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FOREWORD

The 4 papers in this RECORD indicate the wide range of disciplines and interests that are involved in the roadside environmental aspects of highway construction. They include topics of broad and timely interest to highway administrators and project managers and more detailed topics of interest to highway engineers, landscape architects, and planners.

Gordon assesses the effectiveness of an interdisciplinary team approach in addressing problems associated with the impact of highway construction on the environment. A case study reviews the interplay and achievements of an interdisciplinary team. Although the case histories may apply to only 1 section of the country, the approaches used in determining possible damage and the means of mitigating possible damage can be applied widely. Gordon concludes that an interdisciplinary team is an effective means of dealing with complex environmental problems and suggests that transportation agencies provide in-house expertise and retain outside consultants only when highly specialized service is needed.

Rivers and Allen report on the results of a study to control lake pollution caused by highway construction erosion. Erosion control techniques employed during construction were found to be capable of preventing the movement of sand-size particles into the lake, but they were not effective in removing the suspended silts and clays causing turbidity. Floating silt barriers, employed in the arms of the lake, were found to be 93 percent effective in confining suspended fines to localized areas.

Holtman reviews the means by which a registered historic district and a major highway can be planned to coexist. A 10-year controversy over the possible location of an Interstate highway was resolved by use of the National Historic Trust 106 process. A community-supported highway alignment and impact mitigation plan was developed that enabled the district to retain its special identity and, at the same time, minimize the adverse effects of the location on the community.

Duell and Schmit discuss the continuing need to develop more suitable grasses for roadsides and the testing of more than 1,000 varieties or strains of 36 species of grasses. Experimental plots were established and observed for 5 years at 3 Rutgers University sites and at more than 6,400 sites along newly constructed highways in New Jersey. The authors conclude that attractive turf that requires less mowing can be achieved with properly established mixtures of superior varieties of 5 fescues and Kentucky bluegrasses.

INTERDISCIPLINARY TEAM APPROACH TO MITIGATING ADVERSE ENVIRONMENTAL IMPACTS OF HIGHWAY CONSTRUCTION

James R. Gordon, Office of Environmental Planning,
California Department of Transportation

To assess the effectiveness of the interdisciplinary team approach in highway planning and project development in California, the author, by using the case study method, examines the interrelationships and interworkings of engineering and nonengineering skills in addressing problems associated with the impact of highway construction on the sensitive natural environment within the jurisdiction of the Coastal Zone Conservation Commission. As a result of this analysis, the author concludes that agency organizations should provide for an in-house core of expertise and use outside consultants only when highly specialized expertise is needed. Also, the organization must be flexible so that the concept can be applied easily at all stages of the highway planning and project development process. Of importance to the successful operation of the interdisciplinary team approach is the attitude of top management. It must be responsive to issues raised by all disciplines and must consider the contributions of all disciplines equally and fairly. Through the implementation of the California Action Plan, California has committed itself to the effective application of the interdisciplinary team approach.

•PEOPLE, in their efforts to build a better society, have had an enormous impact on the environment. Until a few years ago, their activities rarely were challenged. Today, however, we are witnessing a rise in the surge of public concern over all governmental and private activities, particularly those that can disrupt and degrade the environment. Highway development seems to receive the brunt of this criticism. Highways are the most often seen and used public works, and, thus, are a handy target.

The difficulties being encountered by transportation departments probably will continue. Who is at fault is not important. Transportation departments must consider the problems and try to solve them. Their planning efforts must reflect the present public mood. The public's environmental concerns must be addressed early in the planning process. In meeting this challenge, transportation departments must use a full complement of disciplines to ensure that not only engineering aspects are considered but also that social, economic, and other environmental concerns are addressed properly. The consensus within the transportation community seems to be that the interdisciplinary team concept is the approach that will best satisfy public concerns. How California applies the concept is the theme of this paper.

Public pressure and criticism have brought about federal and state legislation that directs transportation programs. Legislation and regulation have provided the impetus for proper consideration of all environmental factors in the planning process and in day-to-day activities. The National Environmental Policy Act of 1969 (NEPA) provided a statement of environmental policy, a statutory foundation to which administrators could refer for guidance in making decisions when environmental values conflict with other values. And the legislation went further than stating policy. It provided an action-forcing procedure in Section 102(A), which states that all agencies of the federal government shall

> Utilize a systematic interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and decision-making which may have an impact on man's environment.

California enacted the California Environmental Quality Act in 1970, which directed the state to "Develop and maintain a high-quality environment, now and in the future, and take all action necessary to protect, rehabilitate, and enhance the environmental quality of the state." This statement, "take all action necessary," implies that California should use the systematic interdisciplinary approach to conform to federal legislation.

Introducing the systematic interdisciplinary team concept into transportation planning and design has provided impetus for a broad approach to environmental concerns. It ensures that full consideration will be given to all environmental factors encountered in highway planning.

The desirability of a systematic interdisciplinary team approach generally is accepted, but the means of obtaining such an approach are not widely agreed on. The problems in achieving an effective systematic interdisciplinary approach are numerous and difficult. Using a specific case study, I would like to discuss how the California Department of Transportation approaches this problem.

Recognizing the importance of the interdisciplinary team, the Federal Highway Administration in March 1973, convened a panel of experts to discuss the subject. They determined that this approach is

> A process through which pertinent expertise is utilized in an integrated manner in the planning of projects. This insures that inputs on, or aspects of the environment are adequately considered, assessed, and incorporated, and that responsible evaluations and decisions are made.

This pertains to planning of projects. Other cases involve projects for which routes already have been determined (pipeline projects) and are well beyond the planning stage. This paper will discuss an example of this.

ORGANIZATION

Before NEPA was enacted, California recognized that environmental problems would become a dominant aspect of highway planning and development. At the same time, the importance of the systematic interdisciplinary team approach to addressing these concerns was realized. As early as August 1969, Community and Environmental Factors Units were established within the Division of Highways. The units are interdisciplinary; that is, they provide a core of disciplines that can address all aspects of the environment. The general disciplines include law, psychology, business administration, environmental planning, and urban transportation planning. The special disciplines include ecology, archaeology, sociology, economics, engineering, and geology. The units also are flexible so that talents can be applied not only in the early planning states but also on a project-by-project basis. This flexibility is necessary because much of the department's work has already passed the planning stage. The organization of disciplines is shown in Figure 1.

The case study to be discussed in this paper arose as a result of a highway project that was to go through an environmentally sensitive coastal zone. The department consulted with the Coastal Zone Conservation Commission. (This commission came into being after route location on this project had been determined and construction was to begin. This accounts for the fact that alternate route selection and the no-build alternate were not factors in the team's deliberations.) The department determined that it would prepare a special report before construction that would include a study of the impact of the project on the sand dunes, wildlife, and vegetation. In addition, the department agreed to look at possible route and design changes (within existing rights-of-way), construction techniques, and other forms of mitigation that would reduce the impact of the project on the marshes and vernal pools and associated wildlife.

The study area, shown in Figure 2, lies within 1,000 yd (900 m) of the Pacific Ocean between the north boundary of Fort Ord and 0.5 mile (0.8 km) north of Cardoza Avenue near Marina, California, in Monterey County. The project has progressed well into the planning and design process. The environmental concerns basically involved 3 distinct problems, each of which required unique and specific expertise for its solution.

STUDY PROCESS

The unique environmental problems required that the department provide, in addition to engineering, environmental design arts, and planning expertise, the expert knowledge of a biologist, geologist, soil stabilization expert, ecologist, sedimentologist, and soil conservationist. The team was made up of a design engineer, a coastal sedimentologist, a wildlife biologist, a landscape architect, an ecologist, an engineering geologist, and a project engineer. Of the 7 members all but 2 were in-house personnel. The team met first to determine the environmental problems posed by the highway project and the best study approach to arrive at feasible solutions. Field investigations allowed the members to discuss their ideas and to further define the problems. Together they developed a formal approach to the conduct of the studies, a study outline, and sequential deadlines necessary to meet schedules so that the team leader could determine whether objectives were being met and keep the study on schedule.

When the study outline was developed and deadlines were established, the team members addressed problems in their own areas of expertise and consulted with each other to ensure that their individual inputs would result in an integrated final study.

PROBLEM AREAS AND MITIGATION

As the team progressed through its study process, it was able to identify specific environmental problems and alternate measures necessary to mitigate these problems. The development of the mitigation measures made obvious the nature of the interdisciplinary team approach. In this phase, all those involved worked closely together, exchanged information, and educated each other to arrive at measures that were acceptable and feasible for each discipline and the effort as a whole. For example, the sedimentologist suggested a process of highway grade changes for dune stabilization. In his discussions with the geologist and the engineer, he found that his measures were not feasible and that other solutions might be possible.

Sand Dunes

Problem

The southerly portion of the highway right-of-way cuts through large coastal dunes partially covered with coastal sage scrub vegetation. The scrub vegetation had succeeded in stabilizing the dunes to a considerable degree until the 1950s when off-road vehicles (ORVs) began cutting the numerous trails that characterize the surface today (Figure 3). As these trails were cut, the winds began moving the exposed sand, which caused the numerous denuded channels and drifts that characterize the present surface. The demise of the horseshoe-shaped (parabolic) dunes affected by the project is well advanced at present (Figure 4).

The dunes provide open space for outdoor recreation (destructive and nondestructive)

Figure 1. Environmental branch organization.

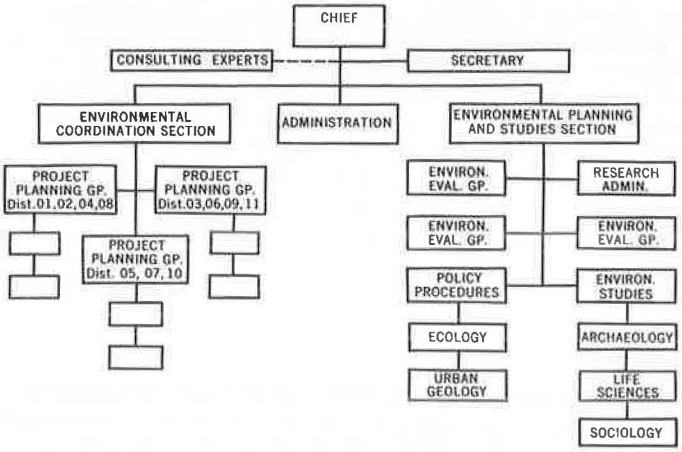
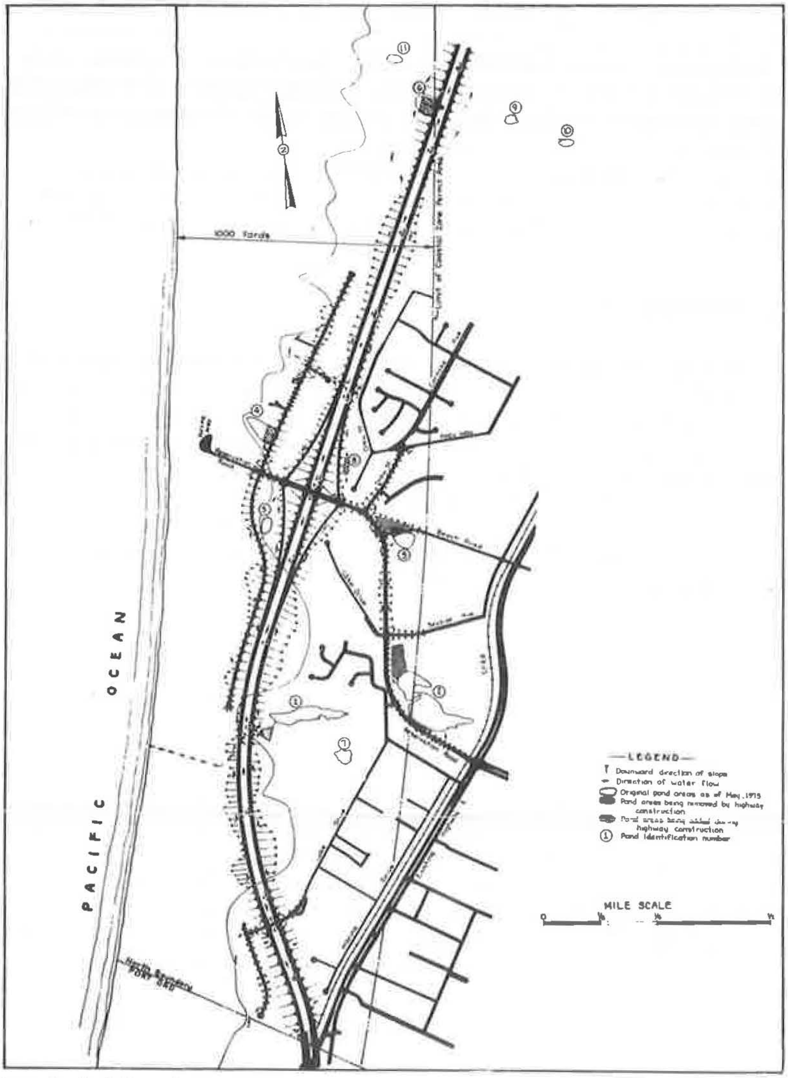


Figure 2. Study area.



Note: 1 yd = 0.9 m. 1 mile = 1.6 km.

Figure 3. Off-road vehicle impact on sand dunes.

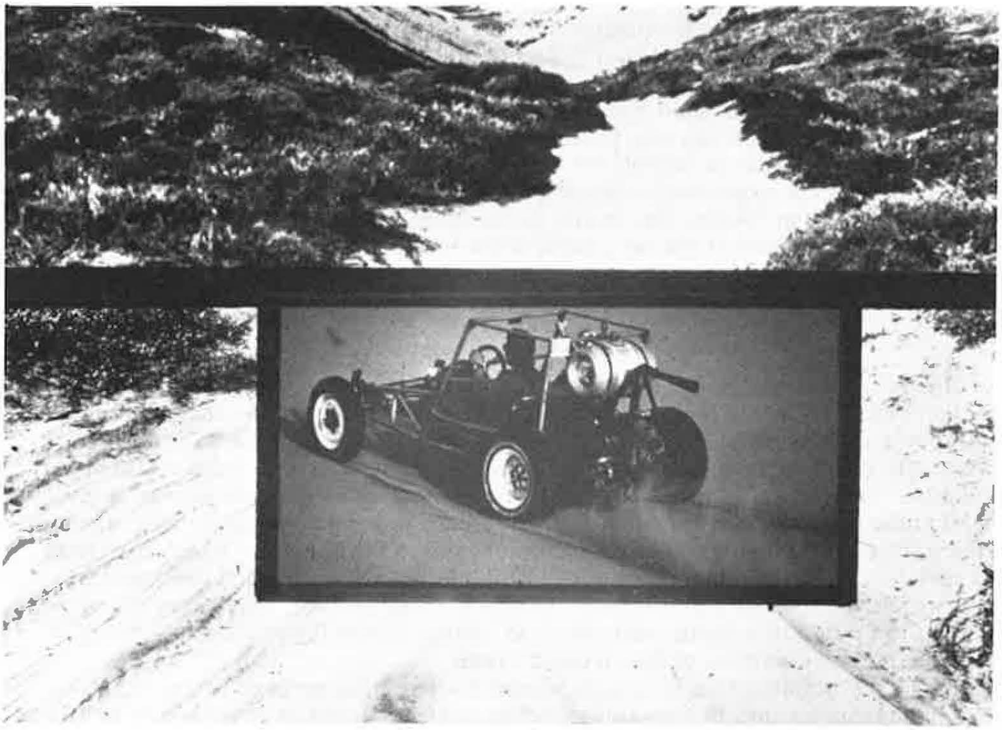


Figure 4. Demise of sand dunes.

and wildlife habitat for numerous wildlife species. The plants providing habitat for these animals vary considerably (Figure 5). Some of the most prominent are salt bush, coyote bush, bush lupin, and sand verbena. Most of them are native to the area; there is a scattering of introduced species. Ice plant is present in widely scattered patches, and the various species are prominent in the present coastal ecosystem. Because of the existing disturbed conditions in the dunes, the team determined that the highway project was not expected to result in a significant loss of vegetation and wildlife habitat. Only a short-term loss would be involved, and then revegetation would take hold. The highway would not be a significant barrier to wildlife.

Mitigation

After full investigation and group meetings, the team determined that the most critical problem associated with this highway project was the stabilization of dune sand on cut and fill slopes and throughout the right-of-way. Associated with this was the need for an aesthetically pleasing landscape that would enhance the environment for travelers and residents. To solve this problem, the team devised an innovative plan to minimize impact and enhance environmental quality. This plan involved spreading a layer of soil-stabilizing compound on disturbed slopes and covering it with special fiber, fertilizer, and seed mix in various combinations. The soil-stabilizing compound used was hydromulch, which consists of 2 emulsions: One is a vinyl acetate, vinyl acrylic, or acrylic base; the other is a lignin sulfonic acid base. These techniques are being used on a considerable portion of the project area.

As a temporary stabilization measure before the establishment of native plants, the department transplanted European beach grass and erected drift fences in critical areas where the wind force is concentrated. These are limited to areas where wind conditions are severe enough to warrant tree planting and will give trees protection. The grass will be replaced through natural plant succession. Drift fences will be removed when stabilized conditions indicate that they are no longer needed. These are the only areas where fertilizer will be used. The fertilizer will be the slow-release type to ensure against excessive nutrient addition to aquatic ecosystems.

The reestablishment of native plants (Figure 6) in the shortest possible time is the key to achieving a stable and attractive environment in the right-of-way. Reliance on native species not only will improve the possibilities for successful erosion control but also will provide wildlife habitat suited to the needs of the native fauna. Trees, in particular, are an important mitigating factor because the coastal strip, at present, contains few trees, and the scattered small groves planted in the right-of-way will serve as nesting and roosting sites for birds and will provide a source of additional feed for birds and other animals. In addition, the team suggested increased planting of trees and shrubs during the highway planting project after road construction to further improve stabilization, aesthetics, and wildlife habitat.

Mitigation measures have improved the aesthetics of the dune area (Figure 7). Where the highway cuts through the dunes, it will be hidden considerably from the inhabited area on the east and totally from the beach area. Although this largely destroys the classical form of 3 of these dunes, it is not a great environmental loss because the dunes over which the freeway will pass are not a rare physiographical feature and they already had been substantially altered. The right-of-way will be changed from a modified and unstable dune landscape to a freeway form containing rounded cuts and fills covered with vegetation. The freeway will be a double-paved surface visible to few people other than highway travelers. The landscape after the highway is built will be more stable than it is at present if ORV activity is eliminated and continuous maintenance of facilities, soils, and vegetation is accomplished.

Figure 5. Plant habitat of sand dunes.

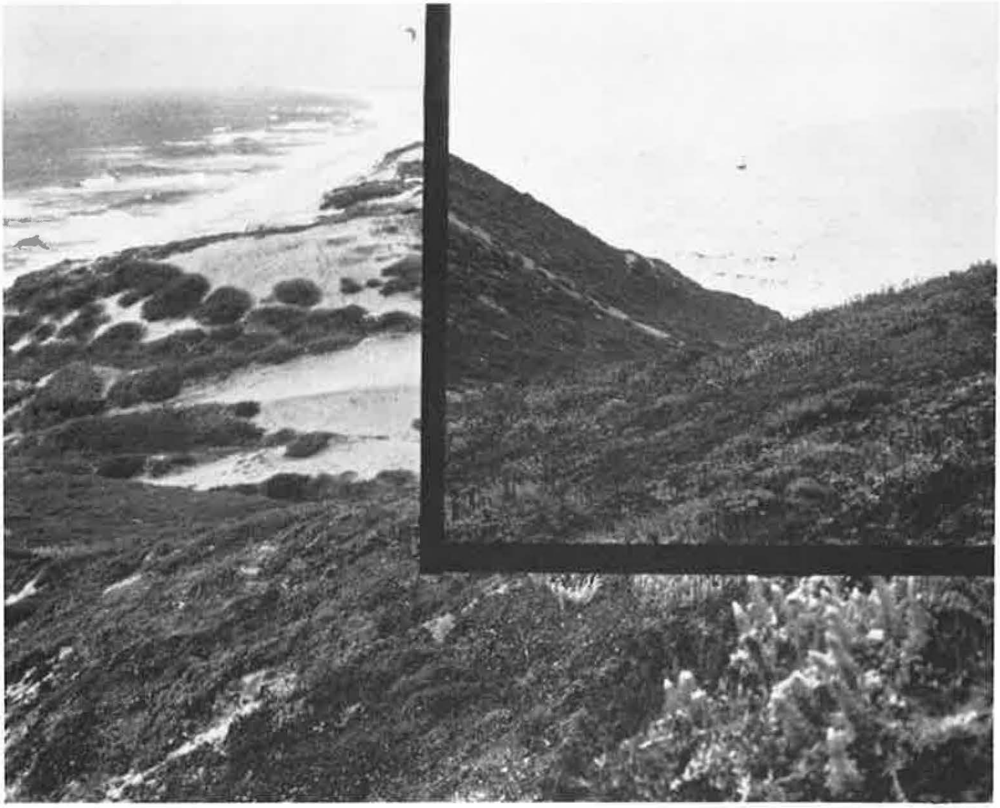


Figure 6. Native plants of sand dunes.

Figure 7. Improved aesthetics of sand dunes.

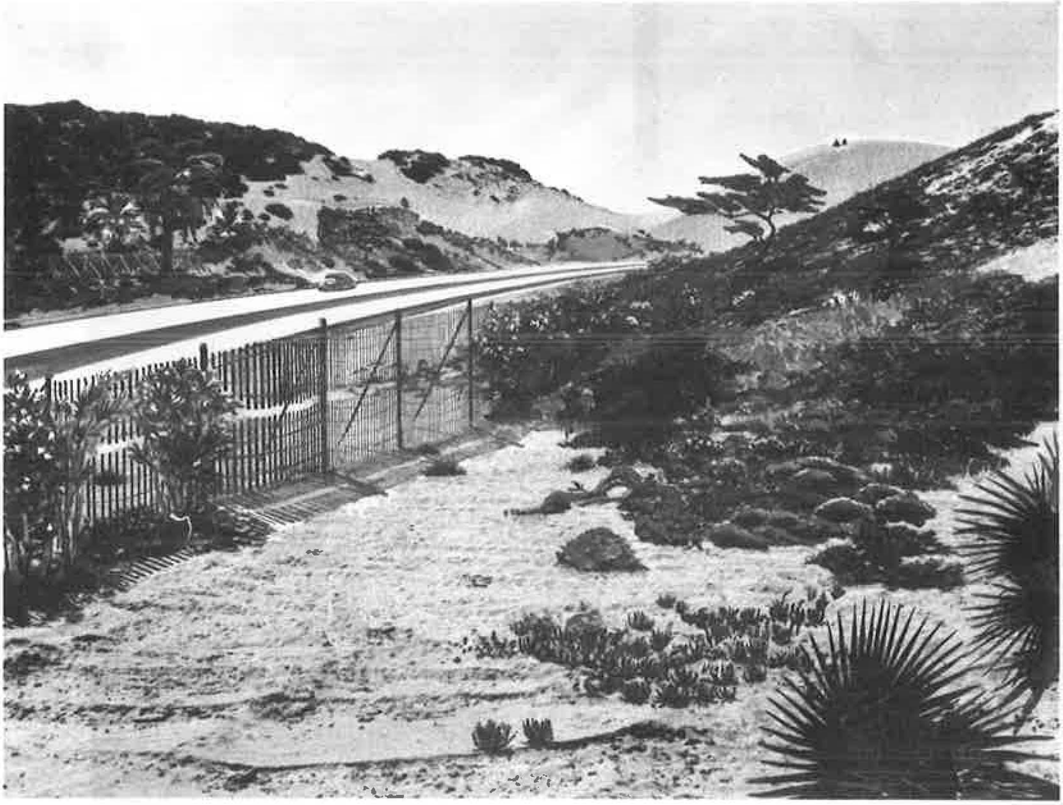


Figure 8. Vernal pool in study area.

Vernal Ponds and Marshes

Problem

The involved vernal, or seasonal, ponds and drainage ponds, which are similar but fresher, have been damaged to some degree by human misuse (Figure 8). Natural processes are very slowly filling in these low spots. However, ORVs, horseback riding, sand extraction, and subdivision activity have been accelerating this process. Some wildlife continue to use the ponds to varying degrees primarily on a seasonal basis.

The marsh vegetation consists of concentric rings determined by water preference and salt tolerance where disturbance is minimal. The form and surface area of the 6 ponds affected by the project will be altered to a certain degree. The vegetation pattern should reestablish itself through natural processes. Vertebrate and invertebrate wildlife will continue to make use of these habitats. Whether they will do so in greater or lesser numbers cannot be determined with certainty.

Vibration of freeway traffic will cause some compaction of sand under the highway. Compaction could cause a minor reduction in subterranean drainage flow, which could cause a slightly higher water table on the east side when there is a great deal of precipitation.

Mitigation

These ponds will be altered considerably through surface area change caused by the highway project. To mitigate this impact, we planned the modifications in such a way that no net loss of surface water area would result from the project (Table 1). Within the highway right-of-way, the small areas of marsh vegetation on the periphery of these pools will be maintained in the natural form developed through the readjustment process. Outside the right-of-way, local land use controls will be needed to ensure preservation of the remaining natural qualities associated with this vegetation. No measurable loss of wildlife habitat is anticipated. The ponds may still be used by schools, nature groups, and others for nature study. The highway project, after completion, will be especially suited to those who wish to learn about the effects of human activities on natural plant and animal communities. Interested parties can compare these disturbed environments with protected natural areas with similar ecosystems to learn more about the impact of the highway and to test mitigation hypotheses. The California Department of Transportation will follow up on these studies.

Table 1. Modification of vernal pools.

Pond Number	Total Area[a] (acres)	Area Taken (acres)	Area Replaced (acres)
1	2.8	0.1	–
2	5.0	0.2	1.1
3	1.1	0.3	0.8
4	1.4	0.6	–
5	0.5	–	–
6	1.0	0.8	–
7	0.7	–	–
8	0.0	–	0.2
9	0.4	–	–
10	0.4	–	–
11	0.4	–	–
Total	13.7	2.0	2.1

Note: 1 acre = 0.4 hm²

[a]Area based on water level as of May 7, 1973.

Private Development and Recreation in Coastal Zone

Problem

Local land use plans for this area include a mix of urban uses including residential and industrial uses on both sides of the proposed freeway. Proposals on open-space zoning in the dune and beach area community park development indicate that retaining open space between freeway and ocean is possible. The recent enactment of the Coastal Zone Conservation Act of 1972 and the completion of the Tri-County Coastline Study of 1972 further emphasize this possibility. Land use will depend on local, state, and federal regulations.

Improved access in the dune land area on the newly constructed roadways will allow increased land development. Other socioeconomic factors will affect this, however. Intensive development of the steeply sloped dunes can be attained only through grading and will result in destruction of natural land forms and biota. Such development may increase the amount of blowing sand, which might result in serious problems for highway maintenance and for other developments. And if the dune area is not developed, ORVs will accelerate erosion of the dunes.

Mitigation

State highways can increase the opportunity for land use control by local agencies. In this case, the freeway could be used as a divider between open coastal space and urbanization on the landward side. It would limit access to the dunes and beach area between Fort Ord and Beach Road to the 2 frontage roads constructed as part of the project. This gives landowners and public officials an opportunity to halt present destructive land uses. As final land use determinations are being made for this area, frontage road use can be carefully controlled by fences and gates.

CONSIDERATION OF ALTERNATIVES

The systematic interdisciplinary team approach must consider all workable alternatives to ensure that all environmental factors are fully considered. In this case study, the team considered the possibility of mitigating adverse impact through location and configuration changes in the right-of-way. The consensus was that significant mitigation could not be achieved because such action would create additional problems involving availability of additional land, legal constraints, costs, and design changes. The team recommended rounding or contouring of slopes in several areas to reduce highway impact on ponds, vegetation, and the natural form of the dune topography. Consideration was given to various grade changes, and a comparative analysis was made between the adopted grade and an alternative that would average 20 ft (61.1 m) higher through the dunes. The team determined that it would provide some benefits in reduced wind erosion and capture of incoming sand. However, it had several disadvantages. Because roadway and slope alterations would be more conspicuous, they would require an additional 1 million yd (0.9 million m) of borrow material, which would have additional environmental impact at the borrow site.

CONCLUSIONS

The team effort produced the results for which it was designed—the development of mitigation measures acceptable to all concerned. In addition, some valuable lessons were learned that will provide guidance in achieving better results in the future.

Team Management and Leadership

This case study showed that the selection of a team manager is important to the efficient and successful operation of the team. The team leader should be a generalist who has the ability to recognize what the problems will be, pull together the expertise needed to address these problems, understand the people on the team, and manage their efforts effectively.

Team Use

It is generally agreed that the systematic interdisciplinary approach must be used at all stages of the highway planning process. However, in California, much present and future work will be pipeline projects. New projects will be limited. Therefore, although it is most important that the interdisciplinary team approach be used early in the planning process, there must be enough flexibility in the system to allow the team approach to be applied at any stage in the planning process. The case study was a good example of the application of the team approach to a specific problem that arose late in the planning process.

Organization

It was apparent from the case study that organizations within highway departments that address environmental concerns must be flexible. Most departments cannot afford the luxury of the full staff necessary to address all the environmental problems that might arise. The California Department of Transportation uses a core of interdisciplinary experts that are retained in-house and bring in outside expertise to address specific problems as required. This approach appears to be effective. The level of effort must be determined on a project-by-project basis. And this will, to a large extent, determine the size and the makeup of the team.

Top Management Attitudes

The action plan being developed by the various states requires that top management be responsive to the issues and contributions of all disciplines. Top management must ensure that people are employed who can recognize what disciplines are required for full-time staff and what disciplines are required only for particular projects or only for various planning stages of projects. Top highway management also must be committed to the interdisciplinary team approach and must develop team leadership to ensure that this commitment prevails throughout the organization.

Consultant Activity

From the results of this case study, one can conclude that outside expertise plays an important role in the structuring and the operation of the interdisciplinary team approach. It is important that, when consultants are used, in-house expertise be used to oversee, coordinate, and evaluate their activities.

SILT BARRIERS AS EROSION POLLUTION CONTROL IN A LARGE RECREATIONAL LAKE

E. Grover Rivers and Charles J. Allen, Office of Environmental Administration, Florida Department of Transportation

Soil erosion from urban development and Interstate highway construction during the winter and spring of 1972 and 1973 resulted in extensive runoff pollution of Lake Jackson, a large recreational lake in northern Florida. Turbidity levels in mid-lake reached levels of 180 Jackson turbidity units, and portions of the lake reached turbidity levels exceeding 500 Jackson turbidity units. Floating silt barriers were deployed in 2 arms of the lake by the Florida Department of Transportation to abate the movement of turbid waters into the main body of the lake. Sediment core analyses were performed to determine the extent of sedimentation that had occurred, and water turbidity was monitered to determine the effectiveness of the silt barriers. Clay and silt fines were found to be the major factor in creating turbid conditions in the lake. Erosion controls were effective in controlling movement of sand-size sediments, but they were ineffective in controlling clays and silts. The silt barriers were up to 93 percent effective in preventing the movement of suspended silt and clay into the main body of the lake.

•THE PROBLEM of soil erosion during highway construction has been a major concern for several years. Of more recent concern has been the pollution effect of sedimentation and concentrations of suspended solids on biotic communities of natural aquatic habitats resulting from construction. Ellis (7) reported that erosion silts can destroy mussel populations in various streams by the direct smothering of mud deposits. Zeibell (15) and Cordone and Pennoyer (6) showed that silt from gravel washing operations in Washington and California could reduce benthic communities by 75 to 85 percent from 1 to 10 miles (1.6 to 16 km) downstream of the washing facilities. Hess (10) made a study during moderately heavy rainfall in the first winter after road construction during a logging operation near a small stream in California. He noted that turbidities reached as high as 3,000 ppm (3000 mg/dm^3) and that sediment had accumulated up to 2 ft (0.6 m) where erosion and slippage had occurred from the road. Immediate detriment was noted to most aquatic invertebrates in South Fork Caspar Creek. However, the loss of invertebrates was offset by an increase of diptera and plecoptera, which may or may not have been a direct result of road construction.

The direct effect of sediments and suspended solids on fish is not well documented. Kemp (11) stated that mud or silt in suspension can clog or cut the gills of fish and mollusks. He believed that suspensions of 3,000 ppm (3000 mg/dm^3) were dangerous when they remained for 10 or more days. Wallen (14) could not detect behavioral differences in warm water fishes until concentrations of turbidity neared 20,000 ppm (20 000 mg/dm^3) in controlled aquarium studies.

Bennett, Thompson, and Parr (4) determined that turbidity could reduce fishing success. It was found that the number of fish caught per person hour decreased from 6.53 to 2.04 when Secchi disk transparency was reduced from 4.0 ft (1.2 m) to 1.3 ft (0.4 m) in Fork Lake, Illinois.

Numerous erosion control techniques have been developed to prevent the transport of soil by water erosion from highway construction sites. Most of these controls involve energy dissipation to reduce the load-carrying capacity of runoff, or they involve chemical soil stabilizers, herbaceous ground cover, or artificial cover to reduce the erodibility of exposed soils from rain, runoff, and wind action (3). Often these controls are not effective enough to prevent the transport of silt and clay fines into natural bodies of water. Such suspensions can cause serious pollution problems as well as create adverse public reaction to highway construction.

Little information has been documented on the use of floating turbidity screens or silt barriers in natural waters to control suspended fines resulting from erosion during highway construction. Such silt barriers can be an invaluable tool in preventing the dispersion of suspended solids in storm-water runoff that are largely beyond the abatement capabilities of conventional erosion controls. This paper documents the effects that can be achieved by use of temporary floating silt barriers to prevent turbid conditions in a large recreational lake.

BACKGROUND

Lake Jackson is a relatively large freshwater lake occupying a surface area of approximately 4,000 acres (1619 hm^2) located in rolling terrain characteristic of the northern panhandle region of the state (Figure 1).

Two of the southern drainage subbasins of the lake, the Meginnis Arm watershed and the Fords Arm watershed, are located in areas of rapid urban expansion in Tallahassee. The subbasins occupy about 5,000 acres (2024 hm^2) of which the Meginnis Arm watershed is approximately 80 percent urban. Because of the rapid urbanization within its watershed, Meginnis Arm has been the recipient of increasingly large quantities of highly polluted storm-water runoff since the early 1960s. The Fords Arm watershed is largely single family residences. It has not been subjected to intense commercial development as has the Meginnis Arm watershed. Although comparable in size to the Fords Arm watershed, storm-water discharge from the Meginnis Arm watershed is 7 times greater than that of the Fords Arm watershed for similar rainfall events (5). Mean total discharge per storm into Meginnis Arm for 20 storms from September 1973 to March 1974 was measured at 730,868 ft^3 (20 696 m^3). Discharge measured into Fords Arm for 18 storms during the same period was 100,328 ft^3 (2841 m^3). Meginnis Arm has shown acute symptoms of cultural eutrophication in recent years in the form of high concentrations of green and blue-green algae that are not characteristic of other portions of Lake Jackson.

Interstate 10 in Florida, when it is completed, will extend west from Jacksonville, its easternmost terminus, through Pensacola to the Florida-Alabama state line. The Interstate facility traverses northern Leon County through portions of both the Fords and Meginnis Arms watersheds involving about 120 acres (49 hm^2) in those drainage subbasins (Figure 2).

Clearing for Interstate construction began in the 2 southern watersheds in May 1972. It was apparent that earth-moving operations and exposed clay soils posed a potential erosion problem because of the relief of the local terrain and the close proximity of the construction site to the southern portion of Lake Jackson. Various erosion controls were employed on the project site to forestall the possibility of transportation of sediments to the lake during rainfall periods. These controls included

1. An 8,000-ft^2 (743.2-m^2) sediment detention basin located in the path of Meginnis Arm tributary with a storage capacity for 600 yd^3 (458.4 m^3) of sediment,
2. Temporary Visqueen slope drains,
3. Earth berms,
4. Brush or hay-bale sediment checks,
5. Temporary grassing and mulching, and
6. Placement of sod on fill slopes after each 5 ft (1.5 m) of fill reached and use of plastic sheet covering at intermediate levels.

Antecedent precipitation for the 2 southern watersheds was extremely sparse during the fall of 1972. Total precipitation for the months of July through October registered at the Tallahassee municipal airport was recorded at 11.22 in. (28.5 cm). The normal

Figure 1. Lake Jackson area.

Figure 2. Interstate 10 alignment through Fords and Meginnis Arms watersheds.

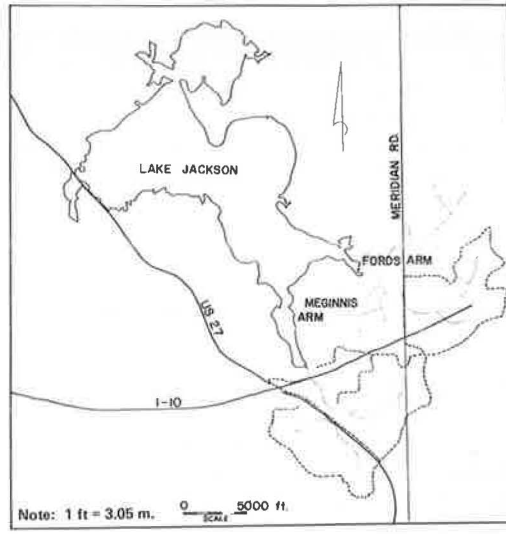
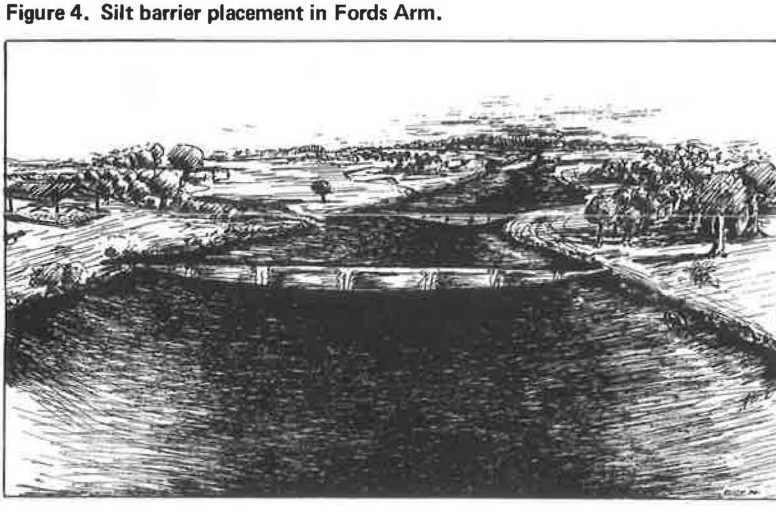


Figure 3. Silt barrier placement in Meginnis Arm.

Figure 4. Silt barrier placement in Fords Arm.



rainfall total for the same period is 22.9 in. (58.2 cm). Lake levels during this period reached a low elevation of 83.4 ft (26.2 m) above sea level.

Beginning in November 1972 and following through May 1973, record rainfall was recorded at 61.76 in. (156.9 cm) for the 7 months. This exceeded normal rainfall by 34.5 in. (87.6 cm) for the same period. Normal yearly rainfall for the Tallahassee area is 56.86 in. (144.4 cm). Lake elevations rose above 87 ft (26.5 m) during this period.

Turbidity and suspended solids reached levels of 1,200 Jackson turbidity units (JTU) and 2,830 ppm (2830 mg/dm^3) respectively where I-10 crosses Meginnis Arm tributary. Turbidity levels in Meginnis and Fords Arms reached as high as 520 JTU, and a noticeable plume of highly turbid, very discolored water had extended from Meginnis and Fords Arms to a point in mid-lake. Its area was equal to about a third of the lake surface. Mid-lake turbidities of up to 180 JTU were recorded. Florida's allowable pollution standard for turbidity is 50 JTU above background. The mean mid-lake turbidity level for the previous year (July 1971 to June 1972) was 7.2 JTU (8).

It became readily apparent that the erosion controls employed were ineffective in preventing the transport of sediments into the lake. An additional sediment detention basin with a capacity of 600 yd^3 (458.4 m^3) was constructed upstream of the project on Meginnis Arm tributary to help control sediment transport from urban Tallahassee as well as provide additional retention for runoff from the highway construction area. Additional ponding on the project site within median and interchange areas further prevented runoff from carrying away erodible materials.

To prevent further degradation of the water quality of the main body of the lake, the builders installed temporary silt barriers (diapers) in the 2 southern arms of the lake. The barriers were placed in such a way as to confine the uncontrolled suspended materials to the 2 arms rather than allow them to spread farther into the lake proper. These diapers originally were developed by the Florida Department of Transportation to control the spread of suspended silts during dredging operations (2). But they had never been applied to the containment of suspended fines from storm-water runoff from upland construction activity. Their effectiveness could only be speculated on because of the volume of runoff encountered and the colloidal nature of the clay fines that were suspected of creating most of the turbidity problems within the lake.

SILT BARRIER APPLICATION AND DESCRIPTION

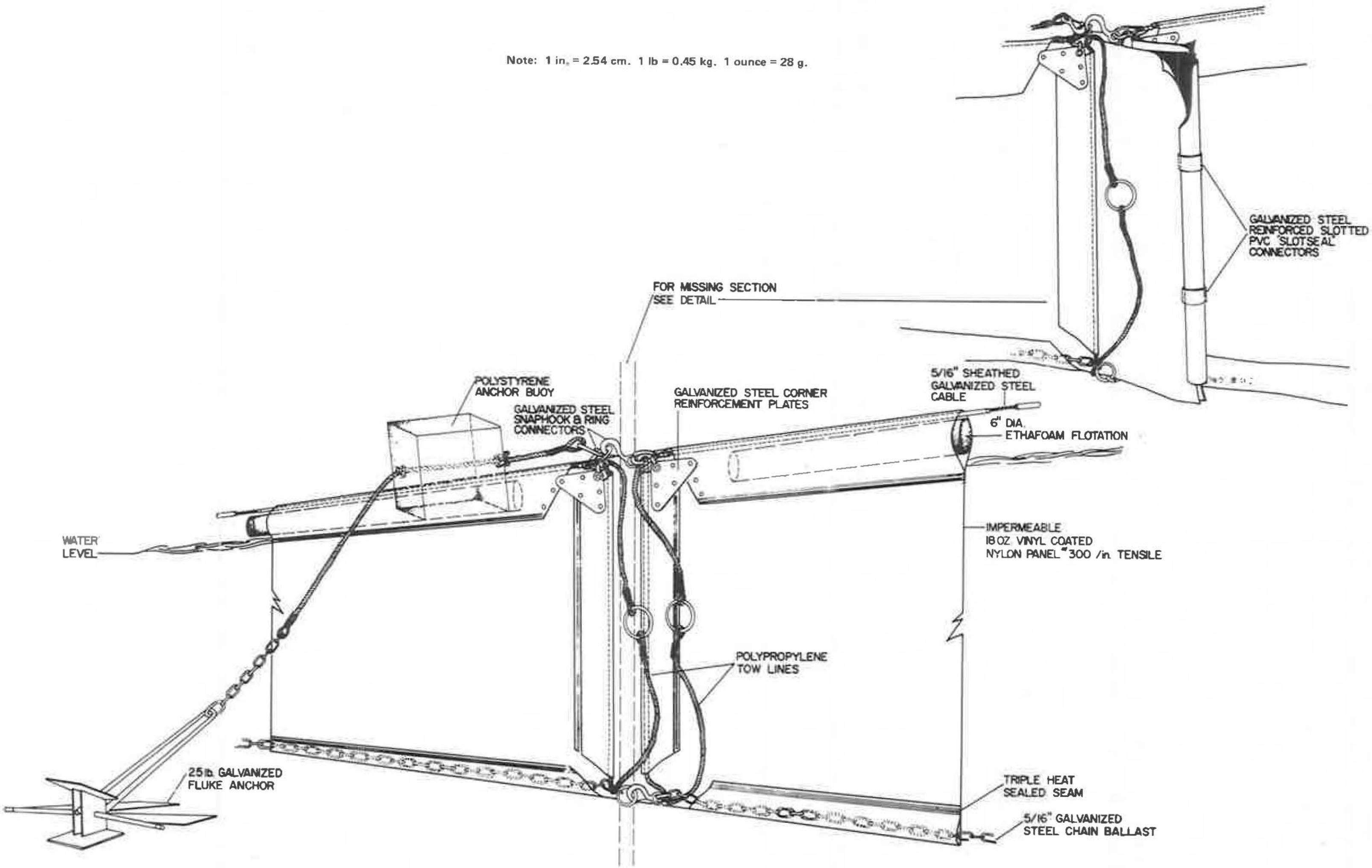
Cross-sectional profiles along selected transects in the 2 arms were measured to determine lake bottom configuration where the silt screens were to be located. Water depths varied in the 2 arms from 2 to 10 ft (0.61 to 3.05 m); widths from shoreline to shoreline varied from 400 to 1,000 ft (121.9 to 304.8 m). Locations were selected that represented areas of low flow where possible to ensure maximum use of low energy currents during high runoff conditions. It was decided that 2 barriers would be deployed in each of the 2 arms of the lake. Figures 3 and 4 show barrier positions in Fords and Meginnis Arms.

The silt barriers cost about $23 thousand. Barriers were constructed of impermeable 18-ounce (504-g) vinyl-coated nylon-fabric material with a tensile strength of 300 lb/in.^{2} (207 kPa/m^2). Flotation was provided with 6-in. (15.2-cm) diameter, 11-lb/ft (16.3-kg/m) buoyancy ethafoam in Meginnis Arm and 6-in. (15.2-cm) diameter, 11-lb/ft (16.3-kg/m) buoyancy styrofoam chip flotation in Fords Arm. The main load line supporting the curtain consisted of $^5/_{16}$-in. (0.79-cm) sheathed galvanized steel cable with a 9,800-lb (4445.25-kg) break strength. Ballast was provided by $^5/_{16}$-in. (0.79-cm) galvanized chain that was heat-sealed into a bottom seam extending the length of each barrier panel (Figure 5).

The barriers were formed by joining 100-ft (33.5-m) panels that were connected end to end by slotted tubes of galvanized-steel-reinforced polyvinylchloride pipe. To keep currents and winds from displacing the barriers from their respective desired positions, 25-lb (11.3-kg) galvanized steel fluke anchors were attached to both sides of the barriers and spaced equally apart at selected points along each curtain. Anchor lines were

Figure 5. Details of silt barriers installed in Fords and Meginnis Arms.

Note: 1 in. = 2.54 cm. 1 lb = 0.45 kg. 1 ounce = 28 g.



buoyed to prevent sagging of the barriers where anchor lines were attached to the main load line.

EVALUATION OF SILT BARRIER PERFORMANCE

The Florida State University Marine Laboratory was employed to monitor the effects of the silt barriers in conjunction with other water quality evaluations in the lake watersheds. Turbidity data were compiled biweekly beginning in May 1973.

Surface water samples were taken at 3 stations on each side of each barrier (Figures 6 and 7). Turbidities were determined by use of a Hach Model 2100A turbidimeter calibrated with formazine standard suspension (1). Readings obtained on each side of the barriers were averaged, and reduction in turbidity percentage was calculated across each barrier. Table 1 gives the results of mean turbidity analyses from May 1973 to June 1974.

Turbidity reductions were consistently lower across the inner (M1) and outer (M2) Meginnis Arm barriers than they were across the inner (F1) and outer (F2) Fords Arm barriers. Reduction across M1 ranged from a low of 3.6 percent to a high of 60.9 percent. Across M2, reduction ranged from 1.7 to 29.4 percent. Reduction across F1 ranged from a low of 5.1 percent to a high of 77.7 percent. Across F2, reduction ranged from 5.1 to 74.8 percent.

The overall objective of installing the silt screens was to prevent turbid waters from encroaching on the main body of Lake Jackson. A more realistic evaluation of their effectiveness can be seen by comparing the overall turbidity reductions from inside the inner barriers of the 2 arms with those from the outside of the outer barriers. When this comparison is made, a much more dramatic representation of turbidity reductions is evident. Figures 8 and 9 show the overall reductions achieved. When calculated as an overall percentage reduction, the range in Meginnis Arm was from a low of 44 percent on October 4, 1973, to a high of 90 percent on April 8, 1974. Fords Arm turbidity reductions ranged from a low of 45 percent on August 17, 1973, to a high of 93 percent in August 1973 and January 1974. The calculated overall mean effectiveness for turbidity reductions in the 2 arms of the lake was 72.3 percent in Meginnis Arm and 68.2 percent in Fords Arm.

These reductions appear somewhat anomalous because turbidity reductions immediately across the 2 barriers in Meginnis Arm were consistently lower than they were for those in Fords Arm. This situation can be explained by comparing the geomorphologic configurations of the 2 arms. Bottom profiles within Fords Arm form a shallow trough-like depression that gradually and uniformly increases in depth from its easternmost shoreward end toward the main body of the lake. There are no flow constrictions as the arm fans outward toward its mouth. This results in an evenly dispersed westerly movement of storm runoff into the lake during heavy rainfall. Although storm runoff discharge is of smaller magnitude in Fords Arm than in Meginnis Arm for comparable rain, the only significant physical obstruction to the transport of suspended materials was the presence of the 2 silt curtains.

Meginnis Arm depth and width vary considerably along its northerly course to the main body of the lake. The arm at its southern end widens drastically where Meginnis Creek empties its storm-water load into the arm. Depths to 15 ft (4.6 m) during high water conditions are achieved because a karst depression is located to the north and west of the mouth of the creek. As the arm progresses toward the lake, depths decrease to about 5 ft (1.5 m) at a narrow constriction about 800 ft (243.8 m) long by 300 ft (91.44 m) wide. This constriction is blocked partially by an earth mound across the channel at a point just south of where the arm again begins to widen along its approach to the lake. A gas pipeline traverses the mouth of the arm and forms an additional earth mound blockage where water depths would normally average about 5 to 6 ft (1.5 to 1.8 m). Thus the flow velocity in this arm is checked by the physical variance of the geomorphology of the arm as well as the placement of the 2 silt barriers. The inability of the silt barriers to completely check turbidity in this arm was obviously offset by the restrictive configuration of the arm during high runoff conditions.

Figure 6. Silt barriers and turbidity sampling sites in Meginnis Arm.

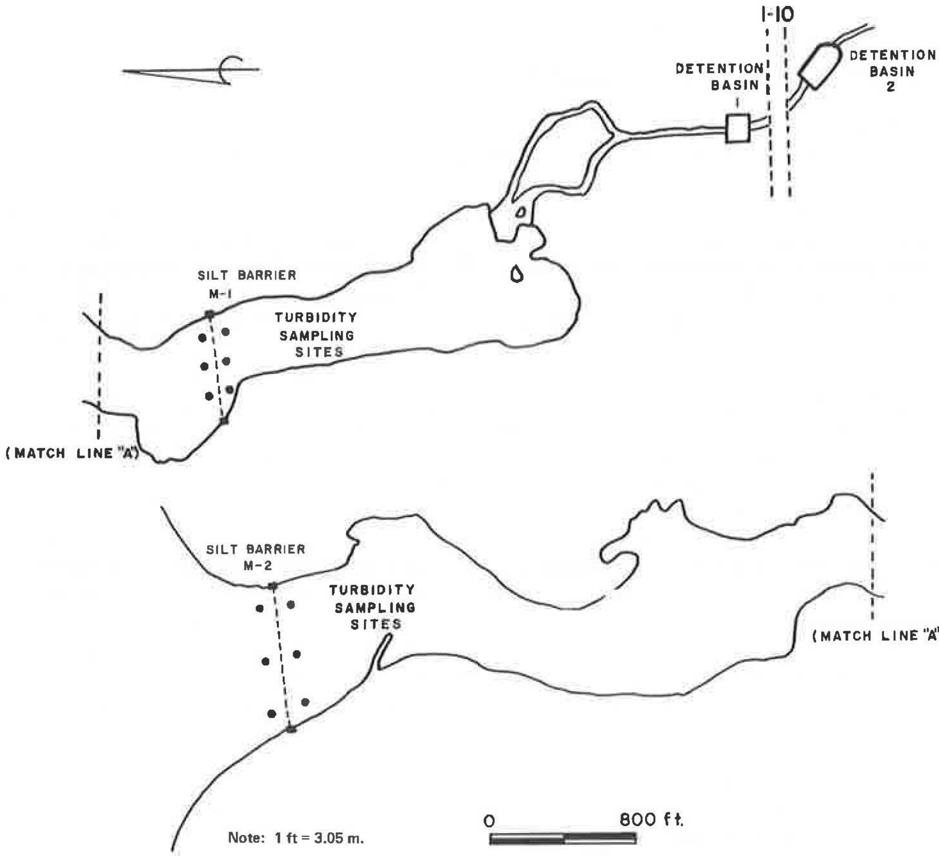


Figure 7. Silt barriers and turbidity sampling sites in Fords Arm.

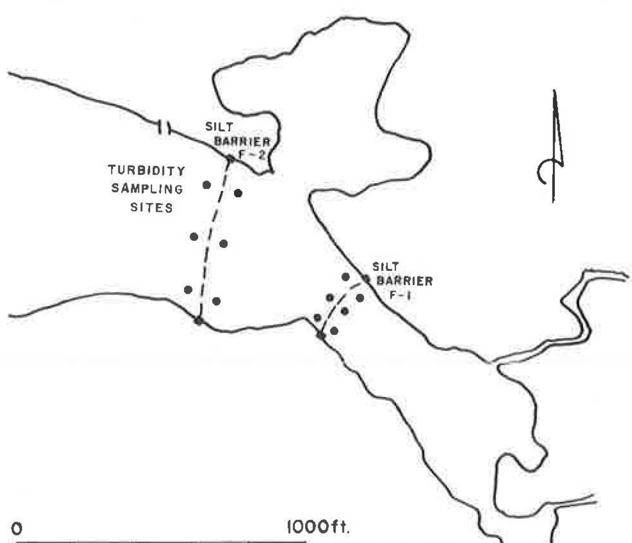


Table 1. Turbidity reductions across silt barriers in Lake Jackson.

		Meginnis Arm Barrier				Fords Arm Barrier			
		Inner		Outer		Inner		Outer	
Date	Turbidity	In	Out	In	Out	In	Out	In	Out
May 30, 1973	Observed, JTUs	92	86	38	37	57	43	32	14
		—	—	—	—	56	44	30	13
		—	—	—	—	—	—	—	—
	Average, JTUs	—		—	—	56.5	43.5	31	13.5
	Percent reduction	6.5		2.6		23		56	
June 18, 1973	Observed, JTUs	29	18	3.5	3.0	18	8.5	12	7.6
		30	17	3.7	3.5	18	8.8	11	7.4
		28	18	3.4	3.0	20	11	11	6.2
	Average, JTUs	29	17.7	3.5	3.2	18.7	9.4	11.3	7.1
	Percent reduction	39.1		10.2		49.5		37.6	
July 5, 1973	Observed, JTUs	16	9.5	6.0	6.2	8.1	2.2	3.2	2.9
		14	10	5.7	5.6	9.8	2.4	3.1	2.9
		13	9.9	6.4	6.0	13	2.2	3.2	2.9
	Average, JTUs	14	9.8	6.0	5.9	10.3	2.3	3.2	2.9
	Percent reduction	30.0		1.7		77.7		9.4	
August 6, 1973	Observed, JTUs	40	22	2.9	5.4	85	27.5	21	6.1
		36	32	6.1	5.1	82	22	21	6.3
		40	30	5.8	5.2	81	27	26	4.9
	Average, JTUs	39	28	4.9	5.2	83	26	23	5.8
	Percent reduction	28.2		+6.1[a]		68.7		74.8	
August 17, 1973	Observed, JTUs	27	16	2.3	3.1	3.8	2.4	2.1	2.1
		25	14	2.4	2.8	3.7	2.1	2.2	2.0
		28	15	2.2	2.9	3.9	2.1	2.7	2.2
	Average, JTUs	27	15	2.3	2.9	3.8	2.2	2.3	2.1
	Percent reduction	44.4		+26[a]		42		8.7	
October 14, 1973	Observed, JTUs	5.3	5.9	2.5	3.8	5.1	2.9	1.7	1.8
		5.6	5.6	2.2	2.7	5.6	2.9	1.9	1.4
		5.6	7.1	2.1	2.7	5.3	2.8	1.7	1.5
	Average, JTUs	5.5	6.2	2.3	3.1	5.3	2.9	1.8	1.6
	Percent reduction	+11.3[a]		+25.8[a]		45.3		11.1	
November 13, 1973	Observed, JTUs	9.6	8.7	2.4	1.8	4.9	4.3	2.3	2.1
		9.4	8.4	2.7	1.7	4.3	3.7	2.7	2.4
		11	8.0	1.6	1.8	4.4	3.9	3.4	2.5
	Average, JTUs	10	8.4	2.2	1.8	4.5	4.0	2.8	2.3
	Percent reduction	16		18.2		11.1		17.9	
December 4, 1973	Observed, JTUs	18	15	3.8	3.2	8.2	11	3.7	3.6
		13	13	3.4	3.7	9.1	8.5	3.7	3.6
		18	14	3.9	3.4	11	10	4.2	3.8
	Average, JTUs	16.3	14	3.7	3.4	9.4	9.8	3.9	3.7
	Percent reduction	14.1		8.1		+4.1[a]		5.1	
December 19, 1973	Observed, JTUs	31	32	5.8	5.8	—	—	—	—
		30	25	6.1	5.0	—	—	—	—
		19	18	3.6	6.3	—	—	—	—
	Average, JTUs	26.7	25	5.2	5.7	—	—	—	—
	Percent reduction	6.3		+8.8[a]		—	—	—	—
January 7, 1974	Observed, JTUs	18	14	5.0	4.5	22	19	17	8.0
		18	14	4.4	4.4	22	19	17	8.0
		19	14	5.4	4.4	22	19	18	9.0
	Average, JTUs	18.3	14	4.16	4.4	22	19	17.3	8.3
	Percent reduction	23.5		4.3		13.6		52.0	
January 13, 1974	Observed, JTUs	—[b]	—[b]	6.3	6.3	58	22	10	4.0
		—[b]	—[b]	7.5	7.2	55	26	18	4.0
		—[b]	—[b]	6.2	5.4	41	28	6.8	3.3
	Average, JTUs			6.7	6.3	51.3	25.3	11.6	3.8
	Percent reduction			6.0		50.7		67.2	
March 4, 1974	Observed, JTUs	6.9	5.7	2.6	3.0	9.6	8.7	7.2	3.6
		6.1	5.2	3.0	3.2	9.8	9.5	7.3	5.1
		6.0	5.6	3.7	2.7	10	9.6	7.0	4.0
	Average, JTUs	6.3	5.5	3.1	3.0	9.8	9.3	7.2	4.2
	Percent reduction	12.7		3.2		5.1		41.7	
March 20, 1974	Observed, JTUs	6.8	7.3	2.9	2.7	7.3	4.9	3.8	2.1
		6.1	7.7	2.7	2.3	7.5	4.7	3.8	2.2
		6.8	8.8	3.4	3.4	7.2	4.8	4.4	2.1
	Average, JTUs	6.6	7.9	3.0	2.8	7.3	4.8	4.0	2.1
	Percent reduction	+16.5[a]		6.7		34.2		47.2	
April 8, 1974	Observed, JTUs	28	29	1.7	2.3	49	38	28	12
		24	18	2.2	1.9	48	40	27	9.4
		31	33	3.6	3.8	51	43	23	12
	Average, JTUs	27.2	26.7	2.5	2.7	49.3	40.3	26.0	11.1
	Percent reduction	3.6		+7.4[a]		18.3		57.3	
April 25,1974	Observed, JTUs	6.1	4.2	2.5	1.4	4.7	3.1	2.7	2.0
		6.7	4.3	2.1	1.5	4.6	3.3	2.5	2.6
		5.4	3.7	2.5	2.3	4.9	3.0	2.2	1.9
	Average, JTUs	6.1	4.1	2.4	1.7	4.7	3.1	2.5	2.2
	Percent reduction	32.8		29.2		44.0		12.0	
May 9, 1974	Observed, JTUs	7.0	3.1	1.7	1.3	4.4	1.4	1.6	1.1
		6.8	2.6	1.5	1.2	4.3	1.9	1.7	1.0
		6.8	2.5	1.5	1.4	3.8	1.7	1.5	1.0
	Average, JTUs	6.9	2.7	1.6	1.3	4.2	1.7	1.6	1.0
	Percent reduction	60.9		18.7		59.5		37.5	
May 24, 1974	Observed, JTUs					13	4.1	3.7	2.8
						13	4.1	3.9	3.4
						13	4.1	3.8	4.0
	Average, JTUs					13	4.1	3.8	3.4
	Percent reduction					68		11	
June 4, 1974	Observed, JTUs					5.8	3.0	3.1	1.7
						5.8	3.2	3.2	1.8
						5.4	3.3	4.3	1.9
	Average, JTUs					5.67	3.17	3.53	1.8
	Percent reduction					44		49	

[a]Higher turbidity on lake side of barrier was due to turbulence.
[b]Barrier loose.

Figure 8. Average turbidity reductions in Meginnis Arm.

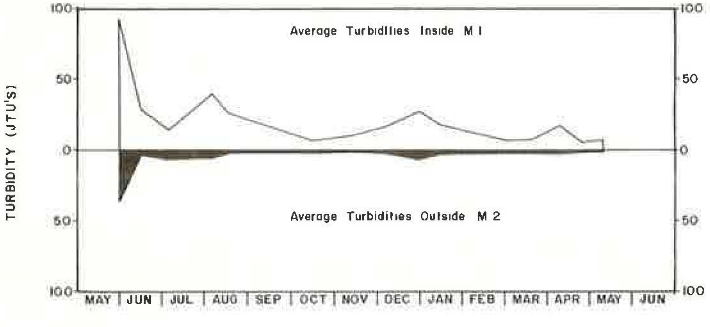


Figure 9. Average turbidity reductions in Fords Arm.

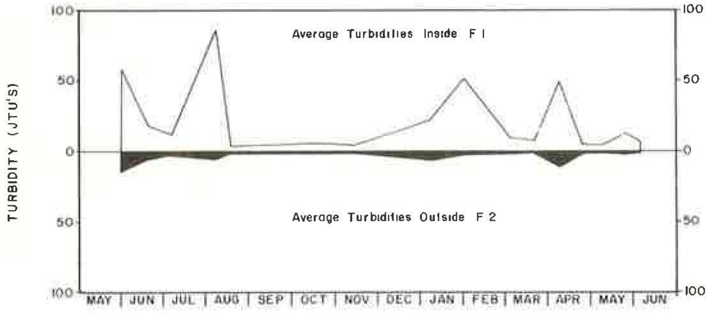


Table 2. Particle size analyses on sediments from I-10 detention basins.

Sediment	Percent in Basin 1	Percent in Basin 2	Size (mm)	Frequency (percent) Basin 1	Basin 2
Gravel	0.49	0.01	More than 2.000	0.49	0.01
Sand	71.60	65.47	1.000 to 2.000	0.42	0.02
			0.500 to 1.000	3.12	0.05
			0.250 to 0.500	22.10	1.10
			0.125 to 0.250	38.13	36.82
			0.062 to 0.125	9.83	27.48
Silt	10.06	20.51	0.031 to 0.062	4.95	13.94
			0.016 to 0.031	1.91	2.60
			0.008 to 0.016	1.81	2.08
			0.004 to 0.008	1.39	1.89
Clay	17.85	14.01	0.002 to 0.004	1.50	2.02
			0.001 to 0.001	1.50	2.14
Volatile	2.50	4.06			
Colloid			Less than 0.001	12.83	9.85

This resulted in the overall high reduction percentage in turbid waters outside barrier M2 compared with that outside barrier F2.

DEPOSITION OF SEDIMENTS

To determine the extent of sedimentation within the 2 arms that occurred during the time Interstate 10 was under construction, researchers from the Department of Geology of Florida State University gathered and analyzed a series of core samples. Weekly cross sections of sediment deposition within the 2 detention basins (Figure 6) were performed to assess the sediment contribution from urban runoff draining to the Interstate facility as well as that deposited from erosion from the highway construction site. Sediment-size distribution was determined to evaluate what particle-size fractions were being retained within the detention basins compared to what suspended materials were being transported into the lake after passing through the basins.

SEDIMENTS IN DETENTION BASINS

Sediments from the 2 basins were removed when cross section data indicated a 600-yd^3 (458.4-m^3) accumulation. From June 1972 to February 22, 1974, a total of 9,600 yd^3 (7296 m^3) of sediments had been removed from the 2 detention basins of which an estimated 75 to 80 percent were deposited from urban runoff not affected by highway construction.

In August 1973, sediments were sampled for grain-size distribution from the 2 detention basins adjacent to the I-10 construction site in the Meginnis Arm watershed. Sediment sizes and classifications were based on the Wentworth scale (9).

Table 2 data indicate that 79 percent of the sediments impounded in basin 1 and 81 percent of the sediments impounded in basin 2 fall within the mid-range of silt-size particles and larger. The majority of materials found within this size distribution can be classified as very fine sand to coarse sand. It would be logical that the majority of those sediments deposited in Meginnis Arm following the construction of the sediment traps would fall below the size distribution classed as fine sands and heavy silts. The data given in Table 2 are modified from the data given by Turner (13).

LAKE SEDIMENTATION

Thirty-nine cores were taken in southern Meginnis Arm and 10 cores were taken in Fords Arm to determine the extent of sedimentation that had occurred before and during the construction of the Interstate highway (12). Those sediments considered most recently deposited (1970 to 1973) were characterized as urban sediments because stormwater runoff was received from urban areas of Tallahassee as well as from highway construction. No distinction could be made between sediments deposited from highway construction and sediments transported from upland private construction activity. Therefore, all sediments attributed to upland soil disturbance from construction activity, regardless of source, will be referred to as urban sediments in this paper unless otherwise specifically stated. Figures 10 and 11 show the locations of the core sample sites (12).

Core analyses indicated that distinctly urban sediments were restricted to the southern half of Meginnis Arm. Those sediments had formed a sandy delta complex on the southeastern shore of the arm, and a thick layer of homogenous clay and silt-clay mud extended northward to core site 15. The deltaic sediments reached a thickness of about 8 ft (2.4 m) where the northern fringe is next to the karst depression in the southern end of the arm. The urban clay and silts in the deepest portion reached thicknesses of up to 29.9 in. (76 cm) at core 13 and 3.9 in. (10 cm) at core 15. Figure shows the deposition of clay sediments for the 1970-1973 period. Sediment volumes

Figure 10. Core sites in Meginnis Arm.

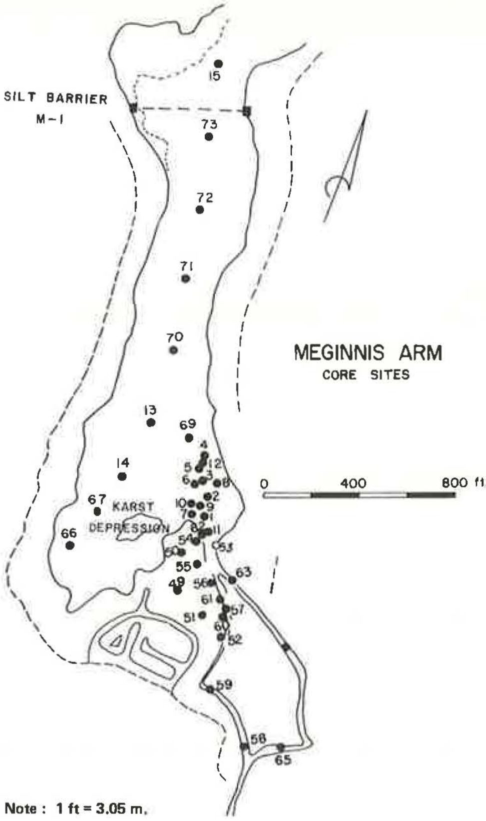


Figure 11. Core sites in Fords Arm.

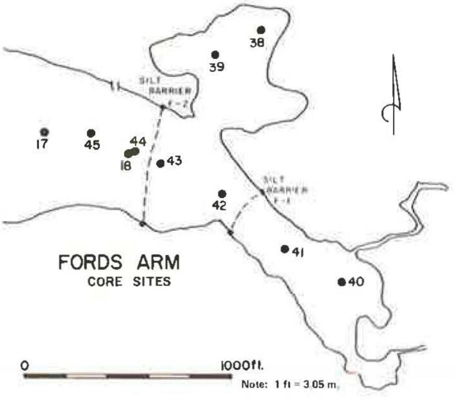
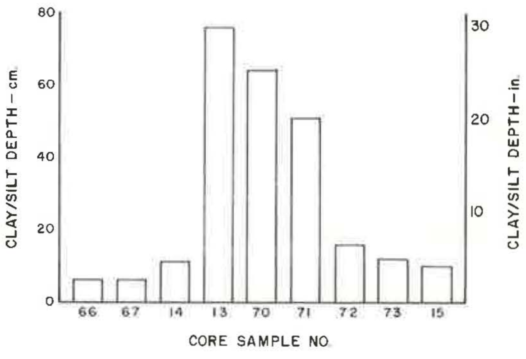


Figure 12. Silt-clay deposition in southern Meginnis Arm.



were estimated to be 15,990 yd^3 (12 152.4 m^3) for deltaic deposits and 32,850 yd^3 (24 996 m^3) for nondeltaic clays and silts.

Fords Arm core samples did not indicate any appreciable urban sediment deposition except at core site 40 where a clay-silt fraction of 0.6 ft (18.28 cm) was intermixed with natural organic muck deposits. This is evidence that volumetrically small contributions of suspended fines can create extreme turbidities (up to 500 JTU) with no significant contribution to bottom sedimentation. The noticeable lack of urban sediments was probably a result of the deposition of eroded sediments upland from the arm before runoff entered the lake.

CONCLUSIONS

The high volume of accumulated clay-silt sediments in Meginnis Arm was primarily responsible for the turbidity problems experienced in Lake Jackson. Although little urban sedimentation was detected in Fords Arm, high turbidities on occasion indicated that small volumes of suspended fines can create excessive murkiness under extreme climatic conditions. Extensive erosion controls on the highway construction site were capable of retaining heavier sand-size sediments but were insufficient in removing suspended silts and clays from runoff from either the construction site or the greater portion of the Meginnis Arm watershed not affected by highway construction.

Floating silt barriers can be a significant tool in confining suspended solids to localized areas in aquatic environs. However, silt barriers should not be relied on as a sole means to control erosion pollution. Properly planned on-site erosion controls and construction phasing should take into account worst case conditions where potential sensitive pollution problems may result from erosion during highway construction.

ACKNOWLEDGMENTS

The bulk of the studies relating to Lake Jackson and its pollution history were admirably executed by Ralph Turner and Thomas Burton of the Florida State University Marine Laboratory. They were extremely cooperative in supplying the data necessary for evaluating the use of the silt barriers. Steve Schamel of the Department of Geology of Florida State University did an admirable job of sediment analysis on very limited funds. Roger Eudy and Mike Stone were most cooperative in drawing the figures and graphs for this paper. Very special gratitude is extended to Bob Wagner for his work on the I-10 job. My thanks also go to the local Tallahassee maintenance office for installing and maintaining the "diapers" in Lake Jackson. Special thanks go to Nell Ball and the Florida Department of Transportation secretarial aides who patiently typed the manuscript.

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URBAN BOULEVARD PLAN FOR FEDERAL HILL-MONTGOMERY STREET HISTORIC DISTRICT IN BALTIMORE

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The Federal Hill-Montgomery Street historic district in Baltimore was placed on the national register for historic places in 1970. A decade of Interstate Highway planning produced a great deal of neighborhood opposition to the Interstate roadway because of adverse impacts on the historic district. In 1974 the Interstate Division for Baltimore City developed a new highway alignment and mitigation plan for the district that was endorsed by the community. Mitigating features that protect the community from noise, traffic danger, air pollution, and aesthetic impairment include (a) landscape treatment of the roadside environment involving earth berms, brick walls, trees, and shrubs and (b) creation of new urban parks in keeping with the historic character of the district. Compromise among the differing groups was achieved primarily by direct involvement and open communication with residents of the district. The success of the Federal Hill project demonstrates the effectiveness of the Federal 106 Process in preserving and protesting an important historic neighborhood while meeting the needs of growing traffic demands.

•THE FEDERAL Hill-Montgomery Street historic district is one of several historic areas in Baltimore within or adjacent to proposed Interstate Highway rights-of-way. The plan proposed by the Interstate Division for Baltimore City for the highway alignment near this district is the first in the city to be developed with the full participation and cooperation of the residents and legal counsel of the involved community, who represented the interests of the historic district. The Federal Hill-Montgomery Street historic district was placed on the national register for historic places in 1970. It is historically significant because it is one of the largest eighteenth-century American working-class neighborhoods still in existence. The best historic structures in the community date from that century. These townhouses, rich in architectural detail and craftsmanship, exemplify urban architecture of the 1700s.

Federal Hill received its name in 1788 when the city celebrated Maryland's ratification of the Constitution. For more than a century after 1775, the open space on the hill functioned as a lookout point for ship owners awaiting the return of their vessels from sea. Shipyards at the foot of the hill launched and repaired merchant ships from around the world and continue to do so today. The waterfront location of the neighborhood and the Fells Point Historic District across the harbor make this area an important part of the heritage of the great port of Baltimore (Figure 1).

In the nineteenth century, the Federal Hill-Inner Harbor area became the center of a busy coastal trade in the port of Baltimore. During the Civil War, the hill served as a garrison for the Union Army, which was intent on keeping Baltimore from joining the Confederacy.

For more than 10 years, various Interstate Highway plans overlaid the area now designated as the historic district. This was a period of controversy and litigation between highway planners and preservationists. The result was a legal impasse in the courts. Some early highway proposals would have destroyed many of the historic structures, and 14 lanes of traffic were to tunnel under Federal Hill Park and bridge over the Baltimore Inner Harbor. A concept team changed the plans in 1968 by

Figure 1. Baltimore inner harbor.

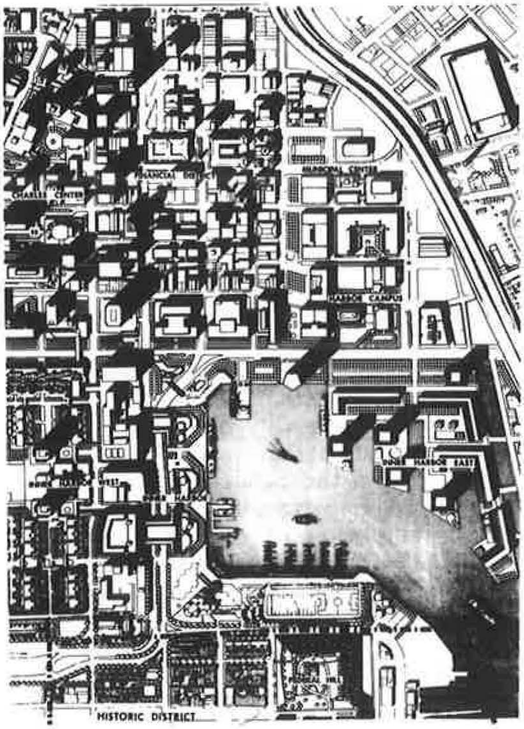
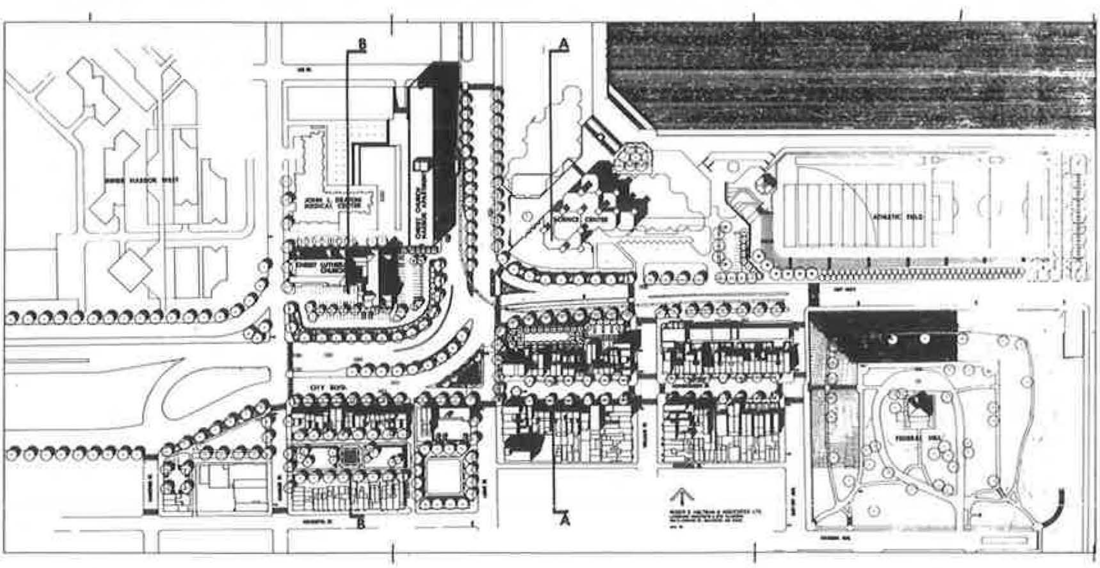


Figure 2. Proposed boulevard plan for Federal Hill historic district.

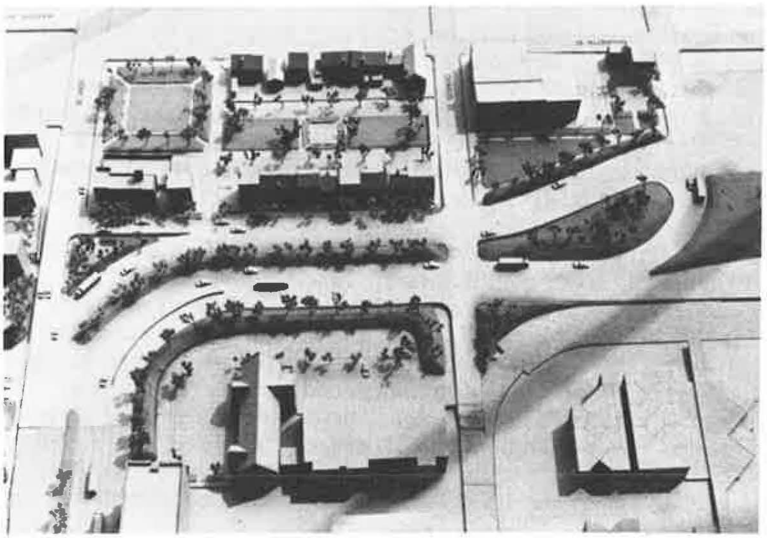


shifting the Interstate Highway out of the Federal Hill area and proposing an urban boulevard in its place. During the 10-year period of controversy, many structures were acquired, families moved, and vacant buildings were boarded up in anticipation of demolition. The unoccupied structures soon created sanitation problems and became fire hazards and targets for vandalism. The result was that many buildings were left in a desolate state.

Concerned Federal Hill residents contacted the mayor of Baltimore in the fall of 1973. They demanded a decision on the status of the highway and either demolition or restoration of the structures. Large-scale restoration was seriously considered but was deemed infeasible. On the other hand, the mayor and his staff indicated a need for the historic preservation societies to agree to the demolition of certain derelict structures that were subject to a lawsuit previously brought by residents to prevent demolition. A compromise was suggested by the mayor; the Federal Hill community was to be actively involved in developing a highway plan that would reflect its concern for the preservation of the historic area.

Community meetings were organized to help people to understand the many problems that had resulted from years of mistrust and indecision. A survey of the area was then conducted. This survey proved useful in clarifying the goals of historic preservation so that plans could be developed for an alignment that would meet those goals. A series of detailed drawings and scale models were prepared that enabled the residents to visualize the exact relation of individual historic structures to the path of the roadway. The result was a new boulevard alignment that was developed with the community and endorsed by it that requires the taking of only 2 historic structures (Figure 2). The boulevard passes through the northwest corner of the Federal Hill historic district, a corner shown not to be critical to the goals of historic preservation in the area survey. After the community's preferred boulevard alignment in this area was established, other highway traffic problems remained to be solved. Because through-street traffic in the historic area was considered undesirable, it was decided to close off Montogomery Street at Light Street. Pedestrian movement at the dangerous intersection of Light Street and Key Highway was studied, resulting in a recommendation that controlled crossing be allowed only at 2 locations. Another major problem was the minimization of the visual and acoustical impacts of the roadway on the historic district. The suggested solution involves the creation of an open-space buffer by means of brick walls and landscape earth berms along the entire edge of the boulevard adjacent to Federal Hill (Figure 3).

Figure 3. Proposal for minimizing visual and acoustical impacts.



Joint efforts also were made to achieve the restoration and beautification goals for the historic district. Federal Hill-Montgomery Street residents made several suggestions, including developing a garden or promenade park that would replace the vandalized row houses along Hughes Street. (It was questionable whether the Hughes Street houses could be restored.) The design and detail of a plan for the garden will accentuate the historic quality and beauty of nearby residential structures.

In an earlier plan for the boulevard, an attractive neighborhood fire station was to be taken. The community insisted that the station be saved along with the historic homes to the west of it. This resulted in the decision to have all these structures remain in their present location and the homes restored.

Landscape planning of streets and public spaces in the neighborhood and along the boulevard is most important for the initial stages of restoration of the district. Several urban parks surrounded by protective brick walls are to be created, all of which will be compatible in detail with the historic houses. On Churchill Street west of Light Street, in the center of the historic area, several derelict warehouse buildings are to be removed to allow for development or urban park open space that will be protected from the boulevard. The 2 blocks of Montgomery Street between Federal Hill and Light Street are to be changed from a 1-way, 3-lane street to a 2-way street, and new brick sidewalks will extend along the entire street on both sides. Reducing the scale of the existing street will render it more compatible with 2- and 3-story historic row houses.

Several important factors emerge as having been decisive in reconciling the various viewpoints involved in the Federal Hill project and in developing plans satisfactory to groups whose interests differ so greatly. Those factors, which figured in achieving the compromise between residents of the historic district and the Interstate Division for Baltimore City, are

1. Direct and open communication,
2. Concern for more issues than merely moving traffic volumes, and
3. Serious interest in minimizing harmful highway impacts.

The mayor of Baltimore and his staff established direct communication with the community organization. Opposing views thus could be aired, and the problems faced by each side were more readily appreciated. The design consultants found that their greatest effort lay in communication. Their initial task was to understand the goals of the community and its assessment of the highway. The design consultants came to appreciate the concern about the derelict and decaying structures on Hughes Street and the image that the residents wanted their district to project. The consultants felt it essential to substantiate the reasons for various aspects of the proposal with proper technical information. The scale model and detailed drawings prepared for the residents of Federal Hill helped in achieving that goal.

Schemes that emphasize traffic volumes generate the most adverse criticism. Collecting of traffic data is an imprecise science, and citizens attack the basis of traffic counts more often than they attack any other premise in arguing against highways. Traffic demands must be met, but they must be balanced against environmental concerns. The plan devised is one of the most traffic-efficient plans, according to the required engineering study.

A realistic attitude about the impacts of a highway and a serious attempt to minimize these impacts elicit warm responses from communities. Much can be done to minimize harm after it is accurately assessed, and simple methods often produce great reductions in impacts. For example, in the Federal Hill plan, the simple use of earth berms and attractive brick walls screens the roadway and softens the noise from it in its environs. The closing of Montgomery Street at 1 end to prevent through traffic is a simple solution to the problem of high traffic volumes. These methods proved satisfactory to many of the residents. Good judgment and flexibility, however, are required to ensure that the cure is not worse than the ailment. Higher walls and berms, for instance, would screen more of the road and its noise, but they would be completely out of scale with the historic district.

The example of the success of the Federal Hill project demonstrates the effectiveness of the Federal 106 Process. Working with the community in assessing alternatives and planning for minimization of harm has proved advantageous to the boulevard plans and to the residents as well. The proposed design creates a new boundary for the northern part of the historic district and allows for the efficient movement of traffic. Virtually nothing will be destroyed in historic areas, and the landscaped buffer, to be developed as part of roadway construction, will protect the area from any road-related impacts. Furthermore, the quality of the Federal Hill environment will be upgraded considerably by the replacement of derelict buildings with several park-like areas. Funding for this project is anticipated from the Federal Highway Administration because it supports required historic preservation under the new Historic Preservation Act.

Thus the Interstate Division for Baltimore City resolved a difficult problem of an urban boulevard right-of-way alignment, which is to be part of the Interstate Highway System, as it relates to the Federal 106 process for nationally registered historic places. It did so by engaging the active participation of residents and the Preservation Commission for the Federal Hill Historic District.

BETTER GRASSES FOR ROADSIDES

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The growing importance of maintenance costs and environmental aesthetics dictates the need to develop better roadside grasses. More than a thousand varieties or strains of 36 species were established in 4-yd² (3.3-m²) plots along 8 roadsides throughout New Jersey and 3 experiment station sites over 5 years. Coarse grasses, including Kentucky 31 tall fescue and redtop, consistently produced conspicuous, persistent seed heads that detract from the appearance of the grassy landscape. Finer turf grasses, including certain varieties of Kentucky bluegrasses and 4 fine fescues, established readily and produced fewer and less objectionable seed stalks. Perennial ryegrass varieties initially produced an abundance of foliage and seed stalks, excessively crowded associated grasses, and disappeared after 2 years of low-intensity management. Outstanding performance of spreading fine fescues at several locations prompted the development of a new variety, Fortress, synthesized from locally collected elite plants. Commercial production of Fortress and a superior Chewings variety, Banner, is anticipated. Such grasses should improve the quality of roadside mixtures, particularly when used with common varieties of Kentucky bluegrasses such as Kenblue. The importance of seed-free mulch is shown. It appears inappropriate to try to keep down vigorous species with frequent mowing or to tolerate their coarse appearance when unmowed. Better appearance with less mowing can be achieved with properly established mixtures of superior varieties of fine fescues and Kentucky bluegrasses.

•IMPROVEMENT of grasses has been oriented toward either their agricultural use or their ornamental value, particularly for lawns. The call for grasses suited specifically to roadsides or comparable low-management situations has not been heeded. Roadside seeding contracts typically state the species rather than the variety of grasses to be used. Hottenstein (2) listed components of roadside mixtures used throughout the United States, and only rarely was the variety of a grass species designated. The most frequently used variety of any species was the Kentucky 31 variety of tall fescue (Festuca arundinacea L.). In some instances, differences between varieties can be as important as differences between species.

In the past, high productivity of coarse grasses used for erosion control was not a problem because grass commonly was used for hay or pasture. To keep down vigorous, coarse grasses by conventional roadside mowing requires more energy and machine maintenance than would be required to mow finer turf grasses. To leave coarse grasses unmowed would present a less attractive and possibly more hazardous roadside.

Current roadside maintenance budgets are being strained because of recent increases in road construction, labor, and equipment costs. But increased public awareness of environmental quality dictates that roadsides be aesthetically acceptable.

Tall fescue dominates productive sites along most of New Jersey roadsides sown since 1955; fine fescue components persist on sites characterized by droughty, acid soils. Common Kentucky bluegrasses frequently are seen on productive sites of older New Jersey roadsides.

Identification of superior varieties of adapted grass species through roadside testing should lead to the formulation of better grass mixtures. More specifically, these grasses should provide the best appearance for the most months of the year with the smallest amount of maintenance. At the same time, they should provide sufficient certainty of establishment in variable situations. These grasses should be serviceable for erosion control and weed exclusion and should provide support for vehicles leaving the pavement. They should be tolerant of roadside environments and not constitute hazards by obstructing vision, causing snow to be deposited on roads, or burning readily.

MATERIALS AND METHODS

Grasses currently specified for roadsides in New Jersey were compared with commercially available grass varieties, plant introductions, experimental seed of various sources, and more recently, seed of our own development. More than a thousand grass varieties or strains of 36 species were sown in 4-yd^2 (3.3-m^2) plots and were replicated 4 times. Including mixtures, this totaled 6,472 plots along 8 newly constructed roadsides throughout New Jersey and 3 experiment station sites over 5 years. Establishment conditions were according to New Jersey Department of Transportation specifications except that rate of seeding was at 40 lb/acre (45 kg/hm^2) rather than the standard 100 lb/acre (112 kg/hm^2) and no legumes were added. Legumes, under certain conditions, can dominate grasses and thereby make comparisons of grasses uncertain. Plots along roadsides were mulched with seed-free hay. Other plots were unmulched. Management was minimal in the first years, but in later tests single nitrogenous topdressings were applied to hasten the transition from seedling stage to mature sod for critical evaluation.

Superior strains of fine fescues were tested as spaced plants in cultivated nurseries. More than 19,000 such plants were screened in the field and greenhouse and an additional 6,000 were involved in the production of breeder seed of newly developed cultivars Fortress (spreading fescue) and Banner (Chewings fescue).

DISCUSSION OF RESULTS

Roadside Tests

Test plots of species, varieties, and combinations that are used at present or might be considered for roadside mixtures were established under conditions simulating roadsides and were rated for quality at various seasons. Completeness of soil cover and uniformity in color, texture, and topography (microrelief) quality were overseen. The data given in Table 1, which are typical of many observations, indicate that additions to the vigorous, dominating, widely used K-31 tall fescue made relatively slight changes in quality ratings. Such plots still looked like tall fescue.

Of the perennial ryegrasses (Lolium perenne L.), Linn, which typifies common types, was stemmier than Manhattan, a turf type. Both proved unsightly on maturing, competed severely with associated grasses under no-mow management, and left a more sparse turf when they died after 2 years. Neither redtop (Agrostis alba L.) nor Canada bluegrass (F. compressa L.) exhibited quality characteristics by themselves or in mixtures. Pennlawn (F. rubra subsp. rubra), the only fine fescue, and the Kentucky bluegrass varieties, alone or in combinations, were usually rated high.

Along many New Jersey roadsides good stands of tall fescue are found where growing conditions are favorable, particularly at the toe of a bank or at original grade at the top of a cut. On the face of steep banks, tall fescue is frequently sparse or missing. Here fine fescues typically provide most of the cover. Such a slope may reveal spots of bare soil from loss of other species from the mixture and the failure of remaining plants to spread.

A trial of 6 commercial varieties of tall fescue under low-intensity management failed to show real differences among varieties of this species. This gave impetus to concentrating research attention on fine grasses like those that persist along old roadsides.

Table 1. Quality ratings of roadside grasses in mature (2.5-year-old) stands in central New Jersey.

Variety	April 7	June 3
K-31[a]	5.0	4.0
Pennlawn[b]	6.7	5.3
Linn[c]	3.6	3.3
Newport[d]	8.2	5.3
Kenblue[e]	8.7	7.0
Redtop	5.4	5.5
Canada[f]	5.7	4.4
Manhattan[g]	3.4	4.4
K-31[a] + Pennlawn[b]	5.0	3.9
K-31[a] + Pennlawn[b] + Linn[c]	4.8	4.1
K-31[a] + Pennlawn[b] + Linn[c] + Newport[d]	6.0	4.0
K-31[a] + Pennlawn[b] + Linn[c] + Newport[d] + redtop	5.7	4.3
K-31[a] + Pennlawn[b] + Linn[c] + Newport[d] + redtop + Canada[f]	5.8	4.2
Pennlawn[b] + Newport[d]	6.9	5.3
Pennlawn[b] + Kenblue[e]	8.2	6.1
Pennlawn[b] + Manhattan[g]	4.5	5.6
Pennlawn[b] + Linn[c]	4.2	5.1
Kenblue[e] + Manhattan[g]	6.9	6.5
Kenblue[e] + Manhattan[g] + Pennlawn[b]	7.2	6.8
Least significant difference at 5 percent	0.7	0.6

Note: Scale is 0 to 9; 9 = best turf grass.

[a]K-31 tall fescue.
[b]Pennlawn creeping fescue.
[c]Linn ryegrass.
[d]Newport Kentucky bluegrass.
[e]Kenblue Kentucky bluegrass.
[f]Canada bluegrass.
[g]Manhattan ryegrass.

Table 2. Quality ratings of 36 grass entries.

Variety	Allentown[a]	Fairlawn[b]	Fairlawn[c]	Millville[d]	Millville[e]	Stanhope[f]	Stanhope[g]	Stanhope[g,h]	Stanhope[i]	Stanhope[h,i]
Turf Kentucky bluegrass										
Merion	7.0	6.2	2.5	2.2	2.2	4.5	2.7	3.7	1.5	2.0
Newport	5.7	5.2	2.5	3.0	1.0	6.2	3.0	4.0	1.7	2.5
Fylking	6.7	7.0	3.0	1.2	1.5	5.7	3.0	4.0	1.0	1.7
Nugget	7.7	5.0	2.7	2.2	1.2	5.5	2.0	2.7	1.0	1.5
P-114	6.5	4.0	1.5	0.5	0.7	4.5	2.0	3.0	1.2	1.7
P-69	5.5	4.7	2.7	1.7	1.5	4.0	1.7	2.5	0.7	0.7
P-107	5.7	5.5	2.0	1.7	1.0	5.5	2.2	3.2	1.0	1.5
P-113	5.7	5.5	1.7	0.2	0.0	4.5	1.7	3.2	1.0	1.7
P-77	6.7	4.5	2.5	0.5	0.0	4.0	2.0	2.7	1.5	2.0
P-72	6.0	3.7	1.7	0.7	0.7	4.2	1.5	2.5	0.5	1.0
P-123	5.5	5.7	1.7	2.2	1.0	4.7	1.7	2.7	1.2	1.5
P-84	6.0	6.5	2.5	1.0	1.5	4.7	2.0	2.7	1.2	1.5
P-57	5.5	5.7	2.7	0.7	0.0	5.0	2.2	4.0	1.0	1.5
P-29	7.0	6.5	3.0	2.2	1.0	4.7	2.5	3.5	1.0	1.2
P-106	6.7	5.0	2.2	0.7	0.0	5.2	2.5	3.0	1.2	1.7
Common Kentucky bluegrass										
Kenblue	6.5	6.0	3.5	2.2	2.0	7.0	3.7	4.5	3.5	4.2
Arboretum	8.2	6.0	3.2	3.2	1.5	6.0	3.5	5.0	3.0	3.7
Minnesota	8.2	5.2	4.2	3.5	1.2	5.5	3.0	4.5	3.0	3.5
Creeping fescue										
Pennlawn	5.5	5.2	3.2	1.0	1.5	7.7	4.0	4.5	3.0	3.5
Ruby	6.0	6.2	2.7	2.5	1.5	8.0	3.7	4.7	2.2	3.2
Golfrood	7.0	6.0	2.7	0.7	0.2	6.2	2.7	3.0	0.7	1.5
Chewings fescue										
Highlight	6.2	5.2	3.7	3.5	3.5	8.0	3.7	5.7	3.0	4.2
Jamestown	5.7	3.0	3.0	1.0	2.0	4.0	2.5	3.5	2.2	3.0
Wintergreen	7.0	5.0	3.7	2.5	2.5	7.5	3.0	5.0	2.2	3.0
Fort McHenry	8.0	6.2	4.5	3.5	3.2	8.0	4.0	6.0	3.2	4.7
C-26 hard fescue	7.2	8.0	6.5	2.0	3.2	6.7	4.0	6.7	5.5	6.5
Tall fescue										
K-31	4.7	5.0	4.2	0.0	0.2	5.2	2.5	3.5	3.0	3.7
Kenwell	4.2	4.2	3.2	1.5	0.7	4.7	2.2	3.2	2.7	3.2
Perennial ryegrass										
Linn	0.5	0.7	2.5	1.0	0.7	2.0	0.0	0.0	1.0	1.0
Manhattan	1.5	4.0	2.2	3.5	1.0	3.0	0.0	0.0	0.7	1.0
Pennfine	3.0	3.0	1.7	3.5	1.2	3.0	0.0	0.0	1.5	2.0
Mixtures										
Kenblue + Ruby	6.5	5.2	3.5	2.5	2.2	8.0	3.7	5.2	3.2	3.5
Fylking + Ruby	5.5	7.0	3.5	2.2	2.0	7.0	3.2	4.5	2.0	3.0
Kenblue + Ruby + Manhattan	5.7	6.2	4.5	3.5	0.7	5.7	3.2	4.5	2.5	3.2
Fylking + Ruby + Manhattan	6.0	5.2	3.5	3.5	2.0	5.7	3.0	3.7	2.5	3.0
Newport + Highlight + Linn	6.2	6.0	3.5	2.5	3.2	6.5	3.5	4.7	3.5	3.7
Least significant difference at 5 percent	2.1	1.9	1.3	1.5	1.2	1.3	1.1	1.0	1.1	1.3
Least significant difference at 1 percent	2.9	2.6	1.7	2.0	1.6	1.8	1.5	1.4	1.5	1.8

Note: Scale is 0 to 9; 9 = best turf grass.

[a]Sown September 17, 1970; rated June 8, 1972.
[b]Sown September 30, 1970; rated June 16, 1972.
[c]Sown September 30, 1970; rated June 18, 1972.
[d]Sown September 26, 1971; rated March 26, 1972.
[e]Sown September 26, 1971; rated October 18, 1972.
[f]Sown September 23, 1970; rated June 28, 1972.
[g]Sown September 23, 1970; rated May 29, 1973.
[h]Fertilized October 17, 1972.
[i]Sown September 23, 1970; rated June 18, 1974.

Subsequently, a series of 36 grasses, including simple mixtures, were sown at 4 roadside locations. Entries were primarily commercial materials, but they did include experimental low-growing turf-type Kentucky bluegrasses (Poa pratensis L.). Sites ranged from a productive soil at the Allentown interchange to a particularly infertile droughty roadside near Millville in southern New Jersey. At the latter site, none of the entries given in Table 2 fared well. At the productive site, even the low-growing Kentucky bluegrasses established and covered the soil adequately. On less productive sites, emergence and initial establishment of turf-type Kentucky bluegrasses were barely adequate, and complete soil coverage never materialized even with further fertilization. The common-type Kentucky bluegrasses, such as Kenblue, Arboretum, and a Minnesota strain, established themselves more quickly, and coverage was more complete than with turf types as indicated by the data given in Table 2. Although the perennial ryegrasses began with great vigor, plants at all locations died by the second year under no-mow management. The fine fescues, either alone or in mixtures, provided better coverage at all sites for the duration of the trials. The 2 tall fescues established themselves well enough but thinned to individual clumps and eventually were rated rather low in quality. The tall fescues failed completely on the poorest site. The 1 hard fescue (F. longifolia Thuill.), C-26, was slow to establish itself but eventually provided the highest quality cover in most ratings.

In time, most entries were rated lower in quality. This was more serious for the turf types than for the common types of Kentucky bluegrasses. Deterioration over time occurred among the commercially available fescues also, but the hard fescue, C-26, retained quality better than any other entry in the test. The final stand of the mixtures generally was dominated by the fescue component.

The Stanhope site consists of a sandy subsoil with 2 to 6 in. (5 to 15 cm) of loamy topsoil added. Initial establishment was good, but deterioration of the stand over time was noticeable. Approximately 2 years after seeding, half of each plot was fertilized with 500 lb/acre (550 kg/hm^2) of 10-6-4. The improvement persisted into the following spring and was still detectable on most grasses at last observation, 21 months after application.

In a supplemental variety trial on the sandy soil at Millville several fine fescues improved with time. The data given in Table 3 indicate that Banner Chewings fescue (F. rubra subsp. commutata Gaud.), Fortress spreading fescue, and K-114 sheep fescue (F. ovina L.) were among the best entries initially, continued to improve their ground cover, and produced fine foliage relatively free of unsightly seed stalks.

Poor grass performance along roadsides may be attributed frequently, in part, to soil conditions that can be changed. At Millville, on soil that was 96 percent sand, the problem was primarily that of establishing a stand on soil with a low moisture-holding capacity. Better establishment of grasses was obtained at this location in supplemental plots amended with 2 in. (5 cm) of silty clay tilled into the surface soil. Intense grazing by rabbits on the small plots of superior vegetation (in contrast with surrounding pine barrens vegetation) further limited grass development.

Seedling Vigor

Quick emergence and growth of sown species are usually desirable, particularly when erosion is of concern. At the outset of these field trials, difference in seedling vigor among grass species was readily apparent. Somewhat less striking, but nevertheless quite consistent and significant, were differences among varieties within species. An appreciation for the extent of the differences was not found in turf-grass literature, for mowing minimizes these differences. Data given in Table 4 typify results of several trials. Measurements in the spring of seedlings that emerged the previous fall and were unmowed indicate great vigor of coarse species such as meadow fescue, (F. pratensis Huds.), intermediate height of the spreading fescues, and smaller stature of Chewings varieties and a hard fescue. Differences among varieties of a species are apparent when one compares the Kenblue and South Dakota Certified Kentucky bluegrasses with the low-growing Merion and Sydsport Kentucky bluegrasses.

Table 3. Quality ratings of a supplemental variety trial established at Millville.

Variety	March 26, 1972	October 18, 1972	June 1, 1973
Bluegrass			
Baron Kentucky	2.0	0.7	1.5
KO-174 Kentucky	1.7	2.2	1.7
KO-175 Kentucky	1.5	1.0	2.0
Fescue			
Arctared Chewings	0.0	0.5	1.5
Banner Chewings	2.7	3.5	3.5
K8-149 Chewings	2.7	1.5	2.5
F. rubra var. commutata	1.5	1.7	3.2
Fortress spreading	2.5	2.5	3.5
F. rubra var. rubra	2.0	1.0	2.7
Alaska station sheep	0.7	1.5	3.5
K-114 sheep	2.5	3.2	4.2
Fine-leaved sheep	0.7	2.0	3.5
C-26 hard	0.7	2.5	3.2
Least significant difference at 5 percent	1.3	1.5	1.3
Least significant difference at 1 percent	1.7	Not significant	1.8

Note: Scale is 0 to 9; 9 = best turf grass.

Table 4. Seedling height of selected fescues and Kentucky bluegrasses.

Variety	Height (cm)
Fescue	
Meadow	34.0
130-16 spreading	17.2
130-17 spreading	18.3
Atlanta Chewings	11.7
Wintergreen Chewings	13.5
C-26 hard	8.0
Bluegrass	
Kenblue Kentucky	12.5
South Dakota Certified Kentucky	10.0
Merion Kentucky	5.5
Sydsport Kentucky	5.2
Least significant difference at 1 percent	5.0

Table 5. Incidence of seed stalks in mature stands of Kentucky bluegrass.

Variety	Rating*
Newport	1.4
Merion	3.6
South Dakota Certified	4.2
Delta	4.6
Kenblue	4.9
Belturf	7.4
Fylking	8.7
Least significant difference at 1 percent	1.0

*1 = most stalks; 9 = no stalks.

Table 6. Incidence of seed stalks in fine fescues.

Variety	Rating*
Highlight	2.4
Pennlawn	4.8
Golfrood	6.2
Atlanta	7.0
Ruby	7.8
Least significant difference at 1 percent	1.5

*1 = most stalks; 9 = no stalks.

Figure 1. Seedling vigor of Chewings fescue and spreading fescue 6 weeks after seeding.

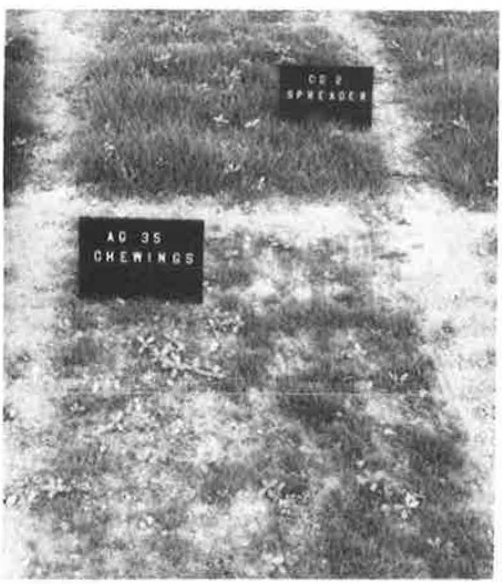
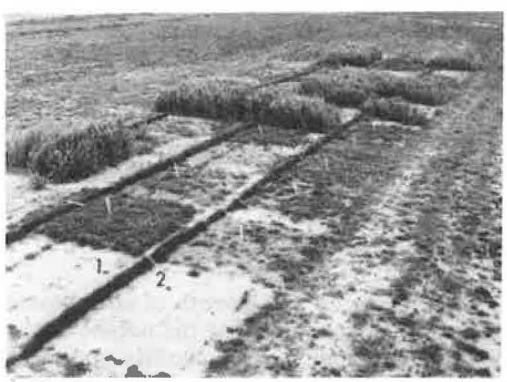


Figure 2. Volunteer grasses from various hay mulches.



In all field trials, except 1 on soil that was 96 percent sand, initial establishment of petite types such as Merion Kentucky bluegrass and C-26 hard fescue was satisfactory in pure stands.

The data in Table 4 indicate the height advantage of spreading fescues over Chewings fescues. Figure 1 shows the vigor of another spreading fescue compared with that of a Chewings fescue in the seedling stage. A separate but similar study of perennial ryegrass varieties indicated that Linn, a common ryegrass, was 41 cm tall and Manhattan, a turf ryegrass, was 23 cm tall. Perennial ryegrasses were observed to persist only 2 or 3 years under no-mow, low-fertilization management. But their initial competition with less vigorous seedlings resulted in appreciably weaker stands of the truly perennial fine fescues or Kentucky bluegrasses. Excessive vigor in the seedling stage of a mixture component is therefore undesirable. Considering that the persistence of a good straw mulch is generally observed to be quite intact 6 months after seeding, one may question the need for fast vegetative cover at the expense of good later coverage.

Mulch

The importance of seed-free mulch was shown in a test of 6 hay samples intended for mulching roadsides. The samples were obtained from several contractors. These typical hay samples were applied at 1 and 2 tons/acre (2.2 and 4.5 Mg/hm^2) on 4-yd^2 (3.3-m^2) plots of methylbromide-treated soil. This treatment killed viable seeds in the soil. Numerous weed and grass seed heads were readily identifiable in the bales, and many of these species established themselves in the plots as shown in Figure 2. One hay sample known to be seed-free ensured establishment of rows of slowly developing grasses sown across plots. Most samples contained seed of coarse forage grasses that eventually suppressed most sown species. Plots 1 and 2 were unmulched.

Volunteer rye (Secale cereale L.) stands tall in Figure 2, and dense stands may compete severely enough to seriously reduce stands of perennial grasses even before elongation begins in the spring. Properly threshed cereal straw should not present this problem.

Domination of roadsides by coarse forage grasses volunteering from seed in hay mulches is common. This is particularly conspicuous when fine grasses are sown. Specifying a straw mulch rather than a hay mulch is particularly important. Most broadleaf weed species can be removed selectively from turf-grass mixtures with herbicides, but perennial grasses cannot be removed. Although specifications typically prohibit seed in the mulch, perennial grass seeds often are overlooked. The seed of cereal crops in straw is easier to detect, and, if excessive, the straw should be rejected for mulch purposes.

Seed Stalks

Seedling characteristics foretell subsequent plant development, particularly in unmowed turf. Grasses with vigorous seedlings may attain sufficient size in a fall seeding to produce seed stalks the following spring. Spreading fescues and common Kentucky bluegrasses sown in the fall generally produce seed stalks the following spring; Chewings fescues and turf type Kentucky bluegrasses under the same conditions typically produce none. Other species of roadside grasses that flower the first spring after a fall seeding include the ryegrasses, Canada bluegrass, tall fescue, and sheep fescue.

Seed stalks affect appearance, and, therefore, are important quality characteristics. With regard to seed stalks, varieties within species differ. Among the Kentucky bluegrasses (Table 5 and Figure 3), Newport annually produced a large number of seed stalks even when not mowed for 5 years. These stalks remained upright and conspicuous for most of the year.

Seed bought as common Kentucky bluegrass or with variety not specified is apt to be Newport, or any other high-seed-yielding variety. A true common type, typified

Figure 3. Seed stalks of Newport and Kenblue Kentucky bluegrass unmowed for several years.

Figure 4. Seed stalks of Merion and Fylking Kentucky bluegrass unmoved for several years.

Figure 5. Suppressed seed stalks of Ruby versus those of Highlight in second spring after fall seeding.

Table 7. Effects of mowing on incidence of seed stalks on fine fescues.

	July 20, 1970, Ratings[a]		June 30, 1973, Ratings[a]	
Variety	Mowed	Unmowed	Mowed	Unmowed
Pennlawn creeping	3.0	4.0	3.8	6.0
Ruby creeping	2.0	5.3	6.2	8.0
Highlight Chewings	2.0	3.7	4.5	7.0
Wintergreen Chewings	2.7	3.7	3.3	5.3

[a]1 = most stalks; 9 = no stalks.

Table 8. Color retention by fine fescues during summer drought, group 1.

Variety	Rating[a]
Pennlawn creeping	2.2
Highlight Chewings	3.2
Wintergreen Chewings	4.2
Ruby creeping	6.2
KO-17 sheep	7.5
Golfrood creeping	8.8
C-26 hard	8.8
Alaska Station sheep	9.0
Least significant difference at 1 percent	1.9

[a]1 = straw color; 9 = best green color.

Table 9. Color retention by fine fescues during summer drought, group 2.

Variety	Rating[a]
Jamestown Chewings	4.8
Highlight Chewings	6.0
Pennlawn creeping	5.5
Ruby creeping	7.8
C-26 hard	7.5
Fortress spreading	7.8
C. P. Shade spreading	8.0
Least significant difference at 1 percent	0.9

[a]1 = straw color; 9 = best green color.

by Kenblue, consistently produced fewer tall seed stalks, but they lodged readily and soon were covered by long leaves. Turf types such as Fylking (Table 5 and Figure 4) produced a few seed heads and maintained good foliar cover in productive sites. Merion annually produces more seed stalks than Fylking does, but it produces fewer than Newport does. Along infertile roadsides, turf Kentucky bluegrasses provided only sparse cover (Table 2).

Although seed-stalk production characteristics of Kentucky bluegrass varieties continue perennially after maturity, those of the fine fescues do not. The first spring after a fall seeding, the size of seedlings (controlled in part by variety) determines the numbers of seed stalks. Vigorous types such as Ruby developed such a dense cover of fall foliage when unmowed that seed-stalk production the following year was inhibited. The data in Table 6 and Figure 5 indicate that Ruby produced fewer seed stalks than did Highlight Chewings fescue, a lower growing bunch grass. The following year, foliage produced by all varieties was sufficient to inhibit seed-stalk production, and differences among varieties were not significant. Fall mowing and removal of a season's accumulation of growth from fine fescues increased the production of seed stalks (compared with those on unmowed plots) the following spring. Data given in Table 7 illustrate the consistency with which varieties increase seed-stalk production after they are mowed. The suppression of seed stalks by unmowed grass is another argument for restricting mowing of roadsides.

Smothering and Persistence

Under no-mow management, smothering of fine fescues and Kentucky bluegrasses has occurred on productive sites. Along roadsides, soil fertility and pH are typically low, and soil moisture also may be limited. Loss of stands of these grasses by smothering has not been a problem in plots located along roadsides. Maintenance of adequate coverage by common varieties of Kentucky bluegrass has been more consistent under low management than it has by turf types. The fine fescues, however, proved even better adapted to infertile dry soils.

Color Characteristics

Colors of grasses vary with seasons. During summer months Chewings fescues develop brown leaves that discolor the unmowed grass on poor sites. C-26 hard fescue and sheep fescue selections retain their color (Table 8). Typically, the sheep fescues are blue green, and the hard fescue varieties are a brighter light green. Ruby creeping red fescue retained color better than Pennlawn creeping red fescue did (Tables 8 and 9 and Figure 6). Ruby and Pennlawn fescues are called creeping red fescues in current seed-trade terminology. Evidence exists that within these varieties many plants may be spreading types and possess 2n = 56 chromosomes (4). The spreading fescue selections (Table 9) were consistent in retaining a good, deep green color during summer drought. Observations such as this stimulated interest in developing an improved spreading variety.

Spring Dormancy

Breaking spring dormancy, or the ability to develop new green leaves, varies among fine fescues and Kentucky bluegrasses. The data given in Table 10 show a few characteristics fine fescue varieties that differed in early spring greenness. Sheep and hard fescues were notably tardy in spring recovery, and creeping fescue varieties were somewhat better than Chewings fescues. Similarly, the data given in Table 11 show that taller growing common Kentucky bluegrasses, such as Delta, were less dormant than shorter growing turf types, such as Newport, were (Figure 7). Increasing the rates of fall-applied soluble nitrogenous fertilizer hastened the production of green

Figure 6. Color differences between Ruby and Highlight during summer drought.

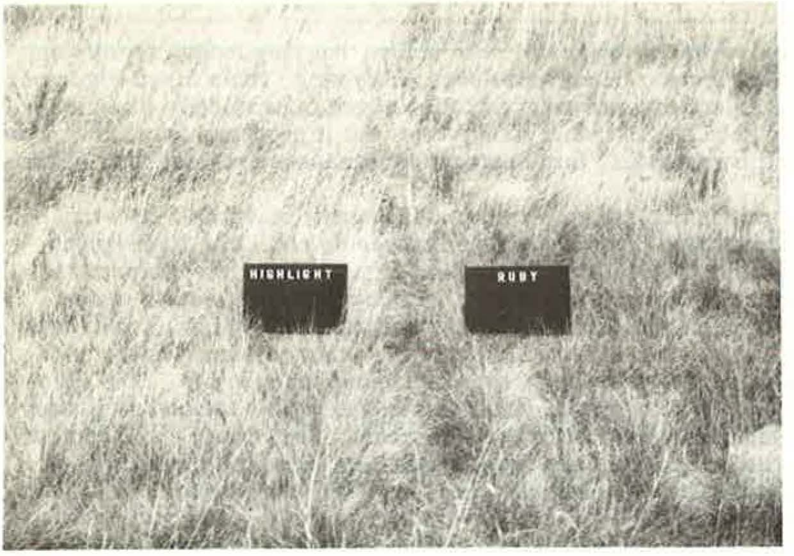


Table 10. Spring dormancy of fine fescues.

Variety	Rating[a]
C-26 hard	1.3
KO-17 sheep	1.7
Alaska Station sheep	2.0
Golfrood	5.0
Wintergreen Chewings	6.0
Highlight Chewings	6.0
Pennlawn creeping	6.3
Ruby	6.7
Least significant difference at 1 percent	1.9

[a]1 = straw color; 9 = best green color.

Table 11. Spring dormancy of Kentucky bluegrasses.

Variety	Rating[a]
Fylking	2.3
Belturf	3.4
Newport	3.4
Merion	3.9
South Dakota Certified	5.9
Kenblue	6.7
Delta	7.9
Least significant difference at 1 percent	1.1

[a]1 = straw color; 9 = best green color.

Table 12. Effect of fall mowing on breaking of dormancy by fine fescues.

	Rating[a]	
Variety	Mowed	Unmowed
Pennlawn	9.0	8.0
Ruby creeping	8.7	7.3
Highlight Chewings	9.0	6.3
Wintergreen Chewings	8.0	5.7
Alaska Station sheep	4.0	2.3
KO-18 sheep	4.0	2.7
C-26 hard	3.3	3.3
Least significant difference at 5 percent	0.8	1.6
Least significant difference at 1 percent	1.1	2.1

[a]1 = straw color; 9 = best green color.

Figure 7. Breaking of spring dormancy by Delta (right foreground) and Newport (left foreground).

color by these varieties in the spring.

Early breaking of dormancy in the spring was enhanced by mowing the previous fall in all fine fescues except C-26 hard fescue as indicated by the data given in Table 12. A cover of foliage, frequently 8 in. (20 cm) deep in unmowed plots, insulates the soil from the warming effects of the sun in the spring and constitutes a barrier to shoots of grass emerging from the soil surface.

Fine Fescue Improvement

Large attractive patches of fine fescues are sometimes found along older roadsides (Figure 8), particularly on infertile soils and droughty sites, including steep, unmowed banks. Such plants grew and spread from single superior seeds. They survived natural selection under minimum management conditions and appear to be better adapted than commercially available creeping and Chewings fescues. Named varieties have been developed in the United States, Europe, and elsewhere principally for fine turf or high seed yields or both rather than for minimum-maintenance turf. Although considerable effort has been made to commercialize varieties, the taxonomy of fescue species has not been consistently clear in the literature. According to Hubbard (3), the several fine fescue species are morphologically distinct, occupy different habitats, and perform differently under turf conditions.

In studies involving field plots, space-planted nurseries, greenhouses, and laboratories, we were able to more clearly characterize a number of fine fescue varieties in the seed trade. If a certain fine fescue is not specified for seeding, any of the characteristics given in Table 13 could develop. Height and color of components of mixtures certainly are important considerations in compounding mixtures. Different chromosome numbers and hour of flowering are also very real natural barriers to the development of cross species. The latter aspect is particularly cogent because Schmidt (4) showed that fescue pollen is short-lived.

To develop superior varieties of grass for roadsides, researchers selected for increase outstanding plants collected earlier from low-maintenance parks, cemeteries, and such areas. Six elite, spreading fescue plants were vegetatively propagated in a polycross nursery. Forty-five elite, Chewings fescue plants were similarly established in a field. Seed from intercrosses in each of these nurseries served as breeder seed for the testing of commercial feasibility of seed production in the center for such culture in the Willamette Valley of Oregon. Results to date indicate that the 2 varieties, Fortress spreading fescue, and Banner Chewings fescue, probably will be released for commercial sales in the near future.

Testing of spreading fescue plants collected more recently from roadside sites, and testing of components of Fortress, revealed the opportunity to select superior plants from these populations that vary in earliness of flowering, leaf-spot resistance, color, stemminess, and rhizome production, and the ability to spread. Seed of superior plants is saved for the production of plants to be tested both in roadside plots and as spaced plants in nurseries. Intercrossing of elite plants of successive generations selected for earlier flowering will mean plumper seeds, and resistance to leaf spot will mean less chance of discolored foliage and possible loss of stand from this fungal disease caused by Helminthosporium spp. A much improved variety of spreading fescue thus should be available for roadside and turf use in the future.

CONCLUSIONS

Hay mulches frequently contain sufficient viable seeds of coarse grasses to negate the advantages of fine-textured grasses. Grasses varied appreciably in seedling vigor. Certain fine grasses such as the spreading fescues and the common Kentucky bluegrasses have sufficient vigor to establish themselves well before the protective mulch disintegrates.

Unmowed ryegrasses provided such an abundance of foliage and stems initially as

Figure 8. Dense, dark green, low-growing fine fescue in the median of Route 130 near Robbinsville, New Jersey.

Table 13. Characteristics of fine fescues.

Type	Species	Height	Spread	Leaf Texture	Number of Chromosomes	Hour of Flower	Typical Varieties	Color
Chewings	F. rubra L. subsp. commutata Gaud.	Low	Very little	Fine	42	6 a.m.	Highlight Jamestown Banner	Light green Dark green Medium green
Creeping	F. rubra L. subsp. trichophylla Gaud.	Medium	Little	Medium	42	2 to 4 p.m.	Dawson Golfrood	Medium green Light green
Spreading	F. rubra L. subsp. rubra	Moderately tall	Good	Broad*	56	3 to 5 p.m.	Fortress Ruby Boreal	Dark green Dark green Dark green
Hard	F. longifolia Thuill.	Low	Very little	Fine	42	6 to 8 a.m.	C-26	Dark green
Sheep	F. ovina L.	Low	Very little	Wiry	28, 42	Noon	None available	Blue-green
Pseudovina	F. pseudovina	Low	Very little	Fine and wiry			Vendome	Very light green
Fine-leaved sheep	F. tenuifolia	Low	Very little	Very fine	14		Barok	Light green

*Similar to Kentucky bluegrass.

to be excessively competitive with associated perennial grasses. Perennial ryegrasses disappeared completely from roadside plots after 2 to 3 years. Tall fescues were stemmy and coarse, became sparse, and provided insufficient cover on poor sites. Stems of these and other coarse grasses were more conspicuous more months of the year than were certain fine fescues and Kentucky bluegrasses. Designation of variety was important also for color characteristics during summer drought and spring breaking of dormancy.

Selected spreading fescues were found to be superior in several of the previously mentioned characteristics. These grasses should provide a more attractive roadside cover with less maintenance than is expended at present for mixtures dominated by tall fescue. Cultivars of spreading fescues should be developed and used as the main component in mixtures for most of the roadsides in New Jersey and similar environments.

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