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To:	Bouquot, Christopher D (Chris) CIV USARMY CEMVM (USA)
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Subject:	FW: IHNC Lock - Reliability Analysis (UNCLASSIFIED)
Date:	Tuesday, June 18, 2019 2:58:00 PM
Attachments:	IHNC - Cost and Closure Matrices - First Draft - 10 August 2015.docx MVN - IHNC - Cost and Closure Matrix - First Draft - 10 August 2015.xlsm

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IHNC Lock Study

OMRRR that we used for the Cost Per Year analysis.

-----Original Message-----
From: Watts, Matthew A LRL
Sent: Monday, August 10, 2015 1:46 PM
To: Morgan, Robert W MVN <Robert.W.Morgan@usace.army.mil>; Haab, Mark E MVN <Mark.E.Haab@usace.army.mil>; Landry, Victor A MVN <Victor.A.Landry@usace.army.mil>
Cc: Smith, Jasmine M MVN <Jasmine.M.Smith@usace.army.mil>; Williams, Louise C MVN <Louise.C.Williams@usace.army.mil>; Brooks, Robert L MVN <Robert.L.Brooks@usace.army.mil>; Andrus, Brenda H MVN <Brenda.H.Andrus@usace.army.mil>
Subject: IHNC Lock - Reliability Analysis (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Team,

Please find the attached Draft Cost and Closure matrices as well as the subsequent write-up for your review. Also please forward to any members who I have accidently left off this email, the more eyes the merrier.

Please don't hesitate with any questions, comments or concerns. I will talk more with Mark to set up a date for a conference call that we can all collaborate and possibly do a live-edit if everyone is ok with that approach. Or you can send me individual comments. Whichever works best.

Respectfully,

-Matt

Matthew Watts
Structural Engineer
Louisville District
502.315.6242

Classification: UNCLASSIFIED
Caveats: NONE

Cost and Closure Matrices for the Inner Harbor Navigational Canal Lock Replacement Project New Orleans District

DRAFT

10 August 2015

Overview of Work

The cost and closure schedules are a series of spreadsheet matrices that detail the anticipated maintenance and repair demands for all IHNC Lock Replacement Project alternatives during the fifty-year study period of 2015-2064. The matrices were developed based upon key indicators including historical performance at the project, the New Orleans District's current maintenance program, as well as multiple large-scale investment strategies from other Corps of Engineers inventory of projects.

Cost and Closure Matrix Guidelines

The IHNC Lock Replacement General Reevaluation Report (GRR) was used to support the framework of the matrices. The GRR outlined the screening process and provided five (5) project alternatives.

There are two scenarios considered when projecting future cost and closure schedules for each alternative. The first scenario is a 'Fix as Fails' option where the historical maintenance pattern is projected into the future and then increased maintenance is required as the structure continues to age. This pattern is based upon the historical data supporting increased maintenance needs. The second scenario will be the 'Advanced Maintenance' schedule following either a major rehabilitation or large-scale improvement (i.e., new lock chamber). Once a major rehab or large-scale capacity improvement is made it is assumed that the chamber returns to a much improved maintenance scenario since all the unreliable features have been replaced as necessary.

Fix as Fails Schedule One of the primary purposes and outputs of this analysis is the long-term investments in infrastructure required of the system in order to keep it a safe and reliable transportation link. The more age and operating cycles that the infrastructure sees, the more cumulative damage occurs to the structure. Based on a historical database search of the last 20 years of maintenance costs and closures within the Corps of Engineers inventory of lock structures, it is evident that older facilities require more frequent maintenance closures than the newer facilities.

Advanced Maintenance Scenario An improved maintenance scenario for this analysis means that either a major rehabilitation or large-scale capacity improvement (i.e., new lock chamber) has taken place and the deteriorated lock that was rehabbed or replaced no longer needs additional closures beyond what history has shown to be "typical" frequencies and durations for reliable locks. The advanced maintenance scenario contains much less maintenance closures than those associated with an aged and deteriorated project. This is because it is assumed all unreliable features would be replaced or substantially improved such that the lock can be returned to a maintenance schedule that is more reflective of a "reliable" lock. The other categories of

maintenance closures are included in the advanced maintenance scenario following a major rehabilitation or new lock chamber. All maintenance up to the date of the completed work uses the 'Fix as Fails' maintenance scenario within the reliability analysis.

Cost and Closure Matrix Schedules

The individual work items and related repairs schedules included in the matrices were determined by a multitude of factors:

- Patterns in historical Operations and Maintenance records at the IHNC
- Conversations with IHNC project personnel, such as Lockmaster, Project Manager, Project Engineers, etc regarding current maintenance schedules, recent work items and costs
- Historical Operations and Maintenance performance data of similar New Orleans District projects (Bayou Sorrel and Calcasieu C&C Matrices were completed in 2011)
- Historical Operations and Maintenance performance data of similar lock projects within the USACE inventory

For the purpose of this analysis, chamber closures were broken down into three primary categories based on cost of work and impact to navigation: No impact, Minor Repair and Major Repair.

No Impact to Navigation These columns are dedicated to all work items that are considered routine maintenance and result in the project not needing to shut down operation more than two (2) hours in order to accomplish the tasks. Examples of work include basic routine maintenance, instrumentation calibration or computer system upgrades where implementation of work can occur either during or in-between normal lock operations.

Minor Repair Minor repair items are closures that are essentially independent of routine maintenance work. These involve down time due to instances that are considered unavoidable. Lock chambers are sometimes closed for unforeseen occurrences regardless of historical level of maintenance.

These columns are dedicated to work items that require the project to shut down operation for entire 12-hour shifts up to 175 cumulative hours and carry a cost of less than $1,000,000. Examples of work include guidewall rehabilitation where a floating plant crew must occupy the chamber to perform the work or a critical piece of machinery (i.e., gate sector gear or valve hydraulic cylinder) must be removed for repair or rehabilitation, thusly rendering the chamber inoperable.

Major Repair Many features of a lock chamber deteriorate with time and usage. As can be expected, the older and high-use projects are closed more often for maintenance. These features require more frequent maintenance to keep them operational. Most of these features (gates, operating machinery, etc) require the lock chamber to be closed in order to perform maintenance.

These columns are dedicated to typically large-scale work items that result in the project to shut down operation for entire 12-hour shifts greater than 175 cumulative hours and carry a cost greater than $1,000,000. Examples of work include routine dewaterings, emergency repairs such as barge impacts to guidewalls and dolphins or hurricane damage. Chamber closure is a result of

emergency failure resulting in direct inoperability and/or extensive repair work with crews occupying the chamber.

Cost and Closure Projection Results

In all scenarios considered for the IHNC Lock Replacement Project, the 'No Impact to Navigation' component is broken out separately and holds an equal value in each case. Given the nature of the items (Routine Maintenance, Security Contracts, Periodic Inspections, etc), this kind of work is considered constant and unlikely to vary in cost or frequency throughout the duration of the study period.

The first matrix compiled was the 'Without Project' condition. This scenario assumes no replacement lock chamber will be constructed and the IHNC lock will be the sole chamber for the entire duration of the 50-year study period. The 'Without Project' condition also assumes typical maintenance (Fix-as-Fails) will continue and no heightened levels of preventative maintenance will be implemented above what is already in place.

With the original lock chamber construction completed in 1923, the project will be 142 years old by the end of the study period. Much degradation has already occurred in all facets from concrete to machinery and with the assumed lack of preventative maintenance in the future, the degradation of the chamber and all of its components will continue and grow more severe throughout the study period. The frequency of repairs is greatest within this scenario and is adequately captured within the matrix.

Alternatives 1 through 4 quantify each replacement lock chamber configuration option based on the screening process from the IHNC Lock GRR. For each alternative, construction of the replacement chamber is scheduled to begin in 2020 and will undergo a 12-year construction schedule. From the initiation of the study period (2015) to the completion of construction (2031), the existing chamber will continue to operate under a Fix-as-Fails maintenance schedule. After completion of the replacement chamber (2032) to the end of the study period (2064) the new chamber will operate under an Advanced Maintenance schedule.

The primary difference between the Fix-as-Fails and Advanced Maintenance schedules is the proactive approach to quality control on critical components. For example, sector gate and culvert valve machinery universally hold a 30-year life expectancy, but instead of waiting for the component to fail (FAF), it may be rehabilitated or repaired during a routine dewatering a few years ahead of its expected lifespan (AM). The result is a small increase in cost and closure for that particular year for the added work, but the gains are seen in the less frequent failures and need for closures throughout the study period.

The screened lock replacement alternatives are as follows:

- Alternative #1 – 110' x 900' concrete U-frame chamber
- Alternative #2 – 110' x 1200' concrete U-frame chamber
- Alternative #3 – 75' x 900' concrete U-frame chamber
- Alternative #4 – 75' x 1200' concrete U-frame chamber

The existing IHNC lock chamber has 5 sets of miter gates. With the closure of the Mississippi River – Gulf Outlet, the need for a deep draft-chamber is no longer required, so every alternative is for a shallow-draft chamber. Subsequently, with a shallow-draft chamber, the need for miter gates is no longer required, so every alternative will consist of 2 sets of sector gates. This uniformity in design makes the matrices for all alternatives very similar, with slight variation in costs coming from the geometrical differences (i.e., rehabilitation on a 1200' guidewall will cost more than a 900' guidewall and similar with a 110' sector gate versus a 75' gate). All closure breakdowns are included as a separate 'Closure Breakdown' tab as well as individual breakdowns included in each Alternative tab.

***Construction cost figures were pulled using estimates from the 2008 Economic Update, but requires additional scrutiny since one set of figures cannot accurately represent four (4) different alternatives with varying geometries. Therefore, the figures in the 'Construction' column for each alternative currently serve as placeholders until more accurate numbers can be inserted.

***A brief write-up of the Economic Investment Model and how the data from the Cost and Closure matrices feed the reliability analysis goes here. This brief portion can be done by the MVN economist or anyone knowledgeable on the model, but that detailed knowledge of the model was not known at the time of this draft. An example is as follows: The Economic Investment Model handles both Minor and Major repairs from a Fix-as-Fails scenario by taking projected closures and costs and assigning a probability of occurrence that is kept the same in each year of the study period. The model handles Advanced Maintenance repairs by testing the rehabilitation dates and 'slides' maintenance closures around to determine the optimum mix of maintenance with reliability..

IHNC Lock Study, Prepared by Louisville District, 10 August 2015
Record of Maintenance

Component	Reason for Outage	Date of Outage
Miter gate	general repairs	1952
NW guidewall and dolphin	replacement	1952
SW fender system	replacement	1960
Mooring System	installation	1964
Dolphin	repair	1976
NW dolphin	replacement	1976
Gates 7 & 8	repair/paint	1980
Dolphin	repair/replace	1981
Gates 9 & 10	repair/paint	1986
SW guidewall	construction	1989
Gates 5 & 6	repair/paint	1992
Valve machinery	replacement	1993
Dolphin	repalcement	1995
NW guidewall and dolphin	replacement	1996
Sluice Gate Frame	replacement	1996
Crane	replacement	2000
SE Guidewall and dolphin	replacement	2001
Electric	general repairs	2006
SW guidewall	replacement	2006
Miter gate	replacement	2012

Without Project Condition: Concrete U-Frame Lock Chamber 75' x 640'							
	Work Item	Frequency	Cost	Closure Time (Hours)	Closure Time (Days)	Closure Breakouts	Impact to Navigation
Fix As Fails	Dewatering & Monitoring / Major Repairs / Gates	10 years	$5,000,000	1440	60	24-hour shifts	Yes
	Rehabilitation of Chamber Guidewall (W & E)	20 years	$4,000,000	720	60	12-hour shifts	Yes
	Rehabilitation of Guidewall (NW & SW)	20 years	$4,000,000	630	53	12-hour shifts	Yes
	Rehabilitation of Guidewall (NE & SE)	20 years	$2,000,000	400	34	12-hour shifts	Yes
	Rehabilitation of Dolphin (NE, NW, SE, SW)	15 years	$1,500,000	250	21	12-hour shifts	Yes
	Hurrican Damage	5 years	$1,500,000	175	8	24-hour shifts	Yes
	Hurrican Damage ***	25 years	$5,000,000	175	8	24-hour shifts	Yes
	Rewiring and Machinery Rehabilitation	20 years	$750,000	175	15	12-hour shifts	Yes
	Maintenance by Hired Labor Units	Annually	$500,000	150	13	12-hour shifts	Yes
	Rehabilitation of Chamber Guidewall Armoring (W & E)	12 years	$500,000	100	9	12-hour shifts	Yes
	Rehabilitation of Guidewall Face Timber (NW & SW)	12 years	$300,000	75	7	12-hour shifts	Yes
	Rehabilitation of Guidewall Face Timber (NE & SE)	12 years	$100,000	50	5	12-hour shifts	Yes
	PLC System Upgrade	5 years	$500,000	10	1	random < 2 hours	No
	Routine Maintenance	Annually	$250,000	75	7	random < 2 hours	No
	Periodic Inspection (PI) Program	5 years	$60,000	0	0	None	No
	A/E Instrumentation (Pre-PI)	5 years	$40,000	0	0	None	No
	Security Maintenance Contract w/ ACE-IT	Annually	$30,000	0	0	None	No
	ED Instrumentation Cost	Annually	$20,000	0	0	None	No

Alternative #1: Concrete U-Frame Chamber 110' x 900' - Routine Maintenance							
	Work Item	Frequency	Cost	Closure Time (Hours)	Closure Time (Days)	Closure Breakouts	Impact to Navigation
Alt #1	Dewatering & Monitoring / Major Repairs / Gates	10 years	$4,000,000	1440	60	24-hour shifts	Yes
	Rehabilitation of Chamber Guidewall (W & E)	50 years	$4,000,000	825	69	12-hour shifts	Yes
	Rehabilitation of Guidewall & Dolphin (NW & SW)	35 years	$5,000,000	825	69	12-hour shifts	Yes
	Rehabilitation of Guidewall & Dolphin (NE & SE)	35 years	$3,000,000	720	60	12-hour shifts	Yes
	Hurrican Damage	5 years	$1,500,000	175	8	24-hour shifts	Yes
	Hurrican Damage ***	25 years	$5,000,000	175	8	24-hour shifts	Yes
	Rewiring and Machinery Rehabilitation	30 years	$750,000	175	15	12-hour shifts	Yes
	Maintenance by Hired Labor Units	3 years	$675,000	150	13	12-hour shifts	Yes
	Rehabilitation of Chamber Guidewall Armoring (W & E)	25 years	$650,000	100	9	12-hour shifts	Yes
	Rehabilitation of Guidewall Face Timber (NW & SW)	15 years	$500,000	75	7	12-hour shifts	Yes
	Rehabilitation of Guidewall Face Timber (NE & SE)	15 years	$250,000	50	5	12-hour shifts	Yes
	PLC System Upgrade	5 years	$500,000	10	1	random < 2 hours	No
	Routine Maintenance	Annually	$250,000	75	7	random < 2 hours	No
	Periodic Inspection (PI) Program	5 years	$60,000	0	0	None	No
	A/E Instrumentation (Pre-PI)	5 years	$40,000	0	0	None	No
	Security Maintenance Contract w/ ACE-IT	Annually	$30,000	0	0	None	No

	ED Instrumentation Cost	Annually	$20,000	0	0	None	No

Alternative #2 : Concrete U-Frame Chamber 110' x 1200' - Routine Maintenance							
	Work Item	**Frequency**	**Cost**	**Closure Time (Hours)**	**Closure Time (Days)**	**Closure Breakouts**	**Impact to Navigation**
Alt #2	Dewatering & Monitoring / Major Repairs / Gates	10 years	$4,000,000	1440	60	24-hour shifts	Yes
	Rehabilitation of Chamber Guidewall (W & E)	50 years	$5,000,000	825	69	12-hour shifts	Yes
	Rehabilitation of Guidewall & Dolphin (NW & SW)	35 years	$6,000,000	825	69	12-hour shifts	Yes
	Rehabilitation of Guidewall & Dolphin (NE & SE)	35 years	$4,000,000	720	60	12-hour shifts	Yes
	Hurrican Damage	5 years	$1,500,000	175	8	24-hour shifts	Yes
	Hurrican Damage ***	25 years	$5,000,000	175	8	24-hour shifts	Yes
	Rewiring and Machinery Rehabilitation	30 years	$750,000	175	15	12-hour shifts	Yes
	Maintenance by Hired Labor Units	3 years	$675,000	150	13	12-hour shifts	Yes
	Rehabilitation of Chamber Guidewall Armoring (W & E)	25 years	$800,000	100	9	12-hour shifts	Yes
	Rehabilitation of Guidewall Face Timber (NW & SW)	15 years	$450,000	75	7	12-hour shifts	Yes
	Rehabilitation of Guidewall Face Timber (NE & SE)	15 years	$300,000	50	5	12-hour shifts	Yes
	PLC System Upgrade	5 years	$500,000	10	1	random < 2 hours	No
	Routine Maintenance	Annually	$250,000	75	7	random < 2 hours	No
	Periodic Inspection (PI) Program	5 years	$60,000	0	0	None	No
	A/E Instrumentation (Pre-PI)	5 years	$40,000	0	0	None	No
	Security Maintenance Contract w/ ACE-IT	Annually	$30,000	0	0	None	No
	ED Instrumentation Cost	Annually	$20,000	0	0	None	No

Alternative #3 : Concrete U-Frame Chamber 75' x 900' - Routine Maintenance							
	Work Item	**Frequency**	**Cost**	**Closure Time (Hours)**	**Closure Time (Days)**	**Closure Breakouts**	**Impact to Navigation**
Alt #3	Dewatering & Monitoring / Major Repairs / Gates	10 years	$3,000,000	1440	60	24-hour shifts	Yes
	Rehabilitation of Chamber Guidewall (W & E)	50 years	$4,000,000	825	69	12-hour shifts	Yes
	Rehabilitation of Guidewall & Dolphin (NW & SW)	35 years	$5,000,000	825	69	12-hour shifts	Yes
	Rehabilitation of Guidewall & Dolphin (NE & SE)	35 years	$3,000,000	720	60	12-hour shifts	Yes
	Hurrican Damage	5 years	$1,500,000	175	8	24-hour shifts	Yes
	Hurrican Damage ***	25 years	$5,000,000	175	8	24-hour shifts	Yes
	Rewiring and Machinery Rehabilitation	30 years	$750,000	175	15	12-hour shifts	Yes
	Maintenance by Hired Labor Units	3 years	$675,000	150	13	12-hour shifts	Yes
	Rehabilitation of Chamber Guidewall Armoring (W & E)	25 years	$650,000	100	9	12-hour shifts	Yes
	Rehabilitation of Guidewall Face Timber (NW & SW)	15 years	$500,000	75	7	12-hour shifts	Yes
	Rehabilitation of Guidewall Face Timber (NE & SE)	15 years	$250,000	50	5	12-hour shifts	Yes
	PLC System Upgrade	5 years	$500,000	10	1	random < 2 hours	No
	Routine Maintenance	Annually	$250,000	75	7	random < 2 hours	No
	Periodic Inspection (PI) Program	5 years	$60,000	0	0	None	No

A/E Instrumentation (Pre-PI)	5 years	$40,000	0	0	None	No

IHNC Lock Study, Prepared by Louisville District, 10 August 2015

Summary Operation Maintenance

	Costs (2015 $)		
	Minor Repairs	Major Repairs	Total
Without Project	$ 36,500,000	$ 106,000,000	$ 142,500,000
Alternative #1 -110' x 900'	$ 23,875,000	$ 65,500,000	$ 89,375,000
Alternative #2 -110' x 1200'	$ 24,175,000	$ 67,500,000	$ 91,675,000
Alternative #3 - 75' x 900'	$ 23,875,000	$ 62,500,000	$ 86,375,000
Alternative #4 - 75' x 1200'	$ 24,175,000	$ 64,500,000	$ 88,675,000

	Closure Durations (Hours)		
	Minor Repairs	Major Repairs	Total
Without Project	9,800	24,750	34,550
Alternative #1 -110' x 900'	5,725	15,715	21,440
Alternative #2 -110' x 1200'	5,725	15,715	21,440
Alternative #3 - 75' x 900'	5,725	15,715	21,440
Alternative #4 - 75' x 1200'	5,725	15,715	21,440