Morganza Control Structure & the Mississippi River Flood Fight

T. (Jerry) Shih, Ph.D., P.E.
David J. Vossen, P.E.
Amena M. Henville, P.E., PMP

U.S. Army Corps of Engineers
New Orleans District
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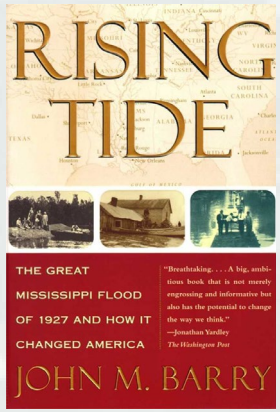
OBJECTIVES

The authors wish to take this opportunity to introduce:

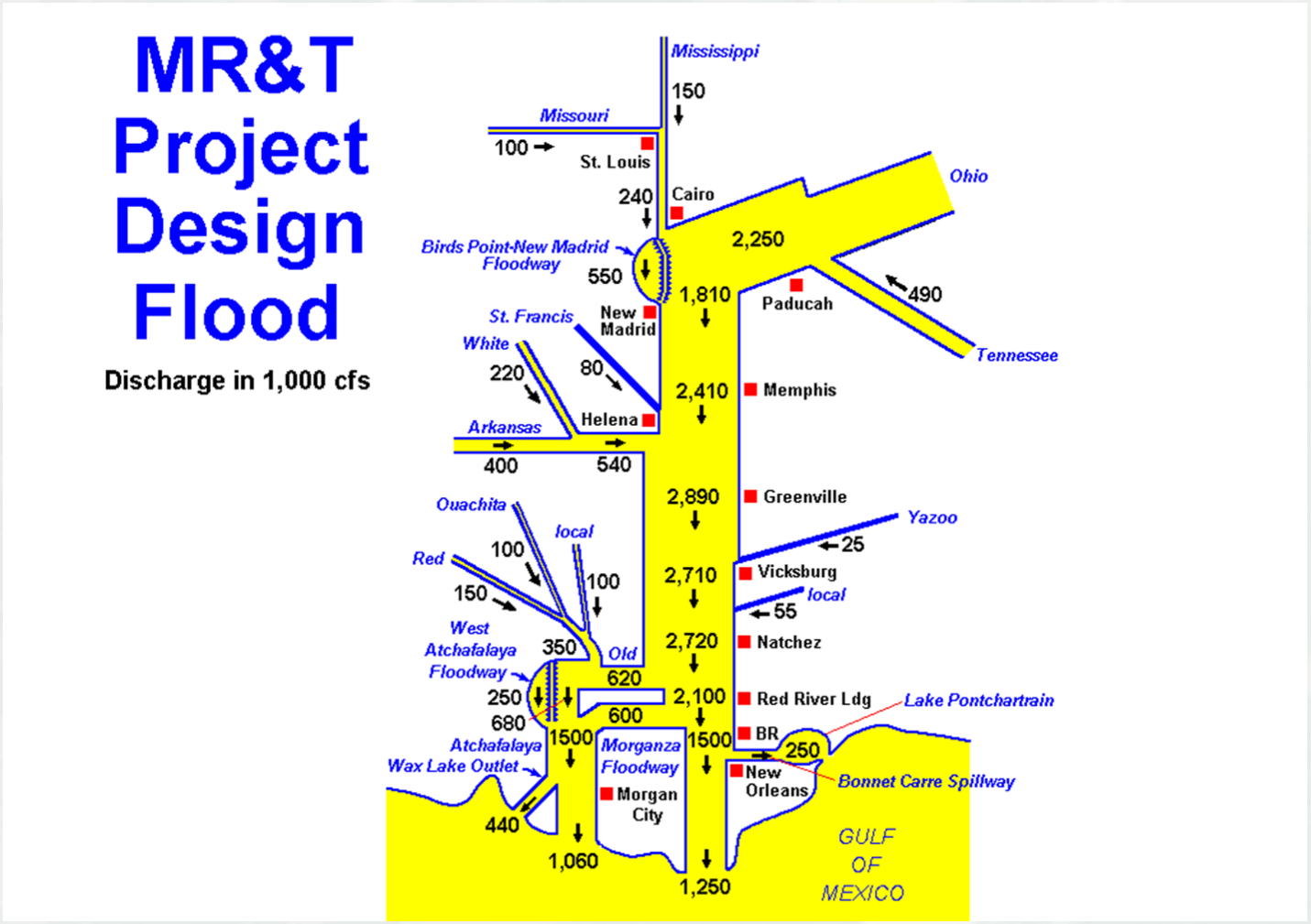
- The authorization for Morganza Control Structure (MCS)
- Previous (1973 & 2011) operations & MCS tailbay scour rehabilitation
- MCS operation criteria & standing instructions
- The U.S. Army Corps of Engineers (USACE) New Orleans District (MVN) Mississippi River and Tributaries (MR&T) flood fight practicing procedure

1. *The Construction Authorization for MCS*

- The 1927 Great Mississippi Flood was most destructive river flood in the history of the United States. The flood affected approximately 1,151,000 square miles basin area.
- The flood-control project for the lower Mississippi River, adopted under Public Act No. 391, 70th Congress, which authorized the construction of Morganza Control Structure (MCS), was approved on 15 May 1928.

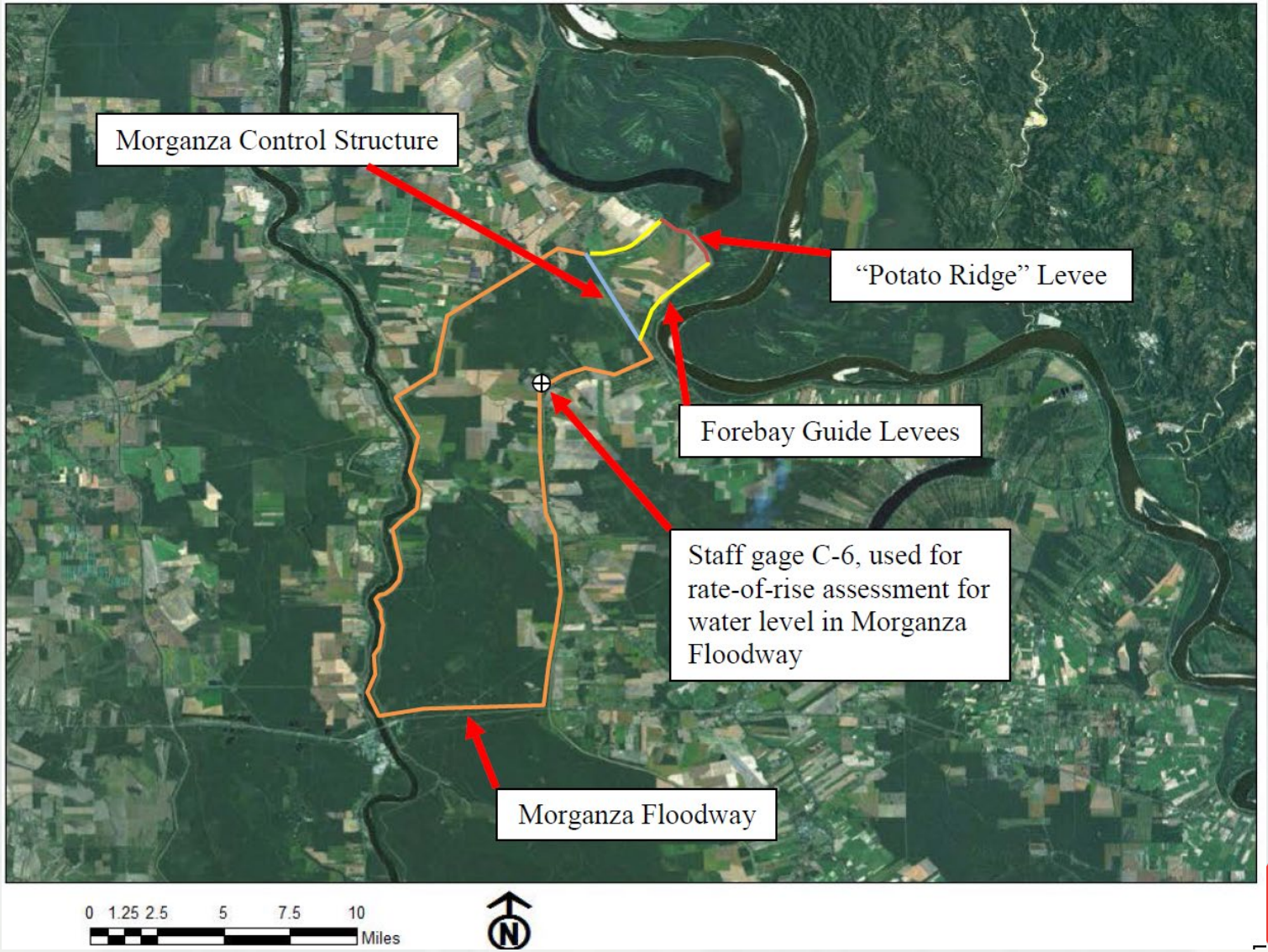


MR&T Project Design Flood

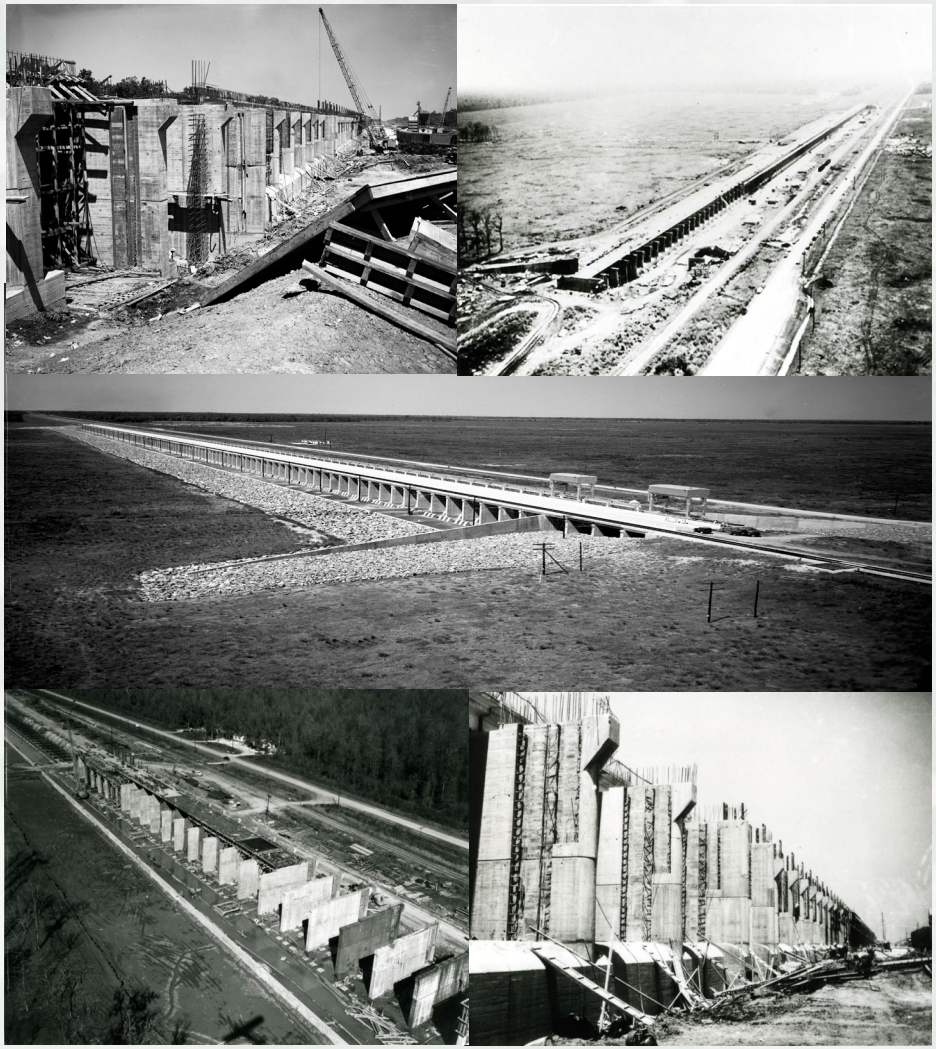


MCS & Its Vicinity

MCS FLOODWAY MAP



MCS Structure



- **Authorized under the Flood Control Act of 1928**
- **MCS was constructed in 1954**
  - **125 Gate Bays**
  - **Gated portion 3,906 feet long**
  - **Each gate bay has a crest weir with a top elevation of 37.5 feet NGVD29. On top of the crest weir is a two-leaf (upper and lower panel) gate.**
- **Floodway is ≈ 71,500 acres**
- **It has only operated twice**
  - **1973 - Peak Flow ≈ 194,000 cfs**
  - **2011 - Peak Flow ≈ 172,000 cfs**

2. Previous Operations & Tailbay Scour Rehabilitation

Both of the 1973 & 2011 operations caused severe scour damage immediately downstream of the structure.

(1) After the 1973 operation, a plunge pool (also known as an energy dissipation pond) was installed behind the middle third gate bays. It is located immediately downstream of the derrick stone apron. The plunge pool bottom was partially lined with concrete and riprap with a bottom elevation of 19.0 feet NGVD29. The horizontal extent of the concrete varied from 90 to 110 feet while the riprap extent varied from 10 to 30 feet. The front and back slopes met with ground elevations at 31.0 feet and 32.0 feet NGVD29, respectively.

(2) The 2011 operation caused more scour damage to the immediate downstream areas of the MCS than the 1973 operation. Nine out of 15 scour indicators, anchored five feet below ground at the tailbay, disappeared during the operation. The largest scour hole was approximately 30 feet deep.

2011 Operation MCS Tailbay Scour Damages

Tailbay Scour Rehab - Physical Model Experiments

Since scour and riprap displacement are caused by dynamic forces and numerical models that could account for the energy loss after a hydraulic jump were not yet well developed, USACE's Engineering & Research Development Center (ERDC) was asked to perform an investigation study via a physical model.

The investigation had four specific purposes:

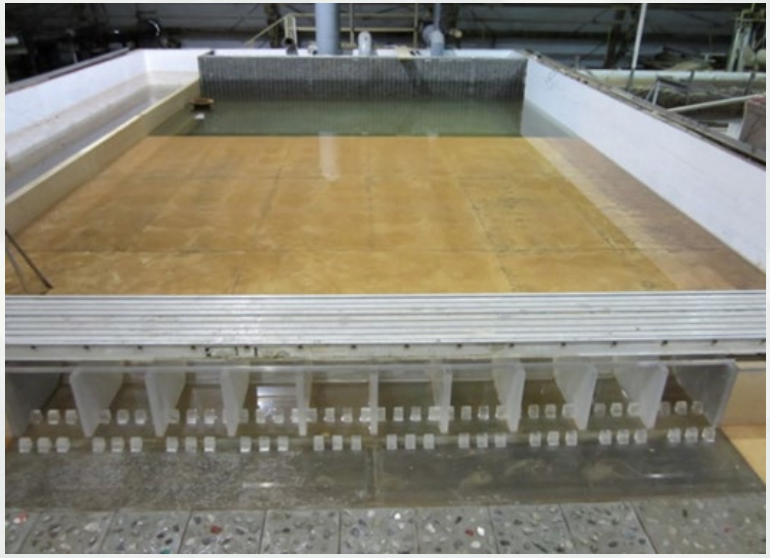
(1) to develop a scour protection plan for the plunge pool gate bays,

(2) to develop a scour protection plan for the non-plunge pool gate bays,

(3) to update the 1951 discharge rating curve to include a higher headwater, actual crest design, and actual pier design information, and

(4) to use the study findings to update the MCS gate operation sequence for reduction/elimination of the scour damage seen in 1973 and 2011.

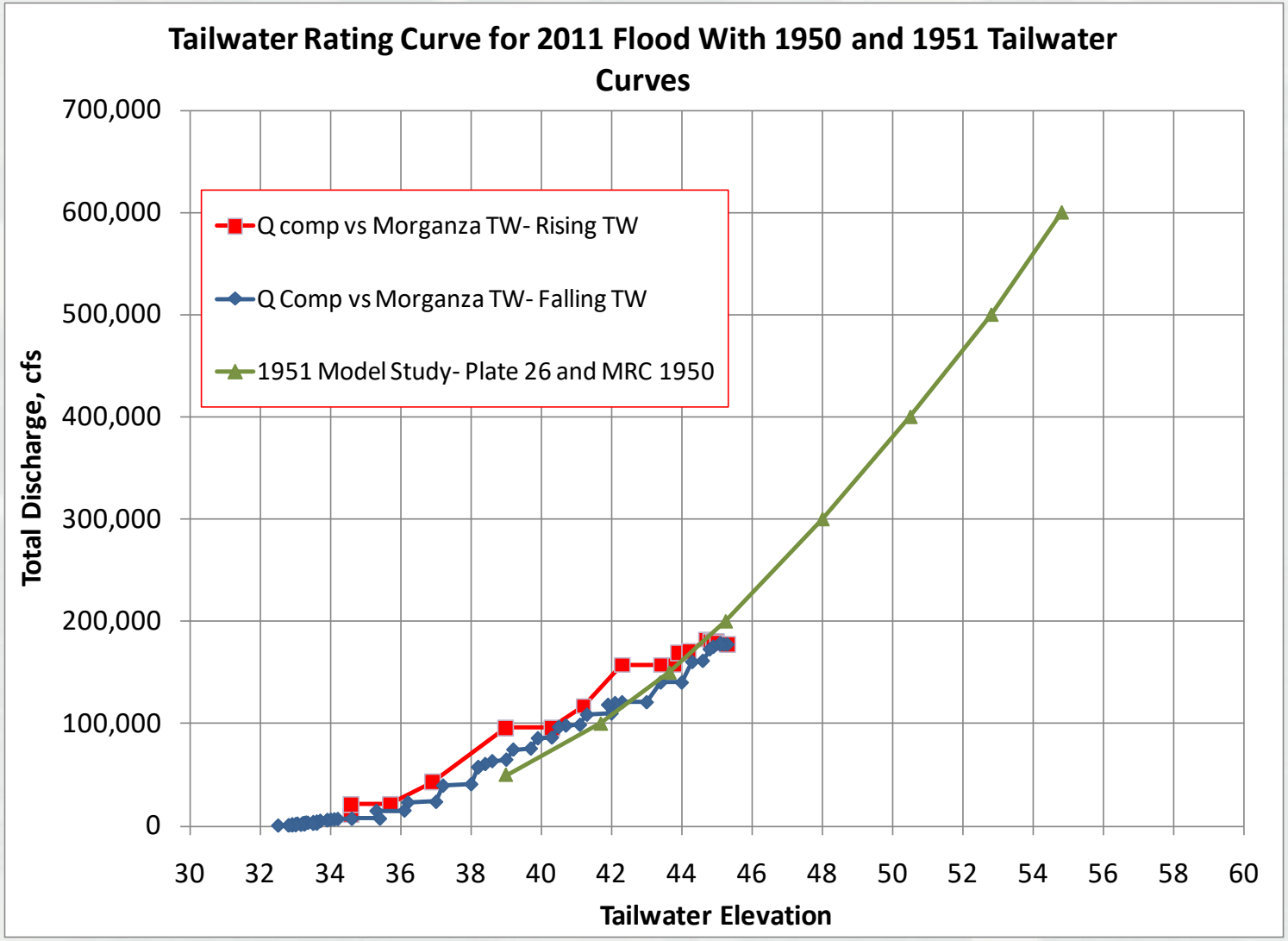
ERDC's Physical Model



- The first 1:22 scale-down physical model simulated 10 gates bays according to the plunge pool configuration.

- After completing the plunge pool modeling, the tailbay portion of the model was reconfigured to include the stilling basin configuration without a plunge pool.

Modified Tailwater Rating Curve



MCS Gate Operation Sequence

MORGANZA STRUCTURE SEQUENCE OF OPERATIONS TABLE I NORTH CRANE					10 Jun 2014
Sequence	Bay	Opening	Sequence	Bay	Opening
1	69	Halfway	44	87	Halfway
2	77	Halfway	45	93	Halfway
3	65	Halfway	46	99	Halfway
4	73	Halfway	47	105	Halfway
5	81	Halfway	48	111	Halfway
6	63	Halfway	49	117	Halfway
7	67	Halfway	50	123	Halfway
8	71	Halfway	51	66	Halfway
9	75	Halfway	52	72	Halfway
10	79	Halfway	53	78	Halfway
11-20	Repeat sequences 1-10, opening gates fully		54	89	Halfway
			55	95	Halfway
21	88	Halfway	56	101	Halfway
22	108	Halfway	57	107	Halfway
23	124	Halfway	58	113	Halfway
24	96	Halfway	59	119	Halfway
25	116	Halfway	60	125	Halfway
26	92	Halfway	61	64	Halfway
27	100	Halfway	62	70	Halfway
28	104	Halfway	63	76	Halfway
29	112	Halfway	64	82	Halfway
30	120	Halfway	65	91	Halfway
31	86	Halfway	66	97	Halfway
32	90	Halfway	67	103	Halfway
33	94	Halfway	68	109	Halfway
34	98	Halfway	69	115	Halfway
35	102	Halfway	70	121	Halfway
36	106	Halfway	71-120	Repeat sequences 21-70, opening gates fully	
37	110	Halfway			
38	114	Halfway	121	85	Halfway
39	118	Halfway	122	84	Halfway
40	122	Halfway	123	83	Halfway
41	68	Halfway	124	85	Full open
42	74	Halfway	125	84	Full open
43	80	Halfway	126	83	Full open

NOTE: The South Crane will open Bay 61 before the North Crane opens Bay 69.

MORGANZA STRUCTURE SEQUENCE OF OPERATIONS TABLE II SOUTH CRANE					10 Jun 2014
Sequence	Bay	Opening	Sequence	Bay	Opening
1	61	Halfway	44	37	Halfway
2	53	Halfway	45	31	Halfway
3	45	Halfway	46	25	Halfway
4	57	Halfway	47	19	Halfway
5	49	Halfway	48	13	Halfway
6	59	Halfway	49	7	Halfway
7	55	Halfway	50	1	Halfway
8	51	Halfway	51	60	Halfway
9	47	Halfway	52	54	Halfway
10	43	Halfway	53	48	Halfway
11-20	Repeat sequences 1-10, opening gates fully		54	35	Halfway
			55	29	Halfway
21	38	Halfway	56	23	Halfway
22	18	Halfway	57	17	Halfway
23	2	Halfway	58	11	Halfway
24	30	Halfway	59	5	Halfway
25	10	Halfway	60	58	Halfway
26	34	Halfway	61	52	Halfway
27	26	Halfway	62	46	Halfway
28	22	Halfway	63	39	Halfway
29	14	Halfway	64	33	Halfway
30	6	Halfway	65	27	Halfway
31	36	Halfway	66	21	Halfway
32	32	Halfway	67	15	Halfway
33	28	Halfway	68	9	Halfway
34	24	Halfway	69	3	Halfway
35	20	Halfway	70-119	Repeat sequences 21-69, opening gates fully	
36	16	Halfway			
37	12	Halfway	120	40	Halfway
38	8	Halfway	121	41	Halfway
39	4	Halfway	122	42	Halfway
40	62	Halfway	123	40	Full open
41	56	Halfway	124	41	Full open
42	50	Halfway	125	42	Full open
43	44	Halfway			

NOTE: The South Crane will open Bay 61 before the North Crane opens Bay 69.

Scour Damage Repair Game Plan

After a full damage assessment (un-watered the plunge pool & surveyed the scour area), the repair work was executed by the New Orleans District (MVN) in three consecutive phases, which each occurred immediately upon completion of its respective physical model experiment.

(1) Phase I – Immediate repairs & haul road construction

(2) Phase II – Plunge pool's tailbay repairs

(3) Phase III – Non-plunge pool's tailbay repairs

Full Damage Assessment

- Un-watered plunge pool to perform assessment
- Investigated concrete slab
- Cored holes throughout concrete slab to determine the extent of undermining status

Un-watered Plunge Pool (13 June 2012)

Undermining Investigation (19 June 2012)

Phase I – Hired Labor Immediate Repairs

Goal: Stabilize the concrete in plunge pool and Prepare for Phase II Stone Placement:

- Dewater scour holes behind plunge pool
- Drive sheetpiles behind and pump grout under the concrete slab
- Move displaced derrick stone back into existing riprap stilling basin and grout the stone in place
- Construct a 3 mile haul road to include widening ramps, approaches, and KCS railroad crossings.
- Grade 100ft of dirt behind concrete slab in plunge pool to EL 10.5 N.G.V.D.

Schedule:

Start Work	19 September 2012
Finish Work	26 April 2013

PHASE I (Drive Sheetpiles, Grout Slab & Stone)

PHASE I (Haul Road Construction)

PHASE I (Plunge Pool Grading)

Phase II – Plunge Pool's Tailbay Repairs

Goal: Protect the structure for the 2013 Flood Season

- ERDC designed and modeled repair solutions to maintain the structural integrity and prevent scour holes during future operations
- Contractor hauled and placed stone in the plunge pool
- MVK graded remaining 205ft in the plunge pool

Schedule:

Start Work	02 April 2013
Finish Work	15 June 2013

Phase II (Plunge Pool's Tailbay Repair & Expansion)

Phase III – Non-plunge Pool Tailbay Repairs

Goal: Structure Fully Repair

- MVK grade area behind the non-plunge pool gates to EL 29 N.G.V.D.
- Contractor to haul and place 2,200lb stone 100ft behind the existing riprap of the non-plunge pool gates

Schedule:

Hired Labor:

Start Work	08 July 2013
Finish Work	02 August 2013

Contract:

Start Work	19 September 2013
Finish Work	30 April 2014

Current MCS & Its Floodway Status

- After 18 months of repair and construction, the MCS is ready and capable of passing the project flood.
- Based on ERDC's recommendation and lessons learned from the 2011 operation, USACE has refined the **MCS Water Control Manual** to ensure that the Corps can safely operate the flood control structure in the future.

3. MCS Operation Criteria & Standing Instruction

MCS Operation Criteria

The operation of the MCS is based on a MR&T flood damage risk reduction feature called the "**Project Flood**." This operation criteria is used to prevent flooding from :

(1) exceeding the approved flow line, i.e. encroachment above freeboard requirements,

(2) limiting flows to the design discharge of 1,500,000 cubic feet per second (cfs) between MCS and Bonnet Carre Spillway, and

(3) limiting flow downstream of the Bonnet Carre Spillway to the design flow of 1,250,000 cfs.

Standing Instruction for MCS Operation

Normal conditions:

- No water control actions are required under normal conditions.

Under emergency conditions:

(1) Pre-opening action

(a) Establish liaison with all interested parties, flood fight sector commanders, and agencies.

(b) Contact State Police Headquarters and arrange for control of traffic by Highway Patrol along LA 1 in the vicinity of the structure and guide levees. Contact the railroad company crossing the structure and arrange for traffic control and a daily list of dangerous cargo crossing the floodway once the structure is in operation.

(c) Inspect and test all operating machinery and install scour indicators in the tailbay.

(d) Approximately two weeks before a possible floodway activation, test operate the Pointe Coupee Drainage Structure (located in the Morganza Upper Guide Levee) by executing a complete normal operation of this structure to verify that it is fully functional.

Standing Instruction of MCS Operation (cont.)

(e) After the "potato ridge levee" in the forebay is overtopped, initiate degrading of this levee using a floating plant if floodway operation appears imminent.

(f) Invoke safety requirements and provide equipment and facilities necessary for protection of MVN personnel and the general public.

(g) Advise EOC and Chief of Operations Division when all of the above has been completed.

(2) Structure opening

(a) Open the structure gates in accordance with the Operations and Maintenance Manual in the order shown in Tables 1 and 2, which was recommended by ERDC in 2014.

(b) The structure shall be operated such that the stage on the river side of the structure does not exceed 57 feet NGVD29 (56.7 feet NAVD88 [2004.65]) and the Mississippi River flow rate below the MCS does not exceed 1.5 million cfs on a projected rise, based upon a 10 day forecast.

Standing Instruction of MCS Operation (cont.)

(3) Activities during operation

(a) Pointe Coupee Drainage Structure - close the Pointe Coupee Drainage Structure coincidentally with the opening of the MCS.

(b) Morgan City Floodwall and East Atchafalaya Basin Protection Levee - There are a total of nine (9) vehicular gates, one railroad gate, and one combined vehicular/railroad gate in the Morgan City Floodwall which must be closed during times of high discharge in the Lower Atchafalaya River.

(c) West Atchafalaya Basin Protection Levee - close the D'Arbonne and Courtableau Structures and the Coulee des Grues Floodgates located northwest of the levee system.

(d) Berwick Floodwall - There are a total of eight (8) vehicular gates, one railroad gate and two (2) combined vehicular/railroad gates in the Berwick Floodwall which must be closed.

(e) Levee West of Berwick - Locals are responsible for operating pumping stations to evacuate local rainfall-runoff coincident with major floods along the lower MR basin.

(f) Melville, Simmesport, and Krotz Springs Ring Levees – Closure of the culverts and secure adequate pumping facilities timely.

Standing Instruction of MCS Operation (cont.)

(4) Structure closure

(a) Close the structure gates in accordance with the Operations and Maintenance Manual in reverse of the order shown in Tables 1 and 2.

(b) Drain the forebay area quickly to allow inspections of the structure and guide levees.

(c) Once forebay stages have fallen to the weir crest, all remaining open bays will be closed and the two 5.5 foot square sluice gates will be used for further drainage.

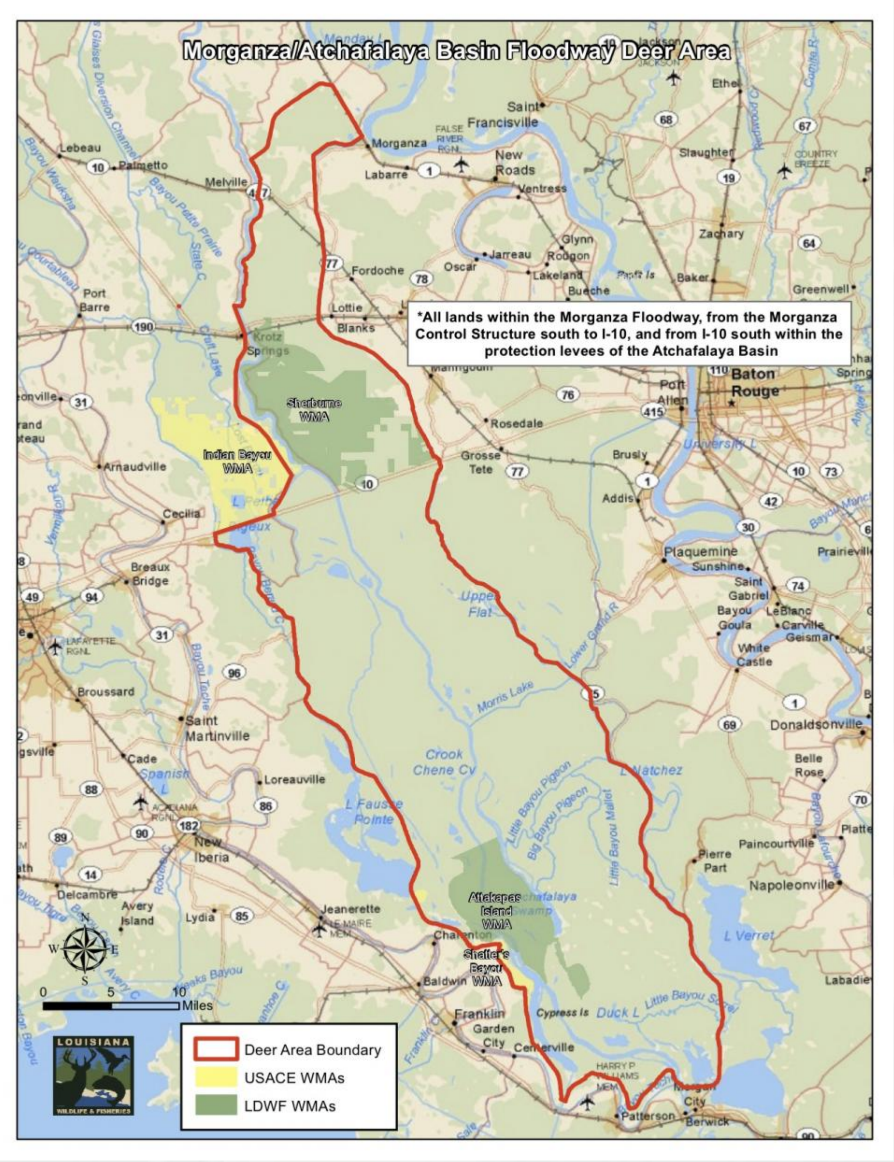
(d) Inform MVN EDH water management section in the event an operational malfunction, erosion, or other incident occurs that could impact project integrity in general or water control capability in particular.

(e) MCS Project Manager refer significant inquiries from citizens, constituents or interest groups regarding water control procedures or actions to CEMVN-EDH.

(f) MVN keeps MVD Watershed Division Office any possible impairments to project integrity or water control capability.

(g) In the event of a total communication outage, the MCS Project Manager will continue to regulate the project using the latest instructions until communications are restored.

Atchafalaya River Basin Map



4. MVN MR&T Flood Fight Practicing Procedure

4. MCS& MR&T Flood Fight Practicing Procedure

The current USACE MVN MR&T flood fight practicing procedure is as follows:

(1) Stage & flow rate forecasting provided by

- National Weather Service (NWS)
- Upper river districts
- MVN experience (rating curve, historical records, etc.)

(2) Diversion structure operations

- ORCC
- Bonnet Carre' Spillway
- MCS

(3) Inspection & monitoring

- Pre-position flood fight crews
- Inspecting structure, taking piezometric pressure measurements, and recording inflow & outflow channel stages
- Inspecting levee stability & integrity daily
- Performing MR Tarbert Landing flow rate survey once/day

(4) Daily teleconferences & briefings

Major Floods on the Mississippi River

RANK	DATE	RED RIVER LANDING STAGE (FT., NGVD)	TARBERT LANDING DISCHARGE (CFS) *	TOTAL LATITUDE DISCHARGE (CFS)	BONNET CARRE' OPERATED	MORGANZA OPERATED
1	1927	60.90	1,779,000	2,342,000	NO **	NO ***
2	2011	63.39	1,641,000	2,304,000	YES	YES
3	1973	58.10	1,498,000	2,261,000	YES	YES
4	1983	60.40	1,470,000	2,150,000	YES	NO
5	1945	58.90	1,520,000	2,123,000	YES	NO ***
6	1997	61.60	1,480,000	2,112,000	YES	NO
7	2008	60.70	1,456,000	2,080,000	YES	NO
8	2018	61.20	1,444,000	2,068,000	YES	NO
9	1950	56.30	1,456,000	2,055,000	YES	NO ***
10	2016	60.60	1,415,000	2,030,000	YES	NO
11	1979	59.10	1,419,000	2,014,000	YES	NO
12	1975	56.00	1,216,000	2,009,000	YES	NO
13	1912	56.80	1,499,000	1,912,000	NO **	NO ***
14	1937	59.10	1,467,000	1,896,000	YES	NO ***

* PRIOR TO 1963 RED RIVER LANDING DISCHARGE WAS USED

** BONNET CARRE WAS NOT BUILT UNTIL 1932

*** MORGANZA WAS NOT BUILT UNTIL 1954

10-Day Mississippi River Stage & Flow Rate Forecasting

RIVER STAGE PREDICTIONS												
DATE	WEEKDAY	CAIRO	ARK CITY	VICKS	NATCHEZ	KNOX LDG	RR LDG	B.R.	D'VILLE	RESERVE	N.O.	
3/10	Sun	53.4	44.6	51.5	57.7	64.0	61.4	43.8	31.7	23.8	16.7	
3/11	Mon	52.7				64.1	61.5	44.0	31.9	23.8	16.7	
3/12	Tue	52.6				64.1	61.5	44.1	32.0	23.9	16.8	
3/13	Wed	52.5				64.1	61.5	44.1	32.0	23.9	16.8	
3/14	Thu	52.9				64.1	61.5	44.1	32.0	23.9	16.8	
3/15	Fri	53.3				63.9	61.3	44.1	32.0	23.9	16.8	
3/16	Sat					63.5	60.9	43.9	31.8	23.9	16.8	
3/17	Sun					63.1	60.5	43.5	31.4	23.9	16.8	
3/18	Mon					62.8	60.2	43.2	31.1	23.8	16.7	
3/19	Tue					62.7	60.1	42.9	30.9	23.7	16.6	
3/20	Wed					62.6	60.0	42.8	30.8	23.6	16.5	
					DATE	3/12	3/12	3/13	3/13	3/13	3/13	
					CREST	64.1	61.5	44.1	32.0	23.8	16.8	

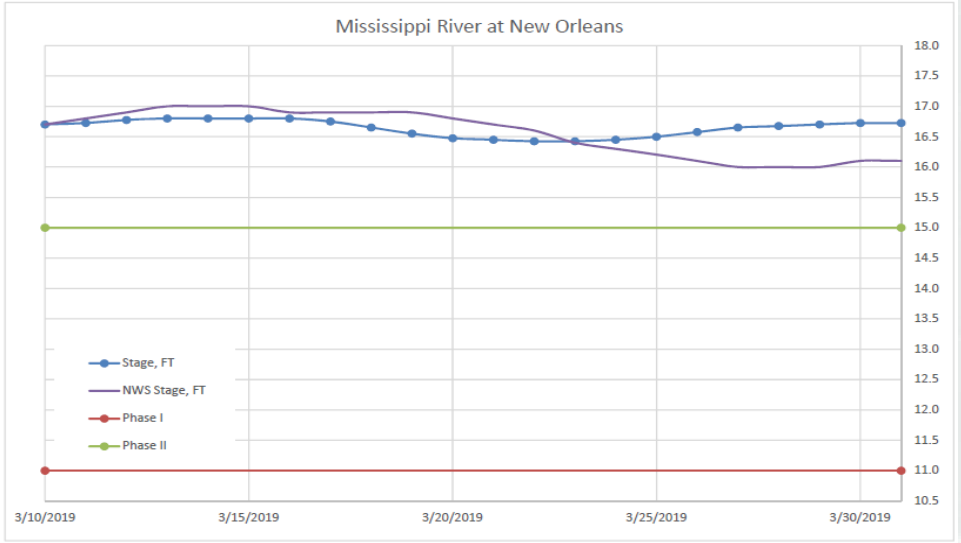
*** Note: These are near crest numbers***

Note: Old River Lock is approximately +0.5 FT higher than Red River Landing.

Routing equation y = 1.1611*x - 12.889where x is RRL and y is Morganza

	Old River Lock	Morganza
3/10	61.8	58.4
3/11	61.9	58.5
3/12	61.9	58.5
3/13	61.9	58.5
3/14	61.9	58.5
3/15	61.7	58.3
3/16	61.3	57.8
3/17	60.9	57.4
3/18	60.6	57.0
3/19	60.5	56.9
3/20	60.4	56.8
3/21	60.4	56.8
3/22	60.5	56.9
3/23	60.7	57.1
3/24	61.0	57.5
3/25	61.3	57.8
3/26	61.4	57.9
3/27	61.5	58.1
3/28	61.6	58.2
3/29	61.6	58.2
3/30	61.6	58.2
3/31	61.4	57.9

Date	Stage	Bonnet Carre" Open	Bonnet Carre" Closed
3/10	16.7	1250	1430
3/11	16.7	1250	1445
3/12	16.8	1250	1453
3/13	16.8	1250	1453
3/14	16.8	1250	1453
3/15	16.8	1250	1453
3/16	16.8	1250	1439
3/17	16.8	1250	1408
3/18	16.7	1250	1378
3/19	16.6	1250	1357
3/20	16.5	1250	1350
3/21	16.5	1250	1342
3/22	16.4	1250	1342
3/23	16.4	1250	1350
3/24	16.5	1250	1365
3/25	16.5	1250	1385
3/26	16.6	1250	1408
3/27	16.7	1250	1415
3/28	16.7	1250	1422
3/29	16.7	1250	1429
3/30	16.7	1250	1429
3/31	16.7	1250	1429



10-Day Atchafalaya River Stage & Flow Rate Forecasting

DATE	Simmesport	Melville	Krotz Springs	Butte LaRose	Morgan City
3/10	41.3	32.4	28.7	20.1	7.8
3/11	41.7	32.7	29.0	20.2	7.9
3/12	41.7	32.7	29.0	20.2	8.0
3/13	41.7	32.7	29.0	20.2	8.0
3/14	41.7	32.7	29.0	20.2	8.1
3/15	41.4	32.5	28.8	20.1	8.1
3/16	40.8	32.0	28.3	20.0	8.1
3/17	40.2	31.5	27.9	19.8	8.1
3/18	39.8	31.1	27.6	19.7	8.1
3/19	39.6	31.0	27.4	19.6	8.1
3/20	39.5	30.9	27.4	19.6	8.0
DATE	3/12	3/12	3/12	3/12	1/14
CREST	41.7	32.7	29.0	20.2	8.1

*** Note: These are near crest numbers***

ALL Stages in NGVD

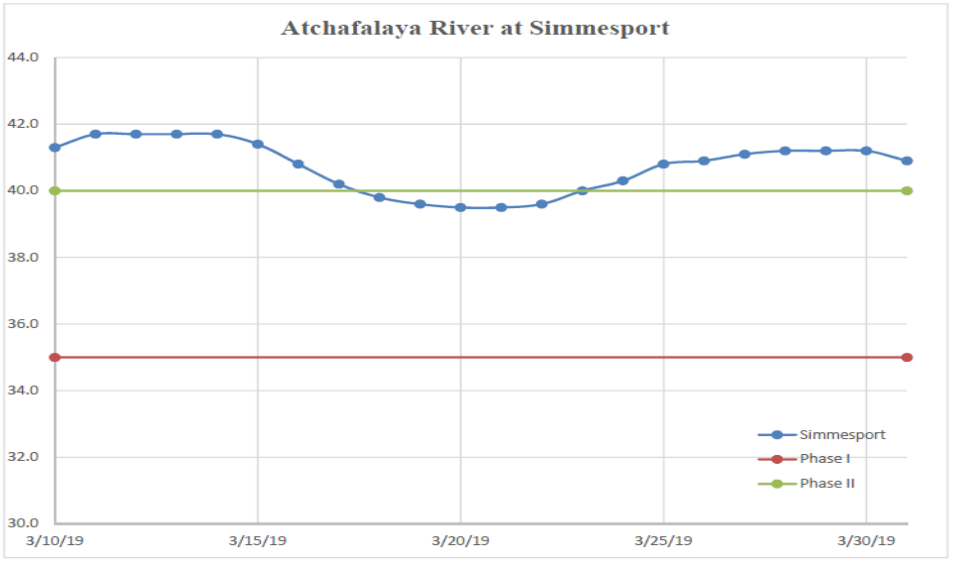
Note: Routing equation y = 0.5265*(X) + 1.3104 is where X is Butte LaRose and Y is Bayou Sorrel (FS.)

Routing equation y = 0.232*(X) + 1.8404 is where X is Bayou Sorrel (FS) and Y is Bayou Sorrel (LS.)

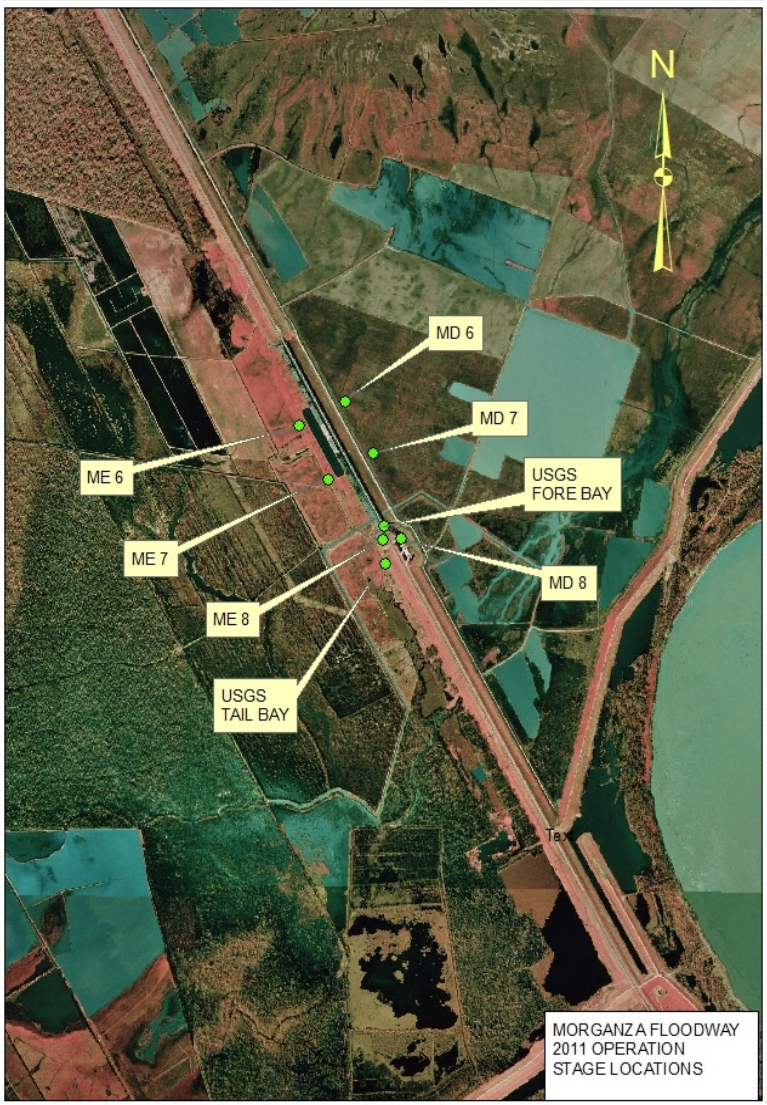
Bayou Boeuf (flood side) is 0.1 FT lower than Morgan City

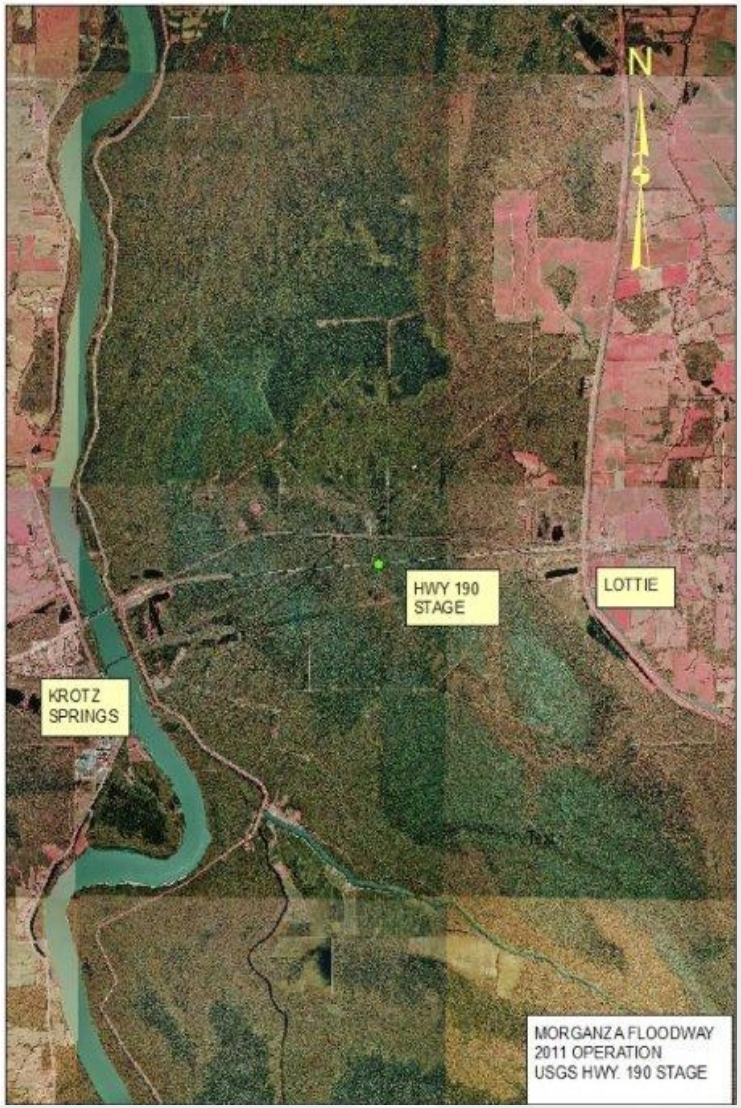
	B. Sorrel FS 49630	B. Sorrel LS 52560	Morgan City 3780	B. Boeuf FS 76400
3/10	11.9	4.6	7.8	7.7
3/11	12.0	4.6	7.9	7.8
3/12	12.0	4.6	8.0	7.9
3/13	12.0	4.6	8.0	7.9
3/14	12.0	4.6	8.1	8.0
3/15	11.9	4.6	8.1	8.0
3/16	11.8	4.6	8.1	8.0
3/17	11.7	4.6	8.1	8.0
3/18	11.7	4.5	8.1	8.0
3/19	11.6	4.5	8.1	8.0
3/20	11.6	4.5	8.0	7.9
3/21	11.6	4.5	7.8	7.7
3/22	11.6	4.5	7.8	7.7
3/23	11.7	4.6	7.7	7.6
3/24	11.7	4.6	7.7	7.6
3/25	11.8	4.6	7.7	7.6
3/26	11.8	4.6	7.7	7.6
3/27	11.9	4.6	7.8	7.7
3/28	11.9	4.6	7.9	7.8
3/29	11.9	4.6	8.0	7.9
3/30	11.9	4.6	8.0	7.9
3/31	11.8	4.6	8.0	7.9

Date	Stage	Flow Kcfs
3/10	41.3	613
3/11	41.7	623
3/12	41.7	623
3/13	41.7	623
3/14	41.7	623
3/15	41.4	617
3/16	40.8	603
3/17	40.2	591
3/18	39.8	582
3/19	39.6	579
3/20	39.5	575
3/21	39.5	575
3/22	39.6	579
3/23	40.0	585
3/24	40.3	594
3/25	40.8	603
3/26	40.9	606
3/27	41.1	609
3/28	41.2	612
3/29	41.2	612
3/30	41.2	612
3/31	40.9	606



MCS STAGE LOCATION MAP





SUMMARY

- Team work is critical to the success of the MR&T flood fight.
- Pre-positioning the flood fight crew to monitor the structure stability and the stage of inflow & outflow channels for the entire high flow event is as important as well.
- Following the Water Control Manual & Standing Instruction to operate the MCS is critical in preventing the tailbay from scouring damage.
- The MCS operation at the falling hydrograph is as important as the rising hydrograph, which the operator shall pay the same attention when closing the gatebays in reverse sequence.
- Collecting the hydrologic data at the floodway for the entire flood fight is extremely important to refining two existing AdH & HEC-RAS floodway hydrodynamic numerical models. These two models are used to simulate inundation impacted areas if MCS will be used in operation.
- Sending a crew to perform a post-flood inspection to document vulnerable parts and locations at the hydraulic structure and protection levee is essential to prepare a repair/reinforce plan so that they can be ready for the next flood fight.

QUESTIONS & ANSWERS