2012 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE
July 2012

TOPIC:
Design Guidelines and Bioengineering Approaches to Levees and Revetments

STATEMENT OF ISSUE:
Bioengineering approaches have been applied on King County levee and revetment projects over the past 20 years. Flood risk reduction, ecological objectives, and long-term maintenance, recreational safety and repair costs are taken into account when determining the best approach to levee and revetment repair projects. This paper explains why King County employs bioengineering approaches to levee and revetment projects and why we need to update our design guidelines. However, we have been asked:

- Should King County continue to employ bioengineering techniques and use large wood as a structural element of river projects given concern about recreational safety?
- Can bioengineering techniques and large wood be incorporated into projects and can public safety be addressed in the design and/or operations of the projects?

BACKGROUND:
King County employs bioengineering approaches to levee and revetment repairs, with the objectives of increasing the resiliency of the structure, reducing maintenance costs over time, and promoting multiple floodplain objectives for habitat, open space, and recreation along our river corridors. By incorporating bioengineering techniques into levee and revetment repair projects permitting agency requirements to provide habitat mitigation can be incorporated on-site using large wood and habitat structures in the project design. This can also reduce permitting time. Including bioengineering techniques may require more time for design and implementation, and an increase in funding needs but this depends on the project location and options for meeting the habitat mitigation requirements. An alternative to incorporating bioengineering techniques into a project would be to construct an off-site mitigation project, which may or may not require additional time and increases costs. Project specific circumstances must be investigated during the planning and predesign phase.

King County modifies rivers through capital projects to achieve flood risk reduction and other regional goals. The approach to these projects generally reconnects river channels to their floodplains, thereby encouraging more dynamic processes to increase flow capacity and better handle floods. Projects can produce substantial changes in river environments, sometimes suddenly occurring during a large flood event, or more incrementally over time. Physical changes resulting from river projects may affect in-river recreationalists that have previously used less complex and dynamic channels. Though these changes are viewed differently by different user groups, some in-river recreationalists may face possible increases in hazards due to changed river conditions. Further, when river channels shift, banks can be undercut, posing possible unseen hazards to riverside recreationalists. It is important to note that these processes and potential hazards are routinely created in dynamic river systems, whether or not any projects are done by King County. King County wants to design, construct, and operate its projects to address recreational safety. Further, King County needs to monitor projects over time to address any safety concerns that come up post project.

The recent MWH report (*Independent Expert Panel Review of Water and Land Resources Division's Project Scoping and Implementation Practices*) evaluated King County's approach to capital project identification and implementation, and stated the following:

> There is increasing awareness in recent decades of the interconnection and mutual influence among different objectives and associated actions for river and floodplain management. Therefore, project formulation and implementation has shifted from the traditional single purpose project, with necessary compensatory mitigations, to a multi-objective approach to incorporate features that promote public safety, flood management, ecosystem restoration and recreation. While traditional river management involves strategies to control a river through channelization or hardening embankments, the more integrated approach seeks opportunities to allow river meandering for transitory storage and potential restoration of critical floodplain functions. This multi-objective approach, especially when applied on a system wide level, allows more flexible management strategies, improved prioritization and effectiveness in using limited resources, and more sustainable outcomes … (King County) uses scientifically accepted principles for managing floodplains within the context of balancing other stated policy objectives" and that "… no consistent or systemic design or siting failures invalidate the new approaches to floodplain management or urge a moratorium on additional projects.

To date, project design has been guided by a collection of design guidelines that are either dated, such as "Guidelines for Bank Stabilization Projects in the Riverine Environments of King County" (Johnson and Stypula 1993) or from other sources, such as the Department of Fish and Wildlife's and the Army Corps of Engineers "Guidelines for the Construction of Levees." However, the Flood District and King County do not have established, county-specific guidelines for project design, construction, and maintenance.

The MWH report "recommended establishing design guidelines and specifications appropriate for integrating public safety and ecological objectives into King County's floodplain management strategies." Further supporting the development of county-specific guidelines, the MWH Report identified the need for the development of a formal process for reviewing project selections and design approaches. One of the primary findings from the MWH Report was the need for King County to clearly describe strategies in the shift from "hard engineering" to "ecological/dynamic" floodplain management strategies and to show how individual projects meet strategic goals or fit with current scientific theory and practice. The Flood Hazard Management Plan update includes policy language that recommends establishing such design guidelines and in each basin's vision and strategy, we will better coordinate and align projects and identify work program needs to develop an integrated river management strategy more clearly linking projects to the overall goals of the Flood Plan.

In response to the MWH report recommendations, King County has conducted recreational use and large wood surveys on the Cedar River, hosted a public workshop on upcoming projects along the Cedar River, documented and strengthened the project prioritization and sequencing criteria, strengthened connections between the Flood Hazard Management Plan with the WRIA salmon habitat plans and 3-year habitat work programs, conducted placed wood public meetings

to encourage stakeholder involvement in project design, and established internal basin coordination teams for each basin.

In addition to the items already implemented, King County is currently putting into practice a number of other recommendations from the MHW report which include: updating its project and construction management manuals, initiating studies to evaluate large wood, recreation, channel changes and sediment transport; conducting a landscape analysis for the Lower Snoqualmie (fish, flood, farm, floaters); developing an integrated river management strategy for each major river basin to be phased in over a 2-3 year period; developing a Lower Green River corridor conceptual approach; and enhancing outreach to stakeholders and the general public through several methods such as a web-based CIP mapping tool, posting project summary documents on the Web, and holding annual public meetings in each basin to discuss basin-wide strategies, goals, and objectives, along with project specific progress.

King County will incorporate recreation into monitoring protocols, as appropriate, and identify additional methods to obtain recreational use information and recreational user input into the design of monitoring approaches. All County projects to re-establish natural river processes now evaluate and plan for a range of likely potential outcomes, acknowledge areas of uncertainty, and identify and plan for mitigation of resulting risks. Further, capital projects will continue to consider river recreation in the planning and implementation of flood risk reduction and habitat improvement projects, and will invest in building public awareness and understanding of river hazards and recreational safety to minimize the potential for personal injury.

Bioengineering Approach

Historically, major maintenance activities on levees consisted primarily of replacing riprap eroded by the river, and clearing vegetation along river channels that were often constrained. This approach often did not address the causes of damage, or normal wear of the levee system. The high cost of frequent maintenance could not be sustained with limited revenue.

As a result of these temporary fixes, which did not fully address the cause of the repeated damage, King County has shifted toward a more systemic solution, increasing the use of bioengineering techniques as the basis for nearly all repairs and retrofits on existing levees and revetments along major rivers and streams. These changes aim to reduce maintenance costs, are more readily permitted to enable the project to be designed and constructed in a timely manner. The 1993 Flood Hazard Reduction Plan (FHRP) incorporated guidelines for the design, construction, and maintenance of structural capital improvement projects (CIPs) for flood reduction and flood control along the major rivers in King County stressing bioengineering approaches to bank stabilization.

This approach emphasized more environmentally friendly bioengineering methods (soil biostabilization) such as vegetative brush layering to stabilize riverbank and levee slopes, and toe-buttress construction with large stone and firmly anchored large wood emplacements at the base of a facility. These actions are designed to address instream habitat along the toe of the facility and to minimize the potential for flood-flow undercutting, erosion, and sloughing of the face of the facility.

The 2006 Flood Hazard Management Plan (FHMP) continues to put forward bioengineering as a design approach for levees and revetments; bioengineering is an available alternative for managing King County's flood protection facilities. Bioengineering mimics natural river bank stabilization techniques by incorporating live plants and engineered log jams (fallen trees lodge in the river channel's bed and banks, riparian vegetation lines the banks helping to slow localized flow velocities while the roots help bind the soil) into the fabric of the flood protection facility and as instream structures, reducing the potential for bank erosion and providing multiple valuable habitat objectives (protective cover from predation, shade, and food).

Incorporating natural elements for bank stabilization through bioengineering methods offer multiple benefits to the system creating more stable riverbanks and reducing long term maintenance and costs than those armored with rock riprap. Through recruitment of vegetation and additional woody debris during flooding, adding roughness to the channel (increasing flow resistance and slowing the river), and allowing vegetation in the project site to become established and form a cohesive matrix of interlocking plant root structures, the bank becomes naturally stronger and more resistant to erosion. At the same time, these methods improve fish and wildlife habitat. These projects provide an environmentally sensitive, low maintenance solution with lower long-term costs. Rather than deteriorating and requiring continual and costly maintenance, these structures grow stronger over time.

However, under certain conditions, bioengineering techniques may not be appropriate, or may need careful consideration when designing a project. A very confined section of a river, with levees on both sides, for example, may not be the optimal choice for applying bioengineering methods. A high energy system with high risk potential also may not be an appropriate location for bioengineering techniques; allowing the time needed for plant roots and wood structures to establish could leave a levee at risk for erosion and potentially increase the risk from flooding. Use of rock is a normal feature of levee project design, particularly in the toe of the levee, below ordinary high water. Wood features can help protect the toe, but bioengineering techniques exclusively do not create a stable toe; there is always an element of rock in the lower bank. County-specific design guidelines that include bioengineering techniques are needed and will increase consistency and provide an objective, transparent mechanism for design considerations and implementation. Updated guidelines will better direct the most appropriate design technique for the site.

Since adoption of the 2006 FHMP, Public Rule "Procedures for considering Public Safety when Placing Large Wood in King County Rivers" was approved to:

1) Consider public safety issues in the design of projects involving the placement of large wood in King County rivers and streams.
2) Evaluate strategies for design of wood placements that will maximize project benefits and minimize risks to public safety.
3) Make available to the public the opportunity to provide input on proposed projects utilizing large wood.

The Public Rule states that at 30% design, King County will document how public safety considerations have been addressed in the design, conduct public outreach in an effort to reach a broad spectrum of the community and incorporate safety features into project design. Further underscoring public safety issues, the MWH Report recommended that King County consider a

dedicated “Office of River Public Use” to support engineers in designing safe projects. We have secured contracts to provide professional expertise in project design to ensure we are addressing public safety issues. Until county-specific guidelines are available, King County will follow Public Rule procedures.

DISCUSSION:

While King County and the Flood Control District have been employing bioengineering approaches to levee and revetment repairs over the past 20 years, current design guidelines are dated. Bioengineering approaches can create resilient structures and reduce maintenance costs over time. Bioengineered structures slow erosive flows, direct higher velocity flows away from banks, and provide multiple objectives such as habitat benefits. When applied as part of an integrated system, this approach allows for a more resilient and sustainable flood risk reduction system.

The MWH report confirms King County is using the right scientific approach but we need updated, county-specific design guidelines that include bioengineering techniques. We are establishing a set of design guidelines that will direct design alternatives to consider appropriateness of scale (i.e. small streams vs. large rivers) and context (i.e. adjacent land uses, inside bend vs. outside bend, river use) for a project while taking into consideration the project location.

The design guidelines will also address how to evaluate recreation impacts (positive or negative) and address public safety either through design, closures, education or other means appropriate for the situation.

ADDITIONAL RESOURCES:

Engineering with Nature (FEMA)
http://www.fema.gov/pdf/about/regions/regionx/Engineering_With_Nature_Web.pdf

Integrated Stream Protection Guidelines (WDFW)
Integrated Streambank Protection Guidelines - WDFW Publications | Washington Department of Fish & Wildlife

Guidelines for Bank Stabilization Projects in the Riverine Environments of King County
http://www.kingcounty.gov/environment/waterandland/flooding/bank-stabilization-projects/guidelines.aspx?print=1

2012 Independent Expert Panel Review of Water and Land Resources Division’s Project Scoping and Implementation Practices http://your.kingcounty.gov/dnrp/library/water-and-land/rivers/1201-wlrd-project-practices-review.pdf
King County Rivers Program Programmatic Biological Effects Analysis
http://www.kingcounty.gov/environment/waterandland/flooding/documents/biological-effects.aspx

2011 King County River Management Survey:
http://www.kingcounty.gov/environment/wlr/sections-programs/river-floodplain-section/river-survey-2011.aspx

2010 Cedar River Recreational Study: http://www.kingcounty.gov/environment/wlr/sections-programs/river-floodplain-section/cedar-recreation-study.aspx

2009 Large Wood Stakeholder Committee http://your.kingcounty.gov/dnrp/library/water-and-land/flooding/0912-large-wood-safety-rule/Large_Wood_Stakeholder_Committee_Final_Transmittal.pdf

2010 Placed Wood Public Rule:
http://www.kingcounty.gov/operations/policies/rules/LandUse/lud121pr.aspx