In-Pulp Treatment of Dissolved As from a Gold Mine

Presented by Bernard Aubé

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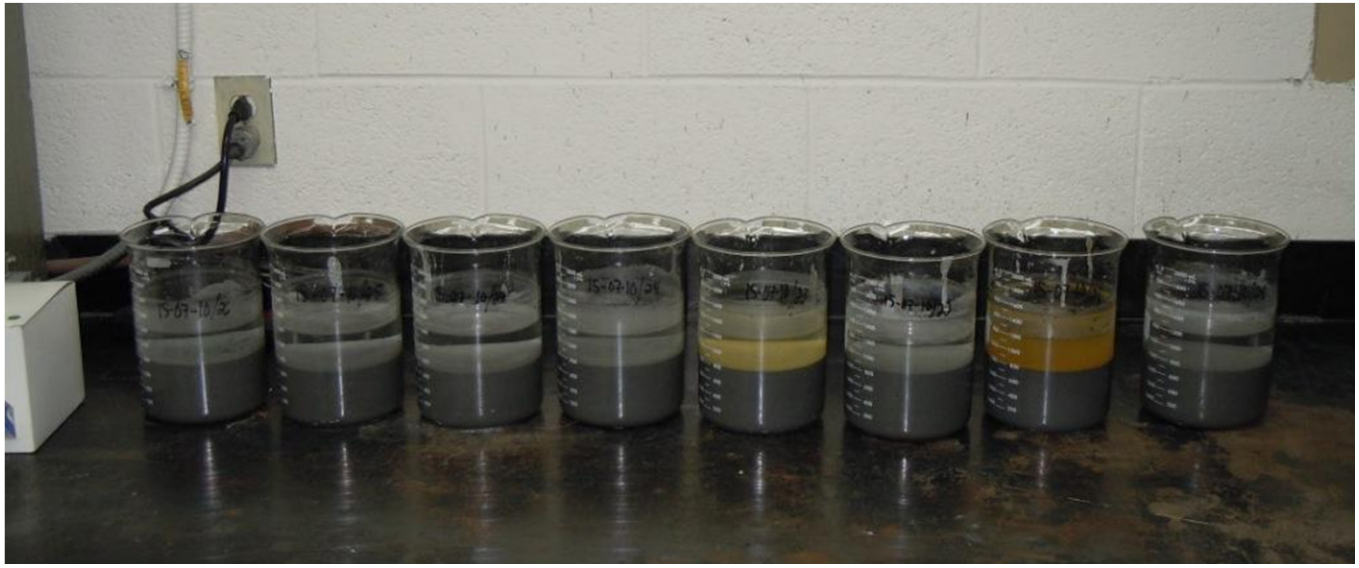
Casa Berardi



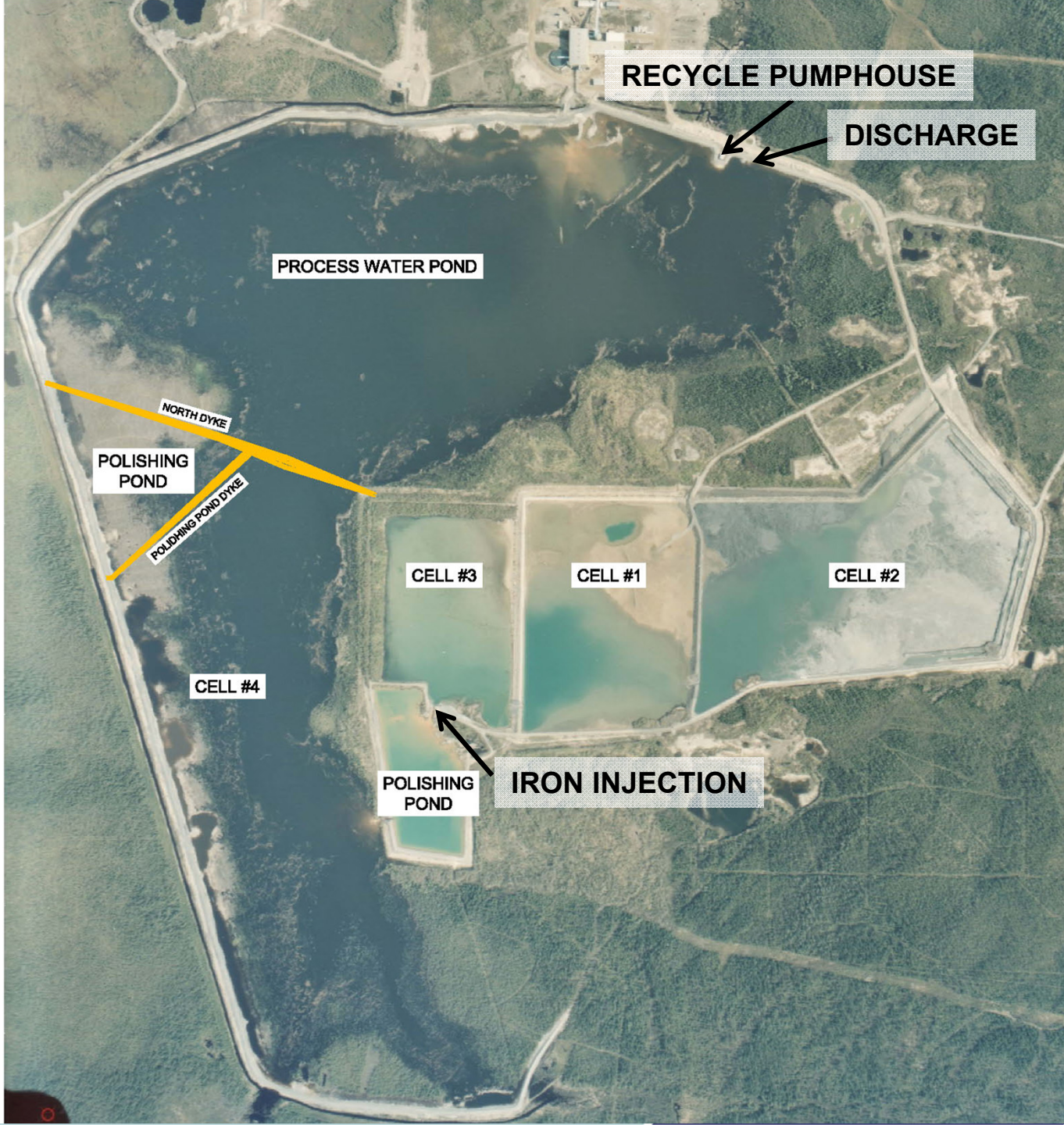
Casa Berardi

- Mines Aurizon, Casa Berardi is a gold mine located on the Ontario-Québec border, 3 hours North of Rouyn-Noranda
- Mines Aurizon re-opened the mine in 2006 at 1,600 tpd, now operating at 2,000 tpd
- Ore is finely crushed and gold is leached using CN and carbon in pulp
- The current plan has the mine operating for another 10 years

Casa Berardi Tailings and Process Water

In 2008, arsenic concentrations were near discharge limits in Process Water Pond.

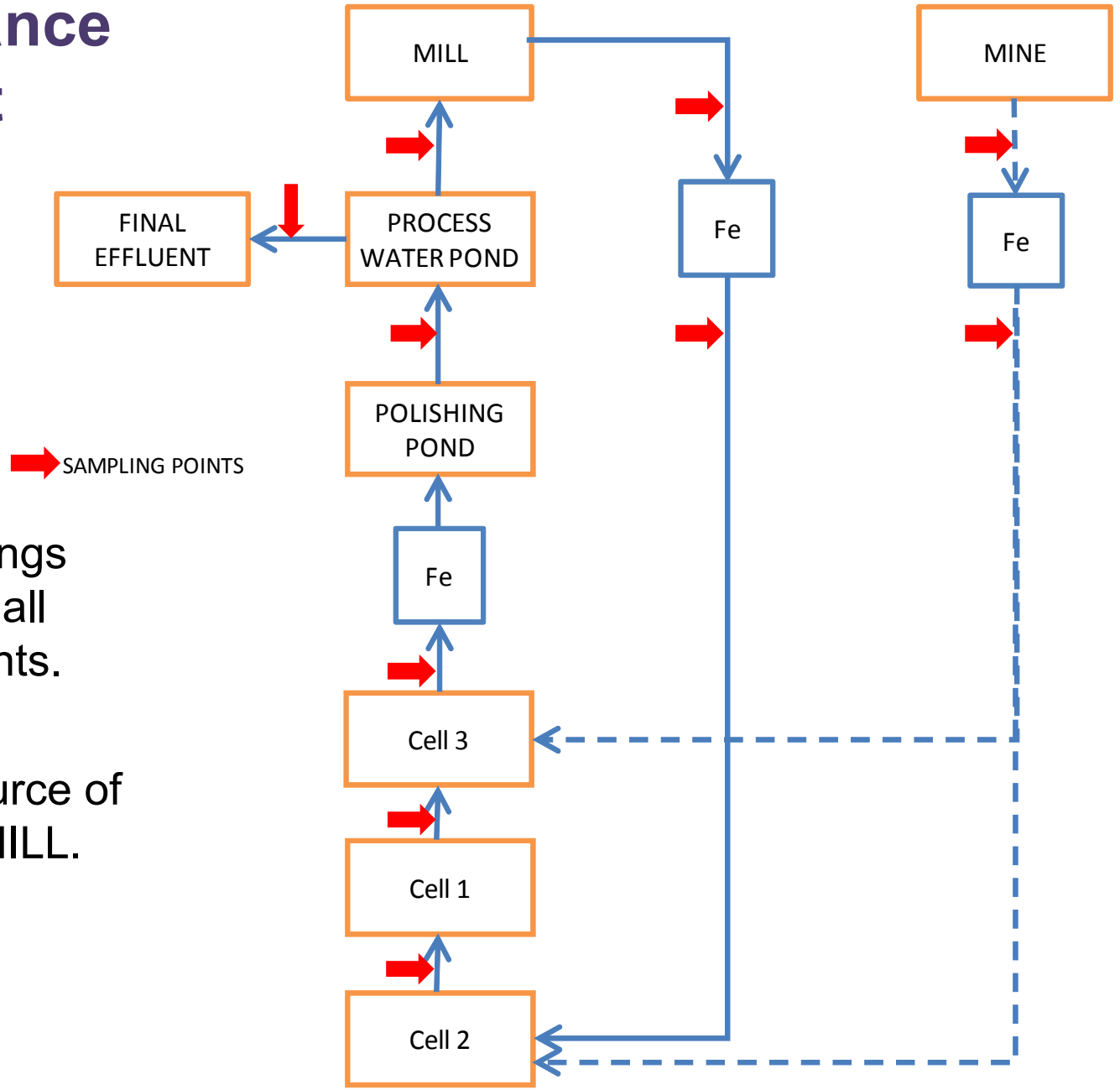
A study was initiated to compare options for treatment and control of As.



Arsenic Issues at Casa Berardi

- A detailed mass balance study was completed to determine the source of As
  - As each overflow from the specific ponds is monitored, it was possible to evaluate the changes in arsenic loading throughout the system
- The mass balance showed that the source of arsenic was the fresh tailings water – As was dissolved in the tailings slurry
- Analyses within the concentrator showed that the As was liberated during the cyanidation

Mass Balance Flowsheet



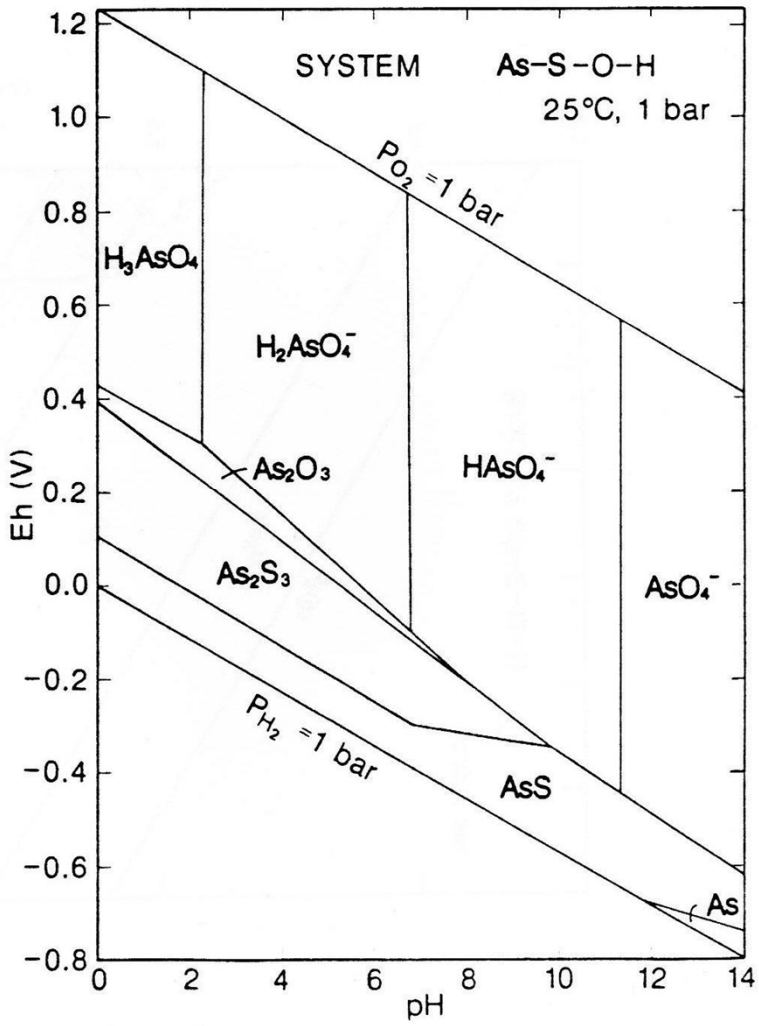
Arsenic loadings calculated at all sampling points.

The clear source of As was the MILL.

As Treatment Theory

- Arsenic can be treated using membrane technologies, adsorption, ion exchange, precipitated as calcium arsenate, and permeable reactive barriers
- Most common treatment is co-precipitation with iron (Fe) and solid/liquid separation
  - Proven technology
  - Most cost efficient
  - Reliable
  - pH of 4 to 5 known to improve treatment efficiency

Arsenic Precipitation



- As can be removed as a calcium arsenate [$Ca_3(AsO_4)_2$] at very high pH but it is not very stable
- As removed as ferric arsenate, $FeAsO_4 \cdot xFe(OH)_3$ is much more stable
- In clear water at optimum pH, a molar ratio of Fe:As of at least 3:1 for efficient removal and long-term stability

Laboratory Testing for Field Treatment

- Some testing was completed at CANMET – MMSL to evaluate the ratio of Fe needed to treat As in clear water at alkaline pH in the field (Polishing Pond)
- Results showed that at an Fe:As molar ratio of 7.5:1 would bring the concentrations down to 0.1 mg/L As
- This is the control that has been applied but this control would no longer be preferred following the construction of Cell 4

Tailings Slurry Treatment

- The information gathered suggested that many advantages are gained if As can be controlled at the mill
- Tests were begun to treat the As in the tailings slurry immediately following the INCO-SO2 cyanide destruction
- First trials were attempted at different ratios of Iron addition. Results were not conclusive due to some success and some failures without knowing the reason for response.
- Detailed Design of Experiment (DOE) was then undertaken.

DOE Design

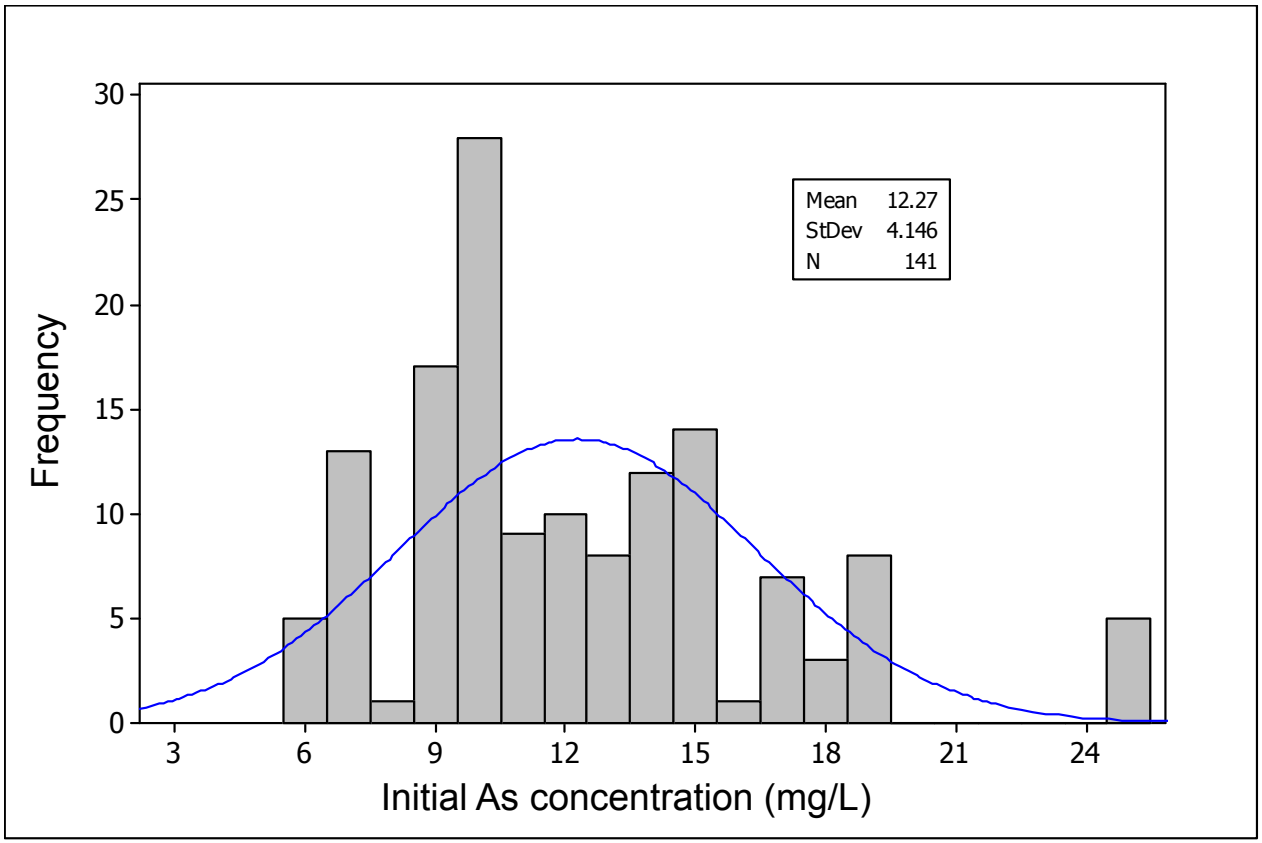
- The DOE was designed to determine the major effects of many parameters on the arsenic treatment efficiency:
  - Fe:As ratio
  - pH and Two-step pH
  - CN concentration
  - Mixing intensity
  - Retention time
  - Aeration
- The target concentration was set at 0.4 mg/L As.
  - Current limit at 0.5 mg/L at effluent, but may become 0.2 mg/L
  - With 4 times dilution in the pond system, 0.4 mg/L in slurry would be near 0.1 mg/L in Process Water Pond.

DOE Challenges

- By far the greatest difficulty during the testing was to obtain the desired ratio of Fe to As because the initial As concentrations varied greatly and rapidly
  - Samples taken the previous day were off by often more than 30%
  - Attempts were made with a colorimeter which was only slightly better
  - On-site AA should soon be available
- Another problem was obtaining proper pH control during one long series of tests. This was corrected in following tests.

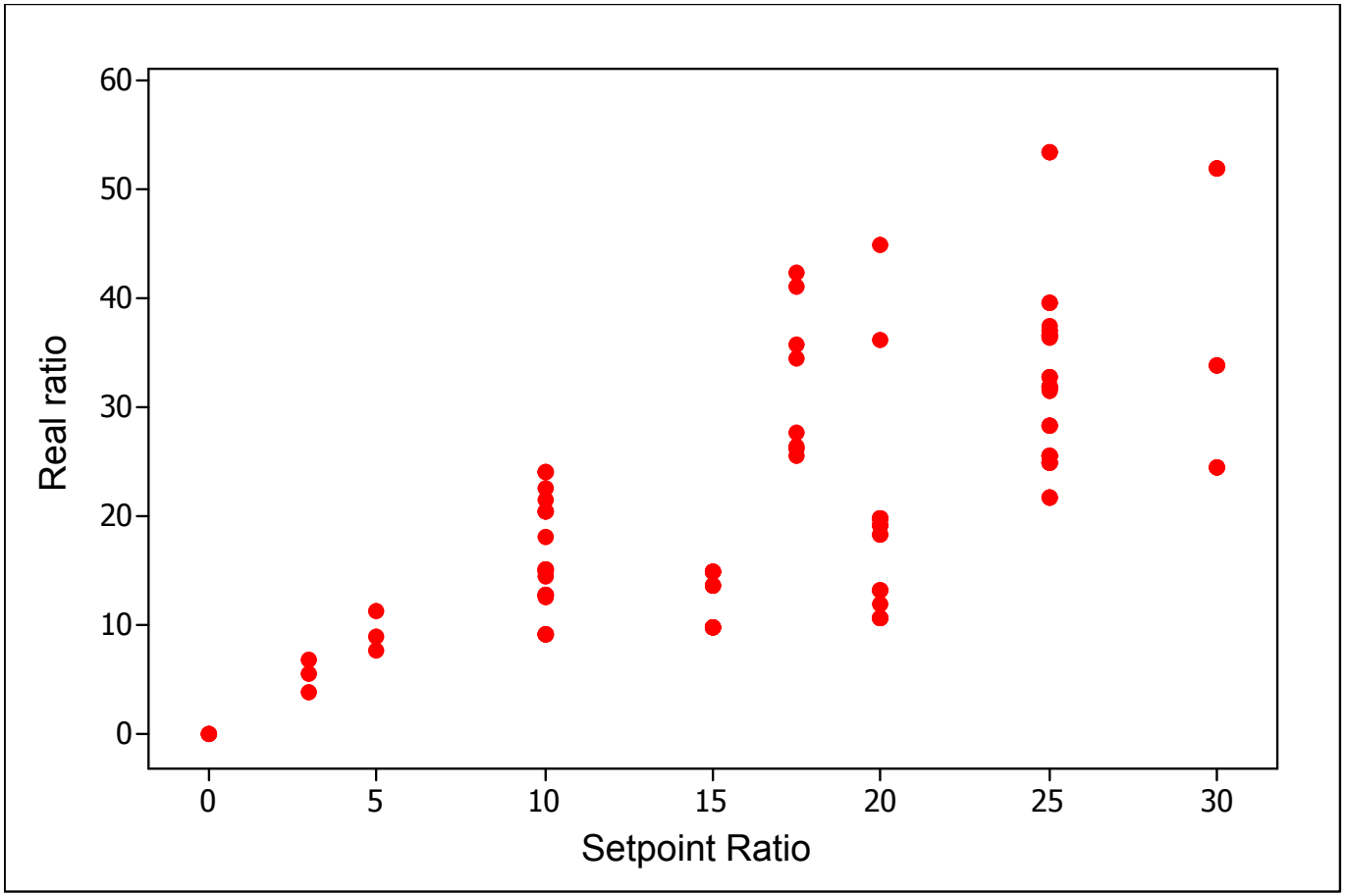
DOE Testing

- Overall, with nearly one year of tests, 141 trials were completed. Initial As concentration varied considerably:



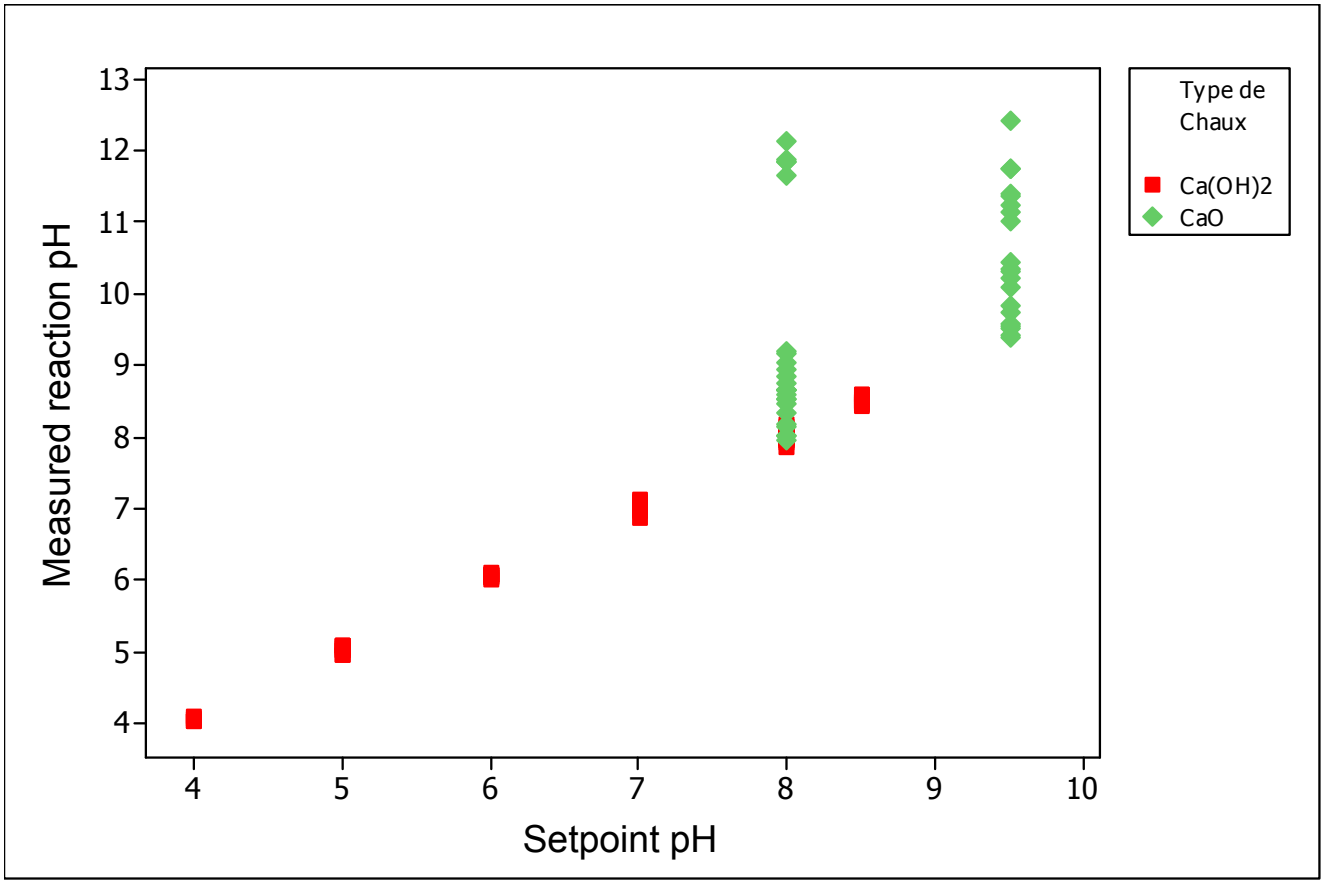
DOE Testing - Ratios

- The Setpoint ratios were difficult to attain due to variability of feed concentration:



DOE Testing - pH

- The Setpoint pH was normally controlled except for one series of tests where quicklime was used:

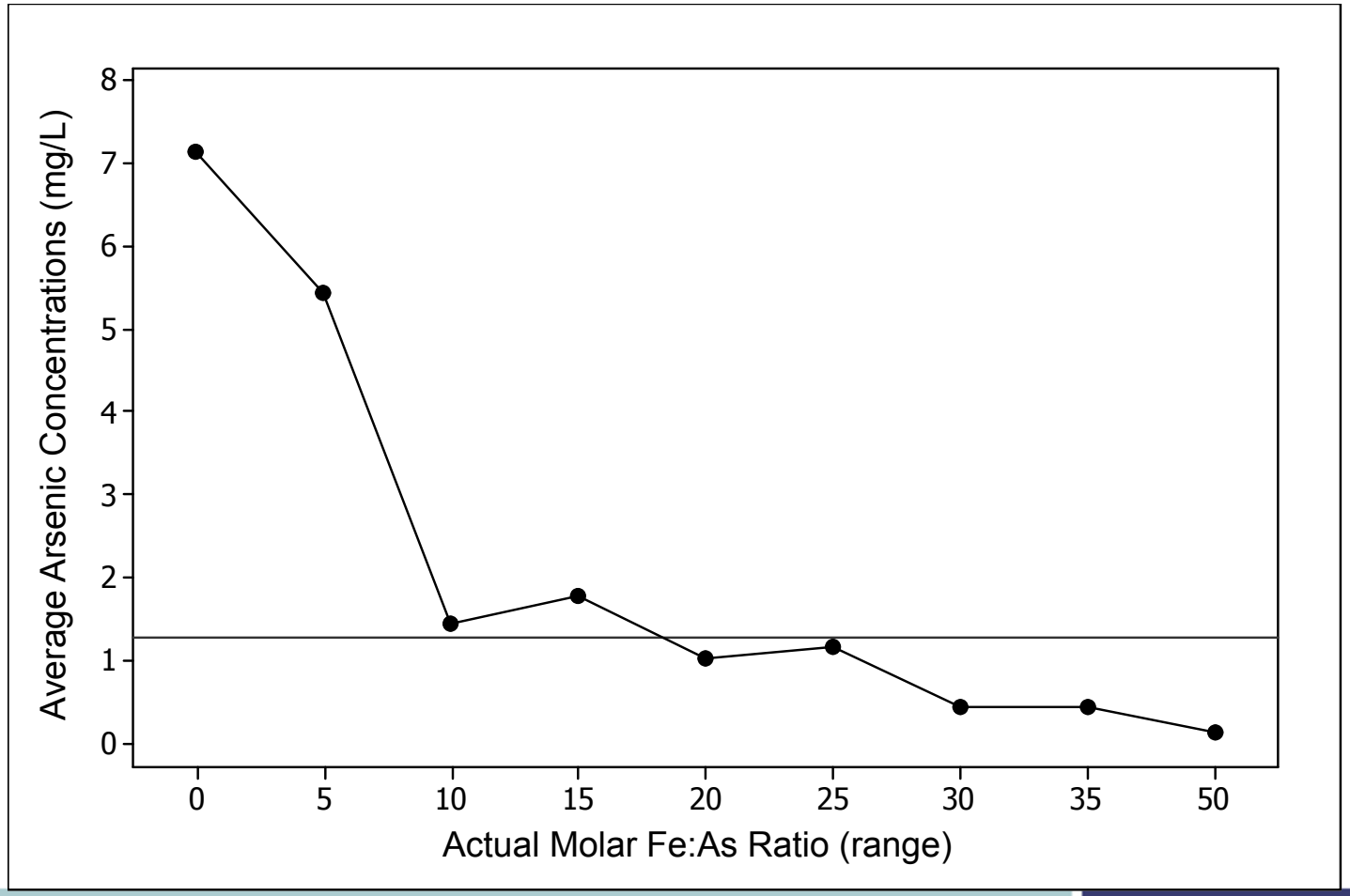


DOE Testing – CN

- Cyanide was most often below 2 mg/L (79 of 141 tests)
- It occasionally exceeded 10 mg/L due to operation of INCO-SO2 system
- It was once above 80 mg/L as the CN destruction system was down

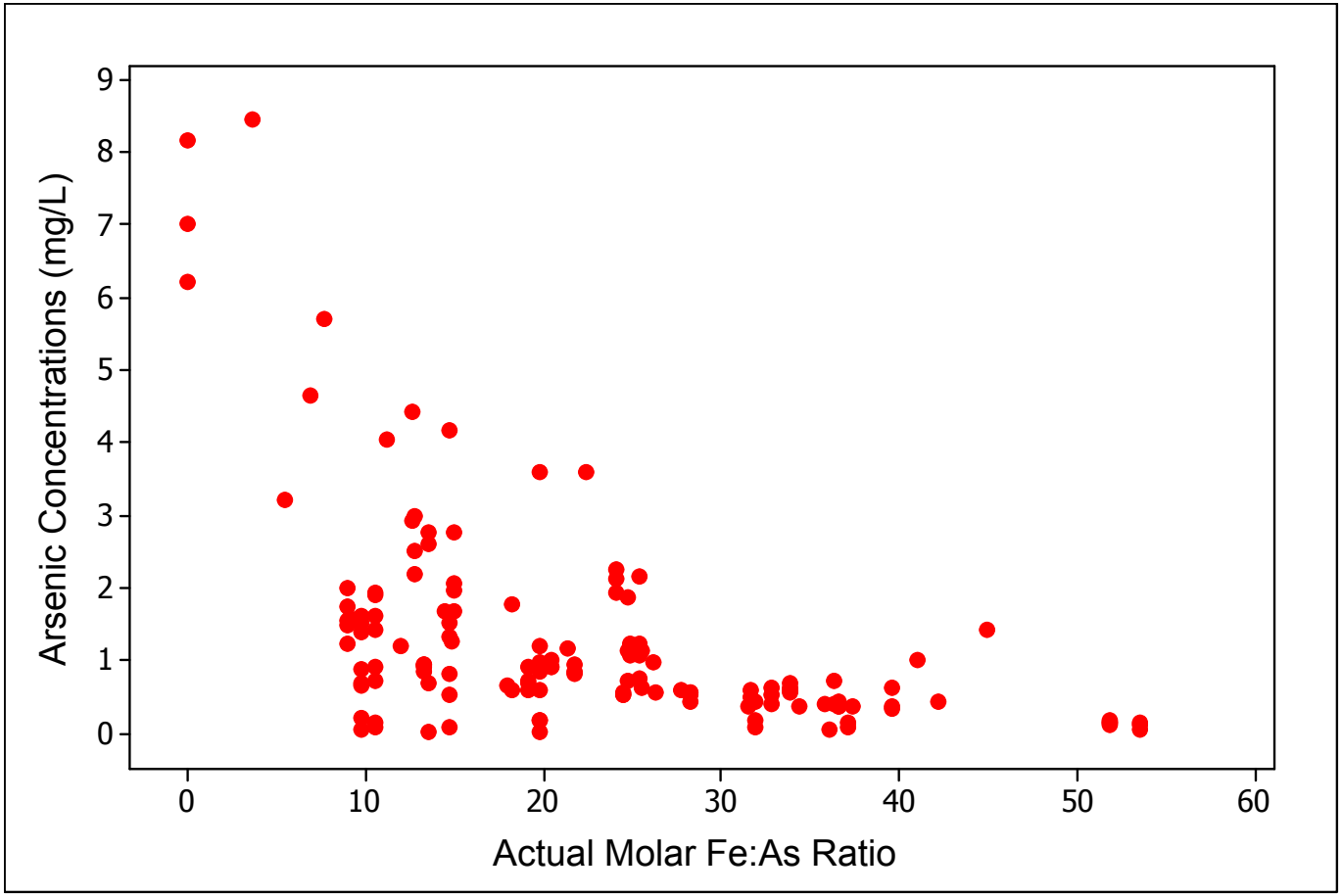
DOE Results - Ratio

- Clearly, the higher the ratio, the better the treatment. High ratios are expensive.



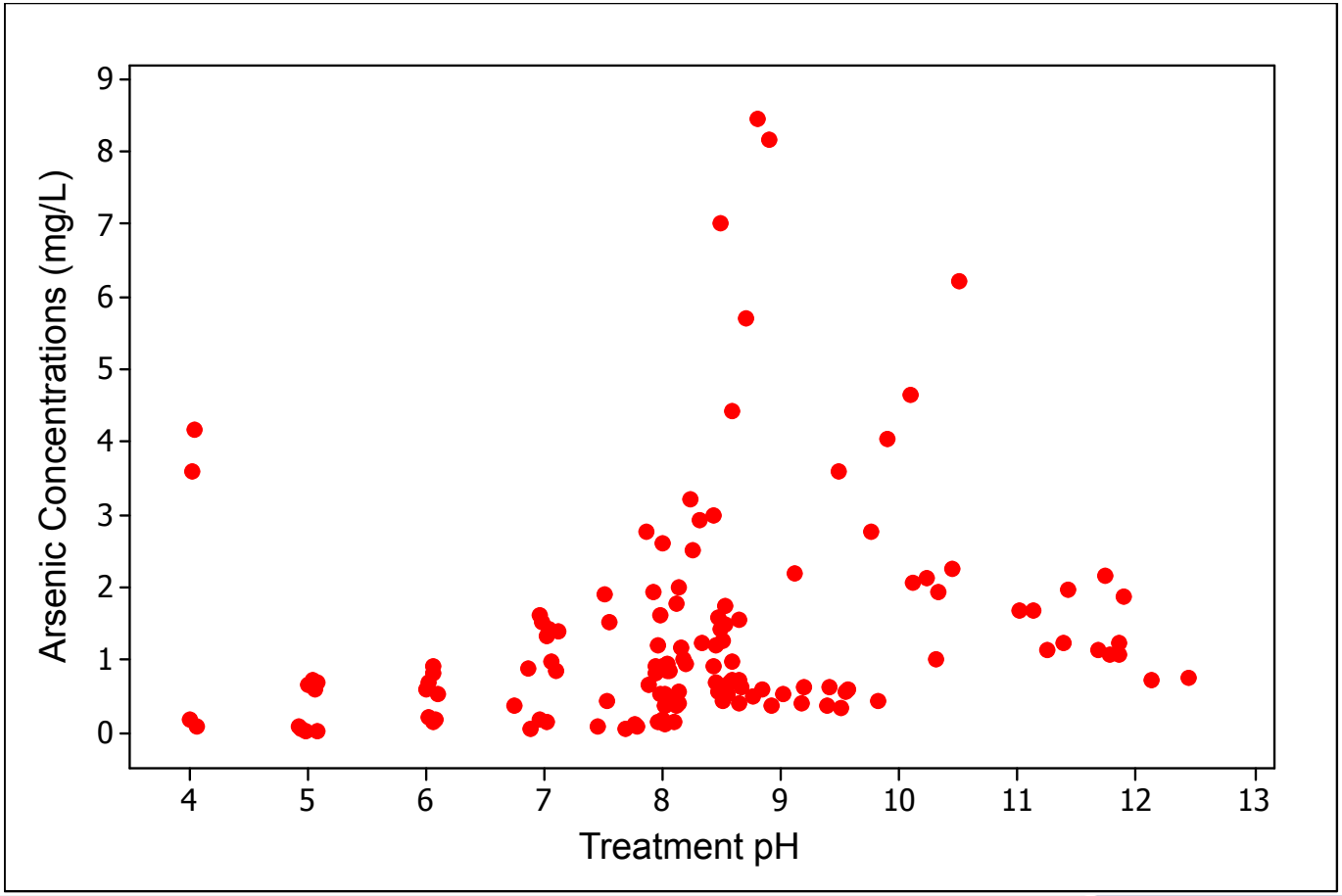
DOE Results - Ratio

- These actual results show some successful treatment (As<0.4 mg/L) at ratios of less than 20:1



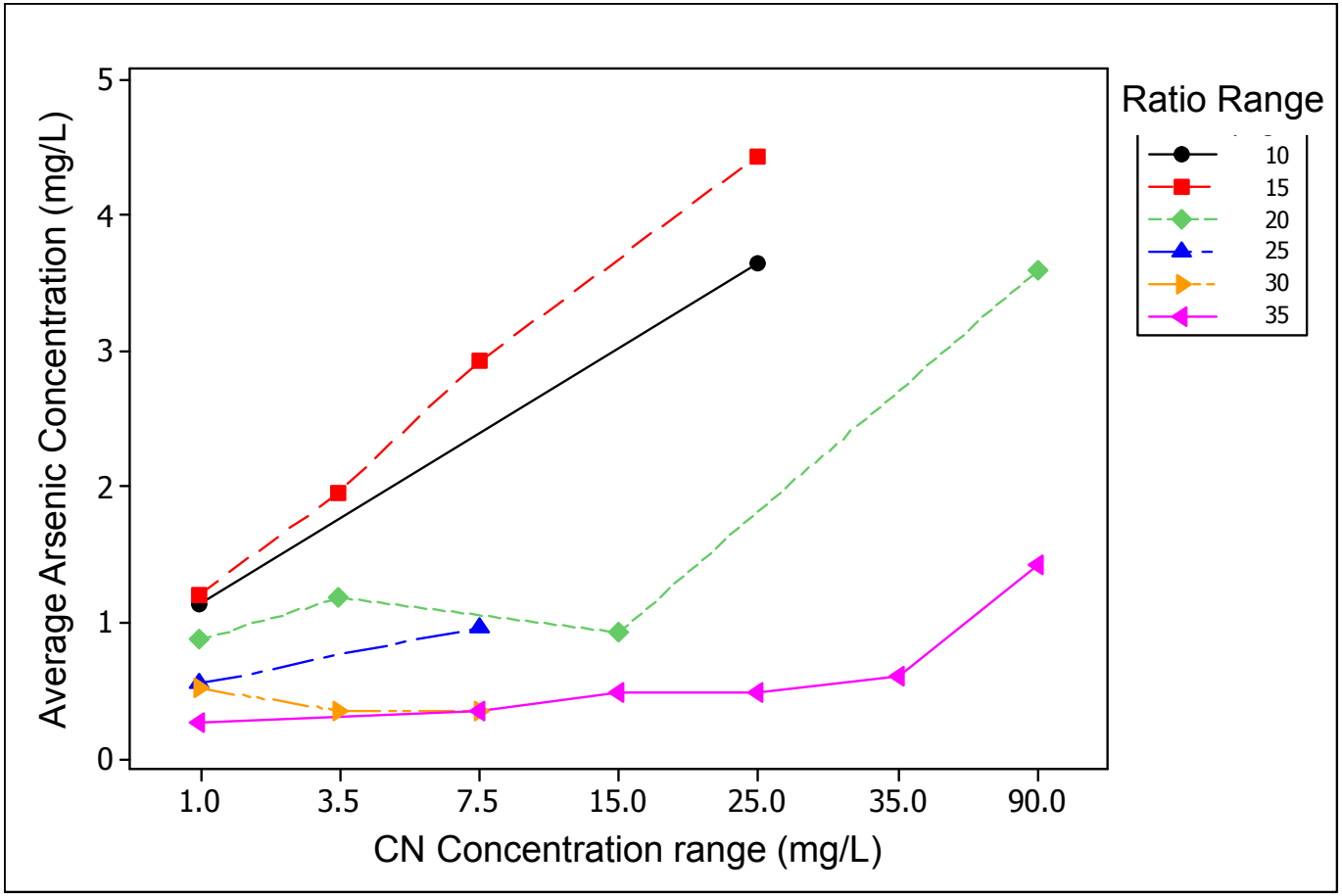
DOE Results – pH

- Lower pH values are better
- Note that low As values at pH>11 are calcium arsenate



DOE Results – CN

- CN Concentrations affect treatment efficiency at low ratios but less so at high ratios – CN complexing consumes Fe.

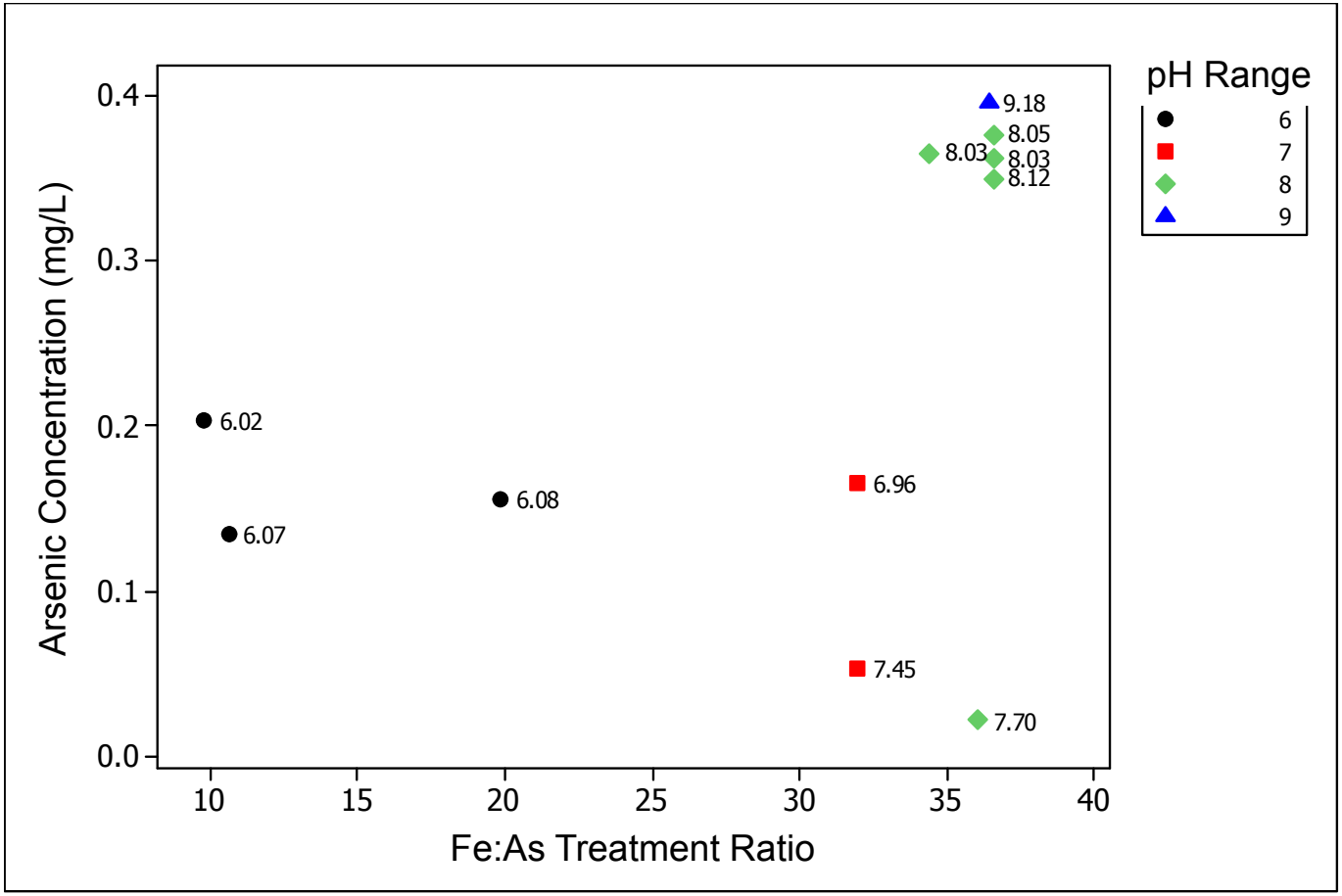


DOE Results – Other Parameters

- Aeration did not show any effects, but all tests were at high pH
- Mixing intensity was not a significant factor
- Negative effects were measured at higher retention times when there was a high pH. At expected pH values, retention time was not a significant factor.

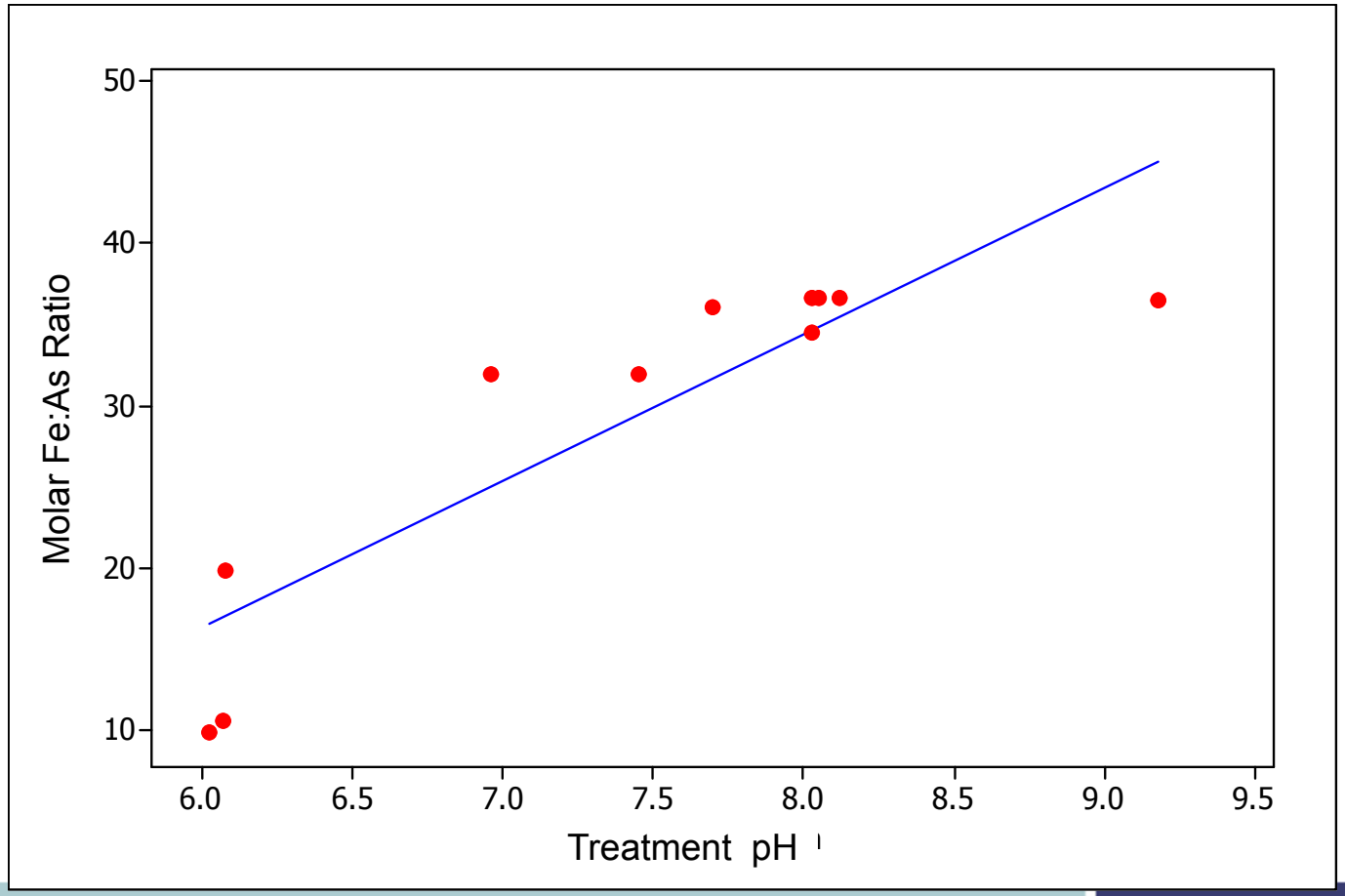
DOE Results – Successful Tests at Ratios < 40:1

- Results shown when CN is well treated (<2 mg/L)



DOE Results – Successful Tests

- All of these tests had As<0.4 mg/L. The regression shows the required Fe:As ratio at given pH values. More tests are needed to confirm or better define this relationship.



Full-Scale Treatment

- On-going with testing, ferric sulphate addition of 3.5 L/min in the tailings pump box has shown significant improvement in dissolved As fed to the tailings ponds
- In the past 4 months, the average dissolved As concentration in the tailings discharge has been 0.43 mg/L
- Feed As concentrations in this time averaged 11.3 mg/L
- This essentially works, but it is an overdose of Fe at a significant cost

Next Step

- A mix tank is to be built in between the cyanide destruction and the tailings pump box – for treating the As with pH control
- The system will be automated and the As analysis will need to be performed regularly to optimise treatment
- Although performance is improved at lower pH values, consideration must be given to issues concerning the tailings placement pH and additional pH modification required in the field

Conclusions

- Although the iron addition rates may be higher, it is possible to treat As in the tailings slurry at reasonable addition rates.
- A compromise must be made between pH for tailings disposal and As treatment efficiency.
- This will allow arsenic to be disposed of with the tailings and eliminates the need for a treatment plant and sludge management.