ORANGE COUNTY SANITATION DISTRICT

phone:
(714) 962-2411
fax:
(714) 962-0356
www.ocsd.com

mailing address:
P.O. Box 8127
Fountain Valley, CA
92728-8127

street address:
10844 Ellis Avenue
Fountain Valley, CA
92708-7018

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June 28, 2006

To Whom It May Concern

SUBJECT: Final Phase II FOG Control Study Report

In April 2002, the Santa Ana Regional Water Quality Control Board issued *General Waste Discharge Requirements* (Order No. R8-2002-0014) requiring Orange County cities and sewering agencies (Co-Permittees) to monitor and control sanitary sewer overflows. One of the elements in the Order was for each Co-Permittee to implement a FOG Control Program. To meet schedule and resource requirements and constraints, and to understand what is required for an effective FOG Control Program, the Orange County Sanitation District (OCSD) and the other Co-Permittees contracted the services of a consultant, Environmental Engineering & Contracting, Inc., to conduct a study to establish FOG Control Program building blocks from which the Co-Permittees can select to assemble FOG Control Programs. The final Phase I report was received in July 2003. The report listed 12 potential building blocks for an effective FOG Control Program. Co-Permittees used these building blocks to assemble their programs.

Phase II field-tested three technologies: nonconventional grease traps (also known as "grease removal devices"), biological additives, and interceptor monitoring devices. These newer technologies were previously identified in Phase I as potential program components, but Phase I concluded that there was insufficient technical data for determining whether they were truly effective. Because of the scope of work, this phase was undertaken with the assistance of a state grant, and the work was supervised by a Technical Advisory Committee consisting of staff from the RWQCB and the Co-Permittees.

Enclosed is the Final Phase II FOG Control Study Report. The Executive Summary to the full report is also available as a separate document.

Mark Kawamoto

Mark Kawamoto, P.E.
FOG Control Project Manager

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ORANGE COUNTY

Fats, Oils, and Grease (FOG) Control Study

Phase II – Final Report

FOG Control Technology Field Testing Evaluations

March 2006

Environmental Engineering & Contracting, Inc.
501 Parkcenter Drive
Santa Ana, California 92705

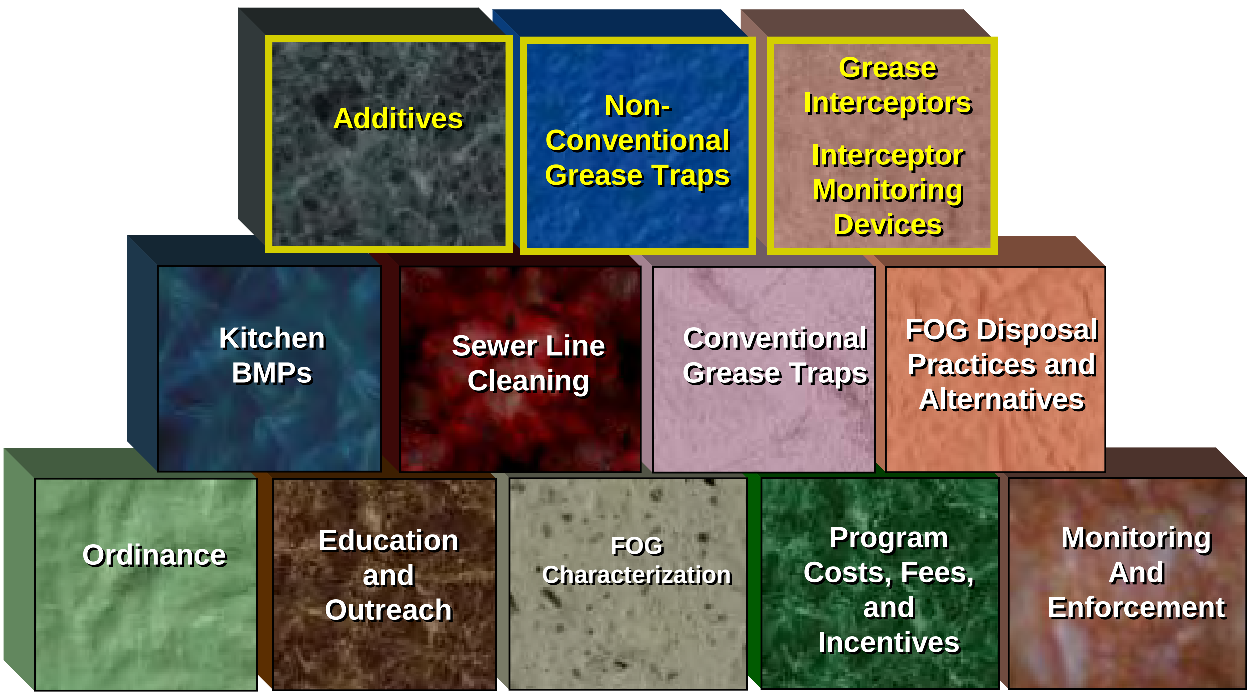
Orange County Sanitation District
10844 Ellis Avenue
Fountain Valley, California 92708

ORANGE COUNTY
FATS, OILS, AND GREASE (FOG) CONTROL STUDY - PHASE II

FOG Control Technology Field Testing Evaluations

Final Report

March 2006



Prepared by:

Environmental Engineering & Contracting, Inc. (EEC)

John Shaffer

Stan Steinbach, P.E.

Jim Kolk

Bart Hamlett

In consultation with Orange County Sanitation District

Mahin Talebi, P.E., Source Control Manager

Mark Kawamoto, P.E., FOG Control Project Manager

Funded by:

State Water Resources Control Board, Sacramento, California

WDR Co-Permittees, Orange County, California

Technical Advisory Committee:

Ken Theisen, Santa Ana Regional Water Quality Control Board

Jim Hyde, Irvine Ranch Water District

Bob von Schimmelmann, City of Orange

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Appendices

Orange County Fats, Oils, and Grease (FOG) Control Study Report Phase II – Final Report

FOG Control Technology Field Testing Evaluations

EXECUTIVE SUMMARY

To understand what is required for an effective Fats, Oils, and Grease (FOG) Control Program and to identify solutions to the FOG blockage problem, the Orange County Waste Discharge Requirements (WDR) Co-permittees[1] funded a FOG Control Study (Study) to develop program and ordinance building blocks from which the WDR Co-Permittees can choose to develop a FOG Control Program that meets their site-specific needs. Phase I of the Study, completed in June 2003, identified 12 potential building blocks for an effective FOG Control Program. However, the Study also concluded that there are relatively new promising FOG control technologies in use at food service establishments (FSEs) and in sewer lines that may provide substantial FOG control benefits, but their level of objective scientific evaluation is limited. Therefore, the Study recommended that these technologies should be evaluated before they are included as building blocks for local FOG Control Programs. This Phase II Study has been designed to evaluate these technologies.

According to the Phase I Study report, less than 50% of the FSEs in north Orange County utilize grease removal equipment (GRE), such as conventional grease interceptors or grease traps, to limit the FOG discharged to the sewer. Furthermore, for many of the FSEs, conventional grease interceptors have not been an adequate solution to control grease blockages and sanitary sewer overflows (SSOs) due to lack of maintenance or improper operation. Therefore, there is a pressing need in Orange County to determine if any of the promising FOG control technologies are effective. If they are found to be effective, then it is important to understand when they should be utilized, or perhaps required, and under what conditions to control the discharge of FOG to the sewer.

Phase II of the Study involved field evaluations[2] of 3 technologies that reportedly have been successful in controlling or monitoring FOG, in certain applications, for some FSEs and collection systems in the United States. The 3 technologies that were tested are divided into 4 applications, and the installations used for the testing are as follows:

[1] In 2002, the Santa Ana Regional Water Quality Control Board (RWQCB) issued *General Waste Discharge Requirements* (WDR), Order No. R8-2002-0014, to north Orange County cities and sewering agencies (the WDR Co-permittees) that included the requirement for each Co-permittee to develop a FOG Control Program as part of an overall Sewer System Management Plan (SSMP).
[2] The workplans for these evaluations are included in Appendix B of the Report.

Technology	Installations Evaluated
Additives, FSE-applied	New Installations
Additives, Sewer Line-applied	New Installations
Non-conventional Grease Traps (NCGTs)	Existing Installations
Interceptor Monitoring Devices (IMDs)	Existing Installations

These evaluations were designed to determine the potential overall effectiveness, practicality, and cost of additive, NCGT, and IMD technologies and the role that they may have in Orange County FOG Control Programs. The evaluations involved the testing and/or observing of specific products so that the technologies can be properly evaluated; however, the evaluations were not designed to endorse or exclude any company or product.

In order to provide practical findings and recommendations for the stakeholders of the Study, the primary goals of the Study for the various technologies were as follows:

- Additives, Sewer Line-applied – to identify if and under what conditions this technology may be acceptable as an alternative to, or enhancement of, sewer line cleaning.

- Additives, FSE-applied – to identify if and under what conditions this technology may be utilized as an alternative to the requirement to install a conventional grease interceptor for FSEs that cannot install a conventional grease interceptor.

- Non-conventional Grease Traps – to identify if and under what conditions this technology may be suitable as an alternative to a conventional grease interceptor.

- Interceptor Monitoring Devices – to identify if and under what conditions this technology may be utilized as an alternative to, or in addition to, conducting inspections of conventional grease interceptors.

SUPPLIER SELECTION PROCESS

To initiate each portion of the Phase II Study, a public notice to prospective suppliers was provided through posting of a notice on the websites of Orange County Sanitation District (OCSD), Environmental Engineering & Contracting, Inc. (EEC), and the Water Environment Federation (WEF). Suppliers that responded to the website posting and the suppliers previously identified in Phase I of the Study were asked to confirm their desire to participate in the Study. The 21 suppliers that confirmed were then provided a copy of the Study workplans and were required to submit a letter of commitment for participation in the Study. In the end, 7 suppliers agreed to participate in the Sewer Line-applied additive portion of the Study, 5 suppliers agreed to participate in the FSE-applied additive portion of the Study, 3 suppliers agreed to participate in the Non-conventional Grease Trap portion of the Study, and 2 suppliers agreed to participate in the Interceptor Monitoring Device portion of the Study.

Note: Direct comparisons of suppliers or products in the Study should not be made due to the variety of field conditions in each evaluation. It is the general findings and recommendations based on the results of all the evaluations that are most important in this Study. This is why the names of the suppliers who participated in the Study have been excluded from the report. However, a key that identifies the suppliers can be found in the report Appendix.

ADDITIVES

Additives are chemical or microbial products used to solubilize, saponify, or digest FOG. They are added either at a kitchen sink drain or directly into the collection system. This technology is being evaluated to determine if it can effectively and efficiently assist in the control of private and public sewer line grease blockages, reduce the requirement for costly sewer line cleaning, and reduce the need for grease disposal. Some additives have reportedly been successful when applied at the source (e.g., restaurant kitchens) or directly in the collection system using a feeder. Therefore, new installations of additives were selected to be field-tested under monitored conditions at FSEs (FSE-applied) and in the collection system (Sewer Line-applied).

Sections of sewer pipe with FOG (grease) build-up that require frequent cleaning (herein referred to as "hot spots") were utilized in the Study from cities and agencies in Orange County, California. These hot spots were selected based on data provided from the cities and agencies indicating grease build-up identified in previous closed-circuit television (CCTV) inspections and cleaning frequencies. Additionally, the Sewer Line-applied application also considered the ability for the product to be applied at a manhole in the middle portion of the hot spot, which would ensure there would be an untreated portion of the sewer pipe (control) to be compared with the treated portion. The FSE-applied application considered hot spots where "ideally" only one significant FOG source was upstream of the hot spot.

A random drawing was conducted to identify which additive supplier would be applied at each selected location. Each of the suppliers visited the selected location, reviewed the pertinent data, and approved the location before initiation of the field tests.

Bench Scale Emulsification Testing[3]

The first phase of evaluation in the additive study was bench scale emulsification testing. This testing was conducted due to the concern reported by some sewering agencies in the United States that some additives may merely emulsify the grease at the point of application, and later the grease may redeposit further downstream. Thus, the design of this test was to determine which products display any emulsification, saponification, or solubilization characteristics in a controlled laboratory setting.

No measurable emulsification properties (i.e., no disturbance of the oil-water interface) were observed in any of the additives tested during the emulsification bench scale tests.

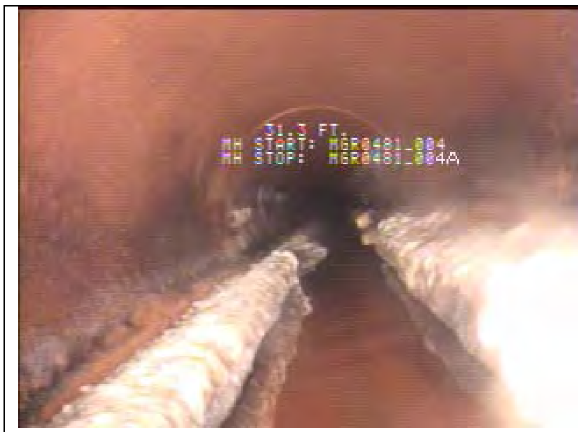
[3] For the purposes of this Study, "emulsification" is the term being used to describe any emulsification, solubilization, or saponification properties based on bench scale test visual evidence or CCTV evidence.

Field Evaluations

The second phase of evaluation in the additive study was the field testing of the products. This testing was designed to identify the effectiveness of the product in reducing the FOG (grease) build-up in the hot spots. Due to the variety of field conditions for each test, no product was compared against another product. Rather, the results are reported for each test including the field conditions.

Sewer-Line Applied Additives

Prior to application of the additive, the testing protocol for a typical Sewer Line-applied additive started with inspecting the sewer line hot spot with CCTV immediately before and after cleaning. This indicated the grease build-up prior to initiation of the test, and also verified that the line does not have any major obstructions or defects that may compromise the test. Photos from the CCTV inspections before and after cleaning at one hot spot are provided below:

<table>
<tr>
<td>
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<tr>
<td>Future Untreated Segment
Collected During FOG Confirmation Inspections</td>
<td>Future Treated Segment
(Upstream of a Severe Sag)
Collected During FOG Characterization</td>
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FOG Accumulation before Cleaning and Field Evaluations

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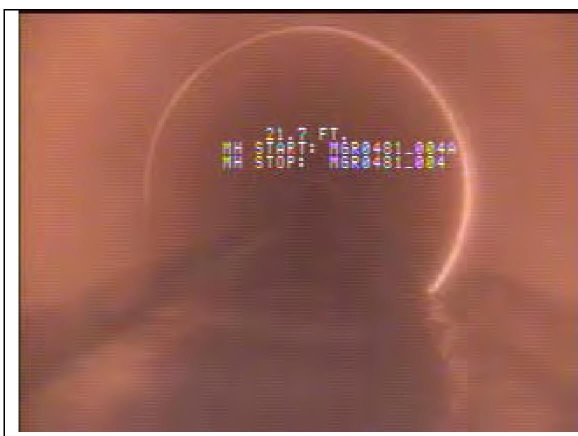
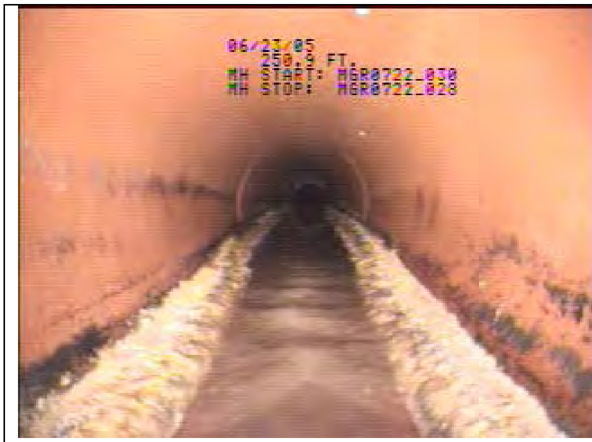
<tr>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>Future Untreated Segment</td>
<td>Future Treated Segment</td>
</tr>
</table>

Sewer Pipe Immediately after Line Cleaning

Immediately after the cleaning and CCTV inspection, the additive was applied in the middle of the hot spot according to the supplier's recommended dosage. This provided the benefit of being able to compare the effect of the additive on a treated section of sewer pipe with an untreated section of sewer pipe in the same hot spot. This comparison was not possible for 1 of the 7 evaluations where the additive was also applied upstream of the hot spot at an FSE (i.e., a Sewer Line-applied/FSE-applied hybrid evaluation). The treated portion of each hot spot was not cleaned for the duration of the test. Every 30 days, at a minimum, the sewer line hot spot was inspected by CCTV. FOG accumulation after 5.5 months is shown in the untreated and treated pipe segments in one evaluation below:

	
Untreated Segment	Treated Segment

FOG Accumulation 5.5 Months after Cleaning

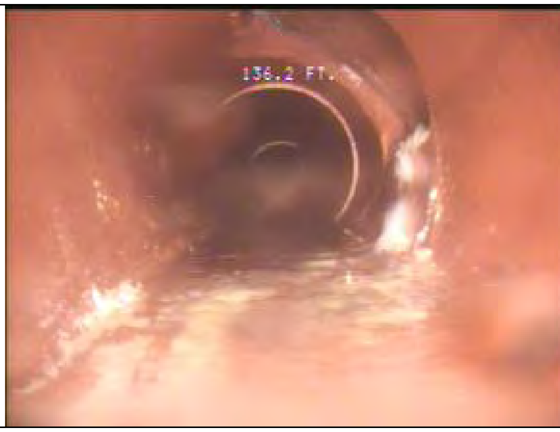
The tests continued for approximately 6 months unless it was determined that cleaning must occur in the treated section of the sewer line to avoid a grease blockage.

FSE-Applied Additives

The testing protocol for a typical FSE-applied additive started with inspecting the sewer line hot spot and the FSE lateral connection with CCTV immediately before and after cleaning. This indicated the grease build-up prior to initiation of the test, and also verified that the line does not have any major obstructions or defects that may compromise the test. Photos from the CCTV inspections before and after cleaning at one hot spot are provided below:

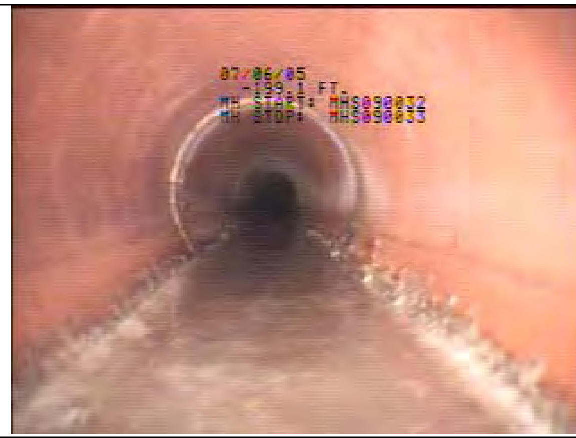
	
Collected During FOG Characterization	Collected During FOG Confirmation Inspections

FOG Accumulation before Cleaning and Field Evaluations

	
Lateral Connection	Hot Spot Segment

Sewer Pipe Immediately after Line Cleaning

Immediately after the cleaning and CCTV inspection, the additive was applied at the FSE according to the supplier's recommended dosage. Since the additive was applied at the source of the FOG (the FSE), there were no untreated pipe segments to compare against treated segments as was conducted in 6 of the 7 Sewer-line applied additive evaluations. The hot spot was not cleaned for the duration of the test. Every 30 days, at a minimum, the hot spot was inspected by CCTV. FOG accumulation after 6 months is shown in the hot spot pipe segment in one evaluation below:

	
Lateral Connection	Hot Spot Segment

FOG Accumulation 6 Months after Cleaning

Conclusions and Recommendations

General Additive Characteristics

According to the products' material safety data sheets (MSDSs), 7 of the 12 primary products contained microbial or bacterial cultures, 2 products contained enzymes, 1 product contained ferment of a yeast, and 3 MSDSs stated that the main ingredient was proprietary.

Based on the results of bench scale tests, none of the 12 additives (or the additional products used in a multi-product treatment) displayed emulsification properties at conservatively high dosages. There was also no evidence of the additives emulsifying the FOG and redepositing the FOG further downstream in the 11 field evaluations where this could be examined.

Based on review of the laboratory analyses, EEC did not identify any pollutants of concern in any of the 12 primary additives in sufficient quantities to exceed OCSD's local limits even if the products were in widespread use.

Based on activated sludge oxygen uptake rate (OUR) test results, there was no indication of activated sludge toxicity at the conservatively high dosages chosen for any of the 12 primary additives tested.

Sewer-Line Applied Additives

The first significant finding was that in each of the Sewer Line-applied evaluations (including the Sewer Line-applied/FSE-applied hybrid evaluation) it was determined that the previous method of line cleaning could be optimized through the use of post-cleaning CCTV monitoring which would allow for the verification of the thoroughness of line cleaning and a more accurate method of determining the proper line cleaning frequencies for each hot spot. Based on the findings in this Study, this optimization would most often lead to a significant reduction in line cleaning frequencies.

This is an important finding because the primary reason for using a Sewer Line-applied additive is to reduce, or possibly replace, the need for costly sewer line cleaning. If line cleaning can be reduced due to an improvement in line cleaning methods, the need for a Sewer Line-applied additive would be reduced.

Generally, the 6 additives utilized in the Sewer Line-applied application (not including the Sewer Line-applied/FSE-applied hybrid) were not effective in preventing the FOG accumulation in the treated sections of sewer pipe. However, there were a couple of evaluations where the accumulation was less in the treated sections of the sewer pipe compared to the untreated sections of the sewer pipe. For the Sewer Line-applied/FSE-applied hybrid evaluation, where there was not an untreated pipe segment for comparison, significant FOG accumulation was observed in the section of the sewer pipe treated at the FSE's cleanout and also in the section of the sewer pipe treated at the manhole.

Based on the results of these evaluations, the Sewer Line-applied additives do not appear to be comparable to effective line cleaning based on the CCTV images of cleaned sewer pipe compared to the CCTV images after 4 to 6 months of utilization of the additive. Although this was generally true, in 1 of the evaluations there was evidence of a potential for a reduction in line cleaning frequency (e.g., 42%) when using the additive at the hot spot in this evaluation. Unfortunately, the potential cost savings due to a reduced line cleaning frequency would likely be exceeded by the additive use cost. Therefore, it is unlikely there would be a net savings in using a Sewer Line-applied additive even if the additive was successful in reducing the line cleaning frequency by as much as 42%. Even in situations where the savings from reduced line cleaning may exceed the use cost of the additive, the savings is unlikely to be substantial.

The Study determined that improving line cleaning practices through the use of post-cleaning CCTV monitoring alone will typically reduce line cleaning frequencies. Therefore, improving line cleaning practices through the use of post-cleaning CCTV monitoring appears to be a more logical focus for sewering agencies until Sewer Line-applied additives are shown to be more effective.

FSE-Applied Additives

Although there was no untreated sewer pipe portion available for comparison to the treated portion,[4] 4 of the 5 evaluations provided results that indicated possible encouraging results. This was based on less FOG accumulation than anticipated at the end of the FSE's lateral and in the hot spot over time. It is important to note that these 4 FSEs made a concerted effort to improve their kitchen best management practices (BMPs) at the same time that the Study was initiated because each FSE was identified by the sewering agency as a significant source of FOG. In this evaluation, it is impossible to determine if the less-than-anticipated FOG accumulation was due to the additive or improved kitchen BMPs, or both.

[4] The Sewer Line-applied evaluations compared the FOG accumulation in untreated and treated portions of the hot spot which provided an ability to conclusively determine the additive's effectiveness.

The encouraging results at 4 of the 5 FSEs may provide some evidence that FSE-applied additives could be considered as an alternative to the requirement to install a grease interceptor at FSEs that cannot install a grease interceptor. However, based on the kitchen BMP variable that was present at the 4 evaluations that provided encouraging results, it is EEC's opinion that further Study of FSE-applied additives should be conducted that evaluates the effectiveness of the additive after improved kitchen BMPs have already been implemented. The report provides suggestions on how a future study could be designed.

Until this additional study is conducted, it is recommended that if an FSE requests to use an FSE-applied additive because they cannot install a conventional grease interceptor, an agency may consider approving the request on a conditional basis. The agency would need to monitor the effectiveness of the additive (and/or the kitchen BMPs) as was done in the Study using CCTV.

Non-conventional Grease Traps (Grease Removal Devices)

Non-conventional grease traps (NCGTs) are grease removal equipment typically installed in FSE kitchens, under or near a sink, or they are sometimes installed underground in a vault or in a basement. Suppliers have made multiple enhancements on the conventional passive grease trap design by providing features with enhanced oil-water separation, automatic grease removal, or biological digestion of the grease. The mechanical or bioremediation features of an NCGT are designed to result in less cleaning than a conventional grease trap but may require more frequent other forms of maintenance.

Based on EEC's research, NCGTs can be separated into 2 categories:

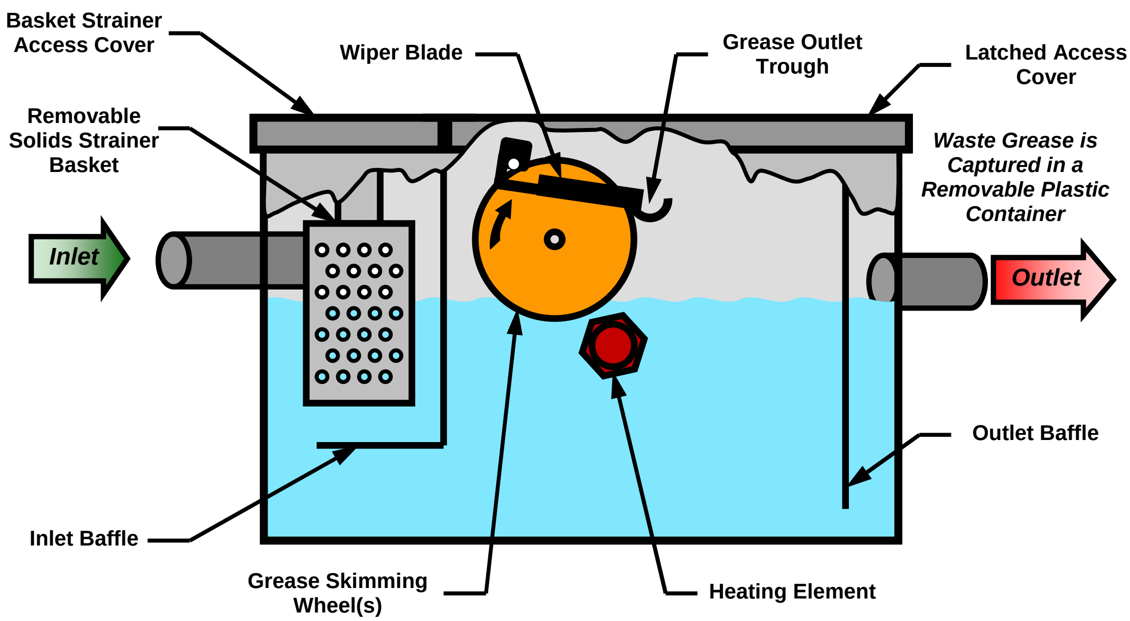
1) **Grease Removal Devices (GRDs)**[5] (previously named "Automatic Grease Traps" in the Phase I Study) – Includes features such as solids separation chambers; heating elements; mechanical skimmers; grease level monitors and pumps; and waste oil containers designed to provide enhanced oil-water separation, automatic grease removal, and temporary waste oil storage.

2) **Bioremediation Grease Traps**[6] – Includes features such as solids separation chambers, biological additive injection, and biological media chambers designed to provide biological digestion of the waste grease.

[5] These devices are often referred to as "grease interceptors" and will be identified as one type of grease interceptor in the 2006 Uniform Plumbing Code (UPC). This report refers to these devices as "grease removal devices" to avoid confusion with conventional grease interceptors.
[6] These devices will be referred to as "FOG Disposal Systems" in the 2006 Uniform Plumbing Code (UPC).

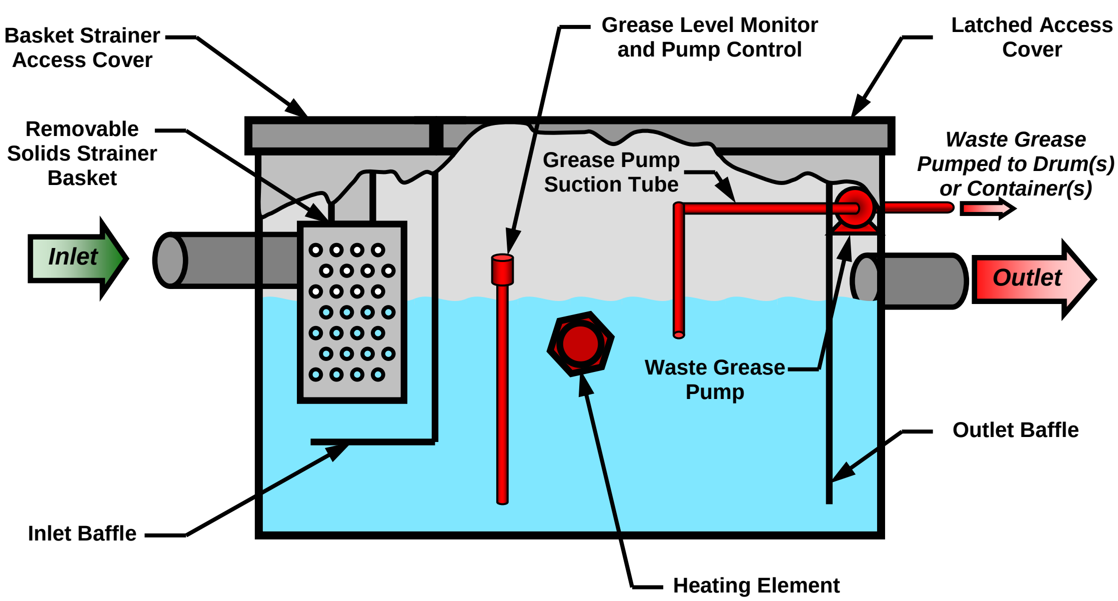
Grease Removal Devices

The only products that were offered by suppliers for evaluation in this portion of the Study were GRDs. The 3 suppliers that committed to the Study provided 2 types of GRDs for evaluation. A conceptual diagram of a GRD with a grease skimming wheel to remove the grease from the main chamber is depicted below:



GRD with Grease Skimming Wheel(s) (Sketch Based on *ASPE Data Book*, Volume 4, Chapter 8, and Information Provided By Suppliers)

A conceptual diagram of a GRD that utilizes a grease level monitor and pump rather than a skimming wheel to remove the grease is depicted below:



GRD with Grease Level Monitor and Pump (Sketch Based on *ASPE Data Book*, Volume 4, Chapter 8, and Information Provided by Supplier)

The typical designed flow rates for GRDs are 15 to 150 gallons per minute (gpm) with 0.5 to 2 minute retention times at maximum flow. Most installations are isolation-type applications, where 1 grease waste drain is typically connected to 1 GRD. Some installations are containment-type applications, where all the grease waste drains are typically connected to 1 GRD in a vault or basement. Most GRDs sold are typically less than 50 gallons in capacity and are installed in FSE kitchens under a counter. However, the report shows that some GRDs are much larger than 50 gallons.

Many cities in the United States are allowing the use of GRDs as an alternative to conventional grease interceptors. This is why the Phase I Study recommended that these types of devices be evaluated as potential alternatives to conventional grease interceptors in Orange County. The recognized concern with GRDs[7] is that they depend upon proper operation and maintenance[8] by the FSE employees, which is lacking at many FSEs. A lesser known concern is the improper or inadequate installation issues related to GRDs. Additionally, the Orange County Health Care Agency (OCHCA)[9] is concerned about the potential sanitation and cross-contamination issues associated with GRDs (and grease traps) located in the kitchen in the vicinity of food preparation. Therefore, these elements were examined in the Phase II Study.

Field Evaluations

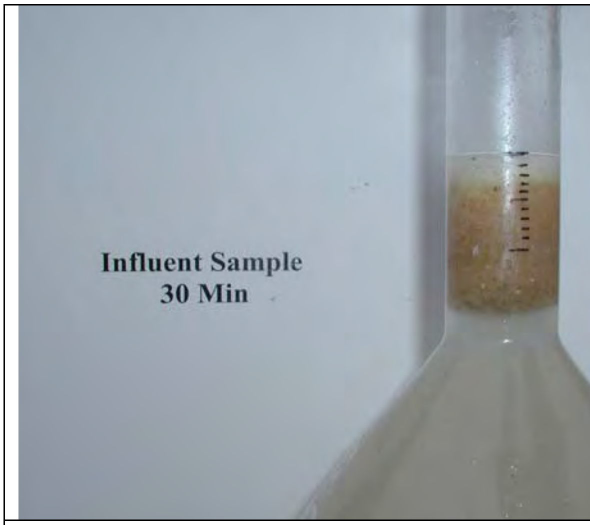
Each of the suppliers had multiple existing installations; therefore, each supplier was asked to provide a list of potential FSE locations for initial evaluations. EEC coordinated with the suppliers and chose 5-9 sites per supplier for the initial evaluations. Each of the FSE's GRDs had been in operation for a minimum of 6 months prior to these evaluations. For each supplier, 3 of those sites were then chosen for follow-up field evaluations and sampling.

Because of the high maintenance associated with each of these products, the maintenance, or lack thereof, was closely examined. Due to the concern of improper installations mentioned previously, proper installation was evaluated as well. The evaluation of existing installations of GRDs at typical FSE kitchens included noting how each GRD was installed (e.g., connected to a pre-rinse sink), the GRD conditions, and maintenance issues.

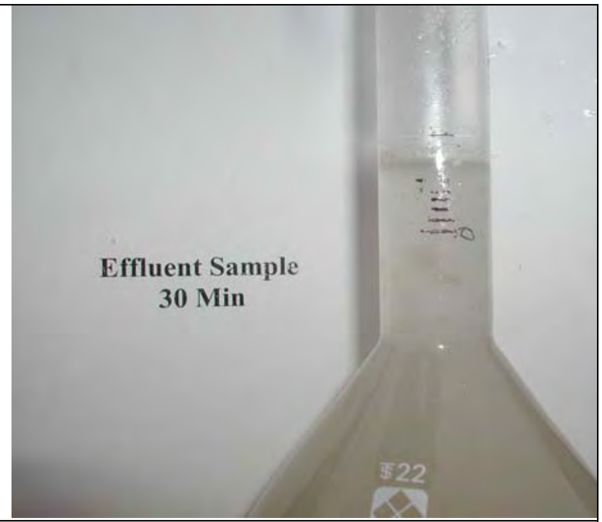
The evidence of a GRD's general effectiveness can be measured through the amount of floating FOG that is removed by the GRD or, more importantly, the evidence of a GRD's ineffectiveness can be measured by the amount of floating FOG that is not removed by the GRD. A 30-minute Floating FOG Test was developed by EEC for the purpose of

[7] Issue identified by 2 of the GRD suppliers in the Study and by California sewering agency personnel during meetings with GRD and grease trap manufacturers on April 27, 2005 and September 13, 2005.
[8] For the sake of this report, maintenance is any cleaning, waste disposal, monitoring, equipment adjustments, parts replacement, or other functions that are not performed by the GRD automatically.
[9] EEC spoke to the Orange County Health Care Agency (OCHCA)/Environmental Health Division on April 11, 2005 to discuss the agency's concerns and policies regarding GRDs and conventional grease traps. The report provides a summary of that discussion.

providing a simple and logical field method of determining the GRD's effectiveness in removing floating FOG from the wastewater. Utilizing this test, measurements of the influent and effluent floating FOG were collected on multiple occasions over a period of 4-6 months under a variety of conditions. Examples of the floating FOG samples are shown below:



Influent Sample



Effluent Sample

Example of Floating FOG Samples after 30 Minutes of Separation Time in the Flask

Initial Field Inspections

Initial field inspections were performed to evaluate the maintenance and installation issues at 21 FSEs. A summary of the pertinent findings from these inspections is provided below:

- Maintenance Issues – Ten (10) of the 21 GRDs had significant maintenance issues (e.g., solids basket missing or under-maintained, skimmer not operating, grease scrapers worn down, waste grease drum level alarm turned off, and waste grease drums overflowing).

- Installation Issues – Nine (9) of the 21 installations were isolation–type, typically connected to only 1 grease waste drain. At 6 of the FSEs with these types of installations, there were other potentially significant grease waste drains (e.g., dishwashing pre-rinse sink) not connected to any grease removal equipment. At the other 3 FSEs, there were other waste drains that would contain some grease (e.g., mop sinks) that were not connected to any grease removal equipment.[10]

[10] Although 12 of the 21 installations in this Study were containment-type, based on interviews with the GRD manufacturers, a vast majority of GRDs sold in the United States are installed as isolation-type.

Follow-up Evaluations

Nine (9) of the 21 sites were chosen for follow-up evaluations. Data was collected on the floating FOG and settled solids in the GRD. Influent and effluent samples were also collected and a floating FOG test was conducted for each sample. A summary of the pertinent findings from 29 follow-up inspections and 26 sampling events is provided below:

- Floating FOG Removal – When the floating FOG was consistently being skimmed or pumped by the GRD due to proper maintenance, 96% of the sampling event results indicated a 30-minute effluent floating FOG volume of 0.25 ml (0.025%) or less. This was an indication that when the GRDs are well maintained and remove the floating FOG as designed, the effluent floating FOG results are relatively low and consistent. This was true even when influent floating FOG concentrations were relatively high. There was also an indication that when the floating FOG layer in the GRD is not adequately skimmed or pumped due to improper maintenance, a portion of the floating FOG is not captured and retained in the GRD and passes through to the effluent.

- Settled Solids Removal – Even with the benefit of the solids strainer basket, settled solids accumulated beyond 15% of the total liquid depth in 45% of the inspections. However, there was no direct correlation identified between the depth of the settled solids layers and the effluent floating FOG volume.

Conclusions and Recommendations

A large percentage of GRDs that are installed or may be installed in the future will not likely be well maintained by the FSEs, or may not be connected to all of the significant grease waste drains, if there is not significant agency oversight. This conclusion is based on the results of the initial inspections and the lack of agency oversight of these issues at the facilities. It is important to note that the facilities that were inspected did not appear to be regulated by a maintenance inspection program by the local agency and there did not appear to be significant oversight by the local building department for installation of the isolation-type GRDs in relationship to being connected to the proper grease waste drains.

The GRD's ability to remove FOG from the wastewater is encouraging based on the floating FOG removal results for well-maintained GRDs, even though GRDs have shorter retention times (e.g., 0.5 to 2 minutes at maximum flow) than conventional grease interceptors. These encouraging results[11] were specific to the well maintained units and for the grease waste drains that were discharging to the GRDs.[12]

[11] These results were observed during a significant flow event, but not at a measured maximum rated flow for the unit.

[12] As discussed earlier, the GRDs were not always connected to other significant grease waste drains at the facility.

In summary, based on the evaluations in this Study, GRDs may work effectively on the fixtures they are properly connected to as long as they are properly sized,[13] installed, and maintained. However, assurances must be made by inspectors approving installations that all GRDs are sized and installed correctly and that the isolation-type GRDs are connected to all potential significant grease waste drains. Additionally, frequent maintenance inspections by a regulatory agency will be required in order to ensure that the GRDs are properly maintained.

Based on these requirements, each agency will need to evaluate the inspection requirements and associated agency costs related to GRDs. Additionally, the agency will need to evaluate the potential risk of a GRD providing inadequate FOG control, which may be due to poor FSE maintenance or not being installed on all of the grease waste drains, allowing pass through of FOG and impacting the sewer system.

In general, when comparing risks associated with floating FOG removal between GRDs and conventional grease interceptors, GRDs possess a higher risk due to the maintenance and installation issues discussed in this report. However, if these risks can be sufficiently mitigated or managed, GRDs may have a role in Orange County FOG Control Programs as an alternative to a conventional grease interceptor at certain FSEs. The risks associated with GRDs and the potential mitigation measures are described in detail in the report.

Conditional Variance

Due to the risks associated with GRDs, if an Orange County FOG Control Program allows GRDs as an alternative to a conventional grease interceptor, it is recommended that the GRD should be approved only as part of a conditional variance.[14] The conditional variance can be revoked due to a track record of improper maintenance or if an accumulation of grease is identified through CCTV evidence in the sewer system downstream of the FSE. If designed properly with an effective inspection and enforcement strategy, this will provide the necessary motivation for the FSE to perform the proper maintenance on the GRD(s).

The concept for a conditional variance that may be utilized is as follows:

- Conditional Variance Request - If an FSE desires to install a GRD(s) (or a conventional grease trap[15]) rather than a conventional grease interceptor, the FSE will be required to request a conditional variance from the city or special district and submit drawings depicting all the significant grease waste drains, at a minimum, that

[13] The Study did not evaluate the effectiveness of the GRDs at the fully rated flow or the sizing criteria for the GRDs. An agency may need to refer to the manufacturer's recommendations for proper sizing.

[14] A conditional variance is authorization to deviate from the Agency's Ordinance, Code and/or Rules and Regulations based on the requirement that specific conditions are achieved and maintained. If the conditions are not achieved or maintained, the variance will no longer be valid and the permittee will be required to comply with standard program requirements.

[15] Conventional grease traps have many of the same installation and maintenance issues related to GRDs.

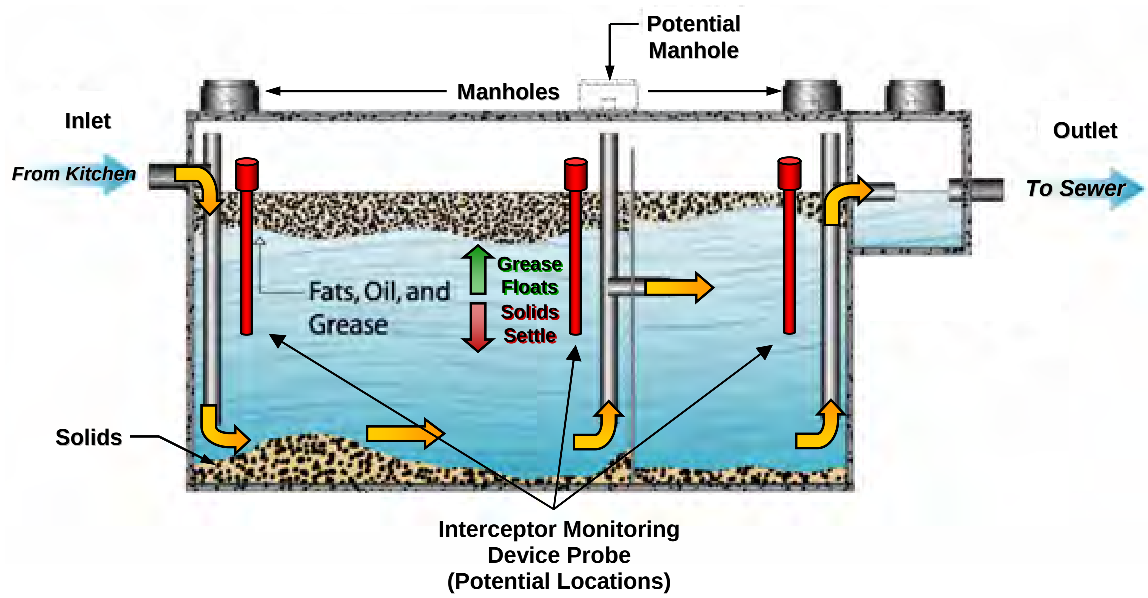
will be connected to the GRD(s). The drawings should also be evaluated by the health department.

- Conditional Variance Requirements - The FSE would be required to perform the required maintenance and maintain maintenance logs.
- Conditional Variance Revocation - The variance "condition" would be if the maintenance is not performed (i.e., too many permit violations) or if there is CCTV evidence of significant FOG build-up in the FSE's lateral or the main sewer line immediately downstream of the FSE, then the variance would be revoked and the FSE would have to install a conventional grease interceptor and/or pay related enforcement fines.
- Conditional Variance Potential Costs - The FSE would possibly have to pay an additional ongoing fee for the city or special district to recover the costs of increased inspections.

Interceptor Monitoring Devices

Interceptor Monitoring Devices (IMDs) are level-monitoring devices, installed in conventional underground grease interceptors, which provide continuous measurement of the floating FOG level and/or the settled solids level. For the grease interceptor to perform correctly, settled solids and floating FOG must be removed before they accumulate beyond a certain level to avoid clogging the plumbing in the interceptor or significantly reducing the overall space in the interceptor, which affects the ability of the interceptor to separate the waste material from the wastewater. The general standard maintenance level for solids and floating FOG accumulation is "The 25% Rule." According to "The 25% Rule," if the combined accumulation of solids and/or FOG exceeds 25% of the capacity of the interceptor, the interceptor must be cleaned. The "25% Rule" was adopted by many of the north Orange County cities and sewering agencies when they adopted their new FOG Control Ordinances in late 2004.

The Phase I Study recommended extensive agency monitoring of grease interceptors due to the importance of proper maintenance of interceptors. IMDs were identified in the Phase I Study as the most promising technology to provide automated monitoring with minimal agency involvement. The IMDs evaluated in the Study utilize different grease and/or solids level monitoring technologies (ultrasonic vs. capacitance), but in both cases, the IMD probe is installed in one of the grease interceptor manholes and is wired to a datalogger (or controller) that displays and records the probe measurements. A diagram of a typical IMD probe installation location in an interceptor is provided below:



Interceptor Monitoring Device (IMD) Installation (Probe Installation Location May Vary)

If found to be accurate, reliable, and cost effective, this technology would dramatically reduce the need to manually measure the floating FOG and settled solids levels in interceptors, either by FSEs or by agency inspectors. This would result in enhanced performance by grease interceptors due to proper maintenance.

Field Evaluation

The evaluation first considered how the IMD was installed (e.g., located within the second chamber) and other pertinent issues (e.g., size of interceptor). The interceptor water level, solids layer depth, and FOG layer depth were manually measured through the use of a core sampler and compared against the measurements that are recorded by the IMD.[16] Photographs of manual floating FOG and settled solids layer measurements are provided below:

[16] One supplier's IMD does not measure settled solids; therefore the settled solids comparisons were not made for those locations.

	
Floating FOG Measurement	Settled Solids Measurement

Core Sampler Measurements

The accuracy and reliability of the IMDs chosen for follow-up evaluations were monitored at each FSE at a frequency of approximately once per month for a period of approximately 6 months.

Two IMD products were evaluated. One (1) supplier's IMD was evaluated at 7 different test sites initially and then 3 test sites were chosen for follow-up visits at each location. Each of these installations was in operation for a minimum of 6 months before the evaluation. The other supplier's IMD was not installed at its 2 locations and ready for evaluation until later in the Study. There was limited data collected on this IMD.

Initial Inspections

Approximately 30% (2 of 7) of one supplier's IMDs and both of the other supplier's IMDs were not functioning correctly during the initial inspections due to installation or calibration problems. The other inspections provided fairly accurate floating FOG and settled solids measurements. A differential of 2 inches or less between the datalogger measurement and the core sampler measurement was considered accurate.

Follow-up Inspections

The results of the follow-up inspections that were conducted at the facilities without installation or calibration problems also provided fairly accurate floating FOG and settled solids measurements.

Conclusions and Recommendations

In EEC's opinion, the accuracy of the IMDs at sites without installation or calibration problems, over a period of 6 months, revealed that the technology was generally accurate over time and was durable for at least a period of 6 months. This data suggests that this technology can be useful for the purposes of monitoring an interceptor to enforce the

"25% Rule" and to determine when it would need to be pumped, if it was pumped, and if it was pumped completely. The data also suggests that the technology, once installed and calibrated correctly, may also be fairly reliable over time.

Based on the data evaluated in the Study, IMDs should be seriously considered for use in Orange County FOG Control Programs provided they are inspected for proper installation, calibration, and accuracy over time. FSEs should be encouraged to utilize IMDs, and FOG Control Program Managers should take advantage of the potential monitoring and enforcement benefits of this technology. Based on the results of this evaluation, there will be some measurement accuracy issues at some installations. However, as long as agencies do not view IMDs as a technology that will completely remove the need for agencies to inspect conventional grease interceptor altogether, the use of IMDs should reduce the frequency of agency interceptor inspections and, therefore, reduce agency costs.

It is EEC's opinion that monitoring the solids in the interceptor is important to prevent clogging the middle tee of the interceptor,[17] solids pass through, and hydrogen sulfide generation caused by decaying solids. Therefore, if solids monitoring is also deemed important by an FSE or an agency, than an IMD that is capable of measuring the settled solids in an interceptor would be preferable to an IMD that does not. An IMD that does not measure solids may be sufficient for FSEs that have a solids interceptor or other solids screening device ahead of the grease interceptor, or for FSEs that discharge very few solids.

A manufacturer approval policy will need to be developed, but the workplan and results of the Study should make this relatively straightforward. Additionally, because of the installation and calibration issues identified in this Study and because the Study did not evaluate the reliability of the technologies beyond the evaluation period, verification of the accuracy of any IMD is recommended to be conducted within 3 months after installation and a minimum of once per year by a qualified inspector or technician.

[17] This could not be monitored if the IMD was installed in the second chamber of the interceptor.

1.0 INTRODUCTION

1.1 Background

Cooking grease in wastewater discharged from Food Service Establishments (FSEs),[18] multi-family housing, and single family homes is causing or contributing to FOG (or grease) blockages in Orange County, California's sanitary sewer collection systems. These grease blockages, located in either the property owner's sewer lateral or the sanitary sewerage system, lead to Sanitary Sewer Overflows (SSOs), which can cause untreated sewage to flow onto streets and travel to storm drains, creeks, and other surface waters. Untreated sewage on private property or in the streets poses an obvious human health risk. If this sewage reaches the ocean, it often results in coastal contamination and beach closures. This has made the control of grease blockages a priority and high profile concern for Orange County residents, agencies, environmental groups, businesses, and regulators.

In 2002, the Santa Ana Regional Water Quality Control Board (RWQCB) issued *General Waste Discharge Requirements* (WDR), Order No. R8-2002-0014, to north Orange County cities and sewering agencies (the WDR Co-Permittees) that included the requirement for each Co-Permittee to develop a FOG Control Program as part of an overall Sewer System Management Plan (SSMP). The RWQCB found that most SSOs are preventable "with adequate and appropriate source control measures and operation and maintenance of the sewage collection system."

To understand what is required for an effective FOG Control Program and to identify solutions to the FOG blockage problem, the WDR Co-Permittees funded a FOG Control Study (Study) to develop program and ordinance building blocks from which the WDR Co-Permittees can choose to develop a FOG Control Program that meets their agency-specific needs. Phase I of the Study, completed in June 2003, identified 12 potential building blocks for an effective FOG Control Program. Many of the agencies and cities in Orange County based their FOG Control Programs on the findings and recommendations in the Phase I Study. The Study also concluded that there are relatively new promising FOG control technologies in use at FSEs and in sewer lines that may provide substantial FOG control benefits, but their level of objective scientific evaluation is limited. Therefore, the Study recommended that these technologies should be evaluated before they are included as building blocks for local FOG Control Programs. This Phase II Study has been designed to evaluate these technologies.

According to the Phase I Study report, less than 50% of the FSEs in north Orange County utilize grease removal equipment (GRE), such as conventional grease interceptors or grease traps, to limit the FOG discharged to the sewer. Furthermore, for many of the FSEs, conventional grease interceptors have not been an adequate solution to control grease blockages and SSOs due to lack of maintenance or improper operation.

[18] Food Service Establishments (FSEs) are those establishments primarily engaged in preparing or serving food to the public such as restaurants, hotels, commercial kitchens, bakeries, caterers, schools, prisons, correctional facilities, and care institutions.

Therefore, there is a pressing need in Orange County to determine if any of the promising FOG control technologies are effective. If they are found to be effective, then it is important to understand when they should be utilized, or perhaps required, and under what conditions to control the discharge of FOG to the sewer.

Phase II of the Study involved field evaluations of 3 technologies that reportedly have been successful in controlling or monitoring FOG, in certain applications, for some FSEs and collection systems in the United States. The 3 technologies that were tested are divided into 4 applications, and the installations that were used for the testing are as follows:

Technology	Installations Evaluated
Additives, FSE-applied	New Installations
Additives, Sewer Line-applied	New Installations
Non-conventional Grease Traps (NCGTs)	Existing Installations
Interceptor Monitoring Devices (IMDs)	Existing Installations

For those facilities without conventional grease interceptors and where a conventional grease interceptor cannot be easily installed, additives and non-conventional grease traps (NCGTs) are currently the most promising technology alternatives that may potentially be used in FOG Control Programs. The Phase I Study also recommended extensive agency monitoring of conventional grease interceptors due to the importance of proper maintenance. Interceptor monitoring devices (IMDs) are currently the most promising technology to provide automated monitoring with minimal agency involvement.

1.2 Study Goals

These evaluations were designed to determine the potential overall effectiveness, practicality, and cost of additive, NCGT, and IMD technologies and the role that they may have in Orange County FOG Control Programs. The evaluations involved the testing and/or observing of specific products so that the technologies can be properly evaluated; however, the evaluations were not designed to endorse or exclude any company or product.

In order to provide practical findings and recommendations for the stakeholders of the Study, the primary goals of the Study for the various technologies were as follows:

- Additives, Sewer Line-applied – to identify if and under what conditions this technology may be acceptable as an alternative to, or enhancement of, sewer line cleaning.

- Additives, FSE-applied – to identify if and under what conditions this technology may be utilized as an alternative to the requirement to install a conventional grease interceptor for FSEs that cannot install a conventional grease interceptor.

- Non-conventional Grease Traps – to identify if and under what conditions this technology may be suitable as an alternative to a conventional grease interceptor.

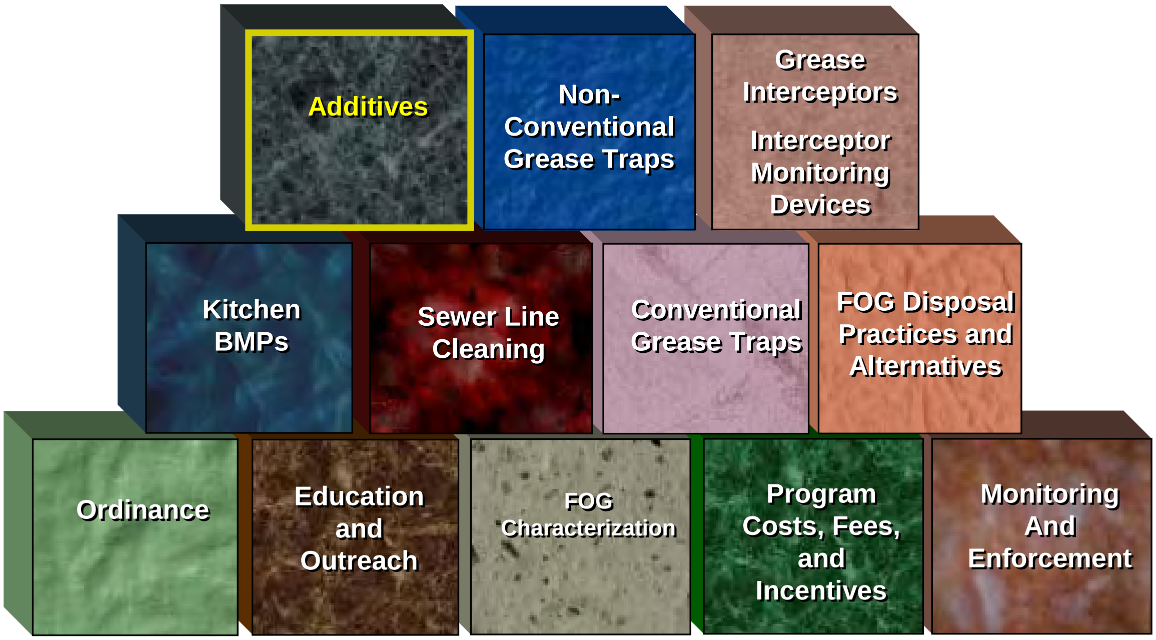
- Interceptor Monitoring Devices – to identify if and under what conditions this technology may be utilized as an alternative to, or in addition to, conducting inspections of conventional grease interceptors.

1.3 Report Structure

This report includes the information that is essential for the reader to understand how the finding and recommendations were formulated. Supporting data, including workplans, field methods, and bench scale testing results are included in the Appendices. *Direct comparisons of suppliers or products in the Study should not be made due to the variety of field conditions in each evaluation.* It is the findings and recommendations based on the results of all the evaluations that are most important in this Study. This is why the Study workplans stated that supplier and product names will be deemphasized in the Study. Therefore, the names of the suppliers who participated in the Study, along with their products, have been removed and replaced by generic names (e.g., Supplier A/Product A or Supplier B/Product B) in the text of the report. For reference purposes, a key has been provided in Appendix A with the names of the suppliers and the associated generic names.

The Study evaluated three distinctly different technologies; therefore, the technology evaluations and the corresponding conclusions and recommendations are reported in three distinct sections:

Section 2: Additives
Section 3: Non-conventional Grease Traps
Section 4: Interceptor Monitoring Devices



2.0 ADDITIVE EVALUATIONS

2.1 Background and Technology Description

Additives are chemical or microbial products used to solubilize, saponify, or digest FOG. They are added either at a kitchen sink drain or directly into the collection system. This technology is being evaluated to determine if it can effectively and efficiently assist in the control of private and public sewer line grease blockages, replace or reduce the requirement for costly sewer line cleaning, reduce the need for grease disposal, and/or provide an alternative to conventional grease interceptors at some FSEs that cannot install a conventional grease interceptor. Some additives have reportedly been successful when applied at the source (e.g., restaurant kitchens) or directly in the collection system. Therefore, new installations of additives have been selected to be field-tested under monitored conditions at FSEs (FSE-applied)[19] and in the collection system (Sewer Line-applied).[20]

2.2 Supplier Selection Process

To initiate the Additive portion of the Phase II Study, a public notice to prospective additive suppliers was provided through posting of a notice on the websites of Orange County Sanitation District (OCSD), Environmental Engineering & Contracting, Inc. (EEC), and the Water Environment Federation (WEF). Suppliers that responded to the

[19] The evaluation of FSE-applied additives does not include additives that are used in conjunction with a grease interceptor. This application may be beneficial to FSEs to reduce odors or interceptor pumping but does not directly address reductions in grease blockages in the sewer system.
[20] The evaluation of Sewer Line-applied additives is specific to sewer line hot spot treatment and does not include additives that are used to reduce pump station maintenance. Pump station applications may reduce maintenance issues but do not directly address reductions in grease blockages.

website posting and the 30 FOG control additives and services suppliers identified in Phase I of the Study were provided a "Fats, Oils, and Grease (FOG) Technology Supplier Participation, FOG Control Additives Field Evaluation and Supplier Requirements" notice (Appendix A) and were required to respond by October 29, 2004, to confirm their desire to participate in the Study. These suppliers were then provided a copy of the additive workplan (Appendix B) and were required to submit a letter of commitment and indemnification (Appendix C) for continued consideration for participation in the Study. They were also asked to choose whether their product would be in the FSE-applied or Sewer Line-applied portion of the Study.

Initially, 21 additive suppliers expressed interest in participating in the Study. In the end, 7 suppliers agreed to participate in the Sewer Line-applied portion of the Study and 5 suppliers agreed to participate in the FSE-applied portion of the Study. Two (2) suppliers that expressed an interest to participate after the October 29, 2004 deadline were placed on a waiting list and were informed that they could participate if they provided the necessary additional funding to evaluate their products. Both suppliers decided not to participate.

2.3 Location Selection Process

Sections of sewer pipe with FOG (grease) build-up that require frequent cleaning (herein referred to as "hot spots") were utilized in the Study from cities and agencies in Orange County, California. These hot spots were selected based on data provided from the cities and agencies indicating grease build-up identified in previous closed-circuit television (CCTV) inspections and cleaning frequencies. Additionally, the Sewer Line-applied application also considered the ability for the product to be applied at a manhole, or other access point, in the middle portion of the hot spot, which would ensure there would be an untreated portion of the sewer pipe (control portion) to be compared with the treated portion. The FSE-applied application considered hot spots where "ideally" only one significant FOG source was upstream of the hot spot.

A random drawing was conducted to identify which additive supplier would be applied at each selected location. Each of the suppliers visited the selected location, reviewed the pertinent data, and approved the location before initiation of the field tests. As discussed in Section 1.3, the names of the suppliers who participated in the Study have been excluded from the report but can be found in Appendix A. The results of the selection process are delineated in the following table:

Table 2.1 Additive Final Participants and Application Location

Additive Supplier	Location	Location ID	Agency
Sewer Line-applied			
Supplier A	First St., West of Newport Ave, Tustin, CA	OCSD HS27	Orange County Sanitation District
Supplier B	Acacia Ave and Buaro St, Garden Grove, CA	GGSD HS4	Garden Grove Sanitary District
Supplier C	Enderle Center Dr, Tustin, CA	OCSD HS15	Orange County Sanitation District
Supplier D	Monrovia Ave and 19th St, Costa Mesa, CA	CMSD GS26	Costa Mesa Sanitary District
Supplier E	Centennial Way at 2nd St., Tustin, CA	OCSD HS9	Orange County Sanitation District
Supplier F	Shattuck St and Palm St, Orange, CA	COO HS28	City of Orange
Sewer Line/FSE-applied Hybrid			
Supplier G[1]	Valencia St., City of La Habra	COLH HS14	City of La Habra
FSE-applied			
Supplier H	Carrow's Restaurant (Fashion Square Lane), La Habra, CA	COLH HS6	City of La Habra
Supplier I	Coco's Restaurant (Harbor Blvd), Garden Grove, CA	GGSD HS106	Garden Grove Sanitary District
Supplier J	Moreno's Mexican Restaurant (Park St.), Orange, CA	OCSD HS30	Orange County Sanitation District
Supplier K	Mimi's Cafe (Newport Blvd), Costa Mesa, CA	CMSD HS14	Costa Mesa Sanitary District
Supplier L	IHOP Restaurant (Cinnamon St.), Costa Mesa, CA	CMSD HS57	Costa Mesa Sanitary District

[1] This application turned out to be a hybrid between Sewer Line-applied and FSE-applied because the additive was added in the sewer line and at the FSE source.

2.4 Study Workplans

The study workplans were designed to evaluate the effectiveness of the additive products in field application and to determine their potential role in Orange County FOG Control Programs. These evaluations involved bench scale and field testing so that the technology could be properly evaluated; however, the evaluations are not designed to endorse or exclude any company or product.

2.4.1 Emulsification[21] Bench Scale Testing Workplan

The first phase of evaluation in the additive study was emulsification bench scale testing. This testing was conducted due to the concern reported by some sewering agencies in the United States that some additives may merely emulsify the grease at the point of

[21] For the purposes of this Study, "emulsification" is the term being used to describe any emulsification, solubilization, or saponification properties based on bench scale test visual evidence or CCTV evidence.

application only to later redeposit further downstream. Thus, the design of this test was to determine which products at conservatively high dosages may display emulsification characteristics in a controlled laboratory setting. If a product was found to display emulsification characteristics in the bench scale tests, then the field evaluation would focus additional resources on determining if there was evidence of emulsification of the grease at the point of application and redepositing the grease further downstream. The findings of these tests are for information only and were not used as a pass/fail test. This test only evaluates if a product changes the characteristics of the FOG/water interface after mixing in the first 60 minutes after addition. This test does not attempt to differentiate between emulsification, saponification, or solubilization. Refer to Appendix B (Phase II Study Workplan) for details of the bench scale testing procedures.[22]

2.4.2 Activated Sludge Toxicity Testing Workplan

One concern with additives is whether their widespread use, either added in the sewer lines or at FSEs, might be toxic to the biological treatment processes downstream at a publicly owned treatment works (POTW). The Study could not test this toxicity concern in the field due to the low overall usage of the additives during the Study relative to the entire collection system. However, the Study can test this in the laboratory by adding conservatively high dosages of each additive to samples of activated sludge from one of OCSD's reclamation plants and determining if the additive is potentially toxic to the microorganisms in the activated sludge. Note: This type of toxicity is not related to the typical hazardous waste definition.

Healthy microorganisms in activated sludge will consume dissolved oxygen rapidly over time if there is food present. Based on this fact, the Water Environment Federation and *Standard Methods for the Examination of Water and Wastewater*[23] provide methods for testing the oxygen uptake rate (OUR), or the oxygen consumption rate, of activated sludge to measure the relative health of the microorganisms in the activated sludge. This OUR test is used for many operational purposes by reclamation plants, one of which is to test the potential toxicity of a new chemical constituent (typically from a new industry) before it enters the reclamation plant. The toxicity test is relatively straightforward and conservative. First, the OUR of a sample of healthy activated sludge is measured as a control test (i.e., the unspiked sample). Next, a simulated high concentration of the constituent of concern is added to a sample of the same activated sludge and the OUR of that sample is measured (i.e., the spiked sample). If the OUR of the spiked sample is significantly lower than the OUR of the unspiked sample, then the constituent of concern is found to be potentially toxic to the microorganisms at that concentration because it has slowed down the uptake or consumption of oxygen by the microorganisms.

For this Study, a test was designed that compares the OUR of activated sludge samples from OCSD's Reclamation Plant #1 with the OUR of the same activated sludge samples

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[22] The bench scale testing procedure was based in part on the procedure used by the City of Everett, Washington.

[23] *Standard Methods for the Examination of Water and Wastewater* 20th Edition Test Method 2710 B & The Water Environment Federation's *Simplified Laboratory Procedures for Wastewater Examination* – 3rd Edition

spiked by a high dosage of each additive. The test procedure, the criteria for toxicity, and the method used to determine the additive dosages were sent to each supplier for their review prior to the testing, and are included in Appendix B.

2.4.3 Field Testing Workplan

The second phase of evaluation in the additive study is the field testing of the products at a variety of sewer line hot spot locations. Due to the variety of field conditions for each test, no product will be compared against another product. Rather, the results will be reported for each test including the field conditions. Refer to Appendix B (Phase II Study Workplan) for details of the field-testing procedures. The workplans were modified slightly during the Study based on the field conditions at each hot spot.

2.4.3.1 Sewer Line-applied Protocol

A summary of the testing protocol for a typical Sewer Line-applied additive is as follows:

1) Information was obtained from the sewering agency identifying the frequency of sewer line cleaning at that hot spot and the last time the sewer line was cleaned.

2) Prior to application of the additive, the sewer line was inspected by CCTV immediately before and after cleaning. The intent was to indicate the grease build-up since the last cleaning and the effectiveness of cleaning[24]. This also verified that the line did not have any major obstructions or defects that may compromise the test.

3) Immediately after the cleaning and CCTV inspection, the additive was applied in the middle of the hot spot according to the supplier's recommended dosage.[25] The treated portion of the hot spot was not cleaned for the duration of the test.

   Note – the application of the additive in the middle of the hot spot is a modification to the original workplan. This change in application location was made to provide the benefit of being able to compare the effect of the additive on a treated section of sewer pipe with an untreated section of sewer pipe in the same hot spot.

4) Each 30 days, at a minimum, the sewer line hot spot was inspected by CCTV.

5) The test continued for approximately 6 months. If it was determined by the sewering agency that cleaning must occur in the treated section of the sewer line to avoid a grease blockage, the test was terminated at that time.

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[24] As will be discussed in section 2.5.4.1 of the report, it was later determined that there were concerns regarding the effectiveness of prior sewer line cleaning; therefore, the rate at which the grease accumulated since the last cleaning could not be determined.

[25] There was one Sewer Line-applied application (Supplier G/Product G, HS14 in La Habra) where the additive was also added at the FSE source. This prevented the ability to compare the effect of the additive on a treated section of sewer pipe with an untreated section of sewer pipe.

2.4.3.2 FSE-applied Protocol

A summary of the testing protocol for a typical FSE-applied additive is as follows:

1) The FSE was identified by CCTV evidence as the most significant contributor of FOG to the hot spot.

2) Information was obtained from the sewering agency identifying the frequency of sewer line cleaning at the hot spot and the last time the sewer line was cleaned.

3) The FSE's lateral sewer line was cleaned (by the FSE's contractor) in coordination with the sewering agency cleaning the hot spot.

4) Prior to application of the additive, the sewer line and the end of the lateral were inspected by CCTV immediately before and after cleaning.

5) Immediately after cleaning and CCTV inspection, the additive was applied at the supplier's recommended location and dosage. The sewer main line and lateral were not cleaned during the test.

6) Each 30 days, at a minimum, the main sewer line and the end of the lateral were inspected by CCTV.

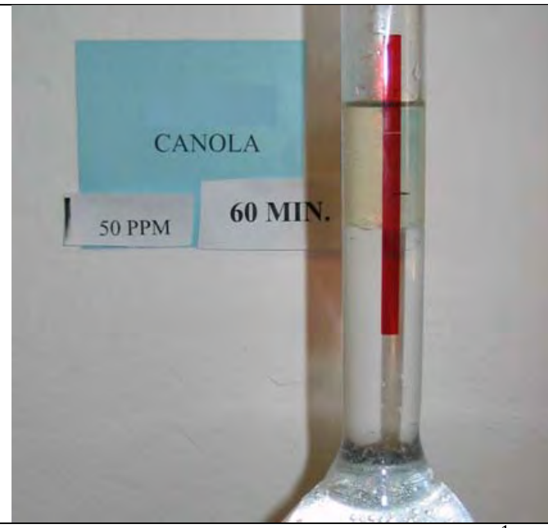
7) The test continued for approximately 6 months. If it was determined by the sewering agency that cleaning must occur in the lateral or main sewer line to avoid a grease blockage, the test was terminated at that time.

2.5 Findings

2.5.1 Emulsification Bench Scale Testing

No measurable emulsification properties (i.e., no disturbance of the oil-water interface) were observed in any of the additives tested during the emulsification bench scale tests. Figures 2.1 and 2.2 depict flasks of water mixed with vegetable oil and lard, untreated and treated with the addition of a supplier's additive. A summary of the results is provided in Table 2.2 and the details for all of the products tested are included in Appendix D.

Test Control Floating FOG (Canola Oil)



Treated Floating FOG (Canola Oil)[1]

Figure 2.1 Bench Scale Test with Canola Oil after 60 Minutes

[1]Note: The apparent increased volume of oil is due to the addition of a high dosage of the additive.

Test Control Floating FOG (Lard)

Treated Floating FOG (Lard)

Figure 2.2 Bench Scale Test with Lard after 60 Minutes

Table 2.2 Emulsification Bench Scale Test Results

Product	Dosage[1]	Visible Lard Emulsification	Visible Canola Oil Emulsification
Product A	1,000	None	None
Product B	12,200	None	None
Product C	1,000	None	None
Product D	5,000	None	None
Product E	15,000	None	None
Product F	1,000	None	None
Product G	50	None	None
Product H	750	None	None
Product I	50	None	None
Product J	50	None	None
Product K	5,000	None	None
Product L	250	None	None

[1] The dosages were based on recommended conservative dosages of the products for this test provided by the suppliers. If the supplier recommended a very low dosage (e.g., 1 ppm), 50 ppm was used. If the suppler did not provide a recommended dosage, 1,000 ppm was used. Dry products were based on dry weight dosage. Liquid products were based on volume dosage. Only the dosages of the primary products are shown in the table.

It should be noted that although none of the additives in this Study revealed visible emulsification properties in bench scale tests, this does not prove that the products do not contain small amounts of emulsifiers nor does this prove that the products may not emulsify grease after longer contact time in a sewer line. This also does not imply that other additives do not emulsify grease.

2.5.2 Material Safety Data Sheets (MSDSs) and Laboratory Analyses

Each of the additive suppliers provided EEC with a MSDS and laboratory analysis[26] of the primary product in their treatment according to the workplan requirements. According to the MSDSs, 7 of the 12 primary products contained microbial or bacterial cultures, 2 products contained enzymes, 1 product contained ferment of a yeast, and 3 MSDSs stated that the main ingredient was proprietary. From the review of the laboratory analyses, EEC did not identify any pollutants of concern in sufficient quantities to exceed OCSD's local limits even if the products were in widespread use. Refer to the Additive Workplan in Appendix B for a list of OCSD's local limits. The MSDSs and laboratory analysis reports are not included in the appendices due to supplier's proprietary information that may be contained in the reports.

[26] Metals by EPA Method 200.7 / 6010B, Volatile Organic Compounds by EPA Method 624 / 8260, and Base Neutrals and Acids by EPA Method 625 / 8270

2.5.3 Activated Sludge Toxicity Testing

All twelve additive products were tested by EEC. The dosages of each additive were based on the maximum dosages encountered during the field evaluations and very conservative assumptions of the potential future widespread usage throughout the North Orange County area flowing to OCSD Reclamation Plant #1. For example, all of the Sewer-Line applied additives were tested at dosages based on the conservative assumption that the product was used at 40 sewer line hot spots at the maximum dosage of that product encountered during the field evaluations. All of the FSE-applied additives were tested at dosages based on the conservative assumption that 300 FSEs were using the product at the maximum dosage of that product encountered during the field evaluations. Photographs of the OUR testing are provided as Figure 2.3. The dosages and the OUR results for each of the products tested are included in Table 2.3. A graph of one of the control tests is provided as Figure 2.4. The data and graphs of all of the test results are included in Appendix D.

Figure 2.3 Oxygen Uptake Rate (OUR) Testing at OCSD's Reclamation Plant #1 Laboratory

Table 2.3 OUR Test Results

Product	Dosage[1] parts per million (ppm)	OUR Result		
		Additive (mg/L/hr)	Control (mg/L/hr)[2]	Indication of Toxicity[3]
Sewer Line-applied				
Product A	0.5 ppm	96.0	94.6	No
Product B	0.002 ppm	109.3	109.3	No
Product C	0.34 ppm	103.4	110.6	No
Product D	0.06 ppm	100.9	100.1	No
Product E	0.3 ppm	100.0	94.6	No
Product F	0.016 ppm	102.4	110.6	No
Sewer Line/FSE-applied Hybrid				
Product G	0.04 ppm	103.1	109.3	No
FSE-applied				
Product H	7.2 ppm	105.9	100.1	No
Product I	0.6 ppm	104.1	100.1	No
Product J	0.23 ppm	108.0	99.1	No
Product K	0.07 ppm	102.0	109.3	No
Product L	0.6 ppm	114.0	120.0	No
Known Toxin Test				
Lysol™	20 ppm	68.6	120.0	Yes

[1] Dosage is based on a low daily flow at the reclamation plant of 83 MGD. Dry products were based on dry weight dosage. Liquid products were based on volume dosage. If more than one product was used in a field evaluation treatment, the primary product was used in the test.

[2] Each of the additive tests was compared against a control test from the same batch of combined return activated sludge and aeration tank influent (i.e., FED sample). Note that the variability between control samples has a range of 94.6 to 120.0 mg/L.

[3] Based on the OUR variability in the control samples, if the additive OUR result was <20 mg/L/hr lower or higher than the control test, the difference is considered to be insignificant due to the inherent variability of the test.

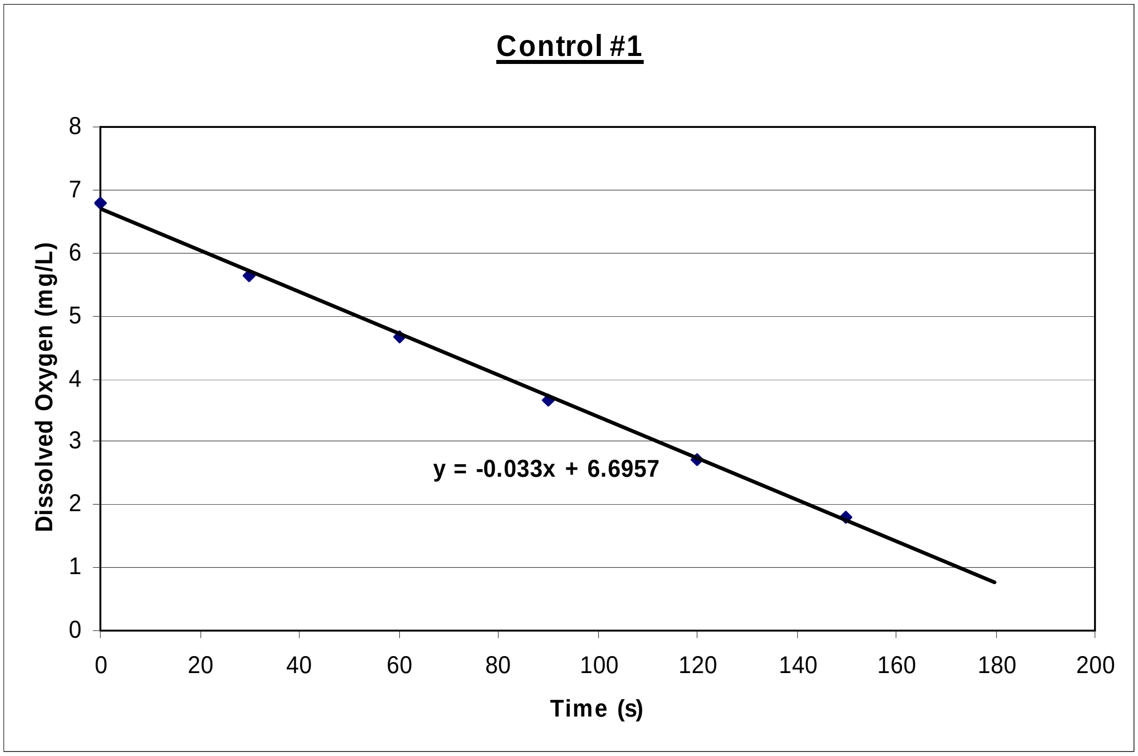


Figure 2.4 Oxygen Uptake Rate (OUR) Test for Control #1 = 120.0 mg/L/hr

As discussed in the workplan and demonstrated by the OUR variability of the control samples listed in Table 2.3, an OUR 20% lower than the control was chosen as the level of toxicity indication.

At conservatively high dosages, none of the FSE-applied additive tests or the Sewer-Line applied additive tests revealed OUR results that were more than 8% lower than the control tests. As a comparison, Lysol®, a known toxin to activated sludge at high concentrations, revealed an OUR that was 42.9% lower than the control sample. Based on these results, there was no indication of activated sludge toxicity at the conservatively high dosages chosen for any of the 12 products tested.

2.5.4 Field Evaluations

The field evaluations of the additives were initiated in December 2004 by conducting preliminary CCTV evaluations of the sewer piping in the selected hot spots. The findings of the field evaluations for each of the additives has been summarized in the following sections, which include: general information concerning the hot spot; details on the potential sources of the FOG; camera images of sections of the hot spot prior to cleaning, after cleaning (baseline), and 1 to 6 months after cleaning; and a description of the potential effectiveness.

2.5.4.1 Data Interpretation

There were many observations made during the additive portion of this Study that should be discussed before interpreting the results. These observations are divided into 6 notes, some of which will be referred to later in the report.

Note #1: It is important for the reader of this report not to compare the sewer line cleaning frequencies reported to EEC[27] before the evaluation to the sewer line cleaning frequencies during the evaluation. The line cleaning frequencies that agencies determine for their hot spots is not based on CCTV monitoring of the FOG accumulation. Rather it is based on a "conservative" reaction to past SSOs, blockages, and sewer line maintenance reports. During the field tests, line cleaning was suspended and was not required unless the agency believed that the CCTV images displayed a significant FOG accumulation that may cause or contribute to a blockage. The conservative agency approach to frequent line cleaning of hot spots was evident in many of the Sewer Line-applied additive evaluations where the untreated segments of the hot spot did not display a significant accumulation of FOG for many months, even though the line cleaning frequency for many of these same hot spots was every 2 to 8 weeks.

Note #2: It is also important for the reader not to directly compare the FOG accumulation in a hot spot or the end of a sewer lateral prior to the evaluation to the FOG accumulation during the evaluation. This is because it could not be shown at what rate the FOG had accumulated prior to the evaluation since there were no verifications of the hot spot or lateral cleaning effectiveness prior to the evaluation (ref: Note #1). In other words, EEC confirmed that the evaluations started with a thoroughly cleaned hot spot and end of the lateral; however, there were no confirmations of a thoroughly cleaned hot spot and end of the lateral after the cleaning event months before the evaluation in which to base the rate of accumulation prior to the evaluation.

Note #3: The 6 Sewer Line-applied additive evaluations (this does not include the Sewer Line/FSE-applied hybrid) included an untreated hot spot segment to compare against the treated segment. The most important data to determine effectiveness of the additive in these evaluations is the comparison of the FOG accumulation in these segments over time. For the FSE-applied additive evaluations and the Sewer Line/FSE-applied hybrid additive evaluation, there are no untreated segments to compare against; therefore, the evaluation of effectiveness is more difficult and will depend upon other factors (e.g., total FOG accumulation).

Note #4: Two (2) of the Sewer Line-applied hot spots contained severe sags in the treated segments which causes the FOG to accumulate more rapidly in those segments than in the untreated segments. Due to the high water level in these sags, FOG also accumulates at the crown of the pipe. This explains the increased FOG accumulation observed in those sections of the treated segments as compared to the FOG accumulation in the untreated segments at these two locations.

[27] The sewer line cleaning frequencies were reported to EEC by the sewer line maintenance staffs for each agency. EEC did not witness previous cleaning events or verify the cleaning results prior to the Study.

Note #5: Since the report could not include video, the photographs that are shown below were carefully chosen to be representative of FOG accumulation in the untreated and treated segments on the video and/or showing the FOG accumulation in the greatest area of concern (e.g., sag areas). For example, if a treated segment had no severe sags, a treated segment location was chosen for the photograph that was representative of the entire treated segment. If a treated segment had a severe sag, that was the location that was chosen for the photograph because that was the area of greatest concern. In some cases, there are other photographs chosen that provide additional valuable information (e.g., FOG accumulation in a tail end segment).

Note #6: When comparing FOG accumulation in the photographs, there are times when the water level is higher than in other photographs. This can be attributable to different times of the day or the presence of a sag, which will cause the water level to be higher than in other portions of the sewer pipe. In these cases, photographs from other months must also be examined to determine if significant FOG accumulation is present below the water level.

2.5.4.2 Sewer Line-applied Additives

2.5.4.2.1 OCSD HS27

2.5.4.2.1.1 Hot Spot General Information

General information concerning the additive evaluation for this hot spot is as follows:

Hot Spot ID:	OCSD HS27	**Cleaning Cycle:**	Every 2 Weeks
Location:	Sewer Line - First Street, West of Newport Avenue, Tustin, CA		
FOG Sources:	Strip Mall with Pepinos, Quiznos, and Whole Food Market		
Untreated Section:	60 feet (SUN0400-00100A to SUN0400-0100)		
Treated Section:	205 feet (SUN0400-0100 to SUN0400-0015)		
Supplier/Product:	Supplier A/Product A		

2.5.4.2.1.2 Hot Spot Summary

Before suspension of the sewer cleaning for this evaluation, cleaning was conducted on a 2-week basis due to grease accumulation from FSEs discharging upstream of the hot spot pipe segment. A severe sag/reverse grade in the pipe contributed to grease accumulation in this location. Due to this sag, "drying" the line with a vacuum truck was required to enable complete CCTV inspection of this pipe segment. Selection of this location as a candidate for the study was based on CCTV inspections conducted during FOG characterization and confirmed with CCTV inspections prior to the start of this study (photos below).

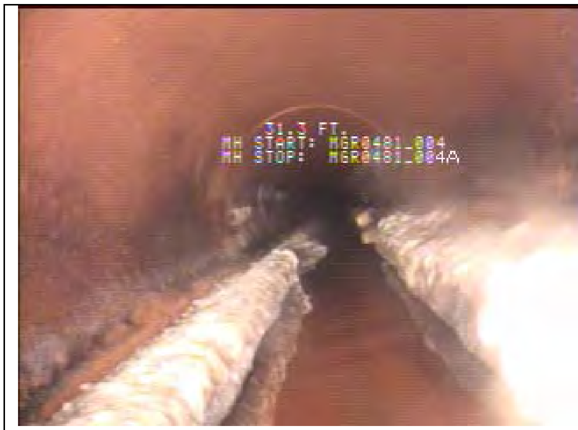
	
Future Untreated Segment - Collected During FOG Confirmation Inspections	Future Treated Segment (Upstream of Severe Sag) - Collected During FOG Characterization

Figure 2.5 FOG Accumulation at OCSD HS27 before Field Testing

2.5.4.2.1.3 Field Test

Line cleaning of this hot spot was conducted with a standard jetting nozzle on 1/4/05, followed by CCTV inspection, where the following baseline (clean pipe) images were collected:

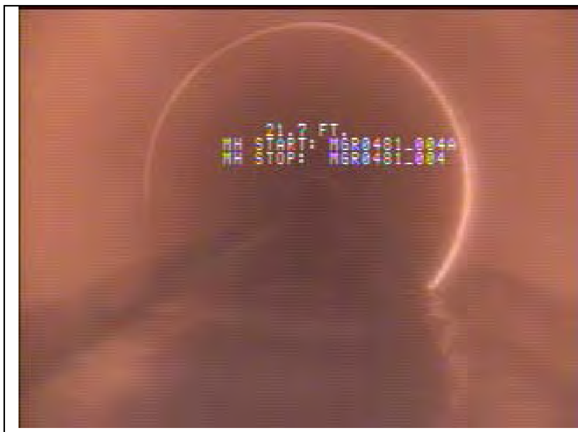
	
Untreated Segment	Treated Segment

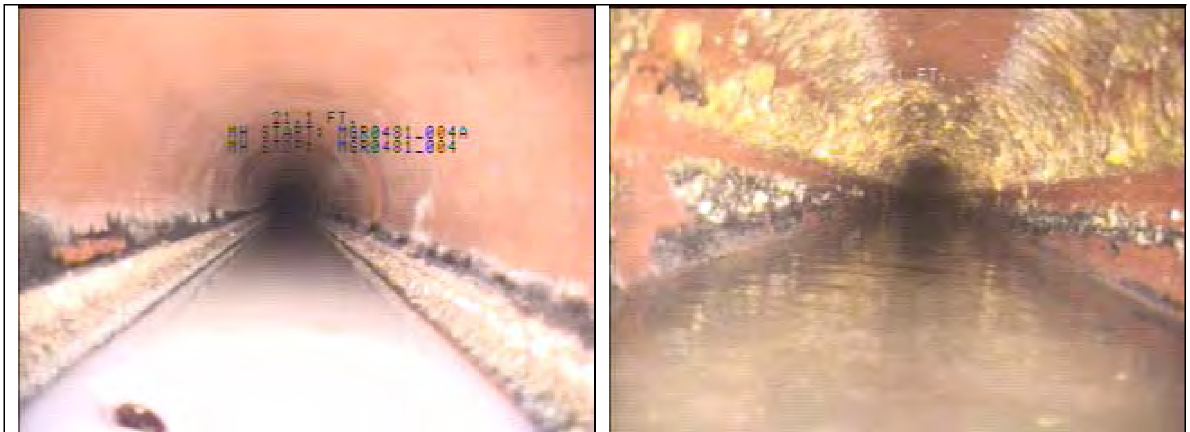
Figure 2.6 OCSD HS27 Immediately after Line Cleaning

The additive setup for this location was conducted on 1/5/05 by a Supplier A representative. The product was dispensed in a liquid form from a holding tank located inside the manhole at SUN0400-0100 (photos below). The holding tank was replenished on a 2-week basis. Some mechanical problems with the dispensing unit were encountered, which resulted in occasional dosing inconsistencies.

Supplier A Holding Tank/Dispensing Unit	Supplier A Holding Tank Stand

Figure 2.7 Additive Dispenser Setup at OCSD HS27

After 1 month of additive application, CCTV inspection of the untreated and treated pipe segments was conducted, and the following images were collected:



Untreated Segment	Treated Segment (Upstream of the Sag)

Figure 2.8 FOG Accumulation 1 Month after Cleaning

CCTV inspections were continued on a 2-week basis for this location. Based on the CCTV inspection conducted on 5/12/05, it was determined by OCSD Sewer Maintenance Staff that line cleaning was required in the treated portion, so the additive evaluation was terminated in this location. This was based on evaluation of the grease accumulation in the treated and untreated segments of this hot spot (photos below).

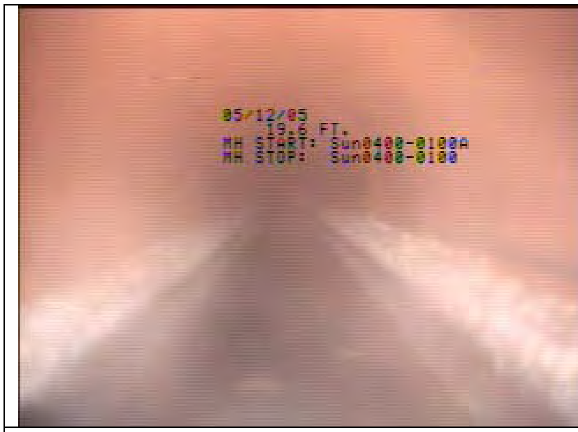
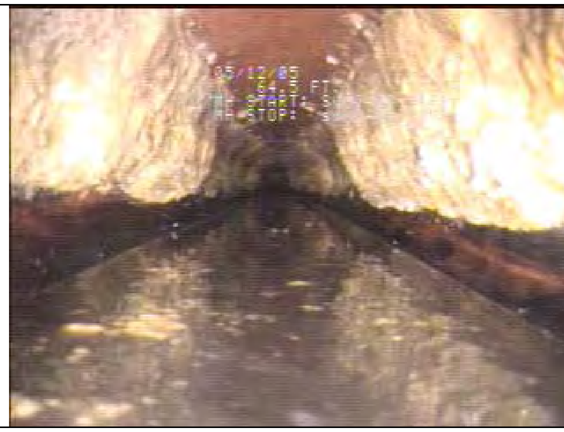
	
Untreated Segment	Treated Segment (Upstream of the Sag)

Figure 2.9 FOG Accumulation 4.5 Months after Cleaning

2.5.4.2.1.4 Discussion of Findings

Significant FOG accumulation was observed in the treated segments of the hot spot after additive addition. The accumulation was most significant in the sag area and immediately upstream of the sag. Direct comparisons of the untreated and treated line segments could not be made due to the tendency for sags to accumulate FOG at a faster rate than a typical pipe segment (ref: Note #4). Testing in this location was terminated by OCSD Sewer Maintenance Staff (by requiring the treated segment to be cleaned) after evaluation of the CCTV image of the treated segment 4.5 months after initial application of the additive.

Unique Issues:	Reverse grade/sag in the treated segment resulted in more accumulation of FOG in the sag area and required a vacuum truck for "drying" the line during the CCTV work.
Dispenser Problems:	The dispenser malfunctioned multiple times.
CCTV Frequency:	Every two weeks
Hot Spot Cleaning:	Cleaned every 2 weeks prior to the evaluation without the benefit of CCTV monitoring (ref: Note #1); the untreated and treated segments were cleaned after 4.5 months of the evaluation due to FOG accumulation based on CCTV monitoring. Note: For this hot spot, the drying of the line by the vacuum truck to facilitate the CCTV monitoring provided some unintentional line cleaning of the sag portion; therefore, it was impossible to determine if improved line cleaning could lead to a reduced frequency of line cleaning at this hot spot.
General Effectiveness:	Both the untreated and treated segments had significant grease accumulation that increased over time. A comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2).

Evidence of FOG Passed Downstream:	Unable to determine due to treated section immediately feeding into another sewer line with other significant sources of FOG. This product did not display any emulsification characteristics in the bench scale tests.
Comparison to Effective Line Cleaning:	Due to the significant accumulation of FOG in the treated section, this additive does not appear to be comparable to effective line cleaning. For this hot spot, due to the sag in the treated segment, it was impossible to determine if the future line cleaning frequency could be reduced by using this additive.
Projected Additive Use Cost (Agency):	$992 - $1,230 per month at a verified dosage of approximately 1 gallon/day (pricing information provided by the supplier).
Other Projected Agency Costs:	$100 per month based on quarterly CCTV monitoring at a minimum cost of $300 per event to monitor the effectiveness of the additive.
Total Agency Cost:	$1,092 - $1,330 per month.

2.5.4.2.2 GGSD HS4

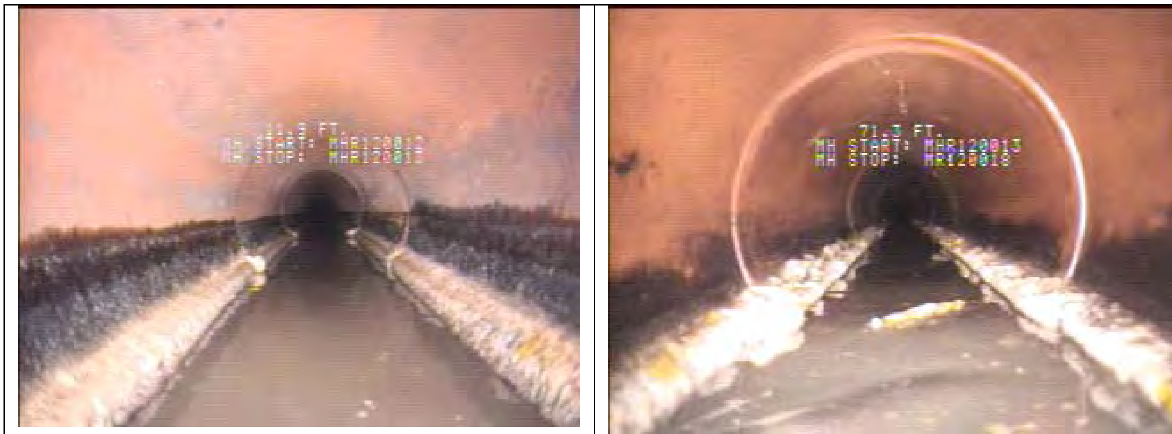
2.5.4.2.2.1 Hot Spot General Information

General information concerning the additive evaluation for this hot spot is as follows:

Hot Spot ID:	GGSD HS4	**Cleaning Cycle:**	Monthly
Location:	Sewer Line - Acacia Ave, West of Buaro St, Garden, Grove, CA		
FOG Sources:	Strip mall with Burger King, El Pollo Loco, KFC, Round Table Pizza, New Peking, Valu Plus		
Untreated Section:	285 ft (MHR120012 to MHR120013)		
Treated Section:	280 ft (MHR120013 to MHR120018)		
Supplier/Product:	Supplier B/Product B		

2.5.4.2.2.2 Hot Spot Summary

Prior to suspension of the sewer cleaning for this evaluation, cleaning in this mixed residential/commercial location was conducted on a monthly basis due to grease accumulation from FSEs located upstream of the hot spot pipe segments. No structural issues were identified as significant contributors to grease accumulation in this location. Selection of this location as a candidate for the study was based on CCTV inspections conducted during FOG characterization and confirmed with CCTV inspections prior to the start of this study (see photos below).

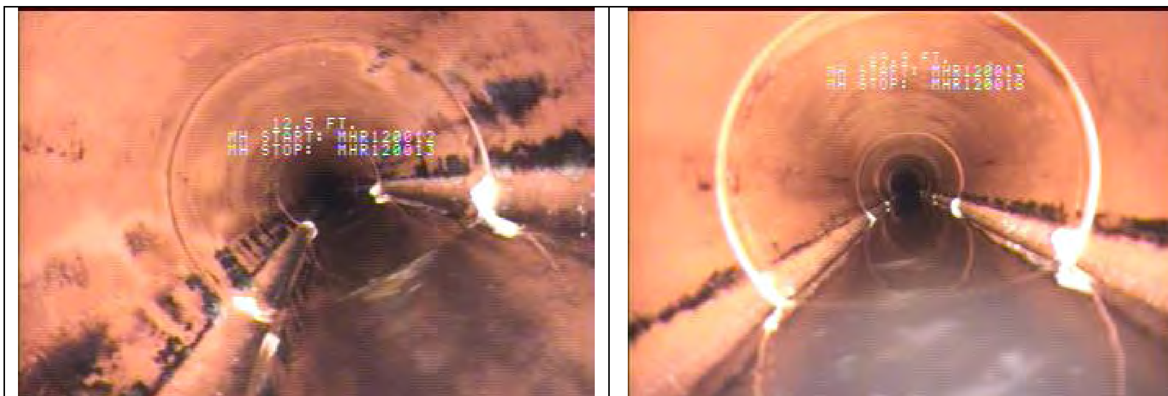


Future Untreated Segment - Collected During FOG Confirmation Inspections	Future Treated Segment – Collected During FOG Confirmation Inspections

Figure 2.10 FOG Accumulation at GGSD HS4 before Field Testing

2.5.4.2.2.3 Field Test

Line cleaning of this location was conducted with a standard jetting nozzle on 1/13/05, followed by CCTV inspection where the following baseline (clean pipe) images were collected:



Untreated Segment	Treated Segment

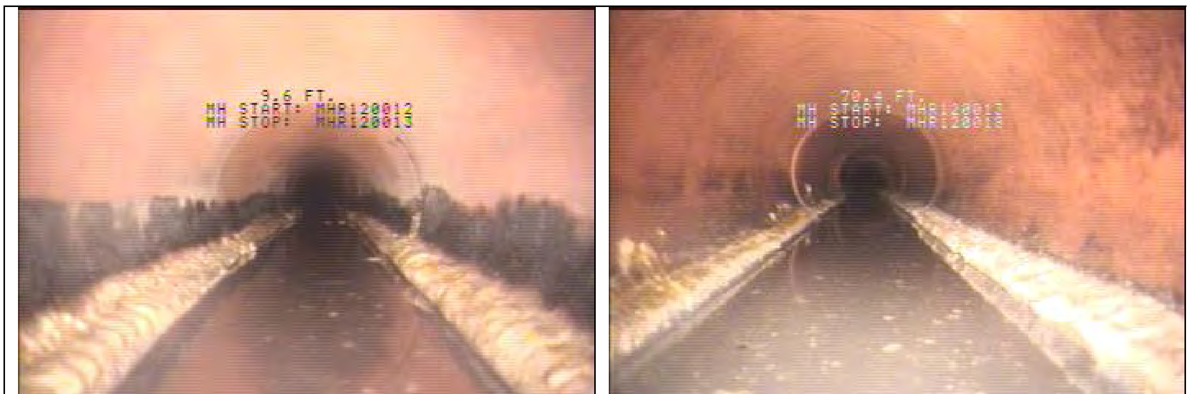
Figure 2.11 GGSD HS4 Immediately after Line Cleaning

The additive setup for this location was conducted on 1/14/05 by a Supplier B representative. The Supplier B product is a solid bar contained in a porous bag (photo below). The bag was suspended in the manhole channel and dispensed as the flowing wastewater dissolved the bar (photo below). Replacement of the bars was conducted on a monthly basis. No problems or complications were encountered during additive set-up and replacements.

Supplier B's Solid Additive Bar in a Bag	Supplier B's Dispensing Method

Figure 2.12 Additive Dispenser Setup at GGSD HS4

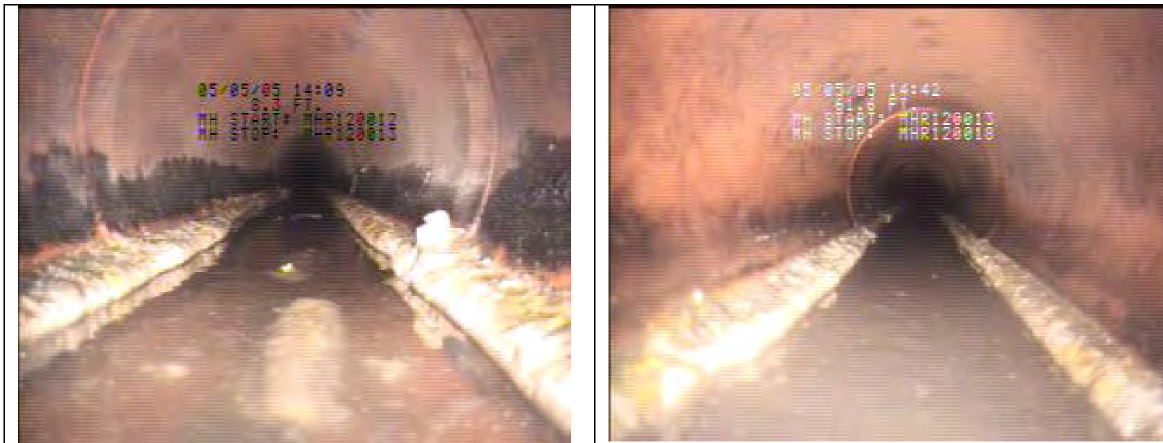
CCTV inspection of the untreated and treated pipe segments was conducted on a monthly basis. After 3 months of additive application, the following images were collected:



Untreated Segment	Treated Segment

Figure 2.13 FOG Accumulation 3 Months after Cleaning

CCTV inspections were continued on a monthly basis for this location. From the CCTV inspection conducted on 5/5/05, it was determined by GGSD Sewer Maintenance Staff that line cleaning was required and the additive evaluation was terminated in this location. This was based on evaluation of the grease accumulation in the treated and untreated segments of this hot spot (photos below).



Untreated Segment	Treated Segment

Figure 2.14 FOG Accumulation 4 Months after Cleaning

2.5.4.2.2.4 Discussion of Findings

FOG (grease) accumulation was observed in the treated segments of the hot spot after additive addition. In general, the treated segments had slightly less FOG accumulation than the untreated segments, but the differences were not significant. Testing in this location was terminated by GGSD Sewer Maintenance Staff (by requiring the treated segment to be cleaned) after evaluation of the CCTV image of the treated segment 4 months after initial application of the additive.

Unique Issues:	None
Dispenser Problems:	None identified
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned monthly prior to the evaluation without the benefit of CCTV monitoring (ref: Note #1); the untreated and treated segments were cleaned after 4 months of the evaluation due to FOG accumulation based on CCTV monitoring. Note: For this hot spot, it was determined that the previous method of line cleaning could be improved through the use of post-cleaning CCTV monitoring and the frequency could then be reduced.
General Effectiveness:	As seen in the photographs, a comparison of the untreated and the treated segments revealed that the FOG accumulation in the treated segments, although generally slightly less than the untreated segments, was not substantially less. A comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2).
Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. This product also did not display any emulsification characteristics in the bench scale tests.

Comparison to Effective Line Cleaning:	Due to the accumulation of FOG in the treated section, this additive does not appear to be comparable to effective line cleaning. For this hot spot, if the line cleaning was improved as recommended, this additive does not appear to provide an opportunity to significantly reduce the future line cleaning frequency.
Projected Additive Use Cost (Agency):	$90 per month at a verified dosage of approximately 2 bars per month (pricing information provided by the supplier).
Other Projected Agency Costs:	$50 per month based on semi-annual CCTV monitoring at a minimum cost of $300 per event to monitor the effectiveness of the additive.
Total Projected Agency Cost:	$140 per month.

2.5.4.2.3 OCSD HS15

2.5.4.2.3.1 Hot Spot General Information

General information concerning the additive evaluation for this hot spot is as follows:

Hot Spot ID:	OCSD HS15	**Cleaning Cycle:**	Every 8 Weeks
Location:	Sewer Line - Enderle Center North of Vandenberg, Tustin , CA		
FOG Sources:	Taco Bell/Pizza Hut, El Toritos, Zov's Bistro, Myst Chinese		
Untreated Section:	256 ft (MGR0722_030 to MGR0722_028)		
Treated Section:	300 ft (MGR0722_028 to MGR0722_012)		
Supplier/Product:	Supplier C/Product C		

2.5.4.2.3.2 Hot Spot Summary

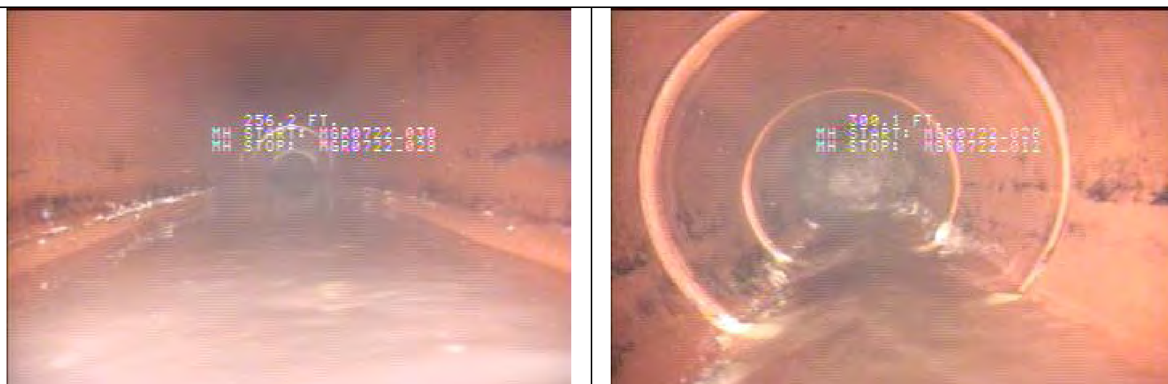
Prior to suspension of the sewer cleaning for this evaluation, cleaning in this location was conducted on an 8-week basis due to grease accumulation from FSEs discharging directly to this hot spot pipe segment. A low flow condition due to the proximity of this pipe segment to the starter may contribute to grease accumulation. Selection of this location as a candidate for the study was based on CCTV inspections conducted during FOG characterization and confirmed with CCTV inspections prior to the start of this study (see photos below).

Future Untreated Segment - Collected During FOG Confirmation Inspections	Future Treated Segment - Collected During FOG Confirmation Inspections

Figure 2.15 FOG Accumulation at OCSD HS15 Before Field Testing

2.5.4.2.3.3 Field Test

Line cleaning of this hot spot was conducted with a standard jetting nozzle on 1/13/05, followed by CCTV inspection where the following baseline (clean pipe) images were collected:



Untreated Segment	Treated Segment

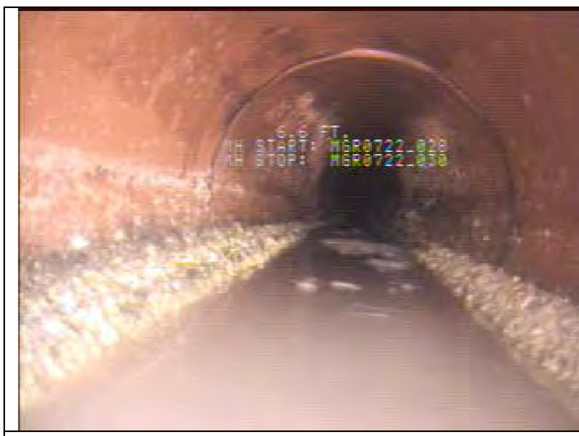
Figure 2.16 OCSD HS15 Immediately after Line Cleaning

The additive set-up for this location was conducted on 1/14/05 by a Supplier C representative. The Supplier C product was dispensed in a liquid form from a holding tank located inside the manhole at MGR0722_028 (photo below). The holding tank was replenished on a weekly basis. No problems with the dispensing unit were encountered during the evaluation.

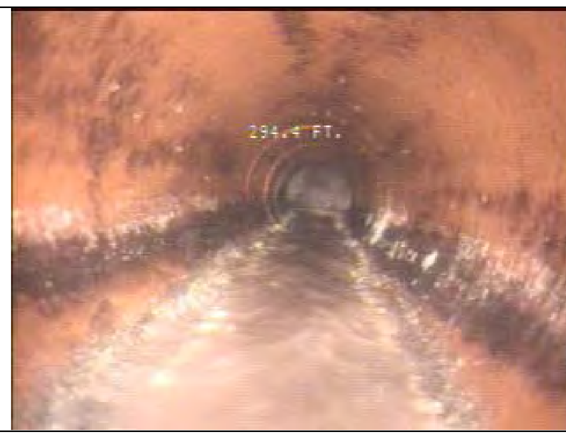
Supplier C Holding Tank/Dispensing Unit

Figure 2.17 Additive Dispenser Setup at OCSD HS27

After 2 months of additive application, CCTV inspection of the untreated and treated pipe segments was conducted and the following images were collected:



Untreated Segment



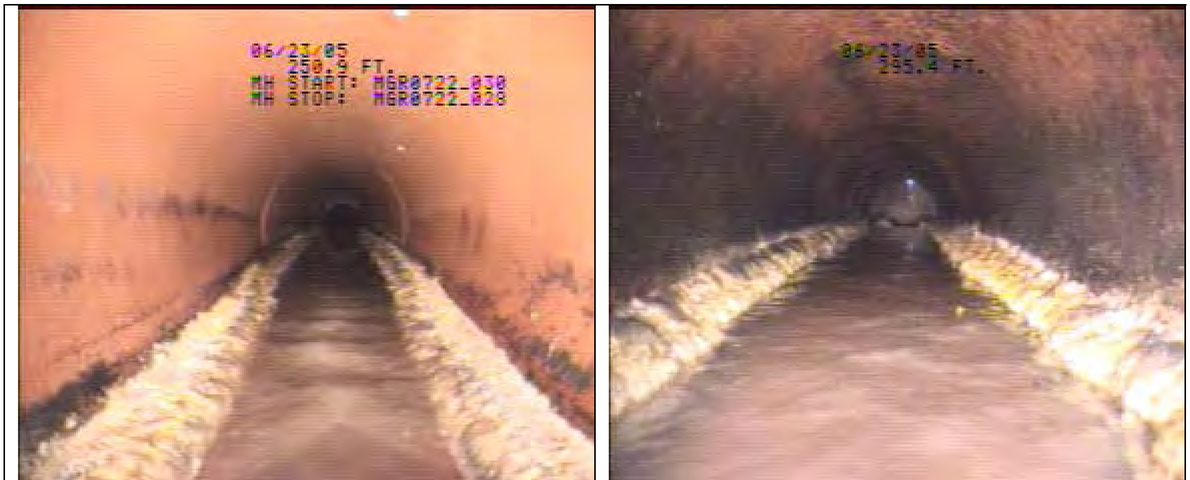
Treated Segment

Figure 2.18 FOG Accumulation 2 Months after Cleaning

CCTV inspections were continued on a monthly basis for this location. Based on the CCTV inspection conducted on 5/6/05, it was determined by OCSD Sewer Maintenance Staff that line cleaning was required in the untreated pipe segment (photos below), but not the treated segment. Cleaning of the untreated segment was conducted by OCSD staff on 5/19/05 and the evaluation was continued in this location.

Untreated Segment	Treated Segment

Figure 2.19 FOG Accumulation 4 Months after Cleaning



Untreated Segment	Treated Segment

Figure 2.20 FOG Accumulation 5.5 Months after Cleaning of the Treated Segment and 5 Weeks after the Second Cleaning of the Untreated Segment

2.5.4.2.3.4 Discussion of Findings

FOG (grease) accumulation was observed in the treated segments of the hot spot after additive addition. In general, the treated segments had less FOG accumulation than the untreated segments. This resulted in the untreated segment needing to be cleaned at 4 months. The treated segment was not cleaned until the termination of the evaluation at 7 months.

Unique Issues:	None
Dispenser Problems:	None identified
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned every 8 weeks prior to the evaluation without the benefit of CCTV monitoring (Ref: Note #1); the untreated segments were cleaned after 4 months of the evaluation due to FOG accumulation based on CCTV monitoring. The treated segment was cleaned after 7 months at the completion of the evaluation. Note: For this hot spot, it was determined that the previous method of line cleaning could be improved through the use of post-cleaning CCTV monitoring and the frequency could then be reduced.
General Effectiveness:	As seen in the photographs, a comparison of the untreated and the treated segments revealed that the FOG accumulation in the treated segments was less than the untreated segments. A comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2).
Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. This product also did not display any emulsification characteristics in the bench scale tests.
Comparison to Effective Line Cleaning:	Due to the accumulation of FOG in the treated section, this additive does not appear to be comparable to effective line cleaning. For this hot spot, this additive may provide an opportunity to reduce the future line cleaning frequency.
Projected Additive Use Cost (Agency):	$540 per month (including service) at a verified dosage of approximately 5 gallons per week (pricing information provided by the supplier).
Other Projected Agency Costs:	$50 per month based on semi-annual CCTV monitoring at a minimum cost of $300 per event to monitor the effectiveness of the additive. There is a potential for the agency to reduce the future line cleaning costs due to potential reduced line cleaning because of the use of the additive.
Total Projected Agency Cost:	$590 per month (not including the potential savings related to reduced line cleaning due to the additive).

2.5.4.2.4 CMSD GS26

2.5.4.2.4.1 Hot Spot General Information

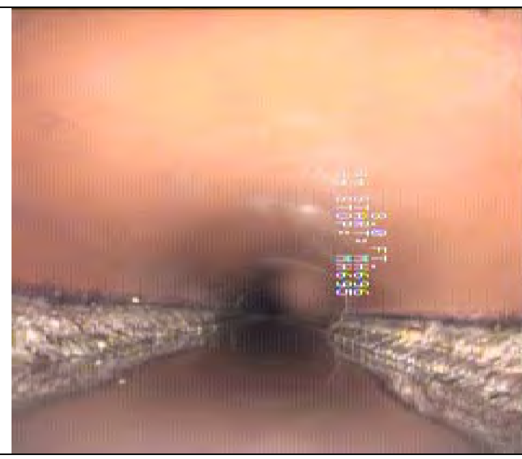
General information concerning the additive evaluation for this hot spot is as follows:

Hot Spot ID:	CMSD GS26	**Cleaning Cycle:**	Weekly
Location:	Sewer Line - Monrovia Ave, South of 19th St, Costa Mesa, CA		
FOG Sources:	Taqueria Granjenal, Hussong's Cantina		
Untreated Section:	250 ft (MH694 to MH695)		
Treated Section:	300 ft (MH695 to MH697)		
Supplier/Product:	Supplier D/Product D		

2.5.4.2.4.2 Hot Spot Summary

Prior to suspension of the sewer cleaning for this evaluation, cleaning in this location was conducted on a weekly basis due to a FOG-like accumulation. FSEs, a laundromat and high density residences discharge directly to the hot spot pipe segments. A low flow condition (due to the proximity to a starter) and slight sags may contribute to grease accumulation in this location. Selection of this location as a candidate for this study was based on CCTV inspections conducted during FOG characterization and confirmed with CCTV inspections prior to the start of this evaluation (see photos below).

Future Untreated Segment - Collected During FOG Confirmation Inspections

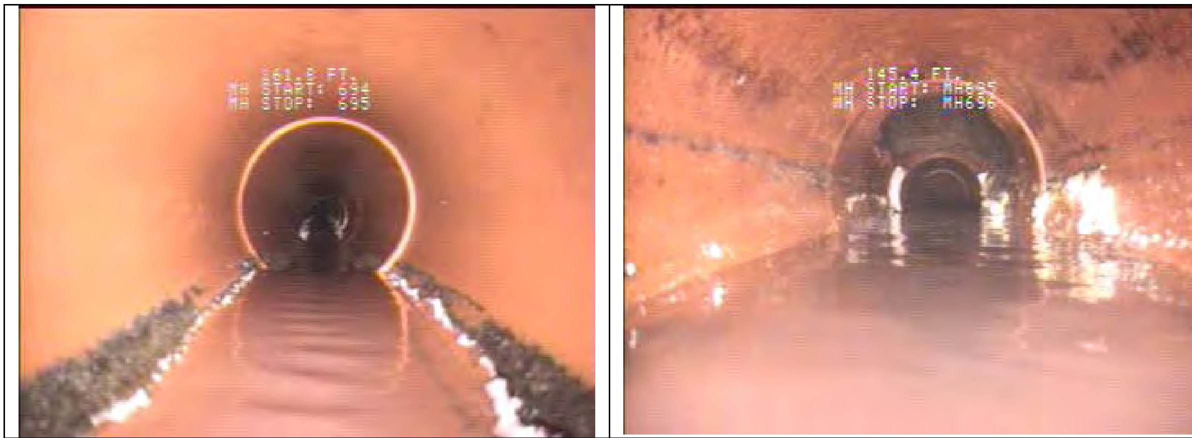


Future Treated Segment - Collected During FOG Confirmation Inspections

Figure 2.21 FOG Accumulation at CMSD GS26 before Field Testing

2.5.4.2.4.3 Field Test

Line cleaning of this location was conducted with a standard jetting nozzle on 1/18/05, followed by CCTV inspection where the following baseline (clean pipe) images were collected:



Untreated Segment — Treated Segment

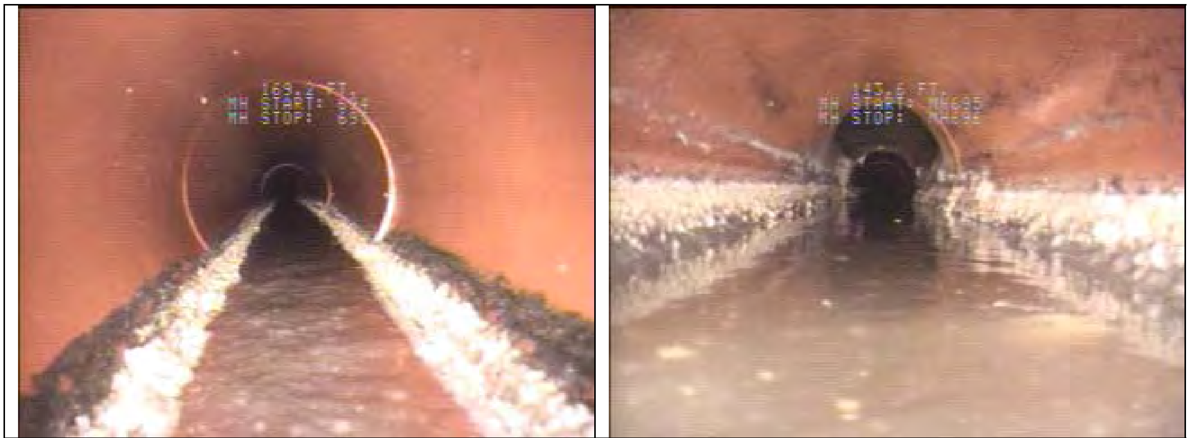
Figure 2.22 CMSD GS26 Immediately after Line Cleaning

The additive setup for this location was conducted on 1/20/05 by a Supplier D representative. The Supplier D product was dispensed in a liquid form from a holding tank located inside the manhole at MH695 (photo below). The holding tank was replenished on a weekly basis. No problems with the dispensing were encountered during the evaluation.

Supplier D's Dispensing Unit — Supplier D's Dispensing Unit

Figure 2.23 Additive Dispenser Setup at CMSD GS26

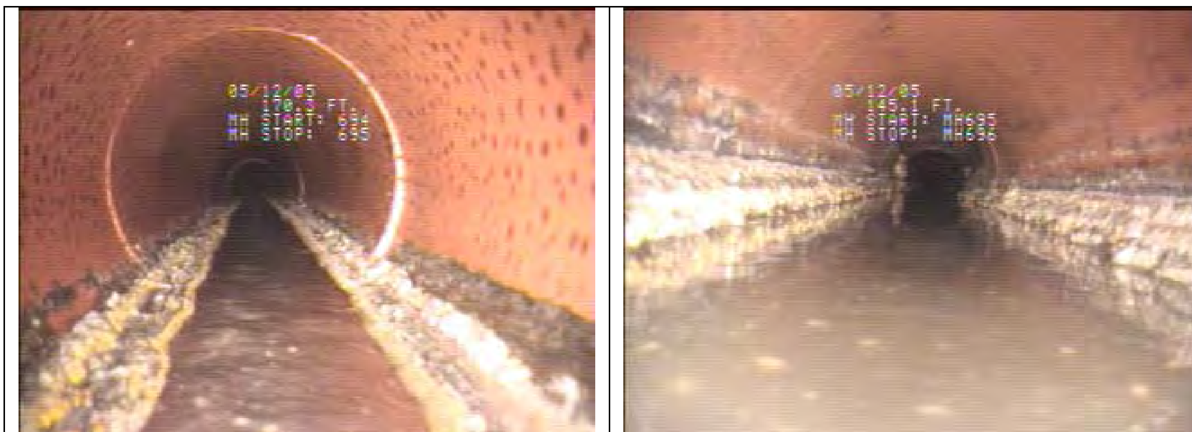
After 1 month of additive application, CCTV inspection of the untreated and treated pipe segments was conducted and the following images were collected:



Untreated Segment	Treated Segment

Figure 2.24 FOG/Residue Accumulation 1 Month after Cleaning

CCTV inspections continued on a monthly basis for this location. From the CCTV inspections, it was determined that line cleaning was not required and the additive evaluation was allowed to continue in this location. This was based on evaluation of the grease accumulation in the untreated and treated pipe segments (photos below).



Untreated Segment	Treated Segment

Figure 2.25 FOG/Residue Accumulation 4 Months after Cleaning

Untreated Segment	Treated Segment

Figure 2.26 FOG/Residue Accumulation 6 Months after Cleaning

2.5.4.2.4.4 Discussion of Findings

What was first thought to be typical FOG accumulation was observed in the treated segments of the hot spot after additive addition, which was slightly greater in some areas than the accumulation in the untreated segments of the hot spot. An analysis was performed on a sample collected from MH695 which identified that a significant portion of the observed FOG accumulation in the treated section appeared to be laundry chemical residue. According to the supplier, this was not a typical application due to the presence of the chemical residue from the upstream laundromat. When the supplier discovered the chemical residue, the supplier asked to be granted a new evaluation at another hot spot without a laundromat. The request was considered by OCSD and EEC, but was not able to be granted due primarily to logistical and fairness issues. For example, all of the suppliers pre-approved their hot spot locations and every hot spot could be said to have some unique circumstance that may make it less than ideal for treatment. The evaluation continued and was completed in 6 months.

Unique Issues:	An unexpectedly low FOG-impacted hot spot. A laundromat discharges to the hot spot causing a significant amount of chemical scale to be combined with the FOG (i.e., FOG Residue) which may have affected the success of the additive.
Dispenser Problems:	None identified
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned weekly prior to the evaluation without the benefit of CCTV monitoring (Ref: Note #1); neither the untreated nor the treated segments were cleaned during the evaluation based on CCTV monitoring of the FOG/Residue accumulation. Note: For this hot spot, it was determined that the previous method of line cleaning could be improved through the use of post-cleaning CCTV monitoring and the frequency could then be reduced.
General Effectiveness:	Due to the presence of chemical scale combined with the FOG, the findings related to effectiveness must take into consideration that the supplier did not expect the additive to be very effective at this hot spot once the chemical scale was identified. Nevertheless, as seen in the photographs, a comparison of the untreated and the treated segments revealed that the FOG/Residue accumulation in the treated segments was similar, and perhaps greater in some areas, than the untreated segments. A comparison of the rate of FOG/Residue accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2).
Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. This product also did not display any emulsification characteristics in the bench scale tests.
Comparison to Effective Line Cleaning:	Due to the accumulation of FOG/Residue in the treated section, this additive does not appear to be comparable to effective line cleaning. For this hot spot, if the line cleaning was improved as recommended, this additive does not appear to provide an opportunity to reduce the future line cleaning frequency.
Projected Additive Use Cost (Agency):	$225 per month at a verified dosage of approximately 5 gallons per week (pricing information provided by the supplier).
Other Projected Agency Costs:	$50 per month based on semi-annual CCTV monitoring at a minimum cost of $300 per event to monitor the effectiveness of the additive.
Total Projected Agency Cost:	$275 per month.

2.5.4.2.5 OCSD HS9

2.5.4.2.5.1 Hot Spot General Information

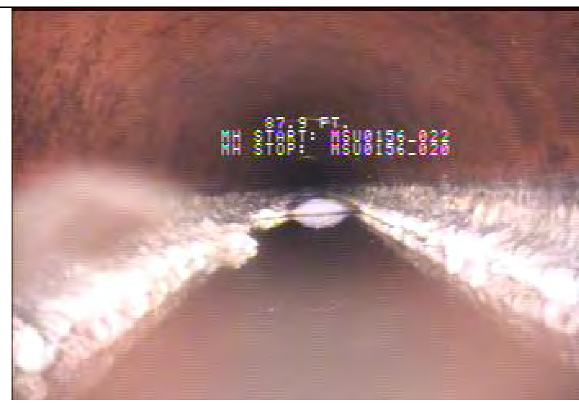
General information concerning the additive evaluation for this hot spot is as follows:

Hot Spot ID:	OCSD HS9	**Cleaning Cycle:**	Every 8 Weeks
Location:	Sewer Line - 2nd St & Centennial Way to Newport, Tustin, CA		
FOG Sources:	Jalepeno's, Tustin Family Donuts, Godfather's Bar & Grill, Naan & Kabob, High Density Residences		
Untreated Section:	275 ft (SUN0390-0070 to SUN0390-0045)		
Treated Section:	581 ft (SUN0390-0045 to SUN0390-0030) (Preble Dr) – 870 ft (SUN0390-0030 to SUN0390-0015) (Main St) – 798 ft (SUN0390-0015 to SUN0390-0000)		
Supplier/Product:	Supplier E/Product E		

2.5.4.2.5.2 Hot Spot Summary

Prior to suspension of the sewer cleaning for this evaluation, cleaning in this mixed residential/commercial location was conducted on an 8-week basis due to grease accumulation from FSEs discharging directly to the hot spot pipe segment. No structural issues were identified as significant contributors to grease accumulation in this location. Selection of this location as a candidate for the study was based on CCTV inspections conducted prior to the start of this study (see photos below).

Future Untreated Segment - Collected During FOG Confirmation Inspections

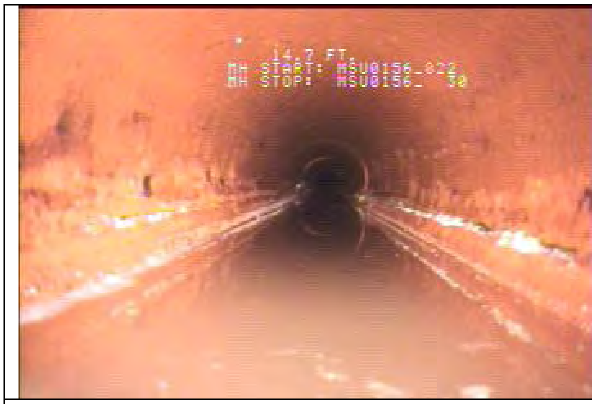


Future Treated Segment - Collected During FOG Confirmation Inspections

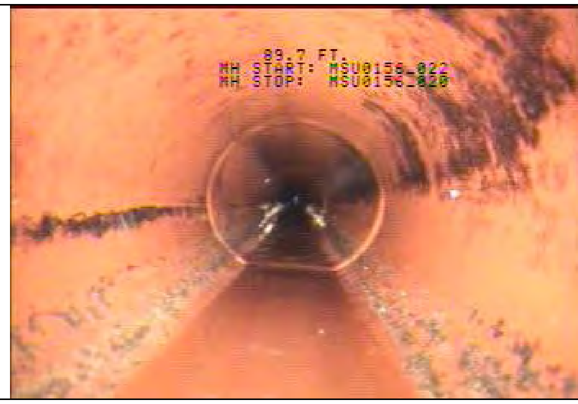
Figure 2.27 FOG Accumulation at OCSD HS9 before Field Testing

2.5.4.2.5.3 Field Test

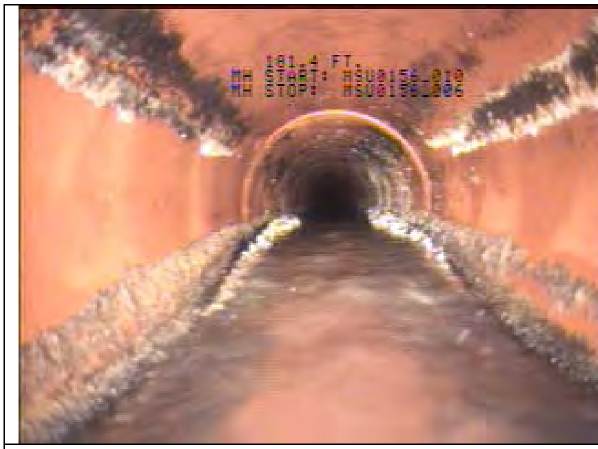
Line cleaning of this hot spot was conducted with a standard jetting nozzle on 1/25/05, followed by CCTV inspection where the following baseline (clean pipe) images were collected:



Untreated Segment



Treated Segment

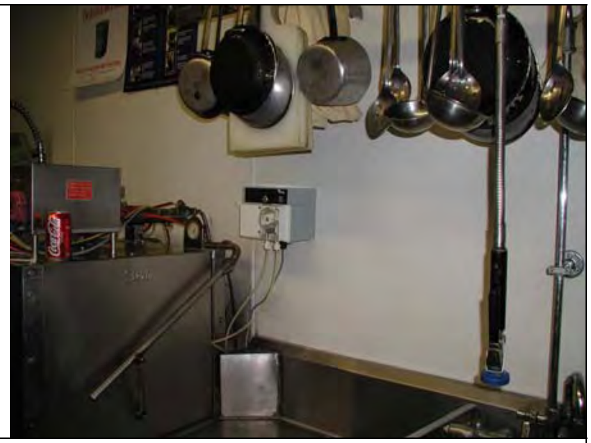


Preble Drive Tail End Segment

Figure 2.28 OCSD HS9 Immediately after Line Cleaning

The additive setup for this location was conducted on 1/26/05 by a Supplier E representative. The Supplier E product was dispensed in a liquid form from a holding tank located inside the Naan & Kabob facility (photos below). The holding tank was replenished on a 2-week basis. No problems or complications were encountered during additive setup and service.

Supplier E Holding Tank (5 Gal Container)

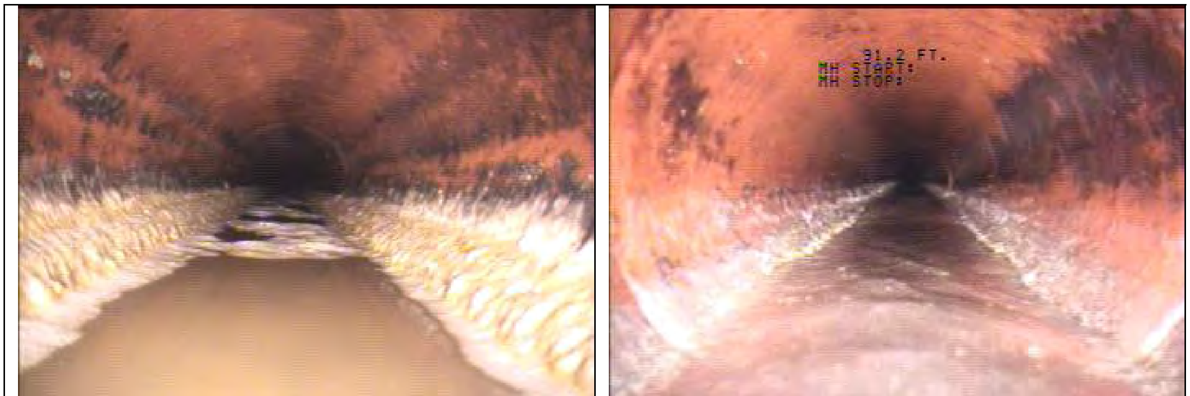


Supplier E Dispensing Unit

Figure 2.29 Additive Dispenser Setup at OCSD HS9

After 1 month of treatment, the untreated and treated segments located north of 2nd St were inadvertently cleaned. Due to this cleaning, the evaluation in this location was delayed by 1 month and was re-started on 3/3/05.

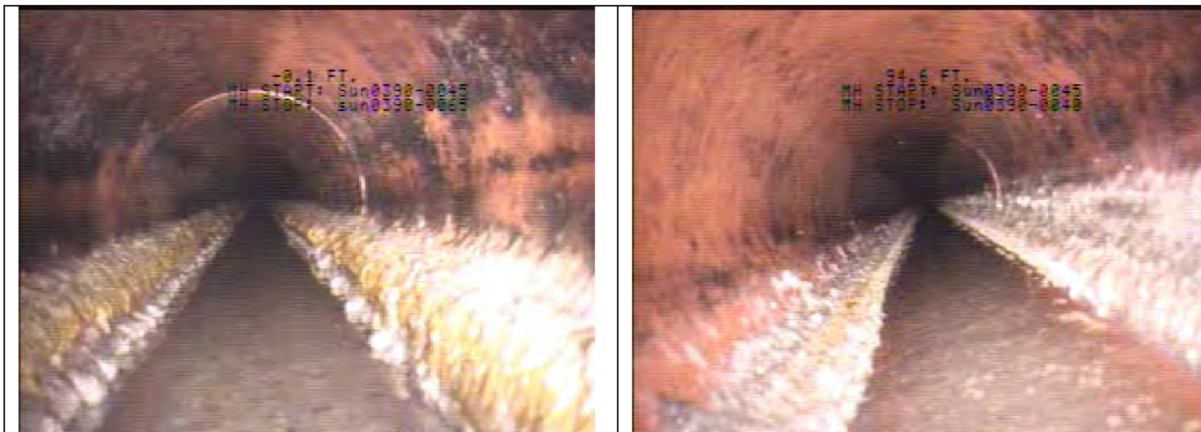
After 1 month of additive application (after evaluation re-start), CCTV inspection of the treated pipe segments was conducted and the following images were collected:



Untreated Segment	Treated Segment

Figure 2.30 FOG Accumulation 1 Month after Cleaning

CCTV inspections were continued on a monthly basis for this location.



Untreated Segment	Treated Segment

Figure 2.31 FOG Accumulation 2 Months after Cleaning

From the CCTV inspection conducted on 4/28/05, it was determined by OCSD Sewer Maintenance Staff that cleaning in the untreated segments was required.

CCTV inspection of the Preble Drive tail end pipe segments was conducted on 5/18/05 and the video was reviewed with OCSD Sewer Maintenance Staff. Based on the observed grease accumulation (photo below), OCSD staff determined that line cleaning was required for the tail end of the treated pipe segments (i.e., the Preble Drive segment) and the evaluation was terminated in this location.

Treated Preble Drive Tail End Segment

Figure 2.32 FOG Accumulation 3.5 Months after Cleaning

2.5.4.2.5.4 Discussion of Findings

FOG (grease) accumulation was observed in the tail end of the treated segments of the hot spot after additive addition and the treated tail end accumulation was similar to the accumulation in the untreated segments of the hot spot during this evaluation. Testing in this location was terminated by OCSD Sewer Maintenance Staff (by requiring the treated segment to be cleaned) after evaluation of the CCTV image of the treated segment 3.5 months after initial application of the additive.

Unique Issues:	The additive was applied at an FSE which discharged to the middle of the hot spot. Portions of the hot spot were inadvertently cleaned after 1 month.
Dispenser Problems:	None identified
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned every 8 weeks prior to the evaluation without the benefit of CCTV monitoring; the untreated and treated segments were cleaned after 3.5 months of the evaluation based on CCTV monitoring of the FOG accumulation. Note: For this hot spot, it was determined that the previous method of line cleaning could be improved through the use of post-cleaning CCTV monitoring and the frequency could then be reduced.
General Effectiveness:	As seen in the photographs, FOG accumulation in the tail end of the treated segments was similar to the accumulation in the untreated segments. A comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2).

Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. Based on observations of the Preble Drive pipe hot spot segment immediately after cleaning, grease accumulation in this tail end pipe segment may be typical for this location. This product also did not display any emulsification characteristics in the bench scale tests.
Comparison to Effective Line Cleaning:	Due to the accumulation of FOG in the treated section, this additive does not appear to be comparable to effective line cleaning. For this hot spot, if the line cleaning was improved as recommended, this additive does not appear to provide an opportunity to reduce the future line cleaning frequency.
Projected Additive Use Cost (Agency):	$154 per month at a verified dosage of approximately 2.5 gallons per week (pricing information provided by the supplier).
Other Projected Agency Costs:	$115 per month based on semi-annual CCTV monitoring at a minimum cost of $700 per event (based on an unusually long hot spot) to monitor the effectiveness of the additive.
Total Projected Agency Cost:	$269 per month.

2.5.4.2.6 COO HS28

2.5.4.2.6.1 Hot Spot General Information

General information concerning the additive evaluation for this hot spot is as follows:

Hot Spot ID:	COO HS28	**Cleaning Cycle:**	Monthly
Location:	Sewer Line - Shattuck St, South of Walnut Ave, Orange, CA		
FOG Sources:	Strip Mall Containing Tacos Jalisco		
Untreated Section:	202 ft (MH3047 to MH3050)		
Treated Section:	559 ft (MH3050 to MH2946)		
Supplier/Product:	Supplier F/Product F		

2.5.4.2.6.2 Hot Spot Summary:

Prior to suspension of the sewer cleaning for this evaluation, cleaning in this mixed residential/commercial location was conducted on a monthly basis due to grease accumulation from an FSE located upstream of the hot spot pipe segments. A severe sag located near the Shattuck/Palm junction contributes to grease accumulation in this location. Selection of this location as a candidate for the study was based on CCTV inspections conducted during FOG characterization and confirmed with CCTV inspections prior to the start of this study (photos below).

	
Future Untreated Segment - Collected During FOG Characterization	Future Treated Segment - Collected During FOG Confirmation Inspections

Figure 2.33 FOG Accumulation at COO HS28 before Field Testing

2.5.4.2.6.3 Field Test

Line cleaning of this location was conducted with a standard jetting nozzle on 1/24/05, followed by CCTV inspection where the following baseline (clean pipe) images were collected:

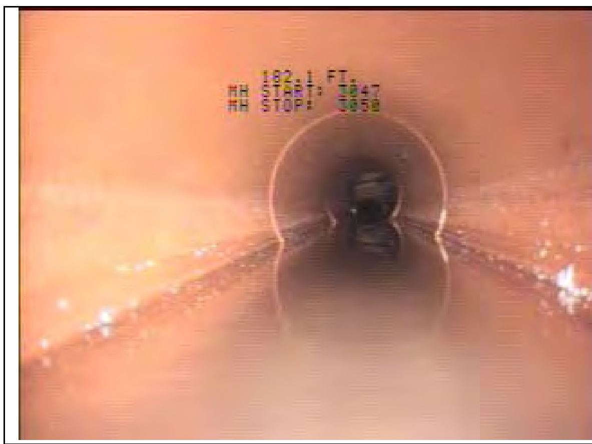
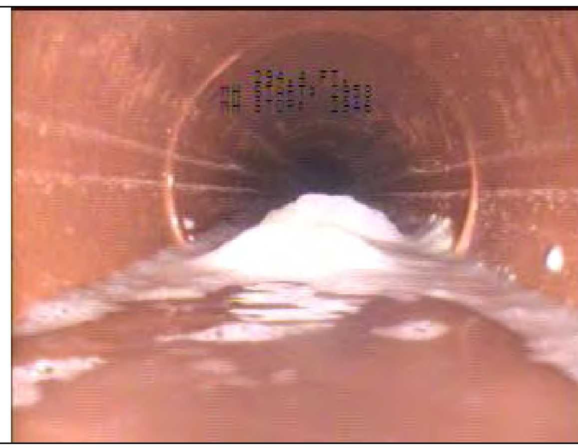
	
Untreated Segment	Treated Segment

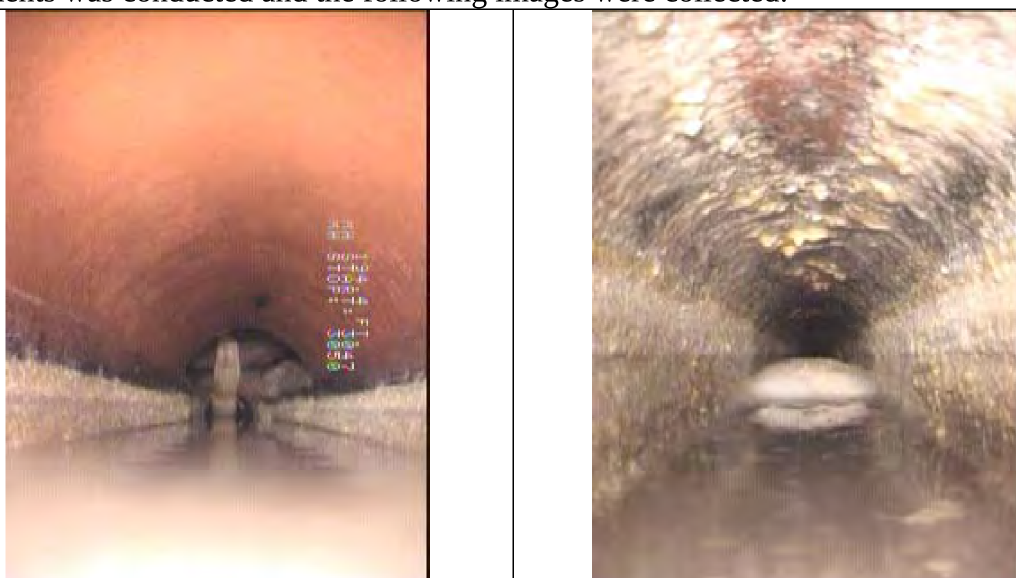
Figure 2.34 COO HS28 Immediately after Line Cleaning

The additive setup for this location was conducted on 1/2605 by a Supplier F representative. The Supplier F product is a dry product contained in a porous bag. The bag is suspended in the manhole channel and dispensed as the flowing wastewater dissolves the product (photo below). Replacement of the product is conducted on a 2-week basis. No problems or complications were encountered during additive setup and replacements.

Supplier F Dispensing Method

Figure 2.35 Additive Dispenser Setup at COO HS28

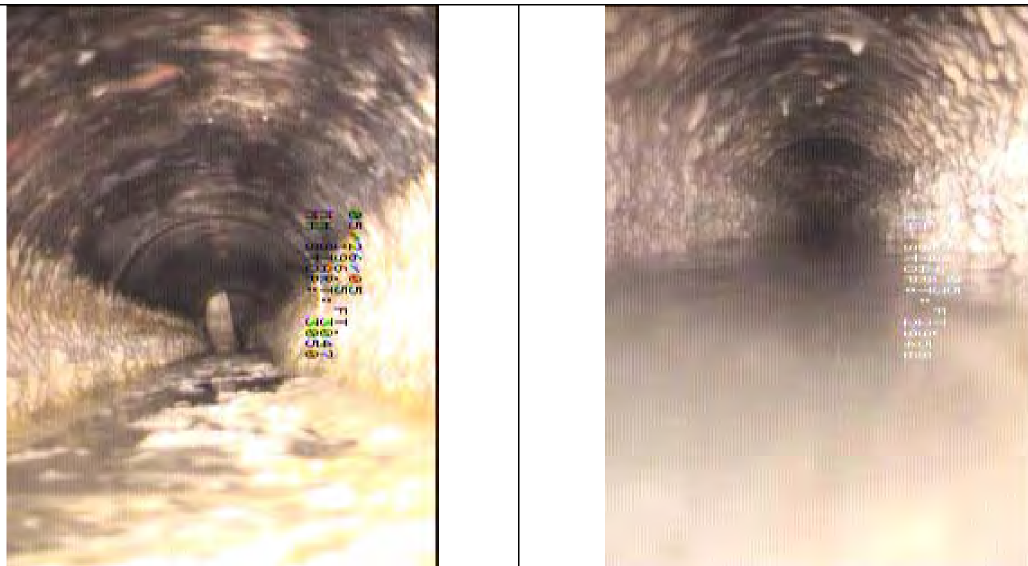
After 1 month of additive application, CCTV inspection of the untreated and treated pipe segments was conducted and the following images were collected:



Untreated Segment	Treated Segment (Severe Sag Area)

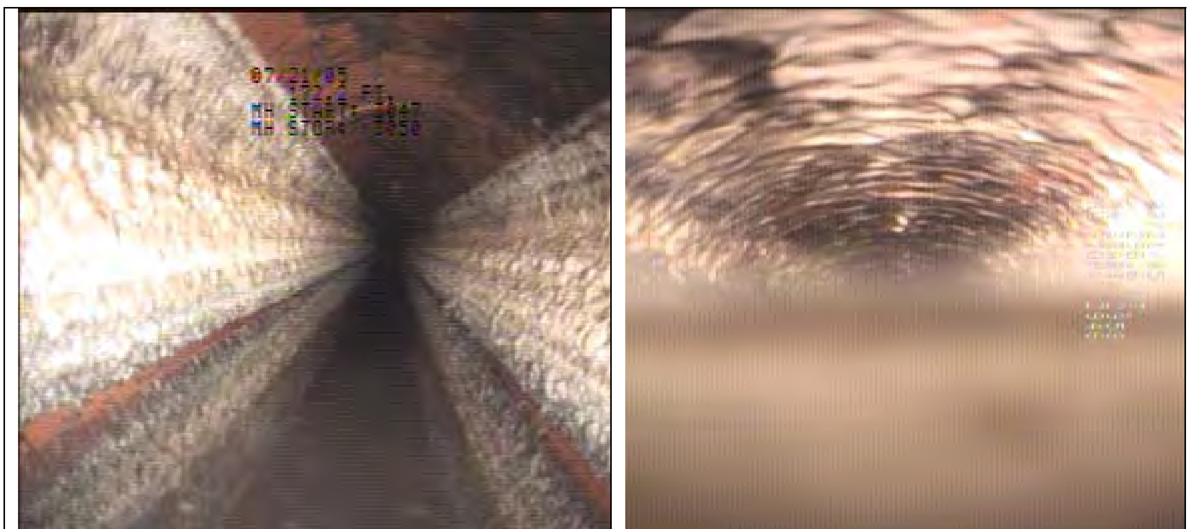
Figure 2.36 FOG Accumulation 1 Month after Cleaning

CCTV inspections continued on a monthly basis for this location. From the CCTV inspections, it was determined by the City of Orange Sewer Maintenance Staff that line cleaning was not required and the additive evaluation was allowed to continue in this location. This was based on evaluation of the grease accumulation in the untreated and treated pipe segments (photos below).



Untreated Segment	Treated Segment (Severe Sag Area)

Figure 2.37 FOG Accumulation 4 Months after Cleaning



Untreated Segment	Treated Segment (Severe Sag Area)

Figure 2.38 FOG Accumulation 6 Months after Cleaning

2.5.4.2.6.4 Discussion of Findings

Significant FOG accumulation was observed in the treated segments of the hot spot after additive addition. The accumulation was most significant in the sag area. Direct comparisons of the untreated and treated line segments could not be made due to the tendency for sags to accumulate FOG at a faster rate than a typical pipe segment (ref: Note #4). Although the FOG accumulation in the sag area was of growing concern, the evaluation continued for 6 months.

Unique Issues:	A severe sag in the treated segment resulted in more accumulation of FOG in the sag area. A laundromat discharged to this hot spot, but no assessment was conducted by the supplier to determine if this affected the additive's results.
Dispenser Problems:	None identified
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned monthly prior to the evaluation without the benefit of CCTV monitoring (ref: Note #1); neither the untreated nor the treated segments were cleaned during the evaluation based on CCTV monitoring of the FOG accumulation. Note: For this hot spot, it was determined that the previous method of line cleaning could be improved through the use of post-cleaning CCTV monitoring and the frequency could then be reduced.
General Effectiveness:	Both the untreated and treated segments had significant grease accumulation that increased over time. A comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2).
Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. This product did not display any emulsification characteristics in the bench scale tests.
Comparison to Effective Line Cleaning:	Due to the accumulation of FOG in the treated section, this additive does not appear to be comparable to effective line cleaning. For this hot spot, due to the sag in the treated segment, it was impossible to determine if the future line cleaning frequency could be reduced by using this additive.
Projected Additive Use Cost (Agency):	$129 per month at a verified dosage of 4 socks per month (pricing information provided by the supplier).
Other Projected Agency Costs:	$167 per month based on quarterly CCTV monitoring at a minimum cost of $500 per event (based on the long length of the hot spot) to monitor the effectiveness of the additive.
Total Projected Agency Cost:	$296 per month.

2.5.4.3 Sewer Line-applied / FSE-applied Hybrid Additives

2.5.4.3.1 COLH HS14

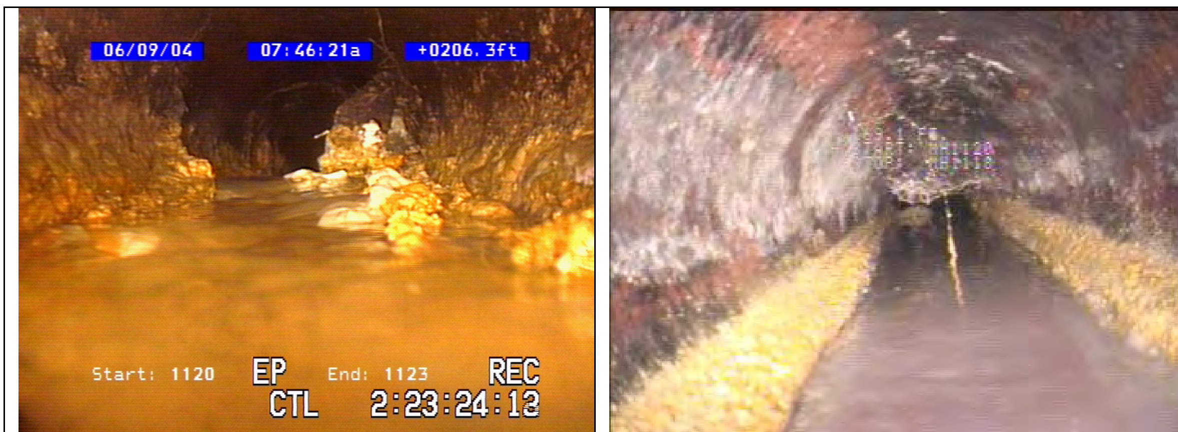
2.5.4.3.1.1 Hot Spot General Information

General information concerning the additive evaluation for this hot spot is as follows:

Hot Spot ID:	COLH HS14	**Cleaning Cycle:**	Quarterly
Location:	Sewer Line - Valencia St and Greenwood Ave, La Habra, CA		
FOG Sources:	Café El Cholo (No GRE)		
Untreated Section:	None		
Treated Section:	614 ft (CO1123 to MH1061)		
Supplier/Product:	Supplier G/Product G		

2.5.4.3.1.2 Hot Spot Summary

Prior to suspension of the sewer cleaning for this evaluation, cleaning in this mixed residential/commercial location was conducted on a quarterly basis due to grease accumulation from an FSE discharging directly to the hot spot pipe segment. A low flow condition due to the proximity of this pipe segment to the starter may contribute to grease accumulation in this location. Selection of this location as a candidate for the study was based on CCTV inspections conducted during FOG characterization and confirmed with CCTV inspections prior to the start of this study (see photos below).

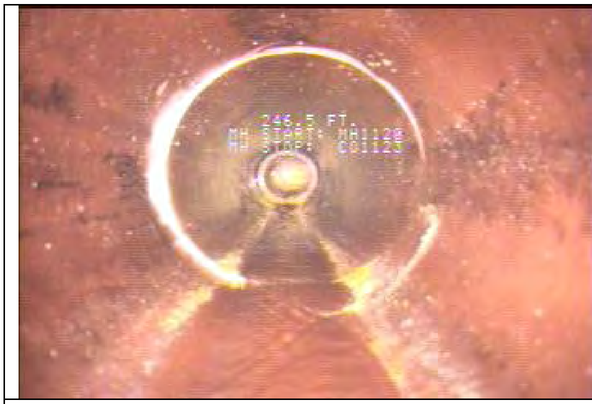


Collected During FOG Characterization	Collected During FOG Confirmation Inspections

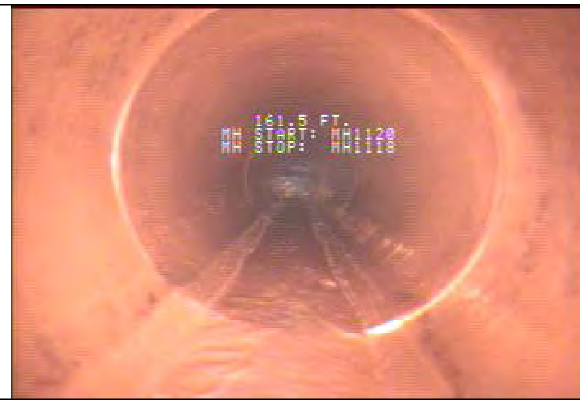
Figure 2.39 FOG Accumulation at COLH HS14 before Field Testing

2.5.4.3.1.3 Field Test

Lateral cleaning was conducted by an FSE contactor on 2/1/05. Line cleaning of this hot spot was conducted with a standard jetting nozzle on 2/2/05, followed by CCTV inspection where the following baseline (clean pipe) images were collected. The images are for the sewer line (depicting the FSE's lateral connection) upstream of the manhole MH1120 and the sewer line downstream of MH1120.



El Cholo's Lateral Connection



Hot Spot Segment, Location #1

Hot Spot Segment, Location #2

Figure 2.40 COLH HS14 Immediately after Line Cleaning

The additive setup for this location was conducted on 2/3/05 by a Supplier G representative. The Supplier G product was dispensed in a liquid form from a holding tank. One dispensing unit was located at a clean-out at the Café El Cholo Facility (photo below). Another dispensing unit was located inside the manhole at MH1120 (photo below). The holding tanks were replenished on a 2-week basis. Problems with the support bracket for the dispensing unit located in the manhole resulted in some dosing inconsistencies.

Supplier G's FSE Mounted Dispensing Unit | Supplier G's Manhole Mounted Dispensing Unit

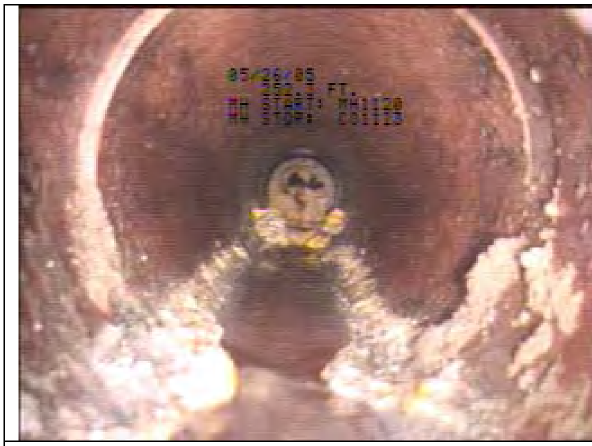
Figure 2.41 Additive Dispenser Setup at COLH HS14

For this application, due to the additive dispensing/application locations in one of the FSE's cleanouts and also in a manhole, there is not an untreated pipe segment to compare with the treated pipe segment results. This is why this application is being called a hybrid between Sewer Line-applied and FSE-applied. CCTV inspections were conducted on a monthly basis for this location for the treated pipe segments upstream and downstream of manhole MH1120. The following images were collected from the CCTV inspection of the treated pipe segments conducted after 3 months of additive application.

Café El Cholo's Lateral Connection | Hot Spot Segment, Location #1

Figure 2.42 FOG Accumulation 3 Months after Cleaning

From the CCTV inspection conducted on 5/26/05, it was determined by La Habra Sewer Maintenance Staff that line cleaning was required and the additive evaluation was terminated in this location. This was based on evaluation of the grease accumulation in the treated segments of this hot spot (photos below).



Café El Cholo Lateral Connection

Hot Spot Segment, Location #1

Hot Spot Segment, Location #2

Figure 2.43 FOG Accumulation 4 Months after Cleaning

2.5.4.3.1.4 Discussion of Findings

FOG (grease) accumulation was observed during this evaluation after additive addition in the treated pipe segment upstream of manhole MH1120 (additive applied at cleanout) and in the treated pipe segments downstream of manhole MH1120 (additive applied in manhole). Testing in this location was terminated by La Habra Sewer Maintenance Staff (by requiring the treated segment to be cleaned) after evaluation of the CCTV image of the treated segments 4 months after initial application of the additive.

Unique Issues:	No untreated hot spot segments to compare with the treated segments. Some of the additive was applied at the FSE; some was applied at a manhole in the middle of the hot spot.
Dispenser Problems:	Dispenser problems caused some dosing inconsistencies.
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned quarterly prior to the evaluation without the benefit of CCTV monitoring (Ref: Note #1); the treated segments were cleaned after 4 months of the evaluation based on CCTV monitoring of the FOG accumulation. Note: For this hot spot, it was determined that the previous method of line cleaning could be improved through the use of post-cleaning CCTV monitoring and the frequency could possibly be reduced.
General Effectiveness:	FOG accumulation in the treated segments was significant enough to require cleaning after 4 months. A comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2). There is insufficient data to determine if the additive provided a benefit.
Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. This product also did not display any emulsification characteristics in the bench scale tests.
Comparison to Effective Line Cleaning:	Due to the accumulation of FOG in the treated section, this additive does not appear to be comparable to effective line cleaning. For this hot spot, there is insufficient data to determine if the future line cleaning frequency could be reduced by using this additive.
Projected Additive Use Cost (Agency):	$238 per month at a verified dosage of approximately 2.5 gallon per month (pricing information provided by the supplier).
Other Projected Agency Costs:	$50 per month based on semi-annual CCTV monitoring at a minimum cost of $300 per event to monitor the effectiveness of the additive.
Total Projected Agency Cost:	$288 per month.

2.5.4.4 FSE-applied Additives

2.5.4.4.1 COLH HS6

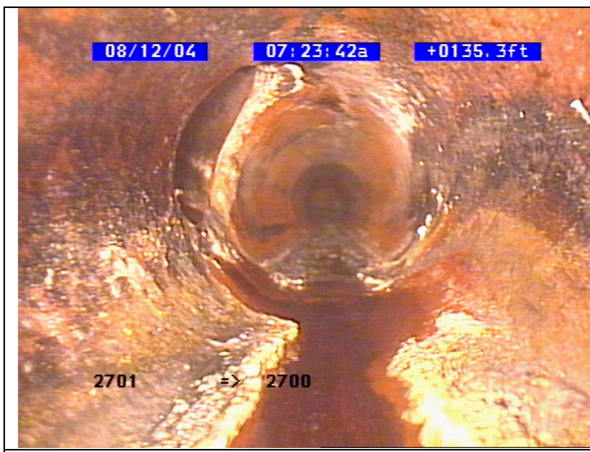
2.5.4.4.1.1 Hot Spot General Information

General information concerning the additive evaluation for this hot spot is as follows:

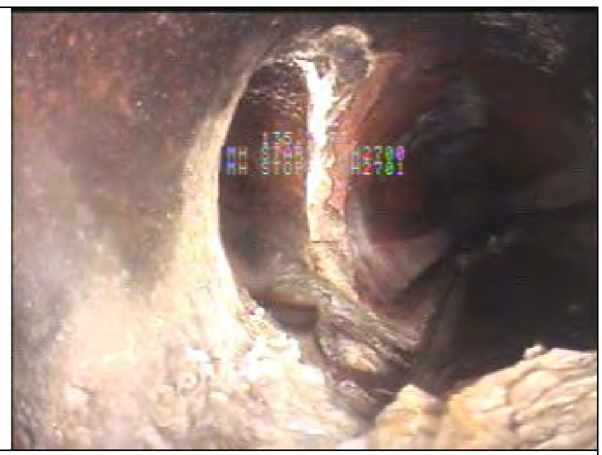
Hot Spot ID:	COLH HS6	**Cleaning Cycle:**	Quarterly
Location:	FSE - Fashion Square Lane, East of Beach Blvd, La Habra, CA		
FSE:	Carrow's Restaurant (No GRE)		
Untreated Section:	None		
Treated Section:	315 ft (MH2701 to MH3363)		
Supplier/Product:	Supplier H/Product H		

2.5.4.4.1.2 Hot Spot Summary

Prior to suspension of the sewer cleaning for this evaluation, cleaning in this location was conducted on a quarterly basis due to grease accumulation from an FSE discharging directly to the hot spot pipe segment. A low flow condition due to the proximity of this pipe segment to the starter may contribute to grease accumulation in this location. Selection of this location as a candidate for the study was based on CCTV inspections conducted during FOG characterization and confirmed with CCTV inspections prior to the start of this study (see photos below).



Collected During FOG Characterization



Collected During FOG Confirmation Inspections

Figure 2.44 FOG Accumulation at COLH HS6 before Field Testing

2.5.4.4.1.3 Field Test

Lateral cleaning was conducted by an FSE contactor on 1/3/05. Line cleaning of this hot spot was conducted with a standard jetting nozzle on 1/4/05, followed by CCTV inspection, where the following baseline (clean pipe) images were collected:

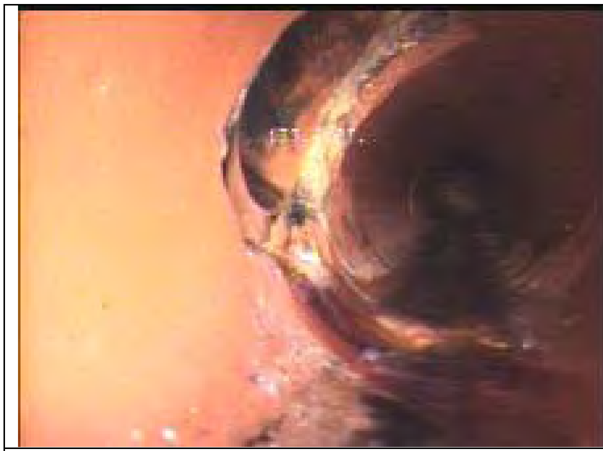
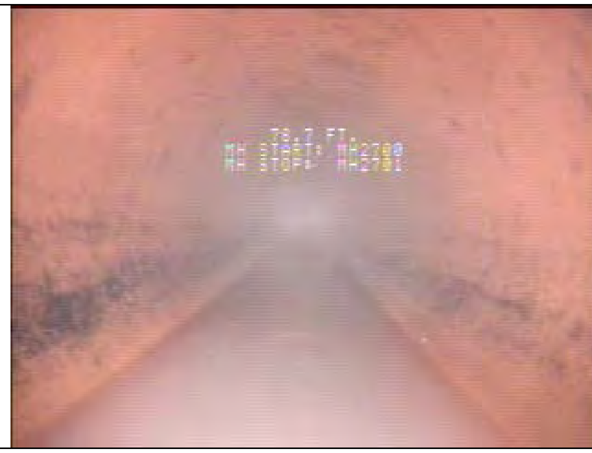
	
Carrow's Lateral Connection	Hot Spot Segment

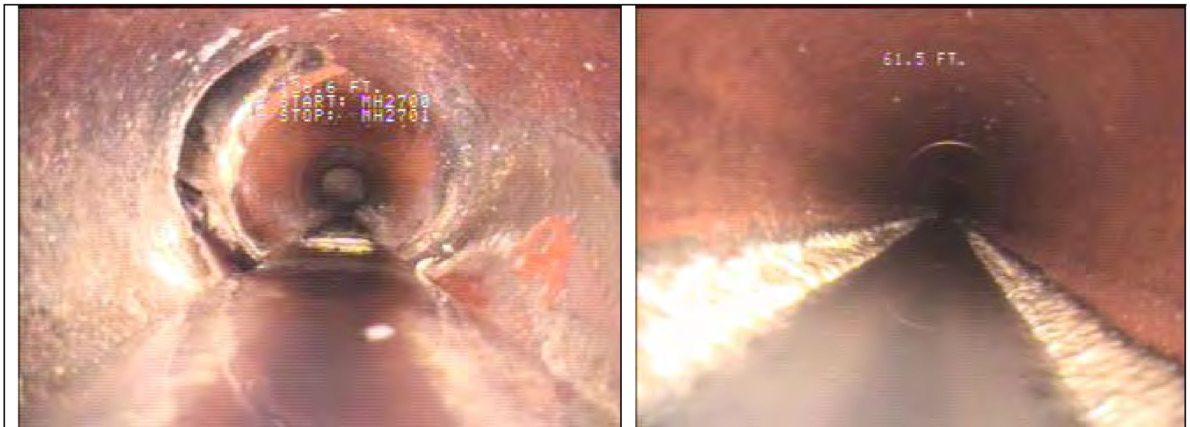
Figure 2.45 COLH HS6 Immediately after Line Cleaning

The additive setup for this location was conducted on 1/6/05 by a Supplier H representative. The Supplier H product is dispensed in a liquid form from a holding tank located inside the Carrow's facility (photo below). The holding tank is replenished on a 2-week basis. No problems or complications were encountered during additive setup and service.

Supplier H Holding Tank

Figure 2.46 Additive Dispenser Setup at COLH HS6

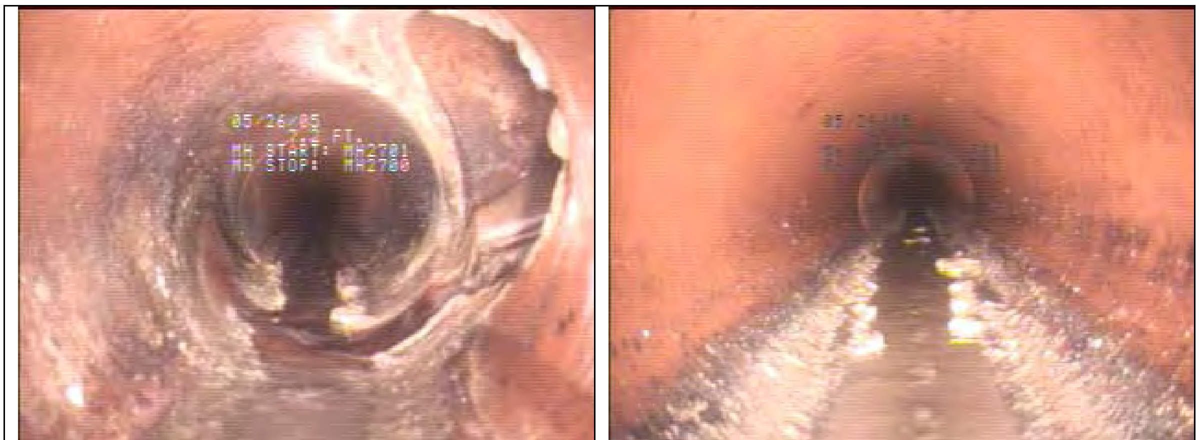
After 3 months of additive application, CCTV inspection of the treated pipe segments was conducted, and the following images were collected:



Carrow's Lateral Connection	Hot Spot Segment

Figure 2.47 FOG Accumulation 3 Months after Cleaning

CCTV inspections continued on a monthly basis for this location. From the CCTV inspections, it was determined by La Habra Sewer Maintenance Staff that line cleaning was not required and the additive evaluation was allowed to continue in this location. This was based on evaluation of the grease accumulation at the lateral connection and in the hot spot pipe segments downstream of this lateral (photos below).



Carrow's Lateral Connection	Hot Spot Segment

Figure 2.48 FOG Accumulation 5 Months after Cleaning

2.5.4.4.1.4 Discussion of Findings

Some FOG (grease) accumulation in the hot spot and the end of the lateral was observed after the addition of the additive, but not as much as anticipated based on the type of FSE and the fixtures in the kitchen. It is important to note that this FSE made a concerted effort to improve their kitchen best management practices (BMPs) at the same time that the Study was initiated because the FSE was identified by the City as a significant source of FOG. This was why this FSE was chosen a candidate for the Study. In this evaluation, it is impossible to determine if the less-than-anticipated FOG accumulation was due to the additive or improved kitchen BMPs, or both.

Unique Issues:	None
Dispenser Problems:	None identified
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned quarterly prior to the evaluation without the benefit of CCTV monitoring; the treated segments were not cleaned during the 6 month evaluation based on CCTV monitoring of the FOG accumulation.
General Effectiveness:	Some FOG accumulation in the treated segments was observed. A direct comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2); however, the FOG accumulation was not as much as anticipated. There was insufficient data to determine if the additive, or improved kitchen BMPs, or both, provided a benefit in this hot spot location (ref. Note #3 and the discussion above).
Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. This product also did not display any emulsification characteristics in the bench scale tests.
Projected Additive Use Cost (FSE):	$395-$595 per month at a verified dosage of approximately 2 gallons per day (pricing information provided by the supplier).
Projected Agency Costs:	$50 per month based on semi-annual CCTV monitoring at a minimum cost of $300 per event to monitor the effectiveness of the additive.

2.5.4.4.2 GGSD HS106

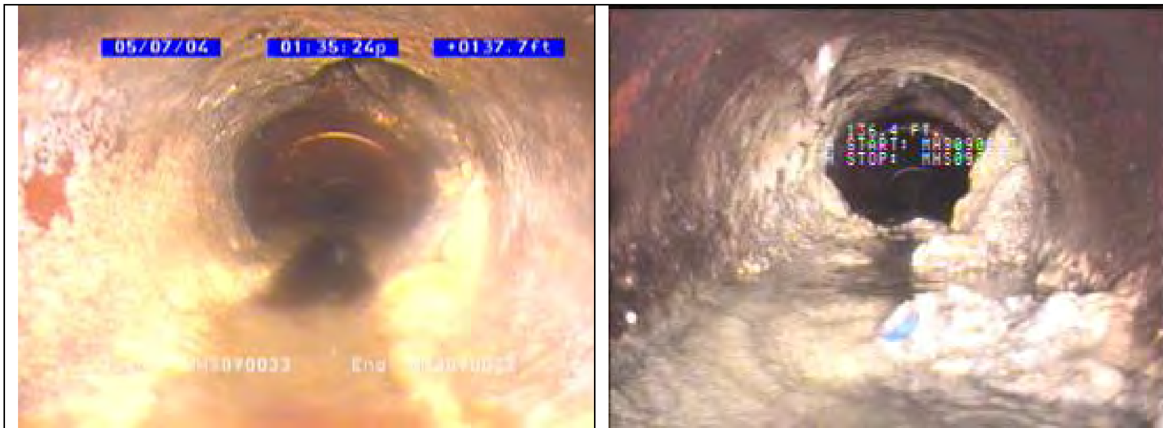
2.5.4.4.2.1 Hot Spot General Information

General information concerning the additive evaluation for this hot spot is as follows:

Hot Spot ID:	GGSD HS106	**Cleaning Cycle:**	Monthly
Location:	FSE - Harbor Blvd South of Chapman, Garden Grove, CA		
FSE:	Coco's Restaurant (No GRE)		
Untreated Section:	None		
Treated Section:	650 ft (MHS090032 to MHS090034)		
Supplier/Product:	Supplier I/Product I		

2.5.4.4.2.2 Hot Spot Summary

Prior to suspension of the sewer cleaning for this evaluation, cleaning in this location was conducted on a monthly basis due to grease accumulation from an FSE discharging directly to the hot spot pipe segment. A low flow condition due to the proximity of this pipe segment to the starter may contribute to grease accumulation in this location. Selection of this location as a candidate for the study was based on CCTV inspections conducted during FOG characterization and confirmed with CCTV inspections prior to the start of this study (see photos below).

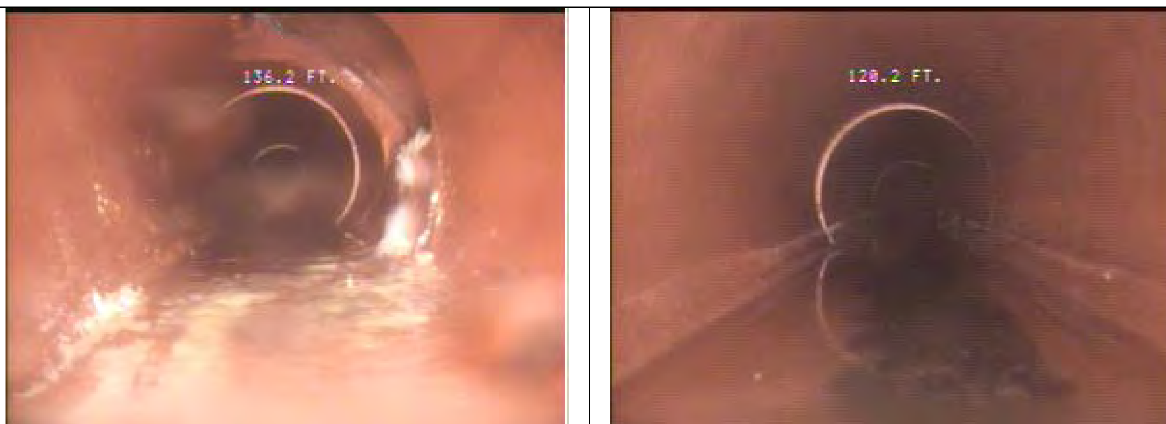


Collected During FOG Characterization	Collected During FOG Confirmation Inspections

Figure 2.49 FOG Accumulation at GGSD HS106 before Field Testing

2.5.4.4.2.3 Field Test

Lateral cleaning was conducted by an FSE contactor on 1/13/05. Line cleaning of this hot spot was conducted with a standard jetting nozzle on 1/13/05, followed by CCTV inspection where the following baseline (clean pipe) images were collected:



Coco's Lateral Connection	Hot Spot Segment

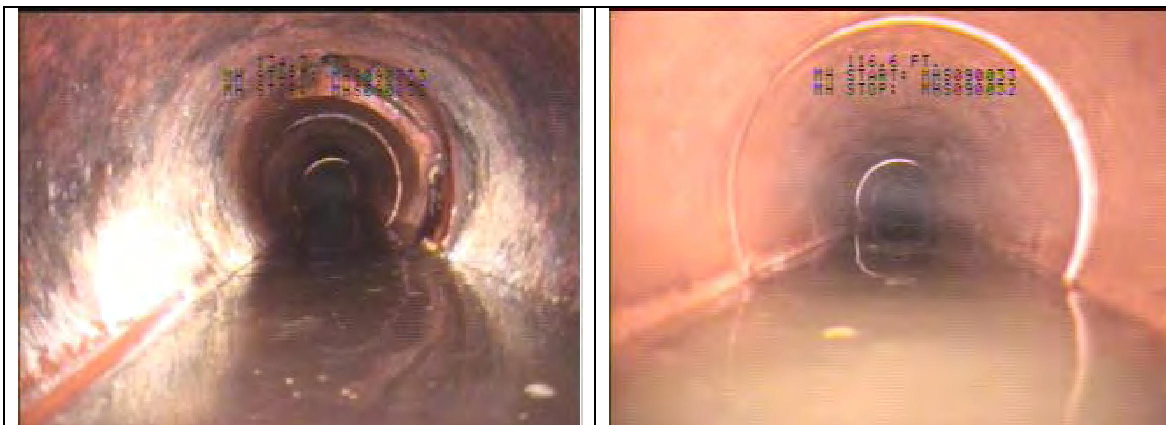
Figure 2.50 GGSD HS106 Immediately after Line Cleaning

The additive setup for this location was conducted on 1/14/05 by a Supplier I representative. The Supplier I product was dispensed in a liquid form from a holding tank located inside the Coco's facility (photo below). The holding tank was replenished on a monthly basis. Each of the 14 drains in the facility were also sprayed with the Supplier I product by a Supplier I representative on a weekly basis. No problems or complications were encountered during additive setup and service.

Supplier I Holding Tank/Dispensing Unit

Figure 2.51 Additive Dispenser Setup at GGSD HS106

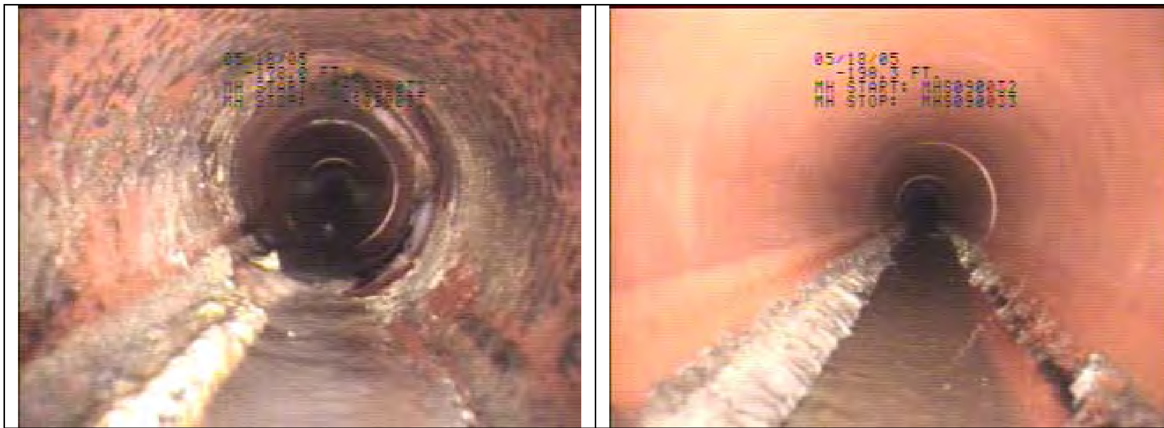
After 1 month of additive application, CCTV inspection of the treated pipe segments was conducted and the following images were collected:



Coco's Lateral Connection	Hot Spot Segment

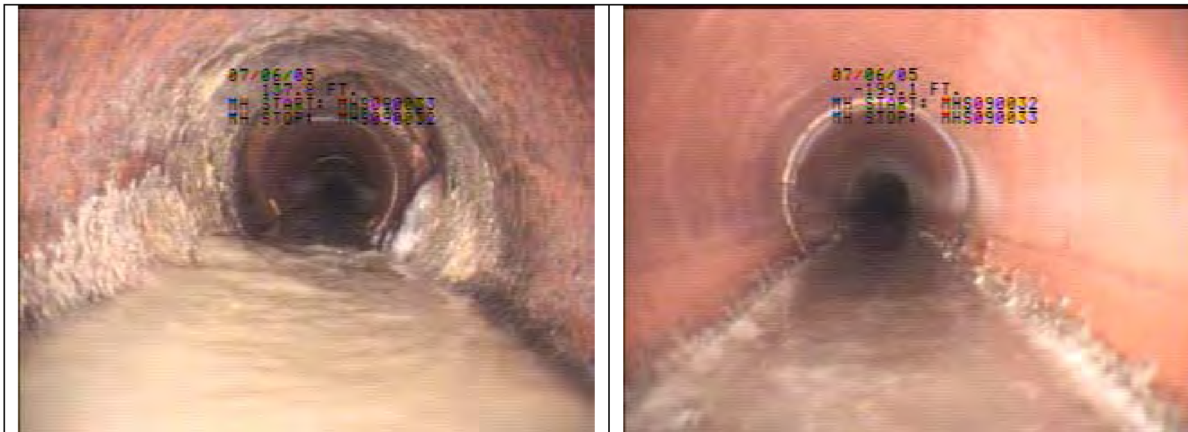
Figure 2.52 FOG Accumulation 1 Month after Cleaning

CCTV inspections continued on a monthly basis for this location. From the CCTV inspections, it was determined by GGSD Sewer Maintenance Staff that line cleaning was not required and the additive evaluation was allowed to continue in this location. This was based on evaluation of the grease accumulation at the lateral connection and in the hot spot pipe segments downstream of the lateral (photos below).



Coco's Lateral Connection	Hot Spot Segment

Figure 2.53 FOG Accumulation 4.5 Months after Cleaning



Coco's Lateral Connection	Hot Spot Segment

Figure 2.54 FOG Accumulation 6 Months after Cleaning

2.5.4.4.2.4 Discussion of Findings

Some FOG (grease) accumulation in the hot spot and the end of the lateral was observed after the addition of the additive, but not as much as anticipated based on the type of FSE and the fixtures in the kitchen. It is important to note that this FSE made a concerted effort to improve their kitchen best management practices (BMPs) at the same time that the Study was initiated because the FSE was identified by the District as a significant source of FOG. This was why this FSE was chosen a candidate for the Study. In this evaluation, it is impossible to determine if the less-than-anticipated FOG accumulation was due to the additive or improved kitchen BMPs, or both.

Unique Issues:	None
Dispenser Problems:	None identified
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned monthly prior to the evaluation without the benefit of CCTV monitoring; the treated segments were not cleaned during the 6 month evaluation based on CCTV monitoring of the FOG accumulation.

General Effectiveness:	Some FOG accumulation in the treated segments was observed. A direct comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2); however, the FOG accumulation was not as much as anticipated. There was insufficient data to determine if the additive, or improved kitchen BMPs, or both, provided a benefit in this hot spot location (ref. Note #3 and the discussion above).
Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. This product also did not display any emulsification characteristics in the bench scale tests.
Projected Additive Use Cost (FSE):	$80 per month at a verified dosage of approximately 5 gallons per month (pricing information provided by the supplier).
Projected Agency Costs:	$50 per month based on semi-annual CCTV monitoring at a minimum cost of $300 per event to monitor the effectiveness of the additive.

2.5.4.4.3 OCSD HS30

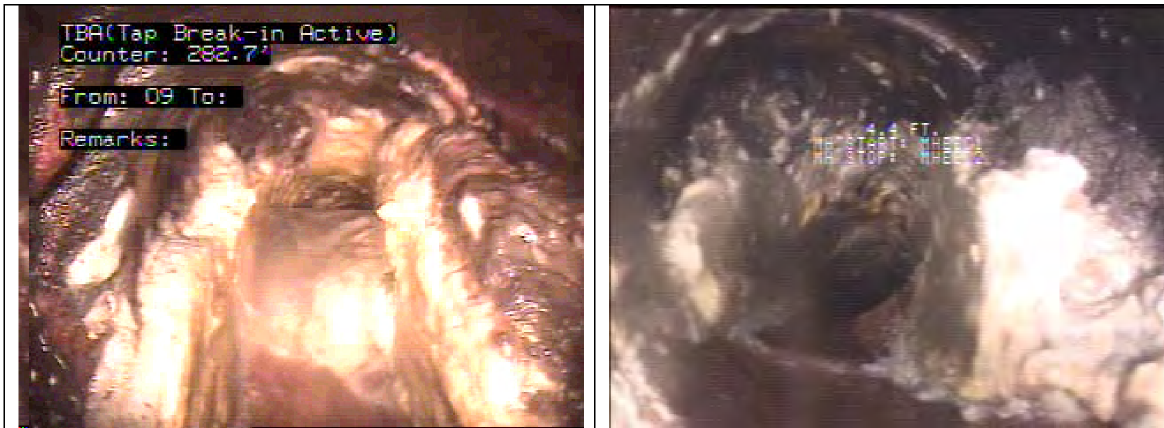
2.5.4.4.3.1 Hot Spot General Information

General information concerning the additive evaluation for this hot spot is as follows:

Hot Spot ID:	OCSD HS30	**Cleaning Cycle:**	Every 8 weeks
Location:	FSE - Park St South of Chapman, Orange, CA		
FSE:	Moreno's Restaurant (No GRE)		
Untreated Section:	None		
Treated Section:	650ft (MGR1118_008 to MGR1118_004)		
Supplier/Product:	Supplier J/Product J		

2.5.4.4.3.2 Hot Spot Summary

Prior to suspension of the sewer cleaning for this evaluation, cleaning in this location was conducted on an 8-week basis due to grease accumulation from an FSE discharging directly to the hot spot pipe segment. A low flow condition due to the proximity of this pipe segment to the starter may contribute to grease accumulation in this location. Selection of this location as a candidate for the study was based on CCTV inspections conducted during FOG characterization and confirmed with CCTV inspections prior to the start of this study (see photos below).

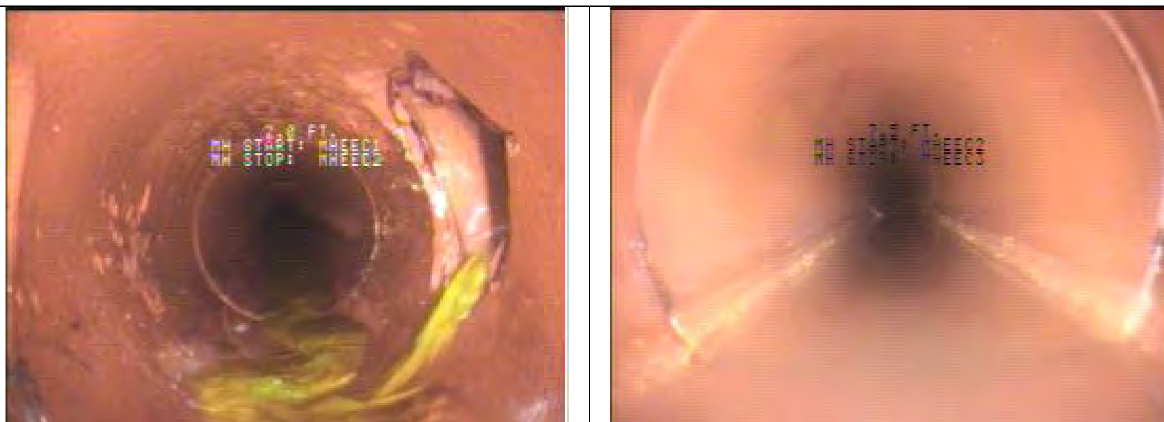


Collected During FOG Characterization	Collected During FOG Confirmation Inspections

Figure 2.55 FOG Accumulation at OCSD HS30 before Field Testing

2.5.4.4.3.3 Field Test

Lateral cleaning was conducted by an FSE contactor on 1/11/05. Line cleaning of this hot spot was conducted with a standard jetting nozzle on 1/12/05, followed by CCTV inspection where the following baseline (clean pipe) images were collected:



Moreno's Lateral Connection	Hot Spot Segment

Figure 2.56 OCSD HS30 Immediately after Line Cleaning

The additive setup for this location was conducted on 1/13/05 by a Supplier J representative. The Supplier J product is a dry product that was mixed with water and dispensed by Moreno's personnel (photos below). The product was dispended into 3 facility sinks twice daily. No known problems or complications were encountered during additive setup and service.

Supplier J Mixing/Dispensing Container

Figure 2.57 Additive Dispenser Setup at OCSD HS30

After 2 months of additive application, CCTV inspection of the treated pipe segments was conducted and the following images were collected:

Moreno's Lateral Connection

Hot Spot Segment

Figure 2.58 FOG Accumulation 2 Months after Cleaning

CCTV inspections were continued on a monthly basis for this location. From the CCTV inspection conducted on 5/5/05, it was determined that line cleaning was required and the additive evaluation was terminated in this location by OCSD Sewer Maintenance Staff. This was based on evaluation of the grease accumulation at the lateral connection and in the hot spot pipe segments downstream of this lateral (photos below).

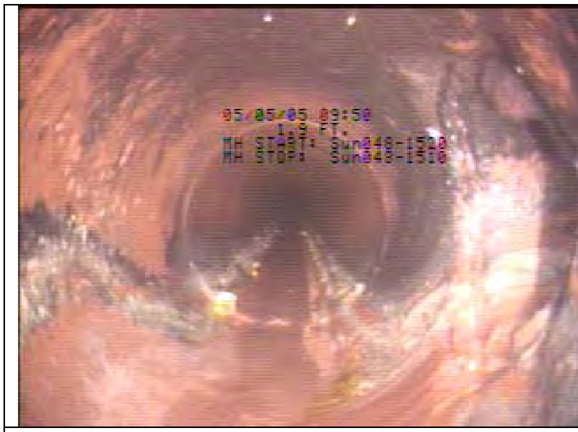
	
Moreno's Lateral Connection	Hot Spot Segment

Figure 2.59 FOG Accumulation 4 Months after Cleaning

2.5.4.4.3.4 Discussion of Findings

Significant FOG (grease) accumulation in the sewer pipe after the addition of the additive was observed. Testing in this location was terminated by OCSD Sewer Maintenance Staff (by requiring the hot spot pipe segments to be cleaned) after evaluation of the CCTV image of the pipe segments 4 months after initial application of the additive.

Unique Issues:	The additive was added manually each day by FSE personnel.
Dispenser Problems:	Not Applicable
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned every 8 weeks prior to the evaluation without the benefit of CCTV monitoring; the treated segments were cleaned after 4 months of the evaluation based on CCTV monitoring of the FOG accumulation
General Effectiveness:	Significant FOG accumulation in the treated segments was observed. A comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2). There was insufficient data to determine if the additive provided a benefit in this hot spot location (ref. Note #3).
Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. This product also did not display any emulsification characteristics in the bench scale tests.
Projected Additive Use Cost (FSE):	$150 per month at a verified dosage of approximately 8 ounces per day (pricing information provided by the supplier).
Projected Agency Costs:	$50 per month based on semi-annual CCTV monitoring at a minimum cost of $300 per event to monitor the effectiveness of the additive.

2.5.4.4.4 CMSD HS14

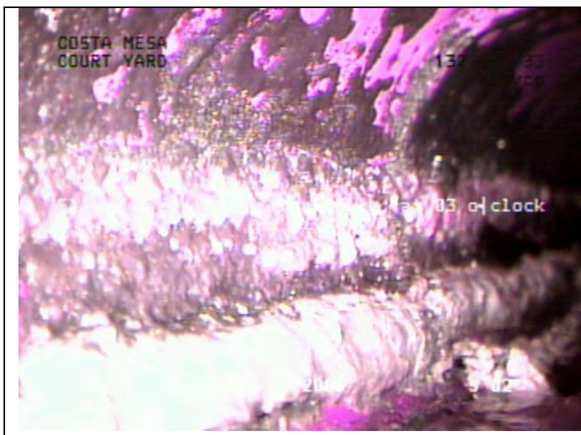
2.5.4.4.4.1 Hot Spot General Information

General information concerning the additive evaluation for this hot spot is as follows:

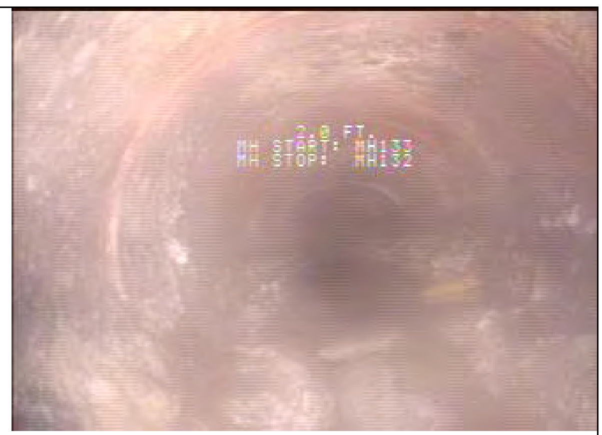
Hot Spot ID:	CMSD HS14	**Cleaning Cycle:**	Weekly
Location:	FSE - Newport Blvd, West of Harbor, Costa Mesa, CA		
FSE:	Mimi's Café (No GRE)		
Untreated Section:	None		
Treated Section:	575 ft (MH132 to MH123)		
Supplier/Product:	Supplier K/Product K		

2.5.4.4.4.2 Hot Spot Summary

Prior to suspension of the sewer cleaning for this evaluation, cleaning in this location was conducted on a weekly basis due to grease accumulation from an FSE discharging directly to the hot spot pipe segment. No structural issues were identified as significant contributors to grease accumulation in this location Selection of this location as a candidate for the study was based on CCTV inspections conducted during FOG characterization and confirmed with CCTV inspections prior to the start of this study (see photos below).



Collected During FOG Characterization

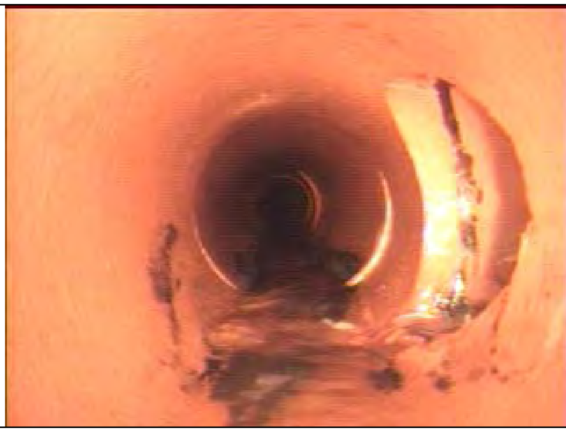


Collected During FOG Confirmation Inspections

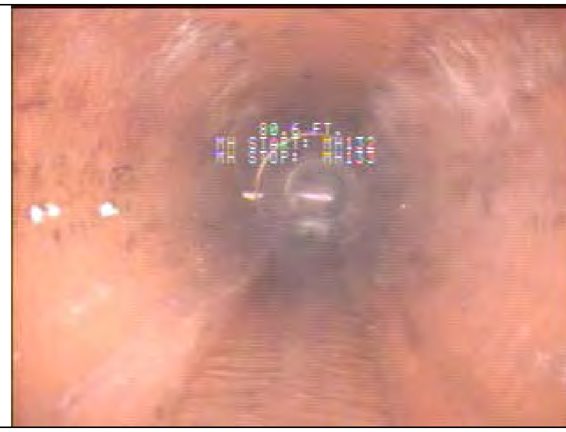
Figure 2.60 FOG Accumulation at CMSD HS14 before Field Testing

2.5.4.4.4.3 Field Test

Lateral cleaning was conducted by an FSE contactor on 1/18/05. Line cleaning of this hot spot was conducted with a standard jetting nozzle on 1/19/05, followed by CCTV inspection where the following baseline (clean pipe) images were collected:



Mimi's Lateral Connection



Hot Spot Segment

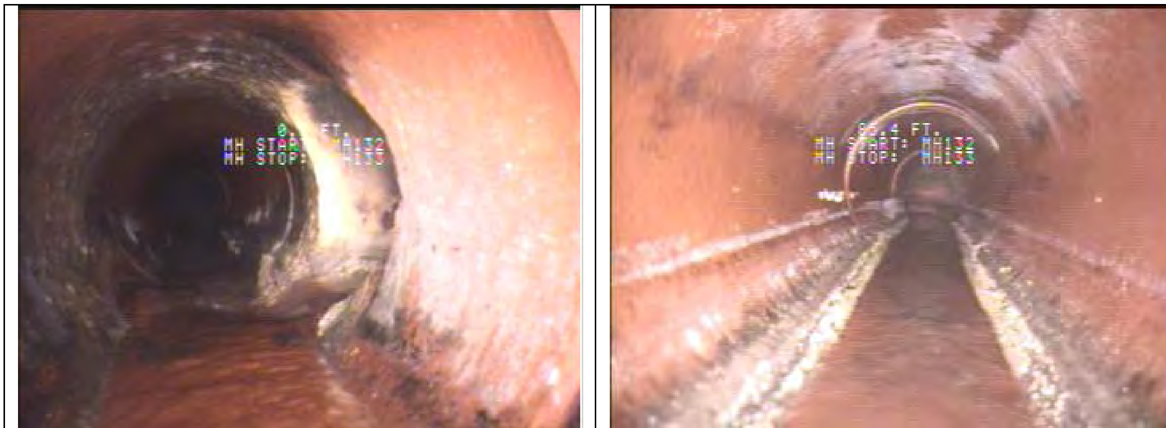
Figure 2.61 CMSD HS14 Immediately after Line Cleaning

The additive setup for this location was conducted on 1/20/05 by a Supplier K representative. The Supplier K product is dispensed in a liquid form to a single drain inside the facility (photo below). A dispensing unit electrical problem caused a 2 week delay at start-up. No other problems or complications were encountered during the evaluation.

Supplier K Dispensing Unit

Figure 2.62 Additive Dispenser Setup at CMSD HS14

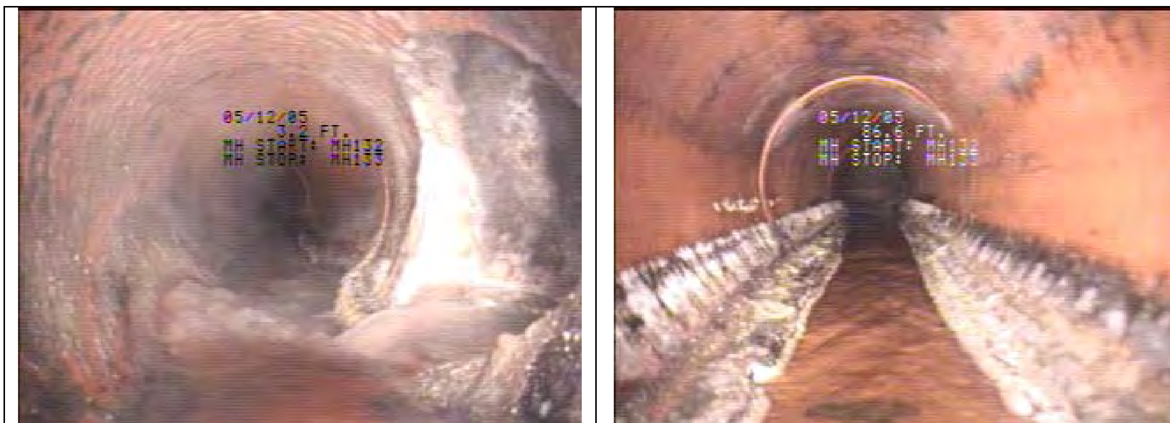
After 1 month of additive application, CCTV inspection of the treated pipe segments was conducted and the following images were collected:



Mimi's Lateral Connection	Hot Spot Segment

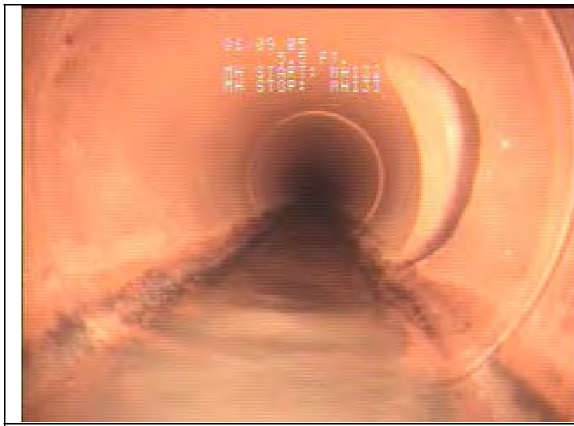
Figure 2.63 FOG Accumulation 1 Month after Cleaning

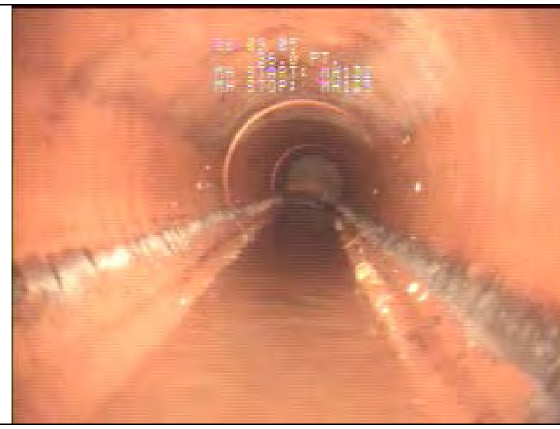
CCTV inspections continued on a monthly basis for this location. From the CCTV inspections, it was determined that line cleaning was not required and the additive evaluation was allowed to continue in this location. This was based on evaluation of the grease accumulation at the lateral connection and in the hot spot pipe segments downstream of this lateral (photos below).



Mimi's Lateral Connection	Hot Spot Segment

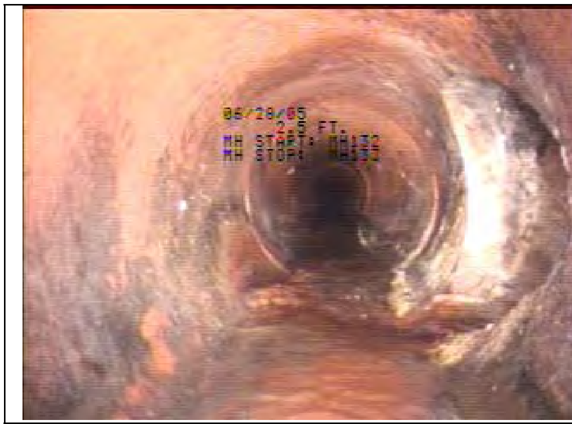
Figure 2.64 FOG Accumulation 4 Months after Cleaning





Mimi's Lateral Connection	Hot Spot Segment

Figure 2.65 FOG Accumulation 5 Months after Cleaning (inadvertent line cleaning was most likely conducted)



Mimi's Lateral Connection	Hot Spot Segment

Figure 2.66 FOG Accumulation 5.5 Months after Cleaning

Mimi's Lateral Connection	Hot Spot Segment

Figure 2.67 FOG Accumulation 6.5 Months after Cleaning

Between the 4^{th} and 5^{th} months of evaluation in this location, a significant decrease in grease accumulation was observed at the Mimi's lateral connection and in the hot spot segment (see photos above). Follow-up CCTV inspections were conducted to investigate the cause of the dramatic decrease in accumulation. During the follow-up CCTV inspections, increased grease accumulation was observed at the Mimi's lateral connection and in the hot spot segment, indicating that the grease removal was most likely due to inadvertent line cleaning rather than attributable to additive performance.

2.5.4.4.4.4 Discussion of Findings

Some FOG (grease) accumulation in the hot spot and the end of the lateral was observed after the addition of the additive, but not as much as anticipated based on the type of FSE and the fixtures in the kitchen. It is important to note that this FSE made a concerted effort to improve their kitchen best management practices (BMPs) at the same time that the Study was initiated because the FSE was identified by the District as a significant source of FOG. This was why this FSE was chosen a candidate for the Study. In this evaluation, it is impossible to determine if the less-than-anticipated FOG accumulation was due to the additive or improved kitchen BMPs, or both.

Unique Issues:	Inadvertent line cleaning appeared to have been conducted between the 4th and 5th months of evaluation.
Dispenser Problems:	The dispenser experienced temporary problems delaying the start-up.
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned weekly prior to the evaluation without the benefit of CCTV monitoring. Even though it was not required by the agency, the hot spot appeared to have been inadvertently cleaned between the 4th and 5th months of the evaluation.
General Effectiveness:	Some FOG accumulation in the treated segments was observed. A direct comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2); however, the FOG accumulation was not as much as anticipated. There was insufficient data to determine if the additive, or improved kitchen BMPs, or both, provided a benefit in this hot spot location (ref. Note #3 and the discussion above).
Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. This product also did not display any emulsification characteristics in the bench scale tests.
Projected Additive Use Cost (FSE):	$78 per month at a verified dosage of approximately 2.5 ounces per day (pricing information provided by the supplier).
Projected Agency Costs:	$50 per month based on semi-annual CCTV monitoring at a minimum cost of $300 per event to monitor the effectiveness of the additive.

2.5.4.4.5 CMSD HS57

2.5.4.4.5.1 Hot Spot General Information

General information concerning the additive evaluation for this hot spot is as follows:

Hot Spot ID:	CMSD HS57	**Cleaning Cycle:**	Weekly
Location:	FSE - Cinnamon, North of Caraway, Costa Mesa, CA		
FSE:	IHOP (No GRE)		
Untreated Section:	None		
Treated Section:	552 ft (MH1000 to MH1003)		
Supplier/Product:	Supplier L/Product L		

2.5.4.4.5.2 Hot Spot Summary

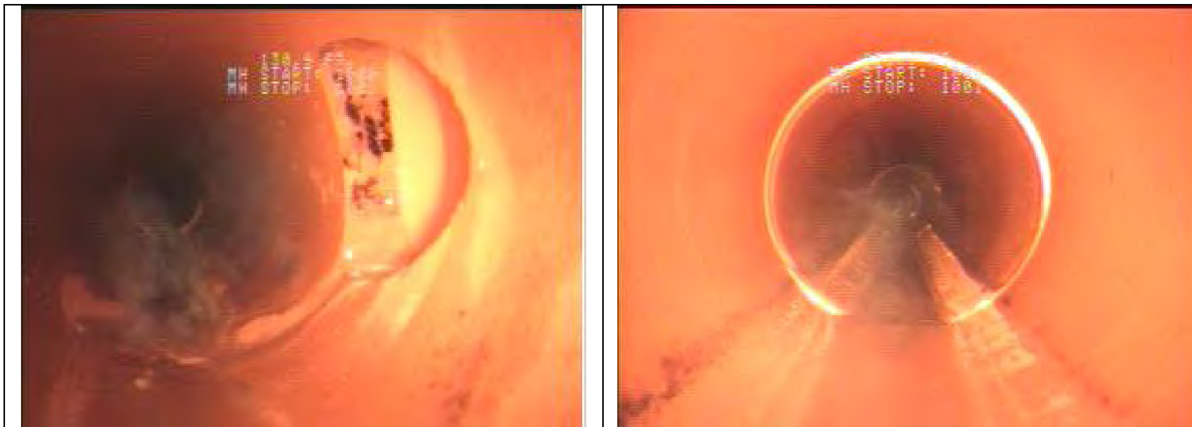
Prior to suspension of the sewer cleaning for this evaluation, cleaning in this location was conducted on a weekly basis due to grease accumulation from an FSE discharging directly to the hot spot pipe segment. Surcharging at the Cinnamon/Coriander junction may be contributing to grease accumulation in this location. Selection of this location as a candidate for the study was based on CCTV inspections conducted during FOG Characterization (see photo below).

Example of Grease at the IHOP Lateral Connection
(Collected During FOG Characterization)

Figure 2.68 FOG Accumulation at CMSD HS57 before Field Testing

2.5.4.4.5.3 Field Test

Lateral cleaning was conducted by an FSE contactor on 1/18/05. Line cleaning of this hot spot was conducted with a standard jetting nozzle on 1/19/05, followed by CCTV inspection where the following baseline (clean pipe) images were collected:



IHOP's Lateral Connection	Hot Spot Segment

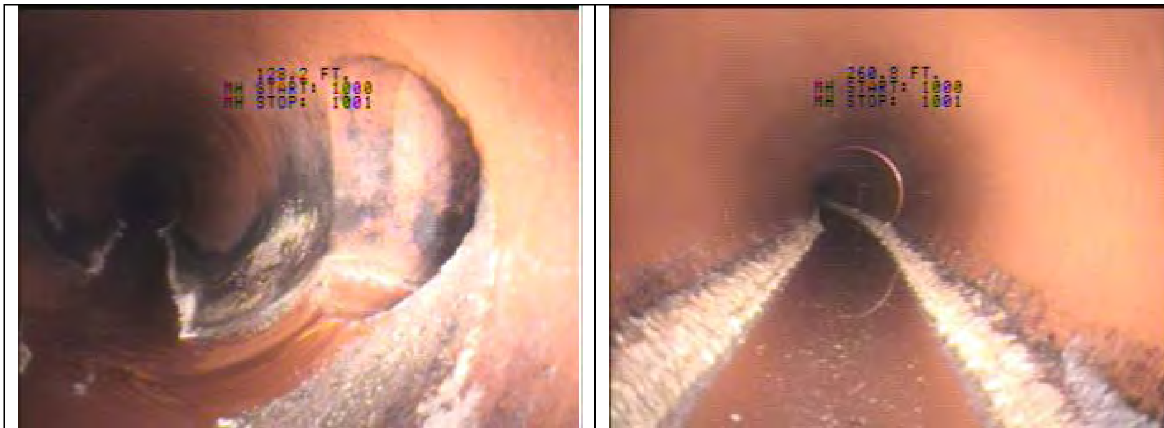
Figure 2.69 CMSD HS57 Immediately after Line Cleaning

The additive setup for this location was conducted on 1/20/05 by a Supplier L representative. The Supplier L product was dispensed in a liquid form from a holding tank located inside the facility (photo below). The holding tank was replenished on a monthly basis. An additional liquid product was applied once monthly to each facility drain by a Supplier L representative. No problems or complications were encountered during the evaluation.

Supplier L Dispensing Unit

Figure 2.70 Additive Dispenser Setup at CMSD HS57

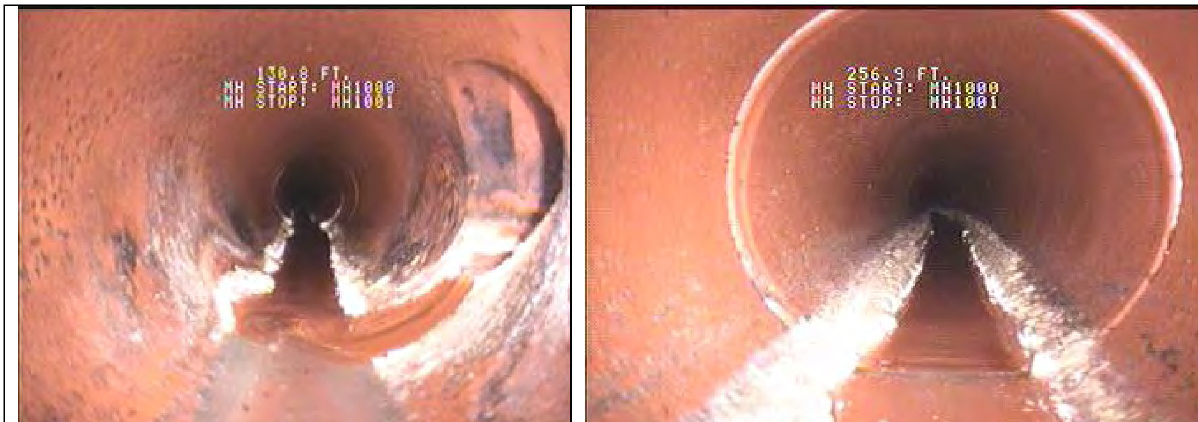
After 1 month of additive application, CCTV inspection of the treated pipe segments was conducted and the following images were collected:



IHOP's Lateral Connection	Hot Spot Segment

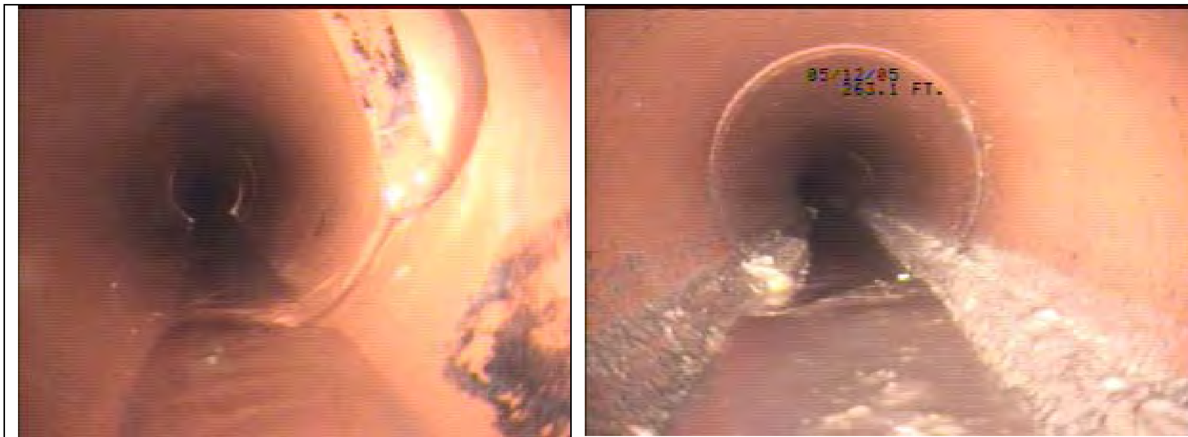
Figure 2.71 FOG Accumulation 1 Month after Cleaning

CCTV inspections continued on a monthly basis for this location. From the CCTV inspections, it was determined that line cleaning was not required and the evaluation was allowed to continue in this location. This was based on the grease accumulation at the lateral connection and in the hot spot pipe segments downstream of this lateral (photos below):



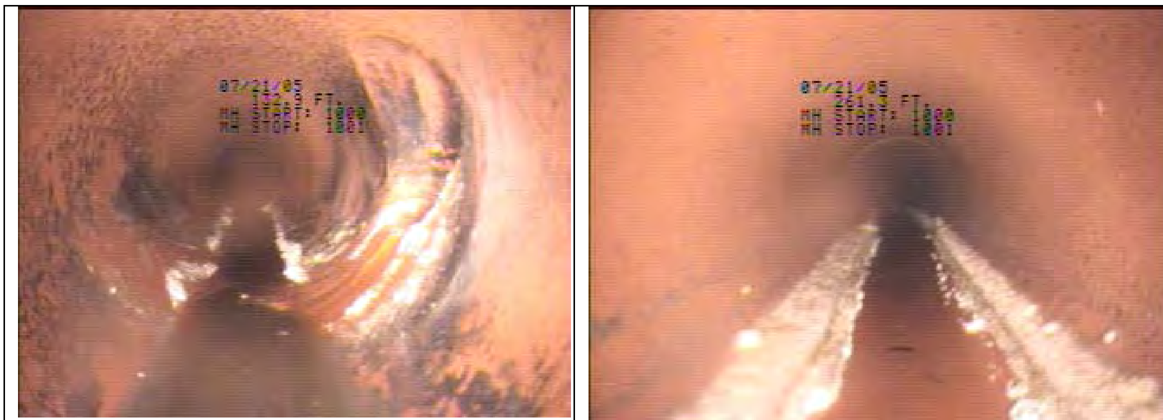
IHOP's Lateral Connection	Hot Spot Segment

Figure 2.72 FOG Accumulation 3 Months after Cleaning



IHOP's Lateral Connection	Hot Spot Segment

Figure 2.73 FOG Accumulation 4 Months after Cleaning (inadvertent line cleaning was most likely conducted)



IHOP's Lateral Connection	Hot Spot Segment

Figure 2.74 FOG Accumulation 6.5 Months after Cleaning

Between the 3rd and 4th months of evaluation in this location, a significant decrease in grease accumulation was observed at the IHOP lateral connection and in the hot spot segment. Follow-up CCTV inspections were conducted to investigate the cause of the dramatic decrease in accumulation. During the follow-up CCTV inspections, increased grease accumulation was observed at the IHOP lateral connection and in the hot spot segment, indicating that the grease removal was most likely due to inadvertent line cleaning rather than attributable to additive performance.

2.5.4.4.5.4 Discussion of Findings

Some FOG (grease) accumulation in the hot spot and the end of the lateral was observed after the addition of the additive, but not as much as anticipated based on the type of FSE and the fixtures in the kitchen. It is important to note that this FSE made a concerted effort to improve their kitchen best management practices (BMPs) at the same time that the Study was initiated because the FSE was identified by the District as a significant source of FOG. This was why this FSE was chosen a candidate for the Study. In this evaluation, it is impossible to determine if the less-than-anticipated FOG accumulation was due to the additive or improved kitchen BMPs, or both.

Unique Issues:	The hot spot appeared to have been inadvertently cleaned between the 3rd and 4th months of this evaluation.
Dispenser Problems:	None identified
CCTV Frequency:	Monthly
Hot Spot Cleaning:	Cleaned weekly prior to the evaluation without the benefit of CCTV monitoring. Even though it was not required by the agency, the hot spot appeared to have been inadvertently cleaned between the 3rd and 4th months of the evaluation based on CCTV monitoring of the FOG accumulation.
General Effectiveness:	Some FOG accumulation in the treated segments was observed. A direct comparison of the rate of FOG accumulation in the treated segment before the evaluation and during the evaluation could not be made (ref: Note #2); however, the FOG accumulation was not as much as anticipated. There was insufficient data to determine if the additive, or improved kitchen BMPs, or both, provided a benefit in this hot spot location (ref. Note #3 and the discussion above).
Evidence of FOG Passed Downstream:	There was no evidence of this in this evaluation. This product also did not display any emulsification characteristics in the bench scale tests.
Projected Additive Use Cost (FSE):	$150 per month at a verified dosage of approximately 5 gallons per month (pricing information provided by the supplier).
Projected Agency Costs:	$50 per month based on semi-annual CCTV monitoring at a minimum cost of $300 per event to monitor the effectiveness of the additive.

2.5.5 Summary of Results

2.5.5.1 General Additive Characteristics

Based on the results of bench scale tests, none of the 12 additives (or the additional products used in a multi-product treatment) displayed emulsification properties at conservatively high dosages. There was also no evidence of the additives emulsifying the FOG and redepositing the FOG further downstream in the 11 field evaluations where this could be examined. In 1 evaluation (OCSD HS9), FOG accumulation was greatest at the tail end of the treated segment of the hot spot, indicating a potential redepositing of FOG if there were no other data to evaluate. However, based on review of the post-cleaning CCTV data before the additive was added, it was determined that the tail end location of this hot spot is an area where increased FOG accumulation is typical.

Based on the review of the laboratory analyses, EEC did not identify any pollutants of concern in any of the 12 primary additives in sufficient quantities to exceed OCSD's local limits even if the products were in widespread use.

Based on the activated sludge OUR tests results, there was no indication of activated sludge toxicity at the conservatively high dosages chosen for any of the 12 primary additives tested.

2.5.5.2 Sewer Line-applied Additives

Improved Sewer Line Cleaning to Reduce Line Cleaning Frequencies

The first significant finding, which in fact was not part of the workplan of the Study, was that in each of the Sewer Line-applied evaluations (including the Sewer Line-applied/FSE-applied evaluation) it was determined that the previous method of line cleaning could be optimized through the use of post-cleaning CCTV monitoring which would allow for the verification of the thoroughness of line cleaning and a more accurate method of determining the proper line cleaning frequencies for each hot spot. Based on the findings in this Study, this optimization would most often lead to a significant reduction in line cleaning frequencies.

This is an important finding because the primary reason for using a Sewer Line-applied additive is to reduce, or possibly replace, the need for costly sewer line cleaning (e.g., $1,500 to $5,000 per hot spot per year).[28] If line cleaning can be reduced due to an improvement in line cleaning methods, the need for a Sewer Line-applied additive would be reduced.

[28] This was based on the line cleaning frequencies at the hot spots in this Study and cost information provided by OCSD and three sewer cleaning contractors.

Additive Dispenser Issues

Two (2) of the 7 dispensers experienced problems which resulted in potential under-dosing or over-dosing of the product for a period of time.

Additive Effectiveness

Generally, the 6 additives utilized in the Sewer Line-applied application (not including the Sewer Line-applied/FSE-applied hybrid) were not effective in preventing the FOG accumulation in the treated sections of sewer pipe. However, there were a couple evaluations where the accumulation was less in the treated sections of the sewer pipe compared to the untreated sections of the sewer pipe.

In 4 locations (OCSD HS9, GGSD HS4, CMSD HS26 and COO HS28), FOG accumulation after approximately 4 to 6 months in the treated pipe segments was similar to the accumulation in the untreated pipe segments during the same time period. For 2 (OCSD HS9 and GGSD HS4) of these 4 locations, the evaluations were terminated after sewer maintenance staff required cleaning of the treated and untreated sections of the sewer pipe. For 1 (CMSD HS26) of these evaluations, a significant portion of the FOG accumulation appeared to be combined with laundry chemical residue based on a sample collected from the accumulation. According to the supplier, the lack of effectiveness of the additive was not surprising considering the amount of chemical residue in the hot spot.

In 2 of the Sewer Line-applied evaluations (OCSD HS15 and GGSD HS4), where a direct comparison of the untreated and treated sections of the sewer pipe could be made, there appeared to be less FOG accumulation in the treated section compared to the untreated section of the sewer pipe. In the case of GGSD HS4, the difference was slight. In the other case (OCSD HS15), the sewering agency chose to clean the untreated portion of the sewer pipe after 4 months and waited to clean the treated portion until 7 months. This was the only evaluation where a reduction in line cleaning frequency (42% in this case) was realized based on the use of the additive.

For the Sewer Line-applied/FSE-applied hybrid evaluation (COLH HS14), where there was not an untreated pipe segment for comparison, significant FOG accumulation was observed in the section of the sewer pipe treated at the FSE's cleanout and also in the section of the sewer pipe treated at the manhole. This application was terminated after sewer maintenance staff required cleaning of the treated sections of the sewer pipe after 4 months.

Additive Cost

The projected agency use cost of the Sewer Line-applied additives (including the Sewer Line-applied/FSE-applied additive) ranged from $90 to $1,230 per month depending upon the severity of the hot spot and the dosage of the product.

2.5.5.3 FSE-applied Additives

Additive Dispenser Issues

One (1) of the 5 products was manually applied by the FSE and the other 4 sites utilized a dispenser to apply the primary additive. At the 4 sites with a dispenser, 1 dispenser had a mechanical problem that delayed start-up.

Additive Effectiveness

Although there was no untreated sewer pipe portion available for comparison to the treated portion,[29] 4 of the 5 evaluations provided results that indicated possible encouraging results. This was based on less FOG accumulation than anticipated at the end of the FSE's lateral and in the hot spot over time. As discussed earlier, it is important to note that these 4 FSEs made a concerted effort to improve their kitchen best management practices (BMPs) at the same time that the Study was initiated because the FSE was identified by the sewering agency as a significant source of FOG. In this evaluation, it is impossible to determine if the less-than-anticipated FOG accumulation was due to the additive or improved kitchen BMPs, or both

One (1) of the additive evaluations (OCSD HS30) was terminated after sewer maintenance staff required cleaning of the treated sections of the sewer pipe after 4 months.

Additive Cost

The projected FSE use cost of the FSE-applied additives ranged from $80 to $595 per month depending upon the type of FSE and the dosage of the product.

2.6 Conclusions and Recommendations

2.6.1 Sewer Line-applied Additives

Based on the results of these evaluations, the Sewer Line-applied additives do not appear to be comparable to effective line cleaning based on the CCTV images of cleaned sewer pipe compared to the CCTV images after 4 to 6 months of utilization of the additive. Although, in 1 of the evaluations, there was evidence of a potential for a reduction in line cleaning frequency (e.g., 42%) when using the additive at the hot spot in this evaluation. Unfortunately, the potential cost savings due to a reduced line cleaning frequency (e.g., projected $500 to $1,000 per year) would likely be exceeded by the additive use cost (e.g., projected $1,000 to $6,000 per year). Additionally, the potential additional cost of CCTV monitoring to confirm the effectiveness of the additive would have to be factored in as well. Therefore, it is unlikely there would be a net savings in using a Sewer Line-

[29] The Sewer Line-applied evaluations provided the benefit of comparing the FOG accumulation in untreated and treated portions of the hot spot which provided an ability to objectively determine the additive's effectiveness.

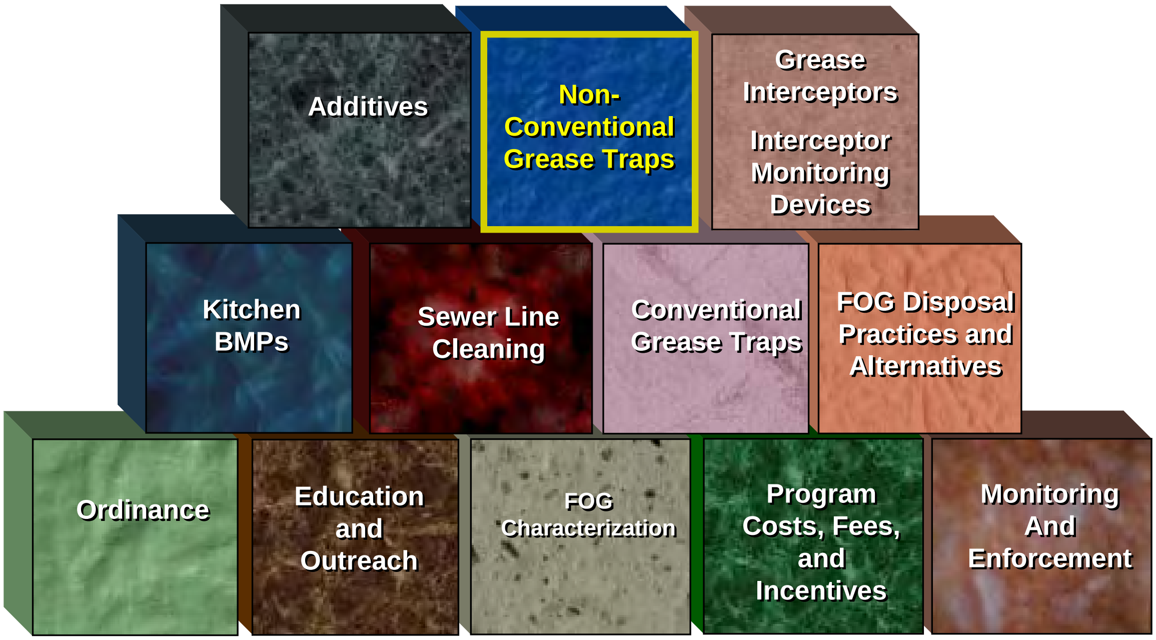
applied additive even if the additive was successful in reducing the line cleaning frequency by as much as 42%. Even in situations where the savings from reduced line cleaning may exceed the use cost of the additive, the savings is unlikely to be substantial. It is important to note that the cost assessment presented above is based on the evaluations in this Study. Severe hot spots not included in this Study that are treated with an effective additive may provide a different cost outcome.

The Study determined that improving line cleaning practices through the use of post-cleaning CCTV monitoring alone will typically reduce line cleaning frequencies. Therefore, improving line cleaning practices through the use of post-cleaning CCTV monitoring appears to be a more logical focus for sewering agencies until Sewer Line-applied additives are shown to be more effective.

2.6.2 FSE-applied Additives

There were encouraging results at 4 of the 5 FSEs that may provide some evidence that FSE-applied additives could be considered as an alternative to the requirement to install a grease interceptor at FSEs that cannot install a grease interceptor. However, based on the kitchen BMP variable that was present at the 4 evaluations that provided encouraging results, it is EEC's opinion that further Study of FSE-applied additives should be conducted that evaluates the effectiveness of the additive after improved kitchen BMPs have already been implemented. In this case, CCTV monitoring should be conducted for a period of at least 6 months before the additive is used and a period of at least 6 months after the additive is used in order to provide a proper comparison where the variable of improved kitchen BMPs is relatively constant throughout the evaluation. It would also be beneficial if the study evaluated the accumulation of FOG downstream of well-maintained interceptors over time for relative comparison purposes.

Until that study is conducted, it is recommended that if an FSE requests to use an FSE-applied additive because they cannot install a conventional grease interceptor, an agency may consider approving the request on a conditional basis. The agency would need to monitor the effectiveness of the additive (and/or the kitchen BMPs) as was done in the Study using CCTV which may cost the agency $600 – $1,200 per year.



3.0 NON-CONVENTIONAL GREASE TRAP (GREASE REMOVAL DEVICE) EVALUATIONS

3.1 Background and Technology Description

Non-conventional grease traps (NCGTs) are grease removal equipment typically installed in FSE kitchens, under or near a sink, or they are sometimes installed underground in a vault or in a basement. Suppliers have made multiple enhancements on the conventional passive grease trap design by providing features with enhanced oil-water separation, automatic grease removal, or biological digestion of the grease. The mechanical or bioremediation features of an NCGT are designed to result in less cleaning than a conventional grease trap but may require more frequent other forms of maintenance.

Based on EEC's research, NCGTs can be separated into 2 categories:

1) **Grease Removal Devices (GRDs)**[30] (previously named "Automatic Grease Traps" in the Phase I Study) – Includes features such as solids separation chambers; heating elements; mechanical skimmers; grease level monitors and pumps; and waste oil containers designed to provide enhanced oil-water separation, automatic grease removal, and temporary waste oil storage.

[30] These devices are often referred to as "grease interceptors" and will be identified as one type of grease interceptor in the 2006 Uniform Plumbing Code (UPC). This report will only refer to these devices as "grease removal devices" to avoid confusion with conventional grease interceptors.

2) **Bioremediation Grease Traps**[31] – Includes features such as solids separation chambers, biological additive injection, and biological media chambers designed to provide biological digestion of the waste grease.

Grease Removal Devices:

The only products that were offered by suppliers for evaluation in this portion of the Study were GRDs. The 3 suppliers that committed to the Study provided 2 types of GRDs for evaluation. A conceptual diagram of a GRD with a grease skimming wheel to remove the grease from the main chamber is depicted in Figure 3.1. A conceptual diagram of a GRD that utilizes a grease level monitor and pump rather than a skimming wheel to remove the grease is depicted in Figure 3.2.

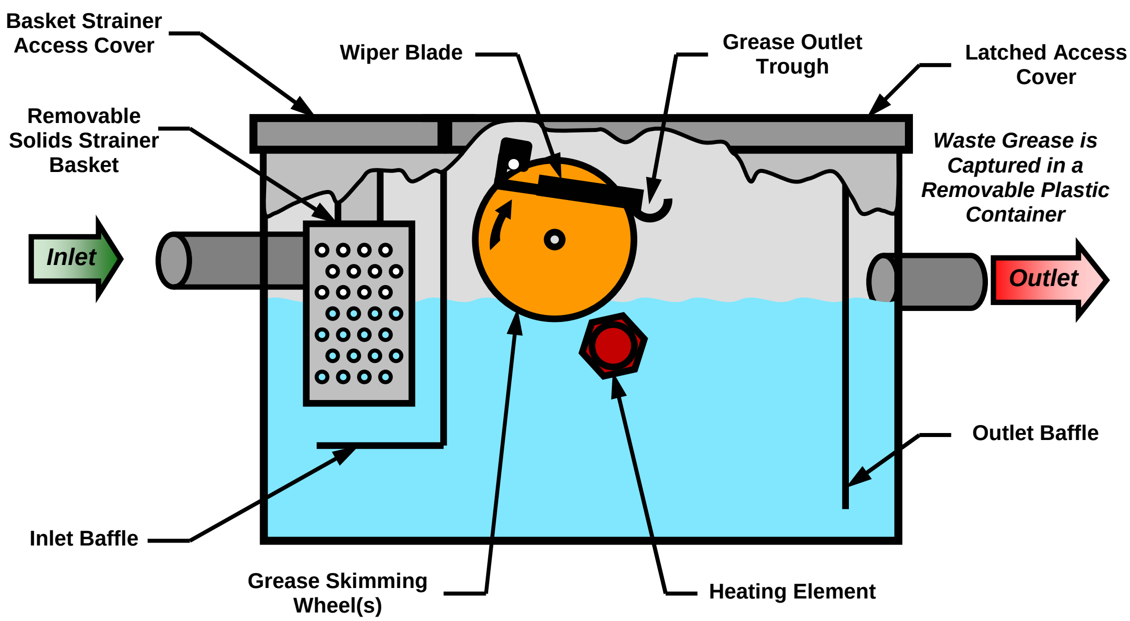


Figure 3.1 GRD with Grease Skimming Wheel(s) (Sketch Based on *ASPE Data Book*, Volume 4, Chapter 8, and Information Provided By Suppliers)

[31] These devices will be referred to as "FOG Disposal Systems" in the 2006 Uniform Plumbing Code (UPC).

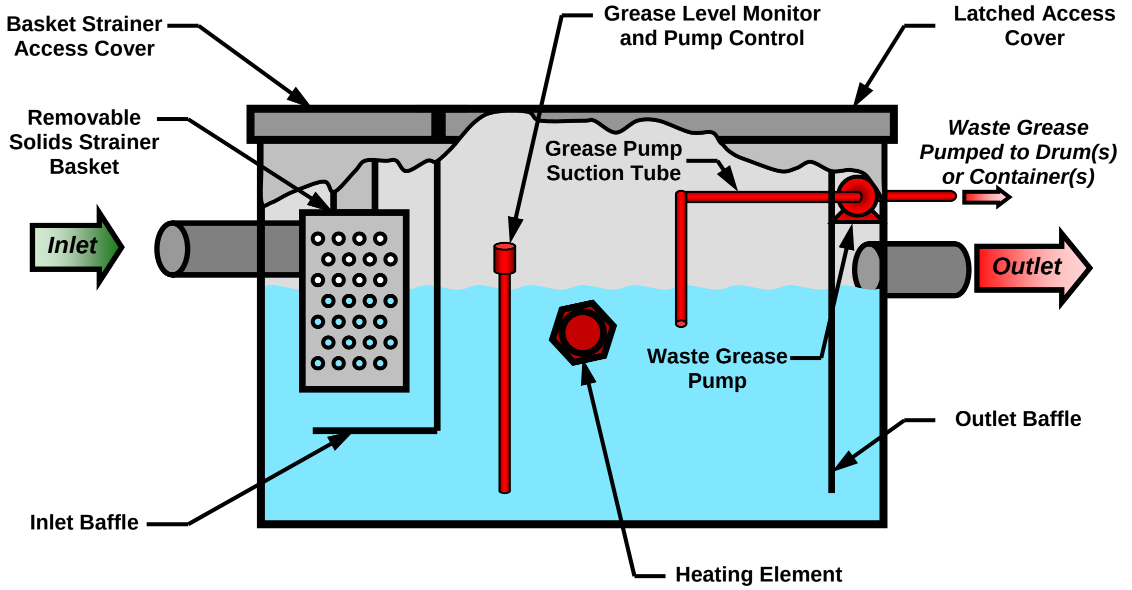


Figure 3.2 GRD with Grease Level Monitor and Pump (Sketch Based on *ASPE Data Book*, Volume 4, Chapter 8, and Information Provided by Supplier)

The general features of the GRDs are as follows:

- A stainless steel tank with 3 to 4 baffled chambers with removable covers.
- A removable solids basket strainer in the inlet chamber.
- An oil/water separation chamber with a heating element to keep the separated grease in a liquid state.
- Either a timer-controlled grease-skimming wheel(s) with scrapers that skim the floating FOG into a small, removable plastic grease container or an electronic grease level monitor that activates a pump to remove the floating FOG and transfer it to a drum or container, typically located outside the building.
- The typical designed flow rates for GRDs are 15 to 150 gpm with 0.5 to 2 minute retention times at maximum flow.

Most GRDs sold are typically less than 50 gallons in capacity and are installed in FSE kitchens under a counter. However, this report will show that some GRDs are much larger than 50 gallons, some are installed underground, and some are installed outside.

Many cities in the United States are allowing the use of GRDs as an alternative to conventional grease interceptors. This is why the Phase I Study recommended that these types of devices be evaluated as potential alternatives to conventional grease interceptors in Orange County. The recognized concern with GRDs[32] is that they depend upon proper operation and maintenance[33] by the FSE employees, which is lacking at many FSEs. A

[32] Issue identified by 2 of the GRD suppliers in the Study and by California sewering agency personnel during meetings with GRD and grease trap manufacturers on April 27, 2005 and September 13, 2005.
[33] For the sake of this report, maintenance is any cleaning, waste disposal, monitoring, equipment adjustments, parts replacement, or other functions that are not performed by the GRD automatically.

lesser known concern is the improper or inadequate installation issues related to GRDs. Additionally, the Orange County Health Care Agency (OCHCA) is concerned about the potential sanitation and cross-contamination issues associated with GRDs (and grease traps) located in the kitchen in the vicinity of food preparation. Therefore, these elements were examined in the Phase II Study.

<u>Installation Application Options:</u>

Isolation-type Application
In this application, the GRD is connected to 1 grease waste drain (e.g., the pre-rinse sink), thereby isolating the grease from that drain and protecting the facility's internal drain lines (Figure 3.3). In some cases, more than 1 grease waste drain is connected to the same GRD if they are in close proximity. In rare cases, more than 1 GRD is installed in a single kitchen to treat multiple grease waste drains (Figure 3.4). Depending upon the manufacturer, the purchase price for 20- to 35-gallon per minute (gpm), isolation-type GRDs ranges from $2,500 to $8,000. Installation costs range from $500 to $1,000 in most cases.

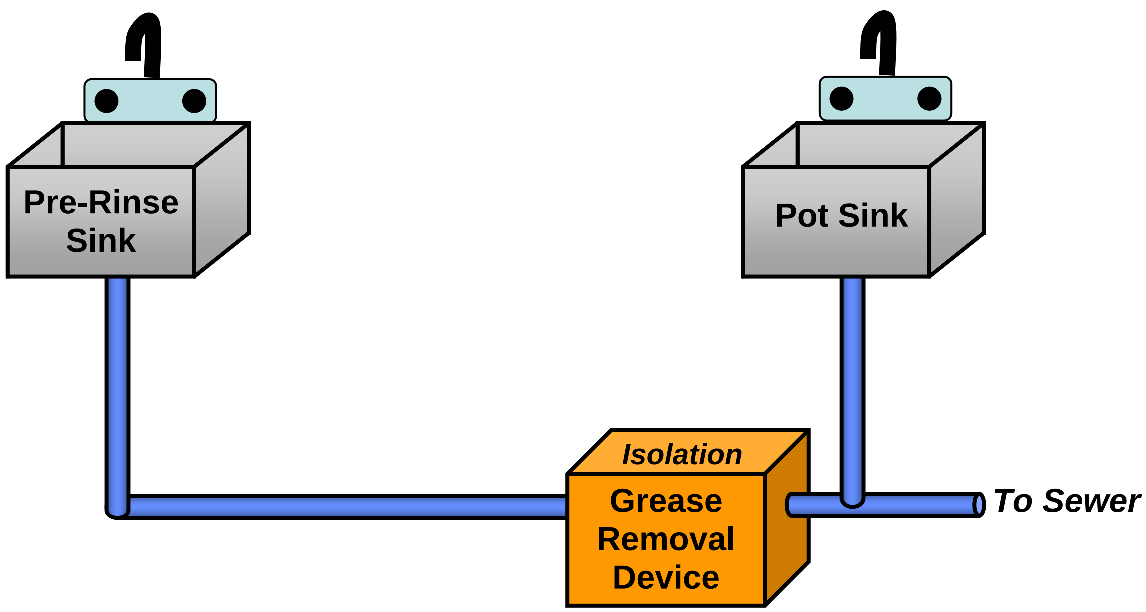


Figure 3.3 Isolation-type GRD Application (1 GRD Example) – One (1) grease waste drain is typically connected to 1 GRD. In many cases, other grease waste drains are not connected to any grease control devices.

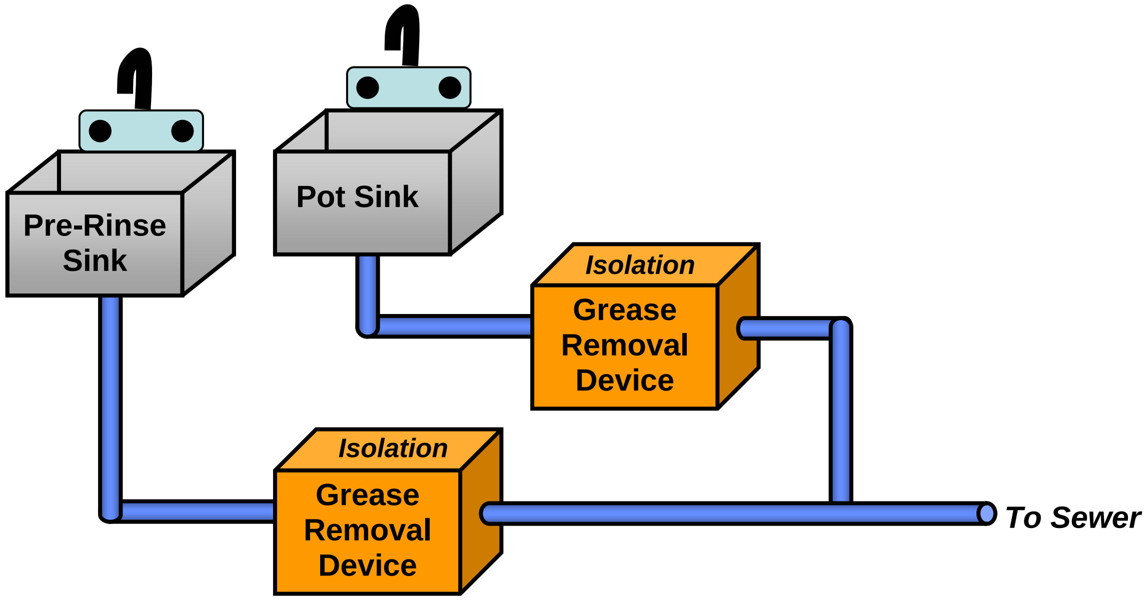


Figure 3.4 Isolation-type GRD Application (Multiple GRDs Example) - Each grease waste drain is connected to a separate GRD.

Containment-type Application

In this application, the GRD is connected to all the potential grease waste drains (e.g., pot sink, pre-rinse sink, kitchen floor sinks, kitchen floor drains, wok floor sinks, and kettle trench drains), thereby protecting the discharge lateral and the local sewer (Figure 3.5). Depending upon the manufacturer, the purchase price for 50- to 150-gpm, containment-type GRDs ranges from $4,500 to $17,000. Installation costs depend on many factors but will range from approximately $2,000 for a basement-type installation (e.g., no excavation or vaults) to $15,000 for a complete vaulted installation.

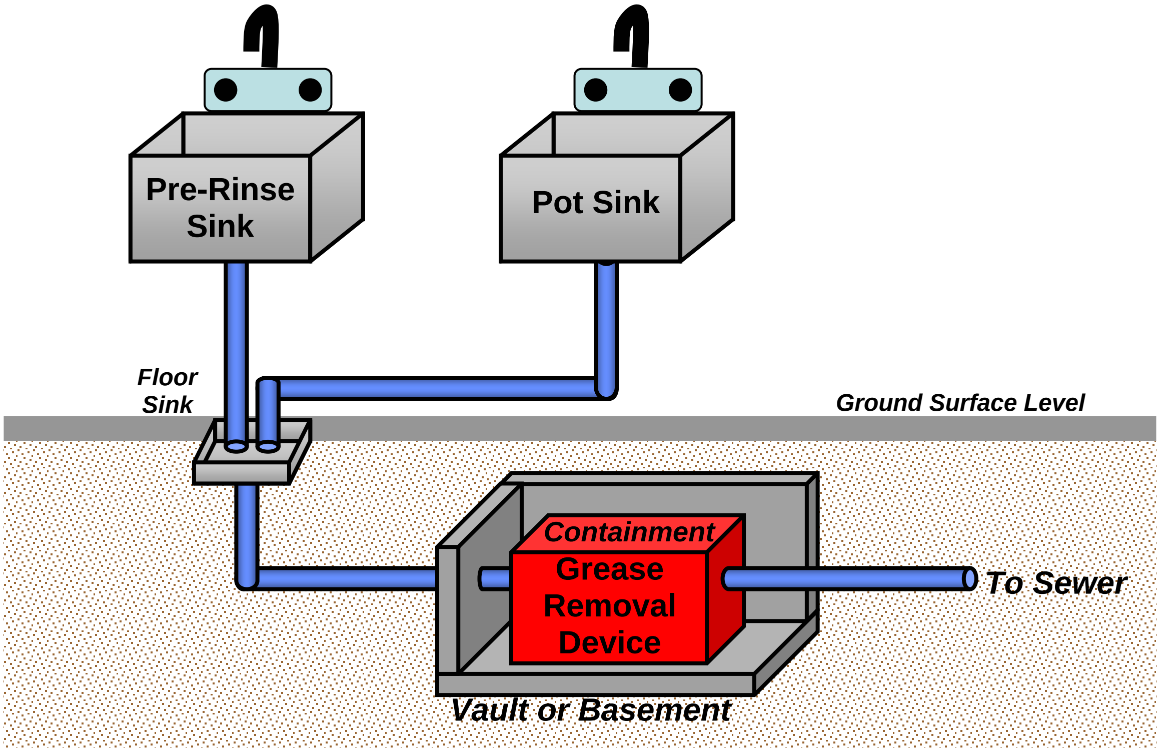


Figure 3.5 Containment-type GRD Application.- One (1) GRD is connected to all the potential grease waste drains. The GRD is typically located in a vault or basement.

Isolation-/Containment-type Application Combination

In this application, there may be 1 or more isolation-type GRDs connected to individual grease waste drains and a containment-type GRD (or conventional grease interceptor) connected downstream to capture all the grease waste drains (Figure 3.6). In this application, the isolation-type GRD is functioning to protect the internal drain lines from blockage, while the containment-type GRD (or conventional grease interceptor) is functioning to protect the discharge lateral and the local sewer lines. Some FSEs also choose this application to reduce the frequency of pumping the conventional grease interceptor by collecting a large percentage of the grease with the isolation-type GRD, then recycling the waste grease.

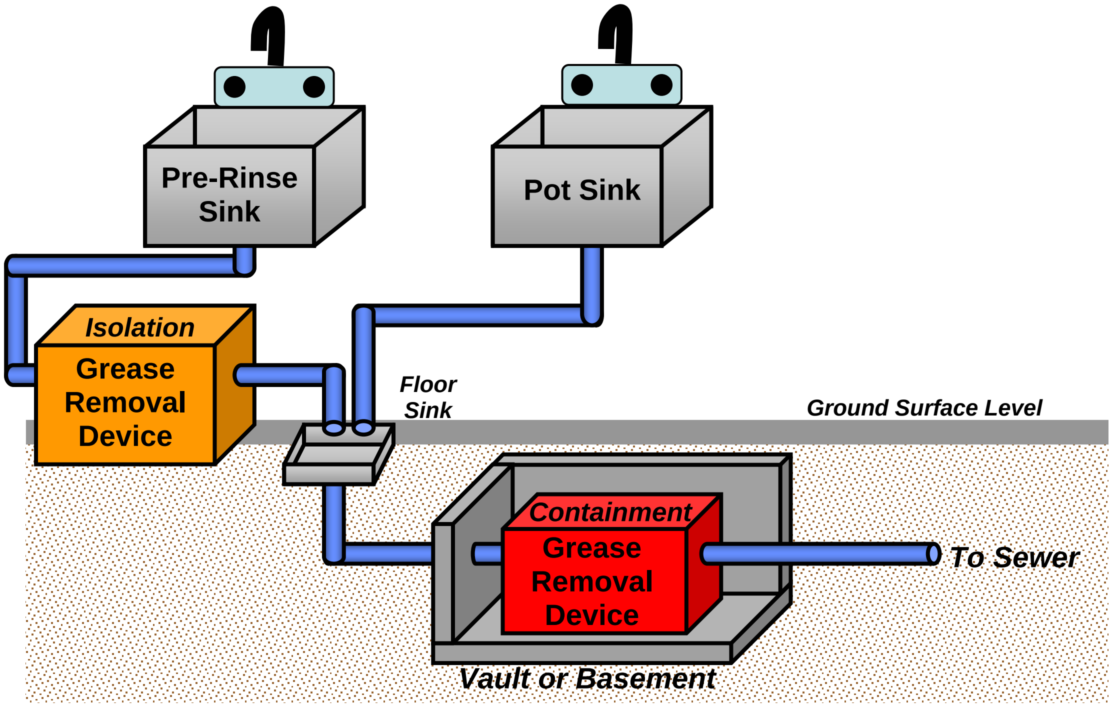


Figure 3.6 Isolation/Containment-type GRD Application Combination - One (1) or more isolation-type GRDs connected to individual grease waste drains and a containment-type GRD (or conventional grease interceptor) connected downstream to capture all the grease waste drains.

Health Department Concerns:

EEC spoke to the Orange County Health Care Agency (OCHCA)/Environmental Health Division on April 11, 2005 to discuss the agency's concerns and policies regarding GRDs and conventional grease traps. The following is a summary of that discussion and the OCHCA policy on GRDs:

The OCHCA does not regulate or have approval oversight of the installation of grease traps or grease interceptors. The OCHCA does have authority regarding sanitation of food service establishments; therefore, the installation of GRDs should be included on the site layout drawing, indicating it is designed and installed in a manner that will maintain surfaces that are easily cleanable. If a GRD or grease trap is placed inside the kitchen, it may cause potential cross-contamination issues with food if maintenance activities occur during food preparation (e.g., an employee cleaning out the solids basket near a food preparation table) or overflow from the unit could come in contact with kitchen workers. OCHCA will ask the food facility operator to follow the procedures outlined below to mitigate any potential contamination issues with food or with employees:

- Food preparation should not occur in the area where the GRD or grease trap is located during servicing or maintenance operations. Optimally, the GRD or grease trap should only be serviced when the facility is closed.

- Ensure that adequate and proper sanitary controls are utilized in the kitchen/food preparation area.
- Vehicles/trucks and equipment utilized for the pump-outs should be properly maintained to ensure that sanitary conditions are upheld.
- Signage outlining best management practices (BMPs) should be posted in the vicinity of the GRD or grease trap to reinforce proper procedures.

3.2 Supplier and Location Selection Process

To initiate the NCGT portion of the Phase II Study, a public notice to prospective suppliers was provided through posting of a notice on the websites of OCSD, EEC, and WEF. Suppliers that responded to the website posting and the suppliers identified in Phase I of the Study were provided a "Fats, Oils, and Grease (FOG) Technology Supplier Participation, FOG Non-conventional Grease Trap Field Evaluation and Supplier Requirements" notice (Appendix A) and were required to respond by October 29, 2004, to confirm their desire to participate in the Study. These suppliers were then provided a copy of the NCGT workplan (Appendix B) and were required to submit a letter of commitment and indemnification (Appendix C) for continued consideration for participation in the Study.

Initial interest was expressed by 8 suppliers; however, only 3 suppliers agreed to participate in the Study. Each of the suppliers had multiple existing installations; therefore, each supplier was asked to provide a list of potential FSE locations for initial evaluations. EEC coordinated with the suppliers and chose 5-9 sites per supplier for the initial evaluations. Each of the FSE's GRDs had been in operation for a minimum of 6 months prior to these evaluations. For each supplier, 3 of those sites were then chosen for follow-up field evaluations. As discussed in Section 1.3, the names of the suppliers who are participating in the Study have been excluded from the body of the report, but a key is provided in Appendix A that identifies the suppliers. The evaluation locations (FSE addresses are not provided) are provided in the following table:

Table 3.1 GRD Evaluation Locations

GRD Supplier	Initial Evaluation Sites	Follow-up Field Evaluation Sites
Supplier M	Wawa's Market #1, PA	Bravo Pizza, PA
	Wawa's Market #2, PA	Ruby's Diner, PA
	Meghans Restaurant, PA	Assisi House Conval. Hospital, PA
	Outback Steakhouse, PA	
	PF Chang's Restaurant, PA	
	Bravo Pizza, PA	
	Ruby's Diner, PA	
	Assisi House Conv. Hospital, PA	
	New Season's Assisted Living, PA	
Supplier N	The Square Café, MA	The Hi Hat Restaurant, RI
	Pranzi Restaurant, MA	L'Alouette Restaurant, MA
	The Hi Hat Restaurant, RI	Rhode Island Convention Center, RI
	L'Alouette Restaurant, MA	
	Rhode Island Convention Ctr, RI	
Supplier O	Sharkey's Mexican Grill, CA	Sofitel Hotel, CA[1]
	Sofitel Hotel, CA	Oh's Catering, CA[1]
	Oh's Catering, CA	El Tapatio Market, CA[1]
	El Tapatio Market, CA	
	Saigon Dish, CA	
	Sushi Ruku Restaurant, CA	
	Karl Strauss Brewery, CA	

[1] These locations were not ready to be sampled until June 2005. Therefore, there is only approximately 1 month of evaluation data at these sites.

3.3 Study Workplan

The evidence of a GRD's general effectiveness can be measured through the amount of floating FOG that is removed by the GRD or, more importantly, the evidence of a GRD's ineffectiveness can be measured by the amount of floating FOG that is not removed by the GRD. This can be accomplished through measurement of the influent and effluent floating FOG on multiple occasions under a variety of conditions. Because of the high maintenance associated with each of these products, the maintenance, or lack thereof, must also be closely examined. Due to the concern of improper installations mentioned previously, proper installation must be evaluated as well. The evaluation of existing installations of GRDs at typical FSE kitchens is based on the following summarized workplan (a copy of the complete original workplan is provided in Appendix B):

1) It was confirmed that all existing installations evaluated are standard installations at typical FSEs. It was noted how each GRD was installed (e.g., connected to a pre-rinse sink) and other pertinent issues.

Note: Due to a desire to evaluate more installations for maintenance and installation issues, the workplan was expanded to include an initial evaluation of more than 20 installations before choosing the sites that will undergo follow-up inspections and sampling.

2) During the initial visit, the FSE operators were interviewed on the GRD's benefits, reliability, required maintenance, and related issues. The GRD's condition was evaluated primarily for installation and maintenance issues.

3) The GRD conditions, maintenance issues, and the influent and effluent floating FOG were measured at each FSE for a follow-up period of approximately 4-6 months (1 month in the case of Supplier O's FSEs that were not ready to be sampled until June).

4) The operation and performance of the unit including any complications or problems experienced by the FSE staff was documented.

Three (3) GRDs per supplier were chosen from the initial inspection sites to be sampled in the follow-up evaluations. A sampling plan was developed that was accepted by the suppliers before the official sampling commenced. The sampling plan is provided in Appendix B. The sampling plan is summarized as follows:

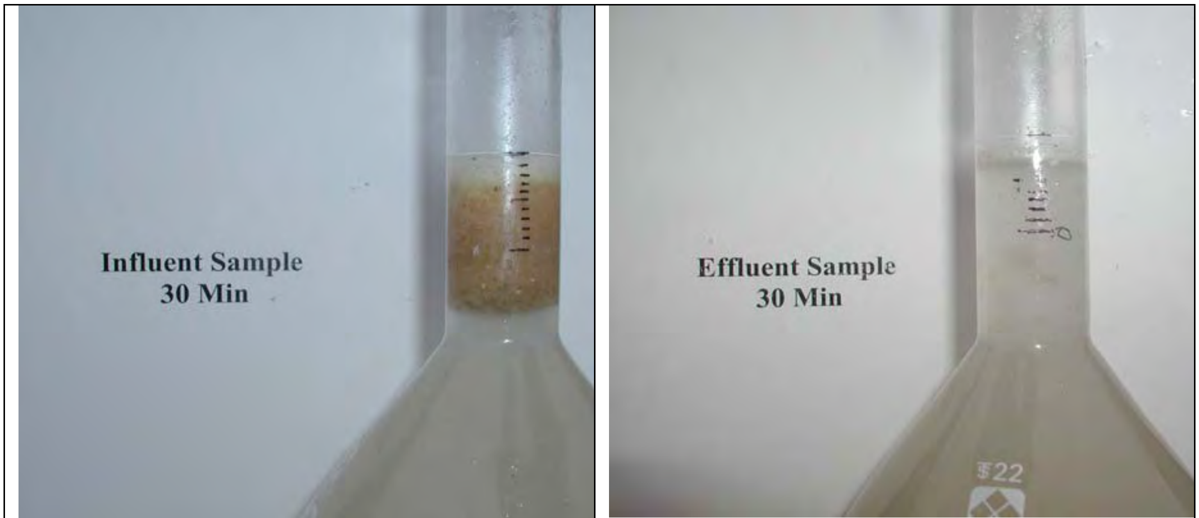
3.3.1 Floating FOG Test

1) The maintenance condition of the GRD was evaluated before sampling by measuring the depths of the total liquid and the solids and grease layers utilizing a core sampler. This indicated if proper operation and maintenance of the GRD was taking place at the time of the sampling.

2) Samples of the influent and effluent of the GRD were collected while there was dishwashing or pot washing taking place. This provided the best opportunity to ensure that grease-laden wastewater was flowing to the GRD. During some inspections, the GRD was not able to be sampled because there were no dishwashing operations at or near the time of the inspection.

3) A clean 1,000-milliliter (ml) volumetric flask was filled with influent wastewater. After approximately 1.5 minutes, a clean 1,000-ml volumetric flask was filled with effluent wastewater. The neck of the flasks was graduated in 1-ml increments to measure the approximate volume of floating FOG in the flask.

4) For each flask, the volume of floating FOG was measured and recorded after 0 minutes, 2 minutes, 5 minutes, 10 minutes, and 30 minutes of separation time. Figure 3.7 displays an example of the floating FOG in GRD influent and effluent samples after 30 minutes of separation time



Influent Sample	Effluent Sample

Figure 3.7 Example of Floating FOG Samples after 30 Minutes of Separation Time in the Flask

The Floating FOG Test was developed by EEC for the purpose of providing a simple and logical field method of determining the GRD's effectiveness in removing floating FOG from the wastewater. The floating FOG in the flask is not necessarily concentrated FOG and often contains a significant amount of floating solids. For this reason, the test should be considered more qualitative than quantitative. However, since GRDs, and other interceptors for that matter, are designed to remove floating FOG, not emulsified FOG, this test provides a practical representation of the effectiveness of the GRD in terms of FOG removal. A 30-minute separation time was included for both flasks to determine if additional floating FOG will separate over time. This will indicate if slowly separating floating FOG (e.g., small diameter colloidal FOG) is passing through the GRD and may accumulate in the sewer line downstream. Therefore, the most conservative and relevant data is the 30 minute influent and effluent separation measurements.

Note: Since the GRDs are not equipped with sample ports, influent samples were collected using a "best possible method approach" by collecting a sample from the first chamber of the GRDs after the solids basket was removed. Efforts were made to sample only the influent and not the FOG that was already floating in the first chamber; however, some floating FOG may have been collected during this process. Thus, the influent samples may contain a slightly higher floating FOG result than what would be actually present in the influent if the sample was collected from a sample port. The main purpose of the influent sample measurement is to show the relative influent floating FOG at the time the GRD was sampled.

3.4 Data and Findings

3.4.1 Initial Field Inspections

As discussed earlier, initial field inspections were performed to evaluate the installation and maintenance issues at 21 FSEs. A summary of the pertinent findings from these inspections is provided below:

- Nine (9) of the installations were isolation-type typically connected to 1 grease waste drain and installed under a sink. At 6 of these FSEs, there were other potentially significant grease waste drains (e.g., dishwashing pre-rinse sink) not connected to any grease removal equipment.[34] At the other 3 FSEs, there were other waste drains that would contain some grease (e.g., a mop sink) that were not connected to any grease removal equipment.
- Twelve (12) of the installations were containment-type presumably connected to all the potential grease waste drains, and they were typically installed in an underground vault outside or in the kitchen.
- One (1) GRD was undersized, and a second GRD had no flow control device installed upstream of the unit.
- Ten (10) of the 21 GRDs had significant maintenance issues (e.g., solids basket missing or under-maintained, skimmer not operating, grease scrapers worn down, waste grease drum level alarm turned off, and waste grease drum overflowing).

3.4.2 Follow-up Evaluations

As discussed previously, 9 of the 21 sites were chosen for follow-up evaluations. In general, these locations were chosen based on their reasonable potential for proper maintenance to be achieved, the ability to sample the influent and effluent waste streams, and the ability to obtain permission from the FSE owner or manager to inspect and sample the GRD on a follow-up basis. The follow-up evaluations occurred from March to June 2005. Supplier O's locations were not available for evaluation until June 2005; thus, only 1 to 2 inspections were performed for the first 2 locations. For Supplier O's 3rd location, the Sofitel Hotel, the facility was visited on 3 separate occasions. In each case, there were no dishwashing operations taking place at the time of the inspections; therefore, no inspection or sampling of the GRD was performed.

As discussed in the workplan, data was collected on the floating FOG and settled solids in the GRD. Influent and effluent samples were also collected and a floating FOG test was conducted for each sample. Some of the influent samples and most of the effluent samples contained less than 1 ml (0.1%) of floating FOG. The accuracy of these small measurements has a significant error factor due to the difficulty in visually measuring small amounts and also due to the presence of foam and floating solids in many of the samples.

[34] This was most likely due to the lack of an approval agency requirement that all potentially significant grease waste drains be connected to grease removal equipment (discussed further in Section 3.4.3.1).

Additionally, it is important to note that the sampling was designed and performed to evaluate the effectiveness of units that were previously installed in the field and at the typical flow rate[35] that occurs during standard operation at the facility. They were not designed to evaluate the unit's performance at the unit's maximum rated flow. Thus, the performance of these units at the maximum rated flow was not evaluated or concluded on in the Study.

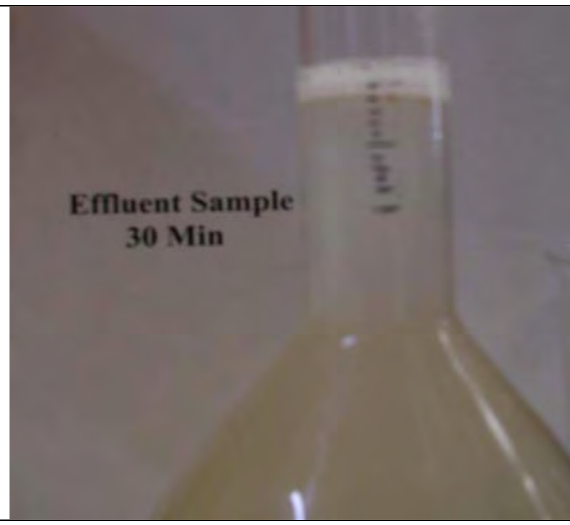
The data from 8 of 9 evaluations is provided below (as discussed above, the Sofitel Hotel did not provide any useful data).

[35] The sampling technician ensured that there was a significant flow through the unit during these sampling events.

3.4.2.1 Bravo Pizza

Figure 3.8 35-gpm Supplier M GRD in an Underground Vault in the Bravo Pizza Kitchen

Influent Sample



Effluent Sample

Figure 3.9 Example of Floating FOG Samples after 30 Minutes of Separation Time in the Flask Collected from Bravo Pizza

Table 3.2 Bravo Pizza GRD Field Data

Site: Bravo Pizza

GRD Manufacturer/Model: Supplier M (35 gpm)

Unit Connected To: All of the Significant Grease Waste Drains in the Kitchen (Containment Type)

Fixture(s) Discharging During Sampling: 3-Compartment Pot Sink

Date Collected	Floating FOG Measurements (1,000-ml Volumetric Flask)			GRD FOG & Settled Solids			
3/8/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	N/A	N/A	Main	13	2	9
	2	N/A	N/A				
	5	N/A	N/A				
	10	N/A	N/A				
	30	N/A	N/A				
3/29/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	<0.5	0	Main	13	1.5	2
	2	<0.5	0				
	5	0.5	0				
	10	0.5	0				
	30	0.5	0				
4/29/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	<1	0	Main	13	0.75	1
	2	<1	0				
	5	<1	0				
	10	<1	0				
	30	<1	0				
6/10/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	0.5	<0.25	Main	13	0.5	2
	2	0.5	<0.25				
	5	1	<0.25				
	10	1	<0.25				
	30	1	<0.25				

8/23/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	<0.25	<0.25	Main	13	0.25	0.25
	2	0.25	<0.25				
	5	0.25	<0.25				
	10	0.25	<0.25				
	30	0.25	<0.25				

N/A = No dishwashing activity during sampling event.

3.4.2.2 Ruby's Diner

Figure 3.10 150-gpm Supplier M GRD in an Underground Vault Outside at Ruby's Diner

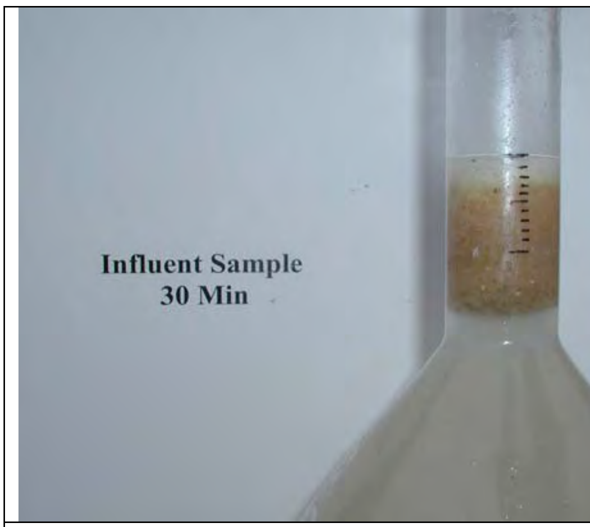
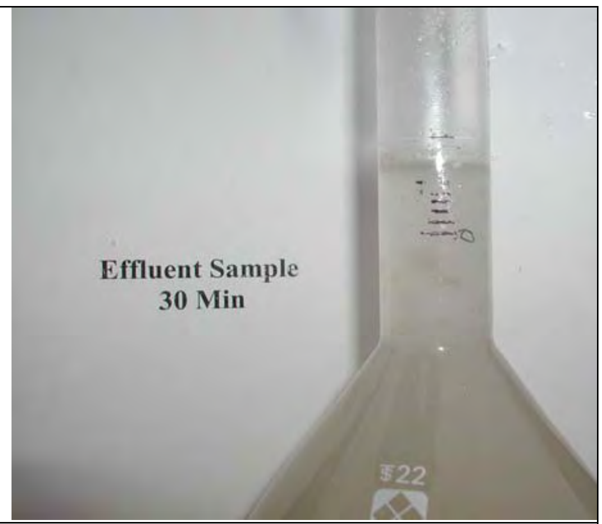
	
Influent Sample	Effluent Sample

Figure 3.11 Example of Floating FOG Samples after 30 Minutes of Separation Time in the Flask Collected from Ruby's Diner

Table 3.3 Ruby's Diner GRD Field Data

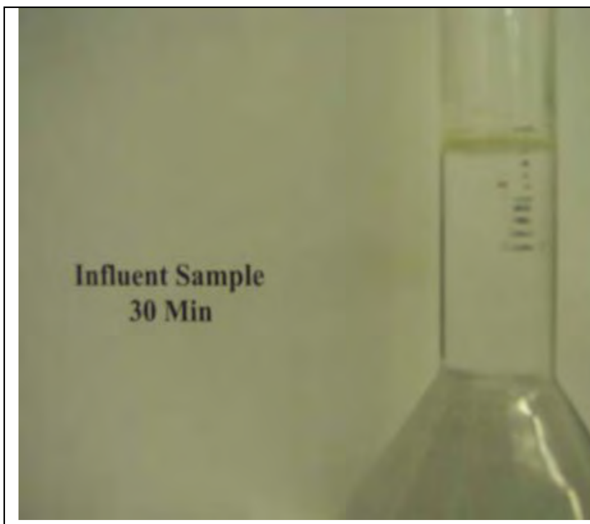
Site: Ruby's Diner
GRD Manufacturer/Model: Supplier M (150 gpm)
Unit Connected To: All of the Significant Grease Waste Drains in the Kitchen (Containment Type)
Fixture(s) Discharging During Sampling: Pot Sinks and Pre-rinse Sink

Date Collected	Floating FOG Measurements (1,000 ml Volumetric Flask)			GRD FOG & Settled Solids			
3/8/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	12	0	Main	26	7	4
	2	12	0.5				
	5	12	0.5				
	10	12	0.5				
	30	12	0.5				
3/29/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	25	0	Main	26	0.25-0.5	0
	2	25	0				
	5	25	0				
	10	25	0				
	30	25	0				
4/29/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	15	0	Main	25.5	0.25	3
	2	15	0				
	5	15	0				
	10	15	0				
	30	15	0				
6/10/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	17	0	Main	25.5	0.25	1
	2	17	0				
	5	17	0				
	10	17	0				
	30	17	0				

8/23/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	9	<0.25	Main	25.5	0.5	3
	2	12	<0.25				
	5	18	<0.25				
	10	18	<0.25				
	30	18	<0.25				

3.4.2.3 Assisi House

Figure 3.12 25-gpm Supplier M GRD Under the Sink in the Assisi House Kitchen



Influent Sample	Effluent Sample

Figure 3.13 Example of Floating FOG Samples after 30 Minutes of Separation Time in the Flask Collected from Assisi House

Table 3.4 Assisi House GRD Field Data

Site: Assisi House

GRD Manufacturer/Model: Supplier M (25 gpm)

Unit Connected To: 3-Compartment Pot Sink (Isolation Type)

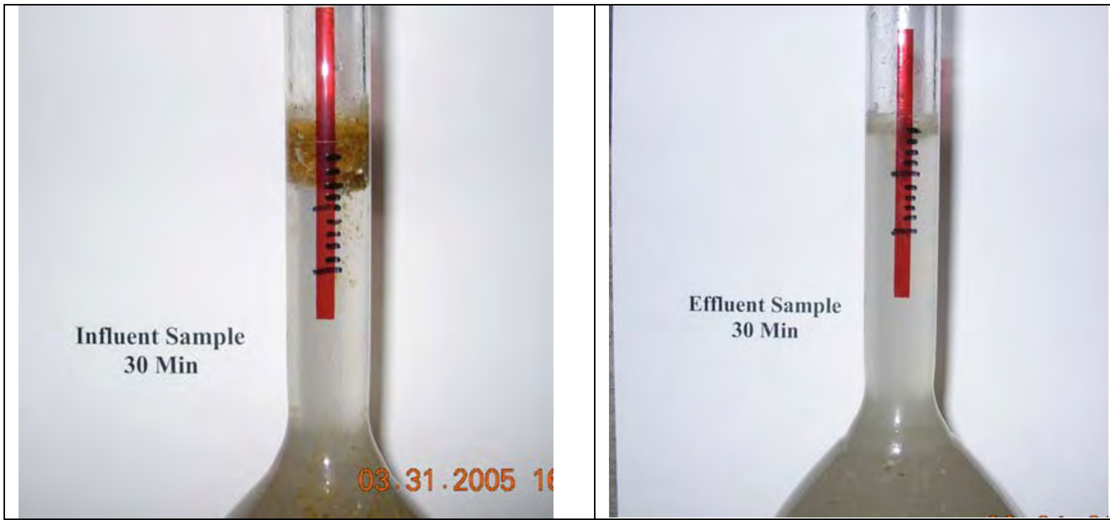
Fixture(s) Discharging During Sampling: 3-Compartment Pot Sink

Date Collected	Floating FOG Measurements (1,000 ml Volumetric Flask)			GRD FOG & Settled Solids			
3/8/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	0	0.25	Main	13	0.5	2
	2	0.5	0.25				
	5	0.5	0.25				
	10	0.5	0.25				
	30	0.5	0.25				
3/29/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches))
	0	1	0.5	Main	13	0.75-1	3
	2	2	0.75				
	5	3	0.75				
	10	3	0.75				
	30	5	0.75				
4/29/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	1	0	Main	13	0.125	2
	2	1	0				
	5	1	0				
	10	1	0				
	30	1	<0.25				
6/10/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	0	0	Main	13	0.25	4
	2	0	0				
	5	0	0				
	10	<0.5	0				
	30	<0.5	0				

8/23/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	<0.25	0	Main	13	1.5	3
	2	<0.25	0				
	5	<0.25	0				
	10	<0.25	0				
	30	0.25	0				

3.4.2.4 Hi-Hat Restaurant

Figure 3.14 25-gpm Supplier N GRD Under a Sink in the Hi-Hat Kitchen



Influent Sample	Effluent Sample

Figure 3.15 Example of Floating FOG Samples after 30 Minutes of Separation Time in the Flask Collected from Hi-Hat

Table 3.5 Hi-Hat GRD Field Data

Site: Hi-Hat Restaurant

GRD Manufacturer/Model: Supplier N (25 GPM)

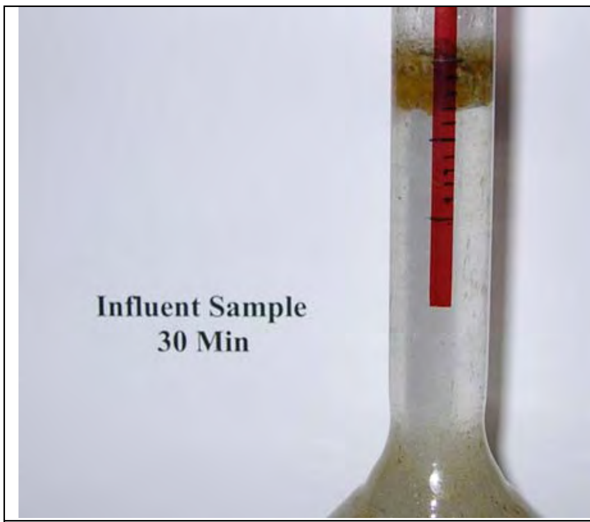
Unit Connected To: 3-Compartment Pot Sink & Pre-rinse Sink (Isolation Type)

Fixture(s) Discharging During Sampling: Primarily the 3-Compartment Pot Sink

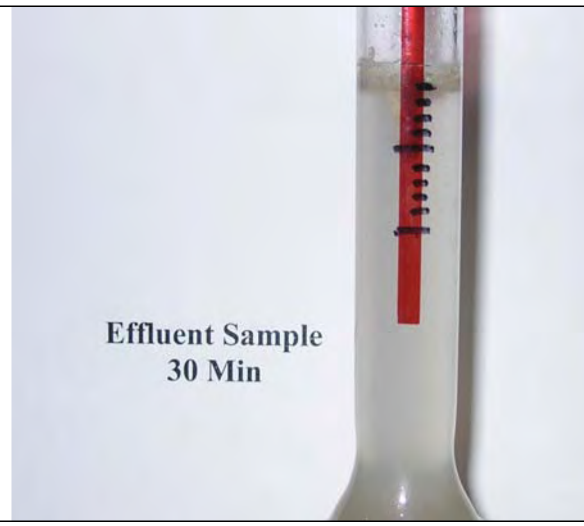
Date Collected	Floating FOG Measurements (1,000 ml Volumetric Flask)			GRD FOG & Settled Solids			
3/15/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	0.5	0	Main	8	0	0
	2	1	0				
	5	1	0				
	10	1	0				
	30	1.5	0				
4/1/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settable Solids (inches)
	0	25	0	Main	8	0.25	1
	2	30	0				
	5	30	0				
	10	30	0				
	30	30	0.25				
5/26/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settable Solids (inches)
	0	30	0	Main	8	0.25	3
	2	35	0				
	5	35	0				
	10	35	0				
	30	35	0				

3.4.2.5 L'Alouette

Figure 3.16 35-gpm Supplier N GRD in the L'Alouette Basement



Influent Sample



Effluent Sample

Figure 3.17 Example of Floating FOG Samples after 30 Minutes of Separation Time in the Flask Collected from L'Alouette

Table 3.6 L'Alouette GRD Field Data

Site: L'Alouette Restaurant

GRD Manufacturer/Model: Supplier N (25 GPM)

Unit Connected To: A Pot Sink & a Pre-rinse Sink (Isolation Type)

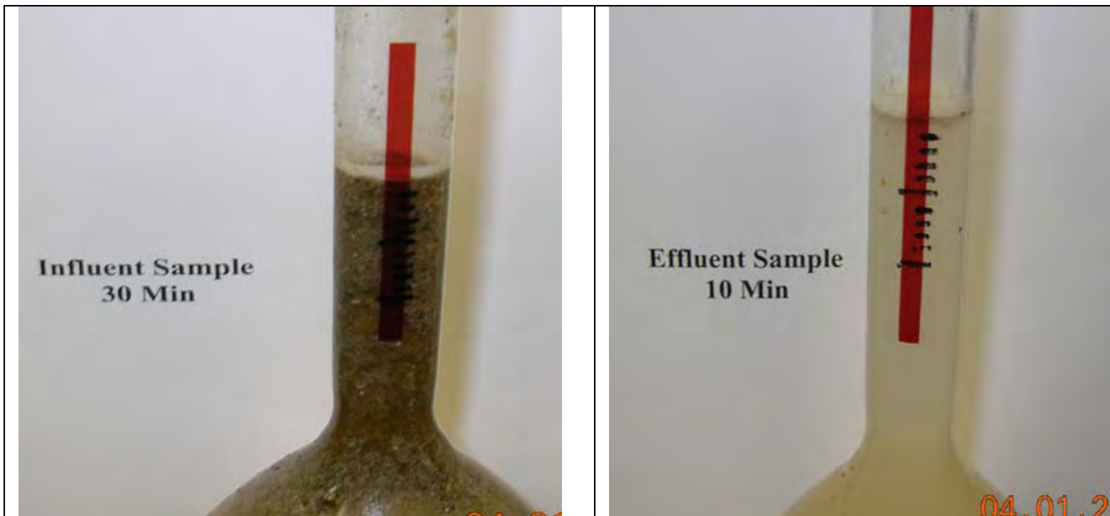
Fixture(s) Discharging During Sampling: Typically the Pot Sink

Date Collected	Floating FOG Measurements (1,000 ml Volumetric Flask)			GRD FOG & Settled Solids			
3/7/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	N/A	N/A	Main	8	<0.25	2
	2	N/A	N/A				
	5	N/A	N/A				
	10	N/A	N/A				
	30	N/A	N/A				
3/14/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	1	0	Main	8	<0.25	2.25
	2	2	0				
	5	2.5	<0.25				
	10	2.5	<0.25				
	30	3	<0.25				
3/31/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	1	0	Main	8	0.25	3.5
	2	2.5	0				
	5	3	<0.25				
	10	3.5	<0.25				
	30	4	<0.25				
5/10/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	3.5	0	Main	8.5	0.25	6
	2	4	0				
	5	4.5	0				
	10	5	0				
	30	5	0				
5/25/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	2.5	0	Main	8.5	0.5-0.75	7
	2	4	<0.25				
	5	5	<0.25				
	10	5.5	<0.25				
	30	6	<0.25				

N/A = No dishwashing activity during sampling event.

3.4.2.6 Rhode Island Convention Center

Figure 3.18 150-gpm Supplier N GRD in the RI Convention Center Basement



Influent Sample	Effluent Sample

Figure 3.19 Example of Floating FOG Samples after 30 Minutes of Separation Time in the Flask Collected from the RI Convention Center

Table 3.7 R.I Convention Center GRD Field Data

Site: R.I. Convention Center

GRD Manufacturer/Model: Supplier N (100 GPM)

Unit Connected To: All of the Significant Grease Waste Drains in the Kitchen (Containment Type)

Fixture(s) Discharging During Sampling: Pot Sinks and Pre-rinse Sinks

Date Collected	Floating FOG Measurements (1,000 ml Volumetric Flask)			GRD FOG & Settled Solids			
3/15/2005	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	N/A	N/A	Main	18	<0.25	0.25
	2	N/A	N/A				
	5	N/A	N/A				
	10	N/A	N/A				
	30	N/A	N/A				
4/1/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	3	0	Main	18	<0.25	0.75
	2	4	0				
	5	5	0				
	10	5.5	0				
	30	5.5	0				
5/26/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches))
	0	30	0	Main	18	0.5	5
	2	35	0				
	5	35	0				
	10	35	0				
	30	35	0				

N/A = No dishwashing activity during sampling event.

3.4.2.7 El Tapatio

Figure 3.20 25-gpm Supplier O GRD Under a Sink in the El Tapatio Kitchen

Influent Sample

Effluent Sample

Figure 3.21 Example of Floating FOG Samples after 30 Minutes of Separation Time in the Flask Collected from El Tapatio

Table 3.8 El Tapatio GRD Field Data

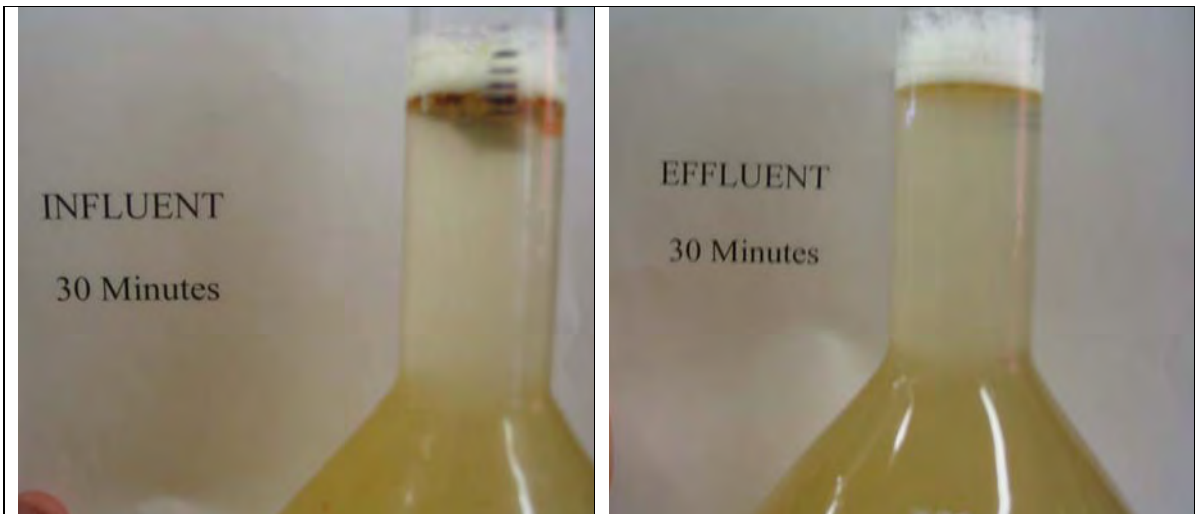
Site: El Tapatio
GRD Manufacturer/ Model: Supplier O (25 gpm)
Unit Connected To: 3-Compartment Pot Sink (Isolation Type)
Fixture(s) Discharging During Sampling: 3-Compartment Pot Sink

Date Collected	Floating FOG Measurements (1,000 ml Volumetric Flask)			GRD FOG & Settled Solids			
6/09/05*	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	300	15	Main	10	6	3
	2	400	20				
	5	400	20				
	10	400	20				
	30	400	20				
6/17/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	400	0	Main	10	3	2
	2	500	0.25				
	5	500	0.50				
	10	500	0.75				
	30	500	1.0				

* The GRD skimmer electronics were shorted out. It is not known how long the unit was failing to skim the floating FOG.

3.4.2.8 Oh's Catering

Figure 3.22 25-gpm Supplier O GRD Under a Sink in the Oh's Catering Kitchen



Influent Sample	Effluent Sample

Figure 3.23 Example of Floating FOG Samples after 30 Minutes of Separation Time in the Flask Collected from Oh's Catering

Table 3.9 Oh's Catering GRD Field Data

Site: Oh's Catering:

GRD Manufacturer/ Model: Supplier O (25 gpm)

Unit Connected To: 3-Compartment Pot Sink (Isolation Type)

Fixture(s) Discharging During Sampling: 3-Compartment Pot Sink

Date Collected	Floating FOG Measurements (1,000 ml Volumetric Flask)			GRD FOG & Settled Solids			
6/09/05	Time (min)	Influent Floating FOG (ml)	Effluent Floating FOG (ml)	Chamber	Liquid Depth (inches)	Floating FOG (inches)	Settled Solids (inches)
	0	1	0	Main	10	<0.25	<0.5
	2	1.5	0				
	5	1.5	<0.25				
	10	1.75	<0.25				
	30	2	0.25				

3.4.3 Summary of Results

3.4.3.1 Initial Field Inspections

Based on the results of the 21 initial inspections, the installation and maintenance concerns expressed by many sewering agencies are well supported by the results of the inspections. The major issues encountered were as follows:

- Maintenance Issues – Ten (10) of the 21 GRDs had significant maintenance issues (e.g., solids basket missing or under-maintained, skimmer not operating, grease scrapers worn down, waste grease drum level alarm turned off, and waste grease drums overflowing). It is logical to assume that a higher percentage of GRD sites are experiencing maintenance issues than were documented here. This is due to the fact that the FSEs had advance warning that the GRDs would be inspected, and many of the FSEs told EEC that they checked the GRD before EEC arrived.

  Note: It is EEC's understanding that none of the GRDs evaluated in these locations were being closely monitored for maintenance issues by the local regulatory agency. For example, EEC interviewed the regulatory agency responsible for monitoring Supplier M's GRDs in that area of Pennsylvania, but monitoring for the proper maintenance of the GRDs was not included in their monitoring program. Additionally, none of the FSE managers interviewed described any enforcement that they had received related to improper maintenance of their GRD.

- Installation Issues – Nine (9) of the 21 installations were isolation–type, typically connected to only 1 grease waste drain. At 6 of the FSEs with these types of installations, there were other potentially significant grease waste drains (e.g., dishwashing pre-rinse sink) not connected to any grease removal equipment. At the other 3 FSEs, there were other waste drains that would contain some grease (e.g., mop sinks) that were not connected to any grease removal equipment.[36] Additionally, 1 GRD was undersized and 1 was missing a flow control device.

  Note: It is presumed by EEC, based on the initial inspections that most of the building departments or other agencies involved with approving the installations of the isolation-type GRDs in the Study did not require that other potential significant grease waste drains be connected to any grease control equipment.

3.4.3.2 Follow-up Evaluations

There were 29 GRD inspections and 26 sampling events due to the fact that there were 3 occasions where there were no dishwashing operations taking place at the time of the inspections. The field data and findings are summarized as follows:

[36] Although 12 of the 21 installations in this Study were containment-type, based on interviews with the GRD manufacturers, a vast majority of GRDs sold in the United States are installed as isolation-type.

<u>General Maintenance Findings:</u>

- Twenty-six (26) of the 29 GRD inspections revealed a relatively thin floating FOG layer (e.g., ≤15% of the total liquid depth) in the main chamber of the GRD, which indicates that the FOG skimming or pumping was being performed at a minimum of 90% of these sites.

- Sixteen (16) of the 29 GRD inspections revealed relatively low settled solids layers (e.g., ≤15% of the total liquid depth) which indicates that some level of solids maintenance was being performed at a minimum of 55% of these sites (e.g., the solids basket was being emptied regularly or the unit was being cleaned out regularly).

<u>Effluent Floating FOG Findings:</u>

- Twenty-two (22) of the 26 sampling event results indicated a 30-minute effluent floating FOG volume of 0.25 ml (0.025%) or less. In many cases, there was foam or floating solids in the floating FOG layer that made it difficult to make more accurate measurements.

<u>General Maintenance/Effluent Floating FOG Correlation Findings:</u>

- In the 26 sampling events conducted when a relatively thin floating FOG layer (e.g., ≤15% of the total liquid depth) in the main chamber of the GRD was measured, only 1 event identified a floating FOG volume in the effluent >0.25 ml (0.75 ml). The influent floating FOG volume for this event was 5 ml. For the other 25 events, the influent floating FOG volume ranged from 0.25 ml to 35 ml, with 11 events exceeding 5 ml. This is an indication that when the GRDs are well maintained and remove the floating FOG as designed, the effluent floating FOG results are relatively low and consistent even when influent floating FOG concentrations are relatively high.

- In the 3 sampling events conducted when a floating FOG layer >15% of the total liquid depth (ranging from 3 to 7 inches) in the main chamber of the GRD was identified, all 3 events identified a floating FOG volume in the effluent >0.25 ml (ranging from 0.5 to 20 ml). The influent floating FOG volume for these events ranged from 5 ml to 500 ml. This is an indication that when the floating FOG layer in the GRD is not adequately skimmed or pumped, there is a portion of the floating FOG that is not captured and retained in the GRD and passes through to the effluent.

- In the 16 sampling events conducted when a relatively low settled solids layer (e.g., ≤15% of the total liquid depth) in the main chamber of the GRD was measured, only 1 of these events identified a floating FOG volume in the effluent >0.25 ml (0.5 ml). However, in the 10 sampling events conducted when a settled solids layer >15% of the total liquid depth (ranging from 2 to 9 inches) in the main chamber of the GRD was identified, only 3 of these events identified a floating FOG volume in the effluent > 0.25 ml (ranging from 0.75 to 20 ml). No direct correlation between the depth of the settled solids layers and the effluent floating FOG volume was identified.

Specific Findings for Events with Floating FOG Layer >15% of the Total Liquid Depth:

- The 6/09/05 El Tapatio inspection and sampling event showed that a GRD with a non-operating skimmer will develop a thick floating FOG layer (e.g., 6 inches or 60% of the liquid depth), which will cause much of the floating FOG (e.g., 20 ml or 2%) to pass through the unit and into the sewer.

- The 6/17/05 El Tapatio inspection and sampling event showed that the GRD had a relatively thick floating FOG layer of 3 inches (30% of the liquid depth), which caused an effluent floating FOG volume of 1 ml (0.1%) to pass through the unit and into the sewer. Although this amount of effluent floating FOG may be a concern, and may be an indication of poor maintenance causing floating FOG pass through, it is interesting to note that this effluent floating FOG amount is at least 10 times less than the 6/09/05 El Tapatio sampling event when the floating FOG layer was 6 inches thick (60% of the liquid depth),. This may be an indication that there is a critical floating FOG layer depth at which floating FOG will more rapidly pass through the unit for a specific flow rate. In this case, the critical point may have been between 30% and 60% of the liquid depth since the flow rates were similar.[37]

- The Ruby's Diner inspection and sampling event on March 8, 2005 revealed a 7-inch floating FOG layer (27% of the liquid depth) in the GRD. This was due to the waste grease drums being full on that day; therefore, the floating FOG could not be pumped out of the GRD. This resulted in an effluent floating FOG result of 0.5 ml, while the other Ruby's Diner sampling event effluent results were 0 ml to <0.25 ml when the floating FOG layers in the GRD were 0.5 ml or less. This indicates the importance of the floating FOG layer being removed frequently to prevent it from becoming too thick and causing pass through of floating FOG.

3.6 Conclusions

A large percentage of GRDs that are installed or may be installed in the future will not likely be well maintained by the FSEs, or may not be connected to all of the significant grease waste drains, if there is not significant agency oversight. This conclusion is based on the results of the initial inspections and the lack of agency oversight of these issues at the facilities. It is important to note that the facilities that were inspected did not appear to be regulated by a maintenance inspection program by the local agency and there did not appear to be significant oversight by the local building department for installation of the isolation-type GRDs in relationship to being connected to the proper grease waste drains.

The GRD's ability to remove FOG from the wastewater is encouraging based on the floating FOG removal results for well-maintained GRDs, even though GRDs have shorter retention times (e.g., 0.5 to 2 minutes at maximum flow) than conventional grease

[37] The flow rates for the 6/9/2005 and 6/17/2005 sampling events were similar because the flow resulted from the release of the water from the same full pot sink by opening the drain stop.

interceptors. These encouraging results[38] were specific to the well maintained units and for the grease waste drains that were discharging to the GRDs.[39]

In summary, based on the evaluations in this Study, GRDs may work effectively on the fixtures they are properly connected to as long as they are properly sized,[40] installed, and maintained. However, assurances must be made by inspectors approving installations that all GRDs are sized and installed correctly and that the isolation-type GRDs are connected to all potential significant grease waste drains. Additionally, frequent maintenance inspections by a regulatory agency will be required in order to ensure that the GRDs are properly maintained.

Based on these requirements, each agency will need to evaluate the inspection requirements and associated agency costs related to GRDs. Additionally, the agency will need to evaluate the potential risk of a GRD providing inadequate FOG control, which may be due to poor FSE maintenance or not being installed on all of the grease waste drains, allowing pass through of FOG and impacting the sewer system.

3.7 Recommendations

The utilization of GRDs as a potential alternative to a grease interceptor in an agency's FOG Program is recommended to be evaluated on a risk basis. There are risks associated with all grease removal equipment in their installation and maintenance. The risks associated with each technology along with the agency's local conditions must be considered when an agency is evaluating when or how these technologies may be utilized.

During the evaluation process, the relative risks of the GRDs should be compared to conventional grease interceptors, which are connected to all the potential grease waste drains, require significantly less maintenance, and have much larger retention times and storage capacity than GRDs. However, it is important to note that the longer retention time in a conventional grease interceptor may result in more hydrogen sulfide generation.

In general, when comparing risks associated with floating FOG removal between GRDs and conventional grease interceptors, GRDs possess a higher risk due to the maintenance and installation issues discussed in this report. However, if these risks can be sufficiently mitigated or managed, GRDs may have a role in Orange County FOG Control Programs as an alternative to a conventional grease interceptor at certain FSEs. The risks associated with GRDs and the potential mitigation measures are as follows:

[38] These results were observed during a significant flow event, but not at a measured maximum rated flow for the unit.
[39] As discussed earlier, the GRDs were not always connected to other significant grease waste drains at the facility.
[40] The Study did not evaluate the effectiveness of the GRDs at the fully rated flow or the sizing criteria for the GRDs. An agency may need to refer to the manufacturer's recommendations for proper sizing.

3.7.1 GRD Risks and Associated Agency Recommendations

3.7.1.1 Improper or Impractical Installation

Risk:

Breakdown in plumbing approval and inspection process based on plumbers' and agencies' unfamiliarity with the manufacturers' recommended installation requirements, resulting in faulty installations or installations in an impractical location (e.g., flow control device missing, undersized unit, and difficult access for maintenance).

Potential Mitigation Measures:

Develop and implement strict and clear requirements for proper installation (fixtures and drain lines to be connected), application approval, and inspection procedures.

3.7.1.2 Lack of Treatment of Other Grease Waste Drains

Risk:

As discussed in this report, 6 of the 9 isolation-type GRDs were not connected to other significant grease waste drains, and the other 3 isolation-type GRDs were not connected to other grease waste drains that would discharge some amount of grease. This is most likely due to a general lack of understanding of grease waste drains by many of the approval agencies and the tendency by many agencies to require either "1 GRD or 1 conventional grease interceptor per FSE" without realizing that 1 GRD is often not sufficient FOG control for many kitchens.

Potential Mitigation Measure:

All of the potential grease waste drains should be considered in the approval process for GRDs. This may often result in selection of an underground containment-type GRD or the installation of more than 1 isolation-type GRD per FSE[41]. For ease of understanding, the following comparisons of isolation-type and containment-type GRD applications are provided:

> Isolation-type Application – The Most Significant Grease Waste Drains Connected to 1 or More GRDs Under the Counter(s): This may be deemed appropriate for FSEs that discharge a vast majority of their grease through 1 to 3 significant grease waste drains (e.g., pot sink or dishwashing sink). In this case, these drains would be connected to 1 or more GRDs under a counter(s). This would avoid an underground or vaulted installation in almost all cases. Potential logical FSEs for this approach could be FSEs with relatively low grease discharge to floor drains and floor sinks (e.g., coffee houses, sandwich shops, and pizza shops). This application may not be deemed appropriate for FSEs discharging to hot spot sewer lines. Note – the other risks associated with GRDs must also be considered when evaluating this application including health department requirements.

[41] This should be aided by the changes in the 2006 Uniform Plumbing Code (UPC), which will include GRDs in the grease interceptor category and will modify section 1014.1 to specify that "*grease interceptor(s)* shall be installed in the *waste lines* leading from sinks, drains, and other fixtures or equipment in establishments…" This plural wording was not present in the previous UPC editions.

Containment-type Application – All Grease Waste Drains Connected to an Underground GRD: This may be deemed appropriate for FSEs with other potential significant grease waste drains beyond the pot sink and dishwashing sink (e.g., mop sink, floor sinks, wok floor drains, kettle trench drains) that may impact the sewer system. This would typically result in 1 underground (typically vaulted) GRD installation. Potential logical FSEs for this approach could be new FSEs; existing FSEs with grease discharge to floor drains or floor sinks as well as the dishwashing or pot sink (e.g., FSEs with fryers, woks, and kettles); and FSEs discharging to hot spot sewer lines. Note – the other risks associated with GRDs must also be considered when evaluating this application including accessibility for maintenance.

3.7.1.3 Requirement for Daily, Weekly, and Monthly Maintenance

Risks:

Many FSEs are not performing the required maintenance (cleaning scrapers, emptying solids baskets, etc.), or the unit is not functioning as designed (e.g., timers set incorrectly, baskets missing, scrapers worn down, alarms turned off). Ten (10) of 21 FSEs in the initial inspections of sites chosen by the suppliers were not performing the required maintenance or had other maintenance-related issues. Many agencies report that many of their FSEs do not perform the required GRD maintenance. Additionally, one dilemma that is caused by an underground, vaulted installation to capture all of the potential grease waste drains is that the GRD will be out of sight and more difficult to clean and maintain. Many of the FSEs that were interviewed during this Study complained about the difficulty in maintaining a GRD in a vault due to the difficulty of access.

Potential Mitigation Measure:

In EEC's opinion, the only way to mitigate the risk of FSEs not performing the required maintenance is through frequent inspections and meaningful enforcement. EEC traveled to Rhode Island and interviewed 5 inspectors and the Pretreatment Manager from the Narragansett Bay Commission (NBC) on May 19, 2005 because their agency has an established FSE inspection program and has more than 400 GRDs in their service area. NBC stated that 30-40% of their GRD inspections result in issuance of a notice of violation (NOV), but there is greater than 90% compliance after re-inspection. The most common NOVs are issued for lack of record keeping (e.g., maintenance logs) and not properly maintaining the GRD as required in their Wastewater Discharge Permit. NBC inspects FSEs with GRDs a minimum of once per year, but they believed that many FSEs should be inspected as often as quarterly. Non-compliant FSEs should be inspected as often as necessary to return to compliance. Note: NBC's recommendations are based on their own set of local conditions (e.g., number of grease-related blockages and back-ups, goals of their FOG Control Program, regulatory environment). Each Orange County city or agency will need to determine the appropriate level of inspections and enforcement based on their local conditions.

A higher frequency of inspections and enforcement will result in a need for increased resources for the FOG Control Program. It is logical that an FSE that is approved for an alternative technology that requires more frequent inspections, such as a GRD, should be charged a higher permit fee or be charged inspection fees for the FOG Control Program to recover these costs. Additionally, a condition for approval could be if the unit is not maintained, then a conventional grease interceptor may be required.

3.7.2 Conditional Variance Recommendation

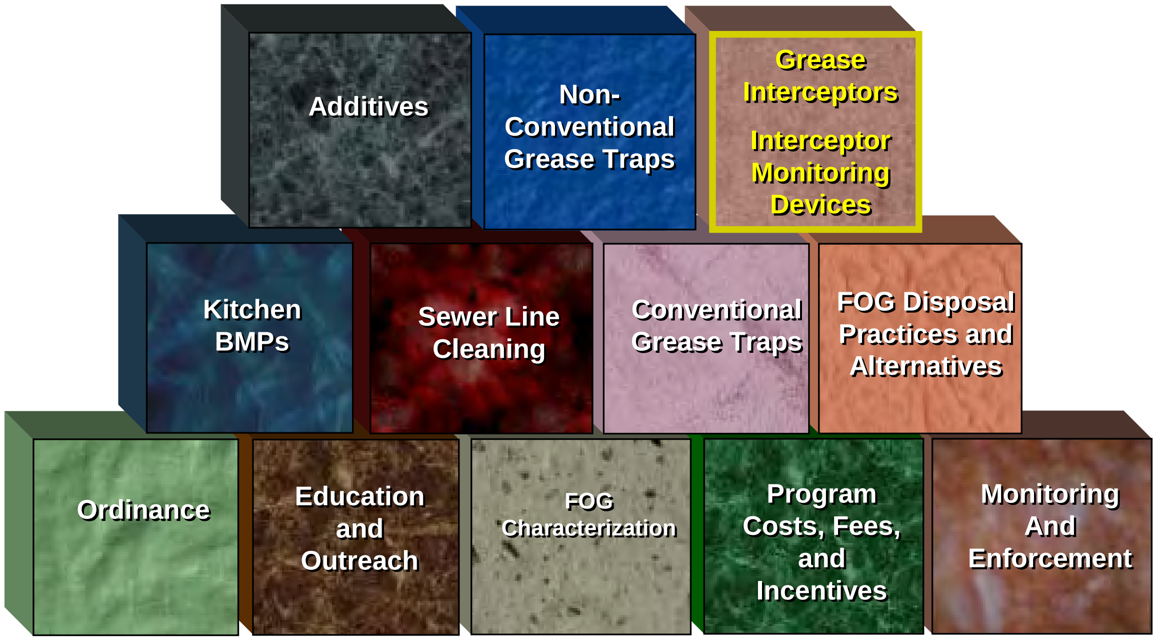
Due to the risks associated with GRDs, if an Orange County FOG Control Program allows GRDs as an alternative to a conventional grease interceptor, it is recommended that the GRD should be approved only as part of a conditional variance[42]. The conditional variance can be revoked due to a track record of improper maintenance or if an accumulation of grease is identified through CCTV evidence in the sewer system downstream of the FSE. If designed properly with an effective inspection and enforcement strategy, this will provide the necessary motivation for the FSE to perform the proper maintenance on the GRD(s).

The concept for a conditional variance that may be utilized is as follows:

- Conditional Variance Request - If a FSE desires to install a GRD(s) (or possibly a conventional grease trap[43]) rather than a conventional grease interceptor, the FSE will be required to request a conditional variance from the city or special district and submit drawings depicting all the significant grease waste drains, at a minimum, that will be connected to the GRD(s). The drawings should also be evaluated by the health department.
- Conditional Variance Requirements - The FSE would be required to perform the required maintenance and maintain maintenance logs.
- Conditional Variance Revocation – The variance "condition" would be if the maintenance is not performed (i.e., too many NOVs) or if there is CCTV evidence of significant FOG build-up in the FSE's lateral or the main sewer line immediately downstream of the FSE, then the variance would be revoked and the FSE would have to install a conventional grease interceptor and/or pay related enforcement fines.
- Conditional Variance Potential Costs - The FSE would possibly have to pay an additional ongoing fee for the city or special district to recover the costs of increased inspections.

[42] A conditional variance is authorization to deviate from the Agency's Ordinance, Code and/or Rules and Regulations based on the requirement that specific conditions are achieved and maintained. If the conditions are not achieved or maintained, the variance will no longer be valid and the permittee will be required to comply with standard program requirements.

[43] Conventional grease traps have many of the same installation and maintenance issues related to GRDs.



4.0 INTERCEPTOR MONITORING DEVICE EVALUATIONS

4.1 Background and Technology Description

Interceptor Monitoring Devices (IMDs) are level-monitoring devices, installed in conventional underground grease interceptors, which provide continuous measurement of the floating FOG level and/or the settled solids level. Conventional grease interceptors operate by gravity separation. Given sufficient space and time, floating FOG and settled solids separate from the kitchen wastewater and slowly accumulate in the grease interceptor. For the grease interceptor to perform correctly, these settled solids and floating FOG must be removed before they accumulate beyond a certain level to avoid clogging the plumbing in the interceptor or significantly reducing the overall space in the interceptor, which affects the ability of the interceptor to separate the waste material from the wastewater. The general standard maintenance level for solids and floating FOG accumulation is “The 25% Rule.” According to “The 25% Rule,” if the combined accumulation of solids and/or FOG exceeds 25% of the capacity of the interceptor, the interceptor must be cleaned. The “25% Rule” was adopted by many of the north Orange County cities and sewering agencies when they adopted their new FOG Control Ordinances in late 2004.

FSEs are responsible for maintaining (pumping out) their grease interceptors; however, they do not typically monitor their interceptors. Therefore, without some form of automated monitoring, the interceptors are typically cleaned on a “best guess” frequency. On this basis, these interceptors are typically either over-maintained or under-maintained. Since FSEs are naturally concerned with the cost of over-maintaining their interceptors, it is logical to assume that many interceptors are under-maintained, which leads to pass through of solids and FOG into the sewer system. In fact, before enforcement of the “25% Rule” was initiated, EEC inspected over 500 grease interceptors in north Orange

County and identified that approximately 30% of the grease interceptors that were inspected exceeded the "25% Rule" of combined solids and FOG accumulation.

The Phase I Study recommended extensive agency monitoring of grease interceptors due to the importance of proper maintenance of interceptors. IMDs were identified in the Phase I Study as the most promising technology to provide automated monitoring with minimal agency involvement. The IMDs evaluated in the Study utilize different grease and/or solids level monitoring technologies (ultrasonic vs. capacitance), but in both cases, the IMD probe is installed in one of the grease interceptor manholes and is wired to a datalogger (or controller) that displays and records the probe measurements. The datalogger is typically located in the FSE General Manager's office or in the kitchen. In the case of one supplier, its IMD measures the floating FOG layer and the settled solids layer. In the case of the other supplier, its IMD measures only the floating FOG layer. Both suppliers offer remote monitoring of their installations through telemetry (e.g., via a modem) allowing FSE managers, service providers, or agencies to access the data via a website. A diagram of a typical IMD probe installation location in an interceptor is provided below.

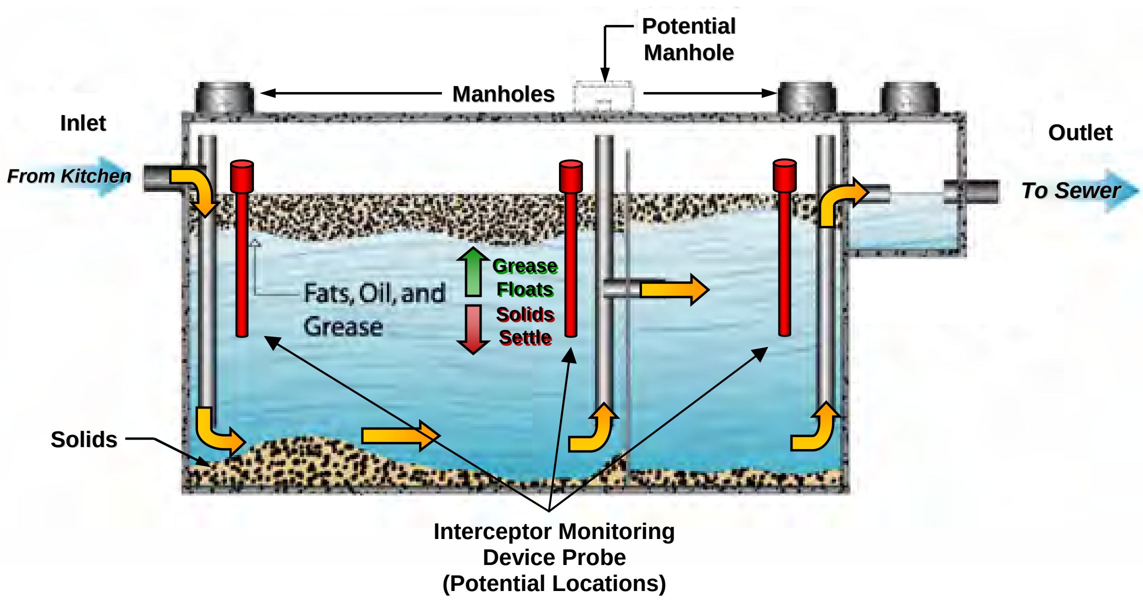


Figure 4.1 Interceptor Monitoring Device (IMD) Installation (Probe Installation Location May Vary)

If found to be accurate, reliable, and cost effective, this technology would dramatically reduce the need to manually measure the floating FOG and settled solids levels in interceptors, either by FSEs or by agency inspectors. This would result in enhanced performance by grease interceptors due to proper maintenance. The price to purchase and install an IMD in a new conventional grease interceptor is approximately $1,000. The price to purchase and install an IMD in an existing conventional grease interceptor is approximately $1,500.

4.2 Supplier and Location Selection Process

To initiate the IMD portion of the Phase II Study, a public notice to prospective suppliers was provided through posting of a notice on the websites of OCSD, EEC, and WEF. The supplier identified in Phase I of the Study and a second supplier identified during discussions with a manufacturer that is involved in the NCGT portion of the study responded to this posting. They were provided a "Fats, Oils, and Grease (FOG) Technology Supplier Participation, FOG Interceptor Monitoring Device Field Evaluation and Supplier Requirements" notice (Appendix A) and were required to respond by October 29, 2004, to confirm their desire to participate in the Study. These suppliers were then provided a copy of the IMD workplan (Appendix B) and were required to submit a letter of commitment and indemnification (Appendix C) for continued consideration for participation in the Study.

These 2 suppliers - Supplier P and Supplier Q - agreed to participate in the Study. The suppliers were asked to provide a list of potential FSE locations for initial evaluations. Supplier P had multiple FSE installations of its product nationwide and provided a list for these initial inspections. EEC then coordinated with Supplier P and chose 7 sites for the initial evaluations. Supplier Q identified only 2 installations in conventional grease interceptors since this was a new application of an existing technology. These were the sites selected for the Supplier Q evaluations. After the initial evaluations were completed, 3 of the Supplier P sites and both Supplier Q sites were selected for the follow-up evaluations.

As discussed in Section 1.3, the names of the suppliers who participated in the Study have been excluded from the body of the report but are included in Appendix A. The evaluation locations are provided in the table below (addresses of the restaurants are not included).

Table 4.1 IMD Evaluation Locations

IMD Supplier	Initial Evaluation Sites	Follow-up Evaluation Sites
Supplier P	Red Lobster Restaurant #1, PA	Red Lobster Restaurant #2, PA
	Red Lobster Restaurant #2, PA	Arby's Restaurant #1, PA
	Ruby Tuesday's Restaurant #1, PA	Lone Star Restaurant, PA
	Ruby Tuesday's Restaurant #2, PA	
	Arby's Restaurant #1, PA	
	Arby's Restaurant #2, PA	
	Lone Star Restaurant, PA	
Supplier Q	P.F. Chang's Restaurant #1, CA	P.F. Chang's Restaurant #1, CA
	P.F. Chang's Restaurant #2, CA	

4.3 Study Workplan

The workplan was designed to examine and evaluate the accuracy, reliability, and durability of the IMDs to determine their potential role in FOG Control Programs. A copy of the original workplan is provided in Appendix B. The workplan was later modified based on the results of the initial inspections. A summary of the modified workplan is as follows:

1) All existing installations evaluated were confirmed to be standard installations at typical FSEs. It was noted how the IMD was installed (e.g., located within the second chamber) and other pertinent issues (e.g., size of interceptor). The interceptor water level, solids layer depth, and FOG layer depth were manually measured through the use of a core sampler and compared against the measurements that are recorded by the IMD.[44] Photographs of manual floating FOG and settled solids layer measurements are provided below.

Floating FOG Measurement | Settled Solids Measurement

Figure 4.2 Core Sampler Measurements

2) FSE representatives familiar with the operation and maintenance of the IMD were interviewed to explore potential problems experienced with the IMD.

3) The accuracy and reliability of the IMDs chosen for follow-up evaluations were monitored at each FSE at a frequency of approximately once per month for a period of approximately 6 months.[45]

Two IMD products were evaluated. The Supplier P IMD was evaluated at 7 different test sites initially in February 2005 and then 3 test sites were chosen for 5 follow-up visits at each location between March 2005 and August 2005. Each of these installations was in operation for a minimum of 6 months before the evaluation.

The Supplier Q IMD was not installed at its 2 locations and ready for evaluation until May 2005. There was limited data collected on the Supplier Q IMD based on 3 visits at 1 location and 1 visit at the other location between June 2005 and December 2005.

[44] The Supplier Q IMD does not measure settled solids; therefore the settled solids comparisons were not made for the Supplier Q locations.

[45] In the case of Supplier Q, this plan had to be adjusted based on the starting date and issues identified at the initial inspections.

4.4 Findings

4.4.1 Initial Field Inspections

Initial Supplier P inspections were conducted at 7 FSEs in eastern Pennsylvania in February 2005. Manual floating FOG and settled solids measurements were collected and were compared against the Supplier P FOG and solids measurements displayed on the datalogger. The IMD probe was installed in the second interceptor chamber at 5 of the FSEs and in the first interceptor chamber at 2 of the FSEs. The FOG and solids in both chambers were measured, but accuracy comparisons were logically made only in the chamber where the IMD probe was located.

Initial Supplier Q inspections were conducted at 2 FSEs in Southern California in June and July 2005. Manual floating FOG measurements were collected and were compared against the Supplier Q FOG measurements displayed on the datalogger. The Supplier Q IMD does not measure the settled solids layer; therefore any manual settled solids measurements were for information only. The IMD probe was installed in the second interceptor chamber at both FSEs; therefore the second chamber floating FOG layer measurement was used for accuracy comparison purposes. The data from these initial inspections are provided in the table below.

Table 4.2 IMD Initial Inspections

	Total Liquid Depth (inches)	Floating FOG Layer Depth (inches)		Solids Layer Depth (inches)	
		Chamber #1	Chamber #2	Chamber #1	Chamber #2
SUPPLIER P – February 9, 2005					
Red Lobster #1					
Manual Meas.	46	7	NA[1]	<4[2]	NA
IMD Meas.	46	8	NA	0	NA
Accuracy	High	High	-	High	-
Red Lobster #2					
Manual Meas.	53	10.5	4 – 24[3]	13.5	<4
IMD Meas.	53	NA	4	NA	0
Accuracy	High	-	Unclear	-	High
Ruby Tuesdays #1[4]					
Manual Meas.	39	1	0.25	<4	<4
IMD Meas.	39	0	NA	0	NA
Accuracy	High	High	-	High	-
Ruby Tuesdays #2					
Manual Meas.	51	12	4	4	<4
IMD Meas.	Error	NA	Error	NA	Error
Accuracy	No reading	-	No reading	-	No reading

	Total Liquid Depth (inches)	Floating FOG Layer Depth (inches)		Solids Layer Depth (inches)	
		Chamber #1	Chamber #2	Chamber #1	Chamber #2
Arby's #1					
Manual Meas.	42	1.5	3 – 12[3]	<4	5
IMD Meas.	44	1	NA	8 (Error)	NA
Accuracy	High	High	-	Inaccurate	-
Arby's #2					
Manual Meas.	44	1	0	6	4
IMD Meas.	45	NA	0	NA	6
Accuracy	High	-	High	-	Questionable
Lone Star					
Manual Meas.	41	1	0.75	20	4.5
IMD Meas.	42	NA	1	NA	4
Accuracy	High	-	High	-	High
SUPPLIER Q – June 1, 2005 and July 8, 2005					
PF Chang's #1					
Manual Meas.	56	10	2.5	7	<4
IMD Meas.	NM[5]	NA	No power	NA	NM
Accuracy	NM	-	No reading	-	-
PF Chang's #2					
Manual Meas.	52	19	14.5	8	<4
IMD Meas.	NM	NA	9.9	NA	NM
Accuracy	NM	-	Inaccurate	-	-

[1] NA – Not applicable (e.g., the IMD was not installed in this chamber)
[2] <4 – There was a 4-inch long valve on the end of the core sampler that is inserted into the grease interceptor; thus, the bottom 4 inches of the interceptor could not be measured.
[3] This chamber had a deep layer of lightly packed floating solids which made it difficult to distinguish visually where the FOG layer started.
[4] This site had two interceptors installed in series with the IMD installed in the first chamber of the second interceptor. The second interceptor measurements are shown in the table.
[5] NM – Not measured (this IMD does not measure the liquid depth or the settled solids layer)

The initial inspections revealed inaccurate or no IMD readings at 2 of the 7 Supplier P FSEs (Ruby Tuesday's #2 and Arby's #1) and both Supplier Q FSEs (PF Chang's #1 and #2). It was determined that the Ruby Tuesday's #2 IMD was not recording any measurements due to a failure by the local service provider to recalibrate the IMD after maintenance work was performed, which occurred shortly before the initial inspection. It was determined that inaccurate solids measurement at the Arby's #1 site was due to the IMD being installed too close to the inlet tee, causing interference with the ultrasonic measurement. Both Supplier Q FSEs (PF Chang's #1 and #2) experienced installation problems. At PF Chang's #1, the kitchen personnel continually unplugged the datalogger (or controller) located in the prep area of the kitchen. Supplier Q was able to identify this problem via their Remote Computer Monitoring and the problem was later corrected by relocating the power source. At PF Chang's #2, the probe was installed originally in the first chamber rather than the second chamber which is the location preferred by the supplier. A modification was made, but the modification was later damaged during a pumping operation resulting in a system failure which generated the inaccurate floating FOG layer measurement.

Relatively accurate measurements (i.e., Supplier P's datalogger FOG and solids depth measurements were very similar to the manual core sampler measurements) were identified at 5 of the installations. For example, at the Red Lobster #1 site, the manual FOG layer measurement was 7 inches, while the IMD datalogger displayed a FOG layer measurement of 8 inches. The manual solids measurement at the Lone Star site was 4.5 inches while the IMD datalogger displayed a solids measurement of 4 inches.

4.4.2 Follow-up Field Evaluations

Three (3) of the 7 Supplier P FSEs were selected to be included in the follow-up evaluations: Red Lobster Restaurant #2, PA; Arby's Restaurant #1, PA; and Lone Star Restaurant, PA. The IMD at Arby's Restaurant #1 was relocated prior to initiating the additional field inspections, due to the inlet tee interference problem identified during the initial inspection. The follow-up inspections were initiated on March 8, 2005, and were conducted in the same manner as the initial inspections. Due to the system failure issue at PF Chang's #2, only the PF Chang's #1 site was chosen for the Supplier Q follow-up inspections. The data from the follow-up inspections are provided in Table 4.3.

Table 4.3 IMD Follow-up Inspections

	Total Liquid Depth (inches)	Floating FOG Layer Depth (inches)		Solids Layer Depth (inches)	
		Chamber #1	Chamber #2	Chamber #1	Chamber #2
SUPPLIER P					
Red Lobster #2 March 8, 2005					
Manual Meas.	53	NA[1]	3	NA	<4[2]
IMD Meas.	53	NA	7	NA	0
Accuracy	High	-	Insufficient	-	High
Red Lobster #2 March 29, 2005					
Manual Meas.	55	NA	5	NA	<4
IMD Meas.	53	NA	6	NA	3
Accuracy	High	-	High	-	High
Red Lobster #2 April 29, 2005					
Manual Meas.	53	NA	2 – 40[3]	NA	<4
IMD Meas.	53	NA	2	NA	3
Accuracy	High	-	Unclear	-	High
Red Lobster #2 June 10, 2005					
Manual Meas.	52	NA	2	NA	11
IMD Meas.	53	NA	3	NA	12
Accuracy	High	-	High	-	High
Red Lobster #2 August 23 2005					
Manual Meas.	54	NA	3-30[3]	NA	<6
IMD Meas.	53	NA	6	NA	0
Accuracy	High	-	Unclear	-	High
Arby's #1 March 8, 2005					
Manual Meas.	41	2	NA	4	NA
IMD Meas.	42	1	NA	4	NA
Accuracy	High	High	-	High	-
Arby's #1 March 29, 2005					
Manual Meas.	41	1	NA	<4	NA
IMD Meas.	42	2	NA	3	NA
Accuracy	High	High	-	High	-
Arby's #1 April 29, 2005					
Manual Meas.	42	1	NA	<4	NA
IMD Meas.	42	0	NA	4	NA
Accuracy	High	High	-	High	-
Arby's #1 June 10, 2005					
Manual Meas.	41	2	NA	<6	NA
IMD Meas.	42	3	NA	7	NA
Accuracy	High	High	-	High	-
Arby's #1 August 23, 2005					
Manual Meas.	42	2	NA	<6	NA
IMD Meas.	42	Error	NA	0	NA
Accuracy	High	No reading	-	High	-

	Total Liquid Depth (inches)	Floating FOG Layer Depth (inches)		Solids Layer Depth (inches)	
		Chamber #1	Chamber #2	Chamber #1	Chamber #2
Lone Star March 8, 2005					
Manual Meas.	41	NA	1	NA	<4
IMD Meas.	42	NA	0	NA	2
Accuracy	High	-	High	-	High
Lone Star March 29, 2005					
Manual Meas.	40	NA	1	NA	<4
IMD Meas.	42	NA	0	NA	1
Accuracy	High	-	High	-	High
Lone Star April 29, 2005					
Manual Meas.	42	NA	1	NA	<4
IMD Meas.	42	NA	2	NA	2
Accuracy	High	-	High	-	High
Lone Star June 10, 2005					
Manual Meas.	41	NA	1	NA	<6
IMD Meas.	42	NA	1	NA	1
Accuracy	High	-	High	-	High
Lone Star August 23, 2005					
Manual Meas.	42	NA	2	NA	<6
IMD Meas.	42	NA	3	NA	0
Accuracy	High	-	High	-	High
SUPPLIER Q					
PF Chang's #1 July 7, 2005					
Manual Meas.	NM[4]	NA	8	NA	NM
IMD Meas.	NM	NA	No power	NA	NM
Accuracy	NM	-	No reading	-	-
PF Chang's #1 December 27, 2005					
Manual Meas.	NM	NA	2	NA	NM
IMD Meas.	NM	NA	4.5 – 5.5	NA	NM
Accuracy	NM	-	Inaccurate	-	-

[1] NA – Not applicable (e.g., the IMD was not installed in this chamber)
[2] <4 or <6 – There was a 4-inch long valve on the end of one of the core samplers that was inserted into the grease interceptor and there was a 6-inch long valve on the end of the other core samplers; thus, the bottom 4 or 6 inches of the interceptor could not be measured.
[3] This chamber had a deep layer of lightly packed floating solids which made it difficult to distinguish visually where the FOG layer started.
[4] NM – Not measured (this IMD does not measure the liquid depth or the settled solids layer)

4.5 Conclusions

Approximately 30% (2 of 7) of the Supplier P IMDs and both of the Supplier Q IMDs were not functioning correctly during the initial inspections. One of the Supplier P initial inspections revealed an installation problem, and another Supplier P inspection revealed that a calibration had not been conducted. These issues identified during the initial inspection are reasons for concern; however, both Supplier P problems were easily identified in the field and were easily corrected by the service provider. In fact, both problems could possibly have been identified through the telemetry (e.g., an “Error” message and a consistent “8 inches” solids measurement over time). One of the Supplier Q installation issues was corrected by relocating the power source. The other Supplier Q installation issue was not corrected during the evaluation and no follow-up inspections were scheduled at that site.

The results of the follow-up inspections that were conducted at the facilities without installation or calibration problems were encouraging. With the exception of one inaccurate FOG layer measurement and 3 unclear FOG layer measurements at Red Lobster #2, one “no reading” FOG layer measurement at Arby’s #1, and the installation issues_at both PF Chang’s, the other 34 floating FOG and settled solids measurements showed only slight differences, if any, between the datalogger readings and the manual measurements. However, even those that had slight differences should not be considered significant for two reasons. First, the bottom of the floating FOG layer and the top of the settled solids layer is not always visibly distinct (ref: Figure 4.2, page 115). In fact, in many cases, depending upon the density of the FOG or solids, there is a possibility for measurement variability of up to 1 inch depending upon the subjective visual measurement of the inspector. Second, because the “25% Rule” is a general rule, it is important to know the approximate depth of the FOG or solids layer, but it is not critical to know the exact depth. In EEC’s opinion, the accuracy of the IMDs at sites without installation or calibration problems, over a period of 6 months, revealed that the technology was generally accurate over time and was durable for at least a period of 6 months. This data suggests that this technology can be useful for the purposes of monitoring an interceptor to enforce the “25% Rule” and to determine when it would need to be pumped, if it was pumped, and if it was pumped completely. The data also suggests that the technology, once installed and calibrated correctly, may also be fairly reliable over time.

4.6 Recommendations

Based on the data evaluated in the Study, IMDs should be seriously considered for use in Orange County FOG Control Programs provided they are inspected for proper installation, calibration, and accuracy over time. FSEs should be encouraged to utilize IMDs, and FOG Control Program Managers should take advantage of the potential monitoring and enforcement benefits of this technology. IMDs can be beneficial for FSEs that want to accurately monitor their interceptor and avoid under-pumping or over-pumping. IMDs can also be beneficial to agencies that want to monitor a large FOG-producing FSE or a non-compliant FSE. For example, if an FSE is cited 2 or more times for failing to maintain their interceptor properly, an agency could require that an IMD be installed. The potential to monitor the interceptor remotely provides potential further obvious advantages for an agency. Based on the results of this evaluation, there will be some measurement accuracy issues at some installations. However, as long as agencies do not view IMDs as a technology that will completely remove the need for agencies to inspect conventional grease interceptor altogether, the use of IMDs should reduce the frequency of agency interceptor inspections and, therefore, reduce agency costs.

Although manufacturers may have a different recommendation based on the design of their IMD, EEC recommends that the IMD probe be located in the chamber of the interceptor that the agency considers to be most important to monitor. For example, many of the North Orange County agencies enforce the "25% Rule" on either the first chamber or the second chamber, whichever exceeds 25% first. Since the first chamber will almost always exceed the "25% Rule" before the second chamber, and because the first chamber is the primary chamber of the interceptor, these agencies should ensure that the IMD probe is installed in the first chamber.[46]

It is EEC's opinion that monitoring the solids in the interceptor is important to prevent clogging the middle tee of the interceptor,[47] solids pass through, and hydrogen sulfide generation caused by decaying solids. Therefore, if solids monitoring is also deemed important by an FSE or an agency, than an IMD that is capable of measuring the settled solids in an interceptor would be preferable to an IMD that does not. An IMD that does not measure solids may be sufficient for FSEs that have a solids interceptor or other solids screening device ahead of the grease interceptor, or for FSEs that discharge very few solids.

A manufacturer approval policy will need to be developed, but the workplan and results of the Study should make this relatively straightforward. Additionally, because of the installation and calibration issues identified in this Study and because the Study did not evaluate the reliability of the technologies beyond the evaluation period, verification of the accuracy of any IMD is recommended to be conducted within 3 months after installation and a minimum of once per year by a qualified inspector or technician.

[46] This is based on EEC's experience with manually inspecting both chambers of over 1,000 conventional grease interceptors. If the second interceptor chamber has a thicker FOG or solids layer than the first chamber, it is most likely due to improper pumping of the interceptor.
[47] This could not be monitored if the IMD was installed in the second chamber of the interceptor.

Appendix A

Public Notices
Supplier Key

Public Notice

Request for Fats, Oils, and Grease (FOG) Technology Supplier Participation in the Orange County FOG Control Study

Response is Required by October 29, 2004 for Consideration in the Study

Environmental Engineering & Contracting, Inc. (EEC) is soliciting participation from FOG control technology suppliers for Phase II of a FOG Control Study being conducted in Orange County, California, on behalf of northern and central Orange County sewering agencies, and the California State Water Resources Control Board. This study has been initiated due to FOG blockages in Orange County sewer lines that are causing sanitary sewer overflows that create a public health hazard and impact ocean water quality. Phase I of the study, completed in June 2003, was a national research project to identify solutions to the problem. Phase I concluded that there are relatively promising newer FOG control technologies that may provide substantial FOG control benefits. Therefore, the study recommended that these technologies be evaluated in the field in Phase II of the study. The three technologies that were selected for Phase II field evaluations are as follows:

1) FOG Control Additives – chemical or biological additives
2) Non-conventional Grease Traps/Grease Interceptors
3) Grease Interceptor Monitoring Devices – level monitoring devices

Prospective participants will have requirements and potential costs for participation in the study. Additive suppliers will be required to provide their product and support to complete product installation, start-up, and technical service during the evaluations for a six to nine month period. Non-conventional grease trap/grease interceptor and grease interceptor monitoring device suppliers will be required to provide onsite technical support during the evaluations for approximately a six month period. For specific applications, if there are more suppliers interested in participating in the study than are currently budgeted, suppliers will be required to provide compensation to recover the additional monitoring and reporting costs. For installations outside of Southern California, suppliers will be required to provide compensation to recover travel costs.

If you have a FOG control product in one of the categories listed above and if you are interested in participating in this study, please E-mail the consultant directly, identifying which field evaluation you would like to participate in. Note – an E-mail response to EEC is required by **October 29, 2004** for consideration of your product in the study.

Environmental Engineering & Contracting, Inc. (EEC)
E-mail address: fogfieldstudy@eecworld.com

EEC will acknowledge receipt of your E-mail and will provide additional information by E-mail (within 1 week after receipt of an E-mail response) providing further participation requirements.

Orange County FOG Control Study, Phase II

Fats, Oils, and Grease (FOG) Technology Supplier Participation

FOG Control Additives Field Evaluation and Supplier Requirements

A Response is Required by October 29, 2004 for Consideration in the Study

Dear Prospective Participant,

Environmental Engineering & Contracting, Inc., (EEC) has received notification that your company is interested in participating in Phase II of the Orange County FOG Control Study, FOG Control Technology Field Testing Evaluations for Additives. The study is being performed on behalf of northern and central Orange County sewering agencies (list attached), and the California State Water Resources Control Board. This study was initiated due to FOG blockages in Orange County sewer lines that are causing sanitary sewer overflows (SSOs) that create a public health hazard and impact ocean water quality. Phase I of the study, completed in June 2003, was a national research project to identify solutions to the problem. Phase I concluded that there are promising FOG control technologies that may provide substantial FOG control benefits. Therefore, the study recommended that these technologies be evaluated in the field in Phase II of the study. The three technologies and the applications that were selected for evaluation are as follows:

1) **FOG Control Additives** – chemical or biological additives
    a. New installations applied in food service establishments
    b. New installations applied in public sewer lines

2) **Non-conventional Grease Traps/Grease Interceptors** (automated units or biological remediation enhanced units) – existing installations at food service establishments

3) **Grease Interceptor Monitoring Devices** (level monitoring devices) – existing installations in grease interceptors

FOG Control Additives Field Evaluations

Additives are chemical or microbial products used to solubilize, saponify, or digest FOG, and are typically added either at a kitchen sink drain or directly into the sewer system. The study will evaluate new additive installations to be field tested under monitored conditions at FSEs ("FSE-applied") and in the collection system ("sewer line-applied") to help determine if this technology can assist in the control of sewer line grease blockages and reduce the requirement for costly sewer line cleaning. The FSE-applied additives selected for evaluation will not include additives used in conjunction with a grease interceptor. This application may be beneficial to FSEs to reduce odors or interceptor pumping, but does not directly address reductions in grease blockages in the sewer system. Also, the sewer line-applied additives selected will be specific to sewer line hot spot treatment and will not include additives that are used primarily to reduce pump station maintenance. Pump station applications may reduce maintenance issues, but do not directly address reductions in grease blockages in the sewer line piping.

Participating suppliers can provide only one additive for testing, which can be evaluated in either the FSE-application or the sewer line-application (not both)[1]. The general evaluation process will require the submittal of a detailed Material Safety Data Sheet (MSDS) of the additive and to have Toxicity Testing and Certification[2] before the initial Emulsification / Saponification / Solubilization Bench Scale Test[3]. Field testing will consist of pre-monitoring of the sewer pipe location with closed circuit television (CCTV) equipment followed by CCTV monitoring of the sewer pipe location after the additive has been dosed for a 6 to 9 month period to evaluate the product's effectiveness. Since there is no scientific way to properly duplicate field conditions for each test, the results of one product test or evaluation will not be directly compared with the results of another product test or evaluation. General findings or correlations for a group of products or a common application may be reported if supporting data is available. In addition, supplier and product names will be de-emphasized in the study to avoid the appearance of criticism or endorsement of any product, particularly in light of the lack of reproducibility of field conditions for each test or evaluation.

Prospective participants will have requirements and potential costs for participation in the study. Additive suppliers will be required to provide their product and support to complete product installation, start-up, and technical service during the evaluations for a 6 to 9 month period. Also, more additive suppliers may be interested in participating in the study than is currently budgeted; however, the intent is not to limit the number of qualified suppliers that can participate in the study. Therefore, once the number of additional additive supplier participants is known, all of the suppliers in that category will be required to provide compensation to recover the monitoring and reporting costs of additional suppliers according to the following method:

Budget Constraints and Potential Supplier Costs			
Product Application	**Budgeted Number of Products**	**Cost for Additional Product Testing**	
		(per product)*	**(per supplier)****
FSE-applied Additives	2-6	$10,500	$0 - $5,250
Sewer Line-applied Additives	2-6	$12,500	$0 - $6,250

* This amount is to recover the monitoring and reporting costs per additional product
**Assuming less than or equal to 12 suppliers participate in that category

[1] This is to assist in providing the opportunity for as many suppliers as possible to participate in the study.

[2] Each supplier will be required to provide certified laboratory analyses of their product for the local pollutants of concern (constituents and local limits attached) and must certify that their product will not be toxic to standard biological treatment processes at standard concentrations.

[3] Bench top tests may be used to categorize the products.

The goal is to evaluate a minimum of 6 product installations per application. Therefore, if 2 FSE-applied additive suppliers participate, the goal would be to evaluate 3 installations for each product. If 6 or more FSE-applied additive suppliers participate, the goal would be to evaluate 1 installation for each product.

In a particular product application category, if there are more than 6 supplier participants, all of the suppliers in that category will be required to provide the necessary additional funding. In this case, the additional cost will be divided equally among the suppliers in that category. The exact amount of additional funding necessary will not be known until it is confirmed how many suppliers agree to the conditions of the study. At that time, the suppliers will be notified of the additional cost and will be provided another opportunity to decide if they agree with the conditions of the study. If at anytime before field evaluations begin a product is voluntarily withdrawn or removed due to lack of receipt of payment, the other suppliers in that category will be notified and will be refunded, as appropriate. If it becomes necessary for suppliers to provide payments due to more than 6 participants in one category, a separate account will be established for receipt of these payments.

Requirements for Participation

If you have a FOG control product in one of the categories listed above and if you are interested in participating in this study, please E-mail the consultant conducting the study. In your E-mail, please identify which field evaluation you would like to participate in, the name and contact information of a key contact and technical resource, and confirm that you have been informed of the vendor support requirements and the potential costs for participating in the study.

This E-mail response to EEC is required by **October 29, 2004,** for consideration of your product and to ensure that you are eligible to participate in the study.

Environmental Engineering & Contracting, Inc. (EEC)
E-mail address: fogfieldstudy@eecworld.com

EEC will acknowledge receipt of your E-mail and respond with the detailed scope of work for the additive portion of the study and a Request for Commitment Form for participation.

Orange County Cities/Sewering Agencies Funding the Study
City of Anaheim
City of Brea
City of Buena Park
Costa Mesa Sanitary District
County of Orange
City of Cypress
El Toro Water District
City of Fountain Valley
City of Fullerton
Garden Grove Sanitary District
City of Huntington Beach
Irvine Ranch Water District
City of La Habra
City of La Palma
Rossmoor Los Alamitos Area Sanitary District
City of Newport Beach
City of Orange
Orange County Sanitation District
City of Placentia
City of Santa Ana
City of Seal Beach
City of Stanton
City of Tustin
City of Villa Park
Midway City Sanitary District
City of Yorba Linda
Yorba Linda Water District

Local Pollutants of Concern*
Silver
Cadmium
Chromium
Copper
Nickel
Lead
Zinc
Priority Pollutants by EPA Methods 624/625

* Analysis according to 40 CFR 136 methodology

Orange County Sanitation District Local Discharge Limits	
Constituent	**mg/L**
Arsenic	2.0
Cadmium	1.0
Chromium (Total)	2.0
Copper	3.0
Lead	2.0
Mercury	0.03
Nickel	10.0
Silver	5.0
Zinc	10.0
Cyanide (Total)	5.0
Cyanide (Amenable)	1.0
Polychlorinated Biphenyls	0.01
Pesticides	0.01
Total Toxic Organics	0.58
Sulfide (Total)	5.0
Sulfide (Dissolved)	0.5

Orange County FOG Control Study, Phase II
Fats, Oils, and Grease (FOG) Technology Supplier Participation
FOG Control Non-conventional Grease Traps/Grease Interceptors
Field Evaluation and Supplier Requirements

A Response is Required by October 29, 2004 for Consideration in the Study

Dear Prospective Participant,

Environmental Engineering & Contracting, Inc., (EEC) has received notification that your company is interested in participating in Phase II of the Orange County FOG Control Study, FOG Control Technology Field Testing Evaluations for Non-conventional Grease Traps/Grease Interceptors. The study is being performed on behalf of northern and central Orange County sewering agencies (list attached) and the California State Water Resources Control Board. This study was initiated due to FOG blockages in Orange County sewer lines that are causing sanitary sewer overflows (SSOs) that create a public health hazard and impact ocean water quality. Phase I of the study, completed in June 2003, was a national research project to identify solutions to the problem. Phase I concluded that there are promising FOG control technologies that may provide substantial FOG control benefits. Therefore, the study recommended that these technologies be evaluated in the field in Phase II of the study. The three technologies and the applications that were selected for evaluation are as follows:

1) **FOG Control Additives** – chemical or biological additives
    a. New installations applied in food service establishments
    b. New installations applied in public sewer lines

2) **Non-conventional Grease Traps/Grease Interceptors** (automated units or biological remediation enhanced units) – existing installations at food service establishments

3) **Grease Interceptor Monitoring Devices** (level monitoring devices) – existing installations in grease interceptors

FOG Control Non-conventional Grease Traps/Grease Interceptors (NCGTs) - Field Evaluations

These are small grease removal devices (typically less than 50 gallons) used in FSE kitchens, typically under the sink. Multiple improvements have been made on the conventional passive grease trap design by providing features with enhanced oil and water separation, automatic grease removal, or biological digestion of the grease. It is proposed to evaluate existing installations at multiple FSEs to evaluate their grease control capabilities along with the maintenance and potential sanitation issues related to kitchen use.

Field evaluations will be conducted to evaluate the product's effectiveness at existing facilities and will consist of monitoring trap conditions, maintenance requirements, potential sanitation issues, waste FOG removed, and influent and effluent free floating oil and grease (FFOG) for a 6-month period. Since there is no scientific way to properly duplicate field conditions for each test, the results of one product test or evaluation will not be directly compared with the results of another product test or evaluation. General findings or correlations for a group of products or a common application may be reported if supporting data is available. In addition, supplier and product names will be de-emphasized in the study to avoid the appearance of criticism or endorsement of any product, particularly in light of the lack of reproducibility of field conditions for each test or evaluation.

Prospective participants will have requirements and potential costs for participation in the study. NCGT suppliers will be required to identify existing installations in Southern California (San Diego County, Orange County, Los Angeles County, and the western portions of San Bernardino County and Riverside County) and provide their normal product support service during the evaluation period. If the supplier does not have enough installations in Southern California, EEC can evaluate other installations if the supplier arranges travel accommodations. Additionally, there may be more NCGT suppliers that are interested in participating in the study than is currently budgeted; however, the intent is not to limit the number of qualified suppliers that can participate in the study. Therefore, once the number of additional NCGT supplier participants is known, all of the suppliers in that category will be required to provide compensation to recover the monitoring and reporting costs of additional suppliers according to the following method:

Budget Constraints and Potential Supplier Costs			
Product Application	**Budgeted Number of Products**	**Cost for Additional Product Testing**	
		(per product)*	**(per supplier)****
NCGTs	2-6	$8,450	$0 - $3,380

* This amount is to recover the monitoring and reporting costs per additional product
**Assuming less than or equal to 10 suppliers participate in that category

The goal is to evaluate 6 different test sites (e.g., 3 products at 2 separate FSEs). Therefore, if 2 NCGT suppliers participate, the goal would be to evaluate 3 installations for each product. If 6 or more NCGT suppliers participate, the goal would be to evaluate 1 installation for each product.

Thus, if there are more than 6 supplier participants, all of the suppliers in that category will be required to provide the necessary additional funding. In this case, the additional cost will be divided equally among the suppliers. The exact amount of additional funding necessary will not be known until it is confirmed how many suppliers agree to the conditions of the study. At that time, the suppliers will be notified of the additional cost and will be provided another opportunity to decide if they agree with the conditions of the study. If at anytime before field evaluations begin a product is voluntarily withdrawn or removed due to lack of receipt of payment, the other suppliers will be notified and will be refunded, as appropriate. If it becomes necessary for suppliers to provide payments due to more than 6 participants, a separate account will be established for receipt of these payments.

Requirements for Participation

If you have a FOG control NCGT product and if you are interested in participating in this study, please confirm your intent to participate by E-mail to EEC. In your E-mail, please identify the name and contact information of a key contact and technical resource, and confirm that you have been informed of the vendor support requirements and the potential costs for participating in the study.

This E-mail response to EEC is required by **October 29, 2004,** for consideration of your product and to ensure that you are eligible to participate in the study.

Environmental Engineering & Contracting, Inc. (EEC)
E-mail address: fogfieldstudy@eecworld.com

EEC will acknowledge receipt of your E-mail and respond with the detailed scope of work for the NCGT portion of the study and a Request for Commitment Form for participation.

Orange County Cities/Sewering Agencies Funding the Study
City of Anaheim
City of Brea
City of Buena Park
Costa Mesa Sanitary District
County of Orange
City of Cypress
El Toro Water District
City of Fountain Valley
City of Fullerton
Garden Grove Sanitary District
City of Huntington Beach
Irvine Ranch Water District
City of La Habra
City of La Palma
Rossmoor Los Alamitos Area Sanitary District
City of Newport Beach
City of Orange
Orange County Sanitation District
City of Placentia
City of Santa Ana
City of Seal Beach
City of Stanton
City of Tustin
City of Villa Park
Midway City Sanitary District
City of Yorba Linda
Yorba Linda Water District

Orange County FOG Control Study, Phase II

Fats, Oils, and Grease (FOG) Technology Supplier Participation

FOG Interceptor Monitoring Devices

Field Evaluation and Supplier Requirements

A Response is Required by October 29, 2004 for Consideration in the Study

Dear Prospective Participant,

Environmental Engineering & Contracting, Inc., (EEC) has received notification that your company is interested in participating in Phase II of the Orange County FOG Control Study, FOG Control Technology Field Testing Evaluations for Interceptor Monitoring Devices. The study is being performed on behalf of northern and central Orange County sewering agencies (list attached) and the California State Water Resources Control Board. This study was initiated due to FOG blockages in Orange County sewer lines that are causing sanitary sewer overflows (SSOs) that create a public health hazard and impact ocean water quality. Phase I of the study, completed in June 2003, was a national research project to identify solutions to the problem. Phase I concluded that there are promising FOG control technologies that may provide substantial FOG control benefits. Therefore, the study recommended that these technologies be evaluated in the field in Phase II of the study. The three technologies and the applications that were selected for evaluation are as follows:

1) **FOG Control Additives** – chemical or biological additives
    a. New installations applied in food service establishments
    b. New installations applied in public sewer lines

2) **Non-conventional Grease Traps/Grease Interceptors** (automated units or biological remediation enhanced units) – existing installations at food service establishments

3) **Grease Interceptor Monitoring Devices** (level monitoring devices) – existing installations in grease interceptors

FOG Interceptor Monitoring Devices (IMDs) - Field Evaluations

FOG Interceptor Monitoring Devices (IMDs) are level-monitoring devices installed in underground grease interceptors that provide continuous measurement of the solids and grease level. If successful, this technology could replace the need to manually measure the solids and grease levels in interceptors. This would result in increased performance by grease interceptors due to proper maintenance. It is proposed to evaluate existing installations of this technology at multiple FSEs.

Field evaluations will be conducted to evaluate the product's effectiveness at existing facilities and will consist of monitoring the interceptor water level, solids depth, and oil layer depth in the interceptor and compare them against the measurements that are recorded by the IMD for a 6-month period. Since there is no scientific way to properly duplicate field conditions for each test, the results of one product test or evaluation will not be directly compared with the results of another product test or evaluation. General findings or correlations for a group of products or a common application may be reported if supporting data is available. In addition, supplier and product names will be de-emphasized in the study to avoid the appearance of criticism or endorsement of any product, particularly in light of the lack of reproducibility of field conditions for each test or evaluation.

Prospective participants will have requirements and potential costs for participation in the study. IMD suppliers will be required to identify existing installations in Southern California (San Diego County, Orange County, Los Angeles County, and the western portions of San Bernardino County and Riverside County) and provide their normal product support service during the evaluation period. If the supplier does not have enough installations in Southern California, EEC can evaluate other installations if the supplier arranges travel accommodations.

Requirements for Participation

If you have a FOG control IMD product and if you are interested in participating in this study, please confirm your intent to participate by E-mail to EEC. In your E-mail, please identify the name and contact information of a key contact and technical resource, and confirm that you have been informed of the vendor support requirements and the potential costs for participating in the study.

This E-mail response to EEC is required by **October 29, 2004,** for consideration of your product and to ensure that you are eligible to participate in the study.

Environmental Engineering & Contracting, Inc. (EEC)
E-mail address: fogfieldstudy@eecworld.com

EEC will acknowledge receipt of your E-mail and respond with the detailed scope of work for the IMD portion of the study and a Request for Commitment Form for participation.

Orange County Cities/Sewering Agencies Funding the Study
City of Anaheim
City of Brea
City of Buena Park
Costa Mesa Sanitary District
County of Orange
City of Cypress
El Toro Water District
City of Fountain Valley
City of Fullerton
Garden Grove Sanitary District
City of Huntington Beach
Irvine Ranch Water District
City of La Habra
City of La Palma
Rossmoor Los Alamitos Area Sanitary District
City of Newport Beach
City of Orange
Orange County Sanitation District
City of Placentia
City of Santa Ana
City of Seal Beach
City of Stanton
City of Tustin
City of Villa Park
Midway City Sanitary District
City of Yorba Linda
Yorba Linda Water District

Orange County FOG Control Study Phase II Supplier Key	
Supplier Letter	**Supplier Name**
A	West Coast Safety Supply Co.
B	BioStim, LLC
C	ALTIVIA Corporation
D	Environmental Biotech, Inc.
E	Neozyme International, Inc.
F	Novozymes Biologicals, Inc.
G	Natural Resource Protection, Inc. (NRP)
H	BioMagic, Inc.
I	BESTechnologies, Inc.
J	ENNIX Inc.
K	Sunburst Chemicals, Inc.
L	Western Exterminator Company
M	Josam Company
N	Lowe Engineering Co. / Highland Tank
O	MRC Technologies, Inc.
P	Worldstone Inc.
Q	Josam Company

Appendix B

Workplans

Orange County FOG Control Study
Phase II
FOG Control Technology Field Testing Evaluations
Workplan
October 29, 2004

1.0 Introduction and Objectives

Fats, oils, and grease (FOG) blockages in Orange County sewer lines are causing sanitary sewer overflows (SSOs) that create a public health hazard and impact surface water and ocean water quality. To look for solutions to this problem, a FOG Control Study (Study) was initiated in Orange County. Phase I of the Study, completed in June 2003, concluded that there are relatively new promising FOG control technologies that may provide substantial FOG control benefits, but their level of objective scientific evaluation is limited. Therefore, these technologies should be thoroughly evaluated before they are included in local FOG control programs. This Phase II workplan has been designed to evaluate these technologies.

According to the Study Phase I report, less than 50% of the food service establishments (FSEs) in north Orange County utilize grease removal equipment (GRE) such as grease interceptors or passive grease traps to limit the FOG discharged to the sewer. For many of the FSEs, grease interceptors have not been an adequate solution to control grease blockages and SSOs due to inadequate design, lack of maintenance, or improper operation.

The Study's Phase I report included a backbone ordinance for the cities and agencies in Orange County to use in developing their own FOG control programs based on the findings and recommendations in the Study. The Study included a recommendation for a 2-year "conditional stay" of the requirement for a grease interceptor for existing FSEs that are not equipped with an interceptor. This may be extended to 3 years by some agencies. One purpose of the 2-year (or 3-year) stay is to allow FSEs and agencies to evaluate potential alternatives to grease interceptors during that time. Additives and non-conventional grease traps (NCGTs) are currently the most promising technology alternatives that may potentially be used in FOG control programs for some FSEs without interceptors. The Study also recommended extensive agency monitoring of grease interceptors due to the importance of proper maintenance of interceptors. Interceptor monitoring devices are currently the most promising technology to provide automated monitoring with minimal agency involvement.

Phase II of the Study involves field evaluations of three technologies that reportedly have been successful in controlling or monitoring FOG, in certain applications, for some FSEs and collection systems in the United States. The three technologies are as follows:

Phase II Technologies	
Technology	**Installations Evaluated**
Additives	New Installations
Non-conventional Grease Traps (NCGTs)	Existing Installations
Interceptor Monitoring Devices (IMDs)	Existing Installations

Note: New installations of additives are being evaluated because it is critical to determine the conditions before the additive is applied in order to provide a "before and after" comparison. This is not necessary for NCGTs or IMDs.

These evaluations will be designed to determine the potential overall effectiveness, practicality, and cost of these technologies and the role that they may have in Orange County FOG control programs. The evaluations will involve testing and/or observing specific products so that the technologies can be properly evaluated; however, the evaluations are not designed to endorse or exclude any company or product.

A description of the three technologies is provided below.

1.1 Additives

Additives are chemical or microbial products used to solubilize, saponify, or digest FOG, added either at a kitchen sink drain or directly into the collection system. If successful, this technology can assist in the control of private and public sewer line grease blockages, reduce the requirement for costly sewer line cleaning, and reduce the need for grease disposal. Some additives have reportedly been successful when applied at the source (e.g., restaurant kitchens) or directly in the collection system using an automatic dispenser. Therefore, it is proposed that new installations of additives be field tested under monitored conditions at FSEs (FSE-applied)[4] and in the collection system (Sewer Line applied)[5]. Phase I of the Study identified over 25 suppliers of FOG control additives and services.

1.2 Non-conventional Grease Traps (NCGTs)

These are small grease removal devices (typically less than 50 gallons) used in FSE kitchens, typically under the sink[6]. Multiple improvements have been made on the conventional passive grease trap design by providing features with enhanced oil and water separation, automatic grease removal, or biological digestion of the grease. It is proposed to evaluate existing installations at multiple FSEs to evaluate their grease

[4] The evaluation of FSE-applied additives will not include additives that are used in conjunction with a grease interceptor. This application may be beneficial to FSEs to reduce odors or interceptor pumping, but does not directly address reductions in grease blockages in the sewer system.

[5] The evaluation of sewer line applied additives will be specific to sewer line hot spot treatment and will not include additives that are used to reduce pump station maintenance. Pump station applications may reduce maintenance issues, but do not directly address reductions in grease blockages.

[6] These devices are often referred to as grease interceptors. This workplan will refer to these devices as grease traps to avoid confusion with larger outdoor underground grease interceptors.

control capabilities along with the maintenance and potential sanitation issues related to kitchen use. Phase I of the Study identified 7 suppliers of non-conventional grease traps.

1.3 Interceptor Monitoring Devices (IMDs)

These are level-monitoring devices installed in underground grease interceptors that provide continuous measurement of the solids and grease level. If successful, this technology would replace the need to manually measure the solids and grease levels in interceptors. This would result in increased performance by grease interceptors due to proper maintenance. It is proposed to evaluate existing installations of this technology at multiple FSEs.

2.0 Scope of Work (Additives)

2.1 Technical Advisory Committee

A Technical Advisory Committee (TAC) has been formed to review and comment on the workplan and key deliverables during the project. The TAC currently consists of the following individuals:

Mark Kawamoto - Orange County Sanitation District
Bob von Schimmelman - The City of Orange
Jim Hyde - Irvine Ranch Water District
Ken Theisen – California Regional Water Quality Control Board (Grant Manager)

2.2 Workplan Approval

The workplan was approved by the TAC and is being distributed to the prospective suppliers by EEC.

2.3 Notice to Prospective Suppliers

Public notice to prospective suppliers of Phase II of the Study was provided through posting of a notice on the websites of OCSD, EEC, and the Water Environment Federation.

2.3.1 ADDITIVE SUPPLIER CONDITIONS

Along with copies of the field testing evaluation protocol, suppliers will be notified of the following conditions and financial limitations of the Study:

General Supplier Conditions

1) Since there is no scientific way to properly duplicate field conditions for each test, the results of one product test or evaluation will not be directly compared with the results of another product test or evaluation. General findings or correlations for a group of products or a common application may be reported, if supporting data is available.

2) Supplier and product names will be de-emphasized in the Study to avoid the appearance of criticism or endorsement of any product, particularly in light of the lack of reproducibility of field conditions for each test or evaluation.

3) Suppliers will be required to make a technical service representative(s) available for the following minimum commitment of service in Orange County during product installation/start-up and/or during the evaluations:

Supplier Technical Service Commitment		
Product	**Installation/Start-up (days)**	**During Field Evaluation (days)**
FSE-applied Additives	1-2 days	1-2 days
Sewer Line Applied Additives	1-2 days	2-3 days

4) The approved budget for the evaluations is limited to the following:

Field Testing Budget Constraints		
Product	**Currently Budgeted Number of Products**	**Cost for Additional Products to be Tested (per product)**
FSE-applied Additives	2-6	$10,500
Sewer Line Applied Additives	2-6	$12,500

Therefore, in a particular product category, if more suppliers request to have their product tested than is currently budgeted, the suppliers in that category will be asked to provide the necessary additional funding. In this case, the additional cost will be divided equally among the suppliers in that category. The exact amount of additional funding necessary will not be known until it is confirmed how many suppliers agree to the conditions of the Study. At that time, the suppliers will be notified of the additional cost and will be provided another opportunity to decide if they agree with the conditions of the Study. If at anytime before field testing, a product is voluntarily withdrawn, or removed due to lack of receipt of payment, the other suppliers in that category will be notified of the cost impact and will be refunded, as appropriate.

Additive Supplier Special Conditions

1) Due to the limited number of evaluation locations, suppliers will be limited to providing one product in one application.

2) It was determined that bench top tests cannot accurately represent actual field conditions. Therefore, bench top tests will not be used to reduce the number of products that will be field tested. Bench top tests may be used to categorize the products.

2.4 Technology Testing and Evaluation

2.4.1 ADDITIVES

For sewer line applied additives, the Study's goal is to evaluate additives at 6 different test sites (e.g. 3 products at 2 separate sewer line hot spots each or 6 products at 1 sewer line hot spot each). For FSE-applied additives, the Study's goal is also to evaluate additives at 6 different test sites (e.g. 3 products at 2 separate FSEs). However, as stated in Section 2.3.1, additional products will be tested, if additional funding is provided.

2.4.1.1 Toxicity Testing and Certification

1) Each supplier will be required to provide a Material Safety Data Sheet (MSDS) and certified laboratory analyses of their product for the local pollutants of concern (constituents and local limits attached) and must certify that their product will not be toxic to standard biological treatment processes at standard concentrations.

2) After field testing, activated sludge toxicity testing will be conducted to determine if any of the products may affect the activated sludge treatment process at OCSD's reclamation plant(s). The Standard Methods oxygen consumption rate (OUR) test method will be utilized (Appendix A). Comparisons will be made between FED samples[7] without the additive (FED-not spiked) and FED samples with the additive (FED-spiked). The additive dosage chosen will simulate "worst-case-scenario" concentrations of the additives in the sewer system.

2.4.1.2 Emulsification/Saponification/Solubilization Bench Scale Test

Some additive products display emulsification, saponification, or solubilization properties which will rapidly change the characteristics of the FOG/water interface. This may or may not be instrumental in the success of a product. It may be important in understanding the proper application of a product.

The bench scale test described below has been designed to determine which products display any emulsification, saponification, or solubilization characteristics in a controlled

[7] FED samples refers to a mixture of aeration tank influent and return activated sludge that approximates the aeration tank concentration

laboratory setting. The findings of these tests are for information only and may or may not be used to categorize the products. This test merely evaluates if a product changes the characteristics of the FOG/water interface after mixing in the first 60 minutes after addition. This test will not attempt to differentiate between emulsification, saponification, or solubilization.

Standard Solution - 1,000 milliliters (ml) standardized wastewater solutions of 10,000 milligrams per liter (mg/L) FOG will be prepared for each product test. The standard solution will be created by adding 10 ml of FOG to 990 ml of tap water from the City of Santa Ana. Two different standard solutions (one animal fat and one vegetable oil) approved by the TAC will be used. The standard solutions will be adjusted to a temperature of 80 degrees F and a pH of 7.7 to simulate sewer conditions in Orange County. The standard solutions will be prepared fresh each day of testing. Free floating oil and grease (FFOG) will be volumetrically measured utilizing graduated volumetric flasks for comparison purposes. One sample without the addition of an additive will serve as a control for each of the batch of tests. The following steps will be conducted for each additive product:

1) Add dosage of additive recommended by the supplier.

2) Slowly invert the product test sample (and control sample) volumetric flask 20 times.

3) Allow the samples to separate (undisturbed) for a 5 minute period.

4) Document the FFOG for each product sample and the control sample, if the FOG/water interface is distinct.

5) Document any other visual observations concerning the FOG/water interface.

6) Repeat steps (4) and (5) at 10 minutes, 15 minutes, 30 minutes and 60 minutes

Note - there is no pass/fail criteria for this test.

2.4.1.3 Field Testing

Due to the tremendous variety of additive products, services, and field conditions, testing additives requires a basic method, or protocol. To develop this protocol, EEC initially conducted numerous interviews with city and agency representatives (e.g., cities of San Diego, CA; Los Angeles, CA; Everett, WA), who have conducted their own field tests. This effort has been coupled with numerous interviews with additive suppliers, including a conference call with six of the suppliers to solicit their assistance in designing scientific, meaningful, and measurable testing protocols. Additionally, EEC also witnessed a pilot test conducted in the City of Costa Mesa. Based on the results of this research and input from the additive suppliers, the testing protocols for additive application to the sewer lines and FSEs have been developed and are presented below.

2.4.1.3.1 Sewer Line Application

"Sewer Line Application" refers to the addition of additives to a sewer line (typically from a manhole location) to control FOG build-up in the downstream sewer line. Some additives are added manually in the manhole on a scheduled basis (e.g., slowly dissolving tablets). Some are added through the use of mechanical dispensers that are timer controlled (e.g., injected through a small pump every 15 minutes).

Sections of sewer line with grease build-up that require frequent cleaning (herein referred to as "hot spots") will be utilized in the Study. These hot spots may be short in length (1-2 manholes in length) or as large as 4-5 manholes in length. The testing protocol for a typical sewer line hot spot will be designed as follows:

1) Information will be obtained from the sewering agency identifying the last time the sewer line was cleaned.

2) Prior to application of the additive, the sewer line will be inspected by a closed circuit television camera (CCTV) immediately before and after cleaning. This will verify the rate of grease build-up since the last cleaning and the effectiveness of cleaning. This will also verify that the line does not have any major obstructions or defects that may compromise the test.

3) Immediately after the cleaning and CCTV inspection, the additive will be applied at the upstream end of the hot spot according to the supplier's recommended dosage. The sewer line hot spot will not be cleaned for the duration of the test.

4) Each 30 days, the sewer line hot spot and the downstream sewer line will be inspected by CCTV.

5) The test will continue for 6-9 months. If it is determined that cleaning must occur in the sewer line to avoid a grease blockage, the test will be terminated at that time.

6) Upon completion of the test, the following data will be compiled and evaluated:

   - CCTV inspections: pre-cleaning, post-cleaning, and 30 day progresses
   - Dosage of the additive throughout the test
   - Adjustments in dosage, dispenser operation, or other operating parameters
   - Notations of service/maintenance requirements or other relevant findings or events
   - CCTV evidence of any positive or negative effects down stream of the test location

7) Based on the results of the tests, particularly the CCTV evidence, the performance of the additive and service will be measured. For example, the sewer line may display a 30-day grease build-up (or pipe obstruction) of approximately 25% before the application of the product. After the application of the product, the sewer line may

display a 90-day grease build-up of approximately 10%. Due to the variety of field conditions for each test, no product will be compared against another product. Rather, the results will be reported for each test including the field conditions. The operating costs will also be determined. Stakeholders of the Study can then derive their own performance criteria or perform their own cost/benefit analysis based on the results of each test and their own local conditions.

The supplier must provide their standard service for typical sewer line applications for the duration of the test. It is important to avoid testing ideal service conditions that will not be present in the standard usage of the product.

2.4.1.3.2 Food Service Establishment Application

"Food Service Establishment Application" refers to the addition of additives at a food service establishment (FSE). In most cases, the addition point is at a kitchen sink drain to keep the lateral sewer line free of grease. To avoid grease blockages in main sewer lines, it is critical to verify if additives are reducing the build-up of grease in the main sewer lines that the laterals discharge to.

The Study will utilize FSEs previously identified (through CCTV evidence) as sources of FOG to the main sewer line. The testing protocol for a typical FSE application is as follows:

1) Information will be obtained from the FSE identifying the last time the lateral line was cleaned and information will also be obtained from the sewering agency identifying the last time the main sewer line was cleaned.

2) Prior to application of the additive, the sewer line and lateral (if feasible) will be inspected by a closed circuit television camera (CCTV) immediately before and after cleaning. This will verify the grease build-up and the effectiveness of cleaning.

3) Immediately after cleaning and CCTV inspection, the additive will be applied at the supplier's recommended location and dosage. Note – it is essential that the sewer main line and lateral not be cleaned for the duration of the test.

4) Each 30 days, the main sewer line and lateral (if feasible) will be inspected by CCTV.

5) The test will continue for 6-9 months. If it is determined that cleaning must occur in the lateral or main sewer line to avoid a grease blockage, the test will be terminated at that time.

6) Upon completion of the test, the following data will be compiled and evaluated:

    - CCTV inspections: pre-cleaning, post-cleaning, and 30 day progresses
    - Dosage of the additive throughout the test
    - Adjustments in dosage, dispenser operation, or other operating parameters

- Notations of service/maintenance requirements or other relevant findings or events
- Evidence of any positive or negative effects down stream of the test location

7) Based on the results of the tests, the performance of the additive will be measured. For example, the lateral or main sewer line may have displayed a 90-day grease build-up (or pipe obstruction) of approximately 25% before the application of the product. After the application of the product, the sewer line may display a 180-day grease build-up of approximately 5%. Due to the variety of field conditions for each test, no product will be compared against another product. Rather, the results will be reported for each test including the field conditions. The operating costs will also be determined. Stakeholders of the Study can then derive their own performance criteria or perform their own cost/benefit analysis based on the results of each test and their own local conditions.

Again, it is important that the supplier provide their standard service for typical FSE applications for the duration of the test.

Local Pollutants of Concern* (Required Analysis)
Silver
Cadmium
Chromium
Copper
Nickel
Lead
Zinc
Priority Pollutants by EPA Methods 624/625

* Analysis according to 40 CFR 136 methodology

Orange County Sanitation District Local Discharge Limits	
Constituent	**mg/L**
Arsenic	2.0
Cadmium	1.0
Chromium (Total)	2.0
Copper	3.0
Lead	2.0
Mercury	0.03
Nickel	10.0
Silver	5.0
Zinc	10.0
Cyanide (Total)	5.0
Cyanide (Amenable)	1.0
Polychlorinated Biphenyls	0.01
Pesticides	0.01
Total Toxic Organics	0.58
Sulfide (Total)	5.0
Sulfide (Dissolved)	0.5

Orange County FOG Control Study
Additives Workplan
Addendum #1
October 29, 2004

Sewer Line Applied Additive Evaluation Conditions & FOG-related Hot Spot Characteristics

- Located in north or central Orange County
- Previously identified as a FOG-related hot spot
- 6"- 10" diameter (8" typical)
- 2 - 5 line segments long
- Monthly to quarterly line cleaning frequency (typically monthly)
- 1 - 10 FSEs discharge either directly to or immediately upstream of the hot spot
- No significant roots
- Product must be manhole applied
- All supplier field activities (e.g., feeder maintenance, dosage adjustments) must be coordinated with and witnessed by EEC
- To the extent possible, all supplier field activities should be planned to coincide with EEC's monthly CCTV inspections
- Traffic control and/or evening scheduling may be required at many of the hot spots. EEC will arrange for traffic control.
- Once the number of participants is known, a hot spot will be randomly selected for each supplier. The random selection process will be witnessed by a member of the Technical Advisory Committee.
- See workplan for other details

FSE Applied Additive Evaluation Conditions & FOG-related Hot Spot Characteristics

- Located in north or central Orange County
- FSE previously identified as a FOG source by kitchen inspection and CCTV inspection
- Downstream sewer line identified as FOG-impacted by CCTV inspection
- No grease interceptor in place
- No food grinder in place
- All supplier field activities (e.g., feeder maintenance, dosage adjustments) must be coordinated with EEC
- Once the number of participants is known, an FSE hot spot will be randomly selected for each supplier. The random selection process will be witnessed by a member of the Technical Advisory Committee.
- See workplan for other details

Orange County FOG Control Study
Additives Workplan
Addendum #2
November 9, 2004

Sewer Line Applied Additives

- Addendum #1 stated that the additive must be manhole applied. However, some sewer line additives are added at upstream sewer lateral injection points through agreements with a nearby FSE, business, school, or other public building. Some suppliers claim that this has advantages over manhole addition. EEC recognizes that this is essentially the same application because it is addressing main sewer line hot spots and the customer is the municipality; therefore, it is no longer mandatory for the additive to be manhole applied in this application. All supplier field activities (e.g., feeder maintenance, dosage adjustments) must still be coordinated with and witnessed by EEC.

  Please keep in mind that some sewering agencies have concerns with complications that may result from sewer line additives being applied at locations that are outside of the agency's control or jurisdiction. Therefore, these issues will be evaluated in the Study. This application will be allowed and identified as a "Sewer Line Applied Additive" during the term of the Study, providing that there are no complications as a result of this application.

- Some suppliers have asked if they can apply their additive at an upstream lift station. This application will not be evaluated in this Study, since none of the candidate hot spots have lift stations upstream.

- Some suppliers have asked for more information regarding the sewer line hot spots. Once your hot spot is randomly chosen (currently scheduled for November 16, 2004), EEC will send you information on your hot spot such as map, line diameter, cleaning frequency, photographs of the area, number and type of upstream dischargers, CCTV tape or digital images, and CCTV inspection notes. EEC will not have all of the information that you will probably need to determine your dosage (e.g., wastewater flow rate); therefore, you are encouraged to arrange with EEC to inspect the hot spot yourself shortly after November 16, 2004.

- Copies of the laboratory analysis of your additive (using a certified laboratory) are due to EEC by November 24, 2004. If you plan to use a dry additive product, please contact John Shaffer at EEC, (714) 667-2300, to discuss the analysis of your product.

FSE-Applied Additives

- Some suppliers have asked for more information regarding the FSE and the downstream sewer line. Once your FSE is randomly chosen (currently scheduled for November 16, 2004), EEC will send you the information that we have on the FSE and the downstream sewer line. EEC may not have some of the information that you will need to determine your dosage and other logistical issues; therefore, you are encouraged to arrange with EEC to inspect the FSE and the sewer line yourself shortly after November 16, 2004.

- Copies of the laboratory analysis of your additive (using a certified laboratory) are due to EEC by November 24, 2004. If you plan to use a dry additive product, please contact John Shaffer at EEC, (714) 667-2300, to discuss the analysis of your product.

  EEC's Mailing Address:
  Environmental Engineering & Contracting, Inc.
  501 Parkcenter Drive
  Santa Ana, CA 92705

end

2.3.1 NCGT SUPPLIER CONDITIONS

Along with copies of the field testing evaluation protocol, suppliers will be notified of the following conditions and financial limitations of the Study:

General Supplier Conditions

1) Since there is no scientific way to properly duplicate field conditions for each test, the results of one product test or evaluation will not be directly compared with the results of another product test or evaluation. General findings or correlations for a group of products or a common application may be reported, if supporting data is available.

2) Supplier and product names will be de-emphasized in the Study to avoid the appearance of criticism or endorsement of any product, particularly in light of the lack of reproducibility of field conditions for each test or evaluation.

3) Suppliers will be required to make a technical service representative(s) available for the following minimum commitment of service in Orange County during product installation/start-up and/or during the evaluations:

Supplier Technical Service Commitment		
Product	**Installation/Start-up (days)**	**During Field Evaluation* (days)**
Non-conventional Grease Traps	N/A	1-2 days

* At a minimum, a Technical Service Representative will need to be present at the initial FSE visit

4) The approved budget for the evaluations is limited to the following:

Field Testing Budget Constraints		
Product	**Currently Budgeted Number of Products**	**Cost for Additional Products to be Tested (per product)**
Non-conventional Grease Traps	2-6	$8,450

Therefore, in a particular product category, if more suppliers request to have their product tested than is currently budgeted, the suppliers in that category will be asked to provide the necessary additional funding. In this case, the additional cost will be divided equally among the suppliers in that category. The exact amount of additional funding necessary will not be known until it is confirmed how many suppliers agree to the conditions of the Study. At that time, the suppliers will be notified of the additional cost and will be provided another opportunity to decide if they agree with the conditions of the Study. If at anytime before field evaluations, a product is voluntarily withdrawn, or removed due to lack of receipt of payment, the other suppliers in that category will be notified of the cost impact and will be refunded, as appropriate.

2.4 Technology Evaluation

2.4.1 NON-CONVENTIONAL GRASE TRAP (NCGT)

Based on EEC's research, non-conventional grease traps can be separated into two categories:

1) Automatic Grease Traps – Includes features such as solids separation chambers, heating elements, mechanical skimmers, and waste oil containers designed to provide enhanced oil/water separation, automatic grease removal, and temporary waste oil storage.

2) Bioremediation Grease Traps – Includes features such as biological additive injection and biological media chambers designed to provide biological digestion of the waste grease.

To this point, a vast majority of cost and performance data has been received from Automatic Grease Trap suppliers. Therefore, this protocol will focus on these technologies. However, EEC is open to adding a slightly adjusted protocol for Bioremediation Grease Traps so that this technology can also be evaluated for the benefit of the Study's stakeholders.

Based on EEC's research, the typical complication concerning non-conventional grease traps is that they depend upon proper operation and maintenance by the FSE employees. Due to the importance of proper maintenance for many of these products, some suppliers now provide maintenance service contracts along with their product that may include checking the mechanical operation of the unit, replenishing the additive, or training of FSE employees. Companies that supply a service along with their product appear to be the most successful in maintaining the effectiveness of the product. Therefore, EEC will evaluate the service that accompanies a non-conventional grease trap, if any is provided.

The evaluation protocol for an automatic grease trap is relatively straightforward because the evidence of success can be measured through the amount of free floating oil and grease (FFOG) that is removed by the unit over time. Conversely, the amount of FFOG that is not removed by the unit can also be measured through measurement of the influent and effluent FFOG over time, utilizing a volumetric flask. Because of the high maintenance associated with many of these products, the maintenance requirements will be closely examined.

Additionally, the Orange County Health Care Agency (OCHCA) is concerned about the potential sanitation and cross-contamination issues associated with all grease traps located in the kitchen. Therefore, these elements will also be closely examined throughout the evaluation.

The Study's goal is to evaluate NCGT products at 6 different test sites (e.g., 3 products at 2 separate FSEs). EEC will evaluate existing installations that have been in operation a minimum of 6 months at locations in Southern California (San Diego County, Orange County, Los Angeles County, and the western portions of San Bernardino County and Riverside County). If more than 6 suppliers agree to the conditions of the Study, EEC can expand the Study through additional supplier funding as discussed in section 2.3.1. If the supplier does not have enough installations in Southern California, EEC can evaluate other installations if the supplier arranges travel accommodations.

The evaluation of existing installations of NCGTs at typical FSE kitchens will be as follows:

1) EEC will confirm that all existing installations evaluated are standard installations at typical FSEs. EEC will note how the NCGT is installed (e.g., connected to a pre-rinse sink) and other pertinent issues (e.g., volume of NCGT and sink).

2) At the initial visit, EEC will interview the FSE operators on the trap's benefits, reliability, required maintenance, and related issues. EEC will evaluate the trap condition, measure waste FOG removed, and measure influent and effluent FFOG.

3) EEC will monitor the trap conditions, maintenance requirements, potential sanitation issues, waste FOG removed, and influent and effluent FFOG at each FSE every 2 weeks for the first 6-8 weeks.

4) EEC will monitor the trap conditions, waste FOG removed, and influent and effluent FFOG at each FSE at least twice during the remaining 4 months.

5) EEC will document the operation and performance of the unit including any complications or problems experienced by the FSE staff.

Upon completion of the field evaluations, the following data will be compiled:

- Measurements of the waste FOG removed and the influent and effluent FFOG
- Notations of service/maintenance requirements, sanitation concerns, or other relevant findings or events

Due to the variety of conditions for each evaluation, no product will be compared against another product. Rather, the results will be reported for each installation including the conditions. The operating costs will also be determined.

NCGT/NCGI Sampling Plan

1) Wait for significant dishwashing activities in order to sample during significant flow with typical grease loading

2) Lift lids, examine general condition of the unit

3) Measure the solids, grease, and total liquid depth in the oil/water separation chamber (using a small sludge judge)

4) Remove the basket strainer from the first compartment and remove the floating grease/solids in the first chamber and the effluent baffle with a small strainer

<u>Influent Sample</u>

5) Insert pre-fabricated sampling baffle into the first compartment to prevent the remaining floating grease/solids from entering the sampling area

6) Using a clean glass sampling beaker, rapidly transfer aliquots of the influent wastewater into a clean 1,000 ml volumetric flask and fill to the mark

7) Using a stopwatch, measure and photograph the volume (ml) of floating fats, oils, and grease (FFOG) at 0 minutes, 2 minutes, 5 minutes, 10 minutes, and 30 minutes of separation time

<u>Effluent Sample</u>

8) Within 60 seconds of collecting the first influent sample, using a clean glass sampling beaker, rapidly transfer aliquots of the effluent wastewater into a clean 1,000 ml volumetric flask and fill to the mark

9) Using a stopwatch, measure and photograph the volume (ml) of floating fats, oils, and grease (FFOG) at 0 minutes, 2 minutes, 5 minutes, 10 minutes, and 30 minutes of separation time

Notes:

The sampler will take care to ensure that the aliquots will be representative of the influent and effluent, without cross contamination from old grease/solids that is floating or has accumulated on the existing baffles

The sampler will note the presence of significant solids settling at the bottom of the flask in either the influent or effluent samples

<u>Equipment:</u>

(2) 1,000 ml volumetric flasks, graduated
(2) Sampling beakers, 200-500 mls (able to fit in the effluent baffle space)
(2) Stopwatches
(1) Influent sampling baffle, to be fabricated
(1) Small sludge judge, to be fabricated
(1) Small solids strainer
(1) Digital camera

2.3.1 IMD SUPPLIER CONDITIONS

Along with copies of the field testing evaluation protocol, suppliers will be notified of the following conditions and financial limitations of the Study:

General Supplier Conditions

1) Since there is no scientific way to properly duplicate field conditions for each test, the results of one product test or evaluation will not be directly compared with the results of another product test or evaluation. General findings or correlations for a group of products or a common application may be reported, if supporting data is available.

2) Supplier and product names will be de-emphasized in the Study to avoid the appearance of criticism or endorsement of any product, particularly in light of the lack of reproducibility of field conditions for each test or evaluation.

3) Suppliers will be required to make a technical service representative(s) available for the following minimum commitment of service in Orange County during product installation/start-up and/or during the evaluations:

Supplier Technical Service Commitment		
Product	**Installation/Start-up (days)**	**During Field Evaluation* (days)**
Interceptor Monitoring Device	N/A	1-2 days

* At a minimum, a Technical Service Representative will need to be present at the initial FSE visit

4) The approved budget for the evaluations is limited to the following:

Field Testing Budget Constraints		
Product	**Currently Budgeted Number of Products**	**Cost for Additional Products to be Tested (per product)**
Interceptor Monitoring Device	2-6	N/A*

* For this category, less than 6 suppliers have expressed interest in participating; therefore, there will be no need for additional funding by the suppliers.

2.4 Technology Evaluations

2.4.1 INTERCEPTOR MONITORING DEVICE (IMD)

During operation, grease interceptors gradually fill up with settleable solids and free floating oil and grease (FFOG). In order to perform correctly, these solids and FOG must be removed before they accumulate beyond a certain level to avoid clogging the plumbing in the interceptor or significantly reducing the hydraulic retention time. The general standard maintenance level for solids and FOG accumulation is “The 25% Rule”. According to “The 25% Rule”, if the accumulation of solids and FOG combined exceeds 25% of the capacity of the interceptor, the interceptor must be cleaned.

FSEs do not typically monitor their own interceptors. Therefore, without some form of automated monitoring, the interceptors are typically cleaned on a “best guess” frequency. On this basis, these interceptors are typically either over-maintained or under-maintained. Since FSEs are naturally concerned with the cost of over-maintaining their interceptors, it is logical to assume that many interceptors are under-maintained, which leads to pass through of solids and FOG into the sewer system. Due to the need to accurately monitor the solids and FOG accumulation in interceptors, interceptor monitoring devices (IMDs) have been developed to automatically and continuously monitor the interceptors.

This protocol will examine and evaluate the accuracy, reliability, and durability of the IMDs to determine their potential role in FOG control programs.

The Study’s goal is to evaluate IMD products at 6 different test sites (e.g., 3 products at 2 separate FSEs). EEC will evaluate existing installations that have been in operation a minimum of 6 months at locations in Southern California (San Diego County, Orange County, Los Angeles County, and the western portions of San Bernardino County and Riverside County. If a supplier does not have enough installations in Southern California, EEC can evaluate other installations if the supplier arranges travel accommodations.

1) EEC will confirm that all existing installations evaluated are standard installations at typical FSEs. EEC will note how the IMD is installed (e.g., location within the interceptor) and other pertinent issues (e.g., design of interceptor, pump-out frequency). EEC will measure the interceptor water level, solids depth, and oil layer depth in 2 to 3 locations in the interceptors and compare them against the measurements that are recorded by the IMDs.

2) EEC will interview the FSE representative most familiar with the operation and maintenance of the IMD to explore potential problems experienced with the IMD. EEC will also determine how the FSE has benefited from the use of the IMD and what data has been the most useful to the FSE.

3) EEC will monitor the accuracy and reliability of the IMD as described above at each FSE every 2 weeks for a period of 2-3 months.

4) EEC will monitor the accuracy and reliability of the IMD as described above at each FSE at least twice during the remaining 3-4 months.

If the interceptor is cleaned during the evaluation, this will be noted. EEC will also note any operation or maintenance issues during the evaluation. For IMDs that measure temperature or other parameters, EEC will measure these parameters as well.

Upon completion of the field evaluations, the following data will be compiled:

- Measurements of the solids and FOG accumulation or other parameters during the evaluations
- Data collected and/or stored by the IMD or its datalogger
- Notations of service/maintenance requirements or other relevant findings or events

Due to the variety of field conditions for each evaluation, no product will be compared against another product. Rather, the results will be reported for each evaluation including the field conditions. The operating costs will also be determined.

Appendix C

Participant Commitment Letter

Orange County FOG Control Study – Phase II
Request for Commitment and Indemnification

Dear Potential Participant:

Your company has expressed interest in participating in Phase II of the Orange County FOG Control Study. In order for your company to be included in the Study, this letter, which includes indemnification provisions below, will need to be signed by an authorized representative of your company and returned to EEC by November 10, 2004. In order for you to verify EEC's receipt of this letter, please send either by registered mail, signed overnight delivery, or by scanning and e-mailing to fogfieldstudy@eecworld.com and requesting a delivery receipt.

Commitment Statement

Participant has reviewed the workplan dated October 29, 2004 and the contents of this letter, including the indemnification provisions herein. Participant accepts the conditions of the Study and understands that Participant may be required to provide additional funding for the Study if there are more than six participants in the category Participant has chosen, as discussed in the workplan. Participant also recognizes that small changes to the scope of work may be made by EEC, due to practical considerations, to benefit the Study. By signing this letter, Participant is committing to participating in the Study in the category marked below, subject to the indemnification provision herein:

	Additive – FSE Applied ☐	NCGT/NCGI ☐
Category (check one)	Additive – Sewer Line Applied ☐	IMD ☐

Indemnification

These indemnification provisions shall apply to the greatest extent allowed by law. Participant(s), its/their officers, agents, and employees shall defend, indemnify, and hold harmless Orange County Sanitation District (OCSD), other northern and central Orange County sewering agencies (attached list), and Environmental Engineering and Contracting, Inc. (EEC) and their Board members, officers, agents, and employees from any and all liabilities, claims, penalties, forfeitures, suits, and the costs and expenses incident thereto (including cost of defense, experts, settlement, and reasonable attorney fees), which they may hereinafter incur, become responsible for, or pay out as a result of actions or omissions of the Participant(s), its/their officers, agents, and employees associated with activities related to the Fats, Oils, and Grease (FOG) study including, but not limited to, conducting any field work activities related to the FOG study.

These indemnification provisions shall apply to the greatest extent allowed by law. Participant(s), its/their officers, agents, and employees shall defend, indemnify, and hold harmless Orange County Sanitation District (OCSD), other northern and central Orange

County sewering agencies (attached list), and Environmental Engineering and Contracting, Inc. (EEC) and their Board members, officers, agents, and employees from any and all liabilities, claims, penalties, forfeitures, suits, and the costs and expenses incident thereto (including cost of defense, experts, settlement, and reasonable attorney fees), which Participant may hereinafter incur, become responsible for, or pay out as a result of actions or omissions of the OCSD, other northern and central Orange County sewering agencies (attached list), and/or EEC, its/their officers, agents, and employees associated with activities related to the Fats, Oils, and Grease (FOG) study including, but not limited to (1) installing any equipment, materials, or additives to sewerage facilities and (2) conducting any activities during the entire operation and maintenance of the FOG study.

Yours truly,
Environmental Engineering and Contracting, Inc.

John Shaffer
President

I, the undersigned, acknowledge, understand, and agree to abide by the provisions stated above.

Name of Participating Company	______________________
Name of Authorized Representative	______________________
Signature of Authorized Representative	______________________
Title	______________________
Date	______________________
E-mail	______________________

FOG Control Study, Phase II Contributors

Partners

Anaheim

Brea

Buena Park

Costa Mesa Sanitary District

County of Orange

Cypress

El Toro Water District

Fountain Valley

Fullerton

Garden Grove Sanitary District

Huntington Beach

Irvine Ranch Water District

La Habra

La Palma

Rossmoor Los Alamitos Area Sanitary District

Newport Beach

City of Orange

Orange County Sanitation District

Placentia

Santa Ana

Seal Beach

Stanton

Tustin

Villa Park

Midway City Sanitary District

City of Yorba Linda

Yorba Linda Water District

Appendix D

Additive Bench Top Test Results

Emulsification Test

Supplier **A**

Standard Solution pH: **7.7 pH** **Dosage of Additive used each test:** **1000 ppm**

Standard Solution Temperature: **80^0 F**

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	3:59	Distinct	9.5*	5
10	4:04	Distinct	9.5*	5
15	4:09	Distinct	9.5*	5
30	4:24	Distinct	9.5*	5
60	4:54	Distinct	9.5*	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	4:01	Distinct	10	5
10	4:06	Distinct	10	5
15	4:11	Distinct	10	5
30	4:26	Distinct	10	5
60	4:56	Distinct	10	5

ppm = parts per million
ml = milliliters
min = minutes
* = Grease adhered to the flask (grease volume was loss in the neck of the flask).

Emulsification Test

Supplier **B**

Standard Solution pH: **7.7 pH** **Dosage of Additive used each test:** **12,200 ppm**

Standard Solution Temperature: **80^0 F**

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	10:54	Distinct	10	4
10	10:59	Distinct	10	4
15	11:04	Distinct	10	4
30	11:19	Distinct	10	4
60	11:49	Distinct	10	4

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	10:55	Distinct	10	4
10	11:00	Distinct	10	4
15	11:05	Distinct	10	4
30	11:20	Distinct	10	4
60	11:50	Distinct	10	4

ppm = parts per million
ml = milliliters
min = minutes

Emulsification Test

Supplier **C**

Standard Solution pH: **7.7 pH** **Dosage of Additive used each test: 1000 ppm**

Standard Solution Temperature: **80^0 F**

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	2:36	Distinct	9.5*	5
10	2:41	Distinct	9.5*	5
15	2:46	Distinct	9.5*	5
30	3:01	Distinct	9.5*	5
60	3:31	Distinct	9.5*	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	2:38	Distinct	9.0*	5
10	2:43	Distinct	9.0*	5
15	2:48	Distinct	9.0*	5
30	3:03	Distinct	9.0*	5
60	3:33	Distinct	9.0*	5

ppm = parts per million
ml = milliliters
min = minutes
* = Grease adhered to the flask (grease volume was loss in the neck of the flask).

Emulsification Test

Supplier **D**

Standard Solution pH: **7.7 pH** **Dosage of Additive used each test:** **5,000 ppm**

Standard Solution Temperature: **80^0 F**

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	12:38	Distinct	9.5*	5
10	12:43	Distinct	9.5*	5
15	12:48	Distinct	9.5*	5
30	1:03	Distinct	9.5*	5
60	1:33	Distinct	9.5*	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	12:40	Distinct	10	5
10	12:45	Distinct	10	5
15	12:50	Distinct	10	5
30	1:05	Distinct	10	5
60	1:35	Distinct	10	5

ppm = parts per million
ml = milliliters
min = minutes
* = Grease adhered to the flask (grease volume was loss in the neck of the flask).

Emulsification Test

Supplier **E**

Standard Solution pH: **7.7 pH** **Dosage of Additive used each test:** **15,000 ppm**

Standard Solution Temperature: **80^0 F**

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	9:50	Distinct	10	5
10	9:55	Distinct	10	5
15	10:00	Distinct	10	5
30	10:15	Distinct	10	5
60	10:45	Distinct	10	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	9:52	Distinct	10	5
10	9:57	Distinct	10	5
15	10:02	Distinct	10	5
30	10:17	Distinct	10	5
60	10:47	Distinct	10	5

ppm = parts per million
ml = milliliters
min = minutes

Emulsification Test

Supplier F

Standard Solution pH: 7.7 pH

Dosage of Additive used each test: 1,000 ppm

Standard Solution Temperature: 80^0 F

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	1:20	Distinct	10	4.5
10	1:25	Distinct	10	4.5
15	1:30	Distinct	10	4.5
30	1:45	Distinct	10	4.5
60	2:15	Distinct	10	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	1:22	Distinct	10	4.5
10	1:27	Distinct	10	4.5
15	1:32	Distinct	10	4.5
30	1:47	Distinct	10	4.5
60	2:17	Distinct	10	5

ppm = parts per million
ml = milliliters
min = minutes

Emulsification Test

Supplier G

Standard Solution pH: 7.7 pH **Dosage of Additive used each test:** 50 ppm

Standard Solution Temperature: 80^{0} F

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	3:43	Distinct	9*	5
10	3:48	Distinct	9*	5
15	3:53	Distinct	9*	5
30	4:08	Distinct	9*	5
60	4:38	Distinct	9*	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	3:45	Distinct	9.5*	5
10	3:50	Distinct	9.5*	5
15	3:55	Distinct	9.5*	5
30	4:10	Distinct	9.5*	5
60	4:40	Distinct	9.5*	5

ppm = parts per million
ml = milliliters
min = minutes
* = Grease adhered to the flask (grease volume was loss in the neck of the flask).

Emulsification Test

Supplier **H**

Standard Solution pH: **7.7 pH** **Dosage of Additive used each test:** **750 ppm**

Standard Solution Temperature: **80^0 F**

1,000 ml Sample with Canola Oil				
Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	8:18	Distinct	9.5*	5
10	8:23	Distinct	9.5*	5
15	8:28	Distinct	9.5*	5
30	8:43	Distinct	9.5*	5
60	9:13	Distinct	9.5*	5

1,000 ml Sample with Lard				
Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	8:20	Distinct	9.5*	5
10	8:25	Distinct	9.5*	5
15	8:30	Distinct	9.5*	5
30	8:45	Distinct	9.5*	5
60	9:15	Distinct	9.5*	5

ppm = parts per million
ml = milliliters
min = minutes
* = Grease adhered to the flask (grease volume was loss in the neck of the flask).

Emulsification Test

Supplier I

Standard Solution pH: 7.7 pH **Dosage of Additive used each test:** 50 ppm

Standard Solution Temperature: 80^0 F

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	1:10	Distinct	10	5
10	1:15	Distinct	10	5
15	1:20	Distinct	10	5
30	1:35	Distinct	10	5
60	2:05	Distinct	10	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	1:13	Distinct	10	5
10	1:18	Distinct	10	5
15	1:23	Distinct	10	5
30	1:38	Distinct	10	5
60	2:08	Distinct	10	5

ppm = parts per million
ml = milliliters
min = minutes

Emulsification Test

Supplier **J**

Standard Solution pH: **7.7 pH** **Dosage of Additive used each test:** **50 ppm**

Standard Solution Temperature: **80^0 F**

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	11:57	Distinct	10	5
10	12:02	Distinct	10	5
15	12:07	Distinct	10	5
30	12:22	Distinct	10	5
60	12:52	Distinct	10	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	12:00	Distinct	10	5
10	12:05	Distinct	10	5
15	12:10	Distinct	10	5
30	12:25	Distinct	10	5
60	12:55	Distinct	10	5

ppm = parts per million
ml = milliliters
min = minutes

Emulsification Test

Supplier K

Standard Solution pH: 7.7 pH

Dosage of Additive used each test: 5,000 ppm

Standard Solution Temperature: 80^0 F

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	10:31	Distinct	10	5
10	10:36	Distinct	10	5
15	10:41	Distinct	10	5
30	10:56	Distinct	10	5
60	11:26	Distinct	10	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	10:33	Distinct	10	5
10	10:38	Distinct	10	5
15	10:43	Distinct	10	5
30	10:58	Distinct	10	5
60	11:28	Distinct	10	5

ppm = parts per million
ml = milliliters
min = minutes

Emulsification Test

Supplier **L (product 1)**

Standard Solution pH: **7.7 pH** **Dosage of Additive used each test:** **250 ppm**

Standard Solution Temperature: **80^0 F**

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	3:15	Distinct	10	5
10	3:20	Distinct	10	5
15	3:25	Distinct	10	5
30	3:40	Distinct	10	5
60	4:10	Distinct	10	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	3:19	Distinct	10	5
10	3:24	Distinct	10	5
15	3:44	Distinct	10	5
30	3:44	Distinct	10	5
60	4:14	Distinct	10	5

ppm = parts per million
ml = milliliters
min = minutes

Emulsification Test

Supplier **L (product 2)**

Standard Solution pH: **7.7 pH** **Dosage of Additive used each test:** **250 ppm**

Standard Solution Temperature: **80^{0} F**

1,000 ml Sample with Canola Oil

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	9:55	Distinct	10	5
10	10:00	Distinct	10	5
15	10:05	Distinct	10	5
30	10:20	Distinct	10	5
60	10:50	Distinct	10	5

1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	9:59	Distinct	10	5
10	10:04	Distinct	10	5
15	10:09	Distinct	10	5
30	10:24	Distinct	10	5
60	10:54	Distinct	10	5

ppm = parts per million
ml = milliliters
min = minutes

Emulsification Test

Supplier **L (product 3)**

Standard Solution pH: **7.7 pH** **Dosage of Additive used each test:** **250 ppm**

Standard Solution Temperature: **80^0 F**

1,000 ml Sample with Canola Oil

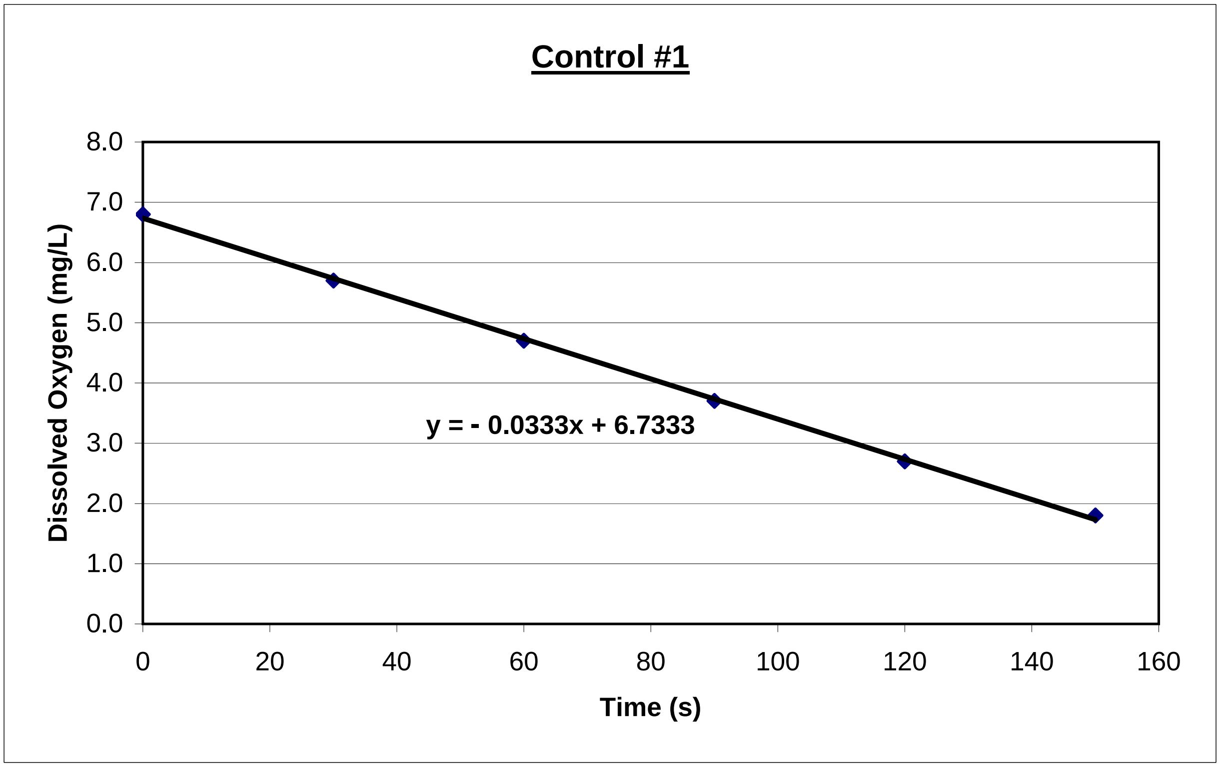
Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	11:46	Distinct	10	5
10	11:51	Distinct	10	5
15	11:56	Distinct	10	5
30	12:11	Distinct	10	5
60	12:41	Distinct	10	5

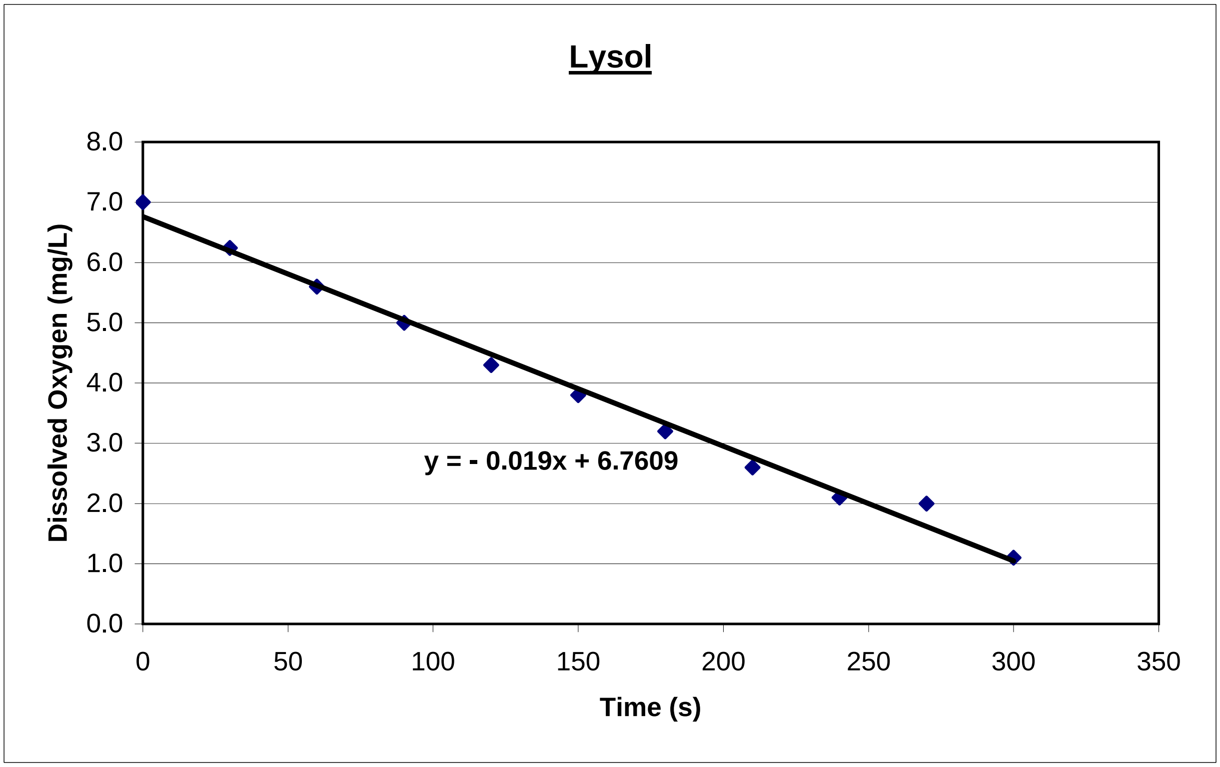
1,000 ml Sample with Lard

Time (min)	Actual Time	FOG/Water Interface (Distinct/Disturbed)	Depth of Oil Layer (ml)	Water Clarity (Rating 1-5)
5	11:49	Distinct	10	5
10	11:54	Distinct	10	5
15	11:59	Distinct	10	5
30	12:14	Distinct	10	5
60	12:44	Distinct	10	5

ppm = parts per million
ml = milliliters
min = minutes

OUR TEST RESULTS





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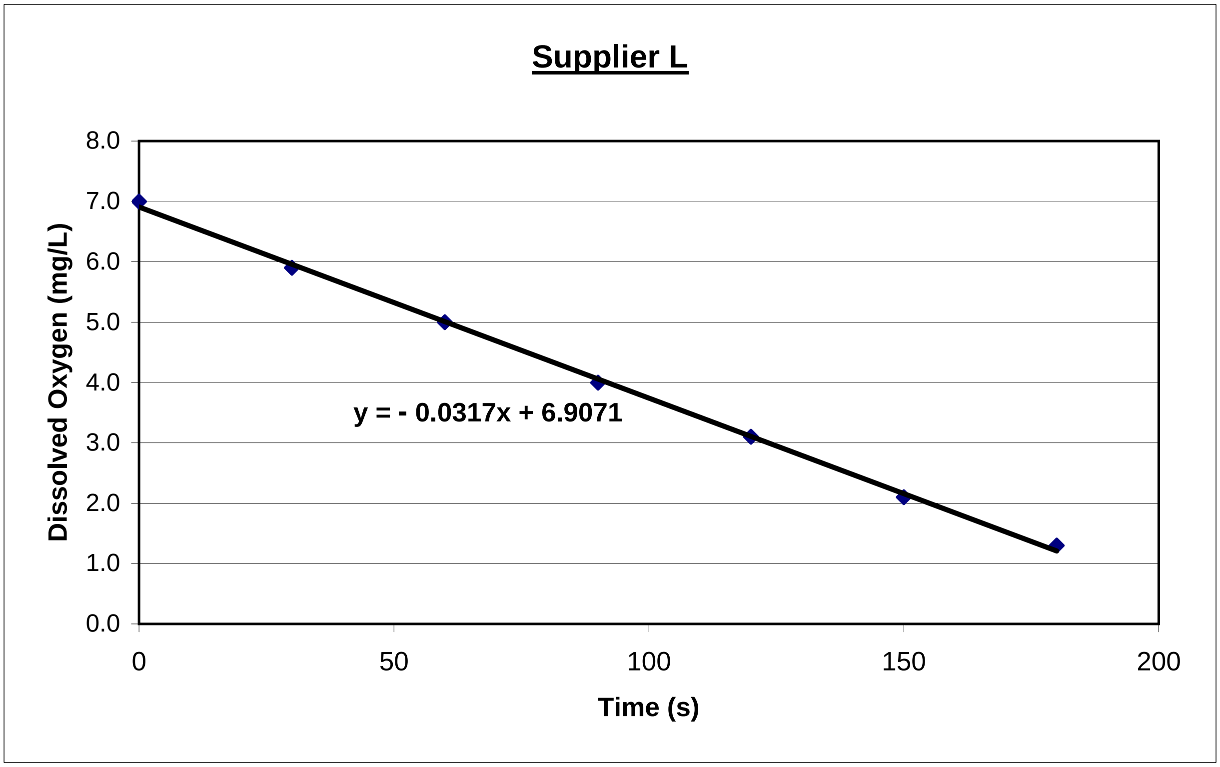

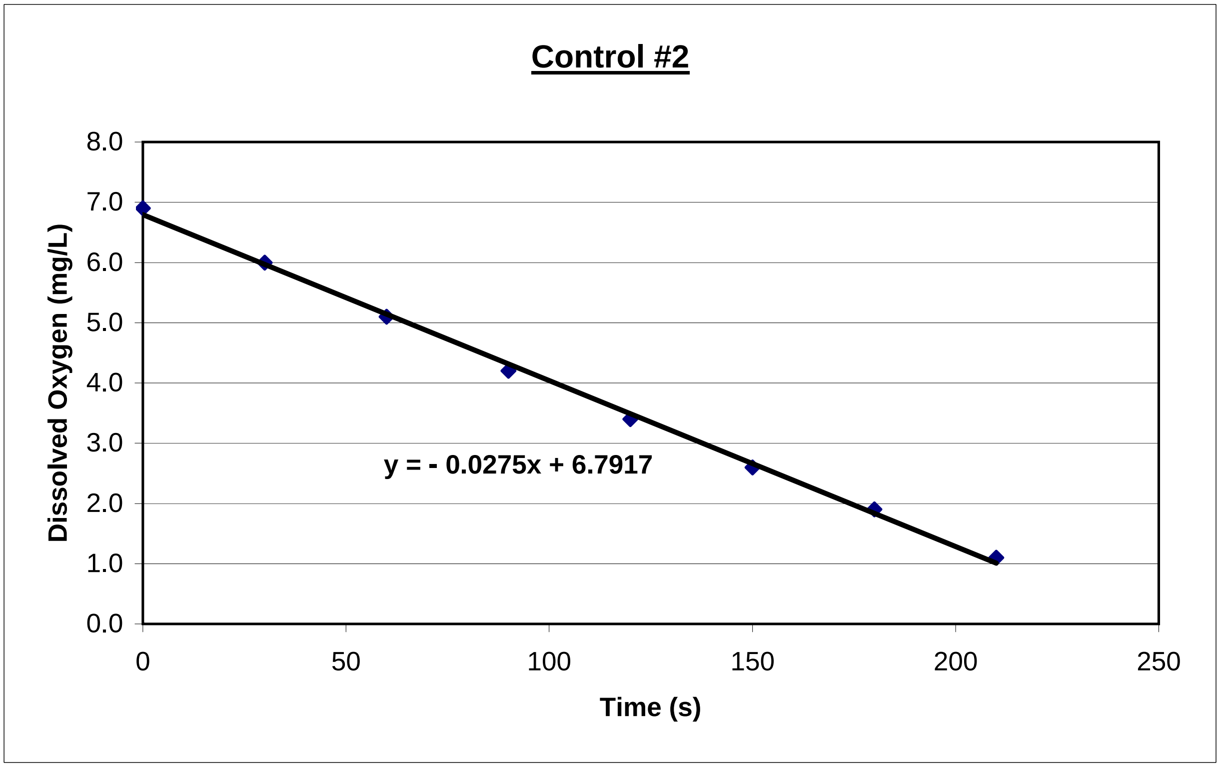

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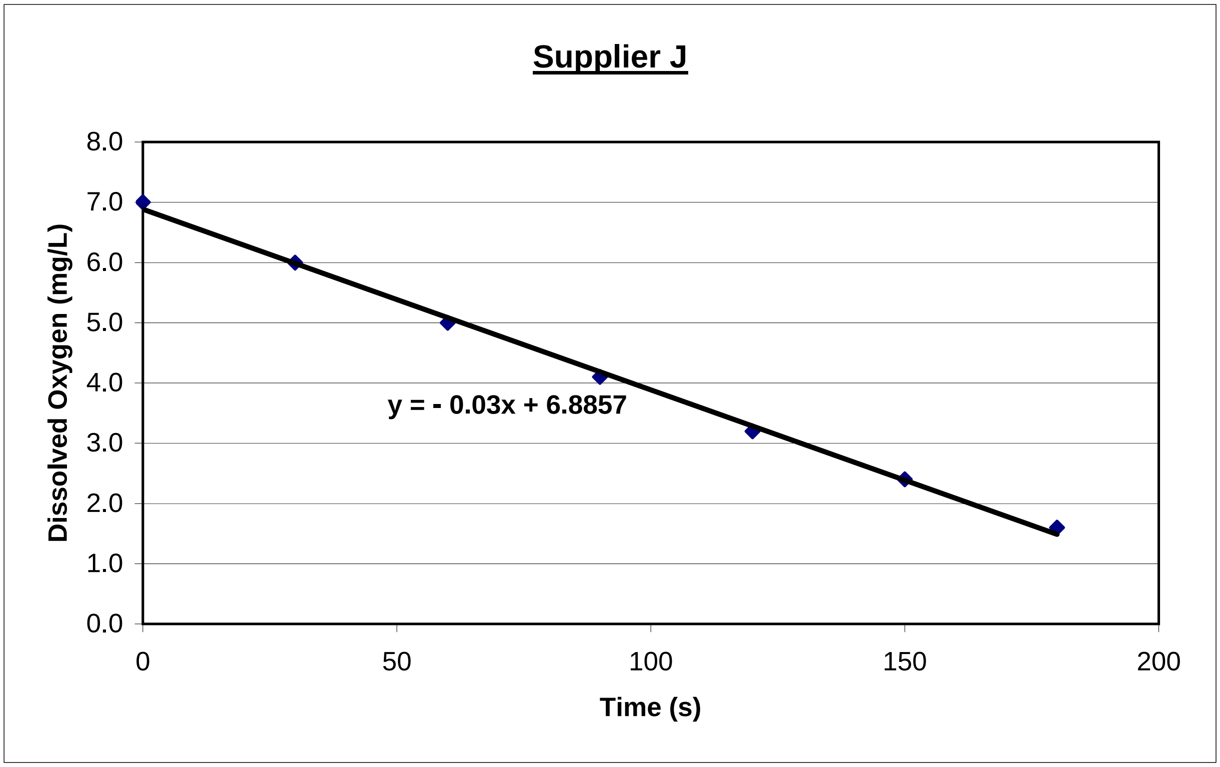

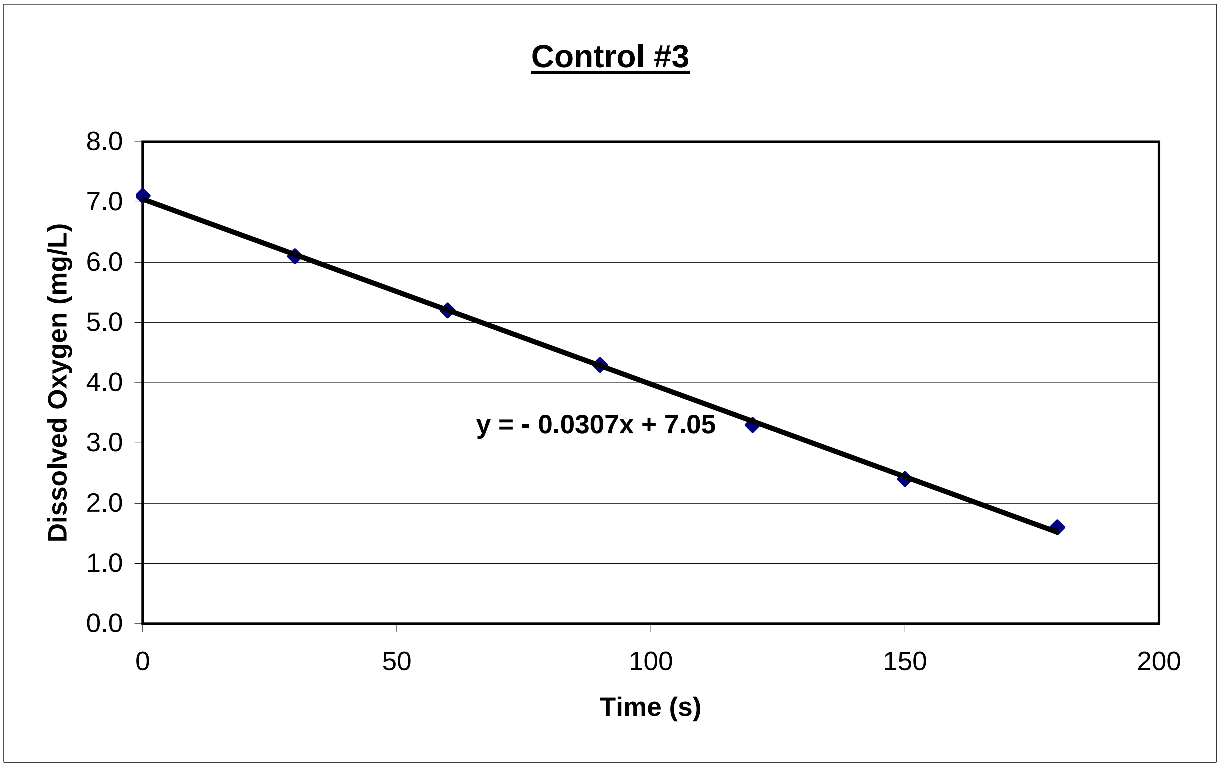

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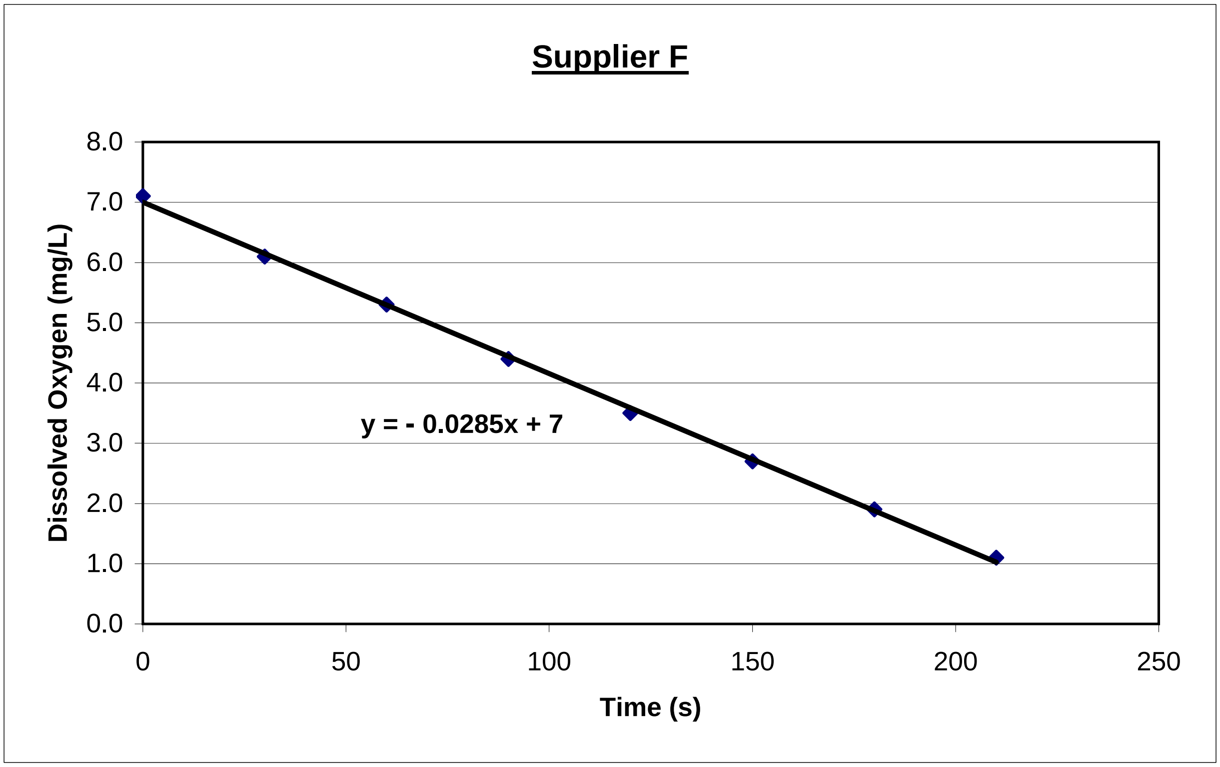

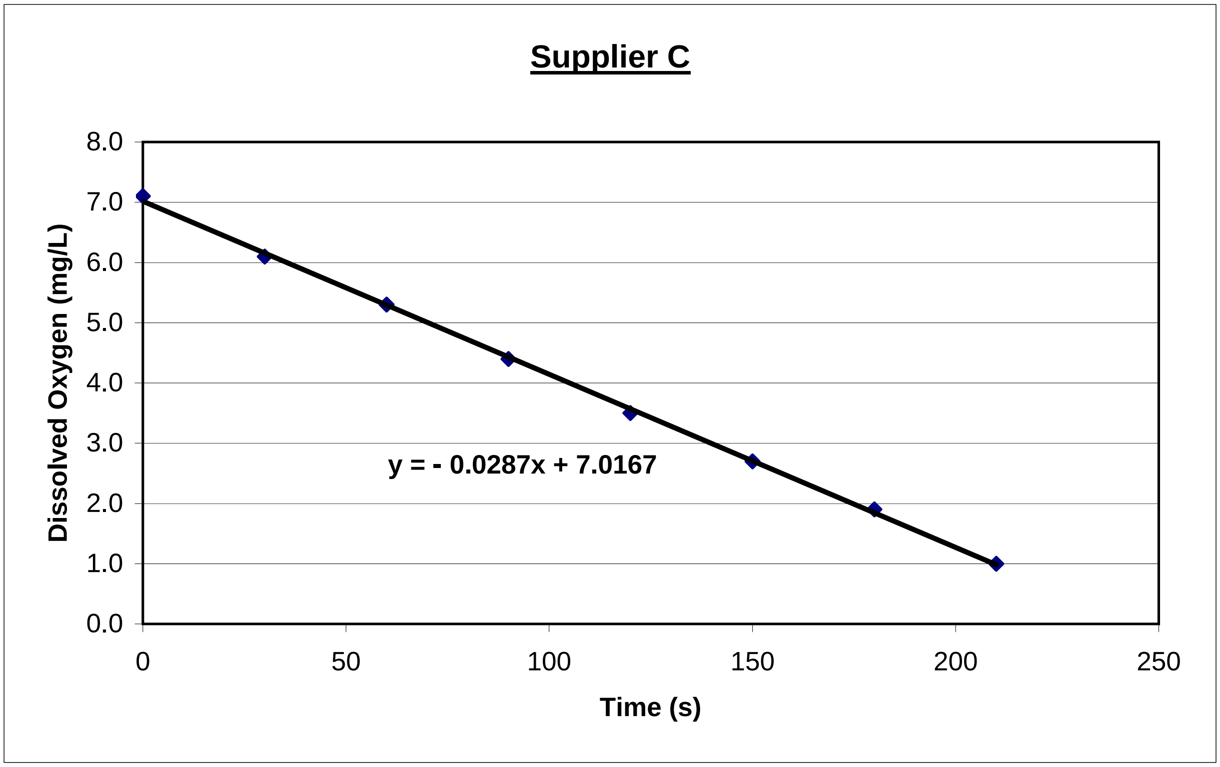

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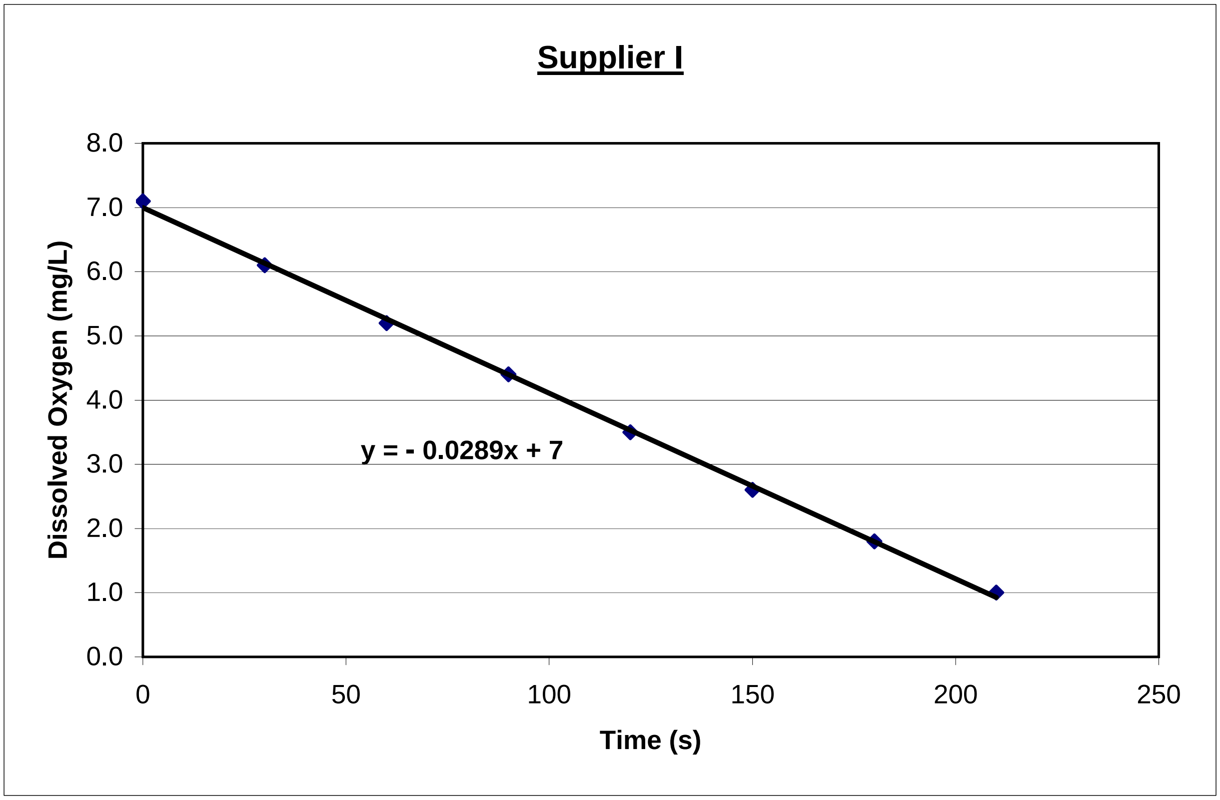

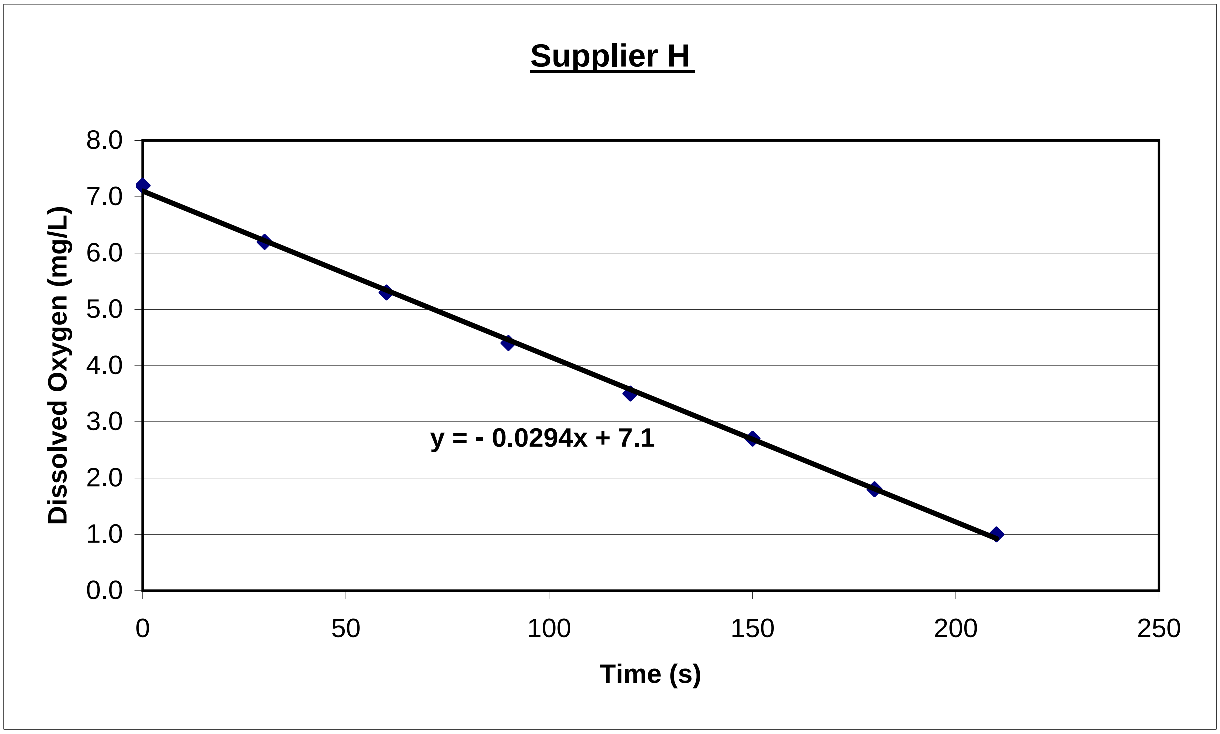

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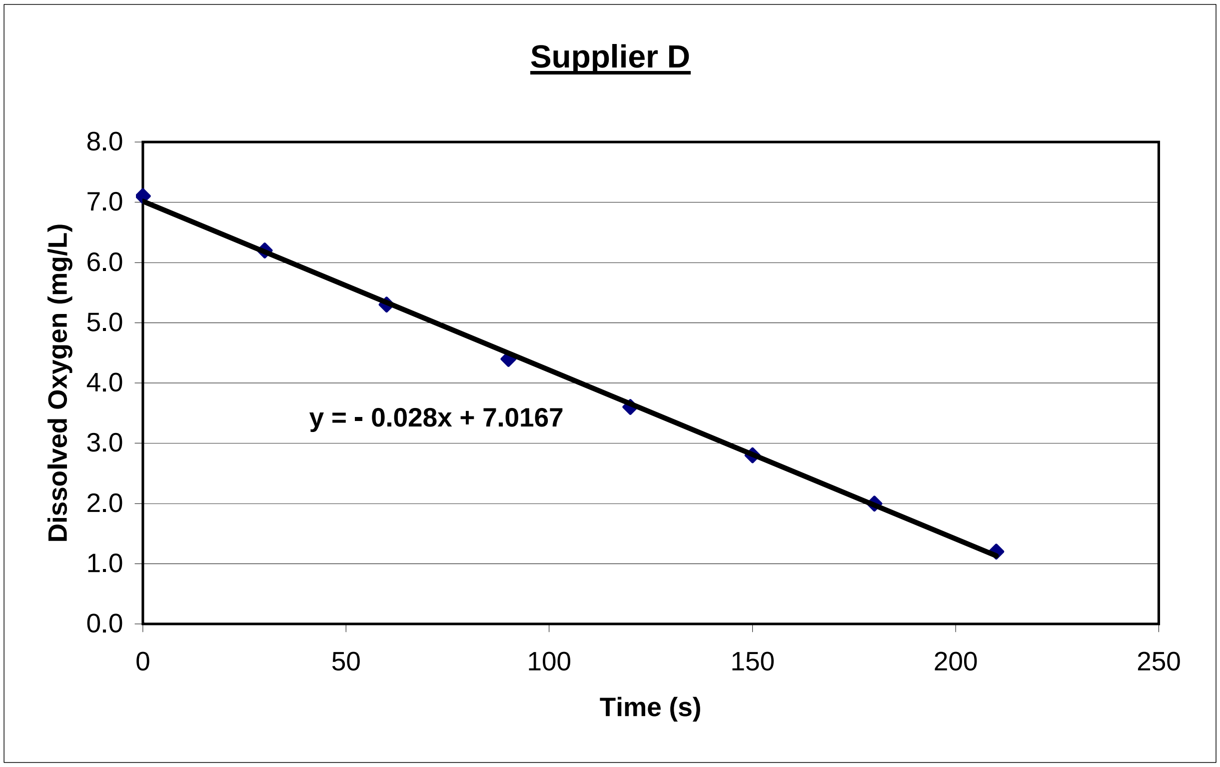

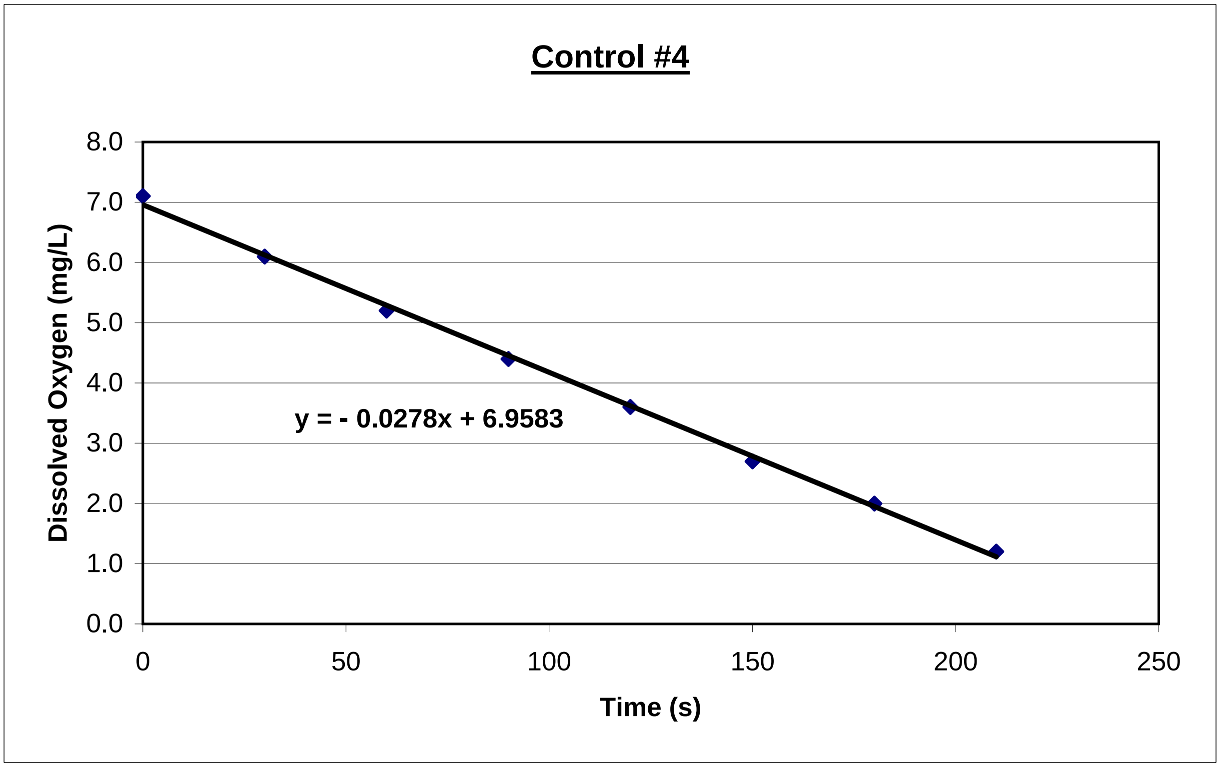

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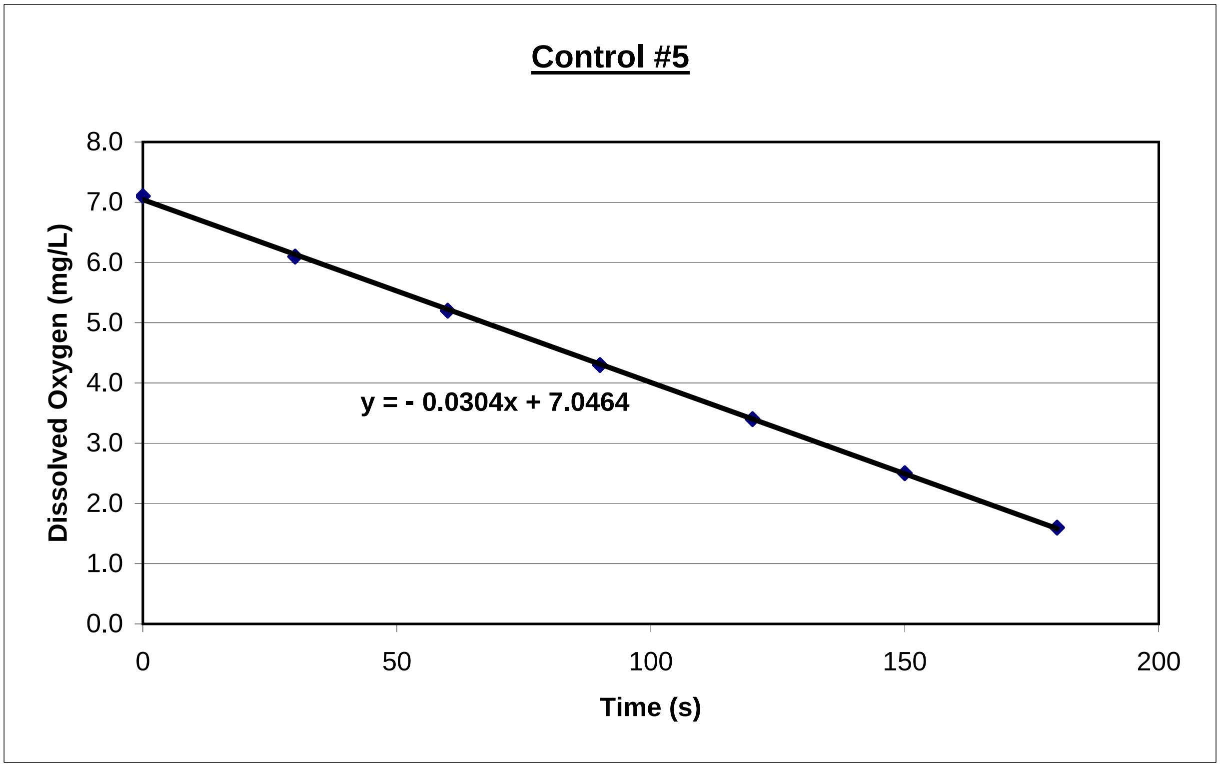
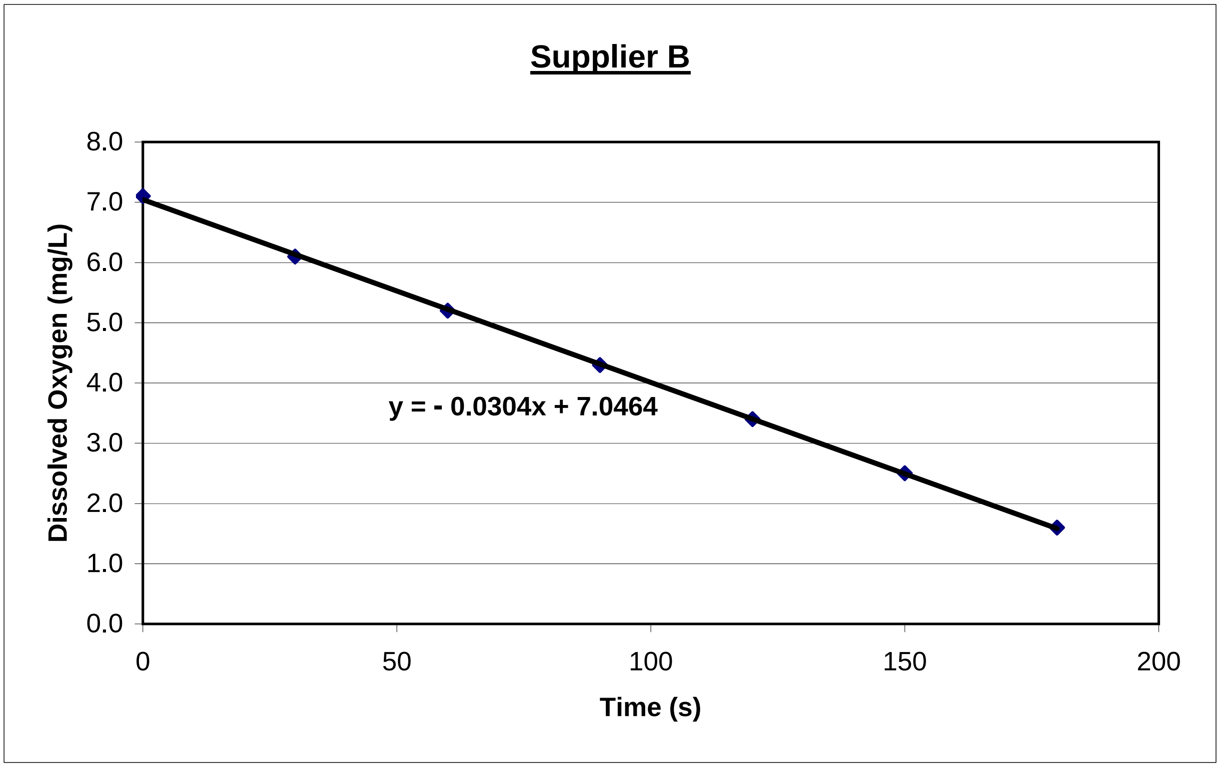
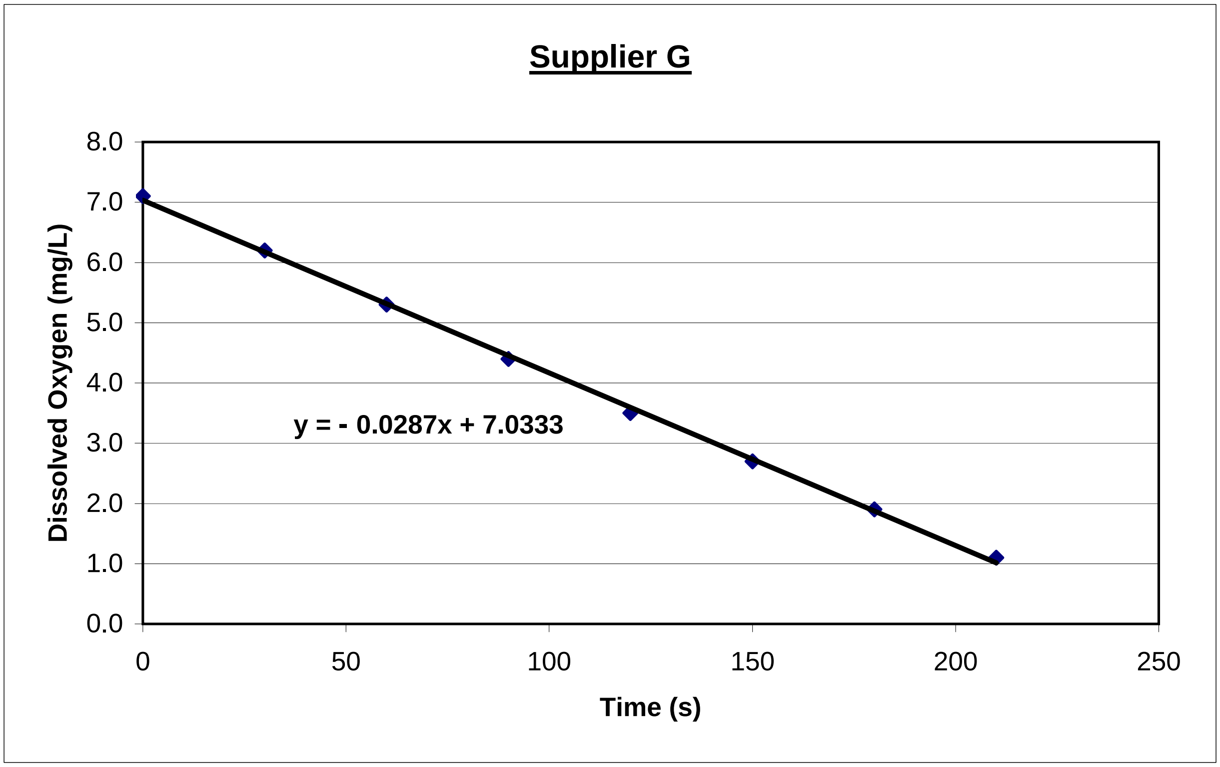
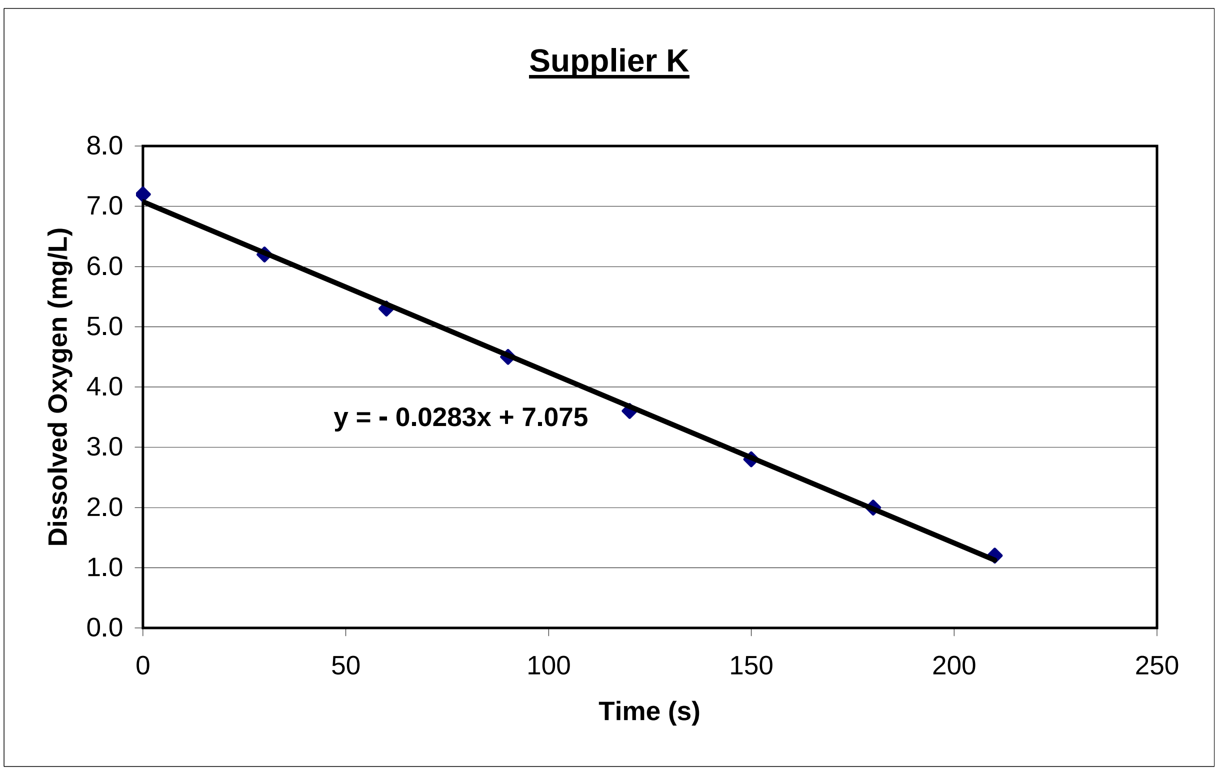


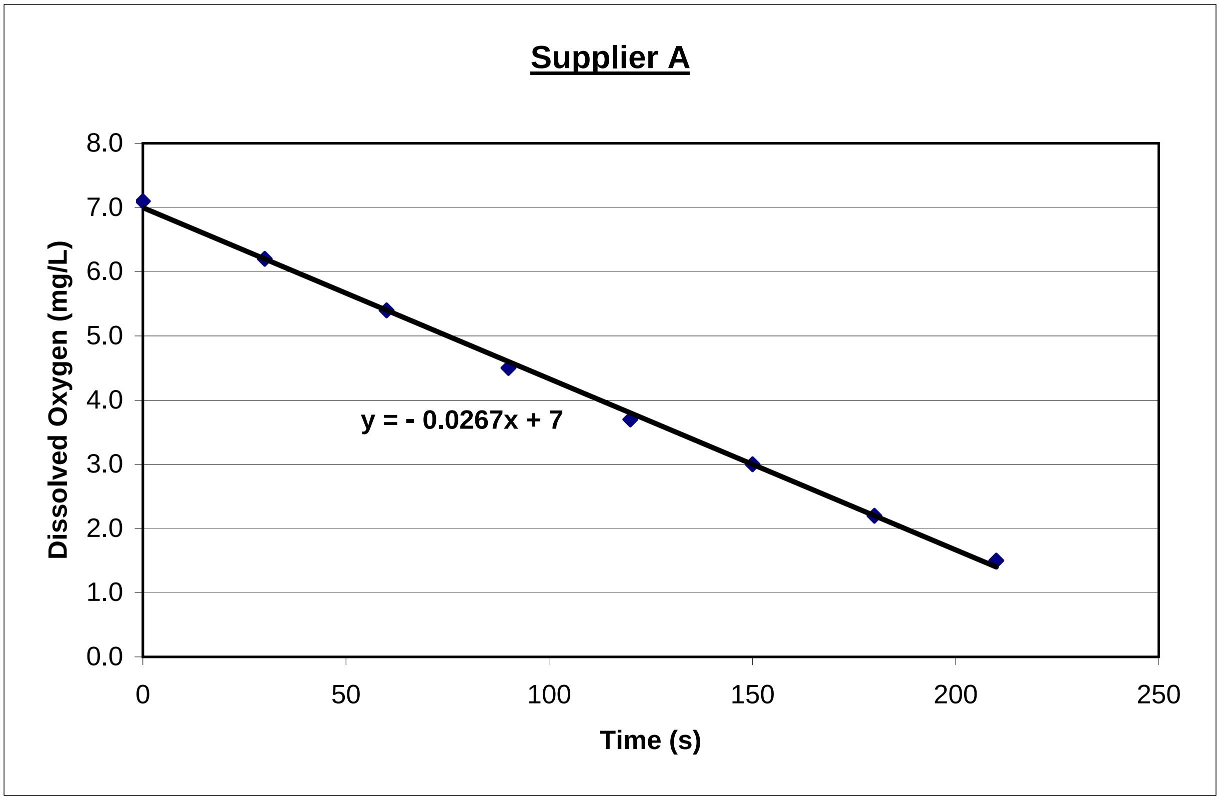


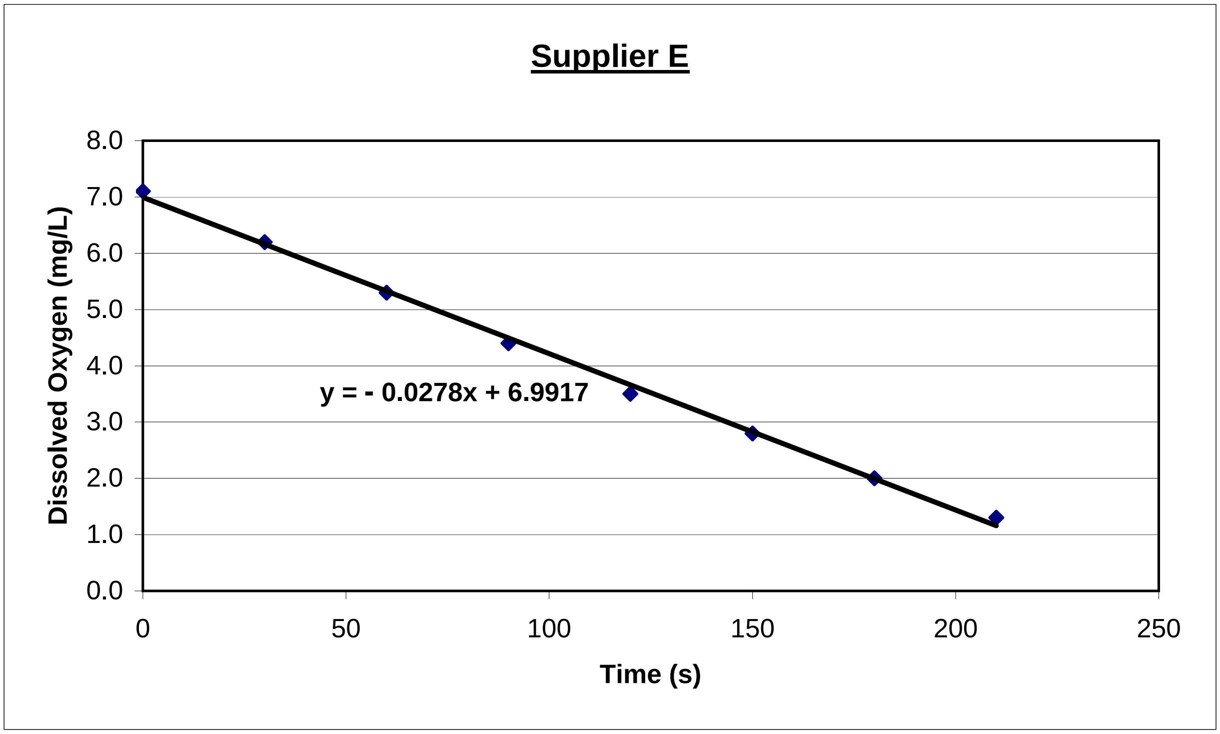
OUR TEST RESULTS





OUR TEST RESULTS





OUR TEST RESULTS