

REPORT ON POLLUTION ABATEMENT ON
HIGHWAY CONSTRUCTION AND MAINTENANCE

Part I : Recommendations to Minimize Pollution in Highway
Construction and Maintenance in Virginia

by

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and

Part II: Literature Review

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PREFACE

It will be obvious to the reader that the authors of this report are urging the Virginia Department of Highways to undertake a very high level of pollution abatement. It will be equally clear that if the recommendations are followed the Department will be doing a better job of pollution abatement than many others who contribute to pollution. Pollution from other sources will likely be a problem in many parts of the state long after highway construction has been exercising a persistent and effective system of pollution control.

Generally, additional funds must be used in exercising this control and this, in effect, means that the funds that can go to improvements for the accommodation of traffic will be lessened unless additional highway revenues are provided. Nor is it desirable to attempt to justify economically the spending of funds on pollution-abating activities and other such amenities. Attempting to quantify qualitative factors in economic terms is generally an exercise in rhetoric and sophistry that deceives few.

It is preferable to recognize that new opportunities are emerging to benefit to a greater extent than ever before the lives of both those who travel and those who live beside highways. And it is also important to recognize that these opportunities encompass qualitative factors that involve judgments to a greater extent than heretofore.

Many of the views expressed in this report are judgments, as was recognized as inevitable at the outset of the study. The attention of many people to anti-pollution matters will be needed over a long period of time but the consequence will be a greater contribution to the quality of the environment in Virginia.

SUMMARY OF RECOMMENDATIONS

1. It is recommended that the responsibility for the pollution abatement program be assigned to a single individual or office within the Department.
2. It is recommended that new discussions among the top management of the Virginia Department of Highways, the State Water Control Board, and the U. S. Soil Conservation Service be undertaken to establish more precisely the role that each can play in abating highway induced pollution.
3. It is recommended that where local anti-pollution programs have higher standards than those of the Virginia Department of Highways, the higher standards be followed.
4. It is recommended that a special catch-up program to provide vegetative cover on bare secondary road slopes be initiated in urban areas having intensive anti-siltation programs.
5. It is recommended that the responsibility for pollution control in those areas having intensive anti-pollution programs be vested in a single individual in each area.
6. It is recommended that an intensive research effort be undertaken to determine the most effective means of slope stabilization in urban areas.
7. It is recommended that all plans be reviewed specifically for erosion control features and the engineer or engineer(s) designated to review the plans be given the opportunity to become familiar with the erosion control work being done in Fairfax County, Virginia, and to take part in educational programs related to erosion control.
8. It is recommended that further discussion with officials of the U. S. Conservation Service be held to assure the continuance of their participation in the Small Watershed Program.
9. It is recommended that an inspection report containing pollution abatement items be required on all interstate and primary construction projects at intervals not exceeding three months.
10. It is recommended that a one-day anti-pollution educational program be developed for presentation to field forces during winter months beginning the winter of 1970-71.
11. It is recommended that certified compliance by aggregate producers with existing anti-pollution laws be made a prerequisite for the use of mineral aggregate on any contract or state work.
12. It is recommended that a flexible policy be established permitting the use of a dust palliative in instances where dust from an unpaved road is a substantial nuisance to a human facility regardless of the distance of the facility from the road.

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INTRODUCTION

Origin of Study

This study was initiated by Commissioner Fugate in March 1970. The purpose of the study was to investigate the ways in which highway construction and maintenance were contributing to pollution and to provide recommendations that would abate serious pollution.

Scope

One important question that had to be faced at the outset of the study was the extent to which the consequences of highway related pollution would be investigated. After considerable thought it was decided that a positive, forward looking program of pollution abatement was more important than an extensive study of the amounts of siltation or air pollution that may have occurred in the past. That is, the authors considered all "pollution" to be important and were more concerned about avoiding pollution in the future than the magnitude of past and existing pollution.

It was also recognized at the outset that any additional actions against pollution would be conducted by the operating divisions of the Virginia Department of Highways. The role of the Research Council, then, was to serve as coordinator of the efforts of the Department in: (1) discovering pollution prone conditions and (2) formalizing the recommendations that emerged from the total in-house pollution abatement program.

It was not the intention, nor was it possible, for the authors to devise an anti-pollution program that would be effective for all future conditions. Rather, it was considered desirable to point out the matters that needed immediate attention and to suggest a system that would yield a constantly improving pollution abatement program. The establishment of an in-house surveillance system is, in fact, considered to be more important and effective over a long period than any specific actions or specifications suggested by this study.

This report is intended to be supplemented with extended discussions within the Department. Although an exhaustive search was made to discover general instances of pollution, no specific cataloging of such instances was attempted. Here again, the emphasis was on what actions should be taken in the future.

Contents of Report

The term "pollution" is used in this report in a general sense. Any action or inaction during construction or maintenance that imposed a physical effect that was injurious to health or degraded the natural environment was considered to be an instance of pollution. Also the "pollution" was considered significant if it resulted in a substantial nuisance to an individual (such as dust from a construction project) or affected entire communities (such as extreme sedimentation of a community lake or reservoir).

This report has seven major segments:

1. Methodology of the Study
2. Inventory of Potential Sources of Pollution
3. Historical Efforts at Pollution Abatement
4. Case Studies of Design Facets of Pollution Abatement in an Urban Area
5. Actions Taken to Date
6. Recommendations and Comments
7. Areas Not Considered at this Time

METHODOLOGY OF STUDY

Both field surveys and discussions were considered necessary to gain an insight into potential sources of pollution and to rectify procedures that permitted pollution to occur.

The views of the following agencies were obtained in discussions:

1. Water Control Board, Commonwealth of Virginia
2. Air Pollution Control Board, Commonwealth of Virginia
3. Commission of Game and Inland Fisheries, Commonwealth of Virginia
4. Division of Water Resources, Commonwealth of Virginia
5. Soil Conservation Service, Regional Office, Charlottesville
6. Soil Conservation Service, Northern Virginia Conservation District
7. Environmental Division, Federal Highway Administration

8. County of Fairfax, Department of County Development
9. National Crushed Stone Association
10. Virginia Institute of Marine Science
11. Virginia Asphalt Association
12. Virginia Commission on Outdoor Recreation
13. Virginia Mineral Aggregates Association

Also discussions were held with several citizens interested in pollution who were members of various conservation groups.

Within the Virginia Department of Highways information relevant to the sources of pollution and the feasibility of pollution abatement programs was obtained from the following:

1. Resident Engineer
2. District Engineer
3. Drainage Subcommittee
4. Representatives of the following Divisions
 - a. Construction
 - b. Landscape
 - c. Location and Design
 - d. Secondary Roads
 - e. Maintenance

INVENTORY OF POTENTIAL SOURCES OF POLLUTION

From field trips, the above discussions, and a review of literature, the following were identified as potential sources of pollution.

Potential Sources of Water Pollution

1. Erosion of soil with resulting siltation of streams, ponds, reservoirs, fields and yards, during construction.
2. Erosion from bare spots on seeded slopes.
3. Erosion from unseeded slopes on secondary roads.
4. Erosion from unpaved ditches on steep gradients.
5. Contamination of streams, ponds, reservoirs, and wells by deicing salts.
6. Improper maintenance of cut slopes.

7. Sediments from wash water used in stone quarries and sand and gravel operations.
8. Cleaning of construction equipment in streams.
9. Depositing of engine oil in streams near shops.
10. Cleaning of spray bar of asphalt distributor into streams.
11. Mud agitation during marine construction.
12. Drainage from concrete batching and mixing operations.

Potential Sources of Air Pollution

1. Burning of debris during clearing of right-of-way.
2. Dust from drying operations of asphalt plants.
3. Dust from quarrying and crushing operations.
4. Dust from detours on construction sites.
5. Dust from unpaved secondary roads.
6. Fumes and particulates from construction equipment.
7. Solvent evaporation from volatile asphalt products and other volatile coatings such as concrete curing compounds.

General

1. Noise from construction equipment.
2. Human waste at rest areas lacking toilet facilities.

HISTORICAL EFFORTS AT POLLUTION ABATEMENT

Pollution abatement activities have received much intensive effort for many years. For instance, the establishment of turf on slopes of primary roads has received much operational attention and research effort for many decades. Erosion is, of course, anathema to highway engineers since it causes drainage ditches to be filled with sediment which must be removed to avoid over saturation of the subgrade soils beneath a pavement. Also erosion prior to seeding causes gullies to form in embankments that must be reshaped at considerable effort and expense. An example of the national awareness in the highway field of the need to retard erosion is shown in "A Policy on Geometric Design of Rural Highways", AASHO, 1965 (page 216).

Erosion prevention is one of the major factors in the design, construction and maintenance of highways. Erosion can be controlled to a considerable degree by geometric design, particularly that relating to the cross section.

In some respects the control is directly associated with proper provision for drainage and fitting landscape development. Effect on erosion should be considered in the location and design stages.

Erosion and maintenance are minimized largely by the use of: flat side slopes, rounded and blended with natural terrain; drainage channels designed with due regard to width, depth, slopes, alinement, and protective treatment; inlets located and spaced with erosion control in mind; prevention of erosion at culvert outlets; proper facilities for ground water interception; dikes, berms, and other protective devices; and protective ground covers and planting.

Here in Virginia there are many actions that indicate an interest in reducing erosion and siltation. For instance, in 1960 the Highway Commission adopted a program to do extensive seeding in watershed development areas. The funding of the program was established, and up to \$70,000 per year could be spent "... to seed highway cut and fill slopes in order to obtain ground cover."* Since that time 20 watershed projects have been conducted at a total cost of \$446,000 to the fund and an additional \$357,000 from other funds.

Also, the 1967 erosion control specifications of the Virginia Department of Highways were cited by the Bureau of Public Roads as a model for other states to follow. An additional indication of interest in conservation is the "memorandum of understanding" between the Virginia Department of Highways and the U. S. Soil Conservation Service throughout the state. These general agreements pledge the efforts of the Virginia Department of Highways in maintaining good conservation practices. A typical agreement between the Department and the Northern Virginia Soil and Water Conservation District is shown in the Appendix.

Many, many additional documents related to specific anti-pollution actions taken by the Department could be cited but the purpose of this report is to aid in achieving even higher levels of pollution control rather than to defend previous efforts.

Other aspects of pollution, however, have not normally been the object of intensive concern. Air pollution, for instance, has received less attention and this is consistent with the national trend. However, the current emphasis on clean air does demand that airborne pollution be attacked in a vigorous manner also.

Still another aspect of potential pollution that is of concern to conservationists but is debatable at this time is that of salt contamination. Studies are currently under way at V.P.I. to determine whether salt contamination from deicing materials is or is not a serious problem.

*Resolution, Highway Commission 4-21-60. See Appendix.

The point to be made by the above observations is that within the gamut of potential sources of pollution are areas in which the Department has already accomplished much, those that have not been given much attention, and those on which there is no expert consensus as to their seriousness at this time.

CASE STUDIES OF DESIGN FACETS OF POLLUTION ABATEMENT
IN AN URBAN AREA

Intensive anti-siltation programs are currently under way in Fairfax County. In discussing the program with officials of the Department of County Development it became apparent that stringent requirements are being imposed on land developers in the county.

Land developers are required to include various anti-siltation structures on their site plans. These plans are reviewed in great detail by engineers in the Department of County Development and only when adequate anti-siltation measures are indicated in the plans are they approved. In addition, an emergency escrow fund is required of each developer. This escrow account is to be used for siltation measures if the developer does not fulfill the plans or if an emergency requires rapid action during a storm.

To gain an insight into what effort would be required in highway construction that would be consistent with that imposed on land developers, the Department of Development of Fairfax County was asked to review three sets of highway plans. They indicated the necessary measures on the plans and made an estimate of the added cost.

It was not possible to reproduce the modified plans so only one set of plans is available. However, it should be noted that the anti-siltation measures were merely additive and did not affect any aspect of the existing design. A listing of the features that were added and the estimated cost are included in the Appendix.

The cost figures are shown below.

Project Identification	Construction Cost	Cost of Anti-Siltation Measures
Braddock Road S901(8) 0620-029-152, C-502	\$1,629,279	\$55,000 (3.6%)
Rolling Road 0638-029-156, C-501	\$ 671,284	\$21,000 (3.1%)
Rte. 711 0711-029-136, C-510	\$ 347,800	\$ 5,000 (1.4%)

Note that the added expense varies from 1.4% to 3.6% of the contract cost. The most common features added to the plans by the Department of County Development include:

1. Casual silt traps in swales (usually straw bales pegged into soil with iron rods).
2. Silt basins of approximately 2-4' height made of earth with "L" shaped outflow pipe.
3. Large silt basins approximately 4-8' in height, often excavated several feet below existing terrain with "L" shaped outflow pipe.
4. Silt traps around storm inlets.

ACTIONS TAKEN TO DATE

Programs Initiated in Recent Years

1. Protection of Rivers, Streams, Impoundments and Forests — Beginning with projects advertised on January 11, 1967, the Department began requiring the Contractor to conduct his construction operations in such manner that siltation and pollution of water resources would be minimized. Specific requirements included the prohibition of discharge of pollutants in or near waterways or channels leading thereto, the screening and covering of borrow sites and waste areas, and the control of water falling onto the top of partially completed embankments.
2. Open Burning — In August 1968 the specifications were again revised to include a reference to the open burning provisions of the State Air Pollution Control Board.
3. Noise Control — Beginning in February, 1969, a provision was added to the contracts which empowered the Department to prohibit or restrict work on the project that produces objectionable noise during normal sleeping hours.
4. Water Pollution — Constriction of Stream Flow — On July 10, 1969, a policy was instituted whereby a Contractor would have to submit a plan for approval prior to performing any operation which would reduce the flow of water even temporarily. This action was taken when it came to light that a number of industrial plants in Virginia are permitted to utilize or discharge into streams based upon a specified minimum flow of the stream. The size and configuration of any constriction placed in the stream above the industrial plant is now evaluated in terms of the effect it will have upon the stream flow past the industrial plant.

Programs Initiated Since April 1, 1970

It was considered desirable by J. E. Harwood, Chief Engineer, to initiate pollution abatement action when it became apparent that corrective action was necessary, rather than await this final report. Below is a summary of the programs initiated since April, 1970.

1. Open Burning — It was decided at the May 14 meeting called by Mr. Harwood that the Department should prohibit the burning of rubber tires, asphaltic materials, used crankcase oil, or similar materials which produce dense smoke, either to dispose of such materials or as an ignitor or promotor in the burning of other materials. This decision was implemented by special provision on projects included on the May advertisement and on current projects by memorandum.

2. Dust Collection System on Asphalt Plants — All new projects, beginning with those advertised in May 1970, contain a provision that asphalt plants be equipped by January 1, 1971 to conform to requirements of the State Air Pollution Control Board with regard to the quality and quantity of air pollutants emitted, unless the deadline has been extended by the Control Board based upon their approval of a plan for control at some future date.

3. Erosion and Siltation Control — Protective Measures During Construction — As of August 6, 1970, the Department began to pay the Contractor for restoration and replacement seeding work when such work was brought about by causes beyond his control. Before, the cost of restoration work was considered incidental to other costs and for this reason the Contractor was always reluctant to perform early seeding or out-of-season seeding.

Beginning with projects advertised in July, 1970, the Contractor was required to seed cuts and fills in increments as they are constructed. Before, the slopes were not seeded until all grading work was completed. Special seed mixtures will be used for year round seeding.

4. A rather comprehensive letter of instructions was published by the Construction Engineer on August 6, 1970, to point up the Department's role in pollution abatement. Quoting from that memorandum, "Finally, I want to impress upon you (District Engineers) the fact that erosion control is to become as much a part of our thinking and planning for construction as has safety, maintenance of traffic and any other phase of the work".

5. Secondary Roads — the Secondary Roads Division has recommended that on all secondary road construction seeding of slopes be routinely included in the plans. In the past, seeding was done only on selected projects so the extension of the seeding program to all secondary construction is an important step in erosion abatement.

6. Research Activities
 - a. Research will be conducted in Fairfax County, where various types of vegetative cover will be placed on secondary road slopes that have less than the desirable 2:1 slope. Ground covers as well as special turfing programs will be included in the experiments.
 - b. A research program on soil stabilizers will be conducted by the Research Council. Such stabilizers may be useful in retarding erosion of slopes prior to emergence of seedlings.
7. Virginia Asphalt Association — The VAA has retained the services of Environmental Evaluation Enterprises, Inc. to work closely with the Department of Highways and the State Air Pollution Control Board. This consulting service will aid the owners of asphalt plants in complying with the air pollution recommendations.

RECOMMENDATIONS AND COMMENTS

The authors believe that the following matters deserve careful attention. Most are general because it is believed that only by further discussion can all ramifications be exposed and the details of the optimum program be specified.

Responsibility for Pollution Control Programs

The discussions held with other agencies and within the Department, and the literature surveyed to date, have led to a number of approaches that it is believed will minimize pollution. It is recognized by all that pollution can not be completely eliminated but there are opportunities for it to be significantly reduced.

It is apparent that much pollution abatement can be achieved at very little additional cost. Included in this category are such procedures as using earth berms along upper and lower edges of embankments, and earlier seeding of embankments during construction. Other features, including such facets as construction of debris or sedimentation basins, and the use of cofferdams around in-water construction, will clearly add to the cost of a highway project. No effort is made to assess precise costs at this time. This will require an in-depth evaluation of specific structures and can be best done as the projects are being estimated.

The following recommendation is considered to be the most significant:

1. Assigning Responsibility for Pollution Abatement. It is recommended that the responsibility for the pollution abatement program be assigned to a single individual or office within the Virginia Department of Highways. The duties could include such activities as:
 - a. Review of plans to determine whether the necessary design oriented pollution abatement features are included.

- b. Field inspections to determine whether anti-pollution programs are being followed.
- c. Review of inspectors' reports on anti-pollution measures.
- d. Initiation of new anti-pollution programs.
- e. Initiation of research where new information is needed.
- f. Coordination of the anti-pollution program of the Department with those of other agencies.
- g. Evaluation of the research that will undoubtedly be emerging from throughout the country.
- h. Participation in drafting specifications that relate to pollution control.

Coordination Among State Agencies

The interviews with many agencies have indicated that coordination of the Department's anti-pollution efforts with the efforts of various state or federal agencies is rather complex. A number of agencies have expertise that can be helpful in abating erosion — especially the State Water Control Board, the U. S. Soil Conservation Service, and the Department of County Development of Fairfax County. Representatives of these agencies feel that they can be of greater service to the Highway Department in siltation control. However, it seems apparent that no extensive routine help is possible from these agencies, because of the lack of personnel, with the possible exception of Fairfax County. The Virginia Department of Highways produces plans for over 200 projects each year and it does not seem reasonable to expect that other statewide agencies could review these plans in detail for erosion control and make necessary field inspections.

In the authors' opinion, however, there is considerable difference of opinion within these agencies and the Virginia Department of Highways as to what level of cooperative effort is feasible. It seems clear that these agencies should be given the opportunity to redefine the capability they possess for advising the Department in abating siltation. The authors are fully aware of past cooperative efforts among the many state and federal agencies but along with the new emphasis on ecological matters new levels of cooperative effort may be discovered.

It is believed highly desirable, however, to develop in-house capability rather than depend on other agencies for technical capability. The authors of this report feel that the anti-pollution program requires considerable flexibility of action and for that reason the role of the other agencies should be advisory.

It is recommended that new discussions among the top management of the Department, the State Water Control Board, and the U. S. Soil Conservation Service be undertaken to establish more precisely the role that each can play in abating highway

induced pollution. Cooperation with other state and federal agencies, such as the Air Pollution Control Board, will be needed in specific instances but the daily cooperative efforts of the Department and the two agencies above would suggest extensive discussions with them.

Special Program for Northern Virginia

As was noted previously the Virginia Department of Highways has had an agreement with the Northern Virginia Soil Conservation District concerning erosion control since November 2, 1956.* A supplement to this agreement was added in August 1969. Essentially this agreement pledged the cooperation of the Department in making intensive efforts to retard erosion and to include good conservation practices in the design and construction of highways.

However, the rapid growth of the area has made it difficult to keep up with the desirable conservation programs. It has become apparent that special anti-pollution programs in highway design, construction and maintenance will be needed for Northern Virginia and especially Fairfax County. The County of Fairfax has initiated a very extensive anti-siltation program and the public is adamant that siltation control measures be used. Fairfax County has a force of approximately 80 people who spend a part of each day with matters relating to siltation control measures in subdivisions and an effort which is the equivalent of two engineers for the review of subdivision plans for siltation control measures is necessary. A fairly frequent complaint that comes from subdivision developers is that the siltation control efforts imposed on them are not matched by highway construction and that erosion from highway construction impairs their own siltation control efforts. Also, conservation minded citizens can point to many instances where highway construction is not utilizing measures required of developers.

Although Fairfax County has taken the strongest steps against pollution, other counties will begin to develop local ordinances especially against siltation matters. In these instances the Highway Department must be certain that the effort it makes is no less than that of the local jurisdiction.

The recommendations below are believed applicable in those urban areas where the problems of pollution are more critical.

1. It is recommended that where local anti-pollution programs have higher standards than those of the Virginia Department of Highways the higher standards be followed.

*A copy is included in the Appendix.

2. A special catch-up program to provide vegetative cover on bare secondary road slopes should be initiated throughout Fairfax County and shortly in the entire Northern Virginia Conservation District.
3. The responsibility for pollution control in the Fairfax Residency should be vested in a single individual.
4. A research effort on slope stabilization in urban areas should be undertaken.

Routine Siltation Control

Most observers would agree that erosion is the major contributor to pollution in highway construction and maintenance. It is equally obvious that a widespread program involving design, specifications and enforcement is needed to further reduce erosion. Also, erosion has both large- and small-scale implications. The large-scale may involve siltation of a lake or reservoir and the small-scale may involve the killing of lawns, shrubs and trees by inundation of roots. The latter is easily corrected by replacement but may often be avoidable by simple, cost free means.

Design Oriented Siltation Abatement

The use of siltation basins is not new in the Department but more widespread use is indicated. The experience in Fairfax County subdivisions is revealing that the amount of silt that washes from denuded land is far greater than intuition would suggest. An instance where even the most favorable conditions of vegetative covering would not have sufficed relates to a small private lake in Albemarle County adjacent to I-64. According to the estimate of the owner approximately 12,000 cubic yards of silt from the construction of I-64 has settled in the lake. Regardless of whether the estimate is accurate or not the many dead trees and the silted-up condition of a good deal of the lake are obviously offensive. This is an instance where a siltation basin or a series of basins would be necessary.

It is apparent also that the construction of permanent siltation basins will add appreciably to the cost of a project but the installation of temporary basins is relatively inexpensive. Often it will be necessary to clean these basins after each heavy rain, which also adds to the cost of construction.

While it is true that the full effectiveness of some siltation control procedures is not well established, enough is known and appears in the literature to warrant the inclusion of these procedures in the highway plans.

It is therefore recommended that all plans be reviewed specifically for erosion control features and the engineer or engineer(s) designated to review the plans be given the opportunity to become familiar with the erosion control work being done in Fairfax County, and to take part in educational programs related to erosion control.

Early Seeding

The new specifications for temporary seeding are a very important step in siltation abatement. One further step would seem beneficial. All will agree in principle that the permanent seeding should be achieved as early as possible. It is therefore desirable that specifications be consistent with this end. It may be desirable to tie the permanent seeding in with the construction of the highway so that seeding must be accomplished prior to a certain stage of construction.

It is suggested therefore that the feasibility of a requirement that seeding be accomplished prior to placing of any pavement layers be examined. This would be a firm positive requirement and probably would require considerable beneficial planning on the part of the contractor to make certain that seeding is accomplished early.

It is realized however that several complicating factors could develop from this practice; included might be the following:

1. Subgrade may be completed during the winter months when seed will not germinate. A mulch alone could be applied during December, January, and February, when erosion is not as serious a problem.
2. Drainage structures such as paved ditches require use of adjoining slopes for equipment and manpower and would disturb the seeded area.

While it is true that the above type of specification may make the application impractical at times and require adjustment, the more usual case would result in beneficial early establishment of permanent plant cover.

Enforcement of Specifications

The field survey has shown that the enforcement of existing anti-erosion specifications has been uneven. Often the berms and other anti-erosion features were in place but at other times they were not. The diligent enforcement of the new specifications and the use of good judgment in utilizing unspecified erosion control measures is dependent upon the importance that the inspectors place on this phase of highway construction.

In a later section it is recommended that one-day conferences be arranged for field personnel and this will be of great benefit both in adding emphasis to the program and in covering specific matters.

Another suggestion that it is believed is worthy of further consideration is that of requiring a quarterly report from the inspection forces. It is realized that inspectors are already burdened with reports and diaries and any unessential additional paper work should be discouraged. However it is believed that the only way of familiarizing the inspection forces with the many anti-pollution matters that require their attention is to use a form report.

This report would also provide useful information in the event of litigation and controversy.

It is recommended that a form report be required on all interstate and primary construction projects at intervals not exceeding 3 months. The Research Council can collaborate with the Construction Division in developing the report form.

Seeding of Slopes on Secondary Roads

It has been noted previously that on all new secondary road construction seeding of slopes will be practiced. Also it was noted that the seeding of slopes on some existing secondary roads in the Small Watershed Program is a routine activity. However, many bare slopes exist on secondary roads. It must be admitted that often slopes on secondary roads cover a fairly small acreage and in this respect are less of a problem than extensive exposed areas on the very high cuts and fills in the interstate system. It should be noted, however, that although the bare area is small it remains denuded for a long period of time and continually provides siltation materials.

The authors believe that a program of establishing or encouraging vegetative cover on the most erodable secondary road slopes is desirable. The funding of such a program would undoubtedly require further discussion among top management and the purpose here is merely to call attention to this matter.

It has occurred to the authors at numerous times during this study that a more widespread use of seeding crews employing state forces would be a great asset to erosion abatement. Great flexibility of usage could accrue from the use of state crews and the programming of a catch-up effort on the most erodable secondary road slopes would be possible.

The authors urge that the desirability of this be discussed among top management, including the District Engineers, to determine whether additional crews and equipment can be profitably utilized.

Small Watershed Projects

As noted in the section on "Historical Efforts at Pollution Abatement" the Department has undertaken special watershed anti-erosion programs since 1960, when an annual fund not to exceed \$70,000 was established. This is a very commendable program and highly complimented by those familiar with it. Because of the increased costs of all material and manpower since 1960 it is to be expected that the fund should perhaps be increased substantially. Also the dire consequences of siltation are better recognized in 1970 and for this reason also the current funds may be inadequate.

A complicating factor is at present retarding the pursuance of the existing program. Officials of the Soil Conservation Service have indicated that in the future the funds for fertilizer, seed, and mulch to be supplied by the U. S. Soil Conservation Districts will not be available.

It is recommended that further discussion with officials of the U. S. Conservation Service be held in an attempt to assure the continuance of their participation in the funding of the Small Watershed Program. However, if such funds are not made available, it is believed that it is in the best interest of the Department to pursue this program with its own funds (the expenditures on the program in the past have averaged 82% state funds and 18% federal soil conservation funds).

While the authors have not had time to examine this program in sufficient depth to arrive at a specific recommendation for increasing the funds, it is suggested that a study be made of the adequacy of the present funding. Again, the authors would caution that the "need" for additional funds can not be established in any precise sense; but would point out that the catch-up work needed on the secondary road system is substantial.

Salt Damage

There has been considerable concern among conservationists that the use of sodium chloride and calcium chloride on roadways would seriously contaminate streams and cause damage to plant life.

During the inventory phase of the study the contamination of wells was mentioned as one consequence of storing deicing salts in the open. The Highway Department now requires that deicing salts be stored under a cover. Often the salts are stored under a roof but occasionally a plastic covering is used. This practice appears to be generally adequate at this time. However, the open storage of abrasives (a combination of fine mineral particles and salt) is a practice that may result in some local drainage to plants and the placement of these materials should avoid the possibility of runoff affecting shrubs or lawns.

The major concern of conservationists about salt is that damaging levels of salt concentration may develop in streams and rivers. High levels of salt solution may damage plant life and be objectionable in water supply systems.

A study, sponsored by the NCHRP, is currently underway at V.P.I. to determine the magnitude of the salt solution problem. A report on one phase of the study has been published.* In the preliminary report no information was offered that would suggest a change in the Department's practices regarding the use of salt.

It is suggested that the final report be examined closely by the Department and appropriate actions taken at that time.

*Hanes, Zelanzy, Blaser, Effects of Deicing Salts on Water Quality and Biota, National Cooperative Highway Research Program, Highway Research Board, 1970.

Siltation Resulting from Quarrying and Sand and Gravel Operations

Both siltation and/or air pollution may occur at quarries. There has been an intensive effort within the industry over the past two or three years to reduce pollution and at a number of quarries substantial investments have been made in dust allaying systems and siltation ponds. No one is prepared to say, however, that all quarries are in compliance with existing state laws regarding air and/or water pollution nor is there concrete evidence that they are not.

At sand and gravel pits the major problem is siltation; since the materials are being wet any substantial dust problem is eliminated.

It is believed in the best interest of the Department to require the certified compliance of quarries and sand and gravel pits with existing state laws. The procedure used with the asphalt plant industry is believed appropriate here.

It is recommended therefore that certified compliance with existing anti-pollution laws be made a prerequisite for the use of mineral aggregates on any contract or state work. A realistic deadline for compliance should be developed in consultation with the state regulatory agencies and should not extend beyond January 1, 1972. Beyond that time no mineral aggregates would be used in state work unless it had been certified by the State Air Pollution Control Board and the State Water Control Board or agencies agreeable to them that the producers were in compliance with existing anti-pollution laws.

Bridge Construction Near Rivers

The Department does often take extraordinary precautions during construction of bridges near waterways. The use of various types of sediment basins near this type of construction is a manifestation of these precautions.

However, it is the authors' opinion that the use of sediment containment basins on a much more extensive scale is warranted. The opportunities for large-scale siltation to occur are rampant at some bridge sites.

Also, it should be pointed out that the establishment of the Scenic Rivers System is a clear indication that conservation of the natural beauty of the river system in Virginia is a high priority matter. Approximately 26 rivers are being studied for inclusion in the program. A very special effort must be made at bridge and roadway construction sites near these rivers and their tributaries. However, it is apparent that additional care and attention must be exerted routinely on all waterways.

The authors are offering no specific recommendations in this section because of the myriad conditions that are apt to be met. But here again there is an opportunity for achieving a new level of anti-pollution activity by extensive and frank discussions among the Virginia Department of Highways and other agencies, especially the Water Control Board and the Virginia Commission on Outdoor Recreation.

Training Field Personnel

It is the opinion of the authors that the new emphasis the Department is placing on anti-pollution measures be conveyed to field personnel. This could be ~~done through~~ formal one-day conferences for inspection and maintenance personnel. Few will dispute that an effective anti-siltation program cannot be accomplished without the assistance and specific input from the grass roots field forces. For instance, the cleaning of ditches often results in the denuding of the adjacent shoulders and if done at the wrong time of year the area may remain bare for 6 months. An improved scheduling of the operation and the modest use of grass seed by maintenance forces after denuding could probably eliminate this minor but frequently mentioned problem. The ideas of the field forces on how to combat erosion could be very useful at the local level and such a program would add emphasis to the total anti-pollution programs.

It is recommended therefore that a one-day anti-siltation program be developed for use in the field during winter months. The Research Council in cooperation with the Personnel Division could develop such a program.

Air Pollution

It has been noted previously that two of the major sources of air pollution, i. e., use of tires and oil in burning debris and stack dust from asphalt plants have been acted upon. The other major sources that require attention are dust resulting from quarrying operations and dust from construction sites and unpaved roads.

A questionnaire was sent to all resident engineers to assess the nature of the complaints they receive from the people in their residencies. The results of this questionnaire are tabulated in Table I. It can be noted that the only item on which the residency obtains "many" complaints is on dust from construction projects and unpaved roads. Eighteen residencies (out of 42) obtained "many" complaints and a total of 33 obtained either a "few" complaints or "many" complaints.

TABLE I

RESULTS OF QUESTIONNAIRE ON POLLUTION COMPLAINTS

Total Replies Received from Residencies — 42

<u>Type of Pollution</u>	<u>Frequency of Complaints</u>		
	<u>None</u>	<u>Few</u>	<u>Many</u>
Siltation of ponds, streams, etc.	8	29	4
Smoke from clearing operations	17	14	3
Dust (from construction & unpaved roads)	5	15	18
Salt & chemical damage to vegetation and wells	15	14	
Miscellaneous:			
Debris on right-of-way (abandoned cars, trash, etc.)		7	4
Drainage ditches (stagnation, grease, oil, etc.)		8	

Dust from Construction Sites

The allaying of dust on construction sites has been a routine practice of highway construction for many years. Water is applied by trucks on the detour areas and on areas used by construction equipment. Yet dust often causes problems for those living near a construction site. Generally, when visual evidence of large amounts of dust are noted the cause has been inattention on the part of the contractor and/or the state inspector. It is reasonable that within the many concerns of the contractor and inspection force, the building of the road to meet structural specifications gets first attention. However, the fugitive dust from a construction site can be a great problem for those who live nearby and cannot be taken lightly.

The authors have not been able to elicit a panacea for this problem but can only urge that the contractor and the inspection force be made aware of the importance of not permitting conditions that will cause dust to settle on adjoining dwellings. It is believed that increased awareness plus the inclusion of this item in the inspector's anti-pollution report will reduce dust. Dust abatement is clearly dependent more on people than on systems.

Dust from Unpaved Roads

There are 16,430 miles of unpaved roads in the state system. It is clear that any treatment of a great portion of these roads with a dust palliative is not practical and often is not warranted. That is, dust arising from unpaved roads in remote areas is a nuisance to drivers who are following another vehicle closely but the heavy dust travels only several hundred feet and does no permanent harm to surrounding woodlands and fields. Any extensive outlays for allaying dust would merely delay the hard surfacing of the more highly travelled secondary roads and thereby delay the many, many benefits that accrue from the asphaltic paving. However, it should be recognized that dust from unpaved roads is a source of considerable complaint from those who live beside such roads.

The spreading of salt as a dust palliative is widely used by the Department. The general rule followed by most resident engineers is to spread salt upon complaint if a dwelling is within 200 ft. of the offending road. A more flexible policy is believed desirable — one in which the discretion of the resident engineer would permit a dust palliative to be used if reasonable evidence exists that dust from the highway is a substantial nuisance to a dwelling, place of business, recreational facility, etc.

It is, therefore, recommended that a flexible policy be established permitting the use of a dust palliative in instances where dust from an unpaved road is a substantial nuisance to a human facility regardless of the distance of the facility from the road. Here again this will be an additional increment in the cost of pollution abatement.

AREAS NOT CONSIDERED AT THIS TIME

Several instances of pollution associated with highways were noted in the interviews but are not discussed in the foregoing sections. They were omitted because they were very complex either from a technical or administrative standpoint. At some future time they should be evaluated to determine what improvements are possible. Areas needing further attention include:

1. Noise from construction equipment.
2. Sanitary conditions at waysides on primary routes where no toilet facilities are provided.
3. Channel alterations due to change in cross sections resulting from bridge and tunnel construction.
4. Damage to biota caused by damming action of highway fills in salt marsh areas.
5. Drainage from concrete batching and mixing operations.
6. Investigation of economical methods of disposing of debris from clearing of right-of-way.

APPENDIX

Resolution of Highway Commission establishing Special Fund for Seeding Slopes on Small Watershed Areas.

Memorandum of Understanding Between Northern Virginia Soil Conservation District and the Virginia Department of Highways.

Cost of Upgrading Highway Siltation Control in Fairfax County.

RESOLUTION OF HIGHWAY COMMISSION ESTABLISHING SPECIAL FUND FOR
SEEDING SLOPES ON SMALL WATERSHED AREAS

WHEREAS, soil conservation districts are being set up throughout the State for the purpose of controlling erosion in the watersheds of certain streams; and

WHEREAS, an erosion problem is caused by raw cut and fill slopes along the highways, which in turn results in highway drainage and maintenance problems; and

WHEREAS, the soil conservation districts have agreed to obtain the necessary easements, arrange for the removal and replacement of fences, and furnish the fertilizer, seed, and mulch necessary to obtain ground cover on the highway cut and fill slopes within the watershed areas being developed.

NOW, THEREFORE, BE IT RESOLVED: That in view of the contribution of easements, adjustment of fences, and fertilizer, seed, and mulch by the soil conservation districts, the State Highway Commission, beginning with the fiscal year 1960-61, will provide funds to prepare and seed the highway cut and fill slopes in order to obtain ground cover. The total of said funds shall not exceed \$70,000 in any one fiscal year and are to be provided from the following sources: For the Primary System, from Primary Maintenance funds; for the Secondary System, from Secondary funds prior to allocation to the counties.

BE IT FURTHER RESOLVED: That in the case of highway projects being constructed within the limits of a watershed development area, provisions will be made to use project funds to control erosion on the cut and fill slopes.

BE IT FURTHER RESOLVED: That where Secondary highway funds have been budgeted for this purpose in fiscal 1959-60, reimbursement will be made from funds available July 1, 1960.

4-21-60

Confirmed letter ballot.

MEMORANDUM OF UNDERSTANDING
BETWEEN THE
Northern Virginia SOIL CONSERVATION DISTRICT
AND THE
VIRGINIA DEPARTMENT OF HIGHWAYS

"The Soil Conservation District" is a governmental sub-division of the Commonwealth, organized pursuant to Virginia State Law, exercising public powers in conservation of soil and water resources, by giving encouragement and promoting cooperative effort among landowners in the use and treatment of their lands in a manner that will insure conservation of these resources, and prevent the deterioration and impairment of productive capacity through erosion and other causes.

"The Virginia Department of Highways" is an agency and a landowner of the Commonwealth charged with responsibility for providing and maintaining roads, structures, and other facilities essential to adequate, comfortable, convenient, and safe highway travel and transportation.

Both agencies recognize that there are many problems of erosion control, landscaping, correct land use, water control and disposal, on highways and on lands adjoining the highways, that are of mutual concern to the Virginia Department of Highways, the Soil Conservation Districts, and individual landowners. THEREFORE, in order that the facilities of the Northern Virginia Soil Conservation District and the Virginia Department of Highways may be most effectively used in solving these and other problems, this Memorandum of Understanding is established as a basis of mutual cooperation and assistance in carrying out their respective responsibilities to the people of the Commonwealth.

The Soil Conservation District agrees to furnish the Virginia Department of Highways a statement of its policies, plan of work, and general objectives in its work area.

The Virginia Department of Highways agrees to supply general information at a local level as to its plans and programs on construction and maintenance of highways, and make available a representative for joint ground inspection and conferences as and when this seems mutually necessary and desirable.

The Soil Conservation District and the Virginia Department of Highways mutually agree to instruct workers of their respective organizations to use every reasonable means at their disposal and within the limits of their authority to further the intent and purpose of this agreement.

J. R. Engle

Chairman, Board of Supervisors
Soil Conservation District

STATE HIGHWAY COMMISSION

J. A. Anderson

James A. Anderson, Commissioner

SUPPLEMENT TO MEMORANDUM OF UNDERSTANDING
BETWEEN THE
NORTHERN VIRGINIA SOIL AND WATER CONSERVATION DISTRICT
AND THE
VIRGINIA DEPARTMENT OF HIGHWAYS

The Memorandum of Understanding between the Northern Virginia Soil and Water Conservation District, hereinafter referred to as the District, and the Virginia Department of Highways dated MARCH 27, 1969, is hereby supplemented to provide for cooperative installation and maintenance of Roadside Erosion Control measures as mutually agreed upon.

The District Agrees:

1. To furnish consultive assistance as needed for the proper installation of needed practices.
2. To furnish a semi-annual analysis of conservation requirements and deficiencies on Highway Department property including road construction projects.
3. To review highway development plans at various stages to identify potential conservation techniques and projects and possible problems which might be prevented through planning and control during the construction process.

The Department of Highways Agrees:

1. To develop a conservation plan covering all highway construction work.
2. To develop a conservation plan for maintenance of Highway Department properties.
3. To present to the Northern Virginia Soil and Water Conservation District these two plans annually.
4. To confer with the Board of Supervisors of the District on the efficacy of these plans and possible improvement in the plans or implementation thereof.

The conservation plans considered will have the following objectives:

1. To prevent off-site damage by sedimentation
2. To control erosion
3. To provide maximum beauty
4. To preserve areas of great scenic beauty

The District and the Highway Department further agree to embark mutually on a highway conservation project within the three-county area covered by the District in which new methods and techniques will be developed and evaluated and existing practices demonstrated and evaluated. The District agrees to solicit the assistance of other agencies such as County Governments, Virginia Polytechnic Institute, etc., and the Highway Department agrees to utilize its existing conservation programs in this effort.

The District and the Highway Department agree to coordinate their efforts in connection with the Pohick Creek Small Watershed Project. The District will make material available to the Highway Department to facilitate highway planning. The Highway Department will confer with the District at an early stage of highway planning in this watershed to assure maximum conservation coordination in this important watershed project.

Attached is a copy of the Erosion and Sediment Control Technical Handbook published by the District WHICH PROVIDES GUIDELINES for conservation work in this area.

Date 9-6-69

Stuart Finley

Chairman, Board of Supervisors,
SOIL & WATER CONSERVATION DISTRICT

Date 8/5/69

Douglas B. Fugate

Douglas B. Fugate, Commissioner of Highways,
VA. DEPARTMENT OF HIGHWAYS

COST ESTIMATES FOR ANTI-SILTATION PROCEDURES
IN FAIRFAX COUNTY

The three following estimates have been made by the Department of County Development, Fairfax County at the request of the authors. The Department of County Development has stated that the use of the means described on a set of plans and outlined on the following tabulation sheets is necessary in their opinion to be consistent with the effort being required of land developers. The plans have been submitted to the Location and Design Division for their review.

COST ESTIMATE -- ROLLING ROAD 0638-029-156 C-501

Sheet 3

5 ea.	Storm Drain Inlet Traps	at	25.00	\$ 125.00
60 Lin. Ft.	Silt Barrier		0.40	24.00

Sheet 3B

1 ea.	Silt Basin	at	5000.00	5,000.00
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Sheet 3F

1 ea.	Silt Basin	at	2000.00	2,000.00
110 Lin. Ft.	Silt Barrier		.40	44.00
2 ea.	Check Dams		20.00	40.00
1 ea.	Settling Basin		500.00	500.00

Sheet 3H

165 Lin. Ft.	Silt Barrier	at	.40	66.00
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Sheet 4

90 Lin. Ft.	Silt Barrier	at	.40	36.00
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Sheet 5

3 ea.	Storm Drain Inlet Traps	at	25.00	75.00
210 Lin. Ft.	Silt Barrier		.40	84.00
200 S. Y.	Bank Stabilization		.50	100.00

Sheet 6

100 S. Y.	Bank Stabilization	at	.50	50.00
1 ea.	Check Dam		20.00	20.00
125 Lin. Ft.	Silt Barrier		.40	50.00

Sheet 7

160 S. Y.	Bank Stabilization	at	.50	80.00
1 ea.	Storm Drain Inlet Trap		25.00	25.00
350 Lin. Ft.	Silt Barrier		.40	140.00

Sheet 8

1 ea.	Silt Basin	at	2000.00	2,000.00
250 Lin. Ft.	Silt Barrier		.40	100.00

Sheet 9

240 Lin. Ft.	Silt Barrier	at	.40	96.00
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Sheet 10

500 S. Y.	Bank Stabilization	at	.50	250.00
1 ea.	Silt Basin		5000.00	5,000.00

Total

\$15,905.00

CONTRACT

\$671,284.00

NOTE: All basins, barriers and check dams are temporary, to be maintained until vegetation is established. No maintenance costs are included. (Est. \$5,000).

24 Sep. 70

BRADDOCK ROAD S 901(8) 0620-029-152, C-502
SILTATION & EROSION CONTROL COST ESTIMATE

Sheet 2D

1 L.S.	Mulch and Seeding Changes	at	5000.00	5,000.00
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Sheet 3

2 ea.	Silt Traps	at	25.00	50.00
25 Lin. Ft.	Silt Barrier		.40	10.00

Sheet 3B

1 ea.	Silt Basin	at	3000.00	3,000.00
260 Lin. Ft.	Silt Barrier		.40	104.00

Sheet 4

100 Lin. Ft.	Silt Barrier	at	.40	40.00
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Sheet 5

150 Lin. Ft.	Silt Barrier	at	.40	60.00
100 Lin. Ft.	Straw Bale Basin		.40	40.00
50 Lin. Ft.	Fence Support		1.00	50.00

Sheet 6

50 Lin. Ft.	Silt Barrier	at	.40	20.00
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Sheet 7

1 ea.	Silt Trap	at	25.00	25.00
1 ea.	Silt Basin		3000.00	3,000.00
300 Lin. Ft.	Silt Barrier		.40	120.00

Sheet 8

1 ea.	Silt Basin	at	4000.00	4,000.00
75 Lin. Ft.	Silt Barrier		.40	30.00

Sheet 9

1 L.S.	Mulch & Seed Stockpile	at	50.00	50.00
1 ea.	Silt Trap		25.00	25.00
75 Lin. Ft.	Silt Barrier		.40	30.00

Sheet 10

1 ea.	Silt Basin	at	3000.00	3,000.00
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Sheet 11

1 ea.	Silt Basin w/filter	at	1000.00	1,000.00
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Sheet 12

2 ea.	Check Dams	at	25.00	50.00
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Sheet 13

1 ea.	Diversion	at	500.00	500.00
1 ea.	Check Dam		25.00	25.00
1 ea.	Silt Basin		1000.00	1,000.00
150 Lin. Ft.	Silt Barrier		.40	60.00

BRADDOCK ROAD (Continued)

Sheet 14

1 ea.	Silt Basin	at	6000.00	\$ 6,000.00
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Sheet 15

400 Lin. Ft.	Diversion Ditch	at	.40	160.00
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Sheet 16

600 Lin. Ft.	Diversion Ditch	at	.40	240.00
1 ea.	Silt Basin		8000.00	8,000.00

Sheet 17

400 Lin. Ft.	Silt Barrier	at	.40	160.00
1 ea.	Check Dam		50.00	50.00

Sheet 18

150 Lin. Ft.	Silt Barrier	at	.40	60.00
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TOTAL				<u>\$35,459.00</u>
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CONTRACT	\$1,629,279.24
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NOTE: All basins and barriers are temporary, to be maintained until vegetation is established.

No maintenance costs are included (Est. \$20,000).

COST ESTIMATE — EROSION CONTROL
PROJECT 0711-029-136, C-510

Sheet 2

1 L.S.	Change to mulch spec.	at	1000.00	\$1,000.00
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Sheet 8

2 ea.	Silt Basins	at	1200.00	2,400.00
2 ea.	Silt Traps		25.00	50.00

Sheet 10

1 ea.	Silt Trap		25.00	25.00
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Sheet 12

100 Lin. Ft.	Silt Barrier	at	40.00	40.00
50 Lin. Ft.	Wire Fence		2.00	100.00

Sheet 14

2 ea.	Silt Traps	at	25.00	50.00
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Sheet 16

1 ea.	Silt Trap	at	25.00	25.00
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Sheet 18

1 ea.	Silt Dam	at	600.00	600.00
3 ea.	Silt Traps		25.00	75.00

Sheet 20

2 ea.	Silt Traps	at	25.00	50.00
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	TOTAL	<u>\$4,415.00</u>
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CONTRACT \$347,800.20

NOTE: All control installations are temporary and must be maintained until vegetation is established.

Maintenance is not included in cost (Estimate: \$600.00)

REPORT ON POLLUTION ABATEMENT ON
HIGHWAY CONSTRUCTION AND MAINTENANCE

Part II: Literature Review

by

W. Cullen Sherwood, Assistant Professor,
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and
Consultant to the Virginia Highway Research Council

and

John W. Reynolds, Chemist,
Virginia Highway Research Council

It would appear at the present writing that two types of pollution emanating from highway construction and maintenance are of greater concern than the others. These two are (1) erosion and sedimentation and (2) air pollution. Due to the relative seriousness of these items, detailed literature reviews were undertaken. Brief resumés of the most significant findings, together with bibliographies, are included in the following sections.

Erosion and Sedimentation

The Problem

Sediment has been referred to, with considerable justification, as "the major form of pollution in the United States" (Corning — 1970) and "the worst pollutant in the Potomac River" (Wolman et al. — 1957). From a phenomenon generally associated with rural areas and agriculture, erosion and sedimentation has jumped to the forefront as a serious problem associated with urban and suburban construction and development. In fact, measurements by Vice et al. (1963) showed that 33% of the sediment deposited in the Potomac estuary originates in the Washington Metropolitan Area. It was also pointed out that while the average sediment yield for the Potomac River basin as a whole is 170 tons per square mile per year, these rates increased to 175,000 tons per square mile (greater than 1000 times the basin-wide rate) in urban areas undergoing construction (Johnson — 1966). The growing awareness of the intensity and extent of the urban sediment problem is reflected in the number of recent papers on this problem contained in the attached list of references.

After a brief look at the magnitude of the problem the question which immediately arises is "What are the deleterious effects of erosion and sedimentation?" Taking these one at a time, erosion is the easier of the two for which to document the specific problems involved. It removes soil. This loss may be in the form of valuable topsoil, in which case stabilizing vegetative cover will be difficult to establish, or it may be in

the form of infertile subsoil removed from construction sites in tremendous quantities. Rills and ditches form, foundations may be undercut and fail and, valuable fill material lost.

While erosion is a considerable problem the resultant sedimentation is considerably more serious and far-reaching in its effects. Brooks and Davis (1966), looking at the economic aspects of urban sedimentation, state "The case of sedimentation is a classic example of third party effects. The consequence of accelerated erosion caused mainly by construction activities scattered throughout an urban area, its effects are felt most strongly not at the eroding site itself, but by adjacent residents and downstream users of streams, lakes and estuaries, very few if any of whom are compensated."

Starting at the source of the sediment and proceeding downstream some of the more pronounced problems are the following: sediment is deposited on adjoining properties, covering lawns and streets and clogging storm sewers; it covers the bottoms of streams, smothering wildlife and destroying their habitat; it fills reservoirs, ponds, and lakes, impairing their capacities and usefulness; and ultimately, it is deposited in estuaries where dredging expenses may run into millions of dollars (Interstate Commission on Potomac River — 1966).

A recent paper by Corning (1970) of the Virginia Game and Inland Fisheries Commission describes the processes whereby induced sediment alters the natural stream environment and drastically affects stream life. The filling in of pools and riffles, the destruction of food plants, and the smothering of deposited fish eggs by silt severely reduce game fish populations. Other adverse conditions related to the silting in and shallowing are a rise in temperature and a lowering of dissolved oxygen so that only very tolerant or "trash" fish may survive.

Specific examples of documented sediment damage in Virginia would include Lake Barcroft and Lake Accotink in Northern Virginia. Each is downstream from areas undergoing vigorous construction of subdivisions and roads. As of 1966 (Anderson — 1967) the residents of Lake Barcroft had spent over \$300,000 on sediment dredging and removal and new sediment was accumulating at rates requiring further remedial work every two years. Lake Accotink was purchased by the Fairfax County Park Authority, which was only to find it seriously polluted and nearly filled with sediment. Initial reclamation of this body of water for needed recreation is estimated to require over a million dollars (Corning — 1970).

Other indirect but related effects of turbid, sediment laden waters are the considerable expenses resulting from water treatment, which were over \$1,000 per day for Washington, D. C., as early as 1949 (Kemp — 1949), and the loss of swimming and fishing recreation, which has been estimated for a single watershed in Missouri by Brown (1943) to be in excess of \$49,000 annually. The matter of aesthetics is also a factor but is difficult to estimate in economic terms.

Sediment Contribution from Highways

While it is generally difficult to separate and evaluate individual sources of sediment in an area undergoing urbanization, some well documented studies of highway erosion and sedimentation have been made. Foremost among these is the study of the small 4.5 square mile Scott Run Watershed in Northern Virginia during the period 1961-64. This study by Vice, Guy, and Ferguson, published in 1969, was undertaken when Interstate 495, Virginia Rt. 123 and the Dulles Airport highway were under construction in the watershed. Figures published in this report show that 66,500 tons of material were eroded from areas of highway construction. Approximately 33,200 tons of this material were deposited within the Scott Run Watershed, while 33,300 tons were carried out of the basin and into the Potomac River. Removal rates were measured as 126 tons per acre, or 80,600 tons per square mile, for the area under construction. Comparing these figures to other land use values within the basin yielded the following information: "The sediment yield per acre for an average storm event in construction areas was about 10 times greater than for cultivated land, 200 times greater than for grass areas, and 2,000 times greater than for forested areas".

Wolman's (1964) work in Maryland has yielded similar results, and he estimates the sediment yield per mile of highway construction to be on the order of 3,000 tons. He also compares sediment yield from highway construction to that from subdivision development and found that for those areas undergoing construction in suburban Maryland in 1964 he would expect 118,000 tons from highways and 228,000 tons from subdivisions.

While the sediment produced from construction projects has been widely recognized and carefully documented in a number of cases, sediment from secondary roads may actually pose a greater problem statewide in Virginia. Representatives of the Commission of Game and Inland Fisheries, the Division of Forestry, and the U. S. Soil Conservation Service all independently expressed this belief. At the time of the interviews with these persons, this view appeared to be somewhat farfetched. However, subsequent surveys over a considerable portion of the state show the presence of extensive mileages of raw banks and ditchlines associated with secondary roads.

Other research oriented specifically to the problems of highway erosion and sedimentation include the studies by Diseker and Richardson (1961, 1962) and Richardson and Diseker (1961) on roadside sediment production and control. These works evaluate various mulches and crops for erosion control. A recent paper by Amein and Chu (1970) evaluated the erosion of roadside drainage channels in North Carolina.

Methods for Reducing Erosion and Sedimentation

Methods which have been suggested for reducing erosion and sedimentation fall generally in three categories: (1) Minimizing denudation (Anderson — 1967); (2) reduction of time of exposure (Wolman — 1964); and (3) construction of sediment traps and impoundments (Anderson — 1967, Soil Conservation Service — 1969).

Minimizing the area denuded can aid in two ways. First, as much natural vegetation as possible is left on a site undergoing construction; and secondly, if only a limited

area is denuded at any one time, then site preparation and construction should proceed rapidly and vegetation can be reestablished after a relatively short interval. While this approach has been directed primarily toward subdivision development some aspects might be amenable to highway problems.

Wolman's (1964) studies in Maryland produced the same observations as have been made in Virginia, i. e., that seeding and mulching have traditionally been among the last items accomplished in what is often a long-term construction project. Soil Conservation Service reports and most other publications agree that one of the most effective points of attack would be to reduce the period of time during which cut and fill surfaces are exposed. Wolman states,

No data are available with which to estimate accurately either benefits or costs to be derived from early initiation of erosion control by seeding and mulching. In a number of states, notably Connecticut, Pennsylvania and Ohio, as well as in the Province of Ontario, however, contractors are encouraged to seed and mulch exposed areas as soon as possible upon completion of segments of highway projects. Correspondence with state and provincial officials indicates that this encouragement has been quite successful in a number of instances. In one region, seeding and mulching activities were carried out by state crews. Here it was found that the flexibility afforded by state operations reduced the cost of seeding and mulching considerably.

On areas to be left exposed for a considerable period a cost figure of \$40 to \$70 per acre for temporary seeding and mulching was offered by Anderson in the bulletin issued by the Interstate Commission on the Potomac River Basin (1963).

While immediate seeding and mulching appears to be the favored method for even temporary stabilization of bare slopes, it is also agreed that attaining a vegetative cover during certain portions of the year (notably the winter months and midsummer) is nearly impossible. Recognizing this Barnett et al. (1967) have evaluated straw with and without asphalt bonding as a temporary measure. Fiber mats and nets and chemical plastic sprays are also being advertised by various industrial firms as temporary means for stabilizing slopes.

Even if the best efforts of erosion prevention discussed above are used, the very nature of highway construction will result in a certain amount of sediment being picked up and moved by running water. Sediment traps and impoundments appear to be the most efficient means to arrest this material before it gets beyond the limits of the project. These structures vary in sophistication from anchored straw bales and brush to large, carefully designed stilling ponds, depending on the volume of sediment and water which must be treated. Particularly valuable information and design specifications for these structures are found in two Soil Conservation Service publications titled "Erosion and Sediment Control Technical Handbook" and "Guidelines for the Control of Erosion and Sediment in Urban Areas of the Northeast". The importance of soil type, slope, basin size, amount of denuded area, and volume of stream flow must be considered and the

facility or facilities designed for the specific needs of the site. Trap efficiencies of too small ponds may be low due to the short residence time of the sediment laden water (Moore et al. — 1960).

Use of straw bales has proved very satisfactory where small flow volumes are expected. The filtering action of the straw tends to hold the sediment while allowing the water to pass through. The straw ultimately rots and adds organic material to the soil, making removal unnecessary (Stultz — 1970).

The typical stilling basins used extensively in the Washington area of Maryland and Virginia consist of an earth dam with a perforated pipe, placed in a vertical position in the basin, draining at the foot of the dam. These basins typically cost about \$1,500 to construct (Wolman — 1964) and may concentrate as much as two to three thousand cubic yards of sediment in a construction season. Here periodic removal of the accumulated sediment is required.

On some larger and more complex areas larger ponds with concrete outlets may be required. In each case, however, it appears that soil conservation practices constitute only a small fraction of construction costs and the costs resulting from downstream sediment damage. It appears that widespread use of these measures is warranted.

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Air Pollution

Air Pollution Defined

According to the definition used by the Virginia State Air Pollution Control Board, "Air Pollution" means the presence in the outdoor atmosphere of one or more substances put there by man or man-made devices in concentration sufficient to cause an unreasonable interference with human, plant, or animal life or the reasonable use of property.

Air pollutants are of two general types: (1) particulate matter, and (2) gases. The particulate matter is composed of solid or liquid particles carried by the air, and ranging in size from 100 microns to less than 0.5 micron. There are two general classes of particulate matter. Those particles greater than 0.5 micron are called dusts, and those less than 0.5 micron are called aerosols. The gaseous pollutants are composed of such substances as carbon monoxide, hydrocarbons, sulfur dioxide and oxides of nitrogen.

The Problem

As recent as 20 years ago the automobile was a negligible source of air pollution, but as the number of vehicles have multiplied so have their role in air pollution. In many localities they are responsible for 50% - 60% of the pollutants. Although automobiles are an important part of the problem, the control of their emissions does not normally come under the purview of highway departments.

The factors for which the Highway Department does have a responsibility are those connected with highway construction and maintenance. They include the following:

1. exhaust emissions from highway construction equipment
2. dust resulting from construction practices
3. emissions from quarries, aggregate plants, hot-mix asphalt and concrete batching plants
4. dust from unpaved roads
5. smoke from open burning of cleared material during highway construction
6. concentration of pollutants in tunnels.

Most highway construction equipment is powered by diesel engines. The major problems created by their exhausts involve smoke and odor. According to Gilpin (1963) the diesel engine produces less carbon monoxide, carbon dioxide, hydrocarbons, and aldehydes than do gasoline engines. Although diesels do emit oxides of nitrogen in

considerable amount, the authors Brubacher et al. state that research indicates that a reduction of these oxides could conceivably increase the photochemical process, which results in smog formation in some localities. It is the dense, black smoke that is objectionable to most people. This smoke is composed mainly of carbon and sulfur, which gives it the coloration and an objectionable odor. During highway construction this smoke creates more of a nuisance than a health hazard.

Dust from highway construction has not received much national interest as a cause of air pollution. This may be because highway construction is present for only a limited time in any one specific area, and as soon as it is completed the source of pollution is eliminated.

Depending upon the type of soil on which the construction is taking place, and the prevailing weather conditions, dust problems can vary from negligible to serious. Zube (1961) gives the problems as follows:

- (1) can create traffic hazards to adjacent roadways.
- (2) detrimental to nearby vegetation
- (3) nuisance to residential districts
- (4) increases maintenance costs of construction equipment
- (5) definite health hazard to men working on the job.

There are several means whereby dust becomes airborne during construction. These would include earth moving operations, vehicular transport over bare earth, drilling and blasting operations, and wind passing over bare earth.

Although gravel roads are being replaced by paved roads, "many small towns with unpaved streets regard this (dust from vehicular movement) as being their most important air pollution problem" (Jacobson — 1962).

Emissions from quarries and sand and gravel aggregate plants are of a particulate nature. Dust emissions start in the quarries with drilling and blasting procedures and continue through the crushing, screening, and transport stages. Wet sprays can eliminate dust from the quarries, but the first crushing exposes a dry surface calling for additional controls.

Of major importance to the highway construction industry are the hot-mix asphalt and concrete batching plants. They release tremendous amounts of dust to the air if no control measures are taken. Even with the use of control measures some plants are still emitting enough dust to create a problem, when they are often located in highly urbanized areas (Friedrich — 1969).

The primary source of dust emission from hot-mix asphalt plants is the rotary kiln, and secondary emission sources include screening, mixing, and conveying processes. Dust emissions from the rotary kiln have been measured up to 6,700 lb/hr. and from secondary sources up to 2,000 lb/hr. (Danielson — 1967).

Concrete plants are of two types: wet-batching and dry batching. They store, measure, and discharge the materials to be used. There is no processing, and the emission comes from the handling of the material. The dust is emitted from receiving, weighing and gathering hoppers, the elevators, and the silo. Dry concrete batching is used extensively in highway construction and produces much more of a problem than wet-batching. The Air Pollution Engineering Manual, published by the U. S. Public Health Service, gives the following reasons for this.

- (1) the amount of concrete batched is larger
- (2) no water is used
- (3) the batched quantities are dropped rapidly into transport trucks to save time.

Careful planning and design are necessary to maintain safe atmospheres inside tunnels. The problem is that the emissions from the vehicles have no room to expand or disperse and traffic can produce dangerous levels of carbon monoxide if ventilation isn't adequate. High altitude tunnels are extremely dangerous to people with health problems because of the combination of thin air and the increased carbon monoxide concentrations (Miranda, Konopinski, and Larsen -- 1967).

Open burning of trees and brush cleared during highway construction constitutes a significant problem in some areas where certain physical and meteorological conditions prevail. These areas may be highly urbanized or in air basins, where because of the existing conditions there is little chance for the dispersion of smoke.

The Solutions

Diesel exhaust emissions can be controlled by several means. Smoke usually comes from underpowered or overloaded vehicles, low air-fuel ratios, and improper maintenance. Solutions to these problems would include higher air-fuel ratios, better power to load matching, and improved maintenance and fuel additives. Additives such as barium in concentrations of 0.25% reduce smoke density by 50% (Brubacher et al. -- 1967).

Dust emission from highway construction practices is much harder to control than that from most other sources because there is no one specific emission point. The primary methods employed are water sprays and surface coatings with agents such as lignon sulfate, petroleum resins, and asphaltic emulsions. They serve to cement the surface together and thereby inhibit dust. Zube (1961), in his studies, found that in some cases sprays other than water were cheaper and more efficient for this use. Other practices would include wet drilling techniques and the use of blasting mats.

Specific air pollution control equipment is available for use in controlling emissions from hot-mix asphalt and concrete batching plants. These include a variety of centrifugal separators, wet scrubbers, electrostatic precipitators, filters and baghouses. Some manufacturers will guarantee a collection efficiency of 99.5% or greater for these devices.

The only workable control that can be put on open burning is when and where it is to be allowed. The state of Pennsylvania has eliminated all open burning in specified air basins. They also require any contractors involved in construction in these air basins to meet with the Regional Air Pollution Control Engineer. Then depending on the specific construction activity, special provisions may be drawn up so that the construction will meet the Department of Health's criteria for air pollution control.

Within tunnels the highway departments are responsible for seeing that adequate ventilation is present, and for monitoring the carbon monoxide level to make sure it stays within reasonable limits. Oxygen masks should be available for emergencies, and when conditions call for it, warning signs should be erected indicating high levels of carbon monoxide and the health hazard resulting from it. Alternate route information should be made available for people with health problems who would be endangered by breathing the air in the tunnel.

In summary, highway departments are responsible for only a minor amount of the total air pollution. However, the type of emissions produced, such as black diesel smoke and dust, are highly visible to the traveling public. Consequently it would appear that rather significant efforts in air pollution abatement are warranted. The costs of such efforts would appear to be nominal to the departments.

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