NORTH AMERICAN WATER AND POWER ALLIANCE

Roland P. Kelly[1/]

This oppprtunity to present the North American Water and Power Alliance concept to you is deeply appreciated by The Ralph M. Parsons Company and me, and we sincerely thank New Mexico State University for honoring us with the invitation. It isn't often one has the privilege of addressing such an important group. We are indeed grateful and pleased to be able to do so.

Throughout the world the chief water problems are (1) too much water, (2) too little water, (3) polluted water, and (4) the growth of human demands for water beyond the perfectly normal and once satisfactory supply. Of these, "too little water" is most in the public eye in most parts of the North American Continent. Water, where it is needed, when it is needed, that is pure enough to drink and cheap enough to use in agriculture and industry, is one of the world's most feverishly sought resources.

New York City, and more than 1,000 other American communities, have had to restrict water usage to stretch the supply to meet the demand. In the northeast, there has been a record-shattering drought from New Hampshire to West Virginia. Likewise, the Prairie Provinces of Canada have experienced severe droughts and still have a serious water shortage in many areas.

Near-record snows and heavy spring rains in 1965 in the upper Mississippi Valley spread devastating floods all the way from Minnesota to Missouri. There were also highly destructive floods in northern California. In Canada they have also often felt the effect of too much water in the Thompson, Fraser, Columbia, and Peace rivers to name a few.

In northern Mexico, immediately across the border lies the most fertile agricultural area of that country, yet it is not developed agriculturally and industrially because of a lack of water. Their water shortage is so critical they are planning large desalting plants to provide water for municipal use. They also have the problem of flash flooding from lack of proper flood control facilities.

In the United States, many of our greatest rivers and lakes now suffer chronic pollution. President Johnson, in a recent message to Congress, described the situation by saying that "Every major river

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system is now polluted." The Canadian Minister of Northern Affairs and National Resources, Arthur Laing, referring to President Johnson's statement said, "We in Canada have not yet reached this condition, but we are not far behind, and I think it is a safe statement to make that most major river systems in the populated parts of Canada are polluted to some extent." Of course, almost everyone is aware of the problems -- pollution, decreased navigation, low power production -- being encountered in the Great Lakes because of the low water levels.

What I have been attempting to do with these few examples is not only to highlight the problem but also to illustrate the commonality of the problem. In other words, the water problem is not unique to the United States. This situation exists now, it is real, and it will grow steadily worse until it reaches alarming proportions by 1980.

I say this because our advancing technology and expanding population will make it so. For example, the average demographic projections show that by the turn of the century the population of this continent will double. By 1980 the demands for water will almost double the amount used today, and they will triple by 2000. In the United States we are said to have a potential supply of 515 billion gallons per day. Our consumption is now 340 billion gallons per day. By 1980 we probably will need 600 billion gallons, and the demand will exceed the natural supply. This is approximately 1,700 gallons per person per day. The total river flow in the United States amounts to about 1.8 million cubic feet per second, or a little more than 5,000 gallons per person per day.

Fresh water supplies can be increased through three means: (1) reducing the need for water; (2) making more efficient use of our present water supply, and (3) finding new sources of water. Many plans and methods have been proposed for solving this nation's water problems and the water problems of the Southwest. There is importation of water, desalination of sea water and brackish water; then there is cloud seeding, better methods of conservation, such as evaporation control, reuse, watershed management, et cetera. Actually none is a panacea. What is needed is a good overall water management plan incorporating as many of the methods possible within economic limits. However, in reviewing the situation, one factor is incandescent and that is the shortage of water.

The NAWAPA concept naturally falls into the last category of finding new sources of water. The requirement for such a plan is, we believe, dictated by the continental nature of the need which I have briefly touched upon earlier.

In simple terms, NAWAPA is a concept for collecting a small percent of the water of the high precipitation areas of the northwestern part of the continent and redistributing it to water-scarce areas of Canada, the United States and northern Mexico.

In presenting the NAWAPA concept, we fully recognize it represents but part of the total water management problem - conservation and distribution, although in providing this element it certainly affects many other elements such as flood control, recreation, reclamation, et cetera, quite substantially.

As I mentioned before, we realize the NAWAPA concept poses many problems which must be solved before work can begin. There are first and foremost the political problems. Then, of course, there are engineering problems, legal, sociological, financial, et cetera.

We are making no attempt at this time to offer solutions to these problems, but are merely presenting a concept for utilizing surplus water now flowing unused into the sea. We are trying to solve one of the water management problems, the problem of proper distribution on this continent.

We are often asked how the NAWAPA concept was developed? It was brought to our attention through our Foreign Operations Division which has been actively engaged in water development projects in Taiwan, India, Iran, Iraq, Kuwait, and many other foreign countries. It was this general knowledge of water and mankind's need for water which lead to a study of means of augmenting the supply of water in the United States. Several years ago we started development of the NAWAPA project, then continued to expand it. The concept was developed entirely by The Ralph M. Parsons Company at Company expense. We have worked on this plan strictly as a free enterprise research and development project without contract from the government or any other agency.

As an aside, I would like to point out that we are engineers, not politicians. We have created the NAWAPA concept based on what we believe to be a definite need -- an ever increasing need. We have based our development and findings solely on the requirement to fulfill that need. In doing so, we have not allowed political boundaries to restrict our thinking because we noted at the outset that mother nature did not take political boundaries into consideration when she bestowed her resource treasures upon this earth. This is not to say we do not fully recognize and appreciate the complexity of the political problems that must be solved before such a project can be undertaken; but from an engineering viewpoint, the best solution to the problem can be obtained looking at it from an objective and practical viewpoint.

Total drainage area involved in the primary NAWAPA collection region is approximately 1,300,000 square miles. It has a mean annual precipitation of between 15 to 60 inches. Of an average annual runoff of 663,000,000 acre-feet of water, approximately 110,000,000 acre-feet, or less than 20 percent of the total flows of the basins, would be utilized. In addition, up to 48,000,000 acre-feet per year, as required, of the unused runoff of the eastern slopes of the Rocky Mountains would be used for development of the Canadian prairies and stabilization of the water level of the Great Lakes.

The primary sources of water collection, as shown on Figure 1, are the Susitna, Copper, and Tanana rivers in southeastern Alaska; the Yukon and Stewart rivers in the Yukon Territory; and the Liard, Stewart, Stikine, Fraser, Peace, Kootenai, and Columbia rivers in British Columbia. A series of dams and power stations would provide for pumping this water up to the Rocky Mountain Trench Reservoir at an elevation of 3,000 feet. From the Rocky Mountain Trench Reservoir, water would be pump-lifted to the Sawtooth Reservoir located in central Idaho. From here, water would flow southward by gravity passing the Sawtooth Mountain barrier through a tunnel.

NAWAPA water would be conveyed via canals and tunnels. The canals would be of trapezoidal cross section and concrete lined. The canals would be based upon a velocity varying from 2 to 3 feet per second and would have a slope of approximately 0.2 foot per mile (.04 foot per thousand feet). Tunnels would be concrete lined. Tunnel design would be based upon a velocity varying from 5 feet to 10 feet per second with a slope varying between 1.2 feet per mile (0.22 foot per thousand feet) to 0.76 foot per mile (0.144 foot per thousand feet). The NAWAPA system would include a total of 6,700 miles of water transfer canals and multipurpose water transfer and navigational canals, and 1,800 miles of tunnels.

Lakes and reservoirs would be the primary delivery points for NAWAPA water. Secondary delivery points would be provided by turnouts on the canals connecting storage facilities. The location and size of turnouts would be dependent upon local requirements.

Total installed power generation capacity of the NAWAPA would be approximately 110,000,000 kilowatts. Based upon an overall efficiency of 83 percent, the total power generation would be 876,000,000,000 kilowatt hours per year. Of this amount, approximately 613,200,000,000 kilowatt hours per year would be available for marketing.

Total pumping plant capacity installed in the NAWAPA system would be 53,500,000 horsepower. Pumping requirements of the NAWAPA system would consume 262,800,000,000 kilowatt hours per year of NAWAPA-generated power. Pumping plant capacity and power consumption are based upon an overall efficiency of 83 percent.

NAWAPA water would be surface waters collected over uninhabited, uncultivated catchment areas of sparse vegetation. The principal catchment areas will be above 2,000 feet and 3,000 feet in glacial regions

Figure 1

NORTH AMERICAN WATER AND POWER ALLIANCE
CONCEPTUAL PLAN

PARSONS

and areas subject to snow cover most of the year. NAWAPA water would contain about 50 p.p.m. of total dissolved solids, have a temperature range between 40 degrees F. and 55 degrees F., and in terms of the United States Public Health Service limits, have a color rating of approximately 2 units and a turbidity below 0.5 units.

Estimated construction costs based on 1964 prices and expressed in United States dollars are tabulated below:

Item	Costs in Billions Of United States Dollars
Land Acquisition and Relocation	16.6
Engineering	8.9
Construction	64.5
Contingencies	10.0
Total	100.0

NAWAPA would require about 20 years to complete after resolution of political and international features. The Rocky Mountain Trench Reservoir, Sawtooth Lift, and Sawtooth Tunnel would be the first elements of the system to be constructed. Following completion of these elements, water deliveries could be made into Utah, Nevada, Arizona, California, New Mexico, Texas, and Colorado.

The NAWAPA concept envisions water deliveries into the Pacific Southwest Region about 9 years after initiation of the program and power deliveries about 8 years after go-ahead.

National benefits accruing to Canada, the United States, and Mexico through implementation of the North American Water and Power Alliance would be significant. The physical benefits would be readily manifest through the creation of scenic inland lakes and waterways.

While the physical results of the North American Water and Power Alliance would affect the three nations, directly and indirectly, the impact created by the economic benefits would influence all facets of their industry and society. The average annual increase in the gross national product of each nation would be increased many times and sustain economic development for generations. The impetus provided industrialization and economic growth would foster and encourage national developments consistent with the needs of ever-increasing populations.

Of particular importance would be the creation of an integrated network of facilities which could be utilized for recreational pursuits such as hunting, fishing, boating, water skiing, hiking, swimming, and related activities. Consistent with an expanding economy and increasing population, potential profits from operation of recreation facilities and enterprises would be a significant factor in the national economy of all three nations.

The primary benefits accruing to the United States alone from NAWAPA water and power are:

1. Water

    a. Delivery of approximately 69,000,000 acre-feet of water annually.

    b. Delivery of approximately 11,000,000 acre-feet of water annually to the Great Lakes for municipal and industrial usage and diversions out of the Great Lakes system in the Chicago area for pollution abatement.

    c. Delivery of approximately 37,000,000 acre-feet of water annually to the Great Lakes system for stabilization of lake levels.

2. Power

    a. Make available 30,000,000 kilowatts of electric power.

    b. Increase and stabilize power production of the Niagara hydroelectric complex.

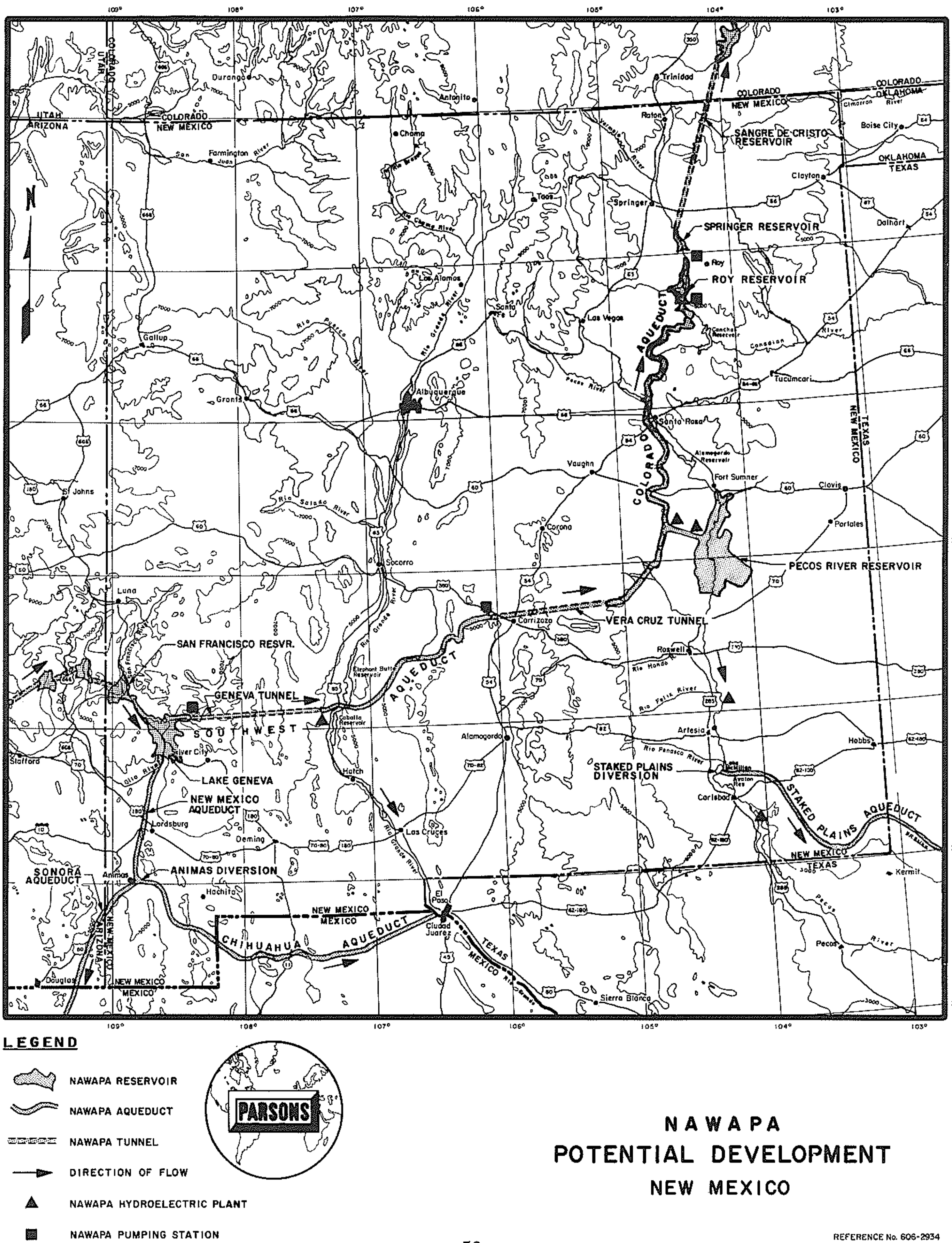
As shown on Figure 2, the North American Water and Power Alliance would entail extensive construction in the State of New Mexico and result in the creation of numerous lakes, reservoirs, and a system of aqueducts crossing the state from west to east and south to north.

NAWAPA water would enter the State of New Mexico in the southwest corner of the state. The Southwest Aqueduct would enter New Mexico from Arizona, north of Reserve, New Mexico, and deliver water into the San Francisco Reservoir. From the San Francisco Reservoir, a continuation of the aqueduct would deliver water into Lake Geneva in west central New Mexico. Lake Geneva, a man-made lake, would be maintained at elevation 4,950 feet above sea level.

Lake Geneva would have two outflows; one to the south designated the New Mexico Aqueduct and one to the east designated the Southwest Aqueduct.

The New Mexico Aqueduct would deliver water into southwestern New Mexico and the northern states of Mexico. North of Animas, New Mexico, at Animas Diversion, water would be diverted into the Rio Grande River via the Chihuahua Aqueduct.

Figure 2



NAWAPA
POTENTIAL DEVELOPMENT
NEW MEXICO
LEGEND
NAWAPA RESERVOIR
NAWAPA AQUEDUCT
NAWAPA TUNNEL
DIRECTION OF FLOW
NAWAPA HYDROELECTRIC PLANT
NAWAPA PUMPING STATION
PARSONS
REFERENCE No. 606-2934
SANGRE DE CRISTO RESERVOIR
SPRINGER RESERVOIR
ROY RESERVOIR
AQUEDUCT
COLORADO
PECOS RIVER RESERVOIR
VERA CRUZ TUNNEL
SAN FRANCISCO RESVR.
GENEVA TUNNEL
SOUTHWEST
AQUEDUCT
LAKE GENEVA
NEW MEXICO AQUEDUCT
STAKED PLAINS DIVERSION
STAKED PLAINS AQUEDUCT
ANIMAS DIVERSION
SONORA AQUEDUCT
CHIHUAHUA AQUEDUCT
COLORADO
UTAH
ARIZONA
NEW MEXICO
OKLAHOMA
TEXAS
MEXICO
Durango
Farmington
Antonito
Chama
Trinidad
Raton
Boise City
Clayton
Dalhart
Taos
Springer
Roy
Los Alamos
Santa Fe
Las Vegas
Gallup
Grants
Albuquerque
Tucumcari
Santa Rosa
Vaughn
Fort Sumner
Clovis
Portales
St Johns
Corona
Socorro
Luna
Carrizozo
Roswell
Silver City
Stafford
Alamogordo
Artesia
Hobbs
Hatch
Carlsbad
Lordsburg
Deming
Las Cruces
Animas
Hachita
El Paso
Ciudad Juarez
Douglas
Kermit
Pecos
Sierra Blanca

The Southwest Aqueduct would deliver water to the eastern and northern sections of New Mexico and into Colorado, Texas, and Oklahoma via the Colorado Aqueduct. From Lake Geneva, the Southwest Aqueduct would be routed almost due east. It would cross the Rio Grande River north of Hot Springs, New Mexico, and continue into the Pecos River Reservoir. At Hot Springs, New Mexico, about 5,000 cfs would be diverted into the Rio Grande River. Diversion would be through a power drop which would produce approximately 300 megawatts of hydroelectric power. The aqueduct would drop 1,000 feet into the Pecos River Reservoir. This head would be developed by two hydroelectric plants generating approximately 1,300 megawatts of power. From the Pecos River Reservoir, the Colorado Aqueduct would be routed almost due north terminating in the Colorado Reservoir east of Denver, Colorado. North of Hobbs, New Mexico, water would be diverted into the Staked Plains Aqueduct for delivery of water into Texas.

The added hydroelectric power potential of the Rio Grande and Pecos rivers, which would exist due to the NAWAPA releases into these river systems, has not been evaluated at this time.

The NAWAPA system in the State of New Mexico would include a total of 500 miles of water transfer canals and 180 miles of tunnels. Storage facilities of the NAWAPA system which are located in the State of New Mexico are tabulated below.

Facility	W.S. Elevation/Feet	Storage Capacity/AF
San Francisco Reservoir	4,955	4,600,000
Lake Geneva	4,950	17,100,000
Pecos River Reservoir	4,000	34,800,000
Springer Reservoir	5,200	2,100,000
Roy Reservoir	5,000	600,000

Potential benefits accruing to the State of New Mexico from development of the North American Water and Power Alliance will be physical as well as economic. The benefits listed herein are indicative of the impact that the proposed project would have on the State of New Mexico.

1. Water

   a. Deliver approximately 10,000,000 acre-feet of water annually into all major irrigable districts of New Mexico.

2. Power

   a. Make available for distribution approximately 1,000,000 kilowatts of electric power.

3. Economic

   a. Provide for an increase in agricultural income of approximately $600,000,000 annually.

   b. Provide permanent employment opportunities in construction, manufacturing, and agriculture.

4. Population Growth

   a. Provide for the support of an additional population of approximately 6,000,000.

5. Recreation

   a. Create a large lake in southwestern New Mexico and one in eastern New Mexico of great value for fishing and recreation by visitors.

   b. Increase recreation and wildlife assets throughout New Mexico.

For NAWAPA planning purposes, it has been assumed that the average cost of delivering water from the NAWAPA facilities to farm ditchside would be approximately $7 per acre-foot, and the average price for NAWAPA irrigation water at the NAWAPA aqueduct would be $4 per acre-foot.

This value may initially be considered high because currently average costs to the farmer's fields or ditchside now run $1 to $4 per acre-foot. Some areas today are charging $3 to $8 and $35 per acre-foot. As water becomes more valuable in our economy, it would appear that the historical American attitude to the price of water must recognize increasing prices consistent with economics. For the purposes of the NAWAPA concept, it was assumed that 94,000,000 acre-feet of water would be used in agriculture. At a sales price of $4 per acre-foot, the revenues from irrigation water sales would be 0.38 billion dollars.

About 16,000,000 acre-feet per year of the water from the NAWAPA project is estimated to be purchased by communities and industries. This would be about equal to some 20 projects the size of the Metropolitan Water District in the Southern California area. Considering the other attendant costs, $15 per acre-foot is considered a reasonable average return to expect at the NAWAPA main canal. The revenue at this sales price would be 0.28 billion dollars.

A reasonable and competitive price for NAWAPA power at the generator busses is between 4 to 5 mills per kilowatt hour using an average 5.7 mills per kilowatt hour for steam-generated power as a guide and adding to the NAWAPA power the cost for transmission of power of one (1) mill per kilowatt hour. This is the fee for transmission on the

Missouri River Basin power system. An average net power production of 70,000 megawatts at 4 mills per kilowatt hour yields an annual gross revenue of 2.45 billion dollars; however, in this study the bus bar power costs are varied from 3 to 5 mills per kilowatt hour.

Other revenues, in addition to those from the sale of water and power include the sale of 48 million acre-feet diverted annually to the Great Lakes, of which 12 million acre-feet annually will be designated for water pollution abatement; navigation toll charges for the 2,000 mile Canadian - Great Lakes Waterway; entrance, license, or permit fees obtained from the recreation areas developed; and the lease and/or rentals obtained from land and/or various concessions on the NAWAPA lakes, reservoirs, waterways, and aqueducts. The net annual income for the above revenue is estimated conservatively at one billion dollars for this financial analysis.

Sale prices of NAWAPA water and power do not reflect radical departures from current practices. However, they do indicate that our present approach to pricing water may be in for serious adjustments. The severity of these adjustments will substantially affect the planning and financing of future water projects. The pressing need for pollution abatement and waste reclaiming will no doubt be reflected in these adjustments.

The NAWAPA concept just presented you is one concept for importing water sufficient to meet the needs of areas consistent with anticipated growth and development. It cannot be overemphasized that this concept is one way of accomplishing water deliveries. In itself, it is not the answer to wise and prudent water management. Water management must include not only the importation of water to meet deficiencies, but also pollution abatement to clean our streams, reclamation of waste waters, adequate storage, and flood control

It is well to note that some of the features of water management will be done with or without NAWAPA. We must clean up our rivers. In order to maintain clean rivers, we will have to clean our wastes. Storage must be provided to take care of devastating floods. All these will be done whether the NAWAPA concept is developed or not. We, of The Ralph M. Parsons Company, feel that the NAWAPA concept is one plan that will weld all features of intelligent water management into an integrated system for obtaining maximum use of our waters.

In closing, I would like to reiterate a few salient points concerning NAWAPA. NAWAPA is a concept. The in-house funded studies performed by The Ralph M. Parsons Company to date on NAWAPA indicate that the water is there, the concept is technically feasible, and economically practical. In the past, many projects have been started without due consideration of the sociological, economical, and ecological impact. These should, and must, be considered in the early stages of the NAWAPA program. In each country of this continent, population growth, industrialization, and an increasing economy are placing serious strains on one of the most important natural resources - water - its supply, distribution, and use. Adequate planning is imperative to insure that water resources are managed with foresight and vision.