Guidance for Establishing Wetland Buffers in CNMI to Protect "Environmentally Sensitive Areas" and Ensure "No Net Loss"

Scientific studies assessing the role of buffers surrounding wetlands and streams uniformly confirm that buffers are essential for the protection of these ecosystems. Wetlands, streams, and riparian areas provide a host of ecosystem services including improved water quality, flood mitigation, habitat for threatened and endangered species, as well as chemical functions including nitrogen fixation and carbon sequestration. In the Commonwealth of the Northern Mariana Islands (CNMI), wetlands are defined as ecosystems with one or more of the following indicators: hydric soils, hydrophytic vegetation, or visible wetland hydrology. Broadly speaking, "buffers" are defined as "linear bands of permanent vegetation, preferably consisting of native and locally adapted species, located between aquatic resources and adjacent areas subject to human alteration" (ELI 2003, *citing* Castelle et al. 1994, Fischer and Fischenich 2000).

Literature reviewed in this assessment included a range of wetland systems, including unique systems ranging from humid, semi-arid, and tropical where data was available. Part 1 of this report summarizes current literature assessing buffer functions and ecosystem services of wetland systems. Next, Part II highlights the scientific data on wetland and stream buffers in terms of function protection. Part III concludes with buffer recommendations and proposed next steps for wetland management to achieve a "no net loss" policy in CNMI.

I. Summary of Wetland Ecosystem Services and Buffer Functions

Wetlands provide numerous valuable functions including water quality improvement, flood moderation, groundwater recharge, wildlife habitat, soil creation, nitrogen fixation, carbon sequestration, as well as research opportunities, recreation, and aesthetic enjoyment (*see e.g.* Crance, 1988; Mitsch & Gosselink, 1993; ELI, 2003). Wetland buffers are transitional vegetated areas adjacent to wetland ecosystems that help protect wetlands from the adverse effects of development and other indirect activities within the watershed.

Buffers function to:

- *Maintain and improve water quality by trapping and absorbing sediments, nutrients, and pollutants before they reach the wetland;*
- *Expand the catchment area of fresh surface waters for groundwater renewal and recharge;*
- *Moderate hydrology by reducing rapid water level fluctuations in wetlands, which can in turn provide flood control in storm events;*
- *Decrease sound and light disturbance from activities in adjacent areas;*
- *Provide food, cover, travel corridors, and breeding areas for wildlife; and*

- *Support bio-chemical processes in wetlands including nitrogen fixation and carbon sequestration in soils.*

Because of increasing recognition of the myriad of values wetland systems provide, conservation efforts nationally have been focusing on improving wetland protection. Although the Clean Water Act of 1972 did establish federal protections for jurisdictional wetlands, numerous studies have concluded that wetland protection without buffer protection is inadequate to maintain and enhance the integrity of these systems, as detailed in Part II. Implications of these data and policy trends support recommendations for buffers in the CNMI proposed in Part III of this report.

II. Efficacy of Buffers to Protect Wetland Ecosystem Services

Studies assessing the efficacy of wetland buffers can be categorized as functioning to (i) protect and enhance water quality, (ii) mitigate negative impacts of hydrology, and (iii) provide fish and wildlife habitat. While few studies have assessed or quantified potential correlations between buffer size and carbon sequestration, valuation of wetland services is discussed briefly here in subsection (iv) in terms of quantification of benefits of healthy wetland systems, which subsections (i) – (iii) demonstrate is reliant on the establishment of minimum wetland buffers.

(i) Enhancing Water Quality

Often located in low-lying areas, wetland ecosystems are particularly at risk of sedimentation from upland sources and erosional scour due to increased water velocities from mismanaged upland surface waters (Brown & Schaefer, 1987). Vegetated wetland buffers can function to reduce the stressors and impacts to water quality by removing pollutants from sediment-laden runoff (Shisler et al., 1987) and allowing more time for removal of water-borne sediments and associated pollutants (WA ECY, 1992, *citing* Broderson, 1973). While numerous factors, including slope length and gradient, surface roughness, and soil hydrologic properties may influence the effectiveness of vegetative buffers, strong correlations have been observed between buffer width and pollutant removal (Phillips, 1989). Soils, plants, and bacteria in wetland buffers remove or transform soluble nutrients such as nitrogen and phosphorus as well as pollutants including heavy metals and fecal coliform yielding measurable water quality benefits (EPA, 1988; Murdoch & Capobianco, 1979; Shisler et al., 1987; Gallagher & Kibby, 1980). Water quality benefits vary not just with the size of the buffer, but also with the flow pattern, vegetation type, percent slope, soil type, surrounding land use, pollutant type and dose, and precipitation patterns (see ELI, 2008, *citing* Adamus, 2007; Wenger, 1999; Sheldon et al., 2005). Numerous studies indicate various resource management benefits of buffer size functions in relationship to water quality parameters, as detailed here in terms of (a) sediment removal, (b) nutrient removal, (c) fecal coliform removal, and (d) temperature moderation.

(a) Sediment Removal

In addition to supporting water quality functions, root systems of vegetated wetland buffers can control the severity of soil erosion during storm events (Shisler et al., 1987). As the Washington

Department of Ecology report summarizes, “Gilliam and Skaggs (1988) found that 50% of the sediment from agricultural fields was deposited in the first 288 feet adjacent to the exit location of the fields,” while “Horner and Mar (1982) found that a 200-foot grassy swale removed 80% of the suspended solids and total recoverable lead” (WA ECY, 1992). Direct, non-linear relationships between buffer width and percent sediment removal have been established, where buffer width requirements must increase to achieve greater sediment removal. In their studies, Wong and McCuen (1982) found that effective buffer widths approximately doubled from 100 feet to 200 feet at 2% slope when the design criteria increased from 90% to 95% sediment removal (WA ECY, 1992).

Numerous studies also assessed the effectiveness of buffers in protecting water quality adjacent to roads (Efta & Chung, 2014; Furniss et al., 1999; Bilby et al., 1989) or logging operations (WA ECY, 1992, *citing* Broderson, 1973, Darling et al., 1982, Lynch et al., 1985, and Corbett & Lynch, 1985). In a study of three watersheds in western Washington, Broderson (1973) noted the importance of vegetated buffers in resisting channelization and protecting water quality. These assessments indicated that buffers have little or no effect on sediment removal if water crosses the land as channelized flow, however, if maintained as overland sheet flow, 50-foot buffers were sufficient for controlling most sedimentation on less than 50% slopes (Id.). Steeper slopes required wider buffers. Broderson concluded that a maximum buffer width of 200 feet would be effective to control sedimentation on steep slopes, and further, recommended that buffer widths be measured from “visual signs of high water” (Id.).

In addition to buffer size, vegetation has also been found to play a significant role in sediment removal and water quality protection. Assessing an Oregon State University formula for protecting streams and wetlands from disturbance and sediment incursions, one report found that “best functioning” buffers demonstrated greater stability over time, and that buffer stability was enhanced by high percentages of vegetative cover (WA ECY, 1992, *citing* Darling et al., 1982). Literature reviews and field evaluations highlight agreement that while sediment trapping capacities of buffers are site-specific, the width of a buffer is a critical driver in effective sediment trapping (Yuan, 2009).

(b) Nutrient Removal

Numerous studies have assessed the efficacy of buffers in controlling nutrient inputs into wetlands and streams. Monitoring feedlots exposed to natural levels of rainfall, Vanderholm and Dickey (1978) found that buffer widths ranging from 300 feet at 0.5% slope to 860 feet at 4.0% slope were effective in removing 80% of nutrients, solids, and oxygen-demanding substances from surface runoff through sediment removal and nutrient uptake (WA ECY, 1992, pg. 8). When studying logging operations, Lynch et al. (1985) found that a 98-foot buffer reduced nutrient levels to “far below drinking water standards” (Id.). In Maryland’s wooded riparian buffers, 80% of phosphorous and 89% of nitrogen were found to be removed from agricultural runoff, with the majority of the removal occurring within the first 62.3 feet (WA ECY, 1992, *citing* Shisler et al., 1987). However, in North Carolina, 75-foot buffers for estuarine shorelines required by state regulations were found to be inadequate for filtering polluted non-point source runoff from typical residential developments (WA ECY, 1992, *citing* Phillips, 1989).

Rather than assessing nutrient removal in terms of buffer sizes by feet, some studies have considered buffer ratios. For example, when studying runoff from caged poultry manure, Bingham et al. (1980) reported that a 1:1 buffer area to waste area ration was successful in reducing nutrient runoff to background levels for animal waste applications (WA ECY, 1992, pg. 9). Similarly, WA ECY reports, Overcash et al. (1981) analyzed grass buffer strips as vegetative filters for non-point source pollution from animal waste and concluded that a 1:1 ratio of buffer area to waste area was sufficient to reduce animal waste concentrations by 90% to 100% (WA ECY, 1992). While other studies indicate that the efficacy of vegetative filter strips may decrease over time as sediments accumulate, these buffers nonetheless provide valuable water quality benefits including reducing localized erosion (Dillaha et al., 1986).

Fennessy and Cronk assessed the effectiveness and restoration potential of riparian buffers to manage nonpoint source pollution using data from major rivers in the U.S. and the U.K. found that vegetative buffer zones of 20 to 30 meters in width can remove up to 100% of incoming nitrate given "favorable conditions" (Fennessy, 1997). In an extensive review of scientific literature, the Environmental Law Institute concluded that data suggests "[d]epending on site conditions, much of the sediment and nutrient removal may occur within the first 15-30 feet of the buffer, but buffers of 30-100 feet or more will remove pollutants more consistently" (ELI, 2008). Given the correlation with land use intensity and water quality degradation, that report concluded that "buffer distances should be greater in areas of steep slope and high intensity land use" (Id.).

(c) Fecal Coliform Removal

Fecal coliform is used as an indicator of pathogenic microorganisms. Thus, removal of fecal coliform is considered beneficial to people and the environment. In 1981, Grismer developed a fecal coliform reduction model for dairy waste management which was applied to the Tillamook basin in northwestern Oregon. The model, which considered the effects of precipitation, season, waste storage and application, die-off of bacteria, soil characteristics, and other factors, suggested that a 98-foot "clean grass" strip would reduce concentrations of fecal coliform by 60% (WA ECY, 1992). Buffer strips were found to reduce concentrations of nutrients and microorganisms to "acceptable levels" in feedlot runoff during summer storms, with 70% coliform removal measured from a 100-foot grass filter strip (Id., *citing* Young et al., 1980). As Wenger summarizes, several studies highlight positive removal trends. Specifically, a 1973 study by Young et al. found that a 60 m (197 ft) long grass filter strip reduced fecal coliform by 87%, total coliform by 84% and BOD by 62% (Wenger, 1999, *citing* Karr and Schlosser 1977). In a study of nonpoint pollution control in Kentucky, 9 m (27-foot) grass filter strips removed 74% and 43% of fecal coliform in two plots (Coyne et al., 1995). Some reviews note that ranges in results for removal of fecal coliform associated with agricultural runoff in relation to buffer size are likely due to variable flow lengths and influent concentrations (Schueler, 1999). However, positive relationships between buffer size and removal rates are routinely reported.

(d) Temperature Moderation

Forested buffers adjacent to wetlands provide ground cover and shade, which helps maintain lower water temperatures in the summer and reduce temperature decreases in the winter. Temperature moderation is important to support healthy ecosystem functions in streams, wetlands, and receiving waters. For example, some studies have found that a minimum of a 40-foot buffer may be adequate to protect streams from excessive temperature elevation following logging, but that an area of 66 to 100 feet may be needed to protect riparian ecosystems from heavy sediment loads (WA ECY, 1992, *citing* Corbett & Lynch, 1985, and Corbett et al., 1978). Removing forest cover can result in apparently minor temperature changes that nonetheless may cause major impacts to fish communities that rely on narrow temperature ranges for survival (Wenger, 1999, *citing* Baltz and Moyle, 1984; Allen, 1995; Morris & Corkum, 1996). Higher water temperatures also decrease oxygen solubility, which harms many organisms and reduces water's capacity to assimilate organic materials and increases the rates at which nutrients solubilize and become available (Wenger, 1999, *citing* Karr & Schlosser, 1978). Because of these impacts, temperature regulation is increasingly viewed as an important function of vegetative wetland buffers.

(ii) Moderating Hydrology

Especially in systems where the majority of stormwater moves through the buffer as sheet flow, buffer vegetation aids in slowing flow rates and increasing residence time of the water, allowing more time for infiltration (WA ECY, 1992, *citing* Broderson, 1973). Numerous studies highlight the growing body of evidence that impervious surfaces are a "major contributor to changes in watershed hydrology" that drive physical, chemical, and at times biological shifts in wetland systems (see Wenger, 1999, *citing* Arnold & Gibbons, 1996; May et al., 1997, Trimble, 1997, Ferguson & Suckling, 1990; see also Crance, 1988). Wenger thus recommends that municipalities experiencing urban and suburban growth should consider enacting impervious surface controls in addition to buffers.

Buffer size also mediates hydrology, which plays a significant role in impacting other wetland functions (Nieber et al., 2011). The location and type of surface runoff as well as the magnitude of subsurface flow strongly influence the effectiveness of buffers (Id.). Based on variability of wetland buffer functions, this study and literature review recommended development of buffer ranking tools to further quantify how management goals were being met by established wetland buffers. While beyond the scope of this report, further study and quantification of wetland and buffers would be warranted, especially given the absence of location-specific data for highly erodible soils in the Pacific region.

(iii) Providing Habitat

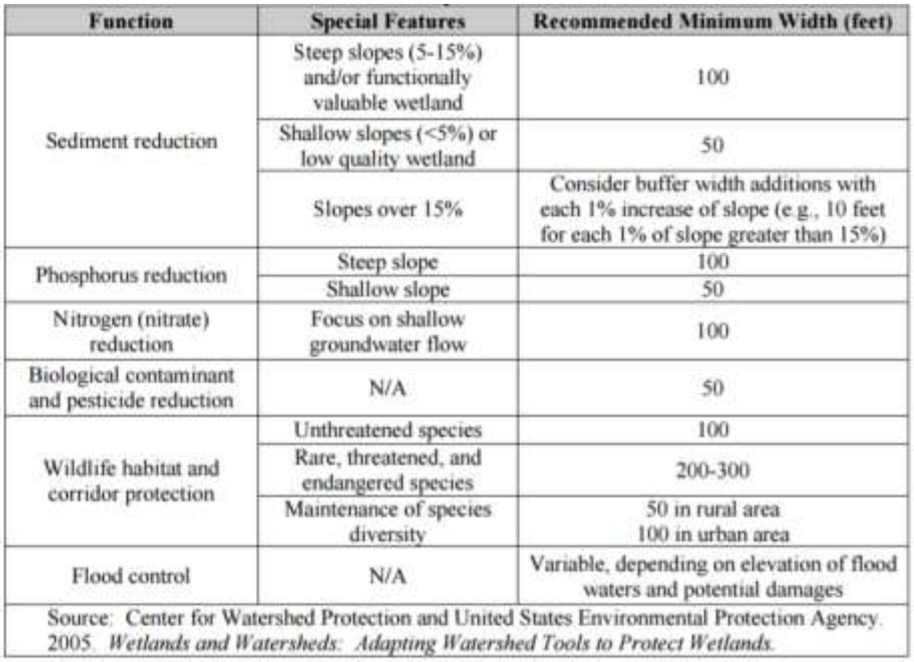
While few studies quantify the efficacy of buffers for habitat protection in the Pacific region, a wealth of data exists linking the importance of vegetative buffers to habitat functions. Moreover, intermittent systems that occur in semi-arid or tropical systems are sometimes mistakenly considered to provide little functional value. However, increasing literature indicates that intermittent stream systems play critical roles in maintaining wetlands, which in turn provide biological linkages for species adapted to these unique conditions (see City of Boulder, 2007). In two studies of California streams, both Erman et al. (1977) and Newbold (1980) found that a 98-foot buffer zone was successful in maintaining background levels of benthic invertebrates in streams adjacent to logging activities (WA ECY, 1992). Thus, establishing buffers on even intermittent streams can protect habitat values and functions of interconnected wetland systems.

Wetland buffers can also help systems maintain habitat functions that may otherwise be impacted due to nearby disturbances. In an assessment of 21 post-human disturbance wetland restoration projects, Cooke et al. concluded that effectiveness of a buffer in protecting adjacent wetlands was dependent on intensity of adjacent land use, buffer width, buffer vegetative cover type, and buffer area ownership. Buffers functioned most effectively when adjacent development was low intensity, when buffer areas were vegetated with shrub and/or forested plant communities and were 50 feet wider or greater, and when land owners understood the rationale for maintaining these buffer areas (Id.). In Hawaii, the Hawaii Conservation Reserve Enhancement Program supports wetland buffers of not less than 20 feet and up to 1,320 to support habitat values and ecosystem functions (HI DLNR, 2013).

III. Recommendations and Next Steps to Maintaining Healthy Wetlands in CNMI

This literature review highlights the importance of implementing minimum buffers on wetland systems to protect ecosystem functions and values. Authoritative sources indicate that adequate buffers are essential for "healthy" wetland systems (*see e.g.* Kusler & Kentula, 1989; Haycock et al., 1996). While few empirical studies have been published regarding wetland buffers in the Northwestern Pacific, extensive literature reviews of buffer studies across the United States as well as select international reports indicate that vegetative buffers are effective at protecting water quality of wetland systems, and that in general, buffer efficiency at filtering out pollutants increases exponentially with width to a certain extent (*see e.g.* WA ECY, 1992; Wenger, 1999; Hawkes and Smith, 2005; Kusler & Kentula, 1989; Davies & Lane, 1995; Haycock et al., 1996; Parkyn, 2004). However, as some literature notes, increasing filtration efficiency "does not increase infinitely;" for example, a study in the Mid-Atlantic found that 90% of sediments were removed by a 62 ft riparian buffer, but only 94% were removed by more than doubling the buffer width to 164 ft" (Hawkes and Smith, 2005). While ranges and the application of buffers vary, there is considerable consensus that to protect wetland values and functions, necessary buffers range from a minimum of 45 to 100 feet (15 – 30 meters) to maintain the "physical and chemical characteristics of aquatic resources" with widths towards the upper end of this range appearing "to be the minimum necessary for maintenance of the biological components of many wetlands and streams" (Castelle et al., 1994). Other reviewers conclude that, in the context of development and other natural stressors, buffers of 150 – 300 feet in size are recommended (JEA et al, 1999). To protect wildlife habitat functions, some studies indicate 100 – 600 foot buffers are recommended (Hruby, 2013), while, in Hawaii, vegetative buffers up to 1,320 feet are incentivized to protected wetland health and water quality (DLNR, 2013). Minimum buffer sizes to support specific management values that are suggested by the Center for Watershed Protection and USEPA are provided in Table 1 below.

Table 1: Recommended Wetland Buffer Sizes by Ecosystem Function



Function	Special Features	Recommended Minimum Width (feet)
Sediment reduction	Steep slopes (5-15%) and/or functionally valuable wetland	100
	Shallow slopes (<5%) or low quality wetland	50
	Slopes over 15%	Consider buffer width additions with each 1% increase of slope (e.g., 10 feet for each 1% of slope greater than 15%)
Phosphorus reduction	Steep slope	100
	Shallow slope	50
Nitrogen (nitrate) reduction	Focus on shallow groundwater flow	100
Biological contaminant and pesticide reduction	N/A	50
Wildlife habitat and corridor protection	Unthreatened species	100
	Rare, threatened, and endangered species	200-300
	Maintenance of species diversity	50 in rural area 100 in urban area
Flood control	N/A	Variable, depending on elevation of flood waters and potential damages

Source: Center for Watershed Protection and United States Environmental Protection Agency. 2005. *Wetlands and Watersheds: Adapting Watershed Tools to Protect Wetlands.*

In the CNMI, minimum vegetative buffers of 50 feet and 100 feet for "high value" wetlands were recommended by the Saipan Comprehensive Wetland Management Plan of 1990 (Comprehensive Management Plan) (ERCE, 1991). The Comprehensive Wetland Management Plan proposed ranking criteria for CNMI wetlands which include hydrophytic vegetation dominance, structural diversity, proportion of native to non-native plant species, extent and frequency of disturbance, wetland-dependent wildlife use, presence of endangered species, wildlife corridor, drainage system, open water component, size significance, and degree of isolation. This approach was adopted by the Bureau of Environmental and Coastal Quality's Division of Coastal Resources Management in the 2015 Rapid Assessment Methodology (RAM). With the development of this guide, wetland systems can be quantitatively valued, and high value systems can be afforded greater protections. As it is currently written in the CNMI RAM, reflecting the 1990 Comprehensive Saipan Management Plan, "High Value" wetlands are allocated larger buffer areas to support a range of conservation values, while "Low Value" wetlands are allotted smaller buffers that are still intended to maintain the integrity of those systems. The objective of these buffers is to allow for an expanded range of uses while controlling indirect impacts associated with development to sensitive wetlands.

As highlighted in Table 1 management goals influence recommended buffer sizes. A minimum 50-foot buffer will support sediment and nutrient reduction on shallow slopes and reduce biological contamination. On steeper slopes, or in more urban areas, higher buffer widths of 100-feet are recommended to further protect water quality. If the wetland system provides endangered species habitat, even larger buffers are recommended. Thus, the minimum recommended buffers suggested in the 1990 Comprehensive Saipan Management Plan are consistent with and reflect best available science from other jurisdictions.

Although studies that are specific to the unique ecosystems in the CNMI are lacking, it stands to reason that minimum buffer requirements from other jurisdictions can be applied to systems in the Pacific using a precautionary resource management approach. While further study and interagency discussions are warranted, a continuation of the 50-foot minimum buffer for all wetlands and 100-foot buffer for “high value” wetlands is encouraged to achieve water quality and ecosystem management goals. In areas with steep slopes or which are exposed to a large influx of urban nonpoint source pollution, doubling these minimum recommended buffers may be necessary to ensure no degradation of water quality or the wetland system as a whole.

While buffer width recommendations vary depending on site conditions and management goals, there is also value in fixed-width buffer recommendations; they are more easily established and enforced, allow for greater regulatory predictability, and require smaller expenditures in both time and money to administer (Castelle et al., 1994). Moving forward, recommendations of the 1990 Comprehensive Management Plan and the 1996 CNMI Wetlands Management Report to Governor Froilan C. Tenorio (Wetlands Management Report) should be revisited. Considering the growing development pressure and limited available land in the CNMI and on Saipan specifically, the suggestion of continued interagency dialog to discuss the establishment and management of a wetland mitigation bank in compensation for activities that result in wetland loss or degradation may be prudent.

As the 1996 Wetlands Management Report noted, despite challenges and shortcomings, mitigation banking may provide a more efficient and predictable regulatory process, as well as a means to recover certain wetland dependent endangered species. Moreover, “wetland mitigation banking is but one of several methods that can be used to improve the wetland regulatory framework, where 'improve' means streamlining the wetland regulatory framework, making it more efficient for applicants and regulators, and minimizing the negative impacts to wetlands from compensatory wetland mitigation” in the CNMI (Wetlands Management Report). Other tools to maintain the “no net loss” wetland policy, such as the development of wetland replacement and restoration guidance for areas that have been or are proposed to be impacted or filled, should be pursued.

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