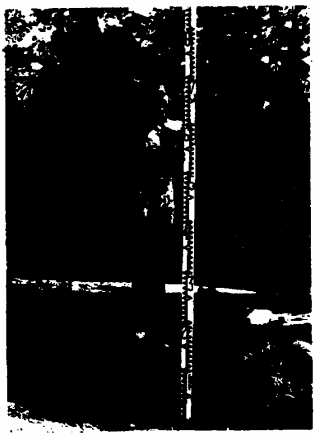
EAGLE CREEK PARK AND RESERVOIR SHORELINE EROSION LOCATION AND ASSESSMENT SURVEY

SITE LOCATIONS AND PHOTOS, COST ESTIMATES, SOIL BIOENGINEERING REMEDIATION CONSIDERATIONS, GEOLOGIC AND SOILS DATA, AND USER MANAGEMENT CONSIDERATIONS



WABASH RESOURCES AND CONSULTING
INDIANAPOLIS, INDIANA

INDY PARKS-EAGLE CREEK PARK

SEPTEMBER, 1994

EROSION SITE ENVIRONMENTAL REVIEW

EAGLE CREEK PARK AND RESERVOIR SHORELINE EROSION

SITE LOCATIONS, SOIL BIOENGINEERING REMEDIATION CONSIDERATIONS, COSTS ESTIMATES, WITH SOILS AND HYDRAULIC DATA

PREPARED FOR

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USE AND REVIEW OF THE COLOR PHOTOS IS STRONGLY SUGGESTED

EXECUTIVE SUMMARY

Shoreline Erosion and Remediation Gains

The areas of shoreline bank erosion (173+) in Eagle Creek Reservoir was assessed in the field during numerous boat rides by the author and field assistants during Spring and Summer, 1994. Erosion variably impacts nearly the entire shoreline of Eagle Creek Reservoir, with only those toe of slope areas at or near elevation 790′ ASL being in good shape. Were the shoreline and lake-bordering bluffs to be remediated using sensitive Soil Bioengineering erosion treatments, and the man-made debris removed (while leaving natural debris), the eroded shoreline areas could be stabilized, while enhancing the aesthetics of the park, while also creating additional fish and wildlife habitat.

Nature and Use of this Report

Because of the large number of 173+ erosion site problems, the site identification nature of this report, the complexity of many of the sites, the variety of options for treatment, and the overlapping agency responsibilities, *no site specific designs are included here*. However, likely origin is included in the generalized site descriptions. Limited field notes were taken as needed and are incorporated into the text discussion and photo captions. **The readers and users of this report should examine the photo and captions carefully, and consult the various maps as needed.** The photos and maps do not take the place of additional field visits or site documentation by the erosion mitigation design firm or DPR staff. The erosion photos are included here in as an appendix, and located on two base maps of the reservoir supplied by Marion County Health Department from the IMAGIS network. This same map is provided in the report.

Use of Soil Bioengineering Techniques

It is assumed that some type of Soil Bioengineering be will use on each site employing a combination of planted vegetation, erosion control fabrics, and existing in-place rip rap and debris. Because of the many material options, changes in materials, and potential changes in the sites, specific treatments are not given. Seawalls and rip rap have been used on Eagle Creek Reservoir in the past, and these existing structures are recognized to be of limited, but continued usefulness. Soil Bioengineering should provide greater aesthetics, limit remediation impacts, and enhance fish/wildlife at lower costs.

Overlapping Ownership and Responsible Permitting Agencies

There are overlapping ownership and responsible federal, state, county and city agencies likely involved in this project due to the nature of the resources and infrastructure involved. The shoreline land below the 795 foot elevation topographic contour line is owned by the Department of Capital Asset Management (DCAM) and leased to the Department of Parks and Recreation (DPR). Lands between 795 and 815 are owned by DPR or private landowners, but DCAM has a so-called "flowage easement" allowing use of this property for flood water

storage. The Department of Capital Asset Management (DCAM; old DOT and parts of old DPW) has jurisdiction over flood control, on the roads within Eagle Creek Park, and the many bridges and roads over and near Eagle Creek Reservoir. New DPW is in charge of maintenance of existing structures. These agencies may have different interests and ideas on the most important sites and the most effective erosion control treatments, and the importance of criteria.

Management Suggestions and Cost Estimates

Several management suggestions are made to address the many causes of ongoing shoreline erosion on a Eagle Creek Reservoir. These include:

1. Review and establishment of a technically-based water level management program which encompasses flood control, nesting and migratory birds, water supply, recreation, and, erosion stabilization. High water levels, especially in Fall/Winter, enhance erosion. Water level control is the least expensive ("free") erosion control method.

2. Review and establishment of a technically-based trail remediation plan to limit continued abuse of shoreline slopes resulting in denudation of vegetation and soils, thus enhancing erosion. Some trails need to be closed for extended periods on a year-round basis (i.e. 560LFA and DCI), while some trails could be closed only for short remediation periods (e.g CD, WP and FC).

3. Review and establishment of a technically-based management plan for stabilization of the Coffer Dam, Nature Center and Overlook slopes. This involves cessation of bird and wildlife feedings, selective planting and clearing of trees and understory plants, and installation of erosion control structures at key sites.

4. Review and establishment of a technically-based and cost effective approach to actually remediating "A" and "B" sites, including obtaining funding for detailed site documentation and remediation design, multi-agency permitting, supplies, and installation. *City-based funding and Non-traditional is needed*. Installation of "pilot projects" may provide experimental data.

ESTIMATED EAGLE CREEK RESERVOIR EROSION REMEDIATION COSTS

"A" Sites:	42 Sites:	$463,880 ($215,000: Nature Center slope)
"B" Sites:	76 sites:	$557,840
"C: Sites:	31 sites:	$97,420
"D" Sites:	19 sites:	$86,681
No Ranking:	5 sites	no estimates,includes 56th St causeway

Total Sites: 173

Subtotal	$1,205,821
Round up for unestimated extra work	$1,225,000
project management; permitting	$ 75,000+

TOTAL ESTIMATED COSTS (Third party services) $1,300,000+

Site Rankings per Eagle Creek Administrator (1994)

A = Very Serious; Capital Structure or major park amenity at risk; Immediate repair indicated
B = Serious to moderate; future monitoring/repair indicated, likely within a few years
C = Moderate to Low;currently not DPR priority;monitor
D = Low or no problem; monitor

KEY TO SITES

	Site Name	Abbreviation	Number of Photo Pages	Number of Erosion Sites
1.	56th Street Causeway	56C	1	2
2.	56th St Overlook Fishing Area	56OLFA	1	4
3.	DeLong Creek Inlet	DCI	2	8
4.	Rowing Overlook Bay	ROB	1	6
5.	Rowing Course Bay	RCB	1	5
6.	Fishback Creek	FC	0.5	1
7.	Interstate Bay	IB	0.5	3
8.	Coffer Dam (I & O)	CD (I & O)	12	30
9.	Waterfowl Sanctuary Bluffs	WSB	9	18
10.	Fisherman's Cove	FC	2	10
11.	Walnut Point	WP	1	5
12.	East Wall	EW	6	14
13.	Amphitheater Inlet/SCS	AI/SCS	2	2
14.	Old Growth Peninsula	OGP	1	4
15.	Water Sports Center	WSC	1	4
16.	Eagle Creek Beach/Admin	ECB/Admin	1	6
17.	Eagle Beach (Boats)	EB	1	2
18.	Private East Shoreline	PES	1	not reviewed
19.	Rip Rap Bay (private)	RRB	1	not reviewed
20.	Private Sand Beach	PSB	1	not reviewed
21.	Hobie Beach (Boats)	HB	1	3
22.	46th Street Meadow	46M	2	1
23.	42nd Street Boat Ramp	42BR	2	8
24.	Restaurant Bluff	RB	2	6
25.	Southeast Bluff	SEB	2	4 (9)
26.	Eagle Creek Dam	Dam	1	not reviewed
27.	Borrow Pit Bay	BPB	1	4
28.	School Creek Inlet	SCI	5	20
29.	Southwest Bluffs	SWB	1	3

1.0 PURPOSE/ELEMENTS OF EROSION SITE ENVIRONMENTAL REVIEW

Environmental Reviews as conducted by the Indianapolis Department of Parks and Recreation (DPR) are undertaken to identify site-specific information that may aid in management decisions prior to acquisition of properties, remediation, and/or construction of facilities. This information is summarized in an Environmental Review Statement using DPR guidelines.

Elements of the Environmental Review Statement can include:

1. The Resource
2. Programming Opportunities
3. The Users: who uses and is interested in the resource
4. Potential Competing Uses
5. Potential Competing Facilities
6. Physical/Technical Modifications Suggested
7. Use/Theoretical Modification Suggestions
8. Conclusions

1.1 Applicability to current review

Because the nature and use of the existing erosion sites, many of the above elements are not addressed directly as might be the case for larger scale, multi-purpose capital asset or program reviews.

This Environmental Review focuses on location, size and brief description of the existing erosion sites only, with passing references to specific remediation options. Site-specific environmental and locational review of erosion and non-erosion aspects will be required of design firms prior to installation (p.c. Chuck Beard, May, 1994).

The overall timing, size and design of each erosion repair is beyond the scope of this report. DPR staff should use this document along with other data from Capital Asset Management (DCAM) and DPW. The Americans with Disabilities Act (ADA) should also be addressed by DPR staff and the design firm, and are beyond the scope of this review.

It should be noted that other erosion sites contributing both soil and debris exist along Eagle Creek Reservoir between the two main park areas, and along Fishback Creek and School Branch Creek, the other largest tributaries of Eagle Creek Reservoir. Time did not allow a review of the entire shoreline of Eagle Creek, although there are many serious problems. Many areas have been addressed in part by adjacent landowners, most of which are viewed as "encroachments" by DCAM.

1.2 Proposed Park Master Plans (See Part One): None given here

1.3 Assessment Methods Utilized and Data Collected

The location of the areas of shoreline bank erosion were assessed in the field visually during numerous separate Spring and Summer, 1994 boat rides and hikes by the author and field assistants. Field notes were taken as needed and are incorporated into the text discussion and/or photo captions. **The readers and users of this report should examine the photo and captions carefully, and consult the various maps as needed.** The photos and maps do not take the place of additional field visits or site documentation by the erosion mitigation design firm or DPR staff. Color photos of the erosion locations and vicinity were taken during April, May and June, 1994. The erosion photos are included here as an appendix, and located on the two IMAGIS base maps.

The data taken in the field and/or reviewed in the office consisted of location on a map, estimated slope, height, width and length, generalized soils, and the apparent cause of the problem. The data sheets are not included in the report, but site data is summarized briefly using the following format. The erosion sites were ranked in terms of severity and priority of need and ease of repair. An "A" ranking was assigned based upon immediate potential for loss of a structure, large trees, or size of erosion site. Many of the "B" and "C" sites should be reexamined for priority as part of a more detailed study. The costs are estimates from a vendor who viewed the sites.

Readers should examine the scaled photos of the 173 sites included in the Appendix for more details (A picture is worth a thousand words!). With only a few exceptions, all photos face the shoreline. For scale purposes, a twelve (12′) stadia rod, and a human male about 6 feet tall is typically used in all photos.

Erosion Site Description Example

Location: FC-2 Ranking:A Estimated Cost:$12,000

Brief Description: L: 12′ H: 6′ East side, wave undercut, tree loss

Rankings per Eagle Creek Administrator (1994)

A = Very Serious; Capital Structure or major park amenity at risk; Immediate repair indicated
B = Serious to moderate; future monitoring/repair indicated, likely within a few years
C = Moderate to Low;currently not DPR priority;monitor
D = Low or no problem; monitor

1.4 Assumption of Use of Soil Bioengineering Techniques

The assessments and cost estimates contained within this report for future work were done based upon the assumption of the use of Soil Bioengineering Remediation Techniques at the direction of Chuck Beard.

The "Brief Description" does not take the place of detailed site-specific surveys and treatment designs. It is assumed that some type of Soil Bioengineering be will use on each site employing a combination of planted vegetation, erosion control fabrics, existing in-place rip rap and debris. Because of the many material options, changes in materials, and potential changes in the site, specific material are not often mentioned. More traditional erosion control techniques based upon use of seawalls and rip rap have been used on Eagle Creek Reservoir in the past, and these existing structures are recognized to be of continued use on Eagle Creek Reservoir. Section 11.0 has more Soil Bioengineering information. Also see Figure 14.

2.0 LOCATION AND GEOGRAPHY OF EAGLE CREEK PARK AND RESERVOIR

2.1 Location, Mapping and Figures

Eagle Creek Park is located on the northwest side of Indianapolis as shown on Figure 1. The park is the largest within the DPR system and the nation having been acquired and developed during the 1970's The park consists of wide to very narrow public lands along all sides of Eagle Creek Reservoir. The 1350 acre reservoir was formed by the 1960's impounding of Eagle Creek, a major tributary of White River.

Figure 2 shows the original creek channel prior to aggregate mining and impoundment, the overall reservoir impoundment (790' pool), and flood storage area (815'), and the local road network. Figure 3 has additional reservoir storage information and a resevoir cross-section.

Figure 4 contains the USGS topographic map of the area from portions of the Clermont and Zionsville quadrangles, with locations of erosion sites described by the Indiana Geological Survey . Figures 5 shows the Eagle Creek watershed above the dam. Figures 6 through 9 are from the Eagle Creek Park Master Plan and depict topography as a range of slope (6), vegetative cover (7), and SCS soils (8-9).

Figures 10 and 11 locate the park on a generalized geologic maps and cross-sections of Marion County. Figure 12 has a generalized geologic cross-section though the dam, along with generalized engineering data on the glacial tills of Marion County.

Figure 14 has Bioengineering Design Criteria and generic treatments from Bestman Green Systems as supplied by Nutec Supply,

2.2 Eagle Creek Park Description

Eagle Creek Park is considered to be a Regional park split into two main portions. Multiple services are available including shelters, picnic areas, beaches, marinas, various recreation facilities, playgrounds, ball diamonds, and multiple parking areas. Multiple street access sites exist, and an extensive road network exists as shown on the various maps. The northern and larger portion of the park is developed principally for multiple users; the eastern treed and grassed portion of the park has been developed chiefly for these uses. The northern and western portion of the park is mostly the steep-banked, wooded, riparian Eagle Creek Nature Preserve. The street address is 7840 West 56th Street, Indianapolis, 46254.

3.0 OVERLAPPING OWNERSHIP/RESPONSIBILITY AND PERMITTING

There are overlapping ownership and responsible federal, state, county and city agencies likely involved in this project due to the nature of the resources and infrastructure involved. The shoreline land below the 795 foot elevation topographic contour line is owned by the Department of Capital Asset Management (DCAM) and leased to the Department of Parks and Recreation (DPR). Lands between 795 and 815 are owned by DPR or private landowners, but DCAM has a so-called "flowage easement" allowing use of this property for flood water storage. The Department of Capital Asset Management (DCAM; old DOT and parts of old DPW) has jurisdiction over flood control, on the roads within Eagle Creek Park, and the many bridges and bridges over and near Eagle Creek Reservoir. New DPW is in charge of maintenance of existing structures. These agencies may have different interests and ideas on the most important sites and the most effective erosion control treatments, and the importance of criteria.

3.1 Encroachments

Figure 13 is the title page and introduction of a report dealing with what DCAM considers "encroachments" within the both the DCAM owned shoreline up to 795′ ASL, and within the flowage easement. The report consists of multiple pages of locations of the encroachments with photos and descriptions. Most of these are on "private" lands.

3.2 Agencies with direct or indirect control on projects

Several city, state and federal agencies would have to grant permits for construction, drainage/grade alteration in-Shoreline work, water quality impacts, etc. These include, but are not limited to:

Local:
- DCAM: drainage permits, curb cuts, etc.
- DMD: Improvement Location Permits
- DPR: floral permits, greenway review process
- all agencies: potential funding
- neighborhood associations

County:
- Soil Conservation Service: Rule 5 Sediment control

State:
- IDEM: 401/404 Water Quality Certification
- IDEM: In-Shoreline work, ecological impacts, etc
- IDNR: Construction in Floodway permits: Shoreline work, etc
- IDEM and IDNR: potential funding

Federal:
- ACOE: Section 404 (wetland permits)
- USFWS: approval of Section 404 and Shoreline work, habitats
- US EPA: water quality and 404 review
- all agencies: potential funding

4.0 PHYSICAL ASPECTS: DOCUMENTATION, GEOLOGY, SOILS, WETLANDS

4.1 Location and Documentation of Erosion Sites

The entire length of Eagle Creek Reservoir from 71st Street on the north side of Eagle Creek Park south and down-Creek to the dam at 38th Street was boated and/or walked at least four times during May and June. 1994. Locations of minor to major erosion were located on 200′ scale maps and photographed with a 12′ stadia rod and human for scale. Some locations were roughly field sketch mapped. Field rankings of erosion impact were assigned for later review by Chuck Beard, DPR.

Following the field work, office ranking were determined by review by Chuck Beard, DPR, as given below. Cost estimates of soil bioengineering costs were made by Jim Blazek of Nutec Supply These costs are rounded upward, and do not include detailed site analysis, permitting, project management, etc. The cost estimates should be used as relative cost guides. Erosion sites are located on two large base map at a scale of 1" = 400′ with two-foot interval contour lines supplied by the Marion County Health Department using the IMAGIS network. These separate rolled maps are attached to the report. A 1" = 1000′ scale map with the sites is in the appendix for quick review of site locations. See also the 60 pages of color photos

4.2 Brief Geology

The Indiana Geological Survey (IGS) has conducted some glacial deposit mapping within Eagle Creek Park and along the shoreline as part of a larger Marion County hydrogeological study funded by the Marion County Health Department. Detailed maps are available from the IGS.

Figures 10 and 11 locate the park on a generalized geologic maps and cross-sections of Marion County. Figure 12 has a generalized geologic cross-section though the dam, along with generalized engineering data on the glacial tills of Marion County.

The park is located along a glacial meltwater sluiceway channel cut into fairly stiff Wisconsinan-age clayey till. This sluiceway is preserved today as the larger Eagle Creek Reservoir valley (see maps). Overlying the till within the active Eagle Creek Reservoir channel and along the valley walls is a mixture of glacial outwash composed sand and gravel, and silty floodplain sediments. These deposits have been extensively mined in the past, especially in the northern portions of the reservoir near the Nature Center and the Waterfowl Sanctuary. The shoreline varies widely in the nature of the soils and the section. Figure 12 has a generalized geologic cross-section though the dam, along with generalized engineering data on the glacial tills of Marion County. More detailed geologic data can be gathered in the field or from available data from geologic publications and open file data.

4.3 Soils Mapping

Figures 6 through 9 are from the Eagle Creek Park Master Plan and depict topography as a range of slope (6), vegetative cover (7), and

SCS soils (8-9). Figure 12 has a generalized geologic cross-section though the dam, along with generalized engineering data on the glacial tills of Marion County.

4.4 Wetlands

Eagle Creek Reservoir proper is labeled on the USFWS National Wetland Inventory maps as L1UBHh. This code translates to Lacustrine, Limnetic, Unconsolidated Bottom, Permanently Flooded, impounded.

The fringe emergent wetlands in the School Creek Inlet are classified as: PEMCh which translates as: Palustrine, Emergent, Seasonally Flooded, Impounded. The wetlands at the mouth of Fishback Creek are classified as PEMFh: Palustrine, Emergent, Semi-Permanently Flooded, Impounded. The wetlands adjacent to I-65 in Interstate Bay are classified asL PEMSA: Palustrine, Emergent, Temporarily Flooded, Impounded. Minor PFO1A wetlands may exist (Palustrine, Forested, Broad Leaved Deciduous, Temporarily Flooded) on floodplain terraces.

5.0 NATIVE AMERICAN AND HISTORIC CULTURAL RESOURCES

The uplands and floodplains in both parks are "topographically suitable" for Native American Cultural Resources. The Eagle Creek Reservoir floodplain was formerly a locally significant natural area center well suited for hunting and farming, and the valley walls and the adjoining upland areas would have been just as well suited for village sites.

While much of the park is heavily disturbed, there are areas which appear to be relatively undisturbed and at original grade. This includes all of the interior upland areas that are chiefly treed. Those working in the park should anticipate finding any types of material, including more recent materials. Objects from settlers and park visitors could also exist. <u>Any cultural materials or burials discovered must be reported to DPR and the IDNR-Division of Historic Preservation and Archaeology.</u>

6.0 CAUSES AND MANAGEMENT ASPECTS OF EROSION SITES

6.1 Pre and Post Impoundment Erosion Grade Conditions

Because Eagle Creek Reservoir has been fairly recently impounded, many former hillsides, small floodplain terraces, and small tributaries now entering the main channel are not at grade. The term "grade" refers to the base level of local surface water that serves as the erosion basement. The original grade of the shoreline was the Eagle Creek Channel prior to impoundment. Figures 5 shows the Eagle Creek watershed above the dam. Figures 6 from the Eagle Creek Park Master Plan depicts topography as a range of slope. Figure 4 has more detailed topography and drainage information.

There are several valleys which enter Eagle Creek Reservoir during storms (Figure 4). These channels have some minor erosion concerns. Floodplain soils and most erosion cuts are fairly dry except following flooding. Some shoreline cutbank seepage does occur, and soils can be moist locally. This seepage does help to variably erode the soils.

6.2 Wave-Induced Shoreline Erosion

The active erosion is caused by the steep, not at grade, upland slopes being continually undercut by wave action, not unlike in a bathtub. The upland slopes were originally fairly steep, but even those originally with low slopes have been wave impacted. The erosion and sloughing on the shoreline is a natural geomorphic system response that is occurring in an artificial impoundment situation.

6.3 Sheetflow and Channelized flow

Surficial sheetflow and channelized flow during storms is a significant contributor to erosion during large events.. Sheetflow in the direction of Eagle Creek Reservoir becomes channelized near the modern day channel walls (often in foot trails), thens cut the channel walls before entering the reservoir, forming rills and gullies, possibly undermining existing structures. This leads to many different problems centered around waterfall retreat. Localized problems can best be addressed during detailed erosion control assessment and trail siting and installation by the design firms and installation contractors. Minor fill and/or drainage re-routing may be required. Use of the 2-foot contour interval DPW base maps at the 1" = 200" scale is suggested to identify these areas.

6.4 Human-Induced Upper Slope and Shoreline Erosion

There are myriad existing designated and User-Originated trail segments along both Eagle Creek Reservoir Shoreline banks which follow and cut across existing topography. The designated trails along and near the Eagle Creek shoreline, as well as the "User-Originated trails" carry a surprising amount of traffic. None of the myriad shoreline trails are shown any maps or Master Plans.

In some regards these trails are in fact "nature trails" as they provide direct access to the natural areas within the park. Shoreline trails are subject to flood and fluvial alteration at anytime. While closure of these trails would be difficult given the large number and the user base, these trails should be examined for remediation.

Some trails are impacted by erosion, and in many cases they are they cause of major erosion. Many of these trails, especially in the 56th Street Overlook Fishing Area, and on the south side of the DeLong Creek Inlet need to be closed temporarily and remediated to prevent further damage. Eagle Creek Reservoir is usually about 10 feet below the trail elevation, and can be as much as 30 feet below the trail. However, many of these trails descend to the waters edge.

In areas with a narrow edge, DPR should consider installing guard rails and signage to enhance safety. Additionally, some trails have wetness in some areas following precipitation events due to small localized drainage patterns, or small depressions.

6.5 What assets are already impacted or at risk?

There are several classes of assets that are already impacted or at risk. These include capital (man-made) and natural park assets:

1. 56th Street Causeway north side is wave undercut.

2. 56th Street Overlook Fishing Area and DeLong Creek Inlet fishermen's trails have degraded into storm water channels while enhancing bank retreat and directly causing past and future loss of large trees/understory. Shoreline access denial must be considered.

3. The Coffer Dam, a unique structure, needs to have the outside margins replenished with soil and large boulders, and have large numbers of water-loving trees and a wetland fringe planted. Limiting fishermens access and a waterlevel management plan would greatly help.

4. The entire east side of the reservoir is retreating via undercutting/slumping, including the Waterfowl Sanctuary Bluffs, the East Wall, the 46th Street Meadow, and the Southeast Bluffs. These are some of the most heavily used and scenic treed and grassed areas. Several capital assets are involved: Nature Center, Walnut Point, Indiana Museum, Rowing Center area, all beach areas, boat ramps, the new Rick's Boatyard Restaurant area, and the dam wing walls.

5. The School Creek Inlet (Sailing Club) southern shoreline has many fishermen's trails similar to the 56OLFA and DCI which need review.

7.0 EAGLE CREEK RESERVOIR AND SHORELINE HYDRAULICS

7.1 Basin Description: Glacial Sluiceway to Reservoir

The Eagle Creek Reservoir valley was originally a glacial meltwater sluiceway channel cut into fairly stiff Wisconsinan-age clayey till that was tributary to the huge White River (Figures 3, 10, and 11) This sluiceway is preserved today as the larger Eagle Creek Reservoir valley (see maps). Overlying the till within the active Eagle Creek Reservoir channel is a mixture of glacial outwash composed sand and gravel, and silty floodplain sediments. Glacial sluiceways which are significantly larger than the pre-impoundment creek are a common feature of the Indiana landscape. Often these sluiceways were wetter than they are today due to drainage modifications by settlers and farmers, including clearing of the forests, filling of oxbow lakes and sloughs, ditching of the main channels along with removal of log jams, etc. Obviously, impoundment of the reservoir has greatly impacted the original erosion grade of the hillsides and the shoreline soils.

These drainage modifications, along with drainage and filling of upper basin wetlands on the adjoining till plains has led to the Creeks becoming "flashy" during storm events: rapid rise and fall of peak discharge volumes, rates of flow and flood elevations. This is exactly the case with Eagle Creek Reservoir, a classic modified urban Creek. Thus, the "normal pool" elevation can vary widely.

7.2 Shoreline Improvements: Erosion Control Structures

Portions of the shoreline, both private and public, have had some Erosion Control Structures installed (see photos). The origin of most of these seawalls is not well documented, even though DCAM and IDNR require Construction in The Floodway permits. SOme structures have been permitted and are available from IDNR on microfiche. DCAM has no readily available records beyond the "encroachment report".

It is interesting to note that erosion has been a concern on Eagle Creek Reservoir for at least 20 years. Also, while many of these walls have failed partially or totally, most of the walls are in place and functioning as designed. However, the eroded shoreline is sterile, and the walls are largely unsupported by sediment or vegetation. The walls are in numerous photos, but were not mapped or described here. See the Rip Rap Bay and Private Eastern Shore photos.

7.3 Modern Day Hydraulics

The Creek has been studied often over the years by USGS, DCAM, IDNR, FEMA and ACOE due to it's flood water conductance role.. Daily inflow, outflow and water level and water level data is available. The water levels ranges widely due to the relatively small size of the drainage basin and the resevoir. Many of the "erosion problems" are really Eagle Creek Reservoir just acting like a natural system that wants to change its grade to a new waterlevel in response to modifications of impoundment gradient changes. Below is some reservoir data from Steve McMann, Dam tender and DCAM engineer Charles Bardonner. More extensive data is available from all these sources.

"Normal" Pool Elevation (typically in Summer): 790.0 feet ASL
100-year Flood: 795.0 (top of DCAM/City ownership)
Historic high: 794.80
Historic low: 782.0
Normal low (Fall): 787.0 (normal Fall drawdown if allowed)
Permitted IWC withdrawl: 12.0 MGD up to 20 MGD, 15 MGD common Summer
Speedway Water Supply and In-Stream Uses: 4 MGD
20 MGD at 790' ASL level is 0.5 inches per day if not replaced
daily water level data/graphs: available from DCAM/dam tender

7.4 Ongoing IDNR/DCAM Studies

The Indiana Department of Natural Resources-Division of Water, Survey Section, and DCAM/DPW have been involved in an ongoing new study of Eagle Creek Reservoir with the aid of Purdue University. See the IDNR letters in the appendix hydraulics information.

The IDNR is now surveying the reservoir for actual size and lake bottom configuration to determine flood capacity and siltation patterns. This project could help determine impacts to the Eagle Creek Reservoir, and help any erosion control installations proposed by DPR and should be reviewed after its completion in early 1995.

7.5 Water Levels in Photos

The level of the pool varied somewhat over the period during which the site photos were taken (May 10 to June 22, 1994;November 5, 1993). The date the photo was taken in on the lower right of the photo.

DATE	WATER LEVEL	DATE	WATER LEVEL
May 10	790.34	June 7	790.82
May 17	790.38	June 10	790.76
May 19	790.61	June 21	791.56
May 24	790.61	June 22	791.53

November 5, 1993 792.0 average (791.47 to 794.68) SCS project

8.0 SAND BEACH LITTORAL DRIFT: JETTIES AND DREDGING

A recurring problem for the Eagle Creek Park staff is the logistical and actual field work related to frequent replenishment of the five artificial sand beaches due to littoral drift of the sand. These area: Walnut Point (swimming and canoe rental), Eagle Creek Beach (main swimming beach), Eagle Beach (boats), Hobie Beach (boats), and the 42nd Street Boat Ramp (swimming and sail boarding). These beaches have a wide range of use, and present longterm management concerns.

While these beaches are nominally at grade with the normal pool elevation of 790 feet ASL, both normal wave action and oblique rip currents remove the sand from the beach, with transport outward and along the shoreline. The intensity, direction, and timing, and duration of the current is unknown. While overall flow of the reservoir is southward, the ponding affect of the impoundment, and the persistent wind from the SW-W-NW directions, and the sporadic pool levels must lead to odd current patterns. Also, while exact volumes placed and lost are unknown, the staff annually place 200-300 tons of new sand in total on the five beaches, while also performing some near shore dredging and replacement in the winter months. *It should be pointed out that all dredging and construction operations performed within the lake proper and below lake level should obtain DCAM, IDNR, and ACOE permits first. DCAM/DPR board approvals would also be needed.*

Staff reports that the largest problems area associated with the transport (loss) of sand occur from Eagle Beach and Hobie Beach, both located on the east side of the reservoir south of 56th Street. Both are used primarily as seasonal direct access drydock storage areas for small sail boats, and both immediately adjoin "private" shoreline areas (private only above the 795 foot elevation DCAM ownership line). Staff has received repeated complaints about deposition of transported sand into near shoreline lake areas which are commonly used for floating boat storage by the private landowners. The problem is complex to both measure in the field since the sand is underwater and little previous lake bottom configuration and dumped sand volume data is available, and because of no clear city policy on the "encroachment" problem (use of DCAM property by private landowners).

The following observation and suggestions are made:

1. The simplest technical way to address the problem of sand migration into unwanted areas of city property which impacts private users is for DCAM and DPR to merely remind these neighbors that the resevoir was built as a flood control and water supply reservoir, and that the recreational and aesthetic uses are secondary and tangential uses. This approach, although minimalist and direct, may prove unpopular and difficult to administer. However, the fact remains that DCAM is the property owner and the city has little technical advantage to gain in removing the deposited sand. Of course, the new sand deposition is building new "free" sand beaches and extending the shoreline in these areas. Perhaps landowners need only to adopt to changing conditions and move offshore mooring areas further offshore.

2. The second simplest technical way to address the problem of sand migration is to cease replenishing the problem sand beaches, "maintaining" only that sand that remains naturally in place regardless of wave action. This would likely result in very thin or nonexistent beaches, with the sand having been deposited in the problem areas, with the situation eventually stabilizing. Dredging of the areas of concern could then be performed, with the sand hauled off site to a non-reservoir area, or placed in deep water. This line of action regrettably leads to diminished use of the beaches by boaters.

3. The suggestion has been advanced by DPR staff that perhaps jetties oriented perpindicular or sub-perpindicular to the shoreline would block the littoral drift of the sand away from the "problem" depositional areas while still allowing for continued use (and replenishment) of the sand beaches. This solution would likely be expensive and logistically challenging due to the unknown current patterns, the many likely land-based vs. lake-based user conflicts, safety and environmental concerns, and all of the needed construction and environmental permits and board approvals. Additionally, jettie construction designed to divert sand away from the shoreline, if coupled with continued sand replenishment would ultimately lead to the up current portion of jetties becoming completely filled with sand, thus extending the shoreline outward into the lake, with eventual spillover of the sand past the jetties. Periodic dredging would then be needed anyway, so the entire jettie building purpose becomes moot.

4. This "problem" needs to be prioritized relative to the many pressing "A" and "B" erosion problems all over the reservoir which are threatening capital assets and important treed and barren slopes which are actively eroding. The "problem" may also be lessened or simply delt with by removal of the sand during Fall/Winter Drawdowns.

9.0 NEED FOR COMPREHENSIVE MULTI-PURPOSE WATERLEVEL POLICY

Perhaps the single least expensive ("free"), simplest and likely most effective remedial erosion option is the development and implementation of a thoughtfully prepared, multi-purpose, legally defensible, resource-driven waterlevel management policy which would address recent high winter lake levels and Fall water quantity concerns, while still allowing for boating and Fall bird attraction. The Dam Tender can easily control the water level at the dam.

Maintenance of a pool level can be difficult in dry years due to limited inflow of water from the smallish Eagle Creek Basin being problematic, while the Indianapolis Water Company can withdraw certain amounts of water (12-15 MGD average, up to 20 MGD), while other certain amounts of water must be released from the dam to satisfy Town of Speedway supply needs in addition to in-stream aquatic needs of downstream Eagle Creek (about 4 MGD total). Water level can vary naturally 3-4 feet during large storms, dry times, and/or seasonally.

Since the implementation of a full-year static pool policy to address water quantity, boating, and aesthetic concerns following the 1988 and 1991 "droughts", the shoreline and the coffer dam have suffered noticeable negative impacts, while the former Fall shorebird migration has become nil. A return to a Fall-Winter drawdown is suggested.

It is suggested that a technical committee review the data and the conflicting uses, and develop a water level policy based upon a naturally occurring water budget, and a man-induced water budget. This committee could led by DCAM and DPR staff augmented by IDNR and IDEM staff, birders, fishermen, boaters, and the Indianapolis Water Company. Flexibility will be key in addressing all concerns.

9.1 Fall Drawdown and Inflow-Outflow Monitoring

Fall drawdowns are normal operating policy in almost all "flood control" reservoirs as the lake lowering from Summer pool elevations accommodates influx from normally anticipated Winter and Spring rains. Eagle Creek has been operated in a sporadic fashion in the perspective over the years. DCAM keeps track of daily stream flow at Zionsville (upstream) and Speedway (downstream) as well as rainfall basinwide, and at the airport (rainfall amount varies widely). DCAM also monitors lake level to 0.01 inches, and has gained some expertise over the years at deliberate lake level control. The normal pool is 790'.

9.2 High lake levels lead to greatest negative erosion impacts

Without a doubt, the greatest negative erosion impact to the shoreline occurs during the periods of high lake level coupled with tall and high energy waves generated by storm winds. While these winds can and do occur 12 months of the year, most big and prolonged storms occur during the "winter" months (November to April). Since the reservoir is just a big bathtub, when the lake level is high, the shoreline wave "slap" is higher and has more force, thus causing differentially increased shoreline undercutting and slumping. Were the lake level

simply lowered and maintained winter-long, possible erosive energy would be depleted. This would likely retard further erosion, as well as protect the remediation areas that may be installed in the future.

High water levels in the main lake directly leads to the Coffer Dam being partially inundated, with the two overflows allowing water to enter the Waterfowl Sanctuary pool area. This causes erosion of the overflows, lessens the already small above-water resting areas, and allows for increased undercutting of the Waterfowl Sanctuary Bluffs (WSB-Nature Center). The Coffer Dam vegetation is also flooded out.

9.3 Fall Shorebird Migration

The Fall shorebird migration occurs from late August into November and has been spectacular in past years. Without recently exposed mudflats upon which to feed, these birds have tended to bypass Eagle Creek entirely in favor of more suitable habitats in recent high pool level years. In past years, Fall lake lowering has resulted in the Interstate Bay area being exposed, with resultant high numbers of migratory shorebirds. An exact Fall pool elevation is not suggested here, as it needs to be determined in the field, but obviously it must be below the elevation of the mudflats (about 786-787 feet ASL).

9.4 Water Supply Perspective

A Fall drawdown of the pool during the August-October period is of concern from a water supply perspective as these are normally the periods of the least amount of rainfall and highest demand. Should the lake be lowered and no or little rainfall occur, the lake levels could become extremely low without a complete or partial cessasation of pumping. While these levels may allow for continued water supply withdrawal, a return to the 1991 levels may not be pleasant for other users. Water supply was not a primary purpose for the construction on Eagle Creek Reservoir, but the Indianapolis Water Company has a longterm lease with the City for certain mandatory/permissible pumpage volumes. Perhaps this arrangement needs to be reviewed, but regardless of any new restrictions, a Fall drawdown could pose constraints.

10.0 NEED FOR MANAGEMENT OF WATERFOWL/COFFER DAM/56TH/SCI AREAS

While the entire shoreline need to be managed as suggested throughout this report, four areas in particular are suffering significantly. These problems are related to high water levels and man-induced problems. Solving these problems may not prove popular with certain users as longstanding traditions and use areas may have to be abandoned for the longterm overall health of the park,

These are: Waterfowl Sanctuary Bluffs (WSB) and Nature Center slope
Coffer Dam (outside and overflow areas especially)
56th Street Overlook and DeLong Creek Inlet fishing areas
School Creek Inlet (Sailing Club) fishing areas

In addition to these listed fishing areas, all foot traffic areas should be reviewed, and thought given to closing some areas to use. These include the Fishermen's Cove and Walnut Point areas.

10.1 Waterfowl Sanctuary Bluffs (WSB) and Nature Center slope

The entire east side of the reservoir is retreating via undercutting/slumping, including the Waterfowl Sanctuary Bluffs, the East Wall, the 46th Street Meadow, and the Southeast Bluffs. These are some of the most heavily used and scenic treed and grassed areas. The Waterfowl Sanctuary Bluffs (WSB) and Nature Center slope in particular are high use and capital intensive areas which need to be studied in detail for development of a longterm management plan.

10.2 Coffer Dam (outside and overflow areas especially)

3. The Coffer Dam, a unique structure, needs to have the outside margins replenished with soil and large boulders, and have large numbers of water-loving trees and a wetland fringe planted. Limiting fishermens access and a waterlevel management plan would greatly help.

10.3 56th Street Overlook and DeLong Creek Inlet fishing areas

2. 56th Street Overlook Fishing Area and DeLong Creek Inlet fishermen's trails have degraded into storm water channels while enhancing bank retreat and directly causing past and future loss of large trees/understory. Shoreline access denial must be considered. The 56th Street Causeway north side is wave undercut, but useful for fishing. Perhaps the causeway could accommodate fishing while the other impacted areas are closed and remediated for a few years. Bank fishing users and local fishing clubs such as BASS chapters should be contacted for input on possible closing recreational impacts and options. A coordinated signage, Public Relations and enforcement program would be critical to longterm success of the remediation.

10.4 School Creek Inlet (Sailing Club) fishing areas

5. The School Creek Inlet (Sailing Club) southern shoreline has many fishermen's trails similar to the 56OLFA and DCI which need review.

11.0 SOIL BIOENGINEERING: SHORELINE DYNAMICS AND VEGETATION

11.1 Introduction to Soil Bioengineering:Industry Information

The assessments and cost estimates contained within this report for future work were done based upon the assumption of the use of Soil Bioengineering Remediation Techniques at the direction of Chuck Beard, Eagle Creek Park Administrator. More common erosion control techniques based upon use of channel walls and rip rap have been used on Eagle Creek Reservoir in the past, and these existing structures are recognized to be of some continued usefulness on Eagle Creek Reservoir. However, Soil Bioengineering is more aesthetic and less expensive, with a high secondary value derived from fish and wildlife.

Soil Bioengineering techniques employ site-specific understanding of Shoreline hydraulics and thoughtful installation of vegetative and erosion control fabric treatments instead of more intrusive channel wall and rip rap installation. These vegetative and erosion control fabric treatments have been successfully used in Europe for decades, and are now being increasingly used in the USA. The Soil Conservation Services is now promoting Soil Bioengineering techniques internally and to those working on Shoreline and other erosion problems.

Enclosed as an appendix is information from Nutec Supply on the types of vegetative and fabric treatments used in erosion control. The DPR Stewardship Section also has a copy of a SCS manual. Other information is available from numerous vendors. A more thorough explanation of Soil Bioengineering is beyond the scope of this report.

11.2 Indianapolis-area Examples of Soil Bioengineering

A SCS demonstration project using Soil Bioengineering techniques was installed on a cutbank on Eagle Creek Reservoir in November, 1993, and a few Indianapolis-area companies routinely use Soil Bioengineering on smaller private projects (e.g. Essex Construction and Nutec Supply).

The City of Indianapolis installed a Soil Bioengineering treatment on William's Creek in 1990 between 79th and 86th streets in a complex meander/cutbank area. This project is very similar to treatments that would be used on Eagle Creek Reservoir.

11.3 Observations on Eagle Creek Remediation Possibilities

It was observed early in this process that the erosion problems along Eagle Creek Reservoir are conducive to Soil Bioengineering techniques. To this end, Nutec Supply of Indianapolis were contacted as possible information sources due to their role in the November, 1993 SCS Eagle Creek Project. Representatives of these firms met with Wabash Resources and city staff on an uncompensated basis to review the situation. This included boating and walking Eagle Creek Reservoir, reviewing the erosion site photos with Wabash Resources and DPR staff. These meetings helped identify the 170+ erosion site problems and possible treatments, and culminated in the cost estimates discussed below. See the lakeshore mitigation article in the appendix.

11.4 The important aspects of remediating erosion locations are:

Erosion mitigation in and along the Shoreline might have measurable negative environmental and some shoreline trail impacts. Existing wooded areas should be surveyed prior to having erosion control measures installed as many native herbaceous and tree species were observed. There is trash in some areas of Eagle Creek Reservoir. Cleanup of the accumulated trash in the wooded Shoreline areas would be an extra environmental gain. As site-specific treatments will have to be designed on-site, overall project impact should be lessened.

1. Avoid clearing wooded areas unless absolutely avoidable. Previously cleared areas likely have better drainage and access, and lessen the impacts to wildlife habitat. Clearing is also costly.
2. Avoid wetland or wet areas as clearing, filling, and poor drainage could cause damage to both plant and animal species.
3. The erosion control installation may require excavation, which should be carefully done with the equipment operators anticipating buried objects, utilities, etc.
4. Installation of a logically signed trail destination routes may be needed on some erosion sites. Route signage will lessen the creation of new paths around recently reconstructed sites.

Soil Bioengineering techniques to be reviewed for multiple use are:

1. Fiber roll/fabric treatment along the normal pool shoreline.

2. Planting of variety of wetland plant pallets near shoreline.

3. Planting of variety of trees species, including various willows.

4. Installation of various erosion fabrics on cutbanks and slopes.

5. Limited use of hand placed rip rap to stabilize slope toes.

6. It is suggested that existing seawalls be repaired as possible.

7. Diversion of surficial sheetflow over the shoreline using minor fill. Sources of existing/future problems could be fixed easily.

8. Shoreline protection using cabled trees obtained on-site.

9. Regrading the shoreline to normal pool using heavy equipment.

10. A dependable source of plantings is critical for project success.

11.5 Cost Estimates of Eagle Creek Reservoir Remediation

Because of the large number of 173+ erosion site problems, limited solution identification nature of this report, the complexity of many of the sites, options for treatment, and the overlapping agency responsibilities, no site specific designs are included here.

Jim Blazek of Nutec Supply of Indianapolis provided initial cost estimates based upon known and anticipated costs identified from past projects, the boating and walking of Eagle Creek Reservoir and the later review of the erosion site photos with Wabash Resources and DPR staff. This pricing and cost data is proprietary data of Nutec Supply, with the estimated costs only being public.

Nutec Supply's final cost estimates for individual sites are included with the individual site data is given below. These estimates are for actual materials and installation only, and do not include consulting fees for project management, ecological and environmental studies, permitting and project maintenance. The individual site costs range from $300 to $215,000. Costs are not linear as physical site size, site problem and access vary the costs widely. These costs are for each site on an Ala Carte basis. As a project, the individual site costs range may be lower if non-union labor is used. If union labor is used these numbers may be accurate. The costs assume maximum use or reuse of existing site plants, soils for backfill, rip rap as needed, flexible schedule and good weather conditions. Costs could be lowered with the use of volunteers, existing city staff, jail inmates. or community service workers.

ESTIMATED EAGLE CREEK RESERVOIR EROSION REMEDIATION COSTS

"A" Sites: 42 Sites:	$463,880 ($215,000: Nature Center slope)
"B" Sites: 76 sites:	$557,840
"C: Sites: 31 sites:	$97,420
"D" Sites: 19 sites:	$86,681
No Ranking:5 sites	no estimates,includes 56th St causeway

Total Sites: 173

Subtotal	$1,205,821
Round up for unestimated extra work	$1,225,000
project management; permitting	$ 75,000+
TOTAL ESTIMATED COSTS (Third party services)	**$1,300,000+**

12.0 SUGGESTED ACTION PLAN AND MANAGEMENT INITIATIVE TOPICS

Below are twenty topics that should be examined in the near future. Most of these have been mentioned directly in the text above.

1. ID purpose and nature of ECR: original and actual uses defined
2. ID users and conflicts and recreational management strategies
3. comprehensive multi-purpose Water level management policy
4. encroachments and DCAM policies: who should fix shoreline?
5 August/Fall/winter drawdown to expose mud flats for shorebirds
6. IWC/DCAM control of water pumpage and contractual arrangements
7. closing of trails in 56OLFA/DCI/SCI areas and fishing perches
8. replenishment and planting of both CD shorelines
9. CD overflow fixed, review Greg Oskay check valve idea
10. extensive plantings on all shorelines as possible
11. diversion of surface flow away from trails and trail repair
12. cabling of logs on all shorelines as possible from boats
13. cease mowing to waters edge on 42M and BPB
14. Nature Center management plan: tree removal, plantings, feeding
15. IDNR lake bottom contour map study due early, 1995
16. water quality agricultural and soil runoff and inflow
17. SCS/Sotir pilot project success should be monitored
18. contract with consultant and suppliers for more detailed studies, advice plans, permits, oversight, supplies
19. prepare all needed permits on a coordinated, one time basis.
20. ID source of funds for A and B sites, and internal DPR abilities

13.0 LOCATION/DESCRIPTION OF AREAS OF CONCERN: EAGLE CREEK PARK

Eagle Creek Reservoir within Eagle Creek Park flows through a north-south trending, 20 foot to 70+ foot deep, densely wooded "gorge" incised into a stiff clayey glacial till and gravelly outwash. The locations were field checked and photographed with a 12 foot stadia rod and 6 foot man for scale. The length and height were scaled and estimated off of the photos. The cost estimate was supplied by Jim Blazek of Nutec Supply. The ranking was decided by Chuck Beard, DPR.

Rankings per DPR Stewardship Section (1993)

A = Very Serious; Capital Structure or major park amenity at risk; Immediate repair indicated
B = Serious to moderate; future monitoring/repair indicated, likely within a few years
C = Moderate to Low;currently not DPR priority;monitor
D = Low or no problem; monitor

KEY TO SITES

	Site Name	Abbreviation	Number of Photo Pages	Number of Erosion Sites
1.	56th Street Causeway	56C	1	2
2.	56th St Overlook Fishing Area	56OLFA	1	4
3.	DeLong Creek Inlet	DCI	2	8
4.	Rowing Overlook Bay	ROB	1	6
5.	Rowing Course Bay	RCB	1	5
6.	Fishback Creek	FC	0.5	1
7.	Interstate Bay	IB	0.5	3
8.	Coffer Dam (I & O)	CD (I & O)	12	30
9.	Waterfowl Sanctuary Bluffs	WSB	9	18
10.	Fisherman's Cove	FC	2	10
11.	Walnut Point	WP	1	5
12.	East Wall	EW	6	14
13.	Amphitheater Inlet/SCS	AI/SCS	2	2
14.	Old Growth Peninsula	OGP	1	4
15.	Water Sports Center	WSC	1	4
16.	Eagle Creek Beach/Admin	ECB/Admin	1	6
17.	Eagle Beach (Boats)	EB	1	2
18.	Private East Shoreline	PES	1	not reviewed
19.	Rip Rap Bay (private)	RRB	1	not reviewed
20.	Private Sand Beach	PSB	1	not reviewed
21.	Hobie Beach (Boats)	HB	1	3
22.	46th Street Meadow	46M	2	1
23.	42nd Street Boat Ramp	42BR	2	8
24.	Restaurant Bluff	RB	2	6
25.	Southeast Bluff	SEB	2	4 (9)
26.	Eagle Creek Dam	Dam	1	not reviewed
27.	Borrow Pit Bay	BPB	1	4
28.	School Creek Inlet	SCI	5	20
29.	Southwest Bluffs	SWB	1	3

14.0 EAGLE CREEK EROSION SITES BY RANKING DESIGNATIONS

Below are the individual sites by ranking designation which were identified in this report. For orderly listing purposes, the sites are given in location sequence beginning at the 56th Street Causeway (the middle of the reservoir), then progressing northward up the west shoreline to the I-65 Interstate bridge over Eagle Creek, then progressing southward down the east shore to the dam, then progressing westward along the dam structure westward and northward through BPB, then westward into SCI along the south shoreline to the wetlands, then eastward along the SCI north shoreline to SWB, then northward to end.

14.1 "A" Ranking: 42 sites (24%)

56OLFA 1
DCI 1S,1E,1W,2E,2W, 3,5,6
ROB 6
RCB 1
CD 3,4,5,6,19,20,21,22,23,24,25,26,27
WSB 1,9,10,11,18
FC 7,8A,8B,9,10
WP 1,2,3,4,5
OGP 1
WSC 1
42BR 1,2,3,4,7,8
RB 1, 2C

14.2 "B" Ranking: 76 sites (44%)

56OLFA 1A,2,3,4
DCI 4,6,7,8
RCB 2,3
IB 4
CD 2A,2B
CD 13,14,15,17,28,29,30
WSB 2,3,4,5,6,8,12,13,14,16,17
FC 1
EW 12,3,4,5,6,7,8,9,10,11,12
SCS 1
OGP 2,3,4
WSC 2,3,4
46M 1
RB 2D,3,4,5,6
SEB1,2,3A
BPB 1,3,4
SCI 1,2,3,4,9,11,12,13,14

14.3 "C" Ranking: 31 sites (18%)

56C 1,2
RCB 4,5
IB 1
CD 7A,7B,8,9,16A,16B,16C
FC 2,5,6
AI 1
ECB 3,4,5
HB 1
SEB 4
SCI 7,15
SWB 2,3

14.4 "D" Ranking: 19 sites (11%)

56C 1,2
CD 1,10,11,12
FC 3,4
ECB 1,6
EB 1,2
42 BR 6
BPB 2
SCI 8,17A,17B,17C,18
SWB 1

14.5 No Ranking: 5 sites (3%)

WSB 16A
HB 2,3
RB 2A,2B
SCI 20

15.0 EAGLE CREEK SITES BY LOCATION WITH RANKING, SIZE AND COST

Below are the individual sites by location designation which were identified in this report. For orderly listing purposes, the sites are given in location sequence beginning at the 56th Street Causeway (the middle of the reservoir), then progressing northward up the west shoreline to the I-65 Interstate bridge over Eagle Creek, then progressing southward down the east shore to the dam, then progressing westward along the dam structure westward and northward through BPB, then westward into SCI along the south shoreline to the wetlands, then eastward along the SCI north shoreline to SWB, then northward to end.

1. 56th Street Causeway 56C 1 2

Location: 56C-1 Ranking:C/D Estimated Cost:$NONE

Brief Description: L:1200 H:2 Wave Undercut Embankment

Location: 56C-2 Ranking:C/D Estimated Cost:$NONE

Brief Description: L:1200 H:2 Wave Undercut Embankment

2. 56th St Overlook Fishing Area 56OLFA 1 4 $8775

Location: 56OLFA-1 Ranking:A Estimated Cost:$1840

Brief Description: L:60 H:8 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: 56OLFA-1A Ranking:B Estimated Cost:$1850

Brief Description: L:40 H:30 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: 56OLFA-2 Ranking:B Estimated Cost:$550

Brief Description: L:10+ H:20 pipe undercut by waves, no vegs

Location: 56OLFA-3 Ranking:B Estimated Cost:$3070

Brief Description: L:100 H:8 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location:56OLFA-4 Ranking: B Estimated Cost:1465

Brief Description: L: 50 H: 6 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

3. DeLong Creek Inlet	DCI	2	8	$18,960

Location: DCI-1S Ranking:A Estimated Cost:$3070

Brief Description: L:100 H:8 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: DCI-1E Ranking:A Estimated Cost:$1960

Brief Description: L:50 H:20 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: DCI-1N Ranking:A Estimated Cost:$1960

Brief Description: L:50 H:20 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: DCI-2E Ranking:A Estimated Cost:$3070

Brief Description: L:100 H:8 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: DCI-2W Ranking:A Estimated Cost:$3070

Brief Description: L:100 H:8 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: DCI-3 Ranking:A Estimated Cost:$900

Brief Description: L:30 H:6 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: DCI-4 Ranking:B Estimated Cost:$2450

Brief Description: 80L: H:8 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: DCI-5 Ranking:A Estimated Cost:$1950

Brief Description: L:60 H:12 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: DCI-6 Ranking:B Estimated Cost:$1280

Brief Description: L:40 H:10 Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: DCI-7 Ranking:B/C Estimated Cost:$600

Brief Description: L:20 H:6+ Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

Location: DCI-8 Ranking:B/C Estimated Cost:$900

Brief Description: L:25 H:6+ Path foot traffic, channeling of storm water and loss of vegetation cause erosion enhanced by wave action

4. Rowing Overlook Bay ROB 1 6 $22,925

Location: ROB-1/2 Ranking:B Estimated Cost:$15,400

Brief Description: L:500 H:8 COMBINED LENGTH Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining.

Location: ROB-3/4/5 Ranking:B Estimated Cost:$2250

Brief Description: L:160 H:4 COMBINED LENGTH Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining.

Location: ROB-6 Ranking: A/B+ Estimated Cost:$5275

Brief Description: L:100 H:15 Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining.

5. Rowing Course Bay RCB 1 5 $30,762

Location: RCB-1 Ranking:A Estimated Cost:$3950

Brief Description: L:75 H:15 Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining.

Location: RCB-2 Ranking:B Estimated Cost:$5050

Brief Description: L:150 H:12 Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining.

Location: RCB-3 Ranking: B Estimated Cost:$7500

Brief Description: L:250 H:7 Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining.

Location: RCB-4 Ranking:C Estimated Cost:$2350

Brief Description: L:80 H:6 Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining.

Location: RCB-5 Ranking:C Estimated Cost:$7950

Brief Description: L:300 H:2 Terrace face is wave pounded

6. Fishback Creek	FC	0.5	1	$22,900

Location: FC-1 Ranking: C/D Estimated Cost:$22,900

Brief Description: L:200 H:60 Large natural stream cut

7. Interstate Bay	IB	0.5	3	$7575

Location: IB-1 Ranking:C Estimated Cost:$675

Brief Description: L:25 H:2 Wave pounded area used by Birders and fishermen. Lack of vegetation to protect shoreline.

Location: IB-2 Ranking:C Estimated Cost:$5000

Brief Description: L:200 H:10 sandy, unstable, wave pounded shoreline

Location: IB-4 Ranking:B Estimated Cost:$700

Brief Description: L:20 H:6 sandy, unstable, wave pounded shoreline

8. Coffer Dam (I & O) CD (I & O) 12 30 $$103,150

Location: CD-1 Ranking:D Estimated Cost:$1300

Brief Description: L:60 H:2 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-2A Ranking:B Estimated Cost:$300

Brief Description: L:10 H:6 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-2B Ranking:B Estimated Cost:$300

Brief Description: L:10 H:6 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-3 Ranking:A/B Estimated Cost:$1600

Brief Description: L:30 H:4 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-4 Ranking:A/B Estimated Cost:$1000

Brief Description: L:40 H:4 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-5 Ranking:A/B Estimated Cost:$375

Brief Description: L:15 H:3 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-6 Ranking:A Estimated Cost:$1900

Brief Description: L:80 H:4 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-7A Ranking:C Estimated Cost:$1700

Brief Description: L:75 H:3 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-7B Ranking:C Estimated Cost:$700

Brief Description: L:30 H:1 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-8 Ranking:C Estimated Cost:$175

Brief Description: L:10 H:1 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-9 Ranking:C Estimated Cost:$1400

Brief Description: L:60 H:3 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-10 Ranking:D Estimated Cost:$200

Brief Description: L:6 H:6 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-11 Ranking:D Estimated Cost:$200

Brief Description: L:6 H:3 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-12 Ranking:D Estimated Cost:$250

Brief Description: L:6 H:2 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-13 Ranking:B Estimated Cost:$2100

Brief Description: L:100 H:3 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-14 Ranking:B Estimated Cost:$250

Brief Description: L:10 H:2 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-15 Ranking:B Estimated Cost:$700

Brief Description: L:30 H:3 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-16A Ranking:C Estimated Cost:$6300

Brief Description: L:300 H:1 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-16B Ranking:C Estimated Cost:$700

Brief Description: L:30 H:2 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-16C Ranking:C Estimated Cost:$1300

Brief Description: L:60 H:1 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-17 Ranking:B Estimated Cost:$12,500

Brief Description: L:300 H:2 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-18 Ranking:C Estimated Cost:$900

Brief Description: L:20 H:2 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-19 Ranking:A Estimated Cost:$2100

Brief Description: L:50 H:1-2 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-20-26 Ranking:A Estimated Cost:$52,700

Brief Description: L:1290 H:1 LONG COMBINED SEGMENT Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-27 Ranking:A/B Estimated Cost:$900

Brief Description: L:40 H:2 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-28 Ranking:B Estimated Cost:$2300

Brief Description: L:100 H:3 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

Location: CD-29-30 Ranking:B/C Estimated Cost:$9000

Brief Description: L:400+ H:3 Artificial embankment, built with a mixture of sandy and clayey soils and large debris, with unstable, wave pounded and under cut shoreline bank subject to full or partial inundation. Most areas suffer from foot traffic and vegetation loss.

9. Waterfowl Sanctuary Bluffs WSB 9 18 $461,200

Location: WSB-1 Ranking:A Estimated Cost:$3400

Brief Description: L:100 H:2 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake

Some aggregate mining impacts

Location: WSB-2 Ranking:B Estimated Cost:$8000

Brief Description: L:200+ H:10 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake

Some aggregate mining impacts

Location: WSB-3 Ranking:B Estimated Cost:$5500

Brief Description: L:150 H:6 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake

Some aggregate mining impacts

Location: WSB-4 Ranking:B Estimated Cost:$9300

Brief Description: L:200 H:6 Old road bed to aggregate mining operation built on former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake

Location: WSB- 5 Ranking:B Estimated Cost:$26,000

Brief Description: L:450+ H:18+ Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake

Some aggregate mining impacts

Location: WSB- 6 Ranking:B Estimated Cost:$19,000

Brief Description: L:300 H:18+ Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake

Location: WSB-7 Ranking:B Estimated Cost:$27,600

Brief Description: L:150 H:20 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake

Location: WSB-8 Ranking:B Estimated Cost:$8400

Brief Description: L:130 H:15 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake

Location: WSB-9 Ranking:A Estimated Cost:$5600

Brief Description: L:100 H:15 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake

Location: WSB-10 Ranking:A Estimated Cost:$215,000

Brief Description: L:500+ H:10-50 NATURE CENTER SLOPE Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake. Cutting of vegetation and feeding of animals and birds lead to loss of vegetation. Old hillside supporting cable network installed Lilly has failed: 3--6′ of hillside retreat. Old fence at lake edge may be useful for cabling trees to shoreline

Location: WSB-11 Ranking:A Estimated Cost:$83,200

Brief Description: L:600? H:60 NATURE CENTER SLOPE Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake. Old fence at lake edge may be useful?

Location: WSB-12 Ranking:B Estimated Cost:$7200

Brief Description: L:300? H:2 NATURE CENTER SLOPE Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake. Old fence at lake edge may be useful?

Location: WSB-13 Ranking:B Estimated Cost:$2400

Brief Description: L:60 H:10 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake. Old fence at lake edge may be useful?

Location: WSB-14 Ranking:B Estimated Cost:$3200

Brief Description: L:80+ H:10 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake. Old fence at lake edge may be useful?

Location: WSB-15 Ranking:B Estimated Cost:$7200

Brief Description: L:120+ H:2 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake. Old fence at lake edge may be useful?

Location: WSB-16A Ranking:NONE Estimated Cost:$NONE

Brief Description: L: H: Old road segment,aesthetics

Location: WSB- 16 Ranking:B Estimated Cost:$9000

Brief Description: L:150 H:20 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake. Old fence at lake edge may be useful?

Location: WSB-17 Ranking:B Estimated Cost:$6600

Brief Description: L:120+ H:15 Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade w/ lake.

Location: WSB-18 Ranking:A Estimated Cost:$14,600

Brief Description: L:140+ H:40-50 OVERLOOK PLATFORM AREA Naturally formed, former Eagle Creek outside meander embankment, with mixture of sandy and clayey soils and large boulders, with unstable, wave pounded and under cut shoreline bank subject to partial inundation. Steep slope not at grade with lake. Need water diversion.

10. Fisherman's Cove	FC	2	10	33,400

Location: FC-1 Ranking:B Estimated Cost:$6000

Brief Description: L:180 H:10 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy soils.

Location: FC-2 Ranking:C/D Estimated Cost:$7700

Brief Description: L:300 H:1 Wetlands with minor cutbank

Location: FC-3 Ranking:D Estimated Cost:$13,500

Brief Description: L:50 H:2 Foot traffic/wave action impacts

Location: FC-4 Ranking:D Estimated Cost:$300

Brief Description: L:10 H:4 Foot traffic/wave action impacts

Location: FC-5 Ranking:C Estimated Cost:$6000

Brief Description: L:15 H:15 Foot traffic/wave action impacts

Location: FC-6 Ranking:C Estimated Cost:$300

Brief Description: L:2 H:10 Foot traffic/wave action impacts

Location: FC-7 Ranking:A Estimated Cost:$1700

Brief Description: L:50 H:10 Foot traffic/wave action impacts

Location: FC-8A Ranking:A Estimated Cost:$400

Brief Description: L:10 H:10+ Foot traffic/wave action impacts

Location: FC-8B Ranking:A Estimated Cost:$500

Brief Description: L:15 H:10+ Foot traffic/wave action impacts

Location: FC-9 Ranking:A Estimated Cost:$1700

Brief Description: L:50 H:12 Foot traffic/wave action impacts

Location: FC-10 Ranking:A Estimated Cost:$1000

Brief Description: L:30 H:8 Beach w/Foot traffic/wave action impacts

11. Walnut Point	WP	1	5	$12,500

Location: WP-1 Ranking:A Estimated Cost:$1000

Brief Description: L:30 H:8 Beach w/Foot traffic/wave action impacts

Location: WP-2 Ranking:A Estimated Cost:$2800

Brief Description: L:100+ H:4 Beach w/Foot traffic/wave action impacts

Location: WP-3 Ranking:A Estimated Cost:$4200

Brief Description:L:150 H:3-4 Beach w/Foot traffic/wave action impacts

Location: WP-4 Ranking:A Estimated Cost:$1250

Brief Description: L:50 H:3-4 Concrete Rip Rap dumped chaotically offers limited protection, and detracts visually from high use area.

Location: WP-5 Ranking:A Estimated Cost:$3250

Brief Description: L:130 H:6

12. East Wall	EW	6	14	$92,669

Location: EW-1 Ranking:B Estimated Cost:$6764

Brief Description: L140: H:12 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils.

Location: EW-2 Ranking:B Estimated Cost:$4837

Brief Description: L:100 H:15 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils.

Location: EW-3 Ranking:B Estimated Cost:$5319

Brief Description: L:110 H:12 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils.

Location: EW-4 Ranking:B Estimated Cost:$3632

Brief Description: L:75 H:8 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils.

Location: EW-5 Ranking:B Estimated Cost:$12,093

Brief Description: L:250 H:10 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils.

Location: EW-6 Ranking:B Estimated Cost:$9674

Brief Description: L:200 H:10 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils.

Location: EW-7 Ranking:B Estimated Cost:$6292

Brief Description: L:130 H:10 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils.

Location: EW-8 Ranking:B Estimated Cost:$6764

Brief Description: L:140 H:10 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils.

Location: EW-9 Ranking:B Estimated Cost:$11,611

Brief Description: L:240 H:12 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils.

Location: EW-10 Ranking:B Estimated Cost:$1454

Brief Description: L:30 H:15 Concrete Rip Rap dumped chaotically offers limited protection, and detracts visually from scenic area.

Location: EW-11 Ranking:B Estimated Cost:$9674

Brief Description: L:200 H:10 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils.

Location: EW-12-14 Ranking:B Estimated Cost:$14,521

Brief Description: L:300 H:12 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils. "Indian Museum" structure is behind EW-13 location w/some risk

13. Amphitheater Inlet/SCS AI/SCS 2 2 $5800

Location: SCS-1 Ranking:B Estimated Cost:$4300

Brief Description: L:100 H:20 Partially remediated site had Soil Bioengineering structures installed in November, 1993 by Soil Conservation Service class under direction of Robbin Sotir. The winter wave action stripped much of the soil off of the willow fascines, live stakes, and other fabrications, resulting in limited growth. However, the mere fact of some protection has resulted in retarded erosion, allowing for moistening of slope and volunteer vegetation, as well as provided important test area in field.

Location: AI-1 Ranking:C Estimated Cost:$1500

Brief Description: L:80 H:5 Wave pounded and undercut southern shoreline. Suffers direct assault in storms. Sandy/till soils.

14. Old Growth Peninsula OGP 1 4 $21,200

Location: OGP-1 Ranking:A Estimated Cost:$5900

Brief Description: L:150 H:12 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils. Major old growth remnant woods in need of protection/aesthetic control.

Location: OGP-2 Ranking:B Estimated Cost:$5700

Brief Description: L:150 H:10 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils. Major old growth remnant woods in need of protection/aesthetic control.

Location: OGP-3 Ranking:B Estimated Cost:$5900

Brief Description: L:130 H:12 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils. Major old growth remnant woods in need of protection/aesthetic control.

Location: OGP-4 Ranking:B Estimated Cost:$3700

Brief Description: L:100 H:8 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils. Major old growth remnant woods in need of protection/aesthetic control.

15. Water Sports Center WSC 1 4 $18.510

Location: WSC-1 Ranking:A Estimated Cost:$4560

Brief Description: L:140 H:10 Water Sports center boat ramp area. Wave pounded and undercut southern/eastern shoreline. Suffers direct assault in storms. Sandy/till soils. High visibility/high use.

Location: WSC-2 Ranking:B Estimated Cost:$5900

Brief Description: L:200 H:5 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils. High visibility/high use. Some rip rap.

Location: WSC-3 Ranking:B Estimated Cost:$5900

Brief Description: L200: H:15 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils. High visibility/high use. Some rip rap. Older gravel boat ramps.

Location: WSC-4 Ranking:B Estimated Cost:$2150

Brief Description: L:75 H:2 Wave pounded and undercut eastern shoreline. Suffers direct assault in storms. Sandy/till soils. High visibility/high use. Some rip rap. Older gravel boat ramps.

16. Eagle Creek Beach/Admin ECB/Admin 1 6 $11,750

Location: ECB-1 Ranking:D Estimated Cost:$2000

Brief Description: L:100+ H:1 Eagle Creek Beach. Wave pounded eastern shoreline. Suffers direct assault in storms. Sand added.

Location: ECB-2 Ranking: NONE Estimated Cost:$NONE

Brief Description: L:550 H:3 SWIMMING BEACH SAND AREA

Location: ECB-3 Ranking:C Estimated Cost:$300

Brief Description: L:10 H:1 Eagle Creek Beach. Wave pounded eastern shoreline. Suffers direct assault in storms. Sand added..

Location: ECB-4 Ranking:C Estimated Cost:$1800

Brief Description: L:40 H:9 Wave pounded and undercut southern/eastern shoreline. Suffers direct assault in storms. Sandy/till soils. High visibility/high use.

Location: ECB-5 Ranking:C Estimated Cost:$900

Brief Description: L:20 H:10 Wave pounded and undercut southern/eastern shoreline. Suffers direct assault in storms. Sandy/till soils. High visibility/high use.

Location: ECB-6 Ranking:D Estimated Cost:$3375

Brief Description: L:150H:4 Stone Rip Rap dumped chaotically offers limited protection, and detracts visually from high use area.

Location: ECB-7 Ranking:D Estimated Cost:$3375

Brief Description: L:150 H:1 Wave pounded eastern shoreline. Suffers direct assault in storms. Detracts visually from high use area.

17. Eagle Beach (Boats)	EB	1	2	$8000

Location: EB-1 Ranking:D Estimated Cost:$6500

Brief Description: L:300 H:1 Eagle Beach. Wave pounded eastern shoreline. Suffers direct assault in storms. Sand added yearly.

Location: EB-2 Ranking:D Estimated Cost:$1500

Brief Description: L:500 H:2 Eagle Beach. Wave pounded eastern shoreline. Suffers direct assault in storms. No vegetation.

18. Private East Shoreline	PES	1	not reviewed
19. Rip Rap Bay (private)	RRB	1	not reviewed
20. Private Sand Beach	PSB	1	not reviewed
21. Hobie Beach (Boats)	HB	1	3 $700

Location: HB-1 Ranking:C Estimated Cost:$700

Brief Description: L:400 H:4 Groundwater seeps along shaped slope.

Location: HB-2-3 Ranking:NONE Estimated Cost:$NONE

Brief Description: L: H: BEACH AREA Wave pounded eastern shoreline. Suffers direct assault in storms. No vegetation. Sand added yearly; erodes and is thought to travel northward to PSB.

22. 46th Street Meadow 46M 2 1 $17,500

Location: 46M-1 Ranking:B Estimated Cost:$17,500

Brief Description: L:700 H:3 ACTIVE UNPROTECTED EASTERN SHORELINE Wave pounded eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated 10-20 feet.

23. 42nd Street Boat Ramp 42BR 2 8 $15,400

Location: 42BR-1 Ranking:A Estimated Cost:$350

Brief Description: L:20 H:5 Foot traffic/wave action impacts

Location: 42BR-2 Ranking:A Estimated Cost:$2200

Brief Description: L:80 H:3 Foot traffic/wave action impacts

Location: 42BR-3 Ranking:A Estimated Cost:$1600

Brief Description: L:80 H:1 Sand beach; Foot traffic/wave action

Location: 42BR-4 Ranking:A Estimated Cost:$2000

Brief Description: L:100 H:1 Foot traffic/wave action impacts

Location: 42BR-5 Ranking: NONE Estimated Cost:$500?

Brief Description: L:90 H:3 LIVE WILLOW STAKING ONLY Rip Rap

Location: 42BR-6 Ranking:D Estimated Cost:$1200

Brief Description: L:80 H:1 Sand beach; Foot traffic/wave action

Location: 42BR-7 Ranking: A/B Estimated Cost:$3250

Brief Description: L:100 H:10 Active slumping is threatening picnic area, large oak tree. Visual and recreational impacts/high use area.

Location: 42BR-8 Ranking: A/B Estimated Cost:$4400

Brief Description: L:150 H:12 Active slumping is threatening picnic area, large oak tree. Visual and recreational impacts/high use area.

24. Restaurant Bluff RB 2 6 $69,380

Location: RB-1 Ranking:A Estimated Cost:$300

Brief Description: L:500 H:4 PLANTS ONLY Stone Rip Rap dumped chaotically offers some protection. detracts visually/high use area.

Location: RB-2A Ranking:NONE Estimated Cost:$5650

Brief Description: L:200 H:4 RICK'S BOATYARD RESTAURANT

Location: RB-2B Ranking:NONE Estimated Cost:$6750

Brief Description: L:150 H:10 RICK'S BOATYARD RESTAURANT

Location: RB-2C Ranking:A Estimated Cost:$12,100

Brief Description: L:200 H:15 OLD OVERLOOK AREA/RESTAURANT

Location: RB-2D Ranking:B Estimated Cost:$9650

Brief Description: L:150 H:20 ACTIVE UNPROTECTED EASTERN SHORELINE Wave pounded eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated.

Location: RB-3 Ranking:B Estimated Cost:$5795

Brief Description: L:100 H:3 ACTIVE UNPROTECTED EASTERN SHORELINE Wave pounded eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated.

Location: RB-4 Ranking:B Estimated Cost:$14,425

Brief Description: L:175+ H:25+ ACTIVE UNPROTECTED EASTERN SHORELINE Wave pounded eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated.

Location: RB-5 Ranking:B Estimated Cost:$8150

Brief Description: L:250+ H:30 ACTIVE UNPROTECTED EASTERN SHORELINE Wave pounded eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated.

Location: RB-6 Ranking:B Estimated Cost:$6560

Brief Description: L:80+ H:25+ ACTIVE UNPROTECTED EASTERN SHORELINE Wave pounded eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated.

25. Southeast Bluff SEB 2 4 (9) $15,400

Location: SEB-1 Ranking:B Estimated Cost:$3400

Brief Description: L:50 H:20 ACTIVE UNPROTECTED EASTERN SHORELINE Wave pounded eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated.

Location: SEB-2 Ranking:B Estimated Cost:$3300

Brief Description: L:50+ H:15 ACTIVE UNPROTECTED EASTERN SHORELINE Wave pounded eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated.

Location: SEB-3A-F Ranking:B Estimated Cost:$69,500

Brief Description: L:1000 H:20 COMBINED LENGTH ACTIVE UNPROTECTED EASTERN SHORELINE Wave pounded eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated.

Location: SEB-4 Ranking:C Estimated Cost:$1800

Brief Description: L:300+ H:20+ UNPROTECTED EASTERN SHORELINE Wave pounded eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated.

26. Eagle Creek Dam Dam 1 1 LIVE STAKE

27. Borrow Pit Bay	BPB	1	4	$42,400

Location: BPB- 1 Ranking:B Estimated Cost:$4600

Brief Description: L:175+ H:5 Somewhat wave pounded western shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated. Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining for dam.

Location: BPB- 2 Ranking:D Estimated Cost:$13,900

Brief Description: L:600+ H:1 Somewhat wave pounded western shoreline nearly at grade with normal pool. Suffers direct assault in storms. Area has retreated. Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining for dam.

Location: BPB-3 Ranking:B Estimated Cost:$16,700

Brief Description: L:650 H:8 Somewhat wave pounded western shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated. Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining for dam.

Location: BPB-4 Ranking:B Estimated Cost:$7350

Brief Description: L:150 H:15 Somewhat wave pounded western shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Area has retreated. Artificial, sandy, unstable, wave pounded shoreline bank was formed by aggregate mining for dam.

28. School Creek Inlet SCI 5 20 $68,320

Location: SCI-1 Ranking:B Estimated Cost:$7330

Brief Description: L:150+ H:15 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem.

Location: SCI-2 Ranking:B Estimated Cost:$7350

Brief Description: L:150 H:15 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem.

Location: SCI-3 Ranking:B Estimated Cost:$8575

Brief Description: L:175 H:15 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem.

Location: SCI-4 Ranking:B Estimated Cost:$4800

Brief Description: L:100 H:14 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem.

Location: SCI-5 Ranking:C Estimated Cost:$1700

Brief Description: L:60 H:1-2 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-6 Ranking:C Estimated Cost:$500

Brief Description: L:20 H:3 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI- 7 Ranking:C Estimated Cost:$750

Brief Description: L:30 H:1-2 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-8 Ranking:D Estimated Cost:$750

Brief Description: L:30 H:6 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-9 Ranking:C Estimated Cost:$450

Brief Description: L:20 H:2 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-10 Ranking:B Estimated Cost:$700

Brief Description: L:30 H:5 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-11 Ranking:B Estimated Cost:$750

Brief Description: L:30 H:6 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-12 Ranking:B Estimated Cost:$1250

Brief Description: L:50 H:3 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-13 Ranking:B Estimated Cost:$5895

Brief Description: L:75+ H:15+ Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion. Major.

Location: SCI- 14 Ranking:B Estimated Cost:$6200

Brief Description: L:120 H:15+ Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-15 Ranking:C Estimated Cost:$3800

Brief Description: L:75 H:15 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-16 Ranking:C Estimated Cost:$2300

Brief Description: L:75 H:6 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem.

Location: SCI-17A Ranking:D Estimated Cost:$800

Brief Description: L:30 H:1 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-17B Ranking:D Estimated Cost:$800

Brief Description: L:30 H:2 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-17C Ranking:D Estimated Cost:$1100

Brief Description: L:40 H:3 Wave pounded southern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-18 Ranking:D Estimated Cost:$850

Brief Description: L:30 H:3 Wave pounded southern/eastern shoreline. Suffers direct assault in storms. No major vegetation is critical problem. Foot traffic, storm water causes enhanced erosion.

Location: SCI-19 Ranking:B Estimated Cost:$12,500

Brief Description: L:75 H:25+ Wave pounded southern shoreline. Suffers direct assault in storms. Loss of vegetation is critical problem. Foot traffic, storm water causes enhanced erosion. Slumping.

Location: SCI-20 Ranking:NONE Estimated Cost:$NONE

Brief Description: L: H: SCHOOL CREEK WETLANDS

29. Southwest Bluffs SWB 1 3 $11,220

Location: SWB- 1 Ranking:D Estimated Cost:$6100

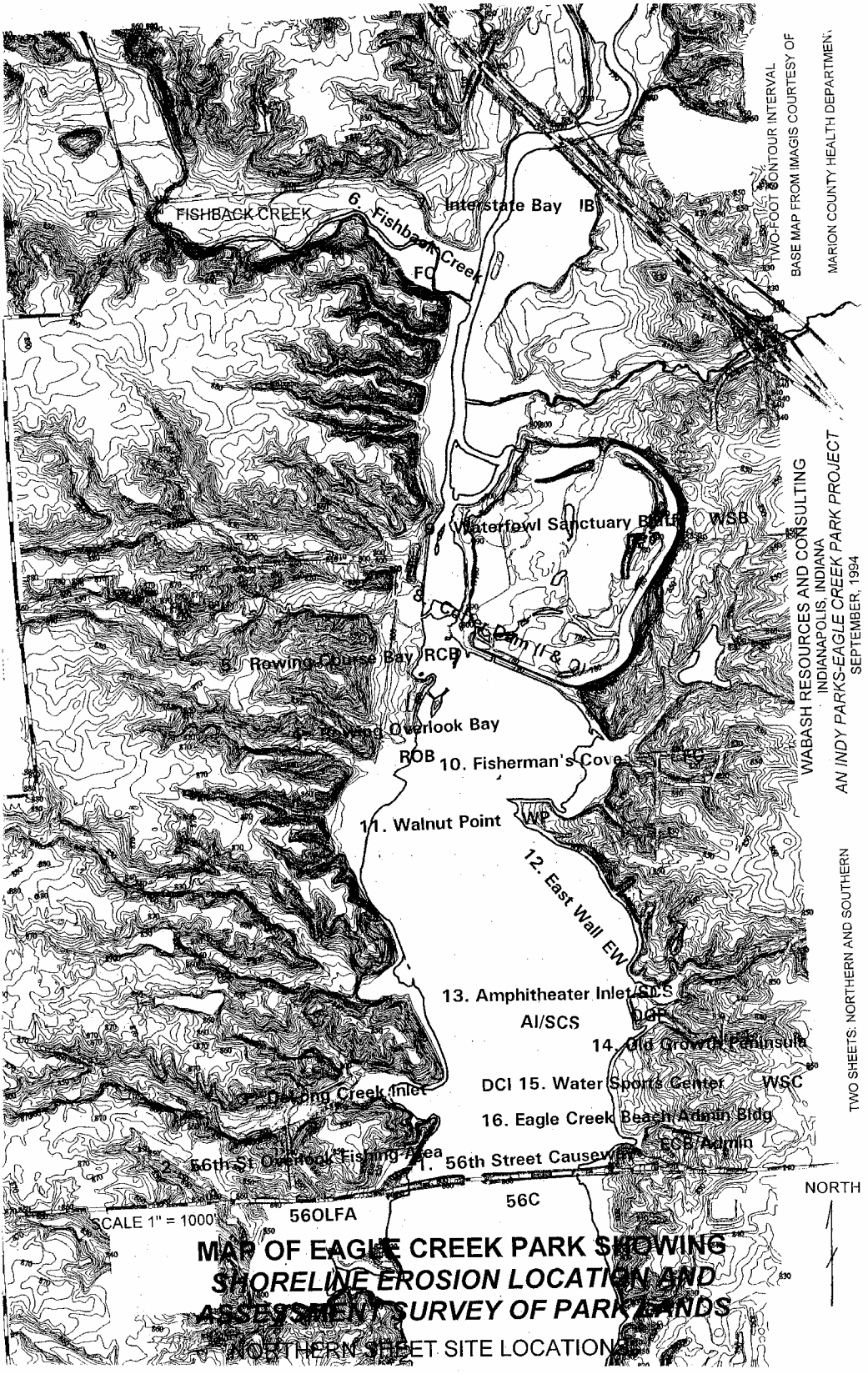
Brief Description: L:200 H:4 Wave pounded western shoreline. Suffers direct assault in storms. Continued loss of vegetation is critical problem.

Location: SWB-2 Ranking:C Estimated Cost:$5120

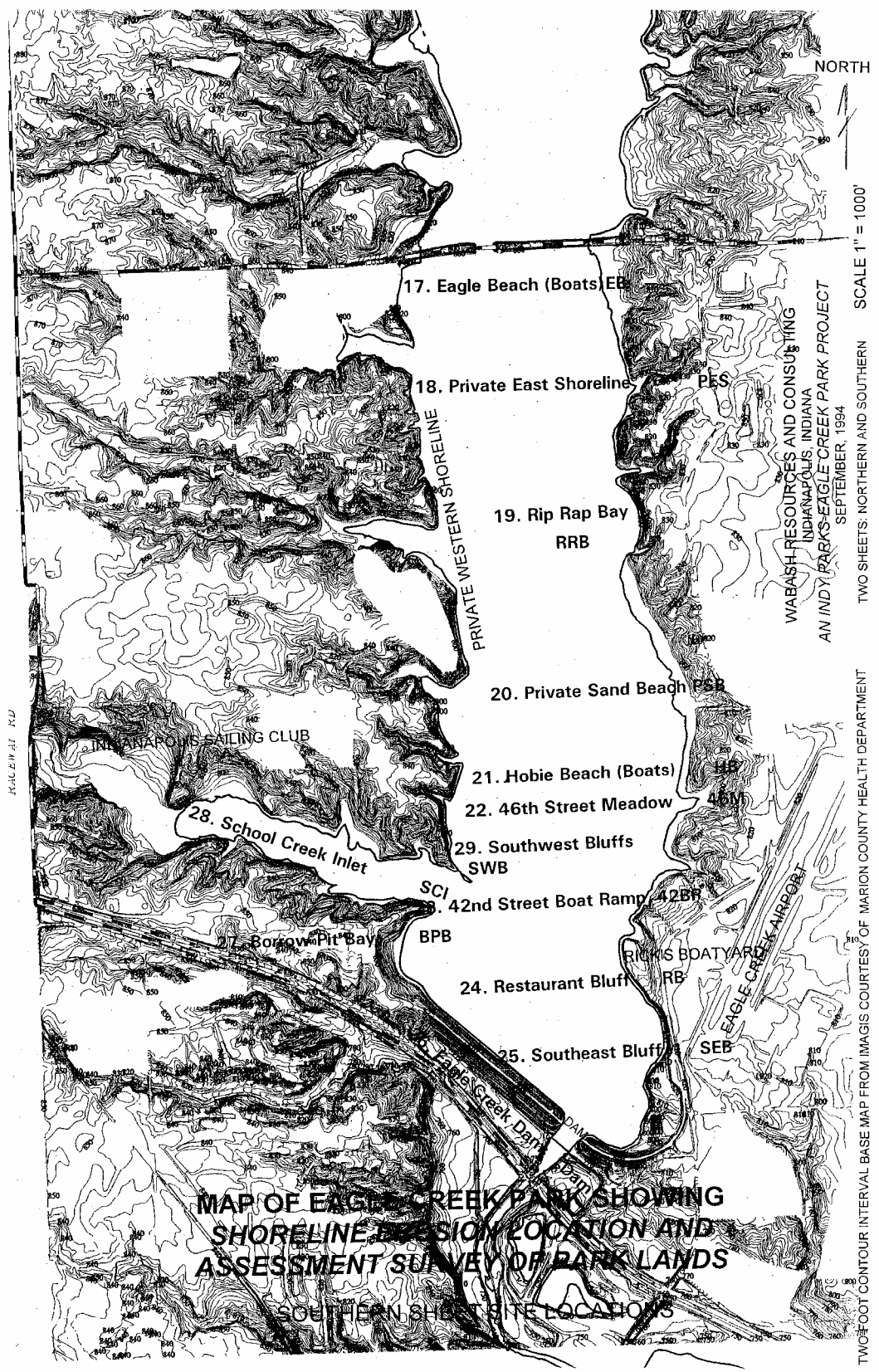
Brief Description: L:100 H:15+ Wave pounded western shoreline. Suffers direct assault in storms. Lack of vegetation and active slumping are critical problems. Continued loss of upland trees.

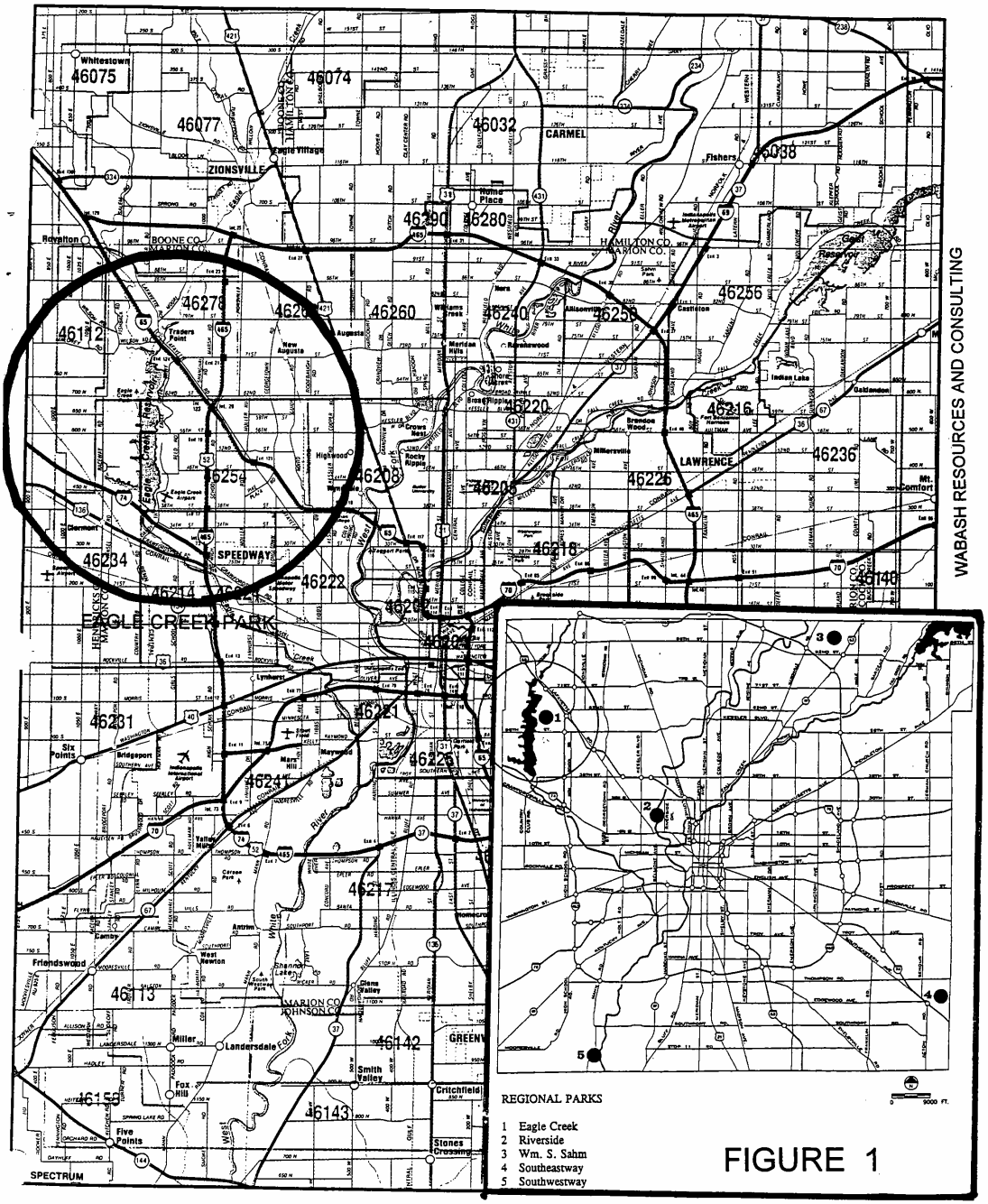
Location: SWB-3 Ranking:C Estimated Cost:$10,200

Brief Description: L:200+ H:15+ Wave pounded western shoreline. Suffers direct assault in storms. Lack of vegetation and active slumping are critical problems. Continued loss of upland trees.

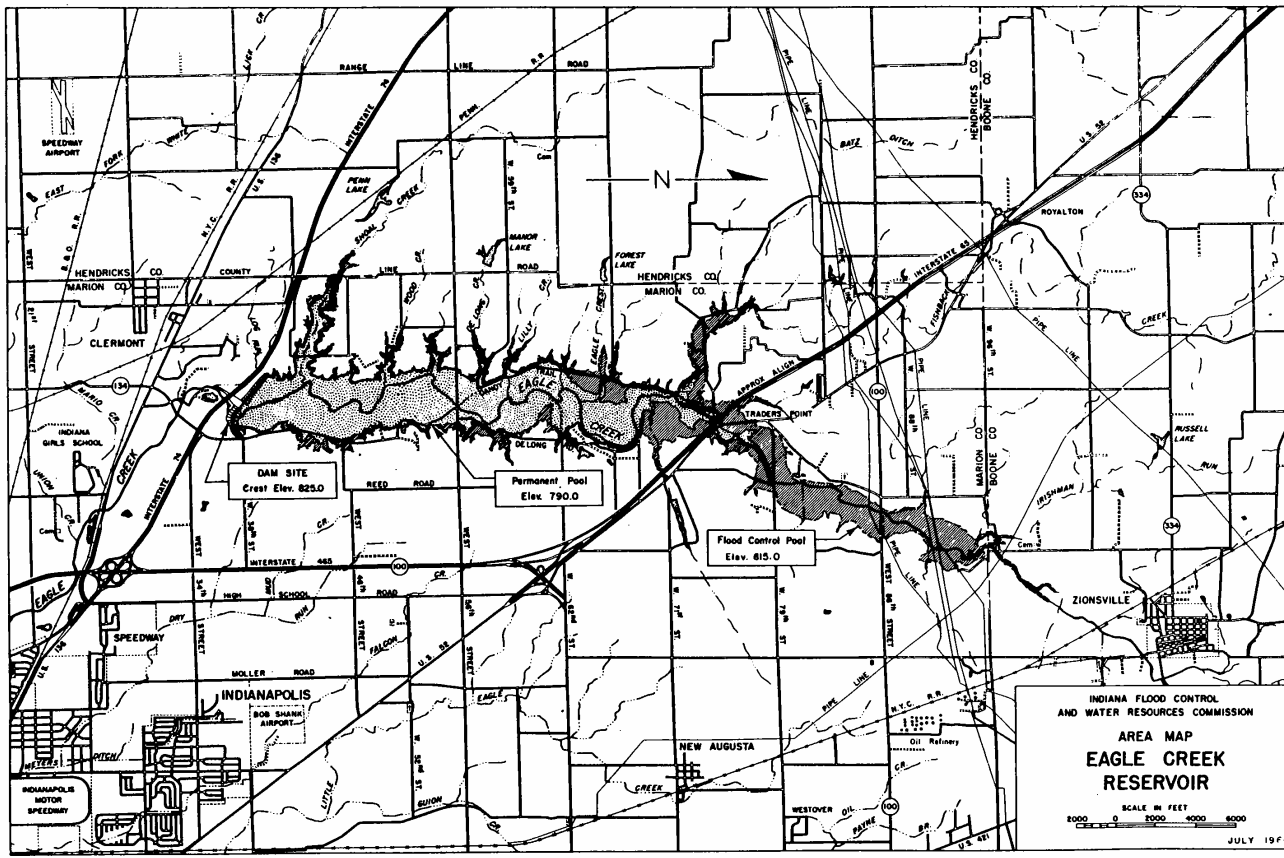


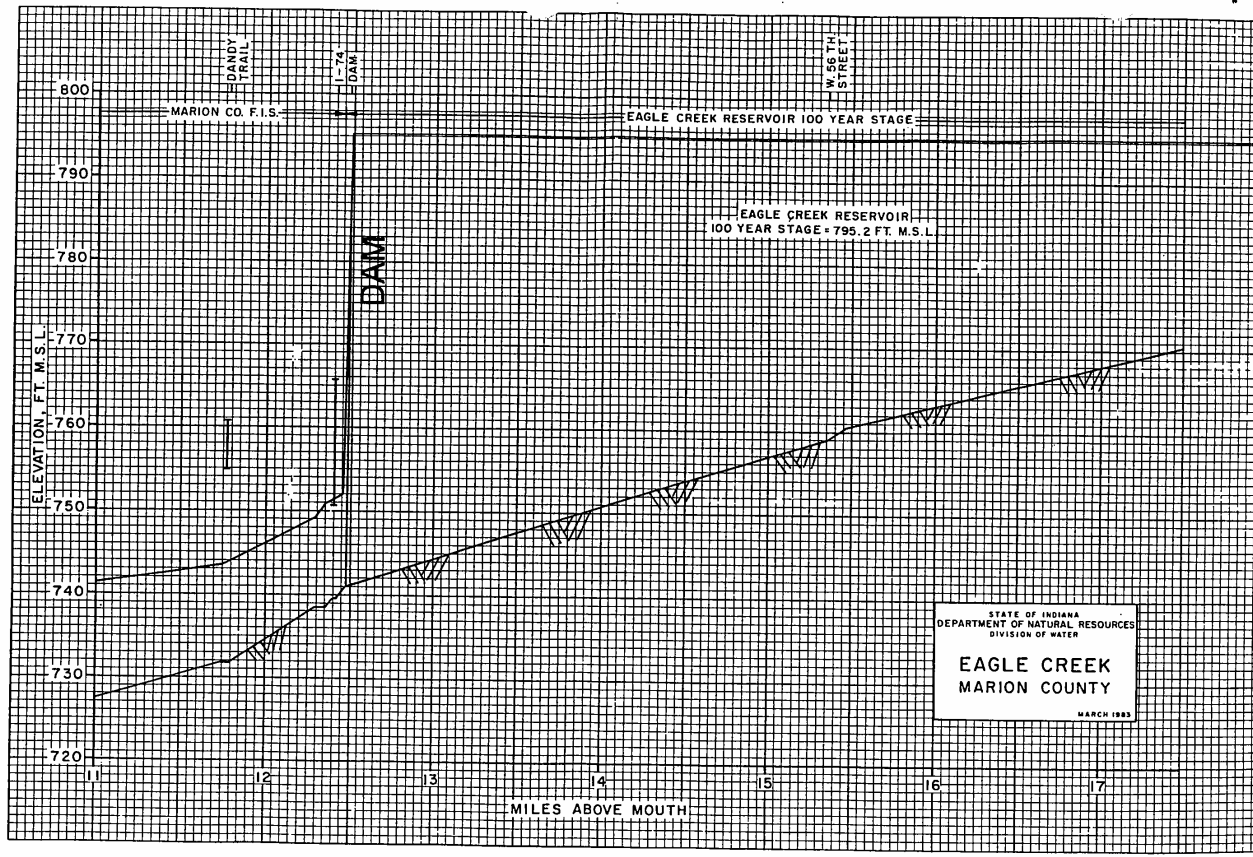
MAP OF EAGLE CREEK PARK SHOWING
SHORELINE EROSION LOCATION AND
ASSESSMENT SURVEY OF PARK LANDS
NORTHERN SHEET SITE LOCATIONS


NORTH
SCALE 1" = 1000'
TWO SHEETS: NORTHERN AND SOUTHERN
TWO-FOOT CONTOUR INTERVAL BASE MAP FROM IMAGIS COURTESY OF MARION COUNTY HEALTH DEPARTMENT
WABASH RESOURCES AND CONSULTING
INDIANAPOLIS, INDIANA
AN INDY PARKS-EAGLE CREEK PARK PROJECT
SEPTEMBER, 1994
17. Eagle Beach (Boats) EB
18. Private East Shoreline PES
19. Rip Rap Bay
RRB
PRIVATE WESTERN SHORELINE
20. Private Sand Beach PSB
INDIANAPOLIS SAILING CLUB
21. Hobie Beach (Boats) HB
22. 46th Street Meadow 46M
28. School Creek Inlet
29. Southwest Bluffs
SWB
SCI
42nd Street Boat Ramp 42BR
27. Borrow Pit Bay
BPB
RICKIS BOATYARD
24. Restaurant Bluff RB
EAGLE CREEK AIRPORT
25. Southeast Bluff SEB
Eagle Creek Dam
DAM
MAP OF EAGLE CREEK PARK SHOWING
SHORELINE DIVISION LOCATION AND
ASSESSMENT SURVEY OF PARK LANDS
SOUTHERN SHORE SITE LOCATIONS



LOCATION OF EAGLE CREEK PARK, MARION COUNTY, INDIANA

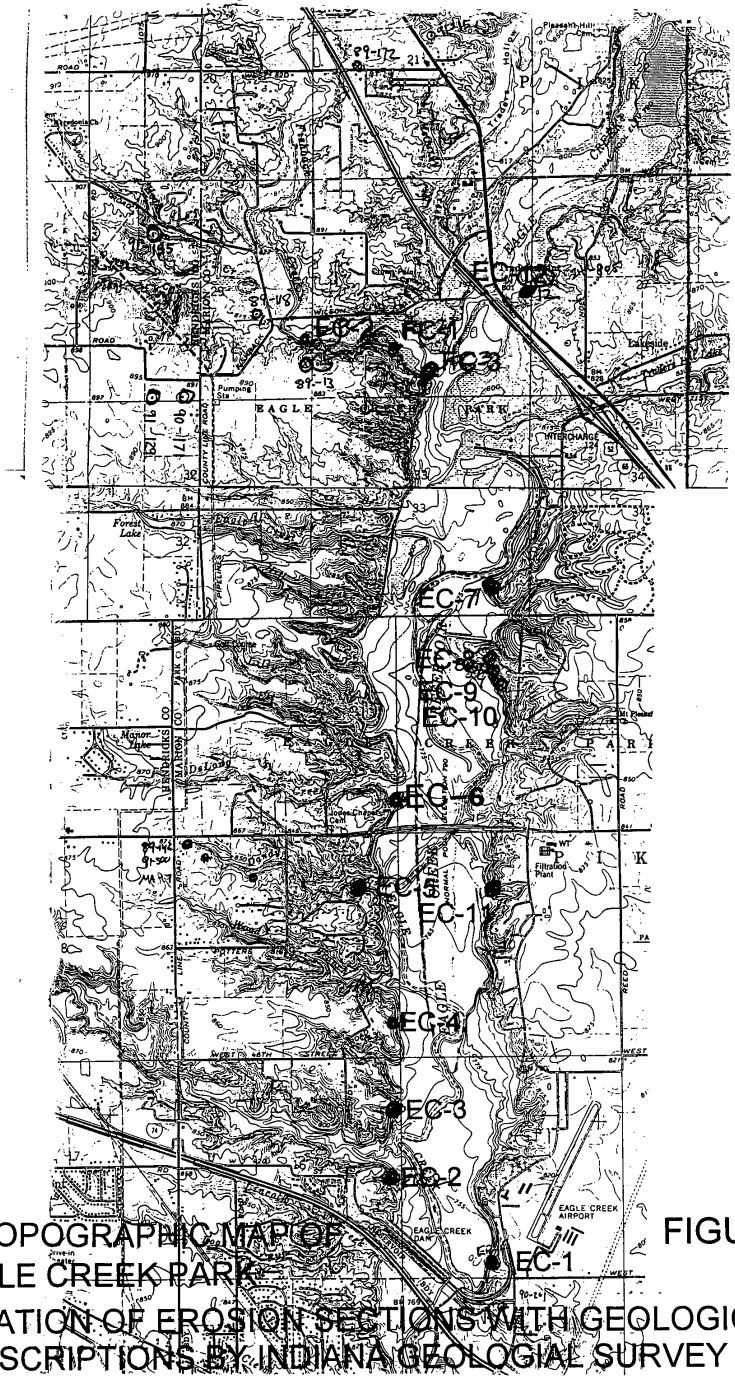

INDIANA FLOOD CONTROL
AND WATER RESOURCES COMMISSION
AREA MAP
EAGLE CREEK
RESERVOIR
SCALE IN FEET
2000 0 2000 4000 6000
JULY 1964
DAM SITE
Crest Elev. 825.0
Permanent Pool
Elev. 790.0
Flood Control Pool
Elev. 815.0
HENDRICKS CO.
MARION CO.
CLERMONT
SPEEDWAY
INDIANAPOLIS
NEW AUGUSTA
ZIONSVILLE
ROYALTON
TRADERS POINT
SPEEDWAY AIRPORT
BOB SHANK AIRPORT
INDIANAPOLIS MOTOR SPEEDWAY
INDIANA GIRLS SCHOOL
PENN LAKE
MANOR LAKE
FOREST LAKE
RUSSELL LAKE
EAGLE CREEK
INTERSTATE 465
INTERSTATE 65
INTERSTATE 70
U.S. 36
U.S. 52
U.S. 421
U.S. 136
U.S. 136
U.S. 136



EAGLE CREEK RESERVOIR

FIGURE 3 FLOOD PROFILE AND TOPOGRAPHIC CROSS-SECTION

WABASH RESOURCES AND CONSULTING

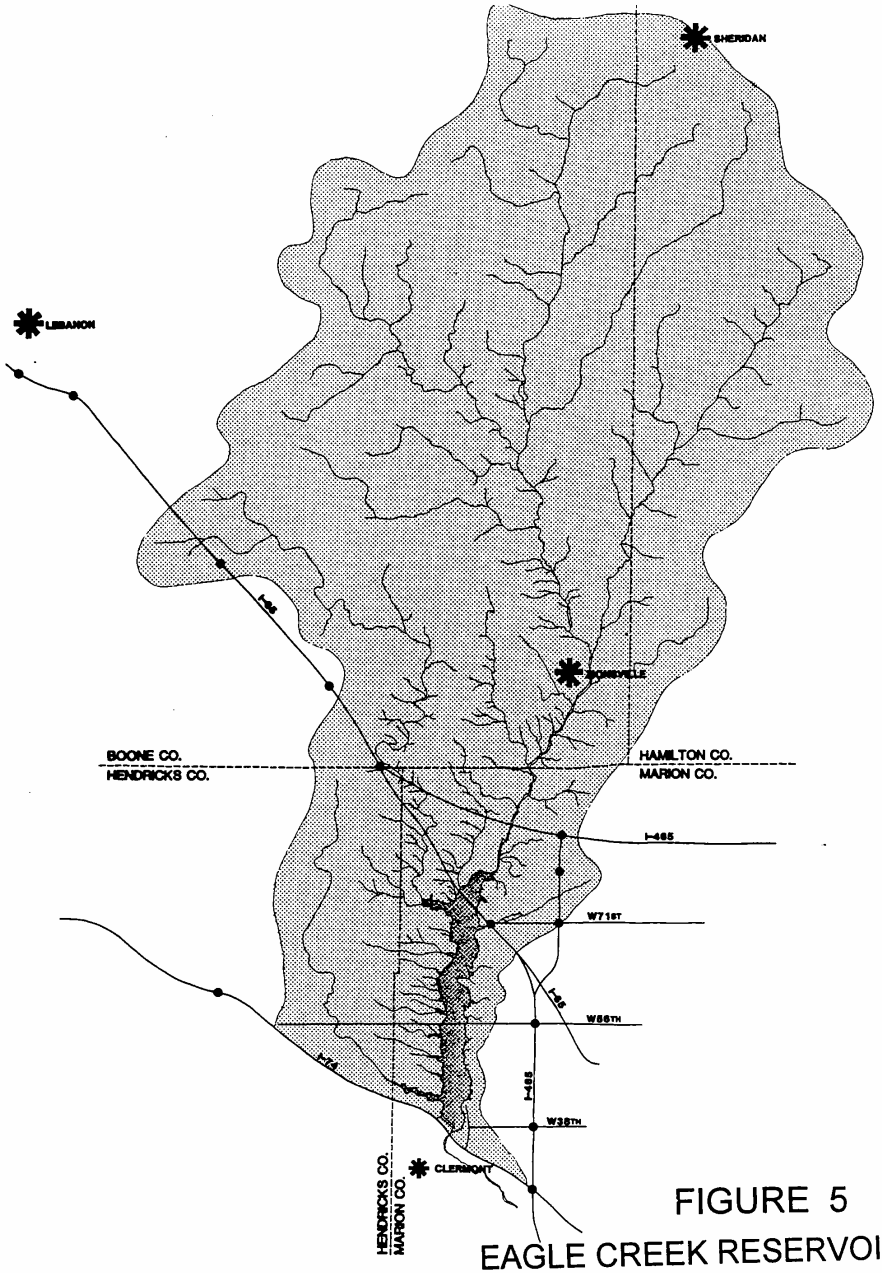


WABASH RESOURCES AND CONSULTING

USGS TOPOGRAPHIC MAP OF EAGLE CREEK PARK

LOCATION OF EROSION SECTIONS WITH GEOLOGIC DESCRIPTIONS BY INDIANA GEOLOGIAL SURVEY

FIGURE 4



WABASH RESOURCES AND CONSULTING

FIGURE 5

EAGLE CREEK RESERVOIR **WATERSHED**

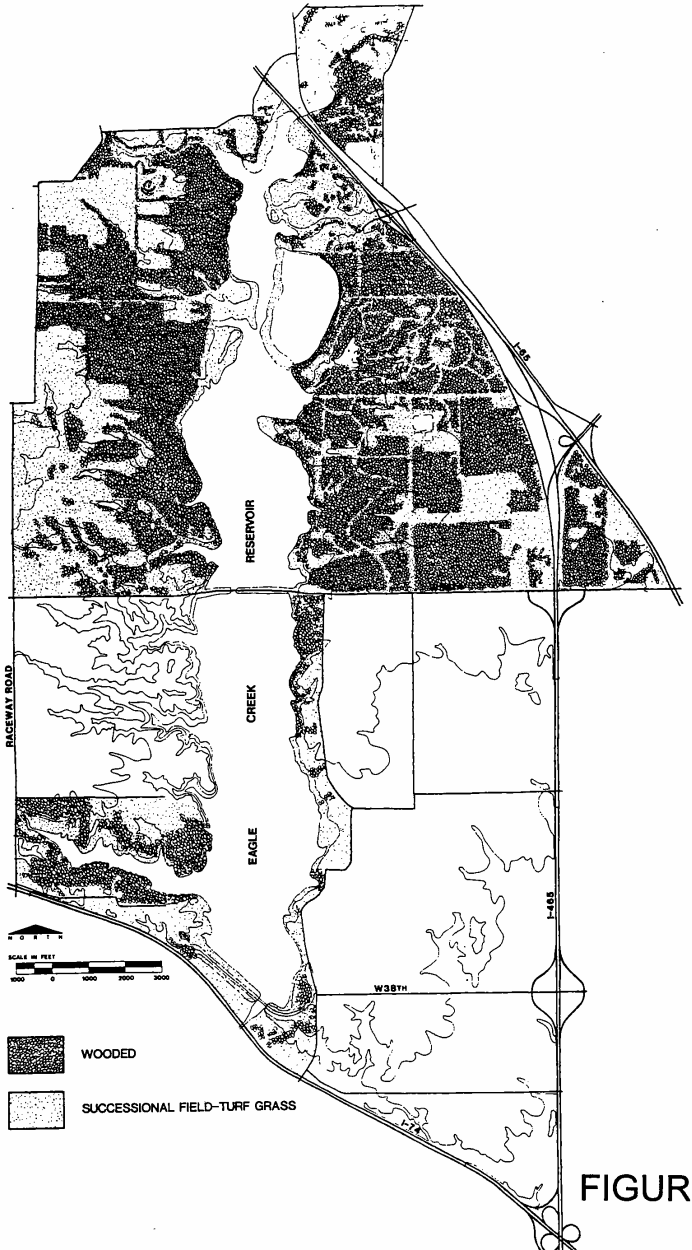
MASTER PLAN MAP OF EAGLE CREEK PARK

FIGURE 6

EAGLE CREEK RESERVOIR
TOPOGRAPHY

WABASH RESOURCES AND CONSULTING

MASTER PLAN MAP OF EAGLE CREEK PARK



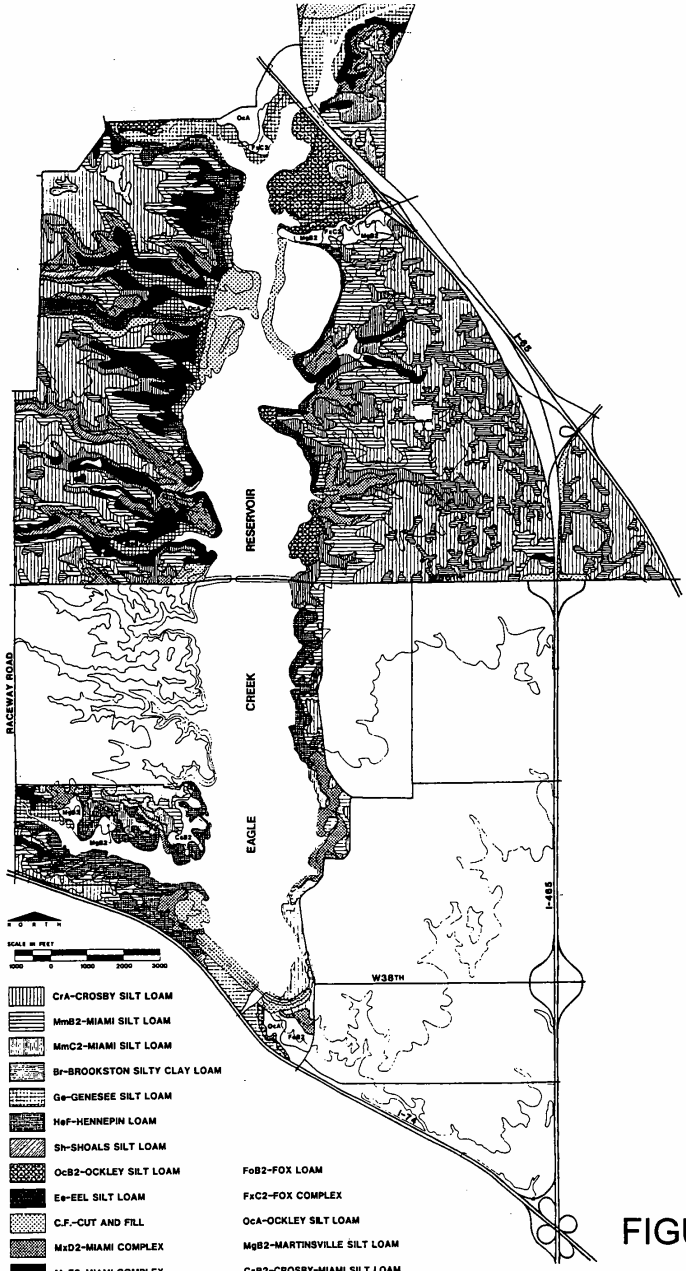
WABASH RESOURCES AND CONSULTING

FIGURE 7

EAGLE CREEK RESERVOIR

VEGETATIVE COVER

MASTER PLAN MAP OF EAGLE CREEK PARK



WABASH RESOURCES AND CONSULTING

FIGURE 8

EAGLE CREEK RESERVOIR **SOILS**

MASTER PLAN MAP OF EAGLE CREEK PARK

Sixteen existing soil types occur within the project area. Cut and Fill represents a seventeenth type, but its characteristics are difficult to determine without performing on-site investigation. The 16 soil types are listed below along with the characteristics with park planning implications.

Br - Brookston Silt Clay Loam
Runoff is very slow; wetness is the main limitation.
Buildings: Severe (wetness)
Roads: Severe (wetness, frost action)
Recreation Development: Severe (wetness)
Wooded areas support fair stands of hardwoods, but some are heavily pastured.

CrA - Crosby Silt Loam, 0-2% slopes
Runoff is slow; wetness is the main limitation
Buildings: moderate (wetness, shrink-swell, low-strength
Roads: severe (frost action)
Recreation Development: moderate (wetness, percolates slowly)
Wooded areas support fair stands of hardwoods, but some are heavily pastured.

CsB2 - Crosby Miami Silt Loam, 2-4% slopes
Runoff is medium; moderate erosion is the main limitation.
Buildings: moderate (wetness, shrink-swell, low strength)
Roads: severe (frost action)
Recreation Development: moderate (wetness, percolates slowly)
Few wooded areas support fair stands of hardwoods.

Ee - Eel Silt Loam
Runoff is slow; flooding is the main limitation
Buildings: severe (floods)
Roads: severe (floods, frost action)
Recreation Development: severe-moderate (floods)
Wooded areas support poor to fair stands of hardwoods. Most areas are cultivated.

FoB2 - Fox Loam, 2-6% slopes
Runoff is medium; moderate erosion and droughtiness are the main limitations.
Buildings: slight - moderate (slope)
Roads: moderate (shrink-swell)
Recreation Development: slight
Few wooded areas support poor to fair stands of hardwoods.

FxC2 - Fox complex, 6-15% slopes
Runoff is medium; moderate erosion is the main limitation.
Buildings: severe-moderate (slope)
Roads: Moderate (slope, shrink-swell)
Roads: severe (slope)
Recreation Development: severe-moderate (slope)
Most areas are wooded with fair stands of hardwoods.

OcA - Ockley Silt Loam, 0-2% slope
Runoff is slow; only slight limitations for most nonfarm uses.
Buildings: slight-moderate (shrink-swell)
Roads: moderate (frost action, low strength)
Recreation Development: slight
Wooded areas support fair stands of hardwoods.

OcB2 - Ockley Silt Loam, 2-6% slope
Runoff is medium; moderate erosion is the main limitation.
Buildings: slight-moderate (shrink-swell)
Roads: moderate (frost action, low strength)
Recreation Development: slight-moderate (slope)
Few small wooded areas support poor stands of hardwoods.

Sh - Shoals Silt Loam
Runoff is very slow; flooding and wetness are the main limitations.
Buildings: severe (floods)
Roads: severe (floods, frost action)
Recreational Development: severe-moderate (wetness, floods)
Wooded areas support poor to fair stands of hardwoods.
Recreation Development: moderate-severe (slope)
Few small wooded areas support poor to fair stands of hardwoods. Most areas are cultivated or in pasture.

Ge - Genesee Silt Loam
Runoff is slow; flooding is the main limitation.
Buildings: severe (floods)
Roads: severe (floods)
Recreation Development: moderate-severe (floods)
Wooded areas support poor to fair stands of hardwoods.

HeF - Hennepin Loam, 25-50% slopes
Runoff is very rapid. Erosion and steepness of slope are the main limitations.
Buildings: severe (slope)
Roads: severe (slope)
Recreation Development: severe (slope)
Wooded areas support fair stands of hardwoods. It is best suited to trees.

MgB2 - Martinsville Silt Loam, 2-6% slopes
Runoff is medium, moderate erosion is the main limitation.
Buildings: slight-moderate (slope)
Roads: moderate (frost action)
Recreation Development: slight
Few wooded areas support fair stands of hardwoods.

MmB2 - Miami Silt Loam, 2-6% slope
Runoff is medium; moderate erosion is the main limitation.
Buildings: moderate (shrink-swell, low strength)
Recreation Development: slight
Few wooded areas support poor to fair stands of hardwoods.

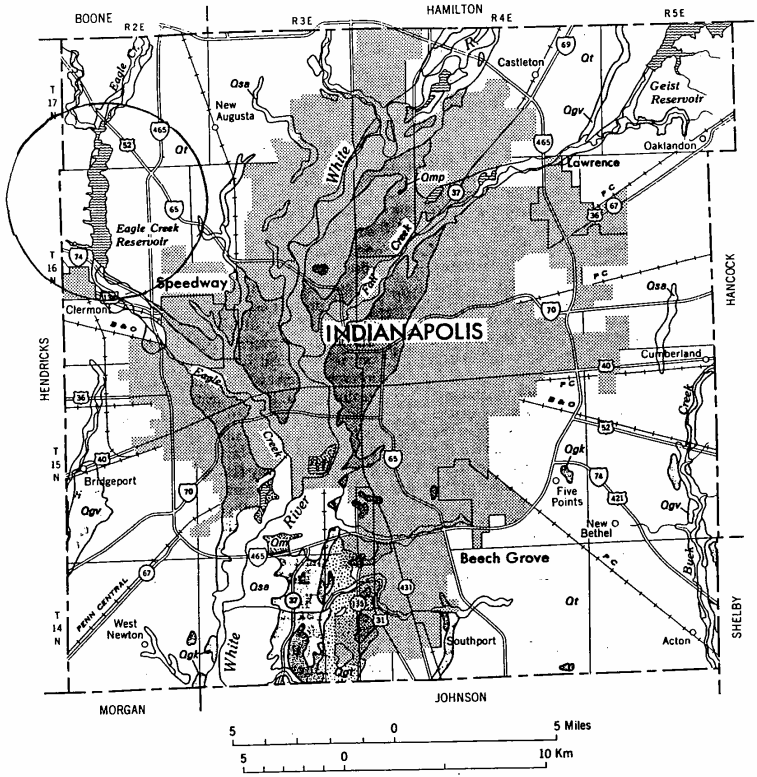
MmC2 - Miami Silt Loam, 6-12% slope
Runoff is medium; moderate erosion is the main limitation.
Buildings: moderate - severe (slope, shrink-swell, low strength)
Roads: severe (low strength)
Recreation Development: slight; playgrounds-severe (slopes)
Wooded areas support poor to fair stands of hardwoods.

MxD2 - Miami Complex, 12-18% slope
Runoff is rapid on the eroded soils and very rapid on the severely eroded soils; erosion is the main limitation.
Buildings: severe (slope)
Roads: severe (slope)
Recreation Development: severe-moderate (slope)
Wooded areas support fair stands of hardwoods.

MxE2 - Miami complex, 18-24% slope
Runoff is rapid; slope is the main limitation.
Buildings: severe (slope)

SCS SOILS DATA OF EAGLE CREEK PARK
FIGURE 9

WABASH RESOURCES AND CONSULTING



Map of Marion County showing surficial geology. From Indiana Geological Survey Regional Geologic Maps 1 and 7.

GEOLOGY

EXPLANATION

Qm

Modified land

Land extensively modified by excavation for limestone or gravel. Small areas not shown

Qsa

Silt, sand, and gravel

Deposits of present streams; includes associated slopewash and swamp deposits

Qmp

Muck and peat

Paludal and lacustrine deposits

Qgv

Gravel, sand, and silt

Deposits of meltwater streams. Valley-train deposits as partial valley fill

Qgk

Gravel, sand, and some silt

Hummocky patches of ice-contact stratified drift

Qgt

Sand, gravel, and till

Undifferentiated ice-contact stratified drift and till with hummocky topography

Qt

Till

Mostly loam till. Till sheets of low relief

GENERALIZED GLACIAL GEOLOGY OF MARION COUNTY

FIGURE 10

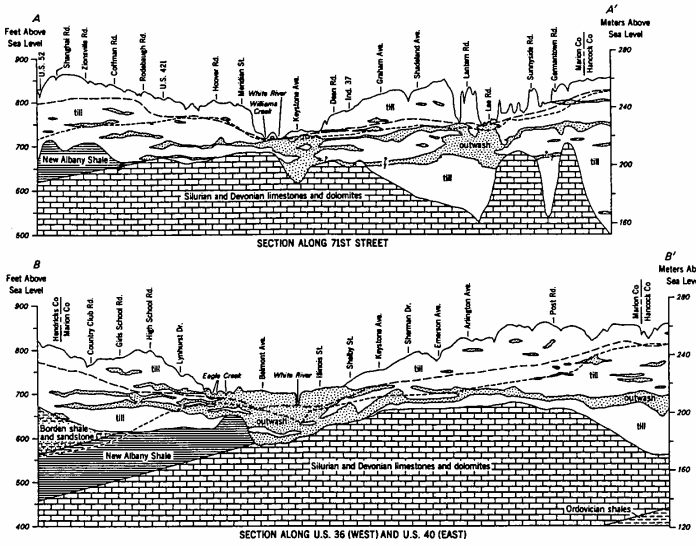


Figure 10. Hydrogeologic cross sections showing aquifer distribution and potentiometric surfaces in the unconsolidated and bedrock materials.

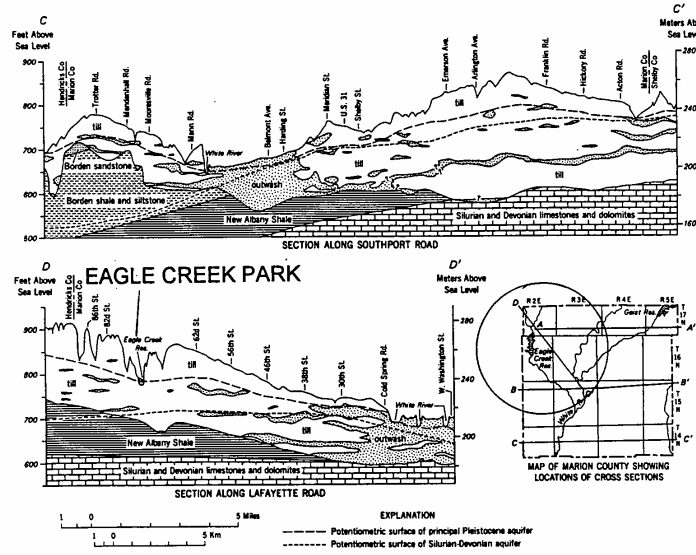
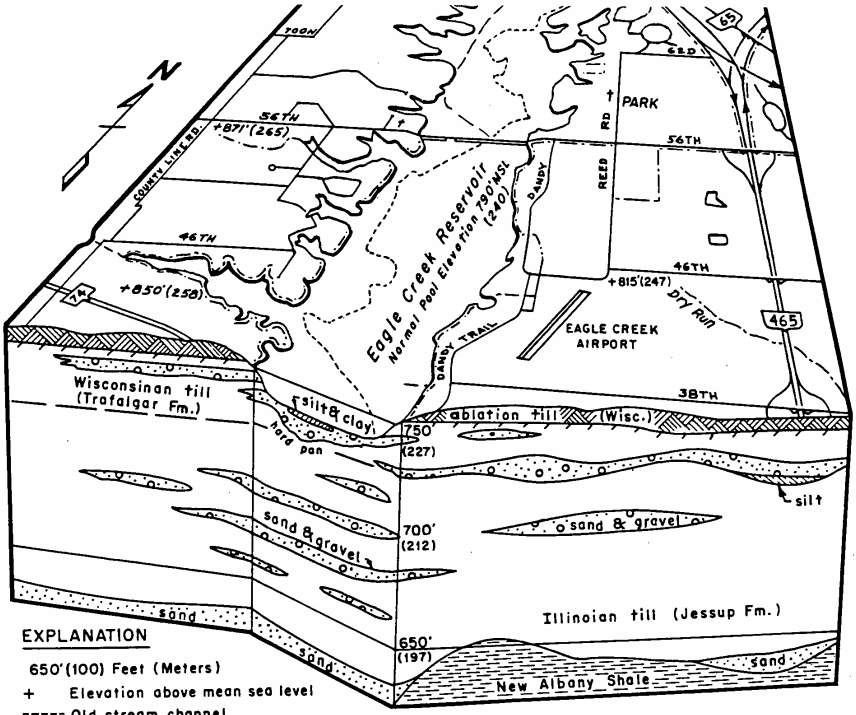


Figure 10—Continued

WABASH RESOURCES AND CONSULTING

FIGURE 11

GEOLOGICAL CROSS-SECTIONS OF MARION COUNTY



GEOLOGIC CROSS-SECTION

Block diagram showing section through Eagle Creek Dam.

Range of characteristics of near-surface till units below depth of 6 feet[1]

Parameter	Range (pct)	Mean (pct)	Standard deviation (pct)	Number
Grain size				
Sand	24- 62	46	10	34
Silt	12- 52	31	7	34
Clay	8- 37	22	6	34
Atterberg limits				
Liquid limit	7- 36	21	5	33
Plastic limit	10- 21	13	3	33
Plasticity index	2- 16	8	4	33
Shrinkage limit	11- 18	12	2	31
Classification				
AASHO[2]	A-4 to A-6 (clay loam to sandy loam)			
Unified	CL			
Natural moisture content	6- 25	14	4	65
Moisture-density relationships				
Dry density	126-129	127	1.8	4
Moist density	139-142	140	1.3	4
Optimum moisture	10- 11	11	.5	4

[1] Compiled from records of augered roadway borings of Indiana State Highway Commission projects: I-465-4(107), 4(108)135, 4(91)113, 4(105)122, 4(106)127, I-65-3(71)100. Tests were performed according to AASHO specifications. Grain-size variations, particularly, are somewhat greater than are to be expected in the near-surface till units. The grain size of the near-surface till generally can be expected to be in the loam to sandy loam range.

[2] AASHO, American Association of State Highway Officials.

TILL SOILS ENGINEERING DATA FIGURE 12

WABASH RESOURCES AND CONSULTING

EAGLE CREEK RESERVOIR SHORELINE INVENTORY

Indianapolis Indiana
April 1990

CITY OF INDIANAPOLIS
DEPARTMENT OF PUBLIC WORKS

FIGURE 13

WABASH RESOURCES AND CONSULTING

0115S

INTRODUCTION

This inventory was undertaken in response to a request from the Indianapolis Department of Public Works, Division of Flood Control. The purpose of the inventory was to identify encroachments onto city property and flowage easements. To this end, the consultant followed these steps:

1. Set lath at elevation 795 (city property).
2. Set lath at elevation 815 (flowage easements).
3. Lath was set using differential leveling, trigonometric leveling, and existing monuments along the reservoir's perimeter.
4. Using a hand level, we surveyed the reservoir to identify the presence of structures below elevation 795 and between elevations 795 and 815.
5. We considered all structures such as landscaping, boat docks, steps to boat docks, retaining walls, tennis courts, and any other permanent fixtures to be encroachments. Trees and vegetation were not considered to be encroachments.

The report presents encroachments by location. Street addresses are provided for each property, along with structures below elevation 795 and between elevations 795 and 815. Photographs of encroaching structures are also included in the report. Field notes were submitted under separate cover.

DESIGN CRITERIA TABLE

BESTMANN
GREEN SYSTEMS

7 Mall Street
Salem, MA 01970

TEL: 508/741-1166
FAX: 508/741-3780

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INTERPRETING THE DESIGN CRITERIA TABLE:

Bioengineering can effectively stabilize streambanks and shorelines within a broad range of physical conditions. In many cases, conditions are too stressful for conventional planting techniques or spontaneous natural revegetation, yet do not require hard structural measures. The following table can be used to determine the specific Bestmann Green Systems materials suitable for cost-effective treatment on a spectrum of hydraulic and morphological conditions.

From the top portion of the table, locate the type and level of stress factors present on the site for proposed bioengineering work. The stress levels shown represent maximal values, not average values. The highest stress level indicated is used to determine the materials needed. In general, materials listed in the lower portion of the table under the same stress level column will provide the necessary protection for the site. If the highest stress level column for the proposed site has two factors in it, move into the next higher stress level column to determine the materials needed. When stress levels are not anticipated within the first two years following installation, move into the next lower stress level column to choose materials. The stress tolerance of the materials shown below assumes that each material is used alone. When Bestmann Green Systems materials are used in combination with eachother, or with additional protective structural measures, the range of application is increased.

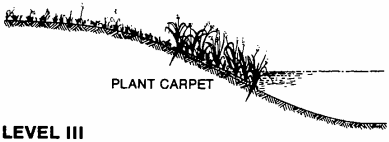
STRESS TYPE	*STRESS LEVELS*				
	1	2	3	4	5
Stream Velocity	<1 ft/sec	<2.5 ft/sec	<5 ft/sec	<8 ft/sec	<12 ft/sec
Wave Height	<6 inches	<1 foot	<20 inches	<2.5 feet	<4 feet
Slope/Profile	<1:10	<1:5	<1:3	<1:2	variable
Sun Exposure	full sun	mostly sun	part sun	part shade	shade
Traffic: Human/Animal	none	slight	moderate	frequent	extreme

Bestmann Green Systems Materials

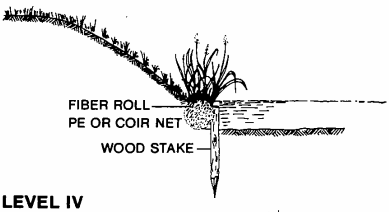
Medium Plant Plugs	X				
Fiber Webbing	X				
Large Plant Plugs	X	X			
Plant Carpets	X	X			
Plant Pallets		X	X		
Fiber Mat		X	X		
Fiber Roll (coir net)		X	X		
Plant Roll		X	X	X	
Brush Carpet		X	X	X	
Fiber Roll (PE net)			X	X	X
Rock Roll				X	X
Plant Revetment				X	X

LEVEL I

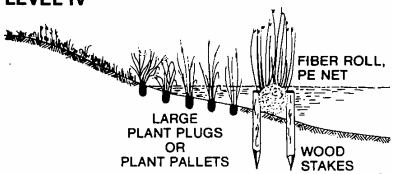
LEVEL II



LEVEL III



LEVEL IV



LEVEL V

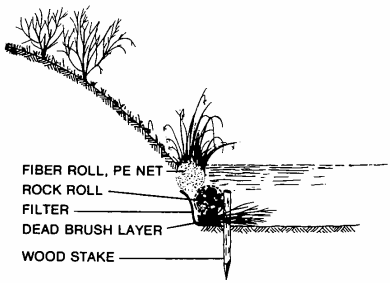


FIGURE 14

BIOENGINEERING FOR EROSION CONTROL, WATER QUALITY, AND HABITAT RESTORATION
WABASH RESOURCES AND CONSULTING

Lakeside Bioengineering

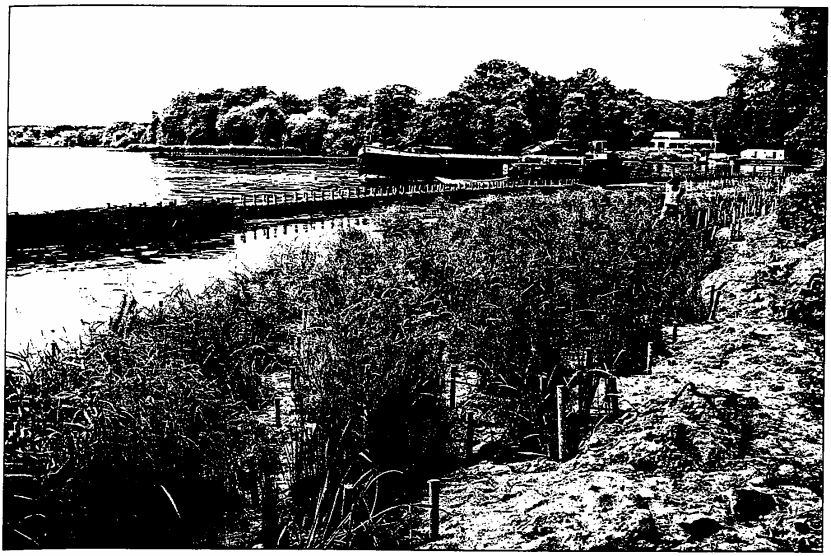
by Wendi Goldsmith

THE enhancement of bordering wetlands on Lake Havel in Berlin provides an instructive example of the long-term benefits of bioengineering techniques in terms of erosion control, water quality functions, and cost considerations. Mr. Lothar Bestmann of Bestmann Green Systems pioneered several bioengineering methods for the purpose of herbaceous vegetation management on inland shorelines. Similar methods have since been used on many lakes and reservoirs in Europe, North America, and Asia. One of the most extensive and carefully monitored projects relating erosion control and water quality, and monitoring performance is on Lake Havel in Berlin, Germany.

Lake Havel, actually a dammed river system, has been heavily used for centuries, with pressure intensifying during the political situation since the 1940s. Before the Berlin Wall fell, residents of Berlin were basically confined to look within city limits for recreation space and drinking water supply. In addition to serving as a link in the regional canal network for commercial canal boats, Lake Havel has been used enthusiastically by recreational boaters. Many of the wells providing city drinking water were located on the shores of Lake Havel, adjacent to the widest borders of wetland plants, based on the conventional wisdom that the vegetation protected water quality. The dieback of lakeshore wetlands and their subsequent restoration were critical to the city.

A Restoration Era?

A growing number of articles in this publication and others are spreading the word about stream and lake restoration methods. A common challenge to restoration efforts is determination of realistic goals and practical strategies, but one of the most consistent technical challenges is the creation of physical stability in the dynamic bank and shoreline zone. Traditional engineering disciplines prescribe structural stabilization as the standard solution. There are clearly a variety of non-traditional treatments available to suit indi-



Plant Pallets of several species staked on shoreline behind Branch Box.

High population density, a long history of agricultural and industrial land use, together with the Green political climate of recent years have propelled Germans earlier into many environmental practices that Americans are just beginning to consider.

vidual situations, ranging from straightforward plantings, to application of synthetic or biodegradable fabrics, to more elaborate bioengineered systems. However, there is little documentation published in English of their performance over time. Although many people realize that the era of restoration has come, it is difficult to persuade sceptics without sufficient data. Many techniques have a longer history of proven application outside North America, and a considerable body of evidence to demonstrate their effectiveness.

Germany is often cited as an example to follow in terms of natural resource management. High population density, a long history of agricultural and industrial land use, together with the Green political climate of recent years have propelled Germans earlier into many environmental practices that Americans are just beginning to consider. We could learn a lot by paying attention to their successes, failures, refinements, and priorities.

Water and wetland resources are highly valued for their importance to humans and ecosystems. Germans, unlike Americans, have not embraced the concept of resource "protection" but rather "restoration". When managing areas already altered by the human hand, the basic model of "protection" does not offer much guidance. Germany has tended to identify critical natural resources, and their functions, and focused on their "restoration". They have drawn on the practice of bioengineering for much restoration along lakes and streams.

During the past decade, Germany has virtually forbidden the use of structural erosion control techniques on water bodies in cases where vegetation including bioengineering can be applied. The reasons are based primarily on the water quality and habitat significance of the shallow water zone along rivers and lakes where erosion typically occurs. The interface between water and land is highly biologically productive. Most structural solutions significantly reduce the natural functions of these areas, often with undesirable, even costly, results.

Common Problems

The situation on Lake Havel is typical of waters under development pressure: a web of interrelated physical, chemical, and biological causes and effects which lead to spiralling wetland dieback, shoreline erosion, and water quality degradation. Ultimately 70% of the original wetland area had been lost. In response to long-term study of the underlying causes, measures were taken to protect and enhance existing wetlands and to replace or create new ones.

Prior to this approach, efforts to address shoreline erosion (rock riprap and concrete revetment) had only worsened water quality by further impoverishing the lake's biotic community. The good news: hybrid structural and bioengineered solutions solved the erosion problem and added acres of functioning wetlands to improve water quality for costs that compared favorably with standard rock and concrete construction alone.

To better understand the design and management issues on heavily developed shorelines, it is useful to study the interrelated causes and effects of shoreline wetland dieback which were identified on Lake Havel.

It is crucial to recognize the interactive physical, chemical, and biological processes, and to pay attention

INTERRELATED CAUSES AND EFFECTS OF SHORELINE WETLAND DIEBACK ON LAKE HAVEL

PHYSICAL CAUSES

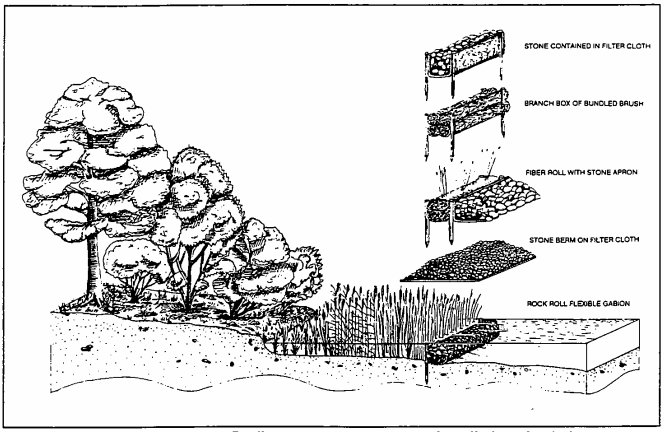
- Waves from recreational and commercial boats cause erosion and scour of the substrate. The "secondary" waves are often many times stronger than wind-caused waves on the same site and create a serious, often underestimated problem.
- Waves strike and tear shrubs, leaves and stems.
- Boats, oars, fishing lines, trees, limbs, crush and cut plants and gouge shoreline.
- Trampling from people and foot traffic crushes plants.
- Wind-driven spray damages leaves and shade-sensitive succulent plants.
- Water levels fluctuate, due to accelerated flow from stormwater from impervious surfaces, and groundwater drawdown from well extraction.
- Turbidity reduces light and retards growth.

CHEMICAL CAUSES

- Discharge of phosphorus from
- Nutrient loading contamination from hydrocarbons, heavy metals, pesticides, herbicides, etc.

BIOLOGICAL CAUSES

- Overgrowth of aquatic plants (including algae) and floating matter which crushes plants.
- Grass shrinking, reducing cause weakened overgrown stems which tend to break off.
- Hatchlings of geese, mensinet for succulent growth.
- Eating and trampling by panicled ducks and geese.
- Reduced plant cover and density unable to perform basic functions such as denitrification.



Wave-breaking devices used in Berlin to protect existing or installed wetland plants.

to the multiple roles vegetation plays. Controlling erosion and sedimentation is often the key to protecting water quality. In addition to the physical disruption caused by sediment particles themselves, many water-borne contaminants adhere to sediments. Healthy vegetation filters sediments and stabilizes shorelines, and can improve water chemistry. Wetland plants support a variety of life forms and biological activity. The metabolic processes of microorganisms, and of the plants themselves, contribute to purification through nutrient uptake, breakdown of hydrocarbons, buffering pH, denitrification, oxygenation, chemical reduction of heavy metals and bacteriocidal effects.

Management and Bioengineering Solutions

The Agency for City Planning and Environmental Protection in Berlin wished to attempt to recreate the necessary functions of the lake system, without necessarily recreating their form or appearance. The restored wetland systems were designed to handle the increased levels of boat wakes, excess nutrients, and contaminants rather than to reproduce the historic quantity, type, and structure of shoreline vegetation. To reduce boat wake impacts, the single largest contributing factor to wetland dieback, the community adopted no-wake zones for boaters on Lake Havel. Commercial boats were limited to speeds of 7.5 mph, and recreational boats were allowed 15 mph in the open water, and less than 5 mph when traveling within 300 feet of the shore.

The remaining patches of bordering wetland on Lake Havel and newly planted zones were protected in many areas using wave attenuation barriers. Materials selected vary depending on the need for short- or long-term protection from waves 1-3 feet in height. Near marinas or steeper offshore profiles, stone barriers were used. Further from regular boat traffic or on gentler profiles, biodegradable materials were used, including hardwood brush, coconut fiber, and other natural fibrous materials (such as straw, jute, sisal, and heather clippings, which were found inadequate for long-term revegetation on sites with wave action). The barriers follow a specified elevation, typically 18" below mean water level, and were designed with baffled openings to allow for water circulation and animal migration through the structure as needed.

Although innovative for inland shorelines, the concept of using bundled brush for erosion protection had been practiced for over a century. Throughout the 1970's, Bestmann sought to identify alternative materials which would provide similar mechanical erosion protection, and serve as a better growing medium for wetland plants. A variety of modular materials have been developed by Bestmann to facilitate shoreline and streambank revegetation. Fiber Rolls are cylindrical modules of densely compressed coconut fiber (9 lbs. per cubic foot) which has an extremely slow decomposition rate and high tensile strength, providing medium-term structural protection, but also offering an excellent medium for plant growth. Young plants are inserted into a Fiber Roll after it has been anchored offshore or along the streambank with wood stakes. Over time, sediment is deposited into and behind the Fiber Roll, providing a protected, organic-rich environment for plant colonization. As the coconut fiber biodegrades, it is replaced by sediment stabilized by living roots.

These Branch Boxes and Fiber Rolls provide stability for a period of five to ten years to help establish a dense stand of herbaceous vegetation sufficient to provide permanent shoreline protection. On sites where exposure to waves is simply too great, usually due to boat wakes, non-biodegradable materials offer long-term wave attenuation offshore from plantings. Some of the structures used at Lake Havel include a stone berm lying on filter cloth, a flexible gabion of stone contained by a polyethylene mesh tube, a compact stone crib contained in geosynthetic, and a Fiber Roll with a stone apron. Both the wave attenuation barrier and the vegetation are needed for the combination of strength, coverage, and

Although innovative for inland shorelines, the concept of using bundled brush for erosion protection had been practiced for over a century.

dissipation of wave energy offshore.

Behind the barrier structure, proper grading and planting techniques are important. Fill was added directly, or trapped by sedimentation structures. Vegetation was installed chiefly as Plant Carpets or the stronger Plant Pallets, coconut fiber reinforced wetland sods transplanted directly into shoreline areas. Both consist of a pre-vegetated substrate of dense coconut fiber felt encased in a woven coconut fiber wrapping. Both can be used on sites with wave action or currents too great for successful use of single plants, based on the fact that each stem and root system shelters and supports the adjacent ones, creating a collective effect. In all cases a diverse community of appropriate native species was used.

Cost/Benefit

The need for protection and restoration of the vegetation surrounding Lake Havel was recognized in formal reports as early as 1968. However, structural shoreline treatments continued as the standard solution until bioengineering replaced it in 1982. The conventional treatment consisted of riprap, ten feet wide and one foot thick, underlain by geotextile and stabilized at the toe. Once installed, this treatment required regular maintenance due mainly to ice damage. Installed riprap costs (for Germany) in today's dollar are approximately $120 per running foot shoreline. The bioengineered treatments had variable costs, depending on materials selected. These systems were not vulnerable to ice damage, and provided many natural functions the riprap did not. Installed costs for grading, fill, and Plant Pallets to form a twenty-foot wide planting belt were $125 per running foot, plus wave barrier costs. The materials and labor costs for planted Fiber Rolls, 20" in diameter were $50 per running foot; Branch Box, 18" in height was $75 per running foot; Stone Berm or Crib, 4 feet in height was $160 per running foot. After ten years of evaluation and maintenance, bioengineered solutions are considered less expensive than structural treatments. It should also be noted that the costs of both treatments, and particularly the plant materials, were inflated due to logistical problems of transportation and labor availability before the Berlin Wall fell.

It is difficult to put a dollar value on the water quality, wildlife and fish habitat, and esthetic character provided by the bioengineering systems, but the entire project has received ongoing political support, and served to increase property values of adjacent real estate — a benefit to owners and the local tax base alike. After over ten years of scrutiny, the vegetated shorelines promise to continue functioning with a minimum of maintenance and repair. More bioengineering has been added each year.

Future Growth

The United States already has its own infant history of applied bioengineering: old laws required plantings of willows along the lower Mississippi, and dune grasses on Cape Cod. During the 1930's when our Soil Conservation Service was pursuing low-cost methods, Charles Kraebel investigated species and techniques for highway embankments in arid California. Although successful, his research never achieved widespread application when the economy recovered. Not until the 1980's did bioengineering again receive serious attention. Andrew Leiser, Donald Gray, Robbin Sotir, Gary Pierce, Lothar Bestmann and other practitioners have designed and installed projects for various site conditions and generally increased public awareness of bioengineering's potential. **L&W**

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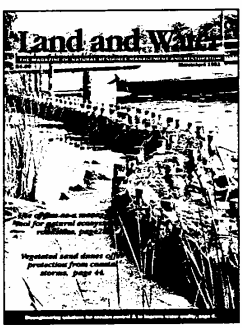

Branch Boxes were used as one of the bioengineering techniques on Lake Havel in Berlin, Germany, one of the most extensive and carefully monitored projects relating erosion control and water quality. See story on page 6.

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PHOTOS OF EAGLE CREEK PARK AND

RESERVOIR EROSION SITES

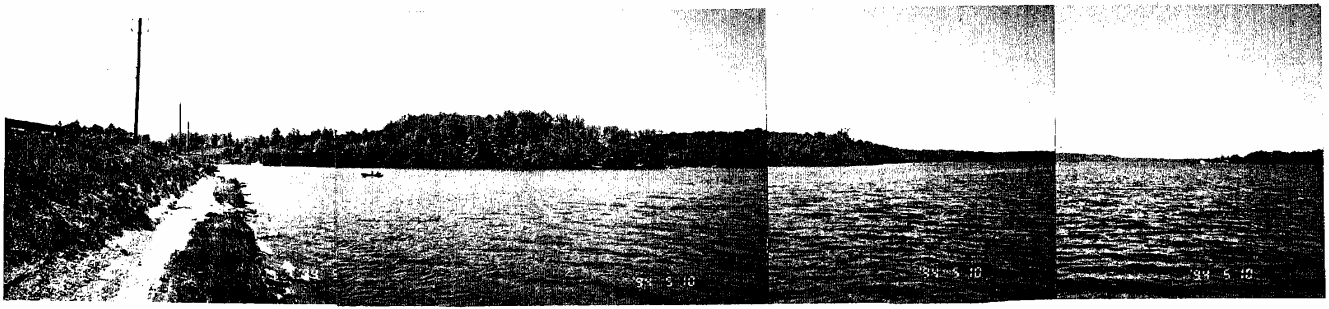
LOCATION/DESCRIPTION OF AREAS OF CONCERN: EAGLE CREEK PARK

Eagle Creek Reservoir within Eagle Creek Park flows through a north-south trendign, 20 foot to 70+ foot deep, densely wooded "gorge" incised into a stiff clayey glacial till and gravelly outwash. The locations were field checked and photographed with a 12 foot stadia rod and 6 foot man for scale. The length and height were scaled and estimated off of the photos. The cost estimate was supplied by Jim Blasek of Nutec Supply. The ranking was decided by Chuck Beard, DPR.

Rankings per DPR-EAGLE CREEK PARK

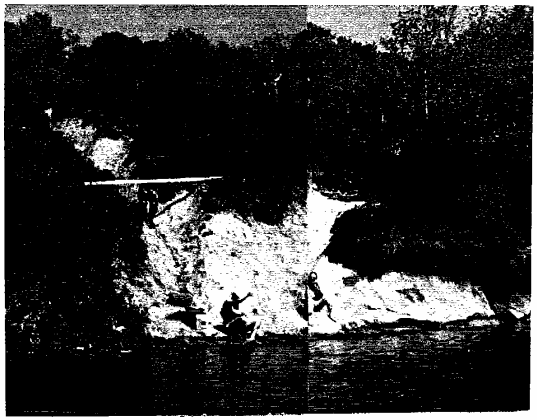
A = Very Serious; Capital Structure or major park amenity at risk; Immediate repair indicated
B = Serious to moderate; future monitoring needed; remediation likely within a few years
C = Moderate to Low; currently not a DPR priority; monitoring needed
D = Low or no problem currently ; monitoring needed

Site Name	Abbreviation	Photo Pages	Number of Erosion Sites
1. 56th Street Causeway	56C	1	2
2. 56th St Overlook Fishing Area	56OLFA	1	4
3. DeLong Creek Inlet	DCI	2	8
4. Rowing Overlook Bay	ROB	1	6
5. Rowing Course Bay	RCB	1	5
6. Fishback Creek	FC	0.5	1
7. Interstate Bay	IB	0.5	3
8. Coffer Dam (I & O)	CD (I & O)	12	30
9. Waterfowl Sanctuary Bluffs	WSB	9	18
10. Fisherman's Cove	FC	2	10
11. Walnut Point	WP	1	5
12. East Wall	EW	6	14
13. Amphitheater Inlet/SCS	AI/SCS	2	2
14. Old Growth Peninsula	OGP	1	4
15. Water Sports Center	WSC	1	4
16. Eagle Creek Beach/Admin	ECB/Admin	1	6
17. Eagle Beach (Boats)	EB	1	2
18. Private East Shoreline	PES	1	not reviewed
19. Rip Rap Bay (private)	RRB	1	not reviewed
20. Private Sand Beach	PSB	1	not reviewed
21. Hobie Beach (Boats)	HB	1	3
22. 46th Street Meadow	46M	2	1
23. 42nd Street Boat Ramp	42BR	2	8
24. Restaurant Bluff	RB	2	6
25. Southeast Bluff	SEB	2	4 (9)
26. Eagle Creek Dam	Dam	1	not reviewed
27. Borrow Pit Bay	BPB	1	4
28. School Creek Inlet	SCI	5	20
29. Southwest Bluffs	SWB	1	3

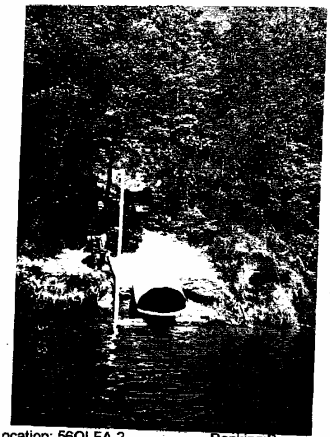


1. 56th Street Causeway 56C 1 2
Location: 56C-1 Ranking:C/D Estimated Cost:$NONE
Brief Description: L:1200 H:2 WAVE UNDERCUT EMBANKMENT

Location: 56C-2 Ranking:C/D Estimated Cost:$NONE
Brief Description: L:1200 H:2

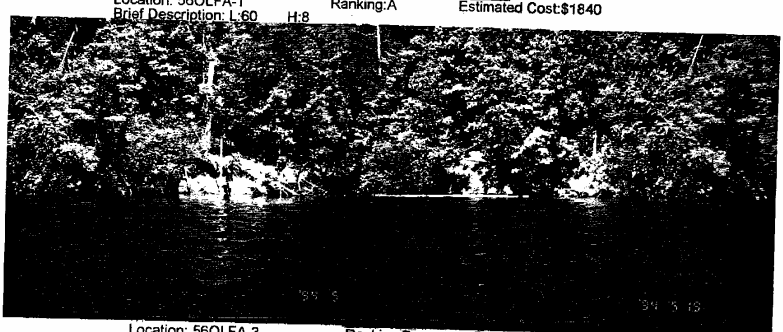


Location: 56OLFA-1A Ranking:B Estimated Cost:$1850
Brief Description: L:40 H:30

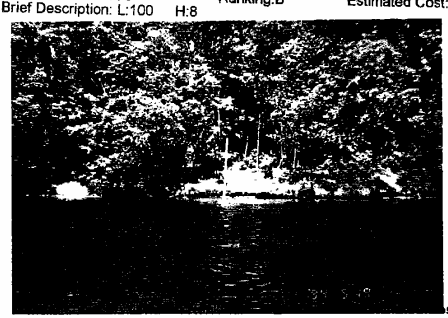


Location: 56OLFA-2 Ranking:B
Brief Description: L:10+ H:20 Estimated Cost:$550

2. 56th St Overlook Fishing Area 56OLFA 1 4
Location: 56OLFA-1 Ranking:A Estimated Cost:$1840
Brief Description: L:60 H:8

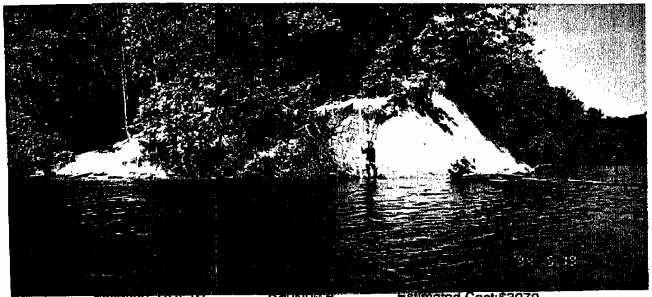


Location: 56OLFA-3 Ranking:B Estimated Cost:$3070
Brief Description: L:100 H:8

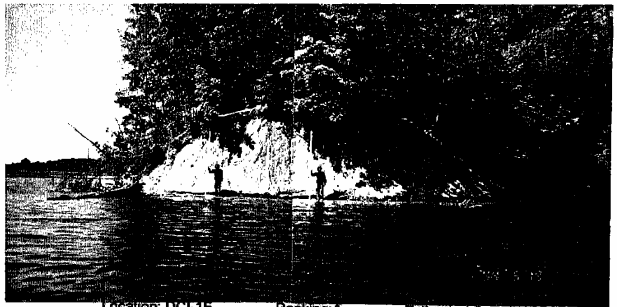


st:1465

2. 56th St Overlook Fishing Area 56OLFA



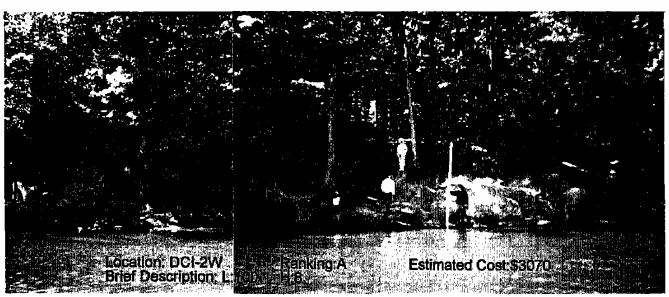
Ranking:A
Brief Description: L:100 H:8
Estimated Cost:$3070



Location: DCI-1E
Brief Description: L:50 H:20
Ranking:A
Estimated Cost:$1960

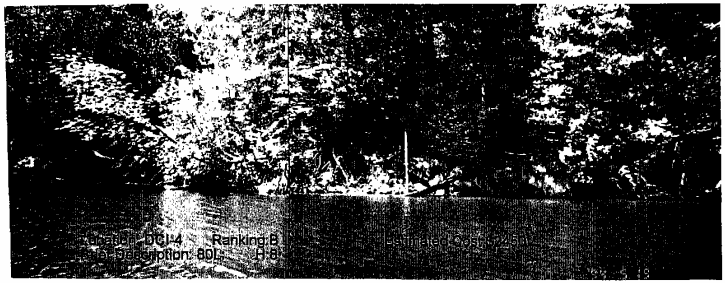
Location:
Brief Des
960

Location: DCI-2E
Brief Description: L:100 H:8
Ranking:A
Estimated Cost:$3070

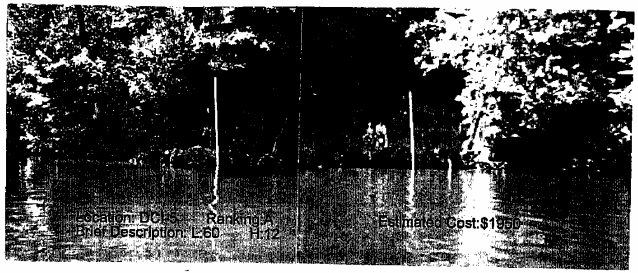


Location: DCI-2W
Brief Description: L:
Ranking:A
Estimated Cost:$3070

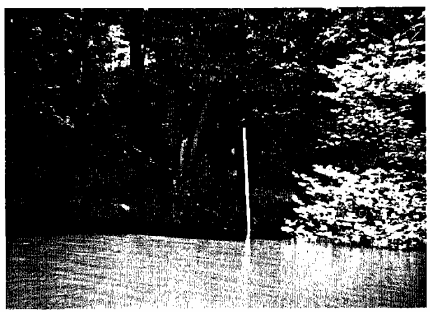
3. DeLong Creek Inlet DCI



Location: DCI-4 Ranking:B
Brief Description: 60L H:8



Location: DCI-5 Ranking:A
Brief Description: L:60 H:12
Estimated Cost:$1950



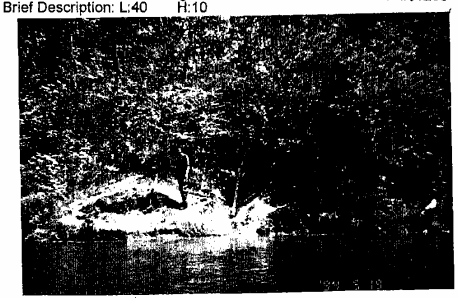
Location: DCI-6 Ranking:B
Brief Description: L:40 H:10

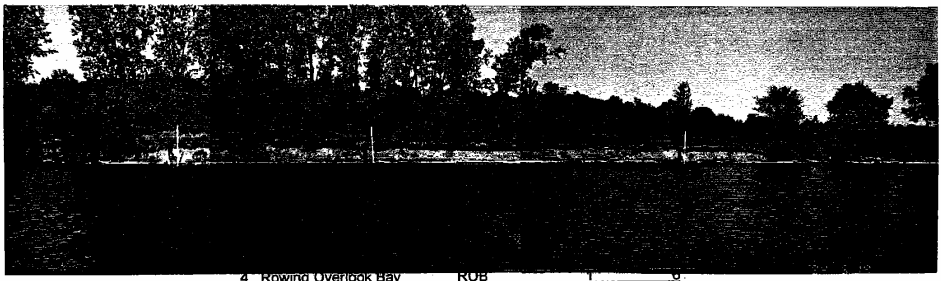
Estimated Cost:$1280

Location: DCI-7 Ranking:B/C
Brief Description: L:20 H:6+
Estimated Cost:$600

Location: DCI-8 Ranking:B/C
Brief Description: L:25 H:6+

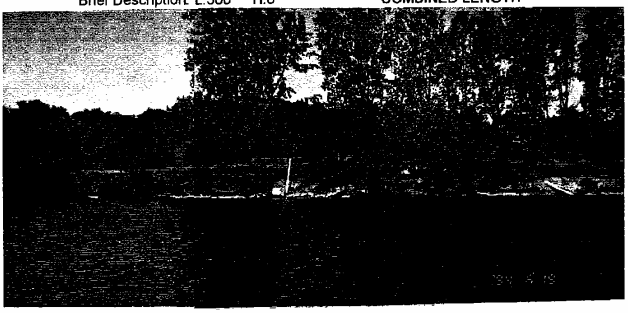
Estimated Cost:$900





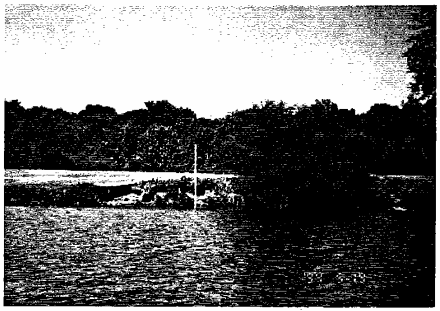
4. Rowing Overlook Bay ROB
Location: ROB-1/2 Ranking:B Estimated Cost:$15,400
Brief Description: L:500 H:8 COMBINED LENGTH

1



2

Location: ROB-3/4/5 Ranking:B Estimated Cost:$2250
Brief Description: L:160 H:4 COMBINED LENGTH



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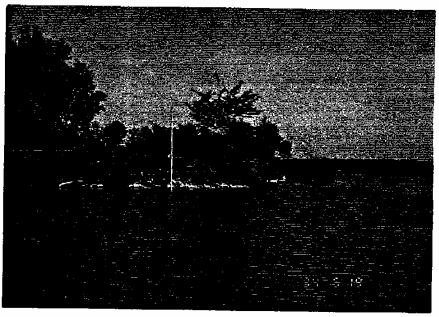

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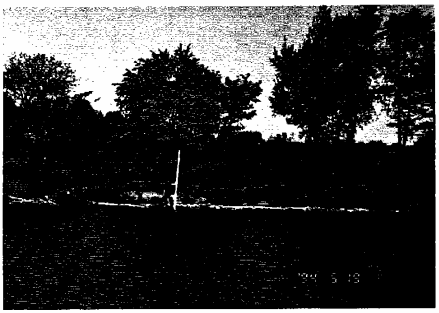
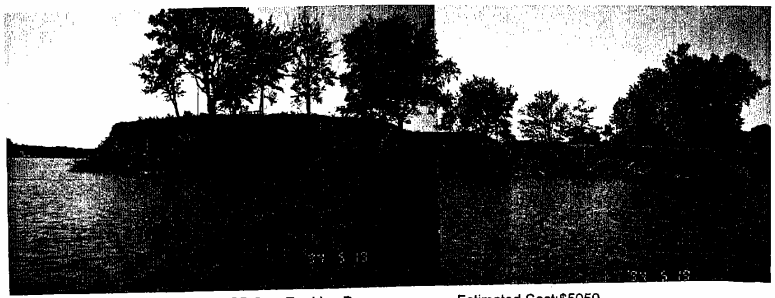


5

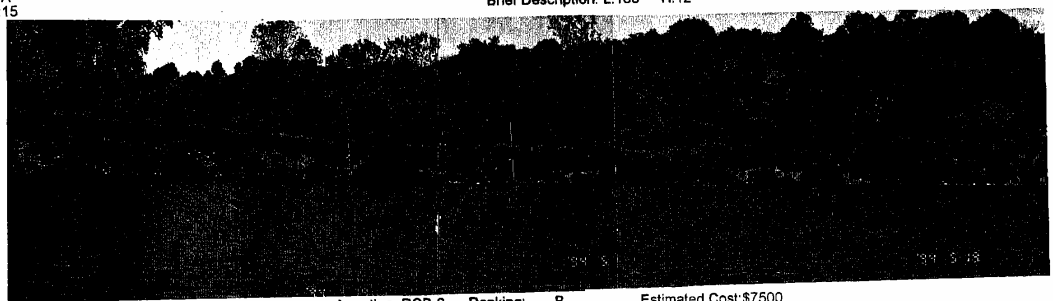
Location: ROB-6 Ranking: A/B+ Estimated Cost:$5275
Brief Description: L:100 H:15

5. Rowing Course Bay RCB

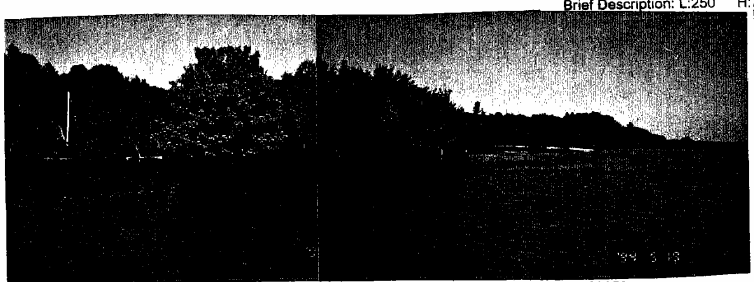
5. Rowing Course Bay RCB 1 5
Location: RCB-1 Ranking:A Estimated Cost:$3950
Brief Description: L:75 H:15



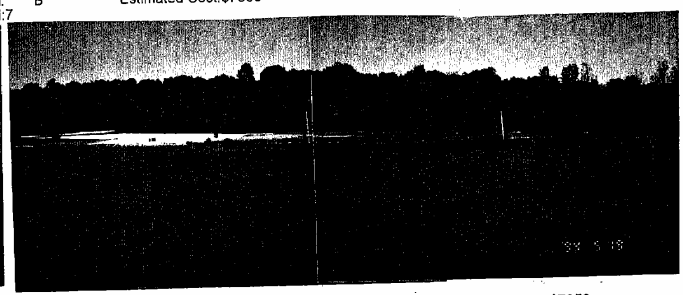
Location: RCB-2 Ranking:B Estimated Cost:$5050
Brief Description: L:150 H:12



Location: RCB-3 Ranking: B Estimated Cost:$7500
Brief Description: L:250 H:7

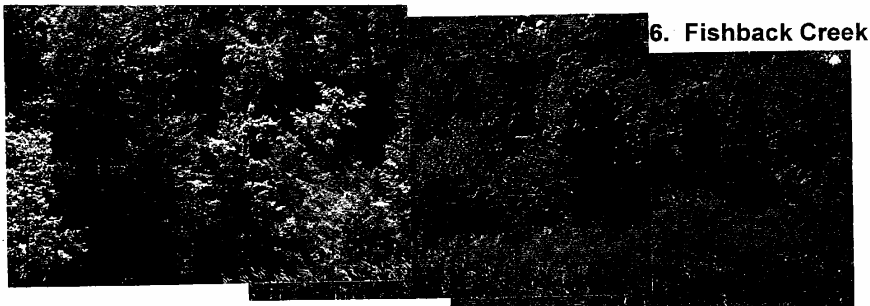


Location: RCB-4 Ranking:C Estimated Cost:$2350
Brief Description: L:80 H:6

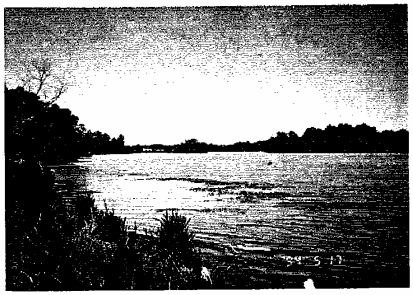


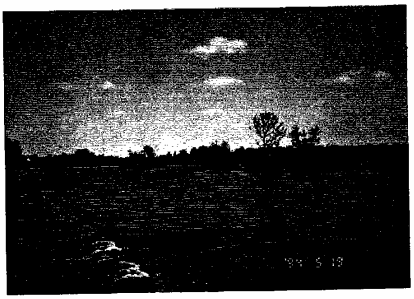
Location: RCB-5 Ranking:C Estimated Cost:$7950
Brief Description: L:300 H:2

6. Fishback Creek

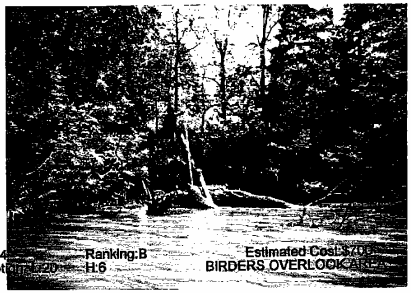


6. Fishback Creek FC 0.5 1
Location: FC-1 Ranking: C/D Estimated Cost:$22
Brief Description: L:200 H:60 LARGE NATURAL STREAM CUT





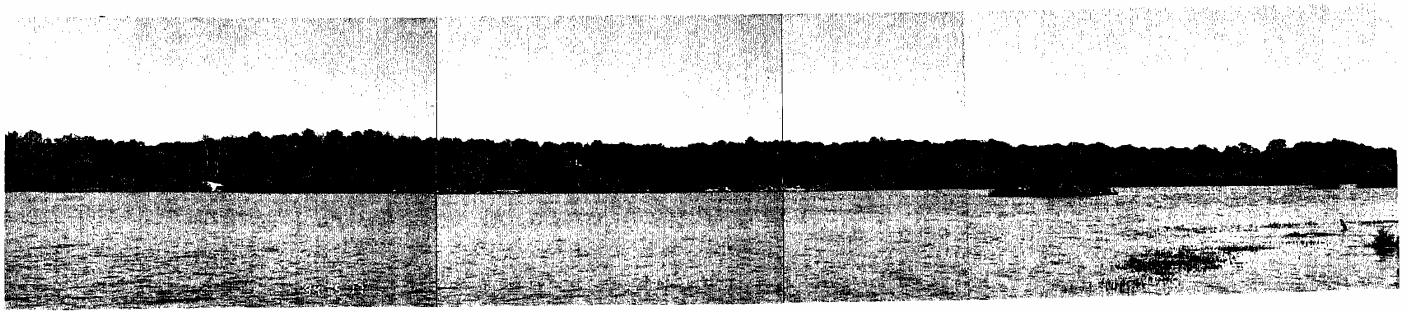
7. Interstate Bay IB 0.5 3
Location: IB-1 Ranking:C Estimated Cost:$675
Brief Description: L:25 H:2 BIRDERS NORTH BAY VIEV



Location: IB-4 Ranking:B Estimated Cost:$700
Brief Description: L:20 H:6 BIRDERS OVERLOOK AREA

Location: IB-2 Ranking:C Estimated Cost:$5000
Brief Description: L:200 H:10 BIRDERS OVERLOOK AREA

7. Interstate Bay IB



8. Coffer Dam (I & O) **CD (I & O)**

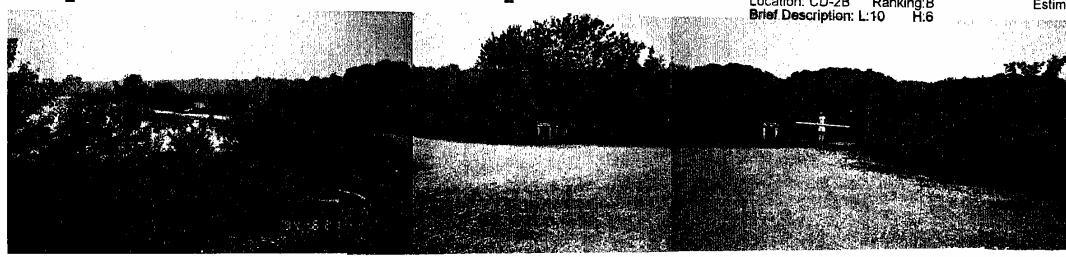
Location: CD-1 Ranking:D Estimated Cost:$1300
Brief Description: L:60 H:2

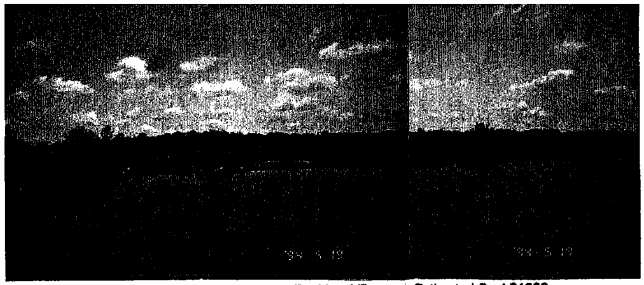
Location: CD-2A Ranking:B Estimated Cost:$300
Brief Description: L:10 H:6

2

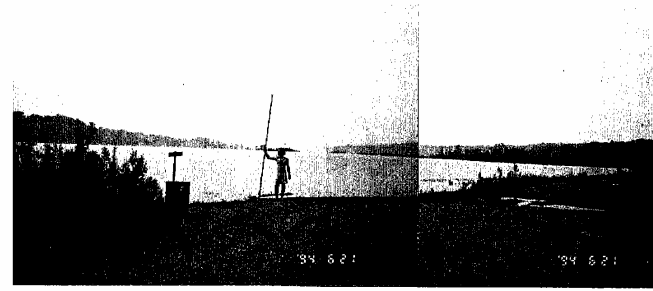
2

Location: CD-2B Ranking:B Estimated Cost:$300
Brief Description: L:10 H:6





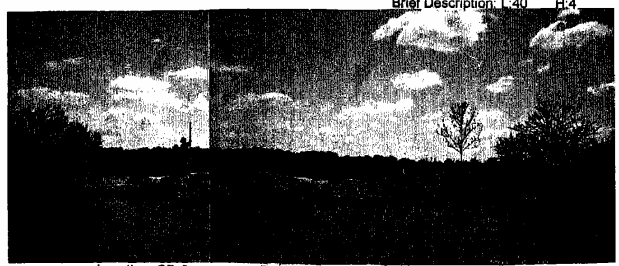
Location: CD-3 Ranking:A/B Estimated Cost:$1600
Brief Description: L:30 H:4



3

Location: CD-4 Ranking:A/B Estimated Cost:$1600
Brief Description: L:40 H:4

Location: CD-5 Ranking:A/B Estimated Cost:$375
Brief Description: L:15 H:3



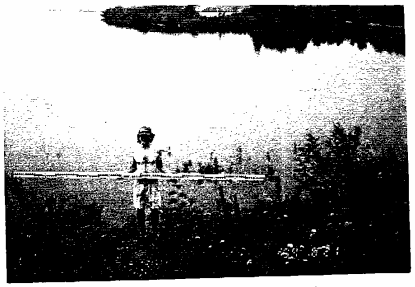
Location: CD-6 Ranking:A Estimated Cost:$1900
Brief Description: L:80 H:4

Location: CD-7A Ranking:C
Brief Description: L:75 H:3

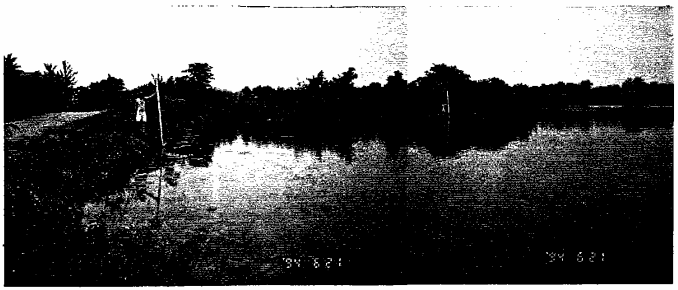
Estimated Cost:$1700

Location: CD-7B Ranking:C
Brief Description: L:30 H:1

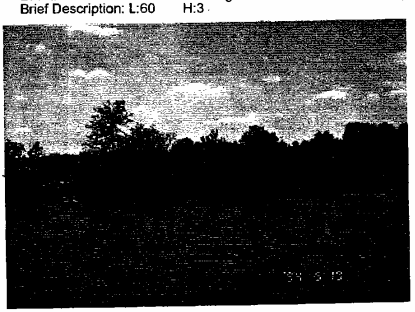
Estimated Cost:$700



Location: CD-8 Ranking:C Estimated Cost:$175
Brief Description: L:10 H:1

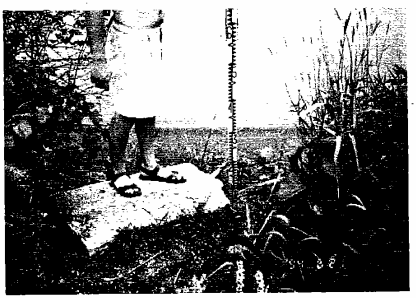


Location: CD-9 Ranking:C Estimated Cost:$1400
Brief Description: L:60 H:3

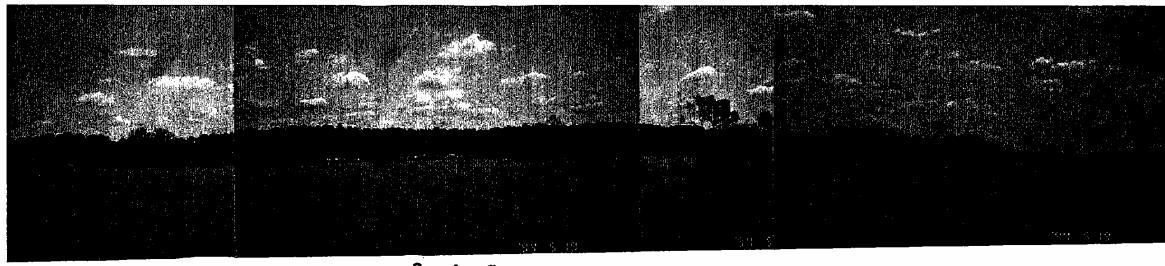


Location: CD-10 Ranking:D Estimated Cost:$200
Brief Description: L:6 H:6

Location: CD-11 Ranking:D Estimated Cost:$200
Brief Description: L:6 H:3



Location: CD-12 Ranking:D Estimated Cost:$250
Brief Description: L:6 H:2



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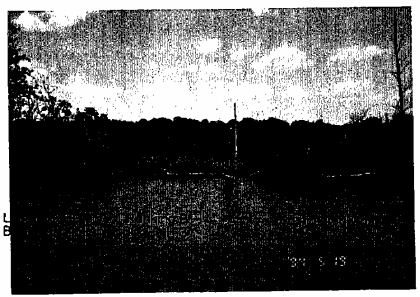


Location: CD-16A Ranking:C
Brief Description: L:300 H:1

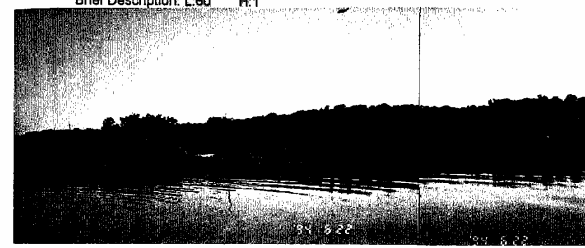
Estimated Cost:$6300

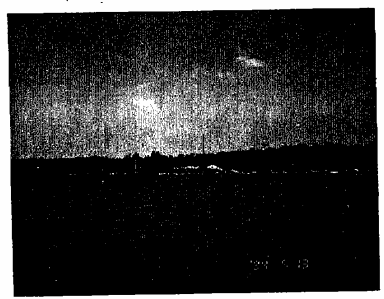
Location: CD-16B Ranking:C
Brief Description: L:30 H:2

Estimated Cost:$700

Location: CD-16C Ranking:C
Brief Description: L:60 H:1

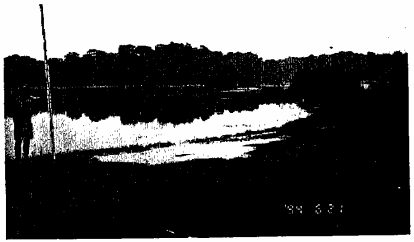
Estimated Cost:$1300

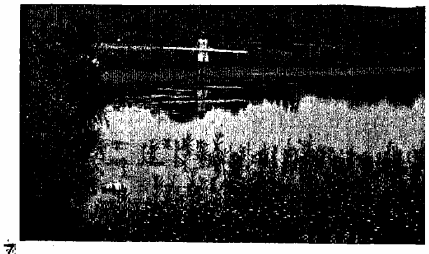




Location: CD-17 Ranking:B
Brief Description: L:300 H:2

Estimated Cost:$12,500
OUTSIDE OF COFFER DAM





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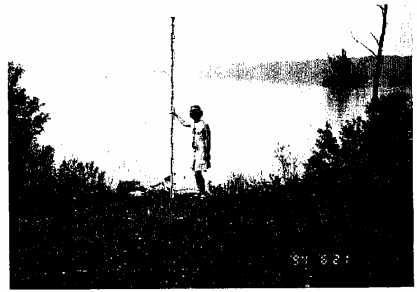
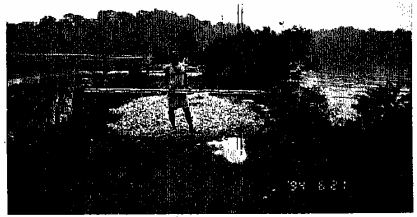


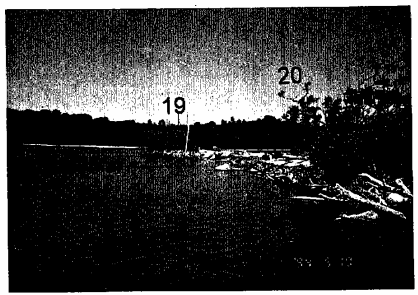
Location: CD-18 Ranking:C
Brief Description: L:20 H:2

Estimated Cost:$900

Location: CD-19 Ranking:A
Brief Description: L:50 H:1-2

Estimated Cost:$2100





19

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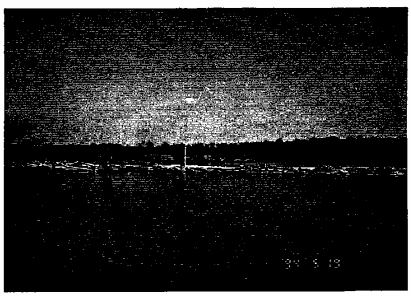
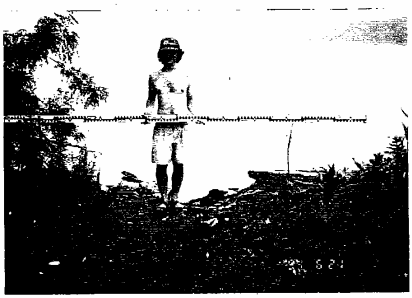
21

Location: CD-20-26 Ranking:A
Brief Description: L:1290 H:1

Estimated Cost:$52,700
LONG COMBINED SEGMENT





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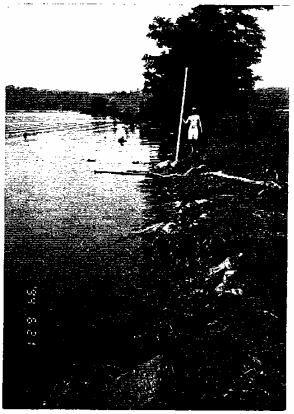
26



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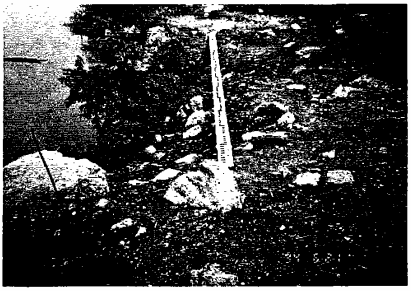
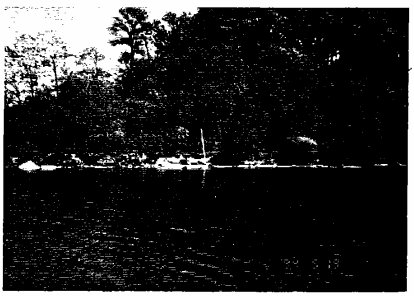


Location: CD-27 Ranking:A/B
Brief Description: L:40 H:2

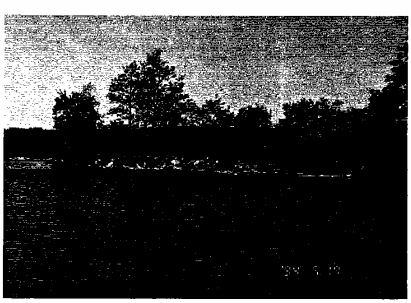
Estimated Cost:$900



Location: CD-28 Ranking:B
Brief Description: L:100 H:3

Estimated Cost:$2300

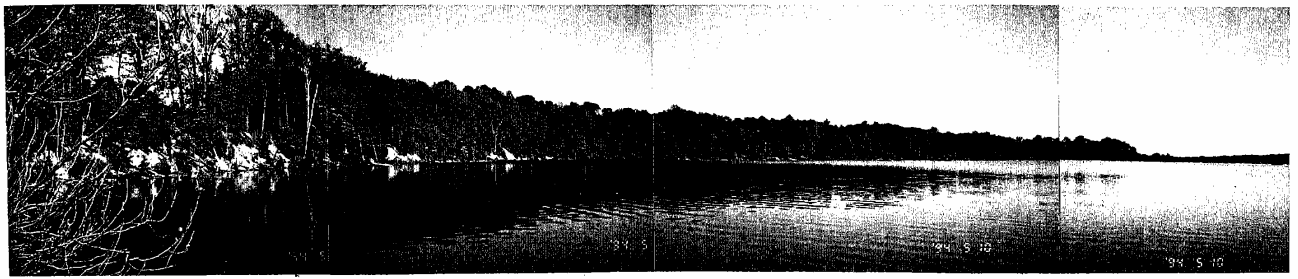
29



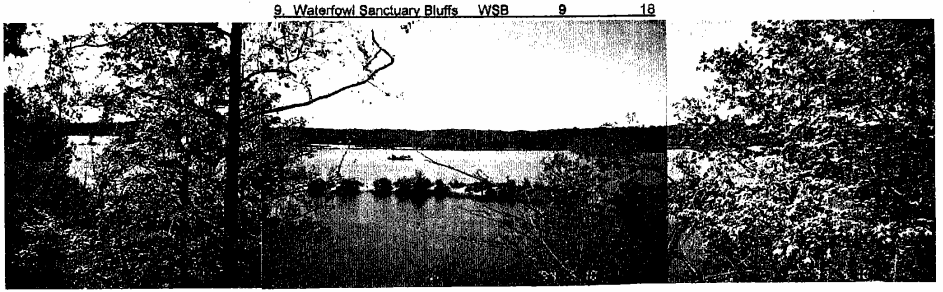
.ocation: CD-29-30 Ranking:B/C
3rief Description: L:400+ H:3

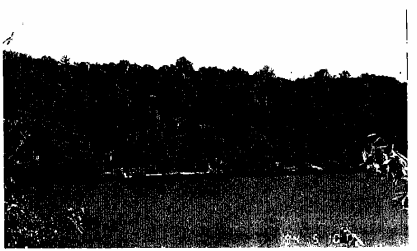
Estimated Cost:$9000

30

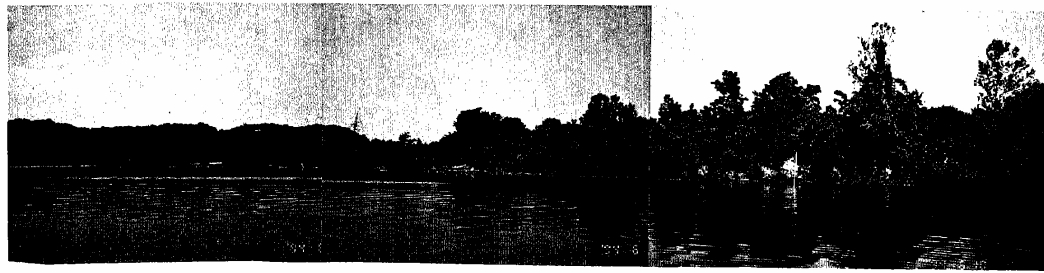


9. Waterfowl Sanctuary Bluffs WSB 9 18





9. Waterfowl Sanctuary Bluffs WSB



Location: WSB-1 Ranking:A
Brief Description: L:100 H:2

Estimated Cost:$3400

Location: WSB-2 Ranking:B
Brief Description: L:200+ H:10

Estimated Cost:$8000

Location: WSB-3 Ranking:B
Brief Description: L:150 H:6

Estimated Cost:$5500

1

1

Location: WSB-4 Ranking:B
Brief Description: L:200 H:6

Estimated Cost:$9300

4

Location: WSB-5 Ranking:B
Brief Description: L:450+ H:18+

Estimated Cost:$26,000

Location: WSB-6 Ranking:B
Brief Description: L:300 H:18+

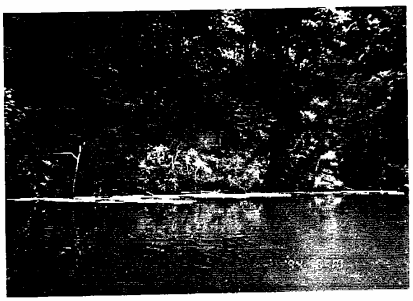
Estimated Cost:$19,000

Location: WSB-7 Ranking:B
Brief Description: L:150 H:20

Estimated Cost:$27,600

Location: WSB-8 Ranking:B
Brief Description: L:130 H:15

Estimated Cost:$8400



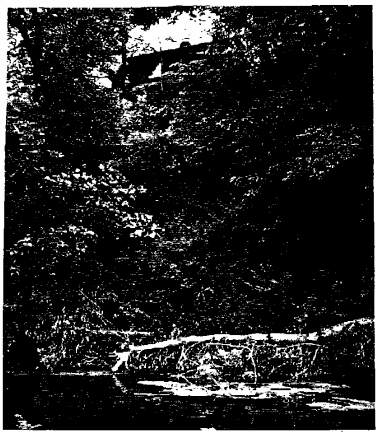
Location: WSB-9 Ranking:A
Brief Description: L:100 H:15

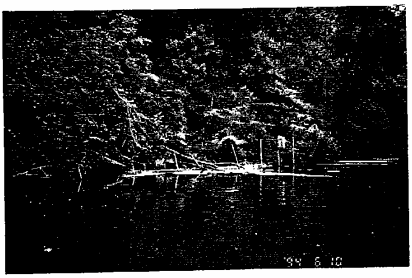
Estimated Cost:$5600

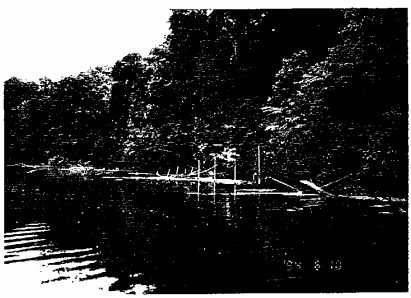
Location: WSB-10 Ranking:A
Brief Description: L:500+ H:10-50

Estimated Cost:$215,000
NATURE CENTER SLOPE

NATURE CENTER SLOPE



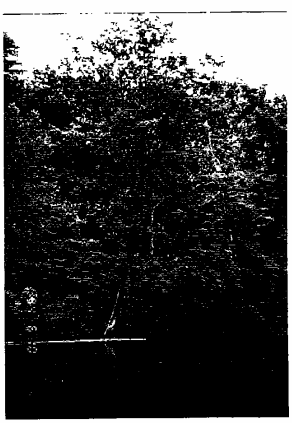




Location: WSB-11 Ranking:A
Brief Description: L:600? H:60

Estimated Cost:$83,200

NATURE CENTER SLOPE

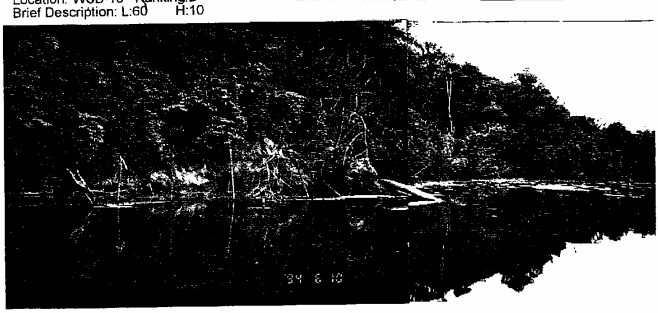


Location: WSB-12 Ranking:B
Brief Description: L:300? H:2

Estimated Cost:$7200

Location: WSB-13 Ranking:B
Brief Description: L:60 H:10

Estimated Cost:$2400



Location: WSB-14 Ranking:B
Brief Description: L:80+ H:10

Estimated Cost:$3200

Location: WSB-15 Ranking:B
Brief Description: L:120+ H:2

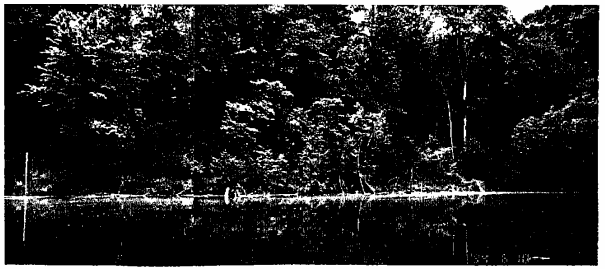
Estimated Cost:$7200

Location: WSB-16A Ranking:NONE
Brief Description: L: H:

Estimated Cost:$NONE
OLD ROAD

Location: WSB-16 Ranking:B
Brief Description: L:150 H:20

Estimated Cost:$9000



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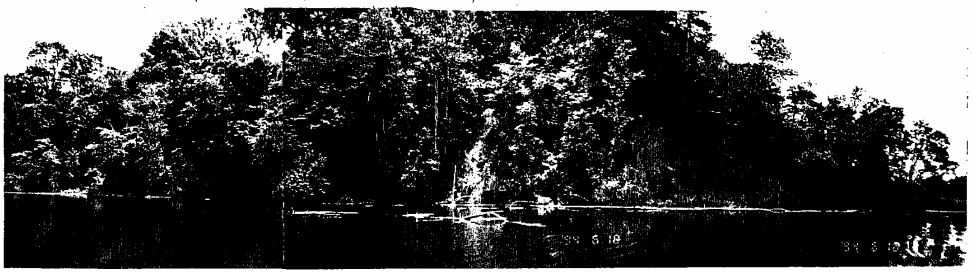
Location: WSB-17 Ranking:B
Brief Description: L:120+ H:15

Estimated Cost:$6600



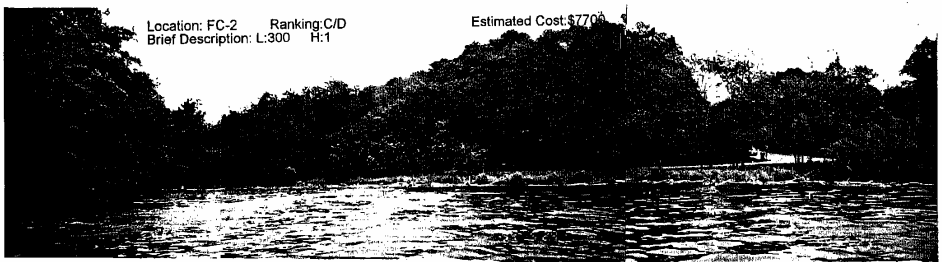
Location: WSB-18 Ranking:A
Brief Description: L:140+ H:40-50

Estimated Cost:$14,600

10. Fisherman's Cove
FC

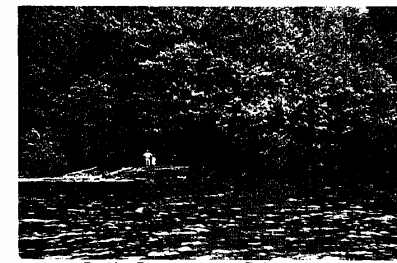
10. Fisherman's Cove FC
Location: FC-1 Ranking:B
Brief Description: L:180 H:10

Estimated Cost:$6000



Location: FC-2 Ranking:C/D
Brief Description: L:300 H:1

Estimated Cost:$770



Location: FC-3 Ranking:D
Brief Description: L:50 H:2

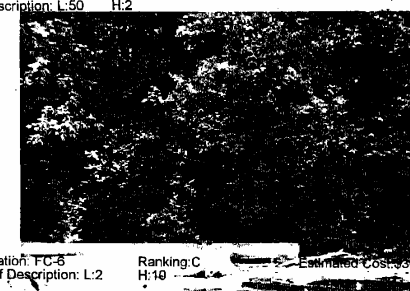
Estimated Cost:$13,500

Location: FC-4 Ranking:D
Brief Description: L:10 H:4

Estimated Cost:$300

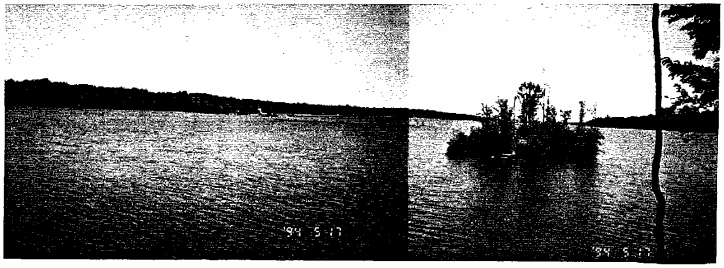
Location: FC-5 Ranking:C
Brief Description: L:15 H:15

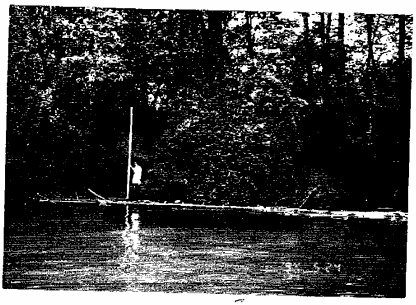
Estimated Cost:$6000



Location: FC-6 Ranking:C
Brief Description: L:2 H:10

Estimated Cost:$300





Location: FC-7 Ranking:A
Brief Description: L:50 H:10

Estimated Cost:$1700

Location: FC-8A Ranking:A
Brief Description: L:10 H:10+

Estimated Cost:$400

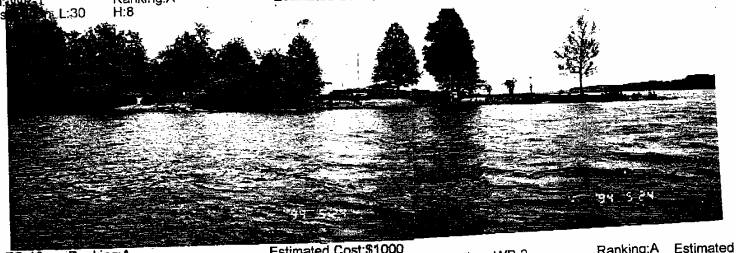
Location: FC-8B Ranking:A
Brief Description: L:15 H:10+

Estimated Cost:$500

Location: FC-9 Ranking:A
Brief Description: L:50 H:12

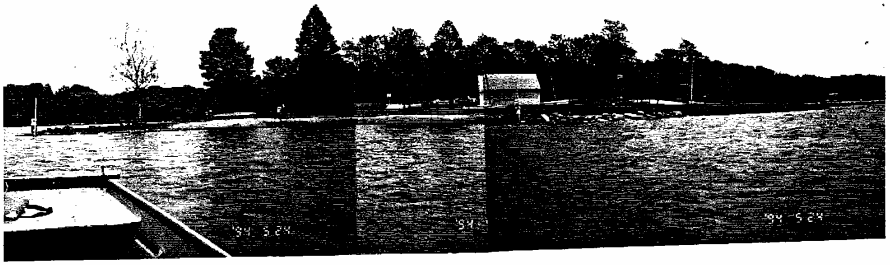
Estimated Cost:$1700

11. Walnut Point WP 1 5
Location: WP-1 Ranking:A Estimated Cost:$1000
Brief Des[illegible] L:30 H:8



Location: FC-10 Ranking:A Estimated Cost:$1000
Brief Description: L:30 H:8

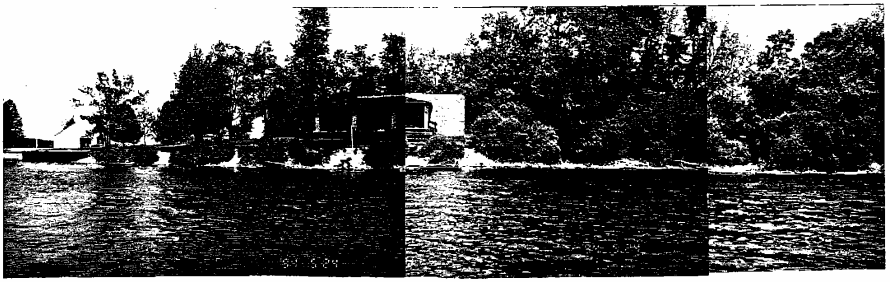
Location: WP-2 Ranking:A Estimated Cost:$2800
Brief Description: L:100+ H:4



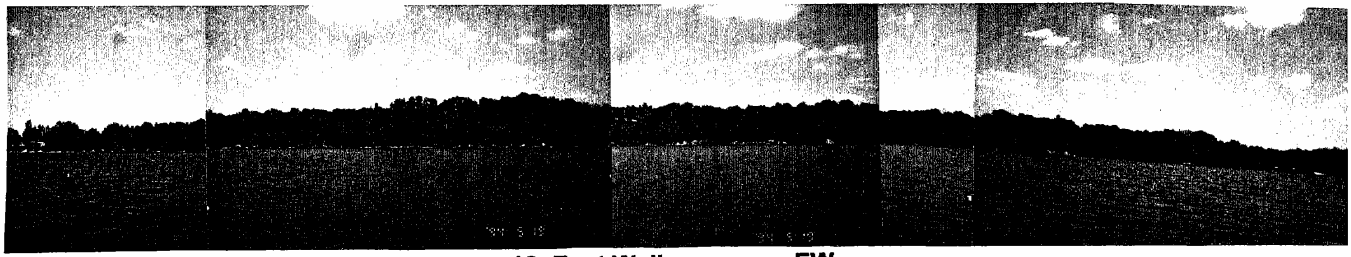
Location: WP-3 Ranking:A Estimated Cost:$4200
Brief Description: L:150 H:3-4

Location: WP-4 Ranking:A Estimated Cost:$1250
Brief Description: L:50 H:3-4

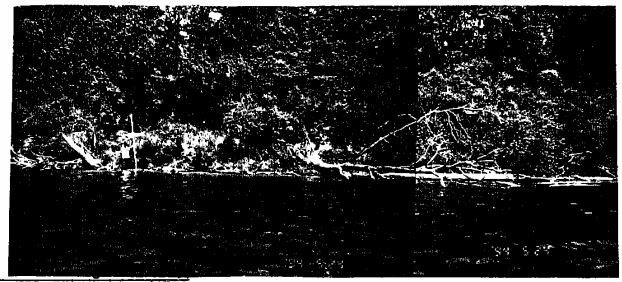
11. Walnut Point WP



Location: WP-5 Ranking:A Estimated Cost:$3250
Brief Description: L:130 H:6

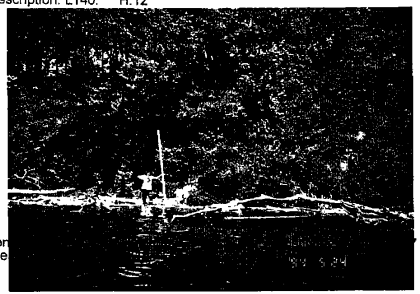


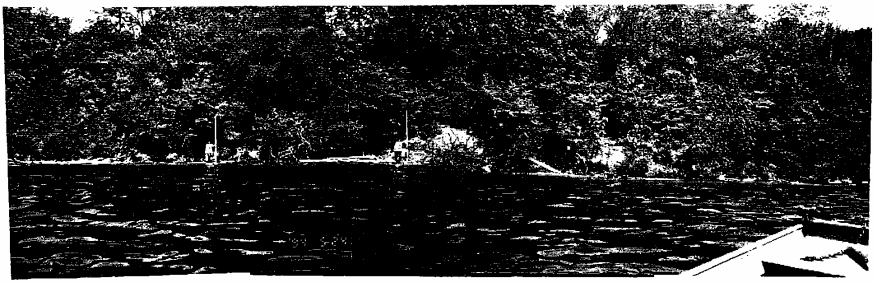
12. East Wall EW



12. East Wall EW
Location: EW-1 Ranking:B Estimated Cost:$6764
Brief Description: L140: H:12

Location
Brief De





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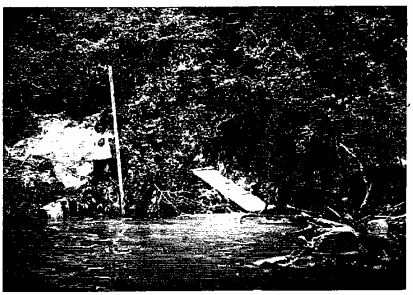
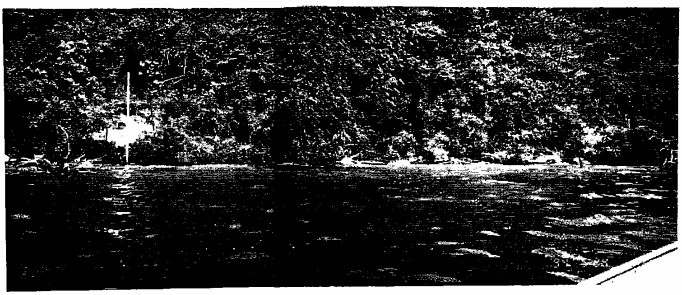
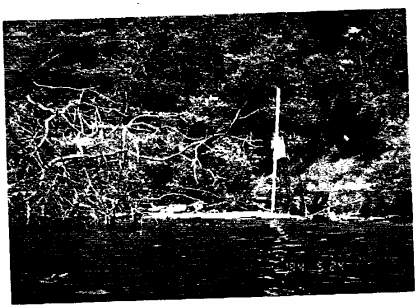


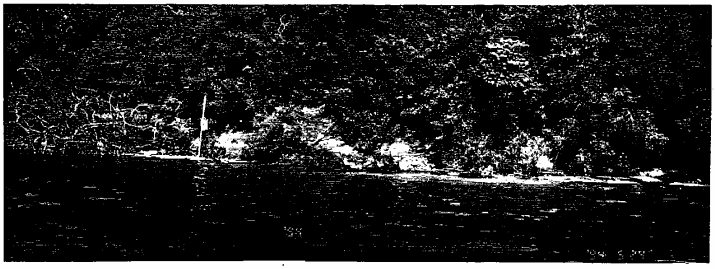
Location: EW-3 Ranking:B Estimated Cost:$5319
Brief Description: L:110 H:12



Location: EW-4 Ranking:B Estimated Cost:$3632
Brief Description: L:75 H:8



Location: EW-5 Ranking:B Estimated Cost:$12,093
Brief Description: L:250 H:10



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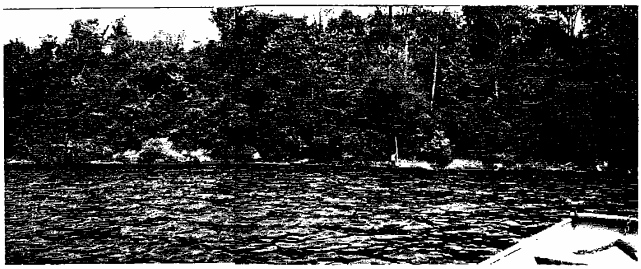

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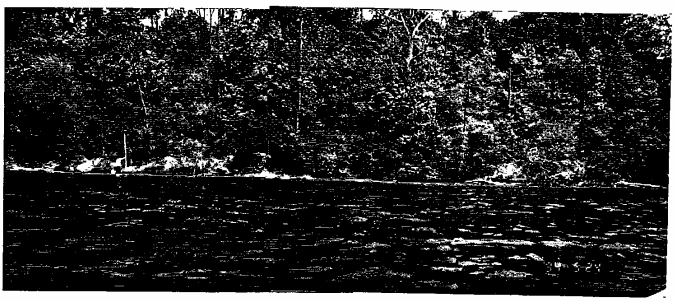
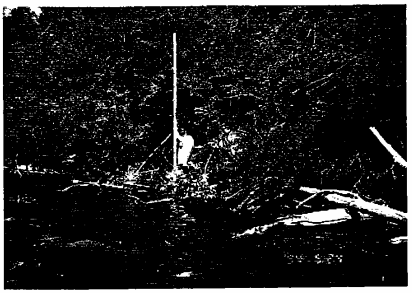
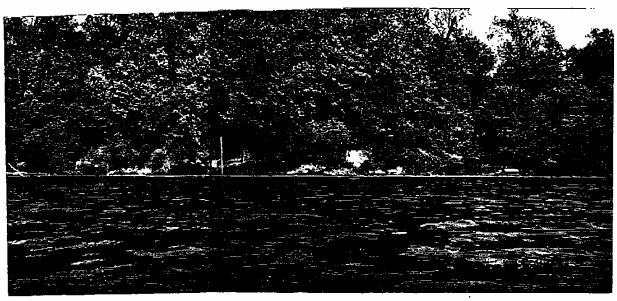


Location: EW-6 Ranking:B Estimated Cost:$9674
Brief Description: L:200 H:10

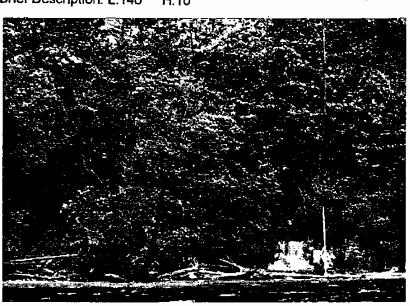
6 7

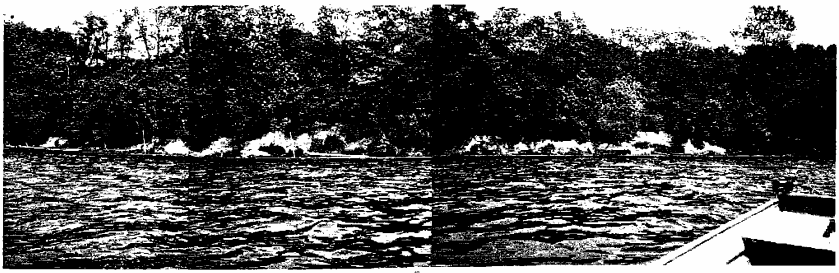




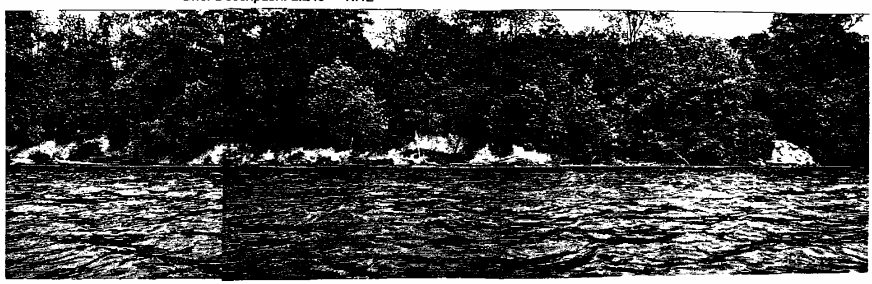
Location: EW-7 Ranking:B Estimated Cost:$6292
Brief Description: L:130 H:10

Location: EW-8 Ranking:B Estimated Cost:$6764
Brief Description: L:140 H:10





Location: EW-9 Ranking:B Estimated Cost:$11,611
Brief Description: L:240 H:12



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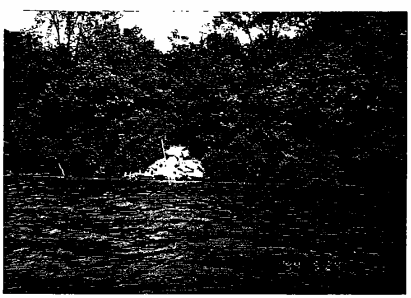
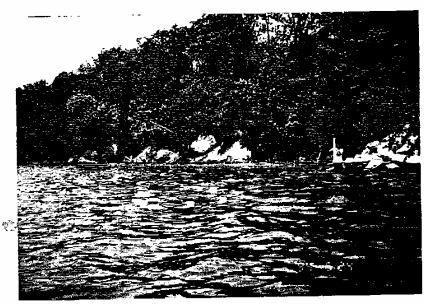
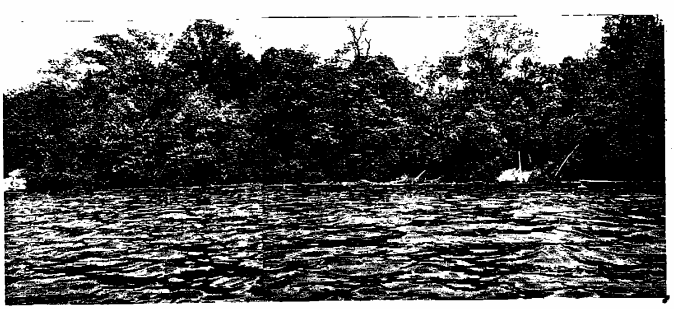


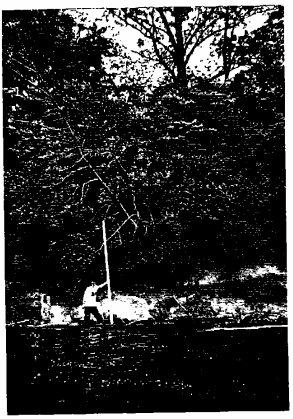


Location: EW-10 Ranking:B Estimated Cost:$1454
Brief Description: L:30 H:15



Location: EW-11 Ranking:B Estimated Cost:$9674
Brief Description: L:200 H:10

11

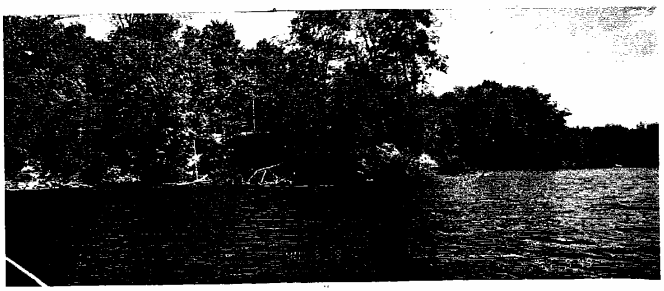


12

13

Location: EW-12-14Ranking:B
Brief Description: L:300 H:12

Estimated Cost:$14,521



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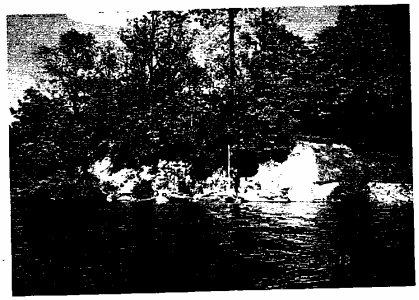
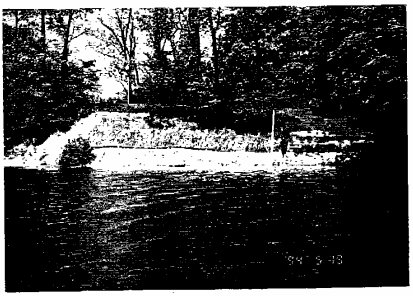
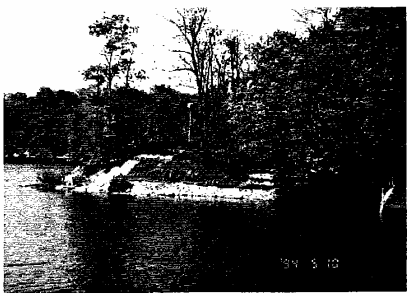
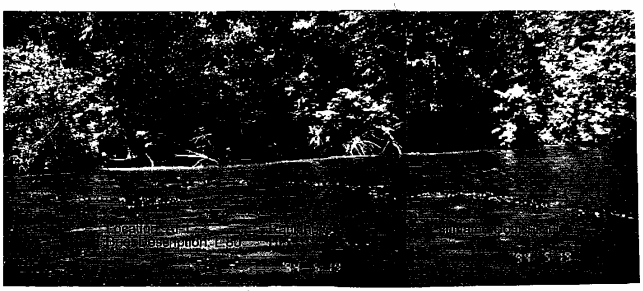


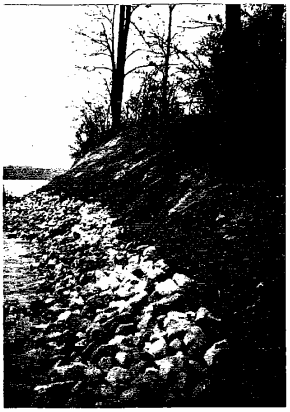


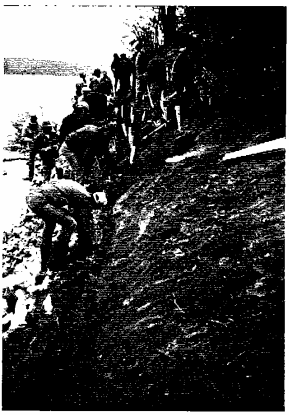
13. Amphitheater Inlet/SCS AI/SCS 2 2
Location: SCS-1 Ranking:B Estimated Cost:$4300
Brief Description: L:100 H:20

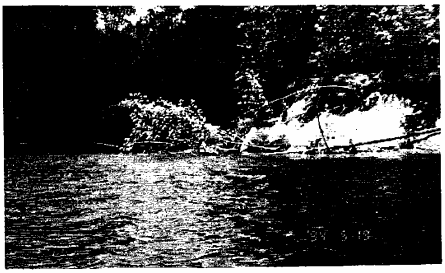


13. Amphitheater Inlet/SCS AI/SCS

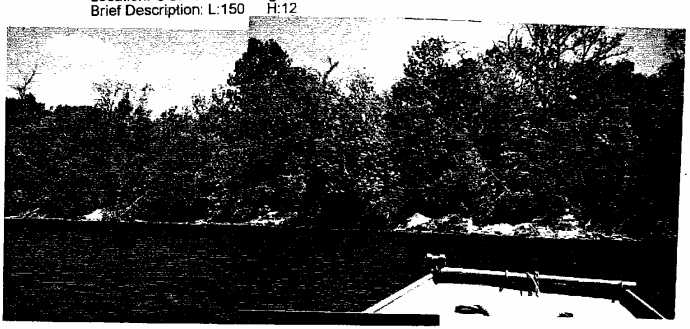




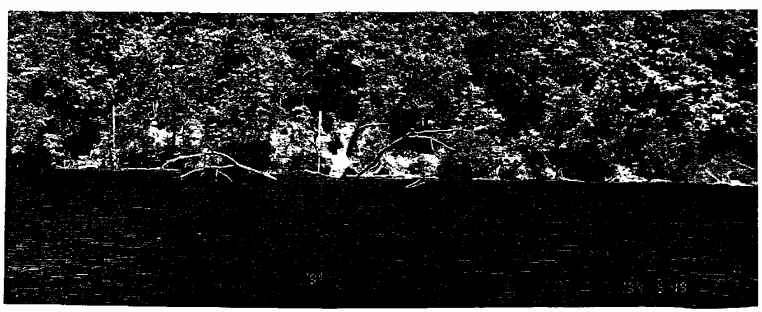




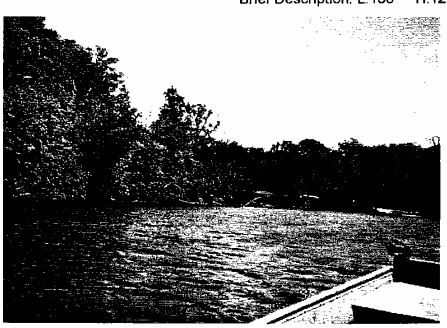
14. Old Growth Peninsula OGP 1 4
Location: OGP-1 Ranking:A Estimated Cost:$5900
Brief Description: L:150 H:12



Location: OGP-2 Ranking:B Estimated Cost:$5700
Brief Description: L:150 H:10



Location: OGP-3 Ranking:B Estimated Cost:$5900
Brief Description: L:130 H:12



3 1

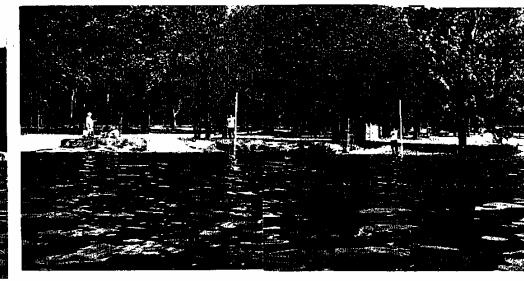
Location: OGP-4 Ranking:B Estimated Cost:$3700
Brief Description: L:100 H:8

15. Water Sports Center WSC

15. Water Sports Center WSC 1 4
Location: WSC-1 Ranking:A Estimated Cost:$4560
Brief Description: L:140 H:10

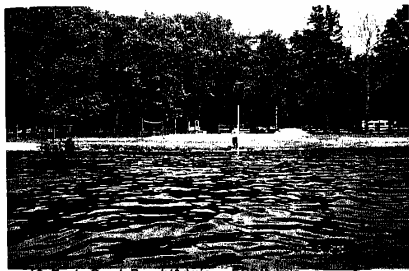
Location: WSC-2 Ranking:B Estimated Cost:$5900
Brief Description: L:200 H:5

Location: WSC-3 Ranking:B Estimated Cost:$5900
Brief Description: L200: H:15

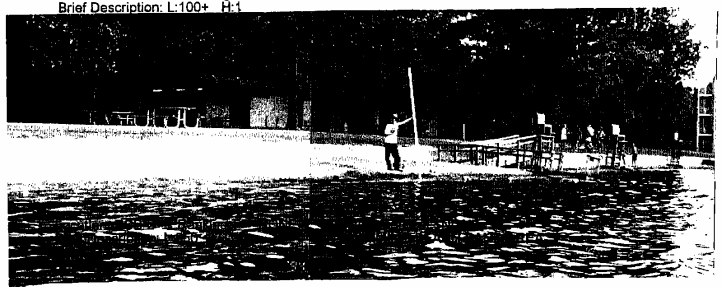


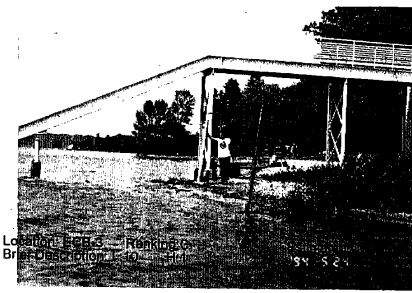
Location: WSC-4 Ranking:B Estimated Cost:$2150
Brief Description: L:75 H:2

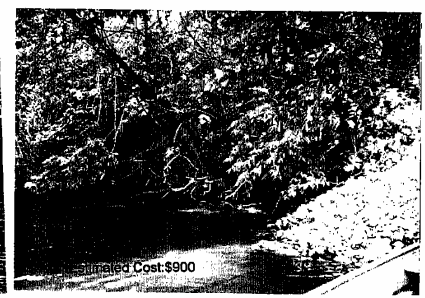
16. Eagle Creek Beach/Admi ECB/Admin



16. Eagle Creek Beach/Admin ECB/Admin
Location: ECB-1 Ranking:D Estimated Cost:$2000
Brief Description: L:100+ H:1

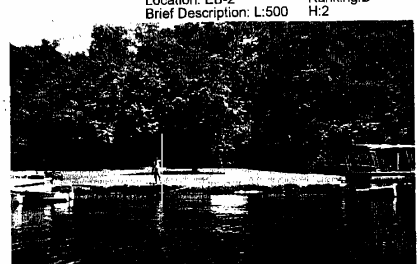




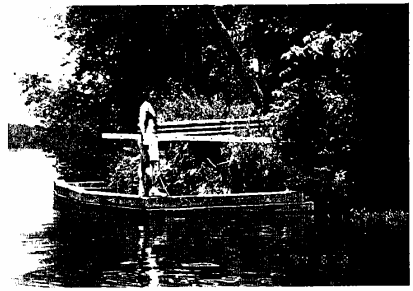


17. Eagle Beach (Boats) EB 1 2
Location: EB-1 Ranking:D Estimated Cost:$6500
Brief Description: L:300 H:1

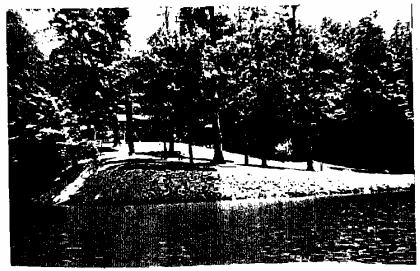
Location: EB-2 Ranking:D Estimated Cost:$1500
Brief Description: L:500 H:2



17. Eagle Beach (Boats) EB

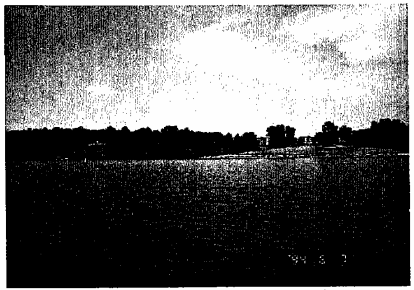


18. Private East Shoreline PES

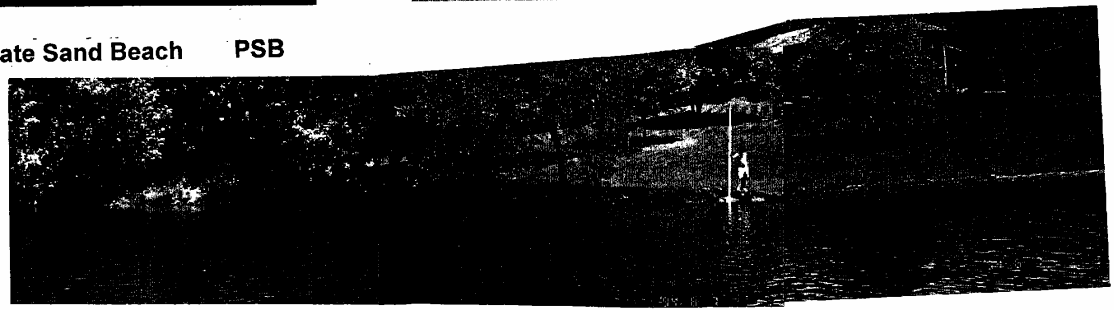


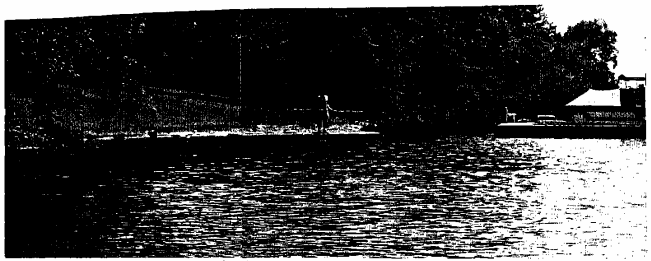
19. Rip Rap Bay (private) **RRB**

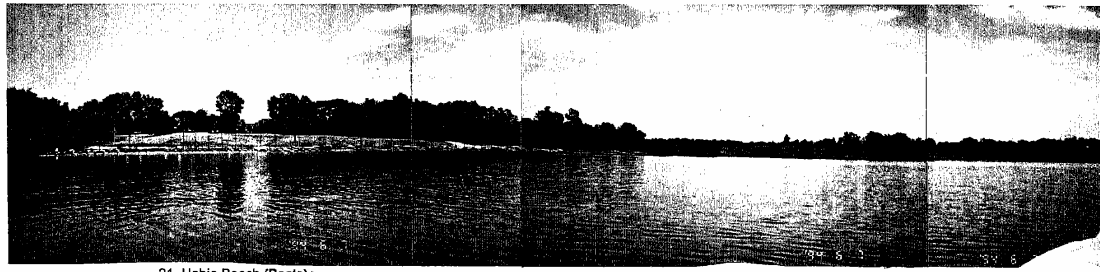
East Shoreline



20. Private Sand Beach PSB



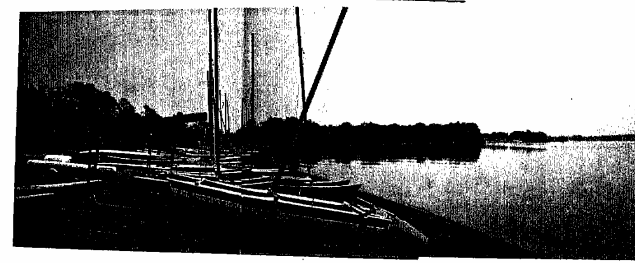




21. Hobie Beach (Boats)

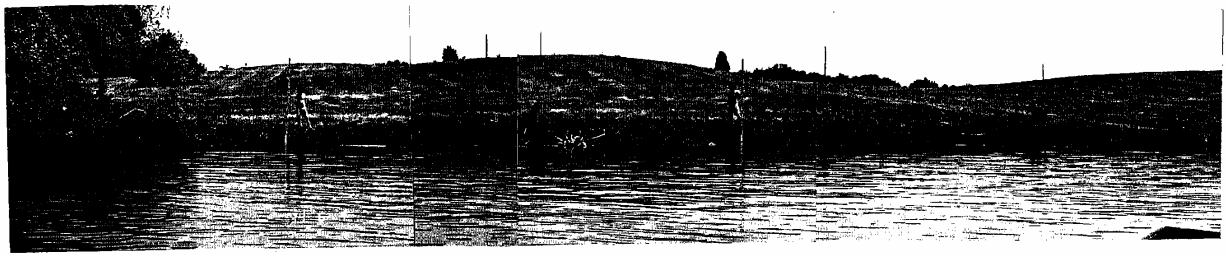
22. 46th Street Meadow

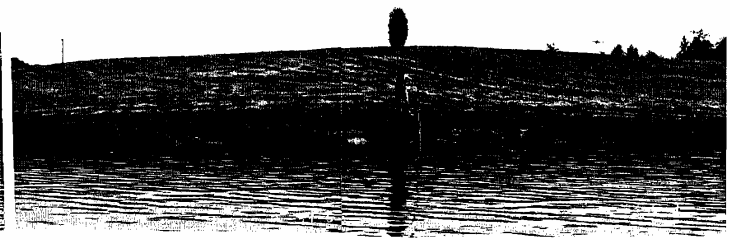
Location: HB-1 Ranking:C Estimated Cost:$700
Brief Description: L:400 H:4



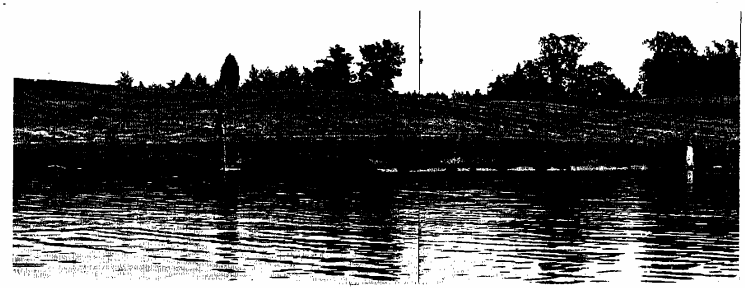
Location: HB-2-3 Ranking:NONE Estimated Cost:$NONE
Brief Description: L: H: BEACH AREA

21. Hobie Beach (Boats) HB

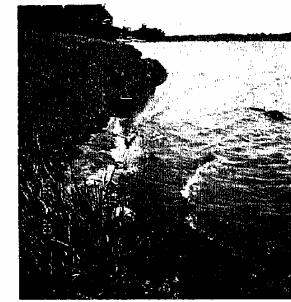


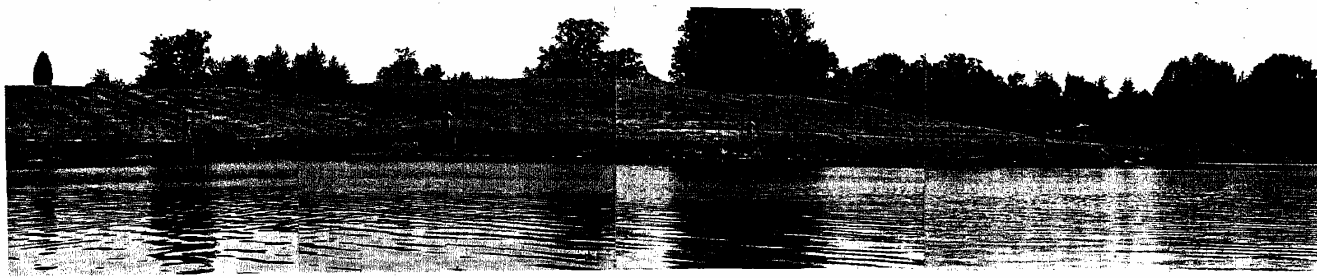


Location: 46M-1 Ranking:B Estimated Cost:$17,500
Brief Description: L:700 H:3 ACTIVE UNPROTECTED EASTERN SHORELINE

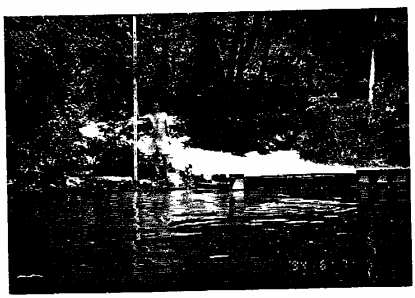


22. 46th Street Meadow 46M





22. 46th Street Meadow 46M

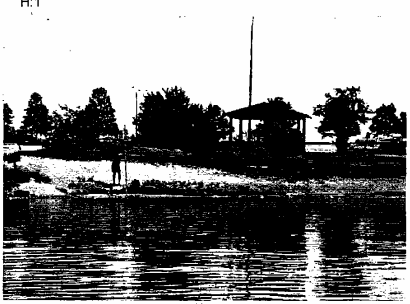


23. 42nd Street Boat Ramp 42BR 2 8

Location: 42BR-1 Ranking:A Estimated Cost:$350
Brief Description: L:20 H:5

Location: 42BR-2 Ranking:A Estimated Cost:$2200
Brief Description: L:80 H:3

Location: 42BR-3 Ranking:A Estimated Cost:$1600
Brief Description: L:80 H:1

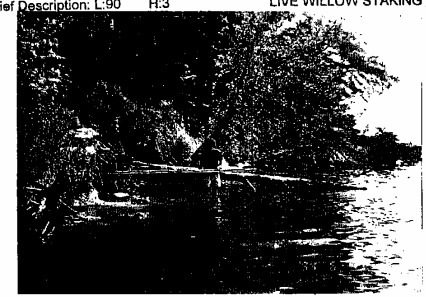


Location: 42BR-4 Ranking:A Estimated Cost:$2000
Brief Description: L:100 H:1

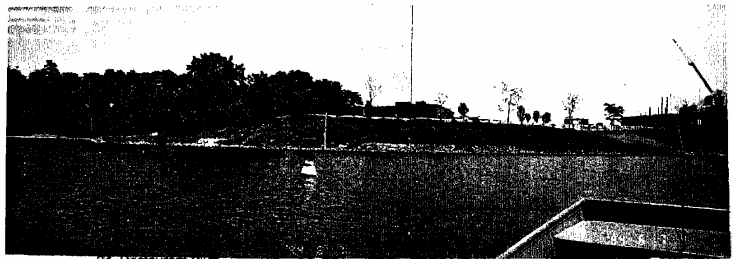
23. 42nd Street Boat Ramp 42BR

42BR-6 Ranking:
Brief Description: L:80
Estimated Cost:$1200

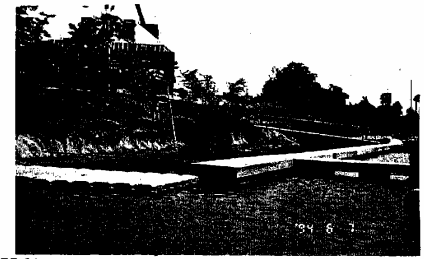
Location: 42BR-5 Ranking: NONE Estimated Cost:$300
Brief Description: L:90 H:3 LIVE WILLOW STAKING ONLY



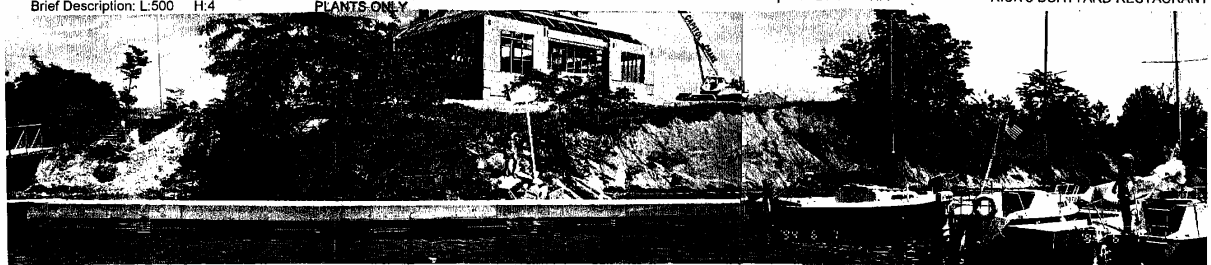
Location: 42BR-7 Ranking: A/B Estimated Cost:$3250
Brief Description: L:100 H:10



24. Restaurant Site RB
Location: RB-1 Ranking:A Estimated Cost:$300
Brief Description: L:500 H:4 PLANTS ONLY



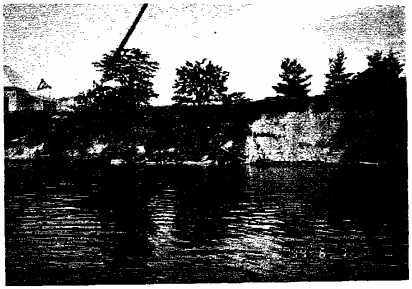
Location: RB-2A Ranking:NONE Estimated Cost:$5650
Brief Description: L:200 H:4 RICK'S BOATYARD RESTAURANT

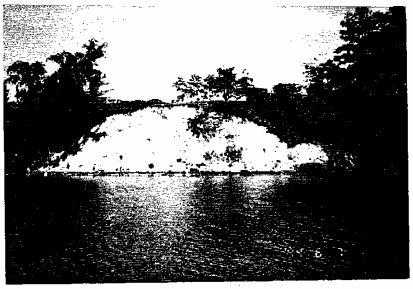


Location: RB-2B Ranking:NONE Estimated Cost:$6750
Brief Description: L:150 H:10 RICK'S BOATYARD RESTAURANT

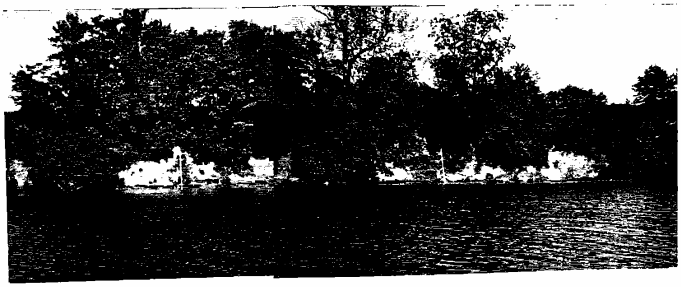
Location: RB-2C Ranking:A Estimated Cost:$12,100
Brief Description: L:200 H:15 OLD OVERLOOK AREA/RESTAURANT

Location: RB-2D Ranking:B Estimated Cost:$9650
Brief Description: L:150 H:20

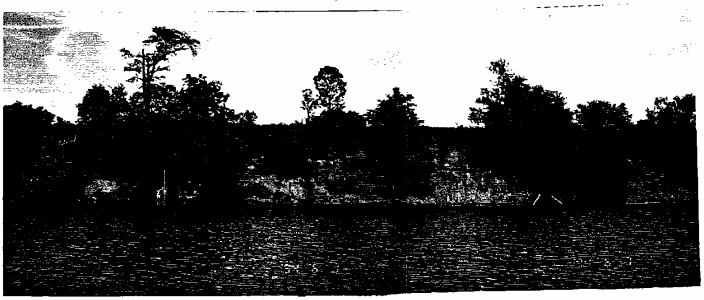




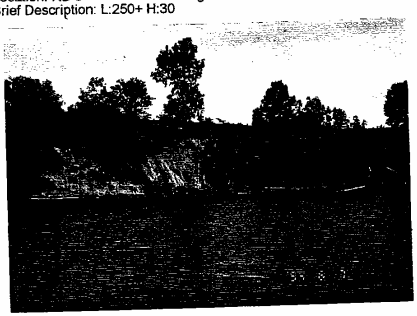
Location: RB-3 Ranking:B Estimated Cost:$5795
Brief Description: L:100 H:3



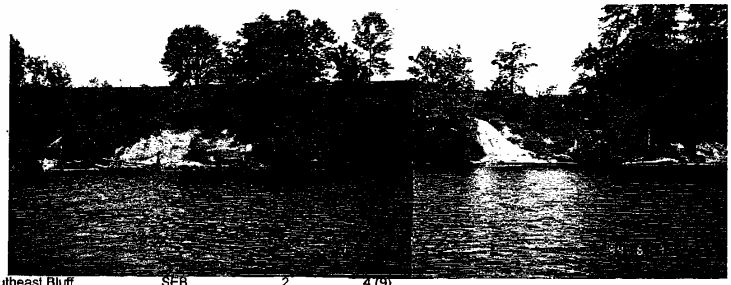
Location: RB-4 Ranking:B Estimated Cost:$14,425
Brief Description: L:175+ H:25+



Location: RB-5 Ranking:B Estimated Cost:$8150
Brief Description: L:250+ H:30



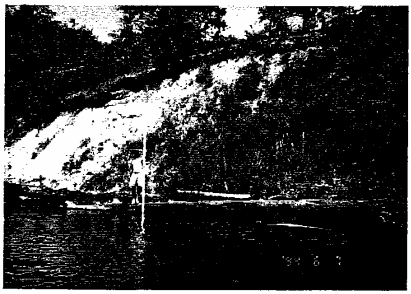
Location: RB-6 Ranking:B Estimated Cost:$6560
Brief Description: L:80+ H:25+



25. Southeast Bluff SEB 2 4 (9)

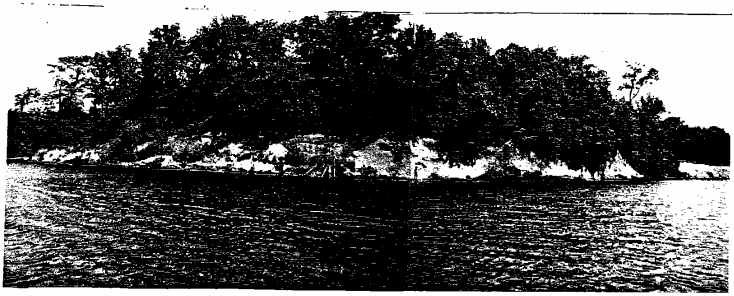
Location: SEB-1 Ranking:B Estimated Cost:$3400
Brief Description: L:50 H:20

Location: SEB-2 Ranking:B Estimated Cost:$3300
Brief Description: L:50+ H:15



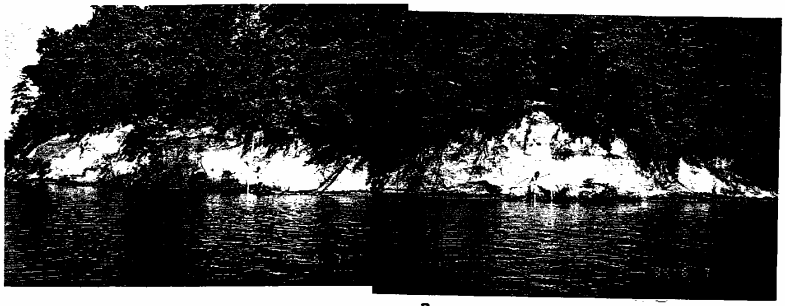
2

3



Location: SEB-3A-F Ranking:B Estimated Cost:$69,500
Brief Description: L:1000 H:20 COMBINED LENGTHS

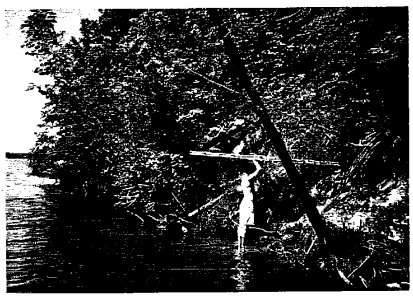
25. Southeast Bluff SEB

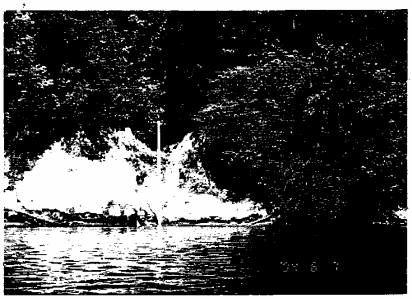


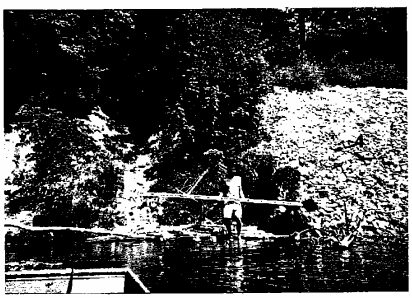
3

3

4



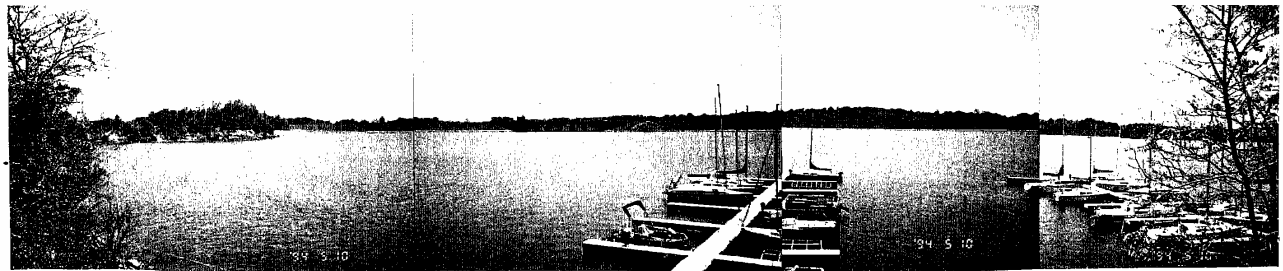




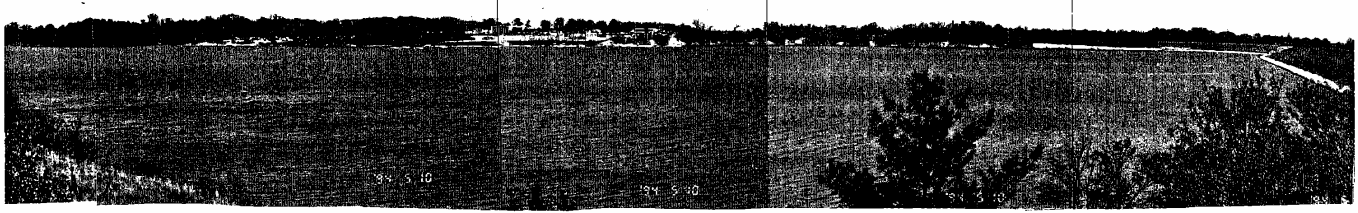
4

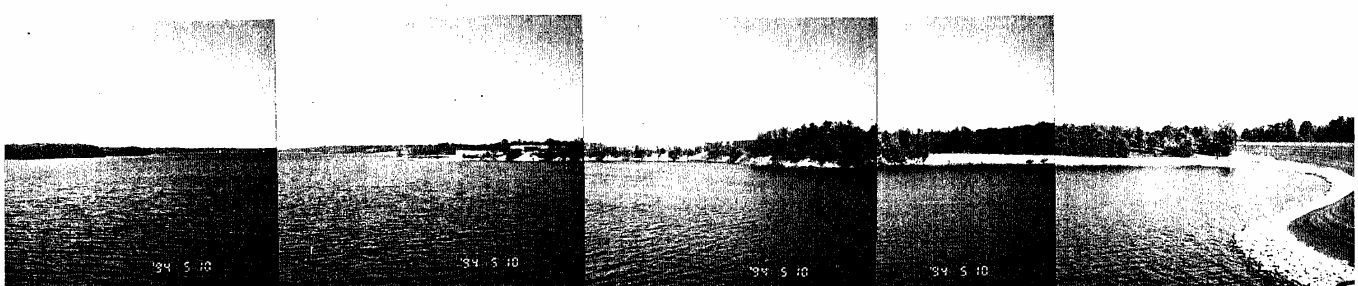
Location: SEB-4 Ranking:C
Brief Description: L:300+ H:20+

Estimated Cost:$1800

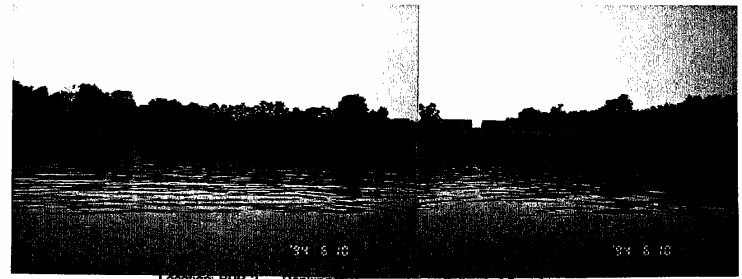


26. Eagle Creek Dam **Dam**

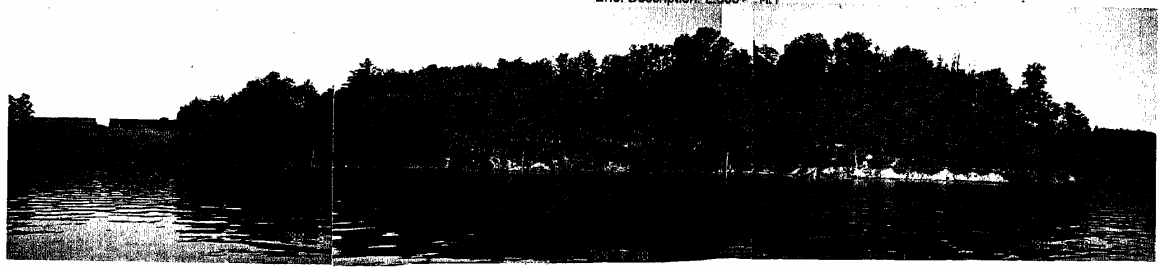




Location: BPB-1 Ranking:B Estimated Cost:$4600
Brief Description: L:175+ H:5

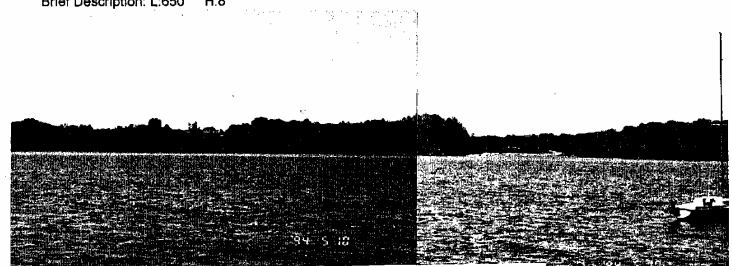


Location: BPB-2 Ranking:B Estimated Cost:$13,900
Brief Description: L:600+ H:1



Location: BPB-3 Ranking:B Estimated Cost:$16,700
Brief Description: L:650 H:8

Location: BPB-4 Ranking:B Estimated Cost:$7350
Brief Description: L:150 H:15



27. Borrow Pit Bay BPB

27. Borrow Pit Bay BPB

28. School Creek Inlet SCI 5 20

Location: SCI-1 Ranking:B Estimated Cost:$7330
Brief Description: L:150+ H:15

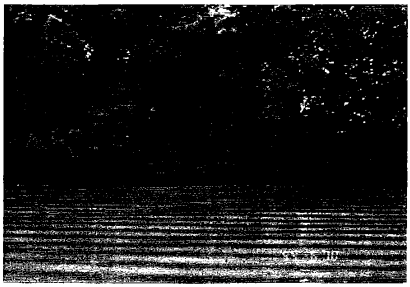
Location: SCI-2 Ranking:B Estimated Cost:$7350
Brief Description: L:150 H:15

Location: SCI-3 Ranking:B Estimated Cost:$8575
Brief Description: L:175 H:15

Location: SCI-4 Ranking:B Estimated Cost:$4800
Brief Description: L:100 H:14

Location: SCI-5 Ranking:C Estimated Cost:$1700
Brief Description: L:60 H:1-2

28. School Creek Inlet SCI



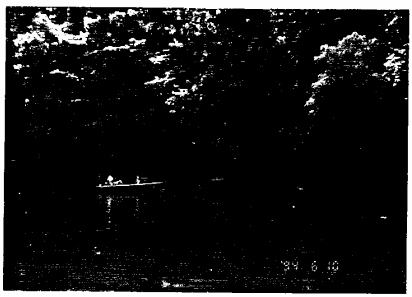
Location: SCI-6 Ranking:C
Brief Description: L:20 H:3
Estimated Cost:$500

Location: SCI-7 Ranking:C
Brief Description: L:30 H:1-2
Estimated Cost:$750

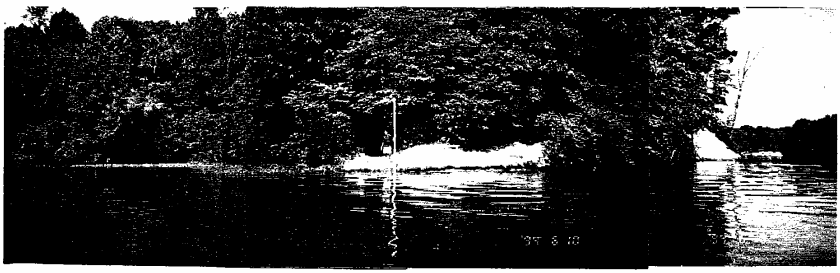
Location: SCI-8 Ranking:D
Brief Description: L:30 H:6
Estimated Cost:$750

Location: SCI-9 Ranking:C
Brief Description: L:20 H:2
Estimated Cost:$450

Location: SCI-10 Ranking:B
Brief Description: L:30 H:5
Estimated Cost:$700



Location: SCI-11 Ranking:B
Brief Description: L:30 H:6
Estimated Cost:$750



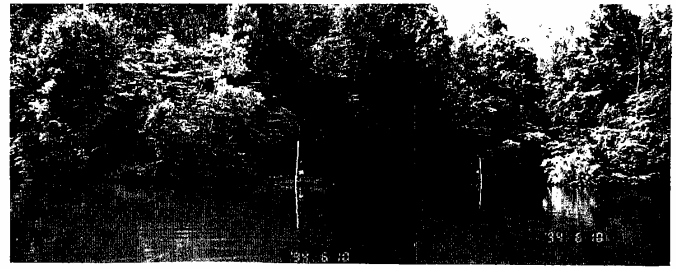
Location: SCI-12 Ranking:B
Brief Description: L:50 H:3
Estimated Cost:$1250

Location: SCI-13 Ranking:B Estimated Cost:$5895
Brief Description: L:75+ H:15+

Location: SCI-14 Ranking:B Estimated Cost:$6200
Brief Description: L:120 H:15+

Location: SCI-15 Ranking:C Estimated Cost:$3800
Brief Description: L:75 H:15

Location: SCI-16 Ranking:C Estimated Cost:$2300
Brief Description: L:75 H:6



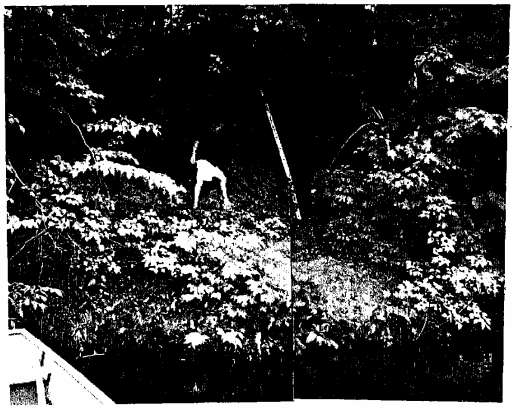
17 A

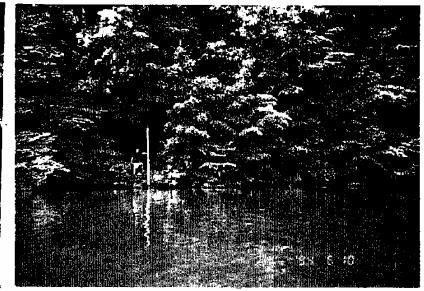
Location: SCI-17B Ranking:D Estimated Cost:$800
Brief Description: L:30 H:2

Location: SCI-17A Ranking:D Estimated Cost:$800
Brief Description: L:30 H:1

Location: SCI-18 Ranking:D Estimated Cost:$850
Brief Description: L:30 H:3

Location: SCI-17C Ranking:D Estimated Cost:$1100
Brief Description: L:40 H:3



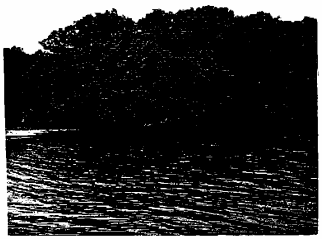


Location: SCI-19 Ranking:B
Brief Description: L:75 H:25+

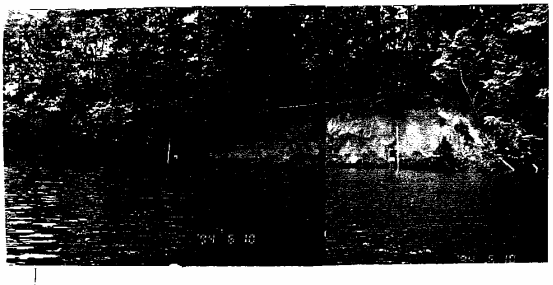
Estimated Cost:$12,500

Location: SCI-20 Ranking:NONE
Brief Description: L: H:

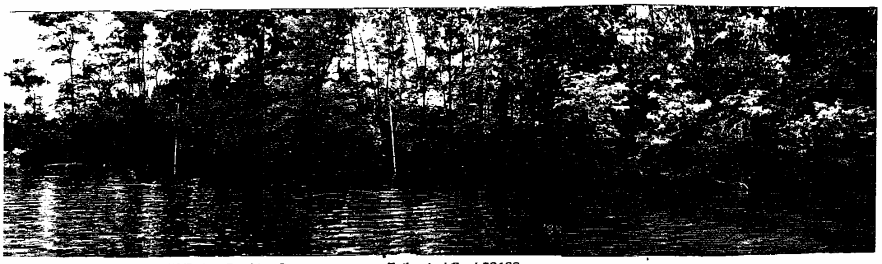
Estimated Cost:$NONE
SCHOOL CREEK WETLANDS



1

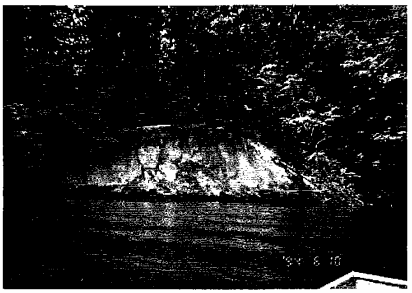


2



Location: SWB-1 Ranking:D
Brief Description: L:200 H:4

Estimated Cost:$6100



Location: SWB-2 Ranking:C
Brief Description: L:100 H:15+

Estimated Cost:$5120

2

Location: SWB-3 Ranking:C
Brief Description: L:200+ H:15+

Estimated Cost:$10,200

29. Southwest Bluffs

SWB

NUTEC SUPPLY

"ONSTRUCTION PRODUCTS FOR THE 21ST CENTURY"

NUTEC SUPPLY began operating in August, 1987 and is a member of the HERITAGE GROUP. ***NUTEC's focus is the education of the design, contractor, development, maintenance, and property management communities regarding the promotion and utilization of erosion control, bioengineering, and geosynthetic materials and techniques.***

Many of these new technologies were developed in Europe. Although these products and systems are relatively new to the United States construction market, substantial historical data and successful projects have accumulated both here as well as internationally. ***NUTEC SUPPLY's new and innovative products and systems are commonly utilized on HIGHWAY, UTILITY, SITE DEVELOPMENT, ENVIRONMENTAL, and LAND RESTORATION projects.***

NUTEC SUPPLY's product line can be divided into four areas:

EROSION CONTROL PRODUCTS

Our erosion control products include temporary and permanent surface applied erosion control/ revegetation mats (ECRM's), permanent turf reinforcement mats (TRM's), woven and non–woven silt fences and silt curtains, gabions, geocells or cellular confinement mats, bioengineering products and plants, fabric formed and concrete block revetment systems, geotextiles and geogrids for soil reinforcement, and retaining walls.

GEOSYNTHETIC PRODUCTS

Our geosynthetic products include a full line of woven and non–woven geotextiles, flexible and rigid geogrids, geocomposites and geonets for drainage, bentonite and PVC geomembranes, pavement overlay materials, porous pavements, retaining walls, and safety fencing.

DRAINAGE PRODUCTS

Our drainage products include a full line of HDPE, PVC, and corrugated metal pipe and fittings, drainage composites, HDPE manholes, catch basins and grates, channel drains, valves, and HDPE chambered storage systems.

BIOENGINEERING PRODUCTS

Our bioengineering products include a full line of 100% biodegradable surface applied erosion control/revegetation mats, geocoir mats and fiber webbing, fiber rolls, plant pallets, plant carpets, plant plugs of emergent & transitional species, and floating islands.

NUTEC SUPPLY prides itself on being a full service organization and a leader in the industry. Our services include site assessment, cost investigation and estimates, design assistance and support, construction training and supervision, maintenance assistance, and our own delivery service. Referrals are available on request.

800-969-6883

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BACKGROUND & HISTORY OF BIOENGINEERING

Bioengineering is a method of construction using living plants, or plants in combination with dead or inorganic materials. Bioengineer-plantings differ from conventional plantings in that they strive for structural stability immediately upon installation versus stability after the plants have had a chance to grow. The practice brings together biological, ecological, and engineering concepts to produce living, functioning systems to prevent erosion, to control sedimentation, or to provide habitat in difficult settings.

Bioengineering is a rapidly developing field, undergoing refinement of terminology and definitions. There is no universal agreement about the term itself, although "Bioengineering" is generally accepted as the dominant English-language term, as indicated by the classic text-book, BIOENGINEERING FOR LAND RECLAMATION AND CONSERV-ATION (Schiechtl, 1980) and the professional organization, "Interna-tional Group of Bioengineers" (c/o John Howell, Fountain Renewable Resources Ltd., The Bell Tower, 12 High Street, Brackley, Northants, NN13 5DT, United Kingdom). Variations of the term are also in use, including "biotechnical slope protection", "biogeotechnical erosion control", "soil bioengineering", and "hydrobioengineering"; these terms sometimes further differentiate sub-fields of bioengineering or differentiate it from the unrelated fields of biomedical technology and genetic engineering.

6000 years ago the Egyptians wove mats out of their local bullrush (papyrus) and staked the mats along the Nile River to hold soil and encourage vegetation. During wartime bioenginering was promoted in this country by the SCS and Forest Service as a useful construction technique given the shortage of available conventional construction materials. Today bioengineering is attractive in developing parts of the world because these nations are typically labor rich and capital poor. In North America bioengineering is becoming increasingly attractive due to its economic, environmental, and ecological aspects.

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GRADING/SITE PREP

Materials:

On-site or imported topsoils, subsoils, sands, gravels, cobbles

Form:

Planting shelf with gradual slope at mean water elevation

Offshore berms for wave attenuation

Application:

Erosion control on water-related sites with low levels of stress

Combination with additional bioengineering elements

GEOTEXTILES

Materials:

Biodegradables provide temporary stabilization for plant development

Synthetics can provide increased strength for long-term structural integrity

Form:

Mesh and Webbing provide an open framework for root attachment

Fabrics and Blankets can protect soil surfaces and retain fine particles

Thick materials with high density can retain fine particles in high energy settings, often combining attributes of Mesh, Blankets, and other materials

Application:

Surface treatment

Buried, wrapped, or keyed in

PRE-VEGETATED GEOTEXTILE UNITS

Materials:

Single plants grown in coir fiber substrate

Thick biodegradable blankets, ideally combining high tensile strength and density for retaining fine particles

Thick synthetic and biodegradable blankets designed for specific needs

Heavy, often rock-filled units incorporating biodegradables and synthetics

Form:

Smaller for manual handling without crushing delicate forms of vegetation

Larger for manual or machine handling, requires rolling up less delicate vegetation and increases efficiency of installation

Heavy units have variable size according to handling requirements

Application:

Stabilization of streambank, lakeshore, coastal sites with flow, waves, ice

Revegetation of detention basins, reservoirs, and swales with fluctuating water levels

Durable plantings for areas with excess waterfowl or foot traffic

GEOTEXTILE ROLLS

Materials:

- Home-made rolls assembled from soil, straw, hay, burlap, etc.
- Uncompressed coir fiber with biodegradable netting exterior
- Compressed coir fiber with biodegradable netting exterior
- Compressed coir fiber with synthetic netting exterior
- Synthetic fabric tubes with filled interiors (linear sandbags)

Form:

- Typically cylindrical, different lengths, diameters of one to three feet
- Pre-vegetated or planted after installation

Application:

- Stabilization of streambanks and shorelines with flow, waves, ice
- Wave attenuation
- Retention of fill and bank toe protection

C \ NVTEC \ BIOETECH

LEVEL I – Geocoir Fiber Webbing Lakebank Stabilization

1. 100 % coir fiber blankets of a specified weight, width, and thickness shall be placed lengthwise with one half the width above and the other half below the mean water line. The upper and lower edges of the coir blankets shall be buried in a 6"–12" anchor trench as specified. The coir blankets shall be installed with good soil contact on a smooth ground free from excess vegetation. Adjacent geocoir blankets shall be over–lapped 8"–12" as specified. Adjacent geocoir blankets shall be anchor–ed with 12" wooden staples, 20" on center in offset rows 24" apart.

2. 2", 3" and/or 6" diameter plants with a coir fiber substrate shall be inserted through the geocoir blanket at a specified rate and location above, at, and below the mean water line. Utilize a planting tool as needed to create a planting hole and avoid damage to sensitive roots. Plantings shall consist of, but not be limited to, randomly interspersed individuals of the following species: Acorus calamus, Carex stricta, Glyceria canadensis, Iris versicolor, Scirpus americanus, Scirpus fluv–iatilis, Scirpus validus, Sparganium, spp., Spartina pectinata.

TYPE II - Geotextile Roll Breakwater with Plugs

1. Two parallel rows, one foot apart, of wooden stakes, 2-inch diameter, 3-foot length, shall be driven one foot on center according to plans. The stakes shall extend 8 to 10 inches above the elevation of the river bed.

2. Biodegradable coir fiber geotextile rolls with a diameter of 12 inches, a density of nine pounds per cubic foot, and an exterior of polyethylene mesh will be used as a wave attenuation barrier. The rolls shall be laced together end-to-end with woven nylon 1/8-inch diameter rope to create a continuous length. End-to-end lacing may be completed before or after placement in stream, to facilitate handling. The lengths of geotextile roll shall be placed in position between the two rows of stakes. The upper surface of the roll shall be parallel to the water surface, with two inches protruding above mean water level (to be determined on site--not necessarily the current water level). Adjustments shall be made as needed, using hand tools to seat the roll such that it lies smoothly at the correct elevation. The upstream and downstream ends of the roll shall be buried three to five feet laterally into the bank.

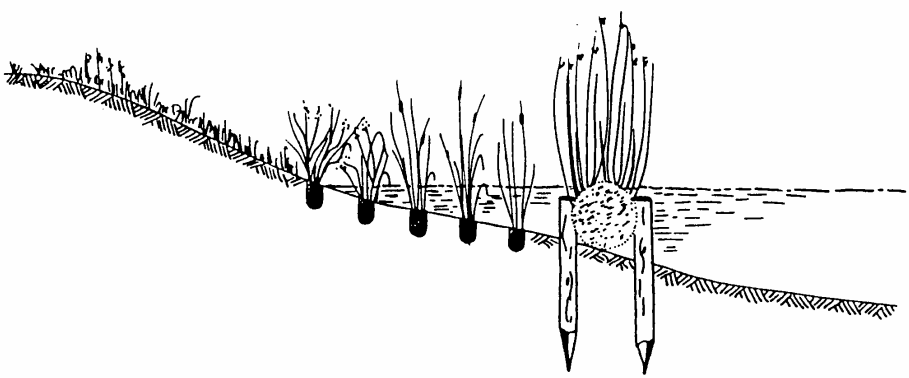
3. Reshaping shall be completed as necessary on the bank above the mean water level only after the roll is fully placed. Care shall be taken to disturb as little soil as possible outside the work area, and to avoid damage to any existing trees and shrubs on or near the bank. All topsoil excavated from the project shall be stored on site and reapplied as a surface layer over any disturbed area. Any excavated subsoil shall be removed from site.

4. A geotextile of 100% biodegradable jute mesh shall be used to cover disturbed banks with slopes greater than 2H:1V. The lower edge of this fabric will be tied to the geotextile roll using 1/16-inch nylon twine. The upper edge and middle section of the fabric shall be fastened to the bank using wood stakes at the rate of three stakes per square yard. All disturbed areas including that covered with fabric shall be overseeded with a conservation grass and legume mix, at a rate equivalent to three pounds per acre.

5. Two-inch diameter plants with coir fiber substrate shall be inserted into the geotextile rolls at the rate of two plugs per running foot, using a planting tool as needed to create a planting hole and avoid damage to sensitive roots. Plantings shall consist of randomly interspersed individuals of the following species: Acorus calamus, Carex stricta, Glyceria canadensis, Iris versicolor, Peltandra virginica, Pontedaria cordata, Scirpus americanus, Scirpus fluviatilis, Scirpus validus, Sparganium, spp., Saggitaria latifolia, Spartina pectinata.

6. Six-inch diameter plants with coir fiber substrate shall be planted three feet on center in one row two feet behind the roll. Plantings shall consist of randomly interspersed individuals of the following species: Acorus calamus, Alisma plantago-aquatica, Iris versicolor, Peltandra virginica, Pontedaria cordata, Scirpus americanus, Scirpus fluviatilis, Scirpus validus, Sparganium spp., Saggitaria latifolia, Spartina pectinata.

7. Three-inch diameter plants with coir fiber substrate shall be planted three feet on center in areas shoreward of six-inch plugs. Plantings shall consist of randomly interspersed individuals of the following species: Acorus calamus, Carex stricta, Glyceria canadensis, Iris versicolor, Peltandra virginica, Pontedaria cordata, Scirpus americanus, Scirpus fluviatilis, Scirpus validus, Sparganium, spp., Saggitaria latifolia, Spartina pectinata.



TYPE IIa - Geotextile Roll Breakwater with Plugs and Pre-vegetated Blankets

1. Two parallel rows, one foot apart, of wooden stakes, 2-inch diameter, 3-foot length, shall be driven one foot on center according to plans. The stakes shall extend 8 to 10 inches above the elevation of the river bed.

2. Biodegradable coir fiber geotextile rolls with a diameter of 16 inches, a density of nine pounds per cubic foot, and an exterior of polyethylene mesh will be used as a wave attenuation barrier. The rolls shall be laced together end-to-end with woven nylon 1/8-inch diameter rope to create a continuous length. End-to-end lacing may be completed before or after placement in stream, to facilitate handling. The lengths of geotextile roll shall be placed in position between the two rows of stakes. The upper surface of the roll shall be parallel to the water surface, with two inches protruding above mean water level (to be determined on site--not necessarily the current water level). Adjustments shall be made as needed, using hand tools to seat the roll such that it lies smoothly at the correct elevation. The upstream and downstream ends of the roll shall be buried three to five feet laterally into the bank.

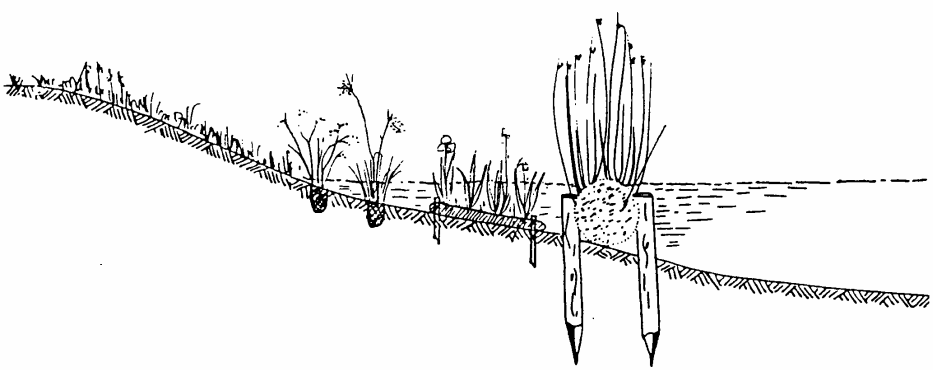
3. Reshaping shall be completed as necessary on the bank above the mean water level only after the roll is fully placed. Care shall be taken to disturb as little soil as possible outside the work area, and to avoid damage to any existing trees and shrubs on or near the bank. All topsoil excavated from the project shall be stored on site and reapplied as a surface layer over any disturbed area. Any excavated subsoil shall be removed from site.

4. A geotextile of 100% biodegradable jute mesh shall be used to cover disturbed banks with slopes greater than 2H:1V. The lower edge of this fabric will be tied to the geotextile roll using 1/16-inch nylon twine. The upper edge and middle section of the fabric shall be fastened to the bank using wood stakes at the rate of three stakes per square yard. All disturbed areas including that covered with fabric shall be overseeded with a conservation grass and legume mix, at a rate equivalent to three pounds per acre.

5. Two-inch diameter plants with coir fiber substrate shall be inserted into the geotextile rolls at the rate of two plugs per running foot, using a planting tool as needed to create a planting hole and avoid damage to sensitive roots. Plantings shall consist of randomly interspersed individuals of the following species: Acorus calamus, Carex stricta, Glyceria canadensis, Iris versicolor, Scirpus americanus, Scirpus fluviatilis, Scirpus validus, Sparganium, spp., Spartina pectinata.

6. Pre-vegetated 100% coir fiber blankets, 3.5" thick, 50" in length, 30" in width shall be staked lengthwise on five foot centers, in a row one foot apart from the roll. Stakes shall be one-inch diameter notched hardwood, placed at the rate of five stakes per blanket piece, at the four corners and center. Plantings shall consist of groups of three to five pre-vegetaed blankest of the same species interspersed with each other: Acorus calamus, Iris versicolor, Scirpus validus, Sparganium spp., Typha latifolia.

7. Three-inch diameter plants with coir fiber substrate shall be planted three feet on center in areas shoreward of sod pieces. Plantings shall consist of randomly interspersed individuals of the following species: Acorus calamus, Carex stricta, Chelone glabra, Glyceria canadensis, Iris versicolor, Lobelia cardinalis, Mimulus ringens, Peltandra virginica, Pontedaria cordata, Scirpus americanus, Scirpus fluviatilis, Scirpus validus, Sparganium, spp., Saggitaria latifolia, Spartina pectinata.



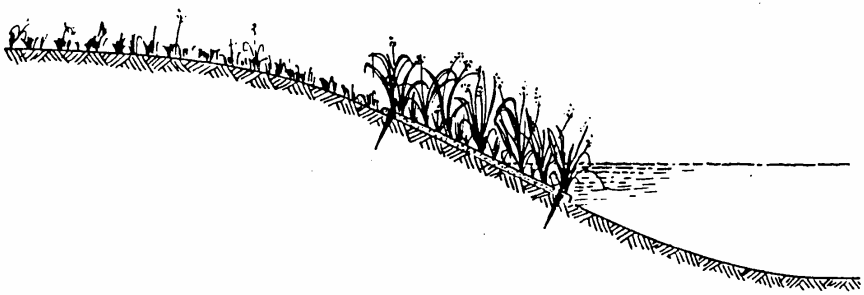
TYPE III - Pre-vegetated Blanket Bank Stabilization

1. Pre-vegetated 100% coir fiber blankets, 2" thick, 16.6' in length, 39" in width shall be placed lengthwise with 12' below the mean water line. Pre-vegetated blankets shall be installed with good soil contact on a smooth ground free from excess vegetation. At the upstream end of the treatment, the end of the blanket shall be buried 12" and staked securely in place. Upstream blankets shall have a six-inch, shingle-style overlap above downstream blankets. Pre-vegetated blankets shall be anchored with 12" length notched wood stakes, three feet on center in offset rows along the upper edge, centerline, and lower edge of the blanket, at the rate of three stakes per square yard. Plant species in the blankets shall include: Carex spp., Iris versicolor, Glyceria canadensis, Leersia oryzoides, Calamagrostis canadensis.

2. Following placement, prevegetated blankets shall be covered lightly with soil and watered to wash soil particles into any gaps and spaces.

3. Reshaping shall be completed as necessary on the bank above the mean water level only after the blanket is fully placed. Care shall be taken to disturb as little soil as possible outside the work area, and to avoid damage to any existing trees and shrubs on or near the bank. All topsoil excavated from the project shall be stored on site and reapplied as a surface layer over any disturbed area. Any excavated subsoil shall be removed from site.

4. A geotextile of 100% biodegradable jute mesh shall be used to cover disturbed banks with slopes greater than 2H:1V. The lower edge of this fabric will be tied to the pre-vegetated blanket using 1/16-inch nylon twine. The upper edge and middle section of the fabric shall be fastened to the bank using wood stakes at the rate of three stakes per square yard. All disturbed areas including that covered with fabric shall be overseeded with a conservation grass and legume mix, at a rate equivalent to three pounds per acre.



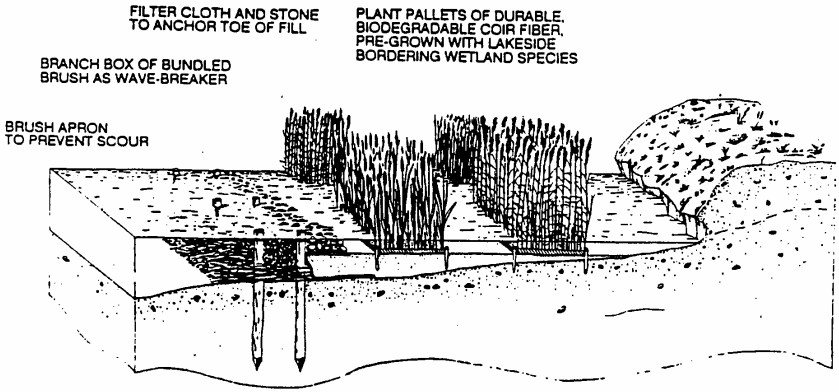


Figure 3. Typical profile of Bestmann shoreline installation on Havel Lake, Berlin.

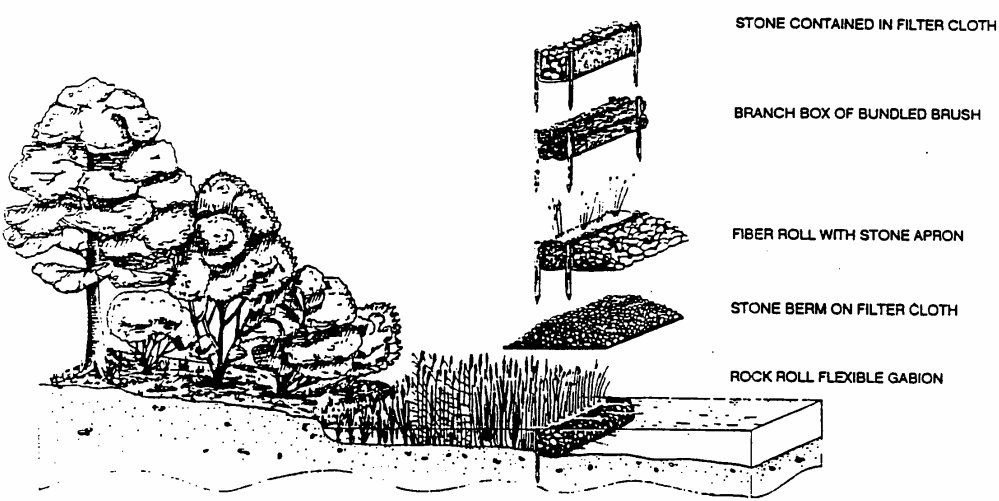


Figure 4. Wave-breaking devices used in Berlin to protect existing or installed wetland plants.

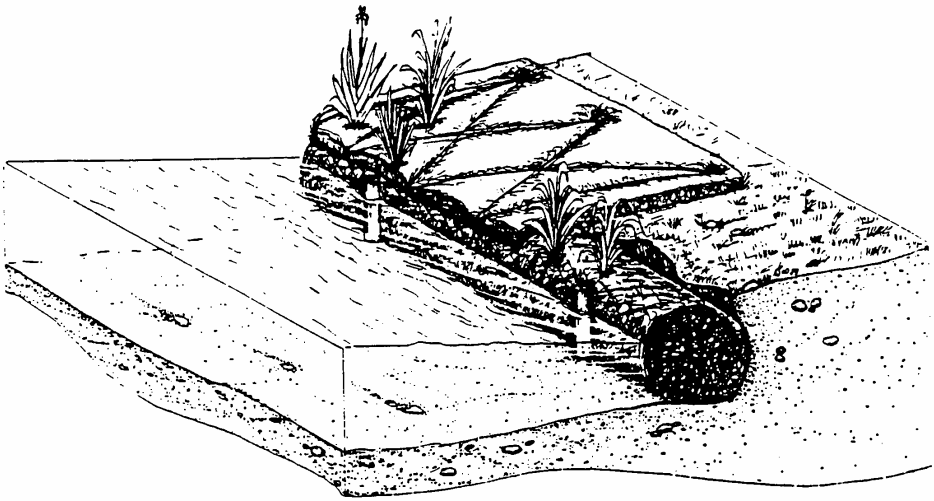


Figure 1. Where wider coverage of vegetation is needed, pre-grown plant carpets provide immediate habitat and erosion protection.

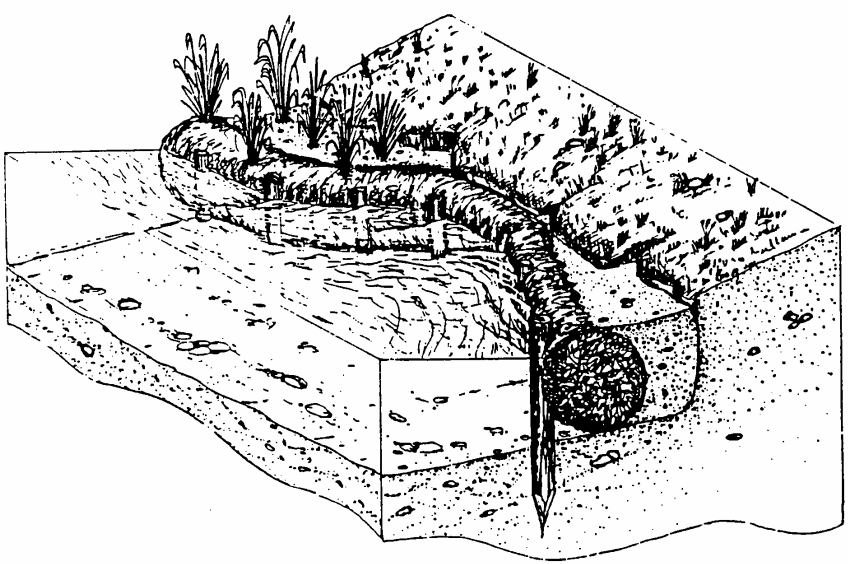
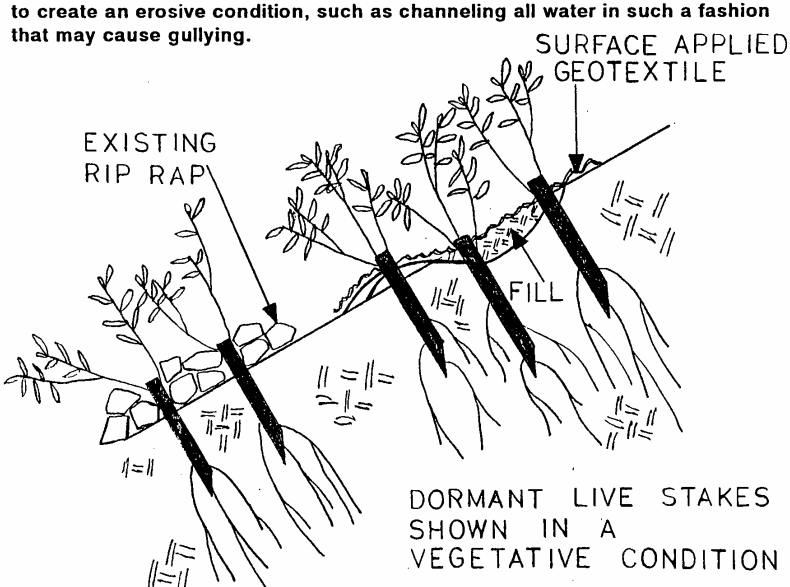


Figure 2. Fiber rolls stabilize banks and permit the establishment of vegetation. The Coir fiber accumulates sediment and biogrades as plant roots develop and become the stabilizing element.

LIVE STAKING

LIVE STAKING of dormant, living, woody plants such as willow and other similar species is a relatively simple, fast, and economical procedure. Living materials must be of sufficient diameter and length to survive being driven into the ground as stakes. Typical uses for LIVE STAKING include stabilizing areas along streams near the waterline, stabilizing shallow earth slips and slumps created by natural piping, and for securing other bioengineering components and/or geotextiles. LIVE STAKES can also be driven into the soil between the spaces of a rock, rubble, or boulder revetment to further enhance stability and improve aesthetics. Don Roseboom with the Illinois Water Survey has used large willow stakes or posts to perform streambank stabilization. LIVE STAKING provides erosion control, habitat, water quality, and aesthetic benefits.

LIVE STAKING must be performed in the dormant season. Living materials should be installed as soon after harvesting as possible (in the interim they should be kept moist). The bottom of the stake should be cut at an angle and the top square to improve installation success. The stakes should be driven into the ground at a 45 degree angle. Care should be taken to replace stakes damaged during installation to prevent infestation. Intimate soil contact is required when working with dormant woody cuttings as is moisture and sunlight availability. The number of LIVE STAKES per unit area depends on specific site conditions. Finally, care should be taken when placing LIVE STAKES so as not to create an erosive condition, such as channeling all water in such a fashion that may cause gullying.



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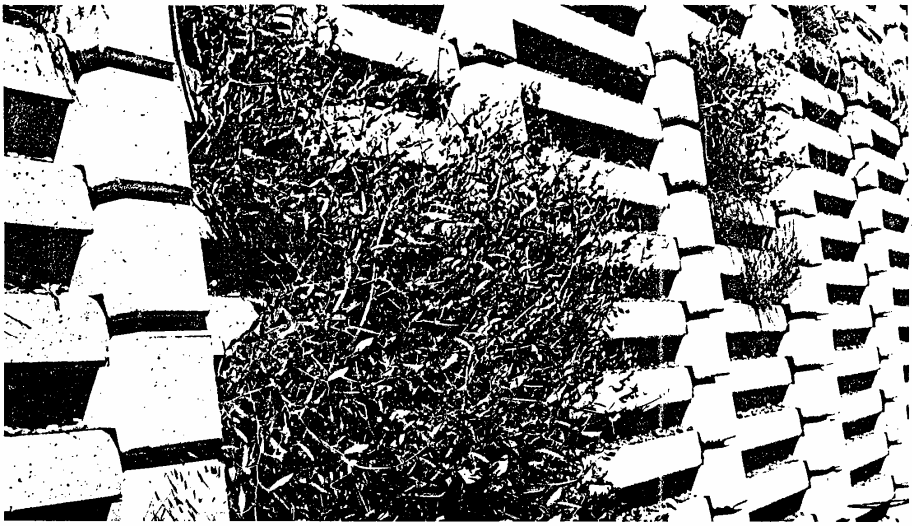


Fig. 4.3. Vegetated ~~concrete~~ timber crib wall. Vegetation was planted in openings between headers at face of wall. (concrete cribwall shown in drawing)

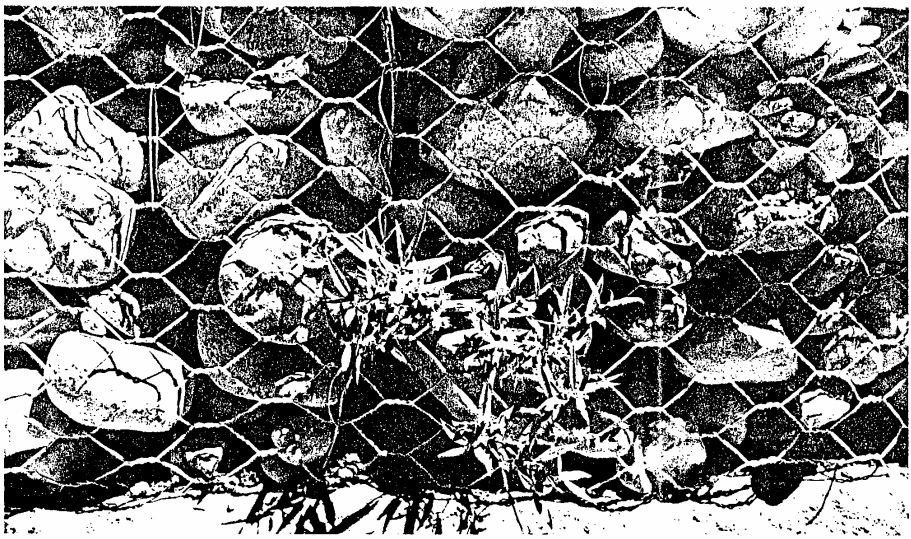


Fig. 4.4. Vegetated gabion wall. Green willow cuttings which were inserted through gabion into backfill have rooted and sprouted.

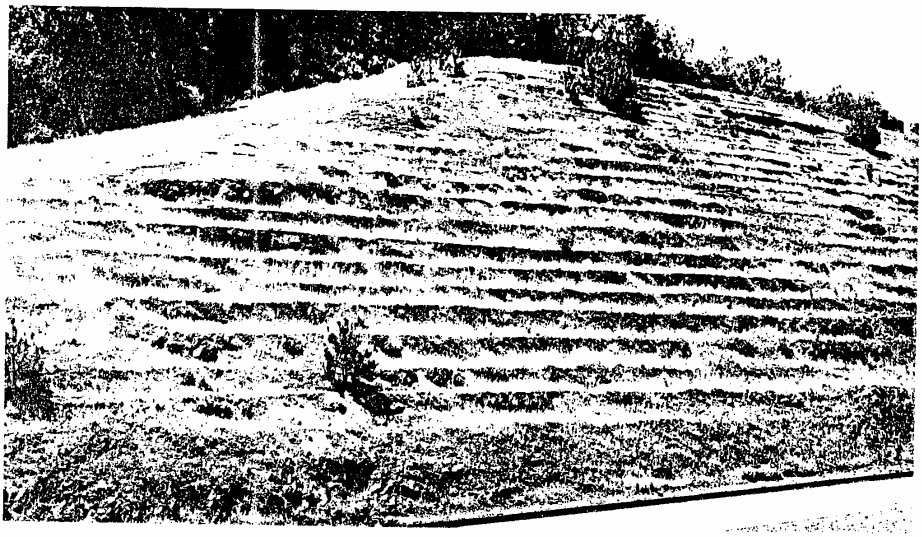


Fig. 4.9. Terraced, cut slope adjacent to highway aids in erosion control. Horizontal steps were seeded with native grasses. Interstate Highway, #80, near Colfax, California.

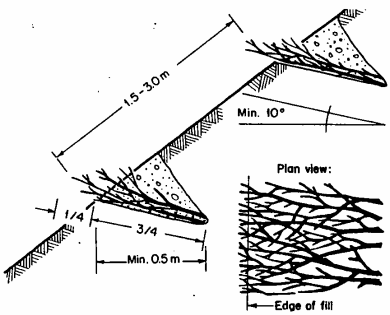


Fig. 4.10. Slope stabilization by brush-layering method. Cut brush or green branches of easy-to-root species such as willows are placed on contour benches across a slope as shown in the diagram.

Table 4.1. Approaches to slope protection and erosion control.

	Category	Examples	Appropriate uses	Stabilizing mechanism or role of vegetation
Live construction	Conventional plantings	—Grass seeding —Transplants	—Control of surficial rainfall & wind erosion —To minimize frost effects	—To bind & restrain soil particles —To filter soil from runoff —To intercept raindrops —To maintain infiltration —To change thermal character of ground surface
Mixed construction	Woody plants used as reinforcement & as barriers to soil movement	—Live staking —Contour-wattling —Brush-layering —Reed-trench-terracing —Brush mats	—Control of surficial rainfall erosion (rilling & gullying) —Control of shallow (translational) mass movement	Same as above, but also to reinforce soil & resist downslope movement of earth masses by buttressing & soil arching action
	Woody plants grown in interstices of low, porous structures or benches of tiered structures	—Vegetated *revetments* (riprap, grids, gabion mats, blocks) —Vegetated *retaining walls* (open cribs, gabions, stepped-back walls, & welded-wire walls)	—Control of shallow mass movements & resistance to low-mod. earth forces —Improvement of appearance & performance of structures	—To reinforce & indurate soil or fill behind structure into monolithic mass. —To deplete & remove moisture from soil or fill behind structure.
	Toe walls at foot of slope used in conjunction w/ plantings on the face	Low, breast walls (stone, masonry, etc.) with vegetated slope above (grasses and shrubs)	Control of erosion on cut & fill slopes subject to undermining at the toe	To stop or prevent erosion on slope face above retaining wall
Inert Construction	Conventional structures	—Gravity walls —Cantilever walls —Pile walls —Reinforced earth walls	—Control of deep-seated mass-movement & restraint of high lat. earth forces —Retention of toxic or aggressive fills & soil	Mainly decorative role

and the use of plants growing in the interstices of porous revetments and retaining walls. The categorization of approaches in Table 4.1 provides a context for studying and describing biotechnical slope protection systems and understanding the role of both vegetation and structures in such systems.

4.2 ROLE OF VEGETATION

Vegetation offers the best long-term protection against surficial erosion on slopes and provides some degree of protection against shallow mass-movement. Vegetation tends to prevent surficial (rainfall) erosion by:

1. Binding and restraining soil particles in place
2. Filtering soil particles out of runoff
3. Intercepting raindrops
4. Retarding velocity of runoff
5. Maintaining infiltration

Wattling installed in a slope provides many of these protective functions. It serves as an energy dissipator for water and soil moving down the slope; it filters and traps downward moving detritus (soil and small rocks); and it provides a series of areas with reduced slope angle on which vegetation (grasses, native seedlings, and transplants) can be established (Fig. 4.10). Portions of the wattling also root and become part of the permanent stabilizing cover.

Deeper, rooted woody vegetation helps to prevent shallow mass-movements by:

1. Mechanical reinforcement from the root system
2. Soil water depletion through transpiration and interception
3. Buttressing and soil arching action from embedded stems

The role of woody vegetation in reinforcing soils and stabilizing slopes is treated in detail in Chapter 3.

Vegetation is self-regulating and self-repairing to a certain extent. Vegetative slope protection measures are also less costly per se than structural measures (White and Franks, 1978). On the other hand, vegetation suffers from several limitations and disadvantages. It is of little use for preventing deep-seated, rotational slope failures, and it is vulnerable to disease, drought, browsing, trampling, and erosion from wave action or streambank scour. Vegetation may also be difficult to establish on steep slopes. Many of these limitations can be overcome, however, by (1) selecting the right type of vegetation, (2) planting and maintaining the vegetation correctly, and (3) using the vegetation in combination with structural–mechanical elements. Procedures for the selection, establishment, and maintenance of vegetation are described in Chapter 6.

4.3 ROLE OF STRUCTURE

Properly designed structures help to stabilize a slope against mass-movement, and they protect the toe or face of a slope against scour and erosion by running water. Structures are generally capable of resisting much higher lateral earth pressures and shear stresses than vegetation. Structures can also be used to divert and convey running water away from critical areas or dissipate the energy of flowing water in a defended area within the structure.

Structures can be built from a number of materials, both natural and artificial. Natural materials include earth, rock, stone, and timber. These materials normally cost less, are environmentally more compatible, and are better suited to vegetative treatment or modification than man-made ones. Artificial materials include steel and cement. Structures made from these materials are stronger and generally more durable than natural structures, but also more energy- and capital- intensive. Some structures are comprised of both natural and artificial materials; examples include concrete crib walls, steel bin walls, gabion walls or revetments, welded-wire walls, and reinforced earth. Steel and concrete in this case mostly provide the rigidity, strength, and reinforcement, while stone, rock, and soil provide the mass. These type of structures can often be planted or vegetated using techniques alluded to previously.

4.3.1 Retaining Structures

A retaining structure of some type will usually be required to protect and stabilize oversteepened slopes. A low toe wall or retaining structure at the foot of a slope permits oversteepening of the slope at its base and flattening above. The latter makes it possible to establish vegetation on the slope, and the former reduces the amount of clearance required between the base of a slope and an adjacent right-of-way or existing use. This advantage and other applications of retaining structures and toe walls are illustrated schematically in Fig. 4.13.

A particularly graphic example of the advantages of a structure used to support a portion of roadway on a slope is shown in Fig. 4.14. An open-faced crib structure resting on a small bench cut has been used in this case to support a fill that in turn is carrying one-third of the roadway. Advantages of this system include:

1. Considerable reduction in amount of cut necessary
2. Accommodation of the cut material in the crib
3. Limitation of side-cast material to the small excavation necessary for the crib foundation
4. Achievement of stable side slopes on the fill
5. Provisions for growing vegetation in openings between headers at the face of the crib

Slope flattening (i.e., reworking an oversteepened slope to form a less severely sloping area) followed by planting with grass and shrubs is frequently employed as a slope stabilization measure. In many instances slope flattening alone may be impractical. Figure 4.15 depicts two slope profiles that illustrate this point. In Case A the previous steeply cut slope (dashed line) is located in an area where the natural, undisturbed terrain is gently sloping. Thus, by constructing a low toe wall or retaining structure at the slope toe and reworking the face to a $1\frac{1}{2}$:1 slope, the total slope length is only slightly increased. Case B differs only in the slope of the natural terrain above the cut slope face. If the same small retaining structure is provided, and the cut face is reworked to a $1\frac{1}{2}$:1 slope, the overall slope length will be increased by 300 percent. This will greatly increase the amount of ground disturbance and surficial erosion hazard on the reworked face. The alternatives are to:

1. Construct a higher retaining structure.
2. Move the slope toe farther out into the roadway.
3. Rework the cut face to an angle somewhat steeper than $1\frac{1}{2}$:1.
4. Use an anchored, ladder grid revetment (see Chapter 5).
5. Use a combination of the above.

Many different types of retaining structures can be used to meet these objectives. Completely new wall concepts, along with improvement of existing designs, have resulted in a wide offering of structures, one to fit nearly any condition. The design and construction of appropriate retaining structures are described in Chapter 5.

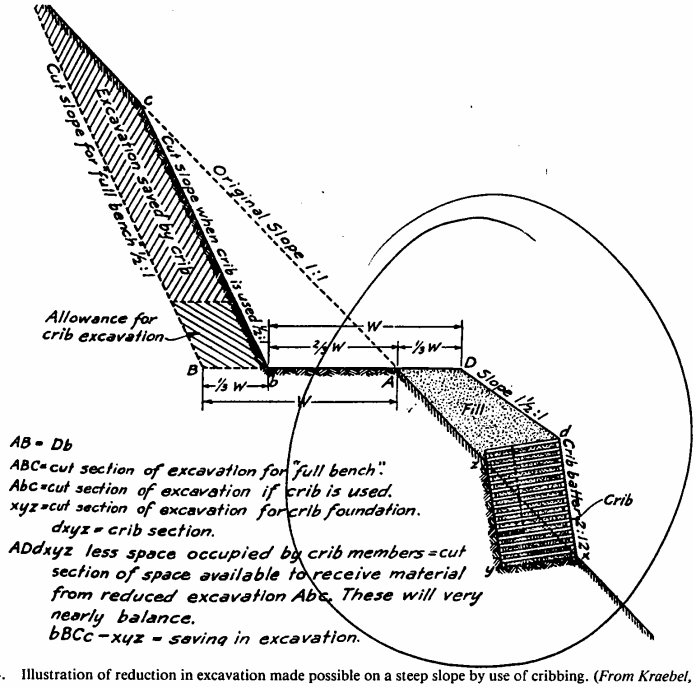


Fig. 4.14. Illustration of reduction in excavation made possible on a steep slope by use of cribbing. (*From Kraebel, 1936*)

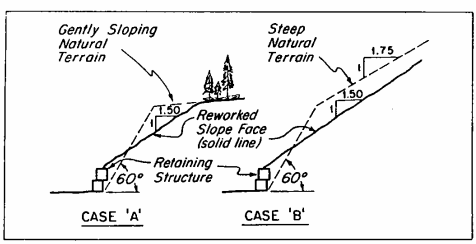


Fig. 4.15. Influence of toe structure on amount of cut slope reworking. (*From White and Franks, 1978*)

4.3.2 Revetments and Grade Stabilization Structures

Revetments and grade stabilization structures are used where protection is required against scour and erosion by running water. A revetment is a structural armoring on a slope. The weight or mass of the revetment may also buttress the slope to some extent and increase its resistance to mass-movement. Revetments may consist of a variety of different materials, including dumped rubble rock, concrete facings, slotted or cellular concrete grids, articulated blocks, rubber-tire mats, or gabion mattresses. Revetments are commonly used to protect streambanks and channels where water velocities are high and bank materials weak.

A grade stabilization structure is used to reduce grade and dissipate the energy of flowing water within the structure itself or nearby defended area. Debris and sediment tend to be deposited and trapped upstream of the structure. This in turn permits establishment of vegetation behind the structure, which further stabilizes the ground. Grade stabilization structures may range from a series of simple, board check dams to earth embankments with pipe spillways. Mechanical box structures of concrete, masonry, steel, treated wood, or gabions have also been used. Grade stabilization structures or check dams, as they are commonly known, are often employed in gully

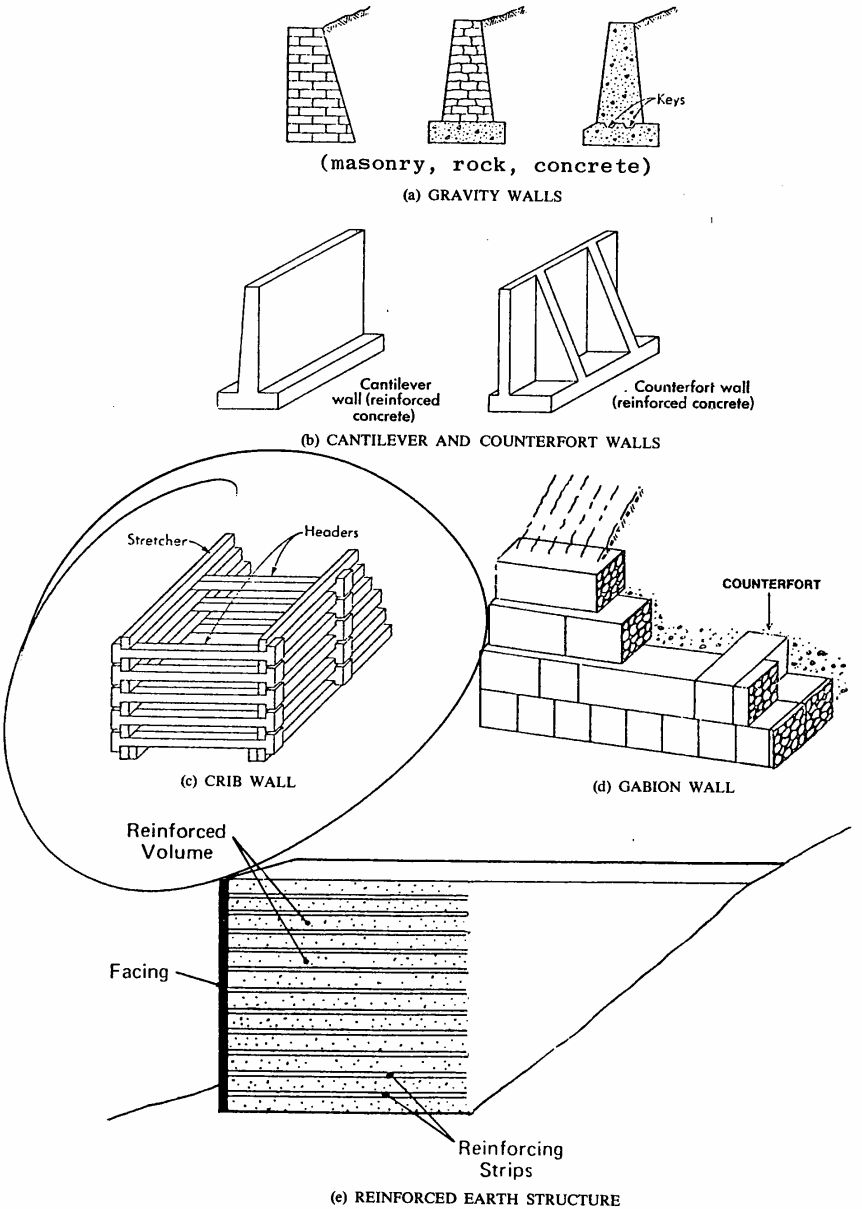


Fig. 5.3. Basic types of retaining structures. (a) Gravity walls. (b) Cantilever and counterfort walls. (c) Crib wall. (d) Gabion wall. (e) Reinforced earth wall. (f) Welded-wire walls. (g) Pile walls. (h) Tie-back or anchored walls.

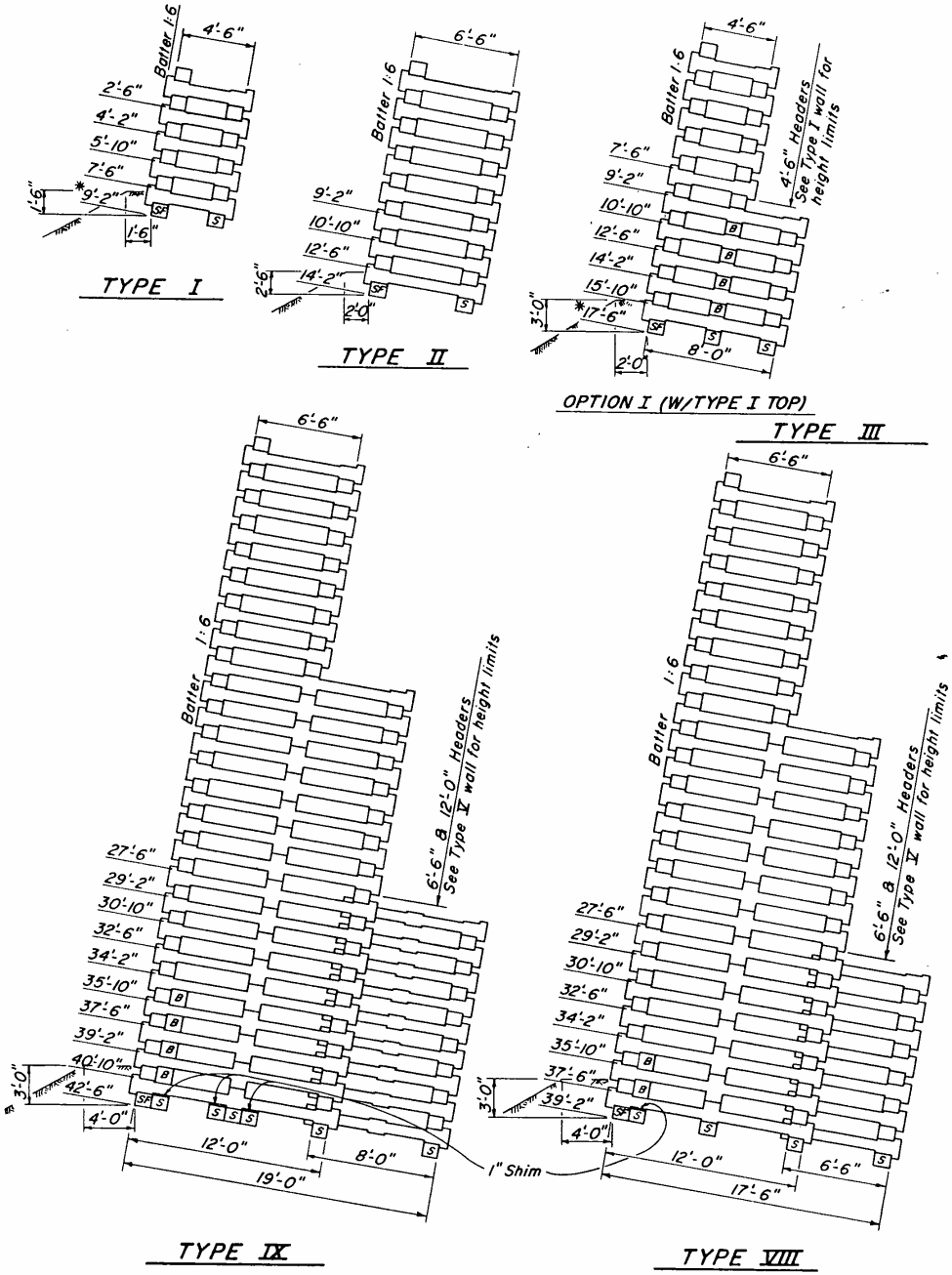


Fig. 5.12. Reinforced concrete crib Concrib walls showing examples of different arrangements of structural members for different wall heights. (*From Hilfiker, 1972*). Reproduced by permission of the Hilfiker Pipe Company, Eureka, California.

Table 5.4. Approximate cost comparisons for low toe walls or retaining structures.

Wall type	Height range, ft	Unit cost,[1] $/sq ft	Remarks
1. Rock breast	0–3 3–6	4–5 5–6	Use ltd. to very low walls. Availability of large rocks on site may reduce costs 15–20%.
2. Gabion	3–9 10–15 16–21	7–9 9–11 11–13	Costs range from $40–70/cu yd on unit volume basis. Higher walls require more gabions in the basal courses.
3. Welded-wire	6–9 9–12 12–18 18–24	6.25 6.75 7.00–7.50 7.50–8.75	Cost estimate exclusive of accessibility to wall site, excavation, and backfill. Welded-wire wall is designed to use native materials (soil and rock) found at 90% of the job sites.
4. Timber cribs	6–9 10–15 16–21	8–10 10–12 12–14	AWPI designs are more expensive. Higher walls require successively wider bases (longer headers).
5. Concrete cribs (Concrib wall)	6–9 10–15 16–27	13 13–14 14–15	Cost estimate exclusive of accessibility to wall site excavation and backfill.
6. Reinforced Earth	< 20	15–17	Costs are for conventional steel or concrete panels. Use of lightweight, wire-mesh facings could decrease costs by 50–60%.

[1] Cost per square foot of front face based on 1978–79 unit price data. Costs shown are for materials, structural fill or cribfill, and assembly. Costs do not include excavation, foundation preparation, and backfilling.

tive control measures is available as a result of erosion control demonstration projects carried out by both the California Department of Transportation (Leiser et al., 1974) and the California State Water Resources Control Board (White and Franks, 1978) in the Lake Tahoe Basin.

A spectrum of erosion control measures were field-tested either separately or in combination in the Lake Tahoe Basin. Details and results of this project are discussed later, in Chapter 9. Only the cost data are presented here. Particular attention was paid in this regard to identifying the most cost-effective methods for erosion control on oversteepened slopes in and around the Lake Tahoe Basin of California. Where possible, individual breakdowns of unit materials, equipment, and labor costs were compiled for each method. In general wages and equipment costs were based upon data published by CalTrans (1976) as of June 30, 1976, plus an additional 10 percent allowance for profit. Material costs are in general equivalent to retail costs quoted by the various manufacturers, distributors, or suppliers of materials used at the project sites including estimated shipping costs as of June 30, 1976. Details of the cost estimating procedure can be found in the publication by White and Franks (1978). Rampant price and wage inflation in recent years has made their published costs obsolete, but the relative cost comparison between methods should still be valid.

A "hypothetical" eroding cut slope was used for the purpose of cost comparison. Such a hypothetical 1.0-hectare cut slope is illustrated in Fig. 5.41. The slope has an average slope length of 10 m and runs for 1000 m adjacent to a paved roadway. It was further assumed that the cut had an average slope angle of 1.25:1 (80 percent) and was continually sloughing eroded material to the ditch along the slope toe.

Table 5.6 summarizes the unit costs and the total costs of selected erosion control techniques if applied to the hypothetical 1.0-hectare road cut. The column entitled "% Labor" refers to the percentage of the total unit cost that is devoted to labor costs reckoned at $16.25 per person-hour. Those percentages that are followed by an asterisk indicate those tasks where a majority, if not all, of the labor could be performed by unskilled conservation corps workers. In this instance total erosion control costs may be reduced significantly because labor costs for unskilled conservation corps workers are considerably less.

As can be seen in Table 5.6, erosion control costs vary considerably. Vegetation stabilization techniques were considerably less expensive, but not necessarily effective

LIVE FASCINES

Description

Live fascines are sausage-like bundles of live cuttings wired or tied together and secured onto the banks with live and "dead stout stakes". See Figures 3A and 3B.

They are placed on contour in dry sections, or at an angle in wet sections on the slope face. They create very little site disturbance.

Live fascine performs several functions in the erosion control process:

- it breaks up the slope length into a series of shorter slopes separated by benches;

- it acts as a mini-bench across the face of a long slope;

- it provides surface stability for the planting or natural establishment of other vegetation;

- it traps debris, seed and vegetation on the slope;

- it slows surface water flows and allows more infiltration on droughty sites;

- it dries excessively wet sites through transpiration as the stems root and grow;

- it serves to promote seed germination, i.e. natural invasion; and

- it reinforces the soil mantle via the developing root systems

Effectiveness

This method offers an inexpensive and immediate protection from erosion when properly anchored.

Live fascines work well to reduce erosion on shallow gully sites.

They are a very effective stabilization technique once rooting is established.

Live fascines are capable of holding fill soil on the face of the streambank or slope by creating mini dam structures. They reduce the slope into a series of smaller slopes.

They serve as pole drains when installed at an angle on the stream bank or slope.

They provide surface stability for the invasion of the surrounding riparian vegetation.

They rapidly become part of the food chain in streambank situations.

Construction Guidelines

Timing

Construction must occur in the dormant season, generally September to March.

Live Materials

Cuttings must be from a species that roots easily, and has long, straight branches. Material such as young willow or red twig dogwood is ideal for this method.

The cuttings are placed in bundles and wired or tied together. Live stakes should be tamped in, below the live fascine bundle. "Dead stout stakes" must be installed directly through the live fascine bundle.

Dead Materials

Wire for bundling or string for tying the bundles shall be required.

"Dead stout stakes" shall be used to secure the live fascines.

Installation

Beginning at the base of the slope, dig the trench for the live fascine.

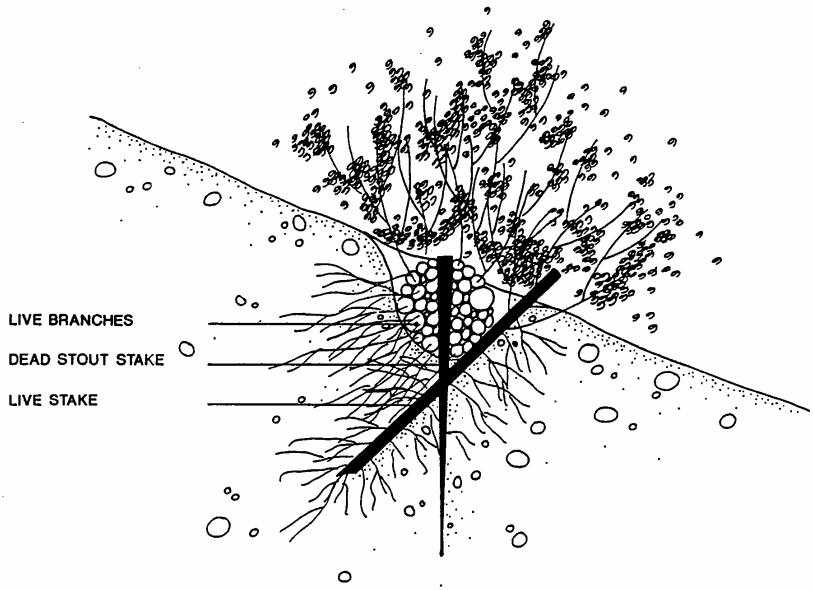
Place the live fascine into the trench.

Drive the "dead stout stakes" directly through the fascine bundles.

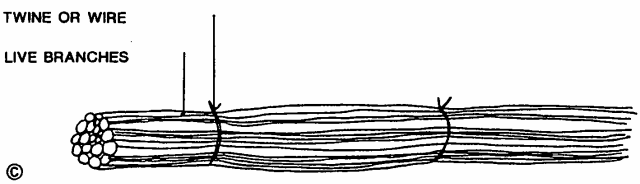
Next, continuing up the face of the bank, repeat the above procedure to the top of the slope.

Place soil along the sides of the bundles.

LIVE FASCINE



SECTION



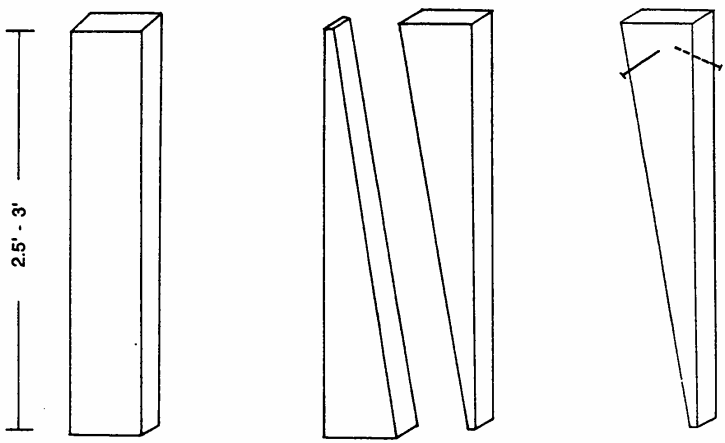
©

NOT TO SCALE

NOTE:
Rooted/leafed condition of the living plant material is not representative at the time of installation.

FIGURE 3A

DEAD STOUT STAKE
(with anchor nails)



1 2 3

1) 2 x 4 Timber member cut to length
2) Saw the 2 x 4 timber diagonally to produce 2 Dead Stout Stakes
3) Dead Stout Stake with nails driven on each side at an angle for anchoring the fabric

NOT TO SCALE

FIGURE 3B

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Eagle Creek Res.

Marion County

Date Sampled	**8/21/91**	**Max. Depth**	**45**
Acreage	**1510**	**Avg. Depth**	**13**

Indiana has over 500 public lakes and reservoirs, ranging from five-acre ponds to the 10,500-acre Monroe Reservoir. These lakes are a valuable resource for all Hoosiers. Protecting and managing the water quality of our public lakes is an important role of the Indiana Department of Environmental Management.

The large amount of data collected during lake water quality assessments can be confusing to evaluate. Because of this, Indiana and many other states use a trophic state index to help evaluate water quality data. A trophic state index condenses the data into a single, numerical index. Different index (or eutrohphy) points are assigned for 11 water quality variables, with each variable receiving a score from 0 to 4. The lower the score, the higher the quality of the variable. The total index is the sum of each variable's eutrophy points. The Indiana index ranges from 0 to 75 points, and are grouped into the following three lake quality classifications:

Trophic State Index Total	Water Quality Classification
0-25	highest quality
26-50	intermediate quality
51-75	lowest quality

A rising score for a particular lake from one year to the next indicates that water quality is worsening, while a lower score indicates improved conditions.

The Trophic State Index score for **Eagle Creek** is: **41**

TROPHIC STATE INDEX PARAMETERS

Phosphorus. An essential plant nutrient, most often controls aquatic plant growth. Found in fertilizers, human and animal wastes, and yard waste.

Soluble reactive phosphorus - dissolved phosphorus concentrations with dense algae populations where it is tied up in the algae themselves. May be released from storage in sediments when dissolved oxygen is lacking.

Eutrophy points: **4**

Total phosphorus -includes dissolved and particulate phosphorus. TP concentrations greater than 0.04 mg/l can cause algae blooms.

Eutrophy points: **4**

Nitrogen. An essential plant nutrient. Found in fertilizers, human and animal wastes, yard wastes, and the air.

Nitrate (NO3) -dissolved nitrogen which is converted to ammonia by algae. Found in lakes when dissolved oxygen is present.

Eutrophy points: **2**

Ammonia (NH3) -dissolved nitrogen, preferred form for algae use. Also produced by decaying plant and animal matter. Found where dissolved oxygen is lacking.

Eutrophy points: **4**

Organic Nitrogen -includes nitrogen found in plant and animal materials. May be in dissolved or particulate form.

Eutrophy points: **3**

Dissolved Oxygen - Dissolved gas essential for respiration of fish and other aquatic organisms. Enters water by diffusion from air and photosynthesis. Consumed by respiration and bacterial decomposition. Affects chemical reactions in water.

DO Percent Saturated - Measured at five-foot depth, compares actual amount of oxygen to what is expected to be present at the lake's temperature and altitude. If saturated beyond 100%, the lake's plant life is producing oxygen quicker than it is being consumed.

Eutrophy points: **0** **Saturation level:** **84** **%**

DO Percent Oxic -Overall depth profile of the lake's ability to support the oxygen needs of fish, bacteria, and other aerobic life.

Eutrophy points: **3** **Percent Oxic:** **45** **%**

Secchi Disk Transparency. The depth to which the black and white Secchi disk can be seen as it is lowered into the lake (named after Professor P. A. Secchi, papal scientific advisor during the latter 19th century). Transparency is reduced by suspended algae and sediment particles in the water. Disk visible to **2.62** foot depth.

Eutrophy points: **6**

Light Transmission. Similar to Secchi disk transparency, this measurement used a light meter (photocell) to determine the rate at which light transmission is diminished in the upper portion of the water column. Another light transmission measurement is the 1% light level; the depth to which one percent of the surface light penetrates and is considered the lower limit to algae growth.

Eutrophy points: **4**

Plankton. Important members of the aquatic food web. Include the algae (microscopic plants) and the zoo plankton (small shrimp-like animals that eat algae). Determined by filtering water through a net having a very fine mesh. The plankton net is towed up through the water column from the 1% light level to the surface. Unlike previous variables plankton receives between 0 and 25 eutrophy points. If blue-green algae comprise more than 50% of total plankton, ten additional eutrophy points are assigned. Blue-green algae are those which most often form nuisance blooms and are indicators of poor water conditions.

Plankton Eutrophy Points: 1

Blue-Green Dominance Eutrophy Points: 10

Plankton per liter

Algae:	Blue greens:	**3574**
	Greens:	**15**
	Diatoms:	**310**
	Other algae:	**0**
Zoo plankton:		**93**
Total plankton/liter:		**3992**

INDIANA DEPARTMENT OF NATURAL RESOURCES

PATRICK R. RALSTON, DIRECTOR

Division of Water
402 W. Washington St., Rm. W264
Indianapolis, Indiana 46204-2212
317-232-4160
FAX: 317-233-4579

June 18, 1993

Dr. J. W. Delleur
Environmental and Hydraulic
Engineering Department
Civil Engineering Building
West Lafayette, IN 47097

Dear Dr. Delleur:

Thank you for your letters dated May 17th and 19th, 1993 and for providing us with a copy of your draft progress report on the Indianapolis levee reliability study. We would like to respond not only to the questions you asked but also to other issues raised in the report.

The peak flood discharges used at the West Fork White River gage at Indianapolis for the years 1904 thorough 1929 were drawn from gage records published by the USGS. This includes the estimated flood peaks between 1904 and 1929. Copies of the relevant Surface Water Supply book should still be available at Purdue's Geosciences Library.

We have some serious concerns regarding the frequency flood peaks published in your draft report. We are extremely reluctant to agree with dropping the March 1913 and June 1975 floods from the analysis even though they appear to be outliers. We would contend that these events may contain important information on the overall flooding behavior of the streams involved. Further, dropping these events from the analysis runs the risk of underestimating the frequency flood discharges. This is very undesirable from the standpoint of public safety.

We recognize that the methods contained in Bulletin 17B (and thus in the program HECWRC) for dealing with historic floods are not adequate for dealing with these events. Therefore, the issue becomes one of putting these two extreme events into their proper contexts. We suggest that comparison to the Probable Maximum Flood could shed some light on the question.

Please take note of the fact that the three streams in the study have "coordinated discharges." This means that an agreement exists between a number of government agencies to use a given set of frequency flood discharge values for flood related studies on these streams. Any new discharges you may propose for these streams must be approved by the agencies involved before they can be used in any study involving a flood control project or any other project that would be regulated by the Department of Natural Resources. Otherwise, you must use the currently

established coordinated discharges.

We were somewhat surprised by your finding that the construction of Eagle Creek Reservoir had a negligible impact on peak flood discharges. In an effort to double-check that finding, a plot was constructed of the cumulative flood peaks recorded at the Zionsville gage versus the cumulative flood peaks recorded at the Indianapolis gage for the period between 1957 and 1990. The enclosed plot confirms your finding. It also shows that flood peaks at the Indianapolis gage have actually increased relative to the Zionsville gage since 1977. It can be speculated that this increase is due to the rapid real estate development that occurred near the reservoir after its construction. In light of this plot, you may want to re-examine the homogeneity of the series at the Indianapolis gage.

You had also inquired about irregularities noted in the stream cross sections of the West Fork White River between River Mile 240.78 and 241.90. The sharp depressions you noted on the left bank represent the Indianapolis Water Company canal which is in the flood plain of the river. Because the canal has a continuous channel, we recommend that you leave its data in the cross section as effective flow area. The sharp spikes noted on the left bank of the stream represent the levee that you are studying. Finally, the sharp spikes in the channel at cross sections 240.8 and 241.52 represent the piers that are part of the bridges which occur at those cross sections.

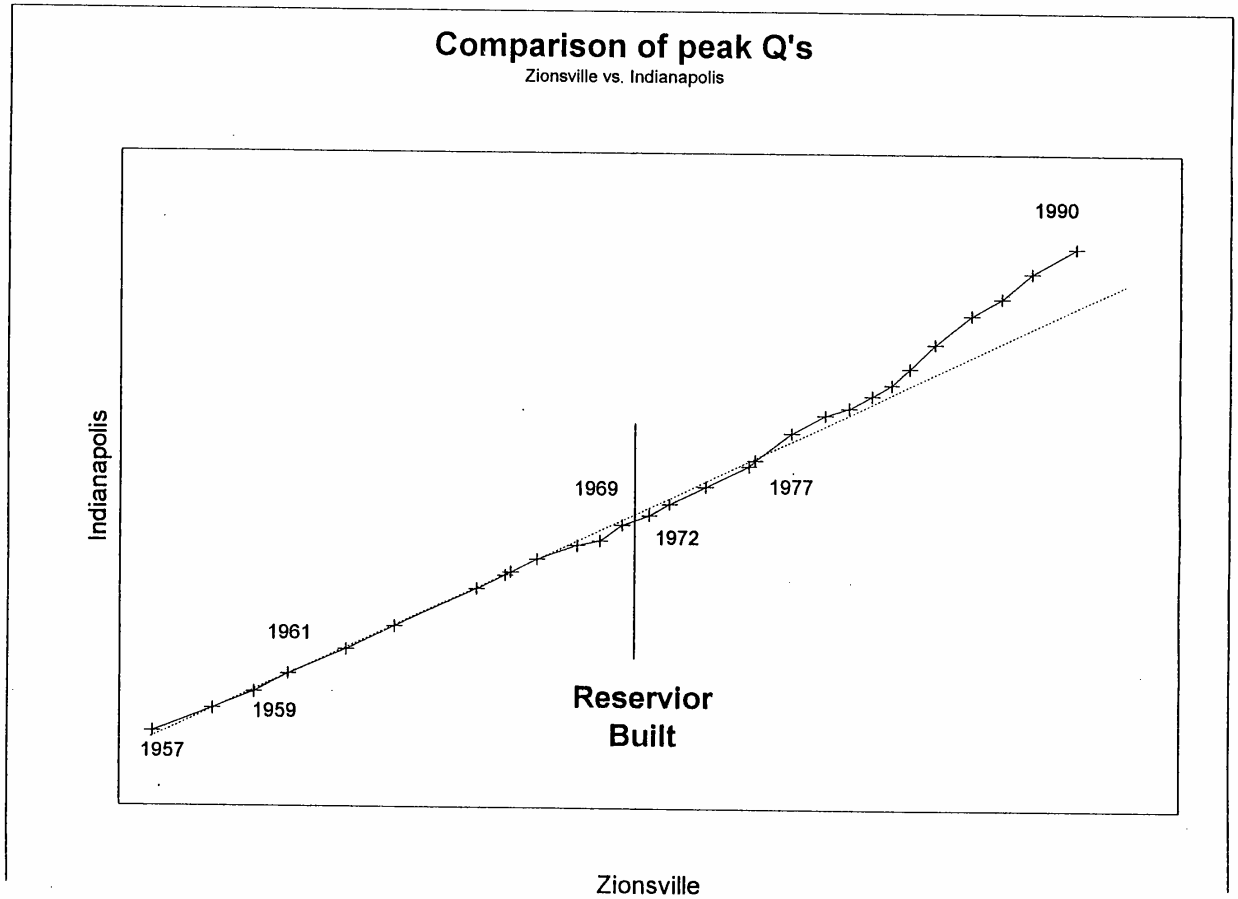
Thank you for the opportunity to comment on your progress report. It is hoped that these comments will prove useful to you as your study progresses. If you have any questions regarding this letter or require further information, please contact Mr. David Finley, P.E., in the Hydrology and Hydraulics Section at (317) 232-4164.

Sincerely,

FOR Peggy L. Shepherd, P.E.
Head, Hydrology and Hydraulics
Division of Water

PLS/DDF
Enclosure

cc: Ms. Clair Baffaut, Purdue University
Mr. Ahmed Hassan, Purdue University
Mr. Greg Henneke, Indianapolis DOT


Comparison of peak Q's
Zionsville vs. Indianapolis
1990
1969
1977
1972
1961
1959
1957
Reservior
Built
Indianapolis
Zionsville

State of Indiana

DEPARTMENT OF NATURAL RESOURCES

Indianapolis

DEPARTMENT MEMORANDUM DATE October 22, 1981

TO: Robert F. Jackson, P.E.
Chief
Division of Water

FROM: Michael W. Neyer, P.E.

SUBJECT: Routing of Probable Maximum Flood Through Eagle Creek Reservoir.

Approximately one month ago you requested that an analysis of Eagle Creek Reservoir be undertaken in order to determine its adequacy under Probable Maximum Flood conditions. By virtue of this memorandum and the associated computations, I will explain the procedures used in, and the results obtained from said analysis. The following three references were employed in the endeavor; Hydrology Report for the Eagle Creek Watershed, Indianapolis, Indiana by Dodson, Kinney & Lindblom, October, 1959, Report of Investigation of Eagle Creek Reservoir, Marion County, Indiana for Flood Control & Allied Purposes, by Dodson, Kinney & Limdblom, May, 1961, and Instructions to Damtender, Reservoir Regulation for Flood Control Purposes, Eagle Creek Dam, October, 1968.

On Exhibit 3 of their 1961 report, DK&L tabulated the synthetic 3 hour unit hydrograph which they developed for Eagle Creek at the damsite. Due to the time required and complexity involved in developing a new unit-graph, DK&L's synthetic graph was adopted for analytical purposes. It should be noted however, that their synthetic unit hydrograph represents a contributing drainage area of 168 square miles not the 162 square mile figure which is published; thus, it may be slightly conservative. Since DK&L's unit-graph was chosen for the analysis it was also necessary to use their drainage area so that the computations for the runoff volumes would be correct.

The first phase of the analysis was devoted to verification of the following; capacity curve, rating curve, and the reservoir routing technique. The capacity curve was computed based on data contained in the 1981 report by Mishler, Toebes, and Houck of Purdue University, Eagle Creek Operation, Phase I Study, which tabulated areas at a 5 foot contour interval. The data was converted to a cumulative capacity table via the Division's TI-59 program for the Average End Area method of volume computation. The rating curve for the structure was taken from Exhibit A, Curve B of the Damtender's report. This curve represents the regulation schedule for the reservoir assuming all six tainter gates are operational. With the capacity and rating curves available an inflow hydrograph was required in order to perform the verification routing. By employing DK&L's synthetic unit-graph, their runoff tables for the Reservoir Design Flood (1961 report, Exhibit 3) and the Maximum Probable Flood (1959 report, Exhibit 27), and our TI-59 program for hydrograph convolution, two inflow hydrographs were developed. The data was used as input to the Division's routing program with the following results being obtained:

Reservoir Design Flood:

	DK&L	IDNR
Peak Inflow, (cfs)	83,000	82,690

(Continued)

Reservoir Design Flood (Con't):

	DK&L	IDNR
Peak Average Outflow, (cfs)	30,000	30,715
Maximum Elevation, (Ft,msl)	811.5	811.55

Probable Maximum Flood:

	DK&L	IDNR
Peak Inflow, (cfs)	167,000	166,800
Peak Outflow, (cfs)	155,000	161,000
Maximum Elevation, (Ft, msl)	814.7	814.7

As is evident, the routings verified that the capacity and rating curves as well as the routing technique were correct.

The second phase of the project concerned the development of an inflow hydrograph for the Probable Maximum Flood using IDNR's techniques. A depth-area-duration table was prepared for the reservoir site by utilizing rainfall data contained in Hydrometeorological Report #51. The transfer of the tabular data to a semilogrithmic graph facilitated the selection of the various rainfall depths at the damsite. The damsite rainfalls were plotted on cartesian paper such that durations which were not readily available could be obtained.

As you are aware, the time distribution of the PMF has long been a point of contention in this office. For this analysis, a duration of 24 hours was selected for two reasons, greater runoff volume, and the severity of the associated time distribution. The National Weather Service distribution was chosen and resulted in 78% of the total precipitation being concentrated in the third six hour block. Once the event had been distributed it was compared to the distribution used by DK&L whose method was slightly less severe with 73% of the rainfall in six hours.

The aforementioned 1981 Purdue report contained a table of land use by soil association, (Page 7, Table II-2). Through the use of this table, the county soil maps, and a table of hydrologic soil-cover complex numbers a curve number of 84 was computed for antecedent moisture condition II. By solving DK&L's rainfall-runoff relationship in reverse order, it was found that a curve number in the range of 84 to 87 would be required to reproduce their work. The previously distributed rainfall was converted to runoff via the Soil Conservation Service technique. This does not agree with DK&L's initial-plus procedure but the overall runoff volume was essentially the same.

Once again the inflow hydrograph was developed through the TI-59 program. The resultant routing of the hydrograph yielded the following:

Probable Maximum Flood, Curve Number 84:

Peak Inflow, (cfs)	173,500
Peak Average Outflow, (cfs)	154,800

(Con't)
Probable Maximum Flood, Curve Number 84:

Maximum Elevation, (Ft,msl) 813,93

Inflow hydrographs for the 10, 25, 50, and 100 year rainfalls were also developed via DK&L's unit-graph, the SCS 24 hour Type II distribution, and the SCS runoff technique (CN=84). The resultant peaks of these hydrographs were in excess of our coordinated discharges approximately 6000 cfs. By forming ratios of the coordinated to the computed discharges and multiplying the computed runoffs by said ratios, runoffs associated with the coordinated discharges were computed. As the rainfalls and desired runoffs were known, a trial and error procedure was employed to compute an appropriate curve number. The computed value was 75. This seems rather low for the Eagle Creek basin but as can be seen from the following table, the peaks correspond very well with the coordinated values:

Recurrence Interval (Years)	Coordinated Discharge (cfs)	Computed Discharge (CN=75, cfs)
100	22,200	21,600
50	19,000	19,100
25	16,000	15,800
10	12,200	12,400

If you will recall, we have had several in office discussions concerning the operation and modification of flows through Eagle Creek Reservoir. By routing the aforementioned hydrographs the following results were obtained.

Recurrence Interval (Years)	Peak Inflow (cfs)	Predicted Outflow (cfs)	Peak Average Outflow (cfs)	Maximum Elevation (Ft, msl)
100	21,600	11,900	13,400	795.12
50	19,100	11,100	11,600	794.02
25	15,800	10,100	10,700	792.68
10	12,400	12,200	10,000	791.25

The predicted outflows are based on the work I performed at the time we were working on hydrology for the Marion County FIS. As is evident, the 10 year flow was anticipated to pass in a unmodified condition but in fact was reduced by 19%. The prediction was based on a so called "no mans land" on the synthetic inflow-outflow curve. By examination of the results it does appear as there will be a point where the inflows are unmodified.

I trust this has answered some of the questions you may have had concerning the Eagle Creek structure. If you have any further questions or require clarification of some aspect of the analysis, please contact me at your convenience.

Michael W. Neyer, P.E.
Head, Surface Water Unit
Division of Water

MWN/vh

October 6, 1981

John N. Simpson, P.E.

Assistant Chief

Division of Water

Michael W. Neyer, P.E.

Review of Eagle Creek Operation Phase I Study

In response to your request of September 30, 1981, I have completed my review of the text entitled Eagle Creek Operation Phase I Study by Mishler, Toebes, and Houck. My general impression of the report is that it is an oversimplification of subjects as vital to Indianapolis as flood control and water supply. My specific comments are as follows:

Page	Comment
6	The statement is made that "soils maps were also used to determine the land use characteristics of the watershed." I don't feel it is possible to compute land use from maps which only depict the basic soil associations. Land use characteristics should be based on field reconnaissance and/or aerial photographs.
7	Table II-2 is a breakdown of the various land uses and soil types by county. Later in the report reference is made to increased runoff due to increasing urbanization; it is interesting to note there is no urban and/or suburban land use in this table.
4	In reference to the watershed "is approximately 162 square miles in size with 61.4% of that area being above Zionsville." The 162 figure is correct but the area published for the Zionsville gage is 103 sq.mi., thus the area above Zionsville is 63.6% of the total.
10	The ungaged portion of the watershed is 36.4% not 38.6%; see comment for page 4.
12	"If a gauge reading was available without a corresponding flow, a fitted regression equation was used to determine the appropriate discharge." I feel the actual rating curve should be used instead of a regression equation.
13	In reference to the rating curve regression equations, same comment as page 12.
14	With respect to the January missing data, I feel the average of the preceding and following days would be preferable over the use of the monthly average.

Page	Comment
49	The actual gate rating should be used instead of the regression equation.
51	It appears as though the seepage estimate is simply used to account for all unaccounted for flows in the model.
Fig. IV-6 Fig. IV-13	Why aren't the ending policy elevations for one year equivalent to the initial policy elevations of the next year?
62	The comment concerning the coarse nature of the model with respect to flooding applies.
63	I believe the maximum withdrawal of 19.84 cfs is for one day, not the entire year as is implied.
67	Same comment as page 63.

If you have any questions or require further explanation of any of these comments, please contact me.

mw

Michael W. Meyer, P.E.
Head, Surface Water Unit
Division of Water

MWM/ds