U. S. Army Corps of Engineers Extraction, Injection and Monitoring Wells Performance Checklist

Installation Name	_____
Site Name / I.D.	_____
Evaluation Team	_____
Site Visit Date	_____

This checklist is meant to aid in evaluating the performance and maintenance of extraction, injection, and monitoring wells. These wells typically are part of either an extraction system or monitoring network. This checklist is divided into the following sections:

1) Evaluation team
2) Rationale for the evaluation of well performance and maintenance
3) References and background information
4) Data collection requirements
5) Evaluation of well performance
6) Recommendations for well rehabilitation or abandonment
7) Recommendations for modifications and alternatives for cost savings
8) Conclusions
9) Supplemental notes and data

This checklist provides a format for recording the recommended information. Supplementary notes should be numbered to correspond with the checklist sections. This checklist is not a substitute for careful observation and evaluation of engineering, hydraulic, geologic, and chemical data to determine whether reported performance matches the design and operational parameters.

1) Evaluation Team

The evaluation of extraction and monitoring wells to determine the need for well rehabilitation or abandonment should be based on objective observation and testing by individuals knowledgeable and experienced in well maintenance and rehabilitation. The following disciplines should be included in the evaluation team:

- Hydrogeologist (attend site visit, subsurface performance evaluation)
- Biologist (biological activity evaluation)

2) Rationale for the Evaluation of Well Performance and Maintenance

Well maintenance includes routine physical inspection and analyses of hydraulic performance and sample quality. The purpose of maintenance is to detect and control deterioration in well performance. Improper maintenance can lead to sample quality degradation or physical problems with the well. These problems are intrinsic to monitoring wells, which are often left idle for long periods of time (as long as a year), installed in non-aquifer materials, and installed to evaluate contamination that can cause locally anomalous hydrogeochemical conditions. Problems may also occur in extraction and injection wells, which operate under similar anomalous hydrogeochemical conditions. Physical and chemical data obtained over a period

of time must be compared for each well in order to identify deficiencies in well performance and the potential for sample quality degradation.

3) References and background information

Coordinate this checklist with the Ground Water Extraction System Subsurface Performance and the Environmental Monitoring checklist. The following references may also be helpful:

EM 1110-1-4000 [1]:	Monitor Well Design, Installation, and Documentation at HTRW Sites
ETL 1110-1-201:	Ground Water Extraction
ASTM D 5092:	Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers
ASTM D 5099:	Standard Guide for Development of Ground Water Monitoring Wells in Granular Aquifers
ASTM D 5299-92:	Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
ASTM D 5978-96:	Standard Guide for Maintenance and Rehabilitation of Ground-Water Monitoring Wells

4) Data Collection Requirements

Site-specific documents are a primary source of data for the evaluation. The following is a list of documents that are frequently useful. Record the title author and date of each document referenced.

- Well atlas or site maps–the locations of the wells
- Long term monitoring plan–describes the purpose of specific monitoring wells
- Well boring log–describes the configuration of monitoring wells
- Well construction details–describes the configuration of monitoring wells
- Historic performance data–may indicate physical deterioration of the wells
- Historic chemical data–may indicate physical or chemical deterioration of the wells
- Maintenance records–necessary to evaluate the adequacy of well maintenance

4.1) Physical inspection and testing

A physical inspection and physical testing are required for maintenance of extraction/injection and monitoring wells. While it may not be necessary for the evaluation team to perform the inspection and testing of each well, the records of such inspections and testing should be included in the documents being reviewed.

a) Wellhead Protection Features: Are above-ground wellheads painted and clearly labeled? Are flush-mount and vault covers and vaults in good repair and clearly labeled? Are wellhead enclosures painted, well maintained, and clearly labeled? Are there locks on the wells? Are concrete pads around the well in good condition? Are bollards present at non-flush-mount installations and are they in good condition?

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b) Well Condition: Has there been physical damage to the well? Are wellheads protected from standing surface water? Is there evidence for frost heave/jacking of the protective casing or well casing? Is there settlement around the well (i.e. due to inadequate compaction or aquifer consolidation)?

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c) Testing Program: Is there a regular program for evaluating the performance of the well (check specific capacity and accumulated sediment)? Is there a regular program to evaluate down hole conditions (e.g., camera survey)? How many gallons of water have the wells injected/extracted since installation.

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d) Is there evidence suggesting the lines between the wells and the plant are occluded? _____
_____

4.2) Chemical and Biological Data Requirements

Chemical well performance deficiencies can be identified by evaluation of chemical data trends and by collecting new data during the physical inspection and testing program. The need for these new data should be identified by observations of anomalous chemical results in the trend analysis.

a) Have BART tests or other bacteriological tests been utilized to evaluate biofouling?

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b) Have the geochemical conditions been evaluated for the potential for scaling and precipitation? For injection wells only, has the treated/injection water been tested for the potential to cause inorganic precipitation?

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5) Well Performance Analysis Calculations

The evaluation of the performance and maintenance of extraction and monitoring wells should incorporate all available information about site-specific factors that could cause sand, silt, or clay pumping, sample turbidity or alteration, corrosion, or clogging. Such information can include biological activity, redox potential, pH, conductivity, alkalinity, and major ions present in the ground water. Hydraulic performance should have been benchmarked at installation and during operations so that changes in performance can be detected. Quantities of sediment in samples should be recorded and compared through the life of the well.

a) Compute current well specific capacity. What was the original specific capacity and how does it compare to the current capacity?

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b) Evaluate the changes in geochemistry; changes in pH, Eh, conductivity, turbidity.

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_____

c) Is there evidence of degradation of well performance?

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d) Is there evidence of well or drop pipe corrosion? _____

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6 Adequacy of Operations and Maintenance

a) Is there a regular well maintenance program? If so, What is the well maintenance protocol:

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_____

_____

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b) Can the prescribed well maintenance be carried out given the layout of the well and the available personnel and equipment?

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_____

c) When were the well(s) last developed and when will it (they) be redeveloped?

_____

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d) Is there a maintenance schedule for the pump and how is it documented? Has there been excessive pump wear noticed due to sediments?

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e) Are all of the flow meters/totalizers in good working order?

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f) Is there an inventory of appropriate spare parts for the pumps and related equipment?

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g) Is there an up-to-date logbook for recording performance & maintenance for each extraction well?

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6) Typical Performance Problems

Causes of poor well performance associated with design and installation should also be considered, such as the following:

- Poor selection of well location or screened interval
- Poor screen design
- Inappropriate selection of well construction materials
- Poor construction
- Ineffective development
- Inappropriate pump selection

Typical problems include the following:

a) Physical damage to the well due to frost, vehicles, or vandalism - can limit or prevent use of the well, compromise integrity of the well and allow contaminated surface water to migrate to the subsurface. Solution: inspection and repair. Severe damage can require well replacement.

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b) Sand, silt, and clay infiltration into well - especially for monitoring wells, fine-grained material enters the well and settles to the bottom, ultimately occluding the screen - causes include improper screen and filter pack design or installation, incomplete development, screen corrosion, and collapse of filter pack. In rock wells, causes include the presence of fine material in fractures and incomplete casing bottom seat. The presence of sand, silt, or clay can result in pump and equipment wear and plugging, turbid samples, and filterpack plugging. Solution: periodic sounding of the well and bailing the sediment when it reaches a certain height above the bottom cap.

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c) Encrustation or fouling - scale or biological growth forms on well screen, reducing open area and increasing water entrance velocities, typically manifested by reduced specific capacity of the well. Solution: periodic rehabilitation when the specific capacity decreases to a predetermined level.

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d) Excess sand production or turbidity - due to inadequate development, corrosion, inadequate design of filter pack or screen. Well redevelopment may be useful, but well replacement may be required if the production is due to corrosion or improper design. Other alternatives (e.g., selective pressure grouting of an affected zone or blank casing / small-slot screen inserts) could be considered for very expensive/deep wells but may not result in adequate well performance.

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e) Low yield and loss of production - causes include dewatering or collapse of fracture or other water-bearing zone, pump malfunction, screen encrustation or plugging, column pipe corrosion or perforation, or hydraulic head increase in water delivery or treatment system. Solution: Reduce pumping rate, pull and diagnose pump malfunction, rehabilitate well, replace corroded drop pipe.

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7) Recommendations for Well Rehabilitation or Decommissioning

Well rehabilitation must consider the cause of the loss of performance, the function of the well (monitoring wells should not be rehabilitated in a way that affects samples taken from the well at a later time), the contaminants, and the health and safety of the on-site workers. Wells that are no longer usable or needed must be decommissioned in accordance with state and local requirements. Also refer to ASTM D5299 for a procedure for decommissioning.

8) Recommendations for System Modifications and Alternative for Cost Savings

Options for system modifications and alternative technologies should be evaluated, especially if numerous wells require rehabilitation or replacement.
Most monitoring wells are installed as part of a permanent monitoring well network for a plume or ground water management zone. If remediation is complete or the extent of contamination changes, each individual well's role in the monitoring well network should be reevaluated. Alternative technologies to monitoring wells include the following:

- buried sensors (e.g., optical sensors)
- surface or borehole geophysical surveys to monitor change
- discrete interval samplers (e.g. Westbay, FLUTe systems)

Alternatives to conventional vertical extraction wells include

- extraction trenches
- horizontal wells
- passive collection systems and treatment walls

9) Supplemental Notes and Data

There are _____ pages of supplemental notes and data attached to this checklist.

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[1] EM: USACE Engineering Manual, available at www.usace.army.mil/inet/usace-docs/