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August 21, 2017
Federal Communications Commission
Ms. Marlene Dortch, Secretary
445 12th Street, S.W.
Washington, DC 20554

RE: Written ex parte submission in RM-11681; IB Docket No. 11-109; IBFS File Nos. SES-MOD-20151231-000981, SAT-MOD-20151231-00090, SAT-MOD-20151231-00091

Dear Ms. Dortch:

I have considerable concern about the validity and rigor of the recent *ex parte* by Harold Furchtgott-Roth submitted by Ligado Networks, LLC.² The filing provides a so-called “economic analysis” related to the company’s request to share spectrum, especially in the 1675-1680 MHz band.³

This will degrade real-time forecasting of weather and water hazards, and will impact numerous elements of the U.S. economy from shipping and port management to local flood forecasting and planning hurricane evacuation zones. **The Ligado-funded Furchtgott-Roth analysis distorts both the issues and the evidence to reach unfounded conclusions.**

¹ The NOAA National Environmental Satellite and Data Information Service.

² Harold Furchtgott-Roth, “Economic Analysis of the Ligado Petitions to the Federal Communications Commission Regarding Spectrum Flexibility and Spectrum Allocations,” (filed as ex parte presentation in IB Docket No. 11-109; RM-11681; IBFS File Nos. SES-MOD-20151231-000981, SAT-MOD-20151231-00090, SAT-MOD-20151231-00091 (filed May 25, 2017) <https://ecfsapi.fcc.gov/file/105253003105609/HFR%20Economic%20Analysis.pdf>

³ Furchtgott-Roth, *ibid.*, applies his analysis to additional flexibility in the form of an ancillary terrestrial component (ATC) for Ligado’s licenses in the L-band as well. This is not addressed in the present submission. The plural “petitions” is used where Furchtgott-Roth is quoted.

Similar to Dr. Furchtgott-Roth, I am also a Ph.D. economist with a history of affiliation with the Hudson Institute, previously serving as their Director of Economic Studies. In private consulting practice, I provide economic analysis to private and public sector clients, with expertise that includes assessing the value of weather, water and other environmental and infrastructure services to users and society.⁴

The Furchtgott-Roth submission makes three assertions with no robust economic basis, all of which are either false or misleading. These are:

- A. "The Ligado petitions create many public benefits for America
- B. There are few if any public objections to the Ligado plan
- C. The public benefits of the Ligado plan exceed any possible costs, if there are any"

In the descriptions below I present the issues and the fallacies of each of the above assertions. The Ligado proposal will interfere with broadcast of GOES data with far reaching impacts. Extensive testimony on these impacts is cited and the addendum in this submission indicates some magnitudes of intermediate and end users of GOES data.

A. "The Ligado petitions create many public benefits for America"

- While there can be large public benefits with the Ligado proposal, there are huge costs to users of public services which the author does not acknowledge much less include in his economic analysis. Ligado has not seriously compared the benefits of its proposal or variations of it with the costs to the public from interference caused by its signals. These costs are considered in the discussion of Point B.

⁴ For example, *Hudson Trend Analysis*, Final Report to the National Oceanic and Atmospheric Administration, Hudson Institute, September 2002
http://www.au.af.mil/au/awc/awcgate/noaa/2002_hudson_trends.pdf, *Socio-Economic Study: Scoping the Value of NOAA's Coastal Mapping Program*, report to the Remote Sensing Division, National Geodetic Survey, National Oceanic and Atmospheric Administration, March 8, 2012
https://geodesy.noaa.gov/PUBS_LIB/CMP_Socio-Economic_Scoping_Study_Final.pdf, *Socio-Economic Benefits Study: Scoping the Value of CORS and GRAV-D*, prepared for the National Geodetic Survey, National Oceanic and Atmospheric Administration, January 2009
http://www.ngs.noaa.gov/PUBS_LIB/Socio-EconomicBenefitsofCORSandGRAV-D.pdf, and "NOAA Economic Studies," presentation to the NOAA Hydrographic Services Review Panel, September 17, 2015
http://www.nauticalcharts.noaa.gov/ocs/hsrp/meetings_washingtondc.htm

- NOAA services that could be disrupted by Ligado signals provide extensive value to the nation. This is elaborated on in the discussion of Point C and in the Addendum. These services make their own important contribution to economic growth and jobs as well as to consumer surplus and the environment.

The issue is not whether expansion of terrestrial broadband services would create large public benefits. Rather, it is the benefits and costs from the Ligado proposal compared to alternatives such as using other frequencies for expanding broadband or modifying Ligado's configuration to make it less harmful. Ligado has not considered benefits and costs of alternatives to its proposal.

- The Ligado-funded study places great emphasis on clarifying property rights quickly. This is not as important as doing so in a way that provides the greatest benefits net of costs. Granting Ligado property rights in the 1675-1680 MHz band, if not done by an appropriate auction, can thwart competition, resulting in higher prices and poorer service to customers. While costs of delay can be substantial, losses from interference with public services together with effects of reduced competition will continue over many years. Achieving competitive broadband expansion cannot be accomplished by first granting property rights and then assessing the consequences.

The argument for granting rights quickly would appear an attempt to supersede use of an auction process which would allow selection of the most suitable proposal and provide revenue to the government. The Furchtgott-Roth submission states that an auction process is preferred, apparently in contradiction to its urging quick action.

Moreover, any auction process for spectrum used for public services should include conditions that protect critical applications. It will take time to clearly identify and establish such conditions because there are so many important applications and because the impacts of signal interference in actual full operation have to be approximated in advance of implementation. **While clarification of property rights is important, it should be done in a way that protects critical public services.**

B. "There are few if any public objections to the Ligado plan

Furchtgott-Roth's claim of few public objections to Ligado's plan is completely contrary to fact. Public objections are numerous, strong and valid. There have been extensive submissions from more than 70 stakeholders expressing concern and opposition to this

proposal to the FCC before, during and since the 2016 FCC public comment period.⁵ These submissions, which were ignored by the Ligado funded analysis, demonstrate just a selection of the numerous benefits of GOES weather satellites to a great many economic sectors, the public and the environment that would be lost if sharing was allowed to move forward as proposed.

Benefits derive not only from the real-time data collected by the NOAA Geostationary Operational Environmental Satellites (GOES) and products of that data, but also from distribution of data from many other sources by the satellites. These sources include radars and a growing number of manned and unmanned land, air and sea vehicles and sensors. In addition to economic and environmental benefits, these services make a great contribution to preventing loss of life and injury.

Many of the users of GOES data are intermediaries such as water companies, emergency managers, wildfire incident managers and aviation operations schedulers that generate extensive benefits to numerous end users. This is not reflected in the numbers of receivers in current use, and use will be growing with new satellites, data assimilation methods, forecasting models, supercomputing and other capabilities.

C. “The public benefits of the Ligado plan exceed any possible costs, if there are any”

The costs of lost information are high and growing rapidly. Many users could go unserved if NOAA and its numerous private sector partners and their constituents that depend on GOES data were limited in their ability to provide real-time weather and water data and prediction services. Part of the gap that would be created by absence of NOAA data would remain unfulfilled because the private sector has an incentive to concentrate on profitable services rather than serving the public sector goal of assuring that services are universally available to meet broad social, environmental and safety-of-life goals. The many state and local government users also would be constrained in their ability to serve the public.

Interference would come at a time dramatically improving capabilities for weather, water and environmental measurement and forecasting will work together to greatly increase benefits.⁶ These improvements come amid rising public concern about natural

⁵ For example Satellite Telemetry Interagency Working Group (STIWG), “STIWG Perspective on DCS Reliance and Preservation,” Whitepaper, September 23, 2015

https://acwi.gov/hydrology/stiwg/stiwg_dcs_reliance_and_preservation.pdf

⁶ For information on GOES 16 which will be operational by the end of 2017 and its family of geostationary weather and environmental satellites, the Joint Polar Satellite System (JPSS) series of satellites which will launch beginning in 2018, other NOAA satellites, the development of algorithms to make use of the

disasters and environmental outcomes. Statements such as “the current light usage of ...the NOAA spectrum”⁷ do not recognize either the present usage or the growth in use and benefits that will come from these new capabilities.⁸

The deployment of many more terrestrial transmitters and their operation at far higher power or closer in frequency to user terminals than those presently operating would make some signals unusable even if interference were intermittent. Both ongoing and transition costs of adaptation for current users would be substantial for those who could even find alternatives.^{9,10} Costs will be especially high if deployment of high powered transmitters is inappropriate and hasty.

information and ways in which data from multiple sources is combined to produce new products, see Steven Volz, “NOAA Satellite Conference,” opening presentation at the 2017 NOAA Satellite Conference, July 17, 2017 http://www.nsc2017.org/wp-content/uploads/presentations/NSC2017_Session_1.1_Volz.pdf and Mitch Goldberg, “JPSS Science and Users,” presentation at the 2017 NOAA Satellite Conference, July 17, 2017 http://www.nsc2017.org/wp-content/uploads/presentations/NSC2017_Session_6.3_Goldberg.pdf For a list of GOES-R products see <http://www.goes-r.gov/products/overview.html> The many innovations include the new National Water Model <http://water.noaa.gov/about/nwm> the developing Offshore Precipitation Capability for aviation <https://www.rd100conference.com/awards/winners-finalists/6556/offshore-precipitation-capability/>, advances in NOAA’s use of supercomputing and NOAA’s Big Data project to make NOAA data readily available through private cloud services

⁷ Furchtgott-Roth, op. cit., p.5, item 2.

⁸ AccuWeather indicates they receive and process more than 9.5 billion digital requests every day. See <https://www.accuweather.com/en/press/43009943>; The Weather Company delivers up to 26 billion forecasts daily <https://ecfsapi.fcc.gov/file/106201877303257/The%20Weather%20Company%2C%20an%20IBM%20Business%20-%20FCC%20RM-11681%20Petition%20for%20Rulemaking.pdf>

⁹ Charlie Ester, Manager, Surface Water Resources, Salt River Project (SRP), Phoenix, Arizona, stated in his June 21, 2016 letter to the FCC that: “As SRP communication engineers point out, a band-sharing agreement within the 1675-1710 MHz range will not be effective because broadband wireless equipment has poor filtering. This will increase noise harmonics that will spill over into the satellite data range and render the data noisy and useless to SRP and our partners.” He also stated: “Any perception that all weather satellite data for water and power operations can be received online, through websites of agencies such as NASA and NOAA, is not correct and is a dangerous misconception. Data received via the internet has the following drawbacks...1. These data are not ‘real time’....2.All data products may not be available.... 3.Internet data transmission requires vast amounts of bandwidth, not only by the user, but by the organization ‘serving’ the data....4.Internet data are not dependable during times of crisis, when operational agencies need critical data the most.” Charlie Ester, Salt River Project, Letter to Marlene H. Dorch, Office of the Secretary, Federal Communications Commission, June 21, 2016 <https://ecfsapi.fcc.gov/file/106212156919978/SRP%20SWR%20to%20FCC%20June%202016%20proceeding%20number%20RM%2011681.pdf>

¹⁰ “Getting GOES satellite information via the cloud will not work for users that rely on high availability ‘real-time’ information which is crucial to tracking active weather and related hazards like tornadoes, hurricanes, wildfires, volcanic ash interruptions and floods. This is primarily because the ‘last mile’ connectivity from the cloud to the end user can be disrupted or damaged during severe weather events when it is needed the most.” American Meteorological Society, “An Invisible Threat to the Weather and Water Community: Radio Frequency Spectrum Access,” fact sheet, downloaded April 4, 2016 <https://www.ametsoc.org/cwwce/index.cfm/committees/ad-hoc-committee-on-radio-frequency-allocations/fact-sheet-impact-of-rf-spectrum-reallocation-revised/>

The Economic Basis of the Furchtgott-Roth Submission Is Misleading

Furchtgott-Roth's discussion of the implications of the work of Nobel Laureate Ronald Coase is also misleading. Applying Coase's reasoning, he notes that greater efficiency could be achieved by auctions. However, he also suggests assigning the rights to Ligado.¹¹

Because the costs to the public are downplayed, Furchtgott-Roth does not consider whether there are arrangements for which there might be lower societal costs. This can involve greater restrictions on interference with GOES signals through use of lower power, more or larger protected zones or other measures, relying on use of other frequencies and auctioning rights to those firms with proposals that would do less harm.

The "Coase theorem" posits that spectrum will be reallocated after it is assigned, with compensation negotiated for those who might be harmed by interference.¹² But (public) property rights also exist for public spectrum which will not be party to a later reallocation through transactions encompassing both public and private parties.

Moreover, the "theorem" holds only when the assumption that transactions costs and uncertainty are not a barrier is realized in practice. This includes costs for negotiation among private parties to rearrange their spectrum holdings and impasses that come about because of differing views about future conditions and profit potential. Many economists including Coase himself have indicated that transaction costs are often large.¹³

A proper analysis accurately considers all of the benefits and costs to society under alternative policies or arrangements. Directing public spectrum for sharing without compensation and leaving the public without critical services based on gross underrepresentation of the costs to individuals, businesses and society is both inappropriate and unconscionable.

¹¹ Furchtgott-Roth, *ibid*, page 4, item 2 states: "Under the Ligado petitions, Ligado would be able to benefit from the more flexible use." Page 4, item 1 states: not adopting the Ligado petitions would limit the uses of these bands of valuable spectrum by leaving them subject to the current command-and-control structure that narrowly defines specific permissible uses for the bands."

¹² R.H. Coase, "The Problem of Social Cost," *Journal of Law and Economics*, Oct, 1960, pp.1-44
<http://www.jstor.org/stable/724810>

¹³ Coase, *ibid.*, p.39, R.H. Coase, *The Firm, the Market and the Law*, Chicago & London: The University of Chicago Press, 1988, pp.37-40 and "Coase Theorem," *Wikipedia* viewed 7-31-17
https://en.wikipedia.org/wiki/Coase_theorem#Criticisms_of_the_Applicability_of_the_Theorem

Even if compensation to those who lost benefits or faced additional costs were required, it often is not possible to adequately identify and compensate many of those who are harmed by loss of public services and to address the harm. This is especially true for the weather and water enterprise where many direct users of the services in turn provide services to numerous end users whose identities and losses cannot readily be determined at an individual level, and where there are large safety-of-life and environmental benefits along with economic benefits.¹⁴ **When the societal costs are very large and compensation to those denied the benefits of GOES signal availability is not feasible, realistic conditions should be established that allow the services to be maintained.**

The points above reinforce the conclusion that this Ligado funded “economic analysis” both distorts the real issues around the sharing of 1675-1680 MHz and promotes conclusions that are unfounded and invalid. It is important that the FCC not consider this analysis in its assessment of whether to move forward given its substantial flaws. The bias inherent in the Ligado funded Furchtgott-Roth analysis reinforces the importance of having additional research (not funded by companies with an interest in the outcome) that fully assesses the impacts of sharing this spectrum before moving forward with any further actions in this proceeding.

In the words of Ronald Coase in his path breaking article:

“...it would be unfortunate if this investigation were undertaken with the aid of a faulty economic analysis.”¹⁵

Regards,

Irving Leveson, Ph.D.

¹⁴ “Global natural disasters in 2016 combined to cause economic losses of US\$210 billion, an amount 21 percent above the 16-year average of US\$174 billion. ... The top three perils – flooding, earthquake and severe weather – combined for 70 percent of all economic losses in 2016. While at least 72 percent of catastrophe losses occurred outside of the United States, it still accounted for 56 percent of global insured losses.” Aon Benfield, *2016 Annual Global Climate and Catastrophe Report*, January 2017, p.1

<http://thoughtleadership.aonbenfield.com/Documents/20170117-ab-if-annual-climate-catastrophe-report.pdf>

Insured losses are just one more indication of the great number of users that rely on the information.

¹⁵ R.H. Coase, “The Problem of Social Cost,” *Journal of Law and Economics*, Oct, 1960, p.19

<http://www.jstor.org/stable/724810>

Addendum

1) Population impacted by the Ligado proposal

In this section I highlight some (but not all) of the population impacted by the Ligado proposal

1,100 meteorologists and other atmospheric scientists including 543 American Meteorological Society certified broadcast meteorologists reach hundreds of millions of people with weather information, warnings and advisories every day.¹⁶ The private weather services industry including meteorologists within companies is estimated to have gross sales of \$3 billion per year.¹⁷

More than 1.8 million people are in occupations involving emergency management:¹⁸

9,770 emergency management directors and 3,060 emergency management specialists

232,000 emergency medical technicians and paramedics

1,162,141 in police protection and 420,318 in fire protection

Many other government officials, personnel of private firms and volunteers in community emergency response teams (CERT), fire and emergency services will have the availability of the services they provide compromised.

2) GOES products affected by Legato proposals and potential impacts

¹⁶ Number of meteorologists is from U.S. Bureau of Labor Statistics, "Occupational Statistics from the Current Population Survey," <http://www.bls.gov/cps/cpsaat11.htm> Number of broadcast meteorologists is from American Meteorological Society, "List of AMS Certified Broadcast Meteorologists," https://www.ametsoc.org/memdir/sellist/get_listofcbm.cfm

¹⁷ Rich Jeffries of UCAR reported in Knowledge@Wharton, "Today's Forecast for the Weather Business: Increased Revenues and a Focus on Innovation," April 10, 2013 <http://knowledge.wharton.upenn.edu/article.cfm?articleid=3229> The estimate may be a crude update of Spiegler, David B., "The Private Sector in Meteorology: An Update," *Bulletin of the American Meteorological Association*, August 2007, pp.1272-1275 <http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-88-8-1272>

¹⁸ Emergency management and EMT are occupation data from U.S. Bureau of Labor Statistics, "Occupational Statistics from the Current Population Survey," <http://www.bls.gov/cps/cpsaat11.htm> Police and fire are industry data are from Willhide, Robert, *Annual Survey of Public Employment & Payroll Summary Report: 2013*, U.S. Census Bureau, G13-ASOEP, December 19, 2014 http://www2.census.gov/govs/apes/2013_summary_report.pdf

Emergency response

Nearly 90% of emergencies declared by FEMA are weather-related.¹⁹

Search and rescue

GOES serves several function in the search and rescue process:²⁰

- É GOES is used for advance positioning of rescue craft for emergencies.
- É GOES is often the first to pick up beacon data from beacons that have their location encoded, for use when the beacon is with the persons being sought.
- É Oceanographic, weather and satellite data including data from GOES are used to predict current position from last known position to increase the probability of detecting the target.
- É Weather data are used in rescues of aircraft and ships. About 4,000 lives are saved each year in 20,000 Coast Guard sea and air search and rescue operations.²¹

Transportation

- The gross value of output of the air transportation industry was \$174 billion in 2013. The private air transportation industry employed 448,000 in July 2015.²² 692 million passengers were boarded at US airports in 2012. Airlines carried more than 12 billion ton-miles of freight in 2011.²³ More than 5,000 public use airports

¹⁹ American Meteorological Society, "Weather Analysis and Forecasting," information statement adopted March 25, 2015

http://www.ametsoc.org/POLICY/2015_weather_analysis_and_forecasting_information_statement_ams.html

²⁰ Interview with Jack Frost, Program Manager for Search Planning Applications Development (SAROPS), U.S. Coast Guard Office of Search and Rescue at Coast Guard Headquarters, October 15, 2015 and NOAA, "Search and Rescue Satellites" <http://www.sarsat.noaa.gov/satellites1.html>

²¹ U.S. Department of Transportation, Bureau of Transportation Statistics, Table 2-49, U.S. Coast Guard Search and Rescue Statistics, Fiscal Year http://www.rita.dot.gov/bts/sites/rita.dot.gov/bts/files/publications/national_transportation_statistics/html/table_02_49.html

²² U.S. Department of Commerce, Bureau of Economic Analysis, "Gross Output by Industry," released April 23, 2015 www.bea.gov

²³ U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, updated July 2015

support general aviation. There are more than 14,000 private use airports and 289 military airports.²⁴ The US has nearly 600,000 pilots.²⁵

- Weather accounted for 34% of airline air traffic delays or cancellations during 2012-2014. Four percent of takeoffs were delayed or cancelled due to extreme weather such as hurricanes, blizzards or tornadoes.²⁶ Up to 50,000 flights per year carrying 10,000 people per day to/from Northern Asia and the US across Alaska require volcanic ash warnings to avoid serious damage to engines & aircraft and danger to passengers.²⁷
- 250 million vehicles depend on weather, flood and emergency information for safety and travelling efficient routes.²⁸ Two-thirds of those vehicles are used with some form of navigation system that can help them avoid dangers and delays if combined with the proper information.²⁹ The contract fleet management market alone was \$10.9 billion in 2013.³⁰
- Ship accidents can cause expensive delays that affect other ships and port operations as well as cause injury and loss of life. The trend toward larger ships, drawing more water and pushing channel depth limits to increase draft so they can carry more cargo is stressing the capacity of U.S. ports. Larger ships, including with the expansion of the Panama Canal, increase the importance of information to monitor water depths, obstructions, bridge clearances and other marine environmental conditions. The Physical Oceanographic Real-Time System (PORTS®), a decision support tool that integrates real-time environmental

http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html

²⁴ *Ibid.*

²⁵ Alliance for Aviation Across America, "Economic Impact Survey: Executive Summary," n.d. <http://www.aviationacrossamerica.com/economic-impact/>

²⁶ U.S. Department of Transportation, Bureau of Transportation Statistics, "Understanding the Reporting of Causes of Flight Delays and Cancellations," <http://www.rita.dot.gov/bts/help/aviation/html/understanding.html>

²⁷ Web page of Anchorage AK Volcanic Ash Advisory Center http://vaac.arh.noaa.gov/vaac_info.php

²⁸ Number of vehicle is an average of Federal Highway Administration and R.L Polk as cited in Oak Ridge National Laboratories, *Transportation Energy Data Book*, Table 3.4 <http://cta.ornl.gov/data/>

²⁹ IHS, "Telematics Market Status," June 2014 <https://www.ihs.com/newsletter/automotive/june-2014/telematics-market-status.html>

³⁰ Fleetmatics, *Fleetbeat Report*, 2014 <http://www.fleetmatics.com/fleetbeatreport>

observations, forecasts and other geospatial information, relies on data from GOES.

Prediction of space weather events

- Space weather warnings derived from GOES and particularly the new GOES-16 sensors reach over-the-pole aircraft for re-routing due to radiation hazards and aircraft dependent on high frequency communications. The power industry requires immediate warnings of space weather, such as coronal mass ejections, to avoid harm to equipment. Retail revenue of the electric power industry was \$375 billion in 2013; the industry employed 390,000 people in May 2014.³¹ Space weather warnings help the GPS system deal with disruptions to radio navigation. Ionospheric irregularities impact dual frequency GPS and satellite communications.³²

Lightning warnings

- GOES satellites provide early warnings of lightning and outbreaks and shifts in positions of wild land fires. The Insurance Information Institute reported that in 2013 over 100,000 homeowners were paid claims for lightning damage at a cost of about \$600 million. Cost per claim increased 122% in 7 years largely as a result of more vulnerable and expensive electronic devices. Lightning has been associated with costs of billions of dollars per year to the power industry, 22,600 building fires during 2001-2011 with \$451 million in direct property damage, 9,000 wildland fires during 2008-2012 and deaths of 4 firefighters per year.³³

Flood warnings

- GOES data is used for flood warnings, controlling water flow through dams, reservoirs and locks, irrigation and depths for ships to clear harbors and bridges.

³¹ U.S. Bureau of Labor Statistics, "Occupational Employment Statistics," <http://www.bls.gov.oes/>

³² Steenburgh, *Op. Cit.*, slide 26

³³ Ronald L. Holle, "Some Aspects of Global Lightning Impacts," 2014 AMS Annual Meeting, Phoenix, 7th Conference on Meteorological Applied Lightning Data, Paper 4.1
http://www.lightningsafety.noaa.gov/resources/Global_Aspects_holle15.pdf

- Water data is collected at 27,000 sites around the country with 7 million observations per day.³⁴
- 20,000 sensors that measure stream flow use GOES, including many of the 8,134 US Geological Survey streamgages.³⁵
- Approximately 2,540 dams on rivers produce hydroelectric power.³⁶
- The EPA reported that in 2008 there were 52,873 community water systems serving 300 million people.³⁷
Single function special purpose local government districts in 2012 include 3,248 for flood control, 2,565 for soil and water conservation, 1,522 for other natural resources, 1,909 for sewerage and 3,522 for water supply.³⁸ Federal, state and local governments employed 202,000 people in water supply, transport and terminals and 788,000 in natural resources and parks and recreation.³⁹ The American Water Works Association has more than 50,000 members.⁴⁰

³⁴ Kay Metcalf, GOES Data Collection System (DCS) Program Manager, based on information from various Federal DCP users.

³⁵ *Ibid.* The historical graph of USGS streamgage numbers is from Carl D. Shapiro, "The Importance of Water to the U.S. Economy," slides for Technical Workshop, US EPA Office of Water, Washington, D.C., September 19, 2012 <http://water.epa.gov/action/importanceofwater/upload/11-Shapiro.pdf>

³⁶ AmericanRivers.org, "Questions About Removing Dams," n.d.
<http://www.americanrivers.org/initiatives/dams/faqs/>

³⁷ U.S. Environmental Protection Administration, "Public Drinking Water Systems: Facts and Figures," <http://water.epa.gov/infrastructure/drinkingwater/pws/factoids.cfm>

³⁸ U.S. Census Bureau, 2012 *Census of Governments*, table on government units by state, 1942-2012
<http://factfinder.census.gov/>

³⁹ U.S. Census Bureau, *Annual Survey of Public Employment & Payroll Summary Report: 2013*, http://www2.census.gov/govs/apes/2013_summary_report.pdf

⁴⁰ American Water Works Association <http://www.awwa.org/about-us/governance.aspx>