UNIVERSITY OF NEBRASKA - LINCOLN

Operation & Maintenance Manual

Ground Water Well Model

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Operation, Set-up and Maintenance of Ground Water Well Model

Introduction

This manual acts as an aide in the use of the Ground Water Well Model. It contains detailed information on the model's use and purpose. Within the manual you will find background information, a sample script for use in the presentation of the model, and operation and maintenance instructions.

The model visually simulates groundwater and aquifer conditions but is not an actual representation. The materials used in the miniaturization of these geological events changes their scale to one another in a way that is not entirely accurate, but allows for the simulation to demonstrate concepts in an accelerated timeframe.

Materials

The following materials are necessary for a successful demonstration of the Groundwater Model and should be included with, or accompany the model.

1 – Ground Water Well Model
2 – Wooden feet (for stand)
2 – Acrylic well inserts (for drawing water from well)
1 – Extension cord/ power strip
1 – Recirculation bucket (red)
1 – Dye bucket (white)
2 – 12" sections of flexible tubing (for overflow)
3 – 4 oz. containers of tracer dye
1 – Crescent wrench
1 – Absorbent towel
1 – Operations manual and parts manual
1 – Recirculation pump with flexible tubing attachments
1 – Hand pump OR variable speed metering pump (only one accompanies each model)

Handling

Warning:

- **NEVER ALLOW THE MODEL TO FREEZE**
- **HANDLE THE MODEL CAREFULLY; IT IS FRAGILE**
- **DO NOT DROP MODEL**

The handling of the model and carrying case must be done with care. Caution should be used when transporting, setting-up and cleaning the model to avoid dropping, bumping or scratching it. The acrylic model is fragile and can be cracked with large jolts or bumps. Jarring the model can also cause the sand and other media to shift and create uneven pressure on the inner walls of the model. Once the acrylic has cracked or warped, it is irreparable and will render the model useless. The acrylic is temperature sensitive and should not be left unattended in extreme temperatures. Also, when saturated with water, the model should never be exposed to freezing temperatures. If any of the water in the model were to freeze, it would compromise the acrylic seams and would likely break the model. The model should be stored upright in an indoor conditioned environment and should not be stored overnight in a vehicle or unconditioned structure or other locations where temperature is unregulated.

Proper drainage and cleaning procedures should be followed so as to prevent damage and maintain the longest usable life of the model. Within an hour of demonstration the model should be cleaned of all traces of dye. If dye is allowed to remain too long in the model it can permanently stain the sand or other media in the model. Before storing the model in its case, the model must always be drained. If however, the model is drained and will be unused for an extensive amount of time (upwards of a month) the clay confining layer may dry out completely and crack. If this takes place the confining layer may not completely rehydrate and may create a faulty seal. To prevent this, inspect the model every 2-4 weeks and rehydrate the media to prevent it from becoming “bone-dry”. For long term storage (upwards of a month) it is advisable to keep the model out of the case in an upright position with the water level above the confining layer. Adding a small amount of chlorine bleach (1 capfull) to the water will help prevent bacterial growth.

Requirements of Presentation Location

It is important to understand the resources of the location in which you will be presenting. Water, electricity and space availability are all important considerations to take into account. If water is not readily available you will have to take along a supply of 3-5 gallons. If the presentation location is not near an electrical outlet, it may be necessary to bring an extra extension cord or a small generator. A level surface or table with at least a three square foot area is necessary.

Set-up

Allow yourself time to orient yourself and become familiar with running the model before a public demonstration. Although the presentation is straightforward and simple, having experience with the model is the best way to ensure a successful presentation. All equipment needed to operate the model is listed in the 'Materials' section and should be included in the accessory kit.

1. Set the two wooden blocks provided to serve as model 'feet' on an even demonstration surface.

2. Remove the model from the carrying case and place it in the wooden feet with the front of the model facing the viewing area.

   Make sure the feet are at least 1 foot apart so the model will be stable (Fig. 1,2).

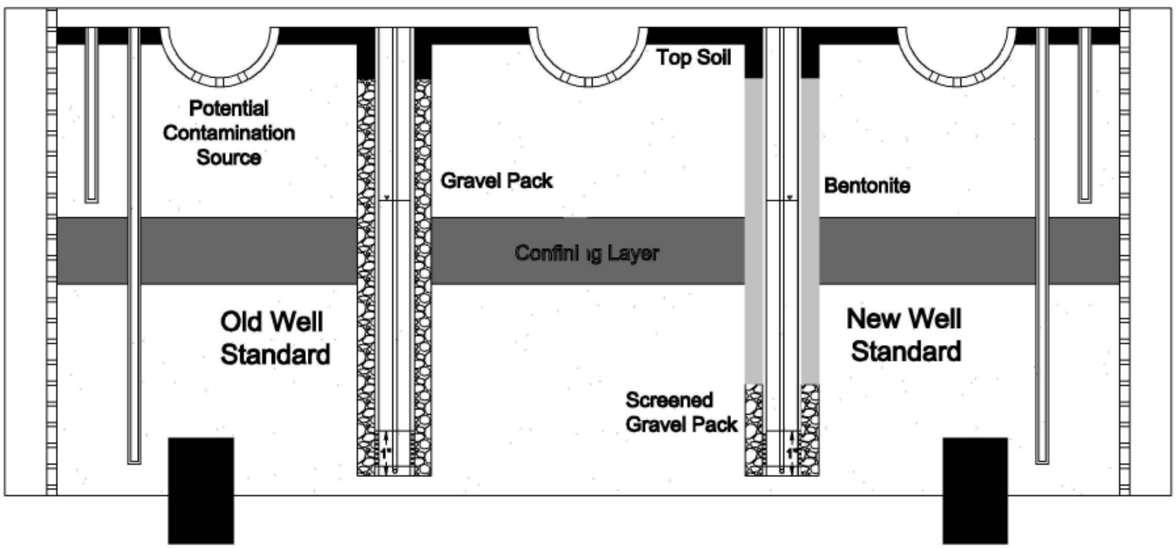

Figure 1. Front of Model Set-up A

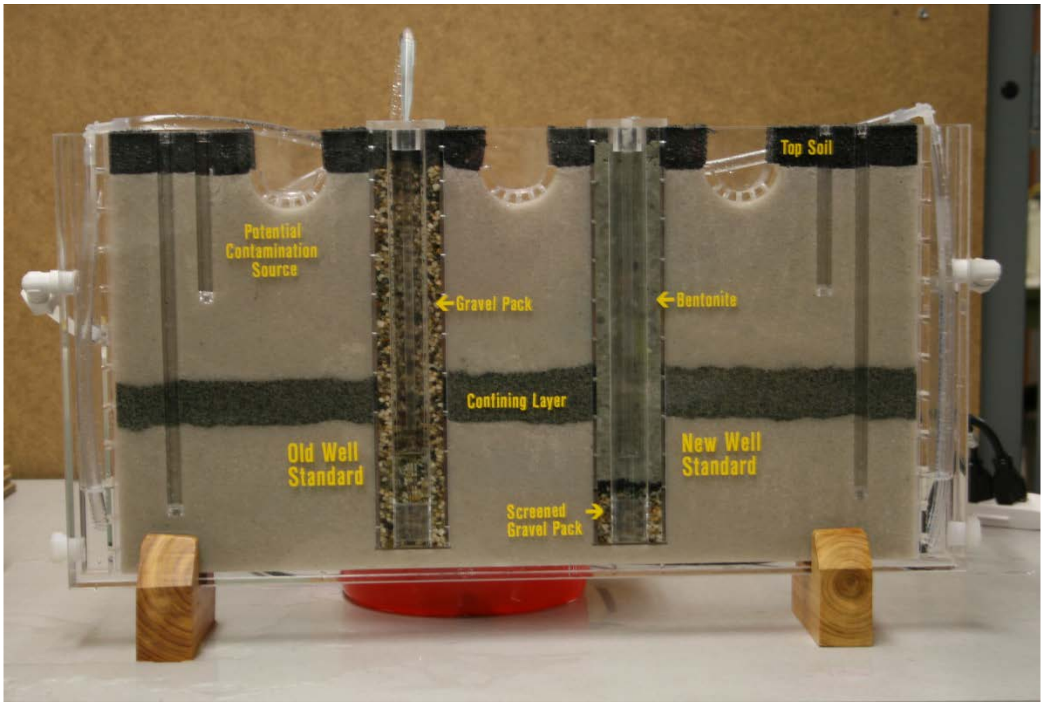

Figure 2. Front Model Set-up B

3. Place both the large red bucket and the white dye bucket on the backside of the model.

4. Place the smaller of the two pumps in the red recirculation bucket.

   This pump should have a network of flexible tubing attached to its outlet port. The flexible tubing has a wye which separates into two supply lines. (Fig. 3,4)

5. Feed the two supply lines into the two cavities on the edges of the model (Fig. 3).

   Continue feeding the flexible tubing down into these cavities until the end touches the bottom.

6. Tilt the two overflow connectors located on each side of the model so the rigid tubing in the connector is parallel (horizontal) to the demonstration surface and pointed towards the backside of the model.

7. Take the two free sections of flexible tubing in the bucket and slide them over the rigid tubing on the overflow valves.

   The other end to each of these overflow tubing sections should be placed in the bucket (Fig. 3,4).

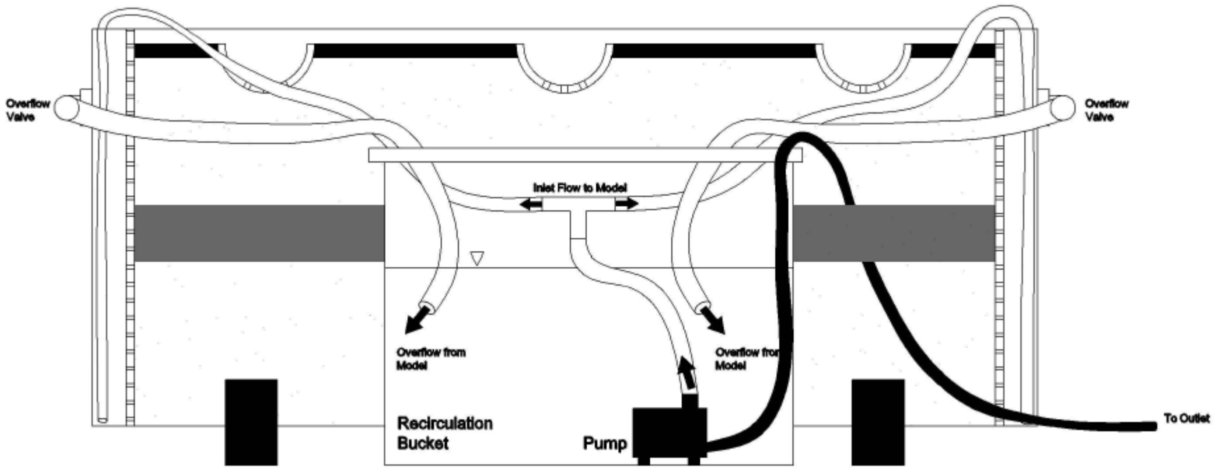

Figure 3. Back of Model Set-up A

Figure 4. Back of Model Set-up B

8. Take the variable-speed metering pump (or hand pump if applicable) and place it behind the model next to the recirculation bucket.

   Take the tip of the inlet line from this pump and insert it into the Old Standard well insert. Take the outlet line of the same pump and feed it into the empty dye bucket. Make sure an outlet is within reach and plug the power strip/extension cord into the outlet.

9. Fill the recirculation bucket with cool tap water (warm water will create condensation inside the model).

At this point the model is physically set-up. Depending on the time of the presentation it may be advantageous to leave the model at this stage until five minutes before the presentation.

10. Three to five minutes before the presentation, plug in the small recirculation pump and allow the model to fill with water from the bucket.

    Once the water level reaches the overflow valve it should begin to drain back into the reservoir bucket. Because the overflow lines are dry, you may need to monitor the model to make sure the side cavities do not overflow. If they get close to overflowing, unplug the pump and angle the overflow lines down towards the recirculation bucket. Make sure steady even overflow takes place and that no suction noises are audible.

11. Next plug in the variable speed pump and allow it to begin drawing water from the New Standard Well. It should continuously draw water from the well without draining it. If the pump is not already set at the correct pumping speed to accomplish this, adjust it using the knob on top of the pump to get an appropriate flow rate.

12. Check your dye supplies and make dilutions is necessary given the instructions below.

    Three colors of Risk Reactor tracer dye, in glass bottles, are included with the Groundwater Model. These tracers are very concentrated and must be diluted before being used in the model. **Do not use concentrated dye in the model - always use a diluted mixture**. The 4 oz. clear plastic squeeze bottles contain the diluted dye and are the correct dyes to be used in the presentation[1] (Fig. 5).

Figure 5. Diluted Tracer Dye

At this point the model is in an equilibrium state and can be let idle for up to 10 minutes before presentation.

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[1] The ratio for dilution is 5 mL per 1000 mL of water.

Operation

A suggested presentation script can be found on page 14 of this manual.

1. Inject 5-7 drops of diluted dye in each of the point source locations on the top of the model (Fig. 6).

   For best visual effect put a different color in each of these locations, with the darkest dye (blue) in the well farthest from the Old Standard Well.

Figure 6. Injection of Dye

2. Add a small amount of water into each using a small beaker (Fig. 7).

   This will flush the dye downward and represents a rainfall event.

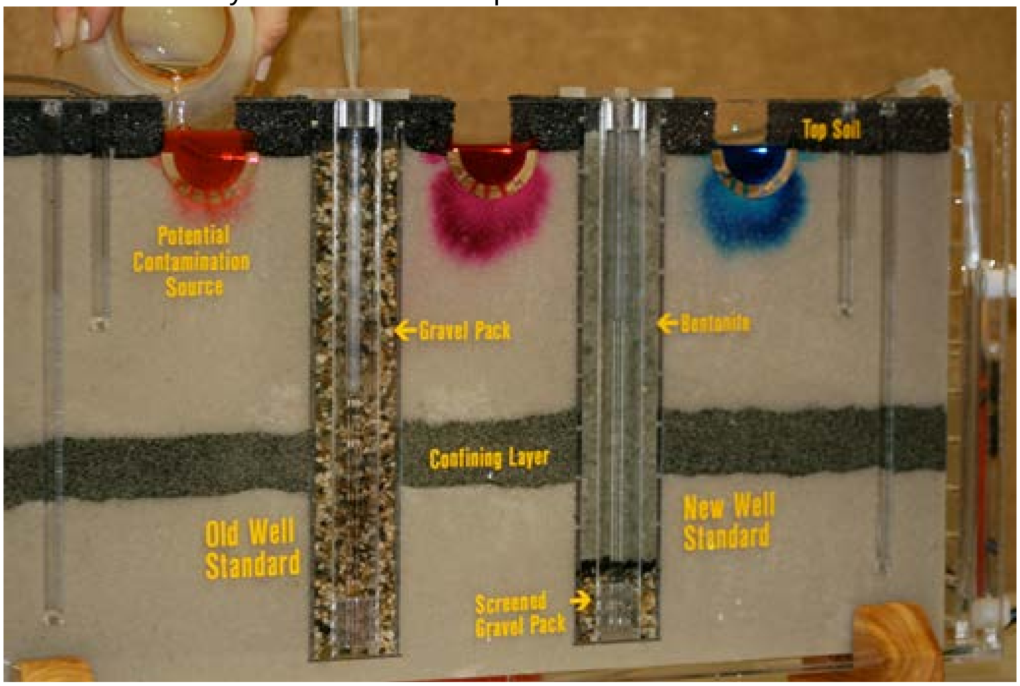

Figure 7. Following Dye with Water

3. If the well pump is not already doing so, begin pumping from the Old Standard Well (can also be done with a hand pump).

   As you pump, dye from each reservoir should start traveling downward towards the Old Well Standard (Fig. 8).

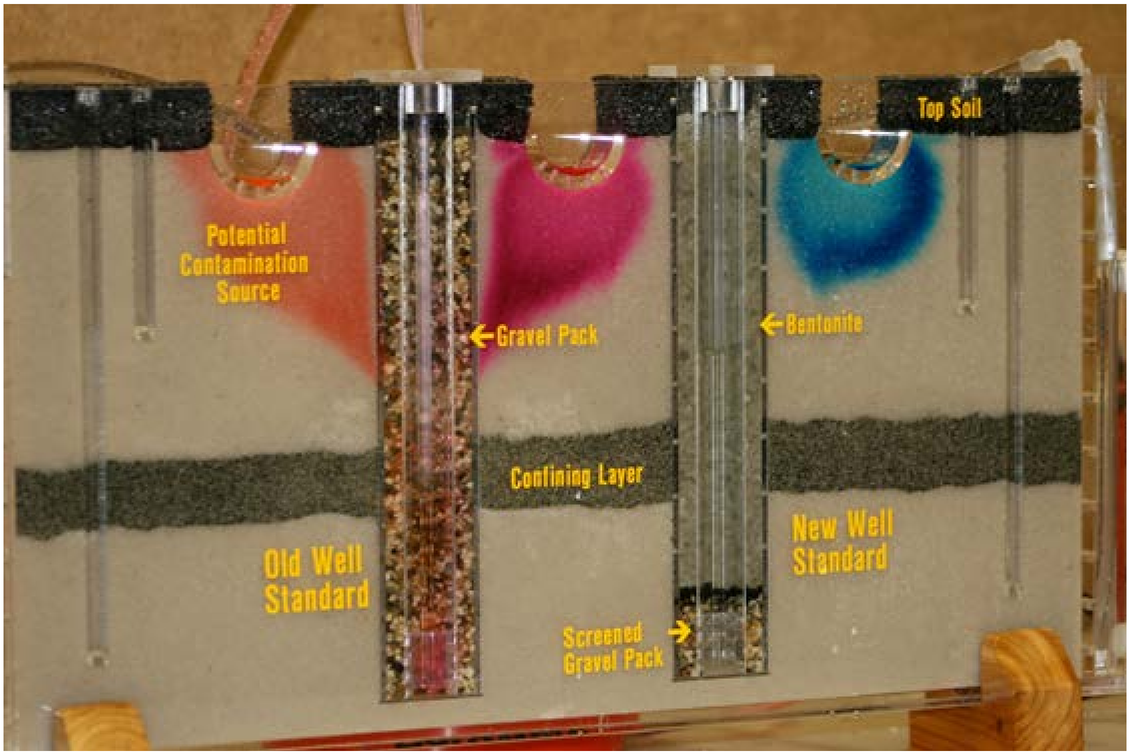

Figure 8. Dye Traveling in Model

Eventually dye will travel down the annular space of the Old Standard Well, past the confining layer, and will contaminate the well water (Fig. 9).

Figure 9. Dye Traveling Down Gravel Packed Annulus

4. Once a fairly strong concentration of dye has gathered in the Old Standard Well, start pumping from the New Standard Well.

   The dye from the Old Standard Well should travel under the confining layer toward the New Well and contaminate the water in the New Standard Well also (Fig. 10).

Figure 10. Dye Traveling From Old Standard Well Towards New Standard Well

A similar demonstration can be done showcasing the danger of abandoned or illegal wells. In this scenario, instead of injecting dye into the point sources along the top of the model, dye can be injected into the smaller abandoned wells on the edges of the model between the standard wells and the filling cavity with operation identical to previous scenario (Fig. 11).

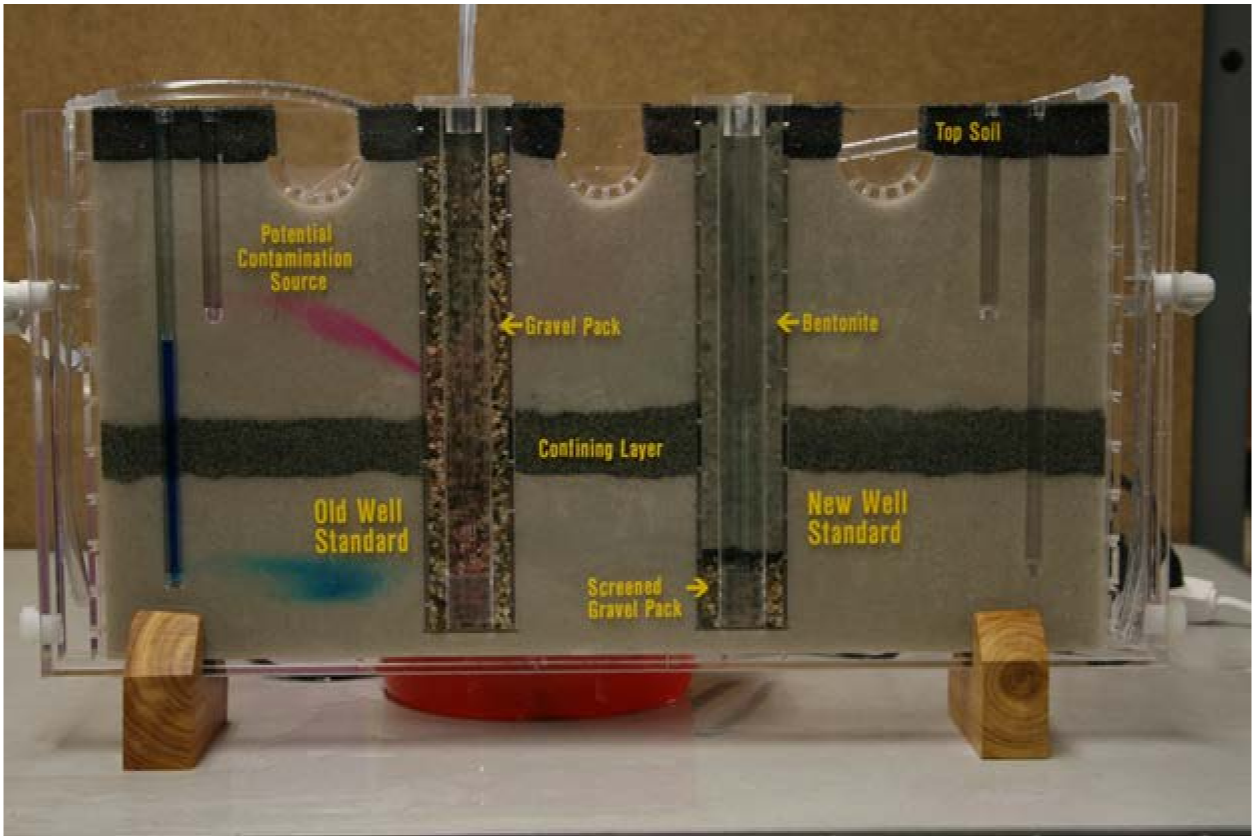

Figure 11. Contamination through Abandoned/Illegal Wells

Background Material / Script for Presentation

A safe and adequate drinking water supply is essential for life. It is important in Nebraska and around the world. Groundwater that supplies drinking water wells naturally contains minerals from the rocks, soil, and air it comes in contact with. Human activities can add more substances to groundwater. Whether or not the groundwater supplying drinking water wells is safe depends on which substances are present and in what concentrations. In 1974 the U.S. Environmental Protection Agency enacted the Safe Drinking Water Act to ensure that all public drinking water meets minimum water quality standards.

Nearly 400 public water supplies in Nebraska have nitrate concentrations of concern. While most are in compliance with Safe Drinking Water Act Standards, concentrations are elevated and, in many cases, are increasing. While treatment can be used to remove or reduce contaminants to acceptable concentrations, it is always more desirable and less expensive to prevent contamination. Drinking water well standards are enacted and enforced to provide the greatest protection of groundwater possible.

Many public drinking water wells and irrigation wells in Nebraska penetrate a confining layer. The confining layer is an impermeable clay layer dividing the upper groundwater zone from the lower aquifer. It was thought that the confining layer adequately protected deep wells from surface contamination. New research found this was not the case. One potential contaminant path is the annular space; the space between the drilled borehole and the water-tight well casing that is placed in the center of the borehole. It can be a conduit for contaminants to enter groundwater, bypassing the confining layer, if it is not filled and sealed properly. Previously, Nebraska regulations called for the annular space to be filled with coarse gravel media. New regulations will require the annular space to be filled with bentonite, an expanding clay material. Bentonite swells when wet, creating a seal, which neither water nor contaminants can move through. The watertight seal provides greater protection of drinking water by blocking the contamination pathway from upper groundwater zones to lower aquifers.

There can be many sources of contamination near a drinking water well. These are referred to as point source contaminants. When a gravel-packed well (the old standard) is pumped, contaminants are immediately pulled into the annular space. As the well is pumped, contaminants move down the annular space, past the confining layer, through the well screen and into the well. This offers no protection against contamination as the well water is now contaminated. Depending on the contaminant and its concentration, the water could present a health risk if not treated.

In contrast, when a bentonite-packed well is pumped, the bentonite creates a plug at the confining layer, which does not allow for water flow. Contaminants are not pulled into the annular space and cannot move through the confining layer, thus remaining in the upper water zone, away from the well screen. The well water is not contaminated.

Although, on its own this bentonite solution is highly effective at blocking contamination, there can still be a high contamination risk, if an old standard gravel-packed well is in close proximity to the bentonite well. When this is the case, because of the open pathway, through the gravel pack, from upper groundwater zone and lower aquifer, contamination can still be drawn down past the confining layer. As the bentonite packed well is pumped, contaminants that entered the aquifer through the gravel packed annular space of the near-by well are pulled into the well screen. The bentonite packed well water is now contaminated. This demonstrates the incentive behind implementing the new regulatory standard.

Abandoned wells pose another contamination risk. While the numbers have not been documented, there are many old, unused wells across the Nebraska landscape. The technical term for these wells that are in poor condition is "illegal well" but most people refer to them as "abandoned wells." Illegal/or abandoned wells are a direct conduits for contaminants to enter groundwater. Contaminants flowing down shallow, abandoned wells immediately contaminate groundwater in the upper water-bearing zone. All shallow wells in this water-bearing zone are now at risk of being contaminated. Similarly, a deeper abandoned passing the confining layer, well might represent an old irrigation well. Contaminants flowing down the well immediately contaminate groundwater in the deep aquifer. All wells in the aquifer, including those that are bentonite-packed are at risk of being contaminated. This demonstrates the need for abandoned wells to be properly decommissioned.

In summary a bentonite packed annular space will prevent surface contaminants from passing into the annular space, through a confining layer into a protected aquifer. This protects well water in deep aquifers from contamination. In addition, properly decommissioned wells will eliminate direct conduits through which contaminants can enter groundwater.

Tear-down/Cleaning

Once the demonstration is complete, fill a beaker with clear water and fill each point source area 2-3 times to flush any remaining dye downwards. Allow the model to run for 2-3 more minutes and pump out as much dye as possible in this way. Then unplug the pump(s) and remove all flexible tubing from the model. Take the model to the nearest sink and use a wrench to unscrew the plastic plug located on the bottom left side of the model. Allow most the water from the model to drain through this hole. If possible, tilt the model and set it securely at a 45° angle in the sink for better drainage. Fill the cavity on the opposite side, repeatedly flushing the model with clean water. Depending on the constraints of the location, it may be more efficient to fill the model with water and use the hand pump or metering pump to pump water out of the large wells or a small monitoring well. After the dye has been flushed from the model, leave the model to drain at an angle in the sink until most of the water has left the model. Then repack the model in its carrying case and store all other accessories in the accompanying box.

If dye begins to stain the sand in the model, periodic flushes with chlorinated water can be performed to clean the sand of any residual dye. This should be done every 3-5 times the model is used to prevent bacterial growth. A cholrine bleach solution of approximately 1 tablespoon/quart of water is sufficient. After running the model with the bleach solution, follow it with 3-4 bottles of clean water to thoroughly rinse it.

Remember:
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HANDLE THE MODEL CAREFULLY; IT IS FRAGILE
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