Willamette Riverbank Design Notebook:

Portland, Oregon

A Tool Designed to Foster Creativity and Innovation in Developing an Urban River's Edge that Improves Conditions for Fish, Wildlife and People

City of Portland, Oregon
Bureau of Environmental Services
Portland Development Commission

GreenWorks, PC Landscape Architecture
ClearWater West
Fishman Environmental Services, LLC
Inter-Fluve, Inc.
KPFF Consulting Engineers

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Design Notebook

Willamette River

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A. Vision

The Portland City Council has decided not to limit itself to the Endangered Species Act's minimum legal requirements. Instead, we have chosen to promote recovery of listed species through the restoration of healthy local watersheds. One of the first tools to accomplish this is the Willamette Riverbank Design Notebook. This Notebook provides guidance for repair and modification of the river's edge, recognizing that this zone is the interface between the river and the upland.

This notebook sets forth a design methodology and range of riverbank design concepts intended to:

- provide project proponents with a level of permitting certainty to the extent possible
- streamline project review and approval timelines
- allow permitting and reviewing agencies the opportunity to review projects in a uniform manner.

This is accomplished through the presentation of design options that are based on common objectives. When incorporated into projects along the Willamette River through urban Portland, these solutions can contribute to the recovery of native fish.

The notebook integrates cultural, physical, biological and economic opportunities and constraints to redevelopment of the river's edge in order to provide optimal design choices for a range of riverbank needs.

An implementation plan for the Willamette Riverbank Design Notebook has not yet been determined. Additional research and work needs to take place before the notebook emerges in its final form as an implementation tool. All or portions of the notebook could potentially appear as any of the following:

- voluntary programs
- a link to Division of State Lands and its State Programmatic Permit process
- regulations or design guidelines in the Willamette River Greenway Plan
- a 4(d) rule exception
- a component of a Metro Title 3 Riparian District
- programmatic Section 7 permits

B. Audience and Purpose

1. USER GROUPS

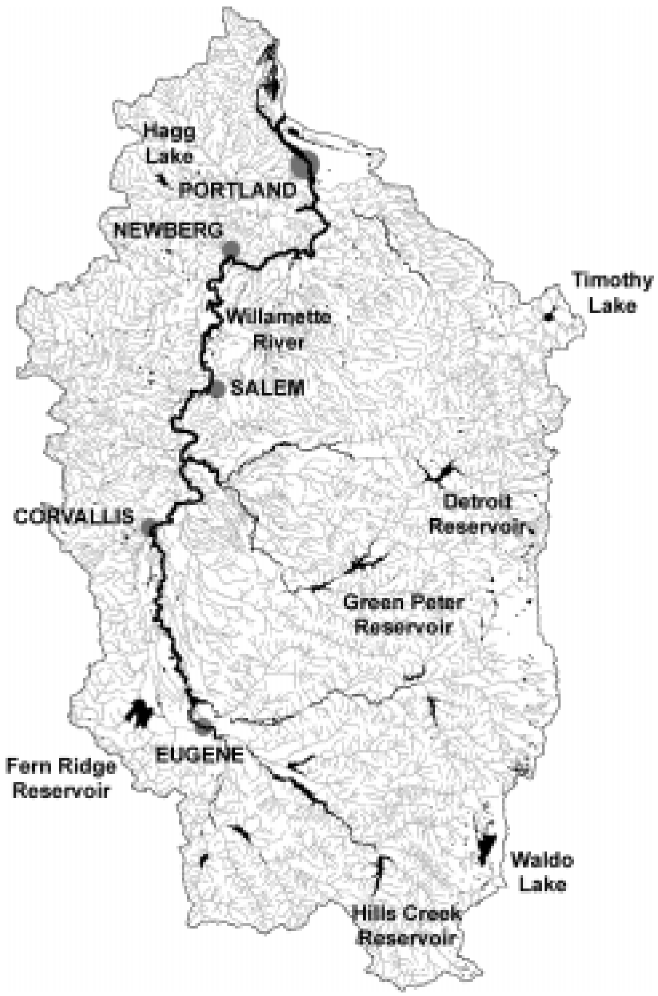
Various user groups will find this notebook useful for determining design approaches for riverbank projects. The following are some of the potential users:

- **Landowners** who wish to develop or redevelop along the Willamette River in Portland can use the notebook to select conceptual bank treatments with the intent to protect or enhance fish habitat, water quality, channel conditions and the functions of riverbanks and channel margin environments, and other project objectives.
- **Designers** can step through a series of analysis questions to determine which conceptual design solutions can best be incorporated into the design of specific projects at the river's edge.
- **Land use planners** can refer to the inventory of bank conditions to develop appropriate comprehensive and site plans. The conceptual design solutions can be used to select appropriate riverbank treatments for greenways and open spaces along the Willamette River.
- **Regulators** who will be reviewing project applications can refer to the notebook to understand the process applicants have followed to select design options.

2. INTENT OF THE NOTEBOOK

Whether the notebook will be used for design or for review, its main purpose is to establish a common frame of reference and common goals for all who are concerned with development at the river's edge. It provides a tool to assist in meeting these goals in the context of dynamic biological, physical and cultural systems. Its use can reduce uncertainty with respect to permitting and allow all participants to focus on the same clear objectives, relying on a common menu of design concepts to achieve them.

This design notebook is intended to be a living document which should be revised as factors influencing Willamette River habitats, morphology and water quality become better understood. The design concepts presented here represent current thinking about how to enhance the river's edge through the most highly urban and industrialized area of Oregon.



The redevelopment of Portland's riverfront is occurring at a time in which there is increasing agency interest in protecting, enhancing and restoring water quality, floodplains, wildlife habitat, and the functions of stream corridors. Furthermore, as older industrial uses leave the river's edge, new opportunities are becoming available to make the riverfront accessible for recreational, residential and other uses. Many planning efforts are underway on the part of all levels of government to meet these and related goals (please refer to Appendix B for a summary of these efforts).

C. Background & Context for the Design Notebook

1. OVERVIEW OF THE WILLAMETTE RIVER WATERSHED

The Willamette River drains a watershed area of about 11,460 square miles in Western Oregon, and has headwaters in the Coast Range and in the snow zone of the Calapooya Mountains and the Cascade Range. It is the tenth largest river in the lower 48 states. The Willamette has 13 major tributaries including the Clackamas and the Tualatin rivers, important streams in the Metropolitan Portland area.

In a 100-mile stretch between the City of Eugene in the upper valley and the City of Portland near the mouth, the mainstem Willamette meanders about 187 miles and drops about 350 feet. The alluvial valley of the Willamette in this zone holds about 87 percent of the state's population of 3 million, and, with the exception of the urbanized areas, is intensely used for agriculture. Timber production is widespread in the mountainous uplands above the valley floor. There are also numerous flood control and hydropower dams within the watershed.

2. CHANGING GOALS FOR RIVER'S EDGE DEVELOPMENT

Portland's riverfront is changing. Redevelopment along the Willamette River through Portland, Oregon, is providing an opportunity to enhance the environment at the water's edge. The public is increasingly concerned about water quality and fish and wildlife habitats, and increasingly recreates on or near the water's edge. Today governments at all levels are working with the public to rehabilitate aquatic habitats for several threatened species of cold water fish in the Portland area. There is a need for guidance about how to accomplish fish-friendly projects at the river's edge.

Design solutions for these public goals need to be compatible with design needs for flood passage, bank stabilization, commercial and industrial water traffic, emergency and recreation access, and other requirements of special districts and operations in the river channel, on the riverbanks and in the near-shore zone.

The chapters of this draft notebook are intended to capture the collaborative thinking of scientists, planners, engineers, landscape architects, and people who use the river and its banks for work or play - and focus their thoughts on fresh designs to meet these changing needs along Portland's Willamette River.

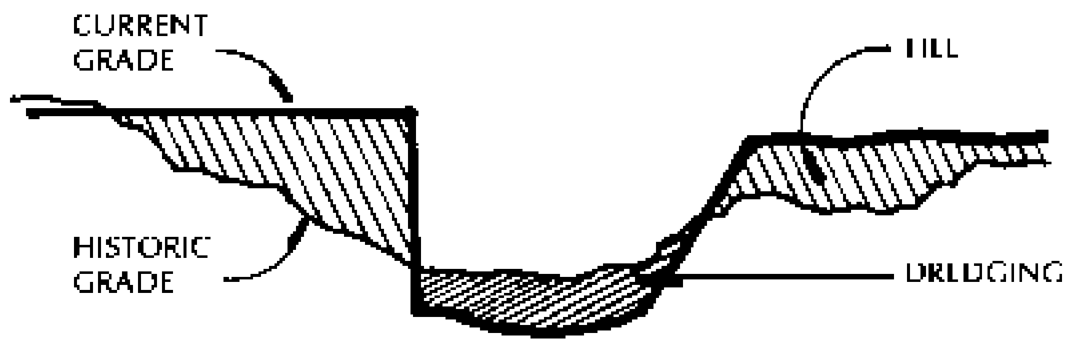
3. CHARACTERISTICS INFLUENCING RIVERBANK DESIGN

The following characteristics of the Willamette River will influence any design approaches to the riverbank for individual sites. These influences need to be thoroughly understood in order to develop as design criteria which will result in effective solutions. These characteristics also interact and affect each other in the context of this river segment.

For this notebook, “riverbank” is defined as the land riverward of top of bank and including the near shore area. For the purposes of this study, “top of bank” is defined as the location of substantial grade break from the riverbank to a more level area inland.

Channelization

The reach of the Willamette River from Portland to Willamette Falls in Oregon City contains the most heavily industrialized area of Oregon. In much of this zone, more than 100 years of dredging, filling, straightening, channelization and bank stabilization have produced a somewhat trapezoidal channel bounded by armored banks.



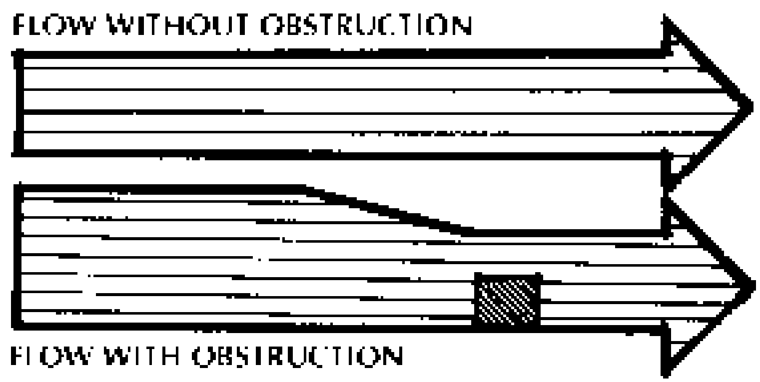
Today, the Willamette River must have the capacity to convey large storm events within a defined channel, whereas historically, floodwaters overflowed into an extensive floodplain. Resulting effects of channelization include an increase in the velocity of water moving downstream, fewer riparian and seasonal wetlands, reduced off-channel backwaters for fish rearing, and decreased exchange of organic materials. Channelization has reduced the capacity of the river margin to slow the velocity of flood flows, allow settlement of entrained sediments and provide desynchonization of flood flows in the main channel.

River Commerce and Recreational Uses

The Willamette River through the Portland area today accommodates regional and international shipping that includes loading and off-loading of raw materials, manufactured products and agricultural crops. Barges, log rafts and ocean-going vessels share the river in this reach with recreational craft. These uses require that riverbank designs accommodate needs for navigation, maneuvering, safety, docking and communication.

Hydraulic Conveyance

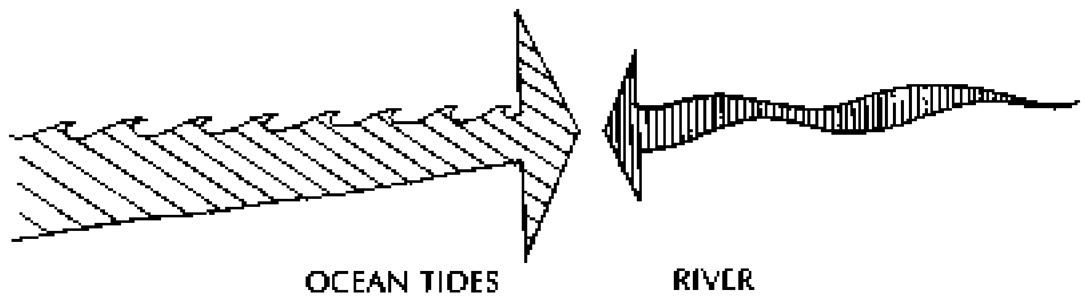
Although there are no dams on the mainstem Willamette, flooding on the river is controlled along its length by means of levees and by dams on tributary streams. Many former floodplain features have been drained, filled, or protected from flooding. Because the river now has limited access to its floodplain throughout much of the valley, mainstem flood flows are artificially high. The maximum discharge estimated through downtown Portland on November 22, 1996 was 213,000 cubic feet per second (cfs). The average discharge is 33,000 cfs, plus or minus 10 percent. Structures placed within the river channel may reduce its capability to move water, thereby raising the water level upstream. (See Diagram) Maintenance of an obstruction-free floodway is one consideration in riverbank redevelopment design.



River Diagram: Longitudinal Section

Tidal Influence

About 12 river miles north and downstream of the city center, the Willamette River joins the Columbia River approximately 100 river miles east of the Pacific Ocean. The tidal influence of the Pacific creates a freshwater backwater in the Columbia River that results in diurnal water level fluctuations of the Willamette River in Portland. There is a six hour lag in impacts between Astoria and Portland. Tidal influence on river levels, velocity and current decreases as the volume of water in the river increases. However, depending on the magnitude of the tide, the river rises and falls as much as 3 feet twice each day.



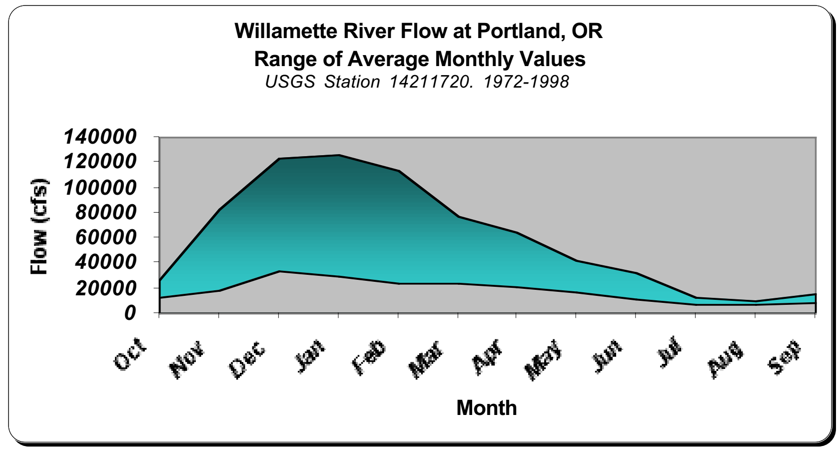
Tidal Forces

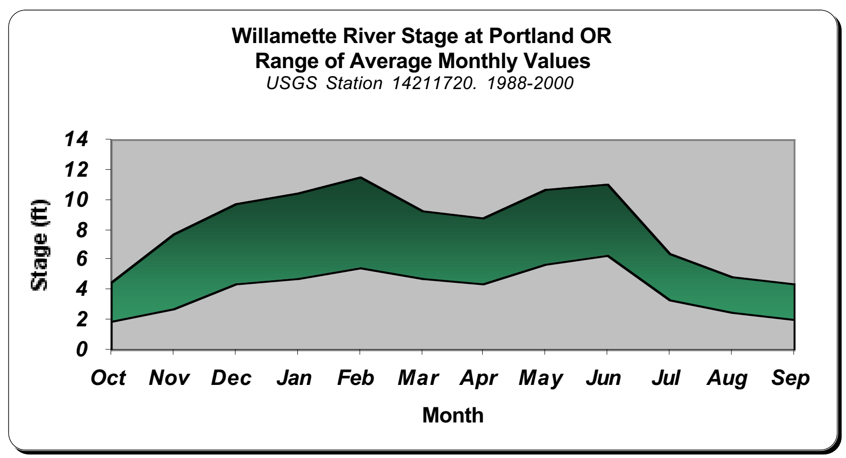
Fluctuating Water Levels

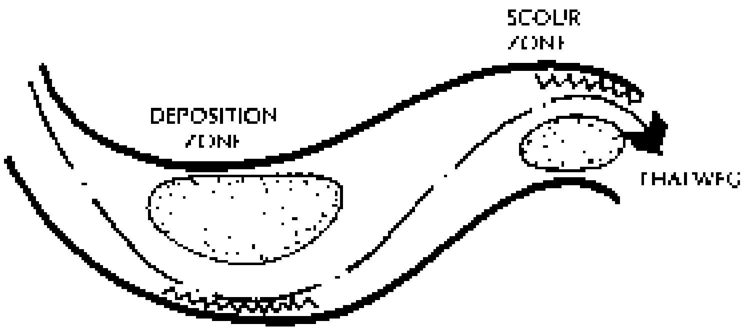
On average, the water level of the Willamette River in downtown Portland fluctuates between 2 feet and 10 feet per year, but during events of magnitude, can rise in excess of 30 or drop below 0. Water levels in this reach of river are governed by a combination of several factors. Tides, river flows within the Columbia River, and the flow of the Willamette River itself all have various effects on water level elevations.

For example, an annual graph of flow volume for the Willamette River shows that, on average, peak flows occur in the December to February period with lesser flows occurring during the remainder of the year. A graph of annual water levels however, shows high water levels occurring both in the winter and again in the spring. These differences in flow and water surface levels can be explained by the influence of high spring flows within the Columbia backwatering this portion of the Willamette. It is therefore possible to have very high water levels within the Portland reach of the Willamette River when actual Willamette River flows are small.

Riverbank designs must carefully consider these annual or other fluctuations in water level. Planting of vegetation, placement of paths and trails, location of structures, and water related facilities are just a few of the proposed actions that must consider water level fluctuations. For example, these annual water level fluctuations create difficulty in providing public access to the water.



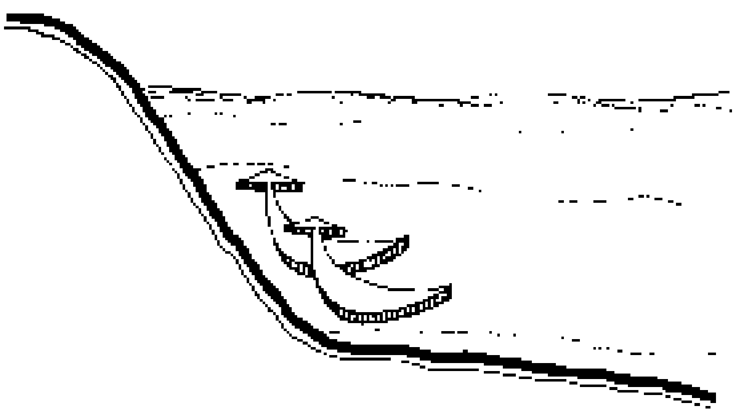




River Current Diagram

River Currents

Where river currents are fastest, they create the deepest part of the channel or "thalweg." The thalweg typically meanders from one side of the channel to the other, causing a scour zone along the bank it is nearest, and a deposition zone on the opposite bank where the velocity is not as great. These forces create the familiar alternating cut banks and point bars of meandering rivers. Although these forces are greatly altered in the confined Willamette River through the urban area, they are still present and are important factors that can affect the selection and success of some riverbank designs.



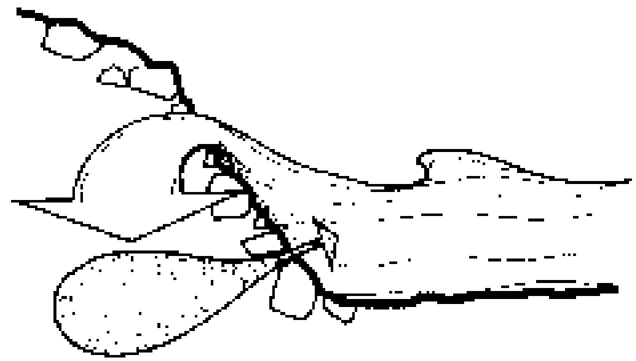
Shear Stress

Shear Stress

Also known as "tractive forces", shear stress is the force that moving water exerts on the bed and banks of the river as it moves downstream. It is generally strongest at the bottom of the bank. Shear stress increases with water depth during flooding and can be responsible for significant riverbank erosion and failure of slopes and rip rap installations. Shear stress also changes with tidal fluctuations. Because the river is confined in this reach, shear stress can be considerable in some locations, and can limit the options for riverbank designs.

Wave Action

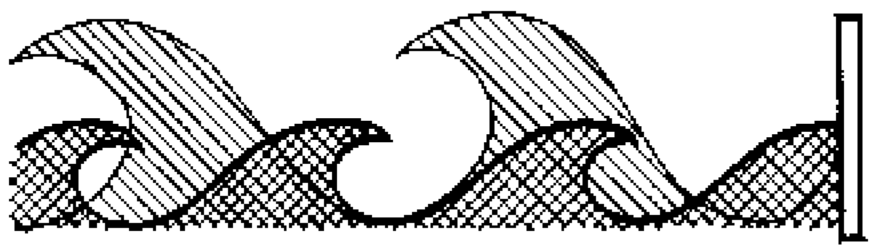
Waves from boat wakes and wind are erosive forces on the banks of the Willamette River in Portland. As waves strike the bank, they dislodge bank materials. As the water from waves saturates the bank, it “pumps” soil fines out through soil pores. Riverbank designs must consider local wave conditions as well as bank materials.



Wave Action on Banks

Wave Reflection

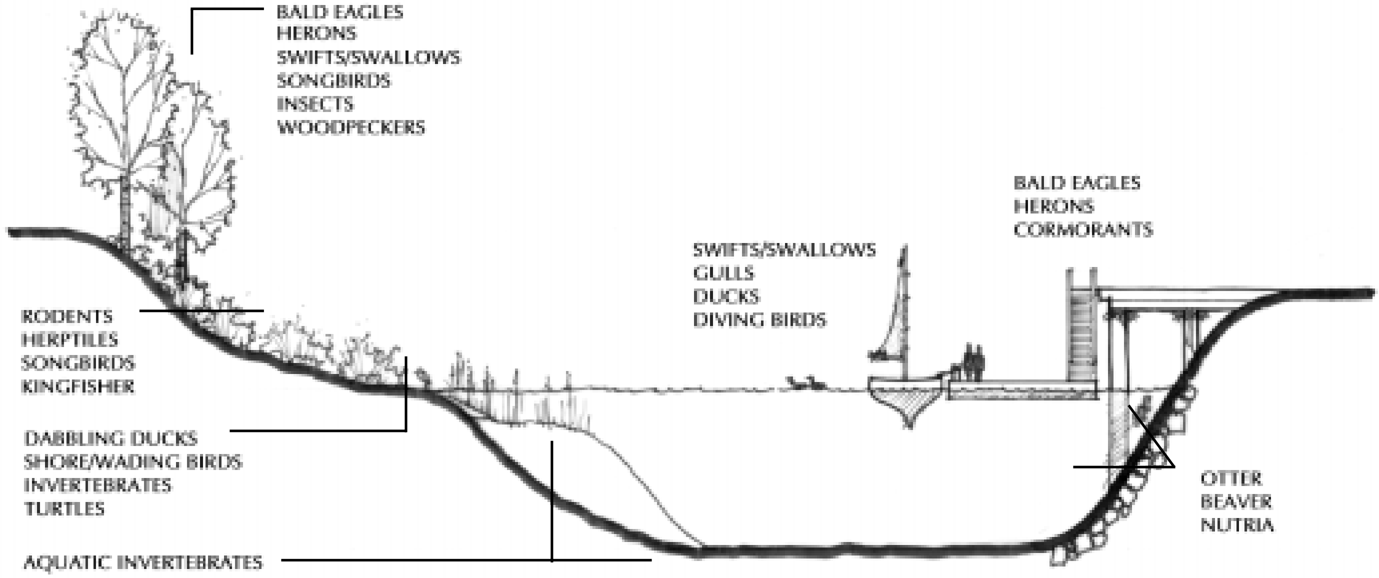
When waves from boat wakes or wind strike a solid object, they will bounce off and travel until their energy is absorbed or dissipated. The energy can be dissipated when the waves strike a less solid bank or run up a gently shelving beach. Waves are amplified when they meet oncoming waves. Wave conditions along the Willamette River vary due to wind conditions, “fetch” (the distance wind travels over the water), ship and boat movements and bank conditions. Riverbank designs need to respond to these ambient factors.



Wave Reflection

Wildlife Habitat

Riverbank designs can provide opportunities to create or enhance habitat for aquatic and terrestrial wildlife species.



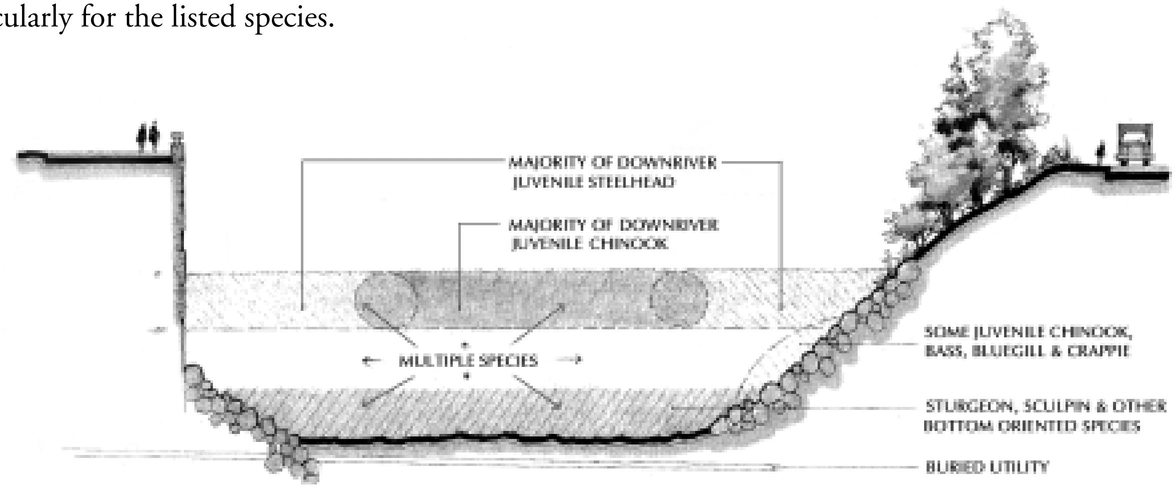
Wildlife Habitat Areas
(Generalized River Cross-Section)

Wildlife habitat of the Willamette River through Portland has both aquatic and riparian components. Aquatic habitat consists of the river, riverbed and inundated banks, including structures in the water, and large woody debris. Numerous species of birds and mammals including gulls, cormorants, grebes, ducks, beaver, nutria and occasionally, river otters, use the aquatic habitat of the river in this reach for some or most of their life activities. Amphibians and reptiles such as frogs and turtles may also be found. Invertebrate animals such as clams, worms, insects and small shrimp-like animals live in the bottom sediments.

Riparian habitat includes the land and associated plants adjacent to the river. Riparian species here include insects, birds, small mammals, amphibians and reptiles. In general, wildlife habitat in the Willamette River downtown is limited and highly disturbed.

Fish Utilization

A central goal of this design notebook is to provide "fish-friendly" environments at the river's edge, particularly for the listed species.



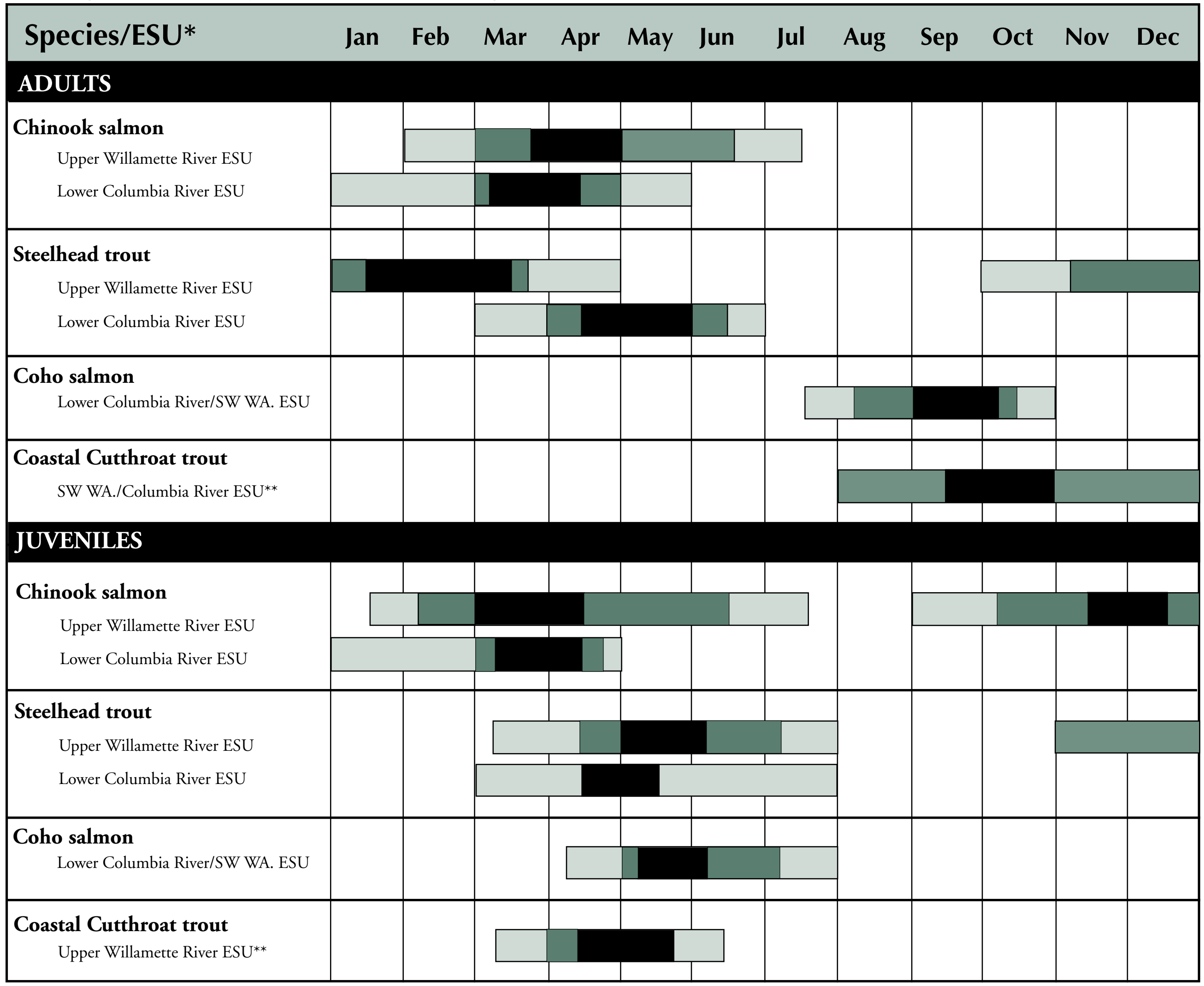
Fish Habitat Areas
(Generalized River Cross-Section and Fish Distribution)

A variety of fish use the Willamette River through Portland. Different fish use the river in this reach in varying ways. Some species migrate through during certain seasons, while others are found year-round. Resident species may use all parts of the river, or only specific areas such as the river bottom.

A recent study (Farr and Ward, 1992) found 38 species of fish, of which 20 were native species. Native resident non-game species include northern pikeminnow, peamouth, and largescale sucker. Non native resident species include shad, bass and assorted panfish. Non-native species may be competing with juvenile salmonids for available food sources.

The native cold-water game fish include the trout and salmon species (most of which are migratory), lamprey and white sturgeon. Lower Columbia River steelhead, Lower Columbia River chinook salmon, Upper Willamette River steelhead, and Upper Willamette River chinook salmon have recently been listed as threatened species under the Endangered Species Act. In addition, the Southwestern Washington/Columbia River sea-run cutthroat trout has been proposed for listing, and another, the Southwest Washington/Lower Columbia River coho salmon is a candidate species for listing.

Timing of adult and juvenile salmonid migrations in the Willamette River below Willamette Falls.



Black bars represent peak periods of migration

Shades of gray represent estimated abundance, lighter shading represents least abundance

*Evolutionarily Significant Unit

**Best estimate based on limited information for Willamette and Columbia Basins

Source: Fishman Environmental Services, 2000

4. SUMMARY

The conditions discussed above influence, and to some extent, limit the environmental values that can be accomplished by redevelopment of riverbanks in an urbanized area where the river itself has been greatly modified from its original condition. A thorough understanding of these conditions and the way they uniquely combine at a specific site is key to a successful design. Understanding the general principles for the Willamette River is not sufficient; it is incumbent upon a project proponent to carefully study and understand how these characteristics affect and interact with their specific site. Professional assistance may be helpful in arriving at this understanding.

Several additional design criteria must be considered when planning redevelopment along the river. These include:

- Risk Analysis of Potential Bank Failure
- Constructability
- Ongoing Maintenance Requirements and Commitments
- Estimated Construction Cost
- Construction Schedule and Seasonal Restrictions

Depending on the level of proposed improvements or modifications to the riverbank, permits may be required from the City of Portland, Oregon Division of State Lands, Army Corps of Engineers and/or the National Marine Fisheries Service. Other state and federal agencies also have permit review authority. This may result in a need for assistance from an engineer or other professional experienced with riverbank design and permitting.

D. Existing Riverbank Conditions

The lower Willamette River today is drastically different from its historic, pre-European settlement condition. Salmonid fishes and other native fish, wildlife and vegetation evolved within a set of physical, chemical and biotic conditions that to a large extent no longer exist in this ecosystem. The lower Willamette was typical of river-floodplain ecosystems where annual, extended duration inundation of the floodplain was a primary determinant that influenced the physical, chemical and biotic environments. Today the floodplain is either non-existent, or is physically separated from the river channel and only very rarely inundated.

It is critical to understand the urban nature of the lower Willamette River, and to understand that for the most part, we cannot recreate or restore the conditions of the historic river-floodplain ecosystem. Instead, this Design Notebook implements designs that are attempts to simulate some of the habitat features we think are important to salmonids; these efforts will hopefully contribute to salmonid recovery.

The riverbank design concepts incorporated into this Design Notebook work within the confines of an urban river that has been straightened (and thus shortened), deepened, and structurally simplified, and whose edges have been armored and floodplain eliminated or isolated. These designs attempt to install a greater diversity of physical and biotic conditions in order to provide a more multi-dimensional environment for plants and animals.

An inventory of bank conditions along the Willamette River within the city of Portland was undertaken as part of this project. Seven bank types were identified. A definition of each type is given below, together with the approximate percentage represented by each type. (Please see Appendix B for maps identifying locations of various bank types, and Appendix C for schematic cross-sections of riverbank types.) Inventory occured on various dates between December 1998 and September 1999. Riverbank development is dynamic and these maps provide a "snapshot" of conditions that existed in this period of time.

Natural bank - 17.5 percent of total. Natural banks appear to be composed of rock outcrop or in-situ native earth materials and to be relatively undisturbed by humans. They may be variably eroded. Vegetative cover varies; native, exotic, living, and dead vegetation may be present.

Rip rap - 26.8 percent of total. Rip rap banks have been intentionally armored with rock of various sizes up to at least ordinary high water. They are generally devoid of vegetation but may be covered with blackberry in some locations. In other locations, trees and shrubs may be present.

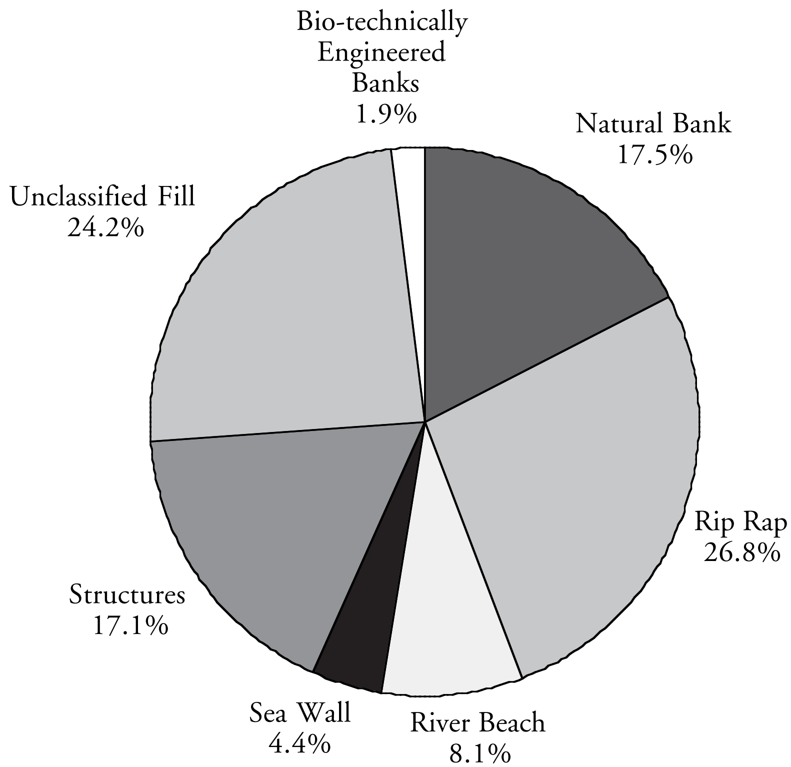
River beach - 8.1 percent of total. This is a shallow shelving shoreline usually 5:1 or flatter, that consists of sand, silt, fine gravel or other sedimentary deposits. In some locations, the beach may be visible below other bank conditions only at low water. Areas such as these have not been included in calculations for bank type percentages but appear on maps in Appendix B. In other locations, the beach may grade gradually up to the adjacent floodplain. These depositional areas may or may not have existed historically. Therefore, they are not included in the "Natural bank" category.

Sea wall - 4.4 percent of total. These are constructed, impervious vertical walls, generally composed of concrete, timber or sheet pile, that extend below ordinary low water.

Structures - 17.1 percent of total. Included in this category are piers, wharves, supported docks, buildings and other structures that cover portions of the riverbank.

Unclassified fill - 24.2 percent of total. These areas appear to have been filled over time with miscellaneous unconsolidated materials. The surfaces of banks composed of unclassified fill have not been covered with engineered rip rap or structures. Such banks generally contain debris of various types and may have become unstable due to erosion by river forces.

Bio-technical and bio-engineered banks - 1.9 percent of total. Bio-technically engineered banks incorporate vegetation as a visible component of the bank, but inert and man-made materials provide the physical structure that ensures bank stability. Bio-engineered banks rely on vegetation and natural fabric materials for bank stability.



Existing Riverbank Conditions

As the percentages above indicate, there is very little natural bank remaining in the study area. The shoreline is composed largely of unclassified fill materials, much of which contain rubble, construction and manufacturing wastes, unconsolidated organic material and contaminants. Of the natural banks that remain, many are disturbed and degraded by wave action at all water levels. Some areas of shallow-shelving shore remain. Where these are protected and quiet water conditions allow, sedimentation occurs. In other areas, waves and currents allow onshore recruitment of organic and other floating debris.

E. Elevation Zones on the Riverbank

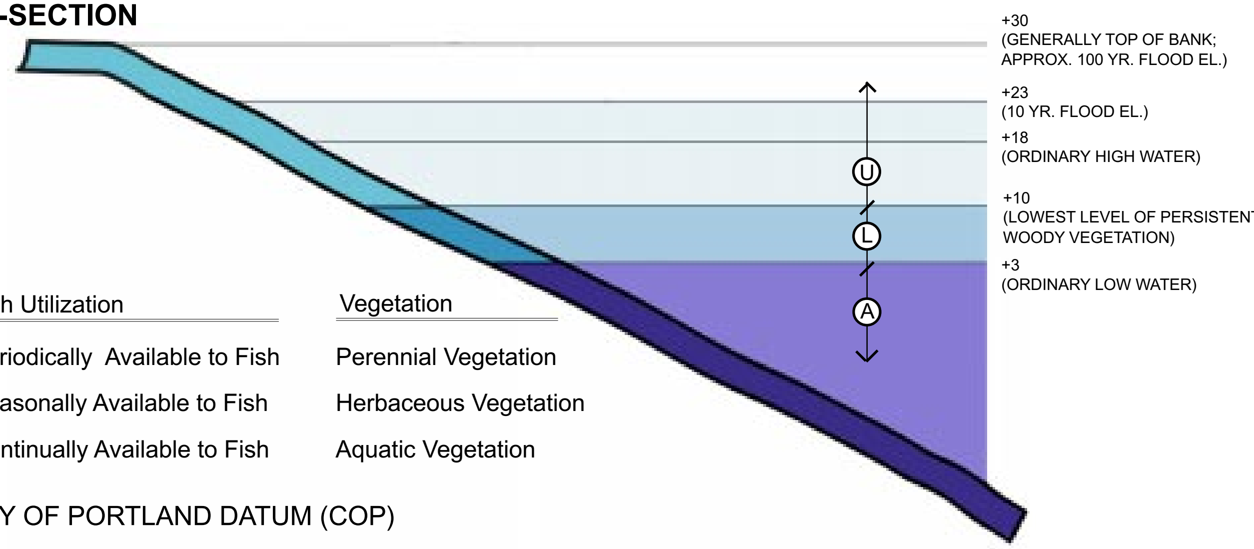
Although seven general riverbank categories have been mapped for the Willamette River in Portland, each site is unique, and cannot be easily characterized by a single cross-sectional drawing. This is because between the top of the bank and ordinary low water, the slope gradient, bank materials and vegetation may change. Therefore, it is helpful to envision riverbank conditions in three elevation zones:

- A zone below ordinary low water. *(below elevation +3 COP – City of Portland Datum)*
- A zone of herbaceous vegetation to about 10 feet above ordinary low water. *(+3 to +10 COP)*
- A zone of persistent woody vegetation higher than 10 feet above ordinary low water. *(above elevation +10 COP)*

In many cases, the selection of riverbank design concepts for a specific site will yield different design approaches for each zone on the bank. As users work their way through the analysis questions on the design worksheet in Chapter Three, they should keep these three bank zones in mind.

For this Design Notebook, all elevations are referenced to the City of Portland datum (COP).

TYPICAL RIVERBANK CROSS-SECTION



Shore Zones

Label	Name	Fish Utilization	Vegetation
Ⓤ	UPPER SHORE ZONE	Periodically Available to Fish	Perennial Vegetation
Ⓛ	LOWER SHORE ZONE	Seasonally Available to Fish	Herbaceous Vegetation
Ⓐ	AQUATIC ZONE	Continually Available to Fish	Aquatic Vegetation

NOTE: ALL ELEVATIONS ARE CITY OF PORTLAND DATUM (COP)

F. Bank Erosion Resistance

Methods and materials used to stabilize banks from erosion by shear stress, wave action, currents, vacillating water levels, piping, and mass failure should be designed with reference to actual site conditions. These include wave heights, soil type and stratigraphy, pore pressures of saturated soils, flood elevations, and flow velocities and directions at various river stages. Materials should be sized and the subgrade prepared according to engineering and bio-technical engineering design standards, to avoid over-building the riverbank and over or under-sizing bank-armoring materials.

It may be helpful to use the following general guidelines in evaluating the risk of erosion at a specific site. Areas of high erosional risk will require greatest design effort and justification. Risk assessment and desired level of protection are the responsibility of the property owner.

EROSION RISK GLOSSARY

Risk of Erosion	Shear Stress	Velocity
Very Low	0-1/2 Pounds Per SqFt.	.25 Feet/Sec.
Low	1/2-2 Pounds Per SqFt.	.25-1.5 Feet/Sec.
Moderate	2-4 Pounds Per SqFt.	1.5-6 Feet /Sec.
High	4+ Pounds Per SqFt.	More than 6 Feet/Sec.

A. Overview

People who pursue or review permits for work in the Willamette River or on its banks in Portland find themselves discussing the same items with owners, design teams and agency people. This design notebook is intended to provide a common understanding of riverbank conditions in order to address opportunities and constraints associated with riverbank projects.

The notebook steps the user through a series of questions intended to help identify design elements that would be appropriate to a specific site. It provides a common design vocabulary, project objectives and design process, and in doing so, has the potential to foster uniformity in the permitting process and collective benefits across numerous projects.

The Design Notebook is <u>not</u> intended to be, and should not be used as a tool to rate or score projects for regulatory compliance. This is not a "pass/fail" exercise, but a tool to guide riverbank design in directions that have multiple natural resource and urban benefits. Factors such as feasibility, cost, schedule and others are also critically important for making design decisions.

The Design Notebook team, seeking to use the best available natural resource science as a foundation for riverbank design criteria, recommended convening a working session of professional aquatic and fish biologists and ecologists to discuss the lower Willamette River. As a result, the City of Portland, with the National Marine Fisheries Service, convened a day-long workshop in June, 1999, of biologists and city, state and federal regulators and resource managers to identify the elements of properly functioning condition for large, low-gradient rivers. From the workshop, several Pathways were identified as being critical to species recovery. These include:

- Water Quality
- Habitat Access
- Habitat Elements
- Channel Condition and Dynamics
- Flow & Hydrology
- Watershed Conditions

- Species Interaction
- Active Floodplains

Using these pathways as a foundation, seven Design Objectives were developed for this Design Notebook. In addition to the species recovery issues addressed in the Pathways, additional issues were incorporated which recognize the unique socio-cultural functions of the riverbank in an urban area. These include the economic, recreational and aesthetic needs and policies of many Willamette River stakeholders.

B. Design Objectives

The seven Design Objectives are listed below. The first five are directly based on the Pathways and Indicators discussed above for the recovery of listed fish species. These objectives are further defined in the Design Worksheet in the next chapter. Accomplishing these objectives will provide the improvements that the scientific community believes are needed to recover these fish species in this reach of the river.

The remaining two Design Objectives recognize the socio-cultural factors that also need to be considered for projects along the Willamette River in Portland.

1. **Conserve, protect and restore a diversity of instream and riparian habitats.**
2. **Provide stable riverbanks where needed to protect development, infrastructure, industrial and commercial use, significant natural resources and public safety.**
3. **Create habitats that support native species interactions while minimizing impacts of introduced species.**
4. **Protect and improve water quality.**
5. **Protect fish and wildlife access to tributaries, floodplains and other off-channel habitats.**
6. **Enhance the aesthetic quality of the riverbank.**
7. **Provide safe public access to the top of bank and to the edge of water, where appropriate.**

Each of the seven Design Objectives is followed, in turn, by Analysis Questions, Implemetation Measures and Design Solutions in the Design Worksheet (see Chapter Three).

C. The Design Notebook Process

Step One: INVENTORY EXISTING CONDITIONS

Evaluate your existing site and rate how well the seven Design Objectives are currently achieved. A qualified person(s) should assess the site, evaluate each Design Objective using the Analysis Questions on the worksheet and describe the existing conditions in terms of the categories outlined below.

1. **Diversity of Instream Riparian Habitats:** Habitat diversity is a goal that can be applied to a specific site or to a larger river reach. Opportunities to increase habitat diversity within a specific site are dependent on site size, existing conditions, substrates, site morphology and other factors.
2. **Riverbank Stability:** Normal river processes include riverbank cutting and bar and floodplain building as the river channel meanders over time. Urban rivers have hardened edges to stop these processes; however, there may be locations where some bank instability would be acceptable and beneficial. The need and justification for bank stability should be assessed for each project.
3. **Native Species Interaction:** Major habitat changes and the introduction of non-native plant and animal species have drastically altered the inter-species interactions in the lower Willamette River. Projects should be evaluated for the potential to increase habitat values for some number of native species while minimizing habitat values for introduced species.
4. **Effect on River Water Quality:** Site conditions and land uses should be evaluated for potential impacts to water quality conditions such as temperature, suspended sediment, chemical contamination, nutrients and dissolved oxygen. Best management practices should be identified and implemented to avoid these impacts.
5. **Fish and Wildlife Access to Off-channel Habitats:** Historic floodplain areas, backwaters and tributaries have been disconnected from the lower Willamette River. The site evaluation should look for opportunities to protect existing, restore historic, or create new off-channel habitats.
6. **Aesthetic Quality when Viewed from Land and Water:** The site assessment should consider opportunities to improve the visual quality of the river's edge. This includes identifying and preserving designated view corridors from, through, and to the river.
7. **Public Access to Top of Bank and to Water:** An objective of the public Willamette River Greenway is to provide appropriate locations for visual and/or physical access to the river. The site assessment should locate appropriate locations for the Greenway trail and possible river view and access points that are sensitive to fish and wildlife habitat.

Step Two: EVALUATE YOUR PROPOSED DEVELOPMENT

In light of your project goals and objectives, go through the Design Worksheet (see Chapter Three) in the following order:

Design Objectives. Scan down the left column to review the seven basic objectives for riverbank designs.

Analysis Questions. Review the analysis questions for each design objective to get a feel for the conditions that can be addressed by riverbank designs at a specific site. For each question that can be answered affirmatively, review the Implementation measures which follow.

Implementation Measures. Identify the implementation measures that can be reasonably incorporated in your unique site, project and budget.

Design Reference. Select a combination of design solutions or notes that cover all three zones of the riverbank, achieve the seven design objectives and fulfill the project's needs.

Step Three: DOCUMENTATION

A. Describe your site's existing conditions as compared to the Design Objectives (from Step One).

B. Describe your project and proposed improvements.

C. Describe your riverbank design selection process and the designs you will incorporate into your project.

D. Describe the expected results for each of the seven Design Objectives once the project is completed.

Step Four: SUBMITTAL

Submit the project proposal for review. Include documentation from step 3.

DESIGN OBJECTIVES	ANALYSIS QUESTIONS		IMPLEMENTATION MEASURES (If yes, then…)		DESIGN REFERENCE (See following section)
1. Conserve, protect and restore a diversity of instream and riparian habitats. *(PFC Pathway: Habitat Elements)*	1.1	Based on size, existing conditions and landscape context, is there a potential for a diversity of habitats within the project site?	1.1.1	Design shoreline to promote a diversity of habitat types where appropriate including: • shallow shelving shoreline • off channel embayments • riparian riverbank with in water structural elements • steep bank with deep channel adjacent • others	A.1a, A.1b, A.2-A.4, L.1, U.1, U.2a, U.2b, U.3, U.4, U.10, G.4a, G.4b, G.5, G.6, G.10, G.11, G.12, G.13a, G.13b, G.14, G.16, G.17, G.18
			1.1.2	Develop a vegetated riparian area starting at the lowest possible elevation on the bank.	A.1, A.3, A.5-A.7, L.1, U.1, U.2a, U.2b, U.3, U.4, U.10, G.4a, G.4b, G.5-G.12, G.16-G.18, N.13, N.16
	1.2	Will the flow dynamics of the site allow the use of bank and bed materials of various sizes?	1.2.1	Utilize a range of sizes in bank and substrate material, consistent with flow dynamics of the site.	A.1a, A.1b, A.3, G.5, G.6, G.12
	1.3	Is there potential for improving existing structures along river and riverbank to provide enhanced habitat value?	1.3.1	Retrofit existing structures to mimic habitat values provided by natural structural elements such as vertical rock outcrops, root wads, fallen trees and large boulders.	A.2-A.4, A.6, U.10, G.4a, G.4b, G.5, G.6, G.13a, G.13b
	1.4	Are there opportunities to incorporate new in-water habitat structures for fish and wildlife?	1.4.1	Install structures that mimic habitat values provided by natural structural elements such as rock outcrops, root wads, fallen trees and large boulders.	A.1-A.7, U.10, G.4a, G.4b, G.12, G.13a, G.13b
	1.5	Are there opportunities to	1.5.1	Locate structural elements upstream to	A.1-A.3, G.5, G.6

DESIGN OBJECTIVES	ANALYSIS QUESTIONS	IMPLEMENTATION MEASURES (If yes, then…)	DESIGN REFERENCE (See following section)
	retain, enhance or create shallow water depositional areas?	facilitate deposition.	
		1.5.2 Incorporate native riparian vegetation.	A.1-A.3, G.5, G.6, N.13, N.16
	1.6. Is there an opportunity to allow the riverbank and shoreline to change as they would in a natural condition?	1.6.1 Design "soft" bank treatments that allow for some localized deformation to the bank, consistent with the need for stability (see II, below).	U.2a, U.2b, G.5, G.6, G.10, G.11, N.1
	1.7. Does existing bank stabilization utilize rip rap?	1.7.1 Install appropriate vegetation in existing rip rap.	L.1, U.3, G.18, N.13, N.16
	1.8. Are there significant habitat areas where public access is not desired and should not be accommodated?	1.8.1 Use dense barrier plantings, pathway alignment and other means to discourage public access into sensitive habitat areas.	N.13, N.16
	1.9 Are there existing areas of established riparian vegetation?	1.9.1 Protect existing vegetation; limb trees if necessary to allow views in specific areas.	G.15, N.13
		1.9.2 Augment with additional native plantings.	G.18, N.13, N.16
2. Provide stable riverbanks where needed to protect development, infrastructure, industrial and commercial use, significant natural	2.1 Is there a need for protection of adjacent lands and infrastructure from erosion?	2.1.1 Determine erosion susceptibility of bank in each of three zones Aquatic, Lower-Shore and Upper-shore.	
	2.2 Does the existing bank lack the needed level of protection or functionality for the proposed development?	2.2.1 Select bank treatment improvements with appropriate amount of stability.	

DESIGN OBJECTIVES	ANALYSIS QUESTIONS		IMPLEMENTATION MEASURES (If yes, then…)		DESIGN REFERENCE (See following section)
resources and public safety. *(PFC Pathway: Channel Conditions and Dynamics)*	2.3	Do expected maximum velocities or bed sheer stress of the river near shore exceed the existing bank's ability to withstand them at various flood stages?	2.3.1	Ensure bank materials have sufficient mass or internal structure to withstand maximum velocities and bed shear stress for anticipated flood conditions.	
	2.4.	Is surface stormwater drainage adversely affecting existing bank stability?	2.4.1	Accommodate stormwater discharge in such a way that riverbanks remain stable.	G.4a, G.4b, G.16, G.17, N.2-N.5
	2.5.	Is this an area of groundwater discharge to the river?	2.5.1	Ensure discharge can occur without dislodging bank materials or contributing to internal drainage stresses.	G.7, N.6, N.7
	2.6	Is the existing bank susceptible to failure due to seasonal and tidal water level fluctuations?	2.6.1	Design appropriate internal drainage for banks to prevent soil loss through surficial erosion or piping.	G.7, N.6, N.7
	2.7	Is there evidence of significant wave-induced erosion on the existing bank?	2.7.1	Design appropriate level of protection for resistance to wave-induced erosion.	A.1a, A.1b, A.2, A.3, A.5, A.7, U.1, U.3, U.10, G.5, G.6, G.9, G.12, N.8
	2.8	Is there a need for overlooks, pier structures, docks and other structures that allow private or public access to edge of water?	2.8.1	Design structures to mimic habitat values provided by natural structural elements such as rock outcrops, root wads, fallen trees and large boulders.	A.2, A.4-A.7, U.5-U.10, G.1-G.3, G.4a, G.4b, G.8, G.9, G.12, G.13a, G.13b, N.9, N.10
	2.9	Does proposed use require a vertical bulkhead?	2.9.1	If possible, design bulkhead to provide substrate for aquatic plants and invertebrates.	G.13a, G.13b, U.10, N.6

DESIGN OBJECTIVES	ANALYSIS QUESTIONS	IMPLEMENTATION MEASURES (If yes, then…)	DESIGN REFERENCE (See following section)
		2.9.2 If possible, design a stepped system of bulkheads which allow for one or more intermediate terraces with riparian vegetation.	U.10, G.12
	2.10 Does proposed use require that slope of bank is 2:1 or steeper?	2.10.1 Incorporate planting in the Lower-shore and Upper-shore zones of the bank.	U.1, U.2a, U.2b
	2.11 Does proposed use require that slope of bank is between 2:1 and 5:1?	2.11.1 Incorporate planting in the Lower-shore and Upper-shore zones of the bank.	G.10, G.18
	2.12 Does propose use allow for slopes of bank to be 5:1 or shallower?	2.12.1 Incorporate planting in the Lower-shore and Upper-shore zones of the bank.	G.11, G.18
3. Create habitats that support native species interactions while minimizing impacts of introduced species. *(PFC Pathway: Species Interactions)*	3.1 Do proposed plantings create opportunities for native species interaction?	3.1.1 Utilize plants native to aquatic and riparian areas of the lower Willamette Valley.	G.10, G.11, G.18, N.13, N.16
		3.1.2 Use plants in their natural associations, wherever possible.	U.1-U.4, G.18, N.13, N.16
		3.1.3 Develop a vegetation management plan to control non-native species and develop a sustainable landscape.	N.13
	3.2 Do the existing riparian and shoreline aquatic areas lack	3.2.1 Incorporate vegetative layers, overhanging vegetation, large woody	A.1-A.3, A.5-A.7, L.1, U.1-U.4, G.4a, G.4b, G.5, G.6,

DESIGN OBJECTIVES	ANALYSIS QUESTIONS		IMPLEMENTATION MEASURES (If yes, then…)		DESIGN REFERENCE (See following section)
		structural complexity?		debris between bank and bed, in-water boulders, shallow shelving shoreline and other elements to achieve structural complexity.	G.10, G.11, G.12, G.13a, G.13b, G.18, N.13, N.16
	3.3	Is the site dominated by non-native vegetation?	3.3.1	Eradicate non-native vegetation and replant with native riparian species.	
4. Protect and improve water quality. *(PFC Pathway: Water Quality)*	4.1	Will proposed construction possibly result in impacts to water quality?	4.1.1	Develop an erosion control and construction materials management plan in place to ensure construction related sediments and pollutants do not enter the river.	N.14
	4.2	Is there a need to isolate contaminated soils or groundwater from the river?	4.2.1	Remove or isolate contaminated materials from water body.	G.5, G.6, N.15
			4.2.2	Utilize design solutions which do not expose contaminated soils or groundwater to the river.	A.1a, A.1b, G.6
	4.3	Are there opportunities to avoid water temperature increases on a localized scale?	4.3.1	Increase streambank shade cover with vegetation.	A.5-A.7, U.1-U.4, U.10, G.6, G.8-G.12, G.18, N.13, N.16
			4.3.2	Limit barriers between river and groundwater zones.	
	4.4	Can bank plantings be	4.4.1	Utilize plantings with limited	G.18, N.13, N.16

DESIGN OBJECTIVES	ANALYSIS QUESTIONS		IMPLEMENTATION MEASURES (If yes, then…)		DESIGN REFERENCE (See following section)
		managed to protect water quality?		requirements for fertilizers, pesticides and herbicides.	
	4.5	Are there opportunities to incorporate stormwater biofiltration and infiltration within or adjacent to the riverbank?	4.5.1	Incorporate stormwater treatment and infiltration in bank designs	G.4a, G.4b, G.16, G.17, N.2-N.5
5. Protect fish and wildlife access to tributaries, flood plains and other off-channel habitats. *(PFC Pathways: Habitat Access and Active Floodplain)*	5.1	Is there existing or potential fish/wildlife access to existing tributaries, backwaters, wetlands or riparian forests on site?	5.1.1	Maintain, improve or construct access to these off channel habitats for fish and wildlife during a wide variety of flow ranges and seasons of use.	G.4a, G.4b, G.14, N.18
			5.1.2	Ensure access is designed to avoid stranding fish in off-channel areas when the river level recedes.	N.18
			5.1.3	"Daylight" piped streams near river.	G.4a, G.4b, N.18
	5.2	Are there opportunities to create off channel shallow areas that support aquatic and annual vegetation?	5.2.1	Construct aquatic berms.	A.1
	5.3	Is there an opportunity to	5.3.1	In areas that flood frequently, remove	G.14, N.18

DESIGN OBJECTIVES	ANALYSIS QUESTIONS		IMPLEMENTATION MEASURES (If yes, then…)		DESIGN REFERENCE (See following section)
		protect or enhance connections to adjacent floodplains?		barriers such as dikes and weirs that prevent or restrict the naturally functioning floodplain.	
	5.4	Is there an opportunity to retain or restore habitat in active floodplain areas?	5.4.1	Utilize native riparian plant communities to restore floodplain habitat.	G.18, N.18
6. Enhance aesthetic quality of the riverbank .	6.1	Are there designated viewpoints or view corridors within the site?	6.1.1	Utilize plantings to frame and accent significant views from the site.	U.5-U.7, G.2, G.15, N.19
			6.1.2	Create scenic overlooks, viewpoints and rest stops along trail where appropriate.	U.5-U.7, G.1-G.3, N.19
	6.2	Does the site have poor visual quality and integrity when viewed from the river or other designated sites?	6.2.1	Remove undesirable debris, unstable slopes, and deteriorated structures or vegetation that result in poor quality appearance of the site.	
			6.2.2	Utilize a mix of native deciduous and evergreen riparian plant species, with contrasts in color, texture and form.	G.18, N.19
			6.2.3	In cases with extensive blank vertical structures such as seawalls, consider applying heavy timber structures to break up visual monotony while providing a substrate for aquatic and	G.13

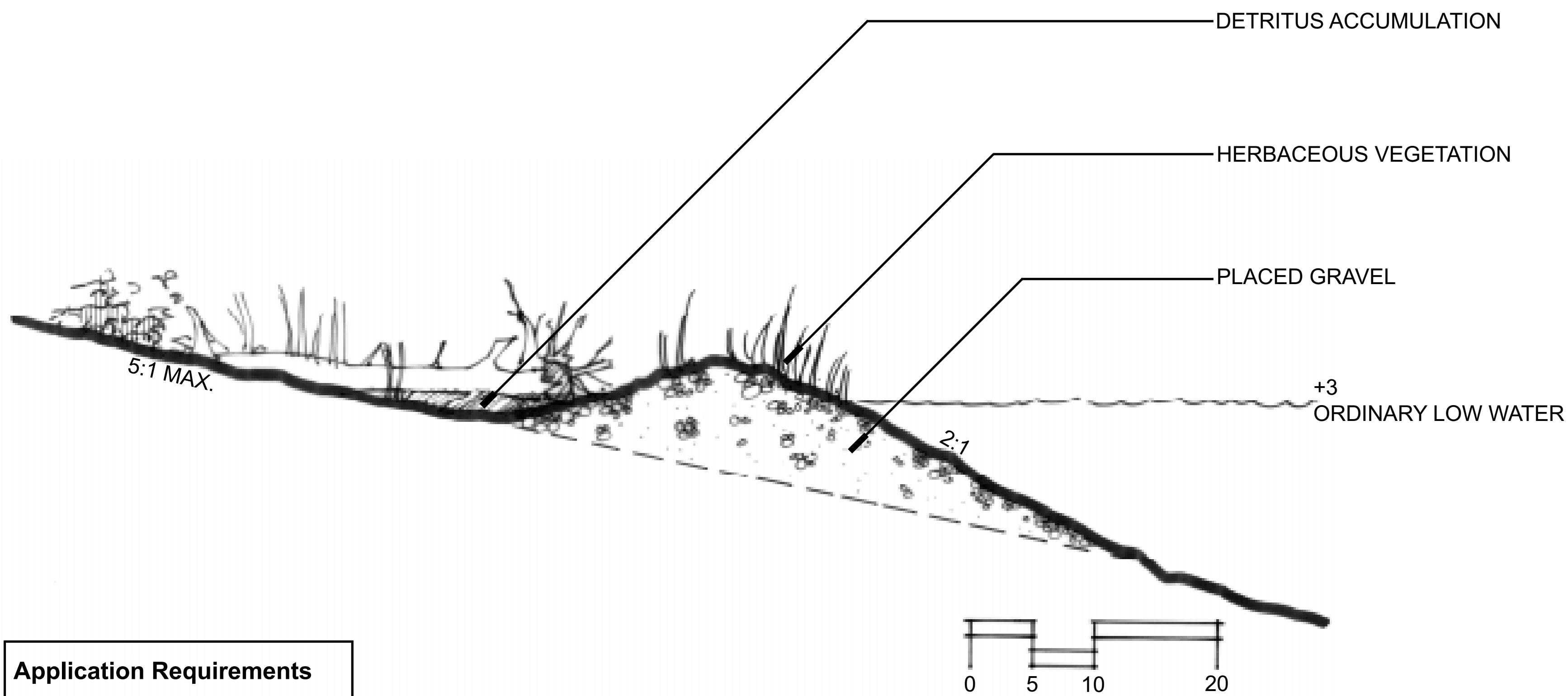
DESIGN OBJECTIVES	ANALYSIS QUESTIONS		IMPLEMENTATION MEASURES (If yes, then…)		DESIGN REFERENCE (See following section)
				riparian vegetation.	
	6.3	Does existing vegetation block designated views?	6.3.1	Ensure that riverbank plantings provide habitat value while protecting designated views as much as possible.	G.15, G.18, N.19
			6.3.2	Utilize riparian trees to frame significant views rather than blocking them.	G.15, N.19
	6.4	Are views of the bank dominated by light colors with minimal texture?	6.4.1	Reduce light colored non-vegetated surfaces as much as possible.	
			6.4.2	Incorporate native plantings into existing riverbank riprap above elevation of persistent woody vegetation.	U.3, N.19
			6.4.3	Utilize dark, non-reflective, natural materials for exposed surfaces of riverbank structures as much as possible.	
7. Provide safe public access to the top of bank, and edge of water, where appropriate.	7.1	Does or will the Willamette Greenway Trail pass through the site?	7.1.1	Incorporate Willamette Greenway Trail in the bank treatment design, consistent with the Willamette Greenway Plan.	
			7.1.2	For public safety, minimize dead-end accessways, provide good visual access to and along trail, and provide for emergency access.	

DESIGN OBJECTIVES	ANALYSIS QUESTIONS		IMPLEMENTATION MEASURES (If yes, then…)		DESIGN REFERENCE (See following section)
	7.2	Is there desire and potential for providing seasonal public access down to water's edge?	7.2.1	Design secondary access down to water's edge that can withstand winter flooding, is barrier-free if possible, and utilizes either distinct paths or gently sloping banks to provide access.	G.1-G.3, G.8, G.9, G.11
			7.2.2	Discourage uncontrolled access on riverbank through effective use of vegetation, topography and other barriers.	U.5-U.8, G.8
			7.2.3	Ensure secondary access does not significantly reduce habitat value of riparian vegetation along riverbank.	
	7.3	Is there potential for improving existing structures along river and riverbank to provide public access to water's edge?	7.3.1	Retrofit existing structures to mimic habitat values provided by natural structural elements such as vertical rock outcrops, root wads, fallen trees and large boulders.	A.2, A.4-A.7, U.10, G.13a, G.13b
	7.4	Is there a need for emergency access to riverbank?	7.4.1	Provide routes for emergency personnel and vehicles to access site.	

General Notes on Design Solutions

The Willamette Riverbank Design Notebook is a tool designed to foster creativity and innovation in developing an urban river's edge that improves conditions for fish, wildlife and people. Because the science and our knowledge will continue to evolve over time, the following notes are important to recognize.

1. This is a working draft; changes will be made as we gain more knowledge. We expect new ideas and designs for improving our river to be generated over time.
2. This is just one component of the recovery strategy for ESA listed fish being developed by the City of Portland.
3. This notebook deals just with the riverbank and nearshore environment.
4. The level of permitting complexity depends on a number of factors. In general, projects includ ing structures below ordinary high water, floating structures, and non-vegetated banks may involve a more complex permitting and monitoring process.
5. There is not at this time an overall master plan for fish and wildlife along the lower Willamette River.
6. Discussions with resource and regularory agencies are ongoing.



Application Requirements

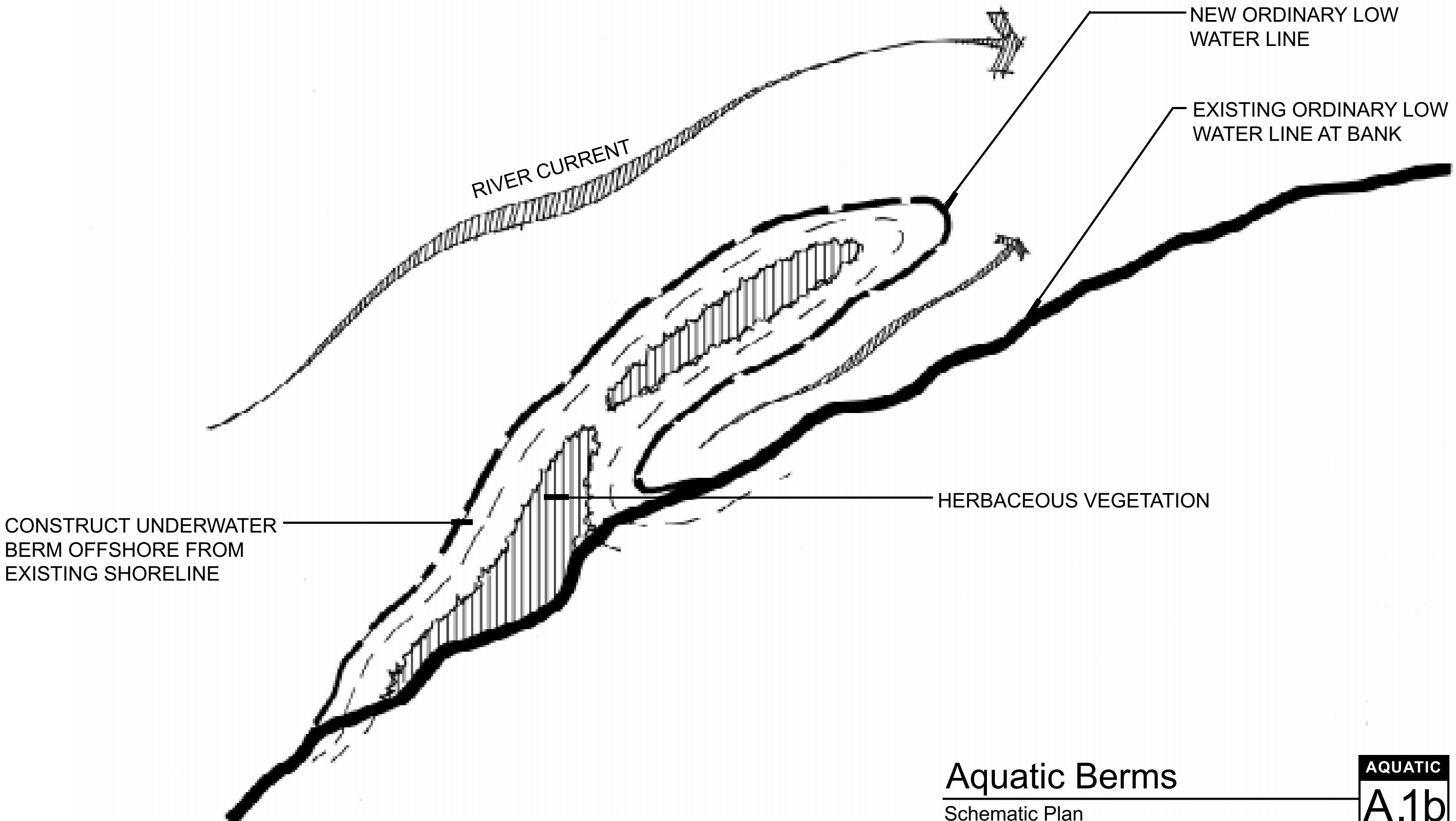
1. Slopes 5:1 or Shallower

Aquatic Berms

Section

AQUATIC

A.1a

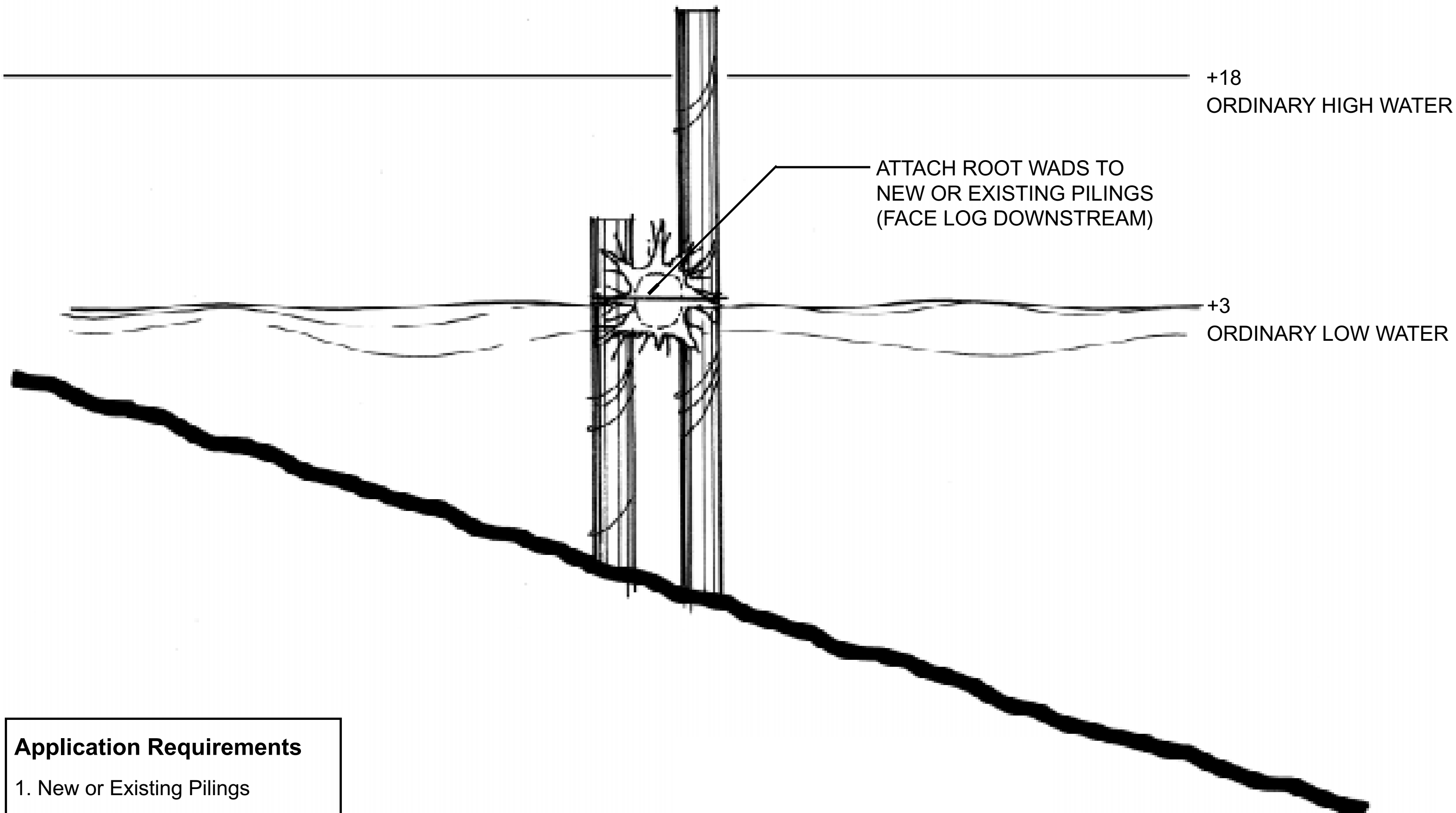


Aquatic Berms

Schematic Plan

AQUATIC

A.1b



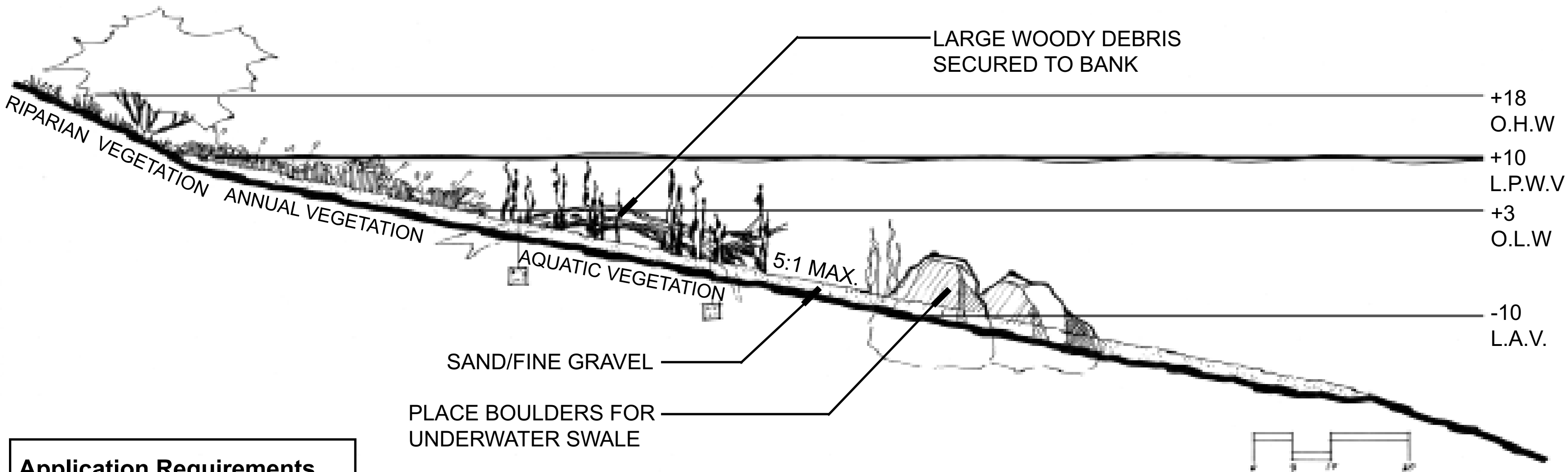
Application Requirements

1. New or Existing Pilings

Habitat Pilings

Section

AQUATIC
A.2



Application Requirements

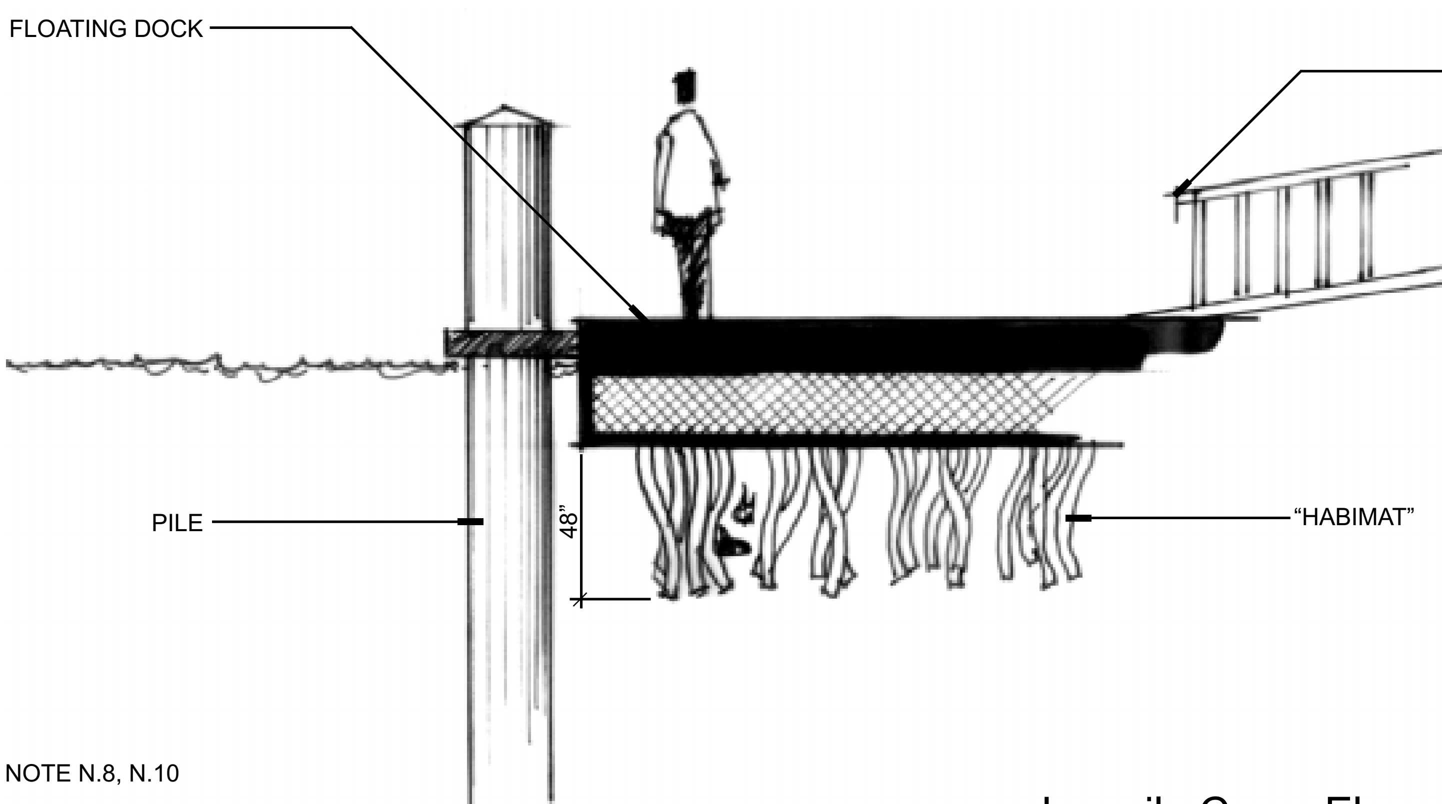
1. Deposition Area Location
2. Slopes 5:1 or Shallower

Sandy Shore

Section

AQUATIC

A.3



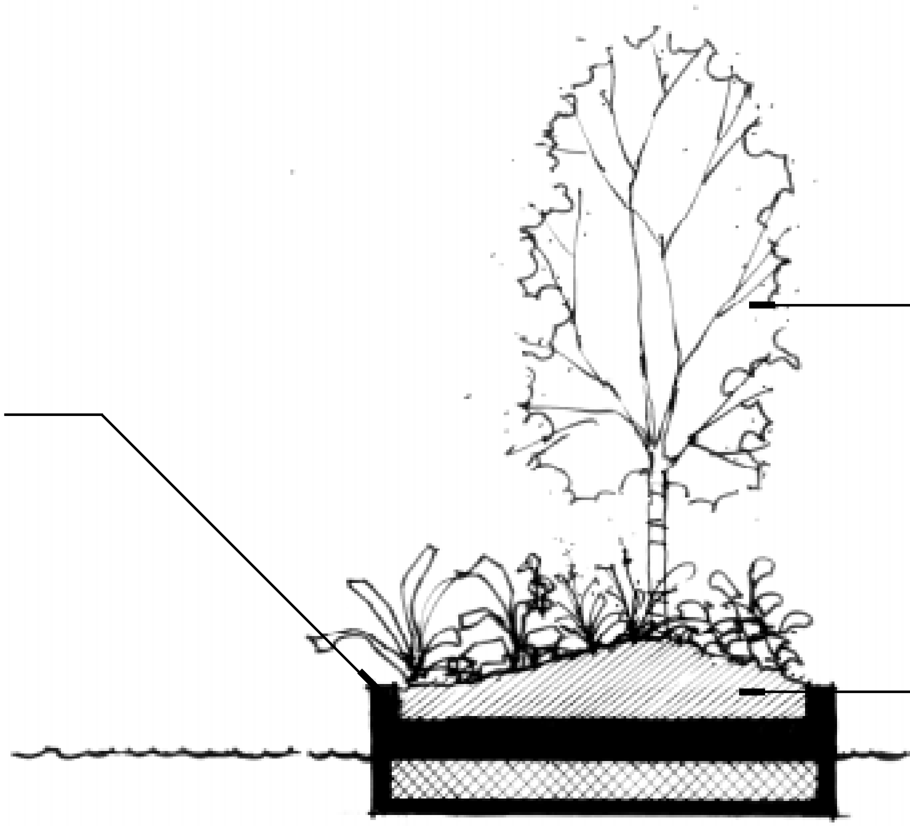
NOTE N.8, N.10

Juvenile Cover Element

Section

AQUATIC

A.4



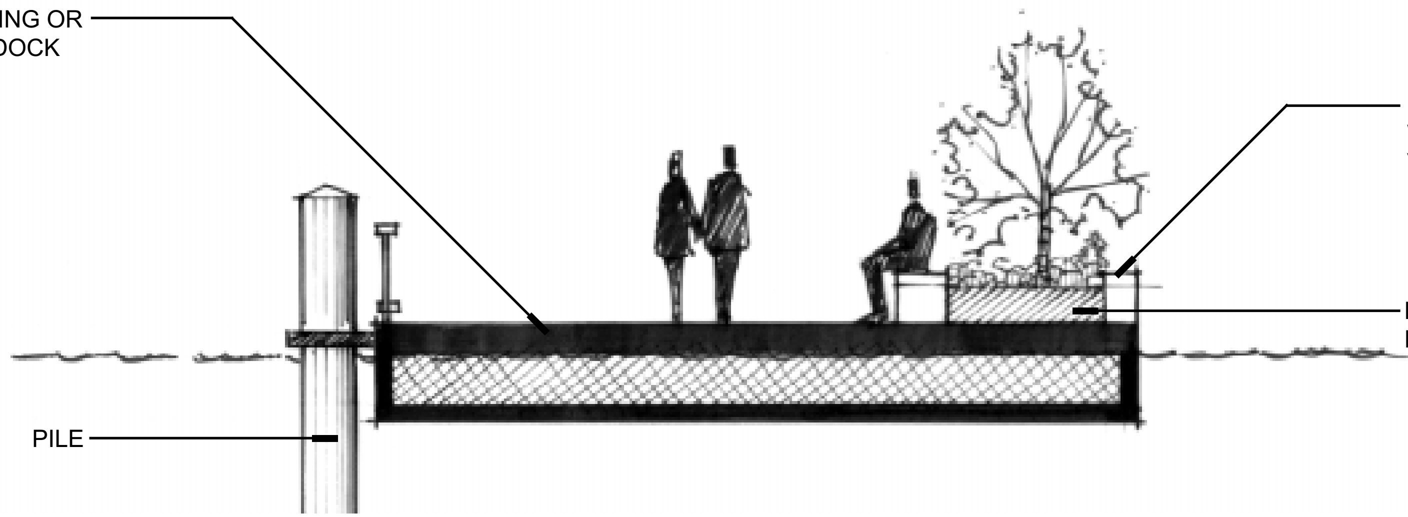
NOTE N.8

Floating Planter

Section

AQUATIC

A.5



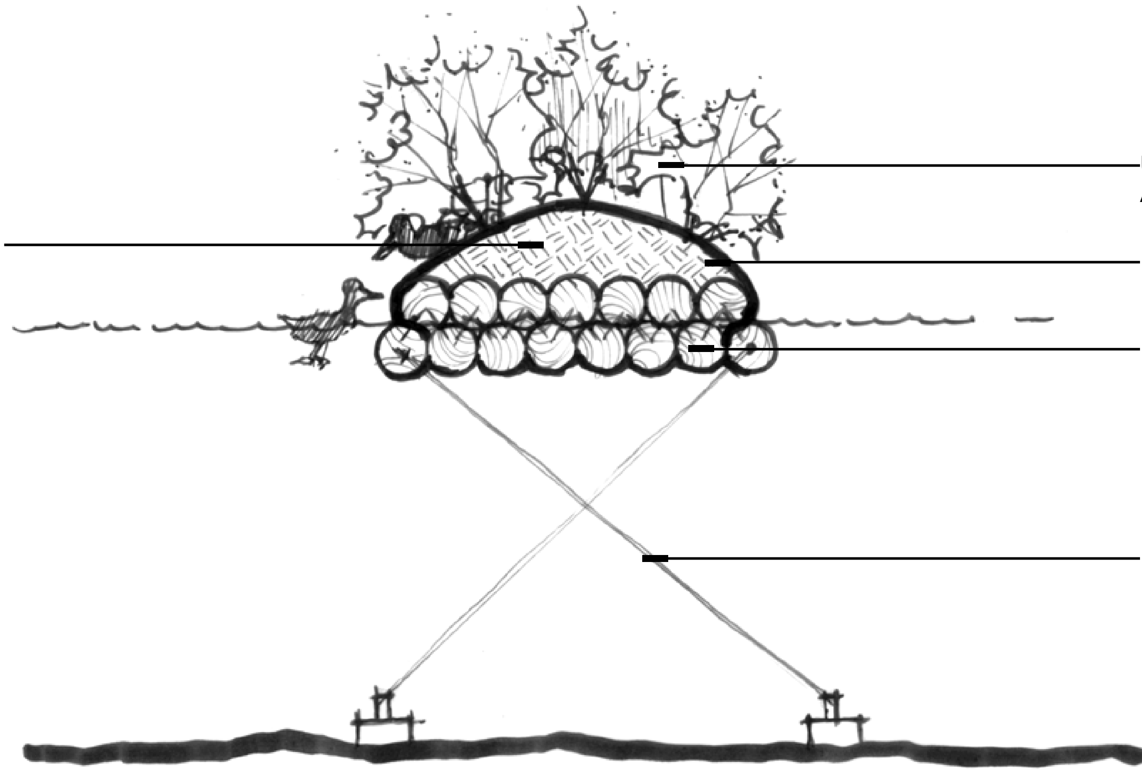
NOTE N.8

Planted Walkway or Dock

Section

AQUATIC

A.6



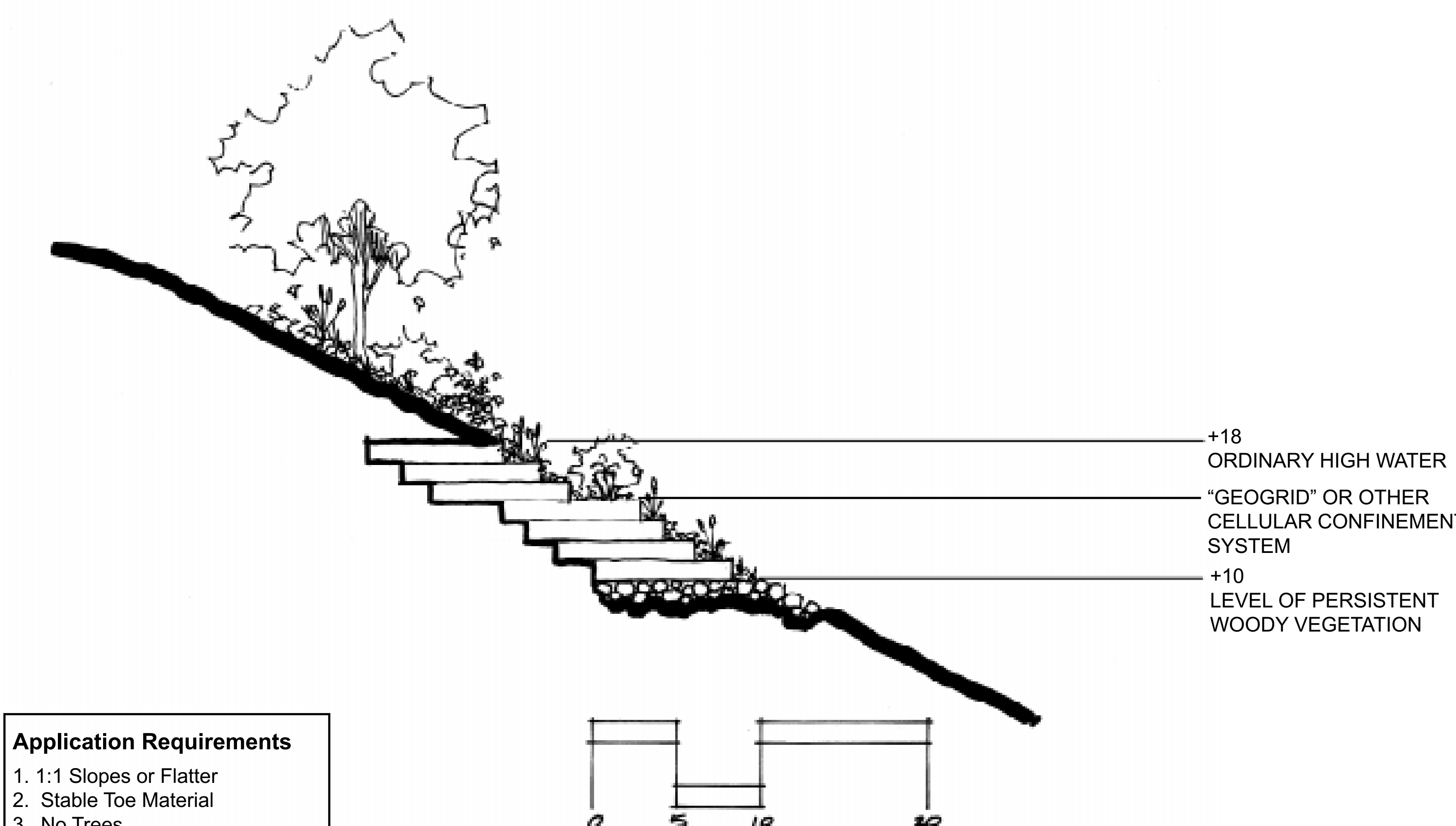
NOTE N.8

Floating Planted Breakwater

Section

AQUATIC

A.7



Application Requirements

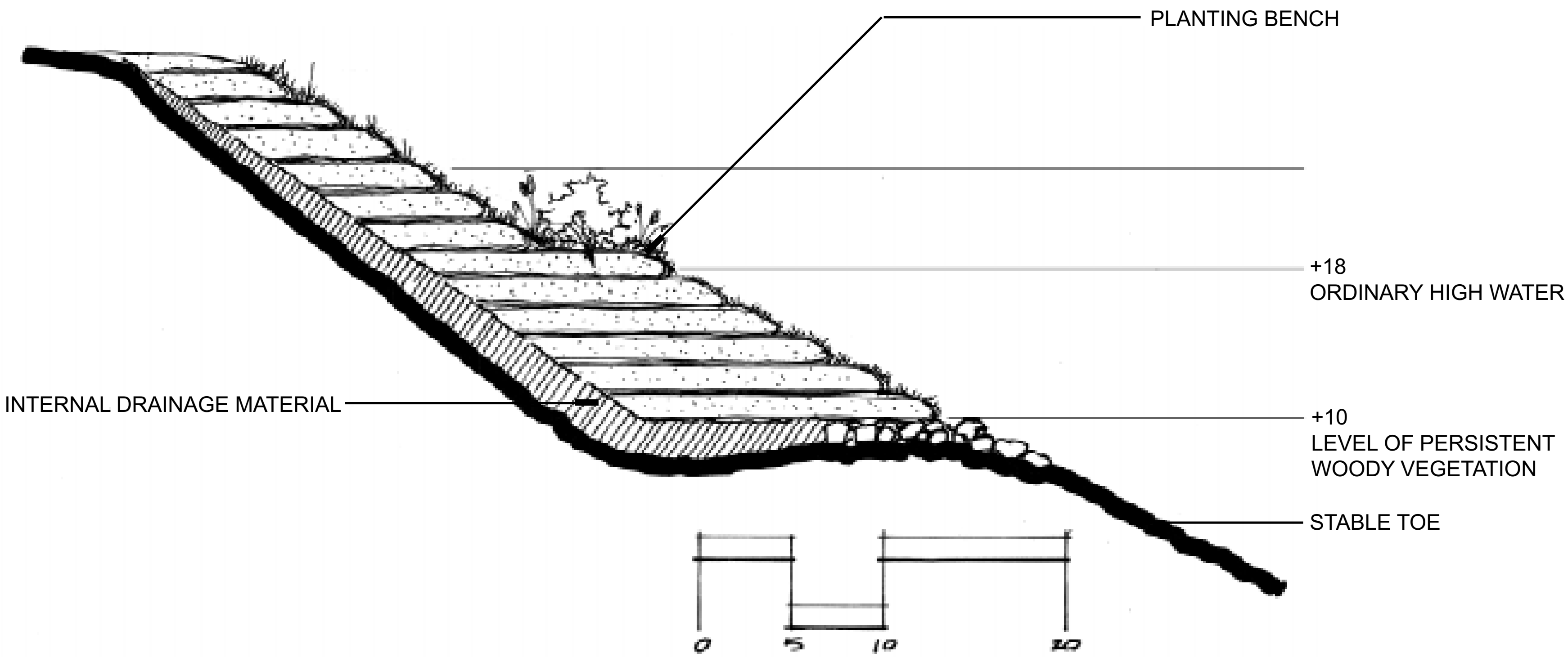
1. 1:1 Slopes or Flatter
2. Stable Toe Material
3. No Trees

Cellular Retaining System

Section

UPPER

U.1



Application Requirements

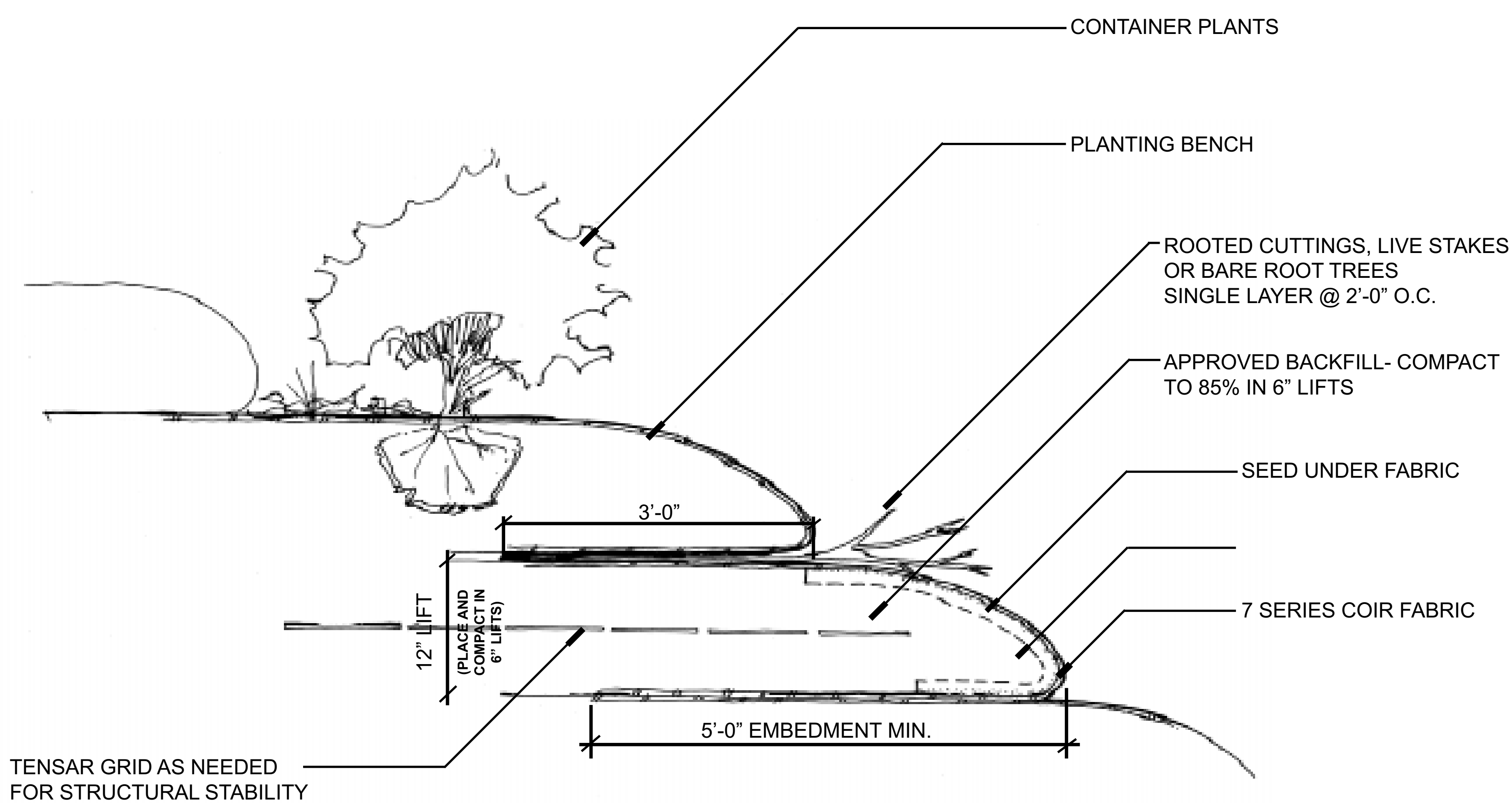
1. Stable Toe Below Level of Persistent Woody Vegetation
2. Slopes 1:1 or Shallower

Structured Soil Bank

Section

UPPER

U.2a

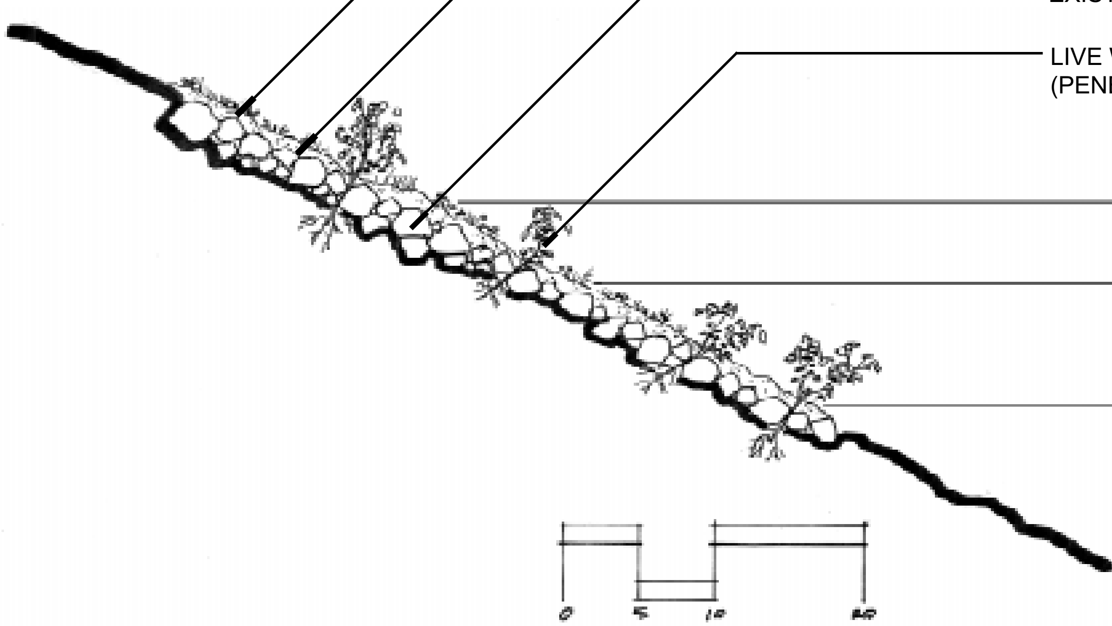


Structured Soil Bank

Section Enlargement

UPPER

U.2b



Application Requirements

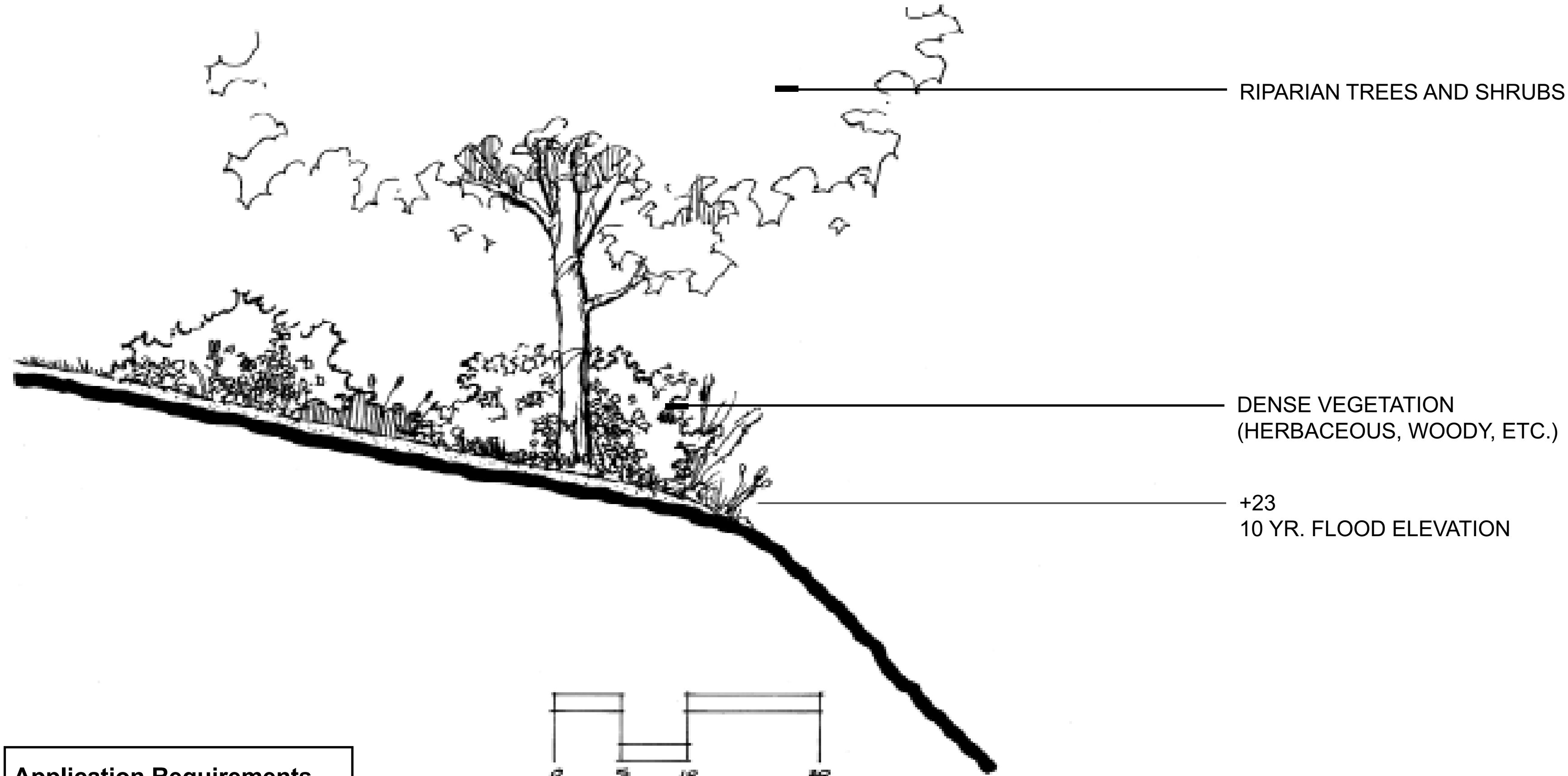
1. Stable Existing Rip Rap
2. 2:1 Slopes or Flatter
3. Rip Rap Depth Less Than 5 Ft.

Planting Existing Rip Rap

Section

UPPER

U.3



Application Requirements

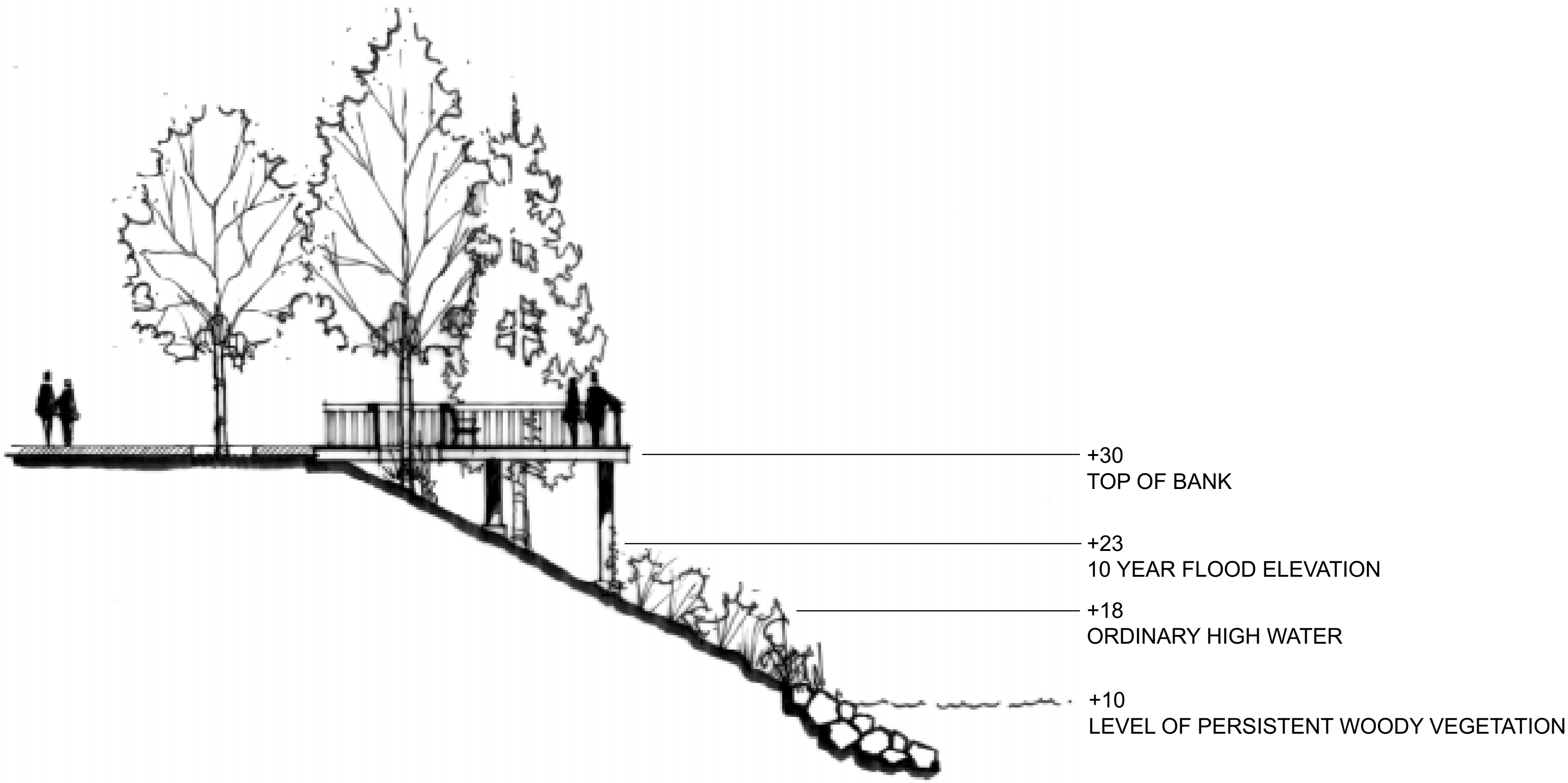
1. 5:1 Slope or Flatter

Non-Reinforced Vegetated Slope

Section

UPPER

U.4



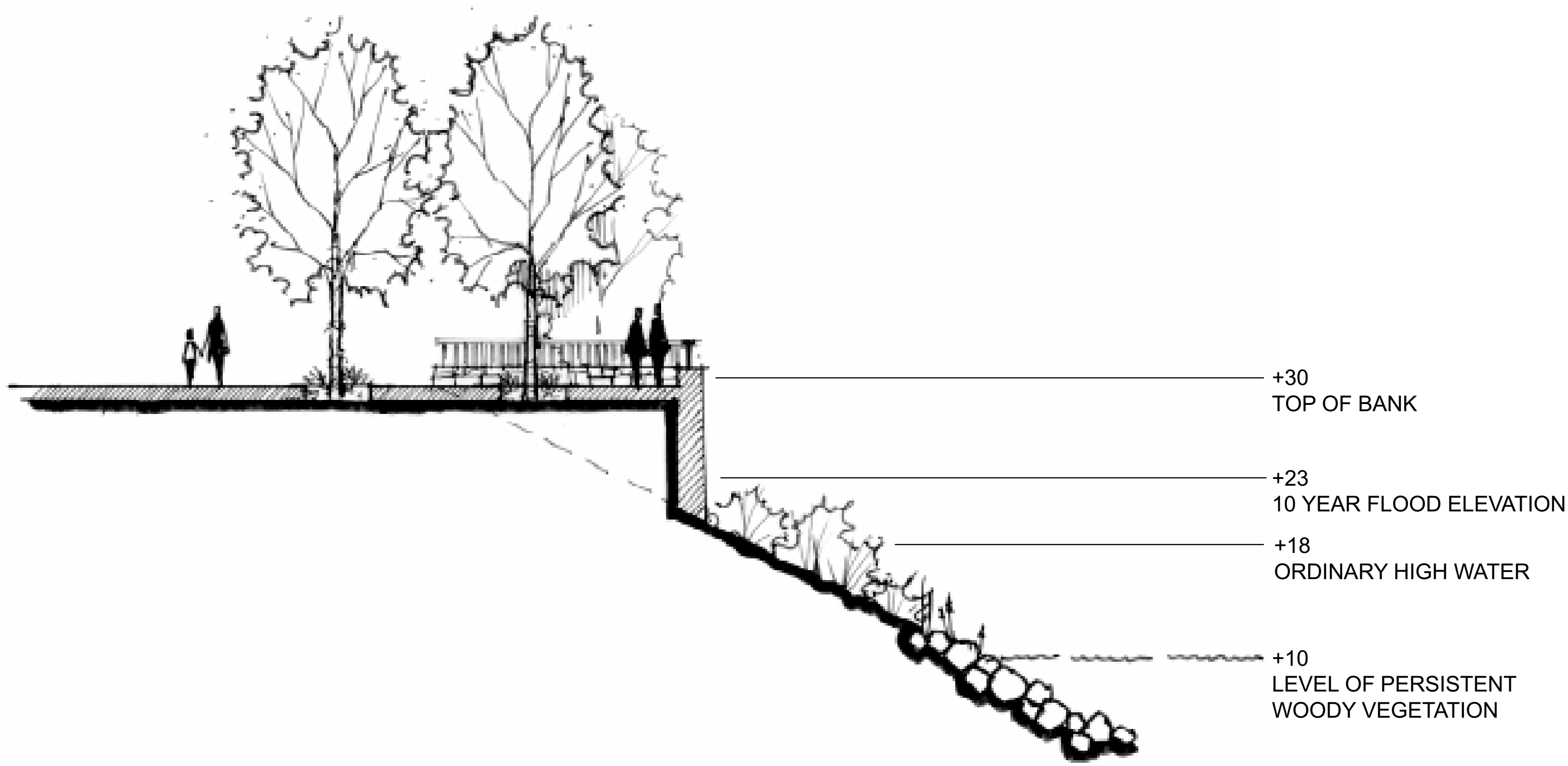
NOTE N.12

Overlook Options: Pile Supported

Section

UPPER

U.5



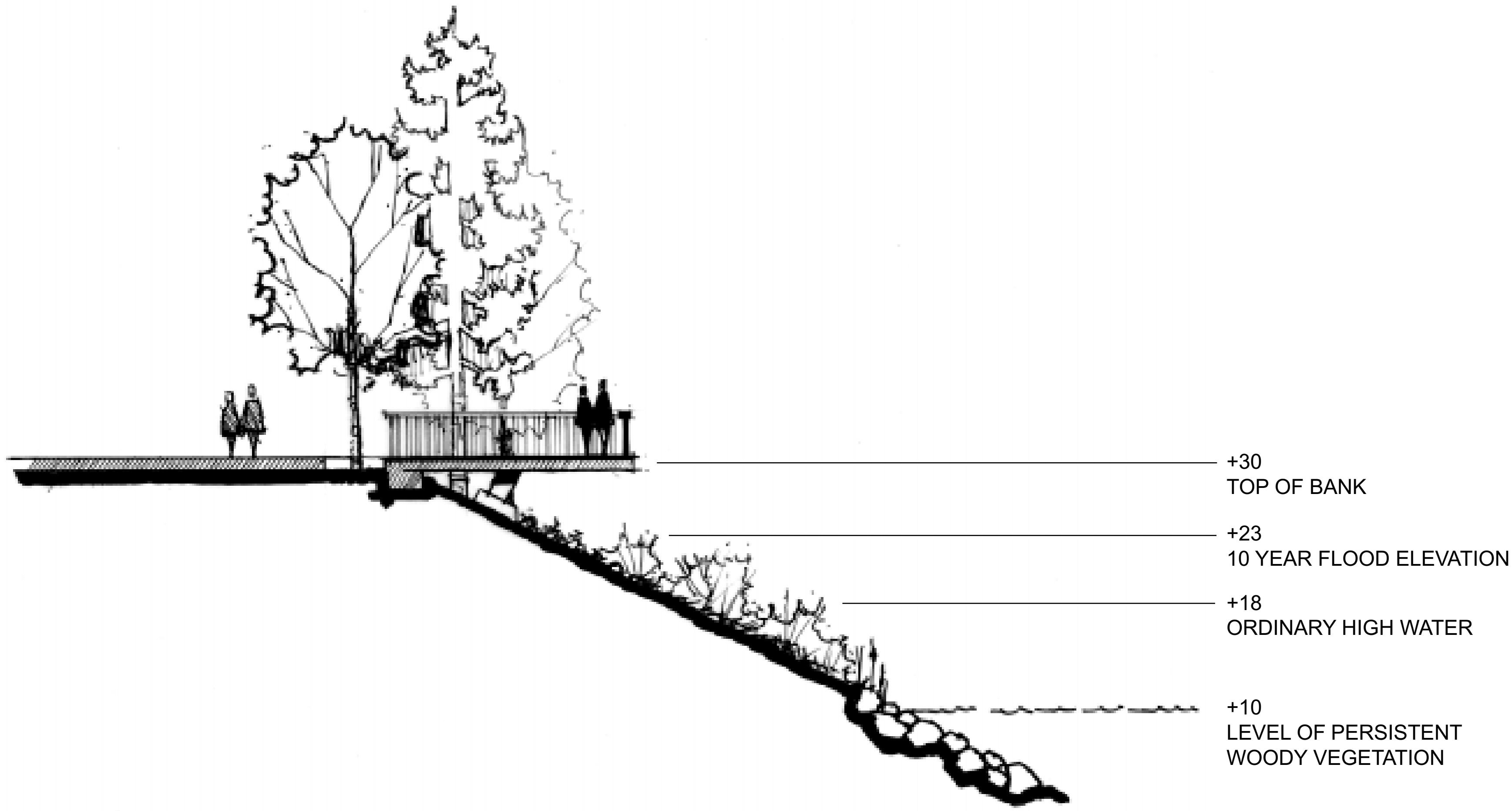
NOTE N.12

Overlook Options: Retaining Wall

Section

UPPER

U.6



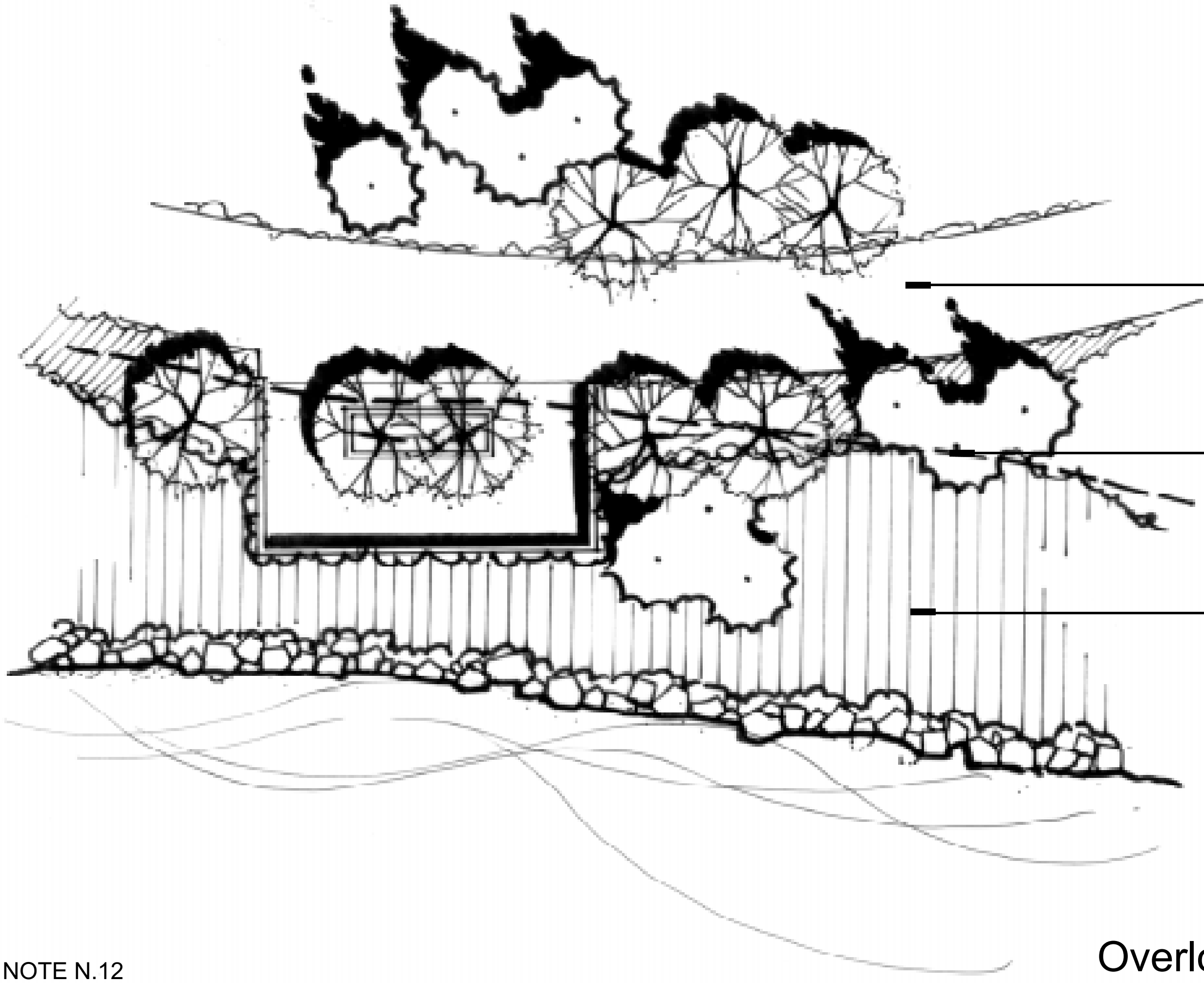
NOTE N.12

Overlook Options: Cantilever

Section

UPPER

U.7



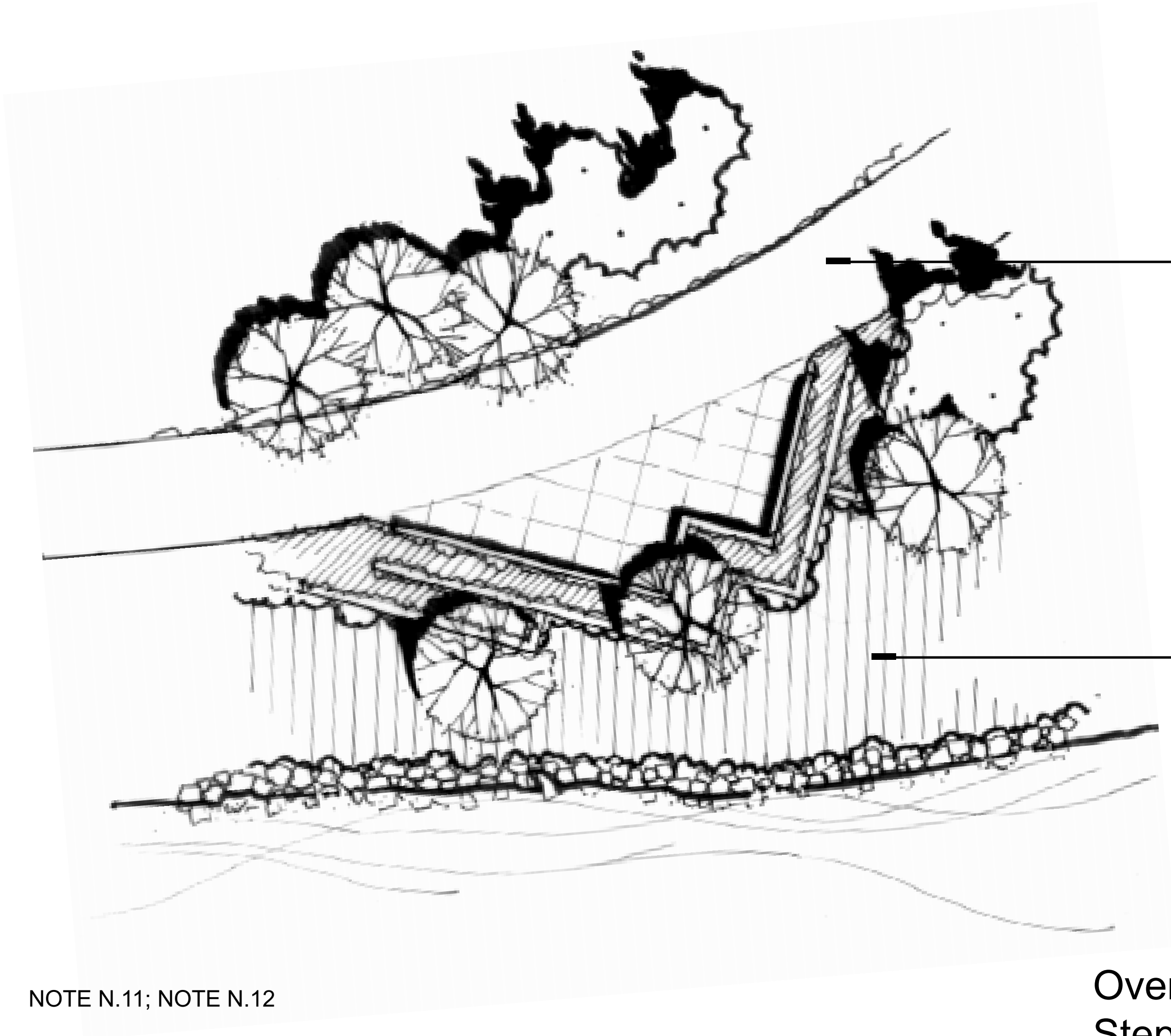
NOTE N.12

Overlook Options: General

Plan

UPPER

U.8



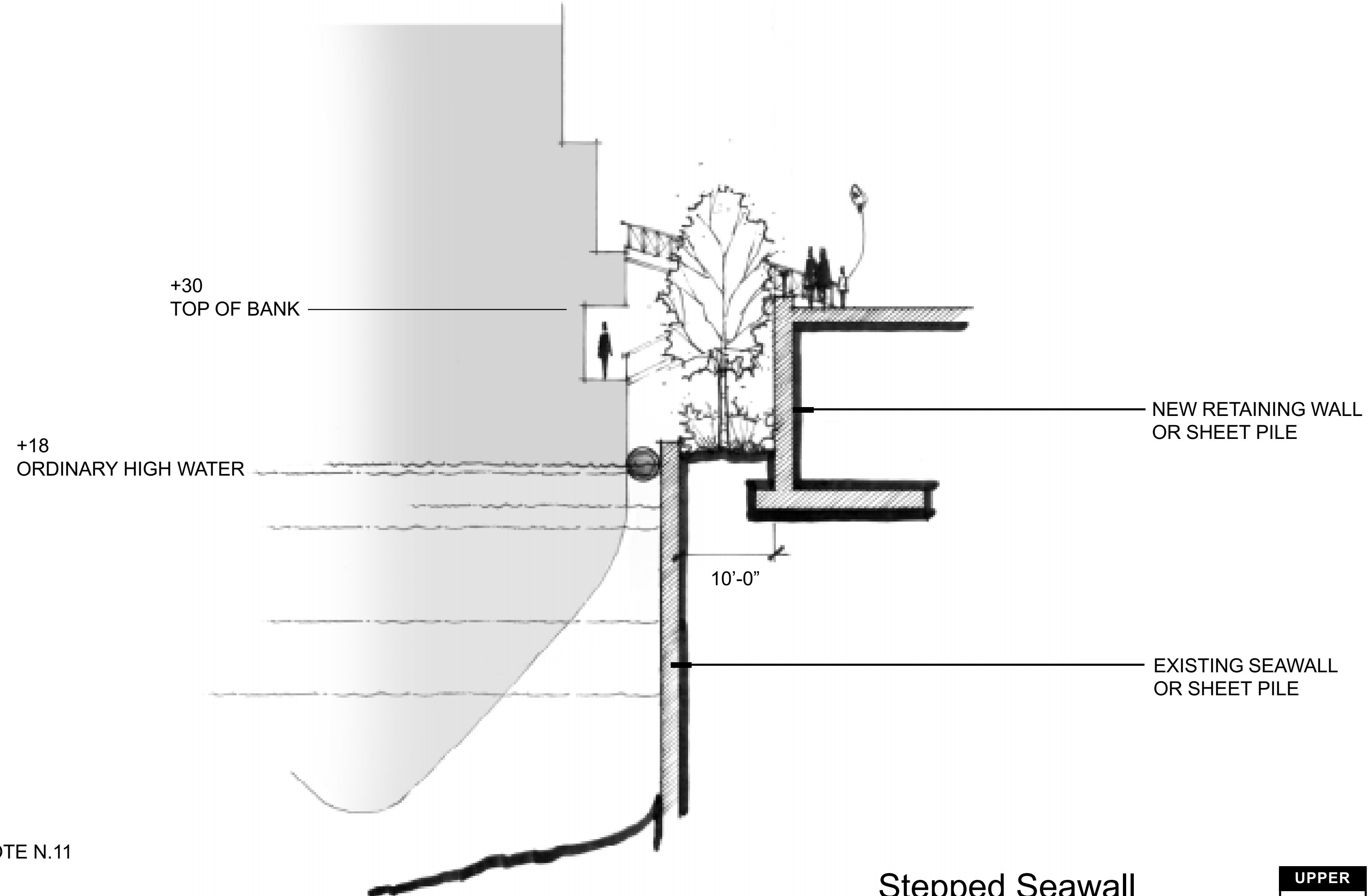
NOTE N.11; NOTE N.12

Overlook Options: Stepped

Plan

UPPER

U.9



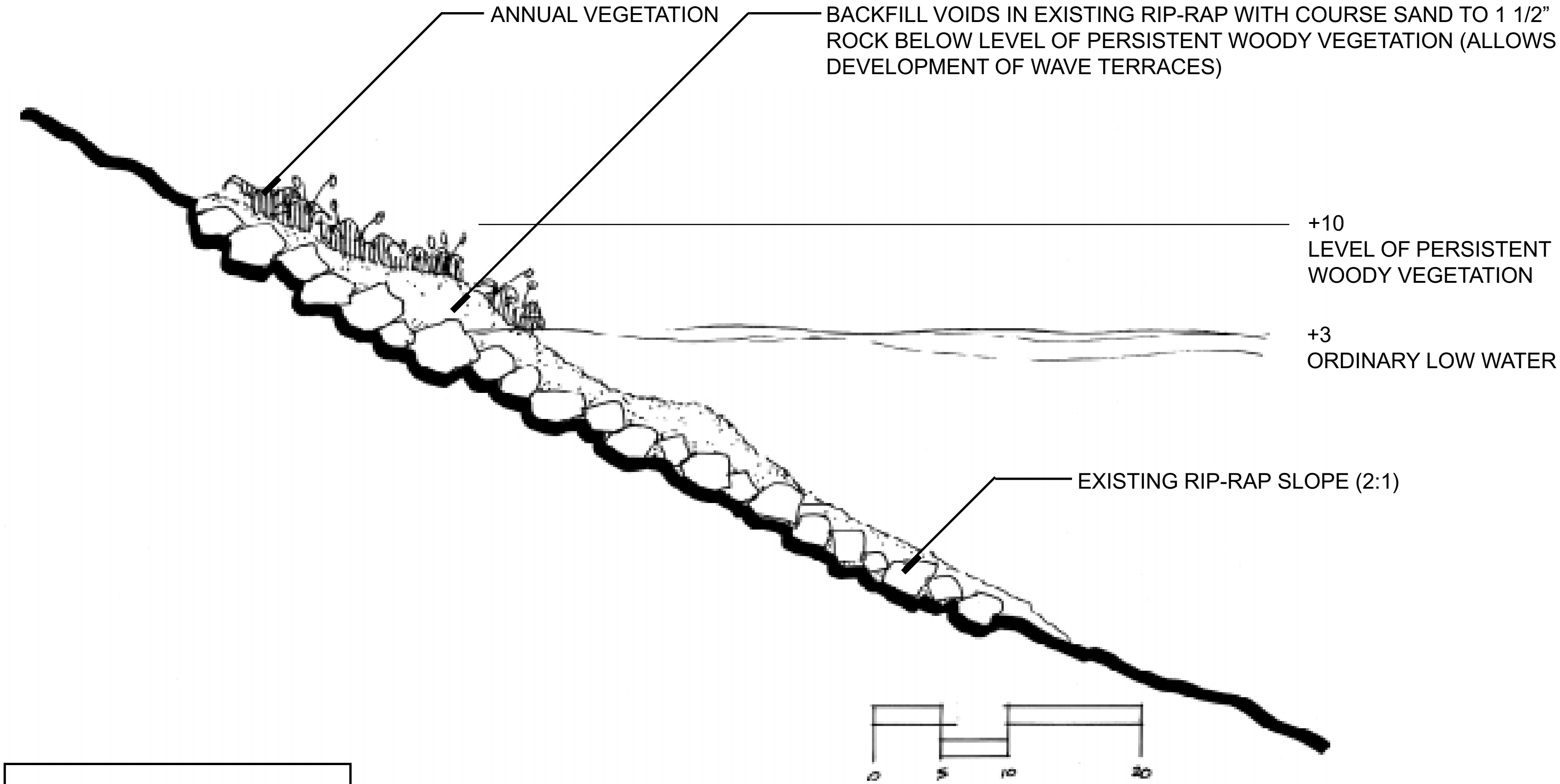
NOTE N.11

Stepped Seawall

Section

UPPER

U.10



Application Requirements

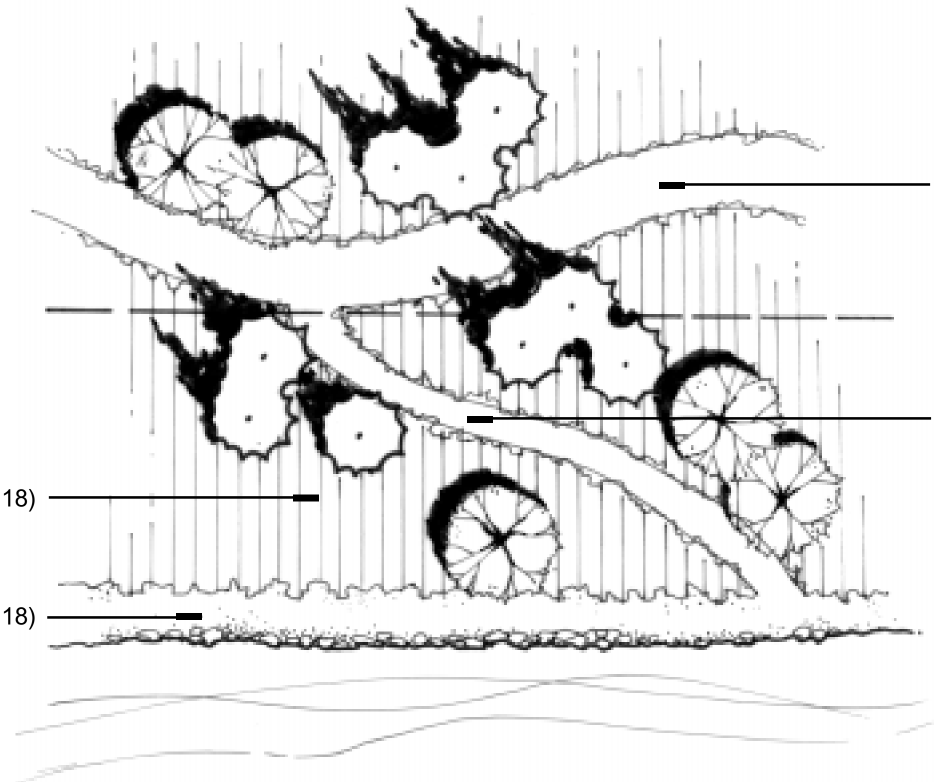
1. 2:1 Slopes and Flatter

Rip-Rap Backfill

Section

LOWER

L.1

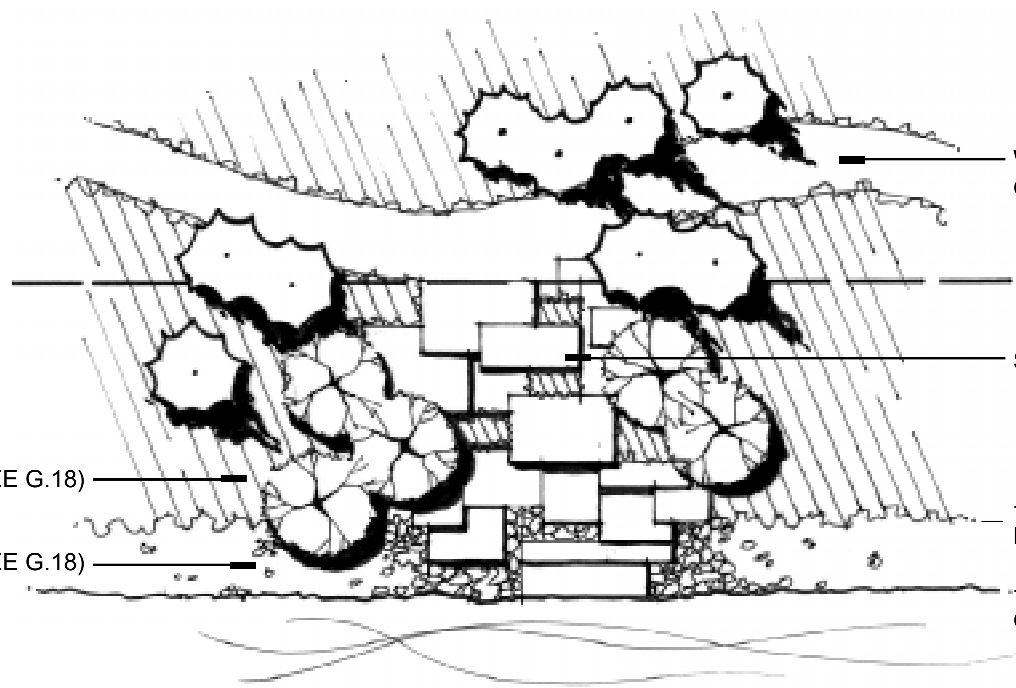


Access Option A

Plan

GENERAL

G.1

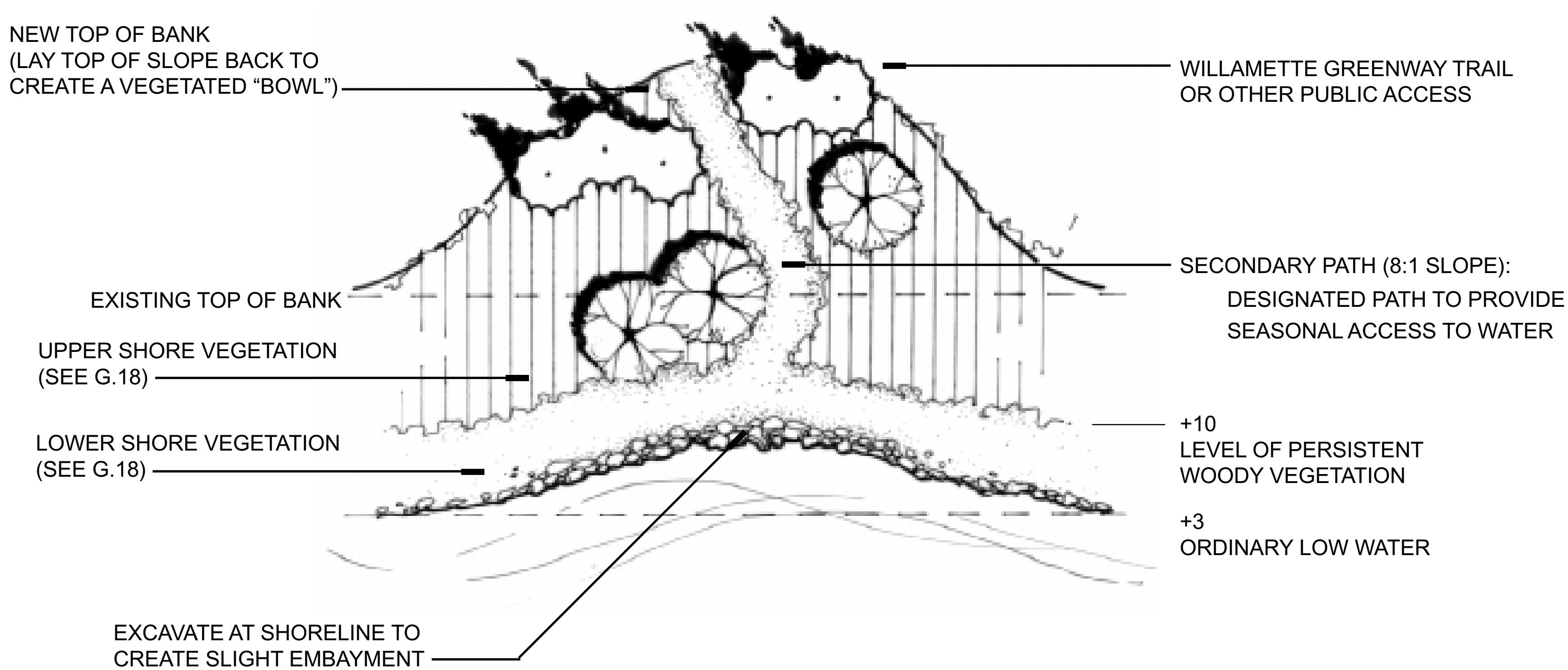


Access Option B

Plan

GENERAL

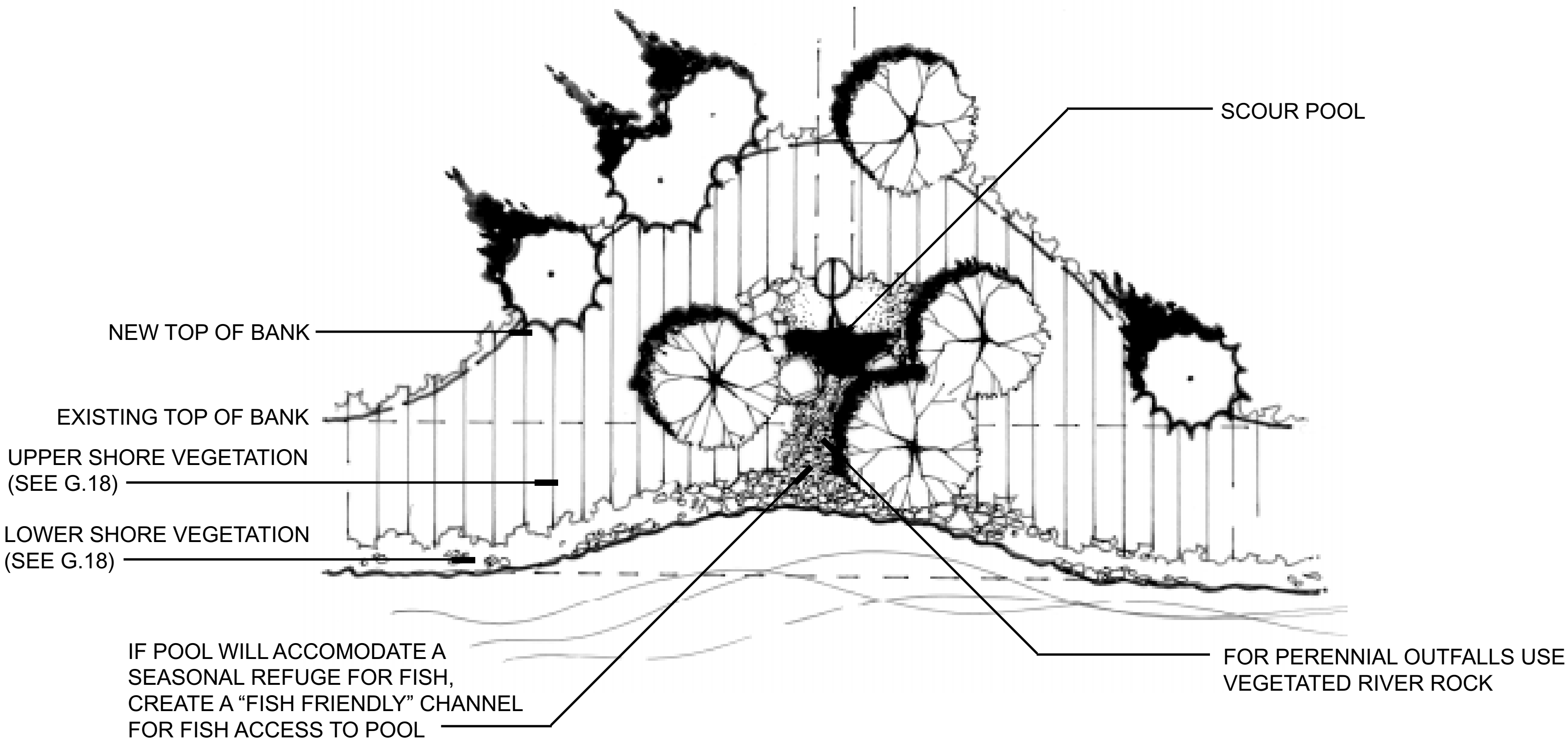
G.2



Access Option C

Plan

GENERAL
G.3

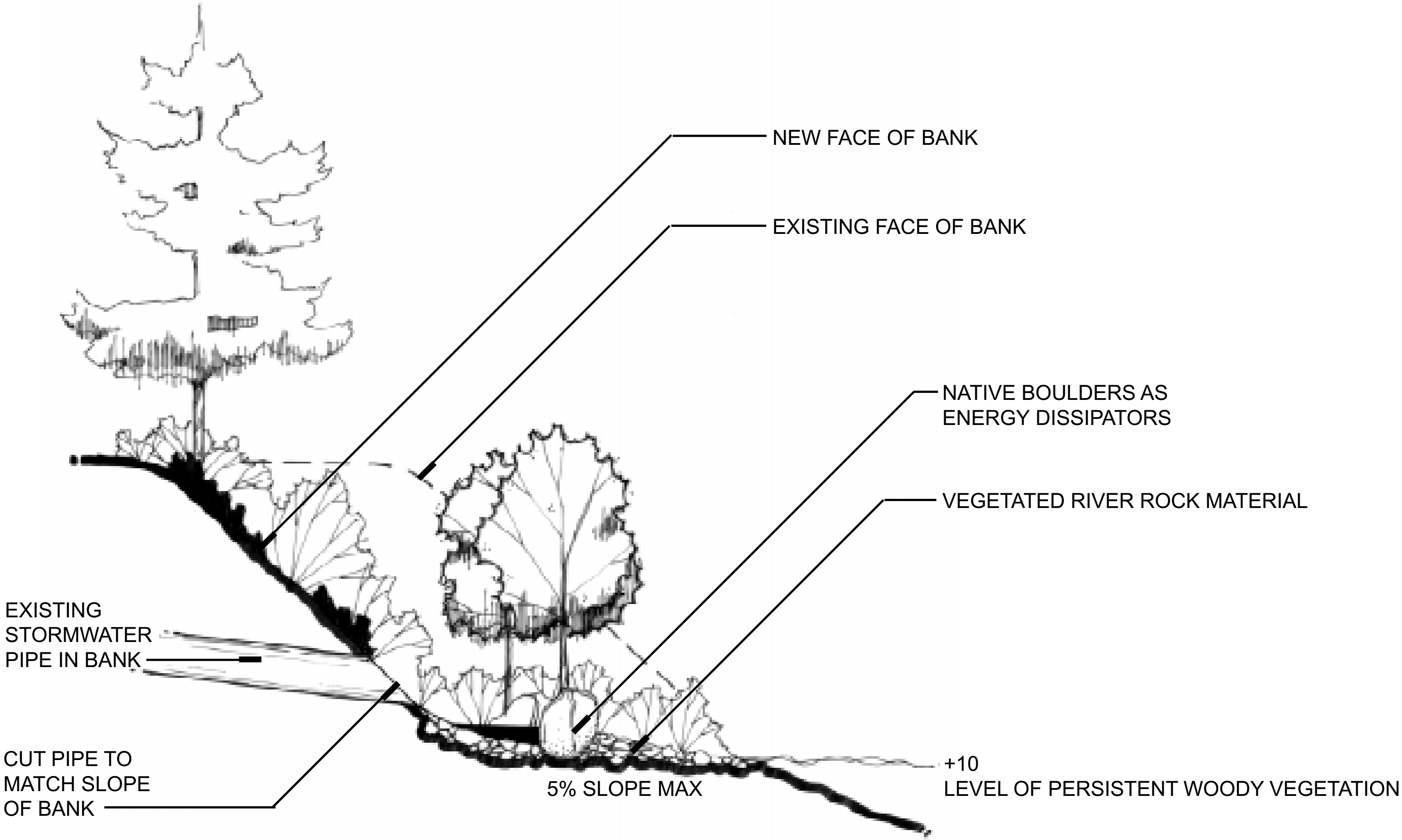


Outfall

Plan

GENERAL

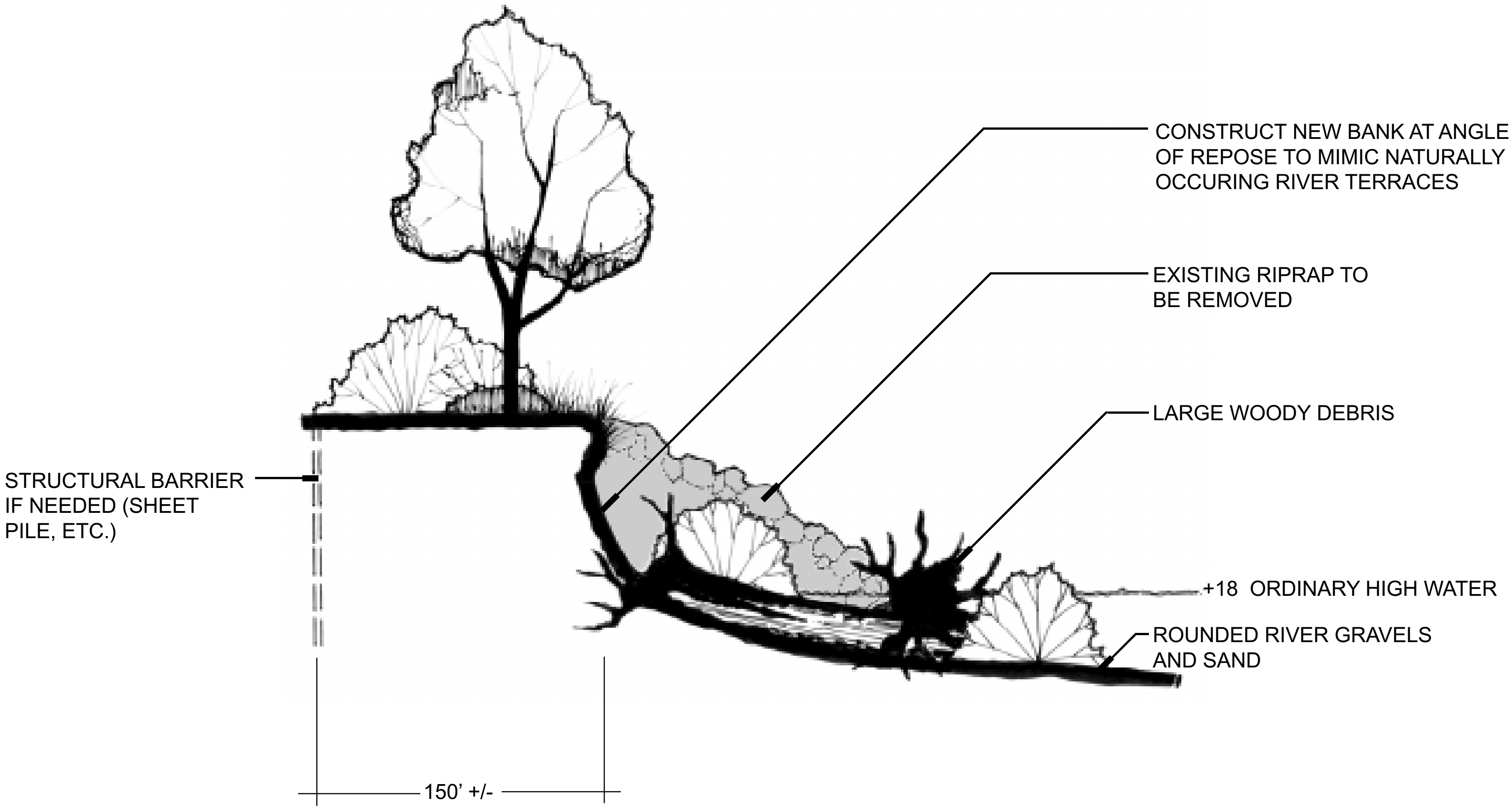
G.4a



Outfall

Section

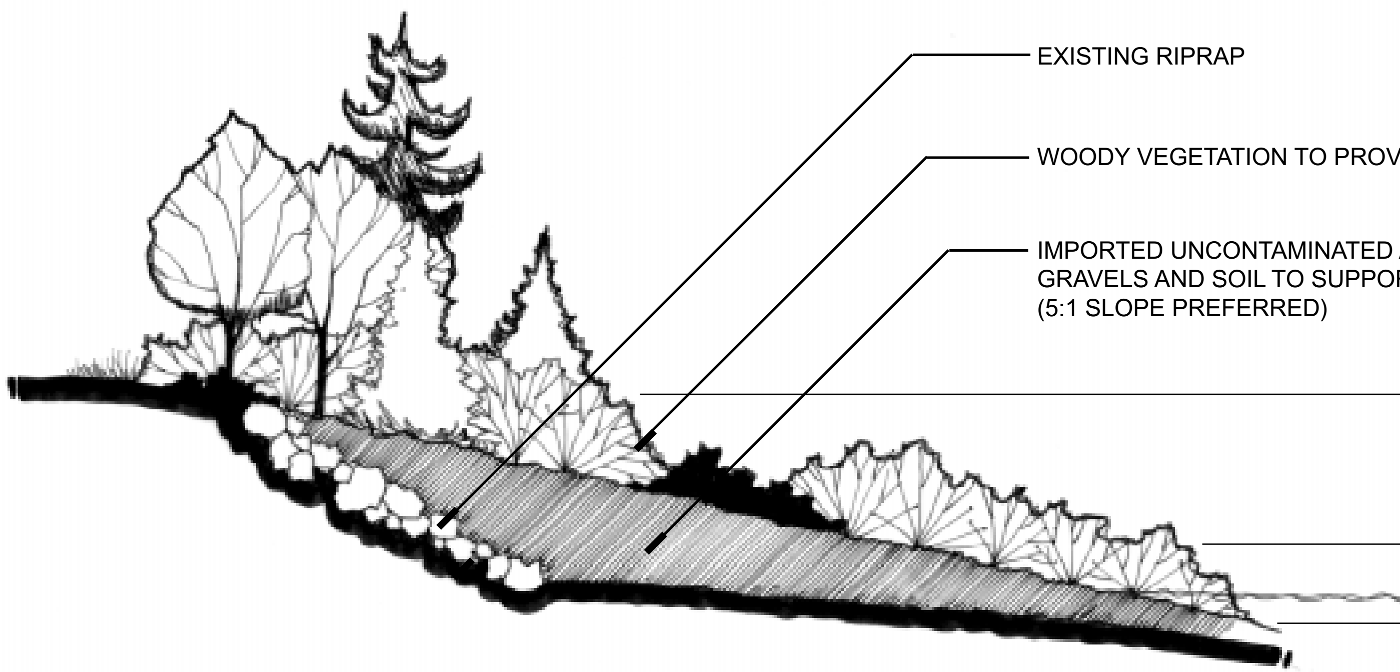
GENERAL
G.4b



Naturalistic Bank

Section

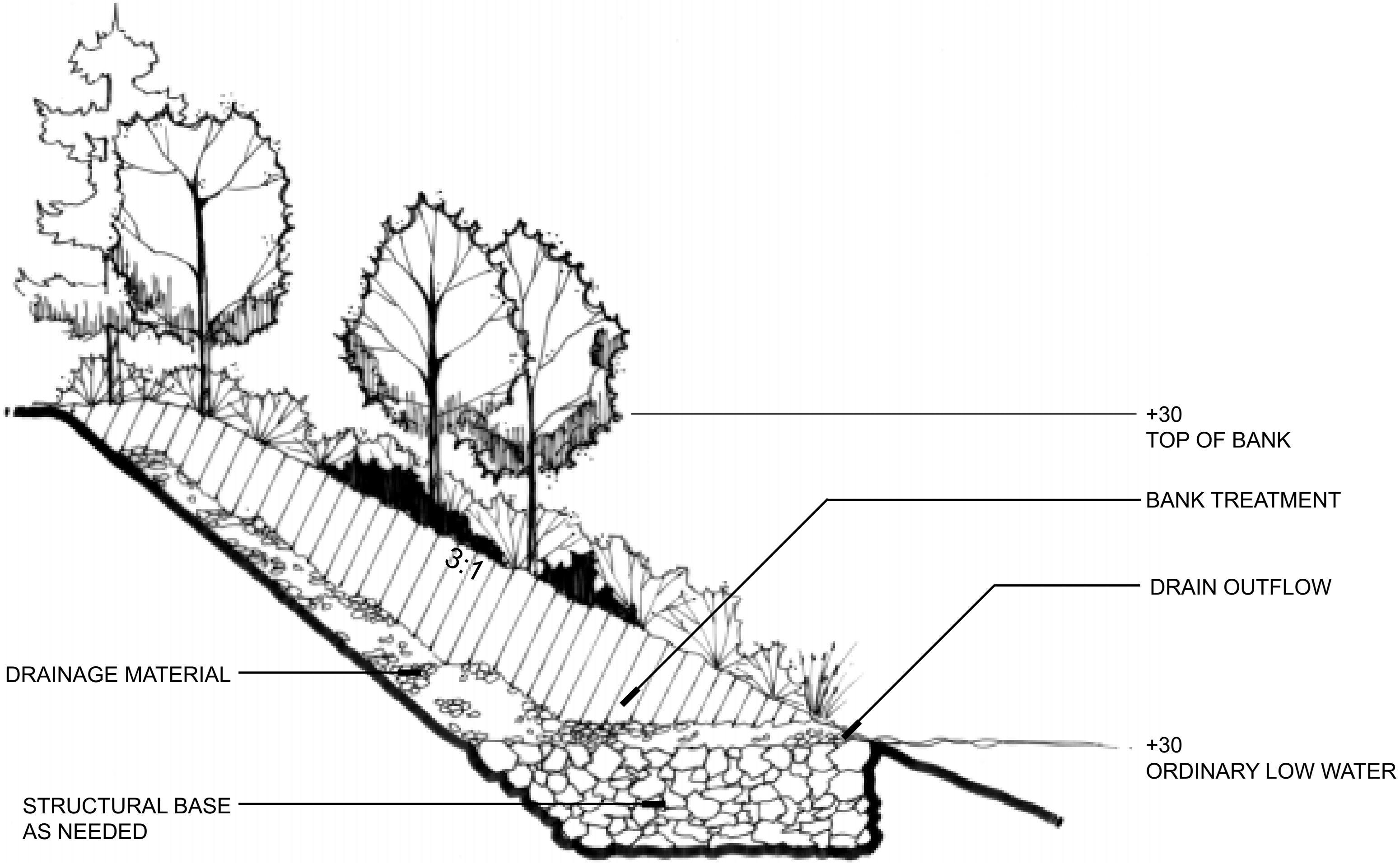
GENERAL
G.5



Gravel Fill

Section

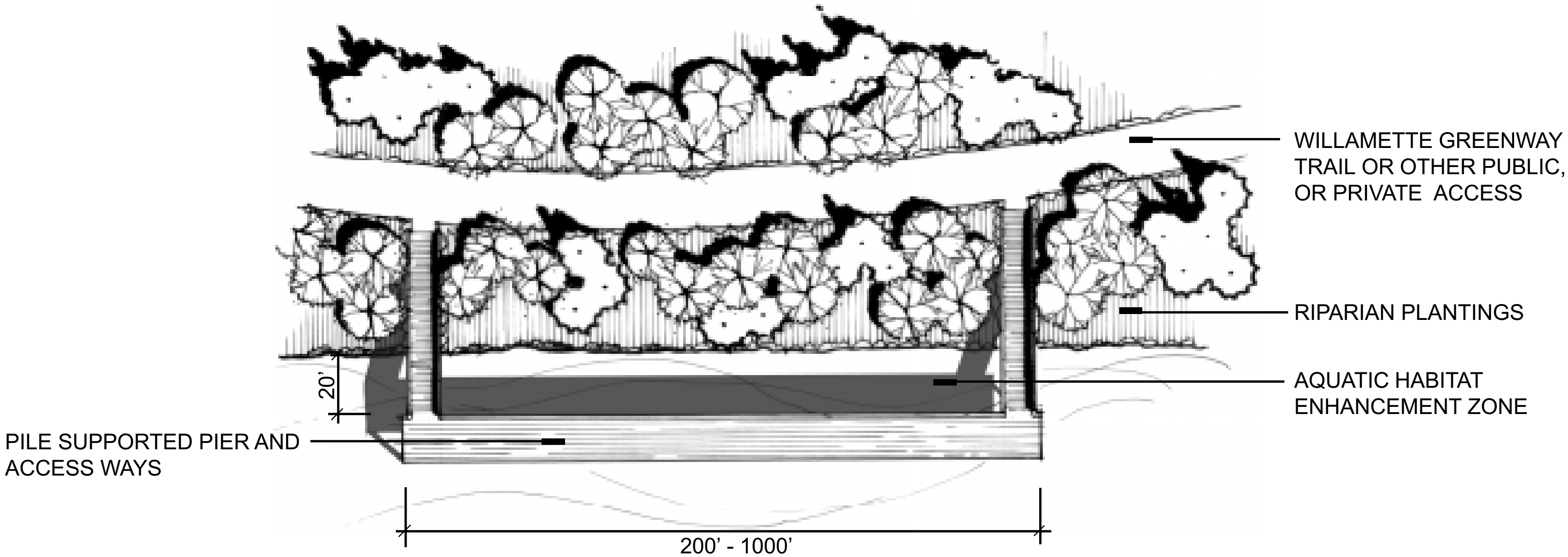
GENERAL
G.6



Internal Bank Drainage

Section

GENERAL
G.7



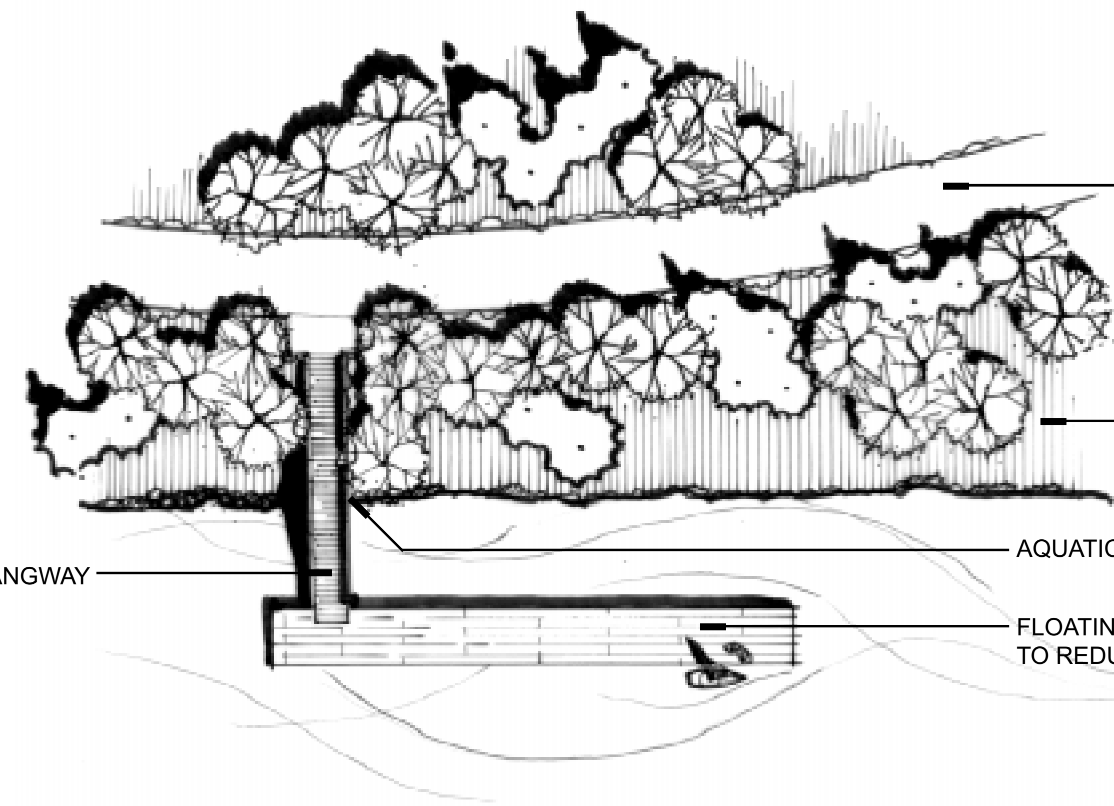
NOTE:
SEPARATING DOCKS FROM SHORELINE ALLOWS FOR SIGNIFICANT RIPARIAN VEGETATION TO EXTEND DOWN BANK TO WATERS EDGE.

NOTE N.9

Pile Supported Pier

Plan

GENERAL
G.8



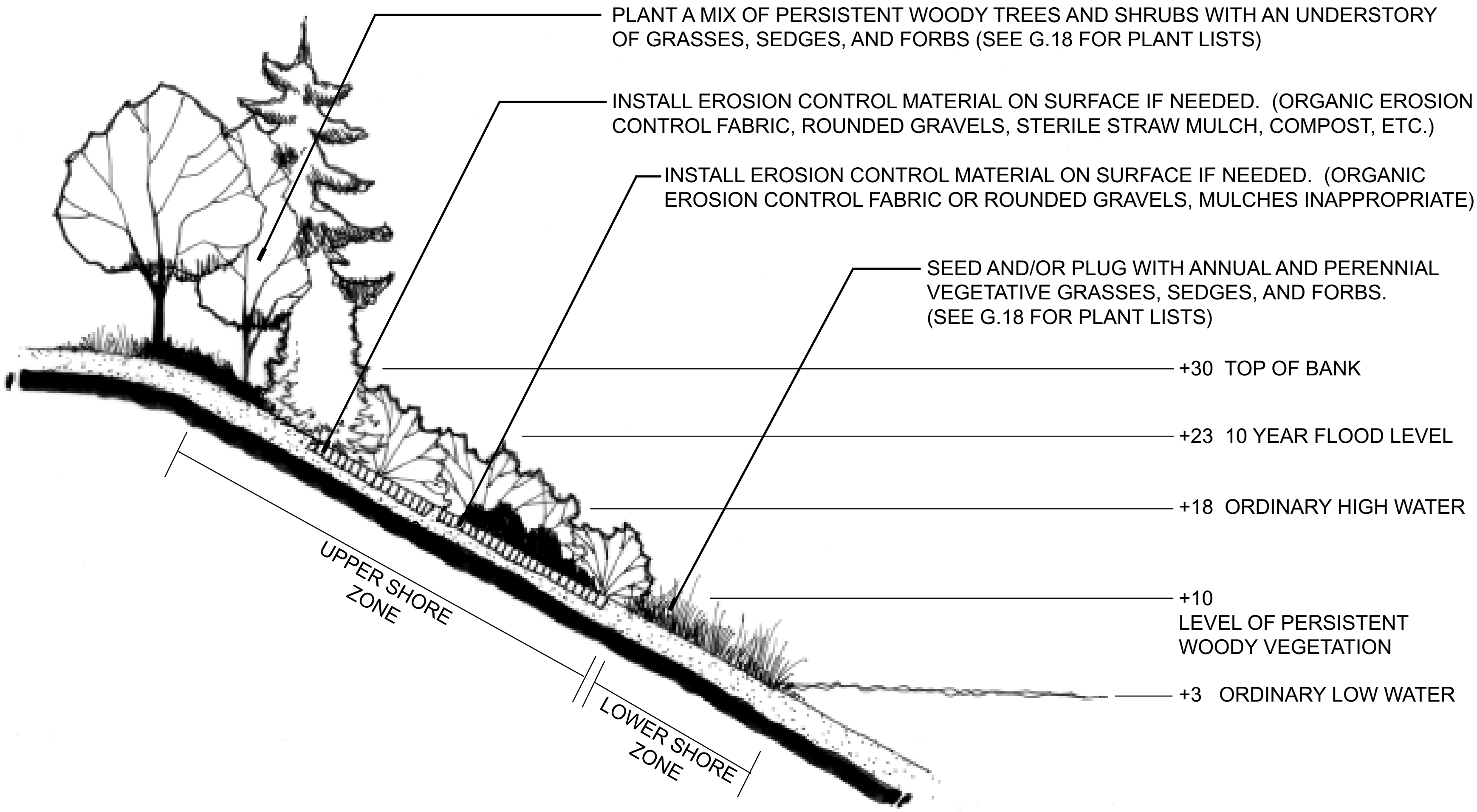
NOTE:
SEPARATING DOCKS FROM SHORELINE ALLOWS FOR SIGNIFICANT RIPARIAN VEGETATION TO EXTEND DOWN BANK TO WATERS EDGE.

NOTE N.9

Floating Dock

Plan

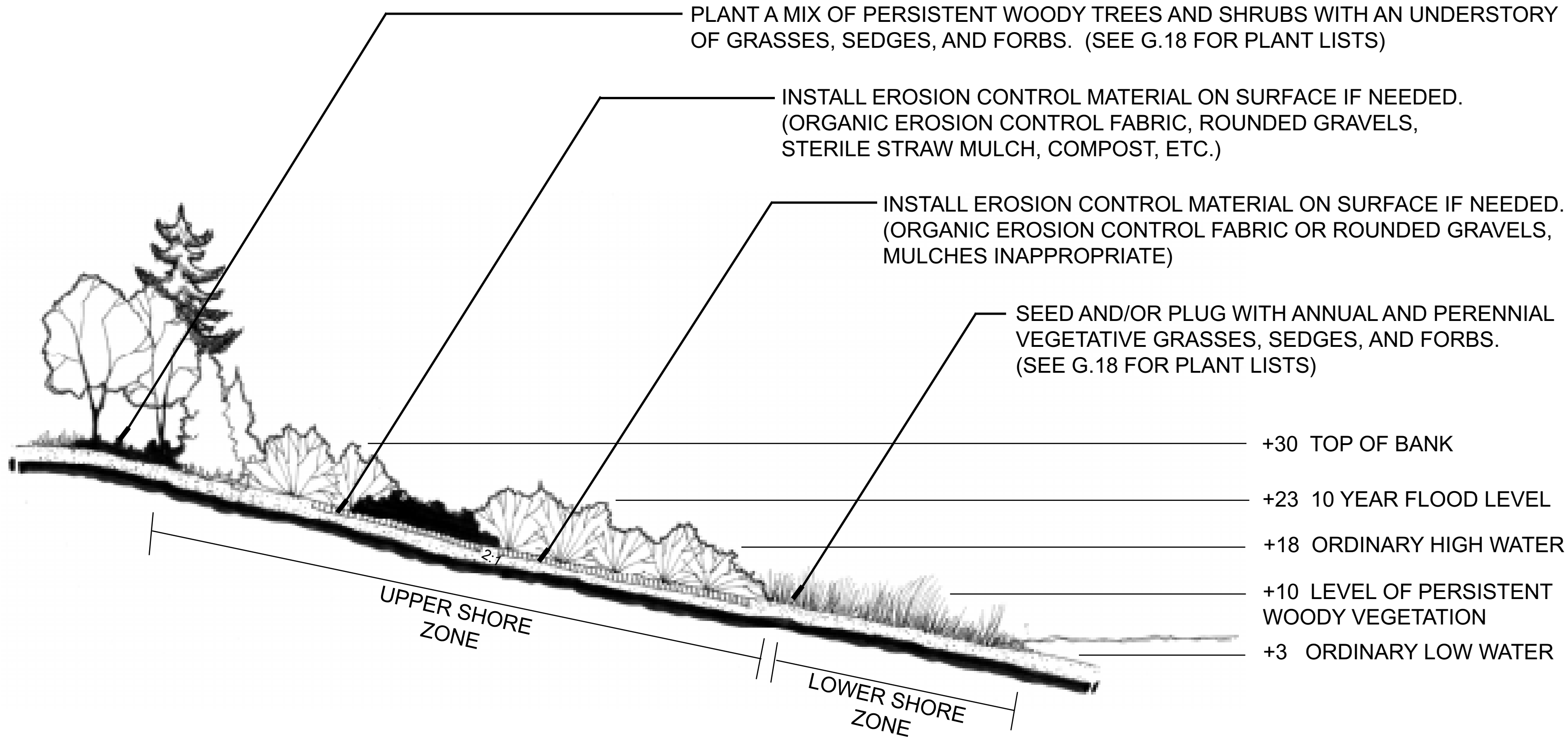
GENERAL
G.9



Vegetated Slope 2:1 - 5:1

Section

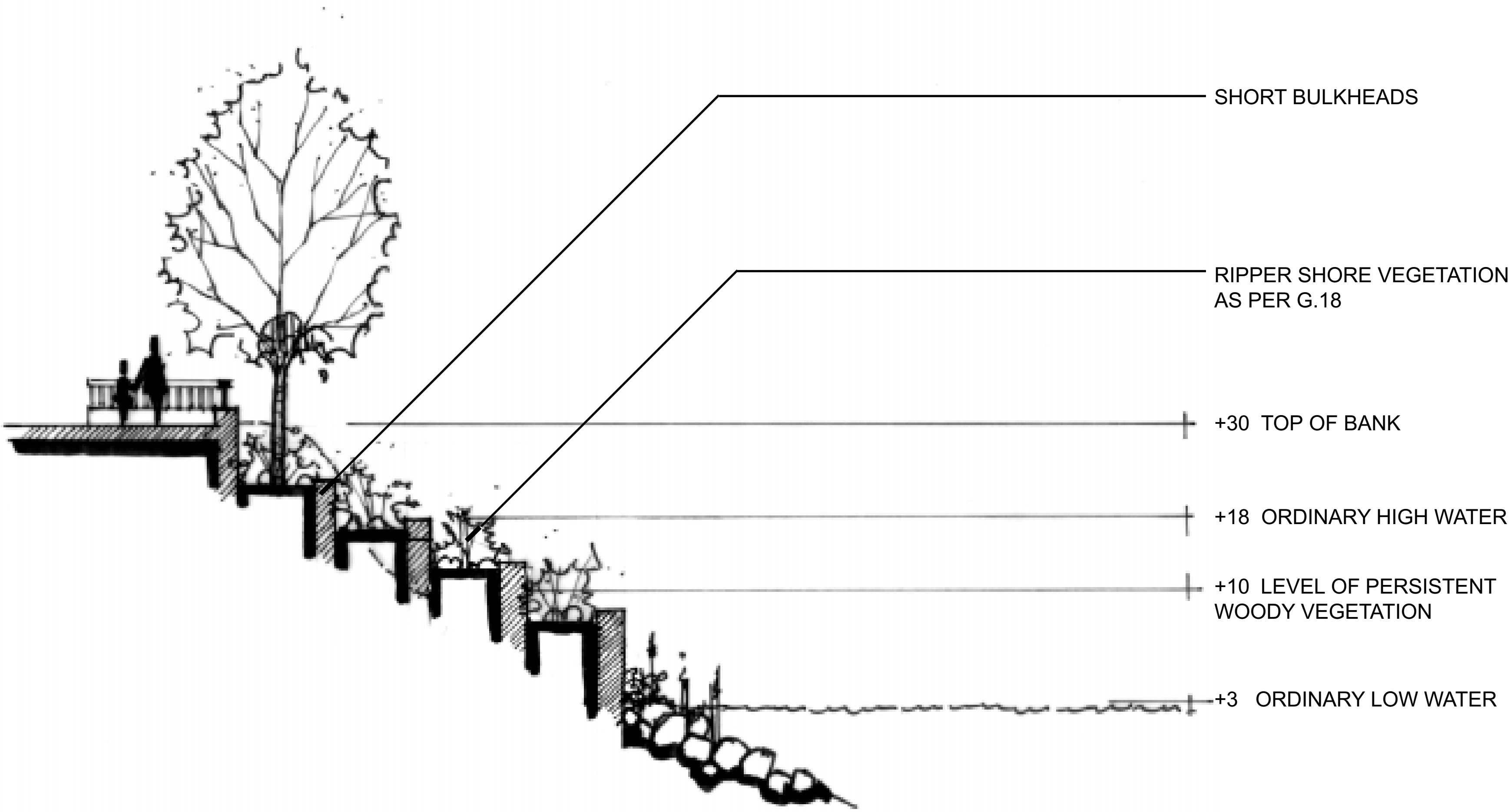
GENERAL G.10



Vegetated Slope 5:1 or Less Steep

Section

GENERAL
G.11



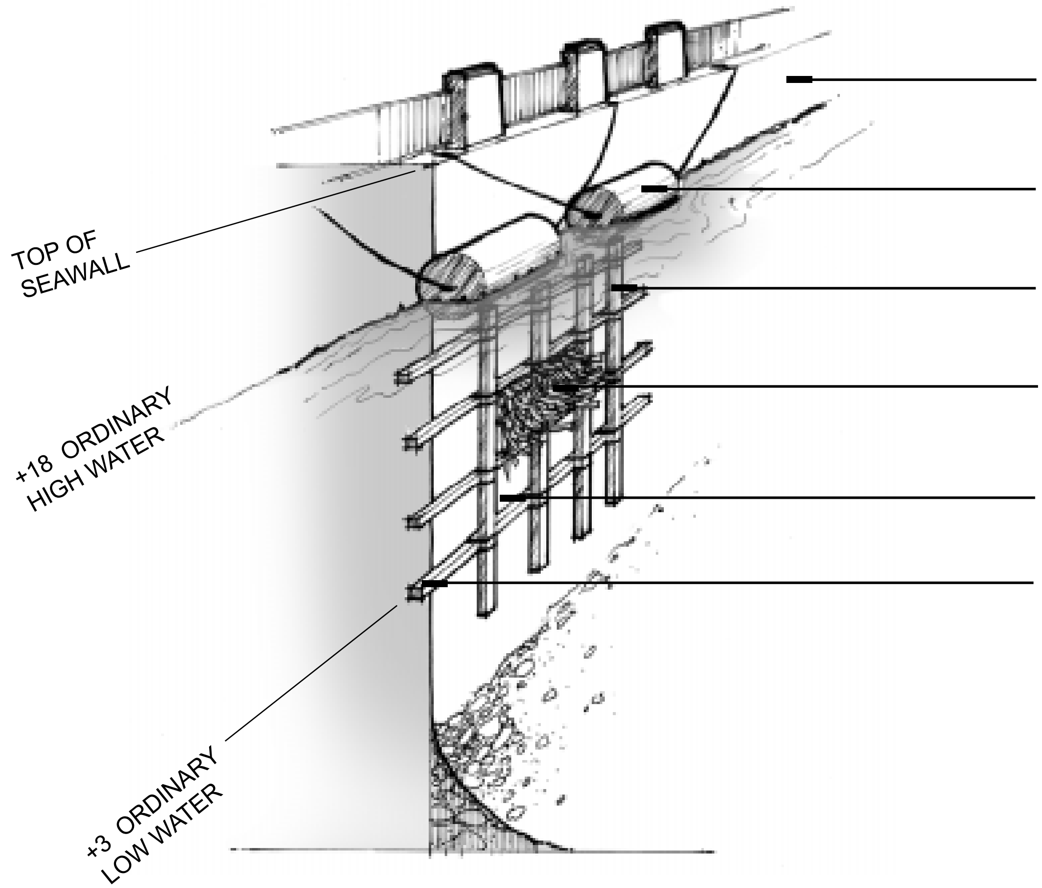
NOTE N.11

Stepped Terraces

Section

GENERAL

G.12



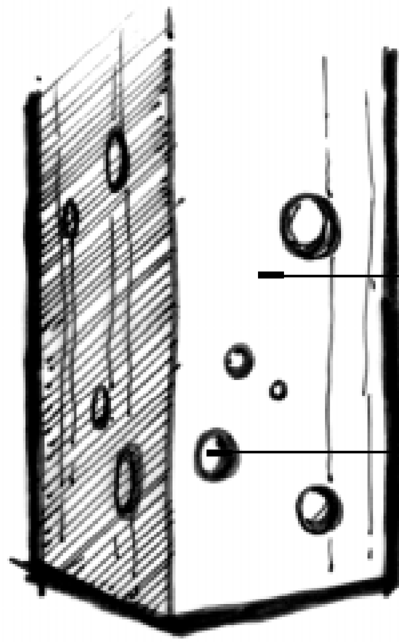
GRID MEMBERS:
PREFERABLY FROM RECYCLED WOOD TIMBERS, BUT OTHER MATERIALS ARE ALLOWED SUCH AS TUBULAR OR CHANNEL STEEL, ETC.

NOTE N.10

Timber Grid

Perspective

GENERAL G.13a

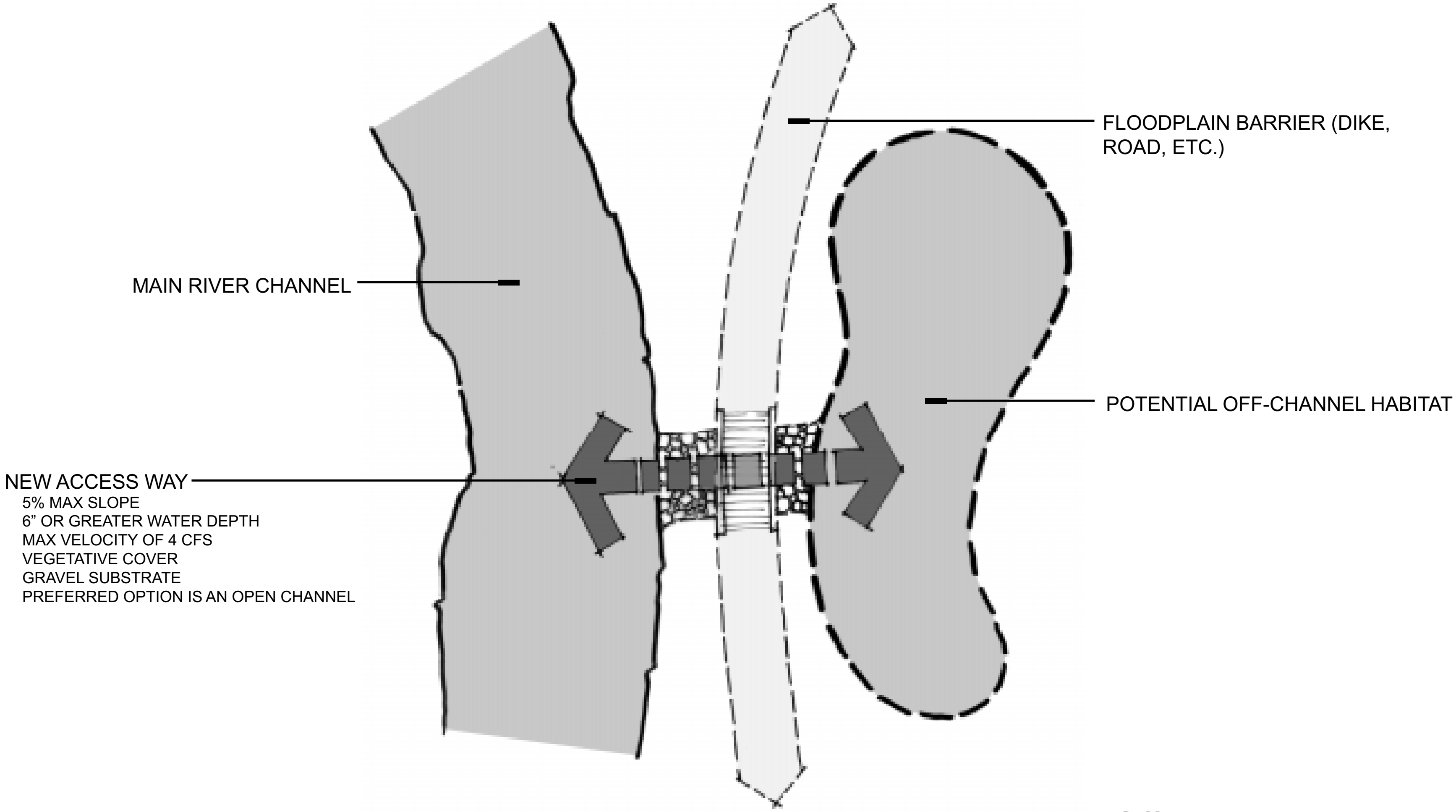


NOTE N.10

“Holy Pile”

Perspective

GENERAL
G.13b

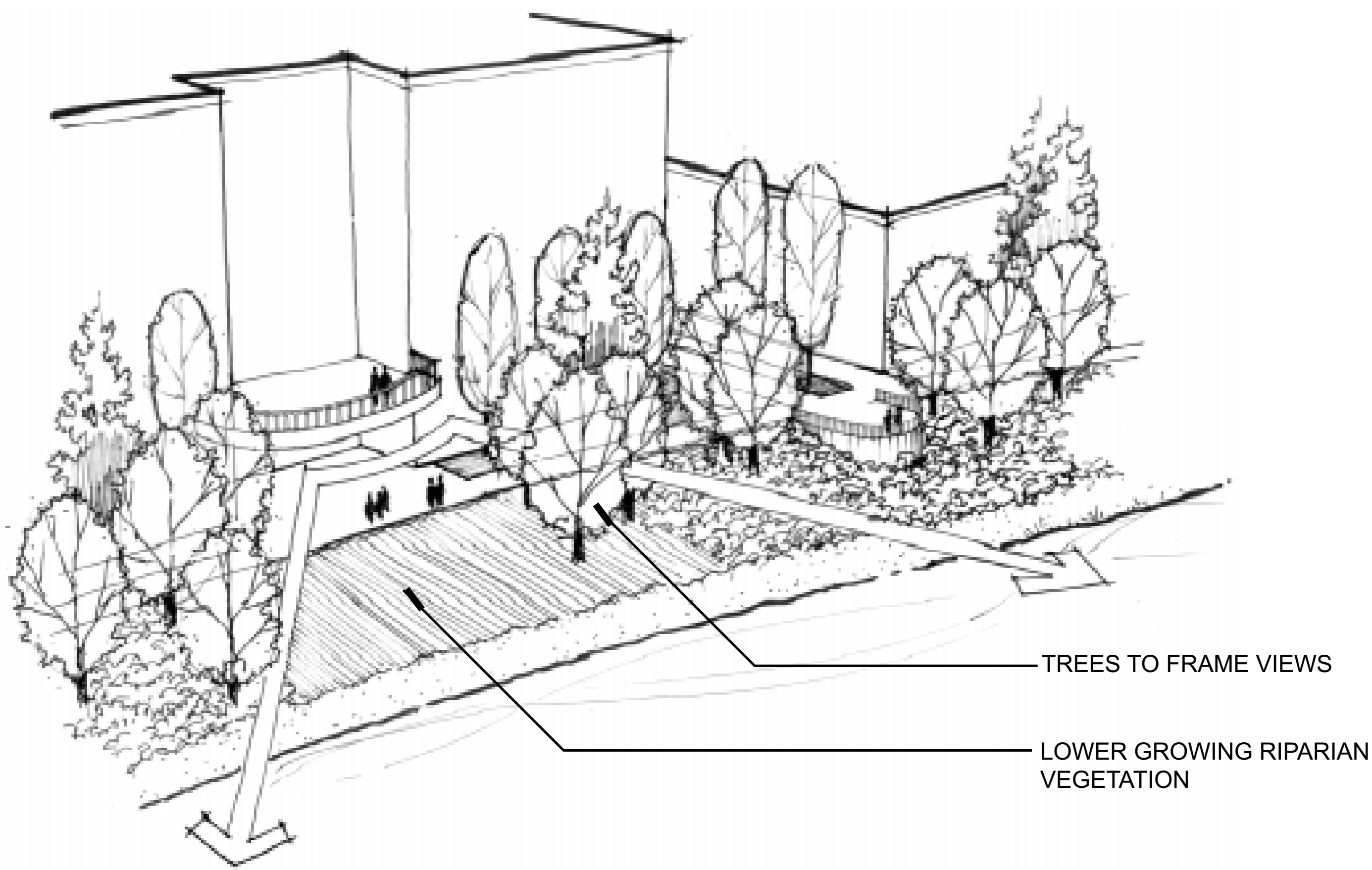


NOTE N.18

Access to Off-Channel Habitat

Plan

GENERAL
G.14

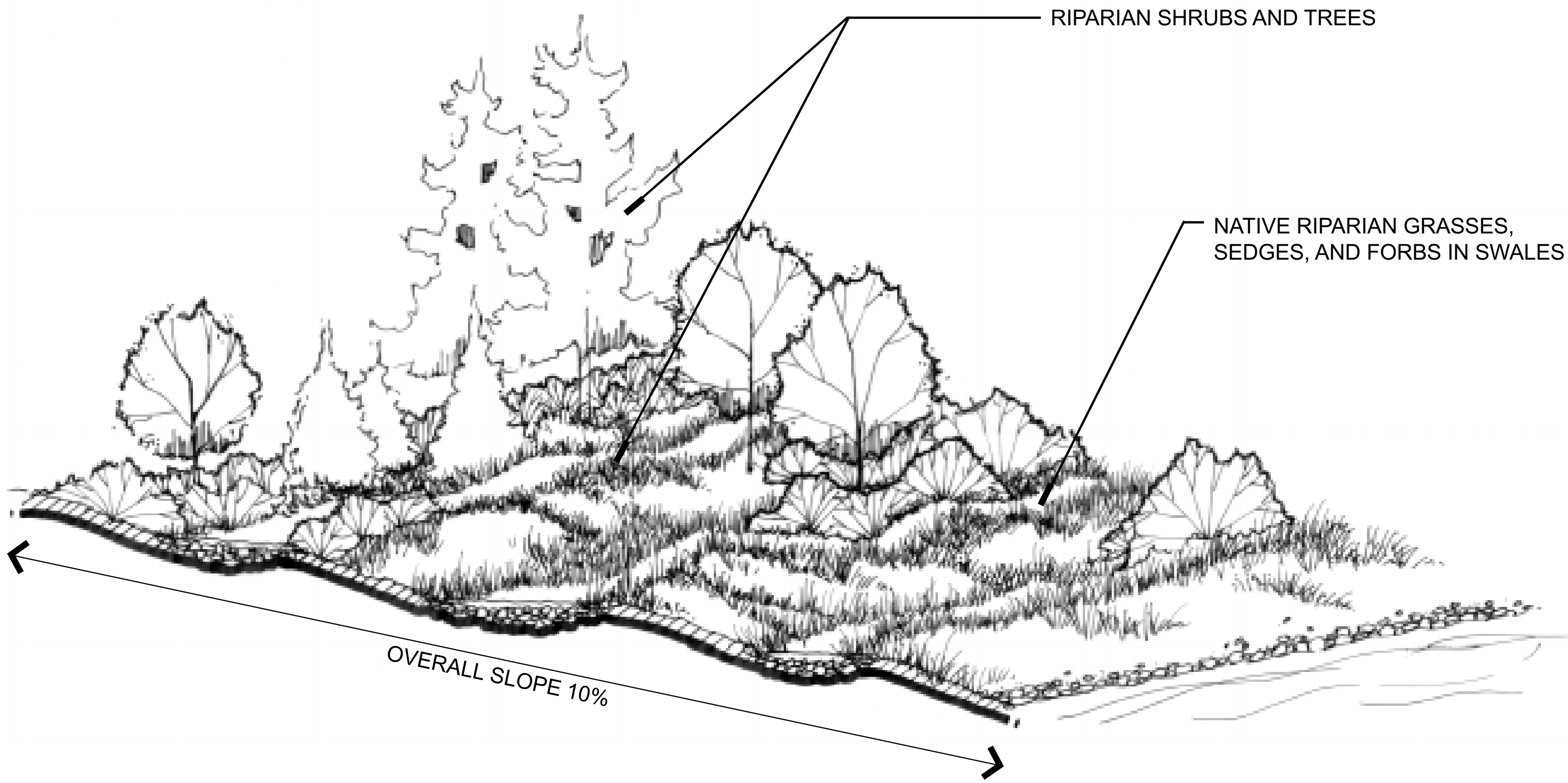


Framing Views

Perspective

GENERAL

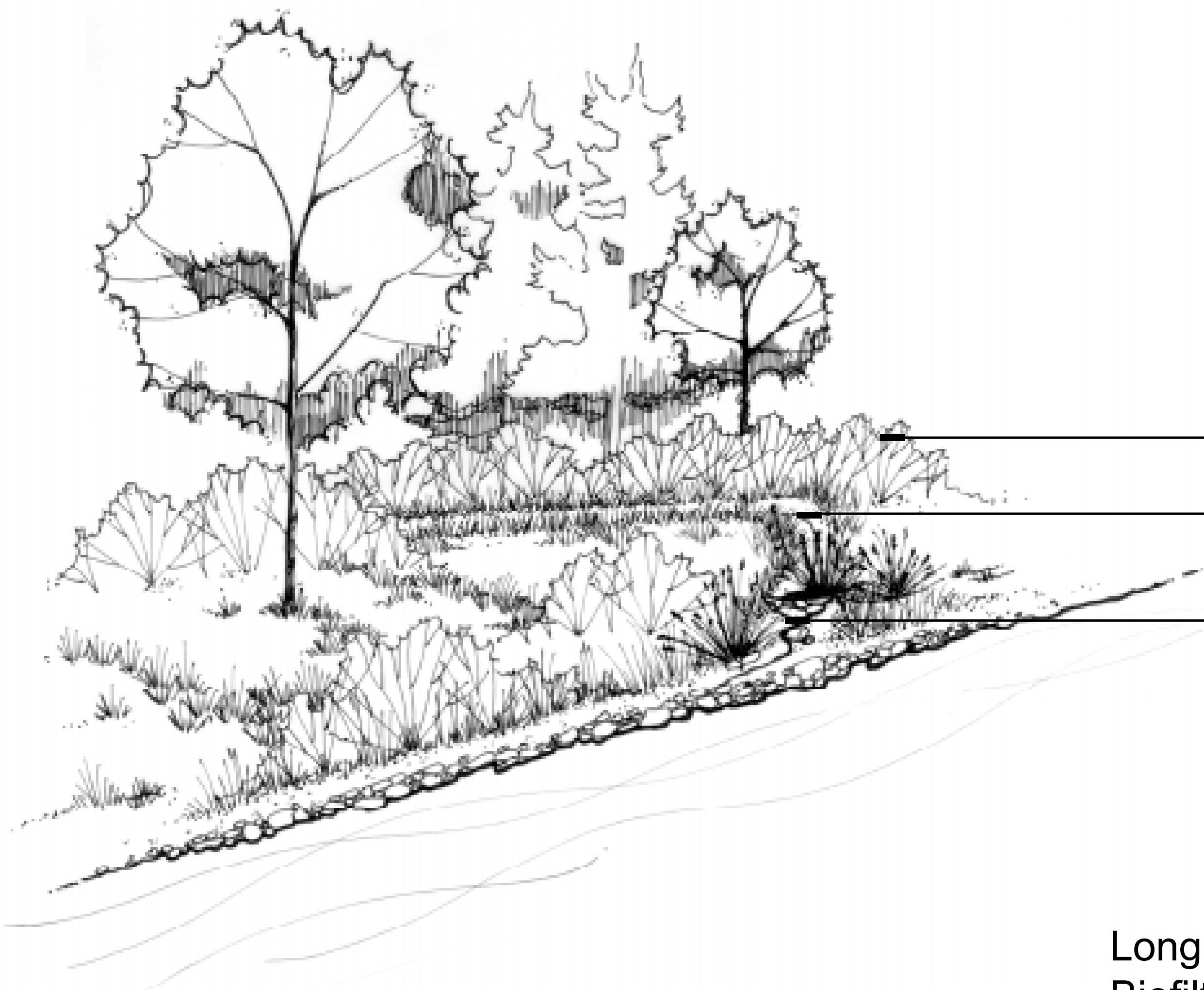
G.15



Wide-Bodied Swales

Section/Perspective

GENERAL
G.16



Longitudinal Biofiltration Swale

Perspective

GENERAL
G.17

Ⓤ UPPER SHORE
Above El. +10 (Level of Persistent Woody Vegetation)

TREES:

Botanical Name	Common Name	Indicator Status
Acer macrophyllum	Big-Leaf Maple	FACU
Alnus rubra	Red Alder	FAC
Cornus nuttallii	Western Flowering Dogwood	UPL
Crataegus douglasii	Black Hawthorn	FAC
Fraxinus latifolia	Oregon Ash	FACW
Malus fusca	Western Crabapple	FACW
Populus balsamifera var. trichocarpa	Black Cottonwood	FAC
Prunus emarginata	Bitter Cherry	FACU
Pseudotsuga menziesii	Douglas Fir	FACU
Salix lucida ssp. lasiandra	Pacific Willow	FACW+
Salix scouleriana	Scouler Willow	FAC
Thuja plicata	Western Red Cedar	FAC

SHRUBS:

Botanical Name	Common Name	Indicator Status
Acer circinatum	Vine Maple	FAC-
Amelanchier alnifolia	Western Serviceberry	FACU
Cornus sericea ssp. sericea	Red-osier Dogwood	FACW
Gaultheria shallon	Salal	FACU
Oemleria cerasiformis	Indian Plum	FACU
Physocarpus capitatus	Pacific Ninebark	FACW
Ribes sanguineum	Red-flowering Currant	UPL
Rosa gymnocarpa	Baldhip Rose	FACU
Rosa nutkana	Nootka Rose	FAC
Salix fluviatilis	Columbia River Willow	FACW
Salix sitchensis	Sitka Willow	FACW
Sambucus racemosa	Red Elderberry	FACU
Spirea douglasii	Douglas Spirea	FACW
Symphoricarpos albus	Commen Snowberry	FACU
Prunus virginiana	Common Chokecherry	FACU
Viburnum edule	Squashberry	FACW

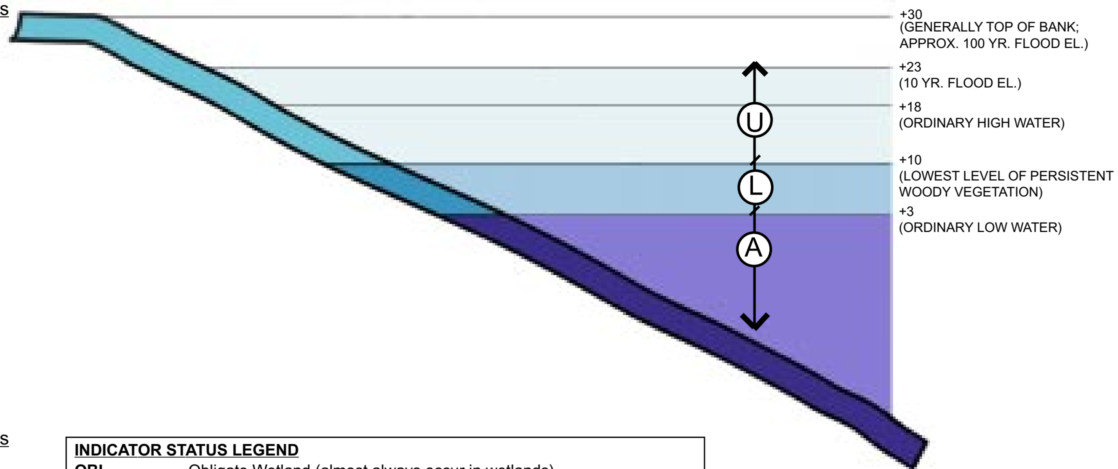
HERBS, GRASSES, AND FORBS:

Botanical Name	Common Name	Indicator Status
Achillea millefolium	Yarrow	FACU
Bromus carinatus	California Brome-grass	UPL
Bromus sitchensis	Alaska Brome	UPL
Carex obnupta	Slough Sedge	OBL
Elymus glaucus	Blue Wildrye	FACU
Equisetum hyemale	Common Scouring-rush	FACW
Festuca occidentalis	Western Fescue	UPL
Festuca subulata	Bearded Fescue	FACU+
Fragaria vesca	Wood Strawberry	UPL
Heracleum lanatum	Cow-parsnip	FAC+
Lupinus polyphyllus	Bigleaf Lupine	FAC+
Lupinus rivularis	Stream Lupine	FACU
Mimulus guttatus	Yellow Monkeyflower	OBL
Polygonum hydropiperoides	Common Waterpepper	OBL
Polystichum munitum	Western Sword Fern	FACU
Tellima grandiflora	Fringecup	UPL

Ⓛ LOWER SHORE
El +3 - El. +10

HERBS, GRASSES, AND FORBS:

Botanical Name	Common Name	Indicator Status
Carex obnupta	Slough Sedge	OBL
Eleocharis ovata	Ovoid Spikerush	OBL
Elymus glaucus	Blue Wildrye	FACU
Equisetum palustra	Marsh Horsetail	FACW
Equisetum hyemale	Common Scouring-rush	FACW
Eragrostis hypnoides	Creeping Lovegrass	OBL
Festuca occidentalis	Western Fescue	UPL
Festuca subulata	Bearded Fescue	FACU+
Glyceria occidentalis	Western Mannagrass	OBL
Helenium autumnale	Sneezeweed	FACW
Juncus effusus	Common Rush	FACW
Juncus ensifolius	Dagger-leaf Rush	FACW
Paspalum distichum	Knotgrass	FACW
Scirpus microcarpus	Small-fruited Bullrush	OBL



INDICATOR STATUS LEGEND	
OBL	Obligate Wetland (almost always occur in wetlands)
FACW	Faculative Wetland (usually occur n wetlands)
FAC	Faculative (equally likely to occur in wetlands or non-wetlands)
FACU	Faculative Upland (usually occur in non-wetlands)
UPL, NOL	Upland, Not Listed (almost always occur in non-wetlands)
NI	No Indicator (insufficient information available or plant is widely tolerant)

Riverbank Plant Transect

Section

AQUATIC **G.18**

N: Design Notes

The following notes are intended as guidelines for successful planning, design, construction and maintenance of the conceptual riverbank designs presented in this notebook. The development of most of these designs will require the coordinated efforts of geotechnical, civil, biotechnical and waterways engineers, fisheries biologists, landscape architects and botanists, wildlife biologists and stormwater and water quality professionals.

N.1. Deformable banks. Deformability of riverbanks is a natural process of great value to the ecological function of habitat and the long-term viability of vegetation. Consider some degree of bank treatment deformation as a way to contribute to the restoration of this process.

Consider the option of incorporating bank treatments that can respond to natural changes in bank position, allowing deformability of the position through erosional or depositional processes.

Wave action and scour. Plan for and allow deformable banks where an acceptable amount of bank failure due to wave action or scour is likely to occur.

Accretion. Plan for and allow deformable banks where an acceptable amount of accretion due to deposition is likely to occur.

Structural barrier. Provide a structural barrier behind the deformable bank material, as needed to protect capital improvements.

Alluvial Material. Use alluvial material that will deform in response to an ecologically important flow event, perhaps a 5-10 year flow event that is the basis for significant regeneration of riparian vegetation.

Root wads. Where root wads are placed on the bank to provide structure, cover, and velocity diversification, make certain that the natural removal/replacement of this material is planned for and hydraulically appropriate relative to uses up and downstream.

Fill over riprap. Consider, leaving existing rip rap in place as a structurally protective barrier with a deformable bank fill over the riprap. The deformable materials might be weed-free native soil or other materials suitable for the hydrologic return interval of inundation.

Replacement of riprap. Consider removal of rip rap with replacement of a more deformable bank treatment.

Remember that different treatments have differing susceptibility to deformation and plan accordingly for both elevational and perodicity factors.

N.2. Stormwater discharge and treatment. Treat stormwater in the upper bank zone, being careful to consider the storm return interval and the hydrologic regimes of the river as well as the catchment for the stormwater facility.

N.3 Longitudinal swale. Limit the gradient to no steeper than one percent of slope. If steeper, provide velocity stops with an appropriate filter medium in the subgrade that can prevent scouring under or around the velocity stop.

N.4 Wide-bodied swale. This is a water quality biofiltration device that allows sediments and phosphorous to be removed from stormwater runoff. This wide-body swale is actually a series of drainage terraces which allows stormwater to flow from one terrace down to the next. The entire swale and terraces will be vegetated with native shrubs, forbs and trees.

The wide-body swale will work on riverbanks with a maximum overall slope of 10%. A forebay-spreader device needs to be constructed at the top terrace to spread the flow evenly across the width of the treatment facility, rather than concentrating into channels down the slope. Installation of these devices require careful grading control during construction to ensure proper function. The width required for the device varies with the amount of run-off treated, but for reference, a storm volume of .14cfs requires a width of about 45 feet.

N.5 Stormwater outfall.

Energy dissipation.

- Create an appropriately sized embayment in the riverbank to create an energy stilling basin where stormwater discharges to the bank. Plant this with woody vegetation.
- Plant woody vegetation to stabilize the lower end of the basin or other stormwater facitility.
- Stabilize the slope below the discharge end of stormwater facilities.

Refuge for fish.

- Confine or otherwise reconstruct the flow pattern of perennial outfalls occuring within the lower shore zone so that these areas can be seasonally accessed by fish and used for cover and refuge where water may be slower and cooler.

N.6. Filter medium. Use appropriate filter material such as fabric or a gravel blanket beneath rip rap or rock revetments, to forestall loss of subgrade materials due to piping.

N.7. Internal drainage. Provide a way for groundwater to move through riverbank face treatments such as fabric-wrapped soil lifts. Drainage can be achieved by installing a vertical gravel lens behind the soil lifts. The lens and soil lifts are placed on a structural base such as a rip rap toe, that provides support. The gravel lens is drained by means of periodically placed pipes or seams of gravel. The lens stops short of ground level, in order to keep it from recruiting surface water that may flow over the site.

N.8. Floating breakwater. Protect riverbanks from wave erosion, allow smaller bank protection materials and more deformable banks by creating a floating planted breakwater.

Floating log raft. Floating log raft. Lash logs together, cover with soil, secure with coir fabric and plant.

Planted walkway. Design planter boxes that wick water from the river.

N.9. Conversion to T-dock. To free up riverbanks for fish friendly treatments, convert sea walls, bulkheads and docks at the river's edge to fixed- or pile-supported T-docks perpendicular to the shore. T-docks require water depth of 20 feet or greater and should not interfere with navigation. The pier should be 20 feet wide to accommodate vehicles. Where it meets the shore, the pier structure may need to be reinforced with rip rap to prevent scouring at high flows. To create structural and flow diversity for fish, such reinforcement can be designed as a rock barb.

N.10. Cover, refuge and resting areas for fish. Install artificial fish cover, resting areas and substrate for aquatic organisms where possible in areas where the shore must remain a vertical sea wall, sheet pile or bulkhead. This can be done by adding roughness to smooth surfaces in order to create diversity of micro hydraulics. Potential treatments include:

Habitat grid. Create a habitat grid between fender piles using welded I-beams, inert geogrid, lumber or other media. The grid will recruit sediments and other debris that will contribute diversity to the habitat grid. It will also provide holding and hiding areas for fish.

Fish cover structures. Install concrete pipe or similar structures to serve as fish cover. The minimum dimensions of fish cover elements should be 18 inches deep and the length of the adult fish (1 foot - 3 feet) expected to use the structures.

Simulated live cover. Install plugs with trailing flags in which migrating smolts can hold.

Holy piles. Install wood fender piles or logs with holes bored in them that can serve hiding places and provide variable substrate to support macroinvertebrates and aquatic plants.

"Habimat" – artificial substrate. Install a textured material such as Astroturf, to smooth underwater surfaces in order to provide a substrate medium that can support a more complex food chain.

N.11. Planted seawall terrace. On vertical seawalls, create a step or terrace above ordinary high water that can function as a planting bench.

N.12. Openings in cantilevered or pile-supported overlooks. To avoid shading the bank with overhead structures, design cantilevered or pile-supported overlooks with openings that allow light to reach the riverbank below.

N.13. Maintenance of plantings. Where native plants have been installed, they will need to be maintained. Essential maintenance activities include inspection, irrigation, weed control, thinning and pruning (in some instances), and monitoring.

Inspection. A designated person should check the plants every other week during the first growing season and be prepared to provide deep watering. During hot weather, trees will need 10 gallons to 15 gallons of water one or two times per week. The plants should also be checked after extreme weather events such as floods, droughts, ice storms and freezes.

Weed control. Hand pull weeds at least several times during the growing season. Make certain that the people who will be doing the weeding are trained to tell the difference between weeds, newly planted seedlings and native plants on the site.

- Plan to mow grasses from around the plants at least twice during the growing season, beginning in May or June. Make sure plants are marked, to protect them from mowers and other equipment.
- Clip or weed-whack blackberries and other nuisance plants at least once a year.

Pruning. Sometimes trees are purposely overplanted, in order to densely fill an area when trees are young, or to encourage height, rather than spreading. Lower side branches can also be pruned to promote height. Thin trees if they are beginning to compete for nutrients and light.

Watering. During the design phase of the project, plan for how water will be supplied to the site and how it will be applied. Develop a schedule for watering, but be prepared to provide extra watering during hot or dry conditions.

Monitoring. The plants should be checked for vigor and survival once a year for five years. Dead plants should be replaced. Species not thriving should be replaced.

Fertilizers. Minimize use of fertilizers.

Coppicing. Habitat diversity and structural enhancement of riverbanks can be achieved by installing particular species of shrubs and trees that can be managed by coppicing, or pruning so that they sprout vegetatively from the root crown or aerial stems. This management practice will allow for vegetative diversity in areas where the presence of tall trees is not appropriate either visually or structurally. Species that respond well to coppicing include Oregon ash, black cottonwood, bigleaf maple, red osier dogwood, red and blue elderberry, and all willows.

N.14. Specify bid items. All erosion control practices and materials should be shown as bid items to assure that the costs of their implementation, inspection and maintenance are included in project schedules and budgets.

N.15. Contaminated soils and groundwater. Remove or isolate contaminated soils and groundwater in a way approved by the Oregon Department of Environmental Quality and the U.S. Environmental Protection Agency. Many of the design options shown in the notebook may be used to isolate particular contaminants.

N.16. Increase streambank shade. Install plants appropriate to riverbank zones in order to increase streambank shade and avoid water temperature increases on a local scale. Refer to the Portland Native Plant List and to the plant transect in this notebook to select trees, shrubs and groundcovers appropriate for each zone.

Lead time for ordering plants. As early as possible during project planning, a nursery should be found that can provide the number and species of plants at the time they are needed. Make certain the order is in by July for fall planting and by January for spring planting. If the nursery must grow the plants, a longer lead time may be needed.

Choosing bare root or containerized plants. Bare root and containerized plants each require different tools, planting methods and timing. Bare root plants are grown in the ground. They are dug out in winter when they are dormant, and are transplanted before spring, while conditions are still cool. They are less expensive than containerized plants. Plants grown in containers are generally available year-round, but transplant best while conditions are still cool and the ground is moist. When ordering bare root plants, specify size.

N.17. Trails. The Willamette Greenway Plan provides guidelines about the alignment of the Greenway Trail and access connections to the trail. Trail requirements and construction standards are addressed in the PZC chapters 33.440 Greenway Zones, 33.272 Trails, 33.272 Public Recreational Trails, 33.272.030E Trail Standards, and 33.440.240 Public Recreational Trails.

N.18. Access to off-channel habitats.

Pipes and culverts.

- **Flow depth, velocity and gradient.** To assure fish passage, pipes and culverts slopes should not exceed five percent nor should flow velocities exceed 4 feet per second. Flow depth should be six inches or greater. These requirements should be met for all flow conditions.
- **Jump pools.** Jump pools should have maximum heights between pool and pipe of 6 inches to allow for free passage of juvenile fish.

Open-bottomed structures. To assure fish passage, opened bottom structures should meet the same depth, gradient and velocity requirements as stated in N.18 above. In addition, open-bottomed structures should be designed to retain placed gravels while passing sediment loads downstream.

N.19. Views. Retain existing trees if possible, by working them into the design. Prune for views, if needed.

Appendix A

ONGOING ISSUES BEYOND THE SCOPE OF THE DESIGN NOTEBOOK

Users of the Design Notebook should be aware of the dynamic nature of the issues regarding the Willamette River. Therefore, the Design Notebook will be an evolving document which will be updated as our scientific understanding of the needs of salmonids increases and the regulatory environment responds.

Some of the issues to be resolved include:

Floodway impacts of in-channel habitat improvement measures. It is uncertain what the regulatory agencies will decide about habitat structures placed in floodways. (Please also see next item.)

Oregon Department of State Lands (DSL):
Special Programmatic General Permit (SPGP).
In cooperation with the U.S. Army Corps of Engineers (Corps), the DSL is consulting on all federally listed sensitive species statewide and species likely to be listed statewide, in order to prepare a Programmatic Biological Assessment on the state's Removal-Fill regulatory program. If issued, the DSL permit would replace certain Corps permits, comply with federal Endangered Species Act (ESA) Section 7 requirements, and protect successful applicants from ESA's "take" provisions, provided applicants fully comply with all conditions.

Willamette Greenway standards. Zoning code regulations, including development standards and design guidelines, for the Willamette Greenway may be modified as a result of Portland's current review of the Willamette Greenway zones.

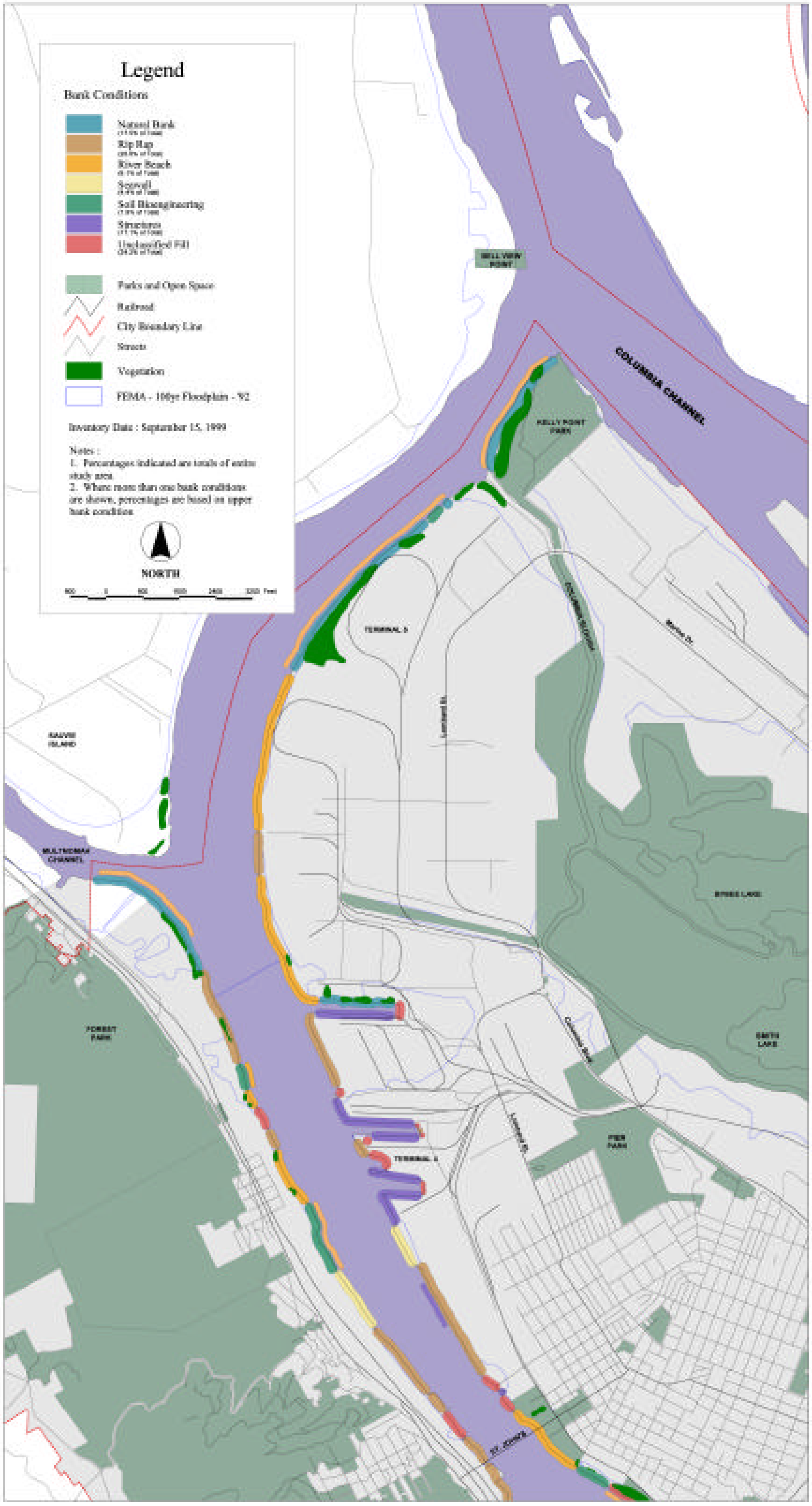
National Marine Fisheries Service (NMFS) 4d Rule. The 4d rule establishes protective regulations that apply to a species listed as threatened under the ESA. The regulations may contain specific proscriptions or exceptions instead of or in addition to, the general prohibitions against harming or killing a listed species. In Dec. 1999, NMFS announced that it would be up to local government to develop mechanisms to assure these protections to listed species. Metro, the regional government, is working on habitat and stormwater elements of Title 3: Water Quality, Flood Management and Fish and Wildlife Conservation, but it appears that it will complete this work in the fall of 2000 at the earliest.

Contaminated sediments. The Oregon Department of Environmental Quality et al are working on a cleanup plan for contaminated sediments in the Portland Harbor. The Portland Harbor has been listed by the Environmental Protection Agency on the National Priorities List as a "Superfund" site.

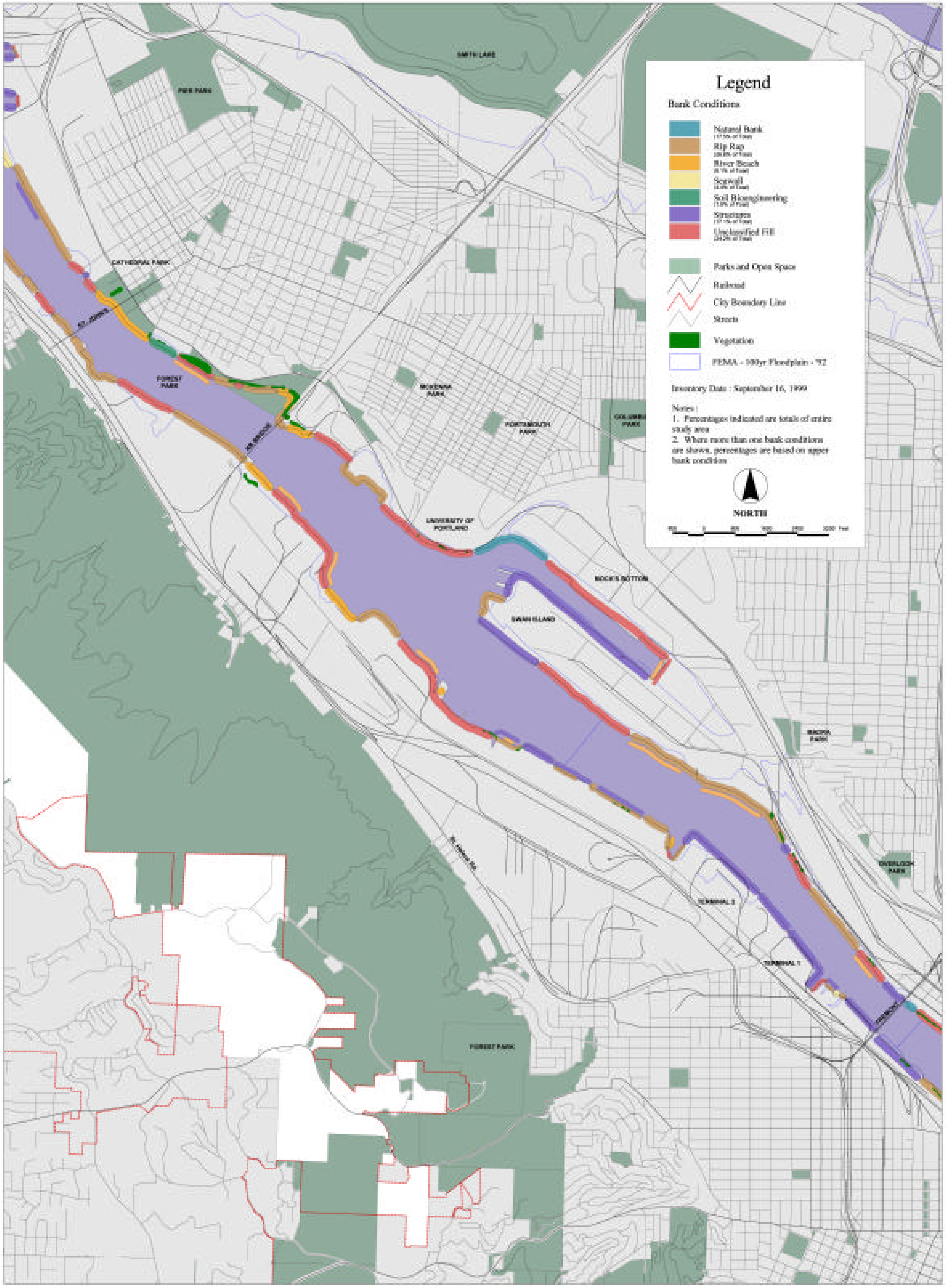
Maintenance responsibility for riverbanks. No funding mechanisms or other instruments have been developed or implemented in Portland to assure ongoing repair and maintenance of bio-technically engineered riverbanks.

Appendix B

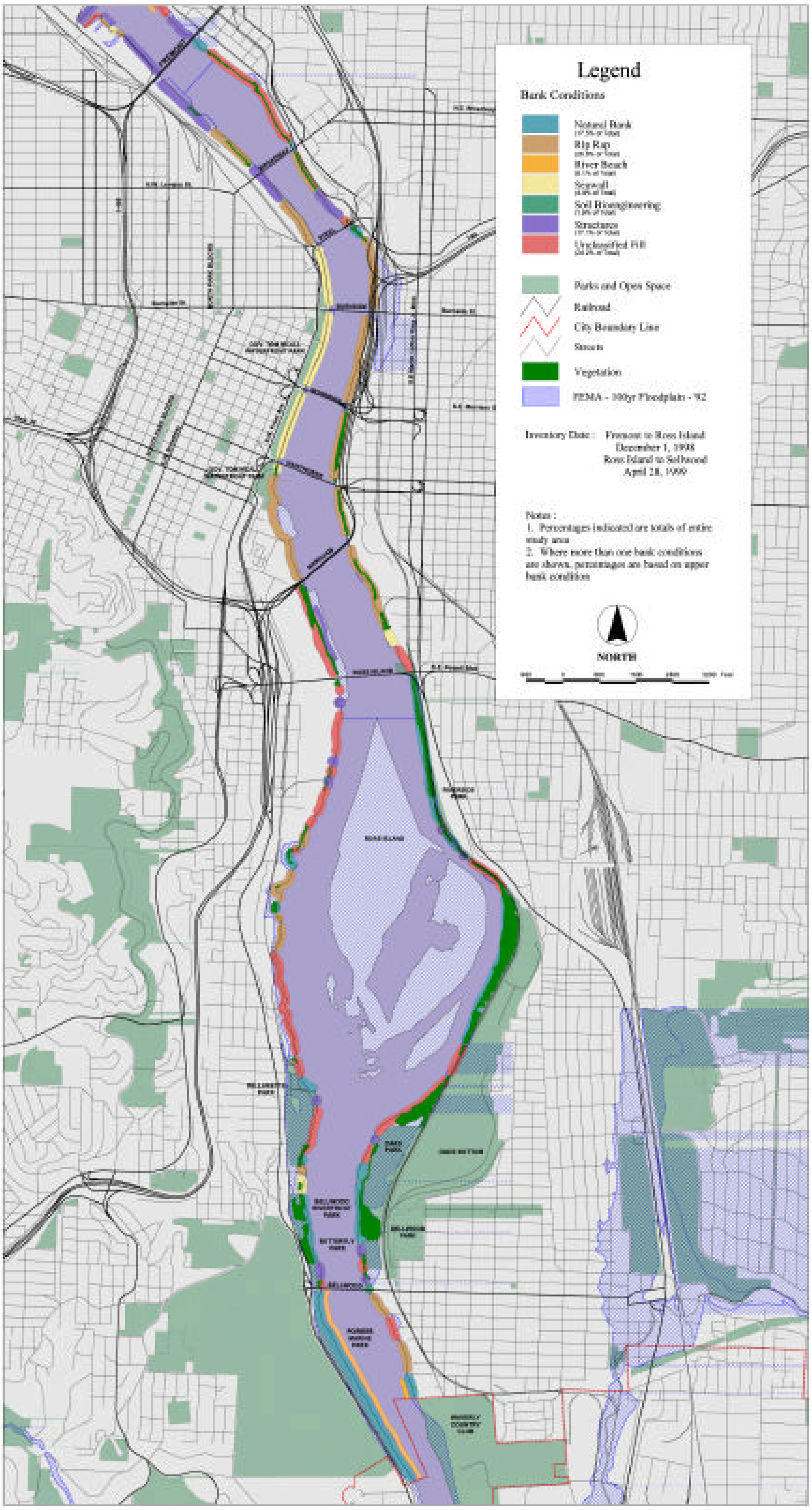
MAPS OF EXISTING BANK CONDITIONS



EXISTING BANK CONDITIONS : NORTH



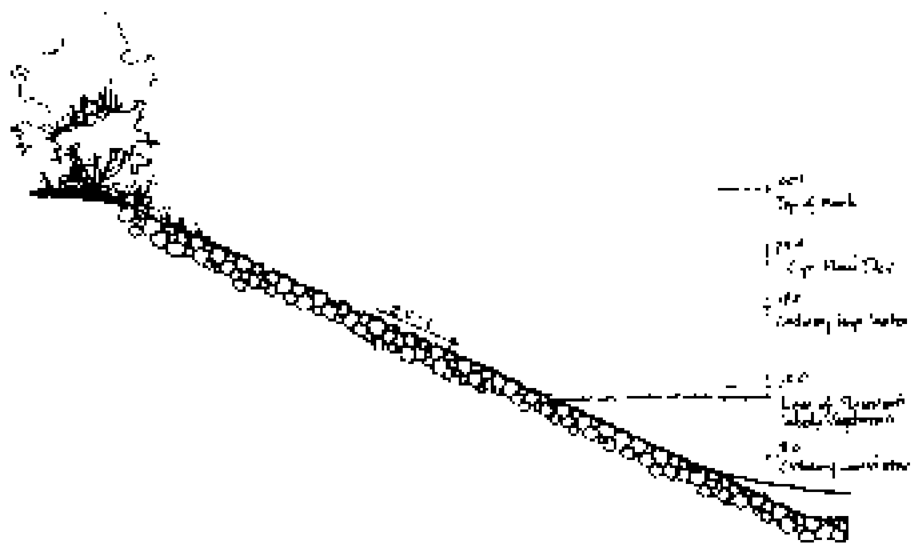
EXISTING BANK CONDITIONS : CENTRAL



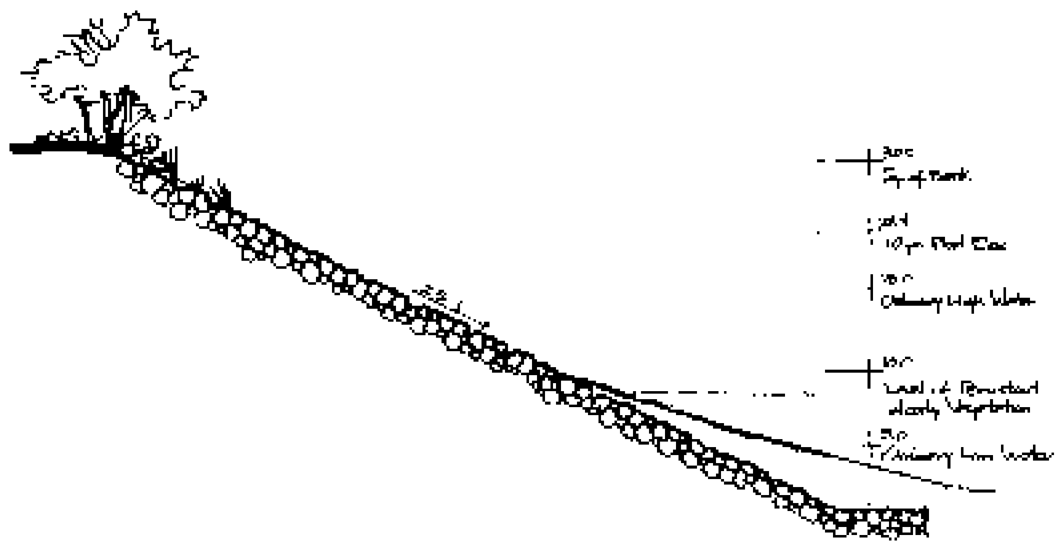
EXISTING BANK CONDITIONS : SOUTH

Appendix C

SCHEMATIC CROSS-SECTIONS OF EXISTING RIVERBANK CONDITIONS

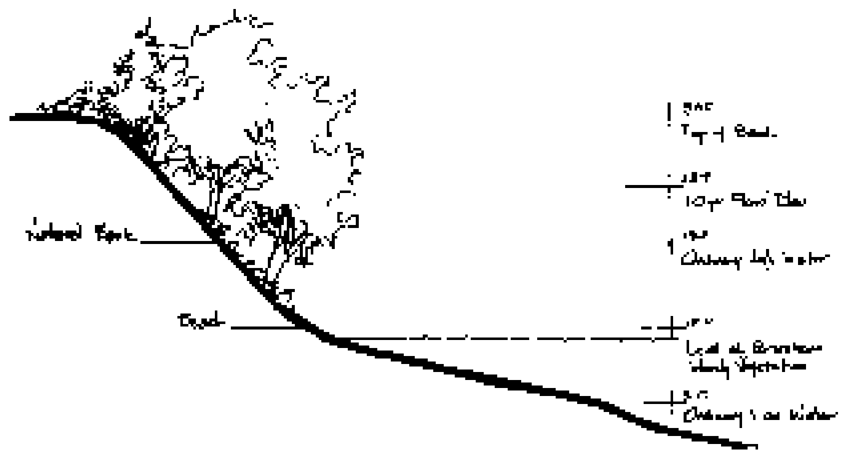


EXISTING BANK CONDITIONS - Traditional Riprap

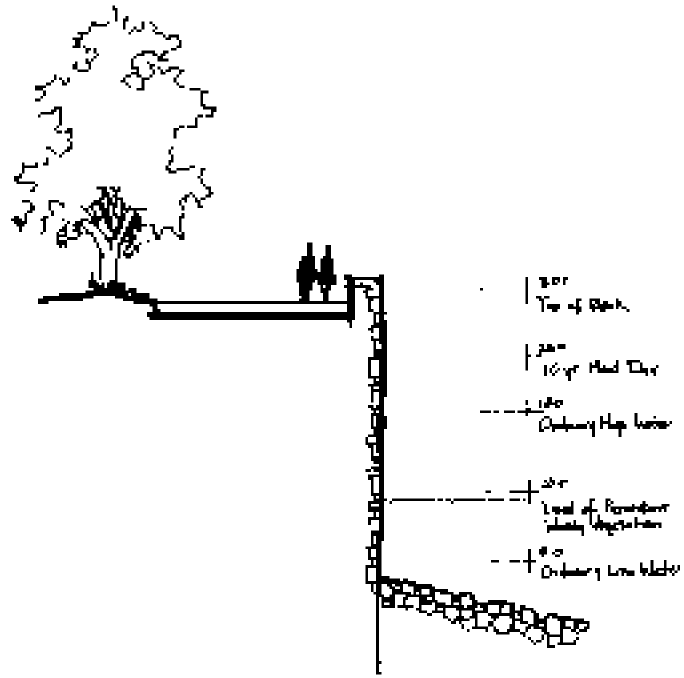


EXISTING BANK CONDITIONS - Rip Rap Beach

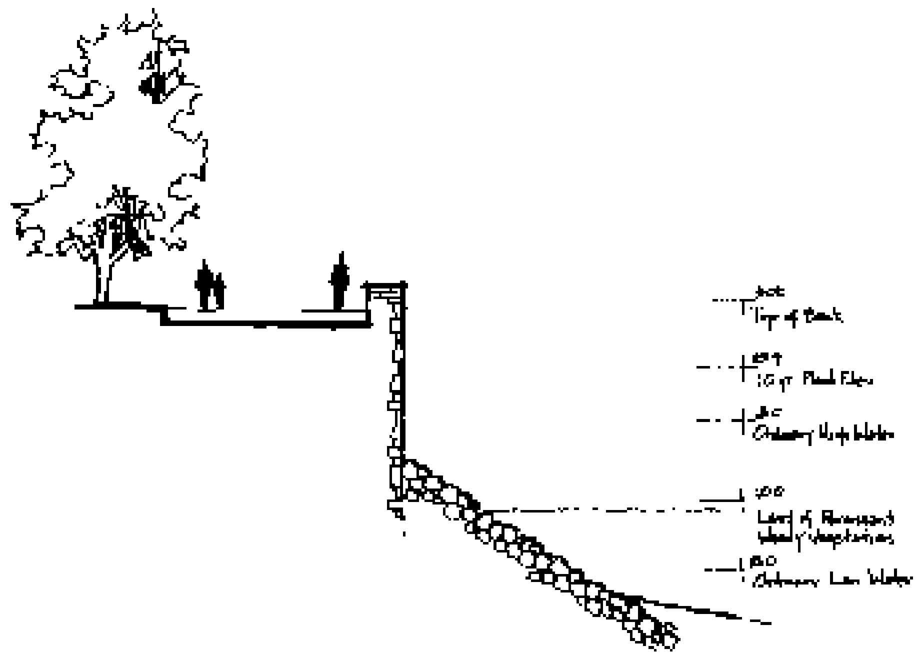
EXISTING BANK CONDITIONS - Vegetated Riprap Beach



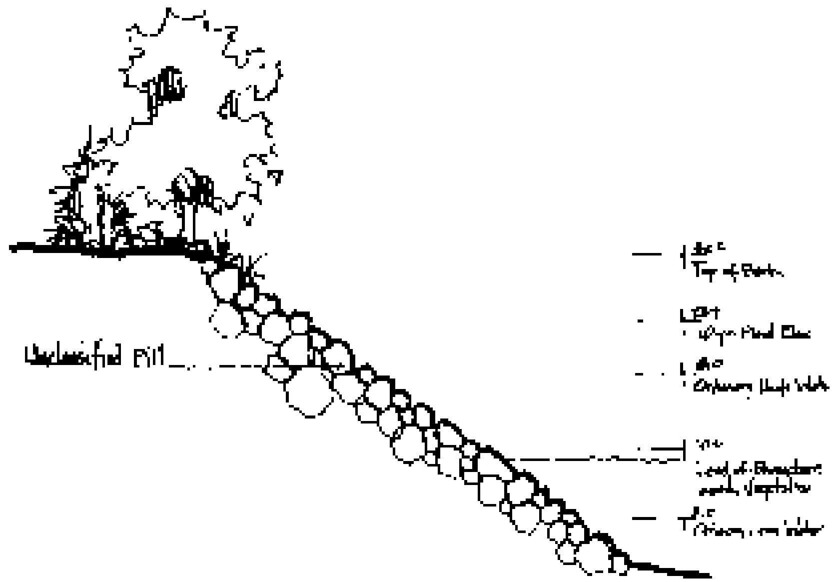
EXISTING BANK CONDITIONS - Natural Bank



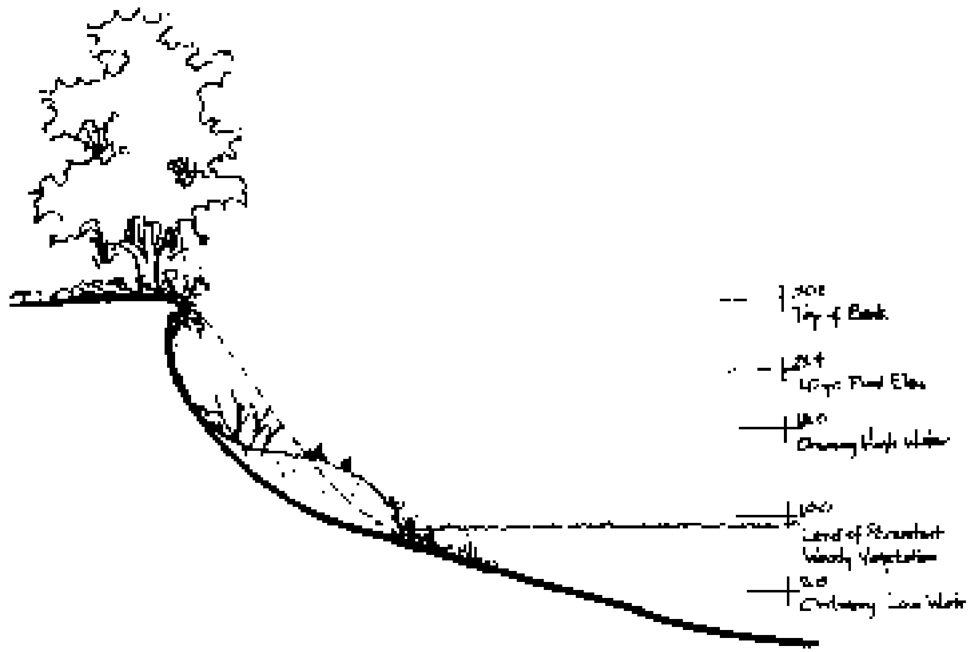
EXISTING BANK CONDITIONS - Seawall



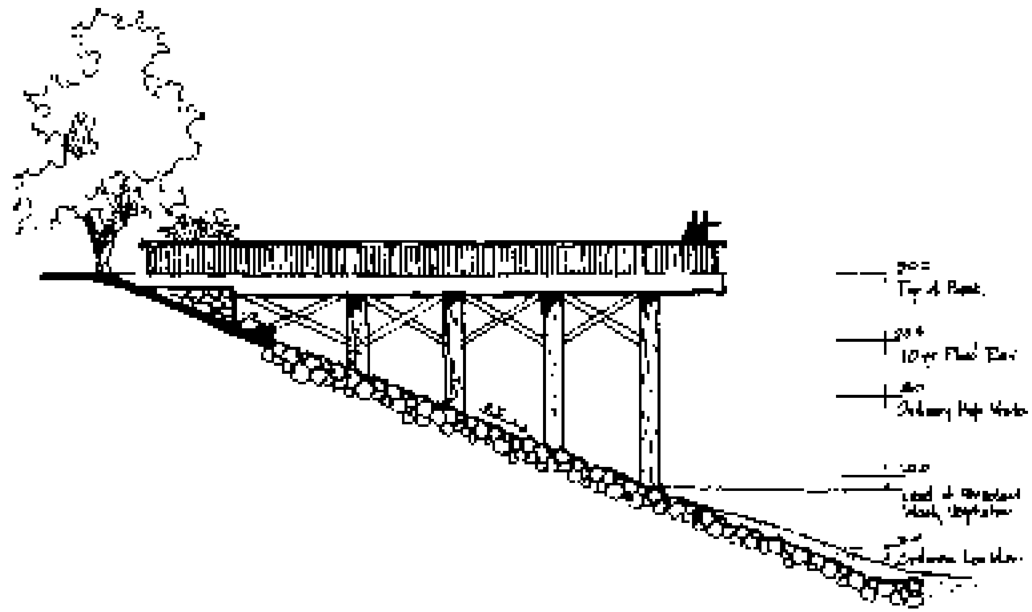
EXISTING BANK CONDITIONS - Seawall/Revetment Combination



EXISTING BANK CONDITIONS - Unclassified Fill



EXISTING BANK CONDITIONS - Failed Bank



EXISTING BANK CONDITIONS - Pier/ Revetment Combination

Appendix D

PLANNING & REDEVELOPMENT CONTEXT

The following efforts are being undertaken by local, state and federal jurisdictions to protect floodplains, water quality and water resources, and to enhance habitat for threatened fish species:

Local:

- The City's Endangered Species Act Program is developing plans for bringing the City's programs and activities into compliance under the ESA using a variety of tools including programmatic and project Section 7 consultation, gaining a formal "limitation" on the 4(d) rule take prohibitions and a Section 10 Habitat Conservation Plan or other comprehensive plan.
- Metro is currently developing additional rule language to protect floodplains and water quality that will require municipalities to apply new protection standards to new development near wetlands and water features.
- Portland BES has developed a stormwater manual at a level of specificity of the renowned King County Stormwater Manual. It will have far-reaching effects on stormwater designs for new development and redevelopment in the City, and has been adopted by City Council.
- Portland Parks is taking another look at inventories pertaining to and design standards for the Willamette Greenway.
- Portland DOT et al will be implementing a model Brownfields program in several redevelopment districts of the Portland Harbor zone.
- Portland BES, Multnomah County, and the International Port of Portland are implementing NPDES Phase I stormwater programs and permitting. All municipalities are preparing to respond to NPDES Phase II.
- Local watershed councils are developing watershed plans for streams that are tributary to the Willamette River in Portland.
- Portland BES is proposing a comprehensive strategy to achieve watershed health and meet Clean Water Act requirements called the Clean River Plan.

State:

State resource agencies have coordinated to develop The Oregon Plan, a funded action plan to restore listed cold water and anadromous fish. The plan leverages the resources of all the agencies to protect watershed functions and values where these threatened and endangered anadromous fish are present. The Oregon Plan represents basin and watershed strategies, and includes elements of:

- DEQ's programs for water quality limited (303(d)) streams, nonpoint source pollution control, coastal zone management, stormwater management (NPDES programs), and The Lower Columbia River Estuary Management Plan
- ODF&W's Basin Plans
- ODF's Streamside Management Zone program, and revisions to the Forest Practices Act that provide enhanced stream protection
- ODA's Natural Heritage Program and agricultural stream protection practices
- Oregon is also working with a broad spectrum of agencies and citizens to develop the Willamette Restoration Initiative.

Concurrently, Oregon's natural resource agencies and watershed councils are undertaking assessments of watershed health and developing action plans to address sources of watershed degradation. The Oregon Watershed Enhancement Board is funding approximately 65 watershed councils statewide to address these problems through a state and federally-funded grant program that promotes interagency, interdisciplinary project designs and public-private agreements at the local level.

In addition, the Oregon Division of State Lands (DSL)is pursuing a Special Programmatic General Permit (SPGP) from the Army Corps of Engineers (ACOE). IF granted, DSL would assume all regulatory responsibility for projects which fall within proposed thresholds of 5000 cubic yards of fill, or one-half acre of wetlands.

Federal:

In response to growing federal concerns about watershed health and water quality, numerous interagency planning efforts have produced bio-regional planning strategies for managing natural resources, including (but not limited to):

- The Lower Willamette Basin Strategic Plan, developed by the Natural Resource Conservation

Service et al

- The Ecosystem Management Plan, developed by the U.S.D.A. Forest Service and federal partners
- The Interior Columbia River Basin Ecosystem Management Project, by the U.S.D.A. Forest Service et al
- The Northwest Power Planning Council is currently redefining the protocols by which mitigation monies (for habitat losses consequent to Columbia River dams) are allocated for state and local projects

CURRENT RIVERFRONT REDEVELOPMENT PROJECTS

A partial list of redevelopment projects currently in progress in Portland includes:

- Eastbank Phase 3: The Crescent
- Eastbank Riverfront Park
- South Waterfront Park
- North Macadam redevelopment
- Tanner Creek Park
- Port of Portland Terminal One redevelopment
- Water taxi and transient boat moorage
- Rose Quarter Master Plan (Red Lion redevelopment)
- PGE Station L Phase II
- Pedestrian crossing of Steel Bridge
- Pedestrian connectors to the Rose Quarter and Convention Center
- Extension of Willamette Greenway on both sides of the Willamette River
- Lone Star Northwest redevelopment

- Caruthers Street Plaza (Water Avenue LID)
- Update of the Willamette Greenway Plan

General provisions for permits for these projects include enhancement of public access, rehabilitation and revegetation of riverbanks, improvement of water quality, protection of wildlife habitats, improvement of riparian habitat and access for wheelchairs and public safety vehicles.

Appendix E

ACTIVITIES & FACILITIES INFLUENCING THE RIVER

Portland's dynamic Willamette River zone includes the most heavily industrialized area of Oregon, the state's highest population density and the Willamette River's greatest concentration of water-dependent commercial uses. These uses include:

- a shipping channel
- ship-building yards and dry docks
- railroad lines
- docks, wharfs, and pile-supported warehouses
- harbor terminals with railroad access
- bridges
- river-dependent and riverside industries
- East Bank Freeway
- Harbor wall at Tom McCall Waterfront Park

In the vicinity of these uses are Holgate Slough and Oaks Bottom, which possess the highest wildlife diversity in the Lower Willamette planning area. Nearby are Hardtack Island and East Island, owned and managed by The Nature Conservancy as plant preserves and wildlife refuges. Riverfront parks include:

- Powers Marine Park
- Willamette Park
- Sellwood Riverfront Park
- Oaks Bottom
- Tom McCall Waterfront Park
- Eastbank Esplanade / Riverfront Park(s)

- The Willamette Greenway
- Cathedral Park

Appendix F

REFERENCE MATERIAL

Technical Literature

Breen, Ann, and Dick Rigby. The New Waterfront: A Worldwide Urban Success Story. McGraw-Hill, 1996.

Breen, Ann, and Dick Rigby. Waterfronts: Cities Reclaim their Edge. McGraw-Hill, 1996.

Fishman, Paul. “Floating Structures and Predation of Juvenile Salmonids in the Lower Willamette River: A Summary of Information.” 4 June 1998.

Gray, Donald H. and Andrew T. Leiser. Biotechnical Slope Protection and Erosion Control. Malabar, Florida: Robert E. Krieger Publishing Company, 1989.

Gore, James A and F. Douglas Shields Jr. “Can Large Rivers be Restored?” BioScience 45:3 (1995): 142.

Jones, Daniel R. and Mark A. Battaglia. “Main Street Rivers: Making Connections Between Rivers and Towns.” Penn State University Department of Landscape Architecture, 1989.

Leopold, Luna B. A View of the River. Cambridge: Harvard University Press, 1994.

Moses, Todd, Scott Morris, and Dave Gorman. “Institutional Constraints to Urban Stream Restoration.” Public Works 128:7 (1997): 36.

Nixon, Will. “Trashed Urban Rivers and the People Who Love Them: New Currents of Activism are Flowing for City Waterways.” Amicus Journal Fall 1995.

Oregon State University Extension Service. “A Snapshot of Salmon in Oregon.” The Oregonian Fall 1998.

Pope, Richard. “River Channel Restoration: Guiding Principles for Sustainable Projects.” The Geographical Journal 163:3 (1997): 311. (full text copyright 1997 by the Royal Geographical Society).

Rosgen, Dave. Applied River Morphology. Pagosa Springs, Colorado: Wildland Hydrology, 1996.

U.S. Geological Survey. “Water Resources Data - Water Year 1997.” Report OR-97-1. n.d.

Natural Resource Studies

Anderson, Chauncey W., Frank A. Rinella, and Stewart A. Rounds. “Occurrence of Selected Trace Elements and Organic Compounds and Their Relation to Land Use in the Willamette River Basin, Oregon 1992-94.” Portland, Oregon: United States Geological Survey, Water-Resources Investigations Report 96-4234, Prepared in cooperation with Oregon Department of Environmental Quality, Willamette River Technical Advisory Steering Committee and National Water-Quality Assessment Program, 1996.

City of Portland Bureau of Planning. “Lower Willamette River Wildlife Habitat Inventory.” March 1986.

Hancock, Danil R. (Hartman Associates) and Steven Johnson (Fishman Environmental Services). “Chemical Characterization of Sediments Adjacent to Stormwater Discharges in the Willamette River Near Portland.” Report for United States Environmental Protection Agency Region 10. Seattle, Washington, February 1995.

Tetra Tech. “Willamette River Basin Water Quality Study: Summary and Synthesis of Study Findings.” Oregon Department of Environmental Quality Contract No. 97-094. Portland, Oregon: Water Quality Division, August 1995.

Plans, Ordinances and Standards

City of Portland, Bureau of Environmental Services. “Preliminary Draft Stormwater Management Manual.” April 1998.

City of Portland, Oregon, Bureau of Environmental Services, Clean River Works, and Parks and Recreation. “Willamette River Six Point Plan.” September 1998.

City of Portland, Oregon, Bureau of Planning. “Willamette Greenway Plan.” January 1988.

“Greenway Zones.” (Title 33, Planning and Zoning, Chapter 33.440). City of Portland, Oregon, July 1997.

GreenWorks, PC. “Park Futures: A Master Plan for Portland’s Park System.” Prepared for Portland Bureau of Parks and Recreation, November 1991.

Hargreaves Associates, Planners. “Eastbank Riverfront Park Master Plan: City of Portland, Oregon.” San Francisco: Prepared for Portland Development Commission & Portland Parks and Recreation, January 1994.

Metro. “Title 3: Water Quality and Flood Management Conservation Stream and Floodplain Protection Plan - Draft Revised Performance Standards.” Portland, Oregon. December 1997.

Metro. “Title 3: Water Quality, Flood Management and Fish and Wildlife Conservation.” Portland, Oregon. July 1998.

MIG, Inc. and EcoNorthwest, Inc. “River District: Recreation and Open Space Needs Assessment, Final Report.” Prepared for Portland Bureau of Parks and Recreation, March 1997.

Oregon Business Council. “A New Vision for Pacific Salmon.” Portland, Oregon.

Oregon State Land Board, Division of State Lands. “Lower Willamette River Management Plan.” September 1992.

SRG Partnership. "Lower Willamette River Management Plan: A Policy and Management Guideline." Developed by the Lower Willamette River Study Team including: Port of Portland, State Water Resources Board Oregon Department of Environmental Quality, et al. August 1973.

USDA Natural Resources Conservation Service and Clackamas, Marion, Multnomah, Polk, Yamhill and Washington Counties. "Lower Willamette Basin Strategic Plan 1996-2001." August 1998.

Wayne Shuyler with assistance from Draggoo & Assoc. "Recreational Boating Management Plan for the Portland Metropolitan Waterways: Report to the Oregon State Marine Board." Prepared for Oregon State Marine Board, 1995.

Maps, Charts, Atlases and Tables

Boating Guide to the Lower Columbia and Willamette Rivers. Chart. Jointly published by the Oregon State Marine Board, OSU Extension Sea Grant Program, Washington State Parks & Washington Sea Grant Marine Advisory Program, 1992.

Channel Status: Columbia River - Mouth of the Columbia to Bonneville Dam. Chart. United States Army Corps of Engineers, Portland District, 1998.

Columbia River - Sheet No. 6: Fales Landing to Portland. Map. National Oceanic and Atmospheric Administration, Office of Coast Survey, National Ocean Service, May 1888.

Lower Willamette River Basin - Spawning and/or Rearing Habitat, Steelhead (Summer Run), Steelhead (Winter Run). Map. Bonneville Power Administration, December 1997.

Lower Willamette River Basin - Spawning and/or Rearing Habitat Chinook Salmon (Fall Run), Chinook Salmon (Spring Run), Coho Salmon. Map. Bonneville Power Administration, December 1997.

Oregon Department of Environmental Quality; Planning and Monitoring Section and Water Quality Division. 1988 Oregon Statewide Assessment of Nonpoint Sources of Water Pollution. Portland, Oregon. 1988.

Oregon's 1994 Water Quality Status Assessment Report - 305(b) Report. Table. Portland, Oregon: State of Oregon Department of Environmental Quality, April 1994.

Portland / Vancouver Toxic Waters. Map. Portland, Oregon: Northwest Environmental Advocates, Columbia-Willamette River Watch, January 1992.

Roles and Responsibilities for the City of Portland's NPDES Stormwater Permit. Table. Portland, Oregon: City of Portland, Bureau of Environmental Services, not date.

Salmon Habitat Throughout Oregon. Map. State of Oregon Division of State Lands, April 1998.

Spawning and/or Rearing Habitat – Lower Willamette R. Table. Online. Available: http://www.efw.gov/Environment/MAPBUILDER/USERMAPSDAT/1709001209120915394.spc.

Water Quality Limited Streams - 303 (d) list, Willamette Basin. Table. Online. State of Oregon, Department of Environmental Quality, no date.

Waterbodies on Oregon's 1994 / 1996 303(d) List and Proposed Endangered Species Act Listings. Oregon Department of Environmental Quality (GIS), January 1997.

Concurrent Planning Efforts

"Brownfields Redevelopment Plan." Portland, Oregon: City of Portland Office of Transportation, Doug McCourt.

"Central City Summit." Portland, Oregon. Co-chairs: Brian Scott, Ethan Seltzer.

"Goal 5 Technical Advisory Committee on Fish and Wildlife Habitat." Portland, Oregon: Growth Management Services Department, Metro, Elaine Wilkerson, Director.

"NPDES Phase I and II." Portland, Oregon: City of Portland, County of Multnomah, International Port of Portland.

"Oregon Steelhead Plan." Salem, Oregon: State of Oregon, Governor's Natural Resource Team, Ken Bierly, Manager.

"Revisions to Essential Indigenous Anadromous Salmonid Habitat." Salem, Oregon: Oregon State Land Board, Division of State Lands. Eric Metz, Manager.

"Steelhead Plan." Portland, Oregon: City of Portland, Bureau of Environmental Services. Mary Abrams, Manager.

"Steelhead Supplement Work Plan." Salem, Oregon: Oregon State Land Board, Division of State Lands.

"Stormwater Management Manual Technical Advisory Committee." Portland, Oregon: City of Portland, Bureau of Environmental Services. Dean Marriot, Director; Dave Kliewer, Project Manager.

"Watershed Assessment Manual." Salem, Oregon: Governor's Watershed Enhancement Board. Ken Bierly, Manager. .

"Waterway / Wetland Streamlining Programmatic Revisions to Oregon's Removal-Fill Permit, Douglas and Linn Counties, Oregon." Salem, Oregon: Oregon State Land Board, Division of State Lands. Eric Metz, Manager.

Other Reports

"Sewer Outfall Report." Portland, Oregon: City of Portland, Bureau of Environmental Services, February 1986.