

**SILVER REDUCTION**  
**IN**  
**PHOTOCHEMICAL SOLUTIONS**  
**USING**  
**PUREFLOW PF-16 COLUMNS**

**By**

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## **Executive Summary:**

ECS Refining has developed PF-16 Pureflow steel wool columns, a significant advancement in the treatment of photochemical solutions. The benefits of Pureflow columns include:

- Silver Discharge concentrations 2.5-10 times lower than that of conventional Steel Wool columns
- A Capacity 1.5 - 4 times higher than conventional steel wool columns (Volume Treated and Silver recovered)
- Developer Tolerance in Mixed Photochemical Solutions (Fixer, Blix, Developer)
- Elimination of drain clogging caused by iron hydroxide
- The technology is transparent to the user. Pureflow columns look like conventional columns, and use the same pump stations.

Long term studies at a number of actual mini-labs have shown that Pureflow PF-16 columns collected significantly more silver while maintaining a lower silver discharge concentration relative to standard steel wool columns. Further, Pureflow PF-16 columns are the only available columns able to treat the combined photochemical solutions from film and print operations and maintain a 0.40 mg/l silver discharge and 250 troy ounce capacity. In addition to their performance, Pureflow PF-16 columns keep drains cleaner by preventing rust from attaching to the drain surface. Converting to Pureflow PF-16 columns is as simple as changing conventional columns, taking as little as 20 minutes.

## **Introduction:**

The recovery of silver from photochemical solutions is an important process that has significant environmental and economic ramifications. Conventional steel wool columns have arguably been the most effective treatment of silver in photochemical solutions among the currently available treatment choices. Steel wool is inexpensive, readily available, and easy to handle. However, steel wool has several weaknesses. First, it will not successfully treat photochemical solutions with developer. Second, it causes costly drain clogging problems. Third, it is not a dependable method for consistently achieving silver discharge limits below 1.0 mg/l. Finally, steel wool columns fail unpredictably, which makes the replacement schedule and silver content unpredictable. Pureflow PF-16 columns are a dramatic improvement over standard steel wool columns because all of the benefits are retained and all of the above limitations are eliminated.

## Product Description:

Pureflow columns are the same size and shape as steel wool columns. They use the same metering pump as standard steel wool columns, making the switch to Pureflow completely transparent to the user. The only differences between a standard steel wool column and a Pureflow column are the internal configuration and proprietary chemical technology.

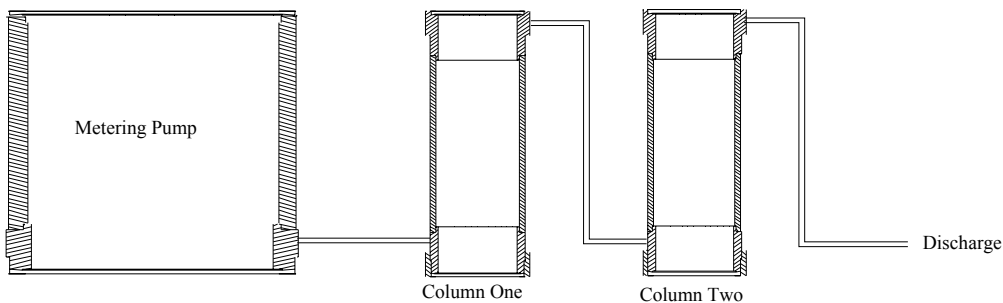


Figure 1. This is a schematic of a silver recovery column installation, using either conventional or Pureflow PF-16 columns. Switching to Pureflow PF-16 columns is accomplished by simply replacing the columns; no other equipment changes are required.

The Pureflow Silver Recovery System consists of a pump station and two columns, which are connected in series. The basic operation of the Pureflow System is the same as a typical steel wool metallic replacement silver recovery system. Specifications for the pump station and columns are as follows:

### Pump Station:

The pump station consists of a feed tank, a feed pump delivering pressure of at least 15 psig with a flow rate of 1 gallon per hour, and a secondary containment vessel with a volume of at least 5 gallons capable of containing two Pureflow columns. ECS Refining can supply pump stations with a 10 gallon feed tank, a self-priming bellows pump, and a high-level alarm with battery backup, having a footprint of 20 by 34 inches (including the secondary containment vessel).

### Pureflow Columns:

The nominal outside dimensions of each Pureflow column are 8.5" by 26". The columns are designed for a maximum flow rate of 1 gallon per hour, 24 hours per day, 7 days per week. For applications where the peak rate of solution generation is greater than 20 gallons per 10 hour work day, the size of the feed tank should be increased to equalize the flow rate over a 24 hour period. Where the average flow rate exceeds 24 gallons per day, 2 or more sets of columns operated in parallel are required.

The columns are single-use, and have a bottom-in, top-out configuration. The inlet and outlet are fitted with ½” female NPT fittings. The installation of sampling valves between the primary and second columns and following the second column are recommended.

Pureflow PF-16 columns are intended to be used only in pairs plumbed in series; one as the primary column and one as the secondary or tailing column. PF-16 columns are designed to be used first as the secondary or tailing column, then as the primary column. The performance of PF-16 columns as the primary column following their use as the secondary column (downstream from another PF-16 column for a maximum flow of 1,600 gallons of waste photochemical solution containing 1,500 ppm of silver, or one year, whichever occurs first) is comparable to the performance shown in the examples below.

### **Sampling and Analysis Procedures**

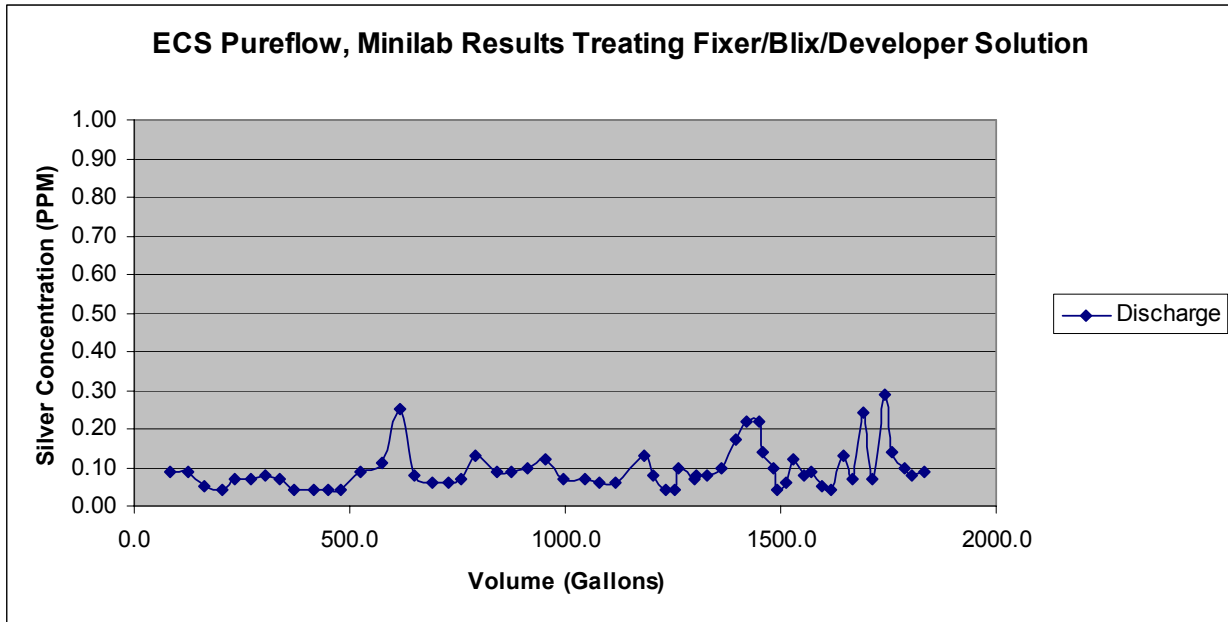
All samples were taken directly after the second column. Sample from Locations 2-4 below were analyzed within 4 hours. The sample from Location 1 was analyzed within 48 hours, due to the distance of the location from the lab.

Analysis of silver was performed by flame atomic absorption using EPA Method 272.1/7760 and a Perkin-Elmer Model 3110 Spectrometer.

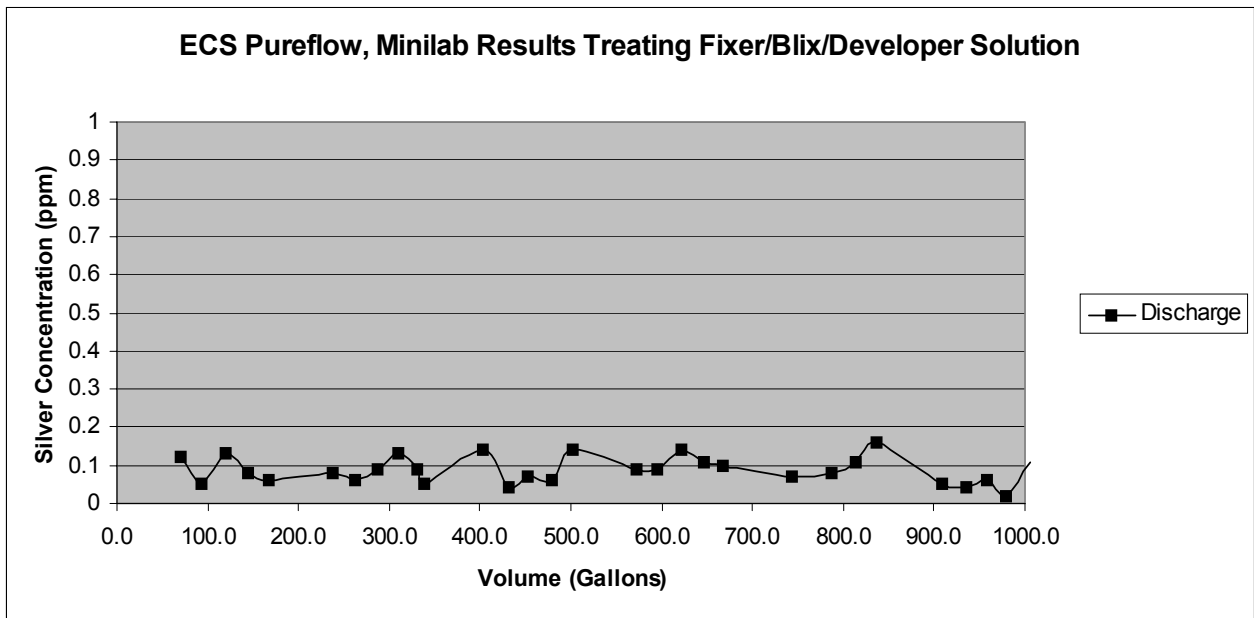
### **Product Performance:**

Pureflow PF-16 columns are installed in over one thousand mini-labs nation wide. In all cases, PF-16 columns treat a mixture of fixer, blix, and developer. Analysis of the silver concentration in the discharge from these stores shows that PF-16 column systems will treat solution from major manufacturers (e.g. Kodak, Fuji, Agfa) including high and low flow versions (e.g. C41/RA-4, CN-16S/CP-48S, SM). The following graphs are representative data from four stores (see graphs for Test Locations 1 – 4 below). This data supplements the reported data from 50 former haul sites tested by San Francisco Bay area municipalities. Further, ECS Refining has successfully batch processed over 2 million gallons of mixed photochemical solution using Pureflow technology at its Santa Clara facility to a silver discharge limit of 0.7 mg/l.

**Test Location Data:**

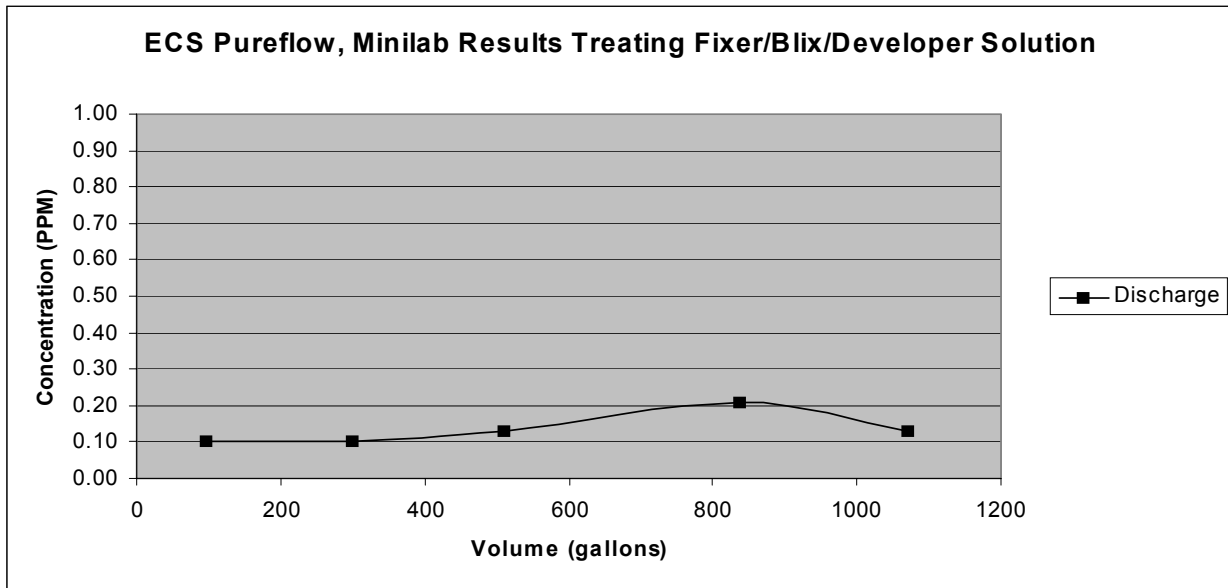


**Location 1.** This is data from a minilab processing Fuji C41/RA-4 chemistry on a Fuji 340 with a standard PF-16 column system (see Figure 1). The columns processed 1,833 gallons with an average silver discharge of  $0.09 \pm 0.05$  mg/l. The average silver concentration of the feed solution is 1,500 mg/l. Each diamond represents an individual sample result.

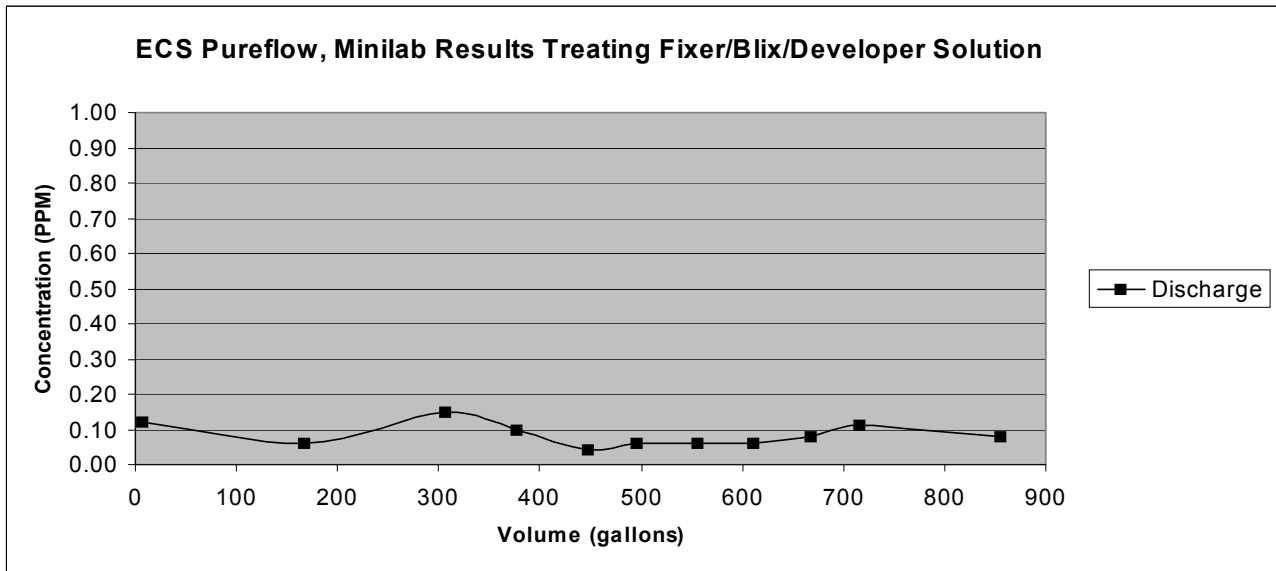


**Location 2.** This is data from a minilab processing Fuji C41/RA-4 chemistry on a Fuji 350 with a standard PF-16 column system (see Figure 1)\*. The columns processed 1,005 gallons with an average silver discharge of  $0.09 \pm 0.04$  mg/l. The average silver concentration of the feed solution is 2,400 mg/l. Each square represents an individual sample result.

\* Solution collected from Location 2 and processed at ECS to allow for 24 hour processing.



**Location 3.** This is data from a minilab processing Fuji Frontier (CN-16S/CP-48S) chemistry on a Fuji 363 with a standard PF-16 column system (see Figure 1). The columns processed 1,070 gallons with an average silver discharge of  $0.09 \pm 0.05$  mg/l. The average silver concentration of the feed solution is 2,550 mg/l. Each square represents an individual sample result. Discharge samples were taken less frequently during this test because earlier tests had demonstrated that discharge silver concentrations from Pureflow PF-16 columns are very stable.



**Location 4.** This is data from a minilab processing Fuji Frontier (CN-16S/CP-48S) chemistry on a Fuji 363 with a standard PF-16 column system (see Figure 1). The columns processed 855 gallons with an average silver discharge of  $0.08 \pm 0.04$  mg/l. The average silver concentration of the feed solution is 2,800 mg/l. Testing stopped due to store closure. Each square represents an individual sample result.

## Summary of Discharge Concentrations

<u>Location</u>	<u>Discharge (mg/l Ave.)</u>	<u>Gallons Treated</u>	<u>Feed Ag (mg/l)</u>	<u>Chemistry</u>
1	0.09 ± 0.05	1833	1,500	C-41/RA4
2	0.09 ± 0.04	1005	2,400	C-41/RA4
3	0.09 ± 0.05	1070	2,550	Fuji Frontier
4	0.08 ± 0.04	855	2,800	Fuji Frontier

## Discussion:

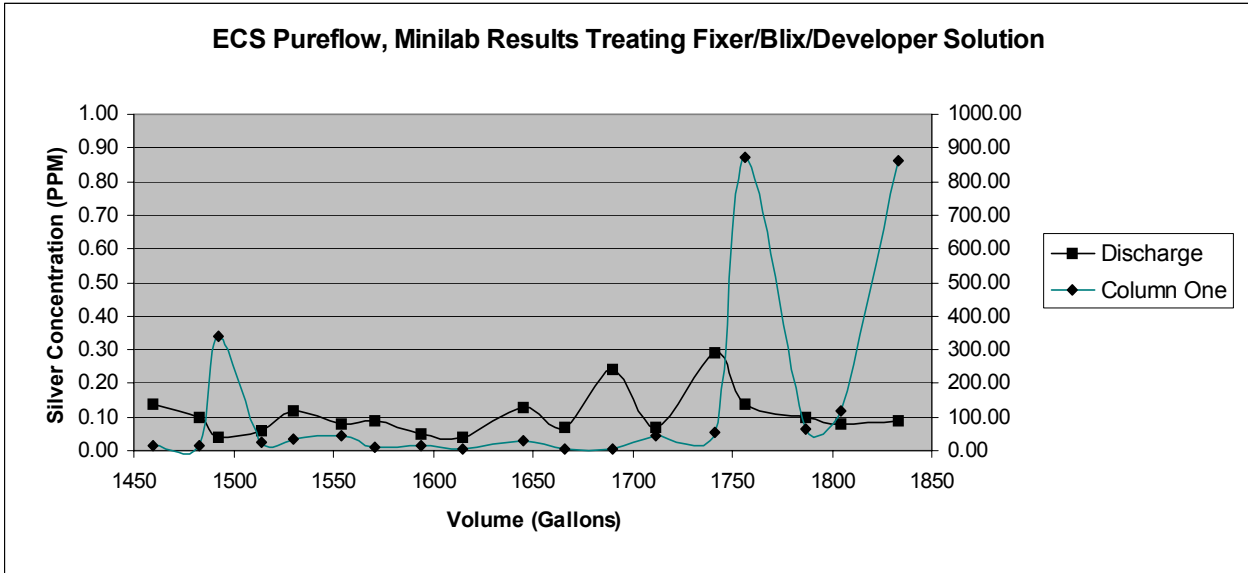
The removal of silver from mixed photochemical solution using Pureflow PF-16 columns is effective in achieving maximum silver discharge concentrations below 0.40 mg/l. The results from the four test locations listed above show that the average discharge silver concentration is ~0.09 (mg/l). This average is maintained despite variations in feed silver concentration, replenishment chemistry, or pump station duty cycle.

These four locations are divided into high and low replenishment rate chemistries. Locations 1 and 2 use C-41/RA4 Chemistry with different replenishment flow rates. The result is that the silver concentrations for the waste photochemical solutions are substantially different. The lower flow rate at Location 2 produces a 2,400 mg/l silver solution compared to a 1,500 mg/l silver solution for Location 1. However, this variation in feed silver concentration produced the same average silver discharge of 0.09 mg/l with maximum discharges less than 0.30 mg/l silver. Locations 3 and 4 are much closer in feed silver concentration to the recovery system, and essentially have the same average discharge concentration of 0.08 – 0.09 mg/l silver. Location 4 was closed and the PF-16 columns were removed before the primary column reached capacity. This store does have a slightly lower average discharge concentration, and this may reflect the premature removal.

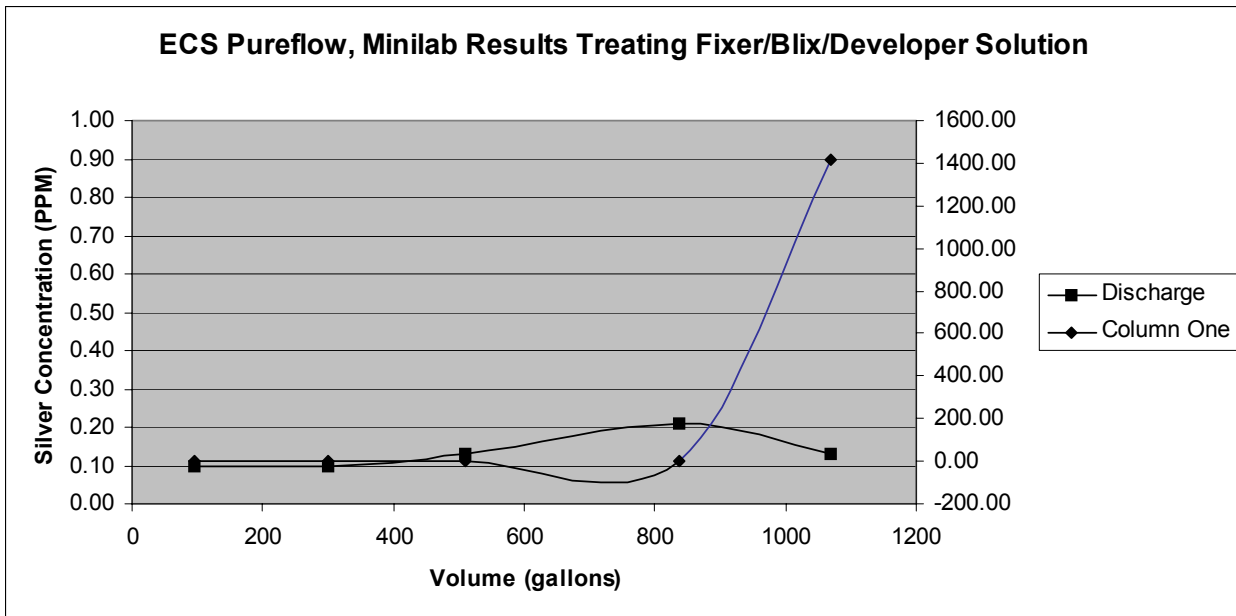
Regardless of location, the average silver discharge concentrations are essentially the same, 0.09 mg/l, with similar small standard deviations. Clearly, small standard deviations are due to small variations in the discharge silver concentration over the life of the first column. A unique benefit of Pureflow PF-16 columns is the ability of the second column to compensate when the first column has substantially failed by maintaining a low discharge. The following graphs demonstrate this effect by including the column one silver concentration data. Graph 1 displays excerpted data from Location 1. This graph demonstrates that even when the primary column silver discharge concentration exceeds 800 mg/l, the discharge from the second column is maintained below 0.30 mg/l silver. Graph 2 (data for Location 3) also shows that the second column maintains a low silver discharge concentration while the primary column discharge concentration exceeds 1,400 mg/l silver.

The practical result of the ability of the second Pureflow PF-16 column to maintain a low silver discharge concentration, even when the primary column fails, is system dependability and improved discharge compliance. Pureflow PF-16 columns can be operated to the predicted failure of the primary column without risking a discharge violation. This dependability allows ECS to rate its PF-16 columns at 500,000 clicks (or

one year, whichever occurs first). The PF-16 column rating for discharge is 0.40 mg/l silver while treating the normal photochemical solution from film and print processing (fixer, bleach-fix, and developer).



Graph 1. This is an excerpt of the data presented for Location 1 showing the discharge concentrations from each individual column. The primary column (Column One) data is read from the right side scale. The data shows that the primary column discharge may exceed 800 mg/l silver, but the second column discharge concentration never exceeds 0.30 mg/l silver.



Graph 2. This is the data presented for Location 3 showing the discharge concentrations from each individual column. The primary column (Column One) data is read from the right side scale. The data shows that the primary column discharge may exceed 1,400 mg/l silver, but the second column discharge concentration never exceeds 0.30 mg/l silver.



An additional benefit to Pureflow columns is a dramatic reduction in costly drain clogging problems. Iron oxide buildup in drains is typical for standard steel wool column users, unless drain cleaning chemicals are used consistently. Eventually, the drains clog and need servicing. However, Pureflow columns maintain clean drains by preventing iron oxide buildup. The following visual demonstration shows an old chrome-plated pipe covered in rust before and after it is treated using the proprietary ingredient in Pureflow PF-16 columns (see Photographs 1 and 2). The first photograph is of the rust-covered pipe before treatment. The second photograph shows the same pipe after treatment. The treatment removed the rust to reveal the chrome surface beneath (with some imperfections).



1



2

Photographs 1 and 2: Photograph 1 is a chrome-plate pipe covered with rust. Photograph 2 is the same pipe after treatment with the proprietary ingredient in Pureflow PF-16 columns. The large dark spot in the middle of the pipe is the reflection of the camera (and photographer).

These photographs illustrate the power of Pureflow technology to prevent (and even clean) iron oxide from surfaces to which it is tightly bonded. The same reaction happens with iron oxide on the inside of a drain when Pureflow columns are operating. Clean drains can be kept clean using Pureflow PF-16 columns. In fact, some rust deposits may be removed.

### **Conclusion:**

Pureflow PF-16 columns represent a substantial improvement over conventional steel wool columns. In fact, they represent the next generation in silver treatment technology. The benefits of Pureflow PF-16 columns are summarized below. These benefits result in substantially lower operating and overhead costs for the user..

We believe that implementing the ECS Pureflow Silver Recovery Service generally provides a substantially better overall financial outcome compared to typical silver recovery vendors and provides you with many additional money-saving benefits as well, such as:

- **Best compliance in the industry** - Pureflow columns have *averaged less than 0.4 ppm Ag discharge* in over two years of in-store use, *an industry first*.

- **Developer tolerance** – No longer will your store personnel have to spend time, effort, and incur risks in handling developer separately from your bleach-fix solutions. *All* solutions can be simultaneously plumbed to Pureflow columns, *another industry first*.
- **Recover silver at costly haul sites** - Pureflow columns will enable you to realize enhanced value from the Ag in their photochemical solutions, rather than throw it away or more costly methods to recover Ag, *another industry first*.
- **Guaranteed column performance** - Pureflow columns are *guaranteed* to last for a minimum of 16,000 rolls or one (1) year, whichever comes first. Should a column fail to meet this guarantee, a new column will be provided at a prorated cost, *another industry first*.
- **Eliminate costly drain cleaning** - Proprietary Pureflow technology will sharply reduce, and ultimately eliminate the need for minilabs to use chemicals, plumbers, or demolition to maintain clean drains in their stores, *another industry first*.
- **Significantly reduce costly and disruptive column change-outs** - Pureflow columns last 100%-150% longer than typical columns.
- **Keep your employees in front of your customers:** - Pureflow technology is so worry-free that employees need not get bogged down with silver recovery, compliance, and solution handling, allowing them to spend more time doing what they do best, *providing quality service to the customers*.