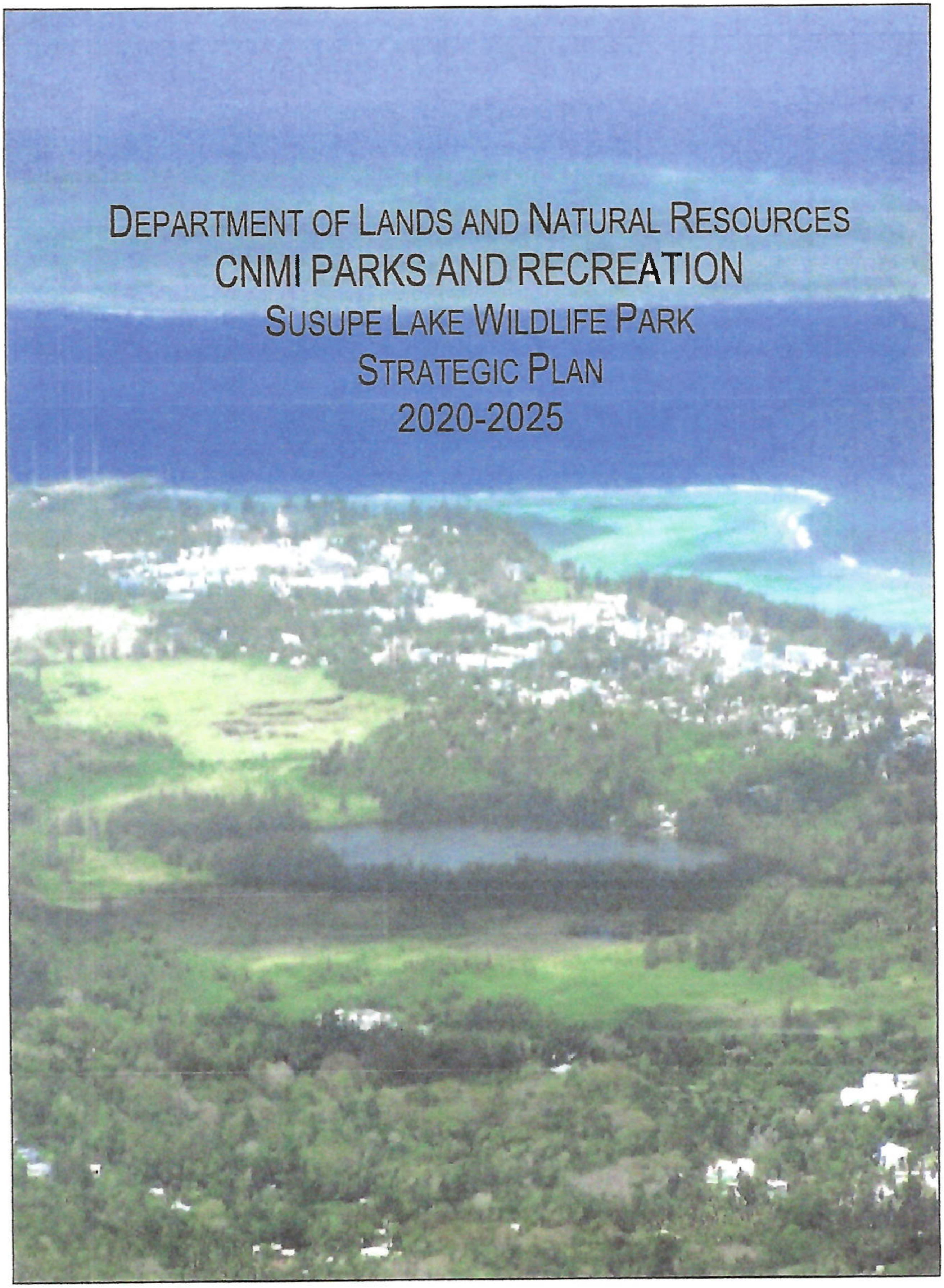
DEPARTMENT OF LANDS AND NATURAL RESOURCES
CNMI PARKS AND RECREATION
SUSUPE LAKE WILDLIFE PARK
STRATEGIC PLAN
2020-2025



I. INTRODUCTION

Wetlands provide many beneficial functions that need to be protected. Among these are flood flow alteration, sediment trapping, nutrient retention/removal and provision of important habitat for fish and wildlife. The extent of wetlands (including forested wetlands) in the CNMI has declined greatly in the past 50 years because of conversion to other land uses and development.

Although the rate of wetlands loss has slowed in recent years, CNMI continues to face challenges in terms of land use for economic development. Current Data Layers indicated that 6% has been weighted for Wetlands in the CNMI.

Executive Summary

The Strategic Wetland Management Plan of Susupe Lake Wildlife Park was formulated under Implementation of Public Law 20-91.

The strategy was formulated based on five basic principles:
1) Ecosystem management;
2) Wetland conservation and wise use;
3) Multi-stakeholder participatory planning
4) Precautionary approach; and
5) Economic stability

Susupe Lake Wildlife Park

"To have abundant water bird and fish species, and to increase the natural heritage and beauty of Susupe Lake Wildlife Park for eco–tourism. The Division of Parks and Recreation will seek cooperation from all local stakeholders to protect, conserve and rehabilitate deteriorated areas for conservation and sustainable wise use of the wetland resources"

Three mission statements of the Strategy are:

1. To restore Susupe Lake Wildlife Park and surrounding areas to the natural healthy state for maintaining and functioning wetland values.
2. To strengthen the effectiveness of protection and conservation of Susupe Lake through the participation of local multi-stakeholders and related organizations.
3. To encourage wise use of Susupe Lake Wildlife Park and promote it to be a well known eco-tourism destination in the CNMI

For the vision and missions to succeed, the working planning team prepared the strategy details consisting of goals, objectives, guidelines, strategic actions, indicators and management zones covering the two.

These projects will be implemented over the 5 year period 2020-2025. The Division will be responsible for training the officers and stakeholders to have knowledge and understanding so that they can apply the strategy to effective actions consistent with the roles and responsibilities of the organizations.

The monitoring with the participation of government agencies and local people is designed in 3 levels:
1. The progress of applying the strategy to implementation;
2. The progress of project implementation; and
3. The awareness of stakeholders and the change in status of wetland ecosystem and environment.

The results of monitoring will assess the effectiveness of project implementation and how far it achieves the vision, goals and objectives defined in the strategy. These outputs are valuable for current management to adapt and improve future implementation of the strategy that will lead to gaining support from the communities and responsible agencies in the future.

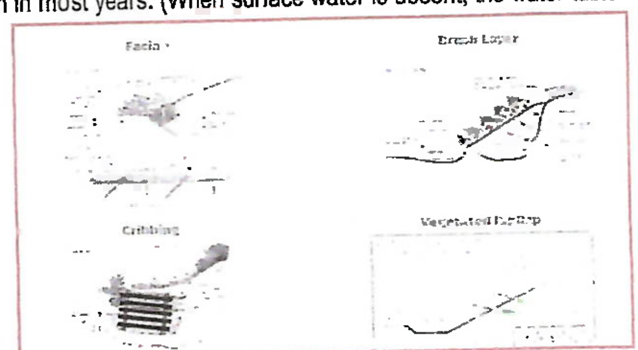
Circumstances in which mechanical site preparation and activities will require additional consideration and sensitivity.

Any mechanical site preparation activities have measurable and significant effect on aquatic ecosystems when conducted in wetlands that are permanently flooded, intermittently exposed, or semi-permanently flooded, and in certain additional wetland communities that exhibit aquatic functions and values that are more susceptible to effects from these activities.

The project will be required in the following areas unless they have been so altered through past practices (including the installation and continuous maintenance of water management structures) as to no longer exhibit the distinguishing characteristics. For the wetland types identified, mechanical site preparation and activities for projects can be evaluated on a case-by-case basis for site preparation and potential associated with environmental effects.

Permanently flooded wetlands, intermittently exposed wetlands, and semi-permanently flooded wetlands.

- Permanently flooded wetland systems are characterized by water that covers the land surface throughout the year in all years.
- Intermittently exposed wetlands are characterized by surface water that is present throughout the year except in years of extreme drought.
- Semi-permanently flooded wetlands are characterized by surface water that persists throughout the growing season in most years and, even when surface water is absent, a water table usually at or very near the land surface.
- Seasonally flooded wetlands are characterized by surface water that is present for extended periods, especially early in the growing season, but is absent by the end of the season in most years. (When surface water is absent, the water table is often near the surface.)
- *Tidal freshwater marshes*. These wetlands are regularly or irregularly flooded by fresh water. They have dense herbaceous vegetation and occur on the margins of estuaries or creeks.



Best Management Practices

The BMPs below were developed because mechanical enhancement have the potential to result in effects on an aquatic ecosystem. Mechanical enhancement for have the potential to cause effects such as soil compaction, turbidity, erosion, and hydrologic modifications if the activities are not effectively controlled by BMPs.

- *Position shear blades or rakes at or near the soil surface and windrow, pile, and otherwise move logs and logging debris by methods that minimize dragging or pushing through the soil to minimize soil disturbance associated with shearing, raking, and moving trees, stumps, brush, and other unwanted vegetation.*
- *Conduct activities in such a manner as to avoid excessive soil compaction and maintain soil tilth. Arrange windrows in such a manner as to limit erosion, overland flow, and runoff.*
- *Prevent disposal or storage of logs or logging debris in SMAs. Maintain the natural contour of the site and ensure that activities do not immediately or gradually convert the wetland to a non-wetland.*
- *Conduct activities with appropriate water management mechanisms to minimize off-site water quality effects.*

In the CNMI, wetland serves as critical cover for fragile soils, habitats for a diverse wildlife species, and corridors for various cultural and traditional resources. Where healthy forests are present, island life is enhanced by replenishment of clean fresh water, intact productive soil, abundant wildlife, healthy reefs, and lagoons that provide seafood and countless wetland resources for native islander's traditional needs and uses.

Fresh water becomes scarce and marine wildlife disappears it is from the continual increase of sediment and chemical changes. These impact would only attribute to too much soil deposit from stream source. Therefore, vegetation are a critical importance in maintaining all of the most necessary things that sustain life: water; soil and food.

In addition, the vegetation surrounding the wetland moderates temperature while balancing the islands ecosystem. When carefully managed, wetlands also provides a sustained yield of herbal medicine, food and fiber to meet the needs of island people. They're vital to the health of our communities, giving us clean and abundant water through aquafer filtration, protecting us from flooding, and reducing the effects of climate change.

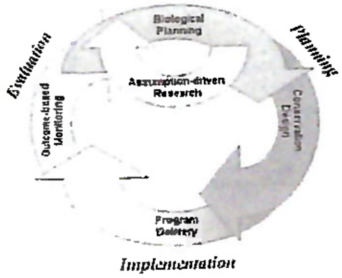
Still, wetlands are sensitive ecosystems - and they're under pressure from land conversion, invasive species, pollution and climate change. Without proper action, our wetlands will be severely be impacted, with many likely to disappear in the face of these significant threats.

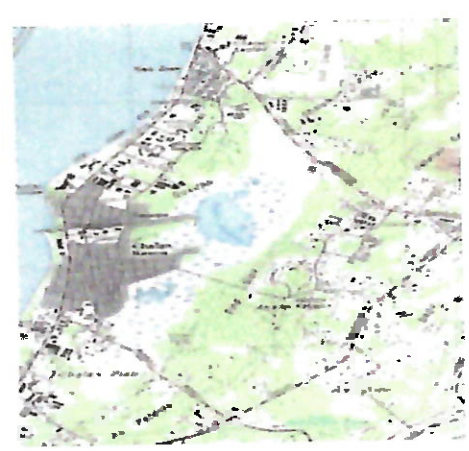
Findings and Purposes.

The Twentieth Northern Marianas Commonwealth Legislature (Legislature) finds that Susupe Lake and its surrounding wetland have been sanctuary for different wildlife species on Saipan, including other bird species from other countries that frequent the place yearly due to climate change in the country of their origin.

The Legislature further finds that Susupe Lake and its surrounding wetland are being destroyed by erosion and water runoff from the nearby hill sides, and by polluters, threatening the endangered wildlife species and their natural habitats. The Legislature believes that these can be prevented by creating programs that are adaptable to such environment, which would provide protection to the endangered wildlife species and their habitats; saving Susupe Lake and its surrounding wetland. And, to meet and accomplish such purposes, Susupe Lake and its surrounding wetland shall be designated for the establishment of "Susupe Lake Wildlife Park", which shall be under the management of the Department of Land and Natural Resources, Division of Parks and Recreation. Small business concessions that are appropriate in such environment and other attractive public amenities for the enjoyment of the local people and their families, visitors, and tourist alike will be an addition of the Susupe Lake Wildlife Park; thus, promoting tourism and the island economy.

The emergence of new, complex conservation challenges over the last decade has spurred the development of a variety of new approaches to systematically plan, prioritize and implement conservation actions. Although the specific management systems vary across organizations and agencies, these approaches generally emphasize an adaptive management cycle of clear, measurable conservation goals; science-based design of conservation actions; efficient, coordinated delivery of conservation actions; and monitoring to measure results and inform adaptive management.





Biological Planning

Terrestrial habitats surrounding wetlands are critical to the management of natural resources. Although the protection of water resources from human activities such as agriculture, silviculture, and urban development is obvious, it is also apparent that terrestrial areas surrounding wetlands are core habitats for many semiaquatic species that depend on mesic ecotones to complete their life cycle. For purposes of conservation and management, it is important to define core habitats used by local breeding populations surrounding wetlands.

Conservation Design

The benefits of restoration of degraded or destroyed wetlands and creation of new wetlands has only recently been recognized. As the population has expanded across the Nation during the past few centuries, wetlands have been drained and altered to accommodate human needs. These changes to wetlands have directly, or indirectly, brought about changes in the migratory patterns of birds, local climate, and the makeup of plant and animal populations. In the past, people used wetland plants and animals for shelter and food. More recently, people have become more aware of other benefits that wetlands provide water-quality improvement, flood attenuation, esthetics, and recreational opportunities. Now, it is recognized that numerous losses are incurred when a wetland is damaged or destroyed. Restoration and creation can help maintain the benefits of wetlands and their surrounding ecosystems, and at the same time accommodate the human need for development.

Wetland restoration rehabilitates a degraded wetland or reestablishes a wetland that has been destroyed. Restoration takes place on land that has been, or still is, a wetland. A term commonly associated with restoration is "enhanced." An enhanced wetland is an existing wetland that has been altered to improve a particular function, usually at the expense of other functions.

Ecological issues and physical limitations:

Wetlands are being considered increasingly important for wastewater treatment because of the ability of many wetland plants to absorb large amounts of nutrient and a variety of toxic substances. The paper highlights the physical, chemical and biological processes which contribute to the improvement of water quality, and the distinction between natural and constructed wetlands. The impacts of long-term wastewater disposal on the biotic changes, reduction in treatment efficiency, and wetland processes such as production of trace gases, are pointed out. It is suggested that while the possibilities for using constructed wetlands based on native species for small communities are explored, greater emphasis should be laid on the restoration of lost and degraded wetlands, especially the river floodplains, lake littorals and coastal wetlands, which can help check pollution from non-point sources.

Questions of this type always arise during planning for wetland restoration and conservation design. Although the wetlands continue to evolve as sediments are trapped and deposited by the vegetation (thus raising the elevation), it might take another 50 years for the restored wetlands to become similar again to the original high marsh (Frenkel and Morlan, 1991). The time required and the ability to develop a fully functional soil system in project wetlands may be major determinants of the eventual acceptance or rejection of restoration and creation as management options.

It is difficult to make a definitive statement about the ability to replace wetland functions. Goals for restoration and creation projects seldom are stated and information on the existing functions of the wetlands seldom are documented. This is due, in part, to the difficulty and expense of quantifying wetland functions. Also, responsible monitoring during construction and after completion of the project wetland is uncommon. Most information available on project wetlands is in the form of qualitative case studies.

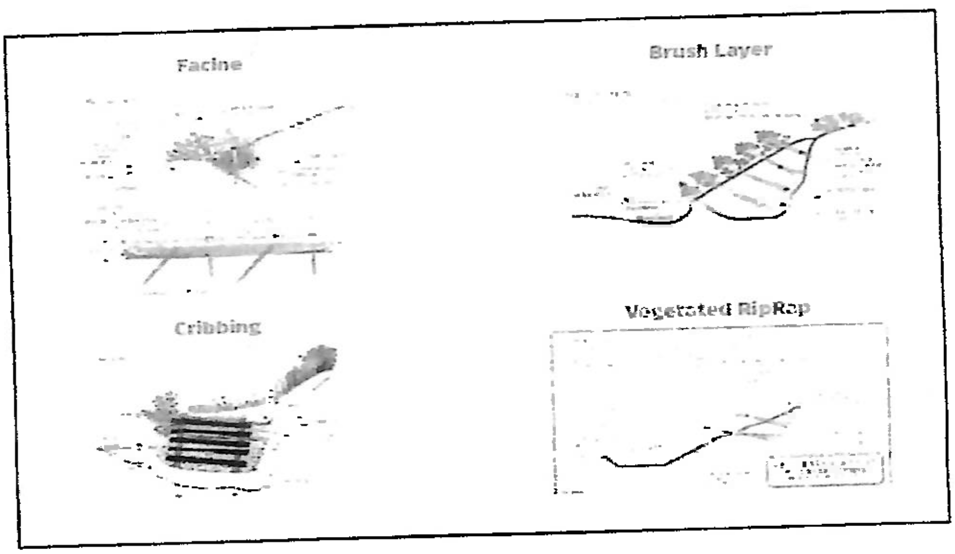
Choosing Materials

Materials used in trail design should be appropriate for the setting. Steel, plastic, concrete, and asphalt may be appropriate in an urban greenbelt, but out of place in the backcountry. Log construction, stone masonry, and dirt trails are appropriate in a primitive, backcountry setting, but out of place in a city. The Forest Service recognized this problem in the late 1970s and developed a system called the Recreational Opportunity Spectrum (ROS). The ROS system establishes seven types of recreational land uses and describes the level of development, management, and construction materials suitable for each of them. The ROS principles may appear overly structured, but their application should result in construction and management that is compatible with the environment surrounding a wetland trail whether that trail is in a remote area, an urban greenbelt, or another setting. The ROS concepts are too detailed to include here, but they should be understood by anyone planning to design and construct wetland trails.

Logs

Wood from logs cut onsite is commonly used in trail construction, but wood is susceptible to attack by insects and fungi. Bark separates from the wood. The gap collects water and provides shade and protection for insects and fungi. Peeling off the bark reduces the likelihood of these attacks. Depending on local conditions, removing the bark may double the life of a log. The bark can be removed by hand or machine. Using a draw knife or bark spud is the traditional way of peeling logs. The random scrape marks left on the peeled logs gives them a rustic appearance. Machine peeling "chews" the bark and some of the wood in a spiral pattern. The finished pieces are almost uniform in size, with a machined appearance that lacks the rustic character of peeled logs. Wood that is exposed to the weather or is in contact with the ground will eventually require replacement. In wetlands, a flood, a heavy snow, a buildup of ice, fallen trees, or animal damage may shorten the life of wooden materials. Trees growing near a wetland site are unlikely to provide a sustainable source of logs for replacement structures. Even in remote areas, logs cut from trees growing in the vicinity may not be the best choice of materials.

Using logs cut onsite for trail construction is an inefficient use of wood and does not represent sustainable design. Tearing up areas near a site and destroying the character of the wetland makes no sense. Today, responsible trail crews are taking commercially obtained logs and other wood materials to remote wetland sites by boat, horse, mule, off-highway vehicle, by hand, or by helicopter, even when adequate material is growing a few feet from where it could be used. Sometimes materials can be hauled in more easily over snow during the winter for use the following summer.



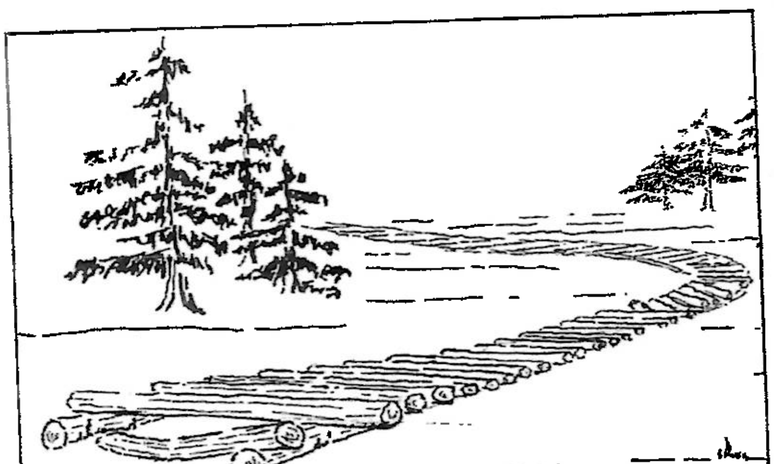
Monitoring:

Wetland monitoring is defined as the systemic observation and recording of current and changing conditions. Wetland resource planning, management, modeling, and policy formulation rely on scientifically sound information regarding the extent, type, and condition of wetlands on the landscape. This requires characterization of wetland resources as well as developing an understanding of how these systems respond to environmental change. Wetland monitoring programs will provide these pertinent information to maintain sound management decision.

Public pathways:

At least eight types of trail structures are commonly built in wetlands. Some of these are built with no foundation. Others have sleepers (sills), cribbing, or piles as foundations. Most of these structures are built of wood. The oldest methods for building a wetland trail were corduroy and turnpike, which require no foundation. Turnpike may require constructing timber culverts, which involves building two small timber walls. The walls must rest on a buried timber sill. Planks span the space between the walls. The various types of puncheon, gad bury, and the simplest form of bog bridge construction may be built on a foundation of sleepers, or on log or timber cribbing. Cribbing is more difficult to construct and is used occasionally where the terrain is hummocky (having small mounds of vegetation interspersed with depressions that hold water). Bog bridges and boardwalks are often supported on pile foundations. Three types of pile foundations have been used for bog bridges and boardwalks: end-bearing piles, friction piles, and helical piles. Piles are the most labor-intensive foundation. Helical piles and some friction piles require specialized machinery for installation. Floating trails are another, less common, technique. Where they are used, you need some form of anchorage. In this manual we describe the structures more or less in historical order. The oldest are early in the list, and the newest or most difficult to construct appear toward the end. The older structures can be built without machines, although machines make the work go faster. The newer structures are easier to build if machinery is available.

Basically, a boardwalk is a series of connected bridges, each with a span as long as is practical, perhaps 8 to 40 feet. At most wetland sites, longer stringers are not practical because they are difficult to transport. Also, building adequate foundations for the long spans often requires large pieces of specialized equipment that cannot negotiate unstable soil.

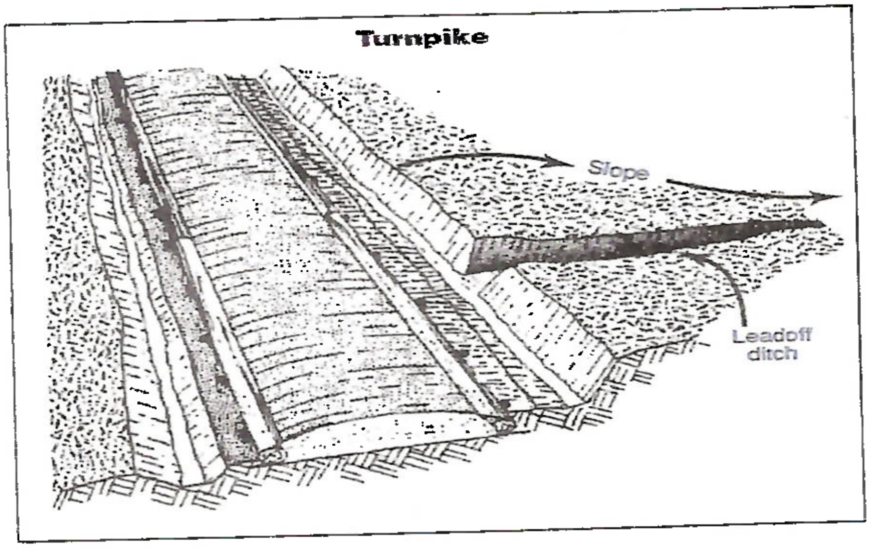


CORDUROY

Corduroy was originally used to provide access through wetlands to areas being logged or mined. Essentially, the technique involved laying a bridge on the ground where the soil would not support a road. Two log stringers or beams were placed on the ground about 6 feet apart. Small-diameter logs or half logs were placed on the stringers, spanning them. The logs became the tread or surface of the road. They were spiked or pinned to the stringers. A variation of corduroy construction was to place the tread logs directly on the ground. No stringers were used, and the logs were not pinned or spiked to the ground or each other. Some excavation was required to ensure the tread logs were level. The tread logs eventually heaved up or sank, creating severe cross slopes in the tread. Corduroy construction was often used in areas with deep shade and considerable rainfall. The combination of sloping, wet tread resulted in a slippery, hazardous surface. The stringers and tread logs soon rotted. With no support, the cross slope on the tread logs became worse and more hazardous. When corduroy was laid directly on the ground, it interfered with the normal flow of runoff. Runoff was blocked in some areas and concentrated elsewhere. Erosion and relocation of minor streams resulted. No plants grew underneath the corduroy, further damaging the wetland resource. Many trees needed to be cut to provide the logs for the corduroy. In many cases, these impacts would be unacceptable today. The useful life of corduroy today is only 7 to 10 years. Corduroy is rarely replaced because suitable trees are even farther from where they are needed for the reconstruction job. Corduroy did not represent sustainable design and required considerable maintenance. Corduroy is rarely used today. We do not recommend it.

Turnpikes

Turnpikes are used to elevate the trail above wet ground. The technique uses fill material from parallel side ditches and other areas to build the trail base higher than the surrounding water table. Turnpike construction is used to provide a stable trail base in areas with a high water table and fair- to well drain soils. A turnpike should be used primarily in flat areas of wet or boggy ground with a 0- to 20-percent side slope. The most important consideration is to lower the water level below the trail base and to carry the water under and away from the trail at frequent intervals. Turnpikes require some degree of drainage. When the ground is so wet that grading work cannot be accomplished and drainage is not possible, use puncheon or some other technique. A turnpike is easier and cheaper to build than puncheon and may last longer. A causeway is another alternative where groundwater saturation is not a problem and a hardened tread is needed.



Trail turnpikes usually cost less than other techniques for crossing seasonally wet areas. Occasional culverts are needed for cross drainage under the turnpike

Lumber and Timber

For the purposes of this text, lumber is wood that has been sawed and planed into uniform pieces with a minimum dimension of 2 inches or less. For instance, a 2 by 6 is a piece of lumber. Timber is wood that has been sawed into more or less uniform pieces, with a minimum dimension of at least 3 inches. Usually, timbers have not been planned smooth. It helps to understand how logs are processed into lumber and timbers. Logs run through a saw-mill are typically sawed into standard-size pieces, usually 1-inch thick or in increments of 2 inches. Common sizes are: 1 by 4, 1 by 6, 2 by 4, 2 by 6, 2 by 8, and 4 by 4. The pieces can also be cut into 3-inch stock. However, such nonstandard timbers would not be readily available at the local lumberyard. Most 4-by-4, 6-by-6, and larger timbers are cut from the center of the log.

Generally 1- and 2-inch materials are cut from the outside of the log. After the pieces of wood are cut from the log, they are referred to as rough sawn. The first step produces a piece that is sawn on its two widest faces. The bark remains on the narrow edges. At this point the piece is described as rough sawn and waney edged. The edges are not parallel or square. Waney-edged wood is used for rustic siding. Waney-edged lumber can be special ordered (figure 68).

Next, the piece of wood is run through another saw, the edger, that trims the edges square and to a standard 2-inch dimension. The piece of wood is now rough sawn on all four sides and is full size—a 2 by 4 is 2 inches thick, 4 inches wide, and as long as the log. The pieces are cut to

The most common sizes of boards used for boardwalk and bog bridge construction.

Size of board	Length of board (ft)						Finished size (inches)
	6	8	10	12	14	16	
	Yield (board ft)						
1 x 6	3	4	5	6	7	8	¾ x 5½
2 x 4	4	5.33	6.67	8	37	11	1½ x 3½
2 x 6	6	8	10	12	14	16	1½ x 5½
2 x 8	8	10.67	13.33	16	19	21	Normally rough sawn
2 x 10	10	13.33	16.67	20	23	27	Normally rough sawn
2 x 12	12	16	20	24	28	32	Normally rough sawn
3 x 4	6	8	10	12	14	16	Normally rough sawn
3 x 6	9	12	15	18	21	24	Normally rough sawn
3 x 8	12	16	20	24	28	32	Normally rough sawn
3 x 10	15	20	25	30	35	40	Normally rough sawn
3 x 12	18	24	30	36	42	48	Normally rough sawn
4 x 4	8	10.67	13.33	16	19	21	3½ x 3½
4 x 6	12	16	20	24	28	32	Normally rough sawn
6 x 6	18	24	30	36	42	48	Normally rough sawn

standard lengths. Normally, the shortest pieces are 8 feet long. Longer pieces are cut in multiples of 2 feet, up to 16 feet. Rough-sawn lumber or timbers can be ordered. A piece of rough-sawn, 2-inch lumber is considerably heavier than the finished lumber normally carried at a lumberyard. Rough-sawn pieces are not completely uniform.

Depending on the capability of the saw-mill, similar pieces may vary 1/8 to 3/8 inch from each other. The pieces will not have a smooth surface, and the edges will be sharp and splintery. Finally, the rough-sawn pieces are run through a planer. The planer removes enough wood to smooth the surface on all sides and to produce standard-size pieces. After planning, a 2 by 4 is 11/2 inches by 31/2 inches and is described as S4S (surfaced four sides). The size after the lumber has been surfaced on all four sides is referred to as nominal size. Most 2-by-4 material is usually run through a special planer to round off the corners. This process is called edges eased and reduces the chances of splinters when handling the wood. Edges eased can also be specified for other dimensions of lumber and the smallest dimension timbers, but must be special ordered. Waney-edged material should be less expensive than rough sawn because it requires less processing. Rough-sawn material should also be less expensive than nominal-size material because it has not been through a planer or had the edges eased. If the imperfections of waney-edged or rough-sawn material are acceptable, there is no point in specifying the nominal size material for a project. Why pay for someone to turn wood into sawdust and shavings that you can't use? Besides, the additional work results in a weaker piece of wood. Wholesalers sell wood by the thousand board feet. A board foot is 12 inches by 12 inches and 1 inch thick, or 144 cubic inches. The board footage of lumber and timber is determined at the time the piece of wood is rough sawn.

Public amenities in the Susupe Lake Park would include suitable building, public rest area, nature reserve, botanical or other garden hiking trail, recreational grounds or open space which is the property of the DLNR-Division of Parks and Recreation.

Wildlife Watching

- A bird watching / feeding station invites a variety of songbirds and water fowl can be seen occasionally seen or sighted in the woods surrounding the Park.
- Five-lined skinks and green anoles make their home around the deck, while many other reptiles and amphibians, including toads, land turtles are regularly seen.
- Susupe Lake also hosts many small invertebrates including wasps and spiders that nest there. An occasional skink can be seen looking for a meal, as well.
- In the warmer months, many different species of butterflies, moths, dragonflies and other pollinating insects can be seen around busy pollinating.

Rest Stop

- Easy access
- Benches on the public deck
- Restrooms and water fountains
- Picnic tables in a shady location allow for a relaxing for lunch.

Dock:

A floating dock, floating pier or floating jetty is a platform or ramp supported by pontoons. It is usually joined to the shore with a gangway. The pier is usually held in place by vertical poles referred to as pilings, which are embedded in the seafloor or by anchored cables.

Piling docks are built by driving heavy wooden beams known as "pilings" (think telephone poles, but shorter) deep into the bed of the lake. The frame is then attached to the pilings, forming a sturdy, wooden walkway. Piling docks typically cost $20-$40 per square foot, depending on the installation.

FLOATING DOCKS

Floating docks are large platforms, often decking placed over airtight drums, which float on the water's surface. They also are available as pre-built sections that can be attached in a variety of configurations and shapes. Floating docks are versatile and rise or fall with the water level, helping them adapt to nearly any condition. They are also ideal solutions for sea, lake or river beds that are unable to support the installation of a fixed dock.

Floating docks are also more practical than other types of docks. They often have fewer permitting requirements because they do not damage sediment. Because they rise and fall with water levels, any critical electrical systems attached to the dock surface will never be submerged. In instances of severe weather or during seasons in which the structure is not in use, floating docks can be hauled away to a safe storage location and easily put back in place when needed. In addition, floating docks can remain in the water all winter in certain instances, such as in locations where there is not a lot of wind or water current that can push the ice against the docks (thus, possibly damaging them).

PILING DOCKS

Piling docks are constructed by inserting large wooden beams called pilings deep into the ground under the water. The dock is then connected to the piling — typically by an attachment that contains hoops, rollers, or both — which will then allow the dock to rise and fall with changing water levels while still maintaining its position in the water. Piling docks are strong and stable, and can withstand strong currents. However, they are expensive to build and maintain, and can't adjust as water levels change. They work best for larger boats or as a fishing dock.

When choosing a piling dock, it's imperative that you plan out its construction thoroughly. The success of this dock rests on its structural integrity, so any mistakes or cut corners could ultimately cause thousands of dollars' worth of damage. Wood posts could rot if not properly treated, so a fiberglass alternative may be used. You also need to protect the pilings from other destructive organisms and protect the piling caps from harmful UV rays.

PIPE DOCKS

Pipe docks are similar to piling docks but are usually built using an aluminum frame with removable docking. They are less stable than piling docks but also less expensive. This makes them an easy-to-build and cost-effective docking system. Pipe docks work well in shallow water — no more than eight feet — and need to be removed in the fall to prevent freezing from damaging the pipes. Since the surface doesn't make significant contact with the land or water, it is one of the least environmentally impactful docking options.

A pipe dock is stationary. While floating docks can rise and fall with the water level, pipe docks can become submerged easily. It's recommended that the dock is raised, lowered or relocated in regions where seasonal variations may significantly influence water level or cause the water to freeze over. Though this dock system is initially less expensive, ice and rough currents may damage the piping or surface. Owners should anticipate repairing or replacing the pipes or surface sections occasionally.

TYPES OF PERMANENT DOCKS: If you'd rather have a permanent dock, you have two main choices:

CRIB DOCKS

Crib docks are made from wooden frames or crates, called cribs, placed along the bottom. These permanent, custom-built wooden frames are then filled with large rocks and covered with decking. Crib docks are very stable and typically very expensive. They basically extend the shoreline and can affect the natural flow of water and disrupt wildlife. Some areas don't allow crib docks because of this.

A crib dock should last for decades, which makes it a great docking structure for permanent applications. However, those who select this type of dock are trading convenience for stability. Crib docks are intended to be installed for long-term use, which means it cannot easily be removed or extended. Crib docks may also cause long-term environmental problems, like disrupting the water flow along the shoreline, affecting nearby wildlife and causing further issues if a flood were to occur.

SUSPENSION DOCKS

Almost the opposite of crib docks, suspension docks hang over the water via cables and anchorage. These docks have a modern appearance and have much less of an impact on the environment compared to crib docks. Their interesting design may be visually appealing; however, due to the engineering required in its installation, suspension docks are very costly and time-consuming.

Much like crib docks, installing a suspension dock is not a decision that should be made until all factors have been considered. There are some drawbacks that suspension dock owners may not immediately anticipate. For instance, while floating docks can be removed during instances of severe weather, suspension docks are stationary and are forced to endure potentially damaging winds or water swells. If the dock is made from wood or aluminum, damaged pieces may cost more to replace than plastic materials.

DOCK MATERIALS

Choosing a dock involves much more than simply picking a style that meets your visual expectations. As described, there are many features of both fixed and floating docks that make each suitable for a particular application. The type of material used to construct the dock should be another critical consideration when designing your new or replacement dock. To make the best decision for your water-side structure, you should examine factors including initial cost, durability, upkeep, damage risks and environmental impact.

Thankfully, you have options when it comes to building both a floating and fixed dock. Wood, aluminum and plastic are three popular boat dock decking materials you'll likely consider. Though all three can provide watercraft owners with a sturdy and reliable platform for launching watercraft, not all materials have similar benefits. The differences between the three impact everything from long-term operating and ownership costs and maintenance responsibilities to the way these materials may potentially cause harm to the environment and those who use the dock.

WOOD DOCKS

Some may picture a traditional wooden dock for their property and it's easy to see why. For those who prefer a natural look, wood is aesthetically pleasing. Though wood is a traditionally well-known boat dock decking material, it does have several drawbacks — including intensive upkeep, a variable lifespan and limited safety hazards. Other factors include:

Cost:

Prices for new wooden decking materials will vary depending on the actual type of wood used. Cedars and hardwoods could range from $3.50 to $4.36 per square foot to as much as $5.00 to $7.50 per square foot. Though many pressure-treated kinds of wood will also fall into that range, synthetic woods can be as expensive as $35 per square foot. However, if you have an existing older dock that doesn't have structural damage, you will want to invest in upkeep and maintenance, as restoring it to its former beauty regularly will increase its longevity.

Insect Damage:

Termites aren't the only threat to wood docks or docks with wood decking — many types of insects can damage untreated wood. Power post beetles could be attracted to the dock and decking depending on the area you live in, and nest in untreated wood — which may not begin to show signs of damage until the beetles emerge. Carpenter ants may nest in wood that's been damaged and begin to tunnel through the structure. Carpenter bees may also bore into wood to lay their eggs.

Upkeep:

Painting and sealing pine or wooden docks is only a temporary solution. Continued exposure to fresh or salt water and rain will cause wood to eventually rot and degrade. Pressure-treated lumber may require constant monitoring and preventative maintenance to stop the wooden components from degrading and ruining the dock. A wood dock may also need to be refinished every two to three years.

Repairs:

Along with becoming a safety hazard, dry-rotted wood replacements could cost you hundreds of dollars. Piling or pipe replacements could cost more, up to as much as $1,600 per piece! However, if you discover minimal rotting or small pitted holes, you can likely repair these areas yourself with wood filler. Other simple fixes to older wooden docks that don't have major structural damage include fixing loose boards, removing stains and discolorations and replacing loose nails and cracked boards.

Environmental Considerations:

Wood is a 100-percent renewable resource and produces less air and water pollution than some other dock options. However, pressure-treated wood, which is used for dock construction in freshwater and saltwater areas, has the potential to contaminate the water. Because the wood-treating process uses chemicals, all manufacturers of treated wood have to abide by EPA minimum retention-rate standards. Freshwater, pressure-treated lumber has to have a retention rate of at least 0.60 pounds per cubic foot. For saltwater docks, the lumber has to meet a minimum standard of 2.5 pounds per cubic feet.

Ability to Expand, Reconfigure or Remove:

Permanent wooden docks such as piling docks or crib docks are not easily removed. Extending or reconfiguring a piling or crib dock would require significant work. A crib dock is typically a customized structure and would require a customized solution to extend or redesign it to your needs. You also must consider any rules and regulations that your area has regarding the installation of dock additions.

How Long They Last: A well-maintained wooden dock made with pressure-treated lumber could last between 10 to 20 years. Unfortunately, even with regular maintenance, there's always a risk of rotting, warping, splitting or splintering. Nails in the wood may also come dislodged over time.

Safety Hazards:

Regarding wood docks, the darker the color of the wood, the more heat it will absorb. Because wood pulls heat deep into the board, the area your feet touch should not be unbearably hot, even in the highest temperatures. This makes choosing a wooden dock surface material preferable to metal. However, one hazard of wooden docks is the threat of splintering. An injury from a wood splinter is an easy way to ruin a perfectly good day on the lake. As wood absorbs moisture, it expands. Then, as it dries out, it contracts. This process can cause the wood to splinter, and splinters can carry bacteria and cause infection. To help minimize the chances of catching a splinter on your deck, you can sand down any split boards or large splinters that you see.

ALUMINUM DOCKS

While a traditional wooden dock may spring to mind when considering your options for decking materials, aluminum decking is another option you can consider. Assembled with interlocking edges, aluminum decking planks create a watertight and gapless seal. Some other considerations are:

Cost:

Typically, aluminum docks are pre-built by the manufacturers and may have a higher initial cost. Aluminum boat dock decking material could cost upwards of $10 dollars per square foot. As a result, it is typically one of the more expensive materials you can choose for your dock.

Durability:

Unlike wood that is susceptible to environmental impacts, aluminum is scratch- and weather-resistant. Aluminum is also as much as four times lighter yet three times stronger than wood.

Upkeep:

Aluminum does not rust, but it will corrode. The corrosion process actually protects the aluminum from rusting. Unfortunately, though you don't have to worry about rust eating away the metal, you do have to worry about the structural integrity of the dock being compromised. Aluminum becomes dull from corrosion and can become encrusted with everything from calcium and lime to hard-water stains. To clean grime, algae and other hazardous substances off of your aluminum dock, you'll need to mix water and baking soda into a paste. Use steel wool or a wire brush to clean contaminated spots thoroughly. Then, pressure-wash the entire dock. For saltwater docks, you'll need to frequently spray them down with plain water to prevent salt corrosion.

Damage to Boats:

Thankfully, aluminum docks are strong enough to resist damage from impact with watercraft. However, as with any vessel that makes contact with a sizeable object, an aluminum dock could cause damage to a boat.

Repairs:

Because aluminum decking will not rot, attract damaging pests or grow mold, repairs are usually minimal.

Environmental Considerations:

Though the mining process and refinement of ore requires a lot of energy, aluminum is heavily recycled. You can reuse uncontaminated aluminum almost indefinitely.

Ability to Expand, Reconfigure or Remove:

Because aluminum docks are typically manufactured in sections for installation, they can be added onto or reconfigured. While permanent structures like wood piling docks cannot be removed easily, aluminum docks can usually be folded and stored when not in use during the winter or seasons with heavy storms.

How Long They Last:

Aluminum decking should stand the test of time. In fact, aluminum frames may last from 30 to 50 years depending on conditions.

PLASTIC DOCKS

Those looking for a durable, innovative floating docking system should consider plastic decking. This type of dock material is easy to install and can cater to budgets of all kinds. It also represents a great option if you want the durability and longevity of aluminum docks but without the high price tag. While permanent wooden docks may have once been the traditional docking system, they're no longer the most practical option. A plastic floating dock tends to offer more benefits and fewer drawbacks than wooden and metal permanent docks combined, including the following:

Cost:

A dock is an investment. For commercial application, you want it to be functional, attractive and able to accommodate your employees or guests. For residential application, you want a dock that is reliable and enjoyable any day of the year. Though you could spend significant amounts of money installing a permanent dock system with high-quality wood or aluminum, you must always consider the overall price of the dock throughout its lifespan. The fact is that price doesn't always equal value. Fixed docks made from wood or aluminum may cost more in overall ownership, but resin or plastic floating docks can actually save you money in the long run. Their ability to be reconfigured instantly allows you to update your dock as your needs change. They're also portable, which means your single docking system investment can move with you wherever you go. Most importantly, they're designed for maximum durability, so you can get the most out of your investment without worrying about excessive repairs or replacement parts.

Durability:

Wood can warp and rot, while metal can dent and rust. Resin decking and plastic docks, however, are made of durable dock surface materials designed to give you more time on the water. In both freshwater and saltwater environments, polyethylene docks won't rot or splinter like wooden docks. You also don't have to worry about replacing an entire structure should one part of it incur damage. If a resin or plastic dock section is damaged, it can be easily replaced. There is no worry about damaged posts, piles or pilings either.

Upkeep:

Wooden docks require regular maintenance, and while aluminum docks may not need as much upkeep, they still require an attentive eye for rust, mold or other unfavorable occurrences. Plastic decks are much easier to maintain. Clearing the deck with a simple sweep can help the surface retain its beauty. You can clean it with soap and water and remove stains with deck cleaners and household degreasing agents.

Repairs:

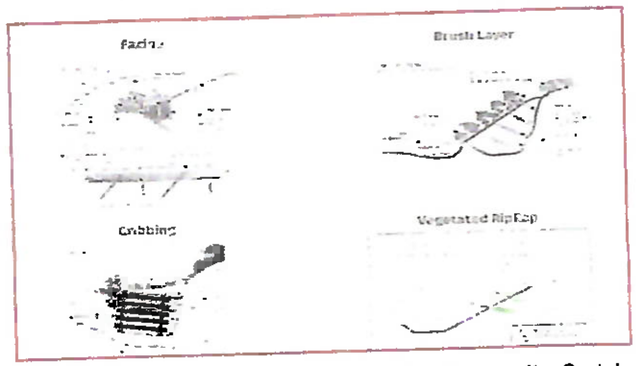
Consider the types of repairs you may have to make on wooden docks. Rotted wood is a significant hazard and any time you have to replace a section, that's an added cost you didn't anticipate. More importantly, replacing pilings or pipes could cost thousands of dollars which then leaves you with a decision to either reinvest in an old deck or go all the way and have a brand new dock installed. Although metal docks usually require fewer repairs, there is always the possibility of incurring additional expenses. With durable floating plastic docks, your initial investment lasts much longer. In fact, many plastic decks come with warranties that protect against certain damages. For example, EZ Dock products and components are covered under our limited warranty. That means that any cracks, leaks, breakage and ultraviolet deterioration due to workmanship or material flaws are covered during the warranty period. All hardware and accessories are covered for the first year as well.

Environmental Considerations:

Whether it's used for boating, swimming, kayaking or simply relaxing, you choose to construct a dock because you and your family, friends or customers want to enjoy the time on the water. Though everyone deserves to experience the serenity of the calm waves and warm sun, it's also our duty to preserve these natural areas as responsibly as we can. This means being mindful of the man-made structures that could potentially contaminate the water or earth, including boat docks. While certain chemical wood treatments or metals could contaminate the water, eco-friendly EZ Dock systems are made from polyethylene and molded rubber couplers that are recyclable and do not harm the environment. They are manufactured without wood products, foam filling or any other materials listed as hazardous wastes by the EPA. Ninety percent of the product is made with pre- or post-consumer waste recycled rubber and does not release any contaminants when damaged.

Ability to Expand, Reconfigure or Remove:

Fixed wooden or aluminum docks may have some advantages, but one significant drawback is that it is quite costly and labor-intensive to expand, reconfigure or remove the existing structure. Floating docks, such as those made by EZ Dock can be easily removed when not in use. They can also be expanded or redesigned to adapt to multiple waterfronts, and are available in customizable floating dock sections in a variety of configurations to cater to every need.



How Long They Last: Any large purchase you make should be an investment that you can rely on to last for years. Not only should your dock be structurally strong enough to maintain its integrity under normal circumstances, it should also be durable enough to endure any severe weather that might threaten its security. Certain types of fixed wooden or metal docks may not be constructed to survive heavy storms, but durable plastic docks are made to last. EZ Dock is designed to withstand many environmental challenges, including most low- to mid-category hurricanes.

POTENTIAL DOCK SAFETY HAZARDS

There should always be a concern for safety when creating and operating any dock. Along with potential hazards along the surface, you should also be aware of any ways that the environment may impact the structure. Heat can make an aluminum dock rise in temperature which could potentially burn the feet or hands of those that use it. Wooden docks may rot or begin to splinter over time. Even treated surfaces can begin to degrade and show signs of damage as water and bacteria take their toll.

Plastic floating docks have an immediate advantage in safety, helping to eliminate most of the potential hazards inherent to wooden and metal docks. The surface of a polyethylene dock is slip-resistant and won't splinter, enabling everyone to enjoy their deck freely without the worry of injuring bare feet. It also stays cool to help protect bare feet.

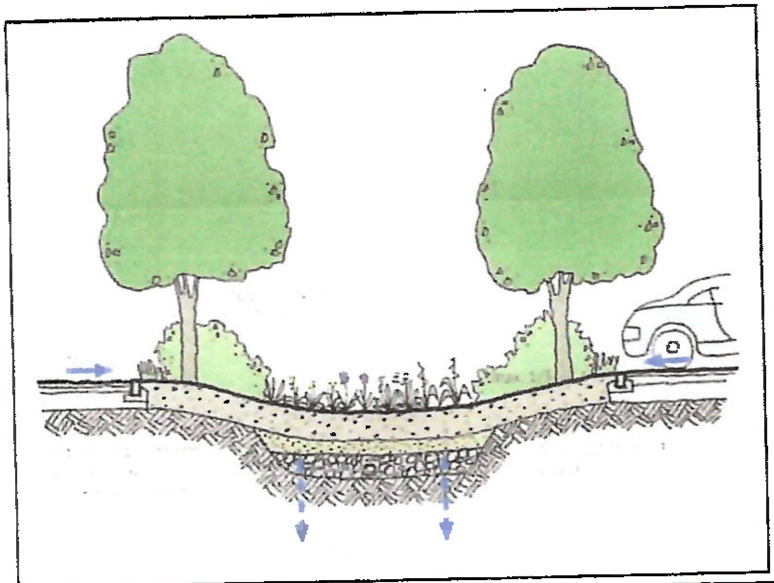
PARKING AREA:

Filtration overview

Filtration and removing sediment or other particles from surface water runoff is one of the main treatment methods for sustainable drainage. This may occur through trapping within the soil or aggregate, on plants or on geotextile layers within the construction. The location of any filtration will depend upon the structure of the particular SuDS component. The components that are classified under filtration include:

- Filter strips
- Filter trenches
- Bio-retention area

Filter strips are gently sloping areas of grass that water flows onto and across, usually towards another component like a swale or filter drain. The main purpose of the filter strip is to remove any silt in the water so that it does not clog up downstream components. Filter trenches provide a similar function and are shallow excavations filled with gravel providing temporary subsurface storage for infiltration or filtration of runoff.



Bio retention areas (figure 1) are vegetated areas with specially designed engineering soils and sand layers, which filter out pollutants from surface water runoff normally associated with highways. Bio retention features have an aesthetic and biodiversity value as they can be planted to enhance local character and are attractive landscape features.

Bio retention areas are often depressions in the ground to create opportunities for storage and attenuation. The filtration layers are usually under drained using a perforated pipe system and where appropriate can allow infiltration. Trees can also be incorporated into bio retention systems and they can therefore be integrated with tree pits in streetscapes and other public realm areas.

COMPONENT: FILTER STRIPS

Description

Filter strips are gently sloping, vegetated strips of land that provide opportunities for slow conveyance and infiltration (where appropriate). They are designed to accept runoff as overland sheet flow from upstream development and often lie between a hard-surfaced area and a receiving stream, surface water collection, treatment or disposal system.

They treat runoff by vegetative filtering, and promote settlement of particulate pollutants and infiltration.

Advantages & disadvantages

Advantages	Disadvantages
Well suited to implementation adjacent to large impervious areas Encourages evaporation and can promote infiltration Easy to construct and low construction cost Effective pre-treatment option	Not suitable for steep sites Not suitable for draining hotspot runoff or for locations where risk of groundwater contamination, unless infiltration is prevented No significant attenuation or reduction of extreme event flows

Easily integrated into landscaping and can be designed to provide aesthetic benefits	

Quantity
Filter strips only attenuate the flow slightly but they can be used to reduce the drained impermeable area.

Quality

Filter strips are effective at removing polluting solids through filtration and sedimentation. The vegetation traps organic and mineral particles that are then incorporated into the soil, while the vegetation takes up any nutrients.

Amenity

Filter strips are often integrated into the surrounding land use, for example public open space or road verges. Local wild grass and flower species can be introduced for visual interest and to provide a wildlife habitat.

Maintenance

Litter/debris removal
Mowing
Repair of eroded or damaged areas

COMPONENT: FILTER TRENCH

Description

Filter trenches are shallow excavations filled with rubble or stone that create temporary subsurface storage of storm water runoff. These trenches can be used to filter and convey storm-water to downstream SuDS components.

Ideally they should receive lateral inflow from an adjacent impermeable surface, but point source inflows may be acceptable.

Advantages & disadvantages

Advantages	Disadvantage
• Important hydraulic benefits are achieved • Can be incorporated easily into site landscaping and fits well beside roads.	• High clogging potential without effective pre-treatment – not for sites with fine particle soils (clay/silts) in upstream catchment • Build-up of pollution/ blockages difficult to see • High historic failure rate due to poor maintenance, wrong siting or high debris input • Limited to relatively small catchments • High cost of replacing filter material should blockage occur.

Where component can be used
Residential: Yes
Commercial/industrial: Yes
High density: Yes
Retrofit: Yes
Contaminated sites: Yes
Sites above vulnerable groundwater: Yes

Performance
Peak flow reduction: Medium

Volume reduction: Low
Water quality treatment: High
Amenity potential: Low
Ecology potential: Low

Maintenance

- Regular inspection for signs of clogging
- Removal of sediment from pre-treatment system
- Removal and cleaning or replacement of stone.

COMPONENT: BIO-RETENTION AREAS

Description

Bio-retention areas are shallow landscaped depressions which are typically under drained and rely on engineered soils, enhanced vegetation and filtration to remove pollution and reduce runoff downstream. They are aimed at managing and treating runoff from frequent rainfall events.

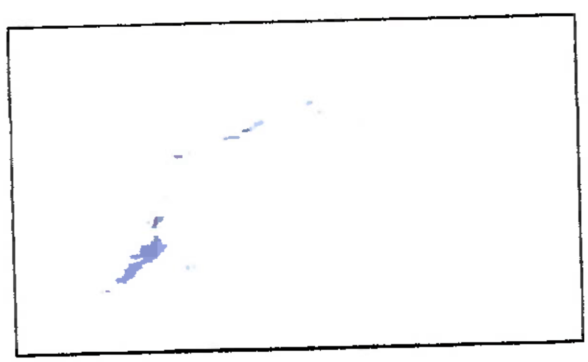
Advantages & disadvantages

Advantages	Disadvantages
• Can be planned as landscaping features • Very effective in removing urban pollutants • Can reduce volume and rate of runoff • Flexible layout to fit into landscape • Well-suited for installation in highly impervious areas, provided the system is well-engineered and adequate space is made available • Good retrofit capability	• Requires landscaping and management • Susceptible to clogging if surrounding landscape is not managed • Not suitable for areas with steep slope

Where component can be used

Residential: Yes
Commercial/industrial: Yes
High density: No
Retrofit: Yes
Contaminated sites: Yes
Sites above vulnerable groundwater: Yes

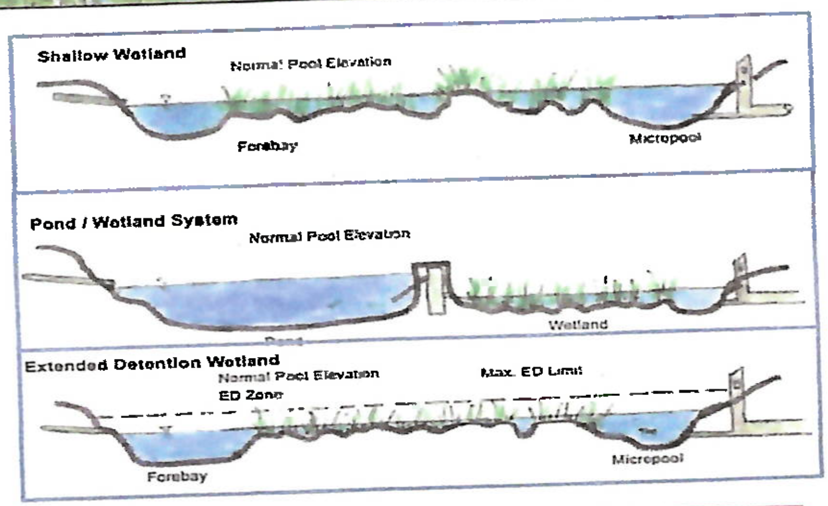
Performance
Peak flow reduction: Medium
Volume reduction: Medium (High with infiltration)
Water quality treatment: Good
Amenity potential: Good
Ecology potential: Medium

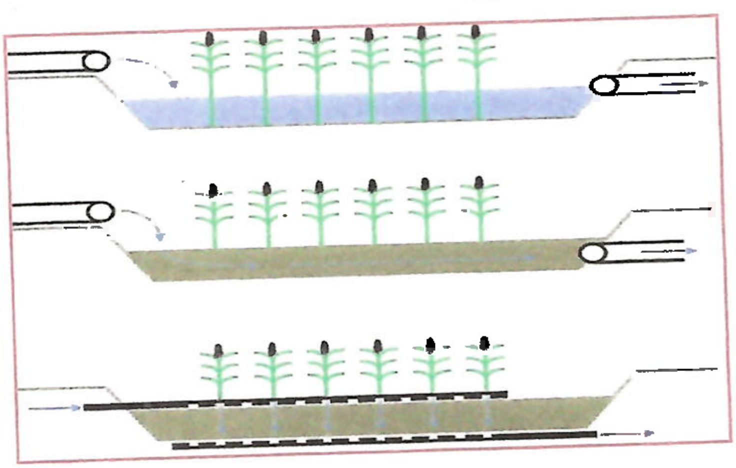


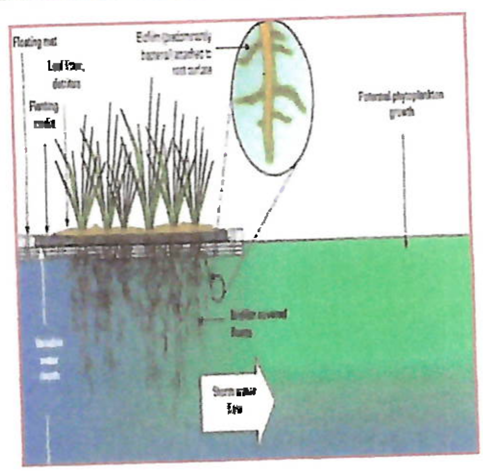
Maintenance

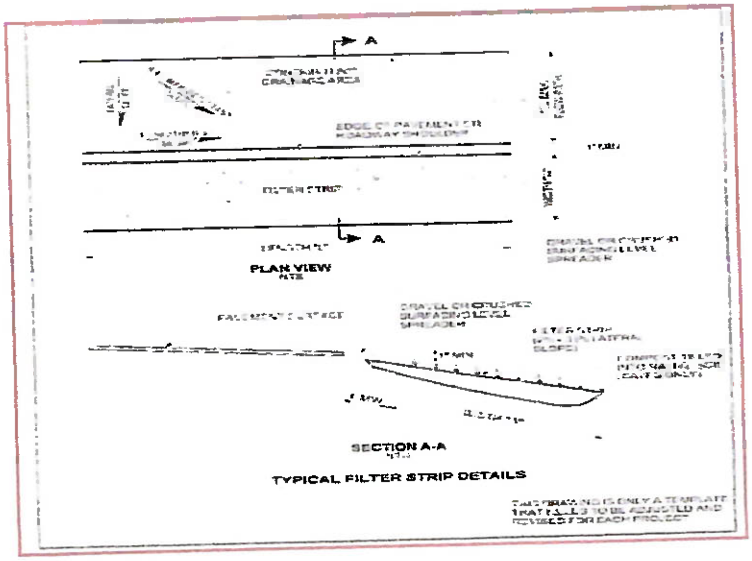
- Regular inspection
- Litter/debris removal
- Replacement of mulch layer
- Vegetation management
- Soil spiking and scarifying

Descriptive Project Title What, where	Wetland enhancement; Saipan
Partnering Agencies & Organizations List all known and potential partners	Government Agencies / NGO's
Project locations A description of location and a list of counties; also attach required map	Garapan

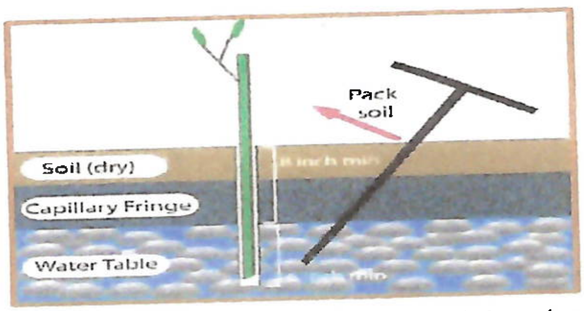


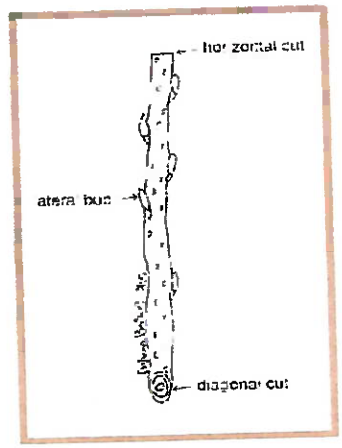






Tools: planting bars (dibbles), rebar, rubber mallet/mini sledge, post-hole diggers, electric hammer-drills, soil augers, power stingers, shovels, buckets, lopping shears.





Bioengineering Plant material recommendations should follow the guidelines presented under seeding, cutting, and container planting information. This includes species, percentage, plant materials type, timing, vigor, size, and plant and/or cutting number, source, handling as well as applicable permits, hydrology, etc. Plant material propagule type (seed, cutting, container, etc.) must be of an appropriate type, timing, and nature to work effectively with the chosen bioengineering technique. Multiple propagule types are often incorporated within the same bioengineering system (e.g., seed and cuttings; seed and plants; seed, plants, and cuttings). The cost of plant materials, including plant materials implementation, must be considered within the budget and true costs for bioengineering systems and project designs. The Revegetation Matrix includes root dimension information useful to understanding the potential contribution made by a specific species, or mix of species, to system performance and resiliency when incorporated into a given bioengineering system

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.

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.

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, WAECY 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

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. 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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