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	Engineering and Design INSPECTION, MONITORING AND MAINTENANCE OF RELIEF WELLS	
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Regulation
No. 1110-2-1942

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Engineering and Design
INSPECTION, MONITORING AND MAINTENANCE OF RELIEF WELLS

1. Purpose. This regulation provides policy guidance for scheduled monitoring, inspection, evaluation, maintenance and rehabilitation of relief wells at civil works projects.

2. Applicability. This regulation applies to all HQUSACE elements and all USACE Commands having civil works responsibilities.

3. References.

a. ER 1110-2-100, Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures.

b. ER 1110-2-l10, Instrumentation for Safety Evaluations of Civil Works Projects.

c. ER 1110-2-1901, Embankment Criteria and Performance Report.

d. EM 1110-2-1901, Seepage Analysis and Control for Dams.

e. EM 1110-2-1908, Instrumentation of Earth and Rock-fill Dams.

f. EM 1110-2-1913, Design and Construction of Levees.

g. EM 1110-2-1914, Design, Construction, and Maintenance of Relief Wells.

h. EM 1110-2-2300, Earth and Rock-fill Dams - General Design and Construction Considerations.

4. Distribution. Approved for public release, distribution is unlimited.

5. Policy.

This regulation supersedes ER 1110-2-1942, 29 February 1988.

a. All Corps of Engineers civil works projects that incorporate relief wells in a project structure or feature will have a plan for inspection, monitoring, performance evaluation and maintenance developed in accordance with this regulation. This includes structures which are owned and/or operated by the Corps of Engineers, and for which the Corps is fully responsible, such as dams, powerhouses, outlet works, tunnels, spillways, levees, floodwalls, pumping stations, locks, canals, and similar facilities. Additionally, access to relief wells and associated collector/transport and discharge systems is essential for inspection, monitoring, flood fighting and maintenance of these critical elements and must be designed, constructed and maintained adequately to address these requirements.

b. For projects or facilities constructed by the Corps of Engineers and turned over to others for operation and maintenance, the operating sponsor should be notified during the project cost sharing agreement stage and again at the time of its acceptance of the sponsors responsibility to operate, inspect, monitor and maintain the relief wells, collector/transport/discharge systems and access to these elements. The field operating activities (FOA) should use this regulation as a guide in preparing local agreements for maintenance of relief wells.

c. An Operation and Maintenance Manual should be prepared by the relief well designer that contains as-built drawings, including a unique number and location for each well, installation reports, and performance tests. It should also present the plan for inspection, monitoring, performance evaluation, and maintenance developed in accordance with this regulation. If not owned or operated by the Corps of Engineers, the O&M Manual should be submitted to the operating sponsor as a part of their accepted responsibility.

6. Definitions.

a. Relief well: A vertically installed well consisting of a well screen surrounded by an annulus of filter material, commonly attached to a riser pipe with discharge control. Relief wells are installed for the purpose of relieving seepage or excess groundwater pressures from beneath a confining layer or structure.

b. Yield: The volume of water discharged from a well per unit of time.

c. Drawdown: The difference between the water level in a well during pumping and the static water level.

d. Specific Capacity: The yield per unit of drawdown. For field determination of specific capacity the duration of pump testing and discharge rate should be based on the local aquifer characteristics, the design of the well, and the intended use of the data. The value obtained for specific capacity at an individual well can be affected by all of these factors. At a minimum, the current aquifer condition (confined, semi-confined, or unconfined) and the condition at the time of installation and testing should be determined. For purposes of comparison, duration and pumping rate for an individual well should be the same for every pumping test performed on that well.

e. Efficiency: The ratio of the actual specific capacity, at the designed well yield, to the maximum specific capacity. Well efficiency can be determined from the results of constant rate pumping tests conducted for adequate duration (approximate steady-state flow conditions) and including drawdown data from nearby observation wells or piezometers. An approximation of the maximum specific capacity can be made if the hydraulic conductivity of the aquifer is known at that well location.

7. General.

a. Relief wells are installed into pervious foundation materials near the downstream toes of dams, at the landside toes of levees, at the base of canal or floodway excavations, beneath powerhouses and stilling basins, and in similar locations beneath other hydraulic structures. Their function is to intercept seepage, and/or reduce seepage uplift forces beneath a confining layer or structure that are caused by excessive seepage or groundwater levels, while preventing piping or internal erosion of the foundation. Proper design, installation, maintenance, and evaluation of relief well systems are essential to the continuing safe operation of the associated project features. Guidance for design, construction and operation of relief wells is contained in References 3e, 3f, and 3g.

b. Adequate systems of piezometers and flow measuring devices must be used in conjunction with relief wells to provide information on the performance of the seepage control measures. Data obtained from such instruments will indicate changes in pressures or flow quantities for associated reservoir pool or river stages. By comparison to initial and historic data, the present measurements should show if there is any deterioration in the relief well system, and if there is any condition that would adversely affect the safety of the structure. All such observations should be made in conformance with a well thought out monitoring and performance evaluation protocol established for such critical performance indicators. Policy and guidance for design and use of instrumentation systems are contained in references 3b, 3d, 3e, 3f, and 3g.

8. Monitoring and Inspection.

a. Relief well systems in readily accessible locations on dams and other hydraulic structures where well flow is continuous or where there has been a significant change in water levels in or against them, should be visually inspected monthly or more frequently where conditions require. Observation should be made for evidence of wet spots on dams or levees or on the ground around wells and structures, for evidence of sloughing or piping, for indications of discharge of sand or other materials from or into the wells and associated collection/transport/ discharge system, and for surficial signs of damage, Piezometric levels should be measured at monthly intervals. Well flows and sediment concentrations should be measured bimonthly. Piezometric levels and flow quantities should also be measured at least daily immediately preceeding and for not less than one week after the attainment of an unusually high reservoir level or river stage to document the maximum piezometric reaction for the loading event.

b. Relief wells in relatively inaccessible locations as beneath stilling basins, should be inspected whenever the structure is unwatered for a general maintenance inspection, or when there is evidence of significantly decreased effectiveness, as shown by changes in flow quantities or piezometric levels for a constant combination of reservoir level and tailwater level.

c. Flowing relief wells located in areas, in which failure would not constitute a hazard to life or property, as on excavated slopes of canals, should be visually inspected quarterly. Measurement of piezometric levels and flow quantities should be made quarterly and when seasonal changes occur that cause large fluctuations in normal groundwater levels.

d. Relief wells that flow infrequently should be visually inspected annually, preferably immediately prior to normal high-water seasons and more often during major flood events. Flow quantities and piezometric levels should be measured before, during and for an appropriate period after a significant peak in the reservoir or river level as described in paragragh 8.a.

9. Pumping Tests.

a. Pumping tests should be performed on wells that flow infrequently at five-year intervals. The tests should be performed to determine the current specific capacities of the wells and their sediment concentration. The amount of sediment in the wells should be measured on a yearly basis, after flood flows, and before and after performance of pumping tests.

b. Wells in relatively inaccessible locations should be pump tested whenever the structure is unwatered or when piezometric data indicate that the well efficiency has decreased significantly.

c. In the case of continuously flowing wells, the discharge should be measured at high pool levels to document and assess their relationship to pool and tailwater levels. The sediment concentration of the wells discharge should also be estimated at that time.

d. A permanent record should be maintained of all monitoring, testing, and performance data.

10. Evaluation.

a. It should be noted that a reduction in well discharge accompanied by a fall in piezometric levels could indicate a decrease in seepage due to siltation in the reservoir, or riverside borrow pits. A discharge reduction can also be caused by sand boils, piping, or removal of an impervious top stratum downstream of the line of wells, all of which create uncontrolled exit points for seepage. Uncontrolled seepage is unacceptable, because it indicates a higher seepage gradient and/or significantly different stratigraphy than assumed in the original design, and an increased potential for piping or uplift between the relief wells and/or immediately downstream from the well line. A reduction in well discharge accompanied by an increase in piezometric levels indicates clogging or obstruction of the relief wells. All such scenarios require immediate evaluation and prompt remedial action, where indicated. Observation of changes in flow and piezometric levels must be related to changes or lack of changes in both reservoir level and tailwater level. Often, variation in tailwater level at a dam has a greater influence on well performance than variation in reservoir level, because the point at which the tailwater may provide drainage from the aquifer is considerably closer to the well system than the effective source of seepage in the reservoir or river.

b. The values obtained from measurement of piezometric levels and flow quantities should be extrapolated to predict the values that would be produced by a maximum design reservoir level or river stage. If the specific capacities or the efficiencies of the wells are less than 80 percent of the values that were obtained at the time of installation of the wells or if these values are greater than those for which the structure was designed or, more critically, if these are above limits associated with reasonable predictions of satisfactory performance, then additional investigations and evaluations should be performed to determine the cause of the inadequacies and appropriate rehabilitation programmed. Reduced well efficiency will result in hydrostatic heads greater than those anticipated in the design. Wells which remain below 80 percent of original, may require replacement or augmentation by additional wells to fulfill underseepage design requirements and provide satisfactory performance of the associated features during high pool level or river stage events. Computer software is available to assist in determining the current capability of an underseepage control system and how it compares with the original design.

11. Rehabilitation.

a. Damage to relief wells and inadequate performance of wells and their associated collection and discharge systems must be corrected promptly. Any condition that restricts flow in or from relief wells, or that permits piping of foundation soils into relief wells and/or associated collector/ transport/discharge system(s) results in potentially unstable and hazardous conditions. Many Corps of Engineers reservoir projects normally operate at reservoir levels well below the maximum design water level. At these lower levels, an inadequacy in relief well function may not be an immediate danger, but could become critical when the project is subjected to higher reservoir levels.

b. Relief wells may malfunction for a variety of reasons including vandalism, breakage, or excessive deformation of the well screens due to ground movements, corrosion or erosion of the well screen and a gradual loss in efficiency with time. The reduction of specific capacity with time can result from mechanical, chemical, or biological processes. The introduction of fines into the well by backflooding of muddy surface waters is the major mechanical agent. The major forms of chemical incrustation are caused by the precipitation of carbonates, sulfates, as well as iron and manganese compounds. Biofouling or clogging of screens and filter packs is caused by the activity of microscopic bacteria, molds, and algae. This activity can manifest itself as slimes, incrustations, precipitation of metals, and accumulation of inorganic fines.

c. Relief wells that have become constricted by chemical and/or bacterial incrustations or mechanical contamination may be redeveloped by mechanical or chemical methods. Design of the appropriate rehabilitation program must consider the site stratigraphy and soil properties, particularly grain size and stratification of the soils adjacent to the well; site hydrogeology; relief well construction; type of incrusting or contaminating materials; and groundwater chemistry. Rapidly developing technology in the fields of chemistry and microbiology, as they relate to wells and aquifers, will require review of the most current developments to assure effective and cost efficient rehabilitation. Environmental concerns also require that applicable Federal, state, and local regulations are followed during well rehabilitation.

d. Mechanical redevelopment methods include, block surging, over-pumping, airlift pumping and backwashing, and high-velocity hydraulic jetting with pumping. The pressures and forces created by a proposed mechanical cleaning method should be determined before its use to avoid damage to the well or filter material. Care should be taken when using high-velocity water jet or air to preclude mixing of the filter pack with the surrounding formation. Older wells possessing wood screens, wide slots and relatively well-graded filter packs can also be damaged or ruined by overly energetic mechanical redevelopment methods. Chemical redevelopment methods include the use of various organic acids, chelating agents, chlorine, hypochlorites, surfactants, dispersants, wetting agents, and hot water or steam. Chemical effects must be thoroughly understood because reactionsdue to existing water chemistry, chemical compounds, or organics could worsen the well condition rather than improving it. Even with chemical treatment, the use of mechanical methods to remove the mobilized material from the screen and filter pack is critical to the success of the rehabilitation.

e. Relief wells which are no longer acceptable due to collapse, excessive sediment production, or other conditions should be properly abandoned by filling with the appropriate sealing materials. Primary sealing materials consist of cement or cement-bentonite grout placed from the bottom upward. In general, abandoned wells should be sealed following procedures established by local, state, or Federal regulatory agencies. New well replacements should be installed and operational before the old ones are abandoned. In addition to the safety aspects of retaining the existing impaired wells until new wells are operational, the existing impaired wells may be of use for lowering or controlling groundwater during installation of nearby replacement wells by temporarily pumping the existing wells.

f. If relief wells are structurally sound and the wells and their filters are found to be free from incrustations and blockages, but piezometric levels are unacceptably high, the well system must be augmented with additional wells, or sometimes with a lowering or improvement of the discharge facilities.

12. Reporting and Review.

a. The primary documents for reporting the relief well installation and the evaluation of performance are the Periodic Inspection Report (ref. 3a) and the Embankment Criteria and Performance Report (ref. 3c). The results of piezometric observations, along with an evaluation of relief well system performance plus the maintenance and rehabilitation records, should be consolidated on a yearly basis and kept on file at the district office. An annual summary should be prepared and combined with the instrumentation report required by ER 1110-2-110 (ref. 3b). Periodic Inspection pre-inspection brochures should include a comprehensive evaluation of instrumentation and relief well system performance reflecting all relevant information since the previous periodic inspection.

b. As part of the Major Subordinate Command (MSC) Quality Assurance responsibilities, the MSC should insure an adequate level of effort and funding is provided for inspection, monitoring, performance evaluation and maintenance of relief well systems.

13. Funding. The appropriate funding (Construction, General and/or Operation and Maintenance, General appropriations, MR&T) should be utilized to accomplish the level of monitoring, evaluation and rehabilitation outlined in this regulation within the time frame indicated.

FOR THE COMMANDER:

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