

Final Report

The Impact of Rural Water Supply Systems on Property Values

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The Impact of Rural Water Supply Systems on Property Values

Executive Summary

This report summarizes the objectives, methods and results of a USGS/NIWR 104G research project which was implemented from 2005 to 2007 in selected areas of central and southeastern North Dakota and single county in eastern Nebraska.

Rural water pipelines and service areas and residential sale locations were digitized into a geographic information system (GIS) database and hedonic multiple regression models were used to measure the marginal impact of rural water on the sale prices of rural-residential homes while accounting for varying housing and locational characteristics.

The study area in North Dakota included seven agricultural counties in the south central part of the State (150 sales) while in Nebraska the focus was a single semi-rural county just north of Omaha (176 sales). A combination of surveys with the buyers/sellers of properties and drive-by inspections were used to collect needed information on the characteristics and condition of homes sold from 2000 through 2005 in North Dakota and 1996 through May 2006 in Nebraska.

In North Dakota, private water quality was higher in areas where residents relied on private wells in contrast to using rural water systems (this water quality issue/connection issue was not evaluated in Nebraska). In both states, approximately half of the sold homes analyzed had rural water connections (in contrast to private wells). Average sale prices for rural water supply homes were higher than private well homes in both states, but these rural water homes were also larger and newer than homes with private wells.

The estimation of a hedonic-based multiple regression model, that accounted for different structural and locational characteristics of sold homes demonstrated that rural water supply connections *do not* have a statistically significant impact on housing prices in *any* of the study locations. This unexpected result is likely influenced by the fact that water scarcity (supply) is not always a major factor in any of the areas studied, yet housing sales and drinking water conditions (private well quality) were found to be highly varied (heterogeneous) across the study areas. This indicates that not all homes may actually require rural water connections in such areas in contrast to other locations with extreme water scarcity and/or unsafe water (i.e. where virtually all homes need to be connected to rural water in order to have any market value and/or be constructed).

The major policy implications are that full participation (signups) for rural water systems in rural areas with generally sufficient water supply and heterogeneous well water should not be assumed prior to planning and implementing rural water supply projects in such areas. Rather, local participation (sign-ups) should be estimated through surveys and/or house and well specific water quality data in order to evaluate potential homeowner participation. These study conclusions are limited to the two study areas in each state and should not be considered to be necessarily representative of all rural water supply systems statewide in North Dakota or Nebraska.

Introduction

In 1986, the federal government authorized for North Dakota, the ‘municipal, rural and industrial (MR&I) water supply program’, funded partially by a \$200 million federal grant, which has helped many North Dakota water systems obtain a clean, reliable supply of water for residences, farms, schools, hospitals and industries. Much of the focus of these funds, which have been matched by state and local governments, has been rural water supply projects. Similar rural water supply projects are being implemented in nearby northern great plain states and many of the economic benefits associated with the large investments are unknown.

It is hypothesized that access to improved water supplies through the implementation of rural water supply projects across North Dakota will positively impact rural residential property values. Rural residential properties in this context are defined as single-family homes outside of traditional city limits (with municipal water and sewer service) and they do not include active farms (although prior farmsteads now separated from agricultural acreages do meet this rural residential classification). The overall goal of this research is to quantify indirect economic benefits associated with rural water supply projects. Such information is considered necessary to justify the substantial financial investments in rural water supply infrastructure across North Dakota. Specifically, comparing the costs and benefits of rural water supply projects is needed to ensure the wise use of public funds and to convince local governments and property owners to provide matching funds (cost-sharing) for such projects. At the same time, by demonstrating that rural property values will increase with improved water services, it is expected that property owners and local decision-makers will further support local cost-sharing required of many federal rural water supply projects. Finally, if properties with rural water supply infrastructures are worth more than similar properties without such water supplies, adjustments should be made to the tax liabilities of those particular properties.

With funding over the 2005-2007 time period from a USGS/NIWR 104G research grant, the impact of rural water supply systems on rural-residential property values was quantified in North Dakota and Nebraska. Rural water pipelines and service areas along

with residential sale locations were digitized into a geographic information system (GIS) database and hedonic multiple regression models were used to measure the marginal impact of rural water on sale prices while accounting for varying housing characteristics.

The study area in North Dakota included seven agricultural counties in the south central part of the State (150 sales) while in Nebraska the focus was a single semi-rural county just north of Omaha (176 sales). Figures 1 and 2 depict the locations and the sample populations of houses in each of these two study areas.

Populations in both study locations rely on groundwater for their drinking water needs. Most sources of groundwater in these states consist of shallow glacial fluvial aquifers composed of gravel and sand. These aquifers tend to be near the surface, small, highly localized, and subject to contamination from nitrates and other agricultural contaminants. In addition to potential health risks from private wells, the aesthetic quality of this water is often considered to be poor by local residents who must frequently replace water based appliances (water heaters and dishwashers) and in some cases haul in their own drinking water, and/or do laundry in nearby cities and towns. The Washington County rural water supply project in Nebraska differs from the North Dakota study area as the Nebraska location is more urbanized with rapidly growing residential developments due to its close proximity to the Omaha metropolitan area.

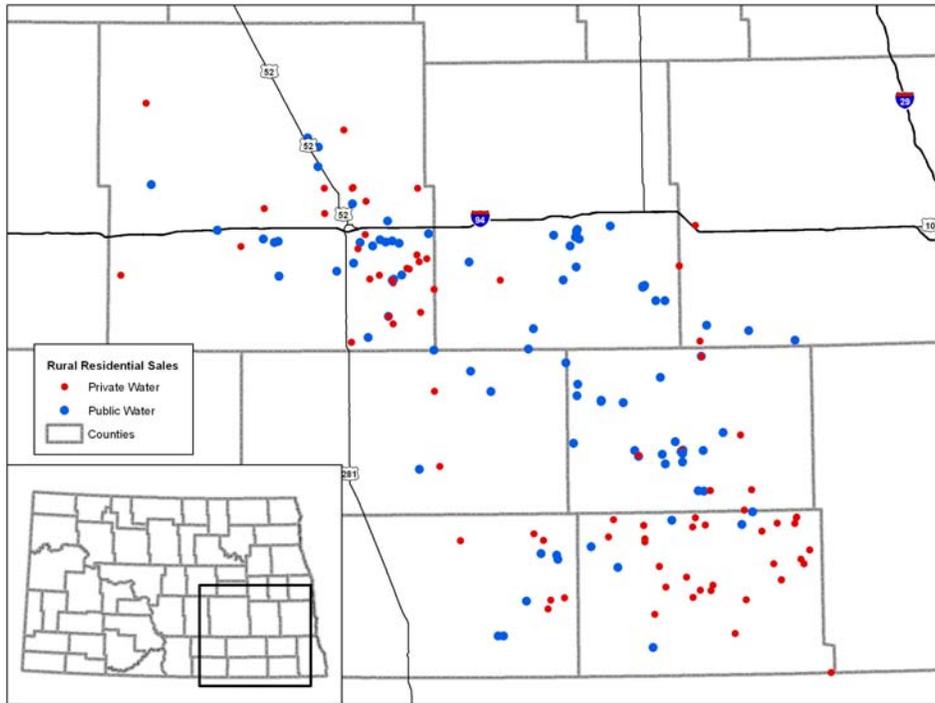


Figure 1. Rural Water Study Location in North Dakota

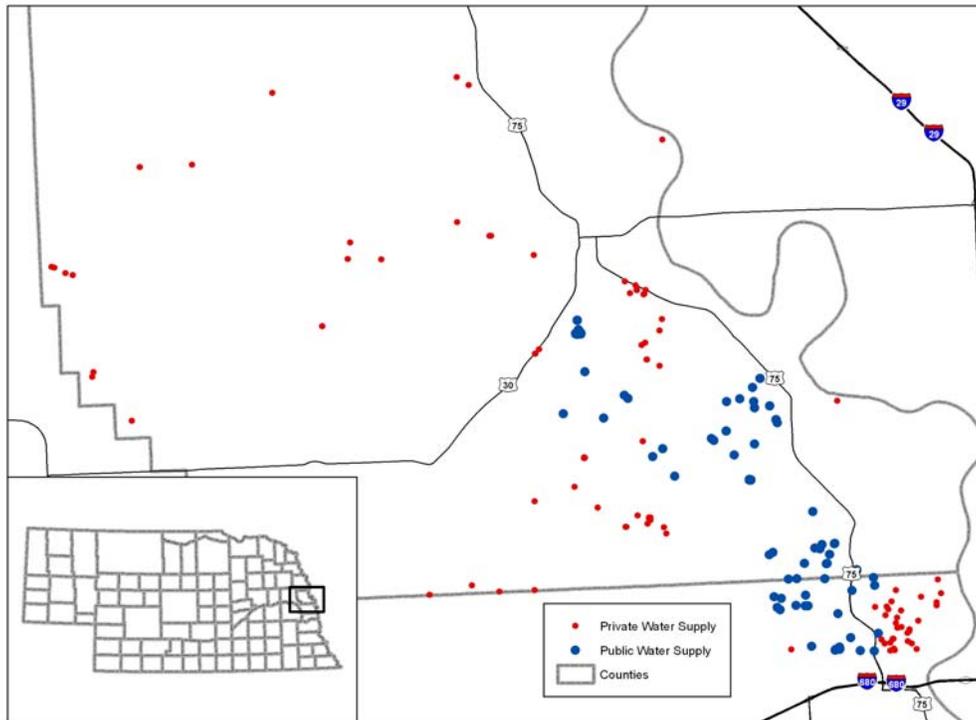


Figure 2. Rural Water Study Location in Nebraska

Rural water systems are unique in that they generally serve fewer than 1,000 people yet may have costs associated with them that mirror systems installed in metropolitan areas. Despite this cost, 46,000 water systems in the country serve fewer than 1,000 customers (United States EPA 1999). In North Dakota many of these small water systems serve isolated, sparsely populated communities (Figure 3). These systems involve large amounts of infrastructure serving few users, often with income levels at or below the median income level for the state or region i.e., rural water systems in North Dakota serve users who may be unable or unwilling to pay the full price for the system.

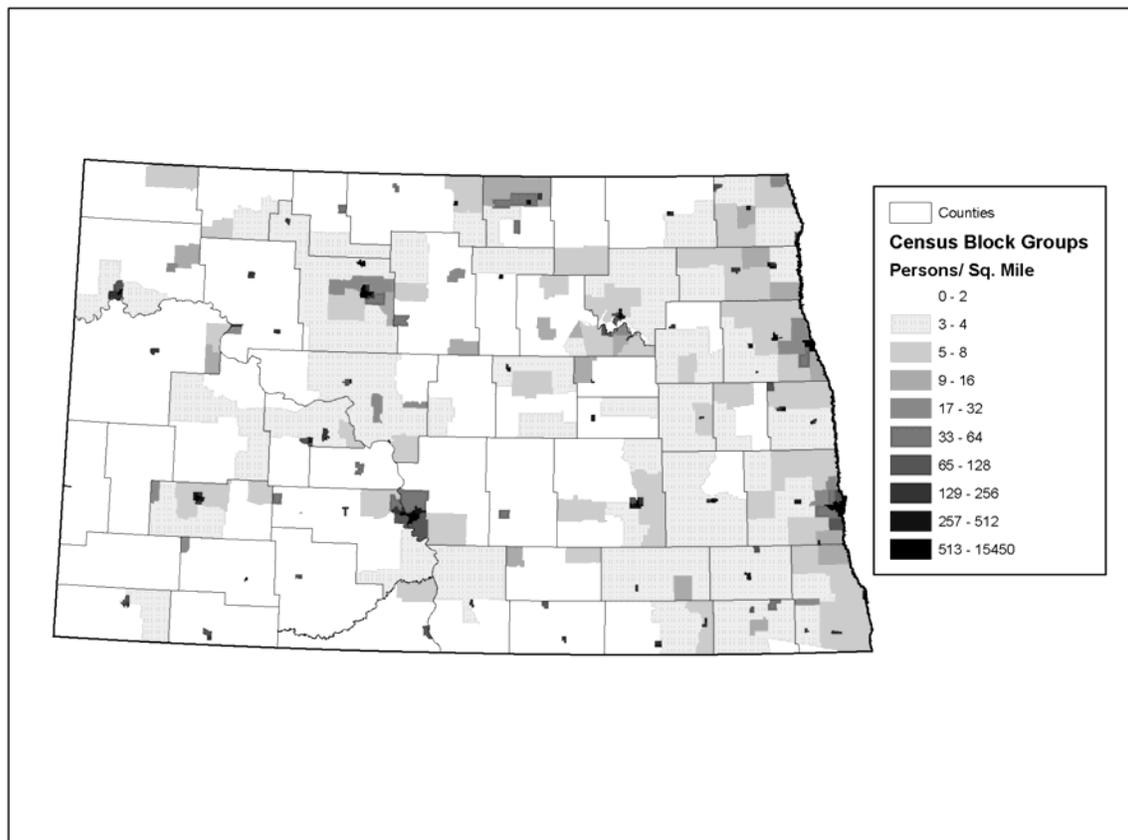


Figure 3. North Dakota Population Density (Census Map)

Opinions regarding rural water systems range far and wide with advocates touting their construction as necessary for economic growth in rural areas and opponents claiming taxpayer financing for these projects as an unnecessary waste of government funds. A recent article in the Minneapolis Fedgazette focused on issues surrounding many of the current and pending rural water supply systems in the region (Davies 2005). This included a

summary of the needs of potential users of rural water supply projects as well as discussions of local, state, and particularly federal funds required of such projects. The article noted that in extreme cases federal funds may provide upwards of \$26,000 for each user on a rural system.

The overall objective of this study is to quantify the impact of rural water supply service. However, in conducting this analysis additional market components will be accounted for. It is expected that the utilization of a hedonic model will provide insight into the performance of rural sales on the housing market and will help to quantify determinants of real property value in rural areas.

The hedonic model is well represented in the academic literature with regards to real property valuation. The technique treats the sale price of a home (or other real estate) as a function of its characteristics (structural, locational or otherwise). Hedonic models rely on relatively large sample sizes and a variety of variables to make inferences regarding the market for real estate in a given area or across a certain class of properties. This study utilizes data collected from county tax authorities in North Dakota and on Multiple Listing Service data in Nebraska to ascertain the effect of water supply projects on housing values in rural areas.

Background

Water Supply Issues in North Dakota

A clean reliable water source is often the limiting factor of development in rural areas. In the absence of a water system many rural homeowners in rural North Dakota (and many other rural areas of the great plain States) rely on groundwater for their drinking water needs. Most sources of groundwater in North Dakota consist of shallow glacial fluvial aquifers composed of gravel and sand. These aquifers tend to be near the surface, small, and highly localized (Figure 4).

Large homogeneous bedrock aquifers underlay large tracts of land in many parts of the Midwest. These bedrock aquifers in North Dakota tend to be very deep and often require expensive well construction for utilization or their water quality is poor or marginal due to salinity. Glacial-fluvial aquifers are located near the surface and require little effort for well drillers to tap. Due to the nature of their formation they tend to be highly localized near glacial moraines or river valleys (Seelig 1994). This precludes their use by many rural residents.

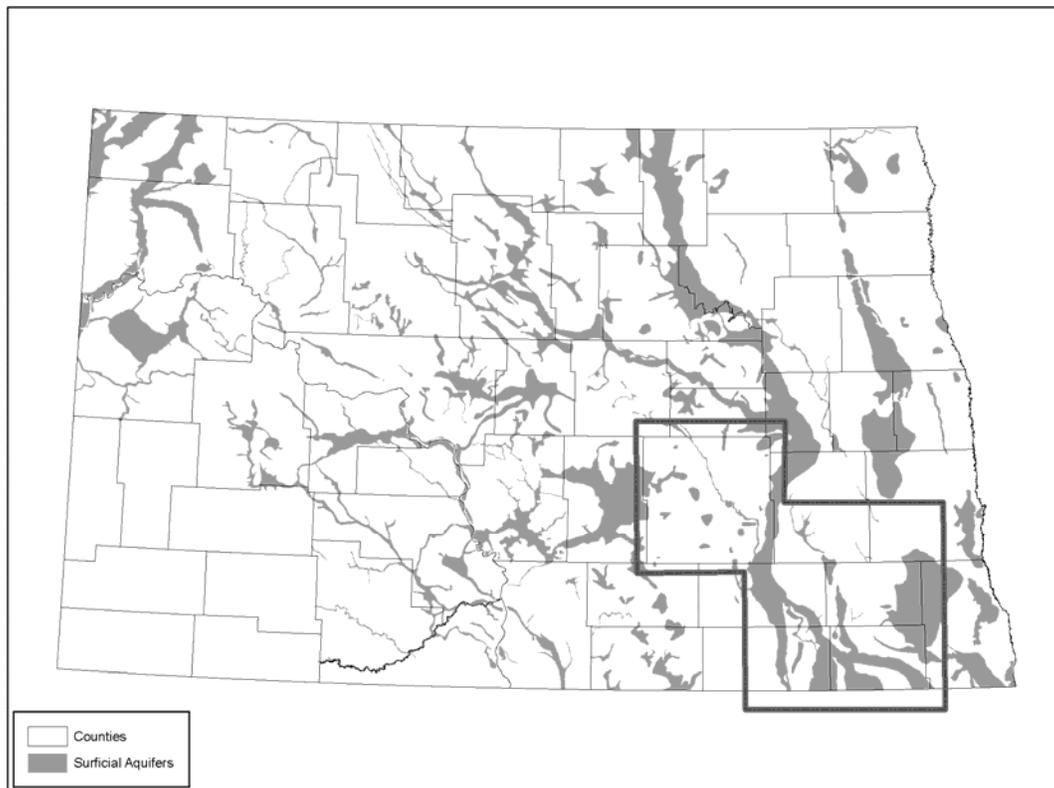


Figure 4. Locations of Surficial Aquifers in North Dakota.

In areas where they occur, glacial-fluvial aquifers tend to be relatively shallow; hydrologically they are well connected to the surface. This close proximity to human activity leaves them highly susceptible to contamination and utilization. Much of this human activity consists of production agriculture, which plays a prominent role in the economy of southeast North Dakota where most land is cropped or used as rangeland.

Agriculture can contribute nitrate, a highly soluble mineral, to the groundwater. High nitrate levels are often the result of fertilizer application and high concentrations of farm animals (Hudak 2005). Leaching due to irrigation and rainfall allows nitrate to move into shallow aquifers. This movement of water also allows arsenic to be released. Arsenic is a naturally occurring element released into groundwater through the weathering of rocks and minerals (EPA 2006). Water is the solvent of the earth, as it moves through aquifers it slowly dissolves the constituents of the medium it moves through. As this movement of water is increased towards high volume irrigation wells the amount of contaminants in the available well water often becomes more concentrated.

The first Rural Water System in North Dakota was constructed in Grand Forks and Trail Counties in the early 1970's using \$3 million in loan financing from the Farmers Home Administration. Since then numerous other rural water supply projects have been developed in North Dakota (Figure 5). The three rural water supply systems in North Dakota chosen for this study include the Barnes Rural Water District, Stutsman Rural Water District, and the Ransom-Sargent Rural Water District. These three systems are contiguous stretching from the central to the southeastern part of the state over a six county range (Figure 4 & 5). The original study design planned to include the southwestern part of the state where several high profile rural water pipeline projects have recently been implemented but there were not enough sales of homes without rural water hooks-ups required for our planned statistical models.

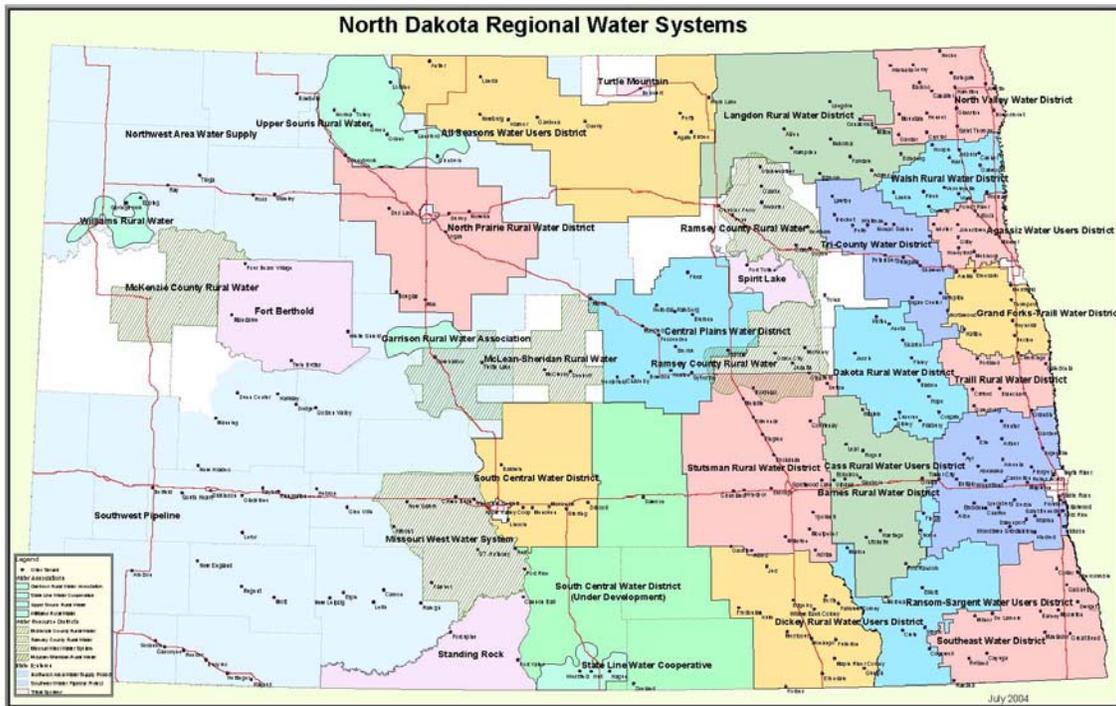


Figure 5. North Dakota Regional Water Systems
 (Source: North Dakota State Water Commission)

In southeastern North Dakota, cases of groundwater contamination described above have become widespread in areas with large underground water supplies. In other areas there simply has never been a reliable source of water for most rural residents, i.e., no aquifer is present under their home. This shortage of clean reliable water has led to the construction of rural water systems throughout much of North Dakota. Rural water systems move water through sparsely populated areas to supply residents that would be overlooked by more conventional water systems.

Barnes Rural Water was completed in 1978 and currently serves 1,367 households with a total population served of 3417. Current costs for system hook-up are \$2,100 which includes meter, equipment and membership fees, plus the homeowner must pay around \$3.50 per foot to connect to the main line. Many users choose to remain on their private well (water) supply due to costs associated with their distance to the main line (Perry Capone, Personal Communication).

Constructed in the 1980's, the Stutsman Rural Water System became operational in 1987 and it currently serves 3,048 users. At its inception homeowners were given a subsidized connection fee of \$350 to allow them to hook up. Today it costs \$1800 plus roughly \$4 per foot from the main line for a homeowner to be connected to the system. Water is available throughout the county, however few residents not currently connected pay to connect if they are further than ½ mile from the main pipeline. Homeowners in the area continue to remain independent of the rural water system for a variety of reasons including but no limited to: lack of resources for the connection fee, satisfaction with naturally occurring water supplies (aquifers, etc.), and/or a desire to remain independent of public utilities (Gary Schultz, Stutsman County Rural Water District Manager, Personal Communication).

Ransom-Sargent Rural Water was completed November 2001 and currently serves 2,025 households. At its inception costs to connect were \$500 Current costs to hook-up to the system are \$700. Many users choose to remain off rural water because they are happy with their own well. The current cost per 1,000 gallons is \$5.00 (Steve Hansen, Personal Communication)

Other recent (major) water projects in North Dakota include the Southwest Pipeline which uses water from the Missouri river to provide water to 2900 individual users and 43 municipalities. The newest area of water development in North Dakota is the proposed Northwest area Water Supply is in the early stages of development and is currently waiting for pending Environmental Impact Statements. Currently there are 47 mile sof pipeline completed running north from Lake Sakaawea (State Water Commission 2006).

Prior to the construction of the rural water supply system in our study area (southcentral North Dakota), the State Water Commission and others conducted a survey of local residents to assess their perceptions of their private well water supplies and their interests in signing up (and paying for) rural water connections. From the 68 completed surveys it was determined between 47% and 64% of all eligible homes were actively interested in rural water (had signed up before the projects began). Despite the fact 77% of residents

felt that they had an adequate supply of water, most (60%) also felt that their water was too hard (contained too many minerals), while 23% reported nitrates or bacterial related problems with their water supplies and 32% of respondents reported that they hauled in drinking water (Table 1).

Table 1. Results of a Prior Water Supply System Survey of Local Residents (ND)

LOCATION / QUESTIONS	RESPONSE / CONTACTED	PERCENTAGE
AREA OF QUESTIONING		
Have a hardness problem?	51 / 68	75
Use a softener?	41 / 68	60.3
Have a NO ₃ /bacteria problem?	9 / 68	13.2
NO ₃ /bacteria problem - unknown?	23 / 68	33.8
Have artisan well?	22 / 68	32.4
Have an adequate supply of water?	53 / 68	77.9
Haul water for drinking?	22 / 68	32.4
DICKEY COUNTY		
Have a hardness problem?	4 / 6	66.6
Use a softener?	3 / 6	50
Have a NO ₃ /bacteria problem?	1 / 6	16.6
NO ₃ /bacteria problem - unknown?	3 / 6	50
Have artisan well?	1 / 6	16.6
Have an adequate supply of water?	3 / 6	50
Haul water for drinking?	1 / 6	16.6
BARNES COUNTY		
Have a hardness problem?	9 / 9	100
Use a softener?	0 / 9	0
Have a NO ₃ /bacteria problem?	4 / 9	44.4
NO ₃ /bacteria problem - unknown?	1 / 9	11.1
Have artisan well?	1 / 9	11.1
Have an adequate supply of water?	8 / 9	88.8
Haul water for drinking?	5 / 9	55.6
LAMOURE COUNTY		
Have a hardness problem?	7 / 8	87.5
Use a softener?	7 / 8	87.5
Have a NO ₃ /bacteria problem?	0 / 8	0
NO ₃ /bacteria problem - unknown?	1 / 8	12.5
Have artisan well?	2 / 8	25
Have an adequate supply of water?	7 / 8	87.5
Haul water for drinking?	2 / 8	25
SARGENT COUNTY		
Have a hardness problem?	13 / 19	68.4
Use a softener?	12 / 19	63.2
Have a NO ₃ /bacteria problem?	2 / 19	10.5
NO ₃ /bacteria problem - unknown?	7 / 19	36.8
Have artisan well?	7 / 19	36.8
Have an adequate supply of water?	17 / 19	89.5
Haul water for drinking?	7 / 19	36.8
RANSOM COUNTY		
Have a hardness problem?	18 / 26	69.2
Use a softener?	19 / 26	73
Have a NO ₃ /bacteria problem?	1 / 26	3.8
NO ₃ /bacteria problem - unknown?	11 / 26	42.3
Have artisan well?	11 / 26	42.3
Have an adequate supply of water?	18 / 26	69.2
Haul water for drinking?	7 / 26	26.9

Table 2-1: Random Telephone Survey Results

Water Supply Issues in Nebraska

Residents in Washington County, Nebraska face many of the same water issues as their counterparts in North Dakota. However their problems are manifested differently. The need for rural water in Nebraska stems both from poor water quality and poor water supply. Private water well water in Washington county often exhibits high iron and manganese content. These minerals are usually not an immediate health concern to residents, they are the source of discolored plumbing fixtures and appliances and often result in water with an offensive odor and taste. Some areas served by rural water in Nebraska also suffers from low pumping rates [gpm] and overall supply issues to private wells.

In an effort to combat poor water quality and supply in the area Washington County Rural Water System #1 was completed in August of 1980 and currently serves 440 rural households (Papio-Missouri NRD 2007). This system is supplied with water by the Metropolitan Utilities District (MUD) which is the utility that serves the Omaha metropolitan area. The cost for users to connect to this system was and still is \$2,500 or the cost to bring the infrastructure to the property line, whichever is greater (Rich Sklenar, Personal Communication).

Another system was added in October of 2005, in Washington County #2, which now serves 240 users (Papio-Missouri NRD, 2007). This system obtains water from the nearby city of Blair, Nebraska. Costs for connection are similar to Washington #1, with connection fees of \$3500 or the total cost of bringing water to the property line, again whichever amount is greater. This system is unique in that while it was constructed the local NRD worked with banks to provide low interest loans of up to \$5,000 for residents to connect to the system. Despite this incentive, roughly 30% of residents still opted out of this system with anecdotal evidence that they were satisfied with their current private well or simply could not afford the costs of implementation. However, according to local managers, residents are still connecting to the system with a few connections every month (Rich Sklenar, Personal Communication). Additionally, it is important to note that residents who connect to rural water will incur fees to decommission their abandoned

well. Nebraska state law requires all abandoned water wells be grouted with bentonite, sand, and gravel by a licensed well contractor.

Previous Studies (Literature Review)

Few studies have looked directly at the price of drinking water supply and quality in developed countries. However, this issue is well researched in poorer areas of developing countries; see Hardner (1996) and Whittington et al. (1990) for examples. Water is rarely traded on a true market by itself, but rather it is often a part of a bundle goods consumers purchase. Additionally water quality and supply can hold value for different uses including but not limited to human consumptive, recreational, industrial and agricultural (irrigation) uses.

Two methodologies have emerged in valuing water quality as it relates to drinking water; *revealed* and *stated* preference. A popular method for amenity valuation with revealed preferences is the utilization of real estate transaction data. The transfer of real property in a true market is a transaction of heterogeneous bundles of housing services, environmental amenities, and access to public goods and services. By desegregating the bid-prices for all housing characteristics the consumer's revealed price for water quality (or other amenity) can be determined. Conversely, stated preference techniques involve surveys or questionnaires designed to solicit from respondents what they would be willing to pay for an amenity. This method has been criticized in that consumers may understate what they would be willing to pay. However, through advanced survey techniques and statistical modeling this bias has been largely overcome.

Contrary to the amount of research involving groundwater specifically with regards to drinking water there are many examples from the literature analyzing the value of surface water quality in the United States for both use and non-use by means of both revealed and stated preference techniques; some examples include Leggett and Bockstael (2000) using residential land prices near the Chesapeake Bay in a hedonic framework and Desvousges, Smith, and Fisher (1987) utilizing a contingent valuation approach for the Monongahela River in Pennsylvania.

Stated Preference Studies of Drinking Water Quality

Much of the text evaluating groundwater quality and protection, especially regarding drinking water, utilize a Contingent Valuation Model (CVM). Shultz and Lindsay (1990) conclude that residents served by a city water system in Dover, New Hampshire would be willing to pay \$40 annually for increased groundwater protection, with much of the risk associated with contamination coming from industrial or commercial sources. Sun, Bergstrom, and Dorfman (1992) show that with a risk of contamination from agricultural chemicals, the mostly urban population (served by water systems) of Daugherty County, Georgia would spend \$641 annually for groundwater protection, although they note that this value is highly variable across demographics of survey respondents. Both of these studies look at water quality from the perspective of health effects.

Cho et al. (2005) found that residents in Southwestern Minnesota would be willing to pay \$33 and \$25 annually for reduction in Iron and Sulfate to desirable levels, respectively. However, they note that this fee would not be enough for the water utility to implement practices to reduce contaminants to desirable levels.

Jordan and Elnagheeb (1993) go a step further and differentiate between public and privately served households. With a sample of 79% publicly-served households they estimate the willingness to pay (WTP) for groundwater separately for each sub-group noting that public water users would pay an extra \$121/year and Private Water users would spend \$149/year. These results show a significant difference between the two types of users, the authors suspect that this is due, in part, to the fact that while public water users currently pay for their water on an annual basis, private water users obtain theirs for free after the installation of a well system.

Poe and Bishop (1999) note differences in the WTP for water quality across varying levels of drinking water contamination for rural residents served by private water systems. They conclude that when survey respondents are presented with their current levels of water quality (shown the extent of contamination) they will respond differently to a valuation survey depending on that amount. They found that the willingness to pay for nitrate reduction does not increase linearly with exposure but rather assumes a cubic

functional form and declines after a certain threshold value. This has interesting implications in that households with highly degraded drinking water may be aware that small increases in quality will not bring their water quality to acceptable levels, and as such, they may not be willing to pay for any increase in quality since mitigation to acceptable levels may be extremely costly.

These studies are similar in that they all analyze households' preferences relating to changes in the quality of their water through direct treatment of their current source. Only one study has considered a switch from one source of water to another. Piper (1998) uses a Contingent Valuation Model to estimate the WTP of Central Montana residents for water to be delivered to existing municipal systems and private rural residences by a newly constructed pipeline. Urban residents (connected to existing municipal systems) are willing to pay from \$49 to \$89 per year for the new system and rural residents (using private wells) would pay between \$65 and \$138 per year to hook-up to the system. These findings coincide with Jordan and Elnagheeb (1993) showing that rural (privately served residents) are willing to pay more for improvements in water quality.

Hedonic Price Studies

There are three known studies that have used residential real estate transaction data to measure the impact of reduced water quality on housing values; one as a case study and two using hedonic modeling techniques.¹ Page and Rabinowitz find that groundwater contamination (in the form of volatile organic compounds (VOCs) stemming from a landfill) in Wisconsin had no measurable effect on residential property values.² Malone and Barrows (1990), also working in Wisconsin studying nitrate contamination use a hedonic model to desegregate residential values. They conclude that well contamination has little or no impact on housing values. They attribute this to the possibility that homeowners are not aware of the health risks or that there is a readily available alternative to the current supply of drinking water. They also speculate that the cost may

¹ A Case Study is a research strategy that is conducted without the need for large datasets by looking at one instance or case. By looking at a phenomenon within context it is possible to discern causes that may be missed when relying on a small number of variables within a large dataset.

² VOCs are carbon based molecules such as aldehydes, ketones, and hydrocarbons. Sources include paint thinners, dry cleaning solvents or petroleum fuels.

be accounted for in other ways such as days on market or the seller may compensate for the contamination through filter installation or the construction of a new well.

Only one hedonic study has found a significant link between drinking water quality and residential real estate values. Des Rosiers, Bolduc, and Theriault (1999) analyzed a sample of 800 single-family detached homes in Charlesbourg, Quebec, of which some were subject to frequent water health advisories. They find that many warnings in an area to boil water caused home values to decline by 1%. However, the situation in Charlesbourg differs from the other two studies in that the warnings were made very public and occurred over broad areas and the health effects of not boiling would be significant and immediate. In contrast, Malone and Barrows (1990) study nitrate contamination which unless present at extremely high levels is generally considered only dangerous to children, especially in the short run.

Methods and Procedures

A Summary of the Procedures:

In North Dakota data on homes sold over the 2000 to 2005 time period (sale prices and housing characteristics) were obtained directly from county tax directors and through surveys with the buyers/sellers of properties, and in some cases drive-by inspections of the outside of homes. In Nebraska, multiple listing service sales data was used to identify homes sold during the 1996 to May 2006 time period. Home locations were geo-coded to measure distances from homes to water supply pipelines, towns and urban areas, and other features. These variables are summarized in Table 2.

Sale locations were digitized into a GIS database and 'Near' functions were used to calculate the distance of the sales to the nearest of a variety of features; cities, interstates and State Highways, Other Paved Roads, groundwater testing sites and rural water service areas. The water supply status of all homes was confirmed either through phone surveys with homeowners and/or reviews of water utility customer records. More detailed descriptions of data collection procedures are presented in the data collection efforts in a subsequent section.

A Model of Rural Water Supply and Property Values

A hedonic model utilizes decisions regarding a differentiable product made by consumers as it is reflected in the prices paid. A theoretical model to serve as a basis for the hedonic technique was first developed by Rosen (1974). Many economists have since utilized this model to estimate the impact of characteristics of real estate markets; a succinct example in reference to residential property markets is given by Palmquist (1984). The basic premise of the model is based on the assumption that differentiated products such as houses are bundles of similar quantifiable housing characteristics (bedrooms, lot size, proximity to environmental amenities and disamenities). Furthermore, it is assumed that the supply of housing is inelastic at a given location allowing the demand for housing (and characteristics of residential property) to be modeled using Ordinary Least Squares (OLS) Regression (vs. more complex simultaneous equation models). In short, the selling price of a home is a function of its structural characteristics, the point in time at which it was sold and the environment surrounding the home.

To estimate this model it is assumed that home buyers seek to maximize utility U :

$$U = U(\delta, \alpha, S, T, E, R)$$

with δ as the composite commodity, α representing socio-economic characteristics of the buyer, physical characteristic of homes S , a time trend vector T , a matrix of environmental variables E , and a variable indicating the presence of rural water L . Homebuyers will maximize utility subject to a budget constraint:

$$Y = \delta + (\text{Price})$$

where Y is income.

E & R are often representative of a variety of environmental characteristics (pollution, open space, and recreation) in this study it is assumed that E is representative of all environmental characteristics except water quality which is represented by R and indicates the presence of rural water. Therefore, to measure the effect of a specific environmental attribute, R , it is assumed that buyers desiring rural water service will purchase homes equating marginal willingness to pay with the marginal implicit value for rural water. The marginal implicit price of rural water can therefore be estimated by:

$$\frac{\partial U / \partial R}{\partial U / \partial \delta} = \frac{\partial \text{Price}}{\partial R} = \beta_R .$$

A further issue regarding the hedonic model is the functional form. Palmquist (1991) among others note that economic theory lends little guidance in choosing a functional form for the equation. Since real property cannot be disassembled and repackaged without cost, most economists agree that the functional form does not have to be linear. In fact many researchers utilize a Boxcox transformation, allowing the data to determine the functional form (Box and Cox 1964). Despite this, there exists a school of thought preferring simpler functional forms to more complex transformations. It is recognized that in applied or empirical studies it is the drawn conclusions that are of the utmost importance especially in terms of interpretation and dissemination where the audience is unlikely to be versed in econometric theory. In a well cited article, Cropper, Deck, and McConnell (1988) show that in the presence of omitted variables (of which hedonic models frequently suffer) it is often simpler functional forms (linear, log-linear, and log-log) which outperform Boxcox and quadratic functions in minimizing bias. In light of this, modeling efforts for this research use a linear model where the coefficients of the explanatory variables represent the change in dollars of the dependant variable with respect to a one unit change in the corresponding independent variable.

The model is specified as follows:

$$\text{Sale Price}_i = \beta_0 + \sum_{i=1}^n \beta_s S_i + \beta_t T_{it} + \beta_e E_{ie} + \beta_r R_{ir} + \varepsilon$$

where the price of a home is a function of it structural characteristics, time, environmental factors and the presence or absence of rural water.

Variables were chosen based on data available from county offices and on other residential real estate studies conducted in the Midwest (Shultz and Fridgen 2001). Some variables are standard housing characteristics used in hedonic models throughout the nation others are unique to North Dakota and/or this study. Lot size and house size are standard and are indicative e of the size of the property, they are logged to account for diminishing marginal returns. Bathrooms, Bedrooms, and Age are regularly and are often seen in these studies. Many hedonic researchers and appraisers also use a housing

condition variable in their valuation models but we were not able to consistently collect such a qualitative measure for our sample of homes (either in ND or NE). However the inclusion of dummy variables representing central air conditioning, gas fireplaces and updated furnaces are expected to proxy for housing quality amongst the sold homes in the sample.

Other explanatory variables were selected based on the housing characteristics and conditions within the study areas. In North Dakota, the total square footage of outbuildings is included to account for barns, shops, storage etc. Additionally certain distance variables are calculated to take into account the remoteness of some of these properties, distance to hospital and large city all give an indication of the locational characteristics of these homes. Latitude and longitude also account for this. A squared longitude term was included after studying scatter plots of the data. It is expected that the presence of Valley City, a major region center, in the middle of the study area affects prices. Furthermore time trend dummies were included to account for the effects of time on real estate markets. It is important to treat time not as a cause but rather as a summation of the socio-political climate at the time of the sale.

A variable unique to the North Dakota portion of this study is a proxy for water quality: Total Dissolved Solids (TDS). It is considered only a proxy since TDS measures are related to the mineral content of the water (with a higher TDS generally leading to poor taste and hardness) and they do not directly relate to other water quality issues (such as arsenic or nitrate pollution). As well, our estimates of TDS come from nearby well data rather than wells associated with specific homes in our study sample. Still it is hypothesized that homes with relatively higher TDS levels (in nearby wells) will have relatively lower water quality in their own homes and have a higher interest in signing up for rural water and that this will be represented in the variable having a statistically significant and positive impact on property values within a hedonic regression model

Table 2. Variable Definitions and Expected Signs

Variable	Variable Definition	ND	NE	Expected Sign
D Rural Water	Rural Water (1=Yes 0=No)	x	x	?
TDS	Total Dissolved Solids	x		-
LN Lot Size	LN Lot Sq. Ft.	x		+
LN House Size	LN House Sq. Ft.	x	x	+
D Central Air	Dummy = 1 If Central Air	x		+
Bathrooms	Number of Bathrooms	x	x	+
Bedrooms	Number Of Bedrooms	x	x	+
Age	Age of Home in Years	x	x	-
D Oil Furnace	Dummy = 1 if Fuel Oil Furnace	x		-
D Gable Roof	Dummy = 1 If Gable Roof	x		+
D Gas Fireplace	Dummy = 1 if Gas Furnace	x		+
Outbuilding Sq. Ft.	Square Feet of All Out Buildings	x		+
Distance to Hospital [miles]	Miles to Regional Hospital	x		-
Dist to Large City [miles]	Miles to City > 500 persons in	x		-
D Block Basement	Dummy =1 Block Foundation	x		+
D 1997	Dummy = 1 if Sold in 1997		x	+
D 1998	Dummy = 1 if Sold in 1998		x	+
D 1999	Dummy = 1 if Sold in 1999		x	+
D 2000	Dummy = 1 if Sold in 2000		x	+
D 2001	Dummy = 1 if Sold in 2001	x	x	+
D 2002	Dummy = 1 if Sold in 2002	x	x	+
D 2003	Dummy = 1 if Sold in 2003	x	x	+
D 2004	Dummy = 1 if Sold in 2004	x	x	+
D 2005	Dummy = 1 if Sold in 2005	x	x	+
D 2006	Dummy = 1 if Sold in 2006		x	+
Latitude	Latitude in Meters UTM 14N	x		-
Longitude	Longitude in Meters UTM 14N	x		+
Longitude^2	Longitude Squared	x		-
Garage Spaces	Garage Spaces		x	+
D Metal Siding	Dummy = 1 if Metal Siding		x	+
D Updated HVAC	Dummy = 1 if updates HVAC		x	+
Basement Finished Sq. Ft.	Finished Basement Sq. Ft.		x	+
D Vinyl Siding	Dummy = 1 if Vinyl Siding		x	-
D Brick	Dummy = 1 if Brick Exterior		x	+

Detailed Descriptions of Data Collection Procedures: North Dakota

For the North Dakota study area, a formal request was made to the state tax commissioner’s office for all rural residential property sales. In North Dakota buyers or sellers have the option of keeping their real estate transaction confidential (North Dakota Century Code, 2005). The North Dakota State Tax Commissioners Office was unable to distinguish between confidential and non-confidential sales. For this reason the North Dakota State Tax commissioner’s office did not provide the study with residential sale information.

All sale information had to be collected directly from county tax assessors and recorders. Seven counties were identified as the emphasis counties for this study: Barnes, Cass, Dickey, Lamoure, Ransom, Sargent and Stutsman. Within these counties certain townships were selected that contained Southeast users or were within close proximity to the Southeast Water Supply project (Figure 6). A request was sent to each county asking for their rural residential sale information. Response was minimal. Trips were made to each county that did not send in their sale information in order to collect the needed sale data. Initial sale data collected included the legal description, price and type of sale.

Certain sales were precluded from the study; these include sales between family members or sales connected to a city water system. The sales in small towns that were allowed into the database include sales in towns where the water is supplied as individual hookups by the pipeline. These towns include Elliot, Stirum, Marion and Fingal.

As digitizing progressed it became evident that more specific legal descriptions would be necessary for many sales. These sales were either located within platted subdivisions or their legal descriptions were not accurate or were missing entirely. For these sales detailed maps were obtained from their respective counties and/or copies made of the sale deed so as to have the full unabridged legal description.

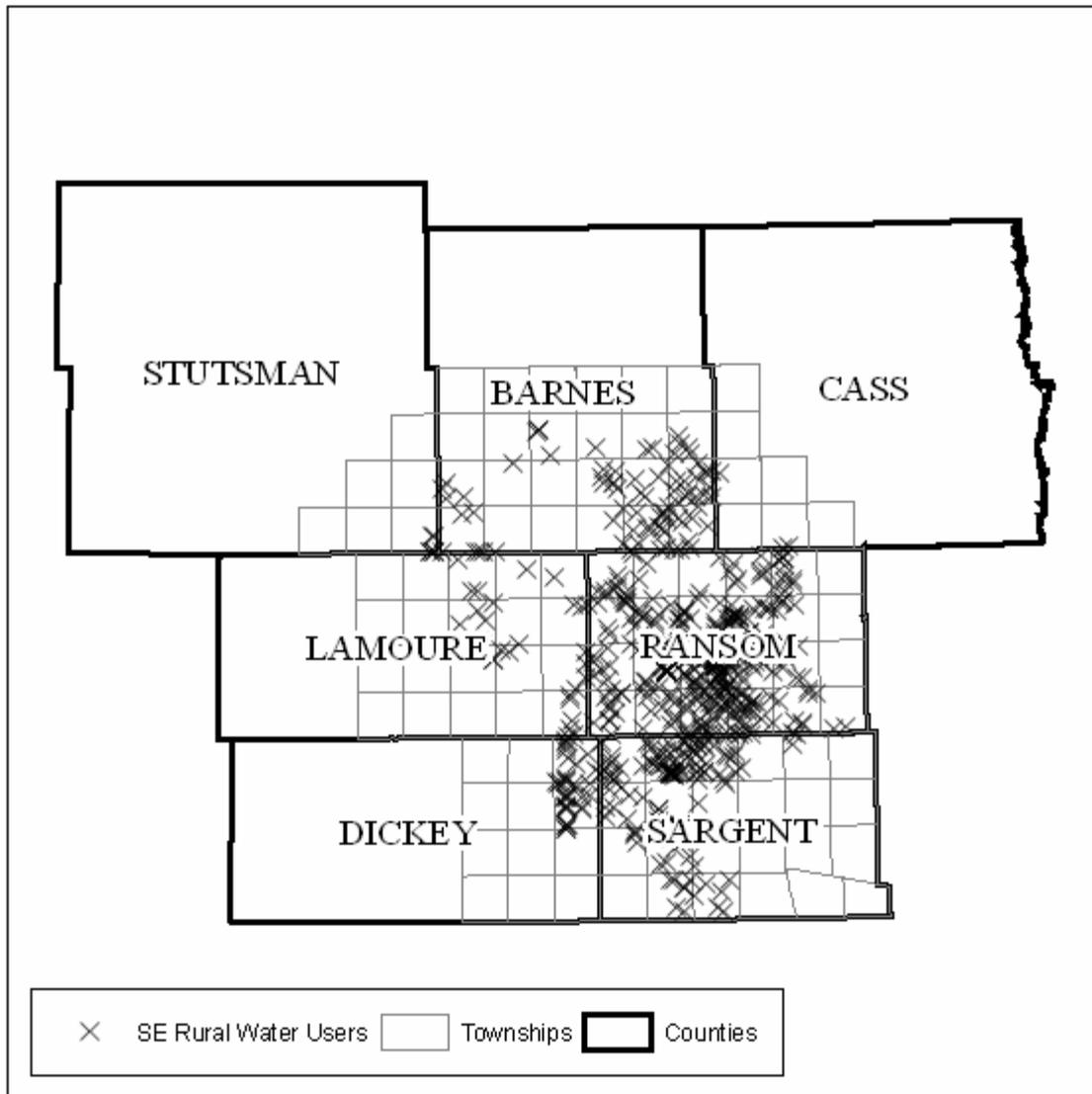


Figure 6. Emphasis Area and Southeast Users

Slightly different data collection methods were needed in Stutsman County (due to different data availability and, in particular, the lack of data available to us from the water utility). In particular, no spatial pipeline information was available. It was determined through the county tax director the public water status of many sales in the county. However, the tax department is currently in the process of updating their records countywide and did not have information available for all areas. To work around this issue a list of all homeowners in our sale database was sent to the Stutsman Rural Water District for verification of their status as rural water users.

A spatial database was digitized by integrating information collected from county tax assessors' offices with the abovementioned data. Legal descriptions and other housing characteristic information were collected from county offices. The legal descriptions were used to digitize the sales into a GIS. In most instances the sale was digitized using the Farm Service Agency's (FSA) National Ag Imagery Program (NAIP). In the case of a few sales it was necessary to obtain detailed parcel information to accurately digitize the sale. In some instances it was deemed accurate enough to place the sale position in the middle of its section. All sales were digitized as points.

To expedite digitizing, a 'script' was compiled to efficiently zoom to the section for each sale. A script, sometimes called a macro, is a custom modification to the standard GIS interface. This particular script ran off of a custom field generated within the PLSS database available from the North Dakota GIS HUB. This field is a compilation of the Section Township and Range numbers. The section was multiplied by 1,000,000 to make six empty digits, the township was multiplied by 1,000 to make 3 empty digits; these numbers were added together along with the range to make a continuous number consisting of the Section Township and Range. For example, Section 13 Township 163 Range 53 would consolidate to form the number 13163053. The zoom script then selected the section from this field based on the value specified in an input box. After selecting the specified section the script zoomed and displayed the section for the digitizer.

With the emphasis section displayed, the digitizer was then able to utilize orthophotos available through the FSA's NAIP along with the legal description to pick the parcel out and place a point to mark its location. The points were digitized using the ArcGIS editing tool. At this time it was also noted whether or not the sale was a southeast pipeline user. This information was recorded within the attribute table of the of the Sale shapefile (See Figure 7).



Figure 7. An Example of Digitized Rural Water Housing Sale

Detailed Descriptions of Data Collection Procedures: Nebraska

The housing data collection efforts for Washington County were completed using markedly different approaches. Residential sales for the Omaha area from January 1, 2000 to May 30, 2006, were extracted from the Great Plains Realtors Multiple Listing Service (MLS). The MLS is a comprehensive database of homes sold through realtors in the area. Homes sold by owner are not included in this sample. Nebraska sales were spatially referenced using address geo-coding with address information made public by

the Environmental Systems Research Institute (ESRI). The MLS provides some variables not collected in North Dakota. However, due to spatial data availability many of the spatial variables collected in North Dakota were not able to be included in the Nebraska data an example being Total Dissolved Solids.

Collecting Housing Characteristics

After compiling the spatial data, it was necessary to obtain housing characteristic data for all sales. Housing characteristics came from a variety of sources including tax assessors, phone interviews or on-site appraisals.

Due to the nature of rural tax equalization districts county tax assessors did not appraise many of the parcels in this study. Other parcels have incomplete information collected on them by the counties. In North Dakota, homes associated with production agriculture are exempt from residential property taxes, for this reason housing information is not maintained for many rural homes by county tax assessors (Fong 2005). Over one-half of the sales used in the study area had no housing characteristic information at the county level. For homes not appraised by counties either the buyer or the seller was called for an interview on the status of their home at the time of sale. Names were obtained from county sale records. In many instances the buyer or seller could not be reached. These remaining homes were subject to on-site appraisals.

Thirty-nine sales were visited for housing characteristic information. To complete the on-site appraisals, a map of the digitized sales was utilized along with a Global Positioning System (GPS). Coordinates for use with the GPS were obtained using the point shapefile of the digitized sales and the ArcGIS function 'compute XY coordinates'. Since researchers were unable to enter these homes or otherwise gain any direct information about the interior, variables such as finished basement or foundation may contain erroneous values for these sales.

By digitizing sales into a GIS database (shapefile) it was possible to integrate the spatial location of the sales with various forms of spatial data relating to population and

proximity to local transportation infrastructure (Table 3). Functions used include intersects and proximity functions.

Table 3. Geo-spatial Data Collected by the Study

Data	Source
Digitizing	
National Ag Imagery (NAIP)	Farm Service Agency's National Agriculture Imagery Program
Public Land Survey Information (PLSS)	North Dakota GIS HUB
Incorporated City Boundaries	North Dakota GIS Base Map CD
South East Rural Water Users	Advanced Engineering
South East Rural Water Pipeline	Advanced Engineering
Analysis	
Transportation	ESRI USA Base Map CD
Census Block Groups	ESRI USA Base Map CD
Bore Hole Locations & Water Quality Data	North Dakota State Water Commission
City Locations	ESRI USA Base Map CD

Intersects were run to compile data related to census information. Data was accumulated for each sale depending on the census block group it was located in. Census block groups are the smallest geographical entity for which the decennial census publishes sample data (U.S. Census Bureau, 1994). Data collected through this function include: Population Per Square Mile, Families, Avg Farm Size, Housing Units, Vacant Units, Owner Occupied Units and Renter Occupied Units.

A near (proximity) function was used to calculate the distance of the sale to the nearest of a variety of features. The "Near" function is a tool in ArcINFO that finds the nearest specified entity to each feature in a specified database. In this case, the database was the sale point database and the near features either cities with a population over 500 persons (points), interstates, state highways, other paved roads (lines), or boreholes used for water quality samples (points). In the case of cities and roads it was simply a matter of obtaining the distance to the nearest. In the case of the boreholes more information was needed about the nearest borehole. After the near function is run it records the distance to the nearest feature and a unique number relating to that feature is assigned to the sale. Through this unique identifier the borehole information was able to be joined back to the

sale database. Information retained relating to the nearest borehole to each sale included total dissolved solids (TDS), hardness, arsenic and nitrate.

GIS-based data collected for the hedonic modeling can be classified into two categories: digitizing and analysis (Table 3). Data classed as digitizing was used to locate the exact positions of the sales (latitude and longitude). Data used for analysis was utilized to obtain data on the sales as it might relate to real estate demand, i.e., this data represents characteristics of a parcel.

Data Collection Procedures Specific to Nebraska

While research in North Dakota was often constrained by data availability, analyses made in Nebraska did not suffer from that that problem. The site of analysis is Washington County, Nebraska. This area was chosen because it contains two rural water systems for which pipeline data was available and with its proximity to Omaha (a major population center) real estate data was also readily available. To conduct research relating to rural water in this county an existing database obtained from the Great Plains MLS was used. Data obtained from this source contains most relevant structural characteristics of sold homes along with the home address. In order to determine the location of homes in relation to rural water service, sales were geo-coded using geo-coding software available with the ArcINFO GIS software package. Seventy-five percent of the sales in the area were successfully geo-coded. Sales were not geo-coded due to errors in the address fields and/or due to incomplete information. Many errors were corrected by simple formatting changes to the database.

Pipeline information was obtained from the Papio-Missouri Natural Resources District (NRD). NRDs in Nebraska are the regulatory bodies governing the use and distribution of natural resources. Maps of pipelines were obtained as paper copies, scanned, geo-referenced, and digitized as line files into a GIS. Service areas were included with the maps and were digitized as separate polygon files (Figure 8). To determine if a sale had the potential for rural water service an intersect was made with the created rural water service polygons. All sales inside the service area were classified as having water service available to them.

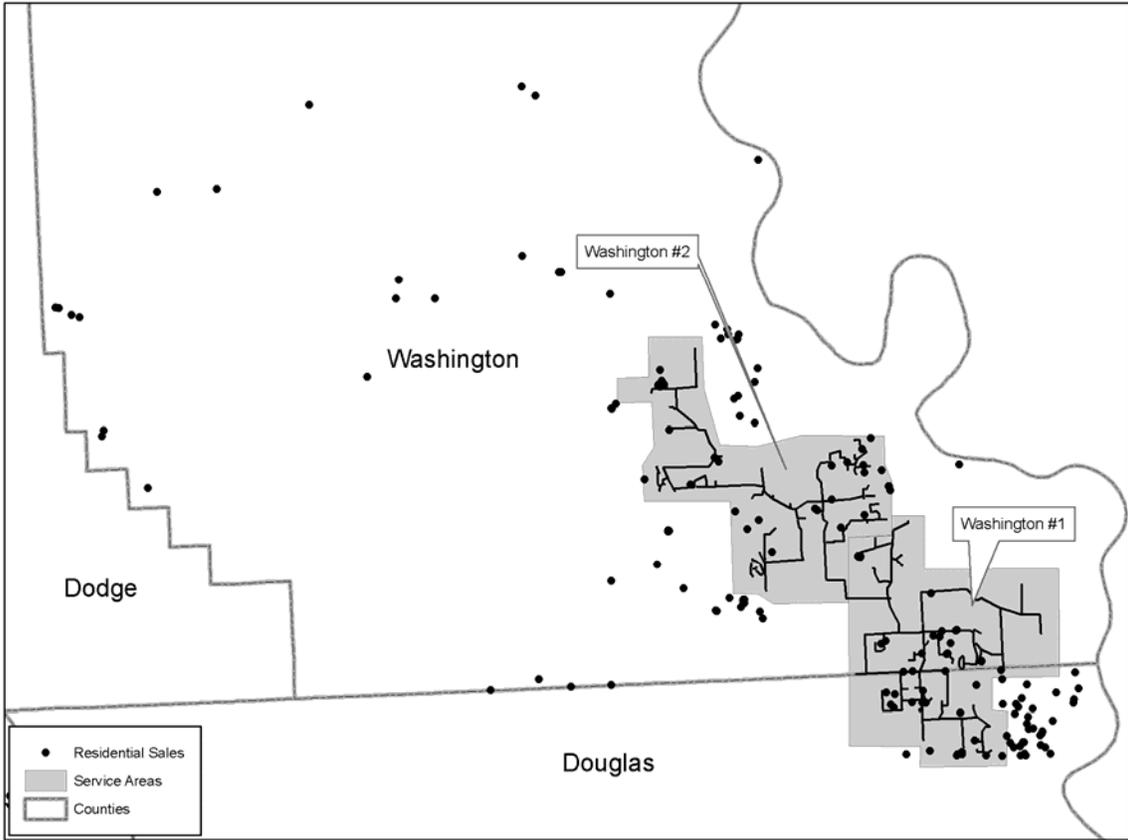


Figure 8. Nebraska Study Areas (Washington County)

Results

Data Collected in North Dakota

The North Dakota rural housing sales database is comprised of 150 successfully digitized sales with complete housing characteristic information. Table 4 shows the density of sales within the emphasis census block groups versus the density of housing units within those block groups. Block groups of larger cities not included in this study have been excluded from the table. Our sale database represents 2% of the total housing units in the emphasis area.

Table 4. Housing Density by County from Emphasis Census Block Groups

County	Sales	Sales/Sq. Mile	Housing Units	Housing Units/Sq. Mile
Barnes	23	.03	1119	1.53
Cass	7	.02	636	1.77
Dickey	12	.02	1150	1.90
Lamoure	6	.01	1522	1.63
Ransom	38	.05	2006	2.33
Sargent	41	.06	1698	1.97
Stutsman	23	.06	633	1.59
Total	150	.03	8764	1.85

The sales in the database are represented by three main types of sales. Most of the sold homes are of wood frame construction. Figure 9 shows the distribution of sales among the various housing types.

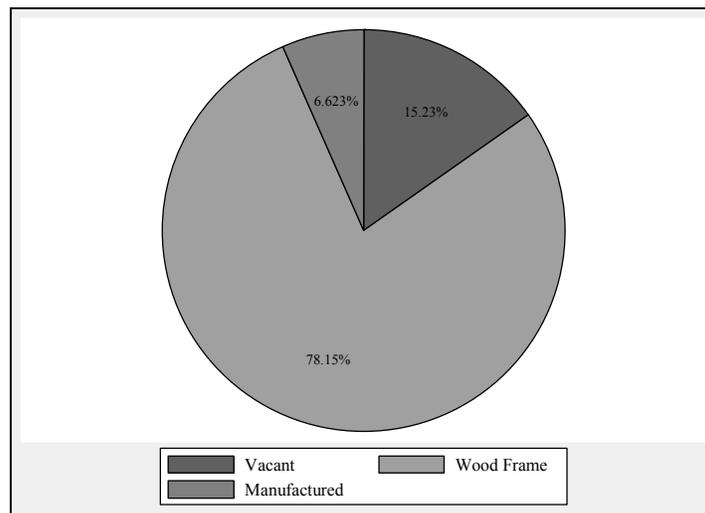


Figure 9. Distributions of Sales Among Housing Types

Across the seven counties, 54% of all the sold homes had rural water connections although by individual counties these ranged from 15% to 96% (Table 5). If our sample of homes is representative of all homes in the study area than only around half homeowners eligible for rural water connections have actually signed up for them. This is consistent with the results of pre-rural water surveys where only between 48% and 64% of residents expressed an interest in signing up.

This implies that under the assumption that sales are representative of all rural-residential homes in the study area, then about half of all study area homes currently have rural water supply connections.

Table 5. Percent of Sales with Rural Water Service

County	Percentage of Sold Homes With Rural Water Connections
Barnes	95.7
Cass	42.9
Dickey	50.0
Lamoure	66.7
Ransom	66.7
Sargent	14.6
Stutsman	30.4
All	54.0

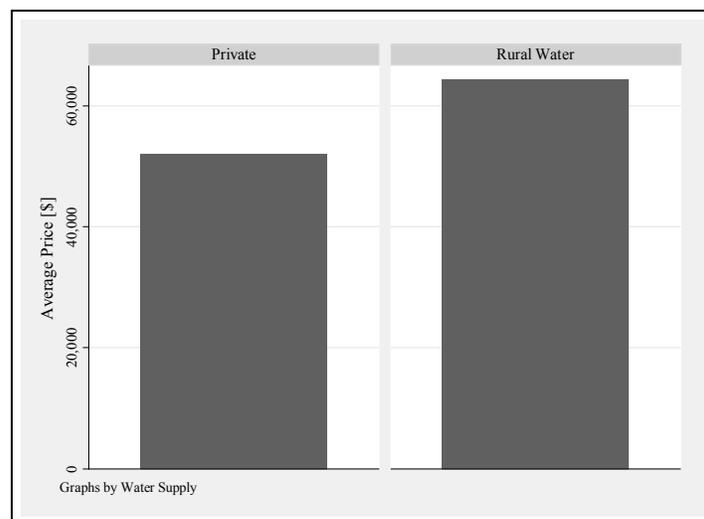


Figure 10. Mean Home Prices With and Without Rural Water Connections

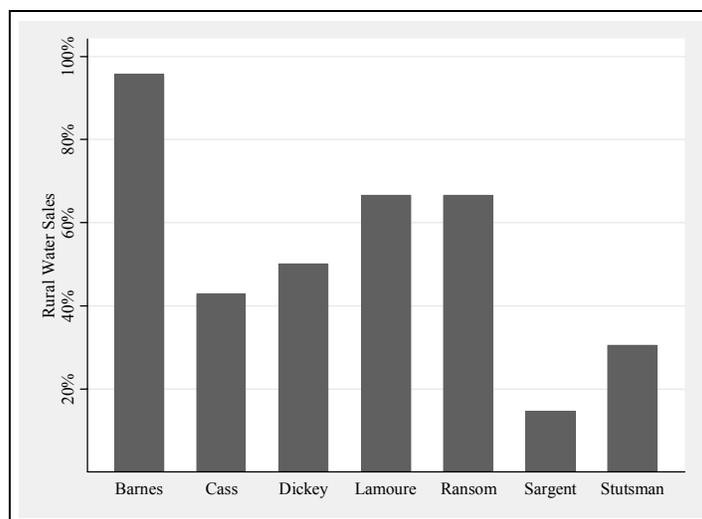


Figure 11. Percent of Rural Water Sales by County

Data Collected in Nebraska

In the Washington county study area data on 176 sales were collected covering the 1996 through May 2006 time period. The average housing density within the study area is 19 homes per square mile. The sale density was 0.47 sales per square mile with approximately 45% of the sold homes connected to rural water systems.

Differences Among Homes With and Without Rural Water Connections

In the North Dakota study sample, rural-residential homes relying on private wells for their water supplies (46% of the sample) are smaller, older and less expensive than homes with rural water supply connections water and rural water homes have higher water quality compared to the wells near homes on public water (Table 6).

Similarly, in Nebraska (Washington County) sold homes supplied by private wells (55% of the sample) were smaller, older and less expensive than homes connected to a rural water system (Table 7).

Table 6. Characteristics of Sold Rural Properties in North Dakota

Variable	Wells (n=69)	Rural Water (n=81)	All (n=150)
Sale Price (\$)	59,206*	71,956	66,168
Total Dissolved Solids (TDS)*	1,756*	2,479*	2,151
Lot Size (acres)	12.2	9.5	10.8
House Sq. Ft.	1,255**	1,483**	1,380
D Central Air	0.26**	0.47**	0.38
Bathrooms	1.32	1.73	1.55
Bedrooms	2.83	3.04	2.94
Age	37	32	34
D Oil Furnace	0.03	0.17	0.11
D Gable Roof	0.84	0.75	0.79
D Gas Fireplace	0.09	0.20	0.15
Outbuilding Sq. Ft.	680	863	780
Distance to Hospital [miles]	14.28	11.03	12.51
Dist to Large City [Miles]	9.29	9.38	9.34
D Block Basement	0.38	0.34	0.36
D 2001	0.14	0.12	0.13
D 2002	0.16	0.22	0.19
D 2003	0.23	0.18	0.20
D 2004	0.16	0.19	0.18
D 2005	0.14	0.14	0.14
Latitude	5,151,653	5,163,143	5,157,927
Longitude	568,240	567,437	567,802

Bold Variables Tested for Difference Using a paired t-test (*5% level, ** 1% level)

Table 7. Summary Characteristics of Sold Rural Properties in Nebraska

Variable	Wells (n=96)	Rural Water (n=80)	All (n=176)
Sale Price (\$)	222,710*	228,116 *	225,137
D Rural Water	0.00	1.00	0.45
Age	29.48 **	24.12**	27.18
House Sq. Ft.	2,543**	2,649**	2591
Garage Spaces	2.21	2.17	2.19
D Metal Siding	0.09	0.06	0.07
Bedrooms	3.53	3.43	3.49
Bathrooms	2.70	2.74	2.72
D Updated HVAC	0.72	0.70	0.71
Basement Finished Sq. Ft.	572	572	572
D Vinyl Siding	0.29	0.13	0.22
D Brick	0.09	0.14	0.11
D 1997	0.03	0.04	0.03
D 1998	0.04	0.08	0.06
D 1999	0.11	0.08	0.10
D 2000	0.12	0.14	0.13
D 2001	0.11	0.17	0.13
D 2002	0.05	0.12	0.08
D 2003	0.12	0.10	0.11
D 2004	0.12	0.07	0.10
D 2005	0.20	0.13	0.17
D 2006	0.09	0.04	0.06

Bold Variables Tested for Difference Using a paired t-test (*5% level, ** 1% level)

Hedonic Price Modeling

A hedonic-based multiple regression model was estimated separately for North Dakota and Nebraska to quantify whether rural water supply systems have a statistically significant impact on the sale prices of rural homes while accounting for an array of other housing and location-based characteristics. The results are summarized in Tables 8 and 9. Due to heteroskedasticity discovered in each model using a White test, both ordinary least square (OLS) and variance weighted least (VWLS) squares results are reported.³

Table 8. Multiple Regression Results (Central and Southeastern North Dakota)

Variable	OLS		VWLS	
	Coef.	P>t	Coef	P>z
D Rural Water	-869	0.882	1,417	0.774
TDS	-1.30	0.354	-2.02	0.131
LN Lot Size	6,313	0.002	5,079	0.001
LN House Size	11,678	0.129	9,275	0.157
D Central Air	25,900	0.000	25,633	0.000
Bathrooms	7,644	0.098	4,855	0.241
Bedrooms	2,357	0.427	4,373	0.077
Age	-314	0.008	-356	0.000
D Oil Furnace	-16,679	0.087	-13,016	0.042
D Gable Roof	-15,219	0.029	-11,134	0.048
D Gas Fireplace	7,531	0.232	10,512	0.094
Outbuilding Sq. Ft.	1.87	0.366	1.36	0.493
Distance to Hospital [miles]	-1,232	0.042	-1,035	0.015
Dist to Large City [miles]	-1,916	0.014	-1,627	0.008
D Block Basement	9,175	0.113	4,298	0.393
D 2001	-11,400	0.263	-8,739	0.296
D 2002	-6,513	0.486	-3,671	0.637
D 2003	-6,455	0.476	-1,548	0.835
D 2004	9,404	0.308	9,786	0.184
D 2005	15,512	0.111	16,128	0.036
Latitude	0.30	0.019	0.33	0.001
Longitude	-6.57	0.004	-5.16	0.003
Longitude^2	0.00	0.003	0.00	0.002
Constant	220,760	0.819	-362,683	0.626
Obs.	150		150	
F-Value	9.08		Chi ²	348.34
Prob> F	0.000		Prob>Chi ²	0.000
R ²	0.624			
Adj. R ²	0.555			
Root MSE	30171			

Bold indicates statistically significant at the 90% confidence level of higher

³ A White test is conducted by regressing the residuals squared from the OLS model on the predicted values and the predicted values squared of the OLS model. If the F-statistic is statistically significant then the null hypothesis of no heteroskedasticity is rejected.

Table 9. Multiple Regression Results (Washington County, Nebraska)

Variable	OLS		VWLS	
	Coef.	P>t	Coef.	P>z
D Rural Water	-1,770	0.855	-8,309	0.253
Age	-157	0.393	-27.77	0.813
House Sq. Ft.	79.10	0.000	82.44	0.000
Garage Spaces	16,686	0.000	18,780	0.000
D Metal Siding	-25,592	0.159	-29,558	0.017
Bedrooms	-26,163	0.000	-31,604	0.000
Bathrooms	21,609	0.006	14,360	0.022
D Updated HVAC	-14,603	0.191	-21,461	0.015
Basement Finished Sq. Ft.	-7.86	0.455	-8.18	0.441
D Vinyl Siding	11,297	0.370	7,121	0.462
D Brick	34,440	0.034	41,186	0.006
D 1997	21,559	0.556	19,596	0.413
D 1998	-6,251	0.841	15,226	0.457
D 1999	49,320	0.102	31,732	0.146
D 2000	21,871	0.447	18,693	0.370
D 2001	22,175	0.444	28,522	0.186
D 2002	13,014	0.674	5,503	0.810
D 2003	57,628	0.050	41,074	0.060
D 2004	78,906	0.010	58,988	0.012
D 2005	50,880	0.069	41,811	0.039
D 2006	79,370	0.013	76,314	0.002
Constant	-11,585	0.752	24,284	0.316
Obs.	176		176	
F-Value	31.02	Chi ²	1163.01	
Prob> F	0.000	Prob>Chi ²	0.000	
R ²	0.8001			
Adj. R ²	0.7743			

Bold indicates statistically significant at the 90% confidence level of higher

The models have R² values of 0.62 (North Dakota) and 0.77 (Nebraska) and most of the explanatory variables have a statistically significant impact on sale prices and are of the correct (expected) sign. Exceptions are house size, bedrooms, and fireplaces in North Dakota where many older homes and homes in poor condition are relatively larger and often have fireplaces. In Nebraska insignificant explanatory variables include age, metal and vinyl siding, siding, updated heating and cooling systems, and basement square footage. In modeling rural real property values variables are often insignificant due the highly heterogeneous nature of housing stock. For instance, an older home is not necessarily functionally obsolete. Many rural homeowners may choose to do extensive remodeling to older farmhouses.

Certain variables in the North Dakota model either did not have expected signs or were insignificant. In particular, is the log of the variable representing house size was not significant coefficient. A possible explanation is that many large farmhouses were in poor condition and sold for a relatively low price in comparison to smaller and newer homes. Another surprising results was that the variable representing total dissolved solids (in wells nearby sold homes) was not significant. Furthermore TDS was not significant indicating that the naturally occurring water quality does not impact home sales. This could be due to the fact that all homes not currently connected to rural water are satisfied with the current water quality. Of particular interest is the dummy variable measuring whether a home has central air conditions which indicates that the presence of central air raises a homes value by over \$25,000. This should in no way be misconstrued in claiming that simply installing central air raises home's value. It is expected that this variable is acting as a proxy for other home improvements i.e., homeowners who remodel and otherwise update their home are likely to place central air as a priority.

The Nebraska model, relied on similar but different variables due to differences in data availability, resulted in some surprising coefficients. Bedrooms, bathrooms, and dummy metal siding were all negative and significant. This is contrary to other hedonic studies and suggests that the sample of rural homes is unique and that these variables are a proxy for other characteristics; possibly indicative of older farmhouses that will tend to have many bedrooms yet will be functionally obsolete. Furthermore the coefficient for age is insignificant. Age is generally considered a strong predictor of housing value however in this sample the variation in homes may create too much noise across ages.

In both North Dakota and Nebraska the year dummies were largely insignificant. While housing trends nationwide were on the rise over this time period it is expected that rural markets are somewhat immune from these speculative bubbles and remain stable over the time period. Although 2004 and 2005 were shown to be strong years in both states which is expected due to the fact that this time period lead up to the peak in nation-wide home prices in early 2006.

Of foremost interest to the study is the fact that the variable representing rural water connection does not have a statistically insignificant relationship with sales price in either state, so the null hypothesis (of no relationship between rural water and prices) cannot be rejected. Therefore, no conclusions can be drawn regarding rural water connections and rural-residential property values.

This unexpected result may be due to the relatively small sample sizes used in each of the two study locations (few arms-length rural residential sales) along with the existence of highly heterogeneous housing and drinking water supply conditions across the study areas which itself is the likely reason why only about half of all homes have signed up for rural water connections in these areas. In other words, it is likely the case that many expensive homes that rely on private wells have excellent water quality and their lack of a rural water connection has no impact on the market price that buyers are willing to pay for their properties.

As well, these results may be specific only to the particular study locations evaluated (in areas with sufficient rural water supplies, and a mix of well water quality measures or alternatively areas where only about half of rural residential homes sign up for rural water connections). That is, in areas of southwestern North Dakota with water scarcity, it would appear obvious that rural water connections are necessary for houses to be built, i.e., usually all existing homes have rural water connections. In fact, due to this phenomenon it was not possible to create a sufficiently large enough sample size of both sold rural water connections and private well users necessary to estimate a hedonic price model.

Dropped/Modified Components of the Original Research

The original proposal associated with this research that was submitted to the USGS/NIWR 104G program for consideration in February, 2005, contained several objectives which turned out to be impossible or infeasible to complete. In particular, it was discovered that the research design would not work in several areas of North Dakota due to lack of sales with and without rural water connections in the southwestern part of the state (Figure 11). As well, required sales data was not obtainable from either the County tax directors, and in many cases, accurate rural water connection data from water utility companies was not provided.

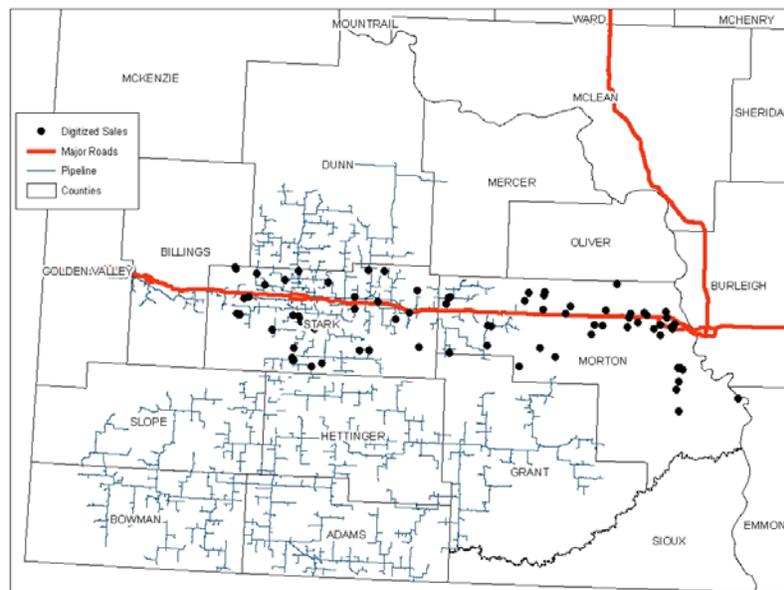


Figure 12. Southwest System and Sales (Almost All with Rural Water Connections)

Another objective that could not be completed was the analysis of the impact of rural water supply (pipelines) on agricultural land values. The underlying hypotheses were that such rural water infrastructure would increase the potential to develop such agricultural land to residential housing and would hence be reflected in sale prices. However, after an analysis of agricultural land sale data it was concluded that too few agricultural land sales have occurred within close proximity to areas of urban development to permit the estimation of a hedonic model. Clearly there exist examples and cases where individual parcels of agricultural land benefited from the existence of rural water supplies, however, such cases do not appear frequent enough to formally model the phenomena in North Dakota.

Conclusions

This research has demonstrated the importance of using multivariate hedonic models to measure the impact of rural water supply connections on property values rather than more simplistic direct comparisons of the average (or median) sale prices of homes with and without rural water supply connections. The regression approach was shown necessary due to the variation in housing characteristics with and without rural water connections.

The primary (and unexpected) result of this research effort is that those rural water supply connections have a statistically insignificant impact on rural-residential housing prices. This may be due to homeowners and homebuyers in the two study areas not placing a large economic value on such water connections, or it may simply be that there are relatively high valued rural residential homes within our sample with sufficiently good private well water quality. This last effect may be compounded by the fact that poor quality (i.e. low valued) homes with poor well water quality and without rural water connections sell infrequently and are hence missing from our sample and modeling results.

Although stated as unexpected, these empirical results demonstrating the insignificance of rural water connections (as a proxy for water quality) are somewhat consistent with the previous literature. That is, each of the three three known studies that have used residential real estate transaction data to measure the impact of reduced water quality on housing values (as described in the literature section) found little to no impact of water quality measures on rural-residential property values.

Policy Implications

The major policy implication arising from this research is full participation (sign-ups) for rural water connections in rural areas of North Dakota and Nebraska with generally sufficient water supply and heterogeneous well water quality conditions should not be assumed ‘a priori’ based on expectation that all homebuyers place a value on such connections. This means that prior to planning and implementing rural water supply projects (in such areas) that local participation (sign-ups) should be carefully assessed

and predicted through surveys and/or relying on well/house specific water quality data. Hopefully, this will enable policy makers at the local, state and federal levels with more accurate assessments of the economic feasibility of particular rural water supply projects.

A secondary implication of this research is that in areas where rural water supply connections do not appear to have an influence on property values, local real estate appraisers and/or tax assessors should avoid making adjustments for rural water connections in the course of appraisals and tax assessments.

Proposed Follow-Up Research

A suggested follow-up study in North Dakota would be to have local rural water districts in conjunction with one or more state agencies test the water quality of the wells of each of the homes in our study sample. The resulting water quality measures could then be directly incorporated into our hedonic price model. It is hypothesized that the use of house-specific rather than general area well water quality measures would improve the accuracy of our model and potentially generate different results regarding the impact of rural water connections on property values.

Another proposed follow-up study (in either North Dakota or Nebraska) is to conduct a mail or telephone survey of all homeowners in the study areas (those with potential access to rural water systems) to determine whether they have rural water connections, their socio-demographic profiles, and their experiences and perceptions of local water quality and supply issues. The collection of such data would create an accurate estimate of what percentage of all potential homes have signed up for rural water (a statistics still missing from most rural water supply projects). It would also allow the estimation of a logit regression model to quantify the factors influencing sign-ups. Likely explanatory variables having an influence would be homeowner's age, education and income, whether they had children living at home, and various measures of their perceptions of water quality and health/risk issues.

Dissemination and Outreach Efforts:

Preliminary results of this research were presented at the following events and venues:

- 1) University of Nebraska Water Center 2007 Water Colloquium, January 31, 2007. “Integrating Water Management Research with Land Valuation Modeling Across Nebraska.”
- 2) Universities Council on Water Resource/NIWR Hazards in Water Resources Conference July 24-26, 2007, Boise, Idaho. “The Impact of Rural Water Supply Systems on Property Values.”
- 3) North Dakota Water Science Center (USGS), August, 27, 2007, Bismarck, ND.. “Final Project Results : The Impact of Rural Water Supply Systems on Property Values.” Fifteen persons participated in this event (listed below) and several of their comments and suggestions have been incorporated into this present report.

Frank Soule	ND Rural Water System
Chuck Mischel	ND Rural Water System
Eric Volk	ND Rural Water System
Cory Chorne	Advanced Engineering
Jack Long	Advanced Engineering
Steve Hansen	Southeast Water Users
Joe Lafave	South Central Rural Water
Jaret Wirtz	Mckenzie Rural Water
Jeffrey Mattern	Nd Water Commission
Jerold Backes	Bartkett and West
Ken Rotse	Bartkett and West
Pat Fridgen	Water Commission
Gregg Wiche	USGS
5 Other USGS Employees	USGS

Electronic Distribution and Planned Journal Publications::

This written project report is also being distributed electronically as a PDF document to as many interested parties as possible and the report authors (Shultz and Schmitz) are currently preparing a shorter version for submission to a professional journal, e.g., the *Journal of the American Water Resources Association*.

Education & Training Components of the Research Project

This research project relied heavily on the paid assistance of undergraduate and graduate students both at North Dakota State University and the University of Nebraska at Omaha. In particular, USGS project funds were used to fund both hourly work (undergraduate and graduate student assistantships) and summer salaries at each of the two institutions. These funds were also used to pay the travel expenses of these student workers (both for field data collection and to attend professional conferences).

One student in particular was present throughout his senior year as an undergraduate at North Dakota State and through the beginning of his Masters Degree at the University of Nebraska at Omaha. This student participated in the full extent of the project including preliminary meetings with the State Water Commission and Data Collection often by leading a team of students. He also was given the opportunity to attend various conferences. In particular he attended and/or presented at:

- Heartland Regional Water Coordination Initiative. Nebraska City, NE. June 5 - 7, 2007. ***Targeting Critical Source Areas for Implementation of BMPs.*** [By Invitation]
- The Nebraska State Data Center. May 31, 2007. ***Overview of the American Community Survey.***
- Ron Bruder, Applied Data Consultants, Inc. Omaha, NE. April 3, 2007. ***Exploring ESRI Geodatabases.***
- University of Nebraska Lincoln. March 26-27, 2007. ***The Future of Water Use in Agriculture. Fourth Annual Water, Law, Policy and Science Conference.***
- Audubon Nebraska. March 16-18, 2007. ***Rivers and Wildlife Celebration.***
- Douglas County Environmental Services. Omaha, NE. February 28, 2007. ***Low impact Development Storm water Best Management Practices and Conservation Design Land Development Workshop.***
- Lied Center, Nebraska City, NE. January 9, 2007, NE, 2007. "Using Spatial Information on Land Values in Targeting Conservation Practices." Paper Presented: ***Heartland Region "Targeting Critical Areas for Implementation of BMPs" Roundtable,***

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