



## Suggested Pilot Filter Study Protocol for The Removal of Arsenic, Iron, & Manganese Using Coagulation / Filtration Process

### Description of The Pilot Study

#### A. Pilot Study Goals / objections

- To verify the effectiveness of the process in removing / reducing contaminants, including: arsenic (As), iron (Fe), and manganese (Mn) in the raw well water to the following United States Environmental Protection Agency (USEPA) Maximum Contaminant Levels (MCL) (See Note 1).

- 1 Arsenic ..... < 10 µg / l
- 2 Iron ..... < 0.30 mg / L
- 3 Manganese ..... < 0.05 mg / L

- Select the most effective filter media (see note 2).
- Determine chemical usage requirements including oxidant; e.g., sodium hypochlorite (NaOCl), co-precipitant; e.g., ferric salts, such as ferric chloride (FeCl<sub>3</sub>) / ferrics sulfate (Fe<sub>2</sub>[SO<sub>4</sub>]<sub>3</sub>), and any other process specific chemicals, such as acid and or caustic to adjust pH.
- Determine pre and post filter chemical dosage rates including oxidant e.g., sodium hypochlorite (NaOCl), co-precipitant, e.g., ferric salts, such as ferric chloride (FeCl<sub>3</sub>) / ferric sulfate (Fe<sub>2</sub>[SO<sub>4</sub>]<sub>3</sub>), and if any other process specific chemicals, such as acid, and / or caustic are required to adjust the pH.
- Determine the most effective and economical filtration rate (gpm/ft<sup>2</sup> of media) that will achieve the treatment goals and provide an effective bashwash to filtration ratio.
- Define the frequency and duration for the filter backwash cycles.
- Provide an accurate estimate of long-term operating costs.

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- Notes:**
1. State and or utility MCL may be lower than teh EPA MCL.
  2. Raw water quality data and or field testing may indicate a requirement to test multiple media types
  3. Varying contaminant levels in the raw water may require an automated pilot filter to test 24/ hrs / day for extended periods,
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## B. Pilot Test Data Requirements

To measure and record the following raw and filtered water parameters throughout the field pilot filter study and laboratory testing:

- pH (raw water, pre-filter, and post-filter)
- Water temperature
- Influent and effluent arsenic concentrations
- Influent and effluent iron concentrations
- Influent and effluent manganese concentrations
- Influent and effluent hydrogen sulfide concentrations
- Free and total chlorine residuals
- Break point chlorination curve must be established before filtered water testing begins. (Chlorinated water samples must be taken ahead of the filter vessel. Raw water contaminants must be completely oxidized before water enters the filter vessel)
- Sodium hypochlorite feed stock concentration (%)
- Sodium hypochlorite dosage rates (mg / L)
- Ferric salt feed stock concentration
- Ferric salt dosage (mg / L)
- Break point chlorination curve
- Acid concentration and dosage rate (if required)
- Caustic concentration and dosage rate (if required)
- Optimum filtration rate (gpm / ft<sup>2</sup>)
- Maximum filter run time
- Differential pressure across filter vessel
- Filter backwash rate (gpm / ft<sup>2</sup>)
- Filter backwash duration
- Backwash water volume (per backwash & total backwash gal/day)
- Backwash water sludge settling time (take time lapse photos)
- Backwash water recoveries (after backwash water has completely settled, test supernatant and residual solids for arsenic, iron, and manganese concentrations). Perform laboratory TCLP test of residual solids



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**Notes:**

1. If residual solids settling time is unacceptable, determine what flocculant and dosage rate is required to cause the sludge to settle within the required time.
  2. Water must be taken from a valve located in the water main immediately downstream from the well pump. Do not pump well water from a storage tank to the pilot filter(s).
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### C. Field Sampling

In addition to field testing of water quality, raw and filtered water "grab samples" will be sent to qualified independent laboratories for verification of field tests. Samples will be taken at significant intervals and should include the following: filtration without ferric salt feed, filtration with ferric salt feed, filtration without pH adjustment, filtration with pH adjustment, and filtration performance at the optimized filter flow and chemical feed rates.

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**Notes:**

1. The responsibility for payment of laboratory testing should be determined before pilot testing begins, e.g., client / consulting engineer / contractor.
  2. Sampling complexity and frequency to be determined before starting.
  3. Refer to Pureflow filtration Div. Bulletin NO. T2.9422.7 Arsenic, Iron, and Manganese General mineral Analysis for sampling protocol.
  4. Chlorine break point must be established and chlorine residual must be on the plus side of break point before filtered water samples are taken.
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### D. Pilot Filter and Laboratory Test Equipment (Suggested Minimum)

**Two** (2) \_\_\_\_\_" I.D. pilot filter with control valves (manual / automatic), effluent and backwash water flow meters, pressure gauges, and raw / treated water sampling valves.

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**Note:** A minimum of two (2) 3" I.D. pilot filter columns is recommended. Other commonly accepted filter sizes are 6", 12", 24", 36", and 48" depending on job site requirements / pilot study protocol.

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**Four (4)** Chemical feed pumps with digital controls to feed: sodium hypochlorite, ferric salt (e.g., ferric chloride), acid (sulfuric, H<sub>2</sub>SO<sub>4</sub>) and caustic (sodium hydroxide, NaOH)

**One (1)** Colorimeter with chemical reagents (for free and total chlorine, iron, and manganese)

**One (1)** Low range arsenic test kit

**One (1)** pH meter

**One (1)** Hydrogen sulfide (H<sub>2</sub>S) test kit (AWWA standard)

**One (1)** Thermometer (water temperature monitoring)

**One (1)** Turbidimeter (NTU)



## E. Daily Test Operations

### Day 1

Equipment setup and calibration. Determine optimum chemical dosage rate to reach chlorine break point. Test for the reduction of arsenic, iron, and manganese levels, without the addition of ferric salt or acid.

### Days 2 & 3

- a) Determine optimum ferric salt dosage rate and continue testing for other optimum chemical dosage rates (and contaminant removal) and determine how arsenic concentration varies with ferric salt dosage.
- b) Determine optimum pH for the removal of contaminants.
- c) Determine optimum filter flux. (Flow rate in gpm / ft<sup>2</sup> of media)
- d) Determine caustic dosage (e.g. sodium hydroxide), if required, to provide water that is non- corrosive, downstream of the filter.

### Days 3 & 4

Determine contaminant removal at various filtration rates, at optimum chemical dosage rates. Confirm chlorine dosage rate required to provide the required disinfectant / free chlorine residual past the filter.

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**Note:** Optimum filter backwash frequency and backwash water sludge settline will be tested each day of the pilot study.

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**Day 5** Continue testing, if required.

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**Notes:**

1. Minimum recommended testing period is three (3) days.
  2. Notify city personnel each day when meaningful sampling can be performed by city staff and Pureflow field personnel.
  3. Laboratory testing must follow AWWA standards including sample bottle type / preparation. Please refer to Bulletin No. T2.944 Pureflow General Mineral Analysis and Design Data Bulletins (arsenic, iron, and manganese), for our recommended field and laboratory water quality test procedures.
  4. At least two (2) samples of filtered water must be taken at each sampling interval. The Client will take one (1) of the samples. The other one (1) samples are to be sent to two (2) separate, qualified, laboratories by the filter manufacturer and / or consulting engineer.
  5. If the results of field testing for arsenic are not verified by the laboratory test results, additional on-site testing may be required.
  6. We suggest contacting the local water analytical laboratory, in advance of the pilot testing, to have them provide a minimum twenty-four hour "turnaround" of the test results.
  7. Disposal of well water must be considered before pilot testing.
  8. Well should be pumped at design flow rate during pilot testing to assure that the raw water quality being tested is the same that the full-scale filter will treat.
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## **F. Pilot Filter Study Report**

The pilot filter study report must be comprehensive, include data pertinent to the particular well and / or wells that are to be treated, and must include the following data as a minimum:

- A brief description of the field conditions and existing water well / treatment equipment
- An executive summary
- List of field personnel on site during testing
- Description of the pretreatment equipment, filtration system and accessories used to run the pilot test
- Photographs of the site / test equipment

- Copies of field testing data sheets for each day on the well site
- Break point chlorination curve
- Water quality test analytical methods
- Field operation procedures
- Discussion of pilot test results
- Tables indicating test results & contaminant removal using various media, oxidant dosage rates, & pH levels
- pH (pre-filter and post-filter)
- Filter vessel pressure losses at various time intervals
- Chemical feed rates vs. contaminant removal
- Filter column configuration including :
  - \* Support media \*Active media \*Column diameter / height \*Backwash loading rate & duration \*Filter run time \*Total media depth \*Filter run time before contaminant breakthrough \*Filter area (sq. ft. media)
- Raw water vs. filtered water quality
- P & ID of pilot filter test process
- Chart showing pressure drop as a function of run time
- Backwash water mass recoveries (CA requires Toxicity Characteristic Leaching Procedure W.E.T. Test)
- Conclusions

**THE FOLLOWING DATA CAN ALSO BE PROVIDED WITH THE PILOT STUDY WHEN REQUESTED BY THE CLIENT / CONSULTING ENGINEER:**

- Recommended treatment process, including P & ID and the dimensions of the area required to install the treatment process.
- Operation and maintenance costs of recommended treatment process, including daily chemical consumption, and estimated daily chemical cost.
- Budget proposal for treatment process.

**COMMENTS**

a) The above information is offered as a guide to prepare a comprehensive protocol for a pilot test filter study to remove arsenic, iron, and manganese from drinking water supplies and industrial applications using a coagulation / filtration (permanent media) filtration system. Other contaminants such as hydrogen sulfide, ammonia (NH<sub>3</sub>), total organic carbon (TOC), etc. can affect the removal of the primary contaminants, and / or the effective filter run time and must be considered during the planning and operation stages of the pilot filter test so that these contaminants are removed along with the primary contaminants.

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**Note:** If arsenic is the primary contaminant to be removed from the drinking water supply and the use of a Disposable Media is under consideration, other contaminants (such as iron, manganese, sulfides, organics, chromium [Cr], silica [Si], phosphates [e.g., sodium phosphate, NaH<sub>2</sub>PO<sub>4</sub>], etc.) will also affect the removal of arsenic by occupying the surface of the media intended to remove arsenic. This will reduce the effective life of the disposable Media, increase the disposal frequency of the media and, the cost of operation.

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b) Potential seasonal variance of contaminants must be considered when evaluating pilot filter test results. Wells that are subject to substantial increase / decrease in contaminants should be tested when the contaminant levels are highest. Short term testing can result in questionable test results if contaminant variation is not considered.



- c) The cost of pilot testing should be considered when writing a pilot filter study protocol. Comprehensive pilot testing often requires more field personnel, increased sampling and laboratory analysis costs, and also increased pilot test report complexity and costs.
- d) Pureflow recommends that clients discuss the proposed pilot filter study protocol with a consulting engineer and their local Department of Health Services (DHS) officer before the protocol is finalized and field testing begins.
- e) If a generator is required to provide power for the pilot trailer, refer to the Pureflow Pilot Trailer Data Sheet for power requirements.
- f) The pilot trailer and ancillary equipment must be protected by a security fence or gated facility.
- g) Refer to Pureflow pilot Trailer data Sheet for operating parameters.
- h) Contaminants such as trihalomethanes (THM), or color in the raw water may require an alternate oxidant such as ozone. Chlorine would be fed to provide a disinfecting residual downstream of the filter system.
- i) Client, contractor, or consulting engineer must provide adequate property insurance to cover the replacement cost of the pilot trailer and testing equipment.

## TREATABILITY STUDY

As an alternate to a comprehensive pilot filter study, water purveyors and consulting engineers can also consider a "Treatability Study". This test is performed at the well site and is generally run with a small diameter pilot filter column (e.g., 3" I.D.), and operated to gather basic data to determine the ability of the process / filter media to remove arsenic, iron, and manganese.

The pilot test data and report are simple, are usually operated for one (1) to three (3) days, and are also much less expensive than a comprehensive pilot test study. "Treatability Studies" are sometimes run prior to a comprehensive pilot test to determine / confirm basic raw water quality and treatment data in order to write a pilot test protocol that is designed for the specific parameters of the raw water to be filtered.

## Bench Testing

Small-batch water samples can be tested in a laboratory using multi-position, variable speed jar testing equipment to simulate chemical mixing, flocculation, and settling conditions in a full scale WTP, and/or small diameter filter columns (typically 1" to 2" diameter). Testing protocol should be established using AWWA standards as a guide. Water should be tested within 24 hours from the time the water samples were taken.

## Contact



[info@waterbypureflow.com](mailto:info@waterbypureflow.com)

[sales@waterbypureflow.com](mailto:sales@waterbypureflow.com)



(800) 926-3426

(562) 945-3425



6739 Washington Ave. / P.O. Box 469

Whittier, CA 90608-0469



[www.waterbypureflow.com](http://www.waterbypureflow.com)

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