Scope Outline of Potential CAWS & Lake Michigan Hydrologic, Hydraulic, and Water Quality Investigations

Overall Objective and Background

As noted in a January 2016 letter to the President and the Great Lakes and Mississippi River Congressional Delegation, the CAWS Advisory Committee (Advisory Committee) determined that further study was warranted to evaluate a system of possible control points as a long-term solution to AIS transfer through the CAWS. Specifically, the Advisory Committee identified further information is needed to design and select a long-term solution, including assessing the following in more detail:

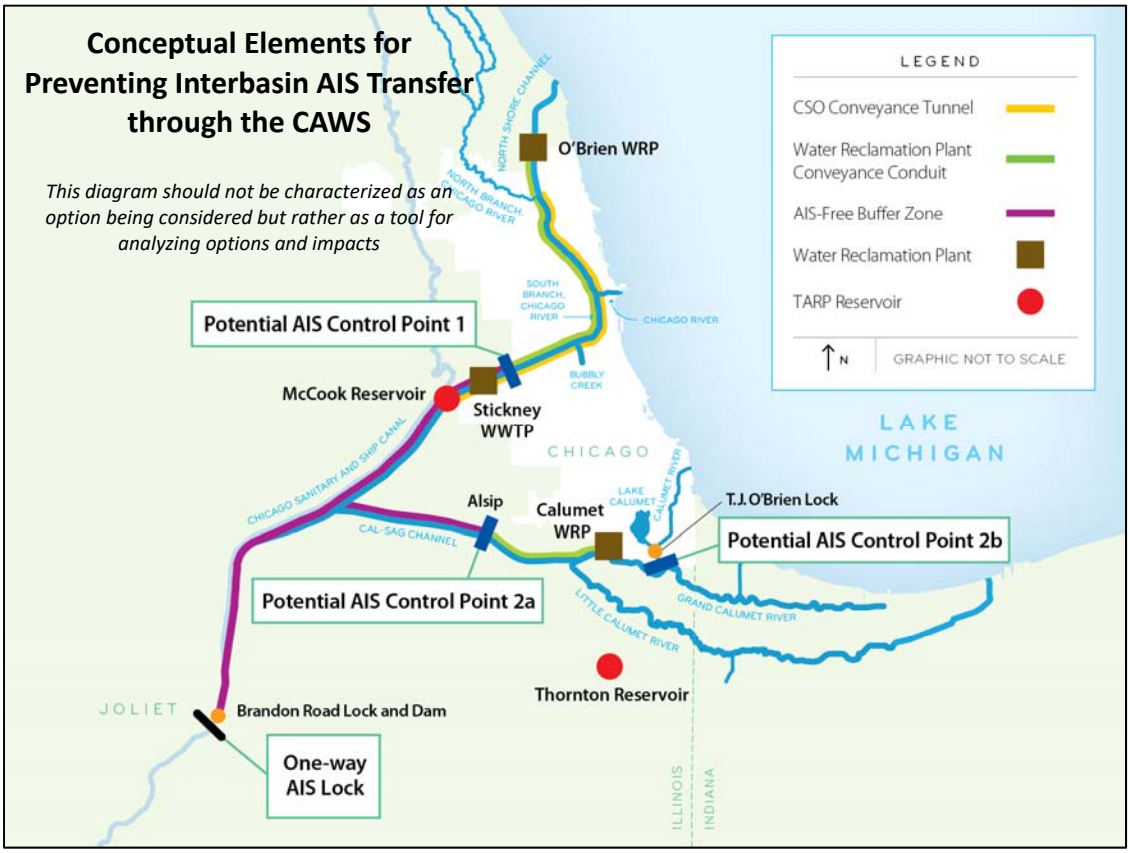
- Whether and how control points could be implemented consistent with mid-system locations identified in GLMRIS

Implications regarding flood risk management and water quality are critical components to the assessment of potential AIS control points, and evaluation of these implications will require additional hydrologic, hydraulic, and water quality investigations. As such, the Advisory Committee has identified hydrologic, hydraulic, and water quality investigations as one of the primary near term topic areas. In support of this near term focus, this document provides a scope outline and plan of activities to refine, enhance, and/or augment existing hydrologic, hydraulic, and water quality models and analyses to inform and evaluate the conceptual elements and components identified for discussion by the Advisory Committee.

Conceptual elements or possible components of a potential long term solution identified for investigation are illustrated in Figure 1. Potential control point locations were informed by previous study results and evolved through CAWS Advisory Committee discussions based on relationship with the working criteria involving AIS risk, flood risk, water quality, and transportation. These conceptual elements and control points were intended to serve as a tool for further evaluation of potential options, and do not necessarily reflect the position of the Advisory Committee or any of its members.

Through direct coordination with Resource Group stakeholders (City of Chicago, MWRDGC, Northwest Indiana Forum, USACE, USGS, and GLC), an initial scope outline document was drafted to identify a broad list of hydrologic, hydraulic, and water quality related tasks needed to further evaluate AIS control points. This draft scope outline was presented to the Advisory Committee for review and input, resulting in a revised draft outline that incorporated Advisory Committee input (Appendix A). The next steps were to develop additional detail and determine an estimated level of effort for performing the identified analyses, which this document and the associated appendices outline.

Figure 1: Conceptual Elements of Potential Long Term Solution



Graphic credit: Great Lakes Commission.

Framework for Evaluations

While possible for some subsequent tasks to be performed in parallel, foundational tasks including establishing baseline water quality conditions and creation of a comprehensive set of linked hydrologic/hydraulic models that encompass the entire study area must be performed first. Effective and efficient development of these foundational investigative components requires coordination with regulators and stakeholders for determining metrics/measures/factors of importance and necessity, baseline conditions, and potential alternatives and associated mitigation strategies. Recognizing the State of Illinois' anti-degradation process for evaluating water quality implications also requires these elements for upfront coordination and strategy, the framework presented in the document for hydrologic, hydraulic, and water quality analyses was created in a complementary manner. While anti-degradation is focused on water quality, variations in water quality implications associated with potential AIS control points are directly related to factors influencing other water related issues (i.e. flood risk management, water supply, and navigation). Due this interdependence, the anti-degradation process provides a logical overarching framework for the extensive set of required water related analyses.

Major Tasks

The specific components of all of the water related analyses outlined in this scoping document can be summarized into 3 major tasks elements:

1) Anti-degradation Review – overarching framework for conducting analyses/modeling including:
    a. Coordination with regulators and stakeholders to determine:
        i. Parameters of concern
        ii. Baseline water quality conditions
        iii. Alternatives and mitigation measures
        iv. Factors of social and economic importance
    b. Evaluation of alternatives – evaluation of a range of non-degrading and less degrading practicable alternatives
    c. Demonstration of social and economic importance – demonstrate potential lowering of water quality is necessary (not an economic cost-benefit analysis)
2) CAWS Hydrologic/Hydraulic/Water Quality Analyses – primarily CAWS focused analyses evaluating a variety of water related issues:
    a. Flood risk management – overland and basement flooding
    b. CSO/TARP conveyance and storage
    c. CAWS water quality and sediment transport
    d. River/lake operational considerations – flood risk, navigation, recreation, and water supply related primarily to water/infrastructure elevations
    e. Water supply investigations – industrial/municipal water supply, navigation, recreation related primarily to volume
3) Lake Michigan Hydrologic/Hydraulic/Water Quality Analyses – primarily Lake Michigan focused analyses requiring linkage with CAWS models/analyses
    a. Develop refined near field hydrodynamic model for Chicago/NW Indiana vicinity and lower CAWS river reaches (assume data collection required for model development/calibration)
    b. Develop sediment transport and contaminant fate model connecting CAWS with Lake Michigan (links with CAWS sediment modeling and assumes additional data collection for model development/calibration)

Additional detail regarding these major tasks is provided in the appendices following this document:

- Appendix A: initial draft scope outline developed through Resource Group coordination and Advisory Committee feedback; subsequently, additional detailed scope documents were developed in support of this overview document and are included as other appendices

- Appendix B: Task Item #1 - Anti-degradation Review scope outline

- Appendix C: Task Item #2 - CAWS Hydrologic/Hydraulic/Water Quality Analyses scope outline
- Appendix D: Task Item #3 – Lake Michigan Hydrologic/Hydraulic/Water Quality Analyses scope outline

It is noted that since the initial draft scope outline was prepared and reviewed by the Advisory Committee, Resource Group and Advisory Committee member MWRDGC has contracted with the University of Illinois at Urbana-Champaign (UIUC) to independently perform a significant amount of hydrologic/hydraulic/water quality modeling of the CAWS as it relates to invasive species alternatives (see Appendix E). While the specific correlation and overlap of this MWRDGC scope with the Advisory Committee draft scope has yet to be determined, initial review of the MWRDGC scope indicates that it draws parallels with the vast majority of the originally identified Task Item #2 (CAWS Hydrologic/Hydraulic/Water Quality Analyses) elements. It is recommended that the Advisory Committee coordinate directly with MWRDGC to leverage the overlapping scope elements and potential coordination of resources for the benefit of all stakeholders.

For purposes of this scoping document, it was assumed that the majority of Task #2 items could be accomplished through coordination and supplementation of the MWRDGC scope. A few specific Task #2 items were identified as items outside of the MWRDGC scope that would require additional focus including:

- Evaluation of future conditions – land use and potential climate change effects
- Calumet System flood risk assessment – potential impacts and mitigation measures including impacts/modifications to USACE Little Calumet Flood Risk Management project
- River/lake operational considerations – navigation requirements, wave/wind effects on rivers when open to the lake, recreational area access/impacts, and industrial/commercial water supply needs (lakeside water elevations)
- Industrial and municipal water supply – industrial/municipal water supply, navigation, and recreation implications related primarily to water volume
- Sediment modeling – expand analyses to include longer duration simulation

Timeframe and Budget

These tasks are envisioned to utilize as much existing information, modeling, and analyses as possible to capitalize on previous efforts and expenditures including general acceptance of models by stakeholders. Nonetheless, considerable effort and evaluation is anticipated for refining and/or augmenting these analyses and models for purposes of evaluating a potential long-term AIS solution involving control points. An approximate timeframe and order of magnitude estimate of costs for conducting these analyses is outlined as below.

Approximate Duration and Conceptual Costs for Potential Water Related Analyses

Task	Approximate Duration[1]	Conceptual Cost
1) Anti-degradation Review		
Coordination	12-18 months	$100-$150k
Alternative Analysis	12-18 months	$650-$850k
Social/Economic Importance	6 months	$50-$75k
2) CAWS Hydrologic/Hydraulic/Water Quality		
MWRD Investigations (UIUC scope)[2]	48 months	$975k
Supplemental Evaluations (beyond UIUC scope)		
Calumet System Flood Risk Assessment	6-12 months	$300-$400k
River/Lake Operational Considerations	6-12 months	$100-$150k
Industrial/Municipal Water Supply Investigation	6-12 months	$200-$300k
Sediment Modeling (Longer Duration)	6-12 months	$400-$500k
3) Lake Michigan Water Quality		
Independent Review of CAWS H&H	3-6 months	$75-$100k
Lake Michigan Water Quality Data Collection & Modeling	18-24 months	$500-$750k
CAWS/Lake Michigan Sediment Data Collection & Modeling	30-36 months	$750k-$1M
Total: MWRD Investigation: **Remaining Total:**	See Timeframe Table	$4M-$5.5M ($975k) **$3M-$4.5M**

Notes: 1) Approximate durations of individual task items; total duration of tasks will not equal the sum of all tasks as some task items can be performed in parallel

2) Based on UIUC scope dated August 15, 2016

While some of the individual task items may be performed in parallel, many of the tasks are dependent upon each other and must be performed in sequence. In particular, establishment of baseline water quality conditions/parameters and creation of a comprehensive set of linked hydrologic/hydraulic models that encompass the entire study area must be performed before conducting the various impact analyses and investigation of alternatives and mitigation strategies. However, some overlap must be incorporated to provide coordination between the sequential tasks and some cyclical analyses, which allows for some tightening of overall schedule.

The table below of approximate timeframes provides a broad level overview of the relation of individual task items to each other as well as the overall timeframe.

Approximate Timeframe[1] for Potential Water Related Analyses

Task	2017		2018		2019		2020		2021		2022	
1) Anti-degradation Review												
Coordination	■	■	■									
Alternative Analysis										■	■	■
Social/Economic Importance												■
2) CAWS Hydrologic/Hydraulic/Water Quality												
MWRD Investigations (UIUC scope)[2]	■	■	■	■	■	■	■	■				
Supplemental Evaluations (beyond UIUC scope)												
Calumet System Flood Risk Assessment						■	■					
River/Lake Operational Considerations						■	■					
Industrial/Municipal Water Supply Investigation						■	■					
Sediment Modeling (Longer Duration)								■	■			
3) Lake Michigan Water Quality												
Independent Review of CAWS H&H				■		■		■				
Lake Michigan Water Quality Data Collection & Modeling						■	■	■	■			
CAWS/Lake Michigan Sediment Data Collection & Modeling						■	■	■	■	■	■	

Notes: 1) Relation of individual task item approximate timeframes are based on anticipated completion of Task #2 elements by MWRD and assume a start date of Task Item #1 in 2017

2) Based on UIUC scope dated August 15, 2016

Appendix A: Initial Draft Scope Outline of Potential CAWS Hydrologic, Hydraulic, and Water Quality Investigations

Overall Objective and Framework

Refine/enhance existing hydrologic, hydraulic, and water quality models and analyses to inform and evaluate the conceptual elements and components identified for discussion by the CAWS Advisory Committee, specifically:

- Whether and how control points could be implemented consistent with mid-system locations identified in GLMRIS (variations of the GLMRIS Alternatives #6 and #7)
    1. Potential AIS Control Points near Stickney and Alsip
    2. Potential AIS Control Points near Stickney and O'Brien Lock along with control points on Grand and Little Calumet Rivers near basin divides

CAWS Hydrology & Hydraulics

Objective

- Revise/enhance existing hydrologic and hydraulic modeling to inform and evaluate the conceptual elements and system components identified for discussion by the CAWS Advisory Committee, specifically related to:
    - Revised CSO design event assumption and storage needs based on stormwater conveyance, potential pumping, treatment, and TARP reservoir optimization (Note: revised CSO assumptions also requires coordination with IEPA/IDEM regarding anti-degradation requirements)

Task Components

- Overall hydrologic and hydraulic modeling elements
    - Extend/combine existing models to incorporate North Branch Chicago River and Grand/Little Calumet reaches in Northwest Indiana to develop a single comprehensive set of models compassing the entire study area
- Hydrologic updates based on precipitation/design events
    - 2-yr (water quality loading) through 500-yr (flood risk) design events
    - Revised CSO design event and storage/conveyance assumptions (associated with CSO/TARP hydraulic evaluation)
    - Future conditions – land use projections and consideration of potential climate change effects through model sensitivity analyses
- Hydraulic Evaluations
    - CSO/TARP Conveyance and Storage Evaluation
        - Evaluate various scenarios for capturing Chicago River system CSO outfalls and/or Racine Avenue Pumping Station (RAPS) and impacts to CAWS water elevations
            - Identify pumping/storage needs and impacts to CAWS water elevations for scenarios:
                1) RAPS outfall routed to McCook
                2) North Shore Channel (NSC) CSO outfalls only routed to McCook (no reroute of RAPS)
            - Evaluate impact of McCook storage volume assumptions (no storage limit vs. 2029 storage) on CSO conveyance and CAWS water elevations
            - Need for high volume pumping/treatment and/or additional reservoir volume during extreme event and back-to-back storms
            - Need for additional conveyance to McCook from NSC and/or North Branch
            - Consider potential reductions in need for conveyance/storage that could result from green infrastructure.

- River/Lake Operational considerations
  - Frequency, duration, and impacts of varying lake levels
  - Impacts of wave effects (some existing evaluation) and wind setup conditions on lower rivers when open to lake
  - Evaluate need for maintaining Chicago and/or O'Brien Lock and/or lower CAWS elevations relative to Lake Michigan
    - Potential drawdown/pumping for storm events to mitigate increased flood elevations
    - Navigation and vessel clearance on the CAWS (non-storm conditions)
    - Recreation area (including City of Chicago Riverwalk) access and impacts (non-storm conditions)
    - Industrial/commercial water supply needs (water elevation)
- Calumet System flood elevation assessment
  - Evaluate potential impacts and identify required mitigation measures of control point scenarios based on overall objective assumptions (potential control point locations and CSO storage)
  - Includes impacts/modifications needed to USACE Little Calumet Flood Risk Management project
- City of Chicago Basement flooding
  - Evaluate potential impacts and identify required mitigation measures of control point scenarios based on overall objective assumptions (potential control point locations and CSO storage)
  - Determine potential impacts of revised CAWS water elevations on sewer conveyance and basement flooding
  - Consider effects of lake level variations, operational needs (maintaining CAWS elevations using locks), and potential reductions in basement flooding from green infrastructure

Potential Existing Resources/Models

- MWRD 2D/3D CAWS models and TARP tunnel modeling including Univ. of Illinois models
- USACE 1D/3D CAWS models from GLMRIS, etc.
- City of Chicago Infoworks Sewer Models

Water Supply Investigations

Objective

- Investigate potential water supply implications and mitigation measures that would inform and evaluate the conceptual elements and system components identified for discussion by the CAWS Advisory Committee, specifically related to:
    - Reduced baseflow and storm event discharges to the Mississippi River basin side of the CAWS downstream of potential ANS control point locations
    - Operational impacts of CAWS water elevations lakeside of ANS control points due to variations in Lake Michigan levels

Task Components

- Navigation water depth requirements – determine potential impacts and mitigation needs, including operational controls, for maintaining navigation (Note: navigation requirement issues on the CAWS lakeside of potential ANS control points will be investigated as part of the CAWS hydraulic evaluations)
    - Focused riverside of the potential ANS control points and primarily downstream of Lockport Lock & Dam
    - Dry weather (non-storm) and storm event conditions (based on revised/new hydrologic/hydraulic models)
    - Evaluate for scenarios with MWRD WRP (O'Brien and Calumet) reroutes to downstream CAWS and without (WRPs discharge to Lake Michigan)
- Industrial and municipal water supply - determine potential impacts and mitigation needs, including operational controls, for maintaining water supply (Note: Industrial/commercial water supply users lakeside of potential ANS control points will be investigated using the revised/new CAWS hydraulic evaluations as water elevation is primarily an operations issue in this area)
    - Water supply evaluation focused riverside of the potential ANS control points and primarily downstream of Lockport Lock & Dam
        - Dry weather (non-storm) and storm event conditions (based on revised/new hydrologic/hydraulic models)
        - Evaluate for scenarios with MWRD WRP (O'Brien and Calumet) reroutes to downstream CAWS and without (WRPs discharge to Lake Michigan)

Potential Existing Resources/Models

- USGS and MWRD stream gage information
- USACE – Illinois River UNET model and reservoir operations model (?)
- Revised CAWS hydrologic and hydraulic models

CAWS Water Quality

Objective

- Investigate potential CAWS water quality implications and mitigation measures that would inform and evaluate the conceptual elements and system components identified for discussion by the CAWS Advisory Committee, specifically related to:
    - Anti-degradation requirements
        - Additional pollutant loadings and required mitigation measures from new continuous discharges to the CAWS lakeside of potential ANS control point locations
        - Potential for pollutant load reductions now entering North Branch, Little Calumet and Grand Calumet
        - Other changes anticipated in pollutant discharge points
    - Contaminated sediment – evaluating the potential for movement/transport of CAWS contaminated sediments and determining appropriate threshold levels

Task Components

- Anti-degradation requirements – extend existing DUFLOW model to include Little and Grand Calumet regions and add non-point/stormwater inflows
    - Determine pollutant loadings from new discharge locations (outfall relocations of existing discharges)
        - MWRD O'Brien and Calumet WRPs
        - Stormwater/non-point and non-MWRD point discharges
    - Evaluate various point source conditions
        - MWRD WRPs rerouted to Mississippi (with and without additional treatment)
        - MWRD WRPs discharged to Lake Michigan (with and without additional treatment)
        - Other upstream point sources that would be discharged to Lake Michigan or rerouted to Mississippi (with and without additional treatment)
    - Evaluate various operational conditions
        - Based on revised CAWS hydraulic modeling for evaluating control structure operational needs related to flooding, navigation, etc.
            - Maintain current Chicago and/or O'Brien Lock water level controls
            - Revised Chicago and/or O'Brien Lock water level controls
    - Assess flow augmentation needs
    - Determine conceptual level costs for mitigation measures required to meet anti-degradation rules (will require coordination w/ IEPA/IDEM and acknowledgement of some level of inherent degradation)

- Contaminated sediment modeling – enhance existing CAWS 3D model and/or develop new model for determining potential transport of contaminated sediments
    - Determine appropriate threshold levels for assessing human and aquatic health risks
    - Assess sediment volume/loadings based on pollutants and determine potential implications for water quality parameters
        - Single event and near term (months/year)
        - Long term (years/decades) transport and loadings/accumulation in the CAWS
    - Evaluate various operational conditions
        - Based on revised CAWS hydraulic modeling for evaluating control structure operational needs related to flooding, navigation, etc.
            - Maintain current Chicago and/or O'Brien Lock water level controls
            - Revised Chicago and/or O'Brien Lock water level controls
    - Determine potential areas of sediment deposits related to dredging needs
    - Determine potential implications related to the Bubbly Creek Superfund sites
- Flow augmentation
    - Identify potential stagnant areas both lakeside and riverside of potential control points requiring mitigation flow augmentation, increased wastewater treatment, or re-direction of current flows Conceptualize flow augmentation mitigation measures and costs (i.e. effluent from WRPs, Lake Michigan water, etc.)
    - Assess opportunities to improve water quality of discharges as part of the analysis of the need for augmentation

Potential Existing Resources/Models

- MWRD – DUFLOW all CAWS
- MWRD WRP data/loadings
- MWRD (or USACE?) CAWS 3D model (EFDC) with sediment transport
- US EPA and MWRD sediment data/studies

Lake Michigan Water Quality

Objective

- Investigate potential Lake Michigan water quality implications and mitigation measures that would inform and evaluate the conceptual elements and system components identified for discussion by the CAWS Advisory Committee, specifically related to:
    - Anti-degradation requirements – additional pollutant loadings and required mitigation measures from new continuous discharges to Lake Michigan
    - Determination of minimum amount of additional pollutant that must be necessarily allowed and potential effect of that increased loading on Lake.

Task Components

- Determine pollutant loadings (unavoidable and potentially mitigated) to Lake Michigan from new discharges – building off of USACE FVCOM model, develop continuous long term model and revised event based model
    - Loading sources
        - MWRD O'Brien and Calumet WRPs
        - Stormwater/non-point and non-MWRD point discharges
        - Contaminated sediment
        - Existing shoreline sources (e.g., direct runoff, stormwater, water fowl) as they impact bacteria levels and contribute to beach closures
    - Evaluate various point source conditions
        - MWRD WRPs rerouted to Mississippi (with and without additional treatment)
        - MWRD WRPs discharged to Lake Michigan (with and without additional treatment)
        - Include upstream point sources discharges in evaluation
    - Evaluate various operational conditions
        - Based on revised CAWS hydraulic modeling for evaluating control structure operational needs related to flooding, navigation, etc.
            - Maintain current Chicago and/or O'Brien Lock water level controls
            - Revised Chicago and/or O'Brien Lock water level controls
    - Determine potential implications for water quality (i.e. beach closures, source water quality, drinking water treatment modifications)
        - Single event and near term (months/year)
        - Long term (years/decades) loadings/accumulation in Lake Michigan
        - Implications and potential mitigation for City of Chicago (and other Lake Michigan water users) drinking source water and/or treatment needs
- Develop new sediment transport and water quality model (or build off of CAWS EFDC and USACE FVCOM)
    - Assess sediment volume/loadings based on pollutants
    - Determine potential areas of sediment deposits related to dredging needs

- Determine conceptual level costs for mitigation measures required to meet anti-degradation rules (will require coordination w/ IEPA/IDEM and acknowledgement of some level of inherent degradation)

Potential Existing Resources/Models

- CAWS EFDC model
- USACE – FVCOM model

Appendix B: Task Item #1 – Anti-Degradation Review Scope Outline

Objective

- Determine whether potential CAWS water quality implications and mitigation measures meet all antidegradation requirements. Compliance with antidegradation requirements will be based on an evaluation of necessity and importance, which will be informed by the following:
    - Coordination with regulators and stakeholders
    - Evaluation of alternatives
    - Demonstration of social and economic importance

Task Components

- Coordination with regulators and stakeholders
    - Effective use of the CAWS and Lake Michigan models for evaluating mitigation alternatives requires: development of water quality baseline conditions for short and long term modeling time periods; assessment parameters of concern; compliance points for assessment; and parameter magnitude, frequency and duration targets. This is important from the perspective of developing a stakeholder agreed upon set of the water quality metrics that can be used to assess the pros and cons of the different mitigation alternatives. This effort should be completed early in the overall effort so that the CAWS and Lake Michigan models are capable of accurately addressing the water quality metrics for decision making purposes.
    - Coordination with regulators and stakeholders to determine key components and measures for determining necessity and importance, with emphasis on the following:
        - Parameters of concern (POC) – Once identified, POCs will form the basis for pollutant loading calculations and impact assessments.
        - Baseline water quality – Baseline, or existing, water quality will be used to assess changes in water quality. Coordination is needed to reach a mutual understanding for how baseline water quality for each POC will be determined including, statistical analyses and spatial endpoints.
        - Alternatives and mitigation measures
        - Factors of social and economic importance
    - Estimated timeframe: 12-18 months
    - Estimated cost: $100,000-$150,000

- Evaluation of Alternatives
    - An alternatives analysis must evaluate a range of non-degrading and less degrading practicable alternatives, which is defined at §131.3(n) as "technologically possible, able to be put into practice, and economically viable." Depending on the outcome of the coordination task, the evaluation will:

        - Determine baseline conditions for all POCs
        - Determine pollutant loadings from new discharge locations (outfall relocations of existing discharges)
            - MWRD O'Brien and Calumet WRPs
            - Stormwater/non-point and non-MWRD point discharges
            - Combined sewer discharges at various levels of control
        - Evaluate various point source conditions
            - MWRD WRPs rerouted to Mississippi (with and without additional treatment)
            - MWRD WRPs discharged to Lake Michigan (with and without additional treatment)
            - Other upstream point sources that would be discharged to Lake Michigan or rerouted to Mississippi (with and without additional treatment)
            - Combined sewer discharges to Lake Michigan and CAWS at various levels of control
        - Evaluate various operational conditions
            - Based on revised CAWS hydraulic modeling for evaluating control structure operational needs related to flooding, navigation, etc.
                - Maintain current Chicago and/or O'Brien Lock water level controls
                - Revised Chicago and/or O'Brien Lock water level controls
        - Assess flow augmentation needs
            - Identify potential stagnant areas both lakeside and riverside of potential control points requiring mitigation flow augmentation, increased wastewater treatment, or re-direction of current flows Conceptualize flow augmentation mitigation measures and costs (i.e. effluent from WRPs, Lake Michigan water, etc.)
            - Assess opportunities to improve water quality of discharges as part of the analysis of the need for augmentation

- Model sediment contamination - enhance existing CAWS 3D model and/or develop new model for determining potential transport of contaminated sediments
    - Determine appropriate threshold levels for assessing human and aquatic health risks
    - Assess sediment volume/loadings based on pollutants and determine potential implications for water quality parameters
        - Single event and near term (months/year)
        - Long term (years/decades) transport and loadings/accumulation in the CAWS
    - Evaluate various operational conditions
        - Based on revised CAWS hydraulic modeling for evaluating control structure operational needs related to flooding, navigation, etc.
            - Maintain current Chicago and/or O'Brien Lock water level controls
            - Revised Chicago and/or O'Brien Lock water level controls
    - Determine conceptual level costs for alternatives and mitigation measures
    - Determine potential implications related to the Bubbly Creek Superfund sites
- Estimated timeframe: 12-18 months
- Estimated cost: $650,000-$850,000

- Demonstration of social and economic importance
    - Regulations at §131.12(a)(2)(ii) provides that before allowing a lowering of water quality, states must find, after an analysis of alternatives, that such a lowering in necessary to accommodate important economic or social development in the area in which the waters are located. A determination of social and economic importance will be made based on those factors agreed upon during the coordination task. Depending on what factors are used, model analyses and existing evaluations from the GLMRIS report may be utilized to demonstrate importance.
    - This task is not an economic cost-benefit analysis, but rather a technical narrative based on alternative analyses demonstrating the social and economic importance
    - Estimated timeframe: 6 months
    - Estimated cost: $50,000-$75,000

Appendix C: Task Item #2 – CAWS Hydrologic/Hydraulic/Water Quality Analyses Scope Outline

MWRDGC has contracted with the University of Illinois at Urbana-Champaign (UIUC) to independently perform a significant amount of hydrologic/hydraulic/water quality modeling of the CAWS as it relates to invasive species alternatives (Appendix E). While the specific correlation and overlap of this MWRDGC scope with the Advisory Committee draft scope has yet to be determined, initial review of the MWRDGC scope indicates that it draws parallels with the vast majority of the originally identified CAWS Hydrologic/Hydraulic/Water Quality Analyses elements described in the initial draft scope outline (Appendix A). Therefore, for purposes of this scoping document, it was assumed that the majority of Task #2 items could be accomplished through coordination and supplementation of the MWRDGC scope. It is also recommended that the Advisory Committee coordinate directly with MWRDGC to leverage the overlapping scope elements and potential coordination of resources for the benefit of all stakeholders.

A few specific Task #2 items were identified as items outside of the MWRDGC scope that would require additional focus and could be performed as supplemental evaluations to the MWRDGC scope including:

- Evaluation of future conditions
    - consideration of hydrologic conditions representing future land use and potential climate change effects through model sensitivity analyses
    - Estimated timeframe and conceptual cost are assumed to be absorbed into UIUC efforts with minimal impact through use of sensitivity analyses
- Calumet System flood risk assessment
    - Evaluate potential impacts and identify required mitigation measures of control point scenarios based on potential control point locations and CSO storage
    - Includes impacts/modifications needed to USACE Little Calumet Flood Risk Management project
    - Assumes use of existing USACE models and/or models to be developed through MWRDGC evaluations (by UIUC)
    - Estimated timeframe: 6-12 months
    - Estimated cost: $300,000-$400,000
- River/lake operational considerations
    - Impacts of wave effects (some existing evaluation) and wind setup conditions on lower rivers when open to lake
    - Evaluate need for maintaining Chicago and/or O'Brien Lock and/or lower CAWS elevations relative to Lake Michigan
        - Potential drawdown/pumping for storm events to mitigate increased flood elevations
        - Navigation and vessel clearance on the CAWS (non-storm conditions)
        - Recreation area (including City of Chicago Riverwalk) access and impacts (non-storm conditions)
        - Industrial/commercial water supply needs (water elevation)

  - Assumes use of models to be developed through MWRDGC evaluations (by UIUC)
  - Estimated timeframe: 6-12 months
  - Estimated cost: $100,000-$150,000
- Industrial and municipal water supply
  - Determine potential impacts and mitigation needs, including operational controls, for maintaining water supply (Note: Industrial/commercial water supply users lakeside of potential ANS control points will be investigated using the revised/new CAWS hydraulic evaluations as water elevation is primarily an operations issue in this area)
  - Water supply evaluation focused riverside of the potential ANS control points and primarily downstream of Lockport Lock & Dam
    - Dry weather (non-storm) and storm event conditions (based on revised/new hydrologic/hydraulic models)
    - Evaluate for scenarios with MWRD WRP (O'Brien and Calumet) reroutes to downstream CAWS and without (WRPs discharge to Lake Michigan)
  - Assumes use of models to be developed through MWRDGC evaluations (by UIUC)
  - Estimated timeframe: 6-12 months
  - Estimated cost: $200,000-$300,000
- Sediment modeling
  - Expand MWRDGC analyses (by UIUC) of CAWS to include longer duration simulation
    - Sediment oxygen demand (SOD) effects on CAWS water quality has been identified as a concern associated with ANS mitigation alternatives. SOD issues are best addressed with inclusion of a sediment diagenesis model (Di Toro, 1985) in the water quality model. It is not clear if the versions of WASP7 used in the existing CAWS modeling framework has a sediment diagenesis submodel capable of calculating SOD. In addition, the application of a water quality model with a sediment diagenesis submodel requires multiple year simulations because decay of particulate organic matter (POM) in the sediment is on the order of a few years. These long term simulations may require long computer run times with the very fine model segmentation used in the CAWS models.
    - Once the CAWS modeling time periods are clarified with UIUC, it may be necessary to increase the modeling time period to at least an annual period to correlate changes to POM loads to the sediment to the resulting SOD and impact on dissolved oxygen levels. It is assumed that this would be completed by UIUC.
  - Assumes use of models to be developed through MWRDGC evaluations (by UIUC) and expanded modeling is performed by UIUC
  - Estimated timeframe: 6-12 months.
  - Estimated cost: $400,000-$500,000.

Appendix D: Task Item #3 – Lake Michigan Hydrologic/Hydraulic/Water Quality Analyses Scope Outline

Summary of CAWS & Lake Michigan Water Quality Modeling

As part of the Great Lakes and Mississippi River Inter Basin Study (GLMRIS), the USACE contracted the USGS and Marquette University to model the effects of hydrologic separation on water quality in the Chicago Area Waterways System (CAWS). Marquette University used the DUFLOW model jointly developed by universities in the Netherlands. DUFLOW is a 1D unsteady hydrodynamic model and was used to evaluate the changes in water elevation and velocity throughout the CAWS with various proposed control and mitigation alternatives intended to prevent the exchange of aquatic nuisance species (ANS) between the Great Lakes and Mississippi Basins. Marquette University linked the EPA WASP5 water quality model to the DUFLOW model to evaluate changes in CAWS water quality associated with various ANS mitigation alternatives. The USACE also contracted with the USGS and Michigan State University (MSU) to model the effects of hydrological separation on water quality in Lake Michigan. The 3D, time-variable Finite Volume Coastal Ocean Model (FVCOM) linked to the WASP5 water quality model was used for the Lake Michigan water quality analysis. The DUFLOW model was used to compute the time-variable pollutant loads from the CAWS to Lake Michigan.

The University of Illinois at Urbana-Champagne (UIUC) has also developed a suite of hydrologic, hydraulic, hydrodynamic and water quality models of the CAWS for MWRDGC over the last ten years. UIUC has developed a 1D hydraulic model (HEC-RAS) of the CAWS that is linked to the hydrologic/hydraulic TARP model (MetroFlow) and they have linked the HEC-RAS model to the EPA WASP7 water quality model to compute water quality changes within the CAWS associated with ANS mitigation alternatives. UIUC has also developed a 3D Environmental Fluid Dynamics Code (EFDC) model of the CAWS that is also linked with the WASP7 water quality model. Use and further development of these models by UIUC for the MWRDGC is planned during 2016-2020 to evaluate mitigation alternatives and their effect on water quality in the CAWS. The 1D HEC-RAS/WASP7 model is not as computationally burdensome as the 3D EFDC/WASP7 model and would be used for water quality model calibration of the CAWS, whereas the more complex 3D EFDC/WASP7 model would be used to evaluate specific mitigation alternatives. It is unknown if UIUC has a Lake Michigan model or intends to extend their EFDC model into Lake Michigan.

The WASP5/7 water quality models to be used in the CAWS and used in Lake Michigan are capable of analyzing the following parameters: organic nitrogen; ammonia nitrogen; nitrite+nitrate nitrogen; organic phosphorus; orthophosphate; BOD; dissolved oxygen; phytoplankton; conservative tracer; bacteria; sediments; pH; various types of toxic chemicals; and temperature. Based on the UIUC planned CAWS modeling efforts for MWRDGC, it is not clear what level of water quality modeling is to be completed (i.e., simple BOD-DO modeling or eutrophication modeling). In addition depending on the WASP7 version used, the sediment diagenesis submodel that calculates sediment oxygen demand (SOD) and nutrient fluxes may or may not be implemented yet. It is assumed that the CAWS water quality modeling will provide sufficient detail for assessing parameters of concern.

The CAWS modeling time periods are unclear at this time but appear to include existing conditions and various storm event modeling. As discussed below, long term modeling simulations may be required to evaluate SOD changes in the CAWS but also to evaluate different longer term hydrologic regimes.

The hydraulic/hydrodynamic models of both universities (UIUC and MSU) have been calibrated, although only the MSU FVCOM Lake Michigan model calibration has been initially reviewed for scoping purposes.

The calibration of lake velocity and temperature for a summer period seems reasonable although there may be some issues with the lake temperature calibration. The only water quality model calibration available and reviewed to date was the WASP5 model of Lake Michigan for a one month period (August 2012) at one water quality station near Burns Ditch (southeast of Chicago).

Recommended Improvements/Changes to Existing Models

Based on this cursory review of the available models for the CAWS and Lake Michigan, the following potential efforts have been identified to build upon the existing modeling efforts by UIUC and MSU.

- Independent Review of CAWS Hydrologic/Hydraulic Modeling
    a. The calibration of the hydrologic/hydraulic, hydrodynamic, and water quality models selected for CAWS ANS mitigation alternative evaluation should be critically reviewed prior to any model application to assess management strategies.
        i. Independent review of the CAWS hydrologic/hydraulic, hydrodynamic and water quality models should be completed to ensure the level of calibration is acceptable for completing evaluation of management alternatives. This should include: model-data comparison and statistical goodness of fit measures review; review of model coefficients and parameters to ensure consistency with typical literature ranges and/or field studies designed to estimate important model rates; review of sediment diagenesis model revisions proposed and results calibration. One component of this review should also consider whether the modeling time period(s) used are sufficient for assessing management alternatives (e.g., short term for bacteria assessment; and long term for dissolved oxygen, nutrient and contaminated sediment assessment). This should include obtaining and reviewing all model files (not just documentation) and reproducing model results.
        ii. Estimated timeframe: 3-6 months after CAWS models are finalized or approximately 1 month after each CAWS model is completed (i.e., hydrologic/hydraulic, hydrodynamic; and water quality).
        iii. Estimated cost: $75,000-$100,000

- Lake Michigan Water Quality Data Collection & Modeling
    The Lake Michigan FVCOM hydrodynamic and water quality model should be calibrated against a much more extensive water quality dataset than the one station near Burns Ditch used for calibration of the FVCOM/WASP5 model before being used to evaluate mitigation alternatives. In addition, there does not appear to be a linked (coupled) CAWS/Lake Michigan modeling framework that can properly represent the potential effect of colder Lake Michigan water intruding inland to any of the rivers that may be opened to free exchange with Lake Michigan as part of an ANS mitigation alternative. UIUC has identified the potential flushing of Chicago River water with clean Lake Michigan water as a potential benefit to CAWS. A possible approach in addressing this issue could be the direct inclusion of rivers opened to free exchange with Lake Michigan into the Lake Michigan FVCOM/WASP5 modeling framework. This is important from the perspective of the potential for stagnant zones in the lower river reaches that are opened to free exchange with the lake that can cause water quality impacts such as depressed dissolved oxygen levels.

The current FVCOM/WASP5 model includes all of Lake Michigan with tens of thousands of model segments and may not be well suited for addressing local water quality concerns or many multiple year model simulations associated with phosphorus (e.g., excessive phytoplankton and *Cladophora* growth), bacteria and dissolved oxygen. A more practical modeling approach may be to use the large Lake Michigan FVCOM model to develop hydrodynamic boundary conditions for a smaller regional hydrodynamic/water quality model that has acceptable solution times for multiple year model simulations and is more spatially focused on the area of concern. This model could also include the lower reaches of the rivers that will freely exchange with lake water for the mitigation alternatives to be analyzed.

Additional data collection is assumed to be required to inform and calibrate the smaller regional hydrodynamic/water quality model proposed for use in long term simulations. This data collection would include field sampling of water quality parameters periodically during one calendar year in order to obtain inputs over a wide range of temperature and flow conditions.

i. Estimated timeframe: 18-24 months total (assumes 6 months overlap of data collection and modeling); 12 months for data collection and 12-18 months after model dataset obtained for an approximate annual modeling time period.
ii. Estimated cost: $500,000-$750,000

- CAWS/Lake Michigan Sediment Data Collection & Modeling

  It is not clear if either the DUFLOW/WASP5 or 3D EFDC/WASP7 modeling frameworks to be developed by UIUC will address the potential resuspension and transport of legacy contaminated sediments from CAWS to Lake Michigan. The UIUC modeling approach intends to develop a sediment transport module within EFDC but the emphasis is on resuspension of benthic organic matter and its effect on overlying water dissolved oxygen in CAWS through enhancing SOD. Any modeling framework for the evaluation of ANS mitigation alternatives should contain a contaminated fate and transport module to define the resuspension of contaminated sediments within the CAWS and subsequent transport of these contaminated sediments to Lake Michigan. Given the complex nature of sediment transport and contaminant fate modeling, it is recommended to first determine critical bottom stresses for different CAWS flow regimes to determine whether bottom sediments have the potential to mobilize and be transported to Lake Michigan. This initial screening effort can help guide the level of modeling needed or whether other less complicated assessment approaches may be acceptable.

  Additional data collection is assumed to be required to inform and calibrate sediment transport and contaminant fate models proposed. This data collection would include field sampling of sediment parameters periodically during an 18 month period in order to obtain inputs over a wide range of temperature and flow conditions.

  i. Estimated timeframe: 30-36 months total (assumes 6 months overlap of data collection and modeling); 18 months for data collection and 18-24 months for developing CAWS/Lake Michigan sediment transport and contaminant fate model.
  ii. Estimated cost: $750,000-$1,00,000

Appendix E: MWRDGC Statement of Work by UIUC (under separate cover) – Invasive Species Mitigation Alternatives Impacts on the CAWS as it Relates to Flooding, Water Quality, and Navigation