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HIGHWAY AND AGRICULTURAL DRAINAGE PRACTICES

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ABSTRACT

THE PRINCIPLES AND PRACTICES OF THE DIVISION OF HIGHWAYS IN THE TREATMENT OF INTERRELATED HIGHWAY AND AGRICULTURAL DRAINAGE AND EROSION CONTROL HAVE BEEN DEVELOPED OVER A PERIOD OF MANY YEARS. MUCH OF THIS INFORMATION, HOWEVER, IS NOT AVAILABLE IN A SINGLE SOURCE. THE PURPOSE OF THIS STUDY WAS THEREFORE TO ASSEMBLE AND ANALYZE DATA RELATING TO THE PRACTICES AND PROCEDURES FOLLOWED BY HIGHWAY AUTHORITIES IN CONTROLLING HIGHWAY AND AGRICULTURAL DRAINAGE WATERS.

INFORMATION CONTAINED IN THIS REPORT WAS COLLECTED FROM HIGHWAY AUTHORITIES, GOVERNMENTAL AGENCIES, CONSULTANTS, AND PRIVATE INDIVIDUALS LOCATED BOTH IN ILLINOIS AND IN OTHER STATES. EMPHASIS WAS PLACED ON DRAINAGE PRACTICES AND PROCEDURES RATHER THAN ON DESIGN DETAILS. THE RESUMÉ OF THE PRACTICES FOLLOWED BY HIGHWAY AUTHORITIES AND OTHERS TOGETHER WITH THE COMPILATION OF THE DRAINAGE LAWS CAN PROVIDE HIGHWAY AND AGRICULTURAL ADMINISTRATORS WITH AN IMPORTANT TOOL TO ASSIST IN THE ESTABLISHMENT OF SOUND DRAINAGE POLICIES.
ACKNOWLEDGMENTS

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GLOSSARY OF TERMS

ALIGNMENT - The horizontal direction of a road, ditch, or other structure as shown on a plan view.

APPLICANT - A person or firm making application for a permit.

ARTIFICIAL WATERCOURSE - A watercourse generally owing its origin to acts of man. Examples are canals, drainage ditches, and subsurface drains.


BORROW PIT - A location where fill material may be or has been excavated.

BRIDGE - A bridge is a structure erected on foundations, piers, or abutments over a depression or an obstacle as over a river, roadway, or railroad, carrying a roadway for vehicular and pedestrian traffic and providing an opening of usually over 20 feet between bearings.

COMMON LAW - The body of principles which develop from immemorial usage and custom and which receive judicial recognition and sanction through repeated application. These principles develop independently of any legislative act and are embodied in the decisions of the courts.

CONTRACT - An agreement to do, or refrain from doing, a certain thing. Consideration, legal subject matter, competent parties, and a meeting of the minds of the parties must all be present.

CULVERT - A drainage structure having a tubular or box-type cross section with an opening of 20 feet or less in width and providing an enclosed channel for either lateral or transverse drainage beneath a roadway. The smaller culverts are usually corrugated metal pipes or concrete pipes with or without headwalls.

DEPARTMENT - The Department of Public Works and Buildings, of the State of Illinois, acting directly or through its duly authorized officers and agents.

DITCH - An artificially constructed open drain or a natural drain which has been artificially improved.

DITCH CHECK - A structure, usually made of timbers or stone, placed in a watercourse to retard the flow of the water, thereby reducing erosion. Ditch checks may be used individually or in series.

DIVERSION - The deflection of surface waters or stream waters so that they discharge into a watercourse to which they are not naturally tributary.

DIVIDE - The watershed or height-of-land from which the heads of streams or run-off waters flow in opposite directions.

DOMINANT LAND - Property so situated that its owners have rights on adjacent property, such as a right of natural drainage.

DRAIN - A ditch and any watercourse or conduit, whether open, covered, or enclosed, natural or artificial, or partly natural and partly artificial, by which waters coming or falling upon lands are carried away.

DRAINAGE - A general term applied to the removal of surface or ground water from a given area either by gravity or by pumping.

DRAINAGE AREA - The area from which water occurring at a given point or location on a stream originates.
DRAINAGE COEFFICIENT - The depth of water to be removed from the drainage area in a unit of time. Units are commonly inches of water in 24 hours, and the drainage coefficient is usually referred to simply as "inches."

DRAINAGE STRUCTURES - Those structures other than drains, levees, and pumping plants which are intended to promote or aid drainage. Such structures may be independent of other drainage work or may be part of or incidental to such work. The term includes, but is not restricted to, catch-basins, bulk-heads, spillways, flumes, drop-boxes, pipe outlets, junction boxes, and structures, the primary purpose of which is to prevent the erosion of soil into a drain.

DRAINAGE SYSTEM - The system by which lands are drained or protected from overflow, or both, which includes drains, drainage structures, levees, and pumping plants.

EASEMENT - An interest in the land of another which gives to the owner of the easement a right to use the other's land for special purposes not inconsistent with the general property rights of the other, for example, the right to the flow of water across a neighbor's land.

EFFLUENT - A liquid which flows out of a containing space; sewage, water, or other liquid, partially or completely treated, or in its natural state, as the case may be, flowing out of a reservoir, basin, or treatment plant, or part thereof; an overflowing branch of a main stream or lake; a stream fed by groundwater.

ELEVATION - Altitude; height in relation to sea level or any assumed datum.

EMINENT DOMAIN - The power of the state to take private property for public use.

EROSION - Wearing away of land surface by running water, wind, or other geological agents.

EXCAVATION - The act of taking out materials, the materials taken out, or the cavity remaining after materials have been removed.

FEE SIMPLE - The unqualified ownership of land.

FILL SECTION - That part of the roadway which, when constructed, is higher in elevation than the original ground.

FLOW LINE - The bed of a stream or culvert.

FLUME - A surfaced apron or trough for conducting water down a relatively steep slope.

FREE WATER - Water which can move through the soil by force of gravity.

HEADWALL - A vertical wall, usually of concrete, at the end of a culvert to prevent earth from spilling into the channel.

HIGHWAY - Any public way for vehicular travel which has been laid out in pursuance of any law of this state or of the territory of Illinois, or which has been established by dedication or used by the public as a highway for 15 years, or which has been or may be laid out and connects a subdivision or plotted land with a public highway and which has been dedicated for the use of the owners of the land included in the subdivision or plotted land where there has been an acceptance and use under such dedication by such owners, and which has not been vacated in pursuance of law. The term highway includes rights-of-way, bridges, drainage structures, signs, guardrails, protective structures, and all other structures and appurtenances necessary or convenient for vehicular traffic. A highway in a rural area may be called a road, while a highway in a municipal area may be called a street.

HIGHWAY AUTHORITY - The department with respect to a state highway; the county board with respect to a county highway or a county unit district road if a discretionary function is involved and the county superintendent of highways if a ministerial function is involved; the highway commissioner with respect to a township or district road not in a county unit road district; or the corporate authorities of a municipality with respect to a municipal street.

INVERT - The floor, bottom, or lowest portion of the internal cross section of a conduit.

LANDOWNER - The owner of real property, including an owner of an undivided interest, a life tenant, a remainderman,
and a trustee under an active trust, but not including a mortgagee, a trustee under a trust deed in the nature of a mortgage, a lien holder, or a lessee.

MAINTENANCE - The preserving and keeping of each type of roadway, roadside, structure and facility as nearly as possible in its original condition as constructed, or as later improved.

MULCH - Any organic matter such as leaves, straw, etc., used to protect plant material and surface soil from heat, cold, and erosion, and to conserve water.

NATURAL WATERCOURSE - If the configuration of land is such that it gives water a fixed and determinate course and discharges it uniformly upon the servient tract as a fixed and definite point, the course followed by the water in its flow is a watercourse.

PLANS - Approved drawings or reproductions of drawings pertaining to the construction or details of the work.

RIGHT-OF-WAY - The entire area reserved for the construction and maintenance of the roadway and the improvement of the roadsides.

RIGHT-OF-WAY PLAN - A number of right-of-way plats indicating all right-of-way in one particular section.

RIGHT-OF-WAY PLAT - A drawing of a tract of right-of-way to be acquired from property owners which indicates location, width, length, acreage, and legal description of said tract.

RIPRAP - A protective covering of stones, with or without mortar, on an earth bed.

RUNOFF - The surface discharge or rate of discharge of a given watershed after a fall of rain or snow.

SERVIENT LAND - If two adjoining pieces of land are so situated that one piece is at a lower elevation than the other, the lower piece of land is considered to be servient.

SEWAGE - Largely the water supply of a community after it has been fouled by various uses. From the standpoint of source it may be a combination of the liquor or water-carried wastes from residences, business buildings, and institutions, together with those from industrial establishments, and with such ground water, surface water, and storm water as may be present.

SIDE DITCH - A highway side ditch is an open channel located adjacent to and within the limits of the highway right-of-way.

SKEW - The angle a stream or structure makes with a line perpendicular to the roadway.

SPECIFICATIONS - The standard specifications, supplemental specifications, special provisions, and all written or printed agreements and instructions pertaining to the method and manner of performing the work or to the quantities and qualities of the materials to be furnished under the contract.

STATUTORY LAW - Laws enacted by the General Assembly to either enlarge or change the common law.

SUBSURFACE DRAINAGE - Collection and removal of underground water.

SURFACE DRAINAGE - Collection and removal of water from the surface of the road and the ground.

SURFACE WATER - Waters which fall on the land from the skies or arise in springs and diffuse themselves over the surface of the ground, following no defined course or channel and not gathering into or forming any more definite body of water than a mere bog or marsh, and are lost by being diffused over the ground through percolation, evaporation, or natural drainage.

VEGETAL COVER - A continuous growth of grass, legumes, vines, shrubs, or other plants which protect surface soil from washing or blowing away.

WATERSHED - The area contained within a divide above a specific point on a stream.
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I. INTRODUCTION

Drainage and erosion control are important in the design, construction, and maintenance of highways and in the management of agricultural lands. They are essential both to the proper functioning of a highway system and to the production of crops on agricultural land. During the early settlement of the United States, there was little need for regulatory measures because of the vast amount of available land. However, as areas became more intensively inhabited and land open for expansion diminished, it became necessary to settle and develop the poorly drained lands. As a result, drainage systems were planned and constructed and disagreements arose regarding drainage rights. It soon became apparent that drainage rules and laws had to be established if poorly drained land was to be utilized.

As the land was occupied, highways and railroads were constructed to meet transportation needs. Modern transportation facilities required improved highway alignments, widening of rights-of-way, and changing of grades. Construction of roads on new rights-of-way required bridges, culverts, drains, borrow pits, channels, and other facilities. This construction tended to place barriers across natural and artificial drainage systems and required the rebuilding and relocating of many drains. In areas where there was greater relief in the topography, problems of erosion and sedimentation arose from changes in slopes, discharge of water, and minor diversions of runoff.

Wherever agricultural lands are crossed by highway facilities, interrelationships develop in the area of drainage that may become very complex. The purpose of agricultural drainage is to remove free surface and subsurface water to create favorable soil conditions for plant growth. Highway drainage systems are designed to remove surface and subsurface water that collects within the limits of the highway right-of-way and not to interfere with the continued functioning of adjacent agricultural drainage systems.

Agricultural and highway drainage practices and erosion control measures followed by the various parties affect not only themselves, but each other. The practices employed by one party are sometimes beneficial and sometimes detrimental to the other. Consequently, the interrelationships of drainage are broad in scope and each party has obligations that must be met. The highway authority has a responsibility to the public to construct highway systems that will satisfy the demands for transportation and a responsibility to the land-
owners to permit the intercepted drainage systems to function at the same level as prior to construction of the highway. The highway authority, however, is not responsible for improving agricultural drainage systems or for protecting adjacent properties from flooding or erosion that occurred prior to the construction. The landowner is responsible for abiding by the rules of drainage, using good conservation practices, and following procedures that will not be detrimental to the highway authority or other landowners.

In general, each drainage problem must be resolved on the basis of its merits. A moral as well as a legal obligation exists on the part of all interested parties, and engineering and legal judgment plays an important role in the satisfactory solutions of such problems. The policies and practices of the highway authority have developed over a period of years. The criteria used as a basis for establishing drainage procedures are based on information gathered from previous experiences, engineering skills, understanding of the implications of drainage law, etc. Many of these criteria have been accepted only after considerable use and experience. This information, however, is not always readily available for use.

To supply the need for more accessible data on drainage, a cooperative study was initiated by the Illinois Division of Highways, the U.S. Bureau of Public Roads, and the University of Illinois. The objectives were twofold: (1) to assemble into one source the laws pertaining to highway and agricultural drainage and (2) to analyze the practices followed by the highway authority and others in meeting the requirements of the law.

The first objective has been completed and the results have been published. The purpose of this report is to fulfill the requirements of the second objective. In a study of this type, it is necessary to investigate general rather than specific problems, since they vary both within and between states. The approach therefore was to identify major areas of interest and then to indicate general techniques for finding a satisfactory solution.

The information in this report was gathered from Illinois as well as from other states. A letter inquiring about the problems that had been encountered and the practices used in solving them was sent to all state highway agencies in the United States. Extensive correspondence was also carried on with various governmental agencies, consulting firms, educational institutions, and others interested in highway and agricultural drainage problems. Finally, various drainage problem areas were reviewed with Illinois Division of Highway engineers. The information from these different sources was then analyzed and assembled.

A number of states indicated that they did not have printed policy statements on the subject of drainage but relied on engineering judgment and experience, with special emphasis on

perpetuating the existing drainage system. Some of the practices included here are recommended by various highway authorities and other groups, while others are not considered to meet all requirements. It has of course not been possible to include all practices, but the general areas have been outlined in some detail.
II. BASIC RESPONSIBILITIES

A. RIGHTS OF DRAINAGE*

The basic rights of drainage have been established in the form of common and statutory drainage law. Common law is a body of principles that develops from use and custom and that receives judicial recognition and sanction through repeated application. This body of law makes up a large and important segment of drainage law, since it applies to adjoining areas having enough difference in elevation to drain naturally. Statutory drainage laws are enacted by legislative bodies and apply to areas where natural drainage rules do not apply. Rights that are applicable to both the highway authority and adjoining landowners have been established under each of these systems of laws.

B. ACCELERATION OF FLOW

1. Legal Interpretation of Illinois Provisions of the Law

Under the rules of natural drainage in Illinois, the owner of the dominant land has the right to permit surface waters to pass off through natural drains upon and over lower, or servient, lands. The question is whether the flow from the dominant land onto the servient land may be appreciably increased in either quantity or rate by improvements made in the drainage system of the upper watershed areas. The courts have established that the dominant landowner has the right to drain water by artificial drains into natural channels on his own land even if the quantity of water deposited upon the adjoining servient lands is thereby increased and the flow accelerated. There are, however, several qualifications:

1. All the lands being drained must be located within a natural basin that drains into a tributary water course draining that basin.

2. The dominant landowner is not permitted to collect and discharge onto the servient land water that would not naturally flow in that direction.

3. The dominant landowner is not permitted to collect even the water that would naturally flow toward the servient land and discharge it in a body except in a natural channel or watercourse.

b. Acceleration of water must meet the requirements of good husbandry. The term good husbandry has not been

*For more detailed information on the legal principles applying to drainage, refer to report on the legal phase of this project: Drablos, Carroll J. W., and Jones, Benjamin A., Jr., Illinois Highway and Agricultural Drainage Laws, Circular 76, University of Illinois Engineering Experiment Station, Urbana, Illinois, 1963.
clearly defined; however, it has been interpreted that any improvement in the course of bona fide farming would come within the meaning.

2. Practices Causing Acceleration of Runoff

The construction of new highway facilities and the implementation of improved farming practices upon the adjoining lands sometimes changes the natural ground surface and, as a result, changes the natural flowage of surface water. These changes may be created by either the highway authorities or the landowners, or both, and as a result there are varying degrees of effect upon the other party.

Changes in land use have in some localities caused an appreciable increase in the movement of water. Sometimes these changes have caused the surface water to move off the upper land in a shorter time and consequently at higher peak flow. Practices that contribute to accelerated flow are:

1. Increase in area of cultivable land after construction of the highway.
2. Improvements made in the natural and artificial drainage systems.
3. Drainage of ponded areas lying upon the dominant land.

Landowners have complained that the highway authority occasionally places a larger quantity of water upon their land after the highway is built than drained naturally onto the land prior to construction. The following reasons are given:

1. Construction of highways increases the impervious area, causing an increase in runoff onto the lower land.

2. The ditches provided by the highway authority allow the water to drain onto the lower land at a faster rate and at a higher peak flow.

In planning highway and agricultural improvements, it is important for highway officials, landowners, and other interested or affected parties to fully consider all of the implications on land management and highway development. It is generally agreed that careful study and planning are necessary to satisfactorily solve any problems that arise. The "Suggested Guide" states:

Close cooperation between highway officials, landowners, representatives of drainage and soil conservation districts, and other agencies involved in joint problems of land management and highway development will offer the best assurance that mutually agreeable solutions can be found for these problems. In planning highway improvements, highway officials can be expected, within the limits of the knowledge available to them, to provide for a continuation of existing land management patterns, or to provide a substitute system agreeable to the affected landowner and to the highway authorities, and to make provision for soil and water conservation and land management programs of landowners and land management agencies which have been planned and surveyed in advance of the completion of right-of-way acquisition. 

The landowner also has a responsibility not to use practices upon his land that may ultimately be detrimental to adjoining landowners, including the highway authority. In his management decisions he must consider the effects upon other landowners. Sound management of drainage waters is essential, and it is necessary that there be a continuity of management programs that will benefit all concerned.
3. Structures and Outlets Required for Accelerated Flow

Who should assume responsibility for the effects of increased peak flow caused by action of the dominant landowner is a question for lawyers and engineers. The law permits the owner of the dominant land to drain by artificial means into natural watercourses on his own land even if the quantity of water deposited upon the adjoining lower lands is thereby increased and the flow accelerated. The only limitation is that the movement of water for agricultural purposes must meet the requirements of good husbandry and natural drainage as previously defined.

The privilege of the dominant landowner to accelerate the flow of water does increase the burden of the servient landowner. Drainage facilities on the lower lands are not always adequate to handle the increased flow. The natural drainage rule, however, stipulates that it is a privilege of anyone located within a watershed to drain into the natural watercourse and the servient landowner cannot object so long as the artificial ditches constructed by the dominant owner drain only into the natural basin. The practices followed by the Illinois highway authority agree with provisions of the natural drainage rule covering acceleration.

It was stated earlier that landowners sometimes complain that highway construction increases the discharge of runoff from higher lands upon their land. This statement is true to a limited extent, since construction of a new roadway may change the land use and improve the natural channels, causing a higher peak flow and in some instances an increase in runoff from the upper land. However, the effect upon the adjoining landowner and his right to take legal action is debatable, since a justification similar to "good husbandry" would seem reasonable. If, however, improvement of the upper watershed area causes undue damage to the servient landowner, he may seek redress through the courts.

Since the highway authority and landowners are governed by the same rules, it would seem reasonable to assume that either party in the servient position must accept the increase in peak flow caused by the dominant landowner.

C. DIVERSION OF FLOW

1. Basic Considerations

Diversion may be defined as deflection of surface waters that causes them to discharge into a watercourse to which they would not naturally flow. The legal use is the unauthorized changing of a stream or drainway from its natural condition so that the water flows onto adjoining land at a location other than the point of natural entry.

The Illinois natural drainage rule provides that the owner of higher ground cannot cut through a natural divide and divert water onto lower land that it could never have reached in a natural state. If the diversion allows water to enter the premises of the lower owner at a point other than the natural entry, the courts will not tolerate this act. Besides not being allowed to remove natural barriers, the dominant landowners cannot collect
FIGURE 1. A LANDOWNER IS NOT PERMITTED TO CUT THROUGH A NATURAL DIVIDE AND DIVERT WATER FROM ONE WATERSHED TO ANOTHER

in one channel water usually flowing onto lower fields through several channels and thereby cause it to flow in excessive quantity to the detriment of the lower owner.

The principles of diversion apply to both highway authorities and individual landowners. Adjoining landowners have a right to drain their lands across or along highways provided they follow the paths of natural drainage. However, highway authorities have a right to prevent landowners from diverting water from its natural course and casting it upon the highway.

Highway authorities have the right to drain roads, but in doing so they also must not divert water from its natural course. Such action would impose an additional burden on the adjoining owner that the law will not tolerate. Under the eminent domain provisions the law does allow the highway authority to drain in other directions provided that it will benefit the public. The landowner will, under these circumstances, be compensated for damages.

2. Combined Flows

Since drainage is required in the construction and maintenance of roads, it is usually necessary to construct a longitudinal ditch adjacent to the roadbed. The purpose is to provide stable waterways for the collection of surface water and also to drain the base of the roadway. (7)

Frequently these side ditches intercept natural watercourses. A temptation may then exist for the highway authority or adjoining landowner to combine the intercepted water from several small channels into a common channel so that only one structure will be required. In this regard the Manual of Highway Construction Practices and Methods states:

In doing this, care should be taken to avoid concentrating such a large flow in one channel that it will cause severe erosion, depositing of sediment or debris, or other damage to the land beyond the culvert outlet, and to make certain the combined flow will not exceed the capacity of a corresponding structure under an adjacent railroad or highway. Also, an existing stream should not be diverted to a new channel if its continued flow in the present channel is required by law or is essential for irrigating, stock watering, or other purpose. (6)

The Illinois natural drainage rule provides that the dominant landowner cannot collect into one channel water usually flowing onto adjoining lands in several channels and thus cause it to flow in unnatural quantities. The general practice followed by highway
authorities in Illinois is therefore to refrain from connecting two or more natural drainage courses for the purpose of eliminating a culvert. Highway engineers indicate that they use crossroad structures whenever the highway intercepts natural drainage courses, regardless of their size.

The problem of combining intercepted flows from small drainage areas and then discharging the concentrated flow onto adjacent land has been encountered by highway authorities in other states. The practice that is followed generally agrees with that in Illinois, which is not to divert runoff from one watershed to another, regardless of the size of the drainage area. If there is no alternative, the rule relating to diversion may be altered by agreement with the affected lower landowners.

There are arguments for making exceptions to the natural drainage rule to combine flows from several channels: (1) It is almost physically impossible for the highway authority to construct a road or for the farmer to cultivate a field without diverting water. (2) The diversion of reasonable quantities of water by use of such practices as terracing to control erosion, diversion ditching to control gullies, and drainage of the top-of-slope ditches adjacent to highway cuts and highway side ditches is sometimes necessary. On this point the ASAE Recommendation for Design Criteria for Interrelated Highway and Agricultural Drainage and Erosion Control states:

The outletting or combining of one or more small waterways into or with a larger one, or combining several waterways to reduce the number of culverts or bridges and downstream channels, will usually be to the mutual advantage of the adjacent property owners, the highway authority, and the community. (1)

From an economic standpoint, this statement is true. However, the practice would have to be carefully used, since the servient landowner would have a valid complaint if such action caused him undue damage. At locations where several watercourses are combined, the involved parties must mutually agree on the handling of diverted water.

3. Diversion of Water Within Limits of Highway Right-of-Way

Landowners sometimes request the privilege of diverting water from dominant land onto the highway right-of-way. Some landowners believe that one of the functions of the highway side ditch is to provide for runoff from adjoining land regardless of whether the runoff is natural drainage. There is no problem if the highway ditch is located within a natural waterway, because the natural rules of drainage apply. However, if the highway ditch is located outside a natural waterway, the landowner has no right to drain into it without permission from the highway authority. The Highway Code stipulates that a landowner through or along whose land a public highway passes may drain into or along such highway provided that (1) the highway authority is given proper notice of the work that is proposed, and (2) the landowner receives written permission from the highway authority to perform the proposed work.

Several problems can develop as a result of drainage work performed by
the landowner within the limits of the highway right-of-way:

1. The landowner located in a servient position to the highway may be receiving additional water because the dominant landowner is draining into the highway right-of-way outside the course of natural drainage. Under these circumstances the landowners below the highway may have an action against the highway authority as well as against the dominant landowner.

2. The Highway Code imposes upon the respective highway authorities the duty to construct, maintain, and repair the highways within the jurisdiction of each authority. The sections imposing the duty of maintenance and repair do not expressly include drainage systems, but such systems would appear to be included within the definition of highways as contained in the Highway Code. The Illinois code has not been interpreted to determine whether drains constructed for private purposes in the highway right-of-way are included within the statutory definition of highway.

It would seem reasonable to assume, however, that the responsibility of the highway authority for maintenance and repair would not extend to such drains. However, it is possible that a maintenance problem could develop, especially if the landowner refused to provide proper maintenance.

3. Another problem that might develop is whether a ditch or drain constructed along the highway and within the right-of-way limits creates an obstruction to the highway. If an open drain were of such depth and located in such a place as to cause a hazard to the traveling public, there would be a question as to who would be responsible for providing the proper precautions, such as guard rails, etc.

Therefore, before granting permission for a landowner to drain within the limits of the right-of-way, the highway authority should consider: (1) who would be responsible for maintaining the proposed drain, (2) whether the drains would create an obstruction or hazard to the highway proper, and (3) whether the rules of natural drainage were being followed.

4. Diversion of Subsurface Water

The principles of diversion under the natural drainage rule also apply to subsurface water. In general practice, water from an existing tile main is not diverted to another tile main in a different drainage area. When such diversion cannot be avoided, the tile receiving the diverted water must be adequate in size to carry all water delivered to it, and permission must be obtained from necessary parties before connections are made.

D. OBSTRUCTION

1. Basic Law

Under the natural drainage rule in Illinois, the dominant landowner has a legal and natural easement in the servient land. The dominant landowner may discharge over the servient land all water naturally falling within a drainage area. The servient landowner takes the land with the obligation of receiving the natural flow of surface water, and he cannot interrupt or prevent such flow to the detriment or injury of the dominant landowner. However, if water is diverted from another watershed and discharged upon the ser-
vient land at a point where it does not naturally flow, the lower landowner is privileged to obstruct such flow.

2. Obstruction of Waterways upon Servient Land

The obstruction of a natural watercourse located below a highway may cause flooding within the limits of the highway right-of-way and also upon the land located above the highway. Under these circumstances the dominant landowners may request the highway authority rather than the servient landowners to remove the obstruction. Under the natural drainage rule in Illinois, if the obstruction to a natural watercourse was artificially created by the owner of the servient land, the dominant landowner may take action against him. It is not the responsibility of the highway authority to take action against the lower owner to remove the obstruction unless damage has occurred within the limits of the highway right-of-way, nor is the highway authority authorized to spend public funds for the purpose of improving private drainage.

When the obstruction is created by natural means, the duty to make repairs is generally not imposed upon the owner of the servient lands. Ordinarily the holder of a natural easement, which under the natural drainage rule is usually the dominant landowner, has the right to keep the drain on the servient land in repair and is obliged, while making the repairs, not to cause unnecessary injury to the lower land.

If the servient landowner has deliberately obstructed the natural waterway, there are statutory provisions in addition to the rules of natural drainage that the highway authority can follow to prevent such action. The Illinois Drainage Code states:

Whoever wilfully obstructs, injures, or destroys any covered drain constructed through the lands of others as provided in Section 2-6 of this Act, or any other drain, drainage structure, or pumping plant, whether private, mutual, or district, is guilty of a misdemeanor and, for the first offense, shall be fined. The dumping of trash, refuse, or debris into an open drain shall be treated and considered as obstructing a drain. (4)

The Highway Code provides:

If any person injures or obstructs a public highway by...plowing or digging any ditch...or by turning a current of water so as to saturate, wash, or damage the same, or by plowing in or across or on the slopes of the side gutters or ditches, or by placing any material in such ditches...without the permission of the highway authority...he shall be fined for every such offense... (5)

The General Laws of Rhode Island has a section applying to the obstruction of a watercourse that is even more explicit than the Illinois provision:

Whenever any culvert, drain, or watercourse has been placed and maintained or has existed under or within a state highway for the purpose of disposing of surface water drainage, it shall be unlawful for any person, firm, or corporation to obstruct, block, or close any intake or outlet from such culvert, drain, or watercourse without first obtaining permission from the state department of public works, which may grant such permits under such terms and conditions as are warranted. (3)

3. Replacing a Natural Drain with a Drain Tile of Inadequate Size

A problem is sometimes created by the replacement of a natural drain with an artificial drain of inadequate size. This problem might occur where a
natural drain is crossed by a highway. The highway design indicates that a 30-inch-diameter pipe culvert is needed across the roadway to handle the flow. The landowner located adjacent to and on the lower side of the highway has completely filled in the natural drain for his convenience in farming and in place of the natural drain has installed a six-inch drain tile. The result may be obstruction of the natural flow and increased possibility that the property of the dominant landowner and also the highway may be flooded. Under the natural drainage rule, the servient owner cannot change a natural water-course if such action would deprive the upper landowners of their legal right to have the channel kept open. If an artificial channel is used in place of a natural drain, it must be large enough to adequately drain all of the water. (2)

E. REFERENCES CITED


7. J. L. Sanborn, "Principles of Highway Drainage and Erosion Control," County Highway Series No. 4, Lafayette, Indiana: Purdue University Engineering Experiment Station in Cooperation with the County Commissioners of Indiana, 1962.

III. PREPARATION OF PLANS

A. BASIC GUIDELINES

1. Basic Drainage Requirements

There is a need for developing some basic guidelines for selecting and using practices that will be effective in solving drainage problems.

During the initial planning stages of the Ohio Turnpike, criteria were developed to fit the needs of both the turnpike and adjoining landowners. The purpose was to provide a uniform policy for planning drainage facilities and structures that would minimize the adverse effects of the turnpike construction on local drainage.\(^1,5,12,14\)

The American Society of Agricultural Engineers also has design criteria for interrelated highway and agricultural drainage and erosion control.\(^2\)

The intent is to (1) define the drainage and flood protection needs for agricultural land and (2) provide for those needs in accordance with land capability and use.

These sources provide basic recommendations for handling various highway and agricultural drainage problems during highway construction. Where subsurface drainage systems are intercepted, modifications are suggested so that the system will continue to function. No improvements of drainage outside the right of way are included, since the highway authority is not permitted to use funds for this purpose unless the improvements are necessary for the highway itself.

2. Restoration of Original Drainage

A basic consideration in drainage design is to protect the highway against damage from surface and subsurface waters. After taking into account the effect of the proposed improvement on traffic and adjoining property, the highway authority attempts not to do anything that would destroy or reduce individual rights concerning the handling of waters. Where drainage systems are intercepted, the general practice therefore is to restore the systems to the approximate standard that existed prior to construction of the highway. In discussing the need for surface and subsurface drainage to function effectively after being intercepted by the highway facilities, an Ohio Turnpike engineer stated:

Another lesson learned in constructing the Ohio Turnpike, and one that could apply to any major highway being built on a new right-of-way, is the importance of pledging a policy of maintaining farm drainage practices in the area through which the road passes. This, of course, is a good public relations procedure which facilitates the acquisition of right-of-way. But, of greater importance, it is sound conservation, which should be the policy and responsibility of all agencies which serve the public and which depend on the public for support.\(^10\)
3. Accommodation

In the construction of highways, it is the purpose of the highway authority to accommodate affected landowners in drainage matters to the extent of the state's obligation and also to protect itself from excessive construction costs.

Highway engineers have encountered circumstances where the landowner expected them to improve the original drainage. He may contend that the condition did not exist prior to the construction of the highway and that the highway authority therefore is responsible for correcting it. In such case the highway authority has taken the position that, if the condition did not exist prior to construction, proper action will be taken to correct it.

Sometimes highway construction may incidentally improve drainage on adjacent properties, but it is not the obligation of the highway authority to improve drainage or protect adjacent properties from potential flooding.

After completion of a highway building program, it is sometimes difficult to determine the original condition of the drainage system or pattern. In Illinois when highways are constructed on a new location, the state highway authority photographs the area before and after construction. This technique assists the authority in determining whether the complaints are justified and in recommending a course of action.

Drainage complaints alleged to result from highway construction are generally handled by maintenance personnel. The problem is viewed in the field and discussed with the complainant.

If it is determined that the highway authority is responsible, corrective action is taken. If drainage complaints generate during or soon after construction, and prior to acceptance of a highway improvement, construction and design personnel are responsible for analyzing the problem and recommending a solution.

B. HIGHWAY LOCATION

1. Basic Objective

The objectives of highway location and design, including drainage facilities, are as follows: (1) to place the highway in optimum conformity with its terrain and adjoining land uses; (2) to protect the highways and bridges against destructive action of water; and (3) to provide foundations, structures, and surfaces which, considering cost in relation to service, will be strong enough to support anticipated traffic and resist natural forces.

When new highways are established, high ground is usually selected to minimize drainage problems and construction costs. This action also permits maximum retention of natural and existing drainage courses. Efforts are also made to avoid existing ponds and lakes. Several typical stages are followed in selecting the most feasible route:

1. Reconnaissance of the region or general area through which a proposed new or relocated highway is to pass.
2. Reconnaissance of possible alternate routes indicated by regional maps and supplementary regional surveys.
3. Preliminary location surveys.
4. Final location surveys and preparation of plans.
FIGURE 2. AERIAL PHOTOGRAPH TAKEN BEFORE HIGHWAY CONSTRUCTION

FIGURE 3. AERIAL PHOTOGRAPH TAKEN AFTER HIGHWAY CONSTRUCTION
2. Reconnaissance

The initial step in selecting a location is to determine all feasible routes for the proposed new or relocated highway. The preliminary reconnaissance study is based largely on maps supplemented by aerial photographs and mosaics. (7)

The second step in the reconnaissance phase is to select and compare a series of possible alternate routes. The procedure is usually carried out by aerial survey covering a series of strips or zones of land. Finally, the most direct and economical routes are usually selected to be investigated further during the preliminary location surveys. One important factor to consider in selecting routes is major stream crossings requiring bridges with a span of 20 feet or more. Major drainage courses requiring large bridges often control route location, and minor drainage courses are considered but they are rarely a controlling factor.

3. Preliminary Location Survey

In the preliminary location survey, the selected alternate routes are analyzed in detail. Large-scale maps are prepared and trial lines are located that bypass poorly drained areas, rough terrain, valuable buildings, and other obstacles. The lines cross streams at points which seem to provide practical bridge sites. From these photographs and maps, cost estimates are made for excavation, bridge and culvert construction, etc. These estimates and comparisons enable the highway authority to select the best and most economical line location on the contour map.

4. Final Location Survey

The use of aerial survey methods normally terminates when the best preliminary line available between selected terminal points, and passing through selected control points, has been laid down on the ground. This line, with necessary minor adjustments during the stake-out process, becomes the final location line.
C. FIELD STUDIES

1. Survey Information

During the investigation, the field location parties must obtain survey and field information pertinent to drainage. After the horizontal alignment of the highway has been established, a complete survey is made. The following types of information are collected and included in the survey notes:

1. Location of all existing pipelines, culverts, and bridges on the present road, including type, size, and condition.

2. Recommendations for placement of drainage structures with respect to the crossline and side line.

3. Exact location and alignment of existing outfall and inlet ditches and streams with respect to the survey centerline.

4. Information on the need to clean out, widen, or deepen existing outfall ditches and drainage structures to get proper drainage under the roadway and adjacent agricultural lands.

5. When item 4 occurs, investigation to determine whether there is sufficient right-of-way to permit proper cleaning and maintenance of the drainage system.

6. Recommendations for constructing new outfall ditches, when warranted, to improve drainage from culverts.

7. Stream profile of upstream and downstream sections and cross sections of existing channel.

8. Drainage areas in acres.


10. Location and size of existing drainage structures at or near the proposed route.

11. Information from local residents and other records on adequacy of existing drainage structures.

12. Information concerning high water, year of occurrence, etc.

13. Complete soil survey along route location.

Before roadway plans are completed, field inspections are often made by design and maintenance personnel and in some cases right-of-way personnel to view drainage along with other matters pertinent to the overall plan.

2. Drainage Areas

U.S. geological maps, soil maps, aerial photographs, and visual field inspections are often used to determine the size of drainage areas. The Florida State Road Department Drainage Manual includes the following section on the determination of drainage areas:

Drainage areas are to be outlined by field survey personnel on county maps, aerial photographs, U.S. Geological Survey contour maps, or specially prepared maps. All drainage area boundaries should have a connection with the job centerline at high points in grade or at other locations where there is a definite division in the direction of flow of storm runoff.

All drainage area boundaries should be followed from job centerline around the area being covered and closed again to the centerline. Ridges which play out, without enclosing an area draining to the project, should not be shown unless pertinent to determination of runoff concentration points.

Exceptions to the rule for closing all drainage area boundaries to centerline are to be indicated clearly on the map by notation. These notations should show location and, if possible, elevation of breakover or diversion to or from the drainage area.
If possible, a drainage area should be closed for each existing culvert along the project and for each probable crossdrain location. In cases where two or more structures operate conjunctively to drain a single area, the information should be noted.

For surveys for municipal-type construction, appropriate city maps or specially prepared maps are to be marked to show the boundaries of total areas contributing to the project, except as directed by the Drainage Engineer. Streets or other drainage facilities in these areas should be marked with flow arrows. It often will be necessary to determine elevations to show accurately direction of flow in gutters.

Careful study is required to show all areas contributing to existing storm sewers which drain to or across the project.

In very flat terrain, such as found in the Miami area, it is often necessary to profile cross streets and parallel streets to make a definite determination of drainage areas. Where such conditions exist, the District Drainage Engineer will request the necessary field work.

After the overall areas are plotted, the Drainage Engineer will subdivide these to show how the various sections contribute to the inlets in the proposed storm sewer system.

Specially flown aerial photography will soon be available for most new construction projects. Ridge lines usually will be indicated on the photographs. When they are available, it will be the function of the field survey party to verify questionable points and supplement the information with structure sizes, elevations, and high waters as required. (4)

3. Pertinent Features

The Florida Manual states:

In areas draining to the project, all streams, ditches, lakes, swamps, significant drainage structures, and other water handling or water control features should be shown. Flow line and centerline grade elevations, and, if possible, previous high water stages should be secured for significant structures. The field notes should give the estimated reliability of the sources of information on flow and high water. (4)

4. High-Water Information

In regard to high-water information, the Manual states:

Reliable water information is necessary to accurately estimate runoff and establish roadway grades. If possible, high water elevations should be shown upstream of the proposed project, upstream of significant existing structures, and at some point along, or at the end of, outfall ditch surveys.

The location at which a high water elevation is taken must be shown clearly in the field notes. It is necessary also that the source of information be noted.

At many locations, it is not possible to obtain documented information on high water. There is no objection to stating that the elevation is estimated by observation of natural growth or by some other method; however, the designer must be given complete information as to how data were obtained.

The resourceful party chief will make available information from local residents, woods riders, maintenance personnel (both state and county), and particularly rural mail carriers.

Normally, water table information is supplied by the soils crews; however, information pertaining to standing water, areas of heavy seepage or springs within the area being surveyed should be noted. (4)

In addition:

1. Any flood marks recorded on buildings or reported by persons acquainted with the stream should be noted.

2. Any flood discharge data that may be available from owners of dams in the vicinity should be obtained.

3. The extent and nature of debris during and after floods should be determined if any persons or records can be found to provide this information.

5. Survey for Lateral Ditch

The Manual states in respect to this topic:

Surveys for most highway section
projects should include lateral ditch surveys at the locations of existing ditches, streams, swales, etc.

These are routine and are intended to give the designer a clear picture of existing conditions at any location where water comes to and/or leaves a proposed project.

These should show clearly the path and approximate elevations of flow. With that data, the designer can (1) determine if reduction in water elevation is practical, (2) determine if realignment or relocation can better serve the overall design, and (3) proportion the structure dimensions.

It is, therefore, essential to show topography and elevations of existing ditches and natural streams in detail. Usually, infall information is necessary only for 100 to 300 feet or a sufficient distance to indicate the degree of channelization and direction of flow.

Information on the outfall portion should extend far enough to determine the direction and degree of channelization and the rate of fall in water surface, and to reach a point of positive disposal.

If ditch or channel work is desired, topography will be necessary downstream to a point at which damage to adjacent property need no longer be considered.

The field party will have to exercise its own judgment in many cases where the slope along a line being considered as an outfall is very flat. Use of such an outfall is in most cases a matter of economics.

If there is serious doubt that an outfall will be used because of its length, the field party should terminate the survey at 400 to 500 feet and indicate by note the approximate distance to a suitable disposal point. This note should give the distance, water elevation at approximate end, and a brief description of the topography—pond, swamp, running stream, etc.—into which the outfall will drain if extended.

The field survey for a lateral ditch always should include property ties which, in many instances, are the determining factors in the ultimate location of outfalls. With property ties made, the Location Engineer is in much better position to determine the extent of cross-sectioning needed to cover possible alterations in alignment, and the designer is aware of the limitations in changes he may consider. (4)

6. Surveys for Bridges and Large Culverts

Finally, concerning surveys for bridges and large culverts, the Florida Manual dictates:

After selection of the project centerline, location of larger culverts and bridges often must be detailed by the Structures Division and/or Drainage Section.

The meander of both banks of a stream for sufficient distance up and downstream to determine the approximate extent of any probable channel relocation should be shown in the field survey. This ordinarily can be shown within 400 to 500 feet laterally from the project.

Any major overflow channels also should be indicated within approximately the same limits or within the limits that these channels leave and return to the main channel. Meandering channels close to and approximately parallel to the project centerline should be located carefully and sectioned.

Across flood plains where the proposed project follows an existing fill, cross-sections should extend laterally far enough to provide a record of natural ground profiles right and left of the project. Any washouts or significant swales, runs, or sloughs should be noted clearly in the topography.

Recommendations for significant realignment or improvement of an existing channel will come often as part of the structure design, and it will be necessary to make a survey at a designated location. For this reason, specific channel location surveys seldom should be made with the initial location survey unless the need for and logical location of such changes are apparent.

Data on existing highway and railroad structures upstream and downstream should be included. For fills and structures in reasonable proximity
to the project, a profile of the existing roadway, showing structure openings, should be included and tied to the project datum. For structures further removed, it is sufficient often to include only a profile and high-water information.

These notes are to include information as to scour, washouts, or other pertinent flow data. Where scour is significant, sections should be taken to determine the depth and extent.

For bridges, it is necessary to obtain certain water elevation data. If reliable data are not available, that fact should be noted by the field party.

Record, if available, the extreme high water, with the location, and give the approximate date of occurrence. If other high waters can be dated, supply as many as practical, showing dates of occurrence.

If possible, determine a "normal" high-water elevation or one which can be expected to recur about every two to three years. Record a normal water elevation which would be expected to prevail through seasons of average rainfall. High water locations within one-fourth mile are also of value.

7. Investigations Beyond Limits of Right-of-Way

When a highway intersects a surface drainage facility, the ultimate objective is to preserve the natural and existing drainage courses. An investigation on both the upstream and downstream portions of the channel or watercourse may be necessary to determine the best location and proper elevation of the proposed cross-road structure, whether it be a culvert or a bridge. Illinois highway authorities report that survey parties do collect data concerning a watercourse, such as the location and elevation of the stream bed and cross sections of the existing channel for a minimum distance of 300 feet up- and downstream from the highway centerline. On larger streams it may be necessary to gather this information for a greater distance.

Engineers with the Soil Conservation Service state that, where drainage district ditches are intercepted, the district plans the improvements as far as two to three miles upstream and as a result the grade line elevation of the district drain is sometimes below the invert elevation of the culvert located across the highway. Under these circumstances, it is advantageous to both the highway authority and the drainage district to mutually explore their drainage needs. The drainage district authorities then know about the proposed route and its location in time to provide plans of their district drainage system to the highway authority showing the present or proposed grade line, characteristics of the drain, etc. This information enables the highway authority to take into account the requirements of the district drain.

A paper presented at a drainage symposium conducted by the Connecticut Highway Department suggested criteria on the extensiveness of investigations to be made in the channel on the up- and downstream sides of the roadway.

Sufficient data should be obtained on each side of the proposed highway and up and down the stream to establish the location and size of the channel for any flood which may be considered in the design. Sufficient sections should be taken to establish the profile of the water surface under the design flood from the downstream controlling section to the approach channel upstream.

In all cases, sections should include one at the centerline of the proposed structure and one each approximately at the toe of slope, upstream
and downstream. In addition, one or more sections should be taken downstream to establish the downstream control. For structures up to 25' span, one section approximately 250' downstream from the centerline will usually be sufficient; whereas for structures of 100' or over, sections should be taken every 500' for a minimum distance of 1,000' downstream. An approximate guide would be 10 times the span of the structure, but...each case will require individual study and the important consideration is to obtain sufficient data to establish the location of the downstream control. The downstream control is that characteristic of the channel which makes any rate of discharge flow at a definite depth. It is most clearly illustrated by a dam. If the size and shape of the spillway is known, the elevation of the water surface upstream can be determined very closely.

Additional sections upstream may be required where the channel is so steep that the design flood approaches the structure as through a chute (supercritical velocity). This may occur if the slope of the channel is more than 1%. The depth of the water is determined in such cases by its own velocity instead of by the downstream control, and a hydraulic jump forms downstream where the stream returns to normal flow....

The sections should extend laterally far enough to include the entire channel out to the limits of the flood plain. Where the flood plain is exceptionally wide, it may be necessary to estimate the outer limits.

The location and size of any dam, rock outcropping or bridge which may be the controlling factor in the elevation of the water surface of the design flood should be noted.

Data on structures up- and downstream should be obtained and should include the distance to the structure, the span, the estimated depth of water, and the behavior of the structure under previous floods (such as washing out of approach fills or overtopping of structure) if any evidence can be found or records obtained concerning these items. (11)

D. LIAISON
1. Objective
The key to harmonious relations between highway agencies and adjacent landowners and their organizations is communication. Each involved party has responsibilities that it must accept if problems resulting from highway building and agricultural improvement programs are to be solved satisfactorily. However, before any solution can be found, it is necessary that all parties understand the problem and realize the responsibilities of each in finding a solution. If a medium is provided through which the involved parties can communicate with each other, a better understanding of mutual problems will develop.

Such liaison permits the highway authority to acquaint the landowner with the proposed plans at an early stage and also allows the landowner to present his needs for consideration and possible incorporation in the drainage plans. Such advance planning makes it possible to take preventive rather than corrective measures.

2. Landowner and Highway Authority
Often it is possible for the highway authority to plan drainage needs directly with the landowners, representatives of drainage districts, etc. Because of the landowners' knowledge of the area, they can point out problems, give the location of existing subsurface facilities, and assist in selecting suitable locations for proposed facilities. Highway authorities say owners can be very helpful in supplying information to survey crews and design engineers relative to existing tile lines, future needs, etc.
State highway projects that affect agricultural drainage are coordinated with the affected parties through public hearings conducted by state highway officials in the immediate area of the project. Plans, specifications, etc., are generally available both to governmental agencies and to the general public.

3. Governmental Agencies

Governmental agencies acquainted with highway and agricultural drainage can provide a valuable service by informing the public of highway and agricultural drainage programs. Highway authorities should work closely with such agencies, which include the Soil Conservation Service and the Cooperative Extension Service.

The ASAE Criteria (2) state that increased cooperation between highway authorities and drainage and other conservation authorities could frequently reduce construction and maintenance costs for both highway and drainage or conservation authorities. Highway authorities in a number of states indicate that all surveys, whether made on interstate, primary, or secondary highways, are available for review. Upon completion of the review, questions can be asked and recommendations can be made regarding drainage by the landowner and the drainage or conservation authority to the highway authority.

In the state of Washington, drainage proposals and plans for projects lying within designated flood control zones must be approved by the State Department of Conservation and Development. In Minnesota, the highway authority cooperates with individuals or groups of owners through the Soil Conservation Service by providing preliminary layouts and programming of highways planned for construction. In this way some of the drains contemplated by the landowners can be installed before highway construction, and the highway department will provide the required structures as it would for an existing ditch.

Ohio has done a great deal to coordinate the needs of the highway authority and affected landowners. Legislation enacted in 1957 emphasized the need to consider the effect of highway construction on agricultural drainage. Section 1511.01 of the revised code stipulates that the Division of Lands and Soil of the Ohio Department of Natural Resources shall make drainage recommendations designed to protect the agricultural status of rural lands adjacent to highways.

This same legislation provided for the establishment of an engineering service within the Ohio Department of Natural Resources. One responsibility of this service is to assist the highway department in planning and programming proper water management facilities under and adjacent to new and relocated highways. As the result of this law, a memorandum of understanding was developed between the Ohio Department of Highways, the Ohio Department of Natural Resources, and the Ohio Soil Conservation Committee. This memorandum provides for cooperative endeavors between these agencies in planning needed drainage and water management facilities along new and relocated highways. Similar memorandums have been developed by Kansas, Maine, and
Pennsylvania. Copies are included in Appendix A.

Highway authorities report that these memoranda of understanding have been helpful in solving many drainage problems. For example, the Maine highway authority states:

Previously our greatest trouble had been changes made by abutting owners of farm property in flowage of surface water through improving their drainage ditches and conducting this surface water to new cross-over culverts or along sections of highway ditch or embankment areas where culverts were inadequate to take the increased flow, and where ditches or embankments suffered erosion because of increased velocities of water. Occasionally farm ponds had been planned to use highway embankments as part of the dam structures. This was especially troublesome on the upstream side of embankments, and created a definite hazard to the roadway.

Since the Soil Conservation Service apparently had no definite hold on the landowner to govern the construction work which was recommended by them, the owner might construct a fractional part of the entire design which might have a disastrous effect on roadways not contemplated by the Soil Conservation Service.

In general, the State Highway Department seems of the opinion that there has been considerable gain from the coordination which is now in effect, and we have received several letters from the Soil Conservation Service setting forth their appreciation for the method in which we have advised them in advance of the timing of road work and supplied plans upon request covering any project for land or farm betterment.(13)

Illinois has developed a "Suggested Guide for Cooperation in Resolving Mutual Problems of Conservation and Drainage Related to Highway Improvement and Maintenance." A copy is included in Appendix B. This guide was prepared by the Conservation and Drainage Subcommittee of the Association of Illinois Soil and Water Conservation Districts in cooperation with the Illinois Division of Highways, the U. S. Soil Conservation Service, the University of Illinois Agricultural Experiment Station and Cooperative Extension Service, the Illinois Agricultural Association, the Illinois Department of Natural Resources, and the Illinois Association of County Superintendents of Highways.

This guide, which has been sanctioned by the highway authority and prominent agricultural agencies, provides a basis for cooperation between highway officials, landowners, and representatives of the various agricultural agencies. However, it would seem advantageous to develop further agreements between the highway authority and agricultural interests in this state similar to the memoranda of understanding previously mentioned.

E. RIGHT-OF-WAY

1. Requirements

After a final location has been selected for the proposed route and the field investigations have been completed, the highway authority prepares right-of-way plans and plats. These plans contain recommendations for various facilities, including drainage. The recommendations may include such items as size and type of structures; acreage and type of drainage basin; flow line of streams; size, location, and elevations of collector mains, submains, and lateral tile; location, elevations, and grades of constructed or reconstructed drainage ditches; and alterations made or to be made in the highway and agricultural drainage...
After sufficient data have been acquired from the right-of-way plans, the right-of-way plats are prepared, showing the land needed together with the area and the type of title to be acquired. To obtain the best results in both efficiency of operation and economy of construction, sufficient right-of-way should be acquired for all inlet and outlet appurtenances and for required channels and dikes.

2. Appraisal

When new roads are built, land must often be acquired from people who do not want to relinquish it. A landowner is entitled to just compensation for the land that is taken and for damages to the remainder. An appraisal is made to determine the fair cash market value of the land to be taken and to determine the effect the proposed improvement may have on the fair cash market value of the remainder.

The Right-of-Way Manual states that the fair market value is the amount of money a purchaser would pay an owner if neither were obligated to buy or sell, considering all reasonable uses for the land and their possible application. The manual also gives various methods of determining market value. The fair cash market value as determined by the appraiser governs negotiations and settlements.

3. Negotiation

It is the task of the right-of-way negotiator to acquire property for the highway authority at reasonable cost. In performing this function, the negotiator often is the only representative who has any direct contact with the landowner. Therefore, it is essential that this responsibility be assigned to persons capable of interpreting and explaining the technical information relating to the proposed facility.

The right-of-way negotiator explains to the property owner the proposed drainage system as shown on plans prepared by the district office. Included are such items as depth, width, grade, and slope of ditches and use of grassed waterways or paving; direction of flow; and size of drainage structures, both entrance culverts and across-road structures. Illinois authorities are giving aerial photographs showing proposed right-of-way lines, size and location of drainage structures, and direction of flow of highway drainage to appraisers to assist in making appraisals, and to the right-of-way negotiator to help explain the proposed drainage system to property owners. Some concerns of the landowner can be eliminated during the negotiations, and others must be considered in the course of final design.

If an agreement cannot be reached with the property owner during the negotiation proceedings, the highway authority has the privilege of exercising the right of eminent domain under the eminent domain laws of the state. However, this privilege is exercised only as the last resort.

4. Right-of-Way Acquisition

a. Agreements made with the negotiator.- During acquisition proceedings, the agreements between the negotiator and the landowner concerning drainage are often placed in letter form, and copies are given to the highway author-
ity design, construction, and resident engineers. This letter notifies the proper individuals of the agreements or stipulations that are to be incorporated into the plans. The Illinois Division of Highways Field Manual states:

The district office should have in its file all right-of-way stipulations and agreements. These papers frequently provide that certain definite things are to be done by the Department for the owner at the time the road is built. You should be given a copy of all such special agreements when you are assigned to the job. Property owners should be notified in writing to move fences, buildings, etc. This should be done as soon as possible after the contract is awarded, and the contractor should be cautioned not to enter property before the owners have been notified and before the expiration of the time limit as noted in the dedication. Most districts have a standard form of notification to property owners. (6)

Section 8.6 of the manual states:

Right-of-way agreements and easements often contain certain reservations or stipulations by the property owners that must be honored and put into effect during construction. The special provisions in the contract frequently require a certain procedure in the work in order to accommodate traffic or to provide for the interests of local residents or property owners. These matters must receive careful attention at the proper time. Keep in mind the entrances to homes, and check on field entrances when cultivation or harvest is in progress, to provide access across ditches or slopes. In general, consideration should be given to the public interest and convenience as far as practicable. (6)

b. Title and easement—For acquisition of property necessary to straighten a ditch, etc., the law in Illinois provides that:

When the Department deems it necessary to build, widen, alter, relocate, or straighten any ditch, drain, or watercourse in order to drain or protect any highway or highway structure it is authorized to construct, maintain, or operate, it may acquire the necessary property, or such interest or right therein as may be required, by gift or purchase or, if the compensation or damages cannot be agreed upon, by the exercise of the right of eminent domain under the eminent domain laws of this State. (9)

The provisions further state that:

The Department, in its name, or any county may acquire the fee simple title, or such lesser interest as may be desired, to any land, rights, or other property necessary for the construction, maintenance, or operation of State highways.... (8)

Before the highway authority exercises the rights of eminent domain, it must attempt to acquire the necessary property, or such interest or right therein as may be required, through negotiation.

The statute provides legal authority to acquire fee simple title to the needed right-of-way either by negotiation or by eminent domain proceedings. Fee title to the right-of-way is acquired on all federal aid interstate routes. Fee title also is acquired on state bond issue and federal aid primary routes except where it is considered economical and feasible to acquire only an easement, such as when an existing route is being widened. Easements or agreements are also acquired to cover channel changes, temporary construction, borrow pits, etc., which are not part of the highway proper.

In taking easements for specific purposes outside the regular right-of-way, the highway authority will sometimes allow the owner limited use of the property. However, in all cases rights of access and future construction should be clearly defined.
THE GRANTOR, ____________________________ of the ____________________________
of ____________________________ of the ____________________________ and State of ____________________________ for and in consideration of ____________________________ Dollars ($ ______________), in hand paid, CONVEY and WARRANT to the STATE OF ILLINOIS, for the use of the Department of Public Works and Buildings, the following-described Real Estate, to-wit:

situated in the County of ____________________________ and State of Illinois, hereby releasing and waiving all right under and by virtue of the Homestead Exemption Laws of the State. And the Grantor agree to remove any and all fences, enclosures, buildings and other obstructions from the above-described tract and to
completely vacate the same within fifteen (15) days after notice in writing from the Department of Public Works and Buildings of the State of Illinois; and the Department of Public Works and Buildings of the State of Illinois, or any other state, county, township or district officials authorized by said Department, and its or their representatives, engineers, agents, contractors and employees are hereby authorized to enter into and take full and complete possession of said tract for any lawful purpose whatsoever; and any fences, enclosures, buildings or other obstructions remaining thereon, after the expiration of said fifteen (15) days, may be removed by them or either of them and the expense thereof the Grantor agree to pay upon demand.

The Grantor, without limiting the fee simple interest above granted and conveyed, do hereby release the Grantee or any agency thereof forever from any and all claim for damages sustained by the Grantor, his or her heirs, executors or assigns by reason of the opening, improving and using the above described premises for highway purposes.

IN WITNESS WHEREOF, the Grantor has hereunto set his hand and seal, this [day of] A. D. 19[...]

(SEAL)

(SEAL)

(SEAL)

(SEAL)

(SEAL)

(SEAL)

(SEAL)

STATE OF [county] ss.

COUNTY OF

I, _____________________________, a Notary Public in and for said County and State aforesaid, do hereby certify that ____________________________

who ____________________________, personally known to me to be the same person whose name ____________________________, subscribed to the foregoing instrument, appeared before me this day in person and acknowledged that he signed, sealed and delivered the said instrument as __________________________, free and voluntary act, for the uses and purposes therein set forth, including the release and waiver of the rights of homestead.

Given under my hand and notarial seal this [day of] A. D. 19______________

Notary Public

(SEAL)

My Commission expires ____________________________, 19______________

FIGURE 6. WARRANTY DEED (REVERSE SIDE)
A warranty deed is an agreement between the highway authority and the landowner for acquisition of right-of-way. This deed is prepared and signed by all parties prior to construction of the highway. The deed usually exempts the state from responsibility for further damages, but outlines all corrective measures agreed upon during the negotiations. The Division of Highway Engineers indicates that, if problems arise later that are not included in this agreement, the state will take corrective action if it is apparent that the trouble was caused by construction of the highway.

An example of a warranty deed used by the Illinois Division of Highways for acquisition of right-of-way is shown in Figure 6.

A directive prepared by the Maryland State Road Commission to establish uniform standards for the preparation of right-of-way plats reads as follows:

Heretofore, the locations of pipes and culverts and the drainage easements required to control the flow of water to and from those structures have been general in nature and were often changed in the field during construction to meet unforeseen or special conditions.

In most cases, the location of structures was not definitely defined on the right-of-way plats; and during construction, a longitudinal shift of twenty-five (25') feet in either direction was permitted.

The right to cut inlet or outlet ditches to and from these structures has usually been obtained by general clauses in the deeds, which simply stated that the Commission had the right to create, use and maintain waterways across the adjacent land of the Grantors at unspecified locations at points indicated by a legend appearing in the upper left-hand corner of the right-of-way plats.

The practice has been to obtain land necessary for culvert headwalls for larger structures and pipes in fee simple where such needed land projected beyond the normal-width right-of-way, but only to obtain an easement for such headwalls in the case of smaller pipes.

It has also been the practice to provide for parallel drainage facilities in the same clause in the deed which granted the Commission the right to create, use, and maintain such slopes as were necessary to retain the highway and/or adjacent property. The clause which previously served this dual purpose further provided that the easement for slopes would cease to be effective at such time as the contour of the land over which it was granted was changed, so that the easement required for slopes was no longer necessary to support or protect the property conveyed in fee simple. No such reverter was contemplated with respect to the portion of such easement which was intended for drainage purposes.

The effect of the Court of Appeals decision requires that all future easements be obtained for the specific purpose for which they are needed and that all such easements be accurately located and carefully defined on the right-of-way plats and properly called for in the deeds which convey such easements to the State Roads Commission.(3)

The directive sets forth the following corrective procedure for acquiring perpetual drainage easements, in compliance with a decision rendered by the Court of Appeals of Maryland making it mandatory that the State Roads Commission revise its entire procedure for preparing all types of right-of-way plats and also the deeds by which it takes title to easements for slope, drainage, and special facilities:

All drainage easements of any nature whatsoever shall be acquired as perpetual or permanent easements. They will be indicated by specific types of symbols and appropriate notations on the right-of-way plats and shall
be described by specific clauses in all options and deeds. Said clauses shall clearly state that the drainage easements are perpetual in nature. (3)

Under Illinois law, the dominant owner has a natural easement over the land of the servient owner for the flow of surface water. The relative position of the land, whether it be higher or lower, directly determines the natural easement rights and responsibilities. If a maintenance problem develops on the servient land, it is the duty of the owner of the easement to keep it in repair. (16)

5. Payment of Damages in Lieu of Reconstruction of Drainage Facilities

At locations where highway improvements interfere with existing drainage facilities, experience has shown that it is not always desirable for the highway authority to pay damages to the property owner in lieu of reconstruction of the drainage facility. In some cases where damages have been paid to the landowner, he has not always taken proper action to correct the drainage problem for which he has been compensated. Then, at a later date, he may file a complaint against the highway authority for improvements to the drainage facility for which damages had previously been paid. Where the landowner has not taken corrective measures, the highway authority may have to take action to protect the facilities within the highway right-of-way.

One argument in favor of payment for damages is that the farmer may be able to do the work at a lower cost than the highway authority. There may be a question, however, about the quality of work performed by the landowner. It is conceivable that the work might be done satisfactorily if payment of damages were withheld until the highway authority could check to determine whether it met the required specifications.

F. PLANS CHECK LIST

The Florida State Road Department Drainage Manual includes a comprehensive check list for use by the district office. (4) It insures that department policies have been complied with, that sound engineering practices have been used, and that plans and calculations are mechanically correct. This check list is included in Appendix C.

G. REFERENCES CITED


4. Drainage Manual, Florida State Road Department.


8. Ill. Rev. Stat., Ch. 121, Sec. 4-501 (1963); Secs. 5-801 and 6-801 are substantially the same.

9. In Ch. 121, Ill. Rev. Stat. (1963), Sec. 4-502 grants authority to the department, Sec. 5-802 to the county, and Sec. 6-802 to the township. The wording of the three is identical except that "proper authority" appears where highway authority is used in the quotation. Secs. 5-802 and 6-802 also include a clause providing for the acquisition of materials by eminent domain.


IV. SURFACE DRAINAGE SYSTEMS

A. PURPOSE

Drainage is the removal of free water from land by natural means or engineering works. The source of free water may be precipitation, snowmelt, irrigation waste, overland flow or underground seepage from adjacent areas, artesian flow from deep aquifers, floodwater from channels, or water applied for such special purposes as leaching salts from the soil or controlling temperature. Artificial drainage systems are needed to supplement natural drainage in many areas. The amount of water to be removed by artificial systems depends upon the effectiveness of the natural drainage.

Drainage is commonly divided into two broad classes: surface and subsurface. The basic functions of a surface drainage system for highway and agricultural lands are (1) to remove excess surface water and deposit it in an adequate outlet and (2) to provide outlets, where needed, for subsurface water. The report on the legal phase of this project provides an insight into many of the obligations of both parties, but the practices that should be followed are not always evident. (5)

A highway drainage system is designed to collect, remove, and dispose of all surface water within the right-of-way and to provide for the continued functioning of intercepted agricultural drainage systems. The purpose of an agricultural drainage system is to remove the surface water from agricultural land in order to create favorable soil conditions for plant growth.

For highway and agricultural drainage systems to function properly, each system will occasionally be dependent upon the other. Therefore, each party must consider the effects upon the other during the planning and the installation of a drainage system.

B. OUTLETS

An adequate outlet is the first need in planning a drainage system, since a drainage system is only as good as its ability to dispose of the water. The method of disposing of water must also meet the requirements and limitations imposed by the law. Landowners in need of drainage are constantly looking for outlets, some of which may connect either into the highway or to adjoining landowners' drainage systems.

When highways are constructed in an area, one reaction of landowners is that the highway drainage system will provide an outlet that previously never existed. This philosophy is not always in the best interest of the highway.
authority or other landowners. The highway authority has the responsibility to perpetuate existing natural drainage systems, but it is neither obligated nor permitted to carry water onto the lower landowner that would not naturally flow in that direction. Whenever highway facilities are used as outlets for drainage of upper lands, the authorities must be sure that the drainage laws are followed and that the highway facilities are not being used as an outlet merely because of their existence.

C. HIGHWAY SIDE DITCHES

1. Purpose

A highway side ditch is an open channel located adjacent to and within the limits of the highway right-of-way. One of its functions is to intercept and remove surface water within the highway right-of-way. The surface water that is removed accumulates from the highway proper and sometimes from flow contributed by areas adjacent to the right-of-way. The accumulated water must be carried to an outlet that is naturally tributary to the drainage area. The ditch must be hydraulically capable of handling the anticipated flow of surface water in such a way as not to endanger the safety of roadway structures or of motorists.

The principal variables in the design of side ditches are (a) position of the grade line with respect to the roadway surface and (b) grade of the ditch bottom. The ASAE Recommendation for Highway and Agricultural Drainage includes the following statement with respect to highway side ditches:

Highway drainage ditches constructed primarily for surface drainage, such as side and top of slope ditches, entrance and outlet ditches at culverts, and stream channels, shall be designed in accordance with the design criteria of the highway authority.

Side ditches or waterways shall be constructed inside the right-of-way on both sides of the highway to provide continued drainage and to protect the adjoining property from flooding and erosion, except that side ditches may be omitted:

(a) When the water drains away from the highway and the adjoining land is in permanent grass or woods.

(b) In deep loessial soils and dry sands where level terracing or water spreading is practiced.

(c) On downstream side of fills when the highway is built upon fill and ponds due to surface irregularities are filled or drained to prevent the impounded water from saturating the adjoining lands.(2)

2. Depth and Width

Since the primary function of the
side ditch is to collect and carry off water within the highway right-of-way, a highway side ditch should be designed to carry the peak runoff from its tributary area with reasonable freeboard allowance and with minimum tolerable erosion. A secondary function of roadside ditches is to drain the base of the roadway to prevent saturation and loss of support for traffic.

To serve these various purposes, it is necessary that the ditch be designed to satisfy all the hydraulic conditions in addition to having the proper depth to satisfy the second function. Roadside ditches may be constructed with parabolic, trapezoidal, or triangular cross sections. The parabolic section has the greatest hydraulic efficiency. The trapezoidal section is easiest to construct and makes an adequate and stable ditch for most locations. The triangular ditch can be easily blocked with debris and is highly susceptible to erosion and is therefore generally not recommended.

The bottom width of the ditch will vary with the quantity of water, the length of ditch, and the grade. The earlier practice of using fixed cross sections and constant depth does not apply to modern highways. The cross section may be increased according to design capacity without making the entire length the maximum size. A minimum width is often established to accommodate maintenance operations. (14)

To drain water from the base course under the pavement, it is recommended that the bottom of the ditch be at least one foot lower than the subgrade elevation. (12) A guide prepared by AISCD provides:

Where drains are outletted into a ditch, the invert of the drain outlet preferably should be between 9 and 18 inches above the established grade line of the ditch. (16)

The requirements for side ditches outlined in the Drainage Manual of the Florida State Road Department are as follows:

Interstate and Primary - In general, all standard side ditches are to be a minimum of three and one-half feet below the shoulder elevations. Where other considerations make ditches of less depth desirable...a minimum depth of two feet can be considered provided underground water and soil conditions are favorable...

The maximum depth [of] standard side ditch(es) allowable without use of a right-of-way ditch is: side slopes of 4:1, maximum depth four feet below the shoulder point; side slopes of 6:1, maximum depth five feet below the shoulder point. These maximum depths are recommended for general use and may vary under special circumstances.

Secondary - In general, the side ditch may vary from no ditch at all to the standard three-and-one-half-foot minimum depth below the shoulder point, listed above, for Interstate and Primary construction, depending on all or a combination of several points of design:

1. Traffic count anticipated.
2. Right-of-way restrictions.
4. Borrow requirements.

Maximum depth [of] side ditches for secondary construction generally follow[s] [the depths] outlined for Interstate and Primary construction.

Bottom width[s] of side ditches may vary from [a] "w" to any width necessary to provide adequate drainage (flat bottom). Normally, a three-foot bottom ditch is standard. Side ditches...[with] more than three-foot bottom[s]...may be necessary for calculated ditch flow along the job. Runoff carried by the side ditch should be calculated at the outlet to determine the sufficiency...
of a three-foot bottom ditch. If a larger ditch is necessary, additional calculations of runoff should be made at various stations to determine at what location the ditch should be enlarged.

The minimum requirements for side ditches in Illinois are a two-foot bottom width and a three-foot depth.

3. Low-Level Areas Adjacent to Highway

Highway engineers in Illinois indicate that in flat areas the previous practice was to raise the grade elevation of the new road 1 1/2 to 2 feet above the adjacent land to allow the snow to blow off and to reduce maintenance operations. To furnish the required fill under these conditions, it was necessary to make ditches wider and deeper than a normally balanced section would require. These ditches have been difficult to drain because of limitations imposed by the flat terrain. As a result, water often stayed in ditches along the highway, and adjoining landowners complained that their fields were being flooded. Even though the side ditches lessened the chance that water would stand on the adjoining land, the many complaints often made it necessary to eliminate these ditches along the highway. The practice now being followed by some highway authorities in low areas is to establish grades sufficiently above adjacent ground levels to make side ditches unnecessary along the highway.

4. Use of Highway Side Ditch as an Outlet

a. Responsibility of the highway authority to provide drainage outlets for landowners - Under the natural and statutory drainage laws in Illinois, the highway authority is not responsible for providing drainage outlets for the adjoining landowner unless the side ditch follows the path of natural flow. The Highway Code does provide, however, that a landowner through or along whose land a public highway passes may drain into the highway if he first gives due notice to the proper highway authority and receives from that authority written permission for any ditching or excavating that he proposes to do within the limits of the highway.

    Before permission is granted, the highway authority should carefully consider the following items: (a) who will be responsible for maintaining the drain, (b) whether the drain will create an obstruction or hazard to the highway proper, and (c) whether the rules of natural drainage are being violated.

b. Cut sections - If the highway is located in a deep cut section, surface drainage ditches usually cannot be safely outletted into highway side ditches without use of elaborate sedimentation and erosion control measures.

c. Terrace outlet - Landowners are usually not permitted to empty the collected runoff from individual terraces into a road ditch. However, where new construction intercepts terraces within the limits of the right-of-way, the highway authority will provide the proper outlet. Also, where the outlet for a system of terraces is natural, it is permissible for it to discharge into a highway ditch.

d. Maintenance responsibility - The Highway Code imposes upon the respective highway authorities the duty
to construct, maintain, and repair the highways within the jurisdiction of each authority. The sections imposing the duty of maintenance and repair do not expressly include drainage systems, but such systems do appear to be included in the definition of highways in the Highway Code. It seems unlikely, however, that drains constructed for private purposes within the highway right-of-way are included within the statutory definition of highway. Therefore, it would seem that the responsibility of the highway authority for maintenance and repair would not extend to such drains.

However, where the landowner does not follow through with proper maintenance practices, the highway authority may be forced to apply certain measures to adequately protect the property within the limits of the right-of-way. Therefore, before the highway authority grants permission to the landowner to drain into the highway right-of-way, it may be desirable to require that the landowner furnish a bond to insure that he will provide proper maintenance. It is necessary that all parties clearly understand the maintenance responsibilities.

D. DRAINAGE DITCHES

1. Criteria

The Indiana Toll Road followed certain criteria for the construction of drainage ditches primarily for agricultural drainage whose capacities would not be affected by or would not affect the adequacy of toll road drainage structures. The Ohio Turnpike Authority followed similar criteria:

   1. Agricultural drainage—...When such ditches serve as outlets for tile drainage fields, the bottoms of the ditches shall be not less than 1 foot below the minimum elevation,
at their outlets, of laterals and collector mains discharging into the ditch. However, when a reconstructed collector main is outletted into an existing ditch, the distance from the bottom of the ditch to the invert of the main at its outlet need not be more than that prevailing on the original collector.

2. Ditch depths—As a provision for future lowering of or extensions to agricultural drainage systems, ditches in regions of artificially drained land or where such drainage is a future possibility shall be constructed to the minimum depths specified below, except that where no outlets are available for ditches of these depths, or where rock is encountered, these depths shall be reduced, provided that all existing tile mains and ditches are outletted:

(a) For ditches outletting collector mains, the minimum depth below average field level shall be 5 feet.
(b) Outlet ditches for Toll Road drainage structures carrying surface water only shall be constructed with the bottoms of the ditches at least 4 feet below the average field level of the right-of-way line on the upstream side of the Toll Road or reconstructed local road.
(c) Outlet ditches for Toll Road drainage structures which also serve agricultural drainage systems shall be constructed with the bottoms of the ditches not less than the following depths below average field level near the upstream side of the right-of-way:

<table>
<thead>
<tr>
<th>Prevailing Slope</th>
<th>Ditch Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0% to 0.25%</td>
<td>6.0 feet</td>
</tr>
<tr>
<td>0.25% to 0.75%</td>
<td>5.5 feet</td>
</tr>
<tr>
<td>0.75% to 1.5%</td>
<td>5.0 feet</td>
</tr>
</tbody>
</table>

3. Ditch design—Ditches intended primarily for agricultural drainage systems shall be designed for the estimated discharge by the Kutter or Manning formula, using a value for "N" of 0.035.

The minimum bottom widths of ditches which are to serve agricultural drainage systems shall be as follows:

<table>
<thead>
<tr>
<th>Side Slopes</th>
<th>Bottom Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatter than 4:1</td>
<td>2 feet</td>
</tr>
<tr>
<td>From 3:1 to 4:1</td>
<td>3 feet</td>
</tr>
<tr>
<td>Steeper than 3:1</td>
<td>4 feet</td>
</tr>
</tbody>
</table>

Side slopes flatter than 2:1 shall not be used if the velocity in the ditch at design flow is less than 2.5 feet per second.(13)

Some drainage authorities caution that ditches of the depth recommended in the above criteria can cause erosion problems that may eventually require the highway authority to take protective measures to prevent erosion damage.

2. Diffused Surface Water

Diffused surface water is water that is not concentrated in a defined watercourse and whose disposal therefore presents a difficult problem in highway design. The report on the legal phase of this project(5) further defines diffused surface and surface water, along with various interpretations of the applicability of the natural drainage rule to diffused water.

The Illinois Division of Highways follows the general practice of receiving the surface water draining upon the right-of-way and passing water in its natural state upon and over the lower land. This practice is applicable without question for surface water confined in a watercourse.

Where the flow of surface water is diffused, there is some question concerning the rights of the dominant landowner to allow it to flow in its natural state upon the servient landowner, as well as concerning the responsibility of the servient landowner to receive this water. This condition generally exists where the drainage pattern is sluggish and poorly defined and, as a result, a portion of the water may stand in basins. The surface water that does flow spreads over a
wide area and is considered to flow in a diffused state. Since the basic question is whether the rules of natural drainage apply to diffused water as well as to surface water, the report on the legal phase of this project presents both sides of the discussion. The conclusion that was reached is that final determination is a matter for litigation.

The drainage practice followed by many highway authorities is, insofar as possible, not to alter the natural ground surface, divert flows, or concentrate waters at any location to any greater extent than is absolutely necessary. This procedure is difficult, however, at locations where diffused surface water is intercepted, because the flow is spread over a wide area. To keep diffused surface water in its natural state would require a continuous opening in the highway embankment for the entire width of flow. Provisions for a continuous opening are not always practical, and it therefore becomes necessary to concentrate the flow to some degree. Since, under these circumstances, it is impossible to perpetuate the existing sheet flow, some highway authorities place equalizer culverts along the route to reduce the concentration of flow across the right-of-way.

One highway authority states that in fill sections culverts should be placed at frequent intervals to prevent any large concentration of water. This practice helps to reduce ponding on upstream land and erosion and undue saturation on downstream land.

In cut sections, top-of-cut ditches are sometimes provided. In this case, disposal methods should eliminate as much liability for damage from diversion as is possible. If down drains are required, closed conduits are sometimes used in preference to open channels.

After the diffused surface water has flowed across the highway right-of-way at selected points where equalizer culverts are located, it is probable it will remain concentrated at selected locations and not flow in a diffused state upon the lower owner. The question then is: Does the lower landowner have the responsibility for accepting this water, since it is no longer in its natural state? Although the courts have not answered this question, it would seem reasonable to assume that there would be no cause for action as long as the collection of diffused surface water does not cause undue harm to the servient landowners.

One out-of-state highway authority states that, although the authorities have known that it was improper to convert sheet flow to concentrated flow, such as through a culvert under the roadbed, they have generally ignored the provision. Now, because of increased and changed land use, such as from pasture land to crop land, there has been an increase in the number of complaints and occasionally it has been necessary to convert the concentrated flow to sheet flow by constructing a weir at the outlet of a culvert.

3. Channel Change

When crossroad structures are used, consideration must be given to inlet and outlet ditches leading to and from the roadway structure. A fundamental
principle is to provide the watercourse or stream with a direct entrance and exit from the structure. If a direct inlet or outlet does not exist, proper alignment can be obtained by making a channel change, a skewed alignment, or both. These changes will (1) permit improved highway alignment, (2) possibly eliminate certain culverts or bridges where the stream or watercourse recrosses the highway, and (3) improve flow conditions in channels at bridge and culvert locations. When a channel change is made, care must be taken not to cause bankcutting or erosion downstream.

The Illinois Division of Highways Bureau of Construction Field Manual states:

The first thing to do in staking out a culvert across the road is to determine whether the location as shown on the plans will fit the channel to the best advantage. A channel change can often be made to improve the hydraulics of the stream. This possibility should be considered when locating the culvert. If you think the culvert should be relocated or the skew angle changed, take the matter up with the district construction engineer.(7)

Other highway authorities indicate that, in practice, they plan the alignment of a structure so that its inlet and outlet will match the natural channel as closely as possible. When this is not possible, special channels are constructed to provide adequate control and protection at any point where the direction of flow is changed.

These required changes sometimes extend beyond the limits of the highway right-of-way and thereby make it necessary for the highway authority to acquire additional right-of-way or easement. The highway authority has the power, by either negotiation or eminent domain proceedings, to build, widen, alter, relocate, or straighten any ditch, drain, or watercourse; to drain or to protect any highway or highway structure it is authorized to construct, maintain, or operate as discussed in Chapter III of this report. Before the highway authority exercises the right of eminent domain, it should attempt to acquire the necessary property, or such interests or rights therein as may be required, through negotiation.

Where it is necessary to acquire an easement for changes to be made in a stream channel, the highway authority generally enters into an agreement with the landowner. An example of the agreement used by the Illinois Division of Highways is shown in Figure 11.
AGREEMENT CONCERNING LAND FOR A STREAM CHANNEL CHANGE

KNOW ALL MEN BY THESE PRESENTS, That

of in the County of _________ and State of Illinois, party of the first part, hereby covenants and agrees with the State of Illinois, acting by and through the Director of the Department of Public Works and Buildings, party of the second part, as follows:

First. The party of the first part hereby represents that he is the owner in fee simple of the tract of land situated in the County of _________ and State of Illinois, and described as follows, to-wit:

Second. The party of the first part hereby agrees with the party of the second part that for and in consideration of the sum of _________ Dollars ($________) paid to _________ by the party of the second part, or on behalf of said party, and the receipt of which is hereby acknowledged, the said party of the second part may and is hereby granted the right, easement and privilege to enter upon the tract of land described above and excavate a new stream channel over the same; provided further that all material so excavated may be placed in fill on the adjacent No. _________ and in the old stream channel; provided further, that wherever it is necessary for fence to be removed in order to afford access to the said tract, said removal and replacement shall be made by the party of the first part.

Third. The party of the first part hereby further agrees that the party of the second part may at any time in the future enter upon the said tract to remove any obstructing materials or objects from the said stream channel.

Fourth. The said party of the first part hereby further agrees, for and in consideration of the sum herein named, to waive all damages of every name and nature that may accrue to him, the premises above described or to any property owned by the party of the first part which is adjacent or contiguous to the premises above described, because of said stream channel change or because of any excavation or removal of material under this agreement.

To these covenants and this agreement party of the first part hereby binds himself, his heirs, executors and assigns forever.

IN WITNESS WHEREOF, the party of the first part hereby signs, seals and delivers this instrument to the party of the second part this _________ day of _________ 19 ______.

Signed, sealed and delivered in presence of:

[SEAL]

[SEAL]

[SEAL]

WITNESSES

PARTY OF THE FIRST PART

FIGURE 11. AGREEMENT CONCERNING LAND FOR A STREAM CHANNEL CHANGE
STATE OF
County of
_, a Notary Public, in and for said County and State.

I,______________________________________ a Notary Public, in and for said County and State.

DO HEREBY CERTIFY that

personally known to me to be the same person whose name subscribed to the foregoing instrument, appeared before me this day in person and acknowledged that

signed, sealed and delivered the said instrument as ________________ free and voluntary act, for the uses and purposes therein set forth.

Given under my hand and notarial seal this ___________ day of ________________, A. D. 19__

Notary Public.

FIGURE 11. (REVERSE SIDE)
4. Permits for Work Within Highway Right-of-Way

a. Purpose - In Illinois any person, firm, or corporation performing work in, upon, along, or under state highways must have permission from the Department of Public Works and Buildings. Permits are granted whenever feasible. The department's object in requiring a permit prior to the beginning of such work is not to prevent the work, but rather to regulate it from the standpoint of safety to traffic, preservation of the state's investment, and fixing of responsibility. Applicants for a permit to perform work on the highway right-of-way must also obtain approval or permission from the adjacent property owner where the state acquires only an easement for highway purposes.

b. Types of permits applicable to drainage and related areas - In Illinois a formal permit, Form BM 37 or BT-717 (Figures 12 and 13) is used to authorize such work as the construction of public and private approaches or access entrances and installation of culverts, storm and sanitary sewers, and residential or commercial water, oil, and gas lines.

In emergency situations the district engineer may authorize a representative to grant verbal permission to carry out a specific task within the highway right-of-way. This verbal authorization is confirmed by a letter-type permit signed by the district engineer, provided a formal permit has been issued for the original installation; otherwise, a formal permit is issued.

Permits for right-of-way for agricultural purpose (Figure 14) authorize fee owners of right-of-way to use and cultivate excess right-of-way until such time as the land is required for highway purposes. This permit is generally used only in special cases, such as where a right-of-way has been purchased and no construction is expected for a period of time. This permit is never issued after the right-of-way line has been established during construction.

c. Agricultural drainage crossings - After a highway has been constructed, except for isolated cases in which the proposed drainage channels might materially benefit the highway, the cost of crossing it is generally borne by the agency responsible for the drainage facility, and the manner of crossing and all details of proposed work within the highway right-of-way are subject to approval by the department. When the adjoining landowner desires to install a drainage facility across the highway right-of-way, it is necessary to obtain permission from the highway authority. The highway authority will usually grant permission, and the landowner may perform the work at his expense.

The Minnesota Department of Highways has a form to be filed by the individual owner or a group enterprise to obtain authorization for the installation of a drainage tile crossing a highway under construction or reconstruction. This form is shown as Appendix D.

The Minnesota highway authority indicates that the state obligation is confined only to tile drainage crossings for highways under construction.
WHEREAS, Illinois, hereinafter termed the Petitioner, requests permission and authority to do certain work herein described, in, upon or along State Highway known as:

Route: from Station ______ to Station ______
Section: from Station ______ to Station ______

County, subject to the following conditions and restrictions:

First: The said petitioner shall furnish material, do all work, pay all costs and shall in a reasonable length of time restore said highway to a condition similar or equal to that existing before the commencement of the described work. It is also understood that the work shall be completed within one hundred and twenty (120) days after the date this permit is approved, otherwise the permit becomes null and void.

Second: That the proposed improvement shall be located and constructed to the satisfaction of the Chief Highway Engineer or his duly authorized representative and the material used shall conform to the standard specifications of the State of Illinois, Department of Public Works and Buildings, Division of Highways.

Third: In performing this work the petitioner shall not interfere with or obstruct traffic on said highway.

Fourth: That the petitioner shall not serve any patron while the vehicle of the patron is parked on any portion of the State Highway.

Fifth: That the said petitioner, his successors or assigns, shall assume all risk and liability for accidents and damages that may accrue to persons or property on account of this work.

Sixth: That the petitioner shall not trim, cut or in any way disturb any trees or shrubbery, along said highway without the approval of the Chief Highway Engineer or his duly authorized representative.

Seventh: That should the State's construction and operation on said highway require any alteration or change of location of the improvement called for in this permit, such alteration or change of location shall be made by the petitioner upon a written request by the Chief Highway Engineer without expense to the State of Illinois or County aforesaid.

Eighth: That this permit is effective insofar only as the Department has jurisdiction and does not presume to release said petitioner from compliance with the provisions of any existing statutes relating to the construction of such improvements.

SIGN AND RETURN TO: Mr. _______ District Engineer _______ Illinois _______.

This permit is hereby accepted and its provisions agreed to this ______ day of ______, ______, 19 ______.

Attest: _______ Witness _______ Witness _______

Signed: _______ Petitioner _______

Given this ______ day of ______, A.D. ______.

Recommended: _______ Department of Public Works and Buildings _______

By _______ Director _______

FIGURE 12. HIGHWAY PERMIT
ACCESS PERMIT

1. Name of Applicant

hereinafter termed the applicant, request permission and authority to construct a driveway(s) on the right-of-way of the State Highway known as

Route Section from Station ______ to Station ______

Section from Station ______ to Station ______

County

The proposed driveway is described in detail as follows:

This permit is subject to the regulation listed in the "Policy on Permit for Access Driveways to State Highways", adopted September 1, 1952, and subsequent revisions, as printed on the reverse side of this sheet. The applicant agrees to complete the work authorized by this permit within ______ after the date of approval, otherwise the permit becomes null and void.

The applicant binds and obligates himself to construct the driveway(s) in accordance with the above description and attached sketch, and to abide by the Policy regulations.

This permit is hereby accepted and its provisions agreed to this ______ day of ______

19______

Signed ______

Witness:

___________________________

___________________________

SIGN AND RETURN TO: District Engineer ______, Illinois

Approved this ______ day of ______ 19______

DEPARTMENT OF PUBLIC WORKS AND BUILDINGS

Form B. T. 717

By ______

District Engineer

FIGURE 13. ACCESS PERMIT
First: The applicant(s) (grantee) represents all parties in interest, and that any driveway or approach constructed by him is for the bona fide purpose of securing access to his property and not for the purpose of servicing vehicles on the highway right-of-way.

Second: That the grantee(s) shall furnish all materials, do all work, and pay all costs in connection with the construction of the driveways(s) and its appurtenances on the right-of-way, including the restoration of any damaged portions of the roadway or other highway appurtenances to substantially the same condition as they were originally. All materials used shall meet the requirements of the Illinois Division of Highway’s Standard Specifications for Road and Bridge Construction, and the type of construction shall be as designated and/or approved by the Engineer.

Third: That no revisions or additions shall be made to the driveway(s) or its appurtenances on the right-of-way without the written permission of the Department.

Fourth: The Department reserves the right to make such changes, additions, repairs, and relocations within statutory limits, to the driveway(s) or its appurtenances on the right-of-way as may at any time be considered necessary to permit the relocation, reconstruction, widening, and maintaining of the highway and/or to provide proper protection to life and property on or adjacent to the highway.

Fifth: That the grantee(s), his successors or assigns, agrees to hold harmless the State of Illinois and its duly appointed agents and employees against any action for personal injury or property damage sustained by reason of the exercise of this permit.

Sixth: That in all permits issued for driveways to serve commercial properties, a permit bond (Form No. BT 754) for an amount and period specified by the Department shall be executed and made a part of the permit. In lieu of individual bonds for each permit, blanket bonds as specified by the Department may be secured.

Seventh: The location, design, and construction of the driveway or driveways described above shall be in accordance with the Policy on Permits for Access Driveways to State Highways. The limits stated therein and shown on the design sketches are in no case to be exceeded. In certain unusual cases the Department may demand suitable dimensions inside of these limits should the local condition warrant.

FIGURE 13. (REVERSE SIDE).

or reconstruction. Thus, if a property owner desires to cross an existing highway, the landowner must finance the required construction and perform the work subject to a permit issued by the Department of Highways. The permit authorizes the applicant to perform the work within the highway right-of-way and subjects him to certain conditions similar to those in Illinois, for protecting the highway facilities and the public safety.

5. Cutting or Damaging State Highways

The Illinois Highway Code states:

No person shall wilfully cut, excavate, or otherwise damage that portion of any highway under the jurisdiction and control of the Department, including the hard-surface slab, shoulders, and drainage ditches, either within or without the corporate limits of a municipality without a permit to do so from the Department. The Department shall issue its permit when such cutting, excavating, or damaging is reasonably necessary, but it is the duty of the person securing a permit to make such repairs to the highway as will restore it to substantially the same condition as it was originally.... To insure the proper repair, the Department may, before issuing its permit, require the person applying for a permit to enter into a bond payable to the People of the State of Illinois in a sum commensurate, in the opinion of the Department, with the injury to be done to the highway, conditioned for its proper restoration within such time as the Department may prescribe....(8)

6. Flow Lines

Proper elevation of the channel flow line crossing the highway right-of-way is a problem that has demanded considerable attention. A conflict of interest often exists. Agricultural interests want across-the-highway structures to be set low enough to provide an outlet for existing and possible future drainage from the
WHEREAS, _______________ of Illinois, hereinafter termed the petitioner, requests permission and authority to perform certain work herein described on a tract of land dedicated to the State for highway purposes on Route ____________ Section ____________, County, more particularly described as follows:

Subject to the following conditions and restrictions:

First: The petitioner shall be allowed to cultivate and use the above described tract for farming purposes only, until such time as the State shall desire to complete the proposed improvement of the public highway.

Second: In accepting this permit the petitioner agrees not to interfere with or obstruct traffic on said highway, or to place any buildings, signs, fence or other obstructions on the above described tract. It is understood and agreed that the petitioner assumes all responsibility for accidents or damages that may accrue to persons or property either public or private, caused directly or indirectly by reason of the petitioner's use of the tract as herein described.

Third: That the petitioner shall not trim, cut or in any way disturb any trees or shrubbery along said highway without the approval of the Chief Highway Engineer or his duly authorized representative.

Fourth: That the petitioner agrees to assume full responsibility for the proper maintenance of any fence which now exists or which he may hereafter construct on the right of way line.

Fifth: Petitioner agrees to relinquish and completely vacate the above described tract within sixty (60) days after notice in writing from the Department of Public Works and Buildings, in the same manner and with the same provisions as if the said petitioner had not been allowed to use said tract for farming purposes. It is expressly understood and agreed that the Department shall not be responsible for any damage to growing crops on said tract.

Sixth: That this permit is effective only insofar as the Department of Public Works and Buildings has jurisdiction.

This permit is accepted and its provisions agreed to this ____________ day of ____________, 19__.

ATTEST: ___________________________  Signed ___________________________

Witness Petitioner

Given this ____________ day of ____________, A.D. 19__.

Recommended: Department of Public Works and Buildings

By ___________________________ Director ___________________________
upper land regardless of the adequacy of the existing outlet channel, while the highway authorities have a responsibility to provide facilities to perpetuate natural drainage for the highway and affected landowners at the lowest cost.

The Illinois Division of Highways has clarified its position with group drainage organizations on adjustment of highway culvert elevations with an administrative memorandum:

This Division is at times requested to lower the flow line of an existing culvert to permit unobstructed flow of water across its right-of-way in connection with the improvement and deepening of a ditch of a legally organized drainage district or a group of landowners seeking such drainage improvement by mutual agreement and action.

This Division has utilized full drainage possibilities of these ditches in the construction and maintenance of its highways without having contributed to the cost of construction or maintenance of the drainage ditches.

Since this Division has chosen, for reasons of economy, to construct structures of a type other than bridges across the many smaller drainage ditches, it will hereafter be our policy to adjust our culvert flow lines to the elevation of proposed drainage ditch improvements to permit full advantage of such improvements. Such culvert adjustments are to be made only after written agreements with the interested groups are executed to assure a correct and satisfactory elevation of the adjusted flow line and to assure that the proposed improvement of the drainage ditch will be carried out as intended. 

Highway authorities indicate that permits will be granted to landowners who desire to lower the flow line across the highway right-of-way in accordance with department regulations, provided a qualified and bonded contractor performs the work. At locations where it is anticipated that landowners will request that a flow line be lowered at a later date, highway authorities indicate that occasionally bridges or other types of structures without floors have been installed. However, care must be taken to insure that the abutments will not be weakened by erosive action within the channel.

Construction of grassed waterways on the downstream side of a structure
presents some problems to highway authorities. There have been instances where the flow line of the grassed waterways in the downstream channel has gradually risen above the flow line of the crossroad structure. Consequently, the channel has become partly obstructed, causing the water to stand within the highway right-of-way. It appears that this difficulty could be reduced if the grassed waterway were properly designed and maintained.

7. Mutual Projects

There are occasions when both the highway authority and the adjoining landowner would benefit by contributing to a mutual project. Such a project might be an erosion control structure located on the right-of-way line. Without the structure, extensive erosion and channel cutting might take place on the property of the upper adjoining landowner or within the limits of the highway right-of-way. As a result, damages might be inflicted both upon the adjoining land and within the highway right-of-way. One remedy might be the construction of an erosion control structure near the right-of-way line to control cutting of the channel upstream from the highway and also to provide protection to the highway property. The net result would be mutual benefits to both parties from the structure. In this case each party would agree to share responsibilities in its construction. For example, the landowner might furnish the material and the highway authority might perform the work.

Before the highway authority can obligate itself to participate in a project of this type, it is necessary that there be substantial benefit to the highway, since highway funds can be expended only for projects providing benefits to highways. Also, under most circumstances, highway funds are expended for projects located only within the limits of the right-of-way.

The drainage manual of the Colorado Department of Highways contains this basic policy statement:

The Department may participate in cooperative projects for flood control or flood protection only with the advance approval of the office of the Chief Engineer. Such projects must be covered by a formal agreement. The amount of participation is based on the legal premise that aid must be restricted to the amount of benefit accruing to the State by reason of improvement. To share to a greater extent is to divert highway user tax funds to purposes other

FIGURE 15. A DROP BOX CONSTRUCTED BY MUTUAL AGREEMENT BETWEEN THE HIGHWAY AUTHORITY AND ADJOINING LANDOWNER TO REDUCE EROSION WITHIN HIGHWAY RIGHT-OF-WAY AND UPON THE UPPER LAND
than highway uses.
Actual construction work performed by the Department under such agreements shall be limited to State right-of-way unless otherwise approved in advance by the office of the Chief Engineer. (4)

8. Maintenance

One problem encountered by the highway authority is to determine its responsibility for maintaining surface drainage systems. The Wisconsin Highway Commission has issued the following memorandum which states in part:

...All roadside ditches, stream channels, etc., which form a part of the highway drainage system shall be kept clean and free of any vegetation, debris, or other matter which impedes or blocks the free flow of surface water in such ditches or channels. Particular emphasis shall be placed on the removal of brush, sediment, etc., which restricts flow in stream channels beneath bridges or at any other location on the highway right-of-way, and on the removal of all vegetation which creates a potential fire hazard beneath timber structures. The highway ditches shall be reconstructed as necessary to provide and maintain sufficient capacity for carrying and discharging normal surface water. Ditch alteration may also be performed at locations where such alteration would result in lowering or otherwise desirably controlling the ground water level.... (10)

The Illinois Division of Highway Maintenance Manual states:

All ditches and slopes should be maintained to the original cross section. If they should be improved, you can develop flat bottom ditches and make the shape and slope of earth slopes conform as nearly as possible to present construction standards and design policies.... Side ditches in all cuts should be kept cleaned and deep enough to keep water table below the subgrade or as much deeper as may be necessary for the ditches to handle the volume of water. (11)

The manual further recommends that: (1) Ditches should be kept to line and grade and not allowed to pond water. (2) Ditches and inlets to culverts should be kept free of dirt and debris.

In discussing the maintenance practice of inlet and outlet ditches, highway authorities indicate that they maintain and keep inlet and outlet ditches open within the right-of-way limits and as far beyond as is necessary to protect the road or street.

In Illinois, under the natural rule of drainage, the holder of the easement ordinarily has the right to go upon the servient land to make the necessary repairs without causing unnecessary injury to the land. It appears that the highway authority may also have the privilege of going beyond the right-of-way limits to make repairs necessary to protect the road or street. The extent to which such work may be done is not clear.
E. REFERENCES CITED


6. Drainage Manual, Florida State Road Department.


8. Ill. Rev. Stat., Ch. 121, Sec. 4-209 (1963).


14. J. L. Sanborn, Principles of Highway Drainage and Erosion Control, County Highway Series No. 4, Purdue University Engineering Experiment Station in Cooperation with the County Commissioners of Indiana, Lafayette, Indiana, 1962.


V. SUBSURFACE DRAINAGE

A. PURPOSE

Subsurface drainage is a means of removing excess water from beneath the surface of the ground. It is accomplished by laying a series of tile in a continuous line at a specified depth and grade so that free water entering the tile joints will flow in the tile by gravity to an outlet. It differs in principle from surface drainage in that water percolates into the soil and is taken out by drains located underneath the surface. The purpose of such a system for agricultural land is to lower the level of the ground water below the root zone of the plant.

A tile drainage system consists of an outlet, a main, submains, and laterals. The function of the laterals is to remove the free water from the soil; the function of the mains and submains is to collect the water from the laterals and carry it to a drainage outlet. Basically, a tile drain may serve one or more of the following purposes:

1. Improve crop environment by lowering the level of the water table.
2. Intercept water and prevent its movement into a wet area.
3. Serve as an outlet for other tile drains.

In highway drainage, the purpose of a subsurface drainage system is to remove detrimental amounts of free ground water within the limits of the right-of-way and thereby provide a stable roadbed and side slopes.

The solution of subsurface drainage problems within the highway right-of-way often calls for a knowledge of geology and soils. There are many variables and uncertainties about actual subsurface conditions. In general, the more obvious subsurface drainage problems can be anticipated in design; the less obvious are frequently uncovered during construction. Extensive exploration may be required to determine the design variables with reasonable accuracy. For these reasons, many designs are based on local experience and empirical rules that have given satisfactory results. (23)

In highway drainage design, an important consideration is to protect the highway against damage from subsurface waters, at the same time taking into account the effect of the proposed improvement on traffic and property. Unless the highway would benefit thereby, the improvement usually does not include drainage of the area outside the right-of-way. (5)
B. BASIC REQUIREMENTS FOR AGRICULTURAL SUBSURFACE DRAINAGE SYSTEMS

1. Selection of Drainage Coefficient

An agricultural subsurface drainage system is designed so that it will have a sufficient capacity to remove excess water rapidly enough to prevent serious damage to crops. The drainage coefficient is the index of the flow capacity to be provided in mains and submains, and it is defined as the depth of water to be removed from the drainage area in a unit of time. Units are commonly inches of water in 24 hours, and the drainage coefficient is usually referred to simply as inches.

Generally accepted requirements for the selection of drainage coefficients for agricultural drainage in Illinois are shown in the table below. (7)

2. Size of Drain

The size of the tile drains is generally determined by applying either Manning's Formula:

\[ V = \frac{1.486 R^{2/3} S^{1/2}}{n} \]

or Yarnell-Woodward Formula:

\[ V = 138 R^{2/3} S^{1/2} \]

in which:

- \( V \) = mean velocity in feet per second
- \( R \) = hydraulic radius
- \( S \) = slope of tile expressed in feet per foot, and
- \( n \) = roughness coefficient.

A convenient chart for determining the required capacity and size of drain tile is shown in Figure 17. If the required capacity is to be provided, the selected drainage coefficient must be applied to the correct area. The following conditions must be considered in selecting the proper size of drain tile for agricultural purposes:

1. When no surface water is admitted directly to the tile through inlets, the selected drainage coefficient should apply only to the wetland area requiring tile drainage. An exception is when the runoff from the upland watershed spreads out over the area to be tile-drained, increasing the load over that produced by actual

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Drainage coefficient (in./24 hr.)</th>
<th>Field crops</th>
<th>Truck crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Where surface drainage is adequate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Organic soils</td>
<td>1/2 - 3/4</td>
<td>3/4 - 1 1/2</td>
<td></td>
</tr>
<tr>
<td>2. Where tile is to take both surface and subsurface drainage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Using blind inlets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.) Mineral soils</td>
<td>3/8 - 3/4</td>
<td>1/2 - 1</td>
<td></td>
</tr>
<tr>
<td>2.) Organic soils</td>
<td>1/2 - 1</td>
<td>3/4 - 2</td>
<td></td>
</tr>
<tr>
<td>b. Using open inlets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.) Mineral soils</td>
<td>3/4 - 1</td>
<td>1 - 1 1/2</td>
<td></td>
</tr>
<tr>
<td>2.) Organic soils</td>
<td>3/4 - 1 1/2</td>
<td>2 - 4</td>
<td></td>
</tr>
</tbody>
</table>
*Space between lines is the range of tile capacity for the size shown between lines

**FIGURE 17. TILE DRAINAGE CHART**
rainfall. If the runoff from this upland watershed cannot be diverted from or channeled through the area to be drained, the drainage coefficient should be applied to the contributing watershed area.

2. When surface water is admitted directly to the tile line through surface inlets, the entire watershed draining into the surface inlet should be included in the design. An exception is when only a small amount of runoff will be impounded at the inlet and the remainder will flow away in a confined channel. The tile line should then be designed to carry away only the impounded water within a reasonable time.

3. For seepage interceptor tile lines, the required size of tile should be based on the estimated inflow rates.

4. The following recommendations will serve as a guide in selecting the minimum size of tile:
   a. Use 4- or 5-inch tile in mineral soils that contain small amounts of fine sand or silt and where good alignment and uniform grade can be obtained.
   b. Use 6-inch tile as the minimum size for unstable soils, such as peat, muck, and quicksand. Lengths greater than 12 inches are recommended for tile drains in unstable, organic, and mineral soils.

3. Depth, Spacing, and Location

   The depth, spacing, and location of drain tile are based on site conditions, including soils, topography, groundwater, crops, and outlets. Indications are that crop yields increase as tile depths are increased from 24 to 42 inches or more. It is therefore desirable for the laterals to be placed 3 to 4 feet deep. The depth and spacing may be reduced under the following conditions:
   1. Soils are slowly permeable.
   2. A layer of extremely tight soil, sand, or large stones prohibits greater depth.
   3. There are depressional or impounded areas.
   4. Outletting is a problem.
   5. Cropping conditions require rapid drainage of upper horizons of the soil profile.

   For soils with uniform permeability, the deeper the drains, the wider the spacing may be to provide the same degree of drainage. Depending on variability of soil profiles, tile depths and spacings in Illinois vary from 3 feet deep at a 60-foot spacing to 4 feet deep at a 120-foot spacing. These depths apply to laterals and not to mains, since the depth of the main is governed primarily by outlets and topography.

   The minimum cover in mineral soils to protect tile from breakage by heavy machinery should be 2 feet, measured from the top of tile to the soil surface. This minimum applies to normal field levels and may exclude sections of line near outlets or sections laid through minor depressions where the tile is not subject to damage by frost or equipment or where site conditions justify other depths.

   In organic soils the minimum depth of cover is 2 1/2 feet for normal field levels. It is recommended that the area be drained first by open tile trenches or other ditches before tile are laid in organic soils.
4. Minimum Grade

In a flat area, the grade for a tile line should be as steep as the topography will permit. A tile system that has little or no grade can soon become ineffective because of siltation. The grade of small-sized drains should be limited to the following:

<table>
<thead>
<tr>
<th>Diameter of tile in inches</th>
<th>Minimum grade in feet per 100 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.10</td>
</tr>
<tr>
<td>5</td>
<td>0.08</td>
</tr>
<tr>
<td>6</td>
<td>0.07</td>
</tr>
<tr>
<td>8</td>
<td>0.06</td>
</tr>
<tr>
<td>10</td>
<td>0.06</td>
</tr>
<tr>
<td>12</td>
<td>0.05</td>
</tr>
</tbody>
</table>

At locations where siltation may occur, the minimum grade should provide a velocity of not less than 1.4 feet per second. If this minimum is impossible, other means should be used, such as filters, silt traps, junction boxes, or manholes.

5. Maximum Grade

High flow velocities in tile systems present definite hazards. The Illinois Drainage Guide contains recommendations concerning maximum grades of tile for various soil textures.

6. Tile Quality

High-quality tile should be used in a subsurface drainage system. The two most common materials are clay and concrete. Clay tile are made of shale, fire clay, or surface clay. Concrete tile are made of Portland cement and a suitable aggregate. Except for certain soil conditions, either good-quality clay or concrete tile is satisfactory.

Good drain tile should have the following characteristics:

1. Resistance to weathering and deterioration in the soil.
2. Sufficient strength to support static and impact loads.
3. High density.
4. Resistance to alternate freezing and thawing.
5. Relative freedom from defects, such as cracks and rough ends.
6. Uniformity in wall thickness.
7. True and circular cross-sectional area.

The American Society for Testing Materials has established specifications for both concrete and clay.

The American Society for Testing Materials (27, 28) has established specifications for both concrete and clay.

### Tile Installation Practices for Steep Grades

<table>
<thead>
<tr>
<th>Soil texture</th>
<th>Grade (ft./100 ft.)</th>
<th>Special construction requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy</td>
<td>Less than 1</td>
<td>Normal practice--lay with tight joints. Use tile with bell and spigot or tongue and groove joints, or continuous rigid pipe. Normal practice.</td>
</tr>
<tr>
<td></td>
<td>More than 1</td>
<td></td>
</tr>
<tr>
<td>Silty or loamy</td>
<td>1/2 to 2</td>
<td>Normal practice, but tamp clay well around tile. Use tile with bell and spigot or tongue and groove joints, or continuous rigid pipe.</td>
</tr>
<tr>
<td></td>
<td>More than 2</td>
<td></td>
</tr>
<tr>
<td>Clay and heavy clay loams</td>
<td>1 to 6</td>
<td>Use tile with bell and spigot or tongue and groove joints, or continuous rigid pipe.</td>
</tr>
<tr>
<td></td>
<td>More than 6</td>
<td></td>
</tr>
</tbody>
</table>
7. Tile Loading

Drain tile should be so installed that the load will not exceed the average crushing strength of the tile. The loads that a tile will carry are determined by the type of soil, depth and width of trench, and manner of bedding. Minimum crushing strengths for various qualities of concrete and clay drain tile are given in the ASTM specifications. Loads on drain tile can be determined from formulas developed by Marston at Iowa State College. Nomographs based on the Marston formulas have been developed to simplify the computation of loads on drain tile. (1)

8. Alignment

Horizontal direction should be changed in such a way as to (1) maintain the specified grade, (2) not impede the flow of water because of excessive roughness, and (3) allow the joints to be fitted according to soil conditions.

Horizontal direction may be changed by one of the following methods:

1. Make the tile trench on a gradual curve so that the trenching machine can dig the trench and still maintain grade.

2. Make a gradual curve by shaving the inner side of the curve and chipping the tile; however, in no case should the radius of curvature be less than 5 feet.

3. Use manufactured bends or fittings so that the change in direction is a smooth curve.

4. Use junction boxes and manholes. (1)

The tile should be laid so that the gap between tile will conform as nearly as possible to the following recommendations:

1. Sandy soil. Tight fit.


3. Clay soil. 1/8 inch, except where local experience indicates a wide spacing.

4. Peat and muck. 1/4 to 3/8 inch. (1)

C. REQUIREMENTS FOR SUBSURFACE FACILITIES WITHIN RIGHT-OF-WAY

1. General

A highway crossing a system of agricultural drains will divide them into two independent systems. Provision must be made to insure the effective performance of such systems without increasing the maintenance or other responsibilities on the part of either the landowner or the highway authority. These requirements can be met by constructing or reconstructing drains across the highway right-of-way or collector drains, outlet ditches, and appurtenances adequate for the area and conforming to the standards for the design and construction of agricultural and highway drainage.

Once these drainage facilities have been installed, the drainage pattern on the upstream side of the highway will have been established. Alteration or improvement of this pattern after completion of the highway will involve construction of additional structures or reconstruction of existing structures under the highway. Such procedures place a heavy...
financial burden on those involved and also present the highway authority with the problem of carrying on the construction while maintaining normal traffic flow.

2. Location

During the preliminary planning or design, all tile drains crossing the proposed highway or otherwise affected by its construction should be accurately located by consulting the property owners and making a careful study of the area. Such study is necessary because property owners often do not know the location of tile, particularly when drains were installed by former owners.

The Illinois Division of Highways Field Manual, section 11-7 states:

Location of existing tile lines is often overlooked by the survey party. You should talk to all property owners or tenants and locate and examine all tile lines, having these parties present at the time. It is valuable for future reference if the condition of these lines is noted on the office plans. Drainage outlets should be considered when establishing the flow line of culverts and ditches. It is advisable either to encase in concrete or to replace with reinforced concrete tile all tile lines that extend across the roadway at less than 3 feet below the natural ground. This should be done regardless of depth if the tile line lies in unstable soil. However, you should locate the lines and then consult your district construction engineer before you do any encasing or replacement work.\(^{(11)}\)

Section 7.16 further states:

It is not always possible to learn ahead of time of the existence of underground structures, such as water pipes, conduits, tile lines, and sewers. Before excavating where there is a possibility of the existence of such structures, you should check with the property owners, or officials, to determine if such underground structures do exist, and warn the contractor of their existence. You should also notify the district office when some underground structure not shown on the plans is discovered in order that plans for its removal or protection may be made. Any unchartered or damaged installations should also be reported to the owner.\(^{(11)}\)

The guide prepared by the Association of Illinois Soil and Water Conservation Districts states:

Highway officials, with the cooperation of the landowner, shall determine within practical limits the location of all subsurface field drainage, where such drainage exists within the right-of-way, and shall make provisions on the construction plans for the continuation of the functioning of any known field drainage system which might be affected by the construction of highways and roads. It is realized that it may be difficult in some cases to locate the field drainage systems. This may be facilitated by contacting the representatives of the local drainage districts, the county or state conservation agencies, or the Soil Conservation Service of the U.S. Department of Agriculture.\(^{(26)}\)

Highway authorities report that they make a determined effort to eliminate possible sources of drainage conflict in the design of highways. They locate all existing farm drain tile in the proposed right-of-way and also in areas of possible future installation by checking data from county engineers and Soil Conservation Service personnel, by visiting landowners or tenants located adjacent to the right-of-way, by conducting field inspections, and by actually probing for tile. Provisions for existing tile are included in the design plans, and additional drain tile found during construction are provided for in the contracts.

Highway authorities caution,
however, that it is sometimes difficult to locate subsurface drains. Various exploratory methods have proved to be both unsatisfactory and costly. The conclusion is that the landowner or the drainage authority is in the best position to locate existing subsurface drains and to point out the requirements of the affected area.

3. Interception

Highway improvement often affects soil and water management facilities located in agricultural areas. Whenever a subsurface drainage system is encountered, the highway authority must decide how to handle the intercepted flow to the best interests of all concerned. The practice of many highway authorities is to provide for the intercepted system to function in a manner similar to the original one. Concerning the interception of collector mains, the criteria developed for the Indiana Toll Road state:

Existing collector mains crossed by the Toll Road shall be outletted into the Toll Road side ditches, shall be carried parallel to the Toll Road at locations outside the Toll Road right-of-way to suitable outlets, or shall be carried under the Toll Road in reconstructed conduits and be reconnected to the existing collector mains or be carried to suitable new outlets. Wherever possible, without constructing undue lengths of mains or ditches, collector mains shall be outletted at points outside the Toll Road right-of-way.(3)

Criteria developed for the Ohio Turnpike authority state:

Existing collector mains crossed by the turnpike were carried to suitable outlets where feasible, or rebuilt under the turnpike and connected to the existing collector. The minimum depths below average field levels of such collector mains which crossed under the turnpike varied from 4 feet in areas with prevailing land slopes, to 5 feet for level lands, except where rock was encountered. Where no outlets were available at these depths, the collector mains under the turnpike were rebuilt to meet the existing depths, with provisions for future lowering of such drainage systems. These provisions were accomplished by the installation of over-sized pipes with the tops at the level of the tops of the existing mains and with the inverts at the minimum depths noted herein. Or, separate pipes for future use were installed under the turnpike at the minimum depths.(9)

ASAE Recommendations for handling intercepted collector mains are as follows:

Collector mains, existing tile mains, intercepting lateral tile drains, or other subsurface drains crossed by the highway shall be: (a) outletted into highway side ditches, (b) carried parallel to the highway at locations outside the right-of-way to suitable outlets in existing ditches or tile mains, (c) carried under the highway in reconstructed conduits and reconnected to existing tile mains, and (d) connected to highway storm sewers and carried to suitable new outlets. Wherever possible, collector mains shall be outletted into ditches or tile drains outside the highway right-of-way; however, construction of undue lengths of collector mains or ditches should be avoided.(2)

Concerning the interception of laterals, the criteria developed for the Indiana Toll Road state:

Existing lateral drain tiles crossed by the Toll Road shall be intercepted approximately 25 feet outside the Toll Road right-of-way line by collector mains and properly outletted. Lateral tile farm drains shall not be outletted into the parallel Toll Road side ditches. Existing ditches, existing collector mains not affected by the Toll Road construction, and Toll Road ditches shall be used for outletting such collector mains. Collector mains shall cross the Toll Road where necessary to find an outlet.(3)
Criteria developed for the Ohio Turnpike authority state:

Existing lateral farm drains which were crossed by the turnpike were not permitted to be discharged into the turnpike side ditches, but were intercepted with a collector main at a point approximately 25 feet outside the turnpike right-of-way line. The collectors were carried to suitable outlets, or connected to an existing outlet main... (9)

The ASAE Criteria recommend that:

Existing systems of lateral tile drains, mole drains, stone drains, and "French" drains crossed by the highway shall be either connected to the highway subsurface drainage system or intercepted approximately 25 feet outside the highway right-of-way line by collector mains, and properly outletted. When outlets are available, scattered subsurface or tile drains laid in a random pattern may be outletted into highway side ditches through pipe outlets.

The highway authority shall have the option of doing the work by contract or placing funds in escrow to have the drain reconstructed by the drainage authority or landowner. (2)

Comments about these criteria suggested that a diversion problem might be encountered where subsurface water was collected in a side ditch and emptied into a common outlet upon the lower landowner. Some authorities indicated that collector mains were not used, but that each intercepted line was extended directly across the roadway from right-of-way line to right-of-way line with a pipe of increased strength.

In handling the flow from widely spaced farm tile that will be undercut by roadway ditches, Ohio (10) follows the practice of outletting at the roadway ditch and carrying the flow by way of the ditch to a roadway culvert. If the highway ditch does not undercut widely spaced farm drains, the drains are replaced within the right-of-way limits by a pipe of adequate size and strength. Farm drains crossed by the highway at spacings of less than 100 feet are intercepted by collector mains located approximately 25 feet outside the right-of-way, and the collector main runs parallel to the highway and joins to a culvert or underground main. All work outside the right-of-way is done by the landowner, and the cost is included in the right-of-way settlement.

Some projects include, as a damage item, the farmer's cost of building necessary collector mains on his property. One highway authority indicates that this procedure has been satisfactory, since the farmer's cost is sometimes less than the highway authority would have to pay for the same work. Usually it is most satisfactory to withhold this payment from the landowner until the installation has been completed.

Highway authorities indicate that, when farm drains cross the road, they take precautions to keep them in at least their original state of efficiency. The Illinois Standard Specifications for Road and Bridge Construction state:

The roadway shall be maintained so that it will be well drained at all times. If, during the prosecution of the work, it is necessary to interrupt existing sewer or under-drainage, temporary drainage facilities shall be provided until the permanent drainage work has been completed....

The Contractor shall be responsible for, and shall take all necessary precautions to preserve and protect all existing tile drains, sewers, and other subsurface drains or parts thereof which may be affected by his
operations, and which, in the opinion of the Engineer, may be continued in use without change. He shall repair at his own expense any and all damage to such drainage facilities resulting from negligence on his part. (25)

The Illinois Field Manual states:

All reasonable precautions should be taken not to damage any existing drain or sewer. The depth of the earth covering is sometimes reduced, as in shallow borrow pits, and the tile exposed to freezing. Shallow tile is sometimes crushed by tractors and scrapers. Instruct the contractor fully as to what drains or sewers it will be necessary for him to maintain in their present position, and remind him of his responsibility in the matter. Occasionally fills and pavements are built over tile lines, making them inaccessible for examination and repair. The weight of embankments sometimes causes settlement which results in breakage in the tile line. These conditions show up long after the work is completed when complaints are difficult and costly to adjust. (11)

The Illinois Suggested Guide (26) states that a drainage tile crossed by a highway or road should be replaced by the highway officials with pipe of the strength required to support the roadway and enable the system to function as effectively as in its original condition. If a system consisting of several parallel drains is crossed, the authorities should consider the possibility of installing a collector pipe parallel to and outside the right-of-way, taking the entire system across the right-of-way in a single pipe, and emptying it into the original system outlet. It is further stated that if, during the highway improvement, isolated or random tiles are cut off by the side ditches of the highways or roads, they may be outletted in the side ditch, where adequate outlets are available. Indiana instructions state that:

Where farm drains cross the road, every precaution should be taken to preserve them in at least their original state of efficiency. Tile drains shown on the plans, which are to be left in place, but are damaged by carelessness on the contractor's part, shall be replaced by the contractor at his expense. Tile drains which are discovered before any work is done, but which are not shown on the plans, should be marked on the contractor's plans as well as the Project Engineer's plans. In general, farm tile 6" to 10" in size, which are 4 feet or less under the ground surface, shall be replaced with sewer pipe, when the tile lies under the roadway. Farm tile 12" or over crossing under the pavement should always be replaced with extra strength V. C., R. C., or concrete pipe. (12)

The comments of highway authorities make it evident that drain tile crossed by the roadway will generally be (1) outletted into the road ditch, with outlets constructed to state standards; (2) intercepted outside the right-of-way and conducted to a suitable outlet; or (3) replaced with a new pipe able to withstand the heavier loads. With any of these methods of disposing of the intercepted subsurface water, care must be taken not to divert the water from one watershed to another to the detriment of the lower landowner. Also, the outlet, whether it be another collector main or an open drain, must have ample capacity to handle the increased flow even if the water is not diverted.

Intercepted tile lines will often appear to be abandoned as a drainage medium. Authorities caution against assuming that such tile are abandoned and need not be replaced until their status has been thoroughly investigated. Too often such tile, if not replaced, can cause difficulty later.
4. Collector Mains

a. Depths - The function of a collector main is to collect water from the laterals and conduct it to a suitable outlet. On the Ohio Turnpike, collector mains were installed at sufficient depths to connect all intercepted lateral tile and subsurface drains. Except under waterways or sloughs, the minimum depth of inverts of such collector mains was generally 3.5 feet below the field elevation. Under sloughs and waterways, the minimum cover over collector mains was 2.0 feet, or sewer pipe or other continuous pipe was used in lieu of drain tile.

In an attempt to preserve existing drainage systems and to provide for expansion over the next 25 to 50 years, collector mains were installed at sufficient depths to permit the connection of intercepted lateral drains. Where existing and adequate outlets would not permit installing collector mains at depths necessary for future requirements, collectors were installed at the maximum depths permitted by existing outlets.

Collector mains for agricultural drainage installed under the Indiana Toll Road and the Ohio Turnpike or under reconstructed local roads were installed to provide invert depths below average field levels adjacent to the upstream right-of-way line as shown below.

<table>
<thead>
<tr>
<th>Prevailing field slope (per cent)</th>
<th>Minimum invert depth (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 to 0.25</td>
<td>5.0</td>
</tr>
<tr>
<td>0.25 to 0.50</td>
<td>4.8</td>
</tr>
<tr>
<td>0.50 to 1.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Over 1.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Where rock is encountered, these depths may be reduced, provided that all existing tile drains are outletted.

Where it is impossible to install collector mains at the minimum depths specified above without the construction of extensive outlet pipes or ditches, provisions for future lowering of the drainage fields shall be made by either one of the following methods:

(a) Providing a pipe of a larger size than that required, with the top of the pipe at the elevation of the top of the existing collector main at the downstream side of the toll road or reconstructed local road and with the invert of the pipe at the required minimum depth.

(b) Installing an additional pipe of adequate size at the required minimum depth and sealing of both ends. (3, 21)

b. Grades - The desirable recommended grade for collector mains is within the range of 0.10 and 0.75 per cent. The maximum recommended grade is 1.0 per cent, and the minimum recommended grade is 0.05 per cent. (2)

The suggested maximum velocities for tile mains with open joints at design rates of flow are as follows: (3)

<table>
<thead>
<tr>
<th>Maximum velocity, feet per second</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of soil</td>
</tr>
<tr>
<td>Sand</td>
</tr>
<tr>
<td>Sandy loam</td>
</tr>
<tr>
<td>Silty clay</td>
</tr>
<tr>
<td>Clay loam</td>
</tr>
<tr>
<td>Clay</td>
</tr>
</tbody>
</table>

c. Capacity - The ASAE Criteria (2) provide that the minimum inside diameter of any reconstructed tile main or collector main shall be 6 inches. They further provide that the minimum inside diameter of conduits placed under the highway for existing or future subsurface drainage shall be the larger of
**Drainage Coefficient (inches)**

<table>
<thead>
<tr>
<th></th>
<th>Areas with grated inlets and no surface drainage</th>
<th>Areas with surface drainage**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral soils</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Organic soils</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

*The area requiring tile or subsurface drainage is here considered the drainage area. Surface water must be removed by separate waterways and/or natural or artificial open ditches.

**The entire contributing watershed of the area from which the surface water must be removed by grated inlets discharging into the tile or subsurface drain is here considered the drainage area. The runoff values may be reduced when detention storage is used in the design. (2)*

12 inches or the diameter as determined in Figure 17, using the drainage coefficient shown in the above table.

D. OUTLETS

1. Outletting Drain Tile

The question of outletting drain tile into a highway side ditch arises either when the tile has been intercepted by highway construction or when the landowner desires to use an existing highway ditch as an outlet. Highway authorities say that it is sometimes necessary to outlet drain tile into a highway side ditch, in which case the outlet end must be adequately protected. However, it is not a favored practice and other means of disposal are preferred.

Landowners express concern about outletting tile or pipes into highway ditches. They fear that the tile or pipe may be damaged or clogged by highway maintenance or by accumulation of silt in the ditch. Also, highway ditches may not drain adequately and the water may back up in the tiles and eventually flood the fields.

Criteria set forth for the Indiana Toll Road provide that existing lateral farm drains crossed by the toll road were not permitted to be discharged into the toll road side ditches, but were intercepted by a collector main at a point approximately 25 feet outside the toll road right-of-way line. (3)

The criteria further stipulate that existing collector mains crossed by the toll road shall be outletted into the side ditches; carried parallel to the toll road, at locations outside the toll road right-of-way, to suitable outlets; or carried under the toll road in reconstructed conduits and reconnected to existing collector mains or carried to suitable outlets. Wherever possible, without constructing undue lengths of mains or ditches, collector mains shall be outletted at points outside that toll road right-of-way.

The ASAE Criteria (2) make a recommendation similar in many respects to that of the Indiana Toll Road criteria for both lateral drains and collector mains. The Illinois Highway Code (20) provides that a landowner through or along whose land a public highway passes and who desires to drain into the highway may do so if he gives due notice to the proper highway authority and receives from that authority...
written permission for any work, ditching, or excavating he proposes to do within the limits of the highway.

2. Invert Elevation

An outlet of a subsurface drainage system, when functioning properly, provides for rapid removal of water. When existing tile mains are used as outlets, the tile must be in good condition and have sufficient capacity to handle the load. For tile systems outletting into open ditches, it is recommended that at least a 12-inch clearance be allowed between the bottom of the tile and the low water stage in the open ditch.\(^{(1)}\) This clearance may be reduced if:

1. There is no low-water flow in the ditch for more than a few hours after storms.
2. The ditch grade is such that sedimentation will not occur.\(^{(21)}\)

The Ohio Turnpike Commission\(^{(9)}\) recommends that outlet ditches constructed for agricultural drainage be deep enough to provide the minimum depth for the collector mains, with the bottom of the ditch one foot below the invert of the collector main at its outlet.

Some highway authorities use a minimum difference of 6 inches in elevation between the tile invert and the bottom of the ditch. Occasionally no criteria are used, and the outlet is installed at the existing elevation. This means that at times the invert of the outlet and the bottom of the ditch are flush.

The Illinois Suggested Guide\(^{(26)}\) recommends that, when drains are outletted into a ditch, the invert of the drain outlet should preferably be from 9 to 18 inches above the established grade line of the ditch. If three or more tile lines join at one point, a junction box should be used. If a junction box is installed in a cultivated field, the top of the box should preferably be a minimum of 18 inches below the ground surface.

3. Protection

The outlet for a tile drain should be protected against erosion, undermining of the tile during periods of submergence and entry of rodents or other animals. The Soil Conservation Service\(^{(13)}\) recommends that this protection be provided by using a rigid pipe for the outlet, with approximately two-thirds of the pipe length embedded in solid earth. The buried portion should not be less than 10 feet. The pipe should extend far enough out to deposit the water at the toe of the ditch slope.
For the Indiana Toll Road, the provisions stated that the outlet ends of all laterals or collector mains should be protected by installation of an endwall for pipe outlets. In lieu of installing an endwall, 20 feet of 10-gauge corrugated metal pipe could be installed at the outlet ends of the laterals or mains.

ASAE Recommendations provide that:
Outlet ends of all lateral tile or collector mains discharging into open ditches shall be protected by installation of pipe outlets. Pipe outlets for reconstructed tile mains or collector mains shall be made of 20 ft. of 16-gauge fully bituminous-coated corrugated metal pipe or its equal. Single or random tile smaller than 6 in. in diameter which are not reconstructed may be outletted through pipe outlets 10 ft. long. Gratings shall be installed on outlet ends of all pipe outlets discharging subsurface drainage, and gates shall be used on the pipe outlets discharging surface water to keep small animals out of the pipes.

Indications are that use of 10-foot corrugated metal pipe has worked to the apparent satisfaction of those involved.

Where surface water enters the ditch at the location of a tile outlet, measures must be taken to safely lower the surface flow to the ditch. ASAE Recommendations provide:
Under this condition some type of structure should be used to outlet the tile and to safely lower the surface flow to the ditch. When there is no spoil bank, the straight-drop spillway is generally the best type of structure. If there is a spoil bank and sufficient temporary storage on the land is possible and permissible, a pipe drop-inlet structure will usually provide the best and most economical installation. Sometimes it may be possible to move the tile outlet out of the waterway or divert the surface water to another location at least 60 to 75 ft. away and lower the surface flow into the ditch over a sodded chute. When practical the tile outlet should be located upstream from the surface-water outlet...

E. DIVERSION
The Illinois law provides that the owners of land may construct open or covered drains and discharge them into a natural watercourse or natural depression draining that area, provided the water will be carried into some natural watercourse. The dominant landowner, however, is not given the privilege of casting water upon the land of an adjoining owner that would
not reach this land in the course of natural flow. The principles of diversion that apply to both highway authorities and individual landowners are fully covered in the legal phase of this study.\(^6\)

F. CONNECTION INTO DRAINAGE SYSTEMS

1. Highway Drains Discharging into Agricultural Facilities

Drainage waters are often discharged into the most convenient watercourse. This right is unquestionable if those waters are naturally tributary to the watercourse and is unchallenged if the watercourse has adequate capacity.

Where there are no natural outlets, under the provisions of the law it appears that it is permissible for the highway authorities to contract with an adjoining landowner for the right to drain onto the adjoining land even if the water does not follow the path of natural flow. If the contract contemplates lawful disposition of the water by the landowner, the highway authority is not responsible for subsequent unlawful disposition.\(^4\)

ASAE Criteria\(^2\) state that surface water from the highway shall not be discharged into existing agricultural tile mains or subsurface drains unless they were designed for this purpose. Criteria for the Ohio Turnpike provide that surface water from the turnpike shall not be discharged into existing agricultural tile mains.\(^24\) Highway authorities in Illinois say they refrain from connecting drainage from highways to existing agricultural drain tile.

2. Agricultural Drains Discharging into Highway Facilities

According to the principle of natural drainage, adjoining landowners have a right to drain their lands across or along highways with or without the consent of the highway authorities, provided they follow the natural depression of the land. On the other hand, when a landowner attempts to divert water and cast it upon the highway out of its natural course, highway authorities have a right to prevent such action. The Highway Code\(^20\) provides that a landowner, through or along whose land a public highway passes, who desires to drain onto the highway right-of-way may do so if he first gives due notice to the proper highway authority and receives written permission.

In reference to subsurface drains, the Highway Code further provides that:

Whenever the highway authorities are about to lay a tile drain along any public highway the highway authorities may contract with the owners or occupants of adjoining lands to lay larger tile than would be necessary to drain the highway, and permit connection therewith by such contracting parties to drain their lands.\(^18\)

The Florida Drainage Manual, in discussing the privilege of making connection to department storm sewers, states:

Storm sewer systems designed for use with state highways are intended to serve as drains for surface run-off from storm waters only. To exercise control over the discharge entering such systems, the Department policy is to refuse all connections. Exception will be made by permit when county or city governments request connections draining areas which the state system has been
designed to accommodate and which will not cause an overload condition in the storm sewer.

However, in such cases the Department will reserve the right to sever the connection if there is discharge of an objectionable nature or of something other than storm waters into the systems.

G. MAINTENANCE

1. Intercepted Tile Lines

In Illinois, drain tile intercepted by newly constructed highways is replaced with reinforced tile or sewer pipe. After the tile has been installed within the limits of the right-of-way, the highway authority then considers it the landowner's obligation to provide the maintenance. Since it is the highway authority's responsibility to replace intercepted drain tile, drainage authorities question whether it is not also its responsibility to maintain the tile within the limits of the highway right-of-way. The indication is that the state will not assume responsibility for maintaining or repairing a sub-drainage system unless it is essential to the highway or unless proof can be provided that the system was damaged at the time the highway was constructed. If, however, the system is to benefit both the highway authority and the landowner, other arrangements may be made. If maintenance is required under the roadway and within the right-of-way, the highway authority will grant permission to the landowner upon request to repair the system.

The practice of the Ohio Turnpike Commission in maintaining tile lines was as follows:

Facilities constructed by the Turnpike Commission for agricultural drainage, such as laterals, collector mains, and outlet ditches for collector mains, were constructed, wherever possible, beyond the limits of the turnpike right-of-way. The maintenance of these laterals, mains, and ditches will not be performed by the Commission, but will continue to be done by those who are presently concerned with the maintenance of drainage systems. The maintenance of collector mains under the turnpike, which were installed for either existing or future drainage systems, will not be done by the Commission, but rights of entry for such maintenance will be granted as they may be required.

2. Maintenance of Highway Facilities Receiving Agricultural Drainage

Maintenance of drainage ditches within the limits of the right-of-way consists of cleaning, mowing, repairing eroded slopes, cleaning culverts, and correlated work. Where highway ditches are used as outlets for agricultural subsurface drainage systems, there is a question about who should be responsible for preventive maintenance of the outlet. The drainage law provides that the landowner must request and receive permission from the highway authority to drain within the limits of the highway right-of-way. It would appear that before granting permission, the highway authority should stipulate who will be responsible for maintaining the drain.

The legal report on this project states:

The Highway Code imposes upon the respective highway authorities the duty to construct, maintain, and repair the highways within the jurisdiction of each authority. An additional section provides the procedural steps for compelling highway commissioners to make road repairs.

The question is whether these sections impose upon the highway
authority the duty to maintain and repair drainage systems along the highway, both when adjoining owners have connected under section 9-107 of the Highway Code and when they have constructed private drains with permission upon land obtained under eminent domain provisions. The sections imposing the duty of maintenance and repair do not expressly include drainage systems, but such systems appear to be included in the definition of "highways" in the Highway Code. However, it is not likely that drains constructed for private purposes in the highway right-of-way are included within the statutory definition of "highway," and therefore it would seem that the responsibility of the highway authority for maintenance and repair would not extend to such drains.

Highway authorities in Illinois report that they receive frequent requests from adjoining landowners for the highway authority to deepen the roadside ditch to either provide or improve an outlet for drainage. The indication is that the highway authority will maintain the ditch to the grade provided in the original construction plans. In one example a landowner was outletting a tile into a side ditch. He requested that the highway ditch be cleaned, since it appeared to be obstructing the flow of water and thereby damaging the upper farm land.

Review of the original plans failed to indicate that there was a tile outletting into the ditch at the time of construction. The plans showed that the existing ditch grade was below the original grade and the existing ditch actually provided a better outlet than the original ditch. Since the existing grade was below the original grade and the tile in question was installed after the original construction, the highway authority refused to improve the outlet.

There have been occasions when a landowner has requested the highway authority to improve the side ditch so that adjacent low areas could be drained. In such cases the highway authority has taken the position that it can not interfere with the original drainage or spend public money to improve drainage systems for the benefit of individuals. However, upon request it may issue a permit to allow the adjacent property owner to deepen the ditch at his own expense.

To determine the validity of a landowner's request for improved outlets within the highway right-of-way, the original right-of-way agreement should be checked to see what agreements were made at the time the right-of-way was acquired. Often the agreement contains specific stipulations for each party, and until they are known it is impossible to determine what responsibility each party has and whether it has been carried out. Also, these agreements may vary widely between landowners, and therefore it is essential to review them before making a decision on a complaint.

It would appear advisable, if special drainage provisions are to be included in the right-of-way agreements, to include further provisions relating to maintenance, reconstruction, etc., to prevent later misunderstandings.

H. RECORD OF PLATS AND PLANS

One question that is usually asked in negotiations for rights-of-way in
new locations is what will happen to the existing tile lines intercepted by the proposed highway. The answer becomes complicated when the property owner does not know the exact location of tile lines and their size, depth, condition, etc.

Highway personnel indicate that lack of adequate information regarding the location of field tile creates many problems during the design and construction of highways. Where the facilities cannot be located, additional expense is often incurred for exploration. This lack of knowledge on the part of the landowner may be due partly to the inadequacy of plats and records of tile lines. The original owner may have relied on his memory, and therefore subsequent owners have little or no knowledge of the tile location. It would appear helpful if a map of all new or improved tile lines could be filed with an agency where it would always be available. When old lines are discovered, the necessary data could be recorded for future use.

Illinois law requires that certain drainage activities be officially recorded. The Drainage Code makes the following provision for extending covered drains through lands of others:

At the time of commencing the action, the plaintiff shall also file a map or plat showing the land proposed to be drained, the land across which the drain is proposed to be constructed, and the starting point, route, and outlet of the proposed drain and a profile showing the elevation of the flow line of the proposed drain and the elevation of the surface of the ground through which the drain is proposed to be constructed. (15)

In a discussion of the subject, the legal report states:

The plaintiff is required to file both a penal bond and a plat of the land to be drained and the land across which the drain is to be constructed. In a leading case, the transcript of the case from the justice of the peace contained a recital that the bond had been properly submitted. This recital, in the absence of any evidence tending to impeach it, was held to be a satisfactory compliance with the statute. In addition, a crude and imperfect sketch of the land to be drained had been submitted to fulfill the plat requirement. The court held that this imperfect sketch was a sufficient attempt at compliance with the statute. (6)

The Drainage Code further states:

The County Clerk of the county in which a district is organized, ex officio, the clerk of that district. He shall maintain for each district organized in his county a well-bound permanent book, to be known as the "Drainage Record," in which he shall record the order organizing the district; any orders enlarging or extending the boundaries of the district; any orders pertaining to the levy of assessments, the performance of work or the duties of the commissioners; the maps, plats, and plans of the district; and all assessment rolls, certificates of levy, reports, and other formal records of the district required by law or by order of court to be recorded… (16)

The Highway Code provides that:

No ditches, drains, track rails, poles, wires, pipe line, or other equipment of any public utility company, municipal corporation or other public or private corporation, association, or person shall be located, placed, or constructed upon or along any highway other than a highway within a municipality without first obtaining the written consent of the appropriate highway authority as hereinafter provided for in this section…

Upon receiving such consent the petitioner shall record the same in the recorder's office of each county wherein it may be effective. (19)
These statutory provisions appear to indicate that the petitioner has a responsibility for making a proper and official record of certain drainage activities. Several sections in the Highway Code also require the highway authority to develop a plat and have it properly recorded. These sections basically provide that, whenever a highway is laid out, widened, or altered in accordance with the Highway Code, the proper highway authority shall cause a plat to be made and recorded in the office of the recorder of deeds of the county or in the office of the registrar of titles for the county if appropriate.

The Suggested Guide states:

Highway officials shall prepare plans showing the alterations which have been made to agricultural drainage systems. The plans shall show: the size, location, and elevations of collector mains, sub-mains, and lateral tile 6 inches in inside diameter or larger; the location of small lateral drain tile; the location and elevation of all appurtenances; the location and elevation and grades of drainage ditches constructed or reconstructed by them. Tile adjustments within rights-of-way should be made with tile of adequate strength and at least equal capacity. Copies of the "as built" plans should be filed with the office of the District Highway Engineer or other highway officials responsible for the road construction.

The Suggested Guide further provides that organized drainage districts shall file with the county clerk the information referred to in the previous statement.

Criteria for the Ohio Turnpike made the following provisions:

As-built plans showing all agricultural drainage facilities altered or constructed by the Turnpike were required to be made. These drawings will be furnished to landowners, county engineers, and other parties with a valid interest.

As-built plans shall be prepared showing the alterations made by the Turnpike Commission to the agricultural drainage systems. The plans shall show the locations and elevations of all mains and sub-mains installed, all connections, the sizes of all tiles, the locations, types, and elevations of all appurtenances, and the location, sizes, and elevations of all ditches serving agricultural drainage constructed or altered by the Turnpike Commission. All elevations shall be referred to U.S.C. and G.S. datum. ASAE Recommendations provide:

The highway authority shall prepare plans showing the alterations which it has made to agricultural drainage systems. The plans shall show:

(a) The size, location, and elevation of collector mains, sub-mains, and lateral tile 6 in. in inside diameter or larger.

(b) The location of all lateral tile 4 and 5 in. in inside diameter.

(c) The location and elevation of all appurtenances.

(d) The location, elevation, and grades of drainage ditches constructed or reconstructed by the highway authority.

Copies of the "as built" plans shall be filed with the drainage district and county clerk.

Some persons believe that the "as built" plan required in the ASAE Criteria places added responsibility on the highway authority. They say that construction plans are always available at the Highway Division Office and that preparation of "as-built" plans would be time-consuming and costly and not the legal responsibility of the highway authority. Illinois highway authorities state that any work affecting subsurface drainage water known prior to or discovered during construction is shown
on the plans and becomes part of the permanent record in the district office.

I. REFERENCES CITED


8. Drainage Manual, Florida State Road Department.


12. General Instructions to Field Men on Road Construction, Indiana State Highway Commission, Sec. 4.


17. Ill. Rev. Stat., Ch. 121, Sec. 4-214 applies to the department, Sec. 5-101.8 to the county, and Sec. 6-328 to the township (1963).


VI. CULVERTS

A. PURPOSE

The general purpose of a culvert is to transmit water flowing in natural streams, or collected on the dominant portion of the right-of-way, from one side of the highway to the other. The culvert must have reasonable cost, eliminate objectionable backwater, and handle velocities that will not damage the structure or downstream properties.

Culverts are generally found in three locations: (1) at the bottom of depressions where no natural watercourse exists; (2) at places where natural streams intersect the roadway; and (3) at required points for passing surface drainage carried in side ditches beneath roads or driveways to adjacent property.

One way to differentiate between a culvert and a bridge is that the top of the culvert does not ordinarily form part of the traveled roadway whereas a bridge is a link in a roadway. Another way is on the basis of span length. On an arbitrary basis, structures having spans of 20 feet or less are often termed culverts, whereas those having spans exceeding 20 feet are termed bridges. This division is by no means standard: various organizations use lengths of 8 to 20 feet as limits. Culverts also differ from bridges by being designed to flow full under certain conditions, whereas bridges are designed to pass floating debris, etc.

The Illinois Division of Highways Maintenance Manual states:

A culvert is a drainage structure having a tubular or box-type cross-section with an opening of 20 feet or less in width and provides an enclosed channel for either lateral or transverse drainage beneath a roadway. The smaller culverts are usually corrugated metal pipes or concrete pipes with or without headwalls. (15)

B. ATTRIBUTES OF A GOOD HIGHWAY CULVERT

When properly designed, culverts will generally meet the requirements of both highway and agricultural interests. To properly serve the highway, a culvert must support the roadway and transmit the water from one side of the highway right-of-way to the other without flooding the roadway. To serve agriculture and the adjoining land, a highway culvert must allow the water to pass under the roadway without obstructing the flow and creating undue flooding on the upstream side. It must also have invert or footing elevations that will permit the future development of surface drainage systems for adjoining lands, as well as needed subsurface drainage systems.
Charles W. Jones points out that, from a highway engineer's point of view, a good culvert may be defined as follows:

1. The culvert, together with its appurtenant entrance and outlet structures, should properly take care of water, bed-load, and floating debris at all stages of flow.
2. It should cause no unnecessary or excessive property damage.
3. Normally, it should provide for transportation of material without detrimental change in flow pattern above and below the structure.
4. It should be designed so that future channel and highway improvements can be made without too much loss or difficulty.
5. It should be designed to function properly after fill has caused settlement.
6. It should not cause objectionable stagnant pools in which mosquitoes may breed.
7. It should be designed to accommodate increased runoff occasioned by anticipated land development.
8. It should be economical to build, hydraulically adequate to handle design discharge, structurally durable, and easy to maintain.
9. It should be designed to avoid excessive ponding at entrance which may cause property damage, accumulation of drift, culvert clogging, saturation of fills, or detrimental upstream deposits of debris.
10. Entrance structures should be designed to screen out material which will not pass through the culvert, reduce entrance losses to a minimum, make use of the velocity of approach insofar as practicable, and by use of transitions and increased slopes, as necessary, facilitate channel flow entering the culvert.
11. The design of culvert and outlet should be effective in re-establishing tolerable nonerosive channel flow within the right-of-way or within a reasonably short distance below the culvert.
12. The outlet should be designed to resist undermining and washout.
13. Culvert dissipators, if used, should be simple, easy to build, economical, and reasonably self-cleaning during periods of heavy flow.
14. Where culverts will be used by humans, cattle, or fish, necessary provisions should be made.
15. Culverts should not be death traps for children.

C. RESPONSIBILITY FOR PROVIDING SUFFICIENT OPENINGS

In following the rules of natural drainage, the upper landowner may discharge over the lower land within the same drainage area water falling or accumulating on his land in a natural state. The lower owner cannot interrupt or prevent such natural flow or passage to the detriment or injury of the upper owner.

Since these rules apply to both the highway authorities and individual landowners, a cause for action exists when flooding results from inadequate openings in embankments crossing watercourses. The legal report on highway and agricultural drainage states:

The case selected as an example concerns a railroad, but perhaps the courts would have handled the problem in a similar manner had it involved a public highway. In this case the railroad possessed a right-of-way that crossed some natural depressions through which surface water naturally flowed. An embankment constructed across the natural drainway did not have sufficient openings to allow water naturally cast upon the land above to pass through the depressions as it had in the past. Later heavy rains caused damage from flooding because of inability of the water to escape.

The court held that parties changing or restraining the flow of water must provide for the consequences of
unusually heavy rainfalls and are liable for damage to the lands of others caused by failure to make such provision. The court further stated that whether the rainfall was so heavy and unprecedented that the damage from overflow might be considered an "act of God," and thus relieve the defendant from liability, is a question of fact to be determined by a jury. Also, each overflow of the lands of an adjoining owner caused by negligent or improper construction of an embankment is a fresh nuisance and creates a new cause for action. (7)

D. CULVERT SIZE

A culvert installation must be of sufficient size and properly proportioned to readily accommodate the anticipated flow in the channel which it contains. The two principal objectives in the hydraulic design of culverts are (1) to keep the headwater within an allowable maximum for the design discharge and (2) to provide a structure that will not require excessive maintenance costs. It is generally considered impractical to design culverts that will not flow full under any circumstances. From an economical standpoint, the barrel of the culvert may be allowed to flow full once in a while.

Among the factors that may help to determine the quantity of water to be carried by a culvert are the length and slope of the invert, the culvert material, the diameter of the culvert (or some similar critical dimension if the culvert is not circular in cross section), head losses occurring at the entrance, and the relation between the elevation of water at the inlet to the culvert (headwater) and the elevation of the invert at the outlet end (or the elevation of water at the lower end if the outlet is submerged).

Two basic considerations frequently determine the design of a given culvert installation: (1) The culvert is designed to flow partly full, with a free outlet. In this case it is designed so that the water never rises above the top of the culvert pipe at the entrance and is removed rapidly enough to prevent tailwater from rising above the invert at the outlet end. Other factors being equal, the flow is dependent upon the elevation of the headwater above the invert of the pipe at the outlet end. (2) It is assumed that the culvert is to flow completely full, with the headwater above the top of the culvert inlet and the outlet end completely submerged. In this case the quantity of flow carried by the culvert, other things being equal, is dependent upon the difference in elevation between the headwater and the tailwater. Besides these two considerations, there are many intermediate situations encountered in culvert design.

The selection of the design frequency often depends on the importance of the highway and the value of the surrounding land and property.

Chow states:

Generally, two conditions should be considered: (1) the headwater is limited to some level that will provide a reasonable amount of freeboard against overtopping the road (the state of pressure flow in culvert occurs); (2) the headwater elevation is limited to some level that will not cause backing up of the water at the entrance to the structure (the state of open channel flow in culvert occurs). For important roads, the recommended design frequency for condition (1) is
50 years and for condition (2) is 5-10 years. On the other hand, the secondary road to which backing up at the entrance would not result in considerable property damage or inconvenience to traffic, the design frequency for condition (1) is 25 years, and for condition (2) is 10-25 years. However, the decision on design frequency for any particular problem must be considered individually. For important structures, a detailed economic analysis based on a frequency analysis of hydrologic data is always necessary. (4)

In the Florida State Road Department Drainage Manual, the following criteria are used as the basis for selecting culvert types and sizes:

A. Interstate Construction
1. Cross drain with endwalls, minimum size, 24" pipe
2. Cross drain inlet on upper end (for infield areas only), minimum size, 18" pipe
3. Median drain with inlet or endwall on upstream end, minimum size, 18" pipe
4. Box culvert, minimum size, 3' x 3'
5. Drains from inlets on high fills, minimum size, 15" pipe
6. Use of multiple pipes is satisfactory; however, generally culverts having an area of opening of over 25 square feet or requiring more than a double line of pipe will call for box culvert construction. Consideration should be given to the problem of debris catching on walls between multiple culverts when selecting the culvert dimensions.

B. Primary-Type Construction
1. Cross drains with endwalls on both ends, minimum size, 24" pipe
2. Cross drains with inlet on upstream end, minimum size, 18" pipe
3. Median drains with inlet or outlet on upstream end, minimum size, 15" pipe
4. Concrete box culvert, minimum size, 3' x 3'
5. Drains down steep slopes from inlets on high fills, minimum size, 15" pipe
6. Multiple pipe culverts are satisfactory up to an area of opening of about 50 square feet and four lines of pipe; however, where economics does not unquestionably justify pipe, the use of box culverts is preferable.

C. Secondary-Type Construction
General criteria for secondary-type construction are approximately that for primary. Deviations resulting from use of existing marginal structures, use of materials on hand and necessity of additional ditch work due to changes in culvert sizes are more apt to be determining factors within the limits of the slightly lower standards of economics set up for this classification.

D. Sizing for Flow Conditions
1. A design average velocity of 6 fps is considered for most normal culvert locations. An approach velocity appreciably greater than 6 fps would justify an increase in design velocity. Unstable or highly erosive soil conditions would indicate a lower design velocity. A design velocity other than the accepted normal of 6 fps may be indicated where back water elevation or head losses through the culvert are the determining criteria.
2. Culvert opening dimensions are in most cases determined by the relationship between the average flow line of the conveyance upstream and downstream of the culvert and the anticipated water surface profile, together with the total area of opening desired.
3. As an exception to sizing for flow conditions, it is sometimes less expensive, particularly with larger multiple box culverts, to raise the crown elevation, which will require a shorter length. A cost estimate should be made in each case, keeping in mind that appreciable decreases in cover over a box culvert sometimes result in need for less top slab reinforcing. (8)
Both the Indiana Toll Road and Ohio Turnpike authorities have established criteria for culvert design. The basic criteria are similar, although the size of watershed areas differ slightly. The Ohio Turnpike divides the watershed into areas less than and greater than 400 acres; the Indiana Toll Road uses one square mile as the division line. For areas of less than 400 acres the criteria for Ohio Turnpike are:

All culverts on the Ohio Turnpike were designed hydraulically to meet the requirements outlined as follows. The design flow was taken from the chart, "Expected Discharge for Areas of Less Than 400 Acres," using the appropriate curves and factors conforming to topography, soil, land use, vegetal cover, and design frequency. Where areas may be more fully developed during the life of a structure, proper allowance was made for such future development.

Pipe culverts up to and including 72 inches in size were designed for a frequency of 10 years with no surcharge at the culvert entrance, and for a frequency of 100 years with a surcharge at the culvert entrance not greater than 2 feet, except that the surcharge for a 100-year frequency was not to be higher than 1 foot below the edge of the roadway shoulder. In flat areas, the culverts were designed for a 100-year frequency with adequate capacity to prevent undue damage to adjacent property from ponding.

Where culverts larger than 72-inch pipe were required, they were designed for a frequency of 25 years with no surcharge at the culvert entrance, and for a frequency of 100 years with a surcharge at the culvert entrance not greater than 2 feet, except that the surcharge for a 100-year frequency could not be higher than one foot below the edge of the roadway shoulder. In flat areas, the culverts were designed for a 100-year frequency with adequate capacity to prevent undue damage to adjacent property from ponding.

For areas greater than 400 acres, the same criteria point out that:

All drainage structures were designed hydraulically, and as a guide the net waterway was checked against the values obtained from the chart, "Approximate Waterway Areas for Bridges and Large Culverts," from the Ohio Department of Highways' "Specifications for Design of Highway Structures." All structures were designed to pass a 25-year flood with no surcharge at the entrance. For structures having clear spans normal to the abutments of 2 1/2 feet or less, no under-clearance was provided. For structures having clear spans normal to the abutments greater than 2 1/2 feet, under-clearances of from one to three feet, depending on the size and type of structure, locality, land use, etc., were provided for a 25-year flood.

Flood flows for 25-year frequency were taken from the chart, "Flood Discharges for Areas of One-Half Square Mile and More." When the total width of required waterway opening exceeded 11 feet, an investigation of the stream was made to determine the size and performance of existing structures above and below the turnpike line, high water marks, channel conditions, and other factors affecting the flow. From such study, an estimate of the flood of record could be made.

High-water marks could be obtained in the field, from the Bridge Record of the Ohio Department of Highways, and from the records of the United States Weather Bureau and the United States Geological Survey. When the estimated flood of record exceeded the 25-year flood found from the aforementioned chart, the structure was designed to pass the flood of record without surcharge.

Single span concrete box culverts were further investigated so that they would pass the maximum design flood, as shown on the chart, with a surcharge above the inside top of culvert of not more than 2 feet, except that the surcharge for the maximum design flood would not be higher than one foot below the edge of the roadway shoulder. Multiple span concrete box culverts, beam
and girder bridges, and other large structures were designed to pass the maximum design flood without surcharge.

Concrete arch culverts were designed so that the depth of flow in the culvert for a 25-year flood would not be greater than six-tenths the normal span of the culvert, and for the maximum design flood shown on the chart would not be greater than three-fourths the normal span of the culvert. (9)

The U. S. Bureau of Public Roads issued the following policy statement dated August 10, 1956:

Designs for all culverts and bridges over streams shall be in accord with the Standard Specifications for Highway Bridges of the American Association of State Highway Officials to accommodate floods at least as great as that for a 50-year frequency or the greatest flood of record, whichever is the greater, with the runoff based on the land development expected in the watershed 20 years hence and with backwater limited to an amount which will not result in damage to upstream property or to the highway. All other drainage facilities are to be designed to keep the traveled ways usable during storms at least as great as that for a 10-year frequency, except that a 50-year frequency shall be used for underpasses or other depressed roadways where ponded water can be removed only through the storm drain system. (17)

In the interest of economy it may sometimes be necessary to design culverts in such a way as to constrict the natural waterway. The normal result is greater depth of flow, with increased ponding at the inlet and higher exit velocities. In such cases, if this additional upstream flooding cannot be tolerated, special inlet structures should be designed to conserve the approach velocity head and accelerate the flow prior to entrance into the culvert. This plan has an added advantage of keeping the silt load moving and thereby reducing silting at this point. In cases where outlet conditions may control the operation of a structure, improving a section of the downstream channel may increase a structure’s efficiency and reduce the cost of the over-all design.

The size of a culvert is determined by many factors, including the type of soil, slope of ground and culvert, value of land, type of crops grown, rainfall, and entrance and outlet conditions. The flood frequency interval is determined by the type of road and the importance of protecting the road and adjacent property against flooding. Along existing highways, past experience and history of drainage problems are helpful in making these estimates.

Several Illinois highway authorities report that they generally follow these criteria in determining the minimum size of culverts:

1. Entrance and side road - 15" - 18"
2. 2-lane primary road - 24"
3. 4-lane primary road - 24" (outlet in median)
4. 6-lane primary road - 36" (continuous across dual pavement)

E. TYPE AND USE OF PIPE

The type of culvert used in a particular location depends primarily upon various hydraulic factors and on engineering economics. It is difficult to make a general statement about costs, since they will depend upon the cost of materials, labor, and equipment required for each installation.

The most frequently used materials
are concrete and corrugated metal. For short culverts, the difference in capacity due to the friction factor is relatively insignificant. However, as the length of the culvert increases or as conservation of the available head becomes more important, smooth pipe has an advantage over corrugated pipe. The situation is reversed, however, with respect to the problem of scour at the outlet of a pipe that is not flowing full. Under these circumstances corrugated metal pipe will usually have somewhat lower velocities, especially for long culverts, and consequently there will be less risk of severe scour at the outlet. (3)

Corrugated metal pipes do have an advantage at locations where the foundation materials are not so stable because of greater flexibility. Both types of pipe will deteriorate if subjected to attack by acids or other chemicals. When a metal pipe is used, its life expectancy can be increased by coating it with asphalt or bituminous material.

In many culvert installations headroom is limited and a circular pipe with sufficient hydraulic capacity is not suitable. In such cases, corrugated metal "pipe arches" or reinforced concrete box culverts may be used. Also, multiplate pipe or arches or reinforced concrete box culverts may be used where unusually high fills will create extreme loads on the culvert, or where the span length would require a bank of several pipe culverts. With structures of this size, however, economic solutions cannot be achieved by rule-of-thumb procedures. In these cases it is necessary to make a careful design both for hydraulic and for structural conditions. (20)

F. PRINCIPLES OF CULVERT LOCATION
1. Location

A primary requirement for the proper functioning of a culvert is that it handle the expected flow with as little interruption as possible. To achieve this purpose, the culvert must be properly located. The Florida Drainage Manual states:

Where water is confined in an infall, the culvert should be located as near as practical to the point where the infall reaches the project and as much in line as possible with the infall. Where other considerations dictate a less desirable location, the roadbed or special ditch must be protected against the turbulence generated in changing the direction of flow.

Where infall and outfall are well confined and cross the project at an angle, the culvert should be located on as nearly the same angle as practical.

Economic considerations may dictate otherwise, but generally a skew angle greater than 30° is not desirable. Culverts at right angles to the project are desirable except where flow conditions definitely dictate a skew angle.

Often a wide flood plain contains a shallow meandering channel for low water flow. If this low water channel does not confine more than about one-half the flood flow, the necessity of a skew culvert is questionable. In such cases, cutting a small low water channel relocation to utilize the 90° culvert is desirable, because the direction of flood flow is not affected appreciably by the relatively small low water channel.

The importance of a detailed field inspection of any culvert site cannot be overemphasized. The nature of the site should be studied with particular reference to such features as existing channels, existing structure alignment and effectiveness, proximity of other topographic
features which might affect location or flow conditions and correlation of proposed design high water with ground conditions. (8)

Generally the culvert is located on the centerline of an existing watercourse or at the bottom of a depression if no natural watercourse exists. The basic objective is to align the culvert so that the inlet and outlet will match the natural or existing channel as closely as possible. When this is not possible and special channels are constructed, extreme care must be taken to provide adequate control and protection at any point where the direction of flow is changed.

The practice followed by the Illinois Division of Highways (15) is to locate the culvert in such a way that all the water it is to carry can enter quickly and easily. Attempts are usually made to perpetuate the drainage pattern of the area by installing cross road culverts in all drainage courses that are crossed. Where a series of shallow, closely spaced swales are crossed, the intercepted flow has been conveyed along the roadway to a more well-defined drainage course within a reasonable distance, provided such change does not adversely affect property owners in the area of change.

2. Alignment

An important requirement in locating a culvert is to provide a direct entrance and exit for the intercepted water. An abrupt change in direction at either end may retard the flow and create a need for a larger structure. (11) The culvert should be so placed that it will fit the natural channel and also, where possible, be in line with the average grade. This is especially important in rolling areas where the water velocities are relatively high. A sudden change in direction of water flowing at a fast rate may create erosion on one side of the watercourse and cause silting on the other side. In these areas culverts are often placed askew of the center line of the roadway. The natural skew may be reduced by keeping the culvert inlet in the stream bed and making the necessary channel change at the outlet. In flatter areas where velocities are lower, alignment may be varied to place the culvert in a dry area or to make a square rather than a skew crossing. Generally the grade should be uniform with the inlet and outlet conforming to the existing channel bed. (20)

Where it is essential to change alignment, a direct inlet and outlet can be provided in one of three ways: (1) making a channel change, (2) making a skewed alignment, and (3) combining the two. It has been suggested that the cost of a channel

FIGURE 21. STRUCTURE CONSTRUCTED ON A SKEW TO IMPROVE LOCATION AND ALIGNMENT
change may be partly offset by decreasing culvert length or size. A skewed alignment requires a longer culvert but is usually justified because of the improved hydraulic condition and safety of the roadbed.

Another principle in culvert location is to use reasonable precautions to prevent the stream from changing its course near the ends of the culvert. Otherwise the culvert may become inadequate, causing excessive ponding and possibly washout or requiring expensive maintenance of the roadway. Riprap, sod, paving, or metal end sections will help keep the banks from eroding and changing the channel.

Figure 23 shows various methods of providing for correct culvert alignment.

Highway authorities in other states also stress the importance of proper alignment. The Colorado Design Manual states:

From the standpoint of hydraulic efficiency, durability and maintenance, abrupt changes in direction or slope are undesirable. Any abrupt change in direction at either end of a culvert will retard the flow and cause scouring or silting. The ideal installation is to locate the culvert in the existing streambed. Because this is not always possible, channel changes or improvements are often necessary. Channel changes should be held to a minimum and should preferably be at the culvert outlet. As a general practice, when a proposed roadway crosses an irrigation ditch the skew angle of the crossing shall not be changed in order to reduce the length of culvert required. So far as is practicable, the culvert pipe or concrete box culvert shall be placed in the existing channel of the ditch and the length of pipe or box determined accordingly. (6)

The California Planning Manual states:

Except where the alignment is sinuous and curvature sharp, head losses at bends may be neglected when velocities are low. In the higher subcritical velocity ranges, bends cause head losses which should be considered in design. In channels with very high velocities, sharp bends should be avoided. (11)

The following practice is described in the Illinois Maintenance Manual:

Except for crossroad culverts installed for ditch relief, the culvert should be placed as nearly as possible in line with the average flow direction of the water, because a change in the direction or velocity of the flow will result in a greater deposit of sediment. Culverts installed as an aid to ditch relief drainage on steep grades should be placed askew of the centerline and, with the help of the proper type headwall, will facilitate the flow of water. (15)

3. Grade

The ideal grade line for a culvert is one that produces neither silting nor excessive velocities and scour. The Armco Handbook states:

The capacity of a culvert with a free outlet (not submerged) is not increased by placing on a slope.

FIGURE 22. A SLOPE WALL TO PREVENT A STREAM FROM CHANGING ITS COURSE NEAR ENTRANCE OF AN ACROSS ROAD STRUCTURE
(A) AND (B) CHANNEL CHANGES IMPROVE ALIGNMENT

(C) POOR ALIGNMENT

(D) GOOD ALIGNMENT

(E) STREAM SHOULD PASS UNDER THE ROAD AT FIRST OPPORTUNITY.

(F) "BROKEN-BACK" ALIGNMENT DESIRABLE IN SOME CASES.

FIGURE 23. VARIOUS METHODS OF SECURING CORRECT CULVERT ALIGNMENT
steep than the "critical slope."  
(About 1 per cent for a 96-in pipe.)  
The capacity is controlled by the amount of water that can get into the inlet.  On the other hand, the capacity of a pipe on a very slight gradient and with a submerged outlet is influenced by the head (difference in elevation of water surface at both ends).  In this case, the roughness of the culvert interior, in addition to the velocity head and entrance loss, is a factor.

A slope of 1 to 2 per cent is advisable to give a gradient equal to or greater than the critical slope, provided the velocity is permissible.  In general, a minimum slope of 0.5 ft in 100 ft is recommended to avoid sedimentation.

Ordinary practice is to make the grade line coincide with the existing streambed.  However, deviation is permissible if for a good purpose, as follows:

1. In freshly graded areas, on relatively flat gradients, expect sedimentation to occur.  Set the culvert invert several inches higher than the streambed, but on the same slope.

2. Where headroom is limited, setting a culvert below streambed grade is likely to result in sedimentation and reduced waterway area.  Either use a low, wide culvert such as a pipe-arch or raise the road grade.

3. Under high fills, anticipate greater settlement of the culvert under the center than at the sides of the fill.  Give the culvert camber by laying the upstream half nearly level and putting all the fall in the downstream half.

4. Under high fills, it may not be necessary to place the culvert at streambed level.  If some ponding is permissible, the culvert can sometimes be placed in firm ground at a higher level, thus reducing the length and simplifying replacement, should that ever be necessary.

5. In steeply sloping areas, as on hillsides, it is not always necessary to place the culvert on the same steep grade.  The culvert can be put on the "critical" slope and then a spillway or cutoff wall provided at the outlet to prevent undermining.  This keeps the culvert shorter and under shallower cover.

6. On steep slopes, it is also possible to use a broken-back grade line under the fill, although this is less desirable.  Or a drop inlet or catch basin will help give the culvert a suitable slope.  (11)

The Colorado Design Manual states:

The ideal grade line for a culvert is one that produces neither silting nor excessive velocities and scour.  In general, the natural grade of the channel should be used, but a minimum grade of 0.5 feet in 100 feet is recommended to avoid culvert silting.  Velocities as great as 10 feet per second cause destructive scour downstream and to the culvert structure itself unless protected.  (6)

The Florida Drainage Manual states:

A design average velocity of 6 fps is considered for most normal culvert locations.  An approach velocity appreciably greater than 6 fps would justify an increase in design velocity.  Unstable or highly erosive soil conditions would indicate a lower design velocity.  A design velocity other than the accepted normal of 6 fps may be indicated where backwater elevation or head losses through the culvert are the determining criteria.  (8)

The Illinois Maintenance Manual states:

The flow line of a culvert should be on a straight grade and steep enough to make the water carry the sediment and debris through with it.  A minimum slope of 0.5 feet in 100 feet is recommended if it can be obtained without changing the velocity of the flow.  A slope of 2 to 4 per cent is advisable when conditions permit.  Any break in the grade which retards the velocity of silt-carrying water will cause sedimentation.  (15)

4. Provisions for Handling Wide Flows

A previous section (IV.2) covers a brief analysis of the problem relating to diffused surface water.  A condition commonly described as sheet drainage occurs where drainage is slow because the land is nearly flat, with no well-defined channels.  A highway
embankment across such land may act as a dam, interrupting normal drainage. Since it is not always possible to perpetuate existing sheet flow, an effort is made to prevent concentration of drainage insofar as possible. Even though crossroad culverts of sufficient size are installed, their maximum capacity may not be realized because the gradient is not steep enough on the downstream drainage area. Usually a broad type of structure is favored under such conditions. One practice is to install equalizer culverts in low points along the route. The culvert can then be placed at right angles on a level grade across the road.(11)

5. Adequacy of Culverts to Handle Flows

Property owners sometimes complain that the proposed drainage structures are not large enough or are not proportioned to handle the required flow. Where flooding occurs, they often assume that highway ditches and culverts are inadequate. They may overlook the fact that servient landowners are blocking the natural flow by artificial means or that the watercourses have become naturally choked with trees, brush, debris, etc.

Landowners also sometimes say that culverts and drainage structures located under railroads running parallel to the highway are not large enough. They think it is the state's responsibility to see that all upper land, including that of the highway authority, is properly drained.

Under the natural drainage rule in Illinois, the servient owner cannot deliberately interrupt or prevent the natural flow of water in a watercourse on the lower side of a culvert to the detriment of the dominant owner. However, where the obstruction is natural, it is the duty of the holder of the easement to keep the drains in repair, and generally no obligation is imposed upon the servient owner to make repairs.

Highway authorities indicate that changes in the flow of surface water due to improvements made in drainage facilities by adjoining landowners sometimes make present structures inadequate. The highway authority, however, must tolerate such action, provided the owners meet the requirements of the drainage law.

G. FLOW LINE

1. Location of Invert

Highway culverts often serve as outlets for farm drainage. To be effective, the flow line should be set as low as the available outlet will permit. Decisions regarding invert elevations should provide for (1) prevention of undue flooding of the highway, (2) possible improvement of agricultural drainage or flood or water-control systems, and (3) reduction of erosion in ditches or waterways where water velocities are erosive.

Authorities for the Ohio Turnpike and Indiana Toll Road and the American Society of Agricultural Engineers have developed similar recommendations for invert depths of culverts under the highway. (2,5,9,19) The ASAE Criteria provide:

When the land on the upstream side of the highway has or requires tile or other subsurface drainage, the invert depths of culverts under the
highway and under reconstructed local roads shall conform to the following table unless a separate conduit is installed to discharge subsurface drainage.

<table>
<thead>
<tr>
<th>Prevailing slope of land affected</th>
<th>Minimum depth of culvert invert below field elevation to upstream right-of-way line</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 to 0.25 per cent</td>
<td>6.0 ft</td>
</tr>
<tr>
<td>0.25 to 0.75 per cent</td>
<td>5.5 ft</td>
</tr>
<tr>
<td>0.75 to 1.5 per cent</td>
<td>5.0 ft</td>
</tr>
</tbody>
</table>

When outlet ditches are not available at the specified minimum depths, the drainage structures shall nevertheless be constructed to the depths specified above as a provision for future improvements to the agricultural drainage and/or water-control systems. Reducing the capacity or raising the invert elevation of a culvert to values less than those given in these criteria cannot be justified on the basis of repairs or additions to existing structures. When existing culverts are extended, the new portions should conform to these criteria...

Inverts of culverts for streams draining more than 3 square miles (1920 acres) shall be such an elevation as to permit future ditch improvements and to provide a minimum velocity of 2.0 fps in the ditch at the 10-year discharge frequency, using 2:1 bank slopes and a value of n of 0.030. The minimum invert depths for culverts in mineral soils, where the watershed area is 100 acres or less, may be 5.0 ft below the average elevation adjacent to the right-of-way line on the upstream side of the highway, provided the culvert invert is 1 ft below the outlet of existing tile drains, or the tile drain is extended until it is outletted on the culvert floor and the requirements (in the following paragraph) are fulfilled.

Where rock is encountered, the minimum invert depths (previously specified) may be reduced to provide only for outletting the existing drainage systems, after a special study is made and the concurrence of the local drainage authority is secured. It will frequently be found desirable to set the invert of the culvert 1 ft or more below the top of the rock to provide the maximum culvert area at low stages.

The inverts of culverts under the highway and under reconstructed local roads shall be at least 3 ft below the field elevation of low areas of tillable land which do not have surface drainage and which are larger than 2 acres in area and are located on the upstream side of the highway or reconstructed local road. The above criterion shall not apply when excessive rock excavation is required or provisions have been made to permit the future removal of the surface water through subsurface drains.

Where no agricultural drainage systems exist, but future flood control agricultural drainage systems are required for the future development of the adjoining land, drainage structures under the highway and under reconstructed local roads shall be reconstructed to the minimum depths specified in previous sections. (2)

There appears to be some speculation that the anticipated agricultural development of an area would necessitate the construction of an outlet at a lower elevation than these criteria suggest. Another opinion is that the specified minimum depth of the invert on the upstream right-of-way line could cause serious erosion.

The practice that is sometimes followed is to locate the culvert invert on the downstream side flush with the present or natural flow line. If, however, the channel appears to be filling, the culvert is placed slightly above the grade line; if it appears to be eroding, the culvert is placed slightly below the flow line. For entrance culverts it is desirable to set all flow lines at such elevation that at least 4 inches of fill can be placed over the culvert. The resulting grade on top of the 4-inch fill should not be higher than the adjacent shoulder edge. (10)
2. Right-of-Way Flow Lines

In plans for the flow line across the right-of-way, it is important to consider the grade of the outlet and inlet ditches in addition to that of the structure. The flow line of a culvert should be on a straight grade and steep enough to make the water carry the sediment and debris through with it. A slope of 2 to 4 per cent is recommended when conditions permit, with a minimum of 0.5 feet in 100 feet. \(^{(15)}\)

In discussing the inlet and outlet ditches, the Illinois Division of Highways Maintenance Manual states:

The grade of the outlet ditch should be either equal to or steeper than the grade of the outlet end of the culvert to prevent a deposit of sediment. If the grade of the outlet ditch is very steep and in erodible soil, the bottom of the ditch should be paved. In some instances, it is necessary to provide a paved spillway or flume at the outlet end of pipe culverts to protect fill slopes. The same applies to cut slopes at the inlet end when water runs down the slope to the pipe. \(^{(15)}\)

The Field Manual for entrance culverts provides that:

After the culvert has been completed, if the plans do not provide a special ditch to drain it, you should run a grade of not less than .1 foot in 100 feet from the flow line of the culvert down the ditch far enough to intersect the standard ditch grade to secure proper drainage. \(^{(10)}\)

Where gullies have formed in the waterway, there is some question about what the legal elevation of the flow line should be. The question is whether the elevation should be the same as before formation of the gully, after formation of the gully, or some where in between.

The legal report \(^{(7)}\) on this project pointed out that where water has been discharged from a culvert under a road upon the servient land for a long period, causing the watercourse to be lowered, the lower landowner has no right to impede the present flow by an obstruction or embankment even though such obstruction is no higher than the original surface of the waterway. The courts explained that it would be extremely difficult, if not impossible, to ascertain what the natural surface originally was and therefore it would be dangerous to allow the watercourse to be dammed on the assumption that the water would thereafter flow as it did naturally.

3. Adjustment of Flow Lines

The highway authority is obligated to provide for existing drainage but it is not obligated to improve agricultural or other types of drainage. There may be some question concerning its obligation so far as future drainage requirements are concerned. This topic is further discussed in Chapter X.

In across-the-road structures, who is responsible for raising or lowering the flow line when the need exists? Highway authorities indicate that their practice is to maintain depth of flow line as established in the original construction plans. This practice is verified in the maintenance manual, \(^{(15)}\) which states: "All ditches and slopes should be maintained to the original cross section."

Highway authorities say that objectives conflict when agricultural interests want highway culverts set low enough to outlet drainage from above the highway—regardless of the
adequacy of the outlet channel--and the highway authorities must provide drainage at the lowest cost that will satisfy highway requirements.

There are cases when the landowner submits a request for the highway authority to lower the flow line of certain structures before they are built. When it is evident that agricultural drainage will be installed, the highway authority attempts to provide structures that will meet the requirements. Such instances emphasize the need for communication channels between the affected parties so that proper provisions can be made prior to construction.

When drainage district drains crossing the highway are improved, the highway authority will adjust the flow line of affected highway culverts. This practice is in agreement with an administrative memorandum issued by the Illinois State Division of Highways which states:

This Division is at times requested to lower the flow line of an existing culvert to permit unobstructed flow of water across its right-of-way in connection with the improvement and deepening of a ditch of a legally organized drainage district or a group of landowners seeking such drainage improvement by mutual agreement and action.

This Division has utilized full drainage possibilities of these ditches in the construction and maintenance of its highways without having contributed to the cost of construction and maintenance of the drainage ditches.

Since this Division has chosen, for reasons of economy, to construct structures of a type other than bridges across the many smaller drainage ditches, it will hereafter be our policy to adjust our culvert flow lines to the elevation of proposed drainage ditch improvements to permit full advantage of such improvements. Such culvert adjustments are to be made only after written agreements with the interested groups are executed to assure a correct and satisfactory elevation of the adjusted flow line and to assure that the proposed improvement of the drainage ditch will be carried out as intended. (1)

Highway authorities in New Hampshire (18) list the major problems encountered in that state, including adjustment of culvert flow lines, as follows:

1. Individual requests by land developers, including farmers and residential and commercial interests for the relocation of a cross road culvert and/or the relocation of a natural drainage ditch.

2. Similar drainage change requests by individual farmers, but for the purpose of land development sponsored by the U. S. Soil Conservation Service.

3. Similar drainage change requests sponsored by the above Service to permit the development of farm ponds.

4. Individual requests by land developers of all kinds for the lowering of an existing cross road culvert below natural flowage level to permit draining low pockets, etc. This often involves extensive ditching on the outlet side and in many cases on land of other parties.

5. Similar lowering requests by individual farmers for land development projects sponsored by the U. S. Soil Conservation Service.

6. Similar lowering requests sponsored by the above Service in connection with farm pond construction. (19)

Authorities in New Hampshire state that their policy is to refuse to participate in items 1 and 4. Per-
mits allowing the performance of required work within highway limits by the individuals are issued when requested. Further policy is to participate under certain conditions in items 2, 3, 5, and 6 (U. S. Soil Conservation sponsored projects) but only if there is benefit to the highway authority.

The New Hampshire authorities further state that culvert alteration projects are approved only on the following basis:

1. Only projects initiated and recommended by the Soil Conservation Service will be approved, and then only when the amount of land area to be improved warrants an expenditure by the department.

2. The benefits to be derived are studied and evaluated against the cost of the project.

3. Survey and design must be made by the Soil Conservation Service. Inlet and outlet ditches must be part of the conservation project. The state's cost is confined to the culvert alteration.

4. Releases must be obtained for unnatural flowage at the outlet end. The state should prepare such releases, but the farmer initiating the project must negotiate for them. Cost of such rights will be paid by the farmer. (18)

H. FARM ENTRANCES

The Illinois Highway Code provides:

In constructing a public highway, if a ditch is made at the junction of highways, or at the entrance of gates or other openings of adjoining premises, the highway authorities shall construct good and sufficient culverts or other convenient crossings. New entrance culverts or crossings or additions to existing entrance culverts or crossings along an existing public highway or street where there is a ditch may be made with the consent of the highway authorities, provided the applicant for such entrance culvert or crossing constructs at the applicant's expense a good and sufficient culvert or other convenient crossing of the type and size specified by the highway authorities, which structure shall then become the property of the public. (13)

Highway authorities indicate that several provisions dictate the locations of entrances to farm land adjacent to a highway improvement:

1. Culverts will be provided for existing entrances to houses, barns, fields, oil wells, or other features not on a natural summit.

2. On highways that are designated freeways, private entrances will be constructed only for agricultural or residential purposes.

3. On relocated highways including frontage roads, entrance locations may be dictated by topography in areas of deep cut, high fill, stream locations, field severance by the highway and/or stream, existing utilities, etc.

FIGURE 24. FARM ENTRANCE CULVERT
1. MAINTENANCE

The main purpose of a culvert is to permit the water to move under the roadway as quickly as possible so that the flow will not interfere with the roadway or the adjoining land. For these structures to function adequately, proper maintenance is necessary. It has been stated that "with the exception of riding qualities of the traveled way, no other single item requires as much attention on the part of the maintenance man as highway culverts."(14)

A cause of many failures is the accumulation of debris at the culvert entrance or on a fence line just above the entrance. Such obstructions create ponded areas within the right-of-way, and they also block the passage so that water is backed up on the adjoining owner. These undesirable conditions are best cured before they occur. Regular inspection will indicate where cleaning is required and will simplify the task of keeping the entire highway drainage system operating properly.

The Ohio Turnpike report(9) states that all culverts, bridges, ditches, and stream channels which were constructed by the Turnpike Commission and which are located within the turnpike right-of-way, or within a permanent turnpike easement, will be maintained by the Commission.

The Illinois Maintenance Manual states:

Culvert barrels, as well as their inlets and outlets, must be kept clean. Any scour or erosion, usually at the outlet ends of culverts, must be corrected promptly to prevent undermining of the culverts, their headwalls, wing walls or aprons. Some corrective methods for scour or undermining to be considered are extensions or pipe spillways and the placement of riprap, cobble, paved flumes or spillways, concrete drop-inlets or outlets, walls, dikes, etc....

If a culvert repeatedly washes out or becomes filled up with sediment, it is evident that it is either improperly installed or deficient in size, and the fault must be corrected. The correction may consist of an extension, addition, replacement or relocation....

The maintenance section man should inspect all drainage facilities frequently, particularly during or following heavy rains. He should make minor structural repairs that are needed and should report any major defects to his supervisor for a decision as to method of repair. The cleaning up of dirt is of course year-round routine work, but it becomes especially important in the fall and early spring because the drainage facilities must be in full working order to handle the unusual runoff from snows and rains. Also, weeds, grass, and bushes should not be permitted to interfere with the flow of the water.(15)

The maintenance responsibilities for drainage district drains are fairly well defined under the statutory provisions in Illinois. Section 12-4 of
the Drainage Code states:

Whenever a district drain crosses a public highway or a railroad other than in the course of natural drainage, the district is liable to the highway authority or the railroad for the cost of constructing any bridge or culvert made necessary by such crossing and shall thereafter be liable to the highway authority or railroad for the cost of repairing and maintaining such a bridge or culvert.

Whenever a natural drain or a ditch constructed in the course of natural drainage crosses a public highway or a railroad, the highway authority or the railroad shall construct and thereafter keep in repair and maintain a bridge or culvert of sufficient length, depth, height above the bed of the drain or ditch, and capacity to subserve the needs of the public with respect to the drainage of the lands within the natural watershed of such drain or ditch, not only as such needs exist at the time of construction, but for all future time. (12)

It appears from the above statement that the drainage authority initiating the installation of an artificial drainage system after the original construction of a highway does have the responsibility for maintaining such systems. However, if the drainage system is constructed in the path of natural drainage, the highway or railroad authority will assume the maintenance responsibility.

J. REFERENCES CITED


8. Drainage Manual, Florida State Road Department.


20. J. L. Sanborn, Principles of Highway Drainage and Erosion Control, County Highway Series No. 4, Purdue University Engineering Experiment Station in Cooperation with the County Commissioners of Indiana, Lafayette, Indiana, 1962.
VII. EROSION CONTROL

A. OBJECTIVE

Erosion control is an important factor for highway authorities to consider in the design, construction, and maintenance of highways. It is also important to adjoining landowners. The highway authority considers erosion control an integral part of drainage from both the structural and maintenance points of view. It involves any portion of the highway property that has a part in conveying water across the right-of-way, whether it be a crossroad structure, side drain, etc. Other portions are also involved in erosion control, such as highway shoulders, shoulder slopes, cut and fill slopes, etc., but only the parts relating to agricultural drainage will be discussed in this report.

In general, it may be stated that erosion control devices are employed where conditions indicate the need for special treatment. Selection of type and location of erosion control device is based on many factors, including quantity and velocity of flow of water, terrain, soil condition, etc.

B. CONTROL MEASURES

The flow of surface water adjacent to and within the highway right-of-way is frequently accompanied by detrimental soil erosion that may cause the destruction of productive soils, the creation of areas of unsightly appearance, and the clogging of ditches and drainage structures. A number of measures in common use and designed to prevent or minimize erosion will be discussed.

Any one or several of the following measures may provide protection against erosion:

1. Erosion checks on ditches and channels.
2. Sod gutters and ditches.
3. Paved gutters, ditches, and channels or channel sides with concrete, rubble, riprap, or bituminous channel lining.
4. Wide channels to reduce velocity.
5. Culverts constructed with a break in grade so that the outlet has a velocity within the allowable limits.
6. Drop structures to dissipate energy at the entrances, at intermediate points, or at the outlets of culverts.
7. Baffles at the outlets of culverts.
8. Stilling basins at the outlets of culverts.
9. Sheet piling cutoffs to protect entrances and outlets of culverts from undercutting.
10. Concrete paving, rubble, or riprap slopes at bridge abutments.
11. Aprons utilized on downstream end of culvert.
12. Cutoff walls at outfall end of...
apron where there are high velocities.

13. Interceptor ditches on top of cut slopes.
15. Proper ditch side slopes.
17. Retaining walls and curbs.
18. Flared outlets.
20. Detention storage.
21. Concrete flumes.

C. GULLY CONTROL

A common type of erosion and one that frequently threatens the area within a highway right-of-way and the adjoining lands is transverse gullies. A gully may form as a result of improper land use, or the side ditch may have been lowered substantially below field level, causing an overfall. Adequate and economical control and reclamation can be accomplished only when the basic cause of gullying has been removed. The basic approach to gully control involves (1) reducing peak velocities through the gully and (2) providing a stable channel for the flow that must be handled.

All parties involved must assume responsibilities if the conditions are to be satisfactorily corrected. The highway authority must construct the highway and its appurtenances in such a way that additional erosive problems will not be created or that unreasonable quantities of silt and debris will not be deposited upon the adjoining lands. Landowners, on the other hand, have an obligation to manage their land in such a way that the highway will not be unduly damaged by erosion or by deposits of silt or other debris.

In the initial stages, gullies can generally be controlled by establishing vegetal protection for the gully channel and modifying the cross section and grade of the channel to limit flow velocity to a level the vegetation can withstand. The adjoining landowner can slow down the flow by applying conservation practices to the contributing watershed. Terraces or diversions, if they follow the rules of natural drainage, may remove the flow either partly or completely from some gullies. If it is necessary to modify the grade line within the path of flow, a permanent type of structure may be needed that will require careful engineering design.

Whenever a gully control structure is installed, (1) it must have sufficient capacity to pass the design discharge, and (2) the kinetic energy of the discharge must be dis-
sipated within the confines of the structure in such manner and degree that both the structure and the downstream channel will be protected.

A structure, when properly placed, will stop or at least reduce the amount of erosion that is taking place. The height of overfall will depend entirely on the location. In general, however, there should be enough drop to reduce the velocity of flow sufficiently to prevent cutting or washing of the waterway.

FIGURE 27. A GULLY CONTROL STRUCTURE LOCATED ON OR NEAR THE HIGHWAY RIGHT-OF-WAY LINE

1. Drop Box on a Highway Culvert

A drop box on a highway culvert is one of the most effective erosion control structures. Many gullies begin at the culvert and work their way back onto adjoining farmland. Old gullies may be filled and new ones prevented by raising the grade line at the culvert. Figure 28 shows a drop box constructed on the upstream side of the culvert. Since the level of the water is raised before it flows over the box and through the culvert, silt is deposited in the gully, gradually filling it in.

The Soil Conservation Service recommends that the minimum cross sectional area of the drop box be 1 1/2 times the cross-sectional area of the culvert.

The ASAE Criteria also provide that the minimum cross-sectional area of the drop box must be 1 1/2 times the cross-sectional area of the culvert in order that it will not limit the maximum discharge of the culvert.

Both highway authorities and Soil Conservation Service personnel indicate that this practice is not always practical. The main reason is that many culverts are larger than the design flow requires. Consequently it is necessary to install a large drop structure with sometimes very impractical proportions.

The highway authority has used drop boxes to varying degrees in Illinois. In some cases where the state would benefit, the highway authority has authorized the construc-

FIGURE 28. A DROP BOX USED IN CONJUNCTION WITH A HIGHWAY CULVERT
tion of and helped the landowner construct a drop box on or near the right-of-way line. Where an erosion problem exists on the adjoining landowner’s property but there is no damage to state property, the highway authority has granted a permit to the landowner to construct an erosion control structure on or near the highway right-of-way. The criteria for granting permits of this type are the same as for permits previously discussed.

Other practices include the use of ditch paving, drop spillways, or other suitable appurtenances to lower the surface water at points where it flows from adjoining fields into drainage ditches. (2)

2. Surface Lining

Some form of protective lining is necessary for most side ditches and also for those that traverse the highway right-of-way. One of the most economical types used by highway authorities is grass. An important requirement is that the grass form a firm, dense turf. The effectiveness of vegetation is limited, however, where the grade is either very flat or very steep. For example, on the flatter grades, the grass may reduce the velocity of flow to such extent that silting or deposition will obstruct the natural path of flow. Obstruction of the natural flow may cause flooding.

When vegetation is being established, mulching is often necessary to anchor the seed and fertilizer on the slopes. The mulch protects against frost, raindrop impact, and erosion until the vegetation becomes estab-

![Figure 29. Grass-lined Highway Side Ditch](image1)

![Figure 30. Mesh Matting Used for Establishing a Vegetated Lining](image2)
lished. Where it is difficult to hold the seed and mulch in place, open-mesh paper or jute matting may be stapled to the ground.

When grades are too steep, the tendency is for increased velocities to cause scouring of the turf and ultimately destroy the lining. Under these conditions a nonerosive lining should be used, for example, Portland cement concrete, stone masonry, grouted rubble, or bituminous material. The lining should extend far enough up the side slope and be impervious enough to keep the water from getting behind or beneath it to weaken or remove the supporting earth. It should be strong enough to withstand scouring, sedimentation, debris, ponding, and other destructive action of water.

In discussing channel linings, the California Planning Manual states:

The main purpose of channel linings are: (a) to prevent erosion damage, (b) increase velocity to prevent excessive sedimentation, and (c) increase capacity.

Two types of linings are commonly used: asphaltic pavement and Portland cement concrete. Asphaltic pavement is used mainly for temporary construction. It cannot withstand hydrostatic pressure and is not recommended for steep side slopes. Portland cement concrete is used for permanent construction under all conditions of service. Seal coats are not recommended for a permanent installation.(9)

Illinois authorities indicate that, in areas where erosion may occur, sod can be used in ditches with slopes up to 4 to 5 per cent with proper cross sections, and paving in ditches with slopes exceeding these values. Where there is no erosion problem, ordinary seeding methods can be used to establish the required turf.

3. Ditch Checks

When steep grades cannot be avoided, erosion can be prevented by building a series of ditch checks across the channel. The checks may be concrete, masonry, metal, wood, rock, or other suitable material. At the downstream side, an apron with a cut-off wall at the end will often be required to receive the water, absorb its energy, and make the transition to the normal type of flow. In some cases wings may also be needed. The
check should extend far enough below the streambed and into the banks to prevent undercutting or bypassing. (7) Ditch checks may be 6 to 24 inches high with the top level to distribute the flow evenly. They may be limited to a lower height not to endanger the traffic. The difference in elevations of the tops of successive checks should not exceed three feet. In Illinois ditch checks are constructed in the side ditches of state highways where necessary.

The Maintenance Manual states:

One of the methods for controlling erosion in open ditches is to provide a succession of dams or weirs across the ditch to decrease the water's speed. This is necessary for open ditches that exceed a 2 per cent flow grade or carry water flowing at velocities in excess of 2 feet per second and in fine-grained or silty soils. Whenever the grade of a ditch is in excess of 5 per cent, it is more satisfactory and economical to use a paved ditch for the entire length of the hill.

Earth-type ditch checks are effective when they are made to fit the ditch and have the upstream slope with a 2 to 1 slope and the downstream slope with a 6 to 1 slope. This type of ditch check is usually made from dirt scooped up from the highway ditch. It should be broad at the base and not less than 2 feet wide at the top and should be well compacted before sod or built-up coating of membrane asphalt is placed at the rate of approximately 1.5 gallons per square yard. In addition to coating the earth dam, the asphalt membrane should extend a few feet up each side of the ditch adjacent to the check to prevent side cutting and for two or three feet above and below the check in the ditch bed to prevent undermining and scouring. Where the volume of water is high, it is possible that a double application of membrane asphalt and an intermediate layer of stone may be advisable. The earth-type ditch checks are economical and have proven satisfactory in performance. From the standpoint of maintenance operations, they offer the least interference to maintenance equipment and still provide correction of erosive action in ditches.

Simple types of ditch checks made of wire mesh and broken concrete or with interlaced fence posts driven into the ditch bottom channel serve as a temporary method of correcting ditch erosion until the soil becomes stabilized with a sod growth. (6)

D. OUTLET PROTECTION

Outletting drainage from upper lands into highway ditches with no proper control of erosion presents a problem to highway authorities. Control of erosion at the outlet is essential to prevent damage to adjacent property as well as to protect the highway itself.

It is the consensus that culvert outlets should be checked for erosion caused by high outlet velocities and by turbulence resulting from the dissipation of energy. In such cases adequate protection can generally be provided with riprap, streambed paving, or energy dissipators.

Sometimes the quantity or velocity of water calls for a more elaborate dissipator structure based on careful hydraulic analysis. In that case a model study will assure the most effective control and may save on the initial cost. In any case the effect of the downstream flow should be carefully determined, and secondary acceleration at the end of the control devices should be prevented.

Points where side ditches outlet into natural waterways or drainage channels are susceptible to erosion. In some cases a vegetated sluice or chute will conduct the water safely.
The grade should be as flat as possible, preferably less than 10 per cent. If there is a large drop from the side ditch to the channel, it may be necessary to divert the sluice or chute away from the road in order to meet the grade requirement.

If a vegetative lining will not do an effective job or if the right-of-way is too narrow to flare the sluice, paving may be used or an outlet structure may be installed. This structure may consist simply of a pipe from the end of the side ditch to the stream. The outlet end of the pipe should be at least one foot above the water level and should extend beyond the bank to eliminate undercutting. Or a drop inlet may also be located in the bottom of the side ditch. This type of structure may be used either when the drop is high or when the flow in the collecting watercourse is so low that scour is likely to occur in the channel.\(^{11}\)

The Illinois Maintenance Manual states:

> You can successfully control ditch and side-slope erosion on steep grades by installing an underground closed drain with inlets. This type of erosion control has been used on short sections with good results. A drainage system consisting of an 8 inch bell-and-spigot concrete pipe with 6 inch bell-and-spigot tees as inlets spaced at approximately 50 foot intervals is usually adequate in most locations. These inlets, which have low dams on the downstream side, should be close enough so that neither the volume nor the velocity of the water will cause erosion.\(^6\)

Headwalls are provided on culverts to protect the sides of the embankment, to prevent disjointing of sectional pipe culverts, and to retain the fill. The use of headwalls on the outlet section of culverts appears to differ. For example, some highway authorities install headwalls at the entrance and outlet ends of pipe culverts and at
It can be generally stated that a headwall will serve the following functions:
1. Prevent scouring and undermining.
2. Prevent seepage and burrowing of animals.
3. Retain the fill.
4. Anchor short sections of pipe.

In general, erosion control devices are employed where conditions indicate the need for special treatment. The type and location of erosion control device are based on the quantity and velocity of flow of water, type of terrain, and soil conditions.

E. CONSERVATION PRACTICES

The effects of erosion and siltation within the highway right-of-way and upon adjoining land can often be reduced by use of conservation practices on the upper land. Illinois highway authorities have found it common for roadside ditches to become filled with silt because of the farming practices of adjacent landowners. It is impossible to force landowners to initiate practices to reduce or eliminate these problems. Therefore, it is necessary to inform them of the effects and advantages of erosion control practices not only to themselves, but to other landowners. This task is not
easy, and there is also a question about who is responsible for conducting a program of this type. It would appear that some educational agency, such as the Cooperative Extension Service, would be able to do this job most effectively and with the least bias toward any of the parties concerned.

Landowners themselves have expressed concern about the increase in erosion on their lands due to highway construction. Highway authorities say that certain soils and slow drainage may present silting problems due to washing of newly disturbed soils during and for a period after construction. Normal design and careful construction methods usually minimize this condition. However, there is no accurate way to forecast such damage or any guides to ascertain the extent before the damage occurs.

F. MAINTENANCE

Maintenance of drainage facilities, including erosion control structures, is most effective when directed toward causes of problems rather than effects. The entire system must be maintained in such a way that it will be capable of functioning under all conditions. Drainage facilities should be inspected frequently, particularly during or after heavy rains. Any defects should be corrected or repaired before they become more severe.

Highway authorities in Wisconsin have a policy memorandum relating to maintenance of drainage structures and facilities which states in part:

Maintenance of culvert pipes...and related drainage facilities shall be performed in such manner and as necessary to insure that such structures and facilities function in the manner for which they were designed and constructed. Sufficient inspections shall be made to adequately plan, initiate, and supervise necessary repair or replacement of such structures or facilities.(10)

Another memorandum further explaining this policy states:

All highway drainage structures and other drainage facilities shall be inspected at least annually (more often should conditions warrant) by the District Maintenance Engineer to insure that they are functioning properly, and any repair or replacement work found necessary shall be instituted promptly and accomplished effectively to correct any deficiencies.

Culverts which are damaged or deteriorated to such extent that they no longer adequately serve as drainage structures shall be repaired or replaced as the urgency of the particular situation requires. If a culvert has collapsed or completely failed, the District Engineer is authorized to effect immediate replacement of same. In such case, the District Engineer shall, as soon as practicable, notify the Maintenance Section of such failure, giving full details of the emergency steps taken. In other than emergency situations, culverts shall be replaced, or additional culverts installed, only as requested by the districts and authorized by the Engineer of Maintenance through an A.F.E. set up for the particular work. Wherever practicable, state-owned salvaged culvert pipe in good condition may be used for culvert replacements.

At certain locations where existing drainage structures are inadequate for proper handling of normal surface water runoff, the installation of additional culvert pipe or pipes shall be considered in accordance with the gravity of the situation. Work of such nature shall be estimated and recommended to the Engineer of Maintenance by the District Engineer. If approved, the work shall be included in the maintenance budget.
Culvert pipes shall be kept reasonably free of debris, weeds, or other obstacles to the unimpeded passage of surface water through the culvert. The patrolmen are expected to clean out the inlet and discharge ends of culverts as often as necessary to insure the free flow of water into and away from the culvert. Particular care shall be exercised to keep off-take ditches at culvert discharges free of vegetation which may block or unduly retard the flow of water. To that end, the use of soil sterilant chemicals in particularly troublesome ditches may be instituted on a limited basis. In early spring, culverts which are frozen and which thereby block normal surface drainage shall be thawed, using suitable equipment, as expeditiously as possible.

Cattle pass structures built wholly or partly with public funds are a maintenance responsibility of the state and, as such, shall be kept reasonably free of sediment deposited by surface drainage, and shall be repaired or otherwise maintained in such manner that they are functional and in reasonably serviceable condition. Discharge ditches shall be cleaned out as necessary to minimize the deposition of material in the structure. Aprons and/or walkways, preferably poured concrete, shall be provided where necessary to eliminate undue soft or muddy conditions at the ends of the structure. Corrugated metal-type cattle passes shall be provided with a serviceable floor covering to eliminate the corrugations wherever such floor is necessary.

The owner or occupant of the property served by a cattle pass shall be required to erect and maintain serviceable fencing along the walkways to the structure, and to clean out the structure when the material to be removed is entirely or largely livestock manure.

Curb and gutter sections in rural areas, including inlet and catch basin grates, sumps, and discharge lines, shall be kept clean and free of sand, dirt, or other debris. Gutters on bridge floors shall be cleaned as necessary to insure the uninterrupted flow of surface water into the floor drains. District personnel should familiarize themselves with any maintenance arrangements made relative to storm sewers on urban projects.

Damaged or deteriorated curb and gutter sections in rural areas shall be repaired as necessary, and any settlement or other distortion of the gutter grade shall be corrected, by mudjacking or other means, as necessary to reasonably maintain the flow line at the grade to which it was constructed where such maintenance has been established by agreement as Commission liability.

Appurtenant drainage facilities, such as sod, drains, flumes, intercepting embankments, ditch checks, etc., shall be periodically inspected and repaired, remodeled, or replaced as necessary to maintain the functioning of the facility in the manner for which it was designed and constructed.

In general, minor or emergency repair or replacement of drainage structures or facilities shall be performed by the patrol organization as a general maintenance function. Major repairs, replacements, new installations, etc., shall generally be accomplished under a maintenance A.F.E. set up for the particular work and included in the annual maintenance budget.

On the subject of erosion, policy memorandum 55-4 states:

Repair of erosion occurring on the highway right-of-way shall be performed as necessary to reasonably restore the right-of-way to its original condition and where feasible to prevent the recurrence of such erosion. Sufficient inspections shall be made to observe erosion in its initial stage and to institute immediate repair or corrective measures.

Interpretive memorandum 55-4 further states:

The entire highway drainage system shall be periodically and carefully inspected for evidence of erosion, particularly after a heavy rainfall, and any erosion noted in ditches, on slopes, or at culverts, shall be repaired immediately to prevent such erosion from reaching major proportions. Such repair shall include the following:

1) Filling of wash-outs in slopes or ditches with suitable materials.
(2) Correcting conditions causing undermining or scour at culverts.
(3) Construction of ditch checks or dams in ditches where the primary cause of erosion is high velocity of the water.
(4) Riprapping or otherwise protecting road slopes subject to erosion due to proximity and alignment of an adjacent river or stream.
(5) Construction of culvert pipe "downspouts" in high cut or fill slopes where the localized concentration of water flowing down the slope results in deep gully formation.

Particular emphasis shall be placed on control or repair of erosion occurring on recently constructed projects. The patrolmen, rather than assuming that new projects require very little maintenance, should concentrate considerable time on observation and repair of minor erosion on such projects....

...At any location where an annual erosion or other drainage problem exists, corrective measures shall be instituted as necessary and feasible to minimize or eliminate the recurrence of such problem. Any such problem of an unusual nature shall be brought to the attention of Maintenance Section personnel. (5)

6. REFERENCES CITED


2. Civil Engineering Report, Indiana Toll Road, J. E. Greiner Co., October 15, 1953.


11. J. L. Sanborn, Principles of Highway Drainage and Erosion Control, County Highway Series No. 4, Purdue University Engineering Experiment Station in Cooperation with the County Commissioners of Indiana, Lafayette, Indiana, 1962.
VIII. IMPOUNDMENT

Impoundment structures are sometimes planned in conjunction with highway embankments. Maintenance problems occasionally occur on the upstream side of these embankments.

The Texas Highway Department follows this policy with regard to relocation or reconstruction that may be necessary to maintain traffic service:

(1) Where existing highways and roads provide a satisfactory traffic facility in the opinion of the Texas Highway Department and no immediate rehabilitation or reconstruction is contemplated, it shall be the responsibility of the reservoir agency at its expense to replace the existing road facility in accordance with the current design standards of the Highway Department, based upon the road classification and the traffic needs.

(2) Where no highway or road facility is in existence but where a route has been designated for construction across a proposed reservoir area, the Highway Department will bear the cost of constructing a satisfactory traffic facility across the proposed reservoir, on line and grade for normal conditions of topography and stream flow, and any additional expense as may be necessary to construct the highway or road facility to line and grade to comply with the requirements of the proposed reservoir shall be borne by the reservoir agency.

The Texas Highway Department makes a further statement with respect to flooding of highways due to the construction of temporary detention dams. These dams temporarily retain flood waters to avoid downstream flooding and have an open outlet pipe located approximately at the flow line of the stream.

WHEREAS, Highway Commission Minute No. 37679 has heretofore established the policy of the Texas Highway Department concerning reservoirs constructed for the impounding of water and the effect of such reservoirs upon the Texas Highway System and outlined the responsibility of each agency involved in such reservoir construction; and

WHEREAS, there now appears to be an increased amount of work in soil conservation throughout the state generally, including the construction of floodwater retarding structures which are for the purpose of temporary detention of floods in the upper reaches of drainage areas in order to avoid downstream flooding; and

WHEREAS, it now appears desirable that a policy be formed relating the Texas Highway System to this development by the Soil Conservation Service of the United States Department of Agriculture;

Now, THEREFORE, BE IT ORDERED that until further notice the Texas Highway Department will extend its usual cooperation on the following basis to all agencies including the Soil Conservation Service in their endeavors to protect the lands of our state:

(1) In those cases where a highway or road operated by the Texas Highway Department will be inundated at less than calculated fifty-year frequencies by construction of a floodwater retarding structure, it will be expected that the Soil Conservation Service or one of its cooperating...
agencies will provide funds as necessary to raise or relocate the road above the water surface elevation which might be expected at fifty-year frequency intervals.

(2) In those cases where a highway or road operated by the Texas Highway Department will not be inundated by floods of less than fifty-year calculated frequency, it will be the purpose of the Highway Department to underwrite this hazard for the general welfare of the state and continue to operate the road at its existing elevation until such time as interruption and inconvenience to highway travel may necessitate raising the grade.

The State Highway Engineer is hereby directed to furnish to the Soil Conservation Service copies of this policy in order that it may serve henceforth in the cooperative endeavor between the Department and the Soil Conservation Service.

It is not the function of the highway authority to design, construct, and maintain impoundments. Such action would, in certain instances, involve the use of public funds for private purposes, which the highway authority is not authorized to do. On the basis of years of experience and many studies in this field, the Texas highway authority concludes that their policy should be not to encourage the creation of reservoirs using highway embankments as dams.

The practice followed in Florida concerning the use of state road fills or structures for impounding or controlling water is as follows:

Requests for use of state road fills and/or structures by others in connection with impounding water or water control will be considered only from public agencies. Favorable consideration will be given only when it can be demonstrated that the operation and maintenance of the water control system will be the responsibility of the owning agency and the Department will not be held liable for flooding or damages resulting.

In North Carolina it has been stated that:

Where a lake or reservoir floods a road or drainage structure causing the relocation of such road or drainage structure, the cost of road relocations to be charged to the water project shall be the difference between the cost of constructing the highway to modern highway design standards on the new location or elevation resulting from the water project and the cost of reconstructing the existing highway to the same modern standards without regard to the water project. Modern highway design standards should be based on a projection of traffic conditions for not more than twenty years in the future.

Highway authorities in Arkansas have indicated that the alteration of existing facilities to accommodate proposed water resources projects, including reservoirs, is done on a cost reimbursement basis by the department under agreements with the federal,
state, and other agencies involved.

The ASAE Criteria recommend that:

Drainage and local flood or water control for individual properties shall be subservient to community drainage and flood water control. It is recommended that the highway authority consider the use of retarding storage on lands of low agricultural, industrial, and residential value to decrease size and cost of drainage structures and to provide incidental flood control benefits to the community. The adjoining property owners, communities, or others benefiting from the incidental flood control should assist the highway authority in procurement of such additional rights-of-way and/or flood easement as are required for retarding storage. (1)

Authorities in Kansas have established a procedure for handling cooperative projects between Soil Conservation Districts and State Highway Commissions. A copy of this memorandum is included in Appendix A of this report. This memorandum states:

A steady increase in requests for impoundment of waters against highway fills now indicates need for recognized standard procedures to handle such matters. Requests for impoundment have frequently reached the Commission directly from private owners and at a time so late in the project schedule that favorable consideration, including investigation of feasibility, is awkward or even impossible.

In order to realize greatest benefits consistent with conservation practices and in order to protect the stability and safety features of the highways, it is necessary that procedures be instituted which clearly define the responsibilities resting with the parties concerned and which furnish a criterion for determining the feasibility of impounding waters at any specific location adjacent to highway fills.

Since each county in Kansas is covered by a Conservation District for the regulation of good conservation practices, it is proper that a private owner's request be channeled to the Commission through his local Conservation District.

The Commission, the State Soil Conservation Committee, and the Soil Conservation Service have now reached agreement on procedure and documentation for cooperation of the Commission in soil conservation practices related to use of highway fills for impoundment of waters. Covering documents will consist of a formal "Agreement" between the Commission and local District, accompanied by a "Certificate and Assignment." These will be executed in headquarters offices, with copies distributed to Divisions and Departments, as now provided for other construction agreements.

An information memorandum to all Conservation Districts has gone out from the State Soil Conservation Committee outlining approved procedure related to cooperative projects. The Commission cooperated in drafting this procedure and expects its own personnel to be guided thereby....

The memorandum as contained in the appendix further explains the step-by-step procedure to be followed by both the highway authority and Soil Conservation personnel for more expedient handling.

REFERENCES CITED
2. Drainage Manual, Florida State Road Department.
3. Minute Order Number 37679, Texas Highway Department, Austin, Texas, dated February 18, 1955.
4. Minute Order Number 38292, Texas Highway Department, Austin, Texas, dated June 30, 1955.
5. Policy of North Carolina State Highway Commission, as it relates to flood control projects, adopted in 1961.
IX. BORROW AREAS

A. PURPOSE

If there is not enough suitable fill material within the limits of the highway right-of-way, additional material must be obtained from other sources. Therefore, a borrow pit or a borrow area will be needed to supply the required fill material.

B. AREA AND LOCATION

The use and value of the borrow pit depends upon the location, topography, and geology. A plan is also needed to make them serve a useful purpose. Generally the borrow areas are furnished by either the contractor or the state. It is stipulated in Illinois that, unless otherwise provided, borrow pits will be furnished by the state. The locations are shown on the plans, and the necessary agreements for removing the material are obtained by the highway department.\(^5\)

The ASAE Criteria\(^1\) recommend that borrow areas be located with the nearest edge not closer than 100 feet to the right-of-way of an existing or proposed highway or railroad. With permission of the engineer, borrow areas may be located within the above-prescribed limits provided the terrain is such that the area will blend into the existing topography and the bottom of the pit is not more than 6 feet below the surface of the existing or proposed road. Permission will not be granted, however, to construct ponds or lakes inside these limits.

The Illinois Highway Code provides:

It is unlawful for any person to excavate or remove or cause the excavation or removal of the lateral support within a distance of 10 feet plus one and one-half times the depth of any excavation adjacent to the established right-of-way of any public highway located outside the corporate limits of any municipality, except that if any of the excavated materials be of solid rock, the depth of such solid rock shall not be considered in computing the limit of excavation from such right-of-way line of such public highway.\(^4\)

The Illinois road and bridge construction manual states that when the borrow is to be furnished by the contractor, the contractor shall furnish and pay for all borrow pits and obtain from the property owners the necessary agreements for removal of the excavated material.\(^5\)

A further provision is that the location of the borrow pits furnished by the contractor shall be approved by the engineer, that the borrow pit will not create an unsightly condition after the completion of the work, the area will be properly drained, and the existing plan of drainage will not be changed.
The Illinois Field Manual further states:
When the contractor furnishes the borrow pit, both material and location must be approved before excavation starts.

The location of the contractor's proposed borrow pit should receive careful study. It not only must avoid being unsightly, but also must not interfere with roadway drainage.

On flat lands that are subject to floods, the borrow pits should be on the downstream side of the fill rather than on the upstream side. This prevents changing of current during high water.

Whenever practicable, borrow pits should be on high ground rather than in bottom land and should be so constructed as not to interfere with the direction of the natural drainage.

If the agreement between the property owner and the state or contractor contains any special agreements, you should see that they are carried out as intended.

The ASAE Criteria point out that, after the borrow area has been located, the contractor should submit a site plan for approval of the engineer before any excavating is done. They recommend that the plan indicate the approximate quantity and quality of borrow to be removed, the proposed final shape of the borrow pit, and methods of restoring drainage and the pit area.

C. EXCAVATION

Borrow excavation generally consists of excavating, transporting, and placing materials obtained from locations furnished by the contractor or by the state. In Illinois borrow pits must be excavated in accordance with the lines and grades shown or established by the engineer and in such manner that they will drain properly.

Also, the slopes of borrow pits shall not be steeper than the ratio of $1 1/2$ horizontal to $1$ vertical, and the excavation area shall be as uniform as possible throughout the pit.

Where the contractor provides the source of borrow, the highway authorities are usually limited to making suggestions and recommendations to the contractors having ownership rights.

Where borrow areas are excavated in areas that will disturb the subsurface drainage system, ASAE Criteria state:

...the contractor shall construct a satisfactory temporary drainage system for service during borrow operations and subsequently replace any disturbed portions of the original system or construct a new drainage system.

D. RESTORATION

Since the area necessary to supply the required borrow is fairly large, restoration of the borrow pit areas by draining, grading, and seeding becomes an integral part of the construction phase. It is generally recognized that borrow areas should be excavated and restored in such a way that they do not become public nuisances. The general requirements in the ASAE Criteria are as follows:

Borrow pit areas, regardless of their location, shall blend into the surrounding topography and shall be maintained and left in a final condition such that (a) they will present a neat appearance, (b) accurate measurement of removed quantities will be facilitated, (c) permanent drainage will be established unless permission is granted to construct a fish pond or reservoir, (d) debris or stones hauled into the borrow pit will be covered with not less than 18
inches of earth, or be placed below
the established water level, and (e)
silt or any other material deposited
in existing drainage ditches during
evacuation and final shaping of the
borrow area shall be removed and the
ditch or waterway restored to its
original condition prior to the
acceptance of the work. The shaping
and restoration of borrow pits shall
be done during excavation, or as
soon as possible after excavation
has been completed without delaying
other construction work.(1)

Occasionally the borrow areas
have been formed into pond areas that
can be used for recreation, fishing,
etc.

The ASAE Criteria state:
If borrow pits are to be used for
fish ponds or reservoirs, the water
shall have a minimum depth of 6
feet over one-half of the pit area
and a minimum depth of 3 feet over
the remainder of the pit. The slope
of the pit bottom at the shoreline
shall not be steeper than 2:1 nor
flatter than 2 1/2:1 to a point of
3 feet or more below the normal ele-
vation of the water in the pond.
The contractor shall construct the
necessary inlet channels and outlet
pipes required to supply and main-
tain the water level for the pond.
Before borrow pits are excavated to
form fish ponds or reservoirs,
approval in writing shall be obtained
from both the engineer and the prop-
erty owner.(1)

In restoration of borrow areas, it
has been specified in Illinois that
borrow pits must be bladed and left in
neat and presentable condition. The
contractor is not permitted to dispose
of brush, rubbish, etc., in the borrow
pit regardless of whether the pit is
furnished by the contractor or where
it is located. (3)

The ASAE Criteria further provide:
Borrow pits which are to be returned
to cultivation shall have a topog-
raphy suitable for cultivation and
be covered with not less than 4 in.
of topsoil. The topsoil shall be
measured after being compacted
beneath a weight of 50 lb. resting
on a surface 10 in. square. The
borrow pit and adjoining disturbed
areas shall be fertilized in accord-
ance with highway specifications and
seeded to a cover crop such as oats
or rye. The seeding rate shall be
1.5 bu. per acre. The seed may be
broadcast or seeded with a drill.
The seed shall be covered 2 in.
deep.

Borrow pits and the adjacent dis-
turbed areas that are not returned
to cultivation, and the disturbed
areas adjacent to, and above the
water line of ponds, shall be fer-
tilized and seeded to adapted
grasses. The rate of application
and the quality of seed, fertilizer,
and mulch shall conform to accepted
seeding practices for roadside im-
provement. Shaley or stony areas
which, in the opinion of the engi-
neer, are not suitable for seeding
or cultivation shall be covered
with 2 in. of top soil in accordance
with highway specifications prior
to fertilizing and seeding.(1)

The highway authorities point out
that the refinements listed in the
ASAE Criteria will increase the con-
struction cost. Therefore, the ad-
vantages of a pleasing appearance must
be weighed against the additional cost.

E. DRAINAGE
On occasion borrow areas located
parallel to the highway serve as out-
let basins for agricultural drainage
systems. The borrow area must be
outletted at such level that the water
surface would be at least one foot
below the inverts of the collector
mains discharging into them. (2)

The ASAE Criteria provide:
All drained borrow pit areas shall
have natural and complete drainage.
The low point in the borrow pit
shall be 2 ft or more above the
flow line of the ditch into which
it drains, and the bottom of the pit
shall have a slope of not less than
0.10 per cent toward the outlet
drain. In areas of fluctuating
ground water, the bottom of the borrow pit shall be 1 ft above the maximum ground water elevation or the borrow pit shall be excavated to conform to [the criteria suggested for borrow pits left as ponds.]

A berm with a minimum top width of 20 ft and side slopes of 4:1 shall be left between the borrow pit and any ditch adjacent to it. When the pit bottom is below the flood water level of the ditch into which it is drained, it shall be drained into the ditch through a culvert placed under the berm. The culvert size shall be determined by Talbot's formula using 0.33 for the coefficient C. If the outlet channel on the downstream side of the borrow pit is excavated to make it possible to secure additional material, the minimum gradient of the channel shall be 0.5 per cent. (1)

Illinois rules stipulate:
The contractor should be informed of the average depth of the pit as decided upon in the agreement with the landowner, and also should be given any special instructions in regard to special ditches, etc. Be sure the contractor understands that the borrow pit must be excavated in such a manner as to drain properly after removal of the required amount of material. Undrained borrow pits are unsightly and also objectionable when the water they contain becomes stagnant.

There are exceptions to this general rule. The gradient may be such that the pit cannot be completely drained. If on private property the owner may desire to make a pond of the borrow pit. However, the exceptions are not many, and if the contractor objects to complying with the specifications consult your district construction engineer before granting any exemptions. (3)

F. REFERENCES CITED


X. FUTURE DRAINAGE

A. RESPONSIBILITY FOR PROVIDING FACILITIES

When plans are made for new highway systems, it is difficult to evaluate the requirements for future drainage. Many landowners consider the highway system a barrier to their drainage and therefore think that the highway authority should provide drainage facilities within the highway right-of-way not only as it exists today, but for all future time. This procedure would include provisions for the extension or enlargement of present systems to accommodate those areas naturally tributary but presently not drained.

For the Ohio Turnpike, this procedure was followed:

...The continued extension and improvement of agricultural drainage systems...presented a problem which had to be considered when the drainage facilities for the turnpike were designed. Unless allowances were made by the turnpike for improvements to the existing agricultural drainage systems and for the extension of such systems to lands not now drained, those areas where land use was dependent upon agricultural drainage would be deprived of the possibility of further development. To prevent the occurrence of this condition, turnpike drainage structures in such areas were so designed that they would not become a barrier to the construction of new agricultural drainage systems or to the lowering of existing systems to depths which are recognized as adequate and as a foreseeable possibility.(4)

It is generally understood that the highway authority is responsible for providing adequate transportation facilities. To fulfill this responsibility it is authorized to use public funds for such facilities, including adequate provision for present highway drainage needs. However, the responsibility for providing for future drainage is questionable, since some of the future facilities proposed by the landowners may never be needed. If the facilities proposed by the landowners and provided by the highway authority were never used, the allocation of funds for this purpose would not benefit the public and therefore would not be justified. Therefore, it is necessary that criteria be established to determine the requirements and obligations of both the highway authority and the affected landowner for future drainage.

B. PRACTICES FOLLOWED BY SOME HIGHWAY AUTHORITIES

The ASAE Criteria state:

The highway authority shall reconstruct affected portions of existing drainage systems to the approximate standard which existed prior to construction of the highway and provide opportunity for future drainage and flood control improvements on adjacent properties, to the standard established by these criteria. The property owners and/or drainage authority shall construct drainage
or flood control systems required for improvements or protection of adjacent properties. It is recognized that highway construction may result in incidental improvement of drainage of adjacent properties, but it shall not be the obligation of the highway authority to improve drainage of or to protect adjacent properties from flooding which occurred prior to the construction of the highway. (1)

The Criteria further stipulate that future developments should conform with the capability and use of the lands served.

In Florida the practice as stated in the Drainage Manual is as follows:

Common law holds that the lower owner is required to take surface waters from the upper owner's improvement if there has been no diversion of flow. With this governing rule, department policy in the design of drainage structures is to consider the expected improvement in the upland areas for a period of from 10 to 25 years. (3)

The Florida Manual stated further:

Department policy is to provide facilities which will adequately pass the runoff from natural areas draining to the project. At the written request of city or county governments, the location and/or elevation of such facilities can be adjusted to suit improvements proposed by those agencies providing they take responsibility for the alterations. The provision of facilities in excess of those described will be done by the department at the expense of the requesting agency. (3)

Other highway authorities indicate that in their plans they endeavor to evaluate trends within the watershed that might change the natural drainage pattern.

The Ohio Turnpike provisions stated that:

Where no agricultural drainage system existed, but future agricultural drainage was evident, drainage structures under the Turnpike and under reconstructed local roads were constructed to the minimum depths specified. . . . When no suitable outlets were available, collector mains for future drainage systems were installed under the Turnpike at the depths specified. . . . (4)

The Suggested Guide formulated in Illinois states:

The acquisition or purchase of land for right-of-way should include provision for reconstructing affected portions of existing drainage or conservation systems to the approximate standard which existed prior to improvement of the highway, and provide opportunity for future drainage and flood control improvements on adjacent properties if such improvements are surveyed and planned in advance of the completion of right-of-way acquisition. The property owners and/or drainage authority shall finance and construct drainage and flood control systems required for improvement or protection of adjacent properties, including that portion of such systems as may occupy the highway right-of-way. It is recognized that highway construction may result in incidental improvement of drainage of adjacent properties, but it shall not be the obligation of the highway authority to improve drainage or to protect adjacent properties from existing floods. (5)

Illinois highway authorities indicate that they will consider future drainage provisions when the landowner can show evidence of positive intention. Such evidence might be drainage plans prepared by the Soil Conservation Service, with a strong indication of immediate action on the part of the landowner.

A practice suggested for underground drainage crossings in toll roads and major free highways is to install cross road tile large enough to drain all of the wetland in the watershed lying higher than the road
base. A survey and ground tests should be made on the upstream side of the road and the number of acres tiled or in need of tiling should be measured. With this information, together with the grade of the outlet pipe through the road, it should be possible to determine the size and depth of main tile that would be adequate for future needs. If a main tile has already been installed for handling tile systems, the main should be examined for depth and fall, and a new line should be constructed according to specifications for present or future use. If no laterals have been installed, the specified main should be laid from fence to fence and sealed on both ends for future needs.

The justification for this action is that the cost will be higher if the main tile line is installed after the road is graded or finished than if installed prior to the fill. Also, tunneling through a roadway to install pipe may cause a dip or break in the pavement due to settling.

On the Indiana Toll Road, it was suggested that conduits be installed under the road to provide for future agricultural tile and subsurface drainage in areas where potential agricultural drainage were evident and where no other outlets were available. The need for such provisions should be determined by soil surveys of adjacent lands and by analyses of soil conditions and drainage practices in adjoining areas. This procedure would involve checking existing data available from county engineers and Soil Conservation Service personnel, visiting landowners or tenants located on the right-of-way, making field inspections, and actually probing for tile.

These investigations require time and funds for research and study of possible future agricultural drainage needs of the many areas traversed by a highway. In certain locations provision can be made for future agricultural needs by installing two culverts. One line would be placed at lowest minimum depth and sealed, and the other at a higher elevation to empty into an existing outfall ditch or main. Upon construction of an outlet at the lower elevation, the buried culvert would be available for the anticipated future agricultural development of an area. This arrangement would involve a certain amount of speculation.

An argument in favor of the use of blind conduits is that the number required for future tile drainage will generally be small, since there will usually be an outlet near the location. Also at locations where it is necessary to provide for future crossings, it will be more economical to provide the crossing at the time of construction that at a later date.

In Minnesota the highway authority is not obligated under law to provide culverts for future private ditches during construction or reconstruction of a highway. The department does, however, through the Soil Conservation Service, cooperate with individual owners or groups of owners by providing preliminary layouts and programming of highways planned for construction. In this way some of the contemplated drains can be installed before highway
construction, and the Highway Department is then obligated during highway construction to provide the required culverts as it would for any existing ditch.

C. REFERENCES CITED


3. Drainage Manual, Florida State Road Department.


XI. SEWAGE AND POLLUTION

A. LEGAL REQUIREMENTS

Sewage and pollution problems have been encountered by both highway authorities and landowners. They involve discharge of effluent onto the right-of-way, interception of sewage lines, etc.

The Illinois statutes indentify these problems and provide remedies for violations of the law governing them. In dealing with the pollution of street and highway drains, the statutes state:

No person, firm, corporation, or institution, public or private, shall discharge or empty any type of sewage, including the effluent from septic tanks or other sewage treatment devices, or any other domestic, commercial, or industrial waste, or any putrescible liquids, or cause the same to be discharged or emptied in any manner into open ditches along any public street or highway, or into any drain or drainage structure installed solely for street or highway drainage purposes.

Any person, firm, corporation, or institution, public or private, in violation of this Section, shall be fined not less than $200 nor more than $500 for each such offense and in addition shall be fined $25 per day for each day such violation exists.

The highway authority having jurisdiction over the public street or highway affected by such violation shall enter a complaint in the proper court against any violator of this Section. Upon the failure of any such highway authority to so act, any other person may, in the name of the political division or municipality, enter such complaint.(4)

The Attorney General of Illinois rendered an opinion in 1954 that adds further meaning to this section:

It will be noted that the prohibitions relate to (1) "any type of sewage," (2) "any other domestic, commercial, or industrial waste," or (3) "any putrescible liquids."

The word "sewage" is defined in Black's Law Dictionary, 4th edition, as follows: "Refuse and foul matter, solid or liquid, carried off by a sewer." It would thus seem clear that the term "sewage" includes the water-carried human or animal waste matter from residences, buildings, or other places.

The term "waste" is defined in Webster's New International Dictionary, as "refuse from places of human or animal habitation."

The word "putrescible" is defined in Webster's New International Dictionary, as "capable of putrefaction; liable to become putrid." The term "putrid" is further defined as "decomposed, especially in an advanced stage of decomposition; rotten"....

It would seem to be the general purpose of this enactment to prohibit the discharge into the open ditches along any public street or highway, or into any drain or drainage structure for street or highway drainage purposes, of such substances as will be likely to create a nuisance or which will be detrimental or injurious to the public health, safety, or welfare. In other words, the prohibitions relate to certain substances which are physically offensive to the senses.
In construing this statute in accordance with its general purpose and object, it would seem that water containing soap or detergents used in connection with shower baths or washing clothes would be "domestic waste" within the meaning and intent of the statute. . . .

Although seepage water [in this case water seeping out of a basement] may possibly be considered to be a form of domestic waste, and thus within the letter of the statute, yet it is clear that if it is nothing more than water containing no deleterious substance, it would not be physically offensive to the senses. Although thus possibly coming within the letter of the Act, it does not come within the general purpose and object of the Act . . . . (3)

It is generally considered that neither the drainage authority nor the property owner shall discharge untreated or improperly treated sewage into the highway drainage system, public or private tile drains, storm sewers, or open ditches.

B. DISCHARGE OF EFFLUENT

In the acquisition of right-of-ways for new highways, it is sometimes discovered that landowners are discharging sanitary sewage into drains not designed for sewage. The cost of correcting such a system is usually considered a non-compensable right-of-way expense.

In established highway systems, it is occasionally discovered that material from septic tanks or other waste products from adjoining premises are discharged into existing highway ditches or into creeks and streams. This procedure violates the statutory provisions previously quoted. Highway authorities indicate that landowners often do not recognize this as a violation of the state law and consequently expect to receive, as damages, payment to reconstruct intercepted sewage systems.

In Indiana where the landowner desires to connect his sewage system to the highway drainage system, the policy adopted by the highway authority is as follows:

In small towns and rural communities, frequent requests are made from property owners for the privilege of connecting septic tank drains to our highway drainage system, underground or surface. In some instances, our improvement eliminates an open ditch formerly used for such purpose, and the property owner assumes the right to perpetuate the arrangement.

The State Board of Health informs us that the type of septic tank normally used for residential use does little more than liquify the sewage. A filter bed or soil filter is needed before the effluent is safe in an open ditch. However, the local public health official is usually better qualified to pass judgment on the efficiency of such treatment and the purity of the effluent.

When requests for such drainage connections are made, require a written certificate from the County Health Officer before you permit such connections to be made. If connection is made to our line of pipe, it is desirable that the work be done under our inspection. Otherwise, unsatisfactory installations may be made that will reduce the efficiency of the sewer. (2)

In the replacement of sewage facilities disturbed during highway construction, the ASAE Criteria(1) recommend that the highway authority shall, by payment of damages for construction or by reconstruction, replace with an equal facility any individual sewage system damaged or made ineffective by the construction of the highway.

For sewer lines crossing under the highway, the Illinois Maintenance Manual provides:
NOTICE OF VIOLATION OF ARTICLE 8, SECTION 151b, OF ILLINOIS ROAD AND BRIDGE LAWS

Book 2, Page 959, Chapter 121, Article 8, Paragraph 168a, of the Illinois Revised Statutes.

To ____________________  Address ____________________
To ____________________  Address ____________________

Dear Sir:

This notice is served for the purpose of informing you that Article 8, Section 151b, of the Illinois Road and Bridge Law is being violated along the State highway adjacent to property owned, rented, occupied, leased, or managed by you in County, Illinois, on State Highway at the following location: ____________________

This notice is served for the purpose of informing you of the law. In order to avoid the issuance of a complaint and the institution of court procedures, request is made that the offense be corrected.

The Statute referred to reads as follows:

"No person, firm, corporation, or institution, public or private, shall discharge or empty any type of sewage, including the effluent from septic tanks or other sewage treatment devices, or any other domestic, commercial or industrial waste, or any putrescible liquids, or cause the same to be discharged or emptied in any manner into open ditches along any public street or highway, or into any drain or drainage structure installed solely for street or highway drainage purposes.

"Any person, firm, corporation, or installation, public or private, in violation of this Section, at the effective date of this Act, who does not on or before July 1, 1954, remove or correct the condition which occasions such violation and any person, firm, corporation, or institution, public or private who creates or causes to be created a condition resulting in a violation of this section after the effective date of this Act shall be fined not less than $200.00 nor more than $500.00 for each such offense and in addition shall be fined $25.00 per day for each day such violation exists.

"This highway authority having jurisdiction over the public street or highway affected by such violation shall enter a complaint, in the proper court against any violator of this section. Upon the failure of any such highway authority to so act, any other person, may in the name of the political division or municipality, enter such complaint."

Please note that the clause in the last paragraph provides that a complaint be issued for court action against violators of this section.

Signed ____________________ (District Engineer)

FIGURE 37. NOTICE OF VIOLATION
1. Minimum depth below ditch line or pavement surface is to be below frost line.

2. No sewage line is to be connected to or placed inside any culvert or other drainage facility.

3. No sewage or other obnoxious drainage matter is to be run into any highway drainage pipe, tile, or drainage ditch. (5)

The Illinois Division of Highways sends a notice to any violators of the statutes informing them of the law and the consequences of violation thereof. Figure 37 shows a copy of this notice.

C. REFERENCES CITED


2. General Instructions to Field Men on Road Construction, Indiana State Highway Commission, Sec. 4.


XII. GOVERNMENTAL UNITS

A. POWERS RELATING TO DRAINAGE

A number of governmental units have powers relating to drainage and flood control. This report will not go into detail on all of these powers but, rather, will identify some of the common units and explain their basic functions. A report, "Summary and Comment on Illinois Laws Relating to Drainage and Flood Control," relates to this subject. The units listed in this report are (1) Soil and Water Conservation District, (2) Soil and Water Conservation Subdistrict, (3) Drainage District, (4) Surface Water Protection District, (5) River Conservancy District, (6) Sanitary District, (7) Cities and Villages, and (8) State Agencies. Following is an explanation of these units as reported by Krausz:

1. Soil and Water Conservation District

In the Illinois act establishing soil conservation districts, it is declared to be the policy of the legislature to provide for the conservation of the soil, soil resources, water and water resources, the control and prevention of soil erosion, and the prevention of erosion, floodwater and sediment damages, in order to preserve natural resources, control floods, prevent impairment of dams and reservoirs, assist in maintaining the navigability of rivers and harbors, preserve wildlife and forests, protect the tax base, and protect and promote the health, safety, and general welfare of the people.

In order to coordinate the individual soil and water conservation districts, a State Soil and Water Conservation District Advisory Board has been established.

This board is advisory to the State Department of Agriculture which is charged with, among others, to assist and inform directors of the soil and water conservation districts, to coordinate the activities of the individual districts, to seek assistance and cooperation of the federal government and the other state agencies, and to disseminate information throughout the state concerning the formation of soil conservation districts....

The governing body of the district consists of five directors, who are owners or occupiers of lands within the district. The directors are empowered to conduct surveys, investigations, research, and to develop comprehensive plans for the conservation of soil and water resources and for the control and prevention of erosion and floodwater and sediment damages, to carry out preventive and control measures, to furnish aid, financial or otherwise, to any government agency or private party in carrying on erosion and flood control, to acquire and improve properties for the purposes of the district (includes power to condemn), to make available to landowners agricultural and engineering machinery to assist them in erosion and flood control, to construct, improve, and operate necessary structures, to administer any erosion project undertaken by the federal government within the district, to sue and be sued in the name of the district, and to require contributions or agreements with
respect to land as a condition to the extending of any benefits to private property.

One important provision of the act deals with the promulgation of land-use regulations. The directors of a district have authority to formulate regulations governing the use of land within the district in the interest of conserving soil, soil resources, water and water resources, and preventing and controlling erosion, floodwater, and sediment damages. Any such regulation proposed by the directors may not be adopted unless three-fourths of the landowners approve. The regulations must be uniform throughout the territory within the district except for certain reasonable classifications based on such factors as soil type, degree of slope, degree of erosion, and other relevant factors, but the ordinance must operate uniformly upon all land within a particular classification....(6)

2. Soil and Water Conservation Subdistrict

Subdistricts were authorized as a sponsoring agency for a new federal project, aid for watershed protection and flood prevention activities....

The governing body of the subdistrict consists of the directors of the soil and water conservation district in which the subdistrict is formed. If the subdistrict falls within more than one district, the directors of all such districts act as a joint governing body.(6)

3. Drainage District

Drainage districts may be formed to construct, maintain, or repair drains or levees or to enlarge in other drainage or levee work for agricultural, sanitary, or mining purposes. The area to be included within the district does not have to conform to any pre-existing political boundaries, and may cover more than one county.

The primary purpose of the Drainage Code is to provide landowners with a legal entity or organization (a drainage district) which can be used to force unwilling owners into the district and to secure adequate drainage or flood protection for the lands lying within such an entity....

Generally speaking, the commissioners of a drainage district have broad comprehensive powers in regard to constructing and maintaining drains and levees.

"A drainage district may be organized by filing in the county court a petition signed by a majority of the landowners who own one-third of the land within the proposed district, or by one-third of the landowners who own a majority of the land in the proposed district. A smaller number of landowners may also petition for organization. The petition must be signed by at least one-tenth of the adult owners who own at least one-fifth of the land. In the event that this alternative method of petitioning is used, a referendum must be held."(6)

4. Surface Water Protection District

These districts are established to provide protection from damage to lives and property caused by surface water, and the district has the power to pass regulatory ordinances and build structures to effectuate such purposes. These structures may include sewers, drains, ditches, levees, etc. In addition, the board of trustees of the district may enact ordinances to provide protection from surface water damage.

The maximum statutory tax rate is .125 per cent. With referendum, it is .25 per cent....

This statute would appear to be useful in solving the problem of flooded subdivisions.(6)

5. River Conservancy District

Such a district may be established where the uniform control of a river system or a portion thereof is desirable. A district is granted broad comprehensive powers as to flood control, drainage, irrigation, conservation, preservation of water levels, sanitation, etc. In addition, the statutes list more specific powers, including the authority to construct dams, levees, bridges. It is the duty of the trustees of any conservancy district to prevent pollution of any stream or other body of water located in such district and cause any person or business unit responsible for pollution to refrain therefrom.

Any plans adopted by the district must be submitted for approval to the Department of Public Works and the Sanitary Water Board.(6)
6. Sanitary District

(1) Sanitary district containing municipalities - Chapter 42 contains a number of acts that provide for the establishment and administration of a sanitary district. However, all but two deal with special situations that will merely be mentioned later. The first of the two main acts concerns sanitary districts containing one or more municipalities.

The district may cover more than one county, and does not have to conform to any pre-existing political boundaries.

The board of trustees of the district has the power to provide for sewage disposal and drainage, which includes the power to construct drains, sewers, laterals, pumps, and pumping stations.

The board may grant easements or permits for the use of any real property which in the opinion of the board will not interfere with the use of such property by the district for its corporate purposes....

(2) Sanitary district outside of municipalities - Such district must be contained within one county and must be outside the limits of any municipality.

The board of trustees of the district has the power to provide for sewage disposal and drainage facilities.

In order to raise revenue, the district may levy a direct annual tax for principal and interest on bonds, a tax up to .25 per cent for general purposes (.50 per cent with referendum), and special assessments. But in no case shall any property be assessed more than it will be benefited by the improvement for which the assessment is levied. In addition, the district may collect from producers of industrial waste fair additional construction, maintenance, and operating costs over and above those covered by normal taxes.

Pursuant to approval by a majority of the voters at an election, the district may purchase, by eminent domain or otherwise, or construct a drainage or waterworks system and thereafter operate it. Necessary funds are raised from revenue bonds, payable solely from the operation of the system. A plan may be submitted to the trustees by petition of at least 10 per cent of the legal voters of the district....

(3) Miscellaneous sanitary districts - The following sanitary districts are merely listed because they are not general in scope, but rather apply to special situations: (a) sanitary districts composed of contiguous territory, within the limits of two counties, having within its limits two or more incorporated cities or villages, and an aggregate population of not less than 3,500 inhabitants, that is so situated as to be subject to overflow from any river or tributary thereof; (b) sanitary districts for towns receiving their water supply from Lake Michigan; and (c) the Chicago sanitary district.

7. Cities and Villages

The corporate authorities of municipalities have the power, for drainage purposes, to construct and maintain drains, ditches, levees, dikes, pumping works, and machinery, and to acquire the necessary land and machinery therefore, and in this manner to provide for draining any portion of the land within their corporate limits, by special assessment upon the property benefited thereby, or by general taxation, or both. Flood hazards may be lessened or avoided by prescribing appropriate rules and regulations for the construction and alteration of buildings and structures....

8. State Agencies

(1) Department of Public Works and Buildings - The Department has authority to make examinations, surveys, and plans for the construction of works for flood control, for improvement of land drainage and for conservation of water flow, in rivers, waters, and watersheds. However, before any expenditures can be made for such improvements, authorization is needed from the General Assembly.

To carry out these plans, the Department may enter into cooperative agreements with the United States Government and with local governments in Illinois, and may purchase lands, easements, or other property to carry out its duties.

(2) Board of Economic Development - The board represents and acts for
the state in matters concerning any project for the improvement of navigation, flood control, or any other purpose on any of the rivers, waters, or watersheds of Illinois by the United States or any agency thereof. Land use and water planning will receive considerable attention, water planning to include water development and conservation. The board has power to study and determine means of coordinating water resources for maximum beneficial use, to assist in reconciling or adjusting conflicting claims of water users, and recommend legislation on water conservation.(6)

B. DRAINAGE DISTRICT WORKING RELATIONSHIPS

1. Purpose

The natural rules of drainage do not always provide for a completely adequate system of drainage, since they depend upon a difference in elevation between adjoining lands. The legislative branch of the state governments has recognized this limitation, and as a result the common law has been enlarged by the enactment of statutory provisions.

A unit that was designed to help alleviate this problem and one that has frequent relationships with the highway authority is the drainage district. The report on the legal phase of this project lists these basic principles governing drainage districts:

(1) They are authorized by the General Assembly but are not specifically created by it. Thus, the legislature creates the framework for a drainage district and gives it certain powers, but leaves it up to the people of the area to determine the need for such a district.

(2) They do not follow existing governmental lines (county, township, or city) but can be created on the basis of physical need, i.e., a natural drainage basin or a unified river network.

(3) Their powers relate solely to the specific purpose at hand....

(4) The procedure for organizing and governing the districts is usually the same, starting with a petition of a certain number of residents of the area to the county judge, a general election, appointment of commissioners or trustees, etc.

(5) Drainage districts are dependent solely upon statutes, and these statutes must be fulfilled to make their organization legal.(1)

With the establishment of drainage districts, the organization as a whole, composed of private landowners, has broader authority than any individual landowner. Therefore, relationships between the organized district and the highway authority are different from those between the landowner and the highway authority. Many of these relationships have been reviewed in the legal study of this project and will not be recorded in this report.(1)

2. Record of Plans

It has been suggested that the highway plans show (1) the size, location, and elevations of collector mains, submains, and lateral tile 6 inches in inside diameter or larger; (2) the location of small lateral drain tile; (3) the location and elevation of all appurtenances; and (4) the location, elevation, and grades of drainage ditches constructed or reconstructed by them.(6)

The Illinois statutes provide that, whenever a highway is laid out, widened, or altered in accordance with the Highway Code, the proper highway authority shall cause a plat to be made and recorded in the office of the recorder of deeds of the county
or in the office of the registrar of titles for the county if appropriate. (5)

The Drainage Code (2) states further that permanent records shall be maintained for each organized district, including such items as maps, plats, and plans of the district, all assessment rolls, certificates of levy, reports, and other formal records of the district required by law or by order of the court to be recorded.

Where any plans are prepared for construction or improvement of facilities which may affect the highway authority or organized drainage district, it is desirable that the other party be informed regarding the proposed action. In Illinois, for example, if a drainage district is involved in a proposed development by the highway authority, the drainage district is properly informed and, if necessary, meetings are arranged to discuss matters of mutual concern.

3. Assessments

The question whether the drainage district has the power to assess the highway authority was discussed in the report on the legal phase. (1) The Drainage Code points out:

Upon the organization of the district, the commissioners shall proceed to make out their assessment roll of benefits, damages, and compensation, and they shall include therein all lands, lots, railroads, public highways, streets and alleys, and other property within the district which, in their opinion, will be benefited, taken, or damaged by the proposed work. . . . (3)

However, the report states that the citations and comments made by the courts relating to this subject appear to be confined to lesser political subdivisions, such as counties and townships and that the state is exempt from any form of taxation or assessment.

One problem concerns the effect on small drainage districts of acquiring for right-of-way land that has been subject to assessment. The result is an increase in taxes for landowners who may not otherwise be affected by the acquisition. In some instances, construction of normal road ditches that help to improve drainage may be a compensating factor. The practice of assessment appears to vary in different states and may therefore be worthy of investigation by individual states.

4. District Drains Crossing Highway Facilities

The Illinois Drainage Code provides:

Whenever a district drain crosses a public highway or a railroad other than in the course of natural drainage, the district is liable to the highway authority or the railroad for the cost of constructing any bridge or culvert made necessary by such crossing and shall thereafter be liable to the highway authority or railroad for the cost of repairing and maintaining such a bridge or culvert.

Whenever a natural drain or a ditch constructed in the course of natural drainage crosses a public highway or a railroad, the highway authority or the railroad shall construct and thereafter keep in repair and maintain a bridge or culvert of sufficient length, depth, height above the bed of the drain or ditch, and capacity to subserve the needs of the public with respect to the drainage of the lands within the natural watershed of such drain or ditch, not only as such needs exist at the time of construction, but for all future time. . . .

If a district, by deepening, widening, or straightening a natural drain or by changing the established
grade, width, or alignment of a
ditch, removes or threatens to re-
move the support from under any
abutment, pier, wingwall, or other
supporting member of a highway or
railroad bridge the district is
liable to the highway authority or
the railroad for the cost of pro-
tecting or underpinning such abut-
ment, pier, wingwall, or other sup-
porting member....

The policies adopted by different
states vary. The following is a state-
ment of policy from North Carolina:

When any drainage district or flood
control project makes necessary the
revision, modification, replacement,
or construction of any drainage
structure on any road maintained
by the State Highway Commission,
the cost of such revision, modifi-
cation, replacement, or construction
of such structure shall be paid as
follows:

(1) Where the drainage district or
flood control project requires the
construction of a new structure
where one has not previously existed,
the entire cost of such structure,
constructed with Standard State
Highway Commission designs, shall
be borne by the drainage district or
flood control project.

(2) Where an existing drainage struc-
ture has to be replaced, the cost of
replacing the existing structure with
a structure of like design, width,
load-bearing capacity, and life
expectancy shall be borne by the
drainage district or flood control project.

(3) Where an existing drainage struc-
ture has to be modified, revised,
or extended due to the deepening or
widening of the waterway approaching,
leaving, or passing under or through
the drainage structure, such modifi-
cation, revision, or extension shall
be borne by the drainage district or
flood control project, provided that
such modification, revision, or
extension does not significantly
improve the general design features,
or does not significantly increase
the width, load-bearing capacity, or
life expectancy of the structure.

Should it be deemed necessary or
advisable by the State Highway
Commission in modifying, revising,
or extending the existing structure
to increase the existing design
features, the width, load-bearing
capacity, or life expectancy of the
structure, the additional cost of
such improvements shall be borne by
the State Highway Commission.

(4) Where a lake or reservoir floods
a road or drainage structure, caus-
ing the relocation of such road or
drainage structure, the cost of road
relocations to be charged to the
water project shall be the difference
between the cost of constructing the
highway to modern highway design
standards on the new location or
elevation resulting from the water
project and the cost of reconstruc-
ting the existing highway to the same
modern standards without regard to
the water project. Modern highway
design standards should be based on
a projection of traffic conditions
for not more than twenty years in
the future.

(5) Any direct benefits to the State
Highway Commission due to the improve-
ment of the drainage structure, or due
to the work proposed by the drainage
district, will be paid for by the
State Highway Commission. The maxi-

(6) The lowering of pipe culverts
will be in accordance with the policy
now in effect, as follows:

Where the elevation of the flow line
of a pipe under a highway is not low
enough to take care of drainage, it
shall be the responsibility of the
State Highway Commission (without
charge to the property owner) to
lower the pipe or otherwise provide
needed lower drainage under the high-
way and within the limits of the
right-of-way.

In general, the condition referred
to above includes pipe installations
where the property owner, in order to provide adequate drainage, has lowered the flow line of the inlet and outlet ditch to a pipe culvert that crosses a highway; where the lowered outlet ditch has satisfactory fall and does not divert water from the natural drainage; where there is reason to believe that it is practical to maintain the outfall; and where the benefit to the affected property equals or exceeds the cost of lowering the pipe.

5. Maintenance

The Drainage Code points out:

Whenever a district drain crosses a public highway or a railroad other than in the course of natural drainage, the district is liable to the highway authority or the railroad for the cost of constructing any bridge or culvert made necessary by such crossing and shall thereafter be liable to the highway authority or railroad for the cost of repairing and maintaining such a bridge or culvert.

The obligation also rests upon the highway authority to maintain and repair bridges and culverts crossing natural watercourses.

Experience shows that drainage districts are sometimes lax in keeping up good maintenance practices, with the result that drainage is sometimes poor. A maintenance program is a continuing item and must be carried on accordingly if the system is to function to the best interest of all parties concerned.

C. REFERENCES CITED


5. Ill. Rev. Stat., Ch. 121, Sec. 4-214 applies to the department, Sec. 5-101.8 to the county, and Sec. 6-328 to the township (1963).


XIII. SUMMARY

The subject of drainage demands serious consideration in highway building and maintenance programs as well as in the implementation of agricultural programs. Since the solution of problems associated with drainage cuts across different lines, relationships may become involved and complex. Two phases that are important are (1) the rights and limitations of involved parties or individuals and (2) the engineering and technical knowledge required to handle the physical characteristics of drainage.

The law provides the basis for many highway and agricultural drainage policies and practices. However, often those not working in the field of law do not fully know or understand the principles. This limited knowledge or understanding can be attributed in part to lack of a single source of information. Consequently, the purpose of the first phase of this project was to search out and compile into one source all Illinois drainage laws applicable to highway and agricultural interests. This study revealed many of the legal responsibilities of the highway authorities and landowners, which provide the framework for many of the present policies and practices.

In addition to understanding the legal responsibilities relating to highway and agricultural drainage, it is necessary for persons working in this field to know some of the engineering problems involved in handling the physical characteristics of drainage. It is this combination that provides the basis for the establishment of principles and practices to be followed by highway authorities and others in working with interrelated highway and agricultural drainage and erosion control problems.

Private landowners must also understand their rights and responsibilities. Establishment of an effective medium of communication will allow the highway authority to acquaint the landowners with the proposed plans at an early stage and also permit justifiable needs of the landowner to be incorporated in the original plans. This action may eliminate many problems that might otherwise be encountered.

Drainage problems vary from one section of the state to another. The methods of handling these problems also vary, even for similar problems in different localities. Most of the policies being followed by highway authorities are adequate. However, many of them have not been recorded or assembled in a single source. Therefore, there is a need to compile a
record of the solutions of problems pertaining to highway and agricultural drainage. These statements should be specific enough to provide the framework for general policy statements that would be adaptable to most localities of the state and broad enough to permit expansion to include the peculiarities encountered in certain localities.

The intent of such statements should not be to limit the freedom of the engineers but rather to provide guidelines to assist them in promoting more uniform practices. The purpose should be to meet the requirements of both highway authority and landowners without placing unjustifiable demands on either party. The statement should (1) assure landowners that their drainage systems will be maintained in the same condition as prior to construction, (2) inform the various agencies having jurisdiction over local drainage systems of the measures the highway authority will take to protect the interests of regions affected by the highway construction, (3) furnish the right-of-way agent with pertinent information for use in making right-of-way negotiations, (4) provide criteria for the uniform handling of agricultural drainage facilities, and (5) provide for cooperative effort and exchange of ideas between the highway authorities and landowners.
XIV. BIBLIOGRAPHY


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17. General Instructions to Field Men on Road Construction, Indiana State Highway Commission, Sec. 4.
18. General Laws of Rhode Island, Ch. 24-8, Sec. 32, Supp. 1964.
30. Ill. Rev. Stat., Ch. 121, Sec. 4-214 applies to the department, Sec. 5-101.8 to the county, and Sec. 6-328 to the township (1963).
31. Ill. Rev. Stat., Ch. 121, Sec. 4-501 (1963). Secs. 5-801 and 6-802 are substantially the same.
34. Ill. Rev. Stat., Ch. 121, Sec. 9-113 (1963).
38. Ill. Rev. Stat., Ch. 121 (1963), Sec. 4-502 grants authority to the department, Sec. 5-802 to the county, and Sec. 6-802 to the township. The wording of the three is identical except that "proper authority" appears where highway authority is used in the quotation. Secs. 5-802 and 6-802 also include a clause providing for the acquisition of materials by eminent domain.
40. C. W. Jones, Design of Culverts from the Point of View of a Highway Engineer, Chairman ASCE Task Force on Hydraulics of Culverts, Unpublished ASCE Paper (no date).
45. Manual of Highway Construction Practices and Methods, American


47. Minute Order Number 37679, Texas Highway Department, Austin, Texas, dated February 18, 1955.

48. Minute Order Number 38292, Texas Highway Department, Austin, Texas, dated July 6, 1955.


51. Ohio Turnpike Supplemental Design Criteria for Agricultural Drainage, J. E. Greiner Company, 1952


60. J. L. Sanborn, Principles of Highway Drainage and Erosion Control, County Highway Series No. 4, Purdue University Engineering Experiment Station in Cooperation with the County Commissioners of Indiana, Lafayette, Indiana, 1962.


In January, 1958, the Commission initiated a procedure for alerting the Soil Conservation Service of proposed highway improvements in order to coordinate their activities in the public interest. The Design Department sends "Notice of Survey" to the State Conservationist at Salina.

A steady increase in requests for impoundment of waters against highway fills now indicates need for recognized standard procedures to handle such matters. Requests for impoundment have frequently reached the Commission directly from private owners and at a time so late in the project schedule that favorable consideration, including investigation of feasibility, is awkward or even impossible.

In order to realize greatest benefits consistent with conservation practices and in order to protect the stability and safety features of the highways, it is necessary that procedures be instituted which clearly define the responsibilities resting with the parties concerned and which furnish a criterion for determining the feasibility of impounding waters at any specific location adjacent to highway fills.

Since each county in Kansas is covered by a Conservation District for the regulation of good conservation practices, it is proper that a private owner's request be channeled to the Commission through his local Conservation District. The Commission, the State Soil Conservation Committee and the Soil Conservation Service have now reached agreement on procedure and documentation for cooperation of the Commission in soil conservation practices related to use of highway fills for impoundment of waters. Covering documents will consist of a formal "Agreement" between the Commission and the Local District, accompanied by a "Certificate and Assignment." These will be executed in headquarters offices with copies distributed to Divisions and Departments, as now provided for other construction agreements.

An information memorandum to all Conservation Districts has gone out from the State Soil Conservation Committee outlining approved procedure related to cooperative projects. The Commission cooperated in drafting this procedure and expects its own personnel to be guided thereby.

Please note that personnel contact, conference and review of problems begins in the Division and then proceeds to Design and other Departments as the project progresses. The covering documents will usually not be executed until the later design states when details have been clarified fully.

Also note that the S.C.S. State Office (at Salina) shall be notified when construction begins on the project. This shall be handled by the Commission's Resident Engineer, but only for projects including cooperative construction.

For your general information relative to this new procedure, we attach:

1. Memorandum to Chairman, Kansas Soil Conservation Districts.
2. Directory of Soil Conservation Service.*
3. Directory of Soil Conservation Districts.*
4. Relations Memorandum KA-6 by S.C.S.*
5. Agreement between Commission and Soil Conservation Districts (standard form).

In order to realize the greatest benefits for all parties concerned, we repeat that private owners requesting impoundment adjacent to new grading projects be referred to their local Soil Conservation District for proper and most expedient handling of the matter.

In summary then, the step by step procedure will be:
1. Design Department sends Notice of Survey to state office of Soil Conservation Service at Salina.
2. State S.C.S. office transmits Notice of Survey information to S.C.S. area and work unit offices.
3. Local S.C.S. units will review local situation.
4. S.C.S. District contacts Highway Commission' Division Engineer.
5. District collects data and sends to Design Department.
6. Design Department follows through with District.
7. Design Department and District obtain signed agreement.
8. District furnishes "Certificate and Assignment" to Design Department for attachment to agreement.

The subject procedure for handling cooperative projects between the Commission and the Soil Conservation Districts shall become effective immediately.

Walter Johnson
State Highway Engineer

* Attached for Divisions only.

MEMORANDUM OF UNDERSTANDING
Between
THE OHIO DEPARTMENT OF HIGHWAYS
and
THE OHIO DEPARTMENT OF NATURAL RESOURCES
and
THE OHIO SOIL CONSERVATION COMMITTEE

Drainage and Water Management Along New and Relocated Highways as provided for in Section 1511.01 of the Revised Code of the State of Ohio.

This memorandum is to provide for the cooperative endeavors of the Ohio Department of Highways, the Ohio Department of Natural Resources and the Ohio Soil Conservation Committee in the consideration of needed drainage and water management facilities along new and relocated highways. It is intended that these facilities will effectively serve present or anticipated agricultural drainage needs.
It is Mutually Agreed That:

1. At the time the "Engineering Report", or its equivalent, for a proposed highway improvement is submitted to the Highway Director he will furnish the Department of Natural Resources with a copy of the map showing the tentative location.

2. The Director of Highways will advise the Director of Natural Resources as soon as the line and grade for a highway project on new location has been approved.

3. The Director of Natural Resources will review the proposed highway work and advise the Highway Director of his findings within 30 days.

4. If the Director of Natural Resources finds that special highway drainage considerations will best serve the public good, he shall advise the Highway Department of the general nature of the recommended special drainage.

5. The Highway Department will be responsible for reasonable effort in the location of all existing underground agricultural drainage within the limits of the proposed highway location.

6. The Department of Natural Resources will furnish substantiating data to justify its drainage recommendations when requested by the Highway Department.

7. Where Blind Conduits, for needed future agricultural drainage, are recommended to be installed under the highway, the Director of Natural Resources will transmit with the recommendation supporting data as to the required size, elevation of the upstream invert, and minimum grade of the conduit.

8. When special highway drainage is recommended by the Department of Natural Resources and a decision to follow the recommendations has not been made at the time of the drainage review, the Department of Natural Resources representative will accompany highway representatives on the plan-in-hand drainage review.

9. Any engineering or administrative expense incurred by any party to this Memorandum of Understanding in the carrying out of its provisions shall be borne by each separate cooperating agency involved.

10. Priority of work shall be as follows:
   a. Highways located in agricultural areas requiring tile drainage.
      (1) Highways on Interstate System.
      (2) Highways not on Interstate System.

11. Working Relationships - All contacts with the Department of Highways in the carrying out of this Memorandum shall be made through, or with the approval of, the designated Engineer representative. All contacts with the Department of Natural Resources in the Carrying out of this Memorandum shall be made through, or with the approval of, the Conservation Engineer of the Division of Lands and Soil.

12. The Ohio Soil Conservation Committee will review all requests from Boards of Supervisors of Soil Conservation Districts concerning problems involving highway and agricultural drainage.

This Memorandum of Understanding becomes effective at the time of signature and will continue for a period of one year. It will be subject to renewal at the end of this period and subject to revisions that may be mutually agreed upon.

Date ________________________  Director, Ohio Department of Highways

Date ________________________  Director, Ohio Department of Natural Resources

Date ________________________  Chairman, Ohio Soil Conservation Committee
Highway Department and Soil Conservation Service Coordination

As a result of a recent joint meeting in Augusta of engineers of the State Highway Department and members of the Soil Conservation Service serving the State of Maine, it has been decided that in the interest of mutual coordination of projects that concern highway design, construction and maintenance, and farm soil and water conservation plans and practices, future policy of the Highway Commission shall include the following:

1. a. Heads of Departments shall advise the Soil Conservation Service Engineers of their yearly program of construction projects well in advance of the construction season. This is similar to our present policy for advising utilities of coming construction work and should be sent to the State Conservationist, Orono, Maine.

   b. Highway plans for current proposed construction shall be made available to the Soil Conservation Service Engineer when requested. The Soil Conservation Service has agreed that the Department will be advised in writing of either concurrence in the design or suggestions for changes in the design as it may affect farm soil or water conservation practices. This could apply to culvert design, outlet or inlet ditch design, or roadway or berm ditch design. Detail of such ditch design should be included in the plans and should conform to recommended Soil Conservation Service design practices.

   c. Highway plans for completed projects shall be made available to the Soil Conservation Service upon request to the Highway Commission.

2. District Supervisors shall, as early as possible, notify in writing the Area Engineer of Soil Conservation Service at either the Presque Isle or Augusta office of proposed State Aid or other minor construction projects, giving location and extent of the work and estimated date of commencement of operations. A copy of this written notification to be sent to State Conservationist, Orono, Maine. These written notifications to be similar to those now being sent to utilities.

3. It has been agreed that Soil Conservation Service plans for farm soil and water conservation projects will be presented to the Division Engineer of the area in which the project is located, in accordance with instructions contained in the Soil Conservation Service State Memorandum 50, dated February 14, 1958. The Division Engineer shall, in turn, forward such plans as relate to contract projects to the respective Division Head together with the recommendations of the Division Engineer. On State Aid or other minor projects, the Division Engineer shall discuss it with the respective district Supervisor. In each case, the plans shall be reviewed and concurred in, if acceptable, or suggestions given for correction of unacceptable parts of the plans by either the Division Head or Division Engineer, in writing.

4. Lists of the State Highway Department Division Engineers, Supervisors and towns covered have been supplied to the Soil Conservation Service headquarters and will be distributed to their various work units.

5. A list of the Soil Conservation Service organization and areas covered in Maine is attached.

6. It is suggested that a meeting of Highway Supervisors and the Division Engineer in each division be held with the Soil Conservation Service representatives covering the respective division area to discuss and initiate coordination of mutual problems, such meeting to be the responsibility of the Division Engineer.

Attach.: S.C.S. State Memo 50
Lists of S.C.S. Organization
The purpose of this memorandum is to set forth the policies and general procedures to be followed in assisting farmers plan and establish soil and water conservation practices where public highways are involved.

1. It will be the policy of S.C.S. in Maine that engineering practices planned for water removal from farm land will be planned so that natural drainage-ways are utilized to the fullest extent possible. It is recognized that highways must be crossed by water courses but the use of highway ditches for carrying diverted run-off from sloping fields is to be avoided whenever possible.

2. It will be the policy of the S.C.S. in Maine to present a copy of plans and design data to the local Division Engineer of the State Highway Commission for review and approval prior to the establishment of practices whenever:
   a. The plan will effect an appreciable increase in peak flow of run-off reaching a highway ditch, bridge, or culvert.
   b. The plan calls for run-off concentration at a new location along a highway.
   c. The plan calls for planned conservation measures to take place within a highway right of way. (Highway officials have indicated that they will not approve the use of highway fills and dams but will usually not object to pond flowage covering part of a right of way. They also indicate that they will cooperate in the establishment of ramps for fire equipment.)
   d. The plan requires the lowering of a culvert or the installation of a supplemental pipe for drainage.

3. The S.C.S. Work Unit representative will keep in touch with the S.H.C. Division Engineer concerning new highway construction. Plans for new highway construction should be studied whenever it is felt that the construction may have an adverse effect on surface or subsurface drainage from cooperator's lands. Highway officials have stated that they can usually make changes when a highway is in the planning or construction stage but that changes are difficult after the highway is completed and turned over for maintenance.

The State Office is to be kept informed by the S.H.C. of the programming of highway construction within the primary and secondary systems. Work Units will be provided this information currently. Notifications concerning State Aid Highways will be sent by the State Aid Division directly to the local S.C.S. representative, probably the S.C.S. Area Engineer.

4. The S.C.S. State Office will keep the Work Unit Conservationist informed of the name and location of S.H.C. Division Engineer representing their locality. The State Office will also keep the State Highway Commission informed of the location of S.C.S. offices and the persons in charge. Contacts between the two agencies will be between the Division Engineer or his District Supervisor and the local Work Unit Conservationist. The Area Conservationist or the Area Engineer may be consulted when necessary.

5. S.C.S. personnel should recognize the fact that owners of land have certain legal responsibilities concerning the disposal of water on land of owners at a lower elevation. The lower property may be farm land, highways, urban property, etc. These responsibilities should be brought to cooperator's attention at the time of planning and occasionally in the farm plan write up. S.C.S. can also assist the S.H.C. by trying to discourage the practice of using highway ditches, shoulders, and pavements as turning ground or head-lands.

6. This memo deals mainly with the three categories of roads in the State System: Primary, Secondary and State Aid. Many of the principles and policies contained herein should govern our dealings with town officials in charge of roads not in the State system. Each Work Unit Conservationist will need to
work out with the various town officials the policy and procedure for handling water disposal problems.

7. To better acquaint the Highway Commission representatives with erosion control methods and problems, occasional tours of District Cooperator's farms should be arranged. Joint tours immediately following severe storms for the purpose of appraisal and evaluation are recommended.

MEMORANDUM OF UNDERSTANDING
Between
THE PENNSYLVANIA DEPARTMENT OF HIGHWAYS
and
THE PENNSYLVANIA DEPARTMENT OF AGRICULTURE
STATE SOIL CONSERVATION COMMISSION

Purpose: Soil and water management facilities that are planned and constructed in agricultural areas are frequently affected by new and relocated highway construction. In some cases tile and surface drainage systems are blocked or severed. Existing or planned conservation and drainage works such as diversion terraces and waterways may be without an outlet unless one is provided during construction. The placement of fill material and location of culverts may change natural surface drainage causing accelerated soil erosion.

The purpose of this memorandum is to establish a cooperative procedure to:

1. Provide liaison between the Department of Highways and affected rural landowners in areas of new and relocated highway construction.

2. Provide a mechanism whereby the Department of Highways can be furnished recommendations and supporting information to serve present and anticipated soil and water management considerations in such areas.

3. Encourage agricultural practices by landowners conducive to economical highway maintenance.

4. Assist the Department of Highways' planning in the location of soil and water management facilities within the limits of its jurisdiction so as to coordinate these facilities with the soil and water management needs of affected landowners.

It is, therefore, mutually agreed that:

1. Following the public hearing and until such time as official prints of a completed plan can be made available to the Secretary of Agriculture by the Secretary of Highways, proposed center line location, grades and other pertinent information will be made available for review to the Secretary of Agriculture or his designated representative at the appropriate highway district office or through the appropriate highway district office if the plan is being developed by other than Highway Department personnel.

2. The Secretary of Agriculture will review the proposed highway work at the District Office and advise the Secretary of Highways and appropriate District Engineer of his findings within 60 days of the public hearing. The aid of county soil conservation districts and appropriate cooperating agencies will be utilized by the Secretary of Agriculture in this review.

3. The report of this review will include recommendations for any special highway considerations deemed necessary in the interest of present and anticipated soil and water management facilities. Substantiating data to justify these recommendations will be furnished to the Department of Highways' District Engineer.

4. The engineering representative of the Secretary of Agriculture will discuss the recommendations and their implementation with the appropriate Department of Highways' District Engineer and will make any further field studies deemed desirable.
5. It is understood that the final decision regarding acceptance or rejection of the recommendations remains with the Secretary of Highways.

6. Any expenses incurred by either party in the carrying out of the provisions of this memorandum shall be borne by the respective agency concerned.

7. Priority of cooperation between the Department of Highways and the Department of Agriculture shall be as follows and shall be specifically confined to agricultural areas:
   b. Federal-aid Primary projects.

8. The Secretary of Agriculture will designate a qualified engineer as his representative in carrying out this memorandum. The Department of Highways will administer its phases of this program as follows:
   a. The Secretary of Highways will designate an engineering and design representative at the Harrisburg level to coordinate this program for the Department of Highways and to be available for consultation on state level matters.
   b. The District Engineer, or his duly authorized representative, will represent the Department of Highways in the negotiations provided for in Paragraphs 2, 3, and 4 above.

9. In order to insure uniform standards and criteria of measure and design, it is understood that the engineering standards and criteria of measure and design of the Department of Highways will be controlling. However, the Department of Agriculture, through its engineering representative, may recommend changes in the engineering standards and criteria of measure and design to the Department of Highways. Final determination of engineering standards and criteria of measure and design will be in the discretion of the Secretary of Highways.

10. The Secretary of Agriculture, after approval of the Secretary of Highways, will arrange for preparation and distribution of educational and training material to acquaint agricultural leaders and conservation personnel of the nature of this program and its limits.

This Memorandum of Understanding becomes effective on the latest date of signature below and is not to be interpreted or construed as an agreement.

Date Secretary of Highways

Date Secretary of Agriculture

Chairman, State Soil Conservation Commission

MEMORANDUM OF UNDERSTANDING
Between
THE COUNTY SOIL CONSERVATION DISTRICT
THE PENNSYLVANIA STATE SOIL CONSERVATION COMMISSION
and
THE PENNSYLVANIA DEPARTMENT OF HIGHWAYS

Statement of Purpose

The ____________________ County Soil Conservation District, hereinafter referred to as the district, has been organized pursuant to the Pennsylvania Soil Conservation Law (General Assembly Act No. 217, approved May 15, 1945) to exercise public powers in connection with work "for the conservation of the soil and soil resources of this Commonwealth, and for the control and prevention of soil erosion, and thereby to preserve natural resources; assist in the control of floods; pre-
vent impairment of dams and reservoirs; assist in maintaining the navigability of rivers and harbors; preserve wildlife; preserve the tax base; protect public lands; and protect and promote the health, safety and general welfare of the people of the Commonwealth," within the district. The creation of the District is evidenced by resolution of the Board of County Commissioners, a copy of which is on file with the State Soil Conservation Commission.

The Pennsylvania State Soil Conservation Commission, hereinafter referred to as the Commission, is authorized by the Pennsylvania Soil Conservation Law to cooperate with and assist soil conservation districts in achieving conservation objectives and to secure for the districts the cooperation and assistance of governmental agencies. The Pennsylvania Department of Highways, hereinafter referred to as the Department, is authorized under the same law to cooperate with and assist soil conservation districts in achieving soil and water conservation. Such cooperation will be extended in accordance with the laws under which the department is authorized to act.

Since its organization the District has adopted a program approved by the Commission, outlining in general its long-time objectives and a work plan as a guide to show how it will carry on its activities, both of which it will keep current. Inasmuch as the work of the District will be furthered by the assistance which the Commission and the Department may be in a position to make available to it, the District, the Commission and the Department enter into this Memorandum of Understanding, in order to establish an enduring basis for such cooperation and assistance.

A. What the District Will Do

1. Promote all reasonable measures for achieving conservation of soil and soil resources and control and prevention of soil erosion within the District.

2. Make available to land occupiers – land owners and operators – individually or in groups, within the District, for carrying on conservation operations, such services, materials and equipment as are available for such use.

3. Determine priorities for (a) work areas, (b) formulation of conservation plans for individual farms and other units within such areas and (c) follow-up work essential to the carrying out of such plans.

4. Be responsible for determining the kind and amount of erosion control and soil conservation work to be performed by it on individual farms and other units of land and for assisting in the fulfillment of the provisions of agreements it enters into with land owners and operators.

5. Use agreements or other arrangements between it and land owners and operators the form of which is mutually acceptable to the District, the Commission and the Department, in extending assistance made available by the Department for carrying on soil and water conservation work.

6. Develop conservation plans and programs to aid the Department in more economical construction and maintenance of highways in the District.

7. Consult with the Department on drainage systems and waterways where water from such operations might effect highway maintenance or future construction.

8. In laying out conservation plans put forth every effort to safeguard highway maintenance in keeping soils from washing into gutters and onto the highways.

9. Keep current records of all materials made available to it by the Department, showing the kinds and amounts used on lands covered by each cooperative or working agreement or other arrangement and on lands owned or leased by the District and obtain receipts for all such materials delivered to cooperators. Such records and receipts will be available for examination at any reasonable time by accredited representatives of the Department and the District will submit to the Department within thirty
days after December 31 of each year, reports of the distribution of such materials for the year ending December 31.

10. Within thirty days after December 31 of each year the District will submit to the Commission, with a copy to the Department, a report on the District’s activities and accomplishments for the year ending December 31.

11. Provide for the execution of surety bonds that may be required with respect to funds or property entrusted to District directors or employees.

12. Keep a full and accurate record of all its proceedings and formal actions.

B. What the Commission Will Do

1. Assist both the District and the Department in carrying forward the principles of this Memorandum.

2. Encourage the District to discover and put into action local resources including those of owners and operators of lands towards solving their soil conservation and erosion control problems.

3. Cooperate with the District in developing suggestions concerning the nature of District Directors' duties and effective methods for administering District work.

4. Assist the District in every practicable manner through resources available to the Commission and in accordance with a Memorandum of Understanding or other appropriate arrangements between it and the District, and endeavor to obtain for the District assistance from local, state and federal agencies.

5. Provide the District with summaries and analyses of annual reports of districts throughout the State concerning their activities and accomplishments.

6. Foster cooperation between districts in the interest of the maximum quantity of effective work throughout the State.

C. What the Department Will Do

1. When the Commission notifies the Department that the District has prepared and adopted a program outlining its objectives and Work Plan, the Department will have a representative meet with the District Directors at a convenient time to discuss the program as to means of cooperation between the District and the Department. If the District and the Commission so desire, the Department will provide assistance in the development of such a program and Work Plan.

2. Keep in mind the objectives of the District program when planning new highways, re-locating or improving present highways and in maintenance operations.

3. Give special consideration in planning highway drainage to safeguard erosion problems wherever possible in line with practical and economical highway construction and maintenance.

4. Advise with the District on District drainage and waterway construction or changes so as to be mutually beneficial to the District and the Department.

5. Make available to the District, such departmental machinery as is available in line with the department policies governing such operations.

6. Cooperate and assist the District in its overall conservation program so far as it is within the province of the Department as specified in the laws governing the Department and its operations.

It is further understood that:

1. This Memorandum shall not be construed to affect the jurisdiction of the State Government, or any agencies thereof, over State-owned lands, which may lie within the boundaries of the District.
2. Neither the Department, the Commission, nor the District is bound by any obligation in this Memorandum which will involve the expenditure of funds in excess of the amounts made available to it, or for a period in excess of that authorized by law.

3. All matters that may require administrative action or approval by the Department, the Commission, or the District will be handled through the established administrative procedures of the Department, the Commission, or the District as the case may be.

4. This Memorandum shall be effective when signed by the three parties. It may be terminated or modified at any time by agreement of the parties, and may be terminated by any party by giving sixty (60) days' notice in writing to the others.

THE COUNTY SOIL CONSERVATION DISTRICT

By Chairman, District Governing Body

Date

The signing of this Memorandum of Understanding was authorized by a resolution of the District Governing Body adopted at a meeting held on , 19__.

By Secretary, District Governing Body

Date

THE PENNSYLVANIA STATE CONSERVATION COMMISSION

By Chairman

Date

THE PENNSYLVANIA DEPARTMENT OF HIGHWAYS

By Secretary

Date
Population expansion, technological progress, and the enormous growth of our total economy have resulted in great pressure for transportation improvements and modernization. Expanded improvement of interstate, state, county, and township roads has resulted.

During the process of highway improvement, drainage, erosion control, and soil and water conservation problems are occasionally encountered or created. Careful study and advance planning to satisfactorily solve these situations are necessary if litigation and adverse public opinion are to be avoided. Advance analysis and planning can assure adequate construction, lower maintenance costs, elimination of safety hazards, and improved public relations.

Drainage patterns have become defined over a long period of time. Some water and soil management patterns have been altered and conservation and drainage implemented by artificial structures and ditches. The continuity of these management programs should be encouraged since land has no value to society unless it can be used for the unlimited future. Sound management of surface and flood water is crucial.

Close cooperation between highway officials, landowners, representatives of drainage and soil conservation districts, and other agencies involved in joint problems of land management and highway development will offer the best assurance that mutually agreeable solutions can be found for these problems. In planning highway improvements, highway officials can be expected, within the limits of the knowledge available to them, to provide for a continuation of existing land management patterns, or to provide a substitute system agreeable to the effected landowner and to the highway authorities, and to make provision for soil and water conservation and land management programs of land owners and land management agencies which have been planned and surveyed in advance of the completion of right-of-way acquisition.

All individuals, groups, organizations, and agencies interested in land conservation, drainage and highway development will be best served by procedures which make use of all available assistance in providing the most satisfactory highway improvement. To this end the following guide is suggested:

1. Highway and road officials, including county superintendents of highways, should confer, during the planning period for construction, with the appropriate representatives of the particular drainage districts, conservation districts, highway committees of county boards, farm organizations, and landowners involved. Problems encountered during construction or during maintenance after the project is completed shall be considered individually with the appropriate agency or landowner involved.

2. Where drainage, or erosion hazards or soil and water conservation and management problems exist, the highway planning will be developed to be as compatible with the solution or program for alleviating such problems as possible.

3. Drainage installations under highways should be of a dimension and elevation to accommodate run-off water from the watershed above. Consideration should be given to the design of drainage installations to eliminate as far as humanly possible the impairment of future land uses.

4. Road ditches should be constructed and maintained to minimize erosion and to hold adjoining land in place but at a grade which will not promote silting of the road ditch channel.

5. Owners and operators of lands adjacent to highways should be encouraged to manage their lands to minimize soil and water losses to protect road and highway ditches adjoining their lands.
6. The Illinois Agricultural Extension Service cooperating with local soil conservation districts and other organizations, groups, or agencies interested in soil and water conservation should carry out an extensive educational program to inform all landowners and operators and assist them in finding solutions to their problems as they may be affected by highway improvement and maintenance.

7. The acquisition or purchase of land for right-of-way should include provision for reconstructing affected portions of existing drainage or conservation systems to the approximate standard which existed prior to improvement of the highway, and provide opportunity for future drainage and flood control improvements on adjacent properties if such improvements are surveyed and planned in advance of the completion of right-of-way acquisition. The property owners and/or drainage authority shall finance and construct drainage and flood control systems required for improvement or protection of adjacent properties, including that portion of such systems as may occupy the highway right-of-way. It is recognized that highway construction may result in incidental improvement of drainage of adjacent properties, but it shall not be the obligation of the highway authority to improve drainage, or to protect adjacent properties from existing floods.

8. Payment of damages in lieu of reconstructing existing drainage systems or in lieu of providing the opportunity for future drainage improvements is not in the public interest and shall be avoided.

9. Highway officials, with the cooperation of the landowner, shall determine within practical limits the location of all sub-surface field drainage, where such drainage exists within the right-of-way and shall make provisions on the construction plans for the continuation of the functioning of any known field drainage system which might be affected by the construction of highways and roads. It is realized that it may be difficult in some cases to locate the field drainage systems. This may be facilitated by contacting the representatives of the local drainage districts, the county or state conservation agencies, or the Soil Conservation Service of the U.S. Department of Agriculture.

10. If a drainage tile is crossed by a highway or road, it should be replaced by the highway officials with pipe of the strength required to support the roadway. If a system consisting of several parallel drains is crossed, a study shall be made of the feasibility of installing a collector pipe parallel to and outside of the right-of-way, and taking the entire system across the right-of-way in a single pipe and emptied into the original system outlet.

11. If, during the highway improvement, isolated or random tiles are cut off by the side ditches of the highways or roads they may be outletted in the side ditch where adequate outlets are available.

12. Where drains are outletted into a ditch, the invert of the drain outlet preferably should be between 9 and 18 inches above the established grade line of the ditch. If three or more tile lines join at one point, a junction box should be used. If a junction box is installed in a cultivated field, the top of the box preferably should be a minimum of 18 inches below the surface of the ground.

13. When a drain tile crosses a highway or road, inspection wells should be installed 6 inches inside the right-of-way on both sides. If adjustment of a substantial length of tile drain is required parallel to the road, inspection wells should be installed as required for proper maintenance of the tile drain by the owner. Such inspection wells may be placed at locations selected by the property owner.

14. Highway officials shall prepare plans showing the alterations which have been made to agricultural drainage systems. The plans shall show: the size, location, and elevations of collector mains, sub-mains, and lateral tile 6 inches in inside diameter or larger; the location of small lateral drain tile; the location and elevation of all appurtenances; the location and elevation and grades of drainage ditches constructed or reconstructed by them. Tile
adjustments within rights-of-way should be made with tile of adequate strength and at least equal capacity. Copies of the "as built" plans should be filed with the office of the District Highway Engineer or other highway officials responsible for the road construction.

15. Organized drainage districts shall file with the County Clerk the information referred to under Item 14 on this page.

16. Diversion of reasonable quantities of water resulting from terracing for erosion control, diversion ditching for gully control, drainage, or by top-of-slope ditches adjacent to highway cuts and highway side ditches is sometimes necessary. Where this work is to be done, arrangements for accommodation of the diverted water shall be worked out with highway officials by mutual agreement for each location individually.

17. It is preferable that borrow pits be excavated in such a way that they do not become public nuisances. They should blend into the topography and be returned to cultivation, revegetated, or excavated as provided in any agreement with the property owners from whom the borrow is purchased. At present in most instances contractors provide the source of borrow-meeting-borrow specifications. Therefore, the highway officials' control is limited to making suggestions and recommendations to the contractors having ownership rights.

AISCD
Conservation and Drainage Sub-Committee
Public Relations Department

George R. Irwin, Chairman

February 14, 1961
Introduction

A comprehensive check is made by the District Office before final plans are submitted to the Tallahassee office. This check assures that Department policies have been complied with, that sound engineering practices have been used and that plans and calculations are mechanically correct. Engineering practices include such items as feasibility of construction, economy of design, quality of design, and avoidance of costly maintenance problems.

The checker should realize that not all field conditions can be shown on the plans; therefore, decisions to change design must be backed by a field review. Design which does not appear to be correct when based on plans information should be questioned, realizing that field conditions may have dictated the decision.

The sections in this chapter supply lists of those points which should be covered in the plans check. The lists are compiled in as logical an order as possible, realizing that some variations may be necessary to adapt them to the individual checker.

Section 13.10—Highway Section Check List

A. General
   1. Check plans file for information which may have bearing on the design.
   2. Check the Tabulation of Drainage Recommendations.
   3. Check the Bridge Design Data Sheet.

B. Drainage Map
   1. Area closed to each structure.
   2. Transfer of work sheet information to drainage map.
   3. Area checked against Tabulation of Drainage Recommendations.
   4. Inserts shown for those areas which extend outside the limits of the drainage map.
   5. Drainage divides shown at proper locations (at peaks in natural ground, proposed ditches, etc.).
   6. High waters at critical locations shown.
   7. Existing structures shown, indicating size or effective area of opening to high water and flow line elevations where possible.
   8. Direction of flow indicated for ditches, streams and structures.
   9. Proposed structures shown in plan and profile, sizes and flow lines checked against Tabulation of Drainage Recommendations.
   10. If run-off has been diverted from one area to another, has proper notation been shown?
   11. Do selections of outfalls appear logical?

C. Typical Section Sheet
   1. Is standard ditch elevation below the undercut section to allow proper drainage of subgrade?
   2. Is there a need for special detail of underdrain?
   3. Does standard ditch provide desired protection from a highwater table?
   4. Note minimum cover for pipes and culverts.
   5. Note any special drainage details and their use.
D. Plan and Profile Sheets
1. Check plan and profile sheets against Tabulation of Drainage Recommendations.
2. Check adequacy of ditches to handle run-off.
3. Has protection against scour in ditches been used where necessary?
4. Check need for berm ditches through deep cuts.
5. Are grades shown on all special ditches?
6. Have ditch blocks been provided where necessary to prevent high water breakover (side ditches and median ditches)?
7. Are high water elevations shown with date of occurrence?
8. Does grade have proper clearance above high water?
9. Does design provide for high water to be lowered where so noted?
10. If high water is to be lowered, is design high water shown?
11. Have side drains of larger than normal size been noted?
12. Compare large pipes with boxes for most economical design.
13. On interstate routes, have box culverts been used when fill height exceeds 12 feet and on Primary and Secondary, has pipe strength been checked when fill height exceeds 20 feet?
14. Will ditch bottom inlet slots have capacity to pick up expected run-off?
15. Is there proper spacing of median inlets?
16. Check intersections for blocked water.
17. Check end walls on seven foot height box culverts to see that they fit the ditch section (infall and outfall).

E. Drainage Structure Sheets
1. Are structures properly shown with size, length, skew angle and flow line elevation?
2. Does structure have proper bedding?
3. If structure invert terminates in a fill slope, has appropriate protection from scour been provided?
4. Do structures have adequate cover?
5. Has underground interference been eliminated?
6. Have additional details been shown where necessary?
7. Is direction of flow indicated?
8. Have proper infall and outfall conditions been provided?

F. Outfall Sheets
1. Do flow line elevations agree with plan sheets?
2. Have positive disposal for and logical termination of outfalls been provided?
3. Has ditch protection been provided to prevent scour where necessary?
4. Have adequate rights-of-way been provided for ditch access and necessary spoil?
5. Is outfall capacity adequate through limits of construction?
6. Have sharp bends in alignment been avoided?
7. Is existing structure shown with water elevations up stream and down stream?
G. Soil Survey Sheets
1. Check elevation of water table to see that adequate protection is provided.
2. Through heavy cut sections, will water table bleed out of back slopes and, if so, has protection been provided?
3. Will lowering of water table damage adjacent property owners, making Department liable?

H. Cross Section Sheets
1. Will spilling of a side ditch cause damage?
2. Are berm ditches shown where necessary?
3. Have existing ditches been replaced where necessary?

Section 13.20—Municipal Section Check List

A. General
1. Check Storm Sewer Tabulation for accuracy of calculations.
2. Check plans file for information which may have a bearing on the design.
3. Check Bridge Design Data Sheet, if applicable.

B. Drainage Map
1. Areas closed to each structure.
2. Areas checked against Storm Sewer Tabulation Sheet.
3. Inserts shown for those areas beyond the limits of the drainage map.
4. High waters at critical locations shown.
5. Existing structures shown, indicating size or effective area of opening below high water and flow line elevations where possible.
6. Pertinent existing storm sewer systems shown, showing inlet elevation, pipe size, flow line elevation and area drained.
7. Direction of flow indicated.
8. Proposed structures shown in plan and profile and sizes and flow lines checked against Storm Sewer Tabulation Sheet.
9. Do selections of outfalls appear logical?

C. Typical Section Sheet
1. Check undercut section for location of underdrain.
2. Is there a need for special details of underdrain not covered by standard index?
3. Note minimum cover for pipes and culverts.
4. Note any special drainage details and their use.

D. Plan and Profile Sheets
1. Do systems have a logical layout?
2. Are there an excessive number of inlets at intersections?
3. Is there excessive depth of cut for construction of pipe?
4. Will construction of pipe endanger private property?
5. Are inlets properly spaced?
6. Are inlets provided in lows?
7. Does hydraulic gradient project above inlet elevations? (One foot below is normal standard.)
8. Check angle conflict of pipes entering structures at same elevation.
9. Can side street water get into gutters without ponding?
10. Check pipes for sharp turns.
11. Check necessity for special treatment due to super-elevation.
12. Check for proper sized inlets to accept large pipes.
13. Check for proper type inlets on steep grades.
14. Check for excessive length of pipe.
15. Check for unnecessary right-of-way requirements due to drainage.
16. Are high waters shown with date of occurrence?
17. Does grade have proper clearance above high water?
18. Does design provide for high water to be lowered where so noted?
19. If high water is to be lowered, is design high water shown?

E. Drainage Structure Sheets
1. Are structures properly shown with size, length and flow line elevation?
2. Does structure have proper bedding?
3. Do structures have adequate cover?
4. Has underground interference been eliminated?
5. Have additional details been shown where necessary?
6. Is direction of flow indicated?
7. Are all stubs at minimum cover where possible?
8. Check grate top inlets to be sure they fit.
9. Check to see that inlet box is large enough to accept pipe.

F. Outfall Sheets
1. Do flow line elevations agree with plan sheets?
2. Have positive disposal for and logical termination of outfalls been provided?
3. Has ditch protection been provided to prevent scour where necessary?
4. Has adequate right-of-way been provided for ditch access and necessary spoil?
5. Is outfall capacity adequate through limits of construction?
6. Have sharp bends in alignment been avoided?
7. Has high water information been shown?

G. Soil Survey Sheets
1. Check elevation of water to see that adequate protection has been provided.
2. Will lowering of water table damage adjacent property owners, making the Department liable?

H. Cross Sections Sheets
1. Check for water being trapped behind sidewalk or curb and gutter.
APPLICATION FORM FOR DRAINAGE CROSSING IN MINNESOTA

Form No. 2188 (Rev. 9-30-60)

To Be Prepared In Quadruplicate Copies

STATE OF MINNESOTA

DEPARTMENT OF HIGHWAYS

T.H. _____ C.S. _____

Appl.

Dist. _____ No. _____

APPLICATION FOR DRAINAGE CROSSING

For installation of Agricultural Tile Drains during construction of Trunk Highways

Name of Applicant

Address

If applicant represents a drainage group or organization, provide name of such organization and applicant's title:

Name of Organization

Applicant's Title

Location of proposed drain crossing: T.H. _____ in

County ___________________ miles _______ of

in ___________________ Section _______ Township _______ Range _______

at engineers' station ___________________ on proposed highway alignment.

Design flow: __________ c.f.s. Size of tile Line: __________ inches

Grade of tile line __________ per cent

Flow line elevation at highway centerline __________ ft. m.s.l. (highway datum)

Direction of tile line: __________ (bearing) Angle of skew with highway: __________ (degrees)

Other pertinent information:

State approximate time when the proposed crossing will be connected to drainage system

The undersigned hereby certifies:

1. That a satisfactory drain outlet for agricultural benefit cannot be secured on the upper side of the highway and that projecting said drain to an adequate outlet on the lower side of the highway is feasible;

2. That the information herein submitted is correct to the best of the undersigned's knowledge;

3. That the undersigned for themselves, their heirs, executors, administrators and assigns do hereby agree to save and hold the State, the Commissioner of
Highways and any employee or agent of the State personally, harmless from any and all claims, demands, damages, actions, or causes of action of any kind or nature whatsoever that may or might arise out of the construction and the maintenance of said drain or the act of the State or any of its employees or officers in projecting said drain across said Trunk Highway and to pay all costs and expenses that either the State, its officers or employees may suffer or incur by reason of any claim by any person whomsoever arising out of the installation and maintenance of said drain and to pay in full any judgment arising out of any claim that ever may be made against the State, its officers or employees arising out of said installation.

Date ______________________ Signed ______________________

Witnesses: ______________________

______________________________

(See Reverse Side for Explanation and Requirements)

--------

AUTHORIZATION FOR DRAINAGE CROSSING

In consideration of the information submitted by the applicant and in compliance with the requirements of the Commissioner of Highways to implement the provisions of Minnesota Statutes 1959, Chapter 500, Article I, Section 20, Subdivision 2, the application for the drainage crossing herein described is approved subject to the following conditions:

______________________________

______________________________

Date ______________________ STATE OF MINNESOTA

DEPARTMENT OF HIGHWAYS

BY ______________________

District Engineer

EXPLANATION

1. This application form shall be used to meet the agricultural drainage provisions of Laws of Minnesota, 1959, Chapter 500, Article I, Section 20, Subdivision 2, which provides: "If any person desires during construction or reconstruction of a highway to install a tile drain for agricultural benefits in a natural drainage line in lands adjacent to any public highway, and if a satisfactory outlet cannot be secured on the upper side of the right of way, and the tile line must be projected across the right of way to a suitable outlet, the expense of both material and labor used in installing the tile drain across the roadbed shall be paid from funds available for the roads affected provided the road authority is notified of the necessity of the tile drain in advance of the construction of the roadbed so that the drain may be placed and the roadbed constructed in the same operation."
2. The length of drain conduit installed by the Department of Highways shall be confined to the roadbed and defined as the distance center to center of road-side ditches or the distance between points five feet outside the toe of the embankment slope where roadside ditches are not provided.

3. Approval of this application and subsequent provision of the drainage crossing by the Department of Highways does not grant permission to enter on the highway right of way and connect a drainage system thereto. Permits for such work shall be issued in accordance with standard procedure prescribed by the Commissioner of Highways and subject to all requirements necessary for public safety and protection of the highway.

4. In the event that the requirements of paragraph 5 (a) and (c), under "Requirements," cannot be met by the applicant at the time of application, and if all other conditions are met, the Department may place the drain if the applicant agrees in writing (as part of the application) that the drain will not be used until said requirements specified in said paragraph 5 (a) and (c) are met by the applicant. In such event a plug will be inserted in the drain and will not be removed until said requirements are met.

REQUIREMENTS

1. This application shall be filed with the district engineer of the district in which the proposed drainage crossing is located.

2. The application shall be filed with the district engineer at least 60 days in advance of advertising for bids for the proposed highway construction.

3. The application shall be accompanied by a drainage plan prepared by a competent drainage engineer showing the lines and grades of the proposed drainage system tributary to the crossing and continuing to an adequate outlet below the highway.

4. Where time prior to construction of the highway will not permit development of a drainage plan, in lieu thereof the applicant shall submit a report prepared by a competent drainage engineer certifying as to the feasibility of a drainage system for the adjacent lands and recommending the exact location, size, and flow line of the proposed drainage crossing.

5. The application shall be accompanied by proof (a) that permission, in the form of land ownership agreements, easements, permits, or other acceptable evidence, has been obtained to extend the drainage system to an outlet below the highway, and (b) that such outlet is hydraulically adequate, (c) an instrument, obtained by the applicant, in the form of a release from any and all damages, claims, actions, or causes of action of any kind or nature whatsoever caused by or arising out of the installation of the drain by the Department will be acceptable in lieu of (a) above.
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