NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

PUMPING PLANT

(No.)

CODE 533

DEFINITION

A facility that delivers water at a designed pressure and flow rate. Includes the required pump(s), associated power unit(s), plumbing, and appurtenances and may include on-site fuel or energy source(s) and protective structures.

PURPOSE

This practice may be applied as part of a resource management system to achieve one or more of the following purposes:

- Delivery of water for irrigation, watering facilities, wetlands, or fire protection
- Removal of excessive subsurface or surface water
- Provide efficient use of water on irrigated land
- Transfer of animal waste as part of a manure transfer system
- Improvement of air quality
- Reduce energy use

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where conservation objectives require the addition of energy to pressurize and transfer water to maintain critical water levels in soils, wetlands, or reservoirs; transfer wastewater; or remove surface runoff or groundwater.

CRITERIA

General Criteria Applicable to All Purposes

This practice shall conform to all federal, state, and local laws, rules, and regulations. Laws, rules, and regulations of particular concern include those involving water rights, land use, pollution control, property easements, wetlands, preservation of cultural resources, and endangered species.

Pump requirements. Design flow rate, range of operating heads, and pump type shall meet the requirements of the application.

Selection of pump materials shall be based on the physical and chemical qualities of the material being pumped and manufacturer's recommendations.

Size and number of pumps and their performance shall be determined based on system conservation requirements in order to meet the intended purpose. Total head shall be determined for critical operating conditions, taking into account all hydraulic losses. Automatic controls shall be included as required.

Pumps utilized for the transfer of wastewater or manure shall be sized to transfer material at the required system head and flow rate determined by the waste management plan. The pump type shall be based on the consistency of material being pumped and the manufacturer's recommendations.

Pumps may be of the turbine, horizontal centrifugal, magnetic drive impeller, diaphragm, mixed flow, or propeller type designed to operate at not less than 70 percent efficiency for given site conditions, except for pumps powered by solar photovoltaic (PV) panels, windmills, and wind turbines which have no minimum efficiency requirements.

Turbine pumps (except those with submersible motors) shall not be installed in wells that are not sufficiently straight and plumb to allow proper operation of the pump. Automatic plants generally will be equipped with self-priming pumps.

The capacity of pumps installed in wells should be based on the yield capacity curve for the well. Pump capacity shall not exceed 90 percent of the well capacity.

Power units. Pump power units shall be selected based on the availability and cost of power, operating conditions, need for automation, and other site-specific objectives. Power units shall match the pump requirements and be capable of operating efficiently and effectively within the planned range of conditions. The power unit shall be sized to meet the horsepower requirements of the pump, including efficiency, service factor, and environmental conditions.

Electric power units may include line power, PV panels, and wind- or water-powered turbines.

Electrical wiring shall meet the requirements of the National Electrical Code (NEC).

Electric motors are usually 3-phase where power requirements exceed 5 horsepower, although phase converters may be used effectively up to 20 to 25 horsepower and shall not be loaded beyond their rated horsepower. The utility company serving the plant shall be consulted relative to power and phase requirements.

Internal combustion engines shall be loaded 80 to 100 percent of the manufacturer's rating to achieve the best engine efficiency. The rating shall be reduced for temperature, altitude, and motor accessories.

Renewable energy power units shall meet applicable design criteria in the Natural Resources Conservation Service (NRCS) and/or industry standards and shall be in accordance with manufacturer’s recommendations.

Variable frequency drives. The owner shall inform the electric power provider that a variable frequency drive will be installed prior to installation and be responsible for following requirements of the electric power provider.

The variable frequency drive shall be protected against overheating.

The variable frequency drive control panel shall provide the readout display of flow rate or pressure.

Solar PV panels. The PV array shall be sized based on average data for the location and the time of year pumping occurs—according to manufacturer’s recommendations. The PV array shall provide the power necessary to operate the pump at the design flow rate and pressure, with the appropriate service factor considering a minimum panel degradation of 10 years. Fixed arrays shall be oriented to receive maximum sunlight. Panel tilt angle shall be based on the location latitude and time of year for power requirements. Panels shall be mounted securely to resist movement by environmental factors.

A pump controller, inverter, fuses, surge protection, storage battery units, and other electronic components shall be provided as recommended by the pump and PV module manufacturers in accordance with NEC requirements.

Windmills. Pumping units shall be sized according to pumping lifts and capacities as specified by the manufacturer. The diameter of the mill shall be based on the stroke length and the average wind speed. Towers shall be proportioned to the mill diameter with adequate height for efficient and safe operation. It is recommended that the tower be high enough to place the wheel at least 15 feet above all surrounding wind obstructions (such as buildings and trees) within a radius of 400 feet.

Water-powered pumps (hydraulic rams). Pumping units shall be sized according to flow rate, lift, fall, and efficiency. Bypass water shall be returned to the stream or storage facility—without erosion or impairment to water quality.

Suction and discharge pipes. To prevent cavitation, suction and discharge pipes shall be designed to account for suction lift, net positive suction head, pipe diameter and length, minor losses, temperature, and altitude. The size of suction and discharge pipes shall be based on hydraulic analysis, operating costs, and compatibility with other system components. Horizontal centrifugal pumps shall be equipped with a suction line no less in size than the discharge.

Appurtenances. Components such as gate valves, check valves, pressure-reducing valves, pressure gages, pipe connections, and other protective devices shall be included to meet the requirements of the application. Horizontal pumps shall be equipped with the required appurtenances to enable them to be easily primed.

Screens, filters, trash racks, or other devices shall be installed as needed to prevent the

intake of sand, gravel, debris, or other objectionable material into the pump. Intake screens shall be designed according to applicable federal and state guidelines to avoid entrainment or trapping of aquatic organisms.

Backflow prevention devices shall be included according to federal, state, and local laws to prevent contamination of water sources connected to the pumping plant.

Buildings and accessories. Pumps shall be securely mounted on a solid foundation such as pilings or concrete. Foundations shall be designed to safely support the loads imposed by the pumping plant and appurtenances. Sheet piling or other measures shall be used (as required) to prevent piping beneath the foundation.

Where buildings are necessary to protect the pumping plant, provisions shall be included for adequate ventilation and accessibility for equipment maintenance, repairs, or removal.

Suction bays or sumps shall be designed to prevent the introduction of air at the intake.

The discharge bay or the connection to the distribution system shall meet all hydraulic and structural requirements.

Structures and equipment shall be designed to provide adequate safety features to protect operators, workers, and the public from potential injury. Drive shaft covers shall be required on all exposed rotating shafts.

Additional Criteria Applicable to Removal of Excessive Subsurface or Surface Water

Design requirements for drainage by pumping are in Chapter 7 of National Engineering Handbook Section 16, *Drainage of Agricultural Land*.

Additional Criteria Applicable to Providing the Efficient Use of Water on Irrigated Land

Design requirements for irrigation pumping are in Chapter 8 of National Engineering Handbook Section 15, *Irrigation* and in Chapter 12 of National Engineering Handbook Part 652 (NEH 652), *Irrigation Guide*.

Provisions for the connection of flow and pressure measurement devices shall be included in power plant system design.

Additional Criteria Applicable to the Improvement of Air Quality

Replacement pumping plants shall have lower total emissions of oxides of nitrogen and fine particulate matter compared to the unit being replaced.

New, replacement, or retrofitted pumping equipment shall utilize a non-combustion power source or cleaner-burning technologies or fuels.

Additional Criteria Applicable to Reduce Energy Use

For fossil fuel or electrical grid power sources, pumping plant installations shall meet or exceed the Nebraska Pumping Plant Performance Criteria (if applicable). Refer to Table 12-2 in Chapter 12 of NEH 652.

CONSIDERATIONS

When planning this practice, the following should be considered as applicable:

- The removal of surface water by a pumping plant can affect downstream flows or aquifer recharge volumes. Consider the potential long-term impacts downstream of the pumping plant.
- If using a pumping plant to remove surface water or groundwater flowing into a wetland, consider the potential impacts on existing wetland hydrology.
- The operation and maintenance of a pumping plant can involve the use of fuels and lubricants that, when spilled, may adversely affect surface or groundwater quality. Consider measures to protect the environment from potential spills. In some cases, secondary containment of spilled fuel may be required by federal and state laws or regulations.
- Pumping plants are often constructed in flood-prone areas or can be subject to other unexpected natural events. Consider how the pumping plant may be protected from extreme natural events and the consequences of damage or failure.
- Include protective sensors to detect low or stopped flow or pressures that are too high or too low.

- The visual appearance of buildings or structures associated with the pumping plant should be compatible with the surrounding environment.
- When installing new or replacing existing combustion equipment, non-combustion and renewable energy sources (such as solar, wind, and water) should be considered.

PLANS AND SPECIFICATIONS

Plans and specifications for constructing pumping plants shall be in accordance with this standard and describe the requirements for properly installing the practice to achieve its intended purpose. As a minimum, the plans and specifications shall include the following:

- A plan view showing the location of the pumping plant in relationship to other structures or natural features.
- Detail drawings of the pumping plant and appurtenances such as piping, inlet and outlet connections, mounting, foundations, and other structural components.
- Written specifications that describe the site-specific details of installation.

OPERATION AND MAINTENANCE

An operation and maintenance plan specific to the pumping plant being installed shall be prepared for use by the owner and responsible operator. The plan shall provide specific instructions for operating and maintaining facilities to ensure the pumping plant functions properly as designed. As a minimum, the plan shall address the following:

- Inspection or testing of all pumping plant components and appurtenances.
- Proper start-up and shut-down procedures for the operation of the pumping plant.
- Routine maintenance of all mechanical components (power unit, pump, drive train, etc.) in accordance with the manufacturer's recommendations.
- Procedures to protect the system from damage due to freezing temperatures.
- When applicable, procedures to frequently check the power unit, fuel storage facilities, and fuel lines for leaks and to repair as needed.
- Periodic checks and removal of debris as necessary from trash racks and structures to ensure adequate flow capacity reaching the pumping plant intake.
- Periodic removal of sediment in suction bays to maintain design capacity and efficiency.
- Inspection and maintenance of anti-siphon devices (if applicable).
- Routine test and inspection of all automated components of the pumping plant to ensure the proper functioning as designed.
- Inspection and maintenance of secondary containment facilities (if applicable).
- Periodic inspection of all safety features to ensure proper placement and function.
- Prior to retrofitting any electrically powered equipment, electrical service must be disconnected and the absence of stray electrical current verified.
- Provide additional water storage volume for solar- or wind-driven pumps for days when the pumps will not be working.
- Repair the pumping plant if damaged by livestock or wildlife.

REFERENCES

NRCS, National Engineering Handbook, Part 652, *Irrigation Guide*

NRCS, National Engineering Handbook, Section 15, Chapter 8, Irrigation Pumping Plants

Fischbach, P. E., and Schroeder M. A., Irrigation Pumping Plant Performance Handbook, 4 ed. 1982, Agricultural Engineering Department, Lincoln, NE

Sandia National Laboratories. Stand-Alone Photovoltaic Systems: Handbook of Recommended Design Practices. Photovoltaic Design Assistance Center, Sandia National Laboratories, Albuquerque, NM, November 1991

Naval Facilities Engineering Command. Maintenance & Operation of Stand-Alone Photovoltaic Systems. Revised 1991. Photovoltaic Design Assistance Center, Sandia National Laboratories, Albuquerque, NM, March 1993

Southwest Technology Development Institute. Photovoltaic Power Systems and the National Electrical Code: Suggested Practices. Review Draft, Sandia National Laboratories, Albuquerque, NM, August 1994

Stevens, John W., et al. Photovoltaic Power as a Utility Service: Guidelines for Livestock Water Pumping. Photovoltaic Design Assistance Center, Sandia National Laboratories, Albuquerque, NM, March 1993