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BATTELLE

It can be done

2019 SEDIMENTS CONFERENCE

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Utilizing

ADAPTIVE MANAGEMENT TECHNIQUES

During An

Environmental Dredging

Remediation Project

Presenter: Rick Elia

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Agenda

- Introduction
- Project Background
- Challenges
- Adaptive Management Approach
- Benefits of Adaptive Management
- Project Recap

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Introduction

- Rick Elia – Bio/Credentials
  - ~20 years remediation experience
    - Over 20 projects completed
      - Various: sediments, soils, residential, federal, commercial
  - Corporate Manager of Subject Project
    - Oversaw from bid through completion

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Project Background

- Lake project amidst residential community
- Little bit of everything:
  - Soils,
  - Sediments,
    - Hydraulic & Mechanical,
    - Stabilization,
  - Dewatering,
  - Water treatment,
  - Restoration
    - Backfill
    - Hydraulic capping
    - Wetlands mitigation




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Work Completed

- 8,000 cys excavated soil
- 16,000 cys mechanically dredged sediment
- 128,000 cys hydraulically dredged sediment
- 71,000 tons dewatered and disposed
- 4,000 trucks disposal/deliveries
- 117 million gallons treated
- 20,000 cys hydraulic capping
- 10,000 cys mechanical capping
- 34,000 plantings
- 2.5 acres of wetlands mitigated

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"Everybody has a plan until they get **punched in the mouth.**"

- Mike Tyson

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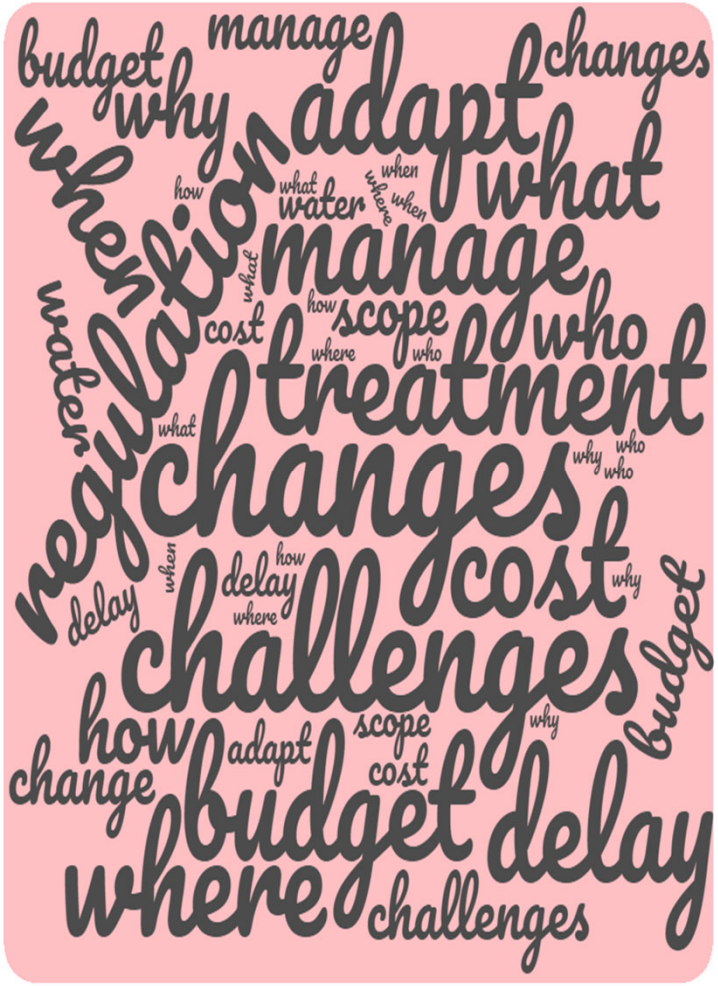
Challenges



CHALLENGES:

1. Delays
2. Scope Increases
3. Water Treatment
4. PH Levels
5. TOC Levels
6. Changed Conditions
7. Coarse Materials
8. …
9. …
10. …

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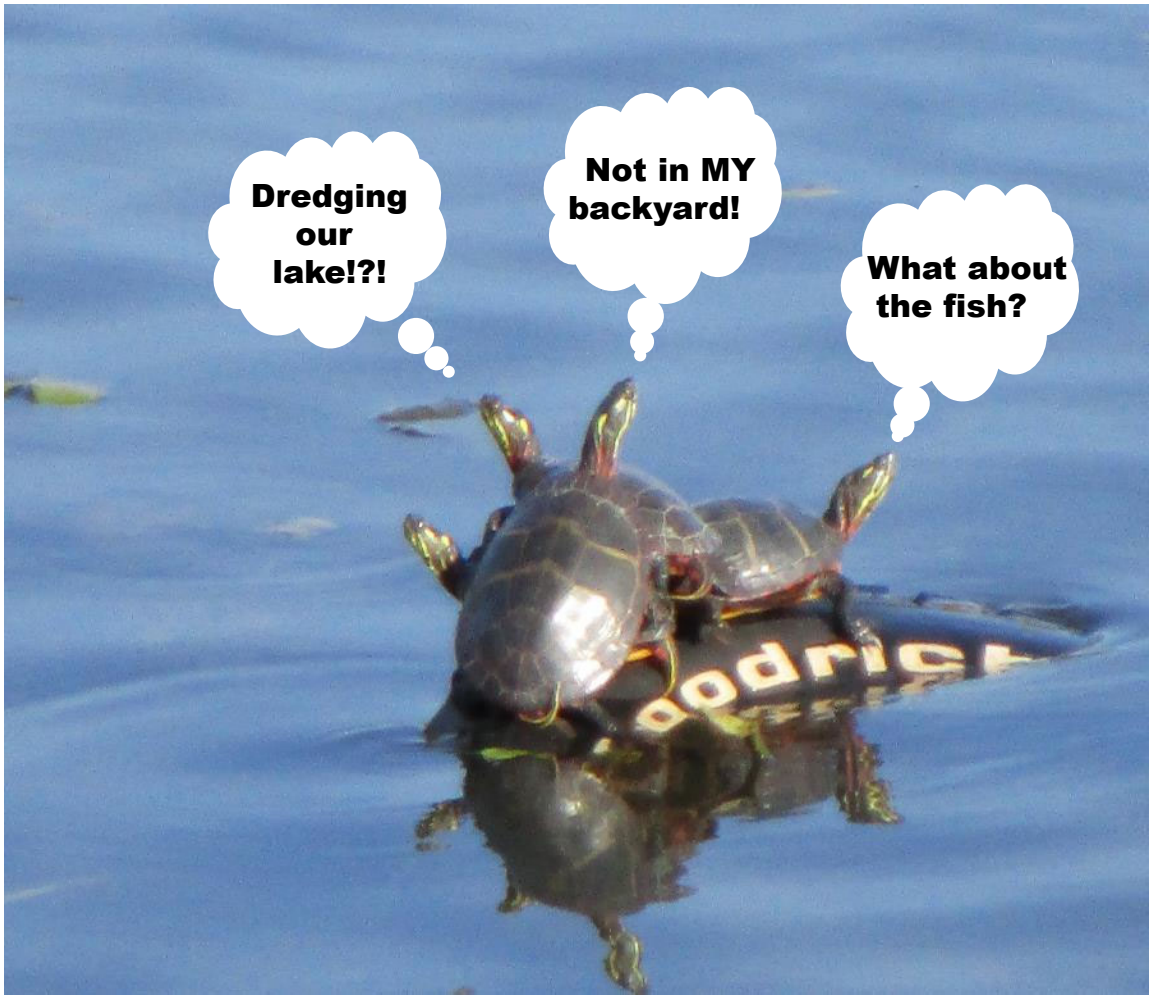
Challenges - DELAYS

- Project Delayed
  - Community Discord
    - Activist Groups
    - Town resistance
    - Agencies reassessing
    - **Several year delay**



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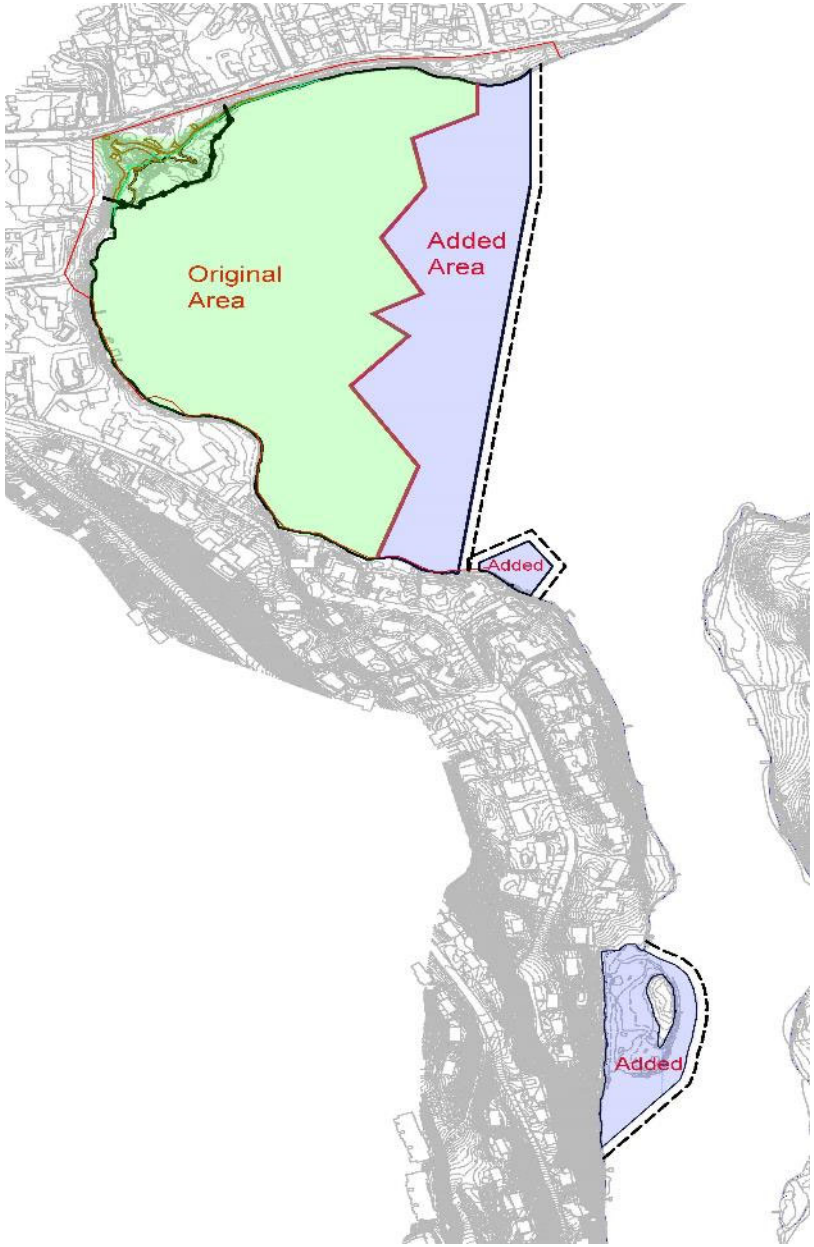
Challenges – Scope Creep

- Scope of Work Increase
  - Dredging and Capping:
    - 50% more hydraulic
    - 40% more acreage
    - Added all mechanical dredging and capping in 2 isolated areas



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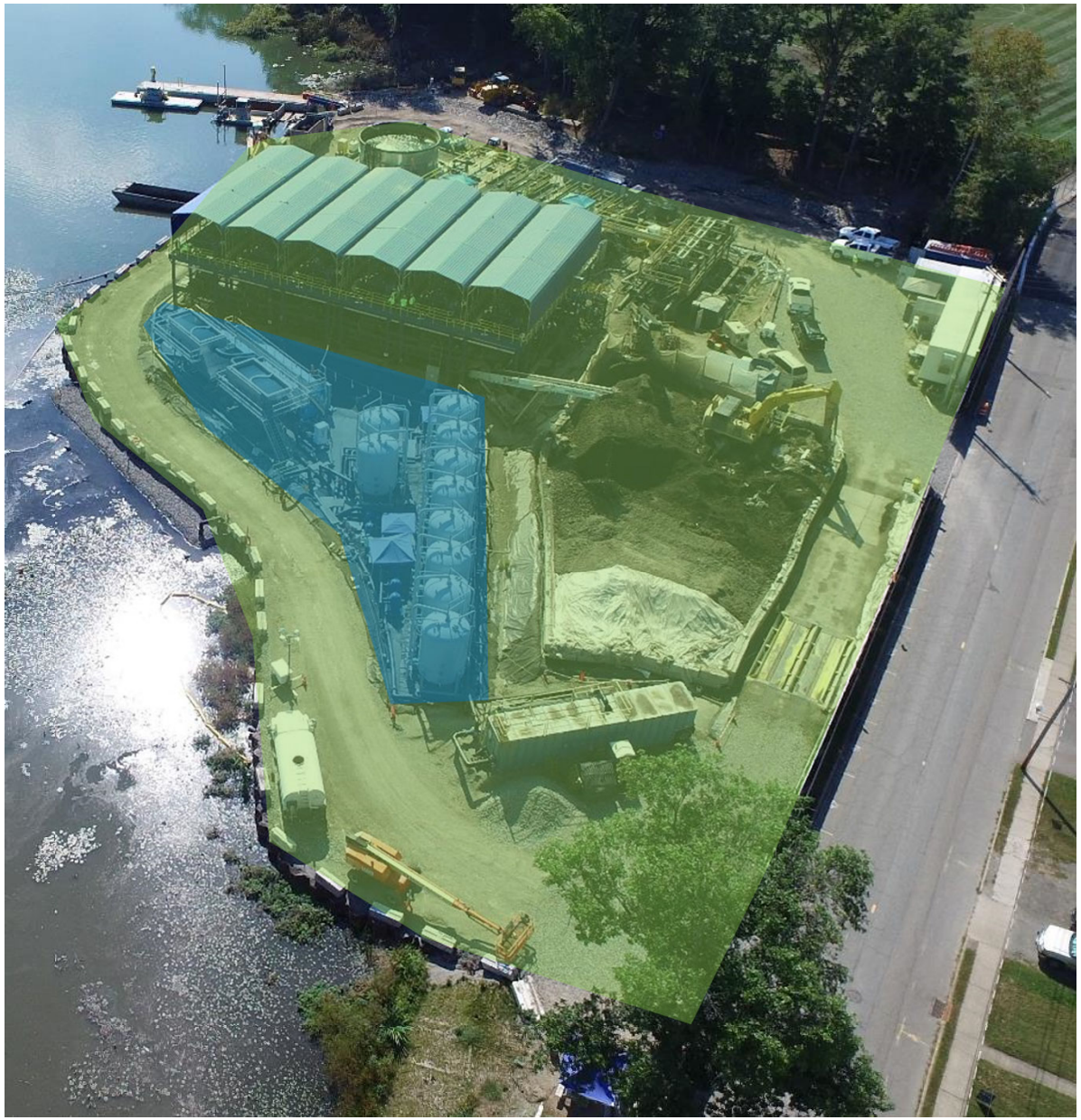
Challenges – Water Treatment

- Originally no WT
  - Discharge direct from presses
- Change to full 2,500 gpm system
  - Discharge meeting NJDEP drinking water standards
  - Squeezed into small area

= 1.1 acres

= 0.12 acres



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Challenges – Water Treatment

- High Levels of TOC
  - Undiscovered in treatability study
  - Exposed upon implementation
- pH Fluctuations
  - Informed lake pH varies due to algae
  - Installed automated system

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Challenges – Water Level

- Marine Clearing
  - High water caused equipment access issues.
  - Required clearing prior to dredging isolated areas

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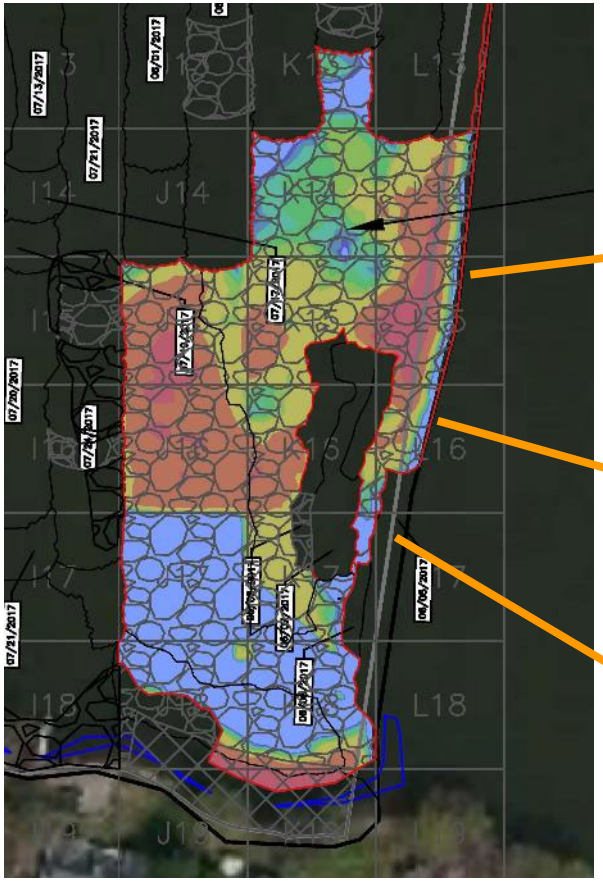
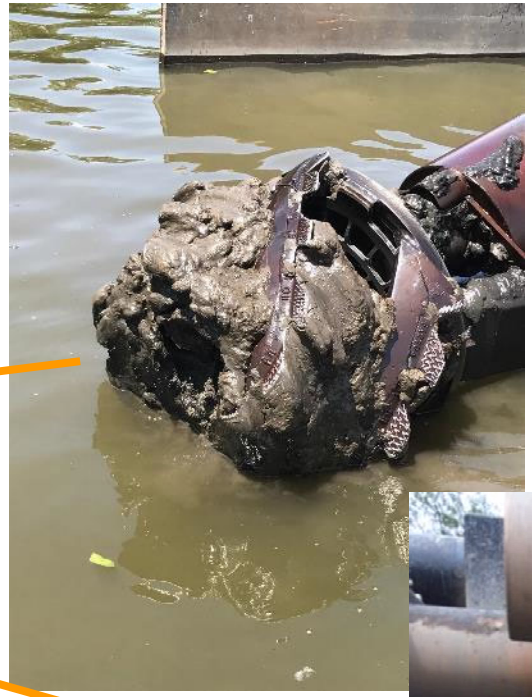
Greatest Challenge! – Changed Condition





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Adaptive Management Approach

- What is Adaptive Management?

"A rigorous approach for designing and implementing management actions to maximize learning about critical uncertainties that affect recurrent decisions while simultaneously striving to meeting multiple management objectives.."

- Marc Nelitz and David Marmorek

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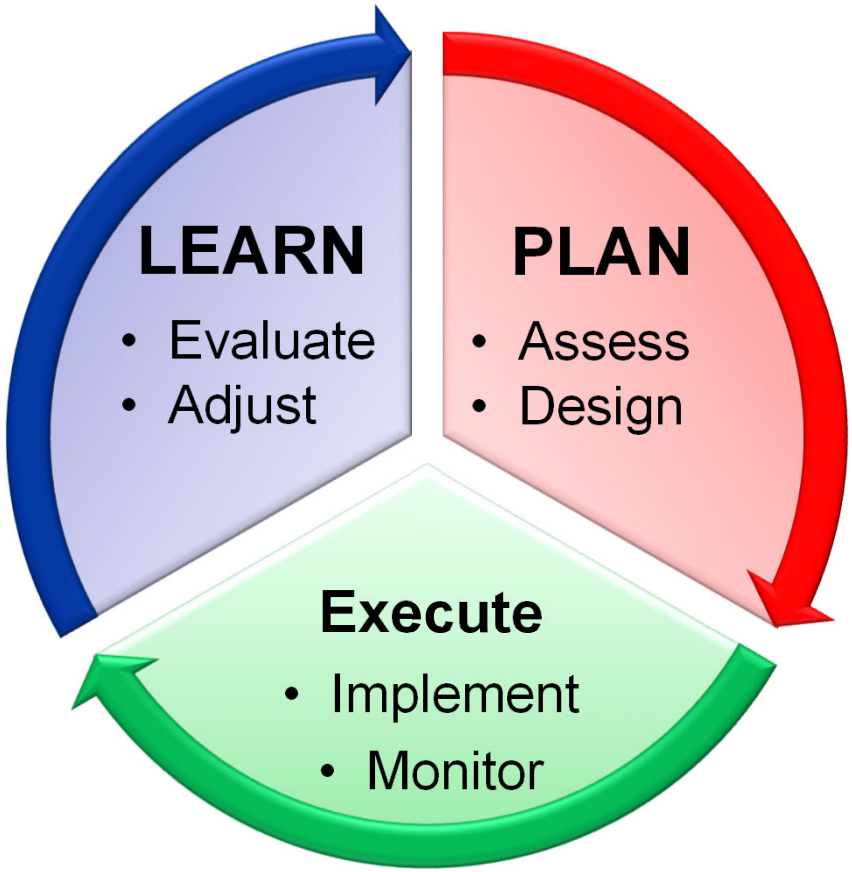
Adaptive Management Cycle



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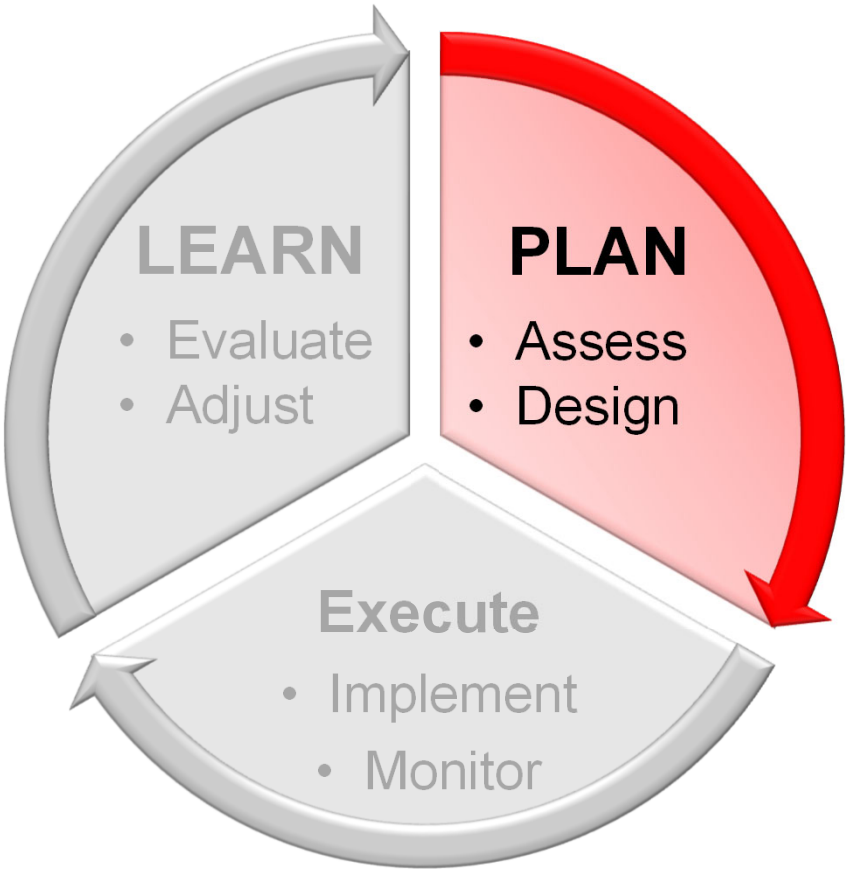
Planning Phase



- **Assess**
  - Frame the problem
  - Define goals
  - Discuss risks / uncertainties
  - Collect data
- Design
  - Brainstorm options
  - Constructability
  - Discuss alternatives

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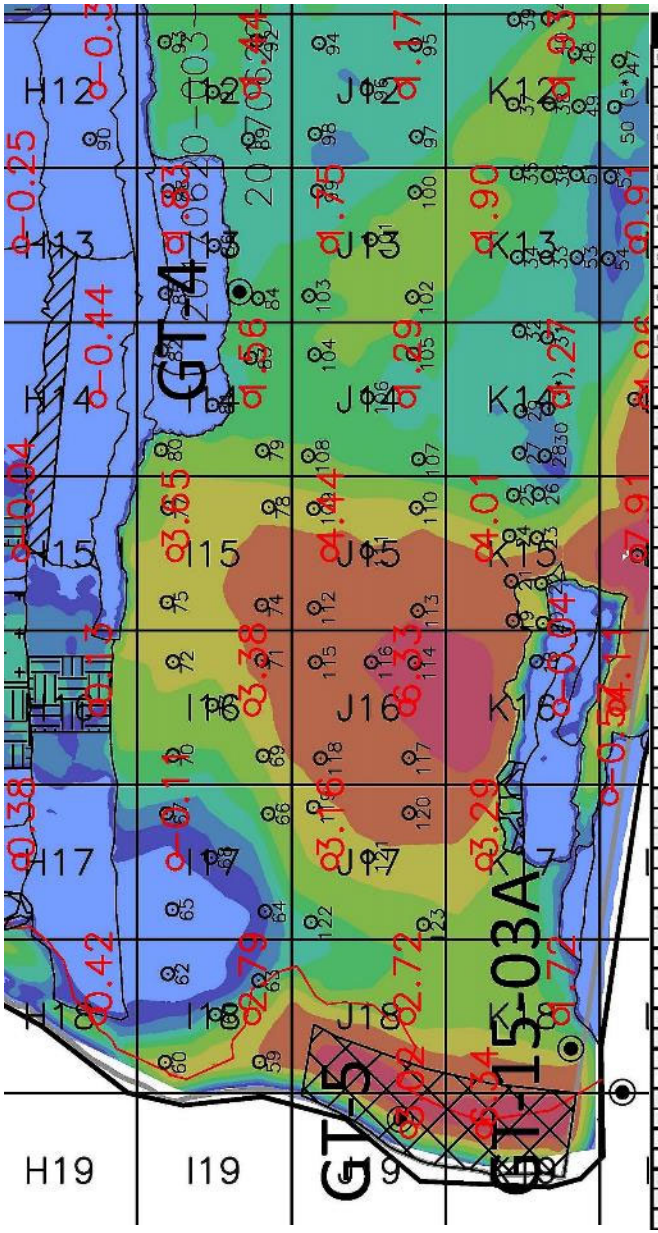
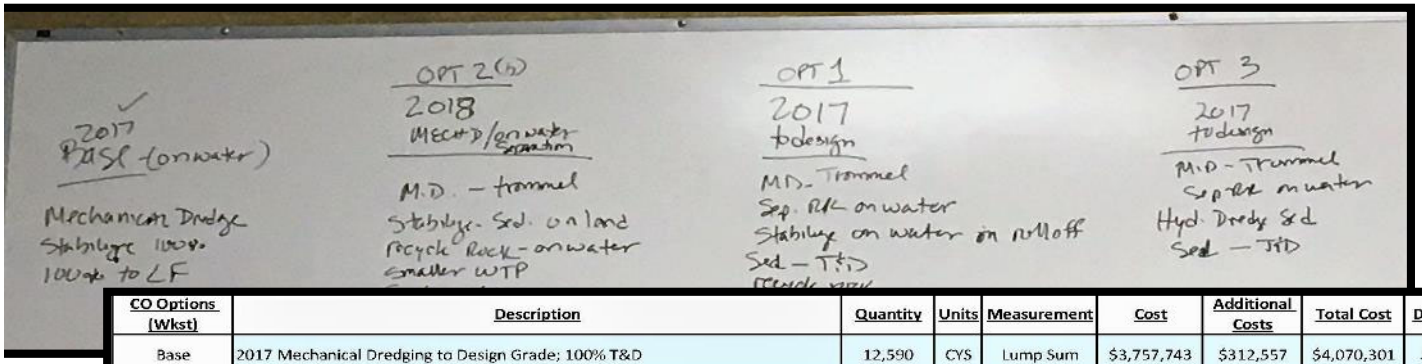
Planning - Assess



Date	New Target #	Old Target #	DMU	Northing	Easting	Start Elevation	Cut	Time	Notes	Picture #
6/30/2017	59	#1	I18	789714.71	552954.99	197.65	3'			110
6/30/2017	60	#2	I18	789714.29	552893.94	195.3	6"			
6/30/2017	61	#3	I18	789745.28	552926.68	192.9	1' below grade			
6/30/2017	62	#4	I18	789771.66	552895.86	193.3	1' below grade			
6/30/2017	63	#5	I18	789767.23	552954.57	193.1	grade			
6/30/2017	64	#6	I17	789812.1	552958.65	191.5	1' below grade			
6/30/2017	65	#7	I17	789813.5	552898.71	192.3	1.5' below grade			
7/5/2017	66	#8	I17	789875.478	552960.89	191.1	grade			
7/5/2017	67	#9	I17	789875.66	552894.84	192.1	grade			
7/5/2017	68	#10	I17	789847.08	552923.62	191.3	below grade			
7/5/2017	69	#11	I16	789912.84	552957.32	192	1'3" cut	8:37		113
										114
7/5/2017	70	#12	I16	789913.26	552899.06	192.8	1' cut	8:48		115
7/5/2017	71	#13	I16	789974.83	552956.56	191.5	1'6" cut	9:01		116
										117
7/5/2017	72	#14	I16	789973.8	552899.05	191.5	6" cut	8:55		118
7/5/2017	73	#15	I16	789945.8	552924.4	191.4	grade	8:57		
7/5/2017	74	#16	I15	790010.6	552956.56	192.1	2' cut	9:43		119
										120
7/5/2017	75	#17	I15	790012.41	552895.09	192	1'3" cut			121
										122
7/5/2017	76	#18	I15	790038.28	552894.45	192.7	2' cut			123
										124
7/5/2017	77	#19	I15	790073.56	552895.66	192.5	1' cut			125
7/5/2017	78	#20	I15	790074.19	552961.1	193.55	2' cut			126
										127
7/5/2017	79	#21	I14	790110.76	552957.18	196.6	6" cut			128
7/5/2017	80	#22	I14	790111.22	552891.28	192.75	6" cut			129
7/5/2017	81	#23	I14	790140.46	552924.46	193.23	grade			
7/5/2017	82	#24	I14	790175.96	552891.74	193	4" below grade			
7/5/2017	83	#25	I14	790170.86	552949.51	194	grade	11:04	at grade no dig Operator - Glen Scott, Sampler - Kevin Crystal	
7/5/2017	84	#26	I13	790209.52	552954.26	194.5	6" cut	12:31	grade (194.0) heavy silt	130

Planning - Design



CO Options (Wkst)	Description	Quantity	Units	Measurement	Cost	Additional Costs	Total Cost	Daily Cost	Notes
Base	2017 Mechanical Dredging to Design Grade; 100% T&D	12,590	CYS	Lump Sum	$3,757,743	$312,557	$4,070,301	$64,657	Mech dredge; stabilize 100% on water in rolloffs; T&D 100%
Option 1	2017 Mechanical Dredge with Trommel to Design Grade; Sediment Stab. & T&D; Recycle Rock	12,590	CYS	Lump Sum	$3,073,592	$312,557	$3,386,150	$53,790	Mech dredge with trommel; recycle rock; stabilize sediment on water in rolloffs; T&D sediment only
Option 2	2018 Mechanical Dredge with Trommel to Design Grade using Land Based Stabilization Pad; Sediment T&D; Recycle Rock	12,590	CYS	Lump Sum	$2,382,917	$537,546	$2,920,463	$79,099	Mech Dredge with trommel; stabilize sediment on land; recycle rock; smaller WTP; T&D sediment only
Option 3	2017 Mechanical Screen Sediment & Rock; Hydraulically Dredge Sediment; Recycle Rock	12,590	CYS	Lump Sum	$678,676	$0	$678,676	$18,381	screen rock > 1-1/2", replace sediment then hydraulically dredge
Option 3 - Hyd I	Added Cost for Hydraulical Dredging Coarse Material Area at lesser CY rate (added days to dredge entire area)	4	days	Days	$104,186	$0	$416,743	$104,186	Contingency for inefficient hydraulic dredging in the screened coarse material area; needs to be considered by SF as opposed to CY.

COR (Wkst)	Description	Quantity	Units	Measurement	Cost	Additional Costs	Total Cost	Daily Cost	Notes
INV	Investigation for changed condition	1	LS	Lump Sum	$57,895	$0	$57,895	n/a	Used debris barge to investigate changed condition
Option 3 - Setup	Setup and Removal of Option 3 Equipment and Resources	1	LS	Lump Sum	$80,420	$0	$80,420	n/a	Use crane to lift and position equipment into ABD from Lakeside

Est Savings	Description	Quantity	Units	Measurement	Unit Rate	Additional Costs	Total Savings	Daily Cost	Notes
Est Save	Dredging - Potential Savings for Coarse Material Dredging - Rock %	8,864	CYS	per CY	$69.62	n/a	-$617,125	n/a	Estimated savings after cost for not hydraulically dredging rock fraction
Est Save	T&D - Potential Savings for Coarse Material Dredging - Rock %	4,512	tons	per Ton	$73.46	n/a	-$331,464	n/a	Estimated savings after cost for not disposing screened rock fraction
Est Save	Dredging Shoreline - Potential Savings for Shoreline Dredging - E13-K19 (cost avoidance)	1,996	CYS	per CY	$69.62	n/a	-$138,962	n/a	Estimated savings after cost for not hydraulically dredging shoreline between E13 and K19
Est Save	Dredging Shoreline - Potential Savings for Shoreline Dredging - Rock % from E14 to M1 (cost avoidance)	234	CYS	per CY	$69.62	n/a	-$16,318	n/a	Estimated savings after cost for not hydraulically dredging shoreline rock fraction between E14 and M1
Est Save	Dredging Shoreline - Potential Savings for Shoreline Dredging - Peat % from E14 toM1 (cost avoidance)	1,758	CYS	per CY	$69.62	n/a	-$122,386	n/a	Estimated savings after cost for not hydraulically dredging shoreline peat fraction between E14 & M1
Est Save	T&D Shoreline - Potential Savings for Shoreline Material Dredging - Rock % from E13-K19 (cost avoidance)	1,018	tons	per Ton	$73.46	n/a	-$74,779	n/a	Estimated savings after cost for not disposing screened shoreline rock fraction between E13 and K19
Est Save	T&D Shoreline - Potential Savings for Shoreline Material Dredging - Rock % from E14 to M1 (cost avoidance)	119	tons	per Ton	$73.46	n/a	-$8,765	n/a	Estimated savings after cost for not disposing screened shoreline rock fraction between E14 & M1
Est Save	T&D Shoreline - Potential Savings for Shoreline Material Dredging - Peat % (cost avoidance)	897	tons	per Ton	$73.46	n/a	-$65,860	n/a	Estimated savings after cost for not disposing shoreline peat fraction between E14 & M1

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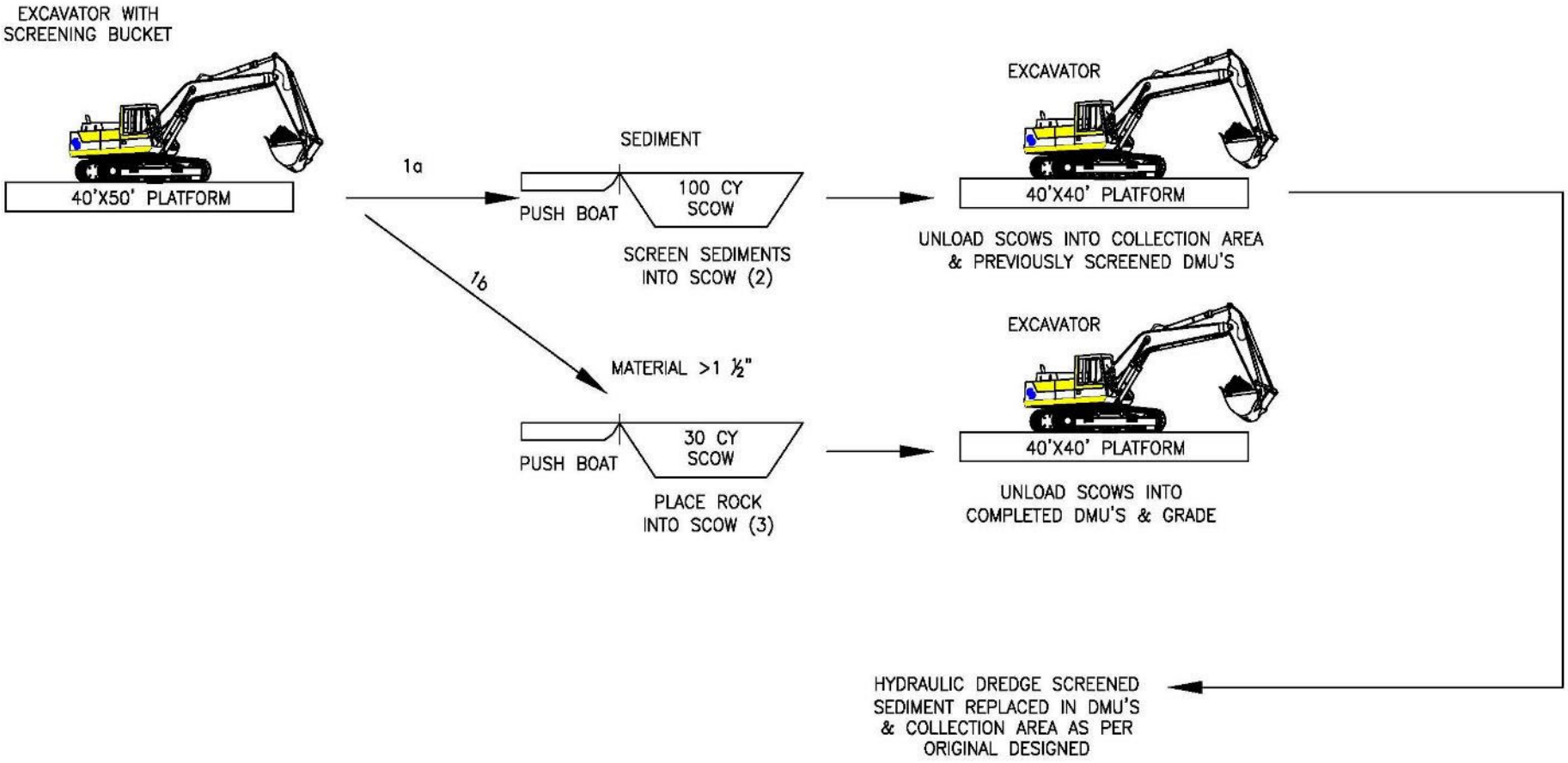
Planning - Design



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Planning - Design

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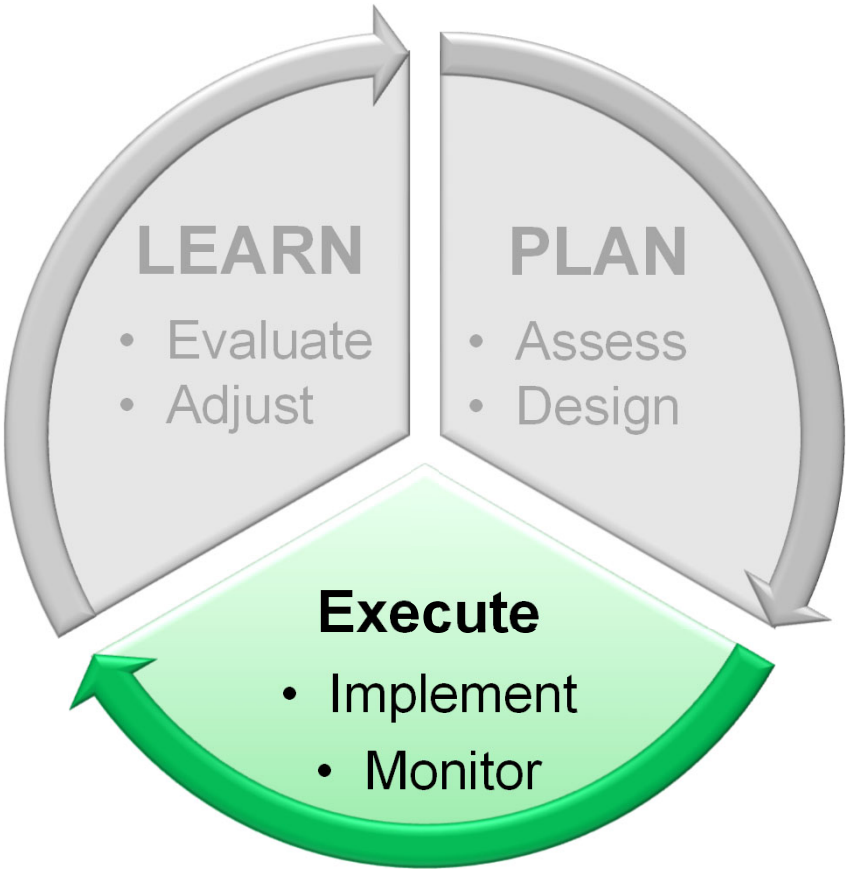
Execution Phase



- **Implement**
  - Put your plan into action
- **Monitor**
  - Make observations
  - Gather data

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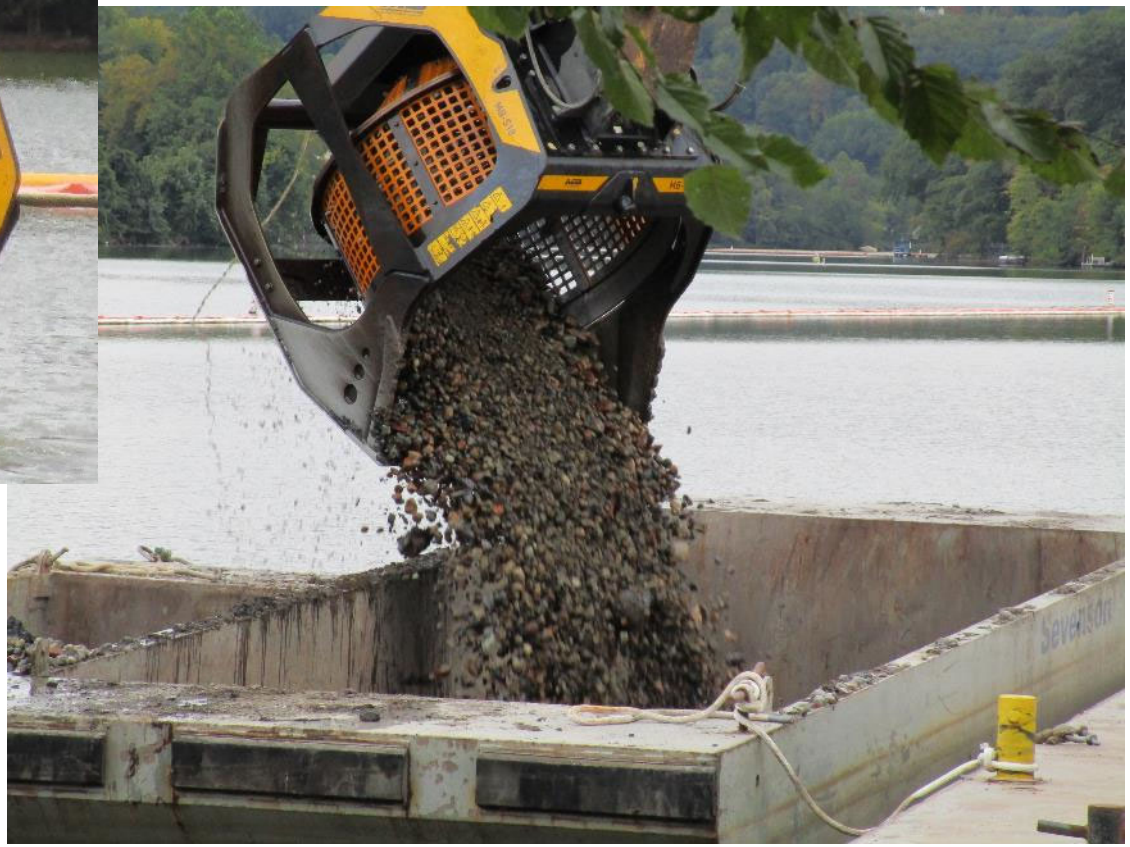
Execute - Implement

Execute - Implement

Execute - Implement



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Execute - Monitor

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Execute - Monitor

Estimated Value

			Dredging					Filter Presses								Water Treatment					Trucking and Disposal			
Dredge Day	Date	Day	Quantity Dredged (CY)	Hours Dredged	CY/Hr	Dredged to Date (CY)	DMU	Filter Presses Online	Run Hours	Drops Today	Drops to Date	Avg Cake Solids	CY Cake Today	CY Cake to Date	Est. Tons Oversize & Sand today	Est. Tons Oversize & Sand to Date	Runtime (mins)	Flowmeter Start	Flowmeter End	Discharge Today	Discharged to Date	Loads Today	Loads to Date	Tons Today	Tons to Date
51	08/15/17	Tue	1,428	11.50	124	48,764	L8-10, E13	6	11.75	28	1,020	52.18%	622	22664	180	6196	695	58,300,000	59,547,000	1,247,000	59,634,936	28	1,407	659.59	32,196.49
52	08/16/17	Wed	1,267	11.50	110	50,031	L8-9, E8	6	11.83	18	1,038	55.45%	400	23064	268	6464	680	59,547,000	60,946,000	1,399,000	61,033,936	36	1,443	856.96	33,055.45
53	08/17/17	Thu	1,475	12.00	123	51,506	L8, K8-10	6	11.75	28	1,066	52.53%	622	23687	291	6775	710	60,946,000	62,200,000	1,254,000	62,287,936	43	1,486	1,003.81	34,059.26
54	08/18/17	Fri	1,058	10.50	101	52,564	C8, K8-10	6	9.50	24	1,090	48.94%	533	24220	75	6850	645	62,200,000	63,119,400	919,400	63,207,336	24	1,510	574.38	34,633.64
55	08/21/17	Mon	1,010	11.75	86	53,574	C8-B8, K8,J8	6	11.50	16	1,106	52.75%	356	24575	213	7063	690	63,119,400	64,519,000	1,399,600	64,606,936	40	1,550	934.40	35,568.04
56	08/22/17	Tue	1,235	11.50	107	54,809	I7, E8-12	6	11.50	19	1,125	47.10%	422	24998	39	7102	705	64,519,000	65,834,000	1,315,000	65,921,936	40	1,590	919.58	36,487.62
57	08/23/17	Wed	1,096	11.17	98	55,905	I7, E12	6	11.13	19	1,144	45.13%	422	25420	75	7177	695	65,834,000	67,067,000	1,233,000	67,154,936	10	1,600	234.85	36,722.47
58	08/24/17	Thu	875	11.58	76	56,780	D9-12, I7	6	11.82	16	1,160	47.37%	356	25775	105	7282	720	67,067,000	68,441,000	1,374,000	68,528,936	16	1,616	375.06	37,097.53
59	08/25/17	Fri	949	12.00	79	60,913	D12-13, D8-10	6	11.50	15	1,175	43.37%	333	26109	120	7402	710	68,441,000	69,688,000	1,247,000	69,775,936	10	1,626	236.28	37,333.81
60	08/28/17	Mon	1,054	11.00	96	61,967	D8-9, D11-13	6	11.75	18	1,193	46.09%	400	26508	105	7507	710	69,688,000	70,909,000	1,221,000	70,996,936	24	1,650	562.79	37,896.60
61	08/29/17	Tue	1,119	12.00	93	63,086	C9-10, I7-5	6	11.50	21	1,214	47.23%	467	26975	108	7615	688	70,909,000	71,997,000	1,088,000	72,084,936	18	1,668	410.75	38,307.35
62	08/30/17	Wed	1,012	12.00	84	64,098	I5, I7-L7	6	11.15	18	1,232	52.40%	400	27375	216	7831	700	71,997,000	73,208,000	1,211,000	73,295,936	30	1,698	690.80	38,998.15
63	08/31/17	Thu	967	12.00	81	65,065	C10-12, L7	6	9.85	15	1,247	50.47%	333	27708	312	8143	705	73,208,000	74,196,000	988,000	74,283,936	42	1,740	977.04	39,975.19
64	09/01/17	Fri	523	7.67	68	65,588	C12-13, I7	6	6.15	11	1,258	43.40%	244	27953	75	8218	435	74,196,000	74,809,000	613,000	74,896,936	20	1,760	475.79	40,450.98
65	09/05/17	Tue	881	10.50	84	66,469	I7,J7,K7,L7	6	8.80	16	1,274	51.17%	356	28308	216	8434	615	74,809,000	75,707,000	898,000	75,794,936	12	1,772	282.59	40,733.57
66	09/06/17	Wed	863	11.83	73	67,332	L7,I6,J6,K6,L6,C8	6	10.21	18	1,292	55.01%	400	28708	96	8530	711	75,707,000	76,852,000	1,145,000	76,939,936	20	1,792	473.45	41,207.02
67	09/07/17	Thu	1,031	12.00	86	68,363	I6,J6,K6,L6,C8	6	11.75	21	1,313	53.35%	467	29175	111	8641	710	76,852,000	78,147,700	1,295,700	78,235,636	30	1,822	691.99	41,899.01
68	09/08/17	Fri	456	6.25	73	68,819	L6-M6, C10-11	6	6.23	13	1,326	48.67%	289	29464	102	8743	400	78,147,700	78,747,000	599,300	78,834,936	40	1,862	925.61	42,824.62
69	09/11/17	Mon	790	11.33	70	69,609	C11-13, B11-12,I5	6	11.50	17	1,343	42.99%	378	29841	192	8935	705	78,747,000	80,078,000	1,331,000	80,165,936	23	1,885	631.39	43,456.01
70	09/12/17	Tue	967	12.00	80	70,566	I5,J5,K5,L5,M5	6	11.75	18	1,361	51.10%	400	30241	285	9220	710	80,078,000	81,349,000	1,271,000	81,436,936	16	1,901	379.30	43,735.31
71	09/13/17	Wed	681	11.16	61	71,247	J5,K5,L5,F14	6	11.30	12	1,373	53.91%	267	30508	216	9436	679	81,349,000	82,591,000	1,242,000	82,678,936	17	1,918	408.65	44,143.96
72	09/14/17	Thu	582	11.50	51	71,829	L5, I3-4, F14-15	6	11.38	8	1,381	51.01%	178	30686	189	9625	710	82,591,000	83,843,000	1,252,000	83,930,936	16	1,934	383.75	44,527.71
73	09/15/17	Fri	512	7.00	73	72,341	I2-3, F15-16	6	6.83	12	1,393	46.18%	267	30952	36	9661	425	83,843,000	84,469,000	626,000	84,556,936	24	1,958	562.21	45,089.92
74	09/18/17	Mon	517	11.75	44	72,858	F16, I4-L4	6	10.22	10	1,403	47.90%	222	31175	213	9874	665	84,469,000	85,524,000	1,055,000	85,611,936	20	1,978	469.82	45,559.74
75	09/19/17	Tue	1,083	11.83	92	73,941	H5-7, I4, L4	6	9.33	16	1,419	52.78%	356	31530	219	10093	700	85,524,000	86,501,000	977,000	86,588,936	19	1,997	463.00	46,022.74
76	09/20/17	Wed	1,028	11.75	87	74,969	H5-7, I4	6	11.72	15	1,434	54.98%	333	31863	249	10342	710	86,501,000	87,496,000	994,000	87,582,936	18	2,015	423.50	46,446.24
77	09/21/17	Thu	802	7.67	105	75,771	G5-7	6	7.62	10	1,444	53.92%	222	32086	165										
78	09/22/17	Fri	1,365	11.67	117	76,024	G5-7, L3-4	6	11.46	16	1,460	53.45%	356	32441	165										
79	09/25/17	Mon	1,285	11.25	114	77,309	G5, L2-4	6	11.46	24	1,484	51.68%	533	32974	228										
80	09/26/17	Tue	1,251	11.67	107	78,560	F5-7, L2, K4	6	12.00	18	1,502	51.03%	400	33374	312										
81	09/27/17	Wed	1,117	11.58	96	79,677	F7, K2-4	6	12.00	21	1,523	48.25%	467	33841	231										
82	09/28/17	Thu	901	12.00	75	80,578	E7,F7,C7,K3-4	6	11.67	14	1,537	51.24%	311	34152	108										
83	09/29/17	Fri	1,128	12.00	94	81,706	E7,F7,K2,K3	6	11.53	14	1,551	48.57%	311	34463	150										
84	10/02/17	Mon	679	9.75	70	82,385	J2-4, E7	6	11.28	14	1,565	49.23%	311	34774	120										
85	10/03/17	Tue	863	11.50	75	83,248	D7,C7,F6,E6	6	11.47	16	1,581	51.11%	356	35130	81										
86	10/04/17	Wed	745	10.67	70	83,993	C6,D6,E6,F6	6	10.30	11	1,592	49.88%	244	35374	72										
87	10/05/17	Thu	763	10.00	76	84,756	E6, J2-4	6	11.70	11	1,603	48.91%	244	35619	144										
88	10/06/17	Fri	976	11.58	84	85,725	J2-3, I4	6	11.28	17	1,620	48.23%	378	35996	150										
89	10/09/17	Mon	675	6.58	102	86,400	I1-3	6	8.03	11	1,631	43.74%	244	36241	42										
90	10/10/17	Tue	679	10.84	63	87,079	F4,G4,H4,C10	6	10.83	10	1,641	42.22%	222	36463	282										
91	10/11/17	Wed	1,074	11.75	91	88,153	B10,C10,E4,F4	6	10.82	17	1,658	44.94%	378	36841	66										
92	10/12/17	Thu	1,179	12.00	98	89,332	C9,C10,B10,E4	6	10.82	17	1,675	43.20%	378	37219	63										
93	10/13/17	Fri	1,190	11.75	101	90,522	A9,B9,C9,H4	6	10.85	13	1,688	40.12%	289	37507	78										
94	10/16/17	Mon	1,036	11.75	88	91,558	B9, F4,G4,H4	6	10.42	15	1,703	42.12%	333	37841	150										
95	10/17/17	Tue	1,121	11.08	101	92,679	C8,B8,F4,E4	6	11.25	19	1,722	40.41%	422	38263	72										
96	10/18/17	Wed	863	9.92	87	93,542	H3,G3,A9,B8	6	11.67	15	1,737	41.07%	333	38596	48										
97	10/19/17	Thu	1,169	11.42	102	94,711	G3,F3,H3	6	11.12	23	1,760	39.75%	511	39107	75										
98	10/20/17	Fri	1,214	10.67	114	95,925	H3,G3,F3,E3	6	11.46	22	1,782	37.32%	489	39596	69										
99	10/23/17	Mon	1,174	10.58	111	97,099	H2,G2,F2	6	10.95	19	1,801	38.97%	422	40018	75										
100	10/24/17	Tue	507	7.83	65	97,606	F2,F5,E5,C7	6	9.26	11	1,812	42.40%	244	40263	93										

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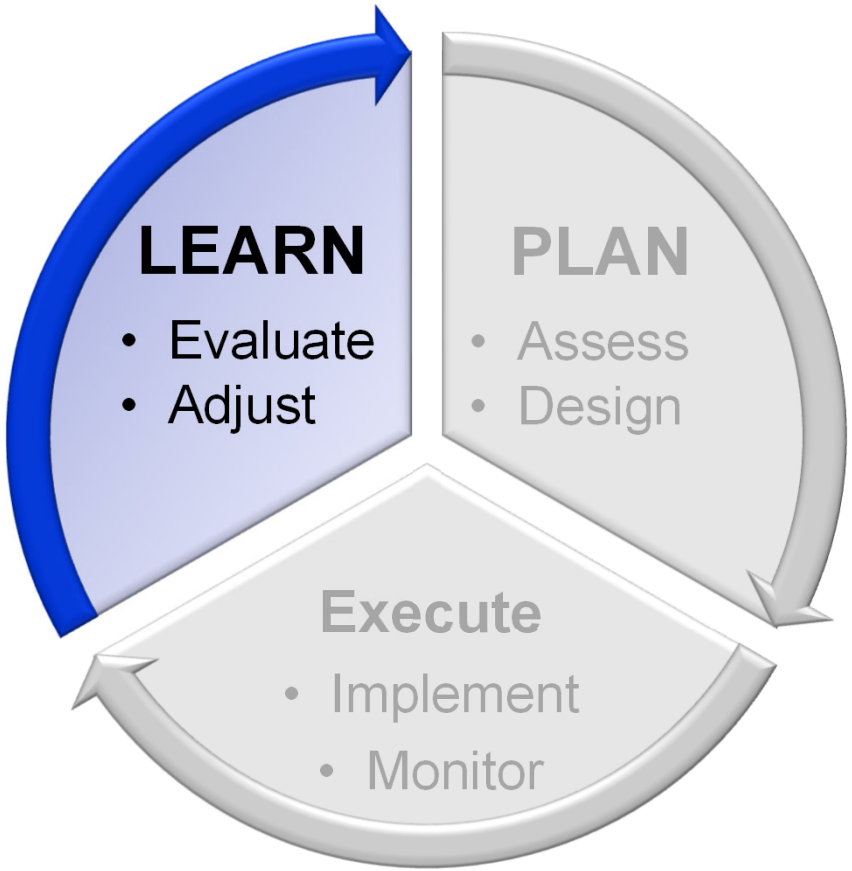
Learning Phase



- **Evaluate**
  - Analyze Data
  - Compare with predictions
  - Draw conclusions
- Adjust
  - Employ lessons learned
  - Modify implementation

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Learning – Evaluate/Adjust

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Benefits of Adaptive Management

- Clarifying Problem
- Empowering Team
- Improving Design
- Communication
- Adjusting
- Learning

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Questions?

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