www.cpcstrans.com

Draft Working Paper

Arizona State Freight Plan

(ADOT MPD 085-14)

Phase 3 Working Paper: Mining Sector Profile and Transportation Performance Needs

Prepared for:

Arizona Department of Transportation

Prepared by:

CPCS

In association with:

HDR Engineering, Inc.
American Transportation Research Institute, Inc.
Elliott D. Pollack & Company
Dr. Chris Caplice (MIT)
Plan*ET Communities PLLC (Leslie Dornfeld, FAICP)
Gill V. Hicks and Associates, Inc.

Solutions for growing economies

CPCS Ref: 14325
September 21, 2015

Working Paper

This working paper is one of 10 papers focusing on key Arizona economic sectors. Its purpose is to document the economic profile, outlook and transportation performance needs of Arizona's mining sector. This working paper will later inform system improvement needs to increase Arizona's economic competitiveness and growth. This working paper is provided for comment and discussion and should not be interpreted as final.

Acknowledgements

The CPCS team would like to thank the Arizona Department of Transportation (ADOT) for its guidance and input in developing this working paper. The team also recognizes the important contribution of the mining sector experts and stakeholders consulted, as well as that of Mr. Bradley D. Ross, who contributed advice and input in the development of this working paper.

Opinions

Except where otherwise indicated, the opinions herein are those of the author and do not necessarily reflect the views of ADOT or the State of Arizona.

Contact

Questions and comments on this working paper can be directed to:

Dr. Joseph F. Schulman
Mining Sector Analyst
T: +1.514.770.7829
jschulman@cpcstrans.com

Donald Ludlow
Project Manager
T: +1.202.772.3368
dludlow@cpcstrans.com

Table of Contents

Executive Summary ..... **i**
Acronyms and Abbreviations ..... **iv**
1 Introduction **1**
1.1 Why an Arizona State Freight Plan? 2
1.2 Project Objectives 2
1.3 Purpose of this Working Paper 3
1.4 Methodology 3
1.5 Limitations 4
2 Mining Sector Profile **5**
2.1 Overview of Mining Sector 6
2.1.1 Overview 6
2.1.2 Copper Mining 9
2.1.3 Construction Aggregates 12
2.1.4 Uranium Mining 13
2.2 Economic Profile and Importance to Arizona's Economy 15
2.2.1 Contribution to GDP 15
2.2.2 Commodity Flows 15
2.2.3 Origins of Inflows to Arizona 15
2.2.4 Destinations of Outflows to Other States 16
2.2.5 International Trade 16
2.2.6 Employment and Wages 18
2.2.7 Economic Impact 18
2.2.8 Copper Outlook 19
2.3 Traffic Profile and Activity Location 19
2.3.1 Activity Clusters 20
2.3.2 Major Origins and Destinations 23
2.3.3 Modal Breakdown 24
3 Supply Chain Structure and Transportation Performance Parameters **25**
3.1 Supply Chain Structure 26
3.1.1 Copper 26
3.1.2 Freeport McMoRan 27
3.1.3 Asarco 28
3.1.4 Capstone Pinto Valley Mine 29
3.1.5 KGHM Carlotta Mine 30
3.1.6 Copper Mines Under Development 30
3.1.7 Construction Aggregates 33
3.2 Transportation Parameters 34
3.2.1 Copper 34
3.2.2 Construction Aggregates 36
3.2.3 Transit Traffic 37

3.3 Transportation Barriers and Needs 38

4 Sector Priorities for Transportation System Performance Improvement 41

4.1 Priority Improvement Needs 42

Appendix A: Stakeholders and Experts Consulted 44

Executive Summary

Economic and Traffic Profile

For over a century copper has been the predominant contributor to the value of mining output in Arizona. It has also historically been one of the "5 C's" comprising the mainstays of the economy (copper, cattle, cotton, citrus and climate). While the mining and agriculture "C's" have given way to new industries that help to drive the economy, mining remains a key component of the Arizona economy. Copper today accounts for 80 percent of the value of Arizona non-fuel mineral production. In 2011, Arizona produced 828,000 tons of copper. Copper and other non-fuel mineral extraction is important to Arizona because—unlike Texas or California—Arizona has no notable reserves of crude oil or natural gas.

	Measure	Mining Sector	Arizona (all commodities)
Economy	GDP (2012, $ million)	$7,362	$271,503
	GDP Annualized Growth (1997-2012)	10.7%	4.9%
Jobs	Employment (2013)	12,019	2,619,055
	Compensation per Employee (2013)	$93,494	$57,393
Transportation	Total Commodity Flows (2012, Mt)	60.9	138.2
	Top Origin (2012, Mt)	Wyoming (4.3)	California (9.5)
	Top Domestic Destination (2012, Mt)	Mexico (3.3)	Mexico (5.6)
	Intrastate Flows (2012, Mt)	53.6	101.8
	% Truck (2012)	78.4%	87.2%

Source: CPCS Analysis of data from Bureau of Economic Analysis and 2012 Commodity Flow Survey

There are ten mines producing copper in Arizona. Nearly all copper is produced in the southeastern quadrant of the State, and dominated by two companies: Freeport McMoRan and Asarco, which produce 72 percent and 19 percent, respectively. These companies also own the two remaining copper refineries in Arizona. Copper mining relies heavily on both road and rail transportation infrastructure. Railroads include the Union Pacific and Burlington Northern Santa Fe, and a number of common carrier and private shortline railroads.

In addition to copper, mining outputs include molybdenum, coal, gold, silver and uranium.

Construction aggregates (sand, gravel and stone) dominate Arizona mining in terms of tonnage. In 2011, Arizona produced approximately 45 million tons (Mt) of construction aggregates. Construction aggregates are normally transported only short distances from production sites, with transportation by road. Approximately three quarters of construction aggregates in Arizona are used in the southern, more populated, part of the State.

Overall, mining is Arizona's top sector in terms of freight tons transported. In 2012, the sector generated over 60 Mt of freight flows, almost half of Arizona's freight movements. Some 88 percent of Arizona mining movements are intrastate, with 85 percent of these being by road. (This data counts domestic flows only.)

Supply Chain Structure and Transportation Performance Needs

The copper supply chain has three components: concentrate, finished copper and products, and inbound supplies. Supply chains can also be simple or complex depending on the number of mines and other facilities owned by a company, as well as the specifics of the operations and available access to transportation modes.

Rail is normally preferred for moving concentrate, cathode, anode and acid. Not all facilities, however, have rail access and trucking therefore has a significant role. Trucking also dominates the movement of inbound supplies, and is preferred where time is the priority, e.g. emergency situations.

Construction aggregates (including concrete and asphalt) are transported to consumers by road. In Arizona, most deliveries are within 20 to 30 miles of the producing facility. On the input side, aggregates are typically mined at the production facility, but other inputs are brought in by road or rail depending on the material and source.

Construction aggregates transportation decisions are made largely on cost, this being a function of haul distance and transit time. Flexibility is essential to avoid traffic delays. Trucks are often confined to local routes, forcing extra mileage. There are also perishable load issues, specifically with concrete and asphalt.

Key Transportation Barriers and Related Priority Improvements

Changes in the health of the mining industry can have a dramatic effect on the communities that are dependent on those operations. This has caused economic boom and bust periods for these smaller communities. Policy mechanisims to help the industry be more stable and profitable are a necessary component of any economic development plan. This includes adequate transportation access for the mining activities themselves, but also some thought as to how the same transportation network can help facilitate later economic diversification in these communities.

Additional complications arise from the fact that issues beyond the control of the state can impact local operations quite dramatically. For example, political turmoil in South America could cause prices to spike and a shuttered local mine to become financially viable, while excess global production could cause prices to fall below the financially optimal level of operations and a mine (and the neighboring community) to go dormant. Thus, current activities may not precisely represent future activities, but Arizona needs to be prepared to provide adequate infrastructure over the longer term since mining will remain part of the state's economy over the longer term.

Road transportation issues are seen as the main barriers in transporting mining products and supplies. Problems cited include a lack of sufficient trucks, particularly for transporting copper.

A second issue is the belief that truck weight limits should be raised to help counter the trucking capacity shortage. Weight limits affect both incoming supplies and outgoing shipments. The condition of roads is a third issue. Stakeholders felt that many roads should be upgraded and/or modified to accommodate increased traffic and heavier truck weights. Road congestion and safety are also major issues. The Arizona Rock Products Association (ARPA) feels the top issue is a need for dedicated and sustained funding of roads.

As identified by the experts and stakeholders consulted, the priority transportation improvement needs may be stated as follows:

- **Increase allowable truck weight limits** to mitigate the trucking capacity shortage and to increase efficiency in transporting mining products and incoming supplies.
- **Improve Arizona's roads and bridges** to increase efficiency and enhance safety, counter increased vehicle maintenance costs, alleviate congestion, provide for future growth and allow for greater truck weight limits.
- **Develop dedicated and sustainable funding sources, including more innovative options,** to enable the needed maintenance, improvement and expansion in the transportation system.
- **Recognize the role of the transportation system in enabling municipalities to use local construction aggregates** based on the opportunity afforded by the Aggregate Protection Act (SB 1598).

Acronyms and Abbreviations

ACA	ARIZONA COMMERCE AUTHORITY
ADOT	ARIZONA DEPARTMENT OF TRANSPORTATION
ARPA	ARIZONA ROCK PRODUCTS ASSOCIATION
ASCE	American Society of Civil Engineers
AZER	ARIZONA EASTERN RAILWAY
BHP	BHP BILLITON
BNSF	BURLINGTON NORTHERN SANTA FE
CAPSTONE	CAPSTONE MINING CORP
CBR	COPPER BASIN RAILWAY
CFS	COMMODITY FLOW SURVEY
DOT	UNITED STATES DEPARTMENT OF TRANSPORTATION
EW	ELECTROWINNING
FHWA	Federal Highway Administration
FMI	FREEPORT-MCMORAN INC.
FR	FOREST ROAD
GDP	GROSS DOMESTIC PRODUCT
ISCR	IN-SITU COPPER RECOVERY
MARCO	MAGMA ARIZONA RAILROAD COMPANY
MPD	MULTIMODAL PLANNING DIVISION
mt	METRIC TON
Mt	MILLION TONS (short tons)
PTF	PRODUCTION TEST FACILITY
PV2	PINTO VALLEY PHASE 2
PVM	PINTO VALLEY MINE
SB 1598	AGGREGATE PROTECTION ACT
SMARRCO	SAN MANUEL ARIZONA RAILROAD COMPANY
SX	SOLVENT EXTRACTION
SX/EW	SOLVENT EXTRACTION/ELECTROWINNING
U.S.	UNITED STATES
UP	UNION PACIFIC
USGS	UNITED STATES GEOLOGICAL SURVEY

1 Introduction

Key Messages

The Arizona Department of Transportation, Multimodal Planning Division, retained a team led by CPCS Transcom, Inc. to assist in the development of Arizona's State Freight Plan.

The aim of this working paper is to establish the freight transportation performance needs, outlook and economic contribution of Arizona's mining sector (defined here as NAICS Codes 212 and 213). This will later inform the analysis of broader transportation system based needs and priorities.

This working paper was developed in large part through expert and stakeholder consultations and research and analysis of mining sector data and information.

1.1 Why an Arizona State Freight Plan?

Arizona's economic potential is supported by the state's transportation infrastructure and services, which connect sources of production to markets.

When transportation infrastructure and related services are efficiently designed and competitively positioned, businesses benefit from lower transportation costs, faster and better transportation services, and increased reliability, which in turn contribute to their own competitiveness and growth, and that of the broader region.

Jurisdictions with access to competitive transportation infrastructure and services are at a competitive advantage in attracting investment, creating jobs and realizing economic growth. Arizona's State Freight Plan can help enable this outcome.

To this end, the Arizona Department of Transportation (ADOT) Multimodal Planning Division (MPD), is developing Arizona's State Freight Plan which will provide strategic guidance to enhance Arizona's economic competitiveness and facilitate economic growth.

1.2 Project Objectives

The State Freight Plan will define immediate and long-range investment priorities and policies that will generate the greatest return for Arizona's economy, while also advancing other key transportation system goals, including national goals outlined in MAP-21.[1] It will identify freight transportation facilities in Arizona that are critical to the State's economic growth and give appropriate priority to investments in such facilities.

The State Freight Plan will ultimately provide Arizona with a guide for assessing and making sound transportation investment and policy decisions that will yield outcomes consistent with the state's vision, goals and objectives, and notably, promote regional competitiveness and economic growth.

[1] MAP-21 is the Moving Ahead for Progress in the 21st Century Act (P.L. 112-141). Signed into law by the President on July 6, 2012, MAP-21 is the current version of the legislation that authorizes the funding of U.S. federal surface transportation programs.

1.3 Purpose of this Working Paper

Since it is economic activity – particularly from goods producing sectors – that drives demand for freight transportation infrastructure and services, optimization of the state's freight transportation system, and related strategies, goals and investments, must start by addressing the transportation performance needs of the sectors requiring freight movement. Yet, the transportation performance needs of freight can differ by sector and commodity group, locations and even company.

For this reason, the study team identified 10 key freight sectors in Arizona for specific focus: wholesalers and retailers, food and beverages, high-tech manufacturing, general manufacturing, transportation equipment manufacturing, transportation and logistics, mining (except oil and gas), energy (oil and gas), agriculture, and forestry.

The purpose of this working paper is to provide a focused assessment of the transportation performance needs, outlook and economic contribution of the mining sector (defined here as corresponding to North American Industry Classification System (NAICS) codes 212 and 213[2]).

Specifically, the working paper addresses the following key questions:

- At a high level, what is the profile and economic contribution of the mining sector to Arizona's economy?
- How do the supply chains of Arizona's mining sector utilize the transportation system and what are the major origins, destinations, intermediate points, and final products of these chains?
- How are mining sector supply chains structured, managed, and what are the primary drivers of transportation decisions and related performance needs?
- What are the key trends in the mining sector, how are these influencing freight flows, and what are the implications, opportunities and challenges for the competitiveness of Arizona's freight system going forward?

1.4 Methodology

This working paper is informed by a combination of research and literature review, data collection and analysis, and extensive consultation with mining sector experts and stakeholders. Source documents reviewed are footnoted throughout the working paper, as appropriate. A list of individuals consulted is provided in Appendix A (unless the stakeholder has specifically requested non attribution).

[2] NAICS 212 is mining except for oil and gas extraction. NAICS 213 is support activities for mining, including oil and gas extraction. Data for Arizona, however, show support activities for oil and gas extraction to be insignificant.

1.5 Limitations

This working paper is in many cases informed by data and input provided by third parties. CPCS has verified this information to the extent possible through analysis and cross-checking with other sources but cannot guarantee the accuracy of data received from third parties.

2 Mining Sector Profile

Key Messages

Copper is Arizona's predominant mine product, accounting for 80 percent of the value of State non-fuel mineral output and 2/3 of the tons of copper produced in the U.S. Arizona produced 828,000 tons of copper in 2011.

Arizona copper production is currently dominated by two companies, Freeport McMoRan and Asarco, accounting for 72 percent and 19 percent, respectively, of the copper produced. Each of these companies also owns one of the two remaining copper refineries in Arizona.

Nearly all Arizona copper is produced in the southeastern quadrant of the State. Copper mining and production rely heavily on both road and rail transportation in Arizona.

Construction aggregates (sand, gravel and stone) dominate Arizona's mining in terms of tonnage. In 2011, Arizona produced approximately 45 million tons of construction aggregates.

2.1 Overview of Mining Sector

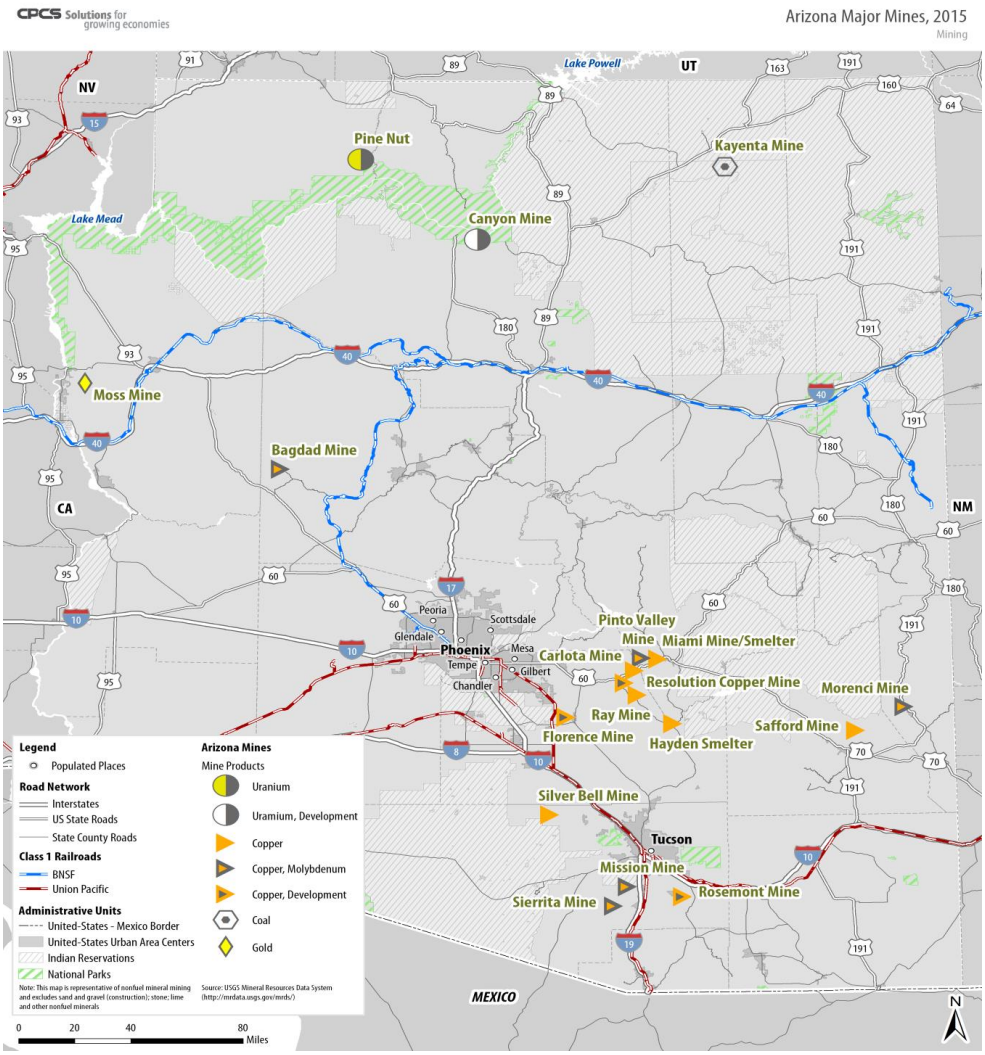
2.1.1 Overview

Mining in Arizona has a long history. For more than a century copper has been the predominant contributor to the value of mining output and remains so today. Copper also has historically been one of the "5 C's" comprising the mainstays of the Arizona economy (copper, cattle, cotton, citrus and climate).[3] Other notable mining outputs, include molybdenum, coal, gold, silver and uranium.

Figure 2-1 below shows the major mines and their locations in Arizona (those currently producing and under development). As can be seen, copper dominates the major operating mines as well as those under development.

[3]Arizona State Library, Archives & Public Records, *The 5 C's* at http://www.azlibrary.gov/arizona-almanac/five-c.

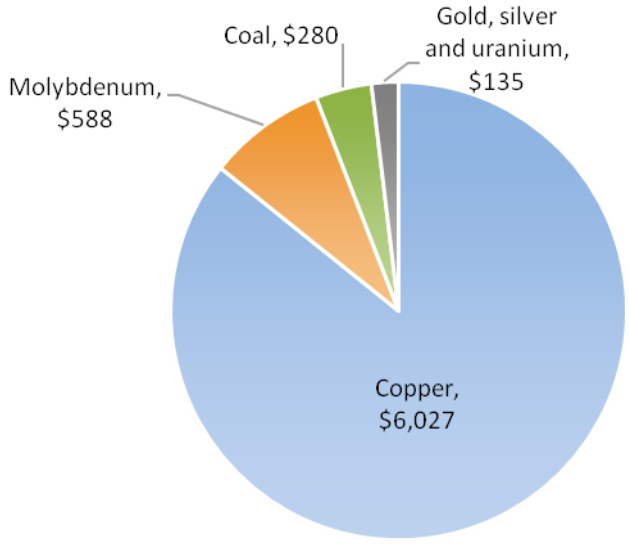
Figure 2-1: Major Mines Currently Producing and Under Development, Arizona 2015



A recent survey of mining companies, undertaken for the Arizona Mining Association, showed that in 2012 Arizona produced 1.6 billion pounds (.8 Mt) of copper, 44 million pounds (.02 Mt) of molybdenum, 8 Mt of coal, 3.8 million ounces of silver, 5,600 ounces of gold, and approximately 375,000 pounds of uranium.[4] Figure 2-2 shows the relative importance of these when measured in terms of dollars. As may be seen, copper makes up 86 percent of the value of Arizona mining output, followed by molybdenum at 8 percent, coal at 4 percent, and gold, silver and uranium combined at 2 percent.

[4] L. William Seidman Research Institute, The Economic Impact of the Mining Industry on the State of Arizona 2012, prepared for the Arizona Mining Association (October 2013), p. 6. Companies surveyed for purposes of this study included all of the major copper producers in the state, companies that made significant equipment purchases and other investments in 2012 and expect to be producing copper in the near future, a coal producer, a uranium producer, and several mining exploration companies. Companies involved in sand, gravel and rock products were not included in this analysis.

Figure 2-2: Value of Arizona Mining Output, 2012 (millions of dollars)



Source: L. William Seidman Research Institute, The Economic Impact of the Mining Industry on the State of Arizona 2012, Figure 1, p. 6

Copper production in Arizona is dominated by two companies, Freeport-McMoRan Inc. (FMI) and Asarco, although they are not the sole producers. Coal is produced at only one mine, the Kayenta Mine operated by Peabody Energy and located in Navajo County, which supplies coal to the nearby Navajo Generating Station.[5] Uranium is mined by Energy Fuels Inc. at its Pinenut mine in northern Arizona from where it is shipped to the White Mesa Mill at Blanding in southern Utah.[6] Molybdenum, gold and silver are produced as important by-products of copper mining although gold is also produced on its own.

Further perspective on the mining sector is provided by Figure 2-3 which focuses on nonfuel mineral production (i.e. excludes coal and uranium). This data, from the advance release of the U.S. Geological Survey (USGS) *Minerals Yearbook* for 2015, shows the quantities and values of nonfuel minerals produced in Arizona in 2010 and 2011 (note that the USGS reports the quantities are in metric tons (mt)[7]). Arizona's nonfuel mineral production was valued at $8.4 billion in 2011, an increase of $1.6 billion, or 23 percent, from the 2010 value of $6.8 billion. As

[5]Under the U.S. Environmental Protection Agency's Clean Power Plan, Arizona is required to reduce its carbon intensity by 52% by 2030. The plan assumes the complete retirement of all Arizona coal fired power plants by January 1, 2020. See Arizona Department of Environmental Quality, EPA Clean Power Plan (February 9, 2015) at https://www.azdeq.gov/function/forms/download/epa_plan.pdf.

[6]Energy Fuels expects economic resources at Pinenut to be depleted in mid-2015 and the production to be replaced by output from the nearby Canyon mine where Energy Fuels has resumed development. Energy Fuels is also evaluating whether to commence permitting operations for two more high-grade breccia pipe uranium deposits at the EZ complex, in northern Arizona. World Nuclear News, *Energy Fuels prepares for Canyon resurrection* (10 February 2015) at http://www.world-nuclear-news.org/ENF-Energy-Fuels-prepares-for-Canyon-resurrection-1002157.html.

[7] One ton (short ton) equals 0.907185 metric tons

noted by the USGS, Arizona ranked second, for the third consecutive year, in the U.S. in nonfuel mineral production value in 2011.[8]

Arizona's high standing in nonfuel mineral production is due to copper, which accounted for 80 percent of Arizona's total nonfuel mineral production value in 2011. As noted by the USGS, Arizona has led the U.S. in copper production since 1910, and in 2011 produced 67 percent of the total U.S. copper production of 1.1 million mt (approximately 1.22 Mt). As well, Arizona's substantial increase in 2011 in total nonfuel mineral production value was due mostly to copper, the production value of which rose $1.3 billion, or 24 percent, owing mainly to a sharp rise in copper prices.[9]

Figure 2-3: Nonfuel Mineral Production in Arizona, 2010 and 2011

	2010		2011	
Mineral	Quantity (000 metric tons)	Value ($ 000)	Quantity (000 metric tons)	Value ($ 000)
Clays, bentonite	W	W	W	W
Copper[1]	703	5,400,000	751	6,720,000
Gemstones, natural	NA	1,550	NA	2,500
Sand and gravel, construction	35,800	296,000	32,800	264,000
Stone	8,301	92,700	8,372	77,200
Other[2]	XX	1,010,000	XX	1,320,000
Total[3]	XX	6,810,000	XX	8,390,000

W Witheld to avoid disclosing company proprietary data; NA Not available; XX Not applicable
[1] Recoverable copper content of ores
[2] Combined values of: cement, clays (common), gold, gypsum (crude), lime, molybdenum concentrates, perlite (crude), pumice and pumicite, salt, sand and gravel (industrial), silver, zeolites, and values indicated by "W".
[3]Data do not add to totals due to rounding

Source: USGS, 2010-2011 Minerals Yearbook Arizona [Advance Release] (April 2015) Table 1, p. 5.4

After copper, the most important nonfuel mineral commodities, in descending order of value, were molybdenum concentrates, construction sand and gravel, silver, and Portland cement. These four mineral commodities, together with copper, accounted for 97 percent of Arizona's total nonfuel mineral production value in 2011. In terms of annual changes, the production value of silver increased 50 percent in 2011, while the production value of molybdenum concentrates increased 30 percent. In contrast, the production value of construction sand and gravel decreased 11 percent in 2011, while that of Portland cement decreased 4 percent.

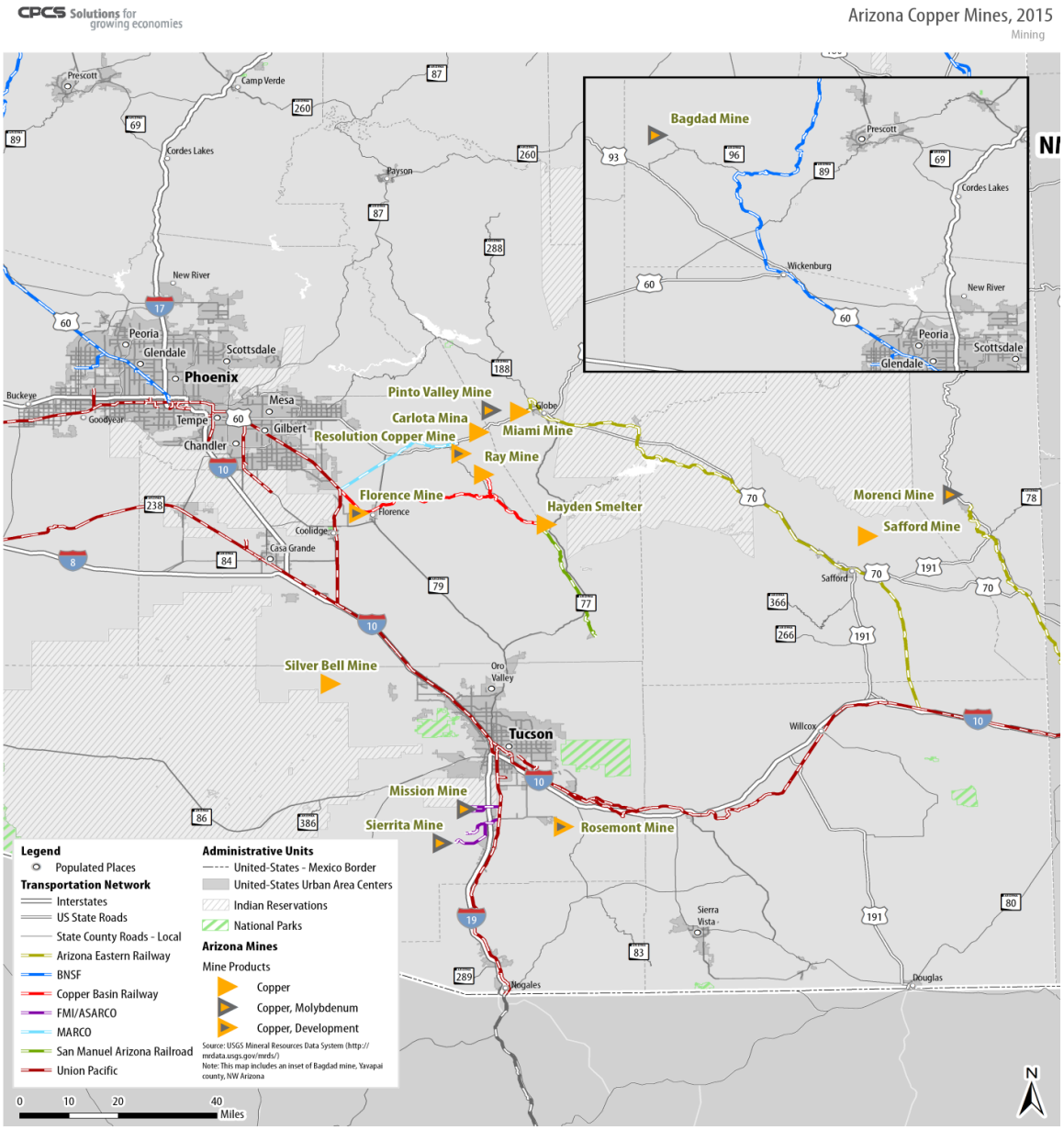
2.1.2 Copper Mining

Nearly all the copper produced in Arizona is produced in the southeast quadrant of the State. Figure 2-4 is a map of this region showing the locations of the mines vis-a-vis the transportation network. These include three major copper mines that are in development, the Hudbay Rosemont mine, the Resolution Copper mine and the Taseko Mines Florence Copper

[8] USGS, *2010-2011 Minerals Yearbook Arizona [Advance Release]* (April 2015), p. 5.1.
[9] Ibid.

project. One producing mine is in the northwestern part of the State. The inset shows the location of this mine.

Figure 2-4: Arizona Copper Mines, 2015



There are currently, in 2015, ten mines that are producing copper. Their recent production history is shown in Figure 2-5. Along with these mines is the Mineral Park mine which is currently not producing as Mercator is in the process of being purchased out of bankruptcy.

Figure 2-5: Arizona Copper Production by Mine, 2011-2014

Mine	Company	Production (000 tons)			
		2011	2012	2013	2014
Morenci	Freeport McMoRan and Sumitomo	307	316	332	406

Bagdad	Freeport McMoRan	97	99	108	119
Ray	Asarco	108	118	114	100
Sierrita	Freeport McMoRan	89	79	86	98
Pinto Valley	Capstone	6	6	50	72
Safford	Freeport McMoRan	76	88	73	70
Mission	Asarco	73	67	58	67
Miami	Freeport McMoRan	33	33	31	29
Silver Bell	Asarco and Mitsui	23	23	22	21
Carlota	KGHM	12	11	11	12
Mineral Park	Mercator	21	20	19	8
Total		**847**[1]	**862**[1]	**902**	**999**

[1]Includes small amounts from mines no longer producing

Source: Nyal Niemuth (Arizona Geological Survey), *Az Copper Mine Production 2010-2020* (data converted to tons by CPCS)

As may be seen, the Morenci mine, 85 percent owned by FMI, is the largest mine. In 2014, it produced .4 Mt, or 41 percent of the total statewide production. Together, the five FMI mines (Morenci, Bagdad, Sierrita, Safford, and Miami) produced .7 Mt in 2014, or 72 percent of the total production. FMI also owns the Miami smelter, one of two copper smelters in Arizona, and a copper refinery in El Paso, Texas.

Asarco, the second largest producer, has three mines. These are the Ray, Mission, and Silver Bell mines (the latter being jointly owned). Together, the three Asarco mines produced 188,000 tons in 2014, or 19 percent of the total statewide production. Asarco also has the Hayden smelter in Arizona, and a copper refinery in Amarillo, Texas.

The remaining copper production, 92,000 tons in 2014 or 9 percent of the total, was accounted for by the recently reactivated Capstone Mining Pinto Valley mine (72,000 tons), the KGHM International Ltd. Carlota mine (12,000 tons), slated to end mining activity in 2014,[10] and the Mercator Minerals Mineral Park mine (8,000 tons).

Copper mining operations in Arizona make extensive use of both road and rail transport. Principal roads used include U.S. Interstate highways I-10 and I-19, U.S. routes 60, 70, 191, and 93 (the latter being in the northwest) and State routes 77, 79, and 96 (the latter being in the northwest).

Railroads include two Class I railroads, the Union Pacific (UP) and the Burlington Northern Santa Fe (BNSF). Shortlines used are the Arizona Eastern Railway (AZER), a common carrier owned by Genesee & Wyoming, Copper Basin Railway (CBR), a common carrier owned by ASARCO, and the private San Manuel Arizona Railroad Company (SMARRCO) owned by Capstone Mining. The AZER comprises two lines running between Clifton, AZ and Lordsburg, NM, and between Bowie, AZ and Miami, AZ, and which are connected by 52 miles of trackage

[10] KGHM POLSKA MIEDZ, *Carlota* at http://kghm.com/en/our-business/mining-and-enrichment/carlota.

rights over UP between Lordsburg and Bowie.[11] The CBR has branch lines connecting the ASARCO Ray mine and Hayden processing facilities, and also interchanges with the San Manuel Arizona Railroad. Resolution Copper also owns a private shortline, the Magma Arizona Railroad (MARCO), providing direct rail connection with UP, which is being rehabilitated as part of the Resolution Copper project.

2.1.3 Construction Aggregates

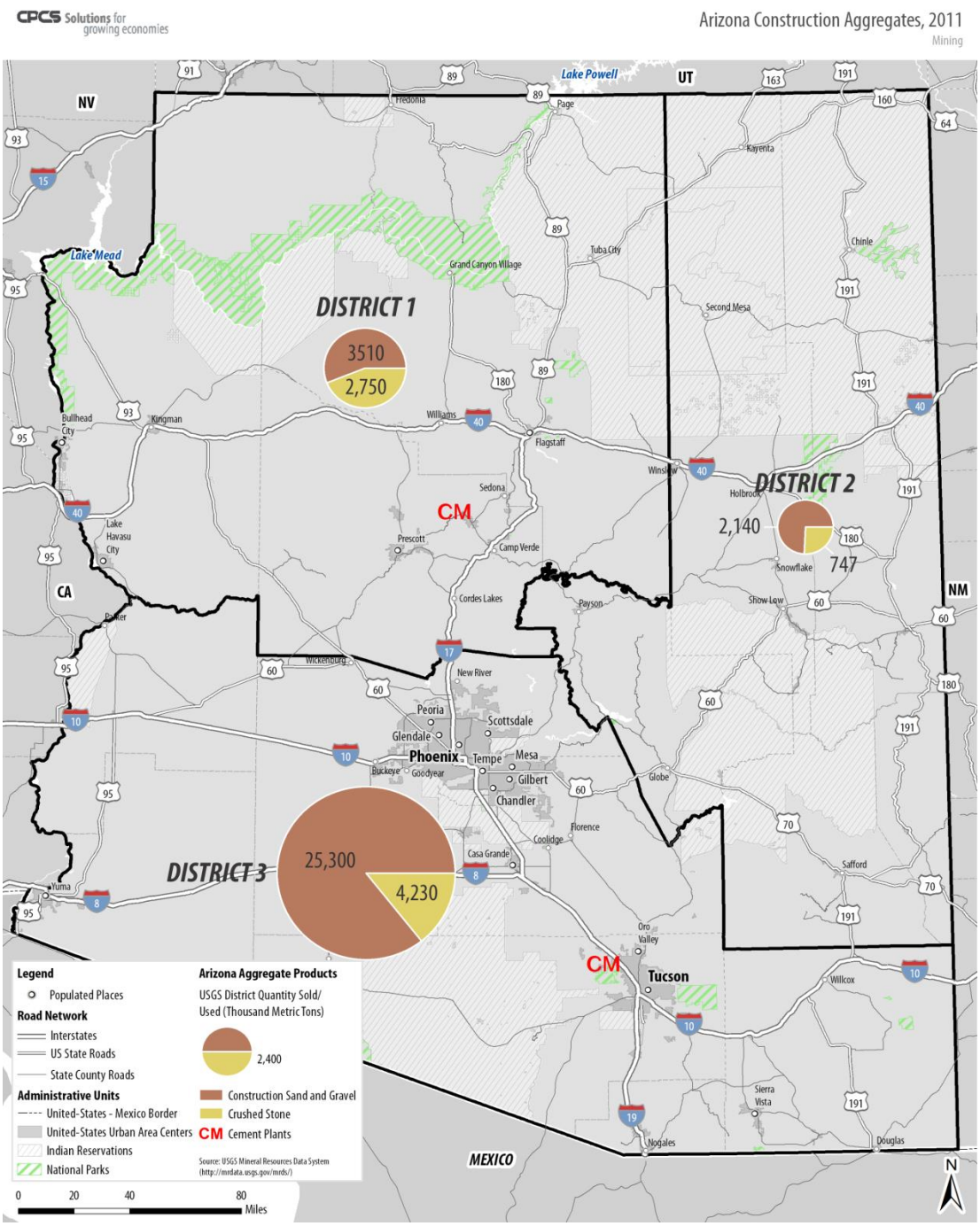
As was seen in Figure 2-3, construction aggregates (construction sand and gravel, and stone) overwhelm mining in Arizona in terms of volume produced, totalling some 41 million mt (approximately 45 Mt) in 2011. At its peak in 2006, construction aggregates produced in Arizona totalled some 109 million mt (approximately 120 Mt).[12]

Construction aggregates are among the most accessible natural resources. Construction sand and gravel is a major basic raw material used mostly by the construction industry. Crushed stone is also a major basic raw material used by construction as well as by agricultural, chemical and metallurgical industries. With the ubiquity, heavy weight and low value of construction aggregates, most facilities producing construction aggregates in Arizona deliver within a 20 to 30 mile radius, with transportation of the product by road.[13]

Figure 2-6 shows the distribution by U.S. Geological Survey District of construction sand and gravel and construction stone sold or used in Arizona in 2011. Of the total volume identified by district — approximately 39 million mt (approximately 43 Mt) — three quarters is accounted for by District 3 which includes the cities of Phoenix and Tucson and their surrounding areas.

[11]Genesee & Wyoming Inc., *Arizona Eastern Railway (AZER) Overview* at http://www.gwrr.com/operations/railroads/north_america/AZER.
[12]Haley & Aldrich, Inc., *Aggregate Protection Guidance, Prepared for Arizona Rock Products Association* (April 2014), p. 5 at http://www.azrockproducts.org/wp-content/uploads/Aggregate_Protection_Guidance_final_4_24.pdf.
[13]Consultation with Arizona Rock Products Association.

Figure 2-6: Arizona Construction Aggregates Sold or Used, by USGS District, 2011



2.1.4 Uranium Mining

Some of the highest grade uranium ore in the United States occurs in formations, called breccia pipes, scattered across the Grand Canyon region of northwestern Arizona, also known as the “Arizona Strip.” The area totals roughly 13,000 square miles, although over two-thirds is off limits to mining because of the National Parks and monuments. The area produced

approximately 24 million pounds of U_3O_8 (one of the most common forms of uranium oxide) prior to the decline of uranium prices in the early 1990's. Existing resources of about 30 million pounds of U_3O_8 contained in several breccia pipes have been reported.[14] In 2012, about one million acres (1,562.5 square miles) of federal land near the Grand Canyon were barred from additional uranium mining development until the year 2032.[15]

Globally, uranium demand and prices plummeted in 2011 following the Fukushima earthquake in Japan, leading Japan to shut down all of its nuclear reactors with other countries following suit. There is now, however, renewed interest in uranium as global concerns about clean energy have re-focused attention on nuclear energy. In Asia, close to $800 billion of new reactors are under development, driven by China and India where demand is climbing for the emission-free energy.[16] Moreover, Japan recently re-started a nuclear reactor, possibly setting the stage for uranium to rally. [17]

The Arizona Strip is a focus both of uranium development and challenges from native and environmental groups. Uranium mining in the Arizona Strip peaked in the 1980s. There are several abandoned uranium mine sites, a legacy of the Cold War. As of early 2015 there was only one mine producing uranium, the Energy Fuels Inc. Pinenut mine located near the Utah border about 35 miles south of Fredonia. Anticipating the closure of Pinenut in 2015 due its economic depletion, Energy Fuels has resumed development at the Canyon Mine, located about six miles south of the Grand Canyon's South Rim, and expects to transition mining personnel from Pinenut to the Canyon Mine during Q3-2015. Development of the Canyon Mine is currently expected to be completed to allow for U_3O_8 production in 2017.[18]

As with Pinenut, ore from the Canyon Mine will be shipped to the White Mesa Mill in southern Utah. Energy Fuels plans to transport the ore using highway 64 and then Interstate 40 before continuing north on highways 89 and 160, a distance of about 255 miles. This routing is required in order to avoid transporting the ore through Grand Canyon National Park.[19]

---

[14] Energy Fuels Inc., *Arizona Strip* at http://www.energyfuels.com/projects/geologic_environment/arizona/.
[15]USGS, *Uranium Mining in the Grand Canyon Region* (December 9, 2014) at http://www.usgs.gov/blogs/features/usgs_top_story/uranium-mining-in-the-grand-canyon-region/.
[16] James Paton, *Asia's $800 Billion Nuclear Splurge to Unlock Uranium Motherlode* (May 7, 2015) at http://www.bloomberg.com/news/articles/2015-05-07/asia-s-800-billion-nuclear-splurge-to-unlock-uranium-motherlode.
[17] Henry Bonner, *Steve Todoruk: Japan Is Setting the Stage for a Uranium Rally* (August 13, 2015) at http://sprottglobal.com/thoughts/articles/steve-todoruk-japan-setting-the-stage-for-a-uranium-rally/
[18]Energy Fuels Inc., *Energy Fuels Announces Quarterly Results for the Three Months Ended June 30, 2015* at http://www.energyfuels.com/investors/press_releases/index.php?content_id=334.
[19]Grand Canyon News, *Environmental groups want re-vamped mining laws* (June 23, 2015) at http://grandcanyonnews.com/main.asp?SectionID=1&SubSectionID=1&ArticleID=11331.

2.2 Economic Profile and Importance to Arizona's Economy

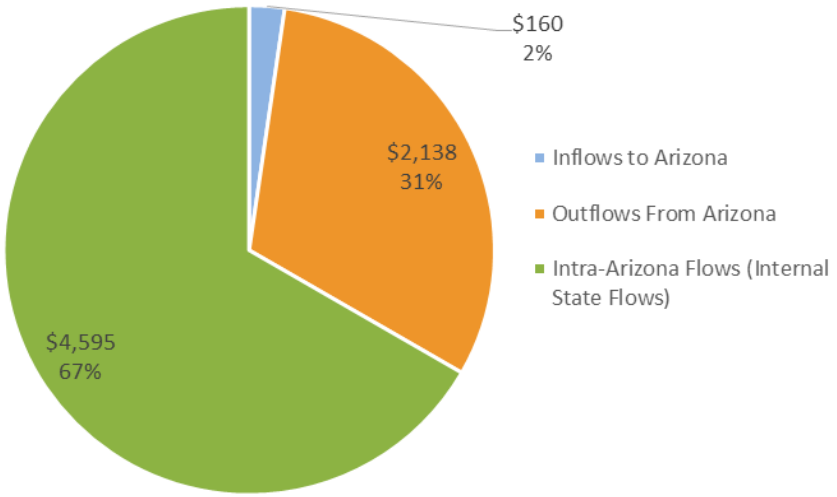
2.2.1 Contribution to GDP

The mining sector[20] in Arizona, according to U.S. Bureau of Economic Analysis Regional Economic Accounts estimates, accounted for $7.4 billion of the State's gross domestic product (GDP) in 2012, representing 2.7 percent of the State's total economic output. Since 1997, GDP in the mining sector has grown at a rate of 10.7 percent per annum, far outperforming the overall state average of 4.9 percent GDP growth per annum.[21]

2.2.2 Commodity Flows

Based on U.S. Department of Transportation (DOT) Commodity Flow Survey (CFS) data, a total of $6.89 billion of mining sector freight flows were moved into, out of, or within the State of Arizona in 2012.[22] Of this, $160 million or 2 percent originated in other states and were destined to Arizona, $2.1 billion or 31 percent originated in Arizona and were destined to other states, and $4.6 billion or 67 percent moved within the state of Arizona.

Figure 2-7: Value of Mining Flows Into, Out of, and Within Arizona, 2012 ($millions)



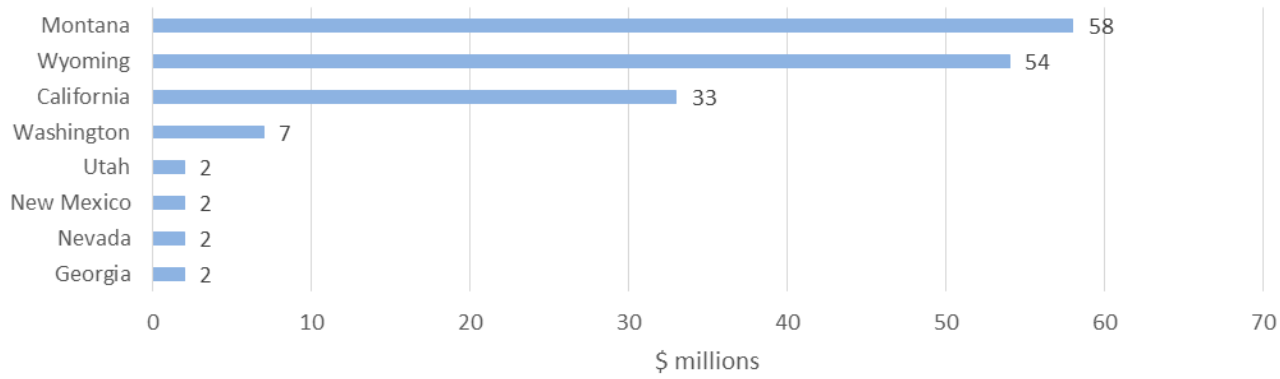
Source: CPCS analysis of Commodity Flow Survey, 2012.

2.2.3 Origins of Domestic Inflows to Arizona

The figure below summarizes the origins of mining products that were transported to Arizona from other states. Montana was the largest origin of mining products destined for Arizona with $58 million shipped to Arizona in 2012, followed by Wyoming and California at $54 million and $33 million, respectively.

[20] See footnote 2 for the definition of the mining sector used in this paper.
[21] Bureau of Economic Analysis Regional Economic Accounts, GDP by State. GDP is in current dollars.
[22] The CFS records movements or flows of freight, which is not necessarily equal to and may exceed mining output or production. Note also that the CFS reports domestic flows only. International flows are not included.

Figure 2-8: Value of Top Mining Sector Inflows to Arizona by State, 2012

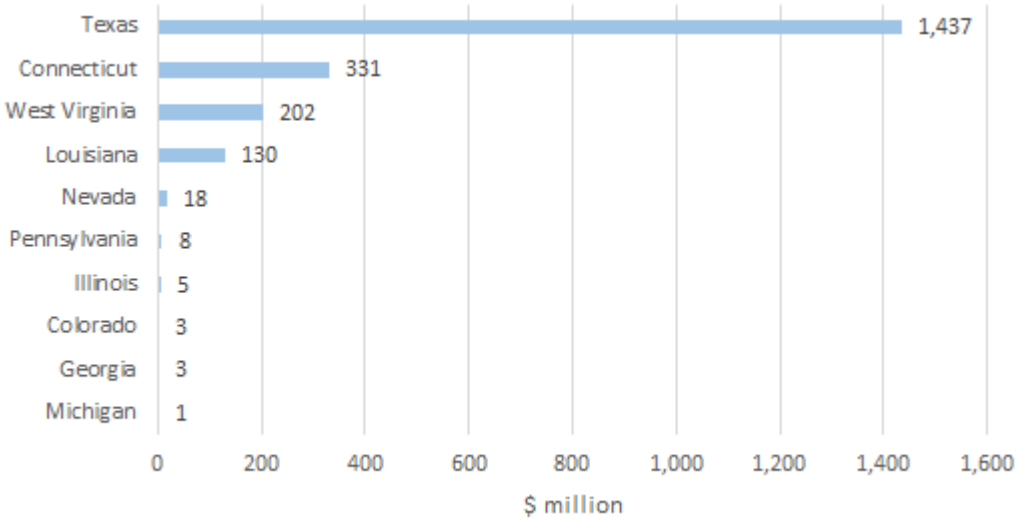


Source: CPCS analysis of Commodity Flow Survey, 2012.

2.2.4 Destinations of Domestic Outflows to Other States

The figure below summarizes the destinations of mining products originating in Arizona and transported to other states. Texas was the largest destination, accounting for $1.4 billion worth of the mining products originating in Arizona and transported to other states.

Figure 2-9: Value of Top Mining Sector Outflows from Arizona by Destination State, 2012



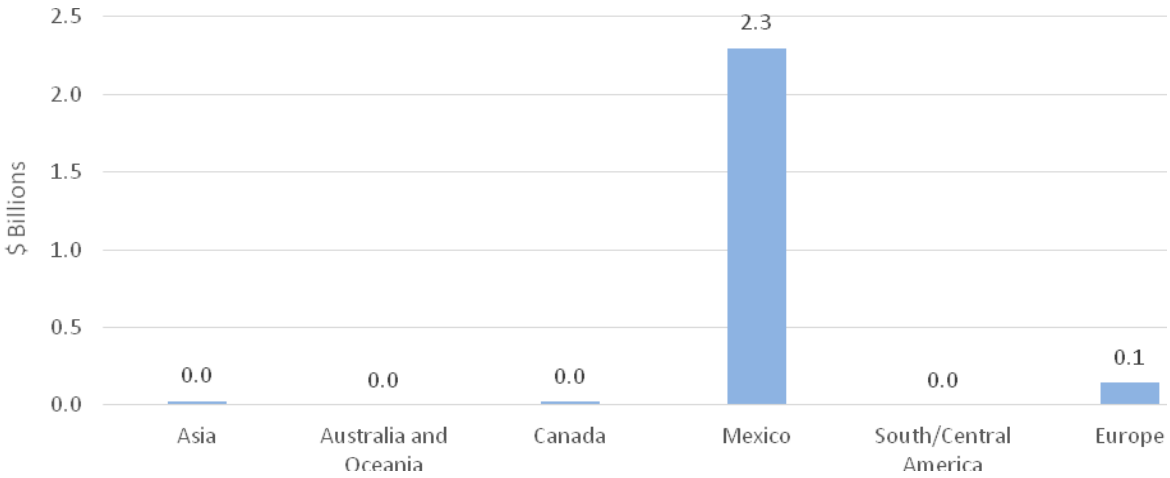
Source: CPCS analysis of Commodity Flow Survey, 2012

2.2.5 International Trade

Based on U.S. Census Bureau foreign trade information, international exports from the Arizona mining sector totalled $2.5 billion in 2014, while Arizona imported only $23 million of mining outputs. Almost all international exports of the mining sector are exported to Mexico

with some smaller amounts destined for Europe. Shipments to Mexico are generally for furtherance by ocean from Guaymas to overseas markets.[23]

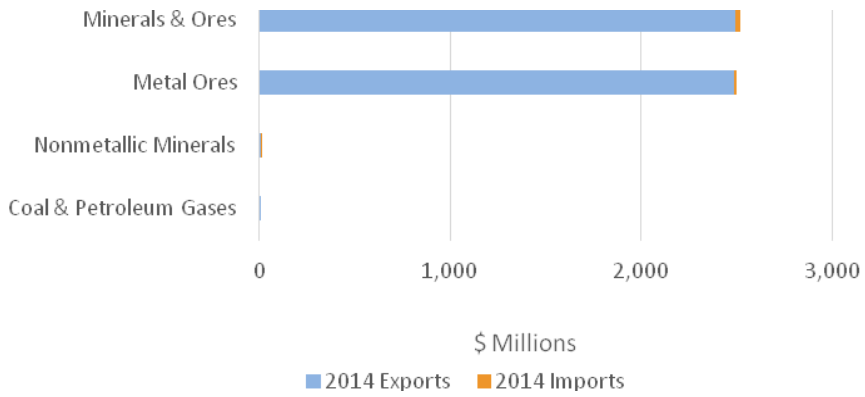
Figure 2-10: Destinations of Arizona Mining Sector Exports, 2014



Source: CPCS analysis of United States Census Bureau Electronic Export Information. Accessed April 2015.

As indicated in Figure 2-11, mineral and metal ore exports accounted for virtually all the mining sector international flows into or out of Arizona. Again, shipments were mostly exported to Mexico, generally for furtherance by ocean to overseas markets.

Figure 2-11: Arizona Mining Sector Top Traded Products, 2014



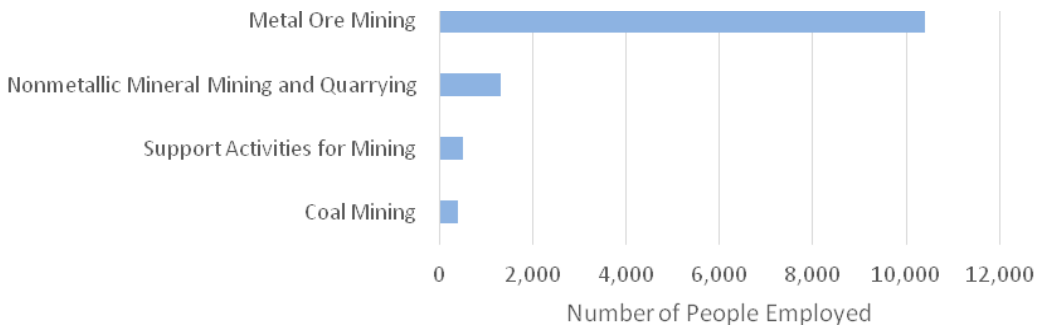
Source: CPCS analysis of United States Census Bureau Electronic Export Information. Accessed April 2015.

[23] See discussion regarding Guaymas on pages 31-32.

2.2.6 Employment and Wages

The mining sector in Arizona employed 12,019 people in 2013, representing 0.5 percent of total employment in the State.[24] The total wages and salaries paid to employees in mining was approximately $1.12 billion in 2013[25], making the average annual wages and salaries per employee in mining approximately $93,494. The largest industry generating employment in the mining sector is metal ore mining, dominated by copper production.

Figure 2-12: Employment in the Mining Sector in Arizona (Q1 2014)



Source: CPCS Analysis of Quarterly Workforce Indicators dataset, United States Census Bureau

2.2.7 Economic Impact

A recently published analysis of the economic impact of mining in Arizona, prepared for the Arizona Mining Association and cited above, estimated the total economic impact of mining, including that of the direct and indirect employment generated. The combined direct employment generated by mining and the first-tier suppliers of Arizona mining companies is estimated at 20,562 jobs in 2012, while the wages, salaries and benefits associated with these jobs is estimated at $1.8 billion.

Taking together all the direct and indirect employment effects, including those associated with upstream purchases by first-tier suppliers, the consumer spending of all employees connected to mining, and the spending of state and local governments out of new tax revenues, mining is estimated to have generated a total of 52,138 jobs, with associated employee compensation of $3.3 billion. Taking all income effects into account (employee compensation, proprietor income, property income, and indirect business taxes) the total income (gross product or value added) generated by mining in Arizona is estimated at $4.8

[24] Excludes self-employment. Bureau of Economic Analysis Regional Economic Accounts, Personal Income and Employment by State. SA7N Wages and Salaries by NAICS Industry

[25] Bureau of Economic Analysis Regional Economic Accounts, Personal Income and Employment by State. SA6N Wages and Salaries by NAICS Industry

billion in 2012, or 1.8 percent of Arizona's GDP.[26] As noted earlier (footnote 4) these estimates do not include the economic impact of the construction aggregates sector.

2.2.8 Copper Outlook

Copper's long importance to the economy of Arizona warrants at least brief consideration of its prospects.

Following the surge in demand during the 2000s, the price of copper, along with that of other world traded commodities, is now facing downward pressure from concerns over slowing growth in China and a strong U.S. dollar. As of July 2015, the price of copper had dropped to U.S. $5,457/mt, down almost 40 percent from its annual average of U.S. $8,828/mt in 2011 when prices peaked.[27] Long term (ten year) fundamentals, however, are widely considered to remain supportive, with global demand projected to grow around 2.7 percent per year (around 4 to 5 percent in the medium term) and the potential for emergence of a significant global supply shortfall.[28] The World Bank projects the price between 2015 and 2025 to increase gradually to U.S. $7000/mt, equivalent to a compound growth rate of 1.8 percent per year.[29] Special factors may also contribute to future demand for Arizona copper, in particular proposals that would bring back the U.S. dollar coin.[30]

2.3 Traffic Profile and Activity Location

Based on the U.S. DOT CFS data, the mining sector in Arizona generated more than 60 Mt of freight movements in 2012, or nearly 45 percent of the total tons of freight movements in the State (Figure 2-13). In terms of tonnage of freight transported, mining is the top sector in Arizona. Some 88 percent (approximately 54 Mt) of the mining volumes transported are intrastate movements. About 9 percent (5.6 Mt) come into Arizona from other states, and 2.6 percent (1.6 Mt) go out to other states (see Figure 2-16 below).

---

[26] L. William Seidman Research Institute, The Economic Impact of the Mining Industry on the State of Arizona 2012, op. cit.

[27] Prices quoted are from the World Bank commodity price data pink sheet, July 2015, and are for copper (LME), grade A, minimum 99.9935% purity, cathodes and wire bar shapes, settlement price, accessed at http://knoema.com/WBCPD2015Jul/world-bank-commodity-price-data-pink-sheet-july-2015.

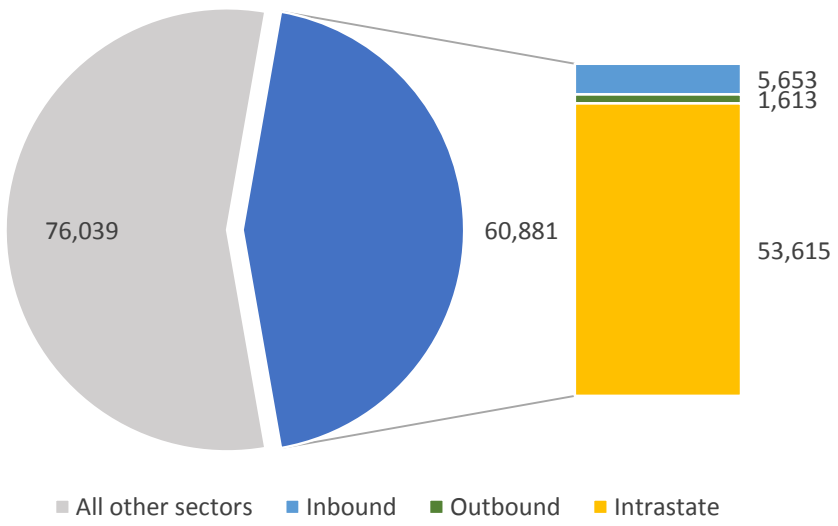
[28] See, for example: Tygesen, Jeff, *Oyu Tolgoi – a world-class copper and gold mine*, BMO 2015 Global Metals and Mining Conference (February 24, 2015); Andrew Stonkus, *Base Metals Markets*, Teck (March 31, 2015); Marcelo Bastos, *Market Outlook*, MMG (April 2015); The Northern Miner, *Wood Mac sees stronger prices for copper, nickel, zinc* (December 3, 2014) at http://www.northernminer.com/news/wood-mac-discusses-supply-and-demand-forecasts-for-copper-nickel-and-zinc/1003374169/#sthash.ovKrurOF.dpuf.

[29] World Bank, *Commodity Markets Outlook* (July 2015).

[30] See, e.g., Arizona Capital Times, *When a dollar is worth $4.4 billion: McCain tries again on dollar coin* (August 10, 2015) at http://azcapitoltimes.com/news/2015/08/10/when-a-dollar-is-worth-4-4-billion-mccain-tries-again-on-dollar-coin/; and Dollar Coin Alliance at http://www.dollarcoinalliance.org/about/

As noted previously, the CFS reports domestic flows only. International flows are not counted. However, some of the domestic shipments may be the domestic portions of international supply chain movements.[31]

Figure 2-13: Arizona Mining Sector Freight Flow Volumes ('000 Tons)



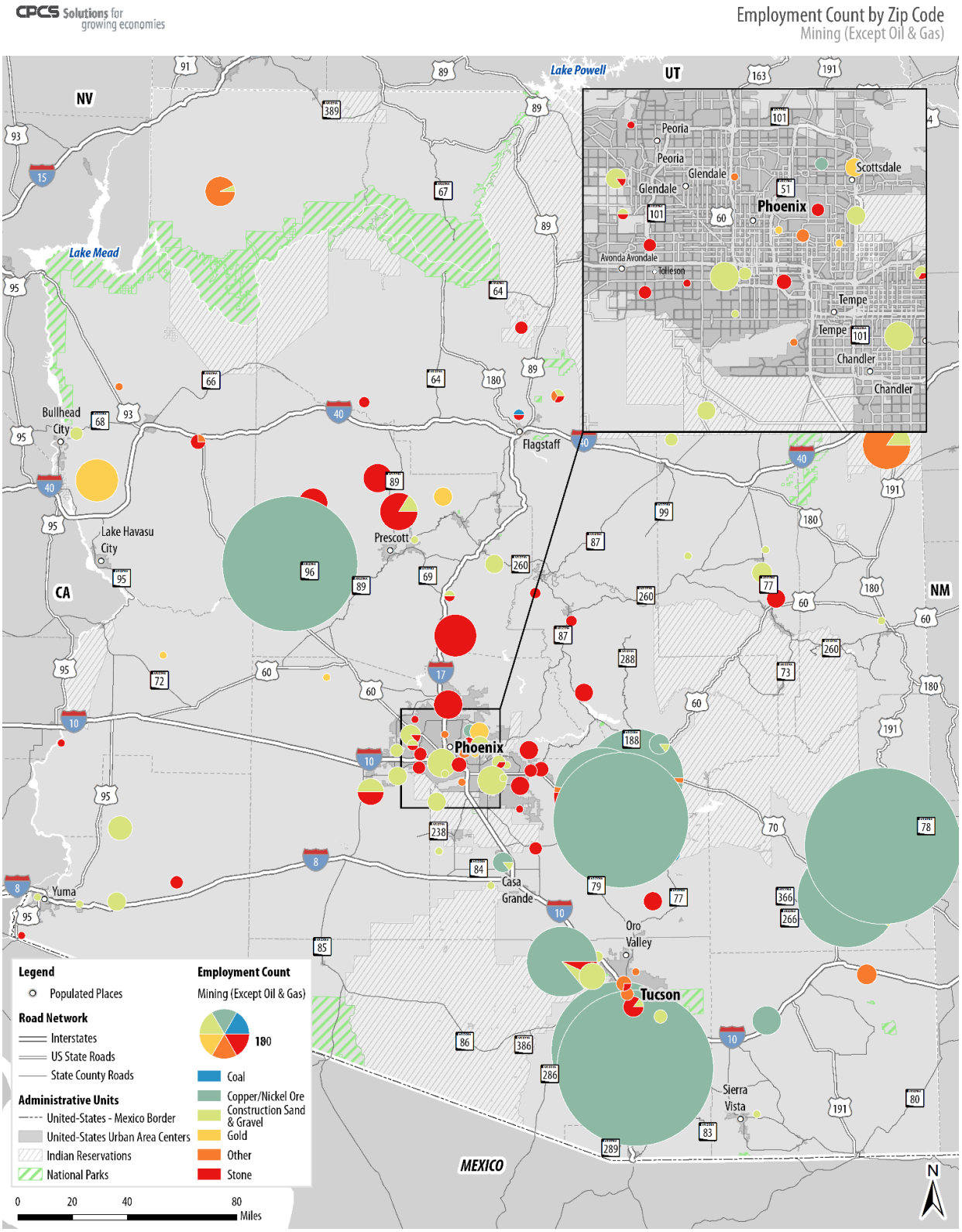
Source: CPCS analysis of Commodity Flow Survey, 2012.

2.3.1 Activity Clusters

Mining activity clusters can be illustrated by the geographic distribution of employment in the sector (Figure 2-14). As already noted copper the principal mining commodity value terms. Copper extraction is clustered southeast of Phoenix, south of Tucson, at Bagdad west of Prescott Valley, and around Safford and Morenci close to the border of New Mexico. There is also employment relating to construction sand, gravel and stone extraction around and north of Phoenix.

[31] In the CFS, the sum of individual state volumes is slightly lower than the national volume which is due to data suppression for reasons of confidentiality and rounding of individual state-to-state movements. For consistency across all the graphics (maps and charts), this paper presents state level total volumes.

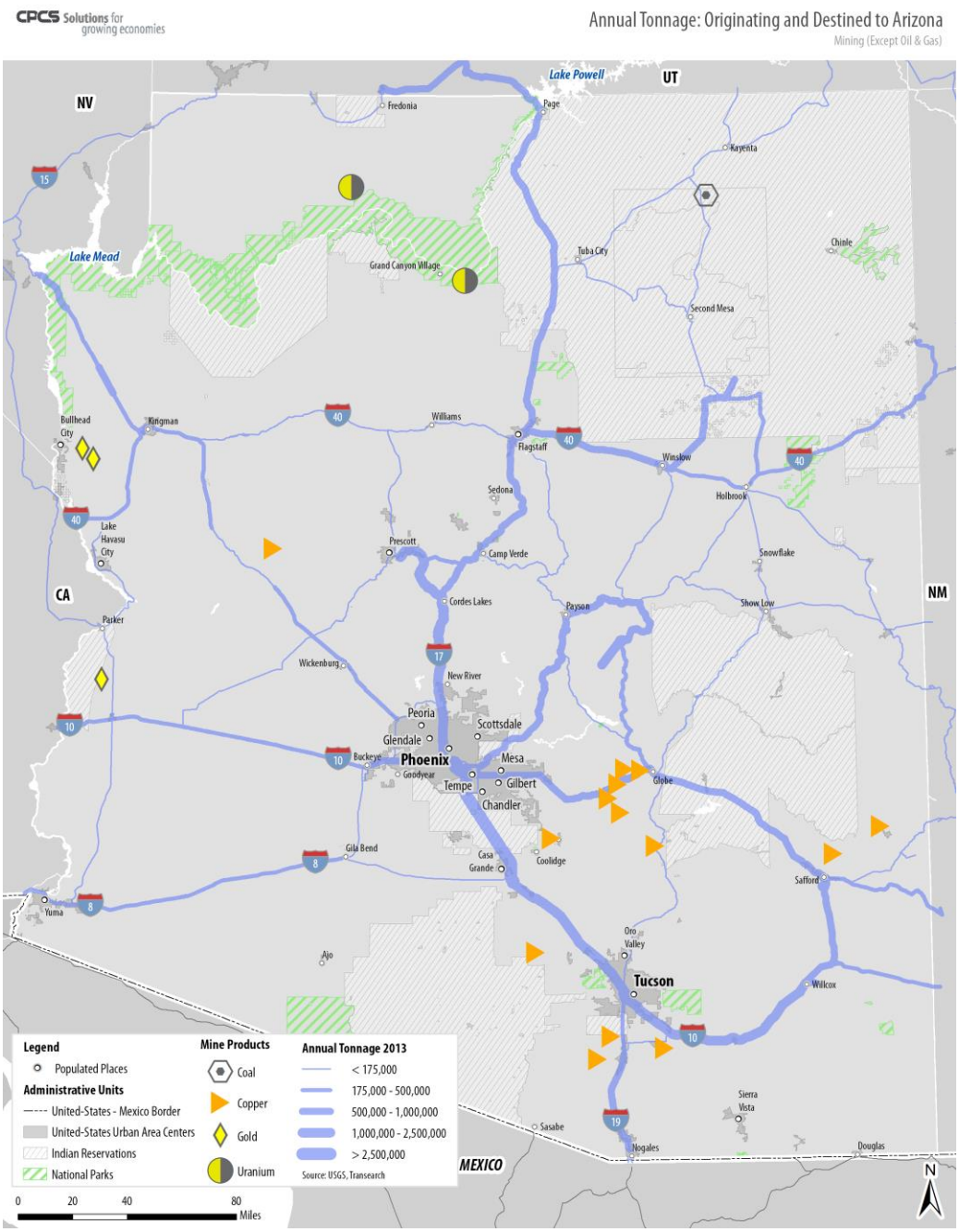
Figure 2-14: Arizona Mining Sector Employment Clusters



Source: CPCS analysis of County Business Pattern Data, 2013 by U.S. Census Bureau.

Figure 2-15 below combines mining sector flows on highways with their area of production. This information was extracted from Global Insight's Transearch dataset for 2013. Only Arizona-generated (originated or destined) flows are shown in the map which excludes any through traffic. The major corridors used by this sector are I-10 from Phoenix southbound, I-17 leading to I-40 and U.S. 89, and I-19 close to Mexico. Apart from I-19 and U.S. 89, no major flows leave Arizona, suggesting predominantly intrastate movements between mines and smelters. Highway I-19 is likely heavily used for exports to Mexico.

Figure 2-15: Arizona Mining Locations and Commodity Truck Flow

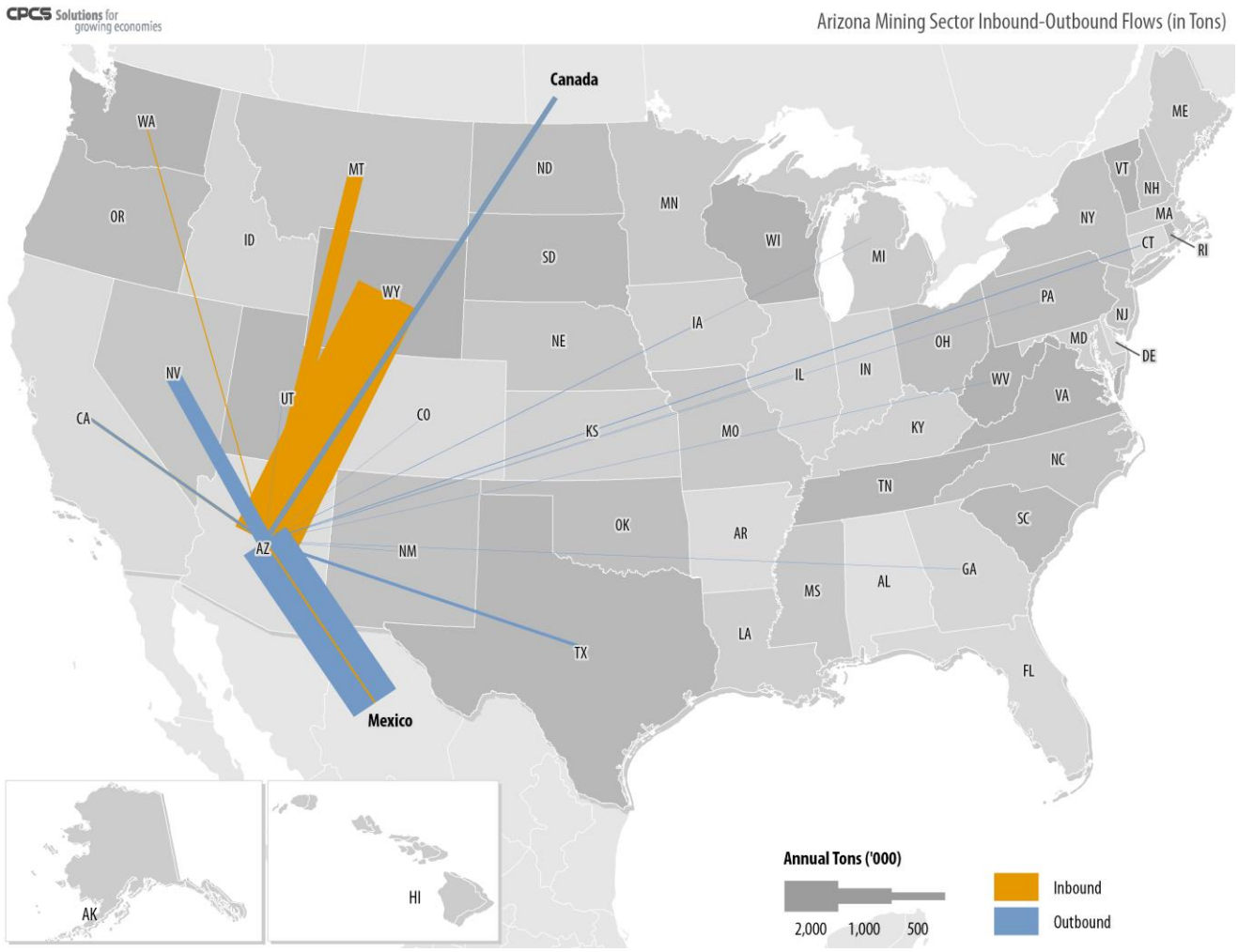


Source: CPCS analysis of Transearch 2013

2.3.2 Major Origins and Destinations

The figure below illustrates the major origins and destination for mining products. In terms of inbound traffic flows, Wyoming and Montana account for the vast majority of traffic. Traffic flows to Mexico (3.3 Mt) account for over 60 percent of outbound traffic, with Nevada, Texas, California and Canada also being important. The outflow from Arizona to Nevada is mostly lime for Nevada's gold mines, and the inflow from Montana and Wyoming is coal brought by rail for electric power generation.

Figure 2-16: Arizona Mining Sector Inbound and Outbound Tonnage Flows

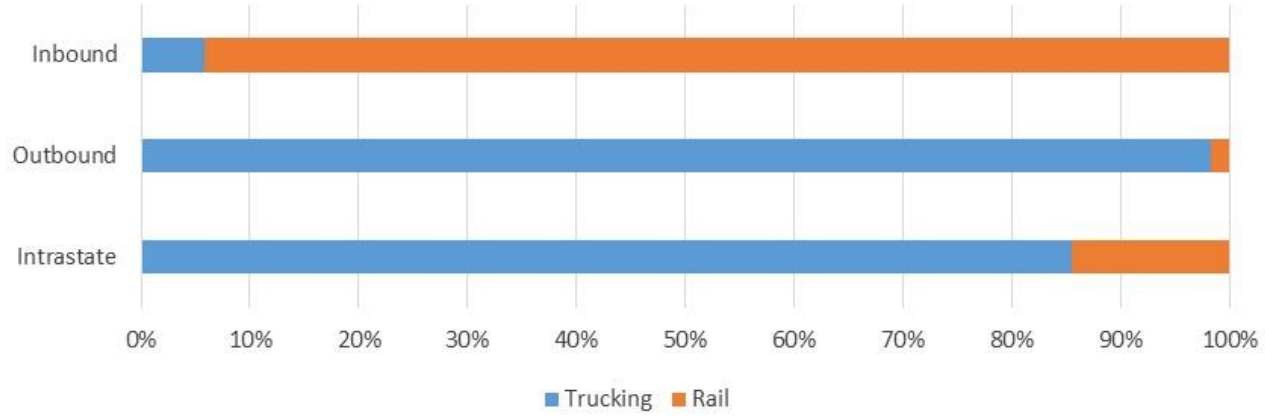


Source: CPCS analysis of Commodity Flow Survey, 2012. The import/export figures were obtained from Freight Analysis Framework 3 estimates for 2012

2.3.3 Modal Breakdown

Arizona's metals and minerals are shipped by both truck and rail.[32] As already seen the majority of these mining movements, some 88 percent or 54 Mt of shipments, are intrastate (Figure 2-13). As shown below, the majority of these intrastate shipments are by truck. However, there are significant intrastate volumes, 15 percent, that are shipped by rail. Also as shown below, almost all inbound shipments are by rail while nearly all of the outbound shipments are by truck reflecting the short distance of these movements.

Figure 2-17: Arizona Mining Sector Volume (Tons) by Mode



Source: CPCS analysis of Commodity Flow Survey, 2012.

[32] In the CFS dataset the individual mode volumes do not add up to the aggregate "All Mode" total which is due to data suppression for reasons of confidentiality and rounding at detailed mode level.

3 Supply Chain Structure and Transportation Performance Parameters

Key Messages

The copper mining supply chain has three components: copper concentrate; finished copper and products; and inbound supplies. Supply chains can also be simple or complex depending on the number of mines and other facilities owned by a company, as well as the specifics of the operations and available access to transportation modes.

Rail, due to its lower unit cost, is normally preferred for moving copper concentrate, cathode, anode and acid. Not all facilities, however, have rail access and truck plays a significant role.

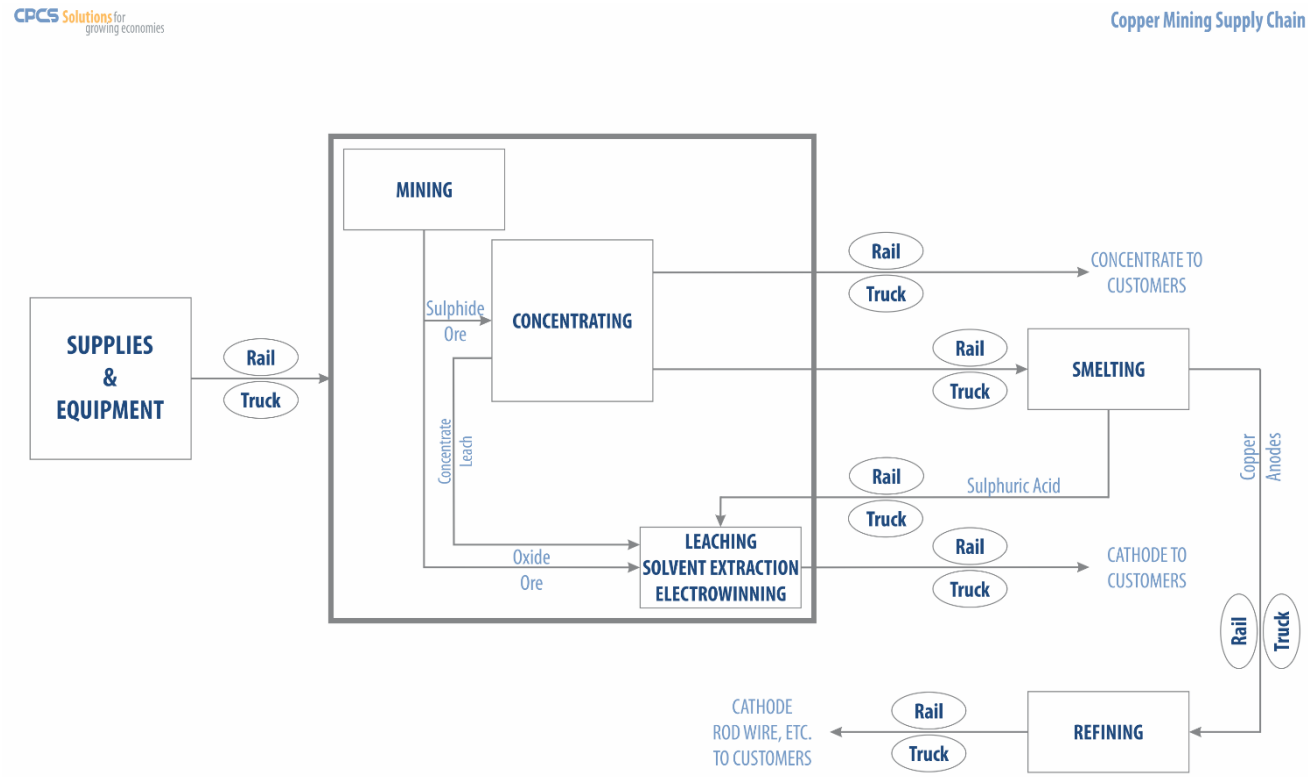
Construction aggregates (including concrete and asphalt) go by road to end users. In Arizona, most deliveries are within a 20-30 mile radius. On the input side, aggregates are typically mined at the production facility but other materials come in by road or rail depending on the material and source.

3.1 Supply Chain Structure

3.1.1 Copper

Figure 3-1 is illustrative of the copper supply chain, though is no single way to characterize "the" supply chain for copper mining in Arizona. In reality, the supply chain ranges from simple to complex depending on the number of mines and other facilities owned by the particular company, as well as the specifics of the operations and the available access to transportation modes (road and rail). Accordingly, the sections below outline each company's mining operations and access to the transportation network.

Figure 3-1: Illustrative Copper Mining Supply Chain



In general, companies mine copper ore which is then processed to produce copper concentrate and/or copper cathode, the latter by either solvent extraction/electrowinning (SX/EW) or by smelting and refining. Cathodes are the basic material used in manufacturing products such as copper rod, tubing and wire. However, the bulk of copper produced in Arizona is in the form of concentrate.

Ore subject to SX/EW first undergoes hydrometallurgical sulphuric acid leaching and then an electrowinning process to produce cathode. Where smelting and refining are involved, the ore is first processed to produce concentrate, which is then smelted to produce anode, which is in

turn refined to produce cathode. Sulphuric acid, a by-product of smelting, is returned to the mine site for use in the leaching process. The two main producers, FMI and Asarco, which together account for over 90 percent of copper produced in Arizona, produce cathode by both methods but their refineries are in Texas.

As a generalization, rail is the preferred mode for transporting concentrate, cathode, anode and acid because of its inherently lower average cost. However, as is evident below, not all mines have rail access and truck transportation necessarily plays a significant role in the supply chain, and in the case of inbound supplies has the dominant role.

3.1.2 Freeport McMoRan[33]

In Arizona, FMI produces copper concentrate at its Morenci, Bagdad and Sierrita mines. The majority of the concentrate produced at these mines is shipped to the company's Miami (AZ) smelter where anodes are produced. The anodes are then shipped to the company's El Paso, Texas refinery where they are used to produce copper cathode. Concentrate not sent to Miami (AZ) for smelting is shipped to the Guaymas, Mexico port for shipping overseas.[34] In addition to concentrate, all five of the FMI mines in Arizona produce SX/EW cathode.

Morenci

Morenci, an open pit operation, is located in Greenlee County approximately 50 miles northeast of Safford. The site has road access as well as direct rail access to the AZER. The operation includes two concentrators capable of milling 115,000 mt per day which produce copper and molybdenum concentrates. The concentrate leach, direct EW facility, on care-and-maintenance status since 2009, is expected to resume operation during 2015. Morenci has also undergone an expansion. Copper production (net of the joint venture partner's share) is expected to average over 400,000 mt per year over the next five years compared to over 300,000 mt in 2014.

Bagdad

Bagdad, an open pit complex, is located in Yavapai County in west-central Arizona, approximately 100 miles northwest of Phoenix. The property can be reached by SR 96, which ends at Bagdad. The closest rail access is to the BNSF at Hillside, approximately 24 miles southeast on SR 96. The operation consists of a 75,000 mt per day concentrator that produces copper and molybdenum concentrates, an SX/EW plant that can produce up to 14,500 mt per year of copper cathode, and a pressure leach plant to process molybdenum concentrates. Copper concentrate is either trucked to southern Arizona, or taken by semi for loading onto rail at Hillside.

[33] Freeport-McMoRan Inc., *2014 Form 10-K.*
[34] Telephone consultation with James C. Watts Consulting (May 11, 2015).

Sierrita

Sierrita, an open pit complex, is located in Pima County, approximately 20 miles southwest of Tucson and seven miles west of Green Valley and Interstate 19. The property can be reached by road and rail, the latter by means of a private spur connecting with UP. The operation includes a 102,000 mt per day concentrator that produces copper and molybdenum concentrates. Sierrita also produces copper by leaching and cathode is plated at the adjacent EW facility. Sierrita also has a copper sulfate crystal plant, and facilities which process molybdenum concentrate produced by Sierrita, by FMI's other mines and from third-party sources.

Safford

Safford is an open-pit copper mining complex located in Graham County, approximately eight miles north of Safford and 170 miles east of Phoenix. The site is accessible by paved county road off U.S. Highway 70. Safford is a mine-for-leach project and produces copper cathodes. The operation consists of two open pits feeding a crushing facility with a capacity of 103,000 mt per day. Leach solutions feed a SX/EW facility with a capacity of 240 million pounds of copper per year. A sulfur burner plant provides sulfuric acid used in SX/EW operations.

Miami

Miami is an open-pit mining complex with a copper smelter and rod plant. It is located in Gila County approximately 90 miles east of Phoenix and six miles west of Globe on U.S. Highway 60. The site is accessible by paved highway and by rail, the latter being direct access to AZER.

Miami mine has reported ore reserves of 3 million mt. Today, however, mining related operations only involve leaching by the SX/EW process, the design capacity of the plant being approximately 90,700 mt per year. There is no active mining of the orebody.

The Miami smelter processes copper concentrate primarily from FMI's Arizona mines. Concentrate processed totaled 603,700 mt in 2014. The smelter is also the most significant source of sulfuric acid for FMI's North American leaching operations. The smelter has been upgraded several times and as part of an expansion will install equipment allowing it to comply with new standards for sulfur dioxide emissions by 2018.

The Miami rod plant is one of several FMI conversion facilities in North America. These include the FMI refinery in El Paso, Texas which refines the Miami copper anode production. The El Paso refinery has the potential to operate at an annual capacity of about 408,000 mt of copper cathode, which is sufficient to refine all copper anode produced at Miami.

3.1.3 Asarco[35]

Asarco, owned by Grupo Mexico, is another integrated miner, smelter and refinery of copper. In Arizona, Asarco produces concentrate at its Mission and Ray mines which is shipped to the company's Hayden smelter where anodes are produced. The anodes are shipped to the

[35] See www.asarco.com.

company's Amarillo, Texas refinery where they are used to produce copper cathode. If Hayden is at capacity, Asarco can send concentrate to the Grupo Mexico Nacozari smelter in Mexico south of Douglas, Arizona. Asarco also produces cathode in Arizona at its Ray and Silver Bell mines.

Mission

The Mission mine, an open-pit complex, is located 18 miles south of Tucson in Pima County, being situated close to Interstate 19 with access from West Pima Mine Road. The mine has direct rail connection with UP by means of a private spur. Production of copper concentrate totalled approximately 61,000 mt in 2012. Concentrate produced at the Mission mine is shipped to the Hayden smelter.

Ray

The open-pit Ray mine complex is located 64 miles southeast of Phoenix in Pinal and Gila counties, and 18 miles west of the Hayden operations. Ray is accessible by road from SR 77. Operations include the mine, a concentrator, and an SX/EW operation. Cathode produced by SX/EW, which totaled approximately 33,400 mt in 2012, is shipped to outside customers and Asarco's Amarillo refinery. The Copper Basin Railway transports ore from the Ray mine to the Hayden concentrator, concentrate from the Ray concentrator to the Hayden smelter, and sulphuric acid from the Hayden smelter to the Ray leaching facilities.

Silver Bell

Silver Bell is an open-pit complex located in Pima County 23 miles west of Interstate I-10 on Avra Valley Road. There is no direct rail connection. All copper extracted from the ore is by means of hydrometallurgical processes and copper is then recovered from SX solution by EW. Cathode produced in the SX/EW operation is sold to producers of rod, tubing and wire.

Hayden Smelter

The Hayden operations, located 70 miles northeast of Tucson, include a concentrator and a 653,172 mt per year copper smelter. Anodes produced at the smelter, which totalled 144,288 mt in 2012, are shipped by rail or truck to Asarco's Amarillo, Texas refinery. Sulphuric acid produced at Hayden is used in the leaching operations or sold into the market to chemical manufacturers in the United States.

3.1.4 Capstone Pinto Valley Mine[36]

Capstone Mining Corp (Capstone) owns the Pinto Valley Mine (PVM), having purchased it from BHP Billiton (BHP) in October 2013. PVM is located in Gila county, 6 miles west of Miami and 13 miles northeast of Superior. Following a large capital improvement and maintenance project, the mine and plant were restarted in December 2012.

[36] Extracted from Capstone Mining Corp, *Annual Information Form for the Year Ended December 31, 2014* (March 16, 2015), p. 1-1 and p.

PVM consists of an open-pit mine, mill, and an SX/EW facility. The mill produces copper and molybdenum concentrates. Despite its proximity, PVM does not send concentrate to Miami (AZ) because the smelter is at capacity.[37] The majority of the copper concentrate is trucked to the San Manuel Arizona Railroad Company (SMARRCO) at San Manuel for transport by rail to the Port of Guaymas, Mexico. SMARRCO was included as part of the PVM acquisition.

The immediate focus is improving reliability and efficiencies. Pinto Valley Phase 2 (PV2) is a planned extension of operations beyond the restart of mining and plant operations. PV2 is based on copper production of approximately 57,000 mt per year to 2026.

Primary road access is from U.S. 60 which runs east and west three miles south of the mine. A three-lane tunnel on U.S. 60, two miles east of Superior, can accommodate mid-size haulage and construction equipment. Extremely large loads can be brought in using alternate routes. Forest Road (FR) 287 provides a paved connection from U.S. 60 to the mine. This also serves as the main access for the neighboring Carlota Mine, owned by KGHM International Ltd.

SMARRCO operates a trans-shipment facility in San Manuel, Arizona and a switching yard in Hayden. Copper concentrate is typically trucked by contractor from PVM to San Manuel and loaded into 100-ton railcars. Concentrate is hauled by SMARRCO to Hayden, approximately 30 miles. Copper Basin Railroad, UP and then Ferromex transport the concentrate from Guaymas for ocean shipment. Upgrades to the San Manuel facility were completed in 2012–2013.

3.1.5 KGHM Carlotta Mine[38]

The Carlota mine is located in the western part of the Miami-Globe mining region. KGHM International Ltd. acquired the project from Cambior Inc. in 2005, with large-scale mining beginning in 2008. Extraction is by conventional open-pit methods, and cathode is produced by means of SX/EW.

Currently the mine is preparing for mine closure. 2014 is the last year of mining, while leaching will continue for the next two years. Following closure the area will undergo a terrain restoration program.

3.1.6 Copper Mines Under Development

Hubay Rosemont Mine[39]

The Rosemont project is in the process of seeking final approvals prior to construction. Acquired by Hudbay in July 2014, a confirmatory drill program was announced in August 2014 to ensure compliance with existing environmental plans, permits and other constraints,

[37] Telephone consultation with Frank Hanson Consulting (May 26, 2015).
[38] http://kghm.com/en/our-business/mining-and-enrichment/carlota.
[39] M3 Engineering & Technology and Corporation, *Rosemont Copper Project, Updated Feasibility Study, Pima County, Arizona, USA,* N1 43-101 Technical Report (August 28, 2012), pp. 21-22, 192-193, 208-210.

improve understanding of the geology and mineralization, and to collect rock characteristic information to validate the current mine plan.[40]

Rosemont is a copper/molybdenum mine and concentrate development expected to produce approximately 400,000 mt of copper concentrate per year. The copper concentrate will be by far the highest volume material moving into or out of the site. The majority of this concentrate (70 percent) is subject to off-take agreements, and will be destined for international markets.[41] Concentrate not sold this way will be trucked to Arizona smelters.

The project is approximately 30 miles southeast of Tucson. Main road access will be via Interstate I-10 and SR 83, the latter intersecting with the main access road into the mine. Modifications to SR 83 are planned for safety reasons. Secondary road access will be provided via South Santa Rita Road and Interstate 19. The majority of the labor and supplies can come from areas surrounding the project in Pima, Cochise and Santa Cruz counties.

There is no direct rail service. Rail access is with UP at Tucson, or at Benson or Sahuarita. The Port of Tucson, a registered Foreign Trade Zone, has rail access from the UP mainline consisting of a two-mile siding complimented by an additional 3,000 foot siding. The Port of Tucson, approximately 24 miles from the project, can transload materials and supplies received by rail to trucks for delivery to site.

FMI's Sierrita and Asarco's Mission mines are nearby. Both use UP's Nogales line to connect with UP's main line at Tucson. It is unlikely that an infrastructure sharing agreement can be reached with either FMI or Asarco as the facilities at both Sierrita and Mission are fully utilized, antiquated and space constrained. Most concentrates produced at Rosemont will, at least initially, be trucked to Tucson for transfer to railcars. Any remainder will be trucked to local smelters.

Taseko Florence Mine[42]

The Florence project, acquired by Taseko in 2014, is to be an in-situ copper recovery (ISCR) operation[43] with an SX/EW plant for production of cathode. Development is planned in two phases, the first being a Production Test Facility (PTF) and the second being construction and operation of the commercial facility with expected average annual production of about 30,844 mt of cathode. The project is currently in the final stages of permitting for the PTF.

---

[40] Rosemont Copper, *Hudbay's Rosemont project to launch short-term drilling program on private land* (August 27, 2014) at http://rosemontcopper.com/drill-program.html.

[41] Hudbay Minerals Inc., Annual Information Form for the Year Ended December 31, 2014 (March 30, 2015), p. B24.

[42] M3 Engineering & Technology and Corporation, *Florence Copper Project, Pre-Feasibility Study, Florence, Pinal County, Arizona,* N1 43-101 Technical Report (April 4, 2013), pp. 25, 72, 194, 196, 248; Taseko, *Annual Information Form for the Year Ended December 31, 2014* (March 30, 2015), pp. 31-35.

[43] ISCR an extraction method used for selected mineral deposit conditions as an alternative to open pit or underground mine methods.

Twenty five percent of the project's anticipated cathode production has been placed under an off-take agreement. All non-committed copper cathode not included in the purchase agreement will be sold in the open market, or subject to off-take agreements to be negotiated.

The project is located in Pinal County within the town of Florence. Road access is from the Hunt Highway, approximately 2.1 miles west of U.S. Highway 79 north of Florence. Hunt Highway, a major road, is presently a two-lane highway but the Town has plans to make it a divided highway. Road improvements are necessary during project development for safety reasons.

The Copper Basin Railway, located 100 feet north of Hunt Highway adjacent to the site, provides direct rail access, with connection to UP at the Magma loading station. The Florence site will utilize rail cars for shipments of copper cathode and for receipt of materials for construction of the plant facilities.

Proposals solicited from southwestern U.S. vendors to supply the acid required for SX have indicated the availability of consistent supplies sourced from domestic and overseas sources, the most economical being sources in Arizona and Utah. Acid supply proposals included transportation by both rail and truck, with transloading from rail to truck as required.

Resolution Copper Mine[44]

The Resolution Copper project is being developed on one of the world's largest undeveloped deposits. It is to be a large-scale underground mining and ore concentration operation, located in the vicinity of Superior in Pinal County.

Engineering studies and gathering of baseline data has been underway for about ten years, including exploration drilling to characterize the nature and extent of the deposit. In 2014, construction of the #10 mine shaft was completed, and drilling, underground development and engineering studies continue.[45] A total operational life of approximately 40 years is projected.

Nominal ore production from the mine will be approximately 120,000 mt per day after ramp up. After being crushed and brought to the surface, the ore will be conveyed to a new concentrator. The concentrate will be transported as slurry to a filtration plant, dewatered and then routed to a train load-out facility for shipment via the rehabilitated Marco rail line and UP to domestic and/or global markets.

There are no plans for a new smelter or other secondary refining. Some smelting could be done in Arizona but this will be investigated closer to mine production in mid-2020. However, due to the limited smelting capacity in Arizona, the majority is expected to take place outside

[44] Resolution Copper Mining, *Mine Plan of Operations, Volume 1: Environmental Setting and Project Description* (filed November 15, 2013) at http://49ghjw30ttw221aqro12vwhmu6s.wpengine.netdna-cdn.com/wp-content/uploads/2014/06/resolution-copper-plan-of-operations-volume-one-introduction.
[45] Rio Tinto, *2014 Annual Report*, p. 31.

the State and likely outside of the U.S. Molybdenum concentrates will be bagged at the concentrator and shipped to market via truck.

Copper concentrate production will average approximately 2.2 million tons per year (not counting moisture content), with peaks up to 3.0 million tons. The load-out facility will be capable of receiving one train of 100 cars at 110 tons per car, and will receive on average 220 trains per year, and up to 300 during peak years. Resolution Copper will own the railcars. A contract rail company will be used to operate between the load-out facility and UP.

Road corridors providing access include U.S. 60 and state routes SR 79, SR 177, SR 88, and SR 24, the latter a planned corridor from southeastern Maricopa County to Florence Junction west of Superior. The nearest federal Interstate is I-10, located approximately 65km west of Florence Junction. County roads within the region include both paved and unimproved.

The project has numerous components and the construction phase is different for each facility. However, construction across all project components and facilities is expected to last about ten years (copper production is expected to begin in year six of construction).

3.1.7 Construction Aggregates[46]

Industry outputs include construction aggregates, ready mix concrete and asphalt. Products leaving the facility go by road to reach local end users. As noted earlier, due to the high weight/value ratio of the products and wide raw material availability, delivery tends to be local within a 20 to 30 mile radius. There are no competing products coming into Arizona. Aggregates and ready mix concrete companies can experience some 200 to 400 truck trips per day. Facilities located in metropolitan areas use interstate highways, major arterial roadways and collector roadways to deliver products to both public and private construction project customers. In rural areas, generally the state highway system is used.

On the input side, construction aggregates are typically mined at the production facility. However, raw materials including aggregate, cement and asphalt oil are imported to the production facilities and incorporated into product manufacturing. Cement comes from the northern and southern parts of the state mostly by truck. Many companies haul by themselves and hire additional transportation services. Aggregate is hauled in and out of sand and gravel operations depending on the job and to supply other plants. Materials are transported to the property for the inert landfill, sometimes as much as 40 to 50 loads a day. Other inputs include diesel fuel, asphalt oil and various other deliveries. There are no refineries in Arizona so all asphalt oil deliveries are from out of state by road or rail from California, New Mexico or Texas. The industry also relies on air and rail to transport equipment and other inputs needed.

[46] This section is based on information provided by consultations with the Arizona Rock Products Association.

3.2 Transportation Parameters[47]

In general, the choice of mode between road and rail is determined primarily by what each location is capable of accepting or by what is practical. For example, the shipment of copper by Asarco from the Hayden smelter to the Amarillo refinery is only practical by rail. At the Asarco Mission complex, the northern mine uses rail and truck but the southern mine does not have rail access. At FMI, when capacity is reached at the Miami (AZ) smelter, it forces FMI to rail concentrates to Guaymas. The choice between using road or rail also depends heavily on the cost and transit times (where timeliness is important). Trucks are preferred where time is the priority, this being the case especially in emergency situations, while rail is generally less costly. The distance between origin and destination can also be a significant factor in modal choice due to cost considerations.

3.2.1 Copper

The copper mining supply chain is comprised of three products: copper concentrate; finished copper and products (cathodes, anodes, rods etc.); and inbound supplies (acid, parts and equipment, fuel, etc.).

Copper Concentrate

Both rail and truck are used to transport metal bearing concentrates. However, not every mine has adequate rail or may not be capable of using both modes to transport concentrate. For example, by virtue of its location, Bagdad moves all concentrate by truck, as did the Mineral Park mine. Concentrate from the Mission Mine can be shipped by rail or truck to the Miami (AZ) smelter but the rail distance is almost four times longer. On the other hand, both Arizona smelters prefer rail shipments as they are limited in the number of trucks they can handle.

Another determining factor is the limited output capacity of Arizona smelters. Arizona used to have numerous copper smelters but due to environmental restrictions there are now only two, which results in an increased reliance on rail to move copper concentrates to ports for shipping to overseas smelters, particularly in Asia. At FMI, significant amounts of concentrates not being treated at the Miami (AZ) smelter are being sent to the Guaymas, Mexico port for shipping overseas. In the case of Pinto Valley, the majority of the concentrate is shipped to Guaymas.

The Port of Guaymas on the Sea of Cortez is currently the only port shipping Arizona copper concentrate overseas. It is set on expanding to become the second largest port in Mexico with

[47] This section is based largely on information sourced from consultations with the following: (organizations) Arizona Mining Association, Asarco, FMI, Golden Vertex, Resolution Copper; (individuals) Frank Hanson Consulting, Ross Consulting, Jim Watts Consulting.

capacity of close to 30 Mt.[48] The inland Port of Tucson and the Port of Guaymas are fostering economic cooperation,[49] with the Port of Tucson aiming to become a hub for ports on the east side of the Sea of Cortez.

There are, however, problems at Guaymas including theft of concentrate from rail cars and criticism by some resident groups over dust and discharge. Guaymas is also becoming risky due to an increase in environmental regulations. There are some 400,000 people in the area and tourism is important along with the cosmetics industry. Both of these industries oppose possible dust and air pollution associated with transporting metal bearing concentrates. Moreover, alternative ports are limited. Only one U.S. port is available to ship concentrates from Arizona, the Kinder-Morgan terminal in Vancouver, Washington, which is very busy and expensive. There has been some consideration given to designing shipping containers suitable for concentrate but no redesign has been agreed upon by the mining or transportation industries. Resolution Copper is considering a new bulk terminal in the San Fransisco area. Rosemont had previously worked on developing a new port facility at Topolobampo, Mexico, but new owner Hudbay Minerals has backed away due to the potentially high cost. FMI and some traders have sent test shipments through Topolobampo, but currently, Guaymas still remains the only viable and cost effective option for shipping metal bearing concentrates from Arizona to overseas.

Anodes and Cathodes

Almost no anode or cathode produced in Arizona is consumed in Arizona. Nearly all is shipped out by rail or truck. Anodes resulting from the smelting process at FMI's Miami and Asarco's Hayden facilities are shipped by rail and truck to the companies' refineries in El Paso and Amarillo, Texas. Most of the cathode produced in Arizona is shipped to outside customers that use the cathode to produce various finished products. The wire and brass industries are both large-scale, high-demand customers. Trucking rates paid by producers to ship copper out of Arizona are influenced by backhaul rates, which are paid to carriers that attempt to transport at full capacity on return journeys. The ability to lower overall shipping charges through backhaul arrangements with non-mining industries also influences the rail rates charged to ship copper out of Arizona because the railroads generally alter transportation charges for copper to compete with the trucking rates.

Inbound Supplies

There are major transportation requirements associated with both construction and operation of mines. During construction, heavy materials can include fuel, concrete, steel, asphalt and other materials needed for construction and production. Major equipment must also be delivered and can include crushers, conveyors, mills, concentrating equipment, pipe,

[48] Arizona Daily Star, *Port of Guaymas set to double its capacity, seeks Arizona ties* (November 24, 2013), at http://tucson.com/business/local/port-of-guaymas-set-to-double-its-capacity-seeks-arizona/article_16947664-811b-56eb-b67a-abf186bac8c7.html

[49] City of Tucson Economic Development, *Mayor Visits Guaymas; Meets with Mexican Officials* at http://www.mayorrothschild.com/business/economic-development/

prefab buildings, tailings equipment and rail cars. Large equipment is also required during operations, such as haul trucks and shovels which are frequently brought into mines. Materials and equipment needed for construction and operation are brought into mines using both road and rail. Overall, however, truck predominates because of how supplies are purchased (different items, different suppliers etc.). Permitted road moves are common.

Sulfuric acid is a key input in the copper leaching process. Smelters produce acid as a by-product and copper mines leach with acid. Acid is very heavy, with a ton of concentrate yielding a ton of acid. Acid from the Hayden and Miami smelters is mostly used in-house, being transported by both rail and truck. Acid to outside customers is also moving by rail and truck. The Arizona copper mining industry also imports acid since not enough is produced within the State.

3.2.2 Construction Aggregates[50]

Transportation decisions are largely made based on cost, this being a function of haul distance and transit time. Reliability is also a critical element. Cost is the driving factor, although transit time is an element in this. Flexibility is a must. The industry works off-hours to avoid traffic and time delays, and restocks plants with incoming materials when traffic volumes are lower (e.g. on Sunday versus Monday morning). Many times, however, industry vehicles are confined to local truck routes which forces additional mileage and cost.

As far as time impacts are concerned, perishable loads of ready mixed concrete must be considered. Thus, jobs can be turned down as a result of traffic patterns, time and cost. Materials can also be rejected by users if they fail to reach the project in time, resulting in perishable load issues. There is a 90 minute window for concrete. Asphalt must also stay at a certain temperatures in order to meet the required materials specifications in order to be accepted on a project. Time is also a factor when parts are needed to repair equipment.

It is much more sustainable for the industry to mine in proximity to markets. Local delivery facilitates compliance with transportation costs, delivery time constraints and in order to meet specifications. However, as aggregate reserves deplete near major metropolitan markets, companies will need to move farther away to establish new sources. The additional distance to markets will increase cost, safety exposure and wear and tear on vehicles and infrastructure. Traffic increases will also increase cost without new projects to relieve congestion. Significantly, Arizona passed in 2011 the Aggregate Protection Act (SB 1598), creating an opportunity for counties, municipalities and special districts to work with the aggregates mining industry to ensure the sustainable growth of communities (see Local Aggregate Protection text box).

[50]This section is based on information provided by consultations with the Arizona Rock Products Association.

Local Aggregate Protection

The Aggregate Protection Act (SB 1598), passed in 2011, establishes a framework and new requirements for planners and communities to address the availability of local construction materials. Over the years, population growth has significantly expanded the urban boundaries of many communities, resulting in the development of residential communities in rural areas, often in close proximity to and in conflict with existing aggregate operations. Further, some areas of Arizona are experiencing shortages of permitted aggregate resources, resulting in producers having to transport aggregate from more distant quarries. SB 1598 requires that General Plans be revised or amended to identify aggregates in the planning area, and that planners develop policies to preserve these aggregates for future use by avoiding incompatible land use.

www.freightlinertrucks.com

It is clear that locally-produced aggregates significantly reduce the costs and other impacts related to the transportation of aggregates. This reduces project costs, makes roads safer and less congested, and reduces road maintenance costs and air emissions. At peak production in 2006, Arizona produced 109 million tons of aggregates. At 25 tons per truck, this generated 8.72 million truck trips (including empty trucks returning to mines) travelling 174 million miles (conservatively assuming a 20 mile haul distance) in Arizona. Using California Air Resources Board emission factors, these trips required more than 26.7 million gallons of diesel fuel and generated more than 506.9 tons of truck emissions. Thus, for every 1-mile of reduced haul distance, some 25-tons of emissions could be reduced per year from the construction aggregate business.

Source: Haley & Aldrich, Inc., *Aggregate Protection Guidance, Prepared for Arizona Rock Products Association* (April 2014), pp. 1-4.

3.2.3 Transit Traffic

The focus of this report is mining activity within Arizona and its implications for the movement of mining-related freight within, into or out of Arizona. Nothing has been said regarding mining-related traffic transiting through Arizona. One potential source of such traffic, however, and consequent pressure on Arizona's land ports of entry, is a recent agreement between Tesla Motors Inc. and the Sonora Lithium Project Partners comprised of mining companies Bacanora Minerals Ltd and Rare Earth Minerals Plc. Under the agreement Tesla is to purchase lithium compounds from a proposed mining site in northern Mexico for use in its Reno, Nevada battery factory currently under construction ("Gigafactory"). The partners

project that once the mine is up and running, it will be able to supply 35,000 tons of lithium compounds per year at first, eventually expanding to 50,000 tons per year.[51]

3.3 Transportation Barriers and Needs[52]

Road related issues are seen as the main transportation barriers in connection with the movement of mining products. This includes the movement of copper, construction aggregates and their inbound mining supplies.

Problems cited, particularly in respect of copper, include the lack of sufficient trucks to transport mining products to markets, attributed to the general lack of industry in Arizona and therefore not enough trucks coming into the State. In addition, the shortage of trucks is exacerbated when farm harvests are peaking as it becomes more difficult to move other commodities at such times. These are not issues that ADOT can directly resolve, but it is felt that more industry and more trucks are needed in Arizona.

A second issue is the belief that truck weight limits should be raised, which could help relieve the shortage of trucks. Arizona limits the amount of freight that can be shipped to 80,000 tons gross vehicle weight per truck. In contrast, both Nevada and Utah have 110,000 ton limits, which increases efficiency because more freight is shipped by each truck. The Arizona load limits are a negative factor both for incoming materials and supplies and outgoing shipments.

A third major issue is the condition of Arizona's roads and bridges (see Key Facts About Arizona's Surface Transportation System text box overleaf). The current conditions in Arizona are deemed inadequate by stakeholders and require maintenance to handle current traffic. Many roads and bridges should be upgraded and/or modified to accommodate increased traffic loads and heavier allowable truck weights. One example is Interstate 10 between the Asarco Mission and Silver Bell mines, which is felt to be poorly built and poorly maintained, causing damage to trucks. Asarco has trouble retaining employees who do not like using these roads and is also concerned by the planned simultaneous construction work along U.S. routes 60 and 77 as these are the only two routes to reach the Ray and Hayden operations. Other examples cited include the inadequacy of state highways 79 and 60 and their intersection, which in the longer term will suffer greater congestion from development of the Superstition Vistas lands and other developments. Bridge weight limits are also cited as too low, for example the bridge outside Superior needing to be circumvented with heavy loads taken instead through Roosevelt.

---

[51]Arstechnica, T*esla strikes deal to buy lithium hydroxide mined in northern Mexico* (August 30, 2015) at http://arstechnica.com/business/2015/08/tesla-strikes-deal-to-buy-lithium-hydroxide-mined-in-northern-mexico/.

[52]This section is based entirely on information gleaned from consultations with the following: (organizations) Arizona Mining Association, Asarco, FMI, Golden Vertex, Resolution Copper, Arizona Rock Products Association; (individuals) Frank Hanson Consulting, Ross Consulting, Jim Watts Consulting.

Key Facts About Arizona's Surface Transportation System*

- Arizona's 60,000+ miles of roadways serve 6.6 million people. Vehicles on roads in Arizona travel nearly 60 billion miles annually (U.S. Census Bureau; Insurance Institute for Highway Safety).
- Seventy-five percent of the $165 billion worth of commodities delivered annually from sites in Arizona is transported by trucks on the state's highways. An additional 16 percent is delivered by parcel, U.S. Postal Service or courier, which uses multiple modes, including highways.
- Seventeen percent of Arizona's urban roads are in poor condition. Driving on roads in need of repair costs Arizona motorists $1.5 billion a year in extra vehicle repairs and operating costs ($318 per motorist).
- Twelve percent of Arizona's bridges are rated as structurally deficient or functionally obsolete. (Nationwide the figure is 24 percent, reflecting the older infrastructure of many states.)
- Forty-one percent of Arizona's major urban highways are congested. Traffic congestion costs American motorists $121 billion a year in wasted time and fuel costs.
- Vehicle travel on Arizona's highways increased by 71 percent from 1990 to 2013, about in line with Arizona's population which grew by 79 percent between 1990 and 2013. (Nationwide, vehicle travel on highways increased 39 percent over 1990-2013, while population grew by 26 percent.)
- Roadway conditions are a significant factor in approximately 1/3 of traffic fatalities. There were 849 traffic fatalities in Arizona in 2013. A total of 4,068 people died on Arizona's highways from 2009 through 2013.
- Arizona's traffic fatality rate of 1.40 fatalities per 100 million vehicle miles of travel is higher than the national average of 1.09. The fatality rate on the state's rural roads is disproportionately higher than that on other roads in the state (3.01 fatalities per 100 million miles of travel versus 1.15).
- Motor vehicle crashes cost Arizona $4 billion per year ($833 for each resident) in medical costs, lost productivity, travel delays, workplace costs, insurance costs and legal costs.

*TRIP, *Key Facts About Arizona's Surface Transportation System and Federal Funding* (April 2015) at www.tripnet.org/docs/Fact_Sheet_AZ.pdf.

While not related to copper, another example is the situation faced by the Northern Vertex Moss gold mine. Here, long haul carriers bring supplies to Bullhead City and unload as they refuse to use the local roads up to the mine. The supplies then have to be taken to the mine by local contractors. ADOT has not repaired these roads due to budgetary issues and a lack of sufficient traffic in the area to justify the upgrading. A solution would be for ADOT to move forward with a planned by-pass of Bullhead city, but this does not appear to be expected in the near future.

Congestion is a major issue around the Phoenix-Mesa Metropolitan Area where an approved and much needed by-pass is running into obstacles from environmental groups. Congestion is also an issue in rural areas where, because of road limitations, trucks have to wait on the side of the road during commuting hours.

Poor safety conditions are another issue identified by stakeholders with respect to road transportation in Arizona. This has been noted to affect even major roads such as U.S. 60 both east and west of Superior where there are a number of dangerous two lane stretches. In some places the road is being divided but this is not possible in all cases due to terrain.

Problems with permitting have also been noted because a significant amount of road transportation, specifically mining equipment and supplies, requires special permitting due to being oversize or overweight. For example, Asarco estimates permits are required several times per year or about once a month. However, budgetary problems being faced by the authorities are causing delays in permitting which is now taking several months for decisions to be made.

The top issue identified by the Arizona Rock Products Association (ARPA) with respect to transportation system barriers and needs is the need for dedicated and sustained funding sources. Indicative of Arizona's road conditions, and reflecting the funding constraints, are the number of urban roads classified in poor condition, highways identified as congested and bridges identified as structurally deficient or obsolete (see Arizona's Surface Transportation System text box). Adequate, dedicated and sustained funding sources would enable the needed upgrading and expansion of the state routes and key local corridors, rural roads, establishment of needed alternative routes and other needs.

Regarding rail transport, those consulted identified the two main issues: the setting of rates for copper which are generally established in relation to the costs of long haul trucking, and a desire for more rail lines. With the present network, many movements by rail entail circuitous routes and multiple interchanges between railroads, such as the shipping of concentrate from FMI's Morenci mine to Guaymas. The movement of a railcar from Morenci to Guaymas, about 460 miles, takes about seven to nine days. The border crossing to Mexico is crowded, and with only a single line between Arizona and Guaymas, and priority trains cause copper concentrate trains to be sidelined and delayed. In comparison, shipping concentrate to Guaymas by truck requires one day, even allowing for the transfer of the trailer at the Mexican border. Other lengthy trips by rail include, as already noted, the movement of concentrate from FMI's Mission mine to the Miami smelter, or the movement of copper from Miami to Tucson, a trip of about 400 miles that takes five or six days including the interchange with UP, compared to a direct trip of about 100 miles. Other issues affecting efficiency include the smaller railroads' lower weight limits, for example AZER being limited to weights of 263,000 pounds versus the Class 1s standard of 286,000 pounds.

4 Sector Priorities for Transportation System Performance Improvement

Key Messages

Consultations with mining industry stakeholders and experts identified the following priorities for Arizona transportation system improvement:

- **Increase allowable truck weight limits** to mitigate the trucking shortage and to increase efficiency in transporting both mining products and incoming supplies.
- **Improve Arizona's roads and bridges** to improve efficiency and safety, counter increased vehicle maintenance costs, alleviate congestion, provide for future growth and to allow for greater truck weight limits.
- **Develop dedicated and sustainable funding sources**, including more innovative options, to enable the needed maintenance, improvement and expansion in the transportation system.

4.1 Priority Improvement Needs

As identified by the mining sector experts and stakeholders consulted for this study, the priority transportation improvement needs are summarized below. The focus of the priorities is the mitigation of road related issues, and many of the priorities are interrelated.

Indirectly Address Truck Shortages. There is a lack of sufficient trucks in Arizona for transporting mining products, which is exacerbated during times of peak demand for transporting agricultural products. This is attributed to a general lack of industry in Arizona but also reflects the low value of mining products which does not permit shippers to pay the premiums that would be needed to otherwise attract carriers. One means for ADOT to help mitigate this barrier would be to allow for heavier truck weight limits, enabling shippers to load more product. Longer term, some relief from the truck shortage may come from Union Pacific's planned large Red Rock Classification Yard southeast of Picacho Peak.[53]

Increase Allowable Truck Weight Limits. In addition to helping to mitigate the problem of the shortage of trucks, allowing increased truck weight limits would increase efficiency by enabling mining companies to benefit from economies of scale in both the shipment of product as well as incoming materials and supplies, for example the heavy acid used in leaching operations.

Improve Road and bridge Conditions. A further top priority is to improve the state of the roads in Arizona. This is needed to improve efficiency and safety, counter increased vehicle maintenance costs, alleviate congestion both in urban and rural areas and provide for future growth. It is also required in order to allow for the increase in truck weight limits. As cited in this report, 17 percent of Arizona urban roads are classified in poor condition, 41 percent of the major urban highways are congested, and 12 percent of the bridges are rated as structurally deficient or functionally obsolete. Stakeholders consulted for this report cited numerous examples of roads and bridges needing improvement or upgrading to handle traffic loads.

Develop sustainable funding sources. As cited by ARPA, there is a need for dedicated and sustainable funding sources, including more innovative funding options such as those adopted by other states. It is the lack of such sources that limits the ability of Arizona to maintain, improve and expand the transportation system to adequately meet current and future needs, including state and local key corridors, rural roads, alternatives to existing routes, and more transloading intermodal facilities. Highlighting the need for sustainable funding sources, the Arizona Chamber of Commerce & Industry, together with other business stakeholders, recently launched the "Accelerate Arizona" program to provide the private-sector voice when

[53]The Arizona Republic, *Planned rail yard near Picacho Peak gains steam* (September 8, 2015) http://archive.azcentral.com/arizonarepublic/news/articles/2012/09/24/20120924picacho-peak-rail-yard-state-land.html.

it comes to expressing the importance of transportation infrastructure investment to the future economic growth of the state.[54]

Recognize the role of the transportation system in enabling municipalities to use local construction aggregates. Construction aggregates place a heavy burden on the transportation system. As compared to more distant sources, relying on local sources significantly reduces both the impacts and costs related to transporting aggregates. It reduces construction project costs (including transportation projects), makes roads safer and less congested, reduces maintenance costs associated with pavement rehabilitation, and makes for cleaner air. Planners should protect locally sourced construction aggregates since distance has a significant impact when it comes to transporting construction materials.

[54] Arizona Chamber of Commerce and Industry, *Accelerate Arizona* (March 5, 2015) at http://www.azchamber.com/blog/accelerate-arizona.

Appendix A: Stakeholders and Experts Consulted

Name	Title	Organization
Joe Bardswich	General Manager	Golden Vertex Corportation
Richard Bark	Director, Government Relations & Environmental Counsel	Freeport McMoRan
Frank Hanson	President	Frank Hanson Consulting
Gary Lombardo	Commodity Manager	Asarco
Bill Mackey	Regional Material Manager	Granite Construction Company
Randy Nickle	Transportation Director/Logistics	Freeport McMoRan
Nyal Niemuth	Economic Geology Section	Arizona Geological Survey
Kelly Norton	President	Arizona Mining Association
Bradley D. Ross, CPG	Geologist/Appraiser	Ross Consulting
David Stanley	Principal Advisor Infrastructure	Resolution Copper
Steve Trussell	Executive Director	Arizona Rock Products Association
Jim Watts	President	Jim Watts Consulting