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Groundwater Pump-and-Treat Facilities Performance Metrics

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788


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Approved for Public Release;
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Contents

Terms

DA	Design Authority
IX	ion exchange
P&T	Pump and Treat

1 Summary

This document describes the methods used to generate and validate production metrics for the Pump and Treat (P&T) facilities. It currently covers the 200-ZP-1 facility and the following 100 Area facilities: KW, KX, KR-4, DX, and HX. It does not address the new 200 West Area bio-facility.

These facilities primarily treat one (monitored) contaminant, which is hexavalent chromium for the 100 Area facilities and carbon tetrachloride for 200-ZP-1.

2 Calculation Description

Figure 1 illustrates a typical process flow with sampling points and flow measurement points. Contaminant concentration is manually sampled on a regular basis at the input (CrIn) and outputs (CrEff) of the ion exchange (IX) resin trains. Flow measurements are taken at three points in the process: 1) at each extraction well (FIT-Ei), 2) at the inlet to each IX column (FIT-Fi), and 3) at each injection well (FIT-Ji). There are no other flow streams (i.e. all water flowing from the extraction well goes through the IX columns and goes into an injection well). Each gallon extracted is assumed to be remediated in accordance with the difference between the sample values at IX influent and IX effluent.

2.1 Contaminant Sampling

Hexavalent chromium samples are taken weekly and may be taken more frequently if conditions warrant as determined by the Design Authority (DA). Carbon tetrachloride concentration is measured less frequently and is not analyzed in the field; lab samples are periodically collected and results may take up to a month to get back. For maximum accuracy, consideration is given to take the samples when the plant is operating stably with the normal mix of wells. Sample results are entered into the control system, by the operator, and verified (i.e., committed) by a second person; upon verification, they are used to calculate the contaminant removal for the water currently being processed. No automated correction or adjustment is made to prior results.

2.2 Flow Summation

Flow is summed minute by minute on a well-by-well basis, using the flowmeter associated with each extraction well. This generates a total accumulated lifetime volume for each well, and those volumes are summed to form the total accumulated lifetime volume for the facility.

2.3 Remediation Calculation

Immediately upon extraction, each gallon extracted is calculated to be remediated by the (current) difference between the influent and effluent sample data. The mass removed is saved as a total accumulated lifetime value for the facility.

2.4 Flowmeter Comparison Alarm

The numerous flowmeters are monitored, and an alarm is generated to warn the operator of difference greater than 10 percent, which could compromise the calculation. For example, after

allowing time for transient conditions, the sum of the extraction flows should equal the sum of IX flows, which should also equal the sum of the injection flows.

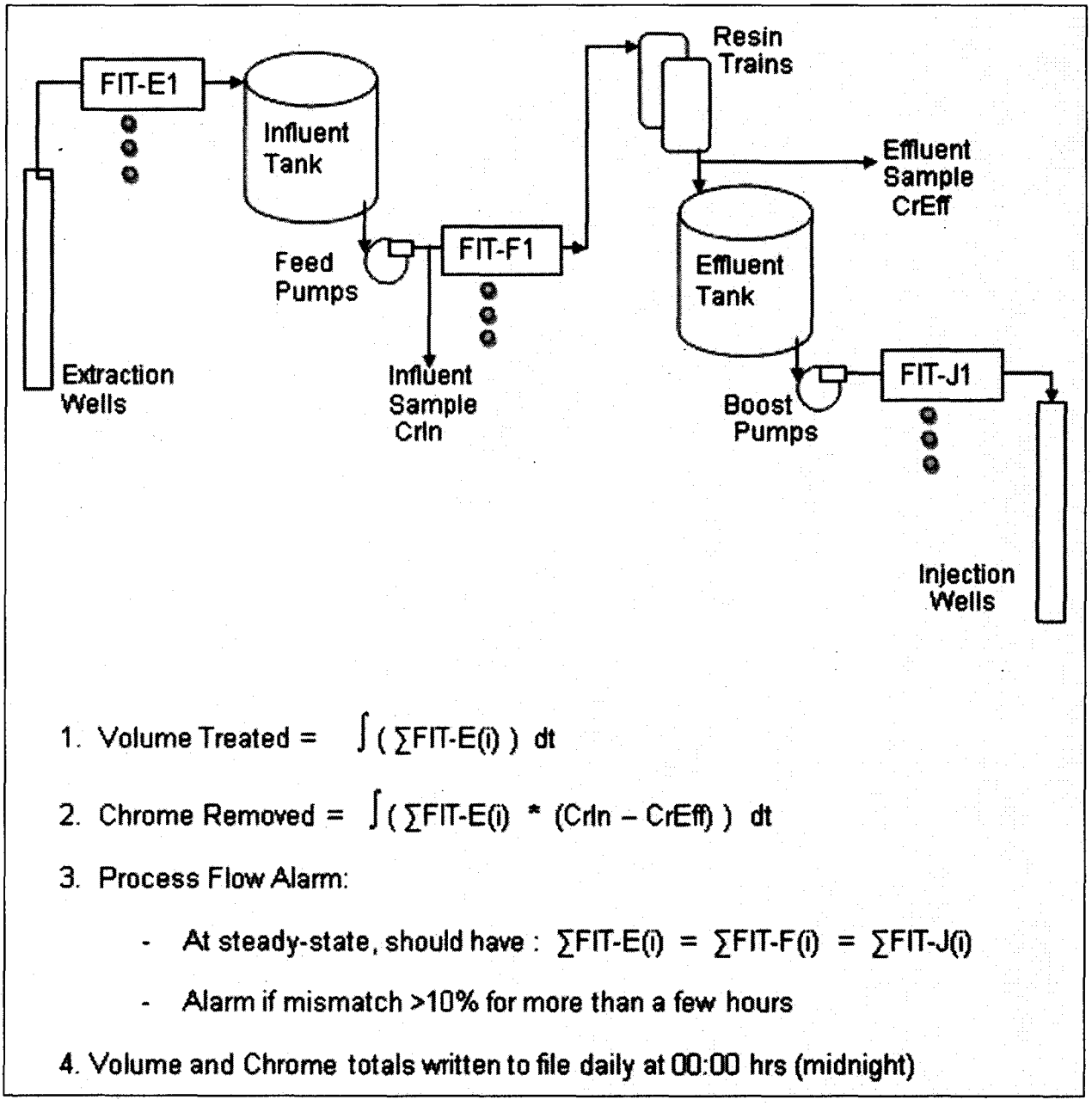

Figure 1. Data Collection Diagram

2.5 Data Recording

The total values of volume and mass removed are daily recorded to file and copied to backup locations.

2.6 Error Discussion

The calculations of volume and quantity removed are fairly straightforward and have been verified by hand calculations (discussed in Chapter 3). The primary sources of errors are: 1) sample error or incorrect sample data entry and 2) flowmeter error.

2.6.1 Sample Error

Carbon tetrachloride samples are always sent to the laboratory and have the accuracy of the laboratory analysis procedures. The field chromium measuring equipment is accurate in the range of 5 to 10 percent of reading for typical influent concentrations, with improving accuracy as the concentration increases. The effluent concentrations are usually below the stated detection limit of the equipment - the instrument does report values, but they are of questionable accuracy. Nevertheless, when subtracted from the larger (more accurate) influent readings, the error in the effluent readings has a minor effect on overall accuracy. For example, (100-2) is only two percent different from (100-4), even though the smaller value has changed by 100 percent. The net result of using the (questionable) effluent value is a small reduction in reported chromium removal compared to assuming zero for values below the stated detection limit. This is a conservative approach. Samples are also sent periodically to an outside laboratory for analysis. The local and laboratory readings usually agree within 5 percent, indicating that it is reasonable to consider the local readings to be within 10 percent accuracy.

Incorrect entry of the contaminant sample value is minimized by requiring a second person to verify the data entry prior to using them for calculation. Both the person entering the data and the verifier know what nominal value to expect, which makes a significant error unlikely. Values are typically committed the same day as measured, and those values continue to be used until the next sample is committed. Consecutive samples typically only differ by an amount within the range of the measuring accuracy, because the change in influent concentration is relatively slow compared to the sample period. The multiple samples, therefore, actually tend to reduce overall long-term error by averaging out the errors in the measurement equipment.

The most significant potential sample related error would be when the (well) flows are different from those during sampling; for example, a high chrome well that was on for the sample but was subsequently shut off. Operators are trained to take the sample during normal flow conditions. This type of error would tend to average out in the long run or be naturally corrected by next scheduled sample. However, in rare instances (for a particularly high concentration well), extra sampling and subsequent manual corrections to the accumulated totals may be appropriate. To assist in managing this issue, samples from individual wells are also entered into the computer and a mixing calculation is performed. This calculated influent concentration is displayed on the HMI for the operator to use as a comparison to the field sampled value.

In summary, with good management of the calibration and sampling activities, it is judged that the overall accuracy of the contaminant concentration values will be within 10 percent.

2.6.2 Flowmeter Error

The inherent flowmeter accuracy is 0.25 percent, with no calibration necessary. The individual errors tend to average out when summed, but statistically, 20 such flowmeters could result in a one percent error in the total accumulated flow. A potentially more significant error would be a

failure which allows water to flow without being measured, or vice versa. The design minimizes this type of error by accumulating volume and chrome only when the well is also commanded to be running, and wells are usually shutdown (via interlock or operator action) when a flowmeter fails. Many failures would trigger a flow limit alarm and/or the flowmeter comparison alarm. However, for some failures, the final error check involves the DA monitoring and understanding the reasons for changes in flows.

Following the process described herein should provide an overall accuracy of flow accumulation values within one percent. Up to five percent accuracy is acceptable and should be readily achieved.

2.7 Managing Plant Errors

Although minimal, potential process upsets could result in erroneous accumulated data values. Therefore, release of raw data is inappropriate, regardless of how much verification is performed on the software and/or calculations. It is necessary and appropriate for the knowledgeable process DA to peruse and verify the inputs and outputs first for integrity. If the DA review identifies data errors, the totalized values and files are manually adjusted to correct the error (see also Chapter 3).

3 Software Verification

Tests have been performed to verify the adequacy of basic software functions.

3.1 Volume Accumulators

Proper operation of the volume accumulators was verified during acceptance and operational tests at each facility. The volume totals were verified to be accurate by comparing them to flowmeter internal parameters and to level changes in the tanks.

3.2 Contaminant Removal Calculation

Hand calculations were used to verify that the computer properly calculated the mass of contaminant removed based upon the sample results and process flows. Results are documented in the following work packages, which installed and tested the calculation software:

- GW-11-00123, KW Software Screen and Software Logic Corrections
- GW-11-00156, KX Software Screen and Software Logic Corrections
- GW-11-00157, KR-4 Software Screen and Software Logic Corrections
- GW-10-07714, DX Software Screen and Software Logic Corrections
- GW-11-06739, HX Software Screen and Software Logic Corrections
- GW-11-00092, 200-ZP-1 Software Screen and Software Logic Corrections

In general, the accuracy of the calculations was <0.01 percent on a daily basis and <0.0001 percent on a monthly basis. The daily results indicated some truncation and/or rounding differences between the online computer and the one used for comparison, which average out over a longer period of time.

3.3 Data Export

Visual inspection, documented in the above work packages, was used to verify that the proper accumulator values were written to the data file and subsequently read and reported.

3.4 Chart Generation

Chart generation programs simply present the raw data from the exported data file in manners that are more conducive to DA review. They have been verified to read and display the data file properly, but the chart generation logic has not been subjected to formal verification/validation because reportable values are not generated by the charting programs.

4 Generation/Reporting of Metrics

There is no intent to have the software program automatically generate reportable values. Before any results are reported, it is essential for the DA to assess system operation for upsets that could affect the raw data and confirm that output data are consistent with expectations.

Several process issues could affect the result, so each reported set of values requires individual validation. To assist this assessment, charts are generated that present the data in various ways. The following assessments will be made for each set of reported performance results:

- The performance of each well will be reviewed over the reporting period. The DA is expected to understand the reasons for any off-normal or unexpected conditions and verify that the incident is understood and is not a result of incorrect data. For example, a flow drop on a specific day could be attributable to a maintenance activity or known operational flow reduction.
- The DA will identify any potential impacts to volume or mass removed calculations and determine if the magnitude is significant enough to merit correction. For example, incidents involving a slightly different set of wells from those running during the sample do not necessarily need to be corrected, unless a particularly high contaminant well is involved; in this case, the issue may have been identified earlier and triggered a new sample.
- As necessary, the volume and mass removed accumulators may be adjusted to correct significant errors.
- Values from the start date and end date will be identified for the reporting period. The starting accumulator value for the current period should be the same as the ending value from the prior period.
- Results will be evaluated for consistency with data from prior months (allowing for explainable differences).
- The calculated ratio of mass removed to volume treated will be verified for consistency with the known sample data for the period, which provides a nominal end-to-end verification of the overall calculation process.

After validation and correction of anomalies, production information is suitable for reporting.

5 Conclusions

A system has been developed for reporting the volume and contaminant removal performance of the various P&T facilities. Status data are available on a daily basis but not suitable for formal

reporting until further validated by knowledgeable process authorities. Programs and reporting tools have been developed to present the data to the technical authorities in a manner that will assist their evaluation of process conditions, which might affect the performance metrics. Following this validation process, metrics with a high confidence of accurately documenting system performance can be reported.

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