

Asset Management for Deep-draft Navigation Channels O&M



Ned Mitchell

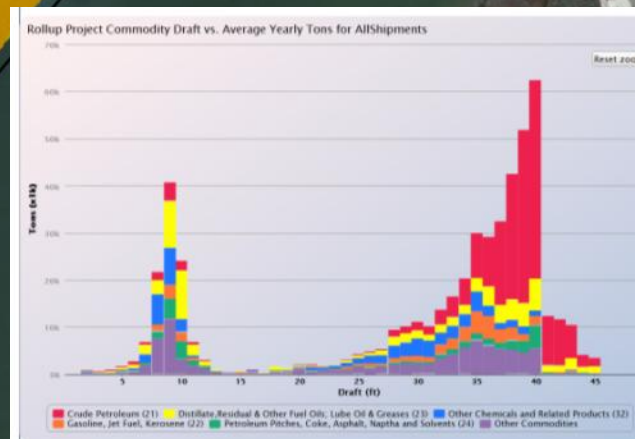
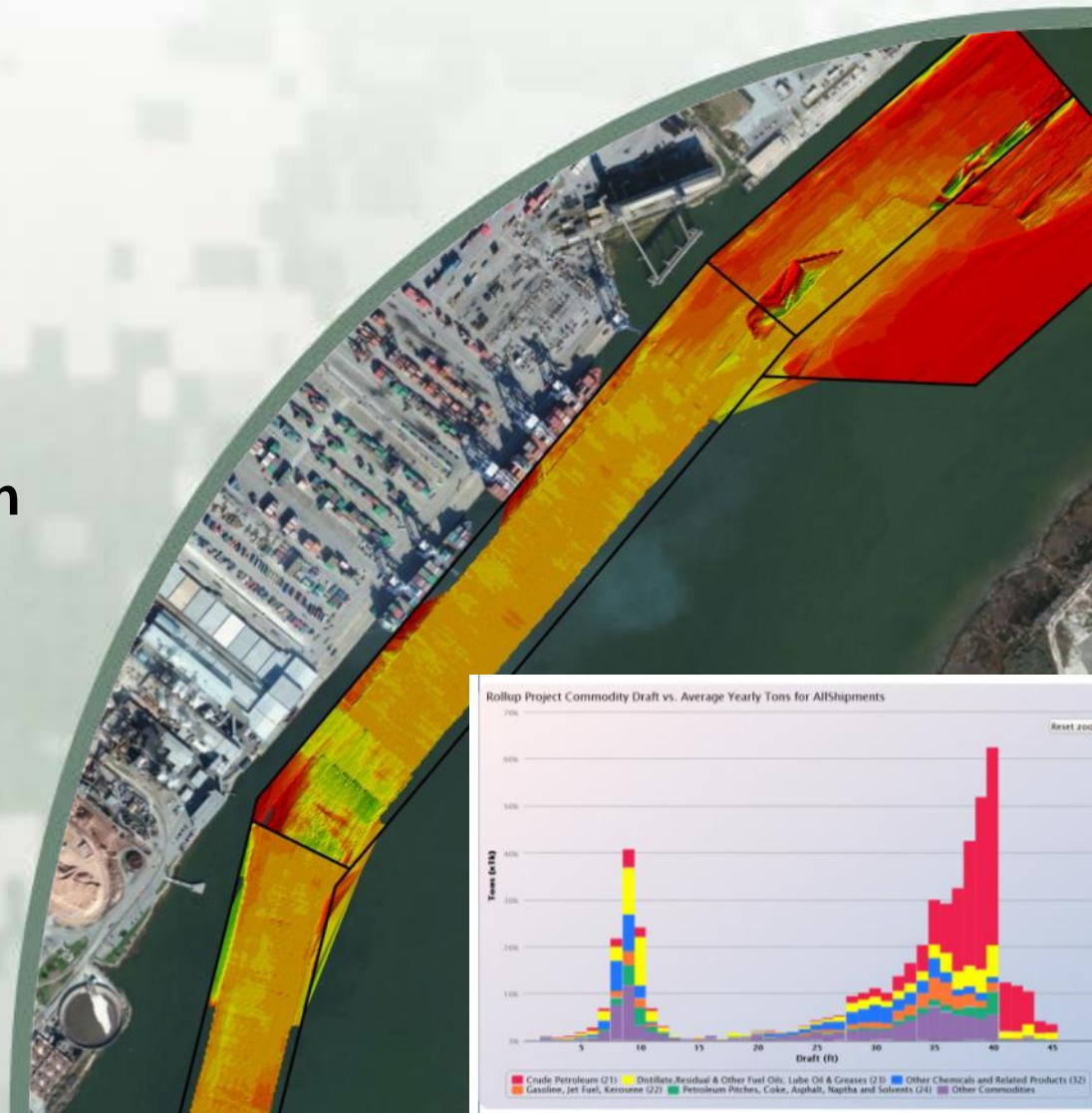
Research Civil Engineer
ERDC-CHL
Vicksburg, MS

**AAPA Harbors and Navigation
Committee Meeting**

Feb. 10th, 2015
Port of Miami



**US Army Corps
of Engineers®**



O&M Dredging and Asset Management

- Given constrained funding, objective is to maximize the efficiency of the Marine Transportation System (MTS) nationwide:
 - ▶ 300+ navigation projects regularly maintained
 - ▶ Channel depth-utilization considerations
 - ▶ Dredging cost tradeoff decisions → work package details
- Corps' Asset Management initiative is accounting for these and other issues within its deep-draft channels PDT.



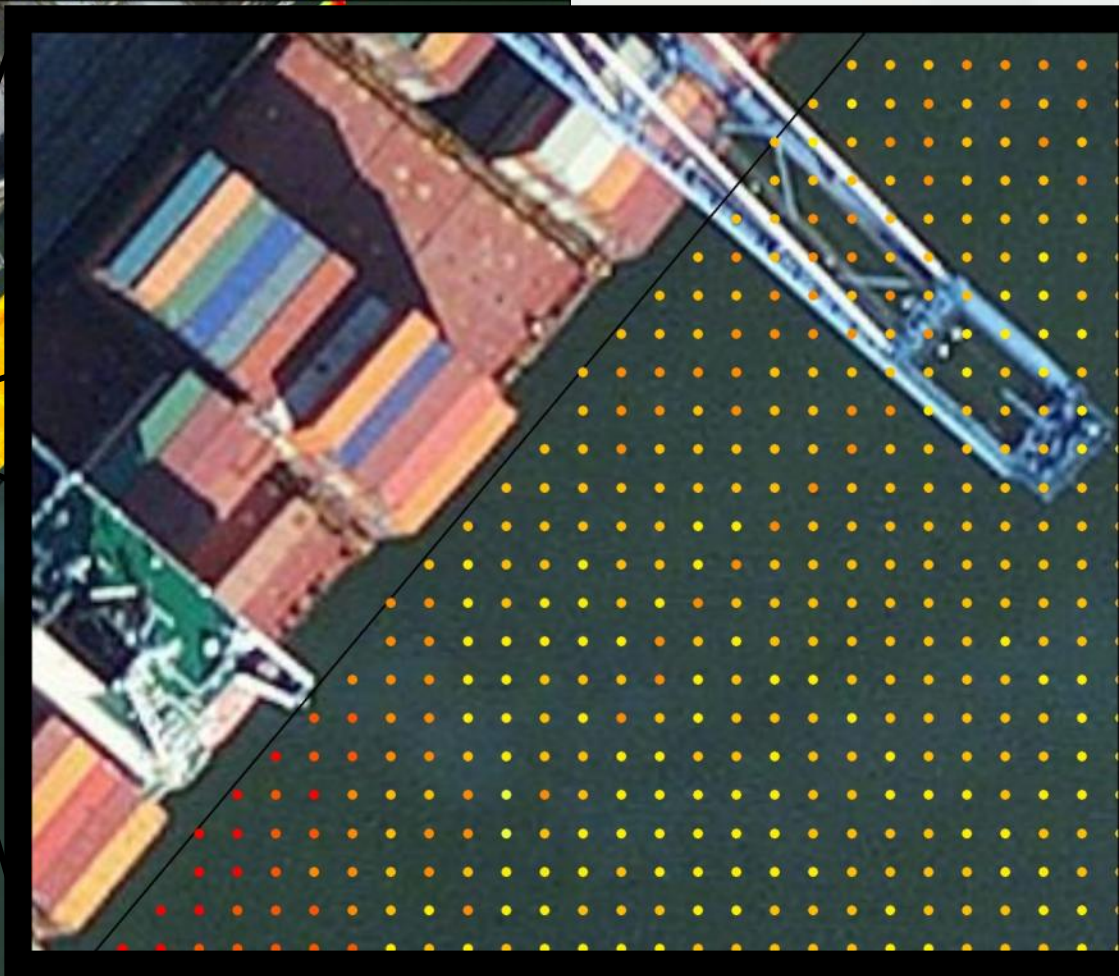
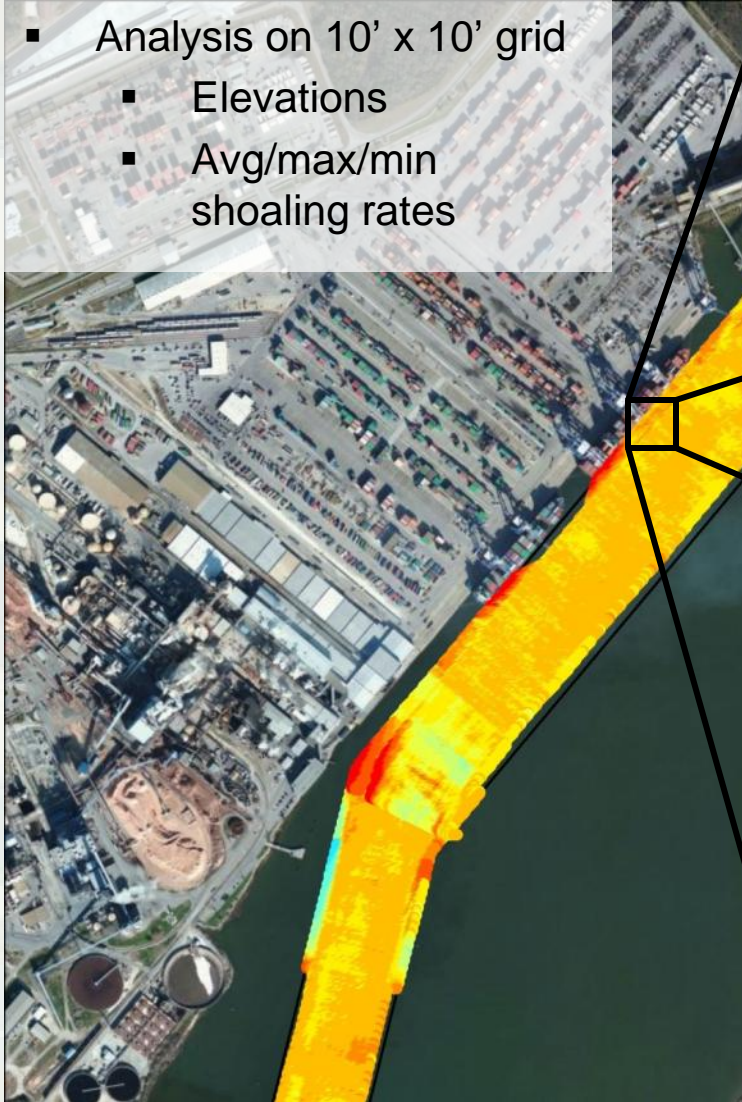
O&M Dredging and Asset Management

- Components of technical approach:
 - ▶ Digitized, hi-res channel surveys for calculating dredging volumes (e-hydro)
 - ▶ Localized shoaling forecasts to capture time component of dredging project management (CSAT)
 - ▶ Detailed Waterborne Commerce data to capture depth-utilization and enable advanced analytics (CPT)
 - ▶ Proxy BCRs to compare (proposed) work package efficiency in a straightforward manner (via CPT)



Detailed Shoaling Data

- Analysis on 10' x 10' grid
 - Elevations
 - Avg/max/min shoaling rates



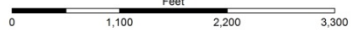
Shoaling Rate

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LEGEND
Shoaling Rate (ft/yr)
Value
High : 3
Low : -3



NOTES:
Horizontal Coordinate System:
NAD 1983 StatePlane Michigan South FIPS 2113 Feet
Datum: North American 1983
Distance Units: Foot US
Vertical Datum:
Soundings are shown in feet and indicate depths below Mean Lower Low Water.
The information depicted on this map represents the results of a survey conducted on the date indicated and can only be considered to represent the general condition existing at that time.
The location of navigation aids are based on and provided by the U.S. Coast Guard.
2009 Aerial Photography data source: U.S.D.A., Service Center Agencies.
** Sheaved Sounding per Quarter per Reach.



U.S. Army Corps of Engineers ERDC - CHL
Contract Number: W91226-04-2-0000
Contract Title: The Army Corps of Engineers is conducting a study to determine the shoaling rate in the Rouge River channel. The study will include a survey of the channel and a comparison of the results to historical data. The study will also include a review of the channel's history and a determination of the causes of shoaling. The study will be completed by the end of the fiscal year 2005.

U.S. ARMY CORPS OF ENGINEERS
PORTLAND DISTRICT

Reviewed By: _____
Checked By: _____
Approved: _____
Date: _____

Channel Project Name
Rouge River

Average Shoaling

Sheet Reference Number
1 of 1

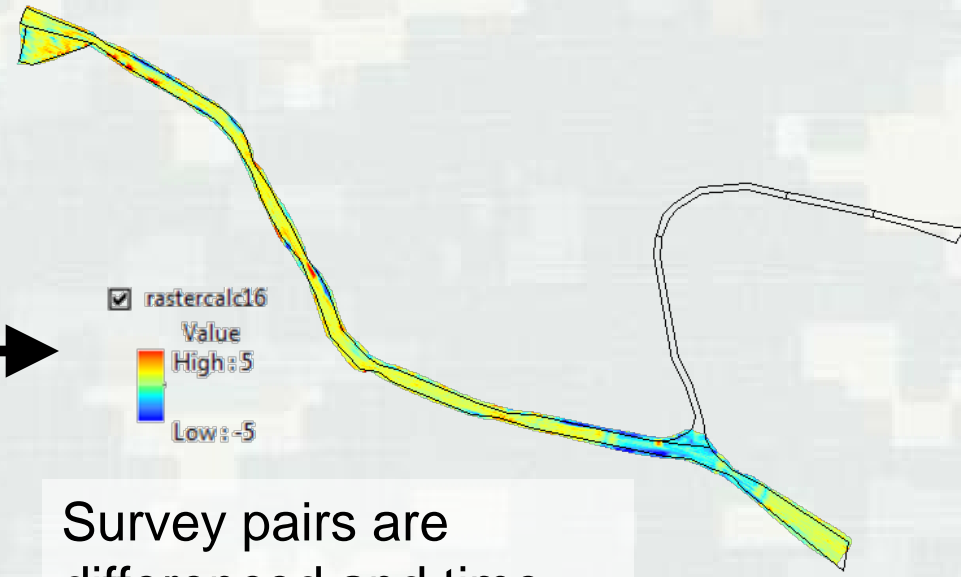
e-Hydro – bathymetry raster

Surveys are processed in e-Hydro and output data is stored in a geodatabase

OBJECTID*	Shape*	SurveyDate Stamp	SurveyId	Sheet_Name	surveyType	District	Projection	Projected_Area	Metadata	Shape_Length	Shape_Area
1	Polygon	12/31/2007	RR_01_ROU_20071231	Rouge River	conditional	CELRE	Michigan South	4919441.92427	<Null>	33144.039956	4919441.924276

CSAT Survey Processing

Survey pairs – compare multiple surveys between dredging events



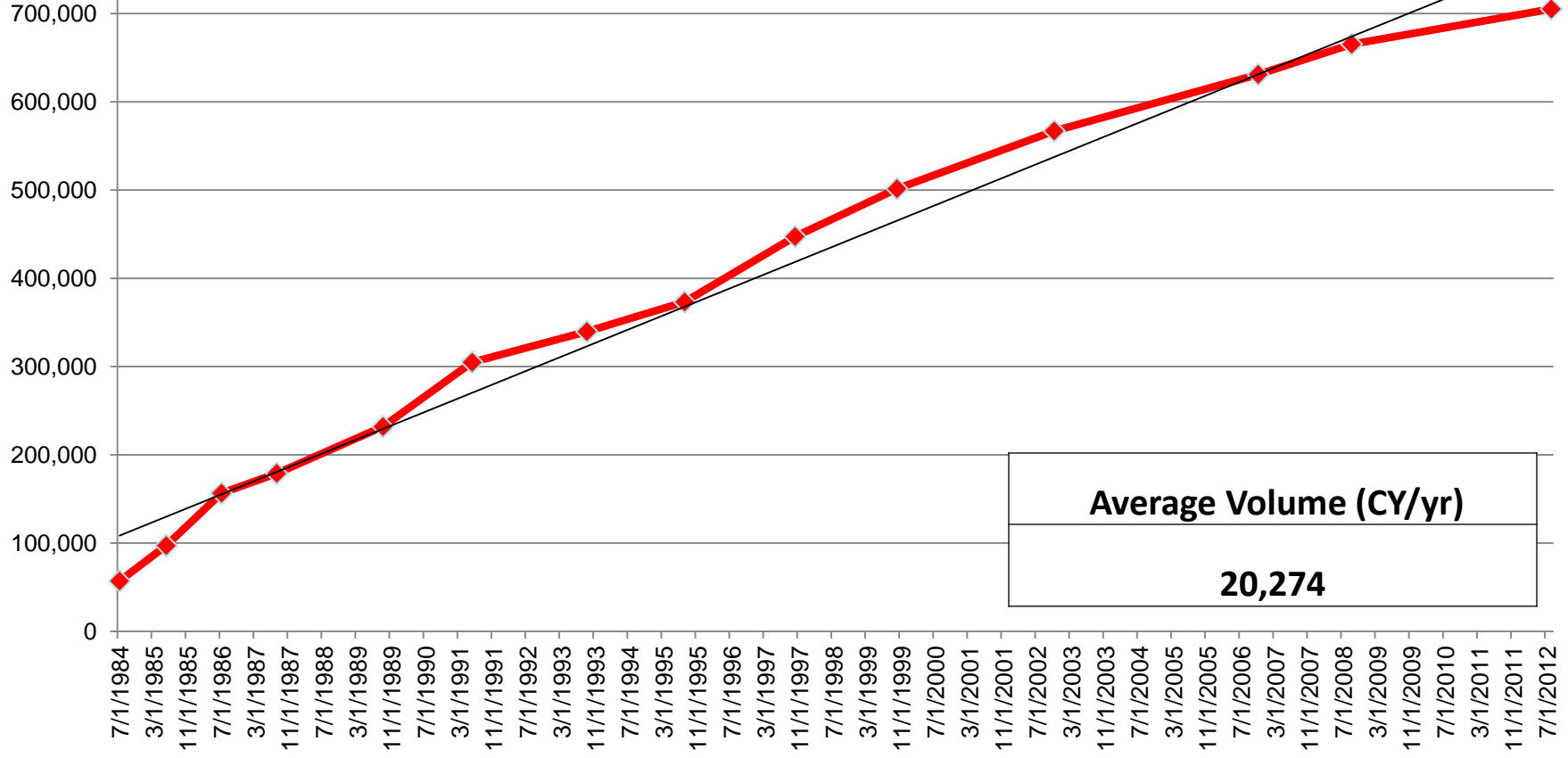
Survey pairs are differenced and time between each event is used to find the average rate of change on the 10'x10' grid.



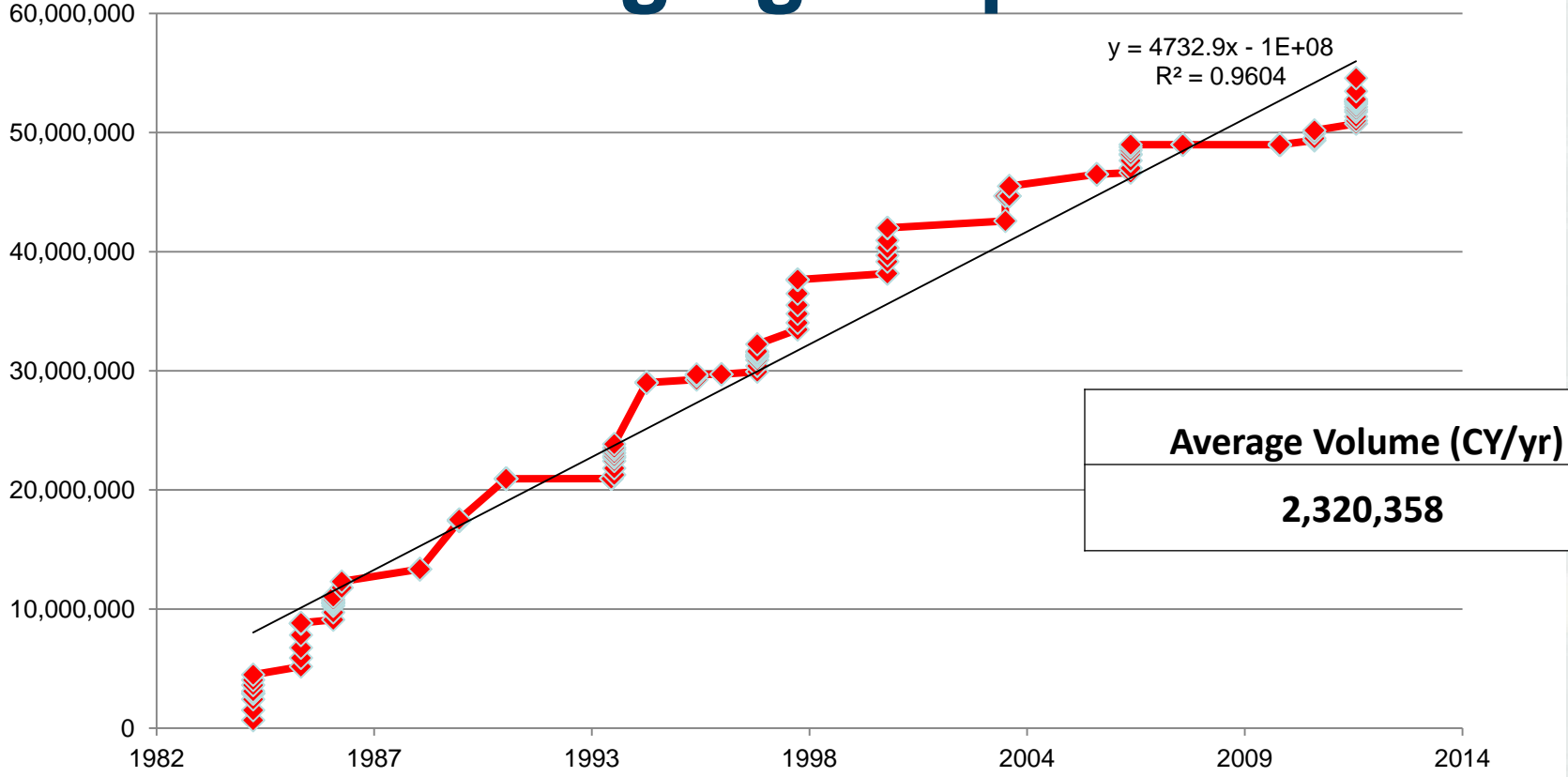
Cumulative Dredging Requirements

Reach_ID	Average Rate (ft/yr)	Average Volume (CY/yr)	Dredge Interval, yrs
RR_01_ROU_1	0.090	10,267	4
RR_01_ROU_2	0.768	10,007	4

$y = 64.066x - 2E+06$



Cumulative Dredging Requirements



Reach_ID	Average Rate (ft/yr)	Average Volume (CY/yr)	Dredge Interval, yrs
GA_01_ENT_1	0.29	224,569	-
GA_02_OBC_2	1.41	410,411	0.97
GA_03_IBC_3	0.77	424,394	0.66
GA_04_BRC_4	0.23	35,537	-
GA_06_BRE_6	1.80	401,986	-
GA_07_ETS_7	1.03	236,065	-
GA_08_TSB_8	2.13	587,395	-
GA_1A_EXT_1*	0.84	537,825	1.31

* Average volume not included in total average volume.



CPT/e-Hydro/CSAT Integration

Target Elev, ft (MLLW)	Dredge Cut ft (MLLW)	Quantity (CY) at different future times to reach specified depth						
		Now	6 mos.	12 mos.	18 mos.	24 mos.	30 mos.	36 mos.
-45	-47	171,608	423,772	790,205	1,207,360	1,625,518	1,999,915	2,230,219
-43	-45	65,202	221,973	502,672	850,467	1,203,905	1,517,865	1,697,573
-41	-43	30,921	11,591	313,894	606,834	915,851	1,195,519	1,353,134
-39	-41	14,615	52,706	184,026	421,057	691,288	939,472	1,080,938
-37	-39	5,801	26,432	102,175	275,375	509,354	730,962	858,071
-35	-37	1,107	12,820	52,997	169,619	358,176	556,497	672,752
-33	-35	0	5,187	27,232	90,895	236,771	407,405	515,969
-31	-33	0	905	13,695	54,885	146,987	282,359	381,179
-29	-31	0	13	5,812	29,088	85,495	182,608	266,129
-27	-29	0	2	1,271	15,452	45,198	107,254	172,888
-25	-27	0	0	172	7,243	21,502	56,055	99,746
-23	-25	0	0	48	2,312	9,467	24,086	46,945
-21	-23	0	0	7	528	3,256	6,834	15,480
-19	-21	0	0	0	39	317	621	1,630
-17	-19	0	0	0	0	0	0	0

CSAT provides these shoaling forecasts

eHydro does this



Galveston Entrance Channel and Harbor

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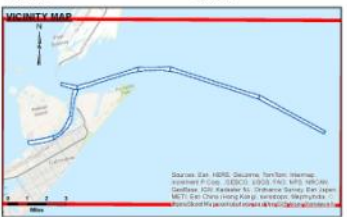


Information on this map is derived from the following sources:
 - Bathymetry: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Centerline: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Width: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Depth: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Orientation: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Length: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Area: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Volume: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Capacity: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Stability: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Erosion: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Sedimentation: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Navigation: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Safety: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Security: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Reliability: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Resilience: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Sustainability: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Viability: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
 - Channel Feasibility: 2009 Aerial Photography Data (ASD) from the U.S. Coast Guard
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Prepared By:	Checked By:	Reviewed By:	Approved By:
Author:	Editor:	Reviewer:	Approver:
Illustrator:	Designer:	Checker:	Approver:
Date: 10/20/2009			

Channel Project Name
Galveston
Average Shoaling

Sheet Reference Number
1 of 1



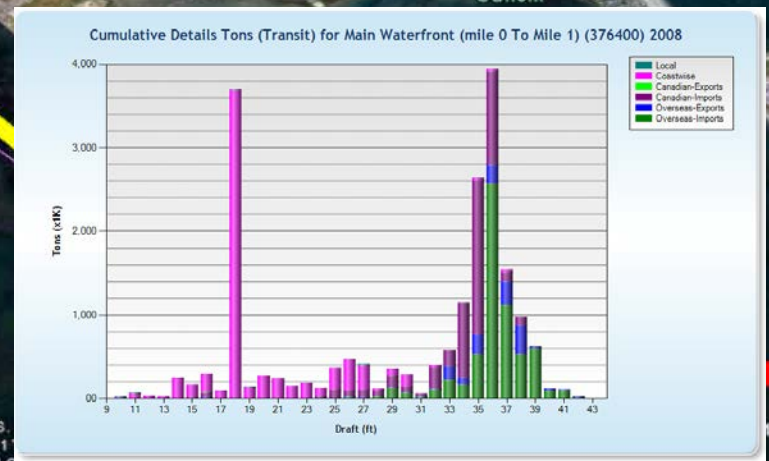
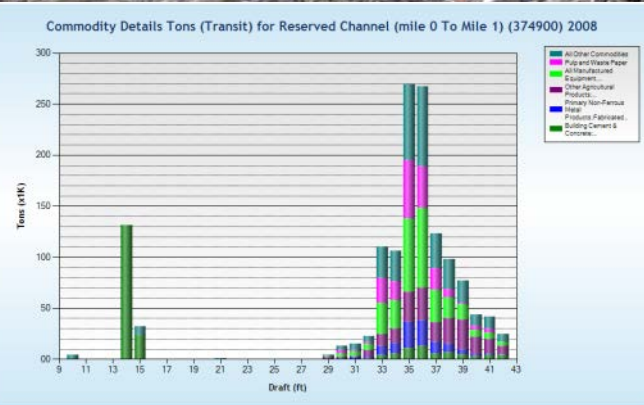
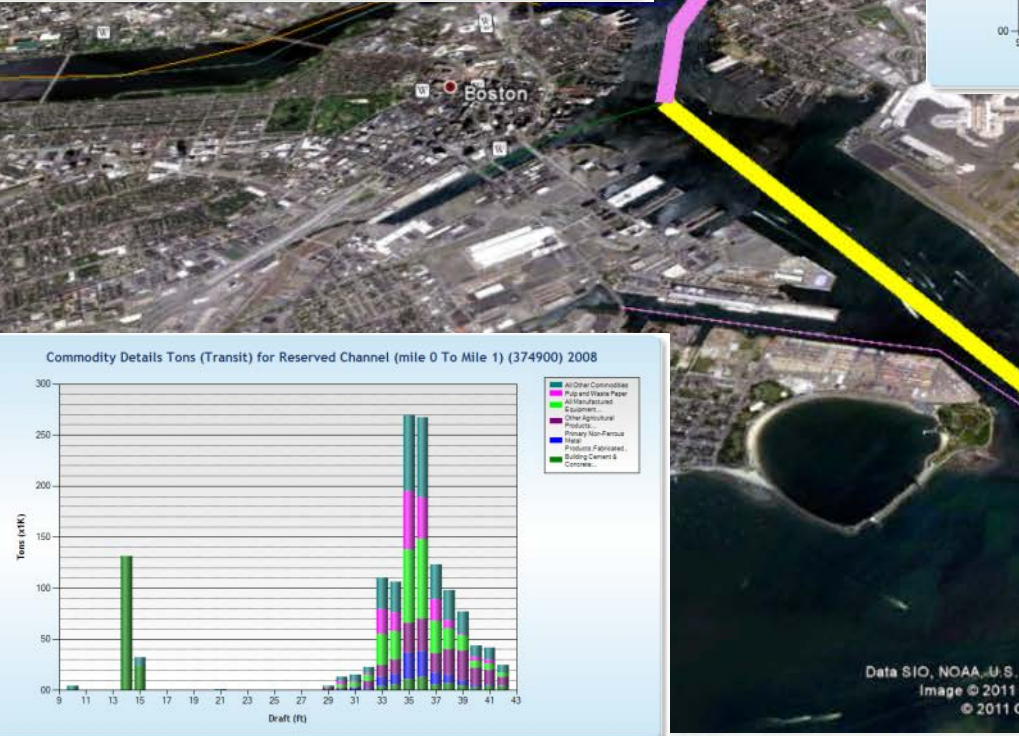
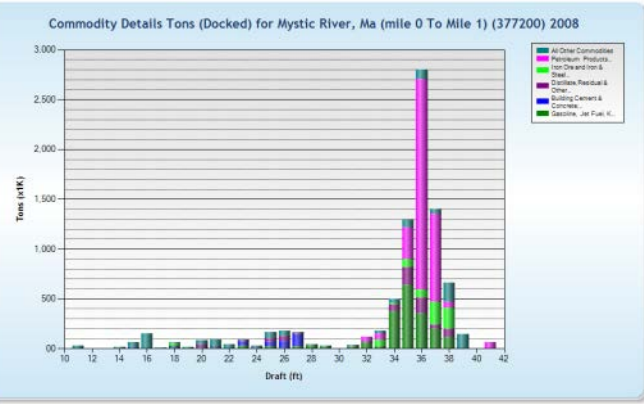
LEGEND
Shoaling Rate (ft/yr)
Value
High: 5
Low: -5



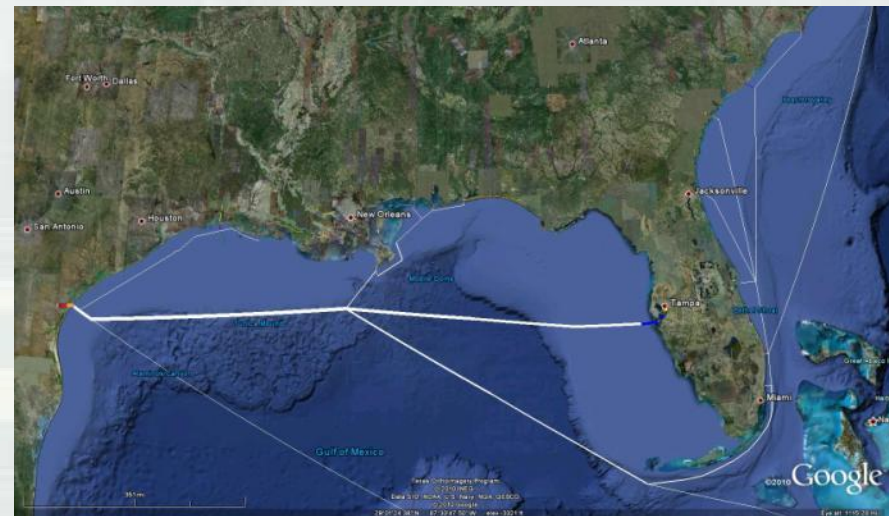
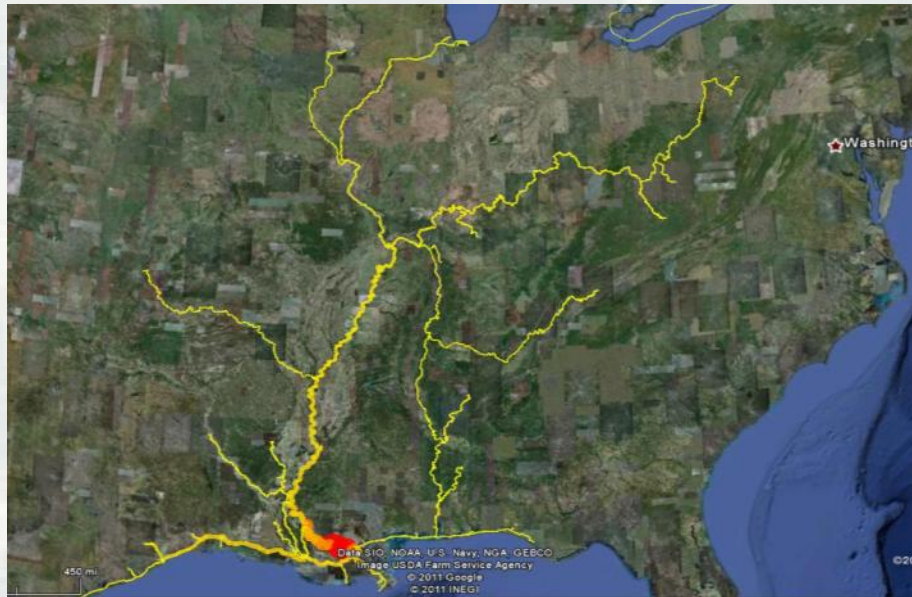
NOTES:
 Horizontal Coordinate System:
 NAD 83 North American Datum 83
 Datum: North American 1983
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 2009 Aerial Photography Data source: U.S.D.A., Service Center Agencies.
 ** Shoaled Shoaling per Quarter per Reach.

Channel Portfolio Tool (CPT)

Via Waterborne Commerce data, CPT can generate depth-utilization profiles showing the distribution of cargo across the range of maintained depths for any system of navigation channels.



Origin-Destination Freight Flows



The O-D flows within the WCSC data allow the Corps to evaluate navigation project interdependencies.

This in turn allows for systems-based optimization approaches.



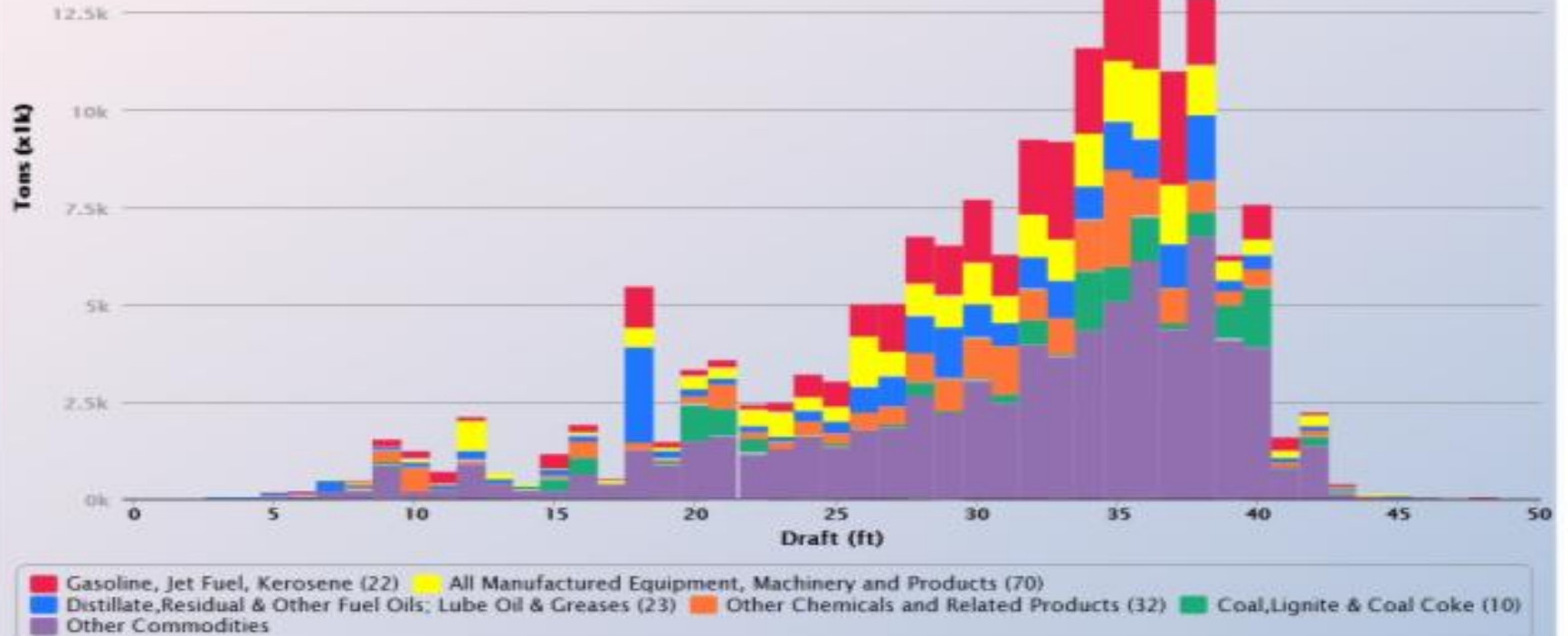
CPT Depth-Utilization

Rollup Reach Commodity Draft vs. Average Yearly Tons for AllShipments

17.5k

Reset zoom

South Atlantic Division



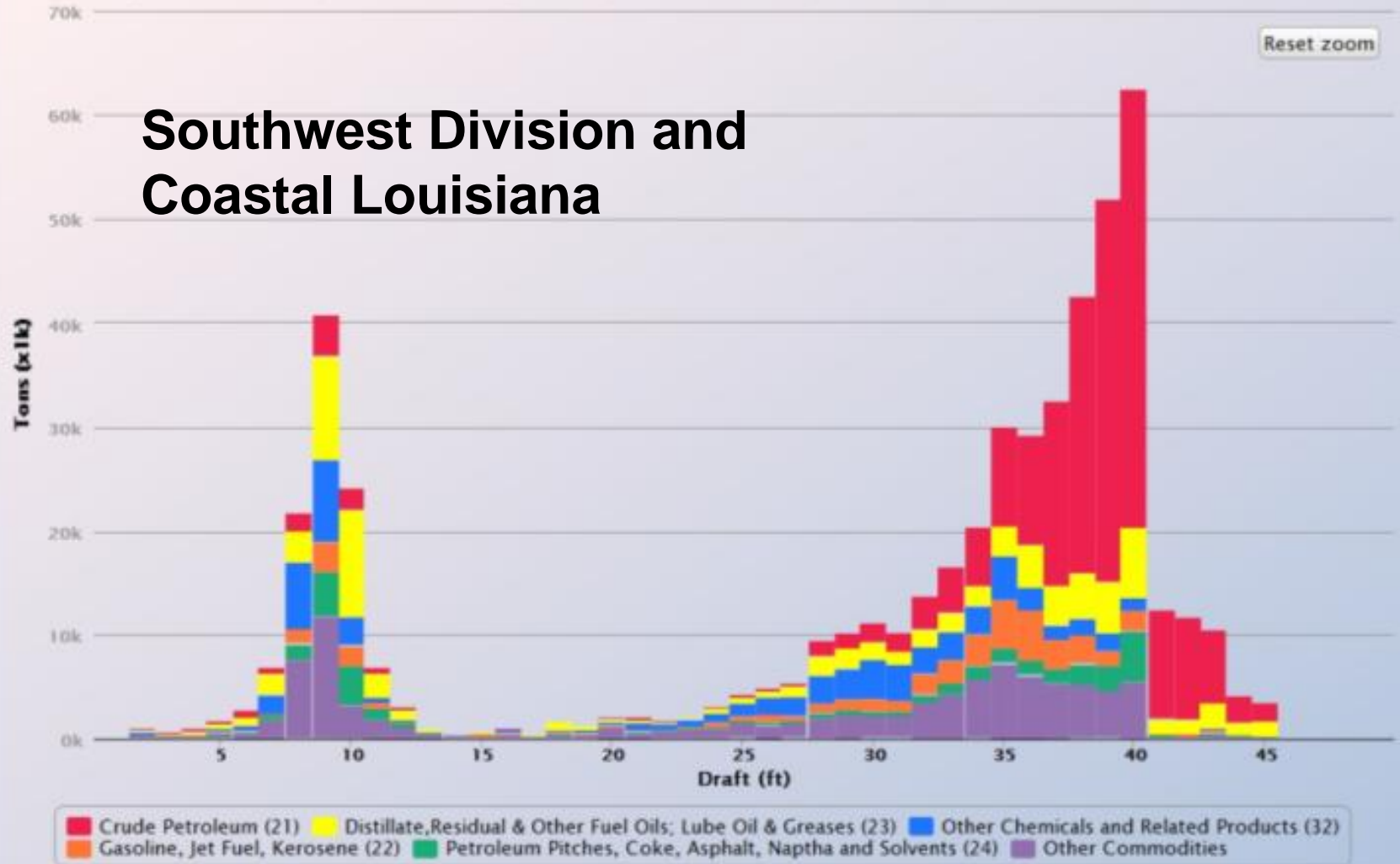
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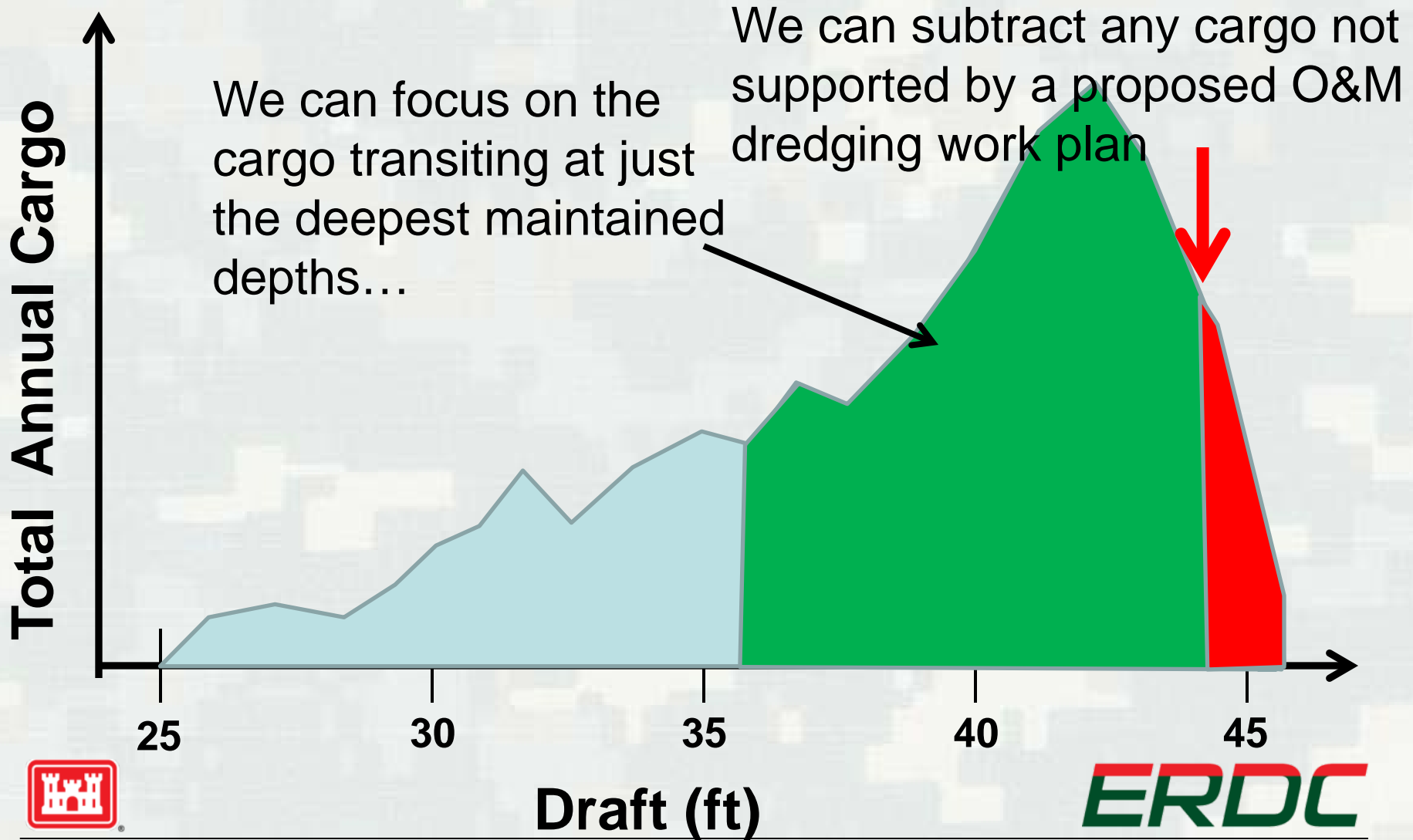
Innovative solutions for a safer, better world

CPT Depth-Utilization

Rollup Project Commodity Draft vs. Average Yearly Tons for AllShipments



Depth-utilization via CPT



Columbia River (near Astoria, OR)

Target Elev, ft (MLLW)	Dredge Cut, ft (MLLW)	Quantity (CY) at different future times to reach specified depth						
		Now	6 mos.	12 mos.	18 mos.	24 mos.	30 mos.	36 mos.
-45	-47	312,962	1,527,520	3,795,422	6,661,576	9,912,000	13,381,110	16,874,650
-44	-46	312,962	1,527,520	3,795,422	6,661,576	9,912,000	13,381,110	16,874,650
-43	-45	312,962	1,527,520	3,795,422	6,661,576	9,912,000	13,381,110	16,874,650
-42	-44	180,540	977,219	2,872,732	5,496,566	8,567,152	11,903,859	15,304,755
-41	-43	48,118	426,918	1,950,042	4,331,555	7,222,303	10,426,608	13,734,860
-40	-42	27,629	248,849	1,377,110	3,445,603	6,112,310	9,147,867	12,329,802
-39	-41	7,140	70,779	804,178	2,559,651	5,002,317	7,869,126	10,924,743
-38	-40	4,214	40,268	533,256	1,965,286	4,145,992	6,808,288	9,707,811
-37	-39	1,287	9,757	262,333	1,370,920	3,289,668	5,747,450	8,490,879
-36	-38	724	5,673	160,583	1,006,025	2,668,627	4,910,082	7,474,515
-35	-37	160	1,589	58,832	641,129	2,047,587	4,072,715	6,458,151
-34	-36	80	895	34,177	445,102	1,610,423	3,424,647	5,631,585
-33	-35	0	201	9,523	249,075	1,173,259	2,776,579	4,805,020
-32	-34	0	103	5,598	164,495	889,617	2,283,336	4,137,170
-31	-33	-	6	1,673	79,915	605,975	1,790,093	3,469,321
-30	-32	-	3	1,065	51,076	440,680	1,435,445	2,935,180
-29	-31	-	-	457	22,237	275,386	1,080,797	2,401,040
-28	-30	-	-	281	14,037	195,155	841,539	1,991,483
-27	-29	-	-	105	5,838	114,924	602,281	1,581,926
-26	-28	-	-	54	3,922	80,042	453,954	1,282,898
-25	-27	-	-	3	2,007	45,160	305,627	983,870
-24	-26	-	-	1	1,356	31,075	225,913	775,127



Columbia River (near Astoria, OR)

Target Elevation (ft)	Time until Dredging Takes place (Years)						
	1	1.5	2	2.5	3	3.5	4
45	21.821	11.368	6.832	5.040	4.130	3.599	3.278
44	21.821	11.368	6.832	5.040	4.130	3.599	3.278
43	21.821	11.368	6.832	5.040	4.130	3.599	3.278
42	26.980	15.868	8.649	5.945	4.673	3.965	3.546
41	35.778	26.927	11.954	7.314	5.419	4.439	3.880
40	34.206	31.812	14.437	8.168	5.747	4.558	3.900
39	26.026	32.891	15.580	7.658	4.982	3.781	3.148
38	23.572	31.945	18.363	8.654	5.329	3.899	3.170
37	22.254	32.557	25.002	10.924	6.166	4.286	3.376
36	20.493	30.290	27.720	12.778	6.841	4.570	3.507
35	18.157	27.119	30.881	15.535	7.630	4.810	3.566
34	15.466	23.143	28.063	16.561	7.959	4.803	3.458
33	12.328	18.481	23.971	17.640	8.183	4.625	3.199
32	9.286	13.924	18.264	15.543	7.593	4.140	2.769
31	7.270	10.905	14.467	14.660	7.740	3.994	2.549
30	5.982	8.973	11.926	12.968	7.729	3.946	2.440
29	4.629	6.944	9.246	10.850	7.605	3.819	2.257
28	3.869	5.803	7.731	9.281	7.321	3.842	2.219
27	3.341	5.011	6.680	8.209	7.453	4.166	2.326
26	2.792	4.188	5.583	6.899	6.754	4.137	2.303
25	2.317	3.475	4.633	5.757	6.121	4.230	2.345
24	1.961	2.942	3.922	4.883	5.382	4.091	2.359
23	1.579	2.369	3.158	3.939	4.507	3.842	2.340
22	1.355	2.033	2.711	3.383	3.925	3.597	2.360
21	1.206	1.810	2.413	3.014	3.545	3.522	2.547
20	1.000	1.500	2.000	2.499	2.955	3.066	2.405



Texas City Approach Channel

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LEGEND

Shoaling Rate (ft/yr)

Value

High : 4

Low : -1



NOTES:

Horizontal Coordinate System:
NAD 1983 StatePlane Texas South Central FIPS 4204 Feet
Datum: North American 1983
Distance Units: Feet US
Vertical Datum:
Elevations are shown on feet and indicate depths below Mean Lower Low Water
The information depicted on this map represents the results of a survey conducted on the date indicated and can only be considered to represent the general condition existing at that time.
The location of navigation aids are based on and provided by the U.S. Coast Guard
2009 Aerial Photography Date source: U.S.D.A., Service Center Agencies.
** Shaded Shoaling per Quarter per Reach.



US Army Corps of Engineers ERDC - CHL

Project Name: Texas City Approach Channel
Project Number: 13-710-000
Contract Number: W912WE-04-2-0000
Task Order Number: W912WE-04-2-0000-0001
Task Order Line Item Number: 0001
Task Order Line Item Description: Texas City Approach Channel
Task Order Line Item Quantity: 1.00
Task Order Line Item Unit of Measure: EA
Task Order Line Item Price: \$1,000,000.00
Task Order Line Item Total Price: \$1,000,000.00
Task Order Line Item Status: Active
Task Order Line Item Start Date: 10/01/04
Task Order Line Item End Date: 09/30/05
Task Order Line Item Location: Texas City, TX
Task Order Line Item Contact Name: [Redacted]
Task Order Line Item Contact Phone: [Redacted]
Task Order Line Item Contact Email: [Redacted]

Prepared By:	Checked By:
Reviewed By:	Approved By:
Published By:	Clear: [Redacted]
Author/Editor:	Clear: [Redacted]
Drawn:	Clear: [Redacted]
Checked:	Clear: [Redacted]

Channel Project Name
Texas City

Average Shoaling

Sheet Reference
Number
1 of 1

Texas City Approach Channel

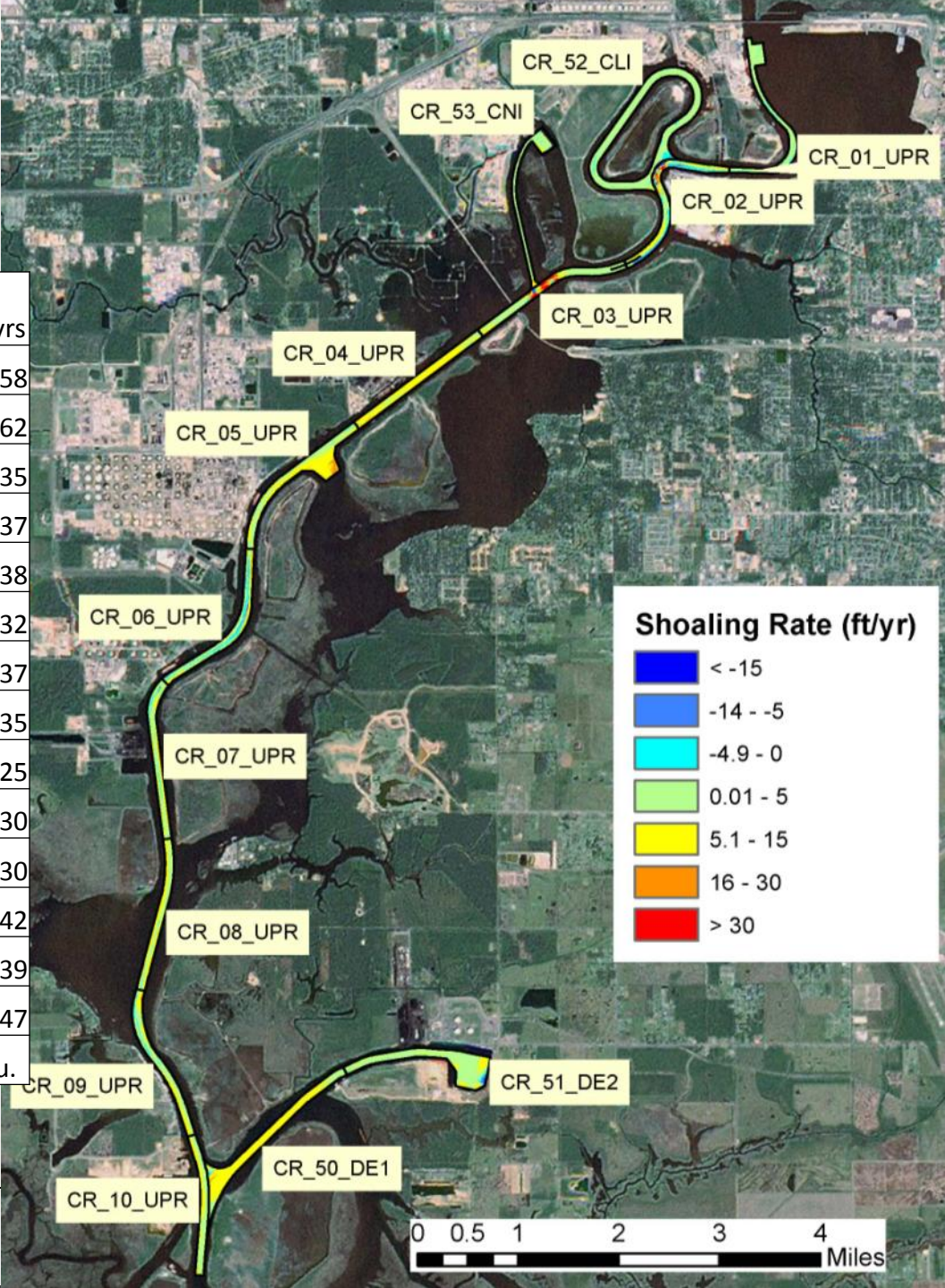
Target Elevation (ft)	Time until Dredging Takes place (Years)						
	1	1.5	2	2.5	3	3.5	4
45	29.780	33.293	33.286	32.103	30.798	29.711	28.932
44	33.343	38.859	39.396	38.043	36.305	34.736	33.522
43	37.828	46.603	48.197	46.626	44.157	41.757	39.796
42	38.561	49.827	53.110	52.169	49.702	47.033	44.751
41	39.578	53.944	59.650	59.750	57.371	54.339	51.590
40	39.395	55.069	62.903	64.241	62.385	59.479	56.637
39	29.471	42.303	50.100	52.345	51.539	49.542	47.349
38	24.186	35.129	42.638	45.605	45.510	44.107	42.394
37	19.914	29.275	36.467	40.037	40.581	39.714	38.434
36	15.738	23.268	29.444	32.996	34.039	33.648	32.773
35	12.886	19.160	24.643	28.227	29.697	29.695	29.141
34	9.591	14.299	18.545	21.598	23.108	23.422	23.170
33	7.996	11.954	15.636	18.527	20.185	20.770	20.734
32	6.692	10.016	13.166	15.759	17.429	18.189	18.355
31	5.438	8.148	10.764	13.019	14.627	15.500	15.829
30	4.638	6.952	9.207	11.210	12.738	13.668	14.127
29	3.996	5.992	7.955	9.751	11.211	12.190	12.765
28	3.124	4.685	6.227	7.668	8.879	9.765	10.332
27	2.251	3.377	4.493	5.558	6.483	7.214	7.718
26	1.719	2.579	3.434	4.259	4.994	5.601	6.052
25	1.170	1.755	2.338	2.907	3.428	3.875	4.232



MVN - Calcasieu

Reach_ID	Average Rate (ft/yr)	Average Volume (CY/yr)	Dredge Interval, yrs
CR_52_CLI_01	0.92	213,622	0.58
CR_53_CNI_01	2.05	150,288	0.62
CR_50_DE1_01	7.75	1,254,602	0.35
CR_51_DE2_02	2.69	442,499	0.37
CR_01_UPR_01	1.80	199,555	0.38
CR_02_UPR_02	1.98	243,007	0.32
CR_03_UPR_03	11.12	1,236,971	0.37
CR_04_UPR_04	6.95	732,436	0.35
CR_05_UPR_05	6.51	1,034,526	0.25
CR_06_UPR_06	4.23	521,544	0.30
CR_07_UPR_07	4.61	519,816	0.30
CR_08_UPR_08	6.52	676,079	0.42
CR_09_UPR_09	3.78	427,084	0.39
CR_10_UPR_10	5.24	496,527	0.47

Quantities are only displayed for the upper portion of the Calcasieu.



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Calcasieu Outer Bar

Target Elevation (ft)	Time until Dredging Takes place (Years)						
	1	1.5	2	2.5	3	3.5	4
45	6.588	6.396	5.899	5.484	5.187	4.980	4.830
44	6.588	6.396	5.899	5.484	5.187	4.980	4.830
43	6.588	6.396	5.899	5.484	5.187	4.980	4.830
42	6.573	6.381	5.886	5.472	5.175	4.969	4.819
41	9.443	8.893	7.828	6.964	6.351	5.926	5.622
40	16.754	14.663	11.678	9.572	8.217	7.337	6.740
39	18.119	17.124	13.156	10.297	8.490	7.328	6.549
38	20.439	22.994	16.191	11.491	8.792	7.168	6.138
37	15.581	19.799	16.328	11.655	8.597	6.782	5.639
36	13.097	19.245	20.704	14.959	10.255	7.620	6.032
35	9.306	13.794	15.980	13.277	9.503	6.958	5.374
34	7.403	11.071	13.913	14.069	10.867	7.744	5.729
33	5.928	8.877	11.333	12.150	10.367	7.773	5.764
32	4.764	7.142	9.267	10.595	10.302	8.366	6.230
31	3.754	5.630	7.359	8.564	8.769	7.663	5.975
30	3.096	4.644	6.116	7.249	7.862	7.546	6.295
29	2.413	3.620	4.787	5.720	6.335	6.366	5.624
28	1.925	2.888	3.836	4.621	5.231	5.535	5.257
27	1.385	2.077	2.762	3.351	3.831	4.146	4.100
26	1.146	1.719	2.289	2.797	3.230	3.579	3.706
25	0.890	1.335	1.778	2.184	2.534	2.841	3.014



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Dredge Work Package Formulation

	Optimal Target Depth (ft)	Time Until Dredging Takes Place (Years)						
		1	1.5	2	2.5	3	3.5	4
Calcasieu Outer	38	20.43943	22.99373	16.1911	11.49139	8.791689	7.167862	6.138435
Calcasieu Gap	40	35.03011	52.46583	68.87481	82.36058	90.64498	94.80497	94.14798
				9538	7.313952	5.418806	4.439269	3.880387
				0344	64.24062	62.38521	59.47904	56.6367
				5194	41.97186	39.26637	37.47005	36.23801
				5794	30.19148	33.13396	32.6626	30.26347
				3099	5.741193	6.888865	8.034747	9.174922
				0451	262.7408	230.1306	197.8446	170.9211
				6375	73.73789	69.79972	66.44992	63.59281
Galveston Harbor	35	2.861038	3.241308	3.678682	2.926068	2.788178	2.876293	2.961408

• Remaining development tasks include CPT interface enhancements to give project dredging managers the capability to formulate efficient work packages.

- Cargo is *shared* between and across navigation projects. CPT Rollup capability ensures no “double counting.”
- Dredging requirements are additive, so straightforward summation of CY to ensure a given target depth.



CPT Dredge Work Package Rollup Example

Reach Name	Target Elev.	Tons Supported	Now	1 year	2 years	3 years
Calcasieu Outer Bar	42	17.1 M	23.1	28.7	24.5	19.2
Calcasieu Lower Reach	42	16.3 M	21.4	26.9	23.5	18.7
Calcasieu Middle Reach	41	16.3 M	19.3	24.3	28.4	31.0
Calcasieu Upper Reach	40	15.8 M	14.5	19.1	18.6	15.2
Lake Charles Terminal Basin	38	14.6 M	13.2	18.1	23.4	21.2
Lake Charles Turning Basin	36	2.3 M	12.9	19.1	26.7	23.1

Work Package Options	Target Elevations	Tons Supported	Now	1 year	2 years	3 years
1	42, 42, 41	17.1 M	12.3	14.3	12.2	9.7
2	42, 42, 40	14.8 M	9.6	10.7	11.1	10.3
3	41, 41, 40	11.9 M	6.7	7.2	6.9	6.2

Other Performance Metrics and Advanced Analytics

- We are not limited to counting stats such as tons and cargo value.
- Benefits, however they are defined, can now be directly compared to these detailed, quantitative dredging cost estimates.
- Benefits can include commodity-specific freight corridors and estimates of shipping cost savings.

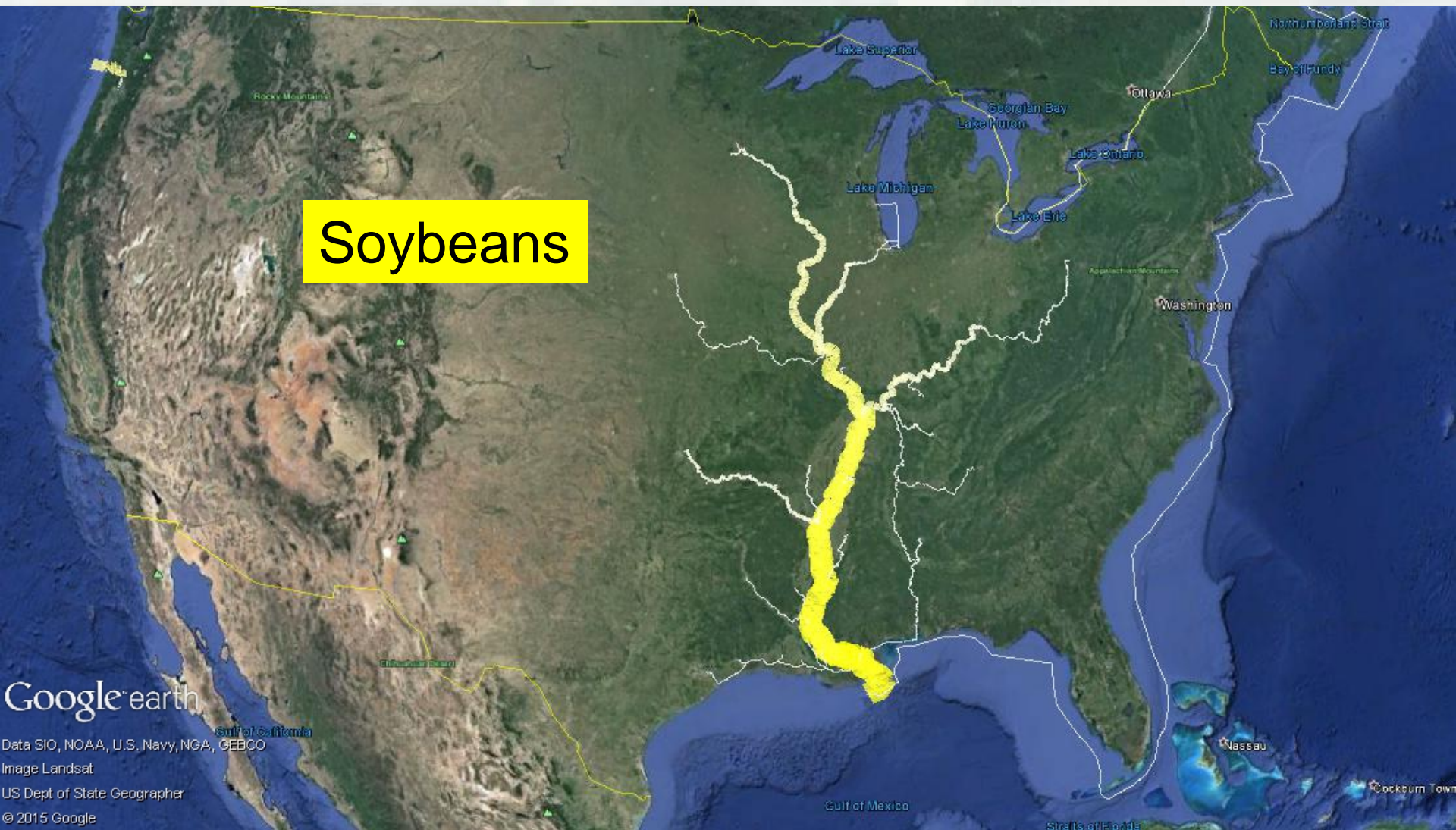


Waterway Freight Corridor Examples

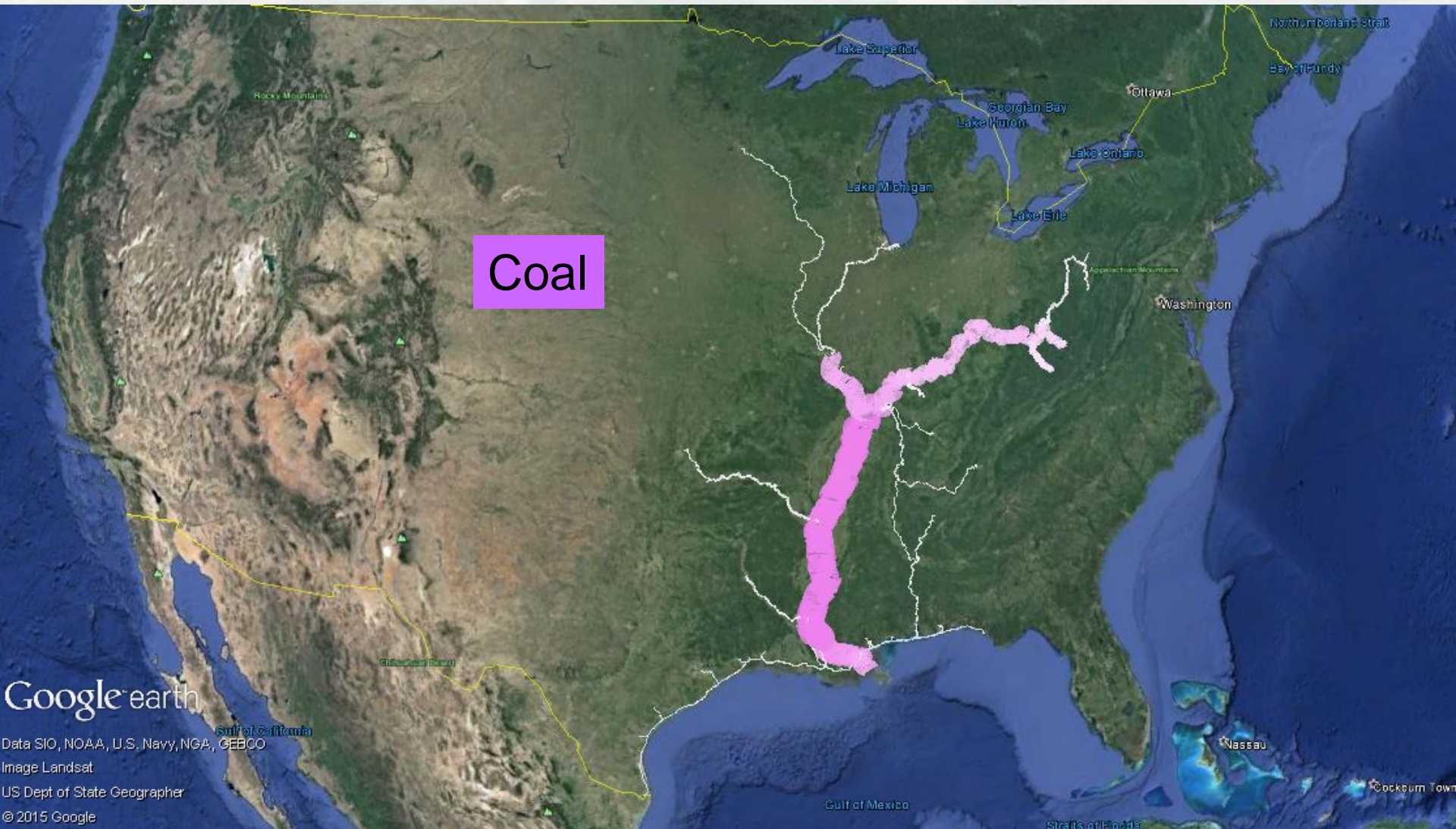


Northeast
fuel shipments

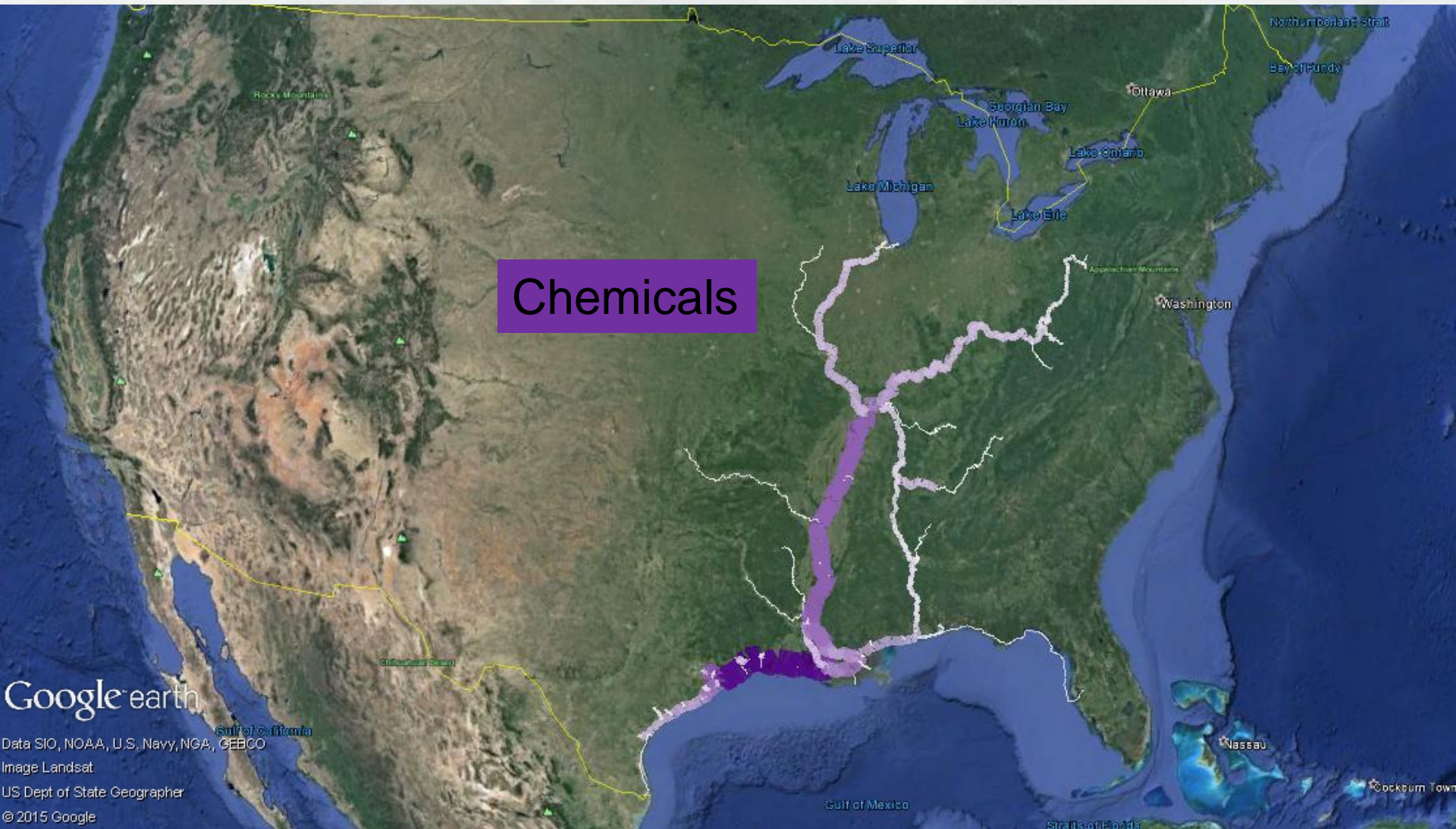
Waterway Freight Corridor Examples



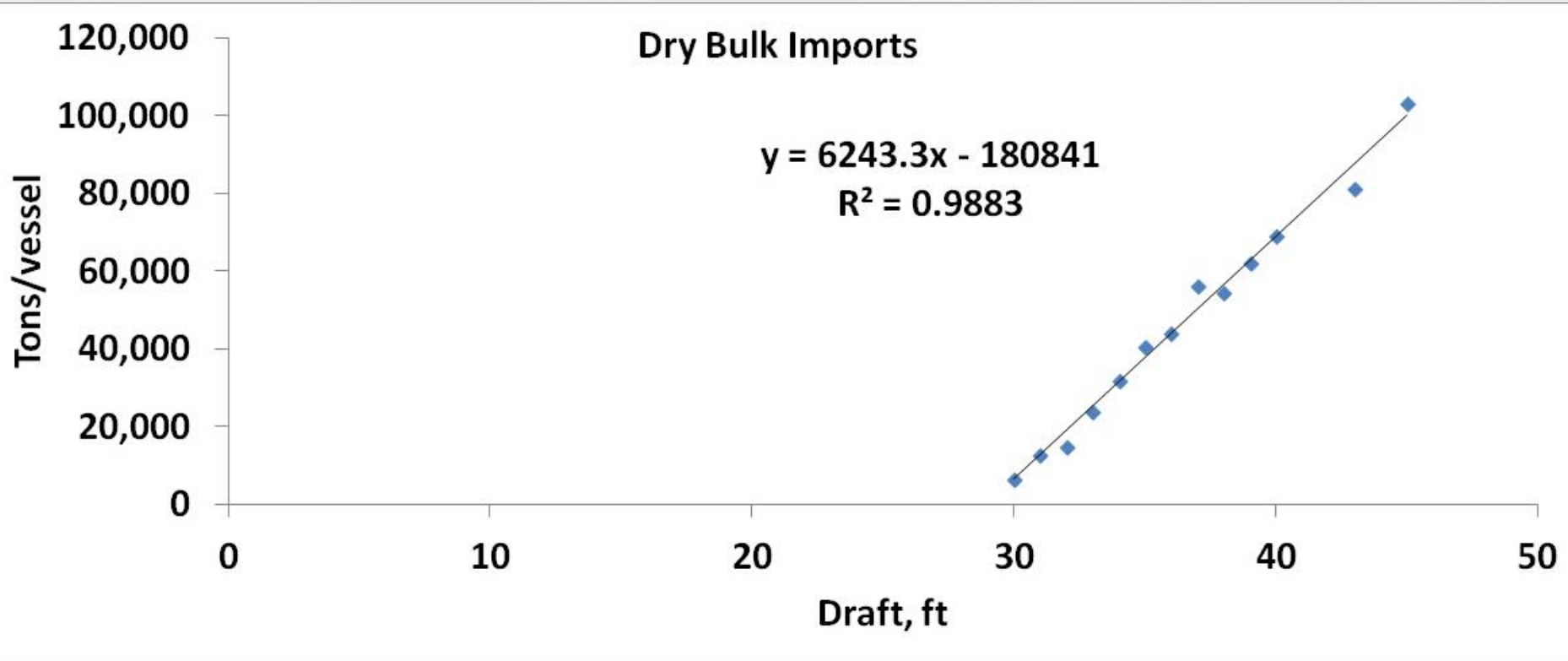
Waterway Freight Corridor Examples



Waterway Freight Corridor Examples



Tons per voyage analysis: National Summary

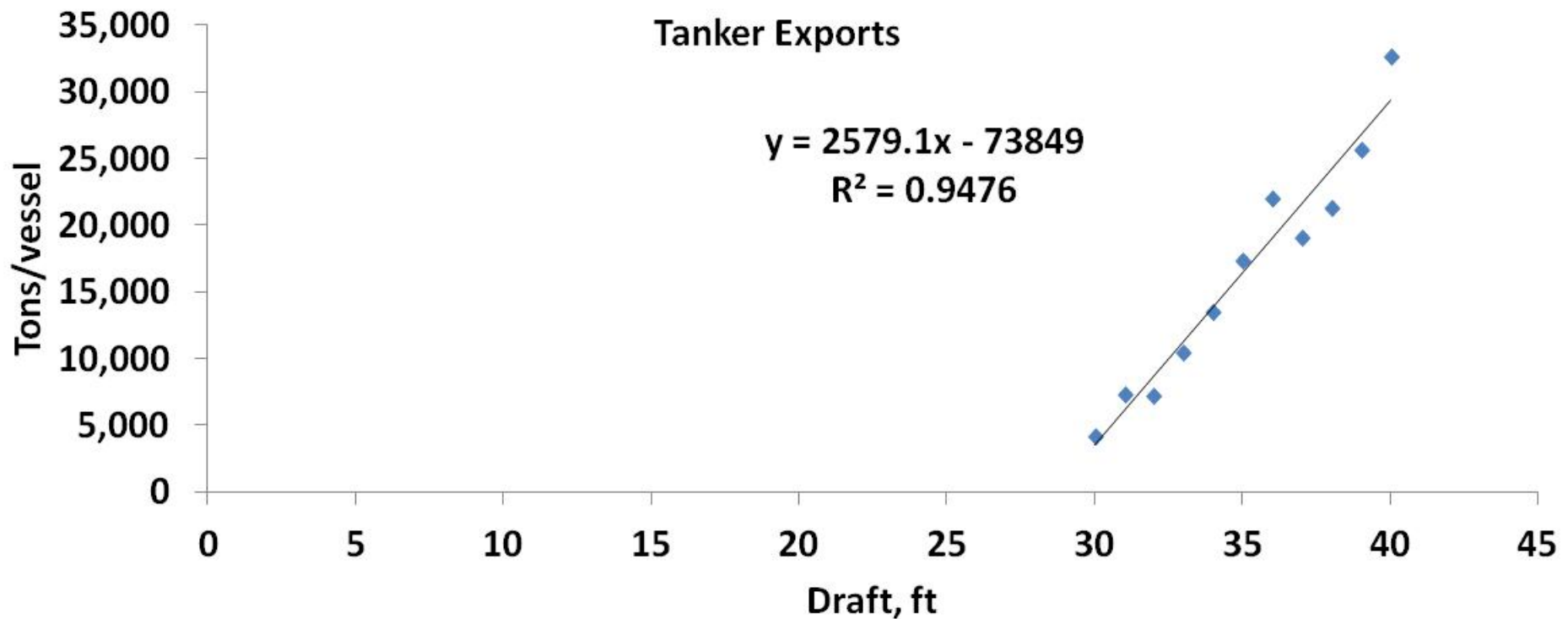


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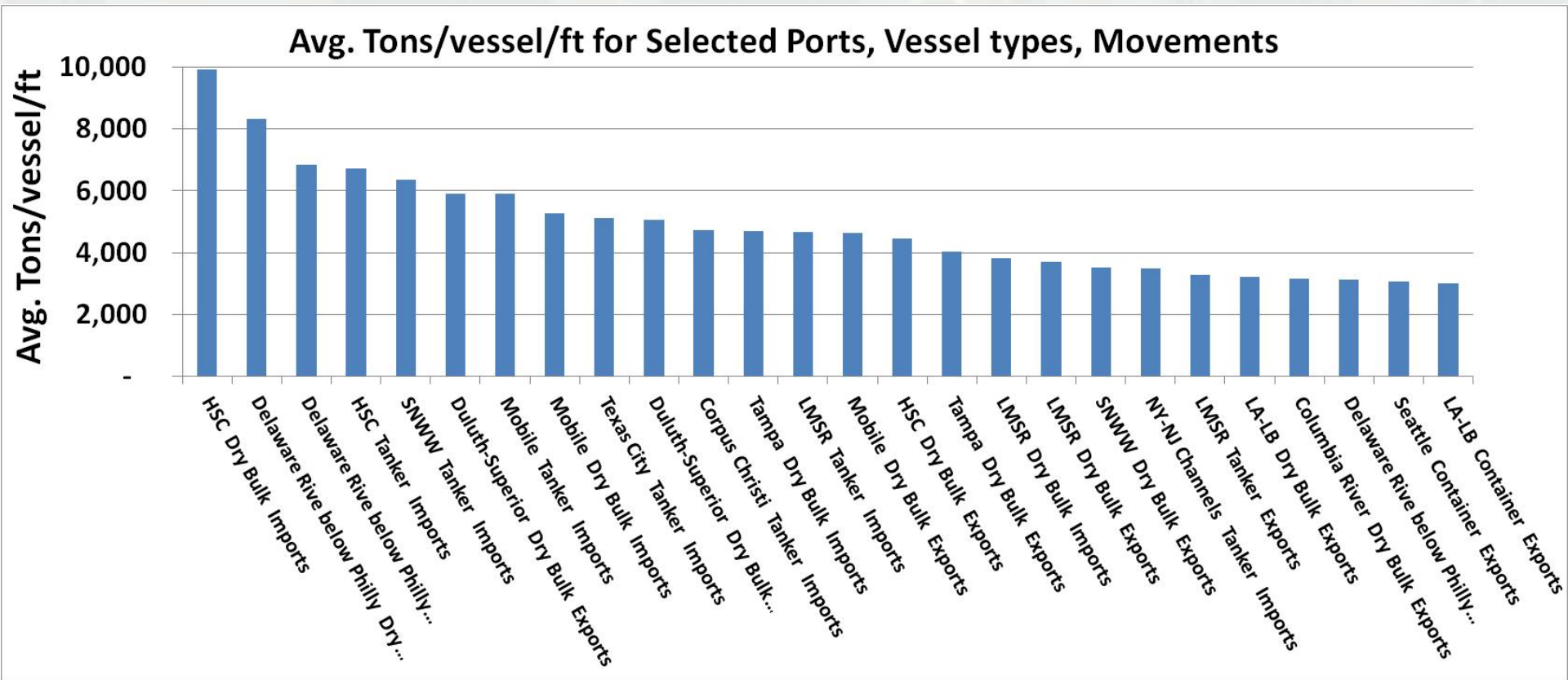
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Tons per voyage analysis: National Summary



Vessel Draft Sensitivities

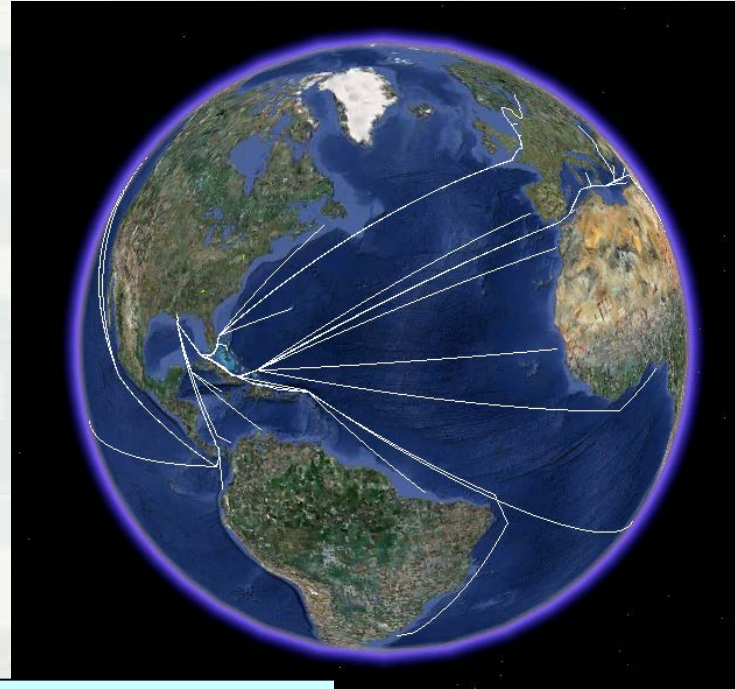


Lower Mississippi River

Average voyage distances, 2007-2008

US Census data on foreign countries of origin/destination for Lower Mississippi River used to estimate average distance per voyage:

Sample Countries of Origin/Destination	Distance (mi)
Venezuela	1750
Estonia	6950
Mexico	650
Brazil	3750
Colombia	1650
India	13300
The Netherlands	5600
Spain	5100
United Kingdom	5300
Egypt	7300



Average Voyage Distances

Tanker Imports: 3640 mi	Dry Bulk Imports: 4853 mi
Tanker Exports: 7311 mi	Dry Bulk Export: 6574 mi

Questions?

Asset Management for Deep-draft Navigation Channels O&M

Ned Mitchell, PhD

Kenneth.n.mitchell@usace.army.mil

601-634-2022

40km
20mi