TECHNICAL MEMORANDUM 3

ADDENDUM TO
FINAL PHASE III RFI/RI WORK PLAN
MULTI-WELL PUMPING TEST PLAN
881 HILLSIDE AREA
(OPERABLE UNIT NO. 1)

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

ENVIRONMENTAL RESTORATION PROGRAM

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1.0 PURPOSE AND SCOPE

This technical memorandum describes techniques that are specific to the multi-well (15 wellpoint array) pumping tests described in the Final Phase III RFI/RI Work Plan, Revision 1, March 1991 (Work Plan) for the 881 Hillside Area, Operable Unit 1 (OU1) at the Rocky Flats Plant (RFP). The technical memorandum is compatible with and complementary to Environmental Management Department (EMD) Groundwater Standard Operating Procedure (SOP) Aquifer Pumping Tests GW 2.08, Revision 0, dated October 29, 1991, and is intended to extend the general procedures described in that SOP to cover OU1-specific test requirements and modifications necessary to implement the scope of work described in the Work Plan.

The Work Plan proposes that three multi-well pumping tests be performed in the Woman Creek alluvium using a 15-wellpoint array to estimate the transmissivity and specific yield of the aquifer. The wellpoint array will also be used to perform multi-well tracer tests. Before the wellpoint array is installed, an exploratory soil boring will be advanced to determine site-specific hydrogeologic conditions. The 15-wellpoint array will then be installed and the pumping test conducted. This technical memorandum describes the equipment and procedures required for installation of the exploratory borings and wellpoint arrays and for performance of the pumping tests.

2.0 EQUIPMENT AND MATERIALS

The following is a list of equipment and materials needed to install the wellpoint array and to perform the multi-well pumping tests:

- Fifteen 1.5-inch-diameter stainless steel drive points, each having a sufficient length of well screen to fully penetrate the saturated thickness of the aquifer. Well screen length and slot size will be determined from site-specific hydrogeologic information obtained from drilling the exploratory borings in addition to wells previously installed in the vicinity of the proposed wellpoint array; 1.5-inch-diameter carbon steel blank casing for use in completion of the wellpoint from the top of the well screen to 1 foot above the ground surface

- Equipment and supplies for the installation and development of the wellpoint array consistent with procedures described in groundwater SOP GW 2.08
- Fifteen 5 psi pressure transducers with an accuracy of $\pm$ 0.14 inch
- One or more data loggers capable of recording 15 channels simultaneously
- Electronic water-level indicator graduated in hundredths of a foot
- Stop watch or clock readable to 1-second increments
- Reliable power source (5 kW generator or equivalent)
- Tank or drums in which to store both groundwater produced during the test and well development water
- Flow meter or other device for measurement of pump discharge rates in hundredths of a gpm
- Peristaltic pump with a minimum capacity of 0.05 gpm, intake and discharge lines
- Field notebook
- Field data sheets.

3.0 PROCEDURES

3.1 WELL INSTALLATION, COMPLETION, AND DEVELOPMENT

An exploratory boring will be drilled at each of the three multi-well test locations outside of the location of the proposed wellpoint array to determine site-specific hydrogeologic conditions. These include depth to water table, the depth to the base of the saturated alluvial aquifer, the initial saturated thickness of the aquifer, and grain size distribution of the aquifer materials. The boring will be advanced using continuous flight hollow stem augers (approximately 2.5-inch inside diameter), according to procedures described in SOP GT.02. Solid stem augers may be used to advance the boring or drive hole for the wellpoint in the event that boulders or cobbles are encountered. Visual logging and sieve analysis of the alluvial material will be performed according to SOPs GT.01 and GW 2.08. The boring will be abandoned according to SOP GT.05.

The 15 wellpoints will be installed in a three-well by five-well array such that the rows of five wells will be oriented perpendicular to the estimated direction of groundwater flow. The wells will be installed on approximately 2-foot centers within the array. Well locations may be modified based on conditions encountered during drilling. Each wellpoint will be installed by first boring a hole using hollow stem augers to within 1 foot of the water table elevation. The wellpoints will be inserted into the boreholes and then pushed or driven to final depth while held in a vertical orientation. Solid stem augers may be used to advance the boring or drive hole in the event that boulders or cobbles are encountered. Final depth will be such that the well screen of each wellpoint fully penetrates the saturated thickness of the aquifer and extends one foot above the water table. The wellpoints will be constructed using 1.5-inch-diameter stainless steel screens and carbon steel blank 1.5-inch-diameter casing. The annular space remaining around the blank well casing will consist of natural formation materials which will fill the annular space upon auger retrieval.

The wellpoints will be developed using methods described in SOP GW 2.08, or by other equivalent methods. Groundwater SOP GW 2.08 requires that a minimum of five well casing volumes be removed for well development. Well development will ensure that the natural formation materials disturbed by the wellpoint will be as representative as possible of the aquifer. After completion of the multi-well pumping tests and associated tracer tests, the wellpoints will be withdrawn from the ground and the remaining boreholes grouted and abandoned as described in SOP GT.05.

3.2 EQUIPMENT INSTALLATION AND INSTRUMENTATION

Following the installation and development of the wellpoint array according to SOPs GT.02 and GW 2.08, the aquifer will be allowed to return to an equilibrium hydraulic condition. Hydraulic equilibrium is the time at which the static water level returns to the elevation measured prior to well development. Water levels will be monitored and recorded before and during the aquifer pumping test using 5 psi pressure transducers with an accuracy of $\pm$ 0.14 inch installed in each well and connected to the data logger(s).

The central well of the 15-wellpoint array will be used as the pumping well during the test activities. All other wells will be used for observation of groundwater-level fluctuations. A teflon intake tube will be lowered into the pumping well to a depth of approximately 1 foot from the bottom of the screened interval. A peristaltic pump with a minimum capacity of 0.05 gpm will be attached to the intake tube, and will discharge through a flow meter to the produced water storage tank. The pump will be powered by a continuous power source during the test. The range of pumping capacities shall be sufficient to accommodate aquifer conditions during the testing activities.

All of the appropriate equipment listed in Section 2.0 shall be available during the test. All equipment used for the tests will be decontaminated according to SOP FO.03.

3.3 STEP-DRAWDOWN TEST PROCEDURES

Before the constant rate multi-well pumping test is performed, a step-drawdown test will be conducted according to SOP GW 2.08. The test will provide information on the efficiency of the pumping well and will be used to help establish the flow rate that can be sustained during the constant rate pumping test. The step-drawdown test shall consist of a minimum of five pumping rate steps to ensure a sufficient range of pumping rates are examined. The lowest pumping rate for the step test shall be 0.05 gpm or lower to ensure a sustainable flow rate. Four successively higher rates shall be used, which are 0.10, 0.15, 0.20, and 0.25 gpm. These rates were approximated using currently available information and estimated *in situ* hydrogeologic characteristics. Additional step drawdown tests may be required depending on results obtained with the pumping rates given here. Each pumping step should be of equal duration (approximately 0.5 to 2 hours) to simplify test analysis. The aquifer shall be allowed to return to hydrostatic conditions before the constant-rate test is performed.

During the step-drawdown test, water levels in the pumping well and observation wells will be collected by the pressure transducer/data logger system. A typical range of time intervals for water level measurements is given in Section 5.3.1 of SOP GW 2.08. In addition, time-

drawdown measurements will be collected manually at selected intervals to provide backup data. Other pertinent information including pumping rates and radial distance and direction from the pumping well to the observation wells will also be recorded. Test data will be recorded in the field notebook, on the field data sheets provided in SOP GW 2.08, and in the data logger files. The results of the test will be analyzed using methods referenced in SOP GW 2.08. A pumping rate will then be selected for use in the multi-well constant-rate pumping test based on drawdown curve calculations (Section 4.4).

3.4 MULTI-WELL CONSTANT RATE PUMPING TEST PROCEDURES

The constant-rate pumping test will be conducted by pumping the central well of the 15-wellpoint array at the constant flow rate determined from the results of the step-drawdown test. The pumping portion of the test will be followed immediately by the recovery portion of the test. The pumping period will have a minimum duration of 4 hours, and may last as long as 24 hours, depending on site-specific hydrogeologic conditions. The duration of the pumping test will be continued until a steady state condition is reached, where recharge of the aquifer equals the pumping rate. According to Kruseman and De Ridder (1989) equilibrium in some tests occurs within a few hours; however, in an unconfined aquifer the cone of depression expands slowly as the aquifer is being dewatered before steady state is reached. Therefore a longer pumping period may be required. The recovery period will be monitored until 90 percent of drawdown is recovered. The pumping test and recovery test will be performed according to SOP GW 2.08. Water produced during the test will be stored in a water tank or in drums and marked for disposal or used in the multi-well tracer test.

Water levels will be monitored in all wells both before and during the pumping and recovery portions of the test using the pressure transducer/data logger system. A typical range of time intervals for water level measurements is given in Section 5.3.1 of SOP GW 2.08. In addition, time-drawdown measurements will be collected manually at selected intervals to provide backup data. The times at which the pumping and recovery portions of the tests begin will be recorded. Flow rates will be measured to the nearest hundredth of a gpm and

will be recorded in conjunction with manual time-drawdown measurements. Information will be recorded in the field log book and on the appropriate field data sheets (see SOP GW 2.08).

Following completion of the pumping and recovery tests, the aquifer will be allowed to return to equilibrium conditions. The pressure transducers may be left in place for use in the associated multi-well tracer test, if that test is to be conducted shortly after the pumping test is complete. Any equipment that is removed will be decontaminated according to SOP FO.03 or disposed of properly.

3.5 DATA INTERPRETATION

The results of both the step-drawdown test and the constant-rate test shall be analyzed using methods referenced in SOP GW 2.08. The step-drawdown test results will be used to estimate a pumping rate for use in the constant-rate pumping test. The analysis methods used will be those that are appropriate to the tests and to site conditions.

4.0 DOCUMENTATION

Documentation for each pumping test described in this technical memorandum shall include the following information as a minimum:

- Aquifer test approval form (with approval obtained before the test is initiated)
- Field data sheets for each test that record pertinent groundwater levels, times, and flow rates
- All numerical and graphical analyses and calculations
- Data logger files of groundwater levels
- Field notebook entries that include as a minimum project name, observer's name, date, time, weather conditions, location and well identification numbers, distance between wells, time and date of relevant information or events (test startup, end, etc.), pumping rate, data logger and transducer serial numbers, assigned transducer channels, decontamination procedures, sampling, and other relevant information.

5.0 REFERENCES

The complete list of source references is cited in SOP GW 2.08.