11-13-2023

Economic Impact of the Muskingum Watershed Conservancy District on the Regional Economy, 2014-2022

Mark Henning
Cleveland State University, m.d.henning@csuohio.edu

Randall Jackson

William M. Bowen
Cleveland State University, w.bowen@csuohio.edu

CSU | Levin College of Public Affairs and Education

Economic Impact of the Muskingum Watershed Conservancy District on the Regional Economy, 2014 - 2022

November 13, 2023

PREPARED BY: ENERGY POLICY CENTER
CLEVELAND STATE UNIVERSITY

PREPARED FOR: MUSKINGUM WATERSHED CONSERVANCY DISTRICT

Acknowledgements

Mark Henning, EPC Research Supervisor: designed and led the data collection, aggregation and conditioning, and prepared the data for use in the input-output models.

Contact Information: m.d.henning@csuohio.edu

Dr. Randall Jackson, Emeritus Professor of Economics, Geography, and Public Policy and former Director of Regional Research Institute at West Virginia University (specializing in economics, input-output analysis, regional development, impacts assessment, and forecasting): Dr. Jackson designed the data conditioning process, and performed the analysis using IO-Snap, a prominent software application that supports all aspects of fundamental input-output analyses.

Dr. William Bowen, Emeritus Professor of Public Administration and Urban Studies at Cleveland State University (specializing in regional analysis, economic development, environmental issues, and energy policy): Dr. Bowen led the review and interpretation of the output data, and the preparation of this report, with the support of the team.

Photos curtesy of Muskingum Watershed Conservation District

Table of Contents

Executive Summary 4
1.Introduction 5
2.Literature Review and Terminology 7
3.Research Methods 10
3.1. Data 10
3.1.1. Data for Spending on Development or Improvement of Facilities 10
3.1.2. Data for Average Annual Spending on Operations and Maintenance 11
3.2. Analysis 12
4.Findings 13
4.1. Impacts of MWCD Expenditures for Development or Improvement of Facilities 13
4.2. Impacts of MWCD Average Annual Spending on Operations and Maintenance 17
5.Discussion and Conclusions 20
6.References 21
7.Technical Appendix 22
8.Endnotes 25

List of Tables

Table 1. Total Economic Impact of MWCD Capital & Operating Expenditures in the 18-County Region for 2014 - 2022 4
Table 2. Direct Commodity and Industry Output Impacts of MWCD Improvement Expenditures by Sector (2014-2022) 14
Table 3. Total Economic, Employment and Income Impacts of MWCD Improvement Expenditures by Sector (2014 – 2022) 15
Table 4. Value Added Impacts of MWCD Improvement Expenditures by Sector (2014 – 2022) 16
Table 5. Average Annual Direct Commodity and Industry Output Impacts of MWCD Operations and Maintenance Expenditures by Sector (2014-2022) 17
Table 6. Average Annual Total Economic, Employment and Income Impacts of MWCD Operations and Maintenance Expenditures by Sector (2014 – 2022) 18
Table 7. Average Annual Value Added Impacts of MWCD Operations and Maintenance Expenditures by Sector (2014 – 2022) 19

Executive Summary

The Muskingum Watershed Conservancy District (MWCD), serving all or parts of 18 counties in Eastern Ohio, has made a significant economic contribution to the regional economy since initiation of its Master Plan for park capital improvements in 2014, enabled by growing revenues derived from Utica and Point Pleasant (together, "Utica") oil and gas leases.[1] This study assesses the economic impact of both construction projects and operations by MWCD in those 18 counties from 2014 through 2022.

MWCD 18-County Regional Economic Impact

The capital expenditures analyzed in this study occurred between 2014 and 2022 in conjunction with MWCD's multiyear capital improvement plan. Over these nine years, a total of 2,287 jobs were created to implement this Master Plan for improving the conservancy district's facilities, paying out $135.6 million in wages and benefits (see Table 1). This labor income was the combined amount earned directly by construction workers, indirectly by employees in supply chain industries that supported construction projects, or induced by workers in direct and indirect industries who spent their earnings on local goods and services. Total value added—the impact of MWCD's capital expenditures after netting out the costs of intermediate inputs—was $221.9 million, and gross output (the sales or revenue from production for industries) was $486.8 million.

Operations and maintenance (O&M) performed by MWCD supported 319 jobs on average annually from 2014-2022, with $18.1 million in wages and benefits per year. Total value added stemming from O&M was $26.5 million per year on average, with gross output exceeding a little over $50 million annually.

Altogether, the total direct, indirect and induced impacts on the region from MWCD's $310.9 million in spending on capital improvements and annual O&M during the nine-year study period was in excess of $938 million (see Gross Output column in Table 1). Even after subtracting out the costs of intermediate inputs in order to avoid double counting whereby more than one link in a supply chain can lay claim to the same gross output, MWCD's total expenditures over this time represented a benefit of more than $460 million to the region (see Value Added column in Table 1).

Table 1: Total Economic Impact of MWCD Capital & Operating Expenditures in the 18-County Region for 2014 - 2022

Period	Expenditures	Employment[2]	Labor Income	Gross Output[3]	Value Added[4]
Annual average	Capital	254	$15.1 M	$54.1 M	$24.7 M
	O&M	319	$18.1 M	$50.2 M	$26.5 M
	Combined Total	**573**	**$33.2 M**	**$104.3 M**	**$51.2 M**
Total for 2014 - 2022	Capital	2,287	$135.6 M	$486.8 M	$221.9 M
	O&M	319	$162.8 M	$451.5 M	$238.9 M
	Combined Total	**2,606**	**$298.4 M**	**$938.3 M**	**$460.8 M**

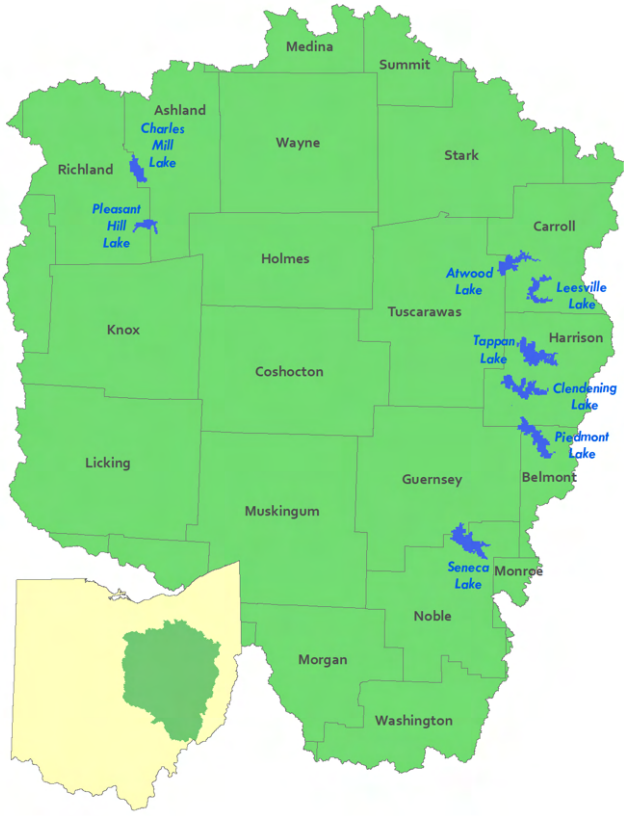
All monetary figures are in $2021 dollars.

In 2022, MWCD leased more than 7,300 acres in Harrison County, OH that will generate bonus payments in excess of $40 million.[5] MWCD anticipates millions more will be paid in royalties from this lease. Spending resulting from this lease agreement is not reflected in this study, although these revenues will catalyze further economic impact through capital improvements and ongoing operations in 2023 and beyond.

1. Introduction

The Muskingum Watershed Conservancy District (MWCD) is a government entity in Ohio, USA, responsible for managing water resources within the Muskingum River watershed. MWCD provides flood control, conservation and recreation throughout the 8,000 square mile watershed district, which covers 20% of the State of Ohio and includes all or part of 18 counties. It was established in the 1930s to address flooding issues and promote water conservation in the region. The MWCD operates a system of dams and reservoirs, including Charles Mill Lake and Seneca Lake, to regulate water flow, control floods, and provide recreational opportunities. The district plays a crucial role in balancing the needs of various stakeholders, including agriculture, industry, and environmental conservation.

From its inception, MWCD inherited oil and gas wells and existing leases with lands it acquired. MWCD added to this oil and gas program, by which acreage primarily on MWCD lands is leased to private operators in return for oil & gas royalties that support the district's operational expenses and enable it to make various recreational and other contributions to the region. Leases for traditional vertical oil and gas wells on MWCD lands that it had negotiated over the past decades have included landowner and environmental protections that were cutting edge at the time.



Prior to 2010, the annual amount of oil & gas production in Ohio was modest, at best. However, the success of operating companies using horizontal drilling and hydraulic fracturing techniques to maximize the recovery of oil and gas in a well in the Marcellus Shale in Pennsylvania, led operating companies in 2011 to come to Ohio to drill—and to successfully produce—the first horizontal wells in the Utica formation.

In 2010-2011, MWCD was presented with the opportunity to recover its minerals from these new horizontal wells. This decision was going to be important to not only the organization, but also the surrounding private lands, and oil and gas production in Ohio. MWCD would then negotiate new custom provisions and safeguards into its standard oil and gas lease and further those protections to these new horizontal wells.

Thereafter, drilling and production activities increased quickly, going from 9 wells producing the equivalent of 2.8 billion cubic feet of natural gas in 2011, to over 810 wells producing the equivalent of 511.6 billion cubic feet in 2014.[6] MWCD likewise saw a significant increase in oil & gas related revenues during this period, going from about $322,000 in average annual lease bonus payments and royalties for 2008-2010, to $28.1 million in average annual payments for 2011-2013, to $41.0 million in average annual payments for 2014-2016.[7]

In 2022, MWCD and a large operator agreed to a lease that covers more than 7,300 acres in Harrison County, OH. Similar to previous MWCD agreements, the lease contains mutually-agreed-upon criteria to mitigate risks to human health & safety, the environment, the watershed, and regional stakeholders.

Since 2014, when shale development in Ohio first began to annually generate billions of dollars' worth of drilling investment and production revenues, MWCD has received around $270 million in bonus payments and royalties from its oil and gas leases.[8] These revenues have enabled the conservancy district to develop or improve a range of facilities in the area, including construction of the $5 million water treatment plant at Atwood Lake, nearly $9 million in renovations at the Charles Milles main campground (including upgrades to utilities and new restroom & shower buildings), $10 million in long-term maintenance dredging at Tappan Lake, and about $13 million for redevelopment of Seneca Lake's Marina Point campground, including utility upgrades, new restroom/shower houses and shelters, and construction of more than 100 new RV sites.

Development of the Utica Shale has generated revenue for MWCD that has enabled it to bring economic benefits to the conservancy district's 18-county service area, including job creation, increased tax revenues, and growth in related industries such as transportation and infrastructure. This research does not consider the downstream effects of lower priced natural gas on the regional economy resulting from development on its leases. Nor does it consider environmental impacts from this development. However, the conservancy district has embedded environmental stewardship into its mission and practice, committing millions of dollars toward strengthening conservation and sustainability.[9] In accordance with its mission of responsible stewardship, MWCD has instituted operational safeguards, land management practices, and environmental protections into its leases that exceed the standard requirements found in most lease agreements (or required by Ohio environmental regulations).[10]

Increases in oil and gas revenues associated with Utica Shale development have enabled MWCD to greatly expand its scope to the point at which it now provides some of the best recreational opportunities in Ohio. It has for example made capital improvements including upgrades or construction of cabins, campgrounds, docks, playgrounds, picnic shelters, shower houses, trails, and wastewater utilities infrastructure.

MWCD has also made investments in conservation including (a) Nutrient Management Programs, (b) Cover Crop Programs, (c) Water Quality Testing and Research, (d) purchase of approximately 6000 acres in Willis Creek, (e) Acid Mine Drainage Mitigation, (f) Abandon Well Program, (g) Sustainability Programs, and (h) the Partners in Watershed Management Program. The Partners in Watershed Management Program has, for example, helped distribute more than $10 million dollars in enhanced flood mitigation grants throughout MWCD's entire service area since 2009 to address storm water management issues and to provide assistance to local communities for conservation and flood control projects that are consistent with the conservancy district's mission.[11]

In 2023, the MWCD contacted the Energy Policy Center (EPC) at Cleveland State University, declaring its interest in coming to better know and understand what sort of economic impact all of these investments and improvements have had on the regional economy. An EPC team agreed to estimate these impacts using input-output (IO) analysis.

Input-output analysis is a macroeconomic, data-driven analytical technique based on data that measure the interdependent flow of resources between different economic sectors or industries. It is widely employed to estimate the impacts of economic shocks, such as MWCD's expenditures in the region, and to analyze the ripple effects throughout the economy. It is specifically based upon data known as "input-output tables" depicting rows and columns of flows of dollars that quantify the supply chains for all of the sectors of an economy. All sales and purchase transactions are expressed in financial rather than physical units.

Three types of impacts are modeled in input-output analysis, as explained in more detail below: direct impacts, indirect impacts, and induced impacts. IO analysis determines the overall economic impacts on a region's economy when certain input levels—such as amounts of MWCD investments and improvements—are changed.

2. Literature Review & Terminology

Input-output analysis is rooted in economics and based on the simple but fundamental notion that the production of economic output requires inputs, and that these can be monetized. The inputs may take the form of raw materials or semi-manufactured goods supplied by firms in the various industrial sectors, or inputs of services supplied by households or government. Households provide labor inputs, while the government supplies a range of services such as farmland preservation, law enforcement, programs that promote healthy small businesses, and the road system. Having purchased inputs from producing sectors, or primary inputs from households, each firm or other entity in a given supply chain then produces a range of outputs, some of which become inputs into other chains. By accounting for these flows of goods, services and resources through multiple rounds of exchange and production throughout a region's economy, the analytical framework allows for a comprehensive understanding of how various sectors within a region interact with and depend on each other.

The input-output analytic approach has proven itself over many years to be a valuable tool in assessing the regional economic impacts of various economic activities and shocks on regional economic systems. It's use in assessing regional economic impacts has evolved over time, gaining prominence for its ability to provide a holistic view of the interconnectedness and impacts of economic activities (Bjerkholt and Kurz, 2006; Hewings, 2020; Miernyk, 2020; Miller and Blair, 2009; Rose and Miernyk, 1989; West, 2020). In addition to the analysis of the effects of various economic shocks, input-output analysis has been used extensively in regional economic modeling, environmental impact assessment, and policy analysis. It is widely used to help to analytically assess the potential consequences of economic activities and policies, such as tax changes, infrastructure investments, or shifts in consumer preferences. See the Technical Appendix for a more detailed introduction.

Input-output analysis has also been applied to assess the economic impact of various water-related events and activities. These include regional water planning (Daniels, Lenzen, and Kenway, 2011), agricultural water management (Sun et al., 2021), and the impact of water supply reductions in the Great Lakes (Garcia-Hernandez and Brouwer, 2021). The IO method can help in understanding how changes in—or expenditures by—one such water-related activity can reverberate throughout the regional economy. For example, when MWCD invests in infrastructure improvements or implements new technologies, this leads to direct and indirect effects on employment, income, and overall economic activity throughout the region.

One of the key insights derived from the input-output model is the concept of multiplier effects. The basic idea is that an initial infusion of dollars into a regional economic system changes hands again and again with additional transactions within the region, but the amount diminishes with each successive transaction. The amount diminishes for a couple of reasons. As dollars repeatedly change hands, leakages from the region's economy occur in the form of taxes, imports and savings. Spending also diminishes through successive rounds because part of the payment to a producer for a product goes to labor (and other value added), which means that the total value of demand for intermediate inputs will be less and less at each successive upstream link in the supply chain. Accordingly, when there is an increase in demand or investment in one sector of the economy, this effectively generates a series of ripple effects throughout the entire regional economic system. These effects can be summarized using multipliers, which show how changes or shocks in one industrial sector's output or expenditures affects other sectors. A high multiplier means that once the ripple effects have been considered, the change in that sector has a big impact upon overall output, employment, income or value added, depending on the particular multiplier in question. The key is to understand that input-output multipliers are estimated in terms of direct, indirect, and income-induced effects.

Direct effects reflect the initial changes in economic activities, such as an increase in investment by MWCD in monitoring the containment of shale drilling effluent. They are like the first domino in a chain. For example, if MWCD were to sign a $500,000 contract with Firm A to monitor the integrity of a set of wastewater tank containment berms, this is a direct expenditure or direct effect. (These containment berms—often made of PVC-coated fabric—are flat protective barriers with walls along the edges that are placed under equipment such as storage tanks to contain leaks and spills.)

The **indirect effects** reflect the fact that Firm A will spend the aforementioned $500,000 for purposes of fulfilling the terms of the contract. They might hire trained personnel to check for proper installation of spill containment berms, ensure that they are correctly positioned around the wastewater tank, perform regular visual inspections and routinely look for signs of wear, damage, or any visible issues with the berms. They may purchase infrared and conductivity sensors for real-time leak detection, remote monitoring systems to sense liquid levels, temperature and pressure, or geospatial monitors for the structure or displacement of the berms through satellite imagery. And they will probably hire inspectors to ensure adherence to industry regulations and standards for environmental compliance. All of this spending by Firm A necessary to accomplish the requirements of the primary contract with MWCD are the secondary or indirect effects of MWCD's direct investment.

When indirect effects of MWCD's investments are all monetized and aggregated across all of the sectors of the economy, and when these are compared to the direct effects, this produces a multiplier. The multipliers show how many times the direct $500,000 output initially invested by MWCD circulates in the regional economy.

Multipliers are calculated for industrial output, employment, household compensation (income), and other value added.[12] Industrial output multipliers reveal the number of times the dollar value of direct industrial output increases as a result of indirect and induced effects within the study area, before it leaks from the regional economy.[13] Employment multipliers show the number of times the indirect and induced effects of spending within the region increase the number of jobs directly supported by the initial change in economic activity. Household income multipliers show the number of times the increase in household income directly attributable to the initial change in economic activity gets multiplied by the corresponding indirect and induced spending. Value added multipliers reveal the ratio of total value added after the indirect and induced spending has occurred to the total value added that occurs as a direct result of the initial change in activity alone.

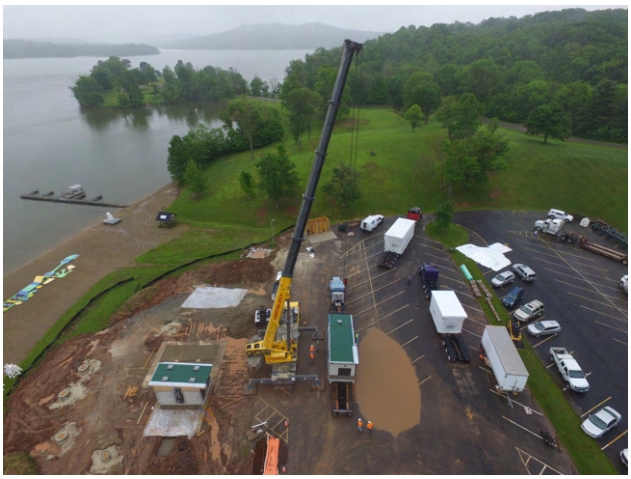
The multipliers reported herein take account not only of indirect but also of **induced effects** or changes in regional output, employment, income and value added resulting from increased consumer spending.[14] For example, to extend the same example used previously, the spill containment berm inspectors hired by Firm A might spend the part of the $500,000 they earn in salary on some new clothes for their children, or on automobile maintenance, or haircuts at the local barbershop. These dollars that run through households comprise the induced effects of MWCD's investments, and they are found and monetized through increased household spending. Income induced demand then triggers additional indirect and induced income impacts as it once again stimulates demand in upstream supply chain industries.

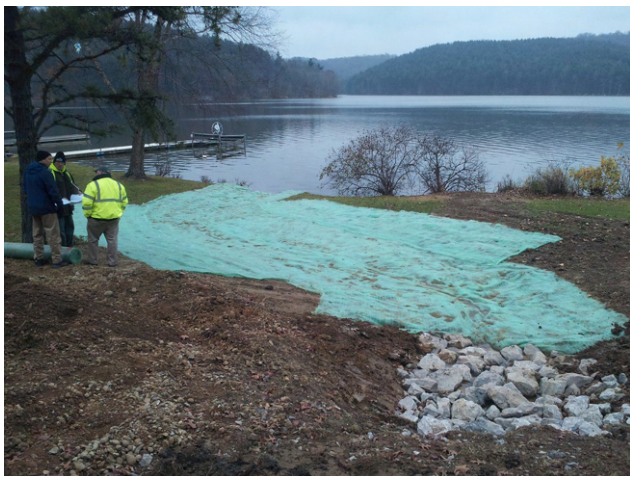
The regional focus of input-output analysis can be particularly advantageous when measuring the effects of economic shocks. It can for instance allow the assessment to be tailored to the specific district's geographic areas, such as the specific MWCD study area analyzed in this report, recognizing the unique economic structures and dependencies within the region. Moreover, input-output analysis facilitates the identification of the impacts of the shock upon key sectors that play pivotal roles in the regional economy.

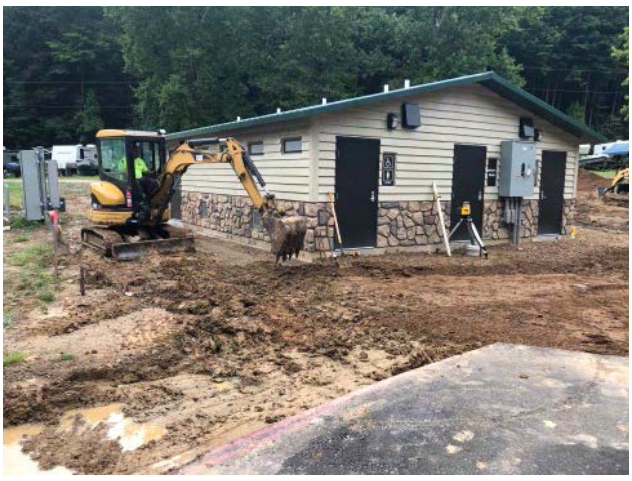
Input-output analysis assumes that the least common denominator of analysis occurs at the level of a commodity or industry. The distinction between commodities and industries is that commodities are made by industries. Industries are composed of groups of firms that produce commodities. They are usually organized and codified using the North American Industrial Classification System (NAICS), which aggregates economic activity by highly similar goods or services and businesses. Commodity data, which can also be assigned to NAICS codes, show the supply of specific commodities by each industry in the economy, and the commodities each industry uses to produce its output.

By understanding the inter-industry relationships within a given study area, stakeholders can pinpoint sectors with high multiplier effects, indicating a strong influence on overall economic activity. This information can be invaluable for strategic planning and resource allocation, guiding efforts to enhance the resilience and sustainability of regional economies.

Uses of input-output analysis to assess regional economic impacts, such as the one in this report by the EPC team, have become a cornerstone in economic research and policymaking. The ability of input-output analysis to provide a nuanced understanding of inter-industry relationships, direct, indirect and induced effects, and sectoral contributions makes it an invaluable tool for crafting targeted strategies to understand and foster regional development. As technology and methodologies continue to advance, input-output analysis is likely to remain a fundamental component of regional economic analysis, guiding efforts to build resilient and sustainable economies.







3. Research Methods

3.1 Data

The data for regional input-output analysis come from regional input-output accounts. Subsets of these accounts, namely the Use and Make tables, provide the parameters that populate the analytical tables on which IO analysis is founded. In these tables, the outputs of one sector become the inputs to another. Purchasing sectors are listed across the top of the table, and producing or selling sectors are listed down the left-hand side of the table. The values in each cell are sales from the producing or selling sector named at the left to the sector named at the top. In effect, these tables capture the value of the transactions along the supply chain for all commodity and industrial sectors of the economy.

The input output tables used in this research are derived from data published by the U.S. Department of the Census and U.S. Bureau of Economic Analysis (BEA) at the U.S. Department of Commerce. Published data used include the annual input-output accounts, employment, gross industry product and its components, government expenditures, and personal income by state and industry, by state and industry, along with personal consumption expenditures by commodity. These comprehensive accounts provide the basis for a detailed set of commodity and industry transactions that express in financial units the goods and services produced by each industry and the use of these goods and services by industries and final users.[15]

The BEA tables were customized for the MWCD study region (i.e., "regionalized") using established methods described in Jackson and Járosi (2020a). Data for 18 Ohio counties were included in the MWCD study region. These included Ashland, Belmont, Carroll, Coshocton, Guernsey, Holmes, Harrison, Knox, Licking, Morgan, Muskingum, Noble, Richland, Stark, Summit, Tuscarawas, Wayne, and Washington counties.

Standard analytical procedures were used to factor two groups of MWCD expenditures into the input output tables for the MWCD study area and to estimate their direct, indirect, and induced impacts on production within other industries. These groups were expenditures for (1) development or improvement of facilities, and (2) annual spending on operations and maintenance.

3.1.1 Data for Spending on Development or Improvement of Facilities

MWCD began receiving revenue from shale-related oil and gas development in 2014, and this was also the year in which the district's capital improvement plan (i.e., its Master Plan) began to be implemented. Therefore, data on MWCD expenditures were gathered on a project-by-project basis for 2014 - 2022.

MWCD provided access to its cloud-based accounting software to the EPC team. This platform includes detailed historical data for expenses, expenditures, vendor information, and project information. The MWCD also provided to the EPC team annual Construction in Progress (CIP) Excel workbooks going back to 2014. The CIP workbooks are the district's means of tracking the completion of projects in accordance with the Master Plan. The projects across the 2014 - 2022 CIPs encompass the universe of spending items for which data were gathered.

Within a given year's CIP workbook, there are separate worksheets for each project under development (e.g., a new waste water treatment plant, or a new campground area). Each worksheet lists every vendor involved in that project, as well as the amount MWCD paid to that vendor on that project. Vendors were involved in either construction or non-construction activities, with the latter including such things as architectural and civil engineering firms that designed and planned projects, or newspapers in which public notices were made.

For vendors involved in construction, the project worksheets within a CIP workbook included a pay application reference number linked to a vendor that worked on that project. A pay application is a detailed construction invoice a contractor submits to provide information about the progress of a contract, and also to request payment for work completed. Portable Document File (PDF) copies of these pay applications were available for download to EPC through MWCD's online accounting platform. These PDFs include itemized details of spending for construction activities, such as how much was spent on cement, how much on PVC pipes, or how much on landscaping. This allowed for construction spending to be broken down by subcategory and grouped by U.S. Bureau of Economic Analysis (BEA) industry code. (There are 71 BEA industries.) BEA industry codes generally follow NAICS codes and are tied to the BEA's input-output accounts that are the building blocks for economic impact analysis. Altogether, the EPC team gathered 112 total pay applications, each with an average of 74 spending line items that were assigned a BEA industry code based on the material or activity described therein.

For non-construction vendors, in lieu of a pay application reference number, the project worksheets within a CIP workbook included a brief description of the work performed by the vendor for that project. Such descriptions included the following: design services; geotechnical services; asbestos surveys; electrical engineering services; and well testing. Spending for non-construction activities was aggregated by BEA industry code based on these descriptions. If the appropriate BEA industry code did not seem obvious based on the description or vendor name, the EPC team consulted the business information databases Data Axle and Mergent Intellect, both of which include fields for NAICS codes that have been associated with specific companies. These NAICS codes were translated to BEA's industry classification system using a BEA crosswalk.[16]

The detail available in the pay applications and online accounting software allowed the EPC team to determine the year in which expenditures occurred for all improvement projects and spending items. All spending amounts were converted from nominal dollars to $2021 dollars using the GDP deflator for the United States.[17] These constant-dollar amounts for all spending on improvements from 2014 through 2022 were then summed by BEA industry code and across all years.

These totals represent the economic shock by industry provided by MWCD's development or improvement expenditures. They were entered as input values into the IO-Snap input-output (IO) analysis software. Altogether there were about 200 separate improvement projects over this timeframe.

3.1.2 Data for Average Annual Spending on Operations and Maintenance

Operations and maintenance data were gathered for the period from 2014 through 2022 to match the timeframe for which improvement expenditure data were gathered. MWCD's online accounting platform allows for running expense reports by year that can include transaction-level detail. For each transaction, the vendor can be identified. There are also fields in the expense reports that include the general type of expense account against which the transaction was charged (e.g., Materials & Supplies, Utilities, Operating Equipment) and that can also include a more detailed description of the transaction's purpose.

Altogether, data for roughly 87,000 such transactions were gathered for spending drawn from MWCD's general maintenance fund. Spending for operations and maintenance (O&M) was aggregated by BEA industry code for these transactions using the fields in the expense reports for vendor name, general account type, and detailed description (if available). If the appropriate BEA industry code did not seem obvious upon reviewing these fields, the EPC team consulted the Data Axle and Mergent Intellect business information databases. The EPC team would also visit company websites when necessary to determine a given vendor's line of business.

All spending amounts were converted from nominal dollars to $2021 dollars using the GDP deflator for the United States. These constant-dollar amounts for all spending on O&M for 2014 through 2022 were

then summed by year and by BEA industry. The mean of spending on O&M across all years was taken for each BEA industry, representing the economic shock provided by MWCD for spending on operations and maintenance.

These amounts for average annual spending were then entered as input values into the IO-Snap input-output (IO) analysis software.

3.2 Analysis

Input-output analysis requires the data about industries and industrial sectors to be conceptually divided into two major categories. The first of these is composed of economic activities that are considered to be determined outside of or independently of the basic, given structure of the region's economy. These external activities are the economic shock or driving force of the change that makes the impacts estimated by the analysis. In this study, the MWCD expenditures were thus considered to be the external, independent, driving factors of change in the MWCD study area's economy. The other category is composed of activities that are considered to be fixed and determined from within the structure of the production functions and supply chains for all sectors of the regional economy. These comprise the processing sector. The monetized relationships between the activities in the processing sector reveal the industrial structure of the regional economy. In this study, the customized input-output tables for the MWCD study area were thus considered to show the industrial structure of the processing sector.

The analytical procedure used in input-output analysis effectively transmits changes in the external, driving force behind the change through the fixed, determined industrial structure of the region in successive and diminishing rounds of spending. These successive rounds are the ripple effects that are captured in the multipliers. In the MWCD analysis, MWCD's expenditures and investments were assumed to be the driving force of change, and the production functions and supply chains found within the study area's industries, as well as within its households and governments, were considered to be the fixed structure of the economy within the study region.

To account for secondary production demand,[18] expenditures by commodity were transformed to expenditure demand by industry using established methods.[19] This transformation is needed for conformability with the inter-industry input-output modeling formulation used to report the impacts.

While both commodities and industries can be assigned to BEA-code categories, data from Ohio are readily available to relate employment and compensation to industry output, but not to commodity output. Therefore, while the direct effects of MWCD expenditures are reported both in terms of commodity and industry, all of the other results are reported exclusively in terms of BEA industrial sectors. The transformation from commodity to industry also helps to account for the region's (in)ability to completely satisfy local demands. See Jackson, R. and P. Járosi (2020a) for mathematical foundations.

The following six summary tables, broken down by industrial sector in the next section, enumerate the relevant results of the input-output analysis of MWCD investments and expenditures.

4. Findings

The following describes the results of the two separate analyses, one for the MWCD expenditures associated with developing and/or improving new facilities, and a second for the expenditures associated with operations and maintenance.

4.1 Impacts of MWCD Expenditures for Development or Improvement of Facilities

The total dollar output impact of MWCD's $182,145,314 direct expenditure to industry for improvement of facilities over the 2014-2022 period was $486,783,349, meaning that each dollar expended was turned over 2.67 times before leaving the 18-county regional economy that comprises the conservancy district's service area.[20] These dollars directly supported 1092 jobs, $74,124,301 of income, and $106,987,419 in value added within the study region.[21] (The average compensation for these direct jobs was $67,887.)[22] As these dollars circulated throughout the regional economy, the indirect and induced effects increased these numbers to 2287 jobs (employment multiplier = 2.09), $135,555,232 in income (income multiplier = 1.83), and $221,940,869 in value added over the period (value added multiplier = 2.07).

Of the MWCD direct improvement expenditures for commodities over the study period, 86% went to three sectors: manufacturing products ($87,820,647), professional and business services ($33,073,287), and payments to households ($35,566,044). In turn, once these MWCD expenditures were turned over and over in the regional economy, as per the multiplier effects, the total impact on these three sectors alone was $123,793,123 and 330 additional jobs in manufactured products, $39,021,371 and 295 additional jobs in professional and business services, and $135,515,695 and 524 additional jobs through payments to households, respectively.

New full-hookup RV campground at Atwood.

Table 2 is a log of how the total MWCD expenditures for development or improvement of facilities was distributed across commodities and industries. These values were obtained, as described above, by the research team's assignment of a BEA industry code based upon the material or activity described in the MWCD records. They represent the magnitude of the initial economic shock to the regional economy provided by MWCD expenditures for improvements, distributed by commodity and industry.

Table 2. Direct Commodity and Industry Output Impacts of MWCD Improvement Expenditures by Sector (2014-2022)

Sector	Direct Output Impacts by Commodity ($)	Direct Output Impacts by Industry ($)
Agriculture, Forestry, Fisheries	3,313,318	$3,306,677
Mining	8,066,386	$8,044,863
Utilities	1,199,572	$788,703
Construction*	26,056	$35,599
Manufacturing	87,820,647	$92,033,406
Wholesale	4,595,262	$4,541,337
Retail	49,464	$375,178
Transportation	797,555	$834,655
Information	818,630	$3,506,005
Finance, Insurance and Real Estate	4,919,322	$4,922,118
Professional and Business Services	33,073,287	$23,625,611
Education, Health Care, Social Assistance	---	$639,211
Arts, Entertainment, Accommodation, And Food Service	31,866	$108,984
Other Services excluding Government	802,704	$672,280
Government	1,065,241	$3,144,682
Households	35,566,004	$35,566,004
Total	**182,145,314**	**182,145,314**

Notes. The conversion from commodity space to industry space makes an adjustment for the region's ability to supply its own demands. Direct output by industry is typically less than direct output by commodity. The difference is primarily attributable to imports into the study area. This means that industry direct output (demand) will all be satisfied by intraregional production, but commodity direct output (demand) will be partly satisfied by imports.

*The relatively small amount for Construction expenditures is a result of breaking down spending on activities and materials required for capital improvements and allocating it—prior to performing the economic impact analysis—to the sectors that provided these inputs (e.g., Manufacturing, Households, etc.).

Table 3 shows the total economic, employment and income impacts of MWCD improvement expenditures by industrial sector for the period 2014-2022.

Table 3. Total Economic, Employment and Income Impacts of MWCD Improvement Expenditures by Sector (2014 – 2022)

Sector	Total Impacts ($)	Total Employment Impacts (Added Jobs)	Total Income Impacts ($)
Agriculture, Forestry and Fisheries	4,292,680	35	307,581
Mining	8,326,713	17	950,971
Utilities	5,880,540	7	1,038,467
Construction	1,965,667	13	664,186
Manufacturing	123,793,123	330	26,066,066
Wholesale	19,852,277	68	5,946,636
Retail	18,183,554	165	5,715,301
Transportation	11,397,612	73	3,862,792
Information	8,254,492	20	1,695,542
Finance, Insurance and Real Estate	49,200,002	121	5,304,326
Professional and Business Services	39,021,371	295	17,838,593
Education, Health Care and Social Assistance	31,798,368	286	17,167,978
Arts, Entertainment, Accommodation and Food Services	10,134,098	150	3,588,003
Other Services excluding Government	7,139,319	107	3,397,653
Government	12,027,837	77	6,445,134
Households	135,515,695	524	**
Total	**486,783,349**	**2,287**	**99,989,228**

Notes. ** Total household impact is the same as total income impact for households.

Table 4 gives input-output estimates of the direct and total value added to the regional economy. As described earlier, these estimates represent the sum of household compensation, payments to government, and gross operating surplus (i.e., profits) in the respective industries. Value added for the Government "industry" seen in Table 3 is defined as it is in value added for the other industries, although the bulk of the dollar value for Government value added is compensation, since intra-sectoral Government payments to Government, and gross operating surplus, are minimal or zero.

Table 4. Value Added Impacts of MWCD Improvement Expenditures by Sector (2014 – 2022)

Sector	Direct Value Added ($)	Total Value Added ($)
Agriculture, Forestry, Fisheries	1,107,499	1,547,873
Mining	4,496,575	4,049,557
Utilities	507,161	3,781,370
Construction	17,881	987,315
Manufacturing	39,264,946	50,614,854
Wholesale	2,717,843	11,880,945
Retail	219,133	10,718,795
Transportation	367,545	5,615,864
Information	2,046,253	4,697,388
Finance, Insurance and Real Estate	3,125,277	31,717,629
Professional and Business Services	14,665,753	23,917,168
Education, Health Care, Social Assistance	421,267	19,369,808
Arts, Entertainment, Accommodation, And Food Service	72,217	5,576,505
Other Services excluding Government	403,694	4,287,056
Government	1,988,368	7,612,739
Households	35,566,004	35,566,004
Total	**106,987,419**	**221,940,869**

The total value added impact of MWCD's $182,145,314 direct expenditure for improvement of facilities over the 2014-2022 period was $221,940,869 (value added multiplier = 2.07). This total value added impact of $221.9 million represents how much total MWCD expenditures for improvements benefitted the region even after netting out the costs of intermediate inputs, both from within and from outside the study area.

The MWCD total direct expenditure to the household sector (an output) is a part of the initial, external shock whose impacts are estimated by the analysis, not a part of the structure of the production functions and supply chains found within the regional economy. Thus, to avoid double-counting, the dollars used in this expenditure are not included in the calculations used to estimate the multipliers. Therefore, to accurately estimate the total income impacts of the expenditure, the value of total direct expenditures to the household sector for the MWCD improvements must be added to the sum of total income impacts based upon the multipliers. Accordingly, the total income impacts in the study area of the MWCD expenditures for improvements is $99,989,228 + $35,566,004 = $135,555,232.

4.2 Impacts of MWCD Average Annual Expenditures for Operations and Maintenance

The total dollar impact of MWCD's $14,308,281 average annual direct expenditure to industry for operations and maintenance over the 2014-2022 period was $50,166,461, meaning that each dollar expended was turned over 3.51 times before leaving the regional economy. Each year, these dollars directly supported 164 jobs, $10,213,475 of income, and $11,824,639 in value added on average within the study region. (The average compensation for these direct jobs was $62,289.) As these dollars circulated throughout the regional economy, the indirect and induced effects increased these number to 319 jobs (employment multiplier = 1.94), $18,088,493 in income (income multiplier = 1.77) and $26,543,873 in value added (value added multiplier = 2.24) annually over the time period.

Of the MWCD for operations and maintenance expenditures for commodities over the study period, a total of 79% went to utilities ($1,377,171) wholesale ($1,167,821) professional and business services ($1,702,620), and payments to households ($8,029,368). In turn, once these MWCD expenditures were turned over and over in the regional economy, as per the multiplier effects, the total impact on these four sectors alone was $25,497,635 and a total of 167 additional jobs in the region.

Table 5 is a log of how the total MWCD expenditures for operations and maintenance was distributed across commodities and industries. These values were obtained, as described above, by the research team's assignment of a BEA industry code based upon the material or activity described in the MWCD records. These represent the magnitude of the initial economic shock to the regional economy provided by MWCD average annual expenditures for operations and maintenance, distributed by commodity and industry.

Table 5. Average Annual Direct Commodity and Industry Output Impacts of MWCD Operations and Maintenance Expenditures by Sector (2014-2022)

Sector	Direct Output Impacts by Commodity ($)	Direct Output Impacts by Industry ($)
Agriculture, Forestry, Fisheries	4,545	2,961
Mining	63,331	30,254
Utilities	1,377,171	876,007
Construction	72	344
Manufacturing	308,483	294,826
Wholesale	1,167,821	1,055,518
Retail	624,496	523,833
Transportation	9,177	15,311
Information	495,777	309,215
Finance, Insurance and Real Estate	544,791	487,806
Professional and Business Services	1,702,620	1,235,013
Education, Health Care, Social Assistance	135,692	93,451
Arts, Entertainment, Accommodation, And Food Service	94,067	74,750
Other Services excluding Government	161,458	130,030
Government	734,851	1,149,595
Households	8,029,368	8,029,368
Total	**15,453,719**	**14,308,281**

Table 6 shows the total economic, employment and income impacts of MWCD expenditures per year on average for operations and maintenance by industrial sector for the period 2014-2022.

Table 6. Average Annual Total Economic, Employment and Income Impacts of MWCD Operations and Maintenance Expenditures by Sector (2014 – 2022)

Sector	Total Impacts ($)	Total Employment Impacts (Added Jobs)	Total Income Impacts ($) *
Agriculture, Forestry and Fisheries	237,810	2	16,705
Mining	170,896	0	13,269
Utilities	1,460,282	2	257,877
Construction	234,566	2	79,258
Manufacturing	4,092,501	10	790,726
Wholesale	2,494,641	9	747,256
Retail	2,864,689	26	903,079
Transportation	892,085	6	308,388
Information	1,033,750	3	213,588
Finance, Insurance and Real Estate	6,201,165	15	670,498
Professional and Business Services	3,454,219	28	1,553,443
Education, Health Care and Social Assistance	4,274,236	39	2,311,498
Arts, Entertainment, Accommodation and Food Services	1,382,501	20	487,226
Other Services excluding Government	936,348	14	445,615
Government	2,348,279	15	1,264,438
Households	18,088,493	129	**
Total	**50,166,461**	**319**	**10,062,864**

Notes. * See endnote ix for a description of the calculation of total income impacts. ** Total household impact is the same as total income impact for households.

Table 7 gives input-output estimates of the direct and total value added to the regional economy.

Table 7. Average Annual Value Added Impacts of MWCD Operations and Maintenance

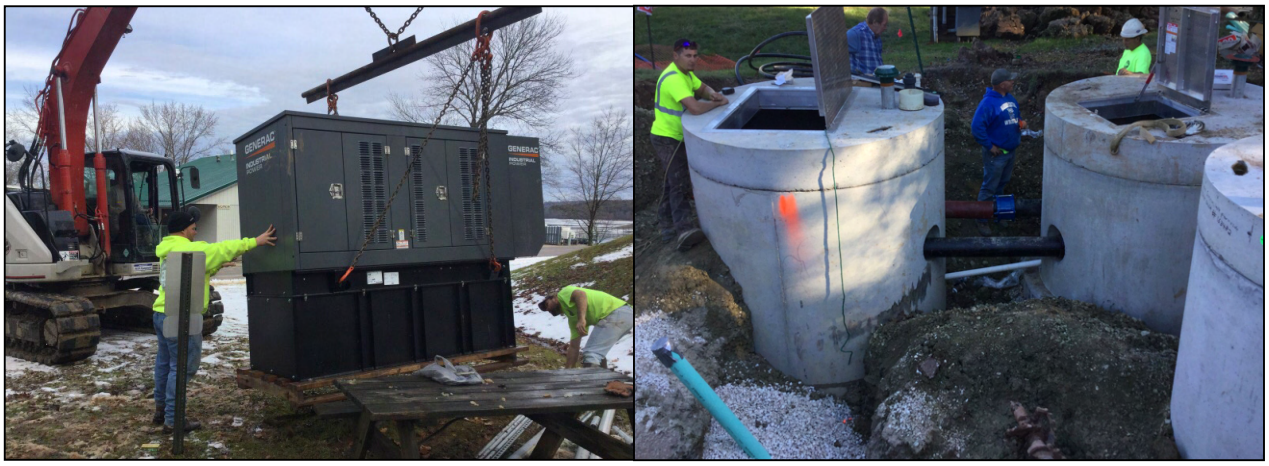
Sector	Direct Value Added	Total Value Added
Agriculture, Forestry, Fisheries	1,107	85,316
Mining	16,988	75,940
Utilities	563,300	939,007
Construction	173	117,818
Manufacturing	136,584	1,600,516
Wholesale	631,693	1,492,962
Retail	315,052	1,693,684
Transportation	7,471	443,153
Information	179,606	586,938
Finance, Insurance and Real Estate	273,989	3,953,677
Professional and Business Services	752,216	2,104,205
Education, Health Care, Social Assistance	64,864	2,608,504
Arts, Entertainment, Accommodation, And Food Service	46,292	763,806
Other Services excluding Government	78,081	562,263
Government	727,856	1,486,718
Households	8,029,368	8,029,368
Total	**11,824,639**	**26,543,873**

The total value added impact of MWCD's $14,308,281 average annual direct expenditure for operations and maintenance over the 2014-2022 period was $26,543,873 (value added multiplier = 2.24). This total value added impact of $26.5 million per year on average represents how much total MWCD expenditures for operations and maintenance benefitted the region even after netting out the costs of intermediate inputs, both from within and from outside the study area.

The MWCD total direct expenditure to the household sector for operations and management is a part of the initial, external shock whose impacts are estimated by the analysis, not a part of the structure of the production functions and supply chains found within the regional economy. Thus, to avoid double-counting, the dollars used in this expenditure are initially excluded from the calculations used to estimate the multipliers. Therefore, to accurately estimate the total income impacts of this expenditure, the value of total direct expenditures to the household sector for operations and maintenance must be added to the sum of total income impacts based upon the multipliers. Accordingly, the total annual income impacts in the study area of the MWCD expenditures for operations and maintenance is $10,062,864 + $8,092,232 = $18,092,232.

5. Discussion & Conclusions

This report analyzed a vast amount of data, some of which was from the Bureau of Economic Analysis and some directly from MWCD. The analysis, which was based upon data about the multitude of interactions that exist between industries within the study region's economic system together with longstanding, widely accepted and applied analytical techniques, provided a significant amount of precise detail about the huge contribution made by MWCD to the study region's economy over the study period. The key finding is that once the multipliers are factored in, the total direct, indirect and induced impacts of the $310,919,843 in combined improvement, operations and maintenance expenditures made to industries, governments and households by the MWCD over this nine-year time period have altogether been in excess of $938,000,000. Thus, there can be no doubt that MWCD has made a significant economic contribution to the regional economy, and that this study has significantly increased the base of available knowledge about this contribution.



Sanitary sewer improvements at Seneca.

6. References

Bjerkholt, O., and Kurz, H.D., (2006). Introduction: the History of Input-Output Analysis, Leontief's Path, and Alternative Tracks. *Economic Systems Research* 18 (4): 331–333.

Daniels, P.L., Lenzen, M., and Kenway, S.J. (2011). The Ins and Outs of Water Use: A Review of Multi-Regional Input-Output Analysis and Water Footprints for Regional Sustainability Analysis and Policy. *Economic Systems Research* 23(4): 353–370.

Hewings, G.J.D. (2020). Regional Input-Output Analysis. Reprint. Edited by Grant Ian Thrall. WVU Research Repository. https://researchrepository.wvu.edu/cgi/viewcontent.cgi?article=1009&context=rri-web-book (last accessed 10/1/2023).

Jackson, R. (1998). "Regionalizing national commodity-by-industry accounts." *Economic Systems Research*, 10(3): 223–238.

Jackson, R. and P. Járosi (2020a). "IO-Snap regionalization." IO-Snap Technical Document 2020 - 01, EconAlyze LLC, Morgantown, WV 26508. http://econalyze.com/TechDocs.

Jackson, R. and P. Járosi (2020b). "Adding foreign imports to IO-Snap regionalization." IO-Snap Technical Document 2020 - 02, EconAlyze LLC, Morgantown, WV 26508. http://econalyze.com/TechDocs.

Jackson, R. (2020). "IO-Snap cross-hauling adjustment." IO-Snap Technical Document 2020 - 03, EconAlyze LLC, Morgantown, WV 26508. http://econalyze.com/TechDocs.

Miernyk, W.H. (2020). The Elements of Input-Output Analysis. Reprint. Edited by Randall Jackson. WVU Research Repository. Original publication date: 1965. https://researchrepository.wvu.edu/cgi/viewcontent.cgi?article=1005&context=rri-web-book (last accessed 10/1/2023)

Miller, R.E. and Blair, P.D. (2009). *Input-Output Analysis: Foundations and Extensions*. Cambridge: Cambridge University Press.

Rose, A. and Miernyk W. (1989) Input–Output Analysis: The First Fifty Years, *Economic Systems Research*, 1:2, 229-272, DOI: 10.1080/09535318900000016

Sun, J.X, Yin, Y.I., Sun, S.K., Wang, Y.B., Yu, X., and Yan, K. (2021). Review on research status of virtual water: The perspective of accounting methods, impact assessment and limitations. *Agricultural Water Management* 243: 06407

West, Guy R. (2020), "Input-Output Analysis in State and Regional Economic Planning." Theory and Methods. 64. https://researchrepository.wvu.edu/rri_iotheorymethods/64 (Last accessed 10/1/2020)

7. Technical Appendix: The Economic Input-Output (IO) Model

The Economic Input-Output (IO) Model is a powerful analytical tool used in economics to study and understand the interdependencies and relationships among various sectors of an economy. This model provides a systematic framework for quantifying the flow of goods, services, and monetary transactions between different sectors and industries within an economy. It is widely employed for a range of purposes, including economic forecasting, policy analysis, and assessing the economic impacts of various events or policy changes.

Here is a more detailed description of the Economic Input-Output Model:

1. **Interconnected Sectors:** At its core, the IO model represents an economy as a complex web of interconnected sectors or industries. Each sector produces goods and services, which are then used as inputs by other sectors. These interdependencies create a network of relationships that can be represented in a matrix format.

2. **Transaction Flows:** The model quantifies the monetary flows between sectors, reflecting how much money each sector spends on inputs from other sectors. This includes intermediate goods and services, as well as final consumption and investment.

3. **Matrix Representation:** The IO model is often presented as an input-output table or matrix, where each row represents a sector, and each column represents a sector. The entries in the matrix indicate the monetary value of transactions from one sector to another. It distinguishes between transactions within the same sector (e.g., a sector purchasing its own products) and transactions between different sectors.

4. **Coefficient Matrix:** An important aspect of the model is the coefficient matrix, which shows the input requirements for each sector to produce a unit of output. This matrix captures the technical relationships between sectors and is crucial for understanding the ripple effects of changes in demand or production within the economy.

Relevant assumptions and definitions in the tables found in this report are as follows.

- The BEA industrial categories used in the analysis are listed in the column labeled "Sector."

- The columns labeled "Direct Output Impacts by Commodity" and "Direct Output Impacts by Industry" are logs of how the total MWCD expenditures were distributed across the corresponding row's BEA-code category. In other words, the direct output impacts are exogenously given primary data provided by MWCD and assigned by the EPC team to the BEA and categories listed in the "Sector" column.

- The column labeled "Total Impacts by Industry" is a mathematical product of the input-output model. It gives the sum total of the direct, indirect and induced effects of MWCD spending specifically in the corresponding industry listed in the "Sector" column, as described above.

- The column labeled "Total Employment Impacts" is the multiplicative product of the Total Impact by Industry for the corresponding industry listed in the "Sector" column, and the total

number of statewide employees per dollar of output in that industry in Ohio. In other words, it gives and estimate of the direct, indirect and induced number of jobs in the sector listed in the "Sector" column attributable to MWCD expenditures. Employment was measured by numbers of jobs (not FTE).

- The column labeled "Total Income Impacts" gives the multiplicative product, by industry, of the Total Employment Impacts (for the corresponding industry in the "Sector Name" column), and mean statewide compensation per employee in that industry. In other words, it estimates the direct, indirect and induced amount of compensation to regional employees in the sector listed in the "Sector" column attributable to MWCD expenditures.

- The Direct Value Added column gives the increment to value added in the corresponding row industry attributable directly to MWCD expenditures. Value added in a given industry represents an increase in true economic profit within that industry: it is the difference between market value of the products or services provided by that industry and the value of the sum of the inputs to its production. In this research it was estimated by the sum, by industry, of employee compensation (wages, salaries, and benefits), payments to government (indirect business taxes), and gross operating surplus (profit).

- The Total Value Added column gives the direct, indirect and induced value added, which is to say the direct value added after factoring in its multiplier.

- Average compensation equals (the sum of direct compensation impacts) / (the sum of direct employment impacts).

- Employment corresponding to direct-to-household payment value is estimated by (payment to households) / (average compensation).

- Note that the Government industry represents the annual costs of operating the government, not the final demand expenditures (like highway investments) that are a part of government's final demand expenditures.

- Multipliers are ratios of total to direct impacts.

The most used commercial economic input-output (IO) software application, IMPLAN, has gained widespread acceptance. A more recently introduced option is IO-Snap software, developed and distributed by EconAlyze, LLC. Another option, RIMS II, is available from the U.S. Bureau of Economic Analysis (BEA), though it is more generally a source for IO multipliers than a full-featured economic software analysis application, and for this reason it was not selected for use in the analysis presented in this document. Below, we compare IMPLAN and IO-Snap, which have some differences in terms of their features, applications, costs, and user bases.

1. Developer and Availability: Both IMPLAN and IO-Snap are commercial software applications developed and maintained by private companies. IMPLAN is developed and maintained by the Implan Group, LLC. It is widely used in the United States and has recently introduced data and application support for some non-U.S. economies. IO-Snap is developed by EconAlyze LLC, also a private company. Its data and application tools do not support applications outside the U.S. Both applications support subnational regional and national data and tools of analysis.

2. Geographic Coverage: IMPLAN data cover substate geographies such as counties, whereas IO-Snap is primarily geared to U.S., state, and multi-state regions, by default. However, users with sub-state employment and or income data by industry can use IO-Snap to generate corresponding customized geographical regions.

3. Sectoral Detail: Implan data are classified into more than 400 industrial and commodity sectors founded on the U.S. Bureau of Economic Analysis (BEA) benchmark input-output accounts that are published every five years. IO-Snap's sectoral detail is nearly identical to that of the BEA's annual input-output accounts. Note that when all data are known and accurate, more sectoral detail will result in more accurate impacts assessment results. However, as geographical regions become smaller (smaller economies as measured by, e.g., numbers of employees, gross product,etc.), an increasing number of critical parameters are suppressed in published governmental reports and hence the need for imputing missing data increases, often quite dramatically. The ratio of the number of reported data values to the number of imputed data values becomes smaller as region size decreases. Recent preliminary empirical experiments have shown that the uncertainty and error that typically accompany data imputation result in a trade-off between sectoral detail and overall model accuracy; i.e., greater detail may come with a loss of accuracy.

4. User Base: Both IMPLAN and IO-Snap users need at least a minimal foundation in economic principles, but in general, IMPLAN requires less user sophistication than IO-Snap. IO-Snap users often use the application not only to generate information from default analytical features as with IMPLAN, but they can also take advantage of user-friendly support for exporting data to be further processed or used as the foundation for computable general equilibrium, simulation, and other models, or simply for users who prefer to generate the regional accounts and then use supplementary software (e.g., Matlab®) to implement the impact assessment. This latter case was employed for the analysis reported here.

5. Cost: IMPLAN allows for local regional analysis at very granular levels of sectoral detail, corresponding to the 6-digit NAICS level. As previously noted, this can necessitate data imputation or estimation as federal agencies generally do not release data that is highly detailed with respect to both geography and industrial sector so as to ensure that data for individual persons and companies are not disclosed. IMPLAN goes to great lengths to generate and provide highly detailed, disaggregated IO account data at the county and even Zip code level. Generating data at this level of detail comes at a cost that is considerably greater than IO-Snap, which relies on BEA's broader Summary level IO account data that corresponds primarily to the 3-digit NAICS level. The Summary level was sufficient to provide an overview of MWCD's impact on the 18-county regional economy.

For these reasons, IO-Snap was selected as the foundation for this analysis.

Despite their many valuable merits, input-output analyses invariably face some challenges. For all of their power and insight, they rely on certain simplifications and generalizations that may not fully capture the complexity of real-world economic systems. They assume, for example, that economic relationships between industrial sectors are stable over time, which may not always be the case, especially when considering time periods that are as long as from 2014-2022. Additionally, input-output analyses simplify the economy by aggregating sectors and thus may not capture all the nuances of real-world economic dynamics. While they admirably model monetary benefits, they do not consider is what the benefits might have been had the distribution of expenditures been directed differently, such as for an entirely different set of capital projects. Nor do they include intangible benefits such as, for example, the improvements in public health or quality of life in the study area attributable to the MWCD expenditures.

8. Endnotes

1. The 18 counties wholly or partially contained in the MWCD jurisdiction are Ashland, Belmont, Carroll, Coshocton, Guernsey, Harrison, Holmes, Knox, Licking, Morgan, Muskingum, Noble, Richland, Stark, Summit, Tuscarawas, Washington, and Wayne.

2. Jobs from capital expenditures are not permanent while jobs from ongoing O&M are, although O&M jobs may be seasonal or part-time.

3. Gross Output is a measure of sales or revenue, including final and intermediate goods and services.

4. Value Added, or gross domestic product (GDP) by industry, is the difference between Gross Output and the cost of intermediate inputs.

5. See Times Reporter. (2022). MWCD to receive $40 million from Tappan Lake oil and gas lease. https://www.timesreporter.com/story/news/2022/05/23/mwcd-receive-40-million-tappan-lake-oil-and-gas-lease/9853899002/

6. See Energy Policy Center. (2023). Shale Investment Dashboard in Ohio Q1 and Q2 2022. Cleveland State University. https://engagedscholarship.csuohio.edu/urban_facpub/1793

7. See Ohio Auditor of State. (2008-2016). Independent Auditor's Report of the Muskingum Watershed Conservancy District, Tuscarawas County. https://ohioauditor.gov/auditsearch/Search.aspx

8. See Energy Policy Center. (2023). Shale Investment Dashboard in Ohio Q1 and Q2 2022. Cleveland State University. https://engagedscholarship.csuohio.edu/urban_facpub/1793. See also Ohio Auditor of State. (2014-2022). Independent Auditor's Report of the Muskingum Watershed Conservancy District, Tuscarawas County. https://ohioauditor.gov/auditsearch/Search.aspx

9. Muskingum Watershed Conservancy District. (2023). MWCD Invests $5 Million in Environmental Stewardship. https://www.mwcd.org/news/2023/01/27/mwcd-invests-5-million-in-environmental-stewardship

10. A summary of the terms for the lease agreement currently in use can be found on MWCD's website at https://www.mwcd.org/news/2022/05/20/mwcd-negotiates-oil-and-gas-lease-with-encino-energy

11. See Muskingum Watershed Conservancy District. (2022). Annual Report of Operations. https://www.mwcd.org/upload/mwcd_annual_report_2022.pdf

12. Output, or *gross output*, is principally a measure of sales or revenue from production for most industries, while *value added* is the difference between gross output and intermediate inputs and represents the value of labor and capital used in producing gross output. Value added is also measured as the sum of an industry's compensation of employees, taxes on production and imports, less subsidies, and gross operating surplus. See Bureau of Economic Analysis. (2018). What is Gross Output by Industry and How Does It Differ from Gross Domestic Product (or Value Added) by Industry? https://www.bea.gov/help/faq/1197

13. Output multiplier comparisons can be difficult to fully understand because output impacts include double-counting, but income, value added, and employment impacts do not. Output multipliers double count because total output impact includes the value of every input at every step in the supply chain. Demand for an automobile, for example, will generate a total output impact that includes the values of the tires plus the value of the rubber in the tires, the radio plus the value of the wires in the radio, the transmission and engine and the value of the metal stampings and the value of mined metals they are made of, the value of the upholstery, the value of the cloth to make the upholstery, the value of the fertilizer for the cotton in the fabric, etc., etc., etc. Because of this "double-counting", there will be a relatively large output multiplier. It could, however, have a total income effect that is very similar to another industry that has a much lower (or even a higher) output multiplier. One explanation (for a given comparison) would be the fact that the costs of intermediate inputs (per input) used in producing autos are much smaller (therefore generating less income per input) than those of the industry with the smaller output multiplier.

14. Specifically (direct+indirect)/direct is a Type I multiplier. A Type II multiplier is (direct+indirect+induced)/direct. The multipliers reported herein are Type II.

15. The input-output accounts at BEA are a series of related detailed tables showing how industries interact with each other and with the rest of the economy. "Make tables" show the production of commodities by industries. "Use tables" show what industries uses these commodities. "Requirements" tables summarize the full supply chain, including direct and total inputs. Direct requirements tables show the row sector per dollar of input per column sector dollar of output, and its elements are direct input-output coefficients. In a total requirements table, the numerator is the direct and indirect requirements from the row sector per one dollar of final demand for the column industry output, and its elements are direct input-output coefficients. https://www.bea.gov/data/industries/input-output-accounts-data

In this research we employed a "commodity–industry" format, enabling us to account for the fact that an industry may produce more than one commodity (product). This was a major reason for the introduction of this sort of commodity–industry accounting system to the United Nations System of National Accounts in the early 1970s – to explicitly account for "non-characteristic" production such as secondary products and by-products. In addition, data organized in this way are more easily integrated with a broader system of national accounts for the country.

For a more detailed description of these accounts, see: (https://apps.bea.gov/scb/pdf/national/nipa/methpap/mpi1_0907.pdf).

16. See U.S. Bureau of Economic Analysis. (2019). Preview of the 2018 comprehensive update of the industry economic accounts. U.S. Department of Commerce. https://apps.bea.gov/scb/issues/2018/08-august/pdf/0818-industry-tables.pdf

17. Organization for Economic Co-operation and Development. (2023). National accounts: National accounts deflators: Gross domestic product: GDP deflator for United States. Retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/USAGDPDEFAISMEI

18. Secondary production demand refers to the commodities produced within those BEA Industries that produce more than one commodity.

19. Documentation of these methods can be found at https://www.econalyze.com/TechDocs/. Relevant documents are listed individually in the References section.

20. The 18 counties wholly or partially contained in the MWCD jurisdiction are Ashland, Belmont, Carroll, Coshocton, Guernsey, Harrison, Holmes, Knox, Licking, Morgan, Muskingum, Noble, Richland, Stark, Summit, Tuscarawas, Washington, and Wayne.

21. Estimates of total employment impacts (numbers of jobs) are rounded to the nearest whole number for the sake of clarity and coherence.

22. Average compensation {(Sum of direct compensation through 67 industries) / (Sum of direct employment) = $67,887} is based upon Ohio relationships among employees, compensation, and output by industry, emphasizing the sectors that are most directly involved in implementing the improvements.