

Cost Comparisons of Local Groundwater Sources to Regional Waterlines

Abstract

Water wells, even with additional household treatment, are more cost-efficient in delivering drinking water to rural and suburban residences than long regional pipelines, based on seven case studies reported here. When wells are not maintained properly or concerns about groundwater quality are raised, homeowners have alternatives to consider: improving their existing well system, adding household water treatment, or seeking water supplied by a regional waterline. Factors for the homeowner to evaluate when deciding between water well improvement or waterline supply include reliability of service, water quality, cost, and management control.

Economies of scale certainly apply. One well can supply more than one household and this approach has been used across the country. For communities that lack any reliable water sources because of overdrafted or contaminated aquifers, as demonstrated in the California drought, connection by pipe may be a necessity.[1]

Many municipal water districts do not allow well drilling and installation within their boundaries. Replacement or rehabilitation of existing wells or, for community systems, central treatment may be efficient responses to water supply needs. In other cases, point-of-entry/point-of-use units for treatment of groundwater can be cost-effective alternatives for households and communities.[2]

General Comparison of Reliability and Quality

Groundwater is generally considered a safe water source[3] in the United States,[4] especially from adequately-deep water supply wells.[5] Over 41 million Americans rely on groundwater supplied by private wells and springs and 87 million more people receive their water from groundwater-supplied public water systems ranging in population served from 25 to 2.3 million.[6]

Some key advantages and disadvantages of each system type for reliability and quality are outlined here.

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Reliability

For private water systems:

Advantages

- Groundwater is generally a reliable water source for private well owners.[7]
- Modern well pumps can operate relatively maintenance-free for 20 years or longer before replacement is needed.[8]
- Servicing a well can be provided through a local water-well contractor.[9]
- Private well water systems are typically leak-free so that water pumped is put to use rather than lost.[10]
- Investor-owned and cooperative electric companies that may provide power to rural households had relatively short outages averaging 1.2 to 1.7 power outages in 2016 with durations of 4 to 6 hours, respectively.[11]
- Annual inspection and maintenance of a groundwater system can provide consistent delivery of high-quality water.[12]
- Onsite wastewater treatment systems return used water to the subsurface, maintaining the groundwater source.
- Well owners manage their own water supply and costs.

Disadvantages

- If needed, a well owner would have to arrange and pay for maintenance as well as the cost of an alternative water source.
- Power outages may affect water well pumping capability and water delivery in small and rural communities. A well owner may need a backup generator for extended power supply outages.
- Well maintenance may be constrained by well owner resources.

For public water systems:

Advantages

- Centralized management removes the burden of water supply management from the water consumer.
- Larger pumps may have a service life of 8 to 10 years[13] with replacement managed to avoid supply disruption.
- Servicing the system can be provided through the water company or contractor.
- Investor-owned and cooperative electric companies that may provide power to smaller rural water utilities averaged short power outages of 1.2 to 1.7 on an annual basis in 2016 with durations of 4 to 6 hours, respectively.[14] For short outages, elevated storage towers may provide continued water supply.
- Groundwater as a source is very dependable as long as overexploitation does not occur.
- Even many large surface water-supplied systems have wells as peak, backup, and emergency supplies and benefit from not losing groundwater to evapotranspiration as can occur from surface water reservoirs.

Disadvantages

- Average water loss in the United States from water system transmission and distribution pipelines is 16 percent, increasing costs to treat and deliver water to consumers.[15]
- Power outages may affect water well pumping capability and water delivery in small and rural communities without elevated water storage.
- Supply disruptions may occur for system flushing, waterline breaks, water supply contamination resolution, flood, drought, and other scheduled and unplanned maintenance.
- Exploitation of water sources by a large population can deplete the resource.
- Typically, wastewater is treated and discharged downstream from the water intake or wells and does not provide groundwater recharge.

Quality

For private water systems:

Advantages

- Well owners can manage protection of their wells from onsite contaminant sources.
- Well owners can arrange for regular well inspection and testing to ensure groundwater quality is safe at reasonable cost.

- Well owners can maintain their onsite wastewater (septic) systems in proper operating condition through regular inspection by qualified contractors to support continued high-quality water production from their wells.[16] State laws and local codes support safe groundwater supplies by requiring setback of wells from potential sources of contamination such as septic systems or underground fuel tanks.
- Household point-of-entry or point-of-use treatment, such as reverse osmosis, activated carbon and distillation for chemicals, and ultraviolet, reverse osmosis and distillation for microbes can typically remove naturally-occurring constituents or pathogens at reasonable cost without central community treatment.[17] Also, point-of-entry or -use treatment can additionally remove dissolved minerals (for example: calcium, magnesium, and iron) that cause water to be "hard," resulting in staining of clothes and taste issues, improving consumers' quality of life. Treatment removes the minerals and "softens" the water for household use.

Disadvantages

- Groundwater source protection and septic system maintenance may be constrained by well owner resources and knowledge.
- If wells are in flood-prone areas, the well owner may need to arrange for water well testing and disinfection for safe water supply after flooding.

For public water systems:

Advantages

- Centralized public water system management removes water supply decisions affecting quality from the consumer.
- Public water systems are typically required to have a sourcewater protection program.
- Public water systems' water quality is high and must meet federal and state drinking water standards before water is delivered to the homeowner's water supply connection.

Table 1. 2018 Estimated Costs of Alternatives for Reliable Rural Water Supply

	Capital Cost	Average Well Depth or Pipe Length*	Number of Wells	Number of Connections	Operating Cost/HH/mo**	Annual Well Inspection Cost/connection/mo	Amortized Well (or Pipe) Cost/HH/mo (over 30 yr @ 3%)	Monthly Expenses/HH INCLUDING Capital Cost	Monthly Expenses /HH WITH GRANT for Capital Cost	Nearby Utility Monthly Water Charge (est.)
Average Private Well Installation	$9,987/ well	376 ft		1.5	$2	$11	$28	$41	$13	$68
(1) Ben Hill GA	$81,200	273 ft	10	19	$1	$9	$18	$28	$10	$49
(2) Milledgeville GA	$29,326	423 ft	4	4	$2	$17	$31	$50	$19	$71
(3) Rogers AR	$52,067	484 ft	5	6	$2	$14	$37	$53	$16	$49
(4) Bulverde TX	$17,975	464 ft	1	1	$2	$17	$76	$95	$19	NA
(5) Suffolk VA	$14,667	580 ft	1	1	$3	$17	$62	$82	$20	$117
(6) Well Rehabilitation – Holly Ridge NC	$47,000	300 ft	3	24	$20	$2	$11 (rehabili-tation)	$33	$22	$55
Alternative Regional Waterline (avg.)	$472,068/ mile	2.6 miles		1.5	$787 ***	—	$1,327	$2,114	—	$54****
(1) Ben Hill GA	$600,000	2 miles		19	$79 ***	—	$133	$212	—	$49****
(2) Milledgeville GA	$110,000	0.7 miles		4	$69 ***	—	$116	$185	—	$71****
(3) Rogers AR	$1,200,000	5 miles		6	$500 ***	—	$843	$1,343	—	$49****
(4) Bulverde TX	$84,092	0.6 miles		1	$210 ***	—	$355	$565	—	NA
(5) Suffolk VA	$2,219,448	3.5 miles		1	$5,549***	—	$9,357	$14,906	—	$117
(6) Well Rehab-Holly Ridge NC	3,150,475	3.8 miles		24	$328 ***	—	$553	$881	—	$55****

Sources of data for first four columns: Water Systems Council/Water Well Trust (www.watersystemscouncil.org); additional sources for cases (4), (5) and (6), Xylem/Watermark (www.xylem.com), and for case (5), Chris Long Foundation (www.chrislongfoundation.org), 2018.

NA = Not Available

*1 foot = 0.305 meter; 10 feet = 3.048 meters; 100 feet = 30.48 meters

1 mile = 1.609 kilometers; 5 miles = 8.047 kilometers

**Average household use assumed: 300 gallons/day/household

*** Regional waterline annual operation and maintenance costs are assumed to be 3 percent of capital costs.

**** Same value as corresponding location listed above, repeated for comparison purposes.

Table 2. 2018 Estimated Cost of Alternatives to Address Groundwater with Radium

Alternative	Capital Cost	Average Well Depth or Pipe Length	Number of Wells	Number of Connections	O&M Cost	Amort Cap Cost/mo	O&M Cost/mo.	Total Cost/mo.	Estimated Average Consumer Cost/mo	Est. Avg. Consumer Cost/mo added to 2015 water rate
10-mile Waterline (Selected)	$4,975,000*	10 miles	0	577	$151,000	$17,396*	$12,583	$29,979	$68.55**	$68.55**
Existing Well with Central Radium Treatment (conceptual)	$319,500***	500 ft	5	577	$20,401	$1,331***	$1,700	$3,031	$5.25	$43.92
New Well with Pipe and Central Radium Treatment (conceptual)	$1,156,500	500 ft	6	577	$33,801	$4,819	$2,817	$7,636	$13.23	$51.90
Existing Well with Decentralized (POE) Radium Treatment (conceptual)	$432,000	500 ft	5	577	$91,050	$1,800	$7,588	$9,388	$16.27	$54.94

* East Bend NC financed $4,175,000 over 20 years at 0 percent interest. The remainder of the cost was covered by a grant and local funds.

**$68.55 is the 2020 monthly water charge in East Bend NC for a household using 4,000 gallons per month.

***This and the other alternatives assume a 20-year term and 0 percent financing arrangement are applicable as in the selected 10-mile waterline alternative to resolve the radium levels.

Well Replacement/Rehabilitation Compared to Regional Waterline

Table 1 shows capital costs, amortized capital costs, and monthly operation and maintenance costs per household for both replaced and rehabilitated wells and alternative regional waterlines. These costs vary from place to place and are calculated for each case. The "Average Private Well Installation" is based on the six cases presented in Table 1. A number of points are notable:

For installed wells:

- Average cost per well was $9,987 with an average depth of 376 feet (114.6 meters).
- Wells installed or rehabilitated at each location ranged from 1 to 10 with connections per well ranging from 1 residence to 8 residences or structures.
- Operating costs for wells counted the expense of pumping water through well systems of varying depths with operating costs/ household/month averaging $2 for an average use of 300 gallons/day (1,135 liters/day).
- Average annual well inspection costs per connection (household)/month were $11.
- Amortized well (capital) costs/household/month (over 30 years at 3% interest) ranged from $18 to $76, with an average of $28. These costs were covered by grants that were not to be repaid. These non-repayable capital grant costs might be viewed from the perspective that if the costs were associated with a large water system, spreading the costs across hundreds or thousands of rate payers each month would result in a very small additional expense for any individual water user of the large water system. The unpaid grant spreads the cost across the grant providers. Thus, the focus for the well owner/user in this case study is on the

operating cost per month compared to adjacent public water system charges.

- The average operating cost per household/month is $13 (operating and inspection costs) with a range of $10 to $20. These monthly costs compare to water charges for similar water use at public community water systems nearby of $49 to $117 per month, with an average of $68/month. The average savings to households is $55/month.
- In three of the cases, the sum of the amortized capital cost of the well replacement or rehabilitation (i.e., ignoring the non-repayable grant) plus the operating cost is less expensive at the consumer monthly expense level than the nearby water system charges. In a fourth case (Rogers AR), the monthly consumer well-related expense and the nearby water system charge are within $4 of each other.
- For rehabilitated wells, the average operating cost per household/month is $22, compared to a public water system charge of $55, in this single case.

The second portion of Table 1 shows the costs of regional waterlines from the nearest public water system to supply the households. Key points relative to waterlines include:

- The average distance to reach the households with a regional waterline is 2.6 miles (4.18 km) with an average cost per mile of $472,068 ($293,392/km).
- Considering the waterlines only, the range in cost per household/month, including the amortized capital cost plus operating costs, is $212 to $14,906. This wide range is affected by both distance for a waterline and the number of connections to the waterline.
- The estimated capital costs for regional waterlines to serve the households are 3.75 to 151 times the capital cost of well installation, depending on depth and number of wells to be installed and distance of the waterline to reach the residences.
- In the case of well rehabilitation, the estimated capital cost of a waterline is 67 times more expensive than the capital cost of rehabilitating three wells to serve 24 residences.

The factor of private water system reliability affected by loss of electric power as noted earlier is minimal. If electric power reliability is a local concern, the well owner could purchase an electric generator (e.g., 3 horsepower, 8,000 watt) at an equipment cost of $800 to $1,000[18] with a life span of 3 to 40 years depending on the adequacy of maintenance.[19] Adding the cost of a generator increases capital costs in Table 1 by 1 to 5.5 percent depending on the case example. If deemed necessary for 1-2 electrical outages per year of up to 6 hours, electric generator purchase would add up to $4 per month to costs.

The results of Table 1, while derived from cases and not from representative statistical output, point to local groundwater infrastructure management as being less capital intensive and for operational expenses more cost-effective than regional waterlines. Each situation should be carefully evaluated on its own merits. With adequate information, this outcome encourages focus on local decision making and control of costs. Households and small communities may be fiscally enabled to tailor their water management to their own needs.

Local Groundwater Treatment Compared to Regional Waterline

Table 2 provides a perspective on the cost of local groundwater quality treatment compared to a regional waterline. Local groundwater treatment, in this case for radium, is more cost-effective and efficient than constructing a waterline, although the community chose the waterline in this example. Since 2003, the town of East Bend, North Carolina, has had fluctuating levels of radium in its groundwater-supplied water system. The radium concentration exceeded the U.S. Environmental Protection Agency drinking water maximum contaminant level of 5 pCi/L (combined Ra-226 + Ra-228) on 19 occasions. The level reached 37 pCi/L at one time. The North Carolina Department of Environment and Natural Resources issued numerous violations resulting in closure of the town wells. Yadkin County was developing its regional water system which afforded East Bend the opportunity to support the county's application for a state loan to install a 10-mile waterline from the Yadkin River to the town to replace the wells as the town's water source.

The water service population of East Bend was 1,466 with 577 water service connections that collectively used approximately 60,000 gallons of water per day. The median household income was $39,640 in 2017, which was 33% lower than the North Carolina median household income.[20] East Bend had five town wells. Its wells were completed in Valley and Ridge and Mississippi Limestone containing radium.[21] A regional well drilling

company drilled the last town well to a depth of 487 feet (148.4 meters) and sealed sections of strata penetrated by the well that were considered to be contributing groundwater with radium at 467 feet (142.3 m) and 224 feet (68.3 m). However, radium continued to be present in the pumped water.

East Bend's water supply alternatives evaluated in the loan process were to: do nothing (not acceptable to the state to protect public health); treatment at the wellheads (which the town found infeasible and did not evaluate further); construct a 14-mile (22.5-km) waterline; and construct a 10-mile (16.1-km) waterline. Other conceptual alternatives that the town could have considered but were not evaluated include: central radium treatment, a new well outside the town boundary with central treatment, and point-of-entry/point-of-use devices at each residence.[22] The county chose the 10-mile waterline and the town's household monthly water costs have risen 77 percent (to $68.55/month for a household with average water use of 4,000 gallons/month [15.1 kiloliters/month]) over the 5 years since the decision was made.[23]

The estimated costs of the selected and conceptual alternatives are presented in Table 2. Key points from Table 2 are:

- The conceptual alternatives to the regional waterline have initial capital costs that are from 76 to 94 percent less costly.
- The conceptual alternatives to the regional waterline may operate at 40 to 86 percent less expense.
- Estimated average consumer water charges for the non-waterline alternatives are calculated by adding the monthly amortized capital and operating costs of the treatment alternatives to the 2015 water charges. The estimated monthly non-waterline alternative charges are from 20 to 36 percent less than the current water charges, suggesting that non-waterline alternatives for groundwater treatment should have been given greater consideration in the decision process for addressing groundwater radium concentrations.

The treatment for radium through the conceptual alternatives may provide treatment for other metals in groundwater, possibly reducing the need for continuing some aspects of the treatment process previously used and thereby reducing operating costs. To obtain a better comparison of costs for these alternatives, a detailed engineering evaluation would be needed similar to the evaluation conducted for the regional waterline. The appendix to this report provides additional information regarding the costs included in this analysis. Additionally, using the local groundwater source allows local decision making and cost management. A feasibility study of alternatives may cost from $15,000 to $100,000, depending on complexity and on availability of information. Such a study would help identify the best investment option among alternatives and flag risks and pitfalls.[24] In this case of information being widely available, a less costly feasibility study may provide adequate information as input to the selection and design of a safe community water supply.

Environmental Considerations

While not evaluated for any alternative, physical environmental factors may also affect decisions in supplying water. Greenhouse gas emissions for the production of well casing and pipe[25] for waterlines and their installation should be considered locally and regionally. The production of 300 to 500 feet (91.4 to 152.4 m) of 4- to 8-inch (10.2- to 20.3-cm)-diameter well casing should have proportionately less GHG emissions than the production of 10,000 to 50,000 feet of 8-inch-diameter regional waterline transmission pipe. Likewise, installation of well casing should have proportionately less GHG emissions than installation of a 2.6-mile (4.2-km) regional waterline, the average of the six earlier cases, and of a 10-mile (16.1-km) waterline, the pipeline distance in the seventh case.

A national assessment of water loss from municipal waterlines found that the average loss is 16%,[26] as noted previously. Water lost from municipal waterlines increases operating and maintenance costs. Pumping additional water to make up for lost water adds to GHG emissions along with increasing costs to consumers. Other costs include expenses to find and repair waterline leaks.

Each case should be evaluated individually to determine whether local groundwater production infrastructure for water supply will be more environmentally friendly than long-distance waterline infrastructure, including environmental assessment of operating conditions for each case.

Conclusion

Addressing local groundwater supply reliability and quality through wells or treatment at or near the groundwater source is less costly than installing a regional waterline for long-distance water supply for the cases considered. All reasonable alternatives should be investigated, including decentralized technologies. Each situation should be evaluated on its own basis, as circumstances vary among locations. Less dependence on imported water from distant sources offers the opportunity to maintain lower operational costs.[27] Regional waterline infrastructure is expensive compared to local groundwater supply to meet small community water needs, even when water

quality treatment is involved as in the case examined. The other cases cited also support local groundwater solutions as cost-effective and efficient actions for individual household and small community water supply rather than regional waterlines. Local decentralized groundwater solutions for water supply needs save resources that may be used to assist households and other small communities with their water infrastructure needs. Local groundwater infrastructure will likely have less environmental degradation from greenhouse gas generation than regional waterline infrastructure. Household and local water system control of water supply decisions enable management of infrastructure tailored to local needs for safe, efficient water delivery.

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Appendix

Information on Costs of Water Supply Alternatives

TABLE 1. Initial Capital Costs of Water Well Supply Compared to Regional Waterline Supply[a, b]

Percent Avoided Capital Cost Savings with Distributed Wells	Date	Location	Need	Central Supply Option	Well Option	Financing Sources
86%	July 2014	Ben Hill County, Georgia	17 homes and 2 churches: require safe reliable water source	Provide central transmission and distribution lines totaling 2+ miles Cost: $600,000	Drill 10 private wells to depths of 245 to 300 feet Cost: $81,200	Water Well Trust: $51,200* Ben Hill Co, GA: $30,000 *(incl. NGWA grant: $10,000)
73%	November 2015	Milledgeville and Gray, Georgia	4 homes: require safe reliable water source	Provide central transmission and distribution lines totaling 3,700 feet Cost: $110,000	Drill 4 private wells to depths of 370 to 485 feet Cost: $29,356	Water Well Trust: $14,226 HUD Comm. Dev. Blk. Grant: $15,090 (loan)
94%	June 2012	Rogers, Arkansas	6 homes without safe reliable water souce	Provide central transmission and distribution lines totaling 5+ miles Cost: $1,200,000	Drill 5 private wells to depths of 351 to 618 feet Cost: $52,067	Water Well Trust: $17,843 Loan: $34,224
99%[c]	June 2018	Holly Ridge Development (near Asheville), North Carolina	24 homes need reliable safe water supply	Provide central transmission and distribution lines totaling 2.4 miles; Initial Capital Cost: $3,189,000; O&M $12,960/yr	Rehabilitate 3 private wells (~300 ft deep), well houses, pumps and wiring; Initial Capital Cost: $47,000; O&M $5,760/yr	Water Well Trust: $24,025 Xylem/Watermark $23,336
79%	July 2019	Bulverde, Texas	Family needs reliable safe water supply	Provide central transmission and distribution lines totaling 3115 feet Cost: $ 84,092	Install new well (464 ft deep) Cost: $17,975	Water Well Trust: $6263 Xylem/ Watermark: $9712
99%	February 2020	Suffolk, VA	Home of family of seven needs reliable safe water supply	Provide central transmission and distribution lines totaling 3.5 miles Cost: $ 2,219,448	Install new well (580 ft deep) Cost: $14,667	Water Well Trust: $8467 Chris Long Foundation: $6200

Source of data: Water Systems Council/Water Well Trust (www.watersystemscouncil.org), Xylem/Watermark [a] (www.xylem.com), and Chris Long Foundation (www.chrislongfoundation.org).

[b] The capital costs are the first investment costs and not life-cycle costs for infrastructure.

Note: 56% O&M cost savings of water well supply compared to regional pipeline supply calculated for this case and documented below.

TABLE 2. Holly Ridge Groundwater Supply Wells Rehabilitation Costs (2018$US)

Existing Well and Control System Rehabilitation	**Cost [28]**
Materials for rehabilitation: pumps, tanks, controls, wire	$15,618.00
Well contractor	$24,025.00
Well house debris removal	$951.00
Well house materials	$3,767.00
Well house contractor	$3,000.00
Total	$47,361.00

TABLE 3. Capital Costs to Install Public Waterline from Candler to Holly Ridge, North Carolina (2018$US)

Public Waterline and Hookup Alternative	**Cost[29]**
8" main 3000' from Pisgah Hwy. to entrance to Holly Ridge @ $125 per foot	$375,000.00
8" main 9,925' from entrance to Holly Ridge to homes	$1,240,625.00
Meters for 24 households at $1,589 each	$38,136.00
New pump station and tank to service higher elevation homes*	$1,250,000.00
Engineering fees for new pump station (20%)	$250,000.00
Plumbing connections to homes - 6,970' at $5 per foot	$34,850.00
Total Capital Cost	$3,188,611.00

TABLE 4. Continuing Annual Operation & Maintenance Costs at Holly Ridge NC

Existing System with Rehabilitation		
24 homeowners fees @ $20/household/month		$ 480/month
(Covers electricity and maintenance)		
	Annualized	$5,760/year
Alternative Waterline (avg. household size in Buncombe Co. = 3.1 persons/family)		
24 residences @ $45/household/month for water charges		$1,080/month
[Waterline Maintenance (@ 3% of capital cost)		$7,971/month]
(assumed to be included in water charge)		
	Annualized	$12,960/year

TABLE 5. Life-Cycle Capital Costs over 30-year Planning Horizon at Holly Ridge NC

Existing System Costs	**Cost 2018**	**Discounted Cost**
- Rehab/pump replacement at 15 years	$47,361.00	$30,399.00
- Rehab/pump replacement at 30 years	$47,361.00	$19,512.00
Total Future Discounted Costs @ 3%		$49,911.00

Alternative Public Waterline Costs	**Cost 2018**	**Discounted Cost**
- Replace water meters at 15 years	$38,136.00	$24,478.00
- Replace water meters at 30 years	$38, 136.00	$15,711.00
Total Future Discounted Costs @ 3%		$40,189.00

TABLE 6. Life-Cycle Comparison of Existing GW System Rehabilitation and Alternative Waterline Capital Costs

Existing GW System Rehabilitation

Capital Costs (2018)	$47,361.00
Rehabilitation at 15 years	$30,399.00
Rehabilitation at 30 years	$19,512.00
Total 30-year Capital Life-Cycle Cost	$97,272.00

Life-cycle capital cost per household is $4,053.

Alternative Public Waterline

Capital Costs (2018)	$3,188,611.00
Meter Replacement at 15 years	$24,478.00
Meter Replacement at 30 years	$15,711.00
Total 30-year Capital Life-Cycle Cost	$3,228,800.00

Life-cycle capital cost per household is $134,533.

TABLE 7. Household Costs and Savings for Holly Ridge Groundwater Supply

	Alternatives	
	3-Wells Rehabilitation	**Municipal Water Pipeline**
Capital Cost	$47,361	$3,189,000
Monthly Household (HH) Costs		
Amortized Monthly Capital Cost @ 3% over 30 years	$8.33*	$0.23**
Monthly Delivered Water Cost/HH	$20.00***	$50.65
Monthly Capital Improvement Fee/HH	$0	$4.26
Total Monthly Cost/Household	$28.33	$55.14
Monthly Savings/Household	$26.81	$0

* Do not include this amount if considering that grants for capital costs are not repaid.

** Monthly cost spread across and allocated to each of 58,084 households (estimated) in water rate base service area benefiting from the municipal water system; total amortized (at 3 percent over 30 years) monthly capital cost is $13,445.

*** Note: The cost per household (assuming 300 gallons [1,136 liters] is used per day per household, the U.S. national average family water use) to pump water from a 300-foot-deep well is $0.48 per day or $14.40/month.

TABLE 8. East Bend NC Alternatives – Capital and O&M Costs

Selected Alternative	**Capital Cost**	**1st-Yr O&M Cost**
Pipeline 1–10 miles	$4,975,000	$151,000 [31]
Conceptual Alternatives	**Capital Cost**	**1st-Yr O&M Cost**
Pipeline 2–14 miles	$6,425,000	$174,000 [32]
Existing Well with Central Radium Treatment	$319,500	$20,401
New Well with Pipe and Central Radium Treatment	$1,156,500	$38,730
Existing Well with Decentralized (POE) Radium Treatment	$432,000	$91,050

Assumptions for TABLE 8 are:

(1) All major capital and operation and maintenance costs for the conceptual non-pipeline alternatives have been identified.
(2) The State loan fund (the NC Drinking Water State Revolving Fund) will provide the same financing terms for the conceptual alternatives as it did for the selected pipeline alternative: 20 years at 0 percent.
(3) The 20-year project horizon of the selected alternative can be applied to the conceptual alternatives.
(4) The O&M costs will not increase over the 20-year project horizon.
(5) In calculating the estimated monthly cost to the consumer, the cost can be spread across all 413 water users (361 water users are residential with the remainder being commercial or institutional water users).

TABLE 9. Cost of Conceptual Alternatives for Radium Treatment at East Bend NC

Existing Well with Central Radium Treatment

Capital Cost		
Well Cost		$0
Water Softening (Fe, Mn, Ra)		$300,000
Central Treatment [33]		
20-40-yr life		
Building [34]		$19,500
	Total	$319,500
O&M Costs - Annual		
Water Quality Testing [35] (1/mo)		$16,800
Resin [36] with automated flow (1/3 cost per yr)		$267
LLRW Disposal [37,38] (1/3 cost per yr)		$1,667
LLRW Transport [39,40] (1/3 cost per year)		$1,667
	Total	$20,401

New Well with Pipe and Central Radium Treatment

Capital Costs	
Hydrogeologic Investigation [41]	$100,000
Well Cost (500 feet, bedrock) [42]	$50,000
Water Softening (Fe, Mn, Ra)	$300,000
Central Treatment [43]	
20-40-yr life	
Building [44]	$19,500
Pipe (1-mile) ($130/ft) [45]	$687,000
25-yr life	
Total	$1,156,500
O&M Costs – Annual	
Water Quality Testing [46] (1/mo)	$16,800
Resin [47] with automated flow	$267
LLRW Disposal [48]	$1,667
LLRW Transport [49]	$1,667
Pipe Maintenance (5% of cap$)	$1,400
Pumping Cost [50]	$12,000
Total	$33,801

Existing Well with Decentralized (POE) Radium Treatment

Capital Costs	
Well Cost	$0
POE Units (Cation Exchange) [51]	$432,000
10-yr life	
360 residential connects	
Total	$432,000
O&M – Annual	
Labor, Resin Repl, Disposal [52]	$68,400
Radium Sample Test ($170/yr) [53]	$20,400
1/3 sampled/yr	
Radium sample labor ($35/hr) [54]	$1,050
0.25 hr/sample	
Radium Sample Shipping ($10ea) [55]	$1,200
Total	$91,050

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