THE IOWA STATE-WIDE RURAL WELL-WATER SURVEY DESIGN REPORT:

A Systematic Sample of Domestic Drinking Water Quality

Technical Information Series 17

Iowa Department of Natural Resources

Larry J. Wilson, Director

February 1990

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ABSTRACT

The Iowa Department of Natural Resources and the University of Iowa (UI) Center for Health Effects of Environmental Contamination conducted a survey (a one-time sampling) of the quality of private drinking-water supplies used by rural Iowans. The State-Wide Rural Well-Water Survey (SWRL) was carried out between April 1988 and June 1989. The two primary objectives were to address: 1. What proportion of private rural wells in Iowa are affected by various environmental contaminants? and 2. What proportion of rural Iowa residents are utilizing well water containing these environmental contaminants?

To provide a statistically valid framework, a systematic sample, stratified by rural population density, was designed. A target of 698 sites was defined, based on statistical considerations, available funds and logistical constraints. The systematic framework was defined using every 5-minute intersection of latitude and longitude in the state; the intersections chosen for sampling sites were distributed proportionally through the population, based on county-level rural-population density. The drinking-water well closest to each chosen intersection was selected for sampling. Iowa Cooperative Extension Service county staff identified eligible participants, based on design criteria.

The effect of temporal variability in groundwater quality during the survey was addressed in two ways: 1. 10% of all sites were sampled a second time, but during a different season; 2. all sites within a county (or counties), typifying six general hydrogeologic regions in Iowa, were sampled quarterly. In addition, routine sampling was seasonally dispersed throughout the state.

Standardized procedures for field activities were employed during SWRL. An appointment was arranged for each site, so that a resident was available to interview. Information was compiled on items such as well construction, agricultural practices, water treatment, past water-quality problems, waste disposal practices, and the general health status of rural residents. The drinking water wells' construction and placement characteristics and proximity to point-sources of contamination were inventoried by field staff. Sampling points were chosen as close to the well as possible; the water-system was purged until tracking measurements stabilized. Samples for laboratory analysis were collected in pre-treated containers supplied by the laboratories. Field quality assurance and quality control (QA/QC) included blank, spiked, and duplicate samples. Custody forms tracked the movement of all sample containers.

All primary samples were analyzed for total coliform bacteria; nitrate (+nitrite)-N, ammonia-N, and organic-N; major inorganic ions; 27 commonly-used pesticides; and selected pesticide metabolites. The participating laboratories had U.S. EPA QA/QC plans in place, and the SWRL plan utilized and verified their implementation. The method detection limits (MDL) for pesticide analyses were set as the minimum practical concentration quantitation limit for each analyte in a groundwater matrix, established through QA/QC procedures. Groundwater-matrix effects necessitated an increase in some SWRL MDLs, relative to a reagent water matrix. This may cause an increase in false negative detections, but should minimize false positive detections.

Overall completion criteria were established for the survey and were met successfully. For 1. site-inventory, sample collection and analysis, and 2. return of voluntary health questionnaires, criteria of 95% and 60%, respectively, were set. These criteria were met, at 98% and 85%. The final SWRL well-water sample was 686 sites. Sample and analysis completeness were also set for each county. County criteria were met with one exception, for inorganic ions: 92 counties (of 99) were sampled at 100% of the design; 94% of the 10% repeat sites were resampled; and 93% of the quarterly sites were sampled 4 times. In total, 1,048 well water samples were collected and analyzed. Of the 686 sites, 47% were the primary rural-residence selected (i.e., closest to the 5-minute intersection), and 79% were among the first three choices. The most common reason a selected residence was not sampled was the inability to contact a current resident (70%); < 8% of persons contacted were unwilling to participate.

INTRODUCTION

As part of the implementation of the Iowa Groundwater Protection Act of 1987, the Iowa Department of Natural Resources (DNR) and the University of Iowa (UI) Center for Health Effects of Environmental Contamination (CHEEC) has conducted a one-time survey of the quality of private drinking-water supplies used by rural Iowans. Nearly all rural Iowans with private water supplies derive their water from wells. Hence, this is also a survey of the condition of these well waters and the groundwater that they tap. This report will outline the design and implementation of this survey and will serve as the basis for future reports that review the water-quality findings.

Many polls and surveys reflect a great concern among Iowans for the quality of their groundwater resources. Summaries of private water-quality data from the University Hygienic Laboratory have shown that, state-wide, an average of about 25% of all private wells exceed the recommended drinking-water standard for nitrate, and, in some areas of the state, up to 60% of all analyses from some counties exceed this limit (e.g., Hallberg, 1986 and 1987a). Local studies have also shown that pesticides are present in these groundwaters and drinking-water supplies much more frequently than anticipated (Hallberg, 1986 and 1987b; Kelley et al., 1986; Libra et al., 1987). However, it is difficult to generalize from these studies to the conditions in Iowa as a whole.

The intent of the Iowa State-Wide Rural Water-Well Survey (SWRL) is to provide a statistically valid state-wide generalization of the condition of private water supplies. This survey may also serve as a baseline for: 1) developing a long-term monitoring program for private water supplies; 2) designing water-quality sampling in other programs (such as DNR's grants program to counties, adopted in 1988, to assist counties with voluntary rural water testing); and 3) measuring future trends and changes in groundwater and/or rural private drinking water quality through further sampling of the selected sites.

SWRL was designed and conducted as a joint effort of the Iowa Department of Natural Resources, Geological Survey Bureau (DNR-GSB), and The University of Iowa (UI) Center for Health Effects of Environmental Contamination (CHEEC). Participating units in CHEEC include: the Department of Preventive Medicine and Environmental Health (PM&EH); the Department of Civil and Environmental Engineering (CEE); and the University Hygienic Laboratory (UHL). Additional support to the survey was provided by the Iowa State University (ISU) Cooperative Extension Service (CES). Principal funding for the SWRL survey came from the Iowa Groundwater Protection Fund.

This report is a summary of pertinent details of the Final Workplan and Quality Assurance Plan prepared for the SWRL study. This plan was developed interactively by the authors of this report, other members of the sponsoring agencies and university departments, and selected outside reviewers from government agencies. Comments and suggestions obtained during the peer review process were incorporated into the final workplan and quality assurance plan, as appropriate. The Final Workplan and Quality Assurance Plan is on file with CHEEC and DNR.

The subsequent discussion will describe the many contingencies that were planned, given the various complications expected during such a complex study. As an introductory note, the weather is always one variable that cannot be controlled in field studies. Ideally, this survey would have been conducted under "normal" or average climatic conditions, for a true reflection of the quality of the state's groundwater supplies. Unfortunately, 1988 and 1989, when the study was conducted, turned out to be a pronounced drought period; 1988-1989 were the two driest consecutive years ever recorded in Iowa. The state-wide average precipitation was more than 18 inches below normal (Office of the State Climatologist, Iowa Department of Agriculture and Land Stewardship). This undoubtedly will influence the number and concentrations of culturally-derived contaminants detected in the samples. Never-the-less, the SWRL study will provide an important picture of the conditions of the state's rural water supplies. Interpretation of the results must be made with the pronounced drought conditions in mind.

Objectives

The primary objectives of the SWRL survey are to answer two questions: 1. What proportion of the private rural wells in Iowa are affected by various environmental contaminants? 2. What proportion of rural Iowa residents (population) are utilizing well water containing these environmental contaminants?

In addition to addressing these two important questions, the SWRL study was also designed to collect information and conduct research into related aspects of groundwater quality and rural environmental health. For example, the following relationships, methods, and observations are being investigated as part of the SWRL study: a. the relationship between well-construction and well-placement factors and contamination of well water; b. the relationship of on-farm chemical handling practices and groundwater contamination; c. the extent of on-farm chemical spills and back-siphoning accidents; d. the relationship among local hydrogeological factors, landuse, and groundwater quality; e. the extent of solid waste and agrichemical container disposal on rural, private lands; f. the extent of use and type of home water treatment systems in rural Iowa; g. basic family health conditions in rural Iowa and the ability to link these survey data with Iowa's existing Cancer and Birth Defects Registries; h. the development and testing of analytical methods for pesticide metabolites (degradation products) in groundwater; and, i. the development and testing of toxicity screening methods for environmental contaminants in rural well water.

Because of its statistical design, the SWRL population forms a very important sampling framework both in terms of rural wells and rural residents. The study population will be used for other investigations, as appropriate, to maximize the utilization of data collected during this primary study. Additional study components have been added as new research ideas and funding sources have become available, to build upon this unique sampling framework. For example, the SWRL population is participating in a systematic survey of radon in rural homes in Iowa. In addition, the SWRL population will be used to evaluate pesticide exposure assessment methods under a contract with the National Cancer Institute. The confidentiality of the sample population can be assured by CHEEC because of the confidentiality afforded medical and health records.

SURVEY DESIGN

There were several important design elements employed to meet the SWRL objectives. First, a strategy was needed to allow selection of a statistically valid sample population. Second, methods were needed for evaluating the temporal variation of water quality during the survey period. Third, survey questionnaires needed to be designed and tested for collecting information on well construction and placement; agricultural practices, chemical handling, and waste disposal practices; and basic health status of SWRL participants. This section summarizes the design of these study elements.

Design Of The Sample Frame

Defining a sampling frame appropriate for this survey was a complex task. There is no listing or index of private wells in the state from which a sample might easily be drawn. From water-quality studies in Iowa and elsewhere, it is known that water quality as recorded by private wells is not a wholly random variable. It is affected by spatial variations in hydrogeologic conditions, and may be affected by local factors of well construction or placement which are not known in advance. While most rural Iowans use wells for their private drinking-water supplies, a non-stratified systematic survey of wells would not necessarily provide an accurate estimate of the proportion of the rural population exposed to various contaminants. Nor would a simple random sample necessarily provide the desired sampling of well-water/hydrogeologic conditions.

Thus, it was concluded that a stratified, systematic sample would be selected. This necessitated a complete, usable sampling frame. For this, a grid of every 5 minute latitude and longitude intersection in the state was generated (approximately 2,300 points). This provided a systematic frame across the entire state, unaffected by external bias.

The sample frame was then stratified according to the rural population density in each county. The population of the unincorporated areas of each county was derived from 1980 population census statistics, and the unincorporated land area of each county was calculated from various landuse inventory data. The rural population was divided by the rural land area to provide a rural population density (persons/square mile) for each county.

Three rural population density strata were defined. Stratum boundaries were derived by inspection of county population densities and compared to the boundaries statistically recommended by the Dalenius-Hodges method (Cochran, 1977). The results were consistent and the original intuitive boundaries were utilized. These three strata are: 1. the high-population density strata, comprised of 18 counties and 33% of the population; 2. medium-population density strata, 41 counties and 42% of the population; and 3. low-population density strata, 40 counties and 25% of the population. Figure 1 shows the counties included in each strata and Table 1 provides summary characteristics.

A sample size of about 700 sites was defined for the survey. This was based on various considerations: the statistical validity, the cost for the number and array of analyses desired, and the time and logistics of completing the survey in a relatively short time frame (18 months). Statistically, an appropriate sample of approximately 400 would be adequate to estimate state-wide proportions with a margin of error of approximately 5%. To significantly improve on the margin of error would require a much larger sample, because the two are related as a quadratic function. The sample of 700 was selected to provide better coverage throughout the state and to improve the power of the estimate to allow reasonable area (multi-county) estimates, as well. The 700 sites were distributed throughout the three strata in proportion to the population density. To do this, the number of sites in each stratum was compared to the number of latitude/longitude intersections in each stratum, and a proportional, systematic selection scheme was calculated. For the high-population density counties, every other intersection was selected. Additionally, every tenth remaining intersection was also selected, to achieve the target sampling proportion for this stratum. In the medium-population density counties, a three, four counting scheme was

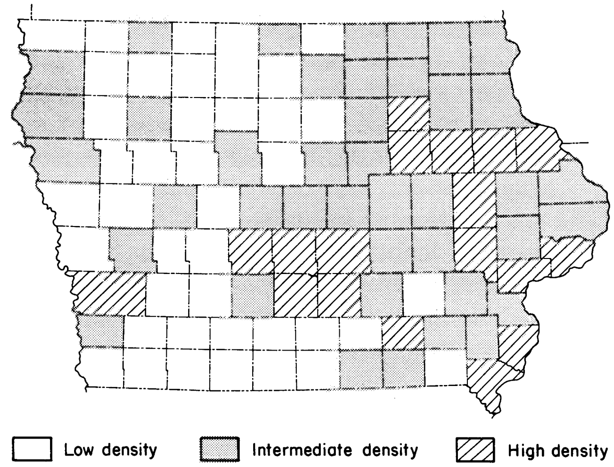

Figure 1. Counties included in each population density strata.

used (i.e., the third, seventh, tenth intersection, and so on). In the low-population density counties every fifth intersection was selected. A number appropriate to each selection scheme was chosen randomly for the first intersection within a stratum and the other intersections were then calculated.

The systematic pattern chosen for the counting/selection procedure began with the northwestern-most intersection of the northwestern-most county within each stratum. The count then proceeded due east to the eastern-most intersection in that row, then moved south one row and the count proceeded back to the west. In turn, at the west end of this row, the count would move one more row south and continue back to the east. The count proceeded in this serpentine pattern until the stratum was finished. The resulting number of intersections in each stratum and the average number per county is provided in Table 1. The locations of these intersections are shown in Figure 2. The application of these methods resulted in the selection of 698 intersections.

Identification Of Actual Sampling Sites

Once the 698 intersections were selected, rural residences with potential participants were identified. The design selection criteria required

Table 1. Summary characteristics of the population density strata.

	Population Density Strata		
	low	medium	high
Number of counties	40	41	18
Range of population density (persons/square mile)	<11	11-17	>17
% of total state population	25%	42%	33%
Number of intersections	182	287	229
Sampling fraction	0.26	0.41	0.33
Average number samples per county	4.6	7.0	12.7

sampling the private well, used as a primary drinking-water supply, that is closest to the selected intersection. Intersections were located on 1:24,000 scale, 7.5 minute series, U.S. Geological Survey topographic maps. From these maps, supplemented by plat books, the five closest prospective residences were identified and highlighted. The sole criteria for selecting these sites was their proximity to the geographic latitude/longitude intersection. Three intersections fell in incorporated areas served by municipal water supplies. For these intersections, the five closest residences in adjacent unincorporated areas were chosen. The five residences were prioritized in the following manner: the closest location was given the priority rank of 1 (being the first choice for sampling), and the remaining sites were ranked 2 through 5 (or higher, when needed) based on their increasing distance from the grid point. Where sites were equidistant, the first site encountered in a clockwise sweep, starting at the 12 o'clock position (due north), was given the higher rank. Once these five residences were identified, occupancy of the sites was determined and contacts initiated with the potential participants, to determine if they qualified and would agree to participate. This task necessitated local familiarity; the county staff of the Iowa State University Cooperative Extension Service (CES) provided this service for the project (typically, the County Agriculturist or the County Extension Director). DNR-GSB staff provided CES personnel with copies of the topographic maps on which the selected intersections and their corresponding ranked potential residences were identified. The CES staff were given instructions and copies of a short questionnaire to use for initial contacts (Initial Site Evaluation Information Form (ISE); see Appendix A). From the mapped locations CES assessed if the rank 1 site was occupied and, if occupied, if it met the selection criteria. If the rank 1 site met the selection criteria, that site was finalized, and CES staff proceeded to another map area in their county. If the rank 1 site did not meet criteria, the CES staff contacted and evaluated the rank 2 site. This process then continued until a site was successfully identified for that intersection. CES staff recorded the outcome of each contact with potential participants on the ISE form.

The ISE forms provided data used to determine participation rates. They also supplied data on reasons for non-participation (i.e., unwilling or unqualified), and the rank for each finalized site. This information was used to evaluate and identify any unintentional bias resulting from the selection process. The evaluation is summarized later in this report.

In some areas of the state, the extensive use of water supplies distributed by rural water

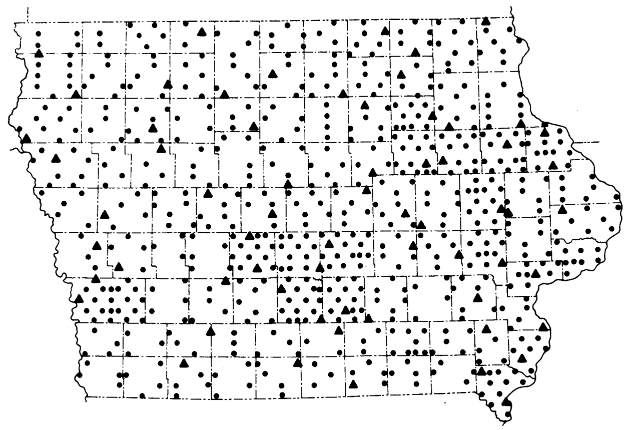

Figure 2. Locations of the 5-minute intersections selected for sampling sites (dots) and the 10% repeat sampling sites (triangles).

districts made it difficult to locate rural residences that were using a well as their primary source of drinking water. In these cases, the residence that was closest to the grid point that utilized a well for other purposes (e.g., supplemental household use or livestock) was selected for sampling. Such conditions affected 25 sites.

Temporal Variability

A concern when conducting a survey of this type and duration is the potential for temporal variability in groundwater quality. Numerous studies in Iowa have shown that groundwater quality often changes over time (Hallberg, et al, 1983, 1984, Libra et al, 1984). Aquifers directly influenced by surficial recharge are particularly susceptible to short-term changes in water quality and many rural wells utilize such aquifers. During periods of recharge, increased concentrations of surficial contaminants often occur. Some contaminants may only be detectable during these short term, often seasonal events. After contaminants move into groundwater, their concentrations may become diluted; they may degrade into compounds not included in the analyses; they may move to depths within the groundwater flow system beyond typical well depths; or they may discharge to surface water via a shallow groundwater-flow system. Hence, to adequately characterize the status of water quality where surficial contaminants are concerned, temporal variability must be addressed. While it might be ideal for a statistical survey, such as the one described here, to be conducted at essentially one point in time, it is logistically impossible. Hence, possible temporal changes were addressed through two additional sampling elements of the SWRL study.

First, 10% of all sites were resampled one time, during a different season (minimum 12 week difference) from the original sampling. A random number (between 1 and 10) was selected to identify the first repeated site; from there every 10th site was selected, for a total of 68 sites. The count pattern for this facet of the sample design cut across population strata; simply counting consecutive sites from the northwest corner of the state and proceeding east and south, following the same serpentine count pattern, described earlier. The locations of the 10% repeat sampling sites are also shown in Figure 2.

Hydrogeologic Regions And Temporal Variability

A second sampling strategy was employed to assess the temporal variability of water quality within different hydrogeologic regions of Iowa. Iowa was subdivided into six generalized areas of broadly similar soil-landscape-hydrogeologic characteristics. These characteristics affect the general nature of the susceptibility of aquifers to contamination, well construction practices, and water availability. Soil-landscape-hydrogeologic conditions also influence landuse and productivity. The six regions are characterized by relatively similar agricultural practices. A county, or counties, judged to be representative of these areas was selected, regardless of population strata or sample numbers, and all sites within these counties were sampled on a quarterly basis, during the course of the study. Figure 3 shows the hydrogeologic regions (delineated by county boundaries) and the counties selected for quarterly sampling. There were a total of 62 sites included for the quarterly sampling.

The definitions of "shallow" and "deep" bedrock used in the descriptions of the regions follow those of Hallberg and Hoyer, 1982, Libra et al., 1984, and Bruner and Hallberg, 1988; these categories have been shown to be a simple, but useful method for evaluating the potential for bedrock aquifer contamination from surface activities. The definitions are: shallow depth to bedrock, ≤ 50 feet of cover, by glacial deposits or other aquitards over the bedrock aquifers; very shallow, ≤ 25 feet of cover, with common areas of bedrock outcrop; deep, > 50 feet, ranging to several hundred feet of cover; very deep, typically > 150 feet of cover.

The six regions and some generalized characteristics are given below (counties sampled quarterly and number of sites, in parentheses):

1. *Northeastern Iowa* -- high relief, shallow, commonly very shallow depth to bedrock, which commonly is Paleozoic carbonate and sandstone aquifers; local karst conditions exist (Winneshiek County, 9 sites);

2. *Eastern Iowa* -- moderate relief, shallow to deep bedrock, with a nearly continuous mantle of relatively fine-textured Pre-Illinoian glacial deposits. Bedrock commonly consists of Paleozoic carbonate aquifers (Bremer and Washington Counties, 19 sites);

3. *South-central Iowa* -- moderate relief, shallow to deep bedrock, but generally lesser thickness of glacial deposits than region 2; Pennsylvanian bedrock with highly variable lithologies and aquifer characteristics (Lucas and Monroe Counties, 6 sites);

4. *Southwestern Iowa* -- moderate to high relief, thick loess and glacial deposits, generally deep bedrock; Pennsylvanian bedrock of variable lithologies and locally Cretaceous Dakota sandstone aquifer present, alluvial aquifers supply most community water supplies (Cass and eastern Pottawattamie Counties, 8 sites);

5. *Northwestern Iowa* -- moderate to high relief, generally thick glacial deposits and deep (to very deep) to bedrock, Dakota sandstone aquifer and related Cretaceous bedrock units are important groundwater sources, along with alluvial aquifers (Sioux County, 11 sites);

6. *North-central Iowa* -- low to moderate relief, high relief along major river valleys, area of youngest glacial deposits in the state (the Des Moines lobe; Clarion-Nicollet-Webster soils), shallow to deep bedrock; bedrock varies from Paleozoic carbonate aquifers to Cretaceous Dakota aquifer (Hamilton and southern Kossuth Counties, 10 sites).

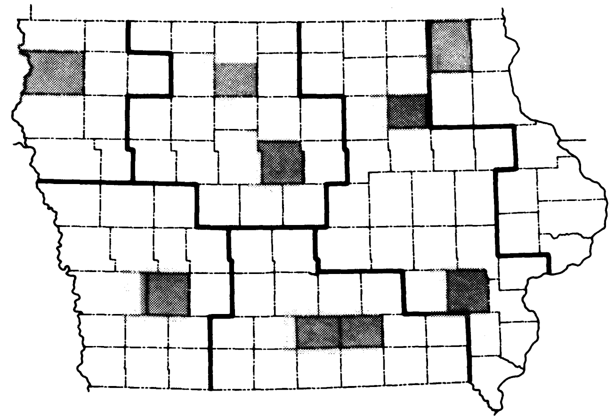

Figure 3. Hydrogeologic regions (outlined by bold lines) and the representative counties selected for quarterly sampling (shaded).

Survey Questionnaires

Information about the wells selected by the SWRL design process, the characteristics of the sites served by these wells, and the basic health status of residents were collected using four types of questionnaires. As described earlier, results of the initial contacts with potential participants were recorded on the ISE forms. Basic health data were collected using the Health Assessment Questionnaire (Appendix B). Information on the target sampling wells and associated sites was collected on either an Inventory Questionnaire for Farming Sites or on an Inventory Questionnaire for Non-Farm, Household/Suburban Sites (Appendices C and D). For the purposes of SWRL, if the residents of a particular site were actively farming the property associated with the site, the site was considered a Farming Site; all others were considered Non-Farm, Household/Suburban Sites.

MANAGEMENT PLAN

The complete management plan is described in the Final Work Plan and Quality Assurance

Plan; it discusses the operation of the SWRL study in terms of the organization and chain of responsibilities, scheduling (for sampling and progress reviews), peer review, reports, files, correspondence/meeting notes, and updates to the work plan. Pertinent details are discussed here.

Organization

Overall responsibility for performance and quality assurance of the study rests with the co-principal investigators: Dr. George Hallberg, DNR; and Dr. Burton Kross, PM&EH. Barbara Saur, PM&EH, provided assistance for project administration. Mr. Roger Bruner, of the DNR, acted as the lead Quality Assurance Officer in implementing the QA plan for this study. Mr. Bruner was not actively involved in the design or analysis of data for the study. Carol Seger was the internal QA Officer for UHL.

Other lead workers were:

1. *Biostatistics* - Dr. Leon Burmeister, PM&EH;
2. *Laboratory Services* - Dr. George Breuer, UHL; Dr. Mustafa Selim and Delon Maas, ATL; Dr. Kent Johnson, EEL;
3. *Data Management* - Dr. Chuck Lynch, PM&EH; William Berger, UHL; Andrew Dudler, PM&EH; Kerry Sesker, PM&EH; Mike Vermace, EEL;
4. *Field Coordination* - Robert Libra, DNR; Mary Lewis, PM&EH; LeAnn Weih, PM&EH; Matthew Culp, DNR; Howard Nicholson, PM&EH.

Schedule

Given the concerns for temporal variability of groundwater quality, it was not desirable to sample a large contiguous area of the state all in one time period. Hence, a schedule was developed that would not allow sampling more than two contiguous counties within four weeks of each other. Figure 4 shows the areas sampled during the second quarter of the study, as an example of the dispersion that was sought in the schedule.

Various extrinsic factors, including weather conditions, vehicle maintenance, previous field progress and scheduling difficulties, affected the schedule from time to time. The dates of

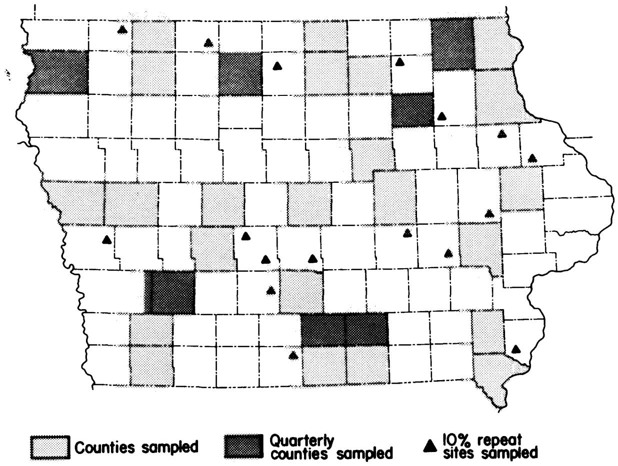

Figure 4. Counties and sites sampled during the second quarter.

sampling are summarized by county in Appendix E. Figure 5 shows the number of sites scheduled for each county.

Pilot Counties

As a check to measure the effectiveness and clarity of the site-selection process for the CES cooperators, a pilot-test of the process was run for four counties: Fayette, Chickasaw, Muscatine, and Louisa. The process operated well, and only minor adjustments were made in the instructions and ISE form. Thus, the procedures described were continued and packets containing maps, instructions, ISE forms and pre-paid return envelopes were distributed to all county CES offices. Each CES office was contacted by mail and telephone to answer questions, ensure cooperation, and thank them for their assistance. This process continued throughout the first 9 months of the project until all sample locations were successfully identified. DNR-GSB received some or all of the ISE forms from all but one county.

Peer Review

Drafts of the Work Plan and Quality Assurance Plan were subject to internal peer review by project participants and by selected members of DNR-GSB and CHEEC who were not actively involved in the design and conduct of the

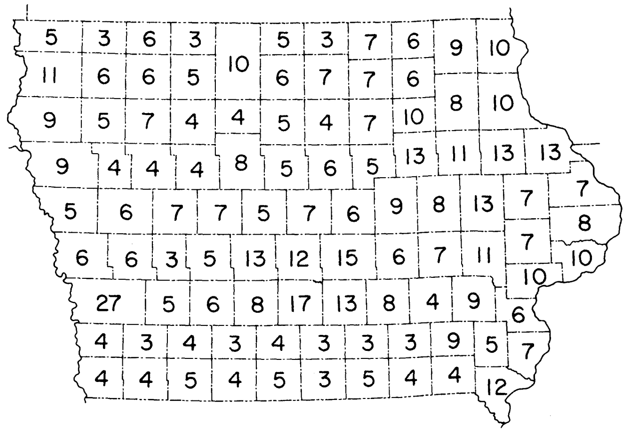

Figure 5. Total number of sites scheduled in each county.

study. In all, there were 24 reviewers during the development of the plan.

External review was also requested from the following: DNR-Environmental Protection Division and Coordination and Information Division; U.S. Environmental Protection Agency (U.S. EPA), Office of Pesticide Programs, and Region VII Office (Kansas City); Agricultural Engineering Department staff, ISU; U.S. Geological Survey, Water Resources Division; and the Illinois State Geological Survey. The questionnaires, survey instruments, and methods used in this study were reviewed and approved by The University of Iowa's Review Committee A, on Protection of Human Subjects.

Comments from the peer review process were incorporated into the Final Work Plan and Quality Assurance Plan, as appropriate. Comments are retained on file at PM&EH for future reference.

Progress Reports

Quarterly progress review meetings were held and progress reports were prepared by the field coordinator(s), beginning July 15, 1988. These reports included: the number of sites sampled; the number of samples analyzed to date; the status of data management; and a statement from the quality assurance officer. Significant problems encountered during the period and a forecast of activities for the coming period were also included. Distribution of these reports was internal to the lead workers (noted above), to other DNR officials as appropriate, and to members of the CHEEC advisory committee. The updates aided lead workers and others involved in scheduling and completing the rigorous field and laboratory agenda.

Updates To Work Plan And Quality Assurance Plan

Quarterly progress reviews also identified logistical problems and any deviations from the operating Work Plan and Quality Assurance Plan. During the early phases of the study, operating experience necessitated a few minor revisions in the procedures. The co-principal investigators, in consultation with other study participants and the quality assurance officer, updated the plans. These alterations led to the Final Work Plan and Quality Assurance Plan.

Each copy of the Work Plan and Quality Assurance Plan was numbered and a listing of controlled copies maintained by the PM&EH field coordinator. Additional copies of the Work Plan and Quality Assurance Plan were not made without the knowledge and consent of the field coordinator and a co-principal investigator. This assured that updates and changes could be conveyed to all official operating copies of the work plan; every cooperator in the project was thus aware of changes in operations and protocols.

Updates and revisions to the plan were controlled and distributed by the field coordinator. Each revised page was marked with the date of revision and substituted into the binder containing the current Work Plan and Quality Assurance Plan. Revised pages were distributed and inserted in controlled copies of the plan by the field coordinator. The field coordinator initialed and dated the plan cover page to indicate that changes had been made.

Files, Records, Working Notes, Correspondence

Centralized project files, including original forms, questionnaires, laboratory data reports, and other SWRL related paperwork have been maintained at the PM&EH Agricultural Medicine Research Facility (AMRF), located on the University of Iowa Oakdale Campus. Access to the files is restricted and is controlled by the

PM&EH field coordinator and administrative staff.

Record keeping within the participating laboratories and data management units are controlled by their individual standard operating procedures.

Correspondence originating from the SWRL study used the PM&EH, University of Iowa letterhead. Copies of correspondence relating to the conduct of the study, originating from any working unit, were sent to the SWRL Project File via the co-principal investigators. Any correspondence or communication of data from the SWRL study was reviewed by a co-principal investigator before external release of the information.

Notes were recorded at meetings and progress reviews of the SWRL study activities. Meeting notes were entered into the project file for future reference. If necessary, formal meeting notes were prepared and circulated to attendees for comment before becoming part of the file record, or as a reminder of needed actions.

Local Communication And Data Reporting

In addition to county CES staff, all county sanitarians and/or Boards of Health were contacted and informed about the study. They were also notified that correspondence to rural participants suggested their office as a local source of information about well contamination and possible health effects. Each office received an executive summary of the study, health advisory communications prepared by the U.S. EPA, and other summary information.

All correspondence to rural participants regarding data results and interpretation were signed by a co-principal investigator. Rural participants received results of nitrate and bacteria analysis prior to results for pesticide and common ion analysis, typically within a 2-4 week period following sampling. Participants were also sent materials explaining their water analysis results. Discussions of health related information (i.e., U.S. EPA Health Advisories) were included as appropriate. Appendix F contains examples of correspondence to rural participants regarding data results.

FIELD PROCEDURES

Standardized procedures for field activities were employed during the SWRL project. An appointment was arranged for each site, so that a resident would be present to interview. At each site, the appropriate inventory questionnaire was administered to a site resident. The target well was located, and its construction and placement characteristics were recorded. The presence and location of potential contaminant sources were noted, and included on a sketch-map of the site. The well was purged, and water samples were collected, according to procedures outlined in the workplan. Several water-quality parameters were analyzed in the field, immediately following collection. Samples for laboratory analysis were maintained according to procedures outlined in the workplan. The following section summarizes the field procedures employed for SWRL.

Site Inventory Procedures

Appendices C and D contain copies of the two types of questionnaires used during SWRL for farm or non-farm (e.g., rural household, suburban) site inventories. Questionnaires were, whenever possible, completed on-site, with the resident(s) most knowledgeable about each specific question. This was not always possible. In some cases the resident interviewed could not answer specific questions, but stated that another resident, if present, could supply an answer. In other cases, no one was at the site at the appointed time. In these cases the interviews were completed at a later time, usually by telephone. The other field activities (described below) were completed when possible in these cases. When it was not possible to complete these activities a second site visit was scheduled.

As part of the inventory process, the target well systems were examined for construction and placement problems, such as cracked (or absent) well casings, the presence and condition of well pits, and proximity of the wells to potential contamination sources. Landuse in the area surrounding each site was also documented. As a final part of the process, health questionnaires were given to residents, along with completion and return instructions. In those cases where no one was present at the time of the appointment, the health questionnaire was mailed to the resident.

Sampling Point Selection

Following the investigation of the well and water delivery systems, access points for sample collection were chosen. The sampling points were chosen to avoid treatment systems, if any were being used, and to be as close to the well as possible, to facilitate flushing of the delivery system. Sample collection points were noted in the inventory questionnaires, and site sketch maps.

Well Purging And Field Analyses

Well purging procedures for SWRL consisted of tracking the temperature and specific conductance of the discharging well water for a minimum of five minutes, or until these parameters stabilized. Stabilization was defined as changes in temperature and specific conductance of $< 0.5^\circ$ Celsius (C) and $< 1\%$, respectively, in a two minute interval. Temperatures were determined using standard glass laboratory thermometers, and recorded to the nearest 0.5° C. Specific conductance was determined with Fisher and YSI conductivity probes and meters. This equipment was calibrated twice daily against standard KCl solutions. Conductance was recorded to the nearest 10 $umhos/cm^2$. In addition to temperature and specific conductance, pH, alkalinity, and dissolved oxygen concentrations (D.O.) were determined in the field. These analyses were conducted after well stabilization had occurred, and before any samples for laboratory analysis were collected. The pH was determined using Beckman portable pH meters and Hach combination pH electrodes. The pH equipment was calibrated at each site against 4.01 and 10.01 pH buffers. Twice daily the calibration was checked against a pH 7.00 buffer. Alkalinity was determined by titration with standard sulfuric acid to pH 4.5; the pH equipment described above was used to track pH during the titration. The pH was recorded to the nearest 0.01 units; alkalinity to the nearest 0.5 mg/L. D.O. concentrations were measured using YSI D.O. meters and probes. The equipment was calibrated at each site in moist air, per the manufacturer's directions. D.O. concentrations were recorded to the nearest 0.1 mg/L. The results of all field analyses were recorded on standardized field measurement forms (Appendix G).

On numerous occasions equipment malfunctions resulted in less than a full suite of field parameters being analyzed. While malfunctions occurred irregularly throughout the course of the project, problems were more numerous during periods of temperature extremes--both in winter and during the exceptionally hot summer of 1988. The electronics in most portable water-quality meters function best between 35° and 90°F, and attempts were made to keep the equipment between these extremes when in use, and in transit between sites.

Collection And Custody Of Samples For Laboratory Analysis

Following the completion of all field analyses, water from the target wells was collected in the containers supplied by, and following the directions of, the participating laboratories. A summary of containers for each analysis is given below:

UHL:

1. Acid Herbicide - a one quart glass bottle with a Teflon liner in lid.
2. Insecticide - a one quart glass bottle with Teflon liner in lid.
3. Nitrogen Series - one 250 ml disposable plastic bottle with plastic lid - bottle contains sulfuric acid preservative.
4. Coliform Bacteria - one 100 ml sterile amber glass bottle with black plastic lid and styrofoam mailer.

ATL:

5. Herbicides - one clear glass quart bottle with polypropelene lid and Teflon liner.

6-7. Metabolites - two clear glass quart bottles with polypropelene lids and Teflon liners.

8. Microtox - Organic Screening - one 50 ml glass reaction tube, parafilm liner and plastic cap.

EEL:

9. Ion Chromatography - one 250 ml Nalgene bottle with lid.

10-11. TOC (Total Organic Carbon) - two 60 ml glass bottles with plastic lids.

12-13. TIC (Total Inorganic Carbon) - two 60 ml glass reaction tubes, plastic lids with Teflon septa.

14. TOX (Total Organic Halides) - one liter glass bottle with a plastic, Teflon-lined lid.

Where water treatment systems were encountered, the samples listed above were collected (if possible) from an untreated tap or hydrant. An additional subset of samples (those employing containers 1 through 5) were collected "downstream" of water treatment. This additional subset was not collected if treatment consisted only of water-softening.

Sampling points for both raw and treated water were flamed prior to collection of samples for bacterial analyses. These samples were the final samples collected at each site. All samples were filled directly from the sample point itself, not through a hose or any other device. Following collection, samples were stored in coolers, either with ice or blue-ice packs, until the samples were delivered to the appropriate laboratory. In numerous cases, samples for bacterial analysis were shipped, with blue-ice packs, to the UHL, because of the short (48 hour) holding time for bacterial samples.

Sample custody forms (Appendix H) were used to document the status and custody of all sample containers, from their issuance by each laboratory, to the field, and back. Container transfers during any part of this process were noted, dated, and initialed by the involved staff. A portion of this form was designed to be removed and shipped with samples for bacterial analysis when necessary.

Quality Control Samples And Analyses

Three types of quality control samples were used during SWRL field activities: blanks, spikes, and duplicates. Two field blank containers from each laboratory, filled with reagent water, accompanied each collection trip. The blanks were transferred, at predetermined SWRL sites, into containers identical to those used for actual sample collection. Two spike samples were supplied by the ATL laboratory for each field collection trip. These samples remained unopened during the trip, and were handled identically to actual samples. A full suite of duplicate samples were collected, and duplicate field measurements performed, at 30 predetermined locations.

Field Identification Of Sites

The vast majority of SWRL sites were identified by county-based ISU-CES staff. In some cases, Extension staff were unable to identify sites, particularly in areas where groundwater supplies are not abundant or are of poor quality, and rural water supply distribution systems are commonly used. In addition, a number of CES-identified sites could not be utilized, for a variety of reasons. For example, during the period between contact by CES staff and the interview and sampling by a SWRL field crew, some residents had moved, and the site was unoccupied; a few wells had become inoperative, because of mechanical problems or falling water levels associated with the prevailing drought conditions, etc. In these cases, field crews located sites (with the closest cooperative residents) that met SWRL selection criteria.

LABORATORY PROCEDURES

The SWRL study involved three analytical laboratories: the University Hygienic Laboratory (UHL); the Analytical Toxicology Laboratory (ATL; formerly a Pesticide Hazard Assessment Project laboratory) associated with PM&EH; and the Environmental Engineering Laboratory (EEL) associated with the University of Iowa Department of Civil and Environmental Engineering. Included below is a brief review of methods and procedures used by the laboratories for this study. Details of standard operating procedures for analytes included in this study are included in the Final Work Plan and Quality Assurance Plan.

The SWRL study was divided into two related components, described in the objectives in this report. The first component involves collection of data on specific chemical parameters in rural well-water supplies. The second component of the SWRL study was the research and development of analytical methods for pesticide metabolites, and for organic and toxicity screening of water supplies.

Analysis Of Specific Environmental Parameters

Tables 2 and 3 provide a summary of the specific water quality parameters measured for the SWRL study. A general description and reference for the standard analytical method is provided, as are the laboratory data requirements. Detailed method descriptions for each laboratory analyte are contained in the Final Work Plan and Quality Assurance Plan.

Sample holding time is defined as the allowable lapsed time from sample collection until analysis in the laboratory (for bacteria and inorganic constituents) or until the sample is extracted into an organic solvent (for pesticides). Extract holding time is defined as the lapsed time between extraction and analysis.

Protocols for determining instrument detection limits (IDL) and method detection limits (MDL) are described in the standard operating procedures for each laboratory. The limits shown on Table 2 as MDLs represent the practical concentration quantitation limit for each analyte in a groundwater matrix. Rigorous quality assurance and quality control (QA/QC) procedures were used to set these limits, particularly for the pesticide analyses. A minimum of 2-column confirmation is required on gas chromatography (GC). The laboratories routinely conducted intermittent confirmation with GC using different columns and detectors and by mass-spectrometry (MS). Internal calibration standards were analyzed in reagent water, and in a standard groundwater matrix. Field (blind) duplicates, field spikes, trip blanks and laboratory spikes, blanks, standards, and replicates were analyzed routinely as part of the QA/QC procedures for this study. Co-elution and storage degradation studies have been conducted as well. These data were evaluated and used to set the MDLs for SWRL. Matrix and interference problems necessitated increasing SWRL MDLs above reagent water derived IDL/MDLs for some analytes. The increase in MDL's for some compounds may result in false negatives, or the reported non-detection of a pesticide, when the compound is actually detected, but below the limit of confident quantitation. Similarly, the increases will also minimize the occurrence of false positive detections.

Analysis Of Research Parameters

The second component of the SWRL study was designed to develop the capacity to analyze water samples for additional environmental parameters. Table 4 summarizes the parameters and methods developed and modified. Some of these parameters, like selected pesticide metabolites, required extensive method development and testing before analyses were performed on field samples. Other parameters, like total organic halogens (TOX), are basically standard methods, but instrumentation was not available at the beginning of the study. Similarly, the Microtox procedure is well-defined for many toxicants in water, but its use to screen for low concentrations of pesticides and other toxicants required modification to the sample preparation procedures. Hence, for several research parameters, results will be available for only a subset of the total SWRL samples. Results of the research components of the SWRL study will not be included in the basic SWRL data reports, but will be published separately in appropriate scientific journals.

DATA MANAGEMENT

SWRL generated a large volume of data and data management procedures were defined to accurately and efficiently manage these records. Central to management of SWRL data was the use of a unique identifier for each site and sample. Each selected SWRL site was given a unique four-digit identifier (site I.D.). The first two digits corresponded to the county. The last two digits were derived by numbering the sites within each county using the serpentine count pattern employed for the site selection. Each individual sample was uniquely identified by the appropriate site I.D., letter code (X) designating the sample type: R for regular samples, D for duplicate samples, etc., and the date of sample collection. The identification code was in the following form:1234Xmmddyy. Dates were reported in month, day, and year order. All questionnaires and the data management form for each site were coded with this identification code.

All SWRL field paperwork was received by the data management unit upon completion of each

Table 2. Summary of environmental contaminants analyzed in SWRL samples, laboratory, methods, and data quality requirements. Table 3 lists references by analyte number.

No.	Analyte name	Other name	Lab	Method	MDL / method detection limit	Sample holding time	Extract holding time	Average % recovery	Relative % diff. of rep-licates
	Bacteria:								
1.	total coliform		UHL	Most probable number	0 to 16+ statistical function	48 hours	N/A	N/A	N/A
	Nitrogen-Series:								
2.	nitrate (+nitrite)-N		UHL	Cu-Cd reduction	0.05 mg/L	28 days	N/A	93%	7%
3.	ammonium-nitrogen		UHL	color/phenate	0.05 mg/L	"	"	98%	10%
4.	organic-nitrogen		UHL	TKN, block digest	0.10 mg/L	"	"	100%	30%
	Common Ions:								
5.	Na, Ca, Mg, K	cations	EEL	ion chromatography	0.10 mg/L	28 days	N/A	100%	10%
6.	Cl, F, sulfate	anions	EEL	" "	0.10 mg/L	"	"	"	"
	Field Measurements:				Units				
7.	Specific conductance			conductivity meter	umho/cm sq. @ 25 degrees C				
8.	Temperature			mercury thermometer	degrees C				
9.	pH			pH meter	pH units				
10.	Dissolved oxygen			D.O. probe	mg/L				
11.	Alkalinity			titration	mg/L as calcium carbonate equivalent				

No.	Pesticides: common chemical name	common trade name	Lab	Method	MDL / minimum quantitation limit	Sample holding time	Extract holding time	Average % recovery	Relative st. dev.
	Herbicides:								
12.	2,4,5-T	many	UHL	GC-ECD	0.10 ug/L	7 days	40 days	71% **	41% **
13.	2,4,5-TP	Silvex	UHL	GC-ECD	0.10 ug/L	"	"	" "	" "
14.	2,4-D	many	UHL	GC-ECD	0.10 ug/L	"	"	" "	" "
15.	acifluorfen	Blazer	UHL	GC-ECD	0.10 ug/L	"	"	" "	" "
16.	alachlor	Lasso	ATL	GC-ECD	0.02 ug/L	"	"	89%	15%
17.	atrazine	Atrazine	ATL	GC-ECD	0.13 ug/L	"	"	79%	20%
18.	butylate	Sutan	ATL	GC-NPD/ECD	0.10 ug/L	"	"	70%	16%
19.	chloramben	Amiben	UHL	GC-ECD	1.00 ug/L	"	"	71% **	41% **
20.	cyanazine	Bladex	ATL	GC-ECD	0.12 ug/L	"	"	42%	50%
21.	dacthal	DCPA	ATL	GC-ECD	0.01 ug/L	"	"	83%	14%
22.	dicamba	Banvel	UHL	GC-ECD	0.10 ug/L	"	"	71% **	41% **
23.	metolachlor	Dual	ATL	GC-ECD	0.04 ug/L	"	"	81%	14%
24.	metribuzin	Sencor	ATL	GC-ECD	0.01 ug/L	"	"	78%	25%
25.	pendimethalin	Prowl	ATL	GC-ECD	0.02 ug/L	"	"	73%	18%
26.	picloram	Tordon	UHL	GC-ECD	0.10 ug/L	"	"	71% **	41% **
27.	propachlor	Ramrod	ATL	GC-ECD	0.02 ug/L	"	"	80%	14%
28.	trifluralin	Treflan	ATL	GC-ECD	0.02 ug/L	"	"	75%	18%
	metabolites:								
29.	de ethyl atrazine	*a.	ATL	GC-ECD/NPD	0.10 ug/L	7 days	40 days	69%	29%
30.	de isopropyl atrazine	*b.	ATL	GC-ECD/NPD	0.10 ug/L	"	"	38%	37%
	Insecticides:								
31.	chlorpyrifos	Lorsban	UHL	GC-FP or NPD	0.10 ug/L	7 days	40 days	104% **	54% **
32.	diazinon		UHL	GC-FP or NPD	0.10 ug/L	"	"	" "	" "
33.	dimethoate	Cygon	UHL	GC-FP or NPD	0.10 ug/L	"	"	" "	" "
34.	ethoprop	Mocap	UHL	GC-FP or NPD	0.10 ug/L	"	"	" "	" "
35.	fonofos	Dyfonate	UHL	GC-FP or NPD	0.10 ug/L	"	"	" "	" "
36.	malathion		UHL	GC-FP or NPD	0.10 ug/L	"	"	" "	" "
37.	parathion		UHL	GC-FP or NPD	0.10 ug/L	"	"	" "	" "
38.	phorate	Thimet	UHL	GC-FP or NPD	0.10 ug/L	"	"	" "	" "
39.	terbufos	Counter	UHL	GC-FP or NPD	0.10 ug/L	"	"	" "	" "
40.	carbofuran (includes carbofuran and metabolites, derivatized as carbofuranphenol)	Furadan	ATL	GC-ECD	0.01 ug/L	7 days	40 days	47%	35%
41.	3-hydroxy and 3-keto carbofuran metabolites		ATL	GC-ECD	0.02 ug/L	7 days	40 days	47%	35%

*a & b. metabolites of atrazine; *b. also metabolite of cyanazine. ** Pooled data, reflects multi-residue method composite. UHL - University Hygienic Laboratory; EEL - Environmental Engineering Laboratory; ATL - Analytical Toxicology Laboratory. GC - gas chromatography; ECD - electron capture detector; NPD - nitrogen-phosphorus detector; FP - flame photometric detector.

Table 3. Summary and references for lab methods for analyzing SWRL water-quality analytes; referenced to the analyte numbers on Table 2.

Analyte Number;	Method Description and Reference
1; total coliform bacteria.	Most Probable Number (MPN) method; using multiple-tube fermentation, presumptive test and confirmation test; statistical derivation of MPN of coliform bacteria in 100 ml of water sample. Based on Standard Methods for Water and Wastewater Method 908A (APHA, 1985).
2; nitrate and nitrite-nitrogen.	Automated, copper-cadmium reduction and colorimetric quantitation. The method is based on U.S. EPA Method 353.2 (USEPA, 1983).
3; ammonia-nitrogen.	Automated phenate reaction, and colorimetric quantitation, using Technicon auto-analyzer IM 780-86T. Based on U.S. EPA Method 350.1 and .2 (USEPA, 1983).
4; organic-nitrogen.	Total Kjeldahl procedure with sulfuric acid, K_2SO_4, and $HgSO_4$ pre-treatment using Technicon IM 780-86T; semi-automated block digester, AAII, colorimetric quantitation. Organic-nitrogen is defined as the sum of free-ammonia and organic nitrogen compounds which are converted to ammonium sulfate, less the ammonia-N determined in procedure 3, above. Based on U.S. EPA Method 415.1 (USEPA, 1983).
5; cations,	Na (sodium), Ca (calcium), Mg (magnesium), and K (potassium). Ion chromatography, using two columns of ion exchange resins with a filtered sample. Based on the American Society for Testing & Materials (ASTM), 1984a; O'Dell et al., 1984; Topol and Ozdemir, 1981.
6. anions,	Cl (chloride), F (fluoride) and SO_4 (sulfate). Ion chromatography, using a precolumn (guard column), a separator column and a suppressor column with an anion exchange resin, and a conductivity detector, with a filtered sample. References as in 5.
7 through 11; On-site Field Measurments	7; Specific conductance; Fisher conductivity meter and temperature compensated probe, standard KCl solutions for calibration (Fisher Sci., 1987). 8; temperature, simple glass, mercury thermometer. 9 and 11; pH and alkalinity; Measured with probe and incremental titration using Beckman ph meter, Hach pH probe, Portable Water Test Kit and Digital Titrator (Beckman, 1987; Hach, 1987a, and b). 10; dissolved oxygen; YSI DO Meter and Probe with Automatic Stirrer (YSI, 1987).
12, 13, 14, 15, 19, 22, and 26; acid-based herbicides.	Hydrolyze derivatives with mechanical shaking 0.1 N sodium hydroxide; extraneous organic material is removed by a solvent wash. Acidify, extract chlorinated acids with ethyl ether by mechanical shaking in a separatory funnel or mechanical tumbling in a bottle. Convert acids to methyl esters; derivatize with diazomethane. Remove excess derivatizing reagent; esters determined by GC using an electron capture detector (ECD). The method is based on U.S. EPA, National Pesticides Survey Method 3 (USEPA, 1987).
16, 17, 20, 21, 23, 24, 25, 27, and 28; common herbicides, multi-residues.	Methylene chloride extraction; extract partitioned, using silica gel, into two fractions for gas chromatograph-electron capture detector (GC-ECD) analysis, employing two-column confirmation. Based on U.S. EPA methods, EPA-600/8-80-038, Section 10, A (USEPA, 1980, p. 431-456)
18; butylate.	Method identical to that for analyte 16, et al., except GC-nitrogen phosphorus detector (GC-NPD) analysis is used for the first fraction. Modified method from EPA-600/ 8-80-038, Section 10, A (USEPA, 1980).
29, 30; metabolites.	Method same as analyte 18, but uses GC-NPD analysis of the second fraction. Modified method from EPA-600/ 8-80-038, Section 10, A (USEPA, 1980).
32 through 39; organophosphate insecticides.	Extraction with with methylene chloride as a solvent at a neutral pH, using a separatory funnel or a continuous liquid-liquid extractor. GC with a flame photometric (FP) or nitrogen-phosphorous detector (NPD) is used for this multiresidue procedure. Based on U.S. EPA, Method 81.40 (USEPA, 1986).
40; carbofuran.	Similar to procedure for 16, et al.; second fraction derivated with pentafluorobenzyl bromide and partitioned, using silica gel, for GC-ECD analysis. Modified method from EPA-600/ 8-80-038, Section 10, A (USEPA, 1980, p. 431-456).
41; carbofuran metabolites.	3-hydroxy carbofuran and 3-keto-carbofuran; derivatization with pentafluorobenzyl bromide, GC-ECD analysis (after Jackson and Soileau, 1981).

Table 4. Water-quality parameters with methods under development in SWRL.

Laboratory/parameter
ATL Laboratory
Pesticide metabolites:
cyanazine amide; cyanazine metabolite; modification of method for analytes 29 and 30, Table 3.
2,6 diethyl aniline (DEA); alachlor hydrolysis degradate; modification from U.S. EPA, Pesticide Analytical Manual, Vol. II, Section 120.249, p. 1-4, dated 7/1/69, provided by USEPA.
Ciba-Geigy Compound 37913 and 49751; metolachlor metabolites; extraction and derivatization followed by GC-ECD and GC-NPD analysis; modification from U.S. EPA Pesticide Analytical Manual, Vol. II, Section 180.368, p. 1-21, dated 12/82, provided by USEPA.
deamino, diketo, and deamino-diketo metribuzin; metribuzin metabolites; methylene chloride extraction; HPLC (high-pressure liquid chromatography) with UV detector, after Parker et al., 1983.
Toxicity Screening:
acute toxicity; Microtox method (Microbics Corp., Inc., 1982).
EEL Laboratory
TOX; total organic halogens; minor modification of APHA (1985) method 506.
TOC; total organic carbon; minor modification of APHA (1985) method 505B (also Dohrmann instrument reference DC-180 for TOC analysis).
TIC; total inorganic carbon; modification of APHA (1985) method 505B; ASTM (1988), D4839-88 (also Dohrmann instrument Tech. Ref. TR-022).

weeks sampling. Transmittal of this paperwork to the data management unit was controlled by the field coordinator(s). A Data Management Form (Appendix I) was developed and used to direct and track the flow of data into the computer database management system. Data management staff, after checking for completeness, filed all paperwork from each site into that site's permanent folder.

Periodically, topographic maps and the DNR-GSB Well Information forms (see Appendix J) were returned to the DNR-GSB field coordinator for confirmation of township-range information, completion of the latitude and longitude information, elevation, and identification of the likely aquifer for each site. Where available, well and casing depths reported by SWRL participants were used to assign a most likely aquifer designation to each well sampled during SWRL. Reported depths were compared to existing geologic well records and relevant publications on file at DNR-GSB. These data sources provided information on the typical stratigraphy, and the types of well construction methods used in specific areas. Where deemed necessary, stratigraphers from DNR-GSB's Geologic and Mineral Resources Section were consulted. Once this process was completed, the data were entered into the computer at the DNR-GSB and electronically transferred to the SWRL database.

Questionnaires, data transmittal forms, and field measurement forms were reviewed by data management, before data entry, to assure that data entry functions were easily and accurately accomplished directly from the questionnaires and forms. Some pre-editing of particular questions was necessary to facilitate data entry in an accurate and expedient manner.

Analytical data from the laboratories was transmitted to the PM&EH field coordinator in hard copy, for permanent file. In addition, UHL data was directly transferred electronically from UHL's Perkin-Elmer LIMS 2000 computer system to other data management units. Procedures for direct electronic data transfer of UHL results into the database management system were in place from previous projects. Data from the other laboratories were entered into the data base manually at PM&EH. Verification of manual data entry was accomplished by comparison with hard copy information. Additional quality assurance checks were done electronically, by having data sets entered by a second operator, and using the data base software to compare for differences between the two data sets.

In addition to routine analytical results, ATL and EEL reported selected quality control data for each analyte. The additional information included items such as: date sample received at laboratory; date sample extract prepared (pesticides only); date sample analyzed. This information and calculated holding times will be included in the database. Similar data regarding SWRL analyses performed at UHL are on file at UHL.

QUALITY ASSURANCE PLAN

Good professional practice dictated that environmental measurements for the SWRL study be adequately conceived, documented, and executed so that the resulting data can be used with a definable degree of confidence. The Work Plan and Quality Assurance Plan was developed in accordance with the U.S. EPA document "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring" (U.S. EPA, 1984). This plan became an integral part of the operation and quality assurance plans for each organization involved in the SWRL study. Details of quality assurance and quality control (QA/QC) procedures vary among the organizations involved and in relation to the analytical procedures used. No effort was made to develop wholly common approaches, because systems were already in place for tracking of samples and for internal lab calibration. All the labs have existing U.S.EPA-reviewed QA/QC plans. The philosophy of the SWRL plan was to utilize existing QA/QC procedures and to verify that these procedures were being implemented fully for the SWRL study.

Copies of organizational quality assurance plans, applicable standard operating procedures, and results of previous quality assurance audits are maintained by each organization. This information was reviewed by the project QA officer and co-principal investigators during the development of the SWRL work plan.

Quality Assurance Procedures

The quality assurance procedures for the SWRL project were designed to evaluate different facets of the program, both quarterly, and after work had been completed. QA/QC plans were in place from the beginning of the SWRL project, but there were unique problems associated with a program of this magnitude. Hence, during each quarter a different aspect of the SWRL program was evaluated and recommended changes were implemented to rectify any shortcomings found by the audit. The first-quarter audit covered field sampling and inventory questionnaire design and implementation, as well as individual laboratory sample tracking, documentation, and laboratory quality control. The second-quarter audit further evaluated the field water-quality testing procedures. The third-quarter audit covered individual laboratory sample and extract-holding times. The fourth-quarter audit reviewed overall laboratory data-management and processing, and repeated sample tracking and documentation. The project quality assurance officer was responsible for monitoring implementation of these procedures, the quality of data generated from the SWRL study, and reporting the results of this effort to the co-principal investigators.

The only problem of concern noted during the audits was violation of sample and extract holding times for a few samples and a few analytes. Holding time studies are underway and initial results indicate a slight but statistically

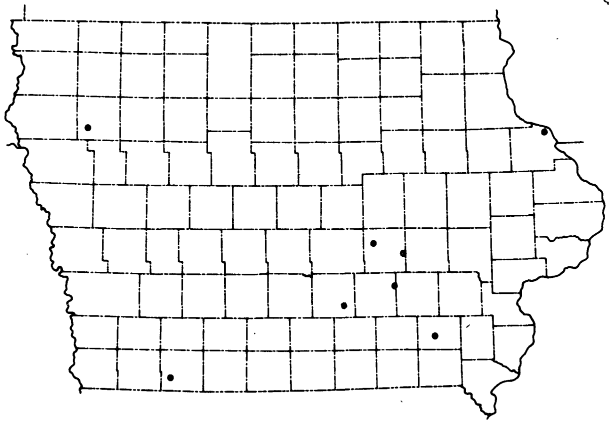

Figure 6. Location of sites where samples were not collected.

significant decrease in the concentration of carbofuran after the holding-time limit is exceeded. This may tend to increase the number of false negatives in the water-quality database (i.e., the decrease in concentrations may lower some true detections below the practical quantitation limit). Further analysis of the complete holding time study should allow a better understanding of the possible number of false negatives.

Survey Completeness Criteria

Completion criteria for the minimum numbers for field sample collection and analysis and the voluntary return of health-questionnaires were set at 95% and 60%, respectively, of the original sample. These standards were met for the state-wide data set. During the course of the study, field sampling was completed at 98.3% of the 698 sites included in the original SWRL sample. Samples were not collected at eight sites; these are shown on Figure 6. The overall return rate for health questionnaires to date is 85%.

Sample completeness criteria were also established for each county. The criteria was set at 50% of the sites originally scheduled in a county. This seemingly low level was selected because in some counties the choice of a completeness percentage is limited by the low number of sites. For example, in counties which have only three sites the choices for levels of completeness are 33%, 66%, and 100%. Setting the completeness at the 50% level made it feasible to meet the criteria, while assuring the sampling of a majority of sites in each county. Sample completeness was met for each of the 99 counties in Iowa. Completion was 100% for all counties except for seven (Table 5).

Sample completeness for each of the analytes in Table 2 was set at 95% of the original sample and 50% of the sites in each county. The state-wide sample completeness criteria were met for laboratory analysis for all analytes. County completion criteria were met for laboratory analysis for all analytes except for anion and cation analysis in Hardin County.

The sample framework for the 698 wells in the original sample was subdivided into 575 wells scheduled to be sampled once, 68 wells scheduled to be sampled twice (10%-repeat sites), and 62 wells scheduled to be sampled four times (quarterly sites) during the course of the study. Table 6 displays the number of sites scheduled, the number actually sampled, and the completion rates for each category. Category totals do not sum to 698 because 7 quarterly sites are also 10%-repeat sites. The change in number of quarterly sites reflects the loss of one site where a participant declined to participate in further sampling.

Table 5. Completion rates for counties where sampling was less than 100% of the original sample.

County	Completion Rate
Powesheik	67%
Jefferson, Taylor	80%
Cherokee	83%
Marion	85%
Mahaska	88%
Dubuque	92%

A total of 1,048 samples were collected from the 686 sites during the course of the study. Each site was scheduled to have a regular sample taken. Regular samples are of raw groundwater sampled from a site's well head or nearby hydrant. Additionally, treated water samples were taken at sites which used a water purification system. At sites where a resident

Table 6. Summary of sites scheduled and sampled, by category.

Site category	Total scheduled	Number sampled	Completion rate
Total Sites	698	686	98.3%
One Time Sites	575	565	98.3%
10% Repeat Sites			
First Sample	68	68	100.0%
Second Sample	68	64	94.1%
Quarterly Sites			
First Sample	62	58	93.5%
Second Sample	62	58	93.5%
Third Sample	61	56	91.8%
Fourth Sample	61	57	93.4%

used rural water district supplies as the primary drinking-water source, a sample from this source was taken in addition to the regular sample from the well on the site. These samples were taken so that future studies of the health information gathered from participants might be accurately compared to both present and past drinking water supplies. Duplicate regular samples were taken at 5% of sites randomly chosen prior to initiation of the field sampling for the study. Table 7 presents the number of samples taken for each category.

Table 7. Summary of samples collected and analyzed, by category.

Sample Category	Samples	Sites
Regular	922	686
Treated	70	54
Rural Water	13	10
Duplicates	43	30
Total	1,048	690

Eighty-six percent of the duplicate samples were collected. The five missing duplicates should not present a problem based on the reproducibility of the remaining duplicate samples and their regular counterparts.

Each site sampled has both an inventory questionnaire and a health questionnaire associated with it. Each site was classified as either a farm or non-farm site dependent on whether the participant actively farmed the site where the well was located. The type of inventory questionnaire administered at a site reflected the site's classification as either farm or non-farm. In total, 467 farm and 215 non-farm sites were inventoried. The health questionnaire for each site includes a section for health information from each member of the sites household. Health questionnaires were likewise classified as farm or non-farm. The inventory questionnaires were administered on site, or in some instances by telephone contact with the residents as previously described. The health

Table 8. Summary of questionnaires completed, by category.

Questionnaire category	Number completed	Percent of Sites
Inventory	682	99.4
Family Health	585	85.0
Individual Health	1,769	na

Table 9. Distribution of sampled sites by rank.

Rank	Number of sites	Percent of sites
1	275	47.4%
2	116	20.0%
3	70	12.1%
4	51	8.8%
5	32	5.1%
6	35	6.0%
7	1	0.2%
Total	580	100.0%

Table 10. Summary of responses for sites with complete ISE sets.

Total Sites 171
Total Responses 351

Response:	no.	%
Unable	245	69.8%
Unwilling	27	7.7%
Unqualified	79	22.5%

questionnaires were left with the resident and they were asked to voluntarily complete these questionnaires for all family members and return them by mail.

Table 8 presents the total number of questionnaires completed for each of these categories for both inventory and health questionnaires.

Evaluation Of Site Selection Process

Initial Site Evaluation Forms (ISE) for rank locations were returned to DNR-GSB when CES personnel had completed the participant selection process for a county. This afforded an evaluation of why more than one ranked location at a site was contacted and whether reasons that a non-selected rank site didn't qualify had any significance on the outcome of the study.

The conclusion of this evaluation is that the site selection process did not bias the outcome of the study. The average rank of SWRL sites was low, rank 2, and at 47% of the sites contacted, the household associated with rank 1 agreed to participate. These indicate that the selection process most commonly secured participation from rural residents nearest to the geographic grid point. The most frequent reason for not selecting a rank site was that CES personnel were unable to contact a household associated with that rank. This most likely reflects changes in rural residence patterns which could not be accounted for during the process of identifying ranks on topographic maps. The overall participation rate was 81% with an average of 1.2 contacts per site. The high participation rate is consistent with rates experienced in other Iowa studies by the investigators.

The summary of the SWRL participant selection process is based on ISE data for 580 sites for which there was an assigned rank for the site selected. Distribution of the sampled site ranks are presented in Table 9. At some sites a rank was not assigned to the site sampled. Sites were left unranked when the actual sample location did not match precisely the rank location on the topographic map. This occurred when topographic maps used did not reflect current residential patterns. Of necessity some participants were identified by field crews. These sites were also left unranked because the participant identification process differed from that used by CES personnel. These circumstances affected 106 sites.

The set of 580 ranked sites was further subdivided into data for sites with complete ISE sets, and data for sites with incomplete ISE sets. If completed ISE forms returned to DNR-GSB for a given site included forms for all the non-selected ranks preceding the selected rank, the site was considered to have a complete set of data. Rank 1 sites were not considered in this subdivision because there were no preceding ranks. There are 171 sites with complete ISE sets. The ISE responses for why a preceding rank was not selected were: 1) unable to contact a household, 2) household was unwilling to participate; and 3) household was unqualified because well water was not the primary source of drinking water. Table 10 shows the total number of responses by category for sites with complete ISE sets. Percentages are based on total number of responses.

For each site with a complete ISE set, the

Table 11. Summary of contact responses.

Agreed to participate	81%
Unwilling to participate	5%
Unqualified to participate	14%

number of ranks where CES staff were unable to contact a resident was subtracted from the sites sampled rank number. This yielded the actual number of contacts for each site (i.e., where a person associated with a rank was spoken to). These data, and the number one ranked sites, enabled estimation of adjusted response rates by 1) agree, 2) unwilling, and 3) unqualified to participate; only 5% of actual contacts were unwilling to participate (Table 11).

SUMMARY

As part of the implementation of the Iowa Groundwater Protection Act of 1987, the DNR in conjunction with CHEEC conducted a one-time survey of the quality of private drinking-water supplies used by rural Iowans. The State-Wide Rural Water-Well Survey (SWRL) was conducted between April 1988 and June 1989, under pronounced drought conditions. This report summarizes the objectives, design, management, and procedures followed during the conduct of the survey.

The primary objectives of SWRL were to answer two questions: 1. What proportion of the private rural wells in Iowa are affected by various environmental contaminants? 2. What proportion of rural Iowa residents are utilizing well water containing various environmental contaminants?

The SWRL survey was also designed to collect information about the well construction, agricultural, water treatment, and waste disposal practices of rural residents, and to assess their general health status. The affects of temporally variable water quality on the implications of results from single samples were addressed. Research components of SWRL included the development and testing of analytical methods for pesticide metabolites, and for organic and toxicity screening of groundwater.

To provide a statistically valid framework to answer these questions, a systematic sample, stratified by rural population density, was designed. The systematic framework was defined using every 5-minute intersection of latitude and longitude in the state; this grid of latitude-longitude intersections provided an independent systematic sampling grid across the state. Inspection of county-level rural population densities defined three strata that were verified statistically. The intersections chosen for sampling sites, were distributed proportionally through the three population strata. A target of 700 sites was defined, based on statistical considerations of the margin of error of the estimates, available funds, and logistical constraints to sample and inventory this many sites.

The systematic scheme used for the distribution and selection of intersections to be sampled, resulted in 698 latitude-longitude intersections initially chosen for the survey. The drinking-water well closest to each selected intersection was chosen as the primary target for sampling. Iowa State University Cooperative Extension Service (CES) county staff identified eligible participants, based on design criteria.

Each selected intersection was highlighted on U.S.G.S.-7.5 minute topographic maps, as were the five closest residences shown on the maps. The residences were ranked one through five (or higher, if needed), in the order of their proximity to the target intersection. Copies of these maps, along with initial interview forms and instructions, were distributed to CES offices in each county. CES staff determined if the residences on the maps were actually occupied, if the residents used a well as their primary source of drinking water, and if the residents were willing to participate. This process encountered problems in a few areas served by rural water distribution systems. A few sites had to be located in the field by SWRL sampling crews in these areas.

Temporal variability of groundwater quality during the survey was addressed by two elements of the survey design. The first element chose 10%, or 68, of all selected sites for a one-time repeat sampling during a different season. A systematic counting scheme was used to identify these sites. The second element divided Iowa into six general hydrogeologic

regions with broadly similar soil, landscape, and geologic characteristics. A county or counties typifying each of these regions was selected, and the 62 sites within these counties were sampled quarterly. With these concerns for temporal variability, the schedule for SWRL field activities was set in advance, and designed to disperse sampling across the state during each season. This schedule did not allow more than two contiguous counties to be sampled within four weeks of each other.

Overall responsibilities for project management were shared by co-principal investigators from the DNR and PM&EH. Other lead workers were designated as responsible for various aspects of the study: QA/QC, biostatistics, laboratory services, data management, and field coordination.

Standardized procedures for field activities were employed during SWRL. Information about the wells selected for sampling, characteristics of the residences associated with these wells, and basic health information on the participating residents were collected on questionnaires designed specifically for SWRL. An appointment was arranged for each site, so that a resident was available to interview. The target well was located, and its construction and placement characteristics were recorded. The presence and location of potential point sources of contamination were noted, and included on a sketch-map of the site. Sampling points were chosen as close to the well as possible while avoiding water treatment devices. Wells were purged prior to sample collection, until repeated temperature and specific conductance measurements stabilized. Alkalinity, pH, and dissolved oxygen concentrations were determined in the field. Samples for laboratory analysis were collected in containers supplied by, and following the directions of, the participating laboratories. Field-related QA/QC (quality assurance and quality control) protocols included blank, spiked, and blind-duplicate samples. Custody forms documented the movement and custody of each well-water and QA/QC sample, from each laboratory to the field and back.

All primary well-water samples collected were analyzed for total coliform bacteria; nitrate (+nitrite)-N, ammonia-N, and organic-N; major inorganic ions; 27 commonly-used pesticides; and selected pesticide metabolites. Analyses were performed by three laboratories: the University Hygienic Laboratory; the Analytical Toxicology Laboratory, with the UI Department of Preventive Medicine and Environmental Health; and the Environmental Engineering Laboratory, with the UI Department of Civil and Environmental Engineering. Methods were developed and tested for additional pesticide metabolites, and for organic and toxicity screening of groundwater, during the project. Therefore, not all samples were analyzed for these parameters.

The labs had U.S. EPA QA/QC plans in place, and the SWRL plan utilized and verified their implementation. The method detection limits (MDL) for pesticide analyses were set as the minimum practical concentration quantitation limit for each analyte in a groundwater matrix, established through QA/QC procedures. These included a minimum two-column confirmation with gas chromatography; intermittent confirmation with other columns and/or detectors, and with mass spectrometry; standards prepared with both a reagent water and a groundwater matrix; field and laboratory QA/QC samples; and co-elution and storage degradation studies. Groundwater-matrix effects necessitated an increase in some SWRL MDLs, relative to a reagent water matrix. This may cause an increase in false negative detections, but should minimize false positive detections.

Accurate and efficient data management was central to the SWRL design. Each individual site and sample were given a unique identifier. All field paperwork was transferred to the data management unit upon completion of each weeks field collection. Data management reviewed for completeness and edited the paperwork, in preparation for data entry. A form was developed to direct and track the flow of data to a computer data base. Analytical data from participating laboratories were transferred to data management both electronically and in hard-copy form. Verification of proper data entry/transfer was accomplished both electronically and by comparison with hard copy.

The Final Work Plan and Quality Assurance Plan for SWRL was developed in accordance with "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring" (U.S. EPA, 1984). As noted, each participating laboratory had existing U.S. EPA QA/QC plans in place. The SWRL design was to utilize these existing plans, and to verify their full implementation during SWRL. Different facets of the program were examined both quarterly and following completion of specific work efforts. The only problem of concern was violation of maximum holding times for a few samples. The effects of the holding time variance are under evaluation.

The Final Work Plan and Quality Assurance Plan for SWRL set overall completion criteria for sample collection and analysis, and for health questionnaire return, at 95% and 60%, respectively; these criteria were met, at 98% and 85%. Only eight sites were not sampled; samples from three sites were of rural water systems only; and at one site, only treated water was available to sample. Therefore the final SWRL sample of raw well water was 686 sites. Sample and analysis completeness were also set at 50% for each county. The small number of sites in some counties necessitated that this standard was set lower than the state-wide criteria. This criteria was met except for the analysis of major inorganic ions in one county. Overall, 92 of 99 counties were sampled at 100% of the initial design. The lowest single county completeness rate was 67%. Ninety-four percent of the 10% repeat sites were resampled, and 93% of the quarterly sites were sampled four times. In total 1,048 well water samples were collected and analyzed during SWRL.

Of the 686 sites SWRL sites, 580 had a verifiable assigned rank from the initial site selection procedure. Of these, 47% were rank one and 79% were sites of rank one through three. The most common reason a potential residence was not selected and sampled was the inability to contact a resident (70%). Less than 8% were unwilling to participate, and almost 23% did not use a well on the premise as their primary source of drinking water.

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The Iowa State-Wide Rural Well-Water Survey was supported, in part, through the Iowa Groundwater Protection Act and the contributed time of the many cooperating agencies and institutions. Also, grants from the U.S. Environmental Protection Agency (USEPA), Region 7, Kansas City, supported parallel efforts which helped to develop the methods and capabilities for analysis of metabolites used in the survey. Without the direct services and cooperative efforts of the Iowa State University Cooperative Extension Service (CES) the survey would not have been possible. The excellent cooperation of most county CES staff in providing the initial screening and evaluation of sites was invaluable. The Integrated Farm Management Demonstration Project, and the Iowa Department of Agriculture and Land Stewardship (IDALS) provided some staff support for the project, as part of Iowa's Agricultural Energy Management programs.

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Perhaps the greatest thanks must go out to the people of Iowa who collaborated in this study. The many private citizens who participated, and gave willingly of their time, were the key to the success of this survey, and indeed are the key to the continued success of Iowa's groundwater protection programs.

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APPENDIX A.

Initial Site Evaluation Information Form

August 5, 1988

Joseph E. Narigon, CED
ISU Extension
1202 E. 2nd
Indianola, Iowa 50125-2802

Dear Mr. Narigon:

Thank you for your assistance in identifying eligible cooperators for the rural water quality assessment. Enclosed are xerox copies of topographic maps. Each map contains one numbered latitude-longitude intersection, highlighted in color. We have ranked, 1 to 5, what appears to be the nearest dwellings to the latitude-longitude point (this is the number to be entered in the rank blank on the enclosed forms). These are the residences we would like you to contact. Residences ranked 1 are the primary sites. There is no need to contact those ranked 2 if residence 1 is occupied, has a well that is used as a drinking water supply, and the occupants are willing to cooperate, answer the questionnaires, etc. If residence 1 does not meet these criteria, proceed to 2, and if necessary 3, and so on.

Forms are provided to aid you during the contact. Please note that these forms should be filled out for all contacts, including those who do not qualify; we are keeping track of all contacts made, as part of evaluating the sample scheme design. Also enclosed is a pre-paid and addressed envelope for you to return the maps and forms in when you have finished. As this project must be completed by June 30, 1989, we hope you will be able to work this into your busy schedule as soon as possible.

Some problems may arise during this contact process. Some of the latitude-longitude intersections will fall within incorporated areas, or other areas where many residences are using some other type of public water supply. We have tried to keep our ranked residences out of such areas when we were aware of them, but that will not always be the case. In such area, feel free to contact a nearby residence that does use a well to supply drinking water, or contact our office with questions.

Thank you again for your cooperation. A project with the scope of this statewide assessment needs local cooperation to hope to succeed, and yours is greatly appreciated.

Sincerely,

Robert D. Libra
Hydrogeologist

Matthew C. Culp
Research Geologist

RDL:mph
Enclosure

INFORMATION SHEET

BACKGROUND INFORMATION:

With the increasing concerns and problems with groundwater contamination in Iowa, the Iowa Department of Natural Resources (DNR) is conducting a survey of private water supplies to determine the extent of water quality problems for Iowa's farm and rural population. The University of Iowa Department of Preventive Medicine, the University Hygienic Laboratory, and the Iowa State Cooperative Extension Service are cooperating with the DNR to conduct this survey.

Statewide, 700 rural households have been statistically selected to be sampled. These households are being contacted by the County Extension Office to determine their eligibility and willingness to participate in the study. The drinking water supply of the participant will be tested, at no cost to the participant, for nitrate, bacteria, pesticides, and other chemicals.

Participation by a household is voluntary. Each of the participants will receive all of the analysis and other information from the study. The results and participation of individual households will be kept confidential; information gathered will be used only in summary form.

During the study, Geological Survey Bureau, staff from DNR will visit a participant's property and inventory their well and water system, sample it, and assess any problems that might affect their water quality. They will also briefly interview the participant to get some background information about the well (age, depth, etc.), water problems they may have experienced, and land use information for their property. They will also leave a questionnaire for participants to fill out and mail in to the Department of Preventive Medicine. This questionnaire is related to the general health of the participant's household.

TOPOGRAPHIC MAPS AND SITE EVALUATION FORMS:

Each topographic map contains one numbered latitude - longitude intersection, highlighted in color. We have ranked, 1 to 5, what appear to be the nearest dwellings to the highlighted intersection. These are the residences we would like you to contact using the site evaluation forms, beginning with the dwelling ranked one. Once you have identified a willing and eligible participant, you do no need to contact succeeding ranks. For example, if you have contacted rank 1 and the household is willing and eligible to participate, then you do not need to contact ranks 2 through 5.

The site evaluation forms contain a series of questions to identify a household's willingness to participate and eligibility. Essentially, a household qualifies for the study if they are willing to have their water sampled and answer the interview questions and have a well or spring which is used as their primary source of drinking water. It may be helpful to use the background information as an introduction to the study before beginning to ask the questions on the site evaluation form.

Please note that on the first page of each site evaluation form, there is a blank space following the site number which corresponds to the map. In this space we would like you to enter the rank number of residences you contact. The forms need to be completed and returned for all contacts, including those who do not qualify. We are keeping track of all contacts made as part of evaluating the sample design. For example, if you were to contact ranks 1, 2, and 3 for a site and ranks 1 and 2 do not quality but 3 does, please complete and return all three forms.

Once you have completed the process of contacting and identifying participants for the study, please return the maps and forms to the Geological Survey Bureau in the envelope provided.

PROBLEMS:

Some problems may arise during this contact process. For example the ranks we have identified may be within incorporated areas or on some other public water supply. Or, you may not be able to identify a willing participant from the ranks we've identified. Under such circumstances please feel free to contact a nearby residence which does qualify, and note the location on the map.

If you have any questions or would like more information, please contact our office. Our number is (319)335-1575.

Iowa Department of Natural Resources, Geological Survey Bureau,
and The University of Iowa Center for Health Effects
of Environmental Contamination

Initial Site Evaluation Information Form

1. ______________ Name of County ______________ Site Number Rank __ __/__ __/__ __ Month Day Year (Today's Date)

RANK IS THE SEQUENCE NUMBER OF THE OPTIONS
FOR AN INDIVIDUAL SITE NUMBER
(i.e., 1=first choice; 2=second choice, etc.).

2. Person Conducting Interview:
(FILL OUT ONCE WITH YOUR FULL ADDRESS. THEREAFTER, JUST INITIAL YOUR NAME.)

Name: ______________________ First ______________________ Last

Telephone Number: __ __ __/__ __ __/__ __ __ __

Mailing Address: ______________________ (Street, P.O. Box, etc.) ____________ City ________ State ________ Zip Code

FOR ALL "Yes" OR "No" QUESTIONS, CIRCLE THE APPROPRIATE ANSWER.

3. Was it possible to contact a member of a household associated with this Site Number and Rank? Yes No

IF "No", GO TO A NEW FORM AND EVALUATE THE
NEXT RANK OPTION. OTHERWISE CONTINUE.

4. Method for contacting this person:
(CIRCLE APPROPRIATE NUMBER.)

1 = Telephone
2 = In person
3 = Other - Specify: ______________________________

INTRODUCE YOURSELF AND EXPLAIN THE SURVEY
BY REFERRING TO THE INFORMATION SHEET.

5. Are you willing to participate in this survey? Yes No

IF "No", GO TO A NEW FORM AND EVALUATE THE
NEXT RANK OPTION. OTHERWISE CONTINUE.

THE NEXT FEW QUESTIONS ARE REQUIRED TO EVALUATE WHETHER QUALIFICATIONS FOR THIS SURVEY ARE SATISFIED.

6. What is your:

Name? ________________________ ________________________
First Last

Telephone Number? _ _ _/_ _ _/_ _ _ _

Mailing Address? ________________________ ____________ ________ ________
(Street, P.O. Box, etc.) City State Zip Code

7. Is there an operating well (or spring) at this site? Yes No

IF "No", GO TO QUESTION 10. OTHERWISE CONTINUE.

8. Is the water from this well (or spring) used as the <u>primary</u> source of drinking water for the household? Yes No

IF "Yes", INFORM THE CONTACT THIS SITE <u>DOES</u> MEET QUALIFICATIONS FOR THIS SURVEY. THEN GO TO QUESTION 11 ON THE NEXT PAGE. OTHERWISE CONTINUE.

9. Is this well (or spring) water used for:

Drinking water part of the time?	Yes	No
Household use other than drinking water?	Yes	No
Livestock?	Yes	No
General farm or outdoor use (e.g., watering lawn, washing vehicles, etc.)	Yes	No
Other?	Yes	No
If "Yes", specify: ________________________		

10. What is used as the <u>primary</u> source of drinking water for members of the household?

Rural Water Association	Yes	No
If "yes", specify name: ________________________		
Nearby Town Water Supply	Yes	No
If "yes", specify name of town: ________________		
Pond	Yes	No
Rainwater	Yes	No
Bottled water	Yes	No
Other	Yes	No
If "Yes", specify: ________________________		

INFORM THE CONTACT THIS SITE <u>PROBABLY DOES NOT</u> MEET QUALIFICATIONS FOR THIS SURVEY. THERE IS A SMALL CHANCE THAT THE DNR-GSB STAFF WILL BE INTERESTED IN INCLUDING YOUR WATER SUPPLY IN THIS SURVEY. IF SO, THEY WILL PERSONALLY CONTACT YOU.

<u>GO TO A NEW FORM AND EVALUATE THE NEXT RANK OPTION.</u>

11. Do you <u>own the property</u> on which the well is located? Yes No

IF "Yes", GO TO QUESTION 13. OTHERWISE CONTINUE.

12. What is the property owner's:

Name? ______________________ ______________________
First Last

Telephone Number? _ _ _/_ _ _/_ _ _ _

Mailing Address? ______________________ ____________ ________ ________
(Street, P.O. Box, etc.) City State Zip Code

13. Do members of the household <u>farm the land</u> around this site? Yes No

14. How <u>many individuals</u> currently use this well water as their <u>primary</u> source of drinking water? ______ NUMBER

15. Should further correspondence about this survey be directed to you? Yes No

IF "Yes", GO TO QUESTION 17. OTHERWISE CONTINUE.

16. To whom should further correspondence be directed?

Name: ______________________ ______________________
First Last

Telephone Number: _ _ _/_ _ _/_ _ _ _

Mailing Address: ______________________ ____________ ________ ________
(Street, P.O. Box, etc.) City State Zip Code

17. What day(s) of the week and time(s) of the day are <u>best</u> for future contact? ______________________________

18. Are there any extended periods of time during the next 6 months when contact <u>should not</u> be made? Yes No

IF "No", GO TO END OF QUESTIONNAIRE. OTHERWISE CONTINUE.

19. When are these time periods? ______________________________

END OF QUESTIONNAIRE. THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

FUTURE CONTACT WILL BE MADE BY DNR-GSB STAFF TO GIVE FURTHER INFORMATION AND TO ARRANGE A SAMPLING TIME. IF (HE/SHE) WOULD LIKE FURTHER INFORMATION NOW, THEY MAY CALL: 319/335-1575, FOR

Matt Culp, Bob Libra, or Deb Quade at the
Department of Natural Resources
Geological Survey Bureau
123 N. Capitol
Iowa City, Iowa 52242

APPENDIX B.

Health Assessment Questionnaire

The Iowa Statewide Rural Well Water Survey
Iowa Department of Natural Resources, Geological Survey Bureau,
and The University of Iowa Center for Health Effects
of Environmental Contamination

Health Assessment Questionnaire

Thank you very much for participating in this study. We greatly appreciate your time and effort.

Iowa citizens and the Iowa General Assembly are very concerned about drinking water quality in the State of Iowa. Because of this concern, funds have been appropriated to analyze your private drinking water for nitrates, bacteria, and pesticides at no cost to you. As part of these analyses, a health assessment questionnaire has been developed to enable health investigators in the Department of Preventive Medicine and Environmental Health at the University of Iowa College of Medicine to better understand your family's health status.

Your participation is, of course, entirely voluntary but is very important to the success of the study. All answers you give will be kept completely confidential under the provisions of the Federal Privacy Act of 1974. Study results will be expressed in the form of statistical summaries only, and names or other identifying information will not appear in any publication resulting from this study.

PLEASE READ THE INSTRUCTIONS ON THE NEXT PAGE BEFORE FILLING OUT THE QUESTIONNAIRE.

If you have any questions about the study, please feel free to telephone contact Dr. Charles Lynch, who is conducting this portion of the study, or Mary Lewis, the Research Assistant, collect at (319) 335-4221.

* Please complete the following questions either by circling the number that best fits your situation or by writing an answer in the space provided.

  For example:

  d. Sex: (CIRCLE NUMBER.)

  1 MALE
  2 FEMALE

  To answer this question you would circle "1" if you are "MALE" or "2" if you are "FEMALE".

  3. What is your telephone number? __ __ __ - __ __ __ - __ __ __ __

  To answer this question you would fill in the area code followed by the remaining seven digits in your number.

  16. What has been (his/her) usual occupation? ____________________
  USUAL OCCUPATION

  To answer this question you would fill in the usual occupation above the line that is provided.

* Circle only one number for each question.

* In some questions we ask you to fill in a number. If you cannot remember the exact number, please provide your best guess.

* Some questions have written instructions telling you to skip certain questions that do not apply to you. Please answer all questions unless you are told to skip them.

^F1^

1. ^F2^ Name of County ^F3^ Site Number __ __/__ __/__ __ Month Day Year (Today's Date)

2. Name of person completing this questionnaire?

______	______	______	______
FIRST	MIDDLE	LAST	MAIDEN NAME (if applicable)

3. What is your telephone number? __ __ __ - __ __ __ - __ __ __ __
(Area Code)

4. What is your address?

______	______	______	______
(STREET, RR, P.O. BOX)	CITY	STATE	ZIP CODE

5. How many individuals currently reside in this household? ______ NUMBER

6. Since January 1, 1973, have any of the individuals in this household been diagnosed as having cancer? (CIRCLE ONE NUMBER.)

1 YES
2 NO

IF YOUR ANSWER IS "NO", GO TO QUESTION 7. OTHERWISE CONTINUE.

a. Since January 1, 1973, how many of the individuals in this household were diagnosed as having cancer? ______ NUMBER

b. Since January 1, 1973, for how many of the individuals in this household was the cancer limited to the skin? ______ NUMBER

7. Are there any females is this household? (CIRCLE ONE NUMBER.)

   1 YES
   2 NO

IF YOUR ANSWER IS "NO", GO TO QUESTION 10 ON THE NEXT PAGE. OTHERWISE CONTINUE.

Exposure to certain environmental chemicals can result in an increased rate of miscarriages or birth defects. The following questions are intended to collect information about this important environmental health concern.

8. How <u>many</u> <u>females</u> are in this household? ______ NUMBER

9. Since <u>January 1, 1983</u>, have any of the females in this household ever been pregnant? (CIRCLE ONE NUMBER.)

   1 YES
   2 NO

IF YOUR ANSWER IS "NO", GO TO QUESTION 10 ON THE NEXT PAGE. OTHERWISE CONTINUE.

a. Since <u>January 1, 1983</u>, how <u>many different</u> females in this household have been pregnant? ______ NUMBER

b. Since <u>January 1, 1983</u>, what is the <u>total number</u> of pregnancies among the females in this household? ______ NUMBER

c. Since <u>January 1, 1983</u>, for all of these females in this household, how frequently was the outcome of these pregnancies:

A normal live birth? ______ NUMBER

A stillbirth? ______ NUMBER

A miscarriage? ______ NUMBER

An abortion requiring the assistance of medical personnel? ______ NUMBER

A child with a birth defect? ______ NUMBER

FOR EACH INDIVIDUAL IN THIS HOUSEHOLD, PLEASE PROVIDE THE FOLLOWING INFORMATION.

FOR INDIVIDUAL #1, PLEASE ANSWER QUESTIONS 10 THROUGH 27.

10. ____________ ____________ ____________ ____________

FIRST NAME | MIDDLE NAME | LAST NAME | MAIDEN NAME (if applicable)

11. Birthdate: ________/________/________

MONTH DAY YEAR

12. Sex: (CIRCLE NUMBER.)

1 MALE
2 FEMALE

13. Race: (CIRCLE ONE NUMBER.)

1 WHITE, NOT HISPANIC
2 WHITE, HISPANIC
3 BLACK, NOT HISPANIC
4 BLACK, HISPANIC
5 ASIAN OR PACIFIC ISLANDER
6 AMERICAN INDIAN OR ALASKAN NATIVE

14. Does (he/she) have a social security number? (CIRCLE ONE NUMBER.)

1 YES
2 NO

IF YOUR ANSWER IS "NO", GO TO QUESTION 15. OTHERWISE CONTINUE.

What is (his/her) social security number? __ __ __/__ __/__ __ __ __

SOCIAL SECURITY NUMBER

15. How many years has this individual used your present well water as (his/her) primary drinking water source? ________

NUMBER

IF THE INDIVIDUAL IS LESS THAN 15 YEARS OF AGE, GO TO QUESTION 17. OTHERWISE CONTINUE.

16. What has been (his/her) usual occupation? ____________________

USUAL OCCUPATION

17. Compared to other people (his/her) own age, what would you say (his/her) general health has been? (CIRCLE ONE NUMBER.)

1 EXCELLENT
2 GOOD
3 FAIR
4 POOR
5 VERY POOR
8 DON'T KNOW

18. During the last 12 months, how would you say (his/her) general health has been relative to (his/her) lifetime general health? (CIRCLE ONE NUMBER.)

1 MUCH BETTER
2 SOMEWHAT BETTER
3 ABOUT THE SAME
4 SOMEWHAT WORSE
5 MUCH WORSE
8 DON'T KNOW

19. Has (he/she) ever smoked cigarettes for six months or longer?

    1 YES
    2 NO

IF YOUR ANSWER IS "NO", GO TO QUESTION 24. OTHERWISE CONTINUE.

20. At what age did (he/she) start smoking cigarettes? ________ AGE

21. Does (he/she) smoke cigarettes now?
(CIRCLE ONE NUMBER.)

    1 YES -- IF "YES", GO TO QUESTION 23.
    2 NO -- IF "NO", GO TO QUESTION 22.

22. At what age did (he/she) stop smoking cigarettes? ________ AGE

23. How many cigarettes does or did (he/she) usually smoke per day? ________ NUMBER OF CIGARETTES PER DAY

24. USING THE CHART BELOW, PUT A NUMBER IN THE MOST APPROPRIATE COLUMN TO INDICATE HOW OFTEN, ON THE AVERAGE, (HE/SHE) HAS DRUNK THE LISTED BEVERAGES. FOR EXAMPLE, IF (HE/SHE) DRANK SOFT DRINKS TWICE A WEEK, PUT A 2 IN THE "WEEK" COLUMN, AND IF (HE/SHE) DRANK ONE CAN OF BEER PER DAY, PUT A 1 IN THE "DAY" COLUMN. IF (HE/SHE) DRANK A LISTED BEVERAGE LESS THAN ONE TIME PER YEAR OR NEVER, PUT AN 'X' IN THE BOX |_X_| "RARELY/NEVER" AND LEAVE THE OTHER COLUMNS BLANK.

	NUMBER OF TIMES PER				
BEVERAGE	DAY	WEEK	MONTH	YEAR	RARELY/ NEVER
a. WHOLE MILK AND BEVERAGES WITH WHOLE MILK (8 OZ. GLASS)	____	____	____	____	|__|
b. SKIM MILK, 1% MILK, 2% MILK, BUTTERMILK OR BEVERAGES WITH THESE MILKS (8 OZ. GLASS)	____	____	____	____	|__|
c. SOFT DRINKS (12 OZ. CAN OR BOTTLE)	____	____	____	____	|__|
d. BEER (12 OZ. CAN OR BOTTLE)	____	____	____	____	|__|
e. WINE (4 OZ. GLASS)	____	____	____	____	|__|
f. LIQUOR (1 SHOT)	____	____	____	____	|__|

25. In this question we are interested in beverages and foods you may drink or eat, using water from your usual water source at home.

Using the chart below, tell us how often you usually have the beverages and foods listed, using water from your usual source at home. Fill in the number in the most appropriate place to indicate how often, on the average, you drink or eat the beverage or food. If you rarely or never drink or eat the beverage or food, place an "X" in the |__| above "rarely or never."

How Often?

Beverage or Food	Using Usual Water Source at Home				
a. Water	________ # Glasses Per Day	or	________ # Glasses Per Week	or	|__| Rarely or Never
b. Coffee (Include Caffeinated and Decaffeinated)	________ # Cups Per Day	or	________ # Cups Per Week	or	|__| Rarely or Never
c. Hot Tea (Include Herbal Teas)	________ # Cups Per Day	or	________ # Cups Per Week	or	|__| Rarely or Never
d. Iced Tea (Include Herbal Teas)	________ # Glasses Per Day	or	________ # Glasses Per Week	or	|__| Rarely or Never
e. Fruit Juices or Fruit Drinks From Frozen Concentrate	________ # Glasses Per Day	or	________ # Glasses Per Week	or	|__| Rarely or Never
f. Fruit Drinks from Powdered or Granulated Concentrate such as Kool-Aid, Lemonade, Tang	________ # Glasses Per Day	or	________ # Glasses Per Week	or	|__| Rarely or Never
g. Soups from Canned Concentrate or from Dry Mix	________ # Bowls Per Day	or	________ # Bowls Per Week	or	|__| Rarely or Never

26. Has a doctor ever told (him/her) that (he/she) had any of the following conditions? (CIRCLE ONE NUMBER FOR EACH ITEM.)

	YES	NO	DON'T KNOW
a. BLADDER OR KIDNEY INFECTION............	1	2	8
b. CHRONIC OBSTRUCTIVE LUNG DISEASE.......	1	2	8
c. PANCREATITIS..........................	1	2	8
d. COLITIS OR OTHER BOWEL INFLAMMATION....	1	2	8
e. GIARDIASIS............................	1	2	8
f. GALLBLADDER DISEASE...................	1	2	8
g. JAUNDICE OR LIVER DISEASE.............	1	2	8
h. HEART ATTACK..........................	1	2	8
i. HIGH BLOOD PRESSURE...................	1	2	8
j. STROKE................................	1	2	8
k. ANGINA OR CHEST PAIN..................	1	2	8
l. HEART FAILURE.........................	1	2	8
m. DIABETES OR HIGH BLOOD SUGAR..........	1	2	8
n. DEPRESSION............................	1	2	8
o. SKIN CANCER, EXCLUDING MELANOMA........	1	2	8
p. OTHER CANCER..........................	1	2	8

IF 'YES' TO 'p', WHERE WAS THE CANCER LOCATED? ________________________
(e.g., lung, breast, colon, etc.)

27. How often would you say (he/she) has experienced the following during the last year? (CIRCLE ONE NUMBER FOR EACH ITEM.)

	ALWAYS	USUALLY	SOMETIMES	SELDOM	NEVER	DON'T KNOW
a. UNUSUAL TIREDNESS....	1	2	3	4	5	8
b. HEADACHE.............	1	2	3	4	5	8
c. DIZZINESS............	1	2	3	4	5	8
d. EYE IRRITATION.......	1	2	3	4	5	8
e. BLURRED VISION.......	1	2	3	4	5	8
f. NOSE BLEEDS..........	1	2	3	4	5	8
g. NAUSEA...............	1	2	3	4	5	8
h. VOMITING.............	1	2	3	4	5	8
i. STOMACH CRAMPS.......	1	2	3	4	5	8
j. DIARRHEA.............	1	2	3	4	5	8
k. WEAKNESS.............	1	2	3	4	5	8
l. CHEST DISCOMFORT.....	1	2	3	4	5	8
m. DIFFICULTY BREATHING.	1	2	3	4	5	8
n. MUSCLE TWITCHES......	1	2	3	4	5	8
o. SKIN IRRITATION......	1	2	3	4	5	8
p. FAST HEART RATE......	1	2	3	4	5	8
q. EXCESS SWEATING......	1	2	3	4	5	8
r. FEVER................	1	2	3	4	5	8

END OF QUESTIONNAIRE

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.
PLEASE RETURN THIS QUESTIONNAIRE IN THE ENVELOPE PROVIDED.
PLEASE USE THE SPACE ON THE BACK OF THIS PAGE IF ADDITIONAL ROOM IS NEEDED TO COMPLETE THE INFORMATION IN THE QUESTIONS.

FOR INDIVIDUAL #2, PLEASE ANSWER QUESTIONS 28 THROUGH 45.

28. ____________ ____________ ____________ ____________

FIRST NAME | MIDDLE NAME | LAST NAME | MAIDEN NAME (if applicable)

29. Birthdate: ______/______/______

MONTH DAY YEAR

30. Sex: (CIRCLE NUMBER.)

1 MALE
2 FEMALE

31. Race: (CIRCLE ONE NUMBER.)

1 WHITE, NOT HISPANIC
2 WHITE, HISPANIC
3 BLACK, NOT HISPANIC
4 BLACK, HISPANIC
5 ASIAN OR PACIFIC ISLANDER
6 AMERICAN INDIAN OR ALASKAN NATIVE

32. Does (he/she) have a social security number? (CIRCLE ONE NUMBER.)

1 YES
2 NO

IF YOUR ANSWER IS "NO", GO TO QUESTION 33. OTHERWISE CONTINUE.

What is (his/her) social security number? __ __ __/__ __/__ __ __ __

SOCIAL SECURITY NUMBER

33. How many years has this individual used your present well water as (his/her) primary drinking water source? ________

NUMBER

IF THE INDIVIDUAL IS LESS THAN 15 YEARS OF AGE, GO TO QUESTION 35. OTHERWISE CONTINUE.

34. What has been (his/her) usual occupation? ________________

USUAL OCCUPATION

35. Compared to other people (his/her) own age, what would you say (his/her) general health has been? (CIRCLE ONE NUMBER.)

1 EXCELLENT
2 GOOD
3 FAIR
4 POOR
5 VERY POOR
8 DON'T KNOW

36. During the last 12 months, how would you say (his/her) general health has been relative to (his/her) lifetime general health? (CIRCLE ONE NUMBER.)

1 MUCH BETTER
2 SOMEWHAT BETTER
3 ABOUT THE SAME
4 SOMEWHAT WORSE
5 MUCH WORSE
8 DON'T KNOW

Note: Questionnaires are sequential and continue for each household member.

APPENDIX C.

Inventory Questionnaire
For Farming Sites

The Iowa Statewide Rural Well Water Survey
Iowa Department of Natural Resources, Geological Survey Bureau,
and The University of Iowa Center for Health Effects
of Environmental Contamination

Inventory Questionnaire Form for Farming Site

1. ____________ ____________ __ __/__ __/__ __
Name of County — Site Number — Month Day Year (Today's Date)

2. Interviewer Initials: ___ ___ ___

3. Person Being Interviewed:

Name? ____________________ ____________________
First — Last

Telephone Number? __ __ __/__ __ __/__ __ __ __

Mailing Address? ____________________ ____________ ________ ________
(Street, P.O. Box, etc.) — City — State — Zip Code

********FOR ALL "Yes" OR "No" QUESTIONS, CIRCLE THE APPROPRIATE ANSWER.

********QUESTIONS 4-6 PERTAIN TO THE PROPERTY ON WHICH THE WELL IS LOCATED.

4. Do you own this property? Yes No

5. Where is the well located that provides your primary source of drinking water?

________1/4, SEC________, T________N, R________W/E
Location/Section-Township-Range

* ____________________/____________________/____________________
(FOR OFFICE USE ONLY: LATITUDE / LONGITUDE / ELEVATION)

6. Is this the only operable well on the property? Yes No

*****IF "Yes", GO TO QUESTION 7. OTHERWISE CONTINUE.

a. How many other operable wells are there? ________ NUMBER

b. Fill in the following information for each of these other wells. **(REMEMBER TO NOTE LOCATION ON SKETCH [Q. 54].)**

Number	Well Depth (ft.)	Location/Section-Range-Township
1	________	________1/4, SEC________, T________N, R________W/E
2	________	________1/4, SEC________, T________N, R________W/E
3	________	________1/4, SEC________, T________N, R________W/E
4	________	________1/4, SEC________, T________N, R________W/E

7. Regarding the well that provides the <u>primary</u> source of drinking water:

a. Do you have any well construction records? Yes No

Place appropriate number in box provided for level of confidence:
1=Very confident
2=Fairly confident
3=Fairly uncertain
4=Very uncertain

		FOR OFFICE USE ONLY - DNR LOGS
b. Driller's Name ____________	[_]	
c. Depth of Well? ____________ ft.	[_]	____________ ft.
d. Year constructed? ____________	[_]	____________
e. Casing depth? ____________ ft.	[_]	____________ ft.
f. Likely aquifer?		____________

g. Number of years used as the primary drinking water source? [_] ________ Years

h. Is the well grouted? [_] Yes No Don't Know

i. Do tile lines discharge into the well? [_] Yes No Don't Know

j. Is there a check valve or relief drain on the well? [_] Yes No Don't Know

8. Are any of the following found on this property:
(REMEMBER TO NOTE LOCATION ON SKETCH [Q. 54].)

	IF "Yes"					
	Feet from Well					
	Minimum	Maximum	# on Property			
Sinkholes?	_____	_____	_____	Yes	No	Don't Know
Ag-drainage wells?	_____	_____	_____	Yes	No	Don't Know
Abandoned wells?	_____	_____	_____	Yes	No	Don't Know
Fuel tanks?	_____	_____	_____	Yes	No	Don't Know
Chemical storage areas?	_____	_____	_____	Yes	No	Don't Know
Septic systems?	_____	_____	_____	Yes	No	Don't Know

*******QUESTIONS 9-14 PERTAIN TO THE WATER SYSTEM.

9. Where does the drinking water go from the pump?

To a below ground brick or tile cistern?	Yes	No
To a concrete storage tank?	Yes	No
To a pressure tank in the house?	Yes	No
To a pressure tank in the pit?	Yes	No
Other?	Yes	No

Specify: ______________________________

10. Describe the water system layout: ______________________________

____

____

____

____

____

____

____

____

11. Does water treatment include:

Softening?	Yes	No
Iron removal filtration?	Yes	No
Reverse osmosis?	Yes	No
Charcoal filtration at an individual tap?	Yes	No
Charcoal filtration in the whole water system?	Yes	No
Chlorination with a chlorinator?	Yes	No
Periodic shock chlorination?	Yes	No
Shock chlorination within the last 4 months?	Yes	No
Other?	Yes	No

Specify: ______________________________

*****IF "No", TO ALL COMPONENTS OF QUESTION 11, GO TO QUESTION 12. OTHERWISE CONTINUE.

a. Does this system remove, or help remove, nitrates from your drinking water supply?	Yes	No	Maybe
b. Does this system remove, or help remove, pesticides from your drinking water supply?	Yes	No	Maybe

12. Does drinking water treatment include:

Softening?	Yes	No
Iron removal filtration?	Yes	No
Other?	Yes	No

Specify: ______________________________

13. In the last two years have you purchased, or looked into purchasing, a water purification system advertised to remove <u>nitrates</u> from your water system? Yes No

14. In the last two years have you purchased, or looked into purchasing, a water purification system advertised to remove <u>pesticides</u> from your water system? Yes No

*****QUESTIONS 15-16 PERTAIN TO THE WELL WATER.

15. Have you had this well water tested previously? Yes No

*****IF "No", GO TO QUESTION 16. OTHERWISE CONTINUE.

a. How often has your well water been tested? (CIRCLE APPROPRIATE NUMBER.)

1 = every month
2 = every other month
3 = twice per year
4 = every year
5 = every other year
6 = irregularly
7 = other - please specify: ______________________
8 = don't know
9 = never tested

b. How many years have you been testing your well water? ______ Years

c. When was it most recently tested? ______ Year

d. For this most recent testing, was the well water tested for:

Turbidity?	Yes	No	Don't Know
Iron?	Yes	No	Don't Know
Coliforms (bacteria)?	Yes	No	Don't Know
Nitrates?	Yes	No	Don't Know
Pesticides?	Yes	No	Don't Know
Other?	Yes	No	Don't Know
Specify: ______________________			

16. Have you had any past water quality problems such as

Turbidity?	Yes	No	
Taste?	Yes	No	
Iron stains?	Yes	No	
Coliforms (bacteria)?	Yes	No	Don't Know
Elevated nitrates?	Yes	No	Don't Know
Detectable pesticides?	Yes	No	Don't Know
Other?	Yes	No	Don't Know
Specify: ______________________			

*****QUESTIONS 17-37 PERTAIN TO FARM OPERATIONS.

17. What type of farm operation is this?
(CIRCLE "Yes" TO ALL THAT APPLY.)

Corn	Yes	No
Soybeans	Yes	No
Wheat	Yes	No
Oats	Yes	No
Set aside acres	Yes	No
Other small grain	Yes	No
Specify: ______________________		
Alfalfa hay	Yes	No
Other hay	Yes	No
Other specialty crops	Yes	No
Specify: ______________________		
Dairy cattle	Yes	No
Beef cattle	Yes	No
Sheep	Yes	No
Poultry	Yes	No
Swine	Yes	No
Other animals	Yes	No
Specify: ______________________		

18. How many acres of land are on this property? ________ ACRES

19. How many of these acres do you presently cultivate? ________ ACRES

20. Has any property been placed in the 10-year conservation reserve program? Yes No

*****IF "No", GO TO QUESTION 21. OTHERWISE CONTINUE.

a. How many acres have been placed in this program? ________ ACRES

21. Approximately how much chemical fertilizer did you apply to corn in the most recent growing season?

Codes

NA = not applicable
DK = don't know
R = refused to answer

	lbs/acre		
	N	P	K
Continuous corn	____	____	____
First year corn following an alfalfa stand	____	____	____
Corn after soybeans	____	____	____
Corn after oats	____	____	____

22. During the most recent growing season, did you apply:

Nitrogen-fertilizer to corn in the spring?	Yes	No
Nitrogen-fertilizer to corn in the spring and again in the late spring or early summer?	Yes	No

Nitrogen-fertilizer to corn in the fall?	Yes	No
Phosphorus and potassium to corn in the spring?	Yes	No
Phosphorus and potassium to corn in the fall?	Yes	No
Other?	Yes	No

Specify: ______________________________

23. Approximately how much chemical fertilizer did you apply to other crops in the most recent growing season?

Codes

NA = not applicable
DK = don't know
R = refused to answer

	lbs/acre		
	N	P	K
Oats	_______	_______	_______
Soybeans	_______	_______	_______
Wheat	_______	_______	_______
Alfalfa hay	_______	_______	_______
Other hay	_______	_______	_______
Pasture	_______	_______	_______
Other	_______	_______	_______

Specify: ______________________________

24. When considering how much fertilizer to apply do you give nutrient credits for:

Manure?	Yes	No
Crop rotation with soybeans?	Yes	No
Crop rotation with alfalfa?	Yes	No
Crop rotation with any other crops?	Yes	No

If yes, specify the crop : ______________________________

25. Did you soil test for your most recent growing season? Yes No

26. How often do you soil test?
(CIRCLE APPROPRIATE NUMBER.)

1 = every year
2 = every other year
3 = every third year
4 = every 3-5 years
5 = irregularly
6 = don't test

*****<u>IF 'don't test', GO TO QUESTION 28 ON THE NEXT PAGE. OTHERWISE CONTINUE.</u>

27. If soil testing is performed, who has done it most recently? (CIRCLE APPROPRIATE NUMBER.)

1 = Cooperative Extension Service (CES)
2 = Iowa State University (ISU)
3 = Crop Consultant
4 = Seed Dealer
5 = Chemical Sales Person
6 = COOP
7 = Commercial Lab
9 = Other
Specify: ______________________________

28. Did you apply herbicides during your most recent growing season? Yes No

*****IF "No", GO TO QUESTION 29. OTHERWISE CONTINUE.

a. Indicate herbicides used for particular crops during the most recent growing season by using the following abbreviations for all that apply to a given herbicide.

CROPS	APPLICATION
C = corn, O = oats/wheat,	0 = preplant/incorporated
S = soybeans, H = hay,	1 = pre-emergence/incorporated
M = fence rows/pasture/other,	2 = split/preplant/early post emergence
R = refused, DK = don't know,	3 = post emergence
NA = not applicable	4 = ropewick
	5 = spot spray
	6 = pre-emergence/non-incorporated
	7 = banded -- preplant
	8 = banded -- pre-emergence
	9 = banded -- post-emergence

Aatrex/Atrazine	________	________
Amiben	________	________
Banvel	________	________
Basagran	________	________
Bicep	________	________
Bladex	________	________
Blazer	________	________
Classic	________	________
Dual	________	________
Eradicane	________	________
Genate/Sutan	________	________
Lasso	________	________
Poast	________	________
Prowl	________	________
Roundup	________	________
Sceptor	________	________
Sencor/Lexone	________	________
Treflan	________	________
2-4, D	________	________
Other #1	________	________

Specify #1: ______________________________

Other #2 ________________ ________________
Specify #2:____

Other #3 ________________ ________________
Specify #3:____

Other #4 ________________ ________________
Specify #4:____

Other #5 ________________ ________________
Specify #5:____

Other #6 ________________ ________________
Specify #6:____

b. Were any of the following methods used for weed control?

Cultivation?	Yes	No
Crop rotation?	Yes	No

c. Do <u>you apply</u> all of your own herbicides?	Yes	No
d. Do <u>you apply</u> some, but not all, of your own herbicides?	Yes	No
e. Do you have all of your own herbicides <u>custom applied</u>?	Yes	No
f. Do you have some, but not all, of your own herbicides <u>custom applied</u>?	Yes	No
g. Do you mix/formulate all of your own herbicides?	Yes	No
h. Do you mix/formulate some, but not all, of your own herbicides?	Yes	No

29. Did you apply insecticides during your most recent growing season?	Yes	No

*********<u>IF "No", GO TO QUESTION 30. OTHERWISE CONTINUE.</u>

a. Indicate insecticides used for particular crops during the most recent growing season and reasons why by using the following abbreviations for all that apply to a given insecticide.

CROPS	REASONS	APPLICATION
C = corn	R = rootworm larval control	B = broadcast
O = oats/wheat	B = black cutworm control	F = in furrow
S = soybeans	E = cornborer control	N = banded
H = hay	L = other	R = refused
M = fence rows/pasture/other	R = refused	DK = don't know
R = refused	DK = don't know	NA = not applicable
DK = don't know	NA = not applicable	
NA = not applicable		

Ambush/Pounce	____	____	____
Bladafume	____	____	____
Broot	____	____	____
Counter	____	____	____
Dipel	____	____	____
Lorsban/Dursban	____	____	____
Dyfonate	____	____	____
Furadan	____	____	____
Guthion	____	____	____
Mocap	____	____	____
Pydrin	____	____	____
Thimet	____	____	____
Toxaphene	____	____	____

Other #1 ____ ____ ____
Specify #1: ________________________

Other #2 ____ ____ ____
Specify #2: ________________________

Other #3 ____ ____ ____
Specify #3: ________________________

b. Were any of the following methods used for insect control?

Cultivation?	Yes	No
Crop rotation?	Yes	No

c. Do <u>you apply</u> all of your own insecticides? Yes No

d. Do <u>you apply</u> some, but not all, of your own insecticides? Yes No

e. Do you have all of your own insecticides <u>custom applied</u>? Yes No

f. Do you have some, but not all, of your own insecticides <u>custom applied</u>? Yes No

g. Do you mix/formulate all of your own insecticides? Yes No

h. Do you mix/formulate some, but not all, of your own insecticides? Yes No

30. Are your pesticides (herbicides or insecticides) mixed:

Within 15 ft. of your well? Yes No
At a hydrant near your well? Yes No

Specify distance in feet: __________ ft.

In the field where you applied the chemicals? Yes No
Other? Yes No
Specify: ______________________________________

31. Have you ever spilled any pesticide mix or liquid fertilizer near your well? Yes No

*****IF "No", GO TO QUESTION 32. OTHERWISE CONTINUE.

When, most recently? _____/_____/_____
Month Day Year

What product? _________________ _________________
Name Amount in Gallons

How far (in feet) from well: ______________ ft.

32. Have you ever had an accident where the pesticides you were mixing back-siphoned through a hose into your well? Yes No

*****IF "No", GO TO QUESTION 33. OTHERWISE CONTINUE.

When, most recently? _____/_____/_____
Month Day Year

What product? _________________ _________________
Name Amount in Gallons

33. When you have finished applying pesticides to a field and have formulation left in the tank do you:

Make another pass on the field and spray it empty? Yes No
Spray on the road when returning home? Yes No
Drain/dump in the field? Yes No
Drain in a road ditch? Yes No
Drain in your farm yard? Yes No
Other? Yes No
Specify: ______________________________________

*****IF 'No' TO ALL COMPONENTS OF QUESTION 33, GO TO QUESTION 34. OTHERWISE CONTINUE.

a. Is there a particular location where you routinely dispose of your pesticides? Yes No

b. If 'Yes', specify location: ____________________

34. Do you rinse your tanks and empty pesticide containers after pesticide application? Yes No

*****IF "No", GO TO QUESTION 35. OTHERWISE CONTINUE.

a. Do you rinse your tanks and empty pesticide containers:

Within 15 ft. of your well?	Yes	No
At a hydrant near your well?	Yes	No
Specify distance in feet:	________ ft.	
In the field where you applied the chemicals?	Yes	No
Other?	Yes	No
Specify: ____________________		

b. With the rinse water, do you:

Drain or spray on the ground where you are rinsing?	Yes	No
Drain or spray on the road?	Yes	No
Drain or spray in the yard?	Yes	No
Drain or spray in the field?	Yes	No
Other?	Yes	No
Specify: ____________________		

c. Is there a particular location where you routinely dispose of your rinse? Yes No

If 'Yes', specify location: ____________________

35. Do you dispose of your empty pesticide containers by:

Sending them to the county landfill?	Yes	No
Storing them on your own property?	Yes	No
Returning them to the dealers or vendors?	Yes	No
Placing them in your garbage pickup?	Yes	No
Burning them?	Yes	No
Other?	Yes	No
Specify: ____________________		

36. Since 1980, which of the following best describes your:

Nitrogen fertilizer applications?	Reduced	No change	Increased
P & K fertilizers?	Reduced	No change	Increased
Herbicide use?	Reduced	No change	Increased
Insecticide use?	Reduced	No change	Increased

37. Do you work with pesticides in farming or your occupation? Yes No

*****IF 'No', GO TO QUESTION 39. OTHERWISE CONTINUE.

38. With over-exposure to some pesticides there is danger of poisoning. After working with pesticides how often would you say you have experienced the the following?
(CIRCLE ONE ANSWER FOR EACH ITEM.)

	ALWAYS	USUALLY	SOMETIMES	SELDOM	NEVER	DON'T KNOW
a. UNUSUAL TIREDNESS....	1	2	3	4	5	8
b. HEADACHE.............	1	2	3	4	5	8
c. DIZZINESS............	1	2	3	4	5	8
d. EYE IRRITATION.......	1	2	3	4	5	8
e. BLURRED VISION.......	1	2	3	4	5	8
f. NOSE BLEEDS..........	1	2	3	4	5	8
g. NAUSEA...............	1	2	3	4	5	8
h. VOMITING.............	1	2	3	4	5	8
i. STOMACH CRAMPS.......	1	2	3	4	5	8
j. DIARRHEA.............	1	2	3	4	5	8
k. WEAKNESS.............	1	2	3	4	5	8
l. CHEST DISCOMFORT.....	1	2	3	4	5	8
m. DIFFICULTY BREATHING.	1	2	3	4	5	8
n. MUSCLE TWITCHES......	1	2	3	4	5	8
o. SKIN IRRITATION......	1	2	3	4	5	8
p. FAST HEART RATE......	1	2	3	4	5	8
q. EXCESS SWEATING......	1	2	3	4	5	8
r. FEVER................	1	2	3	4	5	8
s. OTHER................	1	2	3	4	5	8

Specify____

39. Do you have refuse disposal dumpsites on your property? Yes No

*****<u>IF "No", GO TO QUESTION 40. OTHERWISE CONTINUE.</u>

a. How many refuse disposal dumpsites are on your property? ________ NUMBER

40. Do you dispose of your household refuse and garbage:

By sending it to the county landfill?	Yes	No
By storing it on your own property?	Yes	No
Through a refuse pickup service?	Yes	No
By burning it?	Yes	No
Other?	Yes	No

Specify: ________________________________

41. Which best describes this home?
(CIRCLE APPROPRIATE NUMBER.)

1 = Single Family Dwelling
2 = Duplex, Triplex or Fourplex
3 = Apartment Building
4 = Townhouse
5 = Mobile Home
6 = Other (SPECIFY)________________________

42. How many stories, not including the basement, are there? (CIRCLE APPROPRIATE NUMBER.)

1 = one
2 = two
3 = three
4 = more than three
5 = split level

43. What is the estimated age of this home? ________ YEARS

44. Where is your home located? (CIRCLE APPROPRIATE NUMBER.)

1 = urban
2 = rural
3 = suburban

45. Does it have a basement under any portion? Yes No

*****IF "No", GO TO QUESTION 51. OTHERWISE CONTINUE.

46. Can you get to the basement from inside the house? Yes No

47. Is any portion of the basement used as living or sleeping space? Yes No

48. What type of basement floor? (CIRCLE APPROPRIATE NUMBER.)

1 = concrete slab
2 = wood
3 = dirt
4 = other__________________

49. Do you have a sump pump in the basement? Yes No

50. What type of basement walls? (CIRCLE ALL THAT APPLY.)

1 = poured concrete
2 = cinder or concrete block
3 = stone or brick

51. Does the building have a crawl space under any portion? Yes No

*****IF "No", GO TO QUESTION 56. OTHERWISE CONTINUE.

52. Can you get to the crawl space from inside the house? Yes No

53. Is the floor above the crawl space insulated? Yes No

54. Is the crawl space vented to the outside air? Yes No

55. What is the type of the crawl space floor?
(CIRCLE APPROPRIATE NUMBER.)

1 = dirt
2 = concrete slab
3 = other ______________________

56. Which location best describes where the building sits in relationship to the surrounding land?
(CIRCLE APPROPRIATE NUMBER.)

1 = on a hilltop/upland
2 = on a sideslope/hillside
3 = in a side valley
4 = in a floodplain
5 = on a level plain
6 = a gently sloping/rolling area
7 = a steeply sloping area
8 = comments______________________________

____

____

57. How would you describe the energy efficiency of your home?
(CIRCLE APPROPRIATE NUMBER.)

1 = excellent
2 = above average
3 = average
4 = below average
5 = poor

58. Has this building ever been tested for radon before? Yes No

59. How many cigarettes per day are smoked by all members of your household combined? ________ NUMBER

END OF INTERVIEW. THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

IF ADDITIONAL ROOM IS NEEDED TO COMPLETE THE INFORMATION IN THESE QUESTIONS, USE THE SPACE BELOW. PLEASE IDENTIFY THE QUESTION NUMBER(S).

FIELD OBSERVATIONS

60. Regarding well construction, is the well:

A driven sand-point well?	Yes	No	
A small diameter (<18") drilled well?	Yes	No	
Cased?	Yes	No	
A large diameter dug or bored well?	Yes	No	
Brick or tile lined?	Yes	No	
Grouted?	Yes	No	Maybe
Other?	Yes	No	
Specify: ________________________________			

61. If the well is cased, what is the casing material? ________________

62. Regarding well construction, is:

The pump above ground?	Yes	No	
A pump jack present?	Yes	No	
A submersible pump present?	Yes	No	
A pitless adapter present?	Yes	No	
A suction line present?	Yes	No	
A sealed frost pit around the well head?	Yes	No	
An unsealed frost pit around the well head?	Yes	No	
The well head sealed?	Yes	No	
The casing open in a pit?	Yes	No	
The casing extending below the base of the pit?	Yes	No	Maybe

63. Regarding the well placement, is it:

On a hilltop/upland?	Yes	No	
On a sideslope/hillside?	Yes	No	
In a side valley?	Yes	No	
In a floodplain?	Yes	No	
On a level plain?	Yes	No	
On a gently sloping area?	Yes	No	
On a steeply sloping area?	Yes	No	
In a feedlot?	Yes	No	
Isolated from routine traffic/activity?	Yes	No	
< 25 ft. from the house?	Yes	No	
< 25 ft. from the barn?	Yes	No	
< 25 ft. from an outhouse?	Yes	No	
< 15 ft. from a fuel tank?	Yes	No	
< 15 ft. from a chemical storage area?	Yes	No	
< 50 ft. from a septic system?	Yes	No	Maybe
> 50 ft. from a septic system?	Yes	No	Maybe
< 50 ft. from manure storage?	Yes	No	
> 50 ft. from manure storage?	Yes	No	

64. Can surface runoff enter the well pit or well head? Yes No Maybe

65. Can seepage enter the well pit or well head? Yes No Maybe

66. From your field assessment, is there any evidence of likely:

Contamination from well-construction features?	Yes	No
Contamination from well placement factors?	Yes	No
Contamination from location of the cistern?	Yes	No

67. Is the land in the immediate adjacent area:

Feedlot?	Yes	No
Farmland?	Yes	No
Rowcrop?	Yes	No
Pasture?	Yes	No
Forested?	Yes	No
Suburban houses?	Yes	No
Chemical handling/storage facility?	Yes	No
Other?	Yes	No

Specify: ______________________________

68. Is the land in the surrounding 0.5 mile radius:

Feedlot?	Yes	No
Farmland?	Yes	No
Rowcrop?	Yes	No
Pasture?	Yes	No
Forested?	Yes	No
Suburban houses?	Yes	No
Chemical handling/storage facility?	Yes	No
Other?	Yes	No

Specify: ______________________________

69. Total number of water samples collected with unique IDs? ________ NUMBER

70. Water sample ID numbers:

X-Letter Code

R = regular
D = duplicate (taken at same spot as R sample)
T = treated (taken after water treatment)
B = blank
S = trip spike
U = field spike for UHL
E = field spike for EEL
P = field spike for PHAP

	ID	X	Month/ Day / Year
1.	________	___	____/____/____
2.	________	___	____/____/____
3.	________	___	____/____/____
4.	________	___	____/____/____
5.	________	___	____/____/____
6.	________	___	____/____/____
7.	________	___	____/____/____
8.	________	___	____/____/____

NOTES:

71. DRAW A SKETCH BELOW OF THE PROPERTY, BUILDING LAYOUT, WELL LOCATION, AND LOCATION OF THE WATER SAMPLING SOURCE. <u>INCLUDE A "NORTH" ARROW</u>.

APPENDIX D.

Inventory Questionnaire
For Household/Suburban Sites

The Iowa Statewide Rural Well Water Survey
Iowa Department of Natural Resources, Geological Survey Bureau,
and The University of Iowa Center for Health Effects
of Environmental Contamination

Inventory Questionnaire Form for Household/Non-Farm Site

1. ^F2^ ^F3^ __ __/__ __/__ __
   Name of County Site Number Month Day Year
   (Today's Date)

2. Interviewer Initials: ___ ___ ___

3. Person Being Interviewed:

   Name? ____________________ ____________________
   First Last

   Telephone Number? __ __ __/__ __ __/__ __ __ __

   Mailing Address? ____________________ __________ ______ ______
   (Street, P.O. Box, etc.) City State Zip Code

*****FOR ALL "Yes" OR "No" QUESTIONS, CIRCLE THE APPROPRIATE ANSWER.

*****QUESTIONS 4-6 PERTAIN TO THE PROPERTY ON WHICH THE WELL IS LOCATED.

4. Do you own this property? Yes No

5. Where is the well located that provides your primary source of drinking water?

   ________1/4, SEC________, T________N, R________W/E
   Location/Section-Township-Range

   * ________________/________________/________________
   (FOR OFFICE USE ONLY: LATITUDE / LONGITUDE / ELEVATION)

6. Is this the only operable well on the property? Yes No

*****IF "Yes", GO TO QUESTION 7. OTHERWISE CONTINUE.

   a. How many other operable wells are there? ________
   NUMBER

   b. Fill in the following information for each of these other wells.
   (REMEMBER TO NOTE LOCATION ON SKETCH [Q. 42].)

Number	Well Depth (ft.)	Location/Section-Range-Township
1	________	________1/4, SEC______, T______N, R______W/E
2	________	________1/4, SEC______, T______N, R______W/E
3	________	________1/4, SEC______, T______N, R______W/E
4	________	________1/4, SEC______, T______N, R______W/E

7. Regarding the well that provides the primary source of drinking water:

a. Do you have any well construction records? Yes No

Place appropriate number in box provided for level of confidence: 1=Very confident
2=Fairly confident
3=Fairly uncertain
4=Very uncertain

		FOR OFFICE USE ONLY - DNR LOGS
b. Drillers Name ______________	|_|	
c. Depth of Well? ______________ ft.	|_|	______________ ft.
d. Year constructed? ______________	|_|	______________
e. Casing depth? ______________ ft.	|_|	______________ ft.
f. Likely aquifer?		______________

g. Number of years used as the primary drinking water source? |_| __________ Years

h. Is the well grouted? |_| Yes No Don't Knc

i. Do tile lines discharge into the well? |_| Yes No

j. Is there a check valve or relief drain on the well? |_| Yes No

8. Are any of the following found on this property:
(REMEMBER TO NOTE LOCATION ON SKETCH [Q. 42].)

	IF "Yes"					
	Feet from Well					
	Minimum	Maximum	# on Property			
Sinkholes?	_____	_____	_____	Yes	No	Don't Knc
Ag-drainage wells?	_____	_____	_____	Yes	No	Don't Knc
Abandoned wells?	_____	_____	_____	Yes	No	Don't Knc
Fuel tanks?	_____	_____	_____	Yes	No	Don't Knc
Chemical storage areas?	_____	_____	_____	Yes	No	Don't Knc
Septic systems?	_____	_____	_____	Yes	No	Don't Knc

*****<u>QUESTIONS 9-14 PERTAIN TO THE WATER SYSTEM.</u>

9. Where does the drinking water go from the pump?

To a pressure tank in the pit?	Yes	No
To a below ground brick or tile cistern?	Yes	No
To a concrete storage tank?	Yes	No
To a pressure tank in the house?	Yes	No
Other?	Yes	No

Specify: ______________________________

10. Describe the water system layout: ______________________________

____

____

____

____

____

____

____

____

11. Does water treatment include:

Softening?	Yes	No
Iron removal filtration?	Yes	No
Reverse osmosis?	Yes	No
Charcoal filtration at an individual tap?	Yes	No
Charcoal filtration in the whole water system?	Yes	No
Chlorination with a chlorinator?	Yes	No
Periodic shock chlorination?	Yes	No
Shock chlorination within the last 4 months?	Yes	No
Other?	Yes	No

Specify: ______________________________

*****<u>IF "No", TO ALL COMPONENTS OF QUESTION 11, GO TO QUESTION 12. OTHERWISE CONTINUE.</u>

a. Does this system remove, or help remove, nitrates from your <u>drinking</u> water supply? Yes No Maybe

b. Does this system remove, or help remove, pesticides from your <u>drinking</u> water supply? Yes No Maybe

12. Does <u>drinking</u> water treatment include:

Softening?	Yes	No
Iron removal filtration?	Yes	No
Other?	Yes	No

Specify: ______________________________

13. In the last two years have you purchased, or looked into purchasing, a water purification system advertised to remove <u>nitrates</u> from your water system? Yes No

14. In the last two years have you purchased, or looked into purchasing, a water purification system advertised to remove <u>pesticides</u> from your water system? Yes No

*****<u>QUESTIONS 15-16 PERTAIN TO THE WELL WATER.</u>

15. Have you had this well water tested previously? Yes No

*****<u>IF "No", GO TO QUESTION 16. OTHERWISE CONTINUE.</u>

a. How often has your well water been tested? (CIRCLE APPROPRIATE NUMBER.)

1 = every month
2 = every other month
3 = twice per year
4 = every year
5 = every other year
6 = irregularly
7 = other - please specify: ______________________
8 = don't know
9 = never tested

b. How <u>many years</u> have you been testing your well water? ______ Years

c. When was it most recently tested? ______ Year

d. For this most recent testing, was the well water tested for:

Turbidity?	Yes	No	Don't Know
Iron?	Yes	No	Don't Know
Coliforms (bacteria)?	Yes	No	Don't Know
Nitrates?	Yes	No	Don't Know
Pesticides?	Yes	No	Don't Know
Other?	Yes	No	Don't Know

Specify: ______________________________

16. Have you had any past water quality problems such as

Turbidity?	Yes	No	
Taste?	Yes	No	
Iron stains?	Yes	No	
Coliforms (bacteria)?	Yes	No	Don't Know
Elevated nitrates?	Yes	No	Don't Know
Detectable pesticides?	Yes	No	Don't Know
Other?	Yes	No	Don't Know

Specify: ______________________________

17. How many acres of land are on this property? ________ ACRES

18. Are farm chemicals stored on this property? Yes No

19. Is your well water used to mix or formulate farm chemicals? Yes No

*****IF "No", GO TO QUESTION 20. OTHERWISE CONTINUE.

a. Are your pesticides (herbicides or insecticides) mixed:

Within 15 ft. of your well?	Yes	No
At a hydrant near your well?	Yes	No
Specify distance in feet: ________ ft.		
In the field where you applied the chemicals?	Yes	No
Other?	Yes	No
Specify: ________________________________		

b. Have you ever spilled any pesticide mix or liquid fertilizer near your well? Yes No

*********IF "No", GO TO c. OTHERWISE CONTINUE.

When, most recently? _____/_____/_____ Month Day Year

What product? ________________ Name ________________ Amount in Gallons

How far (in feet) from well: ____________ ft.

c. Have you ever had an accident where the pesticides you were mixing back-siphoned through a hose into your well? Yes No

*********IF "No", GO TO d. OTHERWISE CONTINUE.

When, most recently? _____/_____/_____ Month Day Year

What product? ________________ Name ________________ Amount in Gallons

d. When you have finished applying pesticides to a field and have formulation left in the tank do you:

Make another pass on the field and spray it empty?	Yes	No
Spray on the road when returning home?	Yes	No
Drain/dump in the field?	Yes	No
Drain in a road ditch?	Yes	No
Drain in your farm yard?	Yes	No
Other?	Yes	No
Specify: ________________________________		

*********IF 'No' TO ALL COMPONENTS OF d, GO TO g. OTHERWISE CONTINUE.

e. Is there a particular location where you routinely dispose of your pesticides? Yes No

f. If 'Yes', specify location: ____________________

g. Do you rinse your tanks and empty pesticide containers after pesticide application? Yes No

*********IF "No", GO TO QUESTION k. OTHERWISE CONTINUE.

h. Do you rinse your tanks and empty containers:

Within 15 ft. of your well?	Yes	No
At a hydrant near your well?	Yes	No
Specify distance in feet:	________ ft.	
In the field where you applied the chemicals?	Yes	No
Other?	Yes	No
Specify: ____________________		

i. With the rinse water, do you:

Drain or spray on the ground where you are rinsing?	Yes	No
Drain or spray on the road?	Yes	No
Drain or spray in the yard?	Yes	No
Drain or spray in the field?	Yes	No
Other?	Yes	No
Specify: ____________________		

j. Is there a particular location where you routinely dispose of your rinse? Yes No

If 'Yes', specify location: ____________________

k. Do you dispose of your empty pesticide containers by:

Sending them to the county landfill?	Yes	No
Storing them on your own property?	Yes	No
Returning them to the dealers or vendors?	Yes	No
Placing them in your garbage pickup?	Yes	No
Burning them?	Yes	No
Other?	Yes	No
Specify: ____________________		

20. Do you farm at another location? Yes No

21. Do you use any commercial fertilizer on:

Your lawn?	Yes	No
Your garden?	Yes	No
Fruit trees?	Yes	No
Shrubs?	Yes	No

Ornamental trees?	Yes	No
Other?	Yes	No
Specify: ____________________		

22. Do you use any manure on:

Your lawn?	Yes	No
Your garden?	Yes	No
Fruit trees?	Yes	No
Shrubs?	Yes	No
Ornamental trees?	Yes	No
Other?	Yes	No
Specify: ____________________		

23. Do you use any pesticides (herbicides, insecticides, or fungicides) on:

Your lawn?	Yes	No
Your garden?	Yes	No
Fruit trees?	Yes	No
Shrubs?	Yes	No
Ornamental trees?	Yes	No
Other?	Yes	No
Specify: ____________________		

*****IF "No", GO TO QUESTION 24. OTHERWISE CONTINUE.

a. How many different pesticide product names do you use? ________ NUMBER

b. What are the pesticide product names? (e.g., Weed & Feed)

1. ____________

2. ____________

3. ____________

4. ____________

5. ____________

c. Can you estimate what amount of these products you use annually? Yes No
Specify: ____________________

d. Are your pesticides mixed:

Within 15 ft. of your well?	Yes	No
At a hydrant near your well?	Yes	No
In the field where you plan to apply them?	Yes	No
Other?	Yes	No
Specify: ____________________		

e. When you mix more pesticides than you need do you:

Spray on lawn or garden until gone?	Yes	No
Empty on ground?	Yes	No
Empty wherever you rinse the container?	Yes	No
Other?	Yes	No
Specify: ______________________________		

f. Where do you rinse the application equipment and pesticide container(s)?

Within 15 ft. your well?	Yes	No
At a hydrant near your well?	Yes	No
At an outside faucet on the house?	Yes	No
From a hose on an outside faucet?	Yes	No
Other?	Yes	No
Specify: ______________________________		

g. Have you ever had an accident where the pesticides you were mixing back-siphoned through a hose into your well? Yes No

*********IF "No", GO TO QUESTION h. OTHERWISE CONTINUE.

When? _____/_____/______
Month Day Year

What product? ________________ ________________
Name Amount in Gallons

h. Do you dispose of your empty pesticide containers by:

Sending them to the county landfill?	Yes	No
Storing them on your own property?	Yes	No
Returning them to the dealers or vendors?	Yes	No
Placing them in your garbage pickup?	Yes	No
Burning them?	Yes	No
Other?	Yes	No
Specify: ______________________________		

24. Have you ever spilled any pesticide mix or liquid fertilizer near your well? Yes No

*****IF "No", GO TO QUESTION 25. OTHERWISE CONTINUE.

When, most recently? _____/_____/______
Month Day Year

What product? ________________ ________________
Name Amount in Gallons

25. Do you work with pesticides in farming or your occupation? Yes No

*****IF 'No', GO TO QUESTION 27. OTHERWISE CONTINUE.

26. With over-exposure to some pesticides there is danger of poisoning. After working with pesticides how often would you say you have experienced the the following?
(CIRCLE ONE ANSWER FOR EACH ITEM.)

	ALWAYS	USUALLY	SOMETIMES	SELDOM	NEVER	DON'T KNOW
a. UNUSUAL TIREDNESS....	1	2	3	4	5	8
b. HEADACHE.............	1	2	3	4	5	8
c. DIZZINESS............	1	2	3	4	5	8
d. EYE IRRITATION.......	1	2	3	4	5	8
e. BLURRED VISION.......	1	2	3	4	5	8
f. NOSE BLEEDS..........	1	2	3	4	5	8
g. NAUSEA...............	1	2	3	4	5	8
h. VOMITING.............	1	2	3	4	5	8
i. STOMACH CRAMPS.......	1	2	3	4	5	8
j. DIARRHEA.............	1	2	3	4	5	8
k. WEAKNESS.............	1	2	3	4	5	8
l. CHEST DISCOMFORT.....	1	2	3	4	5	8
m. DIFFICULTY BREATHING.	1	2	3	4	5	8
n. MUSCLE TWITCHES......	1	2	3	4	5	8
o. SKIN IRRITATION......	1	2	3	4	5	8
p. FAST HEART RATE......	1	2	3	4	5	8
q. EXCESS SWEATING......	1	2	3	4	5	8
r. FEVER................	1	2	3	4	5	8

27. Do you have refuse disposal dumpsites on your property? Yes No

*****IF "No", GO TO QUESTION 28. OTHERWISE CONTINUE.

a. How many refuse disposal dumpsites are on your property? ________ NUMBER

28. Do you dispose of your household refuse and garbage:

By sending it to the county landfill?	Yes	No
By storing it on your own property?	Yes	No
Through a refuse pickup service?	Yes	No
By burning it?	Yes	No
Other?	Yes	No

Specify: ________________________________

29. Which best describes this home?
(CIRCLE APPROPRIATE NUMBER.)

1 = Single Family Dwelling
2 = Duplex, Triplex or Fourplex
3 = Apartment Building
4 = Townhouse
5 = Mobile Home
6 = Other (SPECIFY)________________________

30. How many stories, not including the basement, are there? (CIRCLE APPROPRIATE NUMBER.)

    1 = one
    2 = two
    3 = three
    4 = more than three
    5 = split level

31. What is the estimated age of this home? ________ YEARS

32. Where is your home located? (CIRCLE APPROPRIATE NUMBER.)

    1 = urban
    2 = rural
    3 = suburban

33. Does it have a basement under any portion? Yes No

*****IF "No", GO TO QUESTION 39. OTHERWISE CONTINUE.

34. Can you get to the basement from inside the house? Yes No

35. Is any portion of the basement used as living or sleeping space? Yes No

36. What type of basement floor? (CIRCLE APPROPRIATE NUMBER.)

    1 = concrete slab
    2 = wood
    3 = dirt
    4 = other_________________

37. Do you have a sump pump in the basement? Yes No

38. What type of basement walls? (CIRCLE ALL THAT APPLY.)

    1 = poured concrete
    2 = cinder or concrete block
    3 = stone or brick

39. Does the building have a crawl space under any portion? Yes No

*****IF "No", GO TO QUESTION 44. OTHERWISE CONTINUE.

40. Can you get to the crawl space from inside the house? Yes No

41. Is the floor above the crawl space insulated? Yes No

42. Is the crawl space vented to the outside air? Yes No

43. What is the type of the crawl space floor?
(CIRCLE APPROPRIATE NUMBER.)

1 = dirt
2 = concrete slab
3 = other ________________________

44. Which location best describes where the building sits in relationship to the surrounding land?
(CIRCLE APPROPRIATE NUMBER.)

1 = on a hilltop/upland
2 = on a sideslope/hillside
3 = in a side valley
4 = in a floodplain
5 = on a level plain
6 = a gently sloping/rolling area
7 = a steeply sloping area
8 = comments________________________________

____

____

45. How would you describe the energy efficiency of your home?
(CIRCLE APPROPRIATE NUMBER.)

1 = excellent
2 = above average
3 = average
4 = below average
5 = poor

46. Has this building ever been tested for radon before? Yes No

47. How many cigarettes per day are smoked by all members of your household combined?

____
NUMBER

END OF INTERVIEW. THANK YOU VERY MUCH FOR YOUR PARTICIPATION.
IF ADDITIONAL ROOM IS NEEDED TO COMPLETE THE INFORMATION IN THESE QUESTIONS, USE THE SPACE BELOW. PLEASE IDENTIFY THE QUESTION NUMBER(S).

FIELD OBSERVATIONS

48. Regarding well construction, is the well:

A driven sand-point well?	Yes	No	
A small diameter (<18") drilled well?	Yes	No	
Cased?	Yes	No	
A large diameter dug or bored well?	Yes	No	
Brick or tile lined?	Yes	No	
Grouted?	Yes	No	Maybe
Other?	Yes	No	
Specify: ______________________________			

49. If the well is cased, what is the casing material? ______________

50. Regarding well construction, is:

The pump above ground?	Yes	No	
A pump jack present?	Yes	No	
A submersible pump present?	Yes	No	
A pitless adapter present?	Yes	No	
A suction line present?	Yes	No	
A sealed frost pit around the well head?	Yes	No	
An unsealed frost pit around the well head?	Yes	No	
The well head sealed?	Yes	No	
The casing open in a pit?	Yes	No	
The casing extending below the base of the pit?	Yes	No	Don't Know

51. Regarding the well placement, is it:

On a hilltop/upland?	Yes	No	
On a sideslope/hillside?	Yes	No	
In a side valley?	Yes	No	
In a floodplain?	Yes	No	
On a level plain?	Yes	No	
On a gently sloping area?	Yes	No	
On a steeply sloping area?	Yes	No	
In a feedlot?	Yes	No	
Isolated from routine traffic/activity?	Yes	No	
< 25 ft. from the house?	Yes	No	
< 25 ft. from the barn?	Yes	No	
< 25 ft. from an outhouse?	Yes	No	
< 15 ft. from a fuel tank?	Yes	No	
< 15 ft. from a chemical storage area?	Yes	No	
< 50 ft. from a septic system?	Yes	No	Maybe
> 50 ft. from a septic system?	Yes	No	Maybe
< 50 ft. from manure storage?	Yes	No	
> 50 ft. from manure storage?	Yes	No	

52. Can surface runoff enter the well pit or well head? Yes No Maybe

53. Can seepage enter the well pit or well head? Yes No Maybe

^F1^

54. From your field assessment, is there any evidence of likely:

Contamination from well-construction features?	Yes	No
Contamination from well placement factors?	Yes	No
Contamination from location of the cistern?	Yes	No

55. Is the land in the immediate adjacent area:

Feedlot?	Yes	No
Farmland?	Yes	No
Rowcrop?	Yes	No
Pasture?	Yes	No
Forested?	Yes	No
Suburban houses?	Yes	No
Chemical handling/storage facility?	Yes	No
Other?	Yes	No

Specify: ______________________________

56. Is the land in the surrounding 0.5 mile radius:

Feedlot?	Yes	No
Farmland?	Yes	No
Rowcrop?	Yes	No
Pasture?	Yes	No
Forested?	Yes	No
Suburban houses?	Yes	No
Chemical handling/storage facility?	Yes	No
Other?	Yes	No

Specify: ______________________________

57. Total number of water samples collected with unique IDs? ________ NUMBER

58. Water sample ID numbers:

X-Letter Code
R = regular
D = duplicate (taken at same spot as R sample)
T = treated (taken after water treatment)
B = blank
S = trip spike
U = field spike for UHL
E = field spike for EEL
P = field spike for PHAP

		X	Month/ Day / Year
1.	^F3^	____	_____/_____/______
2.	^F3^	____	_____/_____/______
3.	^F3^	____	_____/_____/______
4.	^F3^	____	_____/_____/______
5.	^F3^	____	_____/_____/______
6.	^F3^	____	_____/_____/______
7.	^F3^	____	_____/_____/______
8.	^F3^	____	_____/_____/______

NOTES:

59. DRAW A SKETCH BELOW OF THE PROPERTY, BUILDING LAYOUT, WELL LOCATION, AND LOCATION OF THE WATER SAMPLING SOURCE. INCLUDE A "NORTH" ARROW.

APPENDIX E.

Summary Of County Sampling Dates

SWRL FIELD SAMPLING SCHEDULE

Week	County	Number of Sites SCHEDULED	Number of Sites ACTUAL	10% Repeat Sites	Follow-Up Sampling
FIRST QUARTER (Project Inception to July 15)					
1.	Muscatine	10	8		
	Louisa	6	6		
2.	Fayette	8	8		
	Chickasaw	6	6		
3.	Ida	4	4		
	Woodbury	9	9		
4.	Ringold	4	4		(1) Muscatine
	Decatur	5	5		
	Clarke	4	4		
5.	Winnebago	5	5		
	Hancock	6	6		
	Butler	7	7		(1) Muscatine
6.	Boone	5	5		
	Webster	8	8		
7.	Davis	4	4		
	Van Buren	4	4		
	Jackson	7	7		
8.	Mills	4	4		
	Fremont	4	4		
	Audubon	3	3		
9.	Lyon	5	4	Plymouth, Sac	
	Osceola	3	3		
10.	Buena Vista	7	7	Greene	
	Humboldt	4	4		
	Calhoun	4	4		
11.	Linn	13	11		
	Poweshiek	6	4		
12.	Harrison	6	6	Adams	(2) Linn
	Adair	5	4		
13.	Keokuk	4	4	Louisa, Muscatine	
	Washington*	8	8		
14.	Marshall	6	6	Jasper	
	Hamilton*	5	5		
SECOND QUARTER (July 16 to October 15)					
15.	Kossuth*	5	5		
	Sioux*	11	11		
16.	Pottawattamie*	3	3	Decatur	
	Cass*	5	5		
	Lucus*	3	3		
	Monroe*	3	3		
17.	Winneshiek*	9	9	Chickasaw, Fayette	
	Bremer*	10	10		

18.	Dickinson	6	6	Emmet	(1) Lyon
	Clay	6	6		
19.	Worth	3	3		
	Floyd	7	7		
	Cerro Gordo	7	7		
20.	Allamakee	10	10	Dubuque	
	Clayton	10	10		
21.	Henry	5	5	Des Moines,	
	Tama	9	9	Poweshiek	
22.	Story	7	7	Polk	
	Guthrie	5	5		
	Montgomery	3	3		
	Page	4	4		
23.	Jones	(Rescheduled)		Delaware, Linn,	
	Johnson	11	10	Iowa	
24.	Lee	(Rescheduled)			
	Appanoose	5	5		
	Wayne	3	1		
	Jones	7	7		
25.	Warren	17	17	Madison	
26.	Monona	5	5	Harrison	(1) Johnson
	Crawford	6	6		
	Lee	12	12		
27.	Greene	7	7	Dallas (2)	
	Grundy	5	5		

THIRD QUARTER (October 16 to January 15)

28.	Wapello	8	7	Mahaska	
	Washington*	9	9		
29.	Kossuth	5	5	Humboldt, Osceola	
	Kossuth*	5	5		
	Sioux*	11	10		
	Hamilton*	5	5		
30.	Pottawattamie*	3	3	Adair	(1) Wapello
	Cass*	5	5		(2) Wayne
	Lucus*	3	3		
	Monroe*	3	3		
31.	Winneshiek*	9	8		
	Bremer*	10	10		
32.	Plymouth	9	9	Buena Vista,	
	Sac	(Rescheduled)		Woodbury	
33.	Jasper	15	15		
34.	Clinton	8	8	Johnson	
	Polk	12	11		
35.	Adams	4	4		
	Shelby	6	6		
36.	Pottawattamie	24	24		

37.	Emmet Palo Alto Pocahontas	3 5 4	3 5 4	Clay	

FOURTH QUARTER (January 16 to April 15)

38.	Mitchell Howard Franklin	7 6 4	7 6 4	Allamakee, Cerro Gordo	
39.	Madison Union Taylor	8 3 5	8 3 4		(1) Polk
40.	Black Hawk	13	13	Buchanan	
41.	Lucus* Monroe* Washington*	3 3 9	2 3 9	Wapello	
42.	Kossuth* Sioux* Hamilton*	6 10 5	6 9 5	Boone	
43.	Pottawattamie* Cass*	3 5	3 5		
44.	Winneshiek* Bremer* (Sac)	9 10 4	8 10 4	Butler	
45.	O'Brien Cherokee	6 6	6 5		
46.	Hardin	6	6	Grundy, Marshall	
47.	Carroll Dallas	7 13	7 13		
48.	Wright	5	5	Crawford, Webster	
49.	Delaware	13	13	Clayton	
50.	Benton Cedar	8 7	8 7	Clinton, Jones	

FINAL QUARTER (April 16 to July 15)

51.	Mahaska Marion	8 13	7 12	Warren (2)	
52.	Lucus* Monroe* Washington*	3 3 9	3 3 9		
53.	Kossuth* Sioux* Hamilton*	6 11 5	6 10 5		
54.	Pottawattamie* Cass*	3 5	3 5	Pottawattamie (3)	
55.	Winneshiek* Bremer*	9 10	7 10	Howard, Mitchell	
56.	Iowa	7	7	Black Hawk	

	Buchanan	11	11	
57.	Jefferson (Rescheduled) Des Moines	7	7	Henry, Shelby, Lee
58.	Scott Dubuque	10 13	10 12	Taylor
59.	Jefferson	5	4	

APPENDIX F.

Examples Of Correspondence
To Participants Regarding Data Results

Site No. ^F1^

^F2^

Dear ^F3^:

Enclosed below are the results of nitrate and coliform bacteria analyses from the water samples collected at your residence. The sampling was performed as part of the Iowa Statewide Rural Well Water Survey (SWRL) being conducted by the Iowa Department of Natural Resources, Geological Survey Bureau, and The University of Iowa Center for Health Effects of Environmental Contamination.

The sample was collected on ^F4^ ^F5^.

TEST	RESULTS	ACCEPTABLE LIMITS	INTERPRETATION
Nitrate (NO_3-as N)	^F6^ mg/l (NO_3-as N)	$\leq$10 mg/l	safe
Coliform Bacteria	^F7^ MPN	0	safe

The concentration for coliform bacteria and nitrates from your water are within acceptable limits.

Results for other chemical analyses, including pesticides and common water ions, will be sent to you in the near future. However, a one-time water sample analysis does not provide assurance that your water system will remain safe. A well-water supply inspection conducted by a qualified professional such as the county sanitarian, extension service agent, or reputable water supply contractor, would give better insight into the safety of your well-water supply system. Periodic testing (yearly) of your water for bacteria and nitrates is also a good practice.

We appreciate your participation in this research study. As previously discussed, we will not associate your name and address with any of the results in our reports for this study, and the health assessment questionnaire data will be kept confidential. If you have any questions about the results of these tests or the statewide survey, please contact either Dr. Hallberg (319/335-1575) or Dr. Kross (319/335-4423). Once again, thank you for your cooperation.

Sincerely,

Burton C. Kross, Ph.D., P.E.
Co-Principal Investigator
Department of Preventive Medicine and Environmental Health

George Hallberg, Ph.D.
Co-Principal Investigator
Iowa Department of Natural Resources, Geological Survey Bureau

BCK:GH:kb

July 21, 1989

Site No. ^F1^

^F2^

Dear ^F3^:

Enclosed below are the results of nitrate and coliform bacteria analyses from the water samples collected at your residence. The sampling was performed as part of the Iowa Statewide Rural Well Water Survey (SWRL) being conducted by the Iowa Department of Natural Resources, Geological Survey Bureau, and The University of Iowa Center for Health Effects of Environmental Contamination.

The sample was collected on ^F4^ ^F5^.

TEST	RESULTS	ACCEPTABLE LIMITS	INTERPRETATION
Nitrate (NO_3-as N)	^F6^ mg/l (NO_3-as N)	$\leq$10 mg/l	unsafe
Coliform Bacteria	^F7^ MPN	0	safe

The nitrate concentration in your water exceeded the recommended drinking water standard of 10 mg/l (NO_3-as N). This water should NOT be used in preparing infant formula or for consumption by infants less than six months old. Please note that boiling the water will concentrate the nitrate present thus increasing the danger to infants.

Nitrates, when ingested in sufficient amounts, pose a health risk to infants under six months of age by reducing the oxygen-carrying capacity of the blood. The resulting life-threatening disease is called "blue-baby syndrome" or methemoglobinemia.

Whether nitrates cause cancer and other adverse health effects in adults is unclear. Nitrates are known to be reduced to nitrite by enzymes and bacteria in the adult human mouth and digestive system. Nitrite in turn can form N-nitrosamines, known to be potent animal cancer-causing agents. High nitrate levels in groundwater have been associated with elevated rates of non-Hodgkin's lymphoma (cancer of lymphoid tissues) in a Nebraska study. An Australian study implicated high nitrate in drinking water with increased birth defects. As summarized by a well-respected researcher from the National Cancer Institute, "The jury is still out; there have been a number of studies, some suggestive, and others negative. There's a need for a lot more research."

Nitrate concentrations exceeding the drinking water standard are generally an indication of contamination from such sources as sewage disposal systems, animal manure, or nitrogen fertilizers, and are more likely to occur in shallow wells and in wells which are poorly located, constructed, or maintained. Investigation of any possible source of nitrate contamination should be made and remedial actions taken to restore the structural integrity of the well or water-line distribution system.

A one-time water sample analysis does not provide the complete picture of your water supply system. A well-water supply inspection conducted by a qualified professional such as the county sanitarian, extension service agent, or reputable water supply contractor, would give better insight into the problems of your well-water supply system. Periodic testing (yearly) of your water for bacteria and nitrates is also a good practice.

If home treatment systems are considered for nitrate removal, possible options include anion exchange, reverse osmosis or distillation. The effectiveness of these systems is quite variable. The effectiveness of any home treatment system for removing nitrate from the water should be well-documented with test data results requested from the manufacturer <u>before</u> purchasing. Nitrates are <u>not</u> removed by normal water softeners, iron filters, and granular activated carbon or charcoal filters.

Results for other chemical analyses, including pesticides and common water ions, will be sent to you in the near future.

We appreciate your participation in this research study. As previously discussed, we will not associate your name and address with any of the results in our reports for this study, and the health assessment questionnaire data will be kept confidential. If you have any questions about the results of these tests or the statewide survey, please contact either Dr. Hallberg (319/335-1575) or Dr. Kross (319/335-4423). Once again, thank you for your cooperation.

Sincerely,

Burton C. Kross, Ph.D., P.E.
Co-Principal Investigator
Department of Preventive Medicine and Environmental Health

George Hallberg, Ph.D.
Co-Principal Investigator
Iowa Department of Natural Resources, Geological Survey Bureau

BCK:GH:kb

July 21, 1989

<u>Site No. ^F1^</u>

^F2^

Dear ^F3^:

Enclosed below are the results of nitrate and coliform bacteria analyses from the water samples collected at your residence. The sampling was performed as part of the Iowa Statewide Rural Well Water Survey (SWRL) being conducted by the Iowa Department of Natural Resources, Geological Survey Bureau, and The University of Iowa Center for Health Effects of Environmental Contamination.

The sample was collected on ^F4^ ^F5^.

TEST	RESULTS	ACCEPTABLE LIMITS	INTERPRETATION
Nitrate (NO_3-as N)	^F6^ mg/l (NO_3-as N)	$\leq$10 mg/l	unsafe
Coliform Bacteria	^F7^ MPN	0	unsafe

Coliform bacteria were found in your water sample and the concentration exceeded the generally recommended drinking water standard. A one-time water sample analysis does not provide the complete picture of your water supply system. A well-water supply inspection conducted by a qualified professional such as the county sanitarian, extension service agent, or reputable water supply contractor, would give better insight into the problems of your well-water supply system. Periodic testing (yearly) of your water for bacteria and nitrates is also a good practice.

The presence of coliform bacteria in a drinking water supply indicates contamination from surface or shallow subsurface sources such as septic or cesspool leakage, animal feedlot runoff, etc. Their presence also suggests that disease-causing organisms may enter the drinking water supply in the same manner. You should consider properly disinfecting this water before use for human consumption. Investigation of any possible cause of contamination should be made, such as structural defects of well or system, improperly abandoned well nearby, contamination from repairs or new construction without proper disinfection, cross-connections, improper collection technique, etc. If no defects are apparent, another sample collected at a different tap location in the house may be necessary to pinpoint the problem, paying close attention to proper collection technique, handling and tap selection. If defects are found, remedial action should be taken to restore the structural integrity of the well or water-line distribution system, followed by a shock-chlorination treatment and retest for coliform bacteria.

The nitrate concentration in your water exceeded the recommended drinking water standard of 10 mg/l (NO_3-as N). This water should <u>NOT</u> be used in preparing infant formula or for consumption by infants less than six months old. Please note that boiling the water will <u>concentrate</u> the nitrate present thus increasing the danger to infants.

Nitrates, when ingested in sufficient amounts, pose a health risk to infants under six months of age by reducing the oxygen-carrying capacity of the blood. The resulting life-threatening disease is called "blue-baby syndrome" or methemoglobinemia.

Whether nitrates cause cancer and other adverse health effects in adults is unclear. Nitrates are known to be reduced to nitrite by enzymes and bacteria in the adult human mouth and digestive system. Nitrite in turn can form N-nitrosamines, known to be potent animal cancer-causing agents. High nitrate levels in groundwater have been associated with elevated rates of non-Hodgkin's lymphoma (cancer of lymphoid tissues) in a Nebraska study. An Australian study implicated high nitrate in drinking water with increased birth defects. As summarized by a well-respected researcher from the National Cancer Institute, "The jury is still out; there have been a number of studies, some suggestive, and others negative. There's a need for a lot more research."

Nitrate concentrations exceeding the drinking water standard are generally an indication of contamination from such sources as sewage disposal systems, animal manure, or nitrogen fertilizers, and are more likely to occur in shallow wells and in wells which are poorly located, constructed, or maintained. Investigation of any possible source of nitrate contamination should be made and remedial actions taken to restore the structural integrity of the well or water-line distribution system.

If home treatment systems are considered for nitrate removal, possible options include anion exchange, reverse osmosis or distillation. The effectiveness of these systems is quite variable. The effectiveness of any home treatment system for removing nitrate from the water should be well-documented with test data results requested from the manufacturer <u>before</u> purchasing. Nitrates are <u>not</u> removed by normal water softeners, iron filters, and granular activated carbon or charcoal filters.

Results for other chemical analyses, including pesticides and common water ions, will be sent to you in the near future.

We appreciate your participation in this research study. As previously discussed, we will not associate your name and address with any of the results in our reports for this study, and the health assessment questionnaire data will be kept confidential. If you have any questions about the results of these tests or the statewide survey, please contact either Dr. Hallberg (319/335-1575) or Dr. Kross (319/335-4423). Once again, thank you for your cooperation.

Sincerely,

Burton C. Kross, Ph.D., P.E.
Co-Principal Investigator
Department of Preventive Medicine and Environmental Health

George Hallberg, Ph.D.
Co-Principal Investigator
Iowa Department of Natural Resources, Geological Survey Bureau

BCK:GH:kb

July 12, 1989

<u>Site No. ^F1^</u>

^F2^

Dear ^F3^:

Enclosed below are the results of nitrate and coliform bacteria analyses from the water samples collected at your residence. The sampling was performed as part of the Iowa Statewide Rural Well Water Survey (SWRL) being conducted by the Iowa Department of Natural Resources, Geological Survey Bureau, and The University of Iowa Center for Health Effects of Environmental Contamination.

The sample was collected on ^F4^ ^F5^.

TEST	RESULTS	ACCEPTABLE LIMITS	INTERPRETATION
Nitrate (NO_3-as N)	^F6^ mg/l (NO_3-as N)	$\leq$10 mg/l	safe
Coliform Bacteria	^F7^ MPN	0	unsafe

Coliform bacteria were found in your water sample and the concentration exceeded the generally recommended drinking water standard. A one-time water sample analysis does not provide the complete picture of your water supply system. A well-water supply inspection conducted by a qualified professional such as the county sanitarian, extension service agent, or reputable water supply contractor, would give better insight into the problems of your well-water supply system. Periodic testing (yearly) of your water for bacteria and nitrates is also a good practice.

The presence of coliform bacteria in a drinking water supply indicates contamination from surface or shallow subsurface sources such as septic or cesspool leakage, animal feedlot runoff, etc. Their presence also suggests that disease-causing organisms may enter the drinking water supply in the same manner. You should consider properly disinfecting this water before use for human consumption. Investigation of any possible cause of contamination should be made, such as structural defects of well or system, improperly abandoned well nearby, contamination from repairs or new construction without proper disinfection, cross-connections, improper collection technique, etc. If no defects are apparent, another sample collected at a different tap location in the house may be necessary to pinpoint the problem, paying close attention to proper collection technique, handling and tap selection. If defects are found, remedial action should be taken to restore the structural integrity of the well or water-line distribution system, followed by a shock-chlorination treatment and retest for coliform bacteria.

Results for other chemical analyses, including pesticides and common water ions, will be sent to you in the near future.

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Sincerely,

Burton C. Kross, Ph.D., P.E.
Co-Principal Investigator
Department of Preventive
Medicine and Environmental
Health

George Hallberg, Ph.D.
Co-Principal Investigator
Iowa Department of Natural Resources,
Geological Survey Bureau

BCK:GH:kb

July 27, 1989

Site No. ^F1^

^F2^

Dear ^F3^:

Enclosed are the results of the analyses for pesticides and common chemical ions from the water samples collected at your residence. The sampling was performed as part of the Iowa Statewide Rural Well Water Survey (SWRL) being conducted by the Iowa Department of Natural Resources, Geological Survey Bureau, and The University of Iowa Center for Health Effects of Environmental Contamination.

The sample was collected on ^F4^ ^F5^.

The pesticide and common chemical ion results are given in the attached laboratory reports. Definitions of the chemical terms used and a summary of results which exceed current health advisory levels are highlighted in color on the laboratory reports. If you have questions about the water quality results, please contact us, or your local county board of health or county sanitarian.

We appreciate your participation in this research study. As previously discussed, we will not associate your name and address with any of the results in our reports for this study, and the health assessment questionnaire data will be kept confidential. If you have any questions about the results of these tests or the statewide survey, please contact either Dr. Hallberg (319/335-1575) or Dr. Kross (319/335-4423).

Sincerely,

Burton C. Kross, Ph.D., P.E.
Co-Principal Investigator
Department of Preventive Medicine and Environmental Health

George Hallberg, Ph.D.
Co-Principal Investigator
Iowa Department of Natural Resources, Geological Survey Bureau

BCK:GH:kb
Enclosures

UNIVERSITY OF IOWA -- FIELD MEASUREMENTS

The Iowa Statewide Rural Well-Water Survey (SWRL)

Sample taken July 5, 1988 Report date October 31, 1988

Mr. and Mrs. Mike Schmitt
R. R. 1, Box 15
Kinross, IA 52250

SWRL Project
P.O. Box 196
AMRF Building - Oakdale
Oakdale, IA 52319-0196
(319) 335-4422

Site Number 5404R

--- Listing of Field Measurement Results ---

Measurement	Value
Temperature (Centigrade)	16.0 °
Specific Conductance	-99999 µMHO/CM²
Dissolved Oxygen	1.81 mg/L
pH	7.50
Alkalinity	293 mg/L

Note : -99999 indicates that a measurement was not taken.

UNIVERSITY OF IOWA -- FIELD MEASUREMENTS

The Iowa Statewide Rural Well-Water Survey (SWRL)

Sample taken July 5, 1988 Report date October 31, 1988

Mr. and Mrs. Mike Schmitt
R. R. 1, Box 15
Kinross, IA 52250

SWRL Project
P.O. Box 196
AMRF Building - Oakdale
Oakdale, IA 52319-0196
(319) 335-4422

Site Number 5404T

--- Listing of Field Measurement Results ---

Measurement	Value
Temperature (Centigrade)	16.0 °
Specific Conductance	-99999 μMHO/CM²
Dissolved Oxygen	1.80 mg/L
pH	7.65
Alkalinity	309 mg/L

Note : -99999 indicates that a measurement was not taken.

UNIVERSITY OF IOWA - PESTICIDE HAZARD ASSESMENT LABORATORY

The Iowa Statewide Rural Well-Water Survey (SWRL)
Analytical Report

Sample taken July 6, 1988 Report date October 21, 1988

SWRL Project
P.O. Box 196
AMRF Building - Oakdale
Oakdale, IA 52319-0196
(319) 335-4422

Mr. and Mrs. Mike Schmitt
R. R. 1, Box 15
Kinross, IA 52250

Site Number 5404R
--- Listing of Analyses Performed and Results ---

Analyte (Common Name)		Concentration parts per billion	Method Used	Analyst
Butylate	(Sutan)	< 0.10	G1	ES
Trifluralin	(Treflan)	< 0.02	F2	ES
Dacthal	(DCPA)	< 0.01	F2	ES
Pendimethalin	(Prowl)	< 0.01	F2	ES
Propachlor	(Ramrod)	< 0.02	F2	ES
Atrazine	(Aatrex)	< 0.13	F2	ES
Metribuzin	(Lexone, Sencor)	< 0.01	F2	ES
Alachlor	(Lasso)	< 0.02	F2	ES
Metolachlor	(Dual)	< 0.04	F2	ES
Cyanazine	(Bladex)	< 0.12	F2	ES
De Ethyl Atrazine (metabolite)		< 0.10	H1	ES
De Isopropyl Atrazine (")		< 0.10	H1	ES
Carbofuran	(Furdan)	< 0.01	I1	ES
Carbofuran, 3-KETO		< 0.01	I1	ES
Carbofuran, 3-HYDROXY		< 0.02	I1	ES

Verified by : DM

All analytical results listed with a less than (<) sign in front of them are below method detection limits. This means that the analyte was not present in the sample in amounts greater than or equal to the listed value. Because electrical equipment is needed to measure the amounts of the analytes present, detection down to zero is impossible.

UNIVERSITY OF IOWA - PESTICIDE HAZARD ASSESMENT LABORATORY

The Iowa Statewide Rural Well-Water Survey (SWRL)
Analytical Report

Sample taken July 5, 1988 Report date October 21, 1988

SWRL Project
P.O. Box 196
AMRF Building - Oakdale
Oakdale, IA 52319-0196
(319) 335-4422

Mr. and Mrs. Mike Schmitt
R. R. 1, Box 15
Kinross, IA 52250

Site Number 5404T
--- Listing of Analyses Performed and Results ---

Analyte (Common Name)		Concentration parts per billion	Method Used	Analyst
Butylate	(Sutan)	< 0.10	G1	ES
Trifluralin	(Treflan)	< 0.02	F2	ES
Dacthal	(DCPA)	< 0.01	F2	ES
Pendimethalin	(Prowl)	< 0.01	F2	ES
Propachlor	(Ramrod)	< 0.02	F2	ES
Atrazine	(Aatrex)	< 0.13	F2	ES
Metribuzin	(Lexone, Sencor)	< 0.01	F2	ES
Alachlor	(Lasso)	< 0.02	F2	ES
Metolachlor	(Dual)	< 0.04	F2	ES
Cyanazine	(Bladex)	< 0.12	F2	ES
De Ethyl Atrazine	(metabolite)	< 0.10	H1	ES
De Isopropyl Atrazine	(")	< 0.10	H1	ES
Carbofuran	(Furdan)	< 0.01	I1	ES
Carbofuran, 3-KETO		< 0.01	I1	ES
Carbofuran, 3-HYDROXY		< 0.02	I1	ES

Verified by : DM

All analytical results listed with a less than (<) sign in front of them are below method detection limits. This means that the analyte was not present in the sample in amounts greater than or equal to the listed value. Because electrical equipment is needed to measure the amounts of the analytes present, detection down to zero is impossible.

UNIVERSITY OF IOWA - HYGIENIC LABORATORY

Analytical Report for Sample Number 8807276

Iowa City Laboratory
Oakdale Hall
Iowa City, IA 52242
(319) 335-4500

Des Moines Branch
900 East Grand
H.A. Wallace Building
Des Moines, IA 50319
(515) 281-5371

Date Received: 07/11/88

Date of Report: 08/15/88

Submitter: IGS SWRL
Address: 123 N CAPITOL
City: IOWA CITY, IA 52242

Sample Location: KEOKUK 5404 T
Date Collected: 07/05/88

Sample Description: WATER
Client Reference: 5404 T

Comments

KEOKUK 5404 T 1620 HRS
ACID PESTICIDES, INSECTICIDES
N-SERIES, NITRATE(+NITRITE), AMMONIA, ORGANIC-N(TKN)
COLIFORM

--- Listing of Analyses Performed and Results ---

TEST	CONCENTRATION		METHOD USED	ANALYST
AMMONIA (AS N)	2.4	MG/L	TIM #780-8	RWW
NO2+NO3 AS NO3-N	<0.1	MG/L	EPA 353.2	JAG
ORGANIC NITROGEN (N)	0.2	MG/L	TIM #786-8	RVD

Verified: MTF

TEST	micrograms/L	METHOD USED	ANALYST
BANVEL	<0.1	PR2,PR14	WP,MDH
2,4-D	<0.1	PR2,PR14	WP,MDH
SILVEX	<0.1	PR2,PR14	WP,MDH
AMIBEN	<0.1	PR2,PR14	WP,MDH
2,4,5-T	<0.1	PR2,PR14	WP,MDH
TORDON	<0.1	PR2,PR14	WP,MDH
BLAZER	<0.1	PR2,PR14	WP,MDH
COUNTER	<0.1	PR2,PR14	WP,MDH

PPM - Parts/Million   MG/L - Milligrams/Liter   MG/KG - Milligrams/Kilogram
PPB - Parts/Billion   uG/L - Micrograms/Liter   uG/KG - Micrograms/Kilogram
< - Less than   > - Greater than   pCi/L - pico Curies/Liter

Analytical Report for Sample Number 8807276

TEST	micrograms/L	METHOD USED	ANALYST
DIAZINON	<0.1	PR2,PR14	WP,MDH
DIMETHOATE	<0.1	PR2,PR14	WP,MDH
DYFONATE	<0.1	PR2,PR14	WP,MDH
LORSBAN	<0.1	PR2,PR14	WP,MDH
MALATHION	<0.1	PR2,PR14	WP,MDH
MOCAP	<0.1	PR2,PR14	WP,MDH
PARATHION	<0.1	PR2,PR14	WP,MDH
THIMET	<0.1	PR2,PR14	WP,MDH

Verified: MTF

Description: MOST PROBABLE NUMBER-TOTAL COLIFORMS

TOTAL COLIFORM MPN : 0

Analytical Method: EPA 305

Analyst: C
Verified: MTF

PPM - Parts/Million   MG/L - Milligrams/Liter   MG/KG - Milligrams/Kilogram
PPB - Parts/Billion   uG/L - Micrograms/Liter   uG/KG - Micrograms/Kilogram
< - Less than   > - Greater than   pCi/L - pico Curies/Liter

UNIVERSITY OF IOWA - HYGIENIC LABORATORY

Analytical Report for Sample Number 8807275

Iowa City Laboratory
Oakdale Hall
Iowa City, IA 52242
(319) 335-4500

Des Moines Branch
900 East Grand
H.A. Wallace Building
Des Moines, IA 50319
(515) 281-5371

Date Received: 07/11/88 Date of Report: 08/15/88

Submitter: IGS SWRL
Address: 123 N CAPITOL
City: IOWA CITY, IA 52242

Sample Location: KEOKUK 5404 R Sample Description: WATER
Date Collected: 07/05/88 Client Reference: 5404 R

Comments

KEOKUK 5404 R 1615 HRS
ACID PESTICIDES, INSECTICIDES
N-SERIES, NITRATE(+NITRITE), AMMONIA, ORGANIC-N(TKN)
COLIFORM

--- Listing of Analyses Performed and Results ---

TEST	CONCENTRATION		METHOD USED	ANALYST
AMMONIA (AS N)	2.4	MG/L	TIM #780-8	RWW
NO2+NO3 AS NO3-N	<0.1	MG/L	EPA 353.2	JAG
ORGANIC NITROGEN (N)	0.4	MG/L	TIM #786-8	RVD

Verified: MTF

TEST	micrograms/L	METHOD USED	ANALYST
BANVEL	<0.1	PR2,PR14	WP,MDH
2,4-D	<0.1	PR2,PR14	WP,MDH
SILVEX	<0.1	PR2,PR14	WP,MDH
AMIBEN	<0.1	PR2,PR14	WP,MDH
2,4,5-T	<0.1	PR2,PR14	WP,MDH
TORDON	<0.1	PR2,PR14	WP,MDH
BLAZER	<0.1	PR2,PR14	WP,MDH
COUNTER	<0.1	PR2,PR14	WP,MDH

PPM - Parts/Million MG/L - Milligrams/Liter MG/KG - Milligrams/Kilogram
PPB - Parts/Billion uG/L - Micrograms/Liter uG/KG - Micrograms/Kilogram
< - Less than > - Greater than pCi/L - pico Curies/Liter

Analytical Report for Sample Number 8807275

TEST	micrograms/L	METHOD USED	ANALYST
DIAZINON	<0.1	PR2,PR14	WP,MDH
DIMETHOATE	<0.1	PR2,PR14	WP,MDH
DYFONATE	<0.1	PR2,PR14	WP,MDH
LORSBAN	<0.1	PR2,PR14	WP,MDH
MALATHION	<0.1	PR2,PR14	WP,MDH
MOCAP	<0.1	PR2,PR14	WP,MDH
PARATHION	<0.1	PR2,PR14	WP,MDH
THIMET	<0.1	PR2,PR14	WP,MDH

Verified: MTF

Description: MOST PROBABLE NUMBER-TOTAL COLIFORMS

TOTAL COLIFORM MPN : 0

Analytical Method: EPA 305

Analyst: C
Verified: MTF

PPM - Parts/Million MG/L - Milligrams/Liter MG/KG - Milligrams/Kilogram
PPB - Parts/Billion uG/L - Micrograms/Liter uG/KG - Micrograms/Kilogram
< - Less than > - Greater than pCi/L - pico Curies/Liter

UNIVERSITY OF IOWA - ENVIRONMENTAL ENGINEERING LABORATORY

The Iowa Statewide Rural Well-Water Survey (SWRL)
Analytical Report

Sample taken July 5, 1988 Report date October 18, 1988

SWRL Project
P.O. Box 196
AMRF Building - Oakdale
Oakdale, IA 52319-0196
(319) 335-4422

Mr. and Mrs. Mike Schmitt
R. R. 1, Box 15
Kinross, IA 52250

Site Number 5404R
--- Listing of Analyses Performed and Results ---

Chemical (Symbol)		Concentration milligrams per liter	Analyst
Anions:			
Fluoride	(F)	0.0	JB
Chloride	(Cl)	6.8	JB
Sulfate	(SO4)	301.5	JB
Cations:			
Sodium	(Na)	103.4	JB
Potassium	(K)	7.3	JB
Magnesium	(Mg)	38.3	JB
Calcium	(Ca)	72.6	JB

Verified by : JKJ

THE IOWA STATEWIDE RURAL WELL WATER SURVEY (SWRL)
Definitions of Terms Used in Reporting Well Water Results

People will continue to need and use chemicals, and some chemicals will invariably end up in some drinking water. Therefore, health guidelines and standards for various contaminants have been developed. These may provide a frame of reference for reviewing the results of your water analyses.

How much confidence should we place in numerical standards and guidelines for drinking water? For example, a health advisory might suggest that the concentrations of a particular chemical in drinking water should not exceed 10 parts per billion. If water contains more than that, say 12 parts per billion, is it completely unsafe to drink? If the water contains only 8 parts per billion, is it completely safe? Unfortunately, there is no simple answer.

The process for establishing a drinking water standard or guideline begins with a scientific assessment of the toxicity or risk to public health posed by the contaminant. Scientists typically make a series of "safe" or conservative decisions to determine the contaminant concentration in drinking water that is not expected to cause public health problems.

A risk estimate is used when setting a standard for cancer-causing substances because scientists agree that zero-risk (absolutely safe) levels of exposure to these substances may not exist. A risk estimate is developed by looking at the health effects that high doses produce when administered to laboratory animals; then the risk of human health effects from the much lower concentrations found in drinking water is estimated. For example, the risk estimate for atrazine suggests that 3 parts per billion of atrazine in drinking water could produce 3.5 excess cancer cases per 1,000,000 people who consume the contaminated water over a 70-year lifetime.

INTERPRETING LABORATORY TEST RESULTS

The results of your water analysis are expressed in terms of the concentration of the substance in the water. The following units of measure are used:

1. A MILLIGRAM is one one-thousandth of a gram. One gram is about the weight of a pea. A LITER is about a quart volume.

   **** 1 milligram per liter (mg/L) = 1000 micrograms per liter (µg/L)

2. PARTS (by weight) of contaminants per PART (by weight) of water

   **** 1 part per million (ppm) = 1000 parts per billion (ppb)

To convert from one system to another for the purpose of drinking water analysis:

1 mg/L = 1 ppm
1 µg/L = 1 ppb

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METHOD DETECTION LIMITS

Each analytical method is tested to determine the lowest concentration of chemical that can be reliably and consistently measured in water. This concentration is then defined as the method detection limit. Values reported as less than (<) the method detection limit simply mean that the concentration of the chemical is less than the given method detection limit. The actual concentration of the chemical could be zero, or just below the method detection limit, or any value in between. Since each analytical method involves an electronic instrument, method detection limits of zero are not possible.

COLIFORM BACTERIA

Coliform bacteria are found in human and animal wastes, and in topsoil. Soil acts as a natural bacterial filter (unless the soil is very coarse textured). Bacteria and viruses become trapped as water percolates through unsaturated soil. Water that percolates through 10 to 20 feet of soil before it reaches the water table generally contains no coliform bacteria.

When coliform bacteria are found in wells it is generally due to defects in the top 10 to 20 feet of the well. The defects permit surface water to enter the well without percolating through the "soil filter."

Test results usually indicate the number of coliform organisms in 100 milliliters of water. The abbreviation "MPN" stands for "most probable number," meaning that the number reported is a statistical estimate of the number of coliform organisms in the water rather than a direct count.

Drinking water should be free from coliform bacteria. Coliform bacteria are not a health hazard themselves, but their presence suggests that disease-causing bacteria or viruses may be able to enter the drinking-water supply. In some cases, low coliform counts are caused by accidental contamination of the sterile container when the sample is collected.

NITRATE

Low concentrations (up to 5 mg/L) of naturally occurring nitrate are found in some uncontaminated groundwater. Higher concentrations probably indicate a degree of pollution by fertilizer, manure, septic tank wastes, polluted surface waters, or other sources.

Laboratories report nitrate results in two different ways. Nitrate may be reported as milligrams per liter of nitrate (mg/L of NO_3), or as milligrams per liter of nitrate-nitrogen (mg/L of NO_3-N). The drinking water standard set by the U.S. EPA is 45 mg/L, measured as NO_3, or 10 mg/L, measured as NO_3-N. These two standards are equivalent.

This drinking water standard was set primarily to avoid infant cyanosis methemoglobinemia (blue-baby syndrome), a temporary blood disorder that reduces the ability of an infant's bloodstream to carry oxygen throughout the body. Water containing more than 45 mg/1 of nitrate (10 mg/L NO_3-N) should NOT be used in preparing infant formula or consumed by infants less than 6 months old. Boiling the water will CONCENTRATE the nitrate present, thus INCREASING THE DANGER to infants.

Nitrate is known to be reduced to nitrite by enzymes and bacteria in the adult human mouth and digestive systems. Nitrite in turn can form N-nitrosamine, known to be a potent animal cancer-causing agent. High nitrate levels in groundwater have been associated with elevated rates of non-Hodgkin's lymphoma (cancer of lymphoid tissues) in a Nebraska study. An Australian study associated high nitrate in drinking water with increased birth defects. As summarized by a well-respected researcher from the National Cancer Institute, "The jury is still out; there have been a number of studies, some suggestive, and others negative. There's a need for a lot more research."

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As indicated above, some evidence suggests that nitrate in drinking water might cause cancer, but the EPA has indicated that there is insufficient information currently available to determine whether or not nitrate causes cancer in humans. The current drinking water standard is based only on non-cancer health effects.

ORGANIC NITROGEN

This is a measure of dissolved substances containing nitrogen in combination with carbon and is frequently referred to as total Kjeldahl nitrogen (TKN). Examples are urea (sometimes used as fertilizer), products of breakdown of vegetation, and a long list of herbicides commonly used in Iowa. Neither ammonia, nitrate or nitrite are measured as organic nitrogen. Detection of organic nitrogen in well water raises a suspicion of contamination by degraded organic matter or by agricultural chemicals.

AMMONIA NITROGEN

Ammonia is uncommon in uncontaminated groundwater. As a pollutant, it may come from downward percolation of ammonia applied as fertilizer, from degradation of manure or from septic tank wastes. It may also be derived from bacterial reduction of nitrate contained in the groundwater, and is a natural constituent (in low concentrations) of many deeper groundwaters. Detection of it signifies a degree of contamination from some source. Of itself, ammonia presents little or no direct threat to human health, but it often indicates undesirable pollution. Ammonia is toxic to fish in concentrations above about 1.0 milligram per liter (mg/L).

DISSOLVED OXYGEN (DO)

Many aquatic species in streams and lakes obtain oxygen required for respiration from gaseous oxygen dissolved in the water. The amount of DO depends on many factors: water temperature (the lower the temperature the greater the saturation amount of DO), altitude (higher elevations result in lower saturation amounts of DO), and natural sources such as photosynthetic processes of algae and higher aquatic plants. The average range of DO in water is 0-10 mg/L.

When water remains relatively free of waste material, the DO content will support aquatic life. However, decomposition of organic pollutants by aerobic bacteria consumes DO in the water. A common measure of this process is the biological oxygen demand (BOD) test.

Dissolved oxygen and BOD measurements are typically performed on surface water from streams and lakes to evaluate the ability of these aquatic systems to support fish. In groundwater monitoring, DO levels may provide insight into general water chemistry conditions in the aquifer.

SPECIFIC CONDUCTANCE

Water containing dissolved minerals conducts electricity more efficiently than water that is mineral-free. Conductance is therefore a useful measure of total mineral content. In Iowa, groundwater generally contains substantial minerals dissolved from the surrounding rock resulting in specific conductance values ranging from 500-1500 μMHO/cm^2 (micro mhos per square centimeter.) There are no regulatory standards or limits for specific conductance. Unless the mineral content consists of sodium salts (as in brackish waters not typically found in Iowa), no health hazard is associated with a high level of electrical conductance.

pH

pH is a measure of the acid/base characteristic of water. A pH value of greater than 7.0 means the water is basic, or alkaline. Iowa groundwater is generally slightly alkaline. An approximate acceptable range is 6.5-8.5. This range is based on corrosive effects on the water distribution system rather than health considerations.

ALKALINITY, TOTAL AND AS CARBONATE

These are measures of mineral content, chiefly the bicarbonates and carbonates of calcium and magnesium. Contents in Iowa groundwater are generally high ranging from 100-400 mg/L. This property has no negative health impact. It does affect laundry detergent requirements and scaling and corrosion of water heaters.

HARDNESS

Hardness is caused by naturally occurring calcium and magnesium dissolved from soil or rock formations. Some typical effects are scaling in pipes or water heaters, reduced sudsing of soaps, and formation of soap scum or film. Hardness can be reported in milligrams per liter of calcium carbonate (mg/L as $CaCO_3$) or in grains per gallon of calcium carbonate (gpg as $CaCO_3$).

	Hardness Range	
Classification	mg/L	gpg
Soft	0 - 60	0 - 3.5
Moderate	61 - 120	3.5 - 7.0
Hard	121 - 180	7.0 - 10.5
Very Hard	more than 180	more than 10.5

SODIUM

The sodium ion is commonly found in groundwater. Water softening systems that use resins exchange sodium ions for calcium and magnesium ions, thereby increasing the amount of sodium in the water. For every mg/L of hardness removed, an ion exchange softener adds about one-half mg/L of sodium to the water. For example, typical Iowa well water with about 400 mg/L of hardness, would have about 200 mg/L of sodium added to it if treated with an ion exchange softener. If this water has naturally occurring sodium (some groundwater does), the total sodium will be higher than 200 mg/L.

Total sodium intake in humans has been linked with hypertension. Average total daily sodium intake in the United States ranges from 2,100 to 7,300 mg. Drinking water usually represents about 10% of total daily intake of sodium if the concentration of sodium in the water is less than 200 mg/L.

CALCIUM AND MAGNESIUM

These ions are major contributors to hardness in groundwater. Current levels of calcium and magnesium in U.S. drinking water are well below levels that pose known risks to human health. Elevated levels of calcium have been studied as a risk factor for certain human cancers, but evidence is not conclusive at this time. Elevated levels of magnesium and sulfate together can have a laxative effect.

SULFATE

The U.S. Public Health Service drinking water standard for sulfate is 250 mg/L. Elevated concentrations of sulfate can have a laxative effect on humans. The taste threshold for sulfate in water lies between 300-400 mg/L.

CHLORIDE

The U.S. Public Health Service drinking water standard for chloride is 250 mg/L. Chloride concentrations are normally low in most of Iowa's groundwater so that elevated levels may indicate contamination from surface water or point sources. Reported taste thresholds for chloride anions in water varies from 210-310 mg/L. Chloride content of water varies with the geochemistry of the area and contamination from sewage, industrial, and other waste. Typical chloride concentrations in drinking water contribute relatively little to total chloride intake. Typical chloride concentrations in drinking water are about 20 mg/L. With an average 2 liter/day consumption, water represents about 2% of the lower estimates of total chloride intake.

POTASSIUM

Potassium ions are not considered to have adverse health effects.

FLUORIDE

The U.S. EPA established a National Secondary Drinking Water regulation for fluoride at 2 mg/L to protect against objectionable dental fluorosis (dental mottling, staining, etc.) and a maximum contaminant level of 4 mg/L to protect against crippling skeletal fluorosis. However, the presence of fluoride in drinking water at about 1-2 mg/L has repeatedly been shown to be beneficial because, at these concentrations, fluoride decreases the incidence rate of dental cavities in children. There is no evidence to support that fluoride in drinking water is associated with cancer or birth defects.

PESTICIDES

These chemicals get into groundwater by downward movement through the soil from fields to which the chemicals have been applied, through infiltration by polluted surface waters, spills, and occasionally by back-siphoning accidents that contaminate water in the affected wells. The characteristics of these chemicals vary substantially, there is no single laboratory test for them, and there is no single water treatment unit that will handle all of them equally well.

Pesticide concentrations are reported in units of "micrograms per liter;" the equivalent to parts per billion (ppb).

The pesticides whose concentrations have been measured in the study are commonly used in Iowa agriculture as herbicides and insecticides. After application pesticides naturally break down in the environment through various chemical mechanisms and biological processes. The resulting decomposition compounds are called environmental metabolites. Environmental metabolites of common herbicides were measured because we thought they might serve as "markers" of prior contamination by these herbicides' parent compounds. Little is known about the environmental significances, persistence, and health effects of these metabolites. Currently there are no health advisories or standards established for metabolites.

Table 1 is a summary of health guidance values for pesticides included in the Iowa Statewide Rural Well Water Survey. Consuming water containing pesticides at or below the EPA Lifetime Health Advisory Level is not expected to result in adverse non-cancer health effects.

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SOURCES OF ADDITIONAL INFORMATION

Based on results of analyses conducted on a private water sample, it may be necessary to seek guidance in restoring a drinking water supply to a safe level. Assistance may be available from a local county health department, county sanitarian, extension service, or the state department of public health. Additional information about the health effects of environmental contaminants is available through county health departments or county sanitarians.

The following Iowa State University Extension publications may also provide useful information to help correct water system contamination problems:

Pm-840 Good Wells for Safe Water --- Discusses proper well location and construction. (Note: Pm-840 out-of-print; update pending.)

Pm-899 Shock-Chlorinating Small Water Systems --- Discusses the disinfection of wells to eliminate bacterial contamination.

Pm-987 Water Quality for Home & Farm --- General discussion of factors affecting water for animal and human consumption.

Other water-related publications available from Iowa State University Extension are:

Pm-921 Iowa's Groundwater --- A Valuable Resource

Pm-938 Home Sewage Treatment: Conventional Methods & Equipment

Pm-986 On-Site Wastewater Treatment Using Mound-Type Systems

Pm-1201 Agricultural Drainage Wells in Iowa

Pm-1202 Groundwater Contamination in Northeastern Iowa

CRD-107 Regional Rural Water Systems in Iowa

These publications are available at county extension offices in Iowa from:

Publications Distribution Center,
Printing and Publications Building,
Iowa State University, Ames, IA, 50011.

Prepared by: Center for Health
Effects of Environmental Contamination,
The University of Iowa,
Burton C. Kross, Assistant Professor,
(319) 335-4423

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HEALTH GUIDANCE VALUES FOR PESTICIDES INCLUDED IN THE IOWA STATEWIDE RURAL WELL WATER SURVEY

Analyte	Common Name	Method Detection Limit Micrograms per liter (ppb)	U.S.EPA Lifetime Health Advisory Level[1]	Possible Non-Cancer Health Risks[2]	U.S.EPA Cancer Classification	Estimated Cancer Risk Rating[3]	Wisconsin Preventive Action Limit[4]
acifluorfen	Blazer or Tackle	0.10		liver and kidney damage, effects on blood, delayed fetal development	probable human carcinogen	1.0	
chloramben	Amiben	0.10	100	birth defects and liver damage	insufficient data	N/A[5]	30
dicamba	Banvel	0.10	200	reduced birth weight and increased rate of miscarriages	insufficient data	N/A[5]	(60)
2, 4-Dichloro-phenoxyacetic acid	2, 4-D	0.10	70	liver and kidney damage, central nervous system effects and blood disorders	insufficient data, recent study linking to non-Hodgkin's lymphoma	N/A	20
2, 4, 5-Tri-chlorophenoxy-acetic acid	2,4,5-T, Ded-Weed, Fortex	0.10	70	liver and kidney effects, birth defects	insufficient data	N/A	
2, 4, 5-Tri-chlorophenoxy-propionic acid	Silvex, 2,4,5-TP	0.10	50	liver and kidney damage			2
pichloram	Tordon, Grazon	0.10	500	changes in liver, decreased fertility, birth defects	insufficient data	N/A	
chlorpyrifos	Lorsban	0.10	(20)	cholinesterase inhibitor[6]	insufficient data	N/A	
ethoprop	Mocap	0.10		cholinesterase inhibitor[6]			
fonofos	Dyfonate	0.10	10	cholinesterase inhibitor[6]	insufficient data	N/A	

tt122189BCKpos5

Analyte	Common Name	Method Detection Limit Micrograms per liter (ppb)	U.S.EPA Lifetime Health Advisory Level[1]	Possible Non-Cancer Health Risks[2]	U.S.EPA Cancer Classification	Estimated Cancer Risk Rating[3]	Wisconsin Preventive Action Limit[4]
phorate	Thimet	0.10		cholinesterase inhibitor[6]			
terbufos	Counter, Contraven	0.10	0.9	cholinesterase inhibitor[6]	not cancer-causing	0	
dimethoate	Cygon, De-Fend	0.10		cholinesterase inhibitor[6]			(0.4)
diazinon	Spectracide	0.10	0.6	cholinesterase inhibitor[6]	not cancer-causing	0	
malathion	Cythion	0.10	(200)	cholinesterase inhibitor[6]	not cancer-causing	0	
parathion		0.10		cholinesterase inhibitor[6]			
alachlor	Lasso	0.02	0.4[7]	liver and kidney damage, eye damage	probable human carcinogen	0.4	0.05
atrazine	Atranex, Crisazina	0.13	3	chromosome damage, congestion of lungs, liver, and kidneys, effects on adrenal glands and nervous system, delayed fetal development	possible human carcinogen	3.5	0.35
butylate	Sutan	0.10	700	birth defects and changes in testicles	insufficient data	N/A	6.7
cyanazine	Bladex	0.12	10	increased rate of miscarriage and birth defects	insufficient data	N/A	1.25
dacthal	DCPA	0.01	4000	effects on the liver	insufficient data	N/A	
metolachlor	Dual, Bicep	0.04	100	diarrhea, vomiting, changes in testicles	possible human carcinogen	15	1.5

tt122189BCKpos5

Analyte	Common Name	Method Detection Limit Micrograms per liter (ppb)	U.S.EPA Lifetime Health Advisory Level[1]	Possible Non-Cancer Health Risks[2]	U.S.EPA Cancer Classification	Estimated Cancer Risk Rating[3]	Wisconsin Preventive Action Limit[4]
metribuzin	Lexone, Sencor	0.01	200	kidney and liver damage	insufficient data	N/A[5]	(50)
propachlor	Ramrod, Bexton	0.02	90	changes in liver and kidney, increased rate of miscarriages	insufficient data	N/A	
trifluralin	Treflan	0.02	2	kidney and liver damage, effects on blood	possible human carcinogen	5.0	(0.25)
pendimethalin	Prowl	0.02		phosphorylation, generate hemoglobin			
carbofuran	Furadan	0.01	40	cholinesterase inhibitor[6]	not cancer causing	0	10

[1]Concentration in micrograms per liter (ppb). Consuming water containing the chemical at or below the Lifetime Health Advisory Level is not expected to result in adverse non-cancer health effects. This level includes a margin of safety. The combined effects of several chemicals present in drinking water have not been considered. ( ) means based on draft health advisory. Source: US EPA National Pesticide Survey, Health Advisory Summary.

[2]These effects will probably not occur at levels encountered in typical drinking water. The possible health risks are determined by assuming an adult is exposed to the chemical over a 70-year lifetime. Moreover, health effects data are often based on laboratory animal studies.

[3]Concentration resulting in 1 excess cancer case per 1,000,000 population.

[4]Concentration in micrograms per liter (ppb). Preventive action limits are 10-20% of the enforcement standards in Wisconsin. When these limits are exceeded, specific clean-up or regulation of chemical use are considered. ( ) indicates proposed status, 1989.

[5]N/A means not available at this time.

[6]Large decreases in cholinesterase can cause vomiting, nausea, blurred vision, stomach pain, sweating, and muscle weakness in arms and legs.

[7]Proposed Maximum Contaminant Level (MCL) is 2.0 ppb. Source: U.S. EPA Safe Drinking Water Act proposed regulations.

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APPENDIX G.

Field Measurement Form

THE IOWA STATEWIDE RURAL WELL WATER SURVEY (SWRL)
IOWA DEPARTMENT OF NATURAL RESOURCES, GEOLOGICAL SURVEY BUREAU,
AND THE UNIVERSITY OF IOWA CENTER FOR HEALTH EFFECTS
OF ENVIRONMENTAL CONTAMINATION

FIELD MEASUREMENT FORM

1. WATER SAMPLE ID NUMBER

_______________ COUNTY _________ SITE ____ CODE ___/___/___ MO DAY YR

2. FIELD CREW INITIALS: _ _ _ _ _ _

ON-SITE MEASUREMENTS (PLEASE USE REVERSE SIDE FOR COMMENTS)

3. TEMPERATURE__________C°
4. TIME SAMPLE COLLECTED ________ MILITARY
5. CONDUCTIVITY__________μMHO/CM^2
6. DISSOLVED OXYGEN__________MG/L
7. PH__________
8. ALKALINITY__________MG/L ____ML SAMPLE __________DIGITAL READING X CONVERSION FACTOR

9. WHERE WERE THE WATER SAMPLES COLLECTED?
(PLEASE CIRCLE "YES" TO ALL THAT APPLY.)

AFTER THE CISTERN?	YES	NO
AFTER WATER TREATMENT?	YES	NO
AT THE WELLHEAD?	YES	NO
AT A HYDRANT NEAR THE WELL?	YES	NO
AT AN OUTSIDE TAP?	YES	NO
AT A KITCHEN TAP?	YES	NO
AT A TAP IN THE HOUSE OTHER THAN KITCHEN?	YES	NO
9 = OTHER? SPECIFY:____________________	YES	NO

10. WHAT WERE THE WEATHER CONDITIONS AT THE TIME OF SAMPLE COLLECTION?
(PLEASE CIRCLE THE NUMBER THAT APPLIES.)

1 = RAINING 2 = SNOWING
3 = WARM/SNOWMELT 4 = FAIR TO GOOD

11. ARE THERE ANY OBVIOUS WATER-QUALITY PROBLEMS SUCH AS

TURBIDITY? IF "YES", SPECIFY:____________________	YES	NO
COLOR? IF "YES", SPECIFY:____________________	YES	NO
SMELL? IF "YES", SPECIFY:____________________	YES	NO
OTHER? IF "YES", SPECIFY:____________________	YES	NO

12. HOW MANY MINUTES WAS THE WELL PUMPED BEFORE THE FIELD WATER QUALITY PARAMETERS STABILIZED AND THE SAMPLES WERE COLLECTED? ________ MINUTES

APPENDIX H.

Sample Custody Form

Iowa Statewide Rural Well Water Survey (SWRL)
Iowa Department of Natural Resources, Geological Survey Bureau,
and the University of Iowa Center for Health Effects
of Environmental Contamination

Sample Custody Form

Water Sample ID Number

____________ County	______ Site	______ Code	__ __/__ __/__ __ Mo Day Yr

UHL	PHAP	EEL
# of bottles rec'd_____ Date received_________ From:_______ To:_______ Taken to field by______	# of bottles rec'd_____ Date received_________ From:_______ To:_______ Taken to field by______	# of bottles rec'd_____ Date received_________ From:_______ To:_______ Taken to field by______
Analyses required: Nitrogen Series _____ Acid Herbicides _____ Insecticides _____ Bacteria _____ Other (specify) ______________ _____	Analyses required: Herbicide _____ Metabolites _____ Microtox _____ Other (specify) _____ ______________ _____	Analyses required: IC _____ TOX _____ TOC _____ TIC _____ Other (specify)_____ ______________ _____
# of bottles rec'd_____ Date received_________ Received by _________ Delivered by _________	# of bottles rec'd_____ Date received_________ Received by _________ Delivered by _________	# of bottles rec'd____ Date received_________ Received by _________ Delivered by _________

PLEASE SEND RESULTS OF ANALYSES TO:
Mary Lewis, 226 AMRF, Oakdale Campus 335-4221

(tear along dotted line)

For University Hygienic Lab Bacteria Analysis Only

Water Sample ID Number

____________ County	______ Site	______ Code	__ __/__ __/__ __ Mo Day Yr

Project: SWRL

Chlorinated _____ Depth of Well __________
Non-Chlorinated _____ Sampling Time __________

Comments:____

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APPENDIX I.

Data Management Form

THE IOWA STATEWIDE RURAL WELL WATER SURVEY (SWRL)
IOWA DEPARTMENT OF NATURAL RESOURCES, GEOLOGICAL SURVEY BUREAU, AND THE UNIVERSITY OF IOWA CENTER FOR HEALTH EFFECTS OF ENVIRONMENTAL CONTAMINATION

DATA MANAGEMENT FORM

WATER SAMPLE ID NUMBER

_____________ COUNTY _____________ SITE ______ CODE __/__/__ MO DAY YR

TYPE OF DATA	RESULTS RECEIVED BY	DATE	SUBMITTED TO DATA MANAGEMENT RECEIVED BY	DATE	DATA ENTRY STATUS DATE ENTERED	BY	DATE VERIFIED
1. INITIAL SITE EVALUATION FORM							
2. INVENTORY QUEST. FOR FARM SITE -OR- INVENTORY QUEST. FOR HOUSEHOLD/ SUBURBAN SITE							
3. HEALTH ASSESS. QUEST. ENTER # FOR THIS LOCATION _______							
4. FIELD MEAS. FORM							
5. ANALYTICAL RESULTS							
A. UHL							
BACTERIA---------	--						
NITROGEN SERIES--	--						
ACID HERBICIDES--	--						
INSECTICIDES-----	--						
OTHER (SPECIFY)--	--						
B. PHAP							
HERBICIDES-------	--						
METABOLITES------	--						
MICTROTOX--------	--						
OTHER (SPECIFY)--	--						
C. EEL							
IC IONS							
ORGANIC SCREENING							
OTHER (SPECIFY)							

RESULTS REPORTED TO PARTICIPANTS

1. NITRATE/BACTERIA REPORT

REVIEWED BY _____________ DATE SENT _____________

2. PESTICIDE AND OTHER RESULTS

REVIEWED BY _____________ DATE SENT _____________

SWRL 03 3/88

APPENDIX J.

IDNR-GSB Well Information Form

Iowa Department of Natural Resources, Geological Survey Bureau,
and The University of Iowa Center for Health Effects
of Environmental Contamination

IGSB WELL INFORMATION

1. ____________________ ___________ __ __/__ __/__ __

Name of County Site Number Month Day Year (Today's Date)

2. Interviewer Initials: ___ ___ ___

3. Person Being Interviewed:

Name? _________________________ _________________________
First Last

4. Rank ______________

5. Where is the well located that provides your primary source of drinking water?

_________1/4, SEC_________, T_________N, R_________W/E
Location/Section-Township-Range

* ____________________/____________________/____________________
(FOR OFFICE USE ONLY: LATITUDE / LONGITUDE / ELEVATION)

a. Depth of Well? ______________ ft.

b. Casing depth? _______________ ft.

c. Likely aquifer?

6. Fill in the following information for each other well.

Number	Well Depth (ft.)	Location/Section-Range-Township
1	___________	_________1/4, SEC_______, T_______N, R_______W/E
2	___________	_________1/4, SEC_______, T_______N, R_______W/E
3	___________	_________1/4, SEC_______, T_______N, R_______W/E
4	___________	_________1/4, SEC_______, T_______N, R_______W/E

Iowa Department of Natural Resources
Energy and Geological Resources Division
123 North Capitol Street
Iowa City, Iowa 52242
(319) 335-1575