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# Innovative data mining for enhanced inland waterways performance assessment

Presentation to the TRB Innovative  
Technologies for a Resilient Marine  
Transportation System – June 24, 2014

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# Motivation

- Understanding the efficiency and usefulness of the Inland Waterways
- “In 2010, our inland waterways system handled over 566 million tons of freight”  
*(National Waterways Foundation, Feb 2012)*
- Integral component in national freight network



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# The angle...

- Identifying key trips and vessels allows for their consideration in prioritizing operations improvements, capital investments, sustainability targets
- What does this look like at the local level?
  - Differences between constrained and open waterways
  - Regional opportunities

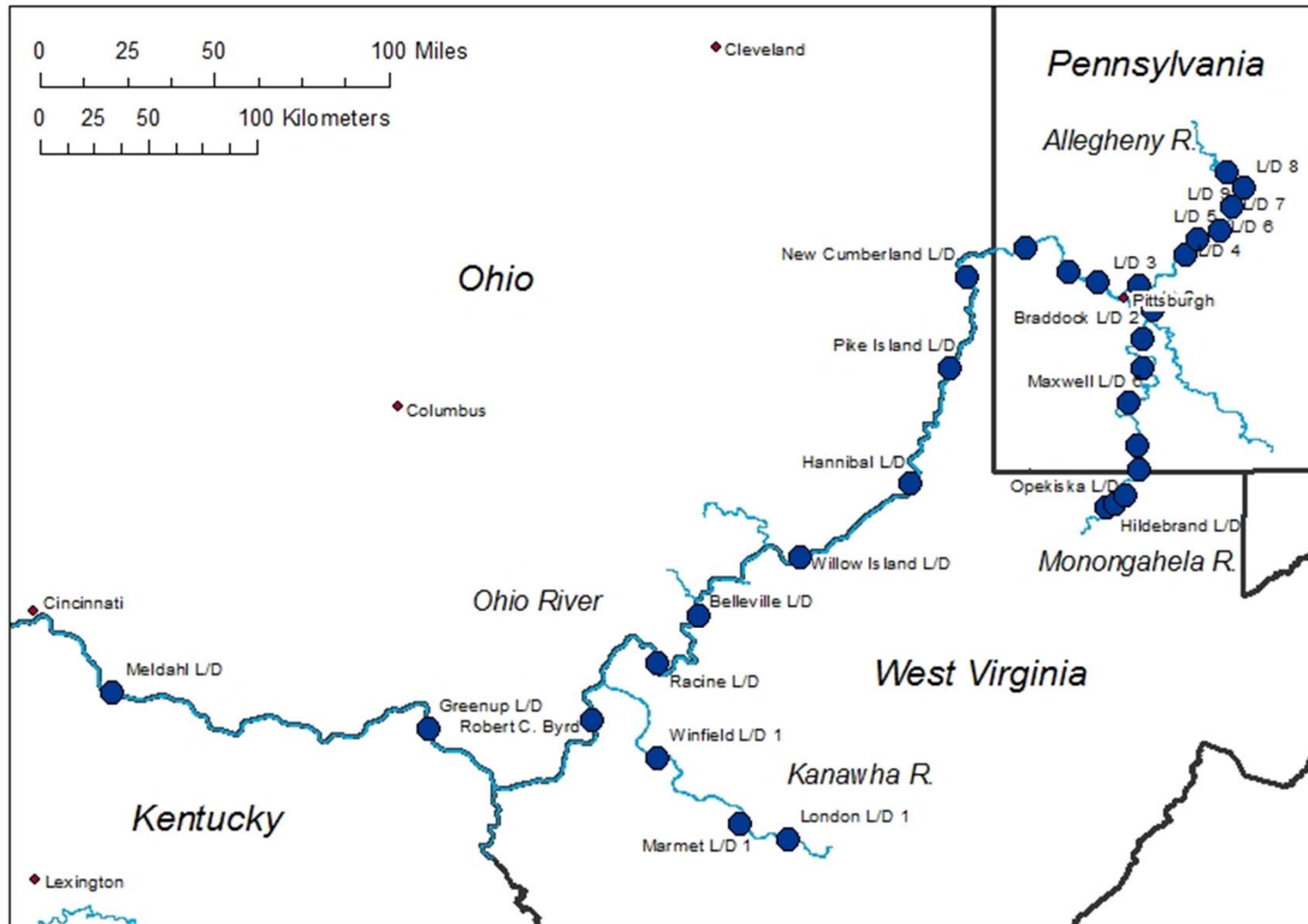


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# Method

- 2010 USACE lockage data
  - Pittsburgh and Huntington Districts, 110,000 records
  - Build trips from consecutive lockages
- 2010 Energy Information Administration survey (EIA-923)
  - 59,000 fuel shipments to power plants
  - 23,000 shipments of coal from mines
  - Barge, rail, truck
- Analyze trips
  - Distance, count, tons, ton-miles, shipping costs, emissions
- Characterize vessels
  - Activity, engine size and age

# Pittsburgh and Huntington District Locks



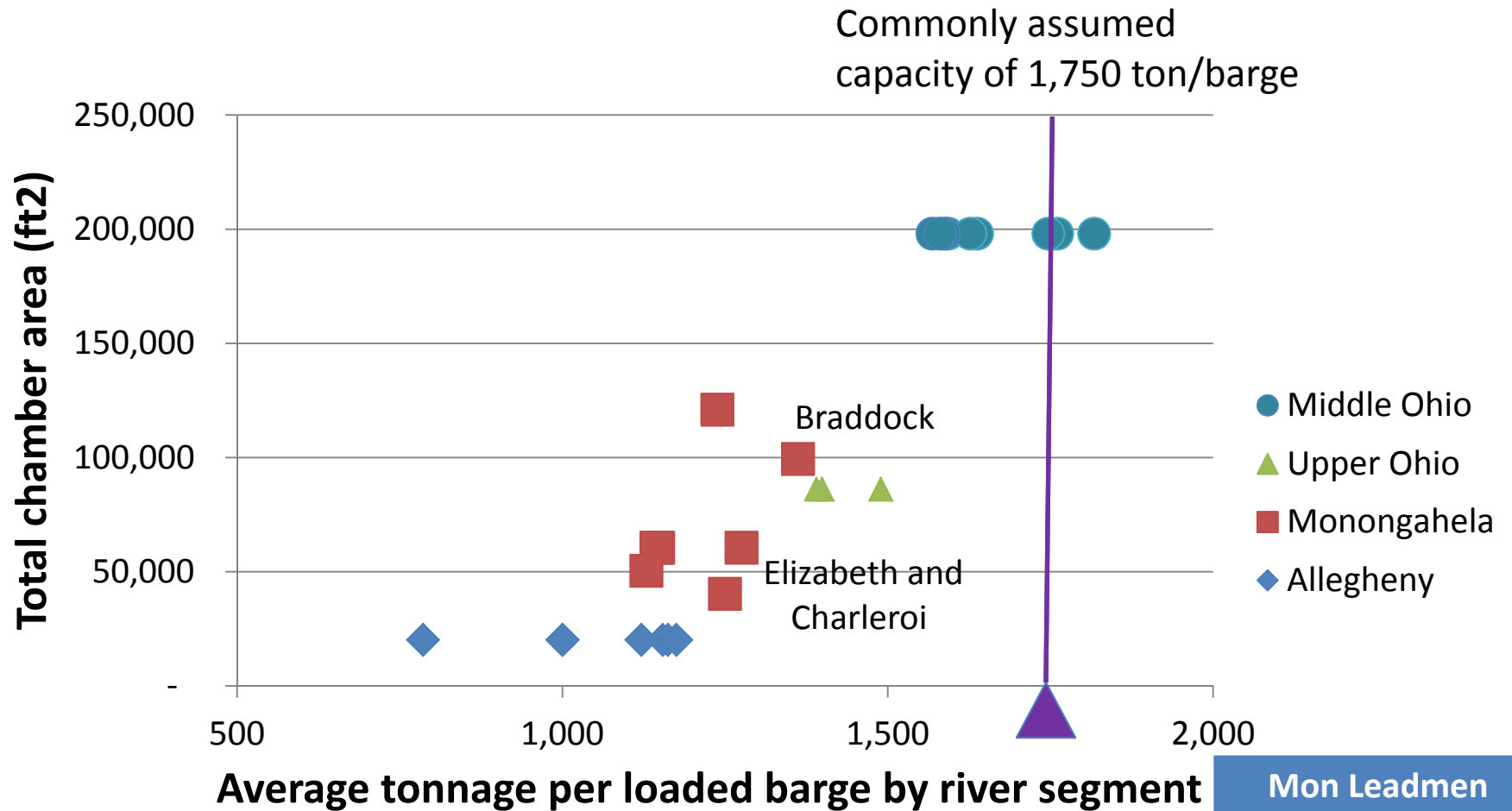
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# How many tons per barge?



- 1,750 tons dry bulk barge (*National Waterways Foundation*)
- Upriver constraints, smaller barges
- Corps barge registration capacity data:
  - Pittsburgh Dist. 1,200 tons
  - Huntington Dist. 1,600 tons
- Corps LPMS estimates tonnage and gives barge counts

# Regional differences in ton/barge



Mon Leadmen Assumptions	
Standard	1,000
Stumbo	1,200
Jumbo	1,500

# Trip Count

- Single lock trips
- Maxwell-Elizabeth, small lock constriction
- Montgomery, change in lock size
- Connection to lower Ohio and beyond at Meldahl

	OHIO										MONONGAHELA					
	Meldahl							Cumberland	Montgomery			Elizabeth	Charleroi	Maxwell		Morgantown
Meldahl	Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
		Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
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					Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
Cumberland							Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
Montgomery								Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
									Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
										Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
Elizabeth											Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
Charleroi												Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue
Maxwell													Dark Blue	Light Blue	Light Blue	Light Blue
														Dark Blue	Light Blue	Light Blue
															Dark Blue	Light Blue
Morgantown																Dark Blue

- **“Trip count” provides measure of regional traffic intensity**

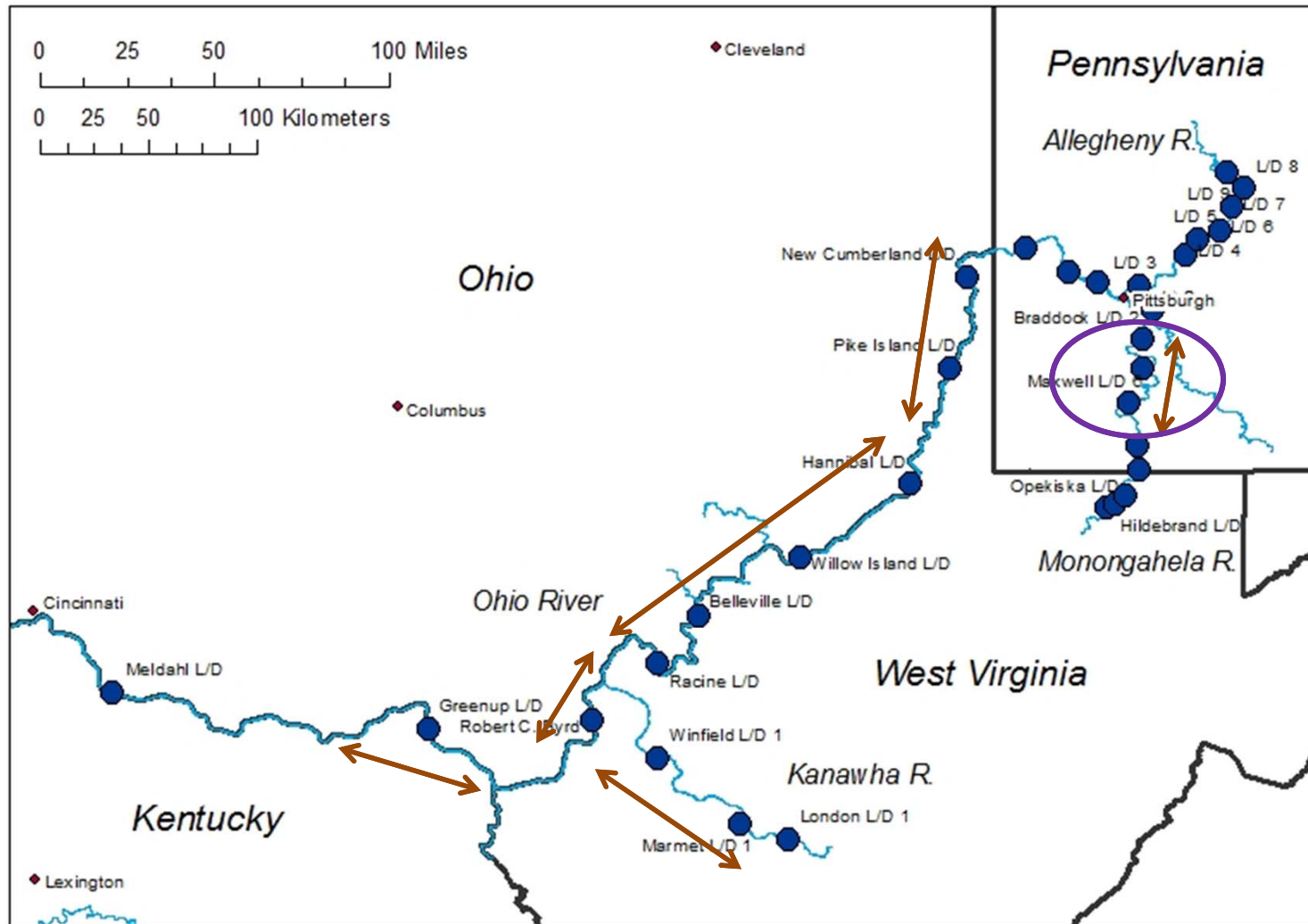


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# Trip rank by ton-mile, ton

- High ton-mileage means higher fuel consumption and emissions
  - Opportunity for efficiency prioritization
- High tonnage trips are critical commodity movements
- Six trips are highly ranked for count, ton-mile, and tonnage

# Critical Transits within Pittsburgh/Huntington



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# Who uses these trips?

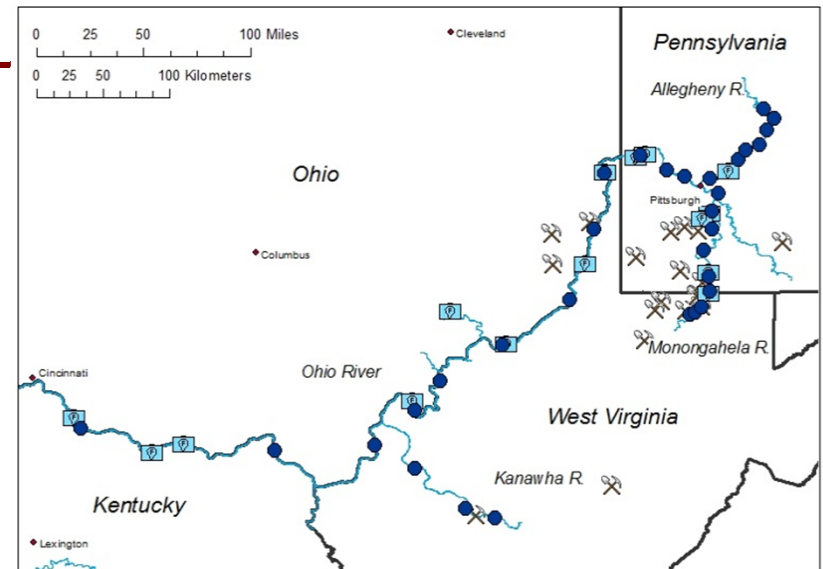
- Elizabeth/Charleroi/Maxwell
  - Shuttling trip across constriction
  - Lower Mon Project to replace Charleroi and remove Elizabeth
- 12 towboats
  - 89% of 1,092 trips
  - average 1,630 hp
  - Average engine update
    - 1983 or 1963?
- Cumberland Mine
  - 3.3 of 5.3 million tons
  - Barge-only mine



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# Coal shipments

- EIA-923 survey
  - Coal mines
  - Primary and secondary modes of transport
  - Fuel properties (heat content, sulfur, delivered cost)
  - Updated quarterly
- O/D matrix for barged transactions
- Cross-walk with ACOE trips



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- Last operating power plant on Monongahela
    - Located below Morgantown Lock (WV)
    - 1,152 MW
  - Plant fully dependent on barge delivery
  - 2.7 million tons of coal in 2010

#### Average barged trip length

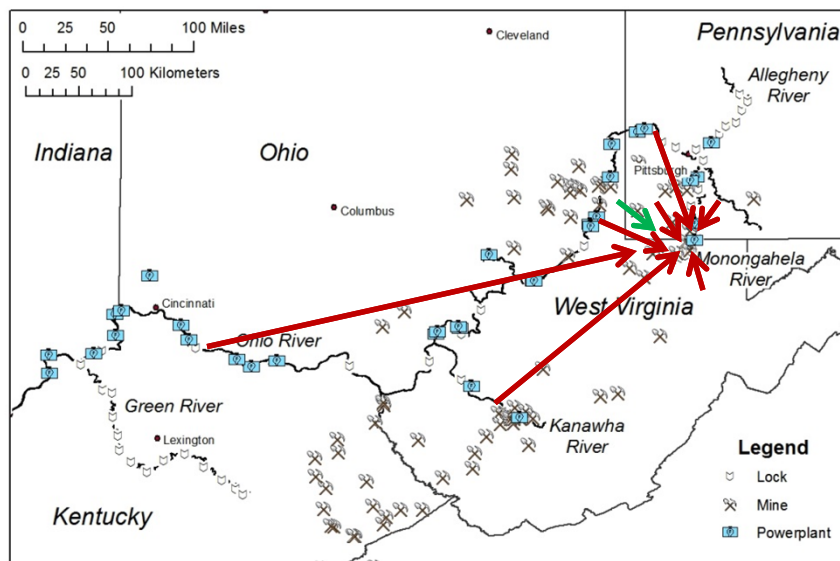
Year	2010	2011	2012	2013
Miles	325	320	175	120

## Fort Martin Power Station



# Comparison of EIA and ACOE trips to Fort Martin

- Isolated above Lock 28 on Mon
- Assume majority of shipments through MN28 are to Fort Martin
- Good conformance

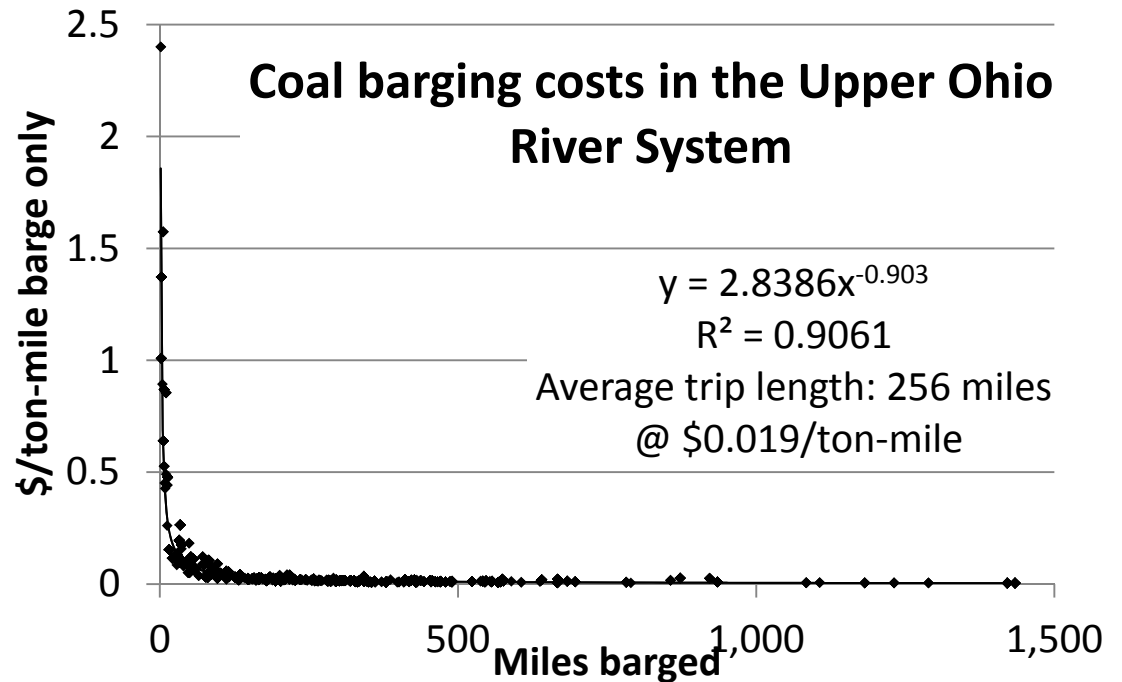


**Shipments toward Fort Martin Power Station (million tons)**

	EIA (coal only)	ACOE (commodity not specified)
Locked	1.8	2.1
Loaded above last lock	0.9	Not visible
<b>Total</b>	<b>2.7</b>	<b>3.1</b> (with non-locked EIA shipment)

# Thermal coal shipping costs

- EIA-923
  - Delivered cost of fuel (public)
  - Commodity cost (not public)
  - Shipping costs derived (barge, rail, truck), aggregated
  - Better coverage than STB Waybill Survey
- Assign rates to shipments, calculate \$/ton-mile
- EPA rate understates shipping costs for shorter trips
  - \$0.0115/ton-mile, barged



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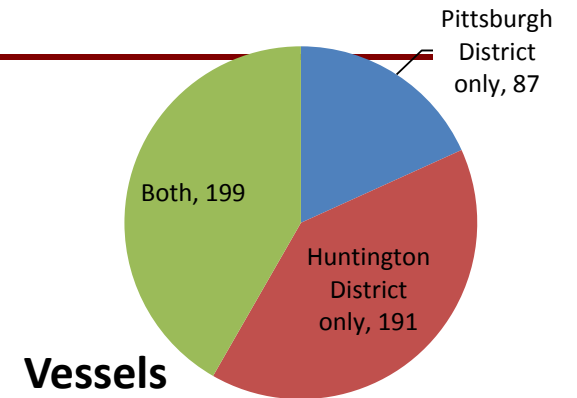
# Use of trip analysis

- Trend and variability analysis
  - Observe (and predict) changes as power plant and mine status change
  - EIA data updated quarterly
- Tools for setting priorities for optimization (operations, investments, sustainability)

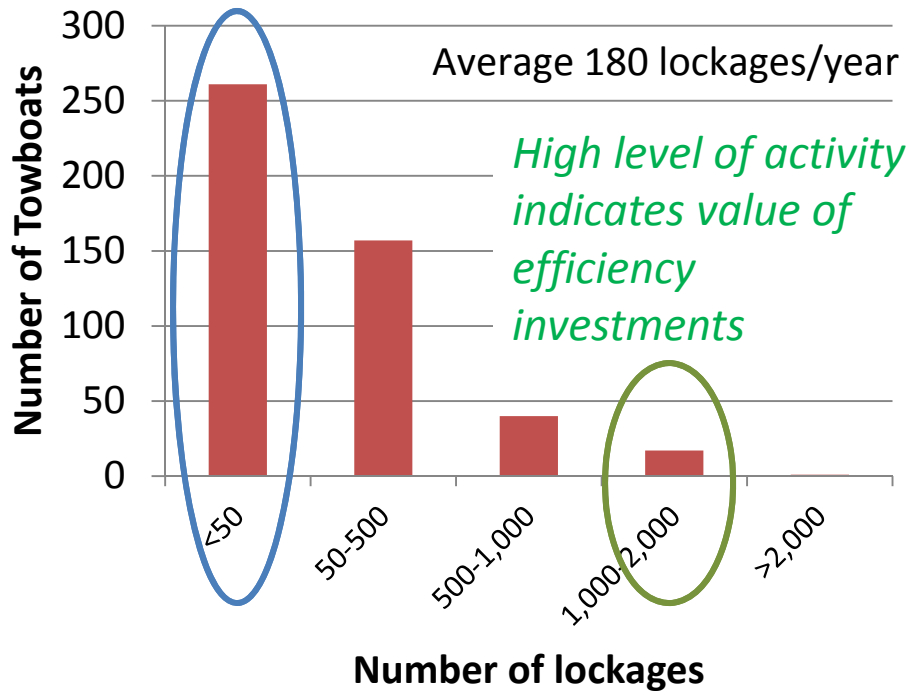


# Fleet analysis

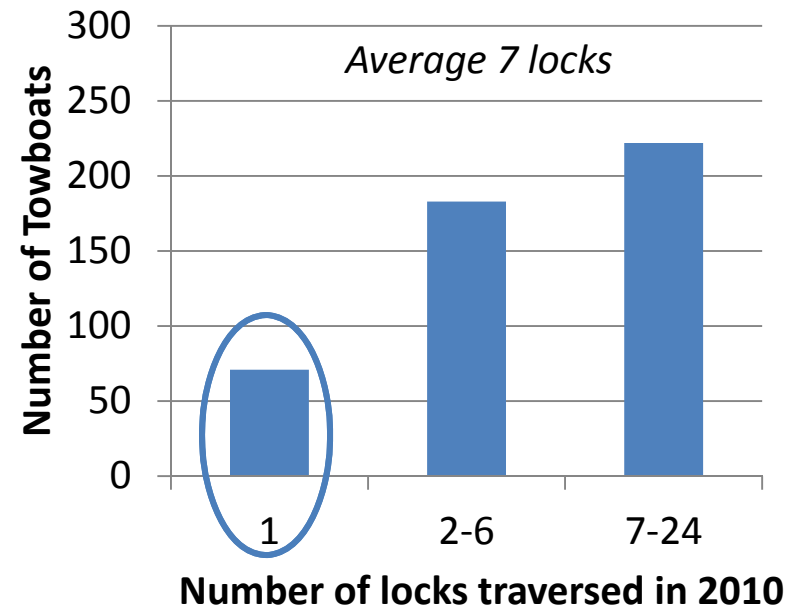
Harbor, helper, or regional visitors? – AIS data needed to fully understand low lockage vessels



**Lockages per year**

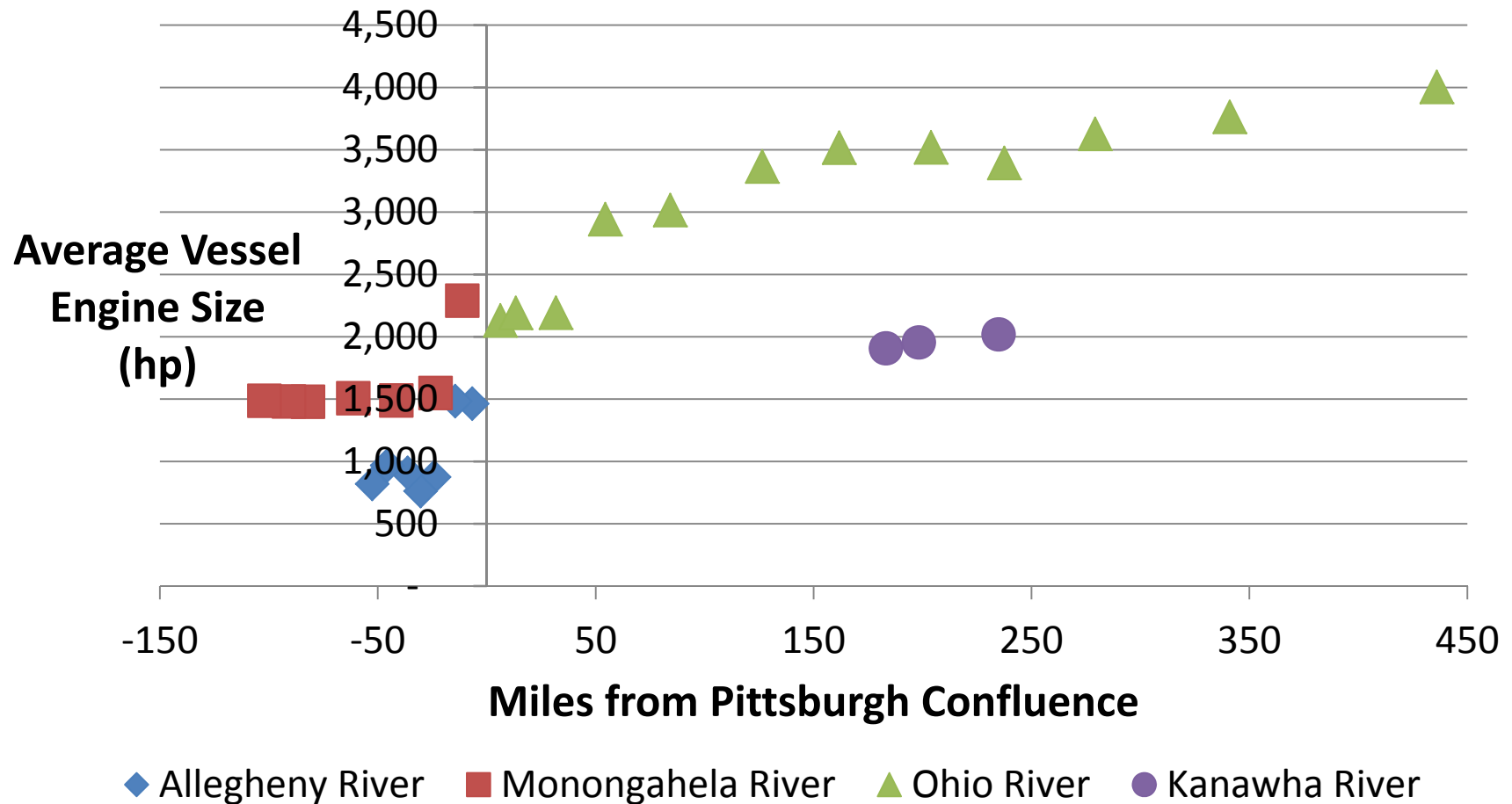


**Locks traversed per year**



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# Changes in Engine Size with Lock Location



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# Ongoing work

- Infrastructure failure implications
- Fuel consumption rate database
- Time study model of delays, locking and travel for key trips and infrastructure changes
- Air emission impacts on key air monitors

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# Backup slides

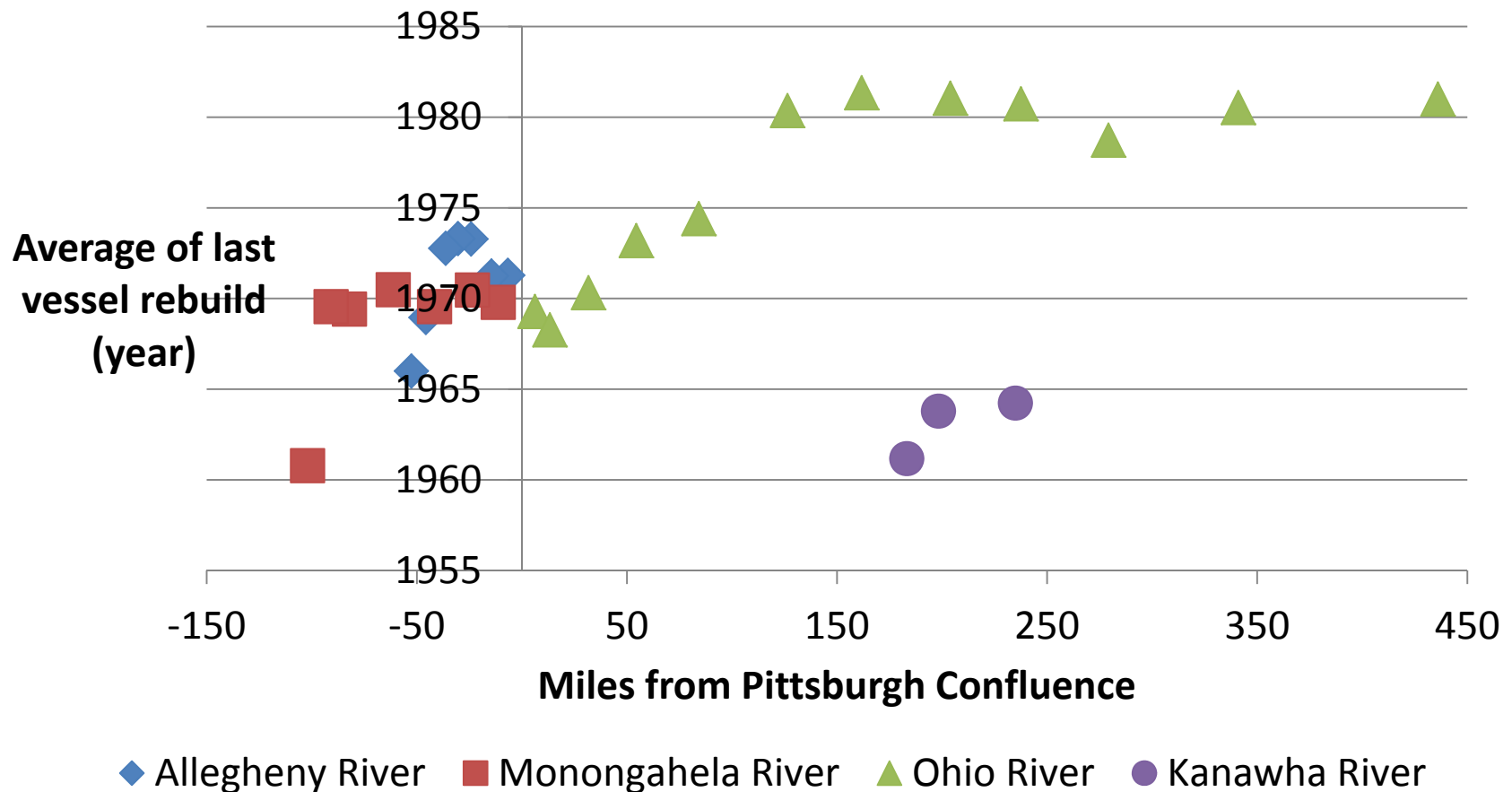
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# Abstract

- Using public source data, the performance of the inland waterways can be assessed in unique ways. The presentation focuses on the U.S. Army Corps' Pittsburgh District but the methodology can be applied across the inland waterways. The primary datasets are the 2010 Lock Performance Monitoring System (LPMS) and U.S. Energy Information Administration (EIA) Survey 923.
- Linkage of individual lockages of each vessel into trips of varying lengths, allowing for an assessment of typical trip lengths and frequencies, as well as the tonnage and ton-miles for these trips and vessels. This methodology may be extended to the Coast Guard's Automatic Identification System (AIS) data
- Examination of the fleet of vessels that operate in the region, in terms of geographic specialization, size, speed, engine age, and emissions. Assessment of potential incremental improvements in emission loadings by engine replacements
- Merging the EIA- 923 data and LPMS data allows for close examination of coal shipments
  - Assessment of coal shipping costs by combining the lockage data with EIA coal shipment valuations collected by (\$/ton, \$/ton-mile)
  - Distribution of trip lengths for steam coal shipments, and assessment of distribution changes over time
  - Methodology to assess mode shifting opportunities and limitations
- Estimation of shipping time savings that may be accrued by completion of the Corps' [Lower Mon Project](#) based on actual lockages (number, duration, vessel)

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# Changes in Vessel Age with Lock Position

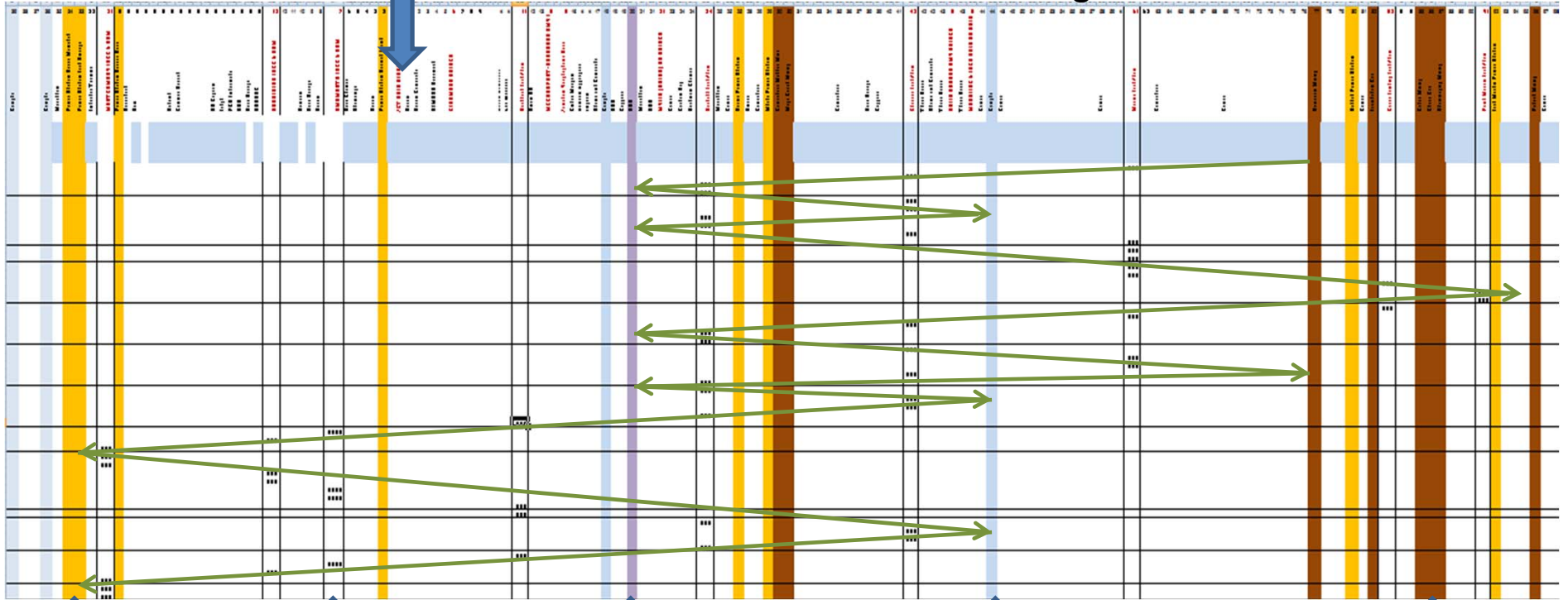


# 2010: Two Weeks Traveling with the Winnie C.

Ohio R.

Confluence

Monongahela R.



Power plants

Locks

Clairton

Company docks

Coal mines



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# Fuel consumption

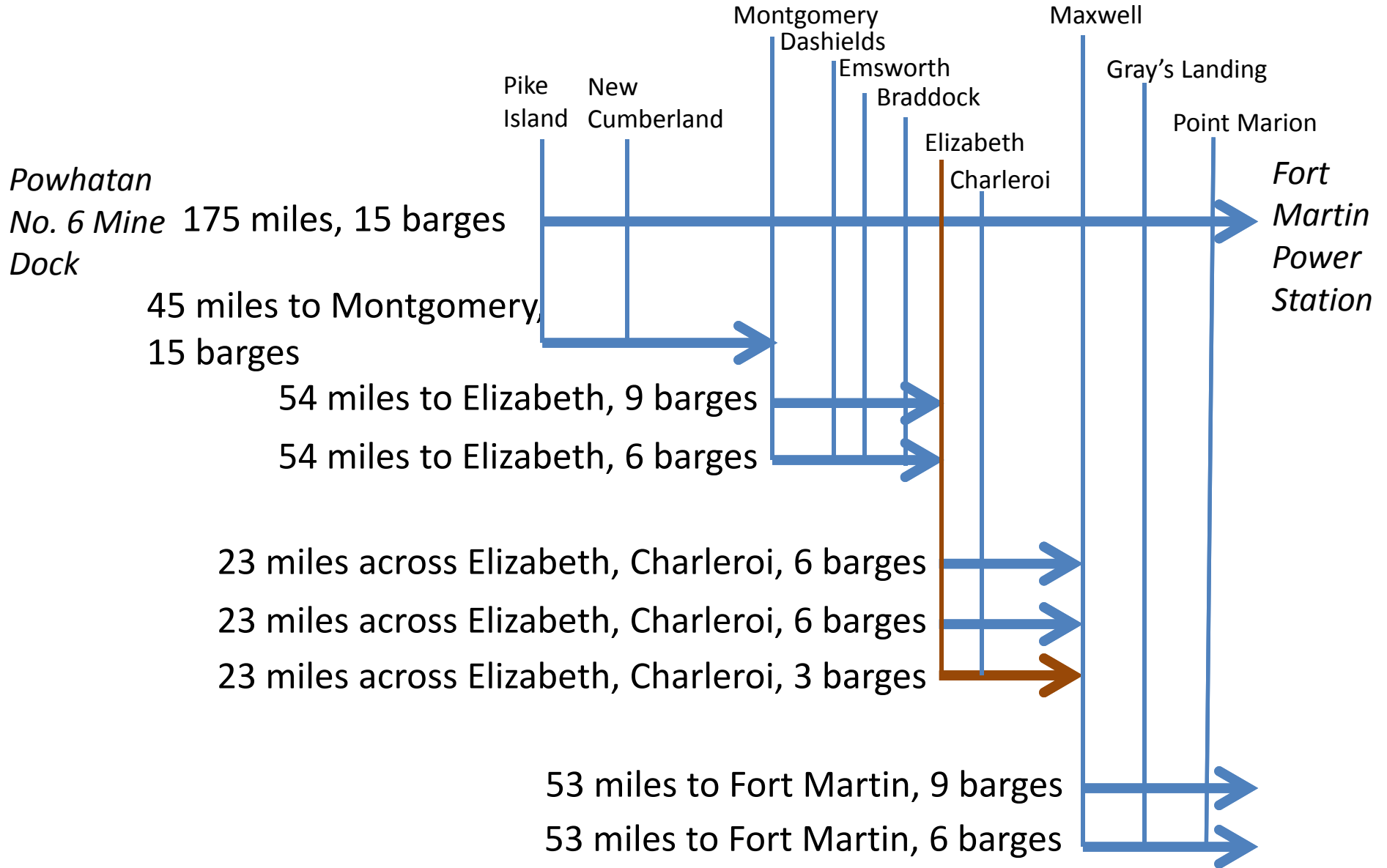
- Standard fuel consumption rate across all vessels (0.367 or 0.350 lb/hp-hr)
- Corps' vessel data base does not reflect all repowering
- Actual fuel consumption can be calculated from reported engine descriptions and specs
- Is the fleet fuel consumption rate lower than standard assumption?

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# Mon towboat fuel consumption

- 97 vessels
  - 44 years old (average, Corps)
  - 32 years old, accounting for reported repowering
- Examined engine specs for reported engines, average BSFC is 0.31, 11% improvement
- Estimate EPA Tiers from ages and engine types (6 Tier 2, 27 Tier 1)
- Implications for assessment of fuel consumption and air emissions





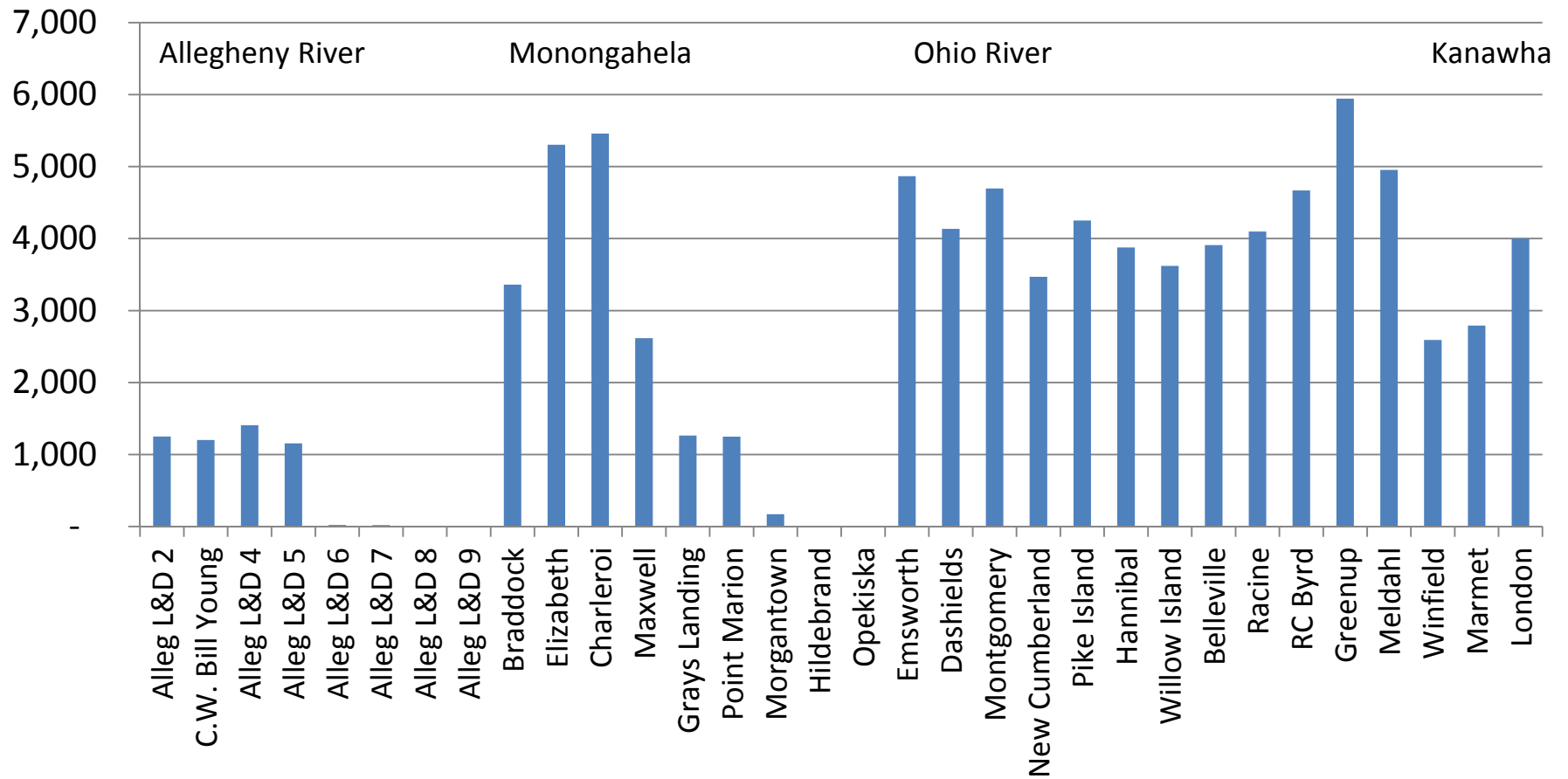
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# Time savings from completion of the Lower Mon Project

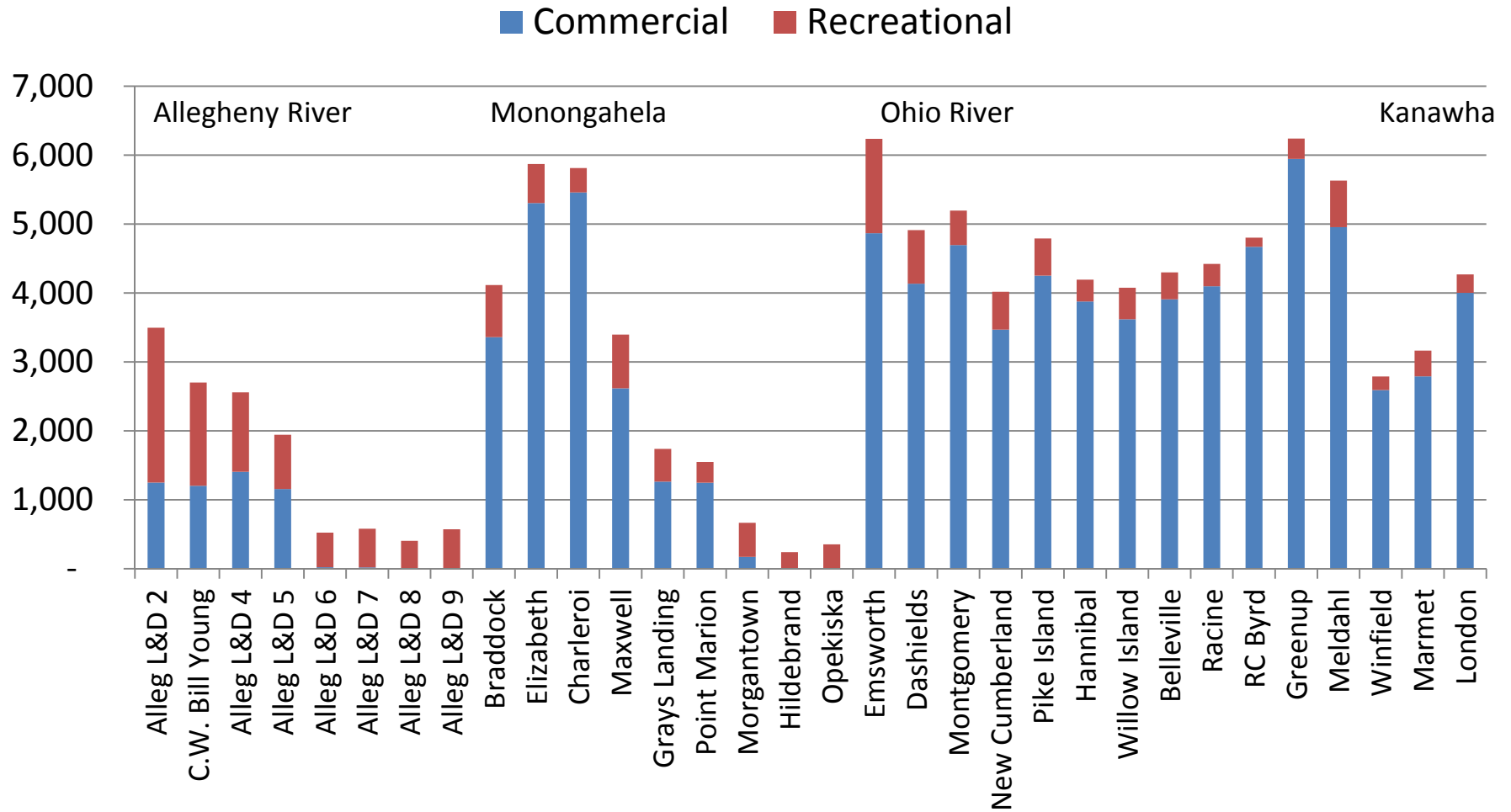
- Extract distributions for times (transit between locks, delays, lockage)
- Firm up model assumptions
- Run model and analyze results
- Expand to include proposed modifications to Upper Ohio L/Ds

# Lockages in Pittsburgh & Huntington, 2010

## Commercial



# Lockages in Pittsburgh & Huntington, 2010



# Top 20 trips by count, ton-mile, ton in PGH/Hunt

Trip	Count	Mile/trip	Trip	Ton-mile	Trip	Tons
KA1_KA2	1428	36.6	OH22_OH71	1158.6	KA1_KA2	10,903,737
OH3_OH3	1101	0.3	OH24_OH71	598.3	OH22_OH71	9,581,475
MN23_MN25	1092	37.7	OH22_OH4	482.5	OH4_OH5	7,330,355
OH24_OH24	1065	0.3	KA1_KA2	399.1	OH24_OH24	6,936,161
AG44_AG45	963	6.2	OH26_OH71	392.1	OH26_OH26	3,854,829
MN23_MN24	837	18.0	OH26_OH4	354.2	MN23_MN25	2,996,021
OH4_OH5	785	29.8	OH24_OH4	312.4	OH5_OH5	2,906,719
MN24_MN24	718	0.3	OH4_OH5	276.0	OH3_OH3	2,799,096
OH26_OH26	709	0.3	MN22_OH24	266.8	OH71_OH71	2,776,942
OH5_OH5	695	0.3	OH22_OH5	257.8	OH22_OH4	2,428,157
KA3_KA3	685	0.3	MN22_OH26	237.8	KA1_KA1	2,426,347
OH22_OH71	615	111.1	OH24_OH26	229.3	OH24_OH71	2,202,989
OH1_OH1	613	0.3	KA1_KA3	203.0	OH24_OH26	2,193,610
KA1_KA3	502	51.7	OH24_OH24	178.9	OH26_OH71	2,001,521
MN23_MN23	497	0.3	OH22_OH72	163.0	OH22_OH22	1,950,265
MN22_OH3	430	42.9	OH21_OH4	119.3	MN22_OH3	1,870,704
MN22_MN22	410	0.3	OH26_OH26	116.9	MN23_MN24	1,843,665
OH22_OH22	367	0.3	MN23_MN25	114.6	MN22_MN22	1,820,815
KA1_KA1	366	0.3	OH24_OH5	112.1	OH4_OH4	1,782,647
KA2_KA2	363	0.3	OH26_OH5	107.7	OH21_OH22	1,747,491

# Top 20 trips by count, ton-mile, ton

Trip	Count	%	Mile/ trip	Trip	Ton-mile (million)	%	Trip	Tons	%
OH24_OH25	1,498	5.2%	95.0	OH25_OH71	2,005.9	11.5%	OH24_OH25	14,258,293	9.0%
KA1_KA2	1,428	5.0%	36.6	OH24_OH25	1,812.8	10.4%	OH25_OH25	11,049,113	7.0%
OH25_OH25	1,342	4.7%	47.8	OH25_OH26	1,473.2	8.4%	KA1_KA2	10,903,737	6.9%
OH3_OH3	1,101	3.8%	0.3	OH25_OH4	1,260.4	7.2%	OH22_OH71	9,581,475	6.0%
MN23_MN25	1,092	3.8%	37.7	OH22_OH71	1,158.6	6.6%	OH25_OH26	7,988,395	5.0%
OH24_OH24	1,065	3.7%	0.3	OH24_OH71	598.3	3.4%	OH4_OH5	7,330,355	4.6%
AG44_AG45	963	3.4%	6.2	OH22_OH4	482.5	2.8%	OH24_OH24	6,936,161	4.4%
MN23_MN24	837	2.9%	18.0	OH25_OH25	467.5	2.7%	OH25_OH71	5,667,598	3.6%
OH4_OH5	785	2.7%	29.8	MN22_OH25	429.2	2.5%	OH26_OH26	3,854,829	2.4%
MN24_MN24	718	2.5%	0.3	KA1_KA2	399.1	2.3%	MN23_MN25	2,996,021	1.9%
OH25_OH26	709	2.5%	156.8	OH26_OH71	392.1	2.2%	OH5_OH5	2,906,719	1.8%
OH26_OH26	709	2.5%	0.3	OH25_OH72	372.6	2.1%	OH25_OH4	2,880,793	1.8%
OH5_OH5	695	2.4%	0.3	OH21_OH25	365.2	2.1%	OH3_OH3	2,799,096	1.8%
KA3_KA3	685	2.4%	0.3	OH26_OH4	354.2	2.0%	OH71_OH71	2,776,942	1.8%
OH22_OH71	615	2.1%	111.1	OH25_OH5	350.0	2.0%	OH22_OH4	2,428,157	1.5%
OH1_OH1	613	2.1%	0.3	OH24_OH4	312.4	1.8%	KA1_KA1	2,426,347	1.5%
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MN23_MN23	497	1.7%	0.3	MN22_OH24	266.8	1.5%	OH24_OH26	2,193,610	1.4%
MN22_OH3	430	1.5%	42.9	OH22_OH5	257.8	1.5%	OH26_OH71	2,001,521	1.3%
MN22_MN22	410	1.4%	0.3	MN22_OH26	237.8	1.4%	OH22_OH22	1,950,265	1.2%



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# Data issues

- Trips with skipped locks
  - One percent of trips impacted
  - LPMS offline, lockages not entered
  - After 2012, uniform data entry across IWS
- Corps databases
  - Missing 24 of 476 vessels
  - Out-dated information on capabilities of docks
  - Funding surveys sporadic

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# Fort Martin

	Mines used by Fort Martin in 2010					
	WV	PA	WY	OH	KY	MT
Tons barged 2010	1,310,000	657,000	469,000	164,000	153,000	900
# of mines	7	5	3	1	1	1
Loading river	Mon. (5) Ohio Kanawha	Mon. (5)	Miss.	Ohio	Ohio	Ohio

*Average trip length: 326 miles*

# Comparison of EIA and ACOE trips

MN28 – Point Marion lock  
at MilePost 90.8 on the  
Monongahela

<b>EIA: coal shipments to Fort Martin</b>	
<b>MN25_MN28</b>	638,019
<b>MN26_MN28</b>	286,845
<b>MN28_KA2</b>	33,133
<b>MN28_MN28</b>	22,126
<b>MN28_OH2</b>	899
<b>MN28_OH4</b>	10,793
<b>MN28_OH5</b>	163,968
<b>MN28_OH25</b>	622,932
<b>MN28 (no lockage)</b>	975,886
<b>Total</b>	<b>2,754,601</b>

# Comparison of EIA and ACOE trips

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<b>MN25_MN28</b>	<b>638,019</b>
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MN28_OH25	622,932
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<b>Total</b>	<b>2,754,601</b>

MN25\_MN28 represents shipments from Consol mines assumed to be using the Alicia transloading facility

# Comparison of EIA and ACOE trips

<b>EIA: coal shipments to Fort Martin</b>	
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EIA reveals significant shipments that do not require lockage

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# Comparison of EIA and ACOE trips

Likely aggregate  
shipments  
down the  
Allegheny R.

ACOE public data does not differentiate between commodities, and only reveals shipments that require lockage

“Trips” determined by vessel movement, can’t see tow transfers between vessels (origins obscured for multi-vessel

<b>ACOE trips toward MN28</b>	
AG43_MN28	6,495
AG45_MN28	2,165
MN22_MN28	329,083
MN23_MN28	479,912
MN24_MN28	93,096
MN25_MN28	702,187
MN26_MN28	338,464
MN28_MN28	31,032
MN29_MN28	16,598
OH1_MN28	14,433
OH2_MN28	54,125
OH3_MN28	28,145
OH4_MN28	10,825
OH5_MN28	8,660
Locked tonnage	2,115,222
<b>+MN28</b>	<b>3,091,108</b>

# Comparison of EIA and ACOE trips

EIA and ACOE data show good conformance for trips to Fort Martin

Difference due to limestone and aggregate shipments not covered in EIA

EIA: coal shipments to Fort Martin		ACOE trips toward MN28	
		AG43_MN28	6,495
		AG45_MN28	2,165
		MN22_MN28	329,083
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