Technical Memorandum 3
Pilot Study Results and Summary

Date: 2 September 2009

To: Ms. Amy Blain
City of Longview

From: Stephen Booth, Ph.D.

Reviewed by: William C. McCarthy, P.E.
Tom Peters, P.E.

Subject: City of Longview Granular Media Pilot Study: Results and Summary
Design of Groundwater Source and Regional Water Treatment Facilities
K/J 0997003*00

Introduction

Kennedy/Jenks Consultants performed a five-week pilot study using generic pilot equipment and raw source water from the Prudential Blvd. Well (formerly the Weber Ave. Well). Raw well water quality is presented in Table 1.

Table 1: Raw Well Water Quality (May 2009)

Parameter		Average Concentration
Target Contaminants		
Iron (mg/L)	Total	1.2
	Dissolved	< 0.02
Manganese (mg/L)	Total	0.601
	Dissolved	0.574
Arsenic (μg/L)	Total	12.7
	Dissolved	11.8
	As-III	6.54
	As-V	7.64
Other Water Quality		
pH		7.8
Alkalinity (mg/L as $CaCO_3$)		130
Temperature (°C)		12
Hardness (mg/L as $CaCO_3$)		112
Total Dissolved Solids (mg/L)		201
Conductivity (μMhos/cm)		307

Parameter	Average Concentration
Color (color units)	5
Total organic carbon (mg/L)	1.8
Dissolved organic carbon (mg/L)	1.6
Total Silicon (mg/L)	25.0
Fluoride (mg/L)	< 0.2
Chloride (mg/L)	12
Nitrate (mg/L)	0.3
Sulfate (mg/L)	0.35
Phosphate (mg/L)	0.55

Notes: mg/L = milligrams per liter
μg/L = micrograms per liter
°C = degrees Celsius
$CaCO_3$ = calcium carbonate
μMhos/cm = micromhos per centimeter

Objective

The purpose of the pilot test was to determine if any of three selected granular media, Greensand, Greensand Plus, or silica sand, could successfully treat the raw groundwater to remove iron, manganese, and arsenic and achieve the finished water quality goals presented in Table 2.

Table 2: Proposed Pilot Study Filtered Water Quality Goals

Parameter	Water Quality Goal	MCL	SMCL
Total Iron	≤ 0.05 mg/L	-	0.3 mg/L
Total Manganese	≤ 0.02 mg/L	-	0.05 mg/L
Total Arsenic	≤ 5 μg/L	10 μg/L	-

Note: MCL = maximum contaminant level
SMCL = secondary maximum contaminant level

Pilot Test Method

The method of conduct of this pilot test is covered in the Pilot Testing Protocol, presented in Appendix 1. From that protocol the following summarizes the pilot testing method:

- Raw well water was pumped from the source well
- Chlorine and/or potassium permanganate, and ferric chloride during selected runs, were added to the filter influent stream
- Filter influent water flowed first to a filter feed tank. The filter feed tank provided approximately 6 minutes of contact time.
- Raw water was then pumped to the three pilot filter columns running in parallel. The pilot filter columns were pressurized and thus operated in a similar fashion as pressure vessels that are typically used to treat iron, manganese, and arsenic.

- Filter effluent, or finished water, flowed to a large bucket where dechlorination chemical was added – then discharged to an adjacent drainage ditch which drained into the City stormwater collection system.

Filter Run Terminology. In conducting a filtration pilot test one of the objectives of the testing is to determine optimum *filter run time* and operational parameters that facilitate achieving optimum filter run time. This data is then used in designing the full scale treatment plant. In order to determine filter run time: (1) the filtration equipment must be operated for a length of time exceeding the actual filter run time (*filter operating time*) and (2) the end point of filter run must be explicitly defined.

Following are definitions of these key filtration terms as used in this pilot study:

End of filter run: That point (time) at which the concentrations of iron or of manganese increased to half the secondary maximum contaminant level (SMCL).

Filter run time: The time between re-starting the filter after a backwash and the end of the filter run.

Filter operating time: The total time a particular filter was receiving influent flow and discharging filtered water; a time greater than the *filter run time*.

Results

Operational Parameters

Besides the type of media to be used to effectively treat a specific raw water, the only significant operational parameter in pilot filtration testing is the hydraulic loading rate (HLR) to the filters. During this pilot test hydraulic loading rates in the range of 2 to 7 gpm/ft^2 were tested. The rate of 4 gpm/ft^2 was found to be the maximum rate that provided a run length of sufficient duration to be both adequately conservative of backwash water generated and conservative of needed filter capacity/capital cost (lower loading rates necessitates more filters to accomplish effective contaminant removal). Operation at higher rates would likely cause an elevated backwash frequency which would result in an excessive volume of backwash water usage and lower rates would incur a much greater capital expenditure for more filter facilities.

Removal of Target Inorganic Contaminants

In general, during each filter run the levels of the target contaminants remained well below the treatment goals (maximum contaminant levels) for the entirety of the filter operating time. Typical data for manganese removal, at a HLR of 4 gpm/ft^2, and feeding chlorine (with a small dose of potassium permanganate), and run data when feeding both chlorine and ferric chloride, are presented on Figures 1 and 2, respectively. When chlorine only was added, filter effluent concentrations of arsenic were consistently greater than 5 μg/L but less than the MCL of 10 μg/L. When ferric chloride was fed at a dose of 2 mg/L, in addition to chlorine, arsenic

concentrations in the filter effluent water were consistently below 5 μg/L, throughout the filter runs.

Also, when ferric chloride was fed, the concentrations of iron and manganese in the filter effluent remained above the treatment goal, and generally below the SMCL, for approximately thirty to sixty minutes of run time immediately following a backwash, before they dropped below the treatment goals.

It was observed in longer duration filter runs that the concentrations of iron, manganese, and to a lesser extent arsenic, began to increase. The higher levels of iron and manganese at the end of filter runs contributed to a visible color in the filter effluent water. By ending the run, and initiating a backwash, at approximately half the SMCL this undesirable colored water was avoided.

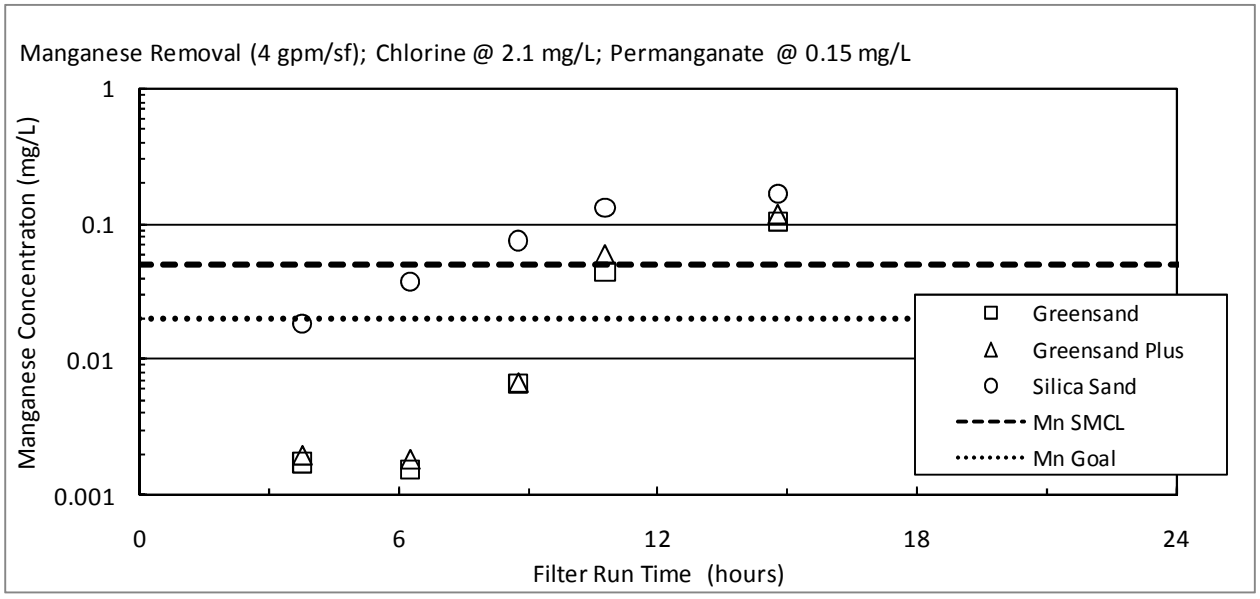


Figure 1: Typical Filter Run Manganese Data (Feeding Chlorine)

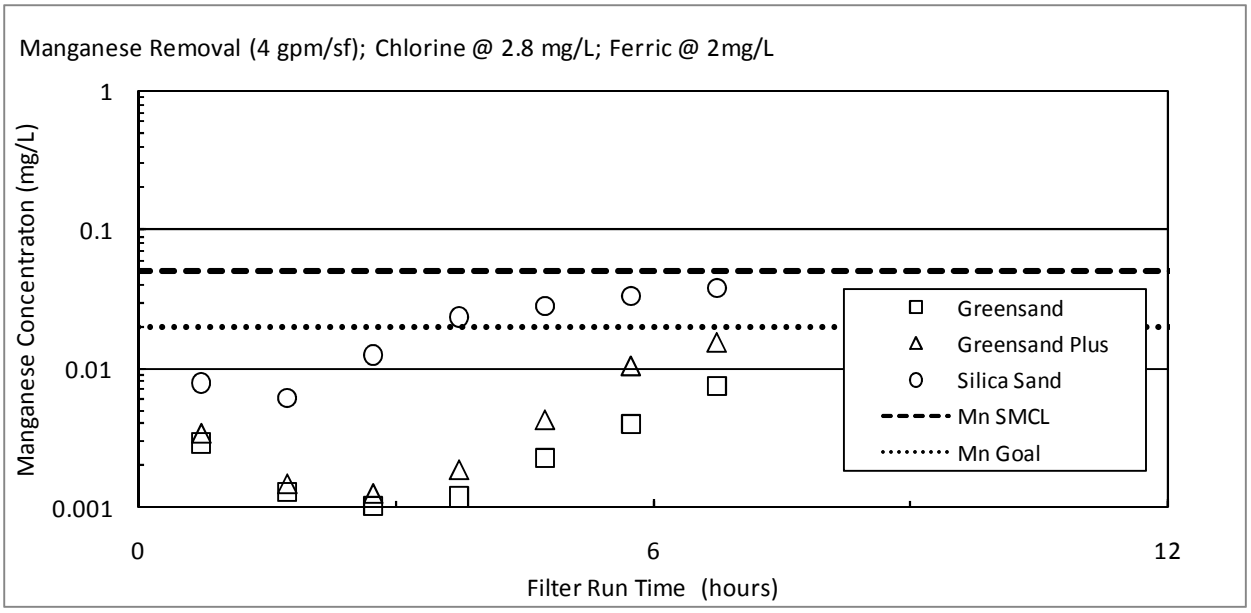


Figure 2: Typical Filter Run Manganese Data (Feeding Chlorine and Ferric Chloride)

Filter Run Time.

Pilot test results showed that Greensand and Greensand Plus demonstrated similar run longevity with silica sand performing at significantly shorter durations. Table 3 presents average filter run times for several runs performed during the pilot study. Other data collected during the pilot study are presented in Appendix 2.

Table 3: Filter Run Length Summary (at 4 gpm/ft^2)

Media	Average Filter Run Length	
	With Chlorine Only*	With Chlorine and Ferric**
Greensand	10 hours	7 hours
Greensand Plus	10 hours	6 hours
Silica Sand	4 hours	4 hours

Note: * Six filter runs performed over 11 days of operation.
** Five filter runs performed over 5 days of operation.

Disinfection By-Products in the Treated Water

The total organic carbon (TOC) of the well water (1.8 mg/L) was higher than normally expected for a groundwater and within the range of values measured in the City's existing source of supply, the Cowlitz River (TOC in the range of 0.73 to 1.8 mg/L, between years 2004 and 2008). Disinfection by-product tests were performed on treated water from the pilot study to determine the extent of formation of the regulated compounds: Total trihalomethanes (TTHM) and

haloacetic acids (HAA-5). Results for samples collected from each of the filter media effluents are as follows:

- Greensand: TTHM = 13.5 μg/L, HAA-5 = 12.7 μg/L
- Greensand Plus: TTHM =13.4 μg/L, HAA-5 = 12.6 μg/L
- Silica Sand: TTHM = 12.4 μg/L, HAA-5 = 11.2 μg/L

All three granular media had similar levels of these by-products. Results for a filter effluent sample collected and held for 24-hours are as follows:

- Greensand Plus: TTHM = 31.1μg/L, HAA-5 = 19.4 μg/L

These results are well below the MCLs for TTHM (80 μg/L) and HAA-5 (60 μg/L).

Anticipated Finished Water Quality

The untreated groundwater at the Mint Farm differs in quality from the surface water that the City currently uses as a source of supply. Table 4 presents calculated values of the Langelier Saturation Index and the Calcium Carbonate Precipitation Potential for the two sources of supply. These indices indicate that the Cowlitz River water is aggressive (*i.e*. tends to dissolve calcium carbonate scale) whereas the groundwater is much less aggressive, and may tend to deposit some calcium carbonate scale.

The treated groundwater has a higher alkalinity than the finished surface water and as a consequence the pH of the water in the distribution system, when using a groundwater source, will be more consistent. This consistency generally provides for better corrosion control and thus the addition of corrosion control chemicals will not likely be required.

Note that the stability of existing pipe scale in the distribution system, and the extent described above of possible scale sloughing, cannot be readily predicted from the calculation of these indices.

Table 4: Comparison of Cowlitz and Well Water Quality

Parameter	Treated Cowlitz River Water	Treated Groundwater
Langelier Saturation Index	- 1.3	- 0.06
Calcium Carbonate Precipitation Potential	- 5.1 mg/L as $CaCO_3$	- 1.3 mg/L as $CaCO_3$

Backwash Water Settling Tests

The settling characteristics of the backwash water solids were determined on a sample of backwash water collected during the pilot study using a standard jar test apparatus. The solids tended to settle readily without the addition of a chemical to aid settling. Gravity settling under

quiescent conditions with a loading rate in the range of 0.25 to 0.5 gpm/ft^2 could be used to remove solids from the backwash water and return the supernatant to the head of the plant. Plate or tube settlers could be used to increase the loading rate to 1 to 2 gpm/ft^2.

Conclusions and Recommendations

The conclusions and recommendations based upon the results from this pilot study are as follows:

1. **The Greensand media is expected to achieve the treated water goals of this study and is preferred for the treatment of this ground water.** Greensand Plus could be considered as an alternative with similar performance, however, the silica sand media had shorter filter runs and was more likely to exhibit higher filter effluent concentrations of iron, manganese, and color in the treated water.

2. **The process of filtering to waste should be considered in the facilities design.** During filter run time, in the first few minutes after backwashing, higher levels of iron and manganese appeared in the filter effluent. Filtering to waste is the practice of sending this first few minutes of filter flow into a storage basin for settling and re-routing of the decanted supernatant water back to the head of the plant. This practice will keep solids-associated iron and manganese from entering the distribution system. Since effluent from all filters is blended it may not be critical or practical to filter to waste. The effluent from a filter that has been returned to service following a backwash will likely be sufficiently diluted by the flow from the other filters since filter effluents are combined. Thus, from dilution, the combined plant finished water may likely comply with the finished water goals. If necessary, filtering to waste can be further investigated during preliminary design.

3. **The contact time requirement using granular media is 6 minutes.** The granular media treatment process may require a short contact time prior to raw water entering the granular media pressure vessels, in order to allow the arsenic to bind to the iron and facilitate its removal. During this pilot test a contact time of 6 minutes was determined appropriate and provided acceptable results. The required contact time will be further investigated during preliminary design. No such contact time will be required if arsenic levels in the raw production well water are above the treatment goal.

4. **Confirm distribution system water quality considerations during production test well operation.** The finished water from the new ground water treatment facility will differ from the treated Cowlitz River water currently in the City's system. At start-up of the new RWTP when existing water and new treated water will blend in the distribution system there may be issues with taste, odor or scaling. Complaints are most likely to cite "water spotting" resulting from higher hardness inherent in the groundwater as opposed to complaints about deposition of a significant amount of calcium carbonate scale within home plumbing. Complaints are more likely during the brief transition period from surface to ground water and these will likely decrease over time. Thus, the anticipated

finished water quality should be confirmed with samples collected during the pump test of the first production well. Also, at start-up of the new treatment facility, the City should be prepared to perform an extensive flushing program to mitigate problems from sloughing of existing scale within the distribution system pipes and to receive and respond to possible complaints due to the greater hardness of the groundwater.

5. **Perform further disinfection by-product testing at longer holding times.** Holding times representative of the maximum water age in the distribution system for each season are recommended to determine if there is a regulatory concern with TTHMs and/or HAA-5. This will be conducted as part of the water quality testing for the first production well.

6. **Backwash water solids settling should be included in the facilities design**. Solids in the backwash waste water tended to settle readily, under quiescent conditions, without the addition of chemicals. Kennedy Jenks recommends including a backwash settling process in the new RWTP so that backwash supernatant can be recycled to the head of the plant and increase the efficiency of the use of the groundwater supply.

7. **Pilot test well water quality is representative of production test well water quality.** The Prudential Blvd. Well, used in this pilot testing study, is located approximately 3,000 feet from the proposed site of the production wellfield (i.e. the 10 acre property northeast of Huber Chemical property). The Prudential Blvd well water quality should be compared to that of the new production test well to determine if any modification to the design guidance provided in this Technical Memorandum is warranted. Water quality data from DW9, the monitoring well nearest the proposed location of the production wells, indicate that arsenic levels are below the treatment goal and the levels of iron and manganese are very similar to those in the Prudential Blvd. well water. Therefore, at this point in time, the piloting conducted to date appears to provide sufficient baseline data for the design of the treatment process facilities. The water quality of the first production well should be confirmed during the pump test scheduled to occur in October 2009. A production well test sampling and testing protocol will be provided in the near future.

APPENDIX 1: Pilot Study Protocol

Memorandum 1

Pilot Study Protocol (Revised per Comments Received)

Date: 4 May 2009

To: Ms. Amy Blain
City of Longview

From: Stephen Booth, Ph.D.

Reviewed by: Tom Peters, P.E.
Milt Larsen, P.E.

Subject: City of Longview Granular Media Pilot Study: Protocol (Revised)
Design of Groundwater Source and Regional Water Treatment Facilities
K/J 0997003*00

This Memorandum presents our responses to comments received on our Draft pilot study protocol followed by the revised protocol.

Response to Comments on Draft Protocol

City's Comments

1. *The treated water goal for the manganese seems high to me. The actual manganese level in the raw water if 0.06-0.07 mg/L and the prior goal in the previous pilot study was <0.01 mg/L… granted some of those goals were never met*.

   The manganese level had been approximately 0.6 mg/L during the previous study and we have measured values in the range of 0.6 to 0.80 mg/L during the current study. This is well above the secondary standard of 0.05 mg/L. Based upon our experience, we believe that a goal of 0.02 mg/L is appropriate to effectively eliminate the problems associated with manganese.

   The AWWA Research Foundation Report (2006) "Occurrence of Manganese in Drinking Water and Manganese Control" states the following: "Our research suggests a more appropriate target level for manganese to limit customer problems would be 0.02 mg/L. The surveys conducted during this study indicated that a standard of 0.05 mg/L was not sufficiently low to ensure minimal customer complaints."

   Summerfeld (1999) has indicated that "...reduction of iron to 0.1 mg/L and manganese to 0.02 mg/L is a positive step, as is maintenance of the distribution system in a clean condition."

Also, in response to this comment and others received by Gibbs & Olson, we have simplified the treated water goals of the study by indentifying a single value as the goal and eliminating average and maximum goals.

2. *Same on max for the arsenic. If, ultimately, the arsenic in the finished water is greater than 0.005 mg/L, the City has to include a public health notice about arsenic in our consumer confidence report. This will not go over well in promoting consumer confidence*.

   We agree and are targeting a treated water goal of 0.005 mg/L or less.

3. *The ATEC system is worth looking into further.*

   We agree that ATEC may be worth further consideration; however, all current ATEC installations are much smaller than the 20 mgd system the City is planning. Also, ATEC is a proprietary treatment system and we generally avoid proprietary treatment systems for 20 mgd treatment plants. If generic media (anthracite and silica sand) is effective for removing the constituents of concern from this water, the filtration process would have the advantage of potentially serving as a pre-filter for downstream membranes, in the event the City were to consider a surface water supply in the future. Greensand and pyrolusite media are not considered appropriate for surface water filtration; they are strictly used for removal of iron and manganese. Piloting the ATEC process will be considered further at the conclusion of the current pilot effort.

4. *I am somewhat concerned about the overall length of the pilot study. We've outlined four weeks total, less weekends (perhaps) and less time to work out the kinks. I want to make sure DOH is fully satisfied with the duration and amount of data generated.*

   A total duration of 4 weeks should be sufficient to meet all DOH requirements and to develop the design data that we will need to update cost estimates for the granular media alternative. We will evaluate the pilot plant performance as the pilot testing proceeds and recommend adjustments in the pilot duration, if needed. We are also sending this Memorandum to DOH to allow them the opportunity to provide additional comments.

DOH Comments

1. *Page 2 –There is no mention of detention times for different oxidants and coagulants used in the study. Please specify contact/detention time for all of the oxidants and coagulants in different filtration media to be piloted.*

   All oxidants and coagulant are fed within a few inches of each other using chemical feed fittings on the raw water line. We have installed a static mixer to mix the chemicals prior to entering a filter feed tank. The filter feed tank has an effective operating volume of 20 gallons. The raw water flow rate is in the range of 4 to 6 gpm; therefore, the contact time in the filter feed tank is 3.3 to 5 minutes.

Generally the contact time in the filter head space is more than adequate for iron oxidation prior to filtration in the Northwest. A longer contact time would be necessary where iron is sequestered by organic material. When chlorine is used as the sole oxidant, no upstream contact time is required as dissolved manganese is removed by adsorption onto the filter media prior to oxidation. Arsenic tends to oxidize from As (III) to As (V) quite rapidly. A short contact time is useful for As (V) adsorption onto the oxidized iron precipitate.

2. *Page 2 states that the dosage of potassium permanganate will be adjusted so that no visible color is present. Please quantify the color units or concentration of dissolved manganese in the finished water that will be used to determine the potassium permanganate dosage.*

   We are planning to feed potassium permanganate only at the start of the study to help to season the granular media to improve the removal of iron and manganese. We are preparing potassium permanganate solutions by weighing a specific amount of powdered potassium permanganate into a specific volume of water (7 gallons). This provides a stock of known concentration to feed to the filters. We are using a visual inspection of the filter feed water to determine that a small residual of potassium permanganate is present. The color is light orange to brown for this water. The residual potassium permanganate can also be determined by measuring the absorbance at a wavelength of 525 nm; however, this method can be inaccurate when the color of the sample is not the normal pink but is altered due to the presence of iron and manganese, as is this case for this water. Samples can be filtered to improve the accuracy of absorbance readings, although that approach is too labor intensive for the purposes of this initial phase of testing.

   We are not planning on feeding potassium permanganate in excess of what would be adsorbed by the filter media. If we get permanganate leakage through the filter it will be measured as manganese in the filtered water, and the permanganate feed rate will be reduced.

3. *Page 2 mentions system alarms. Please specify what alarms will be monitoring*.

   The pilot equipment provides an alarm on each filter to indicate that the filter influent flow rate cannot be maintained or that the filter influent pump has shut down.

4. *Table 3, page 3 – The hydraulic loading rates are much higher than typically recommended 2-5 gpm/ft^2 for anthracite and greensand filtration when chlorine and potassium permanganate are used as oxidants. Please provide references which demonstrate that the treatment processes along with selected oxidants are effective at these higher loading rates.*

   Our goal is to determine the highest loading rate feasible for this water. Some higher rates that are tested during the study may not be feasible and will not be recommended for the full-scale facilities. We have specifically allocated time at the beginning of the study to test a range of hydraulic loading rates to determine their feasibility. Note we are

not suggesting testing potassium permanganate over 4 gpm/ft^2 where we are oxidizing the manganese upstream of the filter. We have a number of large iron and manganese treatment plants using adsorption/catalytic oxidation with chlorine as the sole oxidant operating at significantly higher loading rates (Table 1).

Table R1: Iron and Manganese Treatment Plants Designed at Loading Rates above 5 gpm/ft^2

Treatment Plant	Design Flow Rate (gpm)	Filter Media	Piloted Filter Loading Rate (gpm/ft^2)	Design Filter Loading Rate (gpm/ft^2)
Bailey Water Conditioning Plant, Ventura, CA	8,500	oxide coated-sand & anthracite	10	8
Lakewood Water District View Rd Water Treatment Plant	2,250	oxide coated-sand & anthracite	10	7.5
Santa Paula Centralized Water Conditioning Plant	7,500	manganese greensand/anthracite		7.5
Renton Maplewood Water Treatment Plant	3,500	manganese greensand/anthracite	12	10

However, we do recognize that given the potential need to feed supplemental iron for arsenic removal, it will likely be necessary to operate the filters at a lower loading rate given the elevated concentration of precipitates.

5. *Table 3 – Some of the durations in Table 3 are too short. Report states that "backwashing is anticipated to be performed approximately every one to five days," and some tests are only two days in duration. Each test should be run for a minimum of five days and contain at least two backwashes in order to provide meaningful results*.

   Preliminary tests are being performed for a relatively short duration, in order to assess operating conditions on this raw water source. Once preliminary tests are completed, longer runs of up to 5 days will be performed to test conditions that may be feasible for full-scale operations.

6. *Table 4, page 4 – Both chlorine and permanganate rapidly oxidize As(III) to As(V). Therefore, arsenic speciation of the treated water is not necessary. A one-time test on raw water would be adequate. Arsenic speciation is typically performed as a field test*.

   The arsenic speciation tests will be performed at a commercial laboratory. We agree with your comment that the speciation testing on the filter effluents is of limited value.

7. *Please provide a copy of data sheets that will used for recording/summarizing results during the pilot study.*

   The data sheet is attached.

8. *If ATEC systems are piloted, please include how this will be piloted in an addendum to this report*.

   If invited to perform a pilot test, ATEC Systems will provide a separate pilot study report that will be included as an Addendum to the Pilot Study Technical Memorandum, provided by Kennedy/Jenks. All results and analyses provided by the vendor will be critically scrutinized by our team. A synthesis of all pilot study conclusions will be presented in the Process Evaluation Technical Memorandum.

Gibbs & Olson Comments

1. *Suggest clearly identifying what the goals of the piloting are. For example, is the piloting being done for verification of filtration media on a competitive basis? Is it being done to develop design criteria for the various media to compare performance? Is it being done for verification of chlorine and potassium permanganate doses?*

   The text describing the goals in the protocol has been revised to clarify the goals of this pilot testing. Recognize that this pilot test was conceived to validate the previous piloting effort that recommended a membrane process instead of granular media. The purpose of this testing is to determine if granular media can meet the water quality goals and provide a more cost-effective alternative for the City.

2. *Suggest the manganese treated average goal be less than 0.01 mg/L. If a specific granular media alternative cannot achieve this goal under pilot conditions, the media is questionable for the final treatment process in our opinion.*

   See response to City comment number 1.

3. *Suggest that the proposed maximum level of manganese in the finished water be reduced from 0.04 mg/L to 0.03 mg/L to provide a reasonable cushion below the secondary MCL limit of 0.05 mg/L.*

   See response to City comment number 1.

4. *Suggest that proposed maximum level of arsenic in the finished water be reduced from 10 µg/L to 7 µg/L. Potentially meeting the MCL of 10 µg/L under pilot conditions would not provide G&O with a high level of confidence for full-scale operation. This is because: 1) arsenic concentrations can vary from location to location within an aquifer; and 2) the likelihood that long-term raw water levels will have some variability.*

   See response to City comment number 1. We expect that the arsenic levels may vary as the aquifer experiences increase pumping.

5. *Suggest that a chlorine demand curve be plotted to verify break point. This could be in lieu of, or in conjunction with, the proposed chlorine dosing method. It is our opinion that plotting the chlorine demand curve should be done at least twice during piloting since the information will be used to size chlorination equipment and related supply system.*

   The limited chlorine demand testing described in Draft Protocol is appropriate to meet the goals of the pilot plant testing. We will be monitoring chlorine residuals in the filtered water on a regular basis each day. Breakpoint curves would only be appropriate if ammonia is found in the water. Samples are being collected for low-level ammonia analysis as part of this testing.

6. *Suggest that additional information be added to the pilot protocol outlining how the makeup of potassium permanganate will be done and how a constant feed concentration will be provided.*

   A potassium permanganate concentration solution was prepared at a concentration of 7,700 mg/L. The chemical metering pumps were adjusted to pump at a 2.0 mg/L dosing rate. The feed rate was back-checked by measuring drawdown of the feed solution over the pumping period. Additional information on these pumps will be provided under separate cover. See also response to DOH comment number 2.

7. *Suggest that additional information be added to the pilot protocol outlining what the proposed pH adjustment method will be if needed.*

   Ferric chloride will be used to lower the pH and to provide additional iron both of which will tend to improve arsenic removal. A ferric chloride solution will be fed in the same manner as the other chemicals. We will perform preliminary jar tests to determine an appropriate ferric chloride dosage to remove sufficient arsenic to comply with the treated water goal.

8. *Suggest collecting dissolved iron and manganese data every day in the first week on the raw water at a minimum to establish relationship to total iron and manganese.*

   This testing will be included early in the study, as suggested.

9. *Suggest TOC sampling be performed once per week.*

   Agreed. A minimum of four TOC samples will be collected.

10. *Suggest that consideration be given to performing backwash settling tests with an Imhoff cone so the results are useful with regard to designing backwash handling facilities or determining compliance with sewer discharge standards.*

    The required design data can be obtained with either an Imhoff cone or the standard jar test procedure, mentioned in the protocol. We will determine which type of equipment is available and operable at the City's RWTP.

11. *There is nothing in the pilot protocol discussing/summarizing the well pump in regard to flow rate or the filter rate range available with the pilot equipment. It is not clear if a side stream will be taken from the water pumped by the well pump. G&O suggests this be clarified. If a side stream will be used that is equivalent to 4-8 gpm what rate will the well pump operate at? It is beneficial to the City in our opinion for the rationale used to determine that the pilot source water is representative of the source water that will be provided by the production wells to be clarified in the pilot protocol. There should also be some protocol provided to ensure that raw water quality found during the granular media pilot testing is comparable to that found through other sampling/testing work for the production wells. Additionally, it appears the maximum filter rate available is 7.4 gpm/ft^2. It is unclear what the operating parameter goals or ranges for the pilot filters are.*

    A small submersible pump with a controller and flow meter is being used to supply the pilot plant from the Weber Avenue Well. The pump provides a constant flow of water to a filter feed tank. The filter feed tank is maintained at a constant level by a continuous overflow. Each pilot filter has a dedicated filter feed pump and the flow rate for each can be adjusted independently. Additional information on this equipment will be provided under separate cover.

    The Weber Avenue well was selected for this study because it is drawing water from the deep aquifer being considered as the source of supply by the City and it was readily available for this testing. Water samples are being collected for analysis from the Weber Avenue Well in addition to monitoring wells that are currently under construction, in order to confirm that the water quality is representative of the aquifer.

12. *Suggest adding a section outlining how successful performance of the various granular media filters will be defined. If the loading rates are different for each media, some criteria should be outlined to verify which medias are successful and at what design criteria. This is important for comparative sizing and cost estimating if more than one granular media is deemed successful.*

    The filters will be tested at the same loading rate, except if hydraulic loading rates above 7 gpm/ft^2 are tested. The pilot filters containing the Greensand and Greensand Plus media are limited to a maximum of 7 gpm/ft^2, whereas the maximum loading rate for the silica sand media is 20 gpm/ft^2. See also the response to Gibbs & Olson comment number 1.

13. *Suggest adding a brief discussion of what water stability measure will be used to verify the finished water is stable. A target calcium carbonate precipitation potential (CCPP) value, Langlier Saturation Index (LSI) value and/or Ryznar Index value should be identified that will demonstrate the stability of the finished water.*

    The CCPP and LSI indices will be calculated for the pilot-treated well water and the existing finished water from the RWTP, to determine the stability of the water and as a preliminary assessment of the compatibility of the ground water with the water currently in the existing distribution system. Also, the requirements for pH adjustment of the

treated water will be determined using a water quality model, such as the RTW model.

We recognize, from previous experience, that these indices will not assure the stability of existing corrosion scales on premise plumbing as the water is switched from a high oxidation reduction potential (ORP), low mineralized surface water to a lower ORP, more mineralized groundwater. We propose to test the stability of scales within segments of galvanized steel premise plumbing, downstream of a future proving pilot, operated at the selected design conditions. This test will assess the extent of release of particles from existing scales. The treatment process has not yet been selected, and it is premature to perform such testing now. A future proving pilot test will be considered further once the treatment process has been selected.

14. *The schematic pilot setup drawing shows three filter units, the specific Intuitech drawings show two filter units. This discrepancy should be clarified. Three filter units are required with the three types of granular media being piloted.*

    Two pilot units each with two available pilot filters are being used for this study. Currently a total of three pilot filters are being used; the fourth column is not being operated.

15. *Suggest consideration of extended pilot time for filter verification to ensure initial success with greensand or enhanced greensand is indicative of long-term success by demonstrating good recovery of the greensand. It may be worth discussing continuing the piloting for an additional 1-3 months for selected granular media if one or more of the granular media alternatives prove initially successful though this would require an amendment to Kennedy/Jenks' contract.*

    We suggest addressing the possible need for an extended pilot test at the conclusion of three weeks of pilot testing, based upon data collected up to that point.

16. *Pilot protocol indicates that Kennedy/Jenks may request ATEC to perform an independent and brief pilot study utilizing pyrolusite media. G&O encourages the City and Kennedy/Jenks to have ATEC's media piloted since ATEC has a good track record of treating iron, manganese and arsenic and is a Longview-based company. Having ATEC pilot eliminates any potential questions/challenges as to the viability of pyrolusite granular media in regard to performance or cost-effectiveness.*

    See response to City comment 3.

Revised Pilot Study Protocol

Introduction and Purpose

This memorandum presents the protocol for a pilot study to test the performance of alternative granular media for treating groundwater at the Mint Farm. The three main constituents of concern are iron, manganese, and arsenic. The 4-week pilot study has been scheduled to start in mid-April. The Weber Avenue well at the Mint Farm will provide the source water for the pilot equipment.

The purpose of the pilot study is to determine if the selected media can meet the treated water goals for this study and to determine design and operating parameters under which the goals can be achieved. The parameters being determined in this study are oxidant demand, hydraulic loading rate, filter run time between backwashes, timing of iron and/or manganese breakthrough during the filter run, rate of head loss development, and settleability of backwash solids. Cost estimates will be provided, based upon the design and operating parameters developed in the pilot study.

Kennedy/Jenks Consultants may request ATEC Systems Associates (ATEC) to perform a brief, separate pilot test using pyrolusite media. However, pyrolusite testing is not included in the pilot test described herein.

A Hazard Appraisal and Recognition Plan (HARP) has been completed and will be reviewed by pilot operations staff to mitigate the potential for injury and to provide a safe working environment for the pilot study.

Treated Water Goals

Treated water quality goals for the pilot study are presented in Table 1. During the pilot study, operating conditions will be adjusted to meet these goals.

Table 1: Proposed Pilot Study Filtered Water Quality Goals

Parameter	Water Quality Goal	MCL	SMCL
Total Iron	≤ 0.05 mg/L	-	0.3 mg/L
Total Manganese	≤ 0.02 mg/L	-	0.05 mg/L
Total Arsenic	≤ 5 μg/L	10 μg/L	-

Note: MCL = maximum contaminant level
SMCL = secondary maximum contaminant level
mg/L = milligrams per liter
μg/L = micrograms per liter

Preliminary Oxidant Demand Testing

Preliminary oxidant demand tests will be performed with chlorine and potassium permanganate. The raw groundwater will be dosed with chlorine, and the chlorine residual will be measured after 1 minute, 5 minutes, and 10 minutes. The chlorine dosage producing a chlorine residual in

the range of 0.5 to 1 mg/L after 10 minutes of holding time will be selected as the starting point for pilot operations.

In a second test, potassium permanganate will be dosed at a concentration sufficient to oxidize the dissolved manganese in the water. The potassium permanganate dosage that produces a slight pink color after 10 minutes of holding time will be selected as the starting point for pilot operations. These dosages may be modified during operation of the pilot units.

Pilot Study Equipment

The pilot filter equipment consists of skid-mounted filters, each with a diameter of 6 inches. The operator can vary the flow rate through the filters, and this flow rate is maintained by on-board controls. The filter skids include instrumentation to measure filter head loss, filtered water turbidity, and the flow rate through each filter. The skid is designed to operate automatically and, as such, does not require regular attention to maintain normal operations. Chemicals are dosed using chemical feed pumps that feed chemical solutions, prepared at specific concentrations, at the required dosages. Operator attention is required to verify that the system is operating properly, to address system alarms, to check and replenish chemicals, and to collect water quality samples.

A schematic of the pilot equipment is presented in Figure 1 and drawings of the filter skid are attached to this memorandum. The media design for the pilot filters is presented in Table 2.

Table 2: Pilot Filter Media Design

Parameter	Pilot Filter		
	Greensand	Greensand Plus	Dual Media
Top Media	Anthracite	Anthracite	Anthracite
Depth (inches)	24	24	24
Effective size (mm)	0.95 - 1.05	0.95 - 1.05	0.95 - 1.05
Uniformity coefficient	< 1.4	< 1.4	< 1.4
Specific gravity	1.6	1.6	1.6
Bottom Media	Greensand	Greensand Plus	Silica Sand
Depth (inch)	12	12	12
Effective size (mm)	0.30 - 0.35	0.30 - 0.35	0.52
Uniformity coefficient	< 1.6	< 1.6	< 1.31
Specific gravity	2.4	2.4	2.6
Total L to d ratio	1500	1500	1200

Notes: mm = millimeters
L to d = ratio of media depth to effective size

Pilot Study Experimental Matrix

The pilot study experimental matrix is presented in Table 3. The potassium permanganate dosage will be adjusted so that no visible color is present in the pilot filter effluents. During the first several days of testing, a range of hydraulic loading rates will be tested in order to determine a feasible rate for this source water. Hydraulic loading rates for subsequent tests will be based upon the initial results. The addition of ferric chloride will be tested as a means of

improving arsenic removal by lowering the pH and providing additional iron for adsorption of the arsenic.

Table 3: Experimental Matrix for Granular Media Pilot Testing

Approx. Duration	Chemicals Fed Upstream of Filter	HLR [(a)] (gpm/ft^2)
4 days	Potassium Permanganate	4
6 days	Chlorine	2, 4, and 7
5 days	Chlorine	To be determined [(b)]
3 days	Chlorine and Ferric Chloride @ approx. 1-2 mg/L	To be determined [(b)]
3 days	Chlorine and Ferric Chloride @ approx. 2-5 mg/L	To be determined [(b)]
2 days	Repeat above condition, if necessary	To be determined [(b)]

Note: [(a)] HLR = hydraulic loading rate.
[(b)] Based upon results

Backwash Water Settling Tests

Samples of the backwash water will be collected for settling tests. Settling will be performed under quiescent conditions using standard jar testing equipment or Imhoff cones. The turbidity of the supernatant will be measured as a function of time to determine the settling characteristics of the solids.

Pilot Study Operations

The pilot equipment vendor will provide pilot operation training at the beginning of the study. Kennedy/Jenks Consultants will be responsible for operating the pilot equipment. The pilot operator will perform backwashing using simultaneous air scour and water wash followed by water wash (without air scour) to achieve a bed expansion of approximately 40 percent. Backwashing will be performed on each filter when the iron and/or manganese concentration exceeds the SMCLs presented in Table 1, for two consecutive measurements. Backwashing may be required more frequently when ferric chloride is used.

Sampling and Analysis Plan

Raw Water Characterization

An extensive raw water monitoring program is being carried out as part of this project, including sampling seven shallow monitoring wells, eight deep monitoring wells, and the production wells. The Weber Avenue well will provide the source water for the pilot study because it draws from the deep aquifer that will be the source of supply for the proposed treatment plant.

Pilot Study Sampling and Analysis

The sampling and analysis plan for the pilot study is presented in Table 4. Temperature and pH will be measured at the pilot site using standardized probes. Turbidity, alkalinity, iron and manganese will be measured using Hach™ test methods.

Table 4: Sampling and Analysis Plan

Parameter	Raw	Greensand	Greensand Plus	Manganese-oxide coated Dual Media
Hand-Recorded Data:				
Flow rate (gpm)	3 / day	6 / day	6 / day	6 / day
Head loss (ft)		6 / day	6 / day	6 / day
Turbidity (NTU)		6 / day	6 / day	6 / day
On-Site Analyses:				
Temperature (°C)	1 / day	-	-	-
Chlorine Residual		3 / day	3 / day	3 / day
Alkalinity	1 / week	1 / week	1 / week	1 / week
pH[(a)]	2 / day	2 / day	2 / day	2 / day
ORP	1 / day	1 / day	1 / day	1 / day
Dissolved Oxygen	1 / day	1 / day	1 / day	1 / day
Iron (Total)	3 / day	6 / day	6 / day	6 / day
Manganese (Total)	3 / day	6 / day	6 / day	6 / day
Samples to be Shipped to Certified Lab:				
Iron (Total)	1 / day	1 / day	1 / day	1 / day
Iron (Dissolved)	2 / week	2 / week	2 / week	2 / week
Manganese (Total)	1 / day	1 / day	1 / day	1 / day
Manganese (Dissolved)	2 / week	2 / week	2 / week	2 / week
Arsenic (Total)	1 / day	1 / day	1 / day	1 / day
Arsenic Species (As-III and As-V)	1 / week	1 / study	1 / study	1 / study
Silica (Total)	1 / week	1 / week	1 / week	1 / week
TOC and DOC	2 / study	2 / study	2 / study	2 / study
Washington Department of Health Primary and Secondary Inorganics[(b)]	1 / study	1 / study	1 / study	1 / study
Inorganics for Corrosion Control [(c)]	1 / study	1 / study	1 / study	1 / study

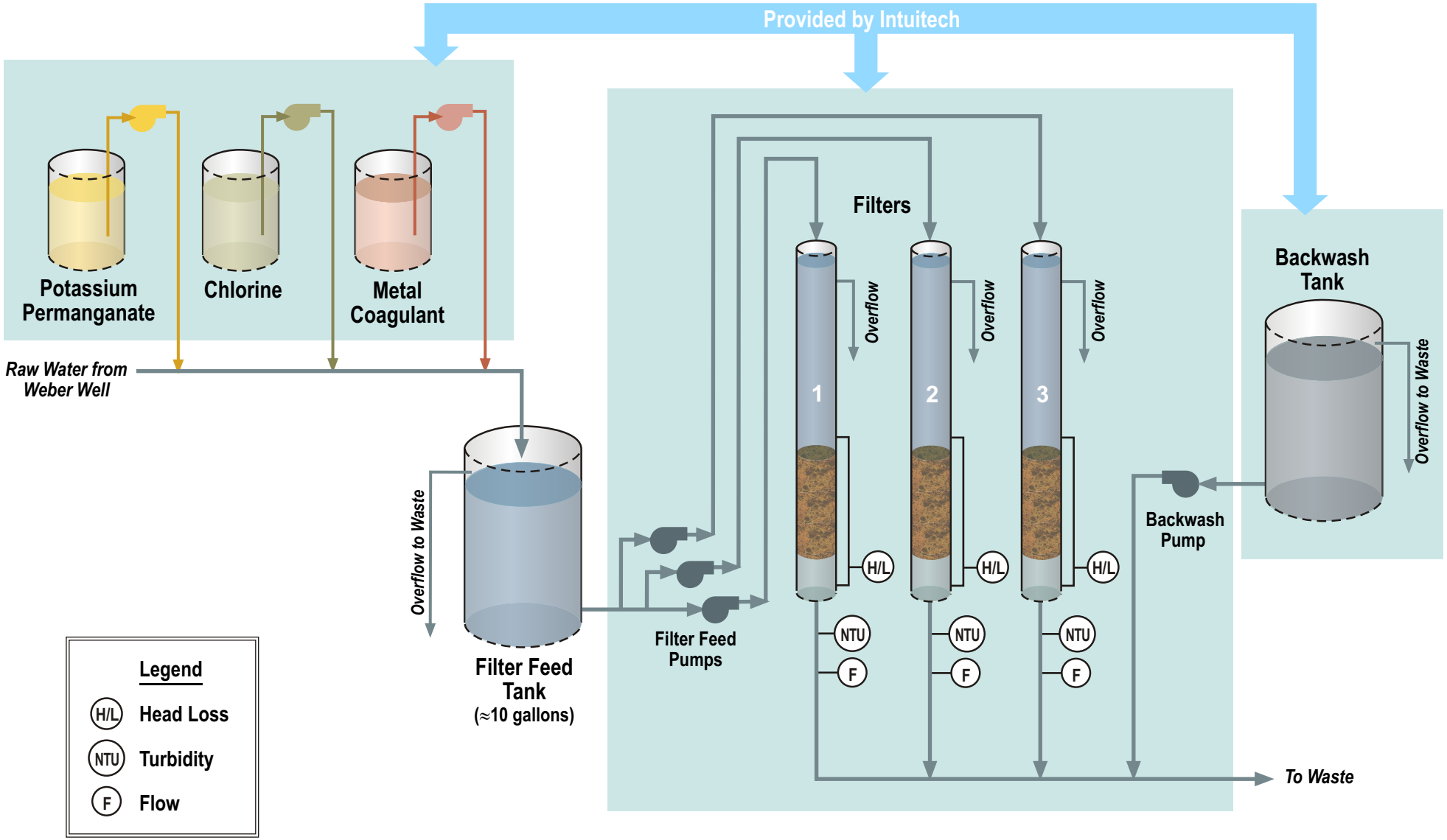
Note: [(a)] pH to be measured before and after addition of chlorine to the raw water.
[(b)] Includes regulated metals, cyanide, fluoride, nitrate/nitrite, calcium, magnesium, chloride, color, sulfate, total dissolved solids, hardness, foaming agents, conductivity, silica and phosphorus.
[(c)] Includes pH, alkalinity, hardness, calcium, total dissolved solids, conductivity, sulfate, chloride.

Iron and manganese concentrations will be confirmed by submitting samples to a certified laboratory for metals analysis using an inductively coupled plasma (ICP) method, with detection limits of approximately 1 microgram per liter (μg/L) for metals. Prior to analysis, dissolved iron and manganese will be determined by filtering the samples through a filter with a nominal pore size of 0.45 microns.

Corrosion Control Evaluation

The corrosion control requirements of the treated water will be evaluated. Treated water quality data will be input into RTW, or a similar water quality modeling program, to determine pH adjustment requirements, if appropriate, to more closely approximate the water quality in the distribution system. Also, the LSI and CCPP of both the treated groundwater and the existing RWTP finished water will be calculated to perform a preliminary evaluation of the compatibility of these two waters. ORP and dissolved oxygen measurements will be collected to compare with the existing surface water supply.

The stability of the existing premise plumbing corrosion scale may be affected by the different water quality characteristics of the groundwater versus the surface water. During the future proving pilot test, we recommend evaluating scale release from galvanized steel premise plumbing samples taken from the distribution system. A protocol for this testing will be developed at a later date, prior to the proving pilot.



Kennedy/Jenks Consultants

CITY OF LONGVIEW, WASHINGTON
GRANULAR MEDIA PILOT STUDY

DRAFT PILOT PLANT SCHEMATIC

FIGURE 1

City of Longview

Granular Media Pilot Study: Pilot Monitoring and Sampling Sheet

Date: _____

	Time:				Time:				Time:			
	Raw	**Filter 1**	**Filter 2**	**Filter 3**	**Raw**	**Filter 1**	**Filter 2**	**Filter 3**	**Raw**	**Filter 1**	**Filter 2**	**Filter 3**
Operational Readings:												
Flow Rate (gpm)												
Head Loss (ft)												
Turbidity (NTU)												
On-Site Analyses:												
Temperature (C)												
Alkalinity (mg/L)												
pH												
Total Iron (mg/L)												
Total Manganese (mg/L)												
Free Chlorine Residual (mg/L)												
ORP												
Dissolved Oxygen (mg/L)												
Sample Shipped to Lab (Y/N):												

Comments:

DRAWINGS

FOR

INTUITECH
GRANULAR MEDIA FILTER MODULE F100
PROJECT 1086

FOR

INSTALLATION

RELEASE #1

APRIL 30, 2008

DRAWING TITLE	DRAWING NAME	REVISION NUMBERS BY RELEASE									
		1	2	3	4	5	6	7	8	9	10
REVISION HISTORY	1086-F1RR-500	0									
PROCESS & INSRTUMENTATION DIAGRAM SYMBOL LEGEND	0000-X1RL-100	1									
DEVICE TAG LEGEND	0000-X1RL-110	1									
GRANULAR MEDIA FILTER MODULE F100 PROCESS & INSTRUMENTATION DIAGRAM	1086-F1PP-100	0									
GRANULAR MEDIA FILTER MODULE F100 GENERAL ARRANGEMENT - FRONT VIEW	1086-F1ML-100	0									
GRANULAR MEDIA FILTER MODULE F100 GENERAL ARRANGEMENT - BACK VIEW	1086-F1ML-101	0									
GRANULAR MEDIA FILTER MODULE F100 ASSEMBLY	1086-F1ML-103	0									

REV	DATE	BY	DESCRIPTION
1			
2			
3			
4			

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TITLE: REVISION HISTORY

CLIENT: INTUITECH	PROJECT: 1086
DRAWN BY: AJB	DRAWN DATE: 05-01-08
DRAWING NAME: 1086-F1RR-500.VSD	P.O.:
SCALE: NONE	REVISION: 0

DEVICE SYMBOLS

- FIELD-MOUNTED DEVICE
- PANEL-MOUNTED DEVICE
- DEVICE MOUNTED BEHIND PANEL
- PROGRAMMABLE OPERATOR INTERFACE (PANEL-MOUNTED)
- PROGRAMMABLE LOGIC CONTROLLER (MOUNTED BEHIND PANEL)

MISCELLANEOUS

- MINOR PROCESS LINE
- MAJOR PROCESS LINE
- ELECTRICAL SIGNAL
- WATER SURFACE
- MAJOR ARROW
- MINOR ARROW
- PROCESS VALUE POINT (??)
- DRAIN WITH AIR BREAK

INSTRUMENTATION

- VARIABLE AREA FLOWMETER
- PADDLE WHEEL/ TURBINE FLOWMETER
- MAGNETIC FLOWMETER (M)
- VORTEX SHEDDING FLOWMETER
- THERMAL DISPERSION FLOWMETER (T)
- ULTRASONIC LEVEL DEVICE
- FLOAT LEVEL DEVICE
- SIGHT LEVEL DEVICE
- PRESSURE DEVICE

CONTROL FUNCTIONS

- f(x) PID — PROPORTIONAL, INTEGRAL & DERIVATIVE
- f(x) PACE — FLOW PACING
- f(x) SUB — SUBTRACTION
- f(x) PWM — PULSE WIDTH MODULATING

PROCESS EQUIPMENT

- ELECTRIC MIXER (M)
- HEAT EXCHANGER
- HEATER
- STATIC MIXER
- WEIR
- EDUCTOR
- FILTER / STRAINER

PUMPS/ BLOWERS

- BLOWER
- CENTRIFUGAL PUMP
- DIAPHRAGM PUMP
- FLEXIBLE IMPELLER PUMP
- GEAR PUMP
- PERISTALTIC PUMP
- PROGRESSIVE CAVITY PUMP

VALVES/ ACTUATORS

- NEEDLE VALVE
- BUTTERFLY VALVE
- BALL VALVE
- CHECK VALVE
- RELIEF VALVE
- GLOBE VALVE
- DIAPHRAGM VALVE
- GATE VALVE
- 3-WAY VALVE
- PLUG VALVE
- GENERAL VALVE
- PRESSURE REGULATING ACTUATOR
- AIR-TO-OPEN/ SPRING TO CLOSE ACTUATOR
- AIR-TO-OPEN/ AIR-TO-CLOSE ACTUATOR
- AIR-TO-CLOSE/ SPRING-TO-OPEN ACTUATOR
- ELECTRIC ACTUATOR (M)
- SOLENOID ACTUATOR (S)
- HAND ACTUATOR
- LEVEL ACTUATOR

CONTROL PHILOSOPHY

- SEQUENCER STEP
- DECISION
- OPERATOR INPUT
- PROCESS
- REFERENCE TO A DIFFERENT PAGE
- IF CONDITION IS TRUE CONTINUE

REV	DATE	BY	DESCRIPTION
1	04-30-08	AJB	ADDED SUBTRACTION & PULSE WIDTH MODULATING SYMBOLS, RENAMED PRESSURE RELIEF VALVE TO RELEIF VALVE
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3			
4			

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SCALE: NONE	REVISION: 1

INPUT DEVICE TAG PREFIXES

PARAMETER	ELEMENT / SENSOR	INDICATOR	TRANSMITTER		SWITCH	
			BLIND	INDICATING	HIGH	LOW
ANALYTICAL (UNSPECIFIED)	AE	AI	AT	AIT	ASH	ASL
CHLORINE	CHE	CHI	CHT	CHIT	CHSH	CHSL
CONDUCTIVITY	CE	CI	CT	CIT	CSH	CSL
CURRENT	CUE	CUI	CUT	CUIT	CUSH	CUSL
FLOW RATE	FE	FI	FT	FIT	FSH	FSL
FLOW TOTALIZER	FQE	FQI	FQT	FQIT	FQSH	FQSL
HARDNESS	HE	HI	HT	HIT	HSH	HSL
LEVEL	LE	LI	LT	LIT	LSH	LSL
NITROGEN	NE	NI	NT	NIT	NSH	NSL
OXYGEN	OXE	OXI	OXT	OXIT	OXSH	OXSL
OZONE	OZE	OZI	OZT	OZIT	OZSH	OZSL
PARTICLE	PCE	PCI	PCT	PCIT	PCSH	PCSL
PH	PHE	PHI	PHT	PHIT	PHSH	PHSL
POWER	PWE	PWI	PWT	PWIT	PWSH	PWSL
POWER TOTALIZER	PWQE	PWQI	PWQT	PWQIT	PWQSH	PWQSL
PRESSURE	PE	PI	PT	PIT	PSH	PSL
PRESSURE DIFFERENTIAL	PDE	PDI	PDT	PDIT	PDSH	PDSL
RESISTIVITY	RE	RI	RT	RIT	RSH	RSL
RELATIVE HUMIDITY	RHE	RHI	RHT	RHIT	RHSH	RHSL
SPEED	SE	SI	ST	SIT	SSH	SSL
STREAMING CURRENT	SCE	SCI	SCT	SCIT	SCSH	SCSL
SUSPENDED SOLIDS	SSE	SSI	SST	SSIT	SSSH	SSSL
TEMPERATURE	TE	TI	TT	TIT	TSH	TSL
TIME TOTALIZER	TQE	TQI	TQT	TQIT	TQSH	TQSL
TOTAL ORGANIC CARBON	TCE	TCI	TCT	TCIT	TCSH	TCSL
TURBIDITY	TUE	TUI	TUT	TUIT	TUSH	TUSL
UV ABSORPTION	UVE	UVI	UVT	UVIT	UVSH	UVSL
VOLTAGE	VE	VI	VT	VIT	VSH	VSL
WEIGHT / FORCE	WE	WI	WT	WIT	WSH	WSL

ALARM DEVICE TAG PREFIXES

PARAMETER	HIGH	LOW
ANALYTICAL (UNSPECIFIED)	AAH	AAL
CHLORINE	CHAH	CHAL
CONDUCTIVITY	CAH	CAL
CURRENT	CUAH	CUAL
FLOW RATE	FAH	FAL
FLOW TOTALIZER	FQAH	FQAL
HARDNESS	HAH	HAL
LEVEL	LAH	LAL
NITROGEN	NAH	NAL
OXYGEN	OXAH	OXAL
OZONE	OZAH	OZAL
PARTICLE	PCAH	PCAL
PH	PHAH	PHAL
POWER	PWAH	PWAL
POWER TOTALIZER	PWQAH	PWQAL
PRESSURE	PAH	PAL
PRESSURE DIFFERENTIAL	PDAH	PDAL
RESISTIVITY	RAH	RAL
RELATIVE HUMIDITY	RHAH	RHAL
SPEED	SAH	SAL
STREAMING CURRENT	SCAH	SCAL
SUSPENDED SOLIDS	SSAH	SSAL
TEMPERATURE	TAH	TAL
TIME TOTALIZER	TQAH	TQAL
TOTAL ORGANIC CARBON	TCAH	TCAL
TURBIDITY	TUAH	TUAL
UV ABSORPTION	UVAH	UVAL
VOLTAGE	VAH	VAL
WEIGHT / FORCE	WAH	WAL

OUTPUT DEVICE TAG PREFIXES

DESCRIPTION	TAG
CHECK VALVE	CV
DISCRETE VALVE (OPEN/CLOSED)	DV
INJECTION VALVE	IV
PILOT VALVE	YV
PRESSURE REGULATOR	PR
PROPORTIONAL VALVE (MODULATING)	PV
PRESSURE RELIEF VALVE	PRV
VACUUM RELIEF VALVE	VRV
SAMPLE VALVE	SV

CONTROL DEVICE TAG PREFIXES

DESCRIPTION	TAG
FLOW CONTROLLER	FC
FLOW INDICATIING CONTROLLER	FIC
PRESSURE CONTROLLER	PC
PRESSURE INDICATING CONTROLLER	PIC
SPEED CONTROLLER	SC
SPEED INDICATING CONTROLLER (VFD)	SIC
TEMPERATURE CONTROLLER	TC
TEMPERATURE INDICATING CONTROLLER	TIC

REV	DATE	BY	DESCRIPTION
1	05-01-08	REM	MODIFIED SRV TO PRV AND ADDED VRV
2			
3			
4			

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TITLE: **DEVICE TAG LEGEND**

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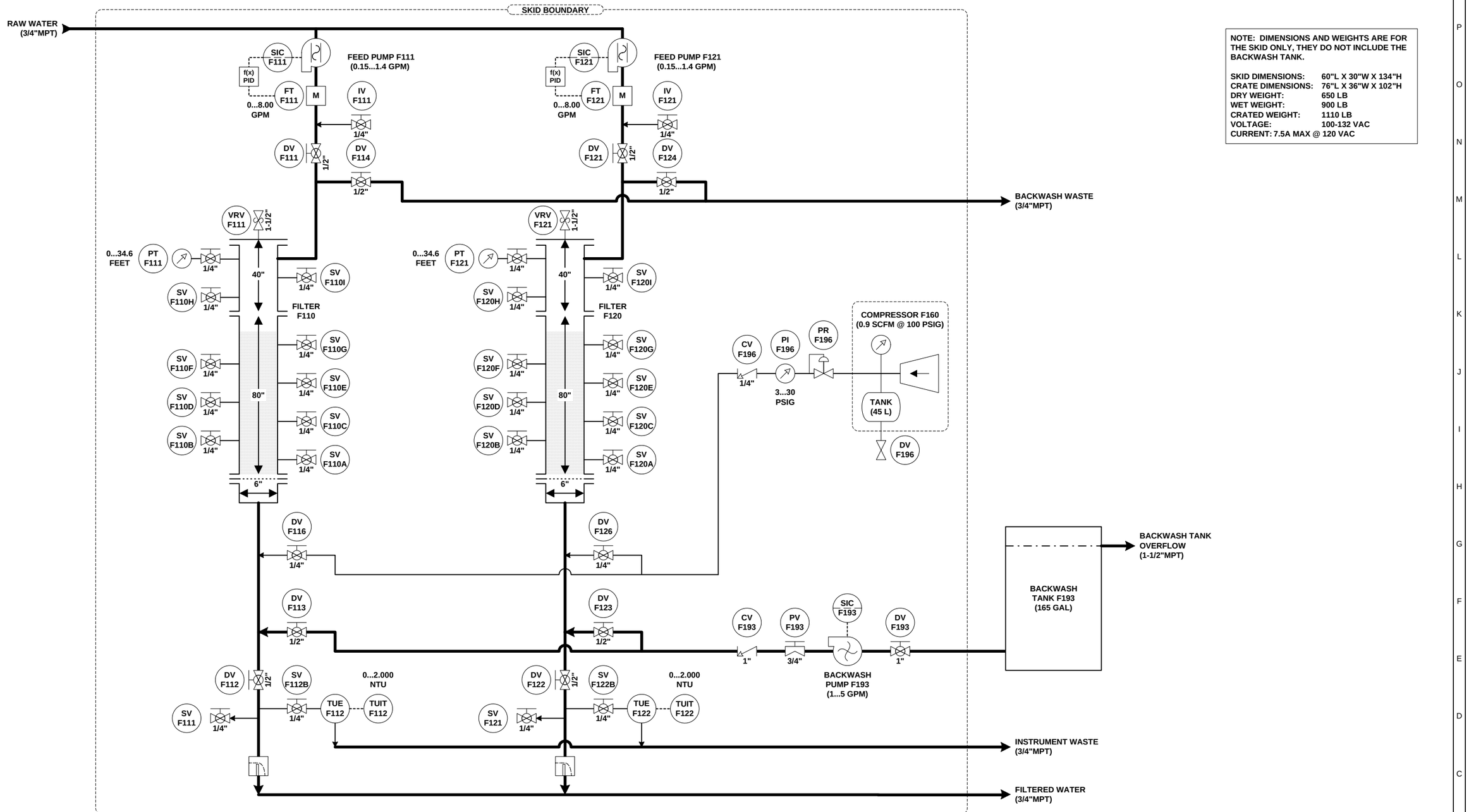
DRAWING NAME: 0000-X1RL-110.VSD | P.O.:
SCALE: NONE | REVISION: 1



REV	DATE	BY	DESCRIPTION

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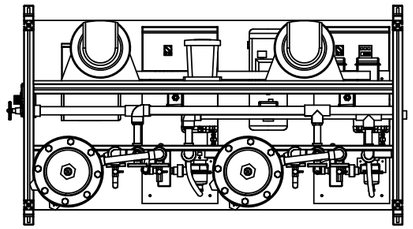
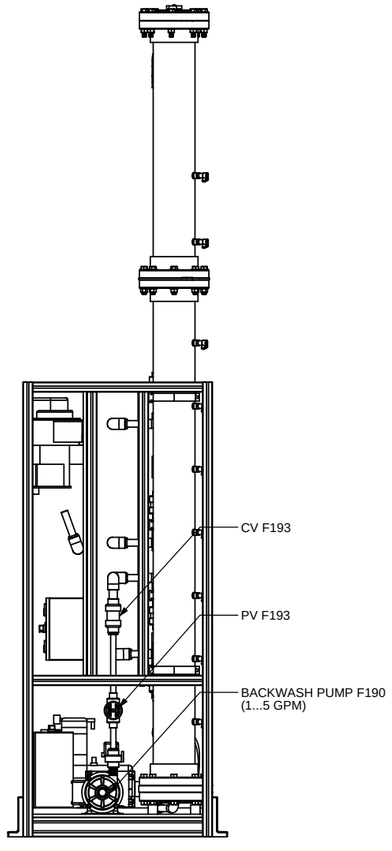
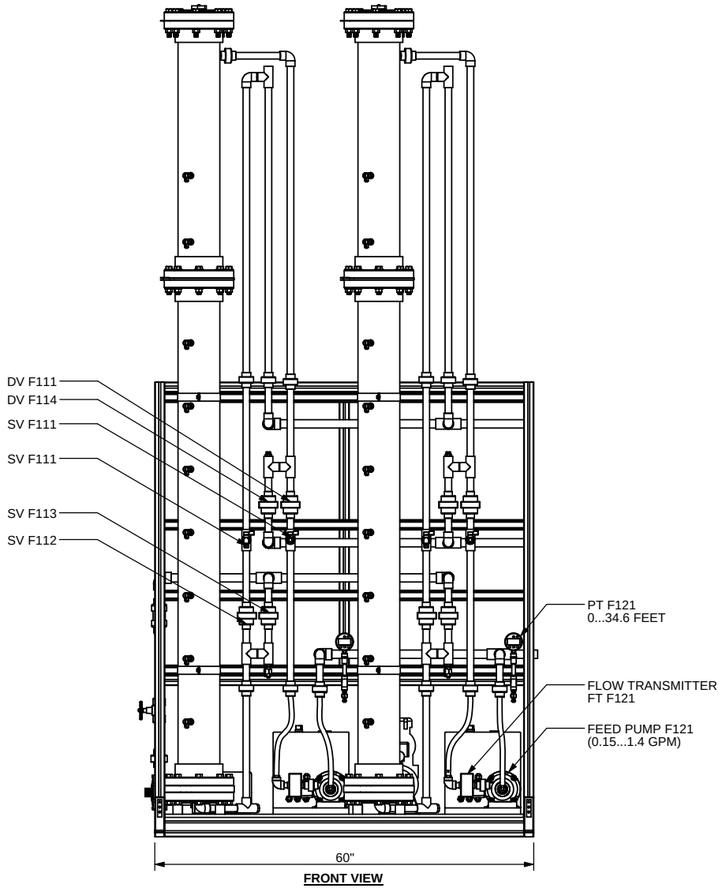
CLIENT: INTUITECH	PROJECT: 1086
DRAWN BY: EJH	DRAWN DATE: 3-28-08
DRAWING NAME: 1086-F1PP-100.VSD	P.O.:
SCALE: NONE	REVISION: 0



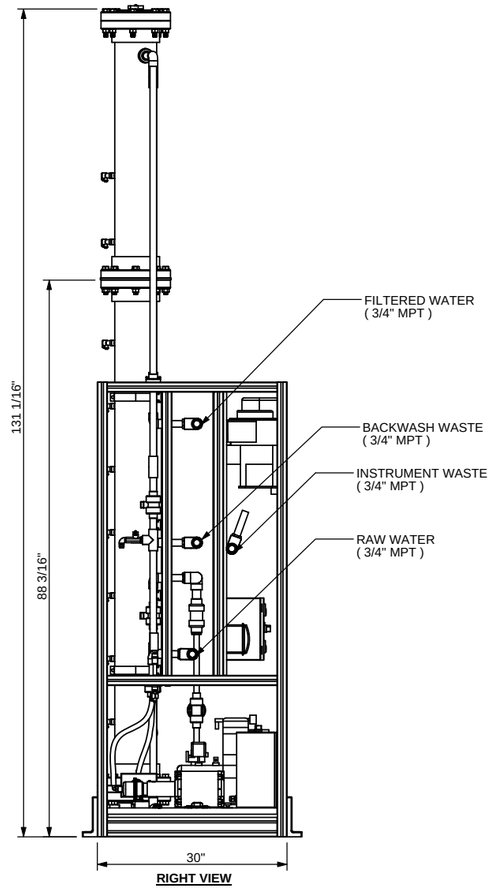
TOP VIEW



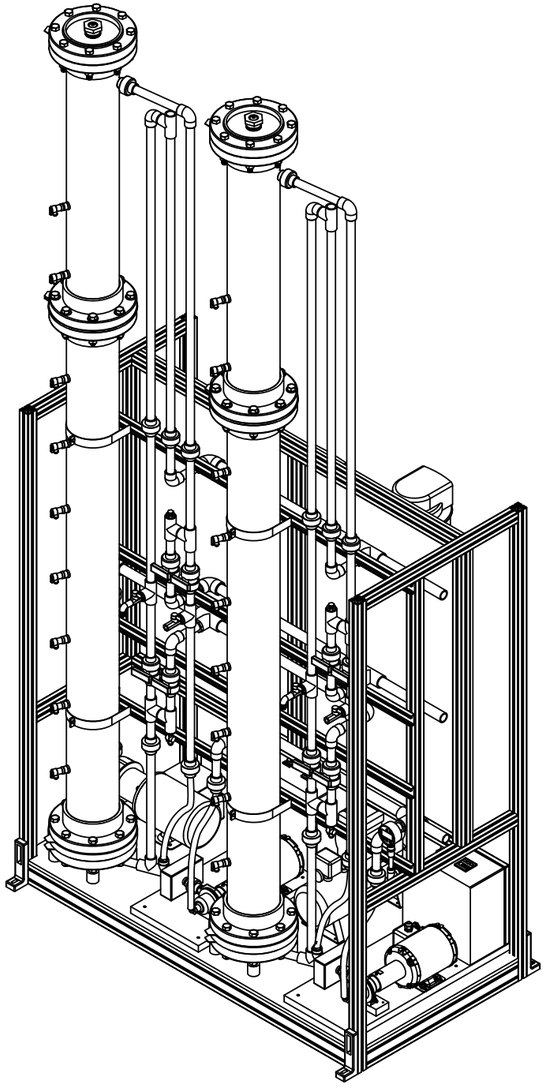
LEFT VIEW



FRONT VIEW



RIGHT VIEW



REV	DATE	BY	CHECKED	DESCRIPTION
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3				
4				

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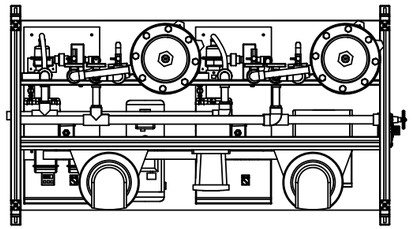
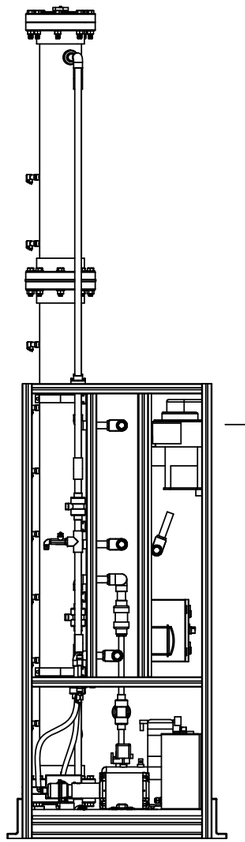
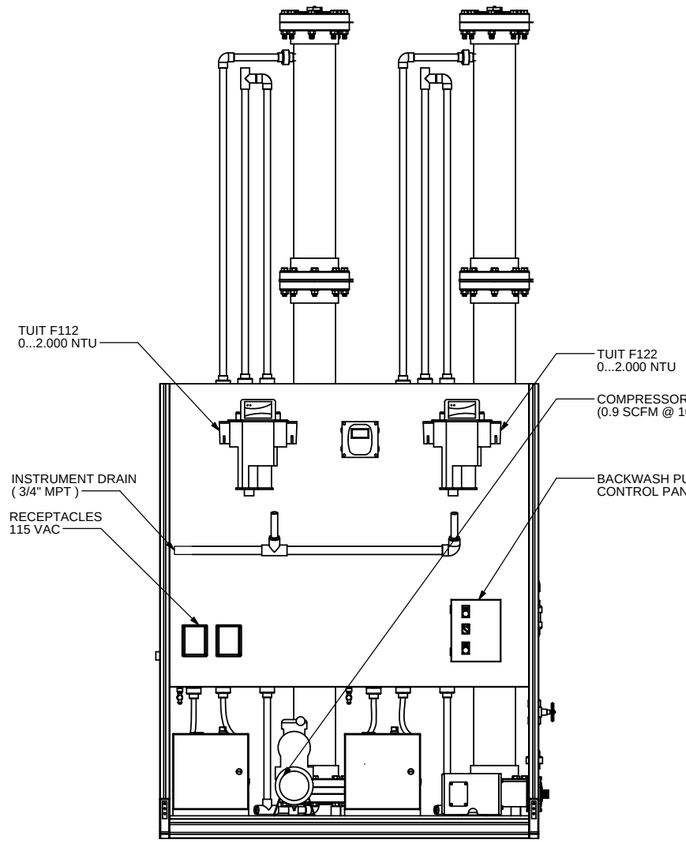
TITLE: GRANULAR FILTER MODULE F100 GENERAL ARRANGEMENT - FRONT VIEW	
CLIENT: INTUITECH	PROJECT: 1086
DRAWN BY: AJB	DRAWN DATE: 03-30-08
DRAWING NAME: 1086-F1ML-100	P.O.:
SCALE: NONE	REVISION: 0



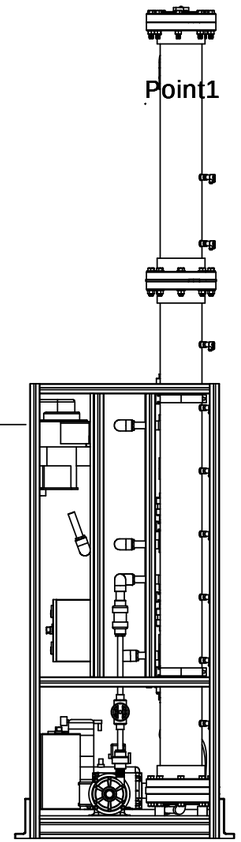
TOP VIEW

Point1

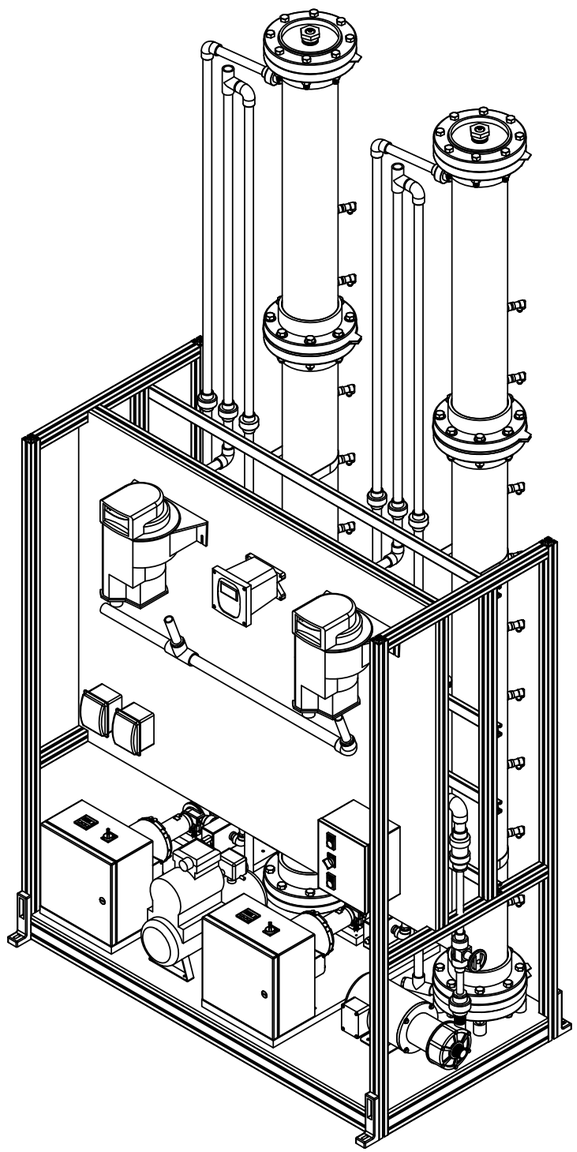




Point1



BACK VIEW



REV	DATE	BY	CHECKED	DESCRIPTION
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2				
3				
4				

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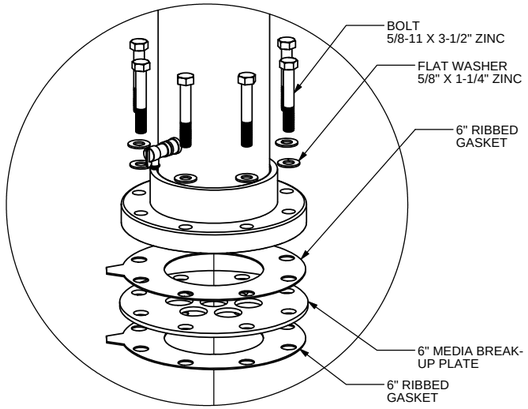
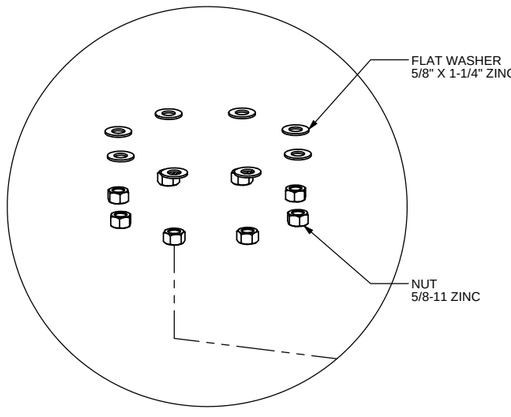
TITLE: GRANULAR MEDIA FILTER MODULE F100 BACK VIEW - GENERAL ARRANGEMENT	
CLIENT: INTUITECH	PROJECT: 1086
DRAWN BY: AJB	DRAWN DATE: 04-18-08
DRAWING NAME: 1086-F1ML-101	P.O.:
SCALE: NONE	REVISION: 0

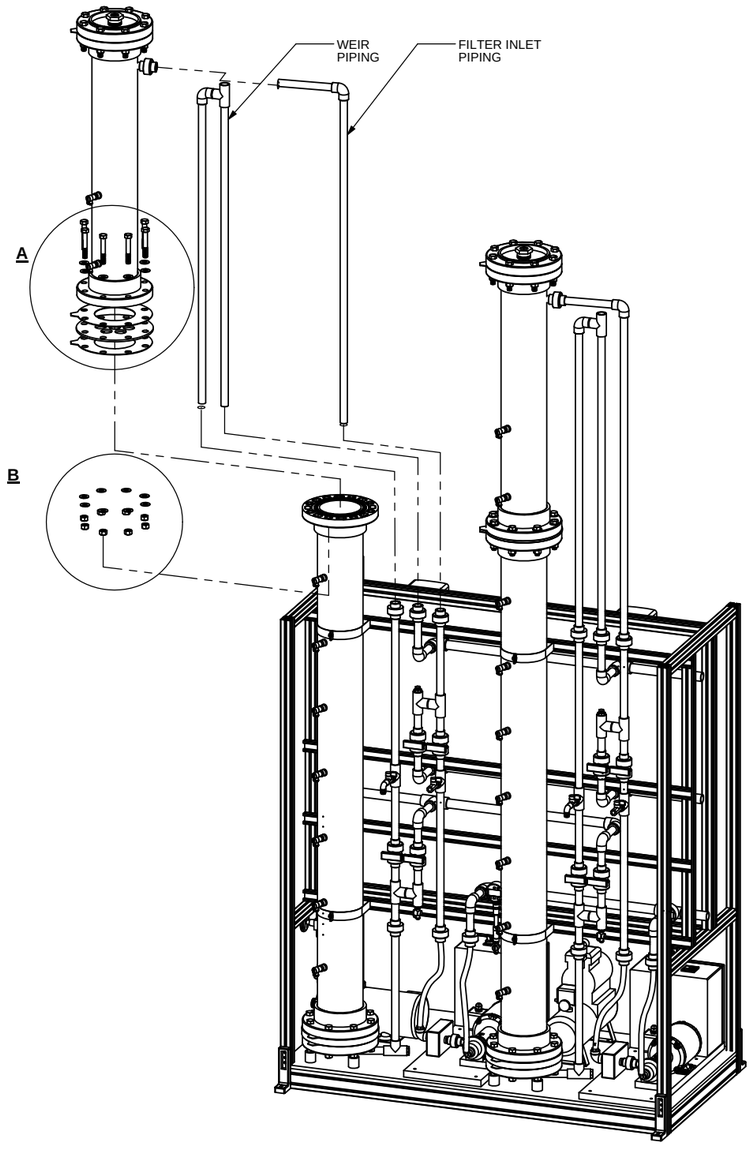


DETAIL A



DETAIL B

COLUMN ASSEMBLY
1 OF 2



NOTES:

1. DO NOT DISASSEMBLE UNDERDRAINS FOR MEDIA REMOVAL
2. LOAD MEDIA THROUGH TOP FLANGE OF LOWER COLUMN SECTION

REV	DATE	BY	CHECKED	DESCRIPTION
1				
2				
3				
4				

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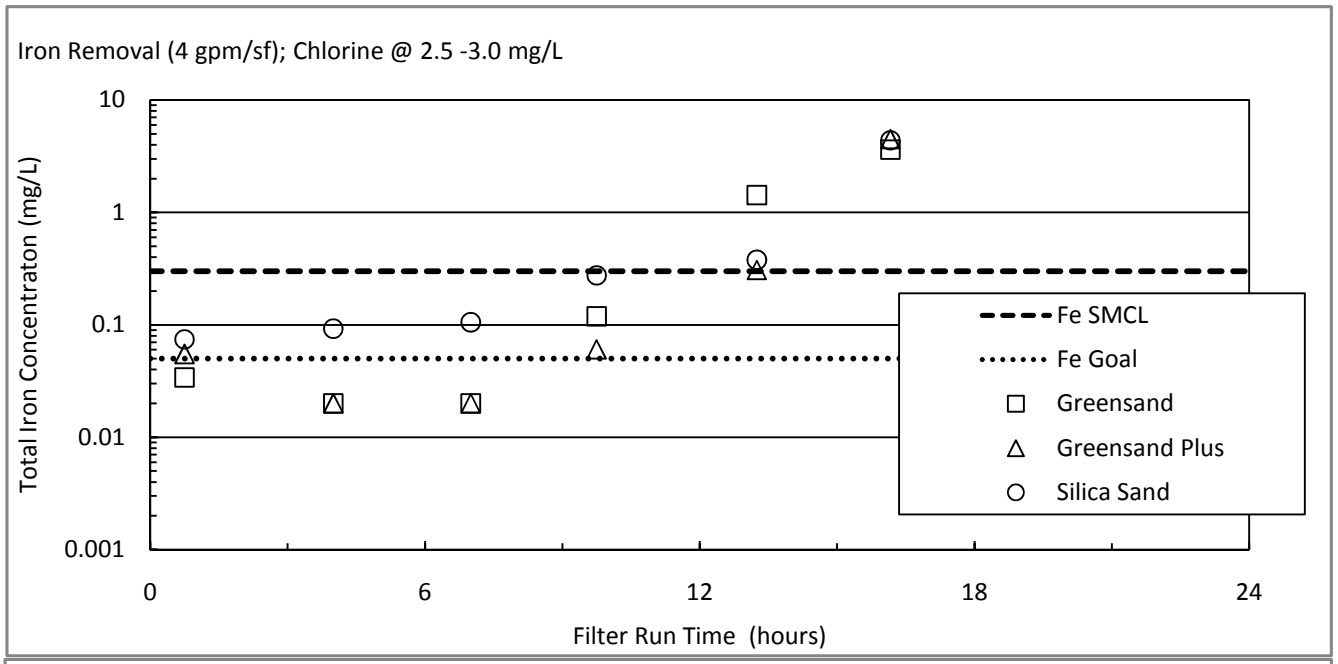
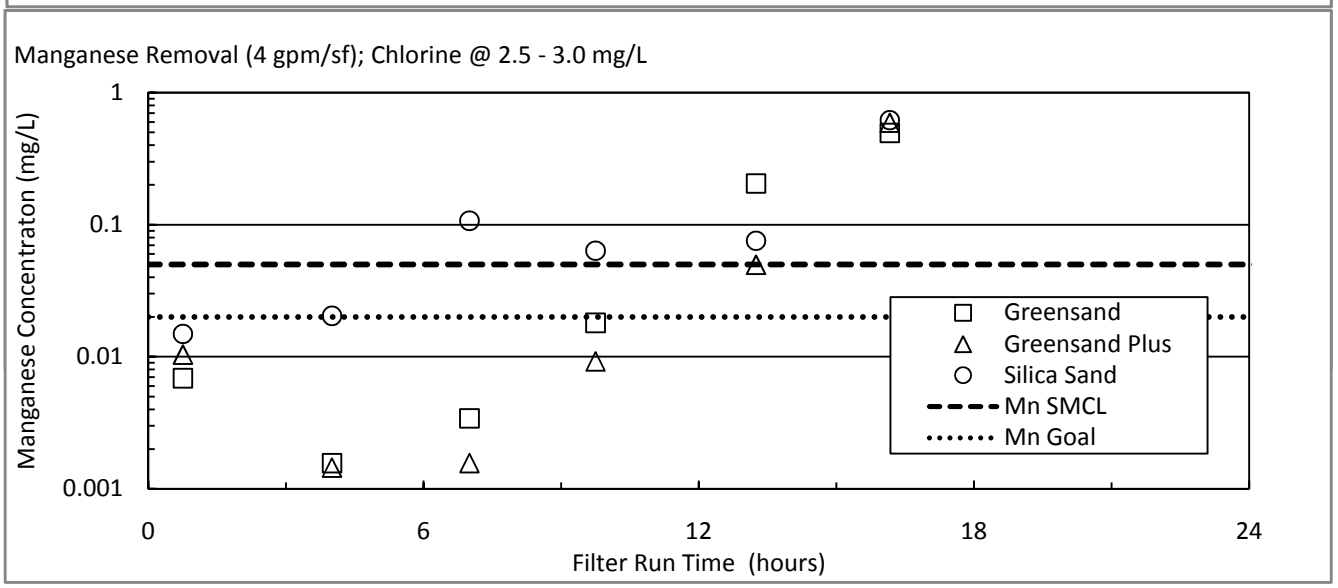
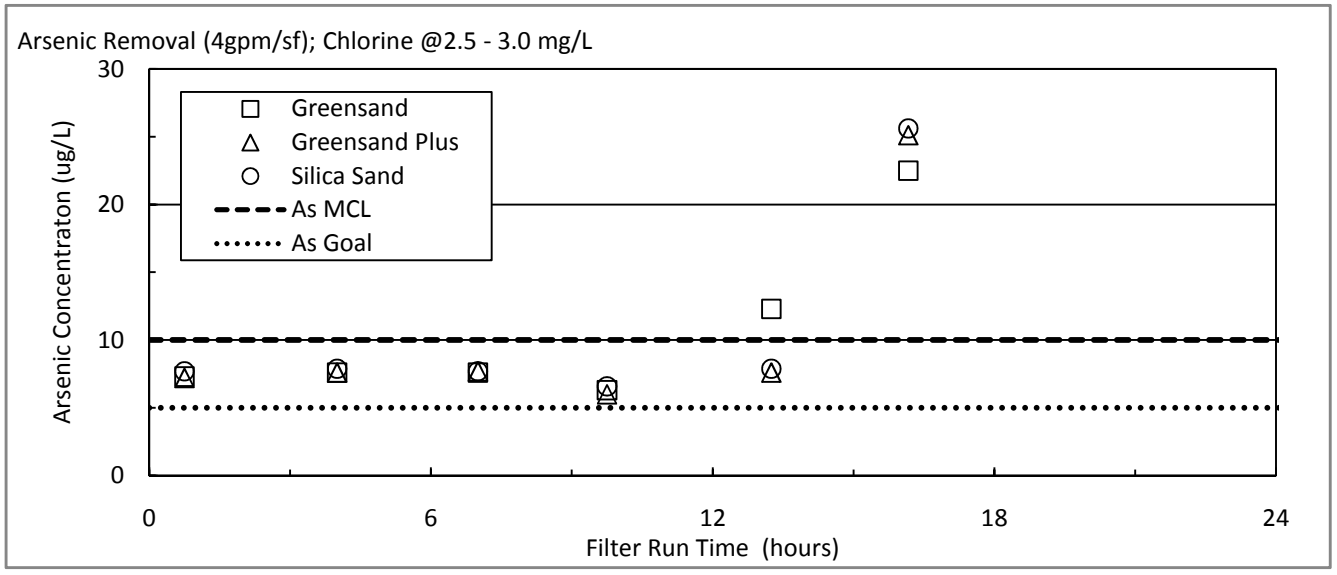
TITLE: GRANULAR MEDIA FILTER MODULE F100 ASSEMBLY	
CLIENT: INTUITECH	PROJECT: 1086
DRAWN BY: AJB	DRAWN DATE: 04-28-08
DRAWING NAME: 1086-F1ML-103	P.O.:
SCALE: NONE	REVISION: 0

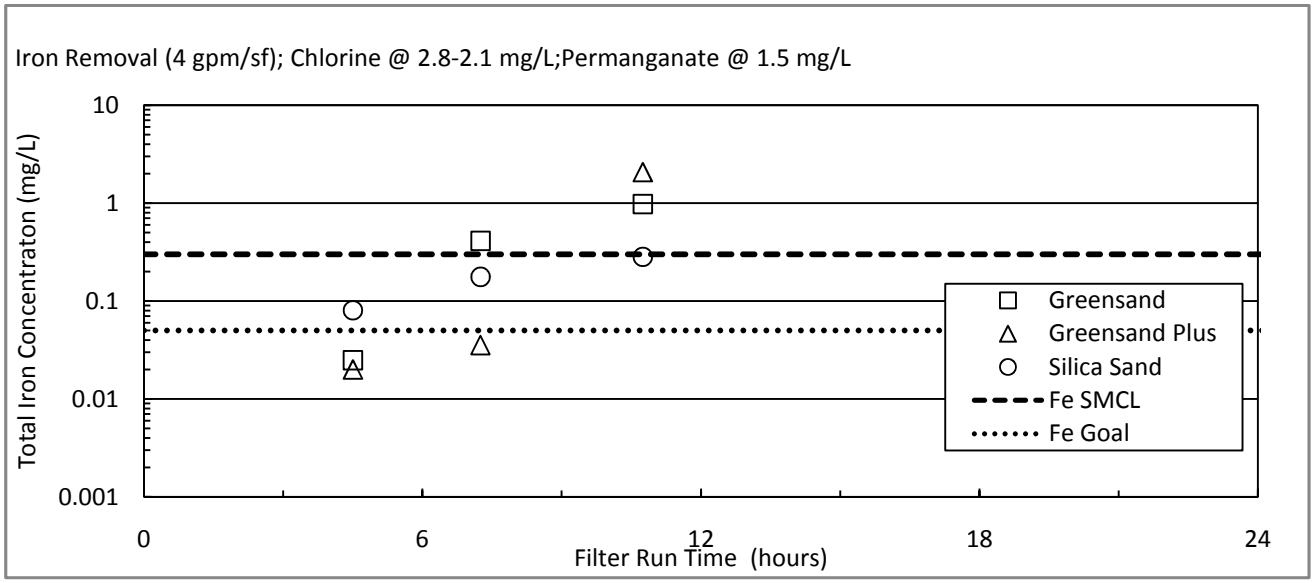
APPENDIX 2: Pilot Study Data

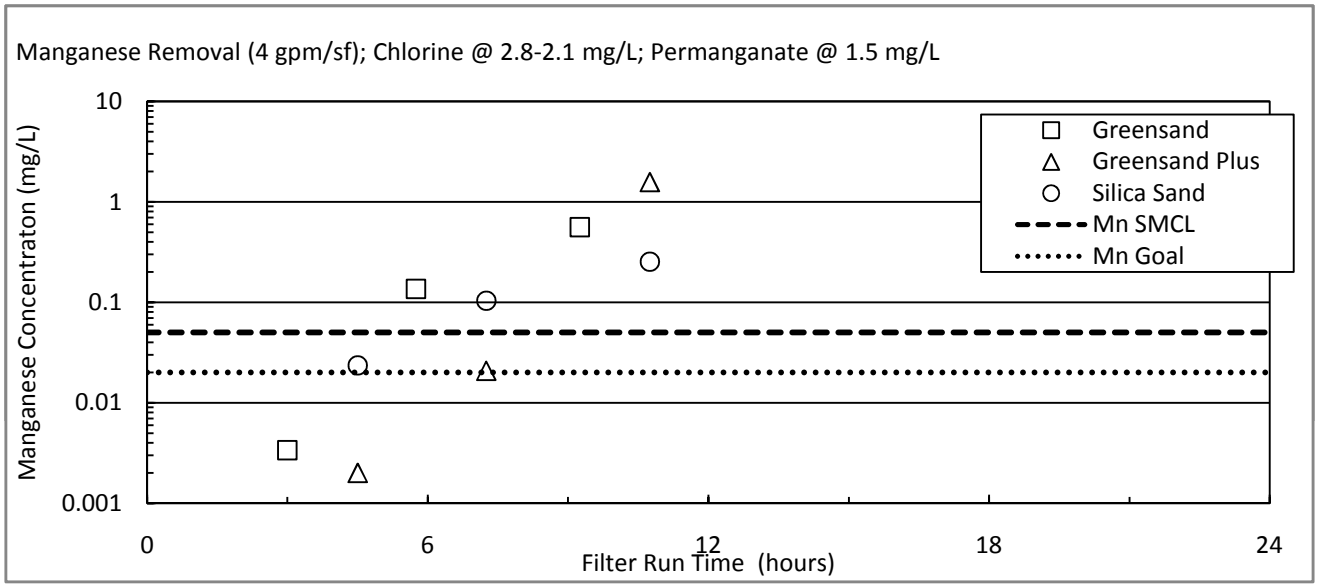
APPENDIX 2A - Iron, Manganese, and Arsenic Filter Run Graphs

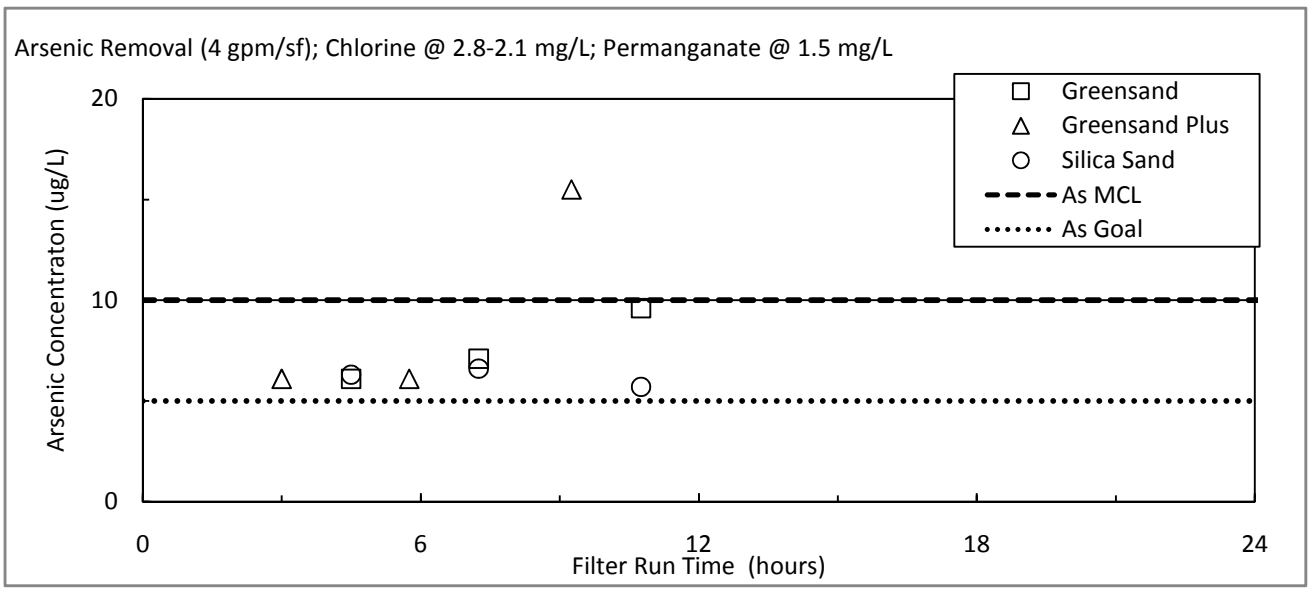

Iron Removal (4 gpm/sf); Chlorine @ 2.5 -3.0 mg/L
Total Iron Concentraton (mg/L)
10
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Fe SMCL
Fe Goal
Greensand
Greensand Plus
Silica Sand

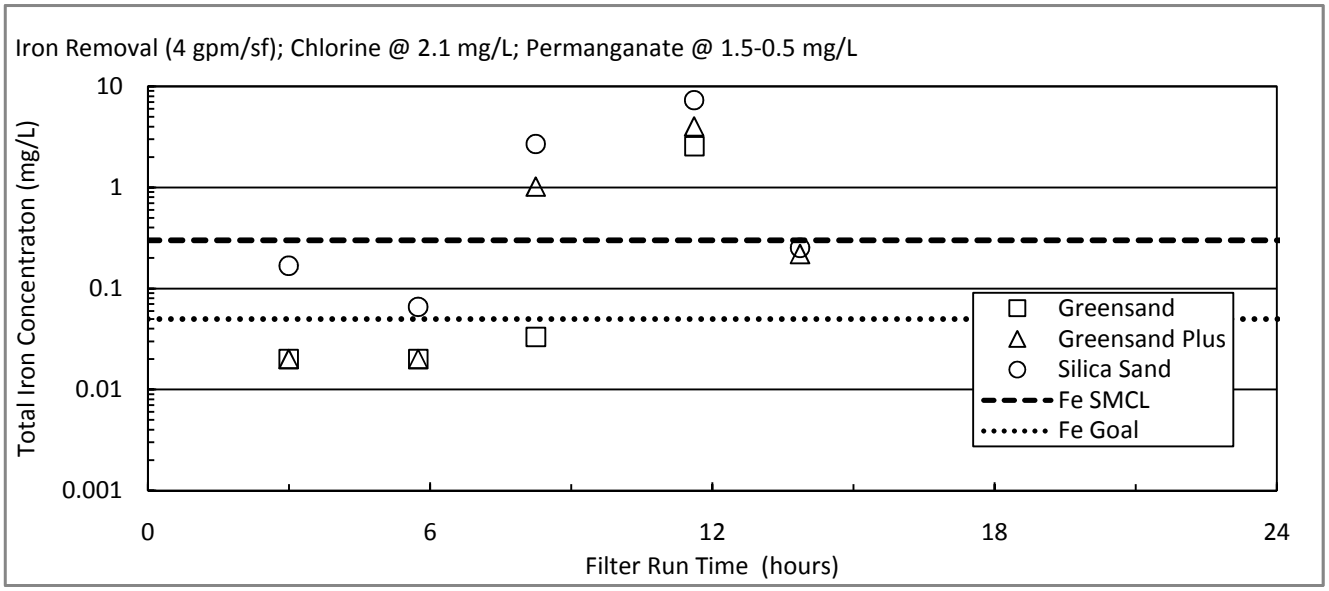

Manganese Removal (4 gpm/sf); Chlorine @ 2.5 - 3.0 mg/L
Manganese Concentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal

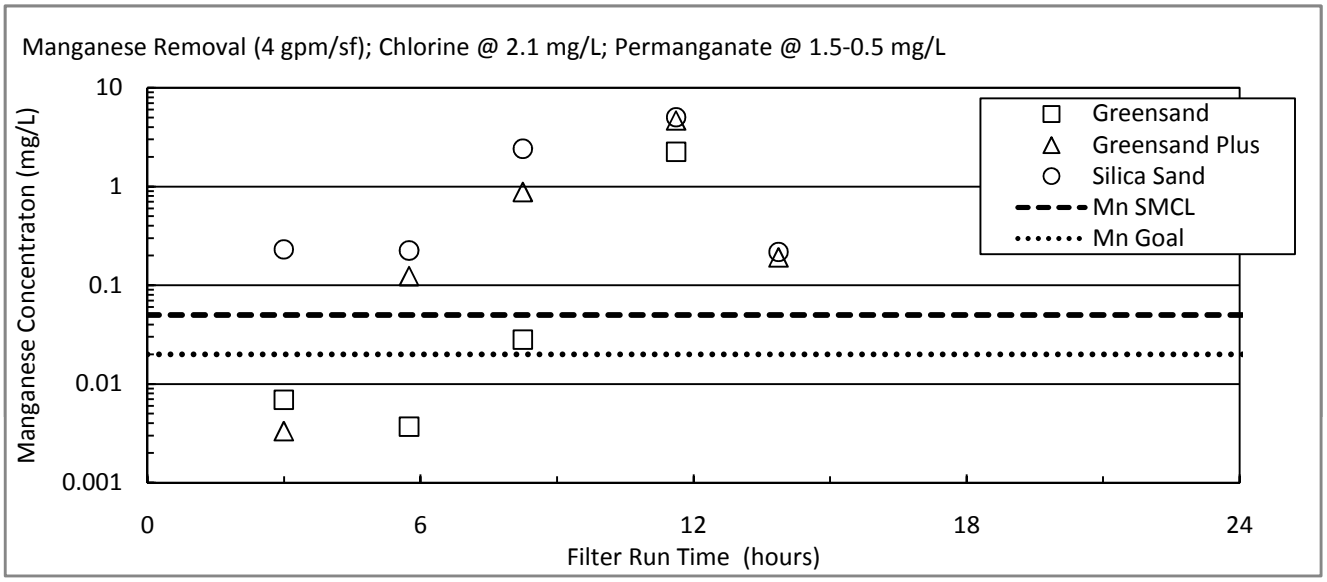

Arsenic Removal (4gpm/sf); Chlorine @2.5 - 3.0 mg/L
Arsenic Concentraton (ug/L)
30
20
10
0
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal

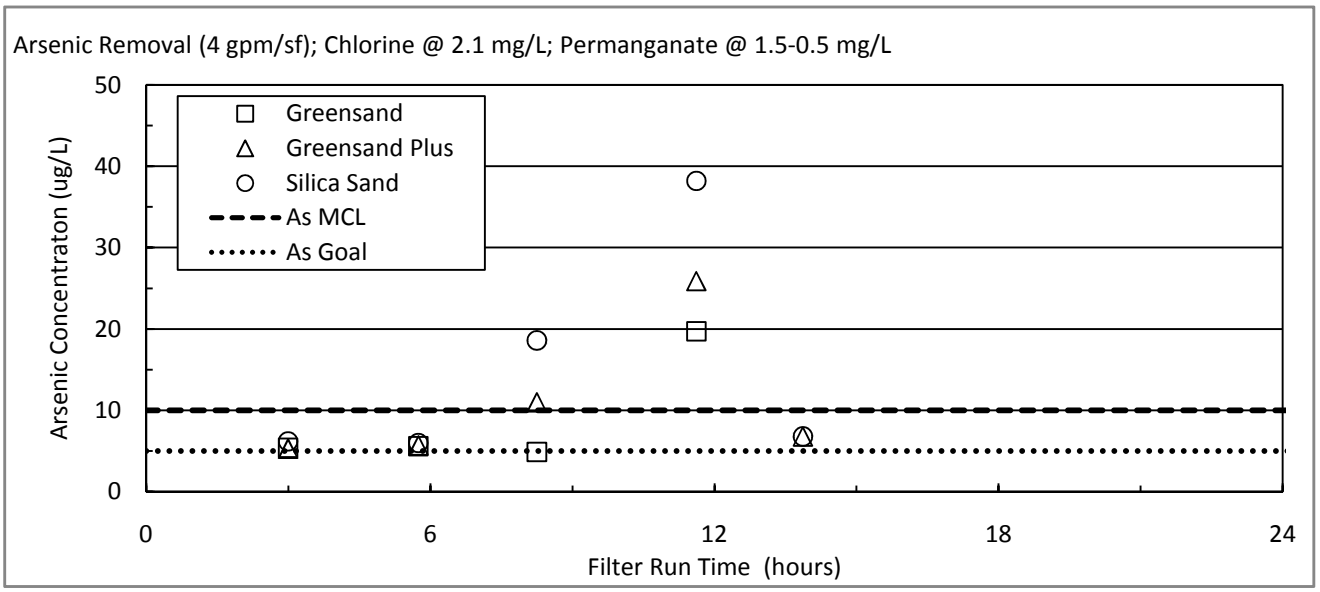

Iron Removal (4 gpm/sf); Chlorine @ 2.8-2.1 mg/L;Permanganate @ 1.5 mg/L
Total Iron Concentraton (mg/L)
10
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Fe SMCL
Fe Goal

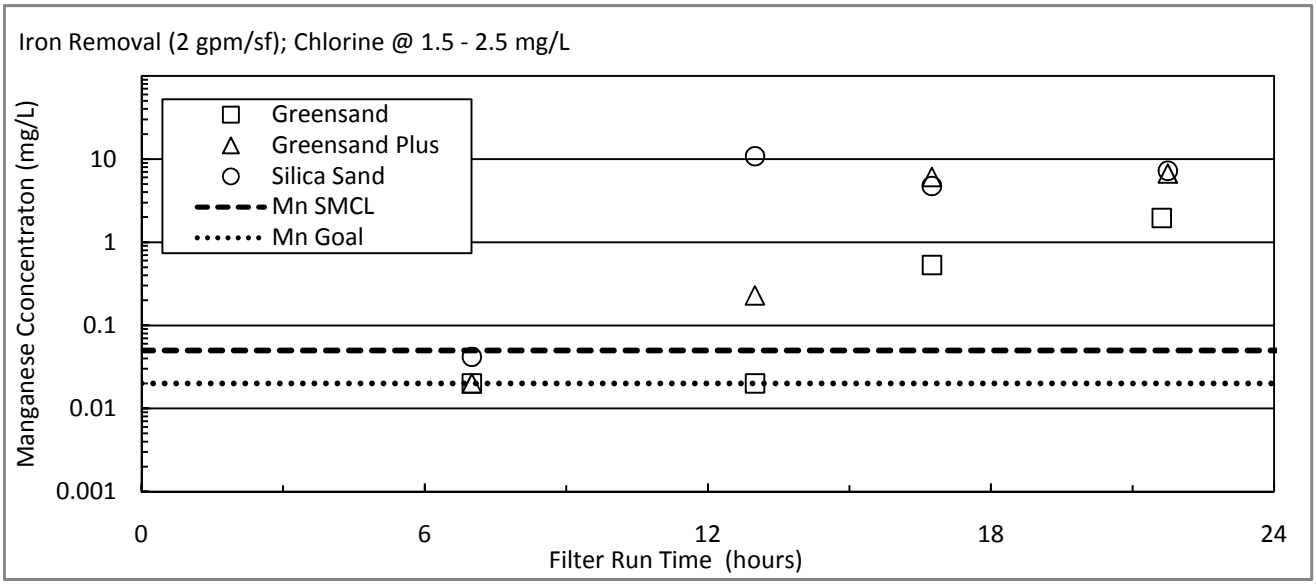

Manganese Removal (4 gpm/sf); Chlorine @ 2.8-2.1 mg/L; Permanganate @ 1.5 mg/L
Manganese Concentraton (mg/L)
10
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal

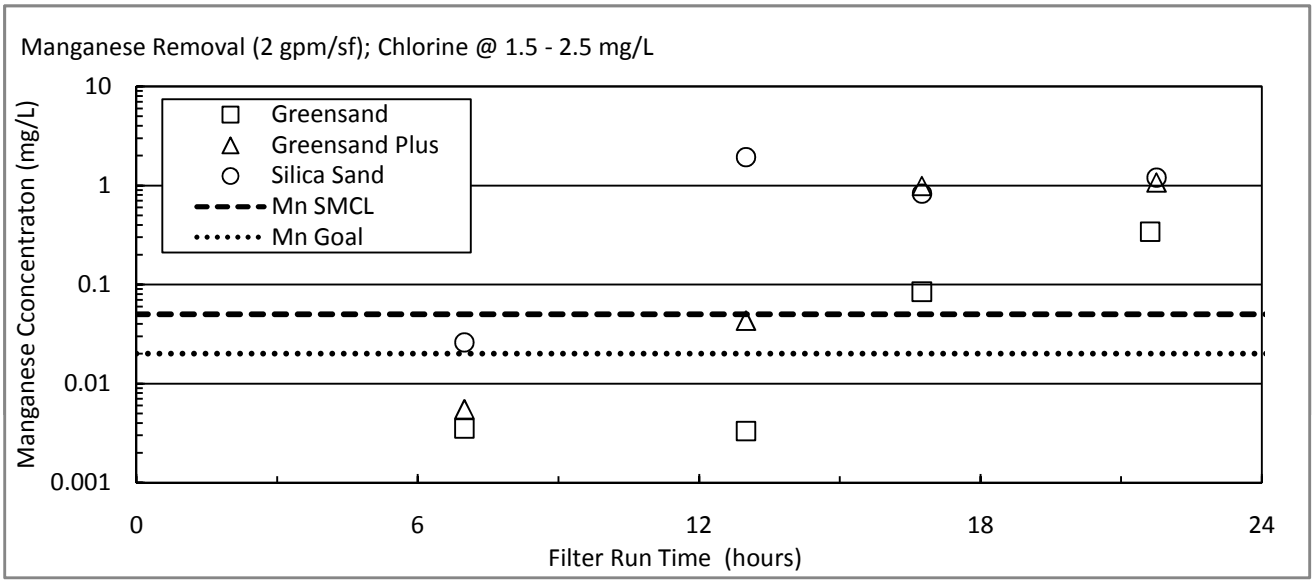

Arsenic Removal (4 gpm/sf); Chlorine @ 2.8-2.1 mg/L; Permanganate @ 1.5 mg/L
Arsenic Concentraton (ug/L)
20
10
0
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal

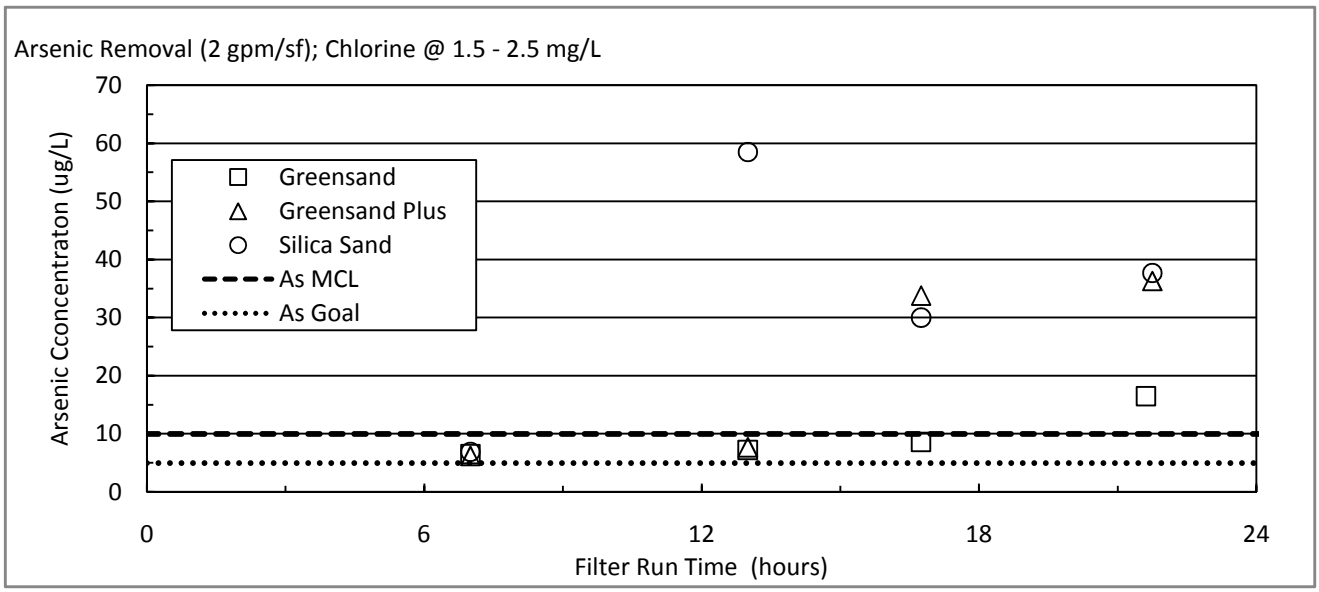

Iron Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 1.5-0.5 mg/L
Total Iron Concentraton (mg/L)
10
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Fe SMCL
Fe Goal

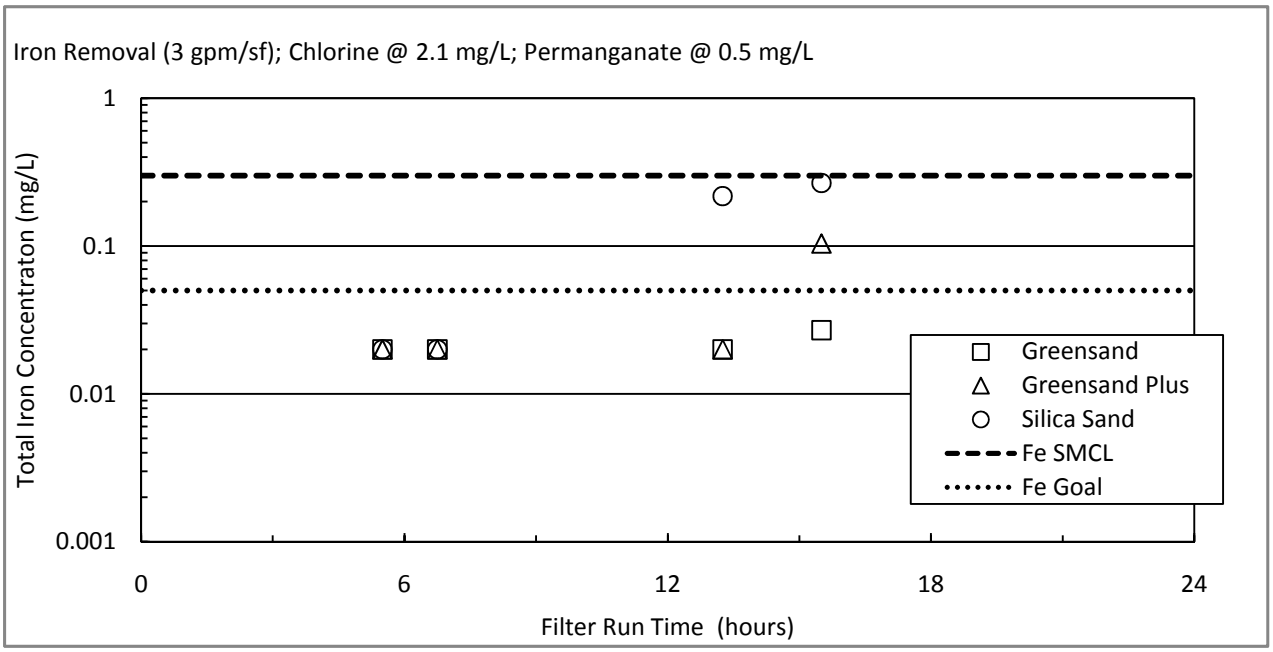

Manganese Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 1.5-0.5 mg/L
Manganese Concentraton (mg/L)
10
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal

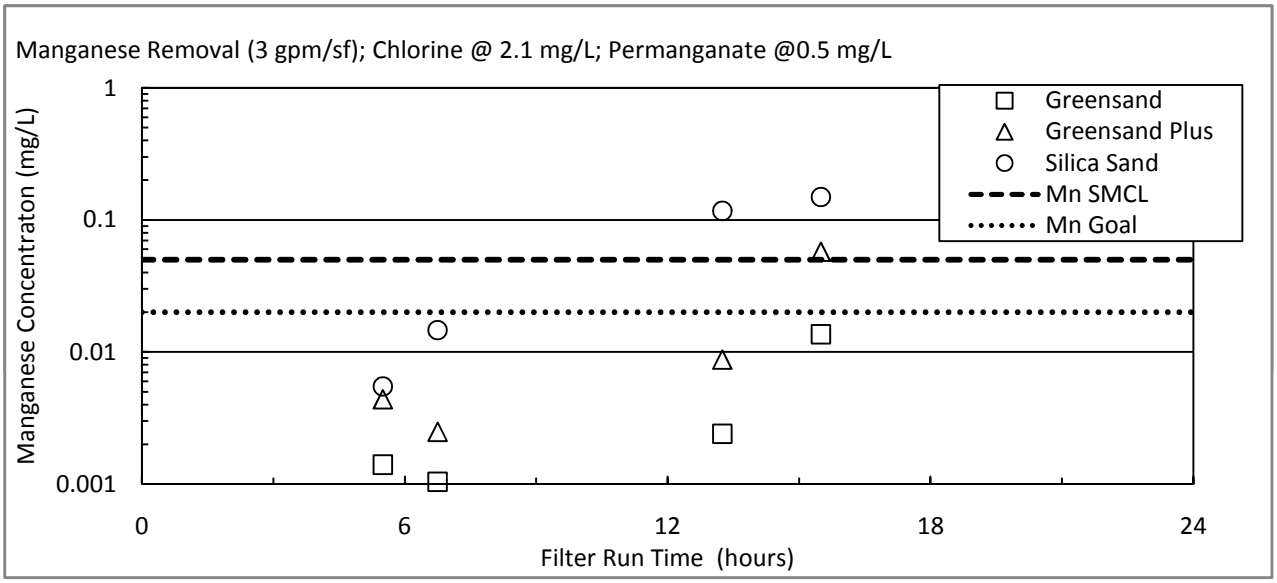

Arsenic Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 1.5-0.5 mg/L
Arsenic Concentraton (ug/L)
50
40
30
20
10
0
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal

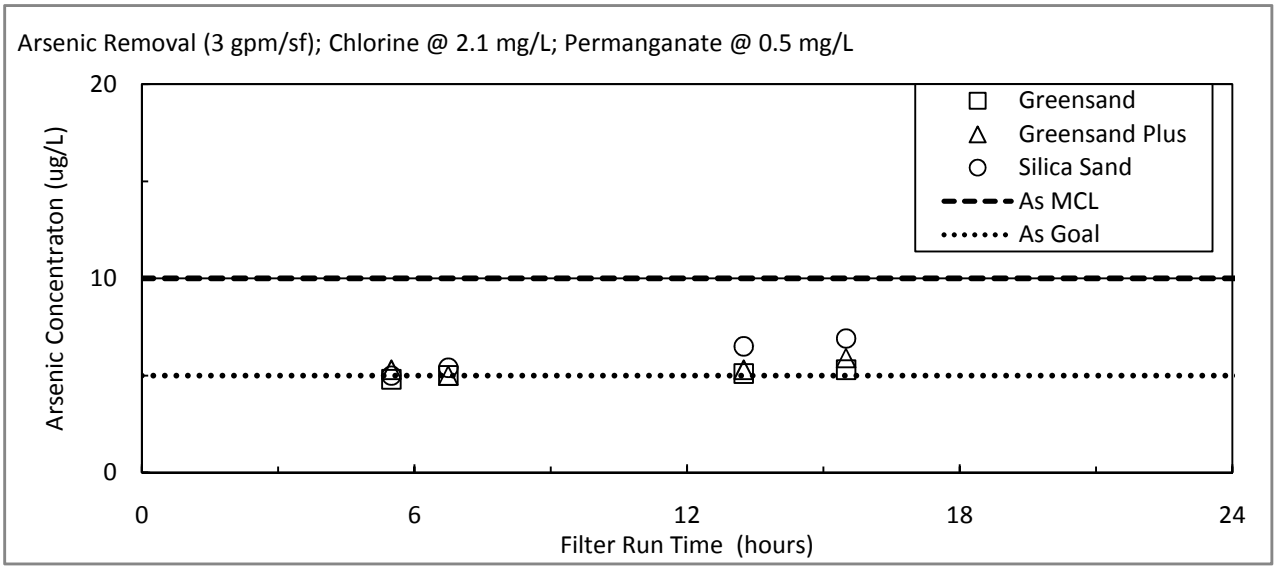

Iron Removal (2 gpm/sf); Chlorine @ 1.5 - 2.5 mg/L
Manganese Cconcentraton (mg/L)
10
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal

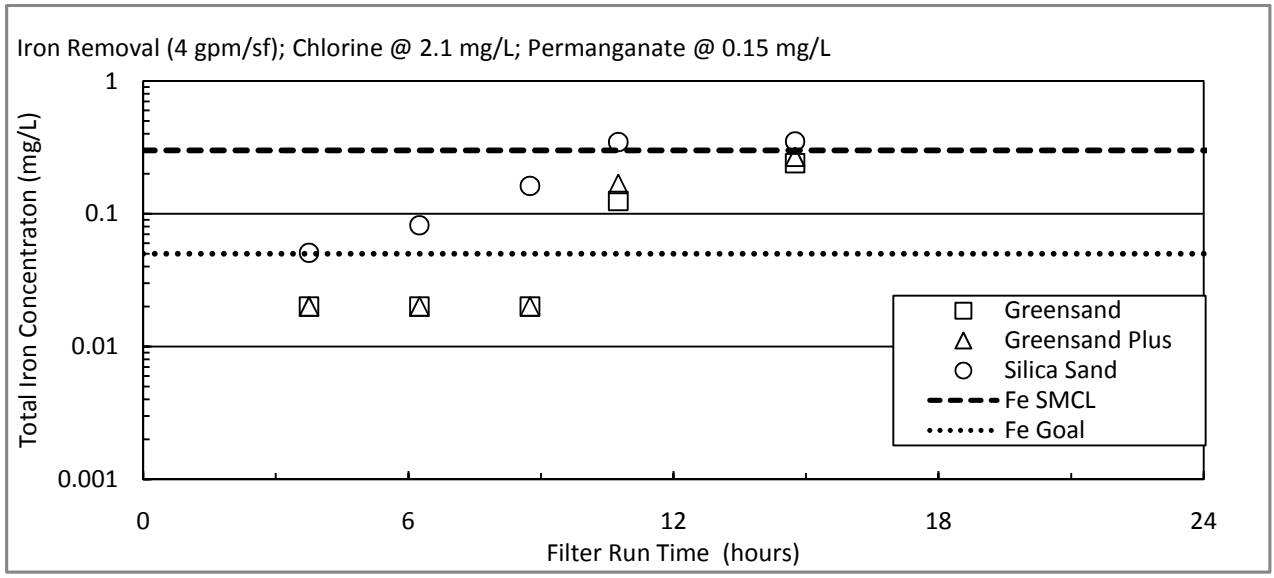

Manganese Removal (2 gpm/sf); Chlorine @ 1.5 - 2.5 mg/L
Manganese Cconcentraton (mg/L)
10
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal

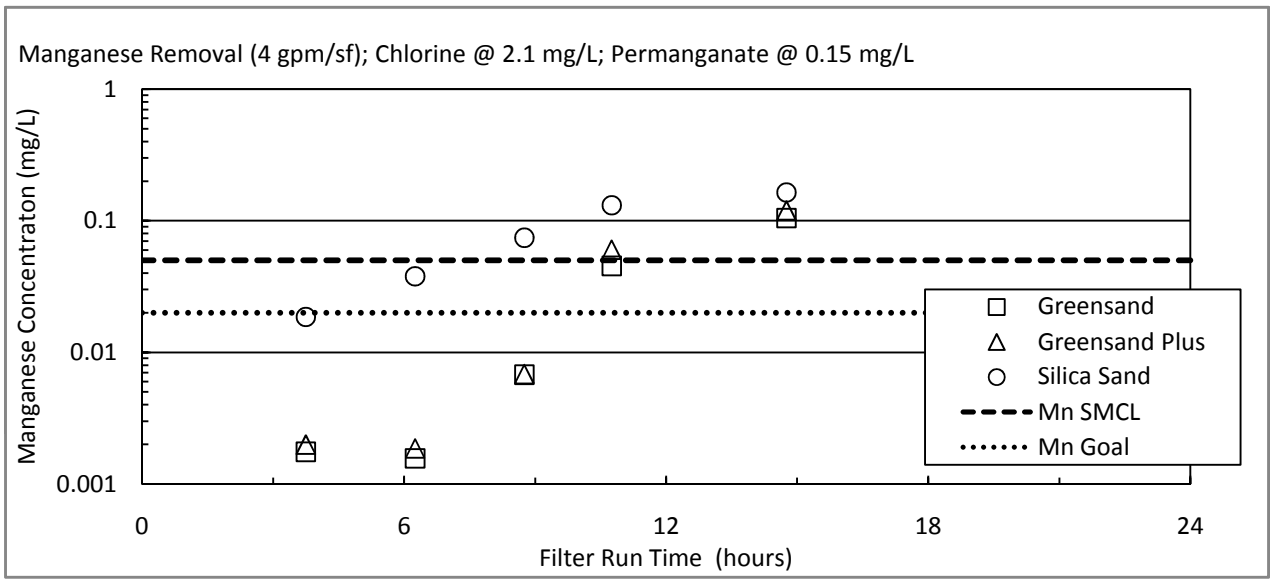

Arsenic Removal (2 gpm/sf); Chlorine @ 1.5 - 2.5 mg/L
Arsenic Cconcentraton (ug/L)
70
60
50
40
30
20
10
0
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal

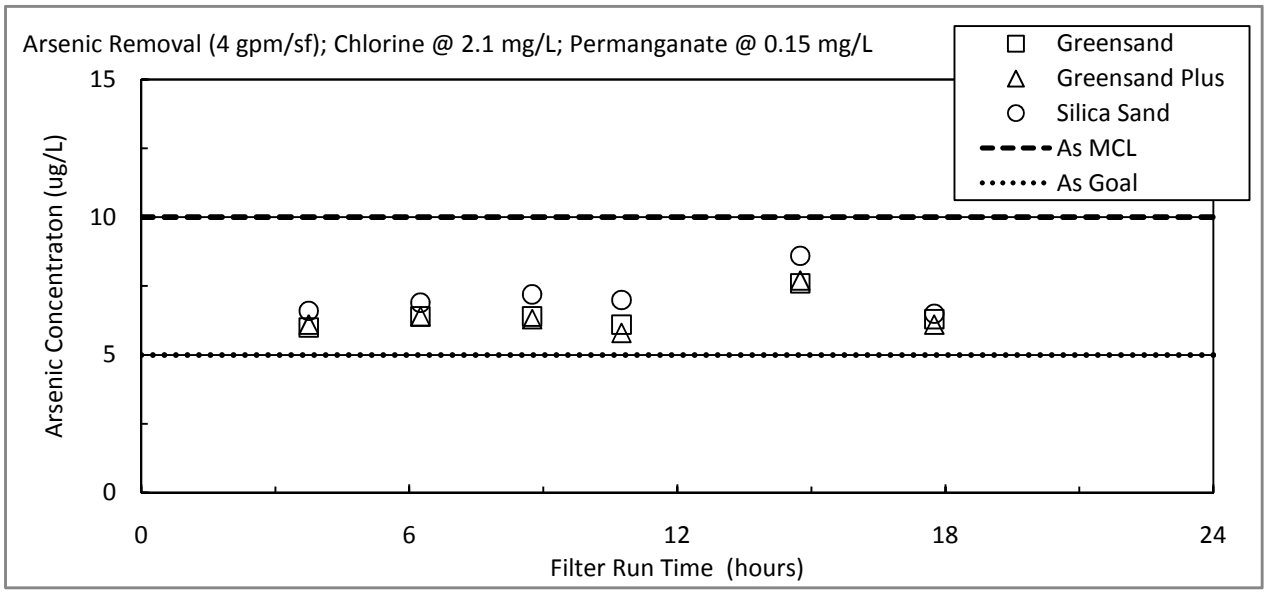

Iron Removal (3 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 0.5 mg/L
Total Iron Concentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Fe SMCL
Fe Goal

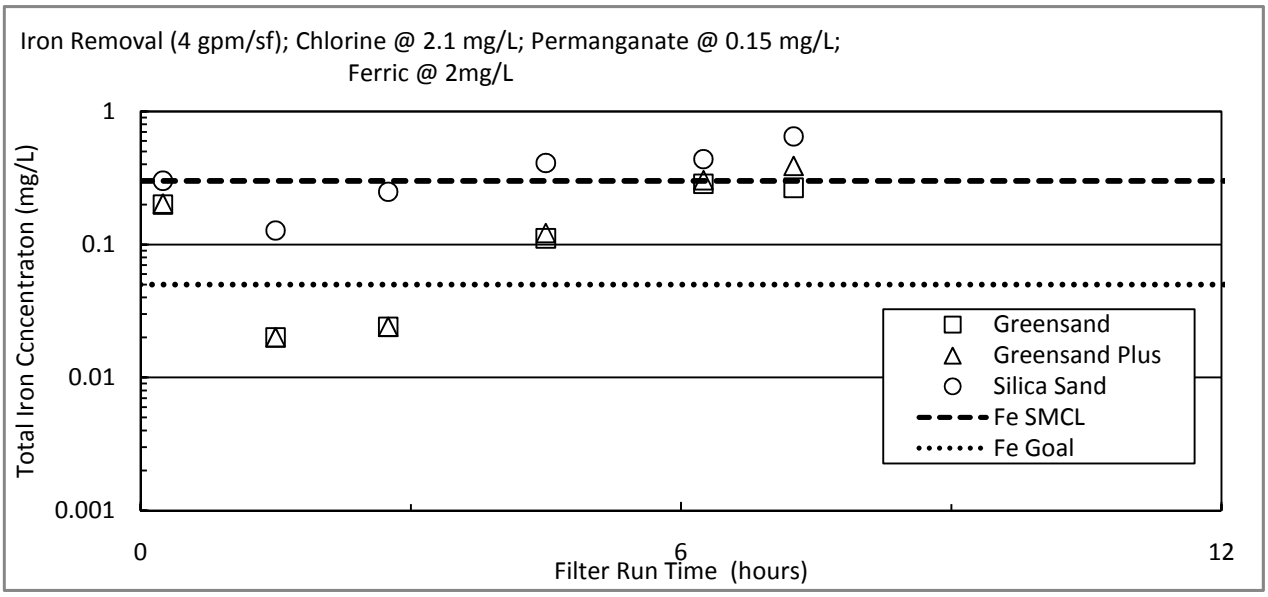

Manganese Removal (3 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @0.5 mg/L
Manganese Concentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal

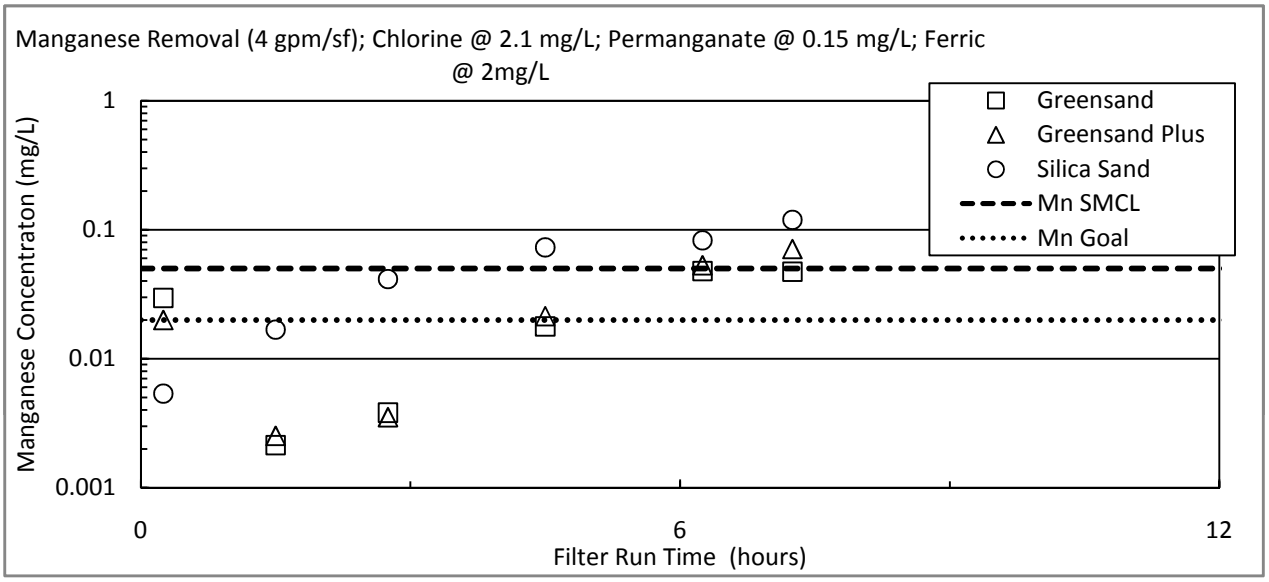

Arsenic Removal (3 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 0.5 mg/L
Arsenic Concentraton (ug/L)
20
10
0
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal

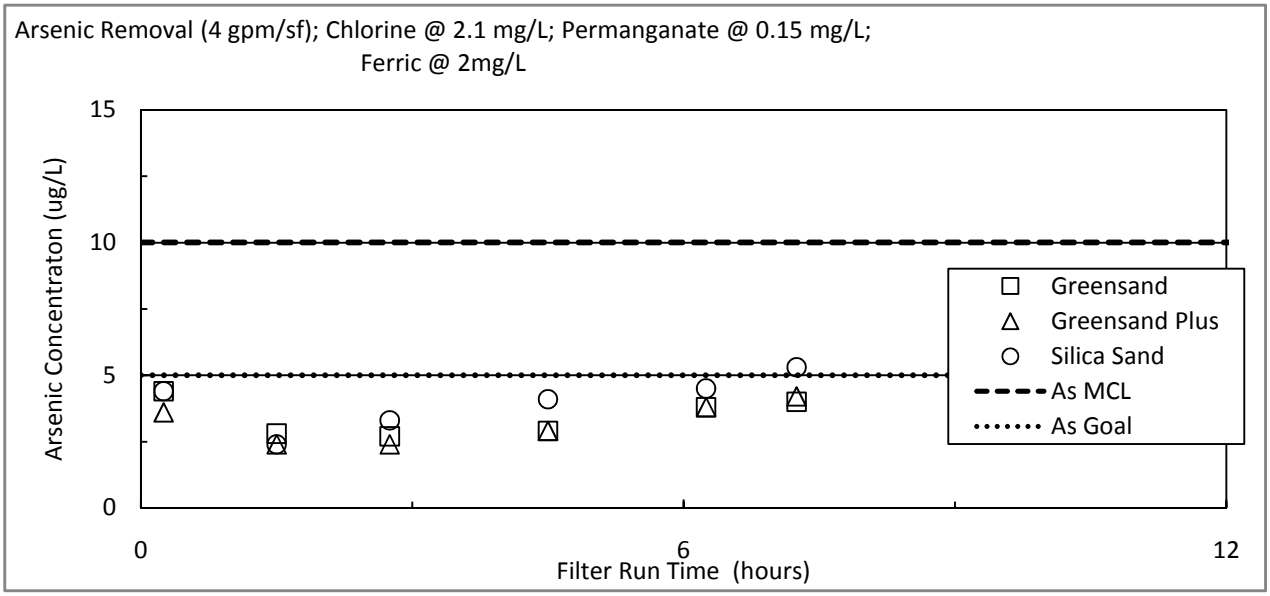

Iron Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 0.15 mg/L
Total Iron Concentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Fe SMCL
Fe Goal

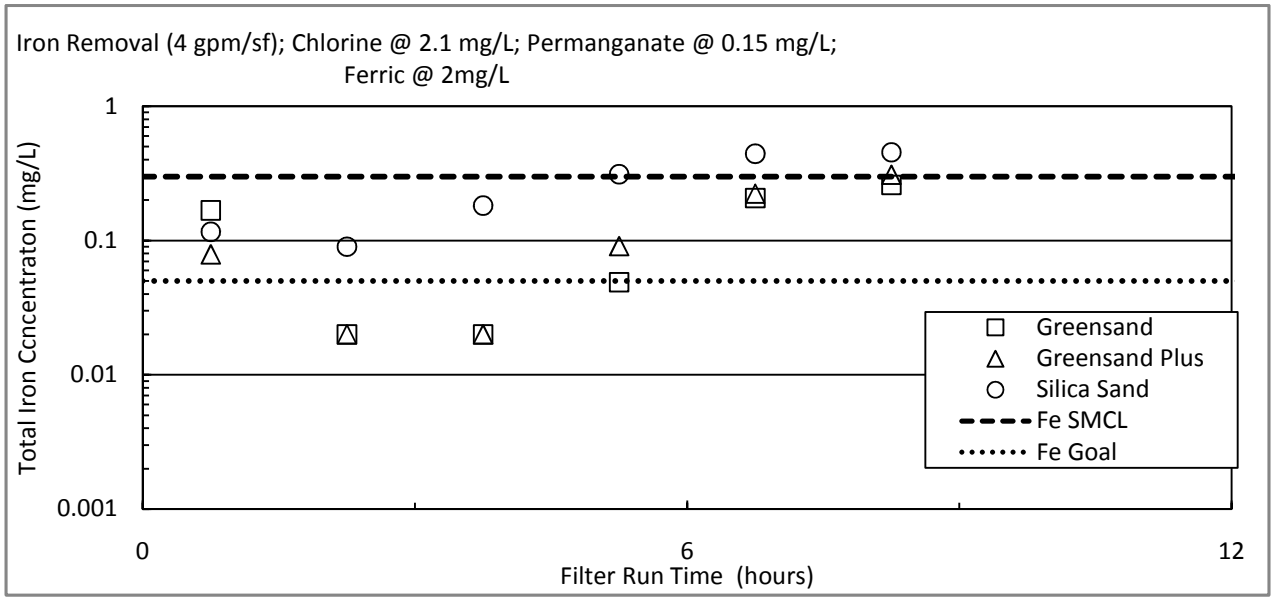

Manganese Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 0.15 mg/L
Manganese Concentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal

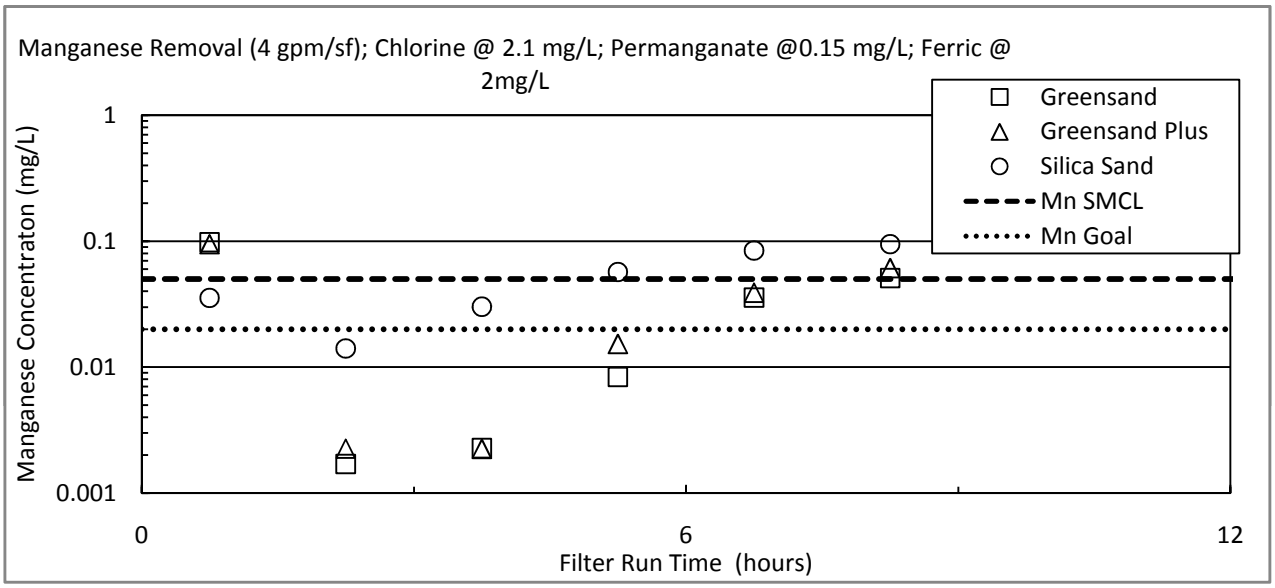

Arsenic Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 0.15 mg/L
Arsenic Concentraton (ug/L)
15
10
5
0
0
6
12
18
24
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal

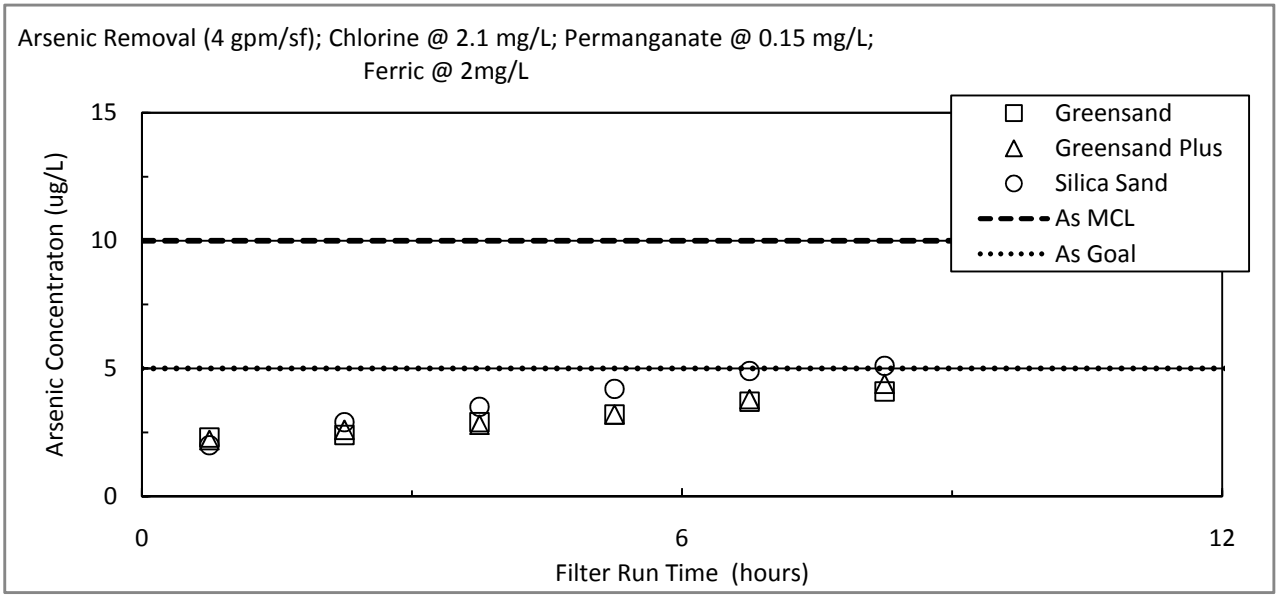

Iron Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 0.15 mg/L;
Ferric @ 2mg/L
Total Iron Ccncentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Fe SMCL
Fe Goal

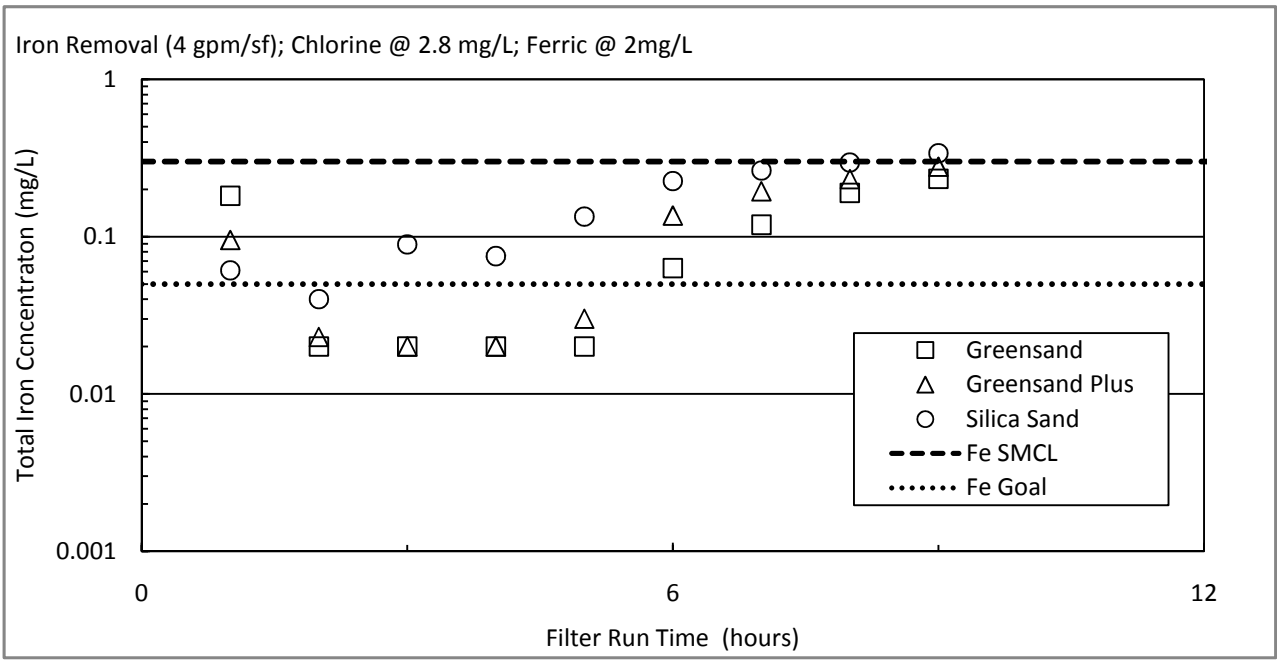

Manganese Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 0.15 mg/L; Ferric
@ 2mg/L
Manganese Concentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal

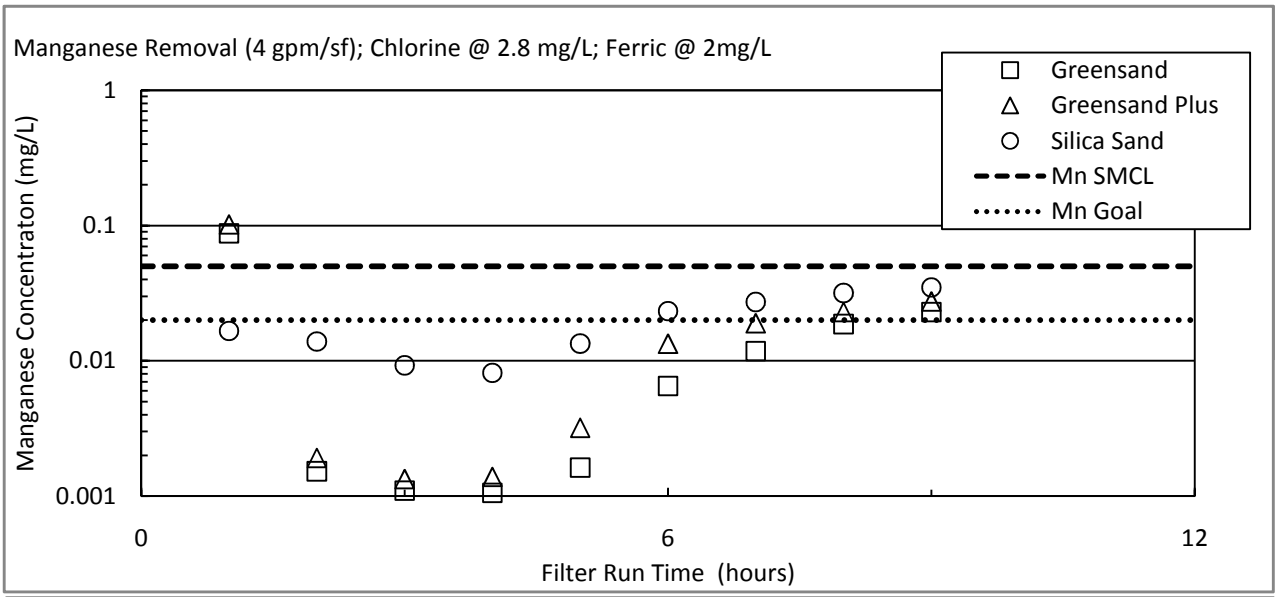

Arsenic Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 0.15 mg/L;
Ferric @ 2mg/L
Arsenic Concentraton (ug/L)
15
10
5
0
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal

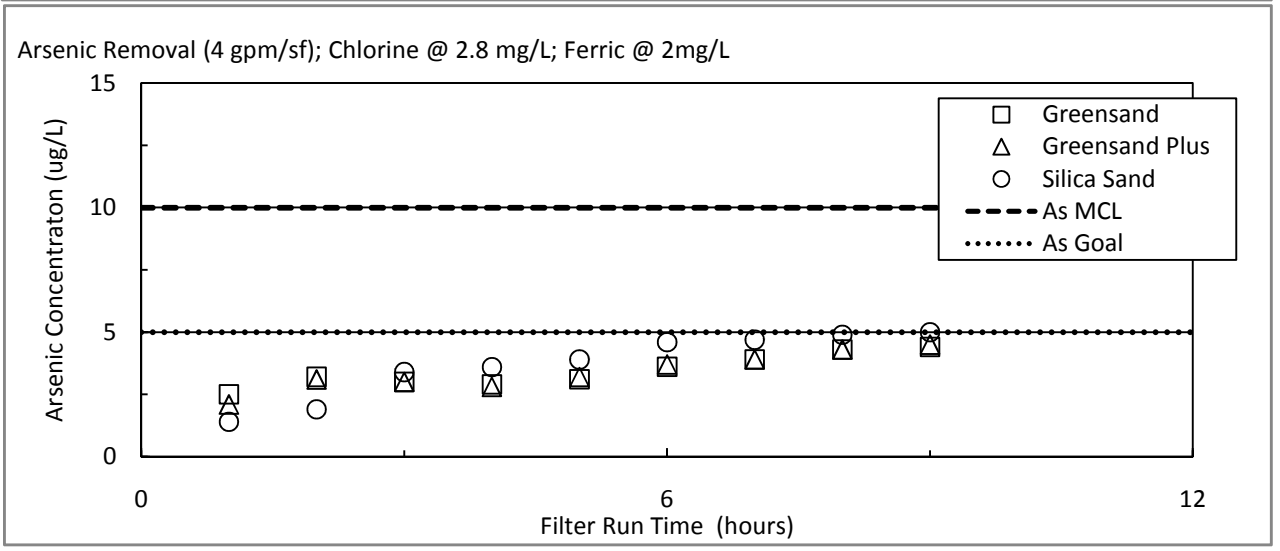

Iron Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 0.15 mg/L;
Ferric @ 2mg/L
Total Iron Ccncentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Fe SMCL
Fe Goal

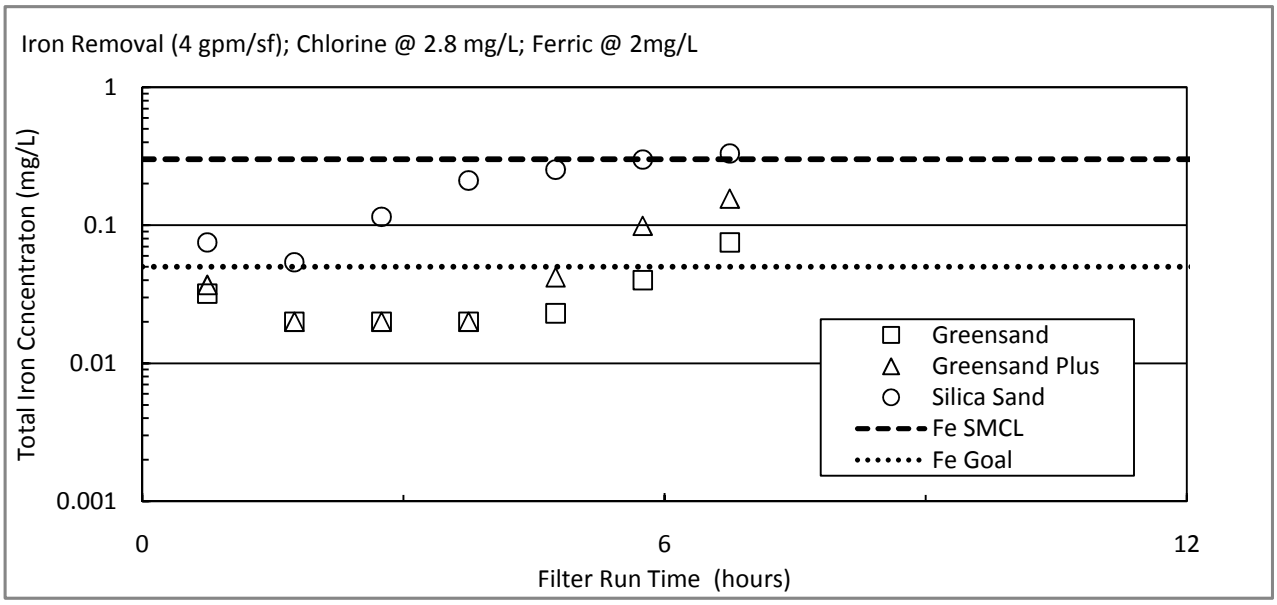

Manganese Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @0.15 mg/L; Ferric @
2mg/L
Manganese Concentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal

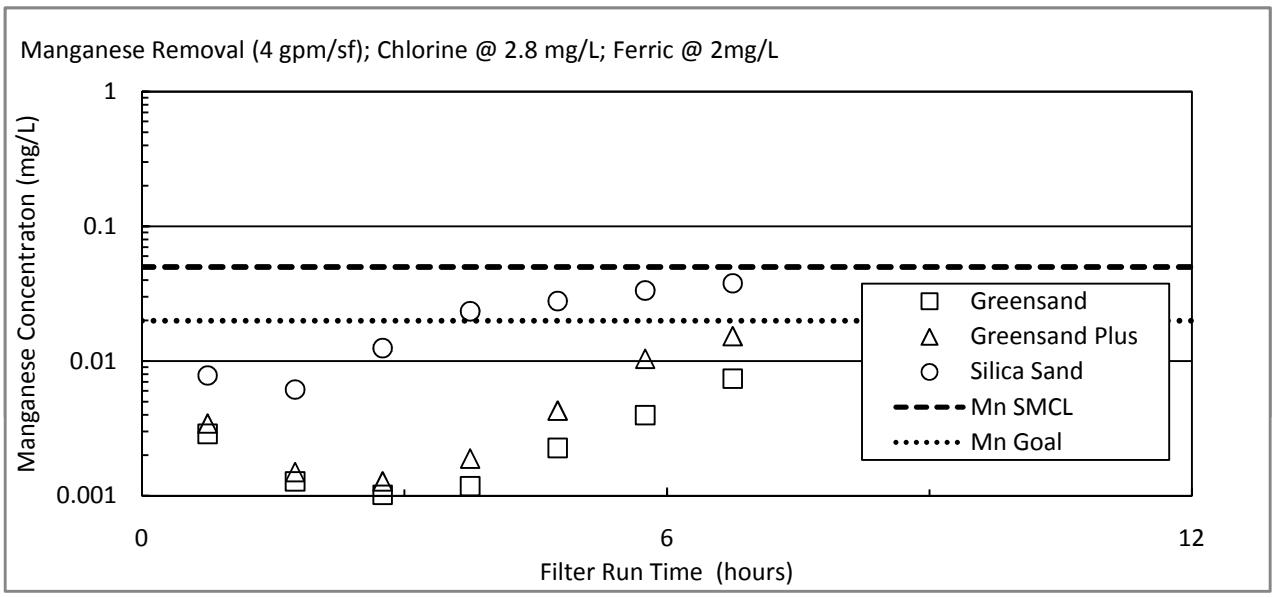

Arsenic Removal (4 gpm/sf); Chlorine @ 2.1 mg/L; Permanganate @ 0.15 mg/L;
Ferric @ 2mg/L
Arsenic Concentraton (ug/L)
15
10
5
0
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal

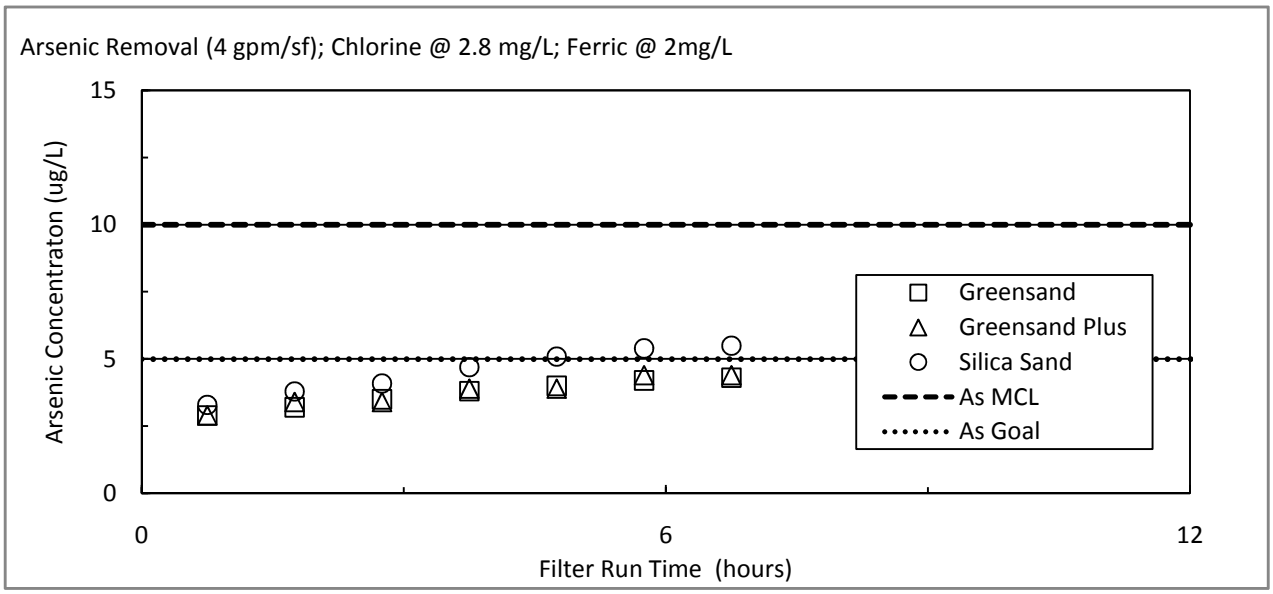

Iron Removal (4 gpm/sf); Chlorine @ 2.8 mg/L; Ferric @ 2mg/L
Total Iron Ccncentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Fe SMCL
Fe Goal

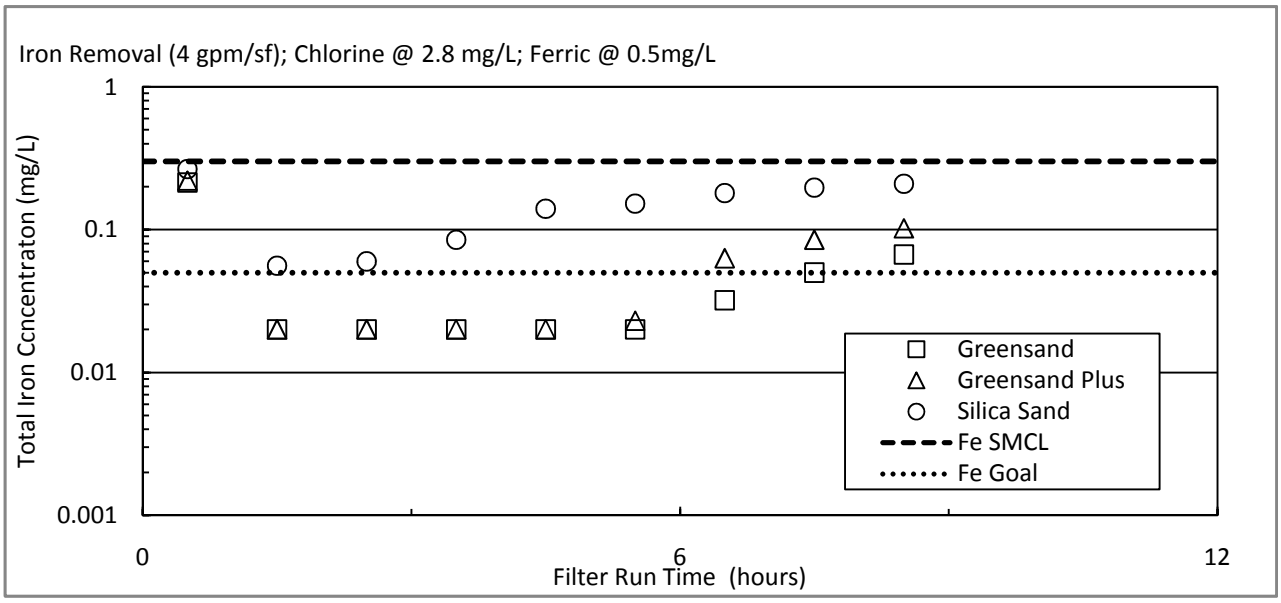

Manganese Removal (4 gpm/sf); Chlorine @ 2.8 mg/L; Ferric @ 2mg/L
Manganese Concentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal

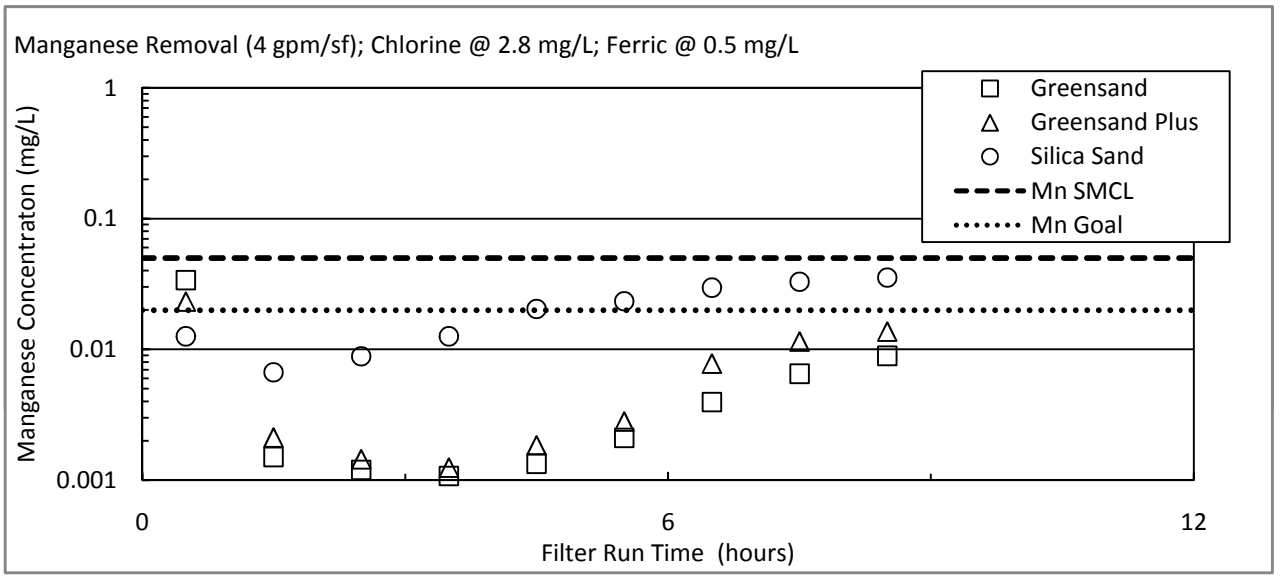

Arsenic Removal (4 gpm/sf); Chlorine @ 2.8 mg/L; Ferric @ 2mg/L
Arsenic Concentraton (ug/L)
15
10
5
0
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal

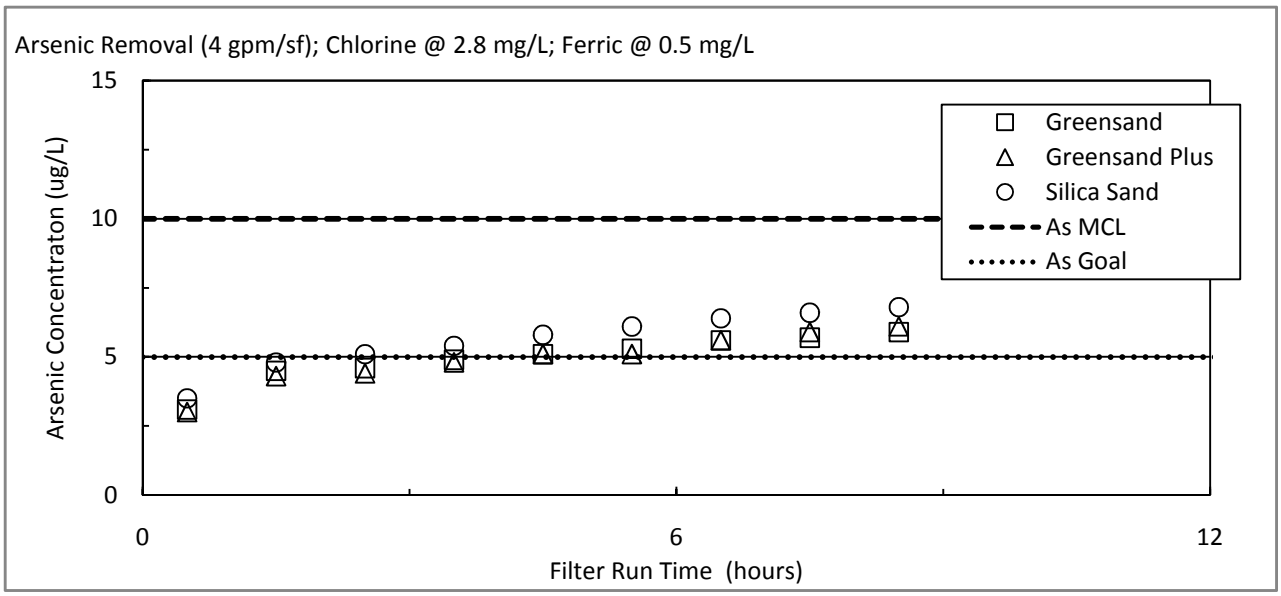

Iron Removal (4 gpm/sf); Chlorine @ 2.8 mg/L; Ferric @ 2mg/L
Total Iron Ccncentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Fe SMCL
Fe Goal


Manganese Removal (4 gpm/sf); Chlorine @ 2.8 mg/L; Ferric @ 2mg/L
Manganese Concentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal


Arsenic Removal (4 gpm/sf); Chlorine @ 2.8 mg/L; Ferric @ 2mg/L
Arsenic Concentraton (ug/L)
15
10
5
0
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal


Iron Removal (4 gpm/sf); Chlorine @ 2.8 mg/L; Ferric @ 0.5mg/L
Total Iron Ccncentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Fe SMCL
Fe Goal


Manganese Removal (4 gpm/sf); Chlorine @ 2.8 mg/L; Ferric @ 0.5 mg/L
Manganese Concentraton (mg/L)
1
0.1
0.01
0.001
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
Mn SMCL
Mn Goal


Arsenic Removal (4 gpm/sf); Chlorine @ 2.8 mg/L; Ferric @ 0.5 mg/L
Arsenic Concentraton (ug/L)
15
10
5
0
0
6
12
Filter Run Time (hours)
Greensand
Greensand Plus
Silica Sand
As MCL
As Goal

APPENDIX 2B - Total and Dissolved Metals Data

Total and Dissolved Metals Data

Note: Values less than the minimum reporting limit (MRL) are listed at the MRL
MRLs: 0.02 mg/L for iron, 0.00005 mg/L for manganese, and 0.5 ug/L for arsenic

			Raw					
		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine Feed, No PP, 2 gpm/sqft								
4/29/2009 12:30								
	4/29/2009 14:15	1.7						
	4/29/2009 15:15	2.7						
	4/29/2009 15:45	3.2						
4/29/2009 17:30	4/30/2009 9:30	6.5						
4/30/2009 8:00	4/30/2009 10:00	7.0	1.14	0.02	0.716	0.606	13.8	12.9
	4/30/2009 10:45	7.7						
	4/30/2009 11:15	8.2						
	4/30/2009 11:45	8.7						
	4/30/2009 14:22	11.4						
	4/30/2009 15:00	12.0						
	4/30/2009 15:30	12.5						
	4/30/2009 15:52	12.9						
	4/30/2009 16:00	13.0	1.18	0.02	0.729	0.602	13.8	12.4
4/30/2009 17:30	5/1/2009 9:22	15.1						
5/1/2009 8:45	5/1/2009 11:00	16.7	1.14	0.02	0.72	0.61	13.8	12.7
	5/1/2009 11:52	17.6						
	5/1/2009 14:22	20.1						
	5/1/2009 15:07	20.9						
	5/1/2009 15:52	21.6						
	5/1/2009 16:00	21.7	1.22	0.02	0.721	0.595	14	12.7

			Raw					
		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine Feed, No PP, 4 gpm/sqft (PP fed last 1 hour of run)								
5/4/2009 9:30	5/4/2009 10:15	0.8	1.2	0.02	0.584	0.568	13.3	12.8
	5/4/2009 11:00	1.5						
	5/4/2009 13:30	4.0	1.08	0.02	0.59	0.569	13.4	12.5
	5/4/2009 15:00	5.5						
5/4/2009 17:30	5/4/2009 16:30	7.0	1.13	0.02	0.593	0.559	13.8	12.8
5/5/2009 8:00	5/5/2009 9:45	9.75	1.44	0.02	0.492	0.465	11.6	10.6
	5/5/2009 10:30	10.50						
	5/5/2009 13:15	13.25	1.11	0.02	0.488	0.466	12.2	11.5
	5/5/2009 15:15	15.25						
	5/5/2009 16:10	16.17	1.04	0.02	0.49	0.459	12.5	11.4
Chlorine @ 2.8-2.1 mg/L, 4 gpm/sqft (PP feed @ ~6.5 hr of run)								
5/6/2009 8:45	5/6/2009 10:37	1.9						
	5/6/2009 11:15	2.5						
	5/6/2009 11:45	3.0						
	5/6/2009 13:15	4.5	1.31	0.02	0.478	0.433	12.2	11.4
	5/6/2009 14:00	5.3						
	5/6/2009 14:30	5.7						
5/6/2009 17:00	5/6/2009 16:00	7.2	1.08	0.02	0.479	0.447	12.5	12
5/7/2009 8:00	5/7/2009 9:00	9.25						
	5/7/2009 10:30	10.75	1.23	0.02	0.509	0.565	12.8	12.3

			Raw					
		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.1 mg/L + PP Feed (adj 1.5-0.5 mg/L thru run), 4 gpm/sqft								
5/7/2009 11:00	5/7/2009 13:00	2.0						
	5/7/2009 14:00	3.0	1.23	0.02	0.495	0.561	12.9	12.6
	5/7/2009 15:15	4.2						
	5/7/2009 16:15	5.3						
5/7/2009 17:30	5/7/2009 16:45	5.7	1.13	0.02	0.493	0.559	13.1	12.5
5/8/2009 8:15	5/8/2009 10:00	8.25	1.4	0.02	0.576	0.533	12.6	11.2
	5/8/2009 10:52	9.12						
	5/8/2009 11:22	9.62						
	5/8/2009 13:22	11.62	1.24	0.02	0.584	0.539	13.4	12.1
	5/8/2009 14:15	12.50						
	5/8/2009 15:37	13.87	1.2	0.02	0.555	0.538	13	12
5/8/2009 17:30	5/11/2009 8:45	16.25						
5/11/2009 8:15								

			Raw					
		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Filter 1 Only								
Chlorine @ 2.1 mg/L + PP Feed @ 0.5 mg/L, 4 gpm/sqft								
5/8/2009 15:15	5/8/2009 15:37	0.4						
	5/11/2009 8:45	2.75						
5/8/2009 17:30	5/11/2009 10:00	4.00						
5/11/2009 8:15	5/11/2009 10:45	4.75	1.29	0.02	0.63	0.576	12.9	11.7
	5/11/2009 12:30	6.50						
	5/11/2009 15:15	9.25	1.18	0.02	0.611	0.593	12.8	12
Filter 2 and 3 Only								
Chlorine @ 2.1 mg/L + PP Feed @ 0.5 mg/L, 3 gpm/sqft								
5/11/2009 9:15	5/11/2009 10:00	0.8						
	5/11/2009 10:45	1.5	1.29	0.02	0.63	0.576	12.9	11.7
	5/11/2009 12:30	3.3						
	5/11/2009 15:15	6.0	1.18	0.02	0.611	0.593	12.8	12
Chlorine @ 2.8 mg/L + PP Feed @ 0.3 mg/L, 3 gpm/sqft								
5/12/2009 9:45	5/12/2009 10:30	0.8						
	5/12/2009 11:30	1.7						
	5/12/2009 13:30	3.8						
	5/12/2009 14:30	4.7						
	5/12/2009 15:15	5.5	1.13	0.02	0.596	0.575	12.7	12.1
	5/12/2009 16:30	6.75	1.21	0.02	0.613	0.57	13.1	11.7
5/12/2009 17:00	5/13/2009 9:15	8.00						
5/13/2009 8:30	5/13/2009 10:15	9.00						
	5/13/2009 11:00	9.75						
	5/13/2009 14:30	13.25	1.24	0.02	0.632	0.64	11.6	11.5
	5/13/2009 16:15	15.00						
	5/13/2009 16:45	15.50	1.21	0.02	0.68	0.633	12.1	10.8

			Raw					
		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, 4 gpm/sqft								
5/14/2009 8:30	5/14/2009 10:45	2.3						
	5/14/2009 12:15	3.8	1.11	0.02	0.618	0.619	13.7	12.9
	5/14/2009 14:45	6.3	1.22	0.02	0.601	0.617	13.6	13
	5/14/2009 17:15	8.8	1.22	0.02	0.6	0.57	13.4	12.1
5/14/2009 17:30	5/15/2009 9:30	10.00						
5/15/2009 8:30	5/15/2009 10:15	10.75	1.44	0.02	0.592	0.555	12.6	11.2
	5/15/2009 11:15	11.75						
	5/15/2009 14:15	14.75	1.2	0.02	0.576	0.551	13	11.9
2.5 hrs AFTER B/W	5/15/2009 17:15	17.75	1.19	0.02	0.567	0.574	12.6	12.1
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/18/2009 9:00	5/18/2009 9:15	0.2	2.05	0.02	0.682	0.642	9.4	8.3
	5/18/2009 10:30	1.5						
	5/18/2009 11:00	2.0						
	5/18/2009 11:45	2.8						
	5/18/2009 13:30	4.5						
	5/18/2009 15:15	6.2						
	5/18/2009 16:15	7.3	1.15	0.02	0.654	0.636	11.7	10.8
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/19/2009 8:30	5/19/2009 9:15	0.8	1.38	0.027	0.657	0.637	11.2	10
	5/19/2009 10:45	2.3						
	5/19/2009 12:15	3.8						
	5/19/2009 13:45	5.3						
	5/19/2009 15:15	6.8						
	5/19/2009 16:45	8.3						

			Raw					
		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.8 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/20/2009 8:15	5/20/2009 9:15	1.0	1.34	0.02	0.656	0.643	11.2	10.7
	5/20/2009 10:15	2.0						
	5/20/2009 11:15	3.0						
	5/20/2009 12:15	4.0						
	5/20/2009 13:15	5.0						
	5/20/2009 14:15	6.0						
	5/20/2009 15:15	7.0						
	5/20/2009 16:15	8.0						
5/20/2009 17:30	5/20/2009 17:15	9.0						
5/21/2009 8:30	5/21/2009 9:15	10.00						
Chlorine @ 2.8 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/21/2009 10:30	5/21/2009 11:15	0.8	1.24	0.02	0.682	0.664	11.7	11
	5/21/2009 12:15	1.7						
	5/21/2009 13:15	2.8						
	5/21/2009 14:15	3.8						
	5/21/2009 15:15	4.7						
	5/21/2009 16:15	5.8						
	5/21/2009 17:15	6.8						
Chlorine @ 2.8 mg/L, Ferric @ 0.5 mg/L, 4 gpm/sqft								
5/22/2009 8:45	5/22/2009 9:15	0.5	1.28	0.02	0.673	0.658	11.6	10.9
	5/22/2009 10:15	1.5						
	5/22/2009 11:15	2.5						
	5/22/2009 12:15	3.5						
	5/22/2009 13:15	4.5						
	5/22/2009 14:15	5.5						
	5/22/2009 15:15	6.5						
	5/22/2009 16:15	7.5						
	5/22/2009 17:15	8.5						

Greensand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine Feed, No PP, 2 gpm/sqft								
4/29/2009 12:30								
	4/29/2009 14:15	1.7						
	4/29/2009 15:15	2.7						
	4/29/2009 15:45	3.2						
4/29/2009 17:30	4/30/2009 9:30	6.5						
4/30/2009 8:00	4/30/2009 10:00	7.0	0.02	0.02	0.0035	0.00208	6.5	6.5
	4/30/2009 10:45	7.7						
	4/30/2009 11:15	8.2						
	4/30/2009 11:45	8.7						
	4/30/2009 14:22	11.4						
	4/30/2009 15:00	12.0						
	4/30/2009 15:30	12.5						
	4/30/2009 15:52	12.9						
	4/30/2009 16:00	13.0	0.02	0.02	0.0033	0.00099	7.2	7.2
4/30/2009 17:30	5/1/2009 9:22	15.1						
5/1/2009 8:45	5/1/2009 11:00	16.7	0.532	0.02	0.0844	0.00167	8.6	6.5
	5/1/2009 11:52	17.6						
	5/1/2009 14:22	20.1						
	5/1/2009 15:07	20.9						
	5/1/2009 15:52	21.6	1.96	0.02	0.341	0.00532	16.5	6.7
	5/1/2009 16:00	21.7						

Greensand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine Feed, No PP, 4 gpm/sqft (PP fed last 1 hour of run)								
5/4/2009 9:30	5/4/2009 10:15	0.8	0.034	0.02	0.0069	0.00102	7.3	7.4
	5/4/2009 11:00	1.5						
	5/4/2009 13:30	4.0	0.02	0.02	0.00157	0.00136	7.6	7.6
	5/4/2009 15:00	5.5						
5/4/2009 17:30	5/4/2009 16:30	7.0	0.02	0.02	0.00342	0.00128	7.6	7.5
5/5/2009 8:00	5/5/2009 9:45	9.75	0.119	0.02	0.0181	0.00096	6.3	5.7
	5/5/2009 10:30	10.50						
	5/5/2009 13:15	13.25	1.43	0.02	0.205	0.00074	12.3	6.2
	5/5/2009 15:15	15.25						
	5/5/2009 16:10	16.17	3.62	0.02	0.495	0.00165	22.5	6.2
Chlorine @ 2.8-2.1 mg/L, 4 gpm/sqft (PP feed @ ~6.5 hr of run)								
5/6/2009 8:45	5/6/2009 10:37	1.9						
	5/6/2009 11:15	2.5						
	5/6/2009 11:45	3.0						
	5/6/2009 13:15	4.5	0.025	0.02	0.00338	0.00192	6.1	6.1
	5/6/2009 14:00	5.3						
	5/6/2009 14:30	5.7						
5/6/2009 17:00	5/6/2009 16:00	7.2	0.414	0.02	0.136	0.00054	7.1	5.9
5/7/2009 8:00	5/7/2009 9:00	9.25						
	5/7/2009 10:30	10.75	0.98	0.02	0.559	0.00026	9.6	4.6

Greensand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.1 mg/L + PP Feed (adj 1.5-0.5 mg/L thru run), 4 gpm/sqft								
5/7/2009 11:00	5/7/2009 13:00	2.0						
	5/7/2009 14:00	3.0	0.02	0.02	0.00693	0.00054	5.4	5.4
	5/7/2009 15:15	4.2						
	5/7/2009 16:15	5.3						
5/7/2009 17:30	5/7/2009 16:45	5.7	0.02	0.02	0.0037	0.0003	5.6	5.6
5/8/2009 8:15	5/8/2009 10:00	8.25	0.033	0.02	0.0281	0.0006	4.9	5.2
	5/8/2009 10:52	9.12						
	5/8/2009 11:22	9.62						
	5/8/2009 13:22	11.62	2.56	0.02	2.25	0.00063	19.7	5.3
	5/8/2009 14:15	12.50						
	5/8/2009 15:37	13.87	X	X	X	X	X	X
5/8/2009 17:30	5/11/2009 8:45	16.25	X	X	X	X	X	X
5/11/2009 8:15								

Greensand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Filter 1 Only								
Chlorine @ 2.1 mg/L + PP Feed @ 0.5 mg/L, 4 gpm/sqft								
5/8/2009 15:15	5/8/2009 15:37	0.4						
	5/11/2009 8:45	2.75						
5/8/2009 17:30	5/11/2009 10:00	4.00						
5/11/2009 8:15	5/11/2009 10:45	4.75	0.02	0.02	0.0014	0.00048	3.4	3.3
	5/11/2009 12:30	6.50						
	5/11/2009 15:15	9.25	0.02	0.02	0.0009	0.00049	5.1	4.8
Filter 2 and 3 Only								
Chlorine @ 2.1 mg/L + PP Feed @ 0.5 mg/L, 3 gpm/sqft								
5/11/2009 9:15	5/11/2009 10:00	0.8	X	X	X	X	X	X
	5/11/2009 10:45	1.5	X	X	X	X	X	X
	5/11/2009 12:30	3.3	X	X	X	X	X	X
	5/11/2009 15:15	6.0	X	X	X	X	X	X
Chlorine @ 2.8 mg/L + PP Feed @ 0.3 mg/L, 3 gpm/sqft								
5/12/2009 9:45	5/12/2009 10:30	0.8						
	5/12/2009 11:30	1.7						
	5/12/2009 13:30	3.8						
	5/12/2009 14:30	4.7						
	5/12/2009 15:15	5.5	0.02	0.02	0.0014	0.00069	4.8	4.8
	5/12/2009 16:30	6.75	0.02	0.02	0.00104	0.00038	5	4.9
5/12/2009 17:00	5/13/2009 9:15	8.00						
5/13/2009 8:30	5/13/2009 10:15	9.00						
	5/13/2009 11:00	9.75						
	5/13/2009 14:30	13.25	0.02	0.02	0.0024	0.00047	5.1	5.2
	5/13/2009 16:15	15.00						
	5/13/2009 16:45	15.50	0.027	0.02	0.0136	0.0056	5.3	5.1

Greensand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, 4 gpm/sqft								
5/14/2009 8:30	5/14/2009 10:45	2.3						
	5/14/2009 12:15	3.8	0.02	0.02	0.00176	0.0058	6	6
	5/14/2009 14:45	6.3	0.02	0.02	0.00157	0.00058	6.4	6.4
	5/14/2009 17:15	8.8	0.02	0.02	0.00678	0.00076	6.4	6.4
5/14/2009 17:30	5/15/2009 9:30	10.00						
5/15/2009 8:30	5/15/2009 10:15	10.75	0.125	0.02	0.0455	0.00268	6.1	5.2
	5/15/2009 11:15	11.75						
	5/15/2009 14:15	14.75	0.24	0.02	0.105	0.00182	7.6	6.2
2.5 hrs AFTER B/W	5/15/2009 17:15	17.75	0.02	0.02	0.00336	0.00071	6.3	6.1
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/18/2009 9:00	5/18/2009 9:15	0.2	0.199	0.02	0.0297	0.00217	4.4	3.3
	5/18/2009 10:30	1.5	0.02	0.02	0.00214	0.00097	2.8	2.4
	5/18/2009 11:00	2.0						
	5/18/2009 11:45	2.8	0.024	0.02	0.00382	0.00115	2.7	2.3
	5/18/2009 13:30	4.5	0.111	0.02	0.0178	0.00231	2.9	2.4
	5/18/2009 15:15	6.2	0.285	0.02	0.0479	0.0289	3.8	2.6
	5/18/2009 16:15	7.3	0.266	0.02	0.0474	0.00451	4	2.6
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/19/2009 8:30	5/19/2009 9:15	0.8	0.168	0.02	0.0981	0.00305	2.3	1.3
	5/19/2009 10:45	2.3	0.02	0.02	0.00171	0.00098	2.4	2.3
	5/19/2009 12:15	3.8	0.02	0.02	0.00228	0.00098	2.9	2.4
	5/19/2009 13:45	5.3	0.049	0.02	0.00837	0.00252	3.2	2.8
	5/19/2009 15:15	6.8	0.208	0.02	0.0357	0.00389	3.7	2.8
	5/19/2009 16:45	8.3	0.26	0.02	0.0511	0.00106	4.1	3

Greensand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.8 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/20/2009 8:15	5/20/2009 9:15	1.0	0.182	0.02	0.0874	0.0296	2.5	1.7
	5/20/2009 10:15	2.0	0.02	0.02	0.00153	0.00073	3.2	2.8
	5/20/2009 11:15	3.0	0.02	0.02	0.0011	0.00055	3	2.7
	5/20/2009 12:15	4.0	0.02	0.02	0.00106	0.00057	2.9	3
	5/20/2009 13:15	5.0	0.02	0.02	0.00163	0.00073	3.1	3.1
	5/20/2009 14:15	6.0	0.063	0.02	0.00653	0.00151	3.6	3.3
	5/20/2009 15:15	7.0	0.119	0.02	0.0118	0.00171	3.9	3.5
	5/20/2009 16:15	8.0	0.19	0.02	0.0187	0.00202	4.3	3.5
5/20/2009 17:30	5/20/2009 17:15	9.0	0.233	0.02	0.0229	0.00189	4.4	3.6
5/21/2009 8:30	5/21/2009 9:15	10.00						
Chlorine @ 2.8 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/21/2009 10:30	5/21/2009 11:15	0.8	0.032	0.02	0.00289	0.00093	2.9	2.6
	5/21/2009 12:15	1.7	0.02	0.02	0.00128	0.00093	3.2	3
	5/21/2009 13:15	2.8	0.02	0.02	0.00102	0.00051	3.5	3.2
	5/21/2009 14:15	3.8	0.02	0.02	0.00118	0.00053	3.8	3.5
	5/21/2009 15:15	4.7	0.023	0.02	0.00227	0.00092	4	3.7
	5/21/2009 16:15	5.8	0.04	0.02	0.00398	0.00129	4.2	3.7
	5/21/2009 17:15	6.8	0.075	0.02	0.00742	0.002	4.3	3.9
Chlorine @ 2.8 mg/L, Ferric @ 0.5 mg/L, 4 gpm/sqft								
5/22/2009 8:45	5/22/2009 9:15	0.5	0.214	0.02	0.0339	0.00327	3.1	2.3
	5/22/2009 10:15	1.5	0.02	0.02	0.00151	0.00093	4.5	4.5
	5/22/2009 11:15	2.5	0.02	0.02	0.0012	0.00067	4.6	4.6
	5/22/2009 12:15	3.5	0.02	0.02	0.00108	0.00062	4.9	4.9
	5/22/2009 13:15	4.5	0.02	0.02	0.00134	0.00072	5.1	5.3
	5/22/2009 14:15	5.5	0.02	0.02	0.00211	0.00083	5.3	5.4
	5/22/2009 15:15	6.5	0.032	0.02	0.00396	0.00146	5.6	5.4
	5/22/2009 16:15	7.5	0.05	0.02	0.00653	0.0018	5.7	5.6
	5/22/2009 17:15	8.5	0.067	0.02	0.00895	0.00219	5.9	5.7

Greensand Plus

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine Feed, No PP, 2 gpm/sqft								
4/29/2009 12:30								
	4/29/2009 14:15	1.7						
	4/29/2009 15:15	2.7						
	4/29/2009 15:45	3.2						
4/29/2009 17:30	4/30/2009 9:30	6.5						
4/30/2009 8:00	4/30/2009 10:00	7.0	0.02	0.02	0.0055	0.00316	6.2	6.3
	4/30/2009 10:45	7.7						
	4/30/2009 11:15	8.2						
	4/30/2009 11:45	8.7						
	4/30/2009 14:22	11.4						
	4/30/2009 15:00	12.0						
	4/30/2009 15:30	12.5						
	4/30/2009 15:52	12.9						
	4/30/2009 16:00	13.0	0.229	0.02	0.0431	0.00129	7.7	6.9
4/30/2009 17:30	5/1/2009 9:22	15.1						
5/1/2009 8:45	5/1/2009 11:00	16.7	6.11	0.02	0.987	0.00361	33.8	6.1
	5/1/2009 11:52	17.6						
	5/1/2009 14:22	20.1						
	5/1/2009 15:07	20.9						
	5/1/2009 15:52	21.6						
	5/1/2009 16:00	21.7	6.7	0.02	1.07	0.0141	36.3	6

Greensand Plus

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine Feed, No PP, 4 gpm/sqft (PP fed last 1 hour of run)								
5/4/2009 9:30	5/4/2009 10:15	0.8	0.055	0.02	0.0104	0.00106	7.2	7.2
	5/4/2009 11:00	1.5						
	5/4/2009 13:30	4.0	0.02	0.02	0.00145	0.00101	7.6	7.5
	5/4/2009 15:00	5.5						
5/4/2009 17:30	5/4/2009 16:30	7.0	0.02	0.02	0.00157	0.0008	7.7	7.5
5/5/2009 8:00	5/5/2009 9:45	9.75	0.0604	0.02	0.00924	0.0008	6	5.9
	5/5/2009 10:30	10.50						
	5/5/2009 13:15	13.25	0.307	0.02	0.0498	0.00135	7.6	5.8
	5/5/2009 15:15	15.25						
	5/5/2009 16:10	16.17	4.49	0.02	0.592	0.00074	25.1	6.6
Chlorine @ 2.8-2.1 mg/L, 4 gpm/sqft (PP feed @ ~6.5 hr of run)								
5/6/2009 8:45	5/6/2009 10:37	1.9						
	5/6/2009 11:15	2.5						
	5/6/2009 11:45	3.0						
	5/6/2009 13:15	4.5	0.02	0.02	0.002	0.00117	6.1	6.2
	5/6/2009 14:00	5.3						
	5/6/2009 14:30	5.7						
5/6/2009 17:00	5/6/2009 16:00	7.2	0.0355	0.02	0.0208	0.00038	6.1	6
5/7/2009 8:00	5/7/2009 9:00	9.25						
	5/7/2009 10:30	10.75	2.07	0.02	1.58	0.00015	15.5	4.7

Greensand Plus

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.1 mg/L + PP Feed (adj 1.5-0.5 mg/L thru run), 4 gpm/sqft								
5/7/2009 11:00	5/7/2009 13:00	2.0						
	5/7/2009 14:00	3.0	0.02	0.02	0.00333	0.00045	5.3	5.5
	5/7/2009 15:15	4.2						
	5/7/2009 16:15	5.3						
5/7/2009 17:30	5/7/2009 16:45	5.7	0.02	0.02	0.124	0.0287	5.7	5.7
5/8/2009 8:15	5/8/2009 10:00	8.25	1.02	0.02	0.882	0.00248	11	4.8
	5/8/2009 10:52	9.12						
	5/8/2009 11:22	9.62						
	5/8/2009 13:22	11.62	4.02	0.02	4.68	0.00596	25.9	5.5
	5/8/2009 14:15	12.50						
	5/8/2009 15:37	13.87	0.219	0.02	0.192	0.00037	6.8	5.6
5/8/2009 17:30	5/11/2009 8:45	16.25						
5/11/2009 8:15								

Greensand Plus

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Filter 1 Only								
Chlorine @ 2.1 mg/L + PP Feed @ 0.5 mg/L, 4 gpm/sqft			X	X	X	X	X	X
5/8/2009 15:15	5/8/2009 15:37	0.4	X	X	X	X	X	X
	5/11/2009 8:45	2.75	X	X	X	X	X	X
5/8/2009 17:30	5/11/2009 10:00	4.00	X	X	X	X	X	X
5/11/2009 8:15	5/11/2009 10:45	4.75	X	X	X	X	X	X
	5/11/2009 12:30	6.50	X	X	X	X	X	X
	5/11/2009 15:15	9.25	X	X	X	X	X	X
Filter 2 and 3 Only								
Chlorine @ 2.1 mg/L + PP Feed @ 0.5 mg/L, 3 gpm/sqft								
5/11/2009 9:15	5/11/2009 10:00	0.8						
	5/11/2009 10:45	1.5	0.02	0.02	0.0027	0.00064	3.4	3.4
	5/11/2009 12:30	3.3						
	5/11/2009 15:15	6.0	0.02	0.02	0.0177	0.00014	4.9	5.3
Chlorine @ 2.8 mg/L + PP Feed @ 0.3 mg/L, 3 gpm/sqft								
5/12/2009 9:45	5/12/2009 10:30	0.8						
	5/12/2009 11:30	1.7						
	5/12/2009 13:30	3.8						
	5/12/2009 14:30	4.7						
	5/12/2009 15:15	5.5	0.02	0.02	0.00439	0.00098	5.3	5.3
	5/12/2009 16:30	6.75	0.02	0.02	0.00249	0.00094	5	5.4
5/12/2009 17:00	5/13/2009 9:15	8.00						
5/13/2009 8:30	5/13/2009 10:15	9.00						
	5/13/2009 11:00	9.75						
	5/13/2009 14:30	13.25	0.02	0.02	0.00876	0.0057	5.3	5.3
	5/13/2009 16:15	15.00						
	5/13/2009 16:45	15.50	0.104	0.02	0.0573	0.0082	5.9	5.3

Greensand Plus

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, 4 gpm/sqft								
5/14/2009 8:30	5/14/2009 10:45	2.3						
	5/14/2009 12:15	3.8	0.02	0.02	0.002	0.00061	6.1	6.1
	5/14/2009 14:45	6.3	0.02	0.02	0.00187	0.00059	6.4	6.4
	5/14/2009 17:15	8.8	0.02	0.02	0.00686	0.00069	6.3	6.3
5/14/2009 17:30	5/15/2009 9:30	10.00						
5/15/2009 8:30	5/15/2009 10:15	10.75	0.168	0.02	0.0604	0.00271	5.8	5
	5/15/2009 11:15	11.75						
	5/15/2009 14:15	14.75	0.269	0.02	0.12	0.00202	7.7	6.2
2.5 hrs AFTER B/W	5/15/2009 17:15	17.75	0.02	0.02	0.00242	0.00083	6.1	6
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/18/2009 9:00	5/18/2009 9:15	0.2	0.203	0.02	0.02	0.00177	3.6	2.7
	5/18/2009 10:30	1.5	0.02	0.02	0.00253	0.001	2.4	2.1
	5/18/2009 11:00	2.0						
	5/18/2009 11:45	2.8	0.024	0.02	0.00353	0.00135	2.4	2.1
	5/18/2009 13:30	4.5	0.122	0.02	0.0214	0.00209	2.9	2.4
	5/18/2009 15:15	6.2	0.305	0.02	0.0531	0.00459	3.8	2.5
	5/18/2009 16:15	7.3	0.39	0.02	0.0709	0.00478	4.2	2.7
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/19/2009 8:30	5/19/2009 9:15	0.8	0.079	0.02	0.0945	0.00115	2.2	1.8
	5/19/2009 10:45	2.3	0.02	0.02	0.00226	0.00098	2.6	2.2
	5/19/2009 12:15	3.8	0.02	0.02	0.00225	0.00091	2.8	2.3
	5/19/2009 13:45	5.3	0.091	0.02	0.0153	0.00349	3.2	2.8
	5/19/2009 15:15	6.8	0.224	0.02	0.039	0.00305	3.8	2.9
	5/19/2009 16:45	8.3	0.31	0.02	0.0611	0.00131	4.4	2.9

Greensand Plus

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.8 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/20/2009 8:15	5/20/2009 9:15	1.0	0.095	0.02	0.102	0.00105	2.1	1.6
	5/20/2009 10:15	2.0	0.023	0.02	0.00192	0.00074	3.1	2.7
	5/20/2009 11:15	3.0	0.02	0.02	0.00134	0.00058	3	2.6
	5/20/2009 12:15	4.0	0.02	0.02	0.00139	0.00065	2.8	2.9
	5/20/2009 13:15	5.0	0.03	0.02	0.00321	0.00103	3.2	3
	5/20/2009 14:15	6.0	0.136	0.02	0.0134	0.00174	3.7	3.3
	5/20/2009 15:15	7.0	0.194	0.02	0.019	0.00172	3.9	3.4
	5/20/2009 16:15	8.0	0.232	0.02	0.023	0.00189	4.3	3.5
5/20/2009 17:30	5/20/2009 17:15	9.0	0.278	0.02	0.0275	0.0019	4.5	3.5
5/21/2009 8:30	5/21/2009 9:15	10.00						
Chlorine @ 2.8 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/21/2009 10:30	5/21/2009 11:15	0.8	0.037	0.02	0.00344	0.00096	2.9	2.6
	5/21/2009 12:15	1.7	0.02	0.02	0.0015	0.00078	3.4	3.2
	5/21/2009 13:15	2.8	0.02	0.02	0.00128	0.00054	3.4	3.3
	5/21/2009 14:15	3.8	0.02	0.02	0.00189	0.00074	3.9	3.5
	5/21/2009 15:15	4.7	0.042	0.02	0.00429	0.00119	3.9	3.6
	5/21/2009 16:15	5.8	0.099	0.02	0.0104	0.00214	4.4	3.7
	5/21/2009 17:15	6.8	0.156	0.02	0.0153	0.00254	4.4	3.7
Chlorine @ 2.8 mg/L, Ferric @ 0.5 mg/L, 4 gpm/sqft								
5/22/2009 8:45	5/22/2009 9:15	0.5	0.22	0.02	0.0232	0.00328	3	2.3
	5/22/2009 10:15	1.5	0.02	0.02	0.00212	0.00086	4.3	4.2
	5/22/2009 11:15	2.5	0.02	0.02	0.00145	0.00078	4.4	4.5
	5/22/2009 12:15	3.5	0.02	0.02	0.00125	0.00068	4.8	4.8
	5/22/2009 13:15	4.5	0.02	0.02	0.00185	0.00086	5.1	5.1
	5/22/2009 14:15	5.5	0.023	0.02	0.00281	0.00109	5.1	5.4
	5/22/2009 15:15	6.5	0.063	0.02	0.00779	0.00225	5.6	5.5
	5/22/2009 16:15	7.5	0.085	0.02	0.0115	0.00245	5.9	5.5
	5/22/2009 17:15	8.5	0.102	0.02	0.0137	0.00245	6.1	5.7

Silica Sand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine Feed, No PP, 2 gpm/sqft								
4/29/2009 12:30								
	4/29/2009 14:15	1.7						
	4/29/2009 15:15	2.7						
	4/29/2009 15:45	3.2						
4/29/2009 17:30	4/30/2009 9:30	6.5						
4/30/2009 8:00	4/30/2009 10:00	7.0	0.042	0.02	0.026	0.00161	6.9	6.8
	4/30/2009 10:45	7.7						
	4/30/2009 11:15	8.2						
	4/30/2009 11:45	8.7						
	4/30/2009 14:22	11.4						
	4/30/2009 15:00	12.0						
	4/30/2009 15:30	12.5						
	4/30/2009 15:52	12.9						
	4/30/2009 16:00	13.0	10.8	0.02	1.93	0.00199	58.5	6.7
4/30/2009 17:30	5/1/2009 9:22	15.1						
5/1/2009 8:45	5/1/2009 11:00	16.7	4.76	0.02	0.829	0.00517	30	6.3
	5/1/2009 11:52	17.6						
	5/1/2009 14:22	20.1						
	5/1/2009 15:07	20.9						
	5/1/2009 15:52	21.6						
	5/1/2009 16:00	21.7	7.22	0.02	1.2	0.00381	37.7	6.3

Silica Sand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine Feed, No PP, 4 gpm/sqft (PP fed last 1 hour of run)								
5/4/2009 9:30	5/4/2009 10:15	0.8	0.074	0.02	0.0149	0.00115	7.7	7.4
	5/4/2009 11:00	1.5						
	5/4/2009 13:30	4.0	0.092	0.02	0.0204	0.00178	7.9	7.4
	5/4/2009 15:00	5.5						
5/4/2009 17:30	5/4/2009 16:30	7.0	0.105	0.02	0.107	0.0523	7.7	6.9
5/5/2009 8:00	5/5/2009 9:45	9.75	0.274	0.02	0.0636	0.00147	6.6	5.4
	5/5/2009 10:30	10.50						
	5/5/2009 13:15	13.25	0.377	0.02	0.0754	0.00153	7.9	5.8
	5/5/2009 15:15	15.25						
	5/5/2009 16:10	16.17	4.36	0.02	0.618	0.00116	25.6	6.6
Chlorine @ 2.8-2.1 mg/L, 4 gpm/sqft (PP feed @ ~6.5 hr of run)								
5/6/2009 8:45	5/6/2009 10:37	1.9						
	5/6/2009 11:15	2.5						
	5/6/2009 11:45	3.0						
	5/6/2009 13:15	4.5	0.081	0.02	0.0236	0.0124	6.3	6.1
	5/6/2009 14:00	5.3						
	5/6/2009 14:30	5.7						
5/6/2009 17:00	5/6/2009 16:00	7.2	0.177	0.02	0.104	0.00052	6.6	5.9
5/7/2009 8:00	5/7/2009 9:00	9.25						
	5/7/2009 10:30	10.75	0.283	0.02	0.254	0.00018	5.7	4.9

Silica Sand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.1 mg/L + PP Feed (adj 1.5-0.5 mg/L thru run), 4 gpm/sqft								
5/7/2009 11:00	5/7/2009 13:00	2.0						
	5/7/2009 14:00	3.0	0.168	0.02	0.231	0.0394	6.2	5.4
	5/7/2009 15:15	4.2						
	5/7/2009 16:15	5.3						
5/7/2009 17:30	5/7/2009 16:45	5.7	0.066	0.02	0.225	0.0192	6	5.7
5/8/2009 8:15	5/8/2009 10:00	8.25	2.69	0.02	2.41	0.0189	18.6	4.7
	5/8/2009 10:52	9.12						
	5/8/2009 11:22	9.62						
	5/8/2009 13:22	11.62	7.28	0.02	5.02	0.0209	38.2	5.3
	5/8/2009 14:15	12.50						
	5/8/2009 15:37	13.87	0.253	0.02	0.218	0.00039	6.8	5.7
5/8/2009 17:30	5/11/2009 8:45	16.25						
5/11/2009 8:15								

Silica Sand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Filter 1 Only								
Chlorine @ 2.1 mg/L + PP Feed @ 0.5 mg/L, 4 gpm/sqft			X	X	X	X	X	X
5/8/2009 15:15	5/8/2009 15:37	0.4	X	X	X	X	X	X
	5/11/2009 8:45	2.75	X	X	X	X	X	X
5/8/2009 17:30	5/11/2009 10:00	4.00	X	X	X	X	X	X
5/11/2009 8:15	5/11/2009 10:45	4.75	X	X	X	X	X	X
	5/11/2009 12:30	6.50	X	X	X	X	X	X
	5/11/2009 15:15	9.25	X	X	X	X	X	X
Filter 2 and 3 Only								
Chlorine @ 2.1 mg/L + PP Feed @ 0.5 mg/L, 3 gpm/sqft								
5/11/2009 9:15	5/11/2009 10:00	0.8						
	5/11/2009 10:45	1.5	0.02	0.02	0.00931	0.00068	3.2	3.2
	5/11/2009 12:30	3.3						
	5/11/2009 15:15	6.0	0.053	0.02	0.0994	0.00054	5.4	5
Chlorine @ 2.8 mg/L + PP Feed @ 0.3 mg/L, 3 gpm/sqft								
5/12/2009 9:45	5/12/2009 10:30	0.8						
	5/12/2009 11:30	1.7						
	5/12/2009 13:30	3.8						
	5/12/2009 14:30	4.7						
	5/12/2009 15:15	5.5	0.02	0.02	0.00548	0.00063	5	5.1
	5/12/2009 16:30	6.75	0.02	0.02	0.0146	0.00029	5.4	5.3
5/12/2009 17:00	5/13/2009 9:15	8.00						
5/13/2009 8:30	5/13/2009 10:15	9.00						
	5/13/2009 11:00	9.75						
	5/13/2009 14:30	13.25	0.218	0.02	0.117	0.00096	6.5	5.6
	5/13/2009 16:15	15.00						
	5/13/2009 16:45	15.50	0.267	0.02	0.149	0.001	6.9	5.4

Silica Sand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, 4 gpm/sqft								
5/14/2009 8:30	5/14/2009 10:45	2.3						
	5/14/2009 12:15	3.8	0.051	0.02	0.0186	0.00068	6.6	6.5
	5/14/2009 14:45	6.3	0.082	0.02	0.0378	0.00091	6.9	6.7
	5/14/2009 17:15	8.8	0.162	0.02	0.0743	0.00086	7.2	6.5
5/14/2009 17:30	5/15/2009 9:30	10.00						
5/15/2009 8:30	5/15/2009 10:15	10.75	0.347	0.02	0.131	0.00481	7	5
	5/15/2009 11:15	11.75						
	5/15/2009 14:15	14.75	0.35	0.02	0.164	0.0019	8.6	6.4
2.5 hrs AFTER B/W	5/15/2009 17:15	17.75	0.029	0.02	0.00963	0.0013	6.5	6.3
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/18/2009 9:00	5/18/2009 9:15	0.2	0.301	0.02	0.00538	0.00195	4.4	3
	5/18/2009 10:30	1.5	0.127	0.028	0.0168	0.00618	2.4	1.7
	5/18/2009 11:00	2.0						
	5/18/2009 11:45	2.8	0.248	0.02	0.0415	0.00429	3.3	2
	5/18/2009 13:30	4.5	0.409	0.02	0.0728	0.00329	4.1	2.4
	5/18/2009 15:15	6.2	0.437	0.02	0.0826	0.00513	4.5	2.5
	5/18/2009 16:15	7.3	0.649	0.02	0.119	0.00678	5.3	2.7
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/19/2009 8:30	5/19/2009 9:15	0.8	0.116	0.02	0.0355	0.00132	2	1.4
	5/19/2009 10:45	2.3	0.09	0.02	0.0141	0.0387	2.9	2.2
	5/19/2009 12:15	3.8	0.182	0.02	0.0302	0.00582	3.5	2.4
	5/19/2009 13:45	5.3	0.312	0.02	0.0569	0.00149	4.2	1.1
	5/19/2009 15:15	6.8	0.443	0.02	0.0844	0.00258	4.9	2.9
	5/19/2009 16:45	8.3	0.454	0.02	0.0946	0.0014	5.1	3.1

Silica Sand

		Run Time (hours)	Total Fe (mg/L)	Dissolved Fe (mg/L)	Total Mn (mg/L)	Dissolved Mn (mg/L)	Total As (ug/L)	Dissolved As (ug/L)
Chlorine @ 2.8 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/20/2009 8:15	5/20/2009 9:15	1.0	0.061	0.02	0.0166	0.00741	1.4	2.8
	5/20/2009 10:15	2.0	0.04	0.02	0.0139	0.00242	1.9	1.6
	5/20/2009 11:15	3.0	0.089	0.02	0.00927	0.00157	3.4	2.8
	5/20/2009 12:15	4.0	0.075	0.02	0.00816	0.00174	3.6	3.2
	5/20/2009 13:15	5.0	0.134	0.02	0.0134	0.00161	3.9	3.3
	5/20/2009 14:15	6.0	0.225	0.02	0.0233	0.00152	4.6	3.7
	5/20/2009 15:15	7.0	0.263	0.02	0.0272	0.0015	4.7	3.5
	5/20/2009 16:15	8.0	0.295	0.02	0.0317	0.00157	4.9	3.8
5/20/2009 17:30	5/20/2009 17:15	9.0	0.338	0.02	0.0348	0.00188	5	3.7
5/21/2009 8:30	5/21/2009 9:15	10.00						
Chlorine @ 2.8 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft								
5/21/2009 10:30	5/21/2009 11:15	0.8	0.075	0.02	0.00784	0.00164	3.3	2.8
	5/21/2009 12:15	1.7	0.054	0.02	0.00617	0.00185	3.8	3.4
	5/21/2009 13:15	2.8	0.115	0.02	0.0125	0.00192	4.1	3.4
	5/21/2009 14:15	3.8	0.211	0.02	0.0234	0.00211	4.7	3.7
	5/21/2009 15:15	4.7	0.253	0.02	0.0279	0.00226	5.1	3.6
	5/21/2009 16:15	5.8	0.299	0.02	0.0334	0.00329	5.4	3.8
	5/21/2009 17:15	6.8	0.331	0.02	0.0377	0.00369	5.5	3.8
Chlorine @ 2.8 mg/L, Ferric @ 0.5 mg/L, 4 gpm/sqft								
5/22/2009 8:45	5/22/2009 9:15	0.5	0.265	0.02	0.0126	0.4485	3.5	2.7
	5/22/2009 10:15	1.5	0.056	0.02	0.0067	0.00264	4.8	4.6
	5/22/2009 11:15	2.5	0.06	0.02	0.00886	0.00278	5.1	5.1
	5/22/2009 12:15	3.5	0.085	0.02	0.0126	0.00343	5.4	5
	5/22/2009 13:15	4.5	0.14	0.02	0.0204	0.00399	5.8	5.6
	5/22/2009 14:15	5.5	0.152	0.02	0.0234	0.00361	6.1	5.5
	5/22/2009 15:15	6.5	0.18	0.02	0.0297	0.00449	6.4	5.7
	5/22/2009 16:15	7.5	0.197	0.02	0.0329	0.00406	6.6	5.8
	5/22/2009 17:15	8.5	0.209	0.02	0.0354	0.0046	6.8	5.8

APPENDIX 2C - Pilot Filter Head Loss Data

Pilot Filter Head Loss Data

			Greensand	Greensand Plus	Silica Sand
		Run Time (hrs)	Head Loss (ft)	Head Loss (ft)	Head Loss (ft)
Chlorine Feed, No PP, 7 gpm/sqft					
4/23/2009 10:30					
	4/23/2009 11:30	1.0	7.3	6.0	5.1
4/23/2009 17:00	4/23/2009 12:00	1.5	7.3	5.9	4.9
4/24/2009 8:15	4/24/2009 9:52	8.1	9.5	7.1	6.0
	4/24/2009 10:45	9.0	9.7	7.1	6.0
	4/24/2009 11:35	9.8	10.1	7.0	5.6
	4/24/2009 13:50	12.1	11.0	7.0	5.2
	4/24/2009 14:35	12.8	11.2	7.1	5.1
	4/24/2009 15:33	13.8	11.7	7.4	5.3
	4/24/2009 16:10	14.4	12.0	7.5	5.3
	4/24/2009 16:30	14.8	12.2	7.6	5.3
Chlorine Feed, No PP, 2 gpm/sqft					
4/29/2009 12:30					
	4/29/2009 14:15	1.7	3.6	3.9	3.8
	4/29/2009 15:15	2.7	3.5	3.9	3.7
	4/29/2009 15:45	3.2	3.7	3.9	3.7
4/29/2009 17:30	4/30/2009 9:30	6.5	1.7	1.0	0.4
4/30/2009 8:00	4/30/2009 10:00	7.0	1.7	0.9	0.3
	4/30/2009 10:45	7.7	1.5	0.7	0.0
	4/30/2009 11:15	8.2	1.7	0.7	0.2
	4/30/2009 11:45	8.7	1.8	0.7	0.3
	4/30/2009 14:22	11.4	2.1	0.5	0.6
	4/30/2009 15:00	12.0	2.2	0.5	0.7
	4/30/2009 15:30	12.5	2.3	0.5	0.8
	4/30/2009 15:52	12.9	2.3	0.5	0.8
	4/30/2009 16:00	13.0	2.4	0.6	0.7
4/30/2009 17:30	5/1/2009 9:22	15.1	1.9	0.8	0.2
5/1/2009 8:45	5/1/2009 11:00	16.7			
	5/1/2009 11:52	17.6	1.9	0.5	0.6
	5/1/2009 14:22	20.1	2.5	0.7	0.7
	5/1/2009 15:07	20.9	2.5	0.7	0.8
	5/1/2009 15:52	21.6	2.6	0.7	0.8
Chlorine Feed, No PP, 4 gpm/sqft (PP fed last 1 hour of run)					
5/4/2009 9:30	5/4/2009 10:15	0.8	2.6	1.4	0.6
	5/4/2009 11:00	1.5	3.0	1.5	0.7
	5/4/2009 13:30	4.0	3.4	1.7	0.8
	5/4/2009 15:00	5.5	3.7	1.8	0.9
5/4/2009 17:30	5/4/2009 16:30	7.0	4.0	1.8	1.0
5/5/2009 8:00	5/5/2009 9:45	9.75	3.9	1.9	1.0
	5/5/2009 10:30	10.50	4.2	2.0	1.0
	5/5/2009 13:15	13.25	4.3	2.1	1.7
	5/5/2009 15:15	15.25	4.6	2.2	1.6
	5/5/2009 16:10	16.17			

			Greensand	Greensand Plus	Silica Sand
		Run Time (hrs)	Head Loss (ft)	Head Loss (ft)	Head Loss (ft)
Chlorine @ 2.8-2.1 mg/L, 4 gpm/sqft (PP feed @ ~6.5 hr of run)					
5/6/2009 8:45	5/6/2009 10:37	1.9	2.8	1.5	1.6
	5/6/2009 11:15	2.5	2.9	1.6	1.6
	5/6/2009 11:45	3.0	3.1	1.6	1.6
	5/6/2009 13:15	4.5	3.3	1.7	1.6
	5/6/2009 14:00	5.3			
	5/6/2009 14:30	5.7	3.5	1.8	1.6
5/6/2009 17:00	5/6/2009 16:00	7.2	3.7	1.9	1.6
5/7/2009 8:00	5/7/2009 9:00	9.25	3.8	2.3	2.1
	5/7/2009 10:30	10.75	3.7	2.2	1.8
Chlorine @ 2.1 mg/L + PP Feed (adj 1.5-0.5 mg/L thru run), 4 gpm/sqft					
5/7/2009 11:00	5/7/2009 13:00	2.0	2.6	1.4	1.4
	5/7/2009 14:00	3.0	2.8	1.6	1.4
	5/7/2009 15:15	4.2	2.9	1.6	1.3
	5/7/2009 16:15	5.3	3.1	1.7	1.4
5/7/2009 17:30	5/7/2009 16:45	5.7	3.3	1.8	1.5
5/8/2009 8:15	5/8/2009 10:00	8.25	3.5	2.2	1.8
	5/8/2009 10:52	9.12	3.7	2.3	1.7
	5/8/2009 11:22	9.62	3.8	2.3	1.7
	5/8/2009 13:22	11.62	4.1	2.5	1.7
	5/8/2009 14:15	12.50	4.2	2.5	1.6
	5/8/2009 15:37	13.87		2.6	1.6
5/8/2009 17:30	5/11/2009 8:45	16.25		3.0	2.1
5/11/2009 8:15					
Filter 1 Only					
Chlorine @ 2.1 mg/L + PP Feed @ 0.5 mg/L, 4 gpm/sqft					
5/8/2009 15:15	5/8/2009 15:37	0.4	2.5		
	5/11/2009 8:45	2.75	2.6		
5/8/2009 17:30	5/11/2009 10:00	4.00			
5/11/2009 8:15	5/11/2009 10:45	4.75			
	5/11/2009 12:30	6.50	2.3		
	5/11/2009 15:15	9.25			
Filter 2 and 3 Only					
Chlorine @ 2.1 mg/L + PP Feed @ 0.5 mg/L, 3 gpm/sqft					
5/11/2009 9:15	5/11/2009 10:00	0.8			
	5/11/2009 10:45	1.5			
	5/11/2009 12:30	3.3		1.1	0.7
	5/11/2009 15:15	6.0			
Chlorine @ 2.8 mg/L + PP Feed @ 0.3 mg/L, 3 gpm/sqft					
5/12/2009 9:45	5/12/2009 10:30	0.8	1.8	1.2	1.5
	5/12/2009 11:30	1.7	2.0	1.2	1.2
	5/12/2009 13:30	3.8	2.3	1.3	1.2
	5/12/2009 14:30	4.7			
	5/12/2009 15:15	5.5			
	5/12/2009 16:30	6.75			
5/12/2009 17:00	5/13/2009 9:15	8.00	2.7	1.8	1.8
5/13/2009 8:30	5/13/2009 10:15	9.00			
	5/13/2009 11:00	9.75			
	5/13/2009 14:30	13.25	3.2	2.2	1.4
	5/13/2009 16:15	15.00	3.3	2.2	2.0

		Run Time (hrs)	Greensand Head Loss (ft)	Greensand Plus Head Loss (ft)	Silica Sand Head Loss (ft)
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, 4 gpm/sqft					
5/14/2009 8:30	5/14/2009 10:45	2.3			
	5/14/2009 11:45	3.3			
	5/14/2009 14:50	6.3			
	5/14/2009 16:45	8.3			
5/14/2009 17:30	5/15/2009 9:30	10.00	3.8	2.3	1.7
5/15/2009 8:30	5/15/2009 10:15	10.75			
	5/15/2009 11:15	11.75	3.9	2.3	1.6
	5/15/2009 14:50	15.33			
2.5 hrs AFTER B/W	5/15/2009 16:45	17.25			
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft					
5/18/2009 9:00	5/18/2009 9:15	0.2	2.4	1.3	1.1
	5/18/2009 10:30	1.5			
	5/18/2009 11:00	2.0	2.9	1.4	1.0
	5/18/2009 11:45	2.8	3.0	1.5	1.0
	5/18/2009 14:30	5.5	3.4	1.6	0.8
5/18/2009 17:30	5/18/2009 15:15	6.2			
5/19/2009 8:00	5/19/2009 8:30	9.00	3.6	2.2	1.6
Chlorine @ 2.1 mg/L + PP Feed @ 0.15 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft					
5/19/2009 8:30	5/19/2009 9:15	0.8			
	5/19/2009 10:45	2.3	2.6	1.4	1.2
	5/19/2009 12:15	3.8	2.8	1.6	1.3
	5/19/2009 13:45	5.3			
	5/19/2009 15:15	6.8	3.3	2.1	1.7
	5/19/2009 16:45	8.3			
Chlorine @ 2.8 mg/L, Ferric @ 2 mg/L, 4 gpm/sqft					
5/20/2009 8:15	5/20/2009 9:30	1.3	2.4	1.4	0.0
	5/20/2009 10:30	2.3	2.7	1.5	
	5/20/2009 12:15	4.0	3.0	1.7	1.2
	5/20/2009 13:30	5.3	3.2	1.7	1.1
	5/20/2009 15:30	7.3	3.4	1.8	1.1
5/20/2009 17:30	5/20/2009 16:30	8.3	3.5	1.9	1.0
5/21/2009 8:30	5/21/2009 9:15	10.00	3.6	2.3	1.5

APPENDIX 2D - Pilot Filter Turbidity and Color Data

Pilot Filter Effluent Turbidity and Color Data

		Greensand		Greensand Plus		Silica Sand	
	Run Time (hrs)	Turb. (NTU)	Lab Color (Color Units)	Turb. (NTU)	Lab Color (Color Units)	Turb. (NTU)	Lab Color (Color Units)
4/23/2009 11:30	1.0						
4/23/2009 12:00	1.5						
4/24/2009 9:52	8.1						
4/24/2009 10:45	9.0						
4/24/2009 11:35	9.8						
4/24/2009 13:50	12.1						
4/24/2009 14:35	12.8						
4/24/2009 15:33	13.8						
4/24/2009 16:10	14.4						
4/24/2009 16:30	14.8						
4/29/2009 14:15	1.7	0.031		0.038		0.043	
4/29/2009 15:15	2.7						
4/29/2009 15:45	3.2						
4/30/2009 9:30	6.5						
4/30/2009 10:00	7.0						
4/30/2009 10:45	7.7						
4/30/2009 11:15	8.2						
4/30/2009 11:45	8.7						
4/30/2009 14:22	11.4						
4/30/2009 15:00	12.0						
4/30/2009 15:30	12.5						
4/30/2009 15:52	12.9						
4/30/2009 16:00	13.0	0.030		0.034		0.037	
5/1/2009 9:22	15.1	0.070		0.063		0.600	
5/1/2009 11:00	16.7						
5/1/2009 11:52	17.6						
5/1/2009 14:22	20.1						
5/1/2009 15:07	20.9						
5/1/2009 15:52	21.6						
5/1/2009 16:00	21.7						
5/4/2009 10:15	0.8	0.033		0.041		0.048	
5/4/2009 11:00	1.5	0.033		0.041		0.048	
5/4/2009 13:30	4.0	0.033		0.038		0.094	
5/4/2009 15:00	5.5	0.035		0.042		0.057	
5/4/2009 16:30	7.0						
5/5/2009 9:45	9.75	0.254		0.316		1.000	
5/5/2009 10:30	10.50						
5/5/2009 13:15	13.25	0.385		0.225		0.500	
5/5/2009 15:15	15.25						
5/5/2009 16:10	16.17						

		Greensand		Greensand Plus		Silica Sand	
	Run Time (hrs)	Turb. (NTU)	Lab Color (Color Units)	Turb. (NTU)	Lab Color (Color Units)	Turb. (NTU)	Lab Color (Color Units)
5/6/2009 10:37	1.9	0.035		0.037		0.049	
5/6/2009 11:15	2.5	0.042		0.039		0.048	
5/6/2009 11:45	3.0						
5/6/2009 13:15	4.5	0.034		0.050		0.252	
5/6/2009 14:00	5.3						
5/6/2009 14:30	5.7						
5/6/2009 16:00	7.2	0.078		0.087		0.387	
5/7/2009 9:00	9.25						
5/7/2009 10:30	10.75	0.335		0.263		0.510	
5/7/2009 13:00	2.0	0.036		0.043		0.064	
5/7/2009 14:00	3.0	0.031		0.039		0.055	
5/7/2009 15:15	4.2	0.034		0.038		0.161	
5/7/2009 16:15	5.3	0.030		0.036		0.119	
5/7/2009 16:45	5.7	0.030		0.036		0.247	
5/8/2009 10:00	8.25	0.047		0.068		0.569	
5/8/2009 10:52	9.12	0.199		0.226		0.512	
5/8/2009 11:22	9.62	0.235		0.256		0.599	
5/8/2009 13:22	11.62	0.482		0.475		0.897	
5/8/2009 14:15	12.50						
5/8/2009 15:37	13.87						
5/11/2009 8:45	16.25			0.409		0.608	
5/8/2009 15:37	0.4						
5/11/2009 8:45	2.75	0.130					
5/11/2009 10:00	4.00						
5/11/2009 10:45	4.75						
5/11/2009 12:30	6.50	0.031					
5/11/2009 15:15	9.25						
5/11/2009 10:00	0.8						
5/11/2009 10:45	1.5						
5/11/2009 12:30	3.3			0.038		0.045	
5/11/2009 15:15	6.0						
5/12/2009 10:30	0.8	0.950		2.760		0.630	
5/12/2009 11:30	1.7	0.037		0.060		0.457	
5/12/2009 13:30	3.8						
5/12/2009 14:30	4.7						
5/12/2009 15:15	5.5						
5/12/2009 16:30	6.75						
5/13/2009 9:15	8.00	0.031		0.037		0.195	
5/13/2009 10:15	9.00						
5/13/2009 11:00	9.75						
5/13/2009 14:30	13.25						
5/13/2009 16:15	15.00						
5/13/2009 16:45	15.50						

	Run Time (hrs)	Greensand Turb. (NTU)	Greensand Lab Color (Color Units)	Greensand Plus Turb. (NTU)	Greensand Plus Lab Color (Color Units)	Silica Sand Turb. (NTU)	Silica Sand Lab Color (Color Units)
5/14/2009 10:45	2.3						
5/14/2009 11:45	3.3						
5/14/2009 14:50	6.3						
5/14/2009 16:45	8.3						
5/15/2009 9:30	10.00	0.065		0.076		0.191	
5/15/2009 10:15	10.75						
5/15/2009 11:15	11.75	0.177		0.191		0.357	
5/15/2009 14:50	15.33						
5/15/2009 16:45	17.25						
5/18/2009 9:15	0.2	0.040		0.105		0.150	
5/18/2009 10:30	1.5						
5/18/2009 11:00	2.0	0.039		0.045		0.122	
5/18/2009 11:45	2.8	0.038		0.046		0.169	
5/18/2009 14:30	5.5	0.099		0.139		0.322	
5/18/2009 15:15	6.2						
5/19/2009 8:30	9.00	0.186		0.183		0.357	
5/19/2009 9:15	0.8		0.1		2.5		0.1
5/19/2009 10:45	2.3						
5/19/2009 12:15	3.8	0.038	0.1	0.043	2.5	0.125	0.1
5/19/2009 13:45	5.3						
5/19/2009 15:15	6.8	0.189		0.197		0.337	
5/19/2009 16:45	8.3						
5/20/2009 9:15	1.0		20		5		5
5/20/2009 10:15	2.0	0.040	0.1	0.047	0.1	0.373	0.1
5/20/2009 11:15	3.0		0.1		0.1		0.1
5/20/2009 12:15	4.0	0.034	0.1	0.043	0.1	0.080	0.1
5/20/2009 13:15	5.0	0.037	0.1	0.056	0.1	0.108	0.1
5/20/2009 14:15	6.0		0.1		0.1		0.1
5/20/2009 15:15	7.0	0.102	0.1	0.141	0.1	0.193	0.1
5/20/2009 16:15	8.0	0.133	5	0.169	5	0.218	5
5/20/2009 17:15	9.0		5		5		5
5/21/2009 9:15	10.00	0.193		0.228		0.287	
5/21/2009 11:15	0.8		0.1		0.1		0.1
5/21/2009 12:15	1.7		0.1		0.1		0.1
5/21/2009 13:15	2.8	0.034	0.1	0.041	0.1	0.108	0.1
5/21/2009 14:15	3.8		0.1		0.1		5
5/21/2009 15:15	4.7		5		5		5
5/21/2009 16:15	5.8		5		5		5
5/21/2009 17:15	6.8		5		5		5
5/22/2009 9:15	0.5		5		5		5
5/22/2009 10:15	1.5		0.1		0.1		0.1
5/22/2009 11:15	2.5		0.1		0.1		0.1
5/22/2009 12:15	3.5		0.1		0.1		0.1
5/22/2009 13:15	4.5		0.1		0.1		5
5/22/2009 14:15	5.5		0.1		0.1		0.1
5/22/2009 15:15	6.5		0.1		0.1		5
5/22/2009 16:15	7.5		0.1		5		5
5/22/2009 17:15	8.5		5		5		5