The

ECONOMIC IMPACT

OF FRAC SAND MINING

A Look at Jobs and Earnings in Wood County, Wisconsin

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Any errors in the report are those of the authors and not the aforementioned individuals. This project was led by EMSI staff members Hank Robison, Chief Economist; Timothy Nadreau, Senior Research Economist; and Joshua Wright, Senior Editor.

EXECUTIVE SUMMARY

The purpose of this analysis is to show the impact of development and expansion of the "frac sand" mining industry in Wood County, Wisconsin. Impacts are reported in terms of newly created jobs and newly created earnings (i.e., labor income). We also estimate the creation of new revenues to county and local governments.

Key Highlights

- New frac sand plant and transport facility investments amounting to over $161 million is projected to occur over the first seven years of the project, including $86 million in the first 18 months, and another $75 million over the subsequent 5½ years.
- In the first year of the project, new facilities construction will result in the creation of approximately 616 new jobs and some $33.3 million in new earnings in Wood County.
- By Year 3 of the project, with plants, mining, and transport facilities in place, frac sand production will account for approximately 700 new jobs and over $42.8 million in Wood County earnings.
- By Year 8 of the project, with both initial and expansion phase investments in place, frac sand production will account for nearly 930 permanent jobs and over $58.7 million in Wood County earnings.
- Frac sand mining will create an array of new county and local government revenues in Wood County. These revenues are estimated to be roughly $1.5 million in Year 1 of the project, growing to nearly $2.6 million per year by Year 8 and continuing at roughly that level every year thereafter.

INTRODUCTION

With the growing demand for hydraulic fracturing and the discovery and extraction of natural gas in the Marcellus Shale, Wood County, Wisconsin is poised to expand its mining and manufacturing of silica sands that are plentiful in the region. The purpose of this analysis is to show the impact of development and expansion of the "frac sand" mining industry in Wood County. The frac sands operations include four major components:

- **Quarrying:** Operating heavy mining equipment, workers extract unprocessed sands from well-defined deposits. Wages are paid, taxes are paid, inputs are purchased, and profits are generated.
- **Hauling:** Trucks and trains haul unprocessed sands from quarry sites to processing plants. Again, wages are paid, taxes are paid, inputs are purchased, and profits are generated.
- **Processing:** Plants representing significant capital investments receive the unprocessed sands and clean and otherwise refine these into finished product ready for shipment. Wages are paid, taxes are paid, inputs are purchased, and profits are generated.
- **Out-Shipping:** Rail and truck transport finished product to final users outside Wood County.

Based on data and discussions provided by members in the industry and City of Marshfield officials, we break our analysis into three phases: 1) initial construction, 2) operations and expansion, and 3) full operation. Capital investments will occur through Phases 1 and 2; after that the industry will settle in Phase 3 into something approximating a steady equilibrium. In equilibrium, the industry will support a more or less constant number of employees, purchase a stable amount of local production inputs, and pay local taxes.

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PHASE 1: INITIAL INVESTMENT IMPACTS

Phase 1 captures the main construction part of the project. These capital construction investments are expected to last 18 months and result in investment spending of $86 million. At the end of Phase 1, operations of the refinery plants and mining will begin.

Plant Construction

Construction in Phase 1 puts in place the initial installation of plant and transport infrastructure. Table 1.1 below focuses on plant construction alone, estimated to account for $65.2 million of the overall $86.0 million in Phase 1 costs. The impacts of transport construction are considered in the next section.

Table 1.1 reports the creation of new labor income (also called "earnings") in Wood County over the 18 months of Phase 1 new plant construction. Even though plant construction is composed of $65.2 million in spending, we convert this spending into earnings to capture the creation of new income in the Wood County economy. For more on the differences between spending and earnings, please refer to the box on the following page.

The first two columns of Table 1.1 show the North American Industry Classification System (NAICS) Code and industry description. The column labeled "initial" shows earnings in the construction devoted to building $65.2 million in new plant infrastructure. The second column shows the multiplier effects, reported as new earnings, resulting from the initial spending on plant construction. In general, multiplier effects result from the spending on input supplies by the construction sector itself (sometimes called "direct effects), the additional labor income created in firms that supply the suppliers (sometimes called "indirect effects"), and the labor income created as a result of consumer expenditures from income generated in the initial, direct, and indirect rounds of spending (sometimes called "induced effects").

The final column sums the initial and multiplier effects of the $65.2 million in new plant infrastructure

Table 1.1: Earnings Impacts of $65.2 Million Spending on Plant Construction

NAICS Code	Industry description	Initial Effects	Multiplier Effects	Total Effects
212322	Frac-Sands Processing	$0	$0	$0
212322	Frac-Sands Mining	$0	$0	$0
482112	Frac-Sands Ore Haulage	$0	$0	$0
21	All other Mining	$0	$45,754	$45,754
11	Agriculture, Forestry, Fishing and Hunting	$0	$46,908	$46,908
22, 23	Utilities, Construction	$30,273,845	$659,760	$30,933,605
31–33	Manufacturing	$0	$1,072,492	$1,072,492
42, 44, 45	Trade	$0	$1,366,327	$1,366,327
48, 49	Transportation and Warehousing	$0	$336,029	$336,029
51, 52, 53	Finance, Insurance, Information, Real Estate	$0	$708,988	$708,988
54, 55, 56	Professional, Management, Administrative Services	$0	$990,697	$990,697
61, 62, 71	Education, Health Care, Arts, Misc. Services	$0	$1,226,670	$1,226,670
72, 81	Accommodation, Food, Misc. Services	$0	$588,082	$588,082
90	Government	$0	$538,954	$538,954
	TOTAL	*$30,273,845*	*$7,580,661*	*$37,854,506*

Sales vs. Earnings

Advocates sometimes favor gross sales over earnings as an impact measure, because sales are always larger than the earnings. Using this as an impact measure has notable drawbacks, however. An immediate drawback is that, unlike earnings, there is generally no published total against which a sales impact can be measured. More importantly, though, the most troublesome aspect of gross sales impact measures is captured in the following example:

Two visitors spend $50,000 each in the economic region. One visits a local auto dealer and purchases a new luxury automobile. The other undergoes a medical procedure at the local hospital. In terms of direct economic impact, both have spent $50,000. However, the expenditures will likely have very different meanings to the local economy. Of the $50,000 spent for the luxury automobile, perhaps $10,000 remains in the county as salesperson commissions and auto dealer income (part of the economic region's overall earnings), while the other $40,000 leaves the area for Detroit or somewhere else as wholesale payment for the new automobile. Contrast this to the hospital expenditure. Here perhaps $40,000 appears as physician, nurse, and assorted hospital employee wages (part of the county's overall earnings), while only $10,000 leaves the area, to pay for hospital supplies, or to help amortize building and equipment loans. In terms of sales, both have the same impact, while in terms of earnings, the former has one-fourth the impact of the latter.

investment. Three sectors see over $1 million in new earnings: "manufacturing," "retail trade," and "health care and social assistance." Other sectors are impacted as shown in the table. Altogether, the construction of new frac sands plants initially creates approximately $30.3 million in new earnings in the construction sector alone, and some $7.6 million in additional multiplier effect earnings. In total, Phase 1 construction amounts to $37,854,506 in new earnings.

Rail Construction

The other large construction taking place in Phase 1 is in rail transport. An estimated $20.8 million is to be spent on upgrades to existing rail lines and construction of new rail lines. The new earnings created by this spending are shown in Table 1.2 on the following page.

Following a parallel logic to that described above for the new plant investment impact, and summing the initial plus multiplier effects, yields a total rail construction impact of $12,099,826 in new earnings.

Total Impacts

We can sum the impacts of plant and rail construction to get the total 18-month impacts resulting from the $86 million in initial investment. Initial investment impacts on Wood County result in a total of **$49,954,332** in additional earnings—the total of impacts for plant (Table 1.1) and rail (Table 1.2).

Because of the time component to this investment (i.e., 18 months), we constructed Table 1.3 that details earnings impacts for Year 1 versus Year 2. Phase 1 construction creates a total of $33.3 million in new earnings in Year 1, and half that amount, approximately $16.7 million, in Year 2.

Table 1.4 shows job impacts. In the case of jobs some additional clarification is in order. As described above, it takes 18 months to complete Phase 1 and absent finer detail on the specific timing of expenditures we are obliged to assume an approximately even expenditure flow. Accordingly, we assume two-thirds of the investment takes place in Year 1 and this in turn creates 606 full-year jobs (as shown in Table 1.4). Year 2 is different; it starts with the same level of day-to-day jobs, 606, but

the project concludes at the half-year mark (i.e., at the overall end of the 18 month investment period). So as not to confuse with the full-year investment (Year 1), we show created jobs in a full-year equivalent sense: so 606 jobs over a six-month period is reported in Table 1.4 as 303 jobs.

Table 1.2: Earnings Impacts of $20.8 Million Spending on Rail Transport

NAICS Code	Industry description	Initial Effects	Multiplier Effects	Total Effects
212322	Frac-Sands Processing	$0	$0	$0
212322	Frac-Sands Mining	$0	$0	$0
482112	Frac-Sands Ore Haulage	$0	$0	$0
21	All other Mining	$0	$14,628	$14,628
11	Agriculture, Forestry, Fishing and Hunting	$0	$14,904	$14,904
22,23	Utilities, Construction	$9,687,524	$209,294	$9,896,818
31-33	Manufacturing	$0	$343,059	$343,059
42, 44,45	Trade	$0	$434,998	$434,998
48,49	Transportation and Warehousing	$0	$107,223	$107,223
51, 52, 53	Finance, Insurance, Information, Real Estate	$0	$225,847	$225,847
54, 55, 56	Professional, Management, Administrative Services	$0	$316,575	$316,575
61, 62, 71	Education, Health Care, Arts, Misc. Services	$0	$387,240	$387,240
72,81	Accommodation, Food, Misc. Services	$0	$187,020	$187,020
90	Government	$0	$171,514	$171,514
	TOTAL	*$9,687,524*	*$2,412,302*	*$12,099,826*

Table 1.3: Earnings Impacts By Year of $65.2 Million Spending on Plant Construction

NAICS Code	Industry description	Year 1	Year 2
212322	Frac-Sands Processing	$0	$0
212322	Frac-Sands Mining	$0	$0
482112	Frac-Sands Ore Haulage	$0	$0
21	All other Mining	$40,255	$20,127
11	Agriculture, Forestry, Fishing and Hunting	$41,208	$20,604
22,23	Utilities, Construction	$27,220,282	$13,610,141
31-33	Manufacturing	$943,701	$471,850
42, 44,45	Trade	$1,200,883	$600,442
48,49	Transportation and Warehousing	$295,501	$147,751
51, 52, 53	Finance, Insurance, Information, Real Estate	$623,223	$311,612
54, 55, 56	Professional, Management, Administrative Services	$871,515	$435,757
61, 62, 71	Education, Health Care, Arts, Misc. Services	$1,075,940	$537,970
72,81	Accommodation, Food, Misc. Services	$516,735	$258,367
90	Government	$473,645	$236,823
	TOTAL	*$33,302,888*	*$16,651,444*

Table 1.4: Jobs Impacts By Year of $65.2 Million Spending on Plant Construction

NAICS Code	Industry description	Year 1	Year 2
212322	Frac-Sands Processing	0	0
212322	Frac-Sands Mining	0	0
482112	Frac-Sands Ore Haulage	0	0
21	All other Mining	0	0
11	Agriculture, Forestry, Fishing and Hunting	1	1
22,23	Utilities, Construction	480	240
31-33	Manufacturing	14	7
42, 44,45	Trade	28	14
48,49	Transportation and Warehousing	6	3
51, 52, 53	Finance, Insurance, Information, Real Estate	11	5
54, 55, 56	Professional, Management, Administrative Services	19	10
61, 62, 71	Education, Health Care, Arts, Misc. Services	32	16
72,81	Accommodation, Food, Misc. Services	18	9
90	Government	8	4
	TOTAL	*616*	*308*

PHASE 2: EXPANSION & OPERATIONS

In Phase 2 the plants and rail transport constructed in Phase 1 become fully operational. But this is not all—production capacities continue to grow though additional infusions of capital investment, this time extending over a five-year period. Phase 2 begins at the midpoint of the second year of the analysis, at the conclusion of Phase 1. The five-year capital expansion entails $75 million in additional investment spending that, for the sake of simplicity, we assume is equally distributed over the five-year period. Operations of the local plants and raw sand extraction from the mining pits also begin in this period.

Readers will note the different effects on jobs and earnings resulting from construction (the initial investment shown in the previous section and expansion investment shown in this section) and the day-to-day ongoing operations of the frac sands mines and processing plants. At the conclusion of construction phases, those jobs and their associated earnings cease. In contrast, jobs and earnings from ongoing plant operations are of a more permanent character.

Phase 2 Capital Expansion

The beginnings of the $75 million in plant investments under Phase 2 follow immediately on the heel of Phase 1's $86 million initial investment (i.e., at the midpoint of Year 2 of the analysis). The total impacts of this investment, including the multiplier effects, are shown below in Table 2.1. Notice that the initial

Table 2.1: Impacts of $75 million Spending on Capital Expansion

NAICS CODE	Industry description	Initial Effects	Multiplier Effects	Total Effects
212322	Frac-Sands Processing	$0	$0	$0
212322	Frac-Sands Mining	$0	$0	$0
482112	Frac-Sands Ore Haulage	$0	$0	$0
21	All other Mining	$0	$52,671	$52,671
11	Agriculture, Forestry, Fishing and Hunting	$0	$53,999	$53,999
22,23	Utilities, Contruction	$34,850,400	$759,498	$35,609,898
31-33	Manufacturing	$0	$1,234,623	$1,234,623
42, 44,45	Trade	$0	$1,572,878	$1,572,878
48,49	Transportation and Warehousing	$0	$386,826	$386,826
51, 52, 53	Finance, Insurance, Information, Real Estate	$0	$816,166	$816,166
54, 55, 56	Professional, Management, Administrative Services	$0	$1,140,462	$1,140,462
61, 62, 71	Education, Health Care, Arts, Misc. Services	$0	$1,412,107	$1,412,107
72,81	Accommodation, Food, Misc. Services	$0	$676,983	$676,983
90	Government	$0	$620,428	$620,428
61	Total	$34,850,400	$8,726,641	$43,577,041

Table 2.2: Phase 2 Expansion Earning Impacts by Year

NAICS CODE	Industry Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
212322	Frac-Sands Processing		$0	$0	$0	$0	$0	$0
212322	Frac-Sands Mining		$0	$0	$0	$0	$0	$0
482112	Frac-Sands Ore Haulage		$0	$0	$0	$0	$0	$0
21	All other Mining		$5,267	$10,534	$10,534	$10,534	$10,534	$5,267
11	Agriculture, Forestry, Fishing and Hunting		$5,400	$10,800	$10,800	$10,800	$10,800	$5,400
22,23	Utilities, Construction		$3,560,990	$7,121,980	$7,121,980	$7,121,980	$7,121,980	$3,560,990
31-33	Manufacturing		$123,462	$246,925	$246,925	$246,925	$246,925	$123,462
42,44,45	Trade		$157,288	$314,576	$314,576	$314,576	$314,576	$157,288
48,49	Transportation & Warehousing		$38,683	$77,365	$77,365	$77,365	$77,365	$38,683
51,52,53	Finance, Insurance, Information, Real Estate		$81,617	$163,233	$163,233	$163,233	$163,233	$81,617
54,55,56	Professional, Management, Admin. Services		$114,046	$228,092	$228,092	$228,092	$228,092	$114,046
61,62,71	Education, Health Care, Arts, Misc. Services		$141,211	$282,421	$282,421	$282,421	$282,421	$141,211
72,81	Accommodation, Food, Misc. Services		$67,698	$135,397	$135,397	$135,397	$135,397	$67,698
90	Government		$62,043	$124,086	$124,086	$124,086	$124,086	$62,043
	TOTAL	*$0*	*$4,357,704*	*$8,715,408*	*$8,715,408*	*$8,715,408*	*$8,715,408*	*$4,357,704*

Table 2.3: Phase 2 Expansion Job Impacts by Year

NAICS CODE	Industry Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
212322	Frac-Sands Processing		0	0	0	0	0	0
212322	Frac-Sands Mining		0	0	0	0	0	0
482112	Frac-Sands Ore Haulage		0	0	0	0	0	0
21	All other Mining		0	0	0	0	0	0
11	Agriculture, Forestry, Fishing and Hunting		0	0	0	0	0	0
22,23	Utilities, Construction		63	126	126	126	126	63
31-33	Manufacturing		2	4	4	4	4	2
42,44,45	Trade		4	7	7	7	7	4
48,49	Transportation & Warehousing		1	1	1	1	1	1
51,52,53	Finance, Insurance, Information, Real Estate		1	3	3	3	3	1
54,55,56	Professional, Management, Admin. Services		3	5	5	5	5	3
61,62,71	Education, Health Care, Arts, Misc. Services		4	8	8	8	8	4
72,81	Accommodation, Food, Misc. Services		2	5	5	5	5	2
90	Government		1	2	2	2	2	1
	TOTAL	*0*	*81*	*161*	*161*	*161*	*161*	*81*

investment takes place in the construction industry and the spending is again converted into earnings impacts. Importantly, Table 2.1 shows the total impact of five years of investment all in one table. Altogether, five years of construction spending will create new regional earnings of **$43,577,041**.

The construction impacts of Phase 2 will be realized over the five-year expansion period. Table 2.2 takes total impacts shown in Table 2.1 and distributes these by year across the five-year expansion period. Note that inasmuch as the expansion starts at the six-month mark, five years of construction actually crosses six calendar years. In the first six-month year, expansion construction creates approximately $4.4 million of new earnings in Wood County. Over the next four years (full 12-month construction years) expansion construction creates approximately $8.7 million in new earnings. Finally, in the terminal construction year, with six months of construction, approximately $4.4 million of new earnings are created.

Table 2.3 presents employment impacts. In each full year, 161 new jobs are created. In the first and last years, lasting six months each, the table reports 81 "full-year equivalent" jobs. As discussed earlier, the project will

actually create 161 jobs, but for only six months, so we accordingly display these as 81 full-year equivalent jobs.

Phase 2 Operations

Operations are set to begin at the 18-month mark, at the conclusion of the initial $86 million new plant and rail transport investment. The operating scale of the plants will continue to grow as a result of the five additional years of investment ($75 million) discussed in the preceding sub-section. The new jobs and earnings in plant and transport operations begin in the middle of Year 2. Table 2.4 shows the earnings related to the operation of the plants. They will operate for six months in Year 2 and grow steadily until operating at nearly full capacity in Year 7 at the end of the expansion process. Table 2.5 tells the same story in terms of operating jobs.

Altogether, plant, transport, and mining operations will create approximately $15.7 million in new earnings in the first year (a six-month year) of operations, approximately $31.1 million in Year 2, and over $56 million in the final Year 7 of development, at the conclusion of expansion investment.

Table 2.4: Phase 2 Operations Earning Impacts by Year

NAICS CODE	Industry Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
212322	Frac-Sands Processing		$7,338,007	$15,955,899	$18,515,669	$21,075,439	$23,635,209	$26,194,979
212322	Frac-Sands Mining		$2,201,402	$4,786,770	$5,554,701	$6,322,632	$7,090,563	$7,858,494
482112	Frac-Sands Ore Haulage		$2,440,480	$5,306,626	$6,157,956	$7,009,287	$7,860,617	$8,711,948
21	All other Mining		$0	$0	$0	$0	$0	$0
11	Agriculture, Forestry, Fishing and Hunting		$31,231	$67,909	$78,803	$89,698	$100,592	$111,487
22,23	Utilities, Construction		$226,920	$493,419	$572,577	$651,735	$730,893	$810,052
31-33	Manufacturing		$197,610	$429,687	$498,621	$567,554	$636,488	$705,422
42,44,45	Trade		$822,890	$1,789,307	$2,076,362	$2,363,417	$2,650,471	$2,937,526
48,49	Transportation & Warehousing		$52,330	$113,787	$132,042	$150,297	$168,551	$186,806
51,52,53	Finance, Insurance, Info., Real Estate		$567,700	$1,234,417	$1,432,452	$1,630,487	$1,828,522	$2,026,557
54,55,56	Profess., Management, Admin. Services		$455,900	$991,317	$1,150,352	$1,309,387	$1,468,422	$1,627,457
61,62,71	Educ, Health Care, Arts, Misc. Services		$672,800	$1,462,949	$1,697,647	$1,932,344	$2,167,042	$2,401,740
72,81	Accommodation, Food, Misc. Services		$499,290	$1,085,665	$1,259,836	$1,434,007	$1,608,178	$1,782,349
90	Government		$184,680	$401,572	$465,995	$530,418	$594,841	$659,265
	TOTAL	*$0*	*$15,691,240*	*$34,119,325*	*$39,593,014*	*$45,066,702*	*$50,540,391*	*$56,014,079*

Table 2.5: Phase 2 Operations Jobs Impacts by Year

NAICS CODE	Industry Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
212322	Frac-Sands Processing		100	217	252	287	322	357
212322	Frac-Sands Mining		30	65	76	86	97	107
482112	Frac-Sands Ore Haulage		30	65	76	86	97	107
21	All other Mining		0	0	0	0	0	0
11	Agriculture, Forestry, Fishing and Hunting		1	2	3	3	3	4
22,23	Utilities, Contruction		4	9	10	11	13	14
31-33	Manufacturing		3	7	8	9	10	11
42,44,45	Trade		19	41	48	55	61	68
48,49	Transportation and Warehousing		1	2	3	3	3	4
51,52,53	Finance, Insurance, Information, Real Estate		10	22	25	29	32	36
54,55,56	Professional, Management, Administrative Services		10	22	25	29	32	36
61,62,71	Education, Health Care, Arts, Misc. Services		20	43	50	57	64	71
72,81	Accommodation, Food, Misc. Services		17	37	43	49	55	61
90	Government		3	7	8	9	10	11
	TOTAL	*0*	*248*	*539*	*626*	*712*	*799*	*885*

PHASE 3: FULL OPERATION

Phase 3 captures operations impacts after all investment ($86 million initial investment and $75 million expansion investment) has taken place. The earnings and jobs in Phase 3 are permanent jobs, reflecting plant, transport, and mining operation at full capacity. Beyond this point no construction impacts will occur. The plants are assumed to be in a steady state of operations. Tables 3.1 and 3.2 show the earning and job impacts stretching out into the future for as long as the plants continue.

Table 3.1: Phase 3 Operations Earning Impacts by Year

NAICS CODE	Industry Description	Year 8	Year 9	Year 10	
212322	Frac-Sands Processing	$27,474,864	$27,474,864	$27,474,864	
212322	Frac-Sands Mining	$8,242,459	$8,242,459	$8,242,459	
482112	Frac-Sands Ore Haulage	$9,137,613	$9,137,613	$9,137,613	
21	All other Mining	$0	$0	$0	
11	Agriculture, Forestry, Fishing and Hunting	$116,934	$116,934	$116,934	
22,23	Utilities, Construction	$849,631	$849,631	$849,631	
31-33	Manufacturing	$739,889	$739,889	$739,889	...
42,44,45	Trade	$3,081,053	$3,081,053	$3,081,053	
48,49	Transportation & Warehousing	$195,933	$195,933	$195,933	
51,52,53	Finance, Insurance, Information, Real Estate	$2,125,574	$2,125,574	$2,125,574	
54,55,56	Professional, Management, Administrative Services	$1,706,974	$1,706,974	$1,706,974	
61,62,71	Education, Health Care, Arts, Misc. Services	$2,519,088	$2,519,088	$2,519,088	
72,81	Accommodation, Food, Misc. Services	$1,869,435	$1,869,435	$1,869,435	
90	Government	$691,476	$691,476	$691,476	
	TOTAL	*$58,750,924*	*$58,750,924*	*$58,750,924*	

Table 3.2: Phase 3 Operations Job Impacts by Year

NAICS CODE	Industry Description	Year 8	Year 9	Year 10	
212322	Frac-Sands Processing	374	374	374	
212322	Frac-Sands Mining	112	112	112	
482112	Frac-Sands Ore Haulage	112	112	112	
21	All other Mining	0	0	0	
11	Agriculture, Forestry, Fishing and Hunting	4	4	4	
22,23	Utilities, Construction	15	15	15	
31-33	Manufacturing	11	11	11	
42,44,45	Trade	71	71	71	...
48,49	Transportation & Warehousing	4	4	4	
51,52,53	Finance, Insurance, Information, Real Estate	37	37	37	
54,55,56	Professional, Management, Administrative Services	37	37	37	
61,62,71	Education, Health Care, Arts, Misc. Services	75	75	75	
72,81	Accommodation, Food, Misc. Services	64	64	64	
90	Government	11	11	11	
	TOTAL	*929*	*929*	*929*	

SUMMARY AND CONCLUSIONS

This section summarizes the fiscal impacts as well as the job and earning impacts discussed in the previous chapters, effectively synthesizing everything into one set of tables and graphs. Table 1 below shows the total annual earnings impacts—construction plus operation—expected from the proposed development of the frac sand mining industry in the region. Figure 1 provides a graphical representation of the data in Table 4.1.

Table 4.2 similarly synthesizes the full-year jobs data from all phases into a single table. Figure 4.2 provides the graphical representation of Table 4.2 data.

Figure 4.1: Total Earning Impact

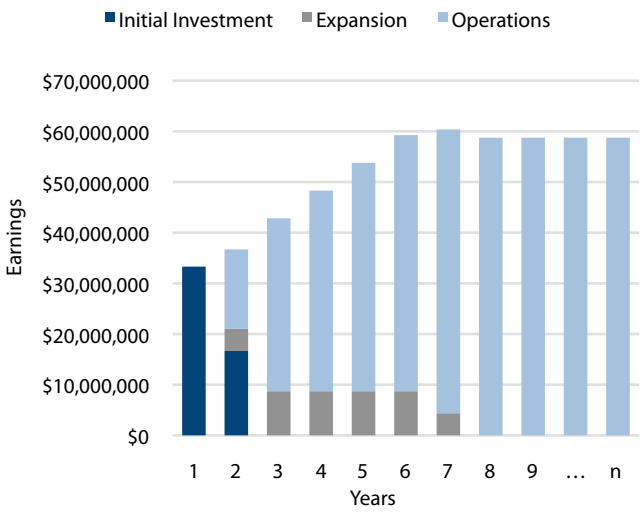


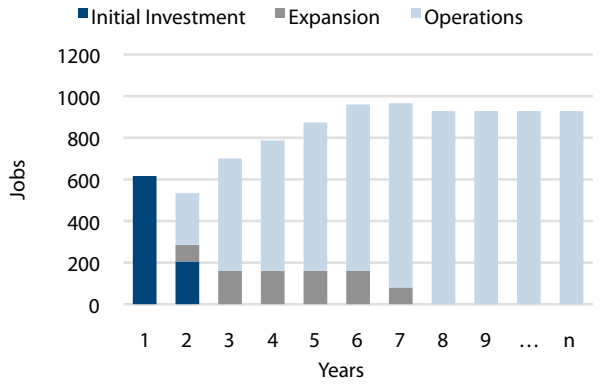
Table 4.1: New Earnings from Frac-Sands Development

Industry Code	Industry Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8		Year n*
212322	Frac-Sands Process.	0	7,338,007	15,955,899	18,515,669	21,075,439	23,635,209	26,194,979	27,474,864		27,474,864
212322	Frac-Sands Mining	0	2,201,402	4,786,770	5,554,701	6,322,632	7,090,563	7,858,494	8,242,459		8,242,459
482112	Frac-Sands Ore Haul.	0	2,440,480	5,306,626	6,157,956	7,009,287	7,860,617	8,711,948	9,137,613		9,137,613
21	All other Mining	40,255	18,685	10,534	10,534	10,534	10,534	5,267	0		0
11	Agriculture, Forestry, Fishing and Hunting	41,208	50,367	78,709	89,603	100,497	111,392	116,886	116,934		116,934
22,23	Utilities, Construction	27,220,282	12,861,337	7,615,399	7,694,557	7,773,715	7,852,873	4,371,041	849,631		849,631
31-33	Manufacturing	943,701	635,639	676,611	745,545	814,479	883,413	828,884	739,889		739,889
42, 44,45	Trade	1,200,883	1,380,472	2,103,883	2,390,938	2,677,992	2,965,047	3,094,814	3,081,053		3,081,053
48,49	Trans. and Warehsng.	295,501	189,513	191,153	209,407	227,662	245,916	225,489	195,933	...	195,933
51, 52, 53	Finance, Insurance, Info., Real Estate	623,223	857,058	1,397,651	1,595,686	1,793,720	1,991,755	2,108,174	2,125,574		2,125,574
54, 55, 56	Professional, Management, Admin. Services	871,515	860,451	1,219,410	1,378,445	1,537,480	1,696,514	1,741,503	1,706,974		1,706,974
61, 62, 71	Educat., Health Care, Arts, Misc. Services	1,075,940	1,172,657	1,745,370	1,980,068	2,214,766	2,449,463	2,542,950	2,519,088		2,519,088
72,81	Accommodation, Food, Misc. Services	516,735	739,233	1,221,062	1,395,233	1,569,404	1,743,575	1,850,047	1,869,435		1,869,435
90	Government	473,645	404,605	525,657	590,080	654,504	718,927	721,307	691,476		691,476
	TOTAL	*33,302,888*	*31,149,907*	*42,834,733*	*48,308,422*	*53,782,111*	*59,255,799*	*60,371,783*	*58,750,924*		*58,750,924*

Table 4.2: New Jobs from Frac-Sands Development

Industry Code	Industry Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8		Year n*
212322	Frac-Sands Process.	0	100	217	252	287	322	357	374		374
212322	Frac-Sands Mining	0	30	65	76	86	97	107	112		112
482112	Frac-Sands Ore Haul.	0	30	65	76	86	97	107	112		112
21	All other Mining	0	0	0	0	0	0	0	0		0
11	Agriculture, Forestry, Fishing and Hunting	1	2	3	3	3	4	4	4		4
22,23	Utilities, Construction	480	227	134	136	137	138	77	15		15
31-33	Manufacturing	14	10	10	11	12	13	13	11		11
42, 44,45	Trade	28	32	49	55	62	68	71	71	•••	71
48,49	Trans. and Warehsng.	6	4	4	4	4	5	4	4		4
51, 52, 53	Finance, Insurance, Info., Real Estate	11	15	25	28	32	35	37	37		37
54, 55, 56	Professional, Management, Admin. Services	19	19	27	30	34	37	38	37		37
61, 62, 71	Educat., Health Care, Arts, Misc. Services	32	35	52	59	66	73	76	75		75
72,81	Accommodation, Food, Misc. Services	18	25	42	48	53	59	63	64		64
90	Government	8	7	9	10	11	12	12	11		11
	TOTAL	*616*	*534*	*701*	*787*	*874*	*960*	*966*	*929*		*929*

Figure 4.2: Total Job Impacts by Year



Now that the earnings and jobs data have been synthesized we can look at the expected annual impacts on government revenues. Table 4.3 shows total government revenue impacts broken out according to five separate entities: City of Marshfield, Wood County, Mid-State Technical College, Marshfield School District, and "all other." In Year 1 (with the commencement of Phase 1 construction), total increase government revenues amount to approximately $1.5 million. This figure eventually climbs to nearly $2.6 million in Year 8 and beyond.

Table 4.3: New Tax Revenues from Frac Sand Development

CHANGE IN TAX REVENUES	1	2	3	4	5	6	7	8		Year n*
City of Marshfield	$426,277	$398,719	$548,285	$618,348	$688,411	$758,474	$772,759	$752,012		$752,012
Wood County	$220,751	$206,479	$283,933	$320,216	$356,499	$392,781	$400,179	$389,435		$389,435
Mid-State Technical College	$77,072	$72,090	$99,132	$111,799	$124,467	$137,135	$139,718	$135,966	•••	$135,966
Marshfield School District	$434,365	$406,284	$558,687	$630,080	$701,472	$772,865	$787,421	$766,280		$766,280
Other	$306,862	$287,024	$394,691	$445,128	$495,564	$546,000	$556,283	$541,348		$541,348
TOTAL	*$1,465,327*	*$1,370,596*	*$1,884,728*	*$2,125,571*	*$2,366,413*	*$2,607,255*	*$2,656,358*	*$2,585,041*		*$2,585,041*

APPENDIX 1: INPUT-OUTPUT MODELING

Introduction and data sources

EMSI's input-output model represents the economic relationships among a region's industries, with particular reference to how much each industry purchases from each other industry. Using a complex, automated process, we can create regionalized models for geographic areas comprised by counties or ZIP codes in the United States.

Our primary data sources are the following:

1. The Industry Economic Accounts from the Bureau of Economic Analysis (BEA); specifically the "make" and "use" tables from the annual and benchmark input-output accounts.
2. Regional and national jobs-by-industry totals, and national sales-to-jobs ratios (from EMSI's industry employment and earnings data process).
3. Proprietor earnings from State and Local Personal Income Reports (BEA).

Creation of the national Z matrix

The BEA "make" and "use" tables (MUTs) show which industries make or use which commodity types. These two tables are combined to replace the industry-commodity-industry relationships with simple industry-industry relationships in dollar terms. This is called the national "Z" matrix, which shows the total amount ($) each industry purchases from others. Industry purchases run down the columns, while industry sales run across the rows.

Table 1: Sample "Z" matrix ($ millions)

	Industry 1	Industry 2	. . .	Industry N
Industry 1	3.3	1,532.5	. . .	232.1
Industry 2	9.2	23.0	. . .	1,982.7
. . .	. . .	. . .	. . .	. . .
Industry N	819.3	2,395.6	. . .	0

The value 1,532.5 in this table means that Industry 2 purchases $1,532,500,000 worth of commodities and/or services from Industry 1.

The whole table is basically an economic double-entry accounting system, configured so that all money inflows have corresponding outflows elsewhere.

In addition to regular industries (such as "oil and gas extraction," "machinery manufacturing," "food and beverage stores," "hospitals," and so on), there are three additional rows representing labor earnings, profits, and business taxes, which together represent industry "value added" and account for the fact that industries do not spend all of their income on inputs from other industries. There are also three rows and columns representing federal, state, and local government (we later separate federal government into civilian and military sectors).

We create two separate Z matrices since there are two sets of MUTs—annual and benchmark. The benchmark data are produced every five years with a five-year lag and specify up to 500 industry sectors; annual data have a one-year lag but specify only 80 industrial sectors.

The basic equation is as follows:

$$Z = VQ\hat{}-1U$$

where V is the industry "make" table, $Q\hat{}-1$ is a vector of total gross commodity output, and U is the industry "use" table.

In reality, this equation is more complex because we also need to "domesticate" the Z matrix by removing all imports. This is needed because we are creating a

"closed" type of national model.

In addition, there are a number of modifications that need to be made to the BEA data before the calculations can begin. These are almost all related to the conversion of certain data in BEA categories to new categories that are more compatible with other data sets we use in the process, and describing them in detail is beyond the scope of this document.

Disaggregation of the national Z matrix

The previous step resulted in two national Z matrices—one based on the benchmark BEA data (five years old, approximately 500 industries) and the other based on the annual BEA data (one year old, but only about 80 industries). These initial national Z matrices are then combined and disaggregated to 1,125 industry sectors. Combining them allows us to capitalize on both the recency of the annual data and the detail of the benchmark data. The disaggregation is performed for each initial Z matrix using probability matrices that allow us to estimate industry transactions for the more detailed sectors based on the known transactions of their parent sectors. The probability matrix is created from detailed EMSI industry earnings data, which are available for all 1,125 sectors and are created using a separate process.

Creation of the national A matrix

The national disaggregated Z matrix is then "normalized" to show purchases as percentages of each industry's output rather than total dollar amounts. This is called the national "A" matrix.

Each cell value represents the percentage of a row industry's output that goes toward purchasing inputs from each column industry. Thus, the cell containing .112 above means that Industry 1 spends 11.2% of its total output to obtain inputs from Industry 2.

Table 2: Sample "A" matrix

	Industry 1	Industry 2	. . .	Industry 1125
Industry 1	.001	.112	. . .	.035
Industry 2	.097	0	. . .	.065
. . .	. . .	. . .	. . .	. . .
Industry 1125	.002	.076	. . .	0

At this point, our additional rows representing earnings, profits, and business taxes are removed. However, we will use them in a different form later.

Regionalization of the A matrix

To create a regional input-output model, we regionalize the national A matrix using that region's industry mix.

The major step in the process is the calculation of per-industry out-of-region exports. This is performed using a combination of the following standard techniques that are present in the academic literature:

- Stevens regional purchase coefficients (RPCs)
- Simple location quotient of value added sales
- Supply/demand pools derived from the national A matrix

We try to maximize exports in order to account as fully as possible for "cross-hauling," which is the simultaneous export and import of the same good or service to/from a region, since it is quite common in most industries.

Another major part of the process is the regionalization of consumption, investment, and local government "row industries" (rows referring to the rows of the A matrix). These represent the percentage of each industry's sales that end up going toward consumption, capital purchases, and taxes to local government, respectively. They are created from the "value added" rows that we removed earlier. Consumption is calculated using each industry's earnings and profits, as well as a constant called "the average propensity to consume," which describes the approximate percentage of earnings and profits that are spent on consumption. Investment and local government rows are calculated by distributing the known total investment and endogenous local government for the entire region to individual industries proportionally to their value added.

The A-matrix regionalization process is automated for any given region for which industry data are available. Although partially derived from national figures, the regional A matrix offers a best possible estimate of

regional values without resorting to costly and time-consuming survey techniques, which in most cases are completely infeasible.

Creating multipliers & using the A matrix

Finally, we convert the regional "A" matrix to a "B" matrix using the standard Leontief inverse $B = (I - A) - 1$. The "B" matrix consists of inter-industry sales multipliers, which can be converted to jobs or earnings multipliers using per-industry jobs-to-sales or earnings-to-sales ratios.

The resulting tables and vectors from this process are then used in the actual end-user software to calculate regional requirements, calculate the regional economic base, estimate sales multipliers, and run impact scenarios.

APPENDIX 2: ABOUT THE AUTHORS

Dr. Hank Robison is EMSI's co-founder and chief economist with 30 years of international and domestic experience. He is recognized for theoretical work blending regional input-output and spatial trade theory, and for development of community-level input-output modeling as the basis for establishing agency protocol for conducting sub-county economic impact analysis. He served 10 years as faculty member and consultant to the University of Idaho, and produced a wide array of grants and contract research. Dr. Robison specializes in economic impact analysis, regional data development, and custom crafted community and broader area input-output models. His client list includes a diverse mix of state and federal government agencies and private industry.

Mr. Timothy Nadreau is a senior research economist at EMSI. While his specialty is in abstract and linear algebras, his consulting work has focused largely on cluster theory, human capital, and international trade. He was awarded the coveted Iddings fellowship for his work on optimal public investments and tuition levels for community and technical colleges. He has also done work revolving around agricultural policies and regional development. In 2011, Mr. Nadreau completed his master's degree in economics at the University of Idaho. Prior to joining EMSI, Mr. Nadreau received a bachelor's degree in theoretical mathematics from the University of Idaho.