

Arizona Geological Survey Economic Impact Report

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Economic
Development Tool



Improves Public
Safety



Enables efficacious
public admin.

CONTRIBUTED REPORT CR-19-A

August 2019

Arizona Geological Survey

azgs.arizona.edu | repository.azgs.az.gov



Arizona Geological Survey

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Manuscript approved for publication in August 2019

Printed by the Arizona Geological Survey

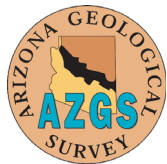
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Recommended Citation: Lizzuo, C., Bartels, A., Brands, C.C. and Yashi, A., 2019, Arizona Geological Survey Economic Impact Report. Arizona Geological Survey Contributed Report OFR-19-A, 21 p., 3 appendices



EXECUTIVE SUMMARY

The Arizona Geological Survey's Impact on the State of Arizona

The Arizona Geological Survey is a publicly funded state agency that saved Arizonans \$30 million over the last 12 months in cost avoidance. AZGS' impact can be categorized under three pillars; it serves as an economic development tool, increases public safety, and allows for more efficient public administration. Key examples under these pillars illustrate the benefits to Arizona enabled by the existence of AZGS.

Findings derived from quantitative and qualitative data

The methodology that produced these findings was four-fold. 1.) The team conducted secondary research into other geological surveys and past economic impact reports they produced. 2.) A survey was administered to AZGS users to produce quantitative information regarding their use of AZGS products and services and the value they placed on those products and services. 3.) The Eller Consulting team interviewed 14 AZGS users to supplement the survey results with qualitative data and detailed examples of use. 4.) The survey results were combined with Google Analytics web traffic data to formulate a "cost avoidance" number.

Saving Arizona money

Cost avoidance is a projection of how much extra AZGS users would have had to pay if AZGS was not around to provide their products and services. AZGS saved its users \$30,382,640 in cost avoidance from April 2, 2018 to March 31, 2019. The cost avoidance value was derived by combining survey results about the replacement cost of each product category with data from Google Analytics regarding web traffic predominantly from AZGS's document repository. As AZGS materials are also accessible through other parts of their website, the true cost avoidance of AZGS is likely even higher.

Products and services that are highly valued

In addition to being used for the cost avoidance value, the survey produced several key takeaways that demonstrate how AZGS products and services are valued. The majority of users work for small to medium sized businesses, as 62% of respondents worked for organizations that employed less than 50 people. 82% and 78% of respondents said that AZGS digital geological maps and geological maps respectively were "always" or "often" essential to their work which reflects AZGS' most used products. 66% of respondents said that replacing AZGS products or services would take up 0-10% of their project budget. While AZGS' products and services may not be of the highest dollar amount, their value is high, and having to replace them would still lead to increased project budgets for its users.

Making an impact in areas critical to Arizona

Interviews with AZGS users supplemented quantitative information with examples and details on how different industries specifically use AZGS products and services. From these interviews, three key pillars were identified which summarize AZGS' impact:

- Tool for economic development
 - Encourages mining investment by easing regulatory compliance and increasing the likelihood of success
 - Increases the competitiveness of small and medium sized businesses
- Improving public safety

- Helps Arizona grow safer by identifying hazards during planning and before development
 - Keeps water clean through the identification of groundwater flows
- Improves the efficiency of public administration
 - Allows the public sector to properly assess land value
 - Improves the identification of water resources and assurance of water supply
 - Sets the industry standard with unmatched credibility as a fact finder

No existing replacement

Through research and interviews, several potential replacements or competitors for AZGS products and services were identified, specifically the USGS, AZ Department of Water Resources, Academic institutions, and the private sector. However, none of these potential replacements provided the full suite of services that AZGS does and none could do it at a similar cost that AZGS does. Relying on any of these sources would raise the cost of doing business and decrease efficiency.

A good investment

As a state-funded agency, AZGS positively impacts Arizona's public safety, the private sector, and the public sector. Without AZGS, the general public would be at greater risk and private and public sector inefficiency and costs would rise. At a cost of \$941,000 per year in state funding, AZGS remains a sound investment for the state Arizona. During the fiscal year 2018, AZGS received \$941,000 in state appropriation, \$1,001,815 from federal grants, \$162,327 in indirect funds, \$139,158 in Non-Federal Grants/Contracts, and \$60,031 from internal sources. AZGS leveraged the \$941,000 provided by the State to generate \$1,363,331 additional funds.

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INTRODUCTION

The Arizona Geological Survey has a historical precedence in Arizona since 1883. Arizona was still a territory at that point and the Survey was known as the Office of the Territorial Geologist. It has served the state since then under various names, by providing the foundational geologic maps and services that allow for developments in the state. AZGS has moved from being a territorial office, to a university bureau, to a state bureau, and since 2016 has returned to a department housed within the University of Arizona.

AZGS products and services include interactive maps, historic document repositories, GIS maps, geologic reports and consulting services. These products and services are utilized by a variety industries and public agencies, which allow for the creation of safer environments, economic development and allows for more efficient public administration.

AZGS commissioned an Eller MBA Consulting team at the University of Arizona to perform an economic impact analysis in order to gauge and document the value that the organization brings to the state of Arizona. Similar geological surveys in other states performed economic impact reports in a similar effort to demonstrate how their agencies are providing value to their respective states. This report uses quantitative and qualitative measurements to demonstrate the value that AZGS brings to Arizona.

AZGS is supported directly by the State of Arizona through appropriations funding and AZGS leverages this funding to generate additional grant funding. During the fiscal year 2018, AZGS received \$941,000 in state appropriation, \$1,001,815 from federal grants, \$162,327 in indirect funds, \$139,158 in Non-Federal Grants/Contracts, and \$60,031 from internal sources. AZGS leveraged the \$941,000 provided by the State to generate \$1,363,331 additional funds.

METHODOLOGY

This report focused on four key ways to generate data. Research of previous economic impact reports created by other state geologic surveys, a survey administered to AZGS users, one-on-one interviews from a cross section of key industries that utilize AZGS products and services, and an analysis of web traffic data. All four areas provided key data that guided the economic impact analysis and formed the core of the results contained within this report.

The initial basis for understanding the impacts that AZGS has on the state of Arizona was formed through a literature review of past reports conducted by geological surveys, specifically those performed in Indiana, Kentucky, and Ohio. These reports provided a basis for an initial understanding of how to view AZGS impacts on Arizona and served as templates on methods for measuring economic impacts. They each showed different approaches used for measuring their respective state geological survey's impacts, which were used in building this report.

Kentucky's report focused on the geological survey as a public good and how much it has contributed to the growth of the state. It successfully demonstrated how Kentucky's growth would have been hampered if the geological survey did not offer its services as a public good. Ohio's report focused on "cost replacement," or how much users anticipate they would have to pay for the geological survey's services if it were not around. Indiana combined survey data with Google Analytics web data to estimate the total amount the geological survey saved users in a year. Specifically, they asked how much users would be willing to pay for the resources on the website and approximated the number of unique users to the website. The Indiana methodology formed the basis for the methodology used to calculate the total impact number derived in this report.

A survey was sent out to AZGS users which formed the basis of this report's quantitative data. The questions were originally drawn from the three previous impact reports, with modifications and refinements made to collect the data most relevant to AZGS. Further refinements were performed in consultations with University of Arizona Professors and AZGS staff.

The survey was delivered to AZGS users in two ways. First, the survey was emailed directly to 168 AZGS users. The second delivery was through 14 "gatekeepers." Gatekeepers are influential professionals in the field of geology within Arizona that maintain extensive networks of other geological professionals. They distributed the survey to their contacts and followed up to ensure a high result of completed surveys. The dual distribution method produced about 170 survey responses, which serves as a representative sample size. The survey was distributed on February 12, 2019 and closed on February 26, 2019. Due to the second distribution method via the gatekeepers, it is unknown how many individuals the survey was sent to so the rate of return is unclear.

Qualitative data was collected through one-on-one interviews with AZGS users to better understand the impacts that AZGS has on Arizona's economy through user stories. 14 phone interviews were held, with each interview lasting roughly 30 minutes. Specific care was taken to ensure a broad cross section of AZGS users were interviewed. Interviews were held from February to April of 2019. Each interview provided unique user stories that helped illustrate how AZGS has impacted their specific industry and the state of Arizona.

COST AVOIDANCE

To value the economic impacts that AZGS has on Arizona's economy, a cost avoidance measurement was constructed. Cost avoidance refers to the cost that Arizona businesses and public agencies would incur if AZGS products and services were not available. These costs can be conceptualized as the costs to contract for equivalent products and services, or the costs associated with recreating the products that AZGS provides to the public for free. Cost avoidance measurements were narrowed down to quantifying immediate costs that Arizona's businesses and public agencies forgo and does not consider secondary effects produced by the multiplier effect. For the purposes of this project, cost avoidance is a tangible way to quantify the value AZGS creates for the state of Arizona.

A literature review was conducted, in which the Indiana Geological Survey's (IGS) Economic Impact Report was studied and their report provided the basis for this reports cost avoidance methodology. It formulated a cost avoidance figure by collecting information via surveys and then combined this information with web traffic data derived from Google Analytics. A willingness to pay (WTP) value was derived from their survey, which was multiplied by web traffic associated with their two most highly valued products (Indiana Map and the Petroleum Database). This was done to value a replacement cost for products offered on their website. The total amount of unique pageviews for those two products was then divided by two, to create a conservative estimate that controlled for individuals that may have accessed the information multiple times from different computers. IGS' methodology was expanded upon and refined in order to generate a cost avoidance number for AZGS.

Cost Avoidance Methodology

Industry experts that utilize AZGS products and services were surveyed on their willingness to pay for the following categories of products: Digital Maps, Mining Data, Geoscience Educational Resources, Geotechnical Reports and Interactive Maps. They were then asked to indicate how frequently they used the same products over the course of a year. A total weighted average cost by product category was calculated by correlating their willingness to pay with the frequency of use.

To evaluate the number of total AZGS product users, web traffic data was collected via Google Analytics on the a) AZGS document repository, b) mining data collection and c) the natural hazard viewer webpages. These pages were analyzed because they, more directly than other sections of the website, offer technical maps and reports that cater directly to users that deliberately access these sites for work purposes. Each webpage was then divided into the above product categories associated with the survey data collected.

Two values were used from Google Analytics associated with each product category to produce an estimated total number of users. The first value was the total number of pageviews recorded by Google Analytics. Google provided values for measuring web traffic in two categories "total pageviews" and "unique pageviews." Unique pageviews are filtered so that IP addresses for a given computer were recorded only once, whereas pageviews records all web traffic, including repeated use by the same IP address. Total pageviews was selected, since a single user could be accessing the webpage multiple times, to access multiple products from the same product page. The number of pageviews was then divided by two to create a more conservative value.

The second value utilized was the bounce rate recorded by Google Analytics. The bounce rate is defined as a single page session, where a web user does not navigate to an additional page. For example, when a user clicks on "Digital Geologic Maps" in the document repository, they are presented with 114 map options. If the bounce rate is 40% for "Digital Geologic Maps," that means 60% of users navigated further to a specific map. Incorporating the bounce rate allows for a more accurate number of total AZGS product users.

Once all the above information was collected and organized by product category, the following equation was used to calculate their dollar value:

$$\text{Product category total value} = (\text{pageviews} * 0.5) * (1 - \text{bounce rate}) * \text{Weighted Average Cost}$$

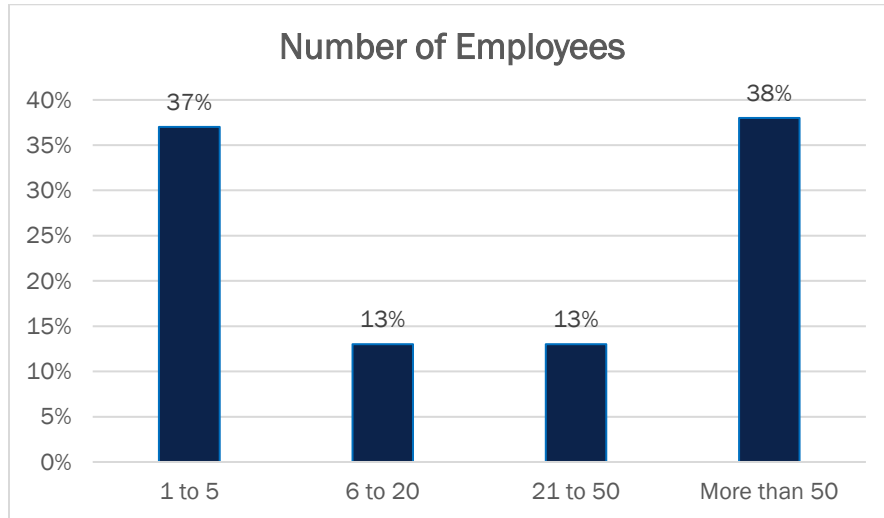
Results:

Table 1 Cost Replacement Valuation

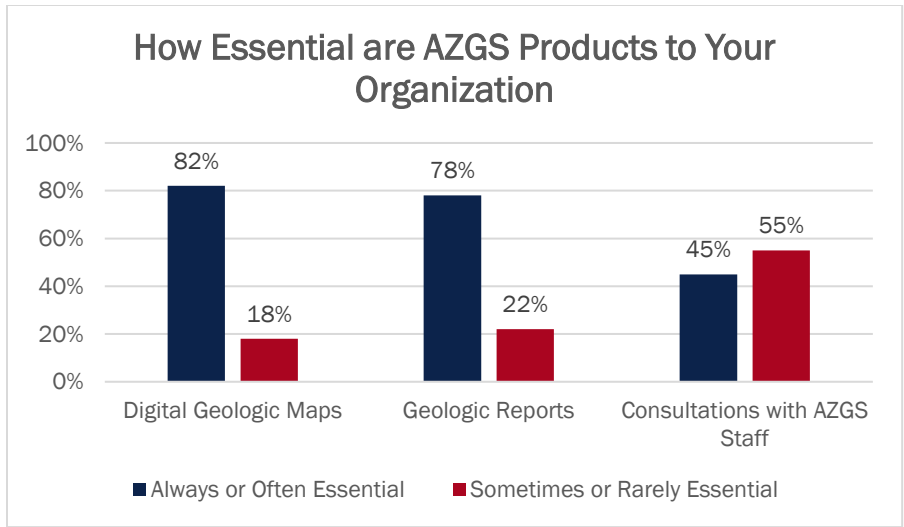
Mining Data	\$20,884,960.58
Interactive Maps	\$4,205,056.57
Digital Maps	\$3,488,970.47
Geotechnical Reports	\$1,331,526.25
Geoscience Educational	\$472,126.36
Total Cost Replacement	\$30,382,640.23

SURVEY TAKEAWAYS

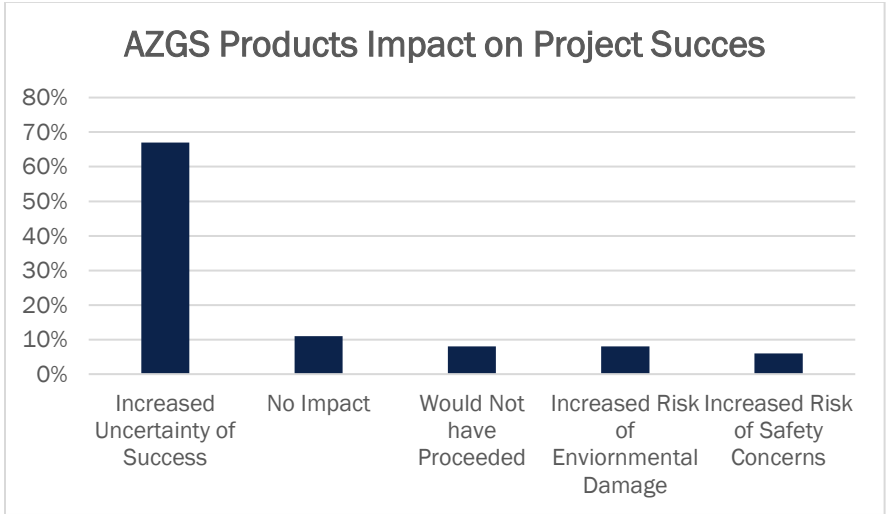
The Eller Consulting team administered a survey to AZGS users to generate quantitative information about the users, how they used AZGS products and services, and the value they placed on those products and services. The survey was returned by approximately 170 respondents.



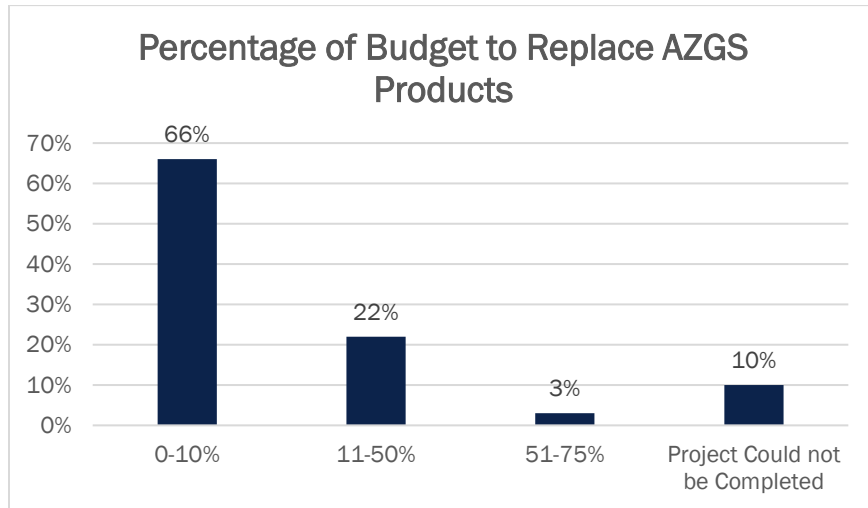
Survey respondents were asked about the size of their organizations and this graph shows that AZGS predominantly serves very small and very large organizations. Based on interviews conducted for this report, very small agencies are typically more reliant on AZGS maps and reports, as they are not capable of reproducing them due to time and budget constraints. This is contrasted by very large organizations that can produce their own maps and reports, but it is highly likely this information would be proprietary and typically not released to outside organizations. This speaks to AZGS's ability to keep their products available as a public good, allowing for small businesses to compete, and preventing wasteful spending by multiple corporations on the same product.



AZGS users were asked how essential these product and service categories were to their work and the majority responded that digital geologic maps and geologic reports are “always or often” essential to their work. Less than 50% believe that staff consultations are always or often essential and this is reflected in the structure of the organization. AZGS products are predominantly accessed through the website and staff consultations are utilized to provide background and supporting information. This also dynamic aligns with the cost avoidance methodology, which focused on measuring the amount of times products were accessed through the website.



Respondents overwhelmingly said that AZGS increases the chances of their project’s success and this means different things in different industries. One example came from an interview with an individual involved in mining explorations. They mentioned when prospecting for new mineral deposits without maps or detailed historic information about the mine, there is no way of knowing where empty cavities that have already been mined are located. Other impacts range from loss of time and resources to more serious cases of physical injury or even loss of life. Another example came from a water source exploration project that AZGS assisted with in the Superstition Mountains. During this project AZGS had performed basin analysis which allowed for more precise drilling when evaluating water supply.



Survey respondents were asked the percentage of the budget they would allocate to replacing AZGS products if they were no longer available and 66% indicated that it would only require 0-10% of their budget to replace AZGS products. Qualitative information gathered through the survey and interview process indicated that this is a function of the size of projects in which AZGS products are utilized. For example, large mining, infrastructure, or development projects will cost upwards of millions of dollars. In this context, replacing AZGS's products would only be a small part of the overall budget. In conjunction with the previous questions, AZGS is a small but critical part of these massive projects. Additionally, the following sections illustrate how AZGS delivers value through their quality and other intrinsic elements that are not captured when just measuring by dollar value.

IMPACT AREAS

AZGS has three pillars that help to support Arizona's economic wellbeing. The first pillar is the Survey's function as a tool for economic development, by seeding growth in the minerals and mining industry, while also supporting small and medium sized companies' competition in the economy. The second pillar is AZGS' improvement of public safety through providing the necessary information to assess and regulate groundwater source and identifying hazards that need to be considered when infrastructure and new developments are built. The third pillar is that their services make public administration more efficient, by helping the public sector properly assess land value, helping to assess water supply and water rights, as well as setting the industry standard due to AZGS' unmatched credibility as an impartial fact finder.

PILLAR 1: TOOL FOR ECONOMIC DEVELOPMENT:

AZGS acts as a tool for economic development through the benefits it provides to the private sector.

- **ENCOURAGES MINING INVESTMENT BY EASING REGULATORY COMPLIANCE AND INCREASING THE LIKELIHOOD OF SUCCESS.**

AZGS encourages mining investment in Arizona through two avenues. The agency eases the ability of mining firms to comply with regulatory requirements and provides the underlying data that informs mining explorers on where to search for mineral resources. The hard rock mining industry has a \$4.28 billion impact on the state of Arizona (Arizona Mining Association, 2017) and Arizona was rated as one of the top-10 most attractive jurisdictions for mining in the world (Jackson & Green, 2017). AZGS products and services play a role in keeping Arizona attractive to the mining industry by making it a more efficient and successful industry.

Eases regulatory compliance

The mining industry is required to comply with different types of regulations that emanate from the local, state, and federal levels. AZGS products and services were cited as being crucial in compliance for:

Arizona and National Historic Preservation Acts: The two separate Historic Preservation Acts administered at both the state and federal level require large-scale developments to preserve any space that has been deemed of natural, cultural or scientific value. It requires surveying and documentation of all lands that may be affected by the development before clearance is permitted (Historic Preservation Laws at a Glance, n.d.). Historical reports and maps provided by AZGS are used in the archaeological and cultural resources investigations performed in compliance with these acts. This may include historical old mines or archaeological records whose existence is documented in special in reports. This information is housed within AZGS' document repository and was cited as the first place that cultural resources experts turn to when performing these investigations.

Arizona and National Antiquities Act: These two separate Antiquities Acts are very similar to the Historic Preservation Acts, however they specifically regulate behavior on state or federally owned land. Historic maps and reports are utilized in the required investigations. AZGS remains the only source for these products.

NI 43-101 – This is a regulation issued by the Canadian stock exchange and is a requirement for all companies listed on the stock exchange who display information related to mineral properties. It requires these companies to create a number of reports providing evidence of their mineral investments. It is intended to protect investors from companies claiming to have access to more minerals than they actually do. AZGS maps and reports offer

the evidence needed to comply with these regulations. More importantly, as a state agency, AZGS can offer the credibility to meet the standards of the Canadian stock exchange. This credibility aspect will be discussed later in this report. Being able to satisfy this requirement allows foreign investment to flow into Arizona's economy (Kuepper, 2019).

In addition to these regulations, three environmental regulations are discussed later in public safety section of this report.

One interviewee estimated that his firm performs \$10 to \$12 million a year worth of services for the mining industry and offered that AZGS saves his firm up to \$375,000 a year. Perhaps more important than the cost savings, AZGS' documents allow consultants to do quicker research, bringing forth more detailed, rich information, which allows mines to get their permits quicker.

Increases chance of success

The search for the next profitable mining vein was described as a "guessing game" by one interviewee who worked in mineral exploration. AZGS mining files were directly referenced for the insight they provide into the past. Historical mine data from the early 20th century offers insight into where past deposits were found, while publications from the 50's and 60's offer evidence for properties that deserve more exploration. This historical information provides information on where mining occurred in the past as well as where it has yet to occur, both aspects which make for a more informed exploration process and one that is less of a guessing game.

➤ INCREASES THE COMPETITIVENESS OF SMALL AND MEDIUM SIZED BUSINESSES

AZGS increases the competitiveness of the business environment in Arizona by making their information publicly accessible. This point is directly tied into AZGS' cost avoidance and the \$30 million that AZGS saved the state of Arizona. Because the information already exists and does not need to be recreated by each individual firm, small and medium sized consulting firms are able to perform more work and to offer their services at a cheaper rate. Cheaper rates reduce the cost of business for the clients of the consulting firm (mining companies, law firms, developers, farmers) and makes them more likely to take advantage of these services. As a result, their work is better informed and of higher quality. By reducing the cost of business by \$30 million, AZGS creates a more efficient competitive marketplace.

The impact AZGS has on small businesses was illuminated by the interviews with consultants. One consultant estimated that the time and cost burden of recreating AZGS products and services would reduce the dollar amount of business that their company performs by two-thirds. Another estimated that they would charge 5-10 times more for their service if they had to recreate or track down the information that AZGS provides as a public good. These testimonials provide examples of how cost avoidance manifests itself for businesses in Arizona.

PILLAR 2: IMPROVES PUBLIC SAFETY:

AZGS the general public through the safety improvements it enables.

➤ HELPS ARIZONA GROW SAFER BY IDENTIFYING HAZARDS DURING PLANNING AND BEFORE DEVELOPMENT

Demographically Arizona continues to grow rapidly, with the population increasing from 6.68 million in 2010 to 7.17 million in 2018. This growth includes an increase in urban developed areas, as well as an increase in the utilities and infrastructure needed to support the population's growing demands. AZGS products and services are utilized by identifying natural hazards ahead of planning and development, so that they can be avoided or mitigated before construction begins.

Multiple interviewees cited AZGS's role in identifying earth fissures as being crucial to guiding the expansion of Arizona's urban developments. The formation of fissures is closely associated with ground subsidence, caused by withdrawing excess groundwater from underlying areas. The arrival of Colorado River water via the Central Arizona Project, and less reliance on groundwater has slowed the appearance of fissures. However, moving away from Colorado River water and back to pumping groundwater will exacerbate the issue. Currently, ground subsidence and the resulting earth fissures impacts more than 3,000 square miles in Arizona, which requires constant identification and response.

Identifying fissures before construction can help to prevent, or mitigate the high costs associated with addressing damages caused by them retroactively. For comparison, repairs to a damaged irrigation canal in Scottsdale in 2007 cost \$820,000 whereas mitigating an identified fissure discovered in the course of the construction of the Red Mountain Highway (Loop 202) in Phoenix cost \$200,000 in 2007 (Earth Fissures and Ground Subsidence, n.d.). In 1992, Luke Airforce Base incurred more than \$3 million in damages when subsidence caused a drainage facility to slope, which caused floodwater to rush into the base (Davis, 2017).

The Arizona Landslide Inventory Database (AzSLID) was cited as being heavily utilized in planning processes. AzSLID is a database that was built by AZGS between the years 2014-2017, through the utilization of a \$170,000 FEMA grant. It documents historic landslide and debris flow events and is used to predict future events. In February 2013, a 250-foot section of US 89 was wiped away by a landslide and was replaced two years later at a cost approaching \$50 million (Earth Fissures and Ground Subsidence, n.d.). One interviewee that provided consulting services for Arizona Department of Transportation specifically cited their heavy use of AzSLID in the course of working on the potential widening of I-17. They estimated that replacing the information taken from AzSLID would cost hundreds of thousands of dollars due to the number of products that were utilized. The need to perform the primary research for these products would also add an indefinite amount of time to the project's completion.

AZGS was also heavily involved in studying the post-fire debris flood flows after the 2010 "Schultz Fire," which occurred in Coconino County. The flooding effects were exacerbated by the heavy erosion and surface damage caused by the fire after heavy monsoon rains. While no people or property were damaged by the fires, over 1,500 properties were damaged by the ensuing floods, as well as the death of a 12-year-old girl, caused by flash flooding.

FEMA sponsored a pilot study to look at the post-fire flood threats faced by Coconino County. It was conducted in the Williams and Fort Valley area and is under consideration by FEMA for application to other municipalities throughout the country. Coconino County, JE Fuller Consultants, and AZGS worked in conjunction on the study, and found that 593 homes, 13 dams and other critical facilities around the Schultz fire location were at increased risk if a similar event were to occur. An economic impact report of Williams found that \$293 million worth of

property value were in the 100-year flood zone and would be threatened by post-fire debris flows (Rousse, Wade; Combrink, Thomas; The Alliance Bank Economic Policy Institute; The W.A. Franke College of Business; Northern Arizona University). AZGS' work on this issue will enable Coconino County and other municipalities to limit the damages that occur from post fire debris-flow flooding through identified proactive measures (Loverich, Youberg, Kellogg, & Fuller, 2017).

AZGS products and services are directly referenced in the Disclosure Reports provided to all new home buyers, as required by the Arizona Department of Real Estate. This report requires developers to disclose any and all risks that a homebuyer should be aware of, in an effort to provide consumer safety and protection. Two requirement sections included in the report are directly informed by AZGS's work.

Section 2: Whether the development lots are subject to subsidence or expansive soils. If subsidence or expansive soils exist, a professional engineer's letter addressing the effects of the condition, remedies, and a buyer's on-going responsibilities in plain language;

Section 6: (University of Indiana Capstone Class 7933, 2017) (Kleinhenz & Associates, 2011) (Subhash B. Bhagwat, 2001) Whether the development lots are subject to any known geological or environmental condition that would or may be detrimental to a purchaser's health, safety, or welfare; (Development Services Division - Frequently Asked Questions, n.d.)

Representatives of the home building industry identified AZGS' work as being the primary resource for this information, specifically the natural hazard viewer, AZGS geological maps, and the document repository. Regulation compliance currently accounts for 25% of a new home's price (Regulations Add a Whopping \$84,671 to New Home Prices, 2016). With 41,154 new residential building permits issued in Arizona in 2018, if developers had to pay for each necessary map, the replacement cost for the industry would be astronomical.

➤ **KEEPS WATER CLEAN THROUGH THE IDENTIFICATION OF GROUNDWATER FLOWS**

AZGS helps keep water in Arizona clean by serving as the primary resource for understanding hydrogeological conditions for modeling groundwater flows. This is especially critical in Arizona, where groundwater accounts for 40% of all water used, and remains the state's largest single source (Arizona Department of Water Resources, n.d.). Interviews and research have identified three regulations on this issue where compliance relies on AZGS products.

Aquifer Protection Permit (APP): This permit is required by any facility that discharges pollutants into the groundwater. In Arizona, this primarily concerns the mining industry. The APP has two key requirements; compliance with the Aquifer Water Quality Standards (AWQS) and compliance with the Best Available Demonstrated Control Technology (BADCT). These standards require the use of engineering controls, processes and operating methods to reduce discharge of pollutants to the greatest degree achievable before they reach the aquifer, to ensure the water quality is not affected (Arizona Department of Environmental Quality, 2019). These requirements necessitate the extensive utilization of AZGS geologic maps to determine the hydrological characteristics of the area in which the mine is being constructed and to ensure that contamination of the aquifer is kept to an absolute minimum.

Safe Drinking Water Act - The SDWA is an EPA regulation enforced by the Arizona Department of Environmental Quality (AZDEQ), which serves to protect the public's drinking water supply. Water system operators rely on AZGS maps and reports when reporting to AZDEQ that their systems are free of contaminants (Environmental Protection Agency, 2004). These operators hire consultants to conduct groundwater modeling, which helps to track the flow of groundwater before it reaches their water system, as well as to understand where it goes from there. These consultants rely on AZGS maps and reports to understand the underlying geological conditions, as

well as how to properly map potentially toxic aggregate materials. These AZGS maps and reports are the consultants' primary resource, with no current replacement available.

Underground Injection Control Program – Similar to the previous two regulations, the UIC is a program under the SDWA that specifically controls for any industrial activity that injects fluids underneath the surface. It aims to ensure that those injected fluids do not enter the water supply. It is currently administered at the federal level by the EPA, though the state of Arizona has recently made efforts to gain “primacy” as the issuing agency within its borders (Arizona Department of Environmental Quality, 2017).

Without AZGS, compliance with regulations would be more expensive and time consuming, as consultants would have to recreate the maps and reports that otherwise would already exist. Multiple interviewees expressed skepticism about their ability to recreate the quality of AZGS work, since they stated they do not have the specialized expertise required to produce these maps and reports. Lower quality products would make it more likely that contaminants could enter into the water system, endangering the public.

Two groundwater contamination cases where AZGS products were utilized were the Tucson Airport Remediation Project (TARP) and at Motorola Plant Groundwater contamination site on 52nd Street in Phoenix. Tucson Airport sits atop a groundwater plume that extends from Los Reales Road past Irvington Road. Within the plume, contaminants such as volatile organic compounds (VOCs) and trichloroethene (TCE) were identified as being above the drinking water standard. This led to municipal wells in that area being shut down. The groundwater remediation process involved identifying contaminated areas, which required the utilization of AZGS hydrogeological and surficial maps before approximately 5,303 lbs. of TCE was removed from the aquifers. Similarly, AZGS products were utilized in the remediation process at the 52nd Street Motorola plant, where groundwater was contaminated with VOCs such as trichloroethylene (TCE) and tetrachloroethene (PCE) through manufacturing and energy production activities were removed.

PILLAR 3: MAKES PUBLIC ADMINISTRATION MORE EFFICIENT:

AZGS helps the public sector and the state as a whole by enabling more efficient public administration.

➤ PROPERLY ASSESSES LAND VALUE:

AZGS surficial maps are utilized by state and federal land management agencies to continuously properly assess the value of the lands that they own. The funds generated from the sale or rental of these lands goes directly towards funding public agencies and their programs. The two biggest agencies who control the valuation of lands are the Bureau of Land Management and the Arizona State Land Department. By using AZGS surficial maps, the agencies identify aggregate materials and minerals held within the lands, which once identified, can be sold or leased for the appropriate amount.

In 2016 (the last year an Annual Report was published), the Land Trust generated \$94 million in revenue from the sale of land that it owned. The Land Trust Mineral Section leased out or sold over 1.2 million acres of subsurface land and rental and royalty revenue generated by the Mineral Section from that land totaled \$8.5 million (Arizona State Land Department, 2016). These funds go directly towards funding Arizona's public-school system. In 2017, the BLM generated \$7.7 million in Mining Holding Fees revenue from BLM land within Arizona (US Department of the Interior, Bureau of Land Management, 2018). AZGS maps and reports were extensively utilized in the valuation of these lands and their proper assessment allows the public sector to generate the most revenue possible, which is applied to public schools in Arizona.

AZGS products are also required for compliance with the Aggregate Protection Act. Passed in 2011, the APA requires municipalities to identify sources of aggregate in their general planning process and to enact policies that avoid incompatible land uses (Seven years after the Aggregate Protection Act: Have we done enough?, 2018). This requirement guarantees that natural resources are preserved and can be taken advantage of. Municipalities do not have the ability to create this information themselves and AZGS is the primary supplier of maps and information indicating the location of aggregates. At the time of this writing, legislation is moving through the Arizona legislative process which would designate AZGS as the source responsible for housing this information and would require municipalities to check with AZGS on this topic during the general planning process. Preserving aggregate materials allows municipalities to appropriately plan around aggregate materials and AZGS is critical in enabling them to do so.

➤ IMPROVES THE IDENTIFICATION OF WATER RESOURCES AND ASSURANCE OF WATER SUPPLY

AZGS provides the hydrogeologic maps required for better understanding the groundwater supplies within the state of Arizona. Any new development in Arizona is legally required to abide by the Assured Water Supply Program as part of the 1980 Groundwater Management Act, which aims to protect and assure sustainable groundwater supplies. The ruling is designed to ensure any subdivided land that is purchased or leased must be able to provide a 100-year assured water supply before sales can begin. AZGS hydrogeologic maps are utilized extensively in this process to better understand groundwater levels and to demonstrate to the Arizona Department of Water Resources a 100-years supply of water. Without AZGS hydrogeological products, developers would have to contract with consultants, raising the cost, and limiting potential new developments within the state.

An example of how AZGS has helps to identify groundwater supplies would be the basin study conducted by AZGS in the Superstition Planning Area. The study served to better understand the potential of the area for water

utility developments. AZGS was contracted to help model the hydrogeologic basin and to better understand the hydrogeology in that area. AZGS helped to locate sites for borings and aligned the hydrogeologic maps with seismic data. “The budget was 1.3 million dollars and AZGS was paid \$251,000. It would have been significantly more if we had to do it on our own.” stated an SRP employee, who also cited the level of expertise, the timeliness, and affordability of AZGS’s work, when compared to that of other hydrogeologic consultants.

The Colorado River Drought Contingency Plan is federal legislation that passed on April 9th, 2019, which controls for water usage from the Colorado River. The plan, drawn up between the seven Colorado Basin states and Mexico serves to protect agriculture and the water supply for 40 million people that rely on the Colorado River after historic lows in water basins which started in the year 2000. Arizona lies in the Lower Colorado River Basin and is now required by law to create contingency plans to address these water shortages. It requires Arizona to contribute additional water to Lake Mead and provide incentives for additional voluntary water conservation. This contingency plan will require an understanding of the hydrogeologic characteristics of the Lower Colorado River Basin. AZGS products specifically address the hydrogeologic characteristics of the basin and are already utilized extensively for groundwater modeling. AZGS products will be of great significance as Arizona begins to implement its contingency plans in accordance with the Drought Contingency Plan

➤ SERVES AS AN UNBIASED FACT FINDER:

AZGS has been crucial in resolving legal disputes by serving as an unbiased state agency. AZGS’ credibility helped resolve a dispute in 2003 regarding potential contamination of the Agua Fria River near Sun City. There were concerns that aggregate and sand operations near the River were leeching into the water supply and exposing nearby residents to asbestos. AZGS conducted studies of sand and gravel deposits from the Agua Fria River drainage areas upstream of Sun City and modeled their potential interactions with the water supply. Their report showed these fears were unfounded, putting to rest the concerns and potential legal ramifications that would have been associated with asbestos contamination (Harris, 2003). If such a study were conducted by a consultant, the validity of the study’s results would have been called into question and may not have resolved the issue. By serving as an unbiased public fact-finding agency, AZGS’s reports are indisputable when it comes to legal concerns.

AZGS was also hired to map the hydrogeological characteristics of the Holocene channel and floodplain alluvium that is associated with the five tributaries that feed into the Verde River. They also consulted with ADWR in order to define sub-flow zones that fed the Verde River. This mapping and demarcating of the Holocene floodplain alluvium was critical for identifying water rights and was utilized in the adjudication processes. Over the course of the project they updated 370 miles of surficial geologic maps along the Verde River which were directly used in legally defining water rights (J.P. Cook, 2010). Without defining the Holocene channel and floodplain alluvium and the associated five tributaries, the court would not have been able to settle the water rights dispute as quickly or as inexpensively.

COMPETITOR ANALYSIS

A cross comparison study was conducted to evaluate whether there were any substitute organizations to AZGS products. Several potential substitutes were identified by users during the survey and interview processes. Though there are multiple organizations capable of creating geological maps and reports, there is no one independent agency that can reproduce the complete suite of products and historic data collection that AZGS provides for the state of Arizona. Documenting historical maps and providing a statewide mapping service for the public are services that only AZGS provides, with industry experts unable to identify viable alternatives.

Though the United States Geological Survey offers similar services, its mission is to provide geological services for the entire country, not just Arizona. Because of this, it takes a significantly longer time for USGS to create the nationwide maps that contain the information AZGS maps do. Additionally, because of its national focus they cannot produce the same detailed information that meets each individual state's geological mapping needs.

The Arizona Department of Water Resources is another public agency that can offer similar mapping and reporting capabilities, though its mission is much narrower, and caters specifically to the State's water supply needs. These maps do not offer as much information to developers, emergency response agencies, agriculturalists, or companies that deal in the minerals and mining industry. Universities have the technical ability to produce statewide geologic maps and reports, but they move slower and are contingent on receiving grants to fund projects.

The private sector was also identified as a potential competitor. Information from interviews indicated that smaller organizations were dependent on AZGS products and didn't have the time or the resources to reproduce AZGS products. When users were asked on the survey how much it would cost to replace AZGS geologic maps responses ranged from \$10,000 - \$50,000. They indicated this price was per map, with many consultants stating this need could be as frequent as a per project basis. In sum the cost to produce or acquire products similar to AZGS would result in higher costs throughout industries that utilize geologic maps and reports. This may also result in businesses leaving Arizona for states that still offered geological maps and services to the public for free.

CONCLUSIONS

The Arizona Geological Survey receives \$941k in funding from the State of Arizona and delivers tremendous value on this investment. Over the past 12 months, it saved Arizonan's over \$30 million in cost avoidance; a 30-1 ratio relative to its state funding. Beyond this dollar amount, its services enhanced the private sector, the general public, and the public sector. The dollar savings and qualitative value from these enhancements takes AZGS' value well beyond just the cost avoidance number. This is further demonstrated in survey responses, where users indicated in multiple ways the high value that they place on AZGS products and services. There is no substitute in Arizona who could replace AZGS' services without driving up cost, reducing quality, and hurting the competitiveness of Arizona's economy. This report demonstrates AZGS' strong impact on Arizona's economy and that it remains a valuable investment of State resources.

REFERENCES

- Arizona Department of Environmental Quality. (2017). *AZ Primacy for Underground Injection Control (UIC)*.
- Arizona Department of Environmental Quality. (2019). *Arizona's Aquifer Protection Permit (APP) Compliance Assistance*. Retrieved from Arizona Department of Environmental Quality: <https://azdeq.gov/node/5204>
- Arizona Department of Water Resources. (n.d.). *Water Your Facts*. Retrieved from Arizona Water Facts: <http://www.arizonawaterfacts.com/water-your-facts>
- Arizona Mining Association. (2017). *2017 Hard Rock Mining Facts*.
- Arizona State Land Department. (2016). *Annual Report 2015-2016*.
- Bureau of Reclamation. (2019, April 19). *Colorado river basin drought contingency plans*. Retrieved from [usbr.gov](https://www.usbr.gov/dcp/): <https://www.usbr.gov/dcp/>
- Davis, T. (2017). *Record Pinal County fissure shows Arizona is still prone to shifting earth levels*. Retrieved from Arizona Daily Star: https://tucson.com/news/local/record-pinal-county-ssure-shows-arizona-is-still-prone-to/article_7746322e-e4a4-55f7-bdd3-5ff9bed82662.html
- Development Services Division - Frequently Asked Questions. (n.d.). Retrieved from Arizona Department of Real Estate: <http://www.re.state.az.us/Dev/DevFaqs.aspx>
- Earth Fissures and Ground Subsidence. (n.d.). Retrieved from Arizona Geological Survey: <https://azgs.arizona.edu/center-natural-hazards/earth-fissures-ground-subsidence>
- Eller Economic and Business Research Center . (2019, April 29). *Arizona's real GDP by industry* . Retrieved from [azeconomy.org](https://www.azeconomy.org/arizona-real-gdp-by-industry/): <https://www.azeconomy.org/arizona-real-gdp-by-industry/>
- Environmental Protection Agency. (2004). *Understanding the Safe Drinking Water Act*.
- Harris, R. C. (2003). *Is Asbestos Present in the Agua Fria River Sand and Gravel* . Tucson: Arizona Geological Survey.
- Historic Preservation Laws at a Glance. (n.d.). Retrieved from West Virginia Department of Arts, Culture, and History: <http://www.wvculture.org/shpo/preslaws.html>
- J.P. Cook, P. P. (2010). *Mapping of Holocene River Alluvium Along Oak Creek, Wet Beaver Creek, West Clear Creek, Fossil Creek, and the East Verde River, Central Arizona*. Tucson: Arizona Geological Survey.
- Jackson, T., & Green, K. (2017). *Annual Survey of Mining Companies: 2016*. Retrieved from Fraser Institute: <https://www.fraserinstitute.org/studies/annual-survey-of-mining-companies-2016>
- Kleinhenz & Associates . (2011). *An Economic Impact Analysis of the Ohio Geological Survey's Products and Services*. Columbus: Kleinhenz & Associates .
- Kuepper, J. (2019). *National Instrument NI 43-101 Report of Canada*. Retrieved from The Balance: <https://www.thebalance.com/what-is-a-ni-43-101-report-1979210>
- Loverich, J., Youberg, A., Kellogg, M., & Fuller, J. (2017). *Post-Wildfire Debris-Flow & Flooding, Coconino County, Arizona*.
- Regulations Add a Whopping \$84,671 to New Home Prices. (2016). Retrieved from NAHBNow: <http://nahbnow.com/2016/05/regulations-add-a-whopping-84671-to-new-home-prices/>
- Rousse, Wade; Combrink, Thomas; The Alliance Bank Economic Policy Institute; The W.A. Franke College of Business; Northern Arizona University. (n.d.). *The Economic Impact of Post Fire Flooding: Bill Williams Mountain*.

Seven years after the Aggregate Protection Act: Have we done enough? (2018, August 3). Retrieved from Haley Aldrich: <https://www.haleyaldrich.com/insights/publications/id/583/seven-years-after-the-aggregate-protection-act-have-we-done-enough>

Subhash B. Bhagwat, V. C. (2001). *Economic Benefits of Detailed Geologic Mapping to Kentucky*. Lexington: Department of Natural Resources (Illinois State Geological Survey).

University of Indiana Capstone Class 7933. (2017). *An Economic Impact Analysis of the Indiana Geological Survey*. Bloomington: University of Indiana School of Public Affairs & Environmental Affairs.

US Department of the Interior, Bureau of Land Management. (2018). *Public Land Statistics 2017*.