Odor Control of Wastewater Containing Leachate in a 14 Mile Sewer

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ABSTRACT

In August of 2012, Monroe County DES initiated a demonstration of **P**eroxide **R**egenerated **I**ron – **S**ulfide **C**ontrol (PRI-SC®) technology as a performance improvement over the existing hypochlorite and hydrogen peroxide odor and corrosion control program. This demonstration was designed to control hydrogen sulfide (H_2S) odors and corrosion along a line from Mill Seat Landfill PS where landfill leachate is introduced into the collection system along the Churchville force Main and gravity line (hereafter referred to as the "Churchville Line") through to the Gates-Chili-Ogden (GCO) pump station. The program was specifically designed to moderate peak sulfide levels at critical points to lessen and eliminate odor complaints as well as moderate corrosion. It was designed to dovetail with peroxide feed at the GCO pump station to reduce the H_2S loading entering the GCO Lift Station and reduce peroxide usage for sulfide control further downstream to the critical odor control point at Shaft 2. Shaft 2 is located on a small green area in the middle of a densely populated residential section of Rochester and was heretofore a source of multiple odor complaints.

The demonstration of PRI-SC® technology from the Mill Seat Landfill PS through the Churchville line to the GCO Lift Station provided odor and corrosion control in an additional 22.5 kilometers (14 miles) of pipe along the Churchville force main and gravity line, from Mill Seat PS to the GCO PS, while enhancing the GCO/Shaft 2 odor and corrosion control program at comparable cost to the current peroxide and bleach program.

KEYWORDS: Monroe County DES Pure Waters, Leachate, Hydrogen Sulfide, PRI-SC®, Hydrogen Peroxide, Iron Salts, Odor Control, Corrosion Control, Collection System, Wastewater

INTRODUCTION

Monroe County DES Pure Waters has had odor and corrosion problems on the Churchville segment of the collection system leading into the GCO Pump Station. A schematic of the Churchville segment of the GCO system and beyond to Shaft 2 is represented in Figure 1.

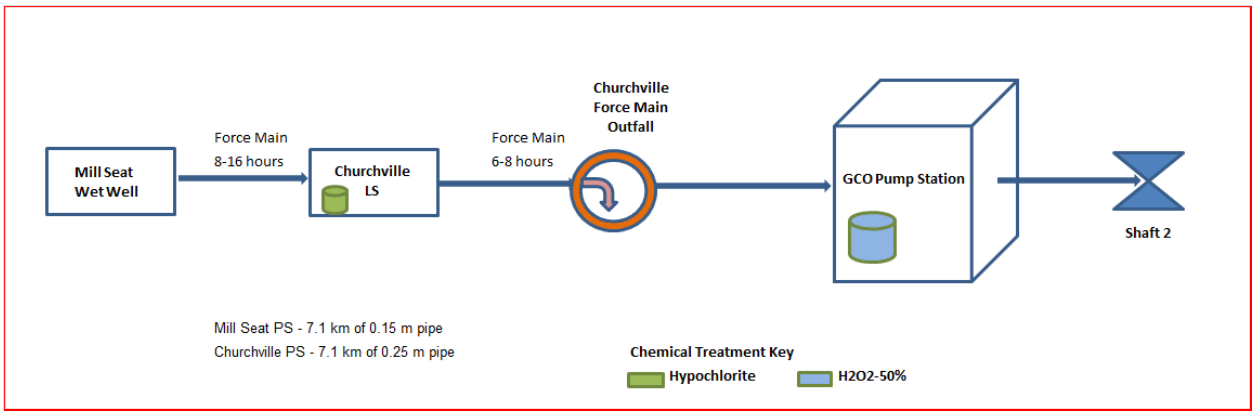

Figure 1. Simplified Schematic Baseline Treatment

Corrosion has been a particular concern at the force main outfall from Churchville pump station. This segment is heavily laden with leachate from the Mill Seat Landfill. Landfill leachate is a notoriously complex substance to deal with, primarily because of its ever-changing composition.

Landfill leachate may be characterized as a water-based solution of four groups of contaminants; dissolved organic matter (alcohols, acids, aldehydes, short chain sugars etc.), inorganic macro components (common cations and anions including carbonate, sulfate, chloride, iron, aluminum, zinc and ammonia), heavy metals (Pb, Ni, Cu, Hg), and xenobiotic organic compounds such as halogenated organics,(PCB's , dioxins, etc.). High concentrations of chemical oxygen demand (COD), BOD, nitrogen, phenols, pesticides, solvents and heavy metals are common in these systems. Typical levels of BOD and COD are 10,500 and 15,000 mg/l respectively. This contributes significantly to high levels of sulfide in a long anaerobic force main like the one from Churchville.

One unexpected operational concern encountered was foaming in the Mill Seat Wet Well. Landfill leachate can be supersaturated with carbonates. The pH of most calcareous soils (soils containing free calcium carbonates such as Honeoye, Lima, Ontario, and Kendaia soils) in the New York lime belt (soils commonly found along Interstate 90 from Buffalo to Albany) ranges from 7-8.5. The pH of Mill Seat Leachate was measured in this range and is likely due to the alkaline nature of the local limestone soils. (Incidentally it's these same soils that help make the Finger Lakes region a good area for vineyards and wineries, along with all that beautiful lake frontage, of course.) Iron salts were being dosed at high concentrations in the low flow Mill Seat line in order to achieve adequate concentration at the100 fold dilution ratio encountered at GCO. The acidic nature of ferrous chloride was liberating large amounts of CO_2 during initial dosing. Due to the naturally occurring surfactants present in the leachate, generous foaming occurred and built up in the wet well. Water spray was used once or twice daily to keep the foam down and after 3 days the foaming issues had settled down. It is believed that the inventory of accumulated carbonates in the wet well sediment was the cause of this initial exaggerated foaming and this excess inventory was depleted after several days when foaming subsided.

The most common method of handling collected leachate is on-site treatment. When treating leachate on site, the leachate is pumped from the sump into the treatment tanks. The leachate may then be mixed with chemical reagents to modify the pH and to coagulate and settle solids and to reduce the concentration of hazardous matter. Further treatment is typically a modified form of activated sludge to substantially reduce the dissolved organic content. Nutrient imbalance can cause difficulties in maintaining an effective biological treatment stage. The treated liquor is rarely of sufficient quality to be released to the environment and may be tankered or piped to a

local sewage treatment facility. Mill Seat landfill does not pretreat its leachate but does collect and moderate flows before sending to sewer.

The Mill Seat landfill is located in Bergen, New York just outside of Rochester in the southwest quadrant of Monroe County, NY. (Please see Figures 2 and 3) The Mill Seat leachate pump station delivers ~190,000 liters per day of leachate through a 7.1 kilometer force main to the Churchville pump station which also receives residential wastewater. The Churchville pump station transfers 1.13 million liters per day of wastewater through a 7.1 kilometer force main that discharges to the Churchville force main discharge (Hereafter referred to as Manhole "1" or "MH1") where historically there has been significant corrosion. Total combined retention times through these two force mains range from 14 to 24 hours. Planned commercial/residential development right next to Manhole 1 has highlighted concerns for odor complaints in the area. There are lateral segments that feed into the Churchville line after Manhole 1until the Churchville line finally meets the GCO Pump Station.

Figure 2. Aerial View of Mill Seat Landfill and Leachate facility

Figure 3. Mill Seat Leachate Pump Station

Monroe County has heretofore treated the Churchville line with sodium hypochlorite added at the Churchville Lift station. This baseline treatment, which was added along with H2O2 at GCO (See Table 1), was not successful in controlling sulfide at the Churchville force main discharge (MH1). During Baseline Hypo/Peroxide treatment, gaseous sulfide levels at MH1 averaged 18 ppm and peaks were recorded as high as 345 ppm. Subsequent corrosion from these high sulfide levels has required relining of MH1.

METHODOLOGY

In order to control sulfide in this section of the collection system, the technology employed needs to be capable of maintaining sulfide control over long distances (22.5 kilometers) and high retention times (14-24 hours). The long duration controls required limits the technologies that can be applied cost effectively. PRI-SC® was chosen due to its ability to control sulfide over long retention times and its proven ability in other North American municipal applications in the United States (Walton, Nguyen and Hetherington, 2005; Neofotistos, Szczucki and Chau, 2006; Lynne, Grubb, Welle and Hausauer, 2009). PRI-SC® combines the use of iron salts (ferrous chloride) with hydrogen peroxide in a unique fashion, whereby the iron salt is added as the primary sulfide control agent in the upper reaches of the collection system, and hydrogen peroxide is added at specific points downstream to regenerate the spent iron (FeS). The key to the technology is the regeneration step, which oxidizes the sulfide to elemental sulfur and in the process "frees up" the iron making it re-usable for subsequent downstream sulfide control. A simplified schematic of the PRI-SC treatment set up on the Churchville line is seen in Figure 4 below

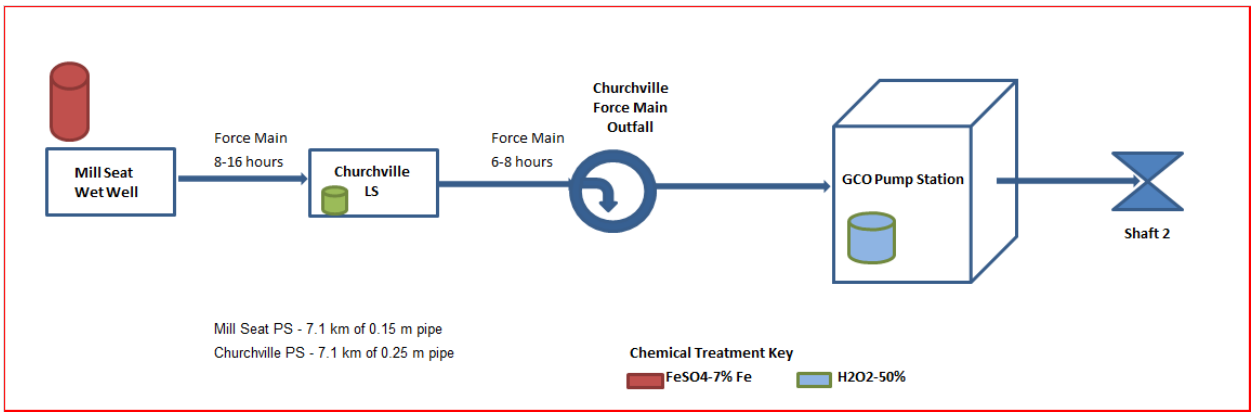

Figure 4. Simplified Schematic PRI-SC®Treatment

Demonstration objectives are listed below:

- Reduce the H_2S loading entering the GCO Lift Station and reduce peroxide usage for sulfide control out to Shaft 2.
- Establish odor and corrosion control in an additional 22.4 kilometers of pipe along the Churchville force main and gravity line, from Mill Seat PS to the GCO PS, as well as enhance the GCO/Shaft 2 odor and corrosion control program at comparable cost to the current peroxide program.
- Moderate peak sulfide levels at critical points such as Shaft 2 to lessen and eliminate odor complaints

RESULTS AND DISCUSSION

The sewer line treated by the US Peroxide PRI-SC® program is the Mill Seat/Churchville/GCO trunk which starts at Mill Seat Landfill PS along the Churchville Line through to the Gates-Chili-Ogden (GCO) pump station. Baseline treatment by Monroe County consisted of 378 liters per day of hypochlorite at the Churchville pump station followed by 1400 liters per day of 50% hydrogen peroxide at the GCO pump station. The three key hydrogen sulfide (H2S) monitoring points are the Churchville force main outfall, GCO influent and downstream of GCO at Shaft 2.

Liquid data was collected at critical manholes along the Churchville sewer line and analyzed for Total Sulfide, Dissolved Sulfide, pH, Total Iron and Ferrous Iron. Tables 1 and 2, seen below, document the iron and pH levels during baseline and PR-ISC® treatment.

Table 1- Baseline Iron and pH Levels

	Average Ferrous Iron (ppm)	Average Total Iron (ppm)	pH
Mill Seat WW	6.0	7.0	7.9
Churchville MH 1	0.0	0.7	7.9
Churchville MH 2	0.0	2.0	8.0
GCO- Churchville	NA	NA	7.6
GCO- Combined	0.4	0.5	7.4
GCO- WW	0.4	0.8	7.2

Table 2 – PR-ISC® Iron and pH Levels

	Average Ferrous Iron (PPM)	Average Total Iron (PPM)	pH
Mill Seat WW	-	-	7.5
Churchville Mill Seat Influent	509.0	523.3	8.0
Churchville Mill Seat Combined	96.7	183.3	8.1
Churchville MH 1	2.3	5.6	7.9
Churchville MH 2	40.0	140.0	7.9
GCO- Churchville	0.7	1.1	7.4
GCO- Combined	0.9	2.4	7.2
GCO- WW	0.5	2.0	7.2

As can be seen in Tables 1 and 2, leachate from the Mill Seat landfill is somewhat alkaline with with a pH near 8. As noted earlier, this can be attributed to the local soils used as cover for the landfill and is well within the range of pH 7 to 8.5, which is typical for soils in the New York lime belt. As the leachate is diluted with sewer water downstream in the collection system, the pH gradually drops to just above 7.

Background iron levels were generally less than one ppm, except at the Mill Seat wet well and at MH2. Iron levels during ferrous addition at Mill Seat showed most was in the soluble ferrous form after the Mill Seat force main discharge at the Churchville Pump Station. After combining with other influents to Churchville Pump Station, nearly 50% of the ferrous was consumed and over 70% was consumed immediately after the Churchville force main discharge at MH 1 and MH2. Please note the unusually low levels of iron at MH1, the site of the Churchville PS forcemain discharge. It is suspected this may be due to the varying of flow from the discharge of the Churchville force main where it combines with a small local flow. MH2 was downstream far enough to better normalize the mixing of iron with the sewer flow.

5.1 Manhole 1 - Churchville FM Discharge

The first critical sample point was at the Churchville force main discharge or MH 1 which is 8.8 miles downstream of the iron feed site at Mill Seat and 4.4 mile downstream of the Churchville pump station where the hypochlorite is added. This site is an area of great gaseous sulfide generation and corrosion which is visible inside the manhole. Baseline treatment data saw averages as high as 38 ppm H_2S with peak as high as 345 ppm as is seen below in this excerpt of baseline data in Figure 5.

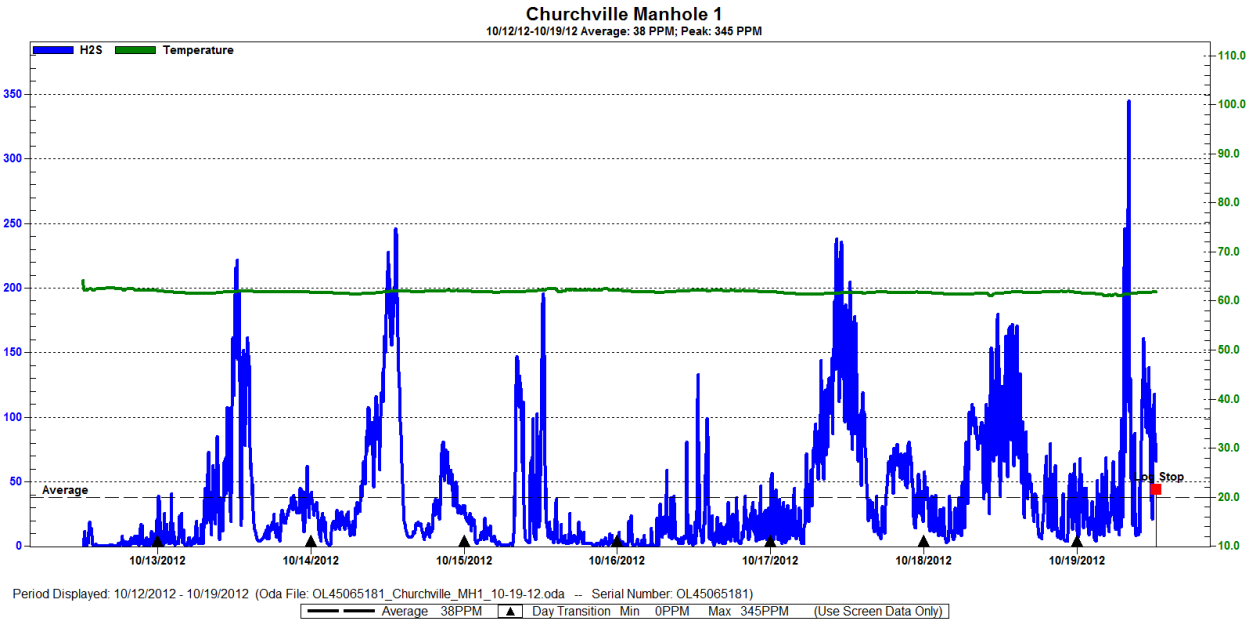

Figure 5

With the addition of 946 liters per day of iron at Mill Seat and after shutting down hypochlorite dosing at Churchville pump station, treatment under PRI-SC® conditions shows a complete reduction to zero ppm average gaseous sulfide with very short term peaks restricted to 5 ppm at the Churchville force main discharge as is shown in the excerpted data in Figure 6 below.

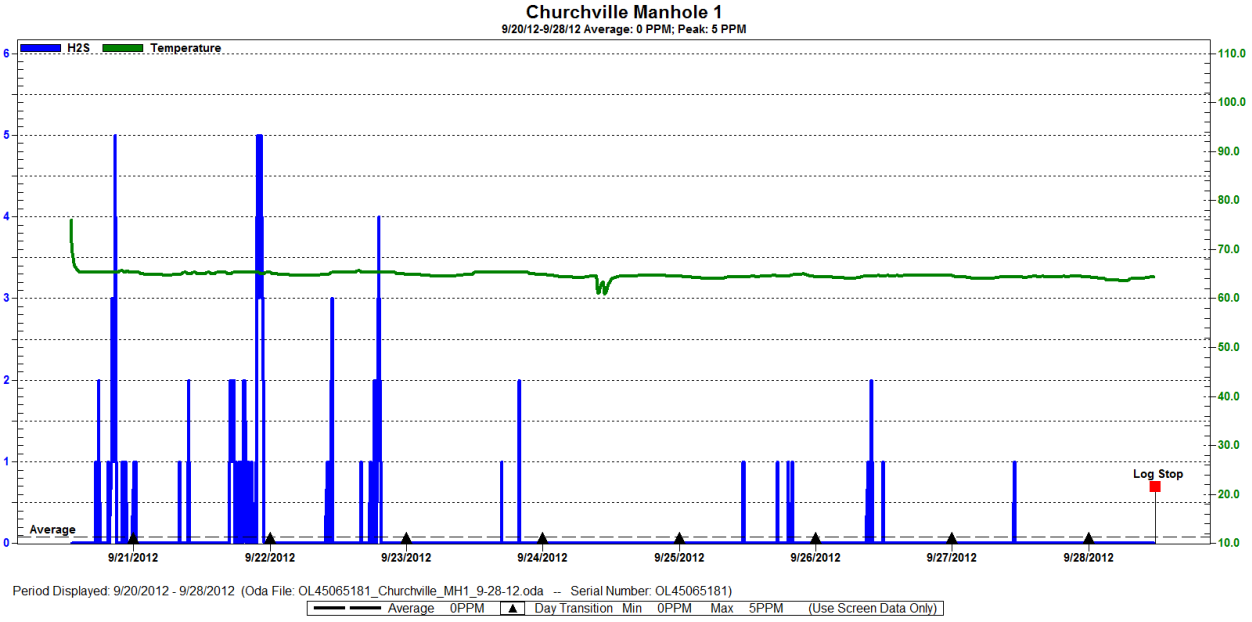

Figure 6

5.2 Churchville GCO Influent

The Churchville GCO influent was another critical sample point. This represented the overall impact of iron dosing at Mill Seat. As can be seen in Figure 7 below, baseline gas levels were at 2 ppm average with spikes up to 18 ppm.

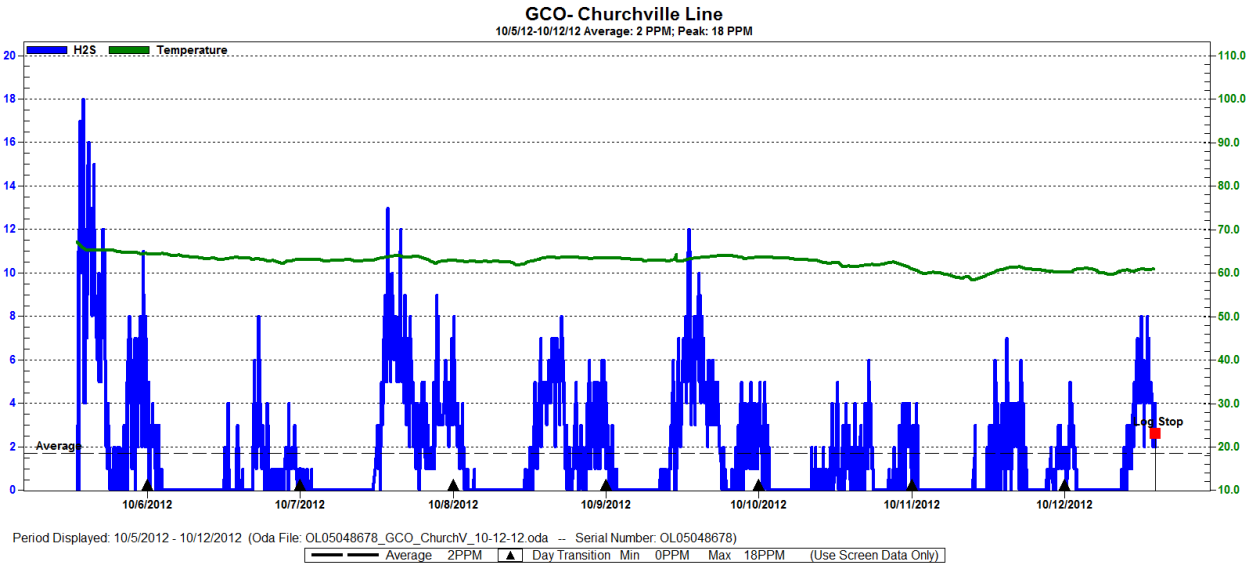

Figure 7

Gaseous sulfide levels at the Churchville influent to GCO under PRI-SC® conditions were reduced to 1 ppm average with peaks of 9 ppm as shown in Figure 8 below.

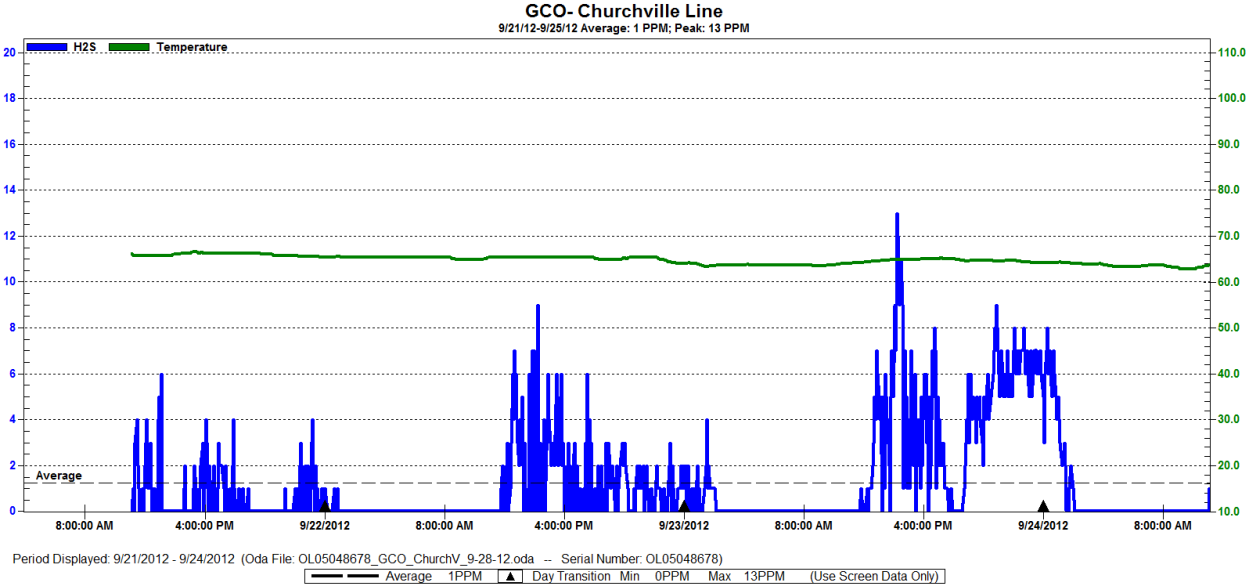

Figure 8

5.3 Shaft 2

Shaft 2 is the most important manhole from a public visibility standpoint. Gaseous sulfide spikes in midafternoon have been correlated to public complaints. As can be seen in the excerpt of baseline data in Figure 9, average levels were 7 ppm. Based on Monroe County feedback, odor complaints seem to center around peak gaseous H2S excursions above 20 ppm. There were ten or so of any significant duration during the time period represented.

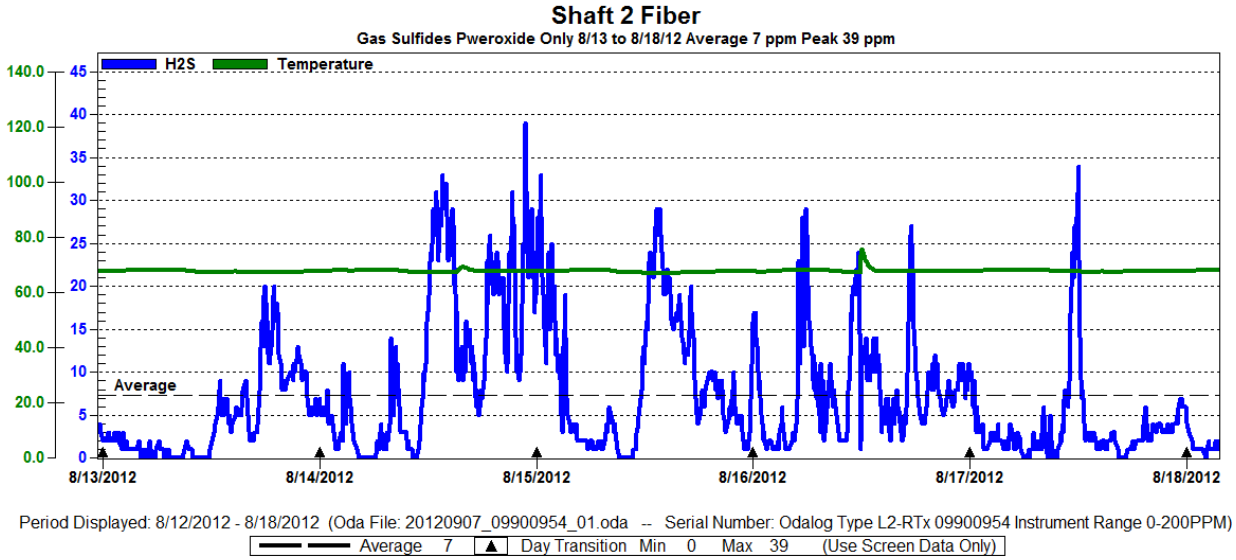

Figure 9

Figure 10 below shows a much better control of gaseous sulfide peaks at Shaft 2 under PRI-SC® conditions.

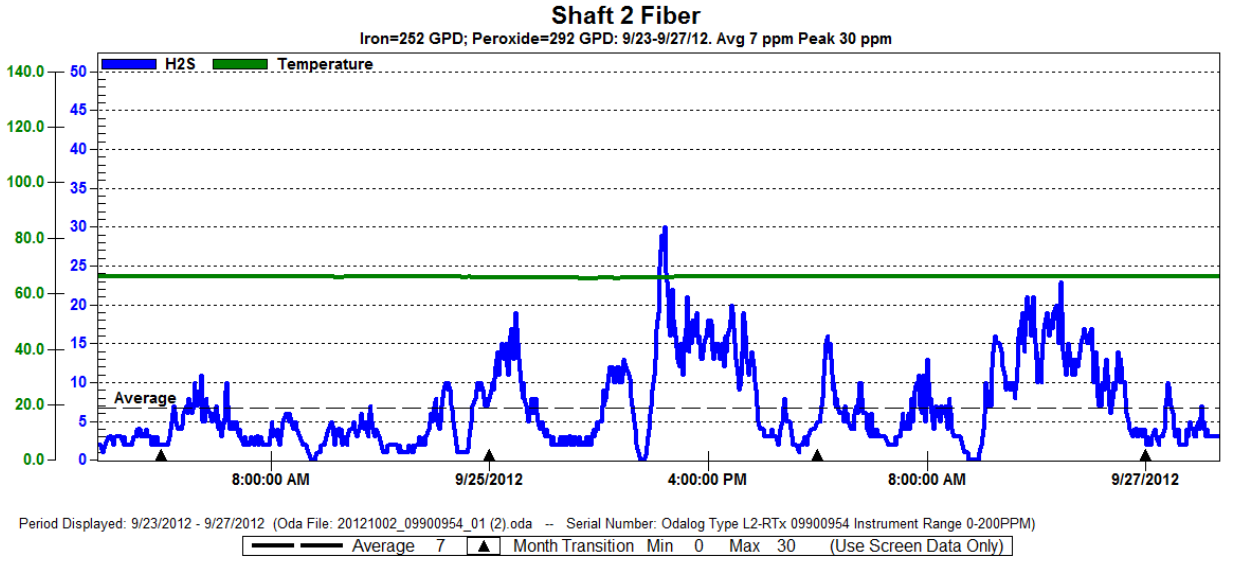

Figure 10

Table 3 below illustrates the average Dissolved Sulfide in each manhole tested throughout the demo. When compared to baseline sulfide data the PRI-SC® program was successful in reducing the sulfide content by 99+% from the Mill Seat Wet Well to the Churchville Pump Station. The PRI-SC® program in reducing the average Dissolved Sulfide by 63% at the Churchville force main discharge (MH1).

Although the average Dissolved sulfide of the Churchville line influent to GCO were reduced by 25%, peroxide regeneration of the spent iron at GCO resulted in average dissolved sulfide at Shaft 2 being reduced by 60% while using 22% less peroxide.

TABLE 3 - Dissolved Sulfide Summary

	Average Dissolved Sulfides- Iron OFF (mg/L)	Average PR-ISC® Dissolved Sulfides- (mg/L)	Average % Reduction
Mill Seat WW	0.50	0.00	99+
Churchville Mill Seat Influent	0.52	0.00	99+
Churchville Mill Seat Combo	0.31	0.00	99+
Churchville MH 1	0.40	0.15	63
Churchville MH 2	0.22	0.02	92
GCO- Churchville	0.52	0.39	25
GCO- Combined	1.20	0.79	34
GCO- WW	1.10	0.50	55
Shaft 2	0.50	0.20	60

Gaseous data is seen in Table 4 below and was collected at all key monitoring points in the Churchville line, at GCO and at Shaft 2. Odalog data compiled showed a 78% reduction of average gaseous sulfide at the Churchville forcemain discharge (MH1) with over 99% of the gaseous sulfide eliminated just downstream at Manhole 2 (MH2). There was an average 38% reduction of gaseous sulfide at GCO. Shaft 2 data showed equivalent average gaseous sulfide levels of baseline vs PRI-SC® treatment.

TABLE 4 - Gaseous Sulfide Summary

	Baseline Average (ppm)	PR-ISC® Average (ppm)	Average % Reduction
Churchville Mill Seat Influent	0	0	NA
Churchville MH 1	18	4	78
Churchville MH 2	19	0	99+
GCO- Churchville	3	2	33
GCO- Combined	8	5	38
Shaft 2	7	7	0

With PRI-SC® technology, using 252 gpd of iron at Mill Seat and 290 gpd of peroxide at GCO, a 78 % reduction of gaseous sulfide was achieved at MH1 with a 68% reduction in dissolved sulfide. Reductions of 33% in gaseous sulfide and 25% in dissolved sulfide were achieved at the GCO Churchville influent line and dissolved sulfide was improved by 60% at Shaft 2.

Treatment costs – Peak Sulfide Levels

- Baseline chemical use. Cost = $1013/day
- PRI-SC® Chemical use. Cost = $1079/day

The cost of a non-optimized PRI-SC® program was within 6.5% of the Hypochlorite/H_2O_2 Baseline with superior performance at the Churchville force main discharge (MH1), GCO and Shaft 2. Further improvement in performance is expected by implementing optimized iron dose profiles at Mill Seat and further profile dose optimization of the GCO peroxide. It is noteworthy that a true baseline comparison which compares equal performance with increased hypochlorite dose at Churchville was not able to be performed in the timeframe allowed for this demo. It is

expected that under equal performance conditions at a higher hypochlorite dose (assuming hypochlorite could achieve similar performance) that PRI-SC® would be less expensive. Additionally, it is expected that performance equivalent to historical bleach/H2O2 could be obtained at a lower cost per day with PRI-SC® by adjusting down the iron at Mill Seat to a level which equaled the performance at MH1 of adding hypochlorite at 100 GPD.

US Peroxide was able to prove the concept of our PRI-SC® technology whereby iron salts were injected into the sewer line at the Mill Seat Landfill to bind with liquid sulfide to create iron sulfide (FeS). Hydrogen peroxide was then added downstream at GCO to regenerate the bound iron by oxidizing the sulfide portion of ferrous sulfide compound and free up the iron to bind with more sulfide further downstream. Weather conditions and Mill Seat force main operational issues cut short the planned 90 day demo after 25 days and before optimization could begin in earnest. Even so, the non-optimized cost for PRI-SC® was within 6.5% of baseline peroxide and hypo treatment with significant improvement in performance throughout.

PRI-SC® reduced liquid sulfide in the 14 miles of line upstream of GCO and has significantly outperformed peroxide/hypo treatment program at all critical control points.

SUMMARY

The program was successful in providing a comprehensive odor control program that was financially comparable to the baseline odor control program with greater control and treatment capabilities. A non-optimized PRI-SC® technology program was demonstrated at a cost within 6.5% of baseline treatment. There was a 33% to 99+% improvement in gaseous sulfide levels on the Churchville line. Significantly, there was a 78% reduction of corrosion causing gaseous sulfide at MH1. Improvements in dissolved sulfide control from 25% to 99+% were seen at all sample sites. Most importantly, dissolved sulfide was reduced by an average of 60% at the critical Shaft 2 location, heretofore a common cause of odor complaints.

The PRI-SC® program has significantly outperformed peroxide/hypo treatment program at all critical control points. Integrating PRI-SC® into the current Churchville line would achieve improved H2S control throughout the segment and it is expected that an optimized PRI-SC® program can be integrated through a turnkey scope of supply under the current operating budget.

ACKNOWLEDGEMENTS

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