REMR TECHNICAL NOTE EI-M-1.4

ISSUES REGARDING VEGETATION MANAGEMENT ON LEVEE EMBANKMENTS

Figure 1. Actively establishing vegetation on levees allows selection of species with desired growth habits and realization of environmental benefits.

PURPOSE: To provide an overview of current issues in the management of vegetation on levee embankments. This information and results of ongoing research can be applied to site-specific levee vegetation management to increase the multiple-use aspect of levee embankments without decreasing their structural integrity.

BACKGROUND: All project levees constructed by the Corps of Engineers (CE) for which PL84-99 emergency repair assistance is requested must be maintained in

accordance with CE guidelines, as typically stipulated in assurance agreements. These agreements, executed when construction is complete, generally transfer all operations and maintenance responsibilities to the local sponsor. Current CE guidelines for levee maintenance and operation limit vegetation on the embankment to sod-forming grasses of 2 to 12 in. in height to provide for structural integrity, inspectibility, and unhindered flood-fight access to levees; these standards allow just enough vegetation on levees to provide resistance to surface erosion (Code of Federal Regulations [CFR] Section 208.10, Title 33. "Flood Control Regulations"; U.S. Army Corps of Engineers 1968). Exceptions are made to allow willow (or similar) growth on overbuilt levee sections and on riverward berms (batture land) for erosion control in areas of high-wave or river-current attack. For a thorough review of pertinent Corps standards and guidelines for vegetation control on levees, see Nolan (Ref a).

In many cases, these standards preclude levees from functioning as high quality, multiple-use structures, and it is increasingly common for local sponsors to be sensitive to this issue. Multiple-purpose use of levees can include wildlife habitat, recreation, separation of land-use activities from the river channel, or, conversely, connecting adjoining areas to the river. Woody vegetation is a critical element in these uses. Furthermore, site-specific relaxation of existing vegetation standards could potentially reduce the frequency, cost, and detrimental environmental effects of required maintenance.

VEGETATION-INFLUENCED STRUCTURAL INSTABILITY ISSUES: Levees may fail from overtopping, surface erosion, shear failure (slope instability) of the embankment or foundation, and piping (Ref b). Vegetation on levees can potentially influence all of these processes.

a. Surface Erosion Control: Vegetation reduces surface erosion on levees by reducing current velocities adjacent to the soil/water interface and by physically holding soil particles in place with roots. The extent to which vegetation reduces flow velocity adjacent to the levee embankment depends upon the surface area of vegetation presented to the flow. Consequently, shrubby species which extend numerous nonrigid branches and leaves into the flow are most effective for this regard. In undisturbed river systems with well-developed bank vegetation, bank erosion can be minimized by the root structures of large, isolated, rigid trees (Ref c, d).

b. Slope Stability: The effects of vegetation on slope stability are best documented in the soil conservation and forest engineering literature summarized in Gray and Leiser (Ref e). More recently, vegetation has been used as a functioning engineering component in slope stabilization efforts (Ref e). In this application, root networks supply additional apparent cohesion to soil well into the embankment; this support represents a net gain in reinforcement even with the decreases in soil density from the addition of roots (Ref f, g). This effect is particularly significant for embankment soils with little or no cohesion. Additionally, evapotranspiration by vegetation can promote slope stability by reducing the pore-water pressure within the soil mantle on natural slopes (Ref h). The levee environment in which pore-water flow is more nearly horizontal across the levee is a different problem. Levee

embankment slopes are generally shallow enough that any overburden weight should act dominantly perpendicular to, rather than parallel to, failure planes, thereby increasing slope stability (E. B. Perry, personal communication). The location of trees on the embankment can influence slope stability analysis to the extent to which their weight might contribute to forces that cause slope failure.

Soil stratification affects seepage pressure and slope stability. For complex stratification of clays, sands, and silts, special consideration must be given to the effects that various types of vegetation may have on hydrostatic pressures due to blockage of seepage paths.

c. Seepage and Piping: Because roots clearly enhance the formation of macroporosity in the soil of levee embankments, significant vegetation is generally allowed only on overbuilt levees which are large enough to allow for a root-free zone at least 3 ft (1 m) thick surrounding the standard cross section. However, macropores are usually highly discontinuous and, therefore, increase the effective porosity less than might be supposed (Ref i). Such discontinuities in levee embankments may, however, increase the retention of water in the slopes, leading to saturated slope areas during sudden drawdown.

Any slopes or embankments, including levees, may fail if rapid seepage through soil pipes occurs. If piping occurs, it propagates from the surface where seepage exits the levee toward the levee interior; therefore, vegetation management on the landward toe of the levee must be governed by seepage considerations.

The development of soil pipes from macropores is a complicated phenomenon and must be studied further in levees before being used to substantially alter existing vegetation management guidelines. However, vegetation management itself may influence the degree of formation of significant macropores. Mowing and grazing decrease macropore density due to associated compaction, while uneven, rapid drying of soil in the absence of significant vegetation can lead to desiccation cracks in the embankment (Ref i, j). Finally, the presence of short turf has been linked in part to high densities of ground squirrels in levees of the Sacramento-San Joaquin Delta system in California, giving rise to large, interconnected macropores. In this type of vegetation, squirrel predators have no cover; therefore, increasing the vegetation cover is considered to be a useful means of controlling squirrel populations (Ref j). The strength of this link is debated, however (Ref k).

VEGETATION - INFLUENCED CHANNEL CAPACITY ISSUE: Vegetation on the river channel side of a levee encroaches on the cross-sectional flow area and retards flow. The result is a reduction in the capacity of the channel which must be taken into consideration. This is not likely to be a problem for wide shallow channels, but could be a problem for narrow channels.

CURRENT MANAGEMENT PRACTICES WHICH ENHANCE MULTIPLE USES OF LEVEES: Levee design, construction and maintenance activities which consider multiple use aspects of the embankments are not yet widespread. Furthermore, it is often very localized conditions (flooding pattern, river channel morphology, vegetation growth, or habitat requirements for sensitive species, for example) which both prompt and allow deviation from common levee management practice. However, continued experience with these levees may provide the confidence required to allow similar design and management practices to be applied more broadly.

a. Overbuilt levees: An overbuilt levee is one which has a larger cross section than required to meet all engineering considerations (Ref 1). Overbuilt levees allow more substantial vegetation on the embankment and, in some settings, may eliminate the need for vegetation maintenance entirely (Ref m). For instance, levees on the canal section of the Tennessee-Tombigbee waterway are oversized with the expectation that they will be naturally revegetated by native plants (Ref m). The constraints on vegetation type and density should depend on inspection, maintenance and flood-fighting needs.

   If penetration into the root-free zone is likely to be an issue, plants can be containerized or planted above a physical barrier. Use of containers is best restricted to urban settings because of increased maintenance needs. Finally, overbuilt levee embankments can be shaped to provide topographic variability, improving the aesthetic qualities of the levee. Hynson, et al., (Ref m) provide additional detail on the design and maintenance of overbuilt sections and discuss other specific projects on which this type of levee was or will be constructed.

b. California Department of Water Resources strategy: Because of varying financial capacity, attitudes, and levee types in the Sacramento and San Joaquin River Flood Control Projects and a desire for these levees to support some of the aesthetic and environmental values of the undisturbed river systems, a vegetation maintenance standard somewhat more tolerant than current CE guidelines exists for these levees. It should be noted that the current version of this standard is applied to project levees by the primary local sponsor, the State of California Reclamation Board, over the objections of local CE District and Division personnel, since the operations and maintenance assurance agreement stipulates that project levees will be maintained to CE standards. All parties are currently seeking a compromise on this issue, which will depend upon the results of a joint 3- to 5-year Corps-State demonstration program. The demonstration program will evaluate the role of vegetation throughout the Sacramento River flood control system. These alternative management guidelines are supported by the relevant state agencies and are outlined in the "Interim Guide for Vegetation on Flood Control Levees" (Ref n). Figures 1 and 2 show the type of vegetation encouraged on these levees by the state agencies acting as the primary local sponsor. Finally, Riley (Ref o) outlines alternative inspection techniques (including walking inspection) which are used by local reclamation

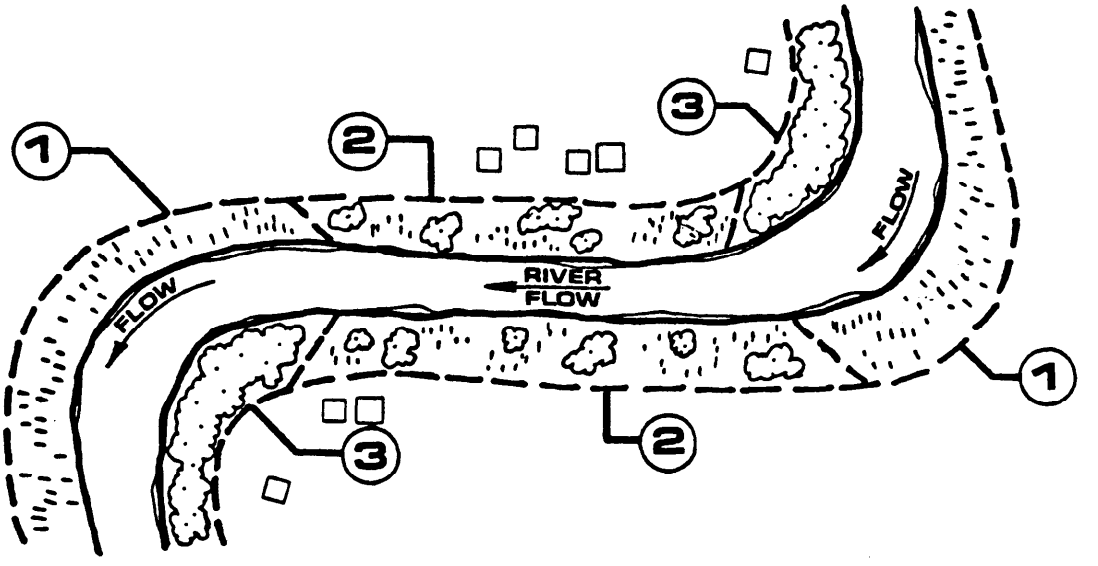
Figure 2. Irrigation may be necessary to establish shrubby vegetation on levee embankments depending upon local soil and hydrologic conditions.

board inspectors and which are effective under conditions of increased vegetation density. While such techniques are not thought to be applicable to an extensive levee system under a single jurisdiction (G. L. Snow, personal communication), they could be employed in special-use management areas.

c. Seattle District strategy: The Seattle District, CE, has developed minimum maintenance guidelines for levees on the Puyallup River near Tacoma, Washington, which are less restrictive than general CE guidance. These guidelines vary the amount of allowable vegetation according to the inherent risk to adjacent property (ex., agricultural vs. urban) and the erosion hazard at the specific location (Ref m). The generalized scheme is reproduced in Figure 3. This variance, which is part of the agreement between the CE and the Puyallup Indian Tribe, was approved by North Pacific Division on the basis of the unique circumstances of the project setting (G. Taxer, personal communication). The Puyallup Flood Control Project is located within the reservation boundaries of the Puyallup Indian Tribe. The Puyallup Tribe has fishing rights that were assigned them in an Indian treaty signed in the 1800's. Therefore, the Seattle District has modified their maintenance procedures to include both the concerns of the structural integrity of the levee system and the need for fish habitat.

NOTE: Vegetation management on levees is a complex issue, and few data exist on the influence of vegetation on the structural integrity of levees. An

MANAGEMENT OF LEVEE VEGETATION



(1) Areas of HIGH potential damage, such as the outside of river bends, historically flooded areas, or levees adjacent to residences and critical use facilities should be cleared of trees and brush which could obstruct access for inspection and repair. In these levee sections, only grass and small forbs would be permitted.

(2) Areas of INTERMEDIATE damage potential such as relatively level, straight reaches and gentle bends could be selectively cleared, leaving clumps or strips of vegetation while allowing unimpeded access for inspection and repair. The type, amount and distribution of this vegetation would be carefully coordinated with the Corps of Engineers to insure levee integrity.

(3) Areas of LOW potential damage, i.e., the inside portion of river bends, levees which are seldom damaged or which protect large areas of undeveloped or relatively low value land could be maintained in a manner which would leave most levee vegetation intact, removing only that vegetation which could constitute a threat to the levee or impede levee accessibility.

Figure 3. Seattle District guidelines for management of vegetation on Puyallup River levees. These relative damage classes are generally applicable to gravel-bedded rivers at moderate flood flows but may not be appropriate in all instances.

ongoing project exists to investigate this relationship at selected levees which do not comply with CE standards (33 CFR). Preliminary results are provided in REMR TN EI-M-1.3.

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