STORM WATER MANAGEMENT SEMINAR
PART 1

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IN DEDICATION

To those in the public service striving for a better quality of life in our cities, and who fairly administer the public's business with equity to all segments of the community.

THE AUTHOR

David L. Daugherty is a 1959 BCE graduate of the University of Louisville Speed Scientific School. His 16 years of specialized interest and training in professional hydraulics includes six years of intensive experience with the United States Army Engineers, Civil Works Division and thereafter in private practice as an engineering consultant. Since 1971 the author has served the Jefferson Fiscal Court (Jefferson County, Kentucky) as Water Management Engineer. Concurrently, since 1973, he has acted as Water Management Consultant to the Lexington-Fayette Urban County Council, Lexington, Kentucky. Mr. Daugherty is a member of the American Public Works Association and assists several universities or college faculties in the promulgation of academic programs relating to urban storm water management planning and design.

The policies, theory and practical applications in this publication are predicated on the author's design or regulatory involvement with an estimated 4,000 separate urban area projects of diverse description.

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DEFINITIONS

1. modified - conditions after new construction

2. natural - conditions before new construction

3. off-site - external to the boundary of a new project

4. on-site - internal to the boundary of a new project

5. point discharge - release of storm water at a specific location

6. retention - (sometimes termed detention) restraining the rate of storm run-off with some natural or man-made device

7. revetment - bank protection on natural or man-made channel

8. rill - specific eroded area, usually on a slope or stream bank, but which can develop in moderately flat areas

9. run-off - rainfall excess after natural losses from infiltration, evaporation, transpiration or incidental pondage

10. sheet drainage - overland run-off prior to reaching a drainage system and usually considered as being moderately uniform flow through natural growth, paved area, etc.

11. stage - depth of flow

12. swale - a surface-type conveyance for storm water, usually informally designed to convey incidental, localized run-off

13. through-drainageway - any ditch, stream, channel or creek which definably originates upstream of a tract in question and passes through that tract

14. velocity dissipator - any chute block, impact basin, stilling basin, roller bucket, flip bucket, or other device which effectively diminishes the energy content of discharge so as to abate the downstream damage potential

CHAPTER 1

INTRODUCTION

Anyone familiar with the quality of life in most American cities, large or small, is aware of the impact of storm water characteristics on the total community. To be sure, there are a few cities with reasonably satisfactory storm water facilities, but the vast majority suffer with tragically inadequate systems. Where such inadequacies exist, the population lives under constant threat of private and public flood damages, and during non-flood periods unhealthy environments are generated by poor neighborhood drainage characteristics. Since few who can afford to do so will live in unsatisfactory environments, poorly drained of floodprone neighborhoods tend towards economic decline. If enough neighborhoods of this type exist, the economic decline of the total community is likely to follow.

Most local governments strive to upgrade their problem areas where funds are available. Unfortunately, many of these same well-intentioned governments continue to permit developmental expansion under the same system of controls which created the old problems. It is usually a losing race with new problems occurring faster than older ones can be corrected. This is not always apparent in view of the time lag between problem creation and the time enough people are adversely effected to focus corrective interest by officials. A continuous cycle of publicly financed remedial construction can ultimately bankrupt a city of metropolitan area government.

Experience has proven that adverse storm water effects of new development can be effectively curtailed or eliminated altogether, thus allowing elected officials to focus their resources on correction of the old problems. This same experience has shown that a fresh, vigorous approach to storm water controls on new development can not only be fruitful for the local government and its' constituency, but can be beneficial to a development industry freed from endless litigation and other citizen opposition.

Modern storm water control techniques are not radically new to the American scene. And yet while some communities have practiced water management at various levels of effectiveness, techniques are constantly evolving on the basis of experience and new technology. Unfortunately, very few engineers are proficient in this technology, and even fewer have had the opportunity to practice water management intensively enough to address the over-all mechanics of an effective program. This publication will attempt to do so, hopefully including information beneficial to engineers, planners, public officials, industrialists and, above all, the general public to whom the professionals have an obligation to serve.

The author does not represent the methods in this publication as being infallible for all communities with storm water problems, but they seem to have worked reasonably well for several years where implemented under the auspices of elected officials who are determined to succeed. The significance of a methodology rooted in sound engineering principles and proven experience should be of interest to those seeking alternatives in abating the urban storm water problem.

CHAPTER 2

THE EVOLUTION OF STORM WATER MANAGEMENT

Storm water facilities design and construction has generally been the least understood and most neglected aspect of city planning. From the perspective of community founders, everyday needs such as roads, water supply systems, housing and other facilities took precedence in their order of priorities. In the early city struggle for survival, the immediate demand for these other municipal needs often excluded even modest consideration for drainage facilities. Unfortunately this attitude prevailed long past the time when other basic survival issues were no longer in question. In many instances even predating the twentieth century, cities had become complacent.

During the post World War II period, population centers formerly recognized as compact communities rapidly evolved into large metropolitan areas. Roads, housing facilities, and commercial areas rapidly radiated from the urban core, employing a drainage system practice reflecting essentially the same level of complacency evident during the communities' formative years. Convenient, yet often inaccurate "rules of thumb" were used in the design and placement of drainage facilities and inadequate thought was given to future maintenance and replacement costs. The old problems remained in existence and were compounded by developmental expansion. Not only were flood damages to individual citizens escalating at an alarming rate, but local governments were confronted with collective neighborhood damages which had to be solved, but without sufficient income from traditional sources.

In the absence of effective governmental controls, citizen groups began resorting to private legal actions against the development industry where it could be proved that new construction would add to area flooding. In a number of states where tested, the courts have found for the citizen actions thereby either curtailing development or forcing local government to exert positive controls. Some local governments have gone even further and enacted ordinances which have the ultimate effect of stopping developmental expansion. Extreme measures of this sort, however, can adversely effect a community in other ways, particularly where a minimum of expansion is necessary to meet ever-growing community needs in housing, the job market, schools and similar facilities. Clearly a new, even-handed approach to developmental control has become necessary for harmonious growth.

Various communities throughout the United States have evolved their own contemporary approaches to drainage-related controls on new development, and up to the present, most have developed their programs independent of other cities using parallel methods.

While the extent to which each program is successful varies considerably, the fact remains that each passing year heralds a large increase in the number of local governments adopting some type of new drainage control systems.

Not infrequently, local governments have been supported in these efforts by industry leaders who perceive the need for responsible controls, either for genuine civic-minded reasons or for the motivation that, otherwise, controls would be superimposed indirectly in the form of court judgements. Then to, it has become increasingly obvious that the Federal Government tends to step into regulatory vacuums where local governments are not responding to environmental problems. By and large the development industry prefers local to Federal regulatory procedures.

Notwithstanding the evident problem needs and available corrective technology, many cities have yet to enact some form of storm water management controls. For whatever reasons particular governments desire not to implement an effective program, the lack of information should not be one of them.

CHAPTER 3

WATER MANAGEMENT PRINCIPLES

Principle is defined formally as a "general truth or law, basic to other truths." Another definition states "moral standards collectively."

Water Management Principles are founded on the assumption that collective moral standards dictate the unacceptability of one entity developing land in such fashion as to induce water-related damages to a passive land owner in the vicinity. It is an equally basic truth that an active owner should be allowed to labor in the development marketplace without undue hindrance by either government or other land owners insofar as buyers or off-site owners are not adversely effected. These two principles equate to a fair balance of land owner rights.

The principles need not be defined with statutory specificity. Regulatory experience in the field of hydraulic design has proven that specific guidelines are a severe handicap to both the developer and the regulatory agency. Far more effective is a program where there is adherence to the two basic principles, yet yielding latitude for the designer and government to flex in coping with a particular problem at hand. Obviously a flexible program placing reliance on two principles must be administered by a technologically proficient agency, and in an equitable fashion well tempered by good judgement. This should not alarm those concerned with capricious requirements by the regulator because data unfolding in later sections of this publication will make evident physical phenomena tending to induce damages unless properly checked.

It is not the intent of this publication to attempt advice on legal instruments necessary for the community to achieve and effective Water Management program. Some local governments are convinced that they have the power to regulate for the protection of their citizens through policies, ordinances or resolutions, and are willing to accept any and all challenges to the reasonableness of a prudently administered regulation. Others desire general statutory provisions which yield broad water-related authority to the City Engineer, County Engineer, or even the Planning Commission. Whatever course is adopted, it seems apparent that local government has not only the right but the responsibility to prevent damaging flood aggravation to the community.

CHAPTER 4

WATER MANAGEMENT OBJECTIVES

As a design and regulatory device, Water Management has two primary objectives.

(1) To insure that new construction of all descriptions shall not impose measurable off-site water-related damages.

(2) To insure that new construction shall be free from on-site water-related damages.

These two objectives pose a host of considerations, or secondary objectives, which must be weighed with each project. The number and importance of the secondary objectives vary from job to job, and are a function of the type and size of project, topography, off-site drainage characteristics, soil types, and other elements germane to the entire drainage perspective. The following is a partial listing of secondary objectives which should be considered for each project.

Off-site Considerations

(1a) During a 100-year frequency storm event, the new project will usually generate an increase in run-off rates owing to re-grading, new impervious areas, and possibly a more efficient on-site drainage system. If the run-off increases computationally aggravate downstream flood damages, then it becomes apparent that the developer must employ off-setting measures. Storm water retention basins either on-site or off-site may be the most desirable means of preventing flood aggravation. An off-site channel improvement may provide the same ultimate effect by enabling a reduction in flood stage height. Diversion of storm water, carefully performed with a basin in-line on the watershed receiving diverted flow is another alternative. There are many options to preclude an increase in off-site flooding.

(1b) Not uncommonly, new projects are inland from a defined drainage-way. Natural run-off from the undeveloped pasture or woodland sheets across property lines, sometimes crossing more than one tract before reaching a defined stream or pipe system. In cases of this sort, even on-site retention will not prevent point discharge from gouging a rill across the neighboring tract. While there is accepted responsibility by the neighboring owner to receive up-hill run-off, it behooves the developer to work out a reasonable arrangement with the neighbor whereby erosive damages are avoided.

(1c) Despite the benefits of on-site retention and the utilization of an acceptable receiving stream, point discharge of storm run-off tends to alter natural characteristics at the development boundary. If the point discharge is high enough to produce erosion, a velocity dissipator, revetment, or other counter measures may be necessary.

(1d) Multiple locations around a project perimeter where the transfer of sheet flow naturally occurs often become problem locations because modified sheeting characteristics are not properly placed under control. In those instances where storm water formerly sheeted onto a vacant field from, say, an adjoining residential yard and the field is developed into lots, a perimeter swale often becomes necessary to avert flowage obstructions caused by contractor re-grades. Conversely, where natural sheeting from undeveloped land onto the adjoining builder, the perimeter swale effectively intercepts flow.

(1e) Through-streams are usually altered by a new development. Sometimes the stream is piped, channeled, or even left in the natural state for scenic or economic reasons. Piping and channeling can alter upstream flow characteristics, and even when the natural state is honored, culverts, and over-lot filling effects flood profiles. Any developmental treatment of a through-stream should be computationally checked to insure that there is no increase in height for a 100-year flood profile at the upstream development boundary or upstream point of damage.

(1f) A common water-related damage is that caused by the transfer of soil across the development boundary by storm run-off. Soil transfer can clog downstream pipes, channels and streams, yards and buildings can be silted, and aquatic life is threatened. In areas where sinkholes prevail, siltation can impede or totally stop the sink functionality. There are many ways to curtail the transfer of soil during low to moderate rainfall events during project construction, and these alternatives should be considered as an integral part of development design.

All of the foregoing are usually major considerations in proposed developments, but there can be others. All reasonable questions of measurable off-site damages should be addressed and satisfied. A following section will deal with the question of what constitutes damages.

On-site Considerations

(2a) Whether or not a community is signatory to the federally sponsored Flood Plain Insurance program is immaterial to the local government's responsibility to its' constituency to prevent flood-prone new construction from being sold to an unwitting public. However, there is no question but that the federal program greatly strengthens a local flood plain program. The 100-year storm is considered to be a reasonable minimum protective level and is discussed under the section entitled "Rainfall Characteristics." All on-site residential, commercial and industrial buildings should be checked to preclude a damage level (first floor or basement) at least on foot above the 100-year flood profile. It should be noted that this check applies not only to those tracts contiguous to main streams, but also any tract subject to flooding from roadside ditches or drainage easements along side or rear property lines. Many communities consider that new public rights-of-way should be free from flooding and should be subject to the same type of check.

(2b) On-site drainage facilities should be checked for efficient, durable functionality. There is little logic in allowing new roads and drainage facilities to be placed in the public system (by record plat) at an unrealistically low construction cost when the public at large will have to meet the cost of reconstruction in a few years. New open channels should be erosion resistant and reasonably self-cleaning, and there should be access provisions for routine maintenance. Pipe systems should be properly jointed to prevent cratering, aligned to preclude opposing flow at catch basins, and otherwise designed for durable functionality.

(2c) The residential subdivision designer should take into account regrade possibilities by builders when laying out the lot pattern, or when considering cuts and fills in the subdivision overlot plan. There may be instances where it is desirable to insert regrade controls on the subdivision record plat.

(2d) Where the residential subdivision employs individual driveway culverts, there should be controls to prevent errors in placement which serves to obstruct flow to others who take the trouble to install culverts properly.

(2e) Drainage easements, particularly where inscribing open channels, should be designed to preclude abuse from reasonable property owners. While there is never any assurance that lot buyers will be reasonable, ill-planned open drainage easements invite intrusion by fencing, filling and undesirable plantings. Effective design can give considerable assistance to the developer and government in policing the integrity of easements as the years go by.

(2f) As a part of on-site design, there should be a clear understanding between the developer, government, and public as to responsibility for future maintenance of drainage and retention easements. A non-functioning drainage system is no drainage system at all.

CHAPTER 5

WATER RELATED DAMAGES

Rivers, creeks, streams and man-made drainage-ways are an unavoidable consequence of natural rain-fall, and it should be recognized that owners of contiguous lands (riparian owners) accepted the inherent disadvantages of riparian ownership as well as the advantages when they purchased the property. Periodic flooding, bank attack and natural accretion are several examples of undesirable consequences the riparian owner must expect. And yet, the riparian owner has a right to governmental protection from certain damages or aggravations of the natural undesirable events.

Just as beauty lies in the eyes of the beholder, damages can be what lies in the perception of the damaged party. Owing to the diversity in citizen attitudes and multiplicity in definitions of damages, government can not expect to regulate storm water to the total satisfaction of all. For the most part, however, reasonable people have very little trouble discerning what constitutes significant damages most of the time. The following are several guides which have proven workable.

Damages caused by measurable increases in flood stage

(1-a) Just as increases of in-bank stages pose little problems, slight increases in some overbank flows on an infrequent basis may cause no discernable damages where the overbank consists of woodland or relatively unimproved rear yards in residential districts. But yards improved to a high state, garages, houses or commercial buildings are ordinarily not subjected to flooding increases without some form of monetary or traumatic damages to the owner. Eroded yards, destroyed fencing or other yard appurtenances, building losses, and furniture losses are several examples of direct flood damages. Indirect damages can be equally important. The depreciated value of a flood-prone building, denial of an individual's driveway access during floods, or depreciated re-sale value of a house are indirect damages. One of the most difficult indirect damages to assess is the personal trauma accruing to an owner as a result of flash flooding over which the owner has no control.

(1-b) An increase in urban run-off peaking often leads to an increase in roadway flooding at some point downstream. While right of way flooding can be an inconvenience to some, it can be a matter of life and death to others when emergency vehicles are denied access. Fire trucks, ambulances and police vehicles should have unrestricted movement on public ways 100% of the time.

(1-c) Peaking increases usually bring velocity increases downstream which tends to damage public culverts, channels and roads if left un-checked.

Damages caused by sediment transport

(2-a) This is often a difficult type of damage to assess, yet is perhaps the most common variety in urban or suburban areas. Mud deposits in channels or pipe systems must ultimately be cleared at a distinct cost, and yet the obstructing effects and consequent higher flood stages accruing therefrom until clearing takes place are difficult to measure. Blanket mud deposition to downstream owner's yards are measurable, yet usually insufficient to make the cost of litigation feasible. Un-recoverable damages are just as unfair as recoverable damages.

(2-b) On-site erosion of topsoil is an indirect damage to a future buyer in the sense that both the buyer and the community are deprived of rich vegetative growth in future years, or must go to the expense of bringing in a topsoil substitute.

CHAPTER 6

GOVERNMENTAL RESPONSIBILITY

Governmental agencies act on a number of issues every day in response to citizen or industry requests. Whether each decision is major or minor from the agencies' view, almost all are considered as major to the applicant for an approval, permit, or some other administrative action. It is important that the Water Management regulator not only exercises responsible judgement, but is perceived by those being regulated as being fair and competent. Government has a responsibility to strive for such a favorable perception, and several of the pivotal factors are listed as follows.

(1) Technical Competency

Since each development plan incorporates on-site considerations unique to all other plans, and since off-site considerations vary from project to project, it is not feasible for an effective regulatory program to rest on a detailed procedural manual. Even if it were possible to document every possible variable on- and off-site, the size of total documentation would be ponderous and probably unusable by industry and citizens. Then to, detailed instruction manuals on technical subjects tend to have the effect of curtailing professionalism. A well-administered Water Management program attempts to instill professionalism. In order to accomplish this end, the regulator must be technically competent in applying hydraulic engineering techniques to the program Principles and Objectives.

(2) Integrity

The development industry and the public at large will expect that such a broad based program shall be administered on an ethical level free of bias on issues not pertinent to storm water. The regulator should not be influenced by zoning issues not related to storm water, satellite political issues, applicant or opponent financial wealth, personal compatibility with an applicant or opponent, or any one of the myriad of issues upon which others base their alignment or opposition to a project. There are sufficient outlets elsewhere for project proponents or opponents.

(3) Flexibility

There are generally a number of views on how best to cope with any drainage situation. So-called established engineering methods may not always be the most effective and economic approach. It behooves the regulator to objectively consider the applicant's proposed methodology whatever it may be, albeit the method finally selected in any given situation will be subject to proof of workability. While the Water Management regulator must accomplish a definite task in plan review, it is to the advantage of all concerned to maintain a flexible approach at minimizing construction costs.

(4) Practical Knowledge

Not only is a practical knowledge of construction techniques and costs necessary, the regulator must have a reasonable knowledge of publicly-financed maintenance costs. It is a certainty that the developer will wish to minimize development costs, but this should not be allowed when the public will have to carry an undue burden of future costs as a result of improper economies during construction.

CHAPTER 7

MINIMIZING DEVELOPMENT PROBLEMS

Far from being and adversary proceeding, Water Management review is intended to regulate a development in a fashion acceptable to the community, and to minimize problems to the developer from litigation and builder-citizen complaints. There are problem aspects which the developer can avert through implementation of the following:

(a) Utilize a competent professional
When a developer retains a competent, experienced engineer, most water-related problems should not occur. Particularly during the construction process, there is no substitute for thoroughly detailed planning.

(b) Thorough project cost projections
Most experienced developers recognize the importance of compiling accurate job cost estimates during the feasibility study stage. Those who do not are faced with the temptation to under-cut expenditures on drainage items. A carefully estimated, profitable job for the developer can be an attractive job from the perspective of both government and the public, but a project on which the developer is losing money is rarely desirable to the community at large.

(c) Thorough supervision
Some developers tend to "broker" all aspects of a project from engineering through construction and lot sales. This can be effectively performed, but not often. If siltation and drainage problems are to be avoided, someone must coordinate all phases of the project with not only the developer's agents, but house builders or lot buyers as well. Subdivision plans can be carefully followed by the development contractor only to have subsequent disruptions to the drainage patterns by builders who have not been instructed as to lot grading requirements. It is not realistic to expect government supervision of the various elements which comprise a successful private project. Only the developer can perform this.

(d) Cooperation
There should always be a sound reason behind governmental controls and Water Management is no exception. A cooperative spirit by all concerned is not only helpful during construction drawing preparation, but in overcoming the numerous small problems which surface during construction.

However mundane these elements may appear, they are the most commonly violated which then produces water problems.