Feasibility Case Study

Replacing Sodium Hydroxide with Calcium Hydroxide as an Alkalinity Agent.

In Partnership with Sudbury Lime Limited.

FloChem Ltd.
Quality Chemical Management

Replacing Sodium Hydroxide with Calcium Hydroxide as an Alkalinity Agent.
A Case Study

Authored By Matt Haggis, General Manager, Sudbury Lime Limited

Overview

In June of 2017, a plant scale test was requested by a potential customer to determine the cost effectiveness and performance of calcium hydroxide slurry as a replacement for sodium hydroxide (NaOH 50 %). The testing was prompted by the recent increases in the cost of sodium hydroxide and the potential for a significant reduction in reagent costs by switching to the lower cost calcium reagent. The customer was also very interested in the potential reduction in environmental impact by reducing sodium levels in their effluents, as well as the higher safety factor of using calcium hydroxide over caustic soda.

The customer historically consumed approximately 1 million kilograms of sodium hydroxide annually at its southern Ontario operations, for the treatment of waste water effluent from their poultry processing operation. Approximately 87 percent of the total NaOH consumption was used for Alkalinity adjustment prior to aerobic digestion, while the remainder was used in the pH control for alum addition later in the treatment process.

Prior to commencing the test work, water samples were taken from various locations within the treatment process for background data comparison. Mobile lime dosing equipment was installed at the site and lime addition was initiated, replacing the NaOH addition for Alkalinity adjustment only.

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During the first week of testing, routine samples were collected throughout the process and field analysis for pH and alkalinity were performed by Flochem and the clients' operating personnel. The target alkalinity was set by the client at 80 mg/l as CaCO3. Lime addition was adjusted as needed (using a variable speed pump) by the customer to maintain a level higher than the target level.

Over the course of the next few weeks, lime consumption rates were compared to the historic usage rates of sodium hydroxide for this applications. Finding the lime consumption rates quite favorable, the customer asked to extend the trial for a three-month period to ensure that all process variables (including weather conditions) would be considered during the testing period.

After several weeks, it became apparent to the customer that the lime was performing very well and there were no apparent detrimental effects to the process due to the switch from Sodium Hydroxide. The customer agreed to enter into a long-term supply contract for the supply of calcium hydroxide slurry. A permanent lime addition system was designed and installed on site to limited space available to the client. The portable system was kept in place to accommodate the until the new system could be commissioned. The customer has not returned to using sodium hydroxide for alkalinity adjustment since the trial began, but continues to use a small amount for pH control in their alum circuit.

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Plant Trial Description

To facilitate the testing of Calcium Hydroxide on a full plant scale basis, it was necessary to mobilize lime storage and metering equipment to the site. This was accomplished using a specialized Mobile Treatment Unit and a 12,000 mobile storage tank. (fig.1). The MTU is equipped with a PLC based control system as well as 3G telemetry capability so that the treatment could be monitored off site by Flochem personnel on a continuous basis. (fig.2a) Although the MTU was equipped with full pH control capability, this was not used during the test at the request of the customer, who preferred to adjust the addition rate manually based on lab test results for alkalinity.

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Figure 1 – Mobile Treatment Unit, Mobile Tank and Control Panel

Lime slurry was transported to the site by 8,000 USG pneumatic tankers and offloaded into the 12,000 USG storage tank. This tank was equipped with mechanical mixers to keep the calcium hydroxide slurry in suspension. The tank level and lime consumption rate were monitored closely by By personnel ***(Fig. 2b)*** and the tank was replenished on an as needed basis.
Each tanker load was weighed at the customers scale house on arrival and departure and the lime volume were estimated based on these scale tickets and product density.

It is important to note that lime addition volumes were controlled exclusively by the customer, based on their typical operating parameters using caustic soda. No attempt was made to streamline reagent addition by use of process control loops of other means, but it is highly likely that efficiency could be even further improved if these options are explored in the future.

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Figure 2a – Remote Monitoring Screen for MTU

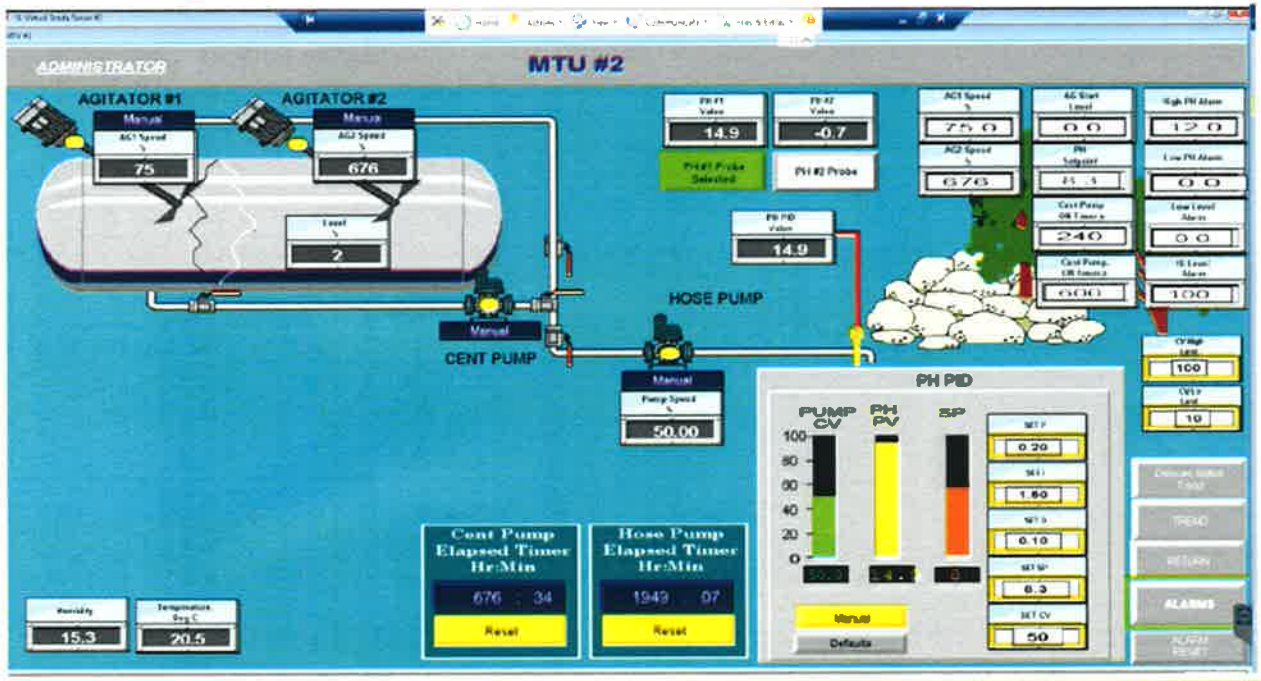

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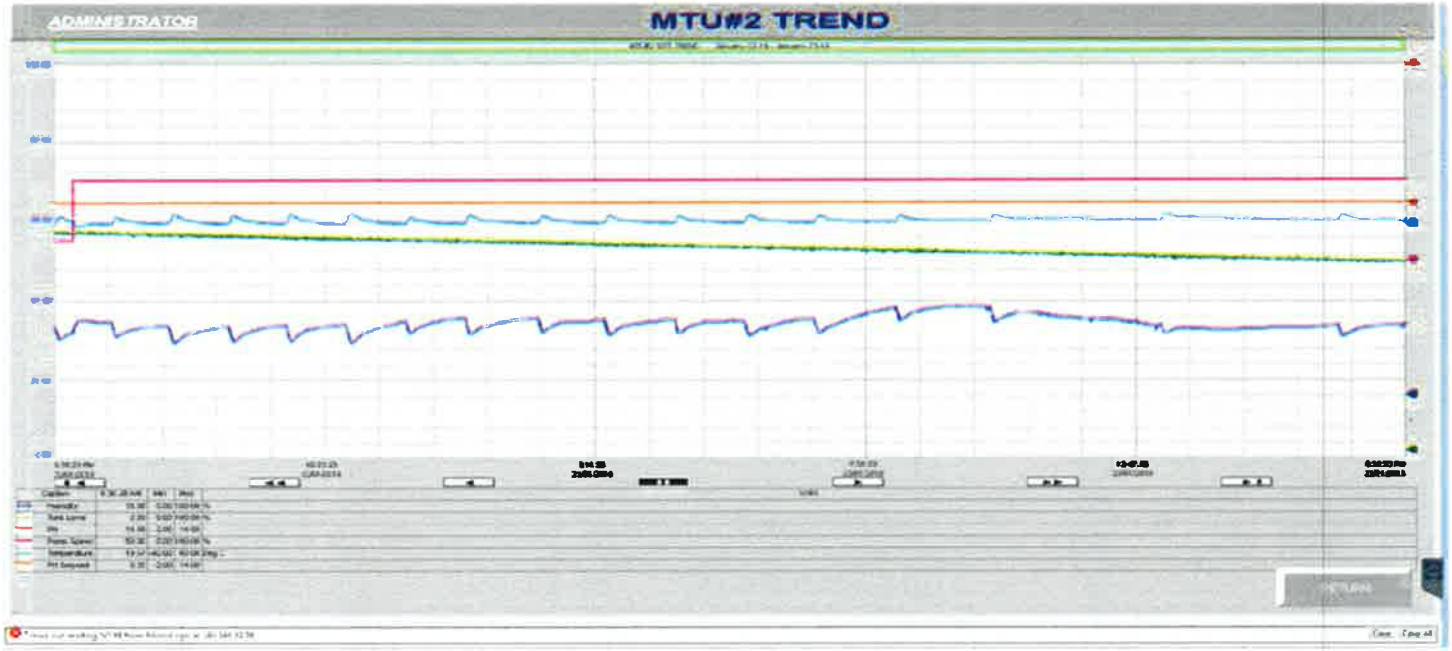
Figure 2b – Remote Monitoring Historical Trending Screen



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Lime Product Description

The lime product produced is a high quality calcium hydroxide slurry that is produced exclusively at the Lime slaking plant. This plant uses only high calcium quicklime (CaO), which is "slaked" with water in a Vertimill Lime Slaking system. The resulting product is a very high quality, grit free Calcium Hydroxide (CaOH2) slurry that can range from 27 to 32 percent solids, depending on the season. The product screen distribution of our product is typically 97 percent passing 325 mesh, which provides considerably higher reactivity (surface area) than most conventional slaking processes. Further information regarding our product can be obtained from our website at www.Flochem.com

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Figure 3 – Typical Wet Screen Analysis of Lime Slurry Product

LIME SLURRY - WET SCREEN ANALYSIS

Sudbury Lime

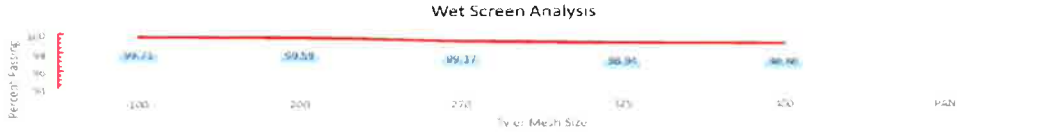
Date of Sample	1/24/2018	Sample #	SA-18-JA24-04	Weight of Slurry Sample (grams)	608	% solids	29.94	Weight of Solids (grams)	182.0352

Tyler #	mm	Retained Weight	% retained	% Passing	Cumulative Passing	Sample Integrity
100	0.149	0.5251	0.29	99.71	99.71	OK
200	0.074	0.2136	0.12	99.88	99.59	OK
270	0.053	0.7745	0.43	99.57	99.17	OK
325	0.044	0.411	0.23	99.77	98.94	OK
400	0.037	0.1415	0.08	99.92	98.86	OK
PAN						SAMPLE ACCEPTED

PERCENT SOLIDS (VOLUMETRIC)		PRODUCT DENSITY:	1208	PERCENT SOLIDS (IR 30) (GRAVIMETRIC)	29.94

Analysis Completed by:	David Hagglund	Date	15-Jan

NOTES: Sample taken from Load #38344 (Loadout). Source TK-201. Taken day after tank cleaning completed



Wet screen analysis performed using a Rotap Model RX - 29 with the Rotap Model LA-11112 Wet Test Kit. This analysis procedure has been developed using the manufacturer's recommendations and industry standards for wet screen testing of lime slurry.

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Product Comparison - Calcium vs Sodium

Prior to the plant trial, much consideration was given to determining how much equivalent lime slurry would be needed to provide the same amount of alkalinity adjustment. As mentioned, the lime slurry used was typically between 27 and 32 percent solids (avg. 29.2%) as Calcium Hydroxide, while the Sodium Hydroxide reagent was supplied as a 50% solution. Historical data obtained from the customer indicated that their annual caustic consumption for the previous year (2016) was 134,798 Imperial Gallons, or 919,188 kilograms. Approximately 87 percent of this volume was consumed for alkalinity adjustment, which was the primary focus of the testing.

Reagent application was typically applied primarily throughout the weekdays only, with reduced consumption on weekend due to lower production rates. The customer expressed that their typical weekday usage of caustic was approximately 500 IGAL (2275 liters) per day. Using this as a guideline and considering the variance in percent solids, the mobile test equipment was sized accordingly, giving the customer the ability to control lime addition rates from 0 to 10,000 liters per day.

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Product Comparison - Calcium vs Sodium

Consideration was also given to the fact that Calcium Hydroxide (Ca(OH)2), being divalent in nature, should deliver twice the neutralization efficiency as the univalent Sodium Hydroxide (NaOH), however this was not factored into the calculations due to the unknown nature of any contaminants in the treated water that might affect the neutralization efficiency factor of either
product. In fact, one of the main purposes of the full-scale plant test was to determine the actual equivalency in a real-time application, rather than rely on chemical formulas such as the information indicated below. (chart 1).

Careful monitoring of lime slurry consumption was carried out over a six month period during the testing. Each load was measured for product density and total volume of product delivered.

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Product Comparison - Calcium vs Sodium

Month	NaOH Consumption (2016) Wet	Ca(OH) 2 Consumption (2017) Wet	NaOH Consumption (2016) Dry	Ca(OH) 2 Consumption (2017) Dry **	Ratio NaOH/ Ca(OH) 2
	Kilograms	Litres	Kilograms	Kilograms	Kilograms
June -Part	47,276	58,978	23,638	19,585	1.207
July	62,708	61,508	31,354	20,425	1.535
August	76,005	99,009	38,002	32,879	1.156
September	65,231	49,296	32,615	16,370	1.992
October	88,122	89,183	44,061	29,616	1.488
November	54,661	94,429	27,331	31,358	0.872
December	108,456	59,026	54,228	19,601	2.767
TOTAL	**502,458**	**511,426**	251,229	169,834	1.479
Average	**81,780 +**	**73,061+**	35,890	24,262	1.479 ++
			CHART 1		

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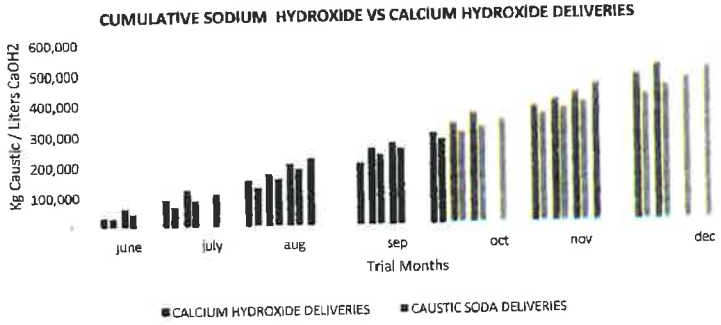

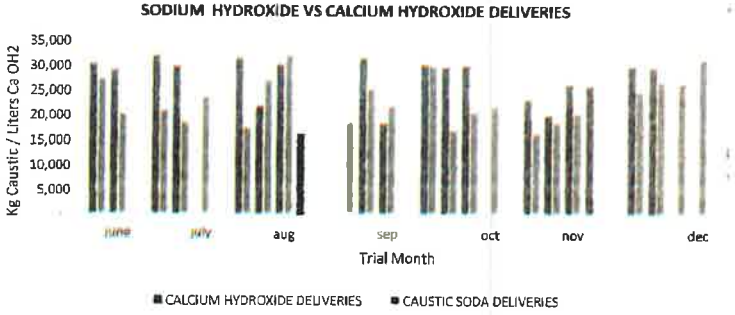

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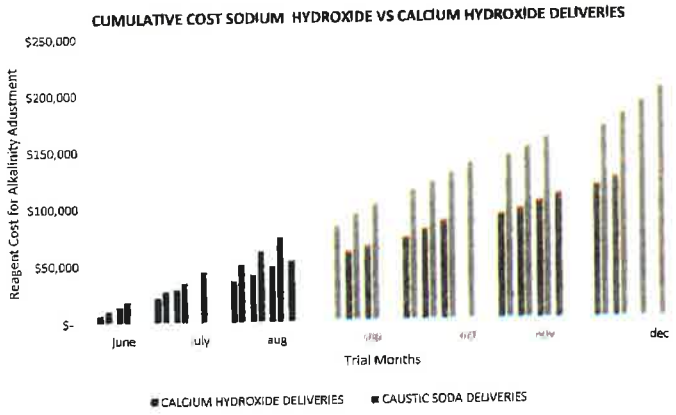
Cost Analysis – Potential Savings

To determine the actual cost saving to the customer resulting from the changeover to Calcium Hydroxide, the historic consumption data supplied by the customer for 2016 was used and an updated cost was applied to these volumes to reflect the current pricing increases for Sodium Hydroxide. ***Note:*** The customer's actual price for Sodium Hydroxide was considered to be somewhat on the low end of current market pricing due to the fact that they were such a large consumer and their long-standing relationship with their caustic supplier. For cost comparison basis, the projected cost of sodium hydroxide (NaOH 50%) for this customer was set at $0.403 per kilogram. The following graph shows the actual cost of lime verses the projected cost of sodium hydroxide during the plant trial (from June to December). Based on the pricing as noted, the six-month savings in reagent costs during the plant trial was $79,748.34. Projecting this over the full year, the customer could potentially save over $150,000.



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Factors to Consider

Some of the concerns expressed by the customer while considering the changeover to Calcium Hydroxide were as follows:

- Effect on effluent water quality
- Effect on sludge production
- Product storage and dosage control
- Reliability of delivery
- Ease of use / safety

The customers concerns were primarily how these factors would affect the overall cost of switching from Caustic Soda. With this in mind, the plant process was monitored closely by both the customer and Flochem to determine if any of these issues would adversely affect operating costs. The results are outlined below.

Effect on Effluent Water Quality Extensive water sampling was carried out during the first few weeks of testing and samples were sent to an independent laboratory for analysis. Expectations were that the most significant changes would be in the Calcium and Sodium levels of the final effluent water. Due to the excessive amount of recycled water within the customers process, sodium levels were very slow to drop and no significant change was noticeable during the first two weeks of testing. There was a significant increase in the calcium levels as expected, increasing from 30,000 ug/l to approximately 70,000 ug/l. All parameters stayed well within the customers regulatory discharge levels, however, indicating that there were no adverse effects caused by the switchover of reagents.

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Effect on Sludge Production

There was some concern that the Calcium Hydroxide would significantly increase the volume of bio solid sludge being produced at the plant. Calcium Hydroxide is known to produce a heavier, denser sludge, which can typically aid in the flocculation and coagulation of solids and promote better settling characteristics in the clarification process. The optimization of flocculation and settling properties was not a focus of this plant trial, however the customer kept close observation on sludge characteristics over the coarse of the trial. After six months of using calcium hydroxide, the customer did not notice any appreciable increase in sludge volumes although they did notice an obvious change in the consistency of the sludge. The customer was very pleased with this result and in fact expressed the opinion that filtration characteristics were somewhat improved with the heavier sludge cake. It was their conclusion that any additional cost resulting from a higher volume sludge disposal cost would be minimal if at all.

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Product Storage and Dosage Control

To ensure the most economical mode of delivery for the lime slurry product, it was necessary to have enough on-site storage to accommodate a full tanker load of product. Since each tanker load typically contains a volume of 8,000 USG or 30,000 liters, the storage tank required for this site needed to be approximately 10,000 USG capacity. To best utilize existing space, a horizontal tank was selected rather than the typical vertical tank. (fig. 4) This style of tank works very well, using three smaller top mounted mixers instead of one larger unit.

Figure 4 – Install of new 10,000 USG Horizontal Tank with Agitators.

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Prior to the plant scale test of the product, the customer had tried calcium hydroxide in the past without much success. Their main issues with the product were due primarily to the fact they were using a dry calcium hydroxide powder and mixing it with water on site. The resulting product was very inconsistent and very messy. It was very difficult to maintain consistent dosage rates due to constant plugging and poor density control. These are all issues that producers have been very aware of for many years and they have developed a product and lime dosing system designed to eliminate these problems.

Operation of the mobile lime system installed at the site for the six-month duration worked nearly flawlessly, with no significant treatment issues. Some minor line flushing was required on an infrequent basis, due to lime "slimes" build up in the recycle pump intake. This usually only occurred during lower storage tank levels, which would reduce the driving head for the recycle pump. This was primarily caused by the temporary design of the mobile equipment which required the use of flexible hose rather than solid piping (fig. 5) To eliminate this problem, the permanent lime installation was installed with solid piping, with minimal distance between the pump intake and the tank outlet. (fig. 6)

Figure 5 – Mobile System Piping

Figure 6 –New Installation Piping

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Reliability of Delivery

Over the six months of the extended plant trial, lime deliveries to the customer went without any significant problems. Each of the nineteen loads were delivered to the site by pneumatic tanker. The mobile tank located at the customers site was continuously monitored by Flochem using our remote monitoring system. Historical trending allowed operators to assess consumption rates and schedule load deliveries accordingly. There were no issues with deliveries, even during winter months and extreme weather conditions.

Ease of Use / Safety

Consideration of operator safety was a very high priority for the customer during this trial. Calcium hydroxide has long been considered a far safer product to use than sodium hydroxide. Evidence of this fact is most noticeable by the requirement for stainless steel or PVC tanks and piping for caustic, where lime systems are typically built using mild steel. Most safety issues associated with lime products are typically encountered while working with the dry forms of the product, particularly in it's pre-slaked form as calcium oxide, also known as quicklime. Flochem product comes in the form of a ready to use, premixed slurry which is much more user friendly. Where caustic soda can burn skin on contact, calcium hydroxide will cause only a mild skin irritation and only if it is left in contact with the skin for longer periods of time. Caution is always recommended to prevent contact with the eyes or ingestion. Product can also be hot to the touch due to the heat generated during the slaking process, so the use of proper protective gloves is also recommended. There were no safety related incidents using the lime slurry during this plant trial. Operators commented quite often that they were much more comfortable working with the lime product over the caustic soda.

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Conclusions

In general, the justification of switching over from sodium hydroxide to calcium hydroxide for this location was very positive. The customer is expected to save a considerable amount of money on reagent costs, as well as having a much safer, user friendly product to work with in the future.

There were virtually no adverse effects from the changeover, with only positive observations to the treatment process and effluent quality. The customer was very pleased with the knowledge that they were reducing environmental impact by lowering sodium levels in their effluent and bio solid production. In addition, the stability of the market pricing for calcium hydroxide was a big factor in convincing the customer to make the commitment to a long-term supply contract and investing in the new lime system installation.