A PLAN

FOR THE RESTORATION

OF THE WISCONSIN RIVER

George C. Becker

John R. Holland

A C.N.R.A. REPORT
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CITIZENS NATURAL RESOURCES ASSOCIATION

OF WISCONSIN

(Incorporated under the laws of Wisconsin – 1953)

3239 - 7th Street
Wausau, Wi. 54401
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To : Messrs. George Becker and John Holland

Subject : Review of "The Wisconsin River - A Plan for Its Restoration"

Thank the Lord for forward looking people like yourselves who have the courage and conviction to put new ideas on paper.

As with all things in the planning process, preliminary plans for a better and cleaner world have to be drawn up and designed so that others may critique, review and modify with constructive changes. This is the planning process which leads to final and practical solutions which consider all factors including environmental and socio-economic concerns which are most feasible.

The Citizens Natural Resource Association of Wisconsin takes great pride in being able to sponsor the publication of this report. Certainly, municipalities and their representatives will wish to take a closer look at regionalizing their waste abatement systems.

The "Hardest Working River in the World" deserves the chance of its comeback towards its pristine qualities which Pere Marquette and Father Rene Menard found so beautiful and yet so challenging.

George's "Pipe Dream" may not come true per se, but something akin to it will. Because of efforts like yours, Wisconsin will become a more beautiful place to live.

In Conservation,

Al Berkman

Al Berkman
President, CNRA

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We are grateful to Dr. Koby Crabtree, Professor of Microbiology, UW-Wausau, and to Herbert Weber, Marathon County Sanitarian, for their critical reviews of the papers. To Maurice Van Susteren, Legal Division of the Wisconsin Department of Natural Resources, we express our gratitude for implanting the original seed and for continued encouragement.

For the Preservation, Management, and Restoration of Wisconsin's Natural Resources

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Part 1

RENOVATION OF THE WISCONSIN RIVER - A MASTER PLAN

George C. Becker
Chmn. Wis. Riv. Restoration Comm.
2617 Prais
Stevens Point, WI 54481

Introduction

There are many redeeming values about the Wisconsin River valley but the water in her mainstem and in many of her tributaries is not one of them. Some officials from municipalities and certain industries say that the Wisconsin River is in better shape today than it was ten years ago. The evidence indicates otherwise.

Water quality standards set recently prescribe scarcely more than minimum standards for those sectors of the stream which receive outfall from industries and municipalities. And, although the remaining sectors of the stream "shall meet the standards for recreational use, and those for fish and other aquatic life," many sportsmen will testify that these standards are a fraud.

The Wisconsin River has a fishery which for many years has been virtually unusable. The odors of the fish flesh interfere with their cooking and edibility. In the past few years even the fish from Lake Wisconsin (the lowermost reservoir) have become tainted. Also Lake Wisconsin sustained a massive and most unfortunate winter kill of large sturgeon. According to one biologist, the blame was due to oxygen-demanding wastes from the paper industries upstream.

Increasing complaints on the condition of the river have been coming from resort owners on the Petenwell and Castle Rock flowages. Large levels of toxic mercury, recently found in the waters of the mainstem and in her fishes, have resulted in the State warning that no more than one meal of fish should be consumed per week. Needless to say, this edict has not helped the resort and recreation business. Even during the height of the fishing season, large reservoirs may be devoid of any fisherman. The resort industry has suffered serious setbacks.

In the light of present river use and current methods for pollution cleanup, it seems likely that little improvement may be expected. Rather the question is being asked: What new disaster will strike? What new toxic heavy metal will be found tomorrow which is also contaminating water and organisms?

THE IDEA

Simply stated, the master plan would eliminate by planned stages all discharge of industrial and municipal wastes into the Wisconsin River and its tributaries. This would include the discharge into public waters of raw wastes, partially-treated and totally treated wastes.

The master plan calls for the treatment of wastes through the most up-to-date, technologically-perfected treatment systems. The clear, reusable water coming from such plants will be piped back for reuse to industry and municipality. Any additional waters needed will come from groundwater sources BUT NOT FROM THE RIVER.

The proposal plans to control pollution through a number of phases. Phase 1 (the present plan) deals with the most serious pollution, which, if implemented, will control better than 95% of the river's pollution load.

WHEREVER THE PLAN IS PUT INTO EFFECT, NO WASTES NOR WATER WILL BE RELEASED INTO THE RIVER, NO WATER WILL BE TAKEN OUT OF THE RIVER.

Eventually the Wisconsin River will run free.

Tied in with treatment of industrial and municipal wastes is the disposal of solid wastes. The master plan utilizes the metals and combustible products of trash to help defray cost of the treatment system and its operation.

THE TECHNOLOGY

In recent years advance in treatment for waste water has progressed to the point where the product water is of highest quality and purity.

> All municipal wastewater could be completely eliminated as a source of pollution in the United States and converted to a quality adequate to provide a valuable water resource for nearly unrestricted reuse of a national annual cost of only about 75 cents per person per month. (Culp and Culp, 1971)

Vinton W. Bacon, former superintendent of the Metropolitan Sanitary District of Greater Chicago and now professor of the University of Wisconsin-Milwaukee, College of Applied Science and Engineering, says:

> Closing the water cycle is the only permanent and complete solution to our problem. There are many successful examples of how this has been done. During a severe drought, the sewage water in Chanute, Kansas, was purified and recycled back into the municipal system. Since spring of 1969, a deliberate and direct recycle system has been in operation in the city of Windhoek, S. W. Africa. One million gallons per day of municipal waste water is reclaimed and added directly back into the municipal water system. The reclaimed water supplies 30 percent of the municipal supply. Someday Windhoek will become famous as the first city to reclaim water for direct, domestic use. So far the world has taken little note of this plant's existence (John 1970).

The South Lake Tahoe sanitary district, using the physiochemical system for treatment of sewage wastes, created with all of its product water an artificial reservoir. The water is so pure it supports a healthy population of rainbow trout, and the reservoir is being used for unrestricted recreation, including boating, water skiing and swimming. (Stevens 1971).

BASIN STATISTICS

The Wisconsin River runs almost the entire length of the state for some 430 miles. Its drainage area covers slightly more than 1/5 of the state, representing some 12,280 square miles. The Wisconsin River originates in Lac Vieux Desert on the Wisconsin-Michigan border and flows diagonally through the middle of the state in a southwesterly direction, emptying into the Mississippi at Prairie du Chien.

The 1970 Census shows a total population of over 502,000 within the Basin. Twenty-three counties lie totally or in part within the area. Detail by counties is available (Biology Seminar 1972).

Manufacturing supplies the basin with an estimated $66,554,000 in taxable payrolls and with jobs for an estimated 90,260 employees (Dept. of Commerce 1968). Manufacturing in the river basin places some 133,329,000 gallons of waste into the river per day. This waste contains a BOD (biochemical oxygen demand) of 329,600 pounds per day. This is equivalent to 2,200,000 people dumping their sewage raw and untreated into the river.

Industry in the basin can be divided into four major groups: paper-pulp, dairy, canning and miscellaneous.

THE PROBLEM

In Wisconsin present methods for the treatment of sewage and industrial wastes are inadequate. Culp and Culp (1971) remark:

> A study of the effluent quality produced by conventional secondary treatment processes will quickly reveal that such treatment methods do not remove many pollutants which may create a pollution problem or prevent reuse of the effluent.

A corollary of this concept is that even if all industries and municipalities of the Wisconsin River basin were to go to conventional secondary treatment, the "treated" water would still pollute the lakes and streams into which it is released.

Heavy metals, which are highly toxic, and enriching minerals which cause noxious algal and weed growth still will be released in high quantities into public waters. Secondary or "biological" treatment does not remove these problem minerals to any appreciable degree, rather it changes them from an organic to inorganic state to avoid robbing the receiving waters of oxygen as they decompose. We must remember that serious toxic and enriching contaminants are still dumped into our lakes and rivers, even after "effective" secondary treatment.

The main source of pollution in the Wisconsin River basin comes from the 16 paper and pulp mills located from Rhinelander to Nekoosa.

> Over 90% of the suspended solids and BOD discharged into surface waters of the Upper Wisconsin River Basin are from pulp and paper mills (Wis. Dept. of Nat. Res. 1970).

The remaining industries and municipal waste sources contribute less than 10% of the total pollution load of the upper river.

The chlorine - caustic soda plant at Port Edwards has added large amounts of mercury to the waters and sediments of the Wisconsin River below that point, rendering the fish flesh dangerous. The effect has been disastrous to the resort and recreation industry on the Petenwell, Castle Rock and Lake Wisconsin flowages. This has led to a study which attempts to assess losses to recreation and associated industries:

> The majority of respondents indicated their property has either decreased in value or that their business suffered economic losses, or that increased business did not materialize because of pollution problems in the Wisconsin River. Significantly, over 50% of the respondents indicated they would expand their businesses if Wisconsin River pollution problems did not exist (Field et al. 1971).

Considering its size and its surrounding physical beauty, the Wisconsin River gets very light recreational traffic throughout its highly polluted central sector. Boating pressure is light, fishing pressure is minimal and swimming is practically non-existent. Shoreland values are low compared with those from lakes and rivers that are unpolluted.

Basically three things are needed for water recreation: an abundance of water, access to the water, and proper water quality. The first two criteria are met by the Wisconsin River, but the problems of water pollution appear to be preventing the Wisconsin River basin from attaining its full potential as a recreational area.

Recreational studies made by the Univ. of Wis. Water Resources Center (David 1970) found that water pollution was a major deterrent to recreational participation. Pollution indicators, such as algae, scum, dark water, odor, sewage and debris, kept people away from the river.

THE SOLUTION

The proposed attack against pollution seeks to fulfill the following objectives:

1. Utilization of a treatment system which would allow the river to flow free without further contamination from the serious pollution sources.
2. Utilization of a treatment system which would produce a product water and other materials that are reusable.
3. Establishment of a system which would handle initially the most serious pollution sources.
4. Establishment of a system which would provide for the later addition of less serious and peripheral sources of pollution without excessive expansion costs.
5. Disposal of solid wastes by recovering their value and energy.

The treatment process which holds much promise in meeting objectives 1, 2 and 3 is the physiochemical system discussed by Holland in Part 2 of this manual. It has been demonstrated at South Lake Tahoe and at the Cuyahoga County Waste Treatment Plant in Rocky River, Ohio (Rizzo and Schade 1969). The process is discussed at length in ADVANCED WASTEWATER TREATMENT (Culp and Culp 1971). It produces water of high quality. The following table taken from Culp and Culp (p. 289) compares it with results from conventional secondary treatment:

PERCENT REMOVAL

	Secondary Treatment	Tahoe Process (physiochemical)
Suspended Solids	89	100
Turbidity	96	99.8
BOD (biochemical oxygen demand)	90	99.8
COD (chemical oxygen demand)	86	96
MBAS (detergents)	93	98
Coliform bacteria	95	99.99+
Phosphorus	52	99.6
Color	incomplete	100
Odor	incomplete	100

With a completely closed loop and with almost 100 percent of the supply coming from recycled water, there is a problem with buildup of dissolved salts. These can be removed by introducing a process capable of demineralizing the water (Culp and Culp 1971). The possible need for this will have to be determined from preliminary studies. Holland (p. 23) suggests methods.

As pointed out above, the most serious pollution sources are the 16 paper and pulp mills. Since large population segments serve and support the industry, there tends to be strong concentrations of municipal sewage wastes at the same locales. It is noted by Holland that there are five natural industry-population concentrations along the basin. Using circles of 15-mile radius he was able to circumscribe all major industries and cities embracing 42% of the total population of the basin (p. 30). Much of the remainder of the population is rural. The only city of consequence which falls outside of these arbitarily established zones (units) is the city of Marshfield (15,600).

Unit or Zone	Population	Key Cities
1	17,300	Rhinelander, Tomahawk
2	67,400	Wausau, Merrill
3	67,300	Stevens Point, Wisconsin Rapids
4	33,900	Portage, Wisconsin Dells
5	24,300	Prairie du Chien, Boscobel

It is estimated that treatment of industrial and municipal wastes within the above zones will remove over 95% of the Wisconsin River's pollution load.

Holland has provided for 30% growth for each unit (Table 1). This is designed to handle anticipated growth to the year 2000. It can also accomodate pollution sources lying outside of the zones, thus complying with objective 4 above.

Although Holland is dealing strictly with a system for the proper disposal of wastewater and recycling of usable water, there are wide possibilities for the recovery of other values (credits) which will not only bring down cost of the operation but which are environmentally sound.

The sludge removed from the initial stages of treatment can be converted into a valuable fertilizer. The City of Milwaukee markets such a product under the trade name Milorganite and has had considerable success in moving all it can produce. Environmentally this process is sound in that it returns minerals back to the land.

As described by Holland, a number of pumping stations will move the wastewaters to the treatment plant within each unit (Fig. 3) and after treatment the reusable water will be pumped back to the source. This takes energy.

Such energy in the form of electrical power will come largely from fossil-fuel supplies, such as coal, oil or gas, although a small amount of energy can be recovered from the wastes within the system itself. For instance, methane, a clean combustible gas, is produced anaerobically from sewage wastes.

A sizeable portion of the energy needed to drive the units can be derived from solid wastes (trash and garbage) produced in the region. These wastes are largely combustible - one pound contains an average of 6,000 B.T.U.'s of energy. Residents of the Wisconsin River basin daily discard about 2 million pounds of solid wastes. In addition to the energy which may be derived from this "throw-away" source, the metals (steel at $10/ton; other metals at $200/ton) and glass ($10/ton) may be salvaged.

The disposal of solid wastes costs approximately $4 per ton and in many communities it is considerably higher. The recovery value of the metals, glass and combustible materials within solid wastes can bring down markedly the costs of solid waste disposal. For instance, in St. Louis when the metals were recycled and the combustible materials were incorporated into boiler fuel, the net disposal cost per ton of trash was reduced from $5 to $1 (Grinstead 1972).

Disposal of solid wastes is also becoming a serious and growing problem in the Wisconsin River basin. Objections are being raised to dumps and landfill sites because of the increasing value of land and for esthetic reasons.

It is logical to include solid waste disposal along with the disposal of municipal and industrial wastes. Since many of the problems are similar, one can expect a more efficient and integrated manner in dealing with them.

ORGANIZATION

Our present system of letting each municipality and each industry plan, construct and operate a sewage treatment plant has resulted in continued deterioration of our public waters to the point of posing serious health hazards. Moreover as stated by Culp and Culp (1971):

> Although an efficient secondary plant removes 90-95 percent of the incoming suspended solids, much poorer removals occur all too frequently during "upsets" of the secondary plant due to poor operation, hydraulic or organic overloads, or mechanical failures... The historically inconsistent performance of secondary plants is a major weakness which can be overcome with proper application of advanced waste treatment techniques to remove all suspended solids.

Allowing each municipality and each industry to handle its wastes is like entrusting the repair of a fine watch to a blacksmith. Sewage treatment has become a very sophisticated profession requiring specialists, engineers, computer analysts. The importance of a properly operating system is emphasized with the fact that in the present plan, treated sewage water must be recycled in pure state ready for human use.

The establishment of a basin corporation similar to the metropolitan municipal corporation of the Seattle basin may be enabled by proper legislation, (Donworth 1969). Under the State of Washington Metro Enabling Act the corporation is granted the power to perform one or more of six metropolitan functions: sewage disposal, public transportation, comprehensive planning, water supply, garbage disposal, and park administration. The municipal corporation is governed by a Metropolitan Council which is granted those powers necessary to carry out its functions.

A second method for administration would be to place responsibility into the hands of a private corporation. As in the case of power utilities, this corporation would be empowered with the construction, operation and maintenance of the treatment units anddisposal of solid wastes. The rates assessed against business and municipality or private consumer would be subject to scrutiny by the Public Service Commission.

ANTICIPATED RESULTS

Once the five treatment units are put into operation, the river would respond dramatically. Within two years after onset of the operation it is safe to predict that the fish will be tasty, the water will lose some of its turbidity and improve in color, and sectors of the bottom will reseed to aquatic insects.

Below the Wyandotte plant the muds will still contain mercury. This element travels from inorganic to organic state through organisms into fish. It has been predicted that contamination from mercury will persist in the river and its fish for many years even if no additional amounts are added. With the operation of Unit 3, all the mercury-contaminated industrial wastes will receive treatment. NO MORE MERCURY WILL BE DUMPED DIRECTLY INTO THE RIVER. In time it is hoped that the partial ban on consumption of mercury contaminated fish will be lifted. However, this may take many years.

Another by-product of the proposed plan is that it matters little what the mechanic or the housewife throw into the sewer. There will be no need to turn to a low-phosphate detergent if the lady-of-the-house insists on getting her clothes whiter than white. Algal blooms or channels choked with aquatic weeds will be discouraged. Phosphates and nitrates will not get into the river, rather they will be extracted at the treatment plant, and incorporated, wherever possible, into commercial items.

Cleaning up the Wisconsin River would undoubtedly create additional recreational facilities and the demand for these facilities. Recreation is already a big business in Wisconsin. It is currently third in total dollar contribution to the State's economy (Wis. Dept. of Nat. Res. 1968).

In 1967 expenditures for overnite or longer recreational trips for the state were between $650-725 million. If trips taking less than a day are included the total revenue would be around $1.25 billion for 1967. According to Wisconsin's Outdoor Recreation Plan, swimming, which is second only to sightseeing in Wisconsin in terms of participation, will have a 48% increase in participation by 1980 and by 2000 will have 4.5 times as much participation as in 1967. This will mean a 17% increase in beach acreage just to meet 1980 needs. Boating, fourth on the recreation activities list in Wisconsin, will increase about 1% faster than fishing, which is fifth on the list. Fishing should increase 17% by 1980 and 100% by the year 2000.

These increases in water based recreation have been mentioned because of the significance they may have for the Wisconsin River basin as the water quality improves.

Much of the demand in the future for water-based recreation will come from the southeastern and eastcentral portions of the state where a heavily concentrated population, whose water facilities are further crowded by invading Illinois citizens, will be hard pressed to find adequate swimming, fishing, canoeing, and water-skiing areas, not to mention land-based types of recreation.

It would be worthwhile to determine what portion of the recreational dollars mentioned above pertain to Wisconsin River businesses and what the expected income of the basin would be with a pollution-free river. Can we expect the recreational value to double or triple? What effect would a pollution-free river have on shoreland values?

Let us estimate conservatively that the present recreational income to the basin is in the neighborhood of $100 million. Any percentage growth over that figure would represent substantial growth in wealth for the basin. When applied against the cost of installation and operation of the proposed treatment system, it appears that the anticipated income growth may justify its cost. Investing in the proposed treatment plan is like the promotion of a good business venture.

Culp and Culp (1971) write:

> If all the benefits of water pollution control are considered and balanced against the cost of even the most advanced treatment, there is little question but that clean water saves money rather than costing it.

They close the above paragraph with this remark:

> ......Unfortunately, the benefits do not often accrue to the same parties who must pay the costs for cleanup.

Perhaps an equitable system may be devised which will place the traffic for treatment installation at least in part on the shoulders of those who stand to benefit most.

COSTS

Holland's cost estimates are purposely inflated to provide a maximum possible cost. In Table 7 we see that the total annual cost, including operation and debt service, would amount to $38,316,000.

Total treatment and pumping costs	$17,640,000
Total debt service	20,676,000
Total annual cost	$38,316,000

Holland assumes in the yearly total treatment and pumping costs that each unit would be operating at 100% capacity (Table 7). Since each unit will be operating at this time at an estimated 70% capacity, the actual operating costs will be considerably reduced from the $17,640,000 figure. Proportionally the figure expected will be in the neighborhood of $12-13 million.

The $20,676,000 listed above for yearly total debt reduction assumes an amortization period of 25 years at a rate of 8% interest. We may, however, expect that a regional plan of this scope would qualify for substantial federal grants. It is not unrealistic to expect a federal grant for 70% of the anticipated total cost of $188,700,000 (Table 6). This leaves the basin authority with a system cost of $56,610,000 for which it must seek financing.

In addition to the federal grant, the plan may qualify for a federal loan comprising 20% of the total systems cost at low interest rates (1.5%). When these adjusted figures are amortized over a 25-year period the $21 million calculated for debt service annually will be substantially reduced.

Not entering into the calculations above are the anticipated values of the recovered products. For instance, conventional treatment plants may spend 11¢ to 16¢ or more for treating 1000 gallons of water which are then dumped into public waterways and lost to the payee. In the proposed plan the water is recyclable and has a current value (let us assume) of 21¢ per 1000 gallons. The millions of gallons returned to industry and municipality daily will be worth hundreds of thousands of dollars at the end of the year.

Fertilizers made from the sludge will have value. Solid wastes, with their potential energy and recyclable values, will lower operational costs together with the present cost of solid waste disposal. When a final cost accounting is made of the three services which will be handled by the proposed plan, namely solid waste disposal, sewage treatment and water supply, we will undoubtedly find that this will compare favorably with the costs of these services at the present time.

In addition the plan foresees a complete restoration of the Wisconsin River to pristine value. There is scarcely a river of this magnitude in the United

States with high water quality. ("Nothing goes into the river, nothing comes out of it!")

The upshot is an anticipated recreational bonanza, including all of the body-contact water sports. Tourism, resorts, camping - all will bring additional millions of dollars into the basin. Shoreline and land values will rise sharply with the restoration of the river. Service businesses will benefit.

This leads to some speculation as to who should really pay the bill. Everyone in the basin will benefit. However, it is entirely feasible that the paper industry, which is the greatest water user in the basin, must be given special consideration in what it pays for recycled water. This probably could be calculated on the basis of present cost plus the costs of installation of pollution abatement equipment which would bring the mills in line with their most recent orders from the DNR.

On the other hand, those industries (recreation, land development, etc.) which would benefit most from the implementation of the proposed plan may well expect to pay additional taxes on the increased growth in business - these taxes applied directly to the debt reduction and operation of the treatment system.

CONCLUSION

At any rate, as suggested by Holland recommendations (p. 28) preliminary studies must be made. Interestingly enough, the Seattle (Wash.) Metro system is a big success (Donworth 1969). The people of the Seattle basin piped the sewage wastes away from their precious lakes and streams into two treatment plants. At this point the Seattle plan departs from our proposal in that the treated effluent is lost by releasing it into Puget Sound. However, the important consideration is that the lakes and rivers in the basin, which were becoming seriously polluted today are running free.

The pipeline concept does work.

It can in the Wisconsin River basin as well.

REFERENCES

Biology Seminar 1972 A plan for living: Wisconsin river renovation. Dept. of Biology. Univ. of Wis.-Stevens Point. 40 p.

Culp, Russell L. and Gordon L. Culp 1971 Advanced wastewater treatment. Van Nostrand Reinhold Co., New York. 310 p.

David, Elizabeth L. 1970 Relation of participation in outdoor recreation and public attitudes toward water quality. An Institutional Design for Water Quality Management: A Case Study of the Wisconsin River Basin. Univ. of Wis. Water Resources Center, Madison. Vol IV, Sec. F. 41 p.

Donworth, C. Carey 1969 Metro - the first ten years. Metropolitan Council. Seattle. 39 p.

Field, Fredric, K. Nelson, A. Richert, P. McCoy 1971 A survey of economic losses to service businesses resulting from pollution in the Wisconsin river. University Extension, University of Wisconsin, Madison. Report # 1971-5 14 p.

Grinstead, Robert 1972 Machinery for trash mining. Environment 14(4):34-42.

John, Mary H. 1970 The environmental dilemma - which way? The UWM Magazine. University of Wisconsin - Milwaukee. 4(4):14.

Rizzo, J. L. and R. E. Schade 1969 Secondary treatment with granular activated carbon. Water & Sewage Works. Aug. 1969. p. 307-12.

Stevens, Leonard A. 1971 Breakthrough in water pollution. The Reader's Digest. January 1971.

Wis. Dept. of Natural Resources 1968 Wisconsin's outdoor recreation plan. Publ. 802. Div. of Conservation, Madison 397 p.

Wis. Dept. of Natural Resources 1970 Upper Wisconsin river pollution investigation survey. Div. of Environmental Protection. Dept. of Nat. Res. Madison 103 p.

Part 2

PHYSIOCHEMICAL TREATMENT

A SYSTEMS PROPOSAL FOR THE WISCONSIN RIVER

John R. Holland
Holland Engineering Corp.
2927 N. Murray Ave.
Milwaukee, WI 53211

Introduction

It has become apparent that major changes are desirable in the institutional structure for water quality management in the United States. The desirable structure would be a regional or basin-wide water quality management authority.

A single agency would control all discharges (industrial and municipal) and operate all treatment plants in a region. It would construct new regional treatment plants in optimum locations and control the distribution and redistribution of treated and partially treated wastes. The authority would be responsible for finding and implementing the least cost solution of meeting the stream (or estuary) water quality goals. The question of setting water quality goals relates to social and economic desires and needs. This question need not be resolved by the authority but it could make valuable contributions to the rationality of the process. When a change in goals is proposed, the authority will determine the optimum solution to meet the changes in addition to the cost. Thus, an informed public should be better able to decide what quality of water it is willing to pay for.

This approach has already been established in the Delaware River Basin and detailed studies have indicated that substantial savings can be realized. For example the cost of optimal treatment under the regional management approach in the Delaware Basin, designed to maintain a minimum of 3.0 Mg/l disolved oxygen, would be $2.291 million per year, optimal treatment at the polluter would be $4.1 million per year, and the cost of uniform legislated standard treatment at the polluter would be $8.153 million per year. (1) These costs include both operating costs and amortization of capital bonds.

It is the purpose of this report to develop a preliminary feasibility estimate of the cost of providing optimal regional treatment in the Wisconsin River Basin. In the Wisconsin River basin we have the heart of a number of Wisconsin's largest industries, these include tourism, paper, agricultural and related industries. Wisconsin can ill afford the loss of any of these important contributors to her well being. In addition Wisconsin can ill afford the further degradation of the esthetic value of the Wisconsin River and it's tributaries.

It appears obvious from the Delaware River studies that the only practical solution to this dichotomy is the informed regional management of water resources in the Wisconsin River Basin. This can not be accomplished overnight. But action must begin now. This report describes the basic skeleton of a regional approach which would represent a first step toward our ultimate goal.

DISCUSSION - PLANT LOCATIONS

Regional water quality management requires above all a political entity with the authority to regulate and enforce the wishes of the public. The discussions in this report assume the existence of such an entity. Primary emphasis is given to the division of the Wisconsin River Basin into regions of controllable proportions having certain unifying characteristics which provide a basis for economic optimization of the treatment systems.

Characteristics such as geographical proximity, the ratio of industrial to municipal waste, economics of waste transportation in the area, and potential growth in the region must all be balanced to provide the optimal distribution of treatment facilities.

Figure 1 illustrates the preliminary solution to this problem based primarily on the geographical cluster of major industries within a few urban centers scattered along the River.

The radius of each of the treatment zones illustrated is fifteen miles. It is important to note that the vast majority of both municipal and industrial sources of pollution are contained within these zones. In addition the sources are, as one might suspect, located along the most valuable resource in the area (i.e. the river). In terms of solving the problem now under consideration, this is fortuitous.

Treatment units located at strategic locations within the zones illustrated would be capable of treating and recycling in excess of 90% of the total gallonage now being discharged to the river. In addition the total piping cost can be held to a minimum by requiring only 150 miles of conduit and a modest pumping system.

The exact treatment unit locations have not been selected because a great deal of additional study will be necessary to select the optimum locations from an economic point of view. Considerable savings may be possible through the judicious selection of plant locations.

Additional savings can also be realized by utilizing centralized support facilities such as carbon regeneration plants, repair and maintenance shops and sludges' disposal. These same sludge disposal furnaces would be adaptable at very low cost to the disposal of municipal refuse and trash.

PROCESS SELECTED

Aerobic biological treatment processes are an essential element of the conventional secondary wastewater treatment system. In recent years, interest in producing higher quality effluents for reuse has led to the concept of tertiary treatment. Such treatment employs additional processes to polish the secondary effluent and to effect nutrient removal. Granular activated carbon has gained wide acceptance as the tertiary treatment process of choice for removing refractory soluble organic compounds.

Based on the results of recent pilot scale studies, it has been suggested that the biological treatment step can be eliminated from municipal wastewater treatment systems designed to produce high quality effluents, and that clarified or chemically treated municipal wastewaters can be applied directly to granular activated carbon beds.

Rizzo and Schade (5) have reported the use of packed beds of granular activated carbon in treating modified primary effluent. The quality of the carbon process effluent was comparable to the quality of conventional biologically treated secondary effluent, Bishop, et al. (3), and Weber, et al. (4) have reported on studies in which a treatment sequence consisting of chemical coagulation of raw waste (or primary effluent) followed by granular activated carbon adsorption produced high quality effluents. The quality of these effluents was comparable, or superior to the quality of effluents reported for the more conventional primary-secondary (Biological) - tertiary treatment sequence.

By incorporating phosphate and nitrogen removal into this system, as shown in Figure 2, the system is capable of producing water of exceptional quality (3). The process described in Figure 2 has come to be known as physiochemical waste treatment. Some of its outstanding advantages over conventional waste treatment are that it will occupy less land area than the conventional biological secondary treatment plant. Estimates by Hager and Reilly (9) are that at the 10 mgd scale, the land area ratio of the two systems is in the order of 1:7. While traditionally land availability has not been a problem in wastewater treatment plant siting, there appear to be increasing numbers of instances where land availability is a pressing problem. This is particularly true in situations which call for the upgrading or expansion of presently existing primary treatment facilities located in urban areas.

The physiochemical system would be less affected by shock or rapidly varying hydraulic or organic waste loads than a biological system. The carbon contactor portion of the system will automatically minimize the effects of loading variations since the active adsorption zone of the contactor would in essence only be forced deeper into the bed with little apparent change in the effluent quality. The ability to adsorb such varying loads is further enhanced by combining countercurrent series operation of individual carbon columns with parallel operation of treatment modules and effluent blending. This type of operation will allow wide adjustments in operating conditions while maintaining excellent effluent quality. The system will also be capable of removing waste material which would be toxic or biologically refractory in nature. Such situations may be more frequently encountered in industrial situations than in municipal waste treatment. In water reclamation, the evidence presented to date indicates that physiochemical systems employing metal salts for coagulation are capable of producing higher quality water in terms of concentration of COD (chemical oxygen demand) or TOC (total organic carbon) remaining in the effluent than can be produced by tertiary treatment of a secondary effluent (3)(4). Also, the reclamation system using physiochemical processes will remove phosphate as part of the coagulation step.

For the reasons stated above only estimates of physiochemical treatment were considered in developing the treatment costs which follow.

HOW IT WORKS:

For those interested in a brief description of how physiochemical treatment functions the following description has been included. For a more technically accurate and detailed description the reader is referred to Bishop, et al. (3).

Waste which enters the plant is treated with a combination of chemicals which coagulate suspended colloidal matter and precipitate the majority of the phosphate present. Lime is the major constituent used in this step. Lime also increases the pH of the waste to above 10 where nitrogen can be substantially removed as ammonia by stripping with air.

The lime sludge containing large quantities of organic matter is then burned to render it sterile while the combustion products, mainly CO_2, are passed through the waste to return the pH to normal and conversely to remove dust and odor from the flue gasses of the incinerator.

A settling step then follows to allow reprecipitated calcium carbonate and other suspended solids to be removed. A polishing filter is used to protect the carbon adsorption columns from possible plugging with unsettled solids. The carbon adsorption step removes all but trace quantities of the organic matter remaining in the waste. Carbon must periodically be thermally regenerated. This can easily be done in the same furnace used for sludge destruction. Ash from these furnaces can be used as landfill without difficulty.

Sterilization of the waste is provided ideally by ozonation. Ozone is considerably more effective for destruction of biological and trace organic matter and leaves no residual as does chlorine. The effluent from this process could be consumed by humans if required.

Continuous recycle would not be possible, however, due to the buildup of inorganic salts which would require an additional step to remove. Potential unit processes capable of removing these dissolved solids are: reverse osmosis, ion exchange, electrolysis and/or flash evaporation.

PLANT SIZE ESTIMATES

Plant size estimates for the three Upper Wisconsin River treatment units are based primarily on the survey conducted by the Dept. of Natural Resources in July of 1970 entitled "Upper Wisconsin River - Pollution Investigation." For these upper units, all of the flows were summed and a 30% growth factor applied to attain the nominal design volume for each unit through the year 2000. It was found that these rough design capacities resulted in an unique size multiple which easily facilitates the use of a single modular plant design. This modular design will greatly reduce the overall engineering and construction cost for implementation of the proposed system. The modular volume concept was then applied to the two proposed lower River treatment units with population used as a basis for estimating treatment volumes. Table 1 illustrates the design flows used in the cost estimates which follow. The Wisconsin Public Service Company's 100 MGD cooling water flow has not been included because on site treatment by the utility is without doubt the most efficient method of treatment for this stream. It should not be construed that these estimates are 100% accurate however it is believed that no serious error will be induced into the cost estimates as the result of the errors inherent in the flow determination.

COST ESTIMATES

It is important to remind the reader that the cost estimates are preliminary in nature and are based on a set of assumptions which although accurate in general may not apply to specific field situations. A general philosophy of conservatism was used to determine costs which were in some doubt. This has the result of making these estimates more or less an upper limit on the cost of the project under examination.

One extremely important aspect of a project of this magnitude, not considered because of difficulty in evaluation, is that associated with the possible effect of very large scale purchases on the price of materials used in the project. In most cases such large scale purchases can result in substantial savings in both material costs and the overall time required to acquire the materials. In some special cases however, where the supply of certain materials may be limited, serious price instability may be induced by unplanned large scale purchasing. As will be seen, this project is of such proportions that the significant market effects may be expected to have effect on prices in both directions.

Three major cost estimates were made to develop an overall cost estimate for this project. These three areas were waste treatment, pumping facilities, and piping. The assumptions used and the details of each estimate are as follows:

1. Waste treatment costs.

To determine the costs associated with producing the highest quality effluent now commercially feasible, several well respected authorities were consulted. (2)(3)(4)(5). In addition to the articles sited, I have collected a library in excess of 800 separate articles on advance waste treatment and it is believed that the data given by Bishop _et al._ (3) represents the most recent and technically comprehensive cost study of physiochemical waste treatment. For this reason, although the other authors' references were used as check, the basic data of Bishop _et al._ were used in developing the cost estimates for the waste treatment portion of this project.

Table 2 illustrates the basic costs of the treatment process, including only the pumping costs associated with internal operation of the treatment plants. Pipeline transfer costs are dealt with in subsequent sections. Table 3 contains a comparison among the authors consulted. The cost data given in Table 2 were developed for large scale operations of the type being considered here. As can be seen in the tables, the cost of producing a high quality effluent is approximately 32.2 cents per thousand gallons of 1969 prices. Debt service charges assume an amortization of 25 years at 8% annual interest. The basic treatment plant module capable of handling 30 MGD would cost approximately $15 million.

2. Pumping Costs

The pumping costs associated with the transfer of waste to the treatment facility and the transfer of recycle water back to primary users is the subject of this section.

A simple model was adopted for the purpose of developing these costs. This model is illustrated in Figure 3.

It was assumed that the sources of the discharges were equally divided and located at the furthest point from the central plant. These assumptions result in the cost being somewhat overstated; however, the estimates which result are quite insensitive to the position of the central plant within the system. Booster stations will be required approximately every 5 miles along the main transfer line. These stations would also serve as collection points for smaller trunk lines as the system was expanded to cover more area in future phases of development. Capital costs for pumps, valving and structures were estimated from Smith (6) and Guthrie (7). Operating costs were estimated from data given by Crane Co. (8).

Table 4 summarizes the results of the calculations of the pumping costs.

11 3. Piping costs

Piping costs have been based on an average installed cost because only detailed field studies of the terrain will yield highly reliable costs for such underground work. As a result the piping estimates reported are the least accurate of all the costs developed in this effort.

The trunk line sizes were calculated using the following assumptions.

a. Standard pressure conduit would be used.

b. Corrosion protection would be of a standard nature.

c. No large section of the pipe line would require hard rock excavation.

d. The superficial velocity in the lines would be 5.0 ft. per second.

e. Figure 3 was used as a model to determine flow volume.

15 MGD/7.45 gal/cu ft. = 2.01 million cu ft/day

2.01 MM cu ft/day / 86,400 sec/day = 23.2 cu/ft/sec

23.2 cu ft/sec/5.0 ft/sec = 4.64 sq/ft

Pipe diameter of 30" = 4.9 sq ft

Therefore parallel line of 30" diameter for units 1, 4 and 5 would result in capacity high enough to handle any foreseeable treatment volume and would allow for location of the treatment unit at nearly any point along the transfer line. Head loss per five mile transfer section would be less than fifty pounds per square inch. Estimates of pumping costs assumed this head loss figure. Table 5 contains a summary of the piping cost calculations.

Table 6 and 7 summarize the total capital and operating costs associated with the development of a regional water management system for the Wisconsin

River basin. These are, of course, rough estimates intended to provide guide lines to individuals and groups interested in the preservation and restoration of this invaluable and irreplaceable natural resource.

As indicated by Field, Nelson, Richert and McCoy in their survey (10), the total economic loss due to direct business losses and the loss of potential income in only four counties along the Wisconsin River, due to its polluted condition, may well be in excess of $1.5 million annually. In addition the reduction of property values in these same four counties certainly exceeds $1.8 million.

In 1969 industries and municipalities in the Wisconsin River Basin expended approximately 10 million dollars on pollution control and abatement (11). Substantial increases in this figure can be anticipated in the next several years. When all real and esthetic costs are considered, the cost of Basin wide water management seems quite reasonable. The surveys referenced certainly represent only the top of the iceberg. Losses in esthetic and recreational value are without doubt much higher than anyone realizes.

In addition, a serious problem exists with regard to businesses development in the area, this problem concerns the lack of a co-ordinated water management policy. A businessman can tolerate very restrictive conditions if those conditions are known and predictable. Uncertainty about the future is a businessman's most feared enemy. Uncertainty about the cost of waste treatment is certainly one of the worst problems facing potential developers of facilities in the Wisconsin River Basin. A co-ordinated water management system would allay the fears of businessmen and greatly inhance the attractiveness of the area to necessary business development.

CONCLUSIONS

It is concluded as a result of this study that over 90% of the municipal and industrial pollution now discharging into the Wisconsin River can be placed under controlled management by the development of a regional water quality management system such as the one described in this report. Such a management system could at the same time restore the quality of the river and encourage businesses to develop in the area.

Such a management system is not only feasible and practical, but, as time will illustrate, an absolute necessity if the Wisconsin River is to be prevented from further deterioration.

RECOMMENDATIONS

(1) Political establishment of regional water management authority is a necessity.

(2) Studies of the detailed pollution patterns along the river should be conducted to develop treatment priorities.

(3) Engineering studies to locate the proposed treatment facilities should be conducted and detailed cost studies completed.

(4) Restoration of the Wisconsin River through the co-ordinated management of regional waste treatment throughout the River Basin should be undertaken as soon as possible.

BIBLIOGRAPHY

1. University of California - "Mathematical Programming for Regional Water Quality Management" FWQA, Dept. of Interior, Program 16110FPX Aug. 1970.

2. Lawrence, Alonzo W. "Granular Activated Carbon Treatment of primary and Chemically treated Effluents," proceedings of the third annual North Eastern Regional Anti-pollution conferences. 1970, 65-80

3. Bishop, D. F. et al. "Physical Chemical treatment of municipal Wastewater" U.S. Dept. of Interior, Oct. 1970.

4. Weber, W. J. et al. "Physiochemical Treatment" JWPCF, Vol. 42. No. 1, Jan. 1970, Pg. 83-99

5. Rizzo, J. L. and Schade, R. F., "Secondary Treatment with Granular Activated Carbon" Water and Sewage Works Vol. 116, No. 8, Aug. 1969, Pg. 307.

6. Smith, Robert, "Preliminary Design and Simulation of Conventional Wastewater Renovation Systems Using the Digital Computor," FWPCA, WP-20-9, March 1968.

7. Guthrie, K. M. "Capital Cost Estimating," Chemical Engineering, March 24, 1969, pg. 114-142.

8. Crane Co. Technical Papers No. 410, 1957.

9. Hager, D. G. and Reilly, P. B. "Clarification - Adsorption in the Treatment of Municipal and Industrial Wastewater," JWPCF, Vol. 42, No. 5, Part 9, May 1970, Pages 794-800.

10. Field, Nelson, Richert and McCoy, "A Survey of Economic Losses to Businesses resulting from Pollution in the Wisconsin River, University of Wisconsin Extension - report No. 1971-5.

11. Dept. of Natural Resources, "Pollution Abatement Progress in Wisconsin, 1969.

APPENDIX

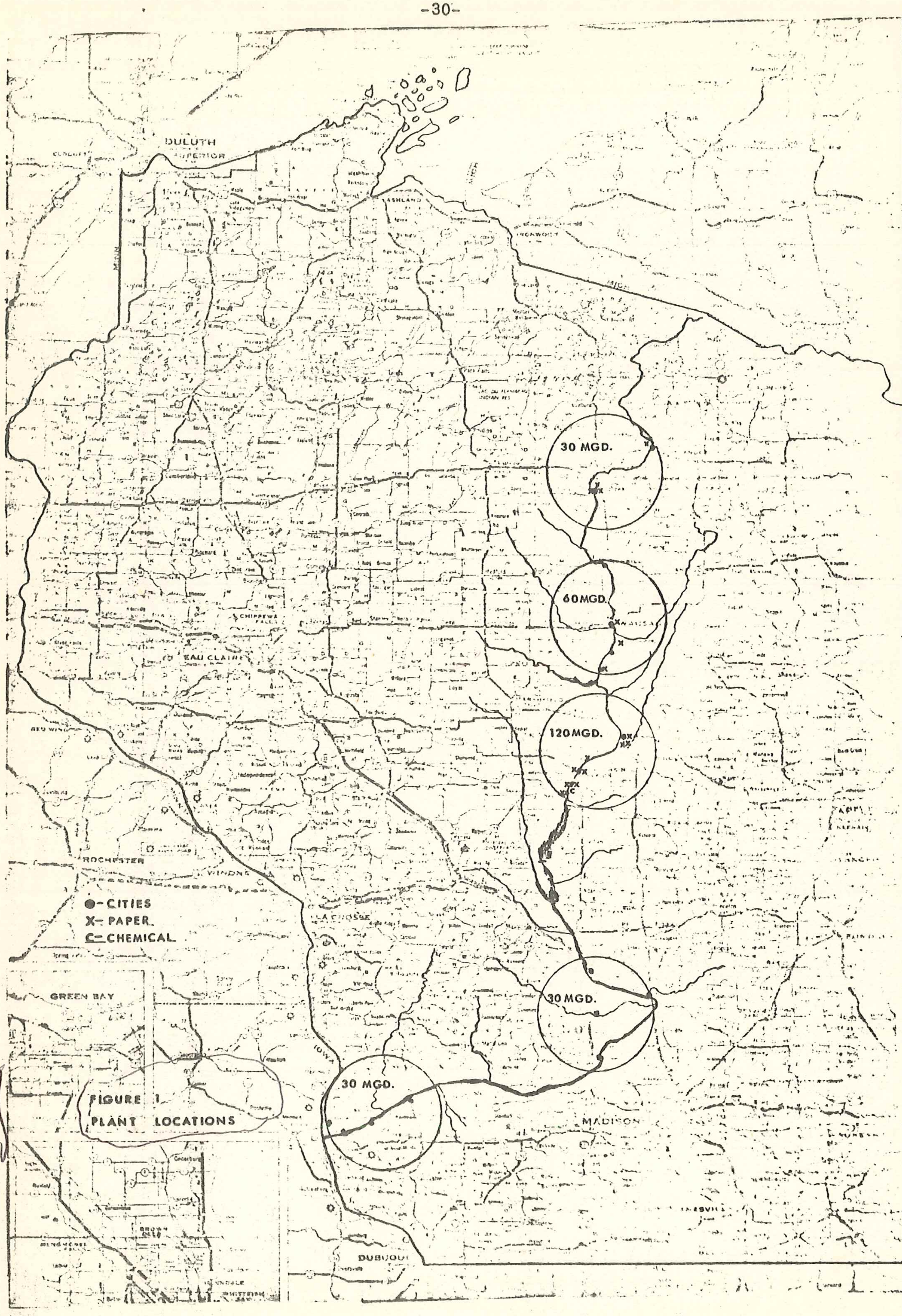

FIGURE 1
PLANT LOCATIONS

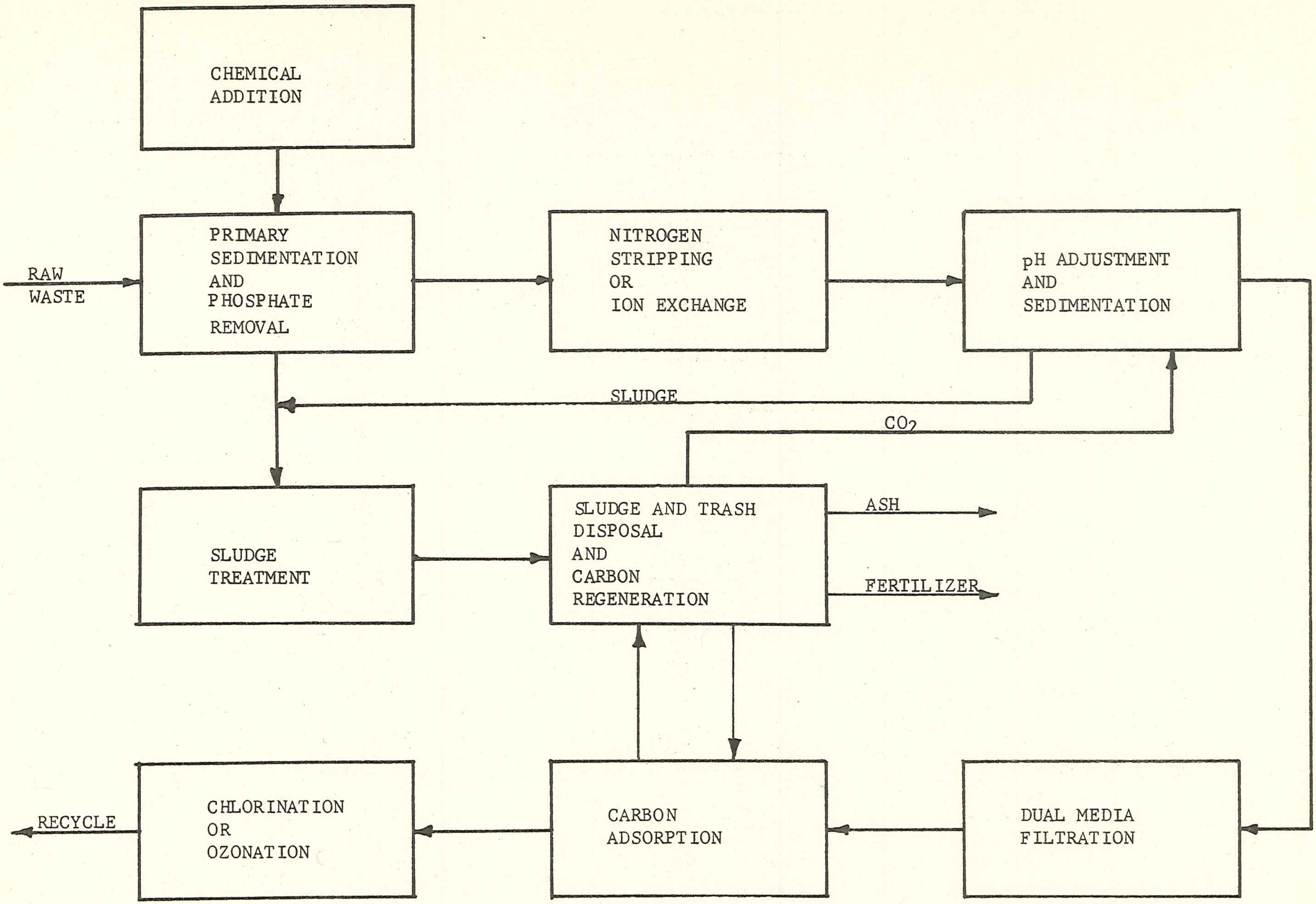

FIGURE 2

PHYSIOCHEMICAL TREATMENT FLOW DIAGRAM

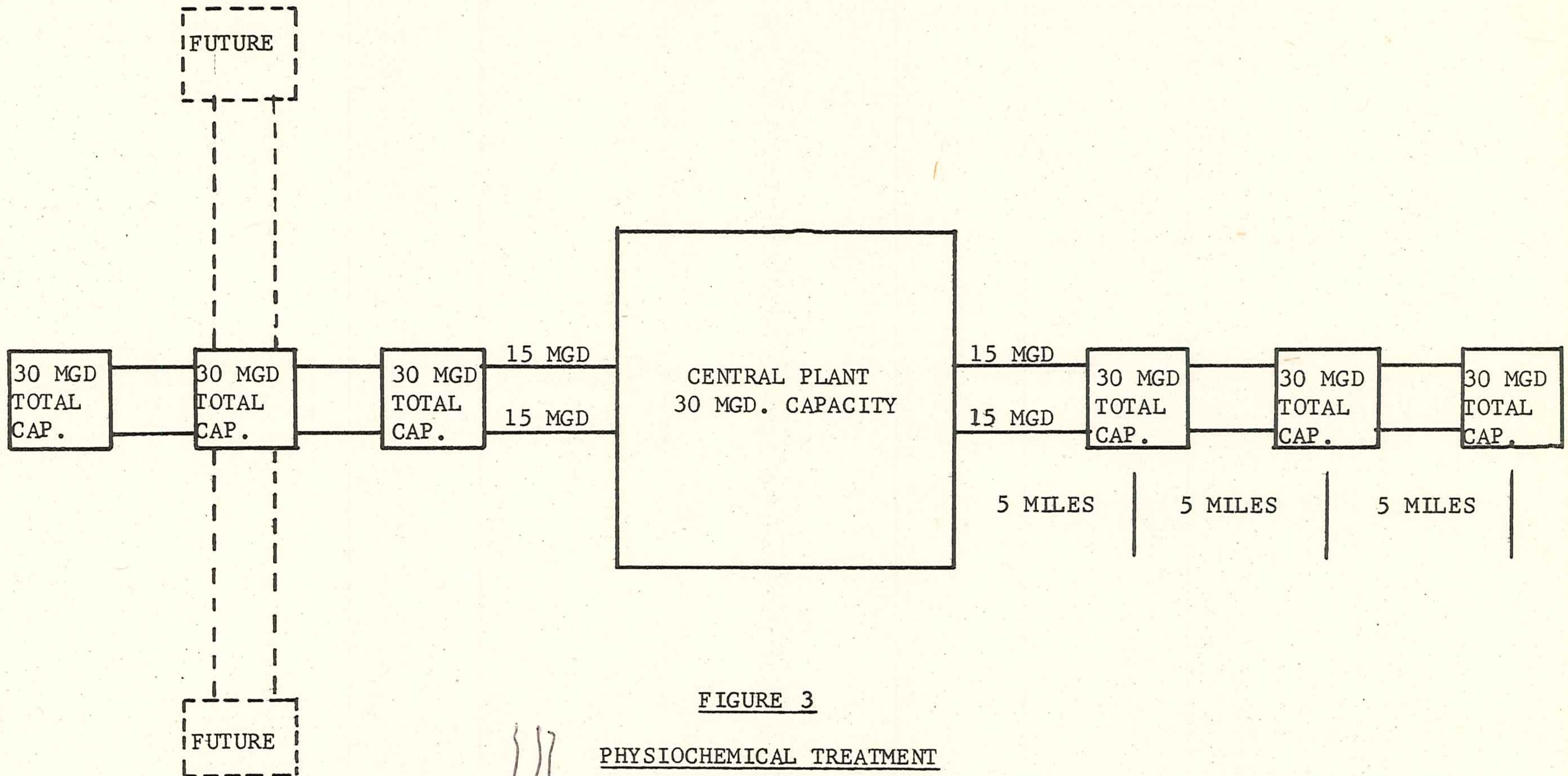

FIGURE 3

PHYSIOCHEMICAL TREATMENT

PIPING MODEL

TABLE 1

Summary of Flow Estimates

	Unit 1[2]	Unit 2[2]	Unit 3[2]	Unit 4[3]	Unit 5[3]
Actual Flow[1]	25.01	41.57	85.60	21.31	19.75
30% Growth	32.50	54.00	110.00	27.70	25.68
Nominal Module Design	30.00	60.00	120.00	30.00	30.00

NOTES:

(1) Millions of gallons per day.

(2) Estimates are based on the Upper Wisconsin River Study of July 1970.

(3) Estimates are based on area population at 200 gallons per day per capata.

TABLE 2

TREATMENT COSTS[1]

	Influent Pumping & Grit Removal	Lime Treatment	Filtration	Solids Disposal	Carbon Adsorption	Ion Exchange	Totals
Fuel	---	0.5	---	1.2	---	---	1.7
Electricity	0.04	0.4	---	0.1	0.3	0.5	1.3
Chemicals	---	2.2	0.3	0.1	---	2.6	5.2
Suppliers	0.04	0.2	0.1	0.1	1.9	1.4	3.8
O & M Labor	0.4	0.6	0.5	0.9	0.6	0.6	3.6
Capital Charges[2]	0.6	4.1	1.0	1.5	4.8	4.6	16.6
TOTALS	1.1	8.0	1.9	3.9	7.6	9.7	32.2

NOTES:

(1) Source of data Ref. 3, costs are given in cents per thousand gallons.

(2) Annual capital cost computed at annual rate of 8% including interest and amortization.

TABLE 3

30 MGD. TREATMENT MODULE COST

	Bishop (3)*	Weber (4)**	Lawerence (2)***
Capital Costs[1]	15,000	11,800	----
Operating Costs[2]	15.60	14.00	----
Total Costs[2]	32.20	26.50	25.80
Annual Costs	3,540	2,900	2,840

NOTES:

(1) Costs are given in thousands of dollars.

(2) Costs are given in cents per thousand gallons treated.

* Estimate assumes 8% interest, 25 year life, 1969 prices.

** Estimate assumes 4.5% interest, 25 year life, 1967 prices. Phosphate and nitrogen removal added.

*** Estimates assume 5% interest, 25 year life, 1969 prices. Nitrogen removal not included.

TABLE 4

PUMPING COSTS[1]

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Total Station Capacity	30 MGD	60 MGD	120 MGD	30 MGD	30 MGD
Station Costs	400	750	1,000	400	400
Annual Operating Costs	250	500	1,000	250	250
Total Capital Per Unit	2,400	4,500	6,000	2,400	2,400
Total Capital Required					17,700

NOTES:

(1) Costs are given in thousands of dollars.

TABLE 5

PIPING COSTS[1]

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Pipe Size Inches	30	42	56	30	30
Flow Capacity MGD	15	30	60	15	15
Excavation Costs Per Mile	60	70	90	60	60
Material Costs Per Mile	90	120	180	90	90
Installation Costs Per Mile	50	60	80	50	50
Total Cost	6,000	7,500	10,500	6,000	6,000
Total System Cost					36,000

NOTES:

(1) Costs are given in thousands of dollars.

TABLE 6

TOTAL SYSTEM COSTS[1]

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Treatment Costs	15,000	30,000	60,000	15,000	15,000
Pumping Cost	2,400	4,500	6,000	2,400	2,400
Piping Cost	6,000	7,500	10,500	6,000	6,000
Total Capital	24,400	42,000	76,500	23,400	23,400
Total Project					188,700

NOTES:

(1) Costs are given in thousands of dollars.

TABLE 7

ANNUAL OPERATING COSTS[1]

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Waste Treatment Actual Cost	1,710	3,420	6,840	1.710	1.710
Waste Treatment Debt Service[2]	1,820	3,640	7,280	1,820	1,820
Actual Pumping Costs	250	500	1,000	250	250
Debt Service Pumping	192	360	480	192	192
Debt Service Piping	480	600	840	480	480
Annual Cost	4,452	8,520	16,440	4,452	4,452
Total Annual Cost					38,316

NOTES:

(1) Costs are given in thousands of dollars.

(2) Debt service charges are at 8% interest per year, 25 year amortization period.