16 Oct 1980

Technological Status and Legal/Regulatory Aspects of Low-Head Hydroelectric Power Development in Missouri

Charles Darwin Morris
Missouri University of Science and Technology, morris@mst.edu

Gordon E. Weiss

TECHNOLOGICAL STATUS AND LEGAL/REGULATORY ASPECTS OF LOW-HEAD HYDROELECTRIC POWER DEVELOPMENT IN MISSOURI

Charles D. Morris and Gordon E. Weiss
Institute of River Studies, University of Missouri-Rolla
Rolla, Missouri

Abstract

This paper will present the broad overview of hardware availability, systems design and legal/regulatory constraints presently connected with the development of small hydropower systems in water rich areas such as southeastern Missouri. There is great interest being evidenced today on the part of major federal agencies and some power companies in regard to the feasibility of utilization of the power potential inherent in small streams. The topic is of particular interest to Missourians because of the vast number of small streams present in Missouri.

1. TECHNOLOGICAL STATUS OF LOW-HEAD HYDROELECTRIC POWER

1.1 INTRODUCTION

Small/low head hydro is one source of energy. It may not always be the source that needs to be developed first--but then to arbitrarily cast it aside because it doesn't completely solve the problem is an incredibly naive view of this world's energy situation. The fact is that with the rapidly escalating costs of "fueled" energy, the economic opportunity for expanded development of the alternative sources using renewable resources is greatly increased.

In some areas the importance of small hydro may not be quantitatively or yet economically advantageous to warrant its serious consideration at this time. But in many areas, even though the overall percentage of power guaranteed by small hydro may be small, its marginal value may be much greater. In some areas hydro, particularly small hydro, offers a substantial and practical contribution to energy problems. Furthermore, because hydro systems are capital intensive relative to operational costs they tend to have built-in inflationary protection. Once built, the fuel--river water--is essentially free.

1.2 TECHNOLOGY

In general, low head and small hydroelectric technical knowledge must advance to a point where equipment works dependably and safely. Afterwards, technical advances can be directed towards improving the economics, i.e., reducing the cost of producing power. The technology of low head and small hydroelectric generation is well past the dependable and safe aspects and are well into the economic aspects. Hydroelectric equipment manufacturers are prepared to design, build, and guarantee dependable and relatively efficient low head and small machinery for a wide range of conditions.

Although recent advances in low head and small hydroelectric design have improved, large reductions in the cost of these installations have not been achieved. Some of this difficulty arises from attempts to improve an already mechanically efficient system. Therefore, the greatest improvements are to be made in more efficient installation of this equipment, i.e., reducing the cost of the civil structure and the use of prefabricated, standardized equipment that will lower equipment cost and cut lead time.

The dam structure, if needed, is usually earthen or concrete. Two important considerations in evaluating potential energy production and cost are related to the amount of water flowing through the penstock, a pipe which conveys water to the turbine and the distance between the water surface and the turbine. The civil works cost is also related to hydroelectric generating units.

Low head and small units are divided into groups. The first group, representing earlier development, has a turbine arrangement that uses a spiral case with wicket gates to control the flow. This arrangement was specifically developed for low head and kaplan turbines. Tubular turbines are a recent addition to the first group of low head plants. They were developed to reduce the cost by simplifying the flow passages and thereby reducing the cost of the civil works. They do this by eliminating the spiral case. Except for some small plants, all tubular turbines are oriented so their axis is horizontal. The flow then approaches the turbine axially but is first given a whirling motion by guide vanes located upstream of the runner. The whirling motion is converted to shaft torque by turbine blades. The draft tube geometry, which is simplified by the horizontal alignment, closely approaches the ideal configuration for energy recovery. A very compact type of tubular turbine, the bulb turbine, has been developed. The compactness of this unit reduces the overall size of the plant and, consequently its installed cost becomes very competitive. The range of capacities that have been equipped with bulb units is large.

A second group, the Schneider engine, a "lift translator" makes extensive use of the extremely large quantity of kinetic energy in low head hydropower settings. It introduces the effective use of "lift translators" as prime movers at fixed locations. Historically, lift translators have been used to transport objects-sails on sailboats, airplane wings, hydroplane foils. In the "lift translators" water flow at the entry is stabilized by the entryway to establish a uniform x-vector velocity distribution. The first cascade guidevanes use the pressure head to produce a downward z-vector component which is absorbed by the downward translating hydrofoils. The pressure head is hydrostatically shared by the second cascade guidevanes to produce an upward z-vector component which is absorbed by the upward translating hydrofoils. The water flow leaves the hydrofoils with only the original x-vector remaining, the kinetic energy of this vector quantity being recovered by means of a draft tube. The linear translation of the hydrofoils is converted to rotational motion of the axle at each end of travel. One of the axles is coupled to a transmission and generator.

The Schneider engine has a very low cost of manufacture, installation, operation, and maintenance. The specific advantages are: (1) a facility to operate cost-effectively at low heads where turbines are not cost-effective, (2) a facility to operate at low heads where discharges are large, (3) a facility to integrate the slope of the river in small increments to produce collectively large quantities of power without inundating valuable land.

A third group, also representing earlier development, has a "bucket" with each "bucket" being divided into two identical parts, separated by a thin edge, or "splitter". When the jet strikes a bucket, the splitter divides it into two portions which are then deflected by the curved sections in opposite directions, nearly opposite to the entry direction. Pelton turbines are normally considered for high head installations. They have found some use in small hydro programs where high head combine with low flows. Ossberger turbines are a recent addition to the third group of low head plants. They are radial, impulse-type, low-speed turbines, often referred to as cross-flow types. The intake water is forced through a rectangular cross-section and guide-vane system through the blades of the cylindrical runner, first from outside to inside and then, after passing through the interior of the runner, from inside to outside. Flow can be restricted by the guide vanes so that the arrangement permits the use of any water quantity with optimum efficiency in most ranges. The Ossberger unit has been used satisfactorily for low head installation.

After the above discussion of low head and small hydro equipment, civil works and their impacts on the development of low head and small hydro will be presented. As a rough rule, the cost of civil works is usually proportional to the head height, all other things being equal. The attractive feature of river, i.e., low head installation is that it requires a minimum of peripheral construction. Another advantage of low head hydroelectric development is its compatibility with the natural environment. Aesthetically, low-head plants can be attractive. The powerhouse with a compact, low, unobtrusive profile can be built. There is virtually no pollution associated with hydroelectric plants either in the form of sound, heat, or smoke. The level of activity around a hydro plant is low. The trend is to automatic control with a minimum of maintenance personnel. As a result, low-head, small plants can be located in areas such as parks where aesthetics are important without introducing an obvious industrial atmosphere to the area. This is in sharp contrast to other power generating facilities with their prominent industrial-type buildings, high stacks, and cooling towers.

Another consideration that affects the development of low-head, small plant sites is the natural tendency for planners of power organizations to look to sources of large amounts of power to meet the need for power. They ignore places that would develop only small amounts of power because these sites by themselves do not solve the problem of the moment. The growth of small capacity sites would probably require a new approach, separate department or organization charged solely with locating and developing sites as they prove feasible.

1.3 SUMMARY

Small hydro is becoming an energy resource worth serious consideration. Many sites are economical now. Although small hydro has many positive attributes, it has development problems. Some of the positive aspects of small/low-head hydro are summarized below.

1.3.1 Positive Aspects

(1) Hydropower uses a renewable resource.

(2) Capital expenditure is a one-time expense and not subject to inflationary factors.

(3) "Fuel" and operating costs are small compared to other energy alternatives.

(4) Hydropower is relatively non-polluting by almost any standard.

(5) The state-of-the-art is fully developed. We know what hydropower can and cannot do.

(6) In most areas the hydroelectric potential far exceeds that which has been developed.

1.4 REFERENCES

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2. GENERAL CONSIDERATIONS ON THE FEDERAL STATUTORY/REGULATORY CONSTRAINTS ON DEVELOPMENT OF SMALL SCALE HYDROPOWER

2.1 INTRODUCTION

Enthusiasm for the reservoir of power potential residual in small streams coupled with an awareness of current technological capability to harness it is, to say the least, an exciting concept to most of us. We are tempted to project, in our mind's eye, the immediacy of protection against "brown outs" and worse, as a result of all out attempts to implement the utilization of this resource. But our enthusiasm may erode rapidly and our anticipation may degenerate to a questioning stance, if we take a realistic view of the history of the federal government's expansion of jurisdiction over energy. If we proceed then to an examination of the present statutory and regulatory milieu of small scale hydropower development we may find ourselves more depressed than enthusiastic and more doubtful than encouraged. And I would inject at this point that I feel certain that the Federal Energy Regulatory Commission and the Department of Energy generally may share some of these feelings.

2.2 HISTORY

In order to gain some perspective on the statutory/regulatory environment imposed on small scale hydropower development, it is necessary to look first at the history of federal involvement in energy production, sale and distribution generally; and in doing this to keep in mind that many tangent statutes and policies are brought to bear on the present situation and not just those which evolved in the fifties, sixties and seventies in connection with environmental matters. First of all, to entertain the notion that small scale hydropower (SSH) will somehow be isolated as a 'special case' and given immunity to the proliferative deluge of constraints at the federal level, is the kind of fantasy which no gambler would indulge in and no planner would ever chance.

The continuous expansion of the federal government's control of energy, started with the passage of the Land Ordinance of 1785, when the national government established policies in regard to reserved mineral lands.[1] Coming forward we find at least one hundred and sixty-five major statutes, policies and federal court decisions which directly affect and shape the broad brush picture of energy development in this country.[2] But even more fundamentally than statutes, policies, court decisions and executive orders, if there remains any doubt about the infinite reach of federal jurisdiction over all kinds of hydropower, one need only peruse the powers given to the federal level under the Constitution. Without laboring the rationale, it has been established pretty clearly in reports issued by the Federal Energy Regulatory Commission and others, recently, that federal jurisdiction of SSH could be based on the Commerce Power, the Proprietary Power, the War Power, the Treaty Power and the General Welfare Power. Let's look at just one of these awesome powers to gain some insight into the meaning of this.[3,4]

2.3 COMMERCE POWER

The U.S. Supreme Court has ruled that the Commerce power extends as far as waterways are navigable and the concept of navigability proclaimed by court decisions in recent times would seem to indicate that virtually any trickle of water on the surface of the earth may be interpreted as being 'navigable'. According to William H. Rodgers, in his monumental handbook on environmental law,[5] navigability has been construed at different times to mean "a meandering river passable at high tide by motorized dories, a non-navigable tributary of a navigable river, a stream once navigable now obstructed by a dam, a creek sustaining no commerce, a marshland subject to inundation by high tide, a wetlands area having an overall elevation below mean high water illegally filled more than four decades earlier, and man-made canals dredged above the mean high tide line connected to navigable waters." Rodgers goes on to reassure us that there are situations where a tag of non-navigability could be applied. He states that a "canal in downtown Richmond, Virginia, filled in and abandoned in 1880 and over which a parking lot has been built," was defined as being definitely non-navigable. In consideration of the broader coverage of the present definitions attached to the concept of navigability, one would feel that caution is mandatory in using a garden hose, out of fear of creating a navigable tributary in one's back yard. The point is, interpretations, such as those mentioned, act to establish the broadest possible base for the jurisdiction of the federal government over small scale projects on small streams which might conceivably, in some remote way, affect a navigable stream. If we went no further than this, it would be obvious that the federal government's power to regulate and control the development of SSH is beyond question and absolute. The other Constitutional powers simply expand the broad base of the federal government's jurisdiction.

2.4 FEDERAL ACTS

Certain federal acts which have had a great deal to do with the national control of hydropower, including development of sites, scale and distribution are:

(1) The Boulder Canyon Act of 1928[6]
(2) The Tennessee Valley Authority Act of 1933[7]
(3) The Public Utility Act of 1935[8]
(4) The Bonneville Act of 1937[9]
(5) The Flood Control Act of 1936, 1938, and 1944[10]
(6) Amendments to the Federal Power Act[11]
(7) The Wilderness Act of 1964[12]
(8) The Water Resources Planning Act of 1965[13]
(9) The Wild and Scenic Rivers Act of 1968[14]
(10) The National Environmental Policy Act of 1969[15]
(11) The Fish and Wildlife Coordination Act[16]
(12) The Endangered Species Act of 1973[17]
(13) The Clean Water Act of 1977[18]
(14) The Public Utilities Regulatory Policies Act[19]

The foregoing list is representative, but not all-inclusive; time and space preclude a comprehensive list of federal statutes which conceivably could directly or indirectly impact SSH. Suffice it to say that a three or four level search on the computer, using eight or ten key words could probably turn up a list at least double the size of the list presented. The point to be made here, however, is that before the true legal/regulatory maze can be delineated, a great deal more statutory research will need to be done and that when it is, the general picture for potential developers may be even more foreboding. We have spoken primarily to federal statutes; we have said nothing about the different federal agencies which may have both direct and indirect administrative input into the decision to allow or disallow a SSH project; nor have we considered their ardor in promulgating regulations pertaining thereto.

2.5 ADMINISTRATIVE AGENCIES

The Congress passes laws to meet certain needs. Within some of these acts, it sets up a mandate for the creation of agencies to implement the law. And, it delegates rule making and quasi-judicial powers to these agencies. The proliferation of such agencies in recent times has been difficult to follow; staying abreast of the explosion of regulatory matter which blossoms in the Federal Register and unfolds in the Code of Federal Regulations has become a challenging pursuit in many areas. Hydropower is no exception and although we have not, at this point, run our computer search on regulations, let us consider a sampling of agencies which face the potential developer of an SSH project. We will list only those agencies or departments which may be directly involved with a given project, as follows:

(1) The Corps of Engineers
(2) The Environmental Protection Agency

(3) The Federal Energy Regulatory Commission
(4) Various units within the Department of Interior
(5) Various units within the Department of Commerce
(6) The Office of Science and Technology Policy (Dam Safety Proc. etc.)
(7) The Water Resources Council
(8) The Office of Water Research and Technology

Here again, this is a representative, but not all inclusive list, but it should be sufficient to demonstrate the ever present hand of the federal government from every point on the compass, and it should make us aware of the potential spectrum of hurdles for the SSH entrepreneur.[20]

2.6 LICENSING

I think at this point, a flow-diagram on the regulation of small dams in a fictitious state, taken from a Department of Energy publication is sufficient to clarify the major point to be made in this cursory coverage of the process facing the SSH developer.

To entertain the notion that SSH is so attractive that entrepreneurs will be anxious (or willing) to invest a great deal of planning, time and money in a proposal and then endure the frustration potential represented by a licensing guantlet such as this is 'wool gathering'. Furthermore, some of the unknown factors associated with unclarified future stances at the state level would, in all probability, render the final coup de'grace to investors' interest.

2.7 SUMMARY

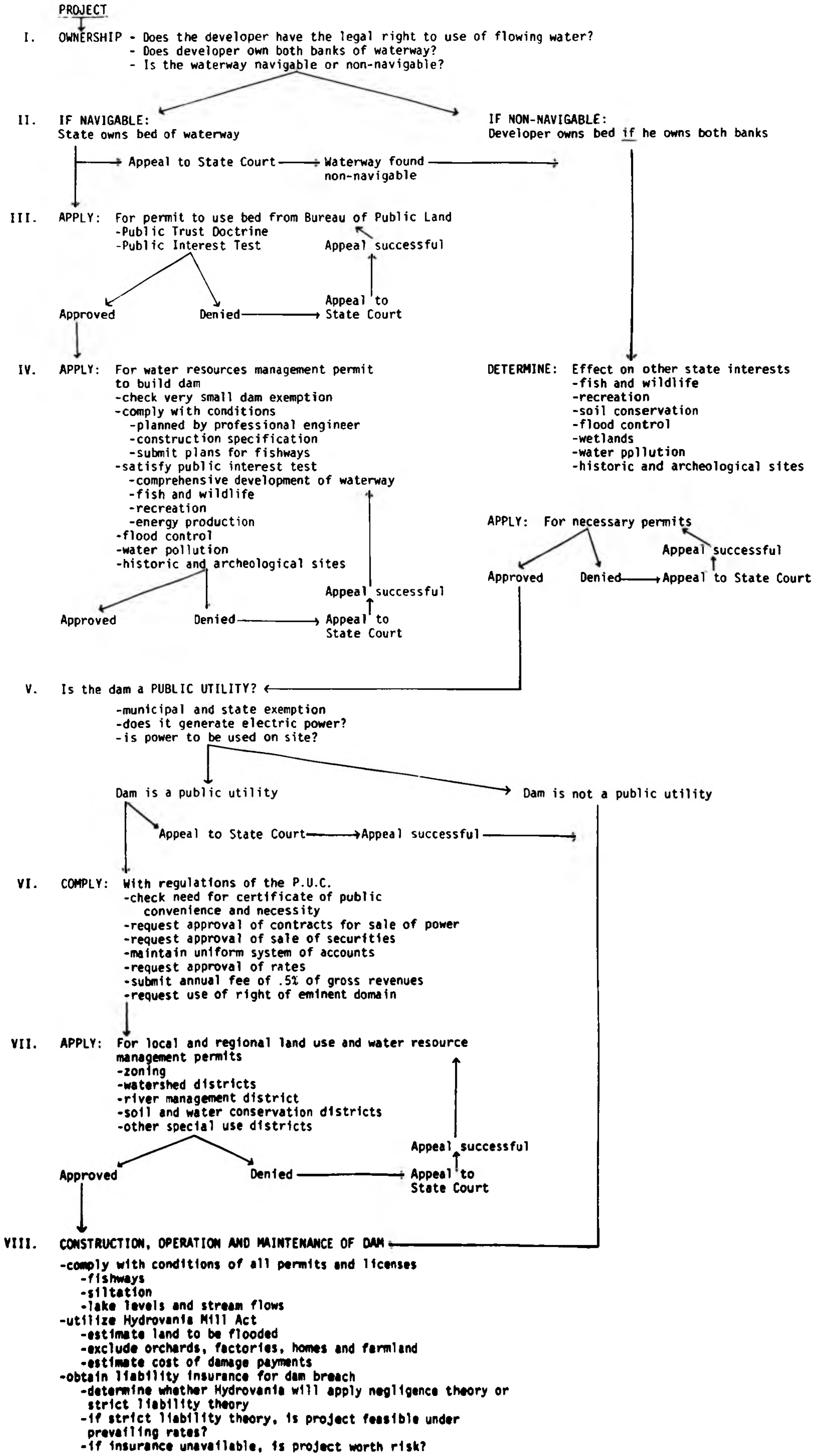
Some conclusions which become most apparent after reviewing several papers on this subject are:

(1) Dual licensing requirements at the state and federal levels should be eliminated. As a matter of fact, if the federal government is interested in the development of SSH, then legislation should be passed at the federal level, declaring a moratorium on regulation of SSH by federal agencies for at least ten years, allowing the states a reasonable time to develop their own SSH test sites.
(2) Before the states draft stringent regulatory obstacles to the development of SSH, a comprehensive effort should be made to build and study SSH projects to determine for certain the correct spectrum of impact they actually have. This would be in contrast to premature assumptions that they would represent a scaled-down profile of problems associated with large hydropower projects.
(3) Institutions of higher education in conjunction with public utilities should be encouraged and supported in an effort to educate the legislatures and the public on all ramifications of SSH. This effort should focus on the importance of eliminating to the extent possible, needless legal/regulatory impediments standing in the way of utilizing the vital energy potential in our small streams. And the legislatures should have it brought home very forcefully that the opportunities for developer harassment by the licensing agency should be eliminated if they exist, or avoided for the future in the formulation of new legislation.

In short, the future faced by SSH will be bright or dull, depending upon our willingness to take away artificial barriers which are residual in the interminable morass of legal/regulatory constraints. If we are unwilling to tear away these suffocating, self-imposed handicaps, then innovativeness in the technology associated with this sector of energy production will count for nothing and we can chalk up one more victory for the advocates of zero-growth in our economy.

This is a remarkable opportunity for the federal government to declare a 'hands-off' policy over a specific time frame, during which each state could attempt to develop, operate, study and optimize resources which theoretically belonged to it at one time.

FLOW DIAGRAM OF REGULATION OF SMALL DAMS IN HYDROVANIA



The Congress has it in its power to do this and the ultimate fate of small scale hydropower will depend upon recognition of it's responsibility in this matter.

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6. (43 U.S.C. § 617 et seq.)
7. (16 U.S.C. § 831 et seq.)
8. (16 U.S.C. §§ 7919-825r)
   (15 U.S.C. §§ 7979z-6)
9. (16 U.S.C. §§ 832-832L)
10. (33 U.S.C. §§ 701a-701f, 701h)
    (33 U.S.C. §§ 701b, 701b-1, 701b-2, 701c, 701c-1, 701f, 701f-1, 701i, 701j, 702a-11, 706)
    (33 U.S.C. §§ 701c-3, 701g, 701n)
11. (16 U.S.C. §§ 791, 791a, 796-800, 803, 807, 810, 817, 818, 824-824h, 825-825r) 1935 (and see '48, '53, '56, '58, '60, '62, '68 and '70 amendments, U.S.C. Popular Names & Tables, page 102)
12. 16 U.S.C. §§ 1131-1136)
13. (42 U.S.C. § 1962d et seq.)(and '71, '72, '73, '75 and '76 amendments, U.S.C. Popular Names & Tables, page 270)
14. (16 U.S.C. §§ 1271-1287)(and '72, '74, '75, '76 amendments, U.S.C. Popular Names & Tables, page 272)
15. (42 U.S.C. § 4321 et seq.)
16. (15 U.S.C. §§ 713c-3)
    (16 U.S.C. §§ 742a-742j)(and amendments U.S.C. Popular Names & Tables, page 110)
17. (7 U.S.C. § 136; Title 16, §§ 460L-9, 460k-1, 668dd, 715i, 715a, 1362, 1371, 1372, 1402, 1531-1543)(and amendments U.S.C. Popular Names & Tables, page 85)
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3. BIOGRAPHIES

3.1 CHARLES D. MORRIS

Charles Darwin Morris was born in Moberly, Missouri on June 27, 1943. After graduating from Jefferson City High School in 1961 he attended the University of Missouri at Columbia and earned a B.S. degree in Civil Engineering in January, 1967, and received a M.S. degree in Civil Engineering, majoring in hydraulics, in August, 1968 from UMC.

In 1968 he accepted employment with the National Aeronautics and Space Administration at Cape Kennedy, Florida. He was commissioned into the United States Public Health Service as a Lieutenant and served from 1968-1970 at Cincinnati, Ohio as a Sanitary Engineer. After being granted inactive duty in the Reserve Corps of the U.S.P.H.S., he attended the University of Illinois at Urbana-Champaign in 1970, studying in the field of Civil Engineering with a major in hydrology and hydraulics. After completing the coursework for the Ph.D. he accepted employment with Clark, Dietz and Associates-Engineers, Inc. as a Design Engineer in charge of hydraulic design, environmental engineering division, 1972-1974. From 1974 to 1975, he became technical consultant in hydraulics and hydrology and in charge of the hydraulics and hydrology section of the firm.

He was an Associate Professional Scientist at the Illinois State Water Survey, in charge of flood studies from 1975 to 1977. In 1977, he was a principal engineer at Camp, Dresser & McKee, Inc., Champaign, Illinois. Dr. Morris is a registered Professional Engineer in the states of Illinois and Missouri. Presently, he is assistant professor of Civil Engineering at the University of Missouri and Associate of the Institute of River Studies. He is a member of Sigma Xi, Chi Epsilon, American Society of Civil Engineers, National Society of Professional Engineers, Illinois Society of Professional Engineers, Missouri Society of Professional Engineers, and the Internationl Water Resources Association.

3.2 GORDON E. WEISS

Gordon E. Weiss was born in St. Louis, Missouri on December 28, 1925. After graduating from J. F. Hodge High School in St. James he served in the U.S. Naval Air Corps in the Asiatic Pacific theatre and was discharged in 1946. He was graduated from Butler University in 1948 and completed work on his law degree in 1969. In addition, he has completed the course on National Security Management through the Industrial College of the Armed Forces and has done post graduate work in the field of management systems and procedures. He is an Associate in the Institute of River Studies and has been a member of the faculty in Engineering Management since 1968 at the University of Missouri-Rolla. Prior to joining UMR he was Director of Planning for a consulting engineering firm.