DECOMMISSIONING OF MONITORING WELLS AND BOREHOLES NORTH DAKOTA STATE DEPARTMENT OF HEALTH

Regulations Pertaining to Abandoned Wells

Rules and regulations for water well abandonment are outlined in Article 33-18 of the North Dakota Administrative Code. The article states that "Any abandoned water wells, uncompleted wells, and completed wells shall be sealed by restoring as far as possible the controlling geological conditions which existed before the wells were drilled... Whenever feasible the wells should be filled with concrete grout or other approved materials."

These guidelines are provided for the decommissioning of monitoring wells and boreholes that were installed for the purpose of investigating and monitoring suspected or actual environmental contamination or those wells that were installed for the purpose of conducting an environmental site assessment as required by the North Dakota State Department of Health and Consolidated Laboratories.

Decommissioning of monitoring wells is necessary to:

a. Eliminate any physical hazards on the surface.

b. Prevent contamination of groundwater.

c. Maintain aquifer pressure head.

d. Prevent intermingling of desirable and undesirable waters.

e. Eliminate the possibility that the well be used for purposes other than intended.

Plugged boreholes and wells should have no greater influence on the local environment than the original geologic setting. It is important to have a good understanding of the geology, hydrogeology, well construction, historic and future land use, and chemicals encountered for successful decommissioning to occur.

Decommissioning of borings and monitoring wells requires that the specific characteristics of each site be considered. The wide variety of geological, topographical, construction practices, and contaminants in the surrounding environment precludes the recommendation of a single specific decommissioning practice. The procedures discussed below are intended to assist the geologist, well driller, or engineer in selecting the tasks required to plan and implement an effective permanent decommissioning operation.

Each individual situation should be evaluated separately and the appropriate technology applied that best meets site conditions. Figures 1, 2, and 3 are representative diagrams of typical wells which have been decommissioned. **Decommissioning should be considered as part of the design of the monitoring well.**

Materials

1. Plugging materials should be chosen based upon their durability which provides for a permanent well closure.
2. Plugging materials should not react with contaminants or adversely impact local groundwater or geologic materials.
3. Decommissioned wells should be less permeable than to the geologic material being sealed.
4. Plugging materials must form a tight bond and seal with the sidewall.
5. Plugging materials should not be readily susceptible to cracking and/or shrinking.

Commonly Used Materials

1. Portland Cement

    a. Concrete Grout - The mixture should consist of one bag of portland cement (ninety-four pounds) and an equal volume of dry sand to not more than six gallons of clean water. Where large volumes are required to fill annular opening, gravel not larger than one-half inch in size may be added.

    b. Neat Cement - The mixture should consist of one bag of portland cement (ninety-four pounds) to not more than six gallons of clean water. Bentonite may be added to the neat cement to reduce shrinkage of the cement and as a thickener to keep cement in suspension prior to its settling. A maximum of five pounds of Bentonite per 94 pound sack of cement is allowed.

2. Bentonite - Bentonite is composed of the clay mineral sodium montmorillinite. It has the ability to absorb large quantities of water and swell to many times its original size. Bentonite has a very low permeability and does not react with most environments. However, bentonite may crack or shrink in the presence of organic chemicals, strong acids or bases, or when allowed to dry.

    a. Pellets - made from powdered bentonite that has been compressed into tablets, commonly 1/4 to 1/2 inch in diameter. When placed above the saturated zone, clean water must be added to thoroughly saturate the pellets.

    b. Chips - Raw-mined bentonite in the form of chunks that are 1/4 to 3/4 inches in size. Their angular shape makes it difficult to place chips to the desired

depth in a well or borehole without bridging. Chips may be applied in large diameter boreholes and when carefully placed into the hole to reduce the possibility of bridging bridging. Chips can be poured over an inclined screen mesh to exclude the fine dust particles that can create bridging problems.

c. Powdered - This form of bentonite is pulverized to pass through a 200 mesh screen. It is designed to be used in drilling muds and as an additive to other plugging materials such as cement to compensate for shrinkage. Bentonite powder slurry can become an effective grout material when combined with density-increasing additives and swelling inhibitors. Powdered bentonite should not be placed through water as it can bridge and stick to the borehole walls.

Decommissioning of Wells

Casing Removal

All existing well construction materials should be removed when the history of the well is unknown. If the well construction history is in question or the well has been damaged downhole, all existing well construction materials such as screen, casing, filter pack, seal, and grout should be removed to reduce the potential for the formation of a conduit to occur at the contact between casing and grout. **Removal of the casing is unnecessary if construction records exist for the well and proper installation procedures were followed.** Most often, monitoring well construction records are available from the site investigation workplan or final report.

Casing should be removed from the ground by either pulling or overdrilling. Steel casing may be removed using jacks to free casing from the hole followed by lifting the casing out by using a drill rig of sufficient capacity. If the annular space has been cemented, this method may not be effective unless a poor contact occurs between the casing and borehole. Small lengths of cement can be removed along with the casing if the drill rig has sufficient lifting power. When the casing cannot be removed, the casing and screen should both be perforated or split using a downhole tool. Steel casing can also be removed by over-reaming or milling the casing. All types of casings and materials encountered need to be handled in an environmentally safe manner and properly disposed.

PVC casing generally cannot be removed by pulling due to its low tensile strength. However, in situations where the annular space is not filled with grout or other plugging materials, it may be possible to pull the casing and screen out of the borehole. PVC can be overdrilled using a solid or hollow stem auger if cement grout is not present in the annular space. When grout is present, air or mud rotary drilling techniques can be used to overdrill the borehole. A drill bit at least equal to the diameter of the borehole or an annular space diameter of 1.5 times the casing diameter is sufficient in many situations. A pilot bit should be placed on the drill bit for guidance. The diameter of the drill bit

used in overdrilling should be able to remove all of the material in the annular space and penetrate a short distance into native materials.

Plugging Procedure

The well should be free of all loose material that may have fallen in during the previously mentioned operations or that could cause bridging during decommissioning. Disinfect the water in the well to a 100 part per million (ppm) chlorine concentration. A 100 ppm chlorine concentration will require two pounds of laundry bleach or 1.2 pounds of calcium hypochlorite per one thousand gallons of water.

The well must be filled with an appropriate plugging material or combination of materials to a depth not less than three feet below surface. Various types of materials may be used in combination to plug the well. These include:

1. **Bentonite Chips or Pellets**

   This material can be used throughout the entire length of the well provided that it is thoroughly saturated after each bag is added. It should take approximately eight gallons of clean water to saturate one 50 pound bag of bentonite. Pour the bentonite chips or pellets into the well slowly to avoid bridging problems. If this material is used, a three foot column of neat cement or cement/bentonite grout must be placed above it to prevent the bentonite from dehydrating and to provide an additional seal.

2. **Neat Cement or Cement/Bentonite Mixture**

   Neat cement or a cement/bentonite mixture may be used throughout the entire length of the well. Inject the grout at the bottom of the hole using a pressure grouting technique or gravity-feed with a tremie pipe forcing grout and well fluids upward. Grout must be slowly pumped to avoid channeling. This operation should be done in one continuous operation. Raise the grout or tremie pipe when grout can no longer be easily forced from the pipe into the hole or when undiluted grout reaches the top of the hole and flows out.

3. **Concrete**

   Concrete may only be used as a cap at surface and several feet below surface. It may not be used at lower depths because it does not have the ability to penetrate seams, crevices, or interstices. Also, the aggregate is likely to separate from the cement if it is not properly placed.

4. **Clean Sand or Gravel**

Clean sand or gravel can be used as fill material opposite the water-bearing formation. Due to the potential for bridging problems, sand placement is not recommended in wells that are less than 6 inches in diameter. The remainder of the hole, especially the upper portion, must be filled with neat cement, cement/bentonite mixture, or bentonite pellets or chips to exclude surface water.

If the casing has been left in place and after the well has been appropriately abandoned, cut the remaining portion of the casing off at least three feet below the surface. Depending on the location and use of the land, the casing hole can be filled with topsoil or concrete. Be sure to grade the surface cap so that all surface water runoff is directed away from the decommissioned well.

Decommissioning of Boreholes

Boreholes that have not been completed as monitoring wells should be plugged using the same methods as outlined for monitoring wells where the casing has been removed. Drill cuttings are an acceptable plugging material for boreholes provided certain conditions are met. Drill cuttings should only be used when the water table has not been encountered, the borehole is no greater than 15 feet in depth, and no contamination is present. The drill cuttings must be compacted in six inch lifts as the hole is being backfilled.

Report

At the completion of field work, a report should be prepared and submitted to the Department. The report should document the entire procedure used in the decommissioning process for the borehole or monitoring well, and should discuss the following items:

1. Decommissioning date.
2. Personnel on hand.
3. Procedures used in the field.
4. Plugging materials used.
5. Measurements made (i.e. diameter, water level, ect.), depths encountered, fluids pumped, well type and description.
6. Field location and identification of the abandoned well.
7. Water quality analyses results, if any.

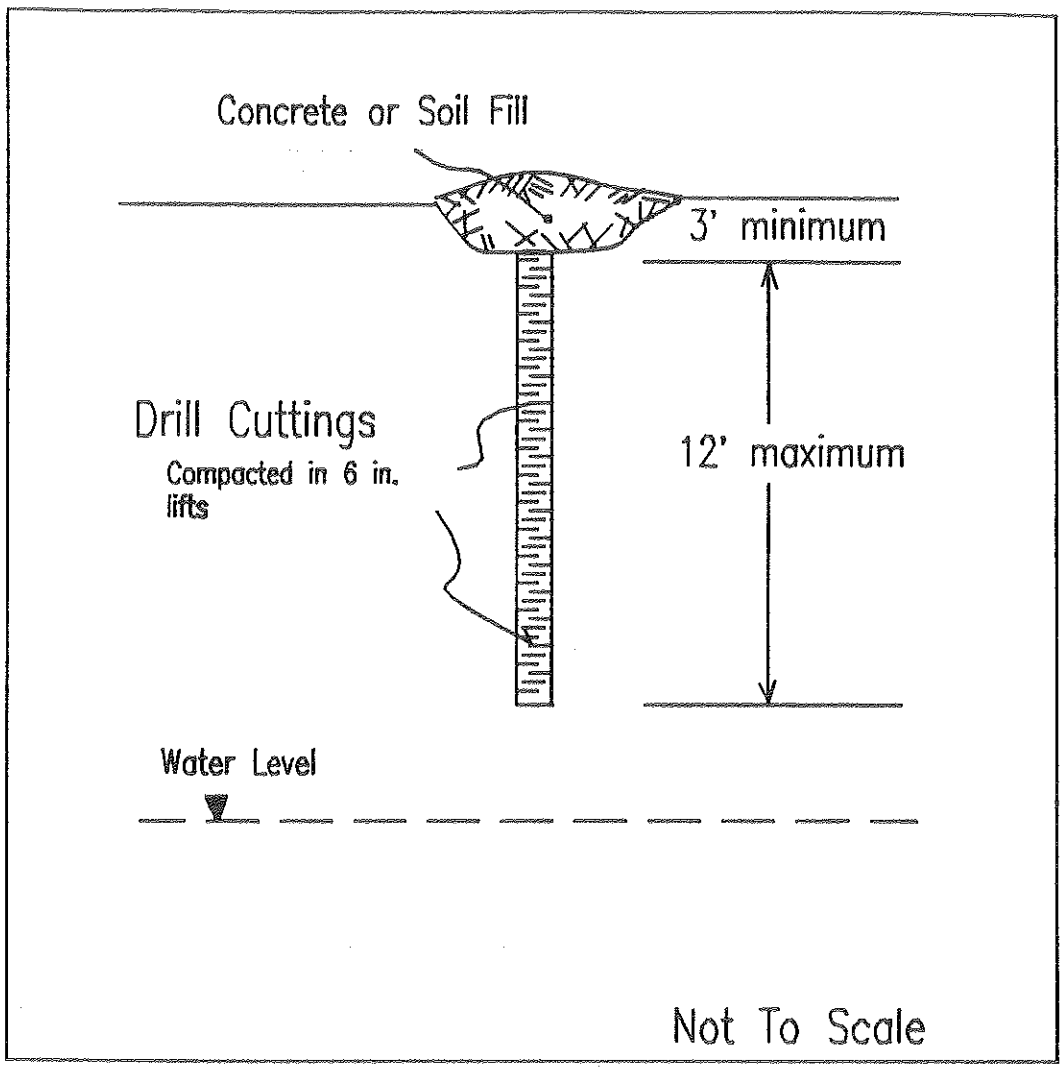

Figure 1: Sealing a shallow boring that does not penetrate the water table and is not contaminated.

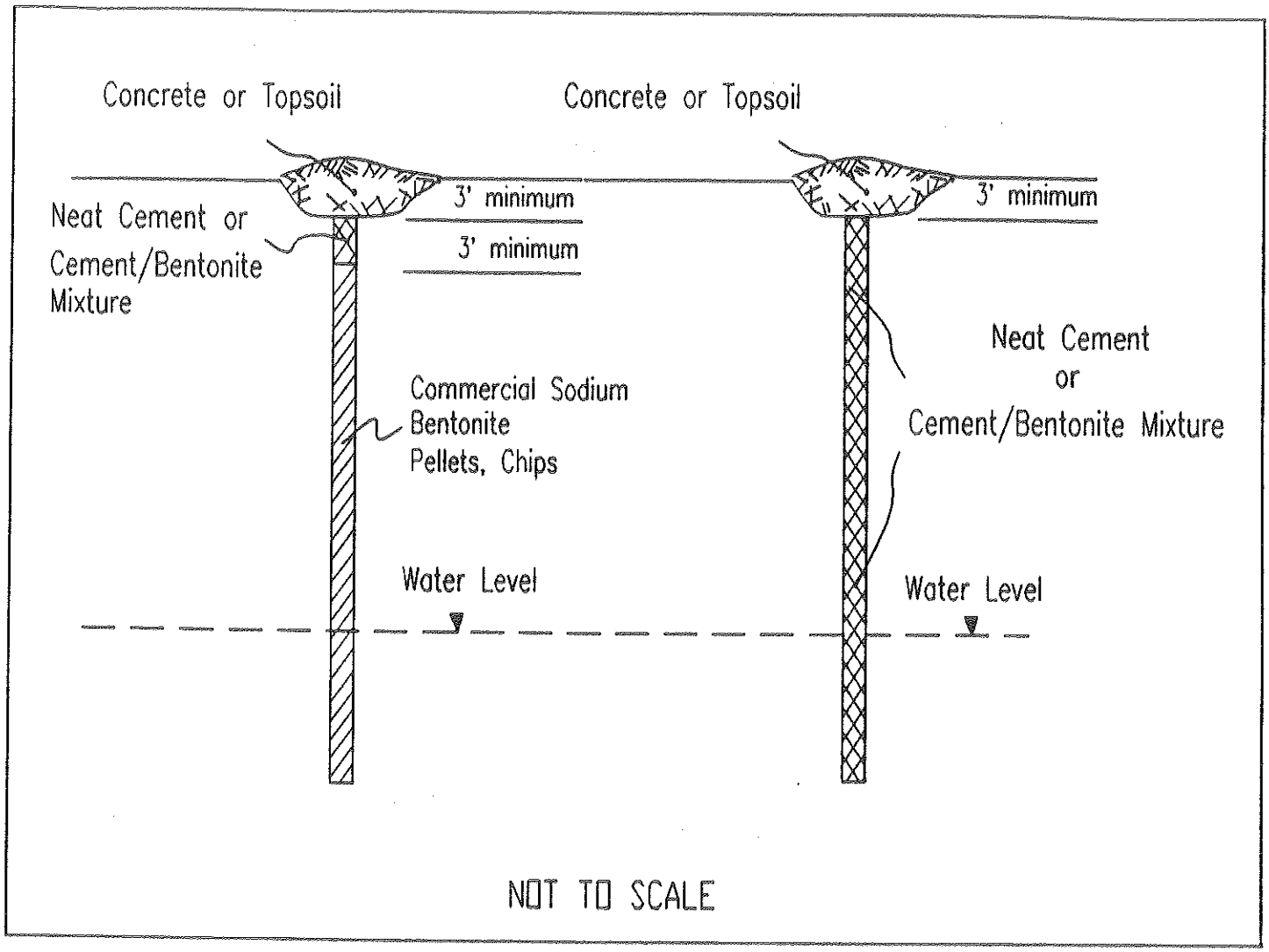

Figure 2: Sealing a boring using bentonite chips, neat cement, or a cement/bentonite mixture.

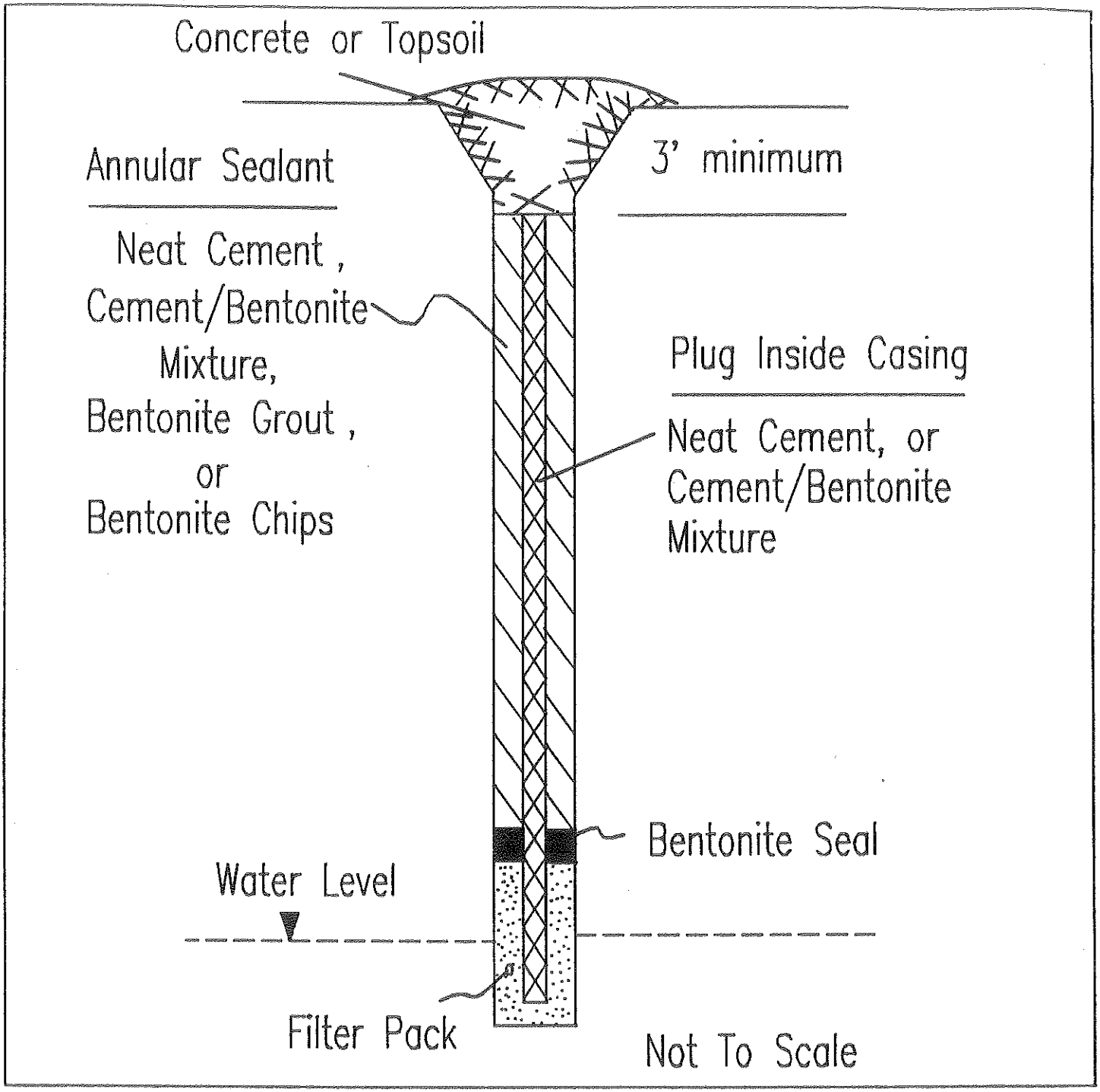

Figure 3: Sealing a monitoring well with casing left in place.