Passive Mixing to Improve Calcium Oxide Dissolution

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Pebble Quicklime

- Pebble Quicklime - 0.56 tons per ton of acidity Hydrated lime - 0.74 tons per ton of acidity.
- Bulk Density - 55 to 60 pounds per cubic foot vs. 30 to 40 for hydrate.
- Solubility - 1.33 g/L while hydrated lime is more soluble at 1.76 g/L.

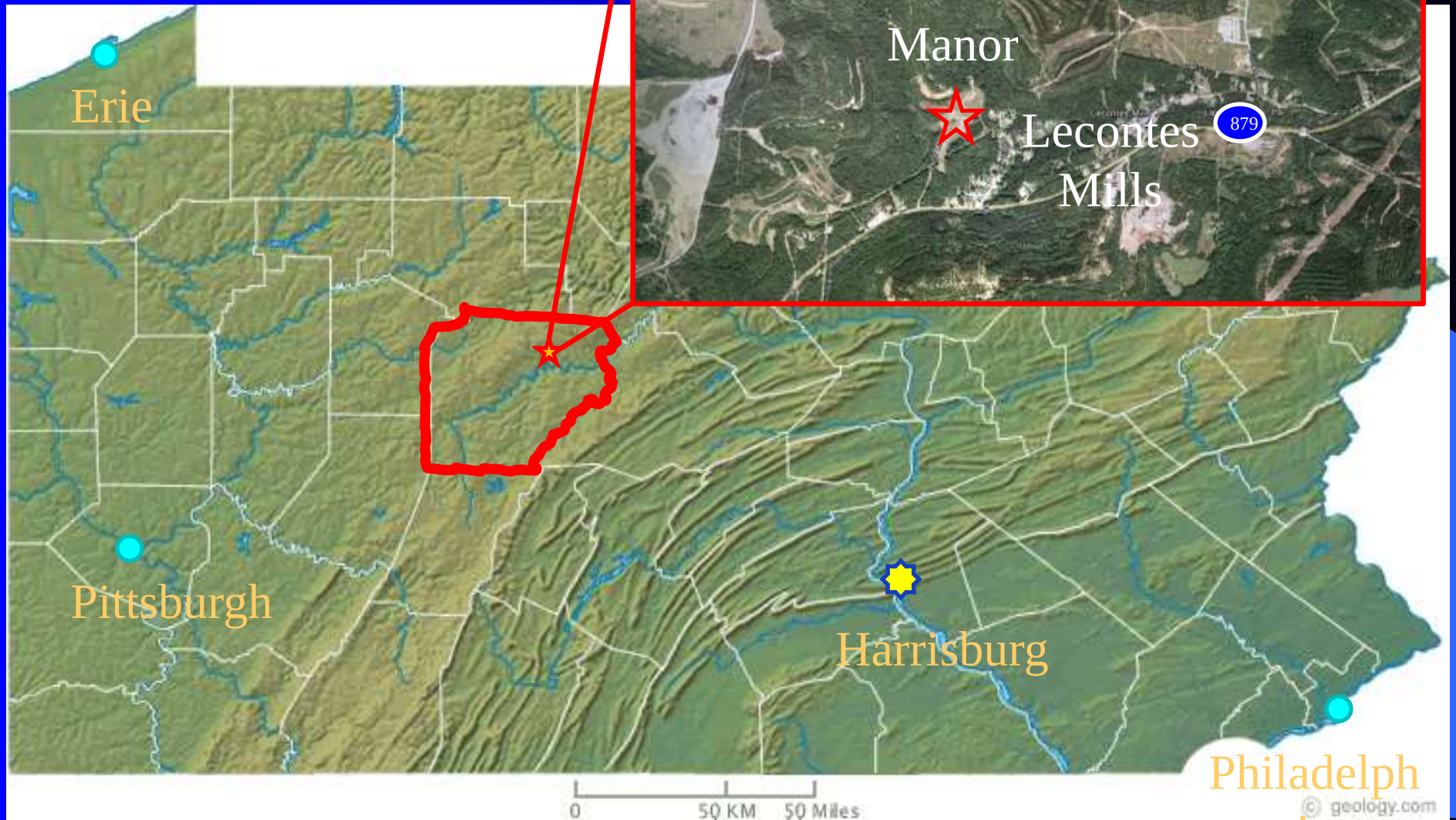
Lime Slaking

- $CaO + H_2O \rightarrow Ca(OH)_2$
- Exothermic reaction
- Limited water to promote temperature rise
- Temperature rise promotes particle breakdown.
- Excess water - insufficient temperature rise lime is “Drowned” leading to low lime utilization.

Semi-Active Lime Dissolution

- Water powered Lime Dosers.
- Long Dissolution Channel.
- Lime Buildup in Channel or Ponds.
- Carbon Dioxide Reacts to Form Calcite.

Manor Site – Clearfield County, PA



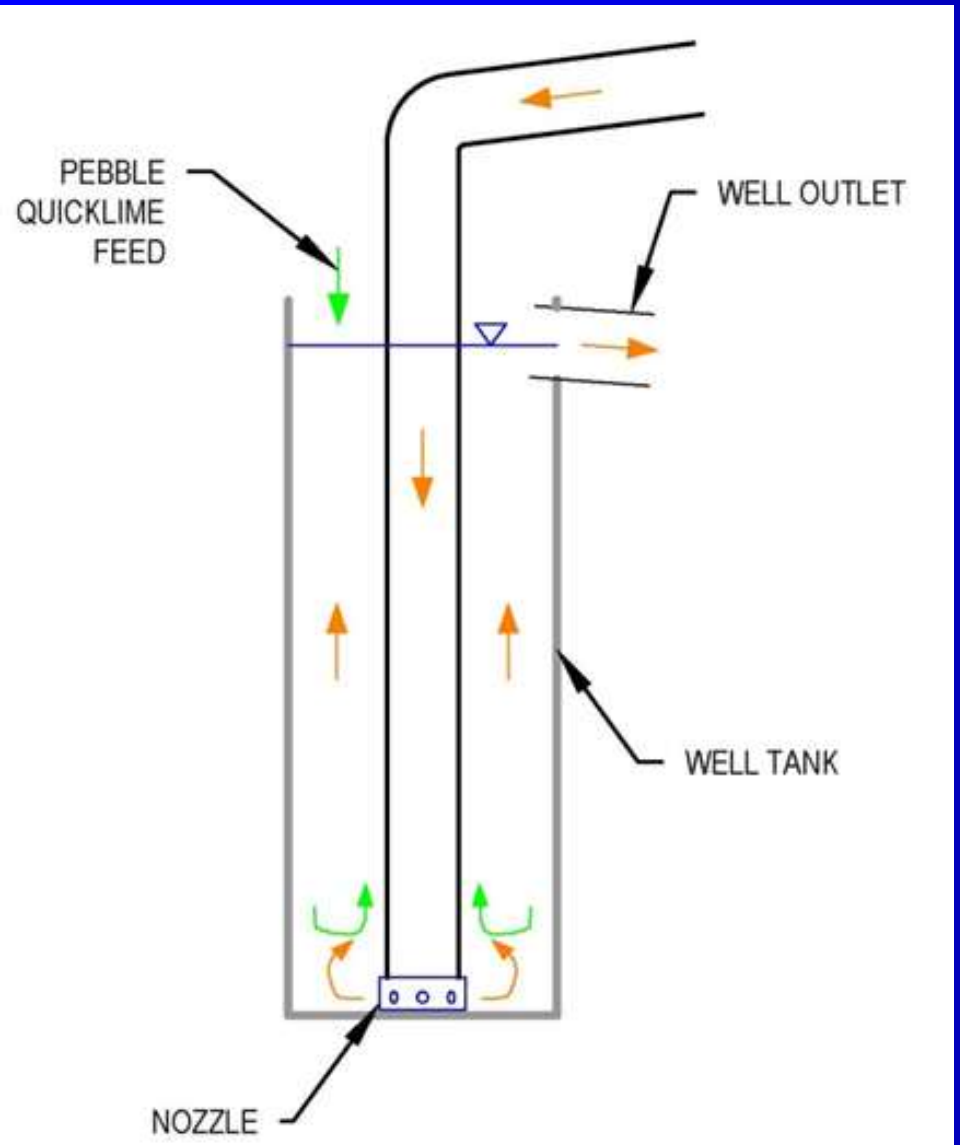
Raw Water Chemistry

Parameter	Date						Units
Date	1-6-12	1-16-12	1-23-12	1-31-12	2-7-12	2-21-12	
pH Field	3.48	3.43	3.53	3.38	3.45	3.69	S. U.
Acidity	466	468	458	445	422	417	mg/L
Iron	233	201	231	183	210	203	mg/L
Aluminum	19.3	22.3	15.6	12.9	11.4	16.8	mg/L
Manganese	3.62	2.99	3.13	3.23	3.43	3.40	mg/L
Calcium	166	140	160	138	145	141	mg/L
Magnesium	43.3	49.7	51.7	54.1	44.9	45.7	mg/L

Add Pebble Quicklime

MixWell

patent pending



- Raw water is feed to the bottom of the MixWell.
- Lime or lime slurry is added to the annulus and sinks to the bottom.
- The lime is agitated by the raw water.
- Only small particles rise to the discharge.

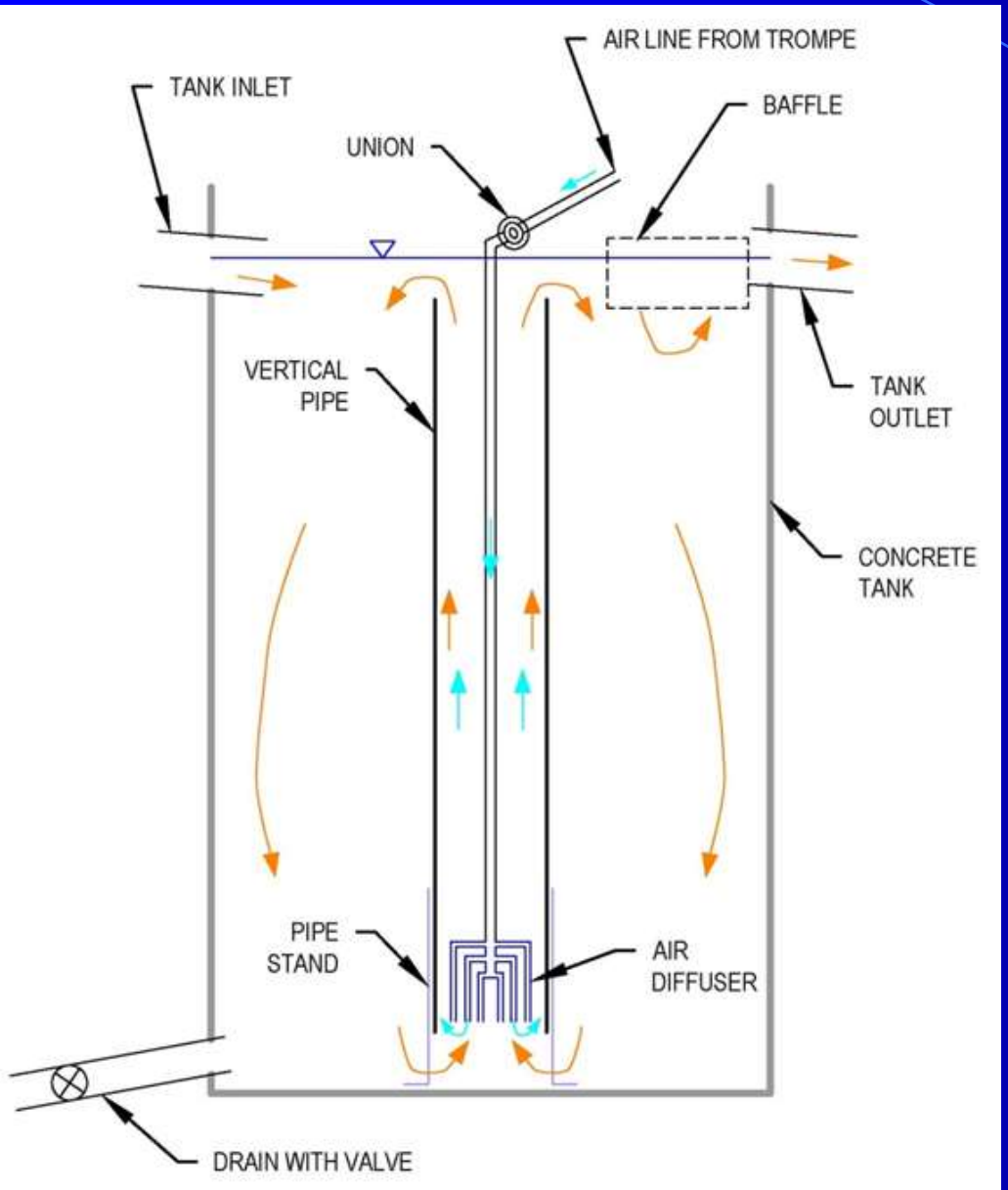
MixWell

Particles Retained in MixWell

Lime Particles from MixWell

A-Mixer

patent pending

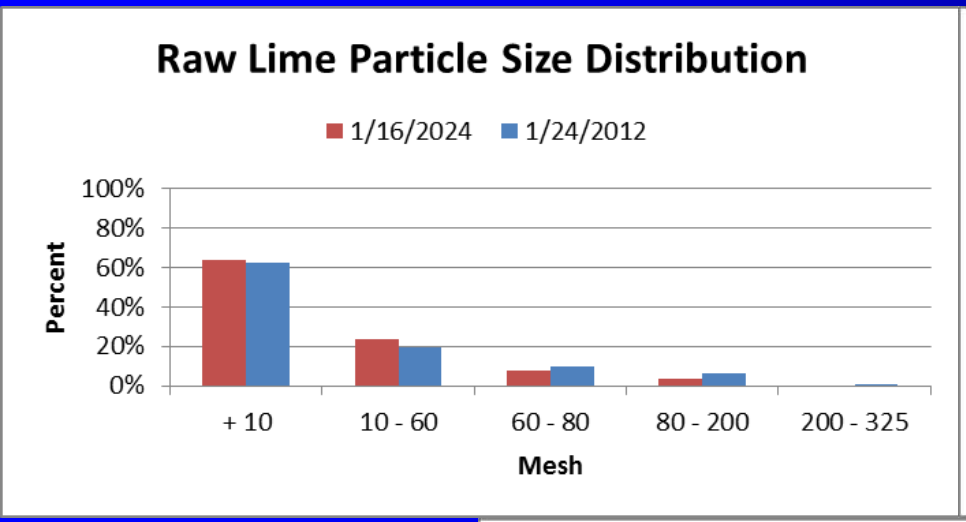


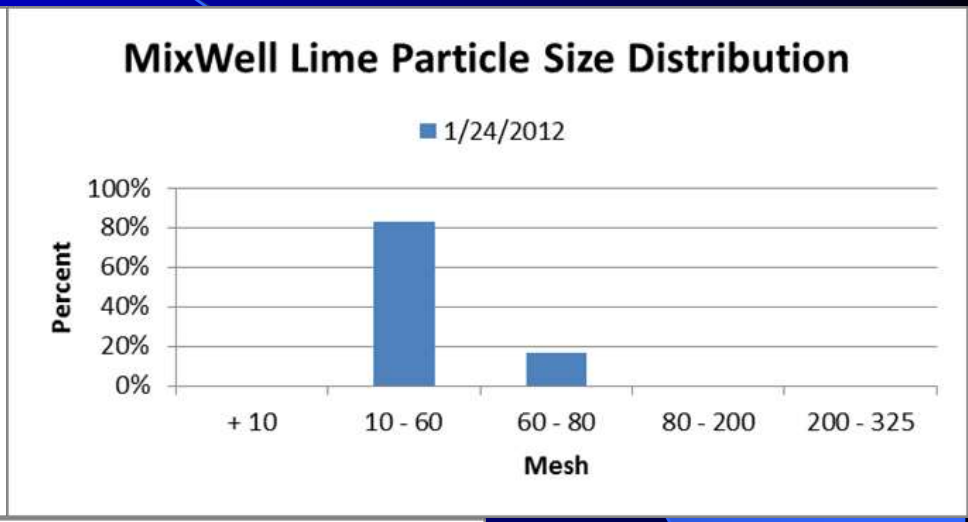
- Compressed Air supplied by Trompe.
- Airlift created in 12 inch pipe.
- Circulation in tank keeps small particles suspended.
- Airlift provides oxygen for iron oxidation.

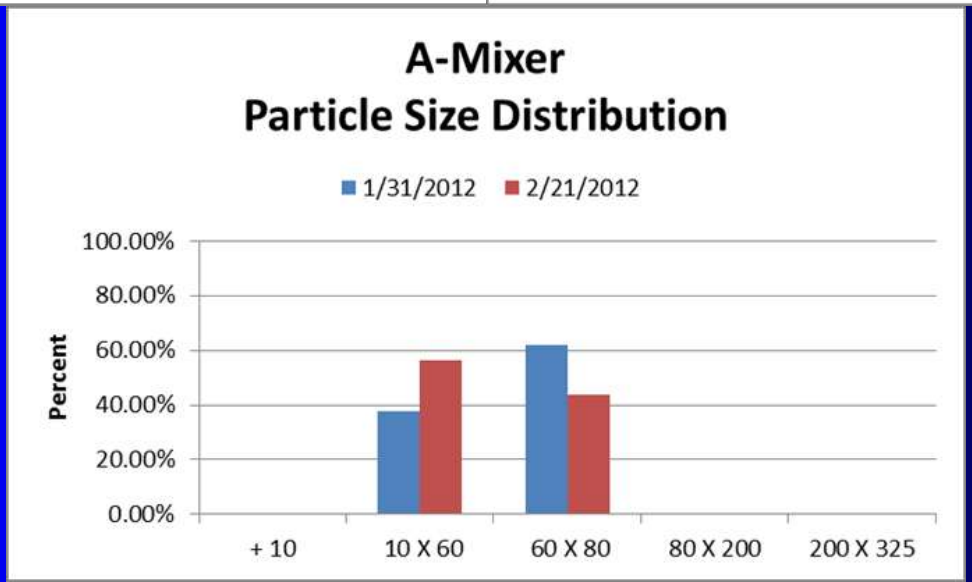
A-Mixer

Lime Particles from A-Mixer

Pebble Quicklime







Chemical Reactions

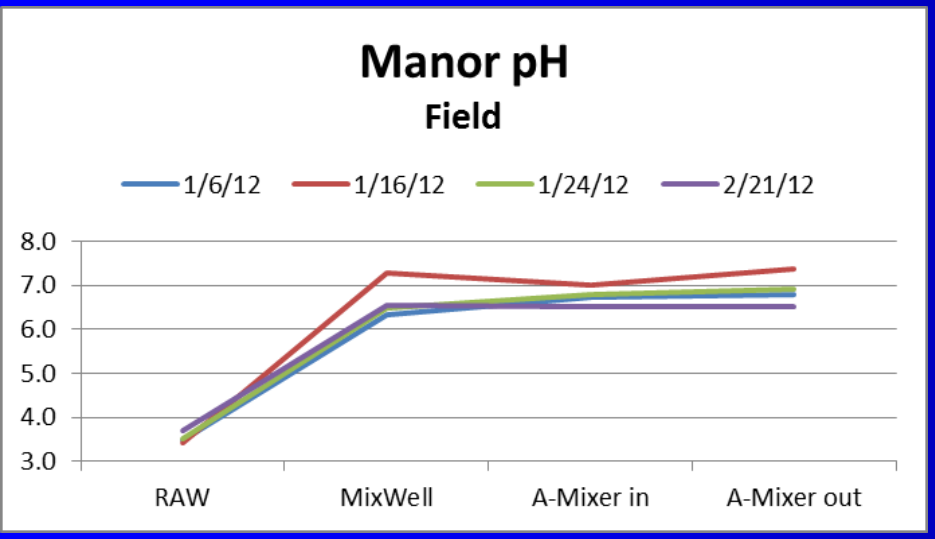
$$Fe^{+2} + \tfrac{1}{4}\, O_2 + H^+ \rightarrow Fe^{+3} + \tfrac{1}{2}\, H_2O$$

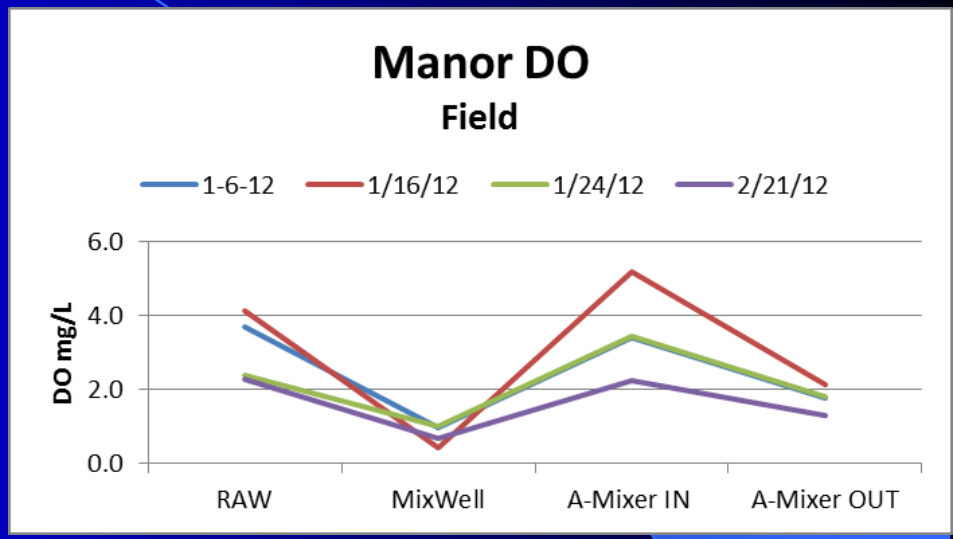
$$Fe^{+3} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+$$

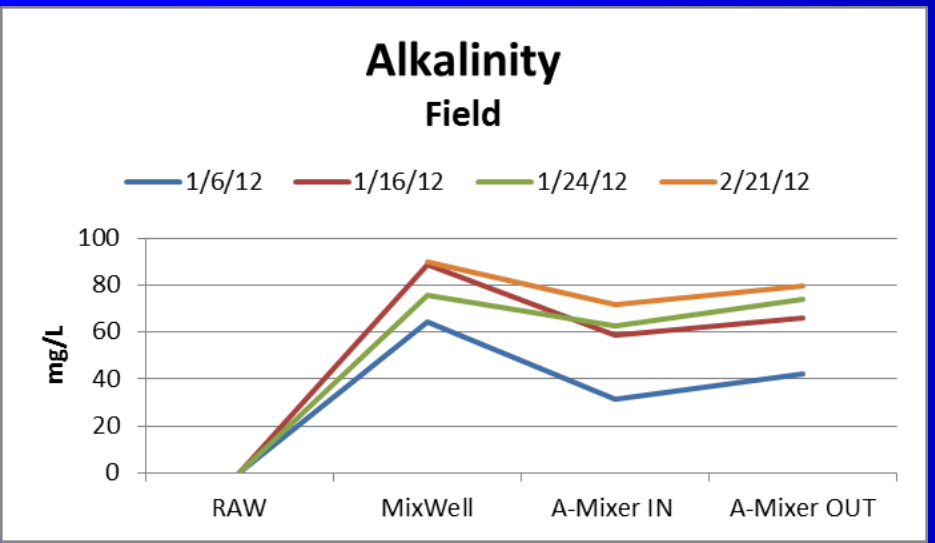
And / Or

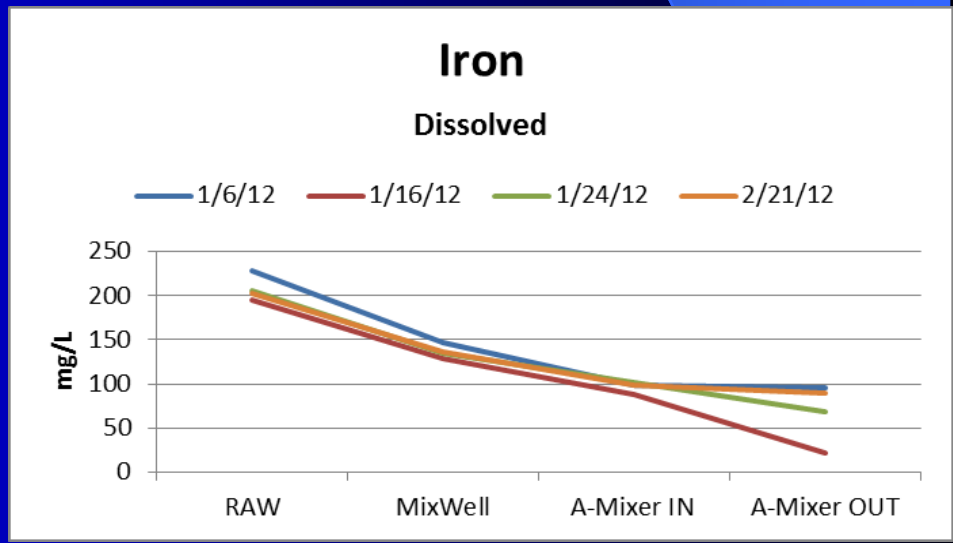
$$Fe(OH)_2 + \tfrac{1}{2}\, H_2O + \tfrac{1}{4}\, O_2 \rightarrow Fe(OH)_3$$

Process Chemistry

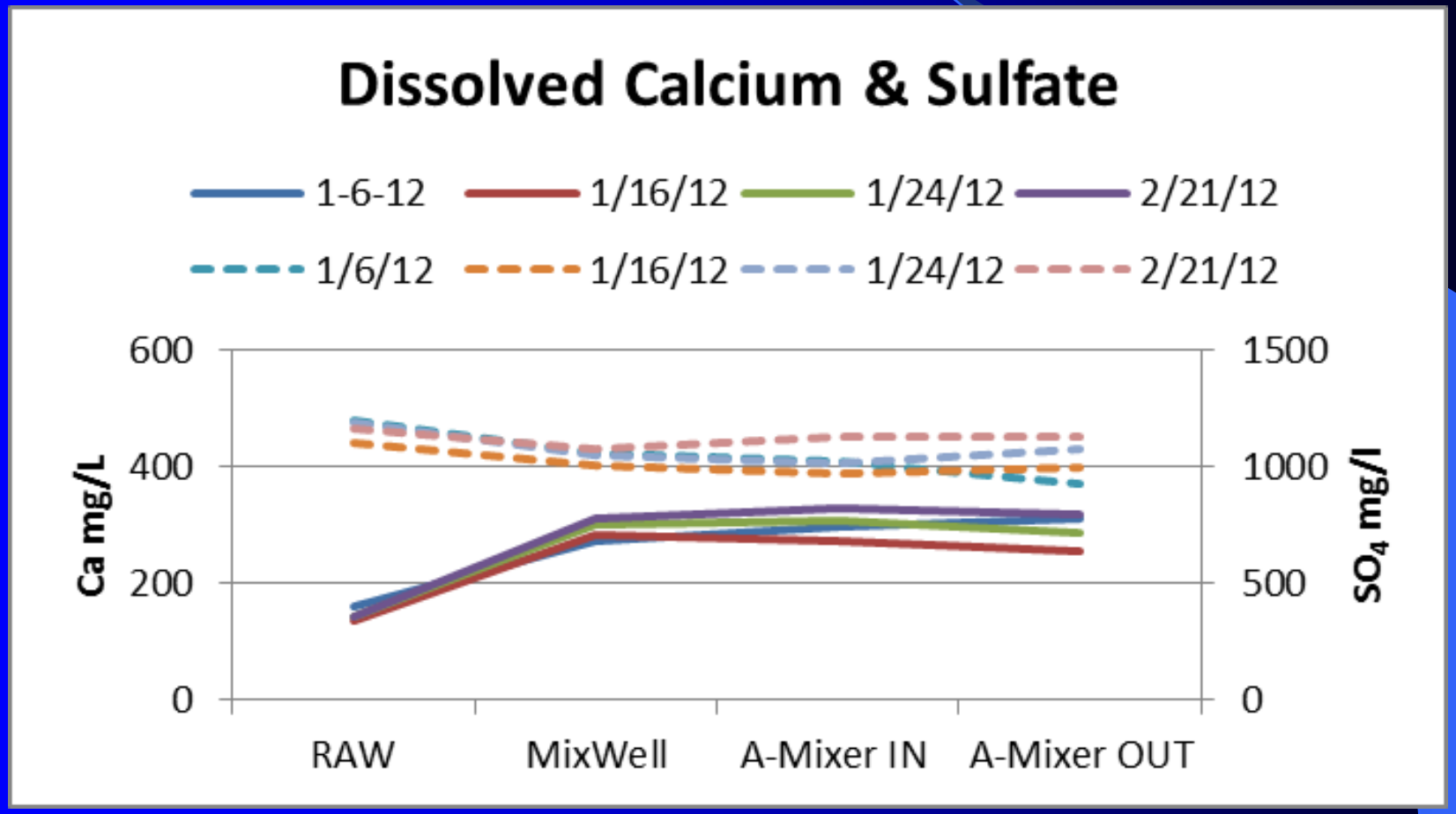




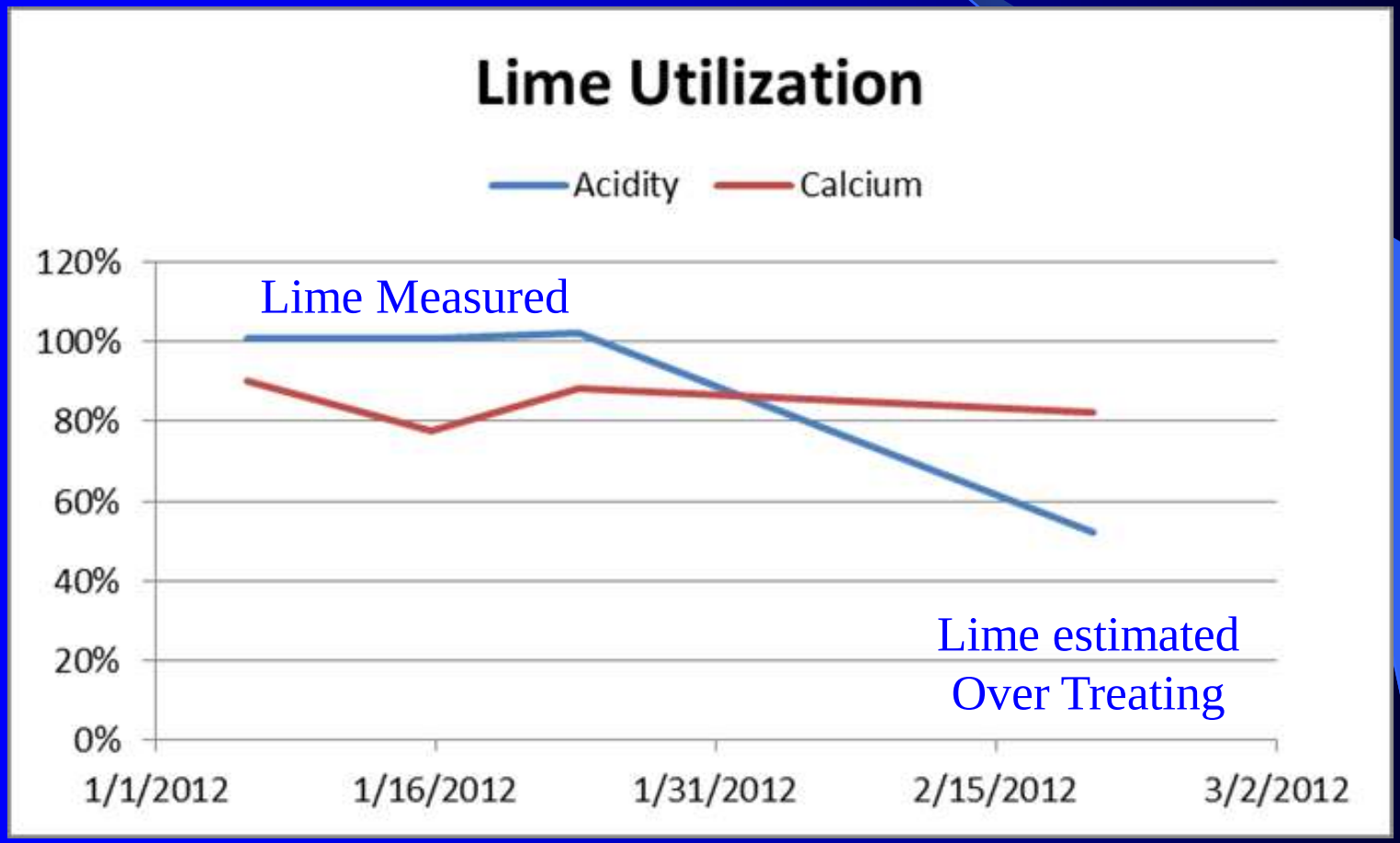




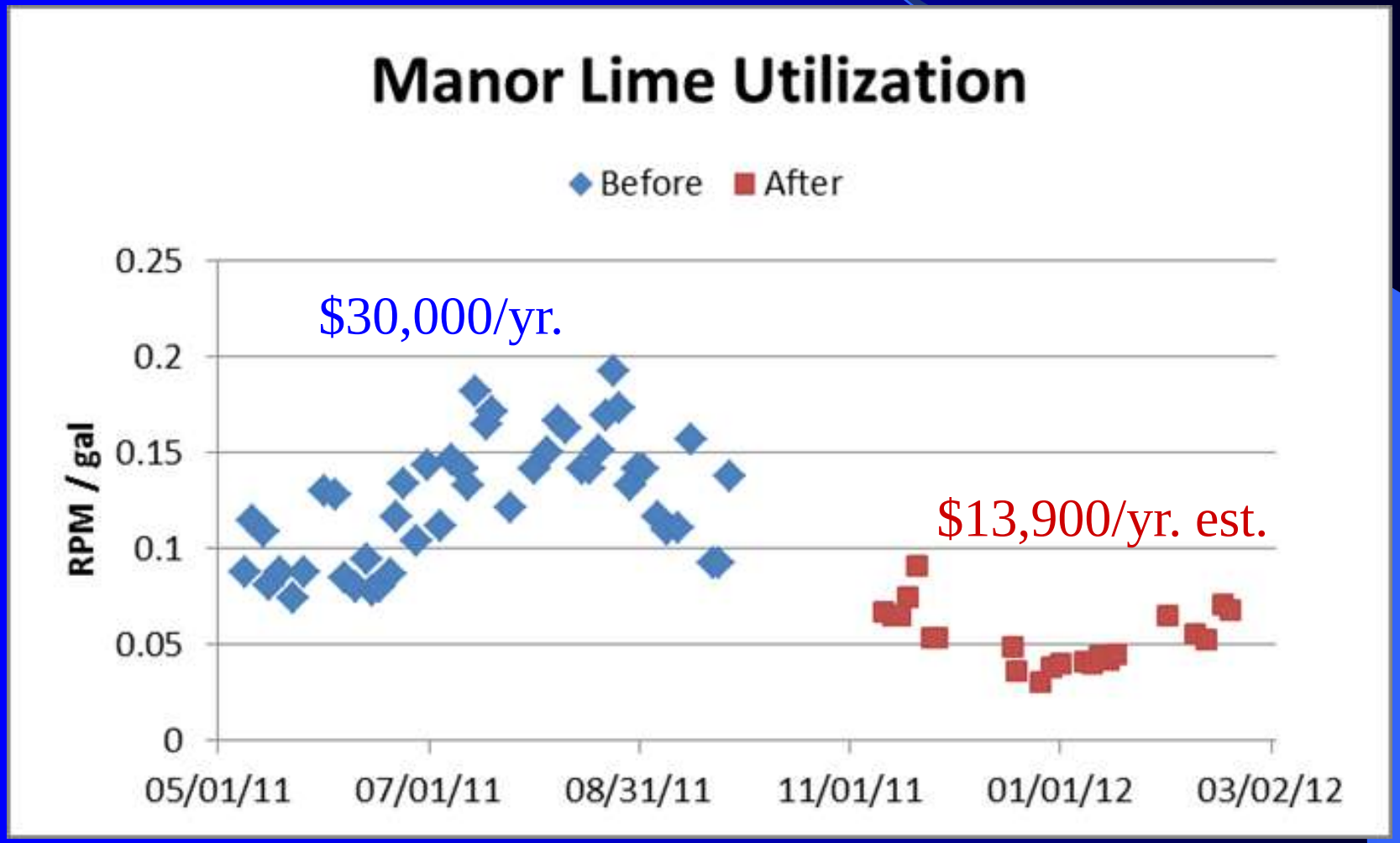
Gypsum Formation



Calculated Lime Efficiency



Significant Cost Reduction



Conclusions

- Passive mixing technology can have a very significant improvement in lime utilization where pebble lime is the source of the alkalinity.
- The MixWell technology is very effective at dissolving pebble quicklime and reducing the particle size of its effluent.
- The A-Mixer, if operated at pH 7 or above, can advance the oxidation of ferrous iron while maintaining pH.

Acknowledgement

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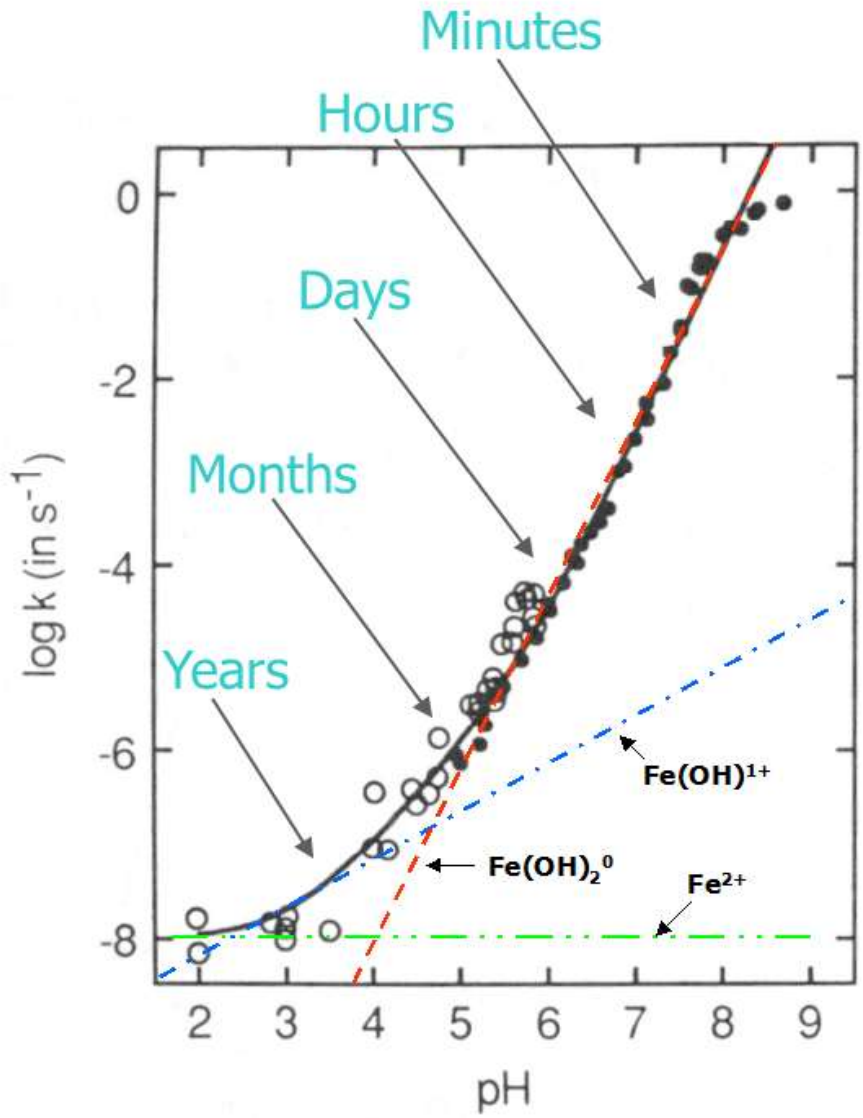
Questions



Effect of pH

- The higher the pH the faster iron is oxidized.
- As iron is oxidized the pH is lowered lengthening the time required for oxidation.
- This increase in detention time requires a commensurate increase in pond size.

After Dietz 2008

What is a TROMPE?

- It is a device that uses falling water to compress air.
- It has No moving parts.
- It does Not use electricity.
- It is Completely passive.

Principals of Operation

- Falling water in a pipe entrains air.
- The high velocity water carries the air down the pipe to an air separation chamber.
- Compressed air is separated from the water by gravity.
- The air is collected for use.
- The water is discharged.