A NEW AFFORDABILITY INDICATOR FOR RURAL ALASKAN WATER UTILITIES

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A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

in

Resource and Applied Economics

University of Alaska Fairbanks

December 2016

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Abstract

The Alaska Department of Environmental Conservation (DEC) administers funding for the construction of new water utilities in rural parts of the state. Funding allocation is partially based on whether the recipient community can cover the annual operation, maintenance, repair, equipment and capital replacement costs of the utility. Currently, the DEC deems a project affordable if the annual costs account for 5% or less of the community's median household income (MHI).

In rural Alaska MHI is an inaccurate affordability indicator. This is partially because MHI fails to reflect the cost burden experienced by below median income households, it is a static snapshot of income, it does not account for living costs, nor does it account for the demographic composition of a community or the distribution of income.

An alternative indicator was developed. The new indicator is composed of a Residential Indicator (RI) and a Financial Capability Index (FCI). RI is obtained by dividing the community's annual user fee by each income quintile value. FCI is composed of socioeconomic indicators chosen for their ability to detail the situation in rural Alaska. The FCI value is obtained by calculating the average of score assigned to the indicators based on pre-established thresholds.

The new indicator was found to be more accurate than the MHI indicator. The new indicator was retroactively applied to Akiachak and found to more accurately assess affordability. The new indicator was also used to assess the current situation in communities with water utilities. The MHI indicator was found to have underestimated the price burden of user fees in numerous communities, and to have overestimated the burden in one community.

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Acknowledgements

I cannot express enough thanks to my committee for their continued support and encouragement throughout my masters: Dr. Joe Little, my committee chair; Dr. Jungho Baek; Dr. Christopher Wright; and Ms. Camilla Kennedy of the Department of Environmental Conservation (DEC).

This project would not have been possible without the advice of Mr. William Griffith (DEC), Mr. Dennis Wagner (EPA) and the many others who patiently shared their experience and knowledge. A special shout out to the Dillingham water utility folks for the very informative and interactive facility tour.

I would like to express my gratitude and appreciation to my family (Maman, Papa, Marc, Marcia, Alexis and Daisy), my friends (particularly Beatrice, Paul and Gaurav), my fellow Econ grad students, and to Sam and Frank and the rest of the OA crew for their unfailing support.

Last but not least Deb Fristoe and Dean Herrmann deserve a loud and heartfelt *Thank You* for their support and help throughout these past few years.

Introduction

In 2014 some expressed puzzlement that the US Census Bureau was still asking whether a lodging has a flush toilet (Cohn, 2014). The confusion is understandable given that nationwide only 2% of American households lack indoor plumbing (US Census Bureau, 2014a). Yet these rates are significantly higher in Alaska where across the state 11% of households lack indoor plumbing (US Census Bureau, 2014a). The rates are even higher in rural parts of the state where in 36 communities less than 55% of homes are served by a piped water, septic tank & well, or covered haul system (Department of Environmental Conservation [DEC], 2014).

In an attempt to remedy the situation every year the federal and state government earmark funding for the construction of water utilities such as drinking water and sewage facilities. The Alaska Department of Environmental Conservation (DEC) is tasked with dispensing the funding to communities. One of the factors that determines how funding is allocated is affordability. While a community does not have to repay the construction costs it must be able to cover the annual operation, maintenance, repair, equipment and capital replacement costs (W. Griffith, personal communication, August 2015). The utility must recoup the entirety of these costs through user fees. Currently, the DEC deems a project affordable if the annual costs account for 5% or less of the community's median household income (MHI).

The DEC's affordability indicator, 5% of MHI, is based on the Environmental Protection Agency's (EPA) affordability criteria (W. Griffith, personal communication, August 2015). Following the 1996 Safe Drinking Water Act amendment, the EPA defined affordability for drinking water services at 2.5% of MHI (EPA, 1998) and for wastewater services at 2% of MHI (EPA, 1997). Thus, the EPA determined that a household with a pre-tax income equal to the median can afford a combined water and wastewater bill of 4.5%.

In light of the shortcomings of the MHI as an affordability indicator (US Conference of Mayors [USCM], American Water Works Association & Water Environment Federation, 2013) a new indicator to better assess affordability in rural Alaska is developed. The new indicator takes into account indicators of socioeconomic well-being as well as income distribution. It is designed to be easy to use and understand. As such, the data used should be readily available, easy to gather and need minimal manipulations. The proposed new indicator is based in parts on the guidance to assess the financial capability of combined sewer overflow projects (EPA, 1997).

The new indicator has been applied to Alaskan communities which are served by water utilities and with known user fees. Compared to the new indicator, MHI is found to overestimate the fee burden for one community. Conversely, the MHI indicator underestimated the fee burden for many communities. Two communities, Akiachak and Shageluk, are used to compare the two indicators on a post hoc and ad hoc basis respectively. Akiachak is a community in which a water utility is shut down due to financial concerns in 2001 (Rural Utility Business Advisory, 2015). Using values from the year 2000 the MHI indicator assessed the water utility as affordable. The new indicator however found the user fee rates placed a high burden on 80% of the population, indicating that the system was conceptually unaffordable for the community – as demonstrated by its financial failure.

The MHI as an indicator

Growing evidence suggests that using MHI as an affordability indicator is problematic and inaccurate (USCM et al., 2013). The MHI indicator's failure to account for socioeconomic and demographic factors results in the erroneous affordability assessments. For example, MHI fails to reflect the cost burden experienced by the 50% of the households which have an income below the median (EPA, 2002). This problem is compounded by the fact that MHI does not account for variations in income distribution between communities. Thus a community with households clustered around the MHI would experience a lower burden than a community with households clustered at lower income levels.

Inaccuracies also stem from MHI being a static snapshot of income which does not account for seasonal and annual income fluctuations. Variations in costs of living create inaccuracies as the indicator would determine similar levels of affordability for two communities with comparable MHIs and user fees. Yet the fees would place a higher burden on the community with higher costs of living. The demographic composition of a community also affects the indicator's accuracy. A community with a high number of people living within a household would experience a higher burden from fees. Finally, the MHI indicator was developed by the EPA to test system wide affordability, and is not designed to establish household affordability (Congressional Budget Office, 2002).

MHI affordability indicators do not adequately address the unique nature of rural communities mixed cash and subsistence economies (Goldsmith, 2007). Alaska's high costs of living are exacerbated in rural areas and vary significantly between communities (Goldsmith, 2007). Temporal and spatial variation in community income distribution matches the composition and seasonal patterns of employment available in remote rural villages (Chapin III et al., 2014; Goldsmith, 2007) which can significantly vary in pay and availability between years. The few year round full time jobs (Haley & Brelsford, 1999) available in rural areas tend to be filled by outsiders. Unsurprisingly, unemployment rates are high (Goldsmith, 2007). In some rural Alaskan communities the number of people per household is much higher than in urban areas (Goldsmith, 2007).

Defining affordability

There is no universally accepted definition of what constitutes an affordable water utility (drinking water and sewage combined) user rate, hereafter referred to as water affordability. The DEC's threshold is based on the EPA's threshold of 4.5% MHI for water and wastewater utilities. The EPA established 4.5% of MHI threshold based on the information contained in the Census Bureaus' Consumer Expenditure Survey (CES). The CES tracks household expenditure, including expenditure on water services. However, it combines this information with expenditure on other public services such as wastewater services and trash removal (Rubin, 2001).

The *Water Affordability Programs,* recommends adopting a 4% MHI threshold (Saunders, Kimmel, Spade & Brockway, 1998). This is supported by recent research on small drinking water treatment plants which suggested a 2% MHI threshold. Affordable threshold levels vary according to agency and geography. The Organization for Economic Co-operation and Development and the World Bank have set affordability thresholds between 3 and 5% of household income for water utilities (Fankhauser & Tepic, 2007). In Latin American thresholds are generally over 4% of MHI, in Mongolia its 6% and in Lithuania 2% (Smets, 2012). Reynaud (2008) defines households who spend more than 3% of their income on water bills as water poor.

Non quantitative measures of affordability also vary. Many of these definitions are taken from the field of housing affordability (Stone, 2006). A price can be considered affordable if it does not incentivize households to consume less than the recommended minimum quantity (Fankhauser & Tepic, 2007; Gawel, Sigel, & Bretschneider, 2011). Alternatively, affordability can be defined as a price level that allows lower income households to pay water bills without reducing their consumption of other essential goods or services (Rubin, 2001) or obliging households to acquire debt (Fankhauser & Tepic, 2007). It is important to note that these definitions concern themselves with household affordability. Community level affordability is slightly different as it involves the utility recouping all operations and maintenance costs for the utility. For the purposes of this project, the term affordability designates household level affordability.

No consensus exists on which indicator to use to determine the affordability of water utilities. The most common indicator is a ratio of water expenses, general user fees, and a measure of income (Gawel et al., 2011; Hutton, 2012). Income values range from MHI (Hutton, 2012), disposable income (Hutton, 2012) to income quintiles (Gan & Hill, 2009). If income quintiles are used, the author suggests calculating the average of the ratio for the income quintiles two through four (Gan & Hill, 2009). Alternatively, one author suggests dividing the monetary amount spent to acquire enough water to meet basic needs by household income (García-Valiñas, Martínez-Espiñeira, & González-Gómez, 2010). The lack of a standardized approach to determining affordability provides little guidance as to what measurement can best serve Alaskan communities.

Utilities in Alaska

Alaska has 180 isolated villages, most of which are off the road system and only accessible by boat, plane or snowmobile (Village Safe Water [VSW], n.d). Nonetheless, most communities have electricity and although most have access to clean water (Hennessy et al., 2008) the type of water utility present varies widely. Prior to 2015, 105 communities had above or below ground piped service, 20 communities had individual wells and septic tanks, 11 had a haul system composed of a holding tank for potable water and a storage tank for wastewater that are serviced by municipal workers. Individual wells and septic tank systems were used in 20 communities, and the remaining 30 communities were unserved (VSW, 2015a). More communities are now unserved than when the data was collected. Unfortunately it is unclear which systems they were using. Many, but not all communities have washeterias, which are centrally located community buildings with sanitation facilities, and drinking water pipes (VSW, n.d.). Washeterias may have limited hours of operations which make them impractical to use (Eichelberger, 2010).

Many households in unserved communities use the euphemistically named honey buckets. These are 5 gallon buckets lined with a trash bag and covered with a toilet seat (Estus, 2015a). The bags are disposed of in sewage lagoons, in communal tanks or in the village dump site. This mode of disposal increases the risk of contamination as it is not uncommon for the content of the bucket to spill on the boardwalk, which results in all-terrain vehicles (ATV), a common mode of transportation in rural communities, transporting fecal bacteria (Chambers, Ford, White, Schiewer & Barnes 2005). During the spring, surface water may transport fecal bacteria (Chambers et al., 2005), and there is an increased risk of contaminated the drinking water source.

Some communities remain unserved due to the challenges associated with developing utilities in rural Alaska. In some parts of the state, the freezing conditions and the permafrost make drilling difficult, and ice jams, flooding and other factors limit accessibility to the communities. Expectedly, construction costs for water utilities are estimated to be four to five times higher (Smith, 1996) in Alaska than in other parts of the country (Colt, Goldsmith, Wiita, & Foster, 2003). Owing to the harsh winter climate maintenance costs are 25% higher than the national average as pipes must be heated and water circulated to prevent freezing. (Colt et al., 2003). Moreover, rural utilities do not benefit from economies of scale due to their small population (Smith, 1996).

Transfers, grants and dividends play an important role in the sustainability of rural utilities. In 2003, it was estimated that in Interior Alaska Permanent Fund Dividend (PFD) payments accounts for 40% of the regional income (Colt et al., 2003). Most villages do not have taxes, and those who do only have a limited tax base. Thus, village operations are heavily depending on revenue sharing with the state (Eichelberger, 2010). Federal funds heavily subsidize telecommunication services (Colt et al., 2003), and residential electricity is subsidized by the state through the power cost equalization program (Villabolos Meléndez, 2012). Water and sewer utilities are not subsidized (Estus, 2015b). Nonetheless, it is estimated that rural households in the lowest income quintile have a median public utility expenditure equivalent to 33% of their income (Eichelberger, 2010).

Impact of unaffordable utilities

As water utility's fees increase, households consume less water to save money or stop paying their bills, altogether. However, the operating and maintenance expenditures remain the same, and so utilities must increase their fees even more (Baietti & van Ginneken, 2006) to cover costs. Baietti and van Ginneken (2006) identify this concept as the vicious spiral of utility decline. As the collection rate decreases and fees do not cover operating costs, maintenance is postponed. This leads to further service deterioration, and so consumers are less willing to pay which results in even lower collection rates.

Eichelberger (2010) found evidence of this spiral occurring in Northwest Arctic Borough communities after the local water utility increased the flat rate charged to households. After the increase some households stopped paying their bills and found alternate sources of water. Some went to their neighbors' house or resorted to using untreated sources of water. Since the communities lacked public facilities, the households which were still paying their water fee also saw an increase in their energy fee as their waterless neighbors used their washers and showered (Eichelberger, 2010).

Additionally, water utilities have a significant impact on health outcomes. In rural Alaskan communities, in house piped services were found to decrease hospitalization rates for pneumonia and respiratory syncytial virus (Hennessy et al., 2008). Piped water is also thought to decrease the incidence of gastro-intestinal diseases in children, which results in considerable time savings for their caretakers (Meeks, 2012). Given that many rural residents engage in subsistence activities, this time is an important factor. Lastly, prolonged closure of a community's' washeteria had a positive correlation with an increase in skin infection rates (Thomas, Bell, Bruden, Hawley, & Brubaker, 2013).

Methods

The new indicator has a matrix form (Figure 1) and is composed of a Residential Indicator (RI) and a Financial Capability Index (FCI). This structure of the indicator is based on one designed by the EPA for determining the affordability of sewers (EPA, 1997). The RI provides a measure of the household's finances and the FCI accounts for factors which could impact the household's disposable income. The affordability is determined by finding the intersection of the RI value and FCI score on the indicator. The indicator runs from right to left and from down to up. Hence the most affordable combination of RI and FCI is in the upper left corner and the least affordable in the right bottom corner. The indicator assesses affordability by determining whether the user fees place a low, medium or high burden on communities. This is done to provide more information to the users. A high burden indicates an unaffordable user rate for the community. A medium burden and low burden both indicate affordable user rates.

Financial Capability Index (FCI)	**Residential Index (RI)**		
	Low ≤ 2%	Mid-Range 2 % < RI ≤ 5%	High > 5%
Strong > 2.5	Low Burden	Low Burden	Medium Burden
Mid-Range 1.5 < x ≤ 2.5	Low Burden	Medium Burden	High Burden
Weak ≤ 1.5	Medium Burden	High Burden	High Burden

Figure 1- The New Affordability Indicator

The RI

The RI calculates the proportion of each income quintile the annual utility costs represent. In other words, the community's annual user fee is divided by each income quintile value. For example, when calculating the RI for Adak (Table 1) the annual $720 user fee are divided by $67,583 to obtain the RI value of 1.07% for the first income quintile (IQ1). An RI value for the community is obtained by averaging the RI values for income quintile one through three. Since we are interested in affordability, and thus the impact of user fees on the poorer households, income quintiles four and five are not used to compute the average. The RI for all communities are shown in Appendices A and B.

Table 1- RI Calculations for Adak Using 2014 Values

IQ1	IQ2	IQ3	IQ4	IQ5
$ 67,583	$ 75,700	$ 93,833	$ 114,500	$ 127,167
Annual user fees: $720				
RI (IQ1)	RI (IQ2)	RI (IQ3)	RI (IQ4)	RI (IQ5)
1.07%	0.95%	0.77%	0.63%	0.57%
Average RI(IQ1-IQ3): 0.93%				

Note: Income Quintile from US Census Bureau 2015a, fees from VSW, 2015b.

The FCI

The FCI is composed of socioeconomic indicators. The FCI value is obtained by calculating the average of score assigned to the indicators based on pre-established thresholds. The scores range from 1, which indicates weak socioeconomic strength, to 3, which represents a strong socioeconomic situation. Detailed FCI calculations are shown in Appendices C, D and E. The socioeconomic indicators used are the:

- percentage of households which are Supplemental Nutrition Assistance Program (SNAP) recipients in the community (USCM et al., 2013),
- percentage of households which receive public assistance (USCM et al., 2013),
- percentage of households living under the poverty level (USCM et al., 2013),
- percentage of people over the age of 16 with full time jobs,
- percentage of MHI spent on an average electric bill and
- cross-price elasticity of demand of water with respect to electricity prices.

These socioeconomic indicators were chosen for their ability to detail the situation in rural Alaska and differ from suggested ones in the literature (EPA, 1997; USCM et al., 2013). For example, unemployment is generally used as an indicator. However, unemployment is the ratio of the number of people out of a job and actively looking for one over the size of the labor force. Given the high number of rural adults not looking for a job (Goldsmith, 2007), the unemployment measure is likely to underestimate the situation. As a substitute, the indicator uses the percentage of people over the age of 16 with full time jobs, which captures the entirety of the working age population. This value is calculated by dividing the number of people over 16 with full time jobs over the total number of people over 16 in the population.

The percentage of households living under the poverty level and the percentage of households which are SNAP recipients are calculated from table S2303. The percentage of households receiving public assistance is calculated from B19028. The indicators were both chosen to mitigate any margin of error in the other. For example, according to American Community Survey (ACS) data barely 1 in 5 adults over the age of 16 has a full time job in Lime Village, yet the reported household poverty level is 0%. Nonetheless, ACS data shows that 50% of households are SNAP recipients. Conversely, in Pelican, 0% of households are reported as SNAP recipients but 17% are under the poverty level.

The price of electricity has a two-fold impact on the affordability of water utilities. Energy costs account for anywhere between 24-70% of rural Alaskan's water utility annual operations costs (Alaska Rural Utility Collaborative [ARUC], 2015; Estus, 2015b). Since operations costs directly impact user fees a change in the price of electricity would likely result in a change in user fees. A change in the price of electricity would also impact household's electric bill and their disposable income. The change in operations costs can be captured by varying the user fees, but the impact of a household's electric bill must be modeled. This is accomplished by calculating what percentage of MHI a community's average electric bill is. It is important to note that MHI is not being used as an affordability indicator but as a measure of disposable income.

Anecdotal evidence also suggests that in rural Alaska water services and electricity are complementary goods (W. Griffith, personal communication, September 2015), so that as price of electricity increases, lower quantities of water will be consumed. Given the flat rate pricing system of rural water utilities, a high enough increase in electricity prices would result in a change in the number of households paying their water utility bill.

The impact of electricity prices on water consumption can be estimated using the concept of cross price elasticity. Elasticity is an economic concept that measures the responsiveness of a good with respect to the change of another economic variable (Nechyba, 2010). For example, the own price elasticity of water measures the percent change in water consumed as a result of a 1% change in the price of water. The cross price elasticity measures the percentage change in water consumed as a result of one percent change in the price of electricity. Given that there is no data on quantity of water consumed in rural Alaska the cross price elasticity is calculated using an adaptation of the Proportionally Calibrated Almost Ideal Demand System (PCAIDS) model (Swinand & Hennessy, 2014).

The PCAIDS model is based on the Bertrand assumption (Epstein & Rubinfeld, 2004). This assumes that product differentiation gives firms market power, since differentiation would result in some consumers still buying a firm's product priced above other market products. In this paper, the market is composed of the water and electric utility and the differentiated goods are electricity and water services such as drinking water and sewage disposal. Consequently, under the Bertrand assumption, some households will still consume electric services after an electrical price increase. Given that these items are necessities, and little substitutes for electricity exist in rural Alaskan, it makes sense that demand is more inelastic. Likewise, some households will still consume water services after an increase in price of water services. The PCAIDS model also assumes that the market share of the other firm in the market will increase by the amount the shares of the other firm decrease as a result of the price increase.

The demand function for water utilities is detailed in Equation 1. When the price of water increases by 1% $\left(\frac{dP_{water}}{P_{water}}\right)$, the market share of water (dS_{water}) will decrease by the own price elasticity of water utilities, namely - 0.23%. Under the PCAIDS assumption, the household consumption lost by the water utility will be gained by the electric utility. Likewise, Equation 2 details the electric demand function, with the own price elasticity of electricity being -0.03 (Villabolos Meléndez, 2012). The market shares for each utility were calculated as a percentage of the entire market. Therefore, in this model the market share of the water utility and the market share of the electric utility sum up to 1.

$$dS_{water} = -0.23\left(\frac{dP_{water}}{P_{water}}\right) + 0.23\left(\frac{dP_{electric}}{P_{electric}}\right) \qquad \textit{Equation (1)}$$

$$dS_{Electric} = -0.03\left(\frac{dP_{Electric}}{P_{Electric}}\right) + 0.03\left(\frac{dP_{Water}}{P_{Water}}\right) \qquad \textit{Equation (2)}$$

The cross price elasticity of water $(\varepsilon_{WaterElectric})$ is calculated using Equation 3. The own price elasticity of electricity(ε_E) is divided by the market share of water (s_w). The quotient is then added to the product of the own price elasticity of the public utility market (ε_{market}) plus 1 times the market share of water(ε_{market}). The own price elasticity of electric utilities is obtained from a paper that calculated the elasticity of rural Alaskan electric utilities (Villabolos Meléndez, 2012). The average value of the own price elasticities of flat rate block systems found in the literature is used as the elasticity of water utilities (Dandy, Nguyen, & Davies, 1997; Garcia & Reynaud, 2004; Nauges & Thomas, 2003; J. F. Thomas & Syme, 1988). The own price elasticity of the public utilities market is assumed to be -1. A negative cross price elasticity indicates that the two goods are complementary.

The $\varepsilon_{WaterElectric}$ value should be interpreted as follows. If the result is -0.20, this means that the electric and water utilities are complementary, and that a 1% increase in the price of electricity decreases the consumption of water by -0.20%.

$$\varepsilon_{WaterElectric} = \frac{\varepsilon_E}{s_w} + s_w(\varepsilon_{market} + 1) \qquad \textit{Equation (3)}$$

Thresholds

To the extent possible the thresholds are established using existing guidelines. The thresholds for the RI are summarized in Table 2 and were established as follows. The "high burden" threshold is established using the DEC's affordability definition, which is 5% of an income value. The "low burden" threshold is based on Janzen, Achari, Dore & Langford's recommendation of 2% (2016). The "medium burden" is defined as the remaining range.

Table 2- RI Thresholds

% cost to quintile	≤ 2%	2% < x ≤ 5%	> 5%
Affordability value	Low Burden	Medium Burden	High Burden

The FCI thresholds are based on Anchorage and Fairbanks rates as no guidance was found in the literature. The threshold values are summarized in Table 3. A score of 1 indicates that the community is doing poorly in that respect, while a 3 is a strong score. The higher the score, the more likely the community can afford to sustain a utility.

Table 3- FCI Threshold Values

% over the age of 16 employed full time	≤ 30%	30% < x ≤ 50%	> 50%
Affordability value	1	2	3
% households under the poverty level	> 20%	10% < x ≤ 20%	≤ 10%
Affordability value	1	2	3
% of households which are SNAP recipients	>20%	10% < x ≤ 20%	≤ 10%
Affordability value	1	2	3
% of households receiving public assistance	>30%	10% < x ≤ 20%	≤ 10%
Affordability value	1	2	3
Electric bill % of MHI	> 5%	2% < x ≤ 5%	≤ 2%
Affordability value	1	2	3
Cross Price Elasticity of Water	<-0.66	-0.66% < x ≤ -0.33	≥ -0.33
Affordability value	1	2	3

Comparison of the two indicators

In order to determine the accuracy of the new indicator a comparison with the MHI indicator is necessary. While the MHI indicator only distinguishes between unaffordable and affordable, the new indicator's assesses whether the fee burden is low, medium or high. For comparative purposes, the low fee burden is considered affordable and the high fee burden is assumed to be unaffordable. Consultation with the DEC (W. Griffith, personal communication, April 2016) resulted in the medium fee burden being undefined until further research identifies the affordable threshold levels in Alaska.

Data

The income and socioeconomic data is obtained from the US Census' ACS. In this survey throughout the year 3.5 million households from a representative sample are contacted (US Census Bureau, 2013) and respondents are asked to provide values for the 12 months preceding the interview (Webster Jr, 2007). A household is defined as anyone and everyone living in one housing unit, independently of whether they are related. For the purposes of income information, data is collected on anyone over the age of 15 present at the moment of the interview (US Census Bureau, 2014b).

Alaskan communities located in areas difficult to access are known as "remote Alaska". The data collection process for these areas is a bit different and data is collected from households in either January or September (US Census Bureau, 2006). Due to their small population, data on these communities is available solely from the 5-year estimates which use 60 months of data.

Communities used in the study were selected based on the availability of user fee data. We used 103 communities total. Of these, 65 have access to water utilities and 38 are unserved communities. The user rates combined water and sewage fees for the served communities and were obtained from the DEC and the Alaska Rural Utility Collaborative (ARUC). The projected user rates for the unserved communities were obtained from the DEC (DEC, 2016).

It is important to mention the limitations of this data. It is likely that selection bias results from the fact that ARUC membership is conditional on certain requirements being met. Furthermore, DEC user rates were collected on a voluntary basis, which again results in a selection bias. In some communities a discrepancy existed between DEC and ARUC records for user fees. In those situations ARUC fees were used. Furthermore, the DEC records showed that an unserved community is charged user fees for piped water systems. Since the community does not have a water utility and no user fees are charged it is moved to the unserved category.

Further data limitations exist as a result of the small size of the communities which produce high margins of error for the ACS data. For example, in Pelican there are no households under the poverty level yet only 27% of adults have a full time job. Given that ACS provides a value of 0 for this indicator and not an indication of a null value, this indicator cannot be excluded. Rather, redundant socioeconomic indicators were added to the FCI to mitigate the impact of any erroneous values.

Another limitation stems from the fact that the ACS data is collected according to the US Census' place boundaries. Since these boundaries might differ from those used by water utilities to define their customer base the ACS data might include people not served by the water utility, or conversely might exclude people who are within the service region. Similar limitations apply to the electric utility data. For example, according to the ACS Alatna only has 2 households. However, the Alatna Electric utility is reported to have 71 customers.

The post hoc analysis of the Akiachak case is limited by a change in the US Census's questions. The author could not find an estimate of the number of households receiving public assistance in 2000, hence that socioeconomic indicator is excluded for the case study. Furthermore, no information on Akiachak's electric bills in 2000 was found, hence this indicator and the cross price elasticity of water are also excluded.

Water utilities in rural Alaska charge a flat rate independently of the amount of water consumed by households. While this is the EPA's recommended fee approach for utilities with 500 or less users (EPA, 2015) this is an uncommon situation in North America. To calculate the cross price elasticity of water an estimate of the elasticity of water is needed, which requires information on the amounts of water consumed. Unfortunately the existing rural Alaskan water utilities do not collect information concerning quantity of water consumed (J. Nickels II, personal communication, April 2016). Since no literature is found on the elasticity of water with flat rates the values used in this study were obtained from papers on flat block rates which are likely to indicate a higher degree of responsiveness to price changes. To mitigate this fact an average value of the elasticities is used.

Summary statistics for the values used to calculate the new indicator are shown in Table 4. The communities' income varies greatly. In 2014 the MHI ranged from $0 to $91,806. Similar variations are seen in the income quintiles, with all of them having $0 as a minimum value. The annual user fees vary between $360 and $7,188. The socioeconomic indicators exhibit similarly vast ranges, suggesting that the communities' financial means vary widely.

Table 4- Summary Statistics of Variables

Name	Description	Frequency	Max	Min	Average	Standard Deviation	Source
MHI	Median household income	97	$91,806	$0	$40,450	$16,803	*US Census Bureau, 2015d*
IQ1	Upper limit of income quintile 1	97	$67,583	$0	$17,958	$8,904	*US Census Bureau, 2015a*
IQ2	Upper limit of income quintile 2	97	$85,600	$0	$32,410	$15,480	*US Census Bureau, 2015a*
IQ3	Upper limit of income quintile 3	97	$108,346	$0	$49,999	$19,034	*US Census Bureau, 2015a*
IQ4	Upper limit of income quintile 4	97	$154,867	$0	$75,613	$26,841	*US Census Bureau, 2015a*
IQ5	Lower limit of income quintile 5	97	$250,000	$0	$130,467	$46,403	*US Census Bureau, 2015a*
Fee	Annual user fees	97	$7,188	$360	$1,860	$1,319	*VSW, 2015b; ARUC 2015; DEC 2016*
%Full Time	Percentage of the population over the age of 16 with a full time job	97	100%	0%	24%	0.14	*US Census Bureau, 2015c*
%SNAP	Percentage of households which are SNAP recipients	97	79%	0%	39%	0.21	*US Census Bureau, 2015e*
%Poverty	Percentage of households below the poverty level	97	100%	0%	30%	0.17	*US Census Bureau, 2015e*
%Public Assistance	Percentage of households receiving public assistance	97	100%	0%	46%	0.23	*US Census Bureau, 2015b*
% MHI Electricity	% of MHI households spend on electricity	91	85.7%	2.1%	8.8%	0.09	*Calculation*
El_W	Price elasticity of demand of water utilities with flat rates	4	-0. 18	-0.26	-.25	-0.04	*Garcia & Reynaud, 2004; Dandy, Nguyen, & Davies, 1997; Nauges & Thomas, 2003; Thomas and Syme 1988,*
El_E	Price elasticity of electric utilities	1	-	-	-0.03	-	*Villabolos Meléndez, 2012*
El_u	Price elasticity of public utilities	1	-	-	-1	-	*Calculation*
Rev_E	Revenue of electric utility in 2011	97	$8,731,502	$133,106	$916,250	$1,200,982	*Fay, Meléndez, & West, 2013*
Rev_W	Revenue of water utility in 2011	78	$2,162,245	$400	$129,848	$298,151	*Department of Commerce Community and Economic Development, 2011*
Rev_U	Total revenue of water and electric utility	78	$10,893,747	$165,566	$1,046,098	$1,485,064	*Calculation*
Mkt_E	Market share of electric utility	78	99.9%	69.9%	89.3%	0.076	*Calculation*
Mkt_W	Market share of water utility	78	30.0%	0.2%	10.7%	0.076	*Calculation*
CP_W	Cross-Price elasticity of demand of water with respect to the price of electricity	78	-0.03%	-9.72%	-0.551%	0..78	*Calculation*

Results

Served communities

The affordability determinations made by the two indicators for the served communities are shown in Table 5 and 6. The 25 communities for which the new indicator and the MHI indicator produce similar results are shown in Table 5. Both indicators find the user fees to be unaffordable for 5 of the presently served communities. While both indicators find the user fees to be affordable for 20 of the communities, the new indicator shows that the fees are a medium burden in 13 of the communities, and represent a low burden in only 7 communities.

Table 6 shows the communities for which the two indicators diverge. The new indicator finds the fees to represent a high and unaffordable burden in 32 served communities while the MHI considers these fees to be affordable. The MHI's assessment of the Ambler community fees as affordable is borderline, as they account for 5% of MHI. In other communities, the difference is more pronounced. For example, in Shaktoolik user fees only account for 2.2% of MHI but the new indicator determines them place a high burden on the community. Interestingly, the MHI indicator deems the Chignik Lake fees to be unaffordable, but the new indicator determines them to only place a medium burden on the community.

Unserved communities

The results for the unserved communities are shown in Table 7 and 8. As shown in Table 7, the two indicators determine the projected user fees to be unaffordable for 29 unserved communities. Only fees are found to be affordable only in the community of Nightmute. The indicators diverge for 5 communities. No ACS income data was found for the community of Alatna, hence the MHI indicator fails to make an assessment. In the case of the remaining 4 communities, the new indicator finds the projected user fees to be unaffordable while the MHI indicator assesses them to be affordable.

Table 5 - Served Communities with Similar Affordability Scores

Community	Matrix Score	% MHI
Adak	Medium	1.0%
Angoon	Medium	1.3%
Chignik	Low	1.1%
Chignik Lagoon	Low	1.3%
Deering	Medium	2.2%
Grayling	High	5.6%
Klawock	Medium	2.7%
Kobuk	High	5.5%
Kotzebue	Low	1.3%
Larsen Bay	Low	1.2%
Lower Kalskag	High	6.0%
McGrath	Medium	2.0%
Nunam Iqua	Medium	1.5%
Ouzinkie	Low	1.4%
Pelican	Low	0.5%
Port Heiden	Medium	1.5%
Sleetmute	High	5.7%
South Naknek	Medium	1.8%
St. George	Medium	2.6%
St. Mary's	Medium	3.6%
St. Michael	High	11.0%
St. Paul	Low	1.2%
Thorne Bay	Medium	2.2%
Toksook Bay	Medium	1.3%
Unalakleet	Medium	1.6%

Table 6- Served Communities with Different Affordability Scores

Community	Matrix Score	% MHI
Akiachak	High	3.6%
Alakanuk	High	2.7%
Ambler	High	5.0%
Anvik	Medium	-
Brevig Mission	High	3.7%
Buckland	High	3.2%
Chevak	High	3.9%
Chignik Lake	Medium	5.7%
Fort Yukon	High	4.3%
Gambell	High	4.3%
Goodnews Bay	High	4.5%
Holy Cross	High	3.7%
Hooper Bay	High	2.8%
Hughes	High	3.7%
Kake	High	1.7%
Kiana	High	4.4%
Kotlik	High	3.4%
Koyuk	High	2.6%
Kwethluk	High	3.0%
Manokotak	High	2.8%
Mountain Village	High	2.5%
New Stuyahok	High	2.8%
Newhalen	High	3.9%
Nondalton	High	2.4%
Noorvik	High	4.0%
Nulato	High	3.3%
Pitkas Point	High	3.5%
Quinhagak	High	4.6%
Russian Mission	High	3.8%
Savoonga	High	3.6%
Scammon Bay	High	4.0%
Shaktoolik	High	2.2%
Shungnak	High	3.2%
Tyonek	High	4.8%
Upper Kalskag	High	4.9%
White Mountain	High	4.9%

Table 7- Unserved Communities with Similar Affordability Scores

Geography	Matrix Score	% MHI
Allakaket	High	12%
Arctic Village	High	15%
Atmautluak	High	6%
Beaver	High	20%
Birch Creek	High	77%
Chalkyitsik	High	7%
Chefornak	High	7%
Circle	High	35%
Crooked Creek	High	10%
Diomede	High	14%
Eagle	High	6%
Kipnuk	High	8%
Kongiganak	High	8%
Koyukuk	High	12%
Kwigillingok	High	10%
Lime Village	High	30%
Napakiak	High	16%
Napaskiak	High	13%
Nightmute	Medium	3%
Shageluk	High	9%
Stebbins	High	20%
Stevens Village	High	20%
Stony River	High	18%
Takotna	High	6.9%
Teller	High	7.1%
Tetlin	High	6%
Tuluksak	High	10%
Tuntutuliak	High	8%
Venetie	High	8%
Wales	High	7%

Table 8- Unserved Communities with Different Affordability Scores

Geography	Matrix Score	% MHI
Alatna	High	-
Mekoryuk	High	4.2%
Nunapitchuk	High	3.0%
Platinum	High	2.9%
Tununak	High	3.9%

Akiachak

The indicators were tested on a post hoc basis for the community of Akiachak using values from 2000. The calculations are shown in Table 9 and 10, and Figure 2 shows where in the affordability matrix each income quintile is located. The new indicator assesses the 2000 fee levels as high for 80% of Akiachak's households as medium for the highest income quintile. The MHI assesses the fees as being affordable.

Table 1- RI calculations for Akiachak in 2000

Annual Fee	RI(MHI)	RI(IQ1)	RI(IQ2)	RI(IQ3)	RI(IQ4)	RI(IQ5)	RI(IQ1-IQ3)
$1,416	4.0%	8.0%	5.0%	4.0%	3.0%	1.0%	6%

Table 20- FCI Results for Akiachak in 2000

FCI indicator	Value	FCI Value	FCI Score
% of adults with full time employment	16%	1	
% household below poverty level	17%	1	1.33
% households on SNAP	32%	2	

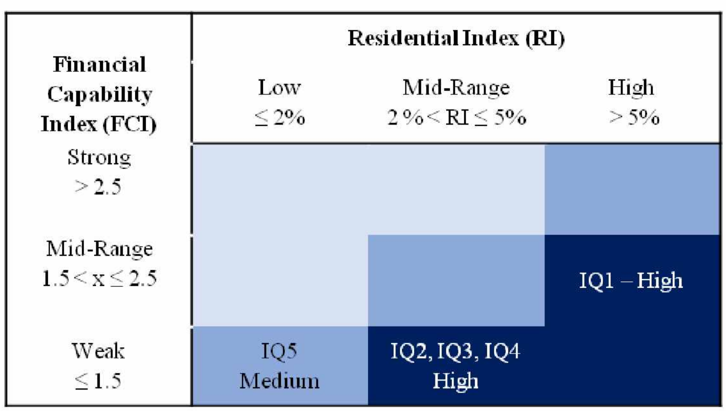

Figure 2- Affordability of fees in Akiachak in 2000

Shageluk

The community of Shageluk was used to test the indicator for future projects and the calculations are shown in Table 11 and 12. The two user fees used are DEC estimates (2016). The variation is due to uncertainty with regards to the community's collection rate. As shown in Figure 3, both rates are unaffordable for 40% of the population. The higher rate is also unaffordable for the third income quintile, while with both rates the fourth income quintile experiences a medium burden and the highest income quintile only experiences a low burden.

Table 11- Shageluk's Affordability Assessment

Annual Fee	RI(MHI)	RI(IQ1)	RI(IQ2)	RI(IQ3)	RI(IQ4)	RI(IQ5)
1200 (A)	7.38%	10.85%	8.89%	4.66%	2.32%	1.36%
1512 (B)	9.30%	13.67%	11.20%	5.87%	2.93%	1.71%

Table 12- FCI of Shageluk

FCI indicator	Value	FCI Value:	FCI Score:
% of adults with full time employment	32%	2	1.5
% household below poverty level	59.26%	1	
% households on SNAP	40.70%	1	
% households on public assistance	81%	1	
% MHI Electric Bill	17.5%	2	
Estimated impact of E prices on H20	-0.36	2	

Financial Capability Index (FCI)	Residential Index (RI) Low ≤ 2%	Mid-Range 2 %< RI ≤ 5%	High > 5%
Strong > 2.5			
Mid-Range 1.5< x ≤ 2.5			
Weak ≤ 1.5	IQ5(A-B)	IQ3(A), IQ4(A-B)	IQ1 (A-B), IQ2(A-B), IQ3(B)

Figure 3- Affordability of Future User Fees A and B for Shageluk

Discussion

Differences in the indicator's assessment

As shown in the result section, the two indicators often show different results. More often than note, the MHI indicator underestimates the fee burden compared to the new indicator. This is likely a result of the fact that the MHI indicator is unable to account for rural Alaskan socioeconomic factors which often result in a decrease in disposable income. For example, Koyuk has an MHI slightly over $36,000 and monthly fees are only $70. However over 40% of households are below the US Census defined poverty level, 73% are SNAP recipients and a little over 1 in 10 adults has a full time job. Given this socioeconomic context, the fees appear to too high for Koyuk.

Chignik Lake is the only community where MHI overestimated the fee burden. Although this community only has an MHI of $41, 875 over 40% of the people over 16 work full time. This statistic is confirmed by the fact that only 4% of household are SNAP recipients, and 12% are below the poverty level. Hence, in this community's case the socioeconomic indicators make the user fees affordable. It appears that few Alaskan rural communities have strong socioeconomic indicators but relatively low financial indicators, which explains why the MHI approach only overestimates the fee burden in one instance.

In several communities, the fees are only borderline affordable. In these cases the new indicator can provide useful information as it disaggregates the affordability by income quintile. A simple glance at the matrix can tell the reader whether the system is deemed to be a high burden for 20% or 40% of the population. In contrast, the MHI indicator is only able to provide a binary assessment of affordability. In the case of Akiachak, an assessment indicating that the fee level posed a high burden for 80% of the population might have helped avoid the closure of the water utility for several years.

The unserved communities

Both indicators assessed the projected fees for the unserved communities as being either unaffordable or on the high end of affordability. This is unsurprising as the last communities to be served are likely to be the most remote or poorest. This theory is supported by the fact that the average MHI of unserved communities is $31, 749 while the average MHI for served communities is $43, 876 in the served communities. Additionally, the average projected monthly user fee for unserved communities is $254, while the average fee in the served communities is $105. Hence, it appears that the unserved communities' poor financial situation is compounded by high user rates.

Given the high burden the fees place on the communities, it is unlikely the communities will be able to financially sustain the water utilities independently. For the utilities to be affordable either the user fees must decrease or the community's financial situation must change. For obvious reasons, the most efficient approach is to target the fee level. As previously discussed, for a utility to be affordable it must cover its annual costs. While this is generally done through user fees alone, in some communities subsidies are available. However, in some cases, promised subsidies never materialize (J. Nickels II, personal communication, April 2016) and the utility must unexpectedly increase its user rates to cover its costs. This is likely to result in households falling behind on their bills in financially strained communities.

Changing the type of utility built can also change the fees charged. Many of the systems projected user fees are for piped water systems, which have extremely high operating and maintenance costs in Alaska (Smith, 1996). In fact, most communities in the Northwest Territories in Canada have a haul system, as piped systems are unaffordable (Colt et al., 2003). This appears to be a viable option as evidence suggests that while there are great benefits to having access to at least 30L of drinking water per capita per day, the increase in benefits disappears beyond 65L per capita per day (Smith, 1996). Yet, this might not be the case in Alaska. While most communities have washeterias, a study found that in house access to water resulted in significantly better health outcomes (Hennessy et al., 2008).

Given the advantages of piped systems, and that these systems are desired by communities (Eichelberger, 2010) it may be beneficial to concentrate on cost cutting measures. For example, ARUC communities are expected to significantly lower their fees in the coming years as a result of costs savings and an increase in the collection rate. ARUC is also working on increasing the energy efficient of the water utilities it operates, to decrease the electrical costs (ARUC, 2015).

Integrating new information

Both the MHI and the new indicator are static indicators which attempt to use a snapshot to establish the affordability of a dynamic system. This was partially done to maintain the simplicity of the new indicator and because the dynamic structures of rural communities are extremely complex, and any attempt to model them will have some inaccuracy. This is partly because many of the dynamics are poorly understood. For example, for years Alaska's rural population consistently decreased year after year. The trend unexpectedly changed in 2010, and the rural population has been increasing since then. As evidence of this, Adak's population grew from 58 people in 2010 to 114 in 2014 (US Census Bureau, 2015e). Since the reasons for this reversal are poorly understand, integrating a model of population changes in the indicator would likely have produced widely inaccurate results.

The strength of the new affordability indicator lies in its simplicity. In theory, obtaining the new values and plugging them into the indicator should only take a few minutes. So while the indicators are all static, it is relatively easy to update them regularly as new information becomes available. For example, user rates are expected to vary as the costs change throughout the years. Rather than attempting to include a model for the variation in costs throughout the lifetime of the utility in the indicator, the new costs can just be plugged into the indicator as a user fee and the new affordability assessment can be produced in minutes.

The new indicator can be easily manipulated. Hence, as new information and metrics become available they can be included in the indicator. This is important as certain factors were not accounted for in the present form of the new indicator. For example, there is no official data concerning the cost of living rural Alaskan communities. While Fish and Game has a subsistence index this information is not readily available nor is it extensive. Surveying villages was outside of the scope of this study and would have been costly. Furthermore, annual surveys would have been needed, making this measure impractical. While there currently is not electricity affordability indicator, if one becomes available its results could easily be included in the FCI component. Integrating new indicators and new information as it becomes available is advisable and will likely only strengthen the results.

PFD, PCE and subsidies

Alaskan residents are eligible to receive an annual dividend called the Permanent Fund (PFD) (Goldsmith, 2012). Alaska Natives also often time receive annual divided from their Native corporation (Burnsilver, Magdanz, Stotts, Berman, & Kofinas, 2016). The PFD and divided amounts fluctuate widely between years and depending on the corporation. Nonetheless, they both increase rural household's cash availability. The Alaskan legislature is currently discussing changing the PFD, and there is a possibility it will no longer be distributed (Knapp, Berman, & Guettabi, 2016). Additionally, the big Alaska Native corporation payouts are linked to the extraction of natural resources, such as oil and gas. As a result there may be a significant decrease in the cash availability of households. Though these changes would be reflected in the income quintiles, they highlight the importance of continuously assessing the affordability of the utility.

The state of Alaska currently subsidizes household's cost of electricity in certain communities under a program known as Power Cost Equalization (PCE) (Villabolos Meléndez, 2012). There is no guarantee that the PCE program will continue, and its dismantlement would likely have severe consequences for the poorest rural households. The impact of a change in price of electricity is accounted for in the cross price elasticity indicator of the FCI as communities with a high responsiveness to change are identified. However, if a significant change in the PCE program occurs, the new information should be integrated in the indicator through new elasticity calculations as well as a new assessment of remaining income.

While there are no statewide subsidies for water utilities, some rural utilities are subsidized. Some of these subsidies come from Native Corporations or local governments. These subsidies are not consistent, and can vary widely between years. Many communities are more subtly subsidized, through their local schools and commercial buildings. Nonresidential customers are often charged significantly higher rates than residents, in essence subsidizing the utility. These rates are accounted for in the user fees, and in the user fee projections. Unfortunately, in some cases schools and commercial ventures opted to use their own water and sewer system, which resulted in the utility's revenue decreasing substantially (D. Wagner, personal communications, February 2016). These changes are modeled in the indicator through the user fees and the resulting RI.

Future research

Future research potential exists with regards to the threshold, particularly the financial ones. Affordable threshold levels are likely to be different in Alaskan than in the rest of the country as a result of the small community size and remoteness of many of the utilities. No formal study has examined what are appropriate thresholds for Alaskan communities, and as a result the thresholds in this paper were obtained from the literature on continental US water utilities.

Elasticity offers another research avenue. The elasticity of water could not be calculated due to lack of information regarding quantity of water consumed. Yet, establishing the price elasticity and income elasticity of water in rural Alaska has very practical application. Currently, the flat rates are essentially a free allowance. In other words, the flat rates allow water to be consumed at a marginal price of 0, as an additional unit of water consumed does not result in an increase in price (García-Valiñas et al., 2010). This often results in inefficient usage of water. Even if Alaskan utilities do not have problems with supplying enough water for their customers, the elasticities could help set new fees.

The creation of a proper assessment of the burden placed on households by other utilities such as electricity would also be beneficial. Due to a lack of data availability, the new indicator only uses a rough estimate of the fee burden of electricity, and no other utilities are included. Yet rural communities also pay for fuel and telephone utilities (Goldsmith, 2007). Given the lack of disposable income in many of these communities, poor households likely must choose which bills to pay, which would impact the collection rate of water utilities.

Conclusion

It is becoming widely acknowledged that clean water access is necessary for economic development (Smith, 1996). Yet, numerous Alaskan communities currently lack access to water utilities. While there is funding for the construction of utilities, communities are expected to independently cover the operations and maintenance costs. As such, before allocating funding the DEC must determine whether a community can afford a project. Inaccurate assessments can be costly. For example, in Akiachak a water utility remained shut for 5 years as the community could not financially sustain it. During this time, the utility's plant suffered some damage and necessitated a million dollar investment before it could be re-opened.

Currently, the DEC uses the MHI indicator. Unfortunately this is a poor affordability indicator, as it fails to account for cost of living, demographics and variations in income. These deficiencies are accentuated in rural Alaska, and as shown throughout this paper, the MHI indicator tends to underestimate the burden the utility fees place on communities. A new indicator is suggested as replacement.

The new indicator has a matrix form and is composed of the RI, which calculates the fee burden by income quintile. The indicator also has a FCI which assigns scores to socioeconomic indicators to assess the community. This indicator better captures the complexities of rural Alaskan communities, and was found to more accurately assess the fee burden level as demonstrated by the Akiachak case study. Indeed, while the MHI indicator assessed the 2000 user fees as affordable for the community, the new indicator found them to be high, so unaffordable, for 80% of the community.

The new indicator and the MHI indicator diverged in their affordability assessment for several served communities. Only in one case did the MHI indicator overestimate the fee burden for a served community. For most unserved communities, the two indicators found the projected user fees to be unaffordable. Discrepancies between the two indicators arose in the case of unserved communities which the MHI indicator assessed as affordable and the new indicator assessed as unaffordable.

Further assessment of the accuracy of the new affordability indicator necessitates further research. The affordability threshold levels offer a promising field for further research. Threshold levels of affordability have yet to be determined for the rural Alaskan context, and given the unique economic characteristics of these communities the threshold levels are likely to differ from those found for communities in other parts of the country. Finally, determining the elasticity of water demand in rural Alaskan communities and further assessment of the fee burden placed on households by other utilities would likely strengthen the accuracy of the new indicator.

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Appendix

Appendix A – Residential Index for Served Communities

Geography	MHI	Income Quintiles (US Census, 2015a):					Annual user fees (VSW, 2015b)	Residential Index (RI) in %:						
		1	2	3	4	5		MHI	IQ1	IQ2	IQ3	IQ4	IQ5	IQ1-IQ3)
Adak	$82,500	$67,583	$75,700	$93,833	$114,500	$127,167	$ 720	0.9%	1.1%	1.0%	0.8%	0.6%	0.6%	0.9%
Akiachak	$39,688	$19,722	$31,667	$55,833	$83,750	$121,563	$ 1,416	3.6%	7.2%	4.5%	2.5%	1.7%	1.2%	4.7%
Alakanuk	$35,156	$15,563	$25,375	$42,889	$61,500	$123,156	$ 960	2.7%	6.2%	3.8%	2.2%	1.6%	0.8%	4.1%
Ambler	$41,944	$18,000	$38,833	$58,200	$82,667	$161,125	$ 2,100	5.0%	11.7%	5.4%	3.6%	2.5%	1.3%	6.9%
Angoon	$30,000	$14,643	$25,781	$38,125	$82,500	$210,625	$ 384	1.3%	2.6%	1.5%	1.0%	0.5%	0.2%	1.7%
Brevig Mission	$32,143	$12,625	$27,125	$35,800	$51,400	$84,500	$ 1,200	3.7%	9.5%	4.4%	3.4%	2.3%	1.4%	5.8%
Buckland	$58,750	$25,350	$38,000	$63,875	$96,333	$138,625	$ 1,860	3.2%	7.3%	4.9%	2.9%	1.9%	1.3%	5.0%
Chevak	$41,719	$20,778	$33,500	$46,167	$76,000	$127,025	$ 1,800	4.3%	8.7%	5.4%	3.9%	2.4%	1.4%	6.0%
Chignik	$81,250	$38,875	$61,750	$95,750	$114,250	$137,125	$ 900	1.1%	2.3%	1.5%	0.9%	0.8%	0.7%	1.6%
Chignik Lagoon	$81,250	$30,167	$76,000	$94,500	$143,000	$196,750	$ 1,020	1.3%	3.4%	1.3%	1.1%	0.7%	0.5%	1.9%
Chignik Lake	$41,875	$18,750	$31,667	$53,125	$75,000	$140,938	$ 2,400	5.7%	12.8%	7.6%	4.5%	3.2%	1.7%	8.3%
Deering	$51,250	$32,750	$40,500	$58,167	$64,750	$106,375	$ 1,140	2.2%	3.5%	2.8%	2.0%	1.8%	1.1%	2.8%
Fort Yukon	$33,194	$9,780	$22,267	$44,833	$86,750	$162,775	$ 1,416	4.3%	14.5%	6.4%	3.2%	1.6%	0.9%	8.0%
Gambell	$32,500	$18,167	$24,500	$46,250	$64,063	$101,667	$ 1,392	4.3%	7.7%	5.7%	3.0%	2.2%	1.4%	5.5%
Goodnews Bay	$22,750	$11,917	$18,389	$27,250	$39,000	$107,125	$ 1,020	4.5%	8.6%	5.5%	3.7%	2.6%	1.0%	5.9%
Grayling	$21,250	$7,000	$18,500	$25,250	$38,000	$123,500	$ 1,200	5.6%	17.1%	6.5%	4.8%	3.2%	1.0%	9.5%
Holy Cross	$35,938	$21,000	$27,300	$39,250	$69,000	$166,000	$ 1,320	3.7%	6.3%	4.8%	3.4%	1.9%	0.8%	4.8%
Hooper Bay	$36,583	$16,350	$31,692	$44,417	$63,800	$110,406	$ 1,020	2.8%	6.2%	3.2%	2.3%	1.6%	0.9%	3.9%
Hughes	$32,500	$27,500	$30,833	$36,250	$66,250	$101,250	$ 1,200	3.7%	4.4%	3.9%	3.3%	1.8%	1.2%	3.9%
Kake	$38,750	$17,688	$29,714	$49,000	$76,615	$158,875	$ 675	1.7%	3.8%	2.3%	1.4%	0.9%	0.4%	2.5%
Kiana	$38,571	$13,050	$32,250	$43,250	$81,500	$120,875	$ 1,680	4.4%	12.9%	5.2%	3.9%	2.1%	1.4%	7.3%

Geography	MHI	Income Quintiles (US Census, 2015a):					Annual user fees (VSW, 2015b)	Residential Index (RI) in %:						
		1	2	3	4	5		MHI	IQ1	IQ2	IQ3	IQ4	IQ5	IQ1-IQ3
Klawock	$38,958	$16,875	$29,375	$51,250	$70,833	$129,097	$ 1,068	2.7%	6.3%	3.6%	2.1%	1.5%	0.8%	4.0%
Kobuk	$43,750	$16,250	$28,750	$53,750	$96,250	$102,188	$ 2,400	5.5%	14.8%	8.3%	4.5%	2.5%	2.3%	9.2%
Kotlik	$37,321	$16,222	$29,833	$45,250	$72,167	$145,094	$ 1,254	3.4%	7.7%	4.2%	2.8%	1.7%	0.9%	4.9%
Kotzebue	$91,806	$43,500	$75,474	$108,346	$154,867	$205,779	$ 1,214	1.3%	2.8%	1.6%	1.1%	0.8%	0.6%	1.8%
Koyuk	$32,679	$17,813	$23,333	$35,000	$52,500	$88,438	$ 840	2.6%	4.7%	3.6%	2.4%	1.6%	0.9%	3.6%
Kwethluk	$42,250	$22,625	$34,400	$47,600	$64,611	$141,792	$ 1,272	3.0%	5.6%	3.7%	2.7%	2.0%	0.9%	4.0%
Larsen Bay	$48,750	$19,100	$39,250	$85,500	$89,250	$142,125	$ 564	1.2%	3.0%	1.4%	0.7%	0.6%	0.4%	1.7%
Lower Kalskag	$31,042	$18,357	$27,071	$32,250	$58,000	$94,125	$ 1,872	6.0%	10.2%	6.9%	5.8%	3.2%	2.0%	7.6%
Manokotak	$34,519	$20,000	$31,667	$47,500	$67,000	$133,438	$ 960	2.8%	4.8%	3.0%	2.0%	1.4%	0.7%	3.3%
McGrath	$63,654	$21,500	$55,000	$67,143	$95,000	$156,250	$ 1,260	2.0%	5.9%	2.3%	1.9%	1.3%	0.8%	3.3%
Mountain Village	$44,063	$20,500	$37,100	$49,700	$67,000	$96,063	$ 1,080	2.5%	5.3%	2.9%	2.2%	1.6%	1.1%	3.5%
New Stuyahok	$40,313	$15,583	$28,500	$47,667	$64,667	$99,438	$ 1,125	2.8%	7.2%	3.9%	2.4%	1.7%	1.1%	4.5%
Newhalen	$53,333	$17,000	$34,500	$60,500	$96,500	$142,375	$ 2,100	3.9%	12.4%	6.1%	3.5%	2.2%	1.5%	7.3%
Nondalton	$30,000	$16,000	$21,333	$43,500	$66,000	$99,750	$ 720	2.4%	4.5%	3.4%	1.7%	1.1%	0.7%	3.2%
Noorvik	$52,500	$26,000	$41,250	$63,750	$102,500	$161,250	$ 2,100	4.0%	8.1%	5.1%	3.3%	2.0%	1.3%	5.5%
Nulato	$39,500	$15,500	$27,833	$47,750	$68,500	$111,688	$ 1,320	3.3%	8.5%	4.7%	2.8%	1.9%	1.2%	5.3%
Nunam Iqua	$51,250	$16,375	$38,500	$68,000	$85,667	$133,625	$ 780	1.5%	4.8%	2.0%	1.1%	0.9%	0.6%	2.6%
Ouzinkie	$39,000	$22,500	$33,438	$58,333	$91,250	$238,333	$ 564	1.4%	2.5%	1.7%	1.0%	0.6%	0.2%	1.7%
Pelican	$86,750	$23,500	$85,600	$92,900	$115,500	$181,063	$ 438	0.5%	1.9%	0.5%	0.5%	0.4%	0.2%	0.9%
Pitkas Point	$40,625	$11,000	$29,000	$55,375	$69,500	$218,063	$ 1,440	3.5%	13.1%	5.0%	2.6%	2.1%	0.7%	6.9%
Port Heiden	$58,750	$28,375	$55,667	$68,000	$123,300	$221,000	$ 900	1.5%	3.2%	1.6%	1.3%	0.7%	0.4%	2.0%
Quinhagak	$32,778	$16,250	$25,625	$42,000	$75,833	$120,625	$ 1,500	4.6%	9.2%	5.9%	3.6%	2.0%	1.2%	6.2%
Russian Mission	$43,750	$25,000	$34,167	$52,500	$95,500	$124,063	$ 1,680	3.8%	6.7%	4.9%	3.2%	1.8%	1.4%	4.9%
Savoonga	$33,594	$14,059	$22,179	$39,929	$57,000	$105,219	$ 1,200	3.6%	8.5%	5.4%	3.0%	2.1%	1.1%	5.7%
Scammon Bay	$31,875	$13,750	$22,273	$38,125	$58,333	$91,250	$ 1,260	4.0%	9.2%	5.7%	3.3%	2.2%	1.4%	6.0%
Shaktoolik	$32,292	$17,500	$28,750	$45,000	$73,750	$104,688	$ 720	2.2%	4.1%	2.5%	1.6%	1.0%	0.7%	2.7%

Geography	MHI	Income Quintiles (US Census, 2015a):					Annual user fees (VSW, 2015b)	Residential Index (RI) in %:						
		1	2	3	4	5		MHI	IQ1	IQ2	IQ3	IQ4	IQ5	IQ1-IQ3
Shungnak	$51,944	$17,417	$50,167	$59,500	$69,500	$137,000	$ 1,680	3.2%	9.6%	3.3%	2.8%	2.4%	1.2%	5.3%
Sleetmute	$26,250	$10,167	$22,750	$32,167	$64,000	$115,250	$ 1,500	5.7%	14.8%	6.6%	4.7%	2.3%	1.3%	8.7%
South Naknek	$58,750	$23,000	$33,500	$80,500	$122,250	$193,625	$ 1,080	1.8%	4.7%	3.2%	1.3%	0.9%	0.6%	3.1%
St. George	$41,250	$21,000	$34,500	$75,500	$98,250	$138,500	$ 1,056	2.6%	5.0%	3.1%	1.4%	1.1%	0.8%	3.2%
St. Mary's	$43,056	$23,833	$41,020	$53,167	$85,333	$124,000	$ 1,560	3.6%	6.5%	3.8%	2.9%	1.8%	1.3%	4.4%
St. Michael	$27,222	$14,083	$21,917	$41,167	$69,500	$237,650	$ 3,000	11.0%	21.3%	13.7%	7.3%	4.3%	1.3%	14.1%
St. Paul	$49,375	$22,923	$38,917	$59,056	$97,900	$206,188	$ 600	1.2%	2.6%	1.5%	1.0%	0.6%	0.3%	1.7%
Thorne Bay	$53,500	$19,188	$41,357	$75,083	$120,464	$155,667	$ 1,158	2.2%	6.0%	2.8%	1.5%	1.0%	0.7%	3.5%
Toksook Bay	$61,250	$31,500	$47,100	$66,889	$79,500	$127,375	$ 780	1.3%	2.5%	1.7%	1.2%	1.0%	0.6%	1.8%
Tyonek	$31,875	$11,800	$23,875	$58,500	$99,625	$146,813	$ 1,539	4.8%	13.0%	6.4%	2.6%	1.5%	1.0%	7.4%
Unalakleet	$57,188	$26,429	$44,868	$72,500	$105,000	$195,521	$ 900	1.6%	3.4%	2.0%	1.2%	0.9%	0.5%	2.2%
Upper Kalskag	$37,083	$12,400	$29,800	$43,000	$60,167	$91,500	$ 1,800	4.9%	14.5%	6.0%	4.2%	3.0%	2.0%	8.2%
White Mountain	$25,714	$11,000	$21,600	$31,000	$74,250	$161,375	$ 1,260	4.9%	11.5%	5.8%	4.1%	1.7%	0.8%	7.1%

Appendix B – Residential Index for Unserved Communities

Geography	MHI	Income Quintiles (US Census, 2015a):				
		1	2	3	4	5
Alatna	-	-	-	-	-	-
Allakaket	$ 27,000	$ 14,667	$ 25,200	$ 29,667	$ 44,000	$ 86,500
Arctic Village	$ 27,250	$ 12,625	$ 23,500	$ 34,667	$ 59,750	$ 93,063
Atmautluak	$ 57,500	$ 21,250	$ 42,500	$ 81,667	$ 101,250	$ 163,750
Beaver	$ 23,750	$ 13,250	$ 21,375	$ 28,500	$ 49,250	$ 125,917
Birch Creek	$ 4,688	$ 3,000	$ 4,125	$ 25,250	$ 26,375	$ 27,219
Chalkyitsik	$ 34,167	$ 23,750	$ 32,917	$ 41,250	$ 56,250	$ 103,750
Chefornak	$ 52,500	$ 25,500	$ 36,000	$ 57,500	$ 80,000	$ 161,250
Circle	$ 19,375	$ 12,000	$ 17,125	$ 30,250	$ 41,000	$ 198,500
Crooked Creek	$ 38,750	$ 14,000	$ 30,500	$ 41,500	$ 78,500	$ 131,063
Diomede	$ 18,750	$ 7,167	$ 14,000	$ 32,000	$ 63,667	$ 82,313
Eagle	$ 28,750	$ 10,667	$ 15,250	$ 39,250	$ 76,000	$ 133,250
Kipnuk	$ 36,563	$ 14,071	$ 30,950	$ 41,857	$ 67,167	$ 100,125
Kongiganak	$ 36,667	$ 10,000	$ 26,667	$ 47,500	$ 64,167	$ 125,625
Koyukuk	$ 17,083	$10,300	$15,500	$22,333	$44,250	$83,875
Kwigillingok	$ 40,833	$ 25,250	$37,000	$51,750	$71,500	$112,250
Lime Village	$ 20,000	$ 4,500	$ 11,500	$ 29,500	$ 148,667	$ 149,667
Mekoryuk	$ 30,000	$ 15,333	$ 20,750	$ 43,500	$ 71,600	$ 89,500
Napakiak	$ 27,188	$13,385	$20,250	$34,083	$53,250	$73,417
Napaskiak	$ 33,036	$22,667	$28,417	$52,833	$88,667	$209,188
Nightmute	$ 48,125	$ 19,083	$ 39,500	$ 63,667	$ 91,833	$ 250,000
Northway Vlg.	$ 18,750	$ 11,500	$ 15,333	$ 22,167	$ 47,000	$55,875
Nunapitchuk	$ 40,625	$ 25,400	$36,800	$ 58,500	$ 100,500	$ 114,625
Platinum	$ 38,750	$ 6,833	$16,750	$ 43,000	$ 44,833	$ 51,813

Annual user fees (DEC, 2016)	Residential Index (RI) in %:						
	MHI	IQ1	IQ2	IQ3	IQ4	IQ5	IQ1-IQ3
$ 4,152	-	-	-	-	-	-	-
$ 3,288	12.18%	22.42%	13.05%	11.08%	7.47%	3.80%	15.52%
$ 4,032	14.80%	31.94%	17.16%	11.63%	6.75%	4.33%	20.24%
$ 3,348	5.82%	15.76%	7.88%	4.10%	3.31%	2.04%	9.24%
$ 4,632	19.50%	34.96%	21.67%	16.25%	9.41%	3.68%	24.29%
$ 3,612	77.05%	120.40%	87.56%	14.30%	13.69%	13.27%	74.09%
$ 2,316	6.78%	9.75%	7.04%	5.61%	4.12%	2.23%	7.47%
$ 3,432	6.54%	13.46%	9.53%	5.97%	4.29%	2.13%	9.65%
$ 6,852	35.37%	57.10%	40.01%	22.65%	16.71%	3.45%	39.92%
$ 3,852	9.94%	27.51%	12.63%	9.28%	4.91%	2.94%	16.48%
$ 2,628	14.02%	36.67%	18.77%	8.21%	4.13%	3.19%	21.22%
$ 1,824	6.34%	17.10%	11.96%	4.65%	2.40%	1.37%	11.24%
$ 2,940	8.04%	20.89%	9.50%	7.02%	4.38%	2.94%	12.47%
$ 2,952	8.05%	29.52%	11.07%	6.21%	4.60%	2.35%	15.60%
$ 2,040	11.94%	19.81%	13.16%	9.13%	4.61%	2.43%	14.03%
$ 4,092	10.02%	16.21%	11.06%	7.91%	5.72%	3.65%	11.72%
$ 6,000	30 %	133.33%	52.17%	20.34%	4.04%	4.01%	68.62%
$ 1,248	4.16%	8.14%	6.01%	2.87%	1.74%	1.39%	5.67%
$ 4,296	15.80%	32.10%	21.21%	12.60%	8.07%	5.85%	21.97%
$ 4,176	12.64%	18.42%	14.70%	7.90%	4.71%	2 %	13.67%
$ 1,680	3.49%	8.80%	4.25%	2.64%	1.83%	0.67%	5.23%
-	-	-	-	-	-	-	-
$ 1,224	3.01%	4.82%	3.33%	2.09%	1.22%	1.07%	3.41%
$ 1,140	2.94%	16.68%	6.81%	2.65%	2.54%	2.20%	8.71%

Geography	MHI	Income Quintiles (US Census, 2015a):			
		1	2	3	4
Shageluk	$ 16,250	$ 11,063	$ 13,500	$ 25,750	$ 51,625
Shageluk	$ 16,250	$ 11,063	$ 13,500	$ 25,750	$ 51,625
Stebbins	$ 36,250	$ 13,250	$ 32,214	$ 39,944	$ 61,000
Stevens Village	$ 18,125	$ 15,875	$ 17,375	$ 18,875	$ 21,500
Stony River	$ 16,250	$ 6,400	$ 11,333	$ 19,250	$ 25,500
Takotna	$ 65,833	$ 18,750	$ 43,750	$ 68,750	$ 101,250
Teller	$ 26,667	$ 9,188	$ 18,500	$ 29,357	$ 54,500
Tetlin	$ 20,750	$ 5,571	$ 9,000	$ 22,400	$ 54,250
Tuluksak	$ 23,000	$ 11,500	$ 16,571	$ 26,643	$ 47,250
Tuntutuliak	$ 36,042	$ 20,625	$ 33,409	$ 40,556	$ 50,000
Tununak	$ 33,182	$ 14,444	$ 27,500	$ 34,773	$ 46,667
Venetie	$ 28,333	$ 7,600	$ 16,000	$ 45,100	$ 65,300
Wales	$ 35,000	$ 8,875	$ 24,250	$ 40,500	$ 49,750

5	Annual user fees (DEC, 2016)	MHI	Residential Index (RI) in %: IQ1	IQ2	IQ3	IQ4	IQ5	IQ1-IQ3
$ 88,313	$1,200	7.38%	10.85%	8.89%	4.66%	2.32%	1.36%	8.13%
$ 88,313	$1,512	9.30%	13.67%	11.20%	5.87%	2.93%	1.71%	10.25%
$ 123,563	$7,188	19.83%	54.25%	22.31%	18 %	11.78%	5.82%	31.52%
$ 64,250	$3,636	20.06%	22.90%	20.93%	19.26%	16.91%	5.66%	21.03%
$ 72,625	$2,916	17.94%	45.56%	25.73%	15.15%	11.44%	4.02%	28.81%
$ 136,250	$4,548	6.91%	24.26%	10.40%	6.62%	4.49%	3.34%	13.76%
$ 91,125	$1,896	7.11%	20.64%	10.25%	6.46%	3.48%	2.08%	12.45%
$ 93,375	$1,308	6.30%	23.48%	14.53%	5.84%	2.41%	1.40%	14.62%
$ 73,375	$2,328	10.12%	20.24%	14.05%	8.74%	4.93%	3.17%	14.34%
$ 98,125	$2,916	8.09%	14.14%	8.73%	7.19%	5.83%	2.97%	10.02%
$ 70,625	$1,296	3.91%	8.97%	4.71%	3.73%	2.78%	1.84%	5.80%
$ 82,250	$2,160	7.62%	28.42%	13.50%	4.79%	3.31%	2.63%	15.57%
$ 65,500	$2,532	7.23%	28.53%	10.44%	6.25%	5.09%	3.87%	15.07%

Appendix C – FCI Socioeconomic Indicators for all communities

Geography	% Full Time	% SNAP	% Poverty	% Public Assistance	% MHI Electricity	Cross Price Elasticity Water*
Adak	54.88%	5.56%	5.60%	19.44%	4.0%	-0.04%
Akiachak	21.00%	57.80%	25.90%	62.22%	5.7%	-
Alakanuk	22.87%	44.65%	39.00%	52.83%	8.7%	-0.26%
Alatna	100.00%	0.00%	0.00%	0.00%	-	-0.61%
Allakaket	12.90%	41.67%	5.60%	50.00%	9.5%	-0.38%
Ambler	27.36%	41.67%	27.40%	47.62%	8.9%	-0.11%
Angoon	25.22%	41.43%	24.30%	46.43%	9.7%	-0.03%
Anvik	33.33%	20.59%	23.50%	23.53%	7.8%	-0.02%
Arctic Village	15.91%	64.71%	33.30%	64.71%	6.7%	-0.59%
Atmautluak	17.10%	60.00%	23.30%	78.33%	5.8%	-0.47%
Beaver	19.12%	39.47%	28.90%	39.47%	10.6%	-0.21%
Birch Creek	0.00%	55.56%	100.00%	100.00%	-	-0.55%
Brevig Mission	13.58%	77.08%	59.40%	77.08%	9.6%	-0.56%
Buckland	25.53%	36.89%	24.60%	41.80%	5.5%	-0.18%
Chalkyitsik	23.53%	36.67%	26.70%	43.33%	3.9%	-0.20%
Chefornak	17.36%	60.00%	18.80%	68.75%	6.6%	-0.49%
Chevak	21.48%	63.32%	34.20%	65.83%	6.3%	-0.66%
Chignik	44.64%	0.00%	0.00%	3.85%	2.1%	-0.01%
Chignik Lagoon	31.48%	0.00%	0.00%	0.00%	-	-0.13%
Chignik Lake	42.22%	4.00%	12.00%	4.00%	-	-
Circle	10.91%	63.89%	38.90%	75.00%	14.4%	-
Crooked Creek	30.16%	47.83%	26.10%	52.17%	7.4%	-0.60%
Deering	15.12%	22.22%	13.90%	25.00%	6.9%	-0.52%
Diomede	47.22%	34.78%	47.80%	43.48%	9.3%	-0.21%
Eagle	25.00%	32.14%	28.60%	39.29%	6.1%	-0.38%
Fort Yukon	29.05%	41.92%	24.00%	47.60%	8.5%	-0.20%
Gambell	18.88%	44.38%	33.10%	49.38%	7.8%	-0.15%
Goodnews Bay	20.78%	53.97%	39.70%	74.60%	12.8%	-0.18%
Grayling	7.48%	43.18%	47.70%	63.64%	10.6%	-0.12%
Holy Cross	14.65%	32.81%	15.60%	37.50%	6.6%	-0.12%
Hooper Bay	18.78%	66.08%	41.90%	69.16%	6.5%	-0.19%
Hughes	26.67%	60.00%	20.00%	65.00%	9.8%	-0.13%
Kake	21.81%	37.16%	17.00%	40.83%	7.5%	-0.21%
Kiana	21.54%	41.51%	33.00%	42.45%	8.4%	-0.05%
Kipnuk	11.35%	54.14%	33.10%	58.60%	5.8%	-0.02%
Klawock	28.70%	23.51%	16.10%	28.07%	4.0%	-0.45%
Kobuk	25.51%	17.14%	40.00%	34.29%	8.9%	-0.08%
Kongiganak	12.89%	61.43%	32.90%	65.71%	10.6%	- 0.48%

Geography	% Full Time	% SNAP	% Poverty	% Public Assistance	% MHI Electricity	Cross Price Elasticity _ Water*
Kotlik	18.58%	56.20%	28.50%	64.96%	9.4%	-
Kotzebue	46.61%	13.93%	10.90%	17.41%	3.2%	-0.20%
Koyuk	14.91%	73.85%	41.50%	76.92%	9.9%	-
Koyukuk	23.08%	34.21%	44.70%	34.21%	7.9%	-0.53%
Kwethluk	17.28%	46.50%	24.20%	54.78%	4.9%	-0.11%
Kwigillingok	17.12%	48.39%	19.40%	54.84%	7.5%	-0.51%
Larsen Bay	33.33%	3.85%	0.00%	3.85%	3.2%	-0.19%
Lime Village	18.18%	0.00%	50.00%	0.00%	8.8%	-0.06%
Lower Kalskag	5.71%	59.77%	32.20%	64.37%	6.5%	-
Manokotak	20.20%	48.00%	16.80%	63.20%	6.1%	-0.08%
McGrath	37.16%	15.38%	13.80%	20.00%	4.1%	-0.12%
Mekoryuk	12.95%	26.56%	26.60%	31.25%	6.2%	-0.33%
Mountain Village	21.84%	60.74%	24.50%	62.58%	7.1%	-0.15%
Napakiak	15.81%	48.98%	44.90%	62.24%	10.6%	-0.53%
Napaskiak	14.58%	49.46%	31.20%	60.22%	8.0%	-0.56%
New Stuyahok	9.77%	50.47%	32.70%	64.49%	8.5%	-
Newhalen	27.35%	15.91%	20.50%	18.18%	4.3%	-
Nightmute	16.16%	36.73%	22.40%	46.94%	5.8%	-0.34%
Nondalton	21.33%	35.94%	32.80%	45.31%	7.6%	-1.00%
Noorvik	20.65%	38.57%	26.40%	39.29%	7.6%	-
Northway Vlg.	0.00%	6.06%	9.10%	6.06%	16.2%	-
Nulato	31.63%	37.21%	26.70%	38.37%	6.5%	-0.09%
Nunam Iqua	18.18%	41.94%	16.10%	41.94%	4.8%	-0.27%
Nunapitchuk	11.07%	56.18%	21.30%	61.80%	6.6%	-0.27%
Ouzinkie	19.13%	16.00%	18.00%	16.00%	4.1%	-0.13%
Pelican	27.08%	17.39%	0.00%	17.39%	3.5%	-0.02%
Pitkas Point	13.95%	61.29%	32.30%	61.29%	6.3%	-
Platinum	21.74%	36.36%	36.40%	45.45%	-	-0.22%
Port Heiden	58.57%	9.38%	0.00%	15.63%	7.6%	-
Quinhagak	12.56%	52.00%	32.70%	60.00%	9.3%	-
Russian Mission	20.93%	66.67%	30.70%	66.67%	7.0%	-
Savoonga	14.08%	70.52%	51.40%	75.14%	8.4%	-
Scammon Bay	14.06%	63.00%	49.00%	71.00%	11.4%	-0.06%
Shageluk	31.71%	59.26%	40.70%	81.48%	17.5%	-0.08%
Shaktoolik	23.72%	29.23%	29.20%	33.85%	13.0%	-0.10%
Shungnak	27.08%	46.88%	20.30%	46.88%	9.4%	-0.09%
Sleetmute	12.50%	38.89%	38.90%	61.11%	9.4%	-

*For cross price elasticity of water calculations please refer to Appendix D

Geography	% Full Time	% SNAP	% Poverty	% Public Assistance	% MHI Electricity	Cross Price Elasticity _ Water*
South Naknek	41.07%	9.68%	12.90%	12.90%	85.7%	-
St. George	31.03%	0.00%	16.70%	0.00%	32.1%	-0.31%
St. Mary's	35.22%	25.00%	18.50%	33.33%	7.3%	-0.15%
St. Michael	29.96%	46.81%	37.20%	48.94%	15.1%	-0.21%
St. Paul	39.15%	16.77%	13.70%	17.39%	5.3%	-0.09%
Stebbins	19.44%	58.54%	33.30%	63.41%	8.5%	-0.61%
Stevens Village	0.00%	75.00%	66.70%	91.67%	-	-0.41%
Stony River	0.00%	42.11%	78.90%	52.63%	13.0%	-0.48%
Takotna	33.33%	15.00%	0.00%	25.00%	4.5%	-0.47%
Teller	20.45%	50.00%	50.00%	53.23%	8.6%	-0.33%
Tetlin	17.95%	39.39%	51.50%	54.55%	8.8%	-0.34%
Thorne Bay	42.49%	11.51%	15.90%	13.49%	2.2%	-0.10%
Toksook Bay	20.42%	34.15%	13.80%	45.53%	4.6%	-
Tuluksak	7.02%	79.07%	62.80%	79.07%	9.9%	-0.52%
Tuntutuliak	11.79%	61.05%	31.60%	68.42%	9.6%	-0.43%
Tununak	10.90%	52.86%	28.60%	60.00%	7.5%	-0.30%
Tyonek	24.00%	9.59%	32.90%	9.59%	3.6%	-
Unalakleet	40.79%	18.60%	16.30%	25.58%	3.8%	-
Upper Kalskag	21.38%	51.56%	25.00%	57.81%	8.3%	-0.37%
Venetie	28.23%	58.06%	56.50%	61.29%	7.4%	-0.35%
Wales	22.88%	42.86%	42.90%	48.21%	8.2%	-0.06%
White Mountain	17.48%	43.10%	37.90%	48.28%	9.1%	-0.37%

*For cross price elasticity of water calculations please refer to Appendix D

Appendix D – Cross Price Elasticity of Water Calculations

Geography	Water Utility Revenue	Electrical Utility Revenue	Total Market Revenue	Electricity Market Share	Water Market Share	Cross Price Elasticity of Water
Adak	$67,558	$1,608,441	$1,675,999	96.0%	4.0%	-0.04%
Akiachak		$905,312	$905,312	100.0%	0.0%	-
Alakanuk	$396,682	$1,144,526	$1,541,208	74.3%	25.7%	-0.26%
Alatna	$107,299	$69,800	$177,099	39.4%	60.6%	-0.61%
Allakaket	$320,700	$516,647	$837,347	61.7%	38.3%	-0.38%
Ambler	$100,000	$785,228	$885,228	88.7%	11.3%	-0.11%
Angoon	$34,466	$1,163,434	$1,197,900	97.1%	2.9%	-0.03%
Anvik	$5,000	$229,636	$234,636	97.9%	2.1%	-0.02%
Arctic Village	$371,000	$259,350	$630,350	41.1%	58.9%	-0.59%
Atmautluak	$347,001	$396,871	$743,872	53.4%	46.6%	-0.47%
Beaver	$239,000	$192,774	$431,774	44.6%	55.4%	-0.55%
Birch Creek	$114,000	$87,900	$201,900	43.5%	56.5%	-0.56%
Brevig Mission	$139,300	$613,797	$753,097	81.5%	18.5%	-0.18%
Buckland	$154,490	$625,499	$779,989	80.2%	19.8%	-0.20%
Chalkyitsik	$193,027	$202,919	$395,946	51.2%	48.8%	-0.49%
Chefornak	$1,230,001	$632,155	$1,862,156	33.9%	66.1%	-0.66%
Chevak	$12,000	$1,128,196	$1,140,196	98.9%	1.1%	-0.01%
Chignik	$55,000	$373,626	$428,626	87.2%	12.8%	-0.13%
Chignik Lagoon	-	$312,000	$312,000	100.0%	0.0%	-
Chignik Lake		$121,000	$121,000	100.0%	0.0%	-
Circle	$425,000	$277,998	$702,998	39.5%	60.5%	-0.60%
Crooked Creek	$239,000	$219,167	$458,167	47.8%	52.2%	-0.52%
Deering	$104,520	$393,000	$497,520	79.0%	21.0%	-0.21%
Diomede	$160,000	$257,559	$417,559	61.7%	38.3%	-0.38%
Eagle	$100,399	$398,126	$498,525	79.9%	20.1%	-0.20%
Fort Yukon	$288,360	$1,645,677	$1,934,037	85.1%	14.9%	-0.15%
Gambell	$202,838	$927,179	$1,130,017	82.1%	17.9%	-0.18%
Goodnews Bay	$59,880	$450,420	$510,300	88.3%	11.7%	-0.12%
Grayling	$42,000	$303,921	$345,921	87.9%	12.1%	-0.12%
Holy Cross	$74,682	$321,563	$396,245	81.2%	18.8%	-0.19%
Hooper Bay	$226,009	$1,541,561	$1,767,570	87.2%	12.8%	-0.13%
Hughes	$55,781	$211,811	$267,592	79.2%	20.8%	-0.21%
Kake	$80,500	$1,572,725	$1,653,225	95.1%	4.9%	-0.05%
Kiana	$17,950	$936,577	$954,527	98.1%	1.9%	-0.02%
Kipnuk	$637,999	$783,318	$1,421,317	55.1%	44.9%	-0.45%

Geography	Water Utility Revenue	Electrical Utility Revenue	Total Market Revenue	Electricity Market Share	Water Market Share	Cross Price Elasticity of Water
Klawock	$169,678	$2,000,260	$2,169,938	92.2%	7.8%	-0.08%
Kobuk		$434,980	$434,980	100.0%	0.0%	-
Kongiganak	$408,000	$434,841	$842,841	51.6%	48.4%	-0.48%
Kotlik		$1,074,828	$1,074,828	100.0%	0.0%	-
Kotzebue	$2,162,245	$8,740,808	$10,903,053	80.2%	19.8%	-0.20%
Koyuk		$702,509	$702,509	100.0%	0.0%	-
Koyukuk	$147,001	$131,469	$278,470	47.2%	52.8%	-0.53%
Kwethluk	$66,065	$525,093	$591,158	88.8%	11.2%	-0.11%
Kwigillingok	$568,999	$547,027	$1,116,026	49.0%	51.0%	-0.51%
Larsen Bay	$60,107	$253,337	$313,444	80.8%	19.2%	-0.19%
Lime Village	$109,000	$1,849,650	$1,958,650	94.4%	5.6%	-0.06%
Lower Kalskag		$309,952	$309,952	100.0%	0.0%	-
Manokotak	$55,000	$672,570	$727,570	92.4%	7.6%	-0.08%
McGrath	$170,000	$1,293,723	$1,463,723	88.4%	11.6%	-0.12%
Mekoryuk	$242,964	$483,408	$726,372	66.6%	33.4%	-0.33%
Mountain Village	$263,185	$1,463,452	$1,726,637	84.8%	15.2%	-0.15%
Napakiak	$564,000	$496,783	$1,060,783	46.8%	53.2%	-0.53%
Napaskiak	$613,000	$477,916	$1,090,916	43.8%	56.2%	-0.56%
New Stuyahok	-	-	-	-	-	-
Newhalen	-	$886,620	$886,620	100.0%	-	-
Nightmute	$163,000	$309,834	$472,834	65.5%	34.5%	-0.34%
Nondalton	$89,000		$89,000	0.0%	100.0%	-1.00%
Noorvik	-	$1,193,137	$1,193,137	100.0%	0.0%	-
Northway Vlg.	-	$788,491	$788,491	100.0%	-	-
Nulato	$58,760	$593,436	$652,196	91.0%	9.0%	-0.09%
Nunam Iqua	$150,044	$408,445	$558,489	73.1%	26.9%	-0.27%
Nunapitchuk	$232,000	$630,242	$862,242	73.1%	26.9%	-0.27%
Ouzinkie	$42,800	$279,121	$321,921	86.7%	13.3%	-0.13%
Pelican	$9,750	$488,022	$497,772	98.0%	2.0%	-0.02%
Pitkas Point	-	$188,771	$188,771	100.0%	-	-
Platinum	$46,000	$159,000	$205,000	77.6%	22.4%	-0.22%
Port Heiden	$1,425	$440,331	$441,756	99.7%	0.3%	0.00%
Quinhagak	-	$930,788	$930,788	100.0%	-	-
Russian Mission	-	$591,431	$591,431	100.0%	-	-
Savoonga	-	$1,030,898	$1,030,898	100.0%	-	-
Scammon Bay	$65,000	$950,679	$1,015,679	93.6%	6.4%	-0.06%

Geography	Water Utility Revenue	Electrical Utility Revenue	Total Market Revenue	Electricity Market Share	Water Market Share	Cross Price Elasticity of Water
Shageluk	$18,913	$207,317	$226,230	91.6%	8.4%	-0.08%
Shaktoolik	$53,680	$509,628	$563,308	90.5%	9.5%	-0.10%
Shungnak	$113,330	$1,094,164	$1,207,494	90.6%	9.4%	-0.09%
Sleetmute	-	$214,354	$214,354	100.0%	-	-
South Naknek	$28,800	$9,302,173	$9,330,973	99.7%	0.3%	0.00%
St. George	$148,000	$326,623	$474,623	68.8%	31.2%	-0.31%
St. Mary's	$231,000	$1,334,332	$1,565,332	85.2%	14.8%	-0.15%
St. Michael	$254,800	$931,416	$1,186,216	78.5%	21.5%	-0.21%
St. Paul	$194,800	$1,900,586	$2,095,386	90.7%	9.3%	-0.09%
Stebbins	$1,172,000	$752,489	$1,924,489	39.1%	60.9%	-0.61%
Stevens Village	$181,100	$264,337	$445,437	59.3%	40.7%	-0.41%
Stony River	$88,001	$94,565	$182,566	51.8%	48.2%	-0.48%
Takotna	$158,000	$177,155	$335,155	52.9%	47.1%	-0.47%
Teller	$246,999	$491,930	$738,929	66.6%	33.4%	-0.33%
Tetlin	$84,000	$163,148	$247,148	66.0%	34.0%	-0.34%
Thorne Bay	$88,082	$762,316	$850,398	89.6%	10.4%	-0.10%
Toksook Bay	-	$789,635	$789,635	100.0%	-	-
Tuluksak	$323,000	$297,957	$620,957	48.0%	52.0%	-0.52%
Tuntutuliak	$441,000	$580,332	$1,021,332	56.8%	43.2%	-0.43%
Tununak	$188,000	$430,409	$618,409	69.6%	30.4%	-0.30%
Tyonek	-	$147,447,600	$147,447,600	100.0%	-	-
Unalakleet	-	$1,615,189	$1,615,189	100.0%	-	-
Upper Kalskag	$270,200	$459,800	$730,000	63.0%	37.0%	-0.37%
Venetie	$248,999	$459,800	$708,799	64.9%	35.1%	-0.35%
Wales	$22,154	$344,784	$366,938	94.0%	6.0%	-0.06%
White Mountain	$136,462	$237,122	$373,584	63.5%	36.5%	-0.37%

Appendix E – FCI Score for All Communities

Geography	% Full Time	% SNAP	% Poverty	% Public Assistance	% MHI Electricity Bill	Cross Price Elasticity of W	FCI Score
Adak	3	3	3	3	2	1	**2.5**
Akiachak	1	1	1	1	1	-	**1.0**
Alakanuk	1	1	1	1	1	3	**1.3**
Alatna	3	3	3	3	-	3	**3.0**
Allakaket	1	1	3	1	1	3	**1.7**
Ambler	1	1	1	1	1	3	**1.3**
Angoon	1	1	1	1	1	1	**1.0**
Anvik	2	1	1	2	1	1	**1.3**
Arctic Village	1	1	1	1	1	3	**1.3**
Atmautluak	1	1	1	1	1	3	**1.3**
Beaver	1	1	1	1	1	3	**1.3**
Birch Creek	1	1	1	1	1	3	**1.3**
Brevig Mission	1	1	1	1	1	3	**1.3**
Buckland	1	1	1	1	1	3	**1.3**
Chalkyitsik	1	1	1	1	2	3	**1.5**
Chefornak	1	1	2	1	1	3	**1.5**
Chevak	1	1	1	1	1	1	**1.0**
Chignik	2	3	3	3	2	3	**2.7**
Chignik Lagoon	2	3	3	3	1	-	**2.4**
Chignik Lake	2	3	2	3	1	-	**2.2**
Circle	1	1	1	1	1	3	**1.3**
Crooked Creek	2	1	1	1	1	3	**1.5**
Deering	1	1	2	2	1	3	**1.7**
Diomede	2	1	1	1	1	3	**1.5**
Eagle	1	1	1	1	1	3	**1.3**
Fort Yukon	1	1	1	1	1	3	**1.3**
Gambell	1	1	1	1	1	3	**1.3**
Goodnews Bay	1	1	1	1	1	3	**1.3**
Grayling	1	1	1	1	1	3	**1.3**
Holy Cross	1	1	2	1	1	3	**1.5**
Hooper Bay	1	1	1	1	1	3	**1.3**
Hughes	1	1	2	1	1	3	**1.5**

Geography	% Full Time	% SNAP	% Poverty	% Public Assistance	% MHI Electricity Bill	Cross Price Elasticity of W	FCI Score
Kake	1	1	2	1	1	2	1.3
Kiana	1	1	1	1	1	1	1.0
Kipnuk	1	1	1	1	1	3	1.3
Klawock	1	1	2	2	2	2	1.7
Kobuk	1	2	1	1	1	-	1.2
Kongiganak	1	1	1	1	1	3	1.3
Kotlik	1	1	1	1	1	-	1.0
Kotzebue	2	2	2	3	2	3	2.3
Koyuk	1	1	1	1	1	-	1.0
Koyukuk	1	1	1	1	1	3	1.3
Kwethluk	1	1	1	1	2	3	1.5
Kwigillingok	1	1	2	1	1	3	1.5
Larsen Bay	2	3	3	3	2	3	2.7
Lime Village	1	3	1	3	1	2	1.8
Lower Kalskag	1	1	1	1	1	-	1.0
Manokotak	1	1	2	1	1	2	1.3
McGrath	2	2	2	2	2	3	2.2
Mekoryuk	1	1	1	1	1	3	1.3
Mountain Village	1	1	1	1	1	3	1.3
Napakiak	1	1	1	1	1	3	1.3
Napaskiak	1	1	1	1	1	3	1.3
New Stuyahok	1	1	1	1	1	-	1.0
Newhalen	1	2	1	3	2	-	1.8
Nightmute	1	1	1	1	1	3	1.3
Nondalton	1	1	1	1	1	3	1.3
Noorvik	1	1	1	1	1	-	1.0
Northway Vlg.	1	3	3	3	1	-	2.2
Nulato	2	1	1	1	1	2	1.3
Nunam Iqua	1	1	2	1	2	3	1.7
Nunapitchuk	1	1	1	1	1	3	1.3
Ouzinkie	1	2	2	3	2	3	2.2
Pelican	1	2	3	3	2	1	2.0
Pitkas Point	1	1	1	1	1	-	1.0
Platinum	1	1	1	1	-	3	1.4
Port Heiden	3	3	3	3	1	1	2.3
Quinhagak	1	1	1	1	1	-	1.0

Geography	% Full Time	% SNAP	% Poverty	% Public Assistance	% MHI Electricity Bill	Cross Price Elasticity of W	FCI Score
Russian Mission	1	1	1	1	1	-	**1.0**
Savoonga	1	1	1	1	1	-	**1.0**
Scammon Bay	1	1	1	1	1	2	**1.2**
Shageluk	2	1	1	1	1	2	**1.3**
Shaktoolik	1	1	1	1	1	3	**1.3**
Shungnak	1	1	1	1	1	3	**1.3**
Sleetmute	1	1	1	1	1	-	**1.0**
South Naknek	2	3	2	3	1	1	**2.0**
St. George	2	3	2	3	1	3	**2.3**
St. Mary's	2	1	2	1	1	3	**1.7**
St. Michael	1	1	1	1	1	3	**1.3**
St. Paul	2	2	2	3	1	3	**2.2**
Stebbins	1	1	1	1	1	3	**1.3**
Stevens Village	1	1	1	1	-	3	**1.4**
Stony River	1	1	1	1	1	3	**1.3**
Takotna	2	2	3	2	2	3	**2.3**
Teller	1	1	1	1	1	3	**1.3**
Tetlin	1	1	1	1	1	3	**1.3**
Thorne Bay	2	2	2	3	2	3	**2.3**
Toksook Bay	1	1	2	1	2	-	**1.4**
Tuluksak	1	1	1	1	1	3	**1.3**
Tuntutuliak	1	1	1	1	1	3	**1.3**
Tununak	1	1	1	1	1	3	**1.3**
Tyonek	1	3	1	3	2	-	**2.0**
Unalakleet	2	2	2	2	2	-	**2.0**
Upper Kalskag	1	1	1	1	1	3	**1.3**
Venetie	1	1	1	1	1	3	**1.3**
Wales	1	1	1	1	1	2	**1.2**
White Mountain	1	1	1	1	1	3	**1.3**