The Cumulative Adverse Effects of Gas Pipeline Development on Wetlands

Background and Assessment Process

Last Revised: November 2018

Written by Wing Goodale, Ph.D.
Biodiversity Research Institute

A Product of the
Association of State Wetland Managers Pipeline Permitting Project

Table of Contents

1 **Summary** 5

2 **Introduction** 5

3 **Part I: Cumulative Adverse Effects Background and Assessment Framework** 6

3.1 Legal basis of Cumulative Adverse Affects Assessments 6

3.1.1 National Environmental Policy Act (NEPA) *7*

3.2 Framework for Considering Adverse Effects 8

3.3 Framework for Considering Cumulative Adverse Effects 8

3.4 Assessing and Evaluating Cumulative Adverse Effects 10

3.5 Mitigation of CAE 11

4 **Part II: Guidance on Assessing and Managing CAE of Pipeline Development on Wetlands** 12

4.1 Methods 12

4.2 Governance Structure 13

4.3 Framing 14

4.4 Assessing 15

4.4.1 Determine anticipated adverse effects and hazard severity *16*

4.4.2 Determine spatial exposure severity *17*

4.4.3 Determine temporal exposure severity *18*

4.4.4 Determine vulnerability severity *19*

4.4.5 Example of CAE index supporting risk evaluation *20*

5 **Conclusions** 21

6 **References** 22

List of Tables

Table 1: The assessment of the CAE of pipelines on wetlands uses a simple matrix to develop a risk index. 15
Table 2: Overall CAE risk categories based upon the index....15
Table 3: Example of how the qualitative *hazard* determination (red) is entered into the CAE risk matrix. 16
Table 4: Example of how the qualitative *spatial exposure* determination (red) is entered into the CAE risk matrix. 17
Table 5: Example of how the qualitative *temporal exposure* determination (red) is entered into the CAE risk matrix. 18
Table 6: Example of how the qualitative *vulnerability* determination (red) is entered into the CAE risk matrix as well as the final CAE index value (yellow). 19
Table 7: Example of how the index can be used to create a matrix to track the relative risk of cumulative adverse effects through a specific state. 20

List of Figures

Figure 1: CAE of pipeline development on wetlands. Homotypic and heterotypic hazards directly/indirectly adversely affect vulnerable receptors. These adverse effects accumulate as vulnerable receptors are repeatedly exposed through time and space to the hazards via additive, synergistic, and countervailing pathways. The adverse effects can then accumulate to a degree that significant wetland functionality is lost within watershed. 9
Figure 2: Preliminary questionnaire....12
Figure 3: The process of governing cumulative adverse effects: First, identify the adverse effects, hazards, and receptors; second, determine the hazard, exposure, and vulnerability; third, evaluate the significance of the cumulative effects; and fourth, select the appropriate conservation measure. 13
Figure 4: Example of the cumulative risk plotted for hypothetical development in Maine. 20

List of Equations

Equation 1: CAE index calculation....15

1 Summary

Large-scale development of multiple pipelines has the potential to cause cumulative adverse effects (CAE) to wetlands through the accumulation of both direct and indirect effects. CAE analysis is required in Environmental Impact Statements, yet in practice such analyses are stymied by a lack of clear guidance on assessment methods. This paper directly addresses the need to improve the assessment process by reviewing existing literature on how CAE has been framed, assessed, and managed and then providing guidance on how to assess the CAE of pipelines on wetlands.

2 Introduction

The national non-profit Association of State Wetland Managers (ASWM) received support from the Switzer Foundation to reduce the impacts of oil and gas pipeline development on wetlands and streams in the United States through improved engagement by states in wetland and other aquatic permit planning and review activities. Overall, ASWM's project provides state wetland permit reviewers with improved access to state-specific information about how and when they can engage in permit planning and review processes.

Energy projects, particularly pipelines, may affect a range of aquatic resources, including short- and long-term impacts on wetlands during construction and operation of natural gas pipeline facilities. Temporary effects on wetlands and other aquatic resources may alter water quality, habitat, and increase invasive species, as well as compromise quality of critical areas and may effect some endangered species. The adverse effects of a pipeline on a single wetland are important, but a greater concern is the effect of pipelines that cross multiple wetlands in one watershed. A single pipeline can cross hundreds of wetlands and streams, which can lead to cumulative adverse effects (CAE).

Developing guidance for states on how to frame, assess, evaluate, and manage CAE from pipeline development is crucial for wetland protection. Specifically, there is a need to identify how CAE could/should be included in planning or permitting decisions, including impacts across state and tribal borders, multiple crossings within one watershed, and in areas where high quality or rare aquatic resources exist.

This white paper was prepared to provide background and guidance on how to conduct replicable and consistent CAE assessments across state boundaries. The legal basis for CAE assessments, a framework for first considering adverse effects and then CAE, a review of the general approaches to CAE assessments, and mitigation approaches are provided in the first part of the paper. A simple assessment process that can be applied across the U.S. is outlined in the second part of the paper.

3 Part I: Cumulative Adverse Effects Background and Assessment Framework

CAE has challenged regulators, developers, and ecologists since it was promulgated in the National Environmental Policy Act (NEPA) in 1970. Broadly defined, CAE is the accumulation of adverse effects over time and space. Due to the broad definition of cumulative effects, assessments are inconsistent (MacDonald 2000) and vary within and across regulatory agencies (MMS 2007, MMS 2009, BOEM 2012, Army Corps of Engineers 2014) as well as among NEPA processes (MMS 2007, MMS 2009, Army Corps of Engineers 2014). This lack of parity results in assessments that cannot be compared and are considered inadequate (Burris and Canter 1997, Cooper and Canter 1997, Baxter et al. 2001, Cooper and Sheate 2002, Duinker and Greig 2006). Problems with CAE assessments include: an absence of frameworks to help determine the significance of effects (Berube 2007, British Columbia Forest Practices 2011); an absence of effective methodologies to conduct assessments (Canter and Kamath 1995, Smith 2006, Masden et al. 2010); difficulties evaluating the likelihood of cumulative effects; and no standard management or mitigation actions have been developed by states or by ecoregion.

Many of the deficiencies in assessments are rooted in the inherent complexity of CAE. Theoretically, all stressors, on all wetlands, for all time should be included in a CAE analysis. However, to be practical, assessments must have boundaries. First the stressor source and receptor need to be identified and then temporal and spatial boundaries of analysis must be defined. Defining these boundaries to reduce complexity becomes the key challenge to CAE assessments. This first section of the white paper will describe the legal basis for CAE and the challenges in defining boundaries. Later, this section develops a framework to define the boundaries of analysis, and concludes with a review of assessment approaches.

3.1 Legal basis of Cumulative Adverse Affects Assessments

Cumulative impacts are primarily considered in three U.S. laws: the Clean Water Act (CWA), the Endangered Species Act (ESA), and, most importantly, the National Environmental Policy Act (NEPA).

Cumulative impacts are required to be considered in issuing general permits under Section 404 of the Clean Water Act. Section 230.7 states "the permitting authority shall set forth in writing an evaluation of the potential individual and *cumulative impacts* of the category of activities to be regulated under the General permit." While assessments are required under the CWA, the permitting process is not successfully minimizing CAE (Stein 1998) on wetlands.

Within the ESA, cumulative effects must be considered as a part of Section 7 consultation as well as in formulating biological opinions (see 50 CFR §402.14(g)(3) and (4)) (UFWS 1998). The ESA defines cumulative effects as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02)." In contrast to NEPA, ESA considers future non-federal actions (see below), which includes past and present action as well as federal actions. While cumulative effects analysis is the last step in a biological opinion, it is often the least documented because of the poor information on future non-federal actions (UFWS 1998).

3.1.1 National Environmental Policy Act (NEPA)

Cumulative adverse effects are most often considered through a NEPA analysis and will be the focus of this white paper. NEPA requires that a federal agency consider in an Environmental Impact Statement (EIS) if the action will significantly affect the environment. In an EIS the agency must describe the affected environment, evaluate alternatives, and assess the direct, indirect, and cumulative effects of the action on the environment. Cumulative effects are defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions" (40 CFR §1508.7).

Past actions are an "aggregation" of all past major anthropogenic actions that are currently impacting the environment (Hegmann et al. 1999). The ambiguity of which past actions to include in analysis has led to legal challenges on the appropriate scope of analysis. The courts have determined that at a minimum an assessment must include a list of past projects paired with a description of adverse effects of each project on the environment. These decisions have further complicated the understanding of how to approach past actions because it is unclear if all past actions need to be listed in an EIS as well as the individual effects of these past actions (Schultz 2012).

Future actions are considered to include both the proposed project and other actions that may adversely affect the environment. First, the assessment needs to include the duration of the proposed action. The full duration and scope of the project's effects is considered "most appropriate" for assessments (CEQ 1997), but generally assessments set a future boundary of five years (Hyder 1999). Second, the assessment must consider other "reasonably foreseeable future action." Generally the courts have concluded that formal proposals and proposals beyond speculation need to be considered while remote and speculative proposals should not be included (Rumrill and Canter 1997).

The spatial scale of the assessment will depend upon the resource being adversely affected and must be determined on a project-by-project basis (Hyder 1999). The temporal boundaries of an assessment should include historic, current, and projected developments (Canter and Kamath 1995, Cooper and Canter 1997, Norman et al. 2007). What to include in temporal analysis is one of the most common legal challenges of CAE assessments within EIS documents (Schultz 2012).

Due to the ambiguity and lack of clear guidance on how to establish boundaries, assessments in the U.S. are inconsistent and inadequate (Cooper and Canter 1997). Despite these inadequacies, there are rarely consequences for poor analysis aside from lawsuits by concerned citizens, (Rumrill and Canter 1997) and today CAE assessments are overlooked in EISs. Therefore, there is a strong need to develop a clear process for framing, assessing, and evaluating CAE. In the next section of this white paper a framework for assessments of pipeline projects is developed.

3.2 Framework for Considering Adverse Effects

Prior to developing a framework to define CAE, a framework for adverse effects needs to be articulated. NEPA considers the terms "effects" and "impacts" to be synonymous (40 C.F.R. 1508.8 (b)). Within the regulations the interchange between these two terms creates confusion. "Impact" constitutes a change resulting from an effect, while "effect" is the response of an individual to a stimulus; i.e., for wetland development an effect would be the conversion of a wetland and an impact would be loss in functionality. Practically, effects will be substantially easier to measure than impacts, but measured effects do not indicate an impact. Effects tend to be considered either positive or negative while impacts can imply a negative or adverse response. For clarity, in this paper the term "adverse effects" will be used to represent actions that have a negative effect on wetland functionality from pipeline projects.

Adverse effects are a function of the physical hazards of pipelines, wetland vulnerability, and exposure (modified from Crichton 1999). The hazards are the changes in environment caused by the project's components during each development phase—also described as "impact-producing-factors" (BOEM 2012, DOE 2013). Vulnerability is the sensitivity of the resource to the hazard and will vary by wetland type and conservation status. Exposure is measured spatially and temporally.

Pipeline development can have direct and indirect adverse effects on wetlands. Direct effects are the result of a stimulus/response relationship (Canter and Kamath 1995). For wetlands, direct effects are the loss of wetland function and/or value (e.g., loam used to fill a wetland) and conversion of wetland type (e.g., palustrine forested wetland to palustrine emergent). Indirect effects occur through multiple pathways and are considered to be second- or third-level impacts (Hyder 1999). For wetlands, indirect effects include degraded modified hydrology, vegetation, or function.

3.3 Framework for Considering Cumulative Adverse Effects

Based upon the above risk assessment framework—adverse effects are a function of hazards, exposure, and vulnerability—a framework for considering CAE is developed. The process of CAE occurs when multiple adverse effects are combined through space and time.

Hazards are divided into two broad categories: homotypic and heterotypic (Irving et al. 1986). Homotypic stressors are the same hazard repeated across a watershed, i.e., multiple pipeline developments or one pipeline with multiple impacts. The homotypic hazard of pipeline development on wetlands is broken into three parts: construction, infrastructure, and maintenance. While all aspects of development will adversely affect wetlands to some degree, the construction phase of development poses the greatest risk. Homotypic hazards of pipeline development are not isolated from other anthropogenic stressors. All the other stressors on wetlands are defined as heterotypic hazards, which include, but are not limited to, roadways, agriculture, and other types of construction.

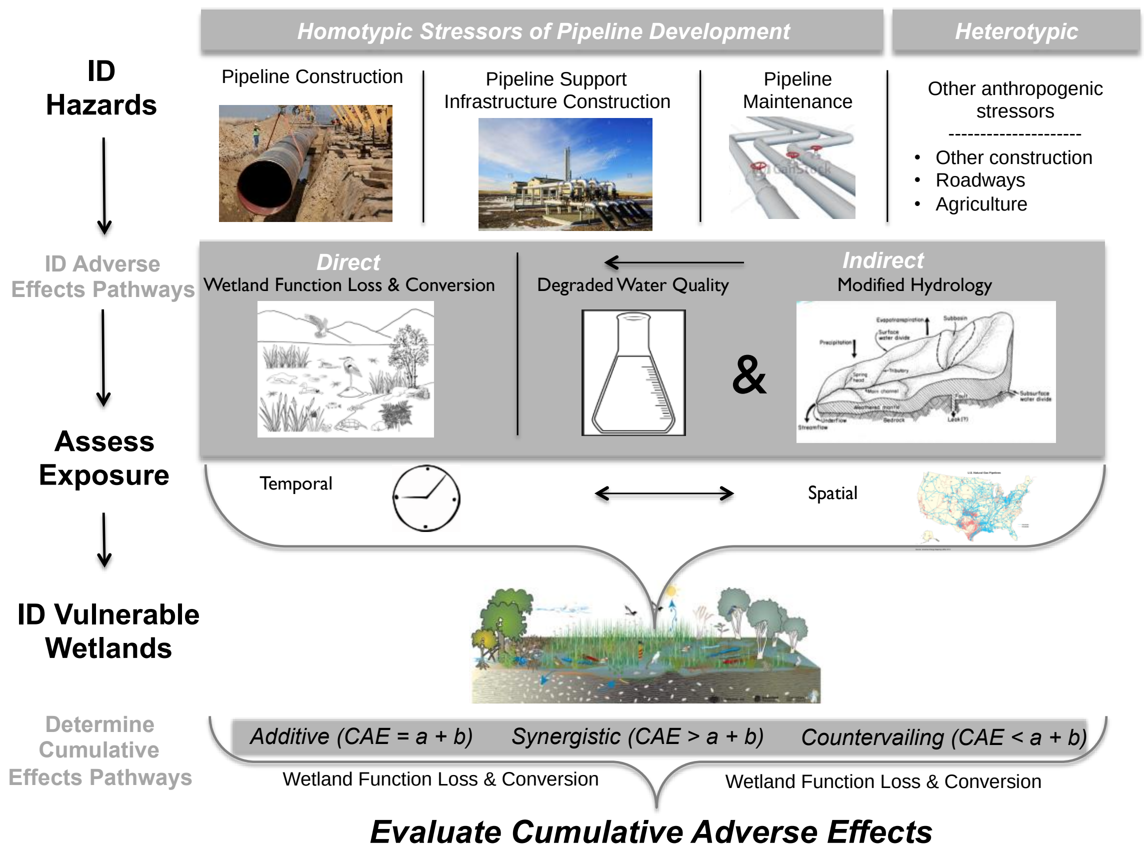

Figure 1: CAE of pipeline development on wetlands. Homotypic and heterotypic hazards directly/indirectly adversely affect vulnerable receptors. These adverse effects accumulate as vulnerable receptors are repeatedly exposed through time and space to the hazards via additive, synergistic, and countervailing pathways. The adverse effects can then accumulate to a degree that significant wetland functionality is lost within watershed.

Exposure relates to the number of wetlands and total area exposed to pipelines (space) within the context of past, present, and future development (time). In general terms, the more pipelines in a watershed the greater the exposure. Vulnerability is primarily a function of two factors: wetland type and conservation status (regional and watershed specific). Wetland type can be identified using the National Wetland Inventory[1] codes and state coding systems. Conservation importance can be measured by national status reports (e.g., USFWS status report[2]) as well as state and regional reports if available.

When multiple pipelines are developed, the individual adverse effects will be combined to cause CAE. The individual effects can be combined via additive (CAE = a + b), synergistic (CAE > a + b), or countervailing (CAE < a + b) pathways. Additive or incremental CAE are simply the sum of effects; synergistic or supra-additive CAE are when the total impacts are greater than their sum; and countervailing is where the CAE are less than the sum of the individual impacts (Irving et al. 1986).

1 https://www.fws.gov/wetlands/data/wetland-codes.html

2 https://www.epa.gov/wetlands/how-does-epa-keep-track-status-and-trends-wetlands-us

3.4 Assessing and Evaluating Cumulative Adverse Effects

There are three phases to assessing and evaluating CAE: identifying the scope of analysis, assessing CAE, and evaluating (judging) the severity of impacts (Hyder 1999). The scoping phase will define the boundaries of analysis and identify what tools should be used in an assessment. Scoping must include identifying the hazard (pipeline), receptor (wetlands), boundaries of analysis, baselines, and thresholds.

Scoping steps include:

1. Determine hazards: Determining the homotypic and heterotypic[3] stressors to include in the analysis.

2. Determine the receptor: Identify the primary resource that is going to be adversely affected.

3. Determining adverse effects: Determining the direct and indirect adverse effects that are of primary concern

4. Determine spatial boundaries: Determine the area to be considered in the analysis (e.g., HUC watershed). For policy decisions, large-scale assessments are most useful, and for project decisions, a smaller area should be considered (MacDonald). For projects, boundaries should be based upon "natural interrelationships between biophysical environment features, man-generated interrelationships between socioeconomic environment features, and the geographical locations of expected impacts" (Canter and Kamath 1995).

5. Determine temporal boundaries: Identify the past, present, and future actions to include in the assessment.

6. Determine the environmental baseline: Determine an environmental baseline for each receptor, e.g., the total number of wetlands or total area of wetlands within a watershed. A baseline is a metric that describes the state of the receptor prior to the proposed action (Goodale and Milman 2016).

7. Stating a threshold: Identify if there is a threshold beyond which there will be significant adverse effects to the receptor. Implicit in measuring CAE against a baseline is the premise that there exists a threshold of adverse effects that should not be exceeded. This threshold will vary from receptor to receptor (Goodale and Milman 2016).

[3] A CAE assessment theoretically must consider both homotypic and heterotypic stressors. Below the analysis is refined to homotypic, but in the future additional stressors could be included.

Once the scope of the analysis has been determined, the CAE assessment has two components: measuring exposure of the receptors to the hazard and then assessing vulnerability of the receptors to the hazard (Goodale and Milman 2016).

There is no one size-fits-all approach to CAE assessments (Smit and Spaling 1995). Methods can be broken into two broad categories: project specific and regional planning. Project-based assessments generally follow analytical approaches that include spatial analysis, network analysis, biogeographic analysis, interactive matrices, ecological modeling, and expert opinion. Regional planning generally uses multi-criteria evaluation, programming models, land suitability evaluation, and process guidelines. The planning approach includes a normative evaluation that incorporates values and participatory decision making to rank different uses of a resource (Smit and Spaling 1995).

Once the assessment is completed the magnitude of CAE can be evaluated. The evaluation of the severity of the risk will be based upon the exposure assessment and documented vulnerability, but ultimately will be qualitative and subjective. The evaluation directs the level of mitigation and monitoring that will be required (CEQ 1997), which is discussed in the next section.

3.5 Mitigation of Cumulative Adverse Effects

Mitigating CAE is based upon avoiding exposure of vulnerable receptors, minimizing the adverse effects of each individual project through use of best practices, and compensating for adverse effects through the creation or protection of the impacted receptor. The US Army Corps of Engineers (USACE) is the lead agency and requires mitigation for unavoidable wetland impacts. FERC follows USACE requirements, including determinations and assessments for mitigation of wetland impacts. Mitigation will be determined on a project-by-project basis (Hyder 1999) using a "no net loss" approach (Hegmann et al. 1999). In addition, the state may have more specific requirements. Mitigation should also be considered on the regional level and focus on reducing other sources contributing to CAE (Hegmann et al. 1999). Mitigation measures should be developed based upon the best available science. CAE is ultimately mitigated through reducing adverse effects on a project level and through regional planning that seeks to avoid critical resource areas. Onsite mitigation should be considered to actively restore wetland functions and values. Some states require mitigation for no net-loss of wetlands. This tool can be of assistance to those seeking to determine the types and quantities of compensatory mitigation appropriate to the cumulative adverse effects identified.

Tying this portion of the project in with the other findings from ASWM's pipeline permitting project, findings from a CAE analysis should be utilized in conjunction with the review of best practices (BMPs) to determine whether more extensive adverse effects may warrant consideration of requiring different or more rigorous use of specific best practices. ASWM's project has also identified a wide range of best practices for improving pipeline permitting and conditioning, some of which are designed specifically to limit the kinds of impacts that lead to adverse effects.

4 Part II: Guidance on Assessing and Managing CAE of Pipeline Development on Wetlands

The purpose of this guidance document is to provide a replicable and practical approach for assessing the cumulative adverse effects (CAE) of pipeline development on wetlands. The process is designed to support an Environmental Impact Statement (EIS)—required by the National Environment Poly Act (NEPA)—as well as to support conditioning pipeline permits through the 401 certification and state permitting process. The overall goal is to provide an actionable guidance document to support management decisions.

4.1 Methods

The guidance process detailed below was developed using expert elicitation. The Association of State Wetland Managers established a cumulative impacts working group comprised of nine state wetland mangers. The working group responded to a questionnaire, participated in a structured question/answer webinar, and peer-reviewed the final guidance approach. Initially, the group was sent a simple questionnaire to identify the key adverse effects of pipelines on wetlands (Figure 1). Based upon the responses from the questionnaire a second set of questions was identified, which focused on developing a practical process for assessing cumulative effects of pipelines on wetlands. The questions were structured around identifying the goals of assessments, the primary adverse effects, buffers for assessments, metrics to be used in measuring CAE, the scope of assessments, thresholds, and management actions. Based upon the responses from the questions, a preliminary assessment process was developed. The process was presented to the group through a webinar. Feedback from the group resulted in a refining of the assessment process, which is presented below.

1. Adverse effects:

What are the primary direct and indirect impacts of pipeline development on natural resources? (Example: direct = wildlife mortality; indirect = degraded water quality)

2. Defining the hazard:

What are the physical changes to the environment caused by the development activities? (Example: Drainage of a wetland; fuel spills during construction; sedimentation of wetland; pipeline passing through the wetland)

3. Defining vulnerable receptors:

What are the natural resources (e.g., habitat, wildlife) that are vulnerable to the hazard? (Example: Fairy shrimp; spotted salamander; wood frog)

Figure 2: Preliminary questionnaire

4.2 Governance Structure

The guidance document is structured around framing, assessing, evaluating, and managing CAE (Figure 2) (Renn et al. 2011). First, regulators must frame the risk to conduct an assessment; second, assess the risk to support an evaluation (judgment); and third, evaluate the risk to identify appropriate mitigation measures.

Figure 2 illustrates the connection between these moving parts, with the initial CAE assessment process involving framing the types of effects from pipelines, then assessing what wetlands are affected, and evaluating the significance of the cumulative adverse effects based upon the severity of the hazard, exposure and vulnerability. In the final phase of this process, the CAE assessment can be used to select conservation measures designed to avoid, minimize or compensate for those adverse effects.

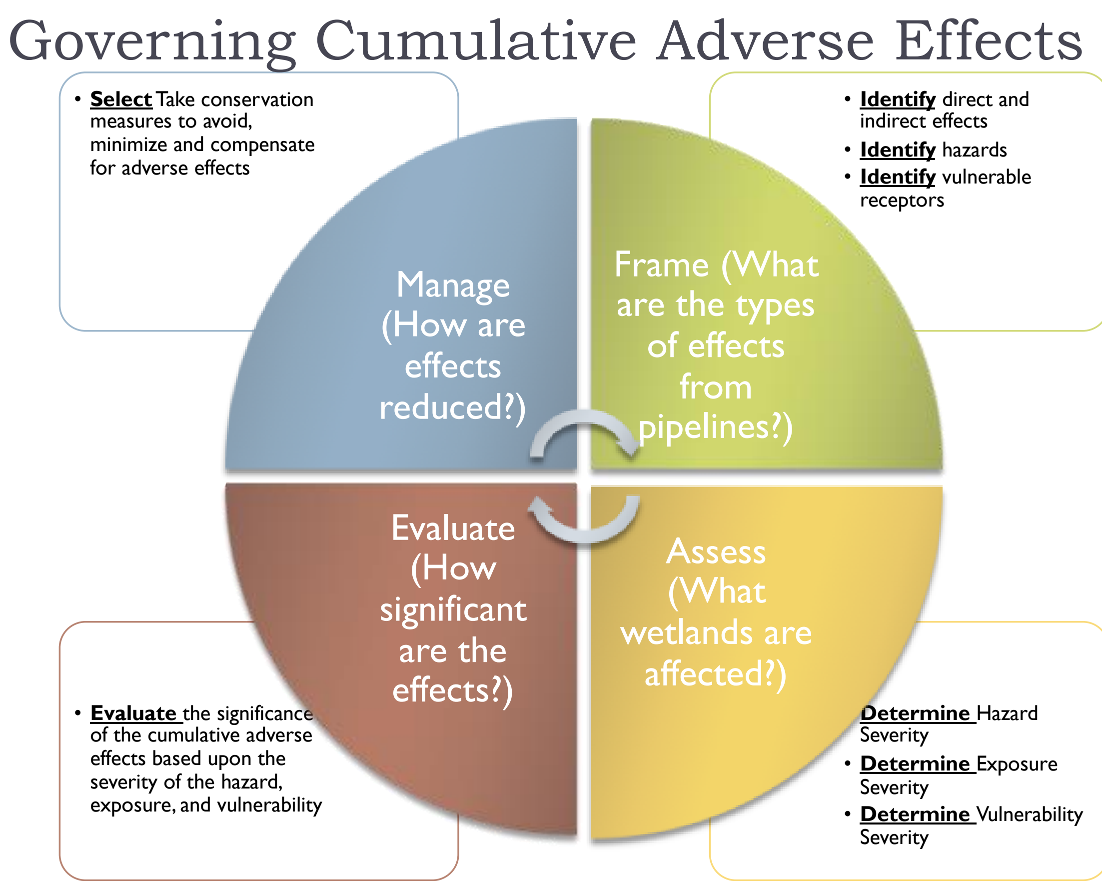

Figure 3: The process of governing cumulative adverse effects: First, identify the adverse effects, hazards, and receptors; second, determine the hazard, exposure, and vulnerability; third, evaluate the significance of the cumulative effects; and fourth, select the appropriate conservation measure.

4.3 Framing

The cumulative adverse effects of pipeline development on wetlands represents all anthropogenic stressors (homotypic and heterotypic) on wetlands through all time and space. Practically, the complexity of assessments must be simplified through a scoping process. While scoping processes will be project- and state-specific, the following approach is suggested to provide a standardized process for assessing CAE across multiple states.

- Hazards scope
    - Homotypic stressor of pipeline development. Heterotypic stressors can be incorporated into the evaluation by using regional (e.g., NWI and NACA) and state wetland conservation status reports.

- Receptor scope
    - Freshwater wetlands as defined by the National Wetland Inventory or other wetland data source accepted by regulators.

- Primary adverse effects
  Impacts for most pipeline construction projects include both temporary and permanent impacts. While most are considered to be temporary, care must be taken to ensure that restoration occurs to ensure they the adverse effects do not become permanent.
    - Direct:
        - Loss of wetland function and conversion of wetland type
    - Indirect:
        - Degraded water quality that causes loss of wetland function
        - Changes in hydrology that cause loss of wetland function or conversion of wetland type

- Spatial boundaries
    - Political boundaries: Individual states
    - Watershed boundaries (HUC size to be selected)
    - Pipeline buffer on either side of the central line of the pipeline (if state has established buffer requirements or preferences)

- Temporal boundaries
    - Past
        - Number of pipelines operating within the HUC watershed defined in the spatial scope
    - Present
        - Number of pipelines currently being permitted within the watershed
    - Future
        - Number of pipelines planned within the watershed

4.4 Assessing

The below risk assessment process is qualitative, simple, and flexible. The goal is to have a process that accounts for the varying levels of state resources available (i.e., personnel, time, technical, and financial) to conduct an assessment). While the Corps is responsible for assessing these effects, sates and tribes can either coordinate with the Corps or conduct their own analysis. Through time, as greater knowledge is gained, complexity can be added to the process.

The assessment process is based upon determining the severity of the hazard, exposure, and vulnerability using a simple matrix. The process determines the extent of the project; the number of wetlands that will potentially be converted or lose functionality within the same watershed; the degree that the proposed project incrementally contributes to adverse effects from past, present, and future development; and the significance or quality of the wetlands exposed. Using the best available information and expert opinion, for each step in the assessment process, state regulators will determine on a scale from 0 (negligible) to 5 (high) severity of each component of the risk assessment (Table 1). The four components of the assessment are then added together and divided by 20 to create a simple index of risk (Equation 1). As knowledge is gained about cumulative effects, the equation could be modified to become a weighted linear combination where each element receives a weight of importance. The index results are then mapped to risk categories (Table 2). Note that consideration should be given to whether impacts are temporary (with less risk if restored) or permanent. Assessment must consider these differences.

Table 1: The assessment of the CAE of pipelines on wetlands uses a simple matrix to develop a risk index.

Project #	Hazard	Spatial Exposure	Temporal Exposure	Vulnerable Wetlands	CAE Index
1	0 - 5	0 - 5	0 - 5	0 - 5	0 - 1

Equation 1: CAE index calculation

$$\text{CAE index} = \frac{\text{hazard score} + \text{spatial exposure} + \text{temporal exposure} + \text{vulnerability score}}{20}$$

Table 2: Overall CAE risk categories based upon the index

CAE Risk Level	CAE Index Value
Negligible	0 – 0.2
Minor	0.2 – 0.4
Moderate	0.4 – 0.6
Major	0.6 – 1.0

By assessing these hazards, exposure, and vulnerability as well as accounting for heterotypic stressors with wetland conservation status reports, state regulators can determine the significance of the cumulative effects. Based upon this evaluation, regulators can then identify management actions to require appropriate BMPs and mitigation measures.

4.4.1 Determine anticipated adverse effects and hazard severity

The initial step in the CAE assessment is to determine the severity (i.e., the magnitude of the hazard) of the proposed pipeline. First, the anticipated adverse effects must be described, and second, the extent of the pipeline must be identified. Based upon the description of the pipeline, an experienced regulator should be able to qualitatively categorize the project as being small (0-1), medium (2- 3), or large (4-5) relative to other projects being proposed in the region. If resources are available for regional quantitative meta-analysis, then a regulator could determine the hazard categories using quantiles (e.g., the extent of the project falls in the lower 25th percentile and thus is considered small). Provided below are questions to define the hazard as well as example answers and risk determination. An example of how the hazard determination is entered into the CAE risk matrix is also provided (Table 3).

Hazard questions

- Question 1: What are the anticipated adverse effects? Are they temporary or permanent? Are they short-term or long-term?
    - Direct:
        - Is wetland loss expected? Wetland loss only happens if there is a permanent effect (e.g. due to construction of a permanent structure). Direct, permanent losses should be restored through compensatory mitigation and this restoration activity taken into consideration in hazard assessment.
    - Indirect
        - Are hydrological changes expected?
        - Will water quality be degraded?
- Question 2: How extensive is the project?
    - How many miles (km) is the planned project?
    - How many support structures are planned?

Example answer: Pipeline length: 10 km
Example qualitative hazard severity determination: 2

Table 3: Example of how the qualitative *hazard* determination (red) is entered into the CAE risk matrix.

Project #	Hazard	Spatial Exposure	Temporal Exposure	Vulnerable Wetlands	CAE Index
1	2	-	-	-	-

4.4.2 Determine spatial exposure severity

The next step in the assessment is to determine the severity of spatial exposure of wetlands to the pipeline. First, the number of wetlands exposed by the pipeline is determined, and second, the exposed wetlands are put within the context of the watershed. Preferably, for consistency, the spatial exposure assessment should use the NWI delineated wetlands. Regulators, using their best judgment, could then either qualitatively—or quantitatively if time and resources allow—categorize the spatial exposure as being negligible (0), low (1-2), medium (3-4), high (5). Below are provided questions to define exposure as well as example answers and risk determination. An example of how the exposure determination is entered into the CAE risk matrix is also provided (Table 4).

Spatial exposure questions

- Question 1: How many wetlands are being exposed?
  - How many NWI wetlands are within the study area (300 feet of the central line of the pipeline)?
- Question 2: How many wetlands within the watershed are exposed?
  - How many watersheds will the pipeline pass through? (Determine HUC size before completing analysis)
  - How many NWI wetlands are in each HUC 8 watershed?

Example answers

1. Wetlands within project area: 17 (1.2 km^2)
2. Number of wetlands in HUC 8 watershed: 754 (8,563 km2)
3. Percentage of wetlands within the watershed exposed by the project: 2.2% (by number), 0.01 % (by area).

Example qualitative spatial severity determination: 4

Table 4: Example of how the qualitative *spatial exposure* determination (red) is entered into the CAE risk matrix.

Project #	Hazard	Spatial Exposure	Temporal Exposure	Vulnerable Wetlands	CAE Index
1	2	4	-	-	-

4.4.3 Determine temporal exposure severity

The next step in the assessment is to determine the severity of temporal exposure of wetlands to the pipeline. This portion of the assessment places the proposed project within the context of past, present, and future development. While fully documenting past actions and predicting the future is fraught with uncertainty, a reasonable assessment can be made. Using the best available information and considering the project within the spatial scope of analysis, a regulator could place the projects into one of the following categories:

- 0 = no past projects, no other projects being permitted, no anticipated projects
- 1-3 = few past projects, few other projects being permitted, few anticipated projects
- 4-5 = many past projects, many other projects being permitted, many anticipated projects

Provided below are questions to define exposure as well as example answers and risk determination. An example of how the exposure determination is entered into the CAE risk matrix is also provided (Table 5).

Temporal exposure questions

- Question: How does the proposed pipeline incrementally contribute to the adverse effects from past, present, and anticipated developments?
    - Past: How many pipelines currently are operational within the watershed defined in the spatial scope?
    - Present: How many pipelines are currently being permitting within the watershed?
    - Future: How many pipelines are planned within the watershed?

Example answers

1. Past: 0 pipelines, 0 km
2. Present: 1 pipelines, 18 km
3. Future: 0

Example qualitative temporal severity determination: 1

Table 5: Example of how the qualitative *temporal exposure* determination (red) is entered into the CAE risk matrix.

Project #	Hazard	Spatial Exposure	Temporal Exposure	Vulnerable Wetlands	CAE Index
1	2	4	1	-	-

4.4.4 Determine vulnerability severity

The final step in the assessment is to determine the vulnerability (i.e., conservation importance) of exposed wetlands to the pipeline. For consistency, the vulnerability assessment should ideally use the NWI conservation ranking. While the specific wetlands will vary by state and region, regulators could place wetlands into the following categories of conservation importance/significance: low (0-2), medium (2-3), high (4-5). If time and resources allow, a state could calculate the proportion of each wetland type within the HUC 8 watershed exposed to the project. Below are provided questions to define vulnerability as well as example answers and risk determination. An example of how the vulnerability determination is entered into the CAE risk matrix is also provided (Table 6). After vulnerability is determined, then the final CAE risk index can be calculates using Equation 1.

Vulnerability questions

- Question: How significant are the wetlands being exposed?
    - What are the wetland types exposed to the project?
    - What is the conservation status of each wetland type?
    - What is the conservation status of the wetlands within the HUC 8 watershed defined in the spatial scope?

Example answers

1. Wetland type, emergent: conservation status = low; number in project areas 2; area of wetlands exposed by project = 0.1 km^2; number in HUC watershed 45; area in HUC = 10 km^2.

2. Wetland type, scrub-shrub: conservation status = moderate; number in project areas 5; area of wetlands exposed by project = 0.4 km^2; number in HUC watershed 546; area in HUC = 1,056 km^2

3. Wetland type, forested: conservation status = high; number in project areas 1; area of wetlands exposed by project = 0.2 km^2; number in HUC watershed 234; area in HUC = 1,056 km^2

Example qualitative vulnerability determination

- 5

Table 6: Example of how the qualitative *vulnerability* determination (red) is entered into the CAE risk matrix as well as the final CAE index value (yellow).

Project #	Hazard	Spatial Exposure	Temporal Exposure	Vulnerable Wetlands	CAE Index
1	2	4	1	5	0.6

4.4.5 Example of CAE index supporting risk evaluation

If the simple CAE index is used consistently within the same spatial scope, the cumulative risk of pipeline projects can be calculated and tracked as development continues through time (Table 7). The tracking of the risk using a consistent tool will allow state regulators to identify trends in overall risk (Figure 4). The trends can then be used to evaluate how individual projects are incrementally contributing to CAE within specific watersheds, across a state, or regionally. Based upon the evaluation regulators could then identify the level of conservation measures they will require for a project under review.

Table 7: Example of how the index can be used to create a matrix to track the relative risk of cumulative adverse effects through a specific state.

Project	Km of Pipeline	Cumulative Sum of Development	CAE Index	Cumulative Sum of Risk
1	7.5	7.50	0.6	0.6
2	23	30.50	0.35	0.95
3	6	36.50	0.35	1.3
4	45	81.50	0.7	2

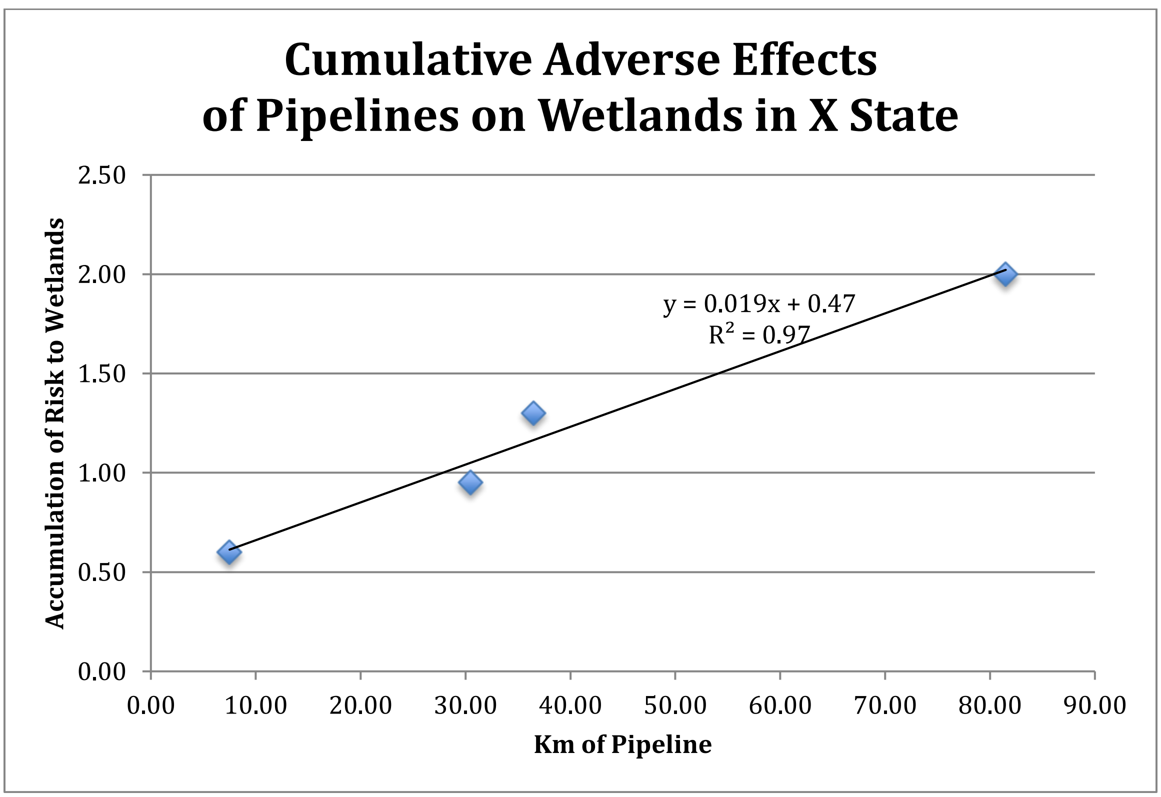

Figure 4: Example of the cumulative risk plotted for hypothetical development in a state

5 Conclusions

This white paper was prepared to provide a background on cumulative effects and guidance on a simple, flexible assessment tool. The assessment method provides a basic structure that can be built upon. Each component of the assessment—hazard, exposure, and vulnerability—can be further developed based upon existing processes. The assessment tool creates a simple index that can be used to evaluate the risks of cumulative adverse effects of pipeline development on wetlands. The evaluation can be used to identify the extent of conservation measures and the management actions that will be required on a project-by-project basis. Ultimately, in the absence of region- wide strategic planning efforts, the only way to reduce cumulative adverse effects is to reduce the adverse effects of each individual project to ensure there is no net loss.

The assessment method provides a basic structure that can be adapted to meet various planning, regulatory and research needs to conceptualize and assess CAE. Each component of the assessment— hazard, exposure, and vulnerability—can be further developed based upon existing processes and measures. The assessment tool creates a simple index that can be used to evaluate the risks of cumulative adverse effects of pipeline development on wetlands. Tracking risk using a consistent tool will allow state regulators to identify trends in overall risk. The identified trends can then be used to evaluate how individual projects are incrementally contributing to CAE within specific watersheds, across a state, or regionally. Based upon the evaluation, regulators could then identify the level of conservation measures they will require for a project under review.

Ultimately, in the absence of region-wide strategic planning efforts, the only way to reduce cumulative adverse effects is to reduce the adverse effects of each individual project to ensure there is no net loss. This form of CAE evaluation can be used to identify the extent of conservation measures and the management actions that will be required on a project-by-project basis.

6 References

Army Corps of Engineers. (2014). "Block Island Environmental Assessment." from http://www.nae.usace.army.mil/Portals/74/docs/Topics/DeepwaterWind/EA17Sep2014.pdf.

Baxter, W., W. A. Ross and H. Spaling (2001). "Improving the practice of cumulative effects assessment in Canada." Impact Assessment and Project Appraisal **19**(4): 253-262.

Berube, M. (2007). "Cumulative effects assessments at Hydro-Quebec: what have we learned?" Impact Assessment and Project Appraisal **25**(2): 101-109.

BOEM. (2012). "Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore Rhode Island and Massachusetts Environmental Assessment." from http://www.boem.gov/uploadedFiles/BOEM/Renewable_Energy_Program/State_Activities/BOEM_RI_MA_Revised_EA_22May2013.pdf.

BOEM (2012). Commercial wind lease issuance and site assessment activities on the Atlantic Outer Continental Shelf offshore Rhode Island and Massachusetts: Environmental Assessment., U.S. Department of the Interior Bureau of Ocean Energy Management Office of Renewable Energy Programs.

British Columbia Forest Practices, B. (2011). "Cumulative effects from assessment towards management." from http://site.ebrary.com/id/10484517.

Burris, R. K. and L. W. Canter (1997). "Cumulative impacts are not properly addressed in environmental assessments." Environmental Impact Assessment Review **17**(1): 5-18.

Canter, L. W. and J. Kamath (1995). "Questionnaire checklist for cumulative impacts." Environmental impact assessment review **15**(4): 311-339.

CEQ. (1997). "Considering cumulative effects under the National Environmental Policy Act.", from https://http://www.energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/G-CEQ-ConsidCumulEffects.pdf.

Cooper, L. M. and W. R. Sheate (2002). "Cumulative effects assessment: A review of UK environmental impact statements." Environmental impact assessment review **22**(4): 403.

Cooper, T. A. and L. W. Canter (1997). "Documentation of cumulative impacts in environmental impact statements." Environmental Impact Assessment Review **17**(6): 385-411.

Crichton, D. (1999). The risk triangle. Natural Disaster Management. J. Ingleton. London, Tudor Rose**:** 102-103.

DOE (2013). Financial Assistance Request for Information: environmental research and observations at the first U.S. offshore wind facilities., Department of Energy. Request For Information: DE-FOA-0000911 CFDA Number: 81.087.

Duinker, P. and L. Greig (2006). "The Impotence of Cumulative Effects Assessment in Canada: Ailments and Ideas for Redeployment." Environmental Management **37**(2): 153-161.

Goodale, M. W. and A. Milman (2016). "Cumulative adverse effects of offshore wind energy development on wildlife." Journal of Environmental Planning and Management **59**(1): 1-21.

Hegmann, G., C. Cocklin, R. Creasey, S. Dupuis, A. Kennedy, L. Kingsley, W. Ross, H. Spaling and D. Stalker (1999). Cumulative effects assessment practitioners guide. Hull, Quebec, AXYS Environmental Consulting Ltd.

Hyder, P. L. C. (1999). Consulting guidelines for the assessment of indirect and cumulative impacts as well as impact interactions., Brussels: EC DGX1 Environment, Nuclear Safety and Civil Protection.

Irving, J. S., M. B. Bain, E. A. Stull and G. W. Witmer (1986). Cumulative impacts: real or imagined. United States, Argonne National Lab. Annual meeting of the Idaho Chapter of the American Fisheries Society, Boise I.D. U.S.A. .

MacDonald, L. H. (2000). "Evaluating and managing cumulative effects: Process and constraints." Environmental Management **26**: 299-316.

Masden, E. A., R. W. Furness, D. T. Haydon, A. D. Fox and R. Bullman (2010). "Cumulative impact assessments and bird/wind farm interactions: Developing a conceptual framework." Environmental Impact Assessment Review **30**(1): 1-7.

MMS. (2007). "Programmatic Environmental Impact Statement for alternative energy development and production and alternate use of facilities on the Outer Continental Shelf: Final Environmental Impact Statement.", from https://http://www.boem.gov/Guide-To-EIS/.

MMS. (2009). "Cape Wind EIS." from https://http://www.boem.gov/Cape-Wind-FEIS/.

Norman, T. B., R. S. K. Buisson and N. P. Askew (2007). Report on the COWRIE workshop on the cumulative impact of offshore windfarms on birds., Report prepared by RPS for COWRIE. COWRIE CIBIRD-01-2007.

Renn, O., M. Klinke A Fau - van Asselt and M. van Asselt (2011). "Coping with complexity, uncertainty and ambiguity in risk governance: a synthesis." AMBIO **40**(0044-7447 (Print)): 231-246.

Rumrill, J. N. and L. W. Canter (1997). "Addressing future actions in cumulative effects assessment." Project Appraisal **12**(4): 207-218.

Schultz, C. A. (2012). "History of the cumulative effects analysis requirement under NEPA and its interpretation in U.S. Forest Service case law." Journal of Environmental Law and Litigation **27**(1): 125-190.

Smit, B. and H. Spaling (1995). "Methods for cumulative effects assessment." Environmental Impact Assessment Review **15**(1): 81-106.

Smith, M. D. (2006). "Cumulative impact assessment under the National Environmental Policy Act: An analysis of recent case law." Environmental Practice **8**(4): 228-240.

Stein, E. D. A. R. F. (1998). "Cumulative impacts of Section 404 Clean Water Act permitting on the riparian habitat of the Santa Margarita, California Watershed." Wetlands **18**(3): 393-408.

UFWS (1998). "Endangered Species Consultation Handbook Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act."