# ADVANCING POLE ATTACHMENT POLICIES TO ACCELERATE NATIONAL BROADBAND BUILDOUT

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CONNECT THE FUTURE

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## EXECUTIVE SUMMARY

Between 14 to 42 million Americans currently lack access to high-speed broadband. In this study, we estimate that expanding broadband access to this unserved population would create anywhere from $83 billion to $314 billion of new economic gains to America's homes and small businesses. This estimated gain represents the social return on new public and private sector investments, namely the productive, commercial, educational, health, and other benefits that stand to be realized by achieving full broadband expansion in America.

Today, broadband deployment is being inhibited or outright stopped due to the lack of effective pole policy to address problematic behavior of certain utility pole owners affecting broadband provider access to utility poles. Specifically, pole owners frequently deny or delay broadband providers pole attachment access, or impose economically unfeasible rates, terms, and conditions that impose excessive costs on broadband providers associated with pole replacement and upkeep. In economics this is known as the *hold up problem*[1], an inefficient concentration of *market power* that harms the *public interest*.

When pole owners hold up the process, the result is foregone economic gains to Americans. In this study, we estimate that every month of delayed expansion due to pole owner hold up costs Americans between $491 million and $1.86 billion.

Utility poles represent a critical input in broadband deployment, as attachment to existing pole networks is the most efficient means to expand high-speed broadband access to currently unserved areas of the country. Policymakers should initiate measures now to recapture this economic value by revising and modifying state and federal pole policies to mitigate pole owner *market power* in order to facilitate broadband deployment.

> Pole Owner
> Hold Up
> Costs Americans
> **$491M – $1.86B**
> *every month*
> it delays expansion.

# INTRODUCTION AND OVERVIEW

Too many American homes and small businesses still lack access to reliable, high-speed, low-latency internet connections. While recent private and public investments at the national, state, and local levels are playing a significant role in helping to bridge America's digital divide, policies to remove remaining barriers to infrastructure deployment are now needed to maximize the social return on public and private broadband investments.[2] In this paper, we demonstrate that the economic gains to full broadband expansion are quite substantial, yet state and federal policies governing pole attachment processes require modification before the digital divide can be fully bridged and those economic gains realized. (See below Appendix A, *Elements of a Model Pole Policy*, for details of these required modifications.)

According to the Federal Communications Commission (FCC), more than 14 million Americans still lack access to reliable, high-speed, low-latency broadband, including nearly 20% of rural households (FCC 2021). An estimate by BroadbandNow suggests that over 42 million Americans still lack access.[3] In this paper, we estimate that connecting these currently unserved populations would create as much as $314 billion of new economic gains to America's homes and small businesses, calculated as additional *willingness-to-pay* (WTP) in net present value over 25 years, or the lower end of average utility pole life, at 5% discount rate.[4] This estimated economic gain represents the potential return on private and public broadband investments, namely the productive, commercial, educational, health, civic, and other social benefits that could be realized by achieving full broadband expansion.

To achieve these economic and social gains requires cost efficient and timely attachment of broadband wires to existing utility pole networks. Deployment of broadband networks into unserved rural areas of the country requires attachment of broadband infrastructure to thousands and thousands of poles. Placement of broadband infrastructure underground isn't feasible or cost efficient in most unserved areas of the country.

Existing pole policies across the country, however, allow electric utility pole owners – i.e., investor-owned electric utilities ("IOUs"), as well as municipal and cooperatively owned utilities ("Muni and Coop") – to exercise significant market power over pole attachment rates, terms, and conditions. Pole owners frequently impose onerous timetables, unfeasible permitting fees, and various pre- and post-construction requirements, including full pole replacements ahead of scheduled replacement, as part of "make-ready" procedures required prior to the actual attachment to the pole. Pole owners sometimes limit the number of pole-attachment applications considered at any given time, and certain pole owners have refused to consider any applications at all. Furthermore, increasing numbers of Muni and Coop owners have themselves become market participants in providing broadband service (Beard et al. 2021).

In the study of economics, this form of market power is known as the *hold up problem*, and it causes delayed or foregone expansion of broadband to currently unserved populations. This inefficient and inequitable advantage, in the absence of effective pole policies, enables certain pole owners to impose economically unfeasible rates, terms, and conditions that harm the *public interest* by holding up broadband deployment. We estimate that every month of delayed expansion due to pole owner market power costs Americans between $491 million and $1.86 billion in foregone economic gain, known in economics as *deadweight loss* (DWL).[5] The economic methodology for this study was initially developed in an earlier paper that focused on North Carolina.[6] That study calculated economic gains that would be realized with full broadband expansion in North Carolina under just one federal program, the Rural Development Opportunity Fund (RDOF), which launched in February, 2020, with a total $20 billion of rural broadband investment across the country.[7]

The need for a nationwide examination is now all the more relevant given the recent passage of the Infrastructure Investment and Jobs Act of 2021 ("IIJA") and its massive $42 billion commitment to broadband buildout across all 50 states. When combined with federal and state funding already in the pipeline as part of the recent COVID-19 relief packages, the government funding commitment to deploy broadband in all 50 states is unprecedented. Therefore, in this study we enhance and expand the analysis beyond North Carolina and the funding being supplied by RDOF. Results in this paper include estimates of economic gain of full broadband expansion for all 50 States, while also including a more granular analysis for five focus states (Florida, Kentucky, Missouri, Texas, and Wisconsin).

The analysis in this paper concludes that if the economic gains from broadband deployment are to be fully realized, policymakers need to facilitate the streamlining of equitable access and cost-sharing arrangements between broadband attachers and pole owners. These improved arrangements, among others, would factor the age and net book value of replaced poles, thus eliminating a common barrier in which broadband providers are too often inequitably (and contrary to sound economic policy) required by pole owners to bear the full monetary burden of pole replacements ahead of scheduled replacement. These and other key elements of a model pole policy that best promote broadband expansion are presented in Appendix A.

This barrier to full broadband expansion arises because in most instances the only practical and economically feasible means for a broadband provider to connect its service to a household or small business location is to attach its wires to the existing network of utility poles. Building underground is unrealistic given the prohibitively higher costs as compared to aerial installations along with the host of other practical, environmental, and topographical barriers associated with underground construction. And the notion that broadband providers could build their own standalone pole networks would not only be a waste of social resources and aesthetically undesirable, in many if not most instances would be effectively prohibited under zoning rules, environmental regulations and other laws and ordinances.

## CRITICAL BACKGROUND AND METHODOLOGY

In this paper, we expand and enhance our earlier analysis for North Carolina.[8] First, we expand our calculations beyond RDOF and to all 50 states. Nationally, RDOF auction participants were awarded over $9 billion to connect 5.22 million locations, or approximately 2 million people.[9] Yet, RDOF is a relatively small program compared to the FCC's estimated 14 million households currently unserved by broadband, and especially small relative to BroadbandNow's estimate of over 42 million unserved, and in the context of the IIJA's $42 billion commitment to broadband infrastructure. Therefore, in this paper we also report the estimated consumer gains if all FCC and BroadbandNow unserved populations become connected.[10]

Second, our North Carolina study focused only on the benefits of improved bandwidth speeds, whereas in this paper we also account for latency improvements being rolled out under current deployments. Bandwidth speed measures the megabits/gigabits of data that a connection can transmit per second (Mbps). Latency measures the milliseconds (Ms) it takes for a connection to transport a data packet between a user's computer and other servers elsewhere on the network. Greater latency degrades a customer's service quality and broadband experience. Appendix D below explains how economists have estimated consumers' WTP for both speed and latency, and how we use those empirical estimates in our calculations of aggregate economic gains.

Our underlying computation methodology begins with a representative household's estimated WTP for broadband, as provided by the Liu, Yu-Hsin, Jeffrey Price and Scott Wallsten (2018). Expressed in layman's terms, WTP is the highest price that a representative household would pay to improve from a slow mobile connection to a fixed connection at higher speeds. WTP therefore represents a dollarized measure of the value to that representative household of broadband's productive, commercial, social, educational, entertainment, health, civic and other benefits, to that household. For example, the representative household is willing to pay $111.08 per month to improve from a Mobile 4/1 Mbps connection at 60-150 Ms latency, to a Fixed 1000/100 Mbps connection at less than 10 Ms.[11]

Next, we aggregate from the household to the societal level by multiplying that monthly WTP by the number of locations becoming connected. In the case of RDOF, for example, if all 5.22 million locations become connected, that would yield an aggregate $579 million per month of new WTP. Next, we simply annualize the computed monthly gains, and then compute the annualized gains in terms of net present value over 25 years at an assumed 5% discount rate.[12] Tables 1 and 2, discussed in the next section, present the results utilizing this method.

As explained in full detail in our earlier paper, economic theory classifies utility poles as a textbook example of a *natural monopoly*, meaning that a single network of poles can supply access to all locations in an area at a lower cost to society than two or more sets of poles can. Given the construction of a network of poles, pole attachments are *non-rival in use* to a degree. For these reasons, economic theory stipulates that efficient pricing of pole attachments—including economically feasible make-ready rates, terms, and conditions—promotes full broadband expansion by resolving the *hold up problem*. This is because pricing practices consistent with economic principles create real-world conditions that facilitate the timely access to high-speed, quality broadband services for consumers in unserved and typically higher-cost and hard-to-reach areas.

On the other hand, the unchecked exercise of market power by pole owners (IOUs, as well as Muni & Coop) enabled by the lack of consistent, efficient pole policies, will continue to impede this important *public interest* goal. This exercise of market power includes the practice of shifting to broadband providers the total cost of new poles, even in cases when pole owners did not otherwise plan to replace poles in their course of operations. Economic theory therefore classifies *hold up problems* as socially harmful concentrations of market power that result in sizeable lost consumer value and reduction in societal welfare, including delayed or denied broadband expansion to unserved communities.

## FINDINGS AND ANALYSIS

### TABLE #1:
### ECONOMIC GAINS IF ALL CURRENTLY UNSERVED POPULATION ACHIEVES BROADBAND ACCESS

| | All Unserved RDOF Locations Gain Access | All FCC Unserved Population Gains Access | All BroadbandNow Unserved Population Gains Access |
|---|---|---|---|
| 150/25 Mbps at <10 Ms | $82.96B | $88.71B | $265.56B |
| 300/100 Mbps at <10 Ms | $91.90B | $98.27B | $294.17B |
| 1000/100 Mbps at <10 Ms | $98.07B | $104.87B | $313.92B |

*Note: Table entries equal net present value of annualized gains over 25 years at 5% discount rate.*

In Tables 1 above and 2 below, we present our main nationwide findings. Table 1 reports aggregate economic gains for three speed and latency thresholds under three sets of assumptions. The selected speed and latency thresholds are comparable to existing broadband service plan offerings rolling out at the time of this writing. The estimates in Table 1 represent a range of possibilities. For example, if all currently unserved locations assigned for deployment under RDOF get connected at 1000/100 Mbps and <10 Ms, this would create $98.07 billion of new economic gains nationwide. But if all 14 million persons estimated by the FCC that lack broadband get similarly connected, that gain would be $104.87 billion. And connecting all 42 million unserved persons as estimated by BroadbandNow would yield $313.92 billion. These calculations are net present value over 25 years, or the lower end of average pole life, at 5% discount rate.

Focusing on Table 2 below, this same computation methodology demonstrates the foregone economic gains, known in economics as *deadweight loss*, due to the pole owner *hold up problem*. As our previous analysis demonstrated, the identified losses in the form of potential foregone consumer value welfare from the delay or unavailability in broadband access, are also quite substantial. As shown in Table 2, aggregated across the fifty states, we compute the magnitude of potential losses to be in the range of $491 million to $1.86 billion per month of delay.

In Appendix D below, we present alternative estimates for different sets of assumptions. And in the state-specific modules below, we report the state-specific estimates equivalent to Table 1 and 2 for our five focus states.

TABLE #2:

## MONTHLY FOREGONE ECONOMIC GAINS (DEADWEIGHT LOSSES) DUE TO POLE ATTACHMENT HOLD UP

| | All RDOF Locations Gain Access | All FCC Estimated Population Gains Access | All BroadbandNow Estimated Population Gains Access |
|---|---|---|---|
| 150/25 Mbps at <10 Ms | $0.491B | $0.524B | $1.57B |
| 300/100 Mbps at <10 Ms | $0.543B | $0.581B | $1.74B |
| 1000/100 Mbps at <10 Ms | $0.579B | $0.620B | $1.86B |

*Note: Table entries are monthly aggregate foregone economic gains.*

We emphasize that these national and state-specific estimates are conservative in magnitude because the underlying WTP estimates do not reflect higher broadband demand since COVID-19 or the higher broadband speeds scheduled for deployment under ongoing expansion plans. As cited in Lopez and Kravtin 2021, the Broadband Internet Technical Advisory Group reports that upload demand rose by 60% from March to December 2020, and the RDOF program was structured to incentivize deployment at high speeds including 1000 Mbps download (BITAG 2021). For these reasons, the true economic gains nationwide of full broadband expansion are likely exceed the estimates shown in Table 1 above.

The magnitude of total consumer value that could be realized with unimpeded access to utility poles by broadband providers highlights the potential magnitude of the public's return on its broadband investment that would be made possible if policies aimed at the hold up power of pole owners were implemented and the full range of productive, commercial, educational, health, civic, and other social benefits widely associated with full broadband expansion could be achieved. The next section of the paper further explores the policy implications and prescriptions for full broadband expansion introduced in our earlier paper.

## POLICY IMPLICATIONS AND PRESCRIPTIONS

As described in Lopez and Kravtin 2021, there are a number of key reasons for the current disconnect between existing utility pole practices, especially those involving pole replacement as part of the make-ready process, and those aligned with economic principles that best promote the *public interest*. These include the economic reality that pole owners, regardless of whether the pole is actually identified by the utility as needing replacement, enjoy operational, strategic, revenue-enhancing, capital cost, and tax savings benefits from pole replacements.[13]

When attachers such as broadband providers are forced to bear 100% of the cost responsibility of replacing partially depreciated utility poles, it results in fewer or delayed broadband infrastructure investments and reduced service availability to the great detriment of unserved areas throughout the nation. This practice disincentivizes broadband deployment for attachers and gifts the utility a significant, windfall economic benefit to the detriment of consumers and the broader economy as a whole.

To ensure consumers benefit from broadband services in a timely and equitable manner, and the economy enjoys as much growth and development gains as possible, public policy should expressly prohibit utilities from requiring an attacher to pay the full replacement cost of a prematurely retired pole, and instead adopt regulations that promote a more economically optimal and equitable approach — e.g., by making attachers only responsible for the remaining un-depreciated value of the replaced pole. In addition, pole owners should be prohibited from exercising hold up power by imposing unreasonable timelines and/or engaging in delay tactics. This approach would avoid the imposition of substantial and unreasonable costs on pole attachers and would ultimately benefit the country's existing—and new—consumers of high-speed broadband services in the form of cost-efficient broadband connectivity.

Pole owners historically have enjoyed unilateral control of most aspects of the make-ready process. Indeed, opportunities exist for pole owners to exert hold up power by raising the expected stream of ongoing costs incurred by broadband providers through the recurring pole attachment rental rates that pole owners charge attachers—even in jurisdictions that have adopted effective recurring pole rate regulation for cooperative and municipal pole owning utilities such as North Carolina, the subject of our earlier paper, or in Kentucky, one of the states we examine in more detail in our current analysis. For example, pole owners can harm the *public interest* by failing to give proper written notice of recurring pole attachment rate increases, thereby diminishing or entirely precluding the attacher from effectively challenging the increase and the right to a just and reasonable rate.

## CONCLUSION AND KEY TAKEAWAYS

Pole owner behaviors and the set of unjust and unreasonable make-ready rates, terms and conditions imposed on broadband providers create substantial lost economic gains for residents and small businesses, especially those in hard-to-reach rural unserved areas. Allowing these behaviors to go unchecked is contrary to any reasonable notion of the economic *public interest*. As federal and state resources are increasingly used to support broadband expansion into unserved areas, the *public interest* in supporting a cost-efficient and timely pole attachment process is only heightened. Some believe that the fair outcome is to allow pole owners, especially the smaller local ones, to charge broadband providers higher fees for access to a vital input necessary to reach American consumers. However, as demonstrated in the analysis presented here, this is a much more harmful outcome from an objective overall societal welfare standpoint, because it reduces or delays consumer access to broadband service, resulting in substantial lost value to consumers.

In the context of achieving full broadband access for residents and small businesses in unserved areas, both theoretical economics and common sense align to create a pressing and justified *public interest* case for policy makers to check the *market power* of pole owners by adopting consistent, efficient policies for poles, including fair and equitable policies around make-ready and pole replacement cost sharing.[14] A number of such legislative and regulatory initiatives are underway across the country, but the ability of pole owning utilities to hold up broadband expansion is going largely unchecked. One of the first of such legislative initiatives enacted to date is Texas HB 1505, passed by the Texas legislature in the spring of this year. The Texas law, further detailed in the Texas chapter of this paper, incorporates a number of the key elements of a model pole policy presented in Appendix A below required to mitigate pole owner impediments to full broadband expansion.

There are always tradeoffs to consider in economics and public policy. Given the pressing need to close the digital divide, there is greater risk to consumers from the current inefficient make-ready and pole replacement cost allocation practices than there is from enacting rules and policies that may have the byproduct of reducing nominal flows of monies to pole owners. This is especially the case in unserved areas as those customers stand to gain substantially as potential users of high-quality broadband, including the impact of full broadband access on economic growth and job creation throughout all areas of our nation.

## APPENDICES

A. ELEMENTS OF A MODEL POLE POLICY

B. GLOSSARY OF TECHNICAL TERMS

C. LISTS OF WORKS CITED

D. EMPIRICAL METHODOLOGY AND COMPLETE RESULTS: BASELINE/ALTERNATIVE ASSUMPTIONS

## APPENDIX A: ELEMENTS OF A MODEL POLE POLICY

Two foundational principles necessary for the success of broadband deployment in unserved areas are: 1) changing the cost equation for the intermediate pole input in order to encourage infrastructure investment in hard-to-reach areas of the country; and 2) the removal of other regulatory or market impediments to the vital pole input that might jeopardize the cost-efficient nature of that infrastructure investment and deployment. These two principles are at the forefront of the effort to achieve full broadband access in unserved rural areas of our country. The first policy priority is being addressed by federal and state programs that seek to support the cost-efficient deployment of broadband in hard to serve areas of the country; however, the second priority requires additional policies, including policies to ensure an economically efficient and fair cost allocation of pole costs that would help to moderate a pole owners' ability to exercise anti-competitive, anti-consumer market power in an otherwise competitive ecosystem.

Key elements of urgently needed broadband deployment promoting policies include:

- Creation of a pole replacement fund or grant program to promote the efficient use of available state and federal infrastructure funding dollars in support of the buildout of utility pole infrastructure into unserved areas, and in conjunction, ensure pole owners provide nondiscriminatory, just and reasonable non-recurring and recurring rates, terms, and conditions of access to broadband providers (consistent with those detailed below);
- Definitions for make-ready related pole replacements that distinguish make-ready pole replacements from those related to the utility's own inevitable electric (or broadband related) infrastructure upgrade costs;
- Terms that require the pole owner to pay the entire cost of pole replacement when due to safety or reliability as a result of normal wear and tear or other natural causes; or the pole has recorded conditions or defects that would reasonably be expected to endanger human life or property and which should be promptly corrected (whether or not officially "red tagged" for replacement);
- Terms that provide for the economically efficient and equitable sharing of costs of pole replacements tied to the age and/or net book value of the utility poles to be replaced that would preclude, as precondition of access, new attachers from having to bear the full cost of replacing aging poles. This would preclude the utility seeking from attachers the full recovery of poles that the utility would have to replace at its own cost in the near future in the absence of the new attachment or overlash;
- Terms that prevent the utility from seeking any cost recovery from attachers associated with pole replacements unrelated to the need to accommodate a new attachment terms that facilitate the efficient use of federal and state grant funding;

- Detailed make-ready related invoices;
- Specify workable time frames for pole permit application, survey timeframes, pre- and post- construction requirements;
- Shorter timelines for make-ready work;
- Longer timelines for assessing new attacher One Touch Make-Ready ("OTMR") requests versus existing attachers whose facilities are slated for OTMR;
- Audit process and costs;
- Reasonable notice-only policy for overlashing;
- Terms that preclude as precondition of access prior to overlashing, requirement for permitting or fixing of preexisting violations;
- Expedited dispute resolution under the auspices of the state utility commission or through the courts subject to applicable law;
- Charges for non-recurring charges, including pole replacement, must be based on actual, reasonable costs, objectively determined (i.e., based on accepted economic cost allocation criteria); and
- Recurring rental rates set based on the widely used FCC cable rate formula.

## APPENDIX B: GLOSSARY OF TECHNICAL TERMS

*Barriers to Entry* – "Factors that increase the cost to new firms of entering an industry" (Cowen & Tabarrok 2021)

*Deadweight Loss* – "the reduction in total [consumer] surplus caused by a market distortion or inefficiency" (Cowen & Tabarrok 2021)
Example: If a household would gain $100 of WTP, but it remains unconnected because of the hold up problem, then the deadweight loss is equal to the foregone economic gain of $100.

*Economic Efficiency* – "Productive efficiency concerns the utilization of resources to achieve the highest possible level of production of a desired mix of goods and services [and] distribution of goods and services in an economy to maximize social welfare." (Cole & Grossman 2005, p.10)

*Hold Up Problem* – the use of market power "to extract by a threat to destroy value" that impedes other's ongoing investments (Cooter & Uhlen 2004, p.271)

*Natural Monopoly* – "a situation when a single firm can supply the entire market at a lower cost than two or more firms" (Cowen & Tabarrok 2021)

*Non-Rival in Use* – "when one person's consumption of the good does not limit another person's consumption" (Cowen & Tabarrok 2021)

*Public Interest* – "the efficient quantity is the quantity that maximizes social surplus" (Cowen & Tabarrok 2021)

*Willingness-to-Pay (WTP)* – "the economic value of something is how much someone is willing to pay for it" (Posner 1992, p.12). Also, "the maximum price a consumer will pay for a good; also called the reservation price" (Mateer & Coppock 2020, p.152)
Example: If a currently unserved household was willing to pay $100 to improve from a low-quality connection at slow speeds to a high-quality broadband connection at high speeds, then we say that the household values this broadband improvement as much as it values $100 of other goods & services.

## APPENDIX C: LIST OF WORKS CITED


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# APPENDIX D: EMPIRICAL METHODOLOGY AND COMPLETE RESULTS: BASELINE/ALTERNATIVE ASSUMPTIONS

The estimates presented in this paper are based on the methodology developed in our earlier paper, Lopez and Kravtin 2021. In Appendix B of that earlier paper, we provide full details on the method underlying the computations in this paper, specifically how we calculate economic gains of broadband expansion as aggregate *willingness-to-pay* (WTP), which is a standard textbook measurement tool in economic theory.

Our calculations in this paper begin with a representative household's monthly WTP for broadband access. The source of our underlying WTP estimates is the peer-reviewed study by Liu, Prince, and Wallsten 2018. The authors employ a discrete choice experimental design to elicit consumers' responses to various broadband price and plan options. The experimental design collects responses in a survey format that is designed to simulate the myriad of realistic choices and possible combinations of actual, realistic options of household and small business internet plans.

From the survey results, the authors utilize conditional logit maximum likelihood estimation to derive econometric estimates of a typical household's WTP for broadband access. Specifically, the authors estimate WTP at various speed thresholds and for various improvements in latency. Table D1 below reproduces select estimates from the Liu et al. study. The dollar amounts in this table represent the amount that a representative household is willing to pay for download speed, upload speed, and latency improvements, relative to a Mobile 5/1 connection. Our methodology adapts these estimates from the Liu et al. study to calculate statewide aggregate figures.

## TABLE D1:
## SELECT WILLINGNESS-TO-PAY ESTIMATES FROM LIU, PRINCE, AND WALLSTEN

| Download Speeds | Estimated WTP for Improvement from 4 Mbps Down |
|---|---|
| 150 Mbps | $71.37 |
| 300 Mbps | $75.60 |
| 1000 Mbps | $82.59 |

| Upload Speeds | Estimated WTP for Improvement from 1 Mbps Up |
|---|---|
| 25 Mbps | $18.57 |
| 100 Mbps | $24.46 |

| Latency Improvements | Estimated WTP for Improvement to Less than 10 Ms |
|---|---|
| From 60-150 Ms | $4.03 |

Table D2 below reports our calculations of WTP for three speed thresholds and improvement from 60-150 Ms to less than 10 Ms latency. For example, our calculation of $93.97 combines the Liu et al. estimated WTP of $71.37 for 150 Mbps download, plus the separately estimated $18.57 for 25 Mbps upload speed, plus the separately estimated $4.03 for improvement to <10 Ms, yielding a combined WTP of $93.97 = $71.37 + $18.57 + $4.03. The other estimates of monthly WTP in Table D2 below are calculated the same way.

TABLE D2:
**SPEED AND LATENCY THRESHOLDS UTILIZED IN THIS PAPER**

| | Speeds (download/ upload) | Household Monthly WTP for Improved Speed and Latency | Household Monthly WTP for Improved Speed Only |
|---|---|---|---|
| 150/25 Mbps | 105/25 Mbps | $93.97 | $89.94 |
| 300/100 Mbps | 300/100 Mbps | $104.09 | $100.06 |
| 1000/100 Mbps | 1000/100 Mbps | $111.08 | $107.05 |

Continuing from the monthly gains estimates in Table D2, we next multiply by 12 to calculate the annualized estimated gain to a typical household. We then multiply the household annualized gain by the number of locations in a state to arrive at annualized aggregate economic gain for that state. Finally, we calculate the net present value of annualized gains over 25 years at an assumed 5% discount rate. For complete details about this computation methodology, see Appendix B of Lopez and Kravtin 2021.

Converting from population to number of locations requires a further assumption in our FCC and BroadbandNow estimates. Both sources, the FCC and BroadbandNow estimates, are provided in terms of unserved *population*. To convert from population to locations, we use the U.S. Census Bureau's American Community Survey, average persons per household 2014-2018 (https://www.indexmundi.com/facts/united-states/quick-facts/all-states/average-household-size#table).

For example, in Texas the FCC's estimated unserved population is 1.23 million, and the persons per household is 2.86, yielding a converted number of FCC locations at 430,070 = 1.23 million persons / 2.86 persons per household. Equivalently for the BroadbandNow estimates, in Texas the BroadbandNow estimated unserved population is 4.39 million, yielding an assumed number of BroadbandNow locations at 1,537,349 = 4.39 million persons / 2.86 persons per household. For the RDOF estimates, we simply use the number of locations reported in the 904 auction results.

In Table D3 below, we present aggregate economic gains for three speed thresholds under three sets of assumptions for all 50 states including our five focus states. The selected speeds (measured in megabits of data) and latency thresholds (measured in milliseconds) are comparable to existing broadband service plan offerings rolling out at the time of this writing. The estimates in Table D3 represent a range of possibilities. For example, in Alabama, if all currently unserved locations assigned for deployment under RDOF get connected at 1000/100 Mbps and <10 Ms, this would create $3.69 billion of new economic gains statewide. But if all currently unserved persons estimated by the FCC to lack broadband get similarly connected, that gain would be $4.48 billion. And connecting all unserved persons as estimated by BroadbandNow would yield $8.86 billion. These calculations are net present value over 25 years, or the lower end of average pole life, at 5% discount rate.

TABLE D3:
## 50-STATE ESTIMATES OF STATEWIDE ECONOMIC GAINS (WTP)

| **State** | Speed and Latency Improvements | If Unserved RDOF Locations Gain Access | If FCC Unserved Population Gains Access | If BroadbandNow Unserved Population Gains Access |
|---|---|---|---|---|
| Alabama | 150/25 Mbps at <10 Ms | $3.12b | $3.79b | $7.50b |
| | 300/100 Mbps at <10 Ms | $3.46b | $4.20b | $8.30b |
| | 1000/100 Mbps at <10 Ms | $3.69b | $4.48b | $8.86b |

| | | | | |
|---|---|---|---|---|
| Alaska | 150/25 Mbps at <10 Ms | $0.00b | $0.61b | $1.34b |
| | 300/100 Mbps at <10 Ms | $0.00b | $0.68b | $1.49b |
| | 1000/100 Mbps at <10 Ms | $0.00b | $0.72b | $1.59b |
| Arizona | 150/25 Mbps at <10 Ms | $3.19b | $2.38b | $5.37b |
| | 300/100 Mbps at <10 Ms | $3.53b | $2.63b | $5.95b |
| | 1000/100 Mbps at <10 Ms | $3.77b | $2.81b | $6.35b |
| Arkansas | 150/25 Mbps at <10 Ms | $2.06b | $3.39b | $5.97b |
| | 300/100 Mbps at <10 Ms | $2.28b | $3.76b | $6.61b |
| | 1000/100 Mbps at <10 Ms | $2.43b | $4.01b | $7.06b |
| California | 150/25 Mbps at <10 Ms | $5.80b | $3.19b | $20.88b |
| | 300/100 Mbps at <10 Ms | $6.42b | $3.53b | $23.13b |
| | 1000/100 Mbps at <10 Ms | $6.85b | $3.77b | $24.68b |
| Colorado | 150/25 Mbps at <10 Ms | $1.21b | $1.00b | $4.19b |
| | 300/100 Mbps at <10 Ms | $1.34b | $1.11b | $4.64b |
| | 1000/100 Mbps at <10 Ms | $1.43b | $1.18b | $4.95b |
| Connecticut | 150/25 Mbps at <10 Ms | $0.05b | $0.17b | $2.42b |
| | 300/100 Mbps at <10 Ms | $0.05b | $0.19b | $2.68b |
| | 1000/100 Mbps at <10 Ms | $0.05b | $0.20b | $2.86b |
| Delaware | 150/25 Mbps at <10 Ms | $0.12b | $0.14b | $0.27b |
| | 300/100 Mbps at <10 Ms | $0.14b | $0.15b | $0.30b |
| | 1000/100 Mbps at <10 Ms | $0.15b | $0.16b | $0.32b |
| Florida | 150/25 Mbps at <10 Ms | $2.25b | $4.82b | $14.24b |
| | 300/100 Mbps at <10 Ms | $2.49b | $5.34b | $15.77b |
| | 1000/100 Mbps at <10 Ms | $2.66b | $5.69b | $16.83b |
| Georgia | 150/25 Mbps at <10 Ms | $2.85b | $3.84b | $10.84b |
| | 300/100 Mbps at <10 Ms | $3.16b | $4.25b | $12.01b |
| | 1000/100 Mbps at <10 Ms | $3.37b | $4.53b | $12.81b |
| Hawaii | 150/25 Mbps at <10 Ms | $0.13b | $0.16b | $3.44b |
| | 300/100 Mbps at <10 Ms | $0.14b | $0.17b | $3.81b |
| | 1000/100 Mbps at <10 Ms | $0.15b | $0.19b | $4.07b |
| Idaho | 150/25 Mbps at <10 Ms | $0.65b | $0.49b | $1.51b |
| | 300/100 Mbps at <10 Ms | $0.72b | $0.55b | $1.68b |
| | 1000/100 Mbps at <10 Ms | $0.76b | $0.58b | $1.79b |
| Illinois | 150/25 Mbps at <10 Ms | $2.54b | $1.59b | $7.53b |
| | 300/100 Mbps at <10 Ms | $2.82b | $1.76b | $8.34b |
| | 1000/100 Mbps at <10 Ms | $3.01b | $1.88b | $8.90b |
| Indiana | 150/25 Mbps at <10 Ms | $2.43b | $1.64b | $5.59b |
| | 300/100 Mbps at <10 Ms | $2.69b | $1.82b | $6.19b |
| | 1000/100 Mbps at <10 Ms | $2.87b | $1.94b | $6.61b |
| Iowa | 150/25 Mbps at <10 Ms | $0.86b | $0.84b | $2.55b |
| | 300/100 Mbps at <10 Ms | $0.95b | $0.93b | $2.83b |
| | 1000/100 Mbps at <10 Ms | $1.01b | $0.99b | $3.02b |
| Kansas | 150/25 Mbps at <10 Ms | $0.74b | $0.79b | $2.16b |

| | | | | |
|---|---|---|---|---|
| | 300/100 Mbps at <10 Ms | $0.82b | $0.87b | $2.39b |
| | 1000/100 Mbps at <10 Ms | $0.88b | $0.93b | $2.55b |
| Kentucky | 150/25 Mbps at <10 Ms | $1.57b | $1.64b | $5.31b |
| | 300/100 Mbps at <10 Ms | $1.74b | $1.82b | $5.89b |
| | 1000/100 Mbps at <10 Ms | $1.85b | $1.94b | $6.28b |
| Louisiana | 150/25 Mbps at <10 Ms | $2.79b | $3.28b | $7.02b |
| | 300/100 Mbps at <10 Ms | $3.09b | $3.63b | $7.78b |
| | 1000/100 Mbps at <10 Ms | $3.30b | $3.87b | $8.30b |
| Maine | 150/25 Mbps at <10 Ms | $0.44b | $0.31b | $2.03b |
| | 300/100 Mbps at <10 Ms | $0.49b | $0.35b | $2.25b |
| | 1000/100 Mbps at <10 Ms | $0.52b | $0.37b | $2.40b |
| Maryland | 150/25 Mbps at <10 Ms | $0.60b | $0.90b | $1.33b |
| | 300/100 Mbps at <10 Ms | $0.66b | $1.00b | $1.47b |
| | 1000/100 Mbps at <10 Ms | $0.71b | $1.07b | $1.57b |
| Massachusetts | 150/25 Mbps at <10 Ms | $0.40b | $0.88b | $1.12b |
| | 300/100 Mbps at <10 Ms | $0.45b | $0.97b | $1.25b |
| | 1000/100 Mbps at <10 Ms | $0.48b | $1.04b | $1.33b |
| Michigan | 150/25 Mbps at <10 Ms | $3.96b | $2.69b | $8.41b |
| | 300/100 Mbps at <10 Ms | $4.39b | $2.98b | $9.32b |
| | 1000/100 Mbps at <10 Ms | $4.68b | $3.18b | $9.94b |
| Minnesota | 150/25 Mbps at <10 Ms | $2.27b | $0.89b | $5.62b |
| | 300/100 Mbps at <10 Ms | $2.51b | $0.98b | $6.22b |
| | 1000/100 Mbps at <10 Ms | $2.68b | $1.05b | $6.64b |
| Mississippi | 150/25 Mbps at <10 Ms | $3.48b | $3.56b | $7.13b |
| | 300/100 Mbps at <10 Ms | $3.86b | $3.94b | $7.90b |
| | 1000/100 Mbps at <10 Ms | $4.11b | $4.21b | $8.43b |
| Missouri | 150/25 Mbps at <10 Ms | $3.16b | $2.72b | $6.81b |
| | 300/100 Mbps at <10 Ms | $3.51b | $3.01b | $7.54b |
| | 1000/100 Mbps at <10 Ms | $3.74b | $3.21b | $8.05b |
| Montana | 150/25 Mbps at <10 Ms | $0.73b | $0.94b | $1.72b |
| | 300/100 Mbps at <10 Ms | $0.81b | $1.05b | $1.91b |
| | 1000/100 Mbps at <10 Ms | $0.86b | $1.12b | $2.03b |
| Nebraska | 150/25 Mbps at <10 Ms | $0.69b | $0.46b | $1.19b |
| | 300/100 Mbps at <10 Ms | $0.76b | $0.51b | $1.32b |
| | 1000/100 Mbps at <10 Ms | $0.82b | $0.54b | $1.41b |
| Nevada | 150/25 Mbps at <10 Ms | $0.49b | $0.52b | $0.83b |
| | 300/100 Mbps at <10 Ms | $0.54b | $0.58b | $0.91b |
| | 1000/100 Mbps at <10 Ms | $0.57b | $0.62b | $0.98b |
| New Hampshire | 150/25 Mbps at <10 Ms | $0.28b | $0.28b | $1.60b |
| | 300/100 Mbps at <10 Ms | $0.31b | $0.31b | $1.77b |
| | 1000/100 Mbps at <10 Ms | $0.33b | $0.34b | $1.89b |
| New Jersey | 150/25 Mbps at <10 Ms | $0.14b | $0.76b | $2.42b |

| | | | | |
|---|---|---|---|---|
| | 300/100 Mbps at <10 Ms | $0.15b | $0.84b | $2.69b |
| | 1000/100 Mbps at <10 Ms | $0.16b | $0.89b | $2.87b |
| New Mexico | 150/25 Mbps at <10 Ms | $1.02b | $1.63b | $2.90b |
| | 300/100 Mbps at <10 Ms | $1.13b | $1.80b | $3.22b |
| | 1000/100 Mbps at <10 Ms | $1.21b | $1.92b | $3.43b |
| New York | 150/25 Mbps at <10 Ms | $0.74b | $1.53b | $7.69b |
| | 300/100 Mbps at <10 Ms | $0.82b | $1.69b | $8.52b |
| | 1000/100 Mbps at <10 Ms | $0.88b | $1.81b | $9.09b |
| North Carolina | 150/25 Mbps at <10 Ms | $2.47b | $2.98b | $9.88b |
| | 300/100 Mbps at <10 Ms | $2.73b | $3.30b | $10.95b |
| | 1000/100 Mbps at <10 Ms | $2.91b | $3.52b | $11.68b |
| North Dakota | 150/25 Mbps at <10 Ms | $0.04b | $0.17b | $0.84b |
| | 300/100 Mbps at <10 Ms | $0.05b | $0.18b | $0.93b |
| | 1000/100 Mbps at <10 Ms | $0.05b | $0.20b | $1.00b |
| Ohio | 150/25 Mbps at <10 Ms | $3.04b | $2.14b | $9.19b |
| | 300/100 Mbps at <10 Ms | $3.36b | $2.38b | $10.17b |
| | 1000/100 Mbps at <10 Ms | $3.59b | $2.54b | $10.87b |
| Oklahoma | 150/25 Mbps at <10 Ms | $2.00b | $2.96b | $5.74b |
| | 300/100 Mbps at <10 Ms | $2.22b | $3.28b | $6.36b |
| | 1000/100 Mbps at <10 Ms | $2.37b | $3.50b | $6.79b |
| Oregon | 150/25 Mbps at <10 Ms | $1.30b | $1.37b | $4.35b |
| | 300/100 Mbps at <10 Ms | $1.44b | $1.51b | $4.82b |
| | 1000/100 Mbps at <10 Ms | $1.53b | $1.62b | $5.14b |
| Pennsylvania | 150/25 Mbps at <10 Ms | $2.93b | $3.39b | $7.91b |
| | 300/100 Mbps at <10 Ms | $3.25b | $3.76b | $8.76b |
| | 1000/100 Mbps at <10 Ms | $3.47b | $4.01b | $9.35b |
| Rhode Island | 150/25 Mbps at <10 Ms | $0.06b | $0.10b | $0.21b |
| | 300/100 Mbps at <10 Ms | $0.06b | $0.11b | $0.23b |
| | 1000/100 Mbps at <10 Ms | $0.07b | $0.11b | $0.25b |
| South Carolina | 150/25 Mbps at <10 Ms | $1.73b | $2.82b | $7.46b |
| | 300/100 Mbps at <10 Ms | $1.92b | $3.13b | $8.27b |
| | 1000/100 Mbps at <10 Ms | $2.04b | $3.34b | $8.82b |
| South Dakota | 150/25 Mbps at <10 Ms | $0.16b | $0.29b | $0.94b |
| | 300/100 Mbps at <10 Ms | $0.18b | $0.33b | $1.04b |
| | 1000/100 Mbps at <10 Ms | $0.19b | $0.35b | $1.11b |
| Tennessee | 150/25 Mbps at <10 Ms | $2.47b | $2.72b | $7.98b |
| | 300/100 Mbps at <10 Ms | $2.73b | $3.01b | $8.84b |
| | 1000/100 Mbps at <10 Ms | $2.92b | $3.22b | $9.43b |
| Texas | 150/25 Mbps at <10 Ms | $4.94b | $6.84b | $24.43b |
| | 300/100 Mbps at <10 Ms | $5.47b | $7.57b | $27.06b |
| | 1000/100 Mbps at <10 Ms | $5.84b | $8.08b | $28.88b |
| Utah | 150/25 Mbps at <10 Ms | $0.16b | $0.70b | $1.12b |
| | 300/100 Mbps at <10 Ms | $0.18b | $0.78b | $1.25b |

| | | | | |
|---|---|---|---|---|
| | 1000/100 Mbps at <10 Ms | $0.19b | $0.83b | $1.33b |
| Vermont | 150/25 Mbps at <10 Ms | $2.96b | $0.26b | $1.11b |
| | 300/100 Mbps at <10 Ms | $3.28b | $0.29b | $1.23b |
| | 1000/100 Mbps at <10 Ms | $3.50b | $0.31b | $1.31b |
| Virginia | 150/25 Mbps at <10 Ms | $0.31b | $3.43b | $6.44b |
| | 300/100 Mbps at <10 Ms | $0.34b | $3.80b | $7.13b |
| | 1000/100 Mbps at <10 Ms | $0.36b | $4.05b | $7.61b |
| Washington | 150/25 Mbps at <10 Ms | $1.60b | $1.76b | $8.01b |
| | 300/100 Mbps at <10 Ms | $1.77b | $1.95b | $8.87b |
| | 1000/100 Mbps at <10 Ms | $1.89b | $2.08b | $9.47b |
| West Virginia | 150/25 Mbps at <10 Ms | $1.90b | $2.09b | $5.91b |
| | 300/100 Mbps at <10 Ms | $2.10b | $2.32b | $6.55b |
| | 1000/100 Mbps at <10 Ms | $2.24b | $2.48b | $6.99b |
| Wisconsin | 150/25 Mbps at <10 Ms | $3.82b | $2.61b | $4.44b |
| | 300/100 Mbps at <10 Ms | $4.23b | $2.89b | $4.92b |
| | 1000/100 Mbps at <10 Ms | $4.52b | $3.08b | $5.25b |
| Wyoming | 150/25 Mbps at <10 Ms | $0.30b | $0.27b | $0.65b |
| | 300/100 Mbps at <10 Ms | $0.33b | $0.30b | $0.72b |
| | 1000/100 Mbps at <10 Ms | $0.36b | $0.32b | $0.77b |

Moving to Table D4 below, this same computation methodology demonstrates the foregone economic gains, known in economics as *deadweight loss*, due to delayed or denied broadband expansion under the pole owner *hold up problem*. As our analysis in Lopez and Kravtin 2021 demonstrated, the identified losses in the form of potential foregone consumer value welfare from the delay or unavailability in broadband access, are also quite substantial. In Alabama, for example, each month of delayed expansion causes DWL in the range of $18.46 million to $52.40, per month, under alternative assumptions.

## TABLE D4:
## 50-STATE ESTIMATES OF FOREGONE ECONOMIC GAINS (DWL) DUE TO POLE ATTACHMENT HOLD UP

| **State** | Speed and Latency Improvements | RDOF Locations Delay Cost Per Month | FCC Unserved Population Delay Cost Per Month | BroadbandNow Unserved Population Delay Cost Per Month |
|---|---|---|---|---|
| Alabama | 150/25 Mbps at <10 Ms | $18.46m | $22.41m | $44.33m |
| | 300/100 Mbps at <10 Ms | $20.45m | $24.82m | $49.11m |

| | | | | |
|---|---|---|---|---|
| | 1000/100 Mbps at <10 Ms | $21.82m | $26.48m | $52.40m |
| Alaska | 150/25 Mbps at <10 Ms | $0.00m | $3.61m | $7.94m |
| | 300/100 Mbps at <10 Ms | $0.00m | $4.00m | $8.80m |
| | 1000/100 Mbps at <10 Ms | $0.00m | $4.27m | $9.39m |
| Arizona | 150/25 Mbps at <10 Ms | $18.85m | $14.06m | $31.77m |
| | 300/100 Mbps at <10 Ms | $20.88m | $15.57m | $35.19m |
| | 1000/100 Mbps at <10 Ms | $22.28m | $16.62m | $37.55m |
| Arkansas | 150/25 Mbps at <10 Ms | $12.16m | $20.05m | $35.30m |
| | 300/100 Mbps at <10 Ms | $13.47m | $22.21m | $39.11m |
| | 1000/100 Mbps at <10 Ms | $14.38m | $23.70m | $41.73m |
| California | 150/25 Mbps at <10 Ms | $34.29m | $18.86m | $123.44m |
| | 300/100 Mbps at <10 Ms | $37.98m | $20.89m | $136.73m |
| | 1000/100 Mbps at <10 Ms | $40.53m | $22.29m | $145.91m |
| Colorado | 150/25 Mbps at <10 Ms | $7.16m | $5.91m | $24.76m |
| | 300/100 Mbps at <10 Ms | $7.93m | $6.55m | $27.42m |
| | 1000/100 Mbps at <10 Ms | $8.47m | $6.99m | $29.26m |
| Connecticut | 150/25 Mbps at <10 Ms | $0.27m | $1.00m | $14.31m |
| | 300/100 Mbps at <10 Ms | $0.30m | $1.11m | $15.85m |
| | 1000/100 Mbps at <10 Ms | $0.32m | $1.18m | $16.92m |
| Delaware | 150/25 Mbps at <10 Ms | $0.73m | $0.80m | $1.59m |
| | 300/100 Mbps at <10 Ms | $0.81m | $0.89m | $1.76m |
| | 1000/100 Mbps at <10 Ms | $0.86m | $0.95m | $1.88m |
| Florida | 150/25 Mbps at <10 Ms | $13.31m | $28.51m | $84.18m |
| | 300/100 Mbps at <10 Ms | $14.74m | $31.58m | $93.25m |
| | 1000/100 Mbps at <10 Ms | $15.73m | $33.70m | $99.51m |
| Georgia | 150/25 Mbps at <10 Ms | $16.86m | $22.68m | $64.09m |
| | 300/100 Mbps at <10 Ms | $18.68m | $25.12m | $71.00m |
| | 1000/100 Mbps at <10 Ms | $19.93m | $26.81m | $75.76m |
| Hawaii | 150/25 Mbps at <10 Ms | $0.76m | $0.93m | $20.36m |
| | 300/100 Mbps at <10 Ms | $0.84m | $1.03m | $22.56m |
| | 1000/100 Mbps at <10 Ms | $0.90m | $1.10m | $24.07m |
| Idaho | 150/25 Mbps at <10 Ms | $3.83m | $2.91m | $8.95m |
| | 300/100 Mbps at <10 Ms | $4.24m | $3.22m | $9.92m |
| | 1000/100 Mbps at <10 Ms | $4.52m | $3.44m | $10.58m |
| Illinois | 150/25 Mbps at <10 Ms | $15.03m | $9.40m | $44.51m |
| | 300/100 Mbps at <10 Ms | $16.65m | $10.41m | $49.30m |
| | 1000/100 Mbps at <10 Ms | $17.77m | $11.11m | $52.61m |
| Indiana | 150/25 Mbps at <10 Ms | $14.38m | $9.69m | $33.06m |
| | 300/100 Mbps at <10 Ms | $15.92m | $10.74m | $36.62m |
| | 1000/100 Mbps at <10 Ms | $16.99m | $11.46m | $39.08m |
| Iowa | 150/25 Mbps at <10 Ms | $5.06m | $4.95m | $15.10m |
| | 300/100 Mbps at <10 Ms | $5.60m | $5.49m | $16.73m |
| | 1000/100 Mbps at <10 Ms | $5.98m | $5.85m | $17.85m |

| | | | | |
|---|---|---|---|---|
| Kansas | 150/25 Mbps at <10 Ms | $4.40m | $4.66m | $12.75m |
| | 300/100 Mbps at <10 Ms | $4.87m | $5.16m | $14.12m |
| | 1000/100 Mbps at <10 Ms | $5.20m | $5.51m | $15.07m |
| Kentucky | 150/25 Mbps at <10 Ms | $9.29m | $16.05m | $31.43m |
| | 300/100 Mbps at <10 Ms | $10.29m | $17.78m | $34.81m |
| | 1000/100 Mbps at <10 Ms | $10.98m | $18.98m | $37.15m |
| Louisiana | 150/25 Mbps at <10 Ms | $16.51m | $19.37m | $41.50m |
| | 300/100 Mbps at <10 Ms | $18.29m | $21.46m | $45.97m |
| | 1000/100 Mbps at <10 Ms | $19.52m | $22.90m | $49.06m |
| Maine | 150/25 Mbps at <10 Ms | $2.61m | $1.86m | $12.00m |
| | 300/100 Mbps at <10 Ms | $2.89m | $2.05m | $13.29m |
| | 1000/100 Mbps at <10 Ms | $3.08m | $2.19m | $14.19m |
| Maryland | 150/25 Mbps at <10 Ms | $3.55m | $5.35m | $7.85m |
| | 300/100 Mbps at <10 Ms | $3.93m | $5.93m | $8.69m |
| | 1000/100 Mbps at <10 Ms | $4.19m | $6.32m | $9.27m |
| Massachusetts | 150/25 Mbps at <10 Ms | $2.39m | $5.20m | $6.65m |
| | 300/100 Mbps at <10 Ms | $2.65m | $5.76m | $7.37m |
| | 1000/100 Mbps at <10 Ms | $2.83m | $6.15m | $7.86m |
| Michigan | 150/25 Mbps at <10 Ms | $23.42m | $15.89m | $49.73m |
| | 300/100 Mbps at <10 Ms | $25.95m | $17.60m | $55.09m |
| | 1000/100 Mbps at <10 Ms | $27.69m | $18.78m | $58.79m |
| Minnesota | 150/25 Mbps at <10 Ms | $13.42m | $5.25m | $33.21m |
| | 300/100 Mbps at <10 Ms | $14.87m | $5.81m | $36.79m |
| | 1000/100 Mbps at <10 Ms | $15.87m | $6.20m | $39.26m |
| Mississippi | 150/25 Mbps at <10 Ms | $20.58m | $21.05m | $42.17m |
| | 300/100 Mbps at <10 Ms | $22.79m | $23.32m | $46.71m |
| | 1000/100 Mbps at <10 Ms | $24.33m | $24.89m | $49.84m |
| Missouri | 150/25 Mbps at <10 Ms | $18.72m | $16.05m | $40.26m |
| | 300/100 Mbps at <10 Ms | $20.73m | $17.78m | $44.59m |
| | 1000/100 Mbps at <10 Ms | $22.13m | $18.98m | $47.59m |
| Montana | 150/25 Mbps at <10 Ms | $4.32m | $5.58m | $10.18m |
| | 300/100 Mbps at <10 Ms | $4.79m | $6.18m | $11.27m |
| | 1000/100 Mbps at <10 Ms | $5.11m | $6.60m | $12.03m |
| Nebraska | 150/25 Mbps at <10 Ms | $4.08m | $2.71m | $7.05m |
| | 300/100 Mbps at <10 Ms | $4.52m | $3.00m | $7.81m |
| | 1000/100 Mbps at <10 Ms | $4.82m | $3.21m | $8.34m |
| Nevada | 150/25 Mbps at <10 Ms | $2.87m | $3.09m | $4.88m |
| | 300/100 Mbps at <10 Ms | $3.18m | $3.42m | $5.41m |
| | 1000/100 Mbps at <10 Ms | $3.40m | $3.65m | $5.77m |
| New Hampshire | 150/25 Mbps at <10 Ms | $1.67m | $1.68m | $9.44m |
| | 300/100 Mbps at <10 Ms | $1.85m | $1.86m | $10.45m |
| | 1000/100 Mbps at <10 Ms | $1.97m | $1.99m | $11.15m |

| | | | | |
|---|---|---|---|---|
| New Jersey | 150/25 Mbps at <10 Ms | $0.82m | $4.47m | $14.34m |
| | 300/100 Mbps at <10 Ms | $0.90m | $4.95m | $15.88m |
| | 1000/100 Mbps at <10 Ms | $0.96m | $5.29m | $16.95m |
| New Mexico | 150/25 Mbps at <10 Ms | $6.03m | $9.61m | $17.17m |
| | 300/100 Mbps at <10 Ms | $6.68m | $10.65m | $19.02m |
| | 1000/100 Mbps at <10 Ms | $7.13m | $11.36m | $20.30m |
| New York | 150/25 Mbps at <10 Ms | $4.38m | $9.04m | $45.49m |
| | 300/100 Mbps at <10 Ms | $4.86m | $10.01m | $50.39m |
| | 1000/100 Mbps at <10 Ms | $5.18m | $10.68m | $53.77m |
| North Carolina | 150/25 Mbps at <10 Ms | $14.58m | $17.60m | $58.44m |
| | 300/100 Mbps at <10 Ms | $16.15m | $19.50m | $64.73m |
| | 1000/100 Mbps at <10 Ms | $17.23m | $20.81m | $69.08m |
| North Dakota | 150/25 Mbps at <10 Ms | $0.26m | $0.98m | $4.99m |
| | 300/100 Mbps at <10 Ms | $0.29m | $1.08m | $5.52m |
| | 1000/100 Mbps at <10 Ms | $0.31m | $1.15m | $5.89m |
| Ohio | 150/25 Mbps at <10 Ms | $17.96m | $12.68m | $54.31m |
| | 300/100 Mbps at <10 Ms | $19.89m | $14.05m | $60.16m |
| | 1000/100 Mbps at <10 Ms | $21.23m | $14.99m | $64.20m |
| Oklahoma | 150/25 Mbps at <10 Ms | $11.85m | $17.52m | $33.94m |
| | 300/100 Mbps at <10 Ms | $13.13m | $19.41m | $37.59m |
| | 1000/100 Mbps at <10 Ms | $14.01m | $20.71m | $40.12m |
| Oregon | 150/25 Mbps at <10 Ms | $7.67m | $8.09m | $25.71m |
| | 300/100 Mbps at <10 Ms | $8.50m | $8.96m | $28.48m |
| | 1000/100 Mbps at <10 Ms | $9.07m | $9.56m | $30.40m |
| Pennsylvania | 150/25 Mbps at <10 Ms | $17.34m | $20.05m | $46.77m |
| | 300/100 Mbps at <10 Ms | $19.21m | $22.21m | $51.80m |
| | 1000/100 Mbps at <10 Ms | $20.49m | $23.71m | $55.28m |
| Rhode Island | 150/25 Mbps at <10 Ms | $0.35m | $0.57m | $1.23m |
| | 300/100 Mbps at <10 Ms | $0.38m | $0.63m | $1.37m |
| | 1000/100 Mbps at <10 Ms | $0.41m | $0.67m | $1.46m |
| South Carolina | 150/25 Mbps at <10 Ms | $10.23m | $16.69m | $44.13m |
| | 300/100 Mbps at <10 Ms | $11.33m | $18.48m | $48.88m |
| | 1000/100 Mbps at <10 Ms | $12.09m | $19.72m | $52.16m |
| South Dakota | 150/25 Mbps at <10 Ms | $0.94m | $1.74m | $5.53m |
| | 300/100 Mbps at <10 Ms | $1.05m | $1.93m | $6.13m |
| | 1000/100 Mbps at <10 Ms | $1.12m | $2.06m | $6.54m |
| Tennessee | 150/25 Mbps at <10 Ms | $14.59m | $16.08m | $47.19m |
| | 300/100 Mbps at <10 Ms | $16.16m | $17.81m | $52.27m |
| | 1000/100 Mbps at <10 Ms | $17.24m | $19.01m | $55.78m |
| Texas | 150/25 Mbps at <10 Ms | $29.22m | $40.41m | $144.46m |
| | 300/100 Mbps at <10 Ms | $32.37m | $44.76m | $160.02m |
| | 1000/100 Mbps at <10 Ms | $34.54m | $47.78m | $170.77m |
| Utah | 150/25 Mbps at <10 Ms | $0.97m | $4.14m | $6.65m |

| | | | | |
|---|---|---|---|---|
| | 300/100 Mbps at <10 Ms | $1.08m | $4.59m | $7.36m |
| | 1000/100 Mbps at <10 Ms | $1.15m | $4.90m | $7.86m |
| Vermont | 150/25 Mbps at <10 Ms | $17.52m | $1.55m | $6.55m |
| | 300/100 Mbps at <10 Ms | $19.41m | $1.71m | $7.26m |
| | 1000/100 Mbps at <10 Ms | $20.71m | $1.83m | $7.75m |
| Virginia | 150/25 Mbps at <10 Ms | $1.82m | $20.26m | $38.08m |
| | 300/100 Mbps at <10 Ms | $2.01m | $22.44m | $42.19m |
| | 1000/100 Mbps at <10 Ms | $2.15m | $23.95m | $45.02m |
| Washington | 150/25 Mbps at <10 Ms | $9.44m | $10.43m | $47.36m |
| | 300/100 Mbps at <10 Ms | $10.45m | $11.55m | $52.46m |
| | 1000/100 Mbps at <10 Ms | $11.15m | $12.33m | $55.98m |
| West Virginia | 150/25 Mbps at <10 Ms | $11.21m | $12.39m | $34.95m |
| | 300/100 Mbps at <10 Ms | $12.41m | $13.72m | $38.71m |
| | 1000/100 Mbps at <10 Ms | $13.25m | $14.64m | $41.31m |
| Wisconsin | 150/25 Mbps at <10 Ms | $22.60m | $15.43m | $26.25m |
| | 300/100 Mbps at <10 Ms | $25.04m | $17.08m | $29.08m |
| | 1000/100 Mbps at <10 Ms | $26.72m | $18.24m | $31.04m |
| Wyoming | 150/25 Mbps at <10 Ms | $1.78m | $1.60m | $3.87m |
| | 300/100 Mbps at <10 Ms | $1.97m | $1.78m | $4.28m |
| | 1000/100 Mbps at <10 Ms | $2.11m | $1.90m | $4.57m |

Finally, in Tables D5 through D9 below, we present our main findings for the five focus states under alternative assumptions. First, we consider the magnitude of economic gains (WTP) and losses (DWL) without latency improvements. These estimates appear in Tables D5 through D9 in parentheses and correspond to the estimates and assumptions made in our earlier study, Lopez and Kravtin 2021. We also consider a more conservative set of estimates, appearing in brackets, that assume only 60% deployment. As Tables D5 through D9 show, even if only 60% of currently unserved locations are connected, the economic gains are still quite substantial, ranging from $1.35 to $10.09 billion in Florida alone, for example. Likewise, the delay costs remain substantial even under the 60% deployment assumption.

## TABLE D5:
# FLORIDA ESTIMATES UNDER ALTERNATIVE ASSUMPTIONS

| Economic Gains | If Unserved RDOF Locations Gain Access | If FCC Unserved Population Gains Access | If BroadbandNow Unserved Population Gains Access |
|---|---|---|---|
| 150/25 Mbps | $2.25b<br>($2.15b)<br>[$1.35b] | $4.82b<br>($4.62b)<br>[$2.89b] | $14.24b<br>($13.62b)<br>[$8.54b] |
| 300/100 Mbps | $2.49b<br>($2.39b)<br>[$1.49b] | $5.34b<br>($5.13b)<br>[$3.20b] | $15.77b<br>($15.16b)<br>[$9.46b] |
| 1000/100 Mbps | $2.66b<br>($2.56b)<br>[$1.59b] | $5.69b<br>($5.49b)<br>[$3.41b] | $16.83b<br>($16.22b)<br>[$10.09b] |

| Foregone Gains | RDOF Locations Delay Cost Per Month | FCC Unserved Population Delay Cost Per Month | BroadbandNow Unserved Population Delay Cost Per Month |
|---|---|---|---|
| 150/25 Mbps | $13.31m<br>($12.73m) | $28.51m<br>($27.29m) | $84.18m<br>($80.57m) |
| 300/100 Mbps | $14.74m<br>($14.17m) | $31.58m<br>($30.36m) | $93.25m<br>($89.68m) |
| 1000/100 Mbps | $15.73m<br>($15.16m) | $33.70m<br>($32.48m) | $99.51m<br>($95.89m) |

*Notes: Economic gains equal aggregate WTP for improvement from a Mobile 5/1 Mbps connection to the listed fixed wireline speeds. Top line entries also include latency improvement from 60-100 Ms to <10 Ms. For comparison purposes, second line entries in (parentheses) exclude latency improvements. Finally, entries in [brackets] assume only 60% of the unserved population gets connected.*

TABLE D6:
## KENTUCKY ESTIMATES UNDER ALTERNATIVE ASSUMPTIONS

| Economic Gains | If Unserved RDOF Locations Gain Access | If FCC Unserved Population Gains Access | If BroadbandNow Unserved Population Gains Access |
|---|---|---|---|
| 150/25 Mbps | $1.57b<br>($1.50b)<br>[$0.94b] | $1.64b<br>($1.57b)<br>[$0.98b] | $5.31b<br>($5.08b)<br>[$3.19b] |
| 300/100 Mbps | $1.74b<br>($1.67b)<br>[$1.04b] | $1.82b<br>($1.74b)<br>[$1.09b] | $5.89b<br>($5.66b)<br>[$3.53b] |
| 1000/100 Mbps | $1.85b<br>($1.79b)<br>[$1.11b] | $1.94b<br>($1.86b)<br>[$1.16b] | $6.28b<br>($6.06b)<br>[$3.77b] |

| Foregone Gains | RDOF Locations Delay Cost Per Month | FCC Unserved Population Delay Cost Per Month | BroadbandNow Unserved Population Delay Cost Per Month |
|---|---|---|---|
| 150/25 Mbps | $9.29m<br>($8.89m) | $16.05m<br>($9.28m) | $31.43m<br>($30.08m) |
| 300/100 Mbps | $10.29m<br>($9.89m) | $17.78m<br>($10.32m) | $34.81m<br>($33.46m) |
| 1000/100 Mbps | $10.98m<br>($10.58m) | $18.98m<br>($11.05m) | $37.15m<br>($35.80m) |

*Notes: See Table D5 notes above.*

TABLE D7:

## MISSOURI ESTIMATES UNDER ALTERNATIVE ASSUMPTIONS

| Economic Gains | If Unserved RDOF Locations Gain Access | If FCC Unserved Population Gains Access | If BroadbandNow Unserved Population Gains Access |
|---|---|---|---|
| 150/25 Mbps | $3.16b<br>($3.03b)<br>[$1.89b] | $2.72b<br>($2.59b)<br>[$1.63b] | $6.81b<br>($6.52b)<br>[$4.09b] |
| 300/100 Mbps | $3.51b<br>($3.37b)<br>[$2.11b] | $3.01b<br>($2.89b)<br>[$1.81b] | $7.54b<br>($7.25b)<br>[$4.52b] |
| 1000/100 Mbps | $3.74b<br>($3.61b)<br>[$2.24b] | $3.21b<br>($3.09b)<br>[$1.93b] | $8.05b<br>($7.76b)<br>[$4.83b] |

| Foregone Gains | RDOF Locations Delay Cost Per Month | FCC Unserved Population Delay Cost Per Month | BroadbandNow Unserved Population Delay Cost Per Month |
|---|---|---|---|
| 150/25 Mbps | $18.72m<br>($17.92m) | $16.05m<br>($15.36m) | $40.26m<br>($38.56m) |
| 300/100 Mbps | $20.73m<br>($19.93m) | $17.78m<br>($17.09m) | $44.59m<br>($42.87m) |
| 1000/100 Mbps | $22.13m<br>($21.33m) | $18.98m<br>($18.29m) | $47.59m<br>($45.87m) |

*Notes: See Table D5 notes above.*

## TABLE D8:
# TEXAS ESTIMATES UNDER ALTERNATIVE ASSUMPTIONS

| Economic Gains | If Unserved RDOF Locations Gain Access | If FCC Unserved Population Gains Access | If BroadbandNow Unserved Population Gains Access |
|---|---|---|---|
| 150/25 Mbps | $4.94b<br>($4.73b)<br>[$2.96b] | $6.84b<br>($6.54b)<br>[$4.10b] | $24.43b<br>($23.38b)<br>[$14.66b] |
| 300/100 Mbps | $5.47b<br>($5.26b)<br>[$3.28b] | $7.57b<br>($7.28b)<br>[$4.52b] | $27.06b<br>($26.02b)<br>[$16.27b] |
| 1000/100 Mbps | $5.84b<br>($5.63b)<br>[$3.50b] | $8.08b<br>($7.78b)<br>[$4.85b] | $28.88b<br>($27.83b)<br>[$17.33b] |

| Foregone Gains | RDOF Locations Delay Cost Per Month | FCC Unserved Population Delay Cost Per Month | BroadbandNow Unserved Population Delay Cost Per Month |
|---|---|---|---|
| 150/25 Mbps | $29.22m<br>($27.97m) | $40.41m<br>($38.68m) | $144.46m<br>($138.27m) |
| 300/100 Mbps | $32.37m<br>($31.14m) | $44.76m<br>($43.02m) | $160.02m<br>($153.83m) |
| 1000/100 Mbps | $34.54m<br>($32.28m) | $47.78m<br>($46.04m) | $170.77m<br>($164.57m) |

*Notes: See Table D5 notes above.*

TABLE D9:

## WISCONSIN ESTIMATES UNDER ALTERNATIVE ASSUMPTIONS

| Economic Gains | If Unserved RDOF Locations Gain Access | If FCC Unserved Population Gains Access | If BroadbandNow Unserved Population Gains Access |
|---|---|---|---|
| 150/25 Mbps | $3.82b<br>($3.65b)<br>[$2.29b] | $2.61b<br>($2.49b)<br>[$1.57b] | $4.44b<br>($4.25b)<br>[$2.66b] |
| 300/100 Mbps | $4.23b<br>($4.07b)<br>[$2.54b] | $2.89b<br>($2.78b)<br>[$1.73b] | $4.92b<br>($4.73b)<br>[$2.95b] |
| 1000/100 Mbps | $4.52b<br>($4.35b)<br>[$2.71b] | $3.08b<br>($2.92b)<br>[$1.85b] | $5.25b<br>($5.06b)<br>[$3.15b] |
| **Foregone Gains** | **RDOF Locations Delay Cost Per Month** | **FCC Unserved Population Delay Cost Per Month** | **BroadbandNow Unserved Population Delay Cost Per Month** |
| 150/25 Mbps | $22.60m<br>($21.63m) | $15.43m<br>($14.76m) | $26.25m<br>($25.13m) |
| 300/100 Mbps | $25.04m<br>($24.07m) | $17.08m<br>($16.43m) | $29.08m<br>($27.95m) |
| 1000/100 Mbps | $26.72m<br>($25.75m) | $18.24m<br>($17.57m) | $31.04m<br>($29.91m) |

*Notes: See Table D5 notes above.*

## END NOTES

[1] The hold up problem is the power to impede others' ongoing investments. In general, hold up problems arise in scenarios where Entity A makes an initial investment that is called "relationship-specific" because its return depends on Entity A subsequently contracting with Entity B. In these scenarios, if Entity B has information about A's investment, then B has market power to extract rents from A's investment and thereby destroy economic value by requiring a high selling price (high, specifically, relative to what the selling price would be in absence of this market power). Hold up problems are classified in economics terms as one example of inefficient concentration of market power that harms the public interest.

[2] In its annual Broadband Deployment Reports, the Federal Communications Commission cites the 1996 Telecommunications Act as charging the Commission with "'encourag[ing] the deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans by removing barriers to infrastructure investment…" (FCC 2021, p.1).

[3] John Busby, Julian Tanberk, and Tyler Cooper, "BroadbandNow Estimates Availability for all 50 States; Confirms that More than 42 Million Americans do not Have Access to Broadband," BroadbandNow Research, May 5, 2021, updated October 21, 2021 ("we manually checked availability of more than 11,000 addresses using Federal Communications Commission (FCC) Form 477 data as the 'source of truth.' Based on the results, we estimated that 42 million Americans do not have the ability to purchase broadband internet.") The discrepancy in unserved locations between the FCC and BroadbandNow databases is largely attributable to the FCC's methodology which only included unserved households in fully unserved census blocks, whereas the BroadbandNow drilled down below the census block level. See https://broadbandnow.com/research/fcc-broadband-overreporting-by-state.

[4] Willingness to Pay (or, WTP) is a standard textbook measure of economic gains created by end-users having access to goods and services, including broadband access. See also Appendix B, Glossary of Technical Terms.

[5] Deadweight Loss (or, DWL) is a standard textbook measure of foregone economic gains created by end-users lacking access to goods and services, including broadband access. See also Appendix B, Glossary of Technical Terms.

[6] See Lopez and Kravtin (2021) specifically Appendix C, Lists of Works Cited, "The Underlying Sources of Pole Owners' Market Power: A Combination of Hold Up Problems and Classic Barriers to Entry", and Appendix D, Empirical Methodology and Complete Results: Baseline / Alternative Assumptions.

[7] See FCC (2020) announcing launch of RDOF on February 7, 2020.

[8] See Lopez & Kravtin 2021, pp. 13-15, citing the Liu et al. study.

[9] Nationally, the average number of persons per household is 2.565 according to the U.S. Census Bureau. Therefore, 5.2 million locations would equate to approximately 2 million persons.

[10] Alaska is excluded from our RDOF calculations due to there being no reported RDOF results, dollars, or locations there. Therefore, our nationwide RDOF calculations include only 49 of the 50 states. Our other calculations that are based on FCC and BroadbandNow estimates of unserved populations are calculated for all 50 states.

[11] Appendix D below explains how this study relies on the underlying WTP estimates from the Liu et al. study.

[12] The appropriate discount rate and duration is debatable. We select the lower range of the average service lives of poles, generally identified at 25 to 50 years. A discount rate of 5% is reasonable, although it may be generously high for consumer and household applications, but it is less than the typical cost of capital

assumptions in the range of 6%.

[13] Poles officially identified as needing replacement by the utility as in situations where a pole has been found non-compliant with safety standards or fails to meet other utility or regulatory requirements such as pole resiliency criteria and placed on a replacement schedule is referred to as “red-tagged.” It is generally accepted that new attachers are not responsible for the cost of pole replacement for red-tagged poles.

[14] See Lopez & Kravtin 2021, Appendix C. and material as reiterated herein in Appendix B.