An Economic Impact Analysis of the Ohio Geological Survey's Products and Services

June 2011

Prepared by
Kleinhenz & Associates

KLEINHENZ
& Associates

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

This study was prepared by Jack Kleinhenz, Ph.D. and Russ Smith, Ph.D. of Kleinhenz & Associates. Our research partners Pat Cirillo, Ph.D., and Amber Young of the Cypress Research Group developed and conducted the on-line user survey.

An Economic Impact Analysis of the Ohio Geological Survey's Products and Services

EXECUTIVE SUMMARY

The purpose of this analysis is to identify and estimate the economic benefits to the State of Ohio from the products, information, services, and expenditures provided by and associated with the Ohio Department of Natural Resources, Division of Geological Survey (commonly known as Ohio Geological Survey [OGS]). Kleinhenz & Associates advanced a theoretical framework to explain the private as well as public good benefits provided by the OGS. A method based upon a review of the literature was developed to calculate estimated benefits based upon avoided costs, percent of project budget, and annual OGS expenditures. Examples of benefits by type of user are also presented. Kleinhenz & Associates collected data from several sources. Expert viewpoints were gathered by conducting a survey of OGS users, two roundtable discussions, and by one-on-one interviews with industry experts. Secondary literature and database sources were also employed.

The benefit of the OGS was simply summed up by an environmental engineer who provided the following comment:

> "The Ohio Geological Survey (OGS) provides a critical public function for engineers and geologists throughout the state. Without the OGS, Ohio would not be as safe and particular industries would be impacted as to being able to perform their critical tasks in order to produce revenue."

Based on information collected, the average per-project replacement cost without using OGS information in 2010 was $65,800. It was estimated that 8,740 projects were undertaken based on the number of items requested from the OGS. To ascertain the calculated benefit of OGS information, the per-project replacement cost was multiplied by the number of projects undertaken, equaling a minimum benefit value of $575 million per year.

Following protocol advanced in the literature, a second estimation was made. Users indicated that 17% of their project costs would be needed to cover the cost for the information gathering or research required if OGS maps and data did not exist. Based on the per-project amount of $1,037,420 and figuring in the 17 percent increase, the 8,740 projects would have cost an additional $1.5 billion per year. These two estimates fall within the range of values reported in other studies measuring the economic benefits of geologic information.

The economic benefits of the OGS were also estimated looking solely at its budgetary expenditures of $3.2 million in 2010. This expenditure accounts for 23 additional jobs either created or supported across the state of Ohio. Sales for businesses total $5.7 million, including the $3.2 million spent by the OGS. For every $1 in state revenue the OGS receives, it receives 80 cents in federal grant money. Attracting out-of-state funds makes the OGS an "exporter" of Ohio services, thereby expanding the Ohio economy. Should the OGS lose its federal revenue, Ohio businesses would lose $2.5 million in sales, and Ohio payroll would be reduced by $1.6 million.

According to the OGS User Survey, 62 percent of respondents reported that information obtained from the OGS was either mandatory (26 percent) or critical (46 percent) to the project's success. The average amount ascribed to avoiding costly mistakes per project equaled $139,442. Users understand the importance of having quality information before beginning projects.

Multiple access points for the OGS include the Internet, telephone, e-mail and personal visits to obtain information. The OGS provides an array of information at no charge via its website. Fifty-one percent of the OGS User Survey respondents reported they did not pay anything for information obtained from the Ohio Geological Survey for their latest project. In 2010, OGS reported 34,887 sales transactions, which did not include information and maps provided free of charge. Annually, there are at least 105,500 unique page views on the OGS website.

Web-based, low-cost access, combined with improved GIS-based maps, allows a wide array of users to benefit from the constantly increasing geologic knowledge base of the OGS. Primary users include oil-and-gas exploration firms, mining companies, the Ohio Environmental Protection Agency, the Ohio Department of Transportation, and other divisions within the Ohio Department of Natural Resources. Survey products and expertise are also employed by many other governmental agencies, university researchers, K–12 educators, and a cross section of environmental and geotechnical engineering consultants that provide services to both private and public sector entities.

Based on conservative estimates, the aggregated value in 2010 of the OGS to the economy of Ohio is a minimum of $575 million. Intangible value due to public safety associated with infrastructure adds to this amount. In Ohio, the extraction industry that depends on OGS data employs more than 10,000 people, with a payroll of $559 million and sales of over $2 billion. These findings illustrate the critical value of OGS programs to Ohio's business attraction, retention, and expansion of the extraction industry and its service providers. The high degree of value added by the OGS may spur further economic development and investment within the state.

BACKGROUND AND INTRODUCTION

This study identifies and estimates the economic benefits to the State of Ohio from the products, information, and expenditures provided by and associated with the Ohio Geological Survey. Commissioned by the OGS to evaluate those economic benefits, Kleinhenz & Associates designed this study using a theoretical framework to explain the private as well as public good benefits and using methods based upon a review of the literature and data collected from several sources.

The Ohio Department of Natural Resources Division of Geological Survey (commonly known as Ohio Geological Survey [OGS]) over its nearly 175-year history has been the primary resource for Ohio's geological information, research, and support. Similar to other state geological surveys, the OGS collects and disseminates information used by industry, consultants, developers, educators, federal and state agencies, and local and regional planners. The information is essential for ongoing commerce; critically important for management and development of the state's mineral, energy, and water resources along with the wise use of the state's natural resources for tourism and recreation; and vital for the safe development and modernization of the state's infrastructure, protecting the public from losses due to geologic and natural hazards as well as anthropogenic hazards. Taken together, geologic mapping and information provide economic benefits to the state and national economies by supporting jobs and various revenues, preventing or minimizing loss due to hazards and natural disasters, and by increasing understanding of Earth's resources.

A succinct explanation of what maps provide is offered by a Canadian geological study:

> "Geological maps provide information collected at a scale pertinent to a variety of regional planning decisions. Generally, the information can inform and/or influence land-use choices such as mineral exploration, waste repository site selection, recreational and conservation designation, establishment of ecological preserves, residential and commercial construction or highway route selection to name a few." (Bernknopf et al. 2007, 5)

The geoscientific information contained in geological maps has a wide array of societal and environmental uses. The uses of maps have characteristics that commonly define a public good—nonexcludability and nonrivalry. A good is said to be *nonexcludable* if once it is produced, a consumer is free to use it. A good is said to be *nonrival* if all can use it repeatedly at no detriment to the good. Geological mapping as a public good has been discussed in the literature (Bhagwat and Ipe 2000; Bernknopf et al. 2007; Halsing, Theissen, and Bernknopf 2004; "The Value of Geologic Maps" 2010). In a normal functioning market, supply-and-demand forces determine price. The equilibrium output is determined to be optimal in that it maximizes the well-being of the buyers and sellers who are the only individuals directly affected by the transactions. A serious obstacle develops if we attempt to use this line of reasoning to a public good. The full costs and full benefits associated with public goods are difficult to measure and undervalued in terms of price. The market demand curve for a public good is either nonexistent or notably understated. Such is the case with OGS products and services.

As reported in the Journal of the Geological Association of Canada, geological maps support "an expanding range of uses, including environmental impact assessments, hazard evaluation, urban land-use planning for groundwater and aggregate." They provide fundamental knowledge for mineral resource development and extraction ("The Value of Geologic Maps" 2010). This "fundamental knowledge" is itself a unique characteristic of geological mapping, different from many public goods, in that its use value is associated only with a "knowledge-creating" process and only measurable when there is an applicable use (Bhagwat and Ipe 2000). Alternatively, the creation of public goods such as roads or water treatment has tangible and visible benefits. Consequently, estimating the "knowledge-creating process," since it remains intangible until used, poses a particular challenge in this study to estimate its value.

Ohio taxpayers benefit from the availability of high-quality geologic information made available to users via the Ohio Geological Survey. In compiling and maintaining geological information for exploration and development, users benefit from increased credibility of reports and studies, time saved in project completions, and unbiased information in maps prepared by scientists without a vested interest. As expressed in a study by the United States Geological Survey, its benefits come from "the value of information as its data is used to permit, facilitate, or improve some public or private decision or process" (Halsing, Theissen, and Bernknopf 2004, 6). This type of scientific knowledge (maps) differs from creation of other public goods that provide physical facilities of commercial or recreational use, such as parks, roads, or bridges (Bhagwat and Ipe 2000) as well as water processing plants (A. Roberts, OGS Roundtable Participant, 2011).

One government administrator said:

> "If detailed geologic information is not available we do go in the field to map the geology, rather we use what is available. Thus, there is not a cost to collect the information; rather the cost is hidden in the quality of the decision made. In areas with limited geologic information the potential for poorer decisions is greater. As you are aware, in these cases it is very hard to set a value on the cost of not having the information. [For example,] if an aquifer becomes contaminated it is very expensive to clean it up or to provide an alternative source of water."

METHODOLOGY & APPROACH

The approach taken for this study was to seek expert input from three primary sources and by employing secondary, published reports. Expert viewpoints were gathered by (1) administering a user valuation survey,[1] (2) holding two OGS user roundtable discussions, and (3) conducting one-on-one interviews with industry experts who are employed in the private and public sectors. A full list of interviewees and roundtable participants are provided in Appendix C. Finally, we computed the economic contribution of the Ohio Geological Survey to the Ohio Economy based on its $3.2 million annual budget.

Our calculations of the economic benefits of the OGS are based upon well-founded economic theory regarding public goods and benefits to society. Benefits of the OGS have been identified for the State of Ohio, its taxpayers, and the public during discussions with users and industry experts. Benefits include but are not limited to "ease of doing business in Ohio" and increased investment and jobs creation due to easily accessible geologic data and a well-informed OGS. They also accrue in the form of increased health and safety as correct, precise, and easy-to-access information is available for public purposes, such as clean water and safely built dams, roads, and bridges. Appendix A provides a theoretical and graphic description of the measurement of public goods. Kleinhenz & Associates gathered data regarding the economic vitality of the primary private industries and public agencies using products and services of the OGS. The data discussed in the following sections illustrates the size and scope of the work is dependent upon very fundamental geologic information and services provided by the OGS.

To determine the economic impact of its expenditures, the OGS provided Kleinhenz & Associates detailed expenditures for goods and services purchased by the division for the fiscal year 2010 budget. We used a well-known input/output model, developed by the Minnesota IMPLAN Group, and its accompanying database to complete the economic contribution and impact analyses.

OGS User Valuation Survey

Expert viewpoints on the value of information, products, and services derived from the OGS were gathered by administering an online survey. The objective of this survey, in particular, was to quantify the value the Ohio Geological Survey brings to its users. Our research partner, the Cypress Research Group, administered the survey beginning on March 4, 2011, and ending on March 18, 2011. The OGS provided Cypress Research Group with a list of 753 recent users of products and services with valid e-mail addresses. The products and services included online maps and data, various geologic maps, project consulta-

[1] A valuation survey consists of a series of questions asking the respondent to place a value on the benefits received or estimated replacement value of a product or service.

tion with staff members, access to the permanent archives, and regular agency publications. Note that this list of users is not a comprehensive list of all OGS customers. Instead, it is a compilation of those where e-mail addresses were captured in the course of doing business within the past year or so. In addition to capturing responses from those targeted for a survey invitation via an e-mail, potential respondents were sent a nontargeted (nonperson specific) e-mail via the distribution list (e.g., e-newsletter recipients) of several professional and educational organizations who interact, either directly or indirectly, with the OGS in the course of their operations. Finally, the general public was invited to respond to the survey via the OGS website and social media outlets.

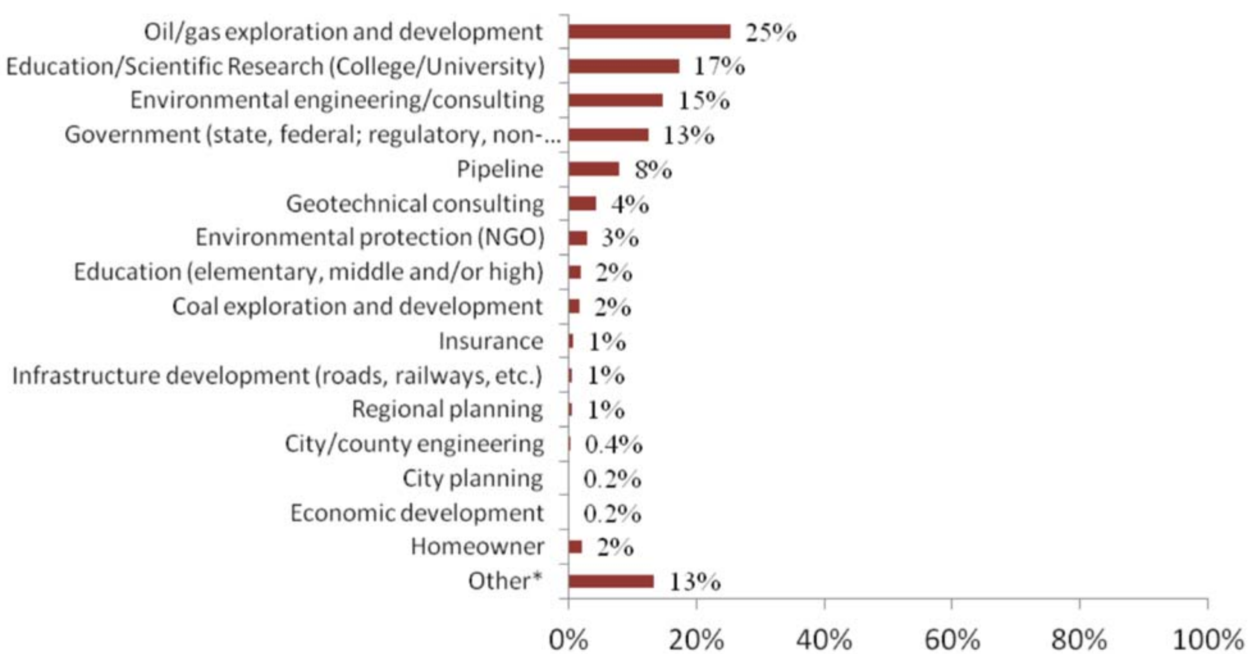
A total of 479 recent users completed surveys; 333 via the customer list of the OGS (described above; 44 percent response rate) and 146 were surveyed via the general e-mail invitation sent from partner organizations. The overall sample size of 479 affords us a margin-of-error of +/-4 percent at the 95 percent confidence level for proportional results, although we caution the reader that the sample is not random as not all recent customers of the ODNR had equal opportunity to participate in the study, making our margin-of-error slightly higher than that. We attempted to reach a wide variety of OGS users but it was not possible to identify all the users or all the potential benefits. Data sourced from nonsampling methods (e.g., Census Bureau data) are used in the overall study in order to provide accurate quantitative estimates.

The following figures illustrate selected findings from the survey:

1. The profile of users of OGS information by survey respondents.
2. Types of information obtained from OGS.
3. Percentage of projects dependent on OGS data or services.

The most common users/beneficiaries of OGS information according to our survey are members of the oil-and-gas industry. Outside of the college/university users, second to the oil-and-gas industry are environmental engineers/consultants. Note that these professionals are often engaged by other user-types shown here: oil/gas exploration/development, pipelines, coal exploration and development, infrastructure development, city/county/regional planning, and economic development. It is likely that the use of the OGS data obtained by environmental engineers and consultants ultimately impacts each of those other industry sectors and is closely related to geotechnical consulting. In contrast, we found very low usage of OGS data from

Figure 1: Users of OGS Information



*Multiple responses accepted; do not total to 100%.

city/county/regional planning or engineering personnel and developers. As noted above, it is likely that many of those entities in Ohio are actually served by the OGS through the environmental engineers/consultants.

Figure 2 illustrates the types of ongoing interactions with OGS. Users reported on the various types of information obtained from the OGS for their most recent projects. The use of maps (e.g., online, Ohio Bedrock, or Ohio Glacial/Surficial) is demanded by a large percentage of respondents. The most common maps used were those obtained online (51 percent). All products/services were used by a significant number of users: even the least-used service (Permanent Archive HRCL) was used by one in twelve respondents. On average, users obtained 2.2 different products/services from the OGS for their most recent projects. Responses from users regarding activities that benefit from the use of geological maps are shown in Appendix B.

Participants were asked about the criticality of the OGS data or maps that were employed for their most recent projects. As with any project, many components must be aligned and employed. The responses from the OGS User Survey, as shown in Figure 3, indicate that 62 percent felt that the component of OGS information was either mandatory (26 percent) or critical (46 percent) to project success. As with most projects, not every piece of information or component is critical, but the component is useful or adds a degree of certainty to decision making. Survey respondents verified this as 24 percent felt the information was useful but not critical.

RESULTS: ECONOMIC BENEFITS PRODUCED BY THE OHIO GEOLOGICAL SURVEY

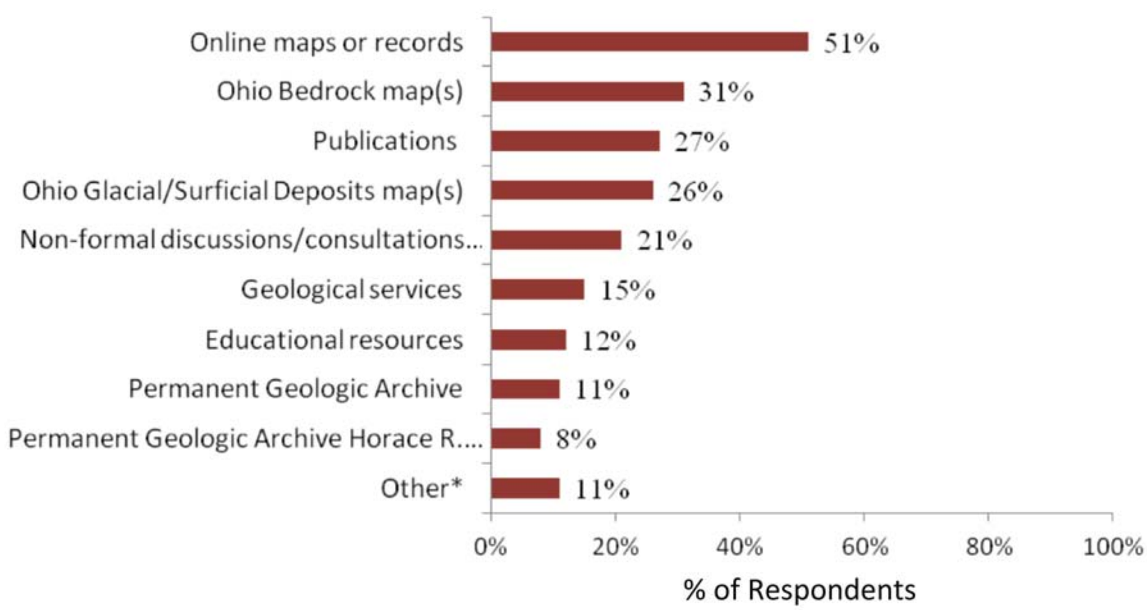
Four approaches were used to measure the monetary value of the products and services provided by the OGS. Each are distinct valuations and not to be viewed as additive.

1. Benefits Based Upon Cost of Replacement
2. Benefits Based Upon Proportion of Project Costs
3. Benefits to Industry and State of Ohio Departments
4. The Economic Contribution of the OGS to the Ohio Economy

Benefits Based Upon Cost of Replacement

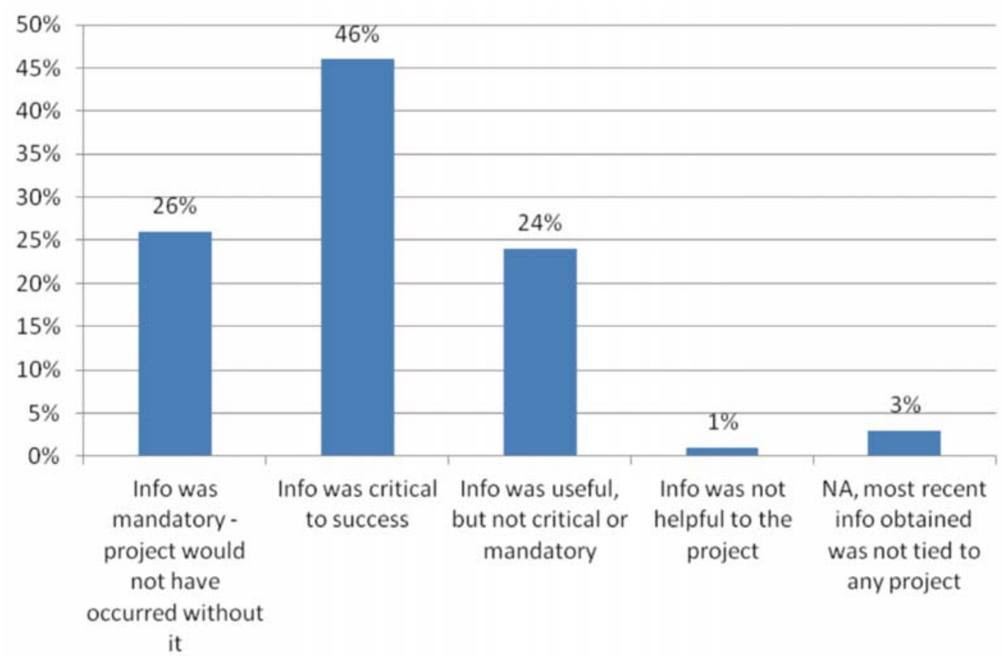
To estimate the aggregate monetary value of OGS information, we focused on a typical project in which OGS geologic information is used. Our calculations used recently collected OGS user survey data (discussed earlier) and OGS transactions records. The OGS User Survey provided data on the products

Figure 2: Information Obtained from Ohio Geological Survey for Most Recent Project*



*Multiple responses accepted; do not total to 100%.

Figure 3: Importance of Information Obtained to Project Success



and services last obtained from the Ohio Geological Survey. On average, the number of items obtained from OGS was 2.2. The documented number of transactions processed by the OGS in 2010 totaled 19,227. By dividing the number of transactions by the average number of items, we generate an estimated 8,740 projects that were undertaken by the entire population using OGS information.

OGS survey respondents were asked, when considering their most recent projects, to estimate the costs they would have incurred had the OGS information not been available. The average replacement cost reported was $124,540. The average cost of the replacement information is used as a proxy value of the average items obtained for a project. Since these items are specific to a project, the value is identical to the project savings. However, two respondents reported benefits of $5 million each. While an argument can be made to accept these two responses, Kleinhenz & Associates decided to view them as outliers.[2] By not accepting the two potential outlier responses totaling $10 million in replacement costs, the average replacement cost per OGS user drops to $65,800.

Multiplying the estimated number of projects for Ohio of 8,740 by the average replacement cost of $65,800 provides the calculated benefit of the OGS information to users of $575,092,000.[3]

Respondents revealed that costly mistakes were avoided by using OGS products and that they placed an average savings per incident at $139,442.[4] However, there is no timeframe offered for either when the incident occurred or the frequency of incidents. The $139,442 is the cost of a mistake that resulted at some historical high point. It does indicate that having geological information prior to a project's start-up is valuable and worthwhile. With this number, respondents are indicating that they know bad things can happen if they don't have good information and the costs can be real and sizable. The average

[2] Two respondents estimated replacement costs of $5 million. While this appears as a large number, it can be interpreted in one of two ways. First, if replacement costs were $5 million, then the project might not have been carried out to begin with and Ohio would have lost the economic benefit brought by the project. In this light, the replacement cost estimate of $5 million seems logical. The second viewpoint considers the potential replacement cost of the OGS gathered at great expense over the last 100 years. Indeed, if thought of in this fashion, a project that employed a great deal of data may legitimately cite a figure of $5 million for replacement costs involving geological information.

[3] Total 2010 sales receipts reported by the Ohio Geological Survey were $94,606. For the purposes of this report, due to the relative small amount, sales receipts are not deducted from the benefits estimated.

[4] Respondents to the survey were asked: "*Could you put a dollar value on that instance? (When information [from a map or other information] from the Ohio Geological Survey saved you or your organization money [or labor] or helped you avoid a costly mistake?)*"

"cost of mistake" is large and it is also a real cost number that they would have remembered actually paying (not an estimated avoided cost).

Potential for Understatement – Free Website Downloads

The reported 19,227 transactions by the OGS in 2010 is a very low number, probably due to the current recession. This number also does not include information (including maps) that was obtained at no cost to the user via the OGS website. In addition, the OGS distributed free-of-charge over 60,000 items (pamphlets, educational leaflets, rock and mineral kits) via mail and over the counter. Most of this material is provided to K–12 teachers for use in the classroom. The OGS documented that there were 52,796 unique page views on their website over the most recent six-month period. On an annualized basis, this results in an estimated 105,592 page views. This finding is not surprising since 51 percent of the OGS User Survey respondents reported they did not pay anything for the information they obtained for their latest project. OGS staff corroborates this development, reporting that sales have been reduced as the information is now available on the Internet site. Respondents that paid nothing for their information reported the average replacement cost to be $62,991. There is no estimate for the number of users of information obtained strictly from the website, and consequently, the value of these benefits are not included in our estimation above. Nonetheless, from all appearances, a large amount of information is being downloaded and therefore benefits are being obtained.

Regarding the use of online information, several of those surveyed responded:

> "We are always looking for new areas to go exploring… for oil and gas. The data that is available from the Survey is invaluable for this purpose. It's readily available to us online and is very cost-effective when putting a new exploration program together."

> "We are drilling 5 to 10 wells per year. I use the online access to the well database on a daily basis for well location data and production data. We also buy from the Survey maps of specific areas when investigating a new area."

The estimated $575 million benefit we calculated is plausible when compared to other analyses conducted in Kentucky and for the United States and Canada (Bhagwat and Ipe 2000; Halsing, Theissen, and Bernknopf 2004; Bernknopf et al. 2007). It should be noted that the Bhagwat and Ipe study looked only at the economic impact of the bedrock mapping program in Kentucky, not the state geological survey as a whole. These studies all find benefits in the billions of dollars.

A one year benefit-cost analysis results in a ratio of $575 million to $3 million[5] or a benefit-to-cost ratio of 192 to 1. Public agencies as well as private users are reaping the benefits of over 100 years of drilling, data collection, data categorization, mapping, computerization, and analysis. The unique combination of private sector drilling and sharing of borehole data combined with publically funded OGS administration has yielded a large benefit over time.

It is important to recognize that the economic value of OGS products and services are derived not just from current work but a legacy of information collected by the OGS over nearly 175 years and several thousands of borings drilled for a variety of purposes. Today's benefits are very much attributable to these past efforts as well as to the value of usage garnered today. For private-sector firms, using previously obtained resource information and reducing the need to obtain costly and perhaps redundant samples provides clear and precise monetary benefits.

Benefits Based Upon Proportion of Project Costs

Our second approach computes benefits based upon the proportion of total project costs for obtaining geological information. This is a similar method developed in the Kentucky study (Bhagwat and Ipe 2000).

Survey respondents were asked to provide an estimate of the total budget for a recent project requiring OGS information. Based on the OGS User Survey, the weighted average value of a project amounted to $1,037,420. On average, 17 percent of project costs, as reported in the User Survey, is attributable to obtaining such information if maps were not available. As discussed earlier, we estimated that 8,740 projects were undertaken by the entire population using OGS information. This estimate, used with the weighted project cost of $1,037,420 and applying a 17 percent savings, would put the average total

[5] $3 million is the approximate OGS 2010 budget.

project cost at about $176,361 per project or an aggregate benefit of $1,541,395,140.

Our estimates are consistent with the findings reported in the Kentucky study (Bhagwat and Ipe 2000). The Kentucky study also found that on average about 17 percent of project costs would be added to the cost of the project to obtain information if maps were not available.

An alternative way to compare these estimated values is to refer to the U.S. Geological Survey (USGS) study which evaluated a proposed initiative to undertake improvements to *The National Map* (Halsing, Theissen, and Bernknopf 2004). This evaluation is a cost-benefit analysis that was required to support the initiative's funding request. The report outlines a 10-year development timeframe requiring expenditures of $25 million per year and outlays of $5 million per year to maintain the National Map. The study reports that the net present value (NPV) of *The National Map* totals $2.5 billion in 2010 dollars ($2.05 billion in 2001 dollars).[6] The average time until the initial investments (the break-even period) are recovered is 14 years (Halsing, Theissen, and Bernknopf 2004, 1). The authors indicate that the NPV amount is robust even in the face of conservative assumption (Halsing, Theissen, and Bernknopf 2004, 13). By their own admission the authors are extremely conservative and seek to further develop the simulation model as they learn more about technology adoption rates and map usages over the lifetime of the National Map. Consequently, they undertake a sensitivity analysis with their model and simulate mapping benefits as reported in the literature and develop a measure of "per applied value" that ranged between $21,461 and $23,838, depending upon the application. However, they assume a per applied value of only $1,000 across all applications. This is considered a starting point because the study is "attempting to measure the change in the total value, not the total value itself;" the authors admit this lower valuation is extremely cautious (Halsing, Theissen, and Bernknopf 2004).

This is simply another example of the value of one map product. The OGS has created and/or archived many such products.

Based on the multiple perspectives we have presented in the previous two sections on evaluating economic benefits, we believe our estimates are plausible and credible based on the range of estimates provided in comparable studies. Figure 4 summarizes the continuity of findings.

[6] GDP deflator calculator applied. (See http://www.areppim.com/calc/calc_usdlrxdeflator.php.)

Benefits to Industry and State of Ohio Departments

The literature on the valuation of geological maps (Silvia 1998; M-NCPPC 1999; Halsing, Theissen, and Bernknopf 2004) identifies several broad categories of benefits:

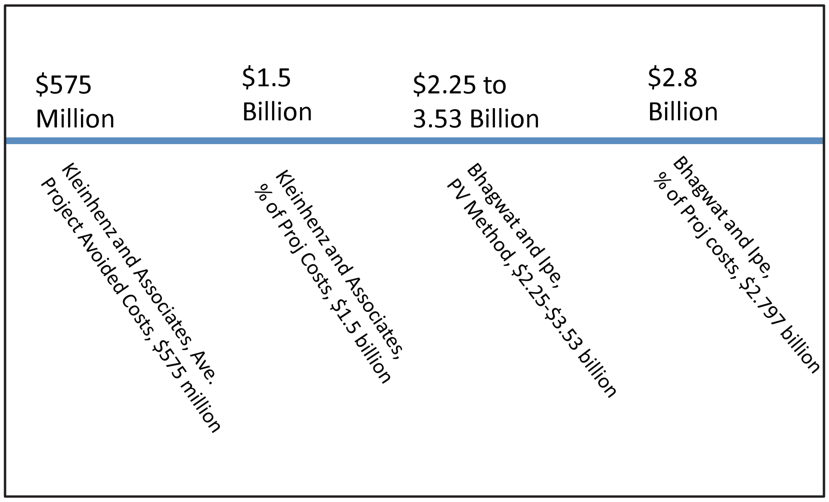
- Reduced potential for maladministration and liability
- Avoided engineering or construction costs
- More rigorous data management
- Enhanced visualization of data
- Improved analytical procedures
- More consistent access to data
- Improved services to customers
- Ability to integrate data
- Ability to respond to unexpected, unplanned, or emergency situations

In this section we examine the economic benefits of the OGS information to Ohio's extraction industries and the economic benefits applied to selected State of Ohio departments. Expert viewpoints and data were gathered by holding two roundtable discussions, and by conducting one-on-one interviews with industry experts who are employed in the private as well as public sectors. All of these sources provided opinions, instances of note, and thoughtful commentary that were used in making assumptions and critical calculations. The selected case studies are presented to provide further perspective on the benefits of geoscientific information and to validate the aggregate estimates we developed in the previous sections. The estimated benefits discussed in the following section, however, are not to be added to the values previously reported.

Benefits to the Extraction Industry

Benefits to the extraction industry are most easily measured in terms of avoided costs. Without the information provided by and constantly updated by the OGS, extractive firms would either "get less done" (according to one industry participant) or else spend a lot more on exploration for minerals, oil, and gas. Either way, doing less or spending more results in less-than-ideal business conditions in the state.

Figure 4: OGS Economic Benefits in Context of Other Studies



Interviewees provided the following specific comments regarding the benefits of OGS information:

"If the optimum spot is missed due to bad information, it might cause a 25 percent reduction in well productivity."

"If we inadvertently mine into an unmarked or mismarked gas well, then we might flood- or gas-out the mine. Not only is this a huge safety issue, but to fix the problem costs us $20,000 of materials and downtime."

"The cores pulled in the early 80's and 90's are very useful. They may amount to 5 or 6 per county, but they tell us what to expect and provide critical information about how to use our resources."

"Right now, the majors are combing through the information provided by the OGS as they research the Marcellus and Utica plays."

Table 1 summarizes key economic data and output on the extraction industry in Ohio. The industry is comprised of an estimated 742 firms that employ 10,461 people. Annual sales

Table 1: Description of Ohio Extraction Industry

Commodity	Number of Firms	Number of Operations	Production (million tons)	Sales (million $)	Employment	Payroll (million $)
Coal	32	88	27.0	$1,104	2,858	$186
Limestone and Dolomite	53	104	44.4	$391	1,506	$70
Sand and Gravel	178	252	28.1	$183	1,296	$55
Sandstone and conglomerate	20	24	1.1	$31	163	$6
Clay	23	27	0.3	$4	28	$1
Shale	15	18	0.5	$7	16	$1
Salt	4	6	5.9	$233	380	$19
Multiple Commodities					214	
Oil and Gas*	417			$665	4,000	$222
Total	742	519	107.3	$2,618	10,461	$559

Source: Wolfe (2010).
*Firms, employees and payroll based on Kleinhenz & Associates (2008). Sales of oil and gas are based upon the Wolfe (2010).

amount to $2.6 billion and, for these capital-intensive firms, payroll amounts to $559 million per year. The table is referenced later in the report.

Example of Avoided Costs for the Oil-and-Gas Industry

There are an estimated 417 oil-and-gas exploration firms in Ohio with annual sales of $665 million. These firms employ 4,000 people and support a payroll of $222 million. The Ohio oil-and-gas industry has been a long-time and very large user of products delivered by the OGS.

In a 2008 study of the Ohio Oil and Gas Industry (Kleinhenz & Associates 2008), Ohio firms spend an estimated $77 million annually on exploration and development. In the OGS User Survey, the Oil-and-Gas Survey respondents reported an average value of 13.6 percent of project costs attributable to obtaining such information if maps were not available. By this account, the industry saves $10.5 million per year by having access to maps produced by the OGS (13.6% x $77 million).[7]

An exploration and development OGS User Survey respondent stated that:

> "The company is attempting to establish a presence in Ohio with eventual goal of opening an office. Without Survey work surrounding [the] Utica Shale, Knox Unconformity, and EOR opportunities, it would not have been possible for me to convince management to spend 6 million dollars to test… these concepts."

Another exploration and development OGS User Survey respondent stated that:

> "Historic oil and gas well records are necessary on an ongoing basis for every project I work on. Much of this data is unavailable anywhere else. Without this data I could not undertake the high risk exploration and development projects that are the mainstay of our business. We'd probably have to work in other states where this type of data is available."

[7] The survey completed in Kentucky found 17 percent as an average portion of project value for all industries. This finding is very close to our Ohio finding of 13.6 percent for the oil-and-gas industry.

Example of Avoided Costs for the Industrial Minerals Industry

There are approximately 293 industrial mineral firms in Ohio with a total of 431 operations. These firms mine limestone, dolomite, sand, gravel, sandstone, conglomerate, salt, shale, and clay. Sales are estimated to total $849 million. Industrial mineral firms provide employment for 3,603 workers and have a payroll of $151 million. Most of the purchase costs of industrial minerals by users is in the form of transport costs. Consequently, much of the demand for the production from Ohio mining and extraction comes from within the state. In the case of chemical limestone, about one half of what is produced in Ohio is consumed in the state. The steel industry is the largest buyer of limestone.

According to one minerals geologist we interviewed:

> "Other states' geological surveys are not as up to date….not all have GIS capabilities. [The OGS data-rich capability] saves firms time and money. [Without OGS maps and information] I'd do a lot more out-in-the-field work, costing the firm time and money."

The commentator further stated that to fill in the knowledge gaps in the absence of the OGS his firm would be forced to drill more test boreholes costing approximately $60 per foot. This geologist argues that by knowing the geology in Ohio, he saves 50 percent of his costs; savings that range from $200,000 to several million dollars per year in Ohio. On a specific project, he identified avoidance costs of $500,000 in drilling and analysis because of OGS maps. In addition, his firm saved much more by avoiding the purchase of nearby homes for the firm's expansion. The OGS data indicated that the mineral resource formation that is being mined became wedge shaped and thus negated the need to purchase adjacent land. At another site owned by this same firm, OGS information determines that the existing mine was not played out, and more production was still available. According to this executive, these findings meant that there was no need for the firm to leave Ohio.

The interview with this one firm uncovered a minimum savings of $200,000 in avoided expenditures for drilling test boreholes. While he mentioned several cases, it was clear that such savings may not occur annually. In addition, after further discussions, not all aggregates firms would use OGS information every year. Thus, assuming that annually only 10 percent of the 293 industrial mineral firms saved $200,000, the annual avoided expenditures would total $5.8 million (29 firms X $200,000).

Example of Avoided Costs for the Coal Industry

Coal respondents in the OGS User Survey reported weighted average replacement costs as a proportion of project costs of 28 percent in the absence of OGS information. Because the data collected contained only three coal firm responses, this calculation may be overstated especially given information was collected during our industry interviews. The consensus viewpoint of the interviewees was that firms would need to spend more on labor dedicated to finding and cross-calibrating old maps as well as on drilling more boreholes without modern OGS information. One firm indicated that an additional "two or three employees might be hired on top of a staff of 30 or so," and the other estimated that "about 10 to 15 more boreholes would have to be drilled over an area of interest." The additional 10 to 15 boreholes are estimated to increase project expenditures by 10 percent per project. Based on these discussions, we concluded that project savings or cost avoidance may plausibly range in the 10–15 percent range.

Using the Ohio coal industry payroll (as reported in Table 1) of $186 million and applying the 10 percent of project costs attributable to obtaining geological information when maps are not available, the average expected savings would amount to $18.6 million. An alternative way to compare these estimated values of OGS information is to apply the 10 percent savings on the average coal industry project cost, as reported in the OGS User Survey, totaling $730,000. This approach yields annual savings of $73,000 for each of the 32 coal firms operating in Ohio or a cumulative savings of $2.3 million per year.

An environmental engineering consultant stated:

> "[Our] project involved the permitting of a longwall mining operation in southern Ohio. We used basic information from the survey which included well logs, coal seam identification, historical bulletins, cross sections, top of rock maps, etc. We used the information which had been generated over the past 100 years and because of this did not have to conduct any additional borings. This process saved expending over $3,000,000 in testing and saved over two years in time."

Examples of Avoided Costs for Environmental Engineering/Consulting

Fifteen percent of the OGS users were in environmental engineering/consulting activities. When asked, "How much did you save or avoid spending on a recent project?" their responses ranged from $1,000 to $1,000,000. The median was $10,000 while the average was $146,000. The range of responses depends upon the types of projects they were undertaking. These consultants are involved in a wide array of development projects across the state of Ohio. The 13 environmental engineers/consultants who placed a value on savings or avoided costs estimated that they saved $1.9 million in aggregate. This subset of respondents accounted for 18 percent of all environmental engineers/consultants. Multiplying $1.9 million by a multiplier of 5.5 (1/.18) yields an estimated $10 million for all the environmental engineers/consultants who responded to the survey. Since the population of environmental engineers/consultants is not known in Ohio, the $10 million estimate may be considered as a minimum for these users within the state.

One environmental engineering consultant reported:

> "Re: Solid waste landfill site characterization for permit application to Ohio EPA. The information obtained from Ohio Geological Survey was critical to be able to put site specific conditions into a regional perspective. There would be no other way to increase the confidence level of how the site conditions relate to the surrounding area."

Another environmental engineering consultant responded:

> "The data repository (well logs, cores, maps and historical records) cannot be replaced. Without that data many projects cannot be performed."

Public Purpose Benefits of Mapping in Ohio

State geological information is provided not only to the private sector in an unbiased form and with sound scientific research, but it is also used by municipal, county, state, and federal government agencies; the public; and academia. Many public sector agencies are largely dependent on published government maps to provide content for their public-purpose activities. The benefits they receive come in the form of "public good," since their objectives are often targeted at maximizing society's welfare (e.g., safety and health). Public users must also include the private agents (contractors) acting on behalf of or at the will of the public entity employing their services.

One environmental engineering consultant explained that:

> "Geological information is critical to all of our environmental investigations. This information allows us to anticipate and then understand the conditions that will affect groundwater occurrence and flow, thereby allowing us to fully understand contaminant migration pathways, potential receptors, and risk to the public. These projects will go on regardless of the source for this information; however, without the readily available information the Ohio Geological Survey provides, obtaining this information would be very time-consuming and much more costly to the Ohio industries that retain our consulting services."

A respondent from the Ohio Public Utilities Commission explained:

> "We evaluate applications for new utility infrastructure in the state of Ohio. We use data provided by ODNR to assist in the investigation of all generation and transmission projects that come before the Ohio Power Siting Board. Most recently we've used bedrock data to help staff evaluate applications for wind generation facilities."

The public (Ohio taxpayers) benefit directly as well as indirectly from the maps and data that the OGS provides. Both are discussed in the following pages. Indirect benefits to taxpayers include the facilitation of economic development within the state due to accurate, unbiased, and ready information provided within the geological maps and by the geological survey's personnel. Ohio's regulatory agencies overseeing mining, drilling, and groundwater protection are heavily dependent on OGS data and maps. These maps and data represent essential framework information so that these agencies can do their jobs efficiently and correctly using the best available geologic science.

This study does not attempt to estimate the volumes of business investments made due to the Ohio Geological Survey. However, during one of our roundtables, arguments were made regarding the regional choices that national firms have in deciding where to invest. Firms in the aggregates industry as well as in the oil-and-gas industry require accurate and readily available data as they select sites to expand. Exploring and developing the Marcellus and Utica shale gas deposits that cover the states of New York, Pennsylvania, and Ohio among others, is a good example of current location decisions faced by investors. Further investment in Ohio leads to public revenues, jobs, and wages. Currently, the extraction industries in Ohio (see Table 1) directly account for 10,461 jobs with a payroll of $559 million per year.

Following are listed just a few examples of public programs impacted by the data and services of the OGS.

Drinking Water Supplies, Ohio Department of Health (ODH)

A professional employed by the State of Ohio said:

> "I work for the Ohio EPA's drinking and ground waters division. As a ground water geologist, well logs can be paramount in determining proper placement of monitoring wells and developing potentiometric surfaces. The karst maps are critical to our Source Water Protection Program (SWAP) in those areas due to the rapid infiltration of precipitation. The karst data, along with ground water modeling help us develop our inner and outer management zones for source water protection."

An environmental engineer/consultant explained his use of OGS information:

> "It is a requirement to show the location of drinking water wells in the vicinity of a contaminated site. The well logs help to understand the geology beneath the site so an appropriate remediation technology can be used."

Large and small cities rely on wells for their water supplies. Having modern framework geologic maps provides essential data to hydrologists and lets them visualize porous deposits at depths that can be contaminated from the surface.[8] The critical issues faced by geologists and hydrogeologists analyzing water-

[8] Roundtable discussion February 24, 2011.

sheds and leach fields include the complex nature of fractured bedrock aquifers, vertical distance to bedrock and seasonal water table, and soil characteristics (the degree of porosity and percolation tests).

The identified costs of failing systems include community costs to fund sewage treatment plants and to regulate and police watershed activities. The Ohio Department of Health documented its findings on the loss of real estate values, impacted recreational areas, and the resulting moratoriums on new construction due to failing systems (ODH 2008). Selected case studies of sewage and salt contamination are discussed and serve as incidents where ODH analyzes contaminants caused by population growth and human activity. Users of such information have the public-purpose objective of clean water. The OGS works with ODH and local sewer districts to provide them geologic data to efficiently analyze a hydrogeologic setting.

One environmental engineer/consultant stated that:

> "Many of the maps developed by the OGS are used as the basis for new municipal water resources development and well exploration, aquifer modeling and environmental assessments."

Sewage Contaminant

Between 1989 and 2004, Ohio counties and communities spent over $1 billion to correct failing sewage systems. Approximately 25 percent of Ohio's households are served by some type of private sewage system. These private individuals spend $49 million per year on new and replacement septic system construction or upgrades. Selected community costs are delineated below (ODH 2008). Surficial geology maps, for instance, are currently being produced by the OGS to determine the subsoil geology to assist professionals about the suitability of a site for on-site sewerage systems. Numerous other geology maps (bedrock, glacial, topographic) reveal vital information for best decision making about this problem.

One environmental engineer/consultant to the public sector stated:

> "I am a tunnel geologist. We design deep tunnels for sanitary purposes in Ohio. [OGS] information is extremely valuable to us. Tunnel construction is highly dependent on the information we receive from ODNR Geologic[al] Survey. It directs our geotechnical investigations, tells us where we need to focus and where our data is lacking. We do not rely 100% on the data, but believe me it saves the cities around here a large sum of money."

Salt Contaminant

According to a 2010 Columbus Dispatch article (Hunt December 12, 2010), over the past two years state environmental regulators have found piles of road salt contaminating groundwater in five counties. The village of Camden, in Preble County, had to abandon its wells. Others recognize a taste difference and admit that corrosion of plumbing could be a resulting problem. Ohio EPA believes this will be a growing problem and recommends that a more cost-effective approach be taken toward one central location with larger piles of salt than to have many smaller piles dispersed. To help solve this problem, environmental professionals will review OGS geologic maps to determine the geologic setting as a means of developing a systematic approach to the solution. Depth to bedrock, type of deposits at depth, and type of bedrock are essential to creating the best solution and all can be provided by the OGS.

Table 2: Costs of Failing Sewer and Water Systems for Selected Areas—Importance of Geological Information

Area	Cost ($ millions)	Comment
Trumbull County	$100 estimated	17 communities have orders to correct failing systems.
Wayne County	$2.1 spent	Property assessments of between $6,700 and $11,900 expected.
South Bass Island[9]	$4.8 spent	Spent to update and correct sewage and water system.

[9] See ODH (2008, 50–54).

Abandoned Underground Mines

A worker with the Ohio Mine Subsidence Insurance Underwriting Association explains:

> "We have a contract with OGS and have protocol set up for use. We have provided funds for several projects they completed. We have a good ongoing relationship. Without their services, the Ohio Mine Subsidence Insurance Underwriting Association would have a difficult time functioning."

Over 800 square miles of Ohio is underlain by abandoned underground mines, many of which predate Ohio's regulations on the extractive industries. The Ohio Geological Survey is the state's permanent archive of this information and is constantly researching and adding to this collection and improving the accuracy of the locations. Modern mine permitting and operations relies on this information. Increasingly, the public is becoming aware of the dangers of building on top of abandoned mines because of the danger of subsidence. Ohio's mine subsidence insurance program is reliant on the OGS for this information. In 2009, nearly 650,000 policies were written and claims totaled $367,500 (OMSIUA 2011).

A homeowner reported using the OGS for:

> "Purchasing a house in a location where the geology under it would be safe, and not end up with costly problems that would make me lose the house."

The Ohio Department of Transportation (ODOT)

One well-known case of not knowing the existence of an underground mine involved I-70, east of Cambridge, Ohio. On March 4, 1995, a 12-foot sinkhole developed in the eastbound lanes of I-70 in Guernsey County, Ohio. Interstate 70 fell into the mine abruptly and the underground mines had to be delineated and filled before the roadway could be rebuilt (Hiner 2010). This incident prompted other geological searches in the region by the OGS that illustrated the intersection of I-70 and I-77 was constructed over abandoned mines. These mines were filled in by ODOT prior to road damage occurring.

"More than 550 lane miles of Ohio's roads run over abandoned underground mines," said Kirk Beach, geology program manager at the Ohio Department of Transportation's Office of Geotechnical Engineering. "Every lane mile requires $4.2 million to repair or reinforce," Beach said. From 1995 to 2004, ODOT spent $31.8 million to repair roads or reinforce abandoned underground mines to prevent problems. The recent bypass project near Nelsonville in Athens County cost the state $30 million in mine remediation, Beach said. Since 1985, Ohio has had more than 400 high-priority subsidence remediation projects at a total cost of $14.7 million. The mines run under 2 percent of Ohio's surface, roughly 800 square miles. They account for a combined area about three-fourths the size of Rhode Island (Hiner 2010).

The OGS is the first step for any geotechnical project. ODOT undertakes about 40 major geotechnical projects per year. Each project undertaken requires ODOT analysts and engineers to review the historical information about subsurface materials. This information is recorded in "geological notes" for each ODOT project. The project analyst refers to OGS bulletins that are published information—"a valuable tool for ODOT and constituents," said Beach. Ease of access to these bulletins is an important facet of their usefulness. As with other users of OGS maps, ODOT conducts its own drilling, sampling, and soil and rock testing to meet its design needs and also pulls its own geotechnical information it has inventoried to supplement the OGS. ODOT spends approximately $6.5 million per year for geotechnical engineering services and laboratory testing (ODOT interview).

ODOT estimated that using the OGS geological maps saved them from having to conduct three or four borings per project. Including analytical time, such costs may amount to $160,000 per project.[10] ODOT employs OGS information, products, and staff expertise to address geologic problems that deserve a trained set of eyes with a regional geologic perspective.

The Ohio Department of Natural Resources (ODNR)

Dam Safety in Ohio

Information from the OGS on geological formations is used extensively in both siting and inspecting dams in Ohio (ODNR roundtable and follow-up interviews). This information is obtained from OGS geologic maps and reports. Any

[10] Kleinhenz & Associate estimate based on $100 per foot, 200-foot borehole, analysis cost equal to cost of boring.

seepage around and under the dam must be explained to adequately address the issue. In addition, water saturation and flow paths both above and below the dam are critical to understanding the dam's capacity. In Ohio, there are approximately 4,500 nonfederal dams (ODNR 2011). Over one half of the dams are privately owned.

> "The potential for damage due to dam failures is increasing along with the increase of residential and commercial development downstream of dams. In many cases, existing dams will need to be modified to keep downstream areas safe from disaster." (ODNR 2011)

2008 Flooding of Bellevue, Ohio, Area

A respondent working in the regulatory realm explained that:

> "Many of my projects are related to karst geology and I use the survey's bedrock geology maps and sinkhole information almost daily (in a GIS format). I wish the Survey had more funding to refine their karst mapping, like they are doing in Delaware County (should be done for all the karst areas in Ohio). Karst aquifers are extremely vulnerable to contamination and karst areas are also prone to geohazards that can cost millions in construction costs. Other states allocate more funding to this extremely important area."

A rising groundwater table near Bellevue, Ohio, caused karst—sinkholes, caves, and caverns that are well documented by the OGS—to flow water. Large surface depressions caused by sinkholes prohibit the surface water from flowing to local streams. The water pooled, causing karst flooding, which can remain for many weeks.

According to the *Plain Dealer* (Nichols May 8, 2008), the city of Bellevue paid $480,000 toward the cleanup of the flooding, but many private homeowners had their homes ruined. This news article highlights the need for municipalities, prior to making land-use and development decisions, to have a complete understanding of subsurface conditions (using OGS information and staff geologists), which helps to avoid potential hazards and risk of losses as well as wasting money on inappropriate maintenance or remedies that affect drainage capabilities.

The OGS had mapped the karst features and helped write a report (see Raab et al. 2009) on the causes of the flooding for local government officials. In this case, GIS maps from a previous project were combined with new mapping to make a site-specific map to assist local citizens and government leaders with planning and zoning.

The Economic Contribution of the OGS to the Ohio Economy

Kleinhenz & Associates used a well-known input/output model, developed by the Minnesota IMPLAN Group, and its accompanying database to complete the economic contribution and impact analyses.

Using the financial reports, a distinction was made between OGS funds measuring "economic impact" and "economic contribution." To assess OGS's economic impact, Kleinhenz & Associates used the portion of OGS expenditures that originates from nonlocal funds. *Economic impact* measures the amount of economic stimulus that results from external money flowing into a region. Outside funding creates new income and new demand for local products and thus generates new activity allowing the economy to grow.

Economic contribution refers to the size of the slice of pie representing the OGS. Typically, service-oriented businesses and organizations act locally; using local dollars to perform locally needed economic activity. For example, a barber cutting hair for local residents does not stimulate the local economy but does perform an important function. We use the portion of the OGS budget that originates from non-Ohio funds to assess the OGS's economic impact. All sources of funds are employed to assess OGS's economic contribution.

Our approach to quantify the economic impacts of OGS operations employs generally accepted economic principles of input-output modeling. This framework identifies three types of impacts:

- *Direct Economic Impacts* are those changes in the flows of dollars and employment that result directly from OGS spending for employees' salaries, equipment, modernization of data, travel expenditures, facilities operations, etc.
- *Indirect Economic Impacts* are created by investment or spending by suppliers to the OGS (and the suppliers to the suppliers), whose goods and services are ultimately sold to the OGS.

- *Induced Economic Impacts* result as household income changes (created by direct and indirect effects on wages and employment) lead to a further effect on consumer spending throughout the county and regional economies. Both OGS employees as well as employees of the OGS suppliers spend their income. These expenditures reverberate or ripple through the Ohio economy to generate further sales and economic activity.

Several forms of economic impacts to the state are estimated. To determine a consistent and reliable set of meaningful results, the analysis will focus on several indicators of economic activity, described as follows:

- *Employment* – A Bureau of Economic Analysis (BEA) concept based on place of work including full-time and part-time employees, as well as seasonal employees. It is important to note that these jobs are simply "jobs" as they are counted and are not necessarily either full- or part-time positions. These jobs are distributed across a number of industries and so, in any given industry, a "job" may represent a summation of positions across a number of industries in which each industry has less than one complete or full-time-equivalent (FTE) position.
- *Labor Income* – All forms of employment income. For the IMPLAN model, this represents employee compensation and proprietor income.
- *Output* – This indicator is also estimated by the model as a measure of economic impact. Output is analogous to sales and is a measure of the total value of both the inputs to labor as well as the value of inputs from materials.

Findings of the Budgetary Economic Impact

The OGS spends approximately $3.2 million per year, $2.8 million of that is allocated to labor either directly or via charge backs made by ODNR.[11] Every $1 the OGS obtains from within the State of Ohio, either from the state government or from in-state sources, is matched with $0.80 brought in from federal grants.

The $3.2 million expenditure made by OGS accounts for an additional 23 jobs either being created or supported across the state and generates approximately $847,000 for those workers ($161,370 + $686,306). As shown in table 3, sales (or output) for businesses across the state total $5.7 million, including the $3.2 million directly spent by the OGS.[12]

Table 3: Contribution to the State of Ohio's Economy

Type of Effect	Employment	Labor Income	Output
Direct Effects	28	$2,773,165	$3,162,410
Indirect Effects	5	$161,370	$416,682
Induced Effect	18	$686,306	$2,156,935
Total Effect	51	$3,620,841	$5,736,027

The OGS attracts 80 cents of federal grant money into the state for every $1 of Ohio revenue it receives. These outside funds can be thought of as making the OGS an "exporter" of Ohio services, similar to manufacturers selling goods outside of Ohio. Such an export role serves to expand the economy of Ohio, in essence "growing the pie." Table 4 estimates the amount of growth in Ohio due to the OGS's portion of federal funding. Should the OGS lose its federal revenue, Ohio businesses would lose $2.5 million in sales, and Ohio payroll would be reduced by $1.6 million.

Table 4: Economic Impact on Ohio Economy Due to 44 Percent of Expenditures Having a Federal Source

Type of Effect	Employment	Labor Income	Output
Direct Effects	12	$1,220,193	$1,391,460
Indirect Effects	2	$71,003	$183,340
Induced Effect	8	$301,975	$949,051
Total Effect	23	$1,593,171	$2,523,851

Top sectors of Ohio's economy impacted by OGS expenditures are identified in table 5 as the model allocates business and labor's expenditures across the various sectors of the economy. Since the majority of economic impact is based upon per-

[11] Note that the 28 employees include 25 staff, 2 contract, and 1 "intern unit" comprised of 10 interns. Also note that actual budget amounts differ slightly due to the modeling necessity of allocating "chargebacks" proportionately across individual budget items. Charge-back payments are payments made by OGS to central services and other support departments. The modeled budget was reduced by approximately $34,500 in recognition that this amount was made on out-of-state expenditures and would not impact Ohio's economy.

[12] Of the $5.7 million in output, $4.6 million stays in Ohio as value added payments made to labor, proprietors, and profits.

sonnel income for OGS employees and their suppliers, sectors that are most affected are retail-type sectors.

Table 5: Ohio Economic Sectors Most Impacted

	Sector	Output
1	Services to buildings and dwellings	$208,002
2	Offices of physicians, dentists, and other health practitioners	$144,791
3	Private hospitals	$130,877
4	Real estate establishments	$127,311
5	Food services and drinking places	$115,690
6	Insurance carriers	$73,290
7	Monetary authorities and depository credit intermediation activities	$57,167
8	Petroleum refineries	$56,425
9	Nondepository credit intermediation and related activities	$48,794
10	Electric power generation, transmission, and distribution	$48,651
11	Nursing and residential-care facilities	$43,128
12	Telecommunications	$41,175
13	Retail Stores - Food and beverage	$37,284
14	Other state and local government enterprises	$35,667
15	Retail Stores - General merchandise	$33,965

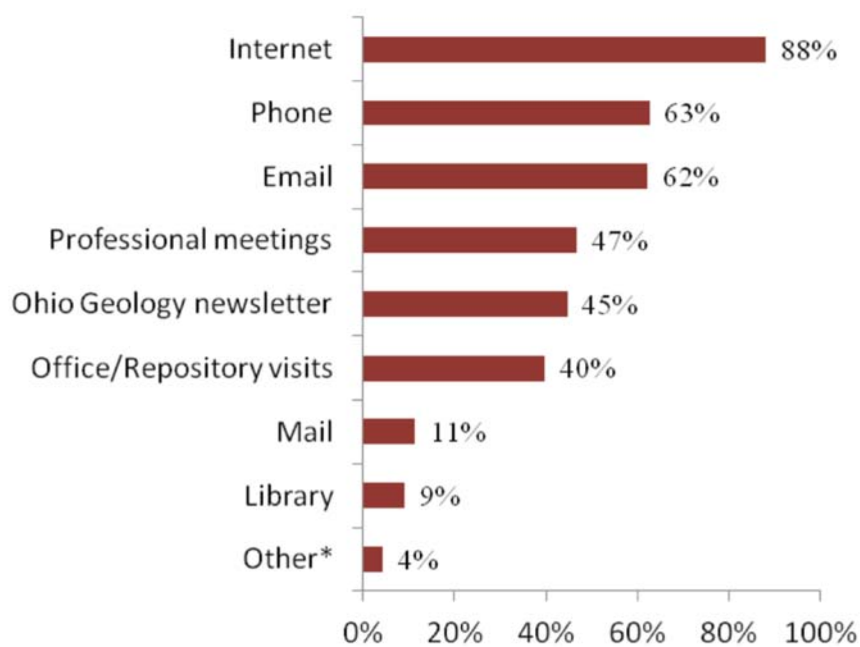
VALUE OF INTERNET ACCESS AND CONTINUED MAPPING IMPROVEMENTS

Round table participants, one-on-one interviewees, and responders to the OGS User Survey all commented on the importance of technology and how it was changing the production, usefulness, and delivery of geological maps. They emphasized that in addition to typical data from well-borings and geological information being discovered about Ohio, GIS capabilities and web-based technologies are making the information more accessible to more and different users. Both the new and existing information is electronically catalogued, cross-referenced with other GIS data, and shared.

The OGS documented that for the six-month period from September 2, 2010, to February 2, 2011, there were 52,796 unique page views recorded for their website (Internet Map Service statistics received through correspondence). Furthermore, the State Geologist and Division Chief states:

> "The more we make available via our website, the less our actual sales via the store. This is especially true of information available via our interactive map systems, from which customers can create and print their

Figure 5: Modes of Interaction with the Ohio Geological Survey



> own maps, as well as copy most data they used to purchase from us. Our oil-and-gas information has, for decades, been our most purchased data. Most of that information is now available via the web for free." (L. Wickstrom, State Geologist and Division Chief)

The OGS has attempted to meet the needs of its users and provide as many of its products in GIS-database format, allowing for many users with many different missions to match their GIS information to that of the OGS's current databases. Conducting business and providing information "on the web" has become standard business practice. Returning to paper maps stored and catalogued in filing cabinets and map drawers is unimaginable in today's high-tech world. Moreover, the cost of discovery and calibration errors would be sizeable if there were a return to paper.

Looking forward, new mapping and delivery technologies will allow the OGS to address important issues with much more knowledge and precision. This is achievable since GIS technologies and practices greatly improve the ability to compare different data sets and maps that might have incompatible formats and scale. In addition the very production of accurate, up-to-date maps based upon a GIS approach is efficient and allows for a wider array of users to easily access such information (M-NCPPC 1999).

Two studies are highlighted below in support of such improvements—one identifying public/taxpayer benefits and the other focusing on benefits to the minerals exploration industry.

A Seattle case study found that newer, more detailed maps delivered much improved information to users (Troost and Booth 2005). Better mapping yielded increased thematic information, by three to four times the previous level of detail, and provided better delineation of weak ground areas. The study compared a newer 2005 map to a 1962 map of the same region and found many valuable differences. The 2005 map identified better delineation of weak ground areas and improved three to four times the level of detail. "This new map provides the critical base for evaluating concerns for storm-water run-off and contamination." It also adds to the development of much improved seismic velocity models that are of great importance to the Seattle area (Troost and Booth 2005, 101–106).

A Canadian research study highlighted the benefits of improved mapping to mineral reserves and exploration (Bernknopf et al. 2007). Both public and private sectors can reap benefits from mineral reserves. While profit motive is evident to the private sector, the public can benefit from jobs, income, tax revenues, and especially in the case of minerals, strategic economic growth or national defense capabilities. The study examined Canada's Flin Flon Belt region and reported that "as a consequence of the quality and quantity of information either the same output can be achieved for less resources or, for the same input, output can be increased" (Bernknopf et al. 2007, 3). The production of finer resolution maps leads to mineral exploration campaigns that are more efficient and productive. The ultimate benefit is a campaign that is less risky and more effective for a set budget. The newer, high-resolution mapping yields "60% more targets and is 44% more efficient" (Bernknopf et al. 2007, 3). Authors calculated that the refined maps offered a 17 percent reduction in exploration and search efforts across all favorable domains and a 55 percent reduction in search effort within the most favorable domains. Such cost reductions can serve as proxies to estimate benefits to the Ohio oil-an-gas exploration and mining industries and provide incentive for exploration in Ohio versus other regions not having high-resolution maps.

The same Canadian report also studied the region of South Baffin Island and projected a 40 percent increase in expected targets and a 27 percent reduction in search efforts when the new, more refined map is employed versus the older, coarser map (Bernknopf et al. 2007, 4). Furthermore, the study estimated that given the lower-risk/higher-efficiency information provided by the maps, exploration investment in the South Baffin Island region would increase between CAN$2.2 million and CAN$15 million. This range depends upon the decision-makers' tolerance of risk and need for efficiency. The study also included estimates of return on investment. Using the older, coarser maps, a return on investment of 4.1 is expected. This compares unfavorably with modern maps which yield an expected return on investment (expected number of targets per million dollars spent) of between 5.1 and 6.6. Production of the newer map cost CAN$1.86 million.

Researchers found the net value of the updated, finer-resolution map to range from CAN$0.42 million to CAN$13.35 million, depending on the exploration campaign implemented (Bernknopf et al. 2007, 39). This range accounts for the additional costs of preparing the new map and the potential exploration investments stimulated by the release of the new map into the public domain. The South Baffin Island map will stimulate private sector exploration investment that might exceed the original government expenditure by as much as a factor of eight.

Modern mapping and finer resolution explain much of OGS's ongoing effort to map the geology of Ohio as new methods and data become available for use. The use of smaller-scale, increased-resolution maps allows details missed during previous mapping to be brought forth for new users and in a GIS format.

CONCLUSIONS

Studies of the value of public expenditures and investments are challenging because of the intangible nature of current and future benefits. Our study is grounded in the economic theory of public goods and uses conservative assumptions to value the OGS information and services. Based on the data gathered, we calculated the aggregate value of the OGS to approximate a minimum of $575 million to the economy of Ohio in 2010.

Our estimate is consistent with the magnitude computed in similar studies that attempt to measure the value of geological information and improved mapping. We believe our estimate is a lower bound since a large fraction of information is obtained by users downloading from the OGS website at no cost. The aggregate value reflects not only current OGS staff efforts and management but also reflects the legacy of data collected and catalogued over nearly 175 years. Moreover, this economic valuation reflects the value to a variety of users. While we attempted to reach a wide variety of OGS users; it was not possible to identify all the users or all the potential benefits. The value of specific information is dependent upon how it is employed. The OGS information generates knowledge that improves the quality and efficiency of decision-makers. The oil-and-gas industry and, in fact, most extraction industries place a relatively high value on OGS information and service. This information is part of a supply chain that leads the private sector to invest and to produce a monetized, high-value product. Alternatively lower-valued usage by the gravel industry uses OGS information only when it needs to expand, a rarity for an industry made up of firms that "mine the same hole for a generation or more." The OGS User Survey found that, the respondents saved, on average, just over $65,000 per project by using OGS data and services.

Though this study measures the avoided costs of having OGS information, the true and intangible value to public purpose institutions delivering public goods is safety. Roads cave in, dams can fail, and water supplies can be contaminated. Similar to usage by the oil-and-gas industry, the OGS information is part of a highly valued supply chain that is obtained by public institutions and their private contractors to maximize outcomes for the public. Outcomes may take the form of enhanced safety, reduced risk, reduced waste, or savings of taxpayer dollars.

Finally, a whole section of this study focused on the usefulness of the OGS strategy to provide information on its website. Embracing the latest GIS technologies and recognizing the efficient and accurate interconnection between geological and geographic GIS information, OGS users access a very efficient and low-cost method of obtaining their information. Over half of the OGS User Survey respondents indicated they downloaded information from the OGS website. Furthermore, those who were interviewed expressed appreciation for this modern delivery approach and believed that among other attributes, it made Ohio an easier region in which to explore and invest.

BIBLIOGRAPHY

American Institute of Professional Geologists (AIPG). "Importance and Future Roles of State Geological Surveys" (statement). Thornton, CO: American Institute of Professional Geologists, 2011. http://www.aipg.org/membership/Role%20of%20State%20Geological%20Surveys%202010-11-30%20final.pdf.

Bhagwat, S.B., and V.C. Ipe. *Economic Benefits of Detailed Geologic Mapping to Kentucky*. Champaign: Illinois State Geological Survey Special Report No. 3, 2000. http://library.isgs.uiuc.edu/Pubs/pdfs/specialreports/sp-03.pdf.

Bernknopf, R.L., A.M. Wein, M.R. St-Onge, and S.B. Lucas. 2007, *Analysis of Improved Government Geological Map Information for Mineral Exploration: Incorporating Efficiency, Productivity, Effectiveness, and Risk Consideration*. [n.p.]: Geological Survey of Canada Bulletin 593/U.S. Geological Survey Professional Paper 1721, 2007. http://pubs.usgs.gov/pp/pp1721/pp1721.pdf.

Boulton, R.B. Refinement and Validation of a Costs, Benefits and Impacts Model for the Targeted Geoscience Initiative—Report prepared for the Geological Survey of Canada. [Ontario]: R.B. Boulton and Associates, 1999.

DeMulder, E.F.J. "Engineering Geological Maps: A Cost-Benefit Analysis." Environmental Geological Water Science 16, no. 1, 1990: 23–28.

Halsing, David, Kevin Theissen, and Richard Bernknopf. *A Cost-Benefit Analysis of The National Map*. Reston, VA: U.S. Geological Survey Circular 1271, 2004. http://pubs.usgs.gov/circ/2004/1271/c1271.pdf.

Hiner, Erich. "Ohio's abandoned coal mines undercut homes, roads, government budgets." *College Green Magazine (collegegreen.com)*, 2010. http://www.collegegreenmag.com/ohios-abandoned-coal-mines-undercut-homes-roads-government-budgets.

Hunt, Spencer. "Proposal May Close Ohio's Coal-Ash Ponds." The Columbus Dispatch (dispatch.com), May 16, 2010. http://www.dispatch.com/live/content/local_news/stories/2010/05/16/proposals-may-close-ohios-coal-ash-ponds.html.

Hunt, Spencer. "Road Salt is Polluting Ohio Drinking Water." *The Columbus Dispatch (dispatch.com)*, December 12, 2010. http://www.dispatch.com/live/content/local_news/stories/2010/12/12/road-salt-is-polluting-ohio-drinking-water.html.

Kleinhenz & Associates. Ohio's Natural Gas and Crude Oil Exploration and Production Industry, Economic Impact Study. Cleveland: Kleinhenz & Associates, January 2008. http://www.oogeep.org/downloads/file/Publications/Value%20Study%202008.pdf.

[Maryland-National Capital Park and Planning Commission (M-NCPPC)]. *Geographic Information System—Cost/Benefit Assessment Report, Submitted to Montgomery County Council's Management and Fiscal Policy Committee.* Silver Spring, MD: Montgomery County Planning Department, April 12, 1999. http://www.montgomeryplanning.org/gis/gisbenefits.pdf.

Nichols, Jim. "Fountains of the Deep Break Open." Cleveland: *The Plain Dealer*, May 8, 2008. http://blog.cleveland.com/metro/2008/05/fountains_of_the_deep_break_op.html.

Ohio Department of Health (ODH). *Report to the Household Sewage and Small Flow On-site Sewage Treatment System Study Commission.* Columbus: Ohio Department of Health, January 1, 2008. http://www.ohiorealtors.org/public_policy/legislative_issues/SewageSystem/ODHStudy.pdf.

Ohio Department of Natural Resources (ODNR). "About the Dam Safety Program." Columbus: Ohio Department of Natural Resources, Division of Soil and Water Resources website. http://www.dnr.state.oh.us/tabid/3322/Default.aspx.

Ohio Department of Natural Resources (ODNR). Dam Safety Report 2009. Columbus: Ohio Department of Natural Resources, 2009. http://www.dnr.state.oh.us/Portals/7/dsafety/annual_rpts/DamSafetyReport2009web.pdf.

Ohio Mine Subsidence Insurance Underwriting Association (OMSIUA). Annual Report. Columbus: Ohio Mine Subsidence Insurance Underwriting Association, 2011. http://www.ohiominesubsidence.com/Content/AnnualReports/MSIAnnualReport2010.pdf.

Raab, James, Bill Haiker, Wayne Jones, Michael Angle, Rick Pavey, Mac Swinford, and Donovan Powers. *Ground Water Induced Flooding in the Bellevue, Ohio, Area Spring and Summer 2008.* Columbus: ODNR Division of Water Technical Report of Investigation 2009-1, January 2009. http://ohiodnr.gov/Portals/7/pubs/reports/Bellevue_Final_Report.pdf.

Silvia, Eliane. *Cost-Benefit Analysis for Geographic Information System—Implementation Justification—Report Submitted to Bruce Oswald, Chair of the NYS GIS Coordinating Body, March 4, 1998.* Albany: New York State GIS Clearinghouse, 1998. http://www.nysgis.state.ny.us/coordinationprogram/reports/cost/index.cfm.

Troost, K.G., and D.B. Booth. "Cost of a 1:12,000 Scale Geologic Map, $500,000; Cost of 3D data, Priceless." In Geological Models for Groundwater Flow Modeling, Workshop Extended Abstracts, Geological Society of America Annual Meeting, Salt Lake City, Utah, Oct. 15, 2005. Champaign: Illinois State Geological Survey website. http://www.isgs.illinois.edu/research/3DWorkshop/2005/pdf-files/troost-ppt.pdf (accessed July 21, 2011).

"The Value of Geologic Maps" (editorial). *Geoscience Canada* 37, no. 3 (September 2010): 119.

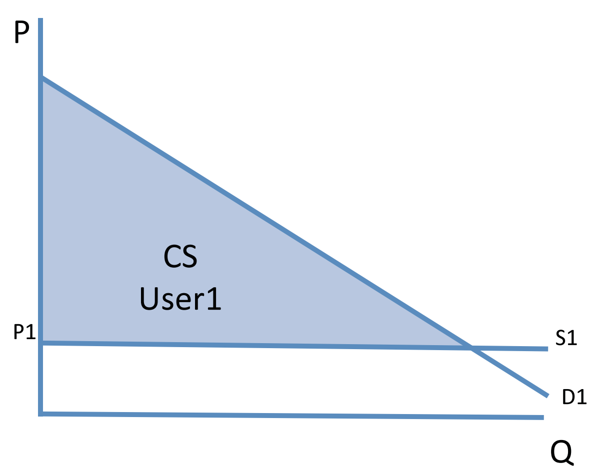
Wolfe, M.E. *2009 Report on Ohio Mineral Industries—An Annual Summary of the State's Economic Geology*. Columbus, Ohio Department of Natural Resources, Division of Geological Survey, 2010. http://www.dnr.state.oh.us/Portals/10/pdf/min_ind_report/MinInd09.pdf.

APPENDIX A: THEORY SUPPORTING THE METHODOLOGY

From an economics perspective, the value of a product to a buyer or seller is not the market price of the item. In a marketplace for a normal good, the *consumer surplus* (CS) is the difference between what a consumer is willing to pay for a product and its market price. The consumer surplus is dependent upon the demand function. The *demand function* is the amount consumers are willing to pay for additional units of a product or service. Consumers will continue to purchase additional units as long as their willingness to pay exceeds the price. They consequently receive diminishing amounts of surplus with each succeeding unit purchased, until the surplus diminishes to zero. We use the *consumer surplus theory* as a useful means in classifying and measuring benefits of the collective OGS products and services.

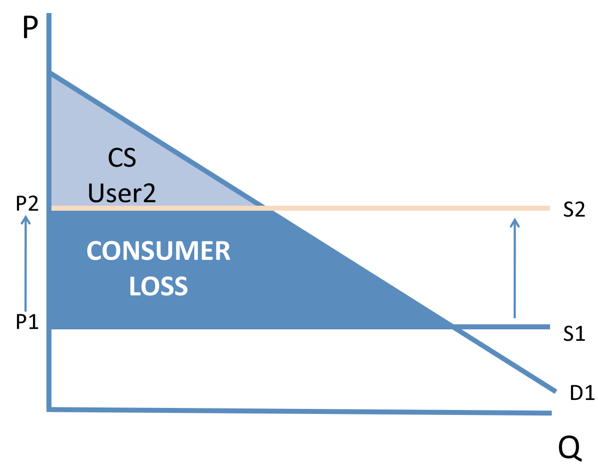
In Figure 6, consider the OGS as supplying the market (S1) for geological information at a price P1. The collective demand for OGS products and services D1 represents the presumed willingness to pay for the perceived benefits of the various extra units of OGS products. Q is quantity of products and services. For users of OGS information, the consumer surplus is illustrated as the shaded area.

Figure 6: Consumer Surplus (CS)



In the absence of the OGS, the replacement cost for the geological information to its users would increase from P1 to P2 as shown in Figure 7. The increase in price is reflected by a shift upwards in the supply curve from S1 to S2. The OGS users' consumer surplus (CS) is diminished as shown as the dark shaded area. We attempted to model the consumer surplus loss in the absence of the OGS.

Figure 7: Reduction in Consumer Surplus (CS) Due to Increase in Price



But other benefits of the OGS have been identified to the State of Ohio, its taxpayers, and the public during our discussions with users and industry experts. Benefits include but are not limited to "ease of doing business in Ohio" and increased investment and jobs creation due to a well-informed OGS. Benefits also accrue in the form of increased health and safety as correct, precise, and easy-to-access information is available for public purposes, such as clean water and safely built dams, roads, and bridges. These added benefits are reflected graphically in Figure 8. D1 represents the demand for geological information from the private sector. D2 conceptually represents the added demand for geologic information to reflect the public benefits of health, safety, and economic development and is inclusive of D1.[13] As shown in Figure 8, the shaded area represents the nonprivate sector value of the OGS. Although these public benefits are not measured in this study, we provide some explanation and summarize selected areas.

Now consider Figure 9 that combines both an in supply from S1 to S2 due to increased price of geological information and the recognition of the added demand for OGS services generated from the public sector.

[13] Public good "prices" are not determined by the market because there is no easily defined market for public goods. However, there are several methods used to estimate the value of public goods and information. We follow such methods in this study by asking the user for their value assessment.

Figure 8: Public Good as Benefits to State of Ohio

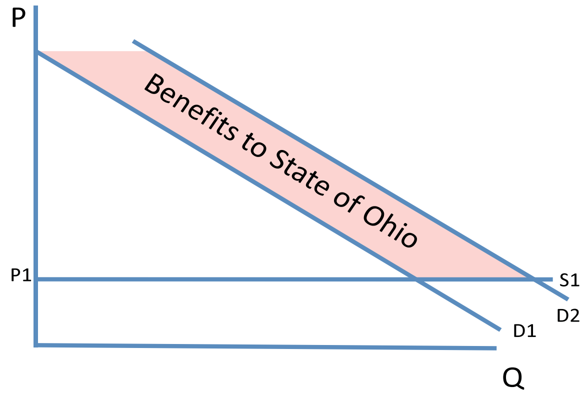
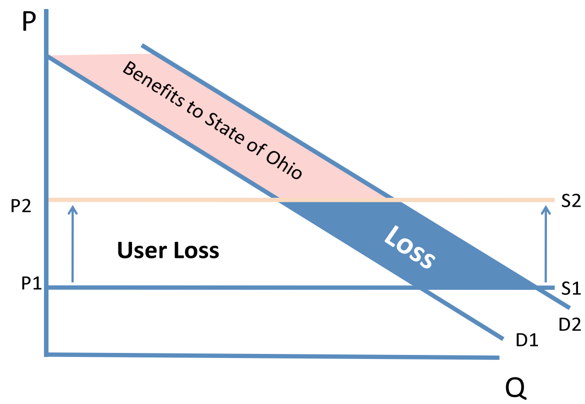


Figure 9: Loss of Consumer Surplus for State of Ohio and Private Users



In the absence of OGS there would remain both a private and public demand for geoscientific information, but a public benefit would be diminished due to the increased cost of replacement of such data. Boulton (1999) calculated the value of geosciences information to the resource exploration industries in Canada, noting that "[e]very $1 million of government investment to enhance the geoscience knowledge base will likely stimulate $5 million of private sector exploration expenditures…."

APPENDIX B: ACTIVITIES BENEFITTING FROM THE USE OF OGS MAPPING

The following figures illustrate on a statewide basis the use of OGS mapping applications by various activities as reported in the OGS User Survey. Respondents were asked specifically about 26 different types of usage. Respondents were grouped based on their project goals.

By far, the most common activities supported by maps were exploration and development (91 percent of users have activities that are supported by geological maps). The use of maps for environmental engineering and/or hazard prevention was true for almost half (45 percent) of respondents. Note that 33 percent of users cited a "city" or "regional planning" use for geological maps. Without those maps, local governments would shoulder the cost of the replacement of those maps from other sources.

Figure 10: Exploration & Development

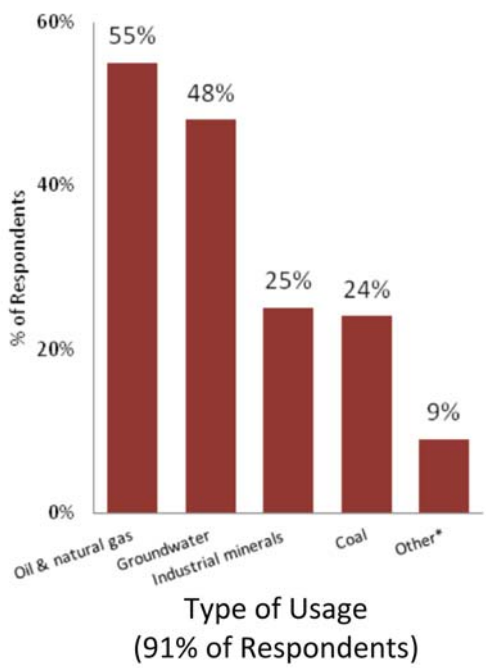


Figure 11: Environmental Consulting

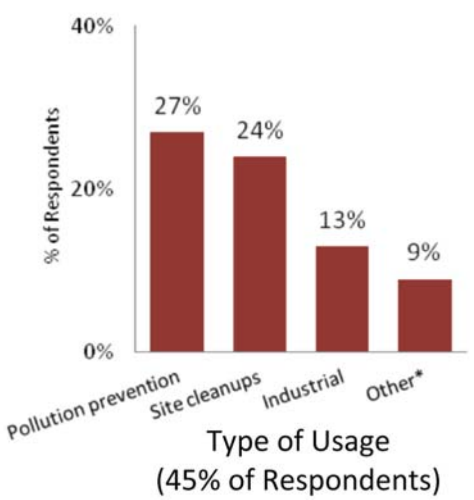


Figure 12: Hazard Prevention/Protection

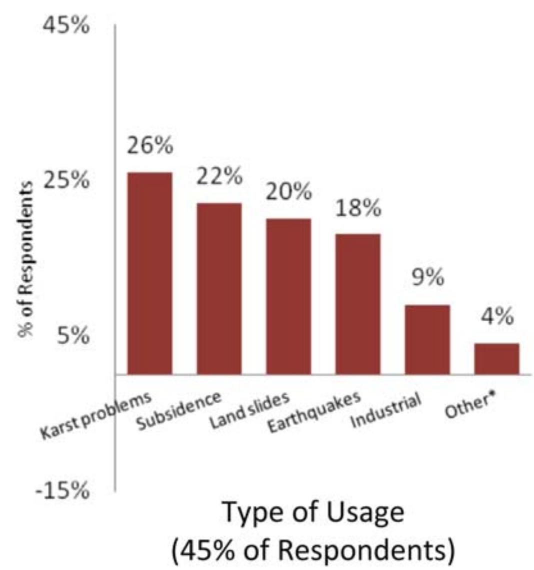


Figure 13: Engineering Applications

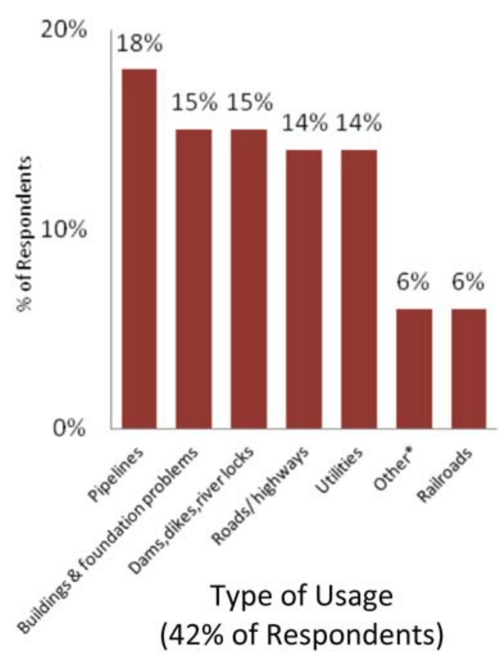


Figure 14: Property Valuation

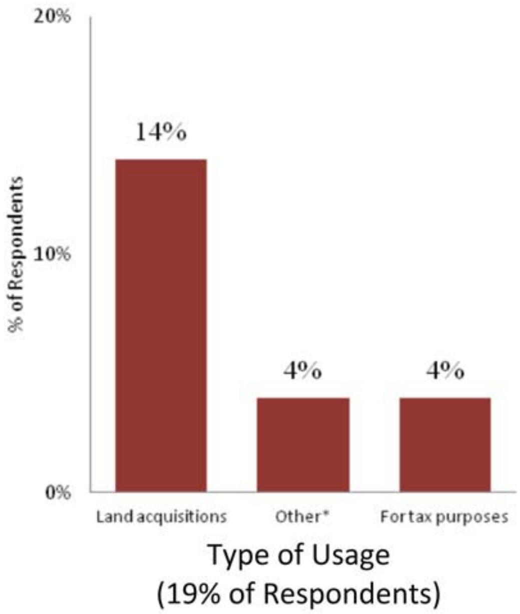


Figure 15: City Planning

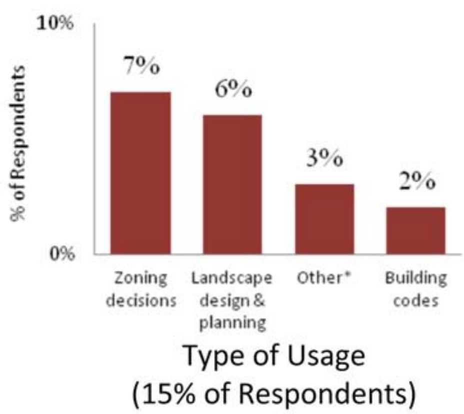
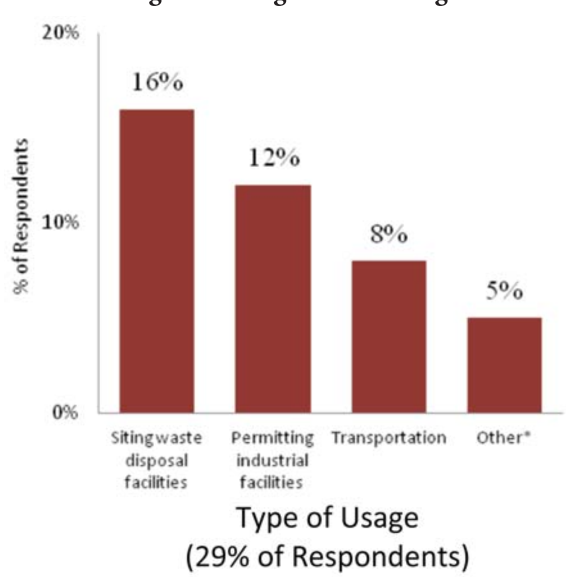


Figure 16: Regional Planning



APPENDIX C: EXPERTS ATTENDING ROUNDTABLES AND/OR INTERVIEWED

Mark Rowland – Burgess and Niple, Ltd. (retired)
Pete MacKenzie – MacKenzie Land & Exploration, President (Ohio-based oil and gas firm)
Dr. Paul Potter – Professor Emeritus, University of Cincinnati, Department of Geology
Steve Cox – Carmeuse Lime Inc., Geologist (Ohio-based aggregates firm)
Rick Ruegsegger – Ohio Department of Transportation, retired
Kirk Beach – Ohio Department of Transportation, Director, Geotechnical Services Group
David Hill – David R. Hill, Inc. (Ohio Oil and Gas Exploration Firm)
Robert Hook – Geological Consultant (to the coal industry), Austin, Texas
Herb Eagon – Eagon & Associates, Inc. (Ohio Geotechnical Firm), hydrogeologist
Brian Mott – Senior geologist at the Columbus office of DLZ Corp., a geotechnical firm
Jerry Olds – Independent oil and gas explorationist and geologist
Paul Archer – Independent oil and gas explorationist and geologist
Dick Martin – Geologist for Bowser and Morner, a large Ohio-based geotechnical firm
Chuck Lowe – Ohio EPA, Geologist, works on Class 1 hazardous waste injection well program
Rebecca Fugitt – Ohio Department of Health, Hydrogeologist, works with sewage treatment program as well as other programs
Andrew Roberts – City of Columbus, Geologist, works at the south Columbus water well field
Matt Justice – Ohio EPA, Hydrogeologist, Div. of Emergency Response, Dayton
Paul Spahr – ODNR, Division of Soil and Water Resources, Geologist and GIS coordinator
Ralph J. Haefner – Supervisory Hydrologist, U.S. Geological Survey Ohio Water Science Center
Greg Kimble – Kimble Companies, Inc. (coal, landfill, oil and gas)
Tim Miller – East Fairfield Coal