Non-Point Sources of Water Pollution

Seminar Conducted by
WATER RESOURCES RESEARCH INSTITUTE
Oregon State University

Spring Quarter 1976

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The Water Resources Research Institute, located on the Oregon State University Campus, serves the State of Oregon. The Institute fosters, encourages and facilitates water resources research and education involving all aspects of the quality and quantity of water available for beneficial use. The Institute administers and coordinates statewide and regional programs of multidisciplinary research in water and related land resources. The Institute provides a necessary communications and coordination link between the agencies of local, state and federal government, as well as the private sector, and the broad research community at universities in the state on matters of water-related research. The Institute also administers and coordinates the inter-disciplinary graduate education in water resources at Oregon State University.

This seminar series is one of the activities regularly undertaken by the Institute to bring together the research community, the practicing water resource specialists, students of all ages and interests, and the general public, in order to focus attention upon current issues facing our state.
Preface

Sufficient progress has been made during the past decade in controlling and reducing the pollutant loads to Oregon streams from point sources -- principally municipal and industrial -- that diffuse pollutants from non-point sources are now emerging as the principal causes of water quality degradation. It is estimated for the Columbia Basin as a whole that over 50 percent of pollution loads entering streams are from non-point sources and that about 80 percent of the stream segments in the Basin are not meeting water quality standards as a consequence.

There are many sources of non-point water pollution significant in Oregon and the Pacific Northwest. Principal among these are forests, agricultural lands, urban areas, mining lands, and construction sites. Surface runoff and subsurface drainage from these lands carry a variety of organic and inorganic matter, including fertilizer and pesticide residues, sediment, oil and other petroleum products, septic tank effluents and matter from solid waste disposal sites. Rainfall adds airborne pollutants to the land drainage system. Bacterial and viral contamination come not only from human wastes but also from animals -- both wild and domestic. Recreational activities contribute pollutants to lakes, streams and seashores.

The diverse origins of the pollutants from non-point sources make it impossible to apply a single remedy or type of at-source treatment. The types of discharge restrictions and controls which have proven to be successful with industrial and municipal wastes simply do not lend themselves well to many forms of diffuse pollution.

To examine some of the issues that focus on non-point sources of water pollution, a series of public seminars was held during Spring Quarter at Oregon State University by the Water Resources Research Institute. Speakers from the University, from state and federal agencies, and from private practice led these seminars. Their delivered papers are presented here for your information and to encourage your further consideration of this critical problem of water pollution.

Peter C. Klingeman
Director

Corvallis, Oregon
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The Federal Water Pollution Control Act Amendments of 1972, more familiarly known as Public Law 92-500, has been called the most complex and far-reaching environmental legislation ever enacted by the Congress. Eighty-eight pages and nearly 45,000 words, it is complex, detailed, and significantly impacting every industry and all levels of government. Among many things, this is the law which directs the Federal Environmental Protection Agency (EPA) to establish a regulatory program to reduce and eventually eliminate pollution in our nation's waters.

This is the law which directs that we are to have "fishable and swimmable" waters by 1983, and that we are to eliminate the discharge of pollutants into the navigable waters by 1985. Section 101(2) states: "...it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water be achieved by July 1, 1983."

This is the law which provides that federal pollution abatement programs will be designed to cover all of the waters of the United States, not just the interstate waters. Sec. 303 of the Act defines goals for water quality standards by establishing stream water quality standards which specifically qualify and quantify conditions necessary on a stream basis to achieve the purposes of the law.

The techniques, or tools, which are provided in the law to achieve the goals and to meet and maintain water quality, are built into a permit program. Sec. 402 of the Act sets up the National Pollution Discharge Elimination System permits, commonly known as NPDES. In sparsely settled Oregon, with only about one percent of our nation's population, we have issued over 800 NPDES permits. Here, permits are both state and federal, since Oregon initiated the permit concept. Permits are required in the law for all point source discharges. They are not required for non-point pollution--and that's the rub.

I have pointed out in previous lectures that "...the permit system is the key to the law. The permit issued under the NPDES provides the legally
enforceable application of the Act's requirements. With a permit, the law is operative. Without a permit, the law is not effective. Point sources must have a permit, and therefore the law applies. Non-point sources, since not permittable, provide an existing and potential source of pollution."

Section 502 of the Act defines point-sources of pollution as "...any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged." Non-point discharge is not defined in the law. The Journal of Soil and Water Conservation editorially has commented: "There are many definitions of point and non-point pollution. The most simplistic of these is "...if it flows through a pipe, and has a spigot you can turn off, then it's point. Everything else is nonpoint."

Region VI, United States Forest Service, in Portland, has defined non-point sources of pollution as "those that pollute receiving waters as a result of naturally occurring events such as precipitation, seepage, runoff, earthquakes, etc., reacting with man's activities on a source area or tributary surface."

The Oregon Department of Environmental Quality has, I feel, the best definition, and one which is understandable and workable: "Non-point source is basically a term used to describe the water which reaches a stream by way of runoff from land. This runoff can be across the land surface (land wash), or through the soil structure (shallow subsurface or groundwater.) The quantity and quality characteristics of land runoff are significantly influenced by soil type and land use or activities which destruct natural vegetation and alter land surface.

"The dominant categories of land use which will influence non-point source water management are as follows: Urban Lands, Forest Lands, Irrigated Agricultural Lands, Non-Irrigated Agricultural Lands, and Range Lands."

What does the law say about "non-point source"? Kenneth Holtje, U.S. Forest Service, Eastern Region, says: "P.L. 92-500 does not specifically define the 'non-point source', nor does it establish or recommend appropriate procedures for controlling non-point sources of pollutants. In fact, the law directs water pollution control agencies to develop 'guidelines for identifying and evaluating the nature and extent of nonpoint sources of pollution.'"

Sec. 208(b)(2), referring to the state's responsibility in water management planning, says: "Any plan prepared...shall include, but not be limited to, (F) a process to (i) identify, if appropriate, agriculturally and silviculturally related non-point sources of pollution, including runoff from manure disposal areas, and from land used for livestock and crop production, and (ii) set forth procedures and methods (including land use requirements) to control to the extent feasible such sources;..."

The law also speaks to non-point in two other sections: Sec 304(e) "The Administrator (of EPA), after consultation with appropriate federal and state agencies, and other interested persons, shall issue to appropriate Federal agencies, the States, water pollution control agencies, and agencies designated under Section 208 of this Act, within one year after the effective
date of this subsection (and from time to time thereafter) information including
(1) guidelines for identifying and evaluating the nature and extent of nonpoint
sources of pollutants, and (2) processes, procedures, and methods to control
pollution resulting from '(A) agricultural and silvicultural activities, in-
cluding runoff from fields and crop and forest lands';..." James Agee, Assis-
tant Administrator of EPA, writing in the Journal of Forestry says: "Silvicul-
ture has been interpreted by EPA to mean all forest management activities."

Section 305(b)(1) says: "Each State shall prepare and submit to the
Administrator by January 1, 1975, and shall bring up to date each year there-
after, a report which shall include (E) a description of the nature and extent
of non-point sources of pollutants, and recommendations as to the programs
which must be undertaken to control each category of such sources, including an
estimate of the cost of implementing such programs."

EPA regulations further speak to non-point sources: 130.17(e)(2);
"...further, the state shall assure that there shall be achieved the highest
statutory and regulatory requirements for all new and existing point sources,
and feasible management or regulatory programs pursuant to Section 208 of the
Act for non-point sources, both existing and proposed."

With the legal background, EPA in 1973 proposed and promulgated rules.
The rules, except for the specific statutory reference to "concentrated animal
feeding operation" (Section 502(14)), provided for placing all agriculture and
silviculture in non-point source category. In other words, agriculture and
forestry were exempt from permit requirements since the determination was made
administratively (by rule) that these activities were not point sources of
pollution as defined by the law.

There were a number of reasons for the decision. Oregon, by the way,
concurred in the decision, although the state did move to require permits from
irrigation companies where a rather readily identifiable point source of dis-
charge was found. The decision was based upon the fact that much of agriculture
and silviculture are non-point. Further, water pollution control agencies in
the states, plus EPA, had more than enough to do in handling known point sources
and getting those sources under permit control without moving into the highly
controversial area of non-point and tackling two of America's largest industries
- agriculture and forestry.

Additionally, the general public was much more interested in the visible,
easily identified point sources of pollution than in the yet-to-be identified
non-point sources. Witness in Oregon the hue and cry about the operations of
Wah Chang and Western Kraft at Albany, Reynolds Metals at Troutdale, Crown-
Zellerbach at West Linn, American Can at Halsey (in its proposal stage), Harvey
(Martin-Marietta) at The Dalles, etc.

A considered judgment had been made by the State Sanitary Authority
(predecessor to the now existing Environmental Quality Commission - Department
of Environmental Quality) that what the public could see, almost daily, and ob-
serve as causing a detrimental environmental impact had to be dealt with first,
even if the emissions from such operations were less damaging than the cumula-
tive contributions of many individual citizens. A case much in point is the
private automobile, causing approximately 70 percent of our air pollution
problems (up to 90 percent in some areas) and only at this late date coming in for serious controlling attention, and as the public notes, bringing with it an attendant uproar from the to-be-controlled public, as evidenced with emission testing in Portland.

There was, I suppose, bound to be disagreement with this approach. There was disagreement also with some of the other actions flowing from EPA's administration of the Act. A federal judge for the District of Columbia had just ruled that Section 208 planning in the Act was a state obligation statewide, meaning that "a State agency had to assume responsibility for planning, management, and control of point and non-point sources where there is no designated agency in charge of the planning" (Dr. Clifford Smith, Region X, EPA, Administrator).

Five days following this ruling, Judge Thomas Flannery ruled on NRDC, Inc., vs Train (The Natural Resources Defense Council, Inc., vs Russel E. Train, Administrator for the Environmental Protection Agency.) Judge Flannery's decision ruled that there was no basis in the law (P.L. 92-500) for EPA to say administratively that agriculture and silviculture were non-point sources and therefore exempt from the permit program. The Judge then proceeded to set forth a time-table for EPA to first propose, and then to promulgate rules and regulations setting forth the terms for NPDES permits system expansion into all point sources in concentrated animal feeding operations and separate storm sewer categories. The Judge also ordered the extension of NPDES into all point sources of all agriculture and silviculture other than concentrated animal feeding operations and storm sewers. While EPA is appealing the ruling, the Judge's requirements stand, and we are now in the process of seeing them implemented.

A SERIOUS PROBLEM

A good question at this point in time certainly is "How serious is the problem? Why the big deal?"

EPA's "Water Quality Strategy Paper", Second edition, March, 1974, says it this way: "Non-point caused water quality degradation will emerge as the major barrier to achievement of the Act's 1983 water quality goals, as substantial control of point source pollution is realized."

In other words, from the standpoint of effectively controlling the point sources with our permit program, we will succeed, only to lose the ball game and not meet our water quality goals in 1983 because of non-point.

If we isolate the entire Pacific Northwest Columbia Basin region, we will find that initial estimates point out that 60 percent of pollution loads is from non-point and that 80 percent of our stream segments are not meeting quality standards as a consequence. The Soil and Water Conservation Needs Inventories of the Soil Conservation Service indicate that at least 2/3 of the non-Federal rural lands of Idaho, Oregon and Washington need some form of conservation treatment in cropland, pasture, range and forests. The sediment, nutrients, pathogens, and the water quality impacts associated with flow manipulation are typical pollutants of concern, with sediment being most important.
According to the Columbia North Pacific Study, 45 percent of the total annual sediment loss in the Columbia Basin comes from agriculture land, 28 percent from rangeland, 23 percent from forest land, and 4 percent from other sources. About 2/3 of the forest land sediment is from a single source -- logging roads -- according to the Region X Environmental Protection Agency office studies.

What did the Congress intend? There is some disagreement on this point. Both sides to the question use legislative history to sustain their case. J. G. Speth and T. J. Barlow arguing the NRDC case said: "Clearly, Congress considered that certain agriculture and silvicultural pollution be considered point-source pollution. For example, Congress included 'concentrated animal feeding operations' in the definition of 'point sources'. And during deliberations over the bill, Congress explicitly rejected an amendment that would have excluded irrigation return flows from regulation under the NPDES program. The legislative history of the Act recognizes that there may be other point sources associated with farming and forestry and directs EPA to provide guidance for identifying these point sources."

On the other hand, EPA speaking in its own defense wrote in the Federal Register, 2/12/76: "The FWPCA and its legislative history make clear that it was the intent of the Congress that most water pollution from silvicultural activities be considered non-point in nature. This intent is reflected in the structure of the FWPCA and its establishment of two different abatement programs for the different types of pollution. Under Sec. 402, NPDES point sources of pollution are required to meet certain numerical effluent limitations on individual permits. Nonpoint sources of pollution, diffuse and runoff sources, are subject to the jurisdictions of Section 304(e) and Section 208 which require, respectively, the issuance of information concerning the nature and control of non-point source pollution and the development and implementation of area-wide or statewide plans and programs of abatement of such pollution.

"Congress clearly recognized that the NPDES permit program would not be adaptable to all types of water pollution. Non-point source water pollution, diffuse runoff resulting from precipitation events is more effectively controlled by the use of planning and management techniques."

The National Commission on Water Quality, on the other hand, in its "Issues and Findings", November 1975, says: "There is little doubt that Congress intended to include irrigation return flows as a point source subject to effluent limitations and NPDES permits, but the BPT and BAT limitation concepts, even with all the problems their application has encountered are more simply and easily applied to industrial than to irrigation discharges." (BPT is the requirement to meet by 1977, which requires the "best practicable control technology currently available" in applying permit limitations. BAT is the 1983 requirement of the "best available technology economically achievable.") Section 301, P. L. 92-500.

CURRENT TRENDS

What's happening now? James Agee, Assistant Administrator for EPA in the Journal of Forestry, Vol. 73, No. 1, says: "EPA's strategy establishes
that the most effective approach to handling non-point source pollution, both from the viewpoint of cost-effectiveness and the availability of technology, is to use the best preventative practices available to minimize pollution, rather than attempt to clean up the water after pollution has occurred.

This is the trend being undertaken. Warren Harper, Hydrologist at the Forestry Research Center, Tacoma, Washington, with Kenneth Holtje, writes: "Non-point sources of pollution should be defined as those that can best be controlled by requiring proper land management practices. Protection of water quality comes from specifying acceptable land management implementation of these practices. Compliance with acceptable management practices should constitute compliance with state and federal water quality standards and the intent of P.L. 92-500.

"Instead of attempting to regulate agricultural and silvicultural activities by effluent limitations and water quality standards, let's require proper land management practices and base compliance on inspection of these activities. When practical water quality standards are developed, research should be able to provide us with the link between downstream water quality and upstream activities and define for us acceptable management practices that are consistent with downstream water quality objectives."

In the Senate Report on the FWPCA (Federal Water Pollution Control Administration -- predecessor to EPA), Congress identified a need for "integrated water pollution control" and a need "...to promote sound land use and control pollution by reducing erosion and runoff." The report also cited "...poor forestry practices, including indiscriminate clear cutting", which would "...generate substantial soil erosion problems." The report also noted that Congress also recognized that the use "...of conservation techniques will be an important part of control of nonpoint sources of pollution."

EPA has followed the Federal Judge's order, public hearings on proposed rules have been held (the Oregon hearing last December 9-10 in Portland), and the rules promulgated and published. In setting forth the rules, EPA said: "We maintain that most water pollution from agricultural and forestry activities is nonpoint in nature, and generally best controlled by management and planning techniques. Nonpoint sources are generally those in which the pollution is not traceable to an identifiable source and is not amenable to end-of-pipe treatment."

The EPA has therefore set forth: "Those agricultural activities including irrigation, that result in surface pollution are subject to the NPDES permit program if the resultant discharge; ...contains pollutants, ...results from controlled application of water by any person, and is not caused or initiated solely by natural processes, ...is discharged from a discernible, confined and discrete conveyance, and ...is discharged into navigable waters."

"A discharge must meet all four of the criteria before it is a point source subject to regulations. These criteria are intended to apply specifically to irrigation return flow ditches.

"It is the intent of these regulations to exclude from the wastewater permit program all natural runoff from agricultural land that results from precipitation events such as rainfall, snowmelt, and natural flooding. The
regulations would not apply to most normal farming operations, and although they would apply to irrigated operations meeting the four criteria, there are no application requirements for issuance of individual permits at this time."

The EPA position statement continued: "The new regulations similarly state that most forestry activities result in nonpoint source pollution, and are not subject to the permit process (NPDES). Water pollution from a forestry activity is not covered by the regulations if it is: ...initiated or caused solely by natural processes including precipitation, drainage, seepage, percolation, or runoff, and ...not traceable to any discrete or identifiable facility." In interpretation of this, EPA said: "These criteria exempt from the NPDES permit program most natural runoff associated with nursery operations, site preparation, reforestation, in all stages of growth, thinning, prescribed burning, pesticide and fire control, and harvesting operations. The regulations for forestry activities would require permits for auxiliary forest operations, including rock-crushing, gravel washing, log sorting, and log storage yard activities where the application of utilization of water by any person results in discharge of pollutants through a discernible, confined, and discrete conveyance into navigable waters. When these point sources move with progressive forestry activities special permits will be considered to accommodate their mobility."

And finally, the position paper prepared by Oregon representatives at the Forest Practices-Water Quality Workshop in Portland, which I chaired for the Oregon group, in speaking to eight points, noted:

"The Oregon group felt that many important requirements for a good forest practices Act are already embodied in the Oregon Forest Practices Act, namely, it is practical, workable, effective, and rules are flexible and adjustable to recognize the inherent variability of the natural forest environment. The rules also recognize the technological and market changes which will occur over time. The group emphasized the Oregon Act's mandate for coordination between government agencies. In addition the State group saw the need to provide incentives for environmental protection in forest management wherever practical. In essence, the Oregon group sought recognition by EPA of the strengths of Oregon's Forest Practices Act."

Specifically, the Oregon recognition is that "The EPA should act promptly to define silviculture practice as coming under non-point source designation." (Of 30 in our Oregon group, 4 did not agree.) Finally, the Oregon group recommended that "The EPA recognize that operator compliance with conditions of the Oregon Forest Practices Act implies compliance with water standards. If there is not compliance with water quality standards, then consider appropriate changes in the Act or regulations to gain reasonable compliance."

In summary, differences between point and non-point sources are difficult to define in many cases. In most instances, agriculture and forestry are non-point sources. The best control techniques will be through land use practices, and development of management techniques. Both forestry and agriculture as industries have developed suggested state legislation to meet the problem. Oregon, and EPA, recommend that this path be followed. With the implementation of land use planning and management tools, such as the Oregon Forest Practices Act, water quality standards should be met. If a practitioner is acting properly under his industry's controlling legislation, i.e., the FPC, then he is determined to be complying with water quality standards. If water
quality standards are found to be violated with industry in compliance with the controlling legislation on land use and proper management techniques, then the route to follow is to change the land use management act and not the water quality standards.

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Presented April 8, 1976 by HENRY A. FROEHLICH, Department of Forest Engineering, Oregon State University.

Inorganic Pollution from Forests and Rangelands

The elimination of the discharge of all pollutants into navigable waters by 1985 is a most challenging goal. When one considers that this is intended to include virtually all waters and non-point as well as point sources of pollution, the scope of the commitment is almost overwhelming. During this seminar we are considering primarily non-point sources of pollution. No doubt the major problem associated with the measurement and enforcement of pollution control from forest and rangeland is that of isolating the man-caused pollutants from among the natural levels of similar material. The man-caused, diffuse sources of pollution are not only transient in location but vary markedly with time. The non-point sources are set in a matrix of highly variable natural loadings which also varies markedly from stream to stream and with time in the same stream. The detection and correction of these sources will require an entirely different methodology than that applied to readily defined point sources of pollution.

DEFINING POLLUTION

There is a wide gap in the philosophy of zero discharge and pollution control where pollution is defined to include some level of damage. The California Coastal Commission has defined pollution as the alteration of the quality of the waters of the state by waste to a degree which unreasonably affects: (1) such waters for beneficial uses, or (2) facilities which serve such beneficial uses. Oregon Revised Statutes defines pollution to mean:

"...such alteration of the physical, chemical or biological properties of any waters of the state, including change in temperature, taste, color, turbidity, silt or odor of the waters, or such discharge of any liquid gaseous, solid, radioactive or other substance into any waters of the state, which will or tends to, either by itself or in connection with any other substance create a public nuisance or which will or tends to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to"
domestic, commercial, industrial, agricultural, recreational or other legitimate uses or to livestock, wildlife, fish or other aquatic life or the habitat thereof."

When the apparent pollutant is also a naturally occurring material we must consider relative amounts rather than the presence or absence of a given material.

During this seminar we will narrow the scope of the discussion to the inorganic pollution originating on forest and rangelands. The inorganic material includes both particulate material and dissolved minerals. Sediment normally makes up the greatest volume of material carried in flowing waters. However, in a few regions the dissolved minerals represent a significant percentage of the total load of inorganic materials.

**NATURAL SEDIMENT LOADS**

**Annual Loads**

Sediment probably makes up a greater volume than all other pollutants combined. It has been estimated that sediment from all sources is 500-700 times that of the sewage load in streams (Glymph and Carlson, 1966). Fortunately the toxicity or pathogenic qualities of sediments do not match that of most other pollutants. The USGS estimates that 491 million tons of suspended sediment is discharged into the oceans each year from the conterminous United States (Curtis, Culbertson and Chase, 1973). This is roughly equivalent to a pile the size of a football field reaching 47 miles high. One can only conjecture at this time how much of this is pollution and how much is sediment of natural origin.

It is well recognized that the nation's upland streams are the primary source of high quality water. Yet few streams are as pure as they appear to the casual visitor. A few examples of the sediment loads experienced by forested streams and the variation within and between streams may help to keep the problem in perspective.

The lowest levels of sediment movement that are reported are from several high elevation streams in the Rockies. The loads from undisturbed forest lands may range from a few to 10 tons per square mile per year. Also, studies in New Hampshire in small watersheds also have reported very low annual sediment loads. These are on coarse textured soils, relatively gentle terrain and very stable slopes of granitic or glacial outwash origin.

Well-stocked, undisturbed southern pine forests of the Coastal Plain may be expected to yield 200-300 tons per square mile per year. Here the terrain typically is gentle and stable, but the sandy soils and intense storms make a big difference in sediment movement. In an area of much lower precipitation, but also with high storm intensities, as in Arizona, sediment yields from forested areas may be 300 to 400 tons per square mile per year. Relatively low vegetative cover and erodible sandstone parent materials add to the problem.

On the West Coast, we find very large differences among streams, but, in general, sediment yields from undisturbed forested watersheds are likely to be in the range of from 150 to 350 tons per square mile per year. A local
example can be taken from the Alsea Study where three small drainages were intensively studied. These watersheds, all in close proximity, yielded average loads of 165, 256, and 313 tons per square mile per year (Brown and Krygier, 1970). These are in steep topography with relatively youthful geological structure and high annual rainfall. However, these are in sharp contrast to several drainages in northern California in areas underlain by recent marine formations of unstable topography. Here sediment loads of at least a few thousand tons per square miles per year should be expected. Also in northern California, but further inland, Castle Creek was reported to yield an average of 935 tons per square mile per year before disturbance.

While these averages will give some impression of the large differences in natural sediment yields, it should also be remembered that it is not uncommon to find the highest annual sediment load in a given stream to be 20 times the lowest sediment load. The highest sediment loads are commonly associated with years of highest annual runoff. It is not unusual for the sediment load for a year with unusually high flows to be equal to the load of several previous years.

**Instantaneous Loads**

This wide array of annual sediment loads is produced by an even larger range of instantaneous loads. The instantaneous peak sediment loads are in response to increases or decreases in stream flow, natural bank slumping, channel shifting, land slides and other natural phenomena. Taking another page from the Alsea Study, we can see how variable the sediment loading is in at least one stream. Figure 1 shows the large variation, up to a ten-fold difference at most flow levels, in this stream. Figure 2 shows that the sediment movement tends to differ between rising and falling stage at the same flow levels (Rice, Thomas and Brown, 1975).

The trend of increased sediment movement with increasing discharge is evident and expected. However, the variance clearly illustrates the difficulty in establishing a background value to use in comparison with a possible pollution level. Figure 3 also shows that we should expect a different response between streams at similar flow levels. Perhaps one of the reasons for the commonly held views of clean mountain streams is due to the fact that most sediment moves during a few high flow periods. It is possible that 80 to 90 percent of a stream's sediment load is moved during a few days or a few weeks. On the uncut Flynn Creek in the Oregon Coast Range, the sediment that moved during January of 1972 was equal to that of the previous 41 months.

Dr. Klingeman's work in Oak Creek illustrates that bed load is also highly variable in time and is strongly correlated with stream discharge. In this study there was a 10-fold increase in bed load movement as discharge increased from 24 cfs to 63 cfs (Oregon State University, 1971).

**STANDARDS FOR LEVELS OF INORGANIC MATERIALS IN STREAMS**

Due to the severe sampling problems, there will be considerable difficulty in establishing and enforcing standards similar to the type used for point sources of pollution. Existing State rules recognize that a natural
FIG 2 - VARIATION IN SEDIMENT TRANSPORT WITH STAGE (FLYNN CREEK)

FIG. 3 - VARIATION IN SEDIMENT TRANSPORT BETWEEN ADJACENT STREAMS

SUSPENDED SEDIMENT (mg/L)

DISCHARGE (cfs)

RISING STAGE

FALLING STAGE

SUSPENDED SEDIMENT (mg/L)

DISCHARGE (cfs)

NEEDLE BRANCH

FLYNN CREEK
background of sedimentation exists. Oregon's general water quality standards prohibit any change in turbidity when background turbidities are less than 30 JTU. A 10 percent increase is permitted if turbidities are above 30 JTU. Special permits may be obtained for short term activities which may give higher turbidities.

Washington's standards are more complex but likewise more flexible. Turbidities may not be increased over 50 JTU above natural conditions at any time. Turbidities may not exceed 10 JTU above background values if averaged over any one-hour period. Measurable changes in turbidity may not extend beyond one-half mile downstream. They may not continue for more than three consecutive years or more than one three-year period in any ten-year period.

California has the simplest general standard in that it prohibits the discharge of silt into streams in quantities deleterious to fish and other uses. However, specific turbidity standards are being developed for given drainages or regions.

The monitoring for violations of any of these standards is nearly impossible. None of the standards described above specify where the sampling shall be taken or how reliable background values are to be obtained.

In a 1973 review draft by the EPA, a water quality criteria of an average of 80 ppm sediment would be adequate for protecting most water uses. It is true that this would probably equate to an approximate tonnage of material now carried by some undisturbed streams but would be entirely unrealistic on many others. In addition, a practice could continue for a considerable length of time before it could be assessed as a violation.

STANDARDS FOR PRACTICES

It seems evident that practices which produce the potential pollutant are more amenable to control than the specific levels of sediment or turbidity in a stream. I believe the type of control exercised by the Oregon Forest Practices Act have been highly successful in maintaining high water quality standards. The rules developed under the Forest Practices Act have not brought about zero discharge. They have, in my opinion, made a significant contribution in maintaining a desirable stream habitat while developing and utilizing the renewable resources on the slopes.

Rangelands have not come under the same degree of control as forest lands. A great proportion of the nation's grazing land is in public ownership and thus controlled by a wide array of prescribed rules and guidelines developed by the agencies involved. Private grazing land does not necessarily come under similar guidelines. In spite of the generally much more gentle topography of grazing land in contrast to the generally steeper forest lands, the potential for accelerated erosion is also quite high. Rainfall in grassland regions is typically low but subject to severe summer storms. The rate of soil loss is, of course, subject to many factors, but the factor most directly under management control is the degree of vegetative cover. Range conditions develop relatively slowly and it seems unlikely that a direct monitoring of runoff quality is a useful approach to maintaining the desired stream quality. It seems essential that standards of inorganic pollution control practices similar to those now applicable to forest lands be developed for rangelands.
CONCLUSION

Considerable research has been done over the past twenty years which indicates that certain logging practices can indeed be the cause of increased sediment loads in adjacent streams. Both improved techniques for logging and road building and improved awareness of the problem has markedly reduced the sediment loads contributed by silvicultural operations. However, there is now no universal equation which would allow us to predict what increase in sedimentation, if any, a given operation would produce. At the same time it has been shown that when specific practices are avoided or others are included, the aquatic habitat need not suffer irreparable harm and water quality standards related to specific uses may be maintained. Faced with the extreme variability of inorganic material loads in natural systems, it seems that standards of silvicultural and grazing practices must be set and monitored rather than direct water quality standards in areas or activities considered as probable non-point sources of pollution.

REFERENCES


Presented April 15, 1976 by LOGAN A. NORRIS, Forestry Sciences Laboratory, U. S. Department of Agriculture, Corvallis, Oregon. (Paper co-authored by Duane G. Moore of the Forestry Sciences Laboratory.)

Forests and Rangelands as Sources of Chemical Pollutants

Technological revolution in American agriculture has produced a 35 percent increase in farm output with a 45 percent reduction in farm labor despite an 11 percent reduction in cropland acreage since 1940 (Barton, 1966). Forestry technology must undergo a similar revolution to provide the products and services the Nation demands from our forests and rangelands. Our past preoccupation with projected needs of the Nation for wood fiber obscured the increasing demands for forage, water, wildlife, and areas for purely recreational purposes. All these needs must be satisfied, so we must compensate for our decreasing production base for wood products by markedly increasing the productivity of each acre of forest land devoted primarily to timber production.

Chemicals have played an important role in the success story of modern American agriculture. These same tools -- fertilizers, insecticides, and a host of other pest control agents -- are equally important in meeting our timber needs. The widespread use of chemicals, however, cannot proceed without adequate consideration of their possible impact on environmental quality. We must know in advance the consequence or hazard from each practice involving the use of chemical tools.

The hazard of using an herbicide is the risk of adverse effects on nontarget organisms. Two factors determine the degree of hazard: (1) the toxicity of the chemical and (2) the likelihood that nontarget organisms will be exposed to toxic doses. Toxicity alone does not make a chemical hazardous. The hazard comes from exposure to toxic doses of that chemical. Even the most toxic chemicals pose no hazard if organisms are not exposed to them. Therefore, an adequate assessment of the hazard from the use of any chemical requires consideration of both the likelihood of exposure and the toxicity of the chemical (Norris, 1971).

\[\text{1 A toxic effect is not restricted to lethality. Any adverse effect is a toxic effect.}\]
CONCEPT OF CHEMICAL ACTION

Chemical action is the direct effect of a chemical on an organism. Chemical action on any organism requires that exposure occurs and the chemical be present at the site of action in an active form in sufficient quantity and for a sufficient period of time to produce a toxic effect.

Toxicity

There are two kinds of toxicity: acute and chronic. Acute toxicity is the fairly rapid response of organisms to a few, relatively large doses of chemical administered over a short period of time. Chronic toxicity is the slow or delayed response or organisms to the exposure of relatively small doses of chemical administered over a relatively long period of time. There are various gradations between these two extremes. The kind of response (acute or chronic) observed in an organism depends on the magnitude of the dose and the duration of the exposure which results from the behavior of the chemical.

Potential for Exposure

The initial distribution of a chemical and its subsequent movement, persistence, and fate in the environment determines the potential for exposure. The laws of physics, chemistry, and biology direct an interaction between the properties of chemicals and the properties of the environment to produce chemical behavior (see Figure 1). The resulting quantities of a chemical in various parts of the environment at various times determine the duration and magnitude of exposure of different organisms to a chemical. The impact of chemicals on target and nontarget organisms and the selective action of chemicals depend on this exposure.

Figure 1. The interaction of chemicals with the environment.
Initial Distribution of Spray Materials

Aerially applied chemicals will be distributed to four major portions of the environment: air, vegetation, forest floor, and water. The amount of chemical entering each portion of the environment will be determined by the chemical used and the environmental conditions which prevail at the time of application (Norris, 1967).

Some spray material will be dispersed by the wind as fine droplets called "drift". The degree of lateral movement of spray drift depends on droplet size, height of release, and wind velocity (see Figure 2) (Reimer, et al., 1966). Additional amounts of chemical may remain in the air due to volatilization of spray materials while falling through the air or from intercepting surfaces. Most of the herbicide not lost through drift or volatilization is intercepted by the vegetation or the forest floor. Some small amount of pesticide may fall directly on surface waters.

![Lateral Movement Diagram](image)

Figure 2. Lateral movement of spray particles of various diameters falling at terminal velocity in an 8 km/hr crosswind. (5 mph = 8 km/hr; 1 ft = 0.3048 m)
Movement, Persistence, and Fate of Pesticides in the Forest Environment

The movement of pesticides includes movement within a given part of the environment such as leaching in the soil profile or movement from one part of the environment to another such as the rain washing of pesticide residues from leaf surfaces to the forest floor. Persistence is the tendency for pesticides to remain in an unaltered form. The fate of pesticides concerns the chemical pathway of pesticide degradation. The following section in this paper considers the movement, persistence, and fate of chemicals in various parts of the forest environment.

Air:

Losses of herbicides and insecticides to the air may be appreciable, but there is little quantitative data. During one test in western Oregon, for instance, from 20 percent to 75 percent of certain herbicides did not reach the ground, but these results are confounded by the presence of nearby overstory vegetation.\(^2\)

Norris, Montgomery, and Warren (1976)\(^3\) report 70 percent to 90 percent recovery of 2,4-D and picloram, respectively, at first intercepting surfaces after helicopter application in southern Oregon. Chemical dispersed in the air is mostly moved to other locations where it may settle to the earth, be washed out with rain, or be taken up by plants and other organisms. Degradation in the air is also possible (Moilanen, et al., 1975).

Vegetation:

The amount of pesticides intercepted by vegetation depends on the rate of application and the density of vegetation. There is limited absorption and very little translocation of many pesticides intercepted by foliage. Through the action of rain, much of the unabsorbed pesticide will be washed from the surface of the leaf. Pesticide remaining on the leaf surface and any pesticide not translocated to other plant parts will also enter the environment of the forest floor due to leaf fall.

Pesticides retained by the plant may be excreted back into the environment through the roots or they may end up in some plant storage tissue to be released at a later time. Through metabolic activities, plants may degrade a pesticide to nonbiologically active substances.

Studies with herbicides show the highest concentrations occurring in foliage shortly after application (see Table I) (Morton, et al., 1967; Getz-endaner, et al., 1969). A combination of factors causes the concentration to

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\(^2\) Unpublished data. M. Newton, L. A. Norris, and J. Zavitkovski, School of Forestry, Oregon State University, Corvallis.

\(^3\) This publication does not contain recommendations for pesticide use nor does it imply that the uses discussed here have been registered. All uses must be registered by appropriate State and/or Federal agencies before recommendation.
decrease rapidly with time. Growth dilution, weather, and metabolism of the herbicide by the plants are particularly important.

### Table 1. Residues of Herbicide in Forage Grass

<table>
<thead>
<tr>
<th>Time after treatment (weeks)</th>
<th>2,4-D</th>
<th>2,4,5-T</th>
<th>Picloram</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>100</td>
<td>135</td>
</tr>
<tr>
<td>1</td>
<td>60</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>52</td>
<td>--</td>
<td>--</td>
<td>3</td>
</tr>
</tbody>
</table>

1. Rate of application - 1.12 kg/ha.
2. Data from Figure 4, Morton, et al., 1967.
3. Data from Table 5, Getzendaner, et al., 1969.

The forest floor is a major receptor of aerially applied spray materials. Pesticides in the forest floor may be volatilized and re-enter the air, absorbed on soil mineral or organic matter, leached through the soil profile by water, or degraded by chemical or biological means. Volatilization of chemicals from the soil surface may be responsible for the loss of fairly large amounts of some pesticides such as DDT and perhaps some phenoxy esters.

The length of time chemicals persist in forest floor and soil bears strongly on the probability they will contaminate the aquatic environment. Pesticide degradation is usually biological, but chemical degradation is important in the loss of amitrole and the organophosphate insecticides.

The common brush control herbicides 2,4-D, amitrole, 2,4,5-T, and picloram are all degraded in the forest floor although their rates of degradation vary considerably (see Figure 3). In red alder (Alnus rubra) forest floor material, 80 percent of the amitrole and 94 percent of the 2,4-D were degraded in 35 days, but 120 days were required to degrade 87 percent of the 2,4,5-T. Picloram degradation was slow, 35 percent in 180 days (Norris, 1970).

Adsorption and leaching are processes which work in opposition to one another. Adsorbed molecules are not available for leaching, but adsorption is not permanent. The amount of pesticide which is adsorbed is in equilibrium with the amount of pesticide in the soil solution (see Figure 4). As the concentration of pesticide in the soil solution decreases, more pesticide will
be released from adsorption sites. Thus, adsorption provides only temporary storage, and the soil is, in effect, a reservoir of chemicals which will eventually be released. Leaching is a slow process capable of moving pesticides only short distances (Harris, 1967, 1968). Herbicides are generally more mobile in soil than insecticides, but mobility is relative, and even the movement of herbicides is measured in terms only of inches or a few feet.

![Figure 3. Recovery of 2,4-D, amitrole, 2,4,5-T, and picloram from red alder forest floor material (Norris, 1970).](image)

\[
\text{CHEMICAL + ADSORBENT} \xrightleftharpoons[k_2]{k_1} \text{CHEMICAL : ADSORBENT}
\]

![Figure 4. Chemical adsorption on soil is an equilibrium reaction.](image)
Surface Waters

Degradation of environmental quality in the forest is often first recognized by changes in stream quality. Stream contamination is also a most important expression of environmental contamination in the forest because water is both the habitat for many biological communities and a critical commodity to downstream water users.

Pesticides may enter streams by several processes. The direct application or drift to surface waters will occur for only a short period of time but may cause high concentrations of pollutant. Pesticides may also enter streams in rainfall which washes particulate and vapor forms from the air or from leaves. Pesticides may move to streams by leaching through the soil profile or in mass overland flow during periods of intense precipitation.

FOREST STREAM CONTAMINATION BY HERBICIDES IN OREGON

Stream contamination by herbicides is a subject which intensely interests the public. Herbicides are the most commonly used group of pesticides in this forest region, and managers can greatly influence the amount of herbicide which enters streams near spray areas.

Direct Application or Drift of Herbicides to Oregon Streams

I have looked for herbicides in streams after regularly scheduled spray projects on forests and rangelands in Oregon. The following examples illustrate several important points about minimizing stream residues (Norris, 1967). You can best study these examples by observing the location of treatment unit boundaries, streams, and sampling points. Note in particular when the peak concentrations of herbicide occurred and how long residues persisted.

About 26 ha of 400-ha Cascade Creek Watershed (western Oregon) were sprayed with low volatile esters of 2,4,5-T, 2.24 kg/ha, in March by helicopter (see Figure 5).

Figure 5. The Cascade Creek and Eddyville Watersheds treatment areas (1 mile = 1.6 km).
A small stream was sampled at point 1 from a 2-ha watershed which was completely sprayed. Streams sampled at points 2 and 3 did not enter but ran adjacent to the treated area. Herbicide residues were measured by gas chromatography in samples collected at these points (see Table 2).

Table 2. Concentration of 2,4,5-T in Cascade Creek

<table>
<thead>
<tr>
<th>Sample Point 1</th>
<th>Sample Point 2</th>
<th>Sample Point 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours after spraying</td>
<td>2,4,5-T (ppb)</td>
<td>Hours after spraying</td>
</tr>
<tr>
<td>0.05</td>
<td>0</td>
<td>0.2</td>
</tr>
<tr>
<td>.6</td>
<td>16</td>
<td>1.3</td>
</tr>
<tr>
<td>1.3</td>
<td>7</td>
<td>2.2</td>
</tr>
<tr>
<td>2.0</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>4.0</td>
<td>4</td>
<td>5.4</td>
</tr>
<tr>
<td>9.8</td>
<td>4</td>
<td>24.7</td>
</tr>
<tr>
<td>48.2</td>
<td>1</td>
<td>74.8</td>
</tr>
</tbody>
</table>

1 Rate of application - 2.24 kg/ha.
2 Herbicide residues were detected at point 1 up to 16 weeks after spraying.
3 No further residues were detected although sampling continued for 10 months.

The drainage basin at point 1 was characterized by a large slump and marshy area which indicated a high water table. The highest concentrations occurred shortly after application started, but low concentrations were found up to 16 weeks later. At points 2 and 3, only low levels of herbicide were found, and these persisted for less than 1 day. Data from points 2 and 3 reflect the small area of the watershed treated as well as the location of the treatment unit boundaries with respect to the sampled stream.

The Eddyville Watershed in western Oregon was treated with low volatile esters of 2,4-D at the same time as the Cascade Creek Watershed (see Figure 5). Several streams were included in the 28 treated hectares.

Higher concentrations of herbicide were found in the Eddyville streams than in Cascade Creek (see Table 3). This is attributed to a slightly higher rate of herbicide application, a larger proportion of the watershed being treated, and, most importantly, the fact that all of the sampled streams flowed from or through the treated area. The highest concentrations of herbicide were found shortly after application. Residue levels declined rapidly with time.
Table 3. Concentration of 2,4-D in Streams Near Eddyville

<table>
<thead>
<tr>
<th>Sample Point 4</th>
<th>Sample Point 5</th>
<th>Sample Point 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours after spraying</td>
<td>2,4,5-T (ppb)</td>
<td>Hours after spraying</td>
</tr>
<tr>
<td>0.8</td>
<td>33</td>
<td>1.3</td>
</tr>
<tr>
<td>1.8</td>
<td>13</td>
<td>2.3</td>
</tr>
<tr>
<td>2.8</td>
<td>13</td>
<td>3.3</td>
</tr>
<tr>
<td>53.5&lt;sup&gt;2&lt;/sup&gt;</td>
<td>9</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>53.6&lt;sup&gt;2&lt;/sup&gt;</td>
<td>25</td>
</tr>
</tbody>
</table>

<sup>1</sup> Rate of application - 2.5 - 3.36 kg/ha.
<sup>2</sup> No further residues were detected although sampling continued for 10 months.

Other studies have been carried out on the Malheur National Forest in eastern Oregon (Norris, 1967). The treatment areas examined in eastern Oregon were generally larger than those in western Oregon, although the distance between units was greater. The spray units in eastern Oregon were treated by helicopter with 2,4-D low volatile esters in early June.

The West Myrtle treatment area is a fairly typical eastern Oregon spray project (see Figure 6). It contained nearly 480 treated hectares in one block. Live streams were included in the treatment area. Herbicide residues were measured near the downstream end of the unit and at another point about 1.6 km downstream. The concentrations of herbicide were higher than those encountered in Cascade Creek in western Oregon but similar to those in the Eddyville treatment area which also included live streams (see Table 4).

The point that needs to be emphasized is that the magnitude of this short term contamination is not a function of the herbicide or the geographical location in which it is used. It is closely related to the manner in which the treatment area is laid out with respect to live streams. Data from the Camp Creek spray unit in eastern Oregon illustrate these points. The Camp Creek unit resembled situations frequently encountered in western Oregon because the spray boundaries were close to, but did not include live streams (see Figure 6). The concentrations of herbicide in Camp Creek after spraying were low and persisted for only a short time (see Table 5).

The Keeney-Clark spray unit (88 ha) in eastern Oregon illustrates a particular type of problem. This unit is a fairly flat, marshy area which contains several small live streams (see Figure 7). Standing water was noted in several areas at the time of treatment which suggested a high water table.
Figure 6. West Myrtle and Camp Creek treatment areas (1 mile = 1.6 km).

Table 4. Concentration of 2,4-D in Myrtle Creek

<table>
<thead>
<tr>
<th>Sample Point 1</th>
<th>Sample Point 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours after spraying</td>
<td>2,4-D (ppb)</td>
</tr>
<tr>
<td>1.7</td>
<td>132</td>
</tr>
<tr>
<td>3.7</td>
<td>61</td>
</tr>
<tr>
<td>4.7</td>
<td>85</td>
</tr>
<tr>
<td>6.0</td>
<td>10</td>
</tr>
<tr>
<td>7.0</td>
<td>26</td>
</tr>
<tr>
<td>8.0</td>
<td>75</td>
</tr>
<tr>
<td>9.0</td>
<td>59</td>
</tr>
<tr>
<td>13.9</td>
<td>51</td>
</tr>
<tr>
<td>26.9</td>
<td>3</td>
</tr>
<tr>
<td>37.9</td>
<td>9</td>
</tr>
<tr>
<td>78.0</td>
<td>8</td>
</tr>
<tr>
<td>80.8</td>
<td>1</td>
</tr>
<tr>
<td>1 week</td>
<td>T</td>
</tr>
</tbody>
</table>

1 Rate of application - 2.24 kg/ha.

2 Sample point 2 is 1.6 km downstream from sample point 1.
Table 5. Concentration of 2,4-D in Camp Creek

<table>
<thead>
<tr>
<th>Hours after spraying</th>
<th>2,4-D (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>T</td>
</tr>
<tr>
<td>2.0</td>
<td>25</td>
</tr>
<tr>
<td>5.4</td>
<td>1</td>
</tr>
<tr>
<td>8.8</td>
<td>1</td>
</tr>
<tr>
<td>84.5</td>
<td>3</td>
</tr>
<tr>
<td>1 week</td>
<td>0</td>
</tr>
</tbody>
</table>

1 Rate of application - 2.24 kg/ha.

Figure 7. Keeney-Clark Meadows treatment area
(1 mile = 1.6 km).

High concentrations of herbicide were found shortly after application (see Table 6). The long persistence of fairly high concentrations of herbicide is characteristic of what would be expected from treating areas of this type. The length of time measurable concentrations flowed from this area is unknown. This particular situation is probably one of the most
dangerous in terms of potential stream contamination. A slight rise in the water table could result in the release of large quantities of herbicide to the streams which drain this area.

Table 6. Concentration of 2,4-D in Streams in Keeney-Clark Meadows

<table>
<thead>
<tr>
<th>Hours after spraying</th>
<th>2,4-D (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7</td>
<td>840</td>
</tr>
<tr>
<td>2.5</td>
<td>48</td>
</tr>
<tr>
<td>3.1</td>
<td>128</td>
</tr>
<tr>
<td>3.6</td>
<td>106</td>
</tr>
<tr>
<td>4.1</td>
<td>106</td>
</tr>
<tr>
<td>6.1</td>
<td>121</td>
</tr>
<tr>
<td>8.1</td>
<td>176</td>
</tr>
<tr>
<td>9.6</td>
<td>138</td>
</tr>
<tr>
<td>14.3</td>
<td>113</td>
</tr>
<tr>
<td>37.8</td>
<td>91</td>
</tr>
<tr>
<td>56.4</td>
<td>76</td>
</tr>
<tr>
<td>100.1</td>
<td>115</td>
</tr>
<tr>
<td>103.6</td>
<td>95</td>
</tr>
<tr>
<td>289.9</td>
<td>5</td>
</tr>
<tr>
<td>297.0</td>
<td>7</td>
</tr>
</tbody>
</table>

1 Rate of application - 2.24 kg/ha.

I want to stress one point based on the data presented. Short-term, high-level contamination results from direct application of herbicide to the water surface. This can be reduced markedly by excluding streams from treatment areas. In other words, if you do not want it in the water, then don’t put it there.

Movement of Chemicals from Treated Areas to Streams

The forest floor is a large reservoir of potential stream pollutants. Any amount of herbicide that has not been degraded, volatilized, or absorbed is available for leaching or surface runoff.

The mechanism by which chemicals are moved from spray deposit to a stream may be visualized as two competing reactions: leaching and surface runoff. Rainfall that is not lost through evaporation either enters the soil
profile or runs over the surface. In either case, it carries surface deposited chemicals either in solution or as suspended matter. The greater the proportion of water entering the soil profile, the lower the proportion of water available for surface flow. In general, where the water goes the chemical also goes but not as fast. There are numerous factors which influence the distribution of water between surface flow and infiltration:

1. Nature of surface
   a. Amount of surface organic matter
   b. Slope
   c. Depth of soil profile
   d. Infiltration characteristics of soil
   e. Immediate previous precipitation history

2. Nature of precipitation
   a. Intensity
   b. Duration
   c. Form

Factors which favor infiltration will decrease the amount of surface runoff occurring and with it the overland flow of chemical. These factors influence the amount of herbicide entering the stream due to surface flow:

1. Distance from stream course to closest point of herbicide application.
2. Infiltration properties of soil or forest floor.
3. Rate of surface flow.
4. Adsorptive characteristics of surface materials.

Conditions which retard the rate of discharge of surface flow to the stream will result in a decrease in the immediate level of contamination. It will also reduce the long term total stream load of herbicide because a longer residence time in the soil will provide greater opportunity for degradation of herbicide.

Surface flow or mass overland flow has the potential to carry a lot of chemical over a long distance in a short time. However, hydrologists say overland flow of this type seldom occurs on western forest lands because the infiltration capacity of the forest floor and soil is much larger than most rates of precipitation. Therefore, most pesticide residues enter the soil where absorption will prevent their rapid or extensive movement.

Leaching is a slow process capable of moving only small amounts of herbicide short distances. It offers little potential for serious stream pollution because the herbicide is available for degradation for a long period of time before sufficient movement would occur to permit release to a stream.
Norris (1967, 1968) looked for the long term entry of 2,4-D and 2,4,5-T into forest streams draining areas receiving these herbicides. In one case, 11 streams in western Oregon were monitored immediately below treatment areas on a regular basis for 9 months after application. In all cases, once the initial stream contamination had declined to nondetectable limits (0.001 mg/l in 3 to 72 hours), no further herbicide residues were detected. In a second case, two other watersheds in western Oregon were studied. In one, the treatment area bordered a stream for more than 3 km extending from 200 to 400 m upslope from the stream. 2,4-D and 2,4,5-T were applied at 1.12 kg/ha acid equivalent (ae) each as low volatile esters in oil in the spring. The second area had 25 different treatment areas totaling 160-ha in an 1135-ha watershed which received the same treatment. In both cases, during the first storms of the fall which raised stream levels, streams were sampled to detect the movement of herbicide from treated areas to the stream, but no residues were found.

FERTILIZERS

Fertilization of forested watersheds is a relatively new but rapidly growing management practice. Operational forest fertilization began in the Douglas-fir region of the Pacific Northwest in 1965 and in the southeastern pine region in 1968. Nearly 300,000 ha of Douglas-fir have now been fertilized in western Oregon and Washington and soon an additional 100,000 ha or more will be fertilized each year.

In the Pacific Northwest, the major coniferous commercial timber types have responded only to additions of nitrogen. As growth response has not been influenced by form of nitrogen, granular urea (46% N), being a high analysis source well adapted to aerial application, is therefore the nitrogen carrier of choice. In the southeast, both nitrogen and phosphorus fertilizers are applied to forest stands by conventional ground equipment or helicopter.

Many concepts concerning the initial distribution of pesticides apply also to fertilizers, but there are some important exceptions. Rate of application of fertilizer varies with site and timber type but is usually 168 or 224 kg of urea nitrogen per ha. In contrast with pesticides, where significant quantities may remain in the atmosphere, essentially all of the fertilizer applied reaches the intended target. However, because of the higher rates of application, it is necessary to make at least two flights over the unit and a uniform rate of application over an entire unit is difficult to obtain (Strand, 1970).

The introduction of large, specially coated urea granules (forest grade) has eliminated drift problems experienced in early applications due to dust. Drift problems still exist, however, when standard agricultural urea (45% N) is used, or when experimental liquid formulations of nitrogen are substituted for the forest (granules. Should liquid fertilizer formulations come into commercial use, their initial distribution in the environment will be subject to the same factors controlling distribution of aerially applied pesticides.

Because very little granular fertilizer is intercepted by a dry forest canopy, the forest floor is the major receptor. The initial distribution of fertilizers is thus restricted to the forest floor and to exposed surface waters within the treated areas.
Urea fertilizer is highly water soluble and readily moved into the forest floor and soil by any appreciable amount of precipitation. Under normal conditions, urea is also rapidly hydrolyzed (4-7 days) to the ammonium ion by the enzyme urease. When moisture is limited, however, urea granules may be slowly hydrolyzed on the forest floor resulting in a marked increase in surface pH and a loss of ammonia nitrogen by volatilization. In a laboratory study, Watkins and Strand (1970) measured losses of ammonia nitrogen ranging from 6 percent to 46 percent of the urea nitrogen applied to forest floor and soil depending on the nature of the surface, surface pH, and rate of air flow across the surface. Although some applied nitrogen is undoubtedly lost by volatilization in the field, it is generally conceded that such losses are small. Time of application is important, and forest fertilization projects are usually conducted during the spring or fall months to take advantage of precipitation. Urea nitrogen is quickly distributed throughout the living complex, becomes a part of the nutrient budget, and is cycled within the ecosystem.

Fertilizer nitrogen may enter the aquatic environment by one of several routes. The greatest potential source is direct application to exposed surface water. This can be minimized by carefully marking and avoiding larger streams during applications, but most applicators find it impractical to avoid small headwater streams. The size of stream which should be avoided has been suggested, but standards have not been established. Ammonia nitrogen volatilized from the forest floor may be absorbed from the air by exposed surface water, but it is doubtful that this source adds significant amounts to streams.

Overland flow, or surface runoff, is a major source of nutrients in streams of many areas but is not important in the Pacific Northwest where surface runoff rarely occurs. Subsurface drainage is another possible route of entry of soluble forms of nitrogen into streams. Forest soils are excellent filters for most plant nutrients because of their high exchange capacities and the dense root systems which can absorb and recycle nutrients (Moore, 1970a). However, measurable levels of ammonia-, nitrate-, urea-, and organic-nitrogen are found in several streams being monitored for water quality in western Oregon and Washington.

There is an enormous literature concerning the effects of farm fertilization on water quality but essentially none concerning the effects of forest fertilization. Soileau's (1969) extensive bibliography (701 entries) on effects of fertilizers on water quality contains no references on effects of forest fertilization.

Several forest fertilization projects have been monitored recently in the Pacific Northwest. Moore (1970b) measured the amounts and forms of nitrogen entering streams during and following aerial application of 224 kg/ha of urea nitrogen to an experimental watershed in southwestern Oregon in March 1970 (see Figure 8). Data obtained during the first 15 weeks after application are summarized in Tables 7 and 8. Urea concentrations increased slowly and reached a maximum of .39 mg/kg urea-N 48 hours after application started. Ammonia-N increased slightly above background but never reached 0.10 mg/kg. Nitrate-N began to increase slowly the second day, reached 0.168 mg/kg in 72 hours and was 0.140 mg/kg at the end of 2 weeks. Nitrite-N was not detected. Only 0.01 percent of the nitrogen applied to the watershed was found in the stream up to 15 weeks after application. About 40 percent of the nitrogen
which did enter the stream was in the urea form while 50% entered as nitrate nitrogen, presumably after hydrolysis and nitrification of the urea.

Figure 8. Coyote Creek Watersheds, South Umpqua National Forest, Oregon (Moore, 1970b) (1 mile - 1.6 km).
Table 7. Concentrations of Fertilizer Nitrogen in Selected Water Samples Collected at Coyote Creek Watershed 2, Following Application of 225 kg urea-N/ha. (ppm)

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Urea-N</th>
<th>NH₃-N</th>
<th>NO₃-N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/25</td>
<td>0800</td>
<td>.007</td>
<td>.001</td>
<td>.002</td>
<td>.010</td>
</tr>
<tr>
<td>3/26</td>
<td>0815</td>
<td>.437</td>
<td>.016</td>
<td>.040</td>
<td>.493</td>
</tr>
<tr>
<td></td>
<td>1230</td>
<td>.237</td>
<td>.012</td>
<td>.069</td>
<td>.318</td>
</tr>
<tr>
<td></td>
<td>2025</td>
<td>.171</td>
<td>.034</td>
<td>.067</td>
<td>.272</td>
</tr>
<tr>
<td>3/27</td>
<td>0805</td>
<td>1.389</td>
<td>.048</td>
<td>.107</td>
<td>1.544</td>
</tr>
<tr>
<td></td>
<td>1640</td>
<td>.606</td>
<td>.036</td>
<td>.150</td>
<td>.792</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>.488</td>
<td>.029</td>
<td>.168</td>
<td>.685</td>
</tr>
<tr>
<td>3/28</td>
<td>0805</td>
<td>.075</td>
<td>.036</td>
<td>.117</td>
<td>.228</td>
</tr>
<tr>
<td>4/ 1</td>
<td>--</td>
<td>.007</td>
<td>.016</td>
<td>.092</td>
<td>.185</td>
</tr>
<tr>
<td>4/ 8</td>
<td>--</td>
<td>.028</td>
<td>.015</td>
<td>.140</td>
<td>.183</td>
</tr>
<tr>
<td>4/15</td>
<td>--</td>
<td>0</td>
<td>.010</td>
<td>.030</td>
<td>.040</td>
</tr>
<tr>
<td>4/22</td>
<td>--</td>
<td>0</td>
<td>.010</td>
<td>.021</td>
<td>.031</td>
</tr>
<tr>
<td>5/ 6</td>
<td>--</td>
<td>0</td>
<td>.013</td>
<td>.022</td>
<td>.035</td>
</tr>
<tr>
<td>5/27</td>
<td>--</td>
<td>--</td>
<td>0</td>
<td>.004</td>
<td>.004</td>
</tr>
<tr>
<td>6/17</td>
<td>--</td>
<td>--</td>
<td>0</td>
<td>.002</td>
<td>.002</td>
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<tr>
<td>7/ 8</td>
<td>--</td>
<td>--</td>
<td>0</td>
<td>.006</td>
<td>.006</td>
</tr>
</tbody>
</table>

Table 8. Nitrogen Lost from Treated (WS-2) and Untreated (WS-4) Watersheds, South Umpqua Experimental Forest, During First 15 Weeks after Application of 225 kg urea-N/ha (pounds N)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Urea-N</th>
<th>NH₃-N</th>
<th>NO₃-N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS-2</td>
<td>1.423</td>
<td>0.600</td>
<td>1.904</td>
<td>3.927</td>
</tr>
<tr>
<td>WS-4</td>
<td>0.049</td>
<td>0.135</td>
<td>0.038</td>
<td>0.222</td>
</tr>
<tr>
<td>Net loss</td>
<td>1.374</td>
<td>0.465</td>
<td>1.866</td>
<td>3.705</td>
</tr>
</tbody>
</table>

Percent of Total: 37.1 12.5 50.4
We don't know if these preliminary data are representative of what can be expected whenever any forested watershed is fertilized. However, comparable concentrations of urea-, ammonia-, and nitrate-nitrogen have been found in other monitoring studies in this region. Nitrite nitrogen is not expected to occur in the well-aerated streams of the Pacific Northwest.

Thut and Haydu (1971) reviewed the effects of forest chemicals on aquatic life and concluded the concentrations of urea fertilizer and its breakdown products are well below toxic thresholds for aquatic life. In some cases, at least, they feel forest fertilization may have a beneficial effect on forest stream productivity.

Research experience and long history of use have established that our important forest chemicals offer minimum potential for pollution of the environment when they are used properly. The key to proper use is an adequate appreciation for the mechanisms by which chemicals behave and thorough understanding of the factors which influence the degree to which these mechanisms operate.

LITERATURE CITED


Note: Dr. Norris is project leader and principal chemist and Dr. Moore is research soil scientist for Research Work Unit 1653 in the Pacific Northwest Forest and Range Experiment Station, USDA Forest Service. RWU 1653 is concerned with the behavior and impact of introduced chemicals in the forest environment and is located at the Forestry Sciences Laboratory in Corvallis, Oregon.
This is a timely series of seminars, informative and useful; hence, I'm pleased to participate in it. I'll confess that it would have been more comfortable and entertaining, if personally less educational, had you let me remain in the audience rather than be up here at the lecturn. Be that as it may, several colleagues with considerable experience on erosion, runoff, water quality studies have generously shared their information resources for our benefit. So much have they offered, in fact, that it has been a real struggle to sort out what might best serve our purposes here today.

At the outset, let me emphasize that except for some local Oregon scenes at the end, most of the slides we'll see and their interpretations are material borrowed from several sources (identified at appropriate place in text). Moreover, much of the information, including the maps in the first series of slides, is printed in the booklet, Control of Water Pollution from Cropland, Volume I, by Stewart, et. al. (1975). A few copies for distribution to those people who have rather urgent need will be here on the table after this talk. For others, a copy of the report's cover sheet is attached with address information for requesting single gratis copies from either ARS of USDA, or EPA. For seminar participants with pressing concern about erosion problems and control of potential pollutants in runoff from cropland, discovering that report alone may be worth your attending today. A related booklet called ACTMO, Agricultural Chemical Transport Model (Frere, et. al, 1975), should also be of interest (copies available here after the seminar).

As you listen, please remember that I am a relatively new and part-time initiate to the jargon and attempted evaluation of hydrologic cycles, weather guesstimating, cropland runoff, and pollutants from agricultural watersheds. As a novice I'll skirt around some of the quicksand of definitions except to say that the "experts" do not yet agree; meanwhile the sticky issues involved apparently are providing a pretty fair living for many legal minds who continue to wrestle endlessly with nonpoint vs. point pollution terms.

You may recall that just a year ago, Bill Clothier from EPA's Region X Non-point Source office said to one of these seminars that to his knowledge there still was no clear, precise, or consistent definition of what nonpoint
pollution is (2). However, Althestan Spilhaus (who visited campus last week and was quoted in the campus newspaper) offered a general definition of "pollution" that should clarify everything for us; i.e., "Pollution is an excess of anything in the environment, but not complete purity." What chance would a citizen have to get a judgment against a polluter using such definitive standards? But that aside, we should remember that trying to write rules/laws for so great a range of conditions as encountered across the face of our country is no easy task. We should know also that subsequent to Mr. Cannon's talk in the first seminar this quarter, new information has appeared in the form of proposed rules and regulations for Agricultural Activities under the NPDES (National Pollutant Discharge Elimination System) as submitted by EPA Administrator, Russell E. Train, dated February 17, 1976, and printed in the Federal Register Vol. 41, N. 36--Monday, February 23, 1976.

The proposed rules try to satisfy critics who insisted that EPA develop factors that would distinguish point sources from nonpoint sources and which would designate most discharges from agricultural activities as nonpoint in nature and thus not subject to the permit program. The intent of the regulations is said to be just that "...to exclude from the NPDES permit program all natural runoff from agricultural land which results from precipitation events." The attempted clarifications apparently apply primarily to irrigation flow ditches and the source of the water flowing into and from them. "When the water pollution from irrigation ditches results from precipitation events, that pollution is nonpoint in nature." If the water is controlled and applied by man, any pollution in the runoff becomes point source in origin and requires a discharge permit, even though the same furrows and collection ditches are involved in both cases. The fact that the water originated from natural causes, i.e., rain, and was not introduced to the land by man is critical. (Your guess is as good as anyone's as to whether the pollution is point or nonpoint in origin when irrigation water and rainwater fall at the same time.) A last quote from the proposed rules helps a little. In elaborating on the nature of nonpoint sources, the EPA draft states that nonpoint sources tend to be characterized by three elements:

First, the pollutants are conveyed by water the source of which is uncontrolled by any person; that is the water pollution results from precipitation, natural flooding or snowmelt. Second, the pollution itself is not traceable to a discrete, identifiable source such as a facility or industrial process. ...Third, the control of nonpoint source water pollution is generally best achieved by planning and management techniques rather than by end-of-pipe treatment to remove pollutants.

Now, because of these new distinctions, the considerable amount of material one colleague sent me to share with you has mostly been deleted because the data pertain to point site outflows from large irrigation tracts; it now seems that they may not fit under the nonpoint source pollutants from cropland definition. Part of the information will be mentioned briefly, since it is some of the better data currently available for the Western U. S.

At this point let's turn on the projector and rather quickly view some slides of material from the booklet on Control of Water Pollution from Cropland (Stewart et. al., 1975). (For Reader reference, figure and page numbers for the maps from this ARS-H-5-1 Report are given in parentheses.)
General Overview of U. S. Cropland

The slides give a good general overview of the distribution of cropland in the U. S. in relation to Total Land Resource Area (TLRA) and in relation to distribution of major crops--both of which have considerable bearing on potential erosion and the kind of runoff carrying "pollutants" from the fields. These crop and cropland distributions are viewed against the backdrop of precipitation patterns and of simulated estimates of "potential direct runoff" for various areas of the country.

--The first map, prepared by SCS personnel, delineates Land Resource Regions and Major Land Resource Areas (Fig. 2, p. 6). Region A, for example, is designated the Northwestern Forest, Forage, and Specialty Crop Region. Within that region are 5 subunits--for example, number 2 being the Willamette and the Puget Sound Valleys; number 5 being the Siskiyou, Trinity Area. There are 156 areas within the 20 regions. (The area outlines show more clearly on several maps to follow.)

--The next map shows "Croplands as percentages of total land resource areas" (Fig. 6, p. 12). One almanac stated there were 300 million acres of harvested crops in 1972. Our reference lists cropland acres in the U. S. as nearer 438 million. Note that more than 50% of the total land area in the North Central "cornbelt", "breadbasket" states still survives as cropland.

--For comparison, the next map shows "Rangelands as percentages of total land resource areas"; this includes grazed forest areas (Fig. 8, p. 14). Commonly, their sparse vegetation is little protection against periodic intense storms. Hence, rapid runoff, though brief, sometimes causes severe erosion.

--The next map shows croplands where erosion is considered the dominant limitation for their agricultural use, again as percentages of the TLRA (Fig. 7, p. 13). Why these areas? Besides kind of soil material, topography, etc., the precipitation-temperature patterns, of course, have major influence. Note the moderate to high erosion hazard for the Columbia Basin-Plateau, and Palouse area. Note that no erosion hazard is shown for west of the Cascades, including the Willamette Valley.

--The next map shows "Average yearly potential direct runoff" (Fig. 3, p. 8). Note the map projects only 1 to 3 inches of direct runoff for much of the northern cornbelt; 3 to 7 inches from south central Texas northeast toward Pennsylvania; and >7 inches for most of the southern states from East Texas to the Atlantic. No estimates are shown for Pacific coastal states, but with 40 inches per year precipitation in valleys of western Oregon and Washington, >7 inches per year direct runoff would seem probable many years, judging from the frequent high water and roily rivers.

--The next map shows "Average growing season potential runoff" (Fig. 4, p. 9). For some regions this average may be more pertinent relative to bare ground exposure and erosion than would yearly...
potential direct runoff. Only a narrow zone along the Gulf Coast states is estimated to have >7 inches per year direct runoff during the growing season. Note the small amount of potential direct runoff in the Midwest, where erosion was said to be the dominant limitation to use of cropland.

--On the next slide let's see when the potential direct runoff generally occurs, (plotted as percentage distribution by 28-day intervals; assumed straight-row corn crop, Fig. 5, p. 10). Note that in the Central Plains, though the potential direct runoff is relatively small, it is concentrated in the April to June period, hard after the winter freezes. In the N.E. Plains states, the distribution is more broadly spread, i.e., from February to July, and more of it comes as heavy thunderstorms associated with spring/summer weather fronts. In the Southeast, the estimated 4 to >7 inches potential direct runoff is distributed more evenly through the whole year. Note how these patterns contrast with the Pacific Northwest where precipitation and runoff are sharply highest from November through February when crop cover on cultivated soils may be small to none.

--Coupling the "potential runoff estimates" with the "erosion hazard/susceptibility estimates" yielded Fig. 9 (p. 15), which shows "Relative potential contribution of cropland to sediment yields from watersheds". Note the high and very high potential in the cornbelt states. Obviously, where croplands are the predominant part of the total acreage, their contribution to sediment yield is likely to be high. Note also the high potential sediment yield from cropland in the Palouse region of Oregon, Washington, and Idaho.

The authors emphasize that these are, of course, simulated relative "potential" hazards and not current practice. There are large local differences in erosion hazard which do occur but which do not appear on the map (yet another note of caution). Prediction of gross erosion and planning suitable controls can be much more accurate on a field basis. And to aid in such planning, the authors have drawn on more than 40 years ARS erosion research which has identified major factors and determined numerical relationships of those factors to soil loss rates. The factors are embodied in what is widely known as the USLE, Universal Soil Loss Equation; the equation and factors are discussed in the manual from which the maps were taken (Stewart, et. al., 1975). Also included in the manual are planning and decision flow-charts for point-by-point, factor-by-factor judgment and control action.

Now why the big emphasis on sediment? Repeatedly, the reason given is that sediment is by volume the greatest single pollutant of surface waters. Additionally, sediment is the principal carrier of chemicals/nutrients, also usually regarded as pollutants. In some watersheds, sediment from nonagricultural sources exceeds that from cropland, and in regions of relatively low rainfall or sandy soils, wind erosion may exceed water erosion. Our interest here however is sediment/pollutants from cropland erosion largely in runoff from rainfall.
Although classified as nonpoint, most of a watershed's sediment may come from a few relatively small areas that need special attention. Likely sources usually are identifiable simply by observation. Conditions on cropland that indicate high sediment-yield potential include items listed on the next slide:

**HIGH SEDIMENT-YIELD POTENTIAL, Cropland**

1. Long slopes, no terraces or runoff diversions
2. Rows up and down moderate/steep slopes
3. No crop residues on surface after new seeding
4. No surface cover; harvest to new crop canopy
5. No vegetated buffer strip; field to stream
6. Runoff from upslope pasture/rangeland washing across cropland
7. Poor stands or poor quality of vegetation

Other sources with high sediment-yield potential are the familiar things listed on the next slide.

**OTHER SOURCES, HIGH SEDIMENT-YIELD POTENTIAL**

1. Gullies
2. Residential or commercial construction
3. Highway construction
4. Poorly managed range or wooded areas
5. Unstable streambanks
6. Unstable roadbanks
7. Surface/strip mine spoils
8. Noncropland barrens

But again, our assignment and interest here are the cropland sources. So let's take a quick look at major crop area distributions in the U. S.

**Areal Distribution of Major Crops Relative to Cropland**

These crops were selected because of their importance in terms of acreage, chemical use, or both. Sizeable increases in acreages of several crops have occurred since the 1969 census figures shown on the maps, but the general distribution is believed little changed.

--Corn (Fig 13, p. 28), shown as 60 million acres in 1969 was estimated at 64 million acres in 1974. Heaviest concentrations are, of course, in the cornbelt from Eastern Nebraska to Central Ohio. Try to visualize this pattern against the precipitation, direct runoff, and erosion hazard maps that we just saw.
--Sorghum (Fig. 14, p. 29) occupies more of the hotter, dryer areas from the tip of Texas through the panhandle and Kansas to S. E. Nebraska (about 15.5 million acres).

--Wheat (Fig. 15, p. 30) has much wider distribution from N.C. Texas, through Kansas, and S. W. Nebraska, to the Northern Plains states, and in the Columbia Plateau area of the Pacific N. W. The 45 million acres noted in 1969 increased to 64 million in 1974.

--Cotton areas (Fig. 16, p. 31) are concentrated in West Central and Gulf Coast parts of Texas and along the high runoff belt from the tip of Illinois south along the Mississippi.

--Soybeans (Fig. 17, p. 32) coincide with cotton areas along the Mississippi and with corn areas throughout the cornbelt. The estimated 38.5 million acres in 1969 increased to 52.3 million in 1974.

--Orchards (Fig. 18, p. 33) at 4.2 million acres are concentrated east of Lakes Michigan and Erie, in Northern Virginia, Georgia, Central Florida, and in central valleys of California and Washington.

--Vegetables (Fig. 19, p. 34) at 3.3 million acres are broadly scattered with large acreages in Wisconsin, New Jersey/East coast, Florida, tip of Texas, valleys of California, Oregon and Washington.

There are similar maps showing density of commercial animals as for example (Fig. 21, p. 39) for milk cows (others for cattle, pigs, chickens, etc.) From these, one can make interesting comparisons in relation to animal wastes as potential pollutants from diffuse source areas. Animal wastes have direct bearing on quality of runoff from croplands where animals forage over the fields and where residues from feed lots or barns are spread back on croplands. Since Dr. Willrich will be discussing livestock production and wastes as pollutant sources next week, little more will be said about that here.

Now, continuing controversies about use of fertilizers and pest-disease control chemicals merit a few words. Of course, the same physical, chemical principles governing sorption, temporary storage, movement, degradation, etc., and the same soil properties enumerated last week by Dr. Norris for forest and range soils also pertain to cultivated crop land soils. Several of the components may differ considerably in proportion (e.g., litter, humus content and distribution); however, the principles still apply. Since Dr. Norris' coverage was rather thorough, with emphasis on herbicide type chemicals, our consideration will be limited to a couple of maps showing crop acreages and general locations of herbicide use (Fig. 27, p. 46). The acreages shown need little comment, except to re-emphasize that these are 1969 data, and there may have been sizeable increases in herbicide use since then. Note the coincidence of herbicides use with acreages of the major crops like corn, soybeans, cotton, and wheat. Crop acreages and insecticide use (Fig. 28, p. 47) show similar patterns. Please recall that many, if not most, of these type chemicals show high affinity for and correlation with soil organic and clay content, which again relates to erodable particles in runoff.
Extent and Rate of Fertilizer Use

The next slide shows 1974 average rates of N and P fertilizer use on four major U. S. crops (p. 35)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres harvested (million)</th>
<th>Percent fertilized</th>
<th>Pounds/acre rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>Corn</td>
<td>63.7</td>
<td>94</td>
<td>87</td>
</tr>
<tr>
<td>Cotton</td>
<td>13.1</td>
<td>79</td>
<td>58</td>
</tr>
<tr>
<td>Soybeans</td>
<td>52.5</td>
<td>22</td>
<td>28</td>
</tr>
<tr>
<td>Wheat</td>
<td>64.1</td>
<td>66</td>
<td>46</td>
</tr>
</tbody>
</table>

Note the wide differences in percent of harvested acres that were treated for the different crops:

--most of the corn, and at higher rates of N;
--about 4/5 of the cotton received N and 3/5 received P;
--much less fertilizer used on soybeans, because they can fix their own N;
--about 2/3 of the wheat received N, less than 1/2 got P.

Some rates of fertilizer use, of course, are much higher; these are national averages. The important thing is how efficiently is the fertilizer N recovered and used by the plant, and what happens to the rest. It is well known that phosphorus fertilizer is usually sorbed quickly or, as some say, inactivated by reversion to less soluble and less plant-available forms. Once attached to soil particles, P moves little, except as particles are moved by external forces like cultivation, rain drop splash, and erosion.

Nitrogen is quite another story, depending on many factors, i.e., form applied, time of year, placement, solubility, moisture, temperature, oxygen level, redox potential, pH, organic residues, their carbon to nitrogen ratios, and yet others. In contrast to P, N fertilizer often is subject to loss -- more by denitrification/gaseous evolution or by leaching than by surface runoff. Generalized projections of potential nitrate N leaching loss when ammonium is applied in the fall are shown in Fig. 34 (p. 81) for example. Compare that with much less potential nitrate leaching loss where ammonium is applied in the spring (Fig. 82, p. 35). Unfortunately, logistics and weather often limit how much N fertilizer can be handled and properly applied during the usually busy spring season.

Specific Examples of Pollutants (?) and Cropland Runoff

So much for the broad perspectives. Now, let's quickly view a series of slides illustrating several of the generalities with some specific, sometimes vivid, examples of particular cases or sites. For the record, much of
what follows is summary information prepared a few years ago by headquarters people of what was then the Soil and Water Conservation Research Division of ARS in Beltsville. Dr. Van Schilfgaarde, who was Division Director (now Director of the U. S. Salinity Lab at Riverside, California), presented the material at various meetings and is due much of the credit. Let us trust that my paraphrasing or condensation has not seriously misquoted any of the material.

As we are repeatedly reminded, often in unfriendly ways, chemical fertilizers are being used at a rapidly increasing rate in so-called modern agriculture everywhere. Over 7 million tons of nitrogen fertilizer, and similar amounts of other fertilizers get spread on our lands each year. Because of possible damage to the environment from excesses, some people are misled by such data to what seems a logical conclusion, i.e., "that since the amounts are increasing so much, fertilizers must be a major contributor to water pollution." You've all heard disturbing reports to that effect, and, there have been abuses. Some of the reports are well documented; others are distorted, out of context, and are not well documented. The latter often get most publicity.

There's no disagreement that all over the country, bodies of water are eutrophying -- as shown by these views from Virginia, Minnesota, and Wyoming. In almost any state you can find bodies of water that to swimmers, sail boaters, water skiers, etc., are pretty sorry sights. But eutrophication is a natural ageing process, as old as geologic time. Unquestionably, man's activities including agricultural practices in the watershed, have aggravated, even helped accelerate the process; but blanket accusations that only blame cropland farm operations are unwarranted. Consider for example a couple of lakes made by the Corps of Engineers in 1963 near Lincoln, Nebraska. When Dr. Wadleigh (former Director of ARS's Soil and Water Conservation Research Division) visited Stagecoach Lake in the late 1960's there was severe water weed growth in the lake. On closer look he found that the entrance to Stagecoach Lake was swampy, very shallow and flat; there were grasses, weeds and organic materials in abundance. Naturally, any water that entered the lake after flowing through such a swampy area was bound to be laden with nutrients, which undoubtedly contributed to the heavy growth of water weeds.

Adjacent to Stagecoach Lake is Wagon Train Lake, also completed in 1963. Wagon Train Lake showed no signs of algae growth or water hyacinths or other weeds. Because of appreciable suspended sediment, the water could hardly be called clear, however. As a matter of fact, Wagon Train Lake carried nearly three times greater soluble phosphorus concentration than eutrophying Stagecoach Lake. Why the difference? The watersheds were much alike; a little different in size but the soil groupings and land uses were similar. A look at the topographic maps was helpful. Wagon Train Lake, the "non-polluted one" in terms of water weeds and algae, had banks of relatively steeper topography and did not have marshes adjacent to the main water body. The topographic map of eutrophying Stagecoach Lake, on the other hand, showed some 500 acres of marshland immediately adjacent to the lake's water surface like these illustrated in the next slide. No wonder then, that Stagecoach Lake was growing water-weeds in abundance. Obviously, the differences between Stagecoach and Wagon Train Lakes related more to topography and the conditions right along the lake proper than to agricultural practices in the uplands.
Another point; when folks get agitated about use of commercial fertilizers, apparently they often don't think about the tremendous withdrawals of nutrients from our cultivated soils over the last hundred years or so. In 1918, Marbut estimated that the virgin soils in the contiguous United States contained nearly 10 billion tons of organic nitrogen. The next slide shows amounts per acre of N in profiles of some different soil types. Recall that crops use <100 to a few hundred pounds of N per acre per year. As shown even the poorer soils usually contain tons of total N in the soil profile. Then why the need to add fertilizer nitrogen? That gets into a complicated story about forms of nitrogen, mineralization, immobilization, etc., i.e., the whole nitrogen cycle. As a generalization, most of the soil N (>95%) normally is "fixed" in organic or inorganic forms unavailable to plants; only about 1 to 2% is "mineralized" by soil microbes to readily available forms during the growing season each year. Moreover, as Jenny estimated years after Marbut, during a period of 50 years, some 40% of this organic nitrogen reserve was lost from our soils by cultivation.

The processes of ammonification, nitrification, and denitrification are natural and dynamic; the balance of different nitrogen forms in the soil is strongly influenced, of course, by microbial action and organic matter decomposition. Data from Mandan, North Dakota, indicate that up to 400 pounds per acre per year of mineral nitrogen can be generated in our northern plains soils; that is part of the environmental management balance with which we must deal. Another interesting point, as you compare the data from the other locations, is that from Texas to Montana, the further north, the greater the nitrification rate. (That's often a surprise to folks who learn about biological reactions being greater at warmer temperatures.)

Looking at fertilizer usage from yet another point of view, George Stanford (ARS N expert in Beltsville) calculated that about 1.8 billion tons of nitrogen has been utilized from the soil by cultivation since the arrival of the white man; by comparison the total amount of N added back to the soil out of the fertilizer "bag" has only been about 90 million tons since 1900 -- some 20 times less than taken out. Where is the wisdom in such continuing robbery from the soil nitrogen bank? Unfortunately the depletion continues in many places. It is estimated that 4 of our major crops use about 8 million tons of nitrogen per year. Thus, whether or not fertilizers from the "bag" contribute to pollution in the aggregate or in local situations, the overall withdrawal of nutrients from our soils is far greater than the amount added back on a national scale.

Furthermore, many soils are naturally deficient in essential elements; conversely, others contain toxic concentrations of micronutrients. Without additions of deficient elements or counter ions to correct these imbalances, crops will grow poorly, if at all, and we people and our animals will not be eating as well as we are now.

We know that phosphorus is deficient in many parts of the country and particularly in the West. Phosphorus deficiency is pretty hard on sheep. It can be even worse on cattle as the deformities on the slides show. Although lambasted as one of the worst water pollutants, P is essential for growth of any organism or animal. It is the primary element in the skeleton of all animals, including man. Phosphorus also is an essential element in the cellular energy exchange of all earth creatures including man and microbes; without P in proper proportion, we could not exist.
For yet another view, let's consider what some people, who often are rather severe critics of agricultural practices, have said about fertilizers and farmland runoff with relation to pollution of the Hudson River. An article in the March 1971 issue of Audubon magazine pointed out that the central part of the Hudson River receives significant runoff of fertilizer; simultaneously the central Hudson is virtually the "chamberpot" of some of the major cities in that area. Coincidentally, in that central area, the Hudson reportedly is also one of the most prolific fishing streams in the U.S. The upper part of the Hudson, on the other hand, is a pristine stream "uncontaminated" by man's activities and "unpolluted" by nutrients. Because of its deficiency in nutrients, however, it is also "uncontaminated" by fish. One could interpret that article as kind of a defense of agriculture in relation to water quality. Admittedly, the lower Hudson is a mess, so there's no room for complacency. But it is a vivid case illustrating that some minimum nutrient level is essential for growth of many life forms that people want; a little higher level is far better; much more begins to get dangerous; and still more becomes excessive, even deadly. The nutrients involved are not a wit different over the whole range from deficiency to toxic levels; it's a critical matter of proportion and balance. So what's with this increasingly common reference to N, P, S, or other nutrients in water as always being contaminants, pollutants or undesirables that are detrimental to water quality? It's an unfortunate oversimplification we should avoid and correct. The question is, "How much is too much?"

Having said that, there's no denying that mismanagement of soils and fertilizers is costly, inefficient, and troublesome.

For several years an experiment has been underway in a citrus orchard near Riverside, California; it's been called a 1,000 acre lysimeter. The basin is underlain by impervious rock and situated so that all the watershed drainage discharges at one point, and thus is readily collected and measured. At one time almost 50% of the applied fertilizer was found coming off the 1000 acres in the drainage water. We trust that with better management practices such as trickle irrigation and more timely fertilization, both the water and fertilizer loss will be minimized in that area.

Concurrently, studies to determine under what circumstances there are severe losses and what might be done about them have been underway in other areas of the country. Some results on nutrient runoff near Morris, Minnesota, show strong dependency on farming practices. The estimated 183 pounds per acre per year loss of nitrogen under fallow compares with 66 pounds lost under continuous corn vs 31 pounds N loss under a corn-oats-hay rotation. (These are averages from 7 years.) Phosphorus losses were about one pound per acre per year. From these same plots, fairly large soil losses were also found associated with poor management practices. Please note that about 90 percent of the nitrogen loss was coupled with loss of soil particles; not dissolved in solution as most folks think, but riding piggyback on the sediment. That most of the P lost by erosion is attached to soil particles has been emphasized for a long time. But only in recent years are people learning it's a similar case for nitrogen, organic carbon, and probably sulfur as well. Why? Because soil humic materials and mineral particles in the clay-size (<2 micrometer) range have tremendous amounts of active surfaces, and they contain the major part of the soils' ion exchange sites and nutrient reserves. (Recall that swelling-type clays can have surface areas exceeding 600 square meters per gram; that
is as much area as a football field contained on a dab of clay only big enough to cover a finger nail.) For many soils, upwards of 3/4 of the total N, P and S is found on the organic-mineral particles of 2 micrometers or smaller. These colloidal particles when once splashed from the soil surface, remain suspended the longest and get carried the farthest; they cause turbidity, and may plug the finest pores. Yes, sheet erosion and runoff often is selective for these "enriched fines". Thus, simple volume or weight measurements of eroded sediments only tell part of the story.

For a comparison of nutrient yields in runoff from woodland vs general farming in another Midwest area, let's consider the Coshocton, Ohio watersheds, established more than 30 years ago for hydrologic studies. In 1967, total P loss in water from a particular 5-acre woodland block was trivial, about .03 pound per acre per year. Usually the P concentration rose perceptibly only when the runoff rate was very low. Obviously, total P loss from an area is the product of the concentration times the volume of runoff; and, both concentration and discharge rate change continuously with rainfall intensity and duration. Hence, one must be very careful in extrapolating "point" data if total annual losses are the data of interest. Statistically, the .06 pound per acre from farmland was significantly greater than the 0.3 pound of P per acre from woodland; but, either of these amounts is hardly cause for excitement. Compared with the Minnesota cropping conditions, erosion control at Coshocton was good and soil loss was maintained at a minimum. The nitrogen loss story was similar. Comparing woodland, general farming, and a small feedlot, N losses increased in that order, from about 0.6 to 1.4 to 3 pounds per acre per year. These are very low numbers considering it is not uncommon to have >5 pounds of N per acre per year in the rainfall itself.

From 30 to 40 years of data on the Rio Grande River, Dr. C. A. Bower found that, notwithstanding an increase in fertilizer use with time, total nitrate load in the river downstream from the irrigation return flow had decreased. The data indicate, at the minimum, that fertilizer use in that area could not be blamed for decreased water quality in the river.

Irrigation, Subsurface Runoff, and Pollutants(?)

Although irrigation return flows are not diffuse sources according to Russell Train's February 17, 1976 memo, let's look at some results on subsurface runoff from dry mountain states for contrast. This information is from Dr. D. L. Carter's data on a 200,000 acre irrigation project near Twin Falls, Idaho. The area is underlain by basalt; subsurface drainage collects and comes out at discrete points like this (slide -- South side drains to Snake River) or spills over the canyon wall on the north side. Dr. Carter found that roughly 30 pounds of nitrogen per acre per year was leaching out in the drainage water. One can say this was too much, or one can say it isn't very much, depending on the point of view; and, it depends upon how this drainage water is to be used. The Snake River is pretty fair fishing water, and to the angler that bit of fertilizer coming from the irrigated area probably is a benefit rather than pollutant. However, it does indicate relatively inefficient use of fertilizer abetted in part by excessive irrigation, leaching, and underground runoff.
The phosphorus story is quite another matter. Unlike N, much P in the turbid irrigation water applied to the land was sorbed somewhere in the soil profile. The net "input" of both total or bicarbonate P measured 140,000 tons per year, or 80% of that contained in the irrigation water applied to the Northside tract; net input on the Twin Falls side tract was about 90 tons per year or nearly 50% of that P incoming with the irrigation water. The soil served as a filter or a sink with respect to P. (Suspended soil particles can also be 'P' scavengers; clearly, it is simplistic to always regard particulates in water as pollutants when they function as cleansing scavengers or sorbing surfaces for unwanted soluble ions or chemicals.) Now where was the soil P concentrated? As we just saw for soil particles in the Midwest soils, there was a heavy concentration of P on the silt-size, but especially on the clay-size materials. This differential has been called "enrichment" and relates to disproportionate loss of total soil nutrient reserves via selective erosion of these finer particles. Beyond that one has to consider the soluble vs fixed forms of P before deciding whether a pollution problem really exists.

Cropland Runoff, Erosion, Non-point Source Pollutants in Western Oregon

Well, that's an interesting story about many places and problems elsewhere in the U.S., but what about runoff, erosion, and so-called pollutants from diffuse cropland sources in Western Oregon? Are there, or are there not serious problems? The generalized maps we saw earlier indicated none. Understanding of the situation is only slightly improved since Bill Clothier (1975) told WRRI seminar participants in this room just one year ago, "The assessment of water quality degradation from nonpoint sources in the Northwest is generally inadequate". (That's a wee understatement to say the least.) He did say their agency reports (EPA, Region X, Seattle) indicate about 70% of the streams in Oregon, Washington, and Idaho are water-quality limited (i.e., do not or will not meet water quality standards even after application of effluent limitations), in other words because of nonpoint source influences. He further indicated that contributions to sediment loads from cropland, according to the Columbia North Pacific Study, were estimated at about 40% of the total sediment yield. Forty to fifty percent contribution to total sediment load is a figure quoted for other cropland areas as well (Stewart, et al., 1975). This contrasts with an early 1960's 28% estimate by Anderson (1954). (Anderson's work was a rather detailed study of about 17 large-area western-Oregon watersheds and major stream systems.) Prevailing attitudes still seem to be that although there is a lot of runoff from western Oregon cropland, erosion and pollution from these croplands is really negligible. However, machinery size, fertilizer use, residue management, burning, burning bans, energy use and abuse, fertilizer prices, and world wheat demand and prices have changed greatly in the last 20 years. Anderson's data are for a bygone era; they need confirmation, updating or revision.

Let me close then with just a few slides of scenes from local areas that could be used to support both points of view; i.e., that runoff from Willamette Valley croplands carries negligible nonpoint source pollutants, vs contentions that runoff to our streams is fouled and dirty every winter, and lots of the "dirties" are coming from croplands.
--This view is of the grass-seed area flats contributing runoff to the East Muddy; scene is S.E. toward American Can pulp-mill plant near Halsey. The road here was flooded a few hours earlier and from trash caught on the fence, you can see that runoff water had been feet higher still in previous years. Although the runoff looks pretty turbid, really it was not bad -- suspended sediments concentration was less than 100 parts per million (ppm).

--At site SH-3, south of Monroe, runoff was from a wooded/timber hillside; water was clear and apparently culinary in quality.

--At site SH-2 about 1/2 mile NE, down Schafer Creek drainage from SH-3, runoff was high and turbid. Particulate concentrations were several hundred parts per million. A major cause was surface and rill erosion from an adjacent hillside planted to winter wheat.

--This view of SH-4 shows rills and cuts deeper than 6 inches from an early storm, late October, 1975. By the third storm (the first week of December) erosion channels were cut to the firm, thick subsoil clay at 9-12". Tons of sediment had washed down to the catchment beside the road.

--A new planting of Christmas trees, just across the road north of SH-4 was yielding particulate concentrations of several thousand ppm. All grass cover had been removed; the soil surface was bare, and subject to raindrop splash and sheet and rill erosion.

--Several miles north of Corvallis on Independence Road near Polk county line (at Ridder's Cemetery), drainage from some grass-seed, grain fields on Amity, Woodburn soils (<6% slope) was turbid and carried several hundred ppm suspended solids.

--From moderately sloping lands north of Suver Road, West of 99W, turbid runoff flowed from grass-seed fields and even more-turbid surface runoff spilled from late-planted winter wheat fields.

With the conversion of more hill-slope areas to wheat, as a result of residue burning restrictions and favorable market prices for wheat vs grass seeds, there seem to be some problem areas. Reports of extensive rill erosion in hilly soils east of Salem have reached us. Considerable rilling also occurred on fields planted to winter wheat near Hillsboro. The amount of runoff, chemical nutrient, salt, or sediment loads from these fields on a seasonal basis has yet to be determined.

In response to apparent need, we began a small grab -sample survey study of runoff from fields in the southern Willamette Valley this last winter. Initial support was supplied from the OSU Water Resources Research Institute. With the acquisition (before next winter) of several flumes and automated water stage recorders (for volume-of-runoff measurements), and some automated pumping samplers (for getting aliquots proportional to runoff), and with recording rain guages to give amount and intensity of precipitation at the watershed site, in a few years, we should have some better information about quantities of nonpoint source pollutants in runoff from some representative valley croplands.
Additional research concerning the extent and mechanisms of surface erosion in Western Oregon is being planned by other OSU Soil Science personnel. These studies will begin later in the year as funds are made available.

Retrospect

Certainly there will be much activity in the next 5 to 8 years here and elsewhere (e.g., Seitz, 1975; Omernik, 1976; Whipple and Hunter, 1975) concerning Sec. 208 planning and development of best management practices for controlling nonpoint source pollutants. In the process, let us hope that people will keep a sense of perspective and remember that some erosion is natural and useful, that suspended sediments and soluble nutrients in runoff are not always bad, nor always to be labeled pollutants, and that zero discharge of "pollutants" from all nonpoint sources is overly simplistic idealism beyond the purse and power of humans. Realistically, the citizen population will ultimately have to decide how much is beneficial and desirable for various competing purposes, how much more can reasonably be tolerated, and how much is just too much?

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Control of
WATER POLLUTION
from cropland

Volume I
A manual for
guideline development

November 1975

Authored by a Committee of Scientists of Agricultural Research Service, USDA.

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Every livestock operation is a potential source of water pollutants. Water pollution, as defined in the Oregon code, "means such contamination or other alteration of the physical, chemical or biological properties of any waters of the state, including change in temperature, taste, color, turbidity, silt or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance, into any waters of the state which either by itself or in connection with any other substance present, will or can reasonably be expected to create a public nuisance or render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational or other legitimate beneficial uses or to livestock, wildlife, fish or other aquatic life or the habitat thereof."

Improperly managed runoff from livestock confinement and manure storage areas or from land areas where livestock manures have been applied on the soil surface can contain sufficient concentrations of manure to alter water properties sufficiently so as to cause a public nuisance, be harmful to public health, or be detrimental to beneficial uses of the water in the stream which receives the runoff.

Manure constituents which have the greater polluting potential include oxygen-demanding matter (principally organic matter), plant nutrients and infectious agents. Color and odor are potential polluting constituents of secondary importance.

Oxygen Depletion - Organic matter from livestock manures, like that from other sources, serves as a source of food and energy for aerobic bacteria when it enters a receiving stream. Associated with bacterial metabolism is the utilization of dissolved oxygen from the water in the stream. When the rate of oxygen utilization exceeds the reaeration rate of the stream, oxygen depletion occurs. Whenever sufficient organic matter enters, oxygen concentrations will be reduced below the level necessary for the fish migration or survival.
The oxygen-depleting characteristic of wastewater has been measured historically as biochemical oxygen demand (BOD). This measurement evaluates the concentration of oxidizable organic material that can be utilized by aerobic bacteria in terms of how much oxygen they will require to metabolize this material during a specified time, generally 5 days, and at a specific temperature, generally 20° centigrade. Having determined the 5-day BOD and knowing the quantity of manure produced, it is possible to determine a daily BOD$_5$ production for various animal species. The BOD$_5$ and other properties of animal manures have been quantified by numerous researchers. Representative values of these properties are provided in Table 1.

### TABLE 1. Livestock manure production and selected properties per 1000 liveweight units (kg or lb).

<table>
<thead>
<tr>
<th>Animal</th>
<th>Feces &amp; urine weight per day (kg or lb)</th>
<th>BOD$_5$</th>
<th>COD</th>
<th>N</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cow</td>
<td>-</td>
<td>1.7</td>
<td>9.1</td>
<td>0.41</td>
<td>0.073</td>
<td>0.27</td>
</tr>
<tr>
<td>Beef feeder</td>
<td>-</td>
<td>1.6</td>
<td>6.6</td>
<td>0.34</td>
<td>0.11</td>
<td>0.24</td>
</tr>
<tr>
<td>Swine feeder</td>
<td>-</td>
<td>2.0</td>
<td>5.7</td>
<td>0.45</td>
<td>0.15</td>
<td>0.30</td>
</tr>
<tr>
<td>Sheep feeder</td>
<td>-</td>
<td>0.9</td>
<td>11.8</td>
<td>0.45</td>
<td>0.066</td>
<td>0.32</td>
</tr>
<tr>
<td>Layer hen</td>
<td>-</td>
<td>3.5</td>
<td>12.0</td>
<td>0.72</td>
<td>0.28</td>
<td>0.31</td>
</tr>
<tr>
<td>Broiler</td>
<td>-</td>
<td>---</td>
<td>---</td>
<td>1.16</td>
<td>0.26</td>
<td>0.36</td>
</tr>
<tr>
<td>Horse</td>
<td>-</td>
<td>---</td>
<td>---</td>
<td>0.27</td>
<td>0.046</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Source: American Society of Agricultural Engineers; data adapted from Structures and Environment Committee 412 report AW-D-1, revised June 1973.

Representative values for chemical oxygen demand (COD) are provided in Table 1, also. COD is another measure of the oxygen-depleting properties of organic and other oxygen-demanding matter based on chemical, rather than biological, oxidation. The COD exceeds the BOD$_5$ of a manure due to the inability of aerobic bacteria to completely oxidize the more resistant constituents under the conditions of the BOD$_5$ test.

The BOD$_5$ or COD values for livestock manures as provided in the table have significance, however, only when fresh excreta is introduced directly into a receiving stream. This usually doesn't occur except where animals have direct access to a stream from which they drink. No reported situations are known where a detrimental oxygen depletion has occurred as the result of livestock manures introduced into a stream by cattle or other animals on pasture or range. In situations where harmful oxygen depletions have occurred, the livestock manures have been transported to the stream with surface runoff from concentrated animal feeding operations such as cattle feedlots.
Results of feedlot runoff studies conducted in Texas, Kansas, Nebraska and Ohio indicate that feedlot runoff quality is highly variable depending primarily on climatic and feedlot surface conditions. Runoff caused by snowmelt contained COD concentrations 2 to 14 times greater than runoff caused by rainfall (Fields 1971, and McCalla et al. 1972). Concentration of pollutants in runoff from concrete lots was 2 to 4 times that from dirt lots. Runoff contained significantly lower pollutant concentrations when rainfall events occurred every few days (White and Edwards 1972). Gilbertson et al. (1971) found that feedlot runoff quality depends more on rainfall than on feedlot slope or animal density.

The reported range in mean values for COD concentrations in beef feedlot runoff as caused by rainfall in these midwestern states was 3,100 to 7,600 mg/l. As a base for comparison, COD concentration in untreated domestic sewage usually varies from 400 to 600 mg/l. Consequently, a unit volume of typical midwestern feedlot runoff will exert an oxygen demand within a receiving stream approximately 10 times greater than a unit volume of untreated domestic sewage if the runoff is conveyed directly to the stream.

State and federal regulatory agencies responsible for water quality management currently prohibit the discharge of untreated municipal sewage into a stream. Likewise, the discharge of runoff from concentrated animal feeding operations is being regulated by state and federal agencies to prevent oxygen depletion and other water quality degradation which interferes with a beneficial use of the water.

Plant Nutrients - Nitrogen and phosphorous are the plant nutrients of primary concern. These elements are present in sufficient quantities in manure and feedlot runoff to increase nutrient concentrations in surface waters and thus stimulate the growth of aquatic plants including algae. Excessive algae growth can adversely affect the taste, odor, and turbidity (cloudiness) of the water and interfere with recreational uses, such as fishing and swimming, in water impoundments.

Loehr (1974) summarized reported data concerning quantities of nitrogen and phosphorus transported by runoff or subsurface drainage from various land uses and contained in precipitation. Based on the information provided in Table 2, Loehr (1974) concluded that control of range land runoff was not needed, that runoff from land receiving manure possibly needed control, and that manure seepage and feedlot runoff should require some degree of control to avoid water pollution.

Range land is usually nitrogen deficient, and the concentration of phosphorus in range land runoff is very low - comparable to that received with rainfall. Considering the annual yield of N and P in runoff, cropland receiving manure is in the same category as cropland receiving other sources of plant nutrients in either organic or inorganic form. Concentrations of N & P in feedlot runoff are 10 to 100 times greater than in most runoff or subsurface drainage from other land uses. Consequently, feedlot runoff control through collection and storage of the runoff followed by application on agricultural land keeps most of the plant nutrients out of the stream and places them on land where they can assist in producing economic crops.
### TABLE 2. Annual areal yield of nitrogen and phosphorus*

<table>
<thead>
<tr>
<th>Source</th>
<th>Total N kg/ha</th>
<th>Total P kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>5.6-10</td>
<td>0.05-0.06</td>
</tr>
<tr>
<td>Forested land</td>
<td>3-13</td>
<td>0.03-0.9</td>
</tr>
<tr>
<td>Cropland runoff</td>
<td>0.1-13</td>
<td>0.06-2.9</td>
</tr>
<tr>
<td>Cropland tile drainage</td>
<td>0.3-13</td>
<td>0.01-0.3</td>
</tr>
<tr>
<td>Irrigated cropland:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western U.S.</td>
<td>3-27</td>
<td>1-4.4</td>
</tr>
<tr>
<td>Surface flow</td>
<td>42-186</td>
<td>3-10</td>
</tr>
<tr>
<td>Subsurface drainage</td>
<td>0.3-13</td>
<td>0.01-0.3</td>
</tr>
<tr>
<td>Urban land drainage</td>
<td>7-9</td>
<td>1.1-5.6</td>
</tr>
<tr>
<td>Range land</td>
<td></td>
<td>0.08</td>
</tr>
<tr>
<td>Cropland receiving manure</td>
<td>4-13</td>
<td>0.8-2.9</td>
</tr>
<tr>
<td>Seepage from stacked manure</td>
<td>3</td>
<td>---</td>
</tr>
<tr>
<td>Feedlot runoff</td>
<td>100-1,600</td>
<td>10-620</td>
</tr>
</tbody>
</table>

*Data do not reflect extreme values caused by improper waste management or extreme storm conditions; 1 kg/ha = 0.89 lb/ac.


Application of feedlot runoff or other wastewaters containing animal manures on agricultural land will significantly reduce the oxygen-depleting characteristics and plant nutrient content of the wastewater even though some may escape with surface runoff.

Boda and Willrich (1976), after applying swine manure lagoon wastewater on fescue-grassed plots near Corvallis, Oregon, reported COD, phosphorus and inorganic nitrogen reductions of 47, 42, and 38 percent, respectively, during cool, wet seasons and 72, 79, and 75 percent, respectively, during warm, dry seasons with only 100 feet of overland flow distance. During wet seasons, about 60 percent of the volume of applied wastewater was caught as surface runoff after 100 feet of overland flow, whereas only about 10 percent of the applied volume remained as surface runoff during dry seasons.

Concentrations of most constituents decreased linearly with distance of overland flow. Extrapolation of results obtained in 100 feet of overland flow indicated that the required distance to achieve maximum alteration of polluting characteristics through overland flow treatment is about 600 feet for conditions similar to those which existed in the investigation. A pertinent property which didn't change significantly with overland flow was the concentration of fecal coliform bacteria.
Infectious Agents - Although fecal coliform and fecal streptococci bacteria are rarely pathogenic, they do serve as indicators that contamination has occurred and that infectious organisms may be present.

Livestock manures are a source of infectious agents that may infect other animals and, in some instances, man (Wadleigh 1968). Although water-borne infectious diseases are relatively rare in the United States, increasing emphasis on water-based recreation creates new opportunities for this mode of infection. Leptospirosis has been spread from cattle to swimmers by the water-borne route (Diesch and McCulloch 1966).

By using the fecal coliform-fecal streptococcus ratio (Kenner, Clark and Kabler 1960), it is possible to distinguish between livestock and human wastes. If the ratio is greater than 2.5, the source of the fecal organisms is probably human wastes. If less than 1.0, livestock manures are the most likely source. As researchers and representatives of regulatory agencies responsible for water quality research and management depart from the historically-used total coliform standard for biological quality evaluation to a fecal coliform - fecal streptococcus standard, the bacterial contribution of animal manures to surface waters will be better understood.

However, it is also important to keep in mind that a variety of wild animal species may contaminate streams with leptospira, coliforms, streptococci and other organisms (Wadleigh 1968). Identification of the specific source of fecal organisms based on the results of water analyses only is rarely possible.

Recognizing the potential water polluting hazards associated with livestock operations, state and federal regulatory agency representatives with water quality management responsibilities have responded to known situations where pollution existed or was highly probable to occur. Over the past few years the Oregon Department of Environmental Quality has identified several pollution problems associated with feedlot runoff and silo drainage. Most of these problems have been corrected through voluntary compliance or enforcement action. Currently, the Oregon DEQ has no documentation of any non-point source pollution problems associated with cattle feeding operations. Undoubtedly pollutants in various quantities are being carried by precipitation runoff to public waters, but no significant pollution problems from these sources are known (Kramer 1976).

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INTRODUCTION

The purpose of this paper is to identify several alternative strategies which might be evaluated as possible management techniques for non-point source pollution control during CRAG's (Columbia Region Association of Governments) continuous planning process for wastewater management.

During the Section 208 wastewater management planning effort underway at CRAG, staff will identify, localize and attempt to quantify the non-point source problem in Clackamas, Multnomah and Washington Counties, exclusive of federal forest lands. Those sources presently identified fall under one of these categories: 1) agricultural runoff, 2) forest land runoff, 3) septic tank effluents, 4) construction, or 5) marine discharges (structure, craft, log rafting).

Table I designates the presumed major point and non-point pollutant sources, keying into the stream map of Figure II.

The following sections will amplify the non-point sources, attempt to narrow the spatial description and then identify potential alternative management strategies.

AGRICULTURAL NON-POINT SOURCES

I. Pollutants released by tilling soil
   (sediment, nutrients, organics, pesticides, heavy metals)

   A. Locations - rural Tualatin River basin, Columbia South Shore area, upper Johnson Creek, upper Kellogg Creek, Molalla River basin, miscellaneous localities.

   B. Alternatives
      1. do nothing
TABLE I
WASTE SOURCE AND STREAM RELATIONSHIPS

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>Willamette River</th>
<th>Tualatin Basin</th>
<th>Columbia Slough</th>
<th>Clackamas River</th>
<th>Molalla River</th>
<th>Sandy River</th>
<th>Johnson Creek</th>
<th>Panno Creek</th>
<th>Rock Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Wastes</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Sludge Disposal</td>
<td>X</td>
<td>X</td>
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<td></td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Sludge Deposits</td>
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<td>X</td>
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<tr>
<td>Industrial Wastes</td>
<td>X</td>
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<td></td>
<td></td>
<td>X</td>
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</tr>
<tr>
<td>Urban Stormwater Runoff</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Combined Sewer Overflows</td>
<td>X</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Vessels and Marinas</td>
<td>X</td>
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<td></td>
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<td>X</td>
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<tr>
<td>Construction Practices</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Logs and Log Rafting</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Agricultural Runoff</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>Forest Land Runoff</td>
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<td></td>
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<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Septic Tanks</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
2. intensify extension service and SCS farmer education programs.
3. construct sedimentation basins in flow paths of natural drainage downstream of fields. Periodically remove sediment and replace on fields.
4. institute county ordinances requiring use of "best tillage practices" to include contour plowing, periodic unplowed contour conforming strips, vegetation in drainage ways, etc.
5. planting or construction of wind breaks and wind hedges where winds drive loose soils.
6. contour conforming strips of alfalfa, clover, fescue, or other soil stabilizing crop.
7. institute county ordinances requiring terracing on steeper slopes.
8. allow fertilization only of established crops, i.e., don't fertilize bare ground.
9. regulate type and application rate of herbicides and pesticides more stringently on a county basis than federal regulations do now.
10. institute state taxes to reduce or discourage use of fertilizers, pesticides and herbicides.
11. mandatory small field crop rotation, holding one field of (four) in fallow each year.
12. establish basin corporations with power to tax "poor" practices and subsidize those who conform to "best practices", i.e., field retention of runoff, contour farming, etc.

II. Pollutants released by irrigation practices

A. Locations - rural Tualatin River basin, primarily north of the river, Columbia South Shore area, miscellaneous localities.

B. Alternatives

1. do nothing
2. intensify extension service and SCS farmer education programs.
3. establish basin corporations which tax poor practices and subsidize those who use "best practices".
4. construct site groundwater recharge facilities for return flows.
   a) gravel or peat sumps
   b) pump injection of aquifers
   c) subsurface drainage tiles
5. regulate irrigating practices by barring sale statewide of irrigation systems producing return flows.
6. establish compliance schedule with legal penalties for converting irrigation facilities to systems not producing return flows.
7. establish state tax incentives for conversion to or purchase of systems not producing return flows.
8. levy county or state surcharge on irrigation water consumption.
9. require vegetation of drainage ways carrying return flows.
10. construct simple secondary treatment plants along return flow ditches at confluences with established streams.
III. Pollutants released by agricultural residuals handling

A. Types: stubble and straw from grain and seed crops, residues from field burning (virtually non-existent in the CRAG 208 study area), leaf and plant matter from vegetable crops, land disposal of processing wastes from canneries, etc.

B. Locations: common to all agricultural areas in region.

C. Alternatives
   1. do nothing
   2. establish properly designed and monitored sanitary landfills for agricultural wastes.
   3. establish regional composting facilities which charge for disposal and offset costs with sale of compost, sterilized potting soil, etc.
   4. research into better practices for disposal of agricultural residues. Implement later, if feasible.
   5. research into actual extent of resultant water pollution problems. Implement preventive programs dealing with identified problem sources.

SILVICULTURAL NON-POINT SOURCES

Although the CRAG 208 program must not plan in national forest lands, the post-208 planning process may, if not funded by EPA monies. This is due to an EPA/Forest Service interagency agreement. Presently, a large part of CRAG's region consists of the Mount Hood National Forest.

I. Pollutants released by logging practices (erosion)

A. Locations - Forest Park, upper lands of all river basins and miscellaneous small woodlots and Christmas tree farms throughout the rural lands.

B. Alternatives
   1. do nothing
   2. ban clear-cutting except where land use is to be changed.
   3. establish maximum contiguous area standards for clear-cutting.
   4. require on-site chopping, mulching and surface coverage of logging residues onto clear-cut sites immediately following reseeding operations or during logging when seedlings are to be planted later.
   5. establish and enforce minimum logging road design standards to include coverage of exposed embankments, drainage structure energy dissipation, etc.
   7. amend State Forest Practices Act to include more "best watershed protection" requirements.
   8. establish forest lands corporation to tax clear-cutting and subsidize selective harvest operations.
II. Pollutants released by natural runoff from forest lands (pesticides, herbicides, fertilizer derived nutrients).

A. Location: All forest lands.

B. Alternatives
   1. do nothing
   2. establish forest lands corporation which taxes application of herbicides, pesticides and fertilizers and uses derived monies to construct and maintain forest lands drainage and runoff control structures.
   3. establish a manual of "best runoff control" practices for practicing loggers.
   4. enhance forestry education at Oregon State University to include course work in forest land runoff pollution mitigation.
   5. amend State Forest Practices Act to provide for better pollution mitigation from forest land runoff.

SEPTIC TANK EFFLUENTS

I. Pollutants entering and contaminating groundwater systems.

A. Locations: rural and suburban unsewered lands throughout the planning area.

B. Alternatives
   1. do nothing
   2. provide sewers and treatment facilities
   3. establish tank and drain field monitoring and inspection program in designated suburban areas.
   4. establish required tank pumping schedule through basin corporation or other institution.
   5. ban construction where contamination exists and sewers are not to be provided. Variances to be granted when applicant installs other suitable facilities, i.e., clivus multrum, individual aerobic treatment system, other suitable land application system for waste water.
   6. require conversion to a public water supply system for all users of aquifer wells (avoiding compounding the existing problem).
   7. convert septic tank to holding facility with regular pumping and eliminate drain field.
   8. establish population density limits through lot size and use type consistent with "aquifer carrying capacity".

II. Pollutants surfacing and causing health hazard

A. Locations: miscellaneous sites on septic tanks where unsuitable or poorly designed, especially in Happy Valley and Glenmorie areas.

B. Alternatives
1. do nothing
2. speed process of officially declaring an area as a health hazard area to qualify for sewerage.
3. ban further construction until problem is mitigated.
4. provide sewers and treatment facilities.

Similar alternatives could be listed for construction and marine discharges, but CRAG staff has not completed that task.

FRAMEWORK FOR SELECTION OF ALTERNATIVES

An institutional analyst is under contract to CRAG and will have inventoried existing legal authorities of various agencies having mandated or implied powers over sewerage, water quality and related functions. Factors such as personnel, budget and financial status shall also have been analyzed. This work should provide the CRAG staff planning for non-point source management with a framework for assessing local, regional and state agency ability to implement an alternative strategy. The planners must also consider starting new agencies such as the basin corporation for these functions.

The previously enumerated alternatives are a potpourrie of different strategies. Other than the "do nothing" alternative, which is viable and must be carefully considered, they all have some or all of the following features:

1. need for implementive agency.
2. need for monitoring to determine actual effectiveness.
3. need for periodic revision of plan to conform with changes taking place.
4. costs incurred by implementive, monitoring and planning agencies.
5. costs to those who must take actions, comply with changed practices and construct abatement works.
6. costs or hardships incurred by the society as a whole.

Prior to any alternative selection, a detailed development of these features must take place. This development includes analysis of the existing problems, their relative priorities and magnitudes and suitability of institutions to effectively institute the necessary programs. Most of the above six features defi precise quantification. For this reason, it is most desirable that technical personnel develop the parameters in light of citizen input.

RELATIONSHIP TO CONVENTIONAL LAND USE PLANNING

The philosophy of land use planning has changed remarkably in the past decade. The overlay map analysis of Ian McHarg is still a useful tool, but not the primary means of deriving the proposed land uses. It is now obvious that such analyses disregard economics and social dynamics and provide overly rigid frameworks into which the human must be placed. Focusing now on the human, planners attempt to define social, environmental and economic goals and guidelines representing the impacted group's aspirations.

A reasonable objective statement for non-point source pollution might be, "to reach and maintain the national goal of swimmable and fishable waters
throughout the year by selective abatement of non-point source pollution. The tandem goal might read, "maximum pollutant concentrations not to exceed:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>coliform bacteria</td>
<td>log mean 200 mg/l</td>
</tr>
<tr>
<td>lead</td>
<td>0.01 of 96 hour LC 50 of salmon</td>
</tr>
<tr>
<td>mercury</td>
<td>0.05 micrograms/liter</td>
</tr>
<tr>
<td>nitrate, nitrite</td>
<td>10 mg/l nitrate N</td>
</tr>
<tr>
<td>pesticides-aldrin/dieldrin</td>
<td>0.003 micrograms/liter</td>
</tr>
<tr>
<td>- DDT</td>
<td>0.001 micrograms/liter</td>
</tr>
<tr>
<td>- malathion</td>
<td>0.1 micrograms/liter</td>
</tr>
<tr>
<td>phosphorous</td>
<td>0.1 micrograms/liter</td>
</tr>
<tr>
<td>solids-dissolved</td>
<td>500 mg/l TDS</td>
</tr>
<tr>
<td>- suspended</td>
<td>25 mg/l</td>
</tr>
</tbody>
</table>

or fall below:

dissolved oxygen               - 5.0 mg/l

downstream of the mixing zone of any point source regulated by an NPDES discharge permit.

These or similar goals and objectives allow planners to test alternative policies of population distribution, building codes, zoning and taxation for their ability to meet the goal and satisfy the objective. After consideration of all fiscal, social, and environmental consequences of the proposed actions, one has the opportunity to revise his goals and objectives to something more achievable or more cost-effective. The process begins again. This reiteration, however time consuming and frustrating, seems to be the only feasible means of performing the tradeoffs necessary to reconcile economic, housing and agricultural preservation goals and objectives with those of water pollution.
Water Pollution from Urban and Other Non-Agricultural Areas

ABSTRACT

The U.S. Geological Survey is currently conducting two urban studies of rainfall-runoff and urban storm-water quality. These studies, and a broader U. S. Army Corps of Engineers urban area study, are being coordinated by the Columbia Region Association of Governments (CRAG) under Section 208 of Public Law 92-500. CRAG and the Corps both have identified urban storm runoff as a problem in the Portland area.

Fifteen gaging stations have been established by the Geological Survey to monitor rainfall and storm-water runoff in Clark, Clackamas, Multnomah, and Washington Counties. The drainage areas upstream from the stations range from 0.21 to 6.63 mi² (0.54 to 17.2 km²). Other basin characteristics measured include percentage imperviousness which ranges from about 2 to 30 and slope which ranges from about 7 to 45 percent. Data on rainfall and runoff will be collected for at least five storms each year during the 4-5 years of the study and will provide hydrographs for the urban storm-water-quality study. Data on drainage area, slope, and impervious area, as well as on soil types, will be used to relate rainfall to storm-water runoff peaks and storm-water runoff volumes. This derived relationship will allow (1) prediction of storm-water runoff as basins are developed and basin characteristics change, and (2) simulation of storm-water runoff in ungaged basins.

At 7 of the 15 rainfall-runoff sites, water-quality data will be collected during five storms per year for a 2-year period. Sufficient data will be collected to describe a pollutograph for each constituent of interest for each storm. Combining the pollutograph with the hydrograph will allow constituent loads to be calculated for each site. In addition to the pollutograph and constituent loads, attempts will be made to derive correlations between different constituents. Some correlations that will be tried include: Dissolved solids (DS) and specific conductance (SC), biochemical oxygen demand (BOD) and chemical oxygen demand (COD), suspended solids (SpSd) and total phosphorus (TP), and SpSd and total Kjeldahl nitrogen (TKN).
All samples brought to the laboratory are first analyzed for SC and turbidity. Only then are samples selected for analysis of BOD, SpSd, DS, TKN, TP, settleable solids (SettSd), alkalinity, dissolved nitrate plus nitrite, and total ammonia. An attempt is made to obtain hourly values throughout a storm for SC, turbidity, BOD, SpSd, and SettSd, which may vary widely during the storm. For example, on December 3 and 4, 1975, about 2 inches of rain fell during a 24-hour period in Kelly Creek basin. During the storm, flow increased from 16 to 241 ft$^3$/s and then decreased to 70 ft$^3$/s (0.51 to 6.83 and to 2.0 m$^3$/s); SC decreased from 94 to 48 and then increased to 80 micro-ohms per centimetre at 25°C; similarly, turbidity increased from 25 to 210 JTU and then decreased to 45 JTU; SpSd from 27 to 934 to 123 mg/l; SettSd from 1.0 to 2.0 to 0.8 ml/l; and BOD ultimate from 4.2 to 11.4 to 4.3 mg/l. These variations demonstrate the necessity for frequent sampling during a storm to describe the pollutograph adequately.

The accuracy of a model to simulate pollutographs and hydrographs for a single basin is determined by the accuracy of sample collection, sample analysis, flow measurements, and derived correlations. As the model is expanded to include several basins, its accuracy also depends on the ability to measure and correlate basin characteristics with basin pollutographs and hydrographs. With the inclusion of several basins, the accuracy of the model may vary with differences in basin characteristics, such as drainage area, basin slope, or percentage impervious area. A model of known accuracy should provide planners with a dependable tool to simulate water quality in ungaged basins or to predict changes in water quality resulting from a change in basin characteristics accompanying future development.
The following discussion of rainfall contamination by air pollutants is essentially a selected compilation from a computer-aided literature search. The individual reports and papers were not evaluated for their scientific merit. The results from the various studies, several of which were available as abstracts only, were accepted as presented by the investigators. A complete discussion of the literature was not attempted, but representative reports are cited. Noncited references are included in the bibliography.

The phenomenon of contaminated precipitation is, of course, directly tied to air pollution. Atmospheric contaminants can be deposited in and on terrestrial and surface water systems in several ways. The most prevalent are dryfall (deposition of particulates on surfaces), adsorption on surfaces, and scavenging during storm events. Precipitation scavenging is the mode of concern in this discussion. The materials and their concentrations found in precipitation depend on the quantity of a given contaminant present in the atmosphere before a storm as well as on the processes of scavenging. The removal of vapors from the air depends on the rate of molecular diffusion of the compounds into the water droplets (Postma, 1970) while removal of particulates depends on the physical dynamics of the particulates and the falling rain droplets (Berg, 1970).

Concern for water quality alterations due to contaminated rainfall stems not only from the ecological effects of the contaminants themselves, but also from the diffuse nature and the present lack of controls on sources of several of the contaminants.

The contaminants chosen for discussion are metals and the oxides of sulfur and nitrogen. The first group is of concern because of its inherent persistence documented bio-accumulation and toxicity. The latter two, when in water, form strong acids which may lower the pH of surface waters. Other materials, such as polychlorinated biphenyls, chlorinated hydrocarbons, and plant nutrients (including nitrogen) are also deposited by precipitation, but this discussion is limited to the noted materials due to their prevalence in the literature and their rather clear documentation of ecological effects.

Metals are generally introduced into the atmosphere as products of combustion of fossil fuels. Biggs et al. (1973) investigated several metals...
in Delaware rain and found cadmium and lead concentrations in rain to frequently exceed U. S. Public Health Service drinking water standards. They reported the concentrations to be highest during the winter when most heating fuels are used. A large percentage of the metals thus deposited remained in the soil, possibly accumulating. Atkins (1969) found the combustion products of fossil fuels, particularly lead, to be higher during the winter in California.

Other studies which note (heavy) metal increases in soils or water include those of Hamilton and Miller (1971) in Ohio, Hutchinson and Whitby (1974) in the Sudbury area of Ontario, and Schlesinger et. al. (1974) in New Hampshire.

The oxides of sulfur and nitrogen may be threats to water quality as such, but are converted to sulfuric, nitric, and other acids in the presence of water, thus lowering the pH of the rainwater. Nisbét (1974) calculates that the 100 to 150 million tons of SO2 released in the northern hemisphere per year, if uniformly distributed across that area, could lower the pH of all rain from a normal of 5.8 to 4.8. In the limestone regions of the midwest, carbonate concentrations and their inherent buffering capacities are quite high and the effects of acid rain on surface waters would likely be neutralized. However, the thin soils overlying granite in upstate New York, New England and southeastern Canada have little buffering capacity, and the surface waters respond to the acid rain with decreasing pH. The prevailing winds from the industrial and highly populated belt extending from the Great Lakes to the Atlantic Coast transport atmospheric contaminants eastward over this region. Therefore, an area least able to tolerate acid rain is most exposed to it.

A pH of approximately 5.0 is noted as critical for fish life by Beamish and Harvey (1972), Beamish (1974b), and Beamish et. al. (1975), in their investigation of the disappearance of fish species from several lakes in the La Cloche Mountains, Quebec. Beamish (1974a) found a reduction in growth of white suckers (Catastomus commersoni) in lakes exhibiting increasing acidity. The suspected source of sulfates are the large metal smelters in Sudbury, Ontario. Working with limnetic crustacean zooplankton in lakes from the same region, Sprules (1975) reported a considerable biological difference between lakes with pH above and below 5. Much simpler communities were found in the lower pH lakes: 9 to 16 species above and 1 to 7 species below pH 5.

Likens et al. (1972) discuss the results from several European workers. The situation there is quite similar to that in North America: air masses from industrial areas move over areas with poor buffering systems, an increase in the acidity of the lakes results, and the pH sensitive fishes, notably the salmonids and esocids, disappear.

The Sport Fishery Institute Bulletin, no. 273, 1976, summarizes a report by Butcher (1976). Butcher notes changes in the pH of Maine Lakes due to acid rain, and points out that acid rain is neutralized to some degree by wind-borne alkaline soil and some pulp mill emissions. However, this neutralizing material is not adequate to prevent acidification of Maine Lakes.

In summary, the literature documents rather well that surface water contaminants are found in air masses and that these materials are transported to the soil and surface water by dry fall and precipitation, frequently in concentrations which alter water quality.
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Control of Pollution
from Construction Activities

INTRODUCTION

"Sediment, in terms of sheer volume, ranks above domestic sewage, industrial wastes and chemicals as a major cause of water pollution." The total amount of sediment moving into the nation's rivers, lakes, estuaries, reservoirs, streams, and other water bodies is estimated at 4 billion cubic yards annually. Of this amount, construction and maintenance of our nation's highways alone is estimated to contribute 56 million tons each year. Population growth, resulting in expanding development and construction in urban and suburban areas, has been a major contributor to sediment sources. Studies indicate that sediment yields from these areas can be as much as 5 to 500 times greater than in rural areas.¹

The effects of sediment from construction on water quality are many and variable in nature. They include:

1. Increased turbidity,
2. Danger to aquatic life,
3. Loss of recreational value,
4. Decreased efficiencies in treatment of domestic water supplies, and
5. Clogged sewerlines and interference with waste treatment facilities.

These are but a few of the problems created by the failure to control pollution from construction operations. However, they do illustrate the need for a defined control program as a specific project requirement during construction phases.

Legal Authority

Despite the fact that sediment from construction practices have caused extensive pollution of the nation’s receiving waters and have cost untold millions in damage to the water environment, the problem of abatement has not been addressed by regulatory agencies until recently. Water quality standards declare that turbidity is a pollutant and quantify the allowable parameters. Oregon law, expressed in Oregon Revised Statutes, Chapter 449 and the Oregon Administrative Rules, Chapter 340, Division 4, further supplemented by Water Quality and Waste Treatment Standards for specific river basins, establish specific requirements for maintenance of water quality standards.

Compliance with the water quality standards is implemented through the issuance of permits required for a construction project in specific geographical locations. These permits often take the form of 1) conditional use, 2) building, 3) navigable waters, or 4) flood plain. Prior to issuance of permits, plan reviews are performed and special conditions are implemented to assure compliance with the appropriate water quality standards.

Implementation and Control

Technical means for controlling construction site erosion have been available to design engineers for many years. Many techniques developed to control erosion in agricultural areas have proven effective on construction projects in urban and suburban areas.

The design engineer must not only recognize the need for controlling potential pollution sources upon the completion of the project; he must also be aware of temporary controls necessary during the actual construction phase. Planning the site should alert the designer to potential problems and their appropriate solutions. Several factors that must be considered during the site planning stage are 1) climate data, 2) soil characteristics, 3) site topography, 4) existing vegetation, and 5) construction timing. Erosion damage by rainfall and wind is greatest when the site soils have been disturbed. Therefore, the need for temporary measures is more acute during the active construction phase.

Common control measures can generally be divided into two basic areas: 1) vegetative and 2) structural. These measures can be used in a temporary or permanent manner and often are used in combination. Some of the vegetative control measures are:

1. Fast growing annual grasses to temporarily stabilize slopes and later worked into the soil preceding permanent planting, and

2. Application of mulches which can either be worked into the soil or overseeded with permanent plantings.

Some of the structural control measures are:

1. Diversions consisting of channels, ditches, or dikes constructed across sloping surfaces designed to intercept surface runoff before velocities and quantities reach damaging proportions. Often on relatively flat slopes discing will accomplish the required protection.
2. Bench terraces can be effectively used on larger project sites and often are incorporated into the final grading plan, thereby providing protection in both a temporary and permanent manner.

3. Bank erosion protection designed to reduce the erosive power of water moving along the bank line.

4. Sediment basins designed to intercept and impound sediment-laden water with controlled overflow. Depending upon its useful life, the basin can be either mechanically cleaned or sized to provide storage until permanent controls are available.

**Summary**

As an illustration of many of the foregoing features, consider the conditions of a project now underway in the Hillsboro, Oregon area where control measures have been incorporated in the project design to minimize the pollution impact on adjacent waterways.

The project covers approximately 20 acres of previously pastured and forested lands with soils generally noncohesive fine-grained silts and sands. Slopes vary from slight to moderate. Ground water ranges from approximately 6 to 16 feet deep and much of the excavation requires dewatering by deep wells or well points. The site is bounded on two sides by Rock Creek and the Tualatin River. Two creek crossings and one river outfall are required. The maximum working force is expected to number approximately 125.

Due to phasing of the construction, large cleared areas would be exposed to winter rains for at least one season.

Regulatory agencies expected to be involved in the project are:

1. Department of Environmental Quality,
2. Washington County Planning Department,
3. Washington County Building Department,
4. Corps of Engineers,
5. Division of State Lands, and
6. State Department of Forestry.

Specific discharge parameters were established by DEQ in Tualatin River Basin Water Quality Standards.

The following describes control measures implemented on the project to meet the established DEQ requirements:

1. Sediments--Waterborne

   --Cleared areas were disced along the slope contour lines and straw mulch was applied to moderate slopes.

   --Sediment ponds with controlled overflow were constructed to intercept surface drainage and water from dewatering systems. Drainage ditches and temporary storm drain piping carried intercepted flows to the ponds.
--Waste materials and spoil, particularly wet materials unsuitable for backfill, are disposed of in a spoil area above the 100-year flood plain and temporarily stored behind dikes for drying prior to final grading and seeding.

--All disturbed stream and river banks to be protected by riprap or vegetation.

--Cover over the river outfall to be a minimum of 3 feet of sand and rock riprap.

--Excavation in waterways to be performed during specific seasonal limits.

--Bentonite materials used in certain phases of the construction to be disposed of in the spoil area.

2. Sediments--Airborne

--Dust control on all traveled areas by watering.

3. Domestic Wastes

--Due to the characteristics of the site soils subsurface disposal of domestic wastes was not possible. Further, due to recent OSHA requirements rather elaborate sanitary facilities are required at the site. An alternate method for disposal was accepted by the regulatory agency wherein holding tanks are provided and the waste is trucked to nearby treatment facilities.

4. Miscellaneous Pollutants

--The project contractors are required to allow no contaminants such as petroleum products, form oils, concrete spills and washdowns, or other toxic materials to enter the adjacent waterways. Equipment, if operated with the waterways, is to be inspected for petroleum contaminants.

Pollution control measures for this project, although far from sophisticated, conceivably will prevent the entrance of approximately 400 tons of sediment pollutants into the adjacent waterways during the construction phase. It is estimated that the temporary control measures represent a construction cost of approximately $12,000, certainly a small price to pay for the construction of a $19 million project designed to provide a high degree of waste treatment for the Beaverton-Rock Creek drainage basin.
Before beginning a discussion on the management of non-point source pollution, one should make the distinction between a non-point and a point source of pollution. Point source pollutants basically are those being discharged from discernable, confined, discrete conveyances. Discharges from these sources are illegal unless authorized by a permit issued by a state or EPA pursuant to Section 402 of the Federal Water Pollution Control Act Amendments of 1972 (FWPCA). Sources other than these are called non-point sources, and they are those which enter surface and groundwater by diffuse pathways. They are commonly associated with land use and water management activities rather than municipal and industrial processing operations.

**NON-POINT SOURCE CATEGORIES**

Let us begin by reviewing categories of activities that are generally considered to be non-point sources of water pollution.

1. Silviculture--i.e., man's activity in growing and harvesting timber for lumber and paper production. The principal source of man-caused sediment in silviculture is the construction and utilization of logging roads. In Oregon alone there are over 110,000 miles of logging roads on state and federal lands.

2. Agriculture--a) irrigation, b) dry land farming, c) grazing.

3. Mining--a) open pit and strip mining, b) abandoned mines and mine tailings.

4. Construction--a) construction of roads, b) construction of urban and suburban buildings and facilities.

5. Salt water intrusion--
a. Sea water intrusion in coastal aquifers -- where coastal groundwater aquifers are over-pumped for municipal or domestic water supply the reversal or reduction of fresh water flow seaward allows the heavier saline water to advance inward under the lens of fresh groundwater. Because of the high salt content of sea water, as little as 2% of it mixed with the fresh groundwater can make that portion of the coastal aquifer unusable in relation to the U.S. Public Health Service drinking water standards for total dissolved solids. Only a small amount of sea water intrusion can have serious implications regarding the future use of an aquifer as a water supply source.

b. Upstream encroachment of sea water -- the position of the interface between fresh water and sea water in a coastal river estuary is dependent on channel geometry, river discharge, and the height of high tide. Changing any of these parameters may cause the salt water-fresh water interface to move upstream or downstream. The resulting shift in salinity level at various points in the estuary can render habitats unsuitable for the native populations of fish and wildlife.

c. Intrusion in inland aquifers -- most of the nation's largest inland sources of fresh groundwater are in close proximity to natural bodies of saline groundwater. Any inter-aquifer transfers of saline water or even of the fresh groundwater can result in a net movement or change in the balance between the bodies of water, resulting in potential contamination of the fresh water system. Because of the relatively slow movement of groundwater any saline water intrusion may produce detrimental effects on groundwater quality that can persist for months or years after the intrusion has ceased.

6. Subsurface excavations--a) wells: industrial and municipal injection wells and industrial production wells, b) municipal and industrial waste treatment lagoons, c) septic tanks and drainfields, d) landfills, e) sewer leakage, f) storage tank and processed pipeline leakage.

7. Hydrologic modification--i.e., pollution resulting from changes in the movement, flow, or circulation of surface or groundwaters, including changes caused by dams, levees, channels, or flow diversions.

8. Urban Runoff--a) storm sewers, b) surface runoff.

NON-POINT SOURCE POLLUTANTS

Now let us review the categories of pollutants that typically are generated by the sources we have just listed. Many of the pollutants are also common to point sources; however, there are several that are unique to non-point sources. Non-point source pollutants include sediment and increased turbidity, heavy metals, temperature increases, pesticides, fertilizers, algal
nutrients such as nitrogen and phosphorus, increased biochemical oxygen demand, dissolved oxygen depletions, build up of total dissolved solids, oil and grease (commonly from urban runoff), suspended solids and particulate matter, bacteria (including possible pathogens), total dissolved gas supersaturation, and direct impacts on stream uses.

The last item, direct impacts on stream uses, is often not adequately considered in water quality control programs so I would like to illustrate one direct impact that is particularly important in the Pacific Northwest.

Juvenile anadromous salmon and steelhead fish migrating downstream in the Columbia and Snake Rivers often pass through the power turbine wheels at several hydroelectric dams before reaching their final destination—the Pacific Ocean. Many fish are killed outright in passing through these turbines and others are injured or stunned and left vulnerable to intensive predation by other species of fish. This, coupled with gas bubble disease caused by high dissolved gas levels in the spillway discharge and the altered migratory rates caused by the impoundments behind the dams, is seriously affecting the ability of these important species of fish to perpetuate themselves.

To impress ourselves with the magnitude and significance of these effects on northwest fish populations we need only review the results of studies conducted by the National Marine Fisheries Service on salmon and steelhead migrating through the Columbia and Snake River systems. In 1966 the number of adult chinook salmon returning to the Snake River was approximately 4% of the known population of juvenile chinook which earlier migrated downstream in that year class. In 1972 the percentage of adult returns had dropped to 0.8%. This represents approximately an 80% decline in the percentage of returning adults. In 1966 the percentage of adult steelhead returning to the Snake River was approximately 5% of the known population of juvenile steelhead. By 1972 the percentage return had dropped to 1%, again an 80% decline in return percentage. Subsequent analysis of the river conditions during the period of these declines revealed that the decline was caused by three primary factors.

The primary causes of the decline in survival of the fish were found to be 1) the passage of the fish through the turbines of hydroelectric dams on the Snake and Columbia Rivers, 2) the high levels of dissolved gas supersaturation and resulting gas-bubble disease, and 3) delays in the rate and timing of the migration of the fish up and down the rivers (anadromous fish moving downstream move about one-third as fast through impounded areas of the river as they did through the original free-flowing reaches). During low flow years Chinook and Steelhead migrating from the Salmon River to the ocean now take 78 days to reach their destination—approximately 40 days later than they did before the dams were constructed. Because the life cycle of an anadromous is precisely tuned to specific environmental patterns, the effect of a delay of this magnitude can be deadly. This is just one example of the type of adverse impact on stream uses which can result from non-point source types of pollution—in this case man's management of a major river system.

CONTROLS OVER NON-POINT SOURCES

Some types of activities have been difficult to categorize as point source or non-point source. Over the past few years EPA has determined that certain types of activities which were traditionally thought of as non-point
sources should actually be classified as point sources. For sources categorized as such, the regulatory controls derive from the national pollutant discharge elimination system (NPDES).

One such category is concentrated animal feeding. Feedlots with over 1,000 animal units (one animal unit is equivalent to one 1,000 lb steer) are required to apply for a waste discharge permit. These permits allow no discharge to navigable waters of any runoff from the feedlot during any rainfall event less than a twenty-five year frequency-twenty-four hour storm. Feedlots with three hundred to a thousand animal units must also apply for a permit if they have a man-made discharge to navigable waters or if a stream passes through or around the facilities and animals can be in contact with the stream. Feedlots under three hundred animal units must apply for a permit if the State or EPA determines, after a site inspection, that there is a water quality problem associated with the facility.

Agriculture is another category of source for which certain types of operations are controlled through NPDES permits. In this case irrigation return flow is defined as surface water runoff resulting from the controlled application of water by any person to land for crops, forage growth or nursery operations. As a result of a recent court opinion, new regulations were published by EPA which require permits for any irrigation return flows. The conditions and procedures for the permit will be proposed in the Federal Register by October 1976.

A third category which has been brought partially under NPDES is that of runoff from urban and suburban areas. Final regulations were published on March 18, 1976 which require an NPDES permit for discharges from storm sewers which are found to be significant contributors of pollution. The conditions and procedures for the permit will be proposed in the Federal Register by October 1976.

Similarly, in the area of silviculture, regulations were proposed in February of this year and finalized on June 18, which brought portions of that activity under NPDES. Under these regulations gravel crushing and washing and log storage and handling are held to be point sources subject to permit. Other activities related to logging and silviculture are considered non-point sources.

A final category which may appear to some as a non-point source has been determined by EPA to be a point source. This is the category of combined sewer overflows -- that is, overflows into navigable waters from sewers which receive a combination of municipal sewage and stormwater runoff. Each of these overflows must be covered by an NPDES permit. These sources are generally covered as part of the permit issued to a municipality for its municipal treatment system discharge. The permit may or may not require secondary treatment for the overflows, depending on their pollutional impact. The permits that have been written to date generally require that the municipality be on a time schedule to assess alternative ways of eliminating the overflows from the combined sewer portions of its collection system.

In several of these categories the concept of a general permit has been alluded to and will probably be incorporated into subsequent regulations which set forth the conditions and procedures for the point source aspects of each of these categories. The general effect of these permits will be to put
the responsibility for developing the actual permit requirements and discharge controls for the point source portions back in the hands of state and local agencies. In other words, the permit will require an assessment of ways of controlling pollution from the source and then require state and local agencies to come up with the control systems which will accomplish that objective. The "208 Program", which I will discuss later, offers a means of carrying this out.

ELEMENTS OF A NON-POINT SOURCE REGULATORY PROGRAM

I have just discussed ways in which an established national program (NPDES) applies to certain point source elements of pollution activity which have heretofore been regarded as non-point sources. I will now discuss some of the matters which a management or regulatory agency must consider in developing control programs for the remaining types of non-point source pollution activity.

The first thing that must be developed, of course, is a technical solution to the problem. In other words an agency must determine for a particular water quality problem the way in which man's activity must be altered or stopped to abate the problem. Once this is done a regulatory or incentive program can be developed and implemented to bring about the desired change. The following essential elements must be included in any regulatory or incentive program which an agency might develop to control a particular non-point source of pollution.

1. A clear statement of the conditions to which the regulation applies;
2. A clear indication of the parties affected by the regulations;
3. The timing of the regulations, notice of hearings prior to their adoption;
4. The form of the regulation, i.e., a) activity permit, b) land use control, c) zoning, d) building code, e) ordinance, f) new law, g) licenses, h) standards;
5. The legal authority for the regulation;
6. The agency responsible for implementing the regulation;
7. The enforcement devices to be used, such as fines, assessments, criminal and civil penalties;
8. A monitoring or inspection program to assess compliance;
9. A financial program to support the agency's activities in carrying out the regulatory program; and
10. Administrative arrangements, such as relationships with other agencies for monitoring and inspection, leveling of penalties, or provision of financial assistance.
REGULATORY CONSTRAINTS

Any agency planning new regulatory programs should be alert to several limitations on regulatory powers during the assignment of regulatory functions to various agencies:

1. The Limited Use of Implied Powers

   It may sometimes appear that regulatory power is "implied" in the existing authority of an agency or in its delegated authority of powers derived from inter-governmental agreements. As a rule, it is better to obtain the necessary regulatory powers in some explicit form rather than depending upon "implied" authority. Implied powers are subject to widely divergent interpretations and limitations by courts across the nation and hence may be open to considerable challenge and protracted litigation. Much of this may be prevented through the creation of a clear, explicit grant of authority to the agencies involved.

2. The Test of Reasonableness

   Any regulatory actions are subject to the common test of reasonableness in the courts. In general, this means that the regulatory actions must not appear to be arbitrary or capricious, must be generally related to some accepted power of government, and must seem relevant to the intent of the regulatory process. While the "reasonableness" of any regulatory action may be subject to differing judicial interpretations, planners should seek to prevent any obvious violation of the reasonableness test and should attempt to anticipate any challenges of this kind in creating a regulatory procedure.

3. Due Process

   All regulatory programs must provide due process in their application to regulated interests. An individual to which the regulation applies must be provided with adequate notice of the application of the regulation to his activity and he must also be furnished the right of appeal to higher authorities.

4. The "Taking Issue"

   When pollution regulation involves restriction upon land use, the "taking issue" may arise. In recent years, courts have been increasingly confronted by property owners asserting that a governmental restriction upon their land use, particularly when imposed in the interest of environmental protection or environmental amenities, constitutes a violation of the Fifth Amendment provision that private property shall not "be taken for public use without just compensation". This issue is likely to arise especially when regulations restrict the most economically advantageous use of the land. The courts have devised very diverse rules for deciding when government may properly restrict land use and when such restriction is confiscatory.

   It may be possible to avoid the "taking issue" if regulatory measures are carefully drafted and applied with these constitutional limitations in mind. In general, the courts are more likely to hold that a regulatory program is not confiscatory when: a) the law is drafted with the explicit legislative intent to serve a major public purpose such as the protection of public health and
safety, the preservation of water quality or other major public goals; b) there are statutory standards defining the limits and conditions of regulation; c) there is a careful enumeration of permitted uses under the law; and d) data exists to provide reasonable justification for the regulation.

5. The "Equal Protection" Issue

Regulatory measures applied to all pollution sources within an area must be formulated in such a manner that the distinction between those regulated and unregulated, and between classes of regulated activities, satisfy judicial standards for equal protection under the law as required by the 14th Amendment of the Constitution. This means, in general, that a) classifications must be based upon reasonable and distinct characteristics that distinguish between classes of activities; b) the law must apply equally to all activities in similar circumstances; and c) the classification must bear a clear relation to the purpose of the law.

208 PROGRAM - AREAWIDE WATER QUALITY MANAGEMENT

I would like now to discuss a program which I feel addresses many of the non-point source control programs and concepts I have mentioned. This program is called Areawide Water Quality Management and it was established under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (FWPCAA). We usually refer to it as the "208 Program".

The 208 program has become one of EPA's top priority activities. There are three basic reasons for this:

1. Analysis of water quality data has revealed that after pollution from point sources is reduced to the levels required in the FWPCAA, the nation will still experience severe water quality problems, due primarily to non-point sources. Section 208 of the Act is the only section which sets forth a program which can deal with these non-point sources.

2. Section 208 allows entities of state and local government to plan and manage the solutions to their own water quality control programs. As such it allows local agencies to determine which problems should receive priority attention and then to develop financial and regulatory programs which are best suited to local circumstances. It thus represents a move on the part of the Federal Government to decentralize some of its authority in one area of water pollution control.

3. The 208 program requires that the affected "public" be substantively involved in each step of the development of control programs. The "public" refers to private individuals, special interest groups such as environmental and trade organizations, local elected officials, other interested agencies, and special organizations such as granges, water-user associations, conservation districts, irrigation districts, and sewer districts. Because of the involvement in the development of the plan by those most affected by it, there is a much greater likelihood that the proposed controls will eventually be implemented.
As I mentioned earlier, some of the point source pollution categories for agriculture, urban runoff, and silviculture will be covered by general NPDES permits. It is intended that the actual control programs will be developed by state and local 208 agencies. Thus non-point source coverage by the 208 program is fairly complete.

Another important aspect of the 208 program is that it will attempt to utilize to the fullest extent possible existing agencies and institutions to control non-point sources. The 208 agencies will seek to expand the authorities and capabilities of existing agencies rather than propose entirely new ones. Some sources can be brought under control by adding provisions to existing permit or licensing programs, thus avoiding the expense of setting up new regulatory and enforcement functions.

**Background**

With the passage of the Federal Water Pollution Control Act Amendments of 1972 the Governor of each state was required to identify areas within the state with substantial water quality problems caused by complex urban and industrial sources, or other factors, and then to designate agencies to develop a water quality management plan for each area. States were required to perform a comparable level of planning for the remainder of the state outside the designated areas. In 1975 ten local areas in this region were designated by Governors as 208 areas. They are shown on the attached map. In 1976 an additional local area was designated—Anchorage, Alaska. To date approximately $11 million in Federal grants have been awarded to these eleven local agencies and the four states in the Northwest Region (Idaho, Oregon, Washington, and Alaska) to fund the development of water quality management plans within approximately a two year period.

**New Emphasis**

The basic 208 planning process is similar to any traditional planning process. It seeks to identify water quality problems, develop proposed technical solutions, and develop mechanisms for implementing the solutions. But at this point it departs radically from previous planning efforts. It requires that regulatory programs be established and that the necessary agency(ies) be designated by the Governor to carry out the management or regulatory function. The 208 plans are to be certified annually by the Governor and are to be the basis for water quality and waste treatment management decisions by local agencies, the state, and EPA. The program also contains a continuation feature which allows the planning agency to continue to upgrade and revise the plans after the initial two-year period.

A second new emphasis of the 208 program is, as I mentioned earlier, that it addresses the control of non-point sources, including groundwater pollution.

It also requires that land use controls be considered and used if appropriate to more effectively or economically abate pollution problems.
The program requires that an environmental assessment be performed which identifies the possible impact that implementing the 208 plan may have on other aspects of the environment.

Finally, the program requires that the public be involved in every stage of development of the 208 plan, from the work plan step to adoption of the final plan. This means that citizens, special interest groups, elected officials, and other affected agencies or groups must be involved in the planning process. It thus is not a process which endeavors to produce a plan at the end of two years and then present it to decision makers in the hope of adoption. Rather, it requires that the decision-making public be involved from the beginning of the planning so as to assure that their participation will influence the direction of the planning and thus increase the certainty of eventual adoption and implementation.

Present Status

Nationwide, approximately $216 million have been granted to state and local 208 agencies. Work plans for ten local agencies in the Northwest (see map) have been completed and approved by EPA. Work plans for the four Northwest states are due to be completed by September 1, 1976. A work plan for Anchorage is due by October 1, 1976. Between July 1, 1977 and April 1, 1978, the first ten local agencies will complete their initial 208 plans. Anchorage and the four states must have their plans completed by November 1, 1978. Again I want to emphasize that by these dates we are expecting more than just plans. We are expecting portions of control programs (i.e., regulations, ordinances, new laws) to be in place and operating to abate portions of the targeted water quality problems.

Example 208 Programs in the Northwest

The following examples will illustrate the types of problems being addressed by 208 agencies in the Northwest and generally the types of control programs we expect to see by the end of the initial two-year planning period.

Vancouver, Washington -- Burnt Bridge Creek, the main source of water to Vancouver Lake, flows through the urbanized area of Vancouver. In its course it receives runoff laden with silt and other urban pollutants. As a result, Vancouver Lake is polluted and its bottom is covered with a heavy layer of silt, making it unsuitable for swimming and other forms of recreation. The Regional Planning Council of Clark County will use their 208 grant to develop a program to rehabilitate and preserve the lake for recreation use. They will develop a system for dredging the lake and disposing of the spoil material, design a flushing channel from the Columbia River, and develop the structural and non-structural measures necessary to control the runoff of pollutants from the city into the Lake's main feeder stream -- Burnt Bridge Creek. At the end of the initial 2 year period, we expect that some of the dredging will have begun and the financial and management program for the remaining facilities will be established.
Panhandle, Northern Idaho -- The primary concerns in this area are preservation of several high quality lakes and protection of the Rathdrum Prairie Groundwater Aquifer -- the main source of drinking water for Northern Idaho and the Spokane area of Washington. Here we expect to see ordinances and permit programs to control pollution from boats and shore facilities around the lakes, and the creation of sewer districts to eventually provide sewer service to areas around the lakes where septic tank failures are causing pollution. There will also be a regulatory program to ensure that septic tanks on lands overlying the Rathdrum Aquifer are limited where necessary to prevent further groundwater pollution. If it is found that new septic tanks must not be allowed in certain areas, the 208 study will propose alternative waste disposal systems which will afford more protection of the groundwater aquifer.

These are but two examples of the types of programs being carried out by the four state agencies and eleven local 208 agencies in Region X. Other pollution problems typically being addressed by these agencies are agricultural runoff, silviculture, dairy farming, urban runoff, municipal regional sewerage systems, flow management, phosphate mining, pre-treatment of industrial waste before discharge to a municipal treatment system, sediment from construction activities, and disposal practices for municipal and industrial sludges.

We in EPA are viewing the 208 program as a new experiment in government where local agencies, with the help of interested citizens and other groups, are being allowed to develop and implement their own solutions to local water quality control problems. If the local agencies are successful and achieve at least partial implementation of their programs, we feel that additional funds will be forthcoming from Congress and that decentralization of other programs such as air quality, solid waste, pesticides and radiation will probably follow. If, on the other hand, the local agencies do not achieve their goals and instead produce ineffective paper plans, it is likely that these programs will be further centralized to higher levels of government through passage of new Federal laws and regulations. We hope this does not happen because solutions worked out at local levels are generally less expensive and more compatible with established local practices and administrative procedures.

REFERENCES


FEDERAL REGISTER REFERENCES


