conductivity Measurements Compared to the Combined Shewhart-Cusum Control Limits



Site 56 Dissolved Zinc Measurements Compared to the Combined Shewhart-Cusum Control Limits



Site 56 Total Sulfate Measurements Compared to the Combined Shewhart-Cusum Control Limits



Proposed Changes to the FWMP



- Add Sites MW-T-10-08A & MW-T-10-08B to the sampling schedule (bimonthly).
- **Developing these sites to replace Site 58 "MW-T-00-01C" & Site 59 "MW-T-00-01A – impacted by the East Ridge expansion.**
- Monitor both sets of wells for minimum of a year and include both in next years report.



STOP