PROMOTING PRIVATE WELL TESTING IN MAJORITY AFRICAN-AMERICAN CENSUS BLOCKS OF EXTRATERRITORIAL JURISDICTIONS IN WAKE COUNTY, NC, USING THE MENTAL MODELS APPROACH TO RISK COMMUNICATION

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ABSTRACT

Erica Wood: Promoting private well testing in majority African-American census blocks of extraterritorial jurisdictions in Wake County, NC, using the mental models approach to risk communication
(Under the direction of Jacqueline MacDonald Gibson)

Residents of predominantly African-American neighborhoods bordering cities and towns in Wake County, North Carolina, historically excluded from municipal water services, are at higher risk for water contamination from bacteria and lead than neighbors with municipal water. More than 40% of survey respondents there had not tested their water quality in the past 10 years. Using the mental models approach to risk communication, we evaluated existing communications and created a new mailer promoting testing of unregulated private wells. Messages focused exclusively on factors that a 2017 survey indicated were predictive of well testing: knowledge of how to test, urgency around testing, non-reliance on sensory perceptions of water quality, and low perceptions of cost barriers. Pilot testing through in-person interviews confirmed clarity of messages and revealed concerns about logistical barriers. Effective risk communications contribute to a more informed public, which can lead to individual and collective decisions that better protect health.
ACKNOWLEDGEMENTS

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INTRODUCTION

Drinking water is a basic health need. Most U.S. residents are fortunate to benefit from the population health advances provided by disinfection of municipal drinking water and from laws regulating community water supplies for the protection of public health. However, the estimated 42.5 million people nationwide who get their drinking water from individual sources, such as private wells serving a single household, are not protected by those same regulations (Dieter et al., 2018). The responsibility for monitoring and maintaining drinking water quality falls on the homeowner. The USGS found that 23% of private wells sampled between 1991 and 2004 contained at least one contaminant that exceeded health-based levels (DeSimone, Hamilton, & Gilliom, 2009). The proportion of drinking water outbreaks associated with individual water systems has increased (1971-2006) while the proportion associated with public water systems has decreased (Craun et al., 2010). Effective outreach and communication could improve stewardship of private well systems and reduce health risks for well users.

Regular water quality testing is the only way to know if drinking water meets health standards. Most health-relevant contaminants have no taste, odor or visible evidence in the water, and their presence or absence in any given water well can change over time. Most private well owners do not know what their risks are because very few households who drink from private wells test their water quality with the recommended frequency. Public health agencies in the U.S. generally recommend testing yearly for bacterial contamination and every 2-5 years for other contaminants (CDC, 2009; NCDHHS, 2018). Studies published in the past 12
years have indicated that few well owners are following this schedule. In a survey in Pennsylvania, 30% of respondents reported never having tested their wells (Swistock, Clemens, Sharpe, & Rummel, 2013) and in Texas, more than 65% had never tested their water (Gholson, Boellstorff, Cummings, Wagner, & Dozier, 2018). Among those who have tested, many are not testing frequently. Only 10% of participants in a large, statewide survey in Wisconsin reported having tested within the past year (Malecki, Schultz, Severtson, Anderson, & VanDerslice, 2017). The North Carolina state health department has expressed concern that “only a very small percentage” of wells are tested each year (Barros, Rudo, & Shehee, 2014). There is a clear need to increase rates of water quality testing among users of private drinking water wells as a critical next step in efforts to protect people from negative health effects of drinking contaminated water.

One of the tools needed to increase the rates of private well testing is communication materials based on evidence about what people need to know to make decisions about well testing. Many health departments and organizations that support private well users have information available on their websites about potential contaminants, health risks, and how to request water tests. Relying on websites as the main method of outreach requires the well user to take the first steps of seeking information, but many may not be actively seeking information. This potential limitation is supported by a 2013 survey of private well users in Newfoundland, in which 95% of respondents felt that advertising testing through a website was ineffective (Roche, Jones-Bitton, Majowicz, Pintar, & Allison, 2013). A 2016 literature review on effective outreach to private well owners recommends active outreach and tailoring communications to the information needs of specific audiences (Morris, Wilson, & Kelly, 2016).
The specific risks associated with drinking water from private wells vary greatly with geography (underlying geology and sources of potential contamination from the surface), and results of previous studies have indicated that information needs and perceived barriers to well water testing vary between groups of people (Malecki et al., 2017). A systematic review identified only two studies that had evaluated the effects of specific communications interventions on well testing behavior (Colley, Kane, & MacDonald Gibson, 2019). One was a mass media campaign with outreach to local officials (Renaud, Gagnon, Michaud, & Boivin, 2011). The other was a partnership between local agencies for an informational campaign and a testing service campaign which mobilized volunteers to collect samples and deliver them to testing labs during a day-long event (Paul, Rigrod, Wingate, & Borsuk, 2015). Neither gave specific information about how they developed their messaging.

The work presented here responds to a gap in research on evidence-based methods for promoting well water stewardship through the application of the mental models approach to risk communication to encourage private well water testing.

**The mental models approach to risk communication**

The mental models approach to risk communication provides a method for learning about the knowledge, beliefs and perceptions of an audience, for the purpose of communicating the most decision-relevant pieces of information. It has shown promising results in risk communications on other topics (Boase, White, Gaze, & Redshaw, 2017). As far as we know, this approach has not been applied to the issue of private well water testing.

This approach gathers information on existing knowledge and beliefs directly from the target audience through interviews and surveys. That information is compared with expert
understandings of the risk to identify gaps and misunderstandings. The communication is designed to include the most prevalent knowledge gaps and misconceptions that are also the most decision-relevant ones. The communication piece is improved through feedback from both subject experts and members of the target audience. The mental models approach also calls for the communication to be tested for effectiveness. (Morgan, Fischhoff, Bostrom, & Atman, 2002)

**A priority audience and key concepts to communicate**

Prior work identified a priority population for promoting well water testing, as well as key factors to address in communication materials.

There are many private well users living at the edges of cities and towns but lacking access to municipal water service. Neighborhoods in these areas are often adjacent to municipal water and sewer lines and are sometimes completely surrounded by them, without having access to this important public health service. There is evidence of racial disparities in the distribution of these resources. There have been a number of documented cases where race has played a role in who lived in or out of the town boundaries, and in which neighborhoods got access to town services (Aiken, 1987; Johnson, Parnell, Joyner, Christman, & Marsh, 2004; Joyner & Christman, 2005; Wilde Anderson, 2008). In North Carolina, and several other states, towns can have zoning and planning authority in areas beyond their municipal boundaries, known as extra-territorial jurisdictions (EJTs). Previous work by this research group showed that in Wake County, NC, the second most populous county in the state and the seat of the state capital, the ETJ census blocks that were majority African-American were more likely to be without municipal water service than other ETJ neighborhoods (MacDonald Gibson,
DeFelice, Sebastian, & Leker, 2014). Evidence from Wake County indicates that people using private wells for drinking water in these neighborhoods are more likely to have bacterial and lead contamination in their drinking water than their near neighbors on municipal water (Stillo & MacDonald Gibson, 2017, 2018). This is the population that we aimed to reach with our communication. A brief demographic summary is provided in Table 1.

Table 1. Demographic characteristics of target audience. Our priority population for promoting well water testing was residents of majority African-American census blocks in extraterritorial jurisdictions without municipal water service in Wake County, NC (n=3598). (reported in Stillo III, Bruine de Bruin, Zimmer, & MacDonald Gibson, 2019).

<table>
<thead>
<tr>
<th>Sex / Race / Age</th>
<th>Education Attainment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Less than high school</td>
</tr>
<tr>
<td>Black/African-American</td>
<td>High school or GED</td>
</tr>
<tr>
<td>Median age</td>
<td>Some college to bachelor’s degree</td>
</tr>
<tr>
<td>Household Income</td>
<td>Graduate school</td>
</tr>
<tr>
<td>Median household income</td>
<td>$56,400</td>
</tr>
</tbody>
</table>

Note: Sex, age and race are reported for census blocks, while education and income represent block groups. From US Census, 2010.

Households in this population were identified by overlaying a map of ETJ boundaries with tax parcel data on water access and with census demographic data identifying blocks that had at least 50% African American residents (MacDonald Gibson et al., 2014). Fizer, et al interviewed 19 private well owners in these neighborhoods about their views on well water and health, and compared their responses to an expert model of how a water well user can be protected from potential contaminants (Fizer, Bruine de Bruin, Stillo, & MacDonald Gibson, 2018).

Using insights from that study, Stillo, et al developed and administered a survey to uncover factors which influence the decision to test well water quality among this audience (Stillo III et al., 2019). The survey, “Questions About Your Water,” was sent to all 934 addresses in these areas, yielding 76 complete responses for analysis, after exclusion of ineligible
participants. Similar to what has been found in other parts of the country, this survey indicated that few households follow public health recommended testing guidelines. Only about 15% had tested within the past year. More than 40% had not tested at all in the last 10 years (Stillo III et al., 2019). Three factors predicted participation in private well water quality testing within the past 2 years, according to the multi-step statistical approach of Principal Component Analysis, logistic regression, and Structural Equation Modeling (Figure 1). Factors are sets of question responses that tended to run together, indicating an underlying commonality in the way respondents thought about them. Based on the topics that appeared in the factor questions, the factors were given the titles of 1) reliance on sensory perceptions, 2) lack of knowledge and urgency about well testing, and 3) perceived cost barriers (Stillo III et al., 2019). See Table 4 in Results for a full list of questions that appeared in the three factors.

Figure 1. Factors predicting well water testing. Structural equation model, showing that participants with higher scores on the factors relating to reliance on sensory perceptions and perceived cost barriers were less likely to have tested their wells within the past 2 years. Those with higher scores on the factor relating to lack of knowledge and urgency were also less likely to have tested, with effect mediated by perceived cost barriers. Well age was also predictive of testing. All associations significant at $p \leq 0.05$. (Stillo III et al., 2019)
The survey provided additional insights to guide development of a communication.

Figure 2 illustrates that postcards and other active forms of communication were considered by many people to be the best ways to provide information. Local universities were seen by the vast majority of survey respondents as a source they would trust for testing their water (see Figure 3), which we took as an indication that many would also trust a local university for information on testing.

Figure 2. Preferred formats for information. Counts of responses in a 2017 survey of our audience to the question, “What is the best way to provide information about well testing?” Participants were asked to rank their top 3.

Figure 3. Trusted sources for well testing. Counts of “yes” answers to the prompt, “Please indicate whether or not you would trust each organization to test your well water” in a 2017 survey of our audience.
Building on this prior work, this study had two objectives:

**Objective 1:** Evaluate examples of existing written communications to promote private well water testing that could be delivered to this audience to see whether we would be reinforcing existing messages or presenting a new focus.

**Objective 2:** Create a targeted communication to promote private well water testing by members of this audience. Following the mental models approach, we sought to design a risk communication mailer that is exclusively focused on the factors that were shown to predict well water testing in these communities.

**METHODS**

The mental models approach calls for selecting content based on the information needs of the target population. In this case, our audience is residents of majority African-American neighborhoods on the edges of cities and towns in Wake County, NC, who do not have access to municipal water service.

**Evaluation of existing communications**

We evaluated existing written communications that promote private well testing for the extent to which they focused on the factors that the mental models survey data indicated were predictive of well water testing in these communities. Our goal was to include communications with overlapping audience and purpose to ours, to see whether the same messages were emphasized. The criteria for selection were 1) a focus on testing of private well water, 2) could be printed as a stand-alone document, and 3) their intended audience overlapped with ours, majority African-American neighborhoods near municipal boundaries and without water service.
in North Carolina. Mailers or brochures targeted to well owners were requested from the public health departments of Wake County and the state of North Carolina, as well as gathered from the websites of national organizations supporting well owners. The US EPA, the CDC, the National Groundwater Association, and The Private Well Class provide information on well testing on their websites, but we did not find documents that met our criteria. The one national resource that we were able to include was an information sheet from the Water Systems Council, a national non-profit with the mission of protecting and promoting private well water systems. For each document, we noted whether messages from each factored question appeared. We also noted whether additional topics were addressed which might detract attention from the main messages identified for this audience. Readability indicators were word counts and Flesch-Kincaid grade level analysis.

**Creation of mailer**

For this new mailer, messages were developed that focused exclusively on the key drivers of self-reported well water testing in our target population, with clear, everyday language and logical organization. Communication source and format were chosen based on preferences indicated in the survey. To craft messages in familiar language, we consulted the transcripts from the mental models interviews of members of our target population (interview analysis in Fizer et al., 2018). We performed a Flesch-Kincaid grade level test on the draft, with a goal of 6th grade. A graphic designer created the layout, color-scheme and graphical elements to support the messages by using colors and images that would cue readers to the content of the postcards.
Pilot testing and revision

In-person “think aloud” interviews were conducted with 5 members of the target population to look for potential misunderstandings when reading our communication.

Participants for the pilot testing interviews were recruited from those who had responded to the mental models survey in this same population and had indicated a willingness to be contacted further. Contact attempts were made until we had completed 5 interviews. Participants were offered a $15 gift card as incentive and expression of our appreciation for their participation.

A pair of researchers met with each pilot participant in a public or semi-public setting (coffee shop or participant’s office). Participants were given 10 seconds to view the postcard and then asked what they had noticed from just a first look. We alternated which side of the postcard was facing up when presented to participants, since either side could be facing up when someone picks up the mail. After the first look, participants were asked to think aloud while they read the full postcard. We specifically mentioned that any comments were fine, even if they seemed irrelevant, and that the participant would not hurt our feelings with any comments about the postcard.

Interviews were recorded and all comments relevant to the evaluation of the communication were gathered into a diagram connecting them to the section of the postcard that they referred to. Space on the diagram was also available for global comments. The two researchers who attended the pilot interviews both contributed to the diagram to make sure all relevant comments were recorded. We looked for: 1) Did participants easily recognize the topic of the mailer? 2) Were the first impressions and key take-aways about our main messages? 3)
Was the source of the mailer easily identifiable and recognizable? 4) Did participants say anything that indicated a misunderstanding of one of our messages? 5) Was anything off-putting or evoking a response that would cause someone to discount or push aside the communication?

Revisions were based on any concerns that came up in pilot testing related to the above questions. In particular, if concerns about any of those areas were brought up by more than one person, we found a way to address it.

**Review by experts**

Early and final drafts were reviewed by two experts on household drinking water well issues at the North Carolina Department of Health and Human Services, who are responsible for communicating with well owners. They confirmed that the factual information was correct.

**RESULTS**

**Evaluation of existing communications**

The documents which met our selection criteria were: 1) A door hanger from Wake County, 2) a 2-page flyer from Wake County, 3) a double-sided flyer published by NC Dept. of Health and Human Services, in collaboration with North Carolina State University, 4) a refrigerator magnet created by NC Dept. of Health and Human Services, and 5) a 4-page info sheet from the wellcare® series by Water Systems Council. All were published within the last 8 years. Copies of each are included in the appendix.

The two pieces from Wake County included some messages from each decision-relevant factor (see Table 2) but none of the examples addressed all of the concepts present in the
factors. Wake County’s door hanger, for example, did not mention what to do if a problem is found; however, the Wake County letter does. Neither of the Wake County pieces included phrases that emphasize urgency in testing, although the door hanger format and specific dates for waiving collection fees might serve the same function. The only other item that seemed to promote a sense of urgency was the reminder refrigerator magnet, with the phrase, “Have you tested your well lately?”

Two of the five pieces did not directly counter the misconception that one can rely on sensory perceptions to detect contaminants in water. The state and national resources did not say anything that might help alleviate concerns about cost barriers. The flyer from NC DHHS mentions a range of possible costs for tests, extending up to several hundred dollars, which could reinforce perceptions of cost barriers.

All pieces also included other topics beyond the concepts that showed up in the predictive factors. For example, some included information about sources of contaminants, effects on health, and/or maximum contaminant levels. See Table 3 for details.

There was great variation in the amount of text in the communications and in the reading level. See Table 3. All except the magnet were at least one full page of text. The magnet expressed its messages using only 66 words. The Water Systems Council wellcare infosheet was the longest, at four pages. All used images to support the text. Four used a chart or table to present some of the information. All used subheadings to guide the reader. The Wake County flyer and the wellcare infosheet had the higher reading levels, at about 10th grade.
Table 2. Evaluation of existing communications for concepts important for our audience. Shaded boxes indicate that a message related to that key concept was found in that communication piece. No existing communication included all identified messages. The two pieces from Wake County included some messages from each factor.

<table>
<thead>
<tr>
<th>Factor 1: Sensory perception misconception</th>
<th>Wake doorhanger</th>
<th>Wake flyer</th>
<th>NC DHHS flyer</th>
<th>NC magnet</th>
<th>wellcare infosheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water looks, smells, and tastes fine, so there is no need to test</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>No need to test, because water looks, smells, and tastes clean</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>No need to test, because I’ve been using the water for years without problems</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 2: Lack of knowledge and urgency for testing</th>
<th>Wake doorhanger</th>
<th>Wake flyer</th>
<th>NC DHHS flyer</th>
<th>NC magnet</th>
<th>wellcare infosheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan to test but haven’t gotten around to it</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>No time to test</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>Don’t know where to test</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>Don’t know how to test</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>Don’t know what to test for</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>Wouldn’t know what to do if failed test</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 3: Cost barriers</th>
<th>Wake doorhanger</th>
<th>Wake flyer</th>
<th>NC DHHS flyer</th>
<th>NC magnet</th>
<th>wellcare infosheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can’t afford to test my water</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>Couldn’t afford to fix if bacterial contaminants are found</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>Couldn’t afford to fix if chemical contaminants are found</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>Would install a water filter if I could afford it</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>Would prefer city water if it were free</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
<tr>
<td>Well water is free</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
<td>❍</td>
</tr>
</tbody>
</table>
### Table 3. Evaluation of existing communications for additional topics, word count, reading level.

Additional topics are outside of the concepts identified as our audience’s key knowledge gaps and misconceptions about well water testing. Word counts exclude maps and tables. Reading levels are Flesch-Kincaid grade level score.

<table>
<thead>
<tr>
<th>Risk Communication</th>
<th>Additional Topics Included in Risk Communication</th>
<th>Word Count</th>
<th>Reading level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wake County, NC Door hanger - “Is your well water safe?”</td>
<td>You can choose your tests When you will get results</td>
<td>324</td>
<td>4.2</td>
</tr>
<tr>
<td>Wake County, NC Flyer - Well testing recommendations</td>
<td>Sources of contaminants (page on radionuclides) Municipal systems</td>
<td>572</td>
<td>10.8</td>
</tr>
<tr>
<td>NC Dept of Health and Human Services Flyer - “Private Well Water and Your Health”</td>
<td>Health concerns Sources of contaminants</td>
<td>407</td>
<td>8.6</td>
</tr>
<tr>
<td>NC Dept of Health and Human Services Refrigerator magnet</td>
<td>none</td>
<td>66</td>
<td>2.4</td>
</tr>
<tr>
<td>Water Systems Council Info sheet “Well Water Testing”</td>
<td>Guideline levels Understanding test results How to take a water sample Additional testing for special situations</td>
<td>953</td>
<td>10.8</td>
</tr>
</tbody>
</table>

### Creation of mailer

Design of the communication (seen in Figure 4) was driven by the results of the survey of the target audience. The preference of a majority of survey respondents for a postcard, over other avenues for receiving information, led us to a large (6” x 11”), two-sided, full-color postcard. (Postcard was the option with highest count as rank #1 (47 / 111) and highest count as rank #1,2 or 3 (69 / 111). Graphical elements, such as faucet, drips and blue color, were chosen to support the messages. The color orange contrasts for urgency. The university logo and contact information indicated a reputable source, as we were aware of mailings in the area from water treatment companies and others which were not focused on public health goals.

The content of the messages focused exclusively on the identified factors: reliance on sensory perceptions, lack of urgency and knowledge about testing, perceived cost barriers (see Table 4). Additional messages, for example about health risks or potential sources of contamination, were left off. Messages directly addressed each question that made up each
factor, with two exceptions. We did not directly address the specific idea that there might be no need to test if one had been using the water for years without problems. This was part of the misconception that senses can be relied upon to know when there is a problem, and was addressed instead by the messages about not being able to see, smell or taste contaminants. We also did not address all of the separate questions in the factor about perceived cost barriers. Three of the questions seemed to deal with perceived costs but did not directly relate to testing the water, specifically, “I would install a home water filter if I could afford it,” “I would prefer to drink city water if it were free”, and “Getting water from a well is free.”

Word choice and phrasing were guided by interview data to be in language familiar to the target audience. The phrase, “Be confident your water quality is good” came from messages that several interview participants gave about why they tested their water or why they would test. A Flesch-Kincaid readability analysis estimated the draft postcard to be at a 6.7 grade level. A clear, direct, informative tone was used throughout.
Table 4. Postcard messages corresponding to the survey responses that predicted not having tested in the past 2 years. 15 survey questions appeared in 3 factors (latent variables).

<table>
<thead>
<tr>
<th>Factor and associated survey questions</th>
<th>Messages included in the mailer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor 1: Sensory perception misconception</strong></td>
<td></td>
</tr>
<tr>
<td>Water looks, smells, and tastes fine, so there is no need to test</td>
<td>You cannot see lead in well water</td>
</tr>
<tr>
<td>No need to test, because water looks, smells, and tastes clean</td>
<td>You cannot smell arsenic in well water</td>
</tr>
<tr>
<td>No need to test, because I’ve been using the water for years without problems</td>
<td>You cannot taste bacteria in well water</td>
</tr>
<tr>
<td><strong>Factor 2: Lack of knowledge and urgency for testing</strong></td>
<td></td>
</tr>
<tr>
<td>Plan to test but haven’t gotten around to it.</td>
<td>Time to test your well! It’s time!</td>
</tr>
<tr>
<td>No time to test</td>
<td>It’s Easy!</td>
</tr>
<tr>
<td>Don’t know where to test</td>
<td>Test through your local health department or a state-certified lab</td>
</tr>
<tr>
<td>Don’t know how to test</td>
<td>Call XXX or Visit XXX</td>
</tr>
<tr>
<td>Don’t know what to test for</td>
<td>Public Health recommended testing schedule</td>
</tr>
<tr>
<td>Wouldn’t know what to do if failed test</td>
<td>Have a free consultation with an Environmental Health Specialist about your options, if any of the tests show a concern.</td>
</tr>
<tr>
<td><strong>Factor 3: Cost barriers</strong></td>
<td></td>
</tr>
<tr>
<td>Can’t afford to test my water</td>
<td>Many counties offer discounted tests.</td>
</tr>
<tr>
<td>Can’t afford to fix my well water if bacterial contaminants are found</td>
<td>Some water treatment options are not expensive.</td>
</tr>
<tr>
<td>Can’t afford to fix my well water if chemical contaminants are found</td>
<td></td>
</tr>
<tr>
<td>Would install a water filter if I could afford it</td>
<td></td>
</tr>
<tr>
<td>Would prefer city water if it were free</td>
<td>[These pieces were not directly included in the postcard because they did not deal with testing. We considered them indicative of beliefs about cost barriers]</td>
</tr>
<tr>
<td>Well water is free</td>
<td></td>
</tr>
</tbody>
</table>
Promote a sense of urgency (Factor 2)

Counter common misconception (Factor 1)

Provide information on how to test, what to test for (Factor 2)

What to do if there is a problem (Factor 2)

Counter perceived cost barrier (Factor 3)

Figure 4. Front and back of postcard used in pilot testing. Key factor concepts highlighted.

Pilot testing and revision

Pilot testing with five members of the target population confirmed that key information stood out. When asked for first impressions, people pointed to, “Time to test your well,” the phone number, the UNC logo and the faucet. No major misunderstandings were identified. Both non-verbal reactions (like long pauses) and comments indicated that the back side seemed a bit “busy” or “complicated.” We revised this side by removing two information bubbles and a
few lines of text that people did not find especially helpful to ensure that the most important
messages came through.

The other concern expressed by pilot testers was whether the process would actually be
easy once they made that first phone call. Representative comments are shown in Figure 5.
They were concerned about getting a lengthy menu of options, a voicemail, or getting
transferred from person to person without results. To address this concern, we changed the
phone number on the card from the general main number of the state DHHS to the direct line
of a state employee who regularly communicates with well owners and who was familiar with
our project.

Although participants suggested a variety of changes and possible pieces of content to
add (for example, how this could impact your family’s health, or your pet), we made changes
based only on whether our chosen messages came through clearly, since our approach was to
only include content that addressed the factors predicting well water testing.

<table>
<thead>
<tr>
<th>Pilot comments</th>
<th>Mailer revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Clear&quot;</td>
<td>Pilot testing confirmed that text was understandable and that design was</td>
</tr>
<tr>
<td>&quot;Important information&quot;</td>
<td>supporting key messages</td>
</tr>
<tr>
<td>&quot;Make sure it is a real person</td>
<td>Changed phone number to direct line of a</td>
</tr>
<tr>
<td>answering the phone.&quot;</td>
<td>state employee familiar with the project.</td>
</tr>
<tr>
<td>&quot;Looks like a lot of work.&quot;</td>
<td></td>
</tr>
<tr>
<td>&quot;This side is kind of busy.&quot; or</td>
<td>Removed section to find and add in your</td>
</tr>
<tr>
<td>&quot;...complicated.&quot;</td>
<td>own county contact.</td>
</tr>
<tr>
<td></td>
<td>Removed orange boxes.</td>
</tr>
</tbody>
</table>

**Figure 5.** Representative pilot testing comments and resulting revisions. Pilot testing indicated no major points of
misunderstanding and that design features supported the message.
The final postcard included messages addressing each of the survey items in Factors 1 (reliance on sensory perceptions) and 2 (lack of urgency and knowledge about testing). To address the perceived cost barriers, we opted to offer a free test as one of the study conditions in the randomized-controlled trial of this communication piece, reported separately. The large-format postcard minimized barriers to the message being seen. Graphics supported the messages and did not distract. Following this application of the mental models approach to risk communication, we had an evidence-based communication, ready to be tested for impact (Figure 6).

Figure 6. Final, revised postcard, front and back.
DISCUSSION

As a result of this work, we have designed an evidence-based print communication, ready to be tested for impact. This postcard mailer promotes private well water quality testing among residents of majority African-American neighborhoods without municipal water service on the edges of cities and towns in North Carolina. The messages were developed directly from surveys of audience members, following the mental models approach to risk communication. It focuses exclusively on the factors that were shown to predict private well water testing in our audience. Pilot testing confirmed the prominence of key messages.

The review of existing communications showed that some key messages for this audience were missing from many of the pieces. There were very few messages promoting a sense of urgency to complete water quality testing. Only three of the five directly addressed the misconception that senses can be a good guide to water quality. To address perceived cost barriers, the county level communications we reviewed gave specific information about costs and also mentioned existing subsidies and any discounts available. Not all counties subsidize testing or offer discounts. The state and national communications do not mention cost. Key messages that were being reinforced by all sources were the recommendations of what contaminants to test for. Consistent, ongoing messaging is important for effective communication to promote behavior change. This can particularly be a challenge if the most important messages differ for different audiences, which has been suggested by several studies (Malecki et al., 2017; Morris et al., 2016). Some of the communication pieces included many other topics outside of our key factors. We don’t know whether this is due to the piece being designed for a broader audience (state or national) or because of the process that was used to
choose the messages, or whether the creators of those pieces had different goals from ours (for example, education on well stewardship, in addition to promoting testing). However, it is encouraging to see that our postcard mailer and Wake County's door hanger and letter share many key messages, since their audiences closely overlap.

This work represents the first time that the mental models approach has been applied to develop a communication around the health risks from unregulated drinking water sources, to the best of our knowledge. The mental models approach to risk communication has been increasingly used and evaluated in recent years, with effects particularly shown in measures of knowledge (Boase et al., 2017). It has been used successfully in communicating about radon in homes, which has a similar context, in that homeowners are responsible for managing the risks and the contamination is not perceptible by the senses. The study applying the mental models process to brochures about radon risks found that the brochure created through this process received fewer comments expressing confusion and outperformed in contradicting misconceptions, compared with a brochure produced by experts that did not use this method (Bostrom, Atman, Fischhoff, & Morgan, 1994). The mental models approach can guide the choice of content so that it focuses on the information that people need to make decisions around managing a risk.

The messages that came out of the use of the mental models approach overlap with existing recommendations of what should go into a communication to promote well testing, but differ in some key aspects. Misconceptions about being able to sense water quality problems were associated with not testing in our survey. Surveys of well owners in Wisconsin and Newfoundland also reported that a reliance on sensory perceptions was a reason for not
testing well water (Knobeloch, 2011; Roche et al., 2013). Many survey respondents in these prior studies also indicated that they were missing information on how to get the tests done (Knobeloch, 2011; Kreutzwiser et al., 2011; Malecki et al., 2017; Roche et al., 2013). This matches one of the factors for our audience, which included lack of knowledge of how to test, where to test and what to test for. These items were all included in the postcard mailer. On the other hand, our survey did not lead us to emphasize the health impacts of drinking contaminated water, as others have suggested would be important (Kreutzwiser et al., 2011; Malecki et al., 2017; Morris et al., 2016; Paul et al., 2015). We do not know whether this difference stems from the use of different theoretical backgrounds to inform analysis and recommendations or whether it comes from differences in the populations surveyed. These other studies were conducted primarily with rural well owners in midwestern and northeastern US states and Canadian provinces. The responses to our surveys indicated that knowledge of health risks was not driving decisions to test wells in African-American neighborhoods on the edges of cities and towns in NC. It would be helpful to have information from additional studies with well owners in North Carolina, and of non-rural well owners beyond Wake County to learn whether these important findings apply more broadly.

Cost has been recognized as a potential barrier to well water stewardship by many researchers and practitioners (Knobeloch, 2011; Kreutzwiser et al., 2011; Liukkonen, 2009; Straub & Leahy, 2014) and was one of the factors identified by our survey as influencing decisions. Although concerns about cost were also identified in our survey as one of the factors influencing decisions to test water quality, we did not include any explicit messages about cost in our final postcard. An alternate way of lowering this perceived barrier is to eliminate some of
the actual costs. Adjusting the costs to well owners for testing or treatment is a potential program option for health departments and other organizations. The decision was made to test both the impact of offering a free test (reducing cost barriers directly) and the impact of a communication focused solely on the key factors using a randomized-controlled trial (Stillo, III, Bruine de Bruin, & MacDonald Gibson, 2019). To clearly separate the two study conditions, we did not include cost information on the postcard.

This postcard will be put to use in promoting well testing, during the randomized-controlled trial. Outcomes of interest include whether a control group that did not receive the communication differed from the group that did receive the communication, in whether they tested their water quality, whether they indicated an intention to test their water, and in how they responded to the knowledge and perception questions that informed the design of the communication.

It could also be used by public health practitioners for repeated outreach and reminders for this audience. Use of the same survey and analysis methods in other audiences could allow for evidence-based modifications of the postcard content to promote well testing there as well. The North Carolina Department of Health and Human Services has already completed the survey in three additional counties and this data (not shown) could inform an adaptation of this communication piece for other areas of the state. It is possible that existing survey data from well owners in other regions could be analyzed using the same techniques and provide comparable insight into factors most influencing decisions to test wells. These insights could allow the application of the mental models approach to develop targeted communications in new settings, with a reasonable input of time and money. Alternately, messages could focus on
a more limited set of factors that appear important across communities. This would be particularly relevant for organizations with state and national audiences that have the added challenge of creating communications that are relevant to many different people. There are now indications from several sources that many people rely on their senses to decide whether to test their well water quality. This could be an important set of messages to include in more communications.

Even after outreach programs achieve greater success in promoting well water quality testing, work still needs to be done to more effectively communicate test results, the health risks related to those results, and the options for managing those risks. The mental models approach to risk communication could also contribute to those efforts.

A 2016 literature review on conducting effective outreach to private well owners emphasized the importance of understanding the audience, including existing knowledge and beliefs (Morris et al., 2016). They stated strongly that no single approach would likely be effective with all groups of well owners. Our application of the mental models approach allowed us to gain important insights about our audience and address only the most relevant information points.

The ultimate goal of this work is to reduce exposures to health risks from unregulated drinking water sources. Promoting private well water quality testing is an important step toward that goal. It also has the potential to support stewardship of groundwater resources, through raising awareness of existing and potential contamination and the potential sources of that contamination.
CONCLUSIONS

By following the mental models approach, we have created an evidence-based communication ready to be tested for impact. This postcard concisely addresses key points that predict well water testing in our audience, residents of majority African-American neighborhoods on the edges of cities and towns, without municipal water service. This postcard can be used as a source of information, a reminder and a cue to action. In Wake County, NC, these underbounded communities have been shown to be at greater risk for drinking water contaminated with bacteria and lead than those on nearby municipal water. In these communities, similar to many others across North America, rates of well testing are low, which is a barrier to the public health goal of protecting against health risks from drinking contaminated water. Surveying other communities could guide adaptation of this communication for additional audiences. This evidence-based communication material, and others like it, can become part of the multi-pronged approaches needed to increase rates of well water testing and other well stewardship behaviors. Ultimately, effectively promoting well testing is one tool among many needed to reach a more equitable distribution of drinking water risks.
APPENDIX: EXAMPLES OF EXISTING COMMUNICATIONS

Is your well water safe?

Why did Wake County leave this on my door?
Wake County has learned that groundwater and/or soil nearby has some harmful things in it. To make sure the water from your well is safe, we recommend that you have your well tested for:

- Bacteria ($25)
- Metals (also called inorganic compounds) ($50)
- Volatile Organics (like gas and solvents) ($50)
- Pesticides ($50)
- Herbicides ($50)
- Uranium ($20)

How can Wake County help?
We will be testing wells in your area during the week of ____________. Wake County charges for each test we do (see prices above). Usually we also charge a trip fee of $50 to collect water for testing. But, if you call us and pay for the tests you would like by ____________, we will not charge you the trip fee (just the test fees).

Who can test my well water?
Wake County Environmental Services and private labs can test your well water. If you use a private lab, be sure to check that they have been certified to do these tests by the State of NC.

Have questions?
Want to schedule and pay for your tests?
Phone: 919-856-7400
Wake County Department of Environmental Services
Groundwater Protection and Wells
336 Fayetteville St., PO Box 550, Raleigh, NC 27602
www.wakegov.com/water/wells

Please have this handy when you call:
We visited your home on: ________________________
at ________ am or pm.
ID# ________ or WPL# ________
Address: ____________________________________

What’s in your well water?
If you own and use well water in your home or business it’s a good idea to have it tested often. Testing well water is up to the owner to get done. But Wake County can help. Read more!

My well water seems fine, why should I have it tested?
Water can have harmful germs (bacteria), metals, pesticides or other things in it and still look, smell and taste good.

You can choose which tests and how many tests you want to have done.
Below are the prices for each test (as of January 2014) and how often the NC Department of Health and Human Services recommends getting these tests done.

<table>
<thead>
<tr>
<th>TEST</th>
<th>COST</th>
<th>RECOMMENDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria</td>
<td>$25</td>
<td>every year</td>
</tr>
<tr>
<td>Metals</td>
<td>$50</td>
<td>every 2 years</td>
</tr>
<tr>
<td>(includes iron, lead, nitrate, nitrite and arsenic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volatile Organics*</td>
<td>$50</td>
<td>every 2 years</td>
</tr>
<tr>
<td>Pesticides*</td>
<td>$50</td>
<td>every 5 years</td>
</tr>
<tr>
<td>Herbicides*</td>
<td>$50</td>
<td>every 5 years</td>
</tr>
<tr>
<td>Uranium*</td>
<td>$20</td>
<td>as needed</td>
</tr>
<tr>
<td>Trip fee</td>
<td>$50</td>
<td>each time we collect</td>
</tr>
</tbody>
</table>

* Only Wake County staff can collect water for testing done through Wake County for organic compounds, pesticides, herbicides and uranium. You can collect water for bacteria and metals testing using a special kit you get from Wake County (the kit tells you exactly how you need to collect the water).

If I have my water tested by Wake County, when will I get the results?
We will give you the results of your water testing as soon as the lab has them ready. This often takes 3 to 4 weeks.
Wake County encourages all residents who use a private drinking water well to test their well water regularly for contamination.

Municipal and community water systems are tested by their operators on a regular basis, but private well owners are responsible for their own water testing. Wake County offers a wide range of well testing services and technical assistance to help well users protect their health.

But my well water tastes, smells, and looks fine!
Tastes, odors, discoloration, or cloudiness are obvious signs of problems with your water, but water that is perfectly clear and tastes fine can still have unhealthy levels of contamination.

I already had my well water tested.
Do you know what it was tested for? Was it tested by a certified drinking water laboratory? There are many free test kits available, but most of these test kits do not check for chemicals that affect your health or don’t provide reliable results.

What if the tests find a problem?
While discovering a problem in your drinking water can be scary, the good news is that nearly all well water problems can be fixed. After you get your test results, Wake County Environmental Services will work with you to help you understand your options and will help connect you to resources to address the problem.

Doesn’t water testing cost a lot?
Wake County charges for well water testing, but the county absorbs some of the cost to make it more affordable. Wake County’s well experts can help you decide which tests you need most so you get the most value for your money. Wake County also offers discounted testing fees for lower-income residents.

<table>
<thead>
<tr>
<th>Test</th>
<th>Cost</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coliform Bacteria</td>
<td>$25</td>
<td>Every year</td>
</tr>
<tr>
<td>Inorganic Compounds</td>
<td>$50</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>(Includes Alkalinity, Hardness, pH, Chloride, Fluoride, Nitrate, Nitrite, Arsenic, Barium, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Selenium, Silver, Sodium and Zinc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volatile Organic Compounds*</td>
<td>$50</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>Pesticides*</td>
<td>$50</td>
<td>Every 5 years</td>
</tr>
<tr>
<td>First-Timer’s Package*</td>
<td>$175</td>
<td>Any well user who has had not their water tested in 5 years or more</td>
</tr>
<tr>
<td>(includes all tests listed above)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiologicals Package*</td>
<td>$100</td>
<td>Select areas of the county (see other side)</td>
</tr>
<tr>
<td>(includes Gross Alpha &amp; Beta Radioactivity and Radon)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = These samples must be collected by Wake County and require an additional fee of $50.00 per trip. One trip fee is charged per address for unlimited sampling on the same day.

Wake County offers reduced fees for these tests for lower-income residents. When you call to request a sample, please ask about your eligibility for discounted testing fees.

Have questions?
Ready to schedule and pay for your water tests?
Call Wake County Environmental Services at
919-856-7400

Wake County Department of Environmental Services - Groundwater Protection and Wells
336 Fayetteville St. / PO Box 550, Raleigh, NC 27602
www.wakegov.com/water/wells
Radionuclides in Wake County Groundwater

Wake County encourages private well users living in the areas highlighted below to have their wells tested for Gross Alpha Radioactivity and Radon. Wake County Environmental Services also recommends testing indoor air for Radon in these areas. Within these two areas, naturally occurring radioactive elements are more common due to granite rock formations underground. The largest of these formations, called the Rolesville Granite, extends into neighboring Franklin and Johnston counties. A similar but smaller granite formation is also present near the Harnett County line.

Well users in other parts of the county who have had problems with Radon in their indoor air should also consider having their well water tested for Gross Alpha Radioactivity and Radon.

If your well is found to have elevated levels of radioactive elements, Wake County will provide information and resources regarding treatment options to help you get safe drinking water.

Gross Alpha and Radon are just two of the many well tests that Wake County Environmental Services offers for private well users. Call Wake County Environmental Services at 919-856-7400 or visit http://www.wakegov.com/water/wells/ for instructions and more information about well testing services.

Legend
Radiological Testing Recommended

Wake County Department of Environmental Services - Groundwater Protection and Wells
336 Fayetteville St. / PO Box 550, Raleigh, NC 27602
www.wakegov.com/water/wells
Private Well Water and Your Health

Most private wells provide a clean, safe supply of water for many people in North Carolina. Unfortunately, sometimes contaminants can pollute private wells.

As a private well water owner, it is up to you to keep your family safe. Test your water to make sure that it is safe to drink.

Why should I test my well water?

- Contaminants in your well water can make you sick. Both germs and chemicals may cause unpleasant symptoms, such as upset stomach, diarrhea, and skin problems. Some chemicals can increase your chance of cancer.

- In 1999-2000, contaminated private well water in the U.S. caused 26 percent of the drinking water outbreaks that made people sick (U.S. Center for Disease Control and Prevention, 2003).¹

- You might not be able to see, smell or taste potentially harmful contaminants in your water.

How often should I test my well?

- Test every year for total and fecal coliform bacteria.

- Test every two years for heavy metals, nitrates, nitrites, lead, copper and volatile organic compounds (VOCs).

- Test for pesticides every five years unless you know of specific pesticides that are being applied. In that case, test for that specific pesticide yearly.

What contaminants could be in my well water?

Certain minerals or chemicals may be present in your water, depending on the geology and land use in your area. Many wells in North Carolina have too much lead, arsenic, iron, manganese, low pH and harmful coliform bacteria.

If you are pregnant or have an infant at home:

Test your water for nitrates. If you have nitrates in your well water, do not drink the water or use the water to prepare your baby’s formula. Use an alternative source of water instead. Boiling your water does not remove nitrates.

(continued)
Who can help me test my well?

Contact the environmental health program at your local health department. They are your best source of information and the most reliable source for testing.

How much can a test cost?

The cost of testing can range from $25 to several hundred dollars.

Whom can I call for questions?

Call your local health department or the N.C. Division of Public Health, Occupational and Environmental Epidemiology Branch at (819) 707-5900.

Additional Information

Visit our website for more information on specific contaminants and potential health effects: http://www.epi.state.nc.us/epi/oil/hsfactsheet.html under well water safety.

1. Healthy Water Frequently Asked Questions, CDC, Summer 2003
<table>
<thead>
<tr>
<th>Test Type and Compound</th>
<th>Frequency</th>
<th>Test Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total and fecal coliform bacteria</td>
<td>Every year</td>
<td><strong>/</strong>/20</td>
</tr>
<tr>
<td>Inorganics such as nitrates, nitrites, manganese, arsenic, and lead</td>
<td>Every two years</td>
<td><strong>/</strong>/20</td>
</tr>
<tr>
<td>Organics such as pesticides and volatile organic compounds (VOCs)</td>
<td>Every five years</td>
<td><strong>/</strong>/20</td>
</tr>
</tbody>
</table>

For more information on testing and cost, contact your county health department's Private Well Program at: [Contact Information]
wellcare® information for you about

Well Water Testing

To keep your well water clean and pure and your well operating at peak performance, regular water testing is an important maintenance tool. Private well owners are solely responsible for the quality of their drinking water. So it is up to you, the well owner, to decide when and how to test your water.

**Recommended Testing**
At a minimum, your water should be tested every year for bacteria, the most common water quality problem. Other tests may be required, depending on where you live and what is located near your water supply.

Table 1 (see page 2) describes some conditions that may prompt you to test for select contaminants. Table 2 (see page 2) lists the limits for some primary contaminants.

For example, if your well is in an area of intensive agricultural use, test for nitrates and the pesticides commonly used in that region. If household tests of radon in the air are high, test for radon in water. If you have problems with taste, odor, staining or color of your water, then test levels of iron, manganese and sulfate.

Testing more than once a year may be warranted in special situations:
- someone in your household is pregnant or nursing
- there are unexplained illnesses in the family
- your neighbors find a dangerous contaminant in their water
- you note a change in water taste, odor, color or clarity
- there is a spill of chemicals or fuels into or near your well.

Contact your local health department, cooperative extension service, state health or environmental agency or your well professional for guidance in selecting tests.

**Choosing a Testing Lab**
Approach water testing as a smart shopper. Get an up-to-date list of all state-approved laboratories and the specific tests they are certified to perform from your state health or environmental agency. Check with individual laboratories to get prices. Ask how soon you should expect results and about the information that will be provided with the test results. A good lab should help you interpret the results and make sense of the scientific data.

*continued on page 3*
# Table 1: Tests for Specific Conditions

<table>
<thead>
<tr>
<th>Conditions or Nearby Activities</th>
<th>Recommended Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recurrent gastrointestinal illness</td>
<td>Coliform bacteria</td>
</tr>
<tr>
<td>Household plumbing contains lead</td>
<td>Copper, hardness, lead, pH, salts</td>
</tr>
<tr>
<td>Radon present in indoor air or region</td>
<td>Radon</td>
</tr>
<tr>
<td>Scaly residues, soaps don’t lather</td>
<td>Chloride, hardness, sodium</td>
</tr>
<tr>
<td>Water softener to treat hardness</td>
<td>Iron, manganese (before purchase)</td>
</tr>
<tr>
<td>Stained plumbing fixtures, laundry</td>
<td>Iron, manganese, sulfate, tannins</td>
</tr>
<tr>
<td>Objectionable taste or smell</td>
<td>Hydrogen sulfide, pH, hardness, metals</td>
</tr>
<tr>
<td>Water is cloudy, frothy or colored</td>
<td>pH, salts, tannins, turbidity</td>
</tr>
<tr>
<td>Corrosion of pipes, plumbing</td>
<td>Copper, lead, pH, salts</td>
</tr>
<tr>
<td>Rapid wear of water treatment equipment</td>
<td>Hardness, iron, manganese, pH, salts</td>
</tr>
<tr>
<td>Nearby areas of intensive agriculture</td>
<td>Coliform bacteria, nitrate, pesticides</td>
</tr>
<tr>
<td>Nearby coal, oil, mining operation</td>
<td>Metals, pH, TDS</td>
</tr>
<tr>
<td>Gas drilling operation nearby</td>
<td>Barium, chloride, sodium, strontium</td>
</tr>
<tr>
<td>Gasoline or fuel oil odor</td>
<td>Volatile organic compounds (VOCs)</td>
</tr>
<tr>
<td>Dump, landfill, factory or dry-cleaning operation nearby</td>
<td>Metals, pH, salts, VOCs</td>
</tr>
<tr>
<td>Salty taste and seawater, or a heavily salted roadway nearby</td>
<td>Boren, chloride, sodium, TDS</td>
</tr>
</tbody>
</table>

# Table 2: Tests for Specific Contaminants

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>When to Test</th>
<th>How to Test</th>
<th>When to Treat / Maximum Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>Baseline test in areas prone to arsenic / annually after treatment</td>
<td>State Laboratory</td>
<td>10 parts/billion</td>
</tr>
<tr>
<td>Bacteria</td>
<td>Annually in spring, newborn in house; well equipment installed</td>
<td>Local health department test of total coliforms</td>
<td>Positive test for total coliforms, presence of fecal coliforms</td>
</tr>
<tr>
<td>Chromium</td>
<td>Near steel/pulp mills or in areas prone to arsenic / annually after treatment</td>
<td>State laboratory</td>
<td>100 parts/billion</td>
</tr>
<tr>
<td>Iron</td>
<td>Water colored or leaving stains of orange/red, rusty</td>
<td>State laboratory</td>
<td>300 parts/billion</td>
</tr>
<tr>
<td>MTBE (methyl tertiary butyl ether)</td>
<td>Water has oily gas smell or oily film in area where MTBE used</td>
<td>State laboratory</td>
<td>20 parts/billion</td>
</tr>
<tr>
<td>Nitrate</td>
<td>Annually in farm areas, pregnant women/infant in house</td>
<td>State laboratory</td>
<td>10 parts per million</td>
</tr>
<tr>
<td>Radon</td>
<td>Area with high radium in bedrock</td>
<td>State laboratory</td>
<td>5 picocuries per liter</td>
</tr>
<tr>
<td>Radon</td>
<td>Before buy / move into new home</td>
<td>State laboratory</td>
<td>Check with State Radon Office</td>
</tr>
<tr>
<td>Sulfur &amp; Manganese</td>
<td>Bitter taste, rotten egg odor, black/brown water or staining</td>
<td>Local health department</td>
<td>250 parts/million - Sulfur, 50 parts/billion - Manganese</td>
</tr>
<tr>
<td>TCE (trichloroethylene)</td>
<td>Near factories/dry cleaners or in at-risk states**</td>
<td>State laboratory</td>
<td>5 parts/billion</td>
</tr>
</tbody>
</table>

* Chromium at-risk states: California, Connecticut, Delaware, Illinois, Indiana, Maryland, New York, New Jersey, Pennsylvania, Texas and Wisconsin
** TCE at-risk states: Pennsylvania, Illinois, Georgia, Texas, Massachusetts and West Virginia
Taking a Water Sample

The laboratory you choose should provide specific sampling instructions and clean bottles in which to collect the water sample. Do not rinse lab containers or fill them to overflowing. Check to see if the sample must be refrigerated or treated with special chemicals.

You may need to take a sample from the tap with the first flush of water in the morning or after the tap has been allowed to run for a period of time. If you suspect a problem somewhere in your home plumbing, you may need to take samples from several points: before and after water enters the hot water tank, for example, or at the inlet and outlet of a filtering device.

Again, carefully follow instructions for taking samples. Sampling is the most important part of testing. A carelessly collected sample can give you inaccurate results.

Understanding Test Results

The report of analysis, as some laboratories call test results, can take a variety of forms. It may be a computer printout of results for the specific tests you requested or a preprinted form with your results typed or written into blocks or spaces. It may include some general information about the laboratory that performs the test and the types of tests that were done or it may provide only your results.

The amount of a specific contaminant in your water sample will be expressed as a concentration of a specific weight of the substance in a specific volume of water. The most commonly used concentration units for drinking water analyses are provided in Table 2.

The test results may also include other symbols and abbreviations. Laboratory methods have detection limits, or levels below which contaminants cannot be reliably detected. That does not necessarily mean that the chemical is not present. There could be so little present that it cannot be reliably detected with the laboratory equipment or testing procedures being used.

continued on next page
The important question is whether the contaminant poses a health threat at that particular concentration. Compare your water test results to the federal standards in Table 2 and to other guidance numbers, such as health advisories, to assess the potential for health problems. If in doubt, contact your state health department or environmental agency, the local extension service, your water well professional or the wellcare® Hotline.

After you get your first test results, you would be wise to follow up with a second test taken at a different time before you decide on any water treatment. This is because there is a certain margin of error in water testing and contamination problems may vary. For more information on understanding test results see our wellcare® information sheet on “Understanding Your Well Water Test Results.”

For more information to help you maintain your well and protect your water supply

wellcare® is a program of the Water Systems Council (WSC). WSC is the only national organization solely focused on protecting the health and water supply of the 43 million people nationwide who depend on household wells for their water supply.

This publication is one in a series of wellcare® information sheets. There are more than 90 available FREE on the WSC website at www.watersystemscouncil.org.

Well owners and others with questions about wells or groundwater can also contact the FREE wellcare® Hotline at 1-888-395-1033 or visit www.wellcarehotline.org.

JOIN THE WELLCARE® WELL OWNERS NETWORK! You can join the well owners network and receive regular information on how to maintain your well and protect your well water...it’s FREE!

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REFERENCES


