

STATUS REPORT: Bacteria and Other Contaminants in Domestic Water Wells in the Jackson Purchase Region

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Introduction

Groundwater is used by approximately 70 percent of the population in the Jackson Purchase Region (JPR). About 30 percent (rural water users) draw drinking water from domestic water wells which generally tap shallow groundwater aquifers with low total dissolved and suspended solids.

Domestic water wells vary in construction type, casing diameter, and overall condition. Local geology determines construction type and casing diameter. The majority of water wells recently drilled in Marshall and Calloway Counties are constructed using 24-inch diameter, jointed, cement tiles, which allow groundwater and possibly surface water to enter the well at varying depths below the land surface. These 24-inch wells (bored wells) (Figures 1a and 1b) are utilized because the shallow gravels and sands generally don't produce adequate quantities of groundwater (> 3 gallons per minute) from 4-inch diameter wells (drilled well) (Figures 1c and 1d).

The overall condition of an individual well indicates how susceptible it is to contamination. A well is more susceptible if it is not constructed properly (Figure 1), if it is not capped, if the well casing is cracked, if surface water is allowed to pond around the casing, or if the well is not properly maintained. This is especially true for older water wells.

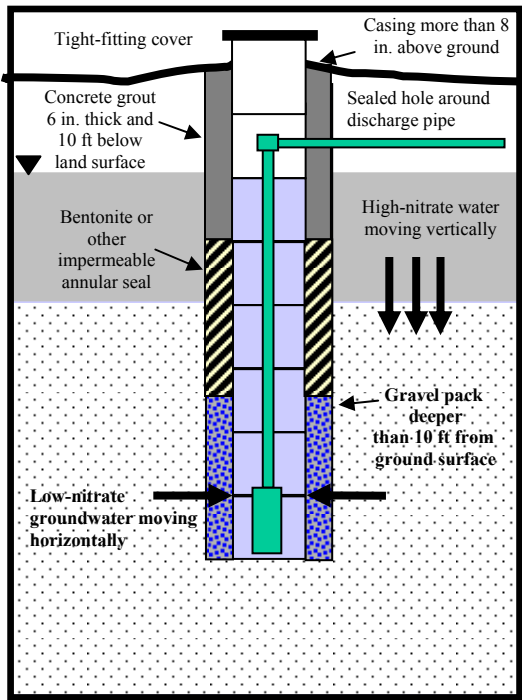
In order to assess the groundwater quality associated with domestic water wells in the JPR, 173 domestic wells were sampled and analyzed for total coliform (TC), *Escherichia coli* (*E. coli*), nitrate-nitrogen (nitrate-N), and three herbicides. In addition to water-quality data, observations and information on surrounding land-use and water-well construction were collected for each well.

Total Coliform and *E. coli*

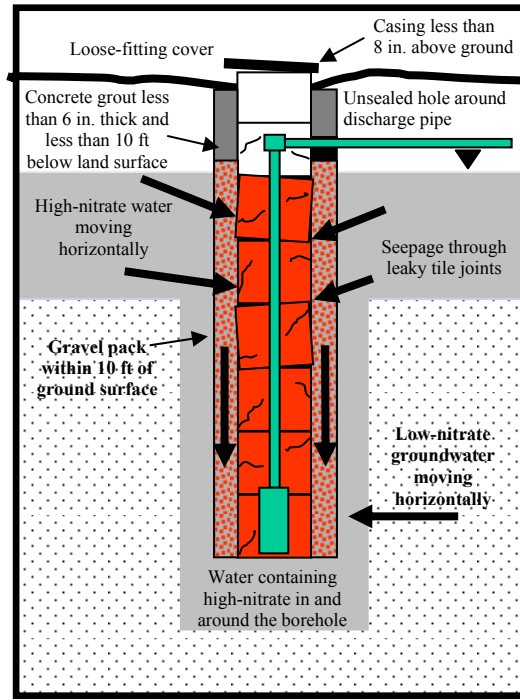
Total coliforms are bacteria that live in soil, water, and the gut of animals. Generally, these bacteria are harmless with the exception of a specific group called fecal coliforms. *Escherichia coli* or *E. coli* are fecal coliforms that naturally live in the gut of animals and humans. If ingested, *E. coli* may cause abdominal cramps, nausea, diarrhea, and bloody diarrhea. In some individuals, especially children < 5 years old, the elderly, and the immunocompromised, hemolytic uremic syndrome can occur, in which the red blood cells are destroyed and the kidneys fail.

Even though total coliforms are generally harmless, apart from fecal coliforms, their presence is an indication that other harmful organisms and contaminants may be present in drinking water. Therefore, the Environmental Protection Agency has set a drinking water standard at zero for both *E. coli* and total coliforms. Well users are encouraged to not drink well water that contains TC or *E. coli* until the well has been disinfected with bleach, resampled, and determined to contain no TC or *E. coli*. Negative bacteria analysis is not an indication that other contaminants are not present in the drinking water. Analyses for additional contaminants are required to ensure that well water is safe to drink.

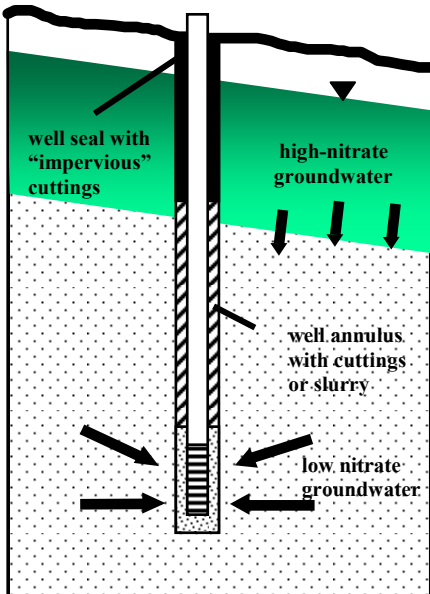
A. Properly Constructed Bored Well



B. Improperly Constructed Bored Well



C. Properly Constructed Drilled Well



D. Improperly Constructed Drilled Well

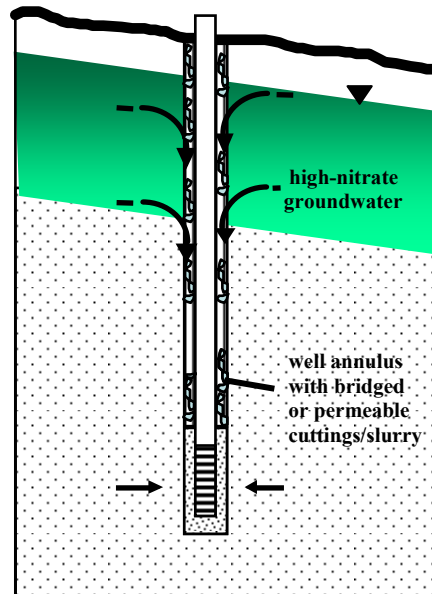


Figure 1. Wells constructed since 1985 should have construction similar to wells A and C, with an impervious fill in the upper part to prevent surface water and shallow groundwater from traveling down the borehole. This forces shallow, contaminated water to move through the soil system, which acts as a natural filtration system. Some domestic wells are constructed similar to wells B and D in that the space between the borehole and the well casing is not adequately sealed. This allows contaminated surface water and shallow groundwater to move directly into the well bypassing the natural filtration system.

Bacteria Results

Between July 1, 2003 and June 30, 2004, 173 domestic water wells were sampled for TC and E. coli. All bacteria analyses were performed by the Marshall County Health Department's Western Kentucky Regional Lab, using the Chromogenic Fluorogenic Substrate Method.

Of the 173 wells sampled, 146 were 24-inch diameter bored wells (bored wells) and 26 were 4-inch diameter drilled wells (drilled wells). Of all the wells sampled, 82 percent contained TC and 20 percent contained E. coli (Figure 2). Eighty-nine percent and 22 percent of the bored wells contained TC and E. coli, respectively (Figure 2). Only one of the 26 drilled wells contained E. coli, but 42 percent contained TC (Figure 2).

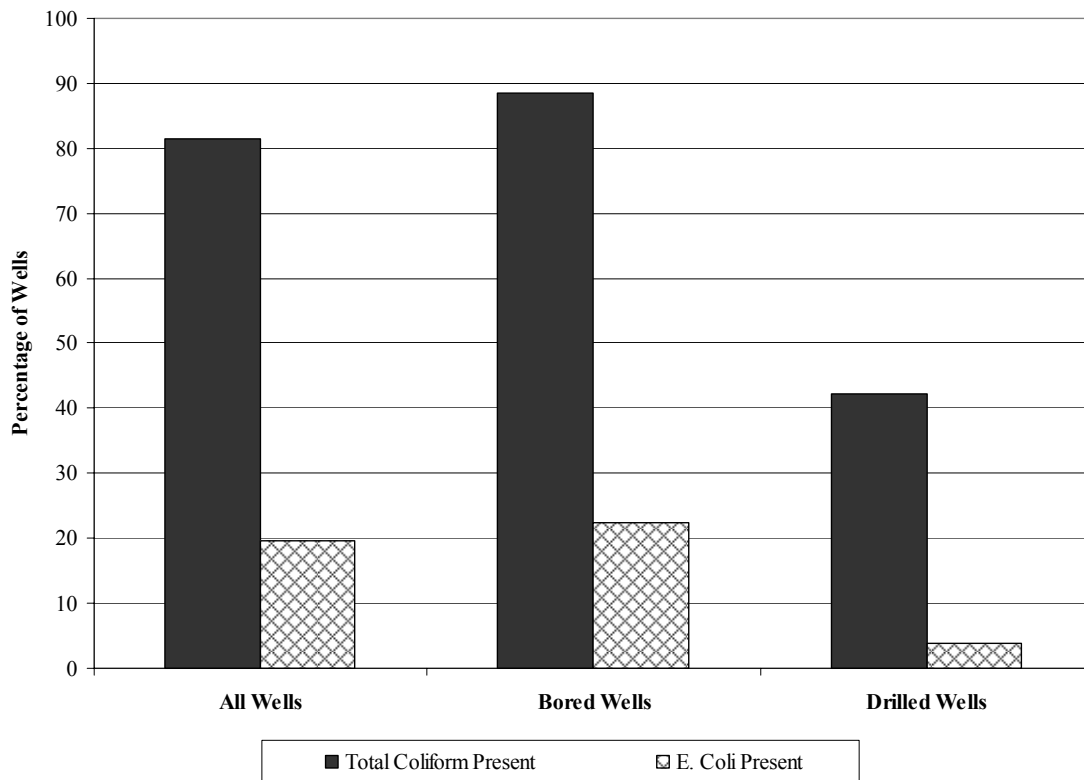


Figure 2. Percentage of all domestic water wells, bored wells, and drilled wells sampled between July 1, 2003 and June 30, 2004, which contain TC and E. coli.

Beginning in 1985 domestic water well installation regulations required all domestic water wells to be installed by certified water well drillers and installation guidelines were to be followed. A list of Kentucky Certified Well Drillers and the domestic water well guidelines can be found at the following web site: <http://www.water.ky.gov/gw/gwtech/gwdrill/>. With these new guidelines being enforced we have a distinct marker in which to look at drinking water quality and well age. Figure 3 shows the percentage of bored and drilled wells containing TC and E. coli relative to well age. Well ages are divided into four categories; present – 1985, 1984 – 1974, older than 1974, and unknown. The unknown category includes wells in which it was not possible to determine the age of the well. There is a measurable increase in TC and E. coli between bored wells installed from present – 1985 and wells older than 1974 (Figure 3). Regarding drilled wells, TC also increased with well age (Figure 3).

The results indicate a trend of having a higher percentage of TC and E. coli contamination as well age increases. Wells installed prior to 1985 are more likely to be improperly sealed (leaky, surface annulus seal), to have cracked casings, or to have off-centered tiles caused by tree roots growing between tile joints. This increases the probability of surface water and/or shallow groundwater carrying bacteria into the bored wells and contaminating the drinking water.

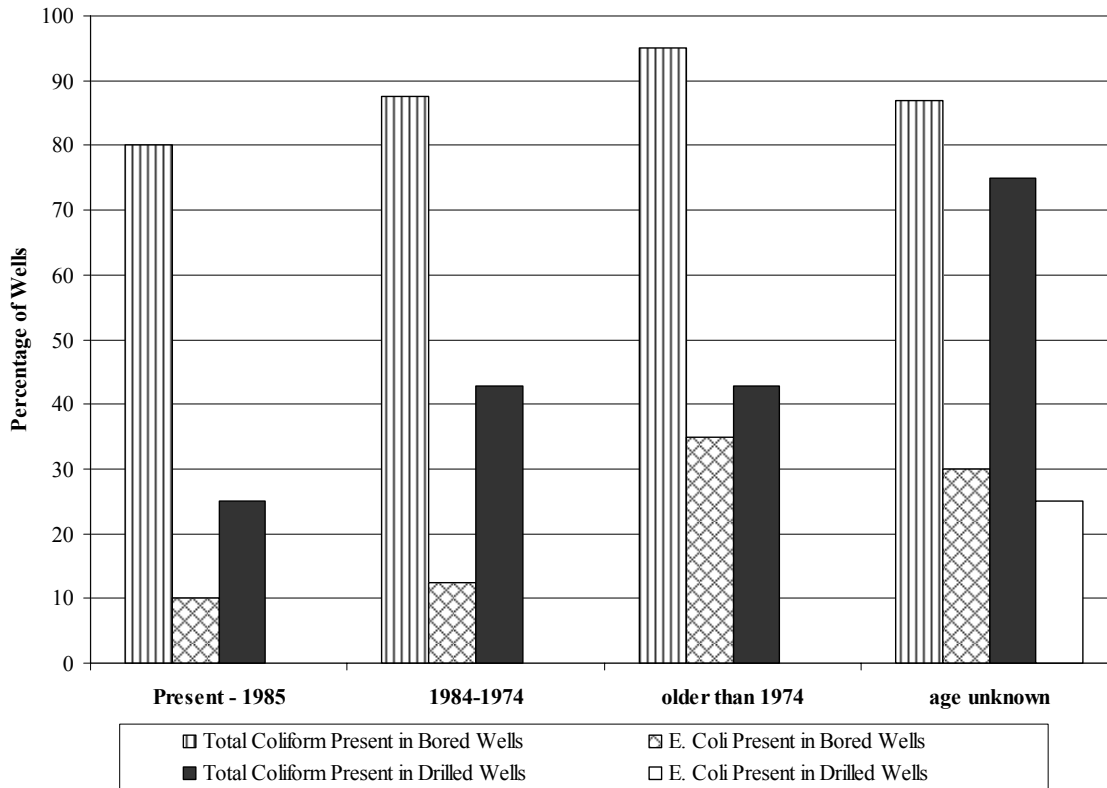


Figure 3. The percentage of bored wells and drilled wells containing TC and E. coli compared to well age.

In addition to well construction type and age, well depth is another parameter that can be used to distinguish differences in drinking water quality in domestic water wells. Sixty-eight percent (97 wells) of the bored wells sampled with known total depth are less than 51 feet deep. Ninety percent of those 97 wells contain TC and 21 percent contain E. coli (Figure 4). Of the bored wells ranging in depth from 51 – 100ft, 82 percent contain TC and 15 percent contain E. coli, a slight decrease from the shallower bored wells (Figure 4). However, all 5 of the bored wells with depths greater than 100ft contained TC and 1 well contained E. coli (Figure 4). This increase may be due to the low number of deeper wells sampled and with deeper wells there are more opportunities for seepage between tile joints. The one well greater than 100ft deep that contained E. coli is the oldest known well of the five. It was installed in 1967. Preliminary results for drilled wells indicate that the number of wells containing TC increases with well depth (Figure 4). This trend is most likely due to the low sample population. Total depth was determined for only 14 of the 26 drilled wells sampled. More drilled wells need to be sampled for TC and E. coli to determine if this relationship between depth and the presence of bacteria persists with this type of well.

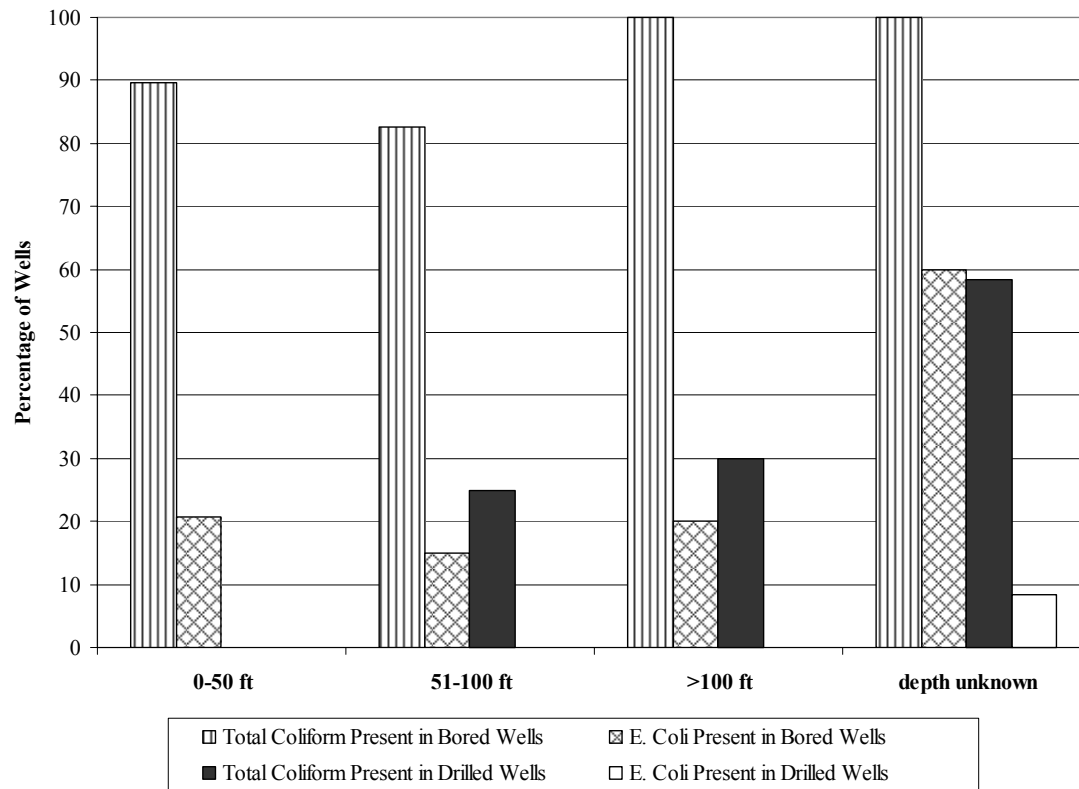


Figure 4. The percentage of bored wells and drilled wells containing TC and E. coli compared to well depth.

Nitrate-N and Herbicides

Nitrate-nitrogen (nitrate-N) can occur naturally, but in Kentucky elevated concentrations of nitrate-N in groundwater are typically introduced by septic tank effluent, animal manure, and/or chemical fertilizers. The drinking water standard or maximum contaminant level (MCL) for nitrate-N is 10 mg/L.

Five percent of the domestic wells sampled contained nitrate-N concentrations exceeding the MCL and 19 percent exceeded half the MCL (Table 1). All of the wells containing groundwater with nitrate-N concentrations greater than the MCL were bored wells (Table 1). Six of the 8 bored wells were less than 70ft deep. The remaining two wells were greater than 100 ft deep. Nitrogen isotope samples were collected to better delineate the possible source of the elevated nitrate-N. Isotope results are still being analyzed by the lab and should be available within the next two months.

Herbicides are manufactured chemicals to control vegetation growth in yards, ditch rows, and row crop fields. Herbicides are applied to the land surface and may be transported to shallow groundwater by precipitation percolating through the soil and the underlying geologic material. Three herbicides were analyzed in this study; triazines (assumed to be mostly atrazine), metolachlor, and alachlor. All three herbicides are used to control broadleaf and grassy weeds in corn and other crops. The MCL for atrazine and alachlor is 3 µg/L and 2 µg/L, respectively. Metolachlor has a health advisory level (HAL) of 100 µg/L.

Data in Table 1 indicates that of the wells sampled, the following had percentages greater than the method detection limit (MDL): 58 percent for atrazine, 28 percent for metolachlor, and 17 percent for alachlor. Atrazine and alachlor were detected above the MCL in two separate bored wells. Both bored wells are less than 70ft deep.

Table 1. Summary of nitrate-N and herbicide results relative to well construction type. The method detection limit (MDL) for nitrate-N, atrazine, metolachlor, and alachlor are 1 mg/L, 0.06 µg/L, 0.08 µg/L, and 0.06 µg/L, respectively. The maximum contaminant level (MCL) for nitrate-N, atrazine, and alachlor are 10 mg/L, 3 µg/L, and 2 µg/L, respectively. Metolachlor has a health advisory level (HAL) of 100 µg/L.

Analyte	All Wells			Bored Wells			Drilled Wells		
	≥ MDL and < half the MCL	≥ half the MCL and < MCL	≥ MCL	≥ MDL and < half the MCL	≥ half the MCL and < MCL	≥ MCL	≥ MDL and < half the MCL	≥ half the MCL and < MCL	≥ MCL
Nitrate-N	76%	19%	5%	75%	20%	5%	83%	17%	0%
Atrazine	53%	5%	0.6%	57%	5%	1%	31%	4%	0%
Metolachlor	28%	0%	0%	29%	0%	0%	11%	0%	0%
Alachlor	16%	0.6%	0.6%	18%	1%	1%	7%	0%	0%

Preliminary Conclusions

Between July 1, 2003 and June 30, 2004, 173 domestic water wells were sampled for TC, E. coli, nitrate-N, and 3 herbicides. Of those 173 wells, 146 were bored wells and 26 were drilled wells. The majority of the wells were sampled in Marshall and Calloway Counties.

Eighty-two percent of all the wells sampled contained TC, and 20 percent contained E. coli. A larger percentage of bored wells contained TC and E. coli. The number of bored and drilled wells containing TC and E. coli increased with well age. The presence of TC and E. coli generally decreased relative to the increasing depth of bored wells. More drilled wells need to be sampled in order to verify the relationship between well depth and the presence of bacteria in the drinking water from the drilled wells.

Five percent of the wells sampled for nitrate-N exceeded the MCL and 19 percent exceeded half of the MCL. All of the wells exceeding the MCL are bored wells.

Concentrations greater than the method detection limit (MDL) occurred for atrazine in 58 percent of the wells, occurred for metolachlor in 28 percent, and occurred for alachlor in 17 percent. Atrazine and alachlor were detected above the MCL in two separate bored wells.

As more data are gathered following re-sampling of these wells and the sampling of more wells, the above information will be incorporated into a final report. Meanwhile, the above results are being released in order to begin an important educational phase for domestic well users in the Jackson Purchase Region.

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Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the U.S. Department of Agriculture.