

# **FINAL REPORT**

Aqueous Cleaning Demonstration Project  
City and County of San Francisco

July 1999



Hazardous Waste Management Program  
Administrative Service Department



### **DISCLAIMER**

The mention and demonstration of commercial products, their source, or their use in connection with information reported herein is not to be construed as an actual or implied endorsement or recommendation of such products by the City and County of San Francisco. Identification and selection of commercial aqueous cleaning units for demonstrations was based on the available information at the time of project implementation, and is not intended to be inclusive or to exclude any commercial aqueous cleaning units in the market or in development.

## EXECUTIVE SUMMARY

The City and County of San Francisco Hazardous Waste Management Program (HWMP) is assisting City departments in identifying cost-effective alternatives to petroleum-based solvent part cleaners in an effort to reduce solvent use and waste solvent generation. Under the Aqueous Cleaning Demonstration Project, the HWMP demonstrated aqueous cleaning units in selected City department facilities to determine the viability of replacing solvent cleaning with aqueous cleaning. Between February 1998 and January 1999, 14 different aqueous cleaning units were demonstrated at three Municipal Railway (MUNI) fleet maintenance facilities: the Woods diesel bus maintenance facility, the Green light rail vehicle maintenance facility, and the Potrero electric bus maintenance facility.

This final report discusses the cleaning operations at the MUNI demonstration facilities, the types of aqueous cleaning units available and their applications, the demonstration results, the waste management practices used to handle aqueous cleaning wastes, the costs of aqueous cleaning compared to those of solvent cleaning, and purchasing requirements for the City departments. The conclusions drawn from the demonstration results are summarized below according to performance criteria established for the project.

### OVERALL CONCLUSIONS

- MUNI facilities can convert to aqueous cleaning using a combination of two or more types of aqueous cleaning units and can realize equal, and in some cases, better cleaning results than those obtained using solvent
- MUNI cleaning requirements were best met by implementing two or more types of aqueous cleaning units.
- MUNI can reduce the total number of cleaning units used by implementing spray cabinets and ultrasonic units with large cleaning capacities.
- Based on the demonstrations of aqueous cleaning units at MUNI, results relevant to all City departments are as follows:
  - Spray cabinets have the greatest potential for application in all City department facilities because of their high cleaning performance, wide range of unit sizes available, and highly favorable economics.
  - Ultrasonic units have potential for application in all City department facilities that have parts that cannot be effectively cleaned by other aqueous cleaning units and can justify the higher capital cost.
  - Sink-top and immersion units have potential for application limited to City department facilities that perform a small volume of parts cleaning, clean primarily lightly soiled parts, or clean and replace vehicle or machinery parts immediately.

### AQUEOUS CLEANING PERFORMANCE

- A total of 9 of the 14 aqueous cleaning units demonstrated were identified as meeting the overall performance requirements of MUNI facilities and as being potentially applicable to other City department facilities. These units are listed below according to unit type.
  - **Microbial sink-top:** ForBest IPC360 and EcoClean Bioflow20

- **Immersion unit:** Mirachem PW-40s
- **Spray cabinet:** Landa SJ-10, Safety-Kleen TLW-2, Safety-Kleen SJW-4, and EMC Jetsink
- **Ultrasonic unit:** GlobalSonics GreaseMonkey Senior and Alpha Cleaning Systems 1818-54

One-page descriptions of these nine units are included at the end of this Executive Summary.

- Spray cabinets were by far the most favorably reviewed aqueous cleaning units because of their high cleaning performance and automated cleaning operations.
- Ultrasonic units were able to provide a high level of overall cleaning performance. In addition, ultrasonic units were able to perform special cleaning applications that other cleaning units could not, such as cleaning interior and hidden part surfaces, removing carbonized soils, and cleaning aluminum parts that would be damaged in a spray cabinet.
- Sink-top and immersion units received a positive response from facility workers in light-duty cleaning applications because workers did not have to smell solvent odors, the skin on their hands did not become chapped, and the warm solution felt good on their hands. However, these units' cleaning performance was inadequate for moderately to heavily soiled parts.

## **PART RUSTING**

- Despite the use of rust inhibitors in all aqueous cleaning chemistries, rusting would often occur on parts cleaned in sink-top and immersion units. Rusting was prevented, however, by wiping parts dry with a rag immediately after cleaning.
- Rusting generally did not occur on parts cleaned in spray cabinets if the parts were removed soon after the cleaning cycle finished.
- Parts cleaned in ultrasonic units almost never rusted.

## **UNIT DESIGN**

- Spray cabinets and ultrasonic units are available in a wide range of capacities, from small to very large. Therefore, these units are appropriate for cleaning applications with a wide range of parts sizes and volumes.
- Medium- to large-sized spray cabinets and ultrasonic units have cleaning capacities equivalent to multiple solvent cleaning units.
- Solution odor was a significant factor in how staff reviewed sink-top and immersion units. In some cases, workers reacted differently to the solution odor from the same unit. Working height and sink-top size were also cited as significant factors with sink-top units.

## **SERVICING REQUIREMENTS**

- Servicing requirements for aqueous cleaning units were minimal, consisting of water additions, chemical additions, filter changes, and solution replacement. The frequency that these services were required varied according to the type of unit and the magnitude of its use. The range of servicing frequencies experienced during the demonstration, from least frequent to most frequent, were as follows:
  - **Water additions:** never (for units with automatic water fill device) to every two days

- **Chemical additions:** monthly to weekly
- **Filter change:** never (for units without filters) to monthly
- **Solution replacement:** greater than 3 months to monthly (full life of most solutions not measured as demonstration lasted for only 3 months)
- MUNI was able to service most of the aqueous cleaning units itself. However, MUNI staff indicated that they would prefer full servicing and waste management services if MUNI converted entirely to aqueous cleaning. Five of the vendors of aqueous cleaning units demonstrated offer full “turn-key” servicing including waste management with their units.

**ECONOMICS**

- Performing aqueous cleaning with sink-top, immersion, spray cabinet, or ultrasonic units is less costly than performing part cleaning using solvent. The potential annual costs savings estimated from the demonstration project results for each type of unit, including the annualized capital cost of the unit, are summarized below.

**Potential Savings from Different Aqueous Cleaner Units**

<b>Aqueous Cleaning Unit Implemented</b>	<b>Number of Solvent Units Replaced</b>	<b>Cleaning Application</b>	<b>Potential Annual Savings</b>
Microbial sink-top	1	Light-duty	\$852
Immersion	1	Medium-duty	\$425
Spray cabinet	2	Heavy-duty	\$21,977
Ultrasonic	2	Heavy-duty	\$16,057

- Spray cabinets are moderate in capital cost and ultrasonic units are high in capital cost, but both units offer significant cost savings because their large cleaning capacities allow them to replace multiple solvent units and their automated cleaning ability reduces cleaning labor requirements. These cost savings offset capital costs and result in short payback periods.
- For example, MUNI could realize significant cost savings by converting from solvent to aqueous cleaning. Estimated capital costs, savings, and payback periods for the MUNI Woods, Green, and Potrero facilities to convert to aqueous cleaning by purchasing aqueous cleaning units are summarized in the table below. Because servicing costs vary according to the number of units implemented and servicing frequency, these costs assume MUNI service the units themselves.

**Costs and Savings from Full Conversion by MUNI Facilities**

	<b>Woods</b>		<b>Green (Entire Facility)</b>	<b>Potrero (Entire Facility)</b>
	<b>Heavy Duty</b>	<b>Preventative Maintenance</b>		
Capital cost	\$30,400	\$6,100	\$39,800	\$14,030
Annual savings	\$134,810	\$13,270	\$226,200	\$13,250
Payback period	< 3 months	< 6 months	< 3 months	1.1 years

- Aqueous cleaning can decrease waste management costs by decreasing the amount of hazardous waste generated.
- MUNI and other City department facilities may realize additional cost savings through a decrease in hazardous waste generator fees paid to the California State Board of Equalization. In 1998, MUNI payed \$6,176 in hazardous waste generator fees.

## **WASTE GENERATION**

- Aqueous cleaning generates significantly less waste than solvent cleaning. Most facilities will be able to decrease their hazardous waste generation by converting from solvent to aqueous cleaning.
- Aqueous cleaning solutions lasted four to twelve times longer than solvent before requiring disposal. The cleaning solution in microbial sink-top units lasted longer than other aqueous cleaning solutions. All four microbial sink-top units demonstrated lasted the duration of the 3-month demonstration period without requiring solution disposal.
- Spent solutions from three aqueous cleaning units were analyzed and determined to be hazardous because of their cadmium, chromium, silver, toluene, and xylene content. Therefore, spent aqueous solutions from all units were disposed of off site by the City Department of Public Health waste contractor or by the aqueous cleaning unit vendors.
- Oil skimmed from aqueous cleaning units was managed as used engine oil and recycled. Spent filters from the units were disposed of by the aqueous cleaning unit vendors or were recycled with spent engine oil filters. State agencies suggest solution filters be disposed of as hazardous waste unless characterized and shown not to be a hazardous waste.
- Five of the vendors of aqueous cleaning units demonstrated offer full “turn-key” servicing including waste management with their units.

## **BEST AQUEOUS CLEANER UNITS DEMONSTRATED**

Based on the demonstration results, MUNI staff rated nine units as good to excellent in meeting their cleaning needs. These units represent all four aqueous cleaning unit types (sink-top, immersion, spray, and ultrasonic). A 1-page summary describes each units’ specifications, demonstration performance results, design, and servicing requirements.

**Demonstration Facility: Green**

Retail Price: \$1,000  
 Electrical Requirements: Standard 110-volt  
 Testing Laboratory-Approved: No (all components are Underwriters Laboratory [UL]-listed)  
 Unit Features: Microbial solution, low solution-level indicator, 200-micron filter  
 Internal Cleaning Dimensions: 36"L x 26"W x 9"H  
 External Dimensions: 38"L x 26"W x 46"H  
 Solution Capacity: 30 gallons  
 Solution Temperature: 110 °F  
 Cleaning Chemical: SeaWash 700  
 Chemical Cost: \$9 per gallon  
 Chemical Concentration: Premixed  
 Waste Management Services Available: Yes



**Description:** The ForBest unit is a microbial sink-top unit made of heavy-duty plastic. The unit has a 200-micron filter on the sink-top drain. Evergreen Environmental Services (Evergreen) provides full servicing and waste management for the unit, including addition of microbes and solution to the unit.

**Performance:** The ForBest unit successfully cleaned lightly to moderately soiled parts. The Green facility supervisor indicated that the unit was able to clean all parts that were previously cleaned in a solvent sink-top unit without significantly increasing cleaning labor; however, a few staff members indicated that the unit was not able to effectively remove more difficult-to-remove soils such as burnt-on carbon deposits and heavy, waterproof grease. Parts would frequently flash rust and were therefore dried immediately after cleaning by wiping them with rags. Of 15 recorded cleaning jobs, the cleaning results on more than half were rated as good and the remaining were rated as okay. Comments provided on the ForBest unit included the following: “releases silicon well,” “cuts oil and grease well,” “works good on bearing housing,” and “flash rusting if parts left standing.” No negative responses to the solution odor were made by MUNI staff.

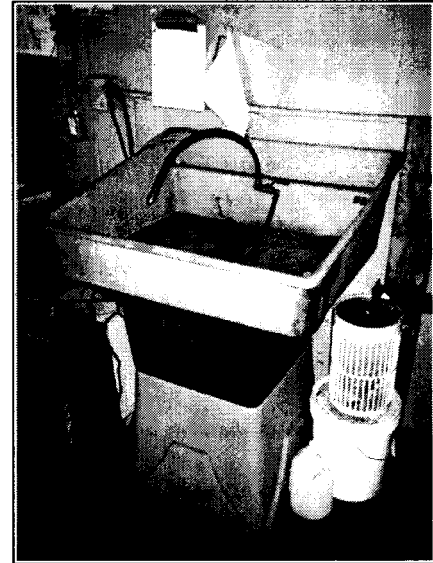
**Design:** The ForBest unit design was liked because of the large sink-top area and comfortable working height. Users found that the filter on the sink-top drain was frequently clogged, and raised grooves on the sink’s bottom prevented parts from lying flat. Some staff thought the floating solution level indicator was too simple in design and preferred an electronic indicator.

**Servicing Requirements:** Evergreen provided servicing of the unit every 4 weeks. Servicing included adding about 5 gallons of solution to the unit, adding microbes to the solution, and cleaning the filter. Evergreen replaces the solution only as needed. Green facility staff indicated that in some cases, Evergreen was late in visiting the facility, and thus the solution would run low. Evergreen explained that this is a new service provided by the company and program details are still being developed and finalized.

ForBest IPC360 Summary	
<b>Cleaning Performance</b>	
⌚	Successfully cleaned parts with light accumulation of grease, oil, and silicon
⌚	Did not remove difficult-to-clean soils, such as burnt-on carbon and heavy, waterproof grease, as effectively as solvent
⌚	Rusting prevented by drying parts with rag
<b>Unit Design</b>	
⌚	Positive aspects included large sink-top area
⌚	Negative aspects included raised grooves on sink’s bottom and frequent filter clogging
<b>Application</b>	
⌚	Effective for light-duty cleaning applications and quick cleaning jobs
•	Not effective for heavy-duty cleaning

**Demonstration Facility: Woods Heavy Duty, Woods Preventative Maintenance, Green**

Retail Price: \$1,295  
 Electrical Requirements: Standard 110-volt  
 Testing Laboratory-Approved: No (all components are UL-listed)  
 Unit Features: Microbial solution, low solution-level light  
 Internal Cleaning Dimensions: 32”L x 25”W x 10”H  
 External Dimensions: 35”L x 29”W x 45”H  
 Solution Capacity: 20 gallons  
 Solution Temperature: 110 °F  
 Cleaning Chemical: PC Solution  
 Chemical Cost: \$5 per gallon  
 Chemical Concentration: Premixed  
 Waste Management Services Available: No



Description: The EcoClean unit is a microbial sink-top unit made of polyethylene. Microbes are introduced into the unit through premixed solution additions. The solution is filtered by placing a filter under the flowing spigot.

Performance: The EcoClean unit was frequently used in the Woods facility Preventative Maintenance section because of the “clean and replace” nature of cleaning performed there, moderately used in the Green facility, and infrequently used in the Woods facility Heavy Duty section. The EcoClean unit successfully cleaned lightly soiled parts. However, the unit was not able to effectively remove more difficult-to-remove soils such as burnt-on carbon and heavy grease. Parts would frequently flash rust and were therefore dried immediately after cleaning by wiping them with rags. Of over 100 recorded cleaning jobs, the cleaning results on the majority of lightly soiled parts were rated as good, moderately-soiled parts as okay, and heavily-soiled parts as poor. Comments provided on the EcoClean unit included the following: “great for final cleaning,” “doesn’t cut wheel bearing grease,” “cleans well for nonsolvent,” and “solution not strong enough.” Several users indicated that the odor of the solution was mildly unpleasant.

Design: MUNI staff liked the design of the EcoClean unit because its large sink-top area provided ample working space and its greater sink-top height was comfortable for taller MUNI staff. The unit was described as frequently running low on solution, probably because of limited use of the drain cover that consists of a small plastic disc that is placed over the sink drain hole.

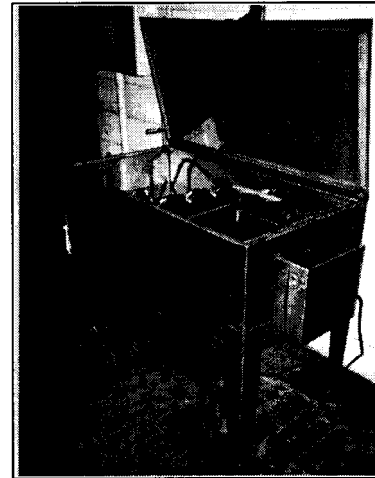
Servicing Requirements: Servicing requirements include adding about 1 to 2 gallons of solution per week and filtering the solution every 2 to 4 weeks. The vendor performed filtering during the demonstration but no longer offers this service and therefore provides filters to all unit users. All the EcoClean units were operated for the duration of the 3-month demonstration period without requiring solution changeout.

EcoClean Bioflow 20	
<b>Cleaning Performance</b>	
⚡	Successfully cleaned parts with a light accumulation of soils
⚡	Did not remove difficult-to-clean soils, such as burnt-on carbon, wheel bearing grease, and other heavy greases, as effectively as solvent
⚡	Rusting prevented by drying parts with rag
<b>Unit Design</b>	
⚡	Positive aspects included large sink-top area and comfortable working height
•	Negative aspects included poorly designed cover and frequent solution additions
<b>Application</b>	
⚡	Effective for light-duty cleaning applications and quick cleaning jobs
•	Not effective for heavy-duty cleaning



**Demonstration Facility: Green**

Retail Price: \$1,867 (with skimmer)  
 Electrical Requirements: Standard 110-volt  
 Testing Laboratory-Approved: No (all components are UL-listed)  
 Unit Features: Stainless-steel construction, automatic oil skimmer (not demonstrated), filtration system (not demonstrated)  
 Internal Cleaning Dimensions: 55”L x 24”W x 18”H  
 External Dimensions: 53”L x 24”W x 39”H  
 Solution Capacity: 40 gallons  
 Solution Temperature: 110 °F  
 Cleaning Chemical: Mirachem 500 (solution)  
 Chemical Cost: \$10 per gallon of concentrate  
 Chemical Concentration: 3:5 dilution ratio  
 Waste Management Services Available: No



Description: The Mirachem PW-40S unit is made entirely of stainless steel, has both a spigot and flow-through brush, and has a 40-gallon soaking capacity. A manual oil skimming system is a standard feature that allows oil to be manually pushed over a weir.

Performance: The Mirachem unit received heavy use at the Green facility and provided good cleaning performance. The supervisor at the Green facility indicated that the unit could clean all parts as well as solvent units without any additional cleaning labor. The Mirachem unit was able to remove moderate accumulations of greases, lubricants, and silicons. The unit was also able to remove burnt-on carbon in some cases. Green facility staff reacted favorably to the immersion feature of the unit and would often soak parts below the false bottom before scrubbing parts clean. Comments by Green facility staff included “I like it” and “excellent.”

Solution Odor: One staff at the Green facility indicated that the odor of the Mirachem 500 solution was too strong; as a result, he wore a respirator when cleaning parts in the unit. No other staff at the facility indicated any problems with the solution odor.

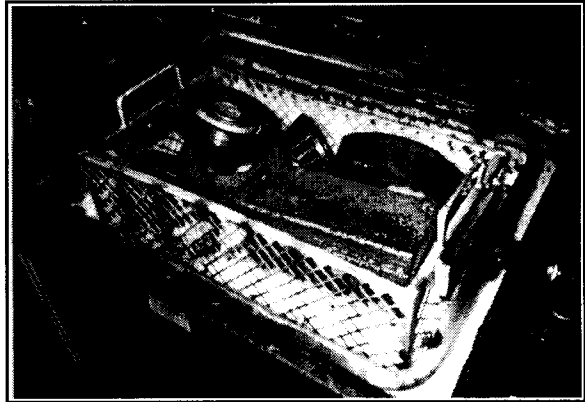
Design: MUNI staff responded very positively to the stainless-steel construction of the unit, indicating that it is durable enough to withstand heavy use. Mirachem is one of the few vendors that offer a unit made entirely of stainless steel. In addition, one staff indicated that the brush was very well designed. The manual oil skimming system was criticized as being difficult to use. Automatic oil skimming and continuous filtration are available options that were not included on the unit demonstrated.

Servicing Requirements: Servicing requirements included manually skimming oil several times a week and changing out the solution after 2 months. Minimal chemical additions were required.

Mirachem PW-40S	
<b>Cleaning Performance</b>	
•	Successfully cleaned parts with light to moderate accumulation of soils
†	In some cases, removed difficult-to-clean soils, such as burnt-on carbon
†	Rusting prevented by drying parts with rag
<b>Unit Design</b>	
†	Positive aspects included soaking area, stainless steel design, and well-designed brush
†	Negative aspects included poorly designed skimmer and strong solution odor
<b>Application</b>	
†	Effective for light- to moderate-duty cleaning applications
•	Not effective for heavy-duty cleaning

**Demonstration Facility: Woods Heavy Duty**

Retail Price: \$2,995 without options; \$3,900 as tested  
 Electrical Requirements: 230-volt, 25-ampere, 1-phase  
 Testing Laboratory-Approved: Yes (ETL Testing Labs)  
 Unit Features: Adjustable thermostat, temperature timer, automatic waterfill, reusable filter screen, pressure gauge  
 Internal Cleaning Dimensions: 26”L x 15”W x 7”H  
 External Dimensions: 42”L x 46”W x 36”H  
 Solution Capacity: 64 gallons  
 Solution Temperature: Adjustable up to 190 °F; 160 °F recommended by vendor  
 Cleaning Chemical: Hotsy Tubmate (powder)  
 Chemical Cost: \$10 per gallon of concentrate  
 Chemical Concentration: 8 to 12 ounces per gallon (1 to 1.5 cups per gallon)  
 Waste Management Services Available: No



Description: The Landa unit is a medium-sized top-loading spray cabinet that cleans parts using a rectangular spray bar that rotates around a stationary, rectangular, steel-mesh basket in which parts are loaded. A flow-through brush is available as an optional feature that also allows manual cleaning of parts.

Performance: The response of Woods facility Heavy Duty section staff to the Landa unit was extremely positive because of its high level of cleaning performance. The Landa unit was demonstrated under heavy use conditions: it was loaded with heavily soiled parts, including brake parts and wheel bearings, and used continuously throughout the workday. Staff stated that the unit was able to clean parts very quickly and effectively. Based on daily data collection logs, 100 percent of the cleaning jobs performed with the Landa unit were rated as good. This unit provided the best overall cleaning performance among all spray cabinets tested.

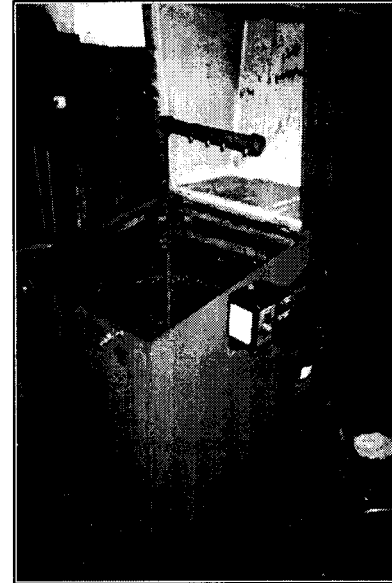
Design: Woods facility staff responded very positively to the user-friendly features of the Landa unit. The unit had a water fill feature that automatically added water to make up for evaporative losses. The unit also had a timer that automatically reduced the solution temperature overnight, thereby lowering energy costs. Other features of the unit included a reusable filter screen that removed solids as small as 0.008 inch from the solution and a pressure gauge to determine when the screen required cleaning. An oil skimmer was not included on the unit demonstrated but is an available option.

Servicing Requirements: The Landa unit was operated for 3 months before the solution was drained and replaced. Although the unit still provided good cleaning quality, sludge had accumulated to such a level that a seal broke on the spray bar and the pump leaked. For heavy use conditions such as those at the Woods facility, the vendor recommended changing the solution once a month. About 1 cup (8 ounces) of chemical was added to the solution each week.

Landa SJ-10	
<b>Cleaning Performance</b>	
⚡	Provided cleaning performance significantly better than solvent
⚡	Successfully cleaned all parts and soils, including wheel bearing grease, carbonized soils, and heavy grime
⚡	Did not usually cause parts rusting
<b>Unit Design</b>	
⚡	Positive aspects included large capacity, automatic water fill feature, and overnight temperature timer
⚡	No negative aspects noted
<b>Application</b>	
•	Effective for cleaning large volumes of parts and heavily soiled parts

**Demonstration Facility: Woods Heavy Duty**

Retail Price: \$3,850  
 Electrical Requirements: 220-volt, 25-ampere, 1-phase  
 Testing Laboratory-Approved: Yes (UL)  
 Unit Features: Adjustable thermostat  
 Internal Cleaning Dimensions: 22" (diameter of circular basket) x 29" (working height)  
 External Dimensions: 35"L x 37"W x 58"H  
 Solution Capacity: 32 gallons  
 Solution Temperature: Adjustable  
 Cleaning Chemical: AquaWorks  
 Chemical Cost: Included in lease agreement  
 Chemical Concentration: Premixed  
 Waste Management Services Available: Yes



Description: The Safety-Kleen TLW-2 unit is a medium-sized, top-loading spray cabinet with a circular part loading basket that rotates to ensure full spray coverage of parts.

Performance: The Safety-Kleen TLW-2 was used frequently throughout the day in the Woods Heavy Duty section, and staff response to the TLW-2 was very positive. A variety of parts were cleaned in the unit, including wheel bearings, brake parts, wheel scrapers, nuts, bolts, and transmission parts. A cleaning cycle of approximately 45 minutes was required to clean heavy grease. Of 46 recorded cleaning jobs, 100 percent were rated as having good cleaning results. Comments on the unit included "very good," "excellent," and "we need more of this kind of machine." Parts rusting was experienced only if parts were left in the unit after the cleaning cycle was completed. Parts removed from the unit immediately after the cleaning cycle rarely rusted.

Design: The simple design of the TLW-2 made the unit easy to use.

Servicing Requirements: Safety-Kleen provided full servicing for the unit, including water and chemical additions and waste solution disposal. Safety-Kleen serviced the unit every 4 weeks. The costs for these services were covered under the existing Safety-Kleen solvent contract.

Safety-Kleen TLW-2

**Cleaning Performance**

- Provided cleaning performance significantly better than solvent
- Successfully cleaned all parts and soils, including wheel bearing grease, carbonized soils, and heavy grime
- Almost never caused parts rusting

**Unit Design**

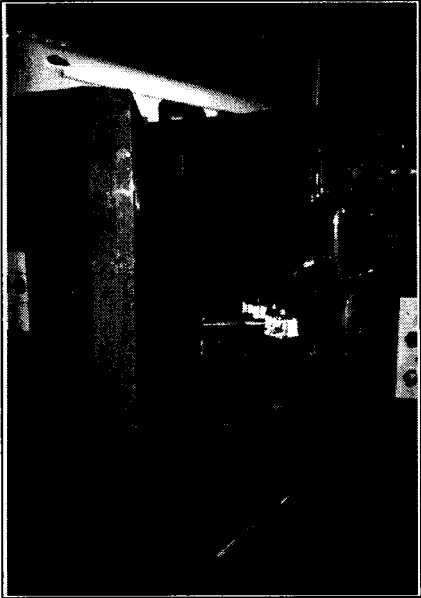
- Positive aspects included the simple, easy-to-use design
- No negative aspects noted

**Application**

- Effective for cleaning large volumes of parts and heavily soiled parts

**Demonstration Facility: Potrero**

Retail Price: \$11,430  
 Electrical Requirements: 220-volt, 25-ampere, 3-phase  
 Testing Laboratory Approved: Yes (UL)  
 Unit Features: Adjustable thermostat  
 Internal Cleaning Dimensions: 40" (diameter of circular basket) x 54" (working height)  
 External Dimensions: 74.5"L x 47"W x 86"H  
 Solution Capacity: 243 gallons  
 Solution Temperature: Adjustable  
 Cleaning Chemical: AquaWorks  
 Chemical Cost: Included in lease agreement  
 Chemical Concentration: Premixed  
 Waste Management Services Available: Yes



Description: The Safety-Kleen SJW-4 unit is a very large, front-loading spray cabinet with a circular part loading tray that rotates to ensure full spray coverage of parts.

Performance: Potrero staff response to the unit was very positive, and the unit was used an average of about 6 hours per day. The facility used the unit to clean parts such as radius rods, hoses, oil seal retainers, tool boxes, hub wrenches, anchor pins, and wheel bearings. Large parts that were cleaned in the unit included trolley bases, wheel hubs, and compressors. One staff member indicated that the unit cannot clean small, intricate parts like gears and screens very well. Although the unit is one of the largest available from Safety-Kleen, axles were too long to fit into the unit. In some cases, the unit cleaned so well that it would strip paint off painted parts. Facility staff typically set the thermostat between 180 and 190 °F.

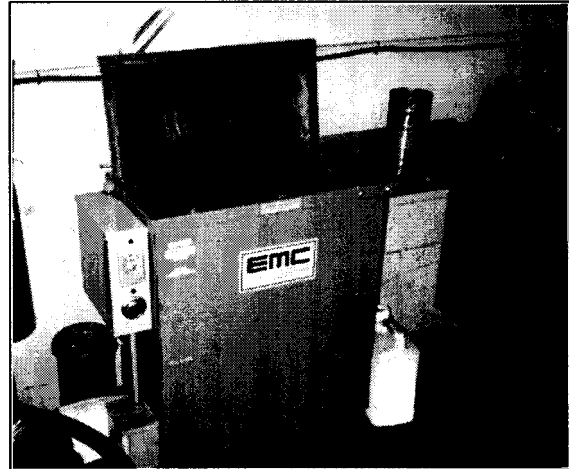
Design: The unit was equipped with a 30-minute cleaning cycle timer; however, some parts required more cleaning time, so the user had to reset the timer and repeat the cleaning cycle. Foaming of the solution was cited as a problem with the unit. Soap suds often escaped from the bottom of the unit, requiring the user to stop the cleaning cycle.

Servicing Requirements: Safety-Kleen provided full servicing for the unit, including water and chemical additions and waste solution disposal. Safety-Kleen serviced the unit every 4 weeks. The costs for these services were covered under the existing Safety-Kleen solvent contract. Because of significant evaporative losses, facility staff added 20 to 30 gallons of water to the unit every 2 days.

Safety-Kleen SJW-4	
<b>Cleaning Performance</b>	
⊕	Provided cleaning performance better than solvent
•	Successfully cleaned large parts and heavily soiled parts
⊕	Unable to clean small, intricate parts like gears or screens
⊕	Sometimes caused parts rusting
<b>Unit Design</b>	
⊕	Positive aspects included the large unit size
⊕	Negative aspects included frequent foaming and overflow of the solution
<b>Application</b>	
•	Effective for cleaning large parts and large volumes of parts

**Demonstration Facility: Woods Heavy Duty**

Retail Price: \$1,695  
 Electrical Requirements: Standard 110-volt  
 Testing Laboratory-Approved: Yes (UL)  
 Unit Features: Adjustable thermostat  
 Internal Cleaning Dimensions: 26”L x 14”W x 15”H  
 External Dimensions: 38”L x 20”W x 37”H  
 Solution Capacity: 25 gallons  
 Solution Temperature: Adjustable: 160 °F recommended by vendor  
 Cleaning Chemical: ALO Jet (powder)  
 Chemical Cost: \$2 per pound  
 Chemical Concentration: 12 pounds per 25 gallons  
 Waste Management Services Available: Yes



Description: The EMC Jetsink unit is a small spray cabinet. The unit is one of the few commercially available spray cabinets that operate on 110-volt electrical current.

Performance: The response of Woods facility Heavy Duty section staff to the spray cabinet was very positive. Staff used the unit to clean brake, fan drive, differential, drive line, radiator, fuel system, suspension, and cooling system parts. Of 26 cleaning jobs monitored and recorded on data collection logs, all were rated as good. The EMC Jetsink unit provided cleaning performance equivalent to that of larger spray cabinets without any moving components or 220-volt electrical requirements. Comments provided by staff on the unit included “cleans real well” and “works great.”

Design: The EMC Jetsink unit was too small to accommodate larger parts cleaned at the Heavy Duty section. In addition, the unit was too small to accommodate the large volume of parts cleaned at the Heavy Duty section. EMC does have larger spray cabinets commercially available.

Servicing Requirements: The local EMC vendor, Safeway Chemical Company, provided full servicing and waste management services, including managing and disposing of waste solution, cleaning the unit, and adding new solution to the unit. Heavy Duty section staff added water to the unit between service visits to make up for evaporative losses and about 5 pounds of ALO Jet powder every week to maintain chemical strength. The solution was replaced on a scheduled-basis by Safeway Chemical Company every 3 weeks.

EMC Jetsink Summary	
<b>Cleaning Performance</b>	
⊗	Provided cleaning performance better than solvent
⊗	Successfully cleaned a variety of parts including heavily soiled parts, such as wheel bearings
⊕	Sometimes caused parts rusting
<b>Unit Design</b>	
⊗	Positive aspects included the small floor space requirements
⊗	Negative aspects included limited capacity for cleaning large parts or a large number of parts
<b>Application</b>	
⊗	Effective for cleaning heavily soiled parts
•	Applicable for facilities with small cleaning operations that want the benefits of spray cabinets
•	Larger units available for cleaning bigger parts and larger loads

**Demonstration Facility: Woods Heavy Duty**

Retail Price: \$10,995  
 Electrical Requirements: 220-volt, 20-ampere, 1-phase  
 Testing Laboratory-Approved: Yes (UL)  
 Unit Features: Adjustable thermostat, filtration system, automatic weir oil skimmer, sweep frequency  
 Ultrasonics Frequency: 25 to 40 kilohertz (Hz)  
 Ultrasonics Power: 1,000 watts  
 Internal Cleaning Dimensions: 27”L x 35”W x 11 “H  
 External Dimensions: 41”L x 31”W x 43,5”H  
 Solution Capacity: 45 gallons  
 Solution Temperature: Adjustable between 150 °F and 185 °F  
 Cleaning Chemical: Brulin 815GD  
 Chemical Cost: \$13 per gallon  
 Chemical Concentration: 1:18 ratio  
**Waste Management Services Available: Yes**



Description: The GlobalSonics unit is a large, ultrasonic unit. It features ultrasonic transducers that generate a frequency that cycles between 25 and 40 kilohertz using 1,000 watts of power; a dual filtration system; and an automatic oil skimmer.

Performance: The GlobalSonics unit received very heavy use during the demonstration, and it received very positive assessments from Woods facility Heavy Duty section staff for its high cleaning performance. Very heavily soiled parts were successfully cleaned in the unit, including bearings, retainer rings, brake valves, brake pads, suspension rods and arms, radiators, air valves, and starters. Section staff indicated that there were no parts in their section that the unit could not clean. Parts were cleaned in as little as 5 minutes; in some cases, light follow-up brushing was required to remove residual soils from parts. The GlobalSonics unit also impressed staff with its ability to clean interior surfaces of parts such as valves and its ability to achieve high levels of cleanliness without damaging rubber components such as the rubber seals on brake valves. Because parts were heated while immersed in the solution, they dried immediately after removal from the unit, eliminating flash rusting. Section staff maintained the solution temperature at 161 °F.

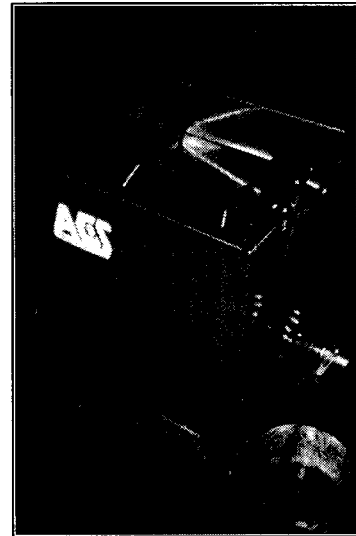
Design: The large size of the units cleaning tank allowed section staff to clean many small parts in the unit as well as larger parts. The digital temperature control and automatic oil skimmer were simple to use. Four staff members indicated that the unit was too noisy.

Servicing Requirements: Servicing of the unit included (1) turning on the oil skimmer and filtration system as needed, (2) adding water and chemical to the unit, and (3) changing the solution. The oil skimmer and filtration system were run daily by pushing a button on the front control panel. About 1 to 2 gallons of cleaning chemical was added to the unit every week by MUNI staff. The solution was drained and replaced every month by the vendor because of the unit’s very heavy use. In addition, the pump clogged once and required servicing by the vendor.

- |  |
|--|
| <p>GlobalSonics GreaseMonkey Senior</p> <p><b>Cleaning Performance</b></p> <ul style="list-style-type: none"> <li>⌘ Successfully cleaned heavily soiled parts</li> <li>⌘ Successfully cleaned hidden surface areas on parts such as valves</li> <li>⌘ Never caused parts rusting</li> </ul> <p><b>Unit Design</b></p> <ul style="list-style-type: none"> <li>⌘ Positive aspects included large cleaning capacity</li> <li>⌘ Negative aspects included operating noise</li> </ul> <p><b>Application</b></p> <ul style="list-style-type: none"> <li>• Effective on parts with intricate designs and hidden surface areas</li> <li>• Effective for cleaning heavily soiled parts</li> </ul> |
|--|

**Demonstration Facility: Woods Heavy Duty**

Retail Price: \$5,300  
 Electrical Requirements: Standard 110-volt  
 Testing Laboratory-Approved: Yes (UL)  
 Unit Features: Adjustable thermostat, adjustable ultrasonic frequency, oil skimmer  
 Ultrasonic Frequency: 40 kHz  
 Ultrasonic Power: 600 watts  
 Internal Cleaning Dimensions: 18"L x 18"W x 18"H  
 External Dimensions: 24"L x 22"W x 30"H  
 Solution Capacity: 25 gallons  
 Solution Temperature: Adjustable between 140 °F to 170 °F  
 Cleaning Chemical: Daraclean 257  
 Chemical Cost: \$25 per gallon  
 Chemical Concentration: 1: 10 ratio  
 Waste Management Services Available: No



**Description:** The Alpha Cleaning Systems 1818-54 unit is a small, low-cost ultrasonic unit. Features of the unit include adjustable temperature setting and adjustable ultrasonic power. An optional oil skimmer was included with the unit demonstrated.

**Performance:** The unit received moderate use at the Woods Heavy Duty section and a positive overall response. The unit was effective in removing particularly stubborn burnt-on carbon and carbonized soils that solvent was unable to remove. The unit provided a high level of cleaning performance for aluminum parts that could not be cleaned in spray cabinets due to concerns over damaging parts. The unit was also effective in cleaning hidden and interior surfaces of parts such as starters, compressors, pistons, air dryers, and valves. Most of the parts cleaned in the unit were made of aluminum. Parts were cleaned for 30 to 45 minutes in the unit, typically with no follow-up scrubbing required. As an indication of its cleaning effectiveness, the unit was even capable of removing paint from painted part surfaces. Negative responses made on-the unit included: (1) its inability to clean heavy grease and (2) if the solution became too diluted with water, the unit lost significant cleaning ability.

**Design:** Woods staff indicated that the unit could not accommodate large parts or a large number of parts. Alpha Cleaning Systems does offer larger ultrasonic cleaning units as part of its full line of units.

**Servicing Requirements:** Unit servicing included (1) skimming oil once a week, (2) adding water and chemical to the unit, and (3) changing the solution. Woods staff skimmed oil every Monday morning when the solution was cool. About 0.5 gallon of cleaning chemical was added to the unit each week. The solution lasted over 2 months before changeout was required. The transducer in the unit broke down because of electrical failure, and the unit was replaced 1 month into the demonstration period.

#### Alpha Cleaning System 1818-54 Summary Cleaning Performance

- ☞ Successfully cleaned delicate parts and parts with interior surfaces, such as valves
- ☞ Successfully removed burnt-on carbon and paint
- ☞ Not effective on heavy grease accumulation
- ☞ Rarely caused parts rusting

#### Unit Design

- ☞ Positive aspects included small floor space requirements
- ☞ Negative aspects included limited capacity for large parts and a large number of parts

#### Application

- ☞ Effective on parts with intricate designs and hidden surface areas
- Effective on aluminum parts that cannot be cleaned in spray cabinets

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## 1.0 INTRODUCTION AND PROJECT OVERVIEW

Tetra Tech EM Inc. provided technical support to the Hazardous Waste Management Program (HWMP) of the City and County of San Francisco for the Aqueous Cleaning Demonstration Project. This project is part of an ongoing effort by the HWMP to assist City departments reduce their hazardous waste generation.

The HWMP has focused waste reduction efforts on petroleum-based solvent cleaning operations because spent solvent is one of the largest and most costly hazardous waste streams generated by City departments.

“Effective September 1, 1999, each facility is allowed only one solvent cleaner with a maximum solvent loss of 20 gallons per year. ”

Bay Area Air Quality  
Management District,  
Regulation 8, Rule 16

In addition, solvents contain volatile organic compounds (VOC) that may be toxic to workers when inhaled and may contribute to smog formation. The Bay Area Air Quality Management District recently adopted a rule that allows only one petroleum-based solvent part cleaning unit per facility beginning on September 1, 1999. The single solvent cleaning unit is allowed a maximum solvent loss through evaporation or dragout of 20 gallons per year. Facilities who continue to operate a solvent cleaning unit must document their solvent loss by maintaining records of the volume of solvent added to the unit and waste solvent disposed. All

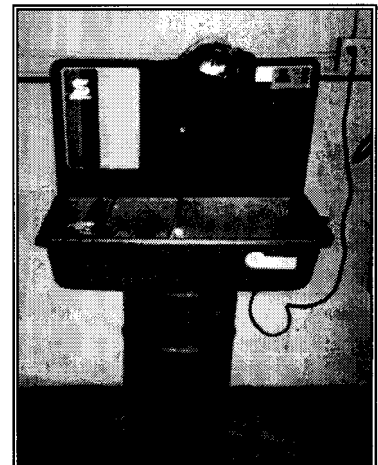
other solvent cleaning units must be either permitted or replaced with units that use aqueous cleaners, which are defined as solutions with 50 grams per liter or less of VOCs.

The purpose of the Aqueous Cleaning Demonstration Project was to determine the viability of replacing solvent cleaning units with aqueous cleaning units in City departments by demonstrating aqueous cleaning units and documenting the results. The following project-specific objectives directed the demonstration activities:

- Evaluate the performance of aqueous cleaning units relative to current petroleum-based solvent cleaning units
- Determine worker preferences for particular aqueous cleaning units based on their usability and performance
- Document operating issued and costs associated with aqueous cleaning units
- Determine waste generation rates and waste management costs for aqueous cleaning units, and compare these values to those for current petroleum-based solvent cleaning units

To meet the project objectives, HWMP in coordination with Municipal Railway (MUNI) (1) identified three MUNI facilities to demonstrate aqueous cleaning units, (2) established baseline conditions at each facility, (3) evaluated over 40 different aqueous cleaning units and selected 14 units for demonstration, and (4) demonstrated the 14 units for a 3-month period and documented the results.

MUNI facilities were selected to demonstrate aqueous cleaning units under the project because MUNI is a significant user of solvent cleaning

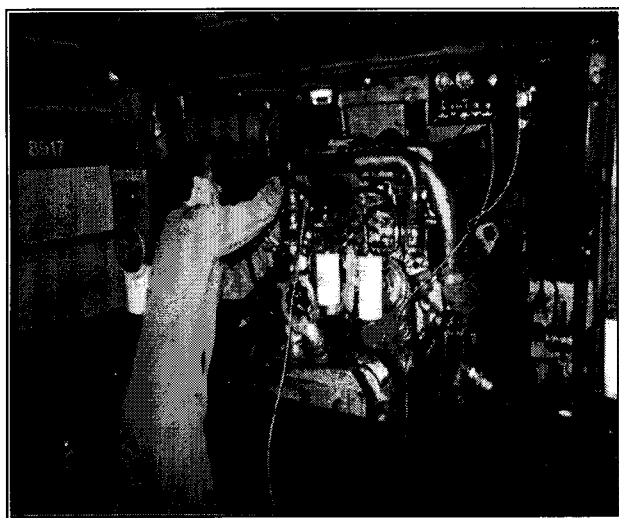


**Solvent cleaning unit at  
MUNI facility**

units and generates large quantities of solvent waste which is currently recycled off site. MUNI operates twelve service and maintenance facilities that use mineral spirits for their cleaning operations. As a result, MUNI generates a total of about 45,000 gallons of spent solvent per year that is managed as hazardous waste. In addition to solvent management and disposal costs, MUNI pays a fee to the California State Board of Equalization based on the amount of hazardous waste generated. In 1998, MUNI paid \$6,176 in hazardous waste generator fees.

MUNI facilities currently contract with Safety-Kleen Corporation (Safety-Kleen) to provide solvent cleaning units, deliver clean solvent, and haul away spent solvent. Three MUNI facilities participated in the project: the Woods, Green, and Potrero facilities. The Woods, Green, and Potrero facilities have 38, 9, and 4 solvent cleaning units, respectively, and generate about 20,670; 6,220; and 1,400 gallons, respectively, of spent solvent solution per year.

Fourteen different aqueous cleaning units were demonstrated during two demonstration periods. Eight units were demonstrated between February and June 1998, and six units were demonstrated between September 1998 and January 1999. Each unit was demonstrated for about 3 months. Aqueous cleaning units and solutions were identified using the South Coast Air Quality Management District vendor list, journal reviews, Internet research, and auto repair and fleet maintenance facility contacts. The 14 aqueous cleaning units were selected based on criteria that included the following:



**MUNI technician servicing a diesel bus engine**

- (1) Cleaning performance (according to references)
- (2) Operation and maintenance (O&M) requirements
- (3) Vendor responsiveness
- (4) Location of the nearest vendor representative
- (5) Servicing support offered
- (6) Availability for demonstration
- (7) Purchase cost

During the demonstration, information on aqueous cleaning unit performance was collected from (1) feedback provided verbally during on-site visits and telephone conversations, (2) data collection logs filled out by facility staff on a daily basis that indicated the types of parts cleaned in each unit and the cleaning results, and (3) final survey forms that were completed by facility staff at the end of the demonstration period to indicate their overall response to each unit. For each unit, information was collected on cleaning performance, unit design, servicing and maintenance requirements, waste generation, and vendor responsiveness.

This final report discusses cleaning operations at the MUNI demonstration facilities (Section 2.0), the types of aqueous cleaning units available and their applications (Section 3.0), the demonstration results for each aqueous cleaning unit and for each MUNI facility (Section 4.0), the waste management practices used to handle aqueous cleaning wastes (Section 5.0), the costs of aqueous cleaning compared to those of solvent cleaning (Section 6.0), and purchasing requirements for the City (Section 7.0). The conclusions drawn from the demonstration results are summarized (Section 8.0).

## 2.0 MUNI DEMONSTRATION FACILITY DESCRIPTIONS

The HWMP selected MUNI to demonstrate aqueous cleaning units because MUNI uses more solvent for cleaning operations than other City departments. Three MUNI facilities participated in the project: the Woods, Green, and Potrero facilities. The solvent cleaning operations at these facilities are described below and are summarized in Table 1. The type of parts typically cleaned at these facilities are listed in Table 2. The addresses and contact information for the MUNI demonstration facilities are included in Appendix A.

Table 1  
MUNI Demonstration Facility Solvent Cleaning Operations

	Woods Facility		Green Facility	Potrero Facility
	Heavy Duty	Preventative Maintenance	Main Work Area	Heavy Duty and Main Work Area
Type and no. of vehicles serviced	Diesel Buses, 331	Diesel Buses, 331	Light Rail Vehicles, 146	Electric Buses, 171
No. of solvent cleaning units	13	3	9	4
Solvent replacement frequency	Weekly	Weekly	Weekly	Every 2 weeks
Labor hours spent cleaning per week	92	23	316	18

**Woods Facility:** The Woods facility is used for maintaining and servicing 331 diesel buses. The Woods facility consists of several different sections that use solvent cleaning units. For the project, aqueous cleaning units were demonstrated on Woods' two main sections: Heavy Duty and Preventative Maintenance. These two sections are described below.

- Heavy Duty:** The Heavy Duty section performs scheduled maintenance and heavy-duty repair of engine, transmission, steering, suspension, and hydraulic systems. The Heavy Duty section uses 13 solvent sink-top units to clean large volumes of parts heavily soiled with grease, dirt, and oil. Brake components and wheel bearings constitute most of the parts cleaned. Wheel bearings are particularly difficult to clean because of the large amount of heavy, viscous bearing grease that must be removed. Of the facilities and sections that participated in the project, the Woods Heavy Duty section generates the most difficult-to-clean parts because of their heavy soil accumulation.



Diesel bus being serviced at the Woods facility

- **Preventative Maintenance:** The Preventative Maintenance section performs light-duty repairs and preventative maintenance on diesel buses. Because this section generates a smaller volume of parts that require cleaning than the Heavy Duty section, it has only three solvent sink-top units. Most parts that require cleaning have a moderate buildup of dirt, grease, and oil, and they are typically cleaned and reinstalled immediately after cleaning.


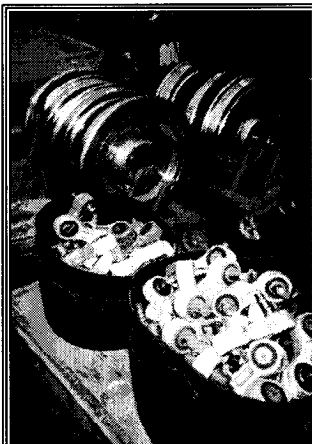

**Green Facility:** The Green facility is used to perform heavy-duty repairs and preventative maintenance on MUNI's fleet of 146 electric light rail vehicles. In addition, components from over 342 electric buses are sent to the Green facility for heavy-duty repair work. Aqueous cleaning units were demonstrated in the main work area, which consists of an electric motor shop, axle shop, hydraulics shop, machine shop, and heavy-duty overhaul shop. The Green facility has nine solvent cleaning units: several are solvent immersion units, and the rest are solvent sink-top units. The Green facility accumulates significant quantities of parts that require cleaning and has as many as eight full-time staff dedicated to cleaning parts. The soil that is most difficult to remove is burnt-on carbon, which is present on about half of all parts cleaned at the facility. Most parts also have a light to moderate accumulation of dirt, grease, and oil.



**MUNI light rail vehicles outside the Green facility**

**Potrero Facility:** The Potrero facility consists of a heavy duty shop and a main work area and is dedicated to performing repair and maintenance work on 171 electric buses. Most of the work performed at the Potrero facility consists of preventative maintenance and light-duty repairs performed in the main work area. Moderate quantities of parts lightly soiled with dirt, grease, and oil require cleaning. The Potrero facility has four solvent sink-top units. Most parts are cleaned and immediately replaced on the electric buses. Of the facilities that participated in the project, the Potrero facility generates the least soiled and least difficult-to-clean parts.

**Table 2**  
**Parts Typically Cleaned at MUNI Demonstration Facilities**

<p><b>Woods Facility – Heavy Duty</b></p>
<p>Brakes, brake valves, brake hubs, fan drives, differentials, drive line parts, radiators, fuel tanks, suspensions, cooling systems, dust covers, anchor brake pins, hub seal retainers, wheel bearings, nuts and bolts, tools, brackets, transmissions, heating systems, fittings, axles, and wheel scrapers</p>
<p><b>Woods Facility – Preventative Maintenance</b></p>
<p>Oil spinners, relay valves, nuts and bolts, heater cores, brake parts, spinner and filter parts, air dryers, brake chamber covers and clamps, air filter housing covers, slack adjusters, shims, tools, wheel bearings, transmission pans, tone rings, carts, metal screens, wheel hubs, oil retainers, drain plugs, plastic heater boxes, valves, injectors, bushings, and steering boxes</p>
<p><b>Green Facility – Main Work Area</b></p>
<p>Check plate bolts, axle bearings, pinion sleeves, speed sensor gears, gear box covers and bolts, coupler, door activators, nuts and bolts, washers, differential parts, bull gears, activators and rams, control arms, lifting gears, compensator screw assemblies, and air lamps</p>
<p><b>Potrero Facility – Heavy Duty and Main Work Area</b></p>
<p>Bearings, retainers, bearing tools, trolley tarret bases, oil seal retainers, tool boxes, hubs, hub wrenches, and anchor pins</p>
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p><b>Wheel bearings at Woods facility</b></p> </div> <div style="text-align: center;">  <p><b>Wheels and control arms at Green facility</b></p> </div> </div>
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p><b>Hydraulic parts at Green facility</b></p> </div> </div>

### 3.0 AQUEOUS CLEANING UNIT TYPES AND APPLICATIONS

This section describes the four types of aqueous cleaning units available - sink-top, immersion, spray cabinet, and ultrasonic - and the specific cleaning applications appropriate for each.

#### 3.1 Sink-Top Unit

Sink-top units are designed for manual part cleaning. They are most appropriate for cleaning lightly soiled parts and for cleaning and replacing parts immediately, such as during preventative maintenance. Aqueous sink-top units are operated in a manner similar to conventional solvent sink-top units. Parts are loaded into the sink-top, and cleaning solution is applied by using a spigot or flow-through brush. Used solution drains back into the storage container below the sink-top, and is recirculated to the spigot or brush by a small pump. The aqueous cleaning solution is typically heated to between 110 and 120 °F. Cleaning occurs primarily through the mechanical action of manually scrubbing the parts with the brush. Parts with more soil buildup may need to be scrubbed longer in aqueous sink-top units than in solvent units. Aqueous sink-top units are available that use microbes to biodegrade oil and grease that accumulate in the solution. Microbes are introduced into the solution through either a filter medium or chemical addition and can significantly extend solution life. Microbial units are typically equipped with aeration or agitation to support the growth of microbes.






Sink Top Unit

#### Sink-Top Unit

##### Applications:

- Parts with light to moderate soil buildup
- Small quantities of parts
- Parts to be immediately replaced on a vehicle
- Preventative maintenance and light-duty cleaning

##### Advantages:

-   
- Little or no waste solution when using microbial unit

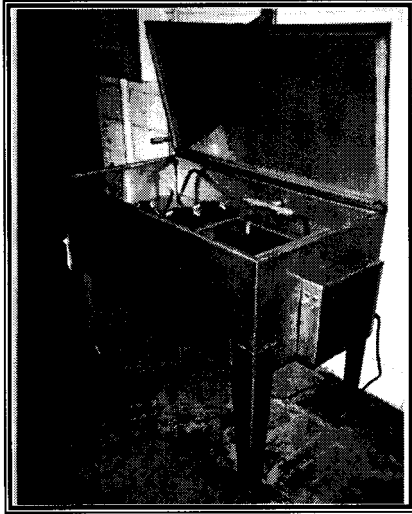
##### Disadvantages:

- May require more scrubbing effort than solvent
- Difficult to clean heavy or “stubborn” soils

Purchase Cost: \$1,000 to \$1,500

#### 3.2 Immersion Unit

An immersion unit consists of a tank filled with aqueous solution and a removable false bottom. Immersion units give workers the option of soaking parts in the aqueous solution below the false bottom, allowing chemical action over time to loosen soils on the parts, or manually scrubbing parts on top of the false bottom much as they would in a sink-top unit. Cleaning solution can be applied to parts using a spigot or flow-through brush. The cleaning solution is typically heated to between 110 and 120 °F. Some immersion units may provide solution agitation by mechanical oscillation of the parts basket or by use of submerged spray nozzles to facilitate removal of dirt from parts.



Immersion Unit

### Immersion Unit

Applications:

- Parts with light to moderate soil buildup
  - Low to moderate volumes of parts
- Light to medium duty repairs

Advantages:

- Soaking can improve cleaning and reduce scrubbing time

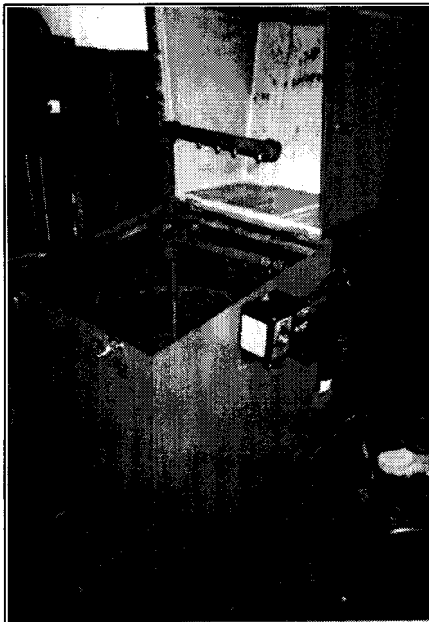
Disadvantages:

- More expensive than sink-top units
- May be difficult to clean heavy or “stubborn” soils

Purchase Cost: \$1,000 to \$3,000

### 3.3 Spray Cabinet

With a spray cabinet, parts are cleaned with heated solution sprayed at high pressure in an enclosed cabinet. Because cleaning with spray cabinets is automated, shops that perform a significant amount of cleaning may realize significant cost savings and reduced cleaning labor by using spray cabinets. The operator places the parts on a turntable or platform inside the unit and then sets the cleaning cycle time (10 to 45 minutes). The cleaning solution is typically heated to a temperature between 130 and 190 oF. Cleaning is enhanced by the physical cleaning action of the sprays. Spray cabinets provide good cleaning performance, even for heavily soiled parts, and they are available in a range of sizes, allowing for large parts to be cleaned in larger models. Small spray cabinets are also available. Some vendors offer spray cabinets with an optional flow-through brush attachment that allows manual cleaning of parts.



Spray Cabinet

### Spray Cabinet

Applications:

- Parts with difficult-to-remove soils
- Moderate to very large quantities of parts
- Moderate-sized to large parts
- Heavy-duty repairs and rebuilding

Advantages:

- Significant reduction in cleaning labor
- High level of cleaning performance
- Large cleaning capacities available

Disadvantages:

- Moderate to high cost

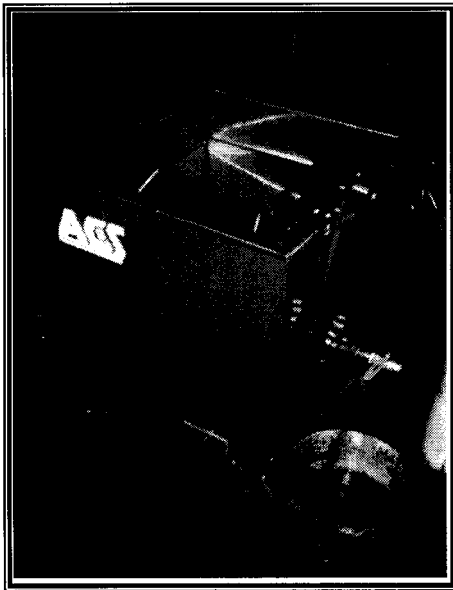
Purchase Cost: \$1,700 to \$12,000



### 3.4 Ultrasonic Unit

An ultrasonic unit consists of a stainless-steel tank filled with solution and transducers located along the side or bottom of the tank. The transducers generate high-frequency sound waves that cause the formation and collapse of low-pressure bubbles in the solution, an effect called “cavitation.” The energy of millions of microscopic bubbles imploding in the cleaning solution produces an intense microscopic scrubbing action at the surface of a part. The effectiveness of an ultrasonic cleaning unit is determined by the frequency of the ultrasonic waves and the power of the transducers. Ultrasonic frequencies between 25 and 40 kilohertz are generally used for automobile and fleet maintenance applications. Lower ultrasonic frequencies are more effective for removing thick grease and oil from heavier parts, while higher frequencies are less aggressive on part surfaces and are therefore applicable for softer metals such as aluminum. Transducer power (measured in watts) determines the overall cleaning ability of the unit. The greater the transducer power, the greater the potential cleaning performance.

Because ultrasonic units provide automated cleaning action, workers can leave parts immersed while they continue to service vehicles. After 5 to 30 minutes, either parts are clean and ready to be used, or they require some light follow-up brushing to remove residual soils. Ultrasonic units are more expensive than other aqueous cleaning units of equivalent size, but they provide high cleaning performance and are particularly effective for cleaning parts with blind holes and hidden surfaces, such as carburetors and transmission parts.



Ultrasonic Unit

Ultrasonic Unit
<b>Applications:</b>
● Parts with blind holes and hidden surfaces
● Transmissions, carburetors, valves
● Parts with heavy, difficult-to-remove soils
● Heavy-duty repairs and rebuilding
<b>Advantages:</b>
● Able to clean transmissions and carburetors
● Very high level of cleaning performance
● Significant reductions in cleaning labor
<b>Disadvantages:</b>
● High cost
Purchase Cost: \$5,000 to \$12,000

#### 4.0 AQUEOUS CLEANING UNIT DEMONSTRATION RESULTS

This section presents the results for the aqueous cleaning units demonstrated at MUNI and the conversion strategy for the demonstration facilities to convert entirely to aqueous cleaning.

##### 4.1 Aqueous Cleaning Unit Evaluation Results

The aqueous cleaning units demonstrated and the solutions used in each unit are summarized in Table 3. Contact information for the vendors that participated in the demonstration is included in Appendix B.

**Table 3**  
**Aqueous Cleaning Units and Solutions Demonstrated**

Manufacturer	Model	Solution	MUNI Demonstration Facilities and Sections
<b><i>Sink-Top Units</i></b>			
ChemFree	SmartWasher	OzzyJuice (microbial)	Woods HD and PM
EcoClean	Bioflow20	PC Solution (microbial)	Woods HD and PM, Green
ForBest	IPC360	SeaWash 700 (microbial)	Green
Graymills	Biomatic	SuperBiotene (microbial)	Woods PM, Green, Potrero
Safety-Kleen	Model 90	AquaWorks (nonmicrobial)	Woods HD and PM
<b><i>Immersion Units</i></b>			
KleenTec	KT 4000	Daraclean 236	Woods HD
Mirachem	PW-40S	Mirachem 500	Green
<b><i>Spray Cabinets</i></b>			
EMC	Jetsink	ALO Jet	Woods HD
Landa	SJ-10	Hotsy Tubmate	Woods HD
Mega-Mate	M30	JetSpray 2000	Green
Safety-Kleen/Intercon	TLW-2	AquaWorks	Woods HD
Safety-Kleen/Intercon	SJW-4	AquaWorks	Potrero
<b><i>Ultrasonic Units</i></b>			
Alpha Cleaning Systems	1818-54	Daraclean 257	Woods HD
GlobalSonics	GreaseMonkey Senior	Brulin 815GD	Woods HD

Notes: HD = Heavy Duty      PM = Preventative Maintenance

Aqueous cleaning units were evaluated using the following criteria: cleaning performance, unit design, servicing requirements, vendor responsiveness, and cost. Cleaning performance was assessed based on an evaluation of three data sources: (1) verbal feedback from supervisors and staff obtained during on-site visits and telephone conversations, (2) data collection logs completed daily by facility staff indicating the types of parts cleaned and the cleaning results, and (3) final survey forms completed at the end of the demonstration by facility staff indicating their overall responses to the units. Based on information collected from the three data sources, an overall evaluation and rating was determined for each unit. Data logs are summarized in Appendix C. The amount and level of detail of data collected on logs varied widely by facility, unit location, and workers. In some cases, insufficient data was collected on

the logs sheets to adequately represent a facility’s overall response to the unit. In these cases, additional verbal comments were solicited to compensate for missing data. Data collected from the final survey forms are summarized in Appendix D. The final survey was conducted at the end of the demonstration and represent MUNI staffs overall response to the unit. An important factor that was considered when determining the overall performance rating was the use of the appropriate type of unit for specific cleaning applications. Some staff that used sink-top units and immersion units for heavy-duty cleaning applications often responded negatively on the final survey forms because of their poor performance on these types of parts, even though those units performed well on light- to medium-duty cleaning applications. In addition, the ultrasonic units demonstrated experienced diminished cleaning performance when the solution became diluted, resulting in some negative responses from staff on final survey forms even though the ultrasonic units provided good overall cleaning performance.

*Sink- Top Units*

Five aqueous sink-top units were demonstrated at MUNI; four used cleaning solutions with microbes, and one, a Safety-Kleen unit, used a nonmicrobial solution. ChemFree, ForBest, and Safety-Kleen offer full servicing and waste management with their units.

Cleaning Performance: Aqueous sink-top units were reviewed positively when used for light-duty cleaning applications. None of the aqueous sink-top units demonstrated were able to clean heavy soil accumulation as efficiently or effectively as solvent sink-top units. Therefore, staff members who attempted to use sink-top units for heavy-duty cleaning often provided negative feedback on the final survey forms due to the sink-top units limited applications for cleaning heavily soiled parts. However, several sink-top units were demonstrated to perform very well for cleaning lightly- to moderately soiled parts. Of the aqueous sink-top units demonstrated, the EcoClean, ForBest, and Graymills microbial sink-top units provided good cleaning performance. Lightly soiled parts were cleaned in about the same amount of scrubbing time and to the same cleanliness level as with solvent. Moderately soiled parts often were soaked before cleaning and often required more scrubbing labor than with solvent. Heavily soiled parts could not be effectively cleaned and certain soils, such as hard deposits and heavy grease, could not be removed in the sink-top units. The Safety-Kleen and ChemFree units were unable to clean even lightly soiled parts and therefore were assessed as exhibiting the least effective cleaning performance.

Sink-Top Units Demonstrated	
Unit	<u>MUNI Facility and Section</u>
ChemFree Smartwasher	Woods (HD and PM)
EcoClean Bioflow20	Woods (HD and PM), Green
ForBest IPC360	Green
Graymills Biomatic	Woods (PM), Green, Potrero
Safety-Kleen Model 90	Woods (HD and PM)
Notes: HD = Heavy Duty PM = Preventative Maintenance	

Despite the presence of rust inhibitors in the solutions of all the units, flash rusting commonly occurred after part washing if parts were left to dry. Rusting was prevented by wiping parts dry immediately after cleaning.

Unit Design: Because staff stand at a sink-top unit to clean parts, unit design is an important factor in staff response. The ChemFree unit had a low working height, requiring staff to bend over when cleaning parts, and a sink-top area with small dimensions, limiting its use to small parts. The Graymills unit experienced several malfunctions: a pump broke down in the unit in the Woods Preventative Maintenance section, fittings and valves broke off in the unit at the Green facility, and filters clogged frequently on the units at all locations. Therefore, the Graymills units were inoperative for much of the

demonstration period at the Woods and Green facilities. Since the completion of the demonstration, ChemFree has produced a new, larger sink-top unit, and Graymills has replaced the plastic components on all of its units with stainless-steel components and has installed a screen to reduce filter clogging. The ForBest and EcoClean unit designs were assessed positively because of their comfortable working heights and large sink-top sizes. The Safety-Kleen unit was the only unit constructed of steel; all other units were primarily constructed of plastic with some steel parts.

Odor from two of the microbial sink-top units, ChemFree and Graymills, generated negative reactions from staff at the Woods and Potrero facilities. Most staff complained that the odors were too strong and caused headaches. However, staff that used the Graymills unit at the Green facility liked the odor of the solution. Since the completion of the demonstration, both ChemFree and Graymills have stated that they have produced a new, odorless solution.

**Servicing Requirements:** Servicing requirements for all the microbial sink-top units with the exception of the Graymills unit were minimal, primarily consisting of chemical additions. Even with moderate to heavy soil loading, the microbial sink-top units effectively minimized oil accumulation in the solution, and none of the microbial sink-top units required solution changeout before the completion of the demonstration. The Safety-Kleen nonmicrobial sink-top solution was replaced on a scheduled basis. The microbial units required regular chemical additions to make up for evaporative and dragout losses. Between 2 to 3 gallons of solution needed to be added to the units every 2 weeks. MUNI staff occasionally allowed the solution level to drop too low in the EcoClean unit, making the unit inoperative.

The Graymills and ChemFree units used a cartridge filter and mesh pad filter, respectively, that required periodic replacement. The Graymills filters frequently became clogged and required replacement with new filters approximately once per month. The ChemFree unit operated for more than a month before requiring filter replacement.

**Vendor Responsiveness:** Vendor responsiveness was fair for all vendors except Graymills, which was unresponsive to MUNI's requests for servicing of broken components and for additional cleaning solution and filters.

<b>Sink-Top Unit Selection Considerations</b>
<ul style="list-style-type: none"> <li>• <i>Unit working height:</i> Make sure the unit is at a comfortable height for your staff.</li> <li>• <i>Unit size:</i> Greater sink-top size allows larger parts to be cleaned.</li> <li>• <i>Pump pressure:</i> Higher pump pressure improves cleaning action.</li> <li>• <i>Materials of construction:</i> Stainless steel is more durable than plastic but is also more expensive.</li> <li>• <i>Solution odor:</i> Staff may not like certain odors.</li> <li>• <i>Filtration:</i> Filters remove solids from the solution and may prolong solution life.</li> <li>• <i>Microbes:</i> Sink-top units are available with microbes that degrade oils and significantly extend solution life.</li> </ul>

Table 4 summarizes the results of the sink-top unit demonstrations.

**Table 4  
Sink-Top Unit Demonstration Results**

	<b>Cleaning Performance</b>	<b>Unit Design</b>	<b>Servicing Requirements</b>	<b>Vendor Responsiveness</b>	<b>Waste Mgmt. Service</b>	<b>Unit Cost</b>	<b>Overall Rating*</b>
ForBest IPC360	Good	Good	Minimal	Fair	Yes	\$1,000	Good
EcoClean Bioflow20	Good	Good	Minimal	Fair	No	\$1,295	Good
Graymills Biomatic	Good	Poor	Significant	Poor	No	\$1,295	Poor
ChemFree Smartwasher	Poor	Poor	Minimal	Fair	Yes	\$1,045	Poor
Safety-Kleen Model 90	Poor	Good	Minimal	Fair	Yes	Leasing only	Poor

\* = The ratings provided rate the overall effectiveness of sink-top units for light-duty cleaning applications only.

***Immersion Units***

Two immersion units were demonstrated at MUNI facilities: KleenTec KT 4000 and Mirachem PW-40s. The two units were similar in their basic design, the most significant difference being that the KleenTec unit was constructed of plastic materials while the Mirachem unit was constructed of stainless-steel. Daraclean 236 supplied by W.R. Grace and Co. was the chemical solution used in the KleenTec unit, and Mirachem 500 solution was used in the Mirachem unit. Both KleenTec and Mirachem offer a full line of aqueous cleaning units, including sink-top units and spray cabinets.

<b>Immersion Units Demonstrated</b>	
<b>Unit</b>	<b>MUNI Facility</b>
KleenTec KT-4000	Woods (Heavy Duty)
Mirachem PW4OS	Green

**Cleaning Performance:** The Mirachem unit received frequent use at the Green facility and provided good cleaning performance when used for light- to medium-duty cleaning applications. The Green facility supervisor indicated that the unit could clean all lightly- to moderately soiled parts as well as solvent without any significant increase in cleaning labor. However, the Mirachem unit was much less effective for heavy-duty cleaning operations and difficult to clean parts with burnt-on carbon and synthetic greases. Therefore, some staff who attempted to use the unit for heavy-duty cleaning applications provided negative feedback on the final survey forms. The KleenTec unit received only light use at the Woods facility Heavy Duty section and received fair to poor reviews for its cleaning performance on moderate- to heavily soiled parts. Too few lightly soiled parts were cleaned in the unit to accurately determine its effectiveness in light duty cleaning applications.

Despite the presence of rust inhibitors in both solutions, rusting commonly occurred after part washing if parts were left to dry. Rusting was prevented by wiping parts dry immediately after cleaning.

**Unit Design:** The Mirachem unit received positive responses from Green facility staff because of its durable, stainless-steel design. The KleenTec unit was constructed from heavy-duty plastic. Both Mirachem and KleenTec offer automatic oil skimmers and filtration systems as options for their units. The Mirachem unit demonstrated did not have a filtration system or oil skimmer. Therefore, Green facility staff manually skimmed solution from the unit, a task they indicated was cumbersome. The KleenTec unit demonstrated included a belt oil skimmer.

Immersion Unit Selection Considerations
. <i>Unit working height:</i> Make sure the unit is at a comfortable height for your staff.
. <i>Unit size:</i> Greater size allows larger parts to be cleaned.
. <i>Materials of construction:</i> Stainless steel is more durable than plastic but is also more expensive.
. <i>Solution odor:</i> Staff may not like certain odors.
. <i>Filtration:</i> Filters remove solids from the solution and may prolong solution life.
. <i>Oil skimming:</i> Oil skimmers are available for some units and may prolong solution life.

One of the staff at the Green facility indicated that the odor of the Mirachem 500 solution was too strong. However, no other staff at the facility indicated any sensitivity to the solution odor.

**Servicing Requirements:** Servicing requirements for the Mirachem unit included manually skimming oil from the solution several times per week and replacing the solution after 2 months of use. Servicing requirements for the KleenTec unit were minimal, primarily because of its minimal use. The belt on the oil skimmer became stretched out and was replaced 2 months into the demonstration. Both units required regular water additions and periodic chemical additions.

Vendor Responsiveness: Vendors were rated fair for their overall responsiveness.

Table 5 summarizes the results of the immersion unit demonstrations.

Table 5  
Immersion Unit Demonstration Results

	Cleaning Performance*	Unit Design	Servicing Requirements	Vendor Responsiveness	Waste Mgmt. Service	Unit Cost	Overall Rating*
Mirachem PW-40s	Good	Good	Moderate	Fair	No	\$2,950	Good
KleenTec KT4000	Not evaluated	Good	Minimal	Fair	No	\$1,867	Not evaluated

\* = The ratings provided rate the overall effectiveness of immersion units for light- to medium-duty cleaning applications only. The KleenTec unit was used on too few light to moderately soiled parts to accurately determine its effectiveness for these applications.

### Spray Cabinet

Five spray cabinets from four different vendors were demonstrated at the MUNI facilities. The five spray cabinets varied significantly in size and cost. The EMC Jetsink was the smallest, lowest-cost unit, while the Safety-Kleen SJW-4 was the largest, most expensive unit. All the vendors that participated in the demonstration provide a full line of aqueous cleaning spray cabinets that vary in size, cost, and features. Safety-Kleen and EMC offer full servicing and waste management with their units.

**Cleaning Performance:** The Landa SJ-10, EMC Jetsink, and Safety-Kleen TLW-2 and SJW-4 units received positive assessments of their cleaning performance. The Landa SJ-10 unit was rated highest among all the units demonstrated based on its ability to efficiently clean very heavily soiled parts in the Woods facility Heavy Duty section. The Mega-Mate unit was unable to clean almost all the parts at

Spray Cabinets Demonstrated	
Unit	MUNI Facility and Section
EMC Jetsink	Woods (Heavy Duty)
Landa SJ-10	Woods (Heavy Duty)
Mega-Mate M30	Green
Safety-Kleen TLW-2	Woods (Heavy Duty)
Safety-Kleen SJW4	Potrero

the Green facility and therefore received poor assessments of its cleaning performance. The Mega-Mate unit's inability to clean parts may have been due to inadequate solution temperature (preset at 150 °F), inadequate spray pressures, and inadequate solution strength.

Parts cleaned in a spray cabinet do not rust if they are removed immediately after the cleaning cycle because the solution evaporates from the hot part surfaces, leaving clean, dry parts. Parts left in a spray cabinet after the cleaning cycle has finished often rust because of high humidity in the cabinet.

**Unit Design:** Each spray cabinet featured a slightly different design. In the Safety-Kleen and Mega-Mate units, the spray nozzles were fixed, and a circular basket in which parts were loaded rotated to fully expose part surfaces to the high-pressure spray. In the Landa unit, the part basket remained stationary while a rectangular spray bar rotated around the basket. The EMC Jetsink unit featured spray nozzles aimed at multiple angles and had no moving parts. The Landa, Safety-Kleen TLW-2, and EMC units were top-loading units; that is, each unit is opened, and parts are loaded into the top. The Safety-Kleen SJW-4 and Mega-Mate M30 units were front-loading units.

All units featured adjustable temperature settings and timers to set the cleaning cycle duration. MUNI particularly liked two features of the Landa unit designed to simplify its operation: an automatic water fill feature and a timer that reduced the temperature of the solution overnight. The Mega-Mate unit featured a sink-top incorporated into the side of the spray cabinet and a patented rag filtration system that allows shop rags to be used as filter media. Green facility staff thought the rag filtration system simplified waste filter management. However, Green facility staff did not use the sink-top of the Mega-Mate unit because of its inadequate cleaning performance. Except for the EMC Jetsink unit, the spray cabinets had cleaning capacities equivalent to those of two or three solvent sink-top units. The EMC Jetsink is a compact unit that was too small for Woods Heavy Duty shop large cleaning operations and therefore received some negative evaluations on the final survey forms due to limits in the size and number of parts it could hold. However, the EMC Jetsink is well suited for facilities with smaller cleaning operations. The spray cabinets required 220-volt power except for the EMC Jetsink, which operated on standard 110-volt electrical service. The Mega-Mate unit had electrical problems that decreased the pump pressure and required servicing.

<b>Spray Cabinet Unit Selection Considerations</b>
<ul style="list-style-type: none"> <li>● <i>Pump power, spray pressure, flow rate, and number of nozzles:</i> Higher spray pressures and greater spray coverage result in better cleaning performance.</li> <li>● <i>Electrical requirements:</i> A 220-volt outlet is often required.</li> <li>● <i>Temperature adjuster:</i> This helps to optimize cleaning performance.</li> <li>● <i>Oil skimming:</i> Oil skimmers are available for some units and may prolong solution life.</li> </ul>

**Servicing Requirements:** Maintenance requirements for the units included water additions, periodic chemical additions, and solution changeout. Because of the high evaporation rate, water additions were frequently required for all units except the Landa unit, which was equipped with a water level indicator and automated water fill valve. Safety-Kleen representatives added water and chemicals to their units, and the Safety-Kleen and EMC representatives managed and disposed of waste solution as part of the servicing they provide.

**Vendor Responsiveness:** All the vendors were rated fair for their overall responsiveness.

Table 6 summarizes the results of the spray cabinet demonstrations.

**Table 6  
Spray Cabinet Demonstration Results**

	<b>Cleaning Performance</b>	<b>Unit Design</b>	<b>Servicing Requirements</b>	<b>Vendor Responsiveness</b>	<b>Waste Mgmt. Service</b>	<b>Unit cost</b>	<b>Overall Rating</b>
Landa SJ-10	Excellent	Excellent	Minimal	Fair	No	\$2,995	Excellent
Safety-Kleen TLW-2	Good	Good	Minimal	Fair	Yes	\$3,850	Good
Safety-Kleen SJW-4	Good	Good	Minimal	Fair	Yes	\$11,430	Good
EMC Jetsink	Good	Good	Minimal	Fair	Yes	\$1,695	Good
Mega-Mate M30	Poor	Good	Moderate	Fair	No	\$8,295	Poor

***Ultrasonic Units***

Two ultrasonic units were demonstrated at the Woods facility Heavy Duty section: GlobalSonics GreaseMonkey Senior and Alpha Cleaning Systems 1818-54. The GlobalSonics is a large unit, while the Alpha Cleaning Systems is a small, lower-cost unit. Both GlobalSonics and Alpha Cleaning Systems have a full line of ultrasonic units that vary in size, cost, and features.

<b>Ultrasonic Units Demonstrated</b>	
<b>Unit</b>	<b>MUNI Facility</b>
Alpha Cleaning Systems 1818-54	Woods (Heavy Duty)
GlobalSonics GreaseMonkey Senior	Woods (Heavy Duty)

**Cleaning Performance:** Both units were very positively received for their ability to quickly and efficiently clean parts. The GlobalSonics unit received very heavy use in the main work area of the Heavy Duty section, where it was loaded with large volumes of parts heavily soiled with grease, oil, and dirt. The Alpha Cleaning Systems unit received moderate use in the unit repair area of the Heavy Duty section, where it was used primarily to remove carbonized soils and burnt-on carbon from aluminum parts. These aluminum parts could not be cleaned in a spray cabinet because they were “bounced” around and damaged due to their lightness. Both units were positively assessed for their ability to clean interior and hidden surfaces on parts. However, both units experienced significantly diminished cleaning performance when their solutions became too diluted, resulting in some negative responses from staff on data collection logs and final survey forms. The solutions became diluted as a result of staff adding water without adding additional chemical concentrate. When the solution concentrations were corrected, MUNI staff responded positively to the units’ cleaning performance.

An additional benefit realized with the ultrasonic units was that almost no parts rusted. Because parts immersed in the solution were heated, the solution evaporated from the parts immediately after their removal from the units. Therefore, the additional step of drying parts was eliminated with the ultrasonic units.

**Unit Design:** The GlobalSonics unit received a positive response for its large capacity, whereas the Alpha Cleaning Systems unit was too small to accommodate some parts. The GlobalSonics unit had a digital temperature control and an oil skimming system that drained oil from the top of the solution into a secondary tank. The Alpha Cleaning Systems unit had temperature and ultrasonic power control settings.



**Ultrasonics Unit  
Selection Considerations**

- . *Ultrasonics power:* The more watts the transducer generates, the greater the cleaning power.
- . *Electrical requirements:* A 220-volt outlet is often required for larger units.
- . *Unit capacity:* Select the size of unit that will provide you adequate cleaning capacity.
- . *Filtration:* Filtration is a feature available on some units that may prolong solution life.
- . *Oil skimming:* Oil skimmers remove oils from the solution and may prolong solution life.

**Servicing Requirements:** Both the GlobalSonics and Alpha Cleaning Systems units required frequent water additions to make up for evaporative losses. The GlobalSonics unit also required 1 to 2 gallons of cleaning chemical additions per week because of its heavy use. Oil skimmers were available for both units and were regularly used to remove oil from the cleaning solutions. The GlobalSonics unit had a skimmer system with water sprays to push oil on the surface of the solution over a weir and into a storage container, and the Alpha Cleaning Systems unit had a belt skimmer. Both units experienced at least one maintenance problem during the demonstration: the GlobalSonics unit had a clogged pump, and the

transducer on the Alpha Cleaning Systems unit broke down.

**Vendor Responsiveness:** Both vendors promptly serviced their units and returned them to operation after maintenance problems. Therefore, the vendors were rated fair in their overall responsiveness.

Table 7 summarizes the results of the ultrasonic unit demonstrations.

**Table 7  
Ultrasonic Unit Demonstration Results**

	<b>Cleaning Performance</b>	<b>Unit Design</b>	<b>Servicing Requirements</b>	<b>Vendor Responsiveness</b>	<b>Waste Mgmt. Service</b>	<b>Unit cost</b>	<b>Overall Rating *</b>
GlobalSonics GreaseMonkey Senior	Excellent	Good	Moderate	Fair	No	\$10,995	Excellent
Alpha Cleaning Systems 1818-54	Good	Fair	Moderate	Fair	No	\$5,300	Good

\* = The ratings provided do not include the results when cleaning performance diminished due to solution dilution.

## 4.2 Muni Facility Conversion Strategy

This section describes the overall ability of aqueous cleaning units to meet part cleaning requirements at the Woods, Green, and Potrero facilities and the conversion strategy for each facility to convert entirely to aqueous cleaning.

### *Woods Facility Heavy Duty Section*

The Woods facility Heavy Duty section demonstrated three sink-top, one immersion, three spray cabinet, and two ultrasonic units. Section staff had a strong preference for spray cabinets and ultrasonic units because they were able to clean almost all parts, including heavily soiled parts, with significantly less cleaning labor than solvent units required. The Heavy Duty section supervisor indicated that spray cabinets reduced cleaning labor up to 90 percent from that required with solvent units and that there was a noticeable increase in staff productivity as a result of using the spray cabinets and ultrasonic units. One spray cabinet (Landa SJ-10) received an extremely positive response because of its (1) exceptional cleaning performance, (2) automatic water fill feature to make up for evaporative losses, and (3) timer that automatically reduces solution temperature overnight and returns it to the

optimal level in the morning. The ultrasonic units impressed staff with their ability to clean interior surfaces and hidden areas on parts and remove particularly stubborn soils such as burnt-on carbon that could not be effectively removed by solvent. In addition, aluminum parts that could not be cleaned in the spray cabinets because they were “bounced” around and damaged were safely cleaned in the ultrasonic units. Minimal part rusting was experienced using the spray cabinets and ultrasonic units. The sink-top and immersion units were used for quick, light-duty cleaning of small parts. Three sink-top units, Graymills, ChemFree, and Safety-Kleen, were disliked by facility staff because of the units’ strong solution odor, inadequate height and sink-top capacity, and poor cleaning performance, respectively.

Based on the demonstration results, the Heavy Duty section can convert entirely to aqueous cleaning while realizing equal or better cleaning performance and a significant decrease in cleaning labor. The Heavy Duty section’s cleaning needs would be best met by installing several spray cabinets to handle most part cleaning, an ultrasonic unit to handle special cleaning applications, and a few microbial sink-top and immersion units for light-duty cleaning. Because of the large cleaning capacity of the spray cabinet and ultrasonic units, the Heavy Duty section would be able to replace two solvent cleaning units with each spray cabinet or ultrasonic unit. By implementing four spray cabinets and one ultrasonic unit, the Heavy Duty section could reduce the total number of cleaning units from 13 to eight.

<b>Woods Facility Heavy Duty Section</b>	
<b>Requirements for Conversion to Aqueous Cleaning</b>	
<b>From</b>	<b>To</b>
<u>{Solvent Units}</u>	<u>(Aqueous Units)</u>
8	→ 4 spray cabinets
2	→ 1 ultrasonic
2	→ 2 microbial sink-top
1	→ 1 immersion
<u>Total: 13 solvent</u>	<u>8 aqueous</u>

***Woods Facility Preventative Maintenance Section***

The Woods facility Preventative Maintenance section demonstrated four sink-top units. In general, section staff responded positively to their decreased exposure to strong solvent fumes, the elimination of chapped hands, and the pleasant feeling of the warm aqueous solution. Of the four sink-top units demonstrated, only one unit (EcoClean) met the overall performance needs of facility staff. The unit was effective for light soil buildup, but some soils, such as burnt-on carbon and heavy grease, were difficult to remove and required more scrubbing time than with solvent cleaning. Although the cleaning solutions in all the units contained rust inhibitors, parts would often flash rust after cleaning. Therefore, staff would dry parts immediately after cleaning to prevent rusting, a step that required minimal additional effort that staff indicated they did not mind performing.

Although the Preventative Maintenance section could convert entirely to aqueous microbial sink-top units and meet most of its cleaning needs, the section would achieve greater cleaning efficiency by using a spray cabinet to clean more heavily soiled parts that do not require immediate replacement on the buses. Spray cabinets successfully demonstrated in the Woods facility Heavy Duty section showed high potential for meeting the Preventative Maintenance section’s cleaning requirements. In addition, the Preventative Maintenance section could install two sink-top units to perform quick cleaning jobs on lightly soiled parts.

<b>Woods Facility Preventative Maintenance Section</b>	
<b>Requirements for Conversion to Aqueous Cleaning</b>	
<b>From</b>	<b>To</b>
<u>{Solvent Units}</u>	<u>(Aqueous Units)</u>
1	> 1 spray cabinet
2	> 2 microbial sink-top
<u>Total: 3 solvent</u>	<u>3 aqueous</u>

**Green Facility**

The Green facility demonstrated three microbial sink-top units, one immersion unit, and one spray cabinet. Two of the sink-top units (EcoClean and ForBest) and the immersion unit (Mirachem) met the facility’s cleaning needs. These units were able to clean most parts at the facility that were previously cleaned in solvent without additional labor, including parts with burnt-on soils and carbonized deposits. The immersion unit was favored over the sink-top units because of its large soaking capacity. Facility staff would often soak difficult-to-clean parts before scrubbing them clean. Although the cleaning solutions contained rust inhibitors, parts would often flash rust after cleaning. Green staff successfully prevented rusting by wiping parts dry with rags after cleaning. One microbial sink-top unit (Graymills) and the spray cabinet (Mega-Mate) did not meet the Green facility’s cleaning needs because of poor cleaning results and an inadequate spray system design, respectively.

Based on the demonstration, the Green facility can convert entirely to aqueous cleaning while maintaining cleaning quality equivalent to that provided by solvent cleaning. If the Green facility were to convert entirely to microbial sink-top and immersion units, it would replace all nine solvent units with nine sink-top and immersion units. However, because of the large volume of parts that require cleaning at the facility, it could significantly reduce cleaning labor by installing automated cleaning units such as spray cabinet or ultrasonic units. The ultrasonic units demonstrated at the Woods facility Heavy Duty section were successful in removing soils, including carbonized deposits, and therefore have high potential for successful application at the Green facility. Spray cabinets may also be effective for this application and are an alternative to ultrasonic units.

<b>Green Facility</b>		
<b>Requirements for Conversion to Aqueous Cleaning</b>		
<b>From</b>		<b>To</b>
<u>[Solvent Units]</u>		<u>(Aqueous Units)</u>
4	→	2 ultrasonic (or 2 spray cabinets)
4	→	4 immersion
1	→	1 microbial sink-top
Total: 9 solvent		7 aqueous

**Potrero Facility**

The Potrero facility demonstrated a microbial sink-top unit (Graymills) and a large spray cabinet (Safety-Kleen SJW4). Both units met the facility’s cleaning needs, and facility staff responded positively to both. The sink-top unit was used to clean most of the small and lightly soiled parts at the facility and was used primarily for quick cleaning applications, such as when a part was removed from a bus, cleaned, and replaced on the bus. Facility staff would soak more difficult-to-clean parts in a small can placed in the sink of the sink-top unit before scrubbing them clean. Almost all facility staff indicated that the sink-top unit provided equal or better cleaning performance compared to the solvent cleaning units. The spray cabinet was generally used to clean larger parts or parts that were not needed right away. Most facility staff indicated that the spray cabinet provided significantly better cleaning performance than the solvent cleaning units. In addition, Potrero realized reductions in cleaning labor by using the spray cabinet.

Based on the demonstration, the Potrero facility can convert entirely to aqueous cleaning while maintaining equal or better part cleaning quality and achieving greater cleaning efficiency. The facility will achieve the greatest cleaning versatility by implementing both a spray cabinet, which provides automated cleaning and a large cleaning capacity, and microbial sink-top units, which are convenient for quick cleaning jobs. Because of the large cleaning capacity of the spray cabinet, Potrero would be able to replace at least two solvent cleaning units with one spray cabinet, thereby reducing its total number of cleaning units from four to three.

<b>Potrero Facility</b>		
<b>Requirements for Conversion to Aqueous Cleaning</b>		
<b>From</b>		<b>To</b>
<u>(Solvent Units)</u>		<u>(Aqueous Units)</u>
2	→	2 microbial sink-top
<u>2</u>	→	<u>1 spray cabinet</u>
Total: 4 solvent		3 aqueous

## 5.0 WASTE GENERATION AND DISPOSAL

This section discusses the wastes generated by the aqueous cleaning units and the vendors that offer full unit servicing including waste disposal.

### 5.1 Waste Generation Rates

The wastes generated during the demonstration of the aqueous cleaning units included spent solution, spent filters, and skimmed oil. This section discusses the generation rates and disposal methods for each of these waste streams. Waste generation information for each aqueous cleaning unit demonstrated is summarized in Table 8.

**Table 8  
Waste Generation Summary**

	Unit Use	Solution Volume (gallons)	Solution Life	Filter	Filter Life	Skimmed Oil
<b><i>Sink-Top Units</i></b>						
Ecoclean Bioflow20	Heavy	20	> 3 months	Yes	1 month	No
ForBest IPC360	Heavy	30	> 3 months	No	---	No
Graymills Biomatic	Light	30	> 3 months	Yes	3 weeks	No
Safety-Kleen Model 90 (nonmicrobial)	Light	25	2 weeks <sup>a</sup>	No	---	No
ChemFree Smartwasher	Light	25	> 3 months	Yes	1 month	No
<b><i>Immersion units</i></b>						
Mirachem PW-40s	Heavy	40	2 months	No	---	Yes
KleenTec KT4000	Light	30	> 3 months	No	---	Yes
<b><i>Spray Cabinets Units</i></b>						
Landa Model SJ-10	Heavy	64	3 months	No	---	No
EMC Jetsink	Heavy	25	3 weeks <sup>a</sup>	No	---	No
Safety-Kleen TLW-2	Heavy	32	4 weeks <sup>a</sup>	No	---	Yes
Safety-Kleen SJW4	Moderate	243	4 weeks <sup>a</sup>	No	---	Yes
Mega-Mate M30 (with sink-top)	Light	60	2 months	No	---	Yes
<b><i>Ultrasonic Units</i></b>						
GlobalSonics GreaseMonkey Senior	Heavy	45	1 month	No	---	Yes
Alpha Cleaning Systems 1818-54	Moderate	25	1 month	No	---	Yes

Note:

a Solution changed on a scheduled basis

### ***Spent Solution***

Waste management considerations for spent solutions include vendor waste management services, frequency of changeout, and spent solution characterization. Ten of the 14 aqueous cleaning units demonstrated had solution changed out on an as-needed basis, as determined by cleaning quality. The other four units had solution changed out on a scheduled basis. Regarding the 10 units where solution was changed out as needed, the solutions lasted between 4 to 12 times longer than solvent, which is replaced

weekly to biweekly at most MUNI facilities. Five units (four of which were microbial sink-top units) lasted the full 3-month demonstration period without solution changeout. The other five units required solution changeout after 1 to 3 months of use. MUNI staff changed out the solution when chemical cleaning action diminished, a significant amount of oil or sludge accumulated, or at the suggestion of the vendor. The microbial sink-top solutions had the longest solution life, and MUNI staff indicated that based on the solution quality, they could have been used for significantly longer than the 3-month demonstration period before requiring changeout. Vendors of microbial sink-top units claim that the solution can last indefinitely without requiring solution.

Of the 14 units tested, four units had waste management services provided by the vendor. The local vendors for the ChemFree, ForBest, EMC, and Safety-Kleen units are licensed waste disposal companies that provide unit servicing and waste management services for their units; therefore, spent solutions from these units were hauled away for off-site disposal. The local vendor for the ChemFree unit is Olympian Oil Company, for the ForBest unit is Evergreen, for the EMC unit is Safeway Chemical Company, and for the Safety-Kleen units is Safety-Kleen. The GlobalSonics vendor has only recently established waste management services for its units and therefore did not provide services during the demonstration.

Spent solutions that were not disposed of by the aqueous cleaning unit vendors are being disposed of off site as hazardous wastes by a City waste disposal contractor under a city-wide waste disposal contract managed by the Department of Public Health. The Department of Public Health analyzed spent solutions from three different units: the Alpha Cleaning Systems, Landa, and Mirachem. These units were sampled because their results are most likely to be representative of the ultrasonic, spray cabinet, and immersion units demonstrated, respectively. Spent solutions from the Alpha Cleaning Systems and Landa units exhibited Resource Conservation and Recovery Act (RCRA) hazardous wastes characteristics because their concentrations of cadmium, chromium, and silver in the toxicity characteristic leaching procedure (TCLP) exceeded federal limits for toxicity (see Table 9). In addition, spent solutions from the Alpha Cleaning Systems and Mirachem units contained toluene and xylene, solvents listed on the federal F-list, making the spent solutions listed RCRA hazardous wastes. Complete laboratory analytical results for the spent solutions from the Alpha Cleaning Systems, Landa, and Mirachem units are included in Appendix E. Sludge that accumulated in the units was disposed of with the spent aqueous solutions. The Department of Public Health is currently arranging for the City waste disposal contractor to dispose of the wastes; therefore, the actual cost for their disposal is not known. The cost for disposal of spent solutions that are hazardous wastes is expected to be between \$2 to \$4 per gallon. Spent solutions from all the aqueous units demonstrated will be managed as hazardous waste.

**Table 9**  
**Summary of Laboratory Analytical Results for Selected Spent Aqueous Solutions**

<b>Analyte</b>	<b>Regulatory Limit</b>	<b>Alpha Cleaning Systems 1818-54</b>	<b>Landa Model SJ-10</b>	<b>Mirachem PW-40S</b>
Cadmium (TCLP, mg/L)	1.0	1.6	7.7	<0.004
Chromium (TCLP, mg/L)	5.0	6	24.8	0.23
Silver (TCLP, mg/L)	5.0	45	93.7	<0.004
Toluene (ppb)	not applicable	281	<0.5	18.6
Xylene - total (ppb)	not applicable	3.2	not detected	1,257

Notes:

mg/L Milligrams per liter  
ppb Parts per billion

### *Spent Filters*

Three sink-top units featured filters that required changeout and disposal. The ChemFree and EcoClean units used wire mesh filters that were disposed of by the vendors. Since the completion of the demonstration, however, the EcoClean vendor has discontinued this service. The Graymills unit used a fabric cartridge filter that MUNI staff managed with spent engine oil filters, which were picked up by a recycling company. Department of Toxic Substances Control (DTSC) regulations do not allow this practice because used engine oil filters are recycled under a special exemption in State of California regulations. For aqueous cleaning units that are permanently installed in City departments, spent filters should be analyzed to determine whether they are hazardous waste. Filters that are hazardous waste should be disposed of by a licensed waste disposal company, and nonhazardous filters can be disposed of in trash cans.

The Mega-Mate spray cabinet has a patented filtration system that uses shop rags as filter media. MUNI sent the spent rags to an industrial laundry company for cleaning and reuse, a practice allowed by DTSC regulations provided the rags do not contain free liquid. The ForBest microbial sink-top, Landa spray cabinet, and GlobalSonics ultrasonic units feature reusable filters that were cleaned and replaced in the units.

### *Skimmed Oil*

Seven of the aqueous cleaning units used in the demonstration had oil skimmers to remove floating oil from the cleaning solution. MUNI combined skimmed oil with used motor oil, which was picked up by an oil recycling company. This practice is allowed by DTSC regulations. The volume of skimmed oil accumulated was typically less than 1 cup per week, and therefore the cost added to the used motor oil recycling cost was negligible. Microbial sink-top units accumulated little or no oil in their cleaning solutions because microbes biodegraded the oil.

## **5.2 Vendors Offering Waste Disposal Services**

The following vendors of units demonstrated offer full “turn-key” servicing including waste management for their units:

- ChemFree
- ForBest
- EMC
- GlobalSonics
- Safety-Kleen

In addition, Mirachem is currently establishing waste management service for their units and expects to have it available to facilities soon. The GlobalSonics vendor has only recently established waste management service for its units and therefore did not provide servicing during the demonstration. All the vendors listed above can dispose of spent aqueous solution and provide new aqueous solution in a similar manner as Safety-Kleen performed with solvent servicing. In addition, these vendors can perform chemical and water additions as needed during their visits. Most facilities, however, will need to add chemicals and water by themselves between servicing visits.

## 6.0 ECONOMIC ANALYSIS

This section discusses costs involved in converting from solvent to aqueous cleaning. The costs for implementing each type of aqueous cleaning unit-sink-top, immersion, spray cabinet, and ultrasonic-are compared to the costs of solvent cleaning. In addition, the costs for each MUNI demonstration facility to convert entirely to aqueous cleaning and the associated potential savings are presented.

### 6.1 Cost Comparison by Aqueous Cleaning Unit Type

This section compares the cost of using existing solvent units to the cost of replacing them with aqueous cleaning units. Costs for each aqueous cleaning unit is compared to solvent sink-top units because the sink-top is the most common type of solvent unit used. Each cost comparison scenario is based on actual costs and demonstration results at MUNI facilities, but is considered representative of potential costs and savings at other City department facilities. The purchase and installation costs of aqueous cleaning units are annualized to facilitate their comparison to solvent unit leasing and management costs, and \$50 per hour is used for labor costs.

#### *Microbial Sink-Top Unit for Light-Duty Cleaning Applications*

This section compares the costs of using a solvent sink-top unit and a microbial sink-top unit in a light-duty cleaning operation. Costs were calculated based on actual costs at the Potrero facility, but these values may also reflect costs for other City department facilities that perform light-duty cleaning. The Potrero facility can realize a cost savings of \$852 per year for every solvent unit replaced by a microbial sink-top unit.

The following assumptions are made under this cost scenario:

- The monthly cost for solvent unit leasing and solvent management services, including solvent disposal, is \$159 per unit.
- An average of 4.6 hours of labor per week is spent cleaning parts in each solvent unit.
- Electricity cost to operate the pump in the solvent unit is \$0.50 per cleaning labor hour.
- The capital cost for the microbial sink-top unit is \$1,200. The annualized cost over a 7-year period at a discount rate of 10 percent is \$266.
- A total of 73 gallons of premixed microbial cleaning solution is used each year (25 gallons for new solution makeup and 4 gallons per month) at \$5 per gallon.
- Filters require changeout once every 2 months. The cost for each filter is \$0. The filter disposal cost is not quantified because of lack of disposal cost data.
- Electricity cost to operate the pump in the microbial unit is \$0.50 per cleaning labor hour. Electricity cost to operate the solution heater is \$240 per year.

<b>Microbial Sink-Top Unit Cost Comparison</b>	
<b><u>Solvent Unit</u></b>	<b><u>Annual Cost</u></b>
Leasing, waste management	\$1,908
Electricity (estimated)	\$120
Cleaning labor (239 hours/year)	<u>\$11,950</u>
<b>Total</b>	<b>\$13,978</b>
<b><u>Microbial Sink-Top Unit</u></b>	
Purchase price (annualized)	\$266
Chemicals	\$365
Filters	\$60
Electricity (estimated)	\$360
Solution disposal	\$100
Disposal labor	\$25
Cleaning labor (239 hours/year)	<u>\$11,950</u>
<b>Total</b>	<b>\$13,126</b>
<b>Annual Savings = \$852</b>	



- The microbial sink-top unit will require solution changeout and disposal once a year. A total of 25 gallons of solution will require disposal as hazardous waste at \$4 per gallon. Half an hour of labor will be required to dispose of the solution.
- Cleaning labor remains unchanged with the microbial sink-top unit.

***Immersion Unit for Medium-Duty Cleaning Applications***

This section compares the costs of using a solvent sink-top unit and an immersion unit. Costs were calculated based on actual costs at the Green facility. These values may also reflect costs for other City department facilities that clean moderately soiled parts. The Green facility will realize a cost savings of \$425 per year by replacing a solvent unit with a stainless-steel immersion unit.

<b>Immersion Unit Cost Comparison</b>	
<b>Solvent Unit</b>	<b>Annual Cost</b>
Leasing, waste management	\$3,360
Electricity (estimated)	\$912
Cleaning labor (1,825 hours/year)	<u>\$91,250</u>
<b>Total</b>	<b>\$95,522</b>
<b>Immersion Unit</b>	
Purchase price (annualized)	\$665
Chemicals	\$1,040
Electricity	\$1,152
Solution disposal	\$840
Disposal labor	\$150
Cleaning labor (1,825 hours/year)	<u>\$91,250</u>
<b>Total</b>	<b>\$95,097</b>
<b>Annual Savings = \$425</b>	

The following assumptions are made under this cost scenario:

- The monthly cost for solvent unit leasing and solvent management services is \$280 per unit. This cost is higher than other facilities because Green has various types of solvent units.
  - An average of 35.1 hours of labor per week is spent cleaning parts in each solvent unit.
  - Electricity cost to operate the pump in the solvent unit is \$0.50 per cleaning labor hour.
  - The capital cost for a stainless-steel immersion unit is \$3,000. The annualized cost over a 7-year period at a discount rate of 10 percent is \$665.
  - A total of 104 gallons of concentrated cleaning solution is used each year (90 gallons for new solution makeup and 14 gallons for additions) at \$10 per gallon. New solution makeups are performed six times per year using 15 gallons concentrated solution and 20 gallons water.
- Electricity cost to operate the pump in the immersion unit is \$0.50 per cleaning labor hour. Electricity cost to operate the solution heater is \$240 per year.
  - The immersion unit requires solution changeout and disposal six times per year. For each changeout, 35 gallons of solution will require disposal as hazardous waste at \$4 per gallon and half an hour of labor will be required.
  - Cleaning labor remains unchanged with the immersion unit.

***Spray Cabinet for Heavy-Duty Cleaning Applications***

This section compares the costs of solvent cleaning and aqueous cleaning using a spray cabinet. Costs were calculated based on actual costs at the Woods facility Heavy Duty section, but the volume may also reflect costs at other City department facilities with heavy-duty cleaning operations. Because the spray cabinets demonstrated in the Heavy Duty section had a cleaning capacity equivalent to that of two solvent sink-top units, this section compares the costs for two solvent sink-top units to the costs for one spray cabinet. The Heavy Duty section will realize a cost savings of \$21,977 per year by replacing two solvent sink-top units with a spray cabinet. In addition, the hours saved from decreased cleaning labor requirements can result in an increase in worker productivity; this benefit, however, is not quantified.

The following assumptions are made under this cost scenario:

- The monthly cost for solvent unit leasing and solvent management services is \$159 per unit.
- An average of 7.1 hours of labor per week is spent cleaning parts in each solvent unit.
- Electricity cost to operate the pump in the solvent unit is \$0.50 per cleaning labor hour.
- The capital cost for a medium-sized spray cabinet is \$3,500. The annualized cost over a 7-year period at a 10 percent discount rate is \$776.
- A total of 51 gallons of cleaning powder is used each year (48 gallons for new solution makeup and 3 gallons for additions) at \$10 per gallon. New solution makeups are performed 12 times per year using 4 gallons concentrated powder and 60 gallons of water.
- Electricity cost to operate the spray cabinet under heavy use conditions is \$3,100 per year.
- The spray cabinet requires solution changeout and disposal 12 times per year. For each changeout, a total of 64 gallons of solution and sludge will require off-site disposal as hazardous waste at \$4 per gallon and one hour of labor will be required.
- Cleaning labor decreases by 70 percent as a result of using the spray cabinet.

<b>Spray Cabinet Cost Comparison</b>	
<b>Two Solvent Units</b>	<b>Annual Cost</b>
Leasing, waste management	\$3,816
Electricity (estimated)	\$369
Cleaning labor (738 hours/year)	<u>\$36,900</u>
Total	\$41,085
<b>One Spray Cabinet</b>	
Purchase price (annualized)	\$776
Chemicals	\$510
Electricity (estimated)	\$3,100
Solution and sludge disposal	\$3,072
Disposal labor	\$600
Cleaning labor (221 hours/year)	<u>\$11,050</u>
Total	\$19,108
<b>Annual Savings = \$21,977</b>	

## Ultrasonic Unit for Heavy-Duty Cleaning Applications

This section compares the costs of solvent cleaning and ultrasonic cleaning. Costs were calculated based on actual costs in the Woods facility Heavy Duty section, but the values may also reflect the costs for other City department facilities that have heavy-duty cleaning operations. Because the ultrasonic unit demonstrated in the Heavy Duty section had a cleaning capacity equivalent to that of two solvent sink-top units, this section compares the costs for two solvent sink-top units to the costs for one ultrasonic unit. The Heavy Duty section will realize a cost savings of \$16,057 per year by replacing two solvent units with an ultrasonic unit. In addition, the hours saved from decreased cleaning labor requirements can result in an increase in worker productivity; this benefit, however, is not quantified.

<b>Ultrasonic Unit Cost Comparison</b>	
<b>Two Solvent Units</b>	<b>Annual Cost</b>
Leasing, waste management	\$3,816
Electricity (estimated)	\$369
Cleaning labor (738 hours/year)	<u>\$36,900</u>
<b>Total</b>	<b>\$41,085</b>
<b>One Ultrasonic Unit</b>	
Purchase price (annualized)	\$2,438
Chemicals	\$1,080
Electricity (estimated)	\$4,000
Solution and sludge disposal	\$2,160
Disposal labor	\$600
Cleaning labor (295 hours/year)	<u>\$14,750</u>
<b>Total</b>	<b>\$25,028</b>
<b>Annual Savings = \$16,057</b>	

The following assumptions are made under this cost scenario:

- The monthly cost for solvent unit leasing and solvent management services is \$159 per unit.
- Electricity cost to operate the pump in the solvent unit is \$0.50 per cleaning labor hour.
- An average of 7.1 hours of labor per week is spent cleaning parts in each solvent unit.
- The capital cost for the ultrasonic unit is \$11,000. The annualized cost over a 7-year period at a 10 percent discount rate is \$2,438.
- A total of 90 gallons of concentrated cleaning solution is used each year (30 gallons for new solution makeup and 60 gallons for additions) at \$12 per gallon. New solution makeups are performed 12 times per year using 2.5 gallons concentrated powder and 42.5 gallons of water.
- Electricity cost to operate the ultrasonic unit under heavy use conditions is \$4,000 per year.
- The ultrasonic unit requires solution changeout and disposal 12 times per year. For each changeout, a total of 45 gallons of solution and sludge will require off-site disposal as hazardous waste at \$4 per gallon and 1 hour of labor will be required.
- Cleaning labor decreases by 60 percent as a result of using the ultrasonic unit.

## 6.2 MUNI Facility Conversions

This section discusses the economics of the Woods, Green, and Potrero facilities converting entirely to aqueous cleaning. For the Woods and Green facilities, this section discusses the economics only for those shops that participated in this demonstration project (the Heavy Duty and Preventative Maintenance sections at Woods and the main work area at Green); other shops at the Woods and Green facilities are not discussed in this section. MUNI will likely lease rather than purchase aqueous cleaning units in converting to aqueous cleaning. However, this section provides an economic analysis based on the purchase price of the units so that a payback period can be calculated. Cost calculations are based on actual costs and demonstration results at the Woods, Green, and Potrero MUNI facilities. Therefore, costs presented in this section do not directly correlate with the costs presented in

Section 6.1 of this report. For the MUNI demonstration facilities and sections, the potential cost savings range from \$13,250 to \$226,200 per year, and the payback period ranges from 3 months to 1 year.

<b>Woods Facility Heavy Duty Section Conversion to Aqueous Cleaning</b>	
<b>From</b> <u>(Solvent Units)</u>	<b>To</b> <u>(Aqueous Units)</u>
8	→ 4 medium spray cabinets
2	→ 1 large ultrasonic
2	→ 2 microbial sink-top
1	→ 1 immersion
Total 13 solvent	8 aqueous
Capital cost = \$30,400	
Annual savings = \$134,810	
Payback period = < 3 months	

**Woods Facility Heavy Duty Section**

Based on the demonstration results, the Woods facility Heavy Duty section can entirely switch from solvent to aqueous cleaning with no loss in cleaning performance. The Heavy Duty section would likely install multiple spray cabinets to handle most of the cleaning workload, an ultrasonic unit for special cleaning applications, and a few sink-top and immersion units for quick and light duty cleaning jobs. Because the spray cabinets and ultrasonic unit have large cleaning capacities, the Heavy Duty section would be able to reduce its total number of cleaning units. If the

Heavy Duty section installed four medium-sized spray cabinets, one ultrasonic unit, two microbial sink-top units, and one immersion unit to replace its 13 solvent cleaning units, the total capital cost for the conversion is estimated to be \$30,400 with an annual cost savings of \$134,810 and a simple payback period of less than 3 months.

**Woods Facility Preventative Maintenance Section**

Based on the demonstration results, the Woods facility Preventative Maintenance section can successfully switch from solvent to aqueous cleaning with no loss in cleaning ability. The Preventative Maintenance section would likely implement two microbial sink-top units for quick cleaning jobs and a medium-sized spray cabinet for more heavily soiled parts. If the Preventative Maintenance section replaced its three solvent units with one medium-sized spray cabinet and two microbial sink-top units, the total capital cost for the conversion is estimated to be \$6,100 with an annual cost savings of \$13,270 and a simple payback period of less than 6 months.

<b>Woods Facility Preventative Maintenance Section Conversion to Aqueous Cleaning</b>	
<b>From</b> <u>(Solvent Units)</u>	<b>To</b> <u>(Aqueous Units)</u>
1	→ 1 medium spray cabinet
2	→ 2 microbial sink-tops
Total 3 solvent	3 aqueous
Capital cost = \$6,100	
Annual savings = \$13,270	
Payback period = < 6 months	

**Green Facility**

Based on the demonstration results, the Green facility identified immersion and microbial sink-top units that can successfully meet its cleaning requirements. Although the facility can convert entirely to aqueous immersion and microbial sink-top units while realizing cost savings, the facility would achieve the greatest cleaning performance and efficiency by implementing a unit that provides automated

cleaning. Based on the demonstration results for the Woods facility Heavy Duty section, an ultrasonic unit has the greatest potential for cleaning parts with burnt-on carbon; therefore, the Green facility would likely implement two ultrasonic units to handle most of its difficult-to-clean parts, several immersion units that provide soaking capability, and a microbial sink-top unit. If the Green facility replaced its nine solvent units with two ultrasonic units, four immersion units, and one microbial sink-top unit, the total capital cost for the conversion is estimated to be \$39,800 with an annual cost savings of \$226,200 and a simple payback period of less than 3 months.

<b>Green Facility Conversion to Aqueous Cleaning</b>	
<b>From</b> (Solvent Units)	<b>To</b> (Aqueous Units)
4	→ 2 large ultrasonic units
4	→ 4 immersion
1	→ 1 microbial sink-top
Total 9 solvent	7 aqueous
Capital cost = \$39,800	
Annual savings = \$226,200	
Payback period = < 3 months	

**Potrero Facility**

The Potrero facility can convert from solvent to aqueous cleaning with no loss in cleaning ability. Based on the demonstration results, Potrero would have its cleaning needs best met by implementing a large spray cabinet and two microbial sink-top units. If Potrero replaced its four solvent units with one large spray cabinet and two microbial sink-top units, the total capital cost for the conversion is estimated to be \$14,030 with an annual cost savings of \$13,250 and a simple payback period of 1.1 years.

<b>Potrero Facility Conversion to Aqueous Cleaning</b>	
<b>From</b> (Solvent Units)	<b>To</b> (Aqueous Units)
2	→ 1 large spray cabinet
2	→ 2 microbial sink-top
Total 4 solvent	3 aqueous
Capital cost = \$14,030	
Annual savings = \$13,250	
Payback period = 1.1 years	

## 7.0 PURCHASING PROCEDURES AND REQUIREMENTS

This section describes City Purchasing Department procedures and Department of Building Inspection recommendations for independent testing laboratory approval.

### 7.1 Purchasing Procedures

The City Purchasing Department (Purchasing) solicits competitive bids and awards contracts for products used by all City department facilities, including parts cleaning equipment. For City department facilities to purchase aqueous cleaning equipment, they must budget for the equipment and receive approval from their management. Each facility then works with Purchasing to review the specifications for its request, and Purchasing sends the bid to potential bidders. For bids over \$50,000, Purchasing Department sends formal "Proposals" to potential bidders and advertises the bids. For bids under \$50,000, Purchasing Department sends out informal bids called "Quotations." These quotations are not advertised but are sent to a minimum of three prospective bidders. Bid specifications can be written for a specific unit type and manufacturer. Purchasing awards bids to the lowest reliable and responsive bidder.

Aqueous cleaning equipment, solution, and servicing falls under the following Purchasing subclass code and description: "9720-19: Parts cleaning/washing systems, equipment, and supplies."

### 7.2 Independent Testing Laboratory Approval

The City Department of Building Inspection recommends that all equipment purchased by City departments that is powered by electricity or natural gas be approved by an independent testing laboratory. Most aqueous cleaning units require electrical power to heat the cleaning solution and power the solution pump. Some vendors offer spray cabinets that use natural gas to heat the solution. The Department of Building Inspection recommends that all electrical products be approved by either UL, ETL Testing Laboratories, Applied Research Laboratories, or Factory Mutual. Gas appliances and accessories must be tested and approved by American Gas Association Laboratories or Gas Appliance Laboratories, Inc. An entire aqueous cleaning unit must be tested and approved even though a unit has approved components. For additional information on obtaining independent testing laboratory approval, please contact the Department of Building Inspection at (415) 558-6040. Appendix F lists the addresses and telephone numbers of all testing laboratories approved by the Department of Building Inspection.

Of the aqueous cleaning units demonstrated for the project, the following six units have independent testing laboratory approval: (1) Landa Model SJ-10 spray cabinet, (2) EMC Jetsink spray cabinet, (3) Safety-Kleen TLW-2 spray cabinet, (4) Safety-Kleen SJW-4 spray cabinet, (5) Alpha Cleaning Systems 1818-54 ultrasonic unit, and (6) GlobalSonics GreaseMonkey Senior ultrasonic unit. Other commercially available aqueous cleaning units not demonstrated for the project may also have independent testing laboratory approval.

Vendor Profile Forms may be obtained by contacting the City Purchasing Department at (415) 554-6743.

City procurement possibilities are published in the "Bid and Contract Opportunities" newsletter published weekly. The "Bid and Contract Opportunities" newsletter is posted on the Internet at [www.ci.sf.ca.us/purchase/index.htm#bids](http://www.ci.sf.ca.us/purchase/index.htm#bids).

More information on City purchasing procedures is available in "How to Do Business with the City and County of San Francisco," which is available on the Internet at [www.ci.sf.ca.us/purchase/](http://www.ci.sf.ca.us/purchase/).

## 8.0 CONCLUSIONS

The results of the demonstration project indicate that aqueous cleaning is a viable and cost-effective option for City department facilities. All City departments should be able to successfully convert from solvent to aqueous cleaning. Aqueous cleaning units were able to meet the part cleaning requirements of three MUNI facilities with a wide variety of cleaning operations and a wide variety of cleaning needs. Other City departments such as the Airports Commission, the Fire Department, Parking and Traffic, Port, the Police Department, Public Utilities Commission, Public Works, Purchasing, and Recreation and Parks are likely to meet their cleaning requirements with aqueous cleaning.

The MUNI demonstration facilities realized the following benefits of aqueous cleaning as compared to solvent cleaning :

- Equal or better cleaning performance in most cases
- Decreased hazardous waste generation
- Decreased cleaning labor requirements
- Increased part cleaning capacity
- Increased productivity and efficiency of overall operations
- Increased staff safety and satisfaction
- Cost savings

With proper aqueous cleaning unit selection, other City department facilities can realize these benefits.

### 8.1 Cleaning Unit Application

Matching the type of aqueous cleaning unit to the cleaning application is critical to successfully implementing aqueous cleaning. Identifying specific units that meet the performance, design, and maintenance requirements of each facility is also critical. Demonstration results for the four types of aqueous cleaning units-sink-top, immersion, spray cabinet, and ultrasonic-and their potential applications in City department facilities are summarized below.

- **Sink-Top Unit:** Sink-top units should be implemented at City department facilities that perform small amounts of light-duty cleaning and at facilities that clean parts and replace them immediately on vehicles or equipment, such as during preventative maintenance operations. Microbial sink-top units have greater potential for application than nonmicrobial sink-top units because their longer solution life minimizes waste solution generation and disposal. Two sink-top units were identified from the demonstration as having potential for successful application at MUNI and other City department facilities: ForBest IPC360 and EcoClean BioFlow20.
- **Immersion Unit:** Immersion units should be implemented at City department facilities that perform small amounts of light-duty cleaning but that occasionally have a moderately soiled or more difficult-to-clean part that requires soaking. One immersion unit was identified from the demonstration as having potential for successful application at MUNI and other City department facilities: Mirachem PW-40s.

- **Spray Cabinet:** Spray cabinets have the greatest potential for widespread application at City department facilities and should be implemented in particular at facilities that have moderately to heavily soiled parts that require cleaning. The benefits of spray cabinets include (1) high cleaning performance, (2) a significant decrease in cleaning labor, and (3) the availability of large capacities. The wide range of sizes available makes spray cabinets applicable for many types of cleaning operations. Small spray cabinets are available for shops that clean small to moderate quantities of parts or for shops that have only 110-volt electrical service. Four spray cabinets demonstrated were rated favorably and have high potential for successful application at MUNI and other City department facilities: Landa SJ-10, Safety-Kleen TLW-2, Safety-Kleen SJW-4, and EMC Jetsink.
- **Ultrasonic Unit:** Ultrasonic units provide a high level of cleaning performance and automated cleaning action. In addition, ultrasonic units offer cleaning performance features unavailable in other aqueous cleaning units, including the ability to (1) clean blind holes and hidden surfaces of parts, (2) clean difficult-to-remove burnt-on carbon, and (3) provide automated cleaning of aluminum parts without damaging part surfaces. City department facilities with these special cleaning needs may be able to justify paying the high capital cost for ultrasonic units. Two ultrasonic units were reviewed favorably during the demonstration and have high potential for successful application at MUNI and other City department facilities: GlobalSonics GreaseMonkey Senior and Alpha Cleaning Systems 1818-54.

## 8.2 Cleaning Unit Servicing, Waste Generation, and Environmental Improvements

City department facilities with a small number of cleaning units may be able to service their own aqueous cleaning units. Larger City department facilities, such as a MUNI facilities, will likely require full “turn-key” servicing and waste management services provided by the aqueous cleaning vendor or a waste management company. MUNI performed servicing on most of the units demonstrated for the project, and the overall time and effort requirements were minimal. However, MUNI staff indicated that it would not be practical for them to service a large number of aqueous cleaning units. The servicing and maintenance requirements of the aqueous cleaning units consisted of water addition, chemical addition, filter replacement, and solution changeout. Solutions were disposed of under the city-wide waste management contract managed by the Department of Public Health. Presently, vendors of 4 of the 9 recommended units - ForBest, EMC, Safety-Kleen, and GlobalSonic - offer full servicing and waste management services with their units. More vendors may begin to offer such services as the aqueous cleaning market in northern California matures.

Hazardous waste generation from part cleaning activities in City departments can be potentially reduced by up to 90 percent by converting from solvent to aqueous cleaning. Solutions in aqueous cleaning units lasted between 4 and 12 times longer than solvents before requiring replacement with new solutions. Only some units generate spent filters that require disposal. Skimmed oil is easily managed because it is recycled with used motor oil.

VOC emissions from City departments can be significantly reduced or eliminated by converting to aqueous cleaning. Mineral spirits used in solvent part washers are 70 to 100 percent VOCs by volume. Based on MUNI estimates that 6 percent of mineral spirits volume loss is due to volatilization, over 9 tons of VOCs is emitted to the atmosphere each year from MUNI part cleaning operations. Aqueous cleaning solutions are allowed to contain a maximum of 5 percent VOCs by Bay Area Air Quality Management District regulations, but most are pure aqueous solutions with no VOCs.



### **8.3 Cleaning Unit Economics**

The cost comparison of solvent to aqueous cleaning from the results of the demonstration project indicates that aqueous cleaning may result in a cost savings of \$425 to \$21,977 per year for every aqueous cleaning unit implemented. Cleaning labor and solution life are the two most significant factors determining the cost savings realized. Spray cabinets and ultrasonic units have the greatest potential for cost savings because (1) their automated cleaning ability can reduce cleaning labor by as much as 90 percent and (2) their large sizes can provide part cleaning capacities equivalent to those of multiple solvent sink-top units. Therefore, although spray cabinets and ultrasonic units have higher capital costs than sink-top and immersion units, their payback period is often very short. In addition, City department facilities may realize an increase in overall productivity as a result of the decreased time required for parts cleaning with spray cabinets and ultrasonic units. Further cost savings may be realized by reduced hazardous waste generator fees owed to the California State Board of Equalization as a result of decreased hazardous waste generation.

### **8.4 Independent Testing Laboratory Certification and Unit Servicing**

Currently, 6 of the 14 demonstrated aqueous cleaning units have been approved by an independent testing laboratory. However, other commercially available units that were not demonstrated may meet this requirement. In addition, more vendors may seek to obtain such approval in order to market their cleaning units.

Overall, 9 of the 14 aqueous cleaning units demonstrated for the project met the overall performance requirements of MUNI and are viable options for full implementation in City department facilities. In addition, numerous other aqueous cleaning units are commercially available that were not demonstrated but may also meet City department facility performance requirements. Aqueous cleaning unit options for City departments may be limited by the number of vendors that provide full servicing and waste management support and by the number of units that have independent testing laboratory approval. As the September 1, 1999 deadline for eliminating all but one solvent cleaning unit per facility approaches, the aqueous cleaning market in northern California is likely to quickly mature, presenting more options for City department facilities.

**APPENDIX A**

**PROJECT MANAGEMENT AND  
MUNICIPAL RAILWAY DEMONSTRATION FACILITY  
CONTACT INFORMATION**

**(One Page)**

**PROJECT MANAGEMENT AND  
MUNICIPAL RAILWAY DEMONSTRATION FACILITY  
CONTACT INFORMATION**

Aqueous Cleaning Demonstration Project Management:

City and County of San Francisco Hazardous Waste Management Program  
1145 Market Street, Suite 401  
San Francisco, CA 94103  
Contact: Alex Dong, (415) 554-1675, and Marjaneh Zarrehparvar, (415) 554-1647

Tetra Tech EM Inc.  
135 Main Street, Suite 1800  
San Francisco, CA 94105  
Contact: Patrick Wooliever and Peter Ko, (415) 543-4880

MUNI Demonstration Facilities :

Municipal Railway Woods Facility  
1095 Indiana Street  
San Francisco, CA 94107  
Heavy Duty Contact: Robert Doering and Lester Dong, (415) 695-7131  
Preventative Maintenance Contact: Larry Schembari, (4 15) 695-7 128

Municipal Railway Green Facility  
2200 San Jose Ave.  
San Francisco, CA 94134  
Contact: Gary Tissell, (415) 337-2302

Municipal Railway Potrero Facility  
2500 Mariposa Street  
San Francisco, CA 94110  
Contact: Larry Harris, (4 15) 554-9318

**APPENDIX B**

**PARTICIPATING AQUEOUS CLEANING  
VENDOR CONTACT INFORMATION**

**(One Page)**

**PARTICIPATING AQUEOUS CLEANING VENDOR  
CONTACT INFORMATION**

<b>Manufacturer'sName</b>	<b>Contact Person</b>	<b>Contact Number</b>	<b>Location</b>
Alpha Cleaning Systems	Dan Kentch	(805) 520-8057	Simi Valley, CA
ChemFree Corporation	Larry Macofsky	(310) 832-9568	San Pedro, CA
EcoClean Corporation	James R. Andrews	(510) 797-4050	Fremont, CA
EMC	Max Lambrecht	(408) 292-9289	San Jose, CA
ForBest Cleaning Solutions, Inc.	Darwin Hall	(310) 769-0022	Los Angeles, CA
Global Sonics	Marty Ehman	(800) 437-7117	Bountiful, UT
Graymills Corporation	Don Kuehnert	(626) 331-5334	Covina, CA
KleenTec	Chuck Kennedy	(714) 978-9496	Anaheim, CA
Landa, Inc.	John Dennett	(408) 998-3051	San Jose, CA
Mega Mate	Ed Maynard	(209) 847-6070	Oakdale, CA
Mirachem	Marty Motian	(602) 966-3030	Tempe, AZ
Safety-Kleen Corporation	Brad Atkinson	(707) 584-0415	Rohnert Park, CA

**APPENDIX C**

**AQUEOUS CLEANING UNIT  
DATA COLLECTION LOG SUMMARY**

**(Six Pages)**

This appendix summarizes data collected from log sheets completed by MUNI staff after cleaning parts in the aqueous cleaning units. The log sheets were posted near the aqueous cleaning units during the demonstration project. MUNI staff were instructed to record the types of parts cleaned, the cleaning results, and any comments on the unit every time they performed a cleaning job. The total number of cleaning jobs logged for each unit varied by facility, unit location, and staff. Based on discussions with MUNI supervisors, significantly more parts were cleaned in the units than were actually logged. Nevertheless, the logs assist in evaluating the types of parts that were successfully and unsuccessfully cleaned in the unit. Data collected from the logs are used in conjunction with other data sources (verbal feedback and final survey forms) to assess the overall performance of the aqueous cleaning units demonstrated.

**ALPHA CLEANING SYSTEMS 1818-54 ULTRASONICS UNIT**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>WOODS SCHEDULED</b>		
2 Poor (only responses)	Wheel bearings; retainer; anchor pins	No good after adding water; dilutes solution; will not clean; too small; no action

Note: Logs were not filled out on a regular basis by Woods staff.

**CHEMFREE SMARTWASHER SINK-TOP UNIT**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>WOODS PREVENTATIVE</b>		
4 Good entries	Tools; bolts and nuts; drain plugs	None provided
13 Okay entries	Plastic heater box; brake hardware; valve; injector; brake chamber cover; bearings; bushings; steering box	Not as good as the old solvent (2)
5 Poor entries	Grease on bearing; brake chamber; big grease	Bring back solvent
<b>WOODS SCHEDULED</b>		
5 Good entries	Nuts; bolts; brake parts; engine parts; brackets; transmission parts; drive line parts	Smells bad (5); got headache
14 Okay entries	Brake parts; nuts; bolts; radiator parts; heating system parts; fittings; suspension parts; axle parts; engine parts;	smells bad (13); makes me sick
2 Poor entries	Wheel bearings; tools	Strong odors; gives headache

**ECOCLEAN BIOFLOW20 SINK-TOP UNIT**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>GREEN</b>		
14 Good entries	Check plate bolts; axle bearing; pinion sleeve; speed sensor; gear; gear box parts; bolts and cover	Satisfactory results; like it; part wipes dry easy; great for final clean; not great cutting through grease; like feeling it leaves on parts; love it; easy on gloves; like it because it's warm; tastes awful
12 Okay entries	Various parts from gear box; gear box covers and bolts; coupler; door activator; inspection cover, bolts, and washers; differential parts	Some parts have light rusting on surface (2); flash rusting (3); must air dry or rust forms; if left wet rust forms (2)
2 Poor entries	Nuts and bolts; bull gear flange[list all parts that met the poor criteria]	No good; solution doesn't seem strong enough
<b>WOODS PREVENTATIVE</b>		
28 Good entries	5-gallon bucket with oil; oil spinner; brake hdnr; relay valve; bearings and nuts; brake hardware; heater core; air filter cover; brake chamber; brake parts; spinner and filter parts; air dryer; brake chamber clamps; air filter housing cover; tools; slack adjuster; shims bolts	Safer than solvent; not as good as old solvent (8)
25 Okay entries	Tools; air dryer; 5-gallon oil bucket; heater core; plastic panel; oil spinner; brake chamber cover and clamp; brake parts and wheel bearings; trans pan; tone ring; cart; metal screen	Safer than solvent; not as good as the old solvent (6); bring back solvent
5 Poor entries	Air dryer' oil spinner; wheel hub; rear hub; oil retainer	Not doing good; chemical need to be changed (3); doesn't cut wheel bearing grease well (2)
<b>WOODS SCHEDULED</b>		
19 Good entries	Differential parts, suspension parts and nuts and bolts; drive line parts and retarder parts; brake parts; radiator parts; brake valves; brake and suspension parts; cooling system parts; engine parts; tools; wheel bearing; anchor pins	Works well with no smell (7); takes more time but works well; cleans good for nonsolvent; have to scrub more but works good; almost as good as solvent; works good; works well; works OK but have to remove grease before hand (2)
3 Okay entries	Brakes; bearings	Doesn't clean as well as solvent
No Poor entries	NA	NA



**EMC JETSINK SPRAY CABINET**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>WOODS SCHEDULED</b>		
26 Good entries	Brake parts; fan drive parts; differential parts; drive line parts; radiator parts; fuel tank parts; suspension parts; cooling system parts; dust cover (brake hub); anchor brake pin; hub seal retainer; bearing; screen metal	Cleans real good (3); works great (3); time saver; can do other work while it's cleaning; excellent (2); leaves grease on some parts; baked dirt onto part; good but not as fast as solvent; cleans screen good
0 Okay entries	NA	NA
0 Poor entries	NA	NA

**FORBEST IPC360 SINK-TOP UNIT**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>GREEN</b>		
9 Good	Gear box parts; LRV gear box parts; bearing housing	Works fine but still has flash rusting; works good but rusts parts if not wiped down; releases silicon well; works good for the housing trainer; works good; temp seems low?; I don't like tank; cuts grease and oil well; flash rusting if left standing; still performs well; filter clogs too soon, must clean often; getting dirty but cleans OK; 1/2 of solution is gone - should I add water? Still cleans well - added water; leaves film on parts
6 Okay	Gear box parts; internal actuator parts	Works fine on internal parts; seems to be losing cleaning performance; solution dirty; flash rusting; must wipe dry ASAP; solution level diminishing; waiting for vendor; still waiting for vendor for servicing
0 Poor	NA	NA

**GLOBALSONICS GREASEMONKEY SENIOR**

No logs were filled out by MUNI Woods staff on this unit.

**GRAYMILLS BIOMATIC SINK-TOP UNIT**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>POTRERO</b>		
4 Good Entries	Bearing; bearing tool; bearing retainer	Clean out grease
4 Okay	Bearing tool; trolley tarret base; rear, inner, and outer bearing	Smells bad; change the smell
1 Poor	Trolley base	None
<b>WOODS PREVENTATIVE</b>		
7 Good Entries	Oil skimmer; air dryer; brakes; bearings; brake parts; tools	Cleans well
1 Okay	Tools	Cleans well
0 Poor	NA	None
<b>GREEN</b>		
4 Good	LRV activator; control arms; lifting gear; differential parts	Cleans parts easily; works nicely; hose valves are of poor quality
3 Okay	Compensator screw assembly; activator ram; air lamp	None
0 Poor	NA	NA

**KLEENTECH IMMERSION UNIT**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>WOODS SCHEDULED</b>		
1 Good	Bolts	Good for cleaning bolts
2 Okay	Anchor pins; bolts	None
1 Poor	Wheel bearings	Not good for bearings

Note: Logs were not filled out on a regular basis by Woods staff.

**LANDA SJ-10 SPRAY CABINET**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>WOODS SCHEDULED</b>		
16 Good	Bearings; engine parts; dust protector; bolts; retainer	Excellent machine; nice washer; needs more service to work more efficiently
0 Okay	NA	NA
0 Poor	NA	NA

**MEGA MATE M30 SPRAY CABINET**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>GREEN</b>		
3 Good	King pins; LRV Comp	None
1 Okay	Hubs	Lots of time used
3 Poor	End bells; other parts	No better than warm water; did not clean parts; parts removed three days later - all rusted

**MIRACHEM PW-40S IMMERSION UNIT**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>GREEN</b>		
6 Good	Gears; large steering gear; gear box parts; booter; actuator	I like it; excellent; I feel ill from inhaling; must wear personal respirator when using
7 Okay	Various gear box parts; end bells	Solution is dirty and needs to be changed; great tank; not so good grease cutting; excellent brush; good volume control; tank skimmer takes too much time to use; too much evaporation; need automatic skimmer
2 Poor	End bells; gear box components	Solution is dirty and needs to be changed; it's as strong as hot water

**SAFETY-KLEEN MODEL 90 SINK-TOP UNIT**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>WOODS SCHEDULED</b>		
0 Good Entries	NA	NA
1 Okay	Shop tools	Won't cut grease; have to scrub real hard; too much scrub time
10 Poor	Differential parts; brake parts; suspension parts; cooling system parts	Have to scrub hard

**SAFETY-KLEEN TLW-2 AND SJW-4 SPRAY CABINETS**

<b>Cleaning Quality</b>	<b>Parts Cleaned</b>	<b>Comments</b>
<b>WOODS SCHEDULED</b>		
46 Good	Bearings; brake parts; wheel scrapers; nuts; bolts; transmission parts	Best machine we've tried; very good; excellent; the best machine in the shop; we need more of this kind of machine
0 Okay	NA	NA
0 Poor	NA	NA
<b>POTRERO</b>		
7 Good Entries	Oil seal retainer; tool boxes; hub wrench; anchor pin; bearings	Cleans well
2 Okay	Hub; bearings	None
0 Poor	NA	NA

## **APPENDIX D**

### **AQUEOUS CLEANING UNIT FINAL SURVEY RESULTS SUMMARY**

**(18 Pages)**

This appendix summarizes data collected from survey forms completed by MUNI staff at the end of the demonstration. The data from the survey forms represent overall response to the aqueous cleaning units and does not account for responses specific to the types of cleaning applications, such as the types of parts and soils cleaned. As a result, sink-top and immersion units that cleaned light- or moderately soiled parts, but failed to clean heavily soiled or difficult-to-clean parts, may have received an overall negative response due to this limitation in cleaning performance. However, this data is to be used in conjunction with other data sources (verbal feedback and final survey forms) to assess the overall performance of the aqueous cleaning units demonstrated, recognizing that some units are appropriate for use only on certain cleaning applications.

FINAL SURVEY FORM SUMMARY

Unit:	Alpha 1818-54	Chemfree Smartwasher	EcoClean BioFlow20	EMC Jetsink	ForBest IPC380	GlobalSonics GreaseMonkey	Gray Mills Blomatic	Kleentec KT4000	Landa SJ-10	Megamate M30	Mirachem PW-40S	Safety-Kleen Model 80	Safety-Kleen SJW-4	Safety-Kleen TLW-2
Number of Facilities	1	2	3	1	1	1	2	1	1	1	1	1	1	1
Number of Surveys Completed	9	14	12	5	5	10	9	6	10	4	4	2	6	12
Level of Use														
More:	0%	21%	0%	70%	0%	70%	11%	0%	100%	25%	0%	0%	50%	78%
About equal:	33%	43%	50%	10%	60%	10%	67%	0%	0%	0%	50%	50%	50%	22%
Less:	67%	36%	50%	20%	40%	20%	22%	100%	0%	75%	50%	50%	0%	0%
<b>Cleaning Performance (compared to solvent unit)</b>														
Significantly better	11%	0%	0%	0%	0%	30%	11%	0%	80%	0%	0%	0%	83%	87%
Slightly better	11%	0%	8%	80%	0%	30%	44%	0%	20%	0%	0%	0%	0%	33%
About the same	11%	0%	17%	0%	20%	20%	33%	17%	0%	0%	25%	50%	0%	0%
Slightly worse	33%	7%	67%	20%	40%	20%	11%	33%	0%	25%	50%	0%	17%	0%
Significantly worse	33%	93%	8%	20%	40%	0%	0%	50%	0%	75%	25%	50%	0%	0%
Cannot Clean These Parts	heavy grease, carbon	grease; wheel bearings	Differential gear assembly, burned-on gear oil; baked on rust and other hard, sticky oil carbon, gasoline, paint, heavy grease	certain tools	heavy black water/grease; hard deposits; trolley coach differential parts	Grease; heavy grease on bearings	Hard, encrusted grime; carbon build-up	"everything"	none	just about everything; grease and baked-on deposits; heavy, baked-on grease; (if solution were stronger it would probably work much better	burnt carbon deposits; trolley coach differential parts; baked-on synthetic grease	Grease	small, intricate parts like gears and screens	
<b>Cleaning Labor Required</b>														
Significantly less	11%	0%	0%	0%	0%	20%	22%	0%	80%	0%	0%	0%	83%	83%
Slightly less	0%	0%	0%	40%	0%	0%	22%	0%	40%	25%	0%	0%	0%	17%
About the same	33%	0%	42%	40%	20%	20%	33%	17%	0%	50%	25%	0%	17%	0%
Slightly more	56%	36%	42%	0%	40%	20%	22%	33%	0%	25%	25%	50%	0%	0%
Significantly more	0%	64%	16%	20%	40%	0%	0%	50%	0%	0%	50%	50%	0%	0%
<b>Capacity</b>														
Greater capacity	0%			0%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%
About equal	56%			60%	60%	38%		50%	30%	0%	25%		33%	33%
Less capacity	44%			40%	40%	63%		50%	0%	50%	75%		0%	0%
<b>Odor</b>														
Pleasant		0%	25%				44%						0%	
Unpleasant		92%	25%				22%					0%		
Neutral		8%	50%				33%					100%		
<b>Unit Design</b>														
Good	0%	0%	30%	0%	25%	0%	0%	0%	50%	50%	25%	0%	33%	83%
Adequate	100%	90%	50%	50%	25%	100%	50%	100%	50%	25%	75%	100%	66%	17%
Poor	0%	10%	20%	50%	50%	0%	50%	0%	0%	25%	0%	0%	0%	0%
Comment					like valve between brush and nozzle; ribs on bottom of uni prevent some parts from resting flat		valves too fragile; hose fittings broke continually		large capacity and no scrubbing		water level not always full; large capacity		like oil skimmer	
<b>Rusting</b>														
Frequently	14%	22%	60%	0%	60%	0%	0%	0%	0%	100%	75%	0%	33%	0%
Occasionally	14%	67%	30%	50%	40%	0%	63%	33%	50%	0%	25%	50%	50%	8%
Never	71%	11%	10%	50%	0%	100%	38%	67%	50%	0%	0%	50%	17%	92%
Parts	air compressor; water pump		machine steel; parts of differential unit; bolts and nuts; almost all parts	bearings	steel; all non-plated parts				wheel bearings other steel parts if you don't dry them soon after		end balls-steel; any metal parts; all non-plated parts	all parts, including aluminum developed deposits; all non-plated parts; metal parts	bearings; sheet metal covers	
<b>Vendor Service</b>														
Good	0%	11%	10%	0%	0%	0%	0%	0%	20%	0%	0%	0%	17%	92%
Adequate	22%	22%	40%	25%	20%	60%	63%	0%	50%	25%	0%	100%	83%	8%
Poor	11%	11%	40%	25%	40%	40%	25%	33%	20%	50%	50%	0%	0%	0%
Not able to evaluate	67%	55%	0%	50%	40%	0%	13%	67%	10%	25%	50%	0%	0%	0%
<b>Liked Best</b>														
Parts Cleaning Ability	3	1	0	0	0	5	1	0	9	0	1	0	1	11
Design of Unit	1	1	1	1	1	3	0	1	7	1	2	0	0	6
Health and safety benefits	8	4	8	4	3	6	3	4	9	1	3	0	0	7
Environmental benefits	7	5	7	3	4	3	1	5	7	1	2	0	0	7
No solvent odor	3	1	1	1	2	4	2	2	10	3	1	2	0	6
Automated cleaning of parts	0			1				0	8	2			5	11
Other		0	1 (not sure)	0		2 (heated cleaning solution)					2: option 1 immerse and soak part		0	
<b>Liked Least</b>														
Parts Cleaning Ability	3	6	3	2	1	1	0	5	0	1	1	0	0	0
Design of Unit	0	0	0	1	2	0	2	0	0	0	0	0	0	0
Odor	1	10	1	1	2	0	4	0	0	0	3	0	2	0
Parts Rusting	1	3	6	1	4	0	2	0	4	3	4	0	2	0
Other	takes too long to heat up		1 (no replacement solution)	0	0	4 (noisy)	0	0	0	1: cleaning time; filling water daily		1 (haven't tested enough)	1 (noise and foaming)	
<b>O&amp;M Problems</b>														
No	88%	83%	80%	100%	40%	75%	29%	67%	80%	75%	50%	50%	83%	100%
Yes	13%	17%	20%	0%	60%	25%	71%	33%	20%	25%	50%	50%	17%	0%
Problem	needs more soap	(none listed)	Filter clogs very fast; liquid level is low; runs out of liquid often	n/a	tank too small; water evaporates too quickly	pump got clogged or/ice	oil belt stretched? (n/a)	water pump seal leak	need to add water and soap frequently	water evaporates too quickly; need to refill water too often	clogs up	foaming		
<b>Recommend</b>														
Definitely Yes	22%	0%	13%	0%	0%	0%	13%	0%	67%	0%	0%	0%	50%	100%
Yes	56%	0%	0%	50%	60%	29%	25%	0%	33%	25%	25%	0%	50%	0%
No	22%	0%	50%	50%	40%	67%	83%	0%	0%	50%	50%	100%	0%	0%
Definitely No	0%	100%	13%	0%	0%	0%	0%	100%	0%	25%	25%	0%	0%	0%
Other	0%	0%	25% (if improved)	0%	0%	14% (not sure)	0%	0%	0%	0%	0%	0%	0%	0%

FINAL SURVEY FORM RESPONSES

Unit: Alpha 1818-54

MUNI Facility: Woods

Shop: Heavy Duty

User Name	Level of Use	Cleaning Performance Compare	Cannot Clean	Surprises	Cleaning Labor and Capacity		Unit Design	Vendor Service	Overall				
					Requirement	Capacity			Rusting	Like best	Like least	O&M Problems	Recommend
George Vargas	About equal	Slightly better	solid grease, carbon	-	about the same	less capacity	frequently; air compressor, water pumps	Designed adequately	not able to evaluate	Health and safety benefits; no solvent odor	Parts rusting	No	Yes
Spiro Zografos	About equal	Significantly better	really dirty grease (takes too long)	-	significantly less	about equal	never	Designed adequately	not able to evaluate	Parts cleaning ability, health and safety benefits, environmental benefits, no solvent odor	design of unit	no	Definitely Yes
Trong Vuong	About equal	About the same	heavy grease	-	slightly more	about equal	never	Designed adequately	not able to evaluate	Parts cleaning ability, health and safety benefits, environmental benefits, no solvent odor	takes too long to heat up	no	Definitely Yes
Harry Chin	Less	Slightly worse	-	-	slightly more	less capacity	never	Designed adequately	adequate	health and safety benefits, environmental benefits	-	No	Yes
John Tom	Less	Slightly worse	-	-	slightly more	less capacity	occasionally	Designed adequately	adequate	design of unit; health and safety benefits; environmental benefits	-	No	Yes
Romeo Camposagrado	Less	Significantly worse	-	-	slightly more	about equal	never	Designed adequately	not able to evaluate	Health and safety benefits, environmental benefits	parts cleaning ability	-	Yes
R. Fonseca	Less	Significantly worse	-	-	slightly more	about equal	-	Designed adequately	poor	Parts cleaning ability	-	No	No
John Tai	Less	Significantly worse	heavy grease	-	about the same	about equal	never	Designed adequately	not able to evaluate	health and safety benefits, environmental benefits	parts cleaning ability	No	Yes
Simon Fong	Less	Slightly worse	grease	no	about the same	less capacity	-	Designed adequately	not able to evaluate	health and safety benefits, environmental benefits, no solvent odor	parts cleaning ability	yes; need more soap	No

FINAL SURVEY FORM RESPONSES

**Unit: Chemfree Smartwasher**

MUNI Facility: Woods

Shop: Preventative Maintenance

User Name	Level of Use	Cleaning Performance	Cannot Clean	Surprises	Labor Requirement	Aqueous Solution			Unit Design	Vendor Service	Overall			
		Compare				Odor	Rusting	Other			Like best	Like least	O&M Problems	Recommend
Paul Attard	Less	Significantly worse	Yes: grease	No	Significantly more	Neutral	Never	No	Designed adequately	No able to evaluate	Health and safety benefits	Parts cleaning ability	No	No
Mark Sangervaso	Less	Significantly worse	Yes: grease	No	Significantly more	Unpleasant	Occasionally	No	Designed adequately	Good	Other: not specified	Parts rusting	No	No
<b>MUNI Facility: Woods</b>														
<b>Shop: Heavy Duty</b>														
Leslie Humphrey	About equal	Significantly worse	--	--	Slightly more	Unpleasant	Occasionally: metal	No	Designed adequately	Poor: no service	Parts cleaning ability; heated cleaning solution	Odor of aqueous solution	--	Definitely no
Jesse Pantaleon	Less	Significantly worse	Yes: grease	Yes	Significantly more	Unpleasant	Occasionally: metal	No	Designed poorly	Not able to evaluate	Heated cleaning solution	Odor of aqueous solution	Yes	Definitely no
Jim Kwan	Less	Significantly worse	Yes: wheel bearing grease	No	Slightly more	Unpleasant	Don't know	No	Designed adequately	Adequate	No solvent odor	Parts cleaning ability; heated cleaning solution	No	Definitely no
John Tom	About equal	Slightly worse	--	--	Slightly more	Unpleasant	Occasionally	No	Designed adequately	Not able to evaluate	Health & safety benefits	Odor of aqueous solution	--	Definitely no
Kwee Soon Lee	About equal	Significantly worse	Yes	--	Significantly more	Unpleasant	Frequently	No	Designed adequately	Not able to evaluate	Design of unit; heated cleaning solution	Odor of aqueous solution	--	Definitely no
Kyin Fong	Less	Significantly worse	Yes: hub grease	No	Significantly more	Unpleasant	Occasionally: parts that are made of ferrous	N/A	Designed adequately	Adequate	No solvent odor	Other: none	No	Definitely no
Mark Foti	About equal	Significantly worse	--	--	Slightly more	Unpleasant	Frequently	No	Designed adequately	--	Environmental benefits	Odor of aqueous solution	--	Definitely no
Ernie Pella	More	Significantly worse	Yes: grease wheel bearings	--	Slightly more	Unpleasant	Occasionally	No	--	--	Health & safety benefits; environmental benefits	Parts cleaning ability; odor of aqueous solution	--	Definitely no
Romeo Camposagrado	About equal	Significantly worse	--	--	Significantly more	Unpleasant	--	No	--	--	Heated cleaning solution	Parts cleaning ability; odor of aqueous solution; parts rusting	--	Definitely no
Richard Fonseca	More	Significantly worse	--	--	Significantly more	Unpleasant	--	No	--	--	Environmental benefits	Odor of aqueous solution	--	Definitely no



FINAL SURVEY FORM RESPONSES

Charles Ortega	more	Significantly worse	--	--	Significantly more	Unpleasant	--	No	--	--	Health & safety benefits; environmental benefits	Parts cleaning ability; odor of aqueous solution; parts rusting; changing the filter	No	Definitely no
Paul Yee	About equal	Significantly worse	--	--	Significantly more	Unpleasant	--	No	Designed adequately	Not able to evaluate	Environmental benefits	Parts cleaning ability; odor of aqueous solution	--	Definitely no

FINAL SURVEY FORM RESPONSES

Unit: EcoClean Bioflow20

MUNI Facility: Green Metro

Shop: Machine

User Name	Level of Use	Cleaning Performance			Surprises	Labor Requirement	Aqueous Solution			Unit Design	Vendor Service	Overall			
		Compare	Cannot Clean				Odor	Rusting	Other			Like best	Like least	O&M Problems	Recommend
Bill Cotter	Less	Slightly worse	No		No	Slightly more	Neutral	Occasionally: Machine steel	I like using it even though it doesn't clean as well as solvent.	Designed well	Good	Design of unit; health and safety benefits; environmental	Parts cleaning ability; parts rusting	No	Definitely yes
William Myhre	Less	About the same	Yes: Differential gear assen; burn on oil (gear oil)		No	About the same	Unpleasant	Frequently: parts of differential unit	No	Designed poorly: unit has no top cover	Not able to evaluate	Environmental benefits	Odor of aqueous solution	No	Definitely no
Mario R. Paz	Less	Slightly worse	Do not know		No	About the same	Unpleasant	Frequently: shiny parts, bolts and nuts	No	Designed adequately	Not able to evaluate	Other: not sure	Parts rusting	No	No
Randy Tom	Less	Slightly worse	Yes: baked on oil		No	About the same	Pleasant	Frequently: almost all parts; must be wiped immediately	Warm solution is O.K.	Designed poorly: needs better cover lid on opening	Adequate	Health & safety benefits	Parts rusting	Yes: filter clogs very fast	Yes
Sulpicio Briones	About equal	Slightly worse	Yes: rust and other hard sticky oil carbon		No	About the same	Neutral	Frequently: after cleaning the tools/parts	No	Designed adequately	Poor: they don't change chemical frequently	Health & safety benefits; Environmental benefits	Parts rusting	No	Yes: but requires improvement

MUNI Facility: Woods  
Shop: Preventative Maintenance

Peter Poon	About equal	Slightly worse	Yes: gasoline, paint, heavy grease		No	slightly more	Neutral	Occasionally: bearing	No	Designed well: right height	Adequate	Health & Safety benefits	Other: No replacement of solution (just add)	No	Yes
Miguel Remigio	Less	slightly worse	Yes: not as clean as Safety-Kleen. it would be better if the liquid is replaced every week		No	significantly more	Pleasant	Frequently: in steel parts and tools	Liquid is filthy - should be replaced weekly not just filtered	Designed adequately	Poor	Environmental benefits	Parts rusting	Yes: runs out of liquid often, level is low	No
Sulpicio Briones	About equal	Slightly worse	Yes: rust and other hard sticky oil carbon		No	About the same	Neutral	Frequently: after cleaning the tools/parts	No	Designed adequately	Poor: they don't change chemical frequently	Health & safety benefits; Environmental benefits	Parts rusting	No	Yes: but requires improvement

MUNI Facility: Woods  
Shop: Heavy Duty

James Cooper	About equal	Slightly worse	Yes: heavy grease		No	Slightly more	Unpleasant	--	--	--	--	--	--	--	--
Charles Ortega	Less	Significantly worse	No		No	Significantly more	Neutral	Never	Will do the job, but takes longer	Designed well	Adequate	Health & Safety benefits; Environmental benefits	Parts cleaning ability	No	--

FINAL SURVEY FORM RESPONSES

Romeo Camposagrado	About equal	About the same	--	--	Slightly more	Neutral	--	--	--	Not able to evaluate	Health & Safety benefits; environmental benefits; no solvent odor	Parts cleaning ability	--	No
L... H...	About equal	Slightly better	--	--	Slightly more	Pleasant	Occasionally: metal	No	Designed adequately	Not able to evaluate	Health & safety benefits; environmental benefits	--	No	No

FINAL SURVEY FORM RESPONSES

**Unit: EMC Jetsink**  
**MUNI Facility: Woods**  
**Shop: Heavy Duty**

User Name	Level of Use	Cleaning Performance	Cannot Clean Yes: not too effective with tools	Surprises	Cleaning Labor and Capacity	Capacity	Rusting	Unit	Vendor	Overall			
		Compare			Requirement			Design	Service	Like best	Like least	O&M Problems	Recommend
Cooper James	Less	Slightly worse		No	About the same	About equal	--	--	--	--	--	--	--
Charles Ortega	Less	Significantly worse	No	No	Significantly more	Less capacity	Never	Designed adequately	Adequate	Health & safety benefits; environmental benefits	Parts cleaning ability	No	--
Romeo Camposagrado	About equal	Slightly better	--	--	About the same	About equal	--	Designed adequately	Not able to evaluate	Design of unit; health & safety benefits; environmental benefits; no solvent odor	Parts cleaning ability; parts rusting	N/A	No
David Lau	More	slightly better	No	Yes: carbon buildup	Slightly less	About equal	Occasionally: bearings	Designed poorly: too small	Poor: only came once since tank installed. Water level got down so low, the unit was smoking	Health & safety benefits	Parts rusting	No	So, so
L... H...	About equal	Slightly better	--	--	Slightly less	Less capacity	--	Designed poorly: too small	Not able to evaluate	Automated cleaning of parts; health & safety benefits; environmental benefits	Design of unit	No	Yes

FINAL SURVEY FORM RESPONSES

Unit: ForBest IPC360

MUNI Facility: Green

Shop: Machine

User Name	Level of Use	Cleaning Performance			Cleaning Labor and Capacity			Unit Design	Vendor Service	Overall			
		Compare	Cannot Clean	Surprises	Requirement	Capacity	Rusting			Like best	Like least	O&M Problems	Recommend
Bill Cutter	Less	Significantly worse	Heavy black waterproof grease	No	Slightly more	About equal	Frequently; steel parts	Designed well; valve between brush and nozzle	Adequate	Design of unit; Health & safety benefits; Environmental benefits; no solvent odor; warm solution	Parts cleaning ability	No	Yes
Joe Gally	About equal	Slightly worse	Hard deposits	No	About the same	About equal	Occasionally: carbon steel	Designed adequately	Not able to evaluate	Health & safety benefits	parts rusting	Yes; tank too small	Yes
John Reimoneng	Less	Significantly worse	Trolley coach diff parts	No	Significantly more	Less capacity	Frequently; non plated parts	Designed poorly	Poor; never saw rep	Environmental benefits	Design of unit; odor of aqueous solution; parts rusting	water evaporates too fast	No
Randall Tom	About equal	Slightly worse	no	-	Significantly more	Less capacity	Frequently; all non-plated parts	Designed poorly; ribs on bottom of unit prevent some parts from resting flat	Poor; never came by	environmental benefits	Design of unit; Odor of aqueous solution; parts rusting	Yes; water evaporates quickly, must keep solution above minimum level at all times	No
Mario K. Paz	About equal	About the same	not sure	not sure	Slightly more	About equal	Occasionally: internal parts	-	Not able to evaluate	Health & safety benefits; environmental benefits, no solvent odor	Parts rusting	No	Yes

FINAL SURVEY FORM RESPONSES

Unit: GlobalSonics Grease Monkey Senior

MUNI Facility: Woods

Shop: Heavy Duty

User Name	Level of Use	Cleaning Performance			Cleaning Labor and Capacity			Unit Design	Vendor Service	Overall			
		Compare	Cannot Clean	Surprises	Requirement	Capacity	Rusting			Like best	Like least	O&M Problems	Recommend
(Illegible)	About equal	About the same	-	-	slightly less	about equal	never	Designed adequately	adequate	Parts cleaning ability	-	No	Yes
David Lau	Less	Slightly worse	Grease	-	slightly more	about equal	never	Designed adequately	Poor	Health and safety benefits, environmental benefits	Parts cleaning ability, noisy	Pump got plugged once	No
S. Fong	More	Slightly better	-	-	significantly less	-	-	Designed adequately	adequate	Parts cleaning ability; health and safety benefits	noisy	Yes	
Mark Mayes	More	Slightly better	-	-	significantly less	greater capacity	-	Designed adequately	Poor; need more detergent	Parts cleaning ability, design of unit, health and safety benefits, environmental benefits, no solvent odor	-	No	Yes
Leslie Humphrey	More	Significantly better	-	-	slightly less	about equal	-	Designed adequately	adequate	parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Yes
Kyin Fong	More	Significantly better	-	-	about the same	about equal	-	Designed adequately	-	Health and safety benefits, environmental benefits; No solvent odor	Too noisy	No	Yes
Kwee Soon Lee	More	Significantly better	-	-	slightly less	greater capacity	-	Designed adequately	-	Parts cleaning ability, design of unit, health and safety benefits, environmental benefits, no solvent odor	noisy	No	No
Richard A. Fonseca	More	slightly better	-	-	slightly less	-	-	-	-	-	-	-	-
Charles Ortega	Less	About the same	not sure - haven't tried on everything yet	no	about the same	about equal	never (I've been blow-drying parts w/air)	Designed adequately	-	-	parts have to soak too long	No	not sure
Paul Yee	More	Slightly worse	heavy grease on bearings	no	slightly more	greater capacity	-	-	-	-	-	-	-

FINAL SURVEY FORM RESPONSES

**Unit: Gray Mills Biomatic**  
**MUNI Facility: Potrero**  
**Shop: Heavy Duty**

User Name	Level of Use	Cleaning Performance	Cannot Clean	Surprises	Labor Requirement	Aqueous Solution			Unit Design	Vendor Service	Overall			
		Compare				Odor	Rusting	Other			Like best	Like least	O&M Problems	Recommend
A. Komala	About equal	Slightly better	-	-	Slightly less	Neutral	Occasionally	-	Adequate	Adequate	Heated cleaning solution	Odor of aqueous solution	Yes. Plumbing parts	Yes
Michael Militaute	About equal	Slightly better	-	-	Slightly less	Unpleasant	Occasionally	-	Adequate	Adequate	Heated cleaning solution	Odor of aqueous solution	Yes. Plumbing parts	Yes
Gary Mar	Less	Significantly better	-	-	Significantly less	Pleasant	Never	-	Adequate	Adequate	Parts cleaning ability	Odor of aqueous solution	No	Yes
Albert Ng	More	About the same	Hard encrusted grime	Light grease/oils	Slightly more	Pleasant	Tools, wrenches, sockets	-	Designed poorly; lines too short/fragile	Adequate	Health and safety benefits	Parts rusting	No	Yes
William Wong	About equal	Slightly worse	No	No	Slightly more	Unpleasant	Never	-	designed adequately	adequate	Environmental benefits	Odor of aqueous solution	No	Yes
Jank Ng	About equal	Slightly better	-	-	Significantly less	Neutral	-	-	-	-	-	-	-	-
<b>MUNI Facility: Green</b>														
<b>Shop: Machine</b>														
Mario R. Paz	About equal	About the same	Don't know	No	About the same	Pleasant	Never	Aqueous solution feels safer	Inadequate design; Plastic valves to fragile	Not able to evaluate	Health and safety benefits	Design of Unit	Yes; aqueous solution's distribution fittings are poor quality	Definitely no
MI	About equal	Slightly better	No	No	About the same	Neutral	Occasionally	-	Designed poorly; cheap	Poor; Never showed up to fix unit	Health and safety benefits; No solvent odor	Parts rusting	Yes; did not work half the time	No
Gary Tisell	Less	About the same	Yes; carbon build-up	-	About the same	Pleasant	Occasionally	-	Designed poorly; hose plumbing fell apart twice	Poor; no response	No solvent odor	Design of Unit	Hose fittings continually breaking	No

FINAL SURVEY FORM RESPONSES

Unit: KleenTec KT4000

MUNI Facility: Woods

Shop: Heavy Duty

User Name	Level of Use	Cleaning Performance Compare	Cannot Clean	Surprises	Cleaning Labor and Capacity		Unit Design	Vendor Service	Overall				
					Requirement	Capacity			Rusting	Like best	Like least	O&M Problems	Recommend
Harry Chin	Less	About the same	-	No	Slightly more	About equal	Never	Designed adequately	Not able to evaluate	Health & safety benefits; environmental benefits, no solvent odor	Parts cleaning ability	No	Definitely No
John Tom	Less	Significantly worse	-	No	Slightly more	Less capacity	Occasionally	Designed adequately	Poor	Health & safety benefits; environmental benefits	Parts cleaning ability	No	Definitely No
Romeo Camposagrado	Less	Slightly worse	-	No	Significantly more	Less capacity	Never	Designed adequately	Not able to evaluate	Health and safety benefits; environmental benefits	Parts cleaning ability	Yes; oil belt stretch	Definitely No
Simon Fong	Less	Slightly worse	-	No	Slightly more	About equal	Never	Designed adequately	Not able to evaluate	No solvent odor	Parts cleaning ability	No	Definitely No
John Tai	Less	Significantly worse	everything	-	Significantly more	About equal	Occasionally	Designed adequately	Poor	Option to immerse and soak parts; design of unit; health and safety benefits; environmental benefits	-	Yes	Definitely No
Mario K. Paz	Less	Significantly worse	-	No	About the same	Less capacity	Never	Designed adequately	Not able to evaluate	Environmental benefits	Parts cleaning ability	Yes; circuit breaker problem	Definitely No



FINAL SURVEY FORM RESPONSES

Unit: Landa SJ-10  
MUNI Facility: Woods  
Shop: Heavy Duty

User Name	Level of Use	Cleaning Performance	Cannot Clean	Surprises	Cleaning Labor and Capacity	Capacity	Rusting	Unit Design	Vendor Service	Overall			
		Compare			Requirement					Like best	Like least	O&M Problems	Recommend
Simon Fong	More	Significantly better	no		Significantly less	Greater capacity	Never	Designed well	Adequate	Automated cleaning of parts; parts cleaning ability; health and safety benefits; no solvent odor	-	No	Definitely yes
John Tai	More	Significantly better	no	-	Significantly less	About equal	Occasionally	Designed adequately	Adequate	No solvent odor	-	No	Definitely yes
R Fonseca	More	Slightly better	no	-	Significantly less	Greater capacity	Never	Designed well	Adequate	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Definitely yes
Romeo Camposagrado	More	Slightly better	no	-	Slightly less	About equal	Never	Designed adequately	Good	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Definitely yes
John Tom	More	Significantly better	no	-	Significantly less	Greater capacity	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Definitely yes

FINAL SURVEY FORM RESPONSES

Harry Chin	More	Significantly better	no	-	Slightly less	Greater capacity	Never	Designed well	Adequate	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Definitely yes
George Vargas	More	Significantly better	no	-	Significantly less	About equal	Occasionally; steel	Designed adequately	Adequate	Parts cleaning ability, health and safety benefits, no solvent odor	Parts rusting	No	Yes
Lester Dong	More	Significantly better	no	wheel bearing grease	Slightly less	Greater capacity	Occasionally; wheel bearing	Designed adequately	Poor; did not service machine	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	Yes; water pump seal leak	Yes
Trong Vuong	More	Significantly better	no	wheel bearing grease	Slightly less	Greater capacity	occasionally	Designed adequately	Poor; did not service machine	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	Yes; water pump seal leaks	Yes
Spiro Zografos	More	Significantly better	no	grease and carbon build up	Significantly less	Greater capacity	Occasionally; steel parts, if you don't wash off soon	Designed well; oil skimmer	Not able to evaluate	Automated cleaning of parts; design of unit, health and safety benefits, environmental benefits, no solvent odor	Parts rusting	No	Definitely yes

FINAL SURVEY FORM RESPONSES

Unit: Megamate M30

MUNI Facility: Green

Shop: Machine

User Name	Level of Use	Cleaning Performance			Cleaning Labor and Capacity		Unit Design	Vendor Service	Overall				
		Compare	Cannot Clean	Surprises	Requirement	Capacity			Rusting	Like best	Like least	O&M Problems	Recommend
Bill Cotter	Less	Significantly worse	just about everything	a dusty part	About the same	Greater capacity	Frequently; end bells - steel	Adequate	Not able to evaluate	No solvent odor	Cleaning time	No	Definitely no
Joe Gauci	Less	Significantly worse	Grease and burnt deposits	slightly dirty parts	Slightly less	Greater capacity	Frequently; G.B. parts	Designed well; large capacity	Adequate	No solvent odor	Parts rusting	No	Yes
John Reimoneng	More	Slightly worse	(if the solution were stronger it would probably work much better)	trolley coach hubs packed with grease	About the same	Less Capacity	Frequently; any metal parts	Designed poorly; water level not always full	Poor; only saw vendor on day unit was delivered	Automated cleaning of parts	Parts rusting; water need to be filled daily	No	No
Randall Tom	Less	Significantly worse	Heavy, baked-on grease	-	Slightly more	Less Capacity	Frequently; all non-plated parts	Designed well; oil skimmer	Poor; only saw vendor on day unit was delivered	Automated cleaning of parts; design of unit, health and safety benefits, environmental benefits, no solvent odor	Parts cleaning ability, Parts rusting	Yes; water evaporates too quickly, must add water and soap frequently	No

FINAL SURVEY FORM RESPONSES

**Unit: Mirachem PW-40S**  
**MUNI Facility: Green**  
**Shop: Machine**

User Name	Level of Use	Cleaning Performance Compare	Cannot Clean	Surprises	Cleaning Labor and Capacity		Rusting	Unit Design	Vendor Service	Overall			
					Requirement	Capacity				Like best	Like least	O&M Problems	Recommend
Michael Barr	Less	Significantly worse	Burnt carbon deposits	No	Significantly more	Less capacity	Frequently; all parts, including aluminum developed deposits	Designed adequately	Not able to evaluate	Option to immerse and soak parts; design of unit	Parts cleaning ability; odor of aqueous solution; parts rusting	No	Definitely No
John Reimoneng	Less	Slightly worse	Trolley coach differential parts	No	Significantly more	Less capacity	Occasionally: metal parts	Designed well; oil skimmer	Poor; never saw him	Design of unit; Health & safety benefits	Odor of aqueous solution; parts rusting	Yes; constantly need to fill with water	No
Randall Tom	About equal	Slightly worse	Baked on synthetic grease (anderol)	will dissolve paint	Slightly more	Less capacity	Frequently; all non-plated parts	Designed adequately	Poor; never came by	Option to immerse and soak parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits	Odor of aqueous solution; parts rusting	Yes; water evaporates quickly	No
Mario K. Paz	About equal	About the same	not sure	not sure	About the same	About equal	-	Designed adequately	Not able to evaluate	Health & safety benefits; environmental benefits, no solvent odor	Parts rusting	No	Yes

**Unit: Safety-Kleen Model 90**  
**MUNI Facility: Woods**  
**Shop: Preventative Maintenance**

User Name	Level of Use	Cleaning Performance Compare	Cannot Clean	Surprises	Labor Requirement	Aqueous Solution			Unit Design	Vendor Service	Overall			
						Odor	Rusting	Other			Like best	Like least	O&M Problems	Recommend
Paul Attard	About equal	Significantly worse	Yes: grease	No	Significantly more	Neutral	Never	No	Designed adequately	Adequate	No solvent odor	Parts cleaning ability	No	No
Cooper James	Less	About the same	Did not notice, since contaminants that were not cleaned were baked on, and even the regular solvent could not remove	Yes: build up of external sludge	Slightly more	Neutral	Occasionally	Clogs up too easy	Designed adequately	Good; Adequate	No solvent odor	Other: have not tested adequately, I like the solvent much better	Yes: clogs up	No

Note: Few workers completed final survey form due to minimal use.

FINAL SURVEY FORM RESPONSES

**Safety-Kleen Spray Cabinet (SJW-4)**

MUNI Facility: Potrero

Shop: Heavy Duty

User Name	Level of Use	Cleaning Performance Compare	Cannot Clean	Surprises	Cleaning Labor and Capacity		Unit Design	Vendor Service	Overall				
					Requirement	Capacity			Rusting	Like best	Like least	O&M Problems	Recommend
A. Komala	More	Significantly better	-	-	Significantly less	About equal	Occasionally	Adequate	Adequate	Automated cleaning of parts	-	No	Definitely yes
Michael Militaute	More	Significantly better	-	-	Significantly less	About equal	Occasionally	Adequate	Adequate	Automated cleaning of parts	Noise and foaming overflow	No	Definitely yes
Gary Mar	About equal	Significantly better	-	-	Significantly less	Greater capacity	Never	Adequate	Adequate	Parts Cleaning ability	Odor of aqueous solution	No	Yes
Albert Ng	About equal	Slightly worse	Small, intricate parts like gears and screens	-	About the same	Greater capacity	Frequently; bearings, sheet metal covers	Designed well; large capacity	Adequate	Automated cleaning of parts	Parts rusting	Yes; Foaming	Yes
Jack Ng	About equal	Significantly better	-	-	Significantly less	Greater capacity	Frequently	Designed well	Good	Automated cleaning of parts; parts cleaning ability	Odor of aqueous solution	No	Definitely yes
William Wong	More	Significantly better	-	-	Slightly less	Greater capacity	Occasionally; iron	Adequate	Adequate	Automated cleaning of parts	Parts rusting	No	Yes

FINAL SURVEY FORM RESPONSES

**Safety-Kleen Spray Cabinet (TLW-2)**

MUNI Facility: Woods

Shop: Heavy Duty

User Name	Level of Use	Cleaning Performance			Cleaning Labor and Capacity			Unit Design	Vendor Service	Overall			
		Compare	Cannot Clean	Surprises	Requirement	Capacity	Rusting			Like best	Like least	O&M Problems	Recommend
Ernie Pellos	More	Significantly better	-	-	Significantly less	Greater capacity	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability; design of unit	-	No	Definitely yes
Kwe Soon Lee	More	Significantly better	-	-	Significantly less	Greater capacity	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability	-	No	Definitely yes
Bruce Heilman	More	Slightly better	-	-	Significantly less	About equal	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability; design of unit	-	No	Definitely yes
Spiro Zagraf (illegible)	More	Significantly better	-	-	Significantly less	Greater capacity	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability; design of unit	-	No	Definitely yes
John Tom	More	Significantly better	-	-	Significantly less	Greater capacity	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability; design of unit	-	No	Definitely yes
H. Sayasam	About equal	Slightly better	-	-	Slightly less	About equal	Occasionally	Adequate	Adequate	Health and safety benefits; Environmental benefits	-	No	Definitely yes
Lester Dong	More	Significantly better	-	Wheel bearing grease	Significantly less	Greater capacity	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Definitely yes

FINAL SURVEY FORM RESPONSES

Paul Yee	More	Slightly better	-	-	Slightly less	Greater capacity	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Definitely yes
Chuck Ortega	More	Significantly better	-	-	Significantly less	Greater capacity	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Definitely yes
David Lau	More	Significantly better	-	-	Significantly less	About equal	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Definitely yes
Troung (illegible)	More	Slightly better	-	-	Significantly less	Greater capacity	Never	Adequate	Good	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Definitely yes
S. Fong	More	Significantly better	-	-	Significantly less	About equal	Never	Designed well	Good	Automated cleaning of parts; parts cleaning ability; design of unit; health and safety benefits; environmental benefits; no solvent odor	-	No	Definitely yes

**APPENDIX E**

**SPENT AQUEOUS CLEANING SOLUTION  
LABORATORY ANALYSIS**

**(8 Pages)**





LABORATORY REPORT

Report Number : 990653  
Purchase Order : POHC99000326  
External No. : MUNI

DAVE WELLS  
OCSF DEPT OF PUBLIC HEALTH  
101 GROVE STREET ROOM 217  
SAN FRANCISCO CA 94102

Date Received : 29-OCT-98  
Date Completed : 18-NOV-98  
Date Sent : 18-NOV-98  
Page # 1 of 2

Sample Description : 2- LIQUID/BULK SAMPLES

Auto No.	Submitter Sample Number	Test Description	EPA Method	Result	Detection Limit	Units
170664	N9810271	Antimony	6010	<0.03	0.03	ug/L
		Arsenic	6010	<0.05	0.05	ug/L
		Barium	6010	<0.002	0.002	ug/L
		Beryllium	6010	<0.0003	0.0003	ug/L
		Cadmium	6010	<0.004	0.004	ug/L
		Chromium	6010	0.23	0.007	ug/L
		Cobalt	6010	<0.007	0.007	ug/L
		Copper	6010	<0.006	0.006	ug/L
		Lead	6010	0.04	0.04	ug/L
		Mercury	7470	<0.001	0.001	ug/L
		Molybdenum	6010	0.008	0.008	ug/L
		Nickel	6010	<0.015	0.015	ug/L
		Selenium	6010	<0.075	0.075	ug/L
		Silver	6010	<0.004	0.004	ug/L
		Thallium	6010	<0.04	0.04	ug/L
		Vanadium	6010	<0.008	0.008	ug/L
		Zinc	6010	<0.002	0.002	ug/L

EPA Methods 601/602

170665	N9810272	1,1,1 Trichloroethane	601	ND	0.50	ppb
		1,1,2 Trichloroethane	601	ND	1.0	ppb
		1,1,2,2 Tetrachloroethane	601	ND	0.50	ppb
		1,1-Dichloroethane	601	ND	0.5	ppb
		1,1-Dichloroethylene	601	ND	0.50	ppb
		1,2 Dichlorobenzene	602	ND	0.50	ppb
		1,2 Dichloropropane	601	ND	0.50	ppb
		1,2-Dichlorobenzene (o)	601	ND	0.50	ppb
		1,2-Dichloroethane	601	1.4	0.50	ppb
		1,3 Dichlorobenzene	602	ND	0.50	ppb
		1,3-Dichlorobenzene (m)	601	ND	0.50	ppb
		1,4 Dichlorobenzene	602	ND	0.50	ppb
		1,4-Dichlorobenzene (p)	601	ND	0.50	ppb



LABORATORY REPORT

Report Number : 990653

Page 1 2 of 2

Table with 7 columns: Auto No., Submitter Sample Number, Test Description, EPA Method, Result, Detection Limit, Units. Lists various chemical tests and their results for sample #9810272.

ND = Not Detected

Remarks : Sample(s) and sampling data as provided : by : DAVE WELLS

Analyst(s) : TL/ED/TS / TL / ED/TWS Ref :

California ELAP No.: 1406
AEMA Accreditation No.: 172
NVLAP Accreditation No.: 101384
AEMA ELAP Accreditation No.: 10985
LACSD Lab No.: 10125

Reviewed by: Thomas Shultz
Thomas Shultz

Technical Approval: Susan Rosenberg
Laboratory Director, Susan B. Rosenberg, CIH

10771 Noel St., Los Alamitos, CA 90720 714/220-3922 FAX 714/220-2081 e-mail hsa@earthlink.net

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LABORATORY REPORT

Report Number : 991155  
Purchase Order : PORC99000326  
External No. : MUNI/WOODS HVY MAINT

DAVE WELLS  
CCSF DEPT OF PUBLIC HEALTH  
101 GROVE STREET ROOM 217  
SAN FRANCISCO CA 94102

Date Received : 03-DEC-98  
Date Completed : 22-DEC-98  
Date Sent : 22-DEC-98  
Page 1 of 2

Sample Description : 1- LIQUID SAMPLE

Sample Number : M9811302 (174536)

Method of Analysis : Gas Chromatography (EPA 601/602)

EPA Method 601 Compound	Sample Concentration (ppb)	Detection Limit (ppb)
1,1,1 Trichloroethane	ND	0.50
1,1,2 Trichloroethane	ND	1.0
1,1,2,2 Tetrachloroethane	ND	0.50
1,1-Dichloroethane	ND	0.5
1,1-Dichloroethylene	ND	0.50
1,2 Dichloropropane	ND	0.50
1,2-Dichlorobenzene (o)	ND	0.50
1,2-Dichloroethane	ND	0.50
1,3-Dichlorobenzene (m)	ND	0.50
1,4-Dichlorobenzene (p)	ND	0.50
2-Chloroethylvinyl Ether	ND	0.50
Bromodichloromethane	ND	0.50
Bromoform	ND	0.50
Bromomethane	ND	0.50
Carbon Tetrachloride	ND	0.50
Chlorobenzene	ND	0.50
Chloroethane	ND	1.0
Chloroform	5.9	0.50
Chloromethane	ND	1.0
Dibromochloromethane	ND	0.50
Dichloromethane	ND	0.50
Tetrachloroethylene	ND	0.50
Trichloroethene	5.5	0.50
Trichlorofluoromethane	ND	1.0
Vinyl Chloride	ND	0.50
cis-1,3-Dichloropropene	ND	0.50

10771 Noel St., Los Alamitos, CA 90720 714/220-3922 FAX 714/220-2081 e-mail hsa@earthlink.net

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LABORATORY REPORT

Report Number : 991155

Page # 2 of 2

Sample Number : M9811302 (174516)

Method of Analysis : Gas Chromatography (EPA 601/602)

EPA Method 601 Compound	Sample Concentration (ppb)	Detection Limit (ppb)
trans-1,2-Dichloroethylene	ND	0.50
trans-1,3-Dichloropropene	ND	0.50

Sample Number : M9811302 (174516)

Method of Analysis : Gas Chromatography (EPA 601/602)

EPA Method 602 Compound	Sample Concentration (ppb)	Detection Limit (ppb)
1,2 Dichlorobenzene	ND	0.50
1,3 Dichlorobenzene	ND	0.50
1,4 Dichlorobenzene	ND	0.50
Benzene	ND	0.50
Chlorobenzene	ND	0.50
Ethyl Benzene	ND	5.0
Toluene	281	0.50
Xylenes-Total	3.2	1.0

Remarks : Sample(s) and sampling data as provided :  
by : DAVE WELLS

Analyst(s) : CEL

Ref :

California ELAP No.: 1406  
AIEA Accreditation No.: 172  
NVLAP Accreditation No.: 101384  
AIEA ELLAP Accreditation No.: 10985  
LACSD Lab No.: 10125

Reviewed by:

*Thomas Shultz*  
Thomas Shultz

Technical Approval:

Laboratory Director, Susan B. Rosenberg, CIH

10771 Noel Sr., Los Alamitos, CA 90720 714/220-3922 FAX 714/220-2081 e-mail hsa@earthlink.net

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## LABORATORY REPORT

Report Number : 991154  
 Purchase Order : PORCS9000326  
 External No. : MONT/WOODS ENVY MAINT

DAVE WELLS  
 CCSF DEPT OF PUBLIC HEALTH  
 101 GROVE STREET ROOM 217  
 SAN FRANCISCO CA 94102

Date Received : 03-DEC-98  
 Date Completed : 25-JAN-99  
 Date Sent : 19-JAN-99  
 Page # 1 of 1

Sample Description : 1- LIQUID SAMPLE

Method of Extraction : Microwave (EPA 3051 - modified)

Method of Analysis : Inductively coupled argon plasma, atomic emission spectroscopy (EPA 6010)

Auto No.	Submitter Sample Number	Test Description	EPA Method	ppm	Detection Limit	Maximum Contaminant Level
174515	M9811301	TTLIC Antimony	6010	12	0.3 ppm	500 ppm
		TTLIC Arsenic	6010	<0.5	0.5 ppm	500 ppm
		TTLIC Barium	6010	12	0.03 ppm	10000 ppm
		TTLIC Beryllium	6010	0.11	0.03 ppm	75 ppm
		TTLIC Cadmium	6010	1.6	0.05 ppm	100 ppm
		TTLIC Chromium	6010	6	0.07 ppm	2500 ppm
		TTLIC Cobalt	6010	1.8	0.07 ppm	8000 ppm
		TTLIC Copper	6010	27	0.06 ppm	2500 ppm
		TTLIC Lead	6010	<5	5 ppm	1000 ppm
		TTLIC Mercury	7471	<0.2	0.2 ppm	20 ppm
		TTLIC Molybdenum	6010	9.4	0.08 ppm	3500 ppm
		TTLIC Nickel	6010	50	0.15 ppm	2000 ppm
		TTLIC Selenium	6010	<0.75	0.75 ppm	100 ppm
		TTLIC Silver	6010	45	0.08 ppm	500 ppm
		TTLIC Thallium	6010	<0.5	0.5 ppm	700 ppm
		TTLIC Vanadium	6010	6.4	0.1 ppm	2400 ppm
		TTLIC Zinc	6010	37	0.03 ppm	5000 ppm

Note: Composite waste samples are inherently non-homogeneous. Therefore, TTLIC, TCLP & STLC results on different sub-sections of the sample may not be comparable.

Remarks : Sample(s) and sampling data as provided :  
 by : DAVE WELLS

Analyst(s) : TZ / TMS

Ref : TZ\_1595

California ELAP No.: 1406  
 ATEA Accreditation No.: 172  
 NVLAP Accreditation No.: 101384  
 ADMA ELLAP Accreditation No.: 10985  
 LACSD Lab No.: 10125

Reviewed by:

*Thomas Shultz*  
 Thomas Shultz

Technical Approval:

Laboratory Director, Jaime Steedman-Lyde

10771 Noel St., Los Alamitos, CA 90720 714/220-3922 FAX 714/220-2081 e-mail hsa@earthlink.net

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**LABORATORY REPORT**

Report No. 991266

Sample Description : 1 Bulk Liquid - Woods/ Randall Mrs.

Method of Analysis: Gas Chromatography EPA 601/602

Results

EPA Method 602 Compound	Sample Concentration ppb	Detection Limit ppb
Benzene	ND	0.50
Chlorobenzene	ND	0.50
1,2 Dichlorobenzene	<0.50	0.50
1,3 Dichlorobenzene	ND	0.50
1,4 Dichlorobenzene	<0.05	0.50
Ethylbenzene	ND	5.0
Toluene	<0.50	0.50
Xylenes- Total	ND	10.0

ND = Not Detected

EPA Method 413.1	Oil and Grease	Sample Concentration	Detection Limit
Sample No. 175313		9,067 ppm	10 ppm

Sample and sampling data as provided  
by: Dave Wells

Analyst: TMS/ED

Reviewed by: Thomas Shultz  
Thomas Shultz

California ELAP No. 1406  
AIEA Accreditation No. 172  
LAUSD Lab No. 10125

Technical Approval: \_\_\_\_\_  
Laboratory Director, Susan B. Rosenberg

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## LABORATORY REPORT

Report No. 991266  
Purchase Order :

DAVE WELLS  
CCSF DEPT OF PUBLIC HEALTH  
101 GROVE STREET ROOM 217  
SAN FRANCISCO, CA. 94102

Date Received : 11-DEC-98  
Date Completed : 12-JAN-99  
Date Sent : 12-JAN-99

Sample Description : 1 Bulk Liquid - Woods/ Randall Mvs.

Method of Analysis: Gas Chromatography EPA 601/602

### Results

EPA Method 601 Compound	Sample Concentration ppb	Detection Limit ppb
Bromodichloroethane	ND	0.50
Bromoform	ND	0.50
Carbon Tetrachloride	ND	0.50
Chlorobenzene	ND	0.50
Chloroethane	ND	1.0
Chloroform	ND	0.50
2-Chloroethylvinyl Ether	ND	0.50
Chloromethane	ND	1.0
Dibromochloroethane	ND	0.50
1,2-Dichlorobenzene (o)	ND	0.50
1,3-Dichlorobenzene (m)	ND	0.50
1,4-Dichlorobenzene (p)	ND	0.50
1,1-Dichloroethane	ND	0.50
1,2-Dichloroethane	ND	0.50
1,1-Dichloroethylene	ND	0.50
trans-1,2-Dichloroethylene	ND	0.50
1,2-Dichloropropane	ND	0.50
Bromomethane	ND	1.0
cis-1,3-Dichloropropene	ND	0.50
trans- 1,3-Dichloropropane	ND	1.0
Methylene Chloride	ND	0.50
Tetrachloroethane (1,1,2,2)	ND	0.50
Tetrachloroethylene	ND	0.50
Trichloroethane (1,1,2)	ND	1.0
Trichloroethene	ND	0.50
Vinyl Chloride	ND	0.50
Trichloroethane (1,1,1)	ND	0.50

ND = Not Detected

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## LABORATORY REPORT

Report Number : 991265  
Purchase Order : POHC99000326  
External No. : NUNI/REC & PARKS

DAVE WELLS  
CCSP DEPT OF PUBLIC HEALTH  
101 GROVE STREET ROOM 217  
SAN FRANCISCO CA 94102

Date Received : 11-DEC-98  
Date Completed : 11-JAN-99  
Date Sent : 31-DEC-98  
Page # 1 of 2

Sample Description : 2- LIQUID SAMPLES

Method of Extraction : Microwave (EPA 3051 - modified)

Method of Analysis : Inductively coupled argon plasma, atomic emission spectroscopy (EPA 6010)

Auto No.	Submitter Sample Number	Test Description	EPA Method	ppm	Detection Limit	Maximum Contaminant Level
175310	N9812101	TTLc Antimony	6010	33.7	0.3 ppm	500 ppm
		TTLc Arsenic	6010	<0.5	0.5 ppm	500 ppm
		TTLc Barium	6010	48.8	0.03 ppm	10000 ppm
		TTLc Beryllium	6010	0.62	0.03 ppm	75 ppm
		TTLc Cadmium	6010	7.7	0.05 ppm	100 ppm
		TTLc Chromium	6010	24.8	0.07 ppm	2500 ppm
		TTLc Cobalt	6010	6.6	0.07 ppm	8000 ppm
		TTLc Copper	6010	81.4	0.06 ppm	2500 ppm
		TTLc Lead	6010	0.36	0.02 ppm	1000 ppm
		TTLc Mercury	7471	<0.2	0.2 ppm	20 ppm
		TTLc Molybdenum	6010	85.5	0.08 ppm	3500 ppm
		TTLc Nickel	6010	94.4	0.15 ppm	2000 ppm
		TTLc Selenium	6010	<0.75	0.75 ppm	100 ppm
		TTLc Silver	6010	93.7	0.08 ppm	500 ppm
		TTLc Thallium	6010	<0.5	0.5 ppm	700 ppm
		TTLc Vanadium	6010	19.2	0.1 ppm	2400 ppm
		TTLc Zinc	6010	173	0.03 ppm	5000 ppm

10771 Noel St., Los Alamitos, CA 90720 714/220-3922 FAX 714/220-2081 e-mail hsa@earthlink.net

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**APPENDIX F**

**TESTING LABORATORIES APPROVED BY  
THE DEPARTMENT OF BUILDING INSPECTION**

**(2 Pages)**



## **DEPARTMENT OF BUILDING INSPECTION**

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**City & County of San Francisco**

**1660 Mission Street, San Francisco, California 94103-2414**

### **TESTING LABORATORIES APPROVED IN SAN FRANCISCO**

The following testing laboratories are recognized as approved by the San Francisco Department of Building Inspection for the testing and labeling of electrical products and devices in San Francisco.

Underwriters Laboratories (UL) , or ETL Testing Laboratories Inc., or Applied Research Laboratories (ARL) , and Factory Mutual (FM).

American Gas Association Laboratories (AGA) has been approved to test and label gas appliances and accessories.

Gas Appliance Laboratories, Inc. (GAL) has been approved for testing and labeling of gas appliances, gas vents, accessories and systems in accordance with UL795, solid fuel burning appliances in accordance with UL 1482, wind and rain testing and UL 737.

Electra Test Incorporated (ETI) has been approved for testing and labeling custom made or a unique electrical product as described in Division G, Article 90-78 of the San Francisco Electrical Code.

Underwriters Laboratories (UL)  
1655 Scott Bl.  
Santa Clara, CA 95050  
(408) 985-2400

ETL Testing Laboratories  
660 Forbes Bl.  
So. San Francisco, CA 94080  
(415) 871-1414

Main office:  
Industrial Park  
Cortland, NY 13045  
(607) 753-6711

Applied Research Laboratories (ARL)  
8751 Jemstone Ct.  
Elk Grove, CA 94524  
(916) 685-5144  
Main office:  
5372 NW 161st St.  
Miami, FL 33014  
(305) 624-4800

Electra-Test Inc. (ETI)  
P.O. Box 159  
3470 Fostoria Way  
San Ramon, CA 94583  
(510) 866-8566

American Gas Assn. (AGA)  
8501 E. Pleasant Valley Rd.  
Cleveland, OH 44131  
(216) 524-4990

Gas & Mechanical Laboratory  
3230 Mines Ave.  
Los Angeles, CA 90023  
(213) 262-1185

MET Electrical Testing Co.  
916 W. Patapaco Ave.  
Baltimore, MD 21230  
(301) 354-2200

**TESTING LABORATORIES APPROVED IN SAN FRANCISCO**

**PAGE 2**

Factory Mutual Research (FM)  
1151 Boston-Providence Turnpike  
Norwood, MA 02062  
(6 17) 762-4300

Power Systems Testing Co.  
2267 Clarmont Court  
P.O. Box 6005  
Hayward, CA 94545  
(5 10) 783-5096

Gas Appliance Laboratories  
3183 E. Olympic Bl.  
Los Angeles, CA 90023  
(213) 261-8161

Canadian Standards Association  
(CSA)  
13799 Commerce Parkway  
Richmond, BC Canada V6V 2N9  
(604) 273-4581  
(604) 273-5815 (FAX)

REVISED: 9/25/95

LABORATO