Assessing the Impacts of Pulp Loading from Non-Dispersible Materials on Downstream Sewer Systems
ASSESSING THE IMPACTS OF PULP LOADING FROM NON-DISPERSIBLE MATERIALS ON DOWNSTREAM SEWER SYSTEMS

by:

John N. Pastore, P.E.
Dudek

2015
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Abstract:

This study subjected wipes from five different manufacturers to a variety of tests to determine if changes to their physical characteristics occur when introduced into a sewer system and what effect the shredded material (pulp) has on the downstream sewer. Shredded and non-shredded, wipes were used in the study utilizing specialized bench-scale testing and live sewer testing.

Results from the benchmark testing and live sewer testing, within both local and regional sewer systems, indicate that the wipes used in the study were significantly reduced in size through shredding and the resulting pulp, while increasing in weight due to water absorption, does not appear to cause clogging in the downstream sewer lines or exhibit noticeable odors. The pulp recovered during live sewer testing was found to consist of individual pieces less than two square inches in size. A small amount of pulp was observed binding with other background material in the sewer when grease and hair were present. The results suggest that shredding of the wipes by a mechanical grinder can minimize impacts to the downstream sewer lines by reducing the size of the material. Recommended actions include: educating the public on what to flush down the toilet, implementing an effective fats, oils, and grease (FOG) program and employing mechanical grinders ahead of pumps, when clogging due to non-dispersible material becomes a problem.

Benefits:

- Results from grinding of five different brands of wipes used in this study show that the resulting shredded pulp, while demonstrating the potential to form rope-like shapes when removed from a screen during bench-scale testing, did not demonstrate the propensity to re-combine during transit within various lengths of sewer lines, based on the results of live sewer testing.

- Based on the observations stated above, in combination with the recovery of significant quantities of the shredded pulp during bench-scale testing, it is concluded that reduction in size of the whole (intact) wipes by a mechanical grinder leads to the decreased likelihood of sewer blockages and/or increased operation and maintenance costs associated with transport of these materials within the sewer.

- Demonstrates that the shredded pulp from the wipes tested did not readily re-combine into rope-like forms capable of causing blockages during sewer transit.

Keywords: Disperse, grinders, non-woven, wipes, water resource recovery facility.
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<td>Entry Point</td>
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<td>Fats, Oils, and Grease</td>
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<td>Horsepower</td>
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<td>Variable Frequency Drive</td>
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EXECUTIVE SUMMARY

The primary objective of this study was to determine the effects that pulp derived from wipes that have passed through a mechanical grinder and pump combination, have on various lengths of downstream sewer systems.

A serious and growing problem facing public wastewater collection and treatment agencies across the country is the proliferation of products, such as cleansing wipes, baby wipes, cosmetic wipes, dusters, diapers, liners, etc., that are improperly disposed of down the toilet. While it is physically possible to flush many of these products down a toilet because of their small size, they may or may not disperse when immersed in water.

The improper disposal of these products has led to significant maintenance and replacement costs for many wastewater agencies, not only in the United States, but in many countries throughout the world. The clogging of sewers, pumps, valves, headwork screens, etc., due to the improper flushing of these types of products down the toilet has led many agencies to seek solutions to offset the effects of these products. One of the more common solutions to this problem is the installation of a grinder ahead of the sewage pump that will shred the material into smaller pieces.

This study investigated a small sample of five different brands of wipes for the purpose of determining the effect of shredding these products on various lengths of downstream sewer systems. Questions to be answered involved:

♦ What does the resulting shredded material (pulp) look like in the downstream sewer system?
♦ What happens to the pulp as it travels down the sewer line and comeslinges with other materials within the sewer?
♦ Does the pulp remain as small shredded pieces of material or does it combine with other shredded pieces of the same material or with other materials found in the sewer?
♦ If the pulp does combine with other materials, at what distances from the grinder does this occur, and are there any catalysts within the sewer that promote this occurrence?
♦ Lastly, what can be done to minimize the effects of wipes entering the sewer system?

The study required significant cooperation and coordination between multiple public agencies and private partners. The field work performed was difficult and required extensive planning, especially in connection with traffic control for testing accomplished within the public streets. Benchmark testing along with live sewer testing was accomplished with the assistance of the City of Santa Ana Department of Public Works (SADPW), the Orange County Sanitation District (OCSD), the Rancho Santa Fe Community Services District (RSFCSD) and JWC Environmental (JWCE).

A series of test trials was conducted prior to the planned live sewer testing in order to better understand the physical characteristics of the study wipes. Protocols were first developed and then modified after each set of testing was concluded. The first benchmark testing took place at the JWC Environmental Regional Facility (JWCERF) in Santa Ana, California with assistance from JWCE staff. This testing utilized a test tank outfitted with a grinder (with identical specifications to the SADPW's grinder that would be used later on in the study for shredding) in
which multiple sample sets of five different brands of wipes were introduced into the tank and then passed through the grinder and allowed to circulate before being captured for observation and measurement. Test samples weighed after capture from the tank nearly doubled in weight, presumably from water absorption. Results of the benchmark tests indicated that turbulence within the test tank caused the shredded wipes (pulp) to become compressed, forming a thin, matted layer of slurry that eventually clogged the collection screen. An additional test involved introducing captured pulp, from one of the five sets of wipes previously tested, into a test pond constructed to replicate a typical sewer environment, for the purpose of determining the effects of hair and grease on the shredded pulp. Results of the pond test indicated that some of the pulp became entangled on the single catch point within the tank and settled to the bottom along with small amounts of the hair and grease.

To better understand what physical changes the wipe material may undergo when immersed in a live sewer, the research team chose to run a series of additional test trials in a live sewer using whole (intact) wipes. Using intact wipes without grinding made it easier to measure any physical changes to the wipes, as well as serve as a practice run prior to conducting live sewer testing, where the wipes would be shredded.

The test trials were conducted with the assistance of the SADPW in a live sewer line located in Santa Ana. Five sample sets of intact wipes, color-dyed for identification, were introduced into a 10-inch sewer line for collection downstream at 300-foot, 600-foot, and 900-foot intervals. Again, the test results proved inconclusive, as problems with capturing the wipe samples led to only one out of 50 sample wipes recovered. However, the very low recovery rate prompted immediate changes to the testing protocol in terms of measuring the sewer flow rate and capture technique. It also resulted in the scheduling of an additional live sewer test trial to validate the protocol changes.

Subsequent testing was conducted in a live sewer within the community of Rancho Santa Fe, California. With the assistance of staff from the RSFCSD, the sewer flow rate was successfully determined using sewer dye. Two sample sets of wipes were then introduced into a 10-inch sewer line and captured using a 10-inch diameter basket, first within a manhole located 260 feet downstream and then 1,320 feet downstream at the headworks of the Rancho Santa Fe Wastewater Treatment Plant (RSFWWTP). In this test, eight of 12 wipes were recovered intact from the downstream manhole and plant headworks. It was noted that the recovered wipes showed no signs of changes to their physical size and shape.

After confirming that the intact wipe samples could be successfully captured using the 10-inch basket, the research team proceeded to determine what happens to the wipes after passing through a grinder and pump in a live sewer system. Subsequently, a series of live sewer test trials were run with the assistance of staff from the SADPW and the OCSD in which multiple sample sets of the wipes were passed through a grinder and pump, located at the Segerstrom Pump Station (SPS) in Santa Ana.

The testing was conducted at night during a period of low flow to increase the likelihood of capturing the maximum amount of shredded pulp from the samples. In the first test phase the pulp was collected at the end of a 10-inch force main approximately 30 feet from the pump station and in the second phase, the shredded material was collected in the 24-inch barrel of OCSD’s 42-inch triple-barrel siphon, located approximately 2,700 feet downstream from the grinder and pump. Individual pieces of pulp were easily identified by their dyed color, however, only a small percentage of the pulp was recovered in both phases of the test trials.
In the first test phase much of the pulp was observed splashing out of the collection screen when it became clogged due to the amount of material discharging from the force main. Likewise, in the second test phase only a small amount of pulp was captured, and although the exact cause is unknown, contributing factors were believed to be the length of transport time in the sewer, timing of the collection screen placement, deposition of material, or the material being caught on roots, joints or other obstructions within the sewer.

The research team was not satisfied with the results of this testing, due to so little material being captured, therefore two additional sets of test trials were run with the assistance of the RSFCSF. The first test consisted of a bench-scale model constructed to replicate a live sewer environment in which the sample wipes would be subjected to a mixing action indicative of that found in a sewer system. The sample wipes were first dry-shredded using the benchmarking grinder located at the JWCEF. The shredded samples were then taken to the RSFWWTP and introduced into a 40-foot long, three-inch pipe that discharged into a five-gallon bucket that acted as a mixing chamber. The content of the bucket was then discharged through a small orifice in the bottom of the bucket and allowed to drop by gravity into a second, five-gallon bucket covered with a ¼-inch mesh screen that had been placed directly beneath the upper bucket. The bench-scale model was used again to run using various quantities of ordinary toilet paper for comparison purposes.

The results of this testing indicated that both, the shredded wipe samples and the toilet paper samples, quickly clogged the screen directly below the flow point discharging from the upper bucket and prevented additional material from passing through the screen. It was observed that the toilet paper initially clogged the screen, but then dispersed under the force of the water allowing the material directly below the flow point to pass through the screen into the lower bucket. The shredded wipe material that was larger than the screen openings remained on the screen and caused much of the remaining material in the upper bucket to splash onto the ground as it fell on to the screen.

The final test was a live sewer test trial conducted in a 10-inch sewer line located approximately 1,320 feet upstream of the RSFWWTP. The site was chosen by the research team to assure maximum recovery of sample material for documentation of any physical changes to the shredded wipe material. The testing involved introducing five sample sets of dyed, pre-shredded wipes into the upstream manhole and collecting them downstream in a screen positioned at the headworks of the plant. The wet pulp captured from each sample set was laid out on a measuring board and photographed for comparison with the dry-shredded sample material, in order to determine what physical changes had occurred to the pulp after transport in the sewer system. It was observed that the individual pieces of the wet pulp closely resembled their original dry shape and size. It was also observed that in this test, the pulp did not combine with the background material in the sewer.

Overall, the investigations conducted in this study have led to the conclusions that, after undergoing shredding through a mechanical grinder, the wipes are reduced into smaller pieces that resemble their original shape and size after transport up to 2,700 feet in the sewer and show no observable reduction in volume. During live sewer testing the shredded pulp did not readily combine with other background material.

When subjected to turbulence or agitation, as experienced in the JWCE test tank, the shredded material transformed into a condensed mixture of water and fiber matrix (slurry) that resulted in clogging of the capture screen. This clogging occurred regardless of whether or not
the wipes were shredded. The installation of grinders upstream of pumps and water resource recovery facilities (WRRFs) can be an effective solution to reducing the size of wipes by minimizing the opportunities for these materials to cause clogging and other maintenance problems during transport in downstream sewer lines. However, if excess turbulence is present in the sewer system the effectiveness of a grinder will be minimized. The clogging of the ¼-inch and #18 mesh screens used in the various tests proved problematic and indicates that similar size screens used at WRRF’s may undergo similar clogging. Proper screen sizing should be carefully evaluated for each installation. Typically, screens such as these are not employed within gravity or pressure sewer systems.
CHAPTER 1.0

INTRODUCTION

1.1 Project Background

Wastewater professionals often refer to rags, cloths, diapers, paper towels, wipes, and other similar materials as being non-dispersible, since they do not breakdown (disperse) in water in the same manner, time period, or consistency of single-ply toilet paper. However, there is a current debate between the wastewater sector and the nonwoven manufacturers over the definition of flushable. Professional wastewater organizations, such as members of the Clean Water Summit Partners (CWSP), have recommended to manufacturers of nonwoven products that they modify labelling to remove the term "flushable" and undertake consumer education campaigns to inform customers of the problems associated with flushing of these types of products, see Appendix A.

To address this problem, INDA, the Association of the Nonwoven Fabric Industry, and EDANA, the international association serving the nonwovens and related industries, issued the third edition of a guidance document, entitled "Guidance Document for Assessing the Flushability of Nonwoven Disposable Products" (INDA, 2013) in 2013 to help wipe manufacturers assess whether their products should be flushed into the wastewater stream. According to a press release issued by the National Association of Clean Water Agencies (NACWA) on March 19, 2015 to membership (NACWA, 2015), “A group of five associations, representing the water sector and the nonwoven fabrics industry, announced today that they are working collaboratively on the joint development of a new edition of guidelines that will influence product design and support the marketing of nonwoven products as "flushable," with no adverse effects on wastewater systems.” The associations also announced a meeting to take place March 26th in Washington, DC, where they will explore the establishment of a collaborative product stewardship initiative to promote greater responsibility for the proper disposal of nonwoven products, including wipes not designed to be flushed.

The association group, which includes INDA, the National Association of Clean Water Agencies (NACWA), the American Public Works Association (APWA), the Water Environment Federation (WEF), and the Canadian Water & Wastewater Association (CWWA) began developing the new edition on January 27, 2015 and is scheduled to complete the process by July 2016. The new "Fourth Edition" guidelines will build on the framework of the "Third Edition Guidance Document for Assessing the Flushability of Nonwoven Disposable Products, (INDA 2013) " which is the current voluntary guidance used by the wipes industry. According to the press release, “the Third Edition Guidance Document represents a reasonable framework to which new information and collaborative sharing of technical expertise between the wastewater sector and the nonwoven fabrics industry should be applied to further improve the flushability guidelines."
In the meantime, the amount of materials that are not designed for disposal via the toilet entering the sewer system continues to increase resulting in serious operational problems at WRRFs and pump stations, as shown in Figures 1-1 and 1-2.

![Image](image1.png)

Figure 1-1. Materials Removed from a WRRF Headworks Screen.

![Image](image2.png)

Figure 1-2. Typical Pump Clog Caused by Rags and Other Materials.

Operational problems can lead to increased maintenance and capital costs, as well as potential blockages and sewer spills. Typical operational problems incurred include:

1. Clogging of pumps and check valves in wastewater pumps and lift stations.
2. Obstructions and settled debris in gravity sewer lines.
3. Clogging of bar screens and washer compactors at pump stations and water resource recovery facilities.
4. Premature wear of pumping equipment components, such as impellers and wear rings.
5. Retrofitting of pump stations with grinders, grinder pumps, bar screens or solids removal equipment.
6. Accumulation of fats, oils, and greases (FOG) that cause wipes or wipe fibers to bind together into larger clumps or rope-like shapes.
Many agencies have undertaken studies of their own to identify the types of materials that are causing their operational problems. The materials recovered from clogged pumps and screens are generally rags and other materials, as shown in Figure 1-3, and often bind together to form large rope-like masses that have the potential to cause sewer blockages and costly spills. A number of such incidents have recently gained notoriety in London, England where a collection of waste fat, sanitary wipes, and household waste, more than 100 feet in length has been found beneath the city streets. Dubbed the "Fatberg", (Saul, 2015), the latest blockage was discovered and cleared by sanitation workers within a sewer beneath a road in Chelsea, west London in March 2015.

![Figure 1-3. Typical Materials Found in the Sewer.](image)

To assess the extent of the problem, one professional wastewater association, the Southern California Alliance of Publicly Owned Treatment Works (SCAP) has compiled a database of reported incidents associated with operational problems caused by materials that do not disperse and are not designed for disposal via the toilet entering the sewer system from public agencies across the nation. Citing confidential information collected between February 2013 and March 2013 from nine different agencies located in five separate states, the database contains 29 separate reports describing 14 incidents of maintenance problems caused by these types of materials in gravity sewers, 20 incidents occurring at sewer pump stations, and three incidents occurring at WWRFs. See Appendix B for a detailed explanation.

In an effort to address the increased operation and maintenance (O&M) costs caused by materials that are not designed for disposal via of the toilet entering sewer collection systems, agencies often use grinders upstream of WRRFs and pump stations to shred the material, in order to reduce its size and presumably minimize the impact to downstream processes. However, there is a lack of scientifically documented data on the impacts of shredded material (pulp) on the downstream sewer system and, in particular, pulp material derived from products such as wipes. For example, does the pulp undergo a reduction in volume similar to ordinary toilet paper or does it maintain its original shape and size? Does it combine with other materials in the sewer downstream of the grinder? Are there odors or deposition problems associated with the pulp?

This study provides data on the impacts of pulp loading from a small sample of wipes that have been passed through a mechanical grinder and transported within various lengths of a sewer system in order to: 1) evaluate the effectiveness of grinders to reduce the size of non-dispersible wipes, 2) study the physical characteristics of the resulting pulp derived from
grinding of the wipes and their interaction with other background material during transport in the sewer; and 3) recommend strategies for educating the public on proper methods of disposal of these types of products. Figure 1-4 depicts the relative size of the five different brands of wipes used in this study.

The SADPW's SPS, located on Bristol Street in Santa Ana was the principal test site for this investigation. This site was chosen because of its prior history with clogging and its successful resolution of the problem after installation of a mechanical grinder. The SPS currently employs a mechanical grinder immediately upstream of the SPS that was used in this study. The SPS has a history of maintenance problems associated with pump clogging caused by rags and other non-dispersible materials. A review of the pump station maintenance log in Appendix C for the period of April 2006 through April 2014 indicates that the SPS experienced 169 clogs caused by rags clogging the pump impellor. The present grinder, used in this study, was installed in October 2011. During the 66-month period prior to installation of the grinder, the SPS averaged 2.2 clogs per month. However, a more detailed look at the maintenance log reveals that each year the ragging incidents increased, which may correlate with the proliferation of products that are not designed for disposal via the toilet being sold on the market and disposed of in the sewer. For the 12-month period prior to installation of the grinder, the number of reported ragging incidents dramatically increased to 5.5 per month. After the grinder was installed, the reported ragging incidents dropped to less than one per month on average.

1.2 Project Objectives

The primary objectives of the study were:

1. To determine what changes the shredded pulp derived from wipes, undergoes throughout its transport within a measured length of sewer system, including any measurable change in weight, size or shape.

2. To determine if the pulp, derived from wipes that have passed through a sewage grinder and pump combo, combines with other background materials in the sewer to form larger masses after transport within a measured length of sewer system.
3. To determine if passing wipes through a grinder and pump result in any observable odors within the downstream sewer system.

4. To provide recommendations related to the proper disposal of materials not designed for disposal via the toilet.

5. To provide recommendations, based on observations during testing, on the effectiveness of grinders to minimize the impacts of wipes on the downstream sewers.
CHAPTER 2.0

METHODOLOGY AND RESULTS

2.1 Approach

This study was primarily focused on an assessment of the impact of shredded, non-dispersible wipes in a measured length of live sewer. Following a series of strategy sessions that were held with staff from the OCSD, the SADPW, the RSFCSD, and JWCE, it was determined that benchmark testing should be accomplished prior to conducting live sewer testing in order to learn more about the physical characteristics of the wipes after immersion in water.

Initial controlled environment benchmark testing was conducted utilizing specialized equipment located at the JWCERF in Santa Ana. Additional benchmark testing was conducted at the RSFWWTP in Rancho Santa Fe. A series of live sewer test trials were performed with the cooperation of SADPW, OCSD and RSFCSD utilizing each of their respective sewer collection systems. The following sections describe the testing procedure and results of each of the testing sessions.

2.2 Equipment Used

The complexity of this investigation required a myriad of equipment, much of which was designed and constructed specifically to test various theories. The following is a list of the major items of equipment used for testing:

- 10-inch metal basket with ¼-inch openings covered with #18 mesh (0.0394-inch).
- 24-inch tire-mounted screen with ¼-inch openings.
- Flat screen with #18 mesh (0.0394-inch).
- Pole-mounted dip net with #18 mesh (0.0394-inch) covering.
- Digital scale.
- Measurement board with ½-inch and one-inch gradations.
- Pressure plates used for squeezing water from samples.
- Test tank with grinder and pump.
- Test pond.
- Bench-scale sewer model.
Figure 2-1. 10-Inch Diameter Sampling Basket.

Figure 2-2. 24-Inch Tire-Mounted Screen.

Figure 2-3. Flat Screen with #18 Mesh Covering.

Figure 2-4. Pole-Mounted Net.

Figure 2-5. Digital Scale.

Figure 2-6. Measuring Board with 1/2-Inch and One-Inch Gradations.
Assessing the Impacts of Pulp Loading from Non-Dispersible Materials on Downstream Sewer Systems
2.3 Controlled Environment Testing at JWCE Regional Test Facility

Testing was performed at the JWCERF in Santa Ana using a test tank that circulated water through a municipal sewage grinder and into a recirculating pond with simulated wastewater debris. The test tank and pond provided controlled environments to gain a basic understanding of the behavior of the sample wipes when processed through a sewage grinder and subjected to a simulated sewer environment. The information gathered during these benchmark tests was used to modify future testing protocols. A copy of this benchmark testing protocol first developed and subsequently modified is included in Appendix D-1.

2.3.1 Site Condition/Description

The test tank consisted of an axial flow pump that circulated flow up to an open channel, through a municipal grinder, through a #18 mesh (0.0394-inch) screen then back to the pump suction. This is shown schematically in Figure 2-11.

![Figure 2-11. Controlled Environment Test Setup at JWCERF.](image-url)
The grinder chosen for the test tank, as shown in Figure 2-12, is a twin-shafted grinder manufactured by JWCE, which is outfitted with an 11-tooth cam cutter, incorporating a six millimeter (mm) perforated drum with a 29:1 reducer, mounted and fitted with a five horsepower (HP)/460-volt motor. The grinder unit was selected to match the model and cutter stack specifications of the grinder unit employed at the SPS.

![Figure 2-12. Mechanical Grinder in Test Tank.](image)

The test pond consisted of a 100-gallon rigid plastic pond partially filled with approximately 50 gallons of clean water and fitted with a submersible circulation pump that was separated from the main pond by a perforated baffle. The discharge hose was oriented and adjusted to achieve a flow circulation rate of approximately two feet per second (fps). The test pond is shown in Figure 2-13. A catch point that extended from the bottom to above the water level was constructed using a plastic tie that was placed inside the pond to replicate an obstruction within the sewer.

![Figure 2-13. 100-Gallon Test Pond.](image)
2.3.2 Objectives

The main objectives of the controlled environment testing were to document the behavior of the sample wipes after passing through the grinder and pump, while circulating in a simulated sewer environment, and to verify the size of the screen most suitable for recovering the majority of the sample material in the upcoming live sewer tests.

2.3.3 Procedure

The testing protocol followed for this set of trials is included in Appendix D-1. Samples consisted of individual sheets of wipes that were purchased from local stores. Five different manufacturer brands of wipes were selected and used throughout the study. For testing, a sample set consisted of ten sheets of wipes. The number of sheets per sample set was determined based on the amount of material reasonably expected to be caught without clogging the screen. Five sample sets were used in the testing with each sample set representing products from each of five different manufacturers (i.e., sample set A consisted of 10 sheets of Brand A, sample set B consisted of 10 sheets of Brand B, etc.). All testing was accomplished using blind sample sets to maintain objectivity.

Documentation of weight and size of each brand of wipe was accomplished prior to performing the experiments in the test tank (Figure 2-14). Sample wipes used throughout the study ranged in size from 36.73 square inches to 31.5 square inches. To assure uniformity and replicate immersion in the sewer, each sample set of 10 wipes was completely saturated by submersion in a bucket of potable water for 15 minutes. Saturated samples were then placed between two perforated plates that were applied with a force of 150 pounds (lbs.) by having a research team member stand on top of the plates for 30 seconds to press (squeeze) as much free water from the samples as possible. A grating was placed beneath the plates to allow for better drainage of the water. After squeezing, the damp weight of each sample set was determined using a digital scale and recorded.
A total of nine experiments were performed. Sample sets from each of the five different brands were used for the first five trials. With the tank assembly in operation and water circulating through the operating grinder, wipes from each sample set were placed individually in the open channel of the test tank and released into the grinder. The grinder was permitted to run until all observed material had been ejected. Each sample set was introduced at five-minute intervals, approximately four feet upstream of the grinder. Approximately 30 seconds was allowed after the last wipe was introduced to assure all material had cleared the grinder before lifting the grinder out of the flow stream using a fork lift, as shown in Figure 2-15.

![Figure 2-15. Removing Grinder from Test Tank at JWCERF.](image)

After two minutes of allowing the pulp to circulate in the tank without the grinder, the capture screen was placed into the tank and flow was allowed to circulate through the screen for an additional five minutes. The screen was then removed and the captured sample material was collected along with any sample material left in the grinder teeth. The collected material was squeezed to remove excess water, weighed, then separated and spread out on a mat with ½-inch and one-inch square markings to evaluate shape and size. The capture screen had ¼-inch perforations and was coated with #18 mesh screen to improve the capture rate.

In the first five trials, the flow was throttled down using a butterfly valve, and samples were allowed to pass through the grinder once. Next, the following three trials were run to address questions the research team had about how the flow dynamics within the test tank affected the physical characteristics of the collected samples:

1. Sample sets were circulated through the test tank with the grinder removed.
2. Sample sets were captured immediately after passing through the grinder.
3. The flow rate in the tank was significantly reduced by retrofitting the pump with a variable frequency drive (VFD) instead of using the butterfly valve for flow throttling.
2.3.4 Results/Discussion

While passing through the grinder, the sample wipes were shredded into pieces that were observable as they passed through the tank for the first time. However, after circulating through the pump and tank a number of times, the material became difficult to observe until captured on the screen. The samples collected on the screen for the first five trials appeared as a matrix of water and fibers with the consistency of slurry. The samples appeared to coat the screen in a thin, compacted layer that could be removed intact by peeling. Individual shredded pieces were unidentifiable. Figures 2-16 through 2-19 show the sample material captured on the screen after a single pass through the grinder. It should be noted that in the following pictures, the captured material exhibited a stained, brown color, which is attributed to rust from the tank components.
After removal of the material from the screen, it was attempted to pull the material apart in an effort to identify individual pieces. This proved to be difficult, as the material tended to roll up into rope-like shapes. Figure 2-20 shows the material from Sample A as it is laid out on the measuring grid after removal from the screen. The material on the right-hand side of the photo is material that was retrieved from the grinder’s cutter teeth and frame and consisted of individual pieces of wipe material that did not resemble the slurry caught on the screen. Figure 2-21 shows material from Sample C that was partially separated after removal from the screen.

![Figure 2-20. Sample A Material Separated After Removal from Screen on the Left, Along with Material Taken from the Cutter Teeth on the Right.](image1)

![Figure 2-21. Close-up of Sample C Material.](image2)

The results of these first trials prompted questions concerning why the captured wipe material appeared as a slurry. After observing material that was retrieved from the grinder’s cutter teeth, it was theorized that the material fibers caught on the screen were either breaking apart (dispersing) after circulating in the tank or an outside factor was causing the material to become compacted onto the screen. The decision was made to perform additional tests to determine the cause. A sample set of wipes from Brand B was chosen for the additional modified trials.

The first modified trial was performed using the same procedure of introducing the wipes into the tank, but in this trial the grinder was removed from the tank to determine if dynamics within the tank were causing results. The results of this trial were identical to previous trials using the grinder to shred the material, suggesting that the compacting of the collected material was caused by one or more of the following:

- Turbulence in the conveyance system.
- Sheer within the butterfly valve used to control flow in the tank.
- Force of the water pressing against the screen.
The collected material from the test trial with no grinder is shown on the screen in Figure 2-22 and after removal from the screen in Figure 2-23.

Figure 2-22. Material Collected on Screen from Test Tank Without Grinder.

Figure 2-23. Material Run Without Grinder After Removal from Screen.
In the second modified trial, the sample wipes were again introduced into the tank as before, however, this time they were captured immediately after passing through the grinder, thereby preventing the material from circulating through the system. As shown in Figure 2-24, the collected material after shredding remained as smaller pieces that rolled up into stringy, rope-like shapes upon removal from the screen.

![Sample Material from Second Trial After Removal from Screen.](image)

The third modified trial involved retrofitting the tank's circulation system with a VFD, in order to reduce velocity while allowing the regulating butterfly valve to be fully opened. This had two profound effects: 1) turbulence in the tank was reduced as was the pressure of the water against the screen, and 2) shear within the butterfly valve was reduced. Figure 2-25 shows the amount of turbulence present in earlier tests as the flow passes through the grinder and screen.

![Turbulence in Test Tank Under Normal Flow Conditions.](image)
Even with the slower rate of flow achieved after installing the VFD, a similar result was obtained as in the previous trials, resulting in the collected pulp forming a slurry across the wetted surface of the mesh screen. This result is shown in Figure 2-26. As the material was removed from the screen it again rolled into a tight-knit rope, as shown in Figure 2-27.

![Figure 2-26. Collected Material from Tank with VFD Installed.](image)

![Figure 2-27. Material from Third Trial After Removal from Screen.](image)
Weighing the samples after squeezing the water from them, as shown in Figure 2-28, provided little value in quantifying the true amount of sample material recovered from the test tank. The weighing results of the test tank experiments are summarized in Table 2-1.

The weight of the material captured from the test tank after squeezing was higher than the weight of the sample material prior to testing in most of the test trials. It is speculated that the collected material has a higher absorption capacity, making it more difficult to squeeze out the remaining water using the pressure plates.

![Figure 2-28. Typical Sample Weighing Procedure.](image)

### Table 2-1. Weight of Dewatered Sample Wipes – Before and After Collection.

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>No. of Sample Sheets Tested</th>
<th>Weight of Dewatered Sheets (Oz.)</th>
<th>Weight of Dewatered Captured Pulp (Oz.)</th>
<th>Percent Change in Weight</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>1.75</td>
<td>3.05</td>
<td>174%</td>
<td>Captured material deposited clung to the screen in a thin layer. When removed it bound together as knotted material.</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>2.05</td>
<td>3.95</td>
<td>193%</td>
<td>Captured material deposited clung to the screen in a thin layer. When removed it bound together as knotted material.</td>
</tr>
<tr>
<td>C</td>
<td>10</td>
<td>1.85</td>
<td>2.9</td>
<td>157%</td>
<td>Captured material deposited clung to the screen in a thin layer. When removed it bound together as knotted material.</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>1.9</td>
<td>2.95</td>
<td>155%</td>
<td>Captured material deposited clung to the screen in a thin layer. When removed it bound together as knotted material.</td>
</tr>
<tr>
<td>E</td>
<td>10</td>
<td>1.45</td>
<td>2.35</td>
<td>162%</td>
<td>Captured material deposited clung to the screen in a thin layer. When removed it bound together as knotted material.</td>
</tr>
<tr>
<td>F1</td>
<td>10</td>
<td>1.65</td>
<td>2.45</td>
<td>148%</td>
<td>Samples were placed in tank w/o grinder and allowed to circulate for standard test period.</td>
</tr>
<tr>
<td>F2</td>
<td>10</td>
<td>1.6</td>
<td>1.05</td>
<td>66%</td>
<td>Samples were placed immediately upstream of grinder and captured immediately after the grinder.</td>
</tr>
<tr>
<td>F3</td>
<td>10</td>
<td>1.55</td>
<td>1.5</td>
<td>97%</td>
<td>A VFD was employed to reduce tank turbulence &amp; velocity.</td>
</tr>
</tbody>
</table>
Following the three modified trials performed in the test tank, one additional test trial was conducted. In this trial, shredded material collected from test Sample B along with approximately 1.5-ounces of Crisco vegetable shortening and 1/2-ounce of hair were introduced into a test pond that was configured to simulate the flow in a sewer system. The amount of Crisco added was intended to raise the concentration of grease in the tank to 100 milligrams per liter (mg/l), which is the concentration of grease found in medium strength sewage (Metcalf and Eddy, 2003). The intent of this trial was to allow shredded sample material to circulate in the pond for a period of one hour with the grease and hair in order to evaluate whether or not it would combine with other materials commonly found in the sewer.

In this experiment, the majority of the shredded pulp from Sample B tended to sink to the bottom and gather around the base of the catch point and in other areas where there was little to no water movement. Figure 2-29 shows hair wrapping around the catch point and sample material collecting at the base. The sample material appears dark brown from the rust in the water of the grinder test tank. The lighter brown material shown in the figure is residual sand from previous, non-related experiments.

![Figure 2-29. Catch Point Inside Test Pond.](image)

Upon completion of the one-hour test, the sample material was collected using a fine mesh strainer. The sample material became tangled with the hair as a result of collecting the material in this manner. The material collected from the test pond is shown in Figure 2-30.

![Figure 2-30. Material Captured from Test Pond.](image)
2.4 Live Sewer Sampling with Whole (Intact) Wipes – Santa Ana, CA

In this test, intact wipes were introduced into a portion of a gravity sewer line located just outside of the JWCERF on Garnsey Street in Santa Ana. These test trials were conducted to observe the behavior of intact wipes in a live sewer environment to achieve a better understanding of any changes to the physical characteristics of the wipes after immersion in the sewer and also to practice sampling techniques prior to live testing using the grinder.

2.4.1 Site Condition/Description

The sewer line used during this set of trials consisted of a 10-inch, polyvinyl chloride (PVC) pipe located in a light industrial section of town, as shown in Figure 2-31. The testing was conducted between 9:00 AM and 3:30 PM. The flow through the sewer at the time of testing was observed to be approximately 30% of pipe depth and consisted of light industrial discharges and some residential sewage.

2.4.2 Procedure

The testing protocol followed for this set of trials is included as Appendix D-2. Prior to beginning the first test trial it was determined that the travel time of the sample materials from the entry manhole to the downstream sampling manhole should be determined. This would minimize the amount of background sewer material collected and maximize the collection of introduced sample material by allowing the capture basket to be placed inside the sampling manhole trough just before the sample material was expected to arrive. To determine flow velocity within the pipe, small pieces of a foam cup were dropped into the upstream entry manhole and their travel time to the downstream sampling point manhole was timed.

Each of the five sample sets used in this trial consisted of 10 sheets of flushable wipes, which were introduced into a selected sewer manhole, one by one, every five seconds. The plan was to collect the sample materials in downstream manholes at various distances. Downstream manholes located at 900-foot, 600-foot and 300-foot intervals from the entry point manhole were chosen. A 10-inch diameter metal, pole-mounted, collection basket covered with #18 mesh screen was used to collect the sample
material. The collection basket is shown inside of a manhole in Figure 2-32.

A total of six test trials were performed: five trials using five different brands of sample wipes, and one trial conducted without introducing any sample wipes, in order to evaluate the characteristics of the background material present in the sewer line. The wipes used in each sample set were dyed red, orange and green, as shown in Figures 2-33 and 2-34, using store purchased T-shirt dye. It was attempted to determine which color dye held its color longer. However, the results of this determination proved inconclusive due to problems encountered in retrieving the wipe samples during these test trials.
2.4.3 Results/Discussion

When sampling at the manhole 900 feet from the entry point, an industrial discharge was observed that lasted the entire test session at that manhole. The sewage was tinted a dark blue/grey color that made observations difficult and stained the collected material a similar color. Inspection of the capture basket after removal from the manhole revealed a mass of pulp material all stained blue/grey from the industrial discharge, as shown in Figure 2-36. No intact sample wipes were observed and no dyed material of any sort was observed. After this first test trial, it was believed that the wipes were undergoing a volume reduction transforming the material into slurry similar to what had been previously observed in the JWCERF test tank. Furthermore, it was believed that the dye coloring used on the wipes was washing out after immersion in the sewer.
After locating the source of the industrial discharge, the decision was made to relocate the sampling point to the closer 600-foot manhole in order to avoid any further staining by the industrial discharge. Unfortunately, the results of the 600-foot test trial were also inconclusive. The material collected in both trials at the 600-foot manhole consisted of a thin layer of pulpy material resembling slurry and nearly identical to what was observed in the previous benchmark testing at the JWCERF. The material can be seen inside of the capture basket in Figure 2-37. No intact wipes were observed and no presence of dyed material was observed.

The material collected in the first trial of the 300-foot manhole appeared to be similar in mass and characteristics as the pulp material collected in previous trials. However, when the red-dyed sample wipes were introduced into the sewer, much of the dye washed off, as the downstream sewage flow was observed to be red in color (Figure 2-38) as was all of the captured material. This did not occur in any of the other trials indicating that the red dye had not set-in sufficiently. In the second 300-foot manhole trial using the orange wipes, pulp material was collected as before, however, one completely intact, orange wipe was captured in the basket.
The final trial involved placing the basket inside the 300-foot manhole to collect background material from the sewer. In this trial no wipes were used. The purpose of this control sample was to characterize the background material in the wastewater flow for comparison with the previous material collected. The material captured in this control trial appeared to have the same mass, color, and physical characteristics of toilet paper closely resembling the material captured in all of the previous trials. See Figure 2-39.

![Figure 2-39. Background Material Collected from Sewer.](image)

An evaluation of the data collected from these field trials, including the appearance of a single orange wipe, raised several important questions relating to: 1) the collection method employed, 2) the calculated travel time of the wipes in the sewer, 3) the effectiveness of the dye used, and 4) the consistency of the captured material, which appeared to resemble wet toilet paper. After much debate, it was concluded that the method employed to measure travel time in the sewer by dropping floatable material was flawed, which may have led to the capture basket not being left in the sewer line a sufficient time to collect the samples.

If true, this may have resulted in the failure to collect all but one of the wipes used in the trials. This hypothesis led to changes in the testing protocol that included using sewer marker dye as a travel time indicator and subjecting the dyed wipes to heat drying in order to improve color retention. To further test this theory and obtain additional data, a second round of testing in a live sewer was scheduled with the cooperation of staff from the RSFCSD.

A summary of the above described tests performed and observations is presented in Table 2-2.
## Table 2-2. Summary of Live Sewer Testing with Whole Samples.

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Distance between Entry and Collection Points (ft.)</th>
<th>Basket Duration in Channel (min.)</th>
<th>Time after First Sample Drop to Basket Removal (min.)</th>
<th>Observed Travel Time from Entry Point to Collection Point (min.)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Red)</td>
<td>900</td>
<td>20</td>
<td>20</td>
<td>–</td>
<td>Collected pulp material that was dyed blue from wastewater. No intact sample wipes were observed. No pre-dyed sample material was observed. Collected pulped material. No intact sample wipes were observed. No pre-dyed sample material was observed.</td>
</tr>
<tr>
<td>B (Green)</td>
<td>600</td>
<td>10</td>
<td>15</td>
<td>6</td>
<td>Collected pulped material. No intact sample wipes were observed. No pre-dyed sample material was observed. Wastewater turned red from dyed wipes. Collected dyed pulped material. No intact sample wipes were observed. Dye from the wipes likely dyed the background material.</td>
</tr>
<tr>
<td>C (Orange)</td>
<td>600</td>
<td>10</td>
<td>15</td>
<td>6</td>
<td>Collected pulped material and one completely intact orange wipe.</td>
</tr>
<tr>
<td>D (Red)</td>
<td>300</td>
<td>6</td>
<td>9</td>
<td>3</td>
<td>Collected pulped material that was white and of the same amount as previous trials.</td>
</tr>
<tr>
<td>E (Orange)</td>
<td>300</td>
<td>6</td>
<td>9</td>
<td>3</td>
<td>Collected pulped material and one completely intact orange wipe.</td>
</tr>
<tr>
<td>Control</td>
<td>300</td>
<td>6</td>
<td>N/A</td>
<td>3</td>
<td>Collected pulped material and one completely intact orange wipe.</td>
</tr>
</tbody>
</table>

### 2.5 Live Sewer Sampling with Whole (Intact) Wipes – Rancho Santa Fe, CA

Additional test trials in a live sewer were performed using a 10-inch gravity sewer line located along El Sicomoro Street, in Rancho Santa Fe, in order to investigate inconclusive results obtained during the previous testing in the 10-inch gravity sewer along Garnsey Street in Santa Ana, in which the results indicated that either: 1) dye was washing off of the wipes and rendering them unidentifiable from background material; 2) the wipes were completely dispersing while immersed in the sewer; or 3) the sample wipes placed into the sewer were not captured due to incorrect assumptions concerning the timing of placement of the capture basket in the sewer.

The objectives of these test trials were: 1) to confirm if the sample wipes remained dyed after being exposed and agitated in wastewater, 2) to determine if wipes remain intact and can be captured after traveling through the sewer for known distances, and 3) to compare two methods of measuring the sewer flow velocity (using floatable material versus using a marker dye).

### 2.5.1 Site Conditions/Description

Sampling was performed in a 10-inch gravity sewer within a residential neighborhood in Rancho Santa Fe, CA. The sewer was flowing approximately 50% full at the time of testing and consisted of entirely domestic sewage. Flow from this line combines with flow from another tributary line before entering the RSFWWTP, which is located 1,600 feet downstream from the Entry Point (EP) 1 manhole. Flow to the downstream treatment plant was approximately 200 gallons per minute (gpm) at the time of testing. Plant staff indicated that the flow contribution from the 10-inch line on El Sicomoro to be about 85%, thus the flow in the line being used was approximately 170 gpm.

Sample Point (SP) 1 was the next manhole downstream from EP1 (approximately 260 feet apart and 1,320 feet from the headworks of the RSFWWTP). SP1 was the same manhole as
EP2 and SP2 was located at the RSFWWTP headworks. Prior to beginning the first test, it was observed that manhole EP1 was surcharging. Collection system staff from the RSFCSD jetted the line between SP1 and EP1 to clear the blockage so testing could proceed. Figure 2-40 shows the entry points and sampling points of the live sewer testing with intact wipes in the RSFCSD sewer system.

Figure 2-40. Sampling Locations for Live Sewer Testing in RSFCSD Sewer System.
2.5.2 Procedure

The testing protocol followed for this set of trials is included as Appendix D-3. Fragments of a foam cup and marker dye were introduced simultaneously into EP1 and the time it took for these items to pass through SP1 was recorded in order to determine how long the capture basket should be kept in-place within the sampling manhole. Sample A wipes (dyed red) were introduced at EP1 (Figure 2-41) to be captured at SP1 using a 10-inch diameter capture basket covered with #18 mesh. Five wipes were introduced individually into EP1. The capture basket was placed at SP1 approximately 30 seconds after the first wipe was introduced. The basket was taken out after three minutes and the contents were evaluated. This procedure was repeated with Sample B wipes (dyed orange).

![Figure 2-41. Dropping Dyed Wipes into EP2.](image)

In the second phase of trials, seven Sample A wipes (dyed red) were introduced into EP2 to be captured at the RSFWWTP headworks (Figure 2-42). After waiting approximately 10 minutes, six of the seven wipes were found caught on the bar screen. It is assumed the missing wipe remained intact but was not recovered.

![Figure 2-42. Bar Screen Located at RSFWWTP Headworks.](image)
2.5.3 Results/Discussion

Table 2-3 summarizes the results of the live sewer testing, at RSFCSD.

Table 2-3. Results of Live Sewer Testing Using Whole Wipes in RSF.

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Entry Point</th>
<th>Sample Point</th>
<th>Distance Between EP and SP (ft.)</th>
<th>Travel Time (min: sec)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Styrofoam Dye</td>
<td>EP1</td>
<td>SP1</td>
<td>280</td>
<td>N/A</td>
<td>Sample was never observed passing through SP1.</td>
</tr>
<tr>
<td>Styrofoam (Red)</td>
<td>EP1</td>
<td>SP1</td>
<td>280</td>
<td>N/A</td>
<td>Sample was never observed passing through SP1.</td>
</tr>
<tr>
<td>Styrofoam (Orange) A</td>
<td>EP1</td>
<td>SP1</td>
<td>280</td>
<td>2:00</td>
<td>4 out of 5 wipes were recovered. Completely whole and dyed.</td>
</tr>
<tr>
<td>Styrofoam (Red) A</td>
<td>EP2</td>
<td>SP2</td>
<td>1,320</td>
<td>9:30 (approx.)</td>
<td>6 out of 7 wipes were recovered. Completely whole and dyed. The remaining wipes introduced earlier at EP1 were recovered as well (whole and dyed).</td>
</tr>
</tbody>
</table>

Test trials confirmed that the use of sewer dye provided an accurate method of measuring the sewer velocity and the anticipated travel time of the wipes within the sewer. Actual travel times recorded for the wipes placed into the sewer were found to be within 90% of the time recorded using the dye. It was found that the wipes took longer to travel the same distance as did the dye, which may be is attributed to the head loss in the sewer line upstream of the sampling manhole created by insertion of the capture basket. The results show that marker dye appears to be a better indicator of the wipes travel time compared to using foam fragments, which were never recovered and may have caught on obstructions within the sewer line. The observed velocity of the wipes from EP1 to SP1 and from EP2 to SP2 was approximately 2.3 fps.

The results of this testing show that, after flowing in a gravity sewer at a flow velocity less than 2.5 fps over distances of 260 feet and 1,320 feet, the sample wipes do not undergo a reduction in volume and remain completely intact (Figure 2-43). It was also verified that the wipes completely maintained their dyed color. The results validate the hypothesis of why 49 of 50 of the wipes introduced during the live sewer testing on Garnsey Street remained intact but were not recovered. It further suggests that the material collected during the Garnsey Street testing was mostly toilet paper and other background material not introduced as part of the testing.

Figure 2-43. Intact Wipes Collected During Testing.
2.6 Live Sewer Sampling with Shredded Wipes – Santa Ana, CA

Upon completion of the additional testing in RSFCSD, field testing commenced in live sewers located in Santa Ana. Based on lessons learned from the recent live sewer test trials, a new protocol was developed for the upcoming live sewer testing that now included the use of dye to predict travel time in the sewer and heat treating of the wipes to assure color retention of the dye. Known quantities of dyed wipes were introduced into the collection system at a point upstream of the SPS grinder (Figures 2-44 and 2-45). This introduction point is known as EP1. The shredded wipe material was then collected at SP1, which is the discharge point of the SPS force main, and downstream at the inlet of a three-barrel siphon at SP2 on Alton Avenue. The collected pulp material was documented and qualitatively evaluated.

The objective was to evaluate and document the behavior of the flushable wipes after they have been shredded by a municipal sewage grinder, passed through a pump and have traveled in the sewer for distances of 30 feet and 2,680 feet.

Figure 2-44. Segerstrom PS/Grinder Location Looking North.

Figure 2-45. Segerstrom PS/Grinder Location Looking South.
2.6.1 Site Condition/Description

SPS is fed by an 18-inch sewer located in a commercial section of town. The flow consists of domestic sewage and a significant amount of food waste discharged from the many fast-food restaurants located nearby. The flow passes through a JWCE Muffin Monster grinder prior to discharging into the pump station’s wet well. The SPS grinder is fitted with an 11-tooth cam cutter, incorporating a six-mm perforated drum with a 29:1 reducer, mounted and fitted with a five-HP/460 volt motor (Figure 2-46). SPS is a dry pit/wet well, pump station with two VFD driven, self-priming, pumps operating as duty/standby, which discharge into a 10-inch force main. At the time of testing, the pumps were operating at approximately 70% speed. The SPS is owned and operated by the SADPW. The SPS force main discharges into a 30-inch gravity sewer and manhole (SP1) owned by OCSD.
Downstream of SP1, the 30-inch sewer confluences with a 42-inch trunk sewer, which then expands to a 48-inch sewer. The flow in this sewer line combines domestic and commercial sewage collected from neighboring residences and business establishments, including fast-food restaurants. Approximately 2,680 feet downstream from SP1, the 42-inch sewer line transitions to a three-barrel inverted siphon system. SP2 is located just upstream of the inlet to the 24-inch barrel of a three-barrel system. See Figure 2-47 for a complete layout of the sampling plan area. During the time of sampling at SP2, all of the flow on the 42-inch main line was diverted to the 24-inch barrel by plugging the other two barrels with inflatable plugs. SP2 is located on Alton Street just east of Bristol Street, adjacent to the street on a bike trail. The gravity trunk sewer was flowing approximately 30-50% at the time of testing.

SPS was cleaned by the SADPW the day before testing, and the 24-inch barrel at SP2 was cleaned by OCSD a few days prior to testing.

Figure 2-47. Live Sewer Sampling Plan – Phases 1 and 2.
Because the entry manhole (EP1) to the SPS grinder, the SPS wet well, and the SP1 manhole are all located within multiple lanes of a busy Orange County thoroughfare, it was decided to perform the testing in the evening (Figure 2-48) when traffic would be steadily decreasing as time progressed. This also provided an advantage to run the testing with lower flows in the sewer lines. SADPW crews provided traffic control beginning at 7:00 PM by channeling three lanes of traffic into one lane, which allowed unrestricted access to the entry and sampling manholes. The OCSD crew simultaneously set up at SP2, which also required traffic control. Although the manhole at SP2 is located on a bike trail, it required one lane closure for safety considerations. Testing began at 8:00 PM and concluded at approximately 3:30 AM.

Figure 2-48. Segerstrom PS/Grinder Location at Night.
2.6.2 Procedure

The testing protocol followed for this set of trials is included as Appendix D-4. Five sample sets of dyed, intact wipes were introduced into the sewer (Samples A through E) at the entry point (EP1) immediately upstream of the grinder. Each of the five sample sets consisted of intact wipes of a different brand. 10 sheets of each sample wipe were used for sampling in SP1, and then increased to 20 sheets for sampling in SP2 to increase the probability of capturing sample material, in consideration of the long distance involved between EP1 and SP2. Sample sets were dyed red and orange in color and were alternated between sets to prevent confusion with material collected from previous sets.

All wipes were soaked in potable water for 15 minutes to simulate exposure to wastewater prior to being introduced into the SPS grinder (Figure 2-49). After soaking, all wipes were squeezed to remove excess water and weighed prior to testing (Figure 2-50). A preliminary test trial using the planned 10-inch diameter basket, which was covered with #18 mesh, at SP1 was conducted but failed due to the basket becoming quickly clogged from the amount of material in the sewer and compounded by the discharge pressure of the force main. After consultation with SADPW and OCSD crews it was decided to use the collection device planned for usage at SP2 to replace the 10-inch diameter basket. The new collection device consisted of a tire with a ¼-inch perforated screen mounted at its center connected by a steel cable, which is used for raising and lowering by a truck-mounted winch. The tire-mounted screen worked well but occasionally became clogged with debris and allowed some material to overflow the sides.
For sampling at SP1, 10 dyed wipes were introduced at EP1, one at a time at approximately five-second intervals. A rain gutter and wash water from a vactor truck were used as a conveyance system to ensure that the wipes were introduced directly upstream of the grinder (Figure 2-51).

One minute after each sample set was introduced; the tire-mounted screen was lowered into place at SP1. The tire-mounted screen (Figure 2-52) was then removed approximately four minutes after being placed. All sample materials (Figure 2-53) were removed from the screen after each trial and placed in separate sealed containers for later evaluation.
For sampling at SP2, green marker dye was introduced into the SP1 manhole five minutes prior to introducing the first wipe. This was done to alert the team at SP2 when to expect the sample materials to arrive. In addition, the OCSD and SADPW crews maintained radio contact to verify sampling status. The first of 20 wipes were introduced at EP1 five minutes after the marker dye was added. The 20 wipes from each sample set were introduced individually at approximately five-second intervals. A rain gutter and wash water from a vactor truck were used as a conveyance system to ensure that the wipes were placed upstream of the SPS grinder. The collection device was put in place at SP2 approximately six minutes after the marker dye was first observed at SP2. The collection device was removed approximately 10 minutes after being placed. After each sample, the larger pieces of organic material were removed from the tire-mounted screen by hand and discarded back into the sewer. The remaining material caught in the screen was then removed and placed in a sealed container for later evaluation. Figures 2-54 through 2-59 show how the tire-mounted screen was used to retrieve the wipe samples in the 24-inch sewer line at SP2.
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Figure 2-56. Tire-Mounted Screen Being Raised.

Figure 2-57. Typical Material Found on Screen.

Figure 2-58. A Few Pieces of Red Colored Wipe Material Visible.

Figure 2-59. Tire-Mounted Screen Prior to Cleaning.
After completion of sampling, the collected sample material was spread out on a graduated surface with one-inch and ½-inch squares (Figure 2-60). The collected sample material was separated as carefully as possible on the grid surface and photographed. The colored sample material was separated for identification but was not weighed.

Figure 2-60. Captured Material Being Separated.

It was originally planned to conduct additional testing 2.5 miles further downstream in OCSD’s 48-inch trunk sewer at SP3, however, this set of test trials was cancelled based on such a small amount of sample material recovered at SP2. It was assumed that the results would be similar to SP2 but with much less sample material captured.
A summary of the sampling performed in the live sewers at SP1 and SP2 using wipes shredded by the mechanical grinder at the SPS is presented in Table 2-4.

**Table 2-4. Sampling Summary.**

<table>
<thead>
<tr>
<th>Sample ID (Color)</th>
<th>Entry Point</th>
<th>Sample Point</th>
<th>Distance Between EP and SP (ft.)</th>
<th>Travel Time (min:sec)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Red)</td>
<td>EP1</td>
<td>SP1</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td>Sample particles observed at SP1 1 minute after introduction.</td>
</tr>
<tr>
<td>B (Orange)</td>
<td>EP1</td>
<td>SP1</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td></td>
</tr>
<tr>
<td>C (Red)</td>
<td>EP1</td>
<td>SP1</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td>One wipe was caught on top of grinder. It was dislodged 1:50 mins after first wipe was introduced. Screen was removed only 2:20 minutes after being placed due to blinding.</td>
</tr>
<tr>
<td>D (Orange)</td>
<td>EP1</td>
<td>SP1</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td></td>
</tr>
<tr>
<td>E (Red)</td>
<td>EP1</td>
<td>SP1</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td></td>
</tr>
<tr>
<td>A (Red)</td>
<td>EP1</td>
<td>SP2</td>
<td>2680</td>
<td>18:45*</td>
<td>One wipe was caught on top of grinder. It was dislodged 2:00 mins after first wipe was introduced. Possibly missed the grinder. Capture screen was in sewer for 12 minutes. Capture screen was in sewer for 10 minutes.</td>
</tr>
<tr>
<td>B (Orange)</td>
<td>EP1</td>
<td>SP2</td>
<td>2680</td>
<td>19:00*</td>
<td>Capture screen was in sewer for 10 minutes.</td>
</tr>
<tr>
<td>C (Red)</td>
<td>EP1</td>
<td>SP2</td>
<td>2680</td>
<td>22:00*</td>
<td>One wipe was caught on top of grinder. It was dislodged 1:00 mins after first wipe was introduced. Capture screen was in sewer for 14** minutes. One wipe was caught on top of grinder. Was not dislodged. Capture screen was in the sewer for 10 minutes.</td>
</tr>
<tr>
<td>D (Orange)</td>
<td>EP1</td>
<td>SP2</td>
<td>2680</td>
<td>21:20*</td>
<td>Capture screen was in the sewer for 10 minutes.</td>
</tr>
<tr>
<td>E (Red)</td>
<td>EP1</td>
<td>SP2</td>
<td>2680</td>
<td>23:00*</td>
<td>Capture screen was in the sewer for 10 minutes.</td>
</tr>
</tbody>
</table>

* The travel time recorded is for the dye. It is assumed that the travel time of the shredded wipes was the same.
2.6.3 Results/Discussion

A small portion of the flow bypassed the device during each trial, especially after the ¼-inch screen openings become clogged with material. Approximately 80% of the total flow was estimated to have been screened at SP1 during testing.

As expected, more sample material was collected at SP1 than at SP2. The red colored wipes were more easily identified from background material compared to the orange wipes. The background material generally consisted of plastics and other non-dispersible material, food, and fecal matter. The collected sample material (pulp) was found both as individual pieces measuring less than one-half square inch in size and in clumps consisting of multiple sample pieces and other background material. In most cases, these clumps were covered with grease and contained strands of hair. Similar clumps containing only background material with no sample material present were also observed, as shown in Figures 2-61 through 2-70.
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Figure 2-65. Sample E at SP1.

Figure 2-66. Sample A at SP2.

Figure 2-67. Sample B at SP2.

Figure 2-68. Sample C at SP2.

Figure 2-69. Sample D at SP2.

Figure 2-70. Sample E at SP2.
It became evident after examination of the collected material that only a small amount of the shredded pulp (estimated to be less than 5%), was collected in the capture device at SP1 during the Phase One testing. It is further estimated that less than 1% of the total amount of shredded wipes used in the Phase Two testing was collected at SP2. No unusual odors were detected from the samples.

2.7 Bench-Testing with Shredded Wipes – Rancho Santa Fe, CA

Additional testing was performed at the RSFWTP, using a bench-scale model that was constructed as shown in Figure 2-71 to simulate a sewer environment, for the purpose of observing how the shredded pulp reacted after being caught on the screen as compared to single-ply toilet paper. The testing protocol followed for this set of trials is included as Appendix D-5.

![Figure 2-71. Bench-Scale Testing Apparatus.](image)

2.7.1 General

The bench-scale model was comprised of a 40-foot length of 2-inch PVC pipe set at a 1% slope. Water flow at 3 gpm was introduced into one end of the pipe along with samples of five shredded and dyed, pre-soaked wipes. For this set of tests, the sample wipes were dyed red and black in color and then taken to the JWCERF prior to the test for grinding in a dry state using the same grinder used in the previous bench-testing. The shredded samples were then placed in plastic bags for transport to the RSFWTP.

A separate set of trials was conducted that involved the introduction of single-ply toilet paper instead of wipes for comparison. The pipe was setup to flow 30% full with a flow velocity of 1.2 fps. The pipe drained into a five-gallon bucket (mixing chamber) until full, in order to allow the introduced material to get agitated and mixed. The full bucket was then drained onto a screen with ¼-inch openings. The screen was then weighed and photos were taken for evaluation.

The purpose of these trials were to: 1) observe and evaluate the behavior of shredded wipes after they have been subjected to minor agitation in a simulated sewer environment and caught on a ¼-inch mesh screen, and 2) to compare the results with the behavior of single-ply toilet paper under the same conditions. Single-ply toilet paper is constructed with a single layer compared to two, three and four-ply toilet paper. The more layers a toilet paper has the stronger...
it is. While single-ply toilet paper is the weakest, it disperses in water faster than toilet paper manufactured with more layers.

Five different sample sets of pre-shredded wipes were used (Samples A through E). Each of the five sample sets consisted of wipes of a different brand. Each trial utilized a batch of five pre-dyed, pre-shredded wipes. The pre-shredded sample material was soaked and then squeezed to remove excess water, and finally weighed before testing. Four additional trials were performed using randomly selected quantities of single-ply toilet paper; the first trial using 0.80 ounces of toilet paper, two trials using 0.50 ounces of toilet paper, and the final trial using 0.30 ounces of toilet paper. The toilet paper samples were not pre-soaked.

2.7.2 Procedure

A ¼-inch screen was placed over a five-gallon bucket (Bucket A). A second bucket with a plugged 1.5-inch orifice (Bucket B) was placed approximately 18 inches over the mesh screen. A 40-foot straight section of 3-inch PVC pipe with a 1% slope was set up to drain approximately 6 inches above Bucket B. A water hose was regulated so that it would deliver a flow rate of approximately 3 gpm. The discharge of the pipe was placed approximately 6 inches above the top of the mixing chamber. Water was introduced into the opposite end of the pipe at a flow rate of 3 gpm along with the contents of a bag containing a sample of shredded wipes. Bucket B was filled up to the five-gallon mark then allowed to settle for approximately 30 seconds. The plug at the bottom of Bucket B was removed and the contents were allowed to drain by gravity through the mesh screen and into Bucket A. The screen mesh with the captured contents was removed and placed on the scale for measurement. The weight of the empty screen was subtracted from the weight of screen with the captured material. Photos of the mesh screen with the captured materials were taken and observations were made.

2.7.3 Results/Discussion

Researchers originally intended to use varying amounts of wipes for each test to match the weight of the shredded wipe samples with an equivalent weight of toilet paper. However, since each brand of wipe weighed differing amounts, researchers decided to continue using five wipes for each sample set. After capturing and weighing the shredded wipe samples, researchers determined that the weight measurements provided no meaningful information, as some material was lost due to splashing after the screen had become clogged. Additionally, the weight measurements obtained from the recovered wipe material showed increases in weight from water absorption in the range of 222-421%, indicating that some brands had a higher adsorption rate than others. Weighing of the recovered toilet paper resulted in higher weight gains in the range of 366-600%, which could also be partially attributable to a higher rate of sample recovery.

What became evident from these tests is that the pulp from the shredded wipes had a tendency to clog the screen as did the toilet paper. However, unlike the shredded wipes, the toilet paper caught on the screen tended to spread out and disperse under the force of the water, which allowed the water to continue passing through the screen. This indicated that, although toilet paper may get caught on a catch point, flowing water may eventually cause the material to disperse until it passes the obstruction. The material caught on the screens can be seen in the following Figures 2-72 through 2-90.
Figure 2-72. Wipe Sample A1.

Figure 2-73. Wipe Sample A2.

Figure 2-74. Wipe Sample A3.
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Figure 2-78. Sample C1.

Figure 2-79. Wipe Sample C2.

Figure 2-80. Wipe Sample C3.
Figure 2-81. Wipe Sample D1.

Figure 2-82. Wipe Sample D2.

Figure 2-83. Wipe Sample D3.
Figure 2-84. Wipe Sample E1.

Figure 2-85. Wipe Sample E2.

Figure 2-86. Wipe Sample E3.
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Figure 2-87. 0.8-oz. Toilet Paper.

Figure 2-88. 0.5-oz. Toilet Paper (Trial One).

Figure 2-89. 0.5-oz. Toilet Paper (Trial Two).
2.8 Live Sewer Testing with Shredded Wipes – Rancho Santa Fe, CA

Live sewer testing was conducted in a 10-inch gravity line located in a residential section of Rancho Santa Fe, CA. The sewer flow consisted primarily of domestic sewage. Pre-dyed, pre-shredded wipes were introduced into a manhole approximately 1,320 feet upstream of the RSFWWTP and recovered at the plant headworks.

2.8.1 General

The purpose of these test trials was to determine if the wipe samples used in the previous live sewer testing at the SPS were affected by forces encountered as they passed through the pump after exiting the grinder. The testing provided an opportunity to introduce pre-shredded wipe material into a live sewer line, without first passing through a pump, for comparison with the pulp captured during the live sewer testing at the SPS. It also afforded the research team with a location where the sample material could be easily captured with minimum loss of material.

2.8.2 Procedure

The testing protocol followed for this set of trials is included as Appendix D-6. Five different sample sets were used (Samples A through E). Each of the five sample sets consisted of wipes of a different brand. Each trial utilized a batch of 10 pre-dyed wipes that were pre-shredded in a dry state at the JWCERF using the same grinder as in the previous benchmark testing. All samples were wetted, squeezed to remove excess water and weighed prior to testing. Each shredded sample was immersed in a quart-sized container with water for ease of introducing the wipes into the flow stream. The wipe samples were dyed red and black for identification purposes.

Samples were introduced into EP1, a manhole 1,320 feet upstream of the RSFWWTP, and recovered at the plant headworks (SP1). Figure 2-91 shows the relative locations of EP1 and SP1.
Sewer dye was introduced into EP1 two minutes prior to introducing the samples. The sampling basket (¼-inch screen with a # 18 mesh screen) was placed directly downstream of a weir at the RSFWWTP headworks one minute after observing the dye at SP1, in order to collect the introduced samples. The capture basket was left in place for three minutes then removed.

The collected sample materials were removed from the capture basket and separated from other debris. The collected sample pieces were placed on a graduated mat with ½-inch and one-inch squares for evaluation and measurement and were photographed.

2.8.3 Results/Discussion

The sample material captured from the sewer at SP1 appeared to be similar in size and shape to the dry-shredded material used in the test. The captured material consisted of both individual pieces and pieces that had bound together making it difficult to obtain an accurate count for comparison with the corresponding dry samples. However, it appeared from observations that less than 50% of the sample material from each of the five test trials was recovered. The reasons for the unaccounted material are not known and test procedures for determining these losses were not addressed in this study. Figures 2-92 through 2-101 show the material captured and placed on a graduated mat with ½-inch and one-inch squares along with a photograph of the corresponding dry shredded material for each sample. Note the similarities in size and shape of the individual pieces of shredded material. Although the test run material was not weighed, it was assumed from previous testing that the captured material had increased in weight due to water absorption. No unusual odors were detected from the samples.
Figure 2-92. Sample A Material After Capture.

Figure 2-93. Sample A Material Before Test.

Figure 2-94. Sample B Material After Capture.

Figure 2-95. Sample B Material Before Test.

Figure 2-96. Sample C Material After Capture.

Figure 2-97. Sample C Material Before Test.
Figure 2-98. Sample D Material After Capture.

Figure 2-99. Sample D Material Before Test.

Figure 2-100. Sample E Material After Capture.

Figure 2-101. Sample E Material Before Test.
CHAPTER 3.0

DISCUSSION

3.1 Background

The objective of this study was to determine the measureable impacts of pulp loading derived from shredded wipes on downstream sewers. The research team was formed with individuals from Dudek, SADPW, OCSD, RSFCSD, and JWCE, who met several times prior to beginning the study and determined that the study should include controlled environment testing to set a benchmark, in addition to live sewer testing. Next, the research team developed specific protocols for both controlled environment testing and the live sewer testing to assure continuity. Following is a summary of the information provided in Chapter 2.0 regarding the testing accomplished and the results obtained.

3.2 Controlled Environment Testing at JWCERF

The study incorporated two controlled environment tests to set a benchmark and five live sewer tests. The first benchmark test was performed at the JWCERF in Santa Ana to observe and measure the physical characteristics of the tested wipes before and after they were passed through a mechanical grinder and pump and circulated for a period of time in water. Researchers hoped that the results of this testing would provide a clear picture of what could be expected when the wipes were introduced into a live sewer for testing. A protocol was developed that incorporated a series of test trials using five different brand name wipes. Sample sets made up of 10 wipes from each of the five manufactured brands (Samples A through E) were introduced into a test tank that circulated water through a mechanical grinder, having identical specifications of the grinder that would later be used in the live sewer tests. Individual wipes from each of the five sample sets were first measured and weighed for documentation of their physical characteristics. Each sample set was then soaked for 15 minutes, to replicate immersion in the sewer, then squeezed of water and weighed before being placed into the test tank where they made a single pass through the grinder. After 30 seconds, the grinder was removed from the tank and the samples were allowed to circulate in the tank for two minutes. After two minutes, a ¼-inch screen covered with an additional #18 mesh screen was inserted into the tank and the samples were collected as they came in contact with the screen. The samples were then dewatered, weighed, measured and photographed. Changes to the benchmarking protocol developed for the upcoming live sewer testing were made that consisted of:

♦ Using #18 mesh to cover the ¼-inch openings in the 10-inch diameter metal basket in order to increase material capture.

♦ Increasing the amount of time the samples were squeezed to remove excess water from 15 seconds to 30 seconds to account for differences in thicknesses of each brand of wipe.

♦ Installing a grating beneath the pressure plates used to squeeze the excess water from the samples to create a path for the water to escape.
Reducing the sampling set size from 50 sheets to 10 sheets to minimize the possibility of screen clogging because of too much material.

Using a scrub pad to remove the material from the screen to maximize material removal.

The material collected on the screen during the first five benchmark trials resembled the consistency of slurry, requiring the matted material to be scraped from the screen. As the material from each trial was removed from the screen it continually rolled up into long rope-like shapes. This made measurement of the individual pieces difficult and consequently did not provide any meaningful data. Weighing the collected samples also did not provide meaningful information, as the results indicate that the sample material increased in weight from 148% to 193% after immersion in the tank, presumably from water absorption.

After completion of the first five trials, questions were raised regarding the observed appearance of the pulp collected. Researchers hypothesized that turbulence in the tank and/or sheer within the partially-opened butterfly valve was causing the shredded wipes to breakdown into extremely small particles. To test this hypothesis, three modified trials were conducted using intact wipes strictly from a single sample set (Sample B).

The first modified trial consisted of removing the grinder from the test tank and allowing the intact wipes to circulate in the tank for eight minutes after which time the screen was re-installed and the samples collected. The material collected on the screen had the identical appearance as the material collected in the previous five test trials.

The second modified trial involved installing the grinder and screen in the tank and collecting the wipe samples immediately after passing through the grinder. The material collected from this trial appeared as individual pieces on the screen but tended to combine into clumps or stringy masses as each piece was removed from the screen.

In the third modified trial a VFD was installed to allow for reduction in pump speed. Researchers believed that this would significantly reduce the flow velocity and consequently the turbulence in the tank, as well as allow the butterfly valve to be fully opened in an effort to reduce the amount of sheer present within the valve. The wipes were introduced into the tank and allowed to pass thought the grinder once and then circulated for additional time after the grinder was removed. Again, the material collected from this test was identical to several of the other tests resulting in a thin layer of pulp compacted tightly against the screen.

Lastly, a test trial was run in which shredded material taken from sample B was placed into a 100-gallon test pond and allowed to circulate for one hour to observe whether or not the material combined with other materials found in the sewer. To replicate the sewer environment approximately 0.5-ounce of human hair and 1.5-ounces of Crisco vegetable shortening were introduced into the test pond along with the shredded material. Additionally, an artificial catch point using a plastic tie was installed to replicate an obstruction, such as roots, that might be present in a typical sewer system. In this experiment, the shredded sample material tended to sink to the bottom and gather around the base of the catch point and in other areas where there was little to no water movement. The grease and hair tended to float on top of the water surface and was observed wrapping around the catch point. The shredded material collected showed no signs of volume reduction.

Based on observations and the data collected from the benchmark testing, researchers concluded that changes to the size and consistency of the wipes were not a result of dispersion but instead caused by turbulence from the flow velocity in the tank and from sheer present in the
partially opened butterfly valve used to regulate flow within the tank. Therefore, the benchmark testing results may not represent the actual conditions found in the majority of live sewers and the physical characteristics of the wipes observed may differ greatly from what might be expected in the more tranquil environment of a sewer. It was concluded that the research team would conduct further testing in a live sewer prior to proceeding with the live sewer tests using a grinder. The research team scheduled a series of test trials using intact wipes without grinding, which would make it easier to measure any physical changes to the wipes, as well as serve as a practice run prior to conducting live sewer testing where the wipes would be shredded.

3.3 Live Sewer Testing at Garnsey St. Sewer – Santa Ana, CA

The next set of testing trials consisted of introducing intact wipes into a live sewer located on Garnsey Street in Santa Ana. The objective of this exercise was to introduce a known quantity of five different brands of whole wipes into the sewer and then attempt to capture them at various distances downstream for observation and measurement. The wipes were dyed to assist with identifying the captured material from other similar materials present in the sewer. Each of the five sample sets contained ten wipes, which were presoaked, squeezed to remove excess water and weighed prior to introducing them into the sewer, according to a developed protocol. Sample wipes were released into the same entry manhole with capture planned for downstream manholes located at distances of 900 feet, 600 feet and 300 feet. A 10-inch diameter metal basket with ¼-inch openings covered with #18 mesh was used for material capture. The timing for placement of the basket prior to arrival of the wipe samples was approximated by using pieces of a foam cup placed into the entry manhole and then timing them as they were observed reaching the sampling manhole. The 900-foot test trial did not provide useful data as the flow was stained by a blue/grey industrial discharge that stained all of the collected material. The collected material resembled a slurry of pulp and no intact wipes were captured. The 600-foot test trial yielded similar results in terms of the collected material resembling a slurry of pulp. Again, no intact wipes were captured. The 300-foot test trial yielded similar results once again with the exception that one orange colored wipe was captured in the basket.

Analyzing the results of the live sewer testing led at first to the belief that the dye was leaving the sample wipes immediately after introduction into the sewer and the wipes were dispersing to the extent that their physical characteristics now resembled the consistency of wet toilet paper. However, the retrieval of one solitary orange wipe caused questions to be raised over the timing of the capture basket placement and opened for discussion the possibility that the remaining 49 sample wipes were not captured. After much discussion, it was hypothesized that the timing of the basket placement was incorrect and that a better method of measuring travel time in the sewer was needed. It was further agreed that an improved method of dying the wipes to prevent color loss was needed and further tests with intact wipes should be conducted to confirm that hypothesis.

3.4 Live Sewer Testing at El Sicomoro – Rancho Santa Fe, CA

To better address the questions raised in the previous live sewer testing concerning travel time estimation and dye retention, a new set of trial tests were performed using a 10-inch gravity sewer line located along El Sicomoro Street, in Rancho Santa Fe. The research team would use these test trials to observe the behavior of intact wipes in a live sewer environment for a better understanding of any changes to the physical characteristics of the wipes after immersion in the sewer and also to practice sampling techniques prior to the live testing using the grinder. The
objectives of these test trials were: 1) to confirm if the sample wipes remained dyed after immersion and transport in the sewer system, 2) to determine if the intact wipes exhibit any volume reduction after traveling through the sewer in a measured distance, and 3) to compare two methods of measuring the sewer flow velocity (using floatable foam material versus using marker dye).

Sampling was performed in a 10-inch gravity sewer line that combines with another tributary sewer line before entering the RSFWWTP, which is located 1,600 feet downstream from the entry manhole used for this test. The first trial involved dropping pieces of a foam cup into the entry manhole along with green marker dye to determine which method provides the most accurate determination of travel time in the sewer. The sampling manhole used for this test was located 260 feet downstream from the entry manhole. The results of the test indicated that the marker dye provided the more accurate method of determining flow rate, as pieces of the foam cup were never observed passing through the sampling manhole.

The second trial involved dropping intact wipes into the same entry manhole, located 260 feet upstream of the sampling manhole, and then capturing them using a 10-inch metal basket covered with a fine mesh screen. A sample set of five red-dyed wipes were dropped into the entry manhole individually and after 30 seconds, the capture basket was lowered into place in the sampling manhole. After three minutes the basket was removed and the contents evaluated. This procedure was repeated for a second sample set of orange-dyed wipes. In all, six of 10 wipes were captured completely intact and with full color retention.

The final trial was run using the former downstream sampling manhole as the new entry manhole. The new entry manhole was located 1,600 feet upstream of the RSFWWTP. A sample set of seven flushable wipes were dropped into the new entry manhole and allowed to flow in the sewer until captured at the RSFWWTP headworks. After waiting approximately 10 minutes, six of the seven wipes were found captured on the bar screen at the headworks. It is assumed the remaining wipe caught on an obstruction within the sewer line. The captured wipes were found intact and with full color retention.

The results of this testing indicate that whole (intact) wipes do not undergo any physical reduction in size after transport in a 10-inch gravity sewer with an estimated flow depth of five inches over distances of 260 feet and 1,320 feet. The testing further verified that the wipes completely maintained their dyed color, validating the previous hypothesis that 49 of 50 wipes used during the live sewer testing on Garnsey Street were not recovered, due to improper timing of the capture basket placement. It further suggests that the material collected during the Garnsey Street testing was mostly toilet paper and other background material and not the sample material used in the testing.

### 3.5 Live Sewer Testing at SPS, Bristol St./Alton Ave. – Santa Ana, CA

Prior to the beginning the next set of testing in live sewers, the testing protocol was modified to include the use of marker dye for estimating travel time in the sewer, and for the wipes to be dried with heat immediately after being dyed in order to assure better color retention. The live sewer trials were conducted at night in two phases using live sewers owned by SADPW and OCSD. The objectives of these test trials were: 1) to measure any physical changes to the shredded wipe material that may occur at various distances in a live sewer after passing through a grinder and pump combination, and 2) to assess the interaction/impacts of the shredded wipe material with other materials within the sewer line.
Traffic control was set up surrounding the SPS at 7:00 PM by the SADPW and testing began approximately one hour later. The first phase of testing involved dropping flushable wipes into an entry manhole containing a mechanical grinder and then collecting it after it had passed through the grinder, a pump and force main. Each of the five sample sets used in the tests consisted of 10 wipes from five different brands. The wipes were dyed red and orange and then presoaked, squeezed to remove excess water and weighed prior to introducing them into the sewer. An 18-inch sewer line owned by SADPW fed the grinder manhole and pump station. Due to the depth of the grinder manhole (approximately 17 feet) and because the grinder was installed against the back wall of the manhole, it was difficult to drop the wipes in front of the grinder's cutting teeth. A method was subsequently developed that consisted of placing a plastic gutter at an angle that allowed the wipes to slide down directly into the cutter teeth. A hose from a nearby vactor truck was used to flush the wipes down the gutter into the grinder. It was originally planned to place the 10-inch diameter metal capture basket in the downstream sampling manhole to collect the shredded material as it discharged from the 30-foot section of force main. However, during a pre-trial test, the basket quickly became clogged and the majority of the force main discharge escaped around the edges of the basket. The decision was quickly made to use the 24-inch tire-mounted screen that OCSD had constructed for sampling in the larger 24-inch sewer line. After another pre-trial test, the tire-mounted screen was found to capture significantly more material discharging from the force main and for a much longer period before clogging.

Phase One testing began and the tire-mounted screen was placed into the sampling manhole (SP1) one minute after the wipes were dropped into the entry manhole (EP1) and removed after three minutes. This procedure minimized the amount of background material captured by the tire-mounted screen, while assuring that all sample material had passed through the grinder, pump and force main. After two minutes into each test trial, the tire-mounted screen would begin to clog and some of the sample material would be observed passing over the edges of the screen. Besides the sample material, other background materials captured in the tire-mounted screen generally consisted of organic food waste, plastics and cloth materials, which were all placed immediately in sealed plastic containers for analysis. Each container of collected material was spread out individually onto a graduated board containing ½-inch and one-inch squares in an attempt to identify and measure the colored sample material. The sample material consisted of small pieces of shredded wipe material less than two square inches in size that were colored either red or orange, depending on the sample set used. A small amount of the captured material appeared to combine with other pieces of background material and in many cases larger clumps of the same colored sample material were found bound together. It was not possible to separate the individual pieces from the clumps without tearing. Furthermore, it was observed that much of the uncolored, non-dispersible, background material also appeared to combine with background material, including strands of hair. Weighing of the collected samples was deemed impractical, and based on observations, it is estimated that less than 5% of the total wipes used in this phase of testing were recovered.

Upon completion of the Phase One testing, Phase Two testing began. In this phase of testing, the sample wipes were introduced into the EP1 using the same procedure as in Phase One, with the exception that each of the five sample sets now contained 20 wipes instead of 10. The amount of wipes used in each set was doubled to increase the chances of capturing material, since the sampling manhole was located 2,680 feet downstream and would contain significantly more background material. The sampling point used was a manhole over the top of OCSD's 48-inch triple-barrel inverted syphon. Researchers decided to collect materials from OCSD's 24-inch
barrel using the tire-mounted capture screen. This required the remaining two barrels to be isolated from the flow using pneumatic inflatable plugs. Radio and phone communication was used by OCSD to converse with the SADPW crew that was dropping the wipes into EP1 at the grinder location. A green marker dye was employed to alert the OCSD crews when to expect arrival of the wipe samples so the tire-mounted screen could be lowered into place. The duration of the time that the tire-mounted screen remained in the channel for each sample set was varied between six minutes and 20 minutes, as the research team wanted to determine if longer exposure times translated into more sample material being caught. In analyzing the collected material from each sample set, it did not appear that the tire-mounted screen placement duration had any significant effect on the amount of material captured.

Similar to the Phase One results, all materials collected from the tire-mounted screen generally consisted of organic food waste, plastics and non-dispersible materials, which were placed immediately in sealed plastic containers for analysis. Each container of collected material was spread out one at a time onto a graduated board containing ½-inch and one-inch squares in an attempt to identify the colored sample material. The sample material consisted of small pieces of shredded wipe material less than two square inches in size, which were colored either red or orange depending on the sample set used. A small amount of the captured material appeared to combine with other pieces of background material and in many cases larger clumps of the same colored sample material were found bound together. It was not possible to separate the individual pieces from the clumps without tearing. Furthermore, it was observed that much of the uncolored, non-organic material also appeared to combine with organic material present, including strands of hair. Weighing of the collected samples was deemed impractical, and based on observations it is estimated that less than 1% of the total wipes used in this phase of testing were recovered.

3.6 Testing at RSFWWTP – Rancho Santa Fe, CA

Upon completion of the live sewer testing in Santa Ana, it was determined that additional testing should be conducted at a location that could lead to better data collection by increasing the chances of capturing more sample materials. To accomplish this, one additional controlled-environment test and one final live sewer test using pre-shredded wipes was conducted with the assistance of the RSFCSD. The objective of the testing was to observe and compare the physical characteristics of the shredded wipe material with that of single-ply toilet paper after passing through a bench-scale model constructed to simulate flow in a typical sewer line.

The bench-scale model was constructed at the RSFWWTP using a ¼-inch mesh screen placed over a five-gallon bucket (Bucket A). A second bucket with a plugged 1.5-inch orifice (Bucket B) was placed approximately 18 inches over the mesh screen. A 40-foot straight reach of 3-inch PVC pipe with a 1% slope was set up to drain approximately six inches above Bucket B. A water hose was regulated so that it would deliver a flow rate of approximately three gpm. The discharge of the pipe was placed approximately six inches above the top of the mixing chamber (Bucket A). Water was introduced into the opposite end of the pipe at a flow rate of three gpm along with the contents of a bag containing a sample of wipes that had been pre-shredded earlier at the JWCERF, using the same grinder utilized in the initial benchmark testing. Bucket B was filled up to the five gallon mark then allowed to settle for approximately 30 seconds. The plug at the bottom of Bucket B was removed and the contents were allowed to drain through the mesh screen and into Bucket A. The captured contents of the screen mesh was then weighed and recorded. Five different samples sets were used (A through E). Each of the five samples sets
consisted of wipes of a different brand. There were three trials run for each sample set. Each trial utilized a batch of five pre-dyed, shredded wipes. All samples wipes were soaked, dewatered and weighed before shredding. Four additional trials were performed using single-ply toilet paper of pre-selected amounts; one trial using 0.80 ounces of toilet paper, two trials using 0.50 ounces, and one trial using 0.30 ounces.

While conducting the test trials with each of the five sample sets, it was observed that as the contents of Bucket B, containing the sample material, fell onto the mesh screen the shredded wipe material quickly clogged the screen and caused much of the shredded material to splash off of the screen. Therefore, the resulting weight measurements proved to be unreliable because of the significant amount of material lost. This also occurred when the toilet paper was tested. However, as the toilet paper collected on the screen it continued to break apart under the force of the water and unlike the shredded wipes, it allowed the water and some material to eventually pass through the screen.

3.7 Live Sewer Testing at El Sicomoro and RSFWWTP – Rancho Santa Fe, CA

The final set of test trials was conducted in a live sewer in El Sicomoro in Rancho Santa Fe. The objective of this testing was to evaluate the behavior of wipes that had been shredded through a grinder and introduced into a live sewer without first passing through a pump, as in previous testing. The RSFCSD sewer system, which terminated at the RSFWWTP, was believed to provide a better opportunity to capture more of the sample material from the sewer line than previous tests performed in the Santa Ana sewers.

In this test, five different sample sets were used (Samples A through E). Each of the five sample sets consisted of wipes of a different brand. Each trial utilized a batch of 10 pre-dyed, pre-shredded wipes. All samples were wetted, squeezed to remove excess water and weighed prior to testing. Each shredded sample was immersed in a quart-sized container with water for ease of introducing the wipes into the flow stream. Samples were introduced into an entry manhole of the 10-inch sewer, approximately 1,320 feet upstream of the RSFWWTP and then recovered at the plant headworks using a 10-inch diameter metal basket covered with #18 mesh.

The individual pieces of material captured varied in shape and size but generally appeared as long, thin strips of material less than two inches in length and closely resembled the dry, shredded material. Although more of the sample material introduced into the sewer in this test was recovered than in previous live sewer testing at the SPS, it was observed that less than 50% of the sample material from each of the five test trials was recovered. The reasons for the unaccounted material are not known and test procedures for determining these losses were not part of this study.

3.8 Study Results

The following results were obtained from the testing conducted during the course of this investigation:

1. Whole (intact) sample wipes that were passed through the mechanical grinder, located at the SPS, were reduced in size to pieces less than two-inches in length.

2. The pulp derived from shredding the sample wipes at the SPS did not undergo any observable reduction in volume after immersion in various lengths and sizes of sewer lines.
3. It is estimated that less than 5% of the sample material introduced into the grinder and pump at the SPS was recovered in the tire-mounted screen at the discharge point of the 30-foot force main (SP1).

4. The tire-mounted screen was held in position at SP1 for a period of three minutes during each test trial to assure that all introduced material was collected, however, after two minutes the screen became plugged with material causing the contents of the screen, including the sample material, to splash over the edges of the screen.

5. The research team was not able to determine the exact causes of why such a large amount of material was not captured during each test trial. Besides the material lost due to clogging of the screen, it is speculated that some material may have dispersed or been reduced to particle sizes less than 1/4-inch and therefore passed through the 1/4-inch screen openings. Some material may have remained caught in the cutter teeth of the grinder and pump impellor.

6. It is estimated that less than 1% of the sample material introduced into the grinder and pump at the SPS was recovered in the tire-mounted screen, located at the 24-inch barrel of OCSD's 42-inch triple-barrel syphon (SP2).

7. The tire-mounted screen was held in position at SP2 for times varying from six to 20 minutes during each test trial to assure that all introduced material was collected. However, after eight minutes the screen became plugged with material causing the contents of the screen to splash over the edges of the screen.

8. Other than the material lost due to clogging of the screen, the research team was not able to determine other causes of why such a large amount of material was not captured during each test trial. It's speculated that some material may have dispersed or been reduced to particle sizes less than 1/4-inch and therefore passed through the 1/4-inch screen openings. Some material may have remained caught in the cutter teeth of the grinder and pump impellor. Some material may have also been caught on obstructions, such as roots or joints within the sewer, or deposited on the bottom of the pipe.

9. Weight measurements indicated that both the intact sample wipes and the shredded wipe material (pulp) increased in weight by as much as 193% after immersion in water or the sewer, presumably due to water absorption of the material.

10. After shredding, the resulting pulp recovered during the live sewer tests at the SPS was observed as both individual pieces and occasionally as pieces bound together into clumps along with background material from the sewer. In most cases the clumps of material included grease and strands of hair.

11. Both the intact wipes and the pulp appear to travel in the sewer at approximately the same velocity as the measured in-pipe sewer flow.

12. Flow measurement using sewer dye proved to be an accurate method of measuring flow rate in the sewer, as compared to using pieces of floatable material.

13. Screen sizes with openings of 0.0394-inch (#18 mesh) and 1/4-inch were employed throughout the study.

14. No unusual odors were detected from any of the samples collected in the live sewer tests.

15. Based on results obtained from benchmark testing within the test tank, located at the JWCERF, it appears that both intact wipes and the pulp were affected by shear associated
with passing through the pump and valve, as well as turbulence present at the discharge point of the return flow pipe. These conditions caused both the intact wipes and the shredded pulp to form a slurry that compacted tightly against the screen in a thin layer.

16. Pulp captured during live sewer testing in the El Sicomoro sewer in Rancho Santa Fe, in which pre-shredded wipes were used without passing through a pump, appear to closely match the size and shape of the original dry, pre-shredded material used in the test. Based on the small sample of pulp collected from the two live sewer tests performed at the SPS in Santa Ana, it appears that the individual pieces of shredded wipe material also match the size and shape of the pre-shredded material used in the El Sicomoro testing. The research team concludes that the sheer action encountered within the SPS pump had little or no effect on further reducing the size of the pulp.
CHAPTER 4.0

CONCLUSIONS

4.1 Study Conclusions

The primary research objective for this study was to determine the effects that pulp derived from wipes that have undergone shredding through a grinder, have on a downstream sewer system. Adverse effects that can occur when whole wipes enter the sewer system include partial or full pipe blockage, clogging of grinders, pumps and screening devices. Shredding of the wipes into smaller fragments has long been considered a means to reduce these adverse effects. The study focused on determining if there are any effects from shredded wipes such as the formation of long fragments, an agglomeration of wipe fragments, or an agglomeration of wipe fragments with FOG or other materials.

The study required significant cooperation and coordination between multiple public agencies and private partners. The field work performed was difficult and required extensive planning, especially in connection with traffic control for the live sewer portion of the testing that took place in the public streets. The testing and sampling was limited to sewer lines and did not include any sampling and testing beyond the treatment plant headworks.

The study consisted of benchmark testing and live sewer testing with whole and shredded wipes. Sample loading for the various tests was limited to a sample range of five to 10 individual wipes per test trial run. A significant amount of sample material was not recovered during the test trials, which may be attributed to inadequate collection techniques, material by-passing the collection devices, obstructions within the sewer system such as roots or joints, dispersion due to turbulence inherent in the grinder and pump, and deposition. Consequently, the amount of data collected was less than expected, resulting in the conclusions drawn to be based solely on observations and measurements performed on collected samples. In consideration of the above, the following study conclusions are presented:

♦ Overall, the research team concluded that the test procedures and subsequent results could be improved by increasing the number of tests and sample wipes employed at each test location. Doing so increases the cost and time commitment associated with the study but would provide additional data for evaluation. Sampling efficiency could be improved by utilizing a primary screen size of ½-inch in combination with a secondary screen of ¼-inch or smaller to capture material lost around the edges of the primary screen.

♦ Shredding of the wipes used in the study through a mechanical grinder reduces their size, thereby minimizing the chances of these materials catching on obstructions or causing clogging during transport within the sewer. However, the effectiveness of the grinder could be reduced if significant turbulence exists in the sewer system, as the wipes used in this study exhibit a tendency to breakdown into fiber-like slurry, which can result in the material passing through screening devices with openings > ¼-inch.
Based on a comparison of samples taken from live sewer testing at the Segerstrom PS with samples taken from live sewer testing at the Rancho Santa Fe WWTP, the shredded pulp did not appear to readily combine with other background material in the sewer unless grease and hair were present. Even when the collected pulp did combine with hair and grease it did not recombine into long stringy shapes but rather into smaller clumps less than one square inch in size.

It is not known with certainty why large amounts of the sample material were not captured during the live sewer testing. It is assumed that losses may have occurred due to the following: obstructions in the sewer, such as roots, pipe joints and sags; dispersion due to turbulence within the pump and valves in the pump station; losses around the edges of the collection devices; and due to the large amount of background material within the sewer, particularly within the longer reaches of sewer line tested.

The loss of material during the benchmark testing is easier to address. During benchmark testing at the JWCERF, the material loss was caused by severe turbulence in the test tank. Particles smaller than #18 mesh (0.0394-inch) were observed floating within the tank after the screen was removed. During benchmark testing at the RSFWWTP, the shredded pulp clogged the ¼-inch collection screen and was observed splashing from the screen onto the ground from the force of the water.

The clogging of the ¼-inch and #18 mesh (0.0394-inch) screens used in the various tests proved problematic and indicates that similar size screens used at WRRF’s may undergo similar clogging and proper screen sizing should be carefully evaluated for each installation. Typically, screens such as these are not employed in sewer systems.

No odors associated with the pulp material were observed.

4.2 Study Recommendations

The following recommendations based upon the results of this study are:

- All materials not designed for disposal via the toilet should be discouraged from flushing. The public should be educated on what is safe to flush.

- Grinders fitted with the proper size cutter teeth can effectively reduce the impact of materials not designed for disposal via the toilet on downstream sewers by reducing material size and susceptibility for catching on roots, joints and other obstructions within the sewer. If severe turbulence is present in the sewer system, the effectiveness of the grinders may be reduced for certain types of wipes or other materials that break apart due to the turbulence.

- Reduction or removal of FOG from the sewer system will reduce the occurrence of FOG combining with the pulp and other background material during transport in the sewer.

- Researchers performing similar studies should be aware that screen sizes ¼-inch and smaller, while effective at catching material, clog easily and secondary screens should be employed to minimize sample material loss during testing.

- The use of sewer dye during this study proved to be an accurate method of determining the flow rate in sewers. A simple test was devised in which the dye was introduced into an upstream manhole and then timed with a stopwatch until observed at the downstream manhole. The flow rate was later confirmed during the sampling process using the wipes.
4.3 Further Investigations

Questions raised during the course of this research project have led to the following proposed areas of study that have the potential for further investigation:

- The transformation of pulp to slurry, as observed on the screen during benchmark testing at the JWCERF, was caused by turbulence and agitation within the test tank. It is not known if this condition could lead to problems downstream at WRRFs. Further investigation is needed that focuses on the headworks, internal treatment processes and solids removal equipment.

- Further information is needed about the impact of pulp loading on downstream sewers from other materials that are not designed for disposal via toilet, such as: paper towels, napkins, feminine hygiene products, dental floss, rags, cleaning cloths, etc.

- This study was unable to determine whether or not deposition from shredded pulp occurred within the sewer. Further investigation should be conducted using closed circuit television camera equipment and cleaning devices, such as a pig.

- Proper screen sizing plays an important role in protecting WRRF equipment and processes and could be the basis of further study involving the determination of appropriate size of screen openings based on the proliferation of materials not designed for disposal via toilet in sewer systems.

- A study could be conducted to evaluate the size fractionation of total suspended solids (TSS) for a sewer system over a period of time with and without a grinder to evaluate the impact of the grinder on the wastewater characteristics.
APPENDIX A

LABELING OF NON-FLUSHABLE PRODUCTS
August 20, 2012

Mr. Richard DiCerchio
Senior Executive Vice-President, COO
Costco Wholesale Corporation
999 Lake Drive
Issaquah, WA 98027

Subject: Labeling of Non-Flushable Products

Dear Mr. DiCerchio,

The undersigned California clean water associations, otherwise referred to as the Clean Water Summit Partners, is a coalition of statewide and regional organizations representing local public agencies engaged in providing clean water services to their communities. Included in the Clean Water Summit Partners are the California Association of Sanitation Agencies (CASA); the Bay Area Clean Water Agencies (BACWA); the Central Valley Clean Water Association (CVCWA), the Southern California Alliance of Publicly Owned Treatment Works (SCAP), whose collective members serve over 90 percent of the sewered population of California, and the California Water Environment Association (CWEA) that includes over 9,000 individual members working in the water quality field within the State of California. Tri-TAC (www.tritac.org) also endorses the Clean Water Summit Partners position.

We wish to thank you for allowing regional representatives led by the City of Kirkland and members of the following referenced national wastewater associations to meet with Costco staff on July 10 to discuss our wastewater industry’s concerns over the labeling of products as “flushable.” The purpose of this letter is to add the Clean Water Summit Partners support to the efforts of the American Public Works Association (APWA), the Water Environment Federation (WEF) and the National Association of Clean Water Agencies (NACWA) to address the problems encountered in our publicly owned wastewater collection and treatment systems as a result of disposal of items claiming to be “flushable” that do not rapidly disperse in the sewer system.

The labeling of products as “flushable” creates a mixed message to consumers. We believe that many products carrying this label do not disperse rapidly enough in the sewer system to prevent problems. As the fifth largest retailer in the United States and as a corporation committed to sustainability, Costco is perfectly positioned to “lead by example” (Costco Corporate Sustainability Report, p.11, 2009) by considering our wastewater industry’s request to modify packaging of your Kirkland Brand products to remove the term “flushable” and to undertake a simple consumer education campaign to inform customers of the problems associated with flushing any products other than toilet tissue.
We sincerely appreciate Costco’s consideration and the time Kim Wailor and her team gave to our wastewater industry’s request for collaboration in this effort to solve this problem.

Sincerely,

James Kelly, Executive Director
Bay Area Clean Water Agencies

Roberta Larson, Executive Director
California Association of Sanitation Agencies

Debbie Webster, Executive Officer
Central Valley Clean Water Association

Cc: Kim Wailor, Costco
    Bobbi Wallace, City of Kirkland, WA
    Karen Raines, Director of Corporate Sustainability, Costco
    Cynthia Finley, Director of Regulatory Affairs, NACWA
    Jeff A. Eger, Executive Director, WEF
    Peter B. King, Executive Director, APWA
    Nick Arhontes, Orange County Sanitation District

Carrie Mattingly, President
California Water Environment Association

John Pastore, Executive Director
Southern California Alliance of POTWs
APPENDIX B

NON-DISPERSIBLES INCIDENT REPORT SUMMARY
Non-Dispersibles Incident Report Summary

SCAP developed the attached Non-Dispersibles Incident Report to create a national database of information relative to incidents involving clogging of sewers, pumps and screens within sewerage systems owned and operated by public agencies. The report template is available in electronic version or can be filled by hand.

For the period of February 1, 2013 through February 28, 2014, nine public agencies from five different states have submitted 29 separate incident reports associated with clogging of pumps or screens caused by non-dispersible materials. Agencies from the following states submitted these reports incident reports attesting to the severity and extent of this problem: California, Connecticut, Idaho, Oregon and Washington.

The 29 reports submitted documented the occurrence of 14 incidents attributed to non-dispersible materials in gravity sewers; 20 incidents at pump stations; and 3 incidents at water resource recovery facilities.

The information contained in the reports was obtained by SCAP in confidentiality and cannot be released without the written consent of the contributing agencies.

By John Pastore, Executive Director

Date 4-13-15
**NON-DISPERSIBLES INCIDENT REPORT**

Date of this Incident: **YYYY/MM/DD**

<table>
<thead>
<tr>
<th>CITY OR AGENCY NAME:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Click here to enter City or Agency name.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FACILITY NAME:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Click here to enter facility name.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FACILITY LOCATION:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(If this is a security issue please provide as much information as your policy allows)</td>
</tr>
<tr>
<td>STREET NUMBER</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Click here to enter St. No.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CITY/SUBURB ZIP CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Click here to enter City.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FACILITY TYPE WHERE THIS INCIDENT OCCURRED?</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Gravity Sewer</td>
</tr>
<tr>
<td>☐ Wastewater Treatment or Reclamation Plant (WWTP)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DESCRIPTION OF THIS INCIDENT *:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Click here to enter description.</td>
</tr>
</tbody>
</table>

* Was this a blockage, unplanned corrective maintenance CM task, planned/routine PM task to minimize blockages and/or ensure reliability, was equipment damaged such as a pump motor, etc.? Include quantity and types of materials found. Identify materials by name brand or distinguishing features if possible. If at a pump or lift station, were other components such as valves or piping clogged, wetwell cleaning needed? Describe the incident as best you can.
**NON-DISPERSIBLES INCIDENT REPORT**

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were photos taken of the non-dispersible debris mass?</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>If yes, attach photos.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Were samples of materials in the debris mass taken, sorted, cleaned,</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>and photographed for follow up identification and use?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ACTION TAKEN TO REMEDY THIS INCIDENT:**

- Click here to enter remedy.
- If known at this time, describe any added changes or capital improvements to the facility you might be planning to prevent recurrence:
  - Click here to enter text.

**Describing this incident please provide estimates of:**

- Staff Labor Hours Used Including Travel Time: Click here to enter text.
- Contractor Hours Used If Any: Click here to enter text.
- Equipment Used: Click here to enter text.

- Estimated Total Labor Cost ($): Click here to enter text.
- Estimated Total Equipment Cost ($): Click here to enter text.
- Estimated Cost of Damage if Equipment or Components Needed Replacement:
  - Click here to enter text.
- Total Estimated Cost of this Incident ($): Click here to enter text.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did the incident cause a sewage spill?</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>If yes, provide estimated volume of spill as also provided to CIWQS in CA.:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Click here to enter number. Gallons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**NON-DISPERSIBLES INCIDENT REPORT**

Additional comments or information you have that you feel is important to provide that was not provided in the fields above?
Click here to enter text.

Contact Name and Phone Number or Email Address for SCAP follow up?
Click here to enter text.

Upon completion, please email or fax report form and any supporting documentation to John Pastore, Executive Director, SCAP at jpastore@scapl.org; fax # 760-479-4881.

www.scapl.org
APPENDIX C

CITY OF SANTA ANA
DEPARTMENT OF PUBLIC WORKS
SEGERSTROM PUMP STATION MAINTENANCE LOGS
<table>
<thead>
<tr>
<th>DATE</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/7/2006</td>
<td>Changed oil on both pumps</td>
</tr>
<tr>
<td>9/19/2006</td>
<td>Repairs have been made to the electronic circuits that have caused failures in the past. As a result, the intrusion alarm is back in service.</td>
</tr>
<tr>
<td>9/20/2006</td>
<td>Cleaned out the check valve on the South pump</td>
</tr>
<tr>
<td>9/21/2006</td>
<td>Converted the bubbler pump #1 to the Esco pump</td>
</tr>
<tr>
<td>12/15/2006</td>
<td>Air Release valve on south pump has been re-built</td>
</tr>
<tr>
<td>2/1/2007</td>
<td>O.C. pump pulled the south pump to rebuild it.</td>
</tr>
<tr>
<td>2/8/2007</td>
<td>Cleaned the check valve of the south pump. Craig rebuilt the air release valve of the north pump</td>
</tr>
<tr>
<td>2/22/2007</td>
<td>O.C. Pump worked on the north check valve exterior lever &amp; shaft ass'y. Is loose from the flapper. Key way eroded away. They replaced the key and tightened the set screws.</td>
</tr>
<tr>
<td>4/6/2007</td>
<td>Settings Lead Off 2.2 on 3.6 Lag Off 3.0 on 4.0</td>
</tr>
<tr>
<td>12/14/2007</td>
<td>Cleaned check valve &amp; impeller - S. Pump</td>
</tr>
<tr>
<td>12/17/2007</td>
<td>Cleaned ck valve &amp; impeller - N. pump</td>
</tr>
<tr>
<td>12/26/2007</td>
<td>N pump not pumping ?</td>
</tr>
<tr>
<td>4/28/2008</td>
<td>Reported hi level alarm 2 times over weekend. Found #1 failed (overload/ over heat) due to loss of primer - was running empty then tripped. Reset, flushed air relief</td>
</tr>
<tr>
<td>10/31/2008</td>
<td>Cleaned #1 check valves and air release (flushed)</td>
</tr>
<tr>
<td>2/11/2009</td>
<td>Cleaned and inspeced check valve at south pump. Also oil change and general pump inspection.</td>
</tr>
<tr>
<td>2/20/2009</td>
<td>Elliot cleaned and inspected the n. pump assembly.</td>
</tr>
<tr>
<td>2/20/2009</td>
<td>Changed the oil in the n. pump.</td>
</tr>
<tr>
<td>7/1/2009</td>
<td>Cleaned &amp; inspected the n. pump</td>
</tr>
<tr>
<td>7/9/2009</td>
<td>Cleaned &amp; inspected the s. pump and inspected the elect. Connections at the motors</td>
</tr>
<tr>
<td>8/31/2009</td>
<td>Ck PAIC over weekend per JG - checked okay</td>
</tr>
<tr>
<td>9/17/2009</td>
<td>N. pump #2 impellers and check valve cleaned.</td>
</tr>
<tr>
<td>10/15/2009</td>
<td>Cleaned seq H/check valve &amp; impeller. Changed oil south #1 also</td>
</tr>
<tr>
<td>12/1/2009</td>
<td>High level alarm &quot;North Pump&quot; Fall, Loss of prime. Need to be cleaned out</td>
</tr>
<tr>
<td>12/1/2009</td>
<td>Checked pump - check valve. It was in closed position. Removed dry</td>
</tr>
</tbody>
</table>

Assessing the Impacts of Pulp Loading from Non-Dispersible Materials on Downstream Sewer Systems  
C-2
<table>
<thead>
<tr>
<th>DATE</th>
<th>NOTE</th>
<th>Indicates Ragging</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/10/2010</td>
<td>Time: 4:43pm - North pump not pumping - clogged. Setting for munifer co.0 425 0 02 20.9 LEL 0</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>Out time 5:06 pm - cleaned pumps setting for munifer co.0 H25 0 02 21.1 LEL 0</td>
<td></td>
</tr>
<tr>
<td>2/17/2010</td>
<td>Booster #1 - Cleaned check valve, pump housing</td>
<td>Ragging</td>
</tr>
<tr>
<td>4/15/2010</td>
<td>Changed oil in #2 pump. 8:15 pm changed terminal 46 wires to terminal 43 and disconnect terminal</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>wire from 43. The scope was to make lead pump run on full speed, since VFD was bad, removed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F3 fuses for the VFD and store them inside cabinet. Pump #1 will remain in lead.</td>
<td></td>
</tr>
<tr>
<td>5/9/2010</td>
<td>Pump #2 - North; Rehabilitated - OC Pumps</td>
<td>Ragging</td>
</tr>
<tr>
<td>5/29/2010</td>
<td>Pump #1 - South: cleaned up homiye, propellers and checks</td>
<td>Ragging</td>
</tr>
<tr>
<td>8/30/2010</td>
<td>checked Seal cavity oil in s. pump</td>
<td>Ragging</td>
</tr>
<tr>
<td>9/13/2010</td>
<td>Cleaned impeller, again</td>
<td>Ragging</td>
</tr>
<tr>
<td>9/14/2010</td>
<td>Hi level alarm - cleaned north and south lift pumps. Full of debris, rags and clothes. Ran</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>system - all okay</td>
<td></td>
</tr>
<tr>
<td>9/17/2010</td>
<td>Hi level alarm - cleaned north and south lift pumps. Full of debris, rags and clothes. Ran</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>system - all okay</td>
<td></td>
</tr>
<tr>
<td>9/20/2010</td>
<td>8:30 - High level alarm on SCADA found #2 lead VFD, bring prime, #1 coming on and off on tag</td>
<td>Ragging</td>
</tr>
<tr>
<td>9/21/2010</td>
<td>Hi level alarm - cleaned north and south lift pumps. Full of debris, rags and clothes. Ran</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>system - all okay</td>
<td></td>
</tr>
<tr>
<td>9/23/2010</td>
<td>Hi level alarm - cleaned north and south lift pumps. Full of debris, rags and clothes. Ran</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>system - all okay</td>
<td></td>
</tr>
<tr>
<td>9/25/2010</td>
<td>Hi level alarm - cleaned north and south lift pumps. Full of rags, debris and clothes. Also</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>removed and repaired sump pump. Ran system - okay</td>
<td></td>
</tr>
<tr>
<td>10/28/2010</td>
<td>VFD Failed @16:12 on &quot;Motor over temp&quot; reset the fault, start the VFD and it failed again on</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>overload two times. Reset again and is working ok. Cleaned pump #2 (north) from rags</td>
<td></td>
</tr>
<tr>
<td>11/1/2010</td>
<td>N Pump was clogged. Cleaned up and placed back in service</td>
<td>Ragging</td>
</tr>
<tr>
<td>11/3/2010</td>
<td>N. Pump was clogged. Cleaned up. Inspected S. Pump and cleaned up</td>
<td>Ragging</td>
</tr>
<tr>
<td>11/7/2010</td>
<td>N. pump not pumping - CLOGGED time: 4:40 Setting for munifer co0 H25 0, 02-20-9, level 0 Out</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>time: 5:00pm - setting for munifer co 0 H25-0, 02-20.9 LEL 0</td>
<td></td>
</tr>
<tr>
<td>11/19/2010</td>
<td>Time: 6:50 pm North pump not pumping, clogged. South pump not running properly. Cleaned both</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>pumps</td>
<td></td>
</tr>
</tbody>
</table>

Assessing the Impacts of Pulp Loading from Non-Dispersible Materials on Downstream Sewer Systems

C-3
<table>
<thead>
<tr>
<th>DATE</th>
<th>TASK</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/25/2010</td>
<td>Time: 2:30 pm North pump clogged, clean pump out back to normal pump 1 on lead CO. 0 H25002 21.7 LEL 0</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/5/2010</td>
<td>North sewer pump and south sewer pump; checked both pumps for cloggage of debris and trash. Ran System - all okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/8/2010</td>
<td>North sewer pump clogged of debris and trash; cleaned out; ran system - all okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/11/2010</td>
<td>North sewer pump clogged of degris and trash cleaned out. Ran System - All okay.</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/14/2010</td>
<td>North sewer pump clogged of debris and trash; cleaned out; ran system - All okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/18/2010</td>
<td>North sewer lift pump clogged of debris, trash and rags - cleaned out; Ran system and all okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/22/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags - cleaned out; ran system and all okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/24/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags; cleaned out; ran system and all okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/27/2011</td>
<td>North pump clogged; cleaned up and ran system; Both pumps are okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/30/2011</td>
<td>Clean up both pumps; check valves and air release valve</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/31/2011</td>
<td>Clean and N. Pump of rags and trash; Pump back in service</td>
<td>Ragging</td>
</tr>
<tr>
<td>1/3/2011</td>
<td>Clean S. pump of rags, trash and debris; Ran system and all okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>1/4/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags; cleaned out; ran system and all okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>1/6/2011</td>
<td>Elliott cleaned the North pump of excessive fabric debris. I modified the high H20 level (from 4.0/4.4) to 4.2/4/5</td>
<td>Ragging</td>
</tr>
<tr>
<td>1/8/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags. Cleaned out and ran system and all okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>1/14/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags; cleaned out and ran system - all okay Checked S pump and found very little debris, trash and rags</td>
<td>Ragging</td>
</tr>
<tr>
<td>1/19/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags. Cleaned out; ran system - all okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>1/22/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags; cleaned out and ran system - All Okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>1/24/2011</td>
<td>South pump clogged of debris, trash and rags. Cleaned out; ran system -</td>
<td>Ragging</td>
</tr>
<tr>
<td>DATE</td>
<td>TASK</td>
<td>NOTE</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>1/27/2011</td>
<td>Both north and south sewer lift pumps clogged of debris, trash and rags - Cleaned out; ran system - all okay.</td>
<td></td>
</tr>
<tr>
<td>1/29/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags. Cleaned out; ran system - all okay</td>
<td></td>
</tr>
<tr>
<td>2/4/2011</td>
<td>Cleaned north pump from rags</td>
<td></td>
</tr>
<tr>
<td>2/8/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags. Cleaned out; ran system - all okay</td>
<td></td>
</tr>
<tr>
<td>2/12/2011</td>
<td>Cleaned south pump - Rags in inlet</td>
<td>13:30 - Cleaned north pump</td>
</tr>
<tr>
<td>2/13/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags. Cleaned out; ran system - all okay</td>
<td></td>
</tr>
<tr>
<td>2/16/2011</td>
<td>North sewer lift pump clogged of debris, trash and rags. Cleaned out; ran system - all okay</td>
<td></td>
</tr>
<tr>
<td>2/21/2011</td>
<td>North pump clogged. Cleaned up - system okay</td>
<td></td>
</tr>
<tr>
<td>2/23/2011</td>
<td>Cleaned north pump of rags</td>
<td></td>
</tr>
<tr>
<td>2/26/2011</td>
<td>Cleaned north pump. Clogged system back to normal</td>
<td></td>
</tr>
<tr>
<td>3/1/2011</td>
<td>Cleaned south and north pumps</td>
<td></td>
</tr>
<tr>
<td>3/2/2011</td>
<td>North pump clogged. Cleaned out and back to normal</td>
<td></td>
</tr>
<tr>
<td>3/3/2011</td>
<td>Cleaned north and south pumps</td>
<td></td>
</tr>
<tr>
<td>3/5/2011</td>
<td>Cleaned north pump - clogged. Pump station back to normal</td>
<td></td>
</tr>
<tr>
<td>3/8/2011</td>
<td>Cleaned north pump - system back to normal</td>
<td></td>
</tr>
<tr>
<td>3/11/2011</td>
<td>North pump clogged of debris, trash and rags. Cleaned out and ran system. Also cleaned out sump pump screen and inlet. Cleaned south pump also.</td>
<td></td>
</tr>
<tr>
<td>3/14/2011</td>
<td>10:30 - Found north pump holding 3.8' at 1525 rpm &amp; 85%</td>
<td>South pump (#1) holding 3.3' at 1538 rpm &amp; 75% 19A</td>
</tr>
<tr>
<td></td>
<td>North pump reads after cleaning 2.6' 1250 rpm 16A</td>
<td>Cleaned south pump</td>
</tr>
<tr>
<td></td>
<td>South pump reads 12.8' 1248 rpm 17.0%, 65.5%</td>
<td></td>
</tr>
<tr>
<td>3/17/2011</td>
<td>Cleaned north pump</td>
<td></td>
</tr>
<tr>
<td>3/19/2011</td>
<td>Cleaned south pump./ 17.8 amp, 58.2 1248 rpm / with level @ 2.5 after clean up</td>
<td></td>
</tr>
<tr>
<td>3/21/2011</td>
<td>13:00 - #2 - 4.0' 1624 rpm, 24A, 91% (invfd mode)</td>
<td>#1 12.7' 1248 rpm, 17.6A 65% invfd mode</td>
</tr>
<tr>
<td></td>
<td>Rainy Day</td>
<td>Cleaned north pump #2 VFD, 2.9' 1248 rpm</td>
</tr>
<tr>
<td>DATE</td>
<td>TASK</td>
<td>Indicates Ragging</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>3/23/2011</td>
<td>North pump clogged - 4.0', 1616 rpm, 23A, 91%</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>2.8', 1249 rpm 16.7 A 64.7%</td>
<td></td>
</tr>
<tr>
<td>3/26/2011</td>
<td>#1 VFD 1605 rpm 12A, 92%, 3.9'</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>#2 VFD 3.2', 1340 rpm, 19A, 75%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#1 VFD after cleaning 1380 rpm 19 A, 77&quot;, 3.3'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#2 VFD after cleaning 1414 rpm, 17.7 A, 80%, 3.5'</td>
<td></td>
</tr>
<tr>
<td>3/28/2011</td>
<td>2:00PM #2 VFD 5.9' 15% rpm, 22.1 % 84%</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>Cleaned out the north pump. Post cleaning the amps were 16.1; at 1250 rpm level was 3.1</td>
<td></td>
</tr>
<tr>
<td>3/29/2011</td>
<td>1150 #2 pump okay, #1VRD&quot; 3/6' 1465 rpm, 20.5A, 82%</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>#1 VFD after cleaning; 2.8' 1248 rpm 17A, 68%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1330 Elliot cleaned north and south pumps</td>
<td></td>
</tr>
<tr>
<td>3/31/2011</td>
<td>20:35 cleaned out the south pump</td>
<td>Ragging</td>
</tr>
<tr>
<td>4/2/2011</td>
<td>11:15 cleaned out the south pump again</td>
<td>Ragging</td>
</tr>
<tr>
<td>4/3/2011</td>
<td>Cleaned out both pumps</td>
<td>Ragging</td>
</tr>
<tr>
<td>4/4/2011</td>
<td>EV cleaned north pump. Tested north and south pump</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>#1 VFD 1300 rpm 19.5A 74.4%</td>
<td></td>
</tr>
<tr>
<td>4/7/2011</td>
<td>12:18 #1 VFD 1463 rpm, 22A, 8.2%, 3.6'</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>Noisy when in &quot;load&quot;. Needs cleaning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13:20 - #2 VFD 1389 rpm, 19A, 77%, 3.3'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EV clean south pump 1248rpm, 18A, 67%, 29'</td>
<td></td>
</tr>
<tr>
<td>4/9/2011</td>
<td>North pump clogged. Clean up and set back to normal</td>
<td>Ragging</td>
</tr>
<tr>
<td>4/12/2011</td>
<td>OCP Removed rear shims &amp; brought forward. The impal to 0.03: for the north pump</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The south pump 0.02&quot;. Tested &amp; pumps were okay</td>
<td></td>
</tr>
<tr>
<td>4/13/2011</td>
<td>Cleaned north pump 1620 rpm 23A 91% 4.0'</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>After: 1249 rpm 17A 56%, 2.4'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#1 (south pump) 1248 rpm 17A 64% 2.7'</td>
<td></td>
</tr>
<tr>
<td>4/15/2011</td>
<td>Cleaned north lift pump of all debris, trash, rags. Ran system - okay</td>
<td>Ragging</td>
</tr>
<tr>
<td>4/23/2011</td>
<td>Cleaned out the north pump</td>
<td>Ragging</td>
</tr>
<tr>
<td>4/27/2011</td>
<td>Cleaned out the north lift pump of all trash &amp; debris</td>
<td>Ragging</td>
</tr>
<tr>
<td>4/29/2011</td>
<td>Cleaned out north lift pump of all trash and debris</td>
<td>Ragging</td>
</tr>
<tr>
<td>5/1/2011</td>
<td>Cleaned out north lift pump of all trash &amp; debris</td>
<td>Ragging</td>
</tr>
<tr>
<td>5/2/2011</td>
<td>Cleaned out north lift pump of all trash and debris</td>
<td>Ragging</td>
</tr>
<tr>
<td>5/5/2011</td>
<td>Cleaned out north pump - clogged with rags. Got system back to normal</td>
<td>Ragging</td>
</tr>
<tr>
<td>DATE</td>
<td>NOTE</td>
<td>Indicates Ragging</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>5/7/2011</td>
<td>Cleaned out north pump - clogged. Got back to normal</td>
<td>Ragging</td>
</tr>
<tr>
<td>5/10/2011</td>
<td>Cleaned out north and south lift pumps of all debris, trash and rags</td>
<td>Ragging</td>
</tr>
<tr>
<td>5/13/2011</td>
<td>Cleaned north pump</td>
<td>Ragging</td>
</tr>
<tr>
<td>5/24/2011</td>
<td>Cleaned out south pump - getting back to normal with south pump on lead</td>
<td>Ragging</td>
</tr>
<tr>
<td>5/29/2011</td>
<td>Cleaned out south pump. Both pumps back in service.</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/1/2011</td>
<td>Cleaned out south lift pump top check valve and inlet impeller of rags, trash and debris</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/2/2011</td>
<td>Cleaned out south lift pump due to surge detected by Smart Covers, per Mike M.</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/5/2011</td>
<td>Cleaned out north pump, clogged. System running with VFD's on auto. Clean and set back to normal</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/7/2011</td>
<td>Clean out north pump clogged. System back to normal</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/10/2011</td>
<td>Clean North pump (clogged)</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/14/2011</td>
<td>Cleaned out north lift pump of all rags, trash and debris</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/18/2011</td>
<td>Cleaned out north pump (rags and trash)</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>Cleaned out north pump (rags and trash)</td>
<td></td>
</tr>
<tr>
<td>6/22/2011</td>
<td>Cleaned out the north pump</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/26/2011</td>
<td>Cleaned the south pump</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/29/2011</td>
<td>Cleaned out north lift pump of all trash, debris and rags</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/30/2011</td>
<td>Cleaned out both lift pumps - check valves</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>Changed brg oil in both lift pumps</td>
<td></td>
</tr>
<tr>
<td>6/30/2011</td>
<td>Cleaned north lift pump of all trash, rags and debris</td>
<td>Ragging</td>
</tr>
<tr>
<td>7/2/2011</td>
<td>Cleaned out pump number 2 lift station</td>
<td>Ragging</td>
</tr>
<tr>
<td>7/5/2011</td>
<td>Cleaned out north pump #2; charged, clean and set back to normal</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>Changed, clear and set back to normal</td>
<td></td>
</tr>
<tr>
<td>7/7/2011</td>
<td>Removed and replaced both pump air release valves. Did maintenance and new gaskets and diaphrags ? and seals</td>
<td>Ragging</td>
</tr>
<tr>
<td>7/19/2011</td>
<td>Cleaned out north pump of all trash, rags and debris</td>
<td>Ragging</td>
</tr>
<tr>
<td>7/21/2011</td>
<td>Cleaned out the north pump</td>
<td>Ragging</td>
</tr>
<tr>
<td>7/23/2011</td>
<td>Cleaned out the north pump</td>
<td>Ragging</td>
</tr>
<tr>
<td>7/25/2011</td>
<td>Cleaned out rags from the north pump again</td>
<td>Ragging</td>
</tr>
<tr>
<td>DATE</td>
<td>TASK</td>
<td>NOTE</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>7/28/2011</td>
<td>Cleaned out north lift pump of all rags, trash &amp; debris</td>
<td></td>
</tr>
<tr>
<td>7/30/2011</td>
<td>Cleaned north pump - clogged.</td>
<td>Clean out - system back to normal</td>
</tr>
<tr>
<td>8/1/2011</td>
<td>Cleaned north pump #2 - clogged</td>
<td>Cleaned and back to normal</td>
</tr>
<tr>
<td>8/3/2011</td>
<td>Cleaned north pump #2</td>
<td></td>
</tr>
<tr>
<td>8/5/2011</td>
<td>Cleaned north lift pump of all rags, trash and debris</td>
<td></td>
</tr>
<tr>
<td>8/8/2011</td>
<td>Cleaned out north pump - clogged. Set back to normal</td>
<td></td>
</tr>
<tr>
<td>8/13/2011</td>
<td>Cleaned out the north pump</td>
<td></td>
</tr>
<tr>
<td>8/16/2011</td>
<td>Cleaned out the north pump of all debris, trash and rags</td>
<td></td>
</tr>
<tr>
<td>8/18/2011</td>
<td>Cleaned out north pump of all debris, trash and rags</td>
<td></td>
</tr>
<tr>
<td>8/22/2011</td>
<td>Cleaned out the north pump</td>
<td></td>
</tr>
<tr>
<td>8/25/2011</td>
<td>Cleaned north pump. Checked valve and pump. Set back to normal</td>
<td>Cleaned upper check valves</td>
</tr>
<tr>
<td>8/27/2011</td>
<td>Cleaned north pump - clogged.</td>
<td>Cleaned and set back to normal</td>
</tr>
<tr>
<td>8/31/2011</td>
<td>Cleaned out north pump. Cleaned and set back to normal</td>
<td></td>
</tr>
<tr>
<td>9/1/2011</td>
<td>VPD Fault 9 shot over temp</td>
<td>Cleaned out pump #2 the north pump and set back to normal.</td>
</tr>
<tr>
<td></td>
<td>Removed and replaced lower check valve. hydraulics</td>
<td></td>
</tr>
<tr>
<td>9/5/2011</td>
<td>Cleaned out north pump - clogged. Adjust impeller-remove, change oil-set</td>
<td>back to normal</td>
</tr>
<tr>
<td>9/6/2011</td>
<td>Changed oil in both sewer lift pumps. Cleaned and checked both lower check valves</td>
<td></td>
</tr>
<tr>
<td>9/8/2011</td>
<td>Cleaned south pump - upper and lower chuck valves</td>
<td></td>
</tr>
<tr>
<td>9/13/2011</td>
<td>Cleaned out north lift pump of all debris, trash and rags</td>
<td></td>
</tr>
<tr>
<td>9/17/2011</td>
<td>Cleaned out the north pump (rags and pads)</td>
<td></td>
</tr>
<tr>
<td>9/19/2011</td>
<td>Cleaned north lift pump of all debris, trash and rags</td>
<td></td>
</tr>
<tr>
<td>9/21/2011</td>
<td>Cleaned north pump - clogged with rags</td>
<td></td>
</tr>
<tr>
<td>9/24/2011</td>
<td>Cleaned out pump #2 (north) - trash and rags</td>
<td></td>
</tr>
<tr>
<td>9/26/2011</td>
<td>Cleaned out north pump - clogged. Check out and set back to normal</td>
<td></td>
</tr>
<tr>
<td>9/29/2011</td>
<td>Cleaned out north pump - clogged with rags. Set back to normal</td>
<td></td>
</tr>
<tr>
<td>DATE</td>
<td>TASK</td>
<td>NOTE</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>10/1/2011</td>
<td>Cleaned out north pump. Set back to normal</td>
<td></td>
</tr>
<tr>
<td>10/3/2011</td>
<td>Cleaned out north pump and set back to normal</td>
<td></td>
</tr>
<tr>
<td>10/7/2011</td>
<td>Cleaned out north lift pump of all debris, trash and rags</td>
<td></td>
</tr>
<tr>
<td>10/7/2011</td>
<td>Cleaned out all four check valves - top &amp; bottom</td>
<td></td>
</tr>
<tr>
<td>10/8/2011</td>
<td>Cleaned out pump #2 north</td>
<td></td>
</tr>
<tr>
<td>10/10/2011</td>
<td>Cleaned out pump #2 north</td>
<td></td>
</tr>
<tr>
<td>10/11/2011</td>
<td>Emergency generator serviced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Engine oil &amp; filter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>control panel wires and engine block heater serviced. To be replaced.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fan belt checked</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Battery voltage checked</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Work performed by sweinhart Electric Co. Buena Park</td>
<td></td>
</tr>
<tr>
<td>10/11/2011</td>
<td>Cleaned out lift pumps of all debris, trash and rags</td>
<td></td>
</tr>
<tr>
<td>10/14/2011</td>
<td>Clean out north and south pumps</td>
<td></td>
</tr>
<tr>
<td>10/16/2011</td>
<td>Clean out north pump</td>
<td></td>
</tr>
<tr>
<td>10/18/2011</td>
<td>Muffin Monster start up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grinder ampere at start up. L1 = 4.2 amps; L2 = 4.7 amps; L3 = 4.6 amps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L2 amps = T1; 3.7 amps = T2; 4.0 amps = T3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current reading measured by: John Kalls 9:30am 10/18/11</td>
<td></td>
</tr>
<tr>
<td>11/23/2011</td>
<td>Normal maintenance done to north &amp; south sewer lift pumps:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cleaned all check valves - top and bottom</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cleaned both air release valves</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Changed bearing oils</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Checked belt tension and seal - good condition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sump pump works properly</td>
<td></td>
</tr>
<tr>
<td>1/14/2012</td>
<td>3:15pm VRD failed. Ovtemp fault #9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MOT? - Reset and placed pump #1 on lead. Back to normal.</td>
<td></td>
</tr>
<tr>
<td>1/25/2012</td>
<td>Performed 3-month scheduled maintenance on muffin monster. Grease and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inspect unit. We use the big crane to lift up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Also cleaned and inspected the north check valve</td>
<td></td>
</tr>
<tr>
<td>1/13/2012</td>
<td>Set points:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lead</td>
<td>Lag</td>
</tr>
<tr>
<td>2/27/2012</td>
<td>Cleaned and inspected both pumps and both check valves. Found the air</td>
<td></td>
</tr>
<tr>
<td></td>
<td>release valve for the north pump stuck in the closed position. Cleaned</td>
<td></td>
</tr>
<tr>
<td></td>
<td>it out and got it working again. (this malfunction may have been the root</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cause behind why the pump was performing poorly this weekend. ie; the pump might have lost prime)</td>
<td></td>
</tr>
<tr>
<td>3/3/2012</td>
<td>Emergency generator run - call out</td>
<td></td>
</tr>
</tbody>
</table>
### TASK

<table>
<thead>
<tr>
<th>DATE</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/15/2012</td>
<td>Arrived at site. Inspected generator, control panel and lift station levels. All running properly</td>
</tr>
<tr>
<td>4/4/2012</td>
<td>Changed the battery and the filter on emergency generator</td>
</tr>
<tr>
<td>4/4/2012</td>
<td>Installation of the &quot;smart lit&quot; device</td>
</tr>
<tr>
<td></td>
<td>Level indicator by the display</td>
</tr>
<tr>
<td></td>
<td>ft. down</td>
</tr>
<tr>
<td></td>
<td>pumps are maintaining 2.5'</td>
</tr>
<tr>
<td></td>
<td>14.5'</td>
</tr>
<tr>
<td></td>
<td>&quot;High H20 level&quot; is set at 4.4</td>
</tr>
<tr>
<td></td>
<td>= 12.5'</td>
</tr>
<tr>
<td></td>
<td>Therefore the &quot;smart lid level is set at 10.5'</td>
</tr>
<tr>
<td>4/16/2012</td>
<td>Generator: 12 month service</td>
</tr>
<tr>
<td></td>
<td>Replaced burned wires and board</td>
</tr>
<tr>
<td>5/9/2012</td>
<td>Ran the generator under a load &quot;D&quot;</td>
</tr>
<tr>
<td>5/29/2012</td>
<td>Debris was lodged between the impeller and the body of the pump in the north pump. Paul increased the space between the impeller and the body using washers as shims. This free'd the debris. However, the pump is now very inefficient. We need to go __________ a few different size shims and replace the washers. Until then, leave the south pump in the lead. Also checked the belts, corrected the alignment of the pullies and change the seal cavity and the bearing oil.</td>
</tr>
<tr>
<td>6/8/2012</td>
<td>Removed the temporary shims and replaced them with thinner shims (north pump). The north pump now maintains a level of 2.8 ft drawing 15.2 a at 1170 rpm</td>
</tr>
<tr>
<td>6/19/2012</td>
<td>Repaired the check valve downstream of the south pump. The key holding the flapper assembly to the shaft had rotted away. Therefore we disassembled, cleaned and repaired and reassembled the check valve. Also: - Inspected the impeller - change the bearing oil and the oil in the seal cavity - rebuilt the air release valve</td>
</tr>
<tr>
<td>7/18/2012</td>
<td>&quot;Benchmark&quot; observation</td>
</tr>
<tr>
<td></td>
<td>North pump (i.e. #2)</td>
</tr>
<tr>
<td></td>
<td>2.8 ft 16.1 amps 1151 rpm</td>
</tr>
<tr>
<td></td>
<td>South pump (i.e. #1)</td>
</tr>
<tr>
<td></td>
<td>2.8 ft 16.9 amps 1135 rpm</td>
</tr>
<tr>
<td>7/24/2012</td>
<td>Sewer crew cleaned the grinder and cleaned out the two wet pits</td>
</tr>
<tr>
<td>8/31/2012</td>
<td>The south pump is performing slightly less efficient than the north pump. We will inspect it early next week.</td>
</tr>
<tr>
<td>9/4/2012</td>
<td>Cleaned out the south pump check valve. Did inspection on impeller. The south pump was put back in service.</td>
</tr>
<tr>
<td>9/12/2012</td>
<td>Cleaned out north pump check valve and impeller. Also did oil change on North pump</td>
</tr>
<tr>
<td></td>
<td>2.8 ft 15.0 amps 1150 rpm</td>
</tr>
<tr>
<td></td>
<td>Changed the oil in the south pump</td>
</tr>
<tr>
<td></td>
<td>Ran the generator load test</td>
</tr>
<tr>
<td>10/3/2012</td>
<td>The contractor serviced the diesel eng. At 165.1 hrs</td>
</tr>
<tr>
<td>DATE</td>
<td>TASK</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 11/14/2012 | North pump: Cleaned the check valve and the impeller; inspected the upstream check valve and changed the oil. 2.6’ 14.0 a 1071 rpm  
South pump: Cleaned the check valve and the impeller; inspected the upstream check valve, changed the oil |                    |
| 12/5/2012  | 8:25:00 AM Replaced sump pump                                                                                   | Ragging           |
| 12/18/2012 | 3:00:00 PM South pump (#1) stopped pumping  
Found the pump ragged up. Cleaned both pumps and both are back in service |                |
| 12/20/2012 | 9:00:00 AM Impaired flow through south pump. (#1) cleaned the check valve (found the impeller to be clean). The problem seemed to be the pump lost prime since the check valve had very little debris in it and moved freely |                |
| 1/30/2013  | Monthly load test:  
Generator hours: 168.0 @ end  
Pump one hours: 87.130.6  
Pump one load: L1-44, L2-43, L3-44 | Ragging           |
| 2/6/2012   | Cleaned both north and south pumps and checked valves.  
Changed bearing oils in both north and south pumps  
North pump hours - 87226.1  
South pump hours - 89077.7 | Ragging           |
| 1/28/2013  | Fleet topped off the emg. Gen. with 60 gal of diesel                                                          |                    |
| 2/28/2013  | Cleaned out north impeller and check valve assemblies                                                          | Ragging           |
| 4/11/2013  | Changed both north and south bearing oils. Found signs of moisture and foam at both seal cavities.  
North pump 88001.6 hrs  
South pump 89836.7 hrs | Ragging           |
13:17 Started full load test at 170.3 hrs. Under at 172.6 hrs  
cleaned both north and south impellers and check valves.  
North pump 88074.8 hrs  
South pump 89911.2 hrs |                    |
| 5/1/2012   | Changed oil in north and south seal cavities. Found traces of foam & moisture.  
North pump 90081 hrs. South pump 88237 hrs |                    |
| 5/8/2013   | Found Pump #2 running at 1235 rpm 18.1 amps 69.2%. I checked and cleaned out impeller and check valve.  
After cleaning check valve and impeller  
1104 rpm 15.1 amps 61.7% | Ragging           |
| 5/14/2013  | Fuel pump #2 running at 1201 rpm 18.1 amps 67.3%. Checked and cleaned out impeller and check valve.  
After cleaning check valve and impeller  
1131 rpm 15.3 amps 63.2% | Ragging           |
| 5/21/2013  | Cleaned out south pump, Check valve and impeller at 88626 hours |                    |
| 5/23/2013  | Reinstalled channel monster after replacing both bottom blade seal bearings and lower blades. (bottom end only - 36 blades)  
Delineation (street) was done by water crew | Channel Monster  
Rebuilt by Santa Ana |
<table>
<thead>
<tr>
<th>DATE</th>
<th>TASK</th>
<th>Indicates Ragging</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/23/2013</td>
<td>Cleaned out both north and south check valves &amp; impeller housings. North pump at 88649 hrs. South pump at 90147 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>6/5/2013</td>
<td>Back up generator load test at 174.2 hrs</td>
<td></td>
</tr>
<tr>
<td>6/9/2013</td>
<td>South pump lost prime. Removed the inspection port and filled the pump with water. Left the south pump in the lead</td>
<td></td>
</tr>
<tr>
<td>6/14/2013</td>
<td>Clean south pump, At 14:25 hours</td>
<td></td>
</tr>
<tr>
<td>7/10/2013</td>
<td><strong>Swienhart Electric Co</strong> Semi annual service was done to back-up generator.</td>
<td></td>
</tr>
<tr>
<td>7/11/2013</td>
<td>Cleaned out south pump, check valve and impeller housing at 89498.1 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>7/17/2013</td>
<td>Cleaned south pump, check valve and impeller housing at 89637.8 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>7/17/2013</td>
<td>Changed bag and seal oil in both north and south pumps at 89637.9 hrs. South pump 90534.1 hrs north pump Load Test for back up brinder @ 177.2 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>8/8/2013</td>
<td>Cleaned out north and south impeller and check valve assemblies, North pump 90578.7 - South pump 90123.4 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>8/13/2013</td>
<td>Cleaned out south impeller and check valve assembly at 90238.7 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>8/28/2013</td>
<td>Cleaned out south impeller and check valve assembly at 90595.4 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>8/28/2013</td>
<td>Ran back-up generator for load test. Ran pump #1 south pump at 180.1 hrs L1=38, L2=34, L3=37 amps under load</td>
<td></td>
</tr>
<tr>
<td>9/1/2013</td>
<td>Cleaned out south impeller and check valve assembly at 90669.9 hrs EHS was here to inspect and check procedures</td>
<td>Ragging</td>
</tr>
<tr>
<td>9/8/2013</td>
<td>Cleaned out north impeller and check valve assembly at 90716 hrs. Cleaned south impeller and check valve assembly Received high level wet pit alarm</td>
<td>Ragging</td>
</tr>
<tr>
<td>9/13/2013</td>
<td>North pump lost prime. Paul inspected and cleaned the air release.</td>
<td></td>
</tr>
<tr>
<td>9/18/2013</td>
<td>Cleaned out north pump impeller and top check valve assemblies at 90915.8 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>10/18/2013</td>
<td>Cleaned out north pump impeller and top check valve assemblies at 91446.3 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>11/15/2013</td>
<td>Cleaned out the north pump impeller at 91690.6 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/4/2013</td>
<td>Changed brg and seal oil both north and south pump. Also cleaned out north impeller and check valve assembly at N.P. 91551 hrs S.P. 91977 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>12/12/2013</td>
<td><strong>Full load generator test - on back up power generator 181.3 hrs.</strong> Cleaned out north lift pump impeller and check valve Replaced _______ Alarm Switch</td>
<td></td>
</tr>
<tr>
<td>1/9/2014</td>
<td>Cleaned out impellar and check valve of rags. Pump lost prime at 93435 hrs.</td>
<td>Ragging</td>
</tr>
<tr>
<td>DATE</td>
<td>NOTE</td>
<td>Indicates Ragging</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>2/13/2014</td>
<td>Cleaned out impeller of rags at 93583.9 hrs- north pump</td>
<td>Ragging</td>
</tr>
<tr>
<td>2/21/2014</td>
<td>Cleaned out rags from impeller and inspected part at 93770 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td></td>
<td>Noticed wear at impeller ends</td>
<td></td>
</tr>
<tr>
<td>2/27/2014</td>
<td>Clean rags &amp; debris from north pump at 93916 hrs</td>
<td>Ragging</td>
</tr>
<tr>
<td>3/7/2014</td>
<td>Cleaned out north pump impeller and check valve assemblies of all rags and debris at 94102.2</td>
<td>Ragging</td>
</tr>
<tr>
<td>3/18/2014</td>
<td>Inspected and cleaned out north pump at 9436 8 hrs. Found volute to be cleaned from garbage. Alex Reyes <em>used degrease in wet pit</em></td>
<td></td>
</tr>
<tr>
<td>4/2/2014</td>
<td>Maintenance on the Muffin Monster under the supervision of reps from JWC Environmental. Raised the grinder for visual</td>
<td><strong>Channel Monster rebuilt by JWC</strong></td>
</tr>
<tr>
<td></td>
<td>Lowered the grinder into the hole to power wash the moving parts. Grease and stringy debris could not be removed from the drum.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D

FIELD TESTS

D-1 Testing Protocol Benchmark Testing of Non-dispersible Wipes ......................... D-3
D-2 Benchmarking Notes and Lessons Learned ............................................................ D-7
D-3 Field Notes 2014-10-16 ....................................................................................... D-9
D-4 Field Notes 2014-10-23 ....................................................................................... D-13
D-5 Field Notes 2014-11-25 ....................................................................................... D-17
D-6 Field Notes 2014-12-03 ....................................................................................... D-23
Testing Protocol for Benchmark Testing of Non-dispersible Wipes

1 SCOPE AND APPLICATION

1.1 This method is used to evaluate the dispersability and re-weave behavior of a series of blind wipe samples.

2 SUMMARY OF METHOD

2.1 A twin-shafted grinder shall be fitted with 11-tooth cam cutters and mounted in a test tank suitable for recirculating water in an open channel.

2.2 Material shall be soaked for a predetermined period of time and the mass of the sample shall be taken on a scale and recorded.

2.3 Sample materials shall be placed in the open channel of the test tank and released into the grinder. The grinder shall be permitted to run for a period of time to eject a suitable quantity of shredded material and the material shall be collected in a perforated screen basket.

2.4 Collected material shall be weighed and the mass recorded. Material shall be separated and spread out on a mat with 1-inch and ½-inch graduated markings. The material shall be labelled, photographed and measured for nominal size. Dimensions shall be recorded in a suitable matrix.

2.5 Collected material shall be placed in the re-weave pond with a predetermined quantity of hair and grease and circulated for a predetermined period of time using a recirculation pump.

2.6 Material shall be extracted from the pond, labelled, photographed and measured for nominal size. Dimensions shall be recorded in a suitable matrix.

3 APPARATUS AND MATERIALS

30005-0018 grinder with 0.310" thick 11-tooth cam cutters, 29:1 speed reducer and 5-hp electric motor
Test tank with pump and pump control
1/4-perforated screen capture basket to interface with grinder mounting frame
5 gallon plastic pail
Collection container suitable for transporting material captured in screen basket
1-quart plastic container
Scale for measuring mass in grams (range: 1-250g)
24" x 36" mat with 1-inch and ½-inch grid markings
Black marker
Camera
5 - 1-quart plastic bags
100 gallon rigid plastic pond
6" long, maximum Y4" diameter catch point
Human hair, 6-8" length.
CRISCO shortening in liquid state.
Spreadsheet for recording data
Gripping retriever
10 sheets of each wipe type

4 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

4.1 Samples shall be collected in container and analyzed within 1 hour of shredding.

4.2 Collection and analysis apparatus shall be adequately cleaned between samples.

5 PROCEDURE (SHREDDING)

5.1 Verify test tank is suitably-clean.

5.2 Install grinder in tank.

5.3 Fill test tank with water to 4" above top of grinder bottom end housing.

5.4 Fill 5 gallon pail with approximately 3 gallons of cool, potable water.

5.5 Place ten (10) sample wipes in 5 gallon pail and ensure all are submerged. Allow wipes to soak for 15 minutes.

5.6 Retrieve sample wipes from 5 gallon pail all at once. Place sample wipes between two perforated wood planks and apply a force of 150 pounds for 10 seconds to release free water before placing in 1-quart container.

5.7 Determine and record mass of wetted sample wipes.

5.8 Use gripping retriever to place one (1) selected wipe approximately six (6) inches below water surface and approximately four (4) feet in front of grinder. Release wipe.

5.9 Allow grinder to run for 5 seconds to clear material.

5.10 Repeat 5.8 thru 5.9 with nine (9) additional wipes.

5.11 Raise grinder above waterline and de-energize.

5.12 Allow pump to run for 2 minutes.

5.13 Lower capture basket into frame.

5.14 Allow pump to run for 5 minutes.
5.15 Extract material captured in basket.

5.16 Transfer captured shredded material to 1-quart container.

5.17 Lower test tank mesh screen into flow and allow pump to run for 5 minutes to capture any fine particles.

5.18 De-energize pump, raise mesh screen, and lower grinder into frame.

5.19 Extract material captured in mesh screen. Dewater collected material as described in 5.6.

5.20 Determine and record mass of shredded material.

5.21 Spread shredded material on graduated mat ensuring any long strips are arranged "vertically" on left side of mat.

5.22 Create label using paper and marker to identify: date, time, test protocol, and wipe type.

5.23 Take photo of mat with label and shredded material, followed by close-up photo of label.

5.24 Collect shredded material from mat and transfer to clean, clear plastic bag. Place label with bag.

5.25 Repeat 5.5 thru 5.24 with each wipe type.

8.31a After last sample remove grinder and recover and quantify bound material found on grinder.

5.26 Perform desired statistical analysis on mass loss and particle size of wipes.

6  PROCEDURE (RE-WEAVE)

6.1 Ensure test pond is suitably-clean.

6.2 Fill test pond with water.

6.3 Position circulation pump in pond and baffle from main section. Place nozzle under the water surface and orient to generate clockwise flow in pond. Adjust water flow rate to achieve circulation at approximately 1-2 feet per second.

6.4 Position catch point vertically from the bottom of the pond approximately 6" from the edge of the opposite side of the discharge nozzle.

6.5 Deposit selected sample of shredded material in pond and stir to disburse.

6.6 Add 1/2 oz. of hair to pond and stir to disburse.

6.7 Add 1.5 fluid oz. of liquid CRISCO to pond and stir to disburse.
6.8 Label and photograph condition of pond.
6.9 Allow system to operate for 1 hour.
6.10 Label and photograph condition of pond.
6.11 Remove test material and place on gridded mat.
6.12 Label and photograph test material.
6.13 Repeat 6.5 thru 6.12 with each wipe type.
6.14 Perform desired statistical analysis on re-weaving behavior.

7 QUALITY CONTROL
As required by individual test procedures.

8 HAZARDOUS WASTE MANAGEMENT
8.1 It is the responsibility of personnel to comply with all federal, state, and local regulations governing waste management. Compliance with all sewage discharge permits and regulations is also required.
8.2 Dispose of samples properly after analysis.

9 REFERENCES
None.
Phase 2 Benchmarking Notes and Lessons Learned

Date: October 8, 2014
Location: Garnsey St., Santa Ana, CA
Start Time: 9:00 AM
End Time: 3:30 PM

Observations and Lessons Learned

1. Introduced whole sheet samples consisting of 10 wipes per sample into manholes located at 300 ft., 600 ft. and 900 ft. intervals.
2. A 10-inch metal, pole-mounted sample basket with an 18 mesh screen was used for collection.
3. Need to make sure that adequate light is available for observations in the manhole. Need a mirror in daylight and flashlight at night.
4. Radios are needed to maintain constant communication.
5. Determine flow rate ahead of sampling by using marker dye and styrofoam cups.
6. Test samples were dyed red, orange and green.
7. When sampling the manhole at 900 ft. an industrial discharge was observed that lasted the entire test session. The sewage was turned a dark bluish/grey color that made observations difficult and stained the collected material a similar color.
8. The metal basket was left in the manhole for an additional time to assure capture of all material.
9. Inspection of basket after removal from the manhole revealed a mass of pulp material all stained blue/grey from the industrial discharge. No in-tact samples were observed and no dyed material was observed.
10. Prior to sampling in the 600 ft. manhole, the two metal tines on the basket were cut off to assure a better fit in the sewer trough.
11. Observations in the 600 ft. manhole test revealed similar results as to the physical characteristics of the sample material collected. No in-tact samples were observed and no dyed material was observed.
12. Observation in the 300 ft. manhole test revealed similar results as to the physical characteristics of the sample material. When the red dyed sample material was introduced into the sewer, it resulted in much of the dye washing off, as the downstream sewage flow was observed to change to the color red and the captured pulp material was all colored red. This did not occur when the orange dyed material was used.
13. One in-tact sheet of orange colored, sample material was captured from the 300 ft manhole test.
14. In each of the 600 ft. and 300 ft. manhole tests, the flow rate was determined using a styrofoam cup.
15. In each of the 600 ft. and 300 ft. manhole tests, the capture basket was left in an additional time to assure capture of all materials.
16. Upon completion of testing, a sample was taken of the sewer line contents without any wipes for comparison purposes.
17. The material captured in the background sample appeared to have the same physical characteristics of all the previous samples.
Questions to consider

1. Why did the captured sample materials not show any evidence of dye coloring?
2. Did dye wash out of the wipes immediately after entering the sewer?
3. Is one color dye better than another.
4. Why did all of the material captured have the consistency of pulp or toilet paper, even though it did not pass through a grinder?
5. Why was only 1 out of 50 sample sheets recovered in-tact?
6. Were the wipes dispersing as advertised, or did we fail to recover them?
7. Should we have left the basket in the sewer line longer?
8. Do the wipes take significantly longer to travel in the sewer than the flow rate indicates?
Assessing the Impacts of Pulp Loading from Non-Dispersible Materials on Downstream Sewer Systems

D-9

FIELD NOTES – PHASE 3 BENCHMARKING TEST

Subject: WERF-Assessment of the Impacts of Pulp Loading on Downstream Sewer Systems
Location: El Sicomoro Street, Rancho Santa Fe, CA
Time/Date: October 16, 2014, 10:00 AM to 11:30AM

Project Team Members in Attendance:

<table>
<thead>
<tr>
<th>OCSD</th>
<th>Santa Ana</th>
<th>JWC</th>
<th>Dudek Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nick Arhontes</td>
<td></td>
<td>Todd Nydam</td>
<td>John Pastore</td>
</tr>
<tr>
<td>Mark Esquer</td>
<td></td>
<td>Kevin Bates</td>
<td>Art Garcia</td>
</tr>
<tr>
<td>Ann Crafton</td>
<td></td>
<td>Alec Mackie</td>
<td>Scott Pastore</td>
</tr>
</tbody>
</table>

Legend: ♨ Attended the meeting in person. ₥ Attended the meeting via telephone. ₨ Unable to attend.

1. General
   a. Benchmarking trials were performed on a 10-inch gravity sewer line along El Sicomoro Street, in Rancho Santa Fe, CA. The purpose of these trials was to validate and understand some inconclusive results obtained during benchmarking trials on the 10-inch gravity sewer along Garnsey Street in Santa Ana, CA, in which the results indicated that either: 1) the dye was washing off of the wipes; 2) the wipes remained dyed and only 1 out of 50 wipes was recovered; or 3) a combination of 1 and 2 occurred.
   b. Site Condition/Description:
      i. Work was performed on a 10-inch gravity sewer flowing about 50% full.
      ii. Flow from this line combines with another tributary line before entering the Rancho Santa Fe Wastewater Treatment Plant (RSFWWTP) which is located 1600-ft downstream of the Entry Point 1 (EPI) manhole.
      iii. Flow to the downstream treatment plant was approximately 200 gpm at the time of testing. Plant staff indicated that the flow contribution from the 10-inch line on El Sicomoro is about 85%, thus the flow in the line being used was approximately 170 gpm.
      iv. Sample Point 1 (SP1) was the next manhole downstream from EPI (approximately 260-ft apart).
      v. EP2 was located at manhole 1,320-ft from the headworks of the RSFWWTP.
      vi. SP2 was at the RSFWWTP headworks.
      vii. The manhole at EPI was surcharging prior to testing. Collection system staff jetted the line between SP1 and EPI to clear the blockage so testing could proceed.

2. Objectives
   a. Compare the results of measuring the sewer flow velocity/travel time using a Styrofoam cup and dye.
   b. Determine if new dying method is effective at preventing dye from washing off after being exposed and agitated in the wastewater.
   c. Determine if wipes remain whole (not dispersed) after traveling through the sewer for some distance.
3. Procedure
   a. Pieces of a Styrofoam cup and tee-shirt dye were introduced into EP1 at the same time. The time it took for these items to pass through SPI was recorded.
   b. Sample A wipes (dyed red) were introduced at EP1 to be captured at SPI using a fine mesh capture basket.
      i. 5 wipes were introduced one by one into EP1
      ii. The capture basket was placed at SPI 30 seconds after the first wipe was introduced.
      iii. The basket was taken out after 3 minutes.
      iv. The contents of the basket were evaluated.
   c. This procedure was repeated with Sample B (dyed orange)
   d. Sample A wipes (dyed red) were introduced into EP2 to be captured at the RSFWWTP headworks.
      i. 7 Sample A wipes were introduced at EP2
      ii. Sample wipe were to be capture by the bar screens at the plant's headworks facilities
      iii. Contents caught on the bar screens were raked and evaluated.

4. Results
   a. The following table summarizes the results of this testing:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Entry Point (EP)</th>
<th>Sample Point (SP)</th>
<th>Distance, feet (Between EP and SP)</th>
<th>Travel Time, min:sec</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Styrofoam</td>
<td>EPI</td>
<td>SPI</td>
<td>280</td>
<td>N/A</td>
<td>Sample was never observed passing through SPI</td>
</tr>
<tr>
<td>Dye</td>
<td>EPI</td>
<td>SPI</td>
<td>280</td>
<td>1:48</td>
<td></td>
</tr>
<tr>
<td>Styrofoam</td>
<td>EPI</td>
<td>SPI</td>
<td>280</td>
<td>N/A</td>
<td>Sample was never observed passing through SPI</td>
</tr>
<tr>
<td>A (Red)</td>
<td>EPI</td>
<td>SPI</td>
<td>280</td>
<td>2:00</td>
<td>4 out of 5 wipes were recovered. Completely whole and dyed.</td>
</tr>
<tr>
<td>B (Orange)</td>
<td>EPI</td>
<td>SPI</td>
<td>280</td>
<td>2:00</td>
<td>2 out of 5 wipes were recovered. Completely whole and dyed.</td>
</tr>
<tr>
<td>A (Red)</td>
<td>EP2</td>
<td>SP2</td>
<td>1,320</td>
<td>9:30 (approx.)</td>
<td>6 out of 7 wipes were recovered. Completely whole and dyed. The remaining wipes introduced earlier at EP1 were recovered as well (whole and dyed)</td>
</tr>
</tbody>
</table>

5. Discussion
   a. The results show that dye appears to be a better indicator of wipes travel time compared to using Styrofoam pieces, which were not able to be identified and might have remained trapped in the sewer line.
i. At the flow rate, distance, and velocity tested, the travel time of the dye was reasonably close to the travel time of the wipes (>90%). The discrepancy in travel times is likely attributed to the headloss created by the capture basket when timing the travel times of the wipes.

b. The results of this testing show that, after flowing in a gravity sewer at the flow velocities and distances tested, the samples wipes introduced do not disperse, and the wipes remain significantly dyed.

   i. The observed velocity of the wipes was 2.3 fps from EP1 to SP1, and approximately 2.3 from EP2 to SP2.

c. The results validate the hypothesis that 49 of 50 of the wipes introduced during the testing on Garnsey Street were not recovered.

   i. The material that was collected on Garnsey Street was mostly toilet paper or other material not introduced as part of the testing.

6. Action Items

   a. **Dudek** to dye wipes using revised dyeing method to ensure wipes remain dyed after exposure to the wastewater.

   b. Wastewater dye will be introduced ahead of introducing wipes in order to anticipate arrival of wipes at the sampling points.
FIELD NOTES – PHASE 1 AND 2 FIELD TESTING

Subject: WERF-Assessment of the Impacts of Pulp Loading on Downstream Sewer Systems
Location: Segerstrom Pump Station, Bristol St., Santa Ana, C; Alton St. west of Bristol St.; and Dudek offices, Encinitas, CA.
Time/Date: October 23, 2014, 7:00 PM to 4:30AM

Project Team Members in Attendance:

<table>
<thead>
<tr>
<th>OCSD</th>
<th>Santa Ana</th>
<th>JWC</th>
<th>Dudek Team</th>
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<td>Mike Garcia</td>
<td>Kevin Bates</td>
<td>Art Garcia</td>
</tr>
<tr>
<td>Ann Crafton</td>
<td></td>
<td>Alec Mackie</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Corey</td>
<td></td>
</tr>
</tbody>
</table>

Legend: □ Attended the meeting in person. ☑ Attended the meeting via telephone. □ Unable to attend.

1. General
   a. Testing trials were performed on live sewers in Santa Ana, CA. A known quantity of dyed wipe samples were introduced into the collection system upstream of the grinder for Segerstrom Pump Station (SPS) (Entry Point 1 - EPI). The shredded sample materials were collected at the discharge of the pump station force main (Sample Point 1 - SP1), and further downstream at the inlet of a three barrel siphon (Sample Point 2 - SP2). The collected material was collected and qualitatively evaluated.
   b. Site Condition/Description:
      i. SPS is feed by an 18-inch sewer. Flow passes through a JWC Muffin Monster grinder prior to discharging into the pump station’s wet well.
      ii. SPS is dry pit/wet pit pump station with two VFD driven, self-priming, pumps operating as duty/standby. At the time of testing, the pumps were operating at approximately 70% speed. SPS is owned and operated by the City of Santa Ana.
      iii. SPS was cleaned the day before testing. The 24-inch barrel at SP2 was cleaned a few days prior to testing.
      iv. SPS discharges into a 30-inch gravity sewer owned by OCSD. The sewer was flowing at approximately 30 to 50% at the time of testing.
      v. SP2 is located 2,680-ft downstream from SP1, at the 24-inch barrel of a 3-barrel inverted siphon system. All of the flow on the 42-inch main line was diverted to the 24-inch barrel. SP2 is on Alton St, just east of Bristol St., along a biking trail.
      vi. A tire with a ¼-inch perforated plate at its center was used as a collection device.

   1. Note: the original 10-inch capture basket with a fine mesh was replaced with the tire because during preliminary trials the basket would become almost immediately blinded with material, and wastewater would flow over the basket without straining additional material.

2. Objectives
   a. To evaluate and document the behavior of the samples after they have been shredded by a municipal sewage grinder, and have traveled in the sewer for a given distance.
b. Determine if wipes remain whole (not dispersed) after traveling through the sewer for some distance.

3. Procedure

a. 5 different samples were used (A through E). Each of the 5 samples were wipes of a different brand.

b. 50 wipes of each sample were dyed with a permanent tee-shirt dye to assure extra wipes were available, if needed.

c. All test samples were pre-soaked in potable water for 15 minutes to simulate exposure to wastewater prior to being introduced to the grinder.

d. 10 wipes of each sample were dewatered and weighed for use in SP1.

e. 20 wipes of each sample were dewatered and weighed for use in SP2.

f. SP1 Sampling:

i. Ten (10) pre-dyed wipes were introduced, one by one at approximately 5 second intervals at EP1. A rain gutter and wash water from a vectar truck were used as a conveyance system to ensure that the wipes were introduced directly into the upstream grinder.

ii. One (1) minute after the first (out of ten) wipe was introduced; the collection screen was put in place in SP1.

iii. The collection screen was removed four (4) minutes after being placed.

iv. Material was removed from the collection screen and placed in a sealed container for later evaluation.

g. SP2 Sampling:

i. Green/yellow sewer dye was introduced into the SP1 manhole 5 minutes prior to introducing the first wipe to alert the team at SP2 when to expect the sample materials to arrive.

ii. The first (of 20) pre-dyed wipes was introduced at EP1. Five (5) minutes after the dye was introduced.

   1. The twenty (20) wipes were introduced, one by one at approximately five (5) second intervals. A rain gutter and wash water from a vectar truck were used as a conveyance system to ensure that the wipes were introduced directly into the upstream grinder.

iii. The collection screen was put in place at SP2 six (6) minutes after the dye was first observed at SP2.

iv. The collection screen was removed generally ten (10) minutes after being placed.

v. Material was removed from the collection screen and placed in a bag for later evaluation.

h. Evaluation (Dudek office, Encinitas):

i. The bagged material was spread out on a surface with square inch and ½ square inch grids.

ii. The collected sample material was separated as much as reasonably possible on the grid surface and photographed.
4. Results

   a. The following table summarizes the results of this testing:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Entry Point (EP)</th>
<th>Sample Point (SP)</th>
<th>Distance, feet (Between EP and SP)</th>
<th>Travel Time, min:sec</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A’ (Red)</td>
<td>EPI</td>
<td>SPI</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td>Fine mesh basket was used but was blinded almost immediately. Next trials used tire with 1/4-inch perforated plate.</td>
</tr>
<tr>
<td>A (Red)</td>
<td>EPI</td>
<td>SPI</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td>• Sample particles observed at SP1 1 minute after introduction.</td>
</tr>
<tr>
<td>B (Orange)</td>
<td>EPI</td>
<td>SPI</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td></td>
</tr>
<tr>
<td>C (Red)</td>
<td>EPI</td>
<td>SPI</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td>• One wipe was caught on top of grinder. It was dislodged 1:50 mins after first wipe was introduced. • Screen was removed only 2:20 minutes after being placed due to blinding.</td>
</tr>
<tr>
<td>D (Orange)</td>
<td>EPI</td>
<td>SPI</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td></td>
</tr>
<tr>
<td>E (Red)</td>
<td>EPI</td>
<td>SPI</td>
<td>~20 (including travel from wet well through forcemain)</td>
<td>~1:00</td>
<td></td>
</tr>
<tr>
<td>A (Red)</td>
<td>EPI</td>
<td>SP2</td>
<td>2680</td>
<td>18:45</td>
<td>• One wipe was caught on top of grinder. It was dislodged 2:00 mins after first wipe was introduced. Possibly missed the grinder. • Capture screen was in sewer for 12 minutes.</td>
</tr>
<tr>
<td>B (Orange)</td>
<td>EP1</td>
<td>SP2</td>
<td>2680</td>
<td>19:00*</td>
<td>• Capture screen was in sewer for 10 minutes.</td>
</tr>
</tbody>
</table>
| C (Red)    | EP1 | SP2 | 2680 | 22:00* | • One wipe was caught on top of grinder. It was dislodged 1:00 mins after first wipe was introduced.  
• Capture screen was in sewer for 14** minutes. |
| D (Orange) | EP1 | SP2 | 2680 | 21:20* | • One wipe was caught on top of grinder. Was not dislodged.  
• Capture screen was in the sewer for 10 minutes. |
| E (Red)    | EP1 | SP2 | 2680 | 23:00* | • Capture screen was in the sewer for 10 minutes. |

* The travel time recorded is for the dye. It is assumed that the travel time of the shredded wipes was the same.

5. Discussion

a. Approximately 80% of the flow was screened at SP1 during testing.
   i. Some flow bypassed the capture screen during each trial. Especially after the screen opening would become clogged with material.

b. More sample material was collected at SP1 then at SP2.

c. The red dyed wipes were more easily identified from background material compared to the orange wipes.

d. The collected sample material was generally in pieces that were less than ½ sq. in.

e. The shredded material appeared to combine with hair and background material to form an agglomeration.
   i. However, background material appeared to exhibit the same behavior without the aid of the shredded wipes.
Assessing the Impacts of Pulp Loading from Non-Dispersible Materials on Downstream Sewer Systems

Subject: WERF-Assessment of the Impacts of Pulp Loading on Downstream Sewer Systems
Location: Rancho Santa Fe WWTP, Rancho Santa Fe, CA
Time/Date: November 25, 2014, 7:00 PM to 4:30AM

Project Team Members in Attendance:

<table>
<thead>
<tr>
<th>OCSD</th>
<th>Santa Ana</th>
<th>IWC</th>
<th>Dudek Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nick Arhontes</td>
<td>Rudy Rosas</td>
<td>Todd Nydam</td>
<td>John Pastore</td>
</tr>
<tr>
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<td>Ann Crafton</td>
<td></td>
<td>Alec Mackie</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Corey</td>
<td>Tyson Ryan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rick Russell</td>
</tr>
</tbody>
</table>

Legend: □ Attended the meeting in person. □ Attended the meeting via telephone. □ Unable to attend.

1. General
   a. Bench scale trials were performed at the Rancho Santa Fe WWTP using a setup of pipes and buckets to simulate a brief portion of a sewer environment. The setup comprised of a 40-ft length of 2-inch pvc pipe at a 1% slope. Water flow at 3 gpm was introduced into one end of the pipe along with samples of 5 shredded and dyed wet wipes. Separate trials involved the introduction of toilet paper instead of wet wipes as a control. The pipe was calculated to flow 30% full with a flow velocity of 1.2 feet/second. The pipe drained into a 5-gallon bucket (Bucket A) until full. This was to allow the introduced material to get agitated and mixed. The full bucket (Bucket A) was then drained onto a screen with ¼” openings. The screen was then weighed and photos were taken for evaluation.

2. Objectives
   a. To evaluate and document the behavior of samples after they have been shredded by a municipal sewage grinder, and have been agitated in simulated sewer environment, then passed through a ¼” mesh screen.
   b. To compare the ability of shredded samples to pass through a ¼-inch screen compared to toilet paper (control)

3. Procedure
   a. 5 different samples were used (A through E). Each of the 5 samples were wipes of a different brand. There were 3 trials of each sample. Each trial utilized a batch of 5, pre-dyed, and shredded wipes.
   b. All samples were wetted, dewatered and weighed before shredding.
   c. Four additional trials were performed with toilet paper. A trial with 0.80 oz of toilet paper, two with 0.50 oz, and one with 0.30 oz.
   d. A 40-foot straight reach of 3-inch PVC pipe with a 1% slope was set up
   e. A smooth 1.5-inch diameter orifice was cut at the bottom of a 5 gallon bucket. A removable plug was provided. This was the mixing chamber for our introduced material.
   f. A water hose was regulated so that it would deliver a flow rate of approximately 3 gpm.
   g. An empty ¼” mesh screen was placed on the scale and the weight was recorded.
   h. The ¼” mesh screen was placed over a separate 5-gallon bucket (Bucket B).
i. The mixing chamber (Bucket A) was placed approximately 18 inches over the mesh screen. The plug was placed inside the orifice to prevent flow from escaping the mixing chamber.

j. Water was introduced the flowing water into the opposite end of the pipe at a flow of 3 gpm as well as the contents of the bag containing 5 shredded wipes of Sample A.

k. The bucket (Bucket A) was filled up to the 5-gallon mark.

l. The mixing chamber (Bucket A) was allowed to settle for about 30 seconds.

m. The plug at the bottom of the mixing chamber (Bucket A) was removed and the contents allowed to drain through the mesh screen and into the other bucket (Bucket B).

n. The screen mesh with the captured contents was removed and place on the scale for measurement. The weight of the empty screen was subtracted from the weight of screen with captured material.

o. Photos of the mesh screen with the captured materials were taken and observations were made.

p. Evaluate the sizes and weights of the material captured on the screen. Compare the results to the control.

4. Results

   a. The following table summarizes the results of this testing:

<table>
<thead>
<tr>
<th>Sample</th>
<th>No. Sheets</th>
<th>Wt. (oz.) (dewatered and weighed)</th>
<th>Wt. (oz.) Captured on Screen</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Blue)</td>
<td>5</td>
<td>0.85</td>
<td>2.20</td>
<td></td>
</tr>
<tr>
<td>A (Blue)</td>
<td>5</td>
<td>0.85</td>
<td>2.05</td>
<td>•</td>
</tr>
<tr>
<td>A (Blue)</td>
<td>5</td>
<td>0.85</td>
<td>2.40</td>
<td></td>
</tr>
<tr>
<td>B (Red)</td>
<td>5</td>
<td>1.05</td>
<td>2.10</td>
<td>•</td>
</tr>
<tr>
<td>B (Red)</td>
<td>5</td>
<td>1.20</td>
<td>3.30</td>
<td></td>
</tr>
<tr>
<td>B (Red)</td>
<td>5</td>
<td>1.10</td>
<td>2.55</td>
<td></td>
</tr>
<tr>
<td>C (Blue)</td>
<td>5</td>
<td>0.90</td>
<td>2.50</td>
<td>•</td>
</tr>
<tr>
<td>C (Blue)</td>
<td>5</td>
<td>0.95</td>
<td>2.60</td>
<td>•</td>
</tr>
<tr>
<td>C (Blue)</td>
<td>5</td>
<td>0.95</td>
<td>3.10</td>
<td>•</td>
</tr>
</tbody>
</table>
5. Discussion

   a. During the experiments, some material was lost due to splashing when the screen
       would become blinded at the location of the water flow as shown on the photo below.
       The lost material
b. The weight measurements taken afterwards may not be completely representative of the capture because it included the weight of the absorbed water and because material was lost off the sides from splashing.

c. What is clear from these tests is that the shredded wipes material had a tendency to blind the screen while the toilet paper did not. Indicating that although toilet paper may get caught on a catch point, flowing water will eventually disintegrate the material until it passes through the obstruction. This is shown in the photo evidence below.

d. Sample A:
ii. Sample B:

i. Sample C:

ii. Sample D:
h. Sample E:
  i. Control (Toilet Paper):
  
  ii. 0.5 oz:
  
  iii. 0.5 oz:
  
  iv. 0.3 oz:
FIELD NOTES – PHASE 1 AND 2 FIELD TESTING

Subject: WERF-Assessment of the Impacts of Pulp Loading on Downstream Sewer Systems
Location: Rancho Santa Fe WWTP, Rancho Santa Fe, CA
Time/Date: December 3, 2014, 7:00 PM to 4:30AM

Project Team Members in Attendance:

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Legend: \(\checkmark\) Attended the meeting in person. \(\box\) Attended the meeting via telephone. \(\square\) Unable to attend.

1. General
   a. Live sewer testing was conducted in a gravity line upstream of the Rancho Santa Fe WWTP (RSFWWTP). Pre-dyed and pre-shredded wet wipes were introduced into a manhole upstream of the RSFWWTP and recovered at the headworks of the plant. The recovered wipes were evaluated for size and shape.

2. Objectives
   a. To evaluate and document the behavior of samples after they have been shredded by a municipal sewage grinder, and have been agitated in a live sewer environment.

3. Procedure
   a. 5 different samples were used (A through E). Each of the 5 samples were wipes of a different brand. There were 3 trials of each sample. Each trial utilized a batch of 10, pre-dyed, and shredded wipes.
   b. All samples were wetted, dewatered and weighed prior to shredding.
   c. Each shredded sample was immersed in a quart sized container with water for ease of introducing the wipes into the flow stream.
   d. Samples were introduced into Entry Point 1 (EPI). A manhole 1,320 feet upstream of the RSFWWTP headworks and recovered at the RSF headworks – Sample Point 1 (SPI).
   e. Sewer dye was introduced into EPI 2 minutes prior to introducing the samples.
   f. 1 minute after the dye was observed at SPI, a capture basket (¼” screen with an 18 mesh fine screen) was placed under a weir at the RSFWWTP headworks to collect the introduced samples.
   g. The capture basket was left in place for 3 minutes before removing.
   h. The captured sample materials were removed from the capture basket and separated from other debris.
   i. The collected sample pieces were placed on a mat with 1-inch grids mat for evaluation and measurement. The material on the mat was also photographed.

4. Results
   a. The following are before and after photographs shown on a graduated mat:
i. Sample A (After)

ii. Sample B (After)

iii. Sample C (After)

i. Sample A (Before)

ii. Sample B (Before)

iii. Sample C (Before)
5. Discussion

a. Significant amount of sample materials introduced at EP1 were able to be recovered at SP1. The collected sample material appeared to be similar in size and shape before and after being introduced to the sewer.
GLOSSARY OF TERMS

Grinder
A mechanical device that shreds or grinds solids to make waste treatment easier.

Dispersible
Particles separate uniformly throughout a liquid.

FOG
Fat, oils, and greases.

INDA
Association of the Nonwoven Fabrics Industry

Non-Dispersible
Particles remain in a solid state and do not separate uniformly throughout a liquid.

Pulp
The ground material produced from the action of passing through a grinder.

Slurry
A thin mixture of a liquid, especially water, and any of several finely divided substances

Water Resource Recovery Facility
A facility for treating wastewater to meet state and federal standards for clean water, while recovering nutrients, producing recycled water and renewable energy.
REFERENCES


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Name
Title
Organization
Address
City State Zip Code Country
Phone Fax Email

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Method of Payment: (All orders must be prepaid.)

- Check or Money Order Enclosed
- Visa
- Mastercard
- American Express

Account No. Exp. Date
Signature

Shipping & Handling:

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<th>All Others</th>
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